Abteilung für Medizinische Strahlenphysik
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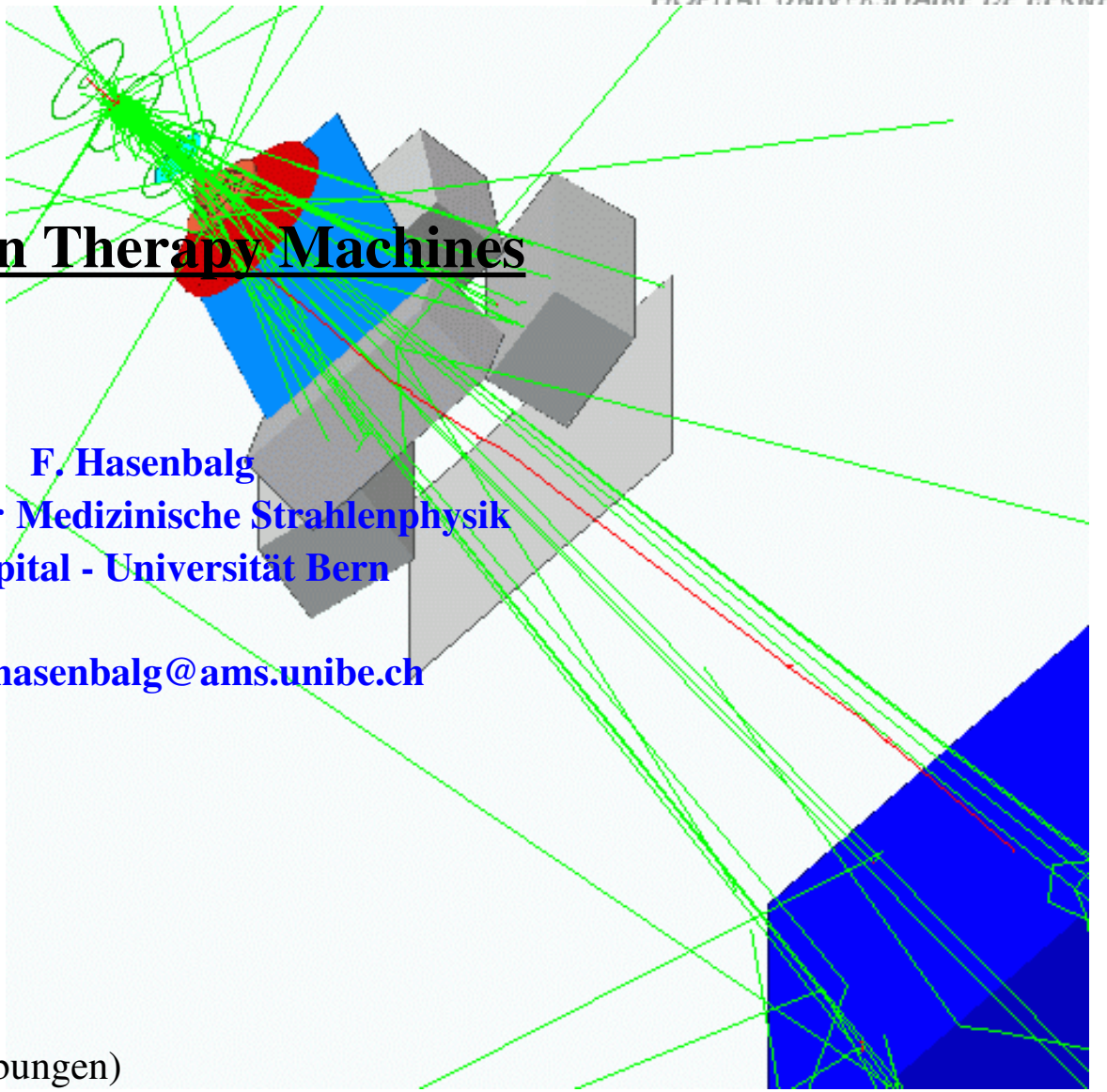
Electron Therapy Machines



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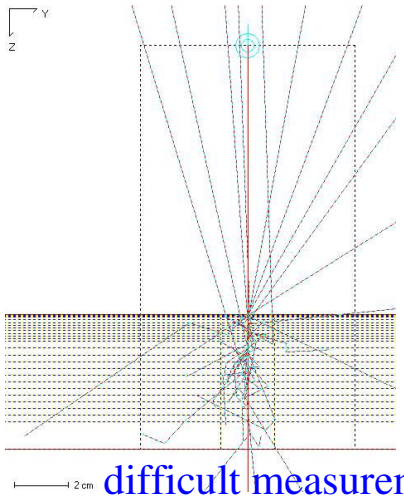
Results assignment 06: X-Ray Properties



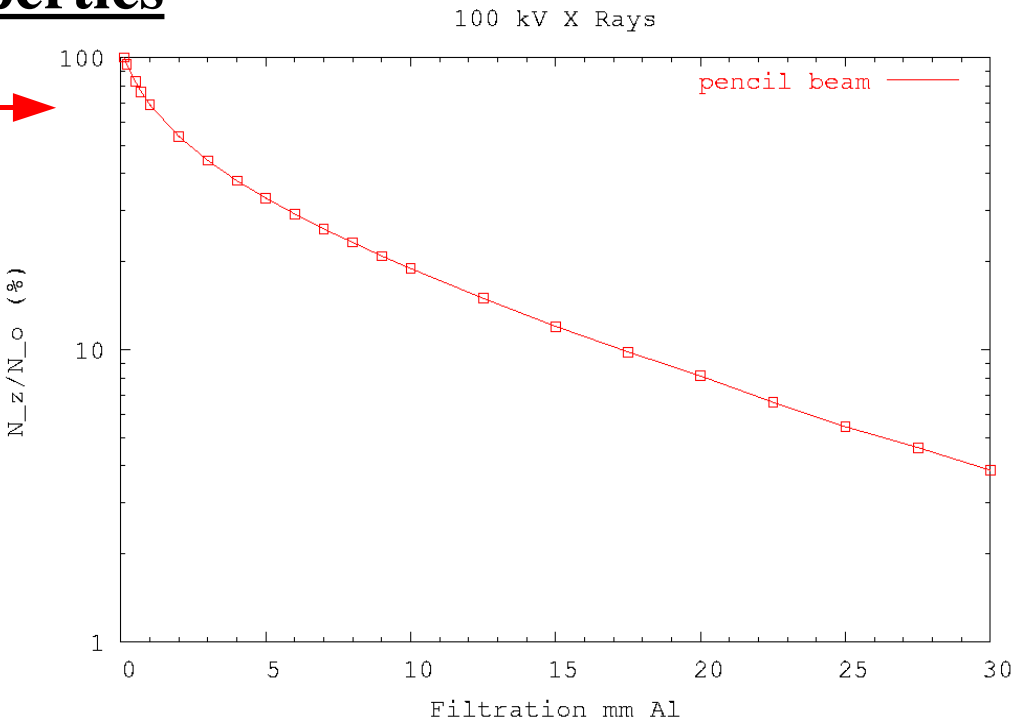
100 kV pencil beam with Generation 1

$$d_{1/2}^{(1)} = 2.4 \text{ mm}$$

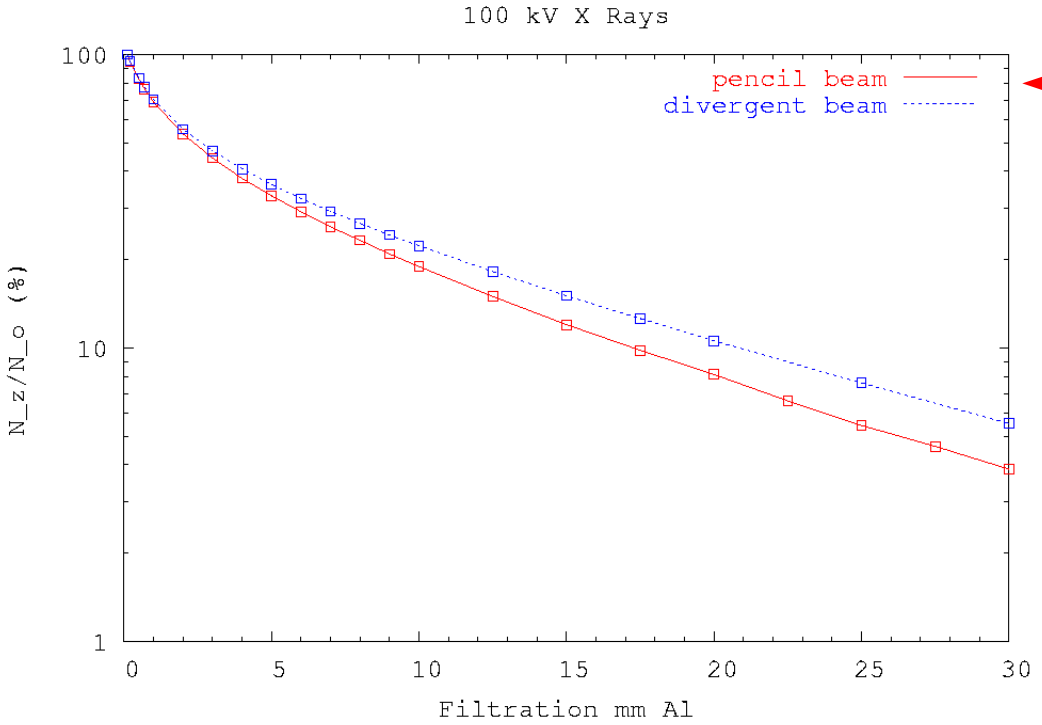
$$d_{1/2}^{(2)} = 4.9 \text{ mm}$$

$$H = \frac{d_{1/2}^{(1)}}{d_{1/2}^{(2)}} = 0.49$$

difficult measurement in real life because scatter is not considered in the simulation.



100 kV pencil beam + divergent beam

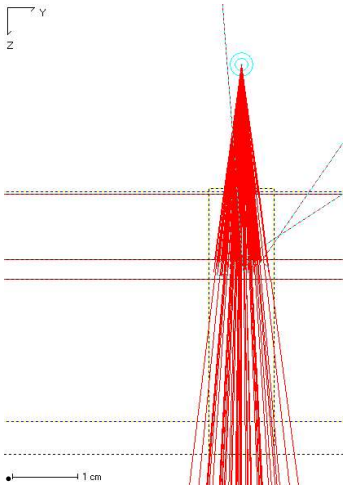


For the divergent beam:

$$d_{1/2}^{(1)} = 2.6 \text{ mm}$$

$$d_{1/2}^{(2)} = 6.1 \text{ mm}$$

$$H = \frac{d_{1/2}^{(1)}}{d_{1/2}^{(2)}} = 0.43$$



divergent beam harder!

Using $\mu = \frac{\log 2}{d_{1/2}}$ and table values:

$E_{eff} \approx 30$ keV

Results assignment 06: X-Ray Properties

125 kV divergent beam →

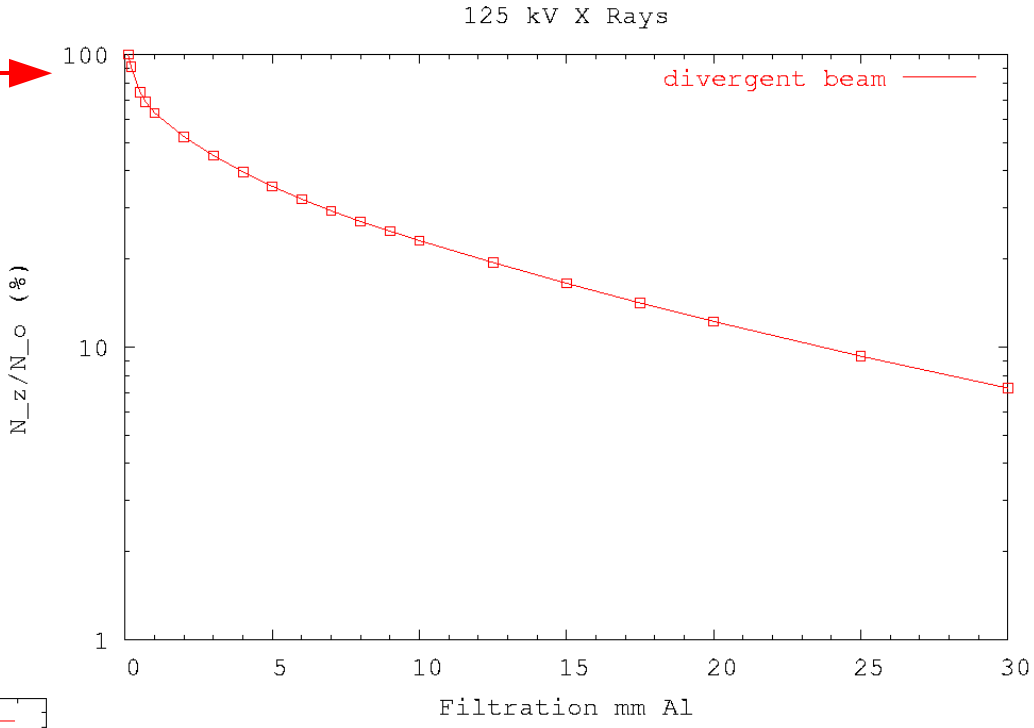
$$d_{1/2}^{(1)} = 2.3 \text{ mm}$$

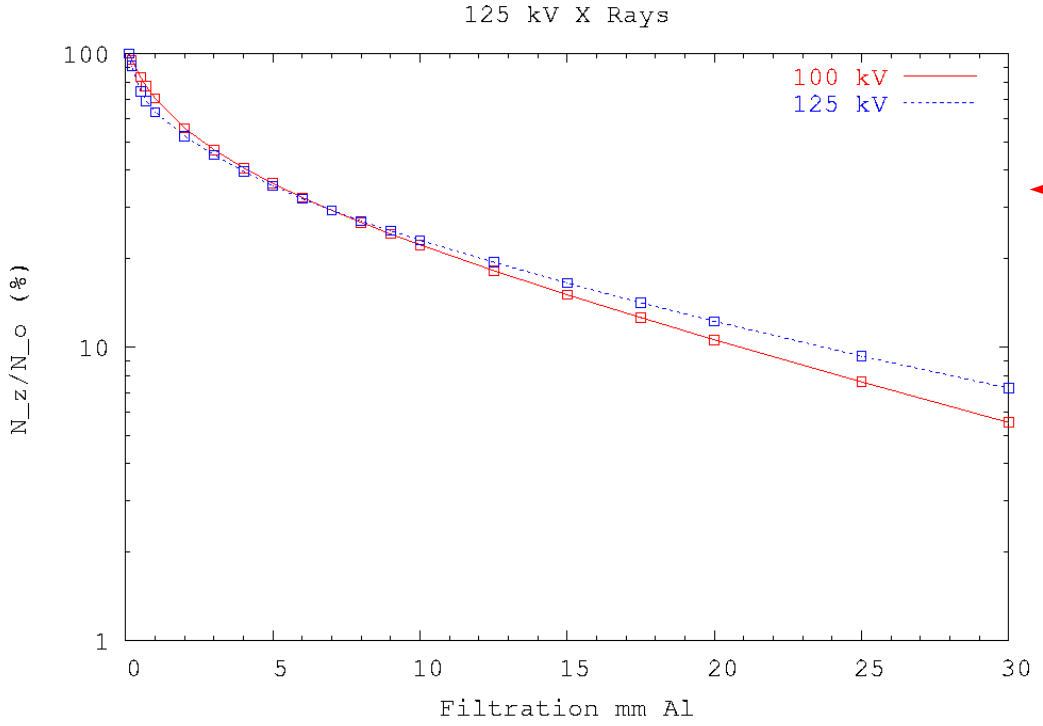
$$d_{1/2}^{(2)} = 6.6 \text{ mm}$$

$$H = \frac{d_{1/2}^{(1)}}{d_{1/2}^{(2)}} = 0.35$$

Using $\mu = \frac{\log 2}{d_{1/2}}$ and table values:

$E_{eff} \approx 30$ keV (not very sensitive technique)





← 125 kV harder than 100 kV.

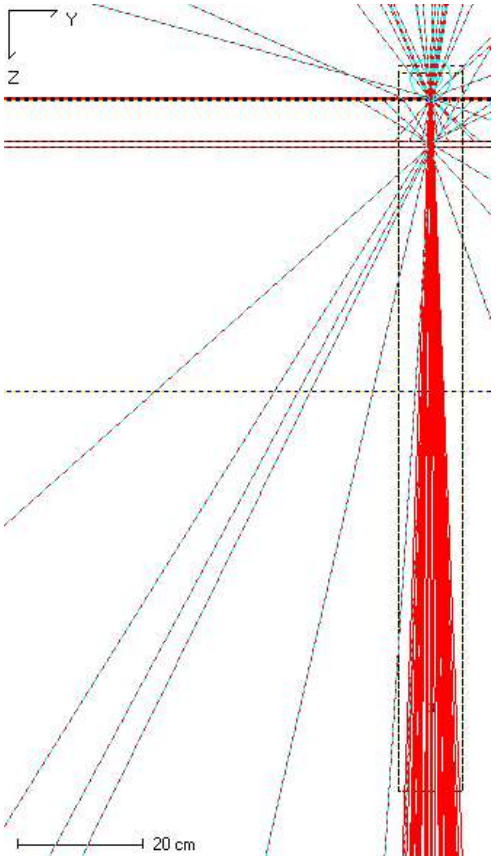
Results assignment 06: X-Ray Properties

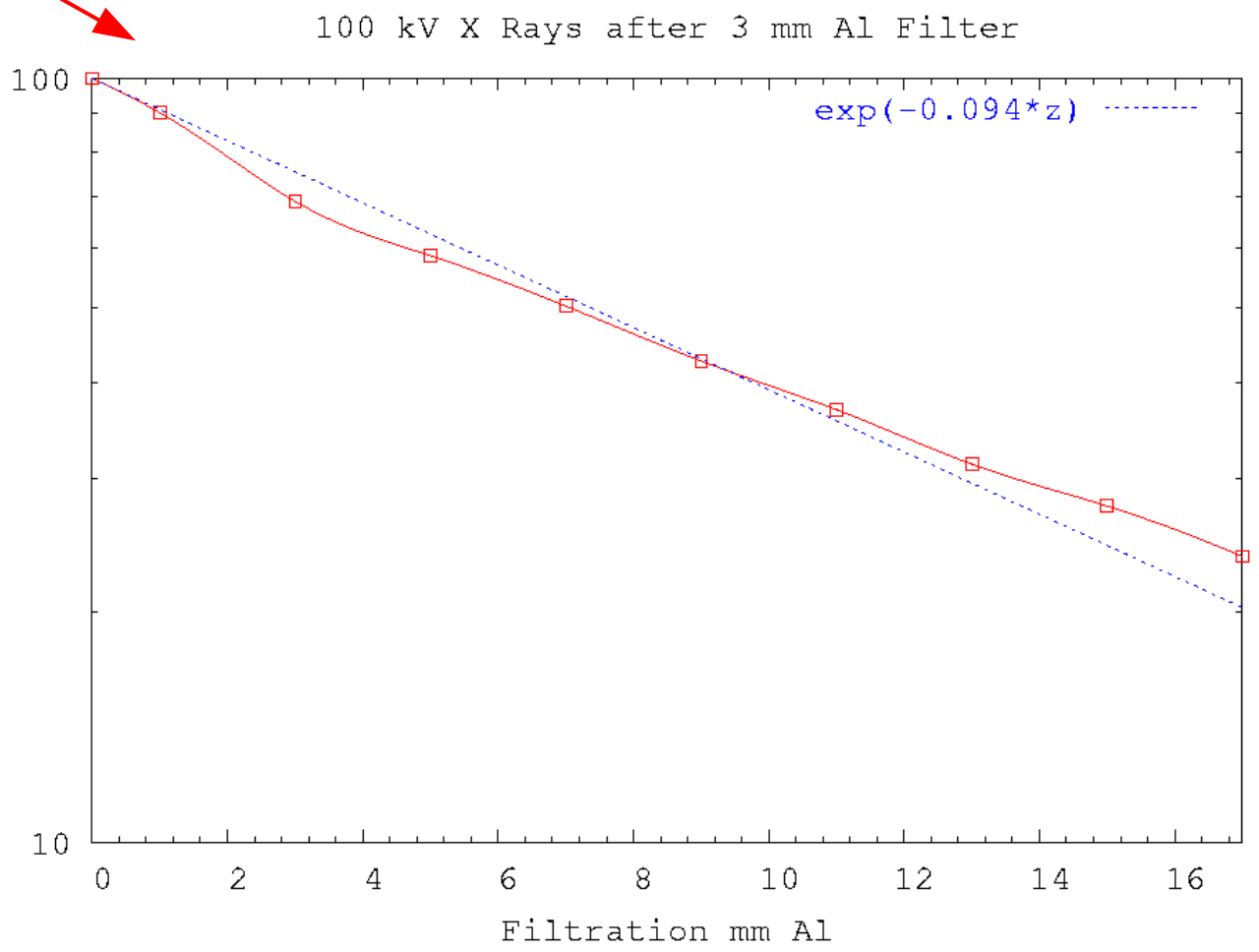
100 kV after 3 mm aluminum filter
measured in a “virtual” ionization chamber

$$d_{1/2}^{(1)} = 7.1 \text{ mm}$$

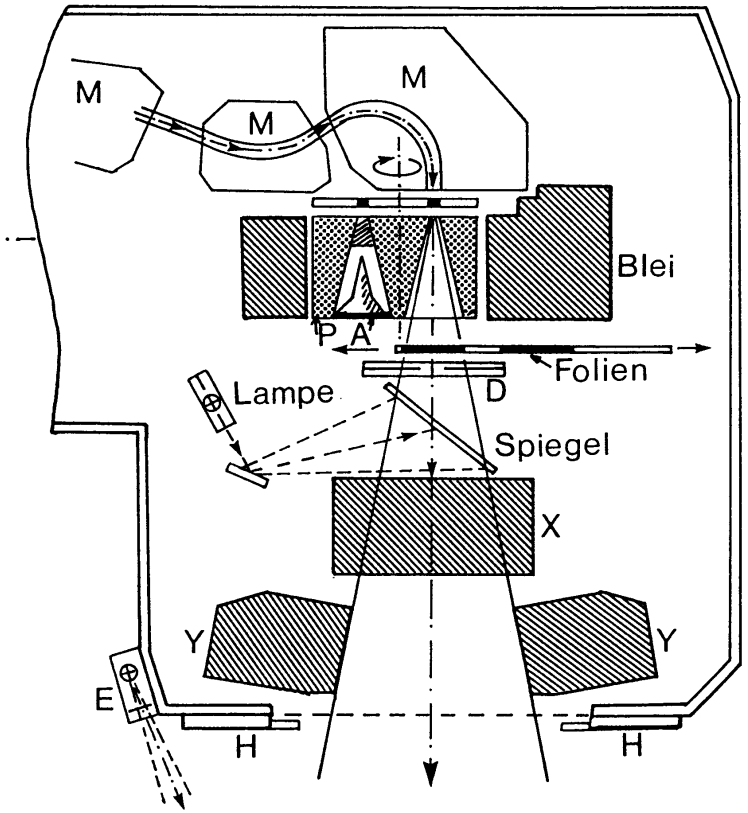
$$d_{1/2}^{(2)} = 9.2 \text{ mm}$$

$$H = \frac{d_{1/2}^{(1)}}{d_{1/2}^{(2)}} = 0.77$$

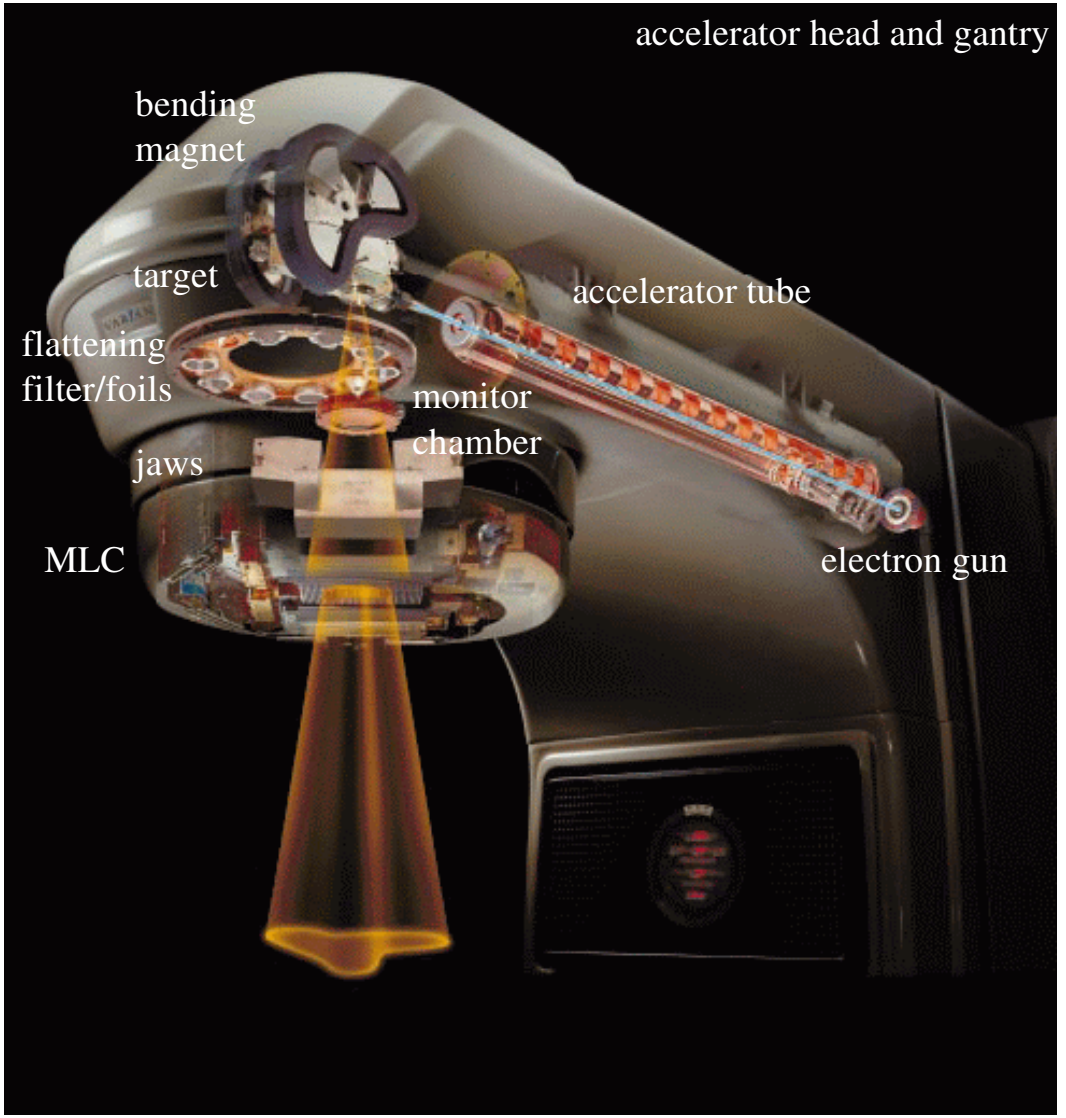




accelerator head



Typischer Strahlerkopf eines modernen medizinischen Elektronen-Linearbeschleunigers. (M: Slalom-Magnete für die Strahlumlenkung, D: Doppeldosismonitor, P: Primärkollimator, A: Photonenausgleichskörper mit vorgeschaltetem Beamhardener und Elektronenfänger, Folien: Ausgleichsfolien für Elektronen, E: Entfernungsmesser, H: Halter für Tubusse und Filter, X,Y: Kollimatorblenden, Lampe und Spiegel: Lichtvisier).



EGSRay: Simplified linear accelerator in vacuum or air

```
' Linac electron beam
' simplified model of an electron field
' in vacuum or air
' and a water phantom
'
Daten
D:\...\700icru.dat
Randomseed
1802 9373
Histories
1000000
Punktquelle
0.  0.  -1.
Richtung
0.  0.  1.
Elektronen
Energie
10.511
Rechenraum
-10.1  -10.1  -2  10.1  10.1  110
Scoringraum
-10.1  -10.1  100  10.1  10.1  110
Voxelgröße
0.2  0.2  0.2
Halbraum
AIR700ICRU
2  0  1
Halbraum
H2O700ICRU
2  100  1
Presta
```

electron source

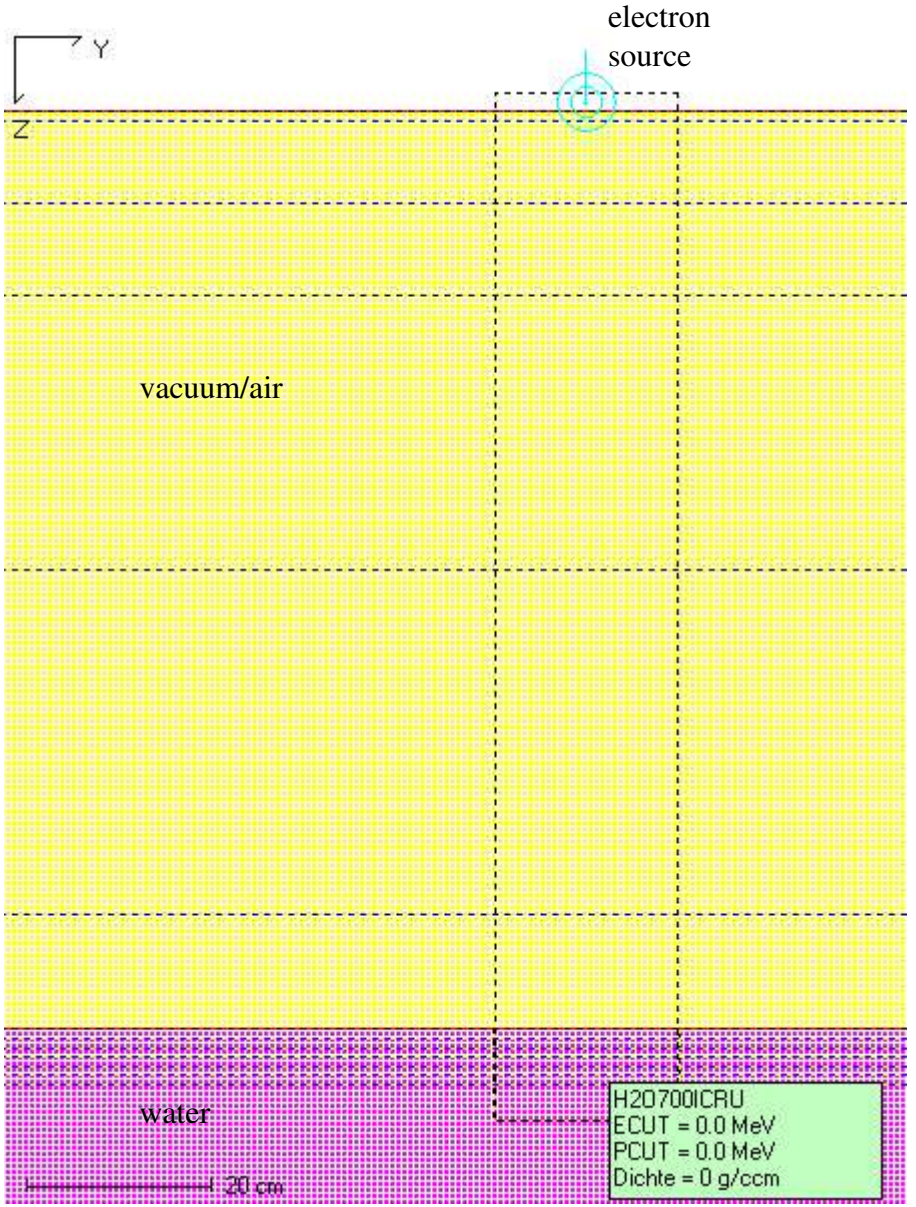
To have vacuum comment these lines

Water phantom at SSD 100 cm

```
Histogramm
2  1
Histogramm
2  10
Histogramm
2  20
Histogramm
2  50
Histogramm
2  87.5
Histogramm
2  100
Histogramm
2  101
Histogramm
2  102
Histogramm
2  103
Histogramm
2  104
Histogramm
2  105
Histogramm
2  106
```

Histograms along the beam

Histograms in the water phantom



EGSRay: Simplified linear accelerator with scattering foil

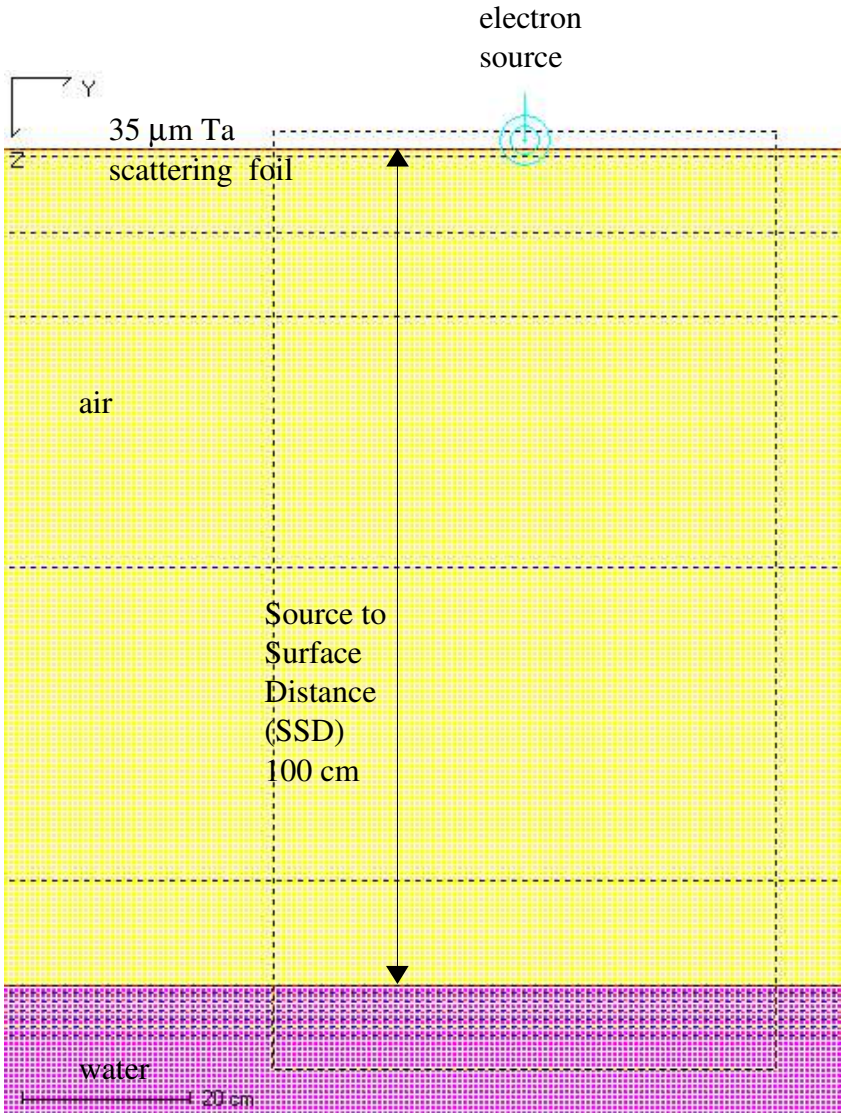
```
' Linac electron beam
' simplified model of an electron field
' with scattering foil, air
' and water phantom
'
Daten
D:\...\700icru.dat
Randomseed
1802 9373
Histories
4000000
Punktquelle
0  0  -1
Richtung
0  0  1
Elektronen
Energie
10.511
Rechenraum
-30.1  -30.1  -2  30.1  30.1  110
Scoringraum
-30.1  -30.1  100  30.1  30.1  110
Voxelgröße
0.2  0.2  0.2
Halbraum
AIR700ICRU
2  0  1
Halbraum
H2O700ICRU
2  100  1
```

electron source

Water phantom at SSD 100 cm

```
rem
rem scattering foil definition
rem
Platte
TA700ICRU
2  0  0.0035
Presta
Histogramm
2    1
Histogramm
2  10
Histogramm
2  20
Histogramm
2  50
Histogramm
2  87.5
Histogramm
2  100
Histogramm
2  101
Histogramm
2  102
Histogramm
2  103
Histogramm
2  104
Histogramm
2  105
Histogramm
2  106
```

scattering foil at z = 0

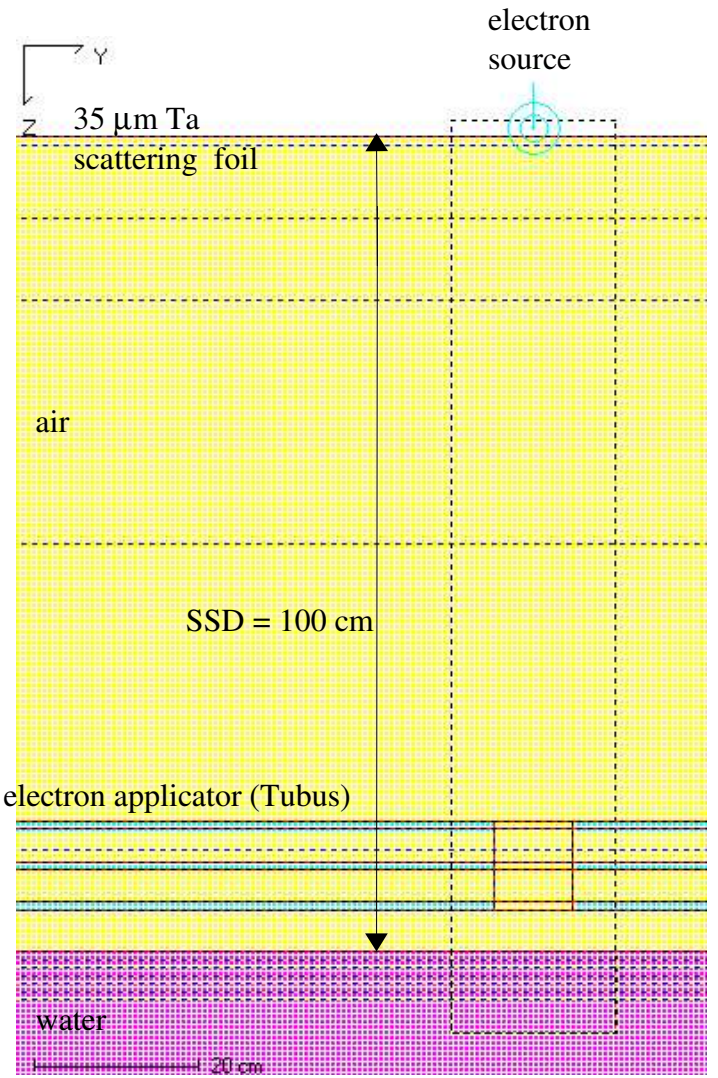


electron beam applicator

EGSRay: linear accelerator with scattering foil and electron applicator

```
' Linac electron beam
' simplified model of a 10x10 cm² electron field
' with scattering foil, e- applicator, air
' and water phantom
'
Daten
D:\...\700icru.dat
Randomseed
1802 9373
Histories
4000000
Punktquelle
0  0  -1
Richtung
0  0  1
Elektronen          electron
Energie             source
10.511
Rechenraum
-10.1  -10.1  -2  10.1  10.1  110
Scoringraum
-10.1  -10.1  100  10.1  10.1  110
Voxelgröße
0.2  0.2  0.2
Halbraum
AIR700ICRU
2  0  1
Halbraum            Water
H2O700ICRU          phantom
2  100  1           at SSD 100 cm
```

```
rem scattering foil definition
Platte
TA700ICRU           scattering foil
2  0  0.0035        at z = 0
rem e- applicator definition
Platte
STEEL700ICRU        electron applicator
2  84  85           (Tubus)
ECUT
1.
Platte
STEEL700ICRU
2  89  90
ECUT
1.
Platte
STEEL700ICRU
2  94  95
ECUT
1.
Box
AIR700ICRU
-4.75  -4.75  84  4.75  4.75  95
Presta
Histogramm
2   1
Histogramm
2  10
.....
Histogramm
2  106
```



Assignment 07: Electron therapy machines

Electron beams E = 10 MeV :

1) Simulate: parallel electron beams in vacuum and in air impinging on a water phantom at SSD = 100 cm

Analysis: study the electron energy spectra, profiles at several depths and depth dose curves. Discuss the results.

2) Simulate: parallel electron beam in air with a scattering foil. Other conditions: same as before.

Analysis: study the electron profiles at several depths and depth dose curve. Discuss the results.

3) Simulate: parallel electron beam in air with scattering foil and electron beam applicator impinging on a water phantom at SSD = 100 cm.

Analysis: study the electron profiles at several depths and depth dose curve. Discuss the results.

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