

An Independent Audit and Analysis of Small Field Dosimetry Quality Assurance



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and RPC staff
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Ladies and Lords

There is a scourge across the Kingdom



Small field
dosimetry

TG-155

Small Field Dosimetry

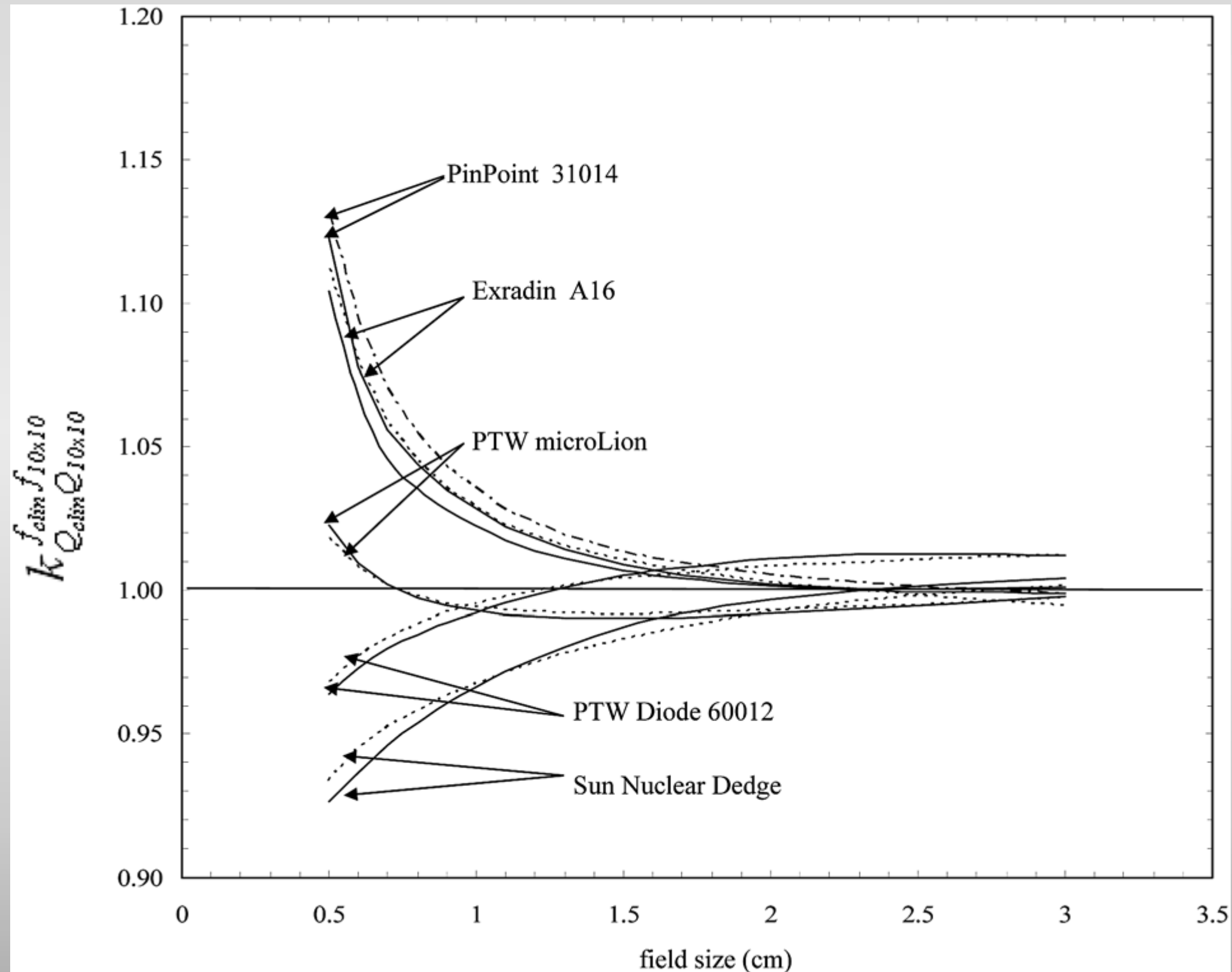
Recommendation:

The unshielded stereotactic diode and micro-chambers are the detectors of choice for measurements in radiosurgery beams. However, we recommend comparing the measurements from at least two different detectors listed in Table 2a, and after **applying corrections** taking their average.

TG-155

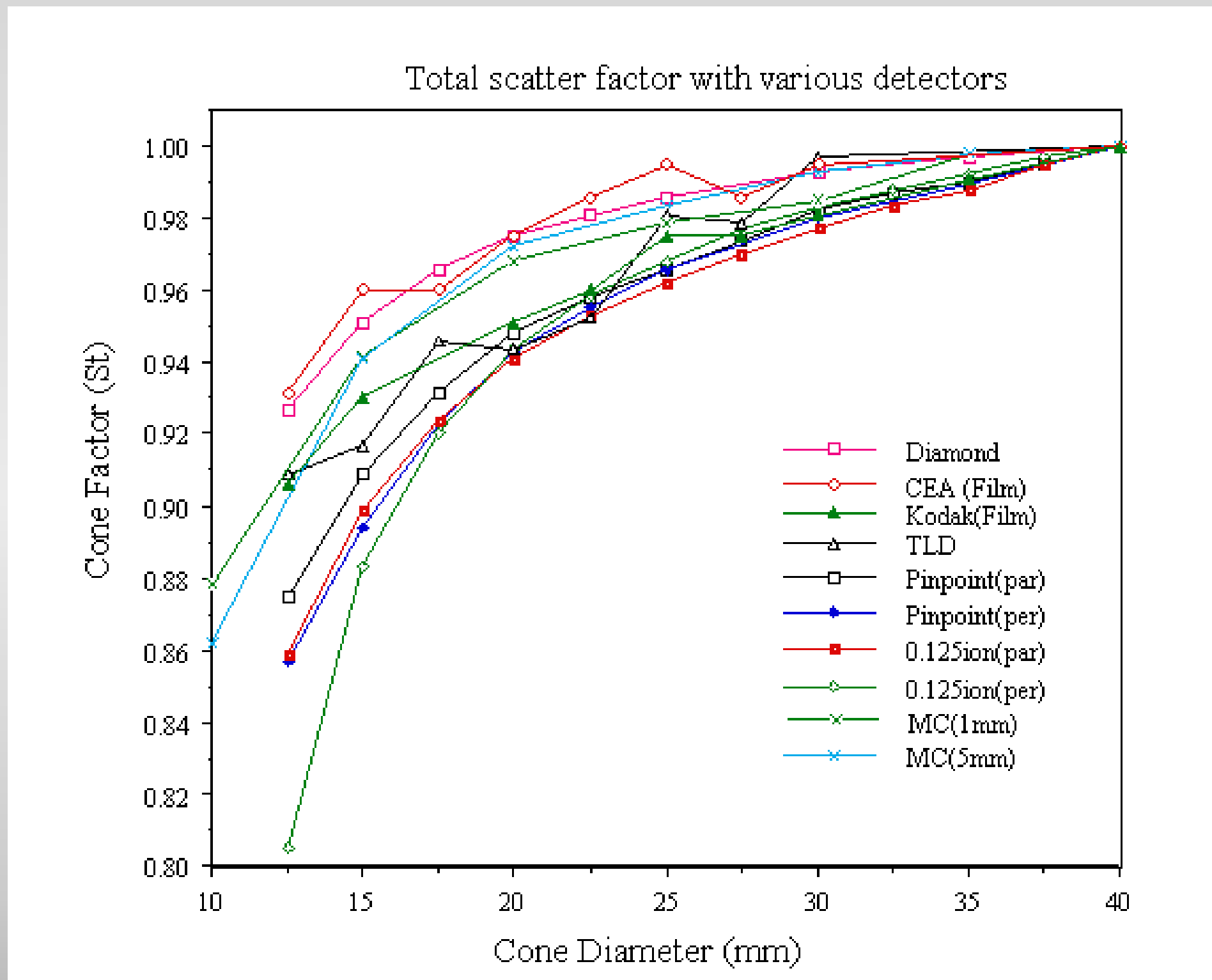
Small Field Dosimetry Corrections

Situation is even worse if you consider using field sizes less than $0.5 \times 0.5 \text{ cm}^2$



Francescon et al
2011 data

What is the truth?



TG-155

Small Field Dosimetry

Recommendation:

It is strongly recommended to independently verify dosimetric measurements in small fields, either through measurements carried out by a different person and/or through an independent external audit, such as that carried out by the RPC .

RPC Measurements during onsite visits

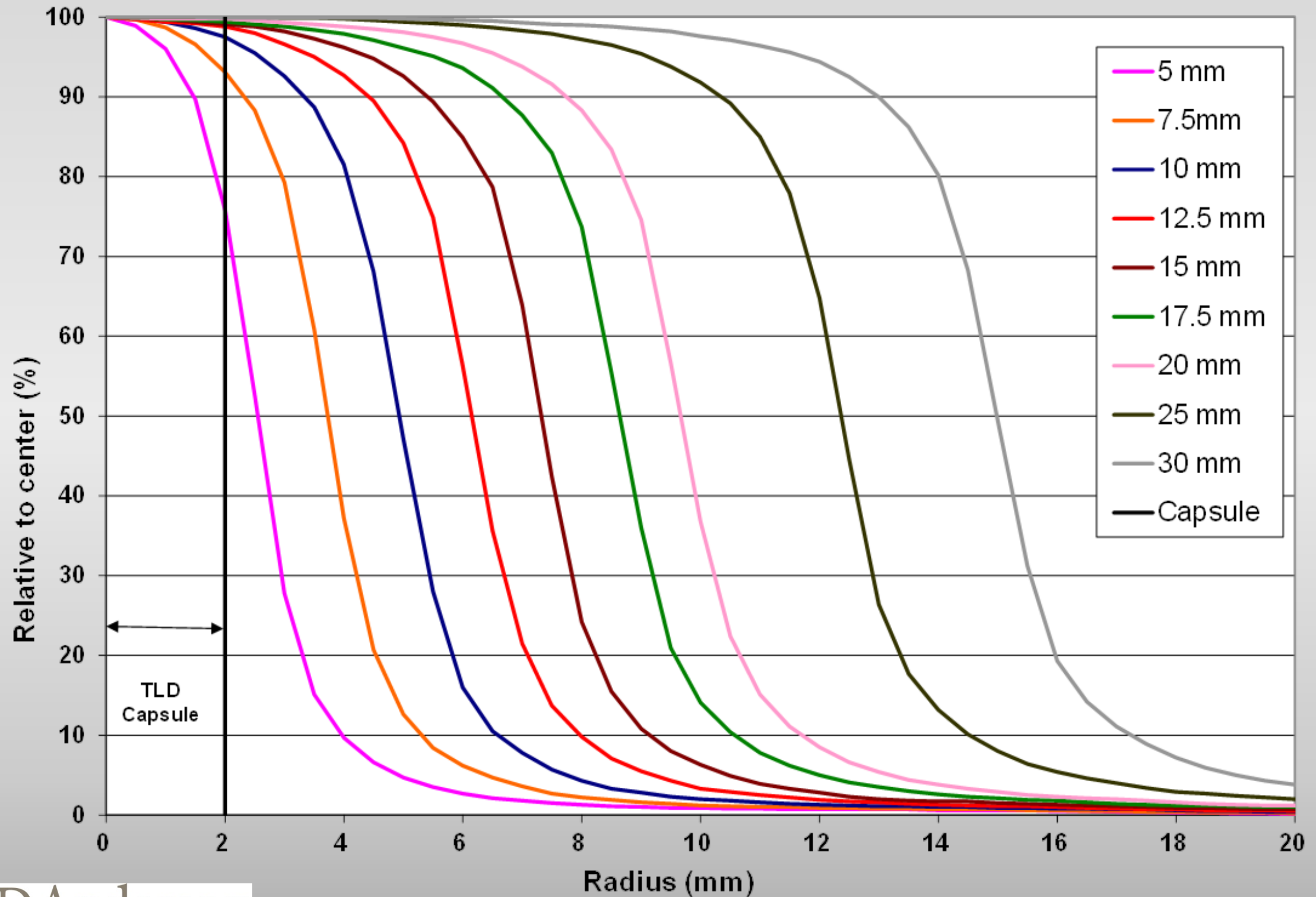
Measurement configuration:

depth = 10 cm, 100 cm SSD, Exradin A16

Just like the Knight in shining armor who is trying to slay the dragon, one must always fully understand their limitations



The Problem is that our Dragon is very small!



Tables of standard small field factors

TABLE 1. The RPC-measured and institution treatment planning system-calculated small field size dependence output factor values for Varian machines. The values in square brackets and parentheses beneath each energy for each field size value are the average absolute percent differences and standard deviations of the values, respectively. For each energy and field size, the number of measurements (accelerators) is also shown.

Field Size (cm × cm)	Varian 6 MV		Varian 10 MV		Varian 15 MV		Varian 18 MV	
	RPC	Institution	RPC	Institution	RPC	Institution	RPC	Institution
10 × 10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
6 × 6	0.921 (0.013) [0.9%] (n=64)	0.929 (0.004)	0.946 (0.017) [0.7%] (n=9)	0.953 (0.016)	0.951 (0.008) [0.5%] (n=14)	0.950 (0.008)	0.949 (0.011) [0.5%] (n=16)	0.950 (0.014)
4 × 4	0.865 (0.018) [1.3%] (n=64)	0.874 (0.021)	0.900 (0.024) [1.3%] (n=9)	0.912 (0.030)	0.909 (0.017) [1.1%] (n=14)	0.909 (0.017)	0.902 (0.014) [1.1%] (n=16)	0.900 (0.024)
3 × 3	0.828 (0.017) [1.7%] (n=62)	0.841 (0.025)	0.867 (0.020) [1.2%] (n=9)	0.875 (0.025)	0.874 (0.014) [1.3%] (n=12)	0.877 (0.019)	0.861 (0.014) [1.7%] (n=16)	0.856 (0.027)
2 × 2	0.786 (0.019) [2.3%] (n=55)	0.796 (0.031)	0.817 (0.015) [1.8%] (n=11)	0.828 (0.019)	0.803 (0.016) [2.8%] (n=10)	0.813 (0.038)	0.784 (0.015) [3.5%] (n=15)	0.782 (0.034)

TABLE 2. The RPC-measured and institution treatment planning system-calculated small field size dependence output factor values for Elekta machines. The values in square brackets and parentheses beneath each energy for each field size value are the average absolute percent differences and standard deviations of the values, respectively. For each energy and field size, the number of measurements (accelerators) is also shown.

Field Size (cm × cm)	Elekta 6 MV		Elekta 10 MV		Elekta 18 MV	
	RPC	Institution	RPC	Institution	RPC	Institution
10 × 10	1.000	1.000	1.000	1.000	1.000	1.000
6 × 6	0.930 (0.010) [0.5%] (n=18)	0.934 (0.009)	0.937 (0.004) [0.7%] (n=6)	0.940 (0.005)	0.945 (0.002) [0.3%] (n=5)	0.947 (0.003)
4 × 4	0.878 (0.015) [1.3%] (n=22)	0.888 (0.027)	0.890 (0.009) [0.6%] (n=8)	0.891 (0.010)	0.901 (0.002) [0.4%] (n=6)	0.918 (0.039)
3 × 3	0.842 (0.012) [0.9%] (n=17)	0.848 (0.009)	0.857 (0.003) [0.6%] (n=6)	0.862 (0.005)	0.861 (0.003) [0.6%] (n=4)	0.863 (0.004)
2 × 2	0.790 (0.007) [1.6%] (n=17)	0.796 (0.010)	0.796 (0.009) [1.3%] (n=6)	0.802 (0.008)	0.786 (0.006) [2.4%] (n=4)	0.798 (0.019)

TABLE 3. The RPC-measured and institution treatment planning system-calculated small field size dependence output factor values for Siemens machines. The values in square brackets and parentheses beneath each energy for each field size value are the average absolute percent differences and standard deviations of the values, respectively. For each energy and field size, the number of measurements (accelerators) is also shown.

Field Size (cm × cm)	Siemens 6 MV		Siemens 10 MV		Siemens 18 MV	
	RPC	Institution	RPC	Institution	RPC	Institution
10 × 10	1.000	1.000	1.000	1.000	1.000	1.000
6 × 6	0.914 (0.008) [0.7%] (n=13)	0.920 (0.008)	0.927 (0.003) [0.9%] (n=4)	0.935 (0.010)	0.940 (0.005) [0.6%] (n=4)	0.946 (0.003)
4 × 4	0.855 (0.010) [1.1%] (n=13)	0.863 (0.009)	0.877 (0.001) [1.2%] (n=4)	0.884 (0.012)	0.891 (0.004) [0.6%] (n=4)	0.896 (0.003)
3 × 3	0.820 (0.008) [1.3%] (n=13)	0.825 (0.011)	0.841 (0.001) [1.1%] (n=4)	0.850 (0.007)	0.849 (0.003) [0.7%] (n=4)	0.855 (0.003)
2 × 2	0.764 (0.010) [2.8%] (n=12)	0.757 (0.042)	0.777 (0.005) [5.8%] ^a (n=4)	0.742 (0.079)	0.795 (0.004) [1.9%] (n=4)	0.779 (0.015)

^aAn institution value was 25% different to the RPC-measured value. The institution corrected its data subsequent to the RPC visit.

Followill et al 2012 and also will be in TG-155

On-Site Dosimetry Review Audit

Discrepancies Discovered (Jan. '05 – April '13)

<u>Discrepancies Regarding:</u>	<u>Number of Institutions Receiving rec. (n = 206)</u>
Review QA Program	152 (74%)
Photon Field Size Dependence	138 (67%)
Wedge Factor (WF)	66 (32%)
Off-axis Factors (OAF)/Beam symmetry	60 (29%)
Electron Calibration	35 (17%)
Photon Depth Dose	33 (16%)
Electron Depth Dose	25 (12%)
Photon Calibration	16 (8%)

This is a beam measurement issue and TPS beam modeling challenge.

There is guidance or possibly a fair maiden after the dragon is slain.

The bigger challenge is with Varian machines due to the tertiary collimation (MLC)

- Varian/Pinnacle combination:

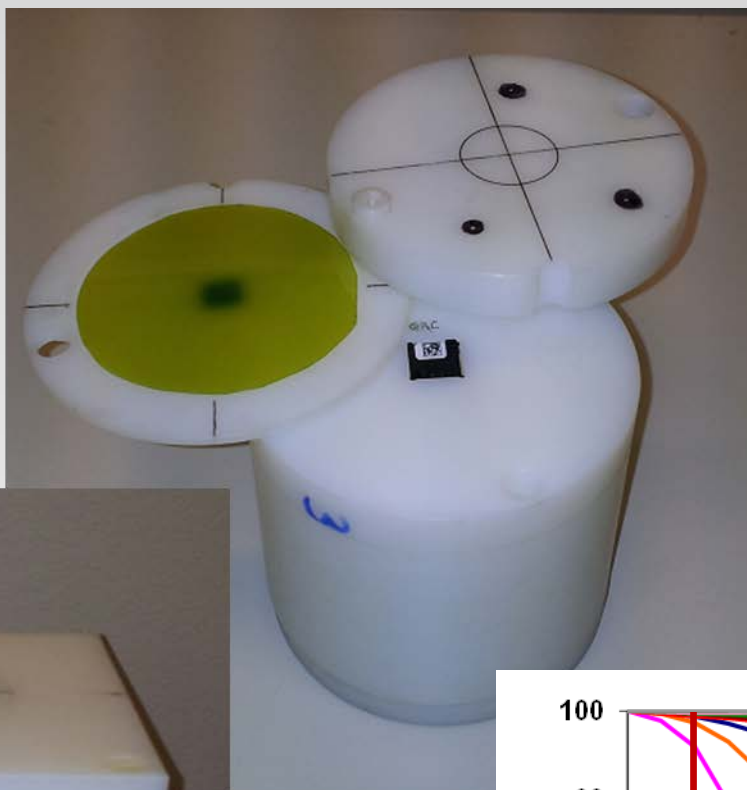
Followill et al, JACMP, vol. 13, No. 5, 2012

- Varian/Eclipse combination:

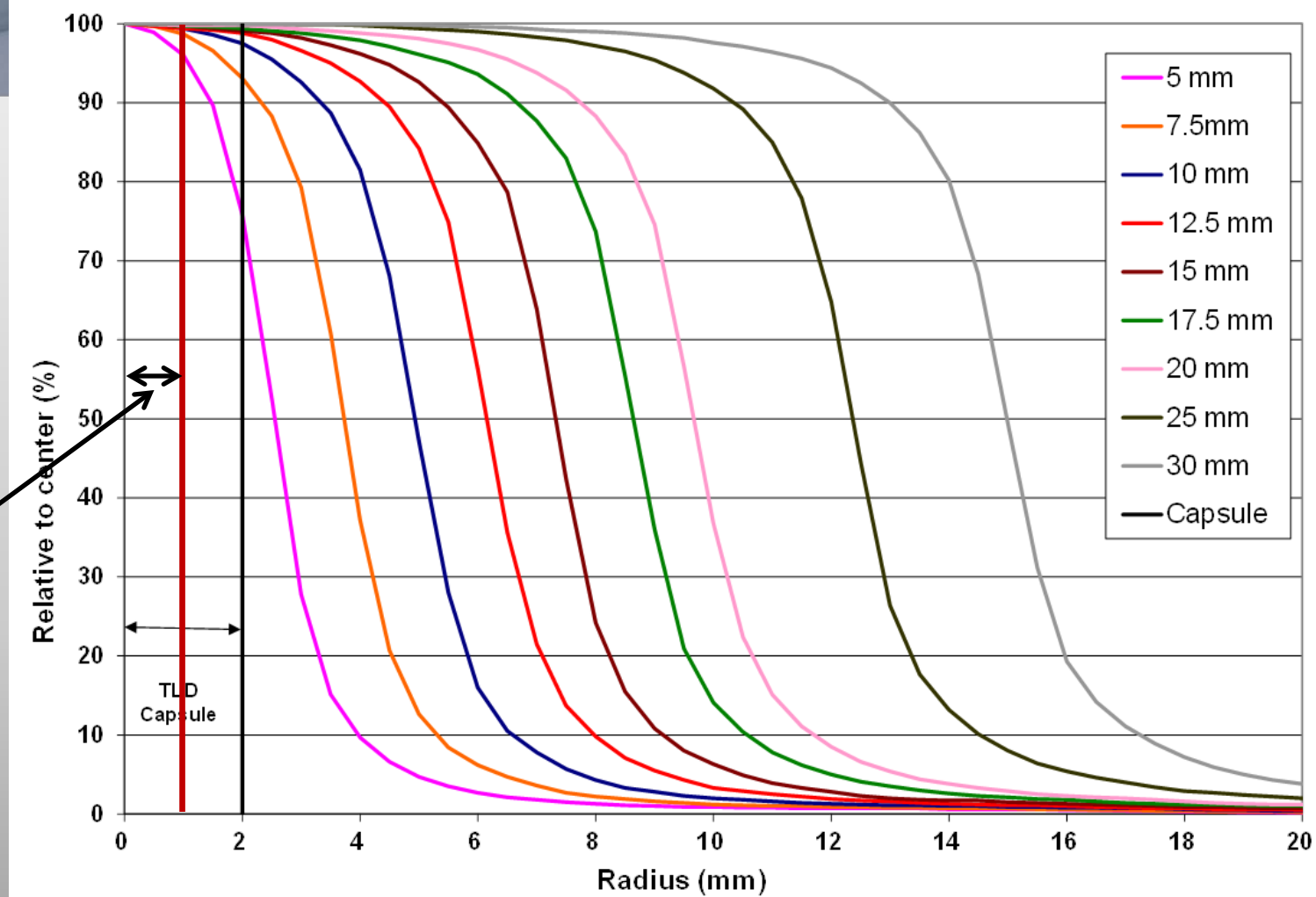
Kron et al, Med Phys, vol 39 (2), 2012



New RPC audit

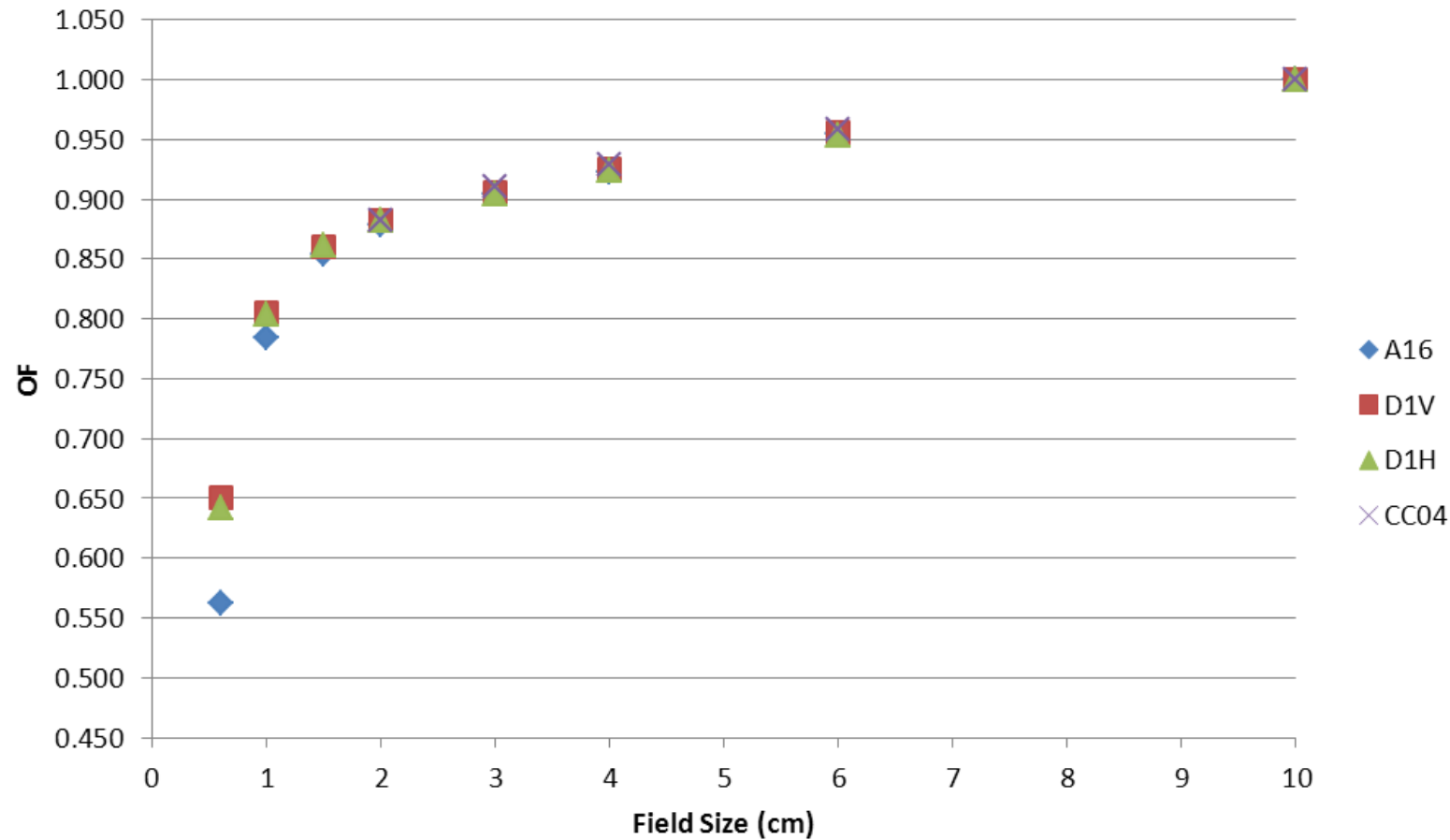


OSLD



Commissioning and Testing

OF at d=1.5cm



Three dosimeters were used to estimate the dose for each field size: Exradin A16

Exradin D1V diode

Exradin D1V diode

PTW CC04

First Test Irradiation away from RPC



Field Size	Trial #	Dose (cGy)	Ave. Meas/TPS
10 mm	1	193.6	
	2	194.3	0.962
	3	189.1	
12.5 mm	1	195.9	
	2	193.2	0.970
	3	192.9	
15 mm	1	203.9	
	2	198.4	1.002
	3	199.3	
20 mm	1	201.6	
	2	201.2	1.002
	3	198.4	
60 mm	1	204.6	
	2	202.4	1.017
	3	203.2	

Conclusions

- The challenge continues for the $<2 \times 2 \text{ cm}^2$ field sizes
- The correct dosimeter is essential.
- There are independent audits and standard data to help.
- We will defeat the dragon!

