RadioOnkologie

Behandeln
Forschen
Lehren

UniversitätsKlinikum Heidelberg

TPS - MC Dosisberechnung

Dosis im Medium oder Dosis in Wasser ?

Bernhard Rhein

Converting absorbed dose to medium to absorbed dose to water for Monte Carlo based photon beam dose calculations

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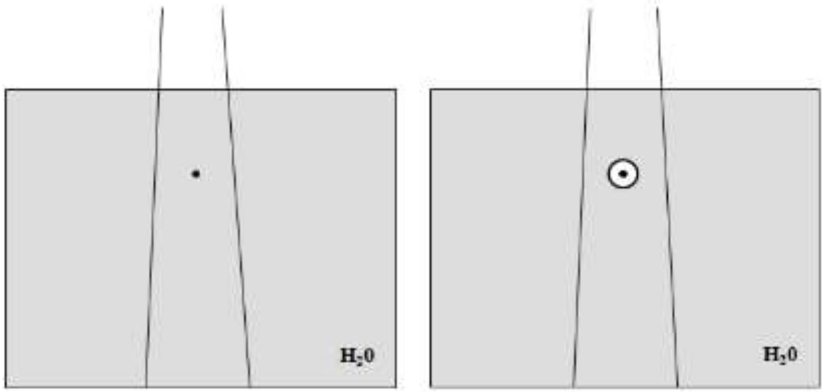
Aussagen aus der Publikation

- Die bisherige klinische Erfahrung beruht auf Dosierungskonzepten basierend auf Dosisberechnungen mit wasserskalierten Pencil Beam Algorithmen
- Zur Vergleichbarkeit mit bisherigen klinischen Erfahrungen sollte daher die Dosis im Medium in die Dosis im Wasser konvertiert werden.
- Die Umrechnung der Dosis im Medium in die Dosis in Wasser erfolgt unter der Annahme, dass einen Zelle einen idealer Bragg Gray Hohlraum darstellt
- Alle Ionisationskammer - Dosimetrieprotokolle beziehen sich auf die Messung der Wasserenergiedosis

Ionisationskammerdosimetrie

$$D_w = D_a \cdot \left(\frac{\overline{L}}{\rho}\right)_a^w \cdot \Pi(p_x)$$

$\Pi(p_x)$ – Produkt von Feldstörungskorrektionsfaktoren



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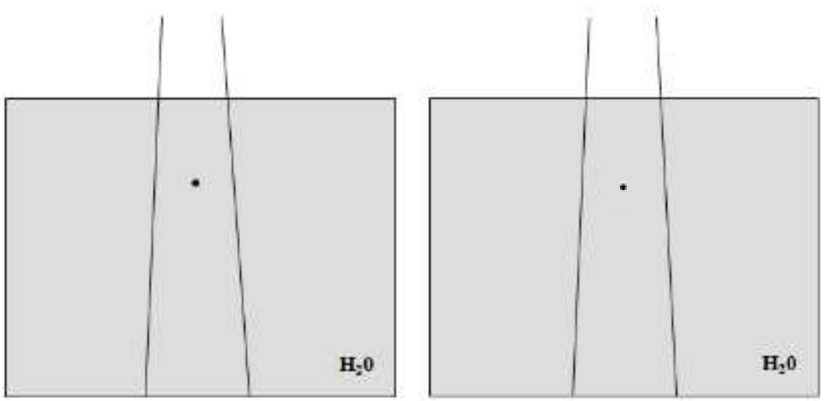

Dm→ Dw Konversion

Annahme von BG Bedingungen und δ Elektronen -Gleichgewicht

$$D_w = D_m \cdot \left(\frac{\bar{S}}{\rho} \right)_m^w$$

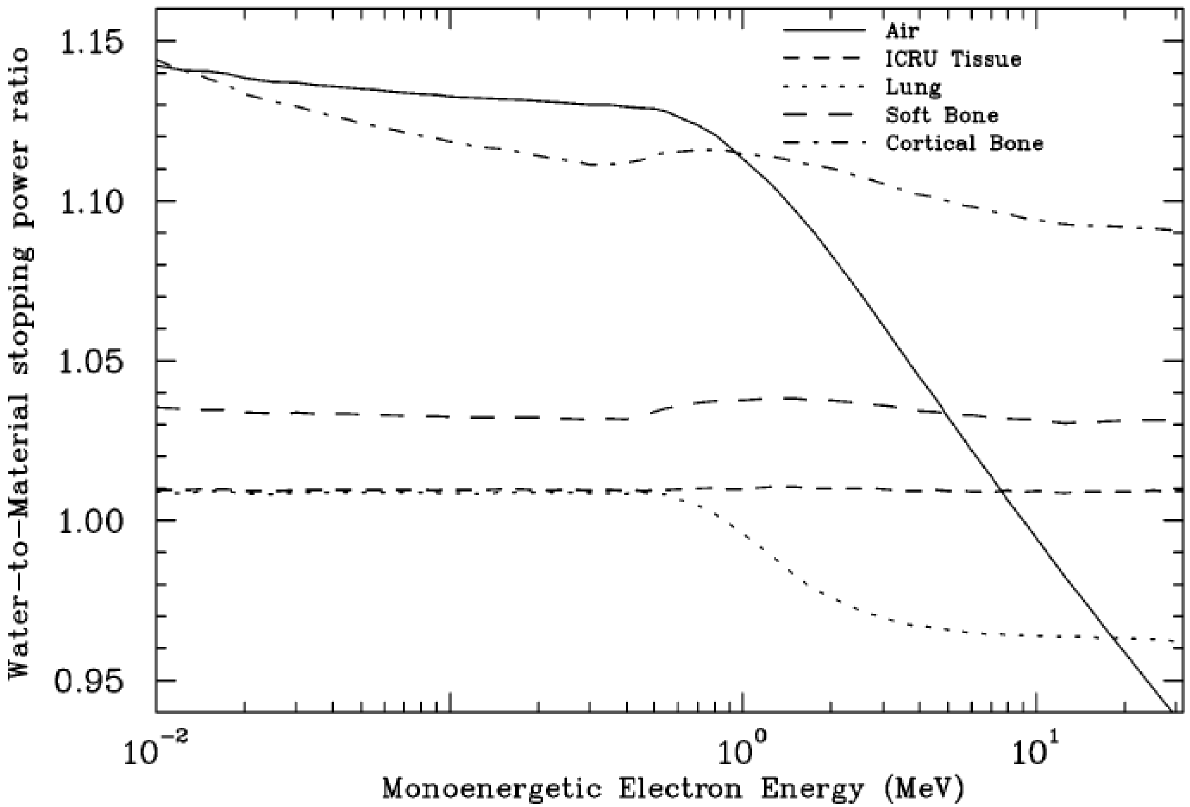

Figure 1. Water-to-medium mass collision stopping power ratios as a function of electron energy. Materials indicated are as specified in table 1.

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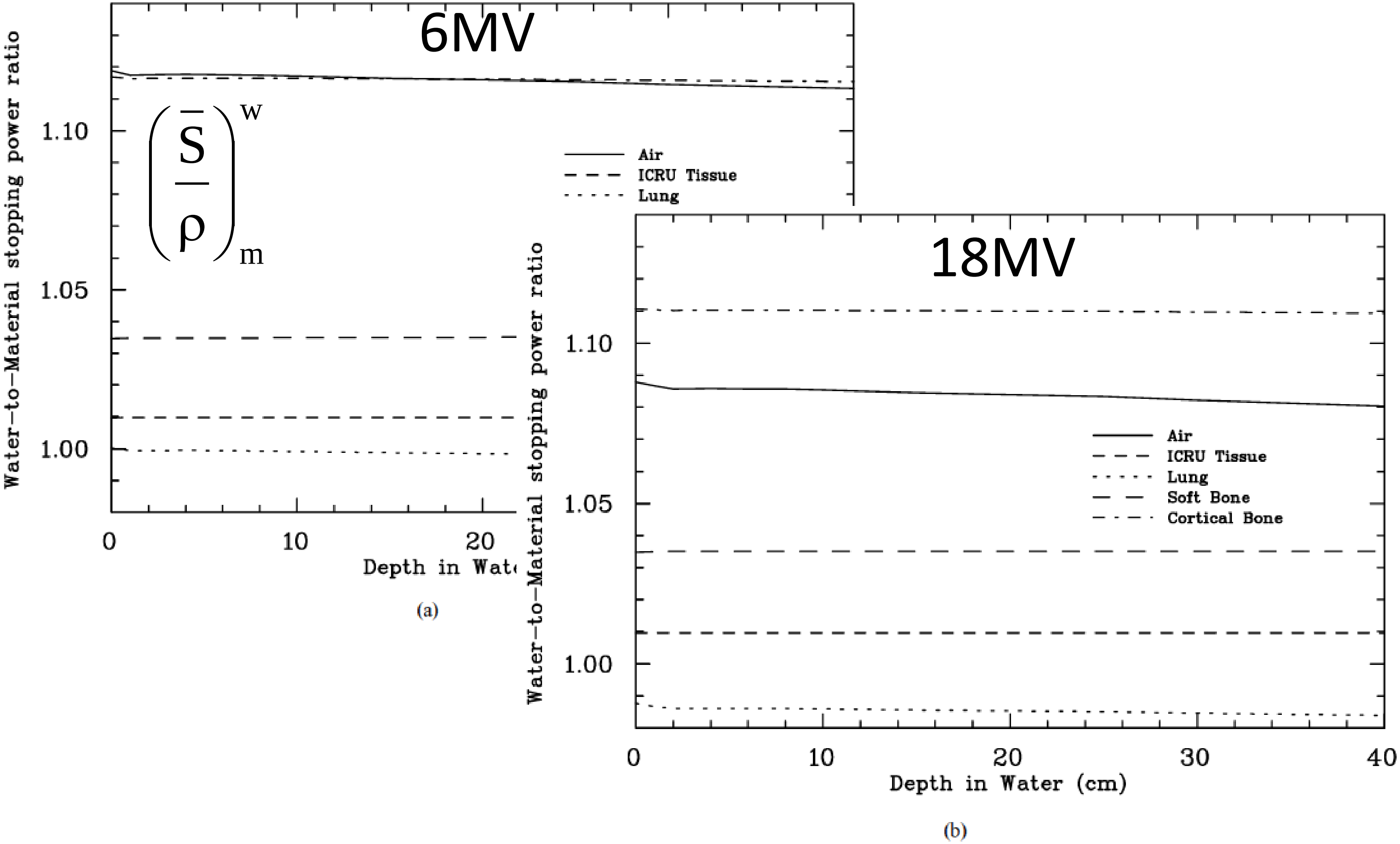

Figure 3. Water-to-medium stopping power ratios as a function of depth in the phantom for (a) 6 MV photons and (b) 18 MV photons. The phantom material for this case is water.

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Report of the AAPM Task Group No. 105: Issues associated with clinical implementation of Monte Carlo-based photon and electron external beam treatment planning

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I J Chetty et al
Med Phys. 34 (2007)

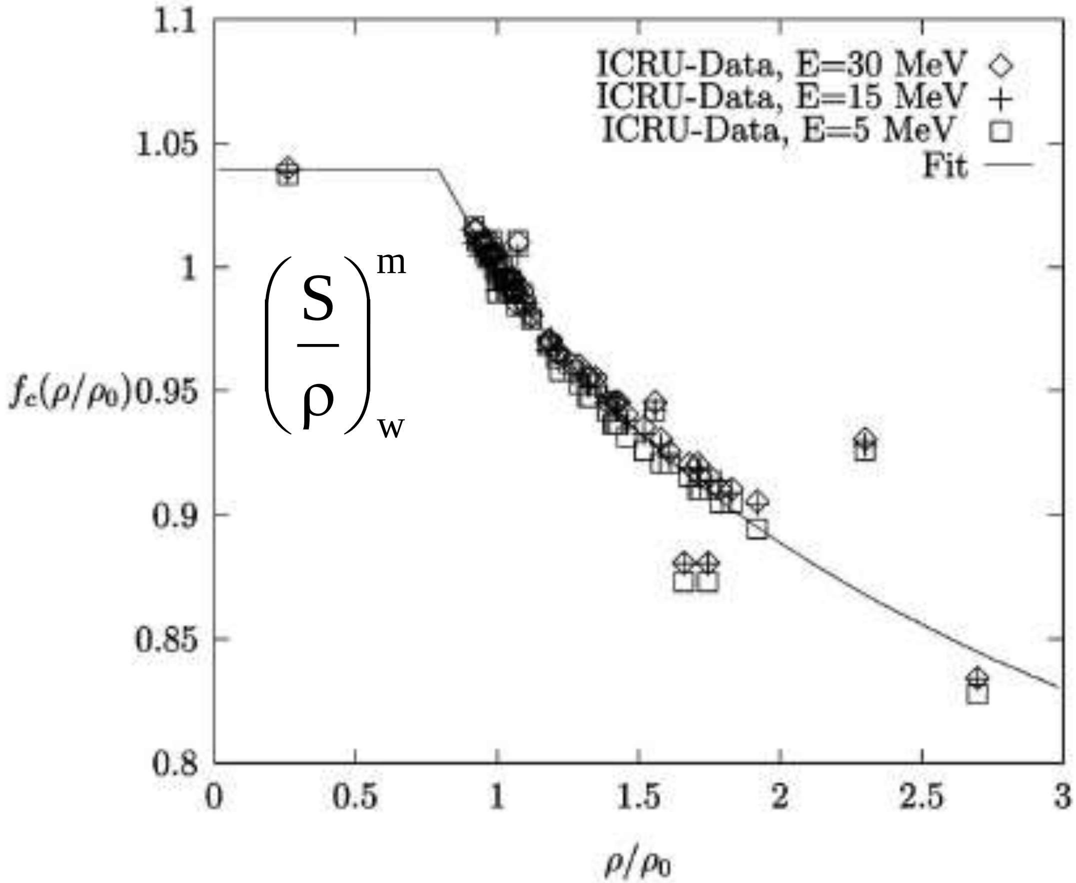

FIG. 7. Mass collision stopping power divided by the mass collision stopping power of water as a function of density normalized to water. A comparison of the fit function to the ICRU data (Ref. 177) for body tissues for electron energies of 5, 15, and 30 MeV is shown. The few points outside the curve are materials like urinary stones, which are considered to have negligible effects. Reprinted from Kawrakow *et al.* (Ref. 37) with permission.

Report of the AAPM Task Group 105: Issues associated with clinical implementation of MonteCarlo photon and electron external beam treatment planning

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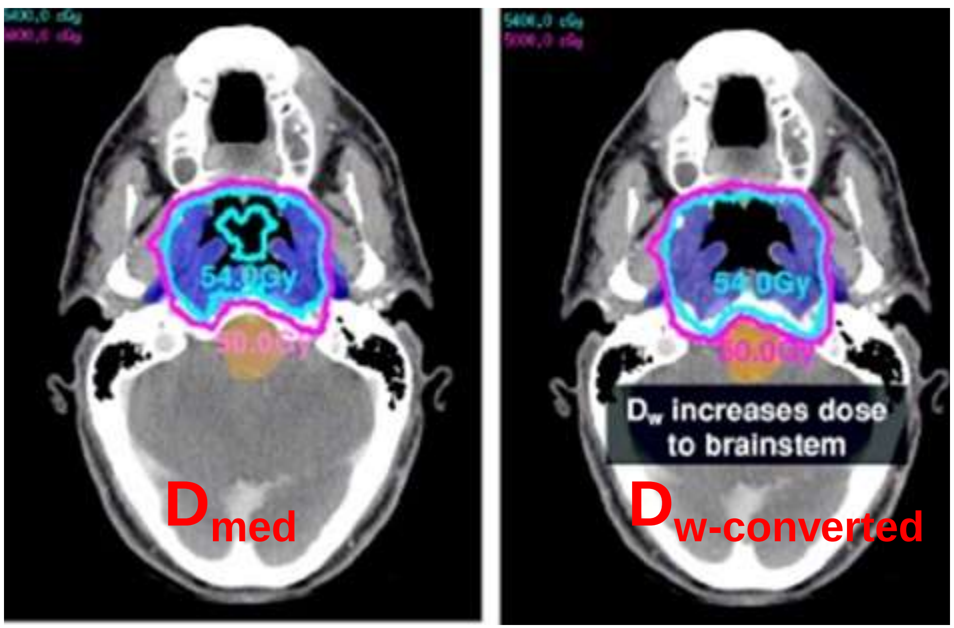
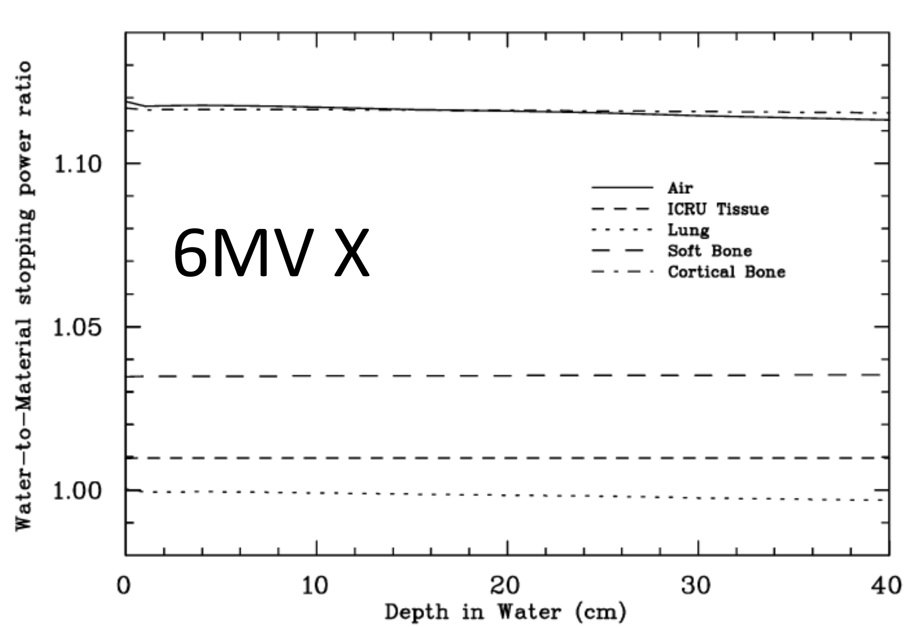
Med Phys. 34 (2007)

$$D_w = D_{med} \cdot \bar{S}_{w,med}$$



Converting absorbed dose to medium to absorbed dose to water



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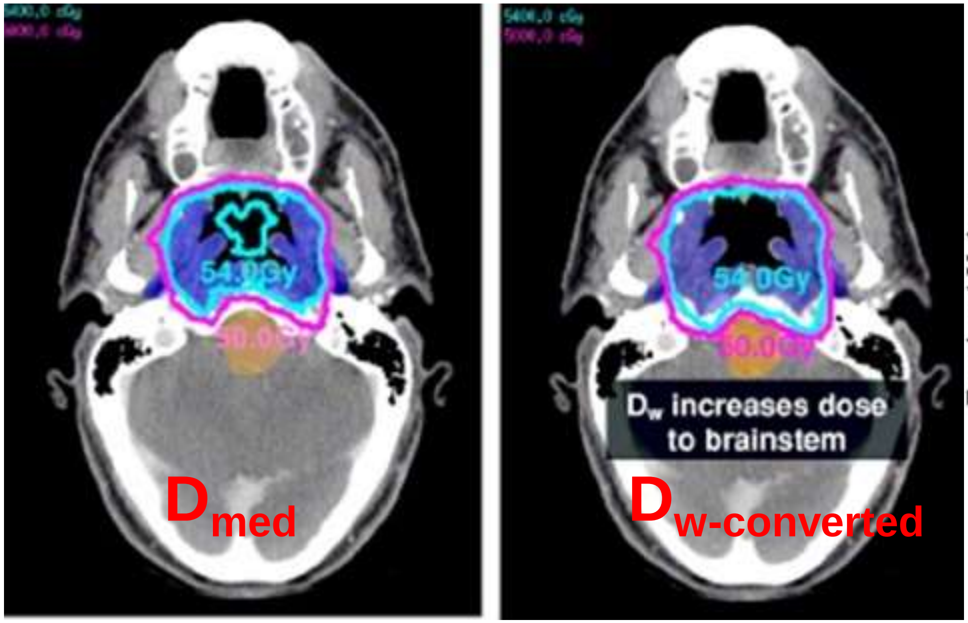

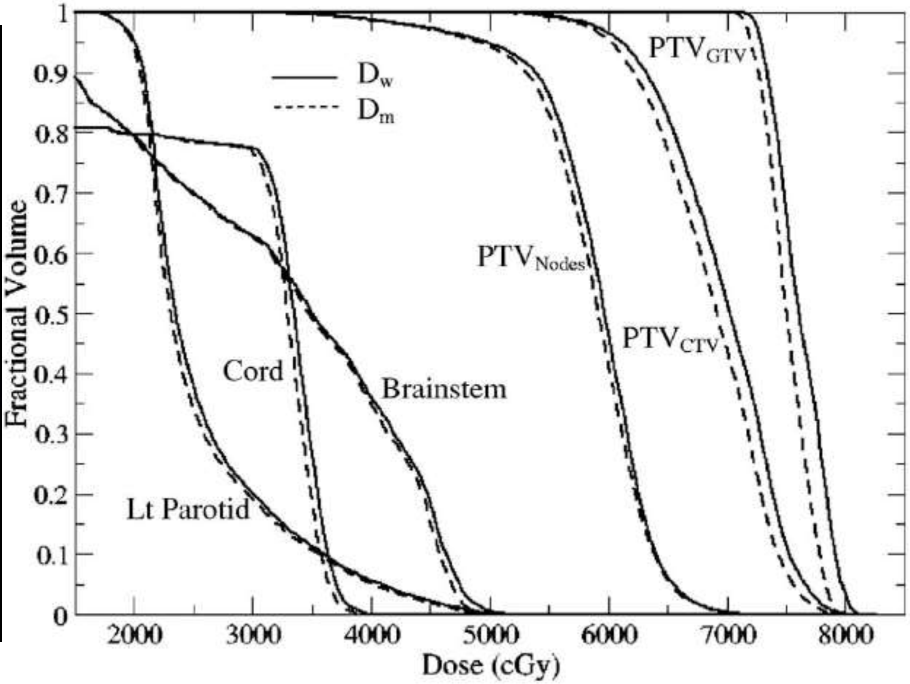

Empfehlung der Task Group 105

Until further studies indicate clinical justification for selecting D_m or D_w, it is the consensus of this task group that MC dose results should: (a) explicitly indicate the material to which the dose is computed and (b) allow conversion between D_m and D_w using one of the methods discussed above, or other methods as developed in future investigations.

Dose specification for radiation therapy: dose to water or dose to medium?

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Abstract
The Monte Carlo method enables accurate dose calculation for radiation therapy

to medium. We will demonstrate that conventional photon dose calculation algorithms compute doses similar to those simulated by Monte Carlo using water with different electron densities, which are close (<4% differences) to doses to media but significantly different (up to 11%) from doses to water converted from doses to media following American Association of Physicists in Medicine (AAPM) Task Group 105 recommendations. Our results suggest that for consistency with previous radiation therapy experience Monte Carlo photon algorithms report dose to medium for radiotherapy dose prescription, treatment plan evaluation and treatment outcome analysis.

(Some figures in this article are in colour only in the electronic version)

2011 Phys. Med. Biol. 56 3073

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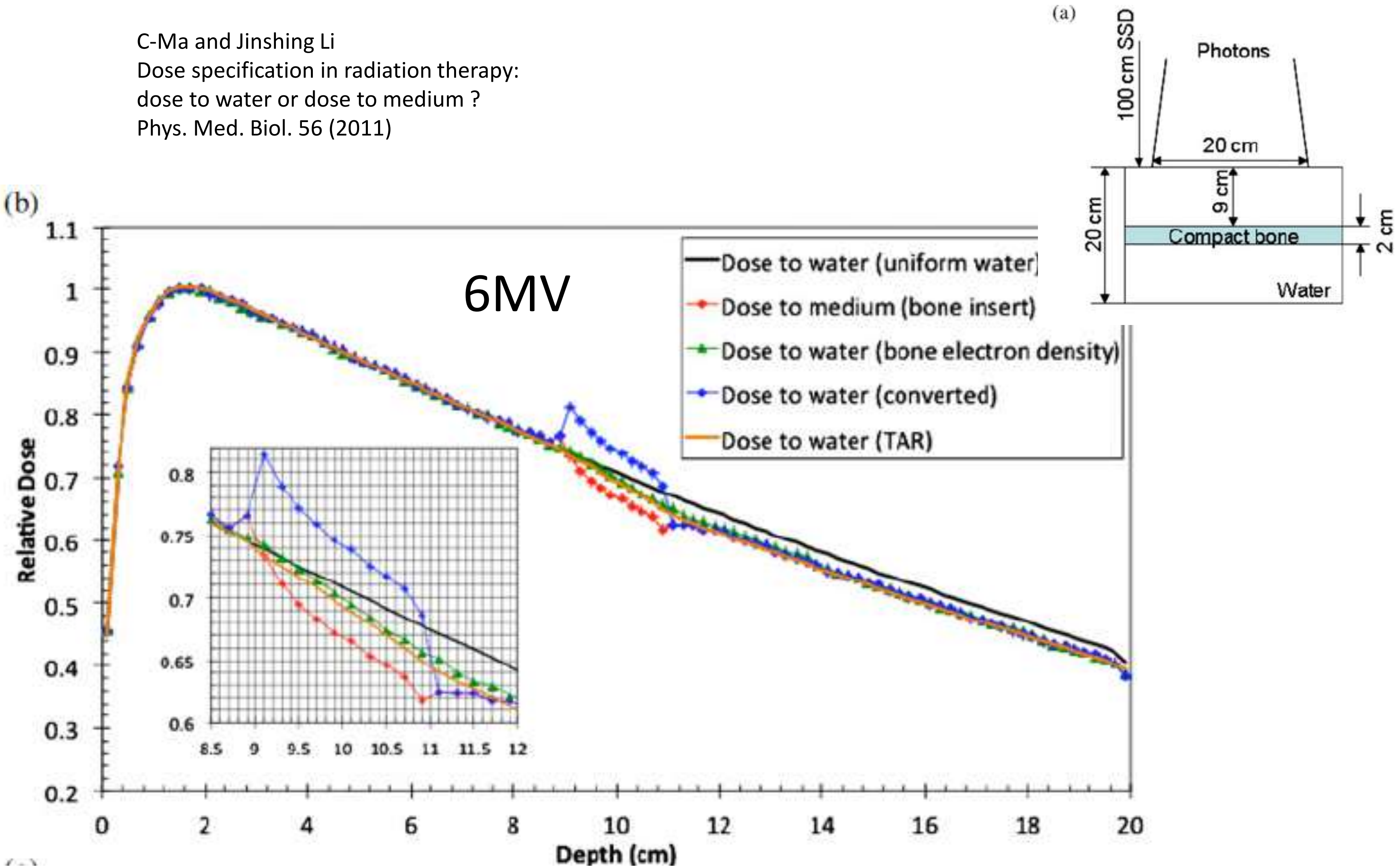
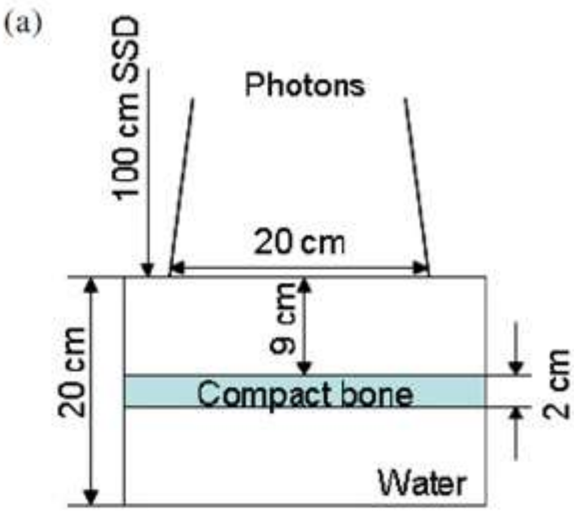
Phys. Med. Biol. 56 (2011)

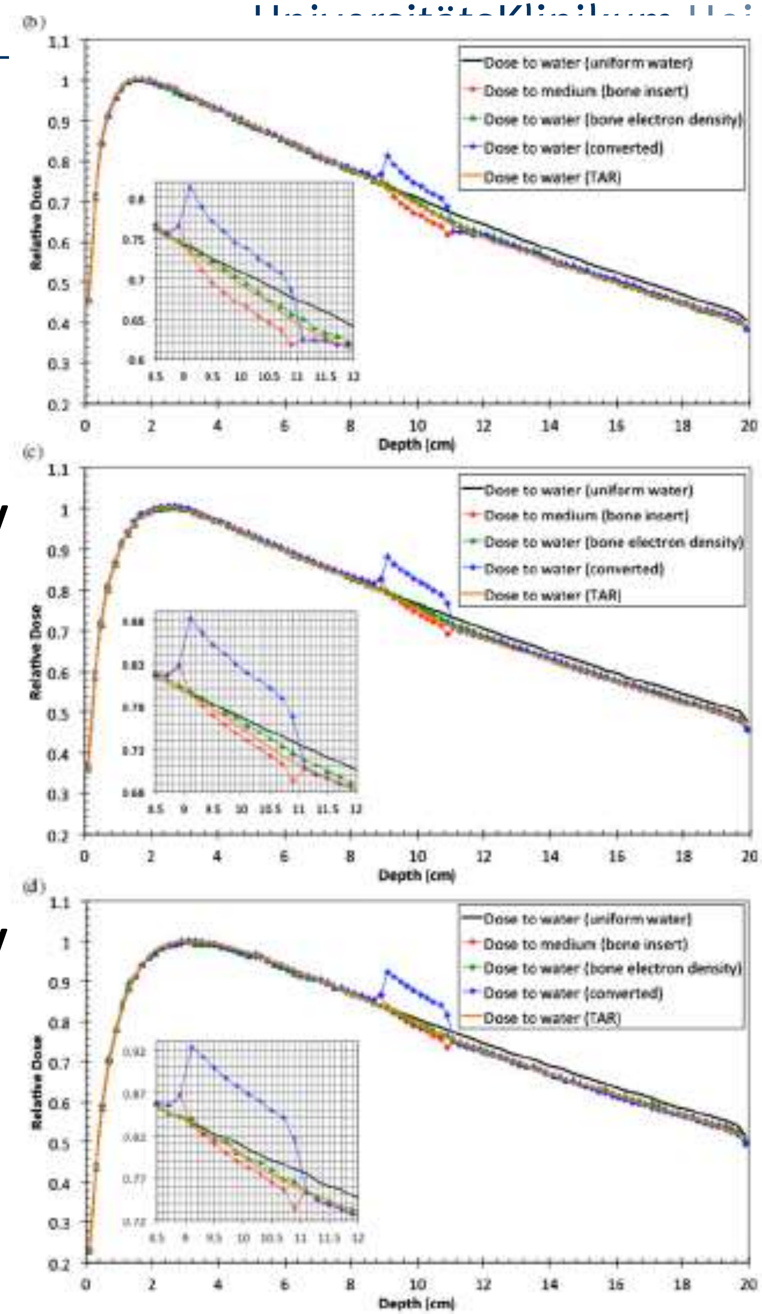




6MV

10MV

18MV



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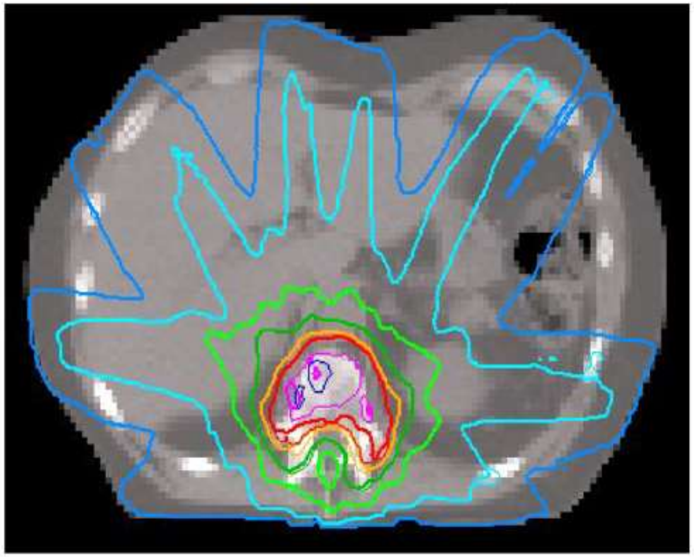
Phys. Med. Biol. 56 (2011)

(a)



(b)

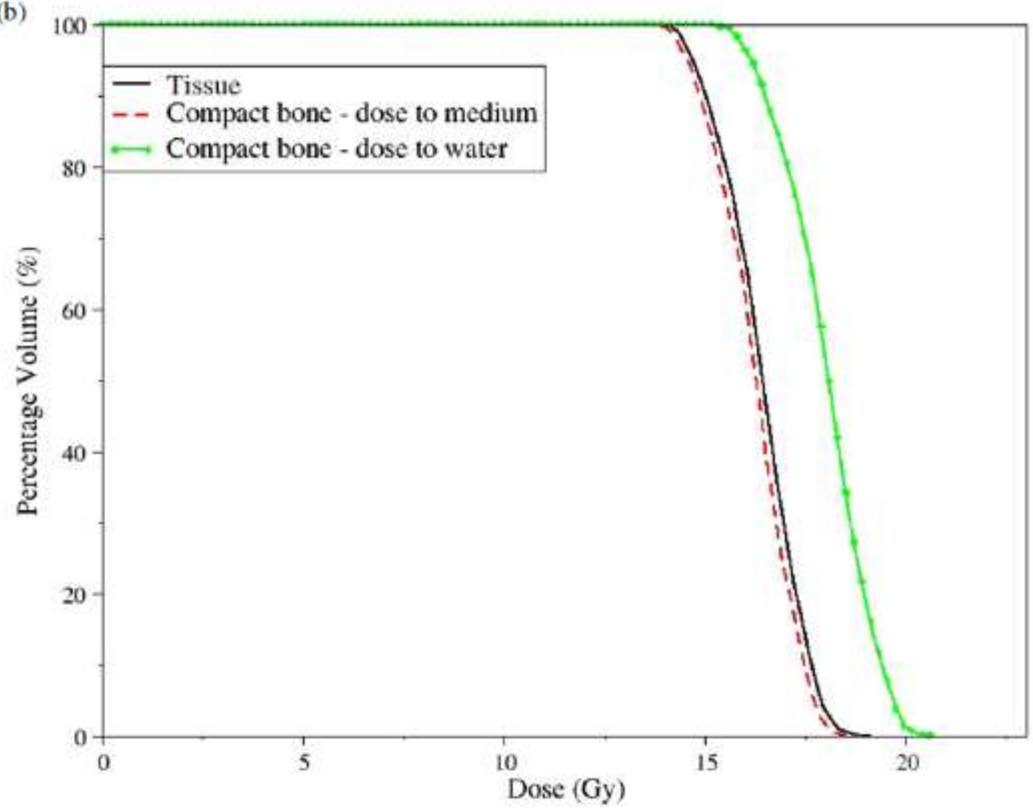


Figure 4. (a) Isodose distributions for the simulation geometry with compact bone filled the entire target volume and soft tissue filled the rest of the external contours (thick lines: D_m, thin lines: D_w converted using stopping-power ratios for water to compact bone). The isodoses lines shown are 10%, 30%, 50%, 70%, 90%, 100%, 120% and 130%, respectively. (b) Target DVHs (black solid line: the entire target volume filled with soft tissue, D_{tissue}; red dashed line: the entire target volume filled with compact bone, D_{bone}; green line with dots: D_w converted from D_{bone}).

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Phys. Med. Biol. 56 (2011)

DIN 6800-2

$$D = (M - M_0) \cdot N \cdot k_\rho \cdot k_s \cdot k_p \cdot k_r \cdot k_Q \cdot \mathbf{k_{NR}}$$

$$k_{NR} = \frac{(k_Q)_{NonRef}}{(k_Q)_{Ref}} = \frac{\left(S^{\Delta}_{w,a}\right)_{Q,NonRef}}{\left(S^{\Delta}_{w,a}\right)_{Q,Ref}} \cdot \frac{(p_{wall} \cdot p_{cav} \cdot p_{cel} \cdot p_{dis} \cdot p_{\Delta})_{Q,NonRef}}{(p_{wall} \cdot p_{cav} \cdot p_{cel} \cdot p_{dis} \cdot p_{\Delta})_{Q,Ref}}$$

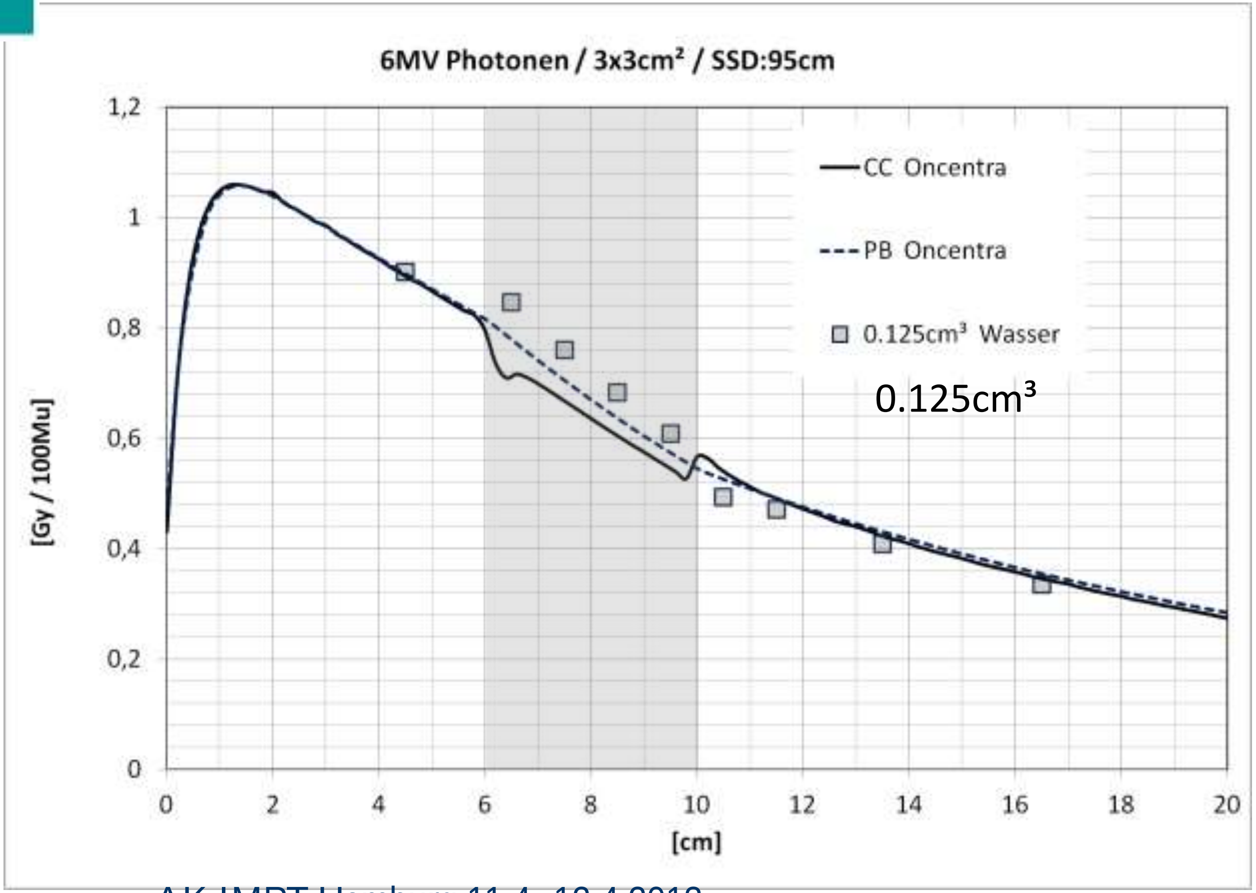
AAPM Report No. 85:

TISSUE INHOMOGENEITY CORRECTIONS FOR MEGAVOLTAGE PHOTON BEAMS

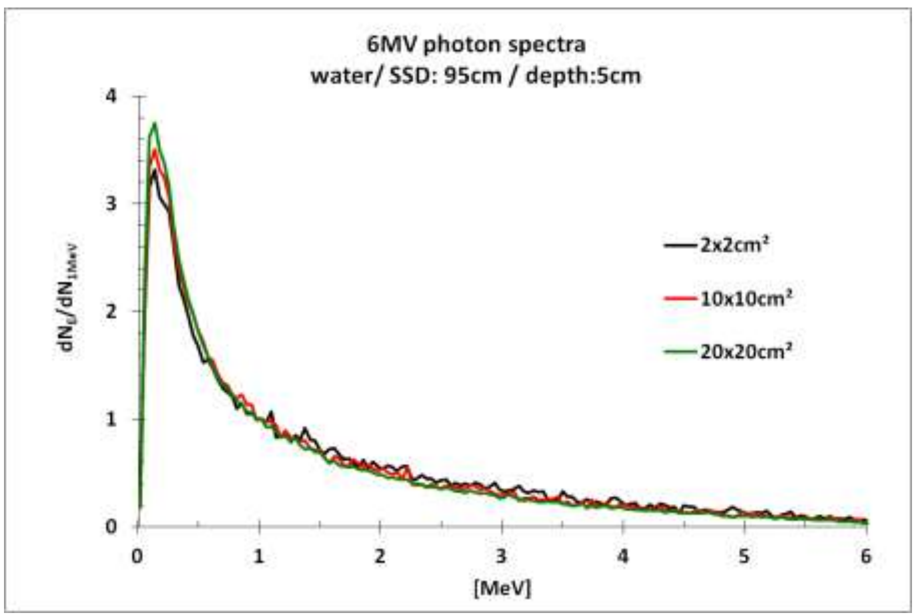
Zur Überführung des Messwertes (D_W) in die Dosis im Medium muss ein Inhomogenitäts-Korrektur-Faktor (ICF) angewendet werden1

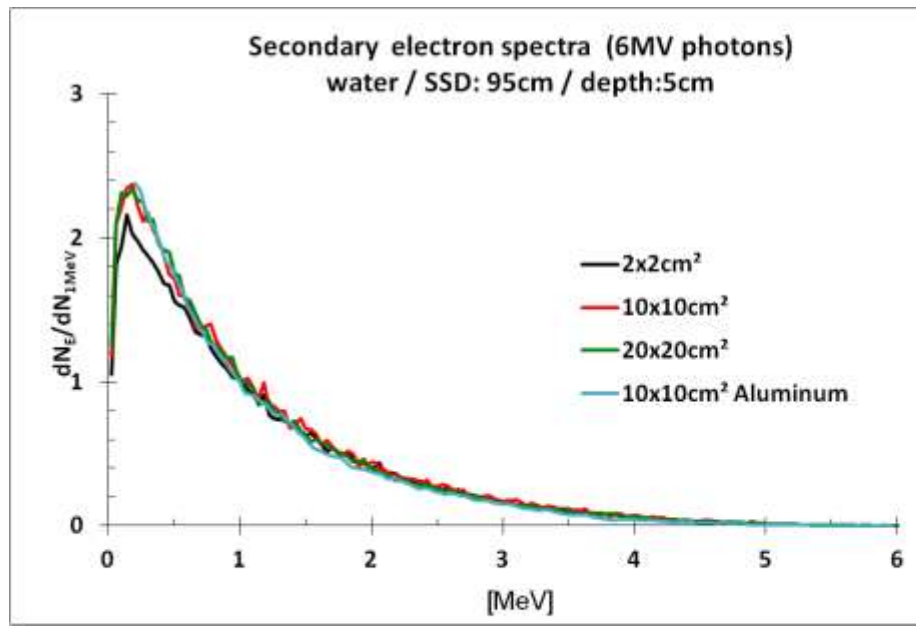
$$ICF = k_{water \rightarrow medium} = \frac{\left(\bar{L}_{medium,air}\right)_Q}{\left(\bar{L}_{water,air}\right)_Q} \cdot \frac{\left(p_{wall(medium)} \cdot p_{cav(medium)}\right)_Q}{\left(p_{wall(water)} \cdot p_{(cav,water)}\right)_Q}$$

- Mit einer in Wasser kalibrierten Ionisationskammer wird in einem beliebigen Medium (Aluminium), ein Wert gemessen, der näherungsweise als Wasserenergiedosis betrachtet werden kann.



$$k_{NR} = k_{water \to Al} = \frac{\left(\overline{S^{\Delta}_{Al,air}}\right)_Q}{\left(\overline{S^{\Delta}_{water,air}}\right)_Q} \cdot \frac{\left(\dfrac{\alpha \cdot \overline{S^{\Delta}_{PMMA,air}} \cdot \left(\overline{\mu}_{en}/\rho\right)_{Al,PMMA} + (1-\alpha)\cdot \overline{S^{\Delta}_{Al,air}}}{\overline{S^{\Delta}_{Al,air}}}\right)_Q}{\left(\dfrac{\alpha \cdot \overline{S^{\Delta}_{PMMA,air}} \cdot \left(\overline{\mu}_{en}/\rho\right)_{water,PMMA} + (1-\alpha)\cdot \overline{S^{\Delta}_{water,air}}}{\overline{S^{\Delta}_{water,air}}}\right)_Q} \cdot 1$$





Lempert GD, Nath R, Schulz RJ
Fraction of ionization from electrons arising in the wall of an ionisation chamber
Med. Phys. 10(1) 1983

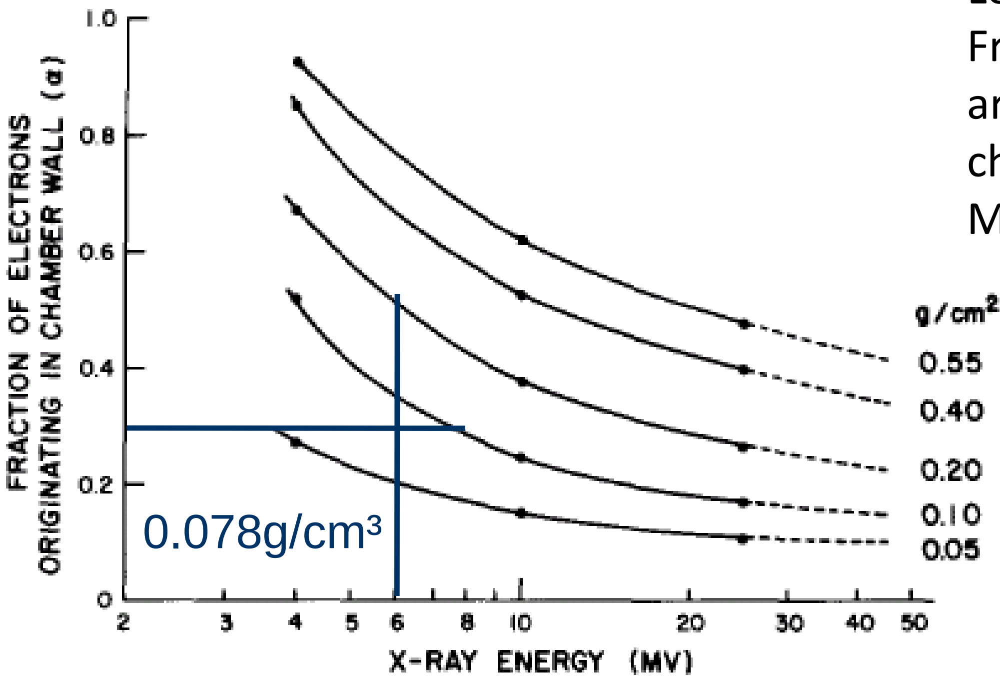
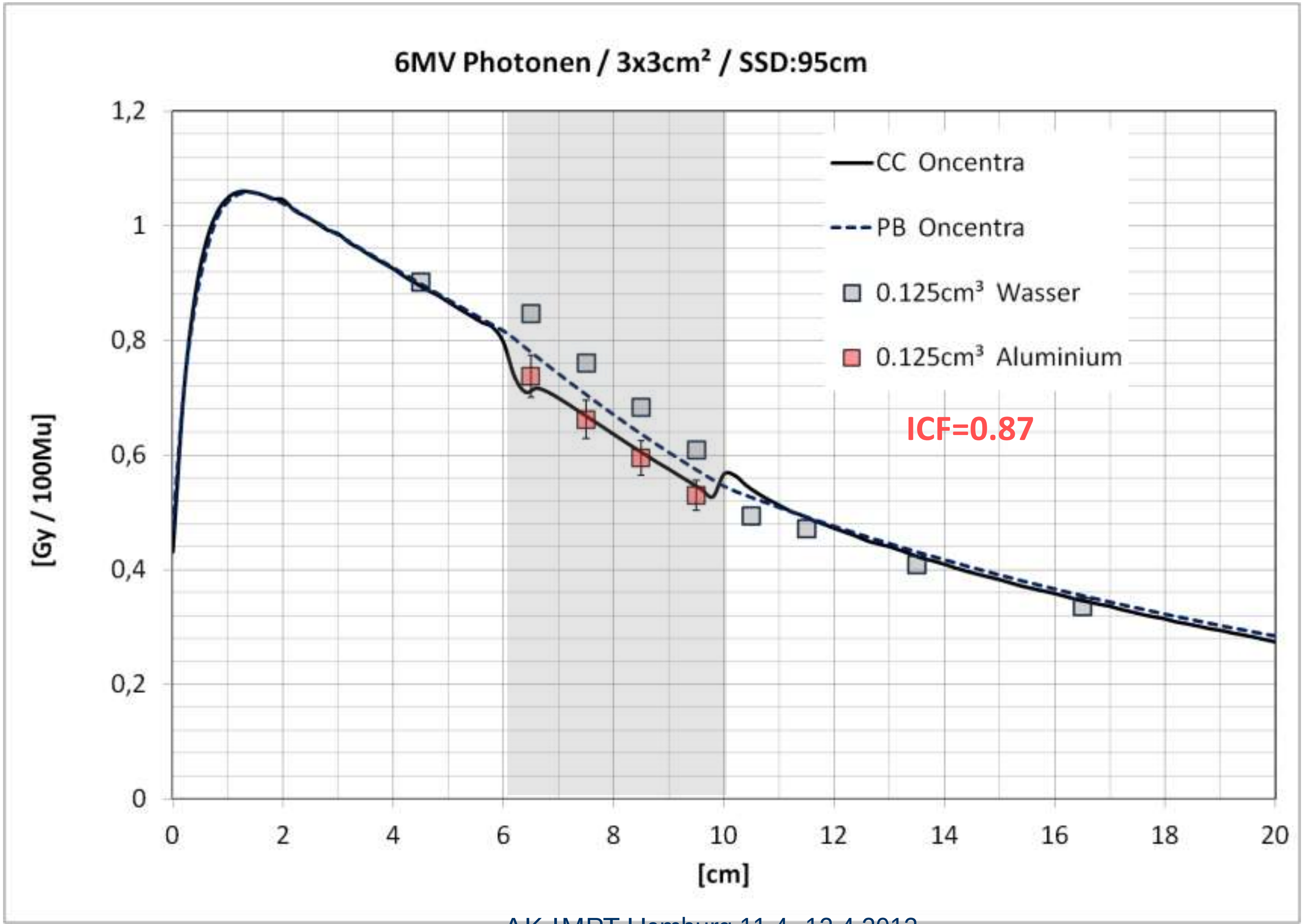
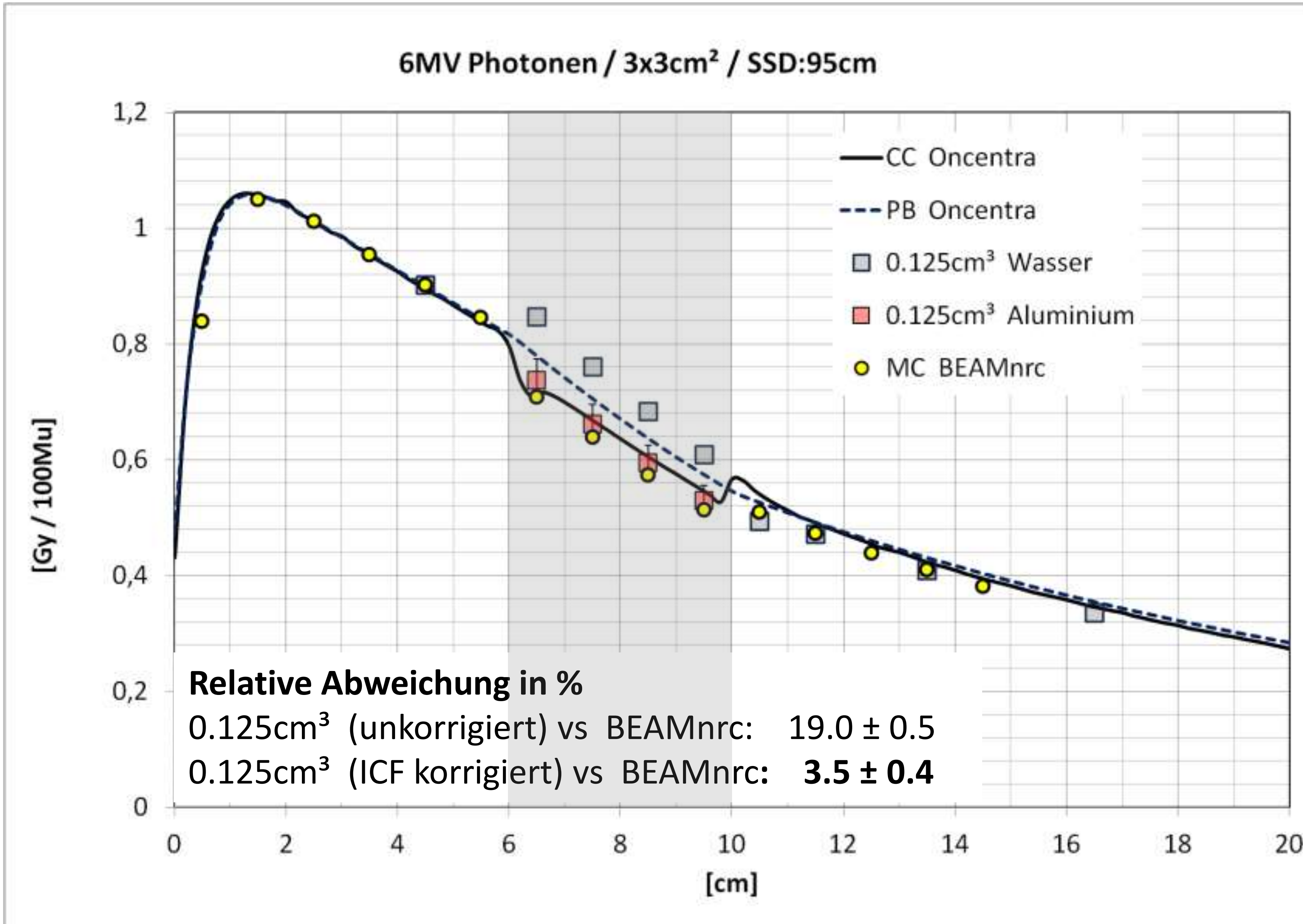
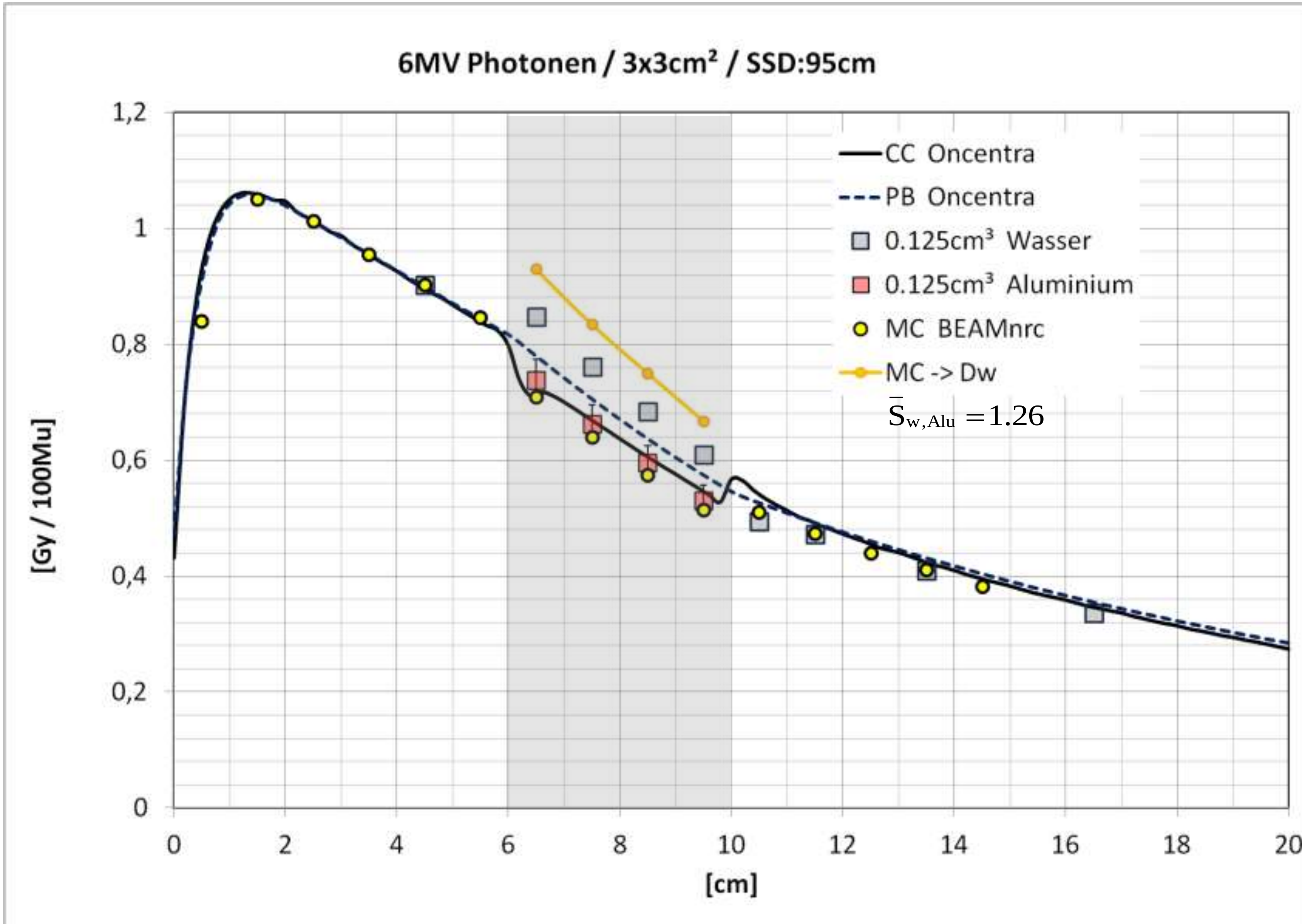


FIG. 4. Values of α as a function of chamber-wall thickness and photon energy. Between 25 and 45 MV, the curves were obtained by extrapolation.

α	0,3	ICF Aluminum 0.125cm^3
$L_{alu,air}$	0,878	**0,87**
$L_{water,air}$	1,11	
$L_{PMMA,air}$	1,076	
$(\mu_{en}/\rho)_{alu,PMMA}$	1,096	
$(\mu_{en}/\rho)_{water}$	1,048	


6MV Photonen / 3x3cm² / SSD:95cm
[Gy / 100Mu]
[cm]
CC Oncentra
PB Oncentra
0.125cm³ Wasser
0.125cm³ Aluminium
ICF=0.87
1,2
1
0,8
0,6
0,4
0,2
0
0
2
4
6
8
10
12
14
16
18
20


6MV Photonen / 3x3cm² / SSD:95cm
1,2
1
0,8
0,6
0,4
0,2
0
[Gy / 100Mu]
0
2
4
6
8
10
12
14
16
18
20
[cm]
CC Oncentra
PB Oncentra
0.125cm³ Wasser
0.125cm³ Aluminium
MC BEAMnrc
Relative Abweichung in %
0.125cm³ (unkorrigiert) vs BEAMnrc: 19.0 ± 0.5
0.125cm³ (ICF korrigiert) vs BEAMnrc: 3.5 ± 0.4


6MV Photonen / 3x3cm² / SSD:95cm
1,2
1
0,8
0,6
0,4
0,2
0
0
2
4
6
8
10
12
14
16
18
20
[cm]
[Gy / 100Mu]
CC Oncentra
PB Oncentra
0.125cm³ Wasser
0.125cm³ Aluminium
MC BEAMnrc
MC -> Dw
$\bar{S}_{w,Alu} = 1.26$

Zusammenfassung

- Die mit wasserskalierten Pencil Beam Algorithmen berechnete Dosis liegt näher an der mit MC berechneten Dosis im Medium als an der konvertierten Dosis in Wasser