Dosimetric Characteristics of the Exradin W1 Scintillator

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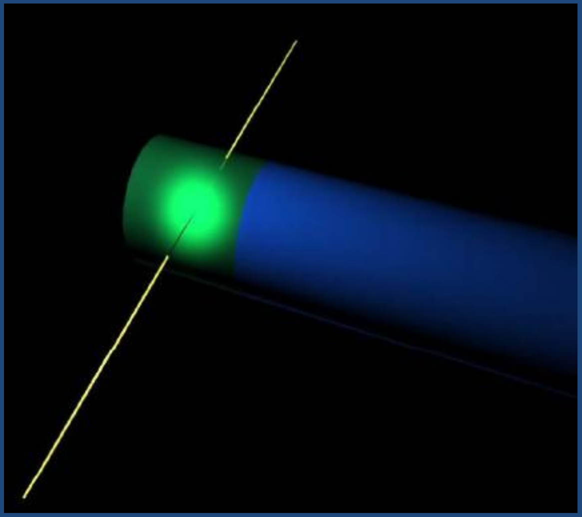
October 28, 2012

Scintillation detectors

- Incident radiation (charged particles or photons) excites atoms or molecules of the scintillating medium.
- The decay of these excited states produces visible light.
- These photons are channeled to a photodetector and then get converted into an electronic signal.



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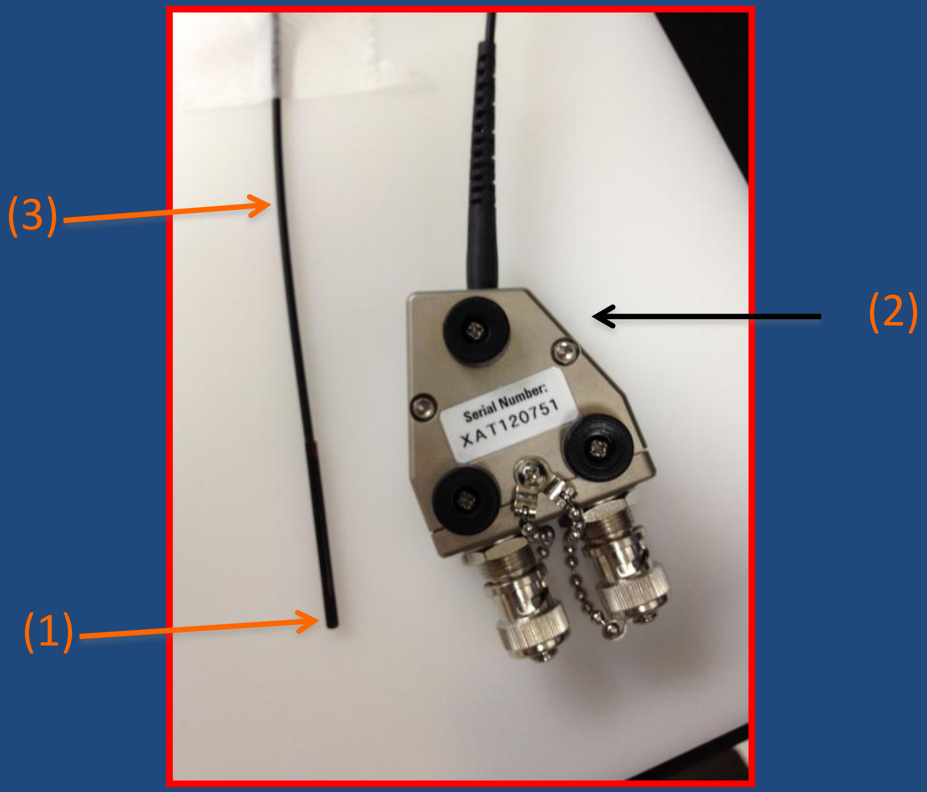
W1Exradin Scintillation Detector Components

- A small-sized scintillating material (1)
- A Photodetector (2)
- An optical fiber (3)
- Remove Cerenkov with background substraction (two wavelength calibration process in a calibration phantom)



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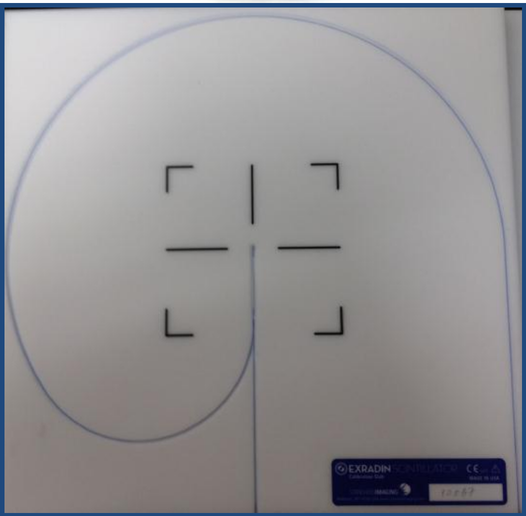
Measurement and Calibration Equipment

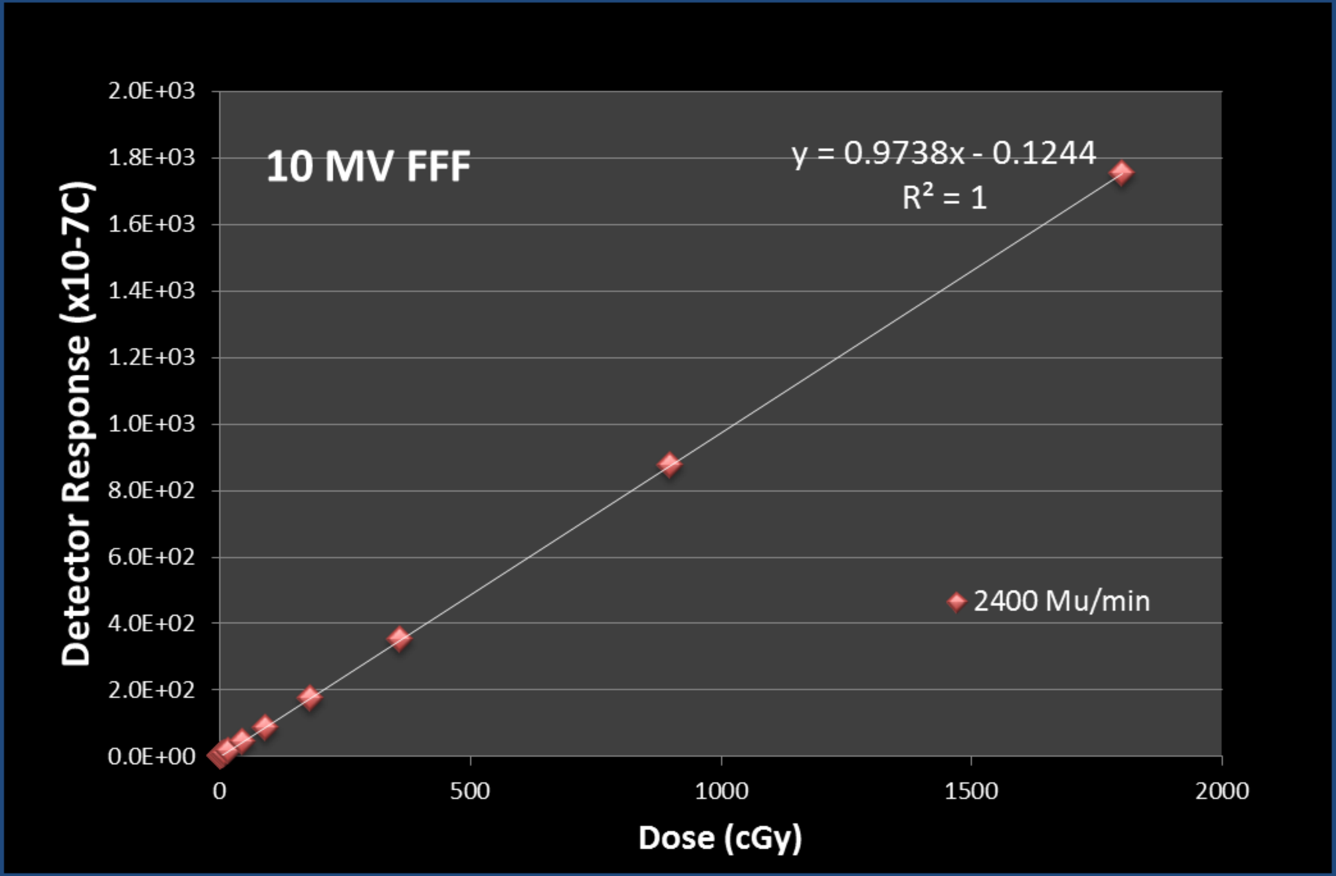
- SuperMAX 2-Channel Electrometer
- Triax Cable connection with the photodetector
- Calibration Phantom
  - 10x10 cm (straight)
  - 40x40 cm (loop) irradiation fields/ fiber geometry



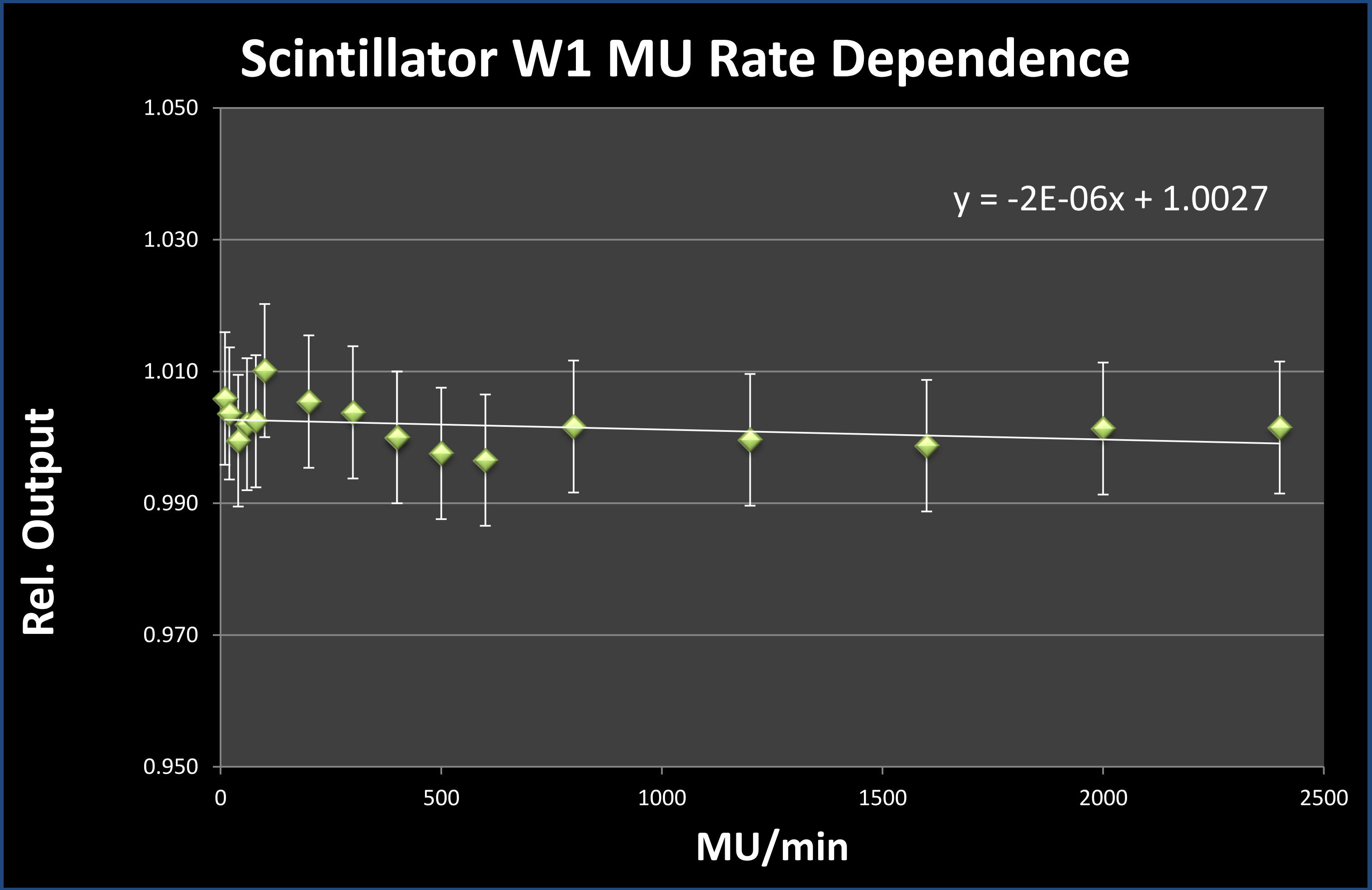
An ideal dosimeter for radiosurgery requires

- Dose linearity
- Dose rate linearity
- Energy independence
- Spatial Resolution
- Orientation independence

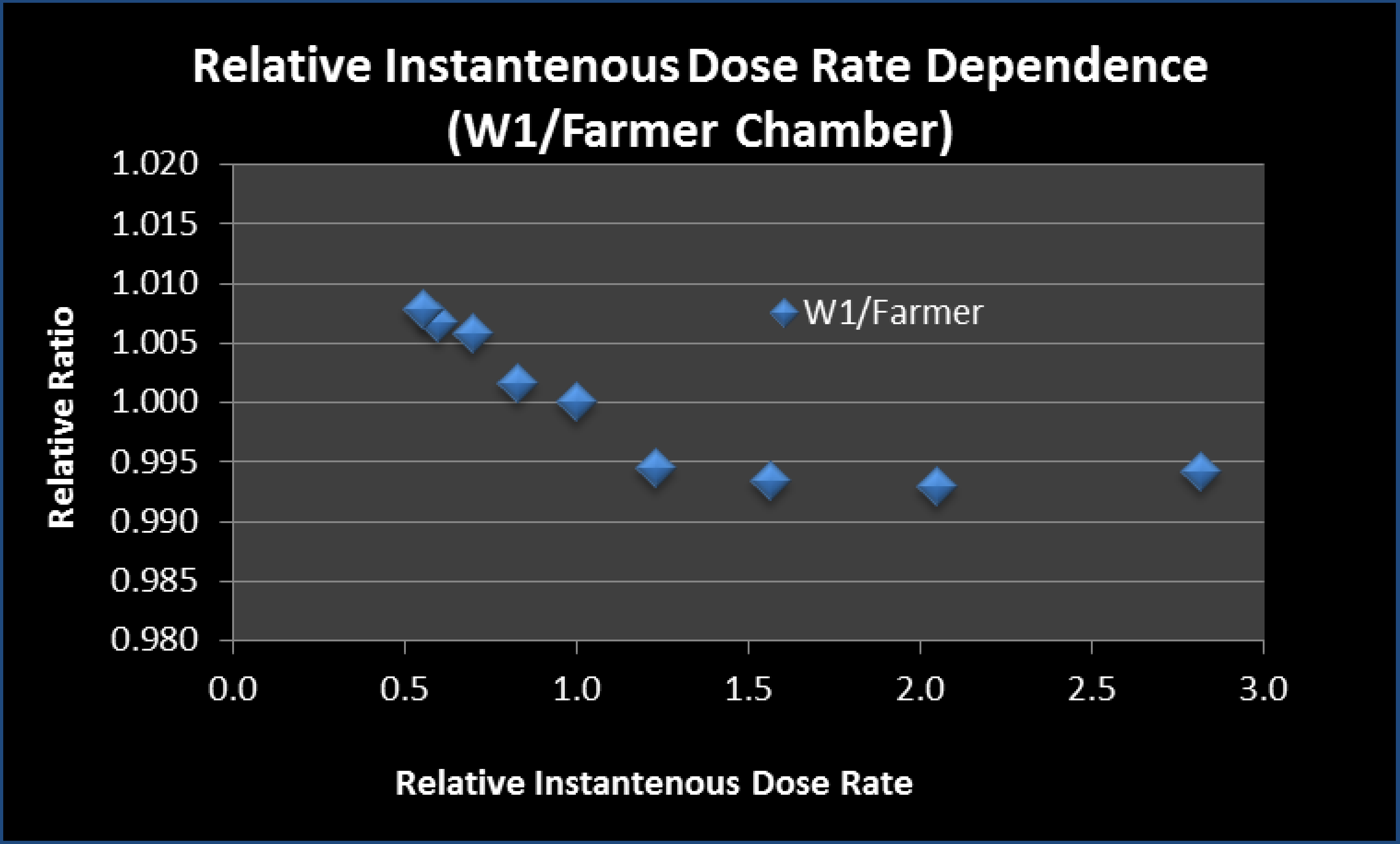
Dose Linearity



Light production is proportional to the dose deposited

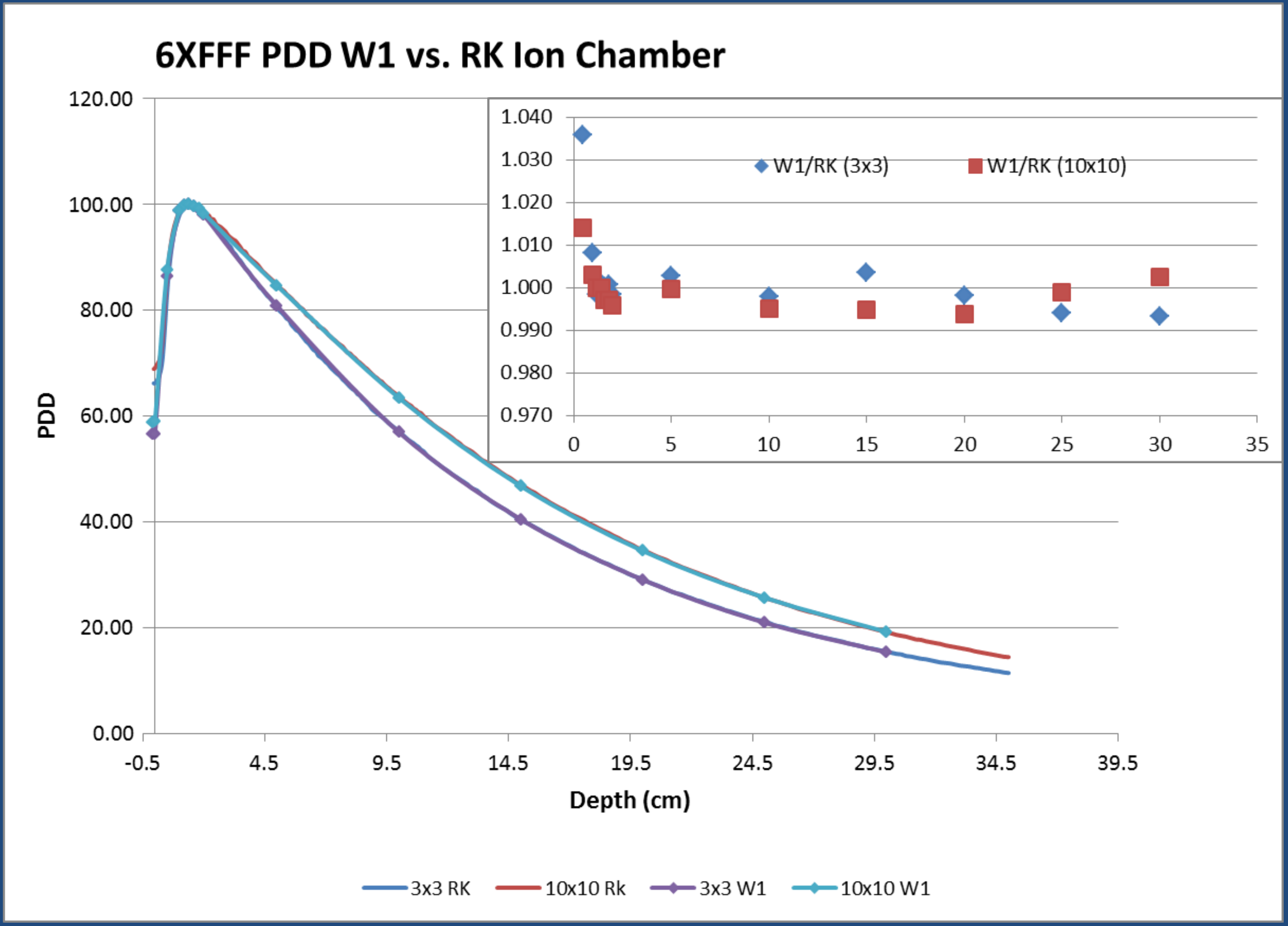


Not affected by dose rate variations over a wide range

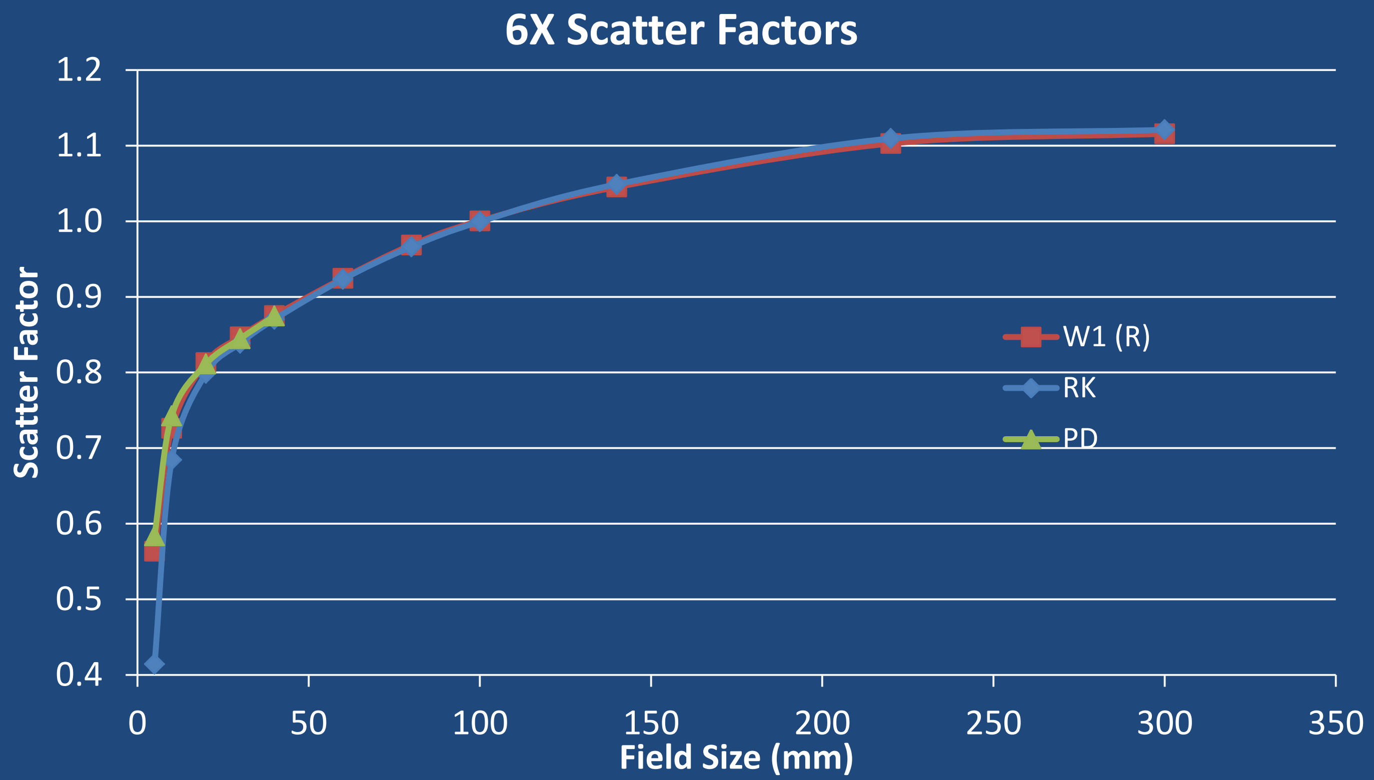


The instantaneous dose rate was varied by varying the source-detector-distance between 60 cm and 135 cm.

Accurate for Photon Beam Measurements



Spatial Resolution



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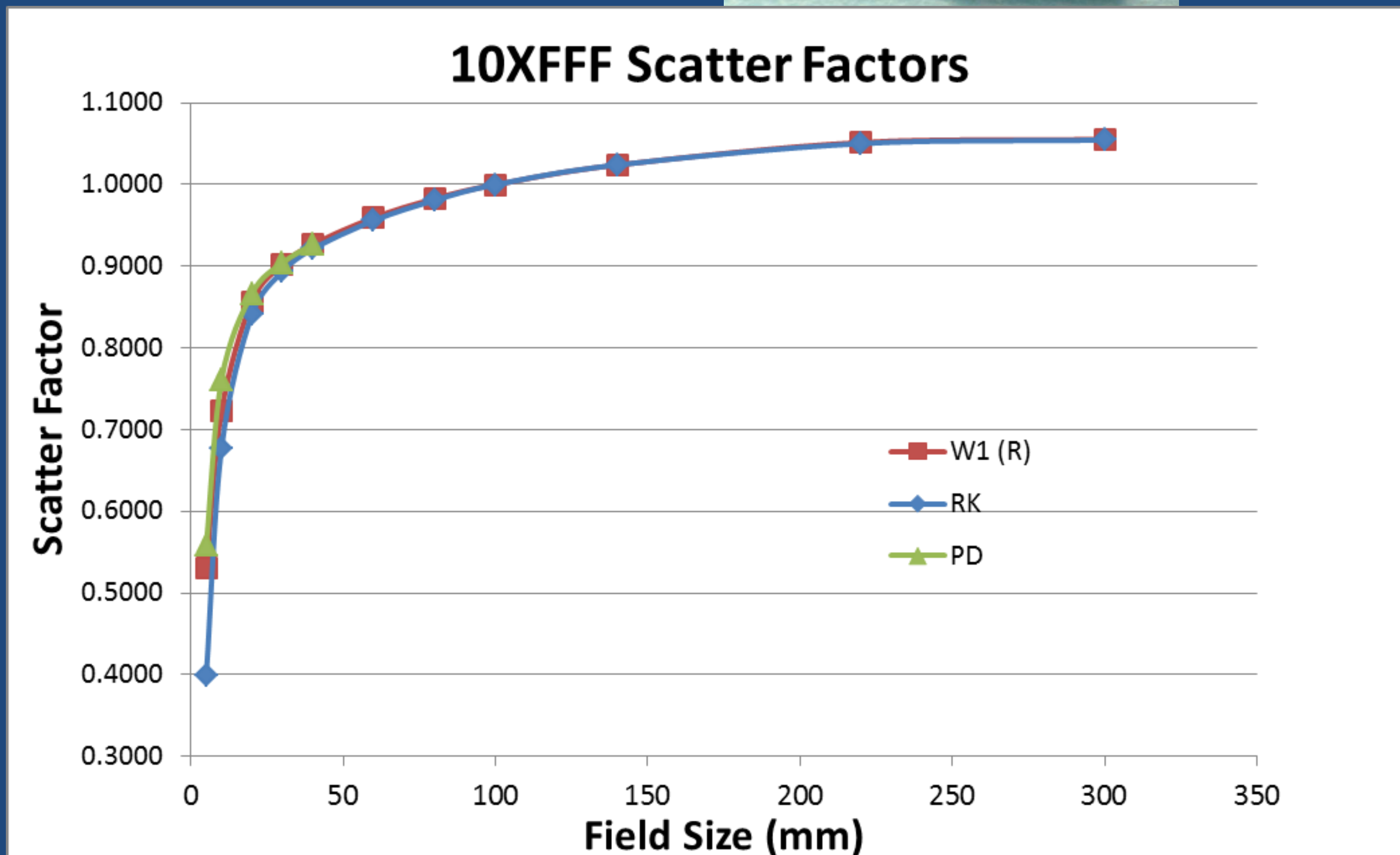
Spatial Resolution

Scintillator

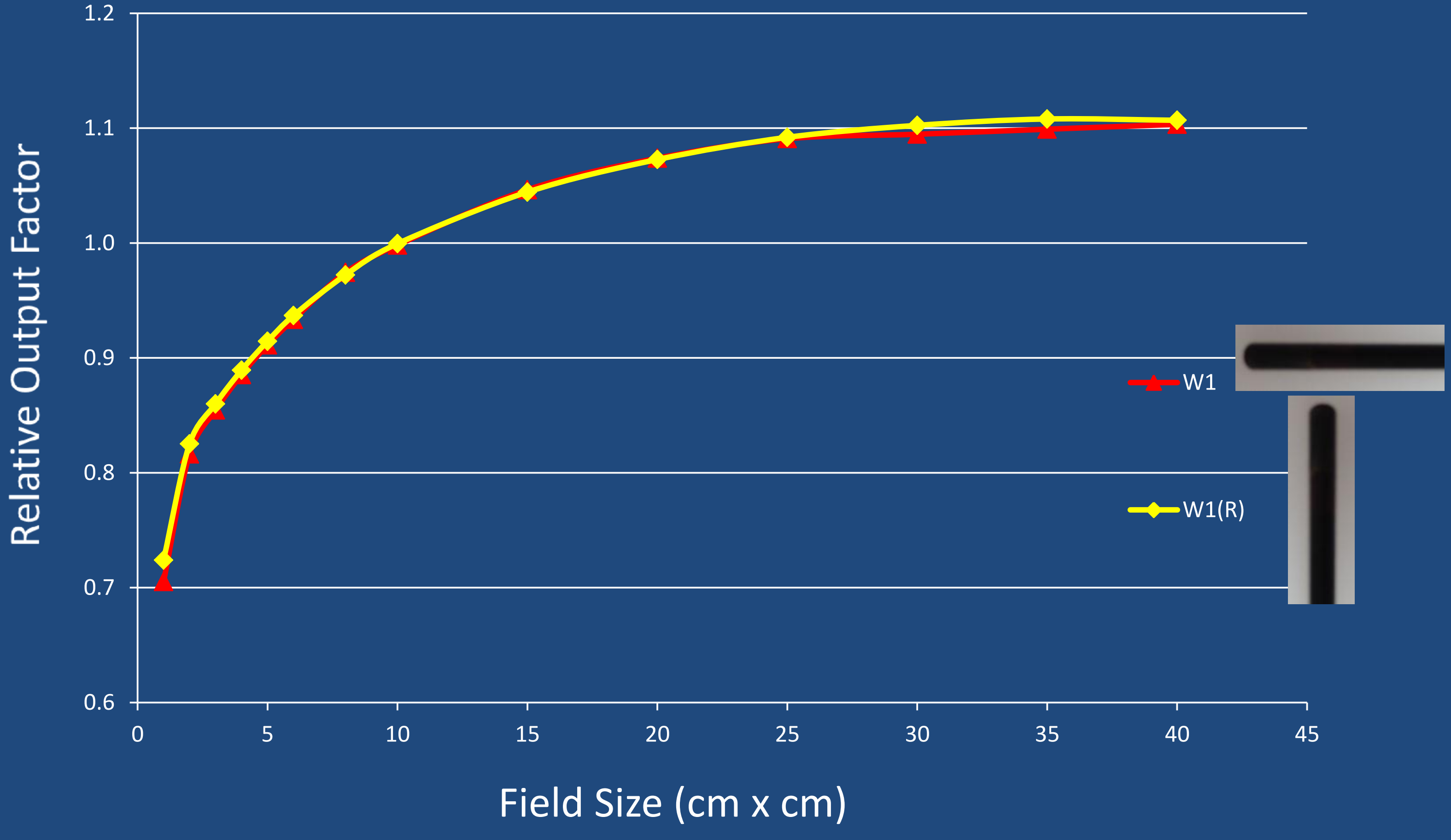
Photon Diode

RK Chamber



Detector Orientation: 6X FFF Output Factors

Two Orientations: parallel and perpendicular to the beam axis



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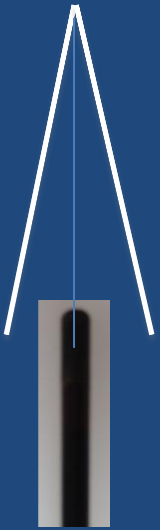
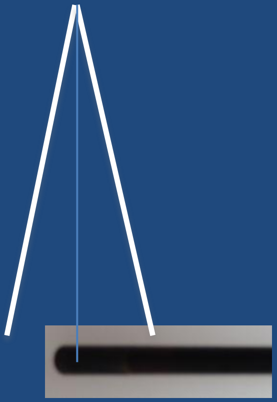
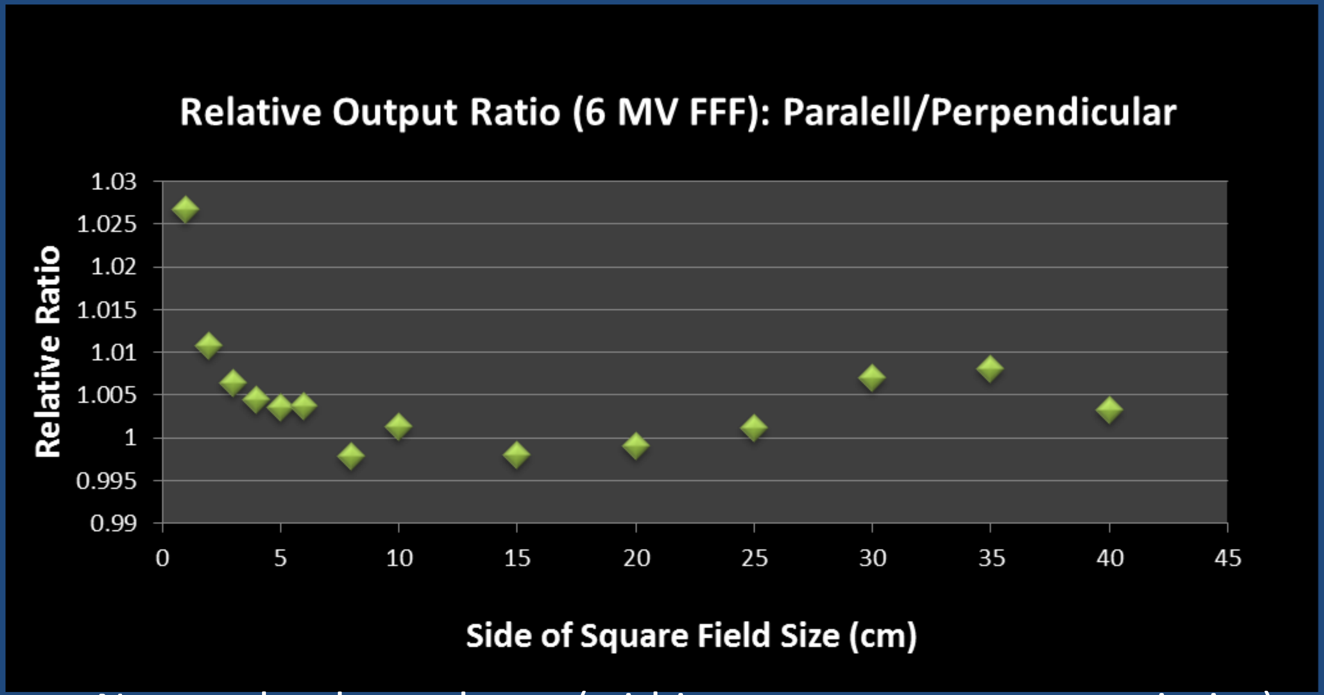
Parallel



Perpendicular





No angular dependence (within measurement uncertainties)

SUMMARY: PART I

- W1 Exradin Scintillator detector has ideal characteristics for small-field dosimetry
- Dose rate independence makes it suitable for measurements in FFF beams
- Detector orientation: no angular dependence between parallel and perpendicular orientations for output measurements
- Performance of two-channel SuperMAX electrometer is excellent for all scintillator measurements

Acknowledgements

- Ji Li, PhD
- Karl Farrey, MS

A Comparison of S_c Measurements with the W1 scintillator and other detectors

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$$S_{cp} = S_c \cdot S_p$$

S_{cp} = In–phantom output(total scatter) = $D(s,d)/D_{ref}(s_{ref},d)$

d generally taken to be 10 cm

S_c =In-air output (collimator scatter) = $[D(s,d)/D_{ref}(s_{ref},d)]_{air}$

d taken to be thick enough to eliminate e^- contamination

S_p = Phantom scatter = $\{D(s,d)/D_{ref}(s_{ref},d)\}_{\text{fixed collimator}}$

Determine $S_p = S_{cp} / S_c$

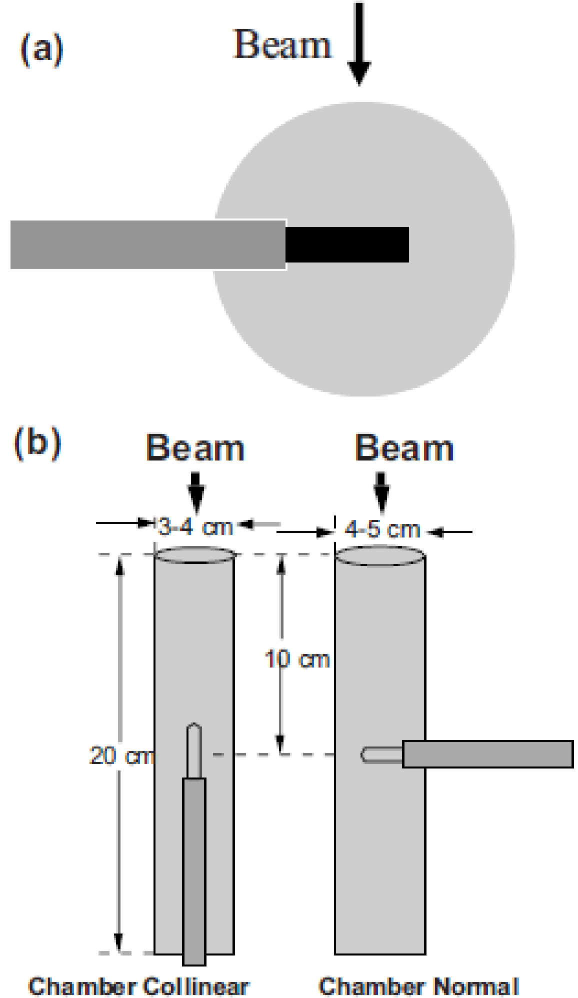


FIG. 7. (a) An example of an old style S_c measurement using a peak thickness build-up cap. Such measurments allowed charged particle contamination to affect the readings inappropriately. (b) Miniphantom as described by van Gasteren.

Zhu et al, Med. Phys. 36 (11) November 2009

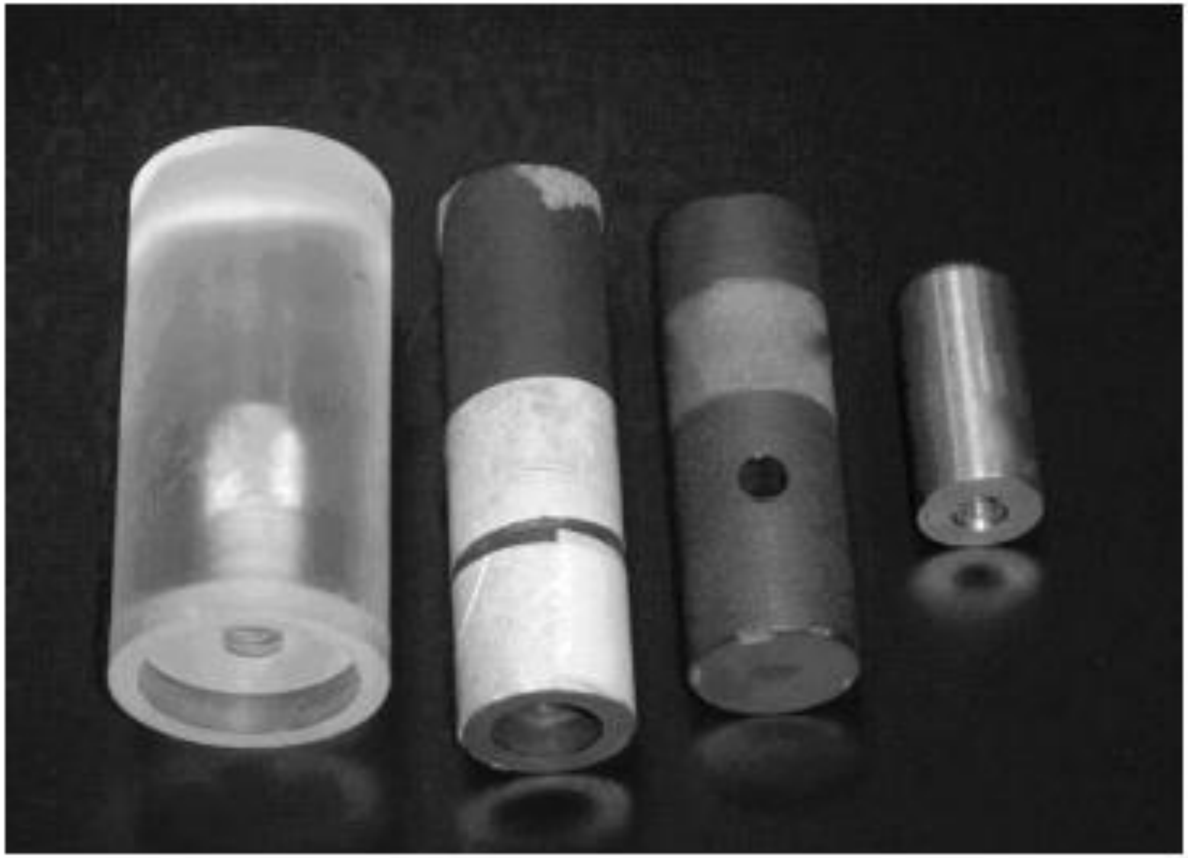


FIG. 9. Recommended miniphantoms for measurement of S_c. The material compositions are, from left to right, Lucite, graphite, and brass. If a high-Z miniphantom is chosen, a correction factor may be required.

Zhu et al, Med. Phys. 36 (11) November 2009

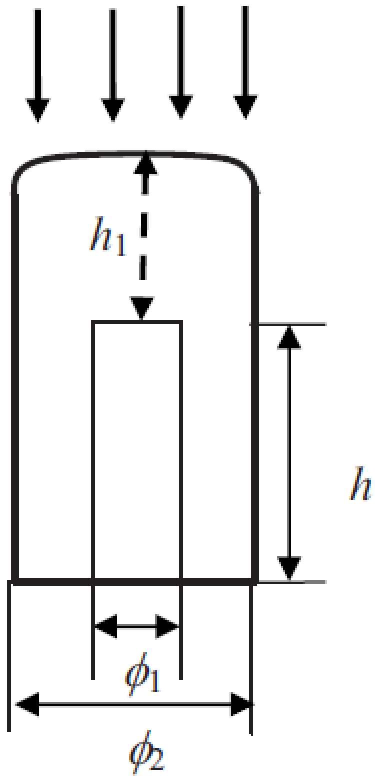
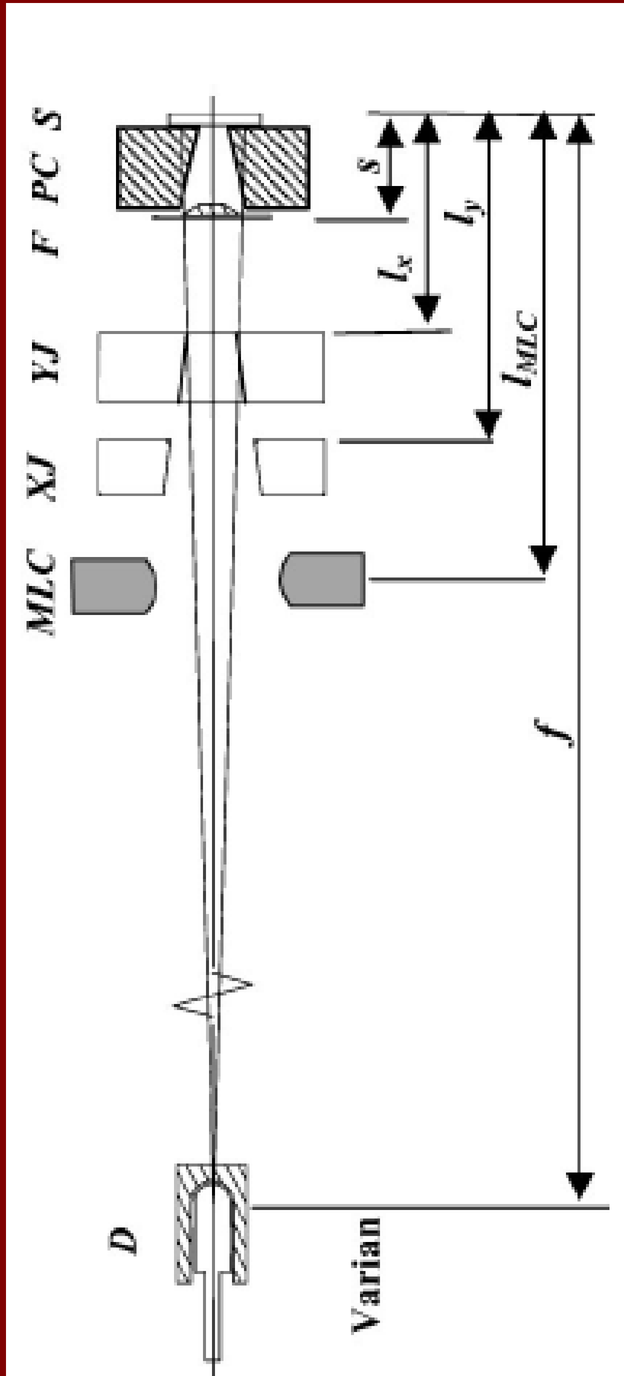


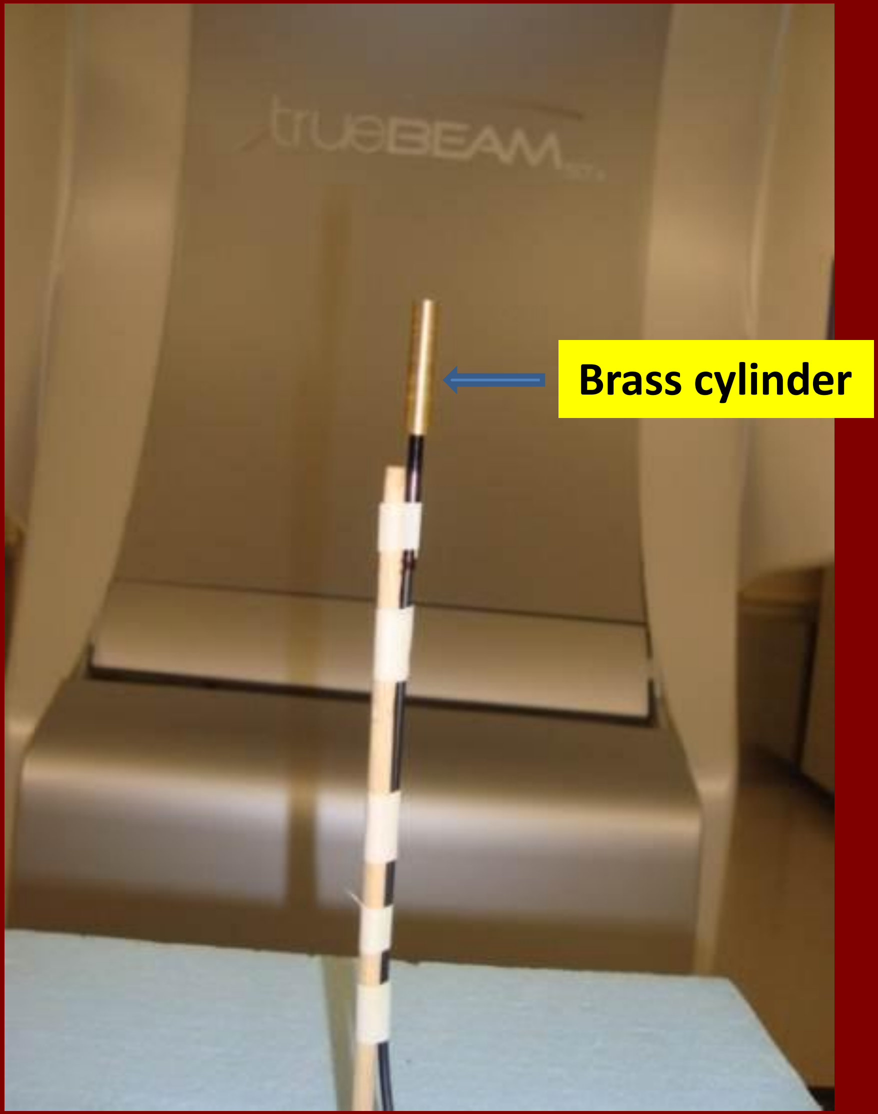
FIG. 10. Schematics of a brass miniphantom recommended for measurements of S_c for square fields larger than 1.5×1.5 cm^2 and photon energy less than 25 MV. The longitudinal thickness (h_l) of the miniphantom facing the radiation should equal to or be larger than 1.2 cm (or 10 g/cm^2, ρ =8.4–8.7 g/cm^3). The inner diameter of the miniphantom, ϕ_1 equals to the outer diameter of the detector, e.g., 0.6 cm. The height, h, should be sufficient long to cover the detector sensitive volume, e.g., 2 cm. The outer diameter of the miniphantom, ϕ_2, can be such that the wall is thinner [but minimum 1.2 mm brass for up to 18 MV (Refs. 107 and 115)] than the thickness required for CPE given that the total lateral dimension above the chamber well ensures lateral CPE for the photon energy, and the effect on S_c measurement falls within required accuracy demands.

Zhu et al, Med. Phys. 36 (11) November 2009

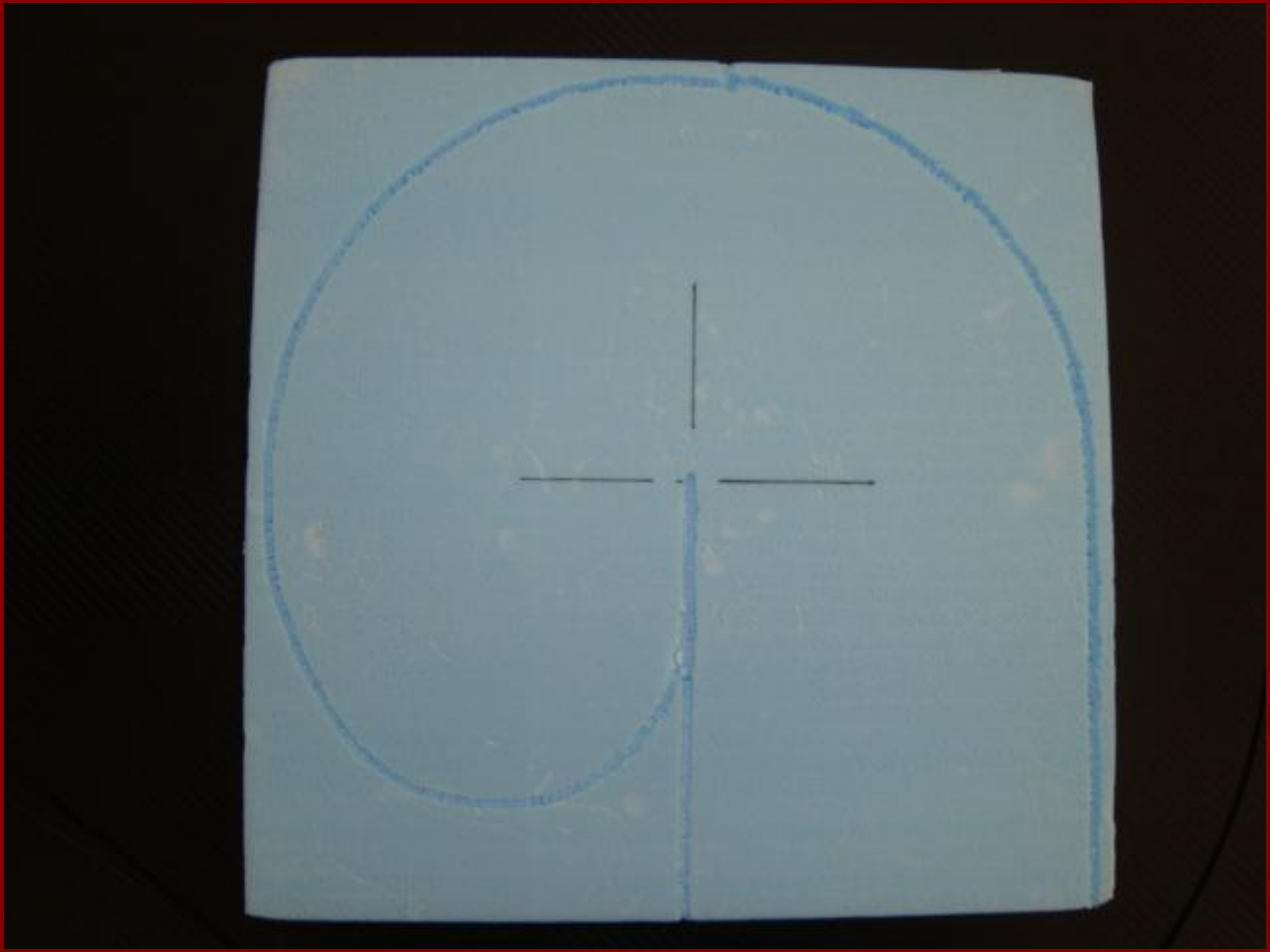


Schematic diagram showing the experimental set-up for measuring S_c

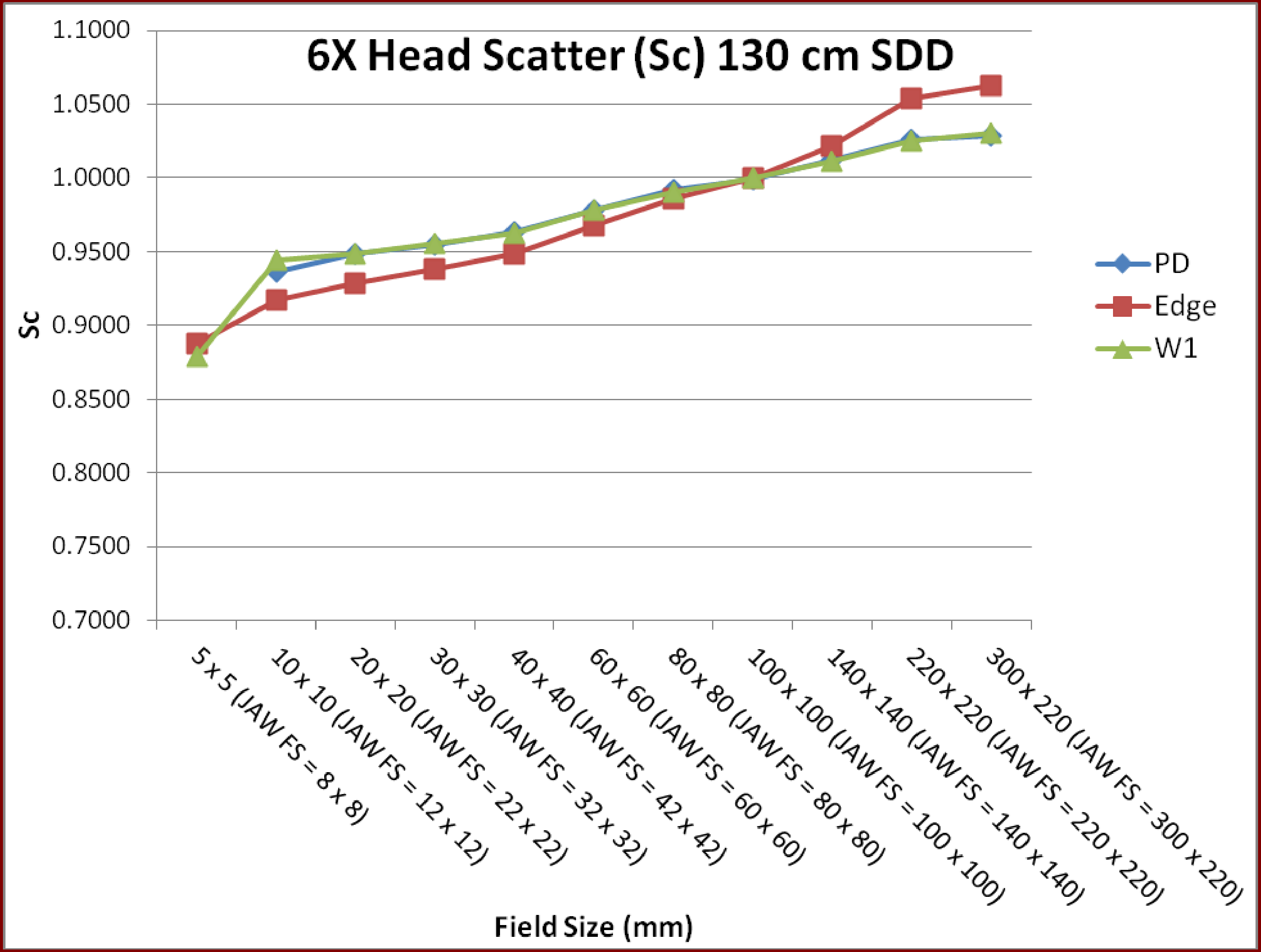
Zhu et al. Med. Phys. 31 (9) 2004



The W1 scintillator with a custom brass build-up cap.

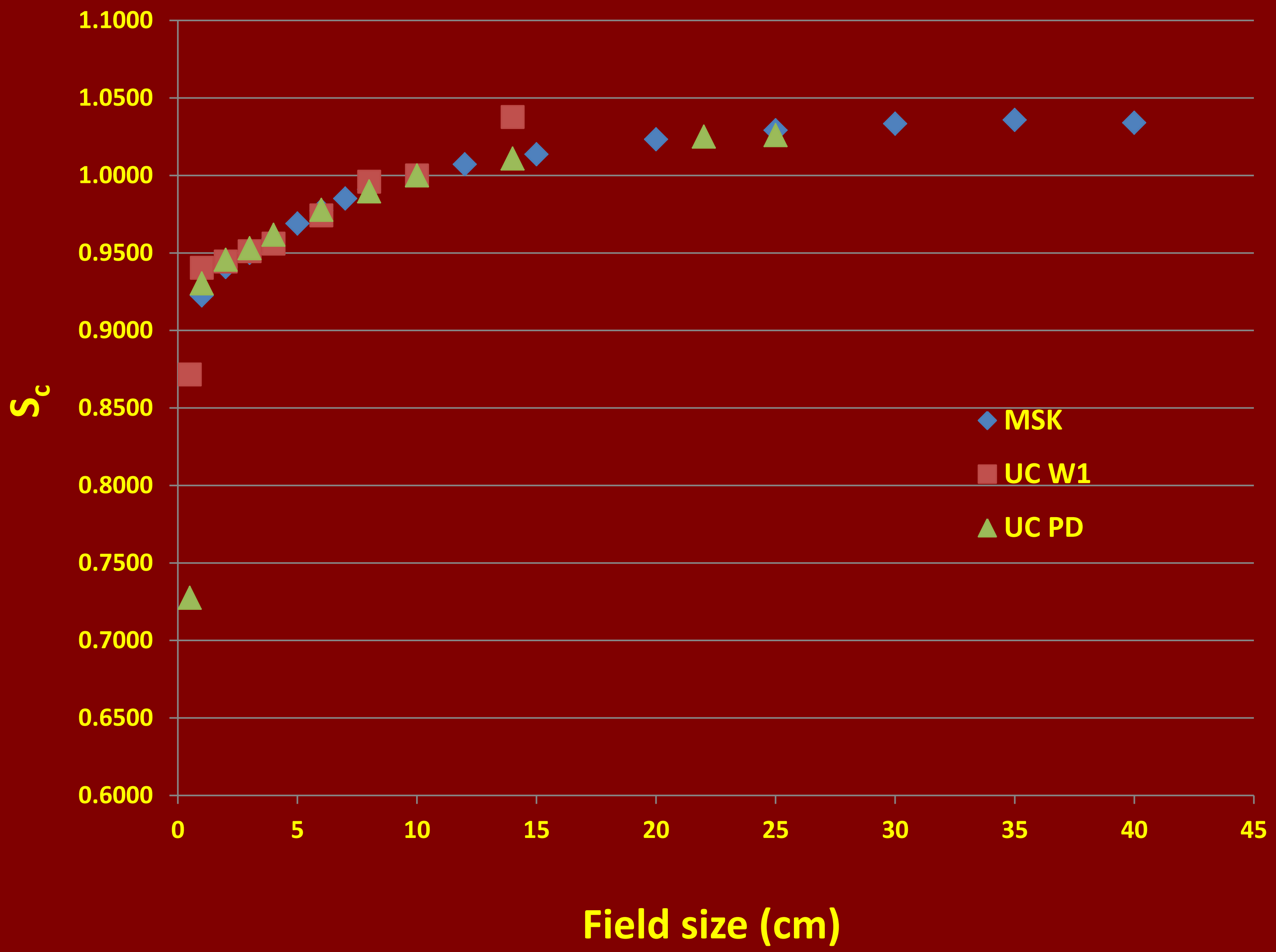


Custom in-air calibration phantom for the W1 scintillator. The pattern on the vendor-supplied calibration phantom was transferred to a piece of Styrofoam and traced out with a drill bit.

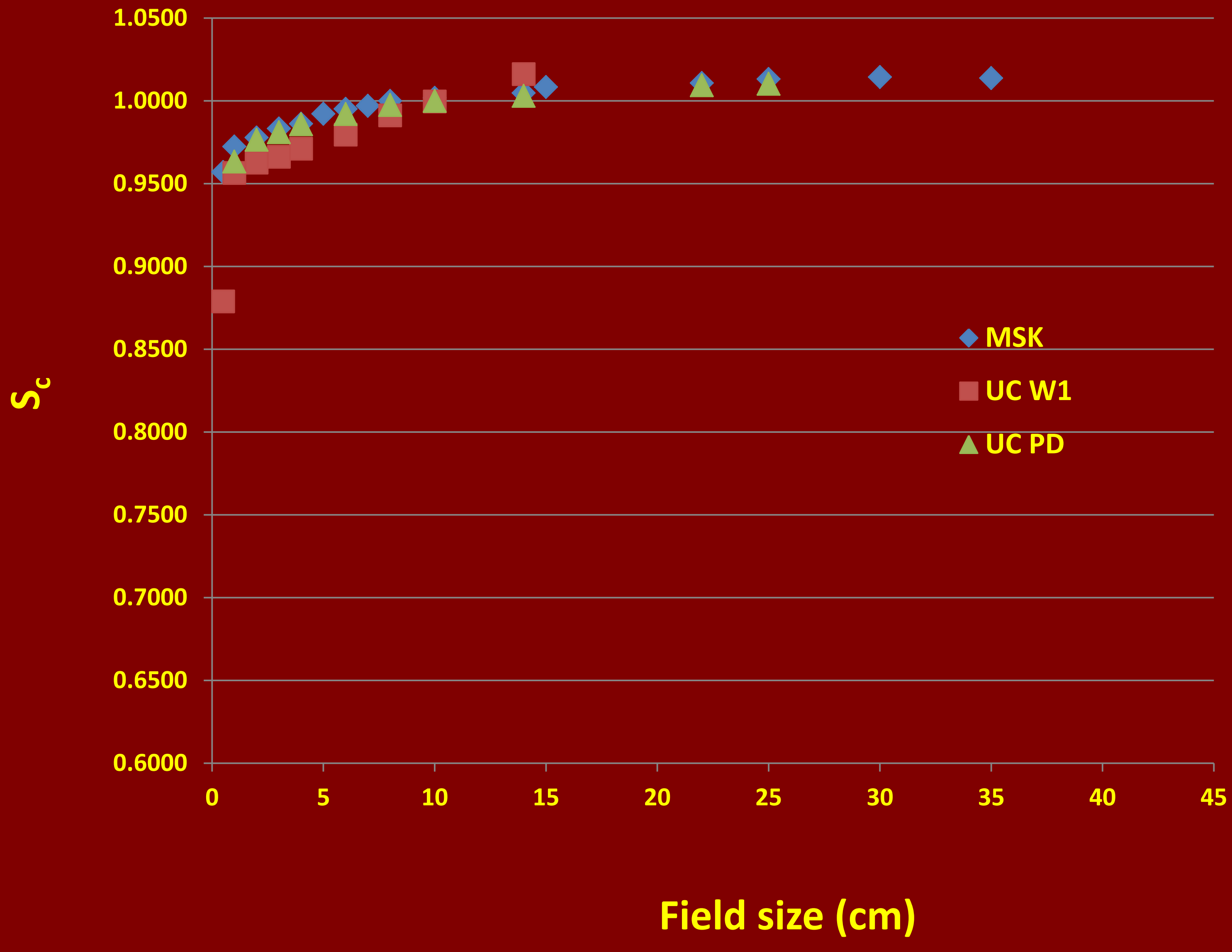


Head scatter (Sc) for 6X photon beam measured with the W1 scintillator, the IBA photon diode and the Edge photon diode. For each detector, a custom made build-up cap was used.

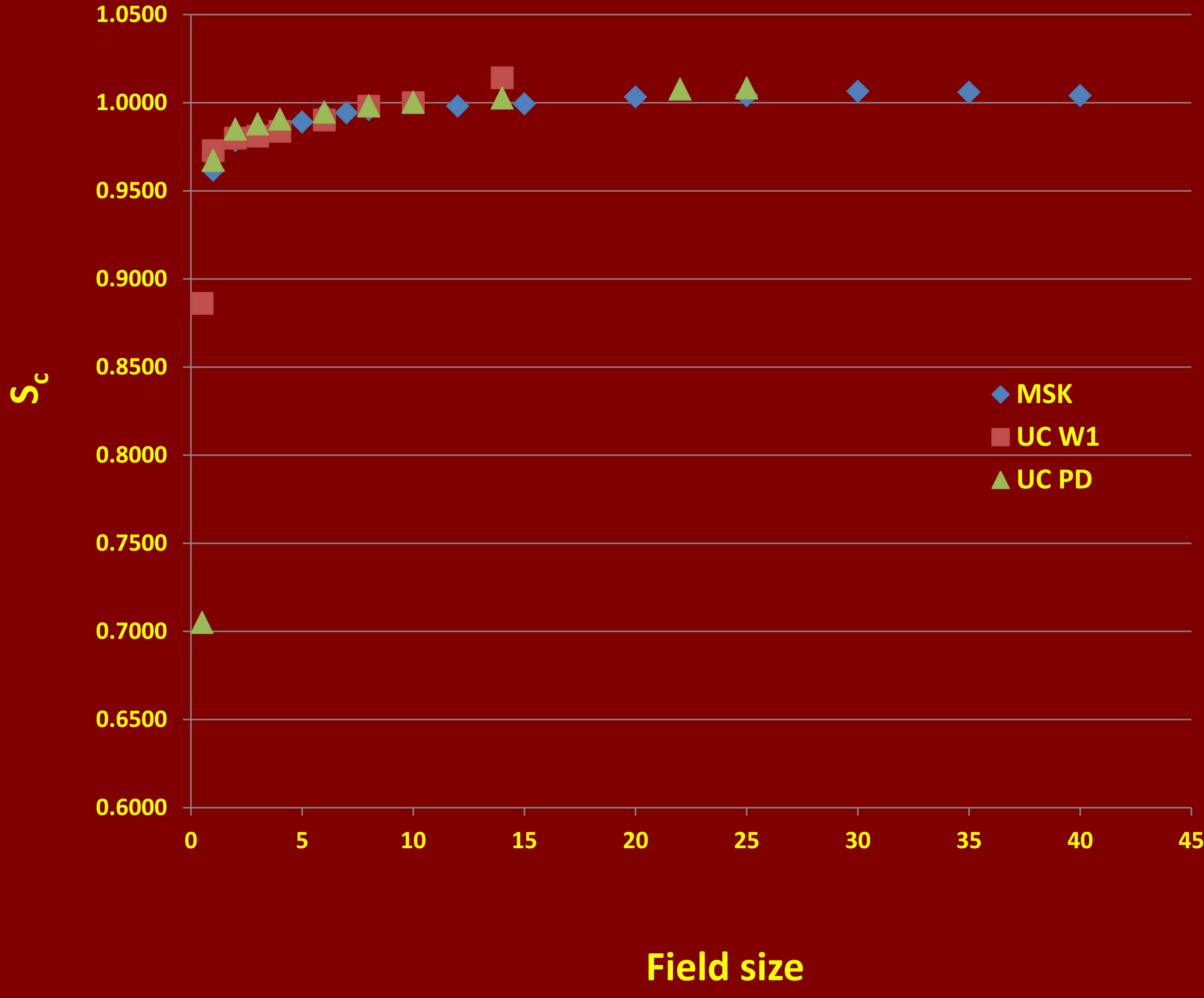
S_c measurements for 6MV



S_c measurements for 6MV FFF



S_c measurements for 10 MV FFF



Thank you for your attention