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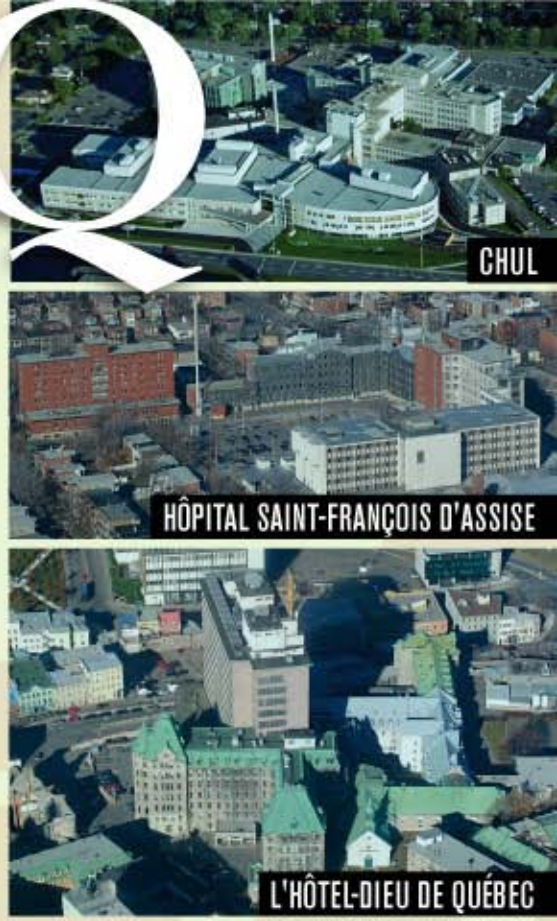

A sub-millimeter plastic scintillation detector for small field measurements delivered by a CyberKnife unit

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[2]Centre hospitalier de l'Université de Montréal (CHUM), Montréal, Canada
[3]Montreal General Hospital (L5-113), Medical Physics Unit, Montréal, Canada
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Problematic

- Limitations for small field dosimetry (≤20 mm)
  - Spatial resolution
  - Water equivalence
  - Energy dependence
  - Dose rate dependence

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main limitations

Work hypothesis

- → Important limitation + → Acceptable ++ → Excellent

Detector	Sensitive volume [mm]	Spatial resolution	Water equivalence	Energy dependence	Dose rate dependence
SFD diode	0.6	++	-	-	++
60012 diode	1.13	+	-	-	+
60008 diode	1.13	+	-	-	+
MicroLion	2.5	-	+	++	+
PSD 0.5 mm	0.5	++	++	++	++
PSD 1.0 mm	1.0	+	++	++	++

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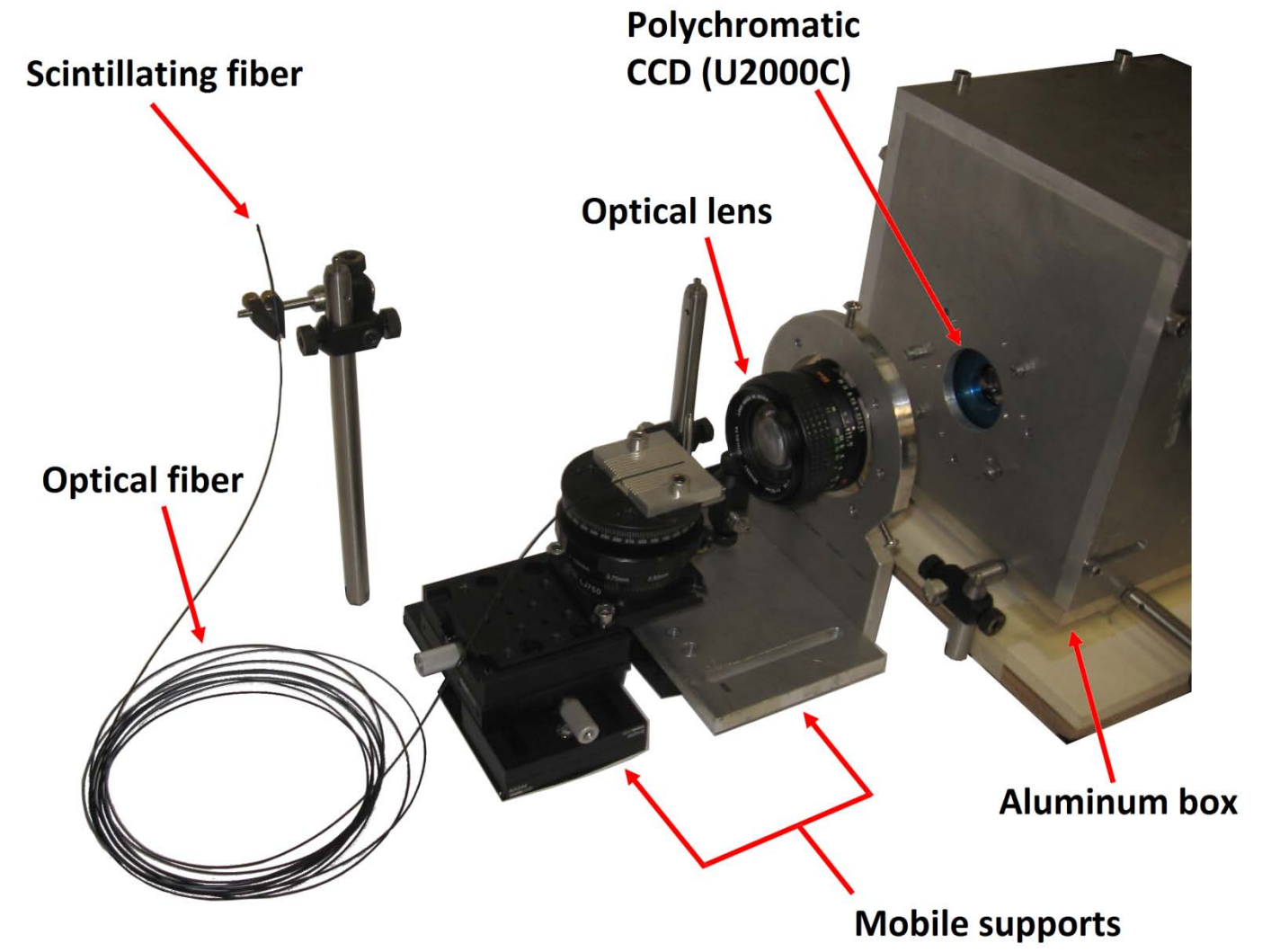
Purpose

To verify the accuracy of the PSDs in small fields on an experimental way

Plastic scintillation detectors



Plastic scintillation detectors

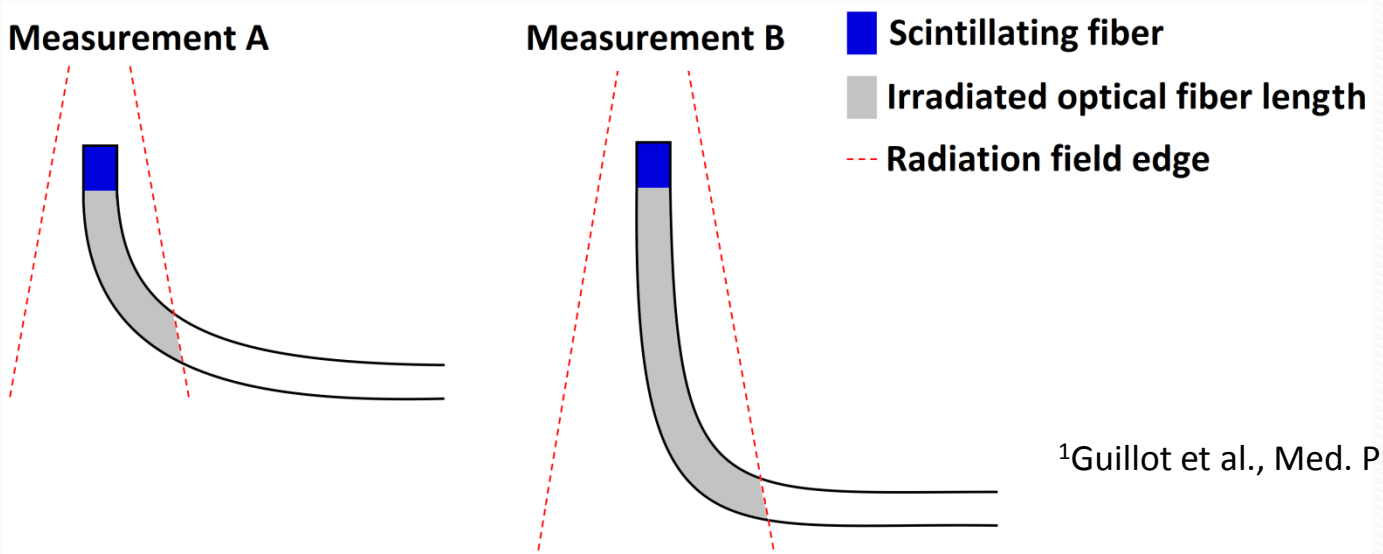
Spectral discrimination → $D = a[b_m-(b_c/g_c)g_m]$[1]

D → Dose (Gy)

a → Gain factor (Gy/light signal)

b_m and g_m → Blue and green measured (scintillation + Čerenkov)

b_c/g_c → Čerenkov light spectrum



[1]Guillot et al., Med. Phys. **38** (2011)

Total scatter factors

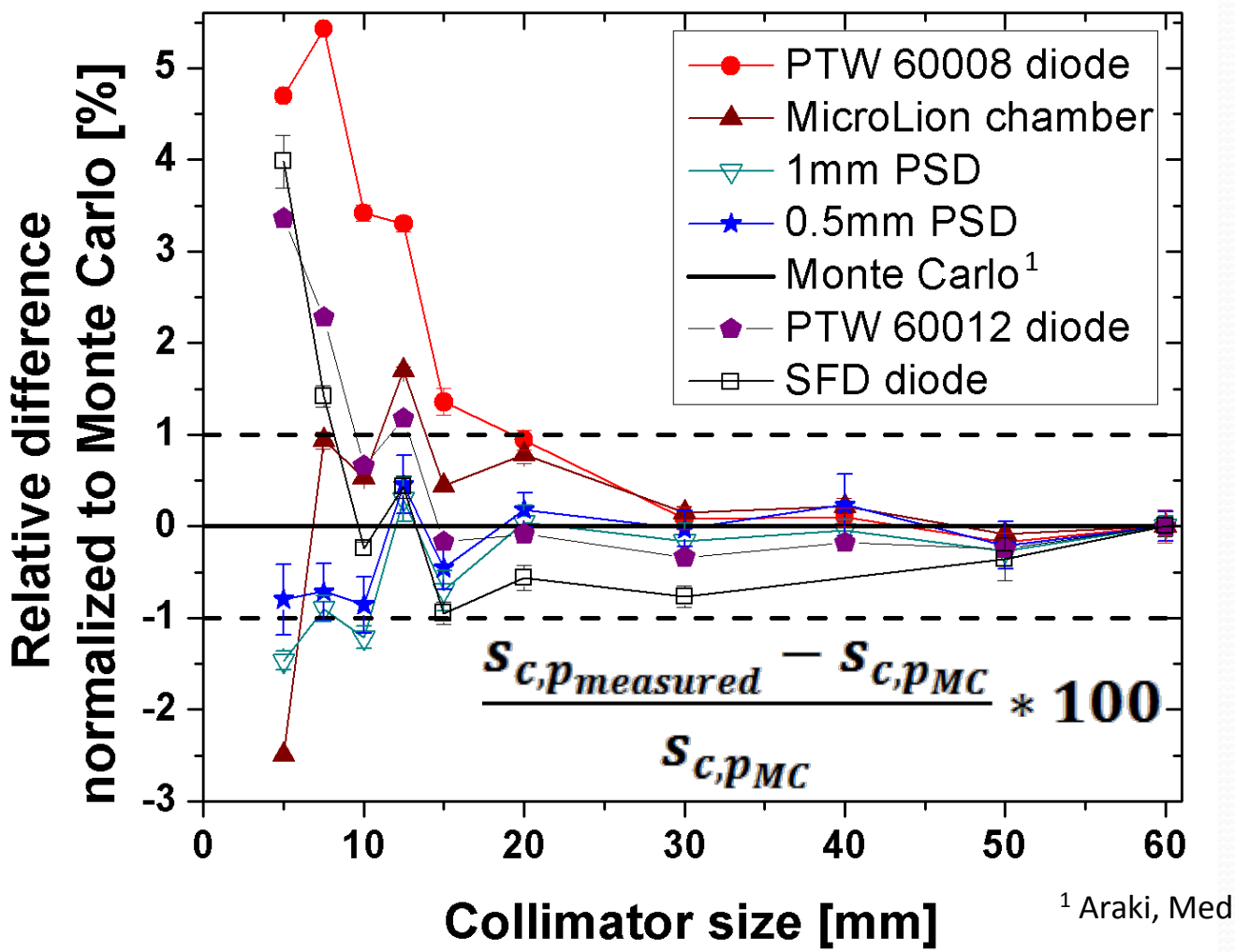
- Total scatter factors
  - Collimator diameters used ⟶ 5, 7.5, 10, 12.5, 15, 20, 30, 40, 50, 60 mm
  - Stem parallel to the beam axis with all detectors

Total scatter factors

- Comparison with two independent Monte Carlo studies
  - Araki (3.2 mm and 6.7 MeV)[1]
  - Francescon (2.2±0.1 mm and 6.6±0.1 MeV)[2]

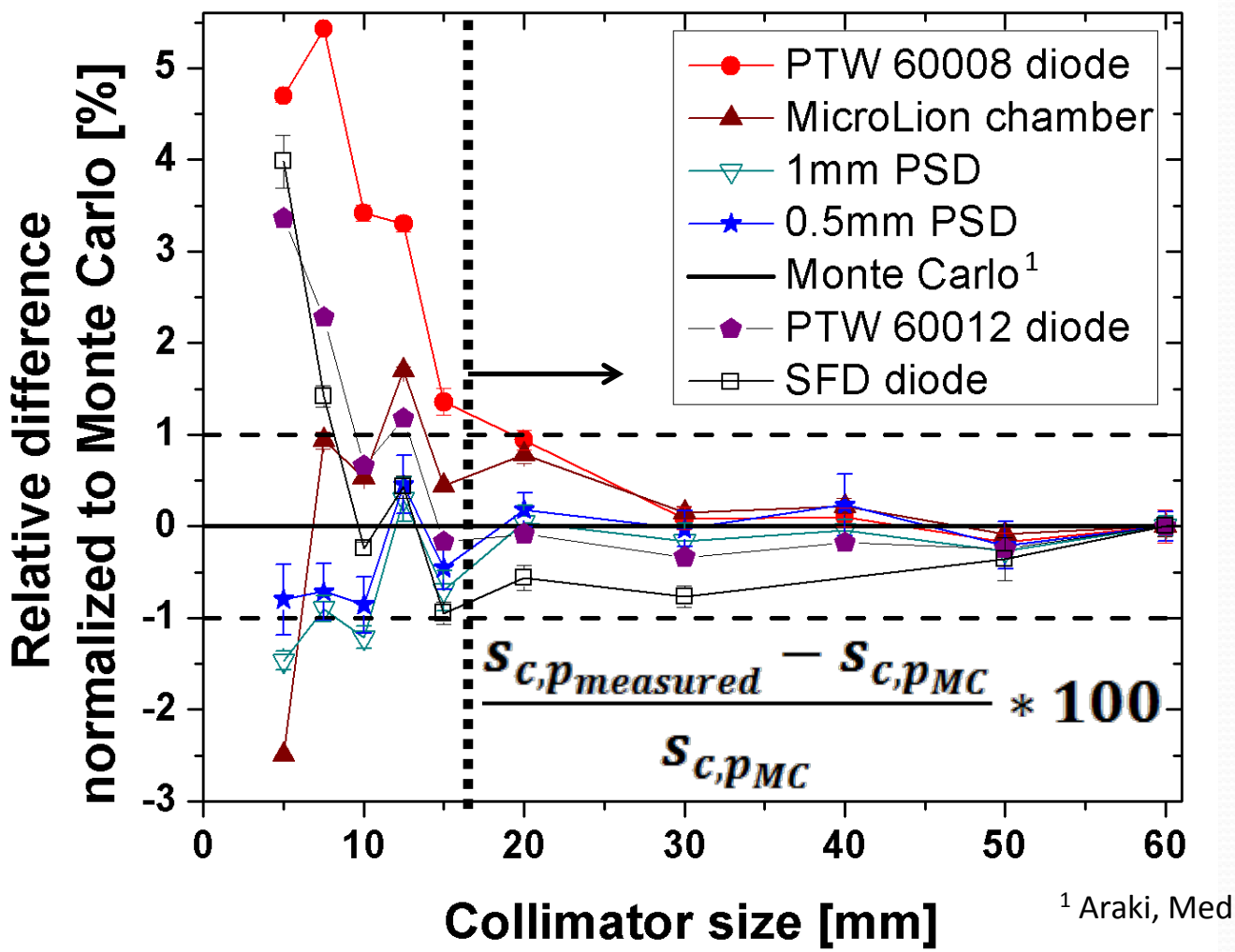
[1] Araki, Med. Phys. **33** (2006)
[2] Francescon et al., Med. Phys. **35** (2008)

Total scatter factors



[1] Araki, Med. Phys. **33** (2006)

Total scatter factors



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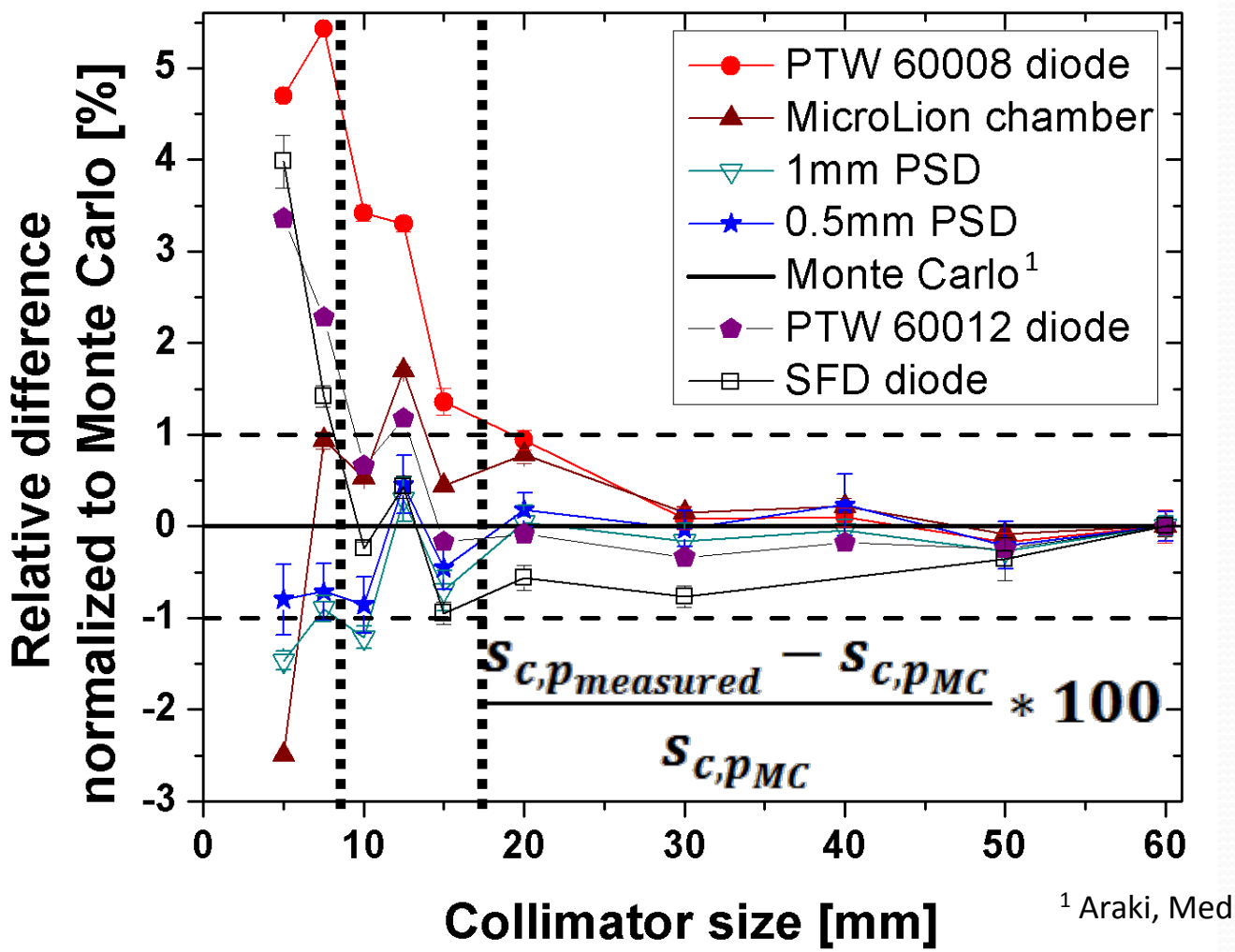
Total scatter factors



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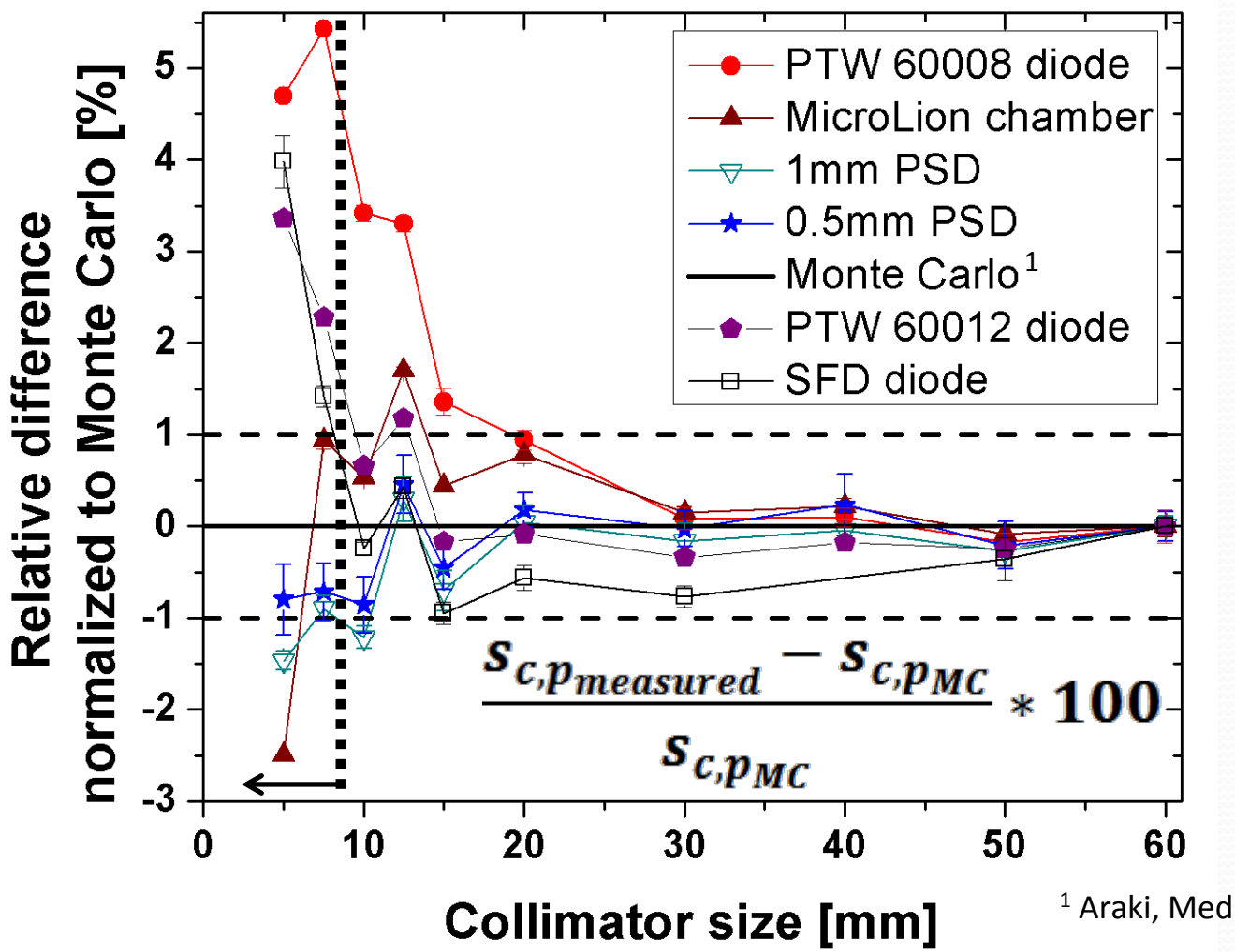

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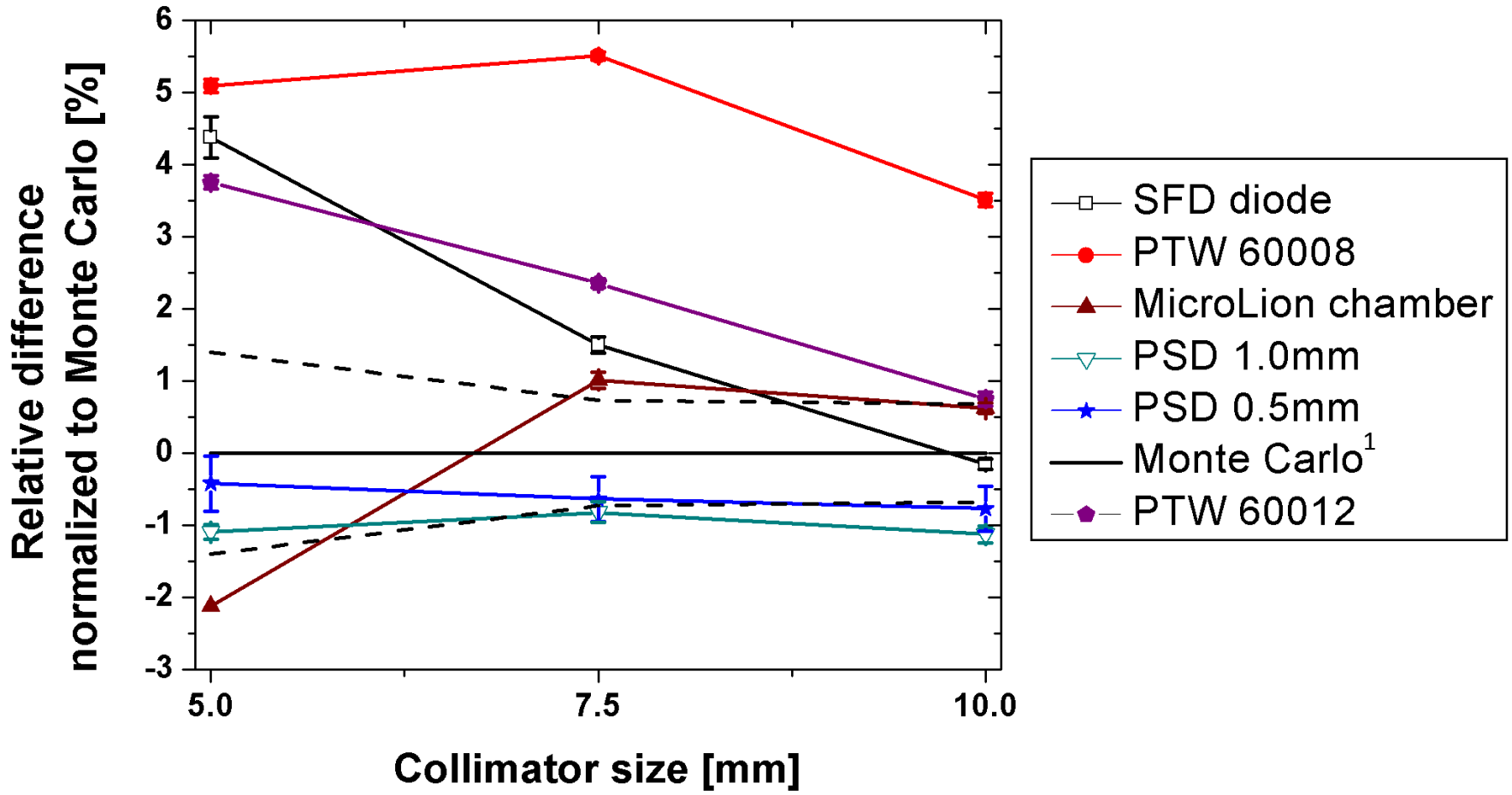
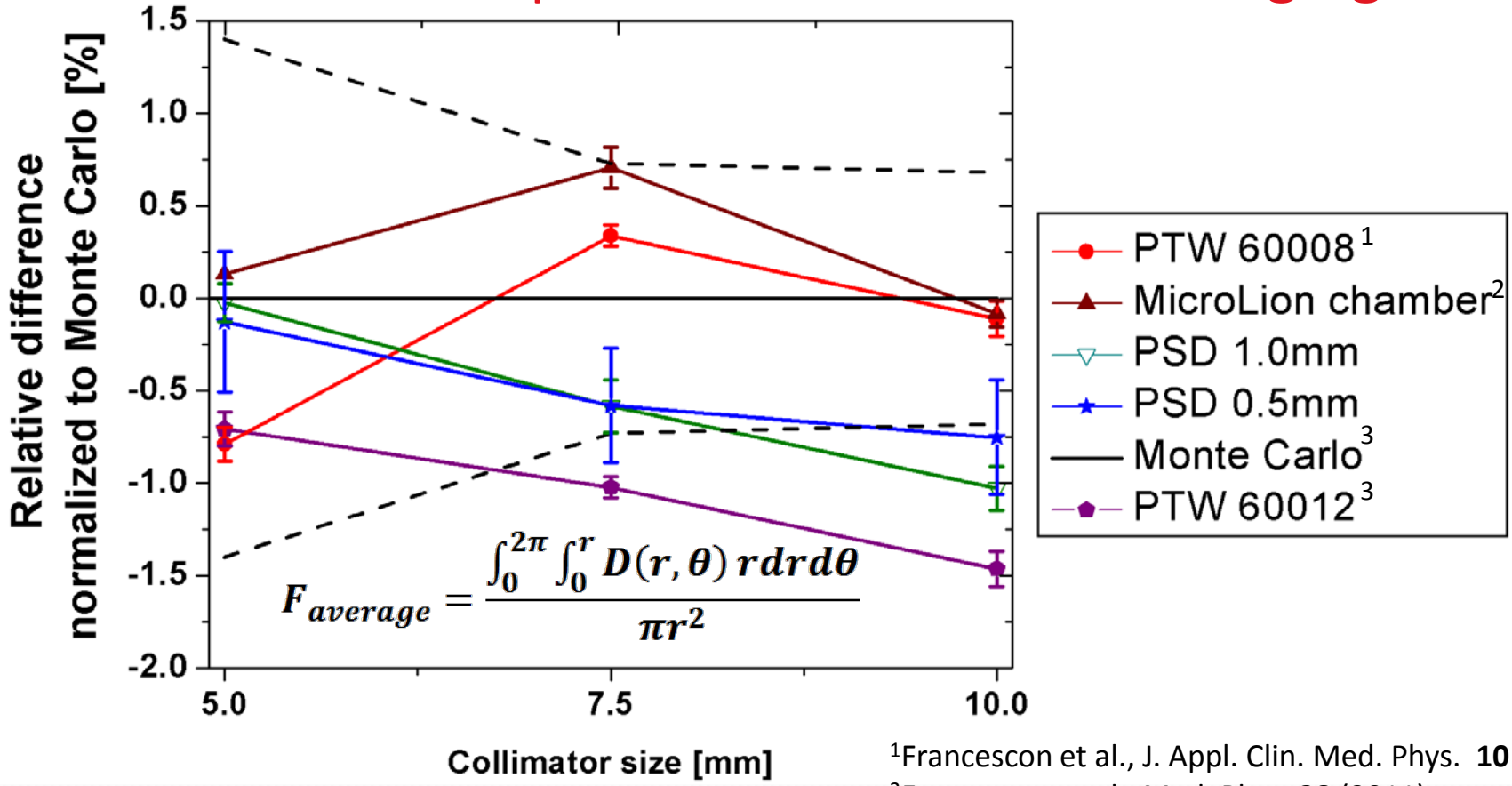


[1]Francescon et al., Med. Phys. **35** (2008)

Total scatter factors

Corrected for composition and volume averaging effect



$$F_{average} = \frac{\int_0^{2\pi}\int_0^{r} D(r,\theta)\, r dr d\theta}{\pi r^2}$$

[1]Francescon et al., J. Appl. Clin. Med. Phys. **10** (2009)
[2]Francescon et al., Med. Phys. **38** (2011)
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Correction factors

Detectors	Collimator diameter [mm]	Correction factors	Literature	Difference [%]
PTW 60008 diode	5	0.950	0.944[1]	0.6
	7.5	0.942	0.951[1]	0.9
PTW 60012 diode	5	0.963	0.957[2]	-0.6
	7.5	0.971	0.967[2]	-0.4
SFD diode	5	0.957	0.952[3]	-0.5
	7.5	0.980	0.976[3]	-0.4
MicroLion chamber	5	1.020	1.023[4]	0.3
	7.5	0.984	0.997[4]	1.3

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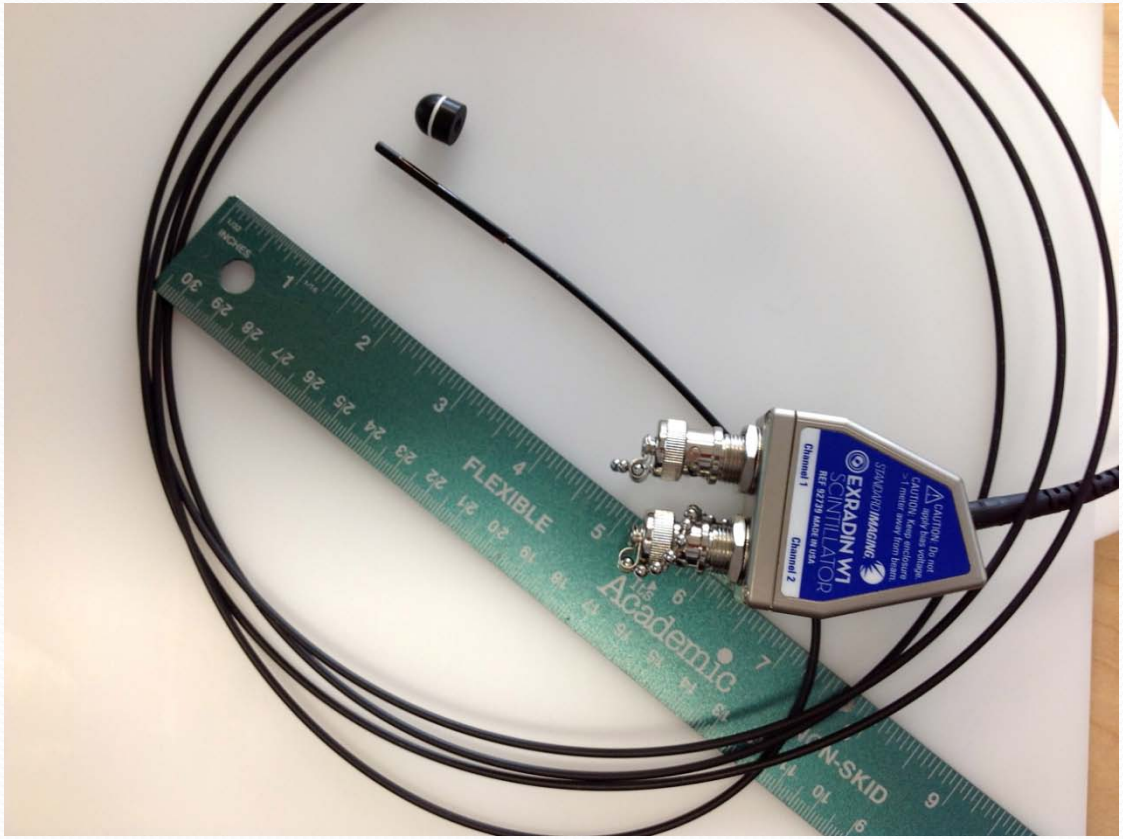
Conclusions

- Commercial dosimeters provide accurate results once corrected
- Plastic scintillation detectors are promising candidate to become reference radiosurgery dosimeter
- Worst case scenario for 1 mm PSD is a 1% underestimation for the 5 mm cone

Conclusions

- PSD now commercially available



Acknowlegments

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