Abteilung für Medizinische Strahlenphysik
Inselspital, Universität Bern, Schweiz
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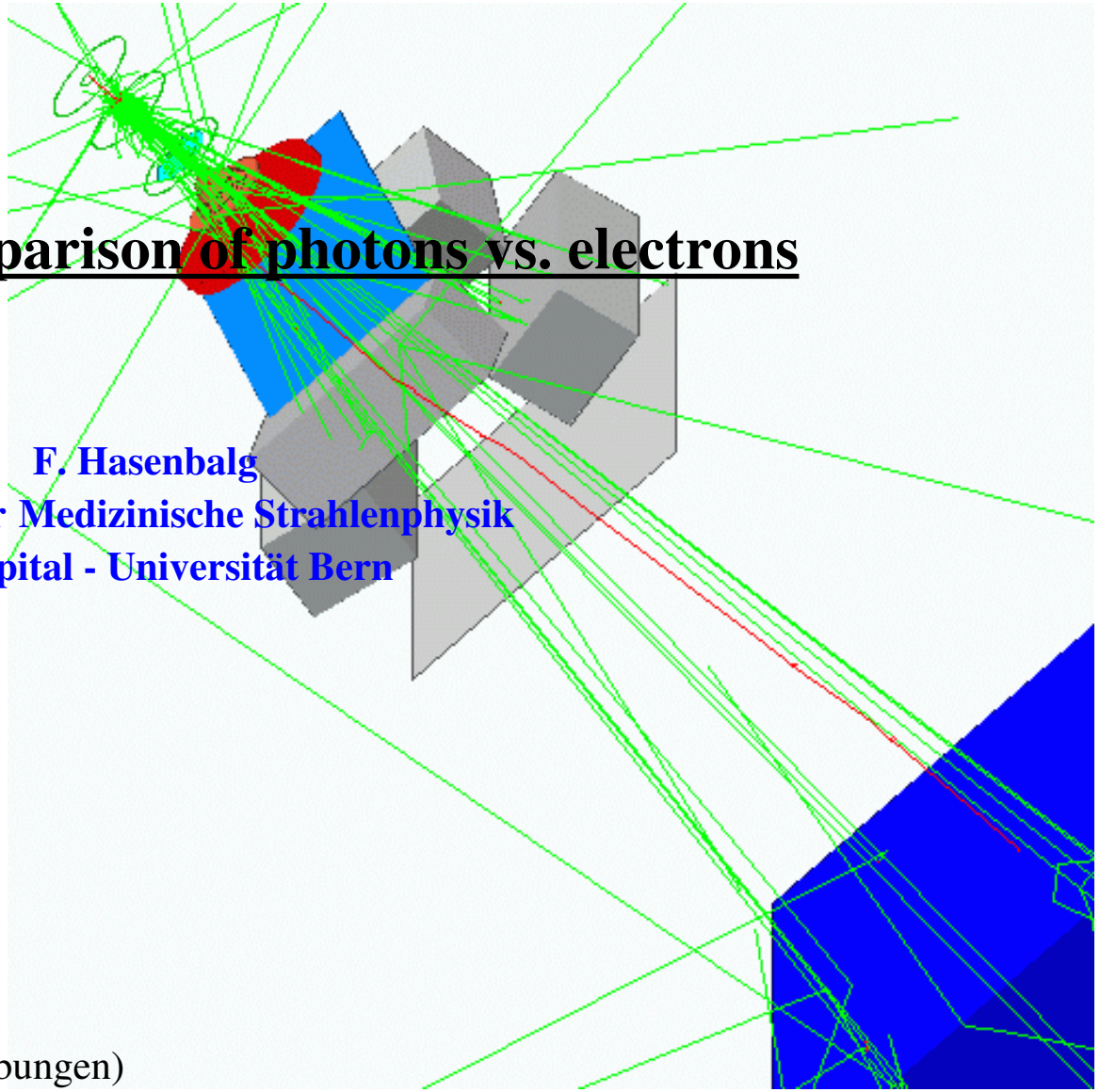
Pencil beam comparison of photons vs. electrons



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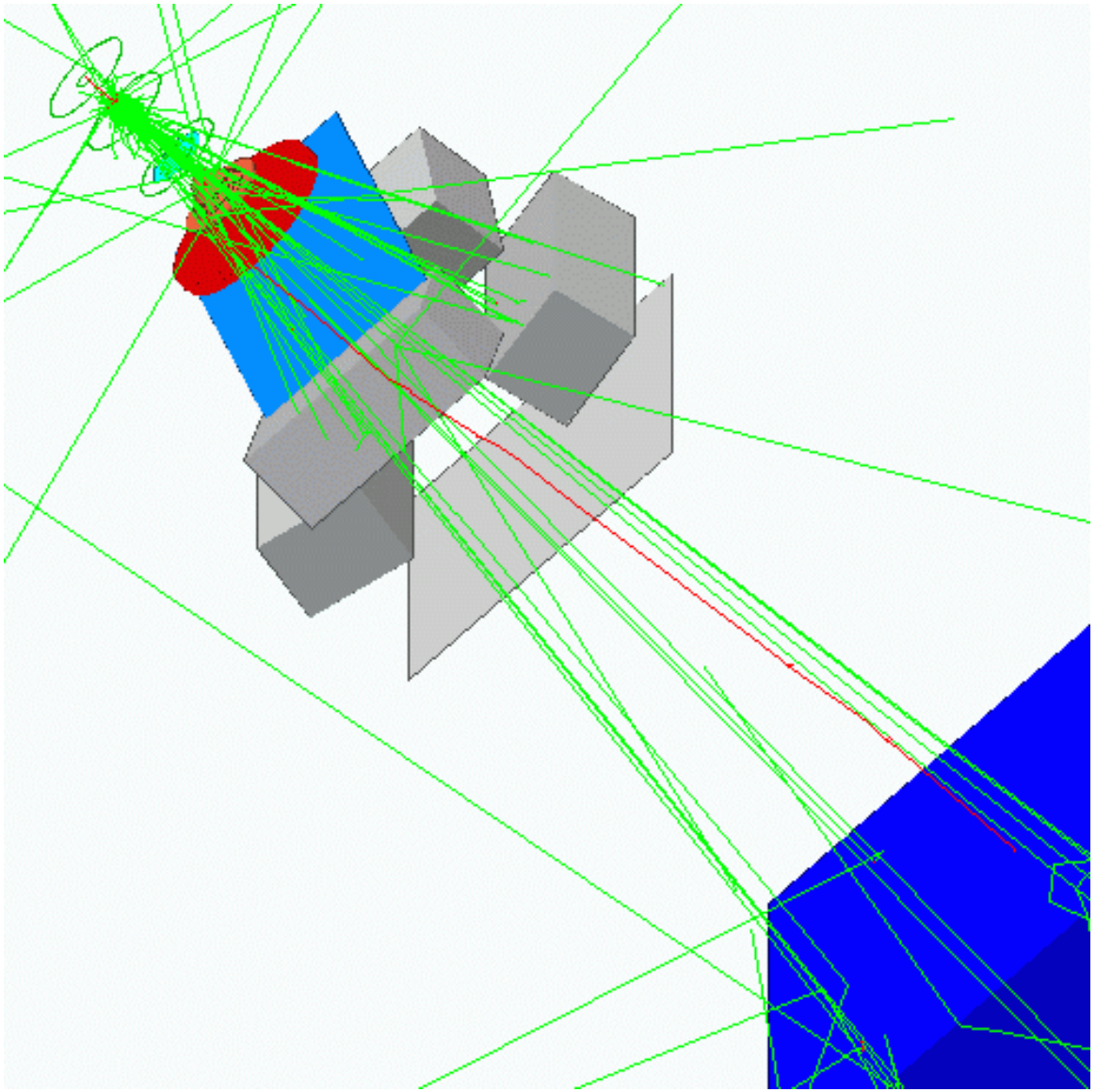
Very important warning concerning EGS-Ray

Important:

EGS-Ray can not be used under
any circumstances in the clinical practice.

EGS-Ray is only a MC
visualization tool for pedagogical purposes

Look also at page 7 of the manual
(EGS-Ray Version 1.0 Anleitung.doc).



EGS-Ray and Handouts

www.ams.unibe.ch

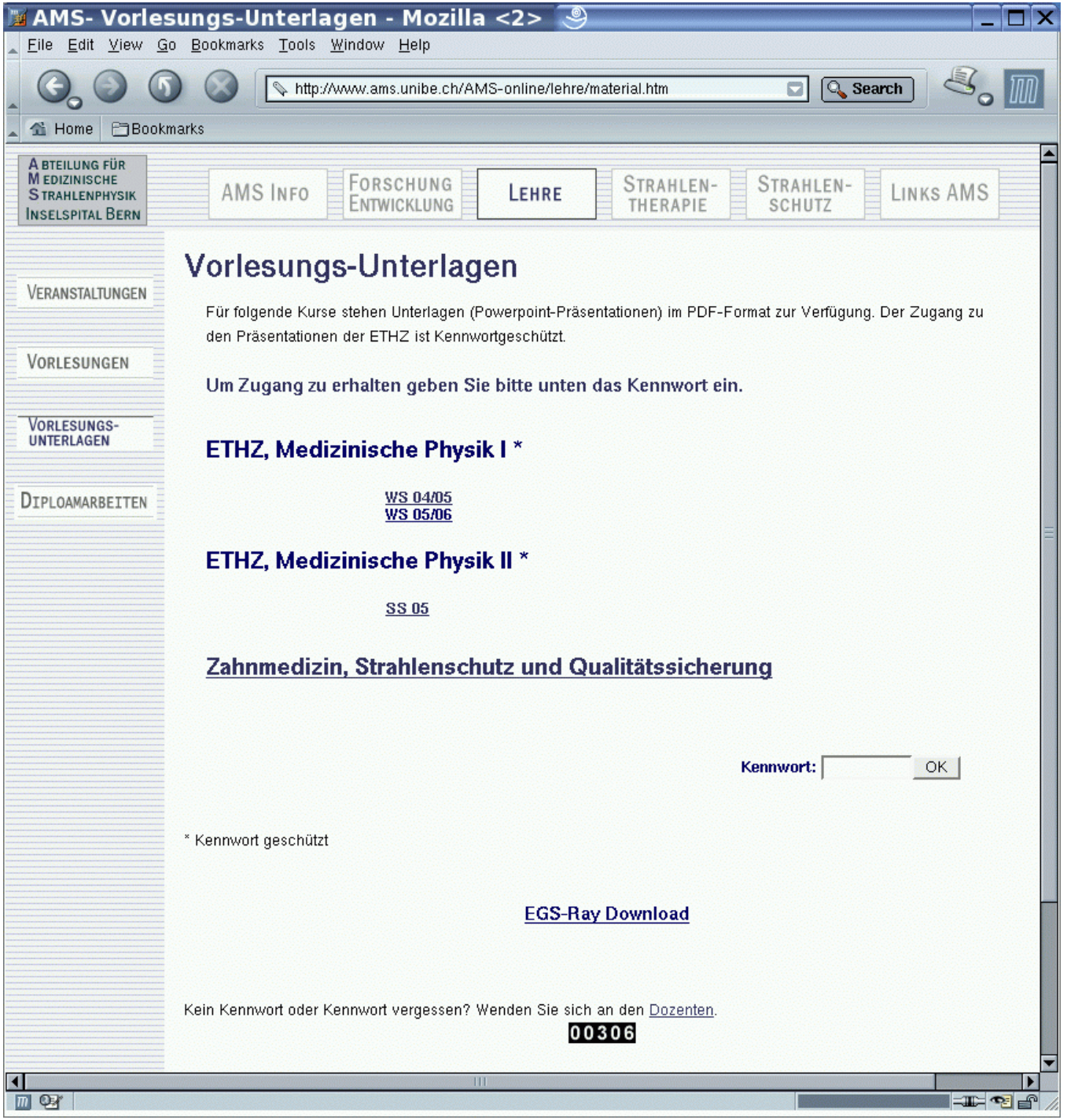
-> Lehre
-> Vorlesungs Unterlagen
-> Medizinische Physik I
-> WS 05/06
Vorlesungs-Unterlagen
Übungs-Unterlagen

Password required:

ministud

-> Lehre
-> Vorlesungs Unterlagen
-> EGSRay-Download

no password required



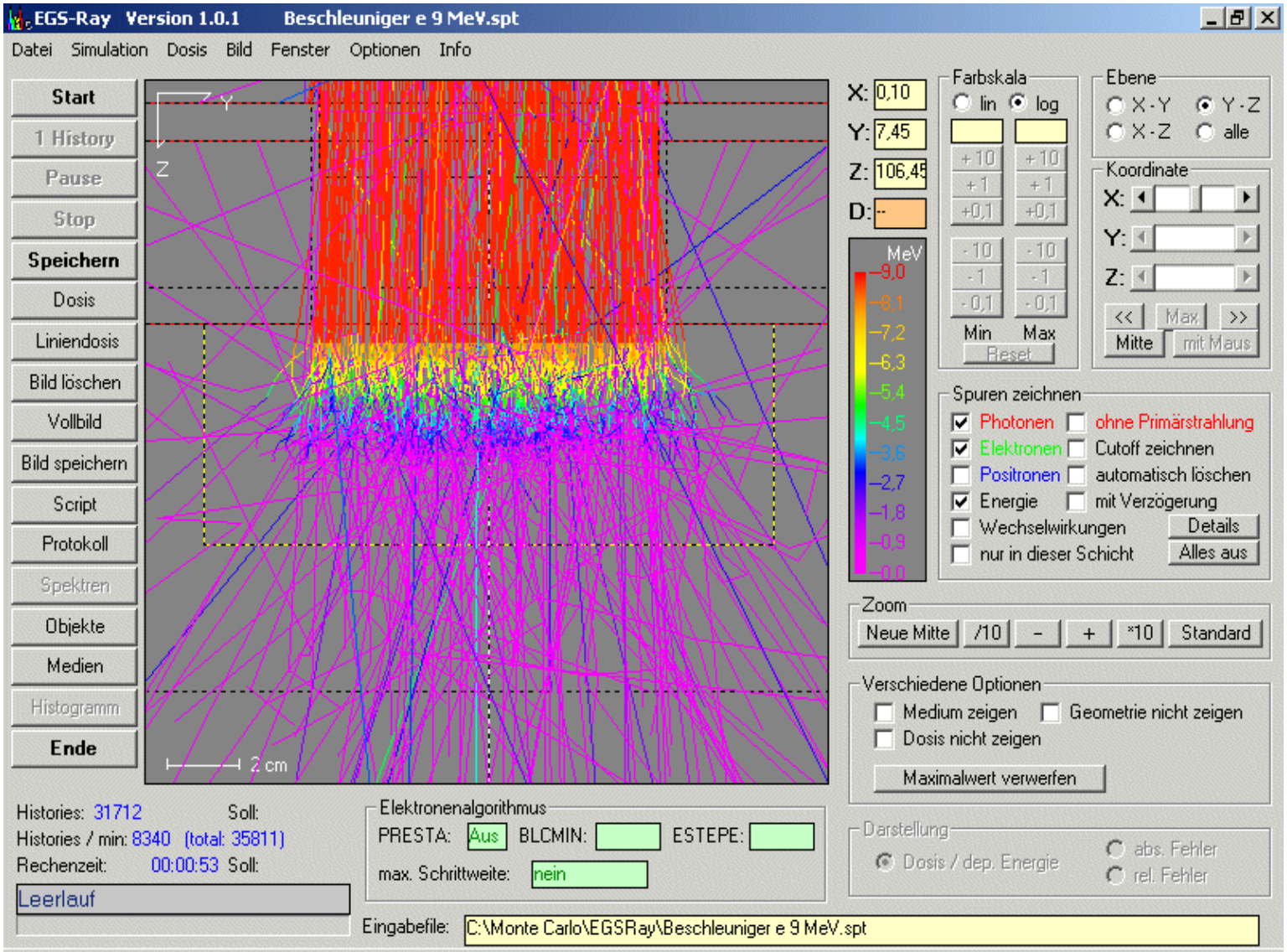
EGS-Ray

Version 1.0.1

Dr. Christoph Kleinschmidt
Städtische Kliniken Köln-Merheim

www.uni-koeln.de/~airm7/EGSRay/index.html

Installation instructions and link to download site:
www.ams.unibe.ch
-> Lehre
-> Vorlesungs Unterlagen
-> Medizinische Physik I, übungen
-> Download des EGSRay Program



EGS-Ray: a simple example

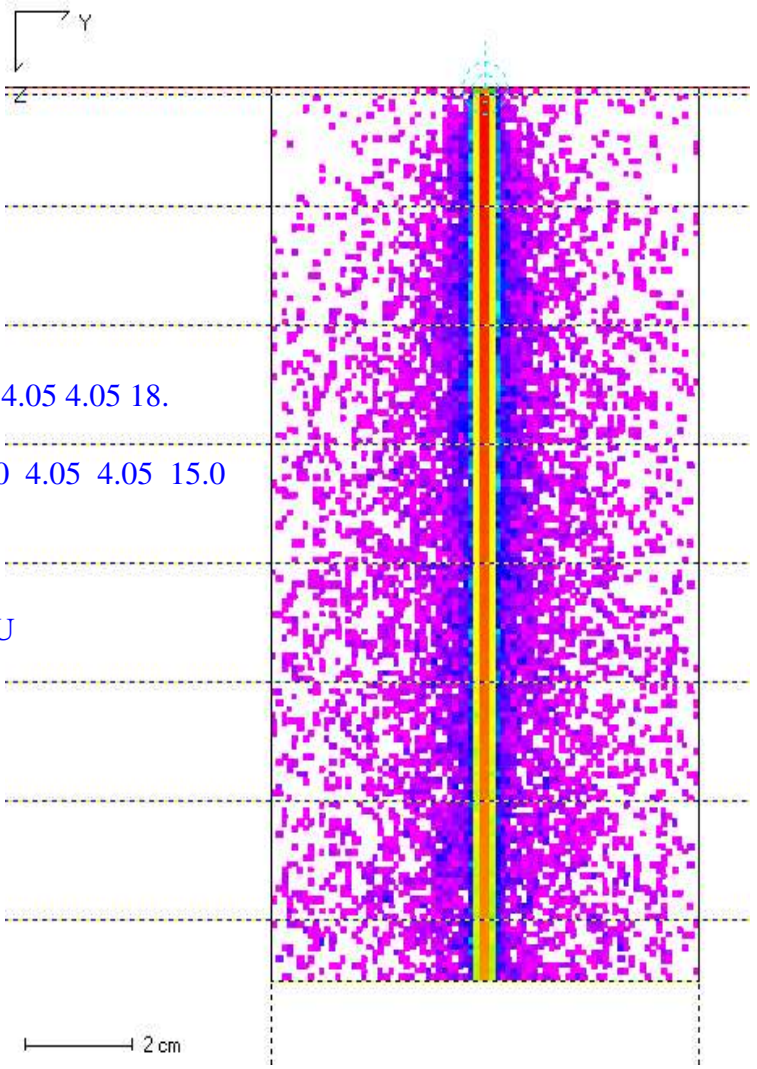
Data tables: Daten
(path to medium data file)

Particle Sources: Punkktquelle
(x,y,z coordinates)
Richtung
(z direction)
Photonen
Energie
(MeV, + 0.511 MeV for e^-, e^+)

Geometry: Rechenraum
where particles are to be computed
(x1,y1,z1 coordinates of 1 corner of a cube
x2,y2,z2 coordinates of opposing corner)
Halbraum
divides the space in 2 regions,
(Mediumname
normal to the dividing surface, z
coordinate on this axis, 0 on the z axis
positive Seitenindex ⇒ values of z > 0
belong to the object

Script file for a simple example

```
Daten
C:\EGSRay\Mediendaten\521icru.dat
Randomseed
1802 9373
Punktquelle
0. 0. 0.
Richtung
0 0 1
Photonen
Energie
1.00
Rechenraum
-4.05 -4.05 0 4.05 4.05 18.
Scoringraum
-4.05  -4.05  0  4.05  4.05  15.0
Voxelgrösse
0.1 0.1 0.1
Halbraum
H2O521ICRU
2 0 1
Histogramm
2 0.1
Histogramm
2 2.0
Histogramm
2 4.0
.....
```



Data Analysis: Scoringraum

where the doses is to be computed
at least 1 scoring room is needed inside the Recehenraum
(coordinates are given as in Rechenraum)

Voxelgrösse

together with Rechenraum and Scoring-raum have direct impact on performance
(x,y,z dimensions)

Histogramm

computes histograms of particle fluence angle and energy
(z axis, coordinate normal to this axis)

Program control:

General

Randomseed

$0 \le i \le 31328, 0 \le j \le 30081$

Physics:

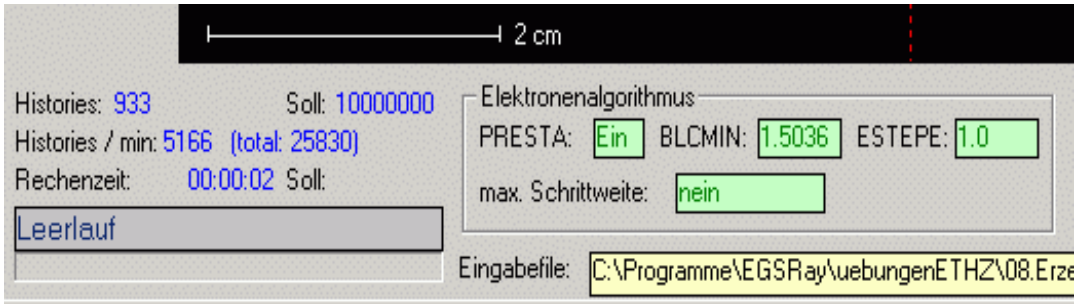
PRESTA

the electron transport algorithm

Script file for a simple example

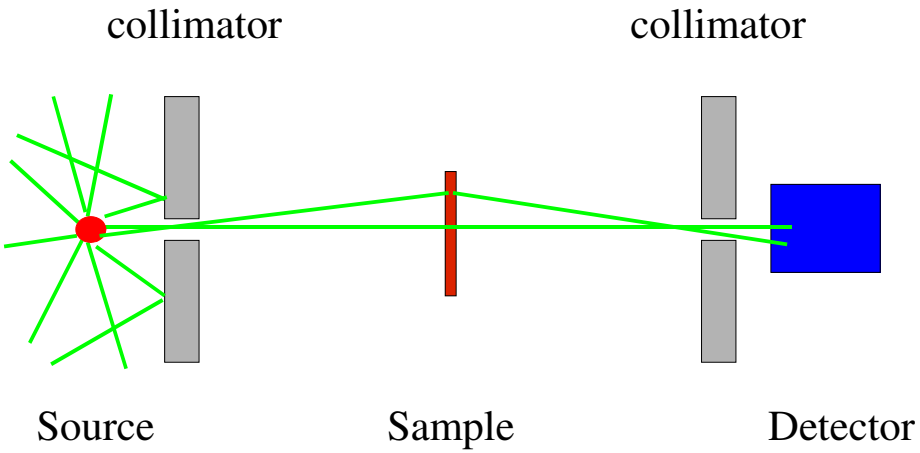
```
Daten
C:\Programme\EGSRay\521icru.dat
Randomseed
1802 9373
....

Scoringraum
-4.05  -4.05  0  4.05  4.0  15.0
Voxelgrösse
0.1 0.1 0.1
Halbraum
H2O521ICRU
2 0 1
Histogramm
2 0.1
Histogramm
2 2.5
Histogramm
2 5.0
.....
.....
Presta
```



Photon attenuation

Good geometry (narrow beam)



Narrow collimation minimizes non-direct photons

Requires a very intense source or large measuring times

From $$dN = -\mu N\, dx$$

dN: reduction in the number of photons due to interactions in a thickness dx

$$N = N_o e^{-\mu x} = N_o e^{-(\mu/\rho)\rho x} \qquad N = N_o e^{-(\mu/\rho) t} \qquad t = \rho x \qquad [t] = g/cm^2$$

μ: linear attenuation coefficient (1/cm)

μ/ρ: mass absorption coefficient (cm^2/g)

Photon attenuation

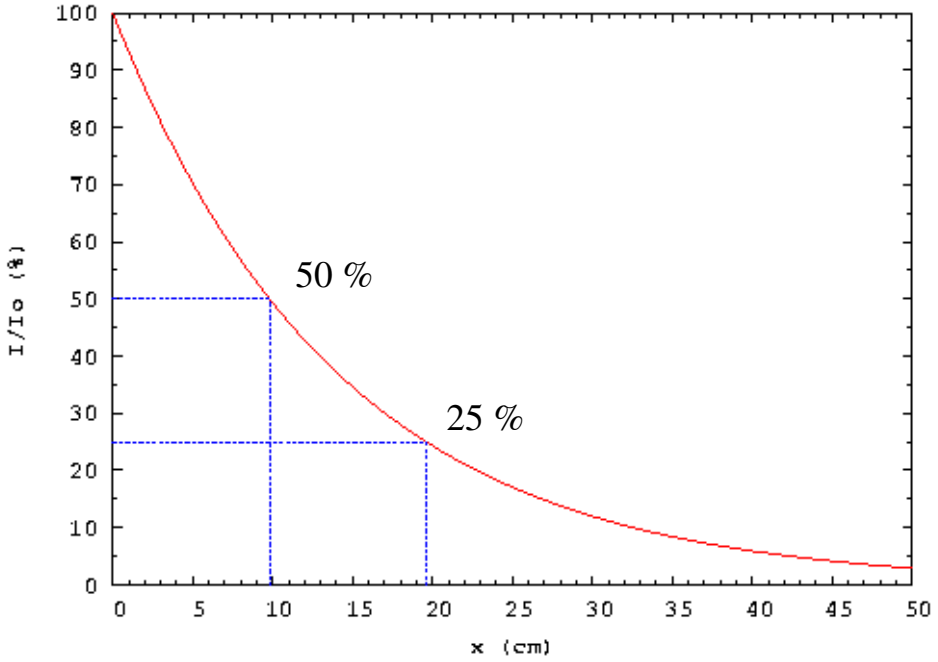
Half Value Layer HVL

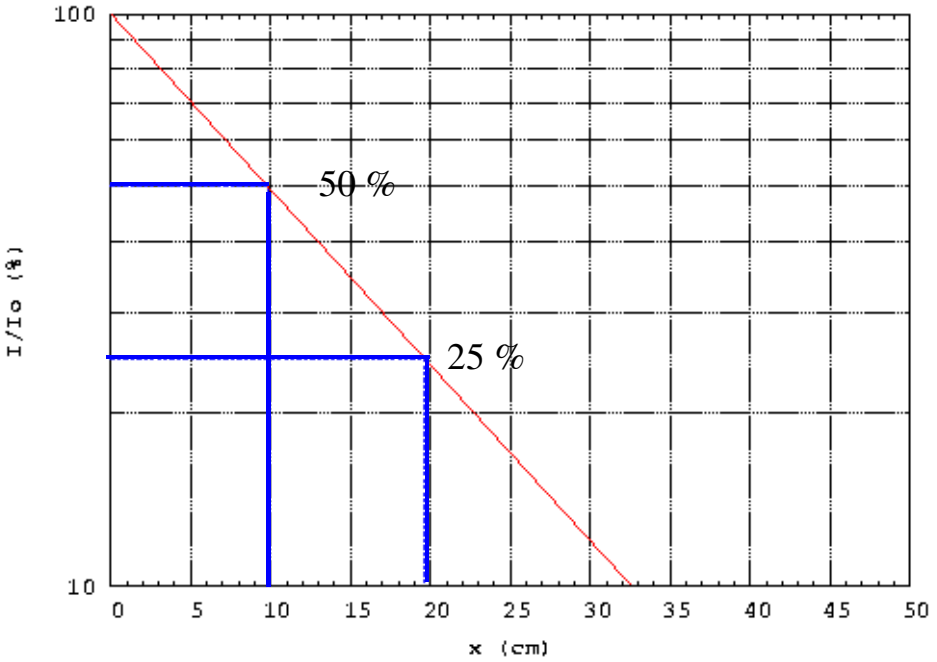
from $N = N_o e^{-\mu x}$ $N/N_o = ½ \Rightarrow ½ = e^{-\mu HVL} \Rightarrow HVL = \ln 2/\mu = 0.693/\mu$

$$N = N_o e^{-\ln 2\, x / HVL}$$

Mean range of photons

$$\bar{R} = 1/\mu = 1.44\ HVL$$



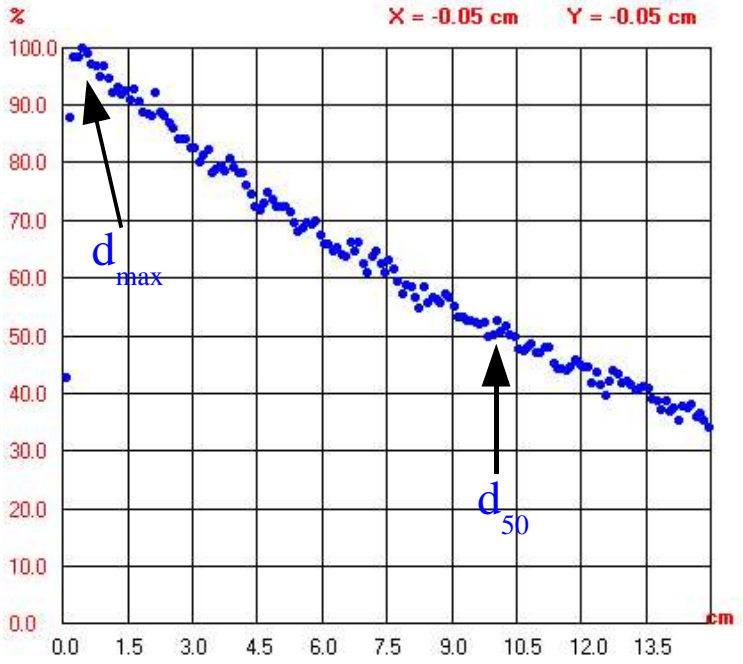


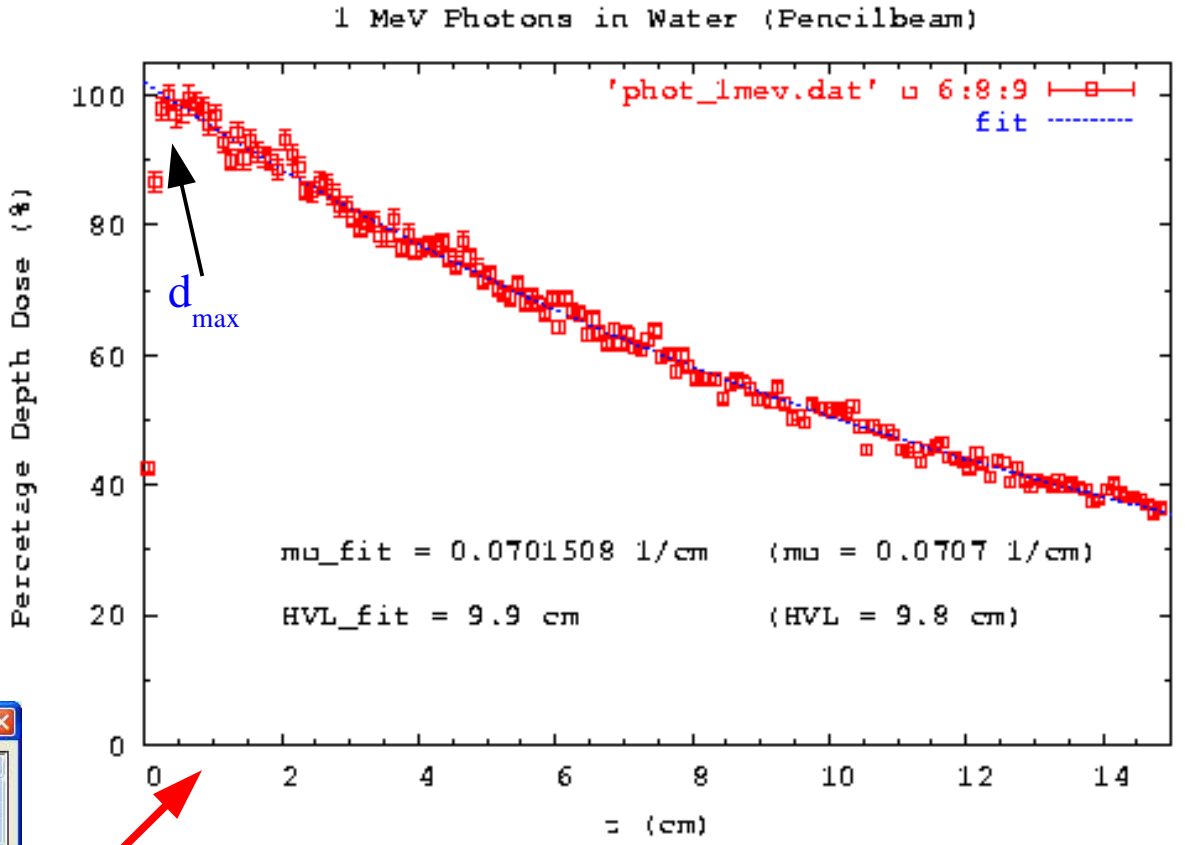
Example: 1 MeV photons in water (pencil beam ≈ "narrow beam")

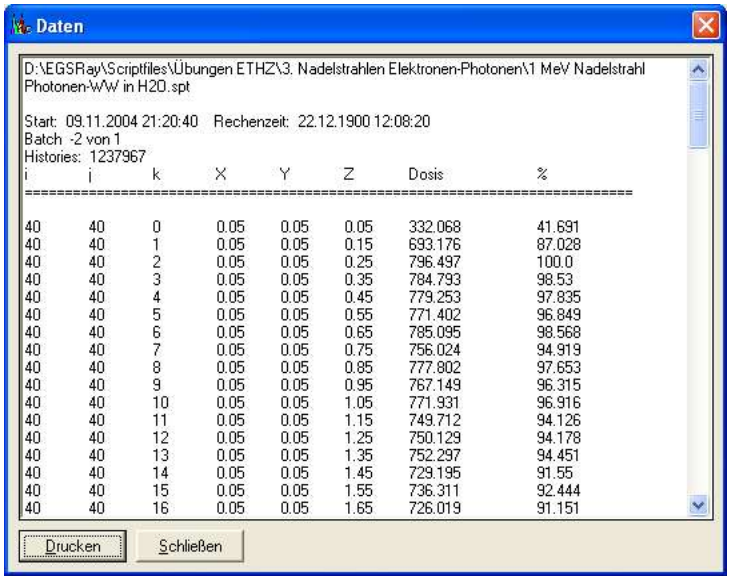
$\mu = 0.07072$ 1/cm $\rho = 1$ g/cm^3 $\mu/\rho = 0.0707$ cm^2/g (H. Krieger Table 17-4)

HVL = 9.8 cm

Photon attenuation in water (1 MeV photons)







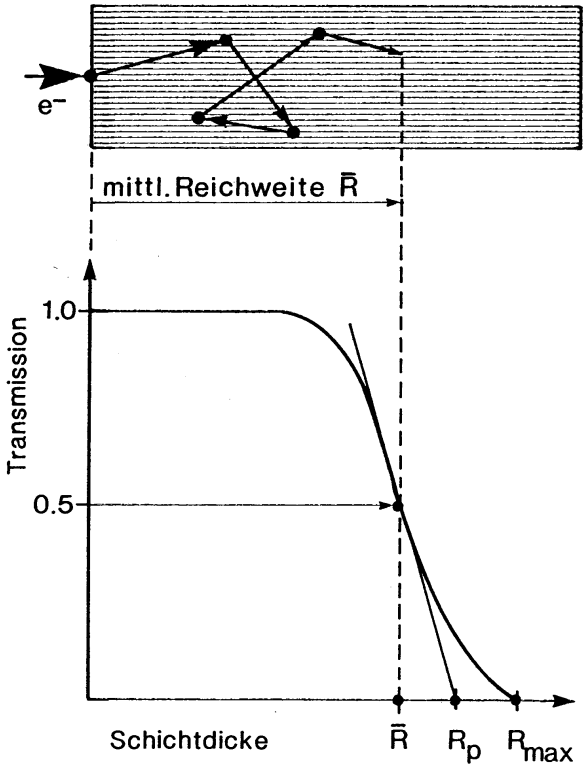
Gnuplot commands to do a simple fit:

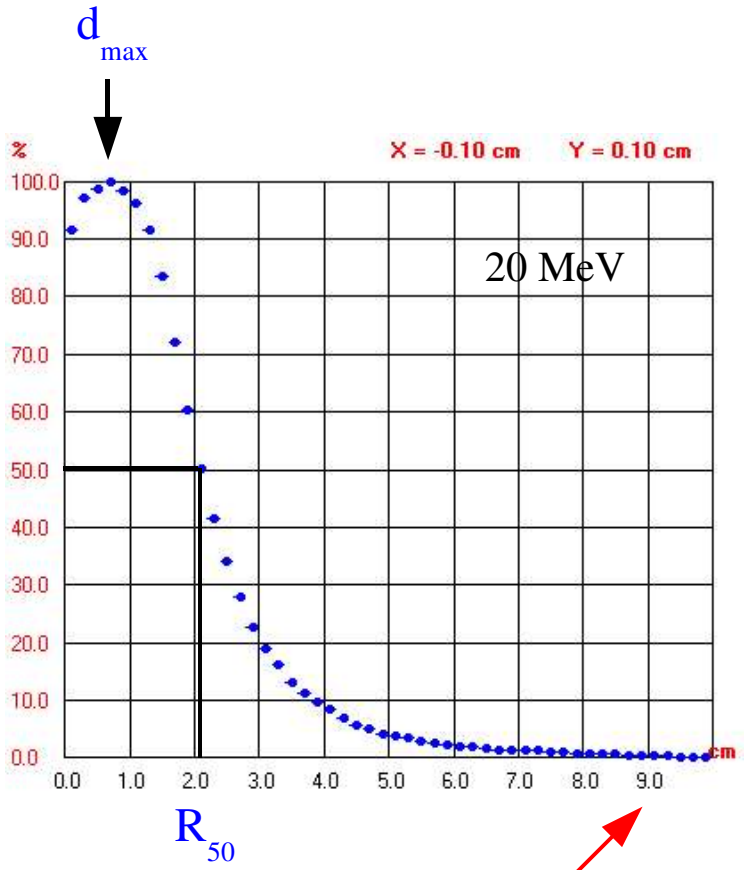
```
gnuplot> plot 'phot_1mev.dat' u 6:8:9 w errorb 1 3
gnuplot> mu = 0.07
gnuplot> dmax = 0.4
gnuplot> y(x) = 100.*exp(-mu*(x-dmax))
gnuplot> fit [0.4:15] y(x) 'phot_1mev.dat' u 6:8:9 via mu, dmax
gnuplot> plot 'phot_1mev.dat' u 6:8:9 w errorb 1 3, y(x) w lin 3
```

initial parameters

function to fit

Electron range in water





20 MeV electrons in water

scoring space only 10 cm !

Assignment 01 (cont.)

Add to the previous example 20 MeV

Simulate: Photon pencil beams E = 1, 10, 20 MeV
Electron pencil beams E = 1, 10, 20 MeV
impinging on a water phantom
scoring dimensions and voxel size adapted to each case
enough statistics (≈ 10^6 particles)

Analysis: Photons: d_{max}, d_{50}, HVL and μ from depth dose curves
(compare μ with table values, Table 17.4 H. Krieger)
qualitative description of the profiles at several depths

Electrons: d_{max}, R_{50} from depth dose curves
qualitative description of the profiles at several depths

Briefly describe the qualitative differences between electrons and photons