IMSURE QA™ SOFTWARE

U S E R   M A N U A L

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General Precautions

Warnings and Cautions alert users to dangerous conditions that can occur if instructions in the manual are not obeyed. Warnings are conditions that can cause injury to the operator, while Cautions can cause damage to the equipment.

⚠ WARNING: Federal law in the U.S.A., and Canadian law, restricts the sale distribution, or use of this product to, by, or on the order of a licensed medical practitioner. This product should be used under the guidance of a medical physicist.

⚠ WARNING: Where applicable, Standard Imaging products are designed to be used with the versions of common radiation delivery devices, treatment planning systems and other common computer software products or systems used in the delivery of ionizing radiation, available at the time the Standard Imaging product is released. Standard Imaging does not assume responsibility, liability and/or warrant against, problems with the use, reliability, safety or effectiveness that arise due to the evolution, updates or changes to these products or systems in the future. It is the responsibility of the customer or user to determine if the Standard Imaging product can be properly used with these products or systems.

⚠ WARNING: IMSure QA is not intended to be used as a primary calculation for patient treatment. Should IMSure QA results differ from the treatment planning or other primary calculation results, the planning result discrepancy will require resolution prior to treatment.

⚠ WARNING: Enter complete and correct data. Ensure that complete and correct data has been entered by viewing the data on the screen before proceeding.

⚠ WARNING: Poor quality Imported Fluence Maps and/or Maps with an incorrect resolution may reduce correlation of the Difference Map and increase the Maximum Difference. It is the responsibility of the user to visually verify Imported Fluence Maps, and to ensure that Fluence Map resolutions are correctly defined in User Preferences.

⚠ WARNING: Conduct Acceptance and routine QA Testing. It is the responsibility of the user to conduct Acceptance Testing on the machine specified for treatment, and to conduct routine QA Testing at appropriate intervals. Algorithm information is provided in this IMSure QA User Manual.

⚠ WARNING: Verify file selection before import and verify imported data. It is the user's responsibility to select the correct Plan and Fluence Map Files for import. Patient name and selected plan data is displayed prior to Plan import to assist in this process. After import, verify plan data before proceeding.

⚠ WARNING: Machines must be commissioned before use. Verify physics data prior to commissioning. Only machines commissioned prior to the initiation of a treatment plan may be used to complete that plan. If a machine is recommissioned while a plan is in progress, the new data will be used starting with the next new plan.

⚠ WARNING: Verify all printed data. Verify that printed data matches the screen display. All pages need to be accounted for and correctly collated. Correct paper size and printer conditions need to be verified for all print jobs.

⚠ WARNING: Verify exported reports. After exporting a report for electronic storage, users are advised to verify the file before closing the plan.

⚠ WARNING: Verify all physics data. Ensure that physics data is complete and correct after entering or importing data by viewing the data screens in the Physics Data Module.

⚠ WARNING: The use of IMSure QA does not preclude the need for routine machine QA.

⚠ CAUTION: Active plans are deleted when Preferences are modified. When any Preference is modified in the User Preferences Module, all existing plan data is cleared out and reset to default. Users are cautioned not to change Preferences when plans are in progress.

⚠ CAUTION: Assign unique names to each machine. Do not attempt to assign the same name to more than one machine.

⚠ CAUTION: Verify precision levels when importing tables. Precision levels on imported tables may affect calculations, due to rounding.

⚠ CAUTION: Only one user may access the Physics Data Module concurrently. On networked machines with a shared Physics Data file, only one user may access the Physics Data Module at any one time.

⚠ CAUTION: Machine changes are effective when the next plan is initiated. The machine that is commissioned at the initiation of a plan is used to complete that plan. If machine parameters are changed while a plan is in progress, the change does not take effect until the current plan is closed.

⚠ CAUTION: Cybersecurity is a shared responsibility between Standard Imaging and the customer. Secure use of this product is dependent upon the proper utilization of passwords, firewalls, networks, computer platforms, operating systems and data storage.

⚠ CAUTION: Back up data files. Data files should be backed up on a regular basis.

⚠ CAUTION: Protect the CD-ROM surface from fingerprints, scratches and other damage. Do not store the CD-ROM in direct sunlight or warm and humid places.

⚠ CAUTION: For professional use only. As desired by IAEA, English is the default language for labeling and manuals. If translated versions are available, resolve any differences in favor of the English versions.

Table of Contents

1 Overview

IMSure QA is designed for use as a redundant check tool for busy Radiation Therapy departments to verify IMRT and VMAT treatment plans quickly and accurately as a tool for verifying and computing simple Monitor Unit (MU) computations ("hand calculations").

For IMRT and VMAT Treatment plans, IMSure QA is intended for use as a secondary, independent verification tool for rapid QA of IMRT and VMAT treatment plans. Using measured physical data from the linear accelerators entered into the system by a trained physicist, IMSure QA performs these calculations based on the patient's data and an IMRT and VMAT plan generated from the inverse treatment planning system.

For standard plans with simple field setups, the IMSure QA program is intended for a secondary, independent verification tool for use in any situation for which a hand-calculation would be appropriate, including both routine independent QA of existing plans and for simple fields when complex 2D and 3D patient geometry are not required for accurate results.

For basic MU calculations, IMSure QA uses the simple treatment setup conditions and field parameters combined with the physician's prescribed dose to calculate the monitor units and associated QA parameters for a standard plan for radiation therapy. Upon completion of the calculations the system can produce a QA report for the treatment suitable for long-term documentation.

IMSure QA is intended for use by trained Medical Physicists, Physicians, or Dosimetrists at the direction and request of a Physician. IMSure QA is designed only to double check the dosimetric calculation of the treatment plan. It is not intended for use as the primary means of treatment planning.

IMSure QA IMRT QA method

IMSure QA Software effectively mimics the traditional IMRT QA protocol in which a phantom is placed on the treatment couch and is irradiated. Generally a chamber is placed in the phantom for a point dose verification and film is placed between the phantom slabs for verification of the delivery for the complete plan. This classic protocol can add up to 2 hours of time to perform this QA for each patient.

The Standard Imaging IMSure QA method uses techniques and algorithms developed at and patented by Stanford University which, if properly implemented can greatly reduce the time effort required to conduct IMRT and VMAT QA. IMSure QA does this in the software by duplicating the two QA steps traditionally accomplished with measurements.

1. Verification of the delivery files is achieved by comparing the Fluence map predicted by the TPS with the independently calculated fluence map within IMSure QA. Several methods of comparison are offered including difference maps, Gamma analysis and a patented correlation coefficient.
2. Verification of the dose delivered by each beam for the prescribed amount of MU to any point or multiple points within the treatment field. The imported treatment plan parameters are re-calculated with the 3-Source Algorithm and then compared with the predicted values from the planning system. It is important to note that

IMSure QA allows the user to import the PATIENT treatment plan facilitating true patient specific QA of prescribed doses. For comparison to measured results, the PHANTOM plan can be imported also.

3. Documentation can then be produced of the above for the patient chart.

What you should already know

It is assumed that the operator of IMSure QA is familiar with a personal computer running a Microsoft Windows environment and the standard technique for using a computer mouse. It is also assumed that the operator is already familiar with IMRT and VMAT planning and delivery processes.

Input data

Physical measurement data such as TMR, OCR, output factors and other machine characteristics and identifiers are required for each linear accelerator in the department. A number of tools are provided to assist the user in inputting and reviewing the data for accuracy. Standard Imaging will assist in this process.

The basic input to the IMSure QA IMRT module is the patient's RTP exchange file or the DICOM-RT Plan file generated by the treatment planning system. RTP exchange files may not contain all the information necessary for the calculation and therefore the DICOM-RT Plan file is recommended. Other input may include the SSD to the calculation point, effective depths if heterogeneity corrections are used in the treatment plan, and fluence maps if not contained in the plan file. Input of CT images and structure set is used for automatic SSD/depth calculations.

All fields for the MU calculation module can be either imported or user-entered. Some fields are required, while others are optional. A user will create a plan summary by beginning with a single field and adding additional fields if required. New fields may also be created by duplicating existing fields. Once all required data has been entered, the MU and other dose point information will be automatically computed and shown to the user.

Documentation in the form of paper or electronic files may then be generated for long term use.

Upon completion of the calculation, the user can request printout or save to an electronic file a QA report, which contains all the information displayed for the current patient.

2 System Requirements

Operating System	Windows 10® Professional, 64 bit recommended
Processor	Dual Core, 1 GHz: Quad Core, 2Ghz Recommended
Memory	64-bit OS: 4 GB, 8 GB Recommended
Hard Drive	32 GB or greater, 3 GB free space for initial software setup. Sufficient free space to store the input RT Plan, Structures and Image files as required. 25% free space recommended
Screen Resolution	1024 x 768 or higher recommended
Optical Drive	Compact Disc (CD) or Digital Versatile Disc (DVD)
Connectivity	IPv4 LAN, 100 Mbit/s or greater
Product Standards:	Designed to meet IEC 60601-1-4

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3 Setting up and Registering IMSure QA

3.1 Setup of IMSure QA Software

New software setup of IMSure will NOT overwrite a previous software setup. Old and new versions of IMSure can run side-by-side. This is typically done to verify calculation results of the new version against the old. To remove a previous version, see "Deleting IMSure QA Software" below.

1. Insert the CD containing the software into your CD-ROM drive.
2. If the software setup program does not start automatically, click the Start button and select Run. Then, type D:\Setup.exe where "D" is the drive letter of the CD-ROM drive.
3. Select IMSure QA from the setup dashboard.
4. Accept the default Destination Folder or choose another folder, and then click Next. NOTE: The default folder is C:\Program Files\Standard Imaging\IMSure 3.8. If you have a previous version of IMSure QA, the new version will be setup in a separate folder.
5. The setup program will create the necessary files. Click Finish when complete.

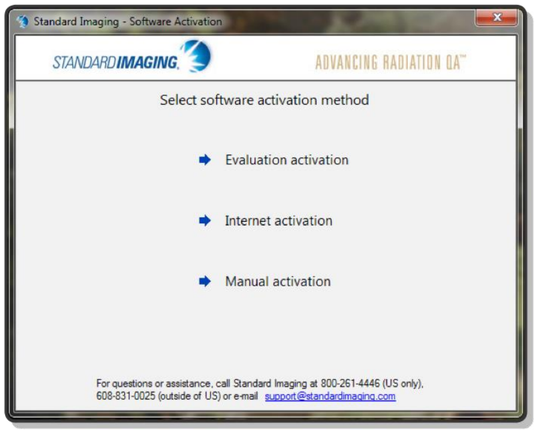
IMSure QA's setup dashboard also includes the choice of installing doPDF:

> doPDF is an 'Open Source' utility program that allows users to export any printable document to a PDF file. IMSure QA requires a program of this type in order to export calculation reports as a PDF. If you already have a PDF creation utility program present on your computer you do not need to install this option.

3.2 Registering IMSure QA

New Setup/License

Launch the application. This will display the 'Standard Imaging – Software Activation' dialog.

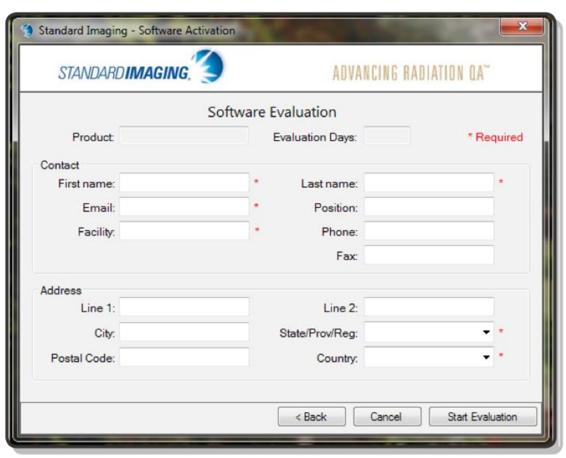


Select one of the licensing options.

Evaluation Activation

Evaluation mode allows full use of the software for a period of 30 days. After 30 days, the evaluation period will expire and the software will no longer be usable until a regular license is purchased.

Begin by selecting [Evaluation activation]. This will display the Evaluation Activation pane.



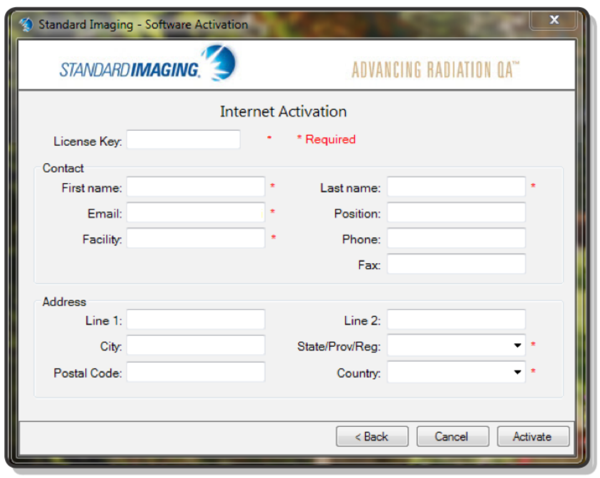
Enter contact and address information, then select [Start Evaluation]. The Evaluation mode will be enabled.

Each time the application is launched, a rolling dialog will be displayed above the task bar, indicating how much time is left until the evaluation expires.

Internet Activation

Internet activation is the preferred method of license activation. The application will register the license key via internet.

Begin by selecting [Internet activation]. This will display the Internet Activation pane.

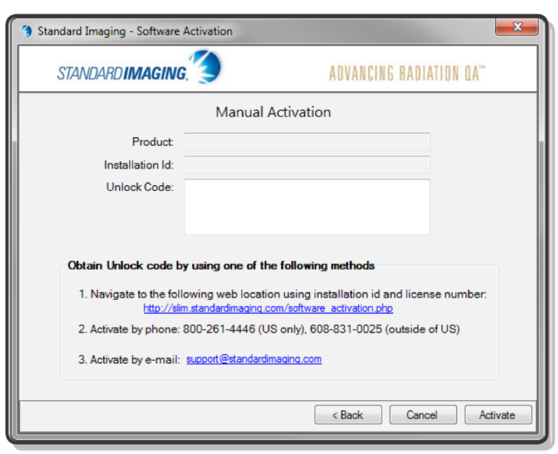


The license key will either be received as an email, or printed on the disk case if a physical disk was received. Enter the license key, contact, and address information. When finished, select [Activate]. This will activate the license and allow the program to be used.

Manual Activation

Manual activation is an option in instances where an internet connection is not available.

Begin by selecting [Manual activation]. This will display the Manual Activation pane.

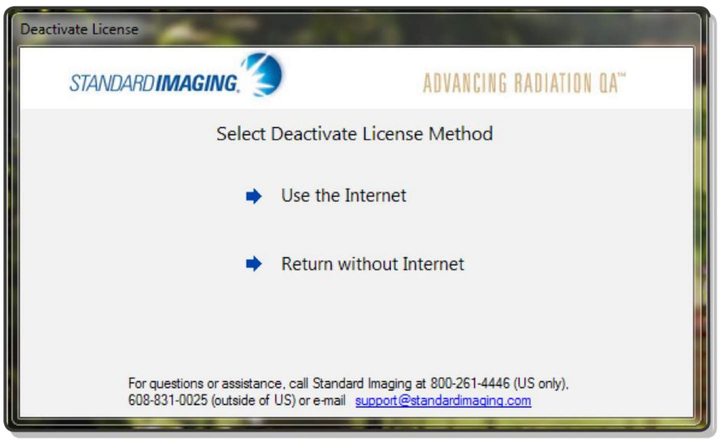


An unlock code is needed to complete a manual activation. Following the directions in the dialog, you can visit the website, call, or email to obtain the unlock code. Once received, the unlock code should be entered into the provided field and select [Activate]. This will activate the license and allow the program to be used.

Deactivate License

It is occasionally necessary to deactivate a license. For example, when moving the software to a different machine, or if the machine itself is being decommissioned. Deactivating a license will prohibit the program from being used. The software cannot be used again until the license is activated.

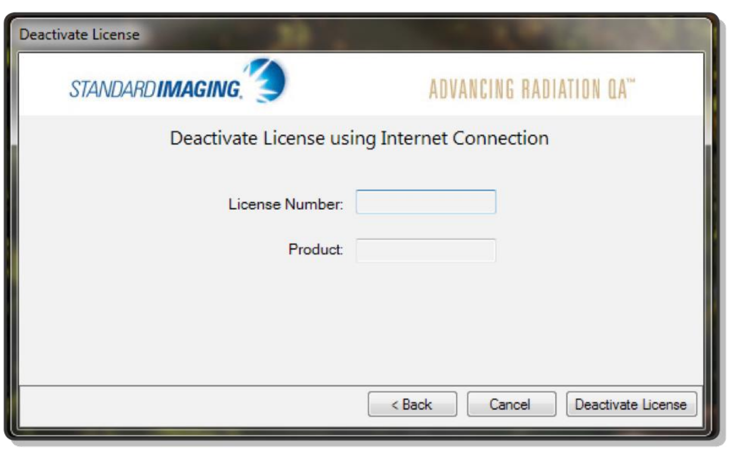
Begin by selecting Help>License>Deactivate License in the main menu. This will display the Deactivate License dialog.



The license can be deactivated through the internet, or manually.

Deactivate using the Internet

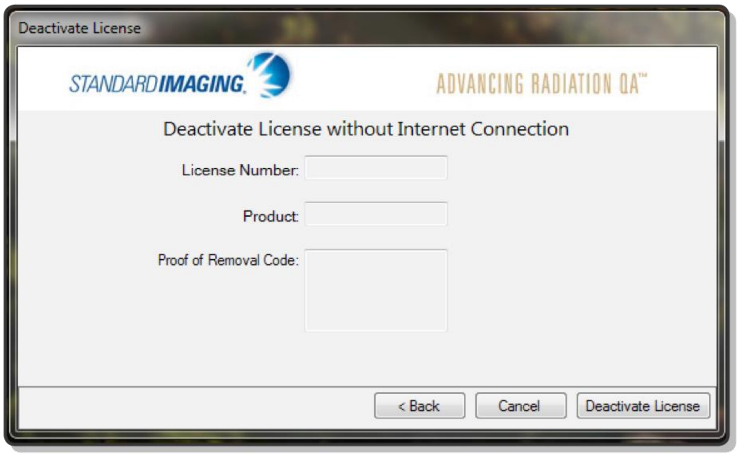
Start by selecting [Use the Internet]. This will display the 'Deactivate License using Internet Connection' pane.



Enter the license number and product name, and select [Deactivate License]. The license will be deactivated automatically. A message dialog will be displayed indicating that the deactivation was successful.

Deactivate without the Internet

Start by selecting [Return without Internet]. This will display the 'Deactivate License without Internet Connection' pane.

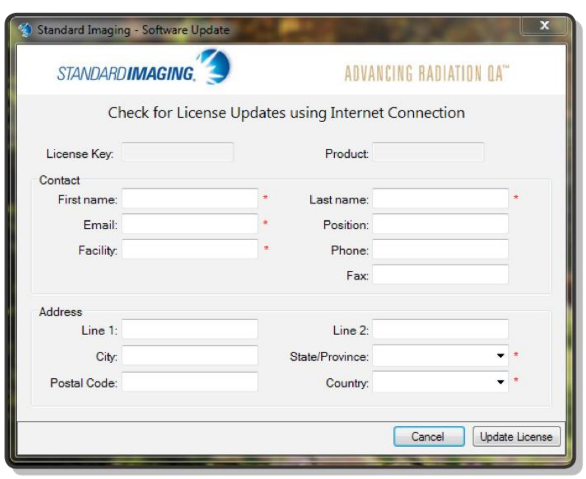


Select [Deactivate License]. This will generate a Proof of Removal code in the specified field. The program will automatically be disabled, but the Proof of Removal code must be communicated to Standard Imaging by email or phone to complete the deactivation process.

Update License

Updating the license is necessary when new features or modules have been purchased in the software.

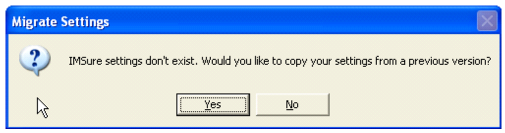
Begin by selecting Help>License>Update License This will display the 'Standard Imaging – Software Update' dialog.



Enter the license key, contact, and address information, and then select [Update License]. If no updates are available, a message dialog will be displayed saying so. If updates are available, the update will occur automatically, and a confirmation message will be displayed.

3.3 Upgrading from your current version of IMSure QA

The first time you open IMSure QA 3.8 after setup the migration module will automatically launch.



The migration module will automatically search the Program Files folder for earlier setups of the software. Choose the prior version you would like to copy from and click on the 'Migrate' button. IMSure will then copy your preferences ("Preferences" on page 8) from the previous version to version 3.8 including your folder paths for your physics (Machine Folder), plans (Plan Folder), maps (Fluence Map Folder) and users (User Management Folder).

If preferences are not automatically detected by the migration module, the browse button can be used to direct its search by navigating manually to the folder in which the prior version's imsure.pref and imsure.user files are located.

3.4 Removing IMSure QA

Please note that removing IMSure does not remove any data files or directories that you may have created and used with a previous version of IMSure. Removal of data files and directories must be done manually.

Before proceeding to remove the IMSure software be sure to read the instructions on transferring the CD key license. (See "Deactivate License" on page 4.)

To delete IMSure QA follow the instructions below.

1. Go the Control Panel.
2. Double-click on Add/Remove Programs.
3. Highlight IMSure QA.
4. Click on Remove.
5. Click Yes to confirm.
6. IMSure QA removal will be complete.
7. Click OK.

The User Management Module provides a minimal level of security that prevents unauthorized users from modifying the physics data and preferences.

4 User Management

4.1 User Levels

The User Management Module allows three user levels:

1. Superuser – may enter all modules;
2. Physicist - may enter all modules except User Management;
3. User - may only enter IMRT QA and MU Calc Modules.

A default Superuser is established at setup. The User Name and User Level for this user may not be changed, but the password may be changed at any time.

User Name: Superuser
Password: Superuser
User Level: Superuser

The first time the IMSure QA software is opened, the system creates the default Superuser. After the initial accounts are set up, all users must log in to gain access to the system.

Users may be added, deleted, and edited by anyone with Superuser privileges.

Users may change their password at time of login by entering their username and current password and then clicking on the 'Change Password' button in the login screen.

4.2 Permission Levels

Three levels of user rights are provided: (1) Superuser; (2) Physics; and (3) User.

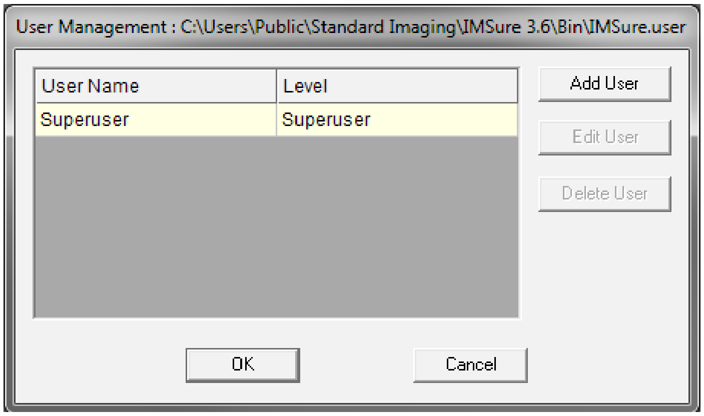
	User	Physics	Superuser
Import, Edit and Calculate plans	X	X	X
Edit Physics, Preferences and Data		X	X
Create new users			X

4.3 User Management Module Operation

Module Entry

The User Management module may be entered at any time by a user with Superuser level privileges by selecting the "Modules/Users" menu item on the main IMSure QA menu. Physics level or User level users cannot enter this module.

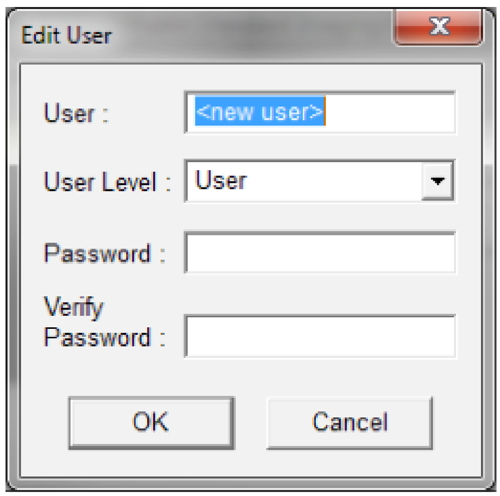
A dialog box with all current users listed by user name and the user level associated with that user is displayed. The Superuser may now Select, Add, Edit, or Delete Users.



Select User

To select a specific user from the list, click on the user name in the list. The user name will be highlighted.

Add User



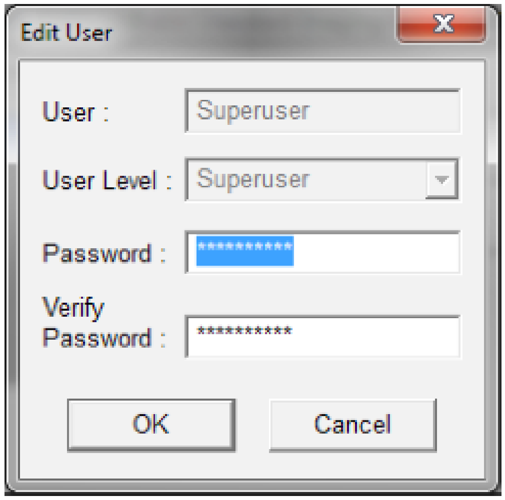
Adds a new user with a default User Level: User and prompts the Superuser to edit the user parameters. User parameters, ranges and defaults are:

Field	Description	Range	Default
User Name	User name	2-12; unique	"New User"
User Level	User permission level	Superuser, Physicist, User	User
Password	User password, characters are hidden	6-12; Alpha/Num	Blank
Verify Password	User password, characters are hidden	6-12; Alpha/Num	Blank

Passwords are hidden, and changes to the password must be confirmed by retyping the password exactly in the Verify Password box.

After entering fields for each parameter, selecting OK will create the new user in the User account. Selecting Cancel will cancel all changes and restore the user list and user parameters to the state it was last in before the Add user option was entered.

Edit User



A user must be selected before editing. The Edit User function allows the Superuser to modify the User Name, Password, and User Level of the selected User, unless it is the Superuser account. Password changes must be verified by retyping the Password exactly in the Verify Password box.

After making changes, selecting OK will apply all changes to the User account. Selecting

Cancel will cancel all changes and restore the user list and user parameters to the state it was last in before the Edit option was entered.

Delete User

A user must be selected before deletion, and this action will delete all references to that user. The Superuser account cannot be deleted.

Accept Changes

When finished with all changes, select OK to save all new account information and exit the User Management Module.

Cancel Changes

If desired, all changes can be canceled by selecting the Cancel button option. This will cancel all changes and restore the User list to the values that existed prior to entering the User Management module.

5 Preferences

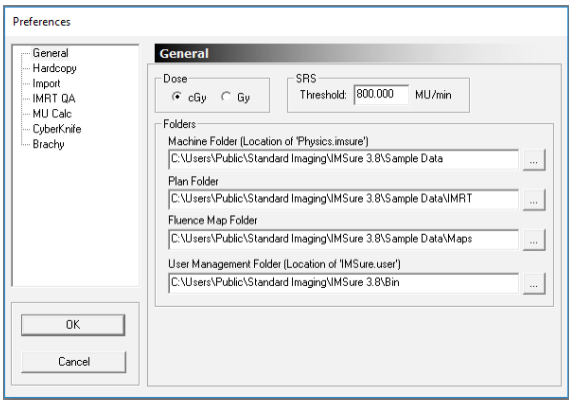
Setup options are found by selecting the Preference Options Dialog using the Prefs icon from the ribbon.   The many option are described by section.

5.1 General Preferences

The General Preferences in IMSure determine where IMSure 'looks' for particular files. There are basically two different ways these preferences can be set for a stand-alone setup or a network-style setup.

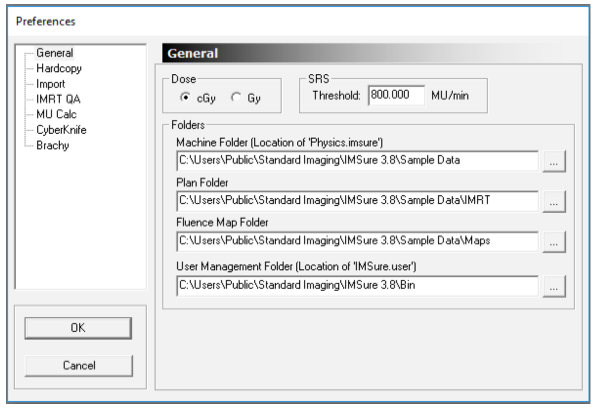
1. Stand-alone setup – This type of setup is best used when you are only going to have a single computer with IMSure. In this type of setup, all of the information that IMSure requires is kept on the machine, e.g. physics3_8.imsure file (see "The Physics3_8.imsure file" on page 13), plan files exported from the treatment planning system, map files exported from the treatment planning system and the users file.

   Fora stand-alone setup use of the default folders created in the designated directory is recommended. These are also the default mappings in the General Preferences and look like this:



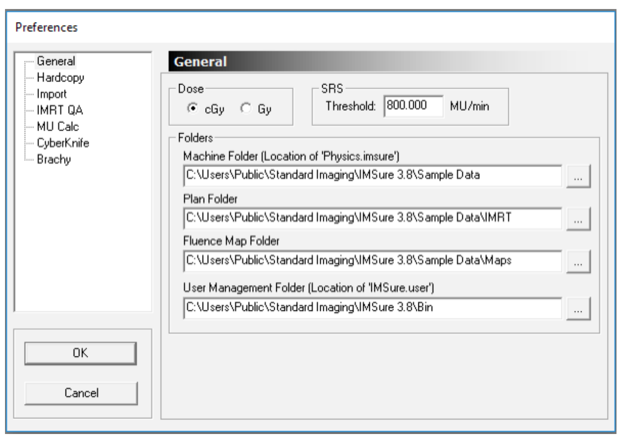
2. Network-style setup – This type of setup is recommended when you are going to have multiple computers with IMSure. With a network-style setup, the information that IMSure requires is kept on the network, e.g. physics3_8.imsure file (see "The Physics3_8.imsure file" on page 13), plan files exported from the treatment planning system, map files exported from the treatment planning system and the users file.

   In this type of setup a directory is created on a network drive (note the drive needs to be mapped for IMSure to be able to see it). Call this directory IMSure. Then within this directory create a folder called Physics, one called Plans, one called Maps and one called Users. In General Preferences this setup will look like this:



The advantage to this setup is that all of your computers will access the same information. For example if you make a change to your physics information you will not have to go to each machine and change it because changing the one file on the network changes it for all users whose configuration is pointed to the same network directory. The same is true for the users file as all users will then have the same login no matter which machine they are signing in on.

IMSure can display doses as either cGy or in Gy values: choose your preferred method.



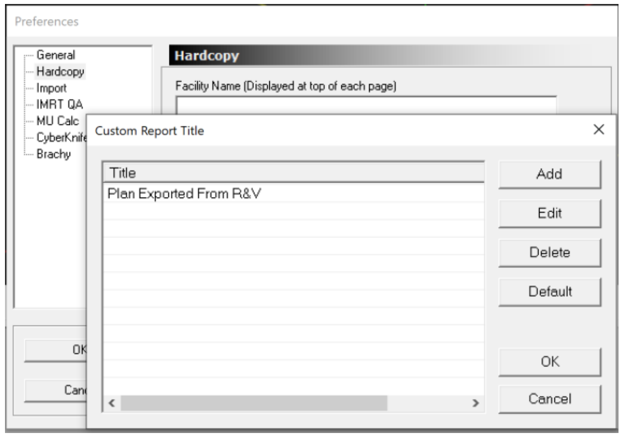
IMSure can automatically detect whether a beam of an imported plan is a stereotactic beam by the dose rate found in the DICOM file. The SRS Threshold value is the minimum MU/min that IMSure defines as an SRS beam.

5.2 Hardcopy Preferences

The Hardcopy Preferences determine what information will be printed on your output. Simply enter your facility name and the information you would like printed in the footer area of the page.

Custom Report Titles

Custom report titles can be created and subsequently chosen at the time of printing. For example, if a center checks plans from their TPS and from their R&V system, you could have a custom report title that tells which system the plan came from. To create a custom report title, click the edit button and in the resulting screen click the ‘Add’ button. Your screen will look like this:



Type in a new title, e.g. ‘Plan Exported From R&V’ and then click OK. The new custom report title is now available for use. You can edit previous entries or delete them as necessary. To set a default selection, highlight it and click on the ‘Default’ button.

Default Hardcopy Reports

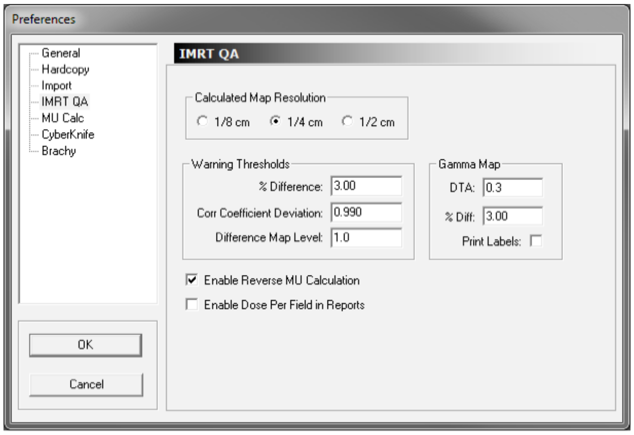
Clicking the box next to any of the reports that can be generated in the different modules will ‘turn on’ that report automatically whenever you select Print in that module. You will have an opportunity in the Print Dialog Box to change your selections before printing.

5.3 Import Preferences

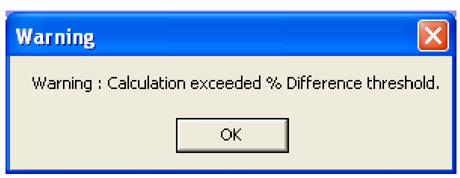
The import preferences determine how IMSure will handle the import of fluence maps exported from your treatment planning system.

1. Import Map Resolution – This value is only used when there isn’t a resolution specified in the fluence map file. If your system does not include this value you will need to enter the appropriate value here. The default value is 0.500 cm.
2. Map Import Defaults – Certain systems export the fluence map files in orientations that are different than the DICOM plan that they are matched to. Changing these settings will automatically orient the maps correctly. You have an opportunity in the Import Module (see “Importing a Plan” on page 52 to change these settings during import).

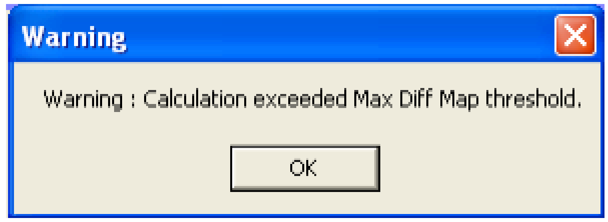
5.4 IMRT QA Preferences



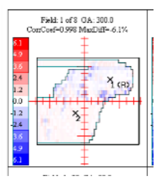
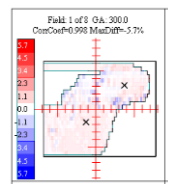
1. Calculated Map Resolution – This value determines the size of the grid that is used when calculating the fluence map through the 3-source model. The appropriate value is determined by the treatment planning system used. Some of the known settings for common TPS are:
   Varian Eclipse: ¼ cm
   Pinnacle: ½ cm
   XiO: ½ cm
   For other TPS some experimentation will be required to determine the appropriate setting.
2. Warning Thresholds
   a. % Difference – This setting will determine when IMSure will warn the user that the calculated difference exceeds the set difference.



   b. Correlation Coefficient Deviation – The correlation coefficient is a patented method of determining how well two distributions match in a 'global' sense. The closer the value is to 1.000 the closer the two distributions match. In most cases a value greater than .990 is considered a good match of the two maps. The setting will determine when IMSure will warn the user that the calculated coefficient is less than the set value.
   c. Difference map level – This setting will determine when IMSure will warn the user that the maximum difference between the imported and calculated fluence maps is greater than the set value.

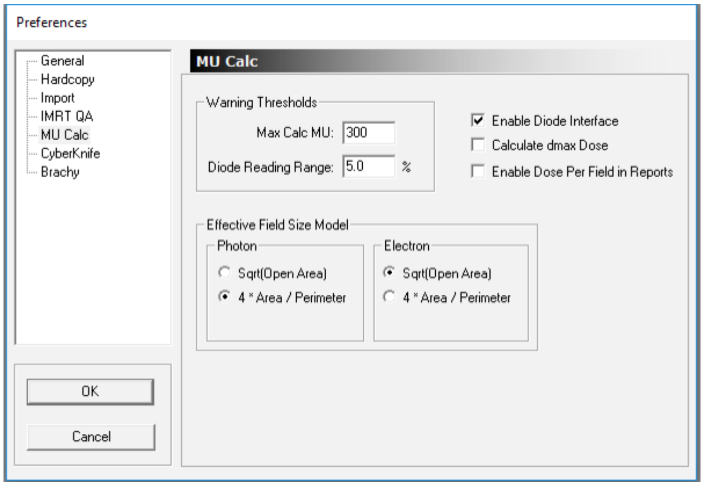


3. Gamma Map Settings
   a. DTA – This is the default value that the Gamma Map will use for the distance to agreement (cm). This value is user adjustable at any time after the maps have been calculated.
   b. % Diff – This is the default value that the Gamma Map will use for the percent difference. This value is user adjustable at any time after the maps have been calculated.
   c. Print Labels – When Print Labels is checked the labels for each calculation point will be included in the printed reports.

With labels -  Without labels - 

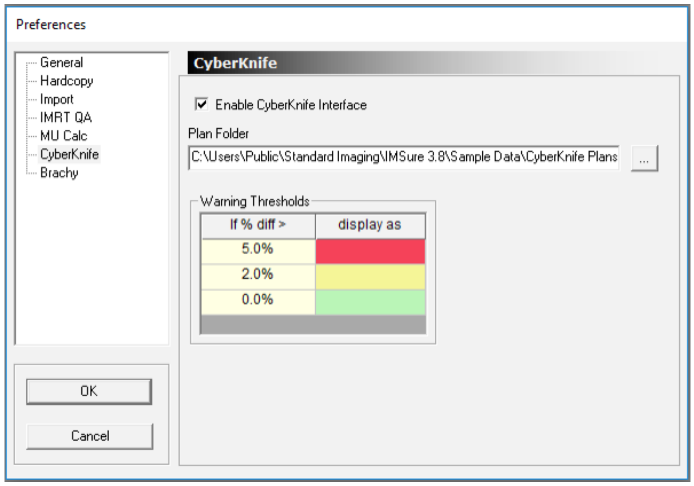
4. Enable Reverse MU Calculation – In the QA module the user has the option to see a reverse MU calculation in the Beams tab. In the reverse MU calculation, IMSure uses the dose that the TPS is attempting to deliver and through the 3-source algorithm determines the number of MU required to achieve that dose. If this box is not checked the MU calculated by IMSure and the difference between the calculated and the TPS is not shown.
5. Enable Dose Per Field in Reports - Selecting this option will print the dose per field and percent differences on the first page of the IMSure report.

5.5 MU Calc Preferences



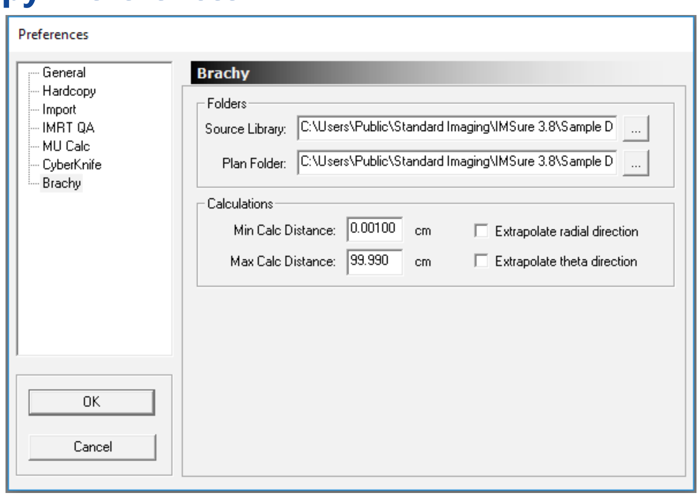
1. Warning Thresholds
    a. Max Calc MU – A warning will be shown in the Calculation Report window when the number of monitor units for any beam exceeds the set amount.
    b. Diode Reading Range – IMSure will automatically calculate a range for an expected diode reading (see point 4. Diode Setup Report, in “Printing Reports (MU module)” on page 34), e.g., if the calculated diode reading is 100 and the range is set to 5%, the range values shown on the report will be from 95 cGy to 105 cGy.
2. Enable Diode interface – If this box is not checked the diode tab in the MU module will not be shown.
3. Calculate dmax dose – If this box is checked the D_{max} dose will automatically be calculated for each calculation point and each field.
4. Enable Dose Per Field in Reports - Selecting this option will print the dose per field and percent differences on the first page of the IMSure report.
5. Effective field size model – There are two different models that can be used in the MU module to calculate the effective blocked field size. These can be set separately for the Photon and Electron calculations.

5.6 CyberKnife Preferences



1. Enable CyberKnife Interface – Check this box if you have a CyberKnife unit and would like the CyberKnife Interface available for calculations.
2. Plan Folder – Use the browse button to set the folder that contains the Plan Overview (POV) and Beam List (BM) files from the CyberKnife planning system.
3. Warning Thresholds – In the CyberKnife Module, results will be color coded-based on the values set here. These values will also determine the values used in the CyberKnife module results window histogram.

5.7 Brachytherapy Preferences



Folder Preferences – If your setup of IMSure QA Software includes a license for the Brachytherapy module, a 'Brachy' preference pane will be available in the Preferences window. Clicking on this pane allows you to choose default folders for placement and retrieval of the Source Library files and Brachytherapy Plan files. In the case of an IMSure setup where Brachytherapy is the only module, the User Management folder assignment can be used to set the location of the users file also.

NOTE: If other IMSure modules (MU or MU/QA) are activated, the User Management folder path set in the "Preferences/General" Folders group will be used instead. The default folders can be set up as for 'Stand-alone' setup or for a 'Network-style' setup. See the "General Preferences" on page 8 for a description of each of these setup methods.

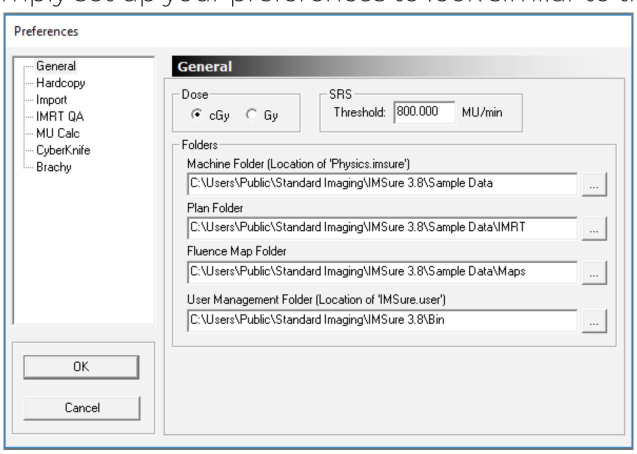
Calculation Preferences – Choose the minimum and maximum distances you would like IMSure Brachy to allow calculation points to be from a given source. The range is from a minimum of 0.001 cm to a maximum of 99.999 cm. You can also set the ability of IMSure Brachy to extrapolate from data found in the Source Library to complete calculations that are outside of the range of data input. NOTE: Extrapolated data can be ill-behaved outside of valid ranges and it is up to the user to verify results that may be achieved with extrapolated data.

5.8 Sample Data

Upon setup of IMSure a folder is created in the StandardImaging\IMSure 3.8 directory called SampleData. In this folder are sample machines for Varian, Elekta and Siemens. The Varian machine is based on the Gold Beam data set available from Varian and is generally within a percent or two of most modern Varian machines. There are also sample plans, fluence maps and other auxiliary files that demonstrate the import of most of the types of plans that IMSure will handle.

There are two ways to use the sample data:

1. Use the sample physics file to practice importing the sample set of plans. To accomplish this simply set up your preferences to look similar to this.



Where the C: in the image represents your local disk.

Here is what the file structure of the Sample Data set looks like:

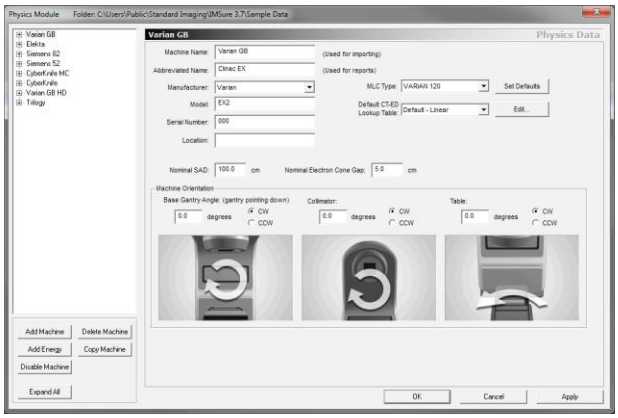
BrachyDCM	5/3/2018 8:57 AM	File folder
CyberKnife Plans	5/3/2018 8:57 AM	File folder
dotDecimal Examples	5/3/2018 8:57 AM	File folder
Eclipse TML Import	5/3/2018 8:57 AM	File folder
IMAT	5/3/2018 8:57 AM	File folder
IMRT	5/3/2018 9:26 AM	File folder
Maps	5/3/2018 9:31 AM	File folder
MU	5/3/2018 8:57 AM	File folder
Pinnacle Import	5/3/2018 8:57 AM	File folder
Sample csv Files	5/3/2018 8:57 AM	File folder
SRS Plans	5/3/2018 8:57 AM	File folder
Structures Examples	5/3/2018 8:57 AM	File folder
FixedSources.imsource	5/18/2009 10:42 AM	IMSOURCE File
Physics3_8.imsure	2/17/2015 3:35 PM	IMSURE File
UserSources.imsource	1/22/2015 3:40 PM	IMSOURCE File

6 Using the Sample Data

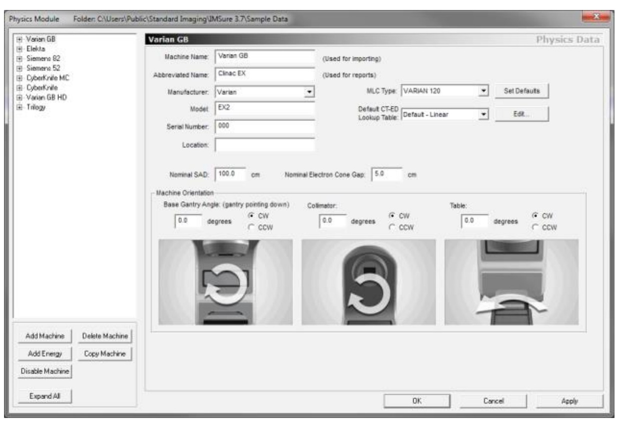
1. The physics3_8.imsure file resides in the base Sample Data directory, then there are directories that contain plans, auxiliary files and sample machine data (.csv) files.
   a. BrachyDCM – contains several HDR and LDR brachytherapy plans.
   b. CyberKnife Plans – contains several sample CyberKnife plans.
   c. dotDecimal Examples – contains a plan sample that uses .decimal compensators in place of MLC. This folder also contains the .decimal compensator files and a structure set file for the plan.
   d. Eclipse TML Import – contains three plans and the corresponding TML exports from Eclipse TPS (see “Using the Import Module” on page 22).
   e. IMAT – contains several arc therapy plans, one RapidArc plan from Eclipse and two SmartArc plans from Pinnacle.
   f. IMRT – contains several IMRT plans from different TPS and for different machines.
   g. Maps – Contains maps for several of the plans found in the IMRT folder and for the .decimal plan in the dotDecimal Examples folder.
   h. MU – Contains several plans that can be imported into the MU module from different TPS and for different machines.
   i. Pinnacle Import – Contains two DICOM plans and the .impe files exported from the Pinnacle TPS (see “Auxiliary Files for IMSure” on page 22).
   j. Sample csv Files – Sample .csv files for the machines found in the Sample Data physics file.
   k. SRS Plans – Contains three plans that take advantage of the SRS capabilities in IMSure. There are two cone based plans and one dynamic arc plan.
   l. Structure Examples – Contains three plans with supporting DICOM structure sets (see “Auxiliary Files for IMSure” on page 22).
2. You can also use the Sample Data physics file to import your own plans from your TPS. The machine parameters in the Sample Data physics file will not match your machine

parameters exactly but this can give you practice in exporting plans from your TPS and importing them until you have your machine parameters set up.
To accomplish this you will need to set up a machine in the Sample Data physics file that has the same name as what your TPS calls your machine.

a. Set the Machine Folder as shown above in option 1 to point to the Sample Data folder.
b. Click on the Physics tab in IMSure.
c. Click on a machine that is made by the same manufacturer as yours: In this example we have a Varian machine:



d. Click on the 'Copy Machine' button.
e. In the 'Name' field change the machine name to match what your TPS calls your machine. In this example, our machine is called 'Varian GB':



f. Click OK to accept changes.
g. You are now ready to export a plan from your TPS and then import that plan into IMSure. NOTE: Make sure to set the 'Plan Folder' in Preferences to point to the directory you have exported your plans to.

7 Setting up the Physics Data

7.1 The Physics3_8.imsure file

IMSure QA Software utilizes a single file named physics3_8.imsure to save all of the physics data that is imported into the Physics Module. This file must have the name 'physics3_8.imsure' for the program to be recognized. Having all of the data saved in this encrypted file allows easy portability of the physics information. The physics3_8.imsure file is found in the directory that is set as the Machine Folder in Preferences/Folder Preferences.

Backup files

When a change is made to the physics data and either the 'Apply' or 'OK' button are clicked an automatic backup copy of the physics data *before* any changes were made is created. These backup files are saved in the Machine Folder with a .bak extension and are named with the timestamp of their creation, e.g. 'Physics3_8[2014-03-03 08.34.45].bak'. To utilize one of the backup files right click on the file name and choose 'rename' and rename it physics3_8.imsure. NOTE: You will need to re-name or delete the existing physics3_8.imsure file first.

7.2 What beam data are needed?

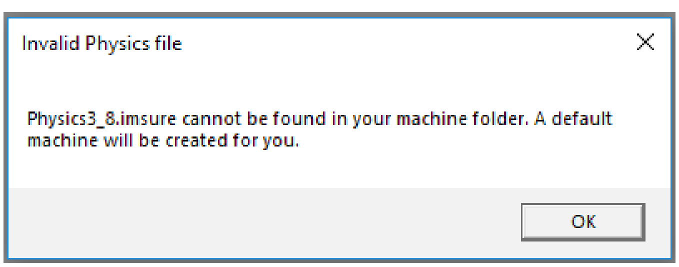
The physics data required for setting up IMSure are similar to the data acquired during commissioning of a linear accelerator. Therefore most people will already have the necessary information. All data need to be set up in a proprietary .csv (comma delimited) format that can be created easily with Microsoft Excel. Examples of these files can be found in the Sample Data folder that installs in the IMSure X.X directory (see "Using the Sample Data" on page 12).

7.3 Creating a physics file

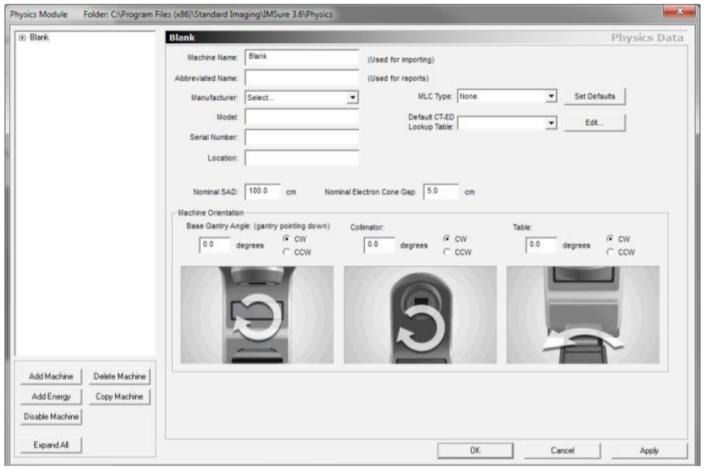
To create a new physics file set the Machine Folder (Preferences/Folder Preferences) to a directory that does not contain a physics3_8.imsure file.

To open the physics module click on the 'Physics' button or go to Modules/Physics in the menu bar.

If a physics file has not been created yet, this message will be shown:

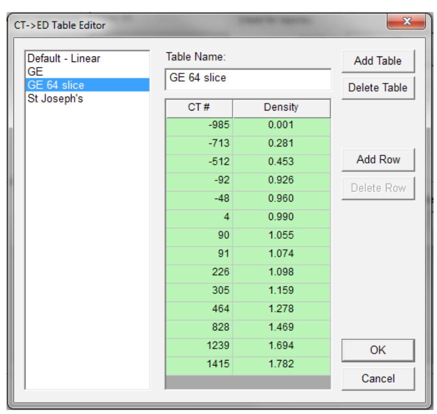


Click OK and a blank physics file (physics3_8.imsure) will be created and the directory structure will be shown:



Enter data for your machine:

1. Name – Must match exactly the name used by your TPS for your machine to allow for importing of plans.
2. Abbreviated Name – Used on reports.
3. Manufacturer – Select the manufacturer of your machine from the drop down list.
4. MLC Type – Choose your MLC configuration and then click the 'Set Defaults' button to automatically set defaults for source to MLC, source to X jaws and source to Y jaws. These values are important for the 3-source model (See Appendix "D. Three Source Model Calculation" on page 64).
5. Default CT-ED Lookup Table - Select (or choose "Edit" and modify/create) a default CT to Electron Density table to be used for plans that have associated CT image sets.

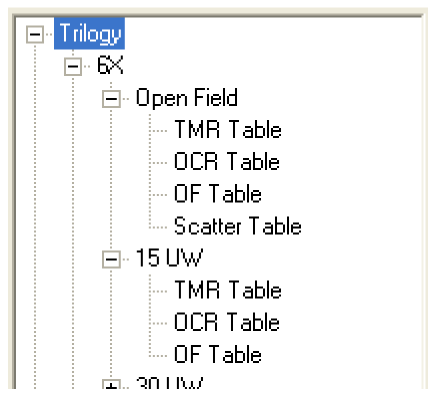


6. Model – The model type or number for your machine. This value is not used in calculations or on any of the reports.
7. Serial Number – The serial number of your machine. This value is not used in calculations or on any of the reports.
8. Location – The physical location of your machine. This value is not used in calculations or on any of the reports.

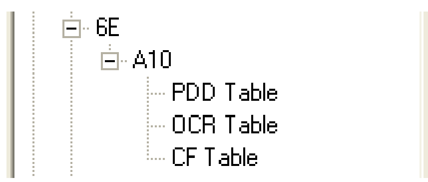
9. Nominal SAD – The distance from the source to the isocenter of your machine (in cm).
10. Nominal Electron Cone Gap – The distance from the end of the cone to the patient or phantom surface when set up at 100 SSD. **NOTE: For most machines this distance is 5 cm.**
11. Machine Orientation – The base angle and rotational direction should match exactly the values that your TPS uses to describe your machine. **NOTE: IMSure uses the IEC conventions for describing rotation. In the case of couch rotation the rotation is described as looking up at the collimator and this can be confusing in looking at the diagram.**

There are three (3) basic structures for machine data.

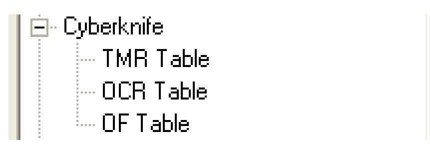
1. Photon, both open and wedged:



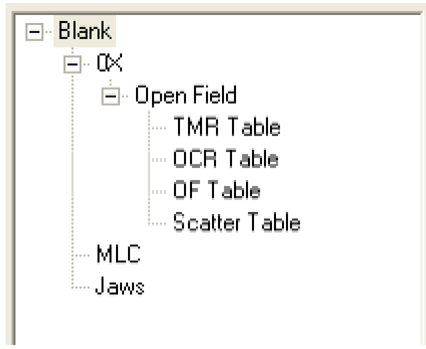
2. Electron:



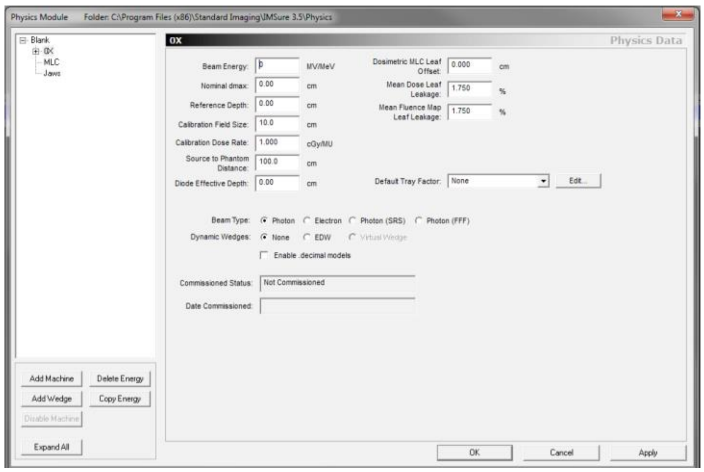
3. CyberKnife:



Click on the 'Expand All' button at the bottom of the screen to expand the tree structure in the new physics file:



Click on the '0X' text to show the main energy page:



7.4 For Standard or SRS Photons

Enter the following values:

1. Beam Energy – machine energy in MV.
2. Nominal d_{MAX} – the d_{MAX} depth of the energy (cm)(e.g. '1.2').
3. Reference Depth – the depth at which your machine is calibrated (cm).
4. Calibration Field Size – the length of one side of the equivalent square field used for calibration (cm).
5. Calibration Dose Rate – The number of cGy per MU that will be delivered at the reference depth and source to phantom distance specified in the module (cGy/MU).
6. Source to Phantom Distance – The distance to the surface of the phantom used when setting the calibration of your machine (cm)
7. Dosimetric MLC Leaf Offset – Used in the 3-source model for calculations in the QA module only. Defined as the 1/2 width, 1/2 max value of dose under the leaf on machines with rounded leaf edges. Typical values for a 6X beam are between 0.075 and 0.125 and for an 18X beam between 0.100 and 0.150.
   NOTE: Varian describes this value as the full width, 1/2 max value so the IMSure value is generally 50% of the value used in the Varian treatment planning system.

NOTE: This value can be used to modify the 3-source model results obtained in the QA module. If during commissioning a consistent calculation of over or under dose is being seen, adjusting this value slightly up or down can bring the IMSure results into closer agreement with measurements and the TPS.

8. Mean Dose Leaf Leakage – Used in the 3-source model for calculating dose in the QA module only. Defined as the percentage of dose that leaks between MLC leaves. Typical values for a 6X beam are between 1.500 and 2.000 and for an 18X beam between 1.750 and 2.500.

   NOTE: This value can be used to modify the 3-source model results obtained in the QA module. If during commissioning a consistent calculation of over or under dose is being seen, adjusting this value slightly up or down can bring the IMSure results into closer agreement with measurements and the TPS.

9. Mean Fluence Map Leaf Leakage - Used in the 3-source model for calculating the fluence maps in the QA module only. Defined as the percentage of dose that leaks between MLC leaves. Typical values for a 6X beam are between 1.500 and 2.000 and for an 18X beam between 1.750 and 2.500. These values are generally the same as the Mean Dose Leaf Leakage.

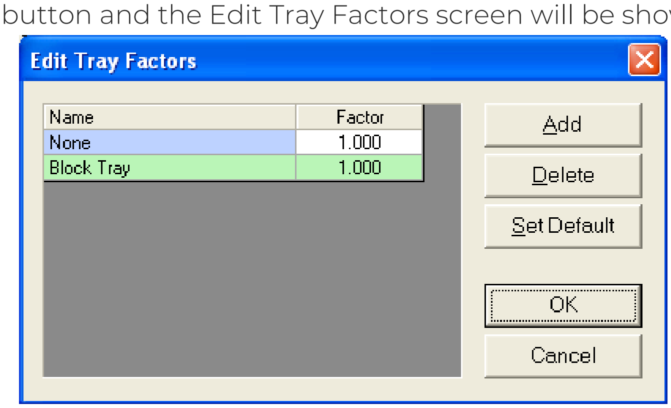
   NOTE: This value can be used to modify the 3-source model results obtained in the QA module. If during commissioning a consistent difference is seen between the imported and calculated fluence maps, adjusting this value slightly up or down can bring the IMSure results into closer agreement.

10. Diode Calibration Factor – This factor will be automatically applied when the dose is calculated in the diode interface in the MU module (see “The Diode Tab” on page 32). The value is also editable at the time of calculation in the diode interface.

11. Diode Effective Depth – Enter the default build up for your in-vivo dosimetry device e.g. d_{MAX}. This effective depth will be used in the calculation of the expected dose in the diode interface in the MU module (see “The Diode Tab” on page 32). This value is also editable at the time of calculation in the diode interface.

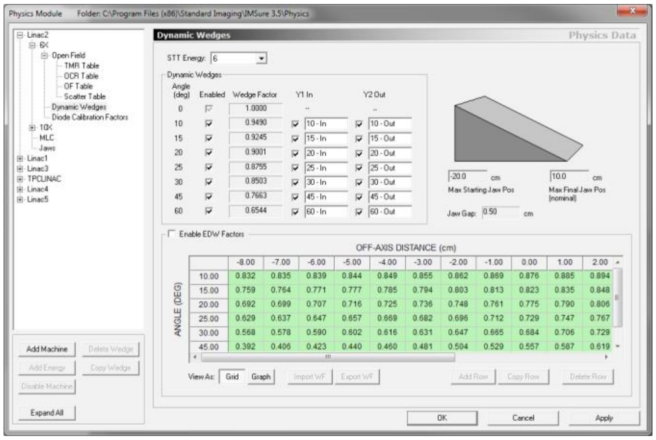
12. Default Tray Factor – Multiple tray factors can be input into the physics module to account for different types or combinations of trays and/or other attenuation factors such as the couch. Tray factors are only used in the MU module.

    Click the ‘Edit...’ button and the Edit Tray Factors screen will be shown:



    a. Click ‘Add’ to add a factor
    b. Click ‘Delete’ to delete a factor
    c. Click ‘Set Default’ to make the hi-lighted factor the default factor used in the MU module

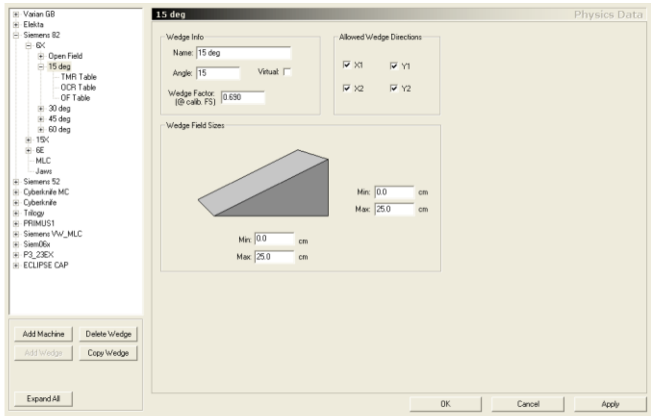
13. Beam Type – Changes between a standard photon, SRS photon, FFF photon, and electron beam types
14. Dynamic Wedges (Standard Photon Only) – For Varian machines with Enhanced Dynamic Wedge capability, IMSure utilizes the published STT tables in the calculation of the EDW. Clicking the EDW button will add a new choice in the tree structure called Dynamic Wedges. Clicking on the Dynamic Wedges text in the tree structure brings up the EDW screen for setting the correct STT table for the wedge.



Choose the correct energy in the STT Energy drop down list and then use the check boxes to let IMSure know which wedge angles and which direction to allow.

Virtual Wedge – The EDW Factor table shown on the lower portion of the screen is an array of output factors at 10 cm depth, 90 cm SSD for a 20x20 cm^2 field relative to the same point geometry in a 20x20 cm^2 open field. These values may be entered for a range of wedge angles and off-axis distances. If the "Enable EDW Factors" option is selected, IMSure will use these data to apply the EDW wedge factor correction method of Gossman and Sharma (J Med Phys. 2010 Apr-Jun; 35(2): 65-72). This method has been shown to improve the accuracy of the STT wedge factor calculations, particularly for points that are not centered within the EDW field.

The field size and off-axis distances used for this correction are somewhat flexible as long as the open and wedge field sizes match, the phantom configuration does not change, and data points are not placed at the edge of the field. Users entering their own data table may opt to use a different field size or off-axis distance spacing from that of the provided tables.



Checking the 'Virtual' box tells IMSure that the data that is imported is for a Virtual Wedge and will be applied correctly when a plan is imported that utilizes the Virtual Wedge for one or more beams.

15. Enable .decimal models – For sites utilizing .decimal compensators, click this checkbox to allow adding information pertaining to compensator beam modeling. For detailed information on .decimal modeling (see "Enabling .decimal modeling for a Photon beam" on page 21).

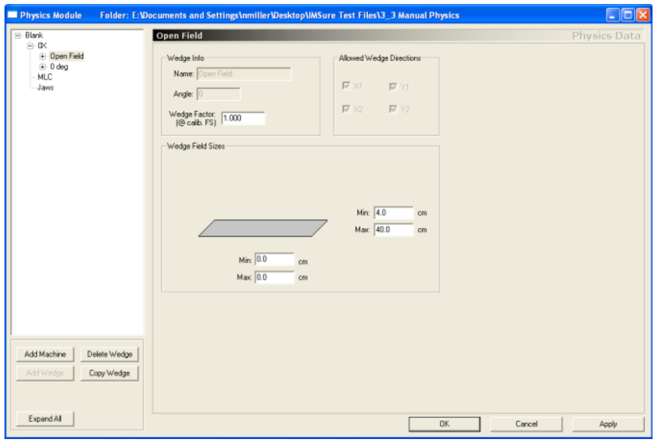
16. The OK button – clicking the OK button on any of the Physics module screens will automatically validate the data that has been input and you will be asked whether you are sure you want to save changes. Clicking 'No' will return you to the Physics Module. Clicking 'Yes' will save changes and close the Physics module. If there are any inconsistencies in the data that have caused an energy to fail, this information will be presented to you at this time. Clicking 'Cancel' in the Log screen will bring you back to the Physics Module. Clicking 'OK' will close the Physics Module with the energy in question not being commissioned for use.

17. The Cancel button – Clicking the 'Cancel' button on any of the Physics Module screens will close the Physics Module without saving any changes.

18. The Apply button – Clicking the 'Apply' button on any of the Physics Module screens will apply any changes made up to that point. If there are any inconsistencies in the data that have caused an energy to fail, this information will be presented to you at this time. Clicking either 'OK' or 'Cancel' in the Log screen will bring you back to the Physics Module to correct the inconsistencies.

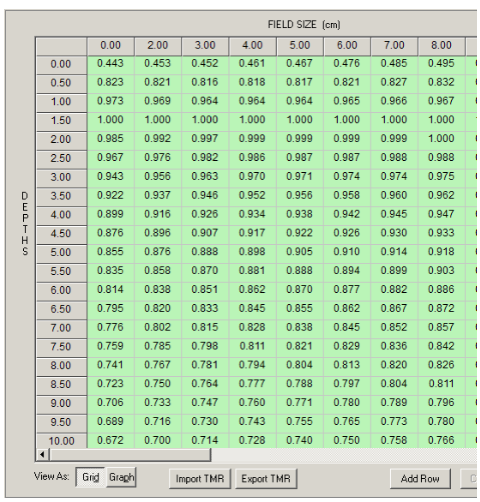
Open Field Data

1. Click on the text ‘Open Field’ to set the field parameters:



Set the parameters for the minimum and maximum field sizes allowed in the X and Y directions.

2. Click on the text ‘TMR Table’.
   a. Click on the ‘IMPORT TMR’ button and if needed navigate to the appropriate directory. Choose the .csv file for your Open Field TMR and then click ‘Open’. The data will automatically be imported into the physics module and shown in tabular format.

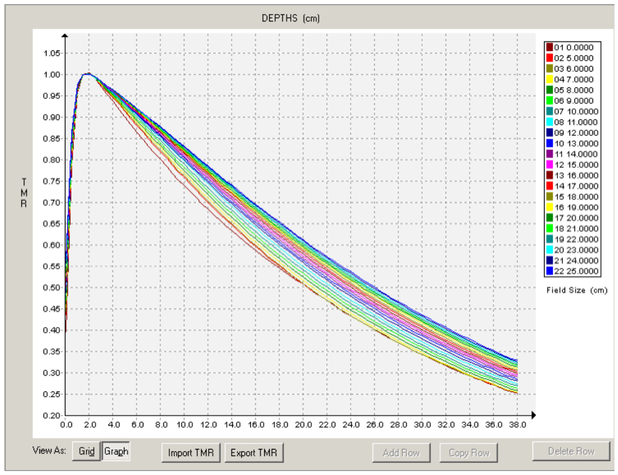


FIELD SIZE (cm)

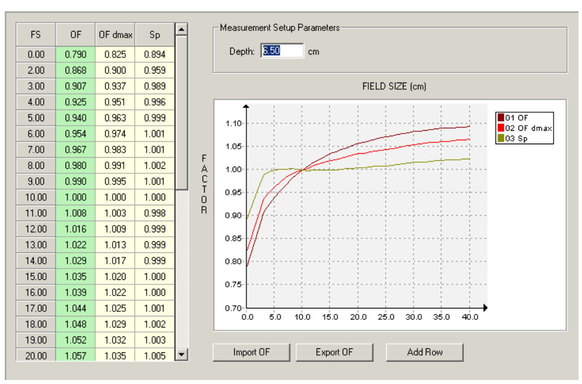
DEPTHS	0.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00
0.00	0.443	0.453	0.452	0.461	0.467	0.476	0.485	0.495
0.50	0.823	0.821	0.816	0.818	0.817	0.821	0.827	0.832
1.00	0.973	0.969	0.964	0.964	0.964	0.965	0.966	0.967
1.50	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
2.00	0.985	0.992	0.997	0.999	0.999	0.999	0.999	1.000
2.50	0.967	0.976	0.982	0.986	0.987	0.987	0.988	0.988
3.00	0.943	0.956	0.963	0.970	0.971	0.974	0.974	0.975
3.50	0.922	0.937	0.946	0.952	0.956	0.958	0.960	0.962
4.00	0.899	0.916	0.926	0.934	0.938	0.942	0.945	0.947
4.50	0.876	0.896	0.907	0.917	0.922	0.926	0.930	0.933
5.00	0.855	0.876	0.888	0.898	0.905	0.910	0.914	0.918
5.50	0.835	0.858	0.870	0.881	0.888	0.894	0.899	0.903
6.00	0.814	0.838	0.851	0.862	0.870	0.877	0.882	0.886
6.50	0.795	0.820	0.833	0.845	0.855	0.862	0.867	0.872
7.00	0.776	0.802	0.815	0.828	0.838	0.845	0.852	0.857
7.50	0.759	0.785	0.798	0.811	0.821	0.829	0.836	0.842
8.00	0.741	0.767	0.781	0.794	0.804	0.813	0.820	0.826
8.50	0.723	0.750	0.764	0.777	0.788	0.797	0.804	0.811
9.00	0.706	0.733	0.747	0.760	0.771	0.780	0.789	0.796
9.50	0.689	0.716	0.730	0.743	0.755	0.765	0.773	0.780
10.00	0.672	0.700	0.714	0.728	0.740	0.750	0.758	0.766

View As: Grid Graph Import TMR Export TMR Add Row

   b. Clicking the ‘Graph’ button will present a graphical view of the data

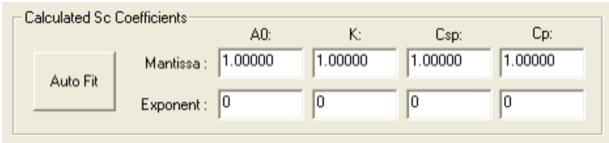


3. Repeat these steps for OCR, OF and Sc tables
   a. OF Table – The output factor table is required for the model and is used to calculate the Sp or phantom scatter. The Sp is calculated using the Formula OF = Sp * Sc. **NOTE: Sp will not be automatically calculated until the Sc values are imported into the module.**
      i. OF measured at other than d_{MAX} – The models in IMSure require output factors to be determined at d_{MAX}. With what is known about electron contamination of the beam at shallow depths it has become common practice to measure output factors at a deeper depth, typically 5 or 10 cm. For output values measured at deeper depths, IMSure will automatically re-calculate the OF to the d_{MAX} value using the TMR table. Enter the depth of measurement in the Measurement Setup Parameters in the OF table window and the calculation is automatic. **NOTE: The TMR table for the energy must be imported before this calculation can be performed.**

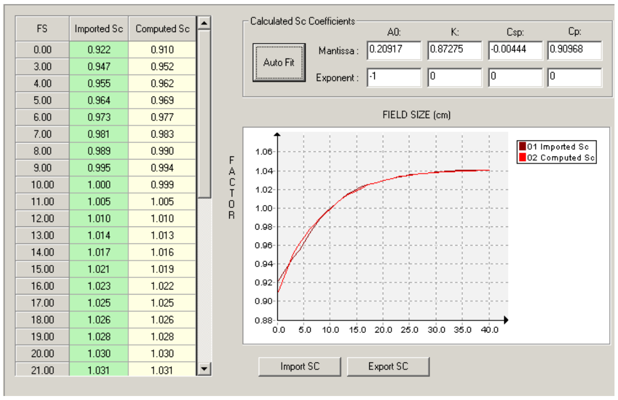


FS	OF	OF dmax	Sp
0.00	0.790	0.825	0.894
2.00	0.868	0.900	0.959
3.00	0.907	0.937	0.989
4.00	0.925	0.951	0.996
5.00	0.940	0.963	0.999
6.00	0.954	0.974	1.001
7.00	0.967	0.983	1.001
8.00	0.980	0.991	1.002
9.00	0.990	0.995	1.001
10.00	1.000	1.000	1.000
11.00	1.008	1.003	0.998
12.00	1.016	1.009	0.999
13.00	1.022	1.013	0.999
14.00	1.029	1.017	0.999
15.00	1.035	1.020	1.000
16.00	1.039	1.022	1.000
17.00	1.044	1.025	1.001
18.00	1.048	1.029	1.002
19.00	1.052	1.032	1.003
20.00	1.057	1.035	1.005

   b. Sc Table - After values for the Sc table have been imported it is important to fit the 3-source model parameters. It is these 4 parameters that determine how well the model will calculate the Sc values in the QA module.



Clicking the 'Auto Fit' button will in most cases create a suitable fitting for the four coefficients.

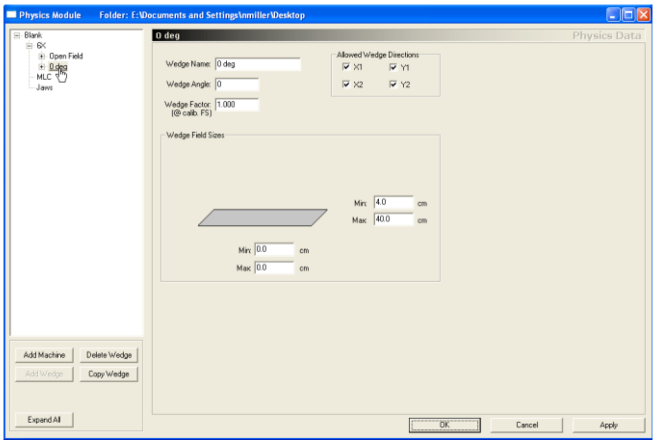


A computed factor within 0.5% of the imported factor is considered to be a good fit. If an 'Auto Fit' does not achieve these figures contact Standard Imaging for assistance.

Hard Wedges (Standard Photons Only)

Individual data can be entered for each of your hard wedges.

1. With the energy chosen in the tree list, e.g. 6x, click on the Add Wedge button. A wedge of 0 degrees (Name: '0 deg') is appended to the tree list.
2. Click on the newly appended entry '0 deg' in the tree list to open the Wedge interface:



   a. Enter the Wedge Name to match the name used by your TPS.
   b. Enter the Wedge Angle in degrees.

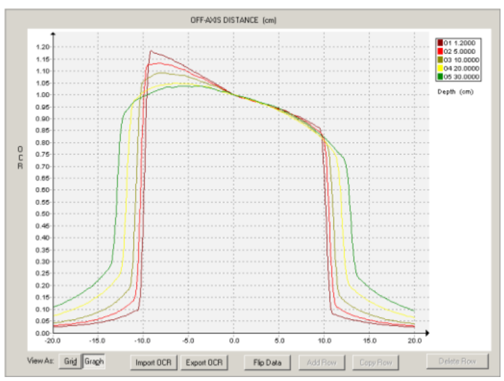
c. Enter the single Wedge Factor (@calib. FS) for the wedge. The Wedge Factor is described as the measured output factor (at d_{MAX}) for a 10 x 10 open field over the measured output factor (at d_{MAX}) of a 10 x 10 field with the wedge in place.

d. Enter the allowed wedge field sizes. The values at the bottom are for allowed field sizes along the wedged direction and the values on the right are for allowed field sizes across the wedged direction. **NOTE: You must have data available for the allowed field sizes in the TMR, OCR and OF tables for the wedge to be valid.** For example if you set the maximum field size to 40 but only have data up to 30 cm in your TMR table, the commissioning of the wedge will fail.

3. Click on the '+' sign next to your wedge name in the tree list:

a. Import TMR, OCR and OF tables for the wedge in the same manner that they were imported for the open beam.

i. Flip Data - OCR for wedges – The OCR table for the wedge must be oriented with the thin part of the wedge oriented to the left of the CAX. If after import, you realize that the data is set up incorrectly, you can click the 'Flip Data' button to correct it automatically. If set up correctly the graph view should look like the following:



ii. Sc for wedges – Sc is not required for hard wedges as IMSure can automatically calculate these values based on the equation $OF_{(wedge)} = Sp_{(Open)} * Sc_{(Wedge)}$ or $Sc_{(Wedge)} = OF_{(Wedge)}/Sp_{(Open)}$.

4. Elekta 'Motorized' or 'Flying' wedge – Elekta machines have a motorized 60 degree wedge that is capable of being inserted into the beam during a treatment so that part of a field is delivered with an open beam and part of the field is delivered with the 60 degree wedge in place with the ability to mimic just about any wedge angle by varying the ratio of open to wedged delivery. For IMSure, only a single 60 degree hard wedge need be entered into the Physics Module to account for this ability. The patient plan files that are imported into IMSure for Elekta have the wedged field split into two separate fields, one open and one with a 60 degree wedge. The effective wedge angle will be calculated automatically.

5. Siemens 'Virtual Wedge' – Siemens machines have a similar ability as the Varian machines to create a wedge profile by sweeping one jaw across the field while the beam is on. Unlike the Varian EDW, IMSure does automatically calculate the Virtual

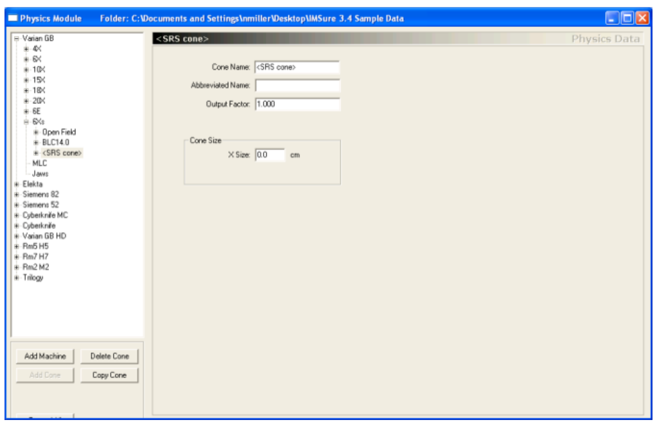
Wedge. To calculate plans that utilize the Virtual Wedge it is necessary to enter each wedge angle the Virtual Wedge is capable of producing as if it were a hard wedge.

4. In order for IMSure to correctly identify the wedge information as that for a Virtual Wedge the 'Virtual' box needs to be checked. If the 'Virtual' box is grayed out, the Virtual Wedge option needs to be enabled in the main energy page (see step 14 in "For Standard or SRS Photons" on page 15).

SRS Cones (SRS and FFF photons only)

Individual data can be entered for each of your SRS cones.

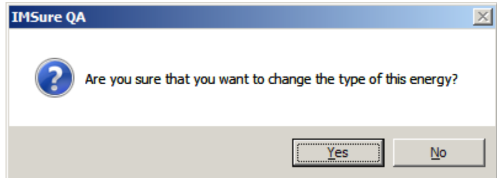
1. With the SRS photon energy chosen in the tree list, e.g. 6Xs, click on the 'Add Cone' button. A cone with the title <SRS Cone> will be added to the tree list.
2. Clicking where it says <SRS Cone> in the tree list opens the SRS cone interface:

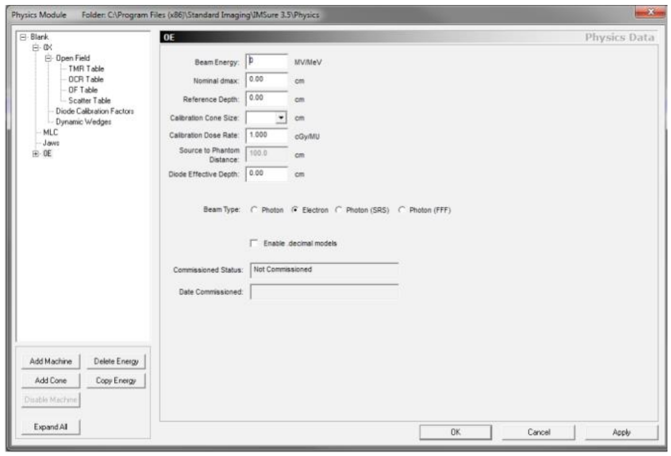


   a. Enter the Cone Name to match the name used by your TPS.
   b. Enter an abbreviated name that will be used in the IMSure QA interface.
   c. Enter a single Output Factor for the SRS cone.
   d. Enter the cone diameter in cm.
3. Click on the '+' sign next to your cone name in the tree list.
   a. Import TMR and OCR tables for the cone in the same manner they were imported for the open beam.

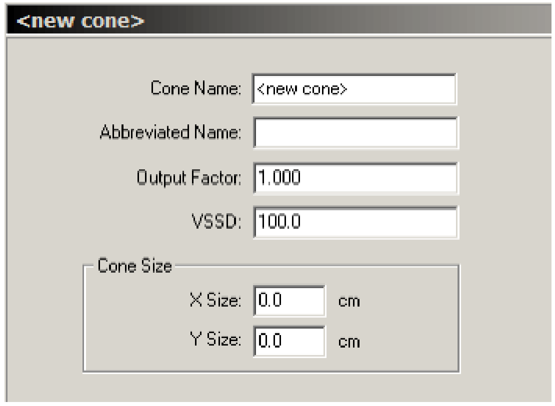
7.5 For Electrons

To add an electron beam, click on the Machine Name in the tree list and then click on the 'Add Energy' button. A photon beam with the name 0X will automatically be created. Click on the text '0X' in the tree list. In the middle of the main energy page you set the beam type by clicking on either Photon or Electron. Click on Electron and then click 'Yes' to change the beam type to electron.





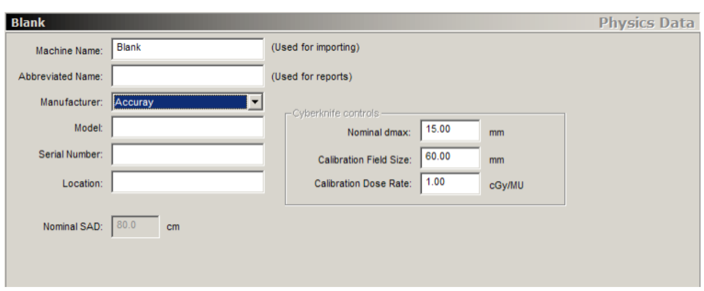
1. Beam Energy – Machine energy in MeV.
2. Nominal d_{MAX} – The d_{MAX} depth of the energy (cm).
3. Reference depth – The depth at which your machine is calibrated to (cm).
4. Calibration Cone Size – The cone size that your machine is calibrated with. NOTE: the dropdown list for this entry will not be fully populated until all cones have been entered.
5. Calibration Dose Rate – The number of cGy per MU that will be delivered at the reference depth and source to phantom distance specified in the module (cGy/MU). NOTE: this value is locked to 100 cm for electron beams.
6. Diode Calibration Table – This table will be automatically applied when the dose is calculated in the diode interface in the MU module (see “The Diode Tab” on page 32). The table is also editable at the time of calculation in the diode interface.
7. Diode Effective Depth – Enter the default build-up for your in-vivo dosimetry device e.g. d_{MAX}. This effective depth will be used in the calculation of the expected dose in the diode interface in the MU module (see “The Diode Tab” on page 32). This value is also editable at the time of calculation in the diode interface.
   a. Click on the ‘+’ sign next to the new electron energy in the tree structure and then click on ‘<new cone> to set the cone parameters



i. Cone Name – Must match the name your TPS calls the cone.
ii. Abbreviated Name – Used on reports.
iii. Output Factor – Output factor measured at 100 SSD and d_{MAX}.
iv. VSSD – The calculated virtual source to surface distance (see “IMSure QA Electron Data Measurements” on page 77).
v. Cone Size – Measured cone size in X and Y directions (cm).
b. Click on the ‘+’ sign next to the cone name in the tree structure
i. Import PDD, OCR and CF tables for the cone. Extended SSD PDDs and Cutout Factors can be entered for each cone if desired.
c. Add additional cones as needed.

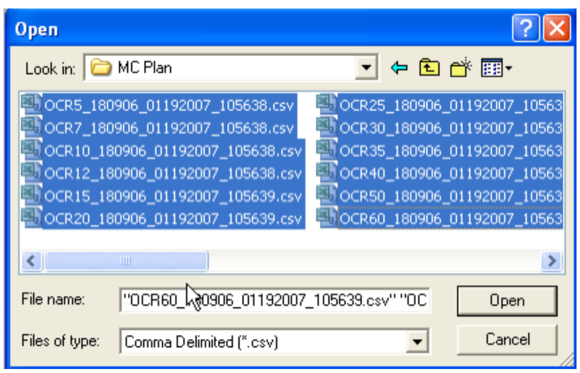
7.6 For CyberKnife

To add a CyberKnife model in the Physics Module click on the Add Machine. In the resulting machine page click on the dropdown arrow for ‘Manufacturer’ and choose CyberKnife:



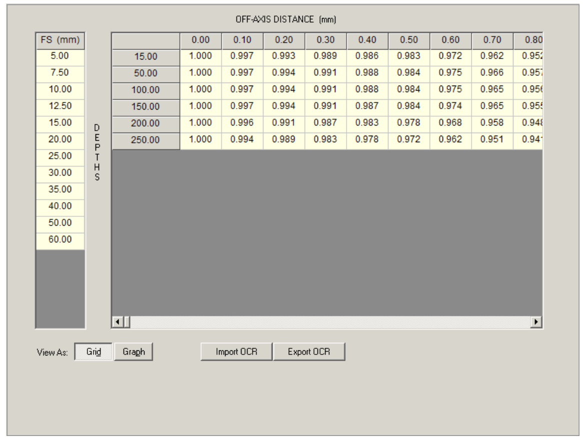
1. Name – Machine name.
2. Abbreviated Name – Used on reports.
3. Manufacturer – CyberKnife.
4. Model – The model type or number for your machine. This value is not used in the calculation or on any of the reports.
5. Serial Number – The serial number of your machine. This value is not used in calculations or on any of the reports.
6. Location – The physical location of your machine. This value is not used in calculations or on any of the reports.

7. Nominal SAD – The distance from the source to the isocenter of your machine for calibration setup.
8. Nominal d_{MAX} – The d_{MAX} depth for the energy of the machine.
9. Calibration Field Size – The size of the collimator used for calibration measurements.
10. Calibration Dose Rate – The number of cGy per MU that will be delivered at d_{MAX} using the specified collimator size.
11. Click on the '+' sign next to the machine name in the tree list.
    a. Click on the 'TMR Table' text in the tree list.
        i. Click the 'Import TMR' button, and if needed navigate to the appropriate directory. Choose the .csv file for your TMR and click 'Open'. The data will automatically be imported into the physics module and shown in tabular format. Click the 'Graph' button to obtain a graphical view.
    b. Click on the 'OCR Table' text in the tree list.
        i. Click the 'Import TMR' button, and if needed navigate to the appropriate directory. For CyberKnife OCR there will be multiple .csv files for the OCR tables for each collimator size. Choose an appropriate .csv file in the list, and then while pressing the 'CONTROL KEY' on your keyboard, click on the rest of the OCR .csv files.



Click 'Open' and each of the OCR tables will be imported and associated with their respective collimator size.

Click on a field size in the resulting table displays the OCR information for that field size.



Clicking the 'Graph' button will present a graphical view.

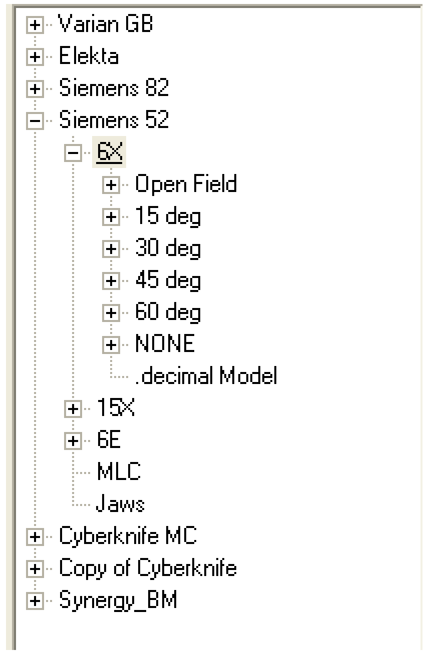
c. Click on the text 'OF Table' in the tree list.
   i. Click on the 'Import OF' button, and if needed navigate to the appropriate directory. Choose the appropriate .csv file for your output factors and then click 'Open'. The data will automatically be imported into the physics module and shown in tabular format. Click the 'Graph' button to obtain a graphical view.

12. Adjusting data – After importation, data can be manually adjusted in many of the tables. Highlight the field you would like to change and type in the new value. There are additional editing abilities available that vary according to table type.
    i. Add Row – Click the 'Add Row' button, specify the entry point for your new data, and then manually enter the data.
    ii. Copy Row – Highlight the row you wish to copy, click the 'Copy Row' button and specify the entry point for the copied data.
    iii. Delete Row – Highlight the row you wish to delete, and click the 'Delete Row' button.

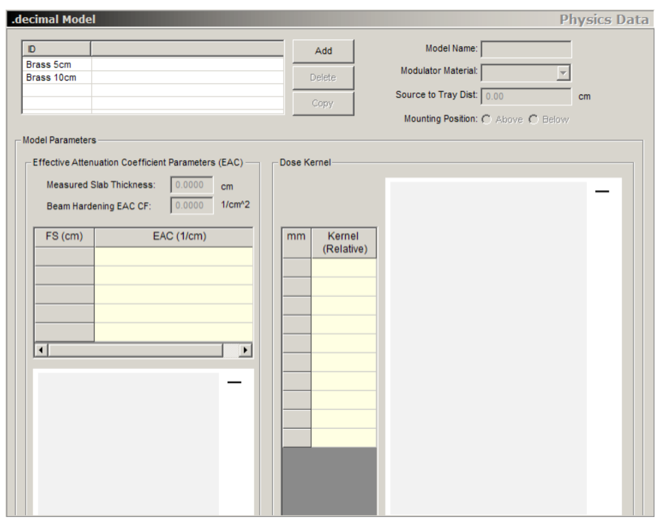
7.7 Enabling .decimal modeling for a Photon beam

Setting up the physics for use with .decimal compensators – Choose a machine that you have commissioned for standard photon data.

1. On the main energy page (e.g. click on '6X') there is a check box just above commissioned status that will turn on the .decimal modeling for this energy.
2. Click the '+' sign next to the energy name to expand the tree structure.
3. Click the 'Enable .decimal models' button and you will now see a '.decimal Model' tab underneath the energy:



4. Click on the phrase '.decimal Model' to obtain the modeling page:



5. Click on the 'Add' button.
   a. Give the model a name and then fill out the information for material, tray distance, position and the Effective Attenuation Coefficient Parameters (EAC) numbers you should have from doing your commissioning of the .decimal system.
6. It is recommended that multiple models be created representing different depths of calculation utilizing different kernel values for each depth. Following are the suggested dose kernel values to use for three (3) different clinical depths:

5 cm	
mm	Kernel (Relative)
1	0.5020000
2	0.0669000
3	0.0225000
4	0.0103000
5	0.0054200
6	0.0031100
7	0.0018000
8	0.0010400
9	0.0006800
10	0.0005100
20	0.0001020
50	0.0000183

10cm	
mm	Kernel (Relative)
1	0.2090000
2	0.0322000
3	0.0114000
4	0.0053400
5	0.0029500
6	0.0016100
7	0.0009580
8	0.0006130
9	0.0003970
10	0.0002890
20	0.0000747
50	0.0000284

20cm	
mm	Kernel (Relative)
1	0.2090000
2	0.0322000
3	0.0114000
4	0.0053400
5	0.0029500
6	0.0016100
7	0.0009580
8	0.0006130
9	0.0003970
10	0.0002890
20	0.0000747
50	0.0000284

7.8 Editing data in the IMSure Physics Module

Most tables in the Physics Module are editable. Clicking in a field will enable editing. Clicking 'Apply' or 'OK' will save the changes.

After data have been entered into the Physics Module it is necessary to verify that they match the data used in the TPS.

The following are suggestions only and it is up to the individual user to determine the appropriate level of commissioning required for their facility.

8 Using the Import Module

8.1 Photons and electrons

The MU module uses a much simpler single-source model for calculations. Because of this, Standard Imaging suggests using this module for initial commissioning as it is an excellent way to assess the self-consistency of the data compared to the TPS.

Create a plan in your TPS with 5-7 fields of increasing square field sizes, e.g., 3x3, 5x5, 10x10, 20x20, and 40x40 cm^2. Then add points of interest down the central axis at differing depths starting with d_{MAX}, e.g., d_{MAX}, 5, 10, 15, and 20 cm. Export this plan to IMSure and import into the MU Module. NOTE: Some Treatment Planning Systems will not export interest points, so these points may have to be entered by hand in the MU Module (see “The Calc Pts Tab” on page 31). Verify that IMSure can match the TPS calculations within 1-2% for all fields and all depths. This simple check verifies the TMR, OF and Sc values in the IMSure model.

Using the same plan, create off-axis points at various distances from the CAX and at differing depths. Re-import the plan, enter calculation point information as needed and verify results. NOTE: The MU Module uses a simplistic single-source model in its calculations. This model’s accuracy is suspect for calculation points that are within 2 cm of a field edge as this model does not take into account the field edge penumbra effects. Also, this model will not calculate dose for any points that are outside the field. This additional check verifies the OCR values in the IMSure model.

Similar tests can be completed for electron verification.

8.2 .decimal models

Create a plan that uses a simple compensator that has three (3) depths: Full thickness, ½ thickness, and minimum thickness each in 1/3 of the field. Place calculation points in the middle of each of the thicknesses. Export the plan and the compensator file to IMSure and import into the MU module (see “Calculating .decimal plans in the MU module” on page 33). Verify that IMSure and the TPS calculations agree. This method is also an excellent way to determine the appropriate Beam Hardening EAC value to enter into the model (see “Enabling .decimal modeling for a Photon beam” on page 21).

8.3 Exporting from your TPS

Before you can import plan data into IMSure it is necessary for you to export the data from your treatment planning system. You do not directly export plan files from your TPS to IMSure, but instead export the files to a directory that IMSure then accesses. The directories that IMSure looks in are set in the Folders group under “Preferences/General” (see “General Preferences” on page 8).

IMSure will import plan information in either DICOM-RT format or in the RTP exchange format. DICOM-RT formatted plan files generally contain more complete information and are the preferred format.

IMSure can import either the actual patient plan or a plan that is copied to a phantom. If a patient plan is imported, there may be additional information that needs to be entered after importing the plan into IMSure before the calculation will be accurate. Including CT image files and structures when exporting a plan will allow IMSure to automatically calculate some beam parameters not included in the plan file.

The following information about the major TPS systems is current as of the printing of this manual and Standard Imaging does not guarantee its accuracy. It should be used as a guideline only.

8.4 Varian Eclipse (ARIA)

The Varian TPS system is a Windows-based system which makes the export fairly straight forward. Export filters can be created in this system making the task more automated. Contact Varian customer support for assistance with this feature if needed. NOTE: IMSure QA Software has been certified by Varian to be installed directly on the Eclipse (ARIA) workstation.

The Varian system does not require a specified interest point for calculation of a plan and in many cases the plan is calculated to a volume. If an interest point is included in the plan, it can cause difficulties in the Record & Verify system. For IMSure to function properly an interest point needs to be included in the plan before export. To accomplish this it is suggested to make a copy of your plan, add an interest point or multiple interest points and then export the copied plan to IMSure. It should also be noted that the Varian TPS will not export SSD information in the DICOM-RT plan file if the plan is not 'approved'.

Auxiliary Files for IMSure

There are a number of auxiliary files that IMSure can make use of to enhance the user's experience with IMSure. Some files add additional functionality while others add to ease of use of the program. Except for fluence map files which have their own directory, all auxiliary files should be placed in the folder designated as the 'Plan Folder' in "Preferences/General" Preferences (see "General Preferences" on page 8)

1. Fluence maps – The Varian TPS will include fluence maps with the DICOM-RT plan file on export. During the export process, choose the 'Include Fluence Map' option when available (IMRT and certain field-in-field plans). There is no need to export fluence maps separately from the plan file.
2. Structure Set files – IMSure allows the importation of the patient structure set file which can be used for visualization purposes and also offers structure specific analysis when comparing fluence maps (see "Using Structure Sets (Volumes) in the QA Module" on page 43). During the exportation process, choose to include the Structures and be sure to save the file in the same directory that 'Plan Folder' is set to in Preferences (see "General Preferences" on page 8).
3. CT images - IMSure uses CT images to calculate SSD, PSSD, and Effective Depth for all calculation points.

8.5 Philips Pinnacle

The Pinnacle treatment planning system runs on the Sun Microsystems Solaris platform. Transference of DICOM-RT plan files from the Pinnacle system requires the use of the DICOM Router. A DICOM Router that works with IMSure is available from Standard Imaging. Please contact Standard Imaging Support for more information.

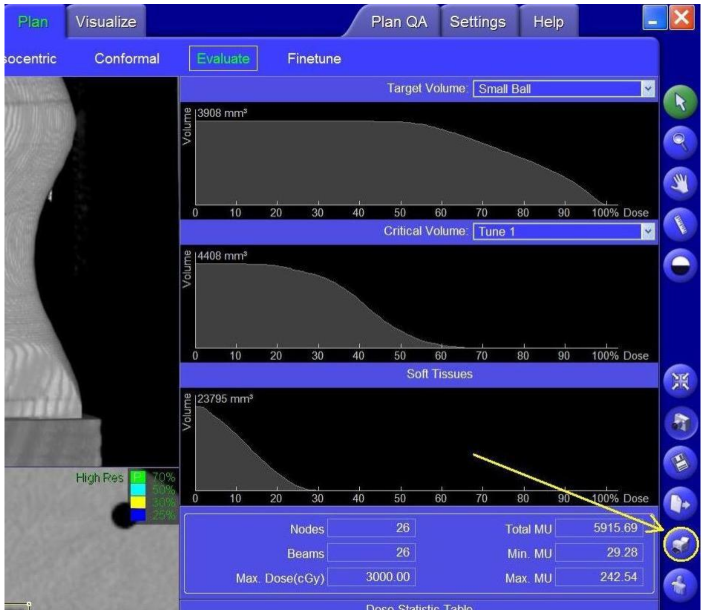
Auxiliary Files for IMSure

There are a number of auxiliary files that IMSure can make use of to enhance the user's experience with IMSure. Some files add additional functionality while others add to ease of use of the program. Except for fluence map files which have their own directory, all auxiliary files should be placed in the folder designated as the 'Plan Folder' in Preferences/Folder Preferences (see "General Preferences" on page 8)

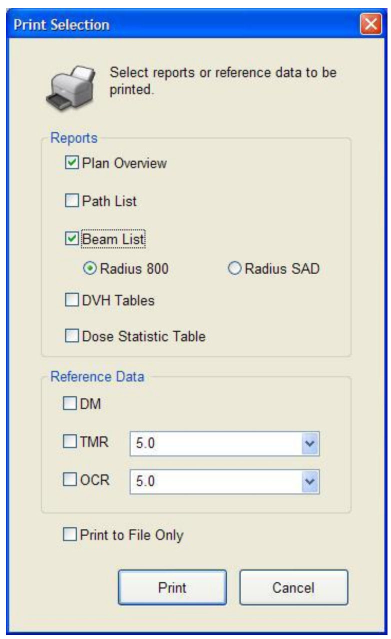
1. Fluence maps – The Pinnacle system does not export a 'true' fluence map. What can be exported is an ODM (opening density matrix) file. Because an ODM is not a true fluence map differences between the IMSure calculated fluence (see "Display Options" on page 40) and the imported ODM are often seen. Please see the technical note available on the Standard Imaging website, http://www.standardimaging.com regarding the Pinnacle ODM file and use in IMSure. The ODM file needs to be exported in an ASCII format and should be saved to the directory that the Map Folder is set to in the IMSure Preferences (see "General Preferences" on page 8).
2. Structure Set files – This version of IMSure allows the importation of the patient structure set file which can be used for visualization purposes and also offers structure specific analysis when comparing fluence maps (see "Display Options" on page 40). During the exportation process choose to include the Structures and be sure to save the file in the same directory that 'Plan Folder' is set to in Preferences (see "General Preferences" on page 8).
3. CT images - IMSure will automatically associate plans with images that have the same study UID. These CT images along with the Structure Set are then used for automatic calculation of SSD, PSSD, Depth and Effective Depth values for all calculation points.
4. Pinnacle .IMPE file – The DICOM-RT plan files from the Pinnacle system contain minimal information and in some cases is missing critical information that IMSure requires to calculate properly, including calculation point coordinates. NOTE: If an imported plan file does not contain any calculation point information, IMSure will automatically default to showing an isocentric calculation point of 0, 0, 0.
5.

8.6 Multi-plan Treatment Planning System (Accuray CyberKnife)

Open the plan for export in Multi-Plan software. Click on Evaluate to show the evaluation screen. Select the print icon on the right side.



In the resulting Print Selection Screen, click the following options: 'Plan Overview', 'Beam List', and 'Print to File Only' and then click 'Print'.



Transfer the BM… and POV… files to the IMSure Import file directory.

NOTE: For Multi-plan version 5.1 or newer, IMSure will only recognize the .xml file format.

8.7 Other Treatment Planning Systems

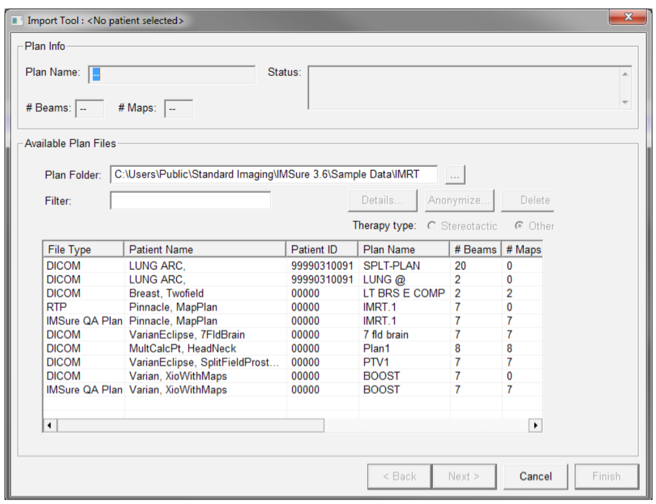
IMSure requires either a DICOM-RT plan file or an RTP exchange plan file be imported before performing verification of either plan MU or delivered dose. How these files are saved to a directory that IMSure has access to will depend on the system, the computing platform it runs on and your facilities network setup. Standard Imaging will work with you and your technology team to assist you in setup. Please contact Standard Imaging customer support for assistance.

8.8 .decimal Compensator Files

.decimal compensators are supported by three treatment planning systems: Varian Eclipse (ARIA), Philips Pinnacle, and Elekta Xio. For each of the systems in order for IMSure to correctly calculate plans that utilize .decimal compensators, the compensator thickness files need to be exported to IMSure. These files generally have the file extension '.dec', and need to be saved in the directory that 'Plan Folder' is set to in Preferences (see "General Preferences" on page 8)

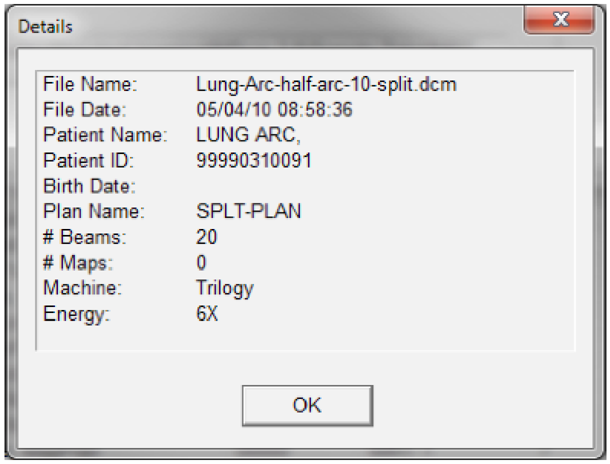
8.9 Importing a Plan

1. In either the MU module, QA module or CyberKnife module, click on the 'Import Plan' button.
2. The Import module will open and will automatically scan the directory that 'Plan Folder' is set to in Preferences (see "General Preferences" on page 8). All valid plan files will then be shown:



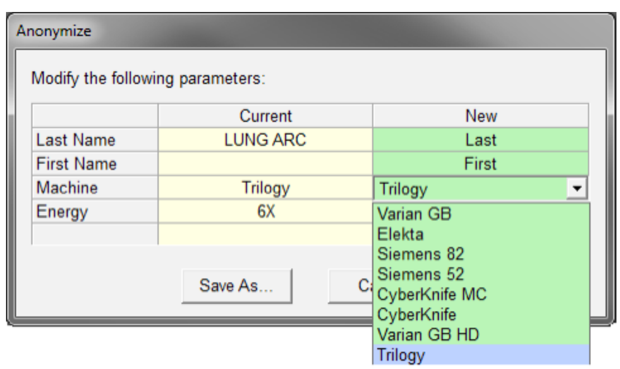
Clicking on the ellipses button to the right of the Plan Folder data  will allow you to browse to any other directory that might contain valid plans.

3. Click on any valid plan to select it.
   a. Status window – If there are any errors associated with the selected plan, this window will turn red and information about the error will be shown.
   b. Details button – Clicking this button will show details of the plan file:



c. Anonymize button – The Health Insurance Portability and Accountability Act (HIPAA) requires that any patient data that is passed onto a third party not authorized to view it have all patient specific information stripped from the file. Clicking the Anonymize button will bring up a screen in which the patient name can be changed. Not only is the patient name changed but the file is automatically stripped of any other patient specific information such as the Patient ID (set to 00000). Click on the 'Save As…' button to save the file in your directory of choice with a filename of your choosing. NOTE: The anonymize function is only available for DICOM and RTP file formats.

The Anonymize feature also can be useful for assigning a plan to be calculated on a different machine than it was originally planned. In the Anonymize screen, click on the Machine name in the 'New' column and a drop-down list of all available machines will be shown:

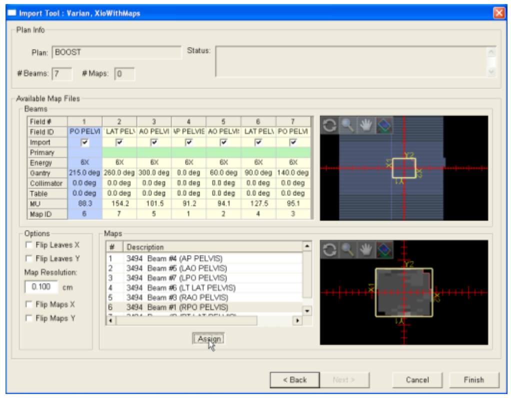


Choose a machine and when the file is saved it will now calculate using that machines data.

d. Delete – Clicking this button will delete any highlighted plan along with its associated CT images and structure file. A verification screen will be displayed. Click OK to delete the files, Cancel to return to the Import Module.

4. Click the 'Next' button (not available for CyberKnife plans).

a. Auxiliary Data Files – If there are any auxiliary files in the directory that match the plan you have chosen they will be shown. These could include CT image set files, structure set files, TML files (Eclipse/ARIA), .IMPE files (Pinnacle) or .decimal compensator files. NOTE: Auxiliary files are only shown if the Patient ID in the auxiliary file matches the Patient ID in the chosen plan file.
   Click on the files you would like to include with the import. Pressing the 'CONTROL KEY' on your keyboard will allow you to choose additional individual files. Pressing the 'SHIFT KEY' on your keyboard will automatically choose all files between the first file you highlight and the next file you choose. Click 'Next' to continue, or 'Finish' to complete the importing process. NOTE: Pinnacle .IMPE files can contain multiple 'Trials' from the Pinnacle planning process. Be careful to choose the correct Trial from the auxiliary file import screen.
b. Map Files – QA module only – If there are no auxiliary files, the Map Import screen will open and will automatically scan the directory that 'Map Folder' is set to in Preferences (see "Preferences" on page 8). All valid fluence map files will then be shown. NOTE: for Varian TPS plans this screen will not be shown as the fluence maps are contained in the DICOM-RT file.
   Click on the files you would like to include with the import. Pressing the 'CONTROL KEY' on your keyboard will allow you to choose additional individual files. Pressing the 'SHIFT KEY' on your keyboard will automatically choose all files between the first file you highlight and the next file you highlight. Click 'Next' to continue to the Summary Screen or 'Finish' to complete the importing process.
c. Summary Screen – This final screen in the import process allows you to verify that the information that is being imported is correct.
   i. Fluence Map – QA module only – For plans in which the fluence maps are imported separately from the DICOM-RT plan file, IMSure will attempt to match the correct fluence map with the correct field. In some cases this matching will fail and will need to be done manually. The lower right Beam's Eye View ('BEV') image can be used to judge the match by comparing the Imported Map fluence to the CIAO (Complete Irradiated Area Outline). The edges of each should line up appropriately. If the maps are not matched correctly click to highlight the field you would like to match in the 'Beams' section, then click the appropriate map in the 'Maps' section, and then click the 'Assign' button:



Repeat as necessary to match up the maps.

ii. Split-Field Correlation - For some IMRT plans, the Linac is unable to treat the entire field at once, and the TPS breaks down a fluence map into sub-fields, called “split-field treatments”. Any imported plan that has fields with identical Gantry, Collimator and Couch Angles is assumed to be the result of a split-field process. Split Fields are identified in the field parameter display in the row titled “Primary”.

d. The first instance of a split-field set will have no value in the Primary box. Subsequent instances of identical Gantry, Couch and Collimator angles will have a value in the Primary box keyed to the Field# of the first instance of the field (the Primary field). The user may modify any Primary-Secondary relationship by entering a different Field # value in the Primary box for any field. Selecting an existing value in the Primary box and deleting it will decouple that field from the primary field.

e. Fields coupled via the Primary value box will be treated as a single field for any Fluence Map display and computation processes. Therefore, the coupling of any field to another by the Primary key will reduce the number of computed fluence maps by one. In the IMRT QA module, map verification results such as Max Diff (%) and Corr. Coef. for any Secondary coupled field will be bundled in with the results of the Primary field and are therefore not displayed.

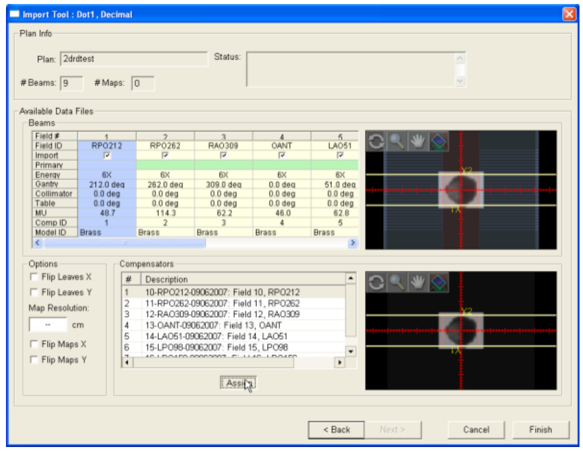
i. Flip Leaves and Flip Maps – If the maps are not oriented correctly in relation to the imported plan file these options can be used to change the orientation appropriately

ii. Map Resolution – The resolution of the map is automatically read from the header information contained in the fluence map file. This can be adjusted manually if necessary.

iii. Import or Don’t Import this Beam – Sometimes plans contain beams that are not relevant to the calculation needed. These could be setup beams or beams for a different phase of treatment (boost). In the Summary Screen Beams section, click ‘Off’ the checkbox in the ‘Import’ row to prevent that beam from being imported when ‘Finish’ is chosen.

vi. .decimal Compensator Assignment - For plans in which .decimal compensators are used IMSure will attempt to match the correct compensator with the correct field. In some cases this matching will fail and will need to be done manually.

If the compensators are not matched correctly, click to highlight the field you would like to match in the Summary Screen 'Beams' section, then click the appropriate compensator in the 'Compensators' section, and then click the 'Assign' button:



Repeat as necessary to match up the compensators.

vii. .decimal Model Assignment – For plans in which .decimal compensators are used, IMSure allows the user to choose which model is utilized to calculate the compensator factor for each beam. In the Summary Screen, the last row in the Beams section is the 'Model ID' field. Click on the down arrow in this field to choose from a list of models created in the Physics Module (see "Enabling .decimal modeling for a Photon beam" on page 21)

d. Click 'Finish' to complete the importing process.

9 The MU Module

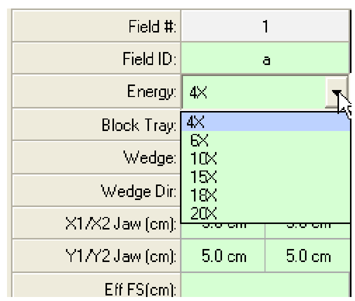
The MU Calculation module allows the user to check the correct monitor units (MU) for a standard radiation treatment comprised of one or more fields. Standard radiotherapy treatments include open beams, wedged beams, with and without blocks.

The MU module can also be used as a secondary check calculation for simple fields where complex 3D patient geometry is not necessary for accurate results.

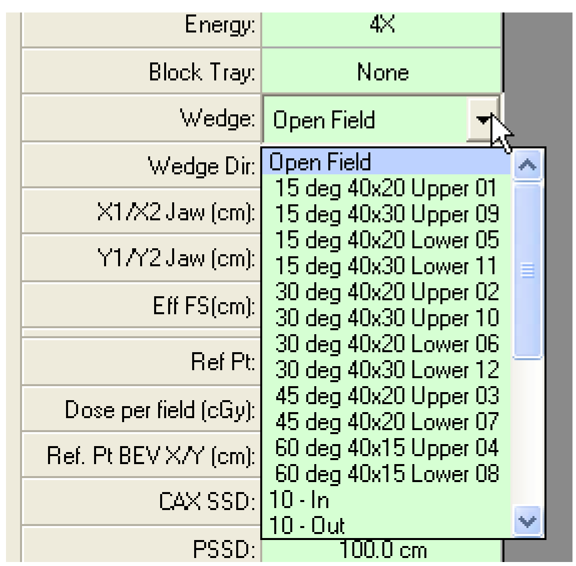
9.1 Creating a simple plan check in the MU module – Using the 2D mode (Photon)

The 2D mode is designed for use as a secondary calculation for simple fields. In 2D mode, several parameters of the plan are not shown, such as gantry, collimator and table angles, and all coordinates are in a simple Beams Eye View X, Y coordinate system.

1. Switch to the MU Module by clicking on the MU Module icon (‘MU’) found in the toolbar, or by selecting the **“Modules/MU Calc View”** menu item.
2. Click on the ‘New Plan’ button, or select the **“Plan/New”** menu item (keyboard shortcut ‘CONTROL KEY’ + N) to clear the view.
3. Click the ‘Simple MU (2D Mode)’ check box. In 2D mode, several parameters of the plan are not shown, such as gantry, collimator and table angles, and all coordinates are in a simple Beam’s Eye View X, Y coordinate system.
4. Enter a Patient Name, Patient ID and a Plan Name.
5. Machine - Choose the machine you will be treating the patient on from the drop-down list
6. Isodose Line - Enter the Isodose Line for the prescription
7. Click the ‘Add’ button (keyboard shortcut ‘ALT KEY’ + A) and a default beam will be added to the Photon tab.
8. Field ID - Enter a Field ID.
9. Energy - Click on the Energy text to see a drop-down list of available energies; choose the energy for this beam:



10. Block Tray – Click on the Block Tray text to view a drop-down list of the block attenuation factors available for the chosen energy (see “For Standard or SRS Photons” on page 15).
11. Wedge/Cone – Click on the text ‘Open Field’ to choose a wedge (cone for SRS photon beams) if one is to be used for treatment:



12. Wedge Dir - Click on the Wedge Dir text to view a drop-down list of available wedge directions: (X1, Y1, X2, Y2); choose a new direction for the wedge if different from the default wedge direction assignment.
13. X1/X2 and Y1/Y2 Jaws (cm) - The default field size is 10 x 10 cm. Enter the jaw positions for the treatment. Jaws can be set to any valid size as defined in the Physics Module (see "For Standard or SRS Photons" on page 15). Jaws can be symmetric or asymmetric.
14. Eff FS – The effective field size is automatically calculated based on the blocked portion of the field by either MLC or a block. This field will be blank if no blocking mechanism is present in the field. If it is known that blocking will be present in the field during treatment an effective field size can be manually entered to account for it.
15. Ref. Point - Click on Ref. Point text to view a drop-down list of Calc Pts that can be used as the reference point for this plan.
16. Dose per Field (Gy or cGy) - Enter the dose to be delivered using the appropriate units.
17. Ref. Pt. BEV X/Y (cm) - Enter any offset in X, Y coordinates for the reference point. X is a lateral offset with positive values going to the right, Y is a coronal offset with positive values going in the "up" direction.
18. CAX SSD - Enter the SSD (Source-to-Surface Distance on the Central Axis).
19. PSSD – Enter the PSSD (Projected Source-to-Surface Distance to the reference point). If the reference point is on the CAX this value will be equal to the CAX SSD entered in the previous step.
20. Proj. Depth - Projected Depth is the depth from the patient surface to the reference point. If the plan is SSD, click on the 'Options' button at the top of the screen, then click to turn off the 'Auto-Calc Depths/PSSD' checkbox. For an SSD plan the user must manually enter both the projected depth and PSSD, while for a SAD plan the PSSD may be automatically calculated using the Auto-Calc option. (Note: For a SAD plan with the auto-calc option turned off the user must ensure that the PSSD and Proj. Depth values are correct as the PSSD is not automatically calculated. Users must always ensure both parameters are correct for an SSD plan.)
f
21. User Factor – A generic factor that can be used to add any other attenuating factors to the field.
22. IMSure calculated values:
    a. Eq. Sq. (open) – The calculated equivalent square based on jaw settings.
    b. Sc – Using the equivalent square field size, IMSure obtains the Collimator Scatter Factor value from the tables input into the Physics Module (Not shown for SRS cones).
    c. Sp – Using the calculated or input Effective Field Size, IMSure obtains the Phantom Scatter Factor value from the tables input into the Physics Module (Not shown for SRS cones).
    d. InvSq. Corr. – A correction value based on the physics of point source radiation that states that the radiation decreases by the square of the distance traveled. This value is calculated by the formula found in Appendix B, eq. B.4 (see page 76).

e. OAR X/Y – Off-Axis factors obtained from the tables input into the Physics Module based on the X/Y offsets input for the reference point.
f. TMR – TMR value obtained from the tables input into the Physics Module based on the calculated or input effective field size and the effective depth (projected depth if no effective depth is entered).
g. Tray Factor – Factor obtained from the information entered into the Physics Module based on the chosen Block Tray. Value is 1.00 if no Block Tray is present.
h. Wedge/Cone Factor – Factor obtained from the information entered into the Physics Module based on the wedge/cone chosen. Wedge/Cone factor value is 1.00 for open beam.

23. TPS MU – For user-created plans this value will be 0. If a plan is imported from the treatment planning system, IMSure will obtain the value from the TPS.
24. IMSure MU – The number of monitor units IMSure calculates to deliver the prescribed plan.
25. MU Diff % - The percentage difference between the IMSure calculated value and the value that is present in the TPS MU field.
26. Add button – Adds additional fields as needed.
27. Copy button – With a field highlighted, click this button to create a duplicate. A Field ID will need to be entered for the new field.
28. Delete button – With a field highlighted, click this button to delete the field.

9.2 Creating a simple plan check in the MU module – Using the 2D mode (Electron)

The 2D mode is designed for use as the secondary calculation for simple fields where complex 3D patient geometry is not required for accurate results. In 2D mode, several parameters of the plan are not shown, such as gantry, collimator and table angles, and all coordinates are in a simple Beam's Eye View X, Y coordinate system.

1. Switch to the MU Module by clicking on the MU Module icon or by selecting the "Modules/MU Calc View" menu item.
2. Click on the 'New Plan' button, or select the "Plan/New" menu item (keyboard shortcut 'CONTROL KEY' + N) to clear the view.
3. Click the 'Simple MU (2D Mode)' check box. In 2D mode, several parameters of the plan are not shown, such as gantry, collimator and table angles, and all coordinates are in a simple Beam's Eye View X, Y coordinate system.
4. Click on the Electron Tab.
5. Enter a Patient Name, Patient ID and a Plan Name.
6. Machine - Choose the machine you will be treating the patient on from the drop-down list.
7. Rx Target – Choose between computing to a depth or to a PDD percentage.
8. Click the 'Add' button (keyboard shortcut 'ALT Key' + A) and a default beam will be added to the Electron tab.
9. Field ID - Enter a Field ID.
10. Energy - Click on the Energy Field to view a drop-down list of available energies; choose the energy for this beam:

11. Cone Size (cm) – Click on this field to view a drop-down list of the cones available for the chosen energy (see “For Electrons” on page 19).
12. Cutout FS (cm) – If an electron cutout is being used enter the estimated field size.
13. Ref. Point – Click on Ref. Point text to view a drop-down list of Calc Pts that can be used as the reference point for this plan.
14. Dose per Field (cGy or Gy) – Enter the dose to be delivered in the appropriate units.
15. Ref. Point BEV X/Y (cm) – Enter any offset in X, Y coordinates for the reference point. X is a lateral offset with positive values going to the right, Y is a coronal offset with positive values going in the “up” direction.
16. CAX SSD – Enter the SSD (Source-to-Surface Distance on the Central Axis).
17. PDepth/PDD (cm) – PDepth is shown if Depth is chosen for Rx Target and is the depth to the reference point. PDD is shown if PDD is chosen for Rx Target and is the percent of depth dose you would like the monitor units calculated to.
18. User Factor – A generic factor that can be used to add any other attenuating factors to the field.
19. IMSure calculated values:
    a. Cone Factor – IMSure obtains the value from the tables input into the Physics Module based on the cone size chosen.
    b. Cutout Factor – IMSure obtains the value from the tables input into the Physics Module based on the entered Cutout Field Size.
    c. InvSq. Corr. – A correction value based on the physics of point source radiation that states that the radiation decreases by the square of the distance traveled. This value is calculated by the formula found in Appendix B, eq. B.4 (see page 76).
    d. OAR X/Y – Off-axis factors obtained from the tables input into the Physics Module based on the X/Y offsets input for the reference point.
    e. PDD/PDepth – Percentage of depth dose is shown if Depth is chosen for Rx Target. The corresponding depth in the PDD curve is shown if PDD is chosen for Rx Target (NOTE: the first depth that matches the PDD value chosen is shown.).
    f. VSSD (cm) – Using the energy/cone size combination chosen, IMSure obtains the Virtual Source to Surface Distance value from the tables input into the Physics Module.
    g. Gap – The distance between the bottom of the cone and the patient surface computed from the formula found in Appendix B, ep. B.4a (see page 77).
20. TPS MU – For user-created plans this value will be 0. If a plan is imported from the treatment planning system, IMSure will obtain the value from the plan.
21. IMSure MU – The number of monitor units IMSure calculates to deliver the prescribed plan.
22. MU Diff % - The percentage difference between the IMSure calculated value and the value that is present in the TPS MU field.
23. Add button – Adds additional fields as needed.
24. Copy button – With a field highlighted, click this button to create a duplicate. A Field ID will need to be entered for the new field.
25. Delete button – With a field highlighted, click this button to delete the field.

9.3 Verifying plans created with commercial TPS systems in the MU Module

The MU Module allows the user to import plans created by commercially available treatment planning systems and verify the number of Monitor Units (MU) to deliver the required dose to a reference point. MU can be verified for Photon, Electron or combination Photon/Electron plans. A DICOM-RT or RTP Exchange format file is exported from the TPS and then imported into IMSure via the Import Module (see "Using the Import Module" on page 22). Most values required for the calculation are automatically extracted from the plan file and entered into the appropriate fields in IMSure. NOTE: After import some values may need to be entered or adjusted for accurate calculations.

To import a plan, follow the instructions in the section entitled 'Using the Import Module' (see page 22).

The MU Module has several color codes that are useful for quick review and edit:

- Red boxes are required values or text. As soon as all required (red) values have been entered, IMSure QA will automatically update the MU results.
- Green boxes indicate a valid entry.
- White boxes are computed values or text of low interest.
- Yellow boxes are computed values or text of high interest.

9.4 Plan information

1. Patient Name, Patient ID, Plan Name – Values entered from the imported plan information. If any of this information is missing in the plan file, the field will be shown in red and a value will need to be entered. Machine name is required for import.
2. Isodose line: If present in the plan file, this value is imported. Otherwise it will be set to a default value of 100%.
3. Patient Origin (cm) (Fixed IEC) - Calculated from information available in your plan data that will result in isocenter coordinates being displayed as 0,0,0 for the first isocenter found in your plan.
4. Calculation Status Report – Any warning messages about calculation errors or missing information that will prevent calculation of either Plan MU, Calculation Point dose, or Diode calculation will be shown here.
5. Rx Total Daily Dose – The total dose delivered to the reference point per fraction based on imported information.

9.5 The Options button

1. Auto-Calc Depths/PSSDs – For SAD plans, entering a PSSD value allows IMSure QA to accurately determine depth to the calculation point from the formula:

   SSD CAX + Depth CAX = SSD Calc Pt (PSSD) + Depth Calc Pt (see Appendix A, Section B. MU Model, page 58). If the plan is not a SAD plan, the 'Auto-Calc Depths/PSSD' checkbox should be turned off to allow individual entry of PSSD and projected depth.

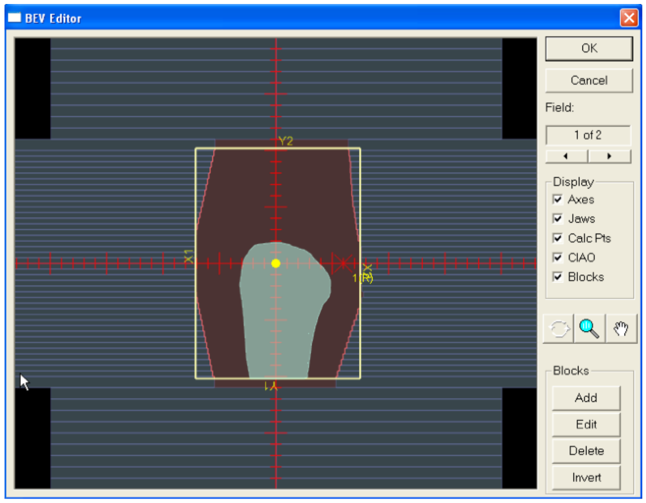
2. Sync Reference Points – Turning off this option will allow different reference points to be assigned to individual fields.
3. Auto Edit Split Beams Dose – Used for Elekta motorized wedge plans (see "The Calc Pts Tab" on page 31). When un-checked it allows for the manual entry of dose for the open and wedged portions of the beam. When checked, an entry into the dose field of either the open or wedged portion of the beam will replace the total dose for both beams with the entered value, which will be split between the two fields accordingly to the effective wedge angle.

9.6 BEV Window

The BEV (Beam's Eye View) enables visualization of the plan by showing the Jaws, the Calculation Points, MLCs, Blocks, and Wedges if present. If the Structure Set (see "Using the Import Module" on page 22) was imported with the plan file these will also be shown.

There are several controls available in the BEV Window:

1. - Reset View – Clicking this button will reset the image to the default view.
2. - Zoom In/Out – Click this button to turn the cursor into a magnifying glass. Left-clicking in the view will zoom in, right-clicking will zoom out. Also, with the cursor in the view, rotate the mouse wheel forward (away from user) to zoom in, or rotate the mouse wheel backwards (toward user) to zoom out.
3. - Pan View – Clicking this button will turn the cursor into a hand. Clicking in the view and dragging the cursor will allow you to pan the view.
4. - Volume Display – For imported structure sets. Clicking this button will bring up the Edit Volume window where you can choose which structures you would like to visualize. For plans with associated CT images, this dialog will also allow density override on a structure-by-structure basis.
5. - Open Block Editor – Clicking this button will bring up the Block Editor. Any block present in the plan file can be edited or deleted here or additional blocks can be created, edited or deleted.



a. Add Button – With this button, chosen left-clicking in the view will create the first point for a new block. Left-clicking again will add successive control points. Double-left-click at any time in order to add a final point and to close the block.
b. Edit Button – With this button chosen, place the cursor over any control point. The control point is highlighted, and left-clicking on the control point allows moving it to any new position. The user can also move the cursor in the view to highlight the block, then right-click to successively remove control points.
c. Delete Button – With this button chosen, left-clicking on a block will delete it.
d. Invert Button – With this button chosen, clicking on the block will toggle the block outline and fill color.

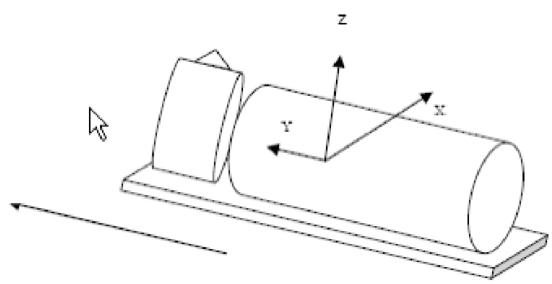
6. Transverse Button - Changes the BEV to the transverse view as if you are looking from the foot of the table. CT images, if imported, are shown in this view. NOTE: Structure sets, if imported, are not shown in the Transverse view if no CT images are imported.
7. Auto SSD/Eff. Depth - Opens the same dialog as the Volume Display.

9.7 The Photon Tab

1. Field ID – Field ID from the imported plan.
2. Energy – Energy from the imported plan.
3. Block Tray – Automatically chosen if a block is included with the imported plan. Defaults to the default tray factor input into the Physics Module. Click on the Block Tray text to view a drop-down list of block attenuation factors available for the chosen energy (see “For Standard or SRS Photons” on page 15).
4. Wedge/Cone:
   a. Wedge (non SRS beam) – Open field or wedge from the imported plan.
   b. Cone (SRS beam) – Open field or cone from the imported plan.
5. Wedge Dir/Cone Size:

a. Wedge Dir (non SRS beam) – Based on the THIN END of the wedge. A wedge direction of X1, indicates that the thin end of the wedge is nearest to the X1 collimating jaw.
b. Cone Size (SRS beam) – The size of the cone in cm.

6. Gantry Angle – From the imported plan. For Dynamic Arc SRS fields a starting and ending gantry angle will be shown.
7. Collimator Angle – From the imported plan.
8. Table Angle – From the imported plan.
9. Isocenter – X,Y,Z coordinates of the isocenter for the field based on the Patient Origin. **NOTE: IMSure uses the IEC coordinate system. This often is different than the coordinate system in your TPS and can lead to confusion.** Imported plan information is automatically transformed into the IMSure QA IEC coordinate system:
   a. X – Lateral direction, increasing to the patient's left.
   b. Y – Coronal direction, increasing towards the patient's head.
   c. Z – Sagittal direction, increasing towards the ceiling.



10. X1/X2 Jaw (cm) and Y1/Y2 Jaw (cm) – From the imported plan. Jaws can be symmetric or asymmetric.
11. Eff FS (cm) – The Effective Field Size is automatically calculated based on the blocked portion of the field by either MLC or a block. This field will be blank if no blocking mechanism is present in the field.
12. Ref. Point. – The calculation point in the Calc Pts tab that the MU are being calculated to.
13. Dose per Field (cGy) – From the imported plan.
14. CAX SSD – Central Axis SSD from the imported plan.
15. User Factor – A generic factor that can be used to add any other attenuating factors to the field.
16. IMSure calculated values:
   a. Eq. Sq. – The calculated equivalent square based on the jaw settings.
   b. Sc – Using the equivalent square field size, IMSure obtains the Collimator Scatter Factor value from the tables input into the Physics Module (Not shown for SRS cones).
   c. Sp – Using the calculated or input Effective Field Size, IMSure obtains the Phantom Scatter Factor value from the tables input into the Physics Module (Not shown for SRS cones).
   d. InvSq. Corr. – A correction value based on the physics of point source radiation that states that the radiation decreases by the square of the

distance traveled. This value is calculated by the formula found in Appendix B, eq. B.4 (see page 76).

e. OAR X/Y – Off-Axis factors obtained from the tables input into the Physics Module based on the X/Y offsets input for the reference point.

f. TMR – TMR value obtained from the tables input into the Physics Module based on the calculated or input effective field size and the effective depth (projected depth if no effective depth is entered).

g. Tray Factor – Factor obtained from the information entered into the Physics Module based on the chosen Block Tray. Value is 1.00 if no Block Tray is present.

h. Wedge/Cone Factor – Factor obtained from the information entered into the Physics Module based on the wedge/cone chosen. Wedge/Cone factor value is 1.00 for open beam.

17. TPS MU – For user created plans this value will be 0. If a plan is imported from the treatment planning system, IMSure will enter the value from the TPS here.
18. IMSure MU – The number of monitor units IMSure calculates to deliver the prescribed plan.
19. MU diff % - The percentage difference between the IMSure calculated value and the value that is present in the TPS MU field.
20. Add button – Adds additional fields as needed.
21. Copy button – With a field highlighted, click this button to create a duplicate. A Field ID will need to be entered for the new field.
22. Delete button – With a field highlighted, click this button to delete the field.

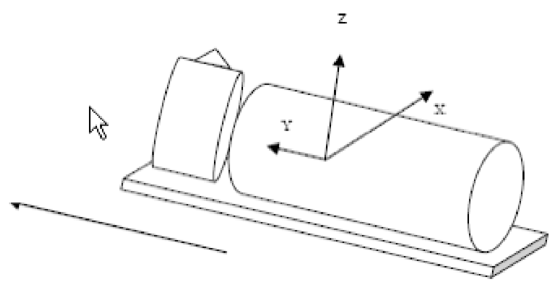
9.8 The Electron Tab

1. Field ID – Field ID from the imported plan.
2. Energy – Energy from the imported plan.
3. Gantry Angle – From the imported plan.
4. Collimator Angle – From the imported plan.
5. Table Angle – From the imported plan.
6. Isocenter – X,Y,Z coordinates of the isocenter for the field based on the Patient Origin. **NOTE: IMSure uses the IEC coordinate system. This often is different than the coordinate system in your TPS and can lead to confusion.** Imported plan information is automatically transformed into the IMSure QA IEC coordinate system:

   a. X – Lateral direction, increasing to the patient's left.

   b. Y – Coronal direction, increasing towards the patient's head.

   c. Z – Sagittal direction, increasing towards the ceiling.



7. Cone Size (cm) – From the imported plan.

8. Cutout FS (cm) - The cutout field size is automatically calculated based on the blocked portion of the field by an electron cutout if available in the plan file. This field will be equal to the cone size if no cutout is present in the plan.
9. Ref. Point – The calculation point for which the MU are being calculated.
10. Dose per Field (cGy) – From the imported plan.
11. CAX SSD – Central Axis SSD from the imported plan.
12. PDepth/PDD (cm) – PDepth is shown by default and is from the imported plan. Changing the Rx target to PDD will show the equivalent percent depth dose.
13. User Factor – A generic factor that can be used to add any other attenuating factors to the field.
14. IMSure calculated values:
    a. Cone Factor – IMSure obtains the value from the tables input into the Physics Module based on the imported cone size.
    b. Cutout Factor – IMSure obtains the value from the tables input into the Physics Module based on calculated Cutout Field size.
    c. InvSq. Corr. – A correction value based on the physics of point source radiation that states that the radiation decreases by the square of the distance traveled. This value is calculated by the formula found in Appendix B, eq. B.4 (see page 76).
    d. OAR X/Y – Off-Axis factors obtained from the tables input into the Physics Module based on the X/Y offsets for the reference point.
    e. PDD/PDepth – Percentage of depth dose is shown if Depth is chosen for Rx Target. The corresponding depth in the PDD curve is shown if PDD is chosen for Rx Target (NOTE: the first depth that matches the PDD value chosen is shown.).
    f. VSSD (cm) – IMSure obtains the value from the tables input into the Physics Module based on the energy/cone size combination.
    g. Gap – The distance between the bottom of the cone and the patient surface computed from the formula found in Appendix B, eq. B.4a (see page 77)
15. TPS MU – For user-created plans this value will be 0. If a plan is imported from the treatment planning system, IMSure will obtain the value from the plan file.
16. IMSure MU – The number of monitor units IMSure calculates to deliver the prescribed plan.

17. MU Diff % - The percentage difference between the IMSure calculated value and the value that is present in the TPS MU field.
18. Add button – Adds additional fields as needed.
19. Copy button – With a field highlighted, click this button to create a duplicate. A Field ID will need to be entered for the new field.
20. Delete button – With a field highlighted, click this button to delete the field.

9.9 The Calc Pts Tab

Any number of calculation points can be calculated in a single plan. Each point is calculated in relation to the reference point. If the TPS supports export of multiple points of interest they will automatically be imported into the Calculation Points Tab. A calculation point only becomes 'active' when a valid PSSD and Projected Depth are entered.

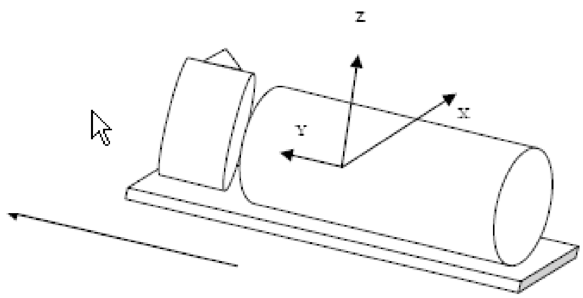
1. Field ID – Field ID from the imported plan.
2. Isocenter – X,Y,Z coordinates of the Isocenter for the field based on the Patient Origin. NOTE: These coordinates are not editable in the Calc Pts tab.
3. CAX SSD - Central Axis SSD from the imported plan. NOTE: This value is not editable in the Calc Pts tab.
   For plans created for Elekta machines that feature the Elekta motorized wedge, IMSure will import the plan and automatically split each beam that features the motorized wedge into two beams representing the open and wedged segments of the delivery. The DICOM-RT plan file only contains the total amount of dose that is to be delivered for both the open and wedged portion of the treatment, so IMSure features a model developed in conjunction with the Academisch Medisch Centrum Hospital in the Netherlands, which will correctly apportion the dose to each of the open and wedged segments, based on the effective wedge angle. If the effective wedge angle is included in the DICOM-RT file it will be automatically entered into the appropriate field in the Calc Pts tab. For DICOM files that do not contain the effective wedge angle an algorithm in the IMSure QA program will automatically determine the appropriate effective wedge angle and input the value into the appropriate field.
   The effective wedge angle can be manually overridden by entering a value in the effective wedge angle field for either the open or wedged portion of any beam.

Field #:	1	2	3	4	5	6	7
Field ID:	Add_1	Add_2	Add_2	Add_3	Add_3	Add_4	Add_5
Eff Wedge Angle:	0.0 deg	32.0 deg	32.0 deg	41.0 deg	41.0 deg	0.0 deg	0.0 deg
Isocenter (cm):	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0
CAX SSD:	86.7 cm	87.3 cm	87.3 cm	82.1 cm	82.1 cm	87.7 cm	86.7 cm
Ref Point:	DP_1	DP_1	DP_1	DP_1	DP_1	DP_1	DP_1

4. Ref. Point – The calc point that is used to calculate the monitor units for the treatment field. Clicking on this field in the grid will show a dropdown list of all valid calculation points. NOTE: To apply a different reference point to each treatment field, click the Options button and click to turn off the 'Sync Reference Points' checkbox that is on by default.
5. BEV X/Y (cm) – Beam's Eye View X, Y coordinates of the calculation point.
6. X/Y/Z (cm) – 3D coordinates of the calculation point. NOTE: IMSure uses the IEC coordinate system. This often is different than the coordinate system in your TPS

and can lead to confusion. Imported plan information is automatically transformed into the IMSure QA IEC coordinate system where:

a. X – Lateral direction, increasing to the patient's left.
b. Y – Coronal direction, increasing towards the patient's head.
c. Z – Sagittal direction, increasing towards the ceiling.



7. PSSD – Projected Source-to-Surface Distance - Since Patient contours are not flat, for accurate calculation of off-axis calculation points in Patient-specific plans, the PSSD value should be entered, as it describes the distance from the source to a point at the surface orthogonal to the calculation point. By entering a PSSD value, IMSure QA can accurately determine depth to the calculation point as SSD CAX + Depth CAX = SSD Calc Pt (PSSD) + Depth Calc Pt for SAD plans (see diagram). If the plan is not an SAD plan, the 'Auto-Calc Depths/PSSD' checkbox (see Options button) should be turned off. This value is usually found in the printed plan output from the TPS. Note: PSSD for the Isocenter calculation point is equal to CAX SSD. For arc plans with static fields and for which CT images and structures have been imported into IMSure, the PSSD will be calculated by averaging the PSSD calculated every 5 degrees over the arc.

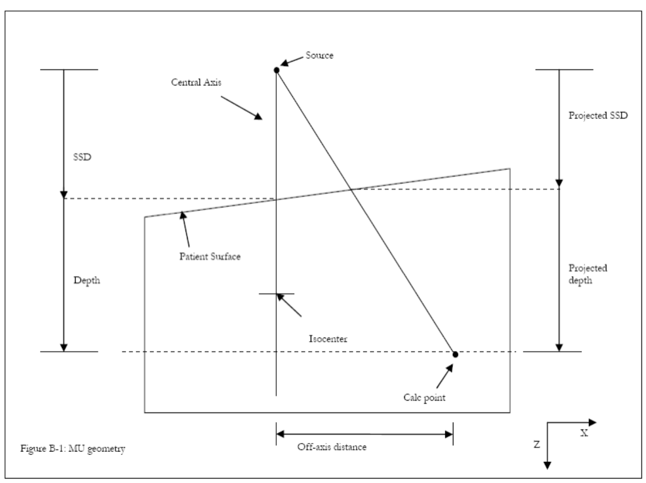


Figure B-1: MU geometry

8. Proj. Depth (cm) - Projected Depth is the depth to the calculation point and will automatically be calculated from the PSSD value based on an SAD plan. If the plan is SSD, click on the Options button at the top of the screen and turn off the Auto-Calc Depths/PSSD function and then enter the correct projected depth. Note: For arc plans with static fields and for which CT images and structures have been

imported into IMSure, the Projected Depth will be calculated by averaging the Projected Depth calculated every 5 degrees over the arc.

9. Eff Depth (cm) - The Effective Depth should be used when Patient-specific plans are being calculated and heterogeneity corrections were used in the TPS. Effective Depth describes the radiological depth to the calculation point, taking into account different electron densities of materials the beam will pass through. This value is usually found in the printed plan output from the TPS. If CT images and a structure set are imported with the plan, IMSure will automatically calculate this value. NOTE: For arc plans with static fields and for which CT images and structures have been imported into IMSure, the effective depth will be calculated by averaging the effective depth calculated every 5 degrees over the arc.
10. TPS Dose (cGy) – Treatment planning system predicted dose.
11. Calc Dose (cGy) – IMSure calculated dose. NOTE: By default, this value is calculated from the IMSure calculated Monitor Units but can be changed in Preferences/MU Calc Preferences (see “MU Calc Preferences” on page 10).
12. DMax Dose – If the preference for showing d_{MAX} dose is set to ‘ON’ (see “MU Calc Preferences” on page 10), the d_{MAX} dose for the beam will be displayed. The d_{MAX} dose is defined as the point at d_{MAX} depth projected along a ray line from the calculation point to the source.
13. % Diff - The percentage difference between the IMSure calculated value and the value that is present in the TPS Dose field.
14. Add button – Adds additional calculation points as needed.
15. Copy button – With a calculation point highlighted, click this button to create a duplicate. A Field ID will need to be entered for the new calculation point.
16. Delete button – With a calculation point highlighted click this button to delete the field.

9.10 The Diode Tab

The Diode Tab is active if the ‘Enable Diode Interface’ preference is set in Preferences/MU Calc preferences.

The Diode Tab is designed for centers that use in-vivo dosimetry devices to verify treatment delivery. When the Diode Interface is enabled, IMSure QA Software will automatically create a diode set for each beam in a treatment plan. A diode will automatically be calculated at the patient’s surface on the central axis projected up from isocenter at a physical depth of 0.0 cm and with an effective depth applied equal to the d_{MAX} depth of the energy being delivered for that beam. Any diode can be associated with any valid calculation point. IMSure will calculate the correct placement of the diode at the patient surface taking beam divergence into account and report the Beam’s Eye View coordinates, the three dimensional coordinates and the expected reading to assist with the proper set up of the diode for measurements.

1. Field ID – Field ID from the imported plan.
2. Isocenter – X,Y,Z coordinates of the Isocenter for the field based on the Patient Origin. NOTE: These coordinates are not editable in the Diode tab.

3. CAX SSD - Central Axis SSD from the imported plan. NOTE: This value is not editable in the Diode tab.
4. Diode Set # – Diode association defaults to Isocenter. Click on this field to enable a drop-down list of available calculation points to associate the diode with.
   a. Associating a diode with a calculation point will automatically input the following values:
   h. The PSSD value from the calculation point (found on the Calc Pts tab).
   ii. An Effective Depth equal to the diode eff. depth of the energy being delivered.
   iii. Beam's Eye View (BEV) coordinates for correct placement of the diode at the patient's surface based on the divergent beam.
   iv. Three dimensional coordinates for the correct placement of the diode at the patient surface based on the divergent beam.
   b. The '--' option will enable editing of the following parameters for the diode:
      i. PSSD
      ii. Effective Depth
      iii. Both BEV and three dimensional (X,Y,Z) coordinates
5. Surface X/Y (cm) – The X and Y offsets from the central axis for correct placement of the diode at the patient's surface.
6. If a diode has been associated with an off-axis calculation point these values will be calculated based on the divergence of the beam ensuring correct placement of the diode.
7. X/Y/Z (cm) – Three dimensional coordinates for correct placement of the diode at the patient's surface.
8. If a diode has been associated with an off-axis calculation point these values will be calculated based on the divergence of the beam ensuring correct placement of the diode.
8. PSSD – The Projected Source-to-Surface Distance to the point of diode placement. NOTE: For diodes that have been associated with a calculation point, this value is automatically entered based on information found in the Calc Pts tab for that calculation point.
9. Eff Depth (cm) – Automatically entered as the depth specified in the physics module for the energy being delivered.
10. Cal. Factor – Entered from information found in the Physics Module for the energy being delivered (see "For Standard or SRS Photons" on page 15).
11. Actual Reading – Editable field for entering the actual reading and determining a difference from the expected reading based on IMSure calculations. This value is included in the 'Diode Summary Report' when printed (see "Printing Reports (MU module)" on page 34).
12. Expected Reading – IMSure calculated value for an expected reading of the diode based on the information input.
13. % Diff - The percentage difference between the IMSure expected value and the value that is present in the Actual Reading field.
14. Add button – Adds additional diode sets as needed.
15. Copy button – With a diode set highlighted click this button to create a duplicate set.

16. Delete button – With a diode set highlighted click this button to delete the set.

9.11 Calculating .decimal plans in the MU module

After a plan that includes .decimal compensators is imported into the MU module, the required MU will automatically be calculated as soon as all necessary information is input. There are several changes to the interface that should be noted.

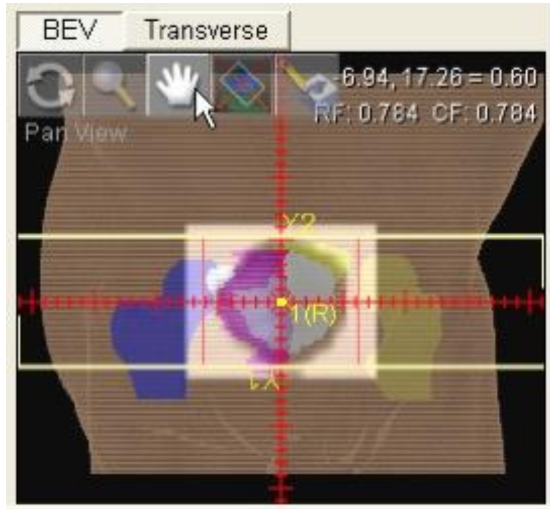
1. An additional factor is added to the grid in the Photon tab called compensator factor. This is the calculated compensator factor at the reference point based on information in the Physics Module and in the imported .decimal compensator files, and is included in the calculation of the MU.
2. The BEV window displays a representation of the thickness map of the .decimal compensator for the chosen beam. Placing your cursor over the map will display important information in the upper right hand corner of the view.
    a. The first line displays the BEV X,Y coordinates of your cursor and the thickness of the compensator at that point (cm).
    b. The second line displays two values:
        i. RF – The relative fluence value under the compensator at that point. The relative fluence only takes into account the actual thickness of the compensator.
        ii. CF – The actual calculated compensator factor under the compensator at that point. The compensator factor takes into account the additional scatter, electron contamination and beam hardening effects of the compensator for a more accurate valuation of the effect of the compensator on the beam. The CF and RF can vary widely especially where modulation results in steep gradients.

NOTE: It is important that an appropriate calculation point(s) is chosen for the calculation of monitor units when a .decimal compensator is present in the beam. It is recommended that the point be placed in an area of the compensator that does not feature steep gradients. It might be necessary to choose a different reference point for each field to achieve accurate results.

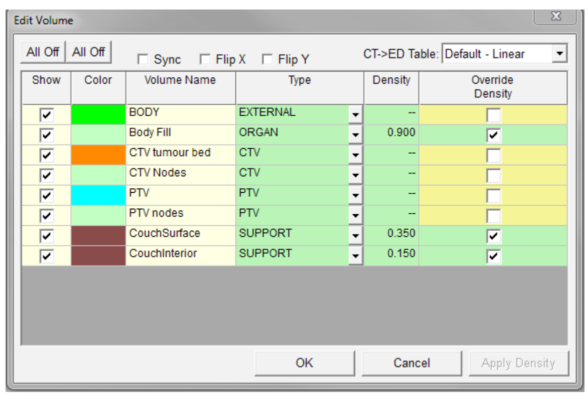
9.12 Using Structure Sets in the MU module

After a plan that includes Structure Sets has been imported into the MU module there are changes to the interface that should be noted.

The Structure sets will automatically be shown in the Beam's Eye View (BEV) window:



To turn off the structures, click on the 'Volume Display' button  to obtain the Edit Volume window:



Click the "All Off" button above the 'Show' column to automatically turn off all of the volumes shown in the BEV window. You can then turn on individual structures as needed.

Structure Sets have several uses in the MU module including automatic SSD and depth calculations (when CT images are present), better visualization of the plan, and guidance for drawing blocks based on anatomical structures.

Drawing blocks based on anatomical structures can be very useful in cases where flash is present in the plan by allowing a block to be drawn in where there is missing tissue. IMSure will then re-calculate the effective field size based on the blocked area resulting in a more accurate calculation.

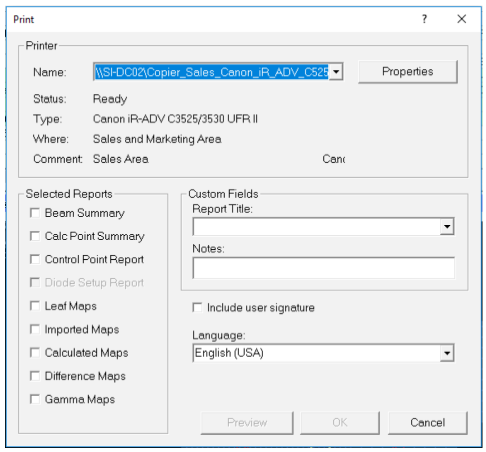
9.13 Printing Reports (MU module)

Reports can be printed by clicking on the 'Print' icon found in the toolbar, or by selecting the "Plan/Print" menu item (keyboard shortcut 'CONTROL KEY' + P). All reports feature a sign-off area at the bottom for accurate record-keeping. NOTE: In demonstration mode, the sign-off area is replaced with a warning that the software is for demonstration use only and not meant for clinical use.

Reports can be automatically exported to a PDF file for electronic record keeping. Select the "Plan/Export to PDF…" menu item. NOTE: The doPDF utility found on the software disk must be installed for this option to perform correctly.

Select the "Plan/Print Preview" menu item to obtain an on-screen representation of the chosen reports.

After choosing to Print, the Print dialog box will open:



Choose the printer and Report Title if necessary. Click the 'Preview' button to obtain an on-screen representation of the chosen reports. Select the appropriate reports for printing. NOTE: Reports will automatically be selected based on options previously set in "Preferences/Hardcopy" (see "Hardcopy Preferences" on page 8) but can be changed here as necessary.

1. Beam Summary – A summary of the information found on the Photon and Electron tabs in the MU module.
2. Calc Point Summary – A summary of the information found on the Calc Pts tab in the MU module.
3. Diode Summary – A summary of the information found on the Diode tab in the MU module.
4. Diode Setup Report – A useful report that can be used by the clinician setting up the patient for treatment. Values are shown both numerically and graphically for correct placement of the diode on the patient for *in vivo* measurements. Expected values are reported along with an expected range for the diode measurement for each field. The report also includes spaces for input of the actual reading recorded, notes about the treatment and sign-offs at the bottom.
5. Leaf Maps – A representation of what is shown in the BEV window in the MU module.
6. Include user signature - If selected, the username and date will be automatically entered in the "Calculated By" field at the bottom of the printed report pages.

Plans can also be exported as .csv files for easy import into a spreadsheet program. This export method is recommended for plans with more than 30 calculation points.

10 The CyberKnife Module

The CyberKnife Module is designed for verification of monitor units and dose of plans created on the Accuray Multi-Plan treatment planning system. The module is present if 'Enable CyberKnife Interface' is chosen in **"Preferences/CyberKnife"** (see "CyberKnife Preferences" on page 10).

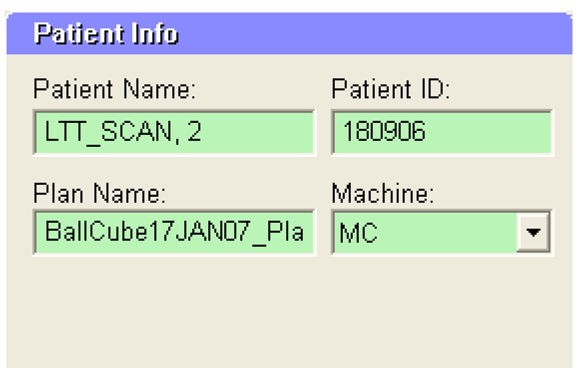
NOTE: As of IMSure 3.5, only .xml files can be imported for version 5.1 and above of Multi-Plan treatment planning system.

10.1 Import Plan

Clicking this button will open the Import Module.

1. Switch to the CyberKnife Module by clicking on the CyberKnife icon ('Cyber') found in the toolbar, or by selecting the **"Modules/CyberKnife View"** menu item. After plan import (see "Multi-plan Treatment Planning System (Accuray CyberKnife)" on page 23), results will automatically be shown.

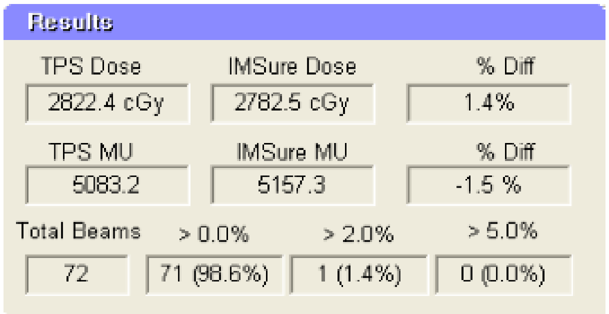
10.2 Plan Information



1. Patient Info:
    a. Patient Name – From the Plan Overview File (POV file).
    b. Patient ID – From the Plan Overview File (POV file).
    c. Plan Name – From the Plan Overview File (POV file).
    d. Machine – If more than one CyberKnife machine is present in the Physics Module, it may be necessary to manually choose the correct machine.

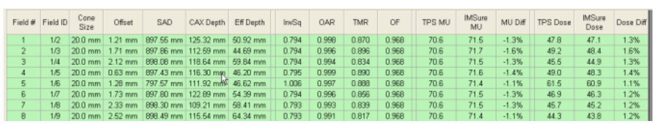
IMSure will automatically choose the first CyberKnife machine shown in the Physics Module.

2. Status – Any warning messages about calculation errors or missing information will be shown here.
3. Results – Results are shown for a composite of all projections along with a histogram of individual projection results based on values set in **“Preferences/CyberKnife”** (see “CyberKnife Preferences” on page 10):



10.3 Individual Projection Results

Results for each individual projection along with values used in the calculation are shown. Data can be sorted on any column by clicking on the column heading. For quick reference about projections results, row backgrounds will be green, yellow or red based on the settings in **“Preferences/CyberKnife”** (see “CyberKnife Preferences” on page 10).



Field #	Field ID	Cone Size	Offset	SAD	CAX Depth	Eff Depth	InvSq	OAR	TMR	OF	TPS MU	IMSure MU	MU Diff	TPS Dose	IMSure Dose	Dose Diff
1	1/2	20.0 mm	1.21 mm	897.55 mm	125.32 mm	50.92 mm	0.794	0.998	0.870	0.968	70.6	71.5	-1.3%	47.8	47.1	1.3%
2	1/3	20.0 mm	1.71 mm	897.86 mm	112.59 mm	44.69 mm	0.794	0.996	0.896	0.968	70.6	71.7	-1.6%	49.2	48.4	1.6%
3	1/4	20.0 mm	2.12 mm	898.08 mm	118.64 mm	59.84 mm	0.794	0.994	0.834	0.968	70.6	71.5	-1.3%	45.5	44.9	1.3%
4	1/5	20.0 mm	0.63 mm	897.43 mm	116.30 mm	46.20 mm	0.795	0.999	0.890	0.968	70.6	71.6	-1.4%	49.0	48.3	1.4%
5	1/6	20.0 mm	1.28 mm	797.57 mm	111.92 mm	46.62 mm	1.006	0.997	0.888	0.968	70.6	71.4	-1.1%	61.5	60.9	1.1%
6	1/7	20.0 mm	1.73 mm	897.80 mm	122.89 mm	54.39 mm	0.794	0.996	0.856	0.968	70.6	71.5	-1.3%	46.9	46.3	1.2%
7	1/8	20.0 mm	2.33 mm	898.30 mm	109.21 mm	58.41 mm	0.793	0.993	0.839	0.968	70.6	71.5	-1.3%	45.7	45.2	1.2%
8	1/9	20.0 mm	2.52 mm	898.49 mm	115.54 mm	64.34 mm	0.793	0.991	0.817	0.968	70.6	71.4	-1.1%	44.3	43.8	1.2%

1. Field # – Projection number; from the Beam List file (BM file).
2. Field ID – Projection ID; from the Beam List File (BM file).
3. Cone Size – The collimator size for the projection; from the Beam List File (BM file).
4. Offset – The radial offset at SAD 800; from the Beam List File (BM file).
5. SAD – Source-to-Axis distance; from the Beam List File (BM file).
6. CAX Depth – The depth to the calculation point; from the Beam List File (BM file)
7. Eff Depth - Effective Depth describes the radiological depth to the calculation point taking into account different electron densities of materials the beam will pass through. From the Beam List File (BM file).
8. InvSq - A correction value based on the physics of point source radiation that states that the radiation decreases by the square of the distance traveled. Calculated from information found in the Beam List File (BM file).
9. OAR – Off-Axis factor obtained from the tables input into the Physics Module based on radial offset at SAD 800.
10. TMR – TMR value obtained from the tables input into the Physics Module based on the collimator size and the effective depth.

11. OF – Output Factor obtained from the tables based on the collimator size and SAD distance found in the Beam List file (BM file).
12. TPS MU – Imported from the treatment planning system; found in the Beam List file (BM file)
13. IMSure MU – The number of monitor units IMSure calculates to deliver the prescribed plan.
14. MU Diff - The percentage (%) difference between the IMSure calculated value and the value that is present in the TPS MU field.
15. TPS Dose – Treatment Planning System predicted dose; from the Beam List file (BM file).
16. IMSure Dose – IMSure calculated dose.
17. Dose Diff - The percentage difference between the IMSure calculated value (IMSure Dose) and the value in the TPS Dose field.

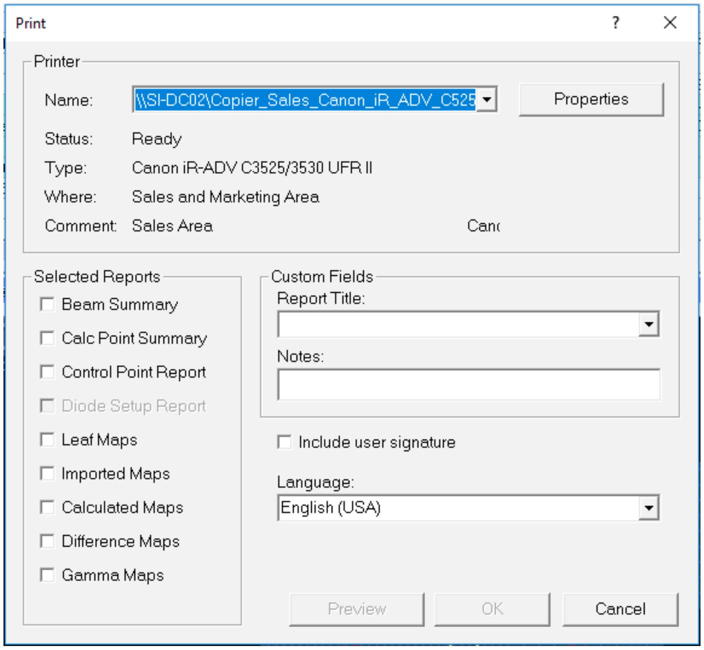
10.4 Printing Reports (CyberKnife Module)

Reports can be printed by clicking on the 'Print' icon found in the toolbar, or by selecting "Plan/Print" menu item (keyboard shortcut 'CONTROL KEY' + P). All reports feature a sign-off area at the bottom for accurate record-keeping. NOTE: In demonstration mode, the sign-off area is replaced with a warning that the software is for demonstration use only and not meant for clinical use.

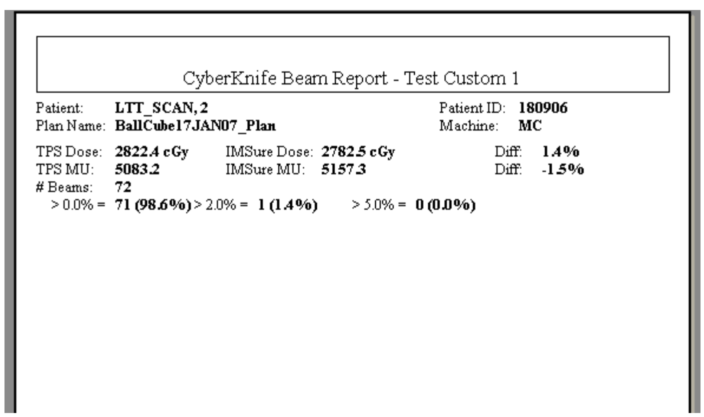
Reports can be automatically exported to a PDF file for electronic record keeping. Select the "Plan/Export to PDF…" menu item. NOTE: The doPDF utility found on the software disk must be installed for this option to perform correctly.

Select the "Plan/Print Preview" menu item to obtain an on-screen representation of the chosen reports.

After choosing to Print, the Print dialog box will open:



Click the 'Beam Summary' checkbox to print out a report containing information for all of the projections. Click the 'Preview' button to obtain an on-screen representation of the chosen reports. If the 'Beam Summary' checkbox is not chosen, a simple summary of the plan will be printed:



11 The QA Module

The QA module is designed to verify IMRT plans created with a commercial treatment planning system.

The module effectively mimics the traditional method of verifying an IMRT treatment plan where a phantom is set up on the treatment machine, a chamber is inserted to measure a point dose and film is placed in between the phantom slabs to measure the fluence which is then compared to the fluence the treatment planning system predicted.

Using the patented 3-source model, IMSure can complete this verification quickly and accurately without any linac time required.

The QA Module can be used to verify non-IMRT plans as long as there is not a wedge or a physical block in the plan. Because this module was designed for IMRT plans and wedges and blocks are not used in IMRT, this module does not understand them and will not calculate a plan that contains them. Support in this module for these types of plans is scheduled for a future release.

The QA module allows the user to import plans created by commercially available treatment planning systems. A DICOM-RT or RTP Exchange format file is exported from the TPS and then imported into IMSure via the Import Module (see "Using the Import Module" on page 22). Most values required for the calculation are automatically extracted from the plan file and entered into the appropriate fields in IMSure. NOTE: After the plan has been imported, some values may need to be entered or adjusted for accurate calculations.

Switch to the IMRT QA Module by clicking on the IMRT QA icon ('QA') found in the toolbar, or by selecting the "Modules/IMRT QA View" menu item. Follow the import instructions found on page 24 of this manual to import a plan.

The QA Module has several color codes that are useful for quick review and edit:

- Red boxes are required values or text. As soon as all required (red) values have been entered, the calculate dose and calculate maps buttons will become active.
- Green boxes indicate a valid entry.
- White boxes are computed values or text of low interest.
- Yellow boxes are computed values or text of high interest.

11.1 Import Plan

Clicking this button will open the Import Module.

11.2 Calculate Map

Clicking this button will calculate the IMSure fluence map and enable comparison to an imported map, if available.

11.3 Calculate Dose

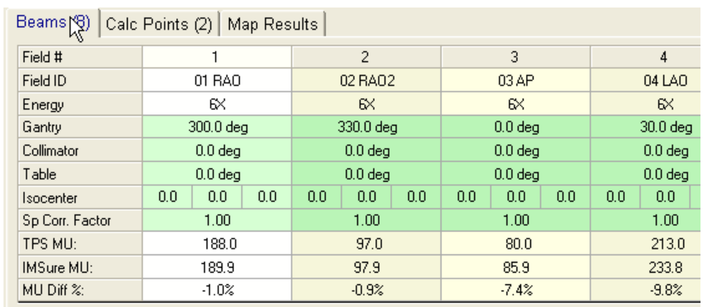
Clicking this button will calculate the dose.

11.4 The Options Button

1. Auto-Calc Depths/PSSDs – For SAD plans, entering a PSSD value allows IMSure QA to accurately determine depth to the calculation point from the formula: SSD CAX + Depth CAX = SSD Calc Pt (PSSD) + Depth Calc Pt (see Appendix A, Section B. MU Model, page 58). If the plan is not a SAD plan, the 'Auto-Calc Depths/PSSD' checkbox should be turned off to allow individual entry of PSSD and projected depth.
2. Sync Reference Points – Turning off this option will allow different reference points to be assigned to individual fields.

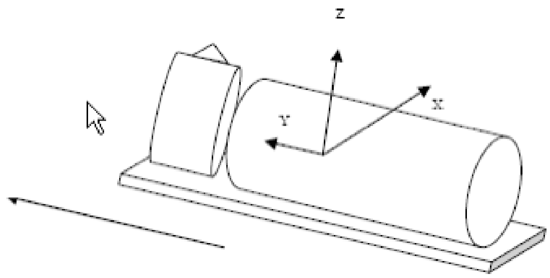
11.5 The Beams Tab

The Beams Tab displays important geometric information about the imported plan:



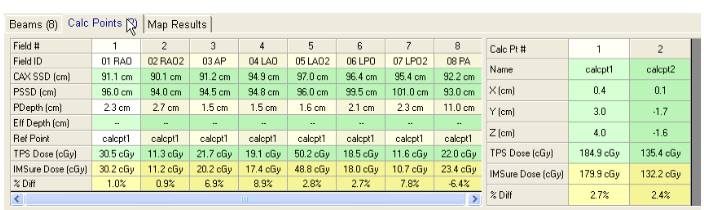
Field #	1	2	3	4
Field ID	01 RAO	02 RAO2	03 AP	04 LAO
Energy	6X	6X	6X	6X
Gantry	300.0 deg	330.0 deg	0.0 deg	30.0 deg
Collimator	0.0 deg	0.0 deg	0.0 deg	0.0 deg
Table	0.0 deg	0.0 deg	0.0 deg	0.0 deg
Isocenter	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0 0.0	0.0 0.0
Sp Corr. Factor	1.00	1.00	1.00	1.00
TPS MU:	188.0	97.0	80.0	213.0
IMSure MU:	189.9	97.9	85.9	233.8
MU Diff %:	-1.0%	-0.9%	-7.4%	-9.8%

1. Field # - Field number.
2. Field ID – Field ID from the imported plan.
3. Energy – The energy being delivered with this beam. IMSure supports plans with multiple energies.
4. Gantry – Gantry angle of delivery. For arc or VMAT plans, the range of angles and gantry rotation direction will be displayed.
5. Collimator – Collimator angle of delivery.
6. Table – Table angle of delivery.
7. Isocenter – X,Y,Z coordinates of the Isocenter for the field based on the Patient Origin. NOTE: IMSure uses the IEC coordinate system. This often is different than the coordinate system in your TPS and can lead to confusion. Imported plan information is automatically transformed into the IMSure QA IEC coordinate system where:
   a. X- Lateral direction, increasing to the patient's left.
   b. Y- Coronal direction, increasing towards the patient's head.
   c. Z – Sagittal direction, increasing towards the ceiling.



8. Sp Corr. Factor – A first order correction to the phantom scatter calculation (Sp) to account for missing tissue (flash). Enter a percentage value of beam coverage in decimal format, e.g. if 80% of the beam is covered by tissue (20% flash) enter 0.80 in this field.
9. TPS MU –The number of monitor units to be delivered by the imported plan. NOTE: Only shown if the 'Enable Reverse MU Calculation' checkbox is turned on in "Preferences/IMRT QA".
10. IMSure MU – The number of monitor units IMSure calculates to deliver the prescribed dose to the field. NOTE: Only shown if the 'Enable Reverse MU Calculation' checkbox is turned on in "Preferences/IMRT QA".
11. MU Diff % - The percentage (%) difference between the IMSure calculated value and the value that is present in the TPS MU field. NOTE: If there is a large percentage shown in this field, review the dose in the Calc Points tab for this field as some IMRT fields deliver very small doses where small absolute differences in calculated dose result in large percentage differences which are reflected in this field.
12. Del Beam button – With a field highlighted, clicking this button will delete it. This can be helpful when plans are imported with setup fields or fields for alternative plans (e.g. boost), are included, but should not be included with the calculation.

11.6 Calc Points Tab



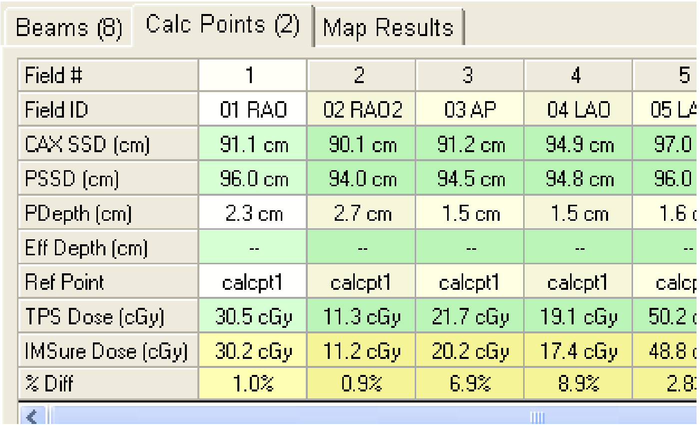
Beams (8) | Calc Points (2) | Map Results

Field #	1	2	3	4	5	6	7	8
Field ID	01 RAO	02 RAO2	03 AP	04 LAO	05 LAO2	06 LPO	07 LPO2	08 PA
CAX SSD (cm)	91.1 cm	90.1 cm	91.2 cm	94.9 cm	97.0 cm	96.4 cm	95.4 cm	92.2 cm
PSSD (cm)	96.0 cm	94.0 cm	94.5 cm	94.8 cm	96.0 cm	99.5 cm	101.0 cm	93.0 cm
PDepth (cm)	2.3 cm	2.7 cm	1.5 cm	1.5 cm	1.6 cm	2.1 cm	2.3 cm	11.0 cm
Eff Depth (cm)	--	--	--	--	--	--	--	--
Ref Point	calcpt1	calcpt1	calcpt1	calcpt1	calcpt1	calcpt1	calcpt1	calcpt1
TPS Dose (cGy)	30.5 cGy	11.3 cGy	21.7 cGy	19.1 cGy	50.2 cGy	18.5 cGy	11.6 cGy	22.0 cGy
IMSure Dose (cGy)	30.2 cGy	11.2 cGy	20.2 cGy	17.4 cGy	48.8 cGy	18.0 cGy	10.7 cGy	23.4 cGy
% Diff	1.0%	0.9%	6.9%	8.9%	2.8%	2.7%	7.8%	-6.4%

Calc Pt #	1	2
Name	calcpt1	calcpt2
X (cm)	0.4	0.1
Y (cm)	3.0	-1.7
Z (cm)	4.0	-1.6
TPS Dose (cGy)	184.9 cGy	135.4 cGy
IMSure Dose (cGy)	179.9 cGy	132.2 cGy
% Diff	2.7%	2.4%

The Calc Points tab is split into two sections. On the left is the individual beam information and on the right is the composite information. NOTE: the individual beam information on the left is tied to the composite information on the right. In order to see or enter information for individual beams in relation to a specific calculation point, that calculation point needs to be 'active' in the right side of the display. To activate a calculation point click on the 'Calc Pt #' at the top of the column.

Individual Beam Information (left)



Beams (8) | Calc Points (2) | Map Results

Field #	1	2	3	4	5
Field ID	01 RAO	02 RAO2	03 AP	04 LAO	05 LA
CAX SSD (cm)	91.1 cm	90.1 cm	91.2 cm	94.9 cm	97.0
PSSD (cm)	96.0 cm	94.0 cm	94.5 cm	94.8 cm	96.0
PDepth (cm)	2.3 cm	2.7 cm	1.5 cm	1.5 cm	1.6
Eff Depth (cm)	--	--	--	--	--
Ref Point	calcpt1	calcpt1	calcpt1	calcpt1	calcp
TPS Dose (cGy)	30.5 cGy	11.3 cGy	21.7 cGy	19.1 cGy	50.2
IMSure Dose (cGy)	30.2 cGy	11.2 cGy	20.2 cGy	17.4 cGy	48.8
% Diff	1.0%	0.9%	6.9%	8.9%	2.8

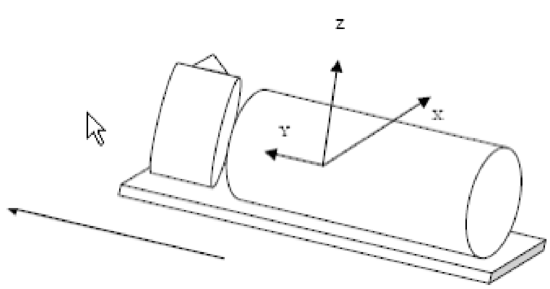
1. Field # - Field number.
2. Field ID – Field ID from the imported plan.
3. CAX SSD (cm) - Central Axis SSD from the imported plan. For VMAT plans, only the initial segment SSD is displayed here.
4. PSSD (cm) - Projected Source-to-Surface Distance - Since Patient contours are not flat, for accurate calculation of off-axis calculation points in Patient-specific plans, the PSSD value should be entered, as it describes the distance from the source to a point at the surface orthogonal to the calculation point. By entering a PSSD value, IMSure QA can accurately determine depth to the calculation point as SSD CAX + Depth CAX = SSD Calc Pt (PSSD) + Depth Calc Pt for SAD plans (see diagram). If the plan is not a SAD plan, the 'Auto-Calc Depths/PSSD' checkbox (see Options button) should be turned off. This value is usually found in the printed plan output from the TPS. (see Appendix A, Section B. MU Model, page 58)
   a. For VMAT plans, only the initial segment PSSD is displayed here.
   Note: PSSD for the Isocenter calculation point is equal to CAX SSD.
   NOTE: It is important when entering PSSD values that the correct calculation point is chosen in the composite information to the right to ensure the appropriate information is attributed to the correct point.
5. PDepth (cm) - Projected depth is the Depth to the calculation point and will automatically be calculated from the PSSD value based on a SAD plan. If the plan is SSD, click on the 'Options' button at the top of the screen, then click to turn off the 'Auto-Calc Depths/PSSD' checkbox, and then enter the correct projected depth. For VMAT plans, only the initial segment PDepth is displayed here.
6. Eff Depth (cm) - The Effective Depth should be used when Patient-specific plans are being calculated and heterogeneity corrections were used in the TPS. Effective Depth describes the radiological depth to the calculation point, taking into account different electron densities of materials the beam will pass through. This value is usually found in the printed plan output from the TPS. NOTE: It is important when entering effective depth values that the correct calculation point is chosen in the composite information to the right to ensure the appropriate information is attributed to the correct point. If CT images and structures are imported with the plan, IMSure will automatically calculate the Effective Depth as well as the SSD, PSSD, and PDepth. For VMAT plans, only the initial segment Eff Depth is displayed here.

7. TPS Dose (cGy) – Treatment planning system predicted dose.
8. IMSure Dose (cGy) – IMSure calculated dose.
9. % Diff - The percentage (%) difference between the IMSure calculated value and the value that is present in the TPS Dose field. NOTE: If there is a large percentage shown in this field, review the dose being delivered, as some IMRT fields deliver very small doses where small absolute differences in calculated dose result in large percentage differences which are reflected in this field.

Composite Information (right)

Calc Pt #	1	2
Name	calcpt1	calcpt2
X (cm)	0.4	0.1
Y (cm)	3.0	-1.7
Z (cm)	4.0	-1.6
TPS Dose (cGy)	184.9 cGy	135.4 cGy
IMSure Dose (cGy)	179.9 cGy	132.2 cGy
% Diff	2.7%	2.4%

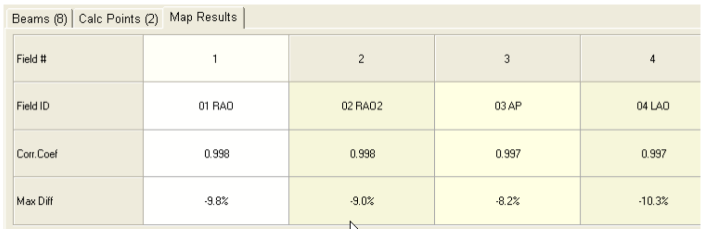
1. Calc Pt # - Calculation point number.
2. Name – Calculation point name from the imported plan, if available.
3. X/Y/Z (cm) – 3D coordinates of the calculation point. NOTE: IMSure uses the IEC coordinate system. This often is different than the coordinate system in your TPS and can lead to confusion. Imported plan information is automatically transformed into the IMSure QA IEC coordinate system where:
   a. X – Lateral direction, increasing to the patient's left.
   b. Y – Coronal direction, increasing towards the patient's head.
   c. Z – Sagittal direction, increasing towards the ceiling.



4. TPS Dose (cGy) – Treatment Planning System predicted dose.
5. IMSure Dose (cGy) – IMSure calculated dose.
6. % Diff - The percentage (%) difference between the IMSure calculated value and the value that is present in the TPS Dose field.
7. Add CalcPt button – Click this button to insert an additional calculation point with default values.

8. Del CalcPt button – Click this button to remove a calculation point from the list. The reference calculation point cannon be removed.

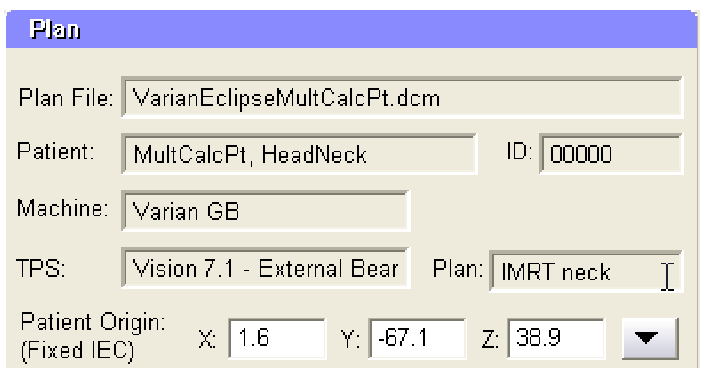
11.7 Map Results Tab


Beams (8) | Calc Points (2) | Map Results

Field #	1	2	3	4
Field ID	01 RAO	02 RAO2	03 AP	04 LAO
Corr.Coef	0.998	0.998	0.997	0.997
Max Diff	-9.8%	-9.0%	-8.2%	-10.3%

1. Field # – Field number
2. Field ID – Field ID from the imported plan.
3. Corr. Coef. – The correlation coefficient between the imported and calculated fluence map in IMSure. This value is a 'global' overview of how well the two maps match and can be an indicator of a map that was not matched to its correct field. In general a value of .990 or better indicates a good correlation coefficient.
4. Max. Diff. – The maximum difference at the *single pixel level* between the imported and calculated fluence map in IMSure. NOTE: Large values can be seen in this field and it should be noted that this represents a single pixel in the fluence map. Care should be taken to evaluate the total map using the available tools before a decision is made about the plan.

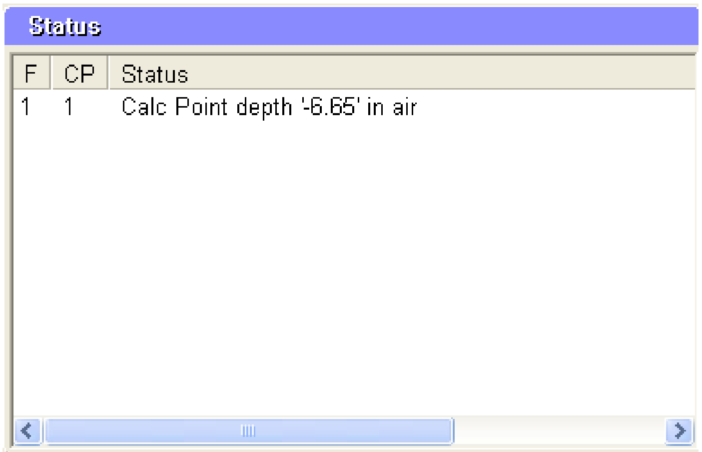
11.8 Plan Information



1. Plan File – The name of the imported DICOM or .rtp file.
2. Patient – The patient's name from the plan file.
3. ID – Patient ID from the plan file.
4. Machine – The name of the machine this plan is to be treated on.
5. TPS – Treatment Planning System this plan was created on.
6. Plan – The plan name from the plan file.

7. Patient Origin (cm) (Fixed IEC) - Calculated from information available in the plan data that will result in Isocenter coordinates being displayed as (0, 0, 0) for the first Isocenter found in your plan.

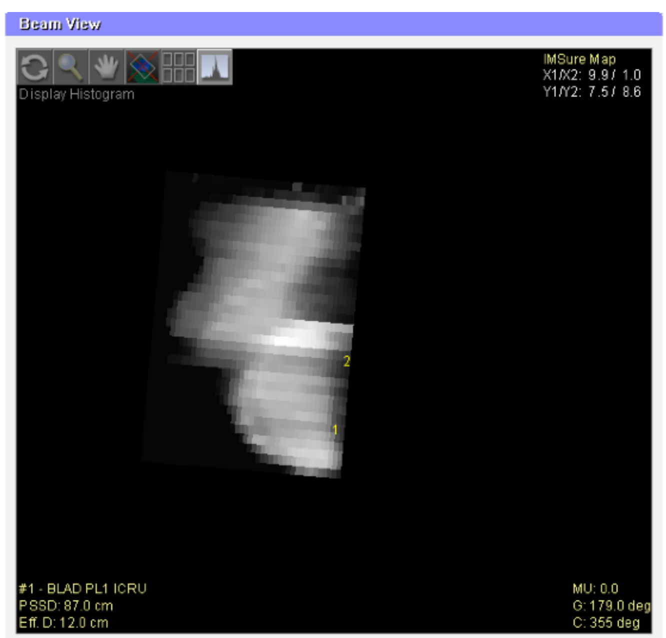
11.9 Status Window



Errors will be shown in this status window along with important information about the imported plan.

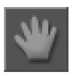
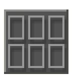
1. Field – Field number of status/warning message, if applicable.
2. CP – Calc Point number of status/warning message, if applicable.
3. Status – This area contains various status and/or warning messages.

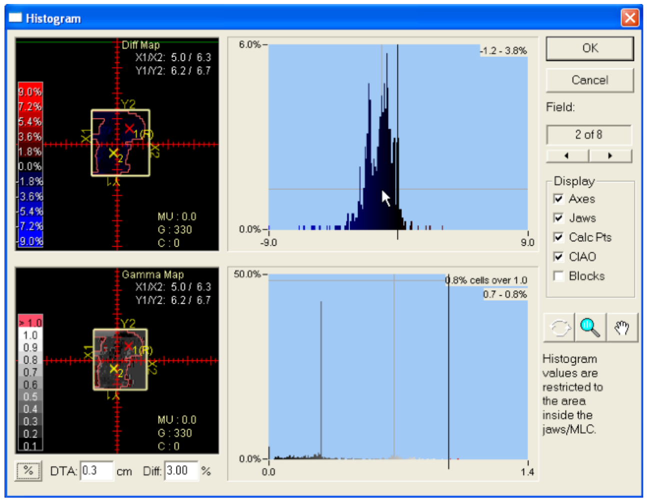
11.10 Beam View Window



The Beam View window enables visualization of the plan by showing the Jaws, MLCs, CIAO, Calculation Points, and fluence maps, if present. If the Structure Set (see “Using the Import Module” on page 22) was imported with the plan file then the structures (Contours checkbox) will also be shown.

There are several controls available in the Beam View Window:

1.  - Reset View – Click this icon to reset the image to the default view.
2.  - Zoom In/Out – Click this icon to turn the cursor into a magnifying glass. Left-clicking in the view will zoom in, right-clicking will zoom out. Also, with the cursor in the view, rotate the mouse wheel forward (away from user) to zoom in, or rotate the mouse wheel backwards (toward user) to zoom out.
3.  - Pan View – Click this icon will turn the cursor into a hand. Clicking in the view and dragging the cursor will allow you to pan the view.
4.  - Volume Display – For imported structure sets. Click this icon to open the Edit Volume window. In this window, the user can choose which structures to visualize, as well as which volumes the fluence map calculations are based on. For plans with associated CT images, this dialog will also allow density override on a structure-by-structure basis.
5.  - Multi-View – Click this icon to open a new window containing 6 different views: Leaf View, Imported Map, Difference Map, Gamma Map, IMSure Calculated Map and Transverse View.
6.  - Histogram – Click this icon to open a new window with the histogram view. The histogram view includes histograms for both the difference and gamma maps.



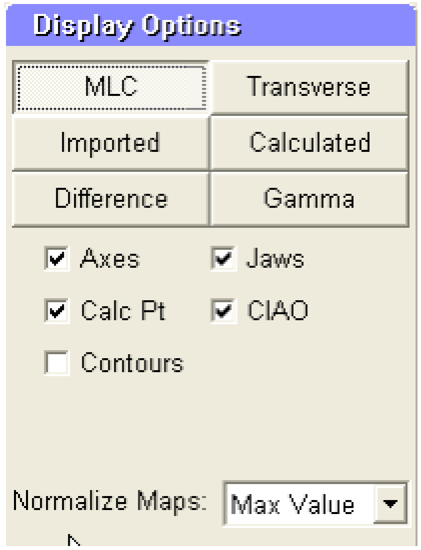
Placing the cursor over the histograms will reveal additional information. In the upper right-hand corner of the histogram view the bin the cursor is over is reported along with the percentage of pixels that fall in that bin. In the example above, the cursor is over the -1.2 percent difference bin, and 3.8% of the total pixels fall into that bin.

7. Jaw Information – X and Y jaw positions for the active beam are shown in the upper-right hand corner of the Beam View window.
8. Beam information – The Gantry angle, Collimator angle and the monitor units that will be delivered (per segment) are shown in the lower right-hand corner of the Beam View window. The currently selected calculation point name as well as the PSSD and Effective Depth for that calc point (per segment) are shown in the lower left hand corner of the Beam View window.

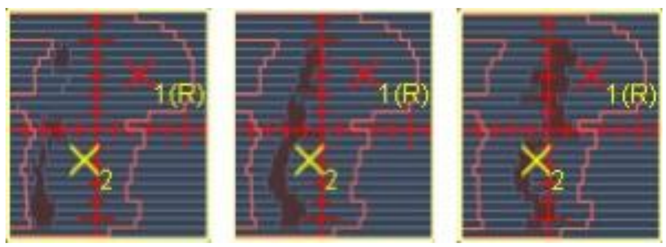
11.11 Field information

1. Field - Use the spinner buttons to step through the fields.
2. Seg – Use the spinner buttons with ‘MLC’ chosen in the Display Options to visualize the MLC motion for the chosen field.

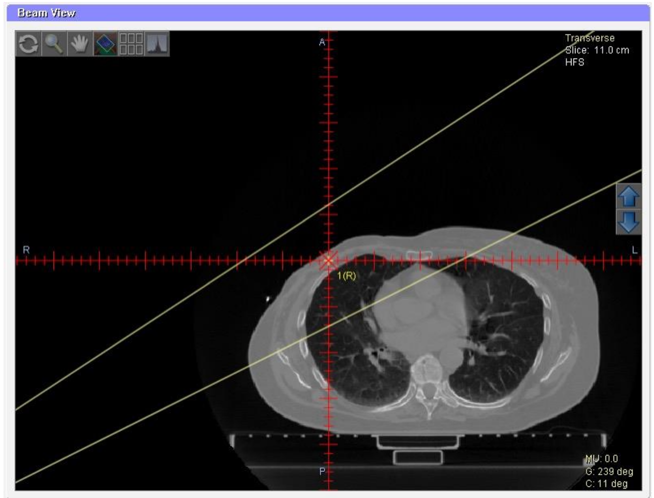
11.12 Display Options



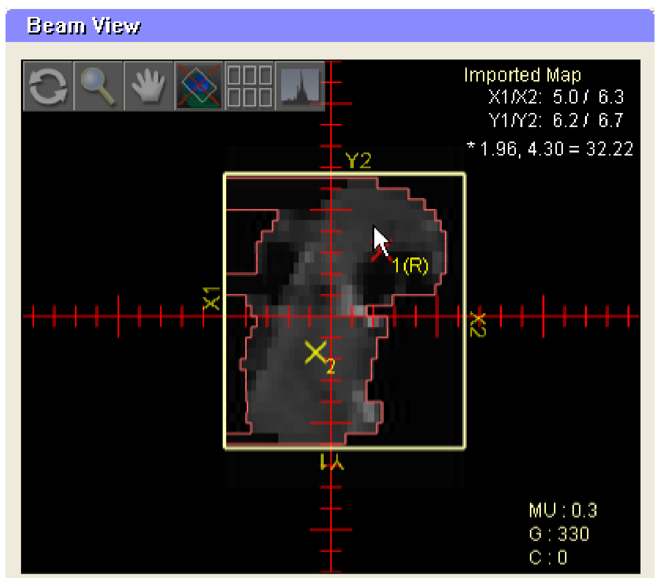
1. MLC – Shows the MLC leaves in the Beam View window. When used in conjuction with the 'Seg' spinner buttons in the Field Information group, this view allows visualization of the MLC motion for the field.



2. Transverse – Shows a transverse view of the beams from the 'foot' of the table, along with CT slices if available. Can be very useful for visualizing calculation point placement in the anterior/posterior direction. The active beam is shown in yellow while the other beams are shown in gray. Arrows at the right of the image allow the user to step through the CT slices.



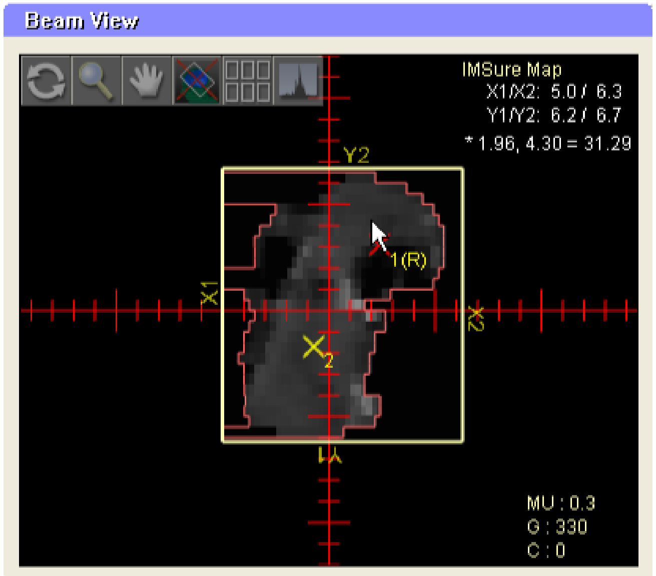
3. Imported – Shows the imported fluence map. Placing the cursor over the map will show the X,Y Beam's Eye View coordinates of the cursor and the grayscale value (0-100, normalized; 0 = Black, 100 = white) of the pixel under the cursor in the upper right-hand corner.



In this example, the cursor is placed at X=1.96 cm, Y= 4.30 cm and the fluence value of the pixel under the cursor is 32.22.

NOTE: This map will not be shown until maps have been calculated.

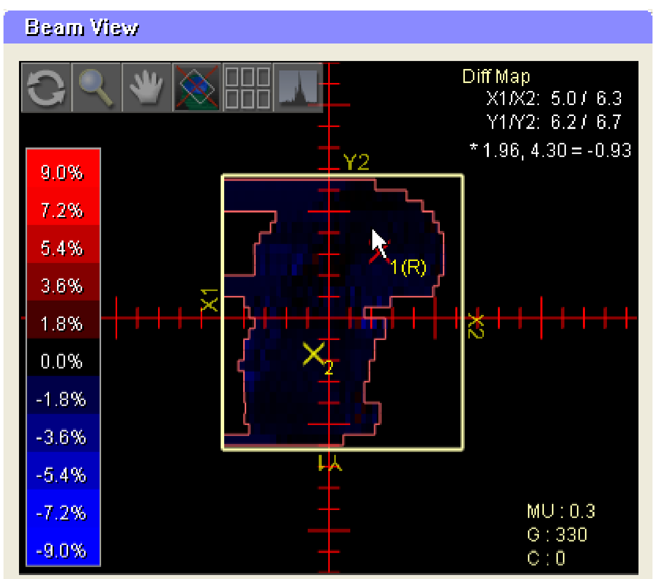
4. Calculated - Shows the calculated fluence map. Placing the cursor over the map will show the X,Y Beam's Eye View coordinates of the cursor and the grayscale value (0-100, normalized; 0 = Black, 100 = white) of the pixel under the cursor in the upper right-hand corner.



In this example, the cursor is placed at X=1.96 cm, Y= 4.30 cm and the fluence value of the pixel under the cursor is 31.29.

NOTE: This map will not be shown until maps have been calculated.

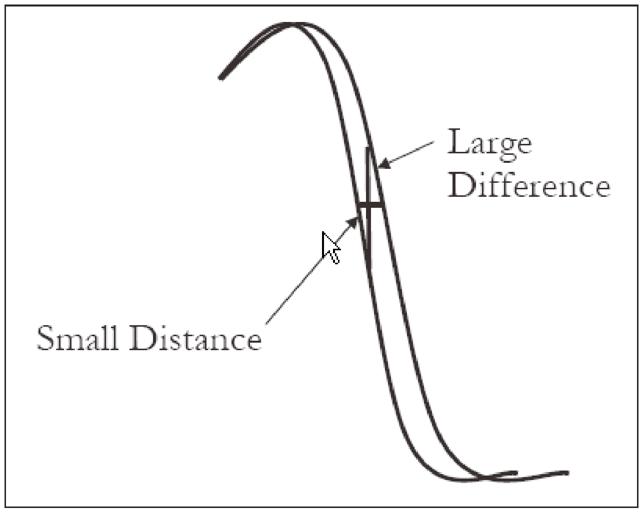
5. Difference – Shows the calculated difference map. The difference map is colored for easy determination of differences between the maps. Blue reflects pixels that are less than or 'colder' in the IMSure calculated map compared to the imported map and red reflects pixels that are higher or 'hotter' than those in the imported map. The scale on the side of the map will go from a minimum to a maximum equal to the absolute value of the maximum difference between the maps. Placing the cursor over the map will show the X,Y Beam's Eye View coordinates of the cursor and the difference value of the pixel under the cursor in the upper right-hand corner.



In this example the cursor is placed at X=1.96 cm, Y= 4.30 cm and the difference value of the pixel under the cursor is -0.93%.

NOTE: This map will not be shown until maps have been calculated.

6. Gamma – The Difference map does not always make the best comparison. When comparing two curves of high gradient, a very large difference may be noted, but may not be important if caused by a small linear shift.

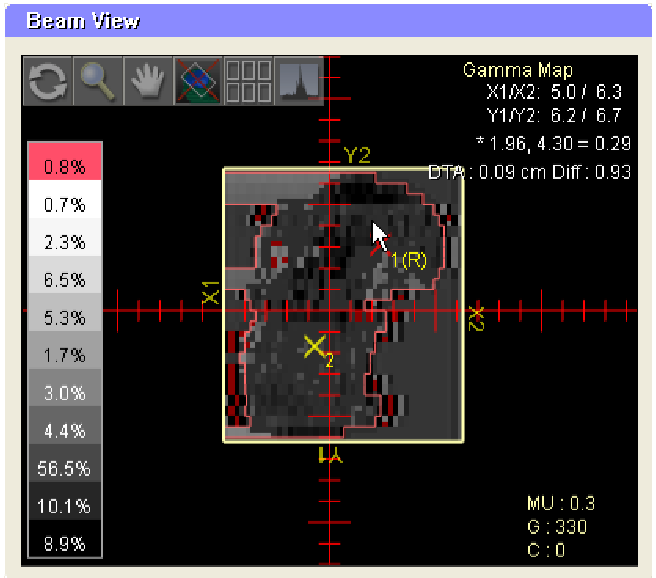


The gamma value is a scoring method for comparing such maps. The power of the gamma value is that it includes the effects of both the absolute difference of the two maps, and the distance-to-agreement (DTA). The gamma value is a weighted comparison of both DTA and diff, relative to pre-selected limits.

The gamma value depends on the choices of threshold. For any point, if the gamma value is below 1.0, the DTA or the Diff (or both) lie within the specified limits. If gamma > 1, then both the DTA and the Diff lie outside of the threshold limits, and the failed pixel will be shown in red on the gamma map.

Default thresholds are set in **"Preferences/IMRT"**, but can be changed at any time by typing new values into the appropriate input boxes shown when the gamma map is active. Clicking the percentage button will change the scale to show the percent of pixels that fall outside of the chosen thresholds.

Placing the cursor over the map will show the X,Y Beam's Eye View coordinates of the cursor and the gamma value of the pixel under the cursor in the upper right-hand corner. It will also report the actual DTA and Diff values for that pixel. This can be helpful if you have a number of failed pixels. If you place your cursor over those pixels and see that the reason they failed is because the difference is 3.16 (threshold set to 3.00) you can adjust your threshold up to accommodate those pixels that are just outside the limit.



In this example the cursor is placed at X=1.96 cm, Y= 4.30 cm and the gamma value of the pixel under the cursor is 0.29. The distance to agreement for that pixel is 0.09 cm and the difference is 0.93%. NOTE: This map will not be shown until maps have been calculated.

7. Axes – Toggles on/off the axes in the view.
8. Jaws – Toggles on/off the jaws in the view.
9. Calc Pt – Toggles on/off the calculation points in the view.
10. CIAO – Toggles on/off the CIAO (Complete Irradiated Area Outline) in the view.
11. Contours – Toggles on/off the contours in the view.
12. Normalize maps – In order to compare the imported fluence maps to the IMSure calculated fluence maps, it is necessary to normalize them to each other. By default, the average value in the two maps is used for this normalization point. If a large difference exists at this maximum point, the normalization can result in that difference being propagated throughout the map resulting in large differences and gamma map failures. To account for this, different normalization points can be chosen: Maximum value (default), Average value, Isocenter, or any valid calculation point. For VMAT plans, normalization to a calculation point is not allowed.

11.13 Using .decimal plans in the QA Module

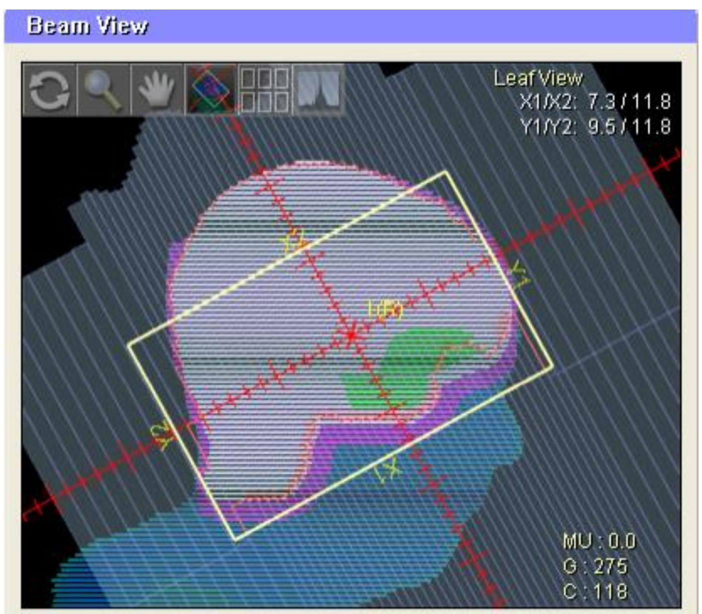
Calculating a plan that includes .decimal compensators in the QA module differs only in that there are several changes to the interface. Import a plan with .decimal compensators (see “.decimal Compensator Files” on page 24).

1. In the Display Options group, the ‘MLC’ button changes to say ‘Compensator’. Click on this button to obtain a thickness map of the .decimal compensator in the Beam View window.

2. After dose has been calculated place the cursor over the thickness map in the Beam View to obtain important information displayed in the upper right-hand corner of the view, underneath the jaw position data.
   a. The first line indicates the BEV X,Y coordinates of your cursor and the compensator thickness (in cm) at that point.
   b. The second line displays two values:
   i. RF – The Relative Fluence value under the compensator at that point. The relative fluence only takes into account the actual thickness of the compensator.
   ii. CF – The actual calculated Compensator Factor under the compensator at that point. The compensator factor takes into account the additional scatter, electron contamination and beam hardening effects of the compensator to more accurately describe how the compensator modulates the beam. The CF and RF can vary widely especially where modulation results in steep gradients.

NOTE: It is important that an appropriate calculation point is chosen for the calculation of monitor units (MU) when a .decimal compensator is present in the beam. The point should be placed in an area of the compensator that does not feature steep gradients. It might be necessary to choose a different reference point for each field to achieve accurate results.

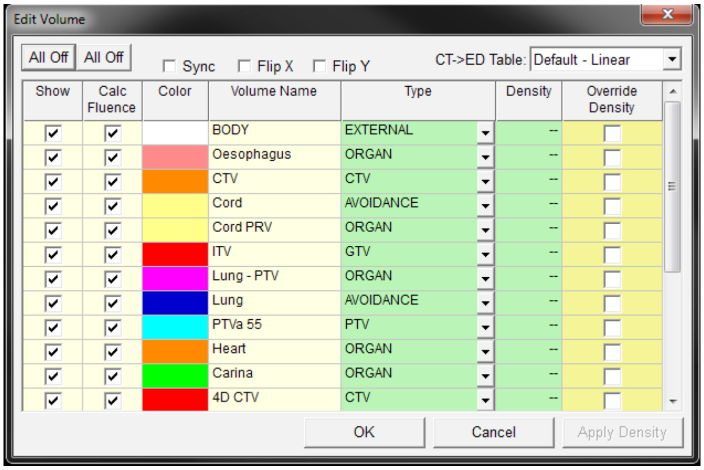
11.14 Using Structure Sets (Volumes) in the QA Module



Including the structure set file when importing a plan in the QA Module (see “Auxiliary Files for IMSure” on page 22) provides the user with better plan visualization. It also enhances functionality of the fluence map comparisons by adding structure specific analysis capabilities.

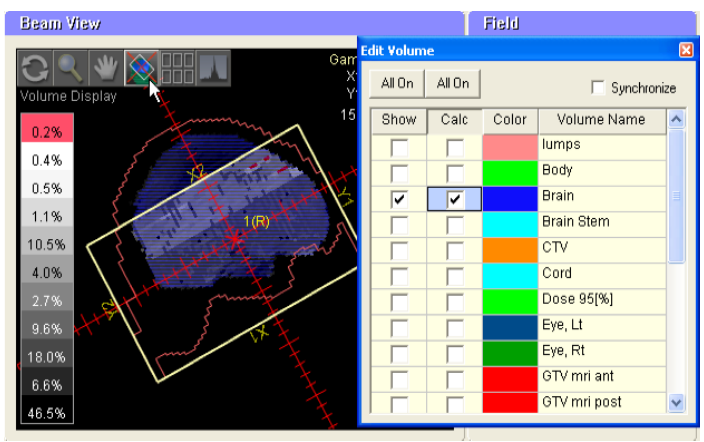
After importing a plan with structure sets and maps calculating, click on the ‘Contours’ checkbox in the Display Options group to enable viewing.

To use the structures-specific map analysis functions, click on the 'Volume Display' icon  in the Beam View to open the Edit Volume window:



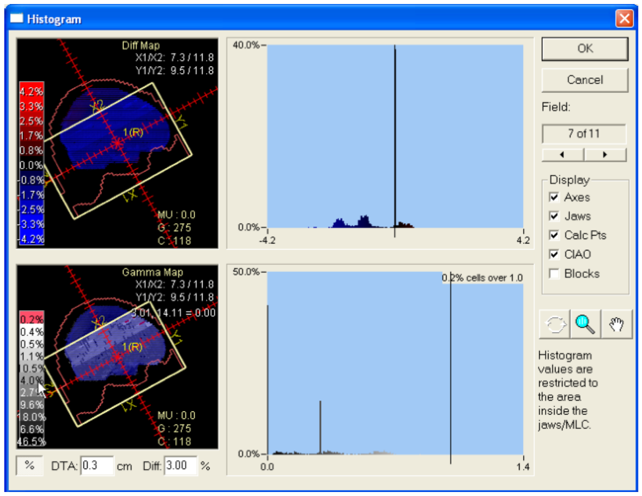
By default, all of the volumes listed in the imported structure set will be 'On' for both visualization (the 'Show' column), and calculation (the 'Calc' column). Clicking the 'All Off' button above either column will un-check all of the selections in that column and the button will change into an 'All On' button.

Choose the map display you are interested in (Gamma Map is chosen for this example). Click on a structure in the Edit Volume window to display the Gamma Map for that structure only:



Clicking on additional volumes in the 'Show' or 'Calc' columns will add or subtract them from the view.

Choosing the 'Display Histogram' (see "Beam View Window" on page 39) will show the histogram based only on the chosen volumes in the Edit Volume window:



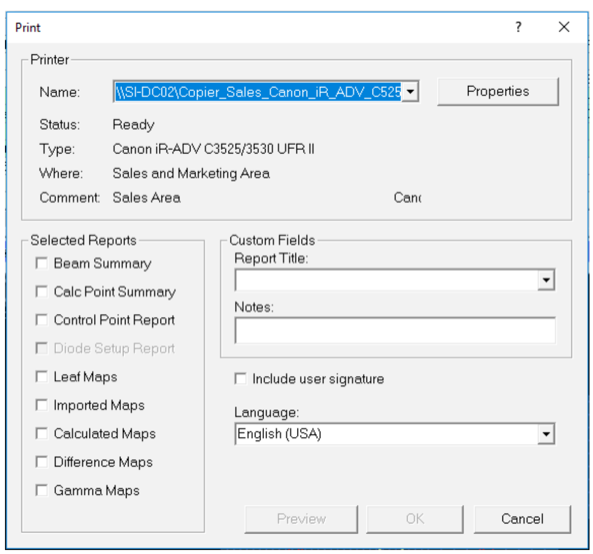
11.15 Printing Reports (QA Module)

Reports can be printed by clicking on the 'Print' icon found in the toolbar or by selecting the "Plan/Print" menu item (keyboard shortcut 'CONTROL KEY + P). All reports feature a sign-off area at the bottom for accurate record-keeping. NOTE: In demonstration mode, the sign-off area is replaced with a warning that the software is for demonstration use only and not meant for clinical use.

Reports can be automatically exported to a PDF file for electronic record keeping. Select the "Plan/Export to PDF..." menu item. NOTE: The doPDF utility found on the software disk must be installed for this option to perform correctly.

Select the "Plan/Print Preview" menu item to obtain an on-screen representation of the chosen reports.

After choosing to Print, the Print dialog box will open:



Choose the printer and Report Title if necessary. Click the ‘Preview’ button to obtain an on-screen representation of the chosen reports. Select the appropriate reports for printing. NOTE: Reports will automatically be selected based on options previously set in “Preferences/Hardcopy” (see “Hardcopy Preferences” on page 8) but can be changed here as necessary.

1. Beam Summary – A summary of the information found on the Beam and Maps Results tabs in the QA module.
2. Calc Point Summary – A summary of the information found on the Calc Pts tab in the QA module.
3. Control Point Report - Tabular display of the SSD and depth information for each calculation point at every control point in the VMAT fields.
4. Leaf Maps – A representation of what is shown in the Beam View window in the QA module when MLC is chosen in the Display Options.
5. Imported Maps – A representation of the what is shown in the Beam View in the QA module when Imported is chosen in the Display Options.
6. Calculated Maps – A representation of the what is shown in the Beam View in the QA module when Calculated is chosen in the Display Options.
7. Difference Maps – A representation of the what is shown in the Beam View in the QA module when Difference is chosen in the Display Options.
8. Gamma Maps – A representation of the what is shown in the Beam View in the QA module when Gamma is chosen in the Display Options.
9. Notes - A short note can be added to the report if desired.
10. Insert User Signature - If selected, this option will automatically enter the user’s user name and a time stamp in the “Calculated by” field of the report.
11. Language - This drop-down menu will show the languages for which a translated printout is available.

Plans can also be exported as .csv files for easy import into a spreadsheet program. This export method is recommended for plans with more than 30 calculation points.

12 IMSure BrachyQA Software

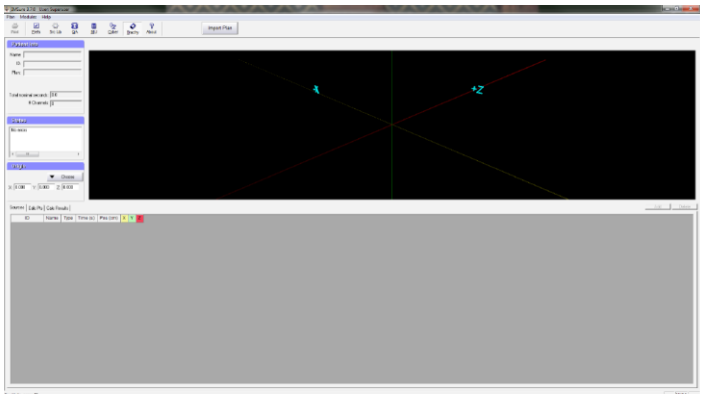
IMSure Brachy QA Software is a stand alone software application product intended for use as a quality assurance tool to verify brachytherapy treatment plans developed on a radiation therapy treatment planning system with the appropriate transfer format. It may also be used as a segregated standalone application in the IMSure QA Software suite of software products.

This product is intended for use by trained medical physicists, physicians, or dosimetrists. The calculation results must be evaluated by qualified personnel before a patient treatment. It is the responsibility of the medical physicist, physician or dosimetrist to determine whether the dosimetric accuracy is adequate for a particular patient.

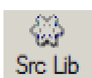
Dose modeling of a source is based on the AAPM TG-43 formalism, and may be adjusted by a qualified user to match measured or published results. IMSure Brachy QA Software does not control any radiation delivery devices and does not allow the export of calculated information.

12.1 Creating a plan in IMSure BrachyQA

Switch to the BrachyQA Software by clicking on the BrachyQA icon ('Brachy') or by selecting the **"Modules/Brachy View"** menu item. The program should now be open on your screen:



12.2 Source Library

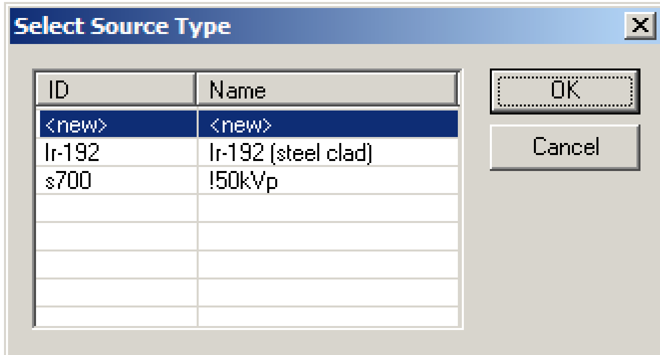


Click on the Source Library icon ('Src Lib') to open the Source Editor. The library is pre-loaded with an IR-192 source (3) and the Xoft Axxent source. Sources can easily be added by either copying an existing source or creating a new one.

To copy a source, click on the source you would like to make a copy of and then click the 'Copy' button. Rename the source and change any of the parameters as needed. After all of your changes have been made, click the 'Physics Approved' button. It should now say 'Yes' in the 'Valid' column for that source.

IMPORTANT
The name of the source must match the name used in your treatment planning system.

To create a source, click on the 'Add' button. IMSure Brachy QA follows the TG-43 formulism for calculating brachytherapy doses so all of the information that needs to be filled in can generally be found in the TG-43 document. You should now see the 'Select Source Type' window:



If the source you are creating is not shown in the list, choose the <new> option and click 'OK'. Otherwise, click on one of the pre-loaded source types and click 'OK'.

Give the source an ID and a name and then fill in the pertinent information in the first screen.

Click on the Anisotropy tab. You can choose between 3 different models. Pre-loaded sources already contain the 2D anisotropy information.

1. Scalar – Enter a scaling factor in the 'Average Anisotropy:' field.
2. 1D Table – To create the anisotropy table, create a table in Microsoft Excel that resembles the following:

	A	B
1	0.2	0.589
2	0.4	0.589
3	0.6	0.589
4	0.8	0.589
5	1	0.589
6	1.25	0.589
7	1.5	0.589
8	1.75	0.589
9	2	0.589
10	2.5	0.589
11	3	0.589
12	3.5	0.589
13	4	0.589
14	5	0.589
15	6	0.589
16	8	0.589
17	10	0.633

   Highlight the table and copy it, then in IMSure Brachytherapy QA Source Editor Anisotropy tab, click the 'Paste Table' twice (first creates the table, the second will actually paste the input data).
3. 2D Table – To create the anisotropy table, create a table in Microsoft Excel that resembles the following:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1		0	1	2	3	4	5	6	7	8	9	10	15	
2	0.2	0.589	0.501	0.518	0.536	0.602	0.615	0.618	0.642	0.699	0.715	0.756	0.814	0.9
3	0.4	0.589	0.501	0.518	0.536	0.602	0.615	0.618	0.642	0.699	0.715	0.756	0.814	0.8
4	0.6	0.589	0.501	0.518	0.536	0.602	0.615	0.618	0.642	0.676	0.7	0.723	0.801	0.8
5	0.8	0.589	0.501	0.518	0.536	0.602	0.615	0.64	0.649	0.679	0.699	0.72	0.798	0
6	1	0.589	0.501	0.518	0.536	0.566	0.611	0.643	0.664	0.686	0.706	0.725	0.796	0.8
7	1.25	0.589	0.501	0.518	0.536	0.568	0.615	0.641	0.663	0.686	0.706	0.725	0.798	0
8	1.5	0.589	0.501	0.518	0.5	0.585	0.616	0.643	0.666	0.689	0.71	0.729	0.801	0.8
9	1.75	0.589	0.501	0.518	0.565	0.597	0.625	0.65	0.671	0.692	0.712	0.73	0.802	0.8
10	2	0.589	0.501	0.529	0.564	0.598	0.627	0.653	0.675	0.696	0.716	0.734	0.806	0.8
11	2.5	0.589	0.501	0.521	0.575	0.608	0.636	0.662	0.684	0.705	0.725	0.743	0.809	0.8
12	3	0.589	0.501	0.533	0.584	0.618	0.646	0.672	0.695	0.716	0.735	0.754	0.818	0.8
13	3.5	0.589	0.501	0.553	0.6	0.632	0.659	0.684	0.705	0.725	0.744	0.761	0.822	0.8
14	4	0.589	0.527	0.56	0.61	0.645	0.674	0.698	0.719	0.738	0.755	0.771	0.829	0
15	5	0.589	0.548	0.591	0.634	0.666	0.692	0.715	0.735	0.752	0.768	0.784	0.838	0.8
16	6	0.589	0.572	0.62	0.659	0.688	0.713	0.733	0.752	0.768	0.782	0.795	0.843	0.8
17	8	0.589	0.621	0.672	0.706	0.731	0.752	0.769	0.785	0.798	0.809	0.819	0.86	0.8
18	10	0.633	0.659	0.702	0.729	0.75	0.769	0.784	0.799	0.811	0.822	0.831	0.87	0.8
19	12	0.675	0.696	0.732	0.755	0.773	0.789	0.802	0.814	0.825	0.834	0.843	0.879	0.9
20	15	0.741	0.755	0.78	0.796	0.809	0.82	0.829	0.838	0.845	0.852	0.859	0.889	0.9
21														

Highlight the table and copy it, then in IMSure Brachytherapy QA Source Editor Anisotropy tab, click the Paste Table button twice (first creates the table, the second will actually paste the input data).

Note: 2D anisotropy tables should span the range from zero to 180 degrees. LDR tables will need to be mirrored to create a full table.

Next, click on the Rad Dose g(r) tab. You can choose between a polynomial equation, or a point array that is created in Microsoft Excel, similar to how the anisotropy tables are created (see above). Pre-loaded sources already contain a polynomial equation for scatter.

Once all of the data has been entered, click on the General tab, and then click the 'Physics Approved' button to activate this source for use.

12.3 Import Plan

Clicking this button will open the Import Module.

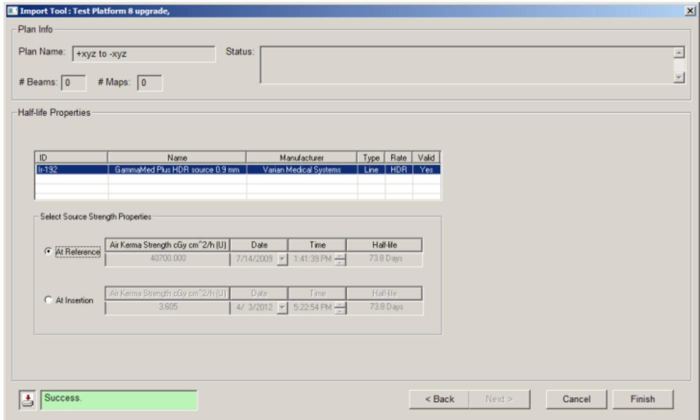
12.4 Using IMSure BrachyQA

After creating a plan using your Brachytherapy treatment planning system, export that plan in DICOM-RT format to a directory accessible to the IMSure Brachytherapy QA program.

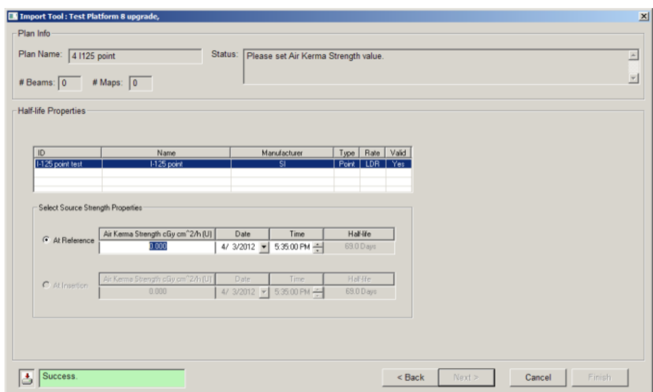
Click the 'Import Plan' button and a list of available plans in the designated folder will be shown.

Click on any valid plan to select it. Then click the 'Next' button.

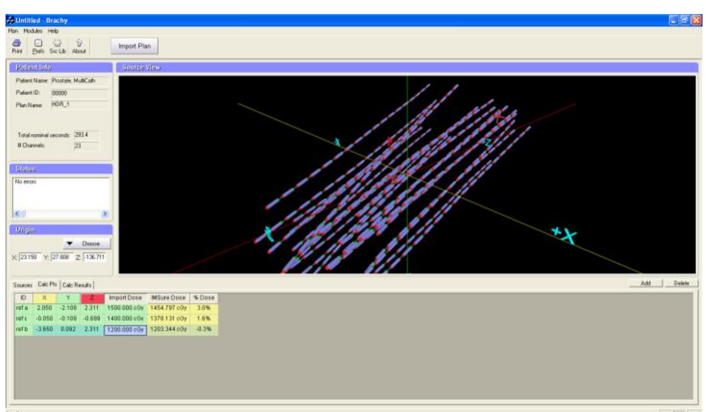
1. HDR plans – For HDR plans, choose the source strength that will be used in the calculation of dose. By default, the source strength that exists in the Source Library for the given source is chosen. IMSure Brachy QA can also calculate source strength based on a date and time of your choosing, e.g. the date and time of insertion, by selecting the 'At Insertion' radio button.



2. LDR plans – For LDR plans, enter the source Air Kerma Strength in cGy cm^2/h (U), and the date and time this source strength was determined. Once this reference source strength has been entered, IMSure Brachy QA can calculate the dose based on the inputted reference source strength, or based on a date and time of your choosing, e.g. the date and time of insertion, by selecting the 'At Insertion' radio button.



In the Source View window, you will see a representation of your sources in three dimensional (3D) space:



Click in the view, and move the mouse to rotate the view in three dimensional (3D) space. Use the scroll wheel to zoom the image; also there are several keyboard shortcuts for changing the view quickly.

P – changes from a perspective view to normal view
A – toggles the axes on and off
S – snaps to a Sagittal view
T – snaps to a Transverse view
C – snaps to a Coronal view
R – snaps to an orthogonal view
E – toggles on and off the display of the ends of the sources

IMSure Brachytherapy QA automatically sets a point of origin that creates a 0,0,0 point at the center of all of the source trains. All calculation points are referenced from that that point.

12.5 Sources Tab

Displays each source train by name and each dwell position, X,Y,Z coordinates, and dwell time.

12.6 Calc Pts Tab

Displays the ID and X, Y, Z coordinates of each calculation point included in the DICOM-RT file exported from the TPS. Dose is automatically calculated for any valid calculation point.

1. Add button – If no calculation points are found in the plan, click the Add button in the Calc Pts Tab to add one or more calculation points. Click on the 'ID' field to enter an ID and click on the X, Y, Z fields respectviely to enter the X, Y, Z coordinates of the point and the calculated dose is automatically updated.
2. Delete button – With a calculation point highlighted, click this button to delete the calculation point.

NOTE: IMSure Brachy QA will not calculate a dose if the point is too close or too far away from the sources. A warning will be displayed in the Status window in either of these cases.

12.7 Calc Results Tab

Clicking on a calculation point in the left hand column of this tab will show the contribution to dose from each dwell point of each source train along with the coefficients used for each calculation. This tab can be very useful for determining where an error might have occurred when calculated results differ from those expected.

13 Tables

13.1 User Preferences Module

The field parameters, ranges and defaults are:

Name	Description	Range	Default
Dose cGy/Gy	Specifies whether the program will display dose in cGy or Gy	cGy or Gy	cGy
SRS Threshold	Specifies the minimum dose rate in MU/min that the system will consider a beam as stereotactic	500.00 – 3000.00	MU/min
Imported Map Resolution	Specifies the resolution of the map the user will import, in square cm/ pixel	0.000 – 1.000	0.500
Calculated Map Resolution	Specifies the resolution the user desires to compute all fluence maps, in square cm per pixel	1/8, 1/4, 1/2	1/4
Flip Leaves Horizontally on Import	Automatically flips the leaf positions horizontally when imported.	On, Off	Off
Flip Leaves Vertically on Import	Automatically flips the leaf positions vertically when imported.	On, Off	Off
Flip Map Horiz. on Import	Automatically flips the maps horizontally when imported.	On, Off	Off
Flip Map Vert. on Import	Automatically flips the maps vertically when imported.	On, Off	Off
Preferred Map Type	Select either Optimal or Total Actual Maps when importing fluence maps.	Optimal, Total Actual	Total Actual
% Difference (value +/-)	Specifies the user notification threshold. If the Dose: Percentage Difference (absolute maximum difference of the TPS Calc Pt Dose compared to the Calculated Calc Pt Dose) is more than this threshold, the user is notified.	0.0 – 10.0	3.0
Correlation Coefficient Deviation	Specifies the user notification threshold. If the correlation coefficient between the imported fluence map and the calculated fluence map falls below this threshold, the user is notified.	0.900 – 1.000	0.990
Difference Map Level (units in %)	Specifies the user notification threshold. If the absolute maximum difference of the imported fluence map compared to the calculated fluence map differs by more than this threshold, the user is notified.	0.00 - 9.99	1.00
Gamma Map	Helps the user analyze and compare the imported and calculated maps by combining the effects of both	DTA: 0.0 - 3.0	0.3

	difference and distance. Values are DTA (Distance to Agreement) and % Diff (Percent Difference between imported and calculated maps).	% Diff: 0.01 - 99.99	1.00
Max Calc MU	Specifies the user notification threshold. If the Maximum MU for any field computed in the MU module exceeds this threshold, the user is notified.	0 – 9999	300
Diode Reading Range	Specifies the acceptable range that diode results should fall within	0 – 10.0	5.0

13.2 Edit IMRT Plan Values

Once a valid IMRT Plan has been imported, several fields in the IMRT Plan may be edited. To edit these fields, select the editable box with the mouse and type in the desired value with the keyboard. The values must fall within the correct ranges as defined below.

Name	Description	Range	Default
	Field Information Pane		
CAX SSD (cm)	Editable field for the beam SSD along the central axis, only editable if the field is a primary field of a split-field series	50.0 – 200.0 cm	Blank
PSSD (cm)	Editable field for the projected source to surface distance	0.0 – 100.0 cm	Blank
PDepth (cm)	Editable field for projected depth to a calculation point. For an explanation of projected depth see Appendix A, figure B.1.	-99.9 – 99.9 cm	0.0
Eff Depth (cm)	Editable field for radiological depth of calculation point for beam	-99.9 – 99.9 cm	Blank
TPS Dose	Editable field for dose predicted by the TPS for the calculation point for beam	0.0 – 999.9 cGy	0.0
Calculation point information pane			
X (cm)	Editable X position of calc point in IEC coordinates	-99.9 – 99.9	0.0
Y (cm)	Editable Y position of calc point in IEC coordinates	-99.9 – 99.9	0.0
Z (cm)	Editable Z position of calc point in IEC coordinates	-99.9 – 99.9	0.0
TPS Dose	Editable field for total dose predicted by the TPS for beam	0.0 – 999.9	0.0

13.3 Photon Tab

Name	Description	Range	Default
Field #	System Assigned, in sequential order	1-Number of photon MU fields (integer)	---
Field ID	Field Identifier	1-16 char	Blank
Energy	Selected from a list of valid energies for current machine	Any valid energy	Blank
Block Tray	Custom block holder	[True, False]	False
Wedge	Selected from a list of valid wedges or dynamic wedge	Any valid wedge	Open
Wedge Dir	Direction of the wedge or dynamic wedge	Any valid direction	First available
Cone (SRS only)	Selected from a list of valid cones	Any valid cone	First available
Cone Size (SRS only)	The chosen cone size in cm	0.1 – 10.0	cm
Gantry (not shown in 2D mode)	Displays the gantry angle of field defined by the TPS file	0-359	0
Collimator (not shown in 2D mode)	Displays the collimator angle of the field defined by the TPS file	0-359	0
Table (not shown in 2D mode)	Displays the table angle of the field defined by the TPS file	0-359	0
Isocenter (not shown in 2D mode)	Displays the isocenter coordinates of the field in relation to the patient origin as described above	0-99.99, 0-99.99, 0-99.99	0,0,0
X1/X2 Jaw (cm)	Editable fields to enter X1 and X2 jaw settings	Machine Range	0.0
Y1/Y2 Jaw (cm)	Editable fields to enter Y1 and Y2 jaw settings	Machine Range	0.0
Eff FS (cm)	Editable field to enter effective fields size. Automatically calculated on import of plan from TPS.	0.0 to (X1 + X2) or Blank	Blank
Ref Pt	Reference point from Calculation point tab that MU values are calculated from	Any valid calculation point	Ref point as described in the plan file or first calc point
Dose per field (cGy)	Centigray units per field	0.0-999.9	0.0

Ref Pt BEV X/Y (cm) (not shown in 3D mode)	Beams eye view X, Y coordinates of reference point that MU values are calculated from	0-99.99, 0-99.99	0,0
CAX SSD (cm)	Editable field for the beam SSD along the central axis	50.0 – 200.0 cm	Blank
PSSD (cm) (not shown in 3D view)	Editable field for the projected source to surface distance	0.0 – 100.0 cm	Blank
Proj. Depth (not shown in 3D view)	Editable field for the depth to the reference point	Same as depth range of TMR table for selected energy	0.0
Eff Depth (cm) (not shown in 3D view)	Editable field for radiological depth of reference point for beam	-99.9 – 99.9 cm	Blank
User Factor	An optional user entered modifier value	0.001-1.999	1.000
TPS MU	Editable field for predicted MU from treatment planning system	0.0-999.9	0.0

*Note for Siemens machines only: Due to the unique configuration of the X jaws with this machine, if the X jaw is set to blank, the jaw is not shown and the MLC leaves are displayed as imported. If the user edits the X jaw to a non-blank value, the MLC leaves for that jaw are set to the X jaw value.

13.4 Computed MU Field Items - Photon Tab

The items computed by the MU Calc Module and their origins are shown below:

Name	Description	Range	Default
Equivalent Square Field Size (open)	Computed by system only if required Field items are non-default and valid	Machine range	0.0
Collimator Scatter, Sc	Computed by system only if required Field items are non-default and valid	0.001 – 1.999	0.000
Phantom Scatter, Sp	Computed by system only if required Field items are non-default and valid	0.001 – 1.999	0.000
Inverse Squares Correction:	Computed by system only if required Field items are non-default and valid	0.250 – 4.000	0.000
OAR X/Y (Off Axis Ratios)	Computed by system only if required Field items are non-default and valid	0.001 – 1.999	0.000
TMR (Tissue Maximum Ratio)	Computed by system only if required Field items are non-default and valid	0.001 – 1.999	0.000

Tray Factor	Inserted by System, from Tray Factor of Current Energy, if Tray Factor option is Enabled on current field, default otherwise	Machine range	1.000
Wedge Factor	Inserted by System, from Wedge Factor of Current Wedge of Current Energy	Machine range	0.000
Cone Factor (SRS Only)	Inserted by System, from Cone Factor of current Cone and current Energy	Machine range	1.000
Calculated MU	Computed by system, if all required fields are valid	0.0 – 999.9	0.0
Difference MU (%)	Computed by system, if both Calculated MU and Planned MU are valid. Defined as (Planned MU - Calculated MU) / Planned MU * 100	-999.9 – 999.9	0.0

13.5 Electron Tab

Rx Target – Gives the user the choice of how to define the point on the PDD table the calculation should be based on.

Name	Description	Range	Default
Field #	System Assigned, in sequential order	1-Number of electron MU fields (integer)	---
Field ID	Field Identifier	1-16 char	Blank
Energy	Selected from a list of valid energies for current machine	Any valid energy	Blank
Gantry (not shown in 2D mode)	Displays the gantry angle of field defined by the TPS file	0-359	0
Collimator (not shown in 2D mode)	Displays the collimator angle of the field defined by the TPS file	0-359	0
Table (not shown in 2D mode)	Displays the table angle of the field defined by the TPS file	0-359	0
Cone Size (cm)	Selected from a list of valid cones for the selected energy	Any valid cone	First Cone
Cutout FS (cm)	Editable field to enter cutout field size. Automatically calculated on import of plan from TPS.	0.0 to (X1 + X2) or Blank	Blank
Ref Pt	Reference point from Calculation point tab that MU values are calculated from	Any valid calculation point	Ref point as described in the plan file or first calc point
Dose per field (cGy)	Centigray units per field	0.0-999.9	0.0

Ref Pt BEV X/Y (cm) (not shown in 3D mode)	Beams eye view X, Y coordinates of reference point that MU values are calculated from	0-99.99, 0-99.99	0,0
CAX SSD (cm) (not shown in 2D mode)	Editable field for the beam SSD along the central axis	50.0 – 150.0 cm	Blank
Depth (cm) / PDD (%)	Editable field for the depth/PDD percentage line to the reference point	Same as values available in PDD table for selected energy	0.0
User Factor	An optional user entered modifier value	0.001-9.999	1.000
TPS MU	Editable field for predicted MU from treatment planning system	0.0-999.9	0.0

13.6 Computed MU Field Items – Electron Tab

The items computed by the MU Calc Module and their origins are shown below:

Name	Description	Range	Default
Cone Factor	Computed by system only if required Field items are non-default and valid	0.001-1.999	0.0
Cutout Factor	Computed by system only if required Field items are non-default and valid	0.001-1.999	0.0
InvSq Corr	Computed by system only if required Field items are non-default and valid	0.250-4.00	0.0
OAR	Computed by system only if required Field items are non-default and valid	0.000-199.99	0.0
PDD/Depth	Computed by system only if required Field items are non-default and valid	0.1-199.99%/0.0 to machine range	0.0
VSSD (cm)	Inserted by system based on energy and cone chosen	50.00-150.00	0.0
Gap (cm)			

13.7 Calc Pts Tab

Name	Description	Range	Default
Field #	System Assigned, in sequential order	1-Number of photon MU fields (integer)	---
Field ID	Field Identifier	1-16 char	Blank

Eff Wedge Angle (Elekta motorized wedge only)	Displays the effective wedge angle either found in the DICOM file or computed by the System for Elekta motorized wedge plans	0.0 – 60.0	60.0
Isocenter (not shown in 2D mode)	Displays the isocenter coordinates of the field in relation to the patient origin as described above	0-99.99, 0-99.99, 0-99.99	0,0,0
CAX SSD (cm)	Editable field for the beam SSD along the central axis-synchronized with field of same name in either the Photon or Electron tab	50.0 – 200.0 cm	Blank
Ref Pt	Reference point from Calculation point tab that MU values are calculated from. Synchronized with field of same name in either the Photon or Electron tab	Any valid calculation point	Ref point as described in the plan file or first calc point
Calc Pt #(x)	Calc Point identifier	TPS dose vs IMSure QA calculated dose	
BEV X/Y (cm)	Beams eye view X, Y coordinates of calculation point	0-99.99, 0-99.99	0,0
X/Y/Z (cm) (not shown in 2D mode)	3D coordinates of calculation point in relation to isocenter	0-99.99, 0-99.99, 0-99.99	0,0,0
PSSD (cm)	Editable field for the projected source to surface distance	0.0 – 100.0 cm	Blank
Proj. Depth	Editable field for the depth to the calculation point	Same as depth range of TMR table for selected energy	0.0
Eff Depth (cm)	Editable field for radiological depth of calculation point for beam	-99.9 – 99.9 cm	Blank
DMax Dose (cGy)	Displays the d_{MAX} dose calculated for the beam and calculation point	0.0 – 1000.00	0.0
TPS Dose (cGy)	Editable field for predicted dose from treatment planning system	0.0-999.9	0.0
Calc Dose (cGy)	IMSure QA calculated dose	0.0-999.9	0.0
% Diff	Percentage difference between IMSure QA calculated dose and predicted dose from treatment planning system	0-999%	0.0

13.8 Diodes Tab

Name	Description	Range	Default
Field #	System Assigned, in sequential order	1-Number of photon MU fields (integer)	---
Field ID	Field Identifier	1-16 char	Blank
Isocenter (not shown in 2D mode)	Displays the isocenter coordinates of the field in relation to the patient origin as described above	0-99.99, 0-99.99, 0-99.99	0,0,0
CAX SSD (cm)	Editable field for the beam SSD along the central axis-synchronized with field of same name in either the Photon or Electron tab	50.0 – 200.0 cm	Blank
Diode Set #(x)	Diode relationship identifier	Isocenter or any valid calculation point	Isocenter
Surface X/Y (cm)	X,Y coordinates for placement of diode on surface of patient	0-99.99, 0-99.99	0,0
X/Y/Z (cm) (not shown in 2D mode)	3D coordinates for placement of diode on surface of patient	0-99.99, 0-99.99, 0-99.99	0,0,0
PSSD (cm)	Editable field for the projected source to surface distance	0.0 – 100.0 cm	Blank
Eff Depth (cm)	Editable field for radiological depth of diode with any applicable bolus	-99.9 – 99.9 cm	d_{MAX} of energy for beam
Cal. Factor	Calibration factor for diode	0.0 – 5.000	Imported from physics data
Actual Reading (cGy)	Editable field for inputting actual reading from diode during treatment	0.0-999.99	0.0
Exp. Reading (cGy)	Calculated expected value for diode reading	0.0-999.99	0.0

13.9 Display and Edit Machine Parameter Values

Selecting a Machine from the tree structure will display and allow the user to edit an existing Machine Parameter value of the currently selected machine. Machine parameters are defined below:

Name	Description	Range	Default

Name	Machine name	--	Blank
Abbreviated Name	Editable field for Machine name	1-8 chars, unique	Blank
Manufacturer	Combo box listing available manufacturers	[Varian, Elekta, Siemens]	Select
Model	Optional user information	0 - 32 chars	Blank
Serial Number	Optional user information	0 - 32 chars	Blank
Location	Optional user information	0 – 32 chars	Blank
Nominal SAD	The machine defined distance from the isocenter to the source.	50.0 - 200.0 cm	100.0
Base Gantry Rotation	IEC 1217 Convention describes 0 degrees as the Gantry pointing down. If your system describes 0 degrees as the Gantry pointing up you would insert 180 to let IMSure QA know that your coordinate system is set 180 degrees from the IEC standard.		
Gantry Rotation Direction	IEC 1217 Convention describes Gantry rotation increasing clockwise (CW) if facing the Gantry from the foot of the couch. 90 degrees will be with the head of the accelerator to the right if facing the gantry from the foot of the couch.		
Base Collimator Rotation	IEC 1217 Convention describes 0 degrees as pointing towards the foot of the couch. If your system describes 0 degrees as pointing towards the Gantry you would insert 180 to let IMSure QA know that your coordinate system is set 180 degrees from the IEC standard.		

13.10 Display and Edit Energy Parameter Values

The energy item displayed on the tree structure takes its name from the Name value of each Energy, with an "MV" or "MeV" field appended to it (e.g. 6 MV). Selecting an Energy item on the tree structure will display and allow the user to edit an existing Energy Parameter value of the currently selected machine. Energy parameters are defined below:

Name	Description	Range	Default
Beam Energy	Must be unique	0-99 integer	0
Nominal d_{MAX}	Depth of maximum dose under calibration conditions	0.00 – 99.99	Blank

Calibration Reference Depth	Automatically set to d_{MAX} value. If your calibration is done at a value other than d_{MAX}, refer to the instructions on adjusting your output factors.	0.00 – 99.99	Blank
Calibration Field Size (photons)	Defined Square Field Size for calibration	0.0 – 40.0	10.0
Calibration Cone Size (electrons)	Defined Cone Size for calibration	Drop down list of available cones	10x10
Calibration Dose Rate	Defined dose per monitor unit under calibration conditions.	0.001 – 9.999	1.000
Source to Phantom Distance (photons)	Distance to phantom surface for calibration.	50.0-200.0	100.0
Source to Phatom Distance (electrons)	Distance to phantom surface for calibration. For electron energies this value is locked to the SAD distance.	50.0 – 200.0 cm	100.0
Tray Factor	Attenuation by tray factor, user measured.	0.001 – 1.999	1.000
Dosimetric MLC Leaf Offset (photons only)	Distance from true physical leaf edge to dosimetric leaf edge (i.e. 50% transmission point).	-2.000 – 2.000	0.000
Beam Type	Radio button to select beam energy type	Photon, Electron	Photon
Dynamic Wedges (photons only)	Enable/disable dynamic wedges	None, EDW, Virtual Wedge (Virtual Wedge is disabled for this release)	None
Commissioned Status	Machine set.	True False	False
Commissioned (Date)	Not editable, always use current date, units are date and time	1/1/2000:0000:00 to12/31/2029:2359:59	current
Mean Dose Leaf Leakage (photons only)	Mean leaf leakage through MLCs used by 3-source model.	0.000 – 99.999%	1.750
Mean Fluence Map Leaf Leakage (photons only)	Mean leaf leakage through MLCs used by Fluence map model	0.000 – 99.999%	1.750
Diode Calibration Factor	Calibration factor to be applied to diodes	0.000 – 5.000	1.0

After any change to the scatter coefficient values, the scatter factors are recomputed for display in the scatter factor table display for that Energy.

13.11 Display and Edit MLC Information Parameter Values

Selecting the MLC Information item on the tree structure will display and allow the user to edit an existing MLC Information Parameter value of the currently selected machine. MLC Parameters are defined below:

Name	Description	Range	Default
Type	May be selected from list, Varian 52, Varian 80, Varian 120, Siemens Primus, Siemens Primus 82, Other	[Varian 52, Varian 80, Varian 120, Siemens Primus, Siemens Primus 82, Other]	Other
Source To MLC	Distance from Source to Bottom of Leaf Bank		0.0
Zsp	Distance to primary collimator scatter source		---
Zsf	Distance to extra-focal scatter source		---
R01	Geometrical descriptor of primary collimator scatter source		---
R02	Geometrical descriptor of primary collimator scatter source		---

13.12 Display and Edit Collimator Information Parameter Values

Selecting the Collimator Information item on the tree structure will display and allow the user to edit an existing MLC Information Parameter value of the currently selected machine. Collimator Parameters are defined below:

Name	Description	Range	Default
Lower Jaw (X)			
Left Jaw Name	When Collimator is at Base Collimator angle, and point-of-view is looking towards isocenter. Used in screen displays and reports.	1-2 char	X1
Right Jaw Name	When Collimator is at Base Collimator angle, and point-of-view is looking towards isocenter. Used in screen displays and reports.	1-2 char	X2
Average Jaw Transmission	For future use.	0.00 – 99.99	BLANK
Min Collimator Jaw Position	In centimeters, and denotes distance. Distance is from central axis line to jaw position. Minimum position indicates the distance the jaw can cross over the Central axis, effectively closing the field.	-20.0 – 20.0	-20.0

Max Collimator Jaw Position	In centimeters, and denotes distance. Distance is from central axis line to jaw position. Maximum position indicates the distance the jaw can move back away from the Central axis, effectively opening the field.	-20.0 – 20.0	20.0
Source to Jaw Distance	Distance from source to bottom of Jaw		36.7
Upper Jaw (Y)			
Bottom Jaw Name	When Collimator is at Base Collimator angle, and point-of-view is looking towards isocenter. Used in screen displays and reports.	1-2 char	Y1
Top Jaw Name	When Collimator is at Base Collimator angle, and point-of-view is looking towards isocenter. Used in screen displays and reports.	1-2 char	Y2
Average Jaw Transmission	For future use.	0.00 – 99.99	BLANK
Min Jaw Position	In centimeters, and denotes distance. Distance is from central axis line to jaw position. Minimum position indicates the distance the jaw can cross over the Central axis, effectively closing the field.	-20.0 – 20.0	-20.0
Max Jaw Position	In centimeters, and denotes distance. Distance is from central axis line to jaw position. Maximum position indicates the distance the jaw can move back away from the Central axis, effectively opening the field.	-20.0 – 20.0	20.0
Source to Jaw Distance	Distance from source to bottom of Jaw		27.9

13.13 Display and Edit Wedge or Open Field Parameter Values

Open fields are a special case of the wedge type. Each Energy must have one and only one open field type wedge, which is always called “Open Field”. In addition, an Energy may have many additional optional wedges, each with its own data, separate and distinct from that of the open field.

For optional wedges, the wedge item displayed on the tree structure takes its name from the Name value of the Wedge with a “degree” field appended to it (e.g. 15 degree). Selecting the Open Field or optional Wedge item on the tree structure will display and allow the user to edit any existing Wedge or Open Field Parameters value of the currently selected Energy. Wedge and Open Field Parameters are defined below:

Name	Description	Range	Default
Wedge Name	User must uniquely identify each beam-modifying device, or wedge. A special case where no device is used, "Open Field" is the default, and must exist.	[Any text]	"Open Field"
Wedge Angle	The beam modification angle.	[0 - 60]	0
Min Wedge Field Size	The allowed square field size minimal range for this wedge.	0.0 – 40.0	Blank
Max Wedge Field Size	The allowed square field size maximal range for this wedge.	0.0 – 40.0	Blank

For optional cones (SRS photons only), the cone item displayed in the tree structure takes its name from the Name Value of the Cone. Selecting the Cone item on the tree structure will display and allow the user to edit any existing Cone Parameters of the currently selected Energy. Cone Field parameters are defined below.

Name	Description	Range	Default
Cone Name	User must uniquely identify each cone. The name entered should match the name of the cone as described in the TPS	[Any text]	<SRS Cone>
Output Factor	A single factor to account for the output of the cone in reference to the reference open beam	0.500 – 2.00	1.00
Cone Size (cm)	The diameter of the SRS cone in cm	0.0 – 10.0	0.0

13.14 Use Dynamic Wedges

If 'Dynamic Wedges' are enabled under the Energy page, the Dynamic Wedges will appear under the energy in the tree control to the left. Selecting the Dynamic Wedge page will bring up the following fields for editing. The associated STT energy table must also be imported.

Name	Description	Range	Default
Angle	Displays angle of dynamic wedge	0, 10, 15, 20, 25, 30, 45, 60	--
Enabled	Check box to enable/disable specific wedge angle	On, Off	On
Wedge Factor	Displays wedge factor for given angle	#.####	--
Enable Y1 In	Check box to enable/disable Y1 In for specific angle	On, Off	On

Y1 In Name	Editable field for Y1 In name for specific angle	1 - 12 chars	<Angle> - In
Enable Y2 Out	Check box to enable/disable Y2 Out for specific angle	On, Off	On
Y2 Out Name	Editable field for y2 Out name for specific angle	1 - 12 chars	<Angle> - Out
Max Starting Jaw Pos (cm)	Displays max starting jaw position.	##.#	-20.0
Max Final Jaw Pos (nominal) (cm)	Displays max final jaw position.	##.#	10.0
Jaw Gap (cm)	Displays jaw gap	#.##	0.50

14 Appendix A: IMSure QA Algorithm

A. Machine Data

Numerous methods for measurement of the physical data exist. However, IMSure QA uses a single approach for formatting these data, and some previously measured data may require additional calculations or normalization prior to import into IMSure QA. The data must be self-consistent in order to provide accurate values when using IMSure QA. For instance, when TMR values are generated from PDD measurements, the phantom scatter factors used in the conversion must be the same as those used by IMSure. Some programs will perform this conversion using published rather than measured scatter data, and using TMR values generated by these programs will introduce errors into IMSure's calculations.

Some common terms and symbols regarding machine data for IMSure (see also Appendix F):

d – depth of the measurement point

d_{ref} – Reference (calibration) depth, normally d_{MAX}

SSD – Source to surface distance

SSD_{ref} – Reference (calibration) source to surface distance

Calibration Factor – User adjusted dose rate in cGy/MU under calibration conditions (FS, d_{ref}, SSD_{ref}).

Calibration Field Size – The reference square field size used to calibrate the machine, e.g. 10x10 cm^2.

PDD – Percent Depth Dose

TMR – Tissue Maximum Ratio. The TMR can be calculated by measuring the PDD for the smallest field size and converting to TMR with the following equation:

(A.1) $$TMR(FS',d) = \frac{PDD(d,FS,SSD)}{100} \times \left(\frac{SSD+d}{SSD+d_{ref}}\right)^2 \times \frac{S_p(FS')}{S_p(FS)}$$

Where

FS is the nominal field size (i.e. width)

FS' is the actual field size (width) at the depth of interest:

(A.2) $$FS' = FS \times \frac{SSD+d}{SAD}$$

PDD is the percent depth dose for each field size (FS) and depth (d) at a fixed SSD. All TMR tables should be normalized to d_{ref} for the calibration field size. Because of beam hardening effects, IMSure QA will be most accurate for wedges if separate PDD and TMR data are respectively measured and computed for each wedge.

The Output Factor (OF) or Total Scatter Factor (S_{cp}) should be measured in water at SAD at a depth of dref for each field size. IMSure uses the TMR tables to convert OF values measured at depths other than d_{ref}. The output factors, in combination with the Collimator or Head Scatter Factors (S_c) are used to compute the phantom scatter (S_p), as S_p = OF/S_c. Output factor should be measured for the full range of useful field sizes and each value is normalized by the value measured at the calibration field size.

S_c for the square field sizes is required 1) to compute the phantom scatter from the output factor and 2) to verify that the three source model head scatter coefficients are modeled correctly. S_c is measured for each field size at isocenter (SAD) with an appropriate buildup cap of at least d_{MAX} effective radius over the measurement chamber, and is normalized to the reference field size measurement.

OCR – Off-Center Ratio, also called an Off-Axis Ratio. All off-axis distances must be measured with the surface of the phantom at the reference Source to Phantom Distance listed in the physics module for that beam energy. Correction for depth dependent divergence is made by IMSure QA based on this distance and the depth of the profiles. No correction is made for the minor variances due to the true depth at off-axis positions, but as the depth to the specification calculation point is defined as the depth parallel to the central axis, no correction is required. Input OCR must be normalized to the central axis value at each depth, thereby making them independent of PDD. Wedge OCR tables must have the 'thin end' (toe) of the wedge oriented toward the negative end of the plot. If needed, users can invert plots in IMSure to meet this requirement.

Tray Factors - The tray factors should be measured for the calibration field size and at the reference depth, and the ratio of this value to the open field measurement should be taken without any changes to the measurement setup.

Wedge Factors - A single wedge factor for calibration field size is required for each wedge. Wedge factors should be measured at the calibration field size and the ratio calculated to the open field measurement under identical conditions, except for the insertion of the wedge. Variation of the wedge factors with field size is accounted for in the wedge output factor tables of each wedge.

B. MU Module

The calculations for the monitor units in the IMSure QA MU module use the method described by F. Khan. The patient geometry for this model is shown in figure B.1

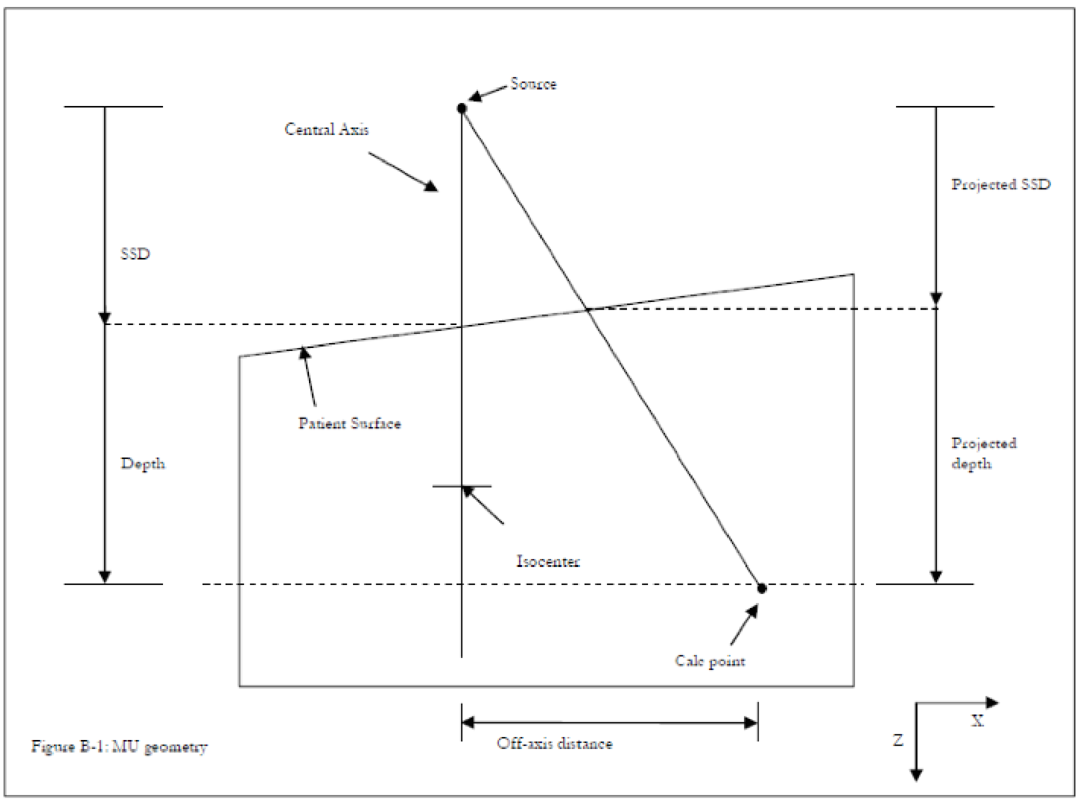


Figure B-1: MU geometry

For a specific machine, energy and wedge type, the Monitor Units are calculated from the following equation.

$$MU = \frac{RxDose / \left(\frac{IsoDoseLine}{100\%}\right)}{TMR \times OCR \times WF \times TF \times S_c(FS) \times S_p(FS') \times CF \times UF \times InvSqCorr}$$ (B.2)

where

RxDose is the prescribed dose to the calculation point, in cGy.

IsoDoseLine is the isodose line intended at the calculation point, in %.

TMR is the Tissue Maximum Ratio at the effective depth of the point of interest and for the blocked field size, i.e. TMR = TMR (FS', d').

d' is the Effective Depth, which if not specified is equal to the physical depth along the central axis.

OCR is the off-center ratio calculated at the radial distance from the central axis to the point of interest and for the effective depth, d'.

OCRx', OCRy' are proportional off-center ratios at the calculation point depth and off-axis distance for both axes. These are computed from the radial OCR according to the off-axis distances x and y:

OCRy' = [OCR ((x_2 +y_2)1/2, d')-1] * y_2/(x_2 +y_2) + 1, and

OCRx' = [OCR ((x_2 +y_2)1/2, d')-1] * x_2/(x_2 +y_2) + 1, such that the total OCR is

OCR = OCRx' * OCRy' = OCR ((x_2 +y_2)1/2, d'

For wedge fields, the additional OCR contribution from the wedge is computed by first removing the effect of the open field from the wedge field profile, and then combining the resulting value with the fractional OCR in that axis. So for a wedge in the x-direction, the calculation would be as follows:

OCR_{wx} = OCR(wedge, x, d')/OCR(open, x, d'), and

OCR_x = $OCR_{x'}$ * OCR_{wx}, such that the total OCR is

OCR = OCR_x * $OCR_{y'}$

WF is the Wedge Factor at the calibration depth and calibration field size, and may be a dynamic wedge factor (see below).

TF is the Tray Factor for the current energy, if a block tray is present,

S_c is the head scatter factor for the open field,

FS is the equivalent square field size for the open field,

S_p is the phantom scatter factor for the blocked field,

FS' is the effective field size, which is the equivalent square field size for the blocked field at the calculation point,

CF is the machine calibration factor in cGy/MU,

UF is a User Factor, a generic correction that may be entered by the physicist,

InvSqCorr is the inverse square correction factor and is computed by

$$InvSqCorr = \left(\frac{SSD_{ref}+d_{ref}}{PSSD+Pdepth}\right)^2$$

(B.3)

where PSSD is the Projected Source to Surface Distance (see Figure B.1), which if not specified is equal to the SSD, and

Pdepth is the projected depth: *Pdepth = SSD + d - PSSD*

The equivalent square open field is computed as FS = 2XY/(X+Y), where Y = Y_1+Y_2 and X = X_1+X_2 for independent jaws. The effective field size, FS', is similar but is calculated using the open area of the field in the plane of isocenter and either a 4*Area/Perimeter or square root of the area method, depending on the preferences chosen by the user. The value of FS' used to determine the proper phantom scatter factor, S_p, for the calculation is also computed with a divergence factor:

or

$$FS' = \left(\frac{4 \times Area}{Perimeter}\right)\left(\frac{PSSD + d}{SAD}\right)$$

$$FS' = \sqrt{Area}\left(\frac{PSSD + d}{SAD}\right)$$

where SAD is the nominal source to axis distance for the current machine.

Dose at each of the calculation points for each field is computed using:

$$Dose(CalcPt_i) = MU \times TMR(FS', d_i') \times OCR(dist_i, d_i') \times WF \times TF \times Sc(FS) \times Sp(FS_i') \times CF \times UF \times InvSqCorr$$

Where d_i' and $dist_i$ are the effective depths and off-axis distances of calculation point i, FS_i' is the effective field size at calculation point i, and InvSqCorr is computed as above but using $PSSD_i$, the projected source to surface distance of calculation point i.

For machines that have a physical jaw pair replaced by MLCs (e.g. Siemens Primus), the missing jaw values in the equivalent square open field size calculation are replaced by the values of the widest (most open) MLC leaf.

Enhanced Dynamic Wedge Factor Calculation Algorithm

Wedge Factors (WF) and Off-Axis Ratios for the Varian Linacs' Enhanced Dynamic Wedges (EDW) are computed from the "Golden Segmented Treatment Table" provided by Varian Medical Systems, Palo Alto, CA. IMSure computes these values using the model developed by Liu (1998). As shown by Liu the Wedge Factor of an EDW field depends strongly on the final position of the moving jaw. During the Varian EDW field delivery, the moving jaw stops 0.5 cm before it touches the jaw at rest. The WF can then be described as

(B.4) $$WF(y) = \frac{STT(y')}{STT(Y_{fin})}$$

where the final jaw position $Y_{fin} = Y_2 - 0.5$ cm for the Y_1-in jaw movement, and $Y_{fin} = Y_1 - 0.5$ cm for the Y_2-out jaw movement, and STT values are interpolated from the STT of the desired beam energy and wedge angle. The variable y is the calculation point y-axis off-axis distance in the collimating coordinate system (i.e. regardless of collimator angle); and when y is scaled to the plane of isocenter, this distance is referred to as y'. For the Y_1-in case, y' is

(B.5) $$y' = y\frac{SAD}{SSD+d}$$

For the Y_2-out case, the slope of the wedge is inverted, so the sign of y' is inverted.

(B.6) $$y' = -y\frac{SAD}{SSD+d}$$

If an effective depth (d') and a Projected SSD are specified, then equations [B.5] and [B.6] are replaced by

(B.5a) $$y' = y\frac{SAD}{PSSD+d'}$$

(B.6a) $$y' = -y\frac{SAD}{PSSD+d'}$$

For EDW beams, the WF includes the effects of any off-axis ratios, such that if a point measurement was made with and without an EDW, the WF would be the ratio of the two beams.

(B.7) $$WF(y) = \frac{EDW\ Dose(y)}{Open\ Field\ Dose(y)}$$

EDW off-axis correction factor

Because the WF calculation outlined above does not completely reproduce the true wedge factor at calculation points away from the center of the wedge field, an additional correction has been implemented following the method outlined by Gossman and Sharma (J Med Phys. 35(2): 65-72 (2010))

First, a table of off-axis EDW wedge factors must be generated for an array of points at depth within a large symmetric EDW field. The default tables provided by Standard Imaging represent the wedge factors for a 20x20 cm^2 field, with a water phantom at 90 cm SSD and points at 10 cm depth spaced 1cm apart from -8 cm to +8 cm along the wedge direction. All data should be normalized to the central axis, and the toe of the wedge should be oriented toward the negative offset direction.

IMSure takes the wedge factor calculation points and creates a ratio of the wedge factors to those calculated using the method outlined above. A line is fit to these values, and the slope (m) and y-intercept (b) are recorded for each wedge angle. For an MU plan in IMSure, the calculated EDW WF is then multiplied by a calculated correction factor, CF(angle) = m*dY+b, where dY is the calculation point displacement from the center of the wedge field along the wedge direction.

Motorized Wedge Angle Calculation

For fields using the Elekta motorized wedge, the Effective Wedge Angle, $_{eff,}$ is calculated by IMSure based on Meterset Weight values (which are essentially MU values or normalized fractional MU values) in the DICOM file for the open and wedge portions of the field.

$$\theta_{eff} = \tan^{-1}\left(\frac{WedgeFactor(FS)\times WedgeFraction\times\tan\theta_{nom}}{WedgeFactor(FS)\times WedgeFraction+OpenFraction}\right) \quad \text{(B.8)}$$

Here, *nom* is the physical wedge angle entered in the Physics module for the specific machine and energy,

WedgeFraction is the ratio of two values from the DICOM file (the Cumulative Meterset Weight and the Final Cumulative Meterset Weight),

OpenFraction is 1 – WedgeFraction, and

WedgeFactor(FS) is the field size corrected wedge factor, calculated as

$$WedgeFactor(FS) = \frac{WF \times WOF(FS)}{OF(FS)}$$

where WF is the Wedge Factor for the physical wedge entered in the Physics module for the specific machine and energy,

WOF(FS) is the Wedge Output Factor for the imported beam effective field size, and

OF(FS) is the open field Output Factor for the imported beam effective field size.

The Effective Wedge Angle is then used to calculate how much of the total field dose, D_{total}, is delivered by the open and wedge fields, respectively. For a point on the central axis, the calculation is straightforward.

$$D_{open} = \left(1 - \frac{\tan\theta_{eff}}{\tan\theta_{nom}}\right) D_{total} \quad \text{(B.9)}$$

$$D_{wedge} = \frac{\tan\theta_{eff}}{\tan\theta_{nom}} D_{total} \quad \text{(B.10)}$$

For points away from the central axis, the off axis ratios have to be considered along with the changing wedge field dose contribution relative to the open field.

$$D_{open} = OCR_{open}\left(1 - \frac{\tan\theta_{eff}}{\tan\theta_{nom}}\right)\left(\frac{1}{(OCR_{wedge} - OCR_{open})\left(\frac{\tan\theta_{eff}}{\tan\theta_{nom}}\right) + OCR_{open}}\right)D_{total,OAX}$$

(B.11)

$$D_{wedge} = OCR_{wedge}\frac{\tan\theta_{eff}}{\tan\theta_{nom}}\left(\frac{1}{(OCR_{wedge} - OCR_{open})\left(\frac{\tan\theta_{eff}}{\tan\theta_{nom}}\right) + OCR_{open}}\right)D_{total,OAX}$$

(B.12)

In these equations, OCR_{open} is the Off Center Ratio for the open field at the calculation point,

OCR_{wedge} is the Off Center Ratio for the wedge field at the calculation point,

and the notation $D_{total,OAX}$ is used to emphasize that the total dose used here is the total dose from the combined open and wedge fields at the off-axis calculation point.

The fraction

$$\frac{1}{(OCR_{wedge} - OCR_{open})\left(\frac{\tan\theta_{eff}}{\tan\theta_{nom}}\right) + OCR_{open}}$$

is a correction factor to preserve the wedge angle at off-axis calculation points. This correction accounts for the change in the relative contributions of the wedge and open fields at off-axis points; i.e. higher contribution from the wedge field relative to the open field for points under the thin portion of the wedge, or lower contribution from the wedge field relative to the open field for points under the thick portion of the wedge. For OCR values of unity, Equations (B.11) and (B.12) reduce to equations (B.9) and (B.10).

C. Single Source Head Scatter Model with Fluence Map Calculation and Correlation

The fluence map is computed from the input leaf sequence file using equations (C.1)-(C.3). Assume that a treatment field defined by the jaws can be partitioned into *M* beamlets. Also, assume that there are *K* segments in the treatment field. At isocenter, the plane is divided into a grid according to the beamlet size. The fluence at a given point, x_n, inside a pixel n is the summation of the contributions of all segments, i.e., (C.1) $$\Phi(x_n) = \sum_{k}^{K} f_k \varphi_k(x_n)$$

where is the fractional MU of the k^th segment, and is the fluence per unit MU from the k^th segment. By denoting the boundary of the k^th beam segment by A_k and introducing a notation

(C.2) $$\delta_{x_n, A_k} = \begin{cases} 1 \; if \; x_n \in A_k \\ 0 \; if \; x_n \notin A_k \end{cases}$$

The fluence per unit MU from the k^th segment can be written as

(C.3) $$\varphi_k(x_n) = \delta_{x_n, A_k} + \alpha(1 - \delta_{x_n, A_k})$$

where α is the average transmission factor representing the amount of radiation passing through the MLC leaves (on average) as a percentage of the radiation that would be received from an open field defined by the jaws.

The dynamic modulation factor, is equal to unity or α, respectively, if the point x_n is in an open or blocked portion of the field during the entire delivery process. The pixel values of a fluence map are usually normalized according to the average fluence of the field.

Dynamic delivery: Dynamic delivery differs from a step-and-shoot mode in that leaf movement and dose delivery are realized simultaneously. In general, the fluence inside a pixel does not have to be a constant, as the leaves sweep across the field, and can be assumed to vary linearly with leaf travel during that segment. For a given point x_n inside the pixel, the field fluence can be written as

(C.4) $$F(x_n) = F_a(x_n) - F_b(x_n)$$

where $F(x_n)$ and $F_b(x_n)$ are the fluence functions produced by a leaf in A and B banks, respectively. For a segment in which at least one of the leaf ends sweeps across x_n, the primary fluence is a linear interpolation of the fractional index f_k of the segment. Similarly, the transmission fluence is a linear interpolation of αf_k. The total fluence at the point is then a summation of all the segments.

The imported map and the calculated map are compared using three methods.

1) The maximum difference method shows the maximum difference between corresponding pixel values in a map inside the Complete Irradiated Area Outline (CIAO), after normalizing both maps. The maximum difference value can be used to describe a local quantity of accuracy.

2) The correlation coefficient, r, represents a global quantity of accuracy between the two maps, and is calculated using the equation:

$$r = \sum_n (F_n - \bar{F})(R_n - \bar{R}) \Big/ \sqrt{\left(\sum_n (F_n - \bar{F})^2\right)\left(\sum_n (R_n - \bar{R})^2\right)} \quad \text{(C.5)}$$

where F_n is the calculated fluence and R_n is the imported treatment planning system computed fluence at any point n. and are the mean values of each map computed over the open field area.

3) A Gamma Map distribution method relates both difference and distance-to-agreement. This method is fully described in section I of this appendix.

Diode calculation

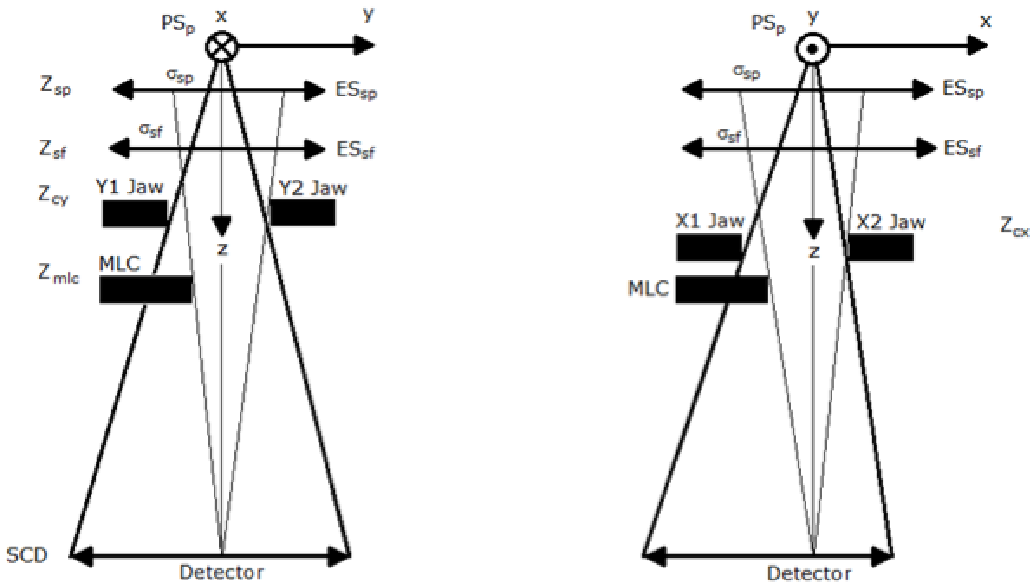
For the Diode tab in the MU module, dose is calculated for the diode based on the following equation

Dose = MU X TMR(FS', d') X OCR X WF X TF X Sc(FS) X Sp(FS') X CF X UF X InvSqCorr(Pdepth = 0)*

*Depending on your settings in Preferences, the MU used in the calculation will either be the MU from your TPS or the MU calculated by IMSure.

D. Three Source Model Calculation

The Three Source Model used by IMSure has been published by Yang, et al (2002 and 2003).



(D.1) Geometry of the three source model

Head scatter factor

The total energy fluence at the point of calculation can be divided into two components: one is the unscattered primary photons from the target, and the other is the scattered photons generated in linac head components, with the flattening filter and the primary collimator acting as the main scattering components. Therefore, IMSure defines three contributions to the fluence: a primary photon source, PS_p, for the primary photons from the target, an extra-focal photon source, ES_{sp}, for the scattered photons from primary collimator, and another extra-focal photon source, ES_{sf}, for the scattered photons from the flattening filter. The primary source is a point source located at the rotational central axis of the collimator in the exit plane of the target. The primary source intensity is constant and does not change with jaw setting. The primary collimator extra-focal source, ES_{sp}, can be represented by a planar annulus source and the flattening filter extra-focal source, ES_{sf}, can be represented by a planar disk source.

The extra-focal source intensity distribution, Ω_{sp}, in the planar annulus is approximately constant and does not change with jaw setting. It can be expressed as

(D.2) $$\Omega_{sp}(r_s) = \begin{cases} C_{sp} & if\ R_{01} \leq r_s \leq R_{02} \\ 0 & otherwise \end{cases}$$

where C_{sp} is a constant, r_s is the distance between the central axis of the beam and a point in the ES_{sp} plane, and R_{01} and R_{02} are the inner and outer radii of the planar annulus source.

The extra-focal source intensity distribution Ω_{sf} changes with linac nominal energy, but the source position does not. For convenience, the source intensity distribution of ES_{sf} can be analytically expressed as

(D.3)
$$\Omega_{sf}(r_s) = \left(\frac{A_0}{r_s}\right) e^{-k \cdot r_s}$$

where A_0 and k are constants, and rs is the distance between the central axis of the beam and a point in the source ES_{sf} plane.

We can obtain the energy fluence at the calculation point by integrating the radiation contributions over the projected areas in each source plane from the detector's eye view. Thus the head scatter factor, S_c, can be expressed as

(D.4)
$$S_c(X_1, X_2, Y_1, Y_2, SSD_{cal}, \sigma) = \left(\frac{SAD}{SCD}\right)^2 C_p + \left(\frac{SAD - Z_{sp}}{SCD - Z_{sp}}\right)^2 \iint_{\sigma_{sp}} \Omega_{sp}(r_s) d\sigma + \left(\frac{SAD - Z_{sf}}{SCD - Z_{sf}}\right)^2 \iint_{\sigma_{sf}} \Omega_{sf}(r_s) d\sigma$$

where Cp is a constant representing the normalized energy fluence at the isocenter from the primary photon source, SAD is the source-to-axis distance, SCD is the source to calculation plane distance, σ_{sp} and σ_{sf} are the projected areas from the detector's eye view in the ES_{sp} source plane and the ES_{sf} source plane, respectively, and Zsp and Zsf are the distances from the source to the ES_{sp} and ES_{sf} planes, respectively. When the calculation point is at the isocenter, Eq. (D.4) can be rewritten as

(D.5)
$$S_c = C_p + \iint_{\sigma_{sp}} \Omega_{sp}(r_s) d\sigma + \iint_{\sigma_{sf}} \Omega_{sf}(r_s) d\sigma$$

Jaw Contributions

From the geometry illustrated in (D.1), the projected areas σ_{sp} in the ES_{sp} source plane and σ_{sf} in the ES_{sf} source plane for a rectangular field can be expressed

(D.6)
$$\sigma_{sp} = k_{x1} X_c \times k_{y1} Y_c$$

(D.7) $$\sigma_{sf} = k_{x2}X_c \times k_{y2}Y_c$$

where k_{x1} and k_{y1} are defined as the field conversion factors from detector plane to the ES_{sp} source plane for the X and Y side, k_{x2} and k_{y2} are similar conversion factors from the detector plane to the ES_{sf} source plane, and X_c and Y_c are the sides of the symmetric field in the X and Y directions in the plane of isocenter. These field conversion factors can be obtained by simple divergent geometry.

(D.8) $$k_{x1} = \left(\frac{Z_{cx}}{SAD}\right)\left(\frac{SCD-Z_{sp}}{SCD-Z_{cx}}\right)$$

(D.9) $$k_{y1} = \left(\frac{Z_{cy}}{SAD}\right)\left(\frac{SCD-Z_{sp}}{SCD-Z_{cy}}\right)$$

(D.10) $$k_{x2} = \left(\frac{Z_{cx}}{SAD}\right)\left(\frac{SCD-Z_{sf}}{SCD-Z_{cx}}\right)$$

(D.11) $$k_{y2} = \left(\frac{Z_{cy}}{SAD}\right)\left(\frac{SCD-Z_{sf}}{SCD-Z_{cy}}\right)$$

where Z_{cx} and Z_{cy} are the distances from the target to the top of the X and Y jaws, respectively.

For a symmetric square field or rectangular field, we can use Eq. (D.6) to Eq. (D.11) to obtain the projected areas σ_{sp} and σ_{sf} and the field conversion factors k_{x1}, k_{y1}, k_{x2} and k_{y2}. These two projected areas can be divided into a matrix of $M_{sp} \times N_{sp}$ elements and a matrix of $M_{sf} \times N_{sf}$ elements, respectively. Assume the elements are square and their size is $l_e \times l_e$ cm^2, the values M_{sp}, N_{sp}, M_{sf} and N_{sf} can be easily obtained by

(D.12) $$M_{sp} = int(k_{x1}X_c/l_e)$$

(D.13) $$N_{sp} = int\left(k_{y1}Y_c/l_e\right)$$

(D.14) $$M_{sf} = int\left(k_{x2}X_c/l_e\right)$$

(D.15) $$N_{sf} = int\left(k_{y2}Y_c/l_e\right)$$

where the symbol int () represents integer operation.

If we use r_{ij} to represent the distance between the center of the extra-focal source and the center of the element (i, j), we can define this distance math-

ematically as $r_{ij} = l_e\sqrt{(i-0.5)^2 + (j-0.5)^2}$. Due to the symmetry of the field, we can rewrite Eq. (D.4) as

(D.16)

$$S_c(X_c, Y_c, SCD) = \left(\frac{SAD}{SCD}\right)^2 C_p + 4\left(\frac{SAD - Z_{sp}}{SCD - Z_{sp}}\right)^2 l_e^2 \sum_{i=1}^{\frac{1}{2}M_{sp}} \sum_{j=1}^{\frac{1}{2}N_{sp}} \Omega_{sp}\left(r_{ij}\right) + 4\left(\frac{SAD - Z_{sf}}{SCD - Z_{sf}}\right)^2 l_e^2 \sum_{i=1}^{\frac{1}{2}M_{sf}} \sum_{j=1}^{\frac{1}{2}N_{sf}} \Omega_{sf}\left(r_{ij}\right)$$

Asymmetric fields

For an asymmetric field, S_c at both the isocenter and the center of the field (COF) in the isocenter plane are required. With the independent jaw settings for an asymmetric field (X_1, X_2, Y_1, Y_2), S_c (isocenter) is calculated by using the projections to the ES_{sp} and ES_{sf} source planes of each jaw separately. The field conversion factors can still be calculated using Eq. (D.8) to Eq. (D.11). The two projected areas σ_{sp} and σ_{sf} from the detector's eye view can also still be divided into a matrix of M_{sp}×N_{sp} elements and a matrix of M_{sf}×N_{sf} elements, respectively. In this case, M_{sp} is expressed as M_{sp} =M_{sp1}+ M_{sp2}, with M_{sp1} and M_{sp2} calculated via Eq. (D.12) but replacing X_c with X_1 or X_2. N_{sp}, M_{sf} and N_{sf} are similarly defined.

Thus we can get the calculation formula of Sc for an asymmetric field at the isocenter

$$S_c(X_1,X_2,Y_1,Y_2) = C_p + l_e^2 \sum_{i=-M_{sp1}}^{M_{sp2}} \sum_{j=-N_{sp1}}^{N_{sp2}} \Omega_{sp}(r_{ij}) + l_e^2 \sum_{i=-M_{sf1}}^{M_{sf2}} \sum_{j=-N_{sf1}}^{N_{sf2}} \Omega_{sf}(r_{ij}) \quad \text{(D.17)}$$

For the S_c(COF) calculation, according to the field geometry shown in fig. D.1, the projected field (X_{sp1}, X_{sp2}, Y_{sp1}, Y_{sp2}) in the ES_{sp} source plane can be calculated as

$$X_{sp1} = \frac{(X_1+X_2)(Z_{cx}-Z_{sp})}{2(SAD-Z_{cx})} + \frac{Z_{sp}}{SAD}X_1 \quad \text{(D.18)}$$

$$X_{sp2} = \frac{(X_1+X_2)(Z_{cx}-Z_{sp})}{2(SAD-Z_{cx})} + \frac{Z_{sp}}{SAD}X_2 \quad \text{(D.19)}$$

$$Y_{sp1} = \frac{(Y_1+Y_2)(Z_{cy}-Z_{sp})}{2(SAD-Z_{cy})} + \frac{Z_{sp}}{SAD}Y_1 \quad \text{(D.20)}$$

$$Y_{sp2} = \frac{(Y_1+Y_2)(Z_{cy}-Z_{sp})}{2(SAD-Z_{cy})} + \frac{Z_{sp}}{SAD}Y_2 \quad \text{(D.21)}$$

The projected field (X_{sf1}, X_{sf2}, Y_{sf1}, Y_{sf2}) in the ES_{sf} source plane is computed with Eq. (D.18) to Eq. (D.21) by replacing Z_{sp} with Z_{sf}. The calculation matrices can be obtained easily, and S_c at the center of the field can be calculated using Eq. (D.17).

MLC Scatter contributions

The scatter contribution from the tertiary collimator is very small and may be ignored, with the tertiary collimator setting treated instead as a "window" for the exit radiation. Only the point of calculation at the isocenter for irregular fields is considered here, but the method can be extended easily to other calculation points. Assume that the collimator jaw setting for an irregular field is (X_1, X_2, Y_1, Y_2), and projected areas of the tertiary collimator in the ESsp source plane and in the ES_{sf} source plane from DEV are σ_{spt} and σ_{sft} , respectively.

Then the projected areas σ'_{sp} in the ES_{sp} source plance and σ'_{sf} in the ES_{sf} source plane of the irregular field from the detector's eye view can be expressed by the Boolean operations

(D.22) $\sigma'_{sp} = \sigma_{sp} \cap \sigma_{spt}$

(D.23) $\sigma'_{sf} = \sigma_{sf} \cap \sigma_{sft}$

where σ_{sp} and σ_{sf} are the detector's eye view projected areas of the jaw setting (X_1, X_2, Y_1, Y_2).

For the irregular field shaped by the MLC, and are the sums of the projected areas of subfields formed by each pair of leaves. Introducing two notations

(D.24)
$$\delta_{ij,\sigma_{spt}} = \begin{cases} 1 & if\ element\ (i,j) \in \sigma_{spt} \\ 0 & if\ element\ (i,j) \notin \sigma_{spt} \end{cases}$$

(D.25)
$$\delta_{ij,\sigma_{sft}} = \begin{cases} 1 & if\ element\ (i,j) \in \sigma_{sft} \\ 0 & if\ element\ (i,j) \notin \sigma_{sft} \end{cases}$$

where ij is the index for the element of the matrix formed by the rectangular jaw setting.

We can rewrite Eq. D.4 as

(D.26)
$$S_c(X_1,X_2,Y_1,Y_2) = C_p + l_e^2 \sum_{i=-M_{sp1}}^{M_{sp2}} \sum_{j=-N_{sp1}}^{N_{sp2}} \delta_{ij,\sigma_{spt}} \Omega_{sp}(r_{ij}) + l_e^2 \sum_{i=-M_{sf1}}^{M_{sf2}} \sum_{j=-N_{sf1}}^{N_{sf2}} \delta_{ij,\sigma_{sft}} \Omega_{sf}(r_{ij})$$

where the numbers M_{sp1}, M_{sp1},N_{sp1}, N_{sp2}, M_{sf1}, M_{sf2}, N_{sf1} and N_{sf2} can be obtained using the jaw setting (X_1, X_2, Y_1, Y_2) by the same method as stated for asymmetric jaw contributions to the scatter.

Three Source Model for Scatter Table

In the Machine definitions of IMSure QA, the scatter coefficients can be used to compare the 3-source model to the measured and imported head scatter factors. The Sc values for this display are calculated using equation (D.17) for the specified field sizes, and using the machine constants A_0, k, C_p, C_{sp}, SSD and the source to jaw distances Z_{cy} and Z_{cx} for the upper and lower jaws.

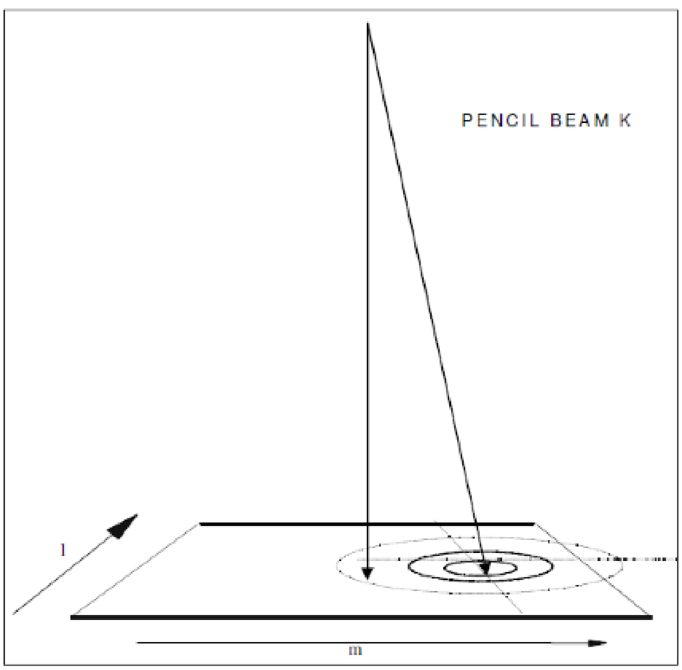
A reduced algorithm can be used to take advantage of the square field symmetry, and reduce the required computations by a factor of four, such that equation D.17 becomes,

$$S_c(X,Y) = C_p + 4l_e^2 \sum_{i=1}^{M_{sp2}} \sum_{j=1}^{N_{sp2}} \Omega_{sp}(r_{ij}) + 4l_e^2 \sum_{i=1}^{M_{sf2}} \sum_{j=1}^{N_{sf2}} \Omega_{sf}(r_{ij})$$

(D.27)

where X_1=X_2=X/2 and Y_1=Y_2=Y/2.

E. IMRT Dose Calculation Model



(E.1) Xing summation model for IMRT

IMSure QA uses the MU calculation formalism developed by Xing et al (2000). For a single incident intensity modulated beam, the treatment field defined by the jaws can be partitioned into M beamlets, and there are K segments in the treatment field. The dose at a given point (x, y, z) in the patient can be expressed as:

(E.2) $$D(x,y,z) = MU \sum_{m}^{M} C_m D_m^0$$

where D^0_m is the dose contribution to the calculation point per unit MU from the *m*-th beamlet when it is open, MU is the total monitor units, C_m is called the dynamic modulation factor, which represents the fractional MU of the *m*-th beamlet when the beam is assigned a unit MU.

When the MLC leaf transmission and head scatter effects are taken into account, the generalized dynamic modulation factor, C'_m, can be calculated by

(E.3) $$C'_m = \sum_{k}^{K} [S_{c,m,k} + \alpha S'_c (1 - \delta_{m,A_k})] f_k$$

with

(E.4) $$\delta_{m,A_k} = \begin{cases} 1 & if \quad m \in A_k \\ 0 & if \quad m \notin A_k \end{cases}$$

where f_k is the fractional MU of the *k*-th segment, A_k is the radiation field shape of the *k*-th segment, $S_{c,m,k}$ is the head scatter factor of the beamlet m in the *k*-th segment computed in equation (D.26), S'_c is the head scatter factor for the rectangular field defined by the jaws as computed in equation (D.17), and α is the average transmission factor, representing the amount of radiation passing through the MLC leaves (on average) as a percentage of the radiation of a reference open field defined by the jaws.

To calculate the absolute dose at an arbitrary point in the patient for a multiple field IMRT plan, a coordinate transform between the patient coordinate system (x, y, z; shown in figure F.1) and the machine coordinate system (x', y', z') is required. In an isocentric treatment, only rotation transformations are involved and the coordinates of a point in the two systems are related by

(E.5) $$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} \cos(\beta+\varphi) & \sin(\beta+\varphi) & 0 \\ -\sin(\beta+\varphi) & \cos(\beta+\varphi) & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta & 0 & \sin\theta \\ 0 & 1 & 0 \\ -\sin\theta & 0 & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

where θ, β and ϕ are the gantry, collimator and couch rotation angles in the IEC convention, respectively, and (x,y,z) and (x',y',z') represent the point of interest in the patient and machine coordinate systems, respectively.

Rewriting equation (E.2) as the sum of the contributions of the primary radiation and the scatter radiation:

(E.6)
$$D(x',y',z') = MU\left[C'_{m_0}D^0_{p,m_0}(x',y',z') + \sum_{m \neq m_0}^{M} C'_m D^0_{s,m}(x',y',z')\right]$$

where m_0 is the beamlet contributing to the primary dose of the verification point (x',y',z'), C'_{m_0} is the corresponding dynamic modulation factor of the beamlet, $D^0_{p,m_0}(x', y'', z')$ is the primary dose per unit MU to the verification point when the beamlet m_0 is open, and $D^0_{s,m}(x',y',z')$ is the scatter contribution to the point per unit MU from a beamlet indexed by *m*.

There are typically multiple beamlets contributing to the primary dose at a given point of interest. While the general ray-tracing rule of determining the primary beamlet(s) is clear, the number of beamlets used in this algorithm is experimentally derived. The primary dose contribution in equation (E.2) can be modeled by a weighted average of the intensities in the surrounding 2×2 cm^2 square, with the weights following a Gaussian radial function,

(E.7)
$$W(r) = e^{-9.7r^{0.27}}$$

The value of $D^0_{p,m_0}(x', y'', z')$ can be calculated using

(E.8)
$$D^0_{p,m_0}(x',y',z') = \left(\frac{100}{100-z'}\right)^2 C_f S_p(0) TMR(d',0) POAR(d',x',y')$$

where C_f is the calibration factor of the linac, d' is the water equivalent depth (i.e. the effective depth) of the calculation point, $S_p(0)$ and $TMR(d',0)$ respectively are the phantom scatter factor and TMR at the effective depth for zero field size. $POAR(d',x',y')$ is the primary off-axis ratio at the calculation point and effective depth.

A modified Clarkson integration method is used to compute the scatter dose contribution. Using square beamlets as the elementary calculation units, since these are natural for MLC-based IMRT, the value of $D^{0}_{s,m}(x',y',z')$ can be obtained by

(E.9) $$D^{0}_{p,m_0}(x',y',z') = \left(\frac{100}{100-z'}\right)^2 C_f S_p(0) TMR(d',0) POAR(d',x',y')$$

where r is the distance between the center of the *m*-th beamlet and the projection of the calculation point on the isocenter plane, $\Delta r = l^2/2\pi r$, *l* is the beamlet size used in calculation, *POAR(d', m)* is the primary off-axis ratio at the center of the *m*-th beamlet in water equivalent depth *d'*.

In the case of multiple incident beams, the dose at a point can be calculated by simply summing the contributions from all beams:

(E.10

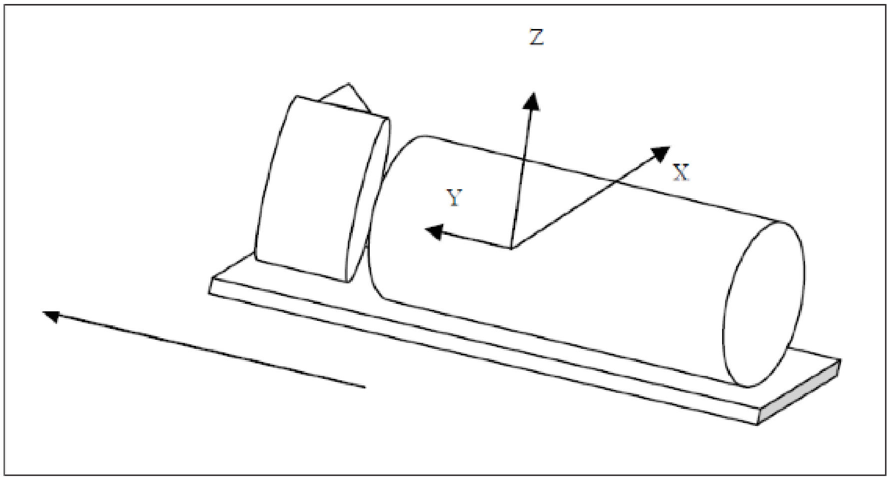
$$D(x,y,z) = \sum_{j=1}^{J} D_j(x',y',z') = \sum_{j=1}^{J} MU_j \left(C'_{m_0,j} D^{0}_{p,m_0,j}(x',y',z') + \sum_{m \neq m_0}^{M} C'_{m,j} D^{0}_{s,m,j}(x',y',z') \right)$$

The index *j* has been added to label each individual incident beam, and *J* is the total number of beams.

F. IMSure QA Patient, BEV, Calc Point and Machine Coordinate Systems and Geometry

Patient Geometry

IMSure QA conforms to the IEC standard Fixed Coordinate System patient orientation for all geometric descriptions of the patient or phantom. In the IEC Fixed Coordinate System standard, for a patient lying headfirst and supine on the treatment table, the positive x-axis is towards the patient's left hand, the positive y-axis is towards the patients head, and the positive z-axis is towards the patient's anterior, as shown in figure F.1. The patient geometry in the user's treatment planning system may differ from the IEC coordinate system. For the purpose of IMSure's calculations, the origin of the patient coordinate system is always set to the isocenter, the origin of the machine coordinate system.



(F.1) Patient coordinate system

BEV Coordinate Systems

In IMSure QA, The Beam View or Beams-Eye-View (BEV), is fixed relative to the position of the source – i.e. aligned with the direction of the beam – regardless of gantry or collimator angle. The axes shown on the image indicate the collimator orientation, while the vertical aspect of the display represents the gun-target axis. For no collimator rotation, the +Y collimator axis will point toward the gantry, and the +X axis will point toward the right of the display. The BEV display is always scaled to the plane of isocenter, which is specified by the Nominal SAD in the physics data for each machine.

IMRT-QA Module Calculation Point Geometry

The display of the BEV is equivalent in the IMRT-QA, Import, and MU modules. However, the coordinate specifications (and thus the relative BEV display) of the Calculation Point(s) are different in the IMRT-QA and MU modules. In the IMRT-QA module, the calculation point is relative to the patient origin, which is also the isocenter. The Calculation Point(s) are then specified relative to this Plan Origin within the fixed coordinate system, regardless of Collimator angle or Gantry Angle. Depending on the Calc Point Position and Gantry Angle, some combinations of the beam with SSD and depth may not be allowed. For example, for a gantry beam pointing straight down, with an SSD of 100 cm and a depth of 5 cm, a calculation point of (0, 0, 10) would place the calculation point 5 cm above the patient surface (which is not allowed), and a calculation point of (0, 0, -10) would place the calculation point 15 cm below the surface.

MU Module Calculation Point Geometry

In the MU module, Calculation Points may be specified in the fixed reference coordinate system or relative to the BEV display, regardless of Gantry angle but respecting the Collimator angle. For the latter method, the Primary Calculation Point is defined by the distance from the source (SSD+depth), the distance towards the right collimator (CalcPt X) and the distance toward the top collimator (CalcPt Y). This definition allows the user a method for combining multiple isocentric plans. Additional Points of calculation are similar, but the distance is specified as PSSD + depth.

Machine Coordinate System

Machine coordinate systems are specified in the Physics module and are based on the IEC 61217 coordinate system (formerly IEC 1217). The *Base Gantry* angle refers to the machine offset when the beam is directed straight down. For IEC coordinate machines, the *Base Gantry* angle is 0.0 degrees. For many Varian Machines, the *Base Gantry* angle will be 180.0 degrees. The *Base Collimator* angle refers to the machine offset when the Collimator is at the nominal or rest position, corresponding to the IEC angle of 0 degrees. For many Varian Machines, the *Base Collimator* angle will be 180.0 degrees. The *Gantry Rotation Direction* refers to the direction the gantry will move when the gantry angle increases, with an observer facing the gantry. The IEC default is CW (clockwise). For many Varian Machines, the *Gantry Rotation Direction* will be CCW (Counter Clockwise). The *Collimator Rotation Direction* refers to the direction the collimator will move when the collimator angle increases, from the viewpoint of an observer at isocenter looking toward the source. The IEC default is CW. For many Varian Machines, the *Collimator Rotation Direction* will be CW (Clockwise) as well.

Jaw, MLC and Wedge Names and Directions

Each jaw may be given a common name. The names refer to the Top, Left, Bottom and Right collimating jaws, as viewed from the source with the collimator at the Base Collimator Angle. In IEC 6_{1217} nomenclature, Left is X_L, Right is X_R, Bottom is Y_L, and Top is Y_R. Many Varian machines refer to (X_L, X_R, Y_L, Y_R) as (X_1, X_2, Y_1, Y_2). Many Siemens machines refer to these as (A_1, A_2, B_1, B_2). Many Elekta machines refer to (Y_1, Y_2, X_1, X_2). Although IMSure QA notates the X jaws as “Lower” and the Y jaws as “Upper” in the physics module, no calculation limitations are made for this reference. However, IMSure QA always expects the MLCs to be oriented parallel to the X axis. For Elekta machines, this limitation must be accounted for with appropriate naming of the jaws, as well as appropriate corrections to the Base collimator angle.

Wedge directions are specified by IMSure QA based on the THIN END of the wedge. A wedge direction of X_1 indicates that the thin end of the wedge is nearest to the X_1 collimating jaw. Allowed Wedge angles may be restricted as needed, for example, Elekta machines should be limited to one direction. Wedge OCRs must be plotted with the toe of the wedge oriented to the negative axis of the off-axis distance.

G. Determination of the fitting coefficients

In order to simplify the calculation, we use the equivalent circular fields for square fields in the extra-focal source planes to calculate Sc in the process of determining coefficients. Thus, we can get an analytical solution for equation (D.5)

$$S_c = C_p + \pi C_{sp}\left(R_{sp}^2 - R_{01}^2\right) + 2\pi A_0 \left(\frac{e^{-kR_{sf}} - 1}{k}\right)$$

(G.1)

where R_{sp} and R_{sf} are the radii of the equivalent circular fields in the extra-focal source planes ES_{sp} and ES_{sf}. These radii can be calculated easily:

(G.2) $$R_{sp} = \frac{2k_{x1}k_{y1}X_cY_c}{\sqrt{\pi}(k_{x1}X_c+k_{y1}Y_c)}$$

(G.3) $$R_{sf} = \frac{2k_{x2}k_{y2}X_cY_c}{\sqrt{\pi}(k_{x2}X_c+k_{y2}Y_c)}$$

Usually, R_{sp} is greater than R_{01} in our measurement and calculation range. When R_{sp} is greater than R_{02}, the value of R_{sp} in equation G.1 is set equal to R_{02}. For a square field, this is

(G.4) $$R_{sp} = \begin{cases} \frac{2k_{x1}k_{y1}}{\sqrt{\pi}(k_{x1}+k_{y1})}X_c & when\ \sqrt{\pi}\frac{k_{x1}+k_{y1}}{2k_{x1}k_{y1}}R_{01} < X_c < \sqrt{\pi}\frac{k_{x1}+k_{y1}}{2k_{x1}k_{y1}}R_{02} \\ R_{02} & when\ X_c \geq \sqrt{\pi}\frac{k_{x1}+k_{y1}}{2k_{x1}k_{y1}}R_{02} \end{cases}$$

A least square fitting method is used to determine the fitting coefficients C_p, C_{sp}, A_0 and k in equation (G.1). Since the first two items in the right side of equation (G.1) are constants for the square fields that have R_{sp} greater than R_{02}, the process of determining the estimate of C_p, C_{sp}, A_0 and k can be separated into two steps. First use the square fields with R_{sp} greater than R_{02} to obtain A_0, k, and an estimated constant for the sum of the first two items on the right side of equation (G.1); then obtain the estimate of C_p and C_{sp} by a simple linear fitting using the square fields with R_{sp} less than R_{02}. The needed input data for this algorithm are a single set of measured S_c values for square fields at the isocenter.

H. Model Parameter Choice and User Preferences Settings

1. Choosing Calculation Grid Sizes.

The calculation resolution can be selected to be ½, ¼ or ⅛ cm. Best results will always be the highest resolution, but the user should always choose grid spacing of at least two points per leaf. For ½ cm leaves, this would be a resolution of ¼ cm spacing.

2. 3-Source Model Parameters

The best estimated values for the location of the source scatter planes, ES_{sp}, and ES_{fs} depend on the physical dimensions of the linac collimating head. For Varian models, the parameters identified by Yang, et al. (2002) are Z_{sp} = 4.0 cm, Z_{sf} = 12.5 cm, R_0 = 0.2 cm, and R_1 = 1.4 cm with Jaw distances of Zx = 36.7, Zy = 27.9 and Zmlc = 48.3 cm. For Siemens models, the parameters identified by the Yang model are Z_{sp} = 4.0 cm, Z_{sf} = 10.5 cm, R_0 = 0.2 cm, and R_1 = 1.1 cm with Jaw distances of Z_x = 28.3, Z_y = 19.7 and Z_{mlc} = 28.3 cm. Note that even though Siemens models have MLC only and no X-jaw, a distance to the X jaw must still be specified for model consistency, but these jaws are always treated in the model as if they were wide open. For Elekta models, the parameters of Z_{sp} = 4.0 cm, Z_{sf} = 12.5 cm, R_0 = 0.2 cm, and R_1 = 1.4 cm have been found to model the beam correctly with Z_x = 40.1, Z_y = 43.4 and Z_{mlc} = 29.8 cm. Note also that the X jaws for the Elekta accelerators are closer to the source than the Y jaws.

Other parameters – namely C_p, k, A_0 and C_{sp} – are also energy and machine dependent. Please refer to the Yang et al. publication for these values. The ranges for good fits for all accelerators are typically $0.5 < C_p < 0.95$, $0.1 < k < 0.99$, $0.001 < A_0 < 0.02$, and $0.0005 < C_{sp}. < 0.009$. IMSure will automatically calculate a fit; however, the user may also begin with published values or values from the demo machines and make small modifications manually until an acceptable fit is achieved. Typical fits have less than 1% maximum error between measured head scatter and modeled head scatter for square fields, and fits with errors below 0.5% are routinely achievable with cleanly measured data.

3. Leaf Leakage Values

Two types of leaf leakage are used for the IMSure QA calculation models, those for the 3-source calculation (Yang model) and those for the single source calculation (Li model) of the fluence map.

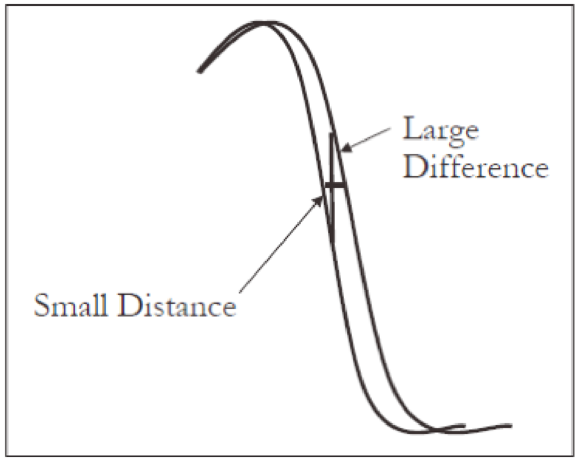
Leaf leakage can be measured by placing an ionization chamber in a polystyrene phantom on the central axis with the phantom surface at 100 cm SSD. Leakage, α, is usually machine and energy dependent. For photon beams, transmission factors are typically between 1% and 2%, but these values must be verified by physical measurements. Adjustment of these parameters can alter the results of the model calculations, and the user is encouraged to find the leaf leakage values that best reproduce the measured results for their own systems.

4. TMR zero

Extrapolation of the TMR zero field size values is required for the 3-source model. A simple method for extrapolating the measured TMR zero values is to begin with a simple linear extrapolation from measured data. Then with a simple 10 cm square field size IMRT ssMLC file, conduct a 100 cm SSD IMRT calculation for a series of depths. Comparisons of the results to measured values at variable depths will indicate required adjustment to the TMR zero values.

I. Gamma Map Calculation Algorithm

The difference map alone is not always the best method to use for comparing computed and imported fluence arrays. As shown in figure I.1, when two curves of high gradient are compared, a very large difference may be noted but may not be important if it is caused by a small linear shift.



(I.1) Effect of Distance and Difference at high gradient

The gamma value is a scoring method for comparing such maps, and the method has been described in detail by Low (1998). The power of this method is that it includes the effects of both the absolute difference of the two maps as well as the distance-to-agreement (DTA). The gamma value is a weighted comparison of DTA and absolute difference, relative to pre-selected limits. At any point, *r*, in the map, the gamma function can be computed as,

$$\gamma(r) = \sqrt{\left(\frac{DTA(r)}{DistThreshold}\right)^2 + \left(\frac{Difference(r)}{DiffThreshold}\right)^2} \quad \text{(I.2)}$$

where *DTA(r)* is the distance from a point in imported map to the nearest point in the computed map of identical value, and *Difference(r)* is the absolute difference between the two maps at any one point. *DistThreshold* and *DiffThreshold* are the pre-selected weighting values.

The gamma value is further modified by restricting it by

$$\Gamma(r) = \min\left(\gamma(r), \frac{|DTA(r)|}{DistThreshold}, \frac{|Difference(r)|}{DiffThreshold}\right) \quad \text{(I.3)}$$

The value of gamma depends on the threshold values that have been chosen. For any point, if the gamma value is below 1.0 the DTA or the absolute difference (or both) lie within the specified limits. If gamma is greater than 1.0, then both the DTA and the difference values lie outside the threshold limits. The further outside the limits the DTA and differences are, the higher the gamma value will be.

For example, when comparing an Imported Fluence Map with a Computed Fluence Map in the IMSure QA module, with a Distance Threshold of 0.3 cm and a Difference Threshold of 3% will often indicate where large regions of discrepancy between the two maps might lie. Determination of the clinical acceptability of these regions is an important decision for the qualified medical physicist when evaluating IMRT plans. Smaller regions of one or two pixels of ¼ cm square may have little or no clinical relevance as the small areas of dose differences from any one field at the actual treatment depth would be small. Larger regions of 5 or more connected pixels could result in clinically significant dose discrepancies that would require further investigation.

It is important for each institution to evaluate and develop policy regarding the acceptability of the comparative results available from IMSure QA.

J. References

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15 Appendix B: IMSure QA Electron MU Calculations and Measurements

The prescribed dose for electrons may be specified in one of two ways, either, A) at a specified depth, or, B) for a specified depth dose. Either approach can be clinically useful. Often method A is useful with well-known anatomy, as obtained from CT images, where the deepest tumor depth can be measured. Method B is a more traditional approach, where a clinician might specify a percent depth dose, as dose coverage will be sufficient down to that implied depth.

Electron MU's are computed as:

(B.1)

$$\mathrm{MU} = \frac{\mathrm{Dose}}{\mathrm{OF(cone)} * \mathrm{CF(cone, FS)} * \mathrm{OAR(r,d)} * [\mathrm{PDD(d)}/100\% * \mathrm{CDR}] * \mathrm{InvSq} * \mathrm{UserFactor}}$$

Dose is the prescribed dose in cGy at the calculation point.

CDR is the Corrected Dose Rate, and is the Calibration Dose Rate (cGy/MU) corrected by the percent depth dose at the reference depth for the intended cone,

$$CDR = \frac{\text{Calibration Dose Rate (energy)}}{\text{PDD(reference cone, energy, d = dref)}/100\%}$$

(B.2)

Although d_{ref} is forced to be the same as d_{max}, it is possible that the reference cone PDD at d_{ref} is not exactly 100%.

PDD(d) is the percent depth dose for the cone and energy of interest at the calculation point depth (if using method A). If using method B, the specified depth dose is used as entered, and IMSure looks up the depth (d) from the PDD table for that cone and energy. If PDD curves are available for multiple SSDs, IMSure will take these nto account as well. As Electron PDD curves may have multiple depths that have the same relative dose, the deepest depth for that table will be used.

OAR(r,d) is the off-axis correction factor for the depth of interest, d, and the distance from the central axis, r, and corrected for divergence, if the SPD (source to phantom distance during measurements) used differs from the nominal SSD, where,

$$r = \frac{\sqrt{(x*x + y*y)} * (SPD + d)}{(SSD_{\mathrm{nominal}})}$$

(B.3)

However, in version 3.0, SPD is required to be the same as the nominal SSD.

InvSq is the inverse square correction factor and is computed as,

(B.4) $$InvSq = \left[\frac{VSSD + d}{VSSD + SSD - SSD_{Nominal} + d} \right]^2$$

Where VSSD is the Virtual Source to Surface Distance (discussed in the Electron Measurement section below), Gap is the distance between the cone and the patient, and $\text{Gap}_{\text{Nominal}}$ is the typical gap, or distance between the cone and the phantom when calibrated. The Gap is computed as,

(B.4a) $$Gap = SSD - SSD_{Nominal} + Gap_{Nominal}$$

CF are the Cone Factors, which account for the increase or decrease in dose output by the shaped cutout, and are the ratio of the dose output at dmax for each cone for the cutout vs. the unblocked cutout. CF are dependent on the SSD and FS'. FS' is the effective field size of the aperture and is computed as,

(B.5) $$FS = \sqrt{Area_{APERTURE}}$$

OF(cone, energy) is the Output Factor for each cone and energy and is the ratio of the dose at the reference depth for the indicated cone versus the dose at reference depth for the reference cone.

User Factor is a factor the physicist may enter to correct for any other known discrepancies, such as elongated fields, sloped patient surfaces, etc. The default is 1.000.

15.1 IMSure QA Electron Data Measurements

Calibration Dose Rate is the absolute dose rate corrected for depth dose at the reference phantom distance (SSD_{ref}) and depth (d_{ref}), for the reference cone for each energy. If the PDD of the 10x10 reference cone at the specified d_{ref} is not 100.0%, then the Calibration Dose Rate must be corrected by multiplying the Calibration Dose rate by the PDD(d_{ref})/100%. For simplicity, PDD data should be normalized to 100.0% at d_{ref} . The reference dose rate, and method of measurement are the responsibility of the clinical physicist.

PDD for each energy and cone should be measured down the central axis with the phantom surface at SSDref. PDD should be normalized to d_{ref}. Additional PDDs may be obtained at varying SSDs.

IMSure has no requirements for the actual depths measured, but in typical use, measurements extending out to the practical range for each energy are preferred (rule of thumb: ½ cm depth for each MeV of energy). IMSure will not extrapolate PDD, and will not compute dose or MU for points that lie outside the PDD table.

OAR should be measured with the phantom surface at the specified SPD, and at several depths. OAR must be normalized to the central axis value for each depth.

In many clinical situations, electron dose will always be specified at the central axis. In this case, where the off axis distances would not be used, the user may choose to use the default single point OAR, which is specified as 1.000 at the reference depth and central axis. IMSure will only allow the user to enter off-axis distances that are contained in this table, and in this case, the user will only be able to enter x and y calculation points as 0,0.

VSSD is the Virtual Source to Surface Distance, and must be measured for each electron energy and each cone. Electron output is affected by jaw and collimator scattering, as well as in-air scattering, and do not follow the inverse square law over large ranges as well as photons do. However, an effective or virtual SSD can be measured and used reliably over short ranges for extended distance use, as are often needed in clinical practice. A typical range for clinical use would be from 100 SSD to 115 SSD.

VSSD can be computed from measured dose at various distances using the method of Khan, with a chamber at the reference depth (d_{ref}) in a water or water equivalent phantom, beginning at SSD_{ref} (e.g. 100 cm) and taking several measurements down to a clinically useful extended distance, 115 cm or 120 cm SSD.

With these measurements, VSSD can be computed by following the algorithm below,

1. Beginning with these measurements, for n points, first compute a set of points,

$$x(i) = \text{Distance}(i) - \text{SSDref} \qquad *.1.a$$

$$y(i) = \text{sqrt}[\text{Dose}(\text{SSDref}) / \text{Dose}(\text{Distance}(i))] \qquad *.1.b$$

2. Compute the average of each set, x' and y'

x' = (x1+x2+...xn)/n , *.2.a

y' = (y1+y2+...yn)/n *.2.b

3. Compute the average area,

xy' = (x1*y1 + x2*y2 + ... xn*yn)/n *.3

4. Compute the average of the distance squared,

xx' = (x1*x1 + x2*x2 + ... + xn*xn)/n *.4

5. Compute the slope (m) of the best least squares fit for these points,

m = (xy' – x'*y'] /(xx' – x'*x') *.5

6. Finally,

VSSD = 1/m – dref *.6

VSSD will vary for each energy and each cone, and must be measured separately. VSSD also vary depending on accelerator and cone construction, but will typically range between 75 and 98 cm.

VSSD Example: For 9 MeV and a 10x10 cone with SSDref of 100.0 cm, six points are measured in Virtual Water™ at various distances from 100 to 115 cm with the chamber at dmax = 1.9 cm and 15 cm backscatter. The measurements are:

i	Distance (cm)	Measurement (nC)	x(i)	y(i)	x(i)*x(i)	x(i)*y(i)
1	100.0	21.34	0	1.000	0.0	0.000
2	103.0	19.91	3	1.035	9.0	3.106
3	106.0	18.62	6	1.071	36.0	6.424
4	109.0	17.45	9	1.106	81.0	9.954
5	112.0	16.38	12	1.141	144.0	13.696
6	115.0	15.41	15	1.177	225.0	17.650
		Average:	7.5	1.088	82.5	8.472

Then, from steps 5 and 6, m = 0.0118, so VSSD = 83.0.

CF should be measured for each cone and energy, with the surface of the phantom as SSDref, and the chamber at depth dref. A series of cutout apertures should be made for each cone, in 10-20% increments, down to 40-60% for the smallest aperture. For example, a 6x6 cone might have 3x3, 4x4, and 5x5 cutouts (and 6x6, by default). A 20x20 cone might range have 10, 12.5 15, 17.5 and 20 cm cutouts. By definition; CF(unblocked field) = 1.000. Typical ranges of CF will be from 0.900 to 1.100, but can go as low as 0.700 for very small cutouts. Additional CF values can be obtained and entered into IMSure for extended SSDs as well.

The root area model for equivalent squares may not be valid for highly elongated fields. For instance, for a 20x20 cone a rectangular aperture of 5 cm x 20 cm is possible, with an FS' = 10.0. But the dose for a 4x20 field can differ from a 10x10 cutout as much as 3%. IMSure does not test for this case. Typically, ratios of long side to short side of 2 or less will follow the root area model fairly well. Limits of the root area model should be tested by the physicist for each cone and energy during the commissioning process. In cases like this, the physicist should verify the computation using additional measurements and make an appropriate correction in the User Factor.

OF(cone, energy) should be measured with a phantom surface set at the at SSD_{ref}, and the chamber at depth d_{ref} for that energy.

Electron PDDs, and OCRs can be imported from comma-delimited files (CSV files), which have the same format as the photon PDD and OCR files. Cone Factors use the same CSV format as the photon OF files.

Electron data rules:

OAR: Must have at least one point = 1.000 at CAX and dmax.

OAR use: OAR depth may be extrapolated. OAR distance must be in table

CF: Must have at least one point (=1.000) for FS' = sqrt(coneX*coneY).

All FS' must be less than sqrt(coneX*coneY).

Minimum FS' of 3 cm

PDD: Must contain at least one point at d_{ref}, which must = 100.0.

PDD depths must increase

OAR distances must increase, depths must increase

VSSD range: 50 to 150

D_{ref} range: 0.1 to 9.999

SSD range: 50 to 150

OF and CF range: 0.1 to 9.9

PDD range 0.0 to 199.9

OAR range; 0.0 to 199.9

User Factor range: 0.1 to 9.9

16 Appendix C: Glossary

Additional Dose Point	The calculated dose delivered to an additional optional calc point by an MU Field. User must specify depth, SSD and optionally OAD.
Asymmetric jaws	Upper or lower jaw pairs that are allowed by the manufacturer to open or close independently.
Block Tray	A plastic sheet placed in the beam path to hold custom Blocks.
Blocked Field Size	The opening defined by the collimating aperture. Often related as an x by y value.
Blocks	Additional non-rectangular blocking of the treatment field, custom built and placed that further collimate the beam into an Effective Field Size. Blocking by MLCs are common. Non-MLC blocking may require a Block Tray.
Calc Point	A three-dimensional point (x,y,z) located either in a patient or a phantom for which dose is computed.
Central Axis vector	The line formed by the source and the isocenter.
Collimator Angle	The rotation of the collimating devices about the line formed between the source and the isocenter.
Computed Fluence Map	The Fluence map computed by this system from imported dMLC or ssMLC files.
Correlation Coefficient	The similarity between the Imported and Computed Fluence maps computed by the method of Xing et al.
Couch Angle	The rotation of the patient or phantom about the vertical line through the isocenter.
CSF, Collimator Scatter Factor	The contribution to the dose variance that results from scatter from the collimating jaws back to the monitor chamber. CSF can be further distinguished depending on the jaw setting, as the scatter from the upper

	jaw is greater than the lower jaw. Energy, Upper Jaw Setting, Lower Jaw Setting and Machine dependent. Always normalized to 1.000 at the Reference Field Size.
Delivered Dose	The dose that the plan actually delivers to a specified Calc point in the phantom or patient.
Depth	The amount of water equivalent material that the beam must penetrate to reach the Calc Point.
Difference Fluence Map	The point-to-point difference between the Imported and Computed Fluence maps.
d_{MAX}	The depth of maximum dose in water or tissue. Varies with field size and energy. Is often generalized to reflect the d_{MAX} under calibration conditions.
dMLC, Dynamic Multi Leaf Collimator	A series of different MLC settings that are treated sequentially to produce the desired fluence profile, or Fluence Map. The dose is delivered without interruption, as the leaves are allowed to move while the beam is turned on.
Effective Equivalent Squares Field Size	The equivalent square model for the Effective Field Size when additional Blocks are used.
Effective Field Size	The reduction of the Collimated aperture by additional blocking.
Energy	A single energy value chosen to specify the penetrating qualities of the photon or electron produces by the machine. Specified in units of MV or MeV.
Equivalent Squares Field Size	A model that relates the rectangular collimated beam to an equivalent square field for purposes of TMR and Output factor computation. Computed as 2*X*Y/(X+Y), where X and Y are the width of the collimator opening for the lower (X) and upper (Y) jaws.
Field	The combination of machine settings that will deliver a specified dose. Also called beam or port. Multiple fields are combined to deliver a plan fraction.
Fluence Map	The spatial variation of the dose through a cross-section perpendicular the direction of the beam that is created by modulating the beam using the dMLC or ssMLC.
FS, Field Size, or Collimated Field Size	The opening defined by the collimating aperture. Often specified as an x by y value.
Gantry Angle	The single planar rotation of the source about isocenter, resulting in the rotation of the beam direction about the isocenter. Allows the beam to be directed into the phantom or patient from any angle in that plane.
IDL, Isodose Line	A percent of the dose to which the prescription is normalized.
Imported Fluence Map	The Fluence map computed by external systems and imported into this system.
IMRT Calc Point	A Calculation point used in an IMRT Plan

IMRT Field	Any Field that is used in combination with dMLC or ssMLC to apply a fluence profile to the treatment.
IMRT Plan	Any plan that is delivered using IMRT.
IMRT QA , IMRT Quality Assurance	The process of verifying that the delivered dose and leaf positions are correct and as intended with a reasonable error threshold.
IMRT, Intensity Modulated Radiation Therapy.	A radiation treatment method that allows the radiation beam to be delivered using fluence modulation.
Inverse Squares Correction	A correction value based on the physics of point source radiation that states that the radiation decreases by the square of the distance.
Isocenter	The virtual point in space that the radiation always points toward regardless of couch, collimator or gantry angle. Most commonly is 1 meter (100 cm).
Leaf Map	The positions of the leaf settings for each segment of a planned dMLC or ssMLC treatment field.
Leaf Segment	The smallest resolvable unit of leaf settings that comprise a leaf map.
Lower Collimating Jaw	A rectangular physical collimating device that modifies the beam aperture from the machine, located further from the source than the upper jaws. Not in all commercial devices. Formed of two opposing jaws, which need not be symmetric for all machines.
Machine	The radiation delivery device. For this software, always refers to a commercially available linear acceleration device.
MLC, Multi Leaf Collimators	An automated blocking system that collimates the radiation beam by adjusting the position of up to 120 Tungsten Leaves to block the beam.
MU Calc Point	A Calculation point used in an MU Plan
MU Dose	The calculated dose at a Calc Point for any field in the MU plan.
MU Field	Any Field that is used in non-IMRT treatments.
MU Plan	A plan that is delivered without IMRT, the historically more common standard.
MU, Monitor Unit	A dose relative value that is delivered by the radiation delivery system.
Nominal SAD	The distance from the radiation Source to the isocenter.
OAD(x), OAD(y)	The length of the constituent vectors of the OAD, relative to the base coordinate system.
OAD, Off-axis Distance	The length of the vector connecting a Calc Point with the central axis, perpendicular to the central axis.
OAR, Off-axis Ratio, open field	The variation in dose or fluence perpendicular to the central axis, normalized to the dose at the central axis at an equivalent depth for an open field. Varies with depth, energy and OAD.
Off-axis Ratio, wedged field	The OAR variation caused by a Wedge, along the wedge axis.
Output factor	A value which relates the Calibrated dose to the actual dose delivered for any field size. The output factor can be separated into two constituents, the Phantom Scatter Factor and the Collimator Scatter Factor, where

	Output Factor = PSF*CSF. Energy, Collimator Field size, Effective Field Size are machine dependent. Always normalized to 1.000 at the Reference Field Size.
Patient	The intended recipient of the intended dose. A patient is represented by a name and ID for this system and for long term documentation.
PDD, Percent Depth Dose	The dose at any depth for any field size relative to the maximum dose for that field size, in percent. Typically specified and measured at SPD = nominal SAD.
Percent (%) Dose Diff.	The percent difference between the IMRT Plan MU and the calculated MU for any IMRT Field.
Percent (%) IMRT Plan Dose Diff.	The percent difference between the total Planned IMRT Dose and the Calculated IMRT Dose of all fields in an IMRT Plan at a calc point.
Percent (%) Field MU Diff	The percent difference between the intended MU and the calculated MU for any MU Field.
Percent (%) Maximum Difference	The largest absolute difference at any point in the Difference Fluence Map.
Percent (%)MU Plan Dose Diff	The percent difference between the intended MU and the calculated MU for any MU Field.
Phantom	A test or measurement device that simulates a patient. Often constructed from water or various plastics in predictable geometric shapes.
Plan	A Plan, or Treatment Plan, consists of one or more Fields that in combination results in the delivery of the Calculated Dose to the Patient. Forms include IMRT Plan or MU Plan.
Prescribed Dose	The dose at a Calc Point that the user intends to deliver.
PSF, Phantom Scatter Factor	The contribution to the dose variance that results from scatter within the radiated material back to the point of measurement. Energy, Effective Field Size are machine dependent. Always normalized to 1.000 at the Reference Field Size.
Reference Depth	The specification depth for the calibrated absolute dose. Nominally is chosen as d_{MAX} for the reference field size.
Reference Field Size	The specification Field Size for the calibrated absolute dose. Nominally is specified as 10cm x 10 cm.
Reference Output Dose	The dose delivered per 1 MU in a water phantom setup at the SPD, at the Reference Depth. Typically specified at 1 cGy per 1MU.
Source	The point in the Machine from which the radiation is emitted.
SPD, Source to phantom distance	The distance from the source to the point used for calibration.
SSD, Source to surface distance	The distance from the radiation course to the surface of the patient. For isocentric plans SSD = nominal SAD - depth. For non-isocentric plans, SSD and depth are independent.
ssMLC, Step and Shoot Multi Leaf Collimator	A series of different MLC settings that are treated sequentially to produce the desired fluence profile, or Fluence Map. The dose is delivered in small incremental stages, and the beam is turned off while the leaves move to the next position.

Sum Additional Dose	The total dose delivered by all fields in a plan to the optional Additional Dose Point. Always assumes that the user has entered the correct coordinates for the additional point for each MU Field in the MU Plan.
Symmetric jaws	Upper or lower jaw pairs that must open or close as a unit.
TMR, Tissue Maximum ratio	Similar to a PDD, but measured for various depths, always at isocenter. Alternatively, and more commonly, can be computed from the PDD mathematically adjusted for the dose reduction effects, by the inverse-squares ratio (see Khan).
Tray Factor	A reduction factor caused by placing a block tray in the beam path.
Upper Collimating Jaw	A rectangular physical collimating device that modifies the beam aperture from the machine, located closer to the source than other jaws. Formed of two opposing jaws, which need not be symmetric for all machines.
User Factor	An allowed factor that the user may enter to compensate for any un-modeled adjustment to an MU field, for instance an Ellis Block compensator device.
Wedge angle	The angle of the slope of the wedge profile. Typically, 15, 30, 45 and 60 degrees.
Wedge Factor	The measured average reduction of the beam output relative to an equivalent open (non-wedged) field.
Wedge, Physical wedge, Hard wedge	A wedge shaped device, usually fabricated from steel, brass or lead that modulates the fluence profile along one axis to produce a sloped or wedged field profile.

17 Appendix D: Physics Data Import Formats

TMR Table:
Version,<Version #>
Table,TMR
Depth,<List of depths, delimited with commas>
FieldSize,<List of field sizes, delimited with commas>
Data,<List of TMR values for first depth>
<Blank>,<List of TMR values for second depth>
…
<Blank>,<List of TMR values for last depth>

Example :
Version, 1
Table,TMR
Depth,0,0.2,0.5,1,1.5,2
FieldSize,0,4,5,6,7,8
Data,0,0.048,0.06,0.072,0.083,0.095
,0.287,0.332,0.343,0.354,0.364,0.375
,0.518,0.556,0.564,0.572,0.579,0.587

,0.746,0.772,0.776,0.781,0.786,0.791
,0.847,0.854,0.859,0.864,0.871,0.878

OCR Table (photon and electron):
Version,<Version #>
Table,OCR
Depth,<List of depths, delimited with commas>
Distance, <List of field sizes, delimited with commas>
Data,<List of OCR values for first depth>
<Blank>,<List of OCR values for second depth>
...
<Blank>,<List of OCR values for last depth>

OF Table:
Version,<Version #>
Table,OF
FieldSize,<List of field sizes, delimited with commas>
Data,<List of OF values at each FieldSize>

Scatter Table:
Version,<Version #>
Table,Scatter
FieldSize,<List of field sizes, delimited with commas>
Data,<List of Scatter values at each FieldSize>

PDD Table (electron):
Version,<Version #>
Table,PDD
Depth,<List of depths, delimited with commas>
SSD,<List of SSDs, delimited with commas>
Data,<List of PDD values for first depth>
<Blank>,<List of PDD values for second depth>
...
<Blank>,<List of PDD values for last depth>

Cutout Factor Table (electron):
Version,<Version #>
Table,CF
FieldSize,<list of field sizes, delimited with commas>
SSD,<list of SSDs, delimited with commas>
Data,<List of Cutout Factor values for first field size>
<Blank>,<List of Cutout Factor values for second field size>
...
<Blank>,<List of Cutout Factor values for last field size>

18 Appendix E: Source Modeling, Geometry and Computation

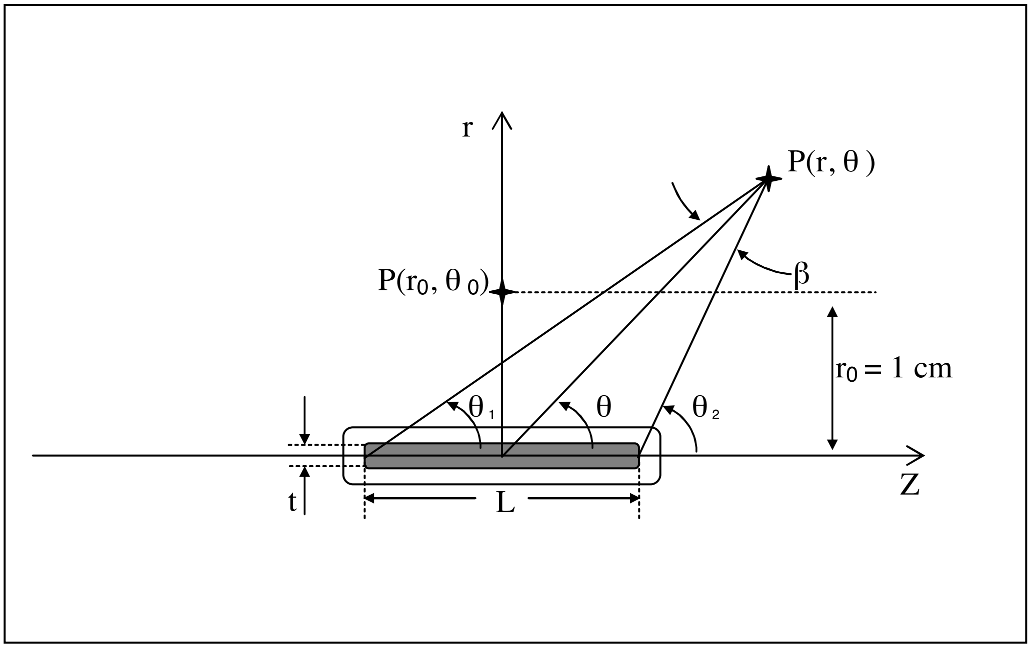


Figure 1. Cylindrically symmetric line source geometry

The IMSure Brachytherapy Calculation Algorithm can calculate the dose to any point in space for seed and line sources. Calculation of dose begins with a model of the dose rate, which follows the method proposed by the AAPM Task Group 43 (TG-43 and TG-43U).

18.1 2-D Cylindrical Dose Rate Formalism

Source construction is typically cylindrically symmetric. Using the geometry illustrated in figure 1, the Dose Rate $\dot{D}(r,\theta)$, in cGy/h is defined as

S_K = the air kerma strength of the source, specified in U, uGy m^2/h, or cGy cm^2/h, and is measured and specified by NIST for any given source construction, and the dose rate is constant, , in cGy/h, is

$$\dot{D}(r,\theta) = S_K * \Lambda * [G_X(r,\theta) / G_X(r_0,\theta_0)] * g_X(r) * F(r,\theta) \qquad \text{Eq. 1}$$

$G_X(r,\vartheta)$ is a geometry factor, specified in 1/m^2 and accounts for the increase in dose rate with increasing distance from a source. The subscript, X, can be either ‘P’ for a point source geometry or ‘L for a line source. For a point source, the dose rate is a purely spherical inverse squares function,

$$G_P(r) = \frac{1}{r^2} \qquad \text{Eq. 2}$$

and is invariant with ϑ. For a linear source, as in figure 1, the active length of the source and the angle, β, subtended by the active source with respect to the point (r,ϑ) will affect the inverse square dose fall off as, follows.

$$G_L(r,\theta) = \frac{\beta}{Lr\sin\theta} \qquad \text{for} \qquad \theta \neq 0\,, \quad \text{or} \qquad \text{Eq. 4a}$$

$$G_L(r,\theta) = \frac{1}{r^2 - L^2/4} \qquad \text{at} \qquad \theta = 0\,, \qquad \text{Eq. 4b}$$

From figure 1, it can be seen that $\beta = \vartheta_2 - \vartheta_1$, is always positive, and can range from $0 < \beta < \pi$. In the transverse axis, for a source of 3 mm, at the nominal specification distance (r_0,ϑ_0), G_L will not equal unity. This must be corrected for any line source geometric model in Eq. 1, by normalizing point, as $G_L(r,\vartheta)/G_L(r_0,\vartheta_0)$.

$g(r)$ is a radial dose function, which accounts for dose fall-off due to scatter and absorption along the transverse axis of the source. As above, the subscript, X, can be either ‘P’ for a point source or ‘L for a line source. It is defined as

$$g_X(r) = D(r,\theta_0) * G_X(r_0,\theta_0) / D(r_0,\theta_0) / G_X(r,\theta_0) \qquad \text{Eq. 5}$$

$F(r,\vartheta)$ is the anisotropy function, which accounts for the effect of differential scatter and absorption at all angles off of the transverse axis. Effectively, $F(r,\vartheta)$ accounts for all remaining variations not already modeled or measured by the radial dose function and the geometry factor. Similar to the way the dose rate function is the residual error along the transverse axis (or plane in 3-space), the anisotropic function is the residual dose at any other angles away from the transverse plane, and is defined as,

$$F(r,\theta) = D(r,\theta) * G_L(r,\theta_0) / D(r,\theta_0) / G_L(r,\theta_0) \qquad \text{Eq. 6}$$

Note that by definition, for all points along the transverse plane, $F(r,\pi/2)=1$.

To better understand the origins of each of these contributions to dose, consider a simple, perfectly spherical, dot of radioactive material in a vacuum. At any distance from the sphere larger than a few radii, the source will behave as a point source. In a vacuum, there will be no scatter, and the only geometrical effect will be the inverse squares affect. So the dose at any point will only depend on 1/r2, the activity of the source, and the kerma strength. As in vacuo measurements are difficult, the actual measurements are conducted in air. Air Kerma strength is a measured value, and will differ for any isotope and source construction. In fact, it will differ for each individual source, but one tenet of brachytherapy is that sources of similar construction and isotope will behave similarly enough that they are interchangeable.

So, for the perfect sphere/point source in a vacuum,

$$D(r) = S_K * \Lambda / r^2 \quad \text{(cGy/hr)} \qquad \text{Eq. 7}$$

Now, take that simple source from the vacuum, and place it into any homogenous medium. Depending on the energy of the source, there will be both scattering and absorption imposed on the radiation emitted from the source. Because we are still working with a perfect, small sphere, this radiation will be identical for any angular or azimuthal direction, only varying with radius.

$$D(r) = S_K * \Lambda / r^2 * g_P(r) \quad \text{(cGy/hr)} \qquad \text{Eq. 8}$$

This radial dose function is defined as in Eq 5, but can be fit to various functions, the most common being a 5th order polynomial,

$$D(r) = S_K * \Lambda / r^2 * g_P(r) \quad \text{(cGy/hr)} \qquad \text{Eq. 8}$$

This fitted function must also specify a range over which the dose rate function is valid. Typically, this range might be from 0.5 cm to 7 cm.

For this example range, beyond 7 cm the effects of the dose rate function can be ignored, as inverse square fall off will dominate any model. Closer than 0.5 cm to any source, however, is very difficult to measure in the laboratory. Points closer to a source than the innermost valid range boundary should not be calculated, or should be labeled as uncertain.

For many sources, which are not perfect point sources but are close enough to treat as point sources, the anisotropy can be further condensed into a simple radial anisotropy. This method effectively averages the entire dose over all angles into a single radial average, called the anisotropy factor,

$$\varphi_{an}(r) = \frac{1}{2D(r,\theta_0)} \int_{\theta=0}^{2\pi} D(r,\theta)\sin\theta \, d\theta \qquad \text{(Unit less)} \qquad \text{Eq. 10}$$

Typically, $\varphi_{AN}(r)$ for most clinical sources will be between 0.9 and 1.00. However, this depends on source construction and is not a requirement of the math or model. The final dose rate is

$$D(r) = S_K * \Lambda / r^2 * g_P(r) * \varphi_{an}(r) \quad \text{(cGy/hr)} \qquad \text{Eq. 11}$$

TG-43 allows the anisotropy factor to be further condensed into a distance independent constant, called the anisotropy constant, $\bar{\varphi}_{AN}$. It should be noted that using models using $\bar{\varphi}_{AN}$ instead of $\varphi_{AN}(r)$ or $F(r,\vartheta)$ will modify the actual final dose rate. IMSure Brachy allows this, but requires the physicist to use the 1-D function, $\varphi_{AN}(r)$, to describe the scalar value, $\bar{\varphi}_{AN}$. It is the physicists' responsibility to enter all values in the models and account for interactions of the various simplifications.

18.2 Model based dosimetry vs. tabular values

These dose functions are painstakingly measured, but can also be obtained using complex Monte Carlo Brachytherapy calculations. These dose functions can, and often are, fit to polynomial functions (historically referred to in Brachytherapy as Meisberger coefficients). Polynomial functions have an inherent danger, in that, they can be ill-behaved outside valid fit ranges. For instance, a 3rd order function can vary drastically outside the original fit range, and TG-43 recommends using at least 5th order polynomials for this reason. With modern computation speeds, the errors (although small) introduced by such models are unnecessary, so IMSure will always use an interpolated value of tabular data for dose rate and anisotropic functions. Should the user prefer better resolution for any given function, the user is free to replace the data tables with different (even variable) sampled data of either measured data or model fit generated data. TG-43U goes so far as to state a preference for tabular functions, but will allow modeled functions.

Some tables will lend themselves to a few simple models, but the user should be aware that the actual data used in computation will be from the table, and not the model used to generate the table. Geometric functions are, however, computed. The reasoning behind this is that the geometric function is perfect and pre-defined, while the dose rate function and anisotropy functions are the residual at any point in space that does not fit the geometric model.

Again, many of these 3D to 1D simplifications have been introduced to simplify calculations. Given the speed of modern computers, there is little reason to make these approximations. An improved dose estimate will result from using the 2D cylindrical measured data whenever possible.

18.3 Dose

The Dose, $D(r,\vartheta)$, at any point in space are a combination of dose and time,

$$D(r,\theta) = \dot{D}(r,\theta) * t \qquad \text{(specified in cGy)} \qquad \text{Eq. 12}$$

For multiple sources, the dose at any point in space is a simple superposition of dose from each source,

$$D(r) = \sum_{j=1}^{m} \dot{D}(r - r_j) * t_j \qquad \text{Eq. 13}$$

for m point sources of spherical geometry, and

$$D(r,\theta) = \sum_{j=1}^{m} \dot{D}(r - r_j, \theta - \theta_j) * t_j \qquad \text{Eq. 14}$$

for m line sources of cylindrical symmetry.

18.4 3-D Cartesian calculations using 1-D spherical and 2-D cylindrical sources

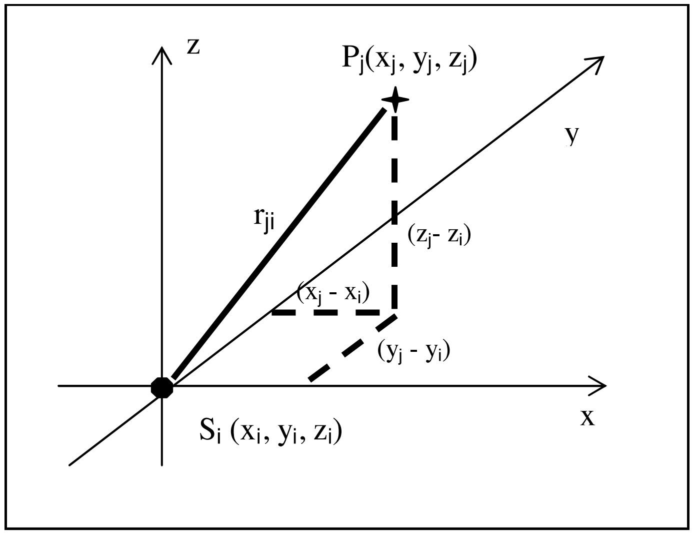


Figure 2: 1-D geometry in 3D space

Dose rate for a spherically symmetric 1-D point source (figure 2), to any calculation point, in 3-D Cartesian coordinate space (x, y, z) can be computed as the distance, r_{ji} from any point, $P_j(x_j, y_j, z_j)$, to the source, $S_i\ (x_i, y_i, z_i)$, is,

$$r_{ji} = \sqrt{(x_j - x_i)^2 + (y_j - y_i)^2 + (z_j - z_i)^2} \qquad \text{Eq. 15}$$

For a cylindrically symmetric 2-D line source, the alignment of the source in 3-D Cartesian space must be must be specified. This specification can either be by using the two end points of the active source, $S_{a,\ i}\ (x_{a,\ i}, y_{a,\ i}, z_{a,\ i})$ and $S_{b,\ i}\ (x_{b,\ i}, y_{b,\ i}, z_{b,\ i})$, or using the center of the source, $S_{o,\ i}\ (x_{o,\ i}, y_{o,\ i}, z_{o,\ i})$, and two rotational angles, Ψ_i and ϕ_i as shown in figure 3.

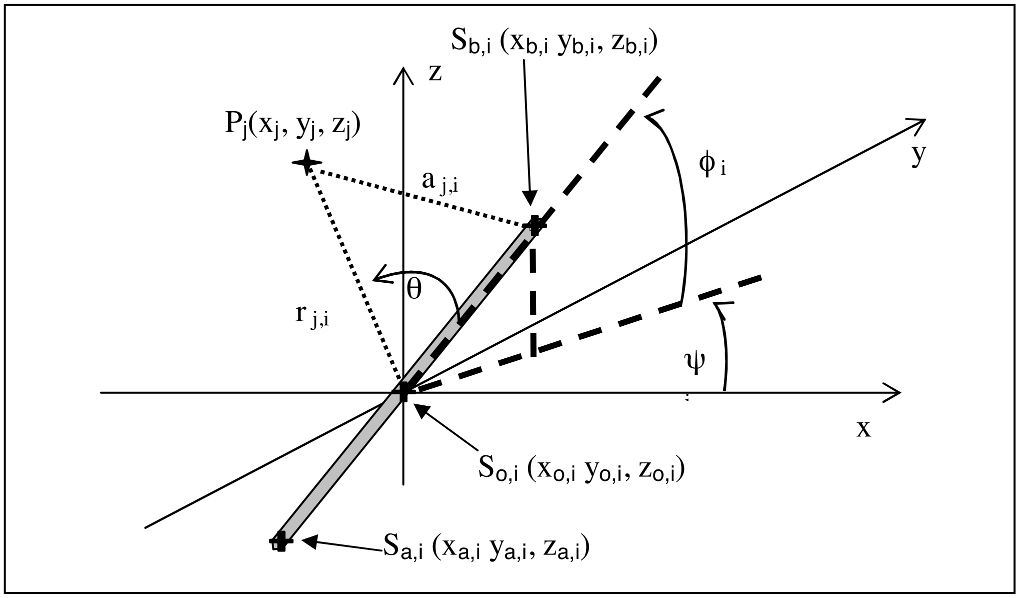


Figure 3: 2-D geometry in 3D space

Using the end point method, the distance, $r_{j,i}$, from the calculation point, P_j , to the center of the source, S_i is,

$$r_{j,i} = \sqrt{\left(x_j - \left(x_{b,i} + x_{a,i}\right)/2\right)^2 + \left(y_j - \left(y_{b,i} + y_{a,i}\right)/2\right)^2 + \left(z_j - \left(z_{b,i} + z_{a,i}\right)/2\right)^2} \quad \text{Eq. 15}$$

The angle, $\theta_{j,i}$, subtended by the rotated line source, S_i to the calculation point, P_j, is

$$\theta_{j,i} = \cos^{-1}\left[\frac{L/2 + r_{j,i} + a_{j,i}}{r_{j,i} * L}\right] \quad \text{Eq. 16}$$

where, L is the length of the source, and the distance, $a_{j,i}$, between the distal source endpoint, S_b and the calculation point, P_j , is

$$a_{j,i} = \sqrt{\left(x_j - x_{b,i}\right)^2 + \left(y_j - y_{b,i}\right)^2 + \left(z_j - z_{b,i}\right)^2} \quad \text{Eq. 17}$$

Normally, the end-point information will not be available from the imported plan data. However, provided more than one source on each catheter is available in the imported plan, the end-points can be determined using a simple spline as in figure 4 below.

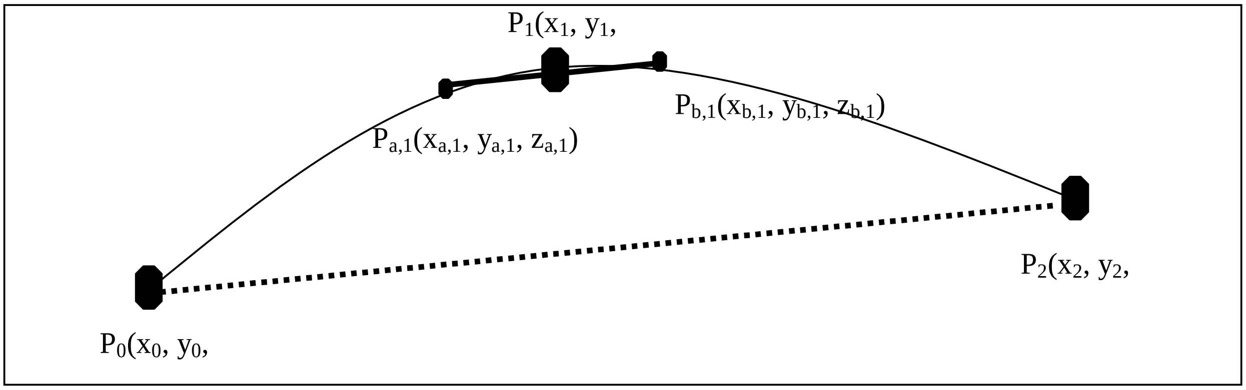


Figure 4: Source end point determination on catheters with 3 (or more) sources

As in figure 4, given three points sources P_0, P_1 , and P_2 , the end-points of the central source, $P_{a,1}$ and $P_{b,1}$, can be determined by

$$x_{b,1} = x_1 + \frac{(x_2 - x_0)}{|r|}, \quad x_{a,1} = x_1 - \frac{(x_2 - x_0)}{|r|}, \qquad \text{Eq. 18a, b}$$

$$y_{b,1} = y_1 + \frac{(y_2 - y_0)}{|r|}, \quad y_{a,1} = y_1 - \frac{(y_2 - y_0)}{|r|}, \text{ and} \qquad \text{Eq. 18c, d}$$

$$z_{b,1} = z_1 + \frac{(z_2 - z_0)}{|r|}, \quad z_{a,1} = z_1 - \frac{(z_2 - z_0)}{|r|} \qquad \text{Eq. 18e, f}$$

where

$$|r| = L/2 * \sqrt{(x_2 - x_0)^2 + (y_2 - y_0)^2 + (z_2 - z_0)^2} \qquad \text{Eq. 18g}$$

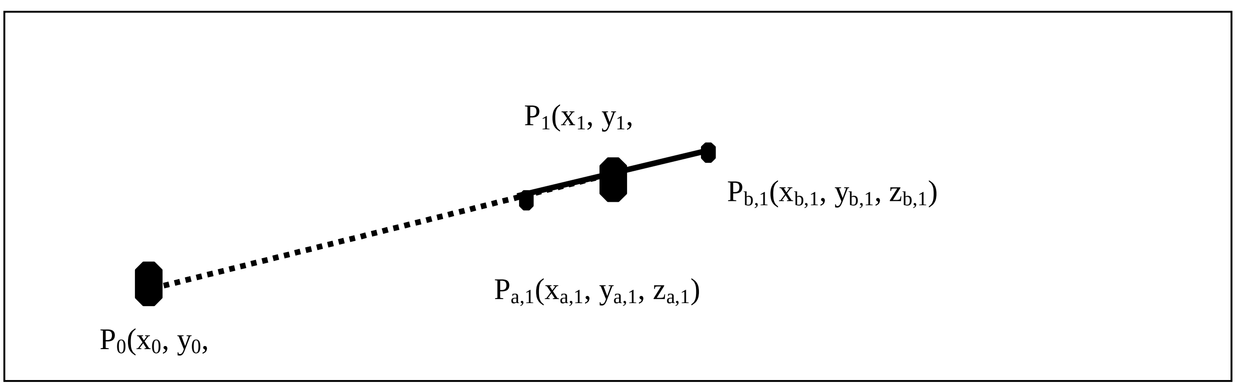


Figure 5: Source end point determination on catheters with 2 sources

If only two points - P_0, and P_1 - exist in the catheter, or for the first or last two points in a catheter (figure 5), the end-points of the central source, $P_{a,1}$ and $P_{b,1}$, can be determined by

$$x_{b,1} = x_1 + \frac{(x_1 - x_0)}{|r|}, \quad x_{a,1} = x_1 - \frac{(x_1 - x_0)}{|r|}, \qquad \text{Eq. 19 a, b}$$

$$y_{b,1} = y_1 + \frac{(y_1 - y_0)}{|r|}, \quad y_{a,1} = y_1 - \frac{(y_1 - y_0)}{|r|}, \text{ and} \qquad \text{Eq. 19 c, d}$$

$$z_{b,1} = z_1 + \frac{(z_1 - z_0)}{|r|}, \quad z_{a,1} = z_1 - \frac{(z_1 - z_0)}{|r|} \qquad \text{Eq. 19 e, f}$$

where

$$|r| = L/2 * \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2 + (z_1 - z_0)^2} \qquad \text{Eq. 19g}$$

Inspection of figures 4 and 5 will show why the 3 source method for end-point determination is preferable to the two-point method, whenever possible. However, in catheter-based brachytherapy, very little curvature is possible, and the positional error will be negligible.

18.5 Discussion

Given that all brachytherapy begins with measured values, one might ask why bother with breaking down the dose into all of these functions. The most important reason is to remove the overriding geometric function from the model, so that very small effects at large distances can be more accurately computed. For single source brachytherapy, this is relatively unimportant, but for brachytherapy with many (over 100 sources) these small errors can add up and become clinically significant.

As there are no true point sources in clinical use, it would seem that a 1D point source model is unneeded. However, in many cases, such as for permanent seed implants, the actual linear alignment cannot be predicted before implantation, nor well characterized post-implantation. In such cases, the point source model gives the best approximation of the actual dose. Various studies, and routine experience will show that loose seeds will fall off the implanted alignment in enough of a random pattern to effectively average out the cylindrical anisotropy. TG-43U strongly recommends only using point source models when clinically appropriate, e.g. when dose at distances great than 1 cm from sources is of interest. This would be the case for loose seed implants, where dose < 1 cm proximal to any given seed can be in error but is of low interest in the scheme of 50-200 seed implants.

Although not covered in TG-43 or TG-43U, brachytherapy with non-azimuthal symmetry may also be possible. Currently no manufacturer intentionally produces sources with known or modeled azimuthal deviations, however, the possibility exists, and is likely to become clinically common, if not desirable. This 3D calculation is a simple extension of the 2D model, including D(r, θ,ϕ) and requires a tremendous number of dose distributional points to be measured. At this time, IMSure Brachy does not accommodate the spherical 3D model approach.

Tables and Extrapolation

With the exception of the geometrical functions, IMSure Brachy only uses the tabular data for 1D and 2D functions to compute dose. An option exists for any source to allow IMSure to extrapolate beyond valid or specified regions. For example, for a simple table shown below

Pt#	r(cm)	Phi AN (r)
1	0.5	0.99
2	1.0	1.00
3	2.0	0.96
4	5.0	0.95

For any calculation point closer than 0.5 or further than 5.0 cm, IMSure will not return a valid dose value, unless "Allow Extrapolation for Phi direction" box is checked in the model parameters for that particular source model. If allowed, a zero-order extrapolation will be used. Therefore, in this example, for all points closer than 0.5 cm, the value returned for phi(r) will be 0.99 and for all points greater than 5.0 would be 0.95.

Along any axis of a 1D or 2D table (r or θ), at least two points must be specified to be valid, unless the "Allow Extrapolation for XXX direction" box is checked for the table. A check option is allowed for each axis (r or θ) for any table. Regardless of allowed user preference, any calculation point requiring an extrapolation will be flagged as a warning in the calculation results.

18.6 Example figures

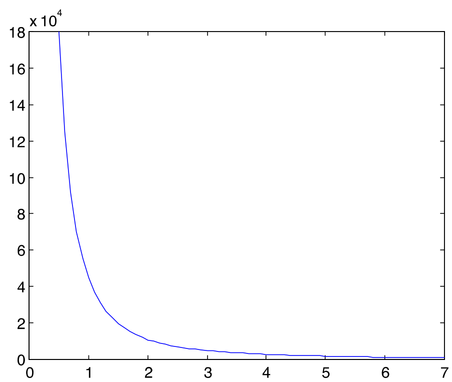


Figure 6a. 1D Dose Rate with distance

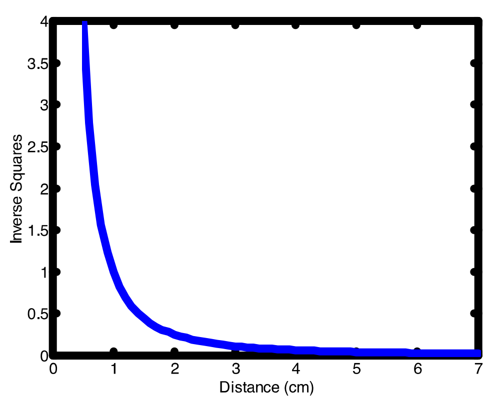


Figure 6b: 1D inverse squares function

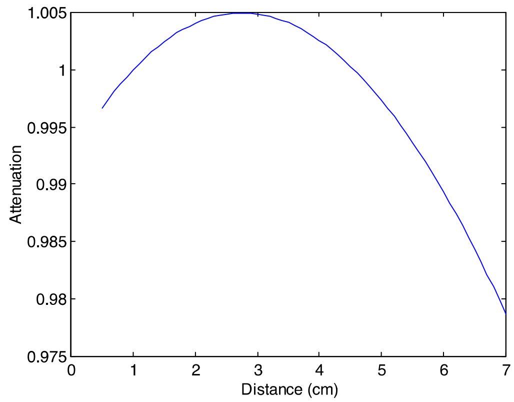


Figure 6c. A 1D dose rate function, g(r)

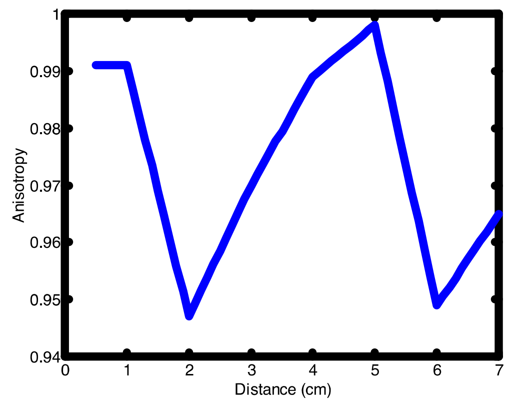


Figure 6d. A 1-D radial anisotropy function

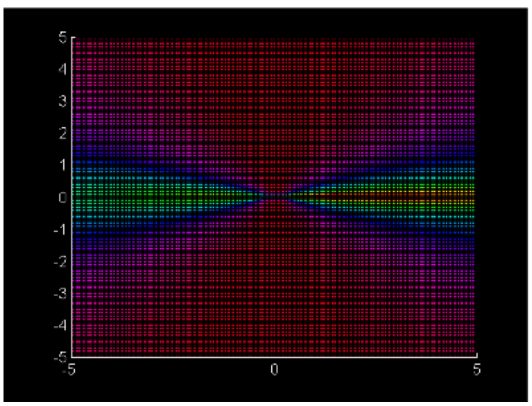


Figure 7a. , F, 2D anisotropy function

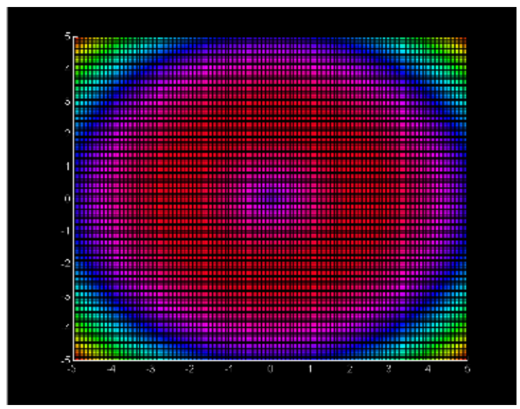


Figure 7b. G_L , 2D radial dose function

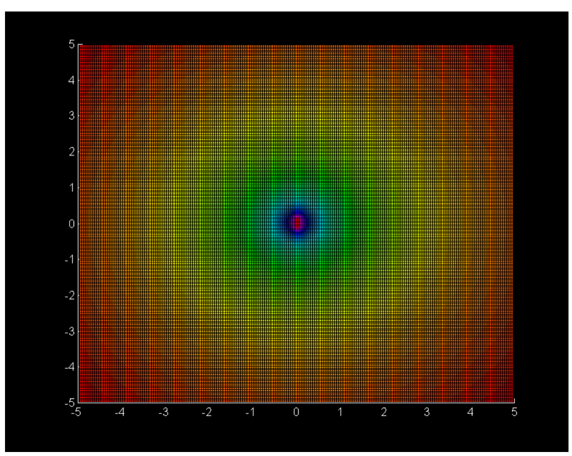


Figure 7c g_L- 2D Line source geometry

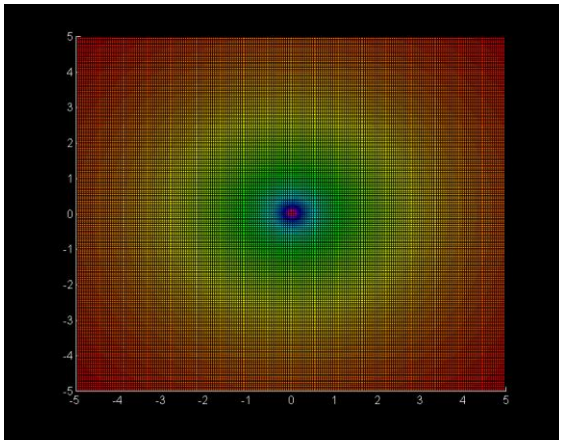


Figure 7d g_P- 2D Point source geometry

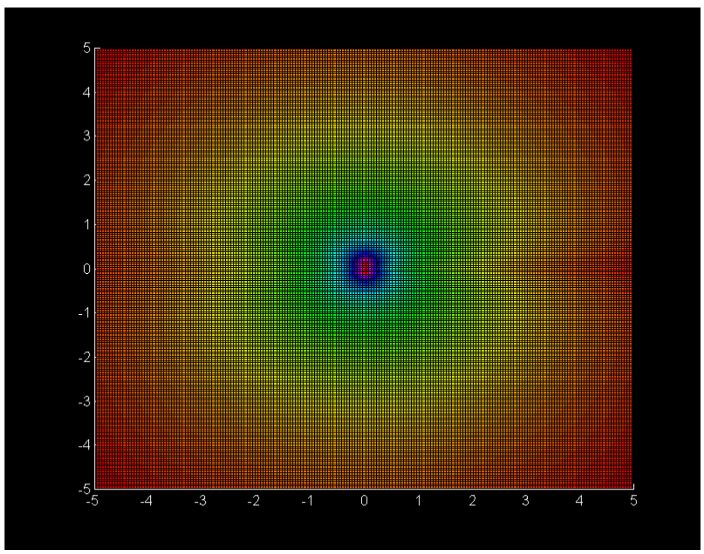


Figure 7e: Dose rate in 2D for a 3 mm line source with g_L, F, G_L

19 Appendix F: IMSure QA Machine Data

Most data required for IMSure QA are similar to the data normally acquired during commissioning of a linear accelerator. With all data readily available, an entire dual energy machine can be set up in as little as a half hour. The items needed for machine data configuration are listed in Table A below.

Items like machine names, configuration, tray factors and calibration specifications can be entered directly in the Physics Module. Tabular data such as TMR, PDD, OCR, OF and Sc must be imported from .csv format files as specified at the end of this guide. Some consistency rules that apply to the imported data are listed in Table B following the discussion of data formatting.

Other machine parameters such as jaw distances, rotation configurations, and average MLC leaf leakages are needed: these parameters are defined in Table A. Jaw distances are common for all available machines and can be noted from our sample data or from Table C on page <OV>. Leaf leakages are also fairly uniform from machine to machine, and this parameter may also be used to make small corrections in final IMSure QA IMRT results.

As many photon and electron energies as desired can be entered along with their respective wedges and cones (i.e., both upper and lower wedges, even old-fashioned split wedges and half beam blocks).

Table A: Machine Names, Configurations, Parameters and Data Used in IMSure QA

Names and Configurations	
Import Machine Name	Must match exactly the name used in the imported RTP or DICOM-RT convention.
Abbreviated Name	Short name for printouts
Manufacturer	(optional)
Machine Model	(optional)
Serial Number	(optional)
Location	(optional)
Nominal SAD	Typically 100 cm.
Nominal Electron Cone Gap	Typically 5 cm. This is the distance from the bottom of the electron cone to the patient surface at 100 cm SSD.
Beam Energy	Nominal in MV (photon) or MeV. (electron)
Nominal dMAX	Depth of maximum dose [cm].
Reference Depth	Depth [cm] at which the calibrated dose rate is set.
Calibration Field Size (Photons)	Length [cm] of square reference field, typically 10 cm.
Calibration Cone Size (Electrons)	Choose from the drop down list of available cones.
Calibration Source-to-Phantom Distance	Distance [cm] to the surface of the calibration phantom. This is typically 100 cm.

Diode Calibration Factor	Calibration factor for diodes used with this energy.
MLC Type	Choose your MLC configuration from the drop down list.
Default CT-ED Lookup Table	Select the CT to Electron Density table to be used for automatic SSD and effective depth calculations for this machine. New tables can be entered using the Edit button.
Wedge Name (Photons)	Common wedge name for hard wedges (e.g. 15 deg). A default zero degree wedge named 'Open Field' must be present for all photon energies.
Wedge Angle (Photons)	The numerical value for the wedge angle. Must match the value used in the imported RTP or DICOM-RT convention.
Cone Name	Common cone name for electron cones (e.g. A10).
Cone Size	The numeric value of the cone that describes its dimension in both the X and Y directions [cm].
Machine Geometry – IMSure QA defaults to the IEC 1217 Convention	
Base Gantry Angle	IEC 1217 Convention describes 0 degrees as the Gantry pointing down. If your system describes 0 degrees as the Gantry pointing up you would insert 180 to let IMSure QA know that your coordinate system is set 180 degrees from the IEC standard.
Gantry Rotation Direction	IEC 1217 Convention describes Gantry rotation increasing clockwise (CW) if one is facing the Gantry from the foot of the couch. The 90 degree position then places the head of the accelerator to the right if one is facing the gantry from the foot of the couch.
Collimator Angle	IEC 1217 Convention describes 0 degrees as the Y1 (A1) jaw oriented towards the foot of the couch. If your system describes 0 degrees as the Y1 jaw towards the Gantry you would insert 180 to let IMSure QA know that your coordinate system is set 180 degrees from the IEC standard.
Collimator Rotation Direction	IEC 1217 Convention describes Collimator rotation increasing clockwise (CW) if one is facing the collimator while lying on the table in standard HFS position. 90 degrees would then place the Y1 jaw toward your left hand in the HFS position.
Table Rotation Angle	IEC 1217 Convention describes 0 degrees as the head of the table pointing toward the gantry. If your system describes 0 degrees as the foot of the table pointing toward the gantry you would insert 180 to let IMSure QA know that your coordinate system is set 180 degrees from the IEC standard.

Table Rotation Direction	IEC 1217 Convention describes Table Rotation increasing clockwise (CW) if one is looking up at the bottom of the table. The 90 degree position would then orient the table such that the gantry is on the left side of a head first supine patient.
Jaw Naming Conventions	May differ between manufacturers. Two alphanumeric characters allowed.
Jaw limits	Machine dependent, may include over-travel. Specified for both upper and lower jaws.
Allowed Field Size Limits	May differ for open and wedged data. May be specified in rectangular form, as for most hard wedges.
Source to Jaw Distances	See Table C for a list of standard values.
Allowed EDW Wedge Angles	Any of 10, 15, 20, 25, 30, 45 and 60 degrees may be chosen.
Source to MLC distances	See table C for a list of standard values.
Allowed Wedge Directions	Refers to the thin end (toe) of wedge for physical wedges.
Measurements and parameters	
Calibration Dose Rate	Dose rate [cGy/MU], at the reference depth and the calibration source-to-phantom distance
Tray Factor (Photons)	Tray Field/Open Field (values should be less than 1.000).
Mean Dose Leaf Leakage (Photons)	Percent of inter-leaf dose leakage. This value is used in the 3-source model and is typically between 1% and 3%.
Mean Fluence Map Leaf Leakage (Photons)	Percent of inter-leaf fluence leakage, usually identical to mean dose leaf leakage and used by the 3-source model for map comparisons. Typical values are between 1% and 3%.
Dosimetric Leaf Offset (Photons)	The distance from the light field edge of an MLC leaf to the radiation field edge.
Wedge Factor (Photons)	Ratio of the wedged field dose at the reference depth to the corresponding open field dose at the reference depth. This value is required for only the calibration field size (usually 10x10 cm).
EDW Wedge Factors (Photons)	Derived from Segmented Treatment Tables (STT). The user must choose the STT energy.
EDW Off-Axis Factors	Table used to correct the STT-calculated EDW wedge factors, especially for points away from the center of the field.
Electron Output Factor	Sometimes called a cone factor, this value is the ratio of the dose at the reference depth for the indicated cone to the dose at the reference depth for the calibration cone.

VSSD (Electron Only)	Virtual Source to Surface Distance, useful over short ranges for extended distance electron calculations.
Tabular Input Data – Tables below must be read in from .csv (comma delimited) files set up in proprietary IMSure QA format.	
TMR (Photons)	Tissue Maximum Ratio, determined for a range of open and wedge field sizes. See discussion below.
PDD (Electrons)	Percent Depth Dose, determined for each cone size and energy. See discussion below.
OCR (Photons and Electrons)	Off Center Ratio, determined at multiple distances and depths for the largest available photon fields (open and wedge field) and for each electron cone. See discussion below.
OF (Photons)	Output Factor, determined for a range of open and wedge field sizes. See discussion below. (For electron output factors, see definition above and discussion below.)
CF (Electrons)	Cutout Factor, determined for blocked fields for each electron cone and energy. See discussion below.
Sc (Photons)	Head Scatter Factor, sometimes called Collimator Scatter Factor, determined for a range of open field sizes. See discussion below.

All tabular data can be read into IMSure QA from a comma delimited file (see format below or the Sample Data CD-ROM for samples). The .csv file format was chosen because it is easily manipulated in Excel spreadsheets.

19.1 What beam data are needed?

The physics data required for setting up IMSure are similar to the data acquired during commissioning of a linear accelerator. Therefore most people will already have the necessary information. All data need to be set up in a proprietary .csv (comma delimited) format that can be created easily with Microsoft Excel. Examples of these files can be found in the Sample Data folder that installs in the IMSure X.X directory (see “Using the Sample Data” on page 12).

Photon Open Field Data

- TMR – Tissue -Maximum Ratio
  - Ratio of dose at depth to the dose at the same position but at a depth d_{MAX}. The field size at the measurement position should not change.
  - TMR values should be determined for a range of field sizes including the smallest and largest available fields, with a zero field size value extrapolated from available data. See the IMSure technical note, Obtaining and extrapolating data for IMSure calculations, that is available from Standard Imaging.
  - TMR must be normalized to the d_{MAX} value and should encompass all clinically relevant depths.

- OCR – Off-Center Ratio (also known as Off-Axis Ratio)
  - Ratio of dose away from the central axis to the dose at the same depth but on the central axis.
  - Only the largest field size is needed; e.g. 40 cm.
  - Ideally OCR data are measured at 100 cm SSD and at multiple depths including d_{MAX}; e.g. d_{MAX}, 5, 10, 15, 20, and 30 cm.
  - OCR data must be normalized to the central axis value. By definition, then, the OAR value at each depth on the central axis is 1.000.
  - For open fields, a diagonal scan, if available, may provide more reliable results. Half beam scans may be used, but must be mirrored before import. IMSure QA does not distinguish between radial (inplane) and transverse (crossplane) scans, but averaged scans of transverse and radial profiles are also acceptable.
  - Correction for depth dependent divergence is made by IMSure QA. No correction is made for the minor variances due to the true divergent depth at off-axis positions, but as the depth to the specification calculation point is defined as the depth the central axis, no correction is required.
- OF – Output Factor
  - Ratio of dose at d_{MAX} for a given field size to dose at d_{MAX} for the calibration field size.
  - The algorithms in IMSure require that output factors be measured at or re-calculated to 100 cm SAD and d_{MAX} depth; however the data are usually acquired using an SAD setup and a deeper depth (5 cm or 10 cm), to decrease the influence of electron contamination.
    - For output factors measured at a different depth, IMSure will automatically re-calculate the output factors at d_{MAX} as long as the measurement depth is specified in the setup and TMR tables have been imported previously (see “Setting up your data for IMSure” on page <OV>).
  - The output factors should be measured for a range of field sizes including the smallest and largest possible fields, and data should be normalized to the calibration field size (10x10 cm). A zero field size output factor needs to be extrapolated for the model. See the IMSure technical note, Obtaining and extrapolating data for IMSure calculations, that is available from the Standard Imaging website. A typical OF table will look like this:

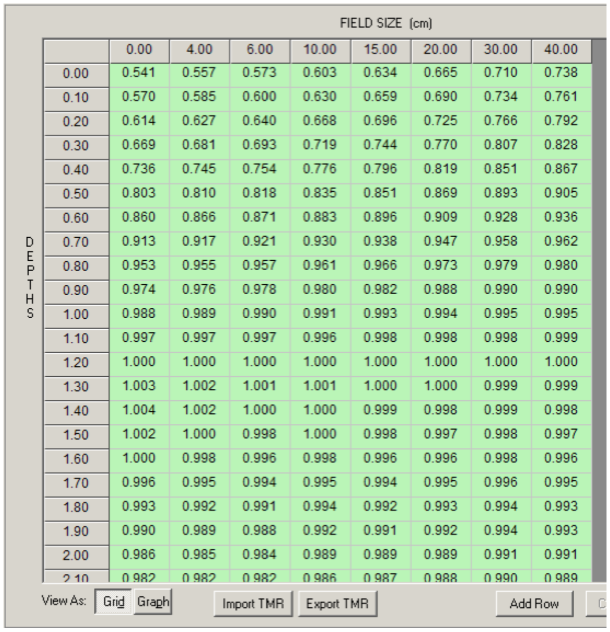
FS	OF	OF dmax	Sp
0.00	0.814	0.814	0.888
3.00	0.905	0.905	0.960
4.00	0.935	0.935	0.967
6.00	0.964	0.964	0.980
8.00	0.985	0.985	0.992
10.00	1.000	1.000	1.000
12.00	1.014	1.014	1.007
15.00	1.030	1.030	1.013
20.00	1.047	1.047	1.021
25.00	1.066	1.066	1.026
30.00	1.080	1.080	1.029
35.00	1.092	1.092	1.031
40.00	1.100	1.100	1.033

- Sc – Head Scatter Factor
  - Ratio of dose in air (or in a mini-phantom) for a given field size to the corresponding dose for the reference field size.
  - Sc is measured for each field size at isocenter (SAD) with a miniphantom or an appropriate buildup cap of at least d_{MAX} effective radius over the measurement chamber. Sc is normalized to the calibration field size (generally 10x10 cm).
  - A zero field size Sc is needed in the 3-source model for the open field data, and this may be extrapolated from the small field size data. Because of the nature of the model, clean Sc data at every cm below 10x10 cm will provide the best results for the 3-source model, although measurements below 3 x3 cm tend to be suspect due to the difficulty of measuring fields this small accurately. See the IMSure technical note, Obtaining and extrapolating data for IMSure calculations, that is available from the Standard Imaging website.
  - Sc is not necessary for wedged fields as this is automatically calculated from the formula Sc(wedged) = OF (wedged)/Sp(open).
  - A typical Sc table will look like this:

FS	Imported Sc	Computed Sc
0.00	0.917	0.920
3.00	0.942	0.944
4.00	0.967	0.957
6.00	0.984	0.982
8.00	0.994	0.994
10.00	1.000	1.000
12.00	1.007	1.006
15.00	1.016	1.015
20.00	1.025	1.028
25.00	1.038	1.039
30.00	1.050	1.049
35.00	1.059	1.058
40.00	1.065	1.065

Photon Wedge Data

- TMR – Tissue Maximum Ratio
  - Ratio of dose at depth to the dose at the same position but at a depth d_{MAX}. The wedge should be in place during both measurements, and the field size at the measurement position should not change.
  - TMR values should be obtained for a range of field sizes including the smallest and largest available fields. No zero field size extrapolation is required for wedge field TMR values. See the IMSure technical note, Obtaining and extrapolating data for IMSure calculations, that is available from the Standard Imaging website.
  - TMR data must be normalized to the d_{MAX} value and should encompass all clinically relevant depths.
  - If the largest field size for the wedge is rectangular – e.g., 40x20 cm – then the table should contain the equivalent square field size, which in this case would be 26.67 cm (equivalent square of 40x20). An additional field of 40 cm should be added at the end of the table duplicating the 40x20 measurements. A typical table would look like this:



FIELD SIZE (cm)

DEPTHS	0.00	4.00	6.00	10.00	15.00	20.00	30.00	40.00
0.00	0.541	0.557	0.573	0.603	0.634	0.665	0.710	0.738
0.10	0.570	0.585	0.600	0.630	0.659	0.690	0.734	0.761
0.20	0.614	0.627	0.640	0.668	0.696	0.725	0.766	0.792
0.30	0.669	0.681	0.693	0.719	0.744	0.770	0.807	0.828
0.40	0.736	0.745	0.754	0.776	0.796	0.819	0.851	0.867
0.50	0.803	0.810	0.818	0.835	0.851	0.869	0.893	0.905
0.60	0.860	0.866	0.871	0.883	0.896	0.909	0.928	0.936
0.70	0.913	0.917	0.921	0.930	0.938	0.947	0.958	0.962
0.80	0.953	0.955	0.957	0.961	0.966	0.973	0.979	0.980
0.90	0.974	0.976	0.978	0.980	0.982	0.988	0.990	0.990
1.00	0.988	0.989	0.990	0.991	0.993	0.994	0.995	0.995
1.10	0.997	0.997	0.997	0.996	0.998	0.998	0.998	0.999
1.20	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1.30	1.003	1.002	1.001	1.001	1.000	1.000	0.999	0.999
1.40	1.004	1.002	1.000	1.000	0.999	0.998	0.999	0.998
1.50	1.002	1.000	0.998	1.000	0.998	0.997	0.998	0.997
1.60	1.000	0.998	0.996	0.998	0.996	0.996	0.998	0.996
1.70	0.996	0.995	0.994	0.995	0.994	0.995	0.996	0.995
1.80	0.993	0.992	0.991	0.994	0.992	0.993	0.994	0.993
1.90	0.990	0.989	0.988	0.992	0.991	0.992	0.994	0.993
2.00	0.986	0.985	0.984	0.989	0.989	0.989	0.991	0.991
2.10	0.982	0.982	0.982	0.986	0.987	0.988	0.990	0.989

- OCR – Off-Center Ratio (also known as Off-Axis Ratio)
    - Ratio of dose away from the central axis to the dose at the same depth but on the central axis.
    - Only the largest field size is needed, and off axis points only along the wedge direction are required.
    - Ideally OCR is measured at 100 cm SSD and at multiple depths including d_{MAX}; e.g. d_{MAX}, 5, 10, 15, 20, and 30 cm.
    - OCR data must be normalized to the central axis value.
    - OCR data for wedges should be set up with the thick edge of the wedge oriented to the right (positive axis) of the off-axis distance plot; i.e., OCR values greater than one should be to the left (negative axis) and OCR values less than one should be to the right (positive axis).
- OF – Output Factor
    - Ratio of dose at d_{MAX} for a given wedge field size to dose at the same point for the wedged calibration field size.
    - Note that for wedge fields, OF values are the ratio of two wedge fields. Conversion between the wedge fields and the open calibration field dose rate is accomplished using a single Wedge Factor measured at the calibration field size.
    - The algorithms in IMSure require that output factors be measured at or re-calculated to 100 cm SAD and d_{MAX} depth; however the measurements are usually performed using an SAD setup and a deeper depth, such as 5 cm or 10 cm, to decrease the influence of electron contamination.
    - For output factors measured at a different depth, IMSure will automatically re-calculate the output factors at d_{MAX} as long as the measurement depth is specified in the setup and TMR tables have been imported previously (see “Setting up your data for IMSure” on page <OV>).

- The output factors should be measured for a range of field sizes including the smallest and largest possible fields. Data should be normalized to the wedge field at the calibration field size. A zero field size output factor does not need to be extrapolated for the wedge.
- The output factors, in combination with the collimator scatter factors (Sc), are used to compute the phantom scatter, as Sp = OF/Sc. OF values are required for wedged fields so that field size dependent wedge factors may be accounted for.
- WF – Wedge Factor
- Ratio of dose at d_{MAX} for the wedge field at the calibration field size to the dose for the open field at the calibration field size.
- Note that this factor is needed for only the calibration field size. Variation of the wedge factors with field size is accounted for using the collimator scatter and the wedge output factor tables.

Enhanced Dynamic Wedge:

The Enhanced Dynamic Wedge model is algorithmically based, and no additional data are required. Optional data may be used to supplement this algorithm to improve agreement with the linac.

- EDW Off-Axis Wedge Factor Table
  - This is an optional table used to improve the calculation of EDW wedge factors, since the STT calculation breaks down somewhat when the calculation point is ot centered in the beam.
  - Open field dose for a 20x20 cm^2 field and a line of points along the wedge direction. The recommended data are points at 10cm depth, 90cm SSD, spaced at 1cm intervals from -8cm (toward the heel of the wedge) to +8cm. Rows of the table show the data for each EDW angle. An example table looks like this.

☑ Enable EDW Factors

OFF-AXIS DISTANCE (cm)

ANGLE (DEG)	-8.00	-7.00	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00
10.00	0.832	0.835	0.839	0.844	0.849	0.855	0.862	0.869	0.876	0.885	0.894
15.00	0.759	0.764	0.771	0.777	0.785	0.794	0.803	0.813	0.823	0.835	0.848
20.00	0.692	0.699	0.707	0.716	0.725	0.736	0.748	0.761	0.775	0.790	0.806
25.00	0.629	0.637	0.647	0.657	0.669	0.682	0.696	0.712	0.729	0.747	0.767
30.00	0.568	0.578	0.590	0.602	0.616	0.631	0.647	0.665	0.684	0.706	0.729
45.00	0.392	0.406	0.423	0.440	0.460	0.481	0.504	0.529	0.557	0.587	0.619

Electron Data

- OF – Output Factor (also known as Cone Factor)
  - The electron output factor is the ratio of the dose from the open cone at the reference depth to the dose from the open reference cone at the reference depth. By definition; OF (reference cone) = 1.000.
  - Data should be measured for each cone and energy, with the surface of the phantom at the calibration source-to-phantom distance and the chamber at the reference depth.
- PDD – Percent Depth Dose

    - Ratio of dose at depth to dose at d_{MAX} along the central axis for the open cone, normalized to 100% at d_{MAX}. A single PDD is required for each cone at each energy, but additional data for extended SSD may also be entered.
    - Data should be measured with the phantom surface at the calibration source-to-phantom distance. IMSure QA has no requirements for the actual depths measured, but in typical use, measurements at least to the practical range for each energy are preferred (rule of thumb: ½ cm depth for each MeV of energy). IMSure QA will not extrapolate PDD, and will not compute dose or MU for points that lie outside the PDD table.
- OCR – Off-Center Ratio (also known as Off-Axis Ratio)
    - Ratio of dose away from the central axis to the dose at the same depth but on the central axis.
    - OCR data should be measured with the phantom surface at the calibration source-to-phantom distance, and at several depths. OCR values must be normalized to the central axis data point for each depth.
    - In many clinical situations, electron dose will always be specified at the central axis. If off axis calculation points will not be used, the user may choose to use the default single point OCR, which is specified as 1.000 at the reference depth and on the central axis. IMSure QA will only allow the user to enter off-axis distances that are contained within the range entered in this table, so in this scenario the user will only be able to enter x,y calculation points as 0,0.
- CF – Cutout Factor
    - Ratio of dose at d_{MAX} for a blocked field to dose at d_{MAX} from the open field for the same cone size.
    - Cutout factors should be measured for each cone and energy, with the surface of the phantom at the calibration source-to-phantom distance and the chamber at the calibration reference depth. Additional optional CF data may be entered for extended SSDs.
    - A series of cutout apertures should be made for each cone, in 10-20% increments, down to 40-60% of the cone size for the smallest aperture. For example, a 6x6 cone might have 3x3, 4x4, and 5x5 cutouts (and 6x6, by default). A 20x20 cone might have 10, 12.5 15, 17.5 and 20 cm cutouts. By definition; CF (unblocked field) = 1.000. The typical range of CF values will be from 0.900 to 1.100, but they may be as low as 0.700 for very small cutouts.

VSSD (Virtual Source to Surface Distance): The VSSD should be measured for each electron energy and cone. Electron output is affected by collimator scattering as well as in-air scattering, and it does not follow inverse square falloff over large ranges as well as photons do. However, an effective or virtual SSD can be measured and used reliably over short ranges for extended distance use, as is often needed in clinical practice. A typical range for clinical use would be from 100 cm to 115 cm SSD.

VSSD can be computed from measured dose at various distances using the method of Khan, with a chamber at the reference depth (dref) in water or a water equivalent phantom. SSD values should range from SSD_{ref} (e.g. 100 cm) to a clinically useful extended distance, such as 115 cm or 120 cm SSD.

With these measurements, VSSD can be computed by following the algorithm below:

1. Beginning with these measurements, for n points, first compute a set of points,
   $x(i) = Distance(i) - SSD_{ref}$ .1.a
   $y(i) = sqrt[Dose(SSD_{ref}) / Dose(Distance(i))]$ .1.b
2. Compute the average of each set, x' and y'
   $x' = (x_1+x_2+...xn)/n$, .2.a
   $y' = (y_1+y_2+...yn)/n$ .2.b
3. Compute the average area,
   $xy' = (x_1*y_1 + x_2*y_2 + ... xn*yn)/n$ .3
4. Compute the average of the distance squared,
   $xx' = (x_1*x_1 + x_2*x_2 + ... + xn*xn)/n$ .4
5. Compute the slope (m) of the best least squares fit for these points,
   $m = (xy' - x'*y'] /(xx' - x'*x')$ .5
6. Finally,
   $VSSD = 1/m - d_{ref}$ .6

VSSD depends on both energy and cone size, so each combination must be measured separately. VSSD will also vary depending on accelerator and cone construction, but will typically range between 75 and 98 cm.

CyberKnife Data

- TMR – Tissue Maximum Ratio
  - Ratio of dose at depth to the dose at the same position but at a depth d_{MAX}.
  - Include all collimator sizes, with depths starting at zero and increasing to encompass clinically relevant depths.
  - TMR must be normalized to the d_{MAX} value.
- OCR – Off Center Ratio (also known as Off-Axis Ratio)
  - Ratio of dose away from the central axis to the dose at the same depth but on the central axis.
  - Separate tables need to be created for each collimator size with measured data at multiple depths including d_{MAX}; e.g., 15, 50, 100, 150, 200, and 250 mm.
  - OCR data should be normalized to the central axis value at each depth.
- OF – Output Factor
  - Ratio of dose at d_{MAX} for a given collimator size to dose at the same point for the calibration collimator.
  - Output factors need to be measured for all collimator sizes at several SADs, with distances typically ranging from 500 mm to 1100 mm.

19.2 Setting up your data for IMSure

There are two choices for getting your data into IMSure. 1.) Send your data to Standard Imaging for conversion and setup. 2.) Convert your data yourself. Each option has its own advantages. Having Standard Imaging convert your data of course means less work up front, and we include the conversion of up to 3 different machines' data if converted within six months of your purchase. On the other hand, doing the conversion yourself gives you the peace of mind that the data were converted correctly and might mean less commissioning of the data before use.

Sending your data to Standard Imaging for conversion

Make sure you have all of the required data. In most cases the data are available from the scanning system that you use, and most scanning system software offers multiple export functions. The data need to be output in ASCII format and ideally output as Excel spreadsheets.

IMPORTANT - For Eclipse users only – The Eclipse system saves all of the raw beam data that is imported for beam modeling. If you use the Eclipse system contact Standard Imaging and ask for the IMSure – Eclipse export instructions. This document includes step-by-step instructions for exporting the required data from Eclipse. This data file then is zipped and sent to Standard Imaging via e-mail. The data are converted to the IMSure format and placed into an IMSure physics file that is then sent to you for commissioning.

Your data will be returned to you formatted into a physicsX_X.imsure file (see "The Physics3_8.imsure file" on page 13). This file contains all of your data pre-formatted for use with IMSure. Place the physicsX_X.imsure file into the directory of your choice, and then in IMSure preferences/Folder preferences (see "Preferences" on page 8) set the Machine folder to the same directory. Clicking on the Physics icon after setting this parameter will display the physics data.

NOTE: You will need to change the Machine Name(s) in the physics file to match the name your TPS uses for your machine.

Setting up your data yourself

Use the sample .csv files that can be found in the Machine Data directory in the Sample Data folder (see "Using the Sample Data" on page 12) as a guide in setting up your data files. The structure of these .csv files is very specific, and the files will not import into IMSure if they are not set up correctly. The .csv formatted files can be created in various programs, but Standard Imaging suggests utilizing Microsoft Excel for this task. The structure for each of the files is as follows:

1. Photons
    a. TMR table – List data from smallest to largest square field size. Ensure that a zero-field TMR value has been included in the open field table. See the IMSure QA Physics Technical note, "Obtaining and extrapolating data for IMSure calculations" regarding extrapolation of zero field size data. Wedge fields only need the smallest to largest field size.
    TMR should be normalized to d_{MAX} for each energy, and the data set must include a point at the reference depth. IMSure QA does not extrapolate TMR depth, so the data table should include all clinically reasonable depths either measured or extrapolated by the user.
    When the largest available wedge field is not square, TMR data should be listed twice for the largest field size – once at the equivalent square of the non-square

field and once at the largest opening size for the individual jaws. For example in the case of a 40x20 cm field, one entry would be listed for a field size of 26.7 cm (equivalent square of 40x20) and one for 40 cm, both containing the same data. NOTE: Data must be set up exactly as shown or the file will not import into the IMSure physics module. (See "Setting up your data for IMSure" on page <OV>)

	A	B	C	D	E	F
1	Version	1				
2	Table	TMR				
3	Depth	0	0.1	0.2	0.3	0.4
4	FieldSize	0	4	6	10	15
5	Data	0.39662	0.41116	0.42571	0.45822	0.49844
6		0.42948	0.44405	0.45863	0.49117	0.52956
7		0.47804	0.49167	0.5053	0.53689	0.57248
8		0.54045	0.55216	0.56387	0.59352	0.6263
9		0.60898	0.61973	0.63048	0.65622	0.68522

Row 1 – Version Number: Must say Version in 1st column and 1 in 2nd column

Row 2 – Table Type: Must say Table in 1st column and TMR in the 2nd column

Row 3 – Depth: Must say Depth in 1st column and then depths increase to the right (in cm)

Row 4 – Field Size: Must say FieldSize (no space) in 1st column and then field sizes then increase to the right (in cm)

Data – Place data in columns under appropriate Field Size value, with Depths increasing, e.g. 0.39662 is the TMR value for Field Size 0 cm, Depth 0 cm and 0.47804 is the TMR value for Field Size 0 cm, Depth 0.2 cm

b. OCR tables – Include only the largest field size for open and wedged fields. List OCR values in order of increasing depth, with OCR distances increasing from negative (left) to positive (right). The central axis value (located at the zero distance point) should be 1.000 for all depths.
For wedge data, only scans in the wedged direction are needed, and only for the largest field size. OCR data should include a profile at the reference depth, and each profile must be normalized to the central axis value at that depth, independent of PDD. Wedge OCR values greater than one should be to the left (negative axis) and OCR values less than one should be to the right (positive axis).
The .csv formatted files can be created in various programs, but Standard Imaging suggests utilizing Microsoft Excel for this task. NOTE: Data must be set up exactly as shown or the data will not import into the IMSure physics module. (See "Setting up your data for IMSure" on page <OV>)

	A	B	C	D	E	F
1	Version	1				
2	Table	OCR				
3	Depth	3	5	10	20	
4	Distance	-16.8	-16.6	-16.4	-16.2	-16
5	Data	0.078068	0.079636	0.081301	0.082868	0.084435
6		0.074028	0.075571	0.077113	0.078758	0.080609
7		0.087421	0.089656	0.092015	0.094375	0.09661
8		0.124344	0.128145	0.132127	0.135928	0.139729
9						

Row 1 –Version Number: Must say Version in 1st column and 1 in 2nd

Row 2 – Table Type: Must say Table in 1st column and OCR in the 2nd

Row 3 – Depth: Must say Depth in 1st column and then depths increase to the right (in cm)

Row 4 – Distance: Must say Distance in first column with negative values starting at left (in cm)

Data – Place data in columns under appropriate distance from CAX, with Depths increasing, e.g. 0.078068 is the OCR value for the distance -16.8 cm from CAX, Depth 3 cm

c. Photon OF tables – List fields from smallest to largest possible square fields, normalized to the calibration (10x10 cm) field size. For wedge fields, the OF should be normalized to the wedged 10x10 cm field. Include a value of 1.000 at the reference field size, and note the depth at which the values were measured. This depth will be entered separately in the physics module in IMSure.
For open field data a zero field size extrapolation is needed. See the IMSure QA Physics Technical note, "Obtaining and extrapolating data for IMSure calculations" regarding extrapolation of zero field size data.
NOTE: Data must be set up exactly as shown or the data will not import into the IMSure physics module. (See "Setting up your data for IMSure" on page <OV>)

	A	B	C	D	E	F
1	Version	1				
2	Table	OF				
3	FieldSize	0	3	4	6	8
4	Data	0.8181	0.9015	0.9293	0.9608	0.9838
5						

Row 1 –Version Number: Must say Version in 1st column and 1 in 2nd

Row 2 – Table Type: Must say Table in 1st column and OF in the 2nd

Row 3 – Field Size: Must say FieldSize (no space) in 1st column and then field sizes increase to the right (in cm)

Data – Place data in columns under appropriate Field Size value, e.g. 0.8181 is the OF value for Field Size 0 cm

d. Sc table - List collimator scatter from smallest to largest open field size as shown in the image below, beginning with the extrapolated zero field size value. Sc for the reference field size should be 1.000.
NOTE: Data must be set up exactly as shown or the data will not import into the IMSure physics module. (See “Setting up your data for IMSure” on page <OV>)

	A	B	C	D	E	F
1	Version	1				
2	Table	Scatter				
3	FieldSize	0	3	4	6	8
4	Data	0.896	0.9442	0.966	0.9819	0.9933
5						

Row 1 –Version Number: Must say Version in 1st column and 1 in 2nd

Row 2 – Table Type: Must say Table in 1st column and Scatter in the 2nd

Row 3 – Field Size: Must say FieldSize (no space) in 1st column and then field sizes increase to the right (in cm)

Data – Place data in columns under appropriate Field Size value, e.g. 0.896 is the Sc value for Field Size 0 cm

e. DF table (diode calibration factors) - List diode factors for increasing field sizes, with one input DF file for each photon energy, although you can modify the existing default table data (SSD 100 cm, Field Size 10 cm) or add other field sizes via the ‘Add Row’ or ‘Copy Row’ buttons.
NOTE: Data must be set up exactly as shown or the data will not import into the IMSure physics module. (See “Setting up your data for IMSure” on page 98.)

	A	B	C	D	E	F
1	Version	1				
2	Table	DCF				
3	FieldSize	15				
4	SSD	100				
5	Data	1.00				
6						

Row 1 –Version Number: Must say Version in 1st column and 1 in 2nd

Row 2 – Table Type: Must say Table in 1st column and DCF in the 2nd

Row 3 – Field Size: Must say FieldSize (no space) in 1st column and then field sizes increase to the right (in cm)

Row 4 – SSD: Must say SSD in 1st column; SSDs then decrease to the right (in cm)

Row 5 – Data: Must say Data in 1st column.

Data – Place data in columns under appropriate SSD value, with Field Sizes increasing, e.g. 1.00 is the DCF value for SSD 100 cm, Field Size 15 cm, and a new DCF value below it would be for SSD 100 cm, at a larger field size.

2. Electrons
    a. PDD tables – List values at increasing depths, with one file for each cone. Only the open cone PDD values are needed. A value of 1.000 at the reference depth must be included in the PDD table.
    NOTE: Data must be set up exactly as shown or the data will not import into the IMSure physics module. (See "Setting up your data for IMSure" on page <OV>)

	A	B	C	D	E	F
1	Version	1				
2	Table	PDD				
3	Depth	0	0.2	0.4	0.6	0.8
4	SSD	100	90			
5	Data	83.630	83.630			
6		85.328	85.328			
7		87.765	87.765			
8		91.520	91.520			
9		95.436	95.436			

Row 1 –Version Number: Must say Version in 1st column and 1 in 2nd

Row 2 – Table Type: Must say Table in 1st column and PDD in the 2nd

Row 3 – Depth: Must say Depth in 1st column; depths then increase to the right (in cm)

Row 4 – SSD: Must say SSD in 1st column; SSDs then decrease to the right (in cm).

Row 5 – Data: Must say Data in 1st column.

Data – Place data in columns under appropriate SSD value, with Depths increasing, e.g. 83.630 is the PDD value for SSD 100 cm, Depth 0 cm, and 87.765 is the PDD value for SSD 100 cm, Depth 0.4 cm.

    b. OCR tables - The file format for electron OCR is identical to photon OCR (see "Setting up your data for IMSure" on page <OV>). A separate OCR file is required for each cone.
    c. CF Tables (cutout factor) – List cutout factors for increasing field sizes, with one file for each cone. Ensure that a value of 1.000 is included at the open cone field size.
    NOTE: Data must be set up exactly as shown or the data will not import into the IMSure physics module. (See "Setting up your data for IMSure" on page <OV>)

	A	B	C	D	E	F
1	Version	1				
2	Table	CF				
3	FieldSize	2	3	4	5	6
4	SSD	100	95			
5	Data	0.758	0.858			
6		0.859	0.928			
7		0.917	0.993			
8		0.963	0.996			
9		0.996	0.998			

Row 1 – Version Number: Must say Version in 1st column and 1 in 2nd

Row 2 – Table Type: Must say Table in 1st column and CF in the 2nd

Row 3 – Field Size: Must say FieldSize (no space) in 1st column and then field sizes increase to the right (in cm)

Row 4 – SSD: Must say SSD in 1st column; SSDs then decrease to the right (in cm).

Row 5 – Data: Must say Data in 1st column.

Data – Place data in columns under appropriate SSD value, with Field Sizes increasing, e.g. 0.758 is the CF value for SSD 100 cm, Field Size 2 cm, and 0.917 is the CF value for SSD 100 cm, Field Size 4 cm.

d. DF table (diode calibration factors - The file format for electron DF is identical to photon DF (see "Setting up your data for IMSure" on page 98). A separate in put DF file is required for each electron energy, although you can modify the existing default tabledata (SSD 100 cm, Field Size 10 cm) or add other field sizes to the table via 'Add Row' or 'Copy Row' buttons.

3. CyberKnife
   a. TMR tables – The CyberKnife planning system can export as text files the TMR tables that were originally input from machine data. The format for the IMSure .csv files for CyberKnife TMR was designed to be very similar to those in order to make it easy to create the correct file structure.
      The TMR table should contain data for each collimator size and all clinical depths and must be normalized to the dMAX value.
      NOTE: Data must be set up exactly as shown or the data will not import into the IMSure physics module. (See "Setting up your data for IMSure" on page <OV>)

(NOTE: CyberKnife measurements are made in millimeters.)

	A	B	C	D	E
1	IMSure Data Import File				
2	Version	2			
3	Table	TMR-CK			
4	Depth\FieldSize	5	7.5	10	12.5
5	0	0.555	0.497	0.509	0.491
6	1	0.648	0.592	0.594	0.574
7	2	0.737	0.684	0.676	0.655
8	3	0.818	0.768	0.752	0.73
9	4	0.888	0.842	0.819	0.798

Row 1 – First column, first cell must say IMSure Data Import File

Row 2 – Version Number: Must say Version in 1st column and 2 in 2nd

Row 3 – Table Type: Must say Table in 1st column and TMR-CK in the 2nd

Row 4 – Depth\Field Size: Must say Depth\FieldSize (backslash and no space) in 1st column and then field (collimator) sizes increase to the right (in mm) with depths increasing down (in mm)

Data – Place data in columns under appropriate Field (Collimator) Size value, with Depths increasing, e.g. 0.555 is the TMR-CK value for the Field (Collimator) Size 5 mm, Depth 0 mm and 0.737 is the TMR-CK value for the Field (Collimator) Size 5 mm, Depth 2 mm

b. OCR tables - The CyberKnife planning system can export as text files the OCR tables that were originally input from machine data. The format for the IMSure .csv files for CyberKnife OCR was designed to be very similar to those in order to make it easy to create the correct file structure.
An OCR table should be created for each collimator size and should contain data out to the maximum radius used clinically at several representative depths. Data should be normalized to the central axis.
NOTE: Data must be set up exactly as shown or the data will not import into the IMSure physics module. (See “Setting up your data for IMSure” on page <OV>)

	A	B	C	D	E
1	IMSure Data Import File				
2	Version	2			
3	Table	OCR-CK			
4	FS	5			
5	Radius\Depth	15	50	100	150
6	0	0.999	0.999	0.999	0.999
7	0.1	0.998	0.998	0.998	0.998
8	0.2	0.995	0.995	0.995	0.995
9	0.3	0.991	0.991	0.99	0.991

Row 1 – First column, first cell must say IMSure Data Import File

Row 2 – Version Number: Must say Version in 1st column and 2 in 2nd

Row 3 – Table Type: Must say Table in 1st column and OCR-CK in the 2nd

Row 4 – Field (Collimator) Size: Must say FS in 1st column and then field (collimator) size in the 2nd (in mm)

Row 5 – Radius\Depth: Must say Radius\Depth (backslash) in 1st column and then depths increase to the right (in mm) with radius increasing down (in mm)

Data – Place data in columns under appropriate Depth, with Radius increasing, e.g. 0.995 is the OCR-CK value for a 5 mm Field (Collimator) Size with Depth 50 mm and 0.2 mm off axis

c. OF table - The CyberKnife planning system can export as text files the OF tables that were originally input from machine data. The format for the IMSure .csv files for CyberKnife OF was designed to be very similar to those in order to make it easy to create the correct file structure.
An OF table should contain the measured output factors for each collimator size and a variety of SAD distances. All output factors are normalized to the 60 mm collimator, so the value of the 60 mm collimator OF is 1.00 by definition.
NOTE: Data must be set up exactly as shown or the data will not import into the IMSure physics module. (See "Setting up your data for IMSure" on page <OV>)

	A	B	C	D	E
1	IMSure Data Import File				
2	Version	2			
3	Table	OF-CK			
4	SAD\FS	5	7.5	10	12.5
5	500	0.625	0.78	0.838	0.888
6	550	0.631	0.791	0.847	0.894
7	600	0.637	0.801	0.856	0.901
8	650	0.643	0.812	0.865	0.908
9	700	0.649	0.823	0.874	0.915

Row 1 –First column, first cell must say IMSure Data Import File

Row 2 – Version Number: Must say Version in 1st column and 2 in 2nd

Row 3 – Table Type: Must say Table in 1st column and OF-CK in the 2nd

Row 4 – SAD\FS: Must say SAD\FS (backslash) in 1st column and then field (collimator) sizes increase to the right (in mm) with SAD increasing down (in mm)

Data – Place data in columns under appropriate Field (Collimator) Size value, with SAD increasing, e.g. 0.801 is the OF-CK value for the Field (Collimator) Size 7.5 mm, SAD 600 mm

Table B: Rules for Machine Data Consistency

1. The maximum field size for the wedge field TMR data must be greater than or equal to the maximum field size for that wedge.
2. For open fields, the minimum field size for the TMR data must be equal to 0.0 cm.

3. For wedge fields, the minimum field size for the TMR data must be less than or equal to the minimum field size for that wedge.
4. A field size must exist in the wedge field TMR data that matches the minimum field size for that wedge.
5. Values for the TMR depths must increase monotonically.
6. Values for the TMR field sizes must increase monotonically.
7. Values for the output factor field sizes must increase monotonically.
8. Values for the collimator scatter factor field sizes must increase monotonically.
9. Values for the off-axis ratio depths must increase monotonically.
10. Values for the off-axis ratio distances must increase monotonically.
11. The minimum value for the off-axis ratio distances must be equal to or less than (-maximum field size/2).
12. The maximum value for the off-axis ratio distances must be equal to or greater than (+maximum field size/2).
13. TMR depths must include the reference depth.
14. The TMR field size set must include the calibration field size.
15. The output factor field sizes must include the calibration field size.
16. The collimator scatter factor field sizes must include the calibration field size.
17. The output factors for all fields must be normalized to the value at the calibration field size (i.e., the output factor at FS=CFS will equal 1.000).
18. The collimator scatter factors must be normalized to the value at the calibration field size (i.e., the output factor at FS=CFS will equal 1.000).
19. The TMR value for the calibration field size and at the reference depth must equal 1.
20. For open fields, the min jaw position for either upper or lower jaws may not be less than (-maximum field size/2).
21. For open fields, the max jaw position for either upper or lower jaws may not be greater than (+maximum field size/2).
22. PDD tables must contain the reference depth and the value at that point must equal 1.000
23. PDD depths must increase monotonically
24. OCR must have a value = 1.000 on CAX for all depths
25. A cutout factor table must contain at least one point = 1.000 for FS = open cone

Table C: Known Geometry Values for Various Linear Accelerator Heads

	Jaw Distances (in cm)	Distances for primary collimator and flattening filter geometry used in 3-source model (Fixed, non-editable)					
Linac MLC Type	Zx	Zy	Zmlc	Zsp	Zsf	R01	R02
Elekta 80 *	40.1	43.4	29.8	4.0	12.5	0.2	1.4
Siemens	28.3	19.7	28.3	4.0	10.5	0.2	1.1
Varian 52	36.7	27.9	48.3	4.0	12.5	0.2	1.4
Varian 80	36.7	27.9	48.3	4.0	12.5	0.2	1.4
Varian 120	36.7	27.9	48.3	4.0	12.5	0.2	1.4

* The IMSure QA model assumes that MLC leaves are in the “X-direction”. The Elekta system can be accommodated by specifying the jaw distances as above with the “Lower Jaw” specified as closer to the source than the “Upper Jaw”. An additional offsetting correction must be made in the Jaw Naming convention, where the expected X jaw and Y jaw names are exchanged.

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Standard Imaging Detectors	1 year
Standard Imaging Well Chambers	2 years
Standard Imaging Electrometers	5 years
Standard Imaging BeamChecker Products	2 years
TomoScanner and TomoElectrometer	2 years
Standard Imaging Software Products	1 year
All Other Standard Imaging Products	1 year
Standard Imaging Custom Products	1 year
Standard Imaging Remanufactured Products	180 days
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Consumables	90 days
Serviced Product	90 days (for service performed)
Resale Products	As defined by the Original Equipment Manufacturer
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A Unique product ID
YY Last two digits of the year
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DDD Day of the year (1≤ DDD ≤ 365)
X Unique unit ID number (0 ≤ X ≤ 9)

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Doc No. 4575-04, 03/25/15

EC	REP	Hoff & Lowendahl AB Högåsvägen 125 SE-741 41 Knivsta, Sweden

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