Abteilung für Medizinische Strahlenphysik
Inselspital, Universität Bern, Schweiz
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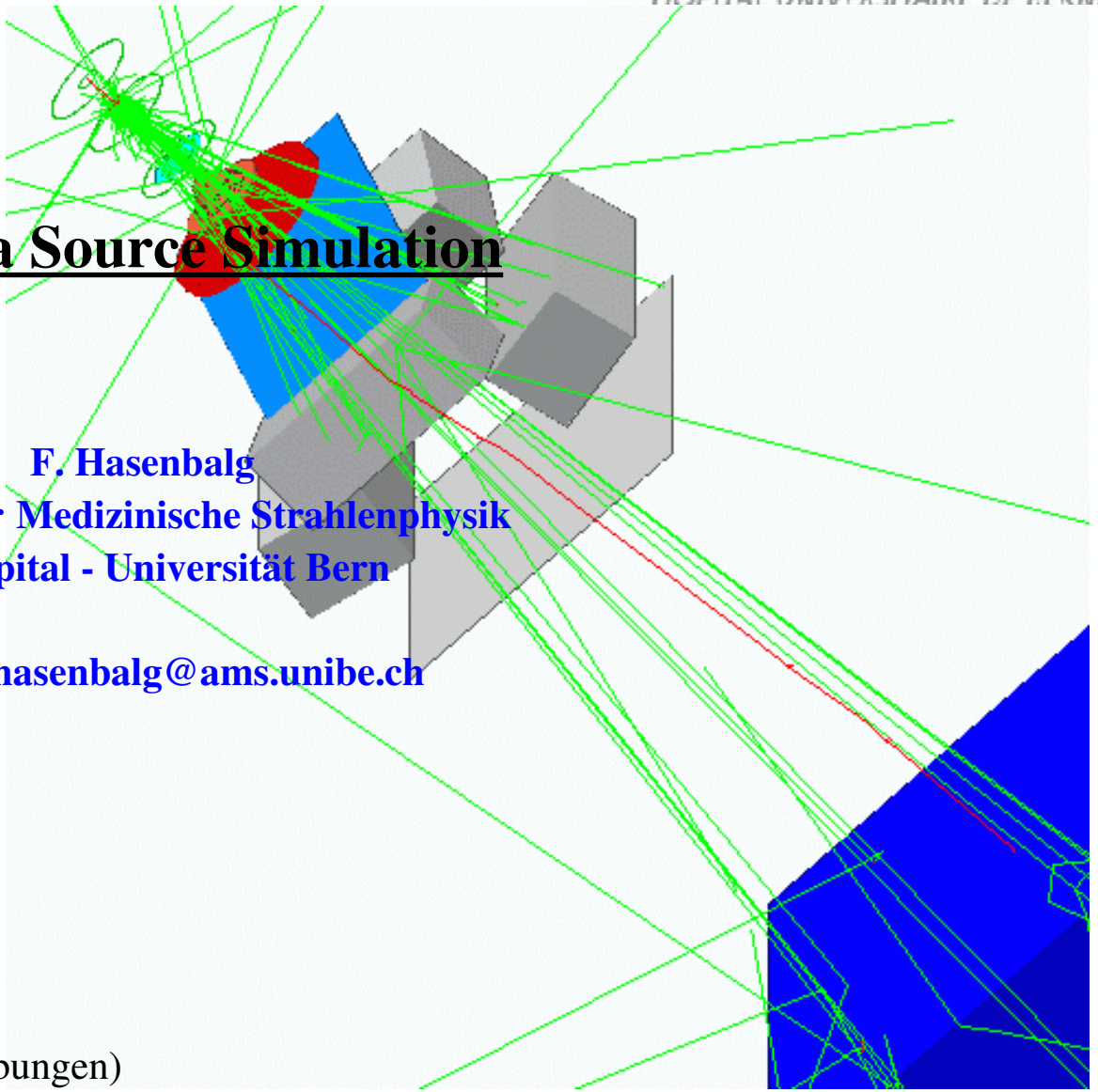
# Gamma Source Simulation



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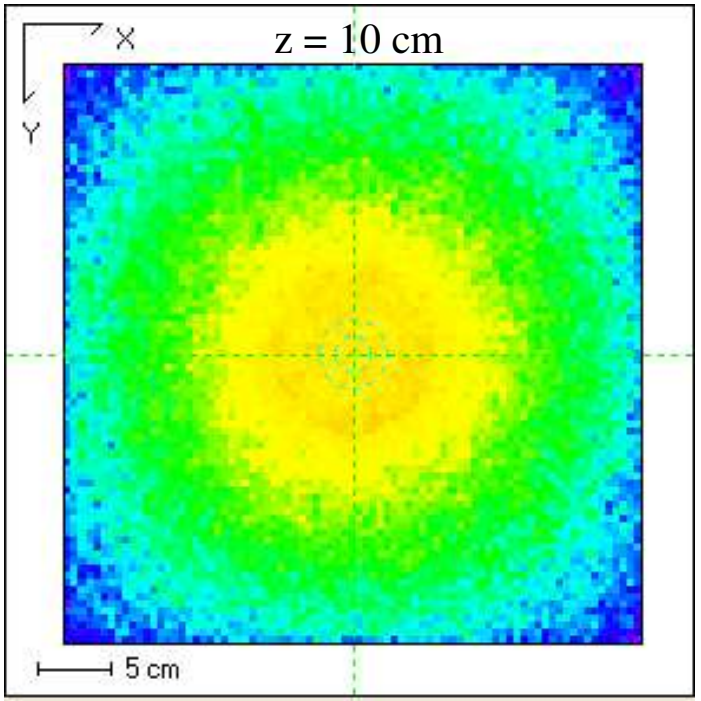
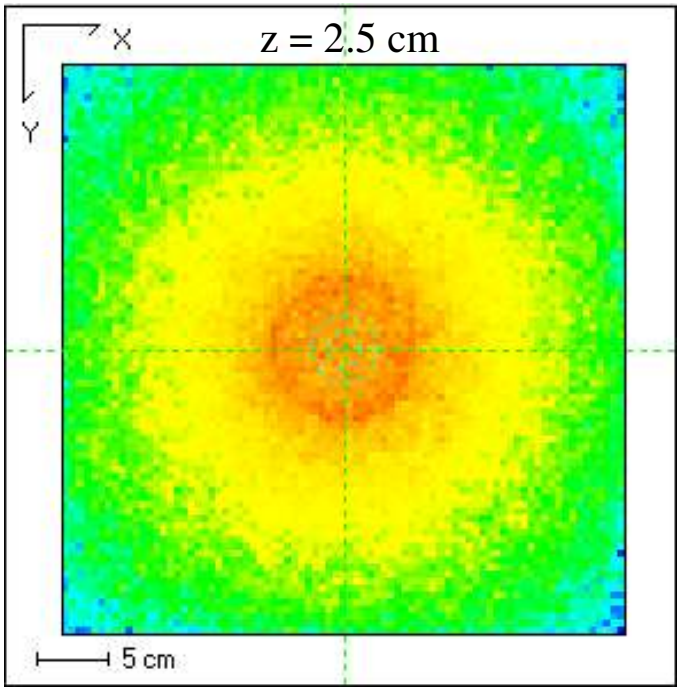
**Inselspital - Universität Bern**

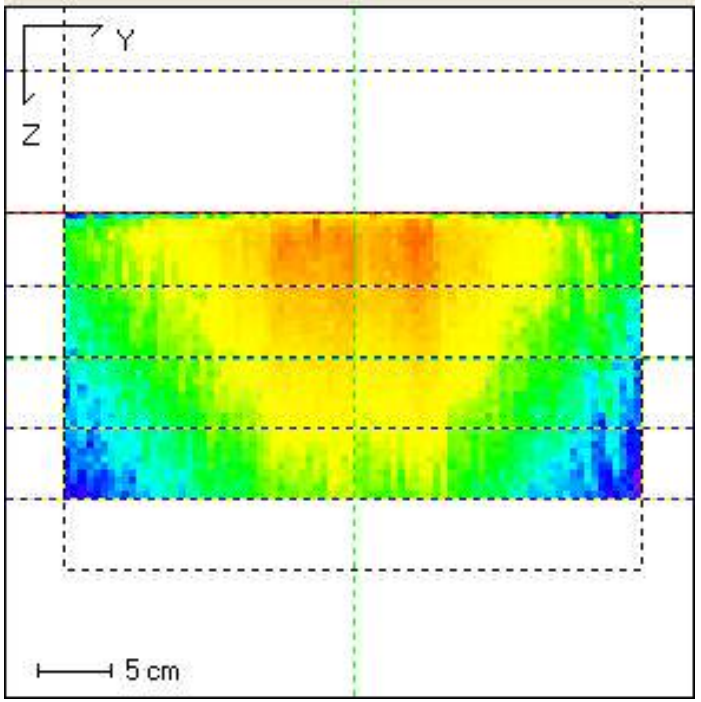
**e-mail: hasenbalg@ams.unibe.ch**

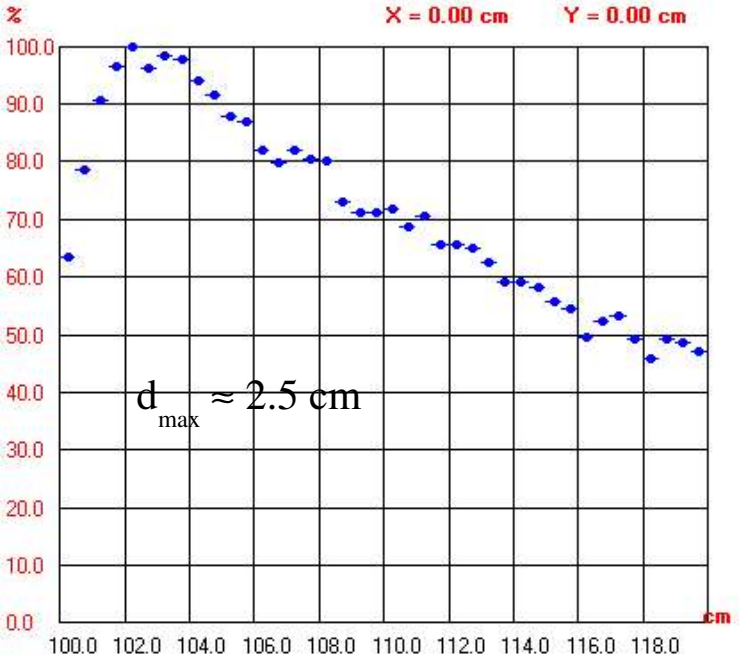
# Simplified linac photon beam with W target



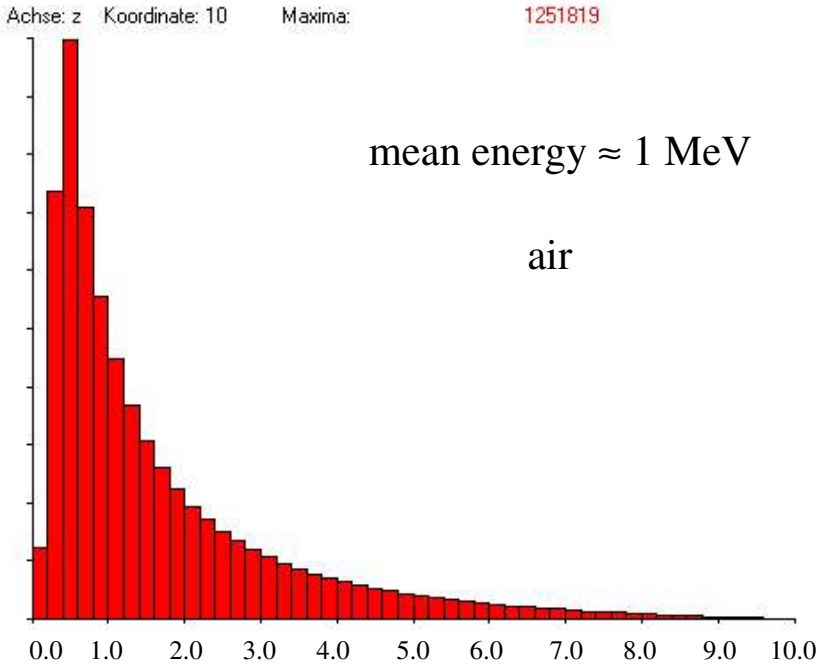




angular distributions
of bremsstrahlung photons
projected onto the
water phantom



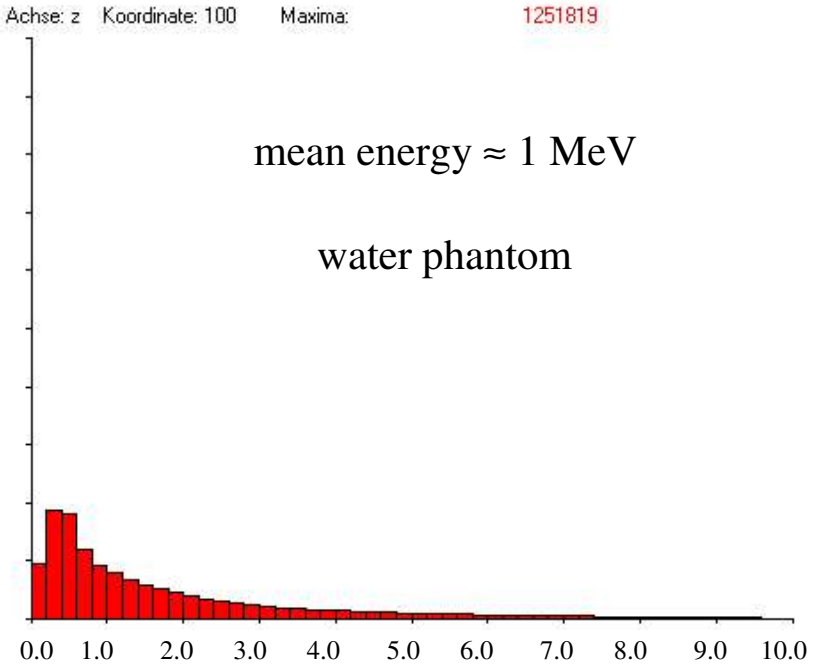



# Photon spectra



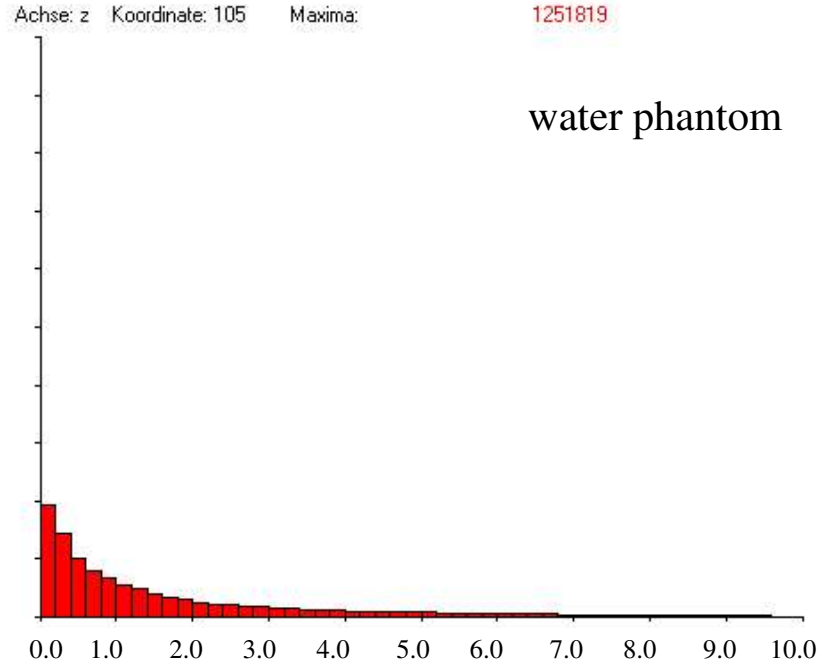

mean energy ≈ 1 MeV

air

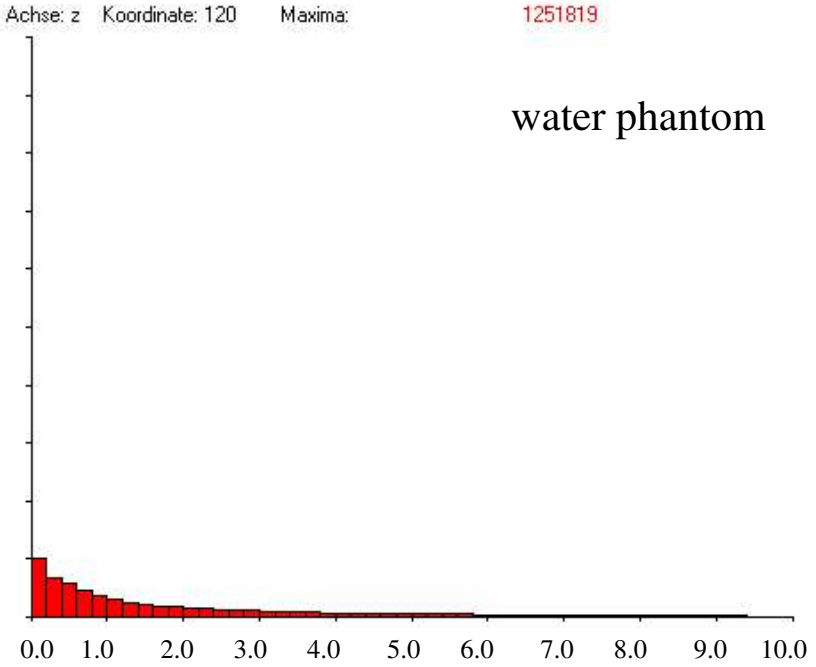



mean energy ≈ 1 MeV

water phantom

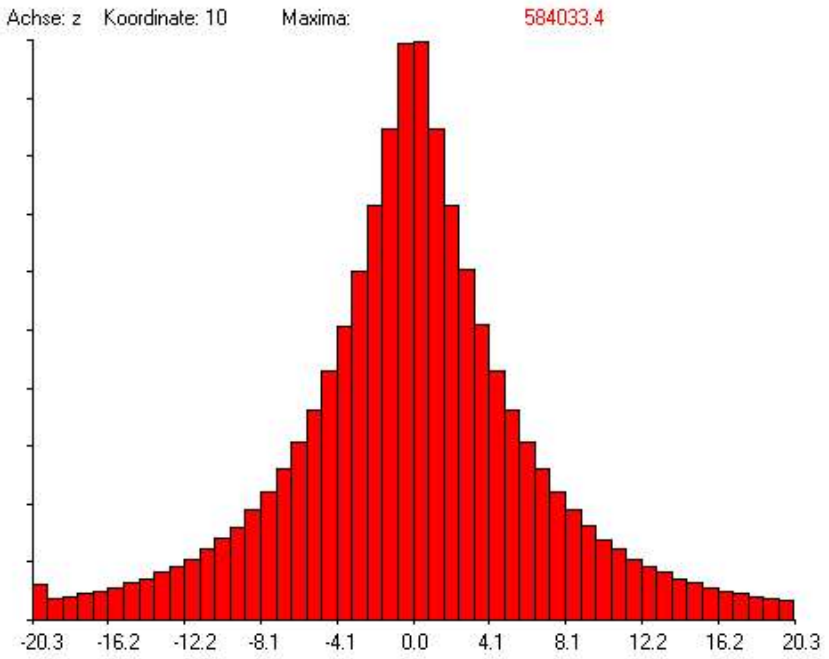


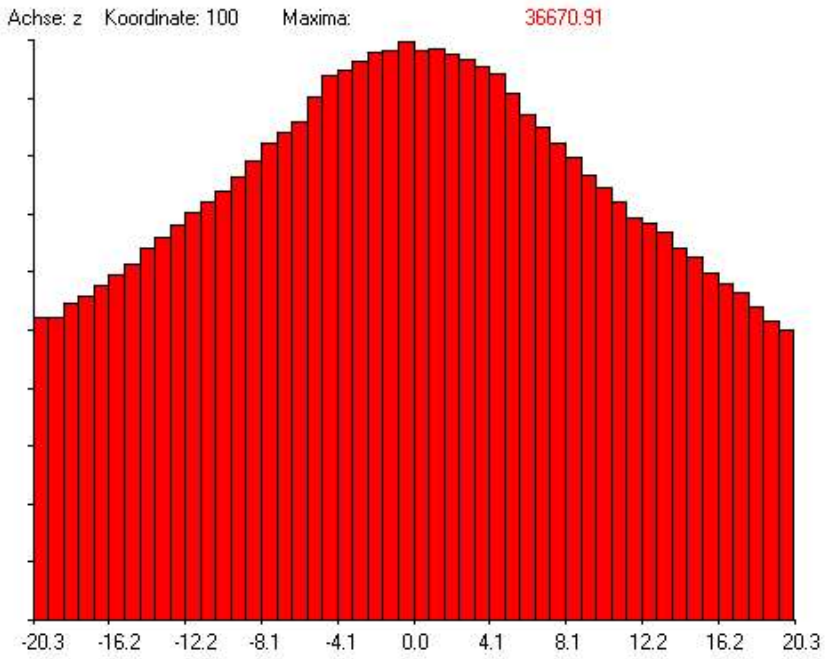

water phantom

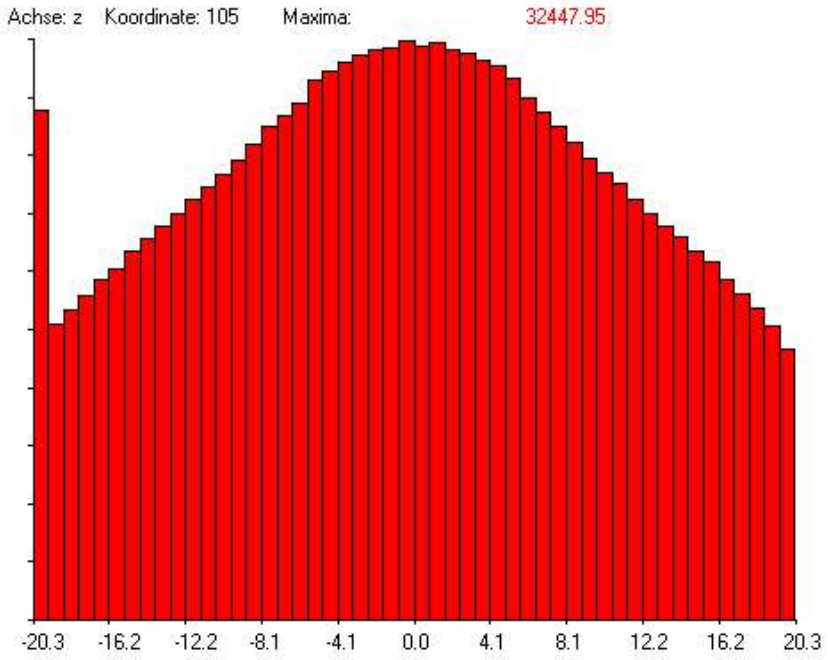


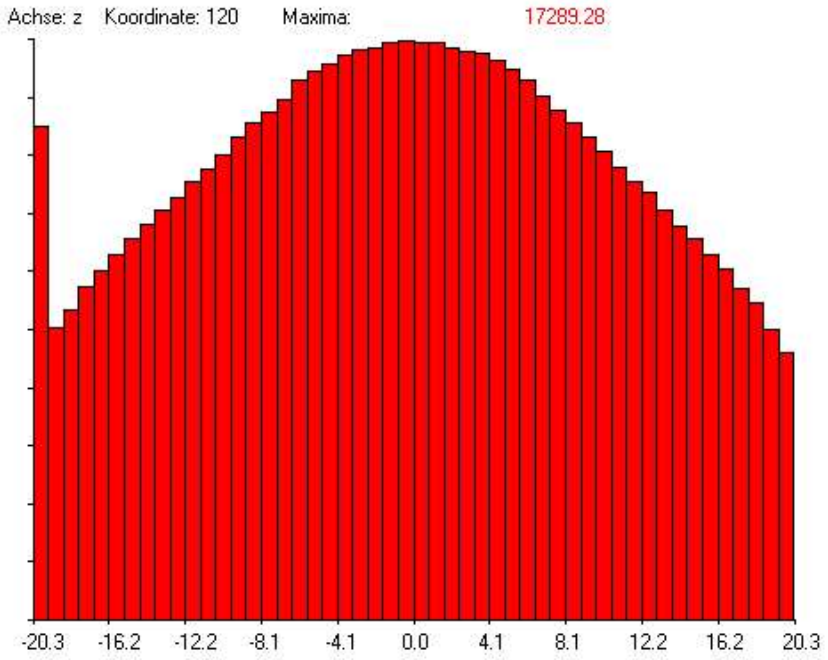

water phantom

# Photon profiles

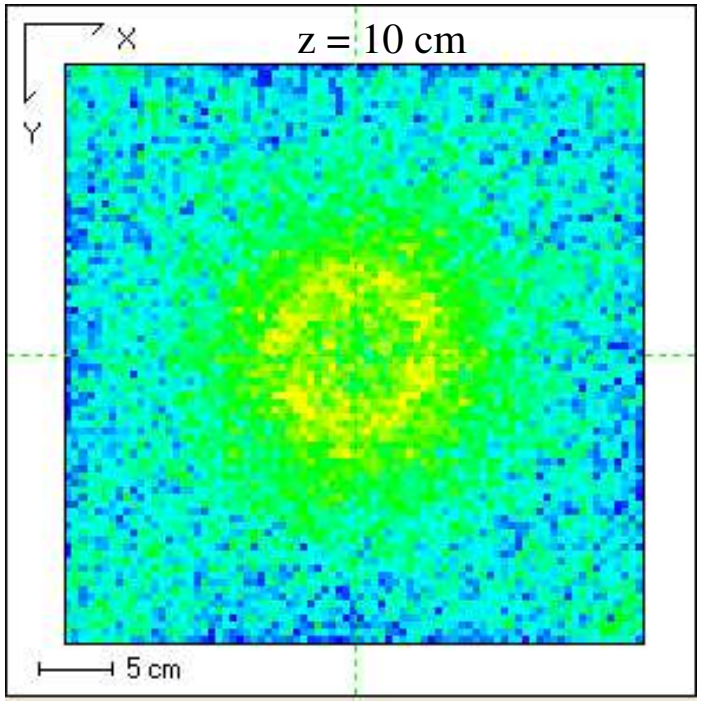


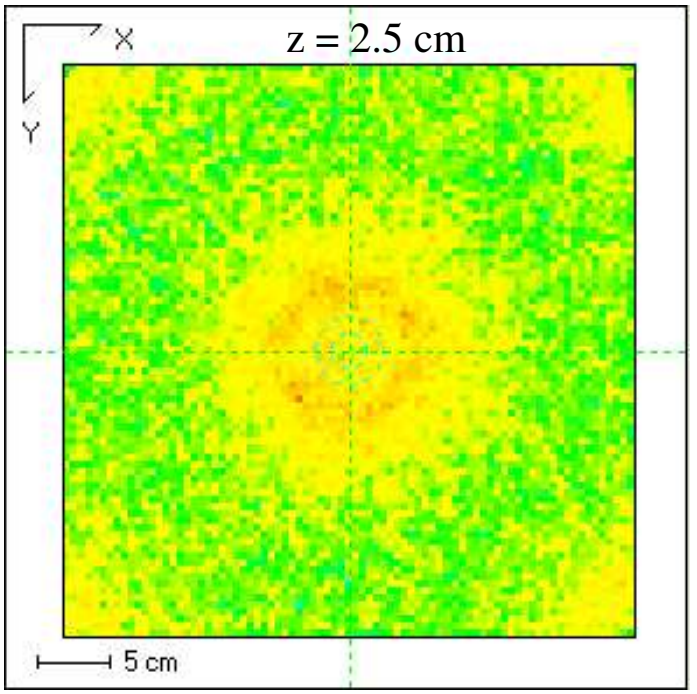



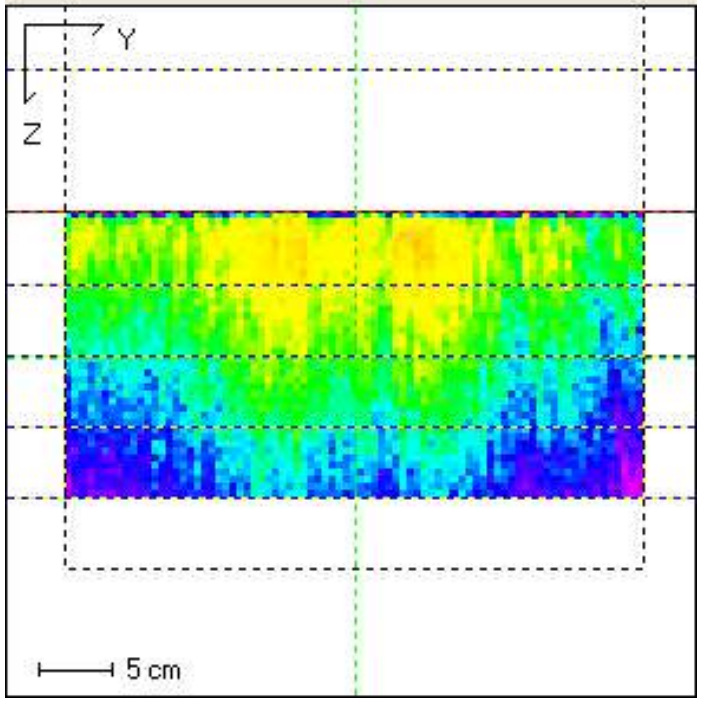
# Simplified linac photon beam with W target and flattening filter

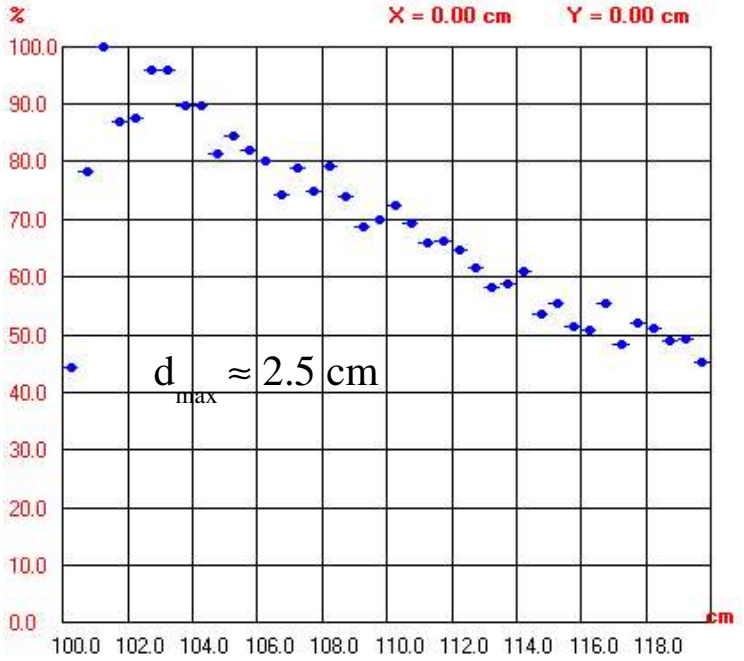


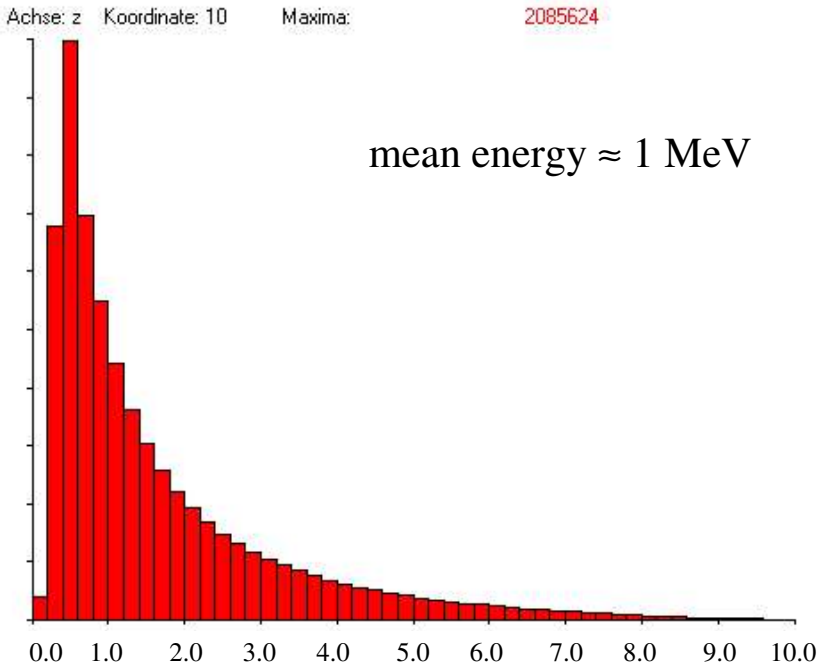

angular distributions
of bremsstrahlung photons
projected onto the
water phantom

dose variations flattened out!

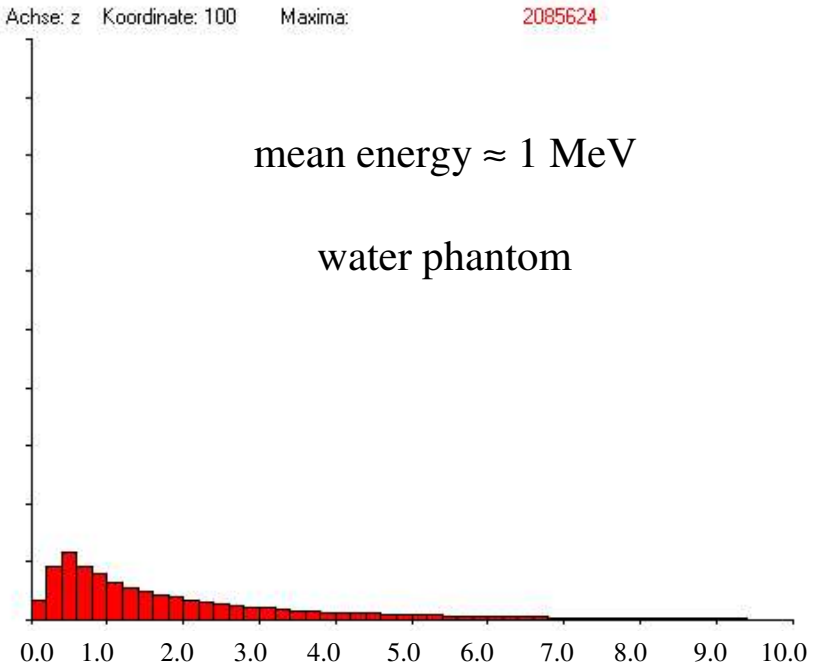


# Photon spectra

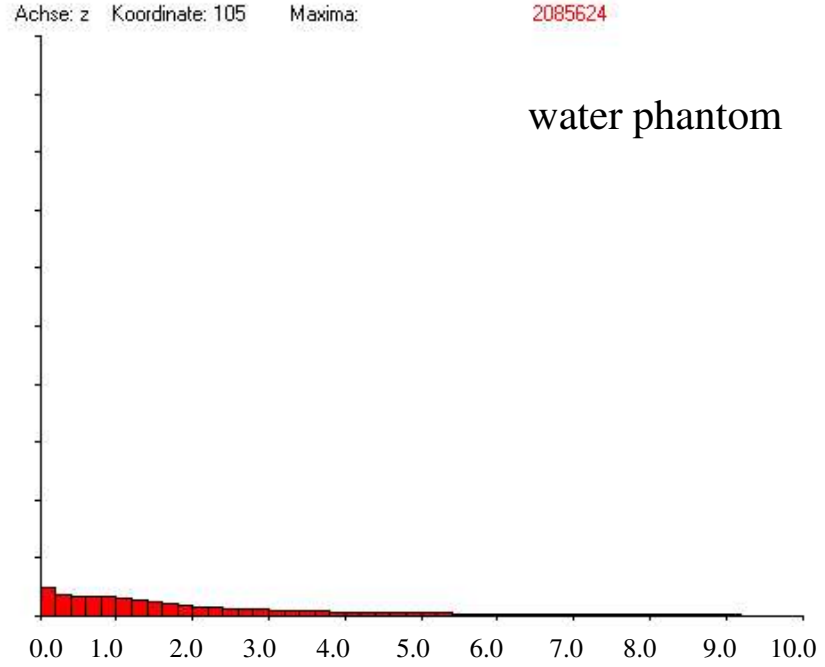



mean energy ≈ 1 MeV

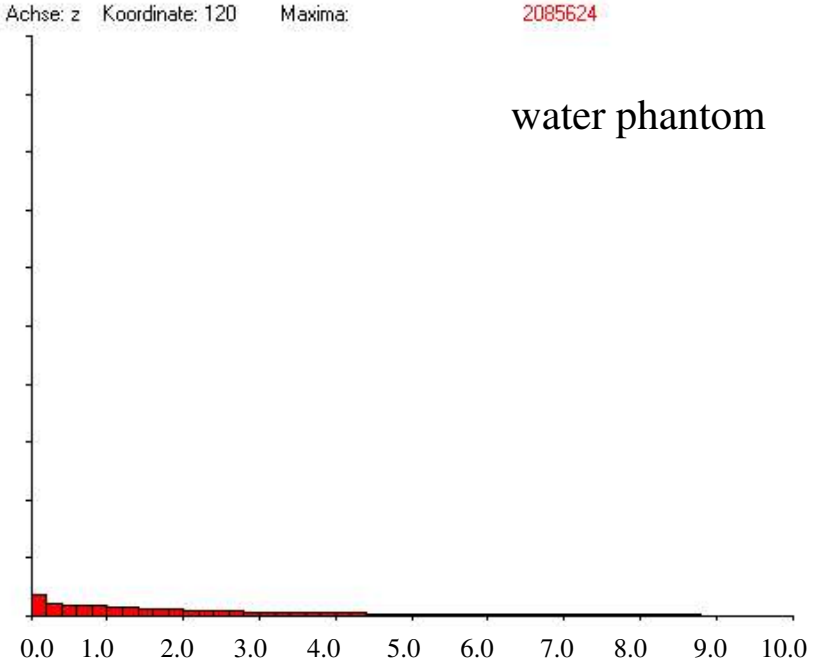



mean energy ≈ 1 MeV

water phantom

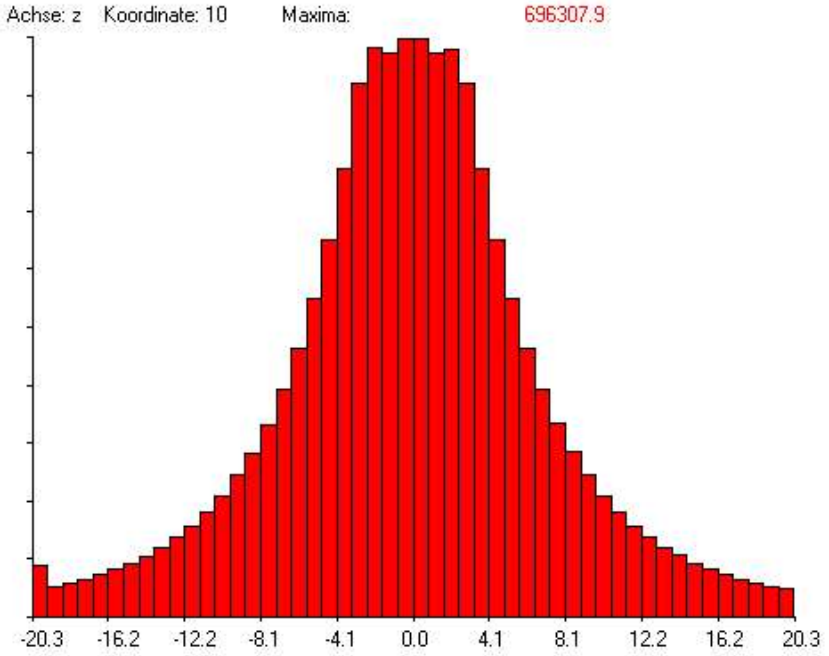


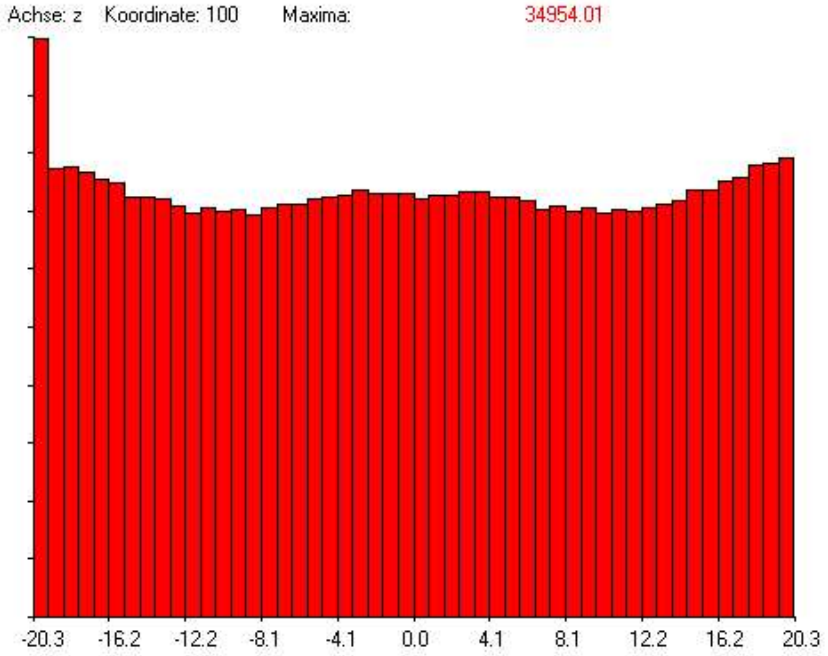

water phantom

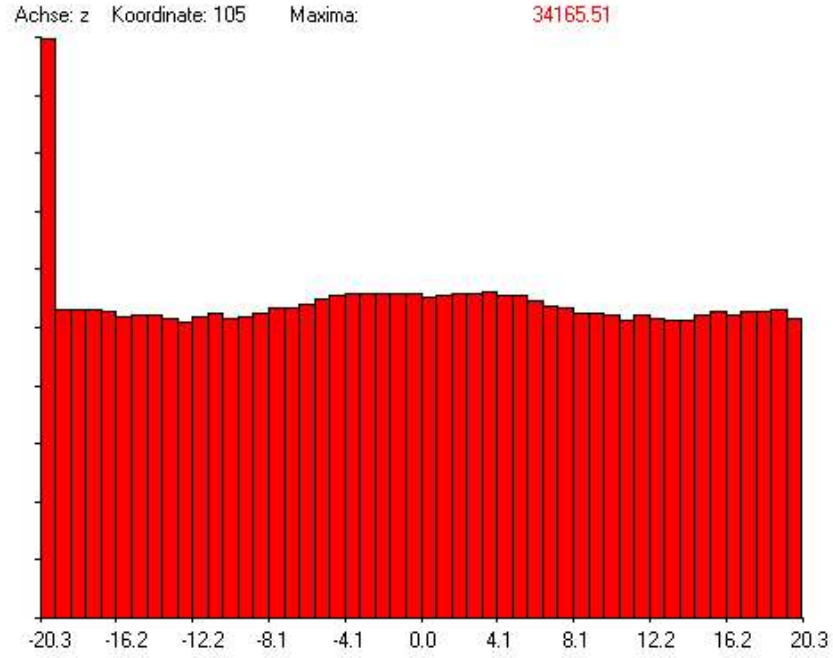


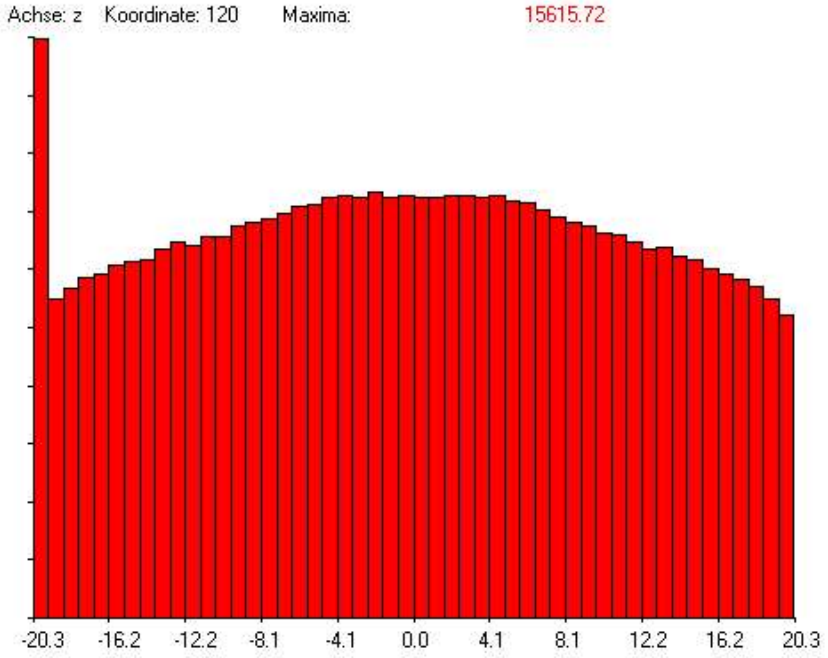

water phantom

# Photon profiles

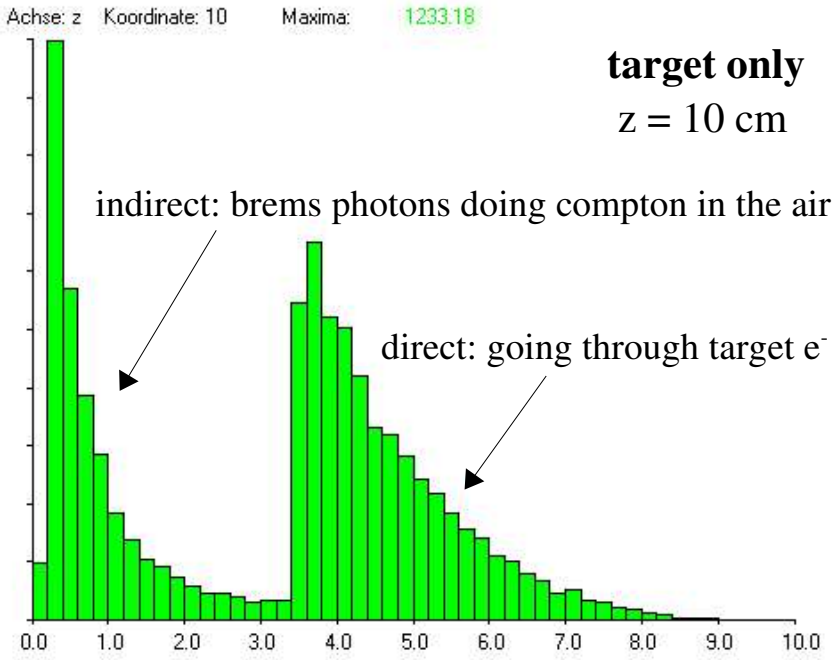


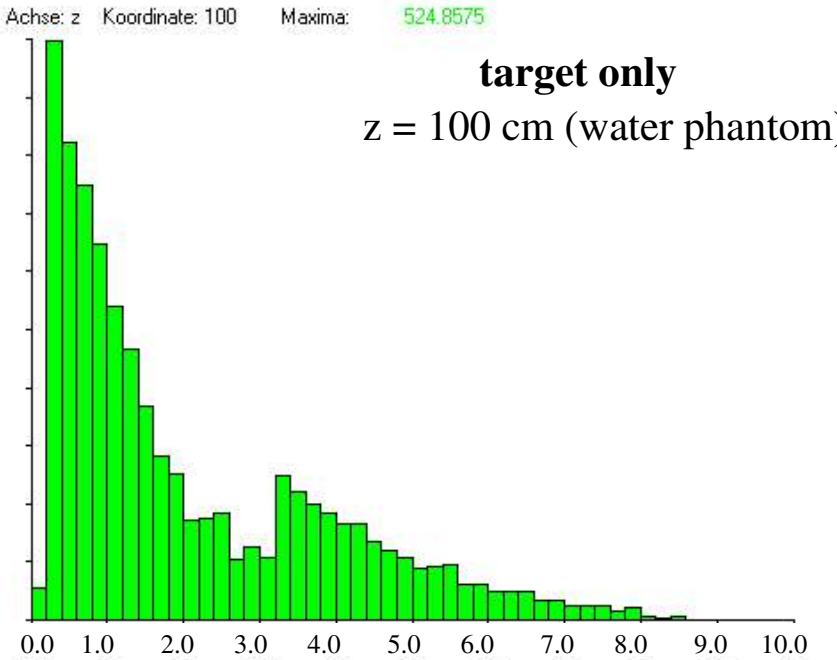
# Comparison of electron spectra



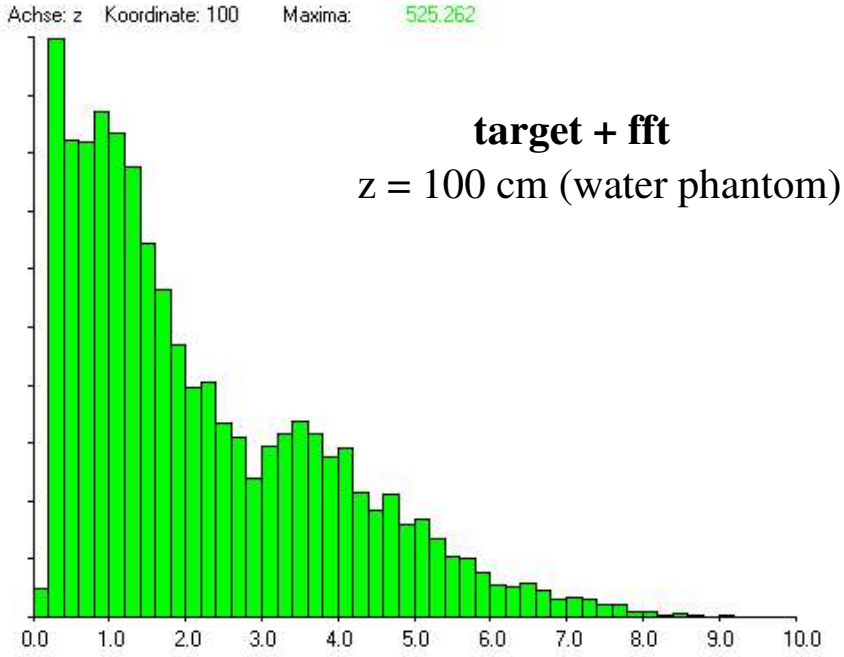

**target only**
z = 10 cm

indirect: brems photons doing compton in the air

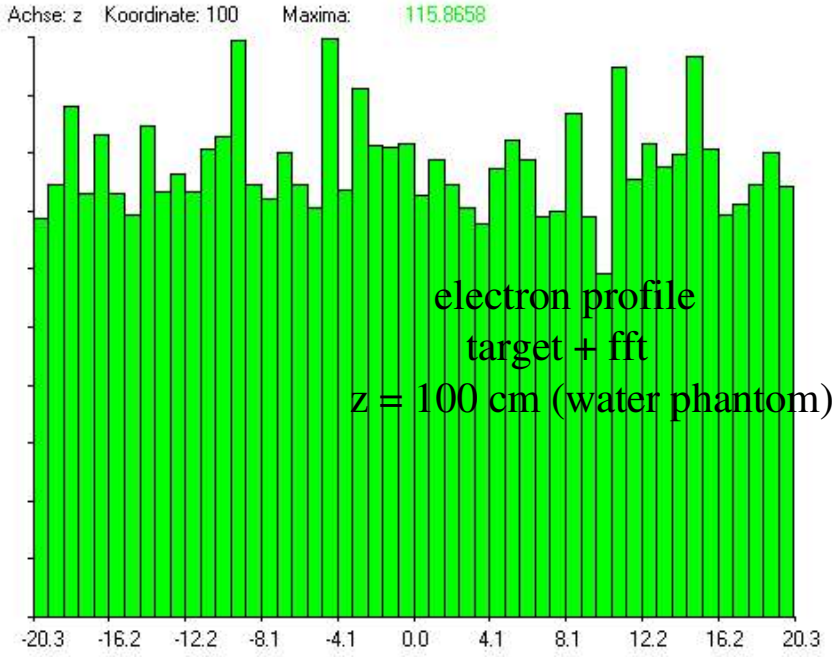
direct: going through target $e^-$




**target only**
z = 100 cm (water phantom)

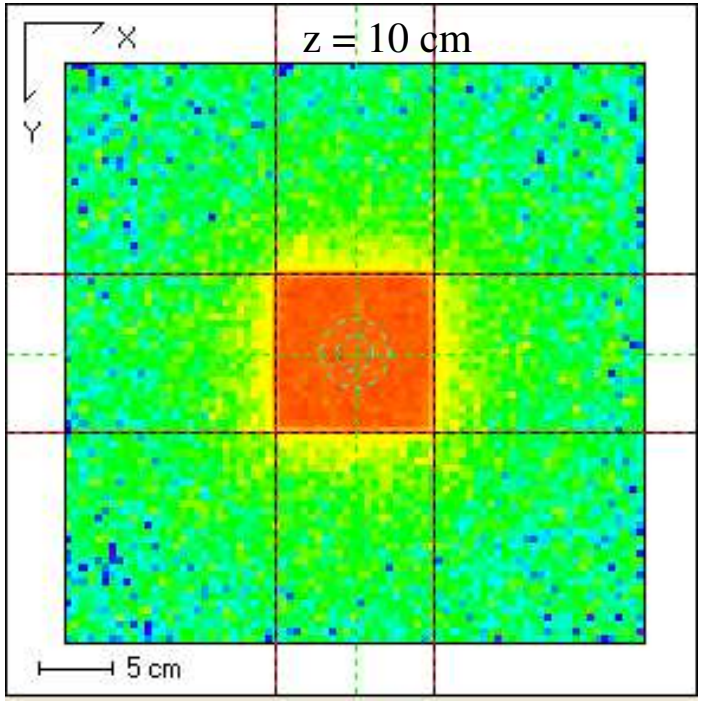


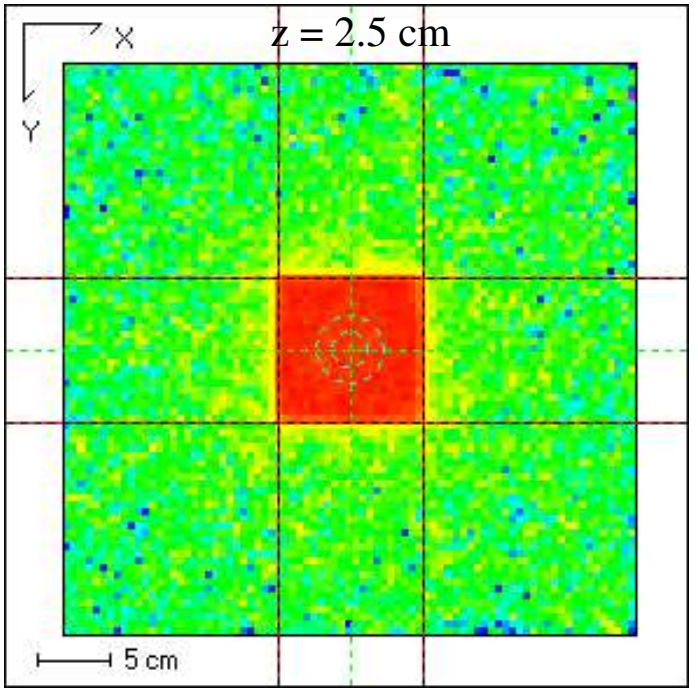

**target + fft**
z = 100 cm (water phantom)

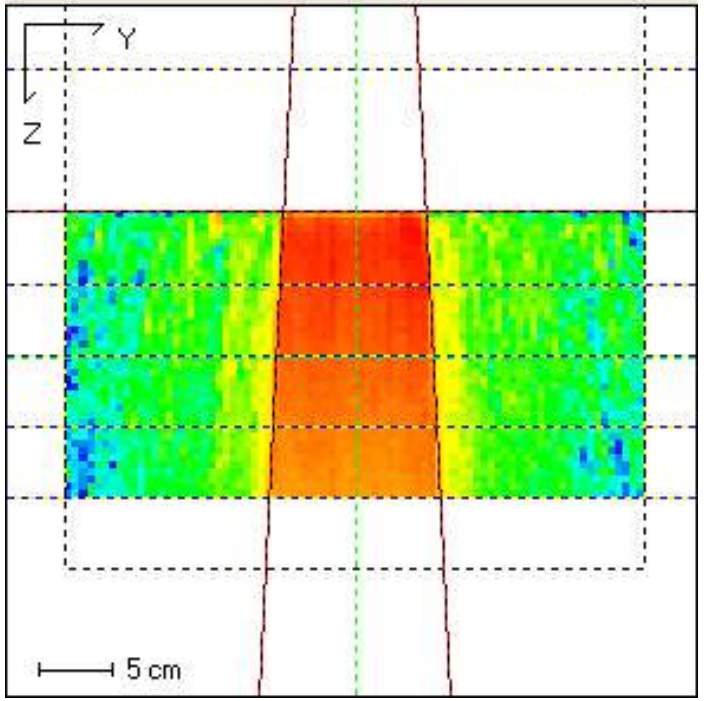


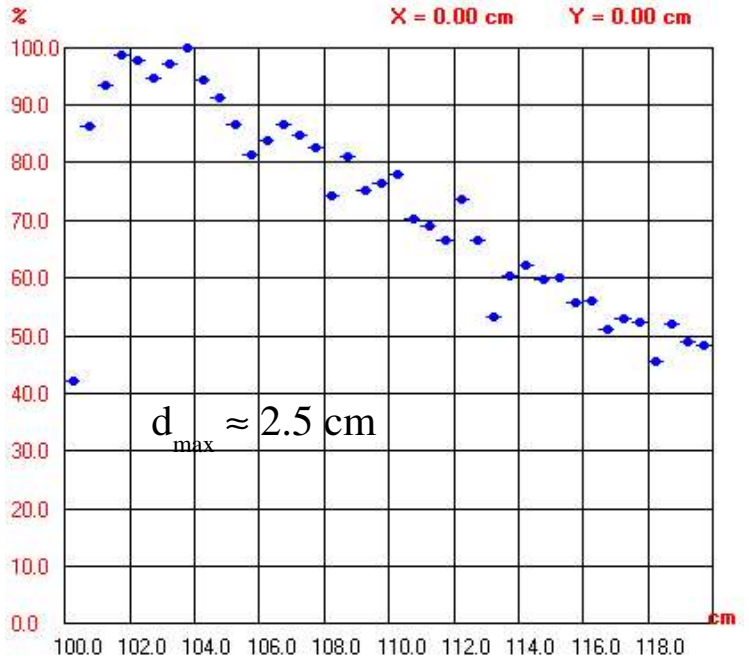

electron profile
target + fft
z = 100 cm (water phantom)

# Linac with W target, flattening filter and divergent collimator

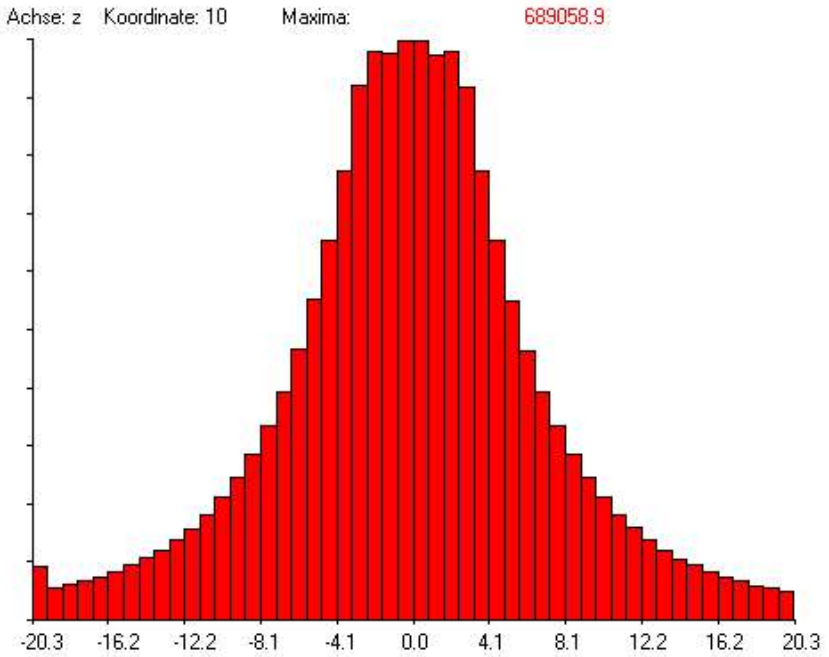


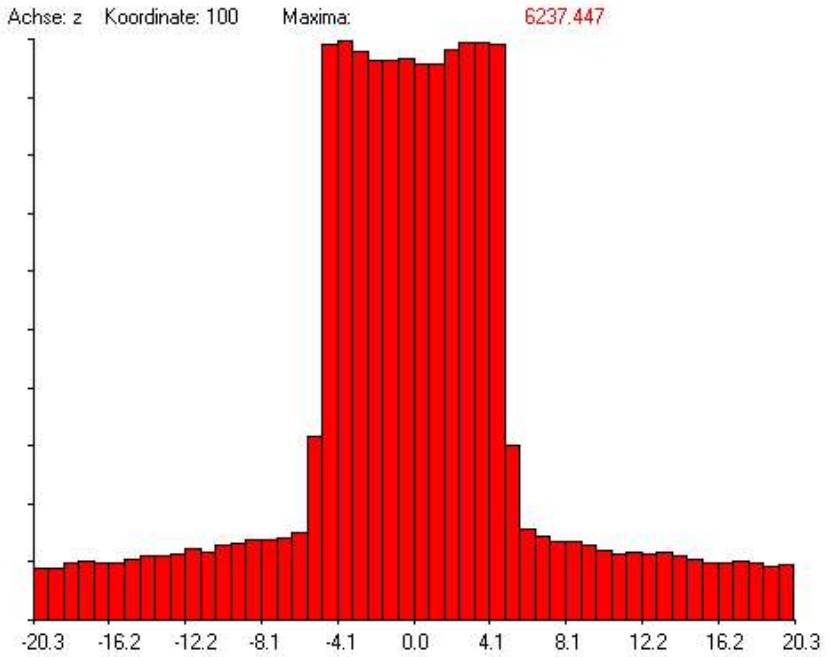



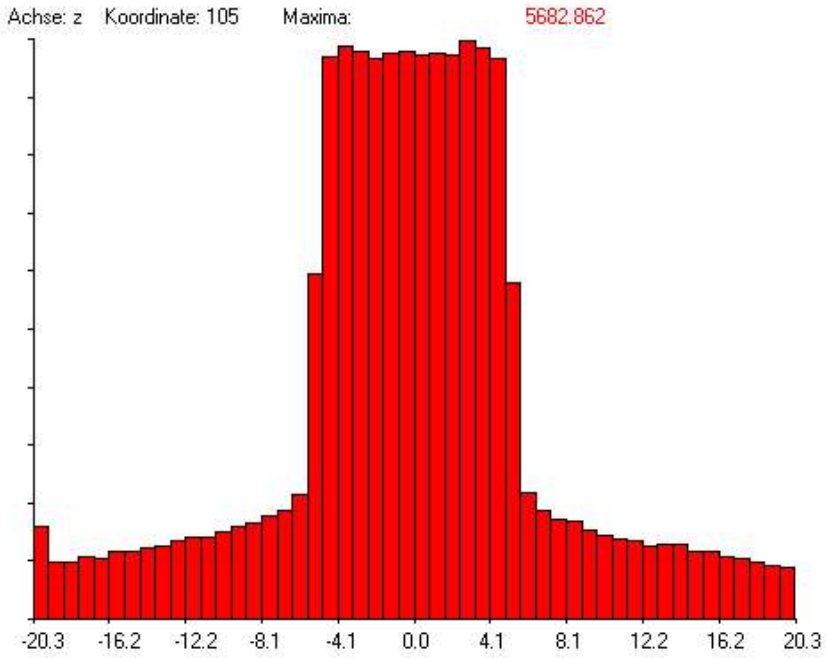



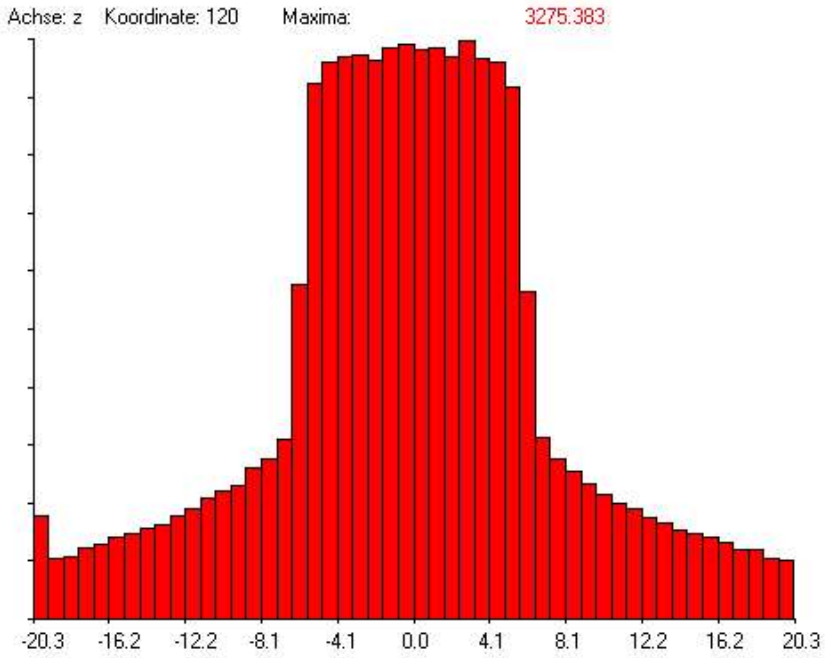



# Photon profiles

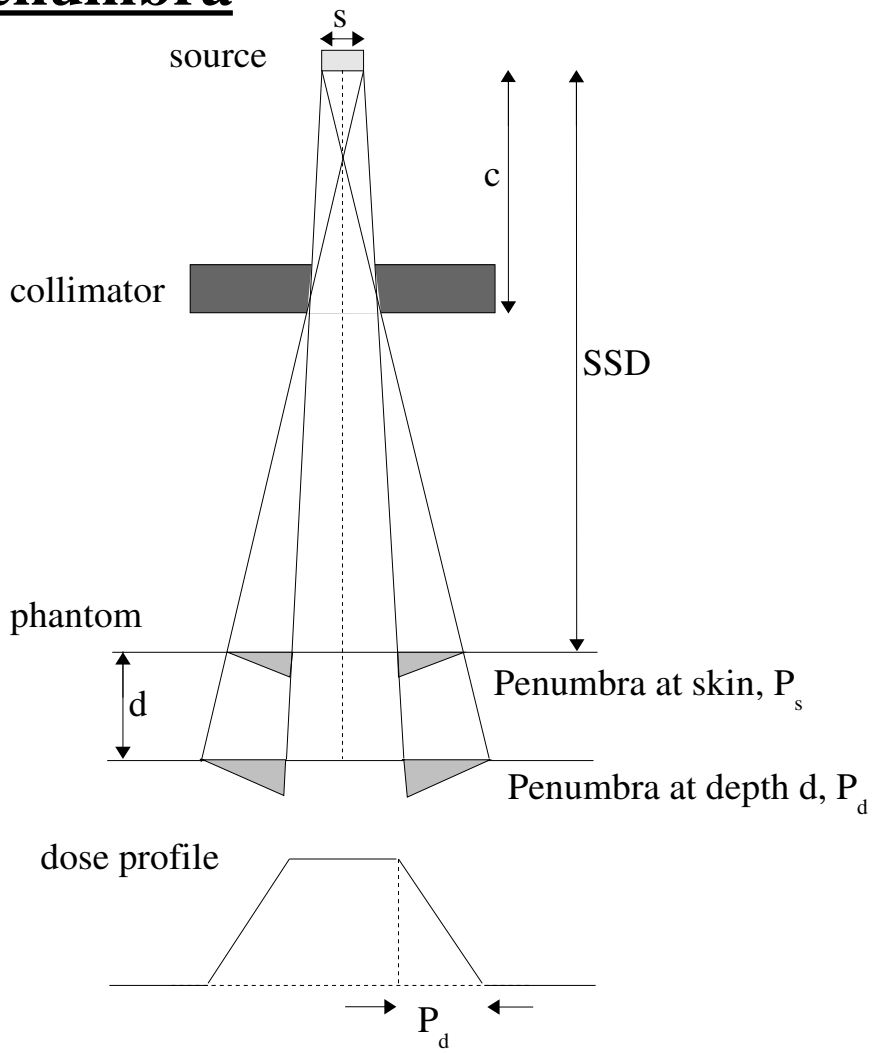


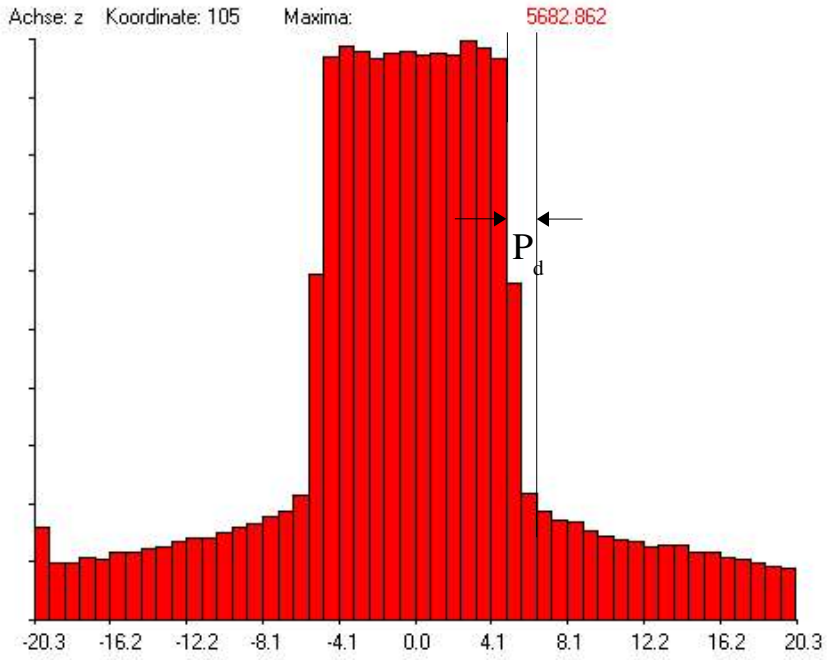



# Penumbra




$$P_s = \frac{s(SSD - c)}{c}$$

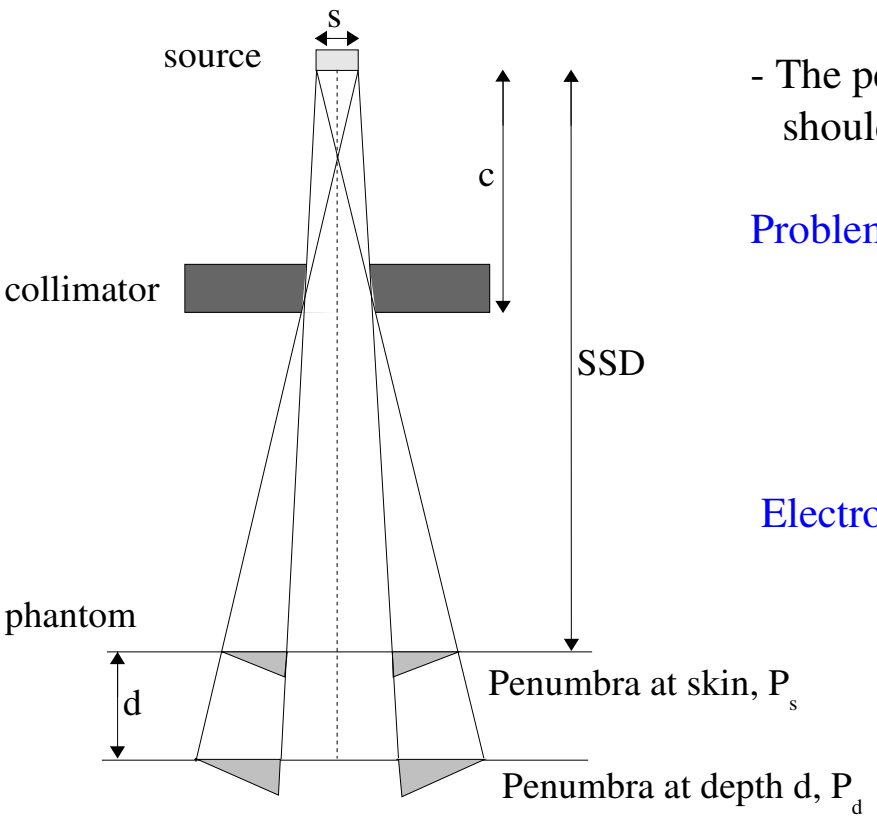
$$P_d = \frac{s(SSD + d - c)}{c}$$

$P_d$ = 1.62 cm

$SSD + d$ = 105 cm $\qquad c$ = 58 cm

$$s = \frac{c}{SSD + d - c} P_d = 2 \text{ cm}$$

# Interesting Remarks




- To make the penumbra small the source (s) may be made small, or the distance (c) large, or both.

- The penumbra at the tumor is larger than the former one and should be considered clinically.

Problems: making the source small reduces the radiation output

making the distance (c) large can produce electron contamination

Electron contamination: electrons scattered from the collimator

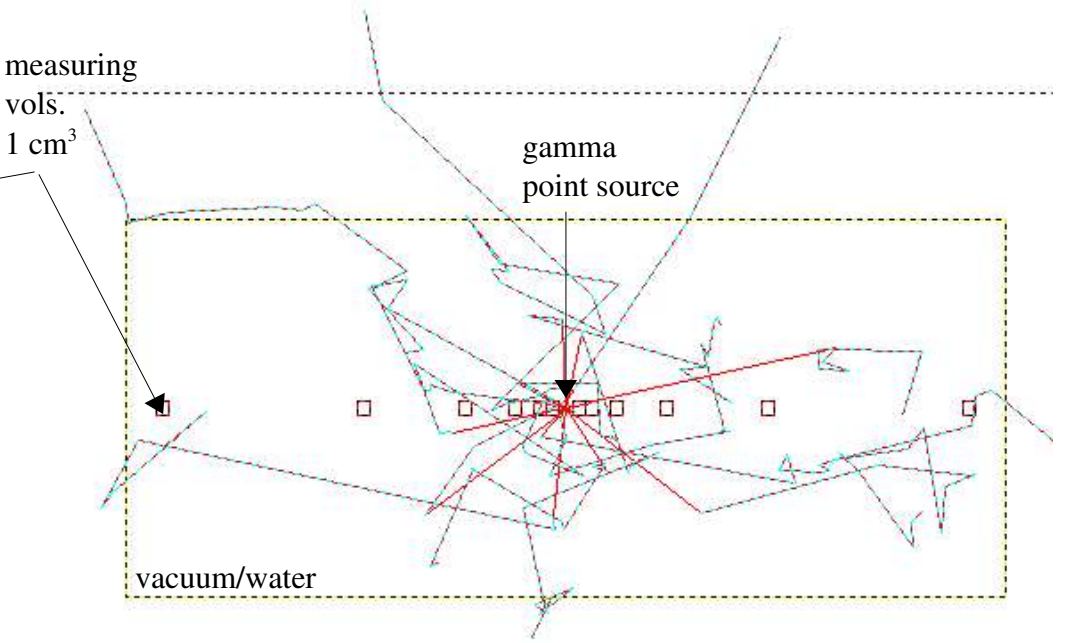
particularly bad if the collimator system extends right down to the skin

if a space of 15 to 20 cm is left, electrons are stopped or scattered in the air and do not reach the skin

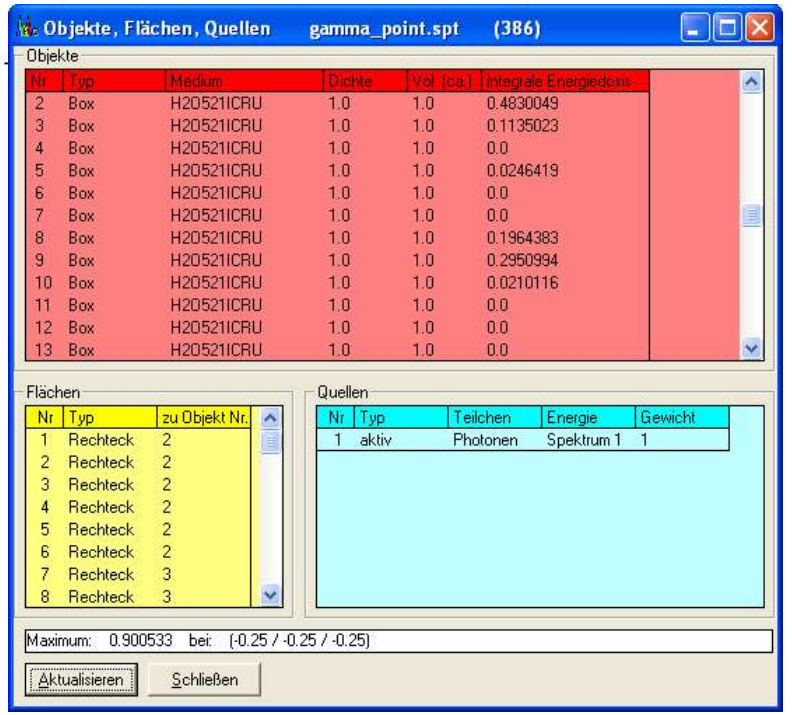
# Gamma point source

```
Daten
D:\...\521icru.dat
Randomseed
1802 9373
Histories
1500000
aktiv
Kugel                          gamma
0  0  0  0.035                 point source
Photonen                       ϕ = 0.7 mm
Spektrum
D:\...\Ir192_spectrum.spc
Rechenraum
-50  -50  -25  50  50  25
Scoringraum
-35  -35  -15  35  35  15
Voxelgröße
0.5  0.5  0.5
Raum                           comment
H2O521ICRU                     to have vacuum
Box
H2O521ICRU          1 cm
0.5  0.5  -0.5  1.5  -0.5  0.5
Box
H2O521ICRU          2 cm
1.5  0.5  -0.5  2.5  -0.5  0.5
Box
H2O521ICRU          4 cm
3.5  0.5  -0.5  4.5  -0.5  0.5
Box
H2O521ICRU          8 cm
7.5  0.5  -0.5  8.5  -0.5  0.5
```

```
Box
H2O521ICRU          16 cm
15.5  0.5  -0.5  16.5  -0.5  0.5
Box
H2O521ICRU          32 cm
31.5  0.5  -0.5  32.5  -0.5  0.5
Box
H2O521ICRU          -1 cm
-0.5  0.5  -0.5  -1.5  -0.5  0.5
Box
H2O521ICRU          -2 cm
-1.5  0.5  -0.5  -2.5  -0.5  0.5
Box
H2O521ICRU          -4 cm
-3.5  0.5  -0.5  -4.5  -0.5  0.5
Box
H2O521ICRU          -8 cm
-7.5  0.5  -0.5  -8.5  -0.5  0.5
Box
H2O521ICRU          -16 cm
-15.5  0.5  -0.5  -16.5  -0.5  0.5
Box
H2O521ICRU          -32 cm
-31.5  0.5  -0.5  -32.5  -0.5  0.5
Presta
```




Measurements with OBJEKTE

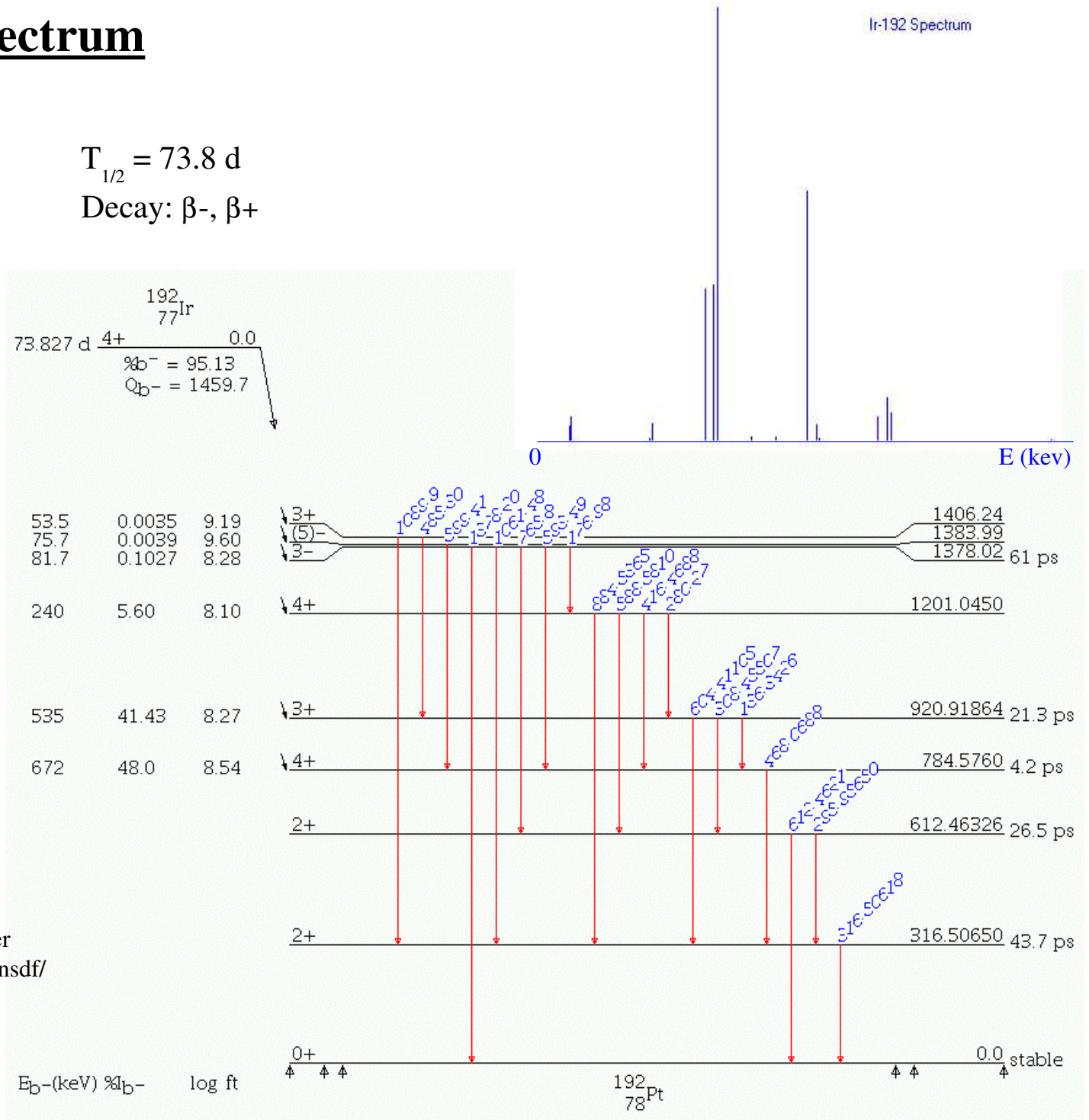


# $^{192}$Ir energy spectrum

| energy (MeV) | absolute intensity per decay |
|---|---|
| Ir-192 Spectrum | |
| 0.063 | 0.0218 |
| 0.06512 | 0.0267 |
| 0.06683 | 0.0458 |
| 0.2013 | 0.00466 |
| 0.2058 | 0.0329 |
| 0.296 | 0.290 |
| 0.3084 | 0.297 |
| 0.3165 | 0.828 |
| 0.3745 | 0.00729 |
| 0.4165 | 0.0062 |
| 0.4681 | 0.478 |
| 0.4846 | 0.0316 |
| 0.4891 | 0.00397 |
| 0.5886 | 0.0452 |
| 0.6044 | 0.0818 |
| 0.6125 | 0.0533 |
| 0.8845 | 0.00302 |

$T_{1/2}$ = 73.8 d

Decay: β-, β+




Isotope Explorer
http://ie.lbl.gov/ensdf/

# Brachytherapy

Permanent or temporary implants (seeds)

| | | |
|---|---|---|
| High dose rate | HDR | > 12 Gy/h |
| Medium dose rate | MDR | 2 -12 Gy/h |
| Low dose rate | LDR | < 2 Gy/h |
| Pulsed dose rate | PDR | simulation of LDR by pulsed irradiation with HDR |


Afterloading

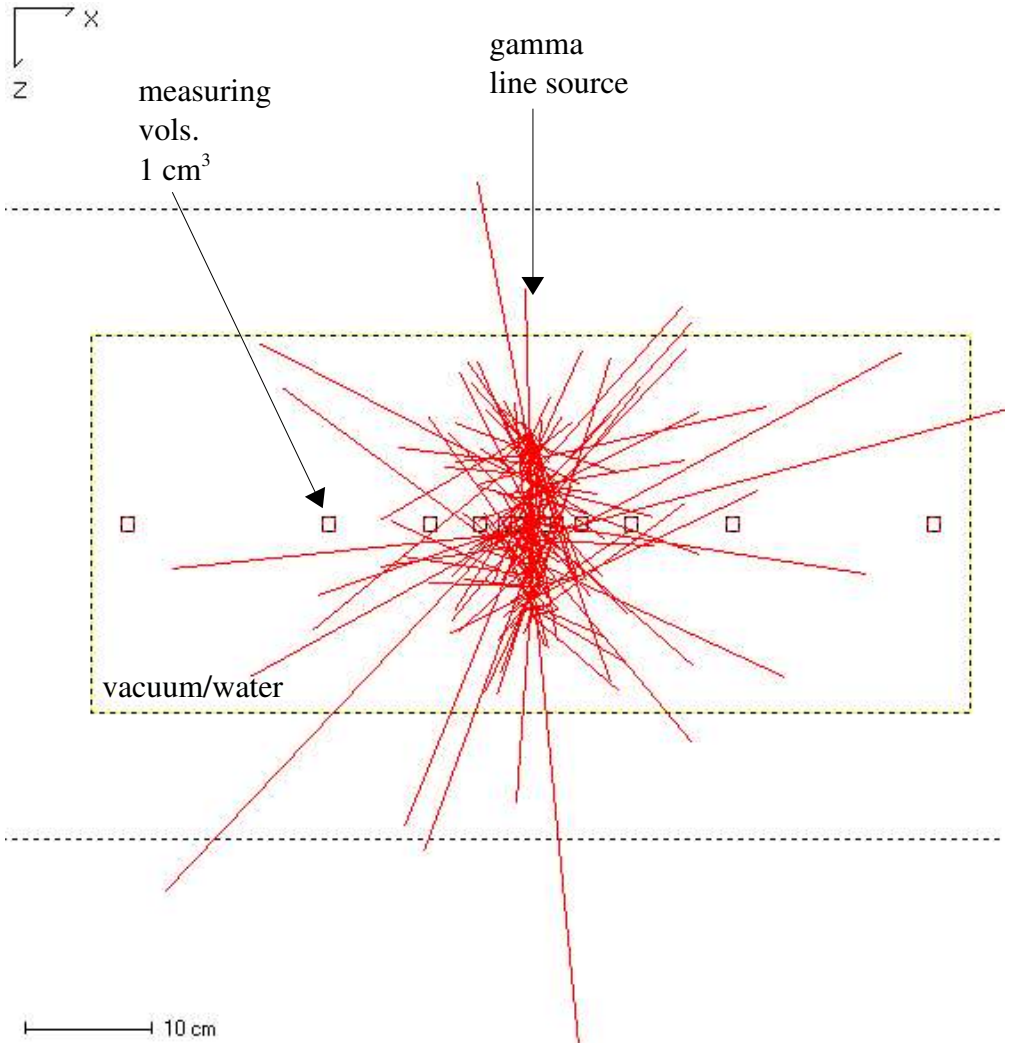
interstitial: therapy of tissues between organs usually with needles. Examples: mamma, prostata.

intraluminal: lumen: internal cavity of tubular organs. Examples: trachea, bronchia, esophagus.

intracavitary: therapy of cavities which can be easily accessed from the outside. Uterus, vagina, colon, rectum, oral and nasal cavities.

# Gamma line source

Daten
D:\...\521icru.dat
Randomseed
1802 9373
aktiv
Säule  radiating cylinder
2 7.5 -7.5
0 0 0 0.035  ϕ = 0.7 mm
Photonen
Spektrum
D:\...\Ir192_spectrum.spc
Rechenraum
-50 -50 -25 50 50 25
Scoringraum
-35 -35 -15 35 35 15
Voxelgrösse
0.5 0.5 0.5
Raum  comment
H2O521ICRU  to have vacuum
Box
H2O521ICRU
0.5 0.5 -0.5 1.5 -0.5 0.5
Box
H2O521ICRU
1.5 0.5 -0.5 2.5 -0.5 0.5
Box
H2O521ICRU
3.5 0.5 -0.5 4.5 -0.5 0.5
Box
H2O521ICRU
7.5 0.5 -0.5 8.5 -0.5 0.5
Box
H2O521ICRU
15.5 0.5 -0.5 16.5 -0.5 0.5
Box
H2O521ICRU
31.5 0.5 -0.5 32.5 -0.5 0.5
Box
H2O521ICRU
-0.5 0.5 -0.5 -1.5 -0.5 0.5
Box
H2O521ICRU
-1.5 0.5 -0.5 -2.5 -0.5 0.5
Box
H2O521ICRU
-3.5 0.5 -0.5 -4.5 -0.5 0.5
Box
H2O521ICRU
-7.5 0.5 -0.5 -8.5 -0.5 0.5
Box
H2O521ICRU
-15.5 0.5 -0.5 -16.5 -0.5 0.5
Box
H2O521ICRU
-31.5 0.5 -0.5 -32.5 -0.5 0.5
Histories
1500000
Presta



# Assignment 09: Gamma source

1) Simulate: a $^{192}$Ir point source in vacuum and in water

Analysis: study the relative dose decrease with radial distance r in vacuum and water.
Consider radii of 1, 2, 4, 8, 16 and 32 cm (take r = 2 cm equivalent to 100%).
Make a graph and discuss your results.

2) Simulate: a $^{192}$Ir line source 15 cm in length in vacuum and in water

Analysis: study the relative dose decrease with radial distance r in vacuum and water.
Consider radii of 1, 2, 4, 8, 16 and 32 cm (take r = 2 cm equivalent to 100%).
Choose the radial coordinate perpendicular to the line source axis.
Make a graph and discuss your results.

*Scoring dimensions and voxel size adapted to each case. Enough statistics.*