Small Field Dosimetry
Challenges for Clinical Physicist

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Treatment Fields

Magna-Fields

200x200 cm^2

Traditional Fields

40x40 cm^2 ⟷ 4x4 cm^2

Small Field

4x4 cm^2 ⟷ 0.3x0.3 cm^2

- Advance Therapy Fields
- SRS/SRT
- Gamma Knife
- Cyber-Knife
- Tomotherapy
- IMRT

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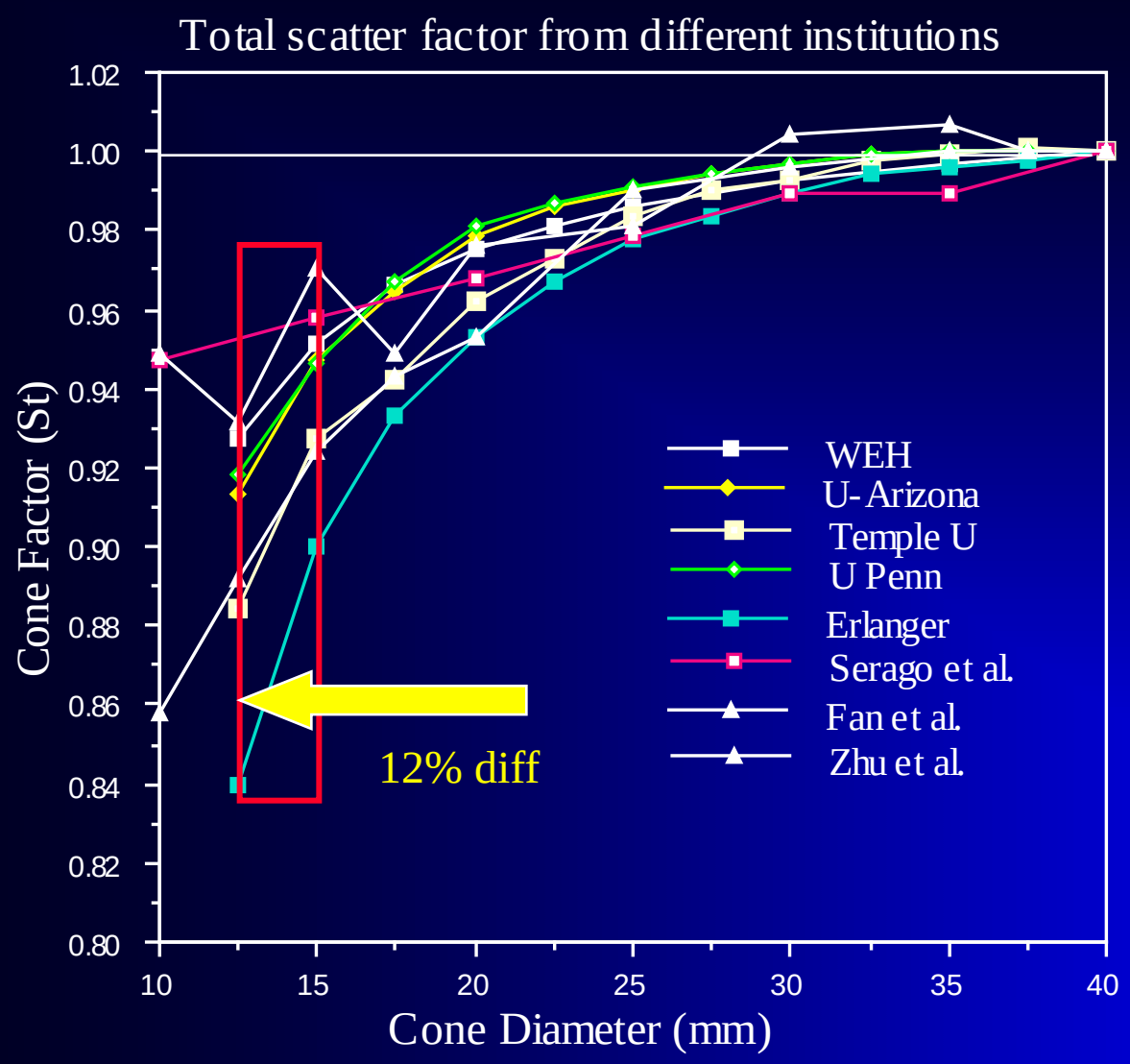
Small Field Dosimetry Problem



Institutional variability in 6 MV Radionics SRS dosimetry

Das et al, J Radiosurgery, 3, 177-186, 2000

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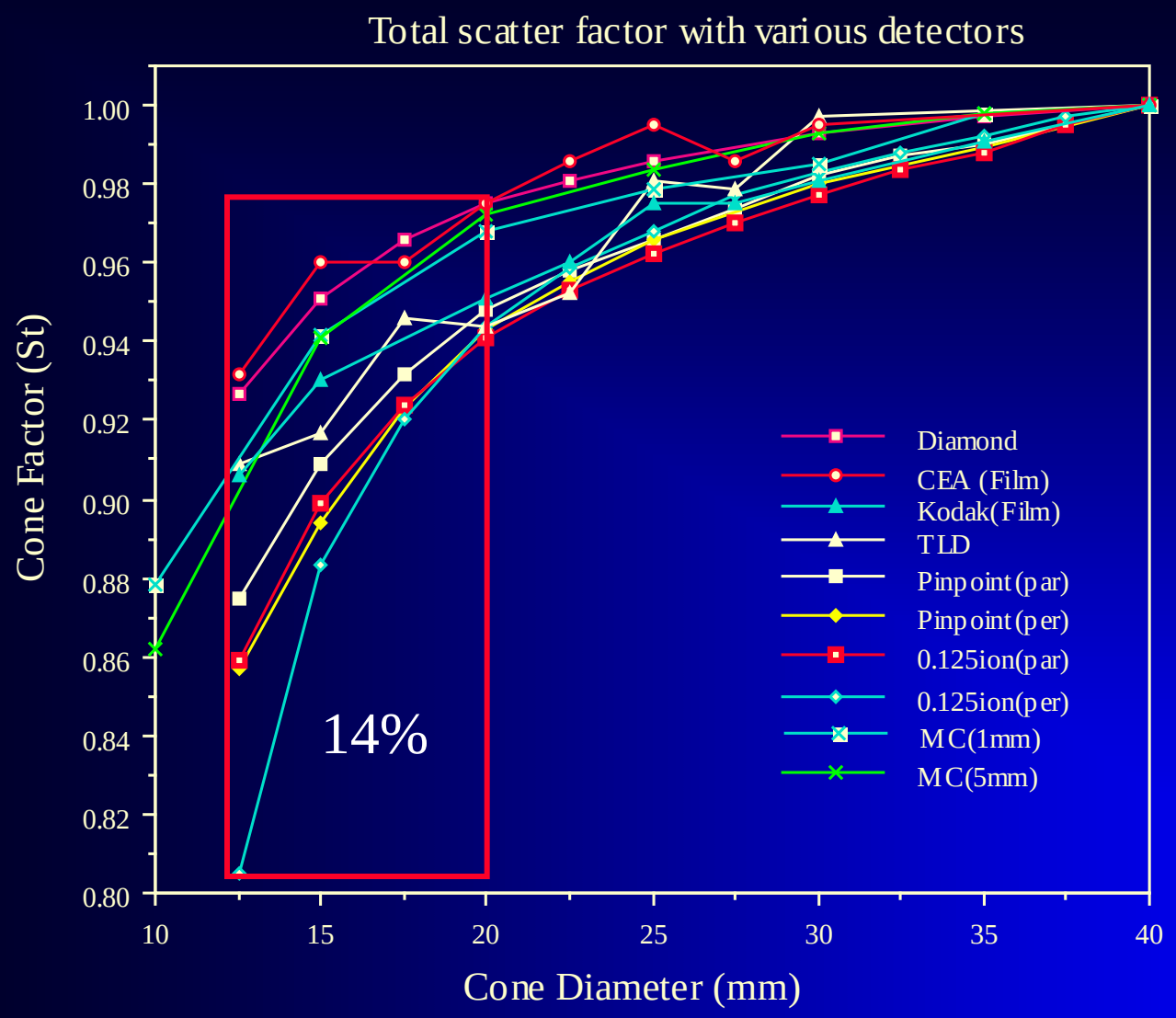
Dosimetric Variation with Detectors



Das et al, J Radiosurgery, 3, 177-186, 2000

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Misadministration Media Coverage

Springfield Hospital Reports Radiation Overdose Administered to 76 Cancer Patients

February 26, 2010

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The New York Times reported on a recent report filed by CoxHealth medical facility in Springfield, Missouri where they admitted to over-radiating 76 cancer patients during treatment. The majority of the patients were being treated for brain cancer, and received about a 50% overdose of radiation therapy. A hospital employee improperly calibrated the machine used to administer the radiation.

The New York Times

U.S.

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Radiation Errors Reported in Missouri

By WALT BOGDANICH and REBECCA R. RUIZ
Published: February 24, 2010

A hospital in Missouri said Wednesday that it had overradiated 76 patients, the vast majority with brain cancer, during a five-year period because powerful new radiation equipment had been set up incorrectly even with a representative of the manufacturer watching as it was done

The hospital, CoxHealth in Springfield, said half of all patients undergoing a particular type of treatment — stereotactic radiation therapy — were overdosed by about 50 percent after an unidentified medical physicist at the hospital miscalibrated the new equipment and routine checks over the next five years failed to catch the error.

Stereotactic therapy delivers radiation in such high doses that usually only one treatment is required. It is commonly used to treat small tumors in the head, which must be firmly stabilized, allowing radiation to be delivered to a precise location.

The error was discovered in September 2009 only after a second physicist received training on the equipment, made by BrainLAB, and the hospital began questioning whether the machine had been installed correctly in 2004, in a process called commissioning.

The overdoses at CoxHealth occurred in a state where there is little or no government oversight of radiation therapy, a fact that Robert H. Bezanson, the hospital's president and chief executive, chose to emphasize.

On Wednesday, he released a letter that he wrote to the Food and Drug Administration, saying that its recent decision to toughen oversight of diagnostic radiation did not go far enough.

"The initiative should be broadened to include regulation of medical radiation therapy as well," he wrote. "We have also learned that the incident here at CoxHealth is, unfortunately, not an isolated occurrence. Rather, similar instances of medical overradiation have occurred at other hospitals throughout the country. Without increased regulation and oversight, these instances of medical overradiation will likely continue."

Wrong detector used for BrainLab cone calibration

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Misadministration Media Coverage

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THE RADIATION BOOM

A Pinpoint Beam Strays Invisibly, Harming Instead of Healing

By WALT BOGDANICH and KRISTINA REBELO
Published: December 28, 2010

The initial accident report offered few details, except to say that an unidentified hospital had administered radiation overdoses to three patients during identical medical procedures.

Enlarge This Image

Marci Faber is nearly comatose after a treatment mistake.

It was not until many months later that the full import of what had happened in the hospital last year began to surface in urgent nationwide warnings, which advised doctors to be extra vigilant when using a particular device that delivers high-intensity, pinpoint radiation to vulnerable parts of the body.

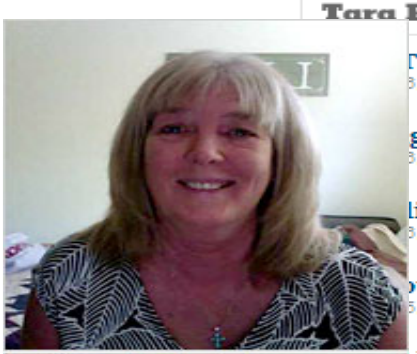
Marci Faber was one of the three patients. She had gone to Evanston Hospital in Illinois seeking treatment for pain emanating from a nerve deep inside her head. Today, she is in a nursing home, nearly comatose, unable to speak, eat or walk, leaving her husband to care for their three young daughters.

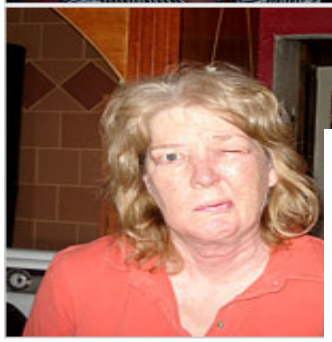
The Radiation Boom

Missing the Target

Articles in this series examine issues arising from the increasing use of medical radiation and the new technologies that deliver it.

Previous Articles in the Series »





Well

Tara Parker-Pope on Health

Therapy for Depression
, 2011, 4:15 PM

g Profits Before Patients
, 2011, 2:10 PM

lies: Garlic for Athlete's Foot
, 2011, 10:07 AM

u Be Addicted to Foods?
, 2011

d: Does Exercising Make You Drink More
l?
, 2011

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What is a Small Field?

- Lack of charged particle
  - Dependent on the range of secondary electrons
  - Photon energy
- Collimator setting that obstructs the source size
- Detector is comparable to the field size

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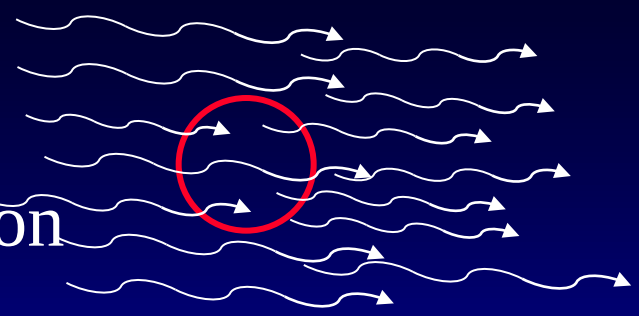
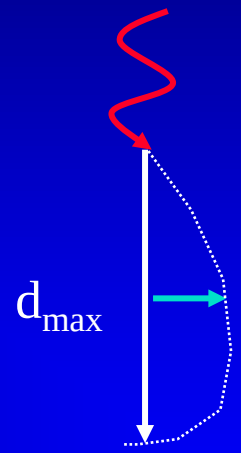
CPE & Electron Range

- CPE, Charged Particle Equilibrium



- Electron range= d_{max} in forward direction
- Electron range in lateral direction
  - ★ Nearly energy independent
  - ★ Nearly equal to penumbra (8-10 mm)
- Field size needed for CPE
  - ★ Lateral range
  - ★ 16-20 mm



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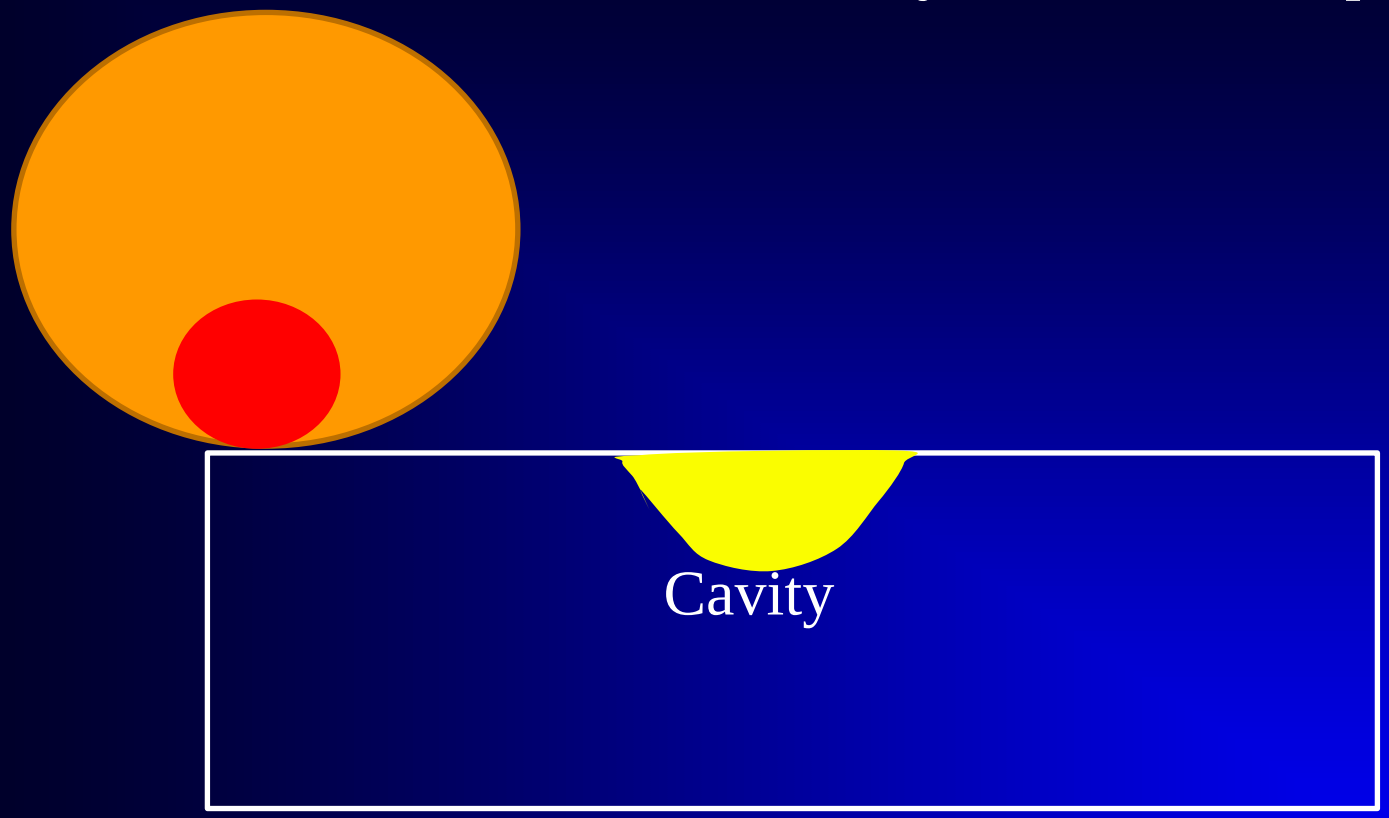
Bragg-Gray Cavity: Range and Cavity Size

Dose is calculated only by charged particle crossers in the cavity &
Cavity should be non-perturbing

Range



$$\text{Dose} = \phi.S/\rho = (\text{number/cm}^2)(\text{MeVcm}^2/\text{g}) = \text{MeV/g} = \text{J/kg (Gy)}$$

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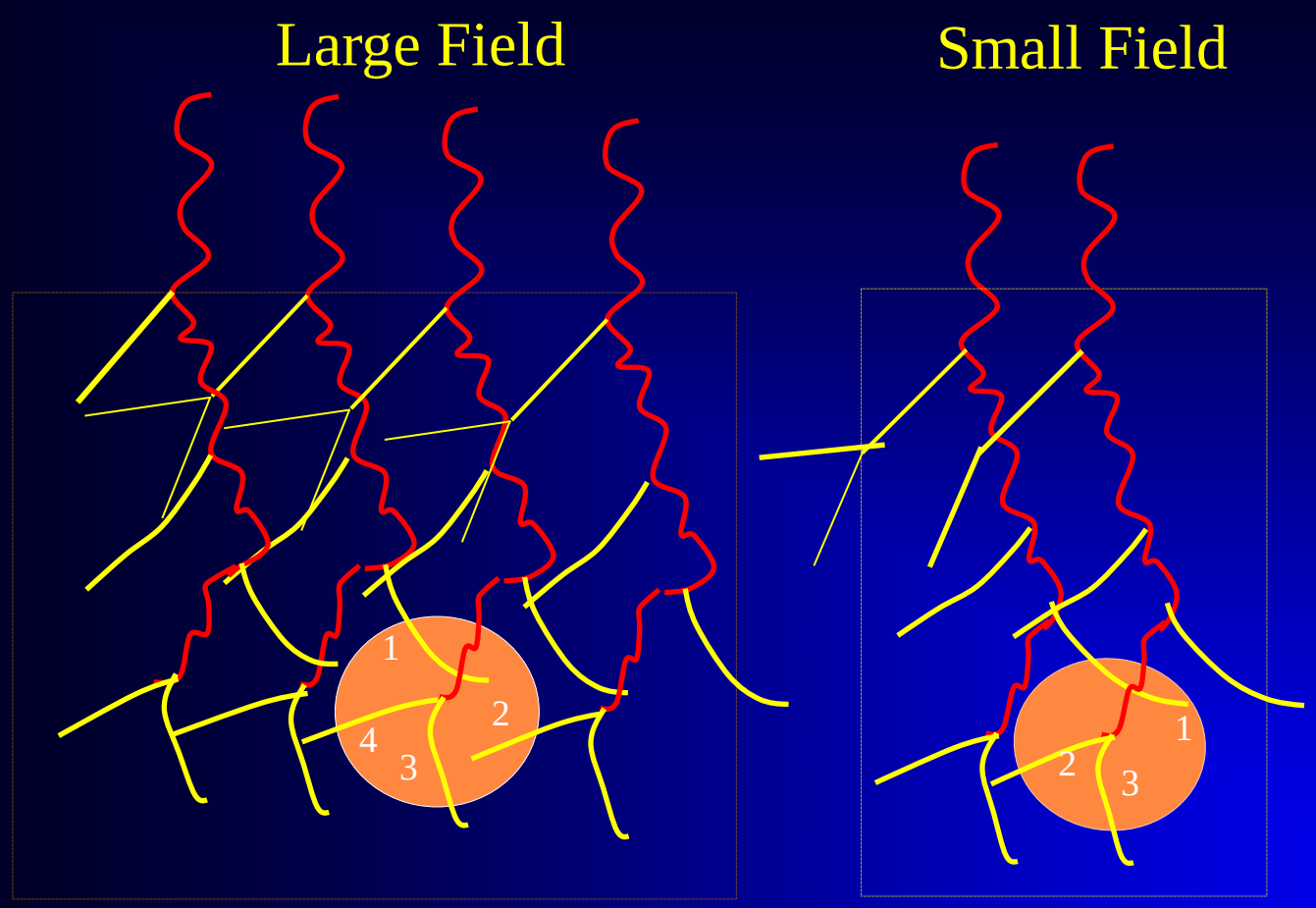
Lateral Electronic Equilibrium, LEE



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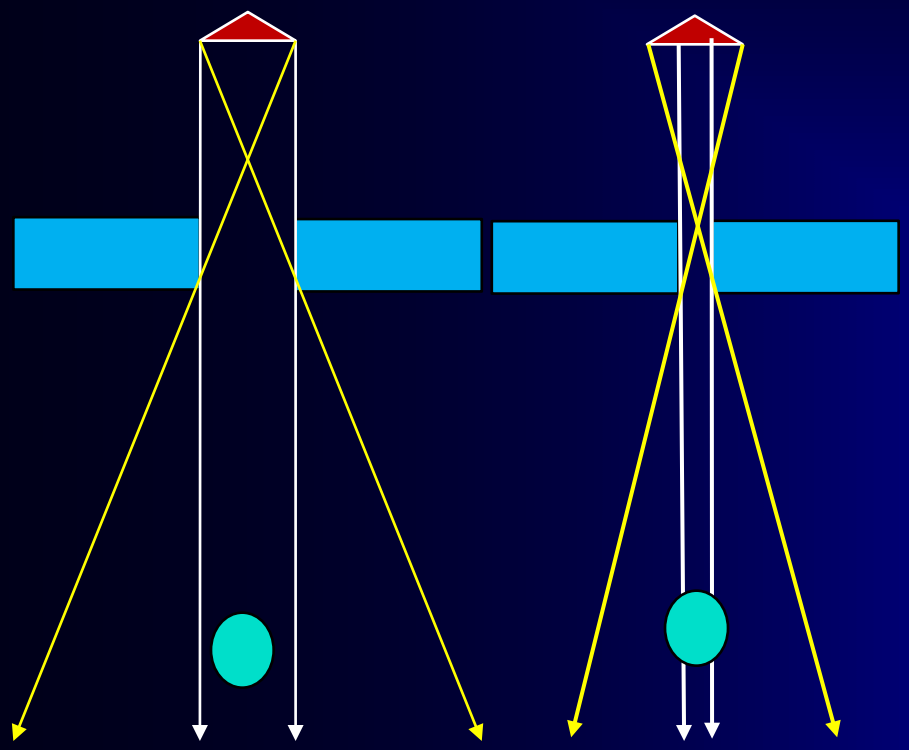
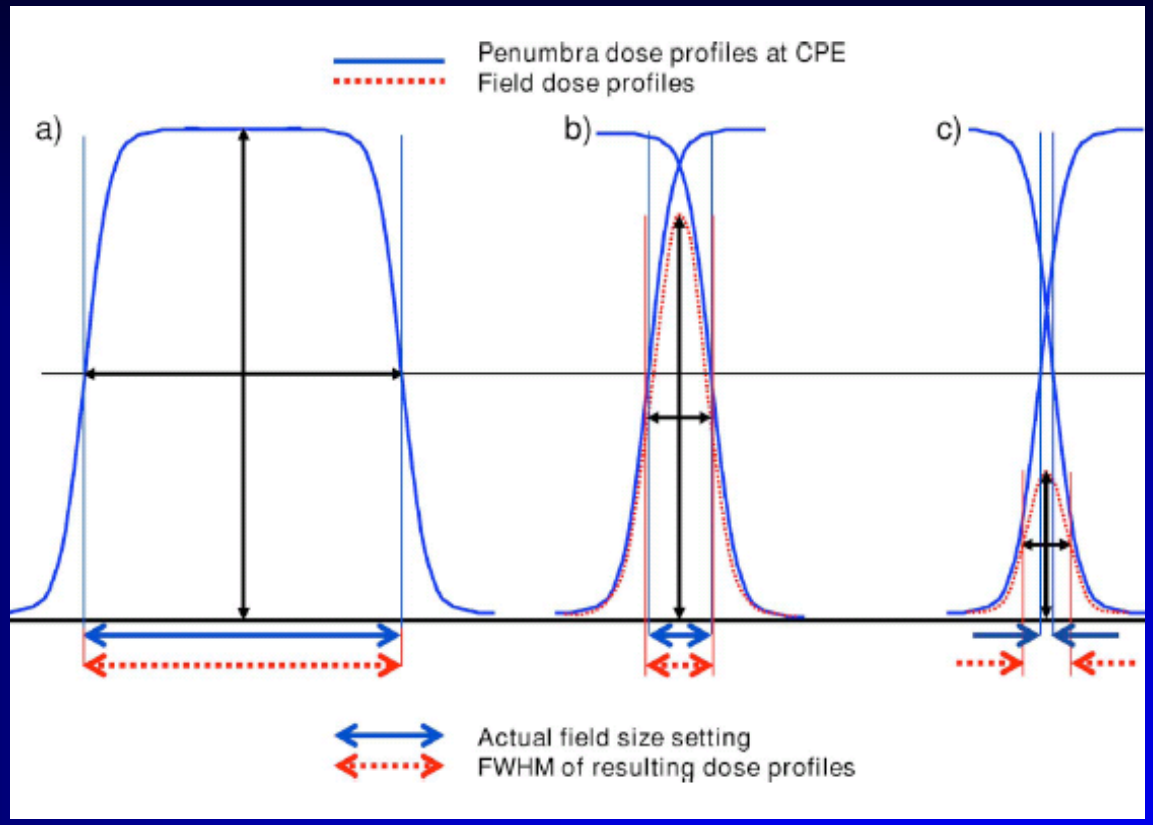
Definition of Small Fields





Das et al, Med. Phys. 35, 206-215, 2008

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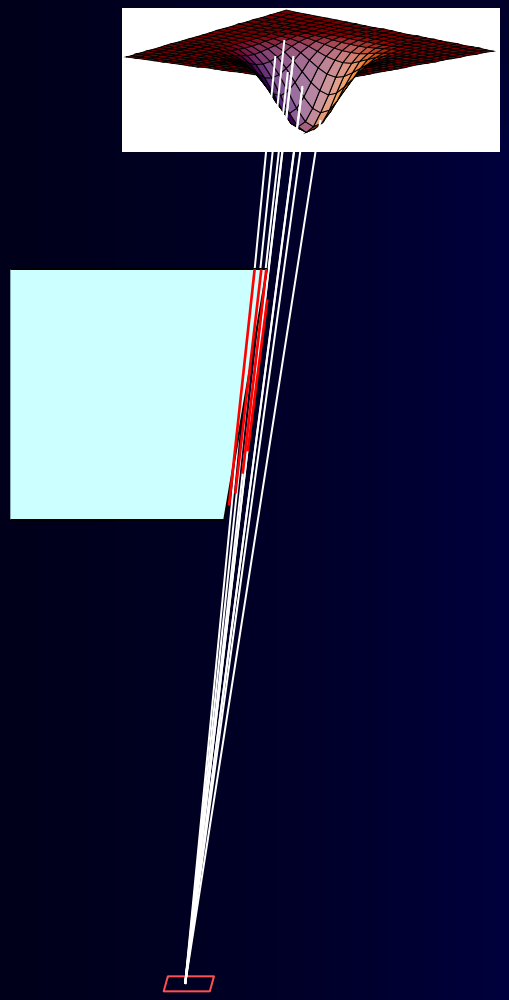
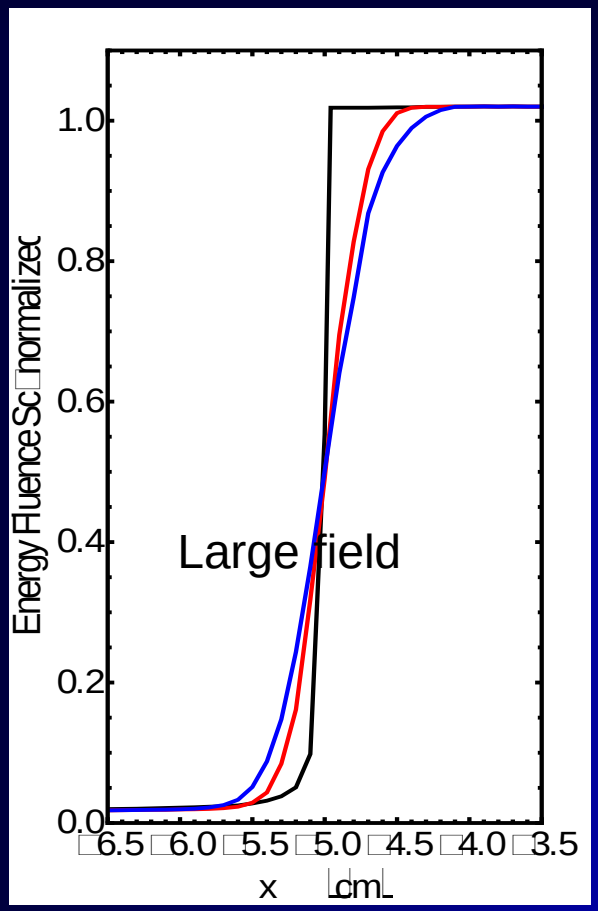
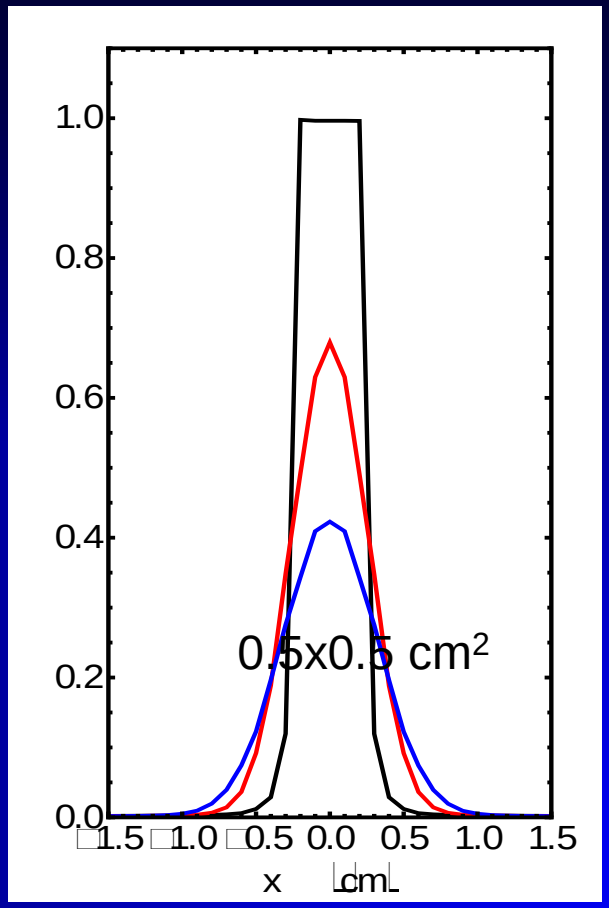
Energy Fluence Penumbra/Output







Source sizes

cm

---- 0.01

---- 0.35

---- 0.50

Nyholm *et al* Radiother Oncol 78, 347, 2006 and Phys Med Biol 51,6245, 2006

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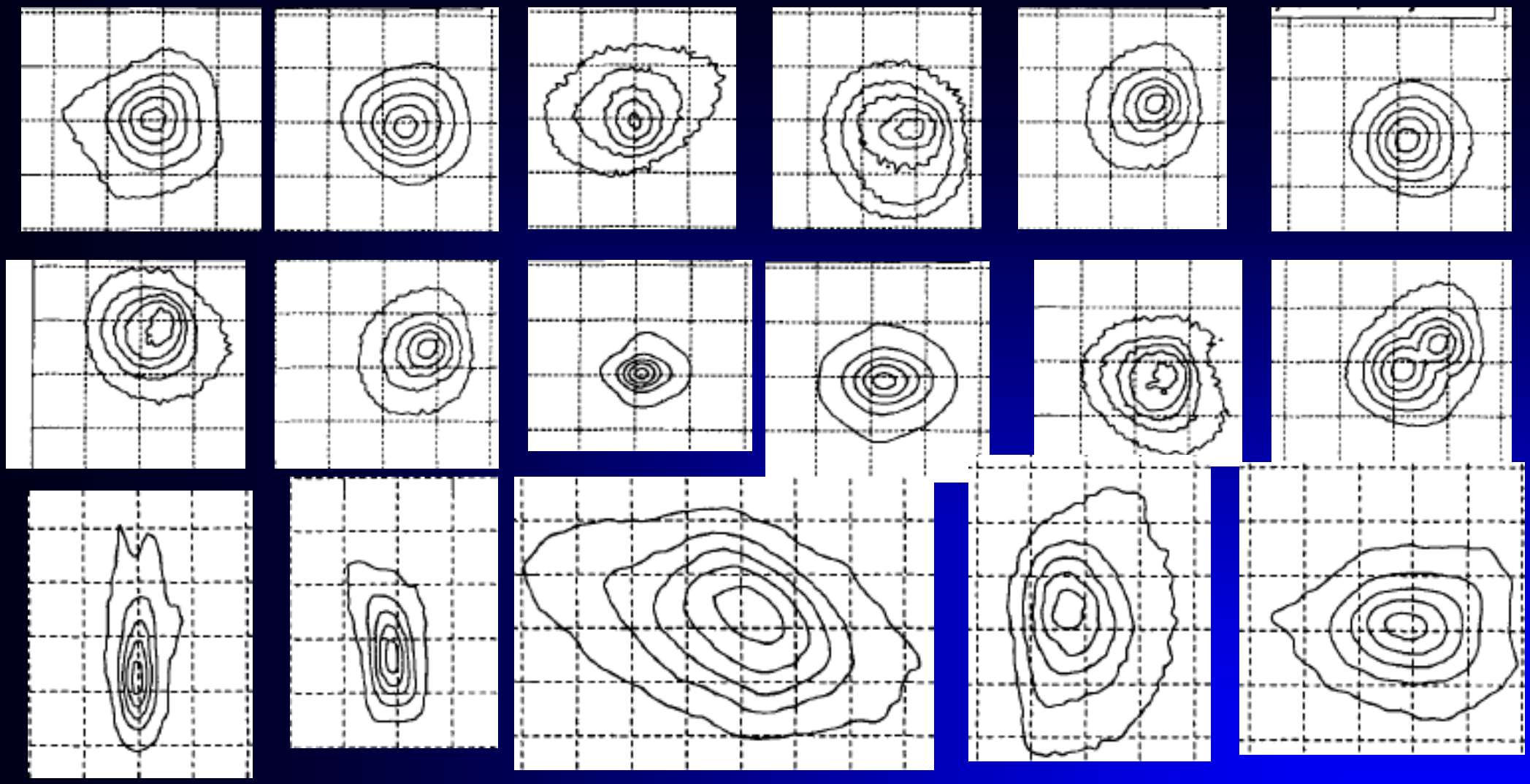
Source Size



90%, 70%, 50%, 30%, 10% iso-intensity line

Jaffray et al, Med Phys 20, 1417-1427 (1993)

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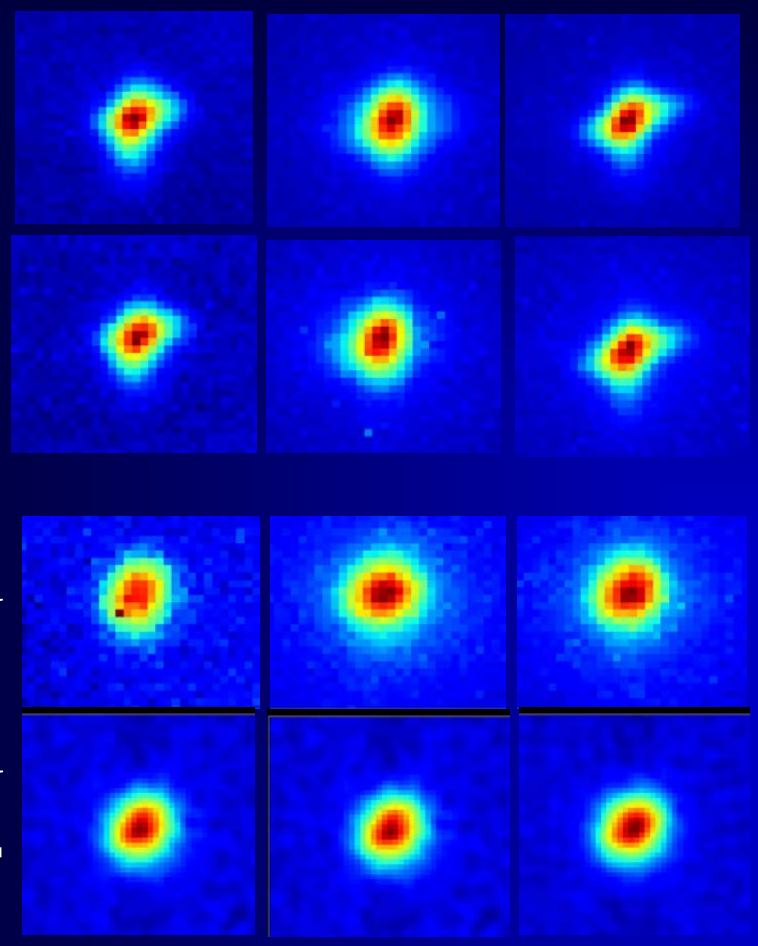
Source Size, Modern Machines

Varian TrueBeam



Dimensions x, y (mm)

0.9, 0.7

0.8, 0.7

0.9, 0.9

0.9, 0.8

Sawkey et al, Med Phys, 40, 332, 2013

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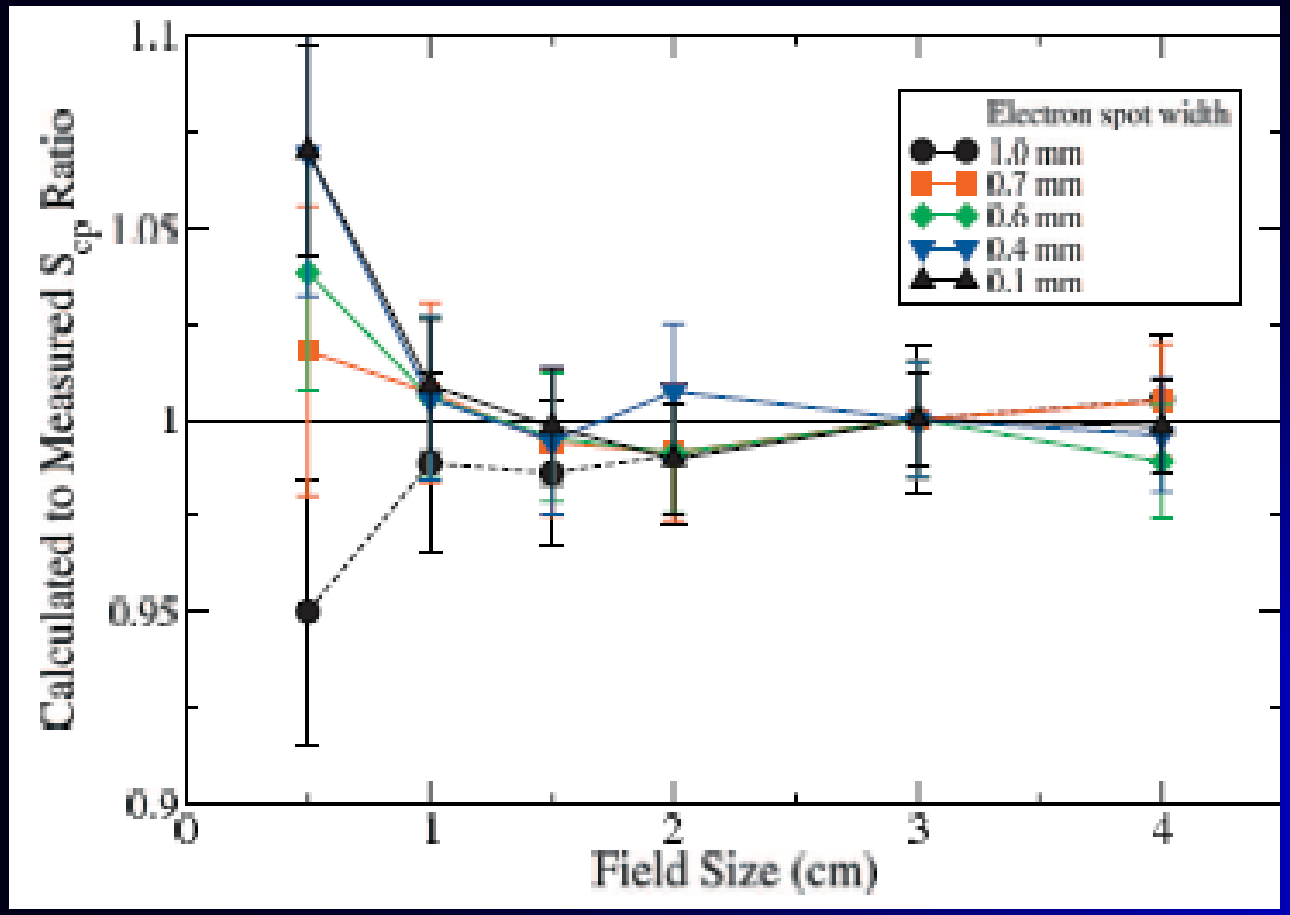
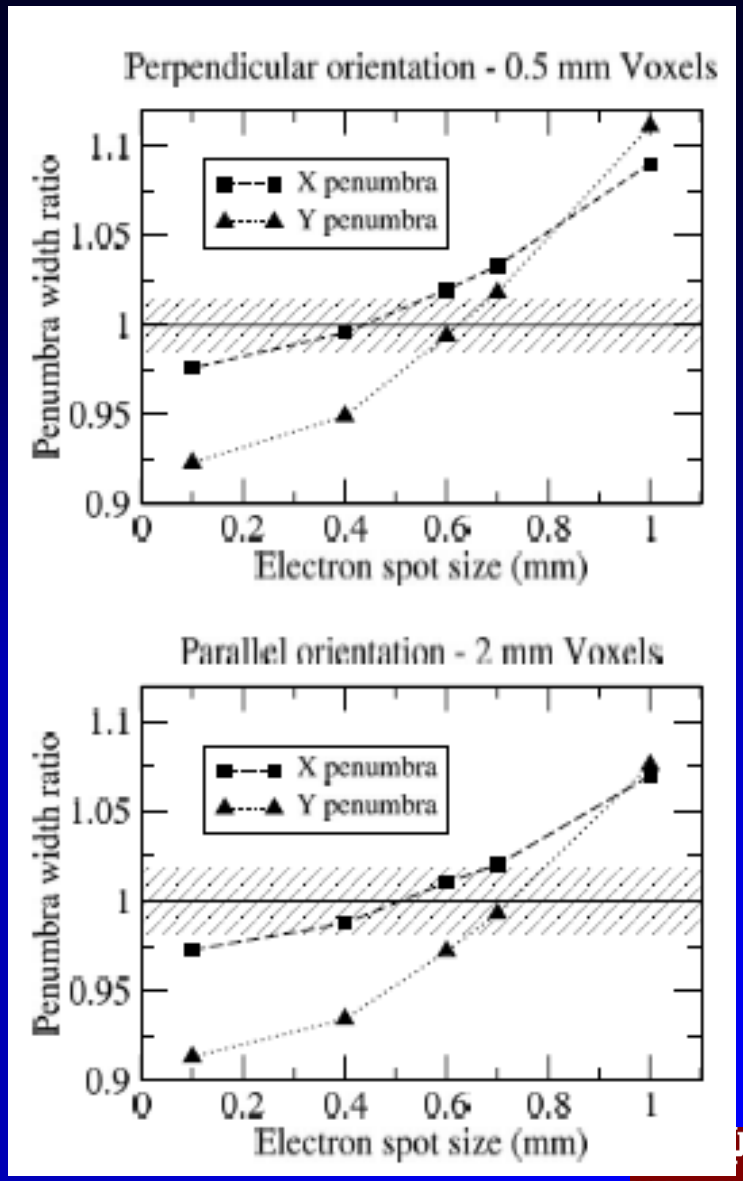
Dose and Penumbra with Spot Size





Scott et al, Med Phys, 36, 3132, 2009

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Dosimetry

- Absolute
  - Dose
- Relative
  - Depth Dose
    - [D(r,d)/D(r,dm)]
  - TMR
  - Profiles
  - Output, S_{cp} (total scatter factor)
    - [D(r)/D(ref)]

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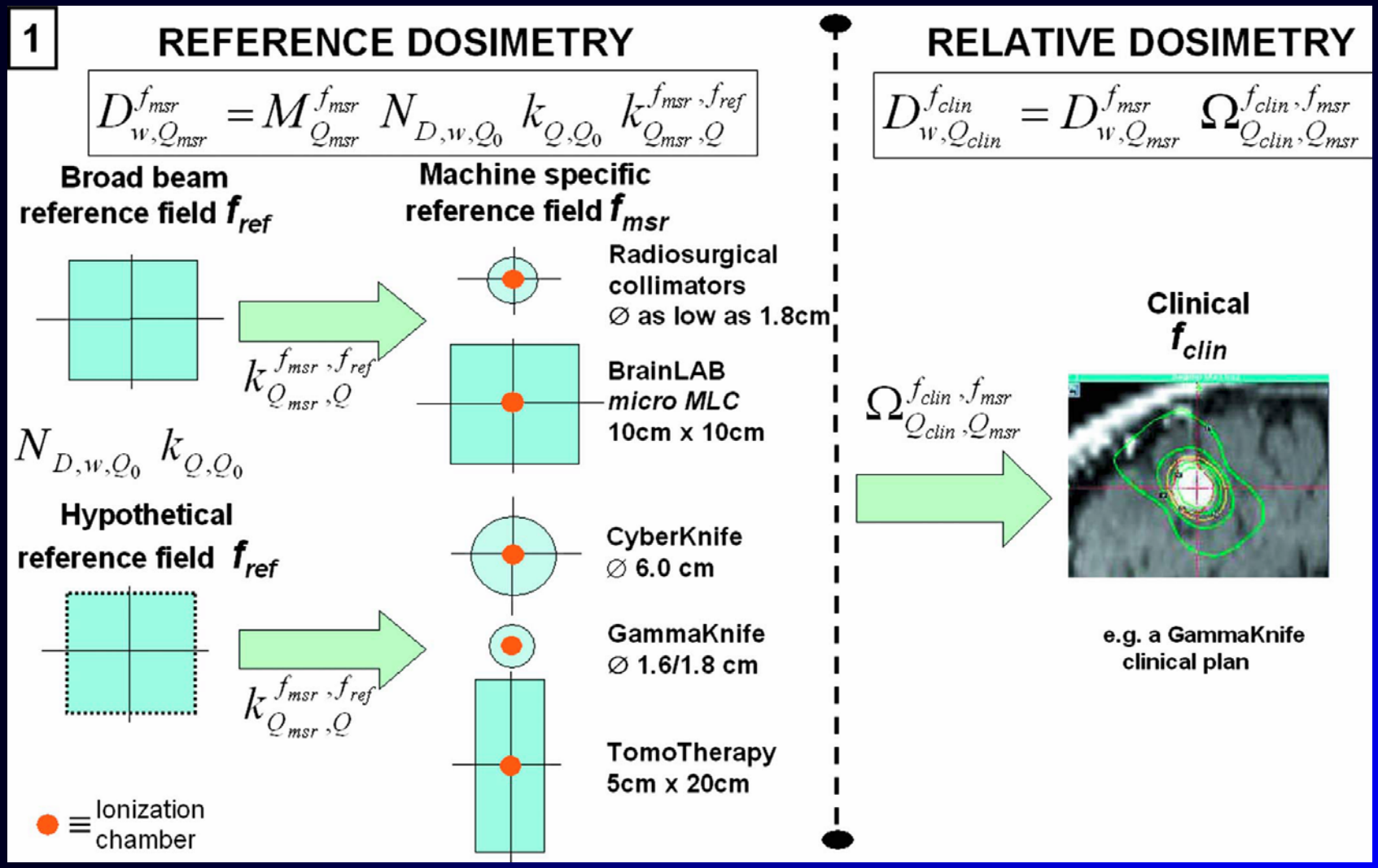
IAEA/AAPM Proposed Pathway



Alfonso, et al. Med Phys ***35****, 5179-5186 (2008)*

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Why So Much of Fuss?

- Reference (ref) conditions cannot be achieved for most SRS devices (cyberknife, gammaknife, tomotherapy etc)
- Machine Specific reference (msr) needs to be linked to ref
- Ratio of reading (PDD, TMR, Output etc) is not the same as ratio of dose

$$\frac{D_1}{D_2} \neq \frac{M_1}{M_2}$$

$$\frac{D_1}{D_2} = \frac{M_1}{M_2} \bullet \left[k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}} \right]$$

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Relative Dosimetry

$$D_{w,Q_{msr}}^{f_{msr}} = M_{Q_{msr}}^{f_{msr}} N_{DW,Qo} k_{Q,Qo} k_{Q_{msr},Q}^{f_{msr},f_{ref}}$$

$$\Omega_{Q_{clin}Q_{msr}}^{f_{clin}f_{msr}} = \frac{M_{Q_{clin}}^{f_{clin}}}{M_{Q_{msr}}^{f_{msr}}} \left[\frac{\left(D_{w,Q_{clin}}^{f_{clin}}\right)/\left(M_{Q_{clin}}^{f_{clin}}\right)}{\left(D_{w,Q_{msr}}^{f_{msr}}\right)/\left(M_{Q_{msr}}^{f_{msr}}\right)} \right] = \frac{M_{Q_{clin}}^{f_{clin}}}{M_{Q_{msr}}^{f_{msr}}} k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$$

$$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}} = \frac{\left(D_{w,Q_{clin}}^{f_{msr}}\right)/\left(M_{w,Q_{clin}}^{f_{clin}}\right)}{\left(D_{w,Q_{msr}}^{f_{clin}}\right)/\left(M_{w,Q_{msr}}^{f_{clin}}\right)} = \frac{(Output)_{rel}}{(\mathrm{Re}\,ading)_{rel}}$$

$$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}} = \frac{(S_{w,air})_{fclin} \cdot P_{fclin}}{(S_{w,air})_{fmsr} \cdot P_{msr}}$$

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Meaning of k in Micro-Chambers

$$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}} = \frac{\left[\left(\frac{\overline{L}}{\rho}\right)_{air}^{w} \cdot P_{fl} \cdot P_{grad} \cdot P_{stem} \cdot P_{cell} \cdot P_{wall}\right]_{f_{clin}}}{\left[\left(\frac{\overline{L}}{\rho}\right)_{air}^{w} \cdot P_{fl} \cdot P_{grad} \cdot P_{stem} \cdot P_{cell} \cdot P_{wall}\right]_{f_{msr}}}$$

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Issues in Radiation Measurements

- Charged particle equilibrium
  - Range of secondary electrons
  - Medium (tissue, lung, bone)
- Photon energy and spectrum
  - Change in spectrum
    - Field size
    - Off axis points like beamlets in IMRT
  - Changes in (μ_{en}/ρ) from reference field, f_{ref}
  - Change in (L/ρ) from reference field, f_{ref}
- Detector
  - Volume
  - Density
  - Signal to noise ratio

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Radiation Detectors

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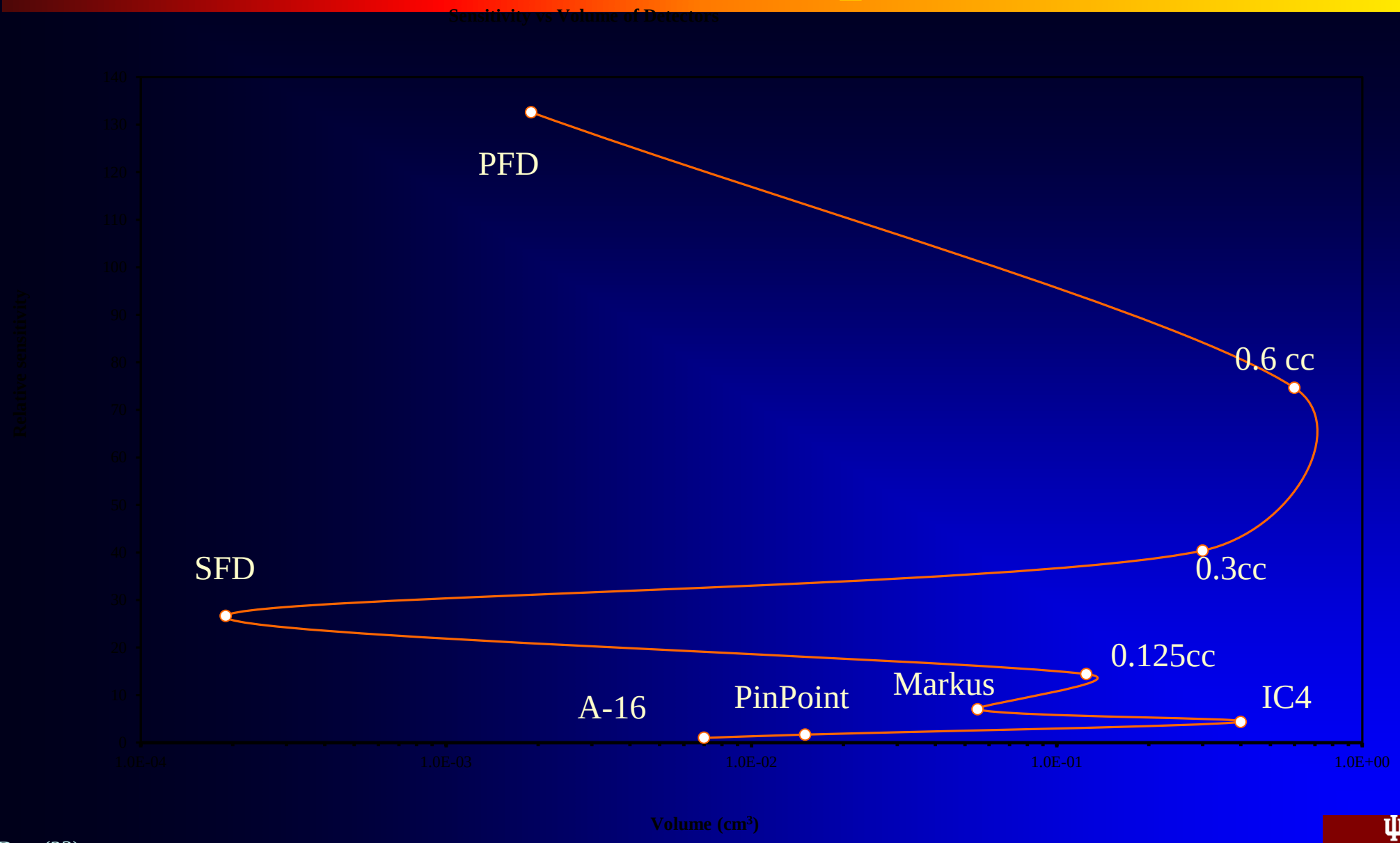
Detector Response



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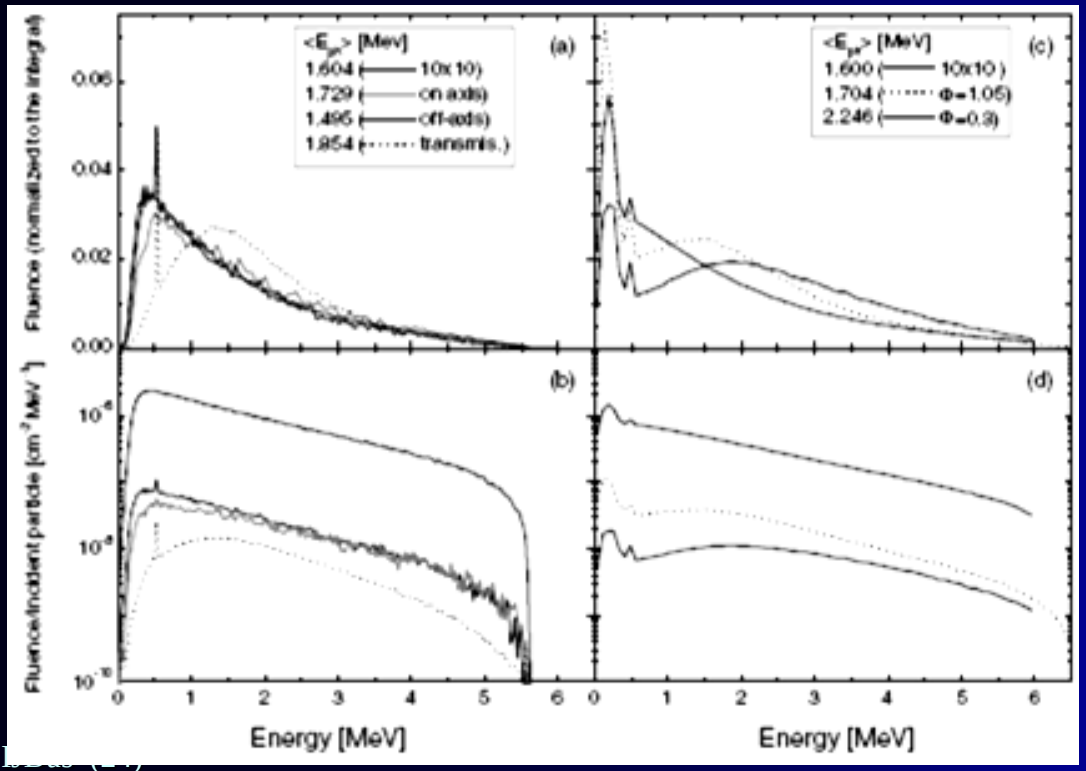
Stopping Power Ratio

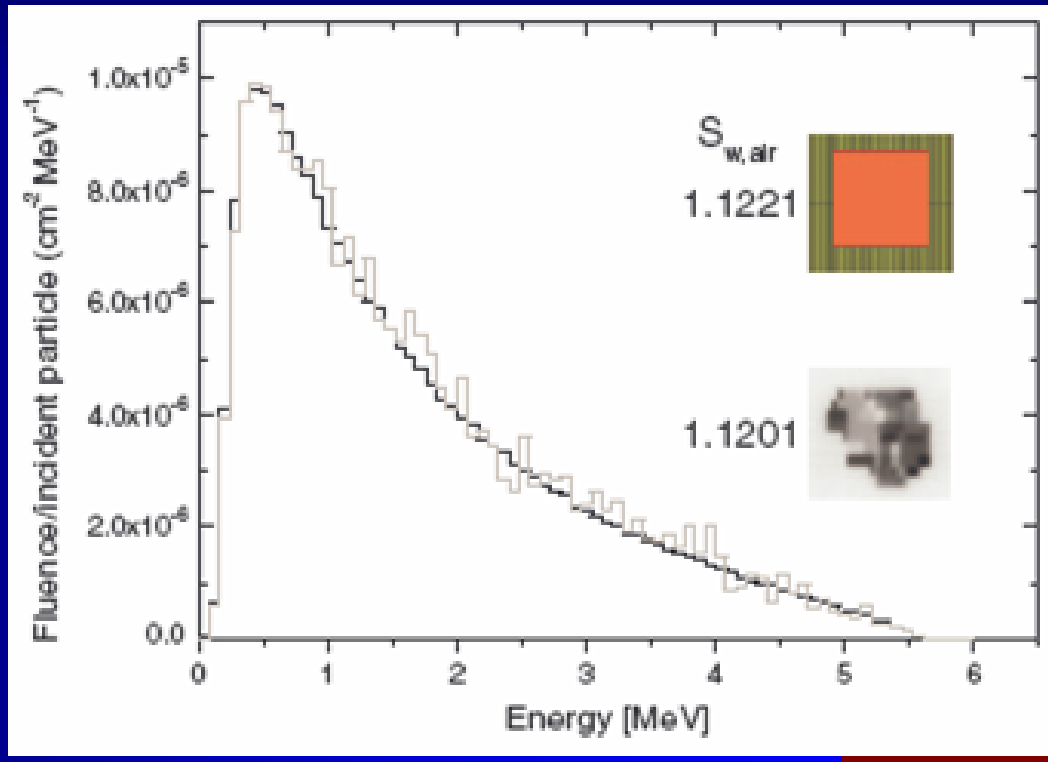
INSTITUTE OF PHYSICS PUBLISHING PHYSICS IN MEDICINE AND BIOLOGY

Phys. Med. Biol. 48 (2003) 2081–2099 PII: S0031-9155(03)61152-8

Ionization chamber dosimetry of small photon fields: a Monte Carlo study on stopping-power ratios for radiosurgery and IMRT beams

F Sánchez-Doblado[1,2], P Andreo[3], R Capote[1,2], A Leal[1,2], M Perucha[2], R Arráns[1], L Núñez[4], E Mainegra[5], J I Lagares[1,2] and E Carrasco[1,2]





Radiological Parameters

6 MV beams	Beam quality ($TPR_{20,10}$)	$s_{w,air}$ Andreo (1994)[a]	$s_{w,air}$ This work	$s_{w,air}$ Ratio this work/ Andreo	$s_{PMMA,air}$ Andreo (1994)[a]	$s_{PMMA,air}$ This work	$s_{PMMA,air}$ Ratio this work/ Andreo	Configuration
Elekta SL-18 radiosurgery								
$10 \times 10\ cm^2$	0.690	1.1187	1.1188	1.000	1.0853	1.0856	1.000	figure 1(a)
1.0 cm diameter			1.1155	0.997		1.0819	0.997	figure 1(b)
0.3 cm diameter			1.1153	0.997		1.0817	0.997	figure 1(c)
Siemens Primus MLC								
$10 \times 10\ cm^2$	0.677	1.1213	1.1221	1.001	1.0880	1.0892	1.001	figure 1(d)
$2 \times 2\ cm^2$ irregular on-axis			1.1203	0.999		1.0870	0.999	figure 1(e)
$2 \times 2\ cm^2$ irregular 8 cm off-axis			1.1250	1.003		1.0922	1.004	figure 1(f)
MLC transmission			1.1300	1.008				figure 1(i)
IMRT beam ($10 \times 10\ cm^2$ approx)			1.1201	0.999				figure 12

[a] These are the values in the IAEA TRS-398 code of practice (Andreo *et al* 2000).

Sanchez-Deblado et al, Phy. Med. Biol., 48, 2081, 2003

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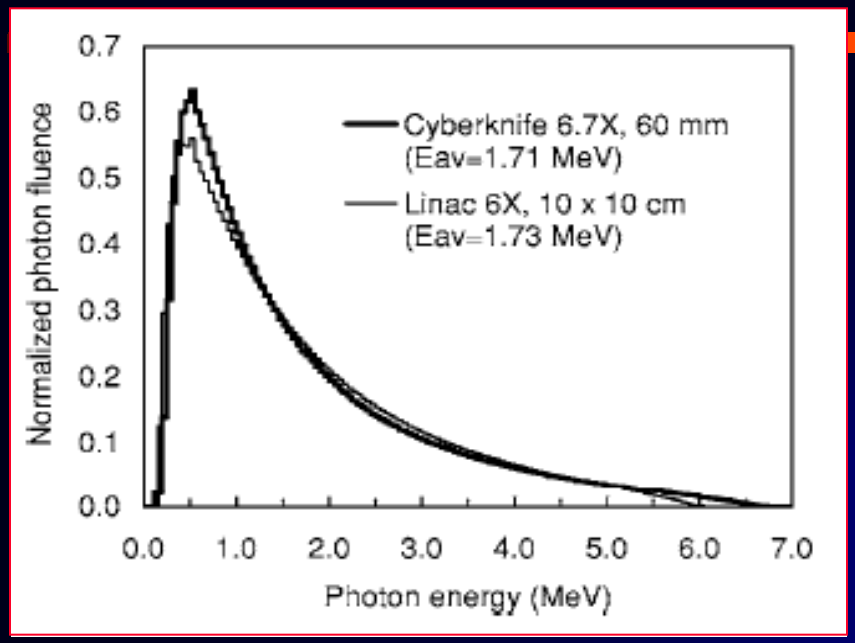
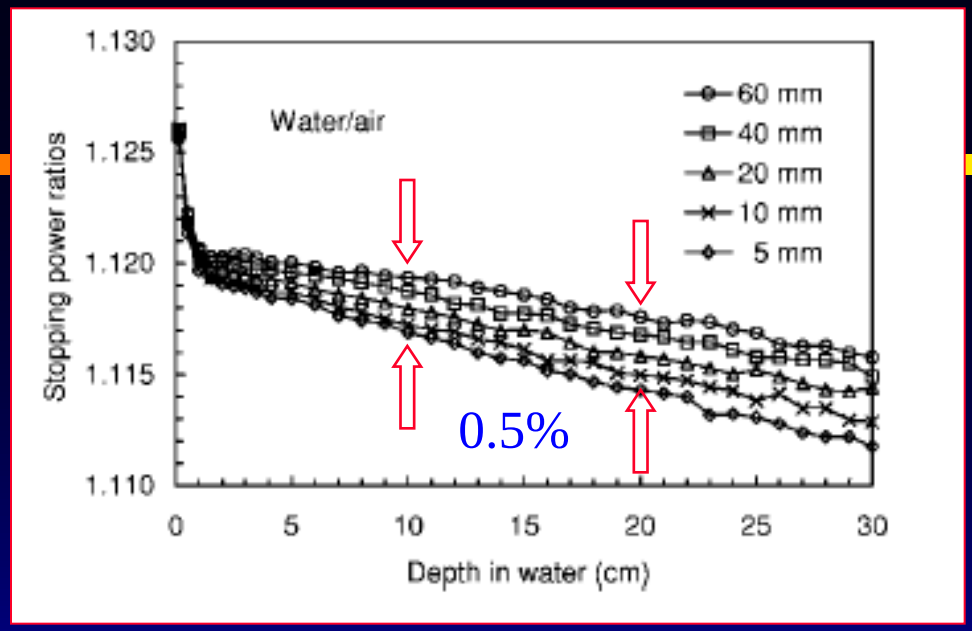
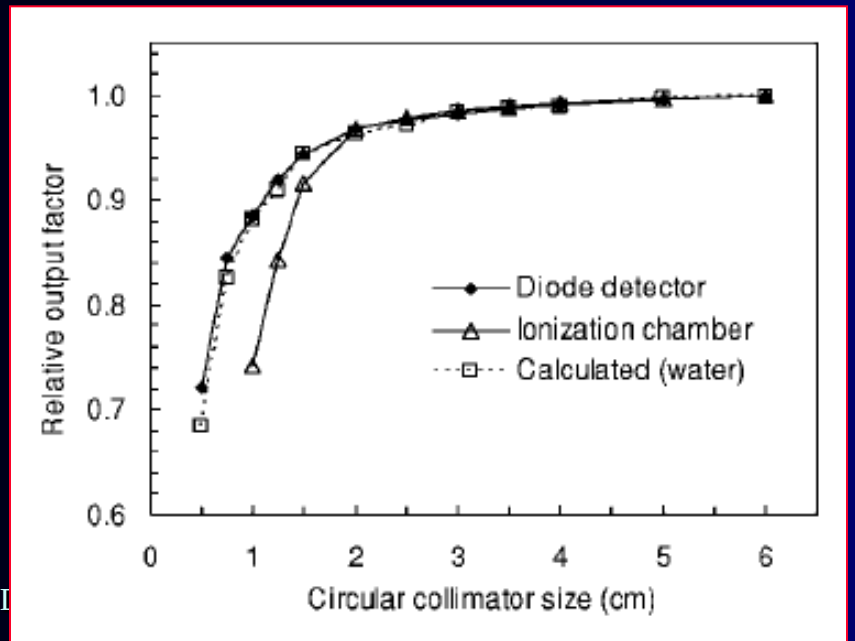
Cyber Knife Dosimetry







Machine type	$\%dd(10)_x$	$(\bar{\mu}_{en}/\rho)^{w}_{wall}$
		Wall=C-552
Linac	66.3	1.1091
Cyberknife	60.8	1.1088
		Wall=Carbon
Linac	66.3	1.1144
Cyberknife	60.8	1.1144
		Wall=PMMA

Machine type	$\%dd(10)_x$	$(\bar{L}/\rho)^{m}_{air}$			
		Water	PMMA	Carbon	C-552
Linac	66.3[a]	1.1208	1.0878	0.9876	0.9836
Cyberknife	60.8[b]	1.1194	1.0859	0.9854	0.9817

[a]For a 10×10 cm^2 field at 100 cm SSD from a Varian 6 MV-linear accelerator.
[b]For a 60 mm circular collimator at 80 cm SSD from a Cyberknife system.

F. Araki, Med. Phys. 33, 2955-2963 (2006).

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Francescon et al, Med. Phys. 25(4), 503, 1998

TABLE III. $s_{c,p}$ measured with parallel-plate micro-chamber (filled with air and TMS dielectric liquid, alternatively), radiochromic film, radiographic film, MOSFETs, $1\times1\times1$ mm^3 chips of TLD-800 and calculated by Monte Carlo BEAM code. For $s_{c,p}$ measured with the ion chamber and MOSFETs, the experimental values have been corrected by means of the F factor, as described in Section II G.

Field diameter (mm)	Exradin pp IC (with air)		Exradin pp IC (with TMS)		Radiochromic film		TLD-800		MOSFETs		Radiographic film		Monte Carlo BEAM code	
	$s_{c,p}$	2σ%	$s_{c,p}$	2σ%	$s_{c,p}$	2σ%	$s_{c,p}$	2σ%	$s_{c,p}$	2σ%	$s_{c,p}$	2σ%	$s_{c,p}$	2σ%
4.4	(0.45[a])	<0.8%	(0.45[a])	<0.8%	0.47	2.4%	0.47	3.7%	(0.48[a])	<1.8%	0.46	3.0%	0.46	<0.5%
→ MC	0.37	0.5%	0.42	0.5%					0.53	1.7%				
6.7	(0.66[a])	<0.8%	(0.65[a])	<0.8%	0.66	2.7%	0.64	1.9%	(0.65[a])	<3.6%	0.66	2.0%	0.66	<0.5%
→ MC	0.58	0.5%	0.62	0.5%					0.71	3.5%				
10.5	(0.82[a])	<0.8%	(0.81[a])	<0.8%	0.81	1.8%	0.80	3.5%	(0.80[a])	<1.7%	0.81	2.3%	0.82	<0.5%
→ MC	0.76	0.5%	0.78	0.5%					0.84	1.6%				
12.7	(0.85[a])	<0.6%	(0.85[a])	<0.6%	0.85	2.5%	0.84	2.8%	(0.84[a])	<1.4%	0.85	2.5%	0.84	<0.5%
→ MC	0.81	0.4%	0.83	0.4					0.86	1.3%				
16.0	(0.87[a])	<0.6%	(0.87[a])	<0.6%	0.88	2.2%	0.87	3.2%	(0.87[a])	<2.0%	0.88	2.5%	0.87	<0.5%
→ MC	0.86	0.4%	0.86	0.4%					0.88	1.9%				
19.0	(0.89[a])	<0.6%	(0.89[a])	0.6%	0.89	2.3%	0.89	2.6%	(0.89[a])	<2.0%	0.89	2.5%	0.89	<0.5%
→ MC	0.89	0.4%	0.89	0.4					0.89	1.9%				

[a]Experimental values divided by the F factor (Section II G).

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Correction Factors

Correction Factor depends on:

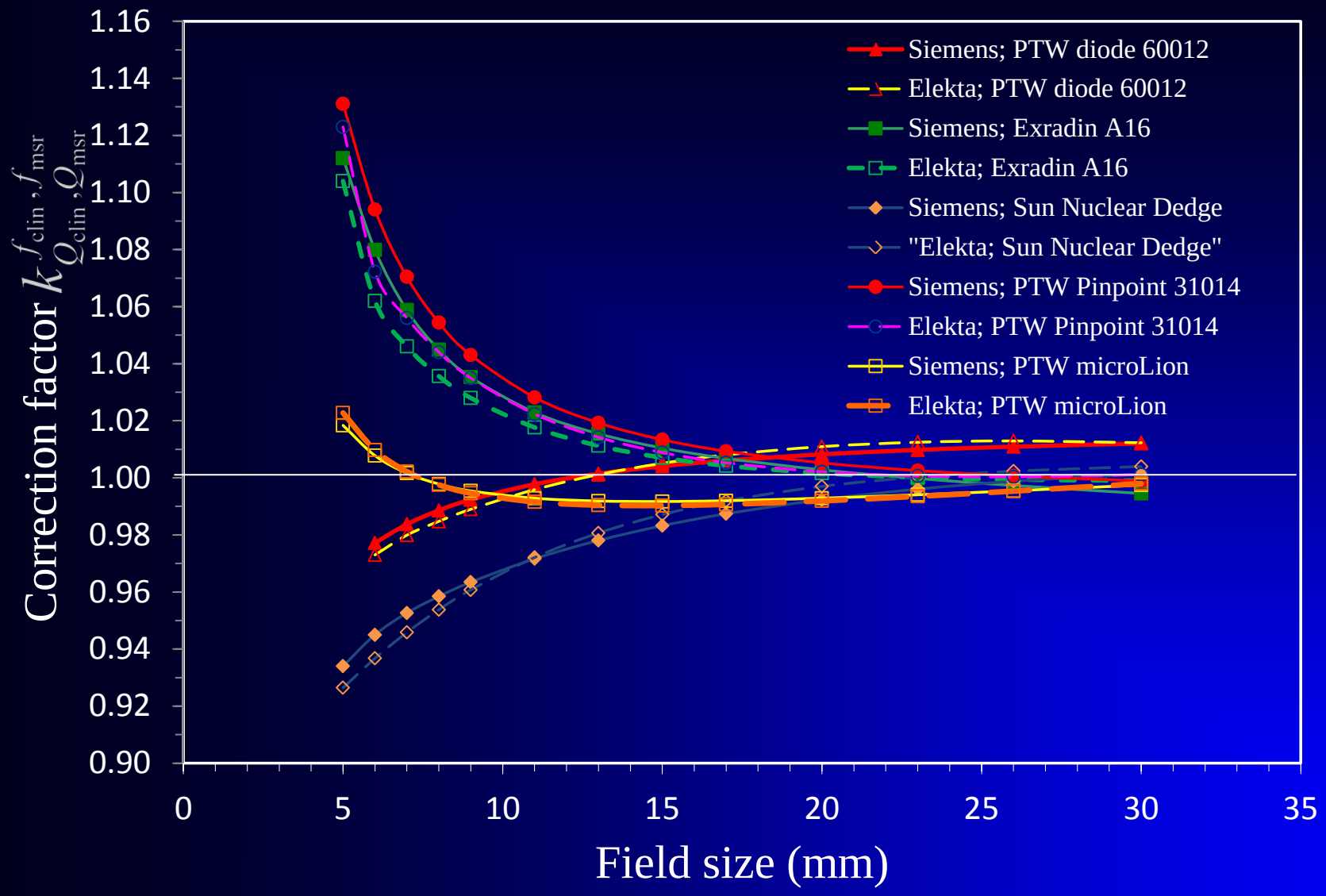
- Field size
- Source size (FWHM)
- Detector type

TABLE VII. F_{corr} of the four detectors for the 5, 7.5, and 10 mm collimators, as a function of the FWHM.

A16	F_{corr}		
FWHM (mm)	5 mm coll	7.5 mm coll	10 mm coll
1.4	1.067	1.021	1.008
1.8	1.087	1.017	1.007
2.2	1.102	1.020	1.012
2.6	1.112	1.027	1.010
Pin Point	F_{corr}		
FWHM (mm)	5 mm coll	7.5 mm coll	10 mm coll
1.4	1.082	1.025	1.017
1.8	1.099	1.024	1.013
2.2	1.110	1.025	1.013
2.6	1.124	1.037	1.016
Diode	F_{corr}		
FWHM (mm)	5 mm coll	7.5 mm coll	10 mm coll
1.4	0.953	0.966	0.978
1.8	0.955	0.966	0.978
2.2	0.957	0.967	0.978
2.6	0.940	0.967	0.978
Diamond	F_{corr}		
FWHM (mm)	5 mm coll	7.5 mm coll	10 mm coll
1.4	1.066	1.001	1.001
1.8	1.093	1.007	1.000
2.2	1.107	1.010	0.999
2.6	1.123	1.012	1.001

Francescon, et al Med Phys 35, 504, 2008

Published data on $k_{Q_{\text{clin}},Q_{\text{msr}}}^{f_{\text{clin}},f_{\text{msr}}}$



Francescon et al Med Phys,38, 6513, 2011

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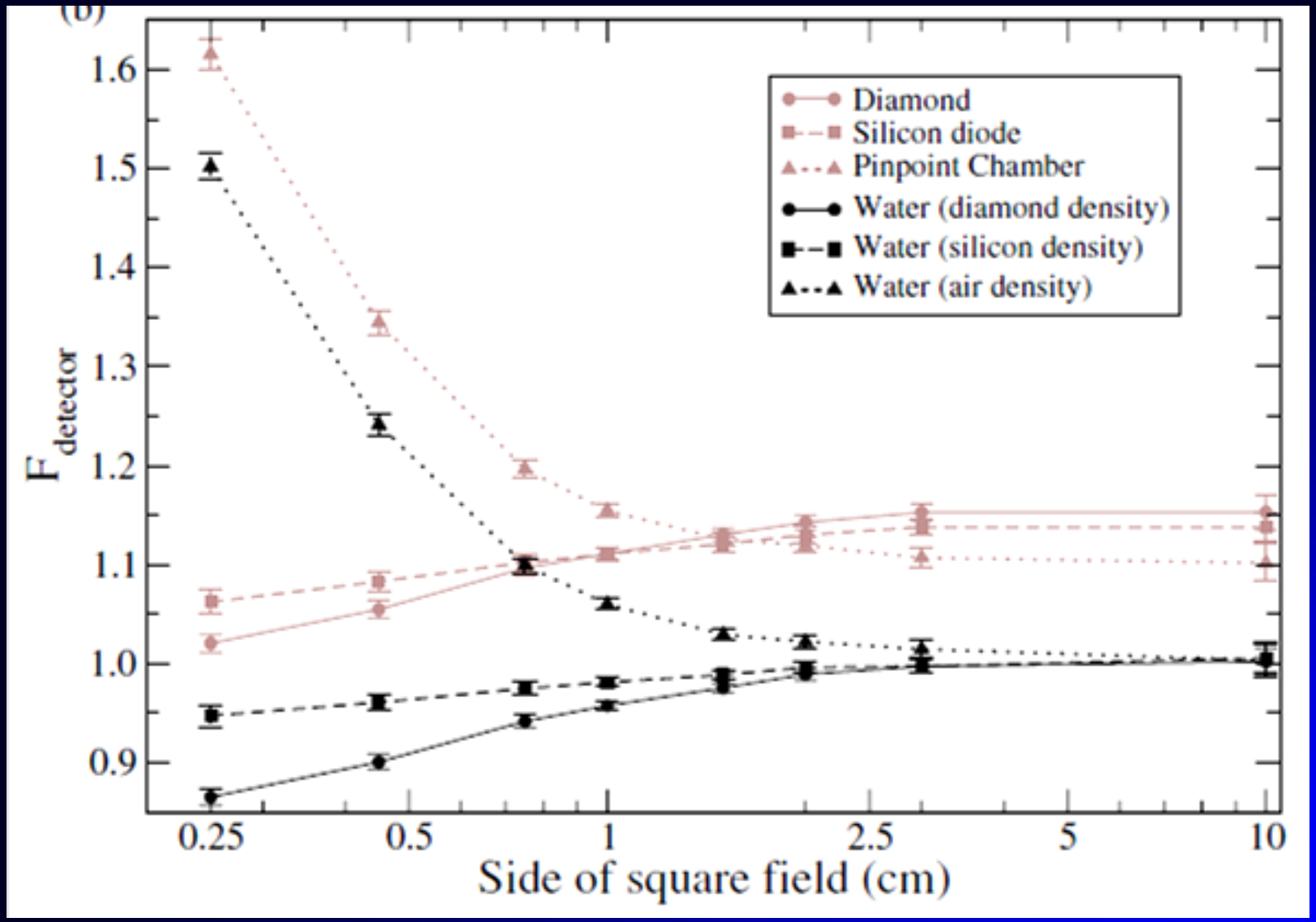
Detector Density Effect



*Scott et al, Phys Med Biol **57** 4461–4476, 2012*

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$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ of Linear Accelerators (Varian)

Implementing a newly proposed Monte Carlo based small field dosimetry formalism for a comprehensive set of diode detectors

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(Received 21 April 2011; revised 11 October 2011; accepted for publication 14 October 2011; published 23 November 2011)

Med. Phys. 38 (12), 6992, 2011

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$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ of Linear Accelerators

Calculation of $k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ for several small detectors and for two linear accelerators using Monte Carlo simulations

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Med. Phys. 38 (12), 6513-6527, 2011

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Experimental small field 6 MV output ratio analysis for various diode detector and accelerator combinations

Gavin Cranmer-Sargison [a,b,*], Steve Weston [b,c], Narinder P. Sidhu [a,d], David I. Thwaites [b,e]

Radiotherapy and Oncology 100 (2011) 429–435

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$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ Cyber Knife

Detector	5 mm		7.5 mm		10 mm	
	$M_{Q_{clin}}^{f_{clin}} / M_{Q_{msr}}^{f_{msr}}$	$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$	$M_{Q_{clin}}^{f_{clin}} / M_{Q_{msr}}^{f_{msr}}$	$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$	$M_{Q_{clin}}^{f_{clin}} / M_{Q_{msr}}^{f_{msr}}$	$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$
A16	0.626 (15)	1.089 (3)	0.811 (10)	1.018 (3)	0.866 (6)	1.010 (3)
PinPoint	0.620 (17)	1.101 (3)	0.801 (7)	1.024 (3)	0.862 (5)	1.015 (3)
Diode 60008	0.726 (1)	0.943 (3)	0.873 (1)	0.949 (3)	0.912 (1)	0.964 (3)
Diode 60012	0.705 (1)	0.956 (3)	0.847 (2)	0.966 (3)	0.891 (1)	0.978 (3)
EDGE	0.726 (1)	0.948 (3)	0.864 (1)	0.955 (3)	0.906 (1)	0.966 (3)
Alanine	0.544 (8)	1.249 (8)	0.785 (12)	1.059 (4)	0.855 (13)	1.019 (3)
TLD	0.668 (4)	···	0.809 (6)	···	0.880 (8)	···
EBT films	0.659 (17)	···	0.811 (16)	···	0.853 (18)	···
Polymer gels[a]	0.702 (21)	···	0.872 (27)	···	0.929 (29)	···

Pantelis et al, Med Phy. 37, 2369-2379, 2010

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Tomotherapy k_{msr} Reference Dosimetry

Reference: 5x10 cm^2, 85 cm SSD, 10 cm

Chamber type	k_{Q,Q_o} (TRS-398)	$k_{Q_{msr},Q}^{f_{msr},f_{ref}}$	$k_{Q_{msr},Q_o}^{f_{msr},f_o}$ (MC)	$k_{Q_{msr},Q_o}^{f_{msr},f_o}$ (previous studies)
Exradin A1SL	0.996	1.001	0.997	0.997 (Refs. 5 and 10)
Exradin A12 Farmer	0.996	1.004	1.000	
PTW 30006 Farmer	0.993	1.004	0.997	0.995 (Ref. 6)
PTW 31010 Semiflex	0.993	1.002	0.995	0.996 (Ref. 10)
PTW 31014 PinPoint	0.994	0.997	0.993	0.992 (Ref. 10)
PTW 31018 microLion (parallel)	N/A	N/A	0.993	
NE 2571 Farmer	0.994	1.003	0.997	0.995 (Ref. 6)

Sterpin et al, Med Phys, 39, 4066, 2012

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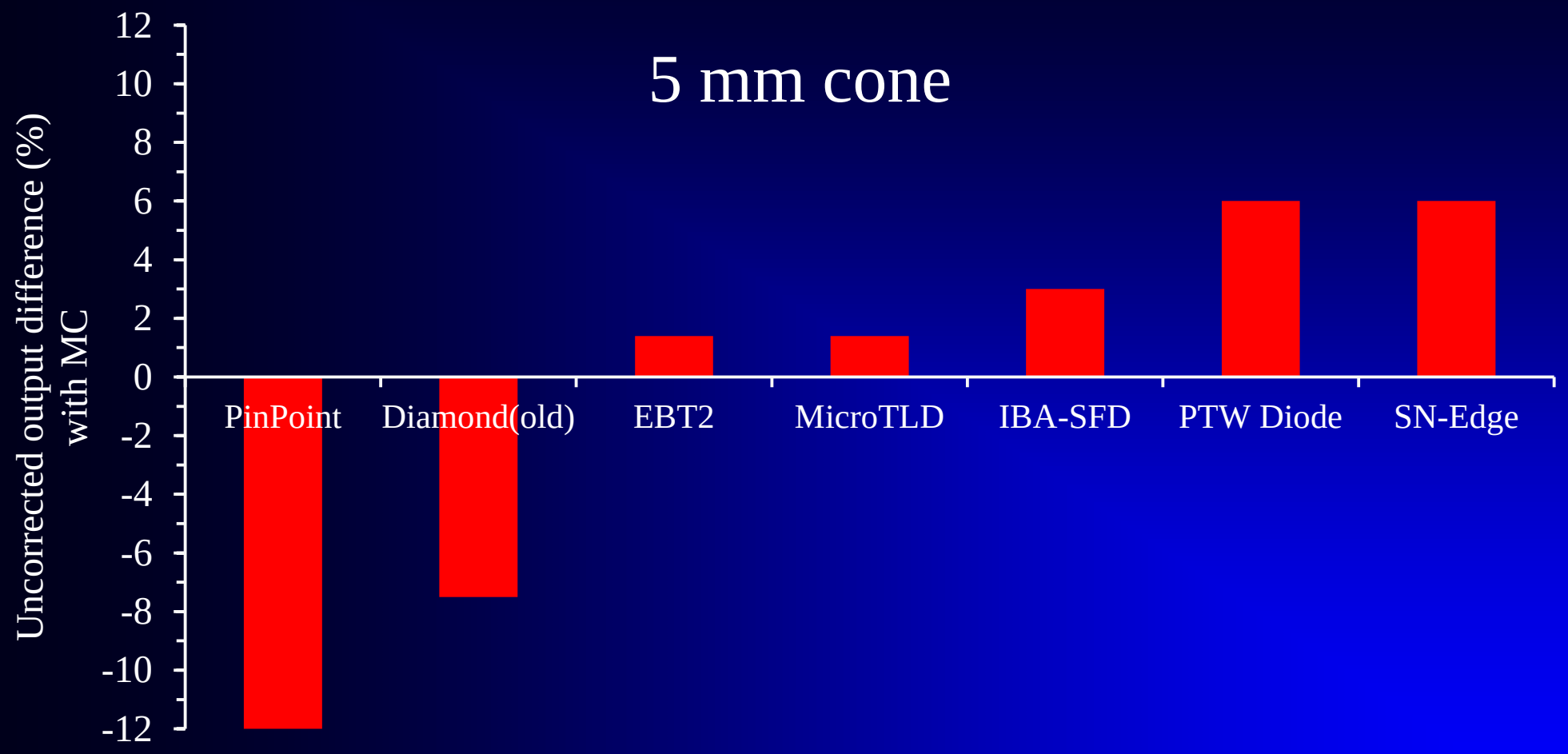
CyberKnife data



Moignier et al, Med Phys 41(7), 071702, 2014

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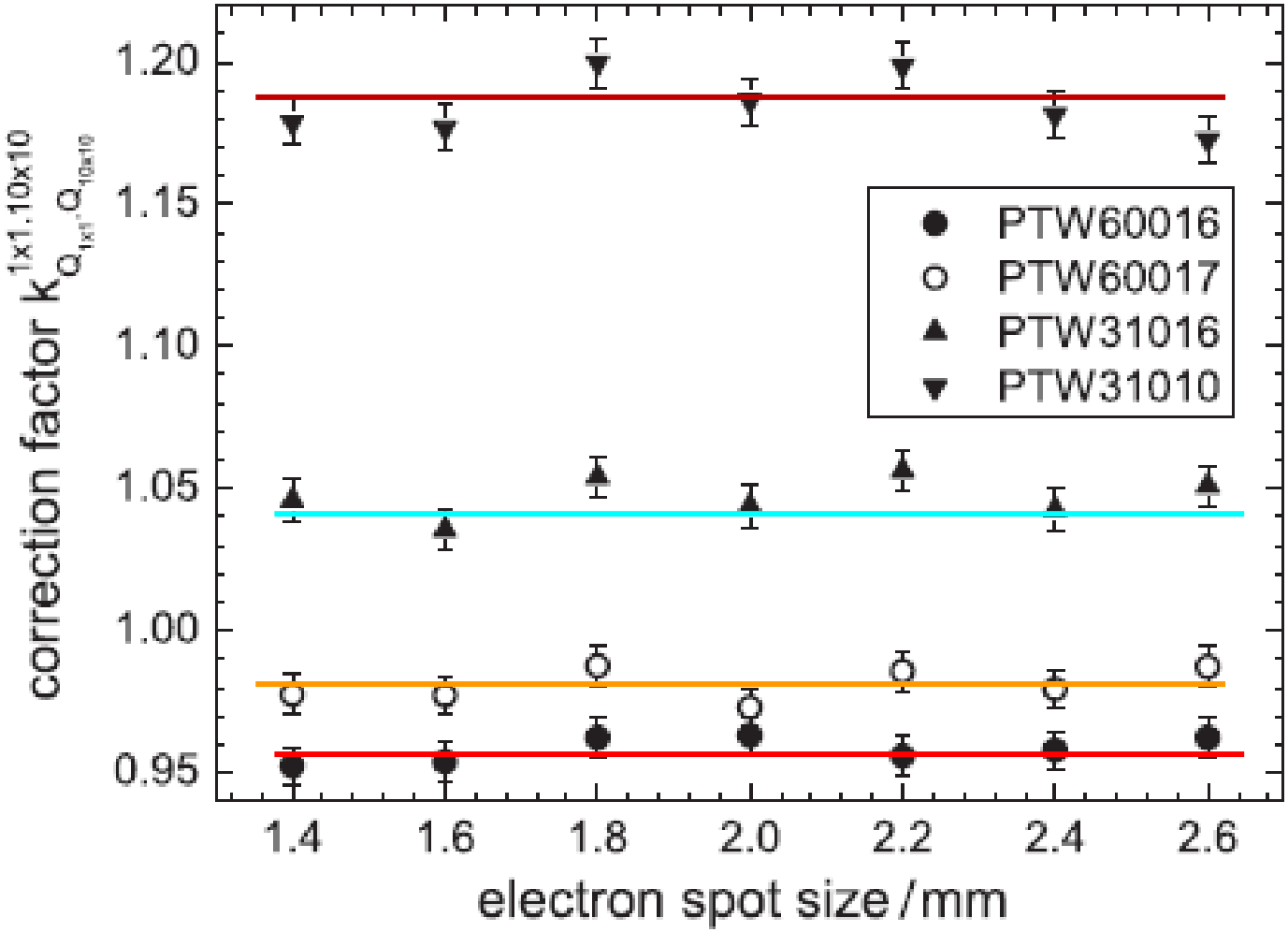
IOP Publishing Metrologia
Metrologia 49 (2012) S215–S218 doi:10.1088/0026-1394/49/5/S215

The influence of linac spot size on scatter factors

D Czarnecki[1], J Wulff[1] and K Zink[1,2]



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Output correction factors for nine small field detectors in 6 MV radiation therapy photon beams: A PENELOPE Monte Carlo study

Med Phys, 41(4), 041711, 2014

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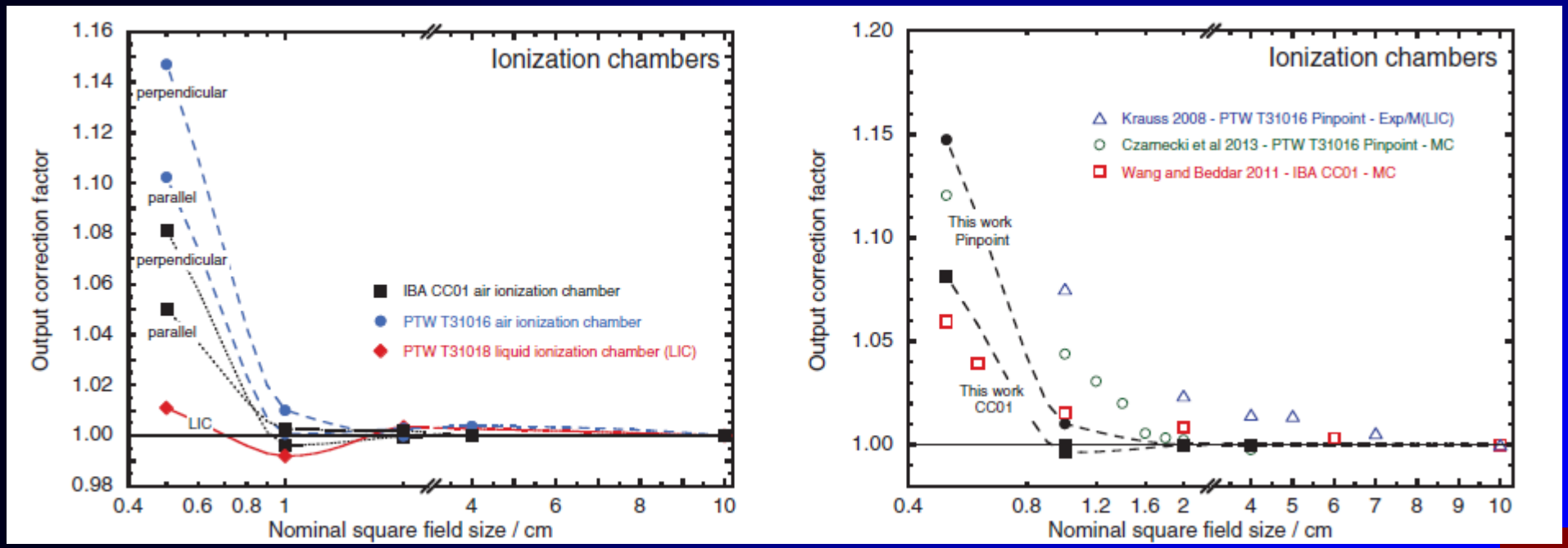

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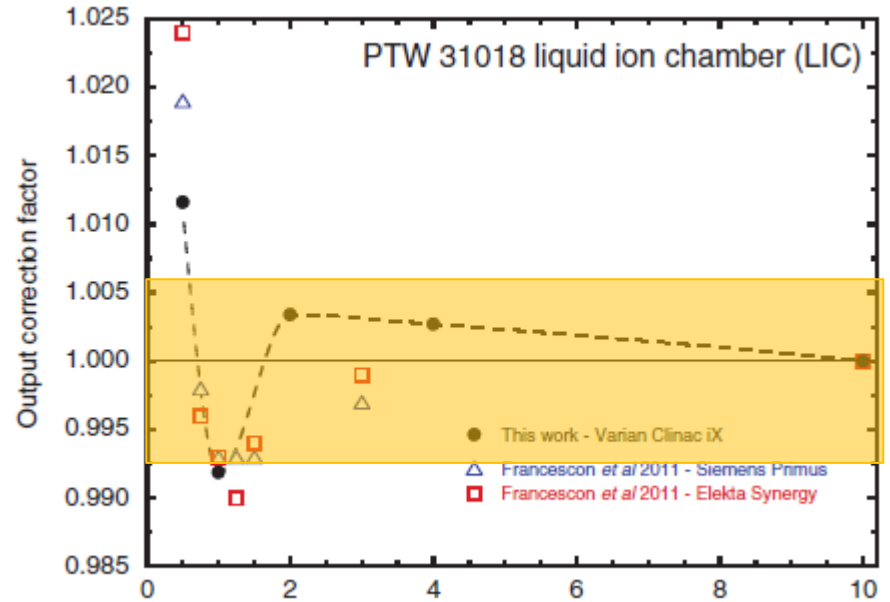
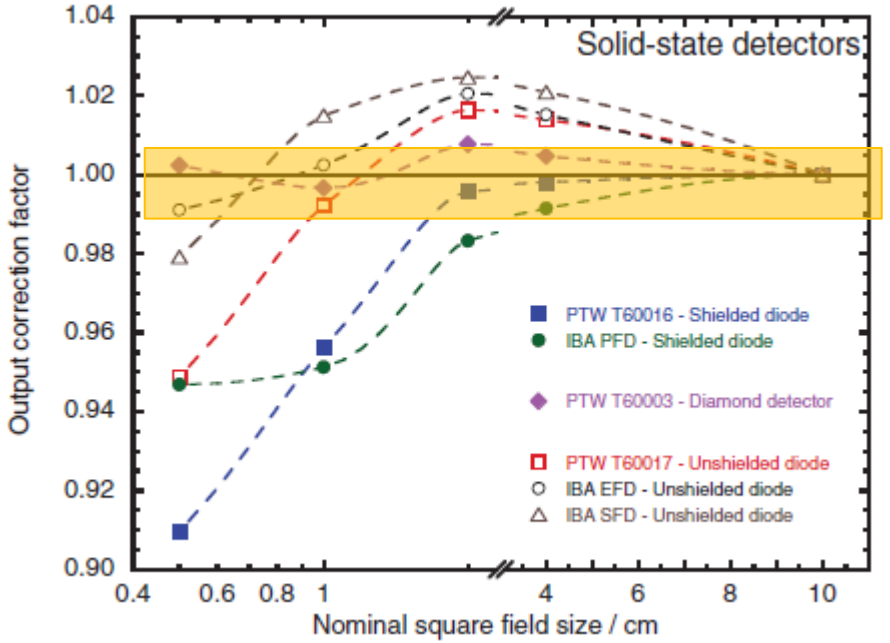
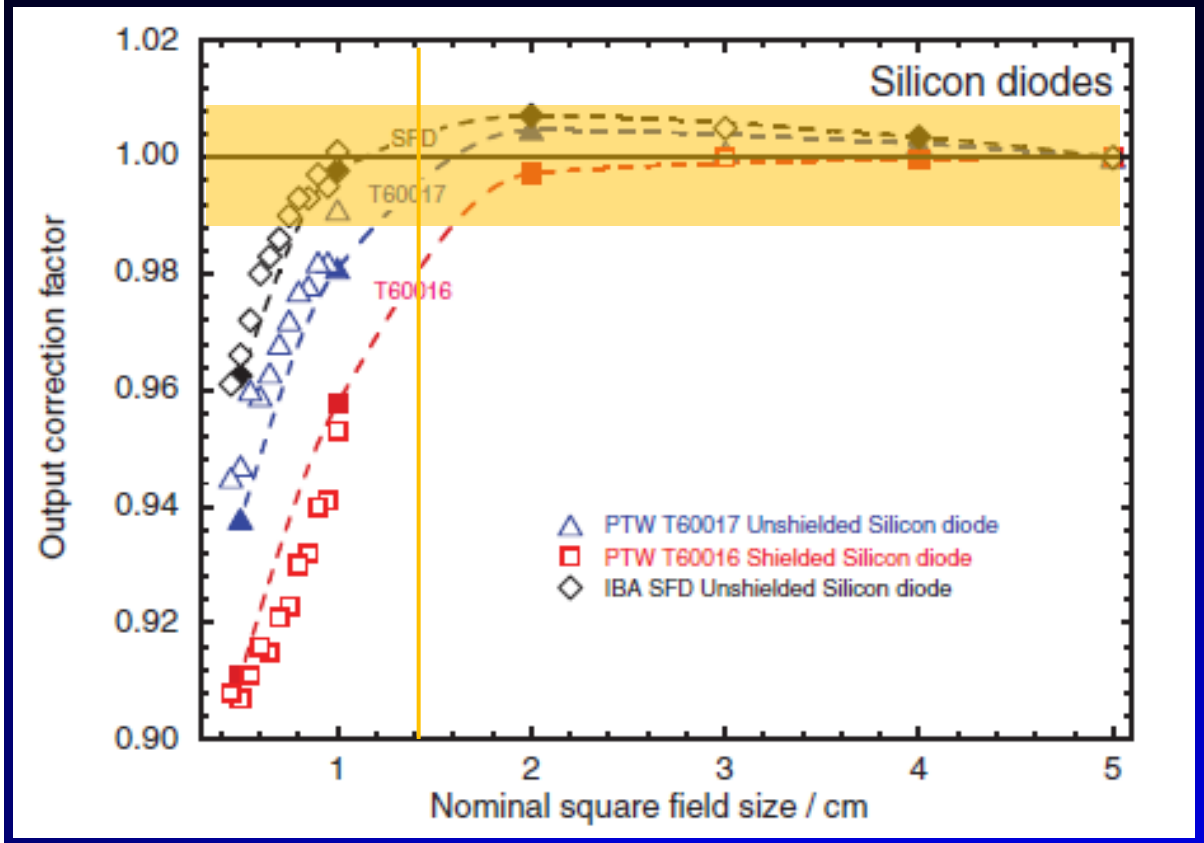
Newer Data on $k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$







Benmakhlouf et al, Med Phys, 41(4), 041711, 2014

New Published data From IAEA

Detector to detector corrections: A comprehensive experimental study of detector specific correction factors for beam output measurements for small radiotherapy beams

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072103-1 Med. Phys. 41 (7), July 2014

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Correction Factors

TABLE V. Detector correction factors $(p_{fl})^{Q_{clin}}_{Q_{int}}(p_{spec})^{Q_{clin}}_{Q_{int}}$. Factors shown are ratios of detector ratios relative to the dose ratios determined from alanine measurement for each field size $(\frac{D^{f_{clin}}_{w,Q_{clin}}}{D^{f_{int}}_{w,Q_{int}}})/(\frac{M^{f_{clin}}_{Q_{clin}}}{M^{f_{int}}_{Q_{int}}} \times (p_{vol})^{Q_{clin}}_{Q_{int}})$.

FS [cm]	0.6	0.9	1.2	1.8	2.4	3.0	4.2	10.0
TLD chips	1.000	...	1.003	1.008	1.004	1.000	1.005	1.010
TLD micro-cubes	0.998	...	1.000	1.001	1.009	1.000	1.001	1.007
IBA SFD diode	0.995	...	0.998	1.002	1.006	1.000	0.990	0.969
IBA PFD diode	0.936	...	0.962	0.985	0.999	1.000	1.000	1.001
IBA EFD diode	0.961	...	0.983	0.992	1.002	1.000	0.997	0.989
PTW 60003Diamond (Sensitive area ~ 15 mm^2)	0.995	...	0.983	0.992	1.002	1.000	0.996	0.995
PTW 60019 microDiamond	0.961	...	0.980	0.990	1.001	1.000	0.999	1.000
RPLD (GDM-302M)	...	...	...	0.993	0.998	1.000	0.994	0.997
Al_2O_3:C	0.980	0.982	0.985	0.991	0.999	1.000	...	0.995
Scintillator 1	1.022	1.009	1.000	0.996	1.001	1.000	...	0.992
Scintillator 2	1.028	1.015	1.006	1.000	1.004	1.000	...	0.988
PTW 31018microLion	0.970	...	0.980	0.990	1.000	1.000	0.999	1.005
IBA CC01	1.000	...	0.993	0.993	1.000	1.000	0.997	0.990
IBA CC04	1.096	...	1.007	0.998	1.003	1.000	0.997	0.998
IBA CC13[b]	...	...	1.033	1.008	1.005	1.000	0.996	0.996
Wellhöfer IC10[b]	...	...	1.030	1.005	1.005	1.000	0.996	0.996
PTW 31014 PinPoint	1.034	...	1.007	1.002	1.000	1.000	0.998	1.002
PTW 31016 PinPoint 3D	1.078	...	1.013	1.000	1.001	1.000	0.998	0.999
PTW 31010 Semiflex[b]	...	...	1.027	1.002	1.004	1.000	0.996	0.997
PTW 31013 Semiflex[a,b]	...	...	...	...	1.013	1.000	0.992	0.993

[a]This chamber was included in the table for completeness but it is not recommended to use for small field dosimetry in fields smaller than 2.0 × 2.0 cm^2 because the volume averaging effect is unacceptably high.

[b]For these ionization chambers, corrections for the smallest field were unacceptably high (>20%) for field sizes smaller than 1 × 1 cm^2 and therefore were excluded from Table V.

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Variation of $k^{f_{clin},f_{msr}}_{Q_{clin},Q_{msr}}$ for the small-field dosimetric parameters percentage depth dose, tissue-maximum ratio, and off-axis ratio

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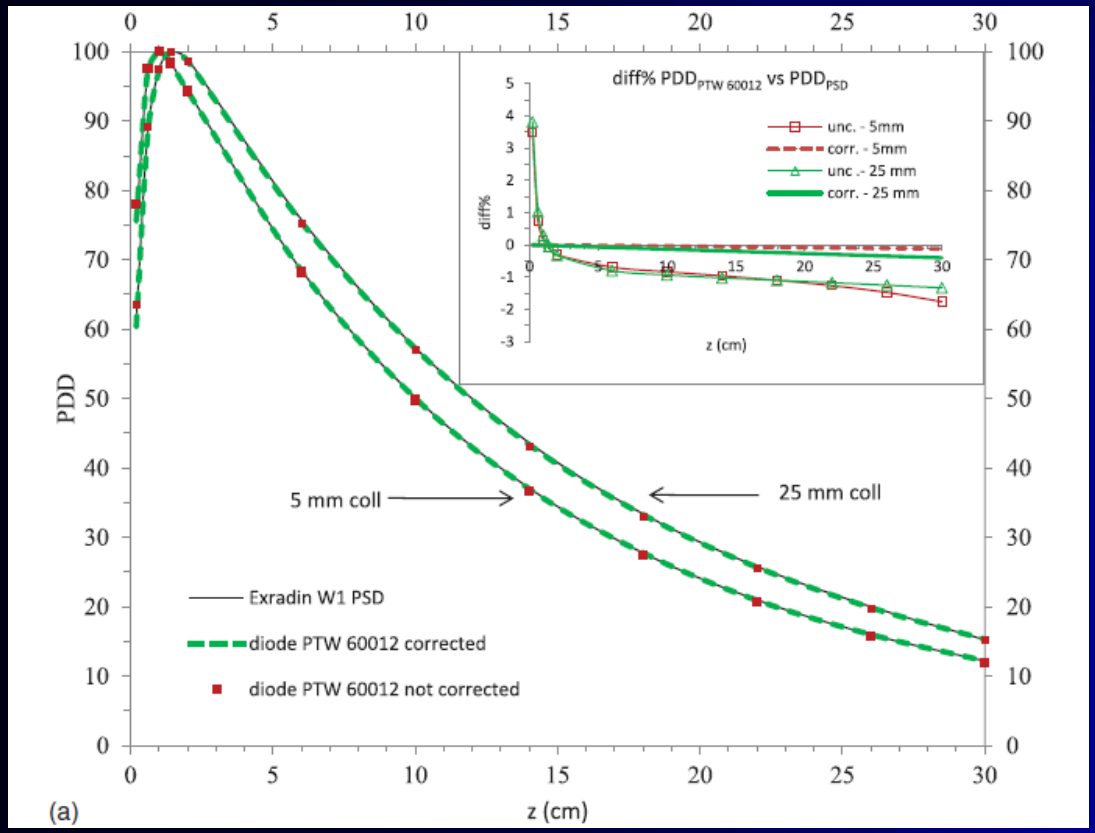
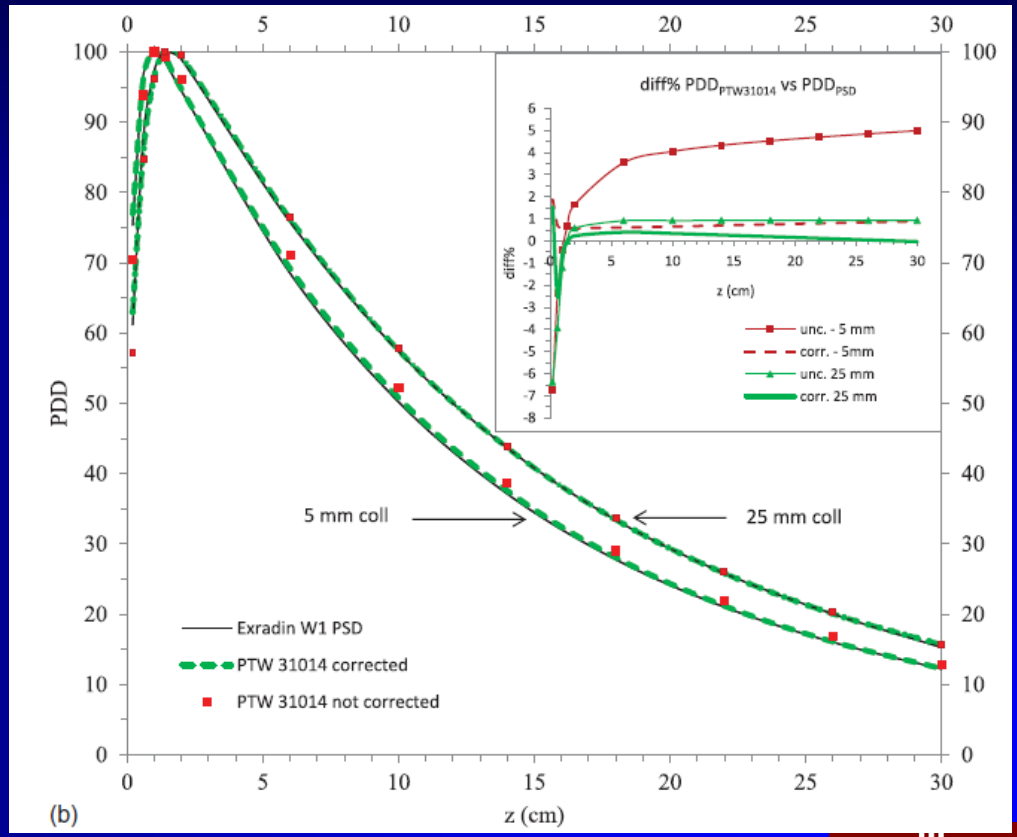
Indra J. Das
Department of Radiation Oncology, Indiana University School of Medicine, Indianapolis, Indiana 46202





Med. Phys. 41 (10), October 2014 0094-2405/2014/41(10)/101708/

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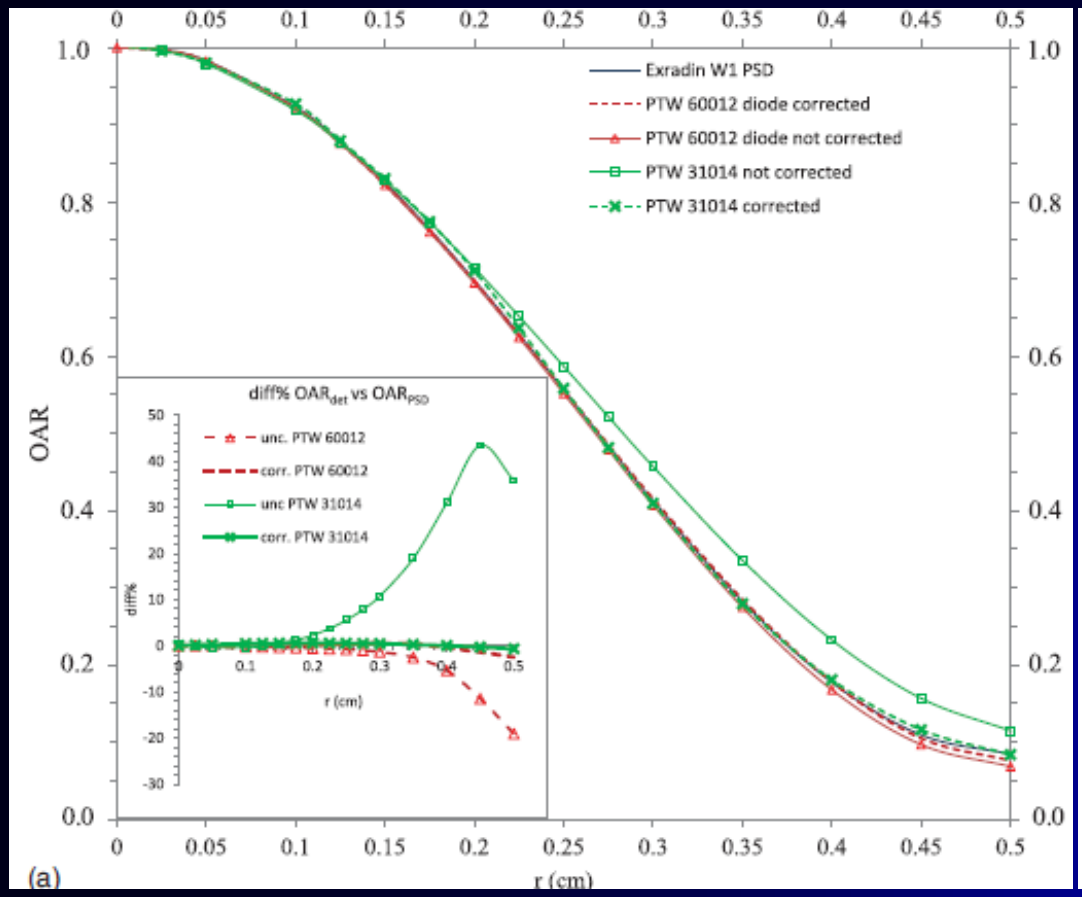
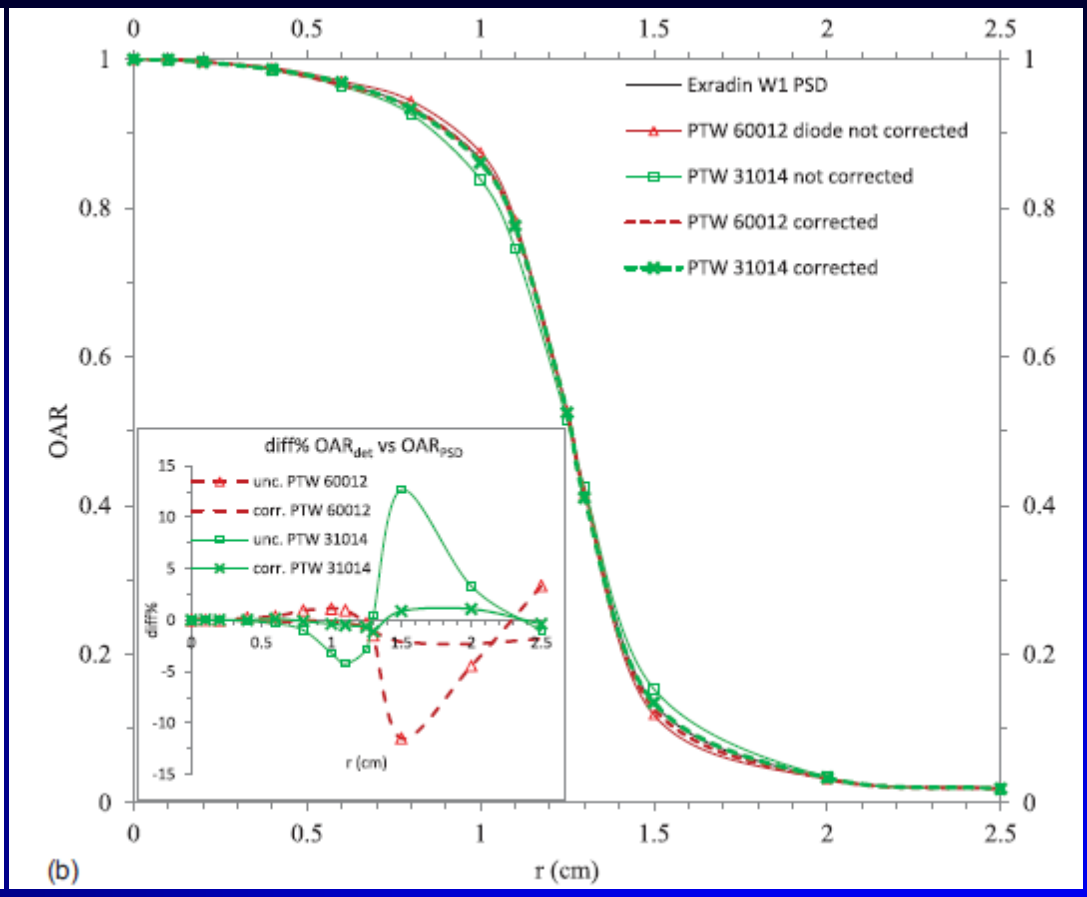
Correction in Profile (OAR)

5 mm cone



25 mm cone



Francescon et al, Med Phys, 41(10), 101708, 2014

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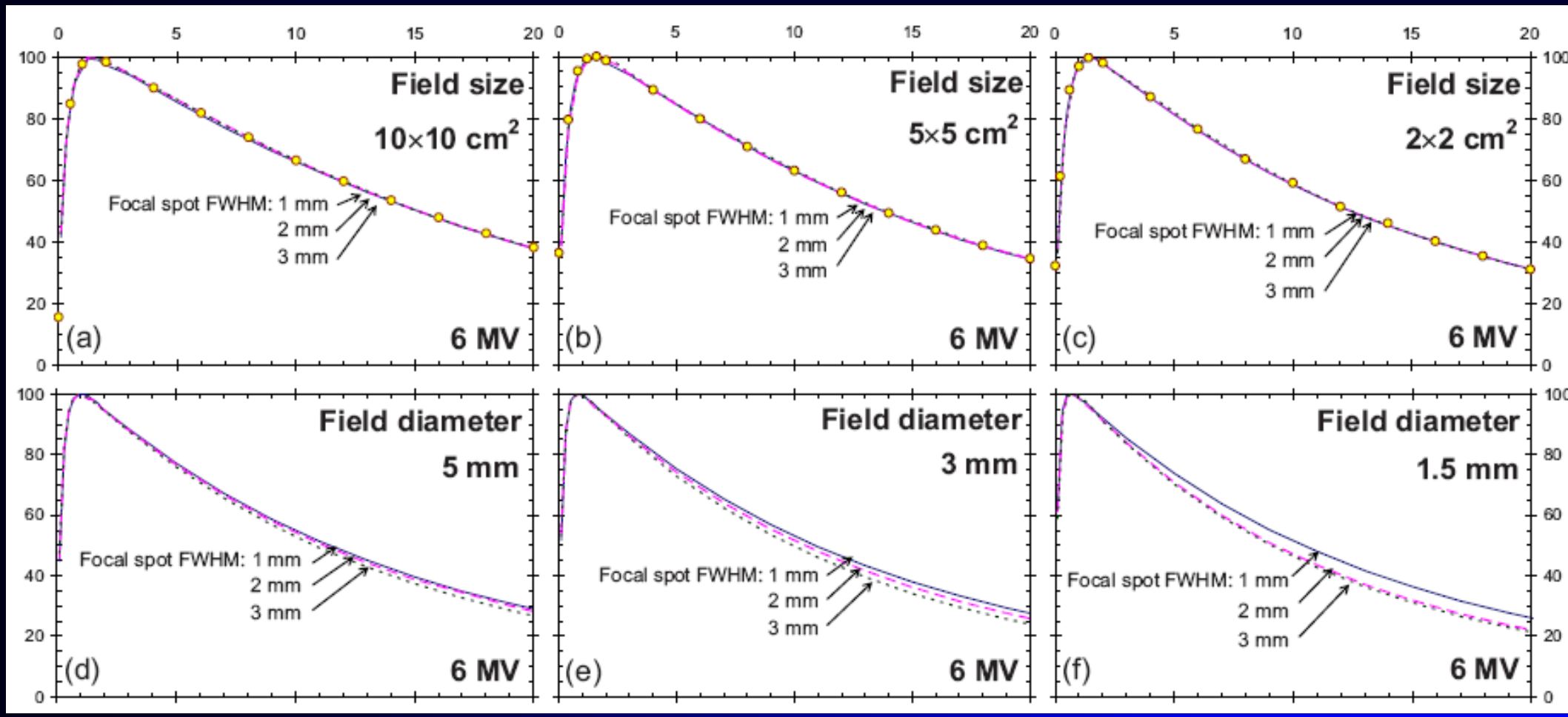
Depth Dose & Source Size



Sham et al, Med Phys, 35, 3317-3330, 2008

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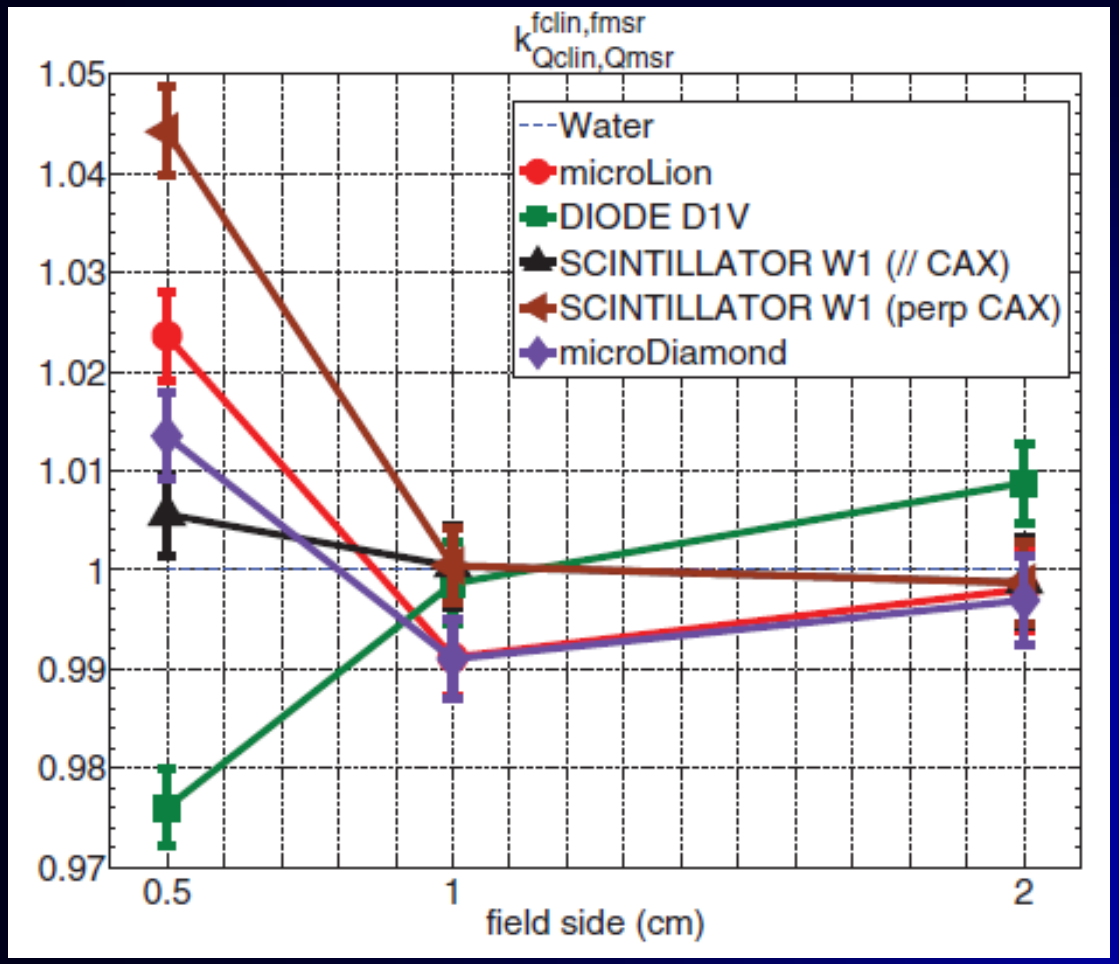
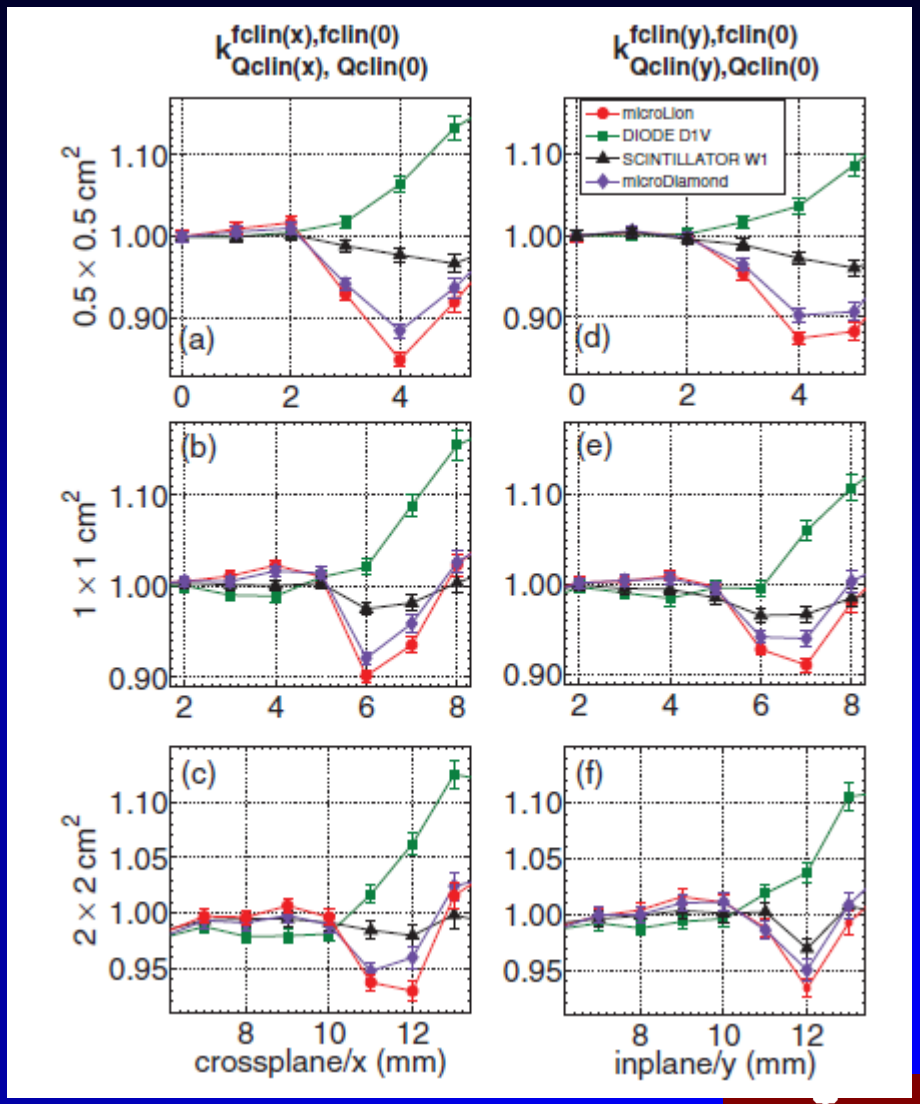
Good News with Modern Microdetectors





Papaconstadopoulos, et al, Phys. Med. Biol. 59 (2014) 5937–5952,

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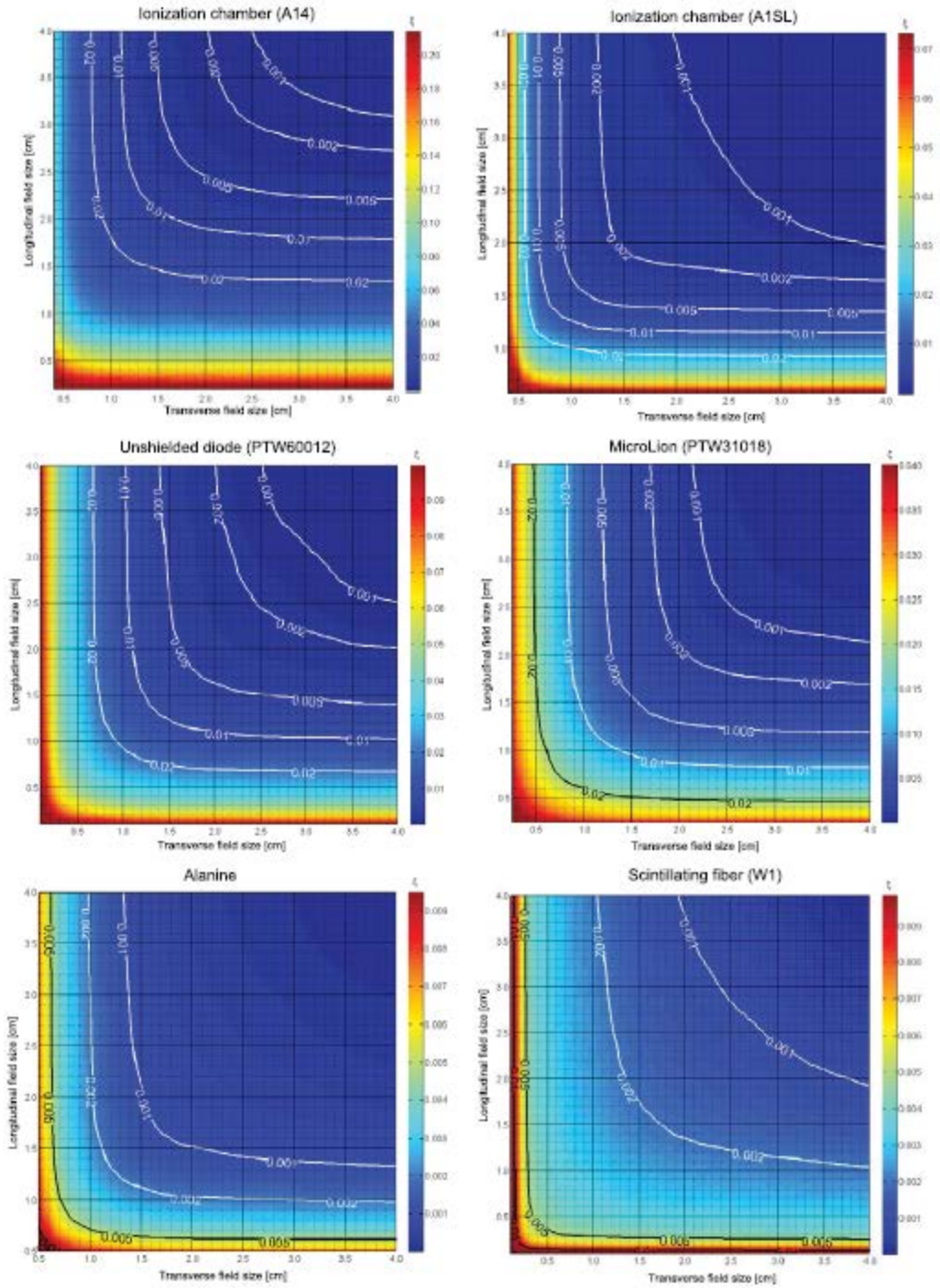

IOP Publishing | Institute of Physics and Engineering in Medicine — Physics in Medicine and Biology
Phys. Med. Biol. 59 (2014) 4973–5002 doi:10.1088/0031-9155/59/17/4973

Correction-less dosimetry of nonstandard photon fields: a new criterion to determine the usability of radiation detectors

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[2] Centre hospitalier de l'Université de Montréal (CHUM), 1560 Sherbrooke est, Montréal, Québec H2L 4M1, Canada
[3] Acoustics and Ionising Radiation Team, National Physical Laboratory, Hampton Road, Teddington TW11 0LW, UK

	6 MV								
	Square field size (cm)								
Detectors	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.50	3.00
MicroLion	3.1	2.0	1.3	0.8	0.5	0.3	0.2	0.1	0.1
N. Diamond	3.8	2.4	1.5	1.0	0.6	0.4	0.3	0.2	0.1
U. diode	4.9	3.0	1.9	1.2	0.8	0.5	0.4	0.2	0.1
Alanine	1.4	0.6	0.3	0.2	0.1	0.1	0.1	0.0	0.0
S. Fiber	0.5	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1

[a] Values are rounded to the nearest 0.1%.

	25 MV								
	Square field size (cm)								
Detectors	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.50	3.00
MicroLion	2.4	1.8	1.4	1.0	0.8	0.6	0.5	0.3	0.2
N. Diamond	3.3	2.1	1.5	1.0	0.8	0.6	0.5	0.3	0.1
U. diode	4.0	2.8	2.1	1.6	1.3	1.0	0.9	0.5	0.3
Alanine	1.5	0.8	0.6	0.4	0.3	0.2	0.2	0.1	0.1
S. Fiber	0.7	0.5	0.4	0.3	0.3	0.2	0.2	0.1	0.1

Kamio & Bouchard, PMB, 59(17), 4973-5002, 2014

In summary, the criterion presented in this work should give the clinical physicist the tools necessary to determine a radiation detector's limits of usability in non-reference condition and thereby perform measurements neglecting correction factors. For small fields, this is accomplished by verifying that the criterion parameter $\xi^{f_{ns},f_{msr}}_{Q_{ns},Q_{msr}}$ is sufficiently small for the field of interest. For composite IMRT fields, the reliance on the measurement of $D^{f_{ns}}_{w,Q_{ns}}$ can be assessed by verifying that the beam (or the VSC beam for composite fields) is acceptably uniform over detector's perturbation zone using the indices presented in this work. When a radiation detector is found to be unsuitable for a particular measurement, the simplest option would be to choose a different detector that is more water-equivalent. If such a detector is not available, the same detector can be used to evaluate an integral-dose value, like the dose area product (DAP) which doesn't require a nonstandard field correction factor (Underwood *et al* 2013a). Furthermore, by using volume-doses instead of point-doses and minimizing the detector's perturbation with the density compensation method outlined in this work it is possible to use small field detectors to measure nonstandard fields with minimal correction as illustrated by the density-compensated microLion shown in this work. Finally, we showed that the new Exradin scintillating fiber (W1) could measure fields sizes of a few mm

tion as illustrated by the density-compensated microLion shown in this work. Finally, we showed that the new Exradin scintillating fiber (W1) could measure fields sizes of a few mm
with corrections under 1% due to its near-water equivalency. With further improvements, the methods presented could eventually serve as the basis of a correction-less dosimetry protocol for nonstandard fields.

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Machine, Cone & Depth?

Can small field diode correction factors be applied universally?

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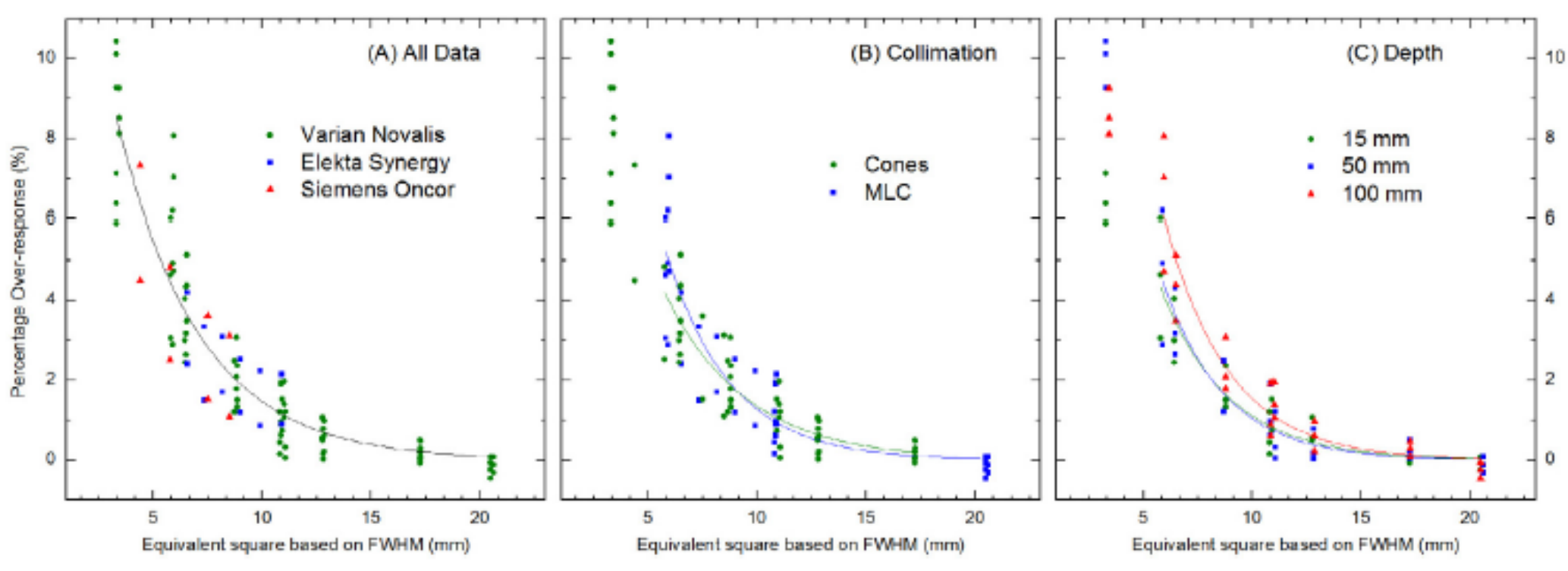
Radiotherapy Oncology, 112, 442-446, 2014



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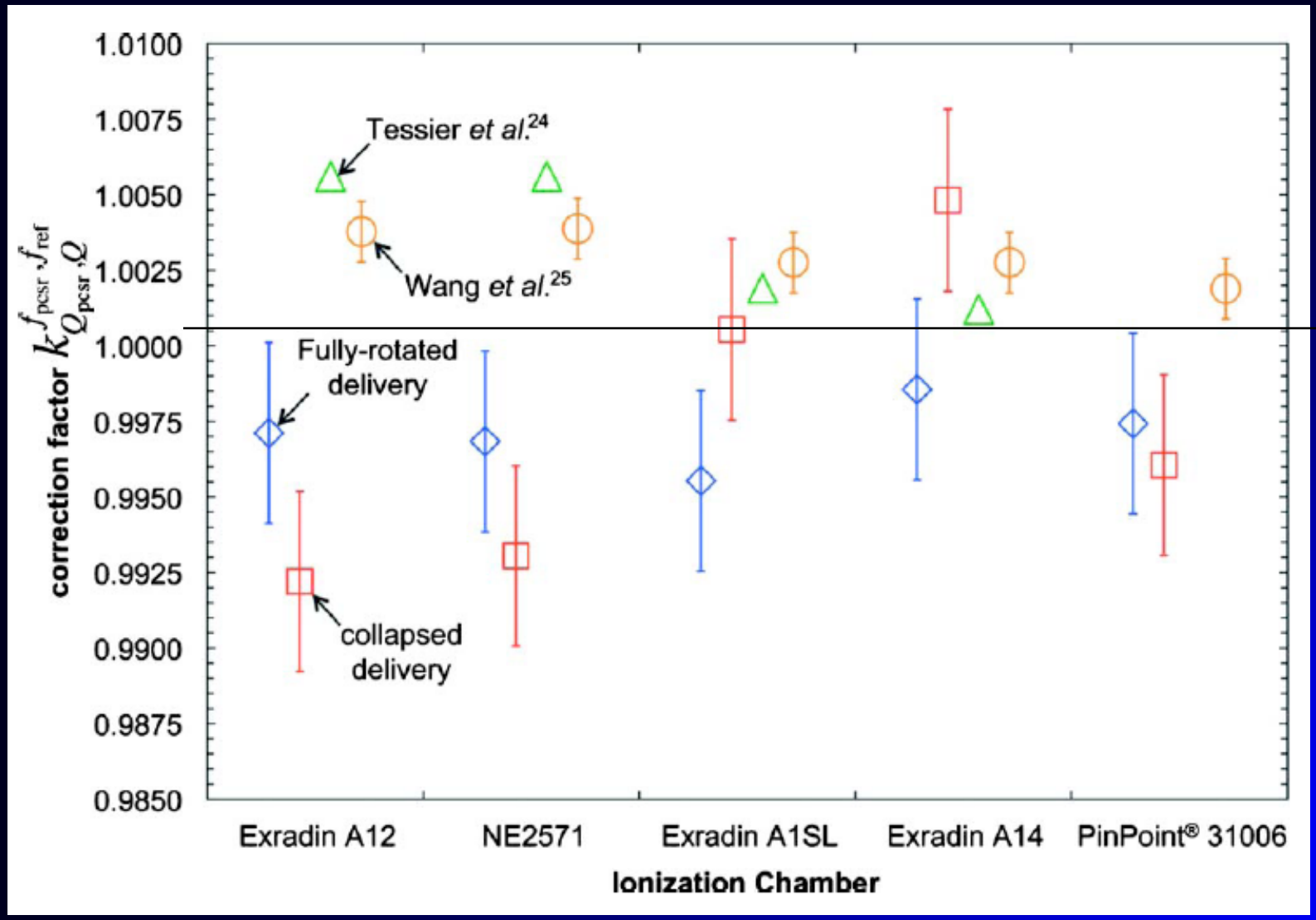
$k_{Q_{clin},Q_{msr}}^{f_{clin},f_{msr}}$ Correction Factor vs Ion Chambers (IMRT, VMAT)



Chung et al , Med Phys, 37, 2404-2413, 2010

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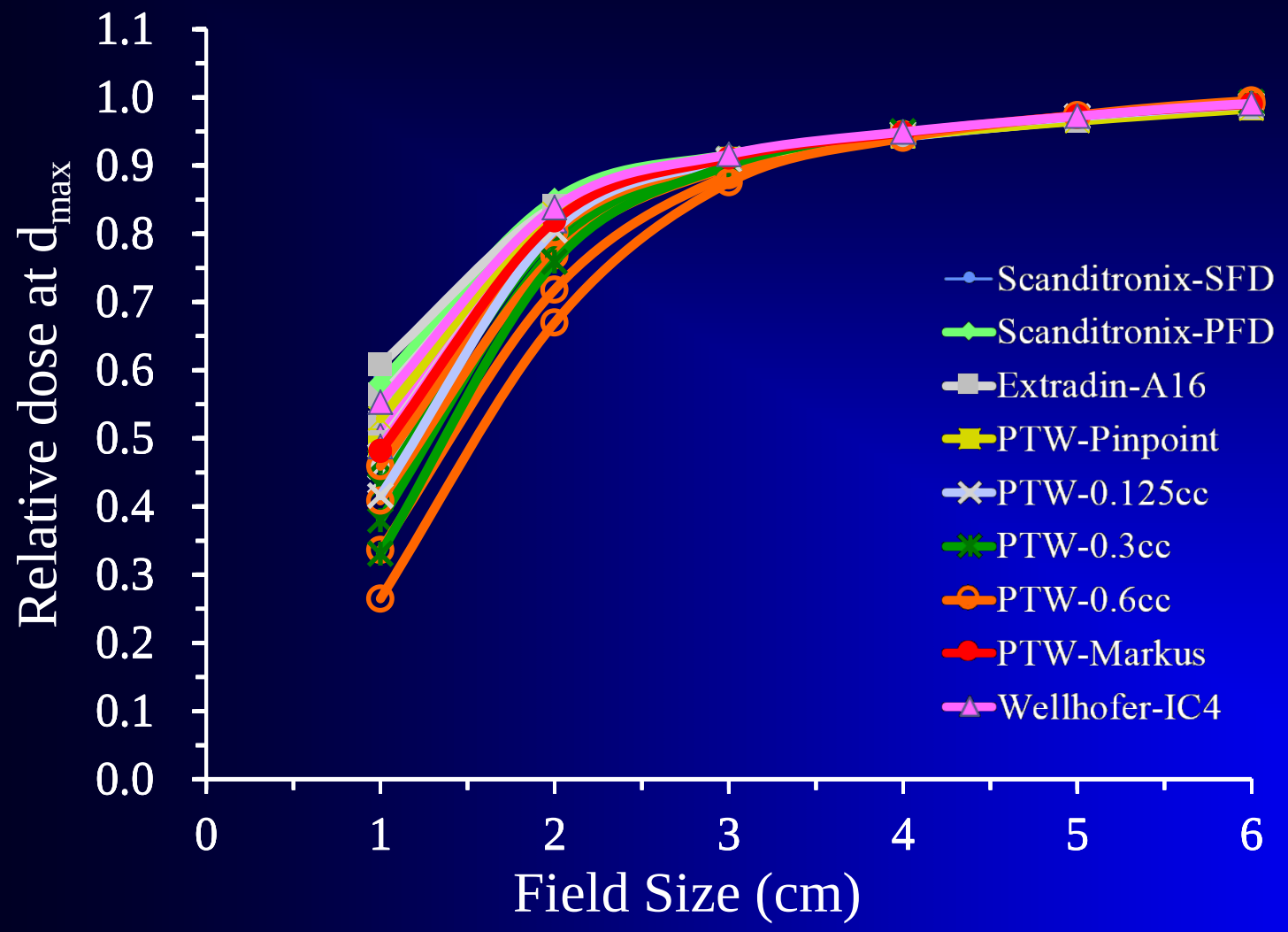
Validity of Proposed Method



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Summary

- Understand the limit of small field
- Focal spot issues
- Detectors that are water equivalent like, MicroLion, MicroDiamond and Plastic Scintillators are best suited
- Use proper correction factors to correct detector response to correct for the dose
- Watch for IAEA and TG-155 guidelines when they are published

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Thanks