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Measurement of Output Factors for small Photon Fields

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Tasks of the project

- Measurement with different detectors
- Finding suitable corrections
- Testing an analytical function for the output vs. field size dependence

Literature

- Karlsson et al found no significant deviations of ionization chamber to Si-Diode signals for field sizes between 4cm and 10cm side length (Karlsson et al. R&O 1997)

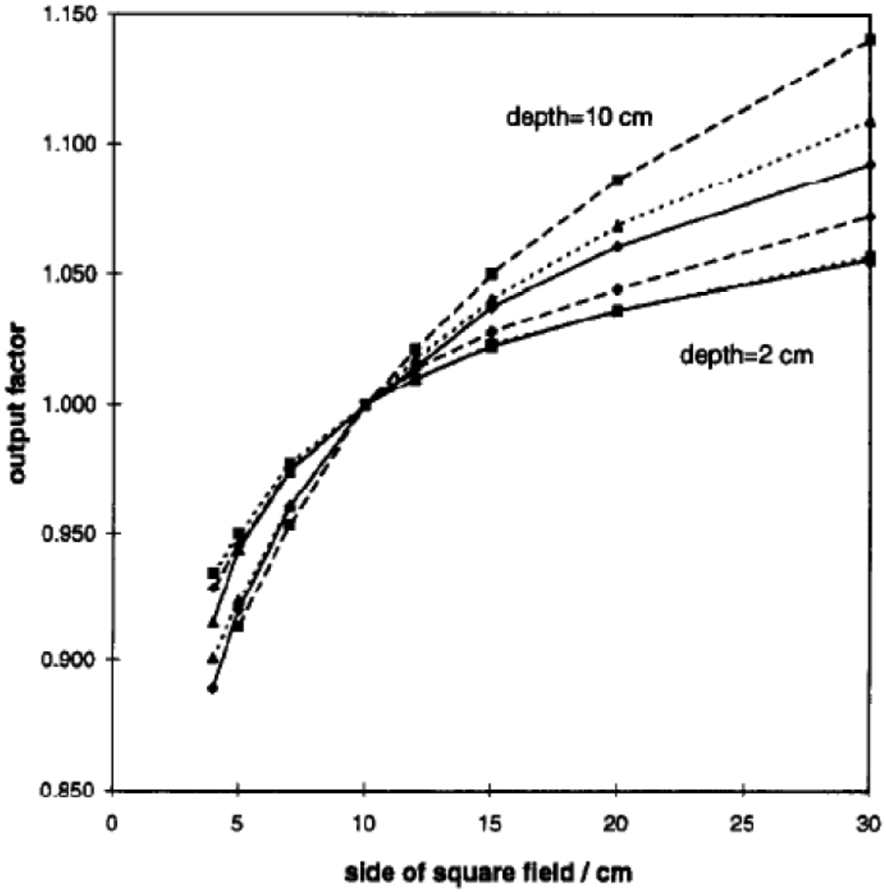


Fig. 2. The output for 10 MV (racetrack microtron) relative to the 10 cm × 10 cm field for various square field sizes. The three upper curves were measured at a depth of 10 cm and the three lower at 2 cm. Solid lines indicate ionization chamber, broken lines unshielded diode and dotted lines shielded diode.

Literature

- McKerracher et al chose the un-shielded diode signal to be the “best estimate“ of the true output for field diameters between 12.5mm to 40mm (McKerracher and Thwaites PMB 1999)

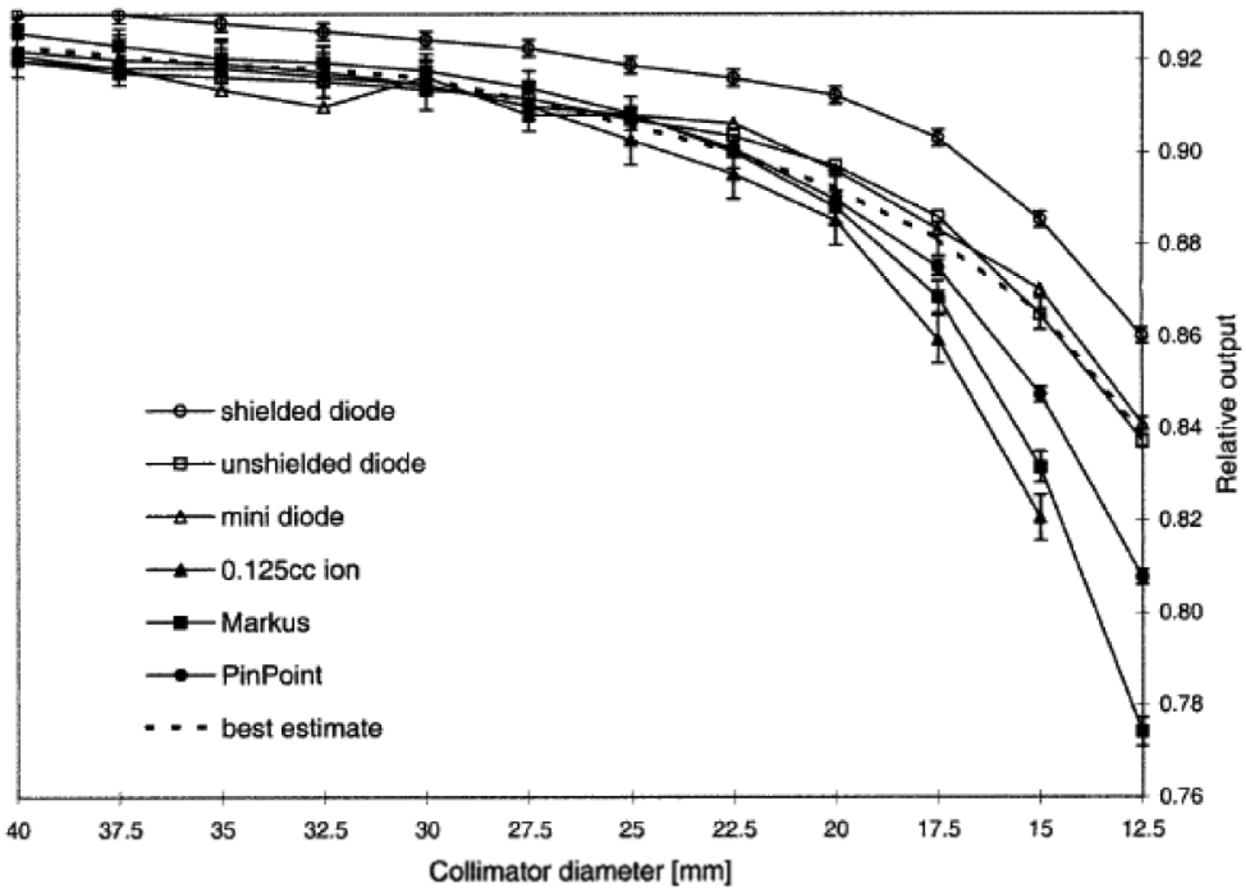


Figure 7. Measured relative output factors (normalized to 100 × 100 mm square open field) and calculated ‘best estimate’ against collimator diameter.

Literature

- Sanchez et al calculated water to air stopping power ratios for field sizes down to 3mm and found no deviations from reference field size values, indicating that correction of the stopping power is not necessary for ionization chambers (Sanchez Doblado, Andreo et al. 2003)

- Seuntjens et al 2003: Perturbation effect?

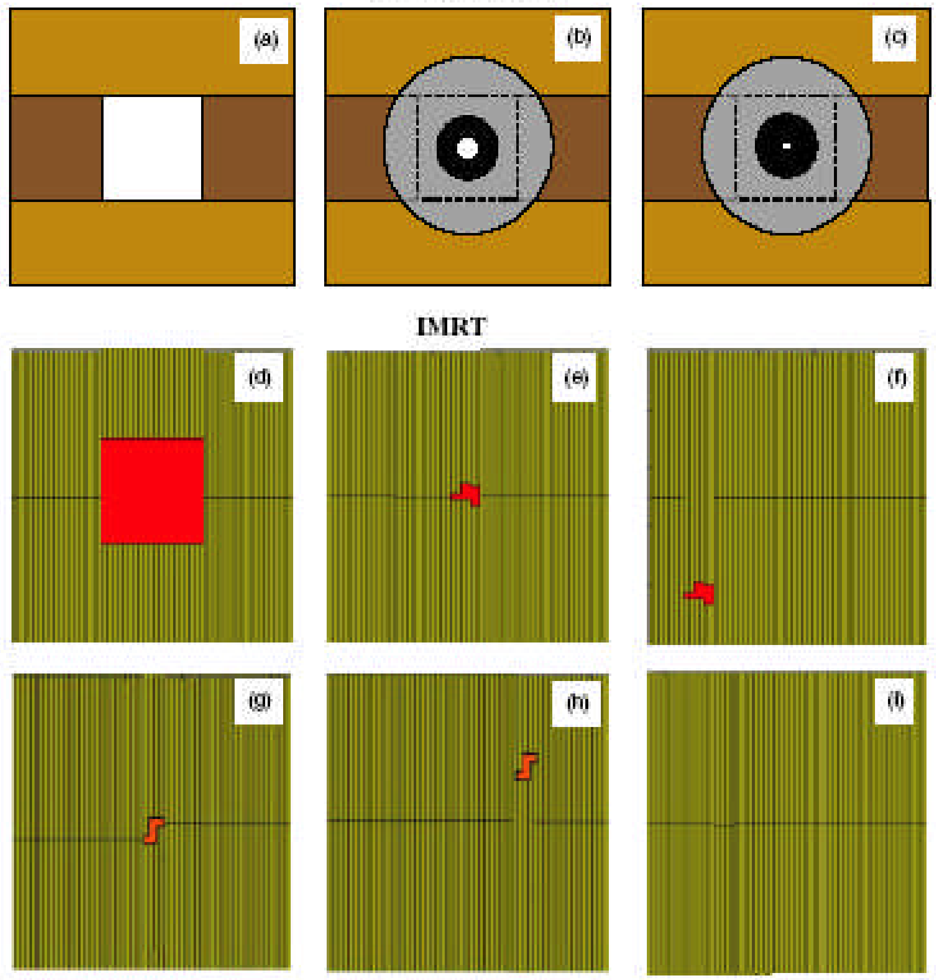


Figure 1. Configurations for the radiosurgery ((a)–(c)) and multi-leaf collimator (MLC) IMRT ((d)–(i)) beams used for the Monte Carlo calculations presented in subsequent figures. Sets (a) and (d) correspond to 10 × 10 cm² reference fields, the latter being produced with a MLC; set (i) corresponds to the cases of transmission leakage through the leafs of the MLC.

Literature

- Yin et al calculated the phantom scatter factor signal from a Si-detector, applying general cavity theory. The calculation was in good agreement with measurements for field sizes between 5cm an 40cm side length (Yin, Hugtenburg et al. 2004)

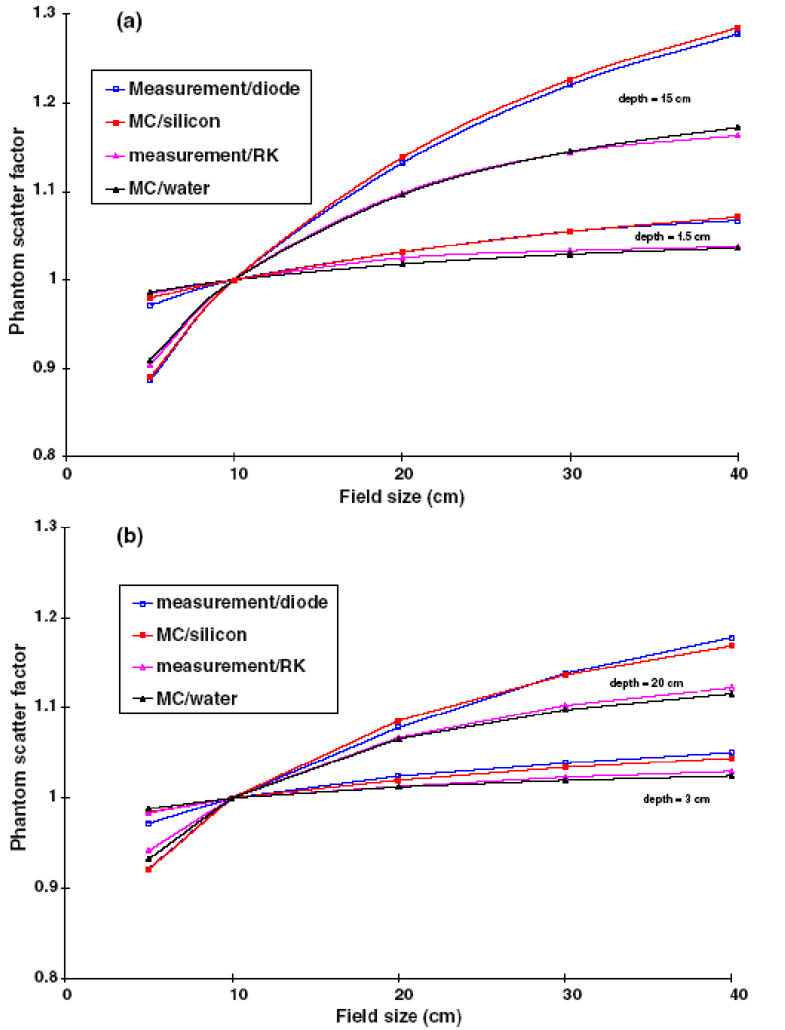
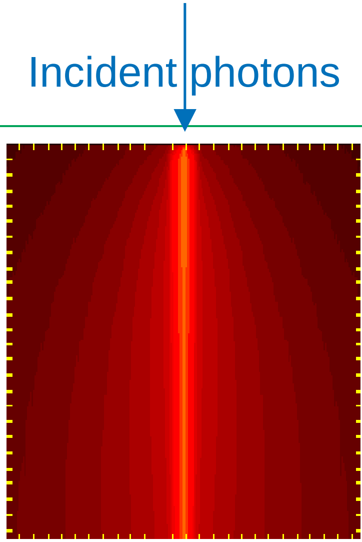


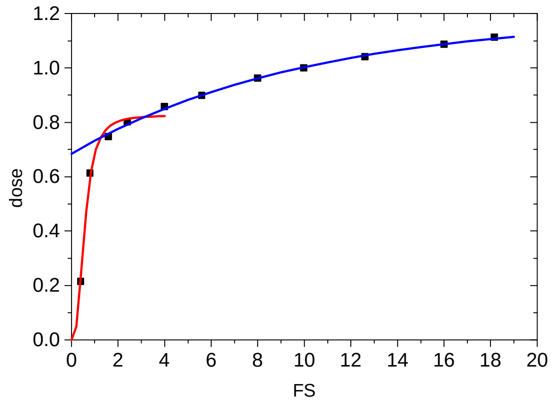
Figure 7. Phantom scatter factor, measured using a diode and RK chamber for (a) 6 MV and at peak and 20 cm depth and (b) 15 MV photon beam at peak and 20 cm depth in a water phantom applying Monte Carlo calculation and spectra to equation (4).

Measurement parameters

- Beam
  - *Elekta Synergy with Beam Modulator (4 mm leaf width @ isocenter)*
  - *Q = 6 MV & 10 MV*
  - *SSD = 90 cm, SDD = 100 cm*
- Detectors
  - *Ionisation chamber PTW 31010, 0.125cc*
  - *Ionisation chamber PTW 31006, PinPoint*
  - *Si-diode Scanditronix-Wellhöfer PFD Photon (yellow)*
  - *Si-diode Scanditronix-Wellhöfer SFD stereotactic (green)*
  - *Si-MOSFET Thomson & Nielson TN-502 RD*
  - *Diamante detector PTW 60003 € Danke an Thomas Koch Bamberg)*

analytical function





- D: dose
- P: primary dose (Hill-function)
- S: scatter dose (see BJR Suppl. 25)

- r: field size

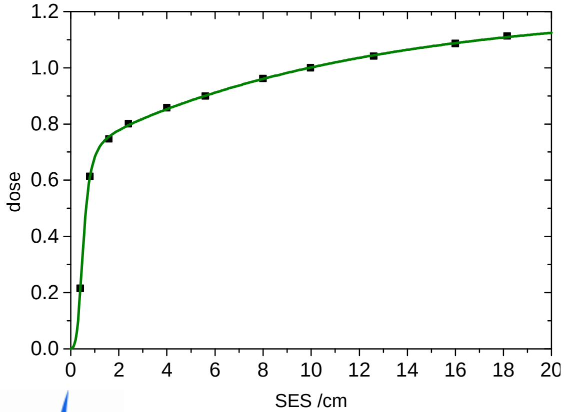
$$D = P + S$$

Fitting parameters:

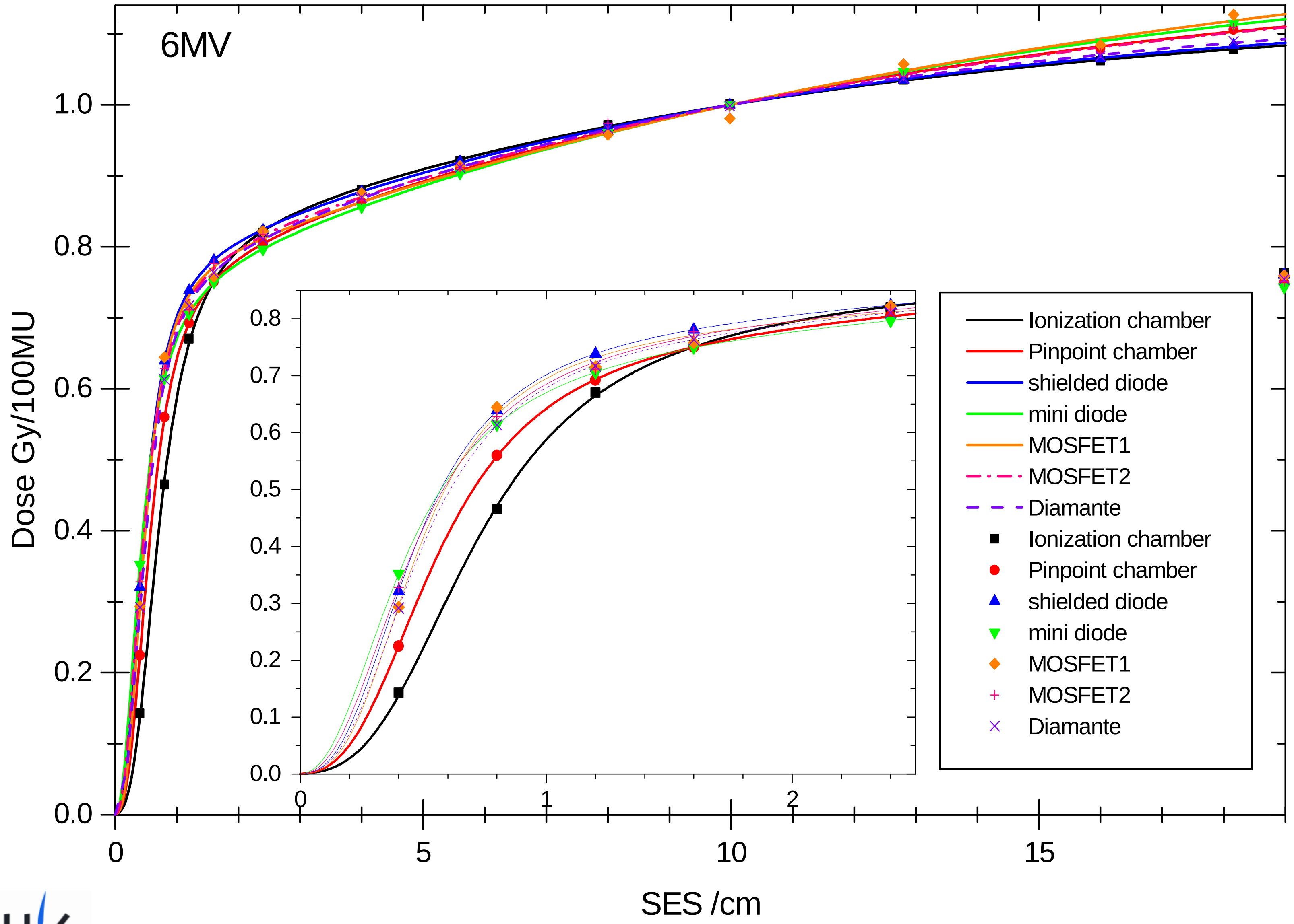
- P_∞, S_∞
- k, n, b

$$P = P_\infty \frac{r^n}{k^n + r^n}$$

$$S = S_\infty \left(1 - e^{-br}\right)$$

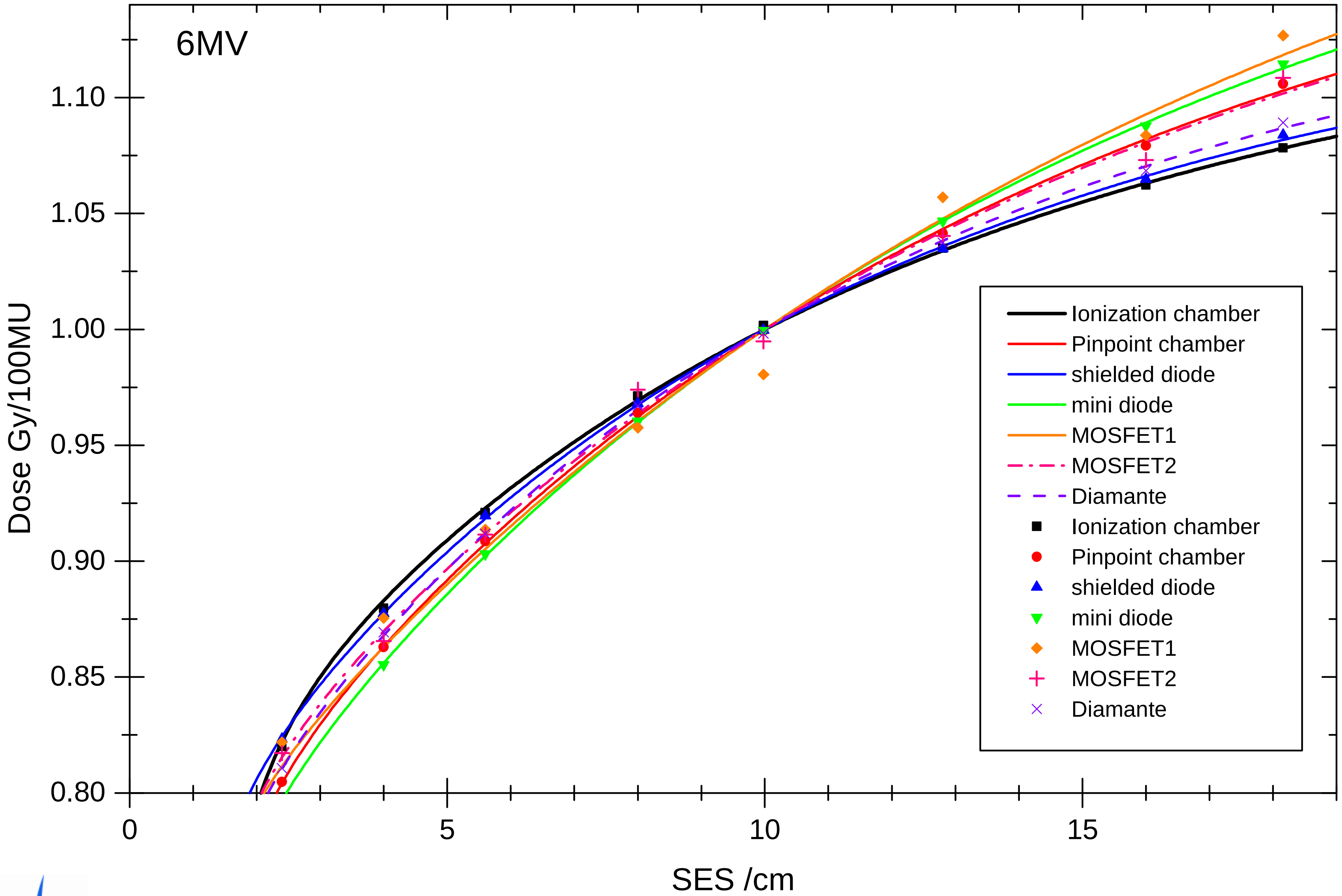


Results

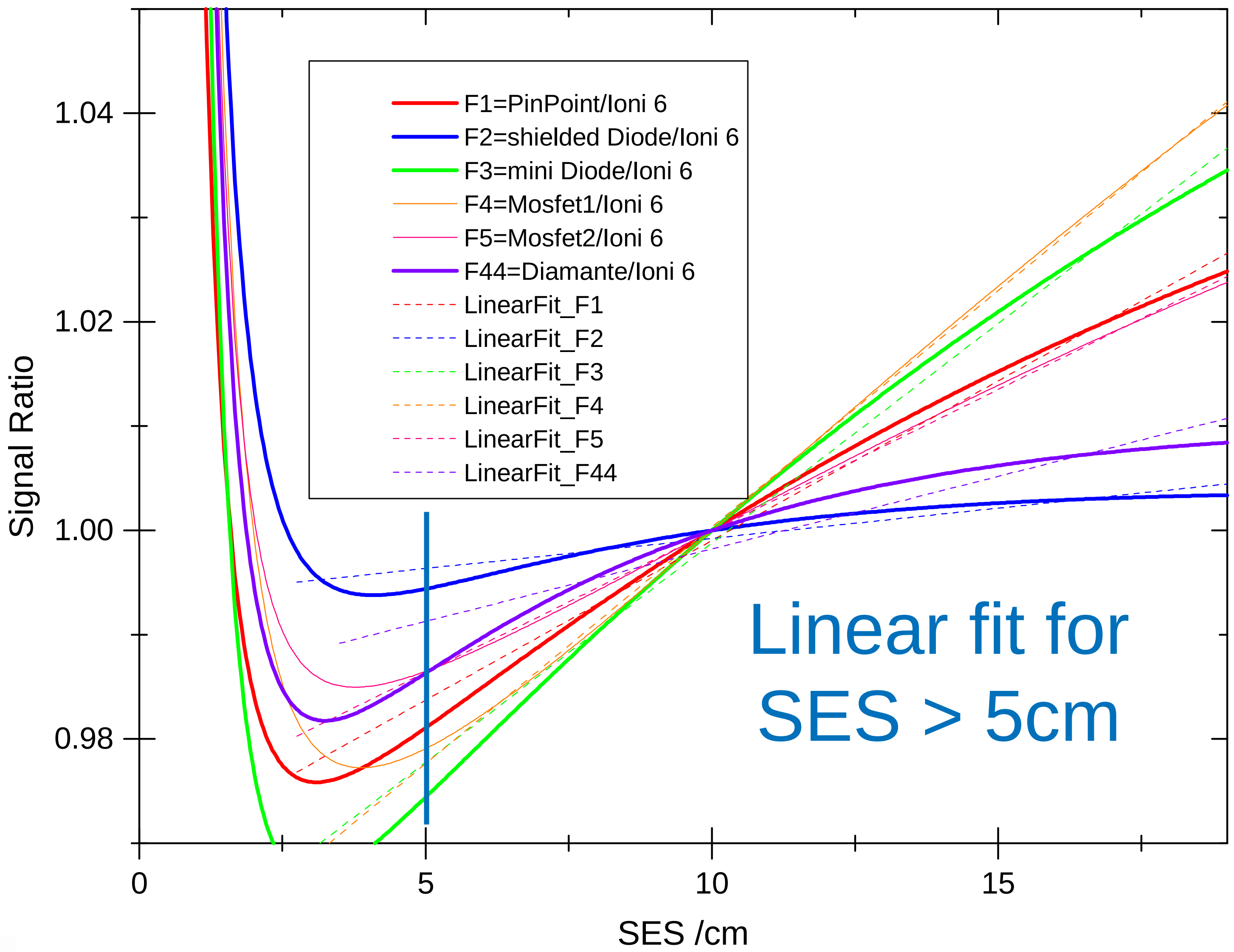


6MV
Dose Gy/100MU
SES /cm
0.0
0.2
0.4
0.6
0.8
1.0
0
5
10
15
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
1
2
Ionization chamber
Pinpoint chamber
shielded diode
mini diode
MOSFET1
MOSFET2
Diamante
Ionization chamber
Pinpoint chamber
shielded diode
mini diode
MOSFET1
MOSFET2
Diamante

Results


6MV
Dose Gy/100MU
SES /cm
0.80
0.85
0.90
0.95
1.00
1.05
1.10
0
5
10
15
Ionization chamber
Pinpoint chamber
shielded diode
mini diode
MOSFET1
MOSFET2
Diamante
Ionization chamber
Pinpoint chamber
shielded diode
mini diode
MOSFET1
MOSFET2
Diamante

Results



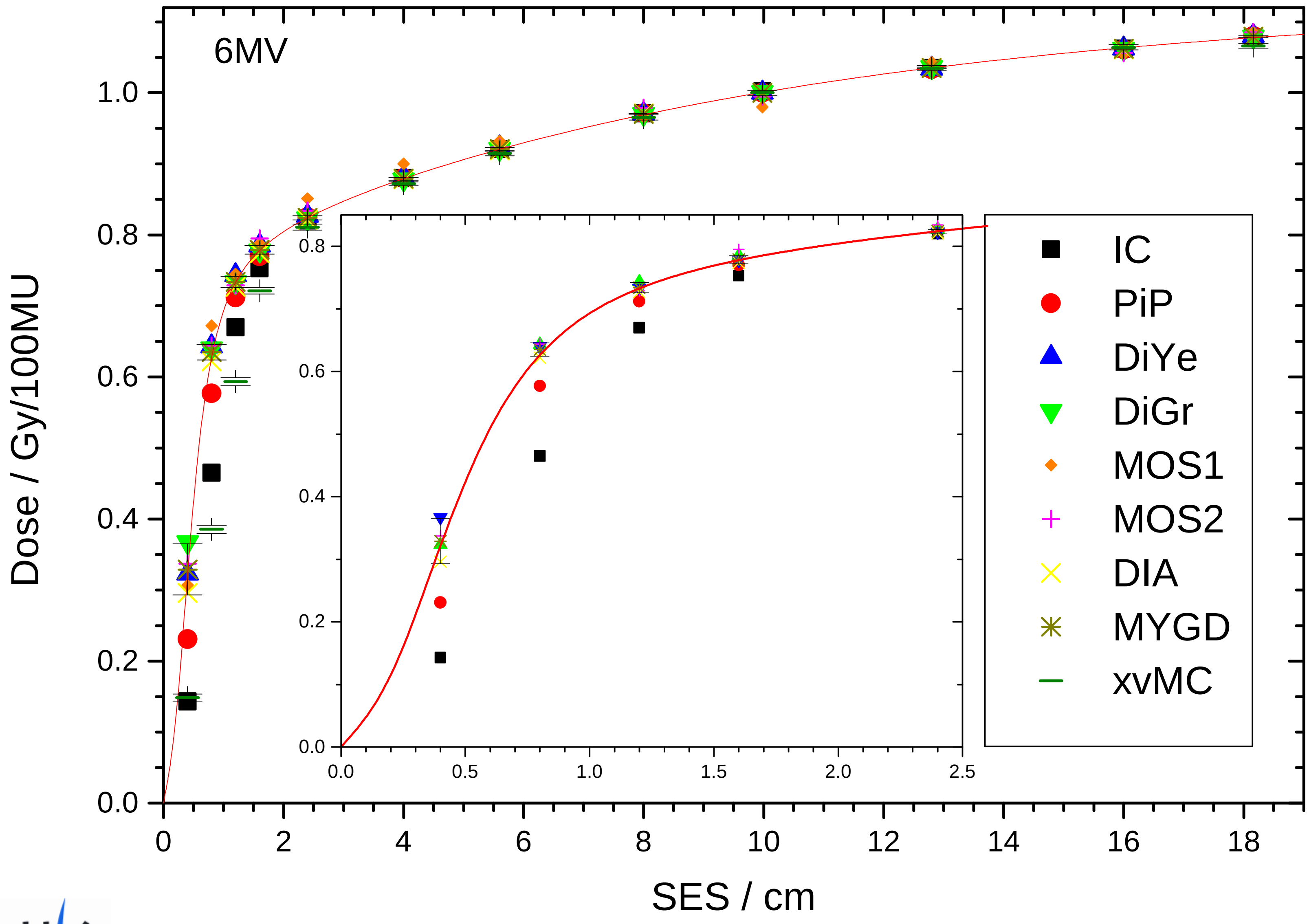
Signal Ratio
1.04
1.02
1.00
0.98
0
5
10
15
SES /cm
F1=PinPoint/Ioni 6
F2=shielded Diode/Ioni 6
F3=mini Diode/Ioni 6
F4=Mosfet1/Ioni 6
F5=Mosfet2/Ioni 6
F44=Diamante/Ioni 6
LinearFit_F1
LinearFit_F2
LinearFit_F3
LinearFit_F4
LinearFit_F5
LinearFit_F44
Linear fit for
SES > 5cm

Results

Parameter	.125cc Ionization-chamber		PinPoint		shielded SC yellow		mini Si-diode green		MOSFET 6.12.		MOSFET 7.12.		Diamante	
Chi^2	2.0000E-05		4.3512E-06		1.3641E-06		1.3545E-06		2.3000E-04		7.0000E-05		3.1586E-06	
p	0.768	0.011	0.735	0.004	0.749	0.002	0.726	0.003	0.756	0.026	0.755	0.018	0.729	0.004
n	2.826	0.069	2.681	0.034	2.648	0.024	2.255	0.024	2.833	0.298	2.392	0.160	2.678	0.036
k	0.717	0.007	0.563	0.003	0.461	0.001	0.426	0.002	0.475	0.017	0.458	0.011	0.482	0.002
s	0.373	0.010	0.478	0.007	0.398	0.003	0.519	0.005	0.563	0.096	0.471	0.035	0.427	0.004
b	0.096	0.011	0.082	0.004	0.100	0.002	0.076	0.002	0.063	0.024	0.076	0.016	0.102	0.003
LinearFit V=Det/Ioni for FS>5: V=A+Bx														
A	1.000		0.968	0.000	0.993	0.000	0.957	0.000	0.955	0.000	0.973	0.000	0.984	0.000
B	1.000		0.003	0.000	0.001	0.000	0.004	0.000	0.005	0.000	0.003	0.000	0.001	0.000
R. SD			0.996	0.001	0.949	0.001	0.996	0.002	1.000	0.000	1.000	0.000	0.954	0.002

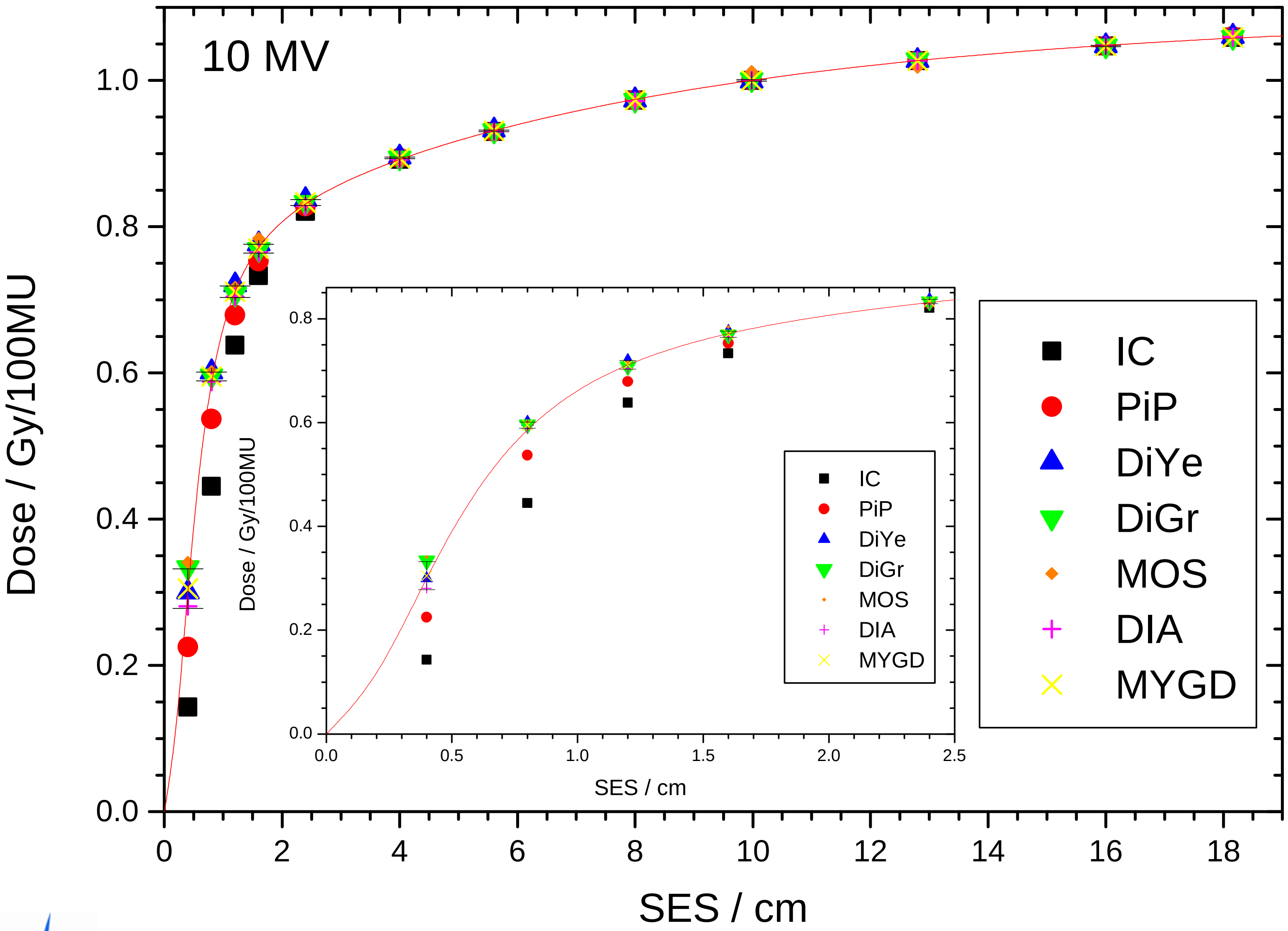
$$D = P_\infty \frac{r^n}{k^n + r^n} + S_\infty \left(1 - e^{-br}\right)$$

Results



6MV
Dose / Gy/100MU
SES / cm
0.0
0.2
0.4
0.6
0.8
1.0
0
2
4
6
8
10
12
14
16
18
0.0
0.5
1.0
1.5
2.0
2.5
IC
PiP
DiYe
DiGr
MOS1
MOS2
DIA
MYGD
xvMC

Results



10 MV
Dose / Gy/100MU
SES / cm
0.0
0.2
0.4
0.6
0.8
1.0
0
2
4
6
8
10
12
14
16
18
IC
PiP
DiYe
DiGr
MOS
DIA
MYGD
Dose / Gy/100MU
SES / cm
0.0
0.5
1.0
1.5
2.0
2.5

Conclusions

- The energy dependence of special detectors should be tested and corrected for.
- The corrected dose is identical for all sufficiently small detectors → perturbation negligible
- The PinPoint-chamber is appropriate to FS>16*16mm² only
- Curve fitting to a physically meaningful analytical function
  - *minimizes the influence of measurement uncertainties*
  - *allows accurate interpolation between measured values*
  - *simplifies and improves the calculation of monitor units*

Conclusions

- Die Energieabhänigkeit spezieller Sonden sollte geprüft und gegebenenfalls korrigiert werden. (auch Diamant und PinPoint-Kammer)
- Die korrigierten Dosis-Werte sind für alle ausreichend kleinen Sonden gleich → Feldstörung vernachlässigbar.
- Die PinPoint-Kammer ist erst ab FG=16*16mm² geeignet.
- Die Anpassung an eine physikalisch sinnvolle analytische Funktion
  - *minimiert den Einfluss von Messunsicherheiten*
  - *Erlaubt ‚fehlerfreie' Interpolation zwischen Messwerten*
  - *Vereinfacht und verbessert die Berechnung von MUs*