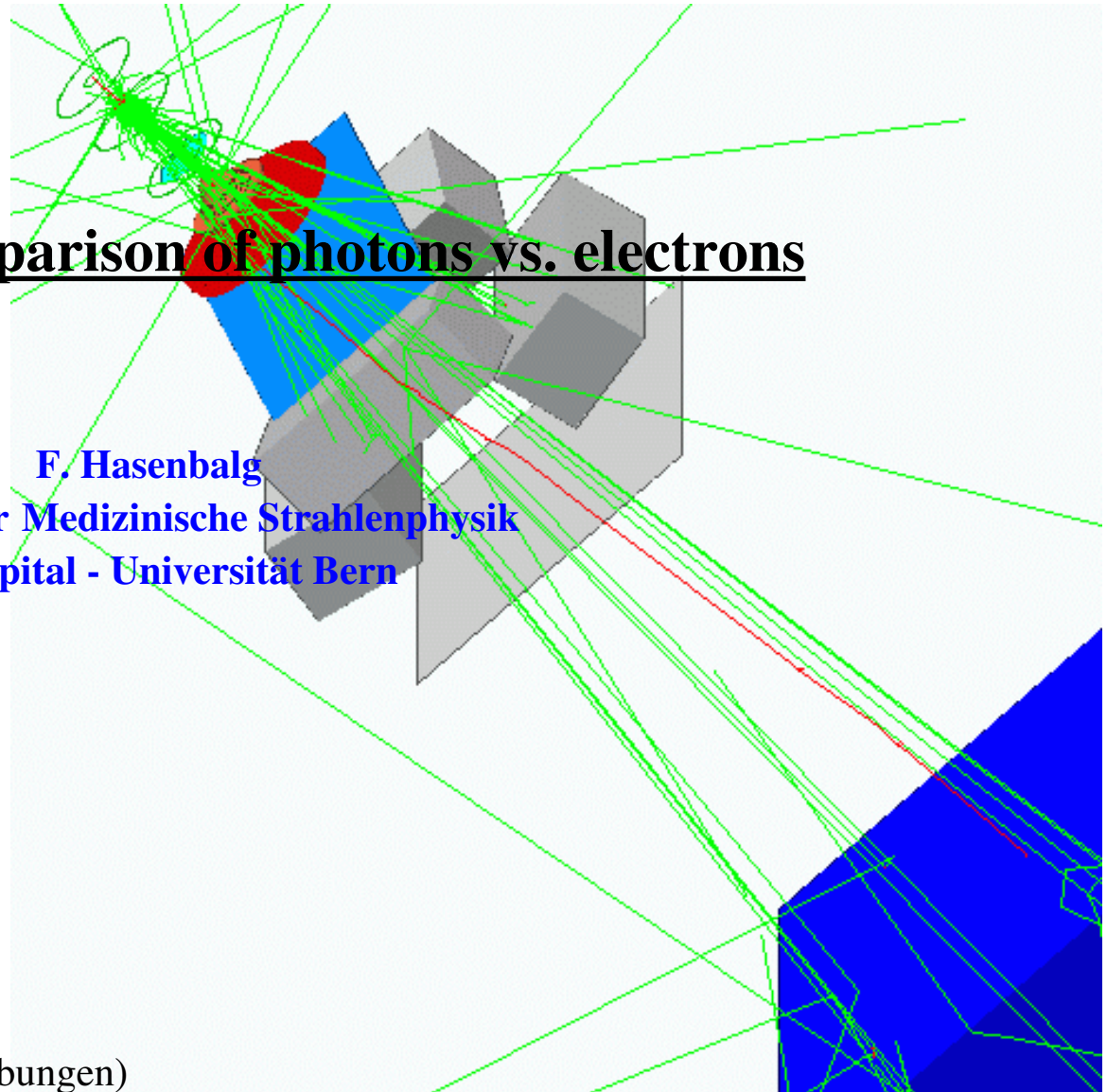




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Pencil beam comparison of photons vs. electrons

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Inselspital - Universität Bern



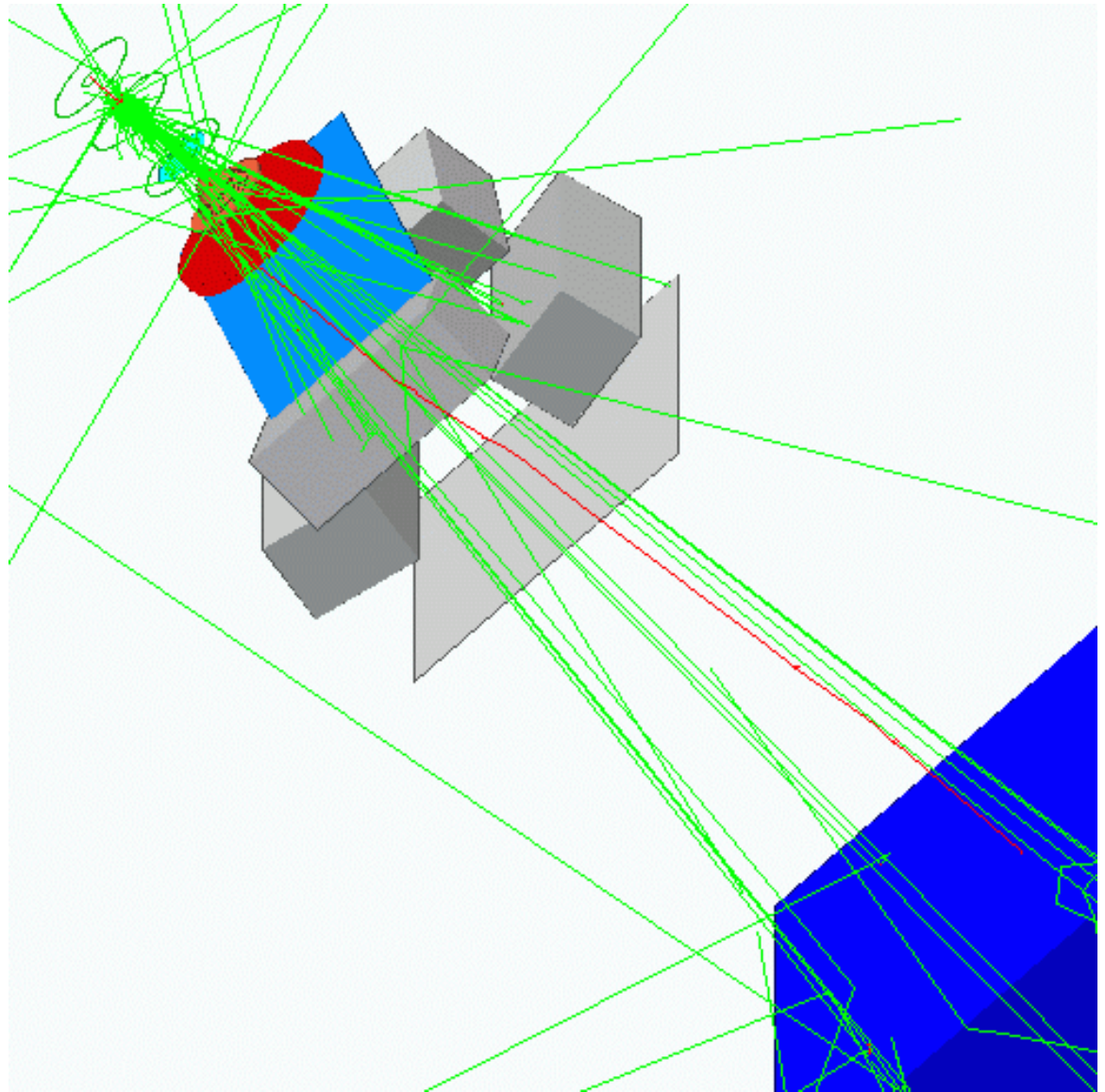
Very important warning concerning EGS-Ray

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

The screenshot shows a Mozilla browser window titled "AMS- Vorlesungs-Unterlagen - Mozilla <2>". The address bar displays the URL "http://www.ams.unibe.ch/AMS-online/lehre/material.htm". The browser's menu bar includes File, Edit, View, Go, Bookmarks, Tools, Window, and Help. The page features a navigation bar with links: AMS INFO, FORSCHUNG ENTWICKLUNG, LEHRE, STRAHLEN-THERAPIE, STRAHLEN-SCHUTZ, and LINKS AMS. A sidebar on the left contains links for VERANSTALTUNGEN, VORLESUNGEN, VORLESUNGS-UNTERLAGEN, and DIPLOMARBEITEN. The main content area is titled "Vorlesungs-Unterlagen" and contains the following text: "Für folgende Kurse stehen Unterlagen (Powerpoint-Präsentationen) im PDF-Format zur Verfügung. Der Zugang zu den Präsentationen der ETHZ ist Kennwortgeschützt." followed by "Um Zugang zu erhalten geben Sie bitte unten das Kennwort ein." Below this, there are three course listings: "ETHZ, Medizinische Physik I *" with links for "WS 04/05" and "WS 05/06"; "ETHZ, Medizinische Physik II *" with a link for "SS 05"; and "Zahnmedizin, Strahlenschutz und Qualitätssicherung". At the bottom right, there is a password field labeled "Kennwort:" with an "OK" button. A note at the bottom left states "* Kennwort geschützt". A link for "EGS-Ray Download" is located at the bottom center. At the very bottom, a footer line reads "Kein Kennwort oder Kennwort vergessen? Wenden Sie sich an den Dozenten." followed by the number "00306".

EGS-Ray

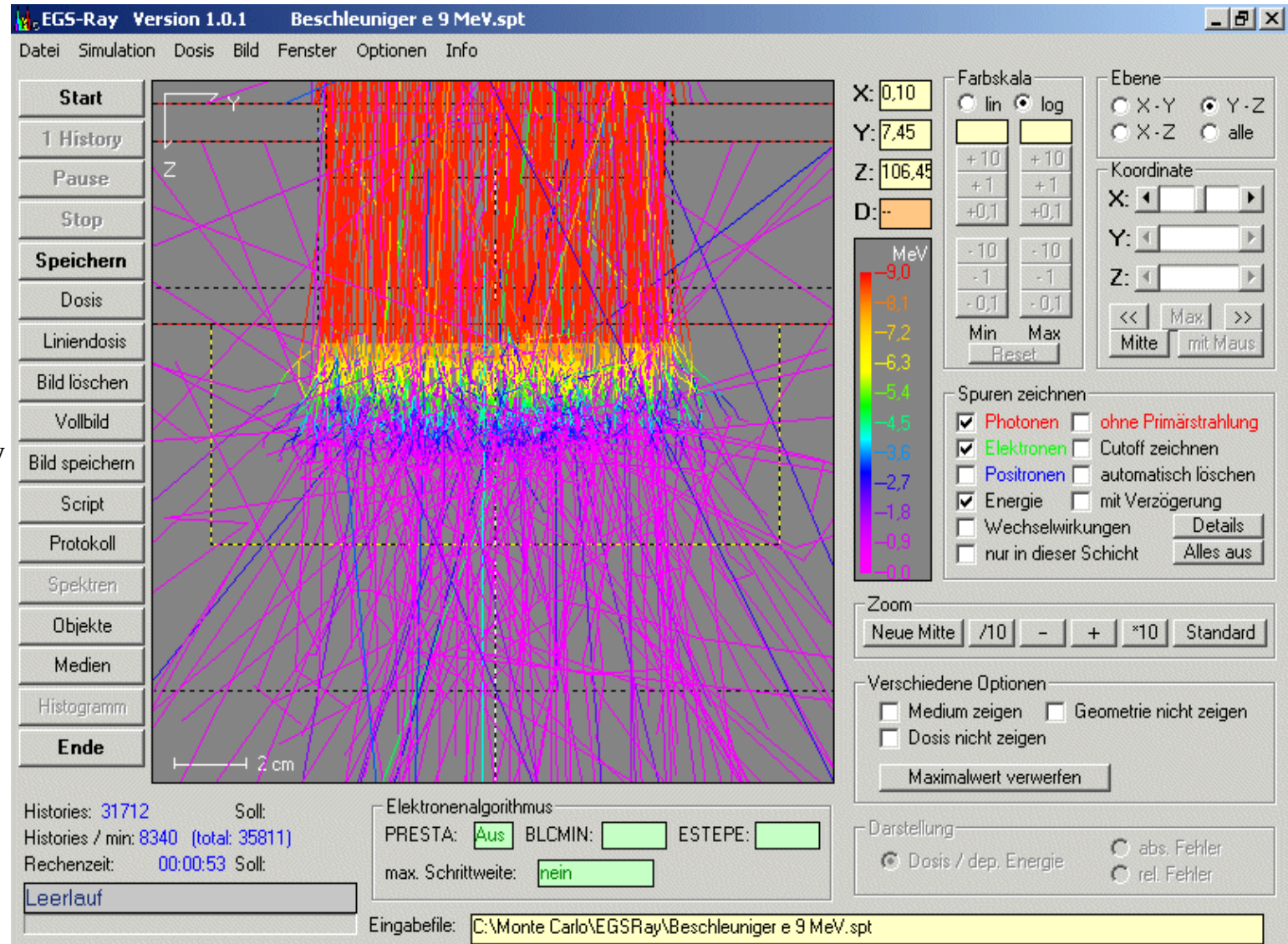
Version 1.0.1

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

Script file for a simple example

Data tables: **Daten**

(path to medium data file)

Particle Sources: **Punktquelle**

(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

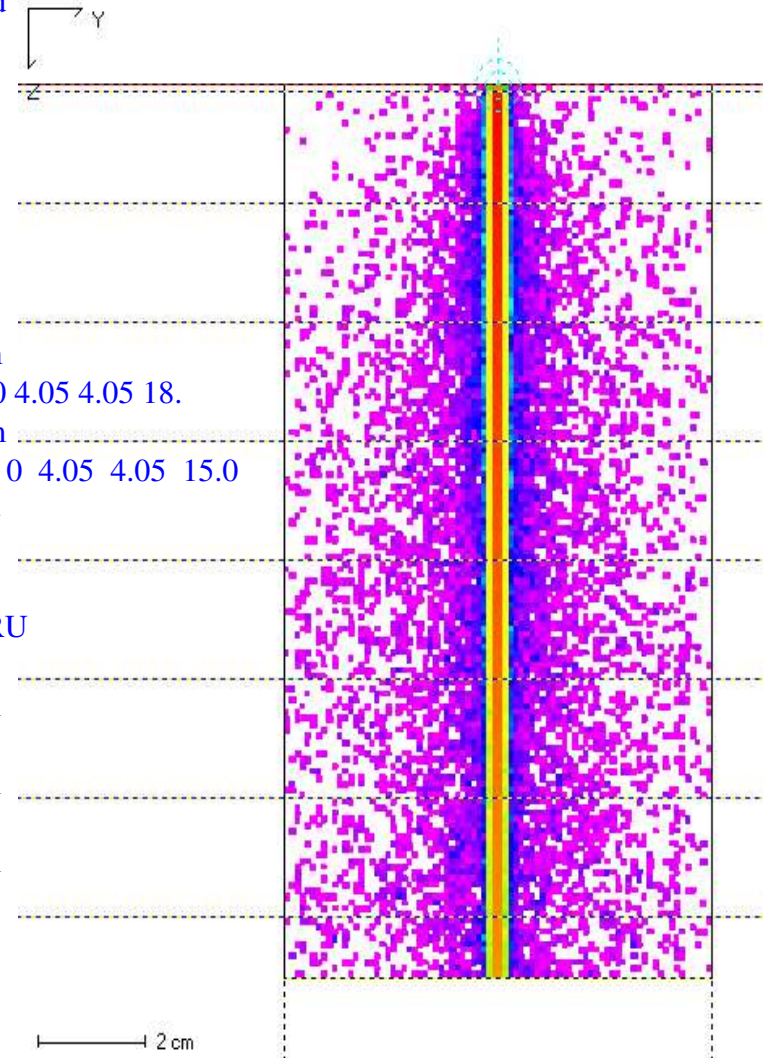
normal to the dividing surface, z

coordinate on this axis, 0 on the z axis

positive Seitenindex \Rightarrow values of $z > 0$

belong to the object

```
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
Rechenraum

(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

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

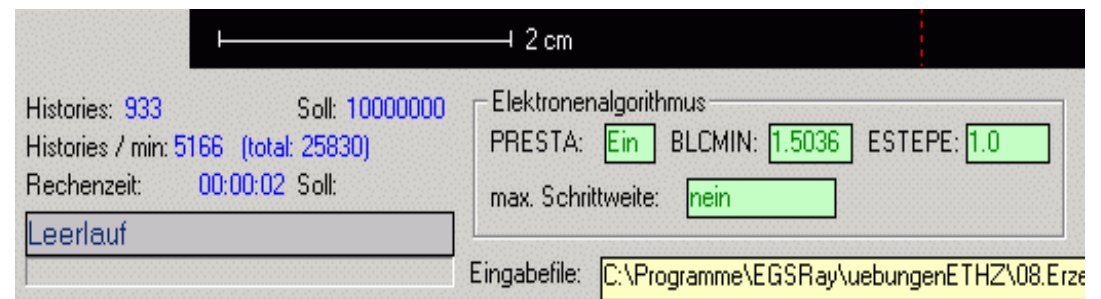
Physics:

PRESTA

the electron transport
algorithm

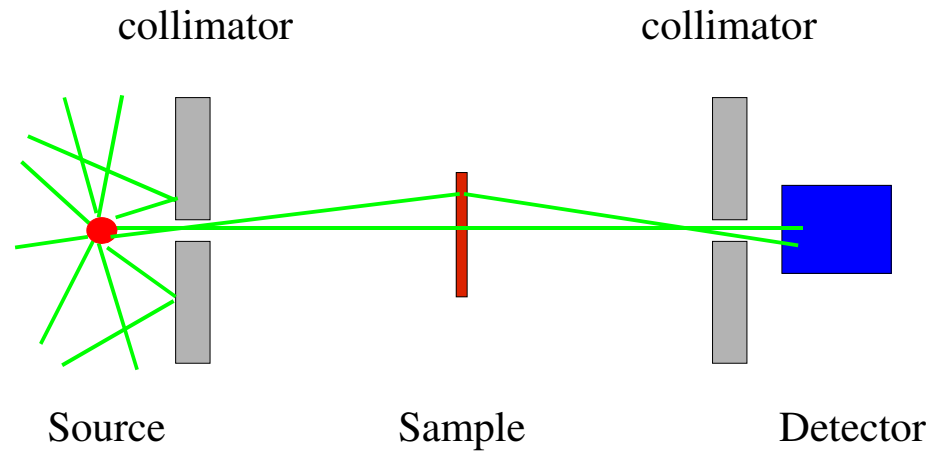
Script file for a simple example

```
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

$$N = N_0 e^{-\mu x} = N_0 e^{-(\mu/\rho) \rho x} \quad N = N_0 e^{-(\mu/\rho) t} \quad t = \rho x \quad [t] = \text{g/cm}^2$$

μ : linear attenuation coefficient
(1/cm)

μ/ρ : mass absorption coefficient
(cm²/g)

Photon attenuation

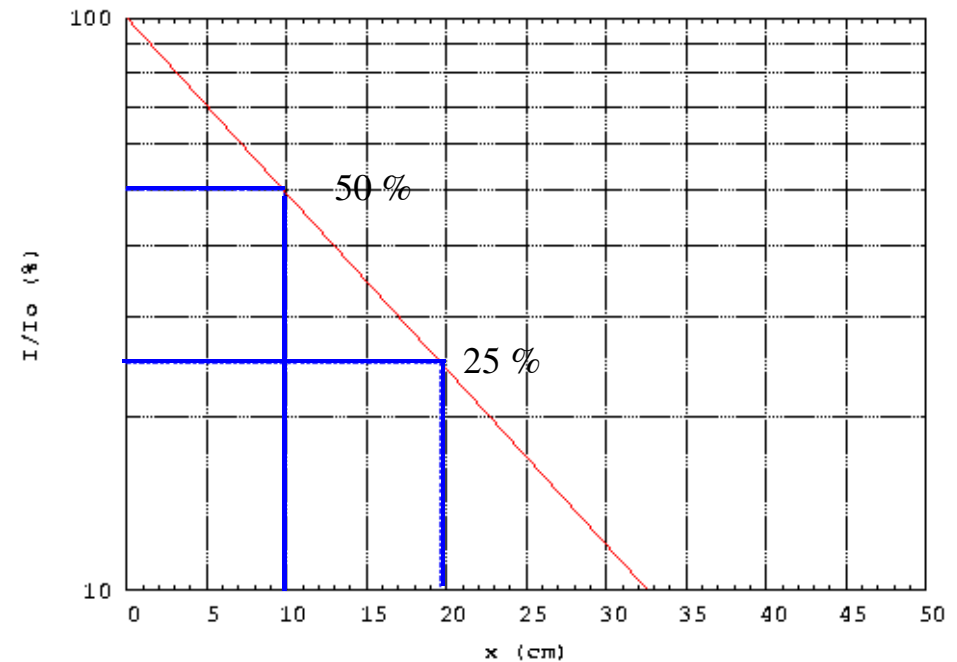
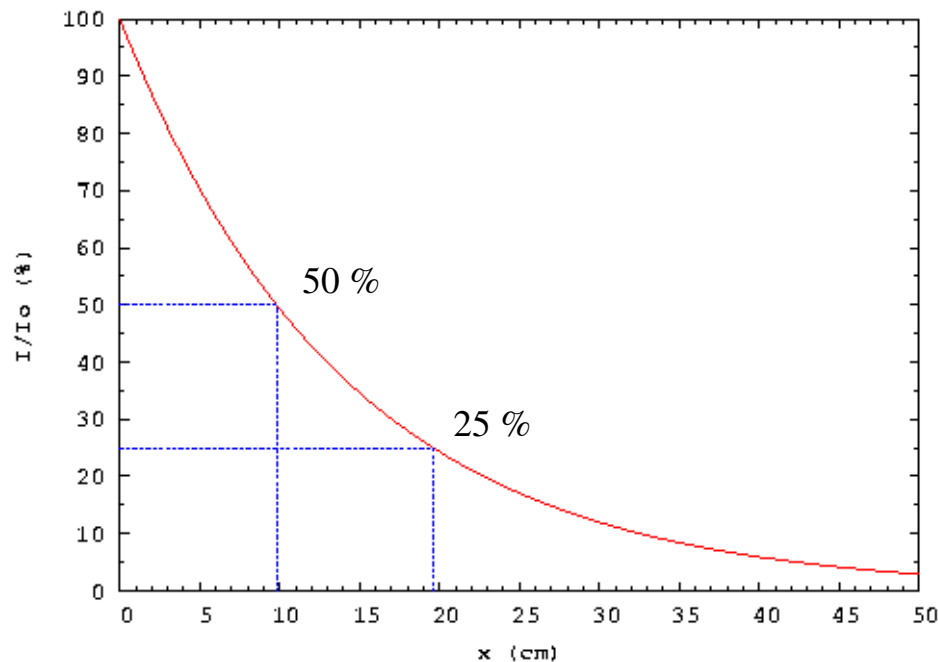
Half Value Layer HVL

$$\text{from } N = N_0 e^{-\mu x} \quad N/N_0 = 1/2 \Rightarrow 1/2 = e^{-\mu \text{HVL}} \Rightarrow \text{HVL} = \ln 2 / \mu = 0.693 / \mu$$

$$N = N_0 e^{-\ln 2 x / \text{HVL}}$$

Mean range of photons

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

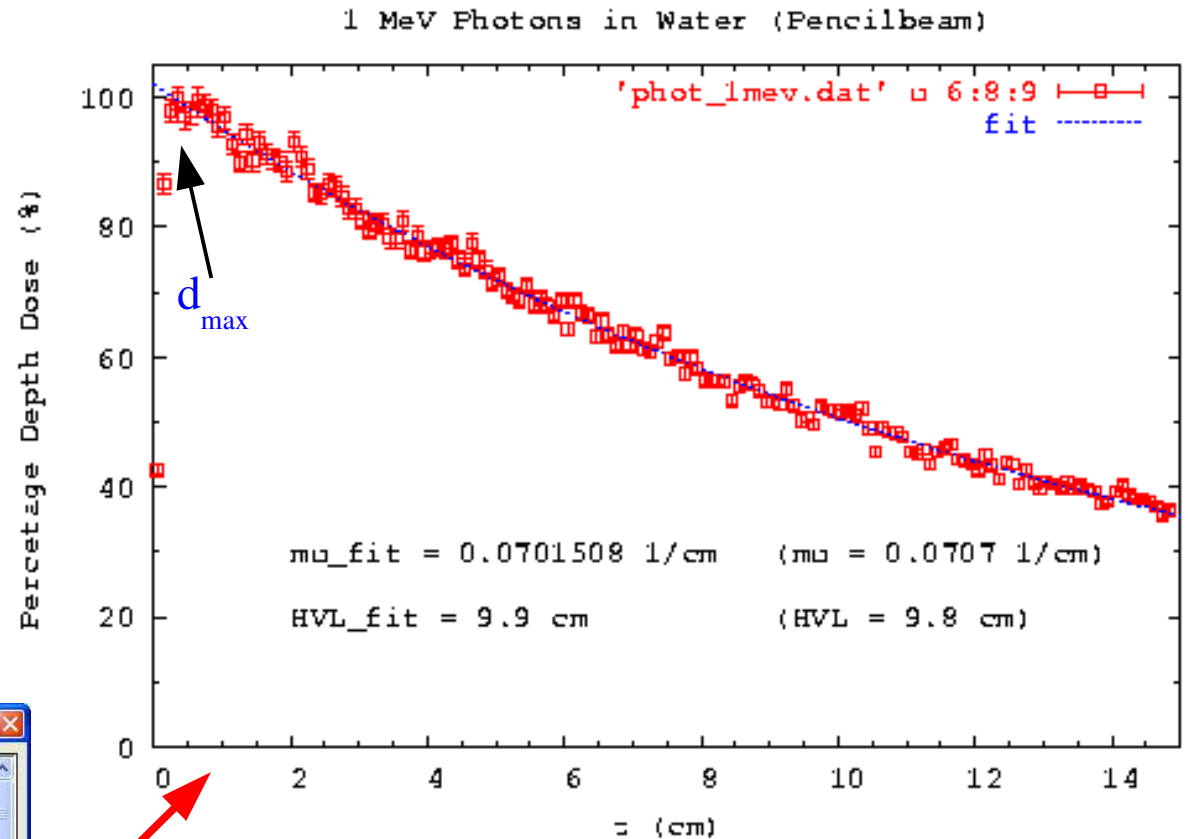
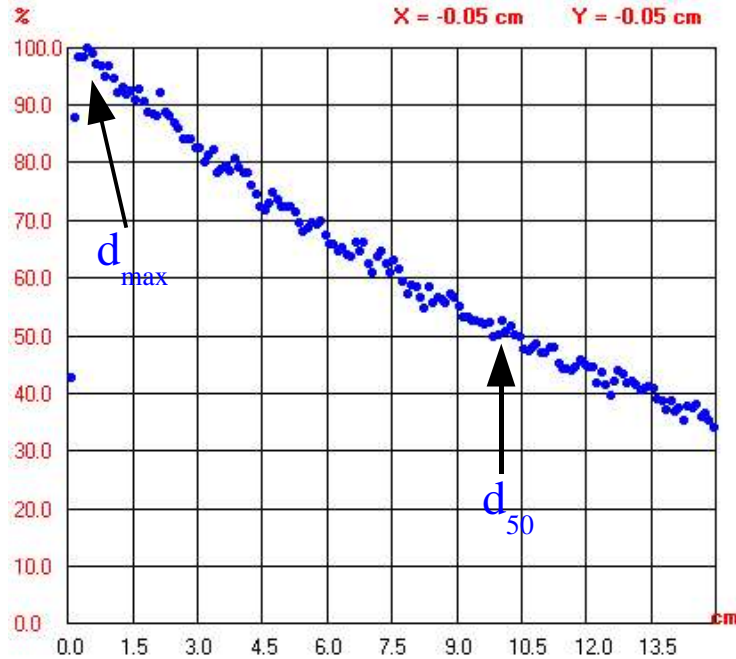


Example: 1 MeV photons in water (pencil beam \approx “narrow beam”)

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

$$\text{HVL} = 9.8 \text{ cm}$$

Photon attenuation in water (1 MeV photons)



Daten

D:\EGSRay\Scriptfiles\Übungen ETHZ\3. Nadelstrahlen Elektronen-Photonen\1 MeV Nadelstrahl
Photonen-WW in H2O.spt

Start: 09.11.2004 21:20:40 Rechenzeit: 22.12.1900 12:08:20

Batch: -2 von 1

Histories: 1237967

i	k	X	Y	Z	Dosis	%
40	40	0	0.05	0.05	332.068	41.691
40	40	1	0.05	0.05	693.176	87.028
40	40	2	0.05	0.05	796.497	100.0
40	40	3	0.05	0.05	784.793	98.53
40	40	4	0.05	0.05	779.253	97.835
40	40	5	0.05	0.05	771.402	96.849
40	40	6	0.05	0.05	765.095	95.568
40	40	7	0.05	0.05	756.024	94.919
40	40	8	0.05	0.05	747.802	93.653
40	40	9	0.05	0.05	737.149	92.315
40	40	10	0.05	0.05	729.931	91.916
40	40	11	0.05	0.05	749.712	94.126
40	40	12	0.05	0.05	750.129	94.178
40	40	13	0.05	0.05	752.297	94.451
40	40	14	0.05	0.05	729.195	91.55
40	40	15	0.05	0.05	736.311	92.444
40	40	16	0.05	0.05	726.019	91.151

Drucken Schließen

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

initial parameters

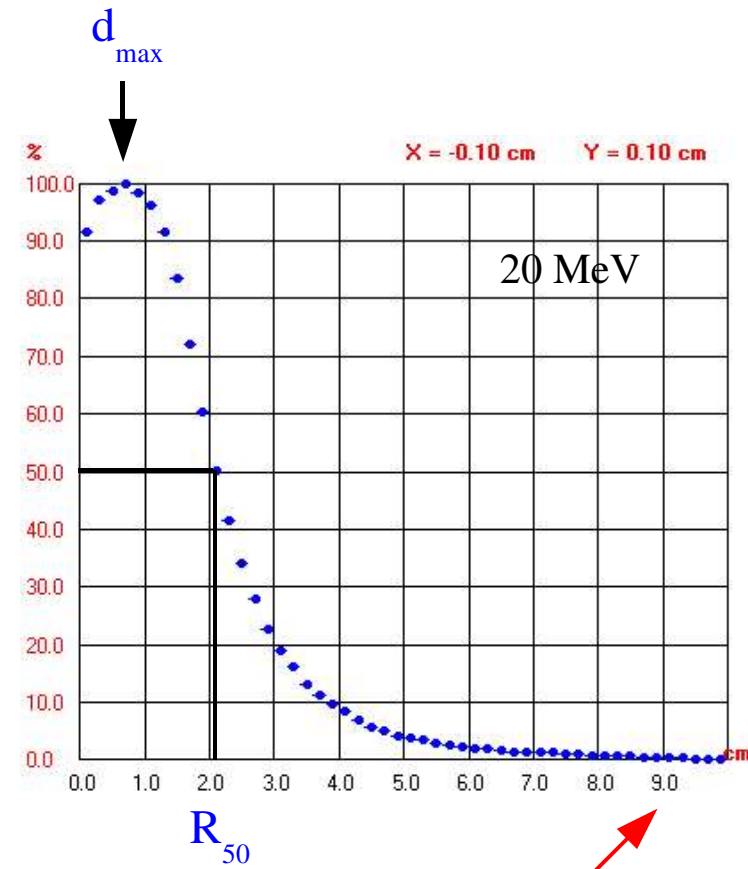
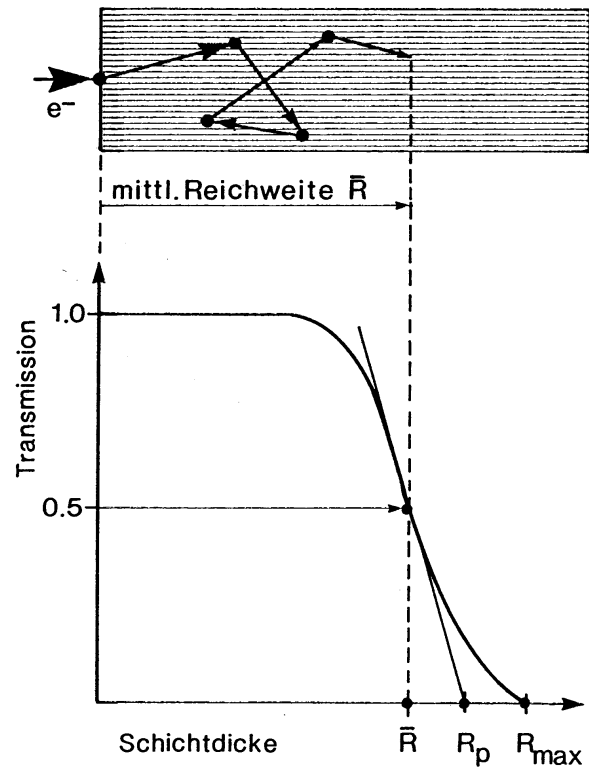
gnuplot> y(x) = 100.*exp(-mu*(x-dmax))

function to fit

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

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 $E = 1, 10, 20 \text{ MeV}$
Electron pencil beams $E = 1, 10, 20 \text{ MeV}$
impinging on a water phantom
scoring dimensions and voxel size adapted to each case
enough statistics ($\approx 10^6$ 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