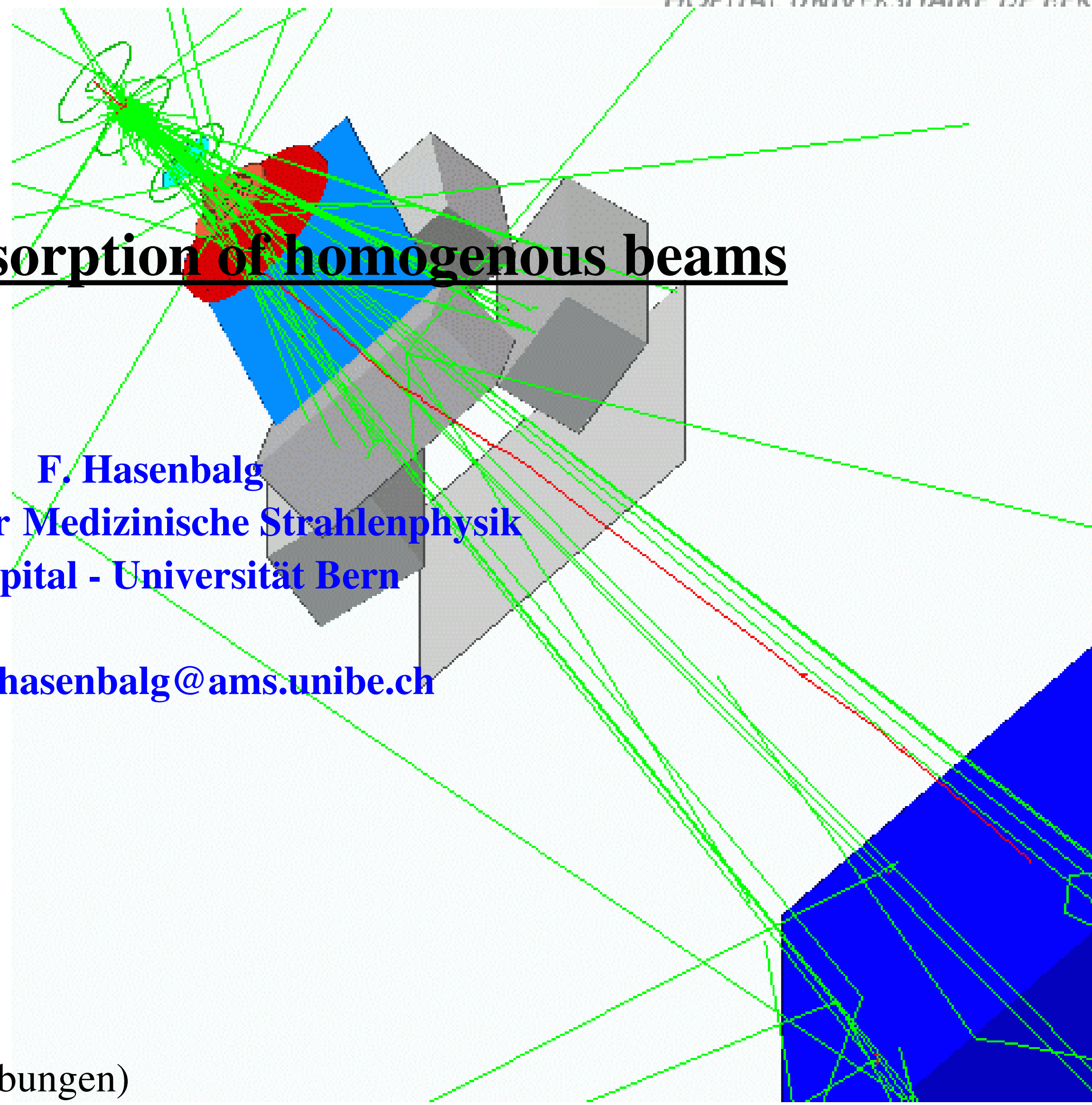

# Electron absorption of homogenous beams


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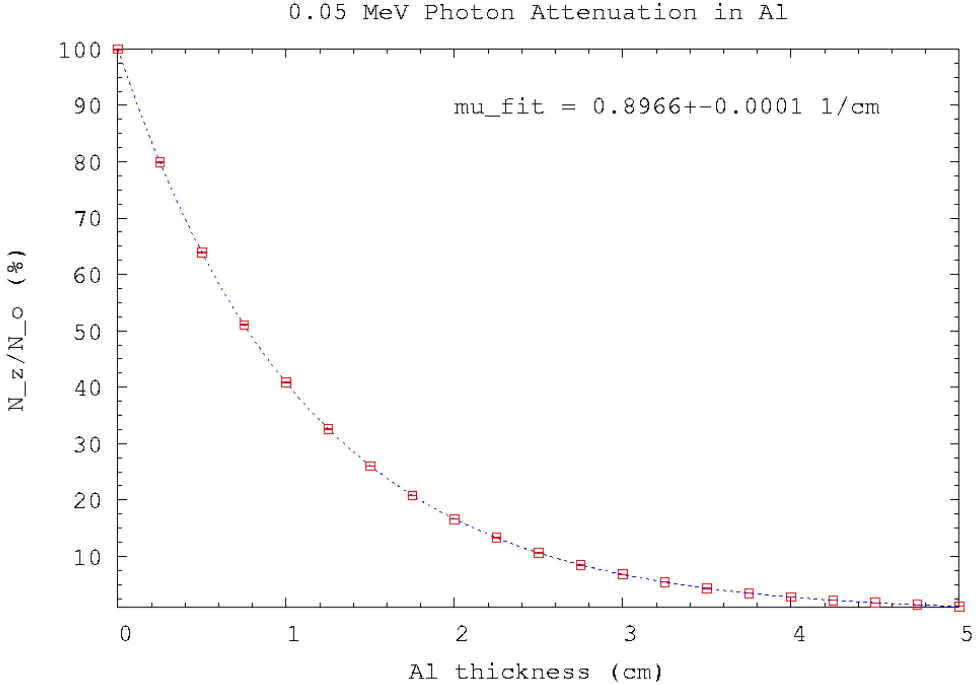
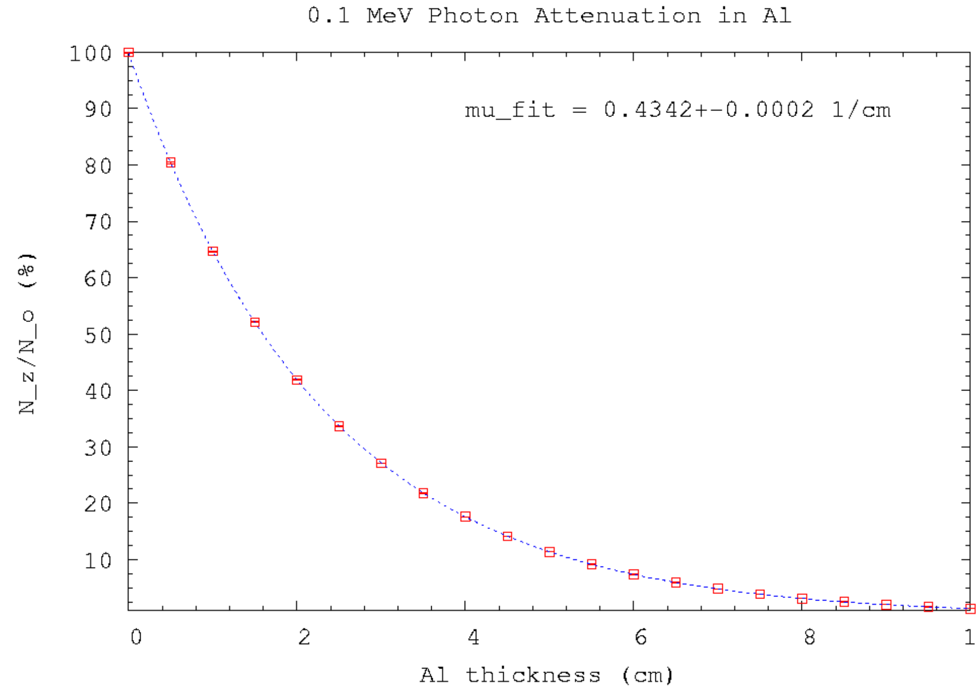
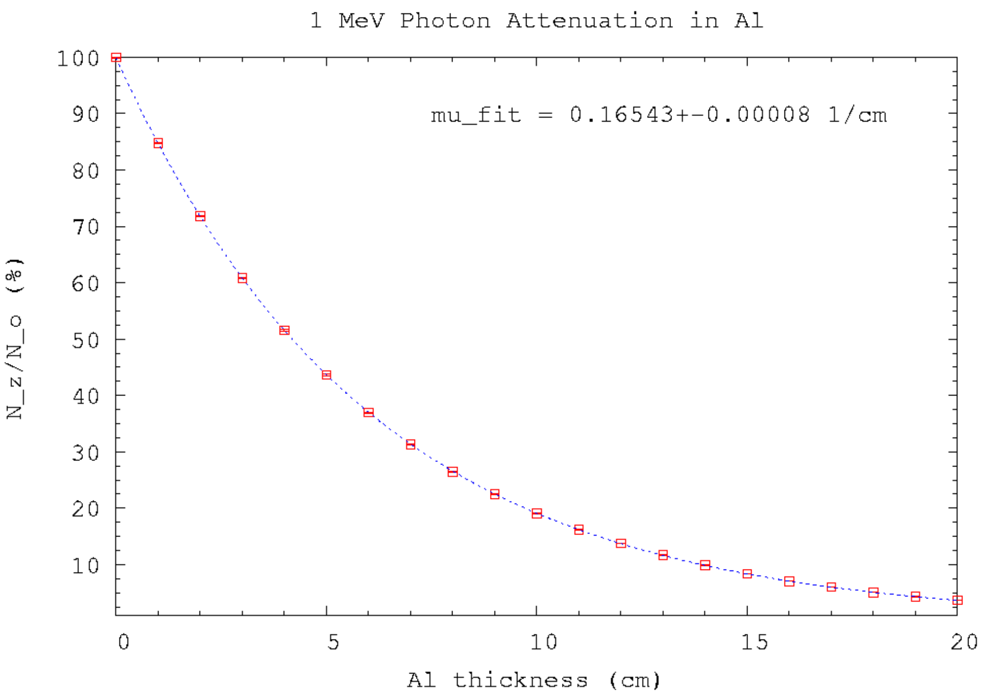
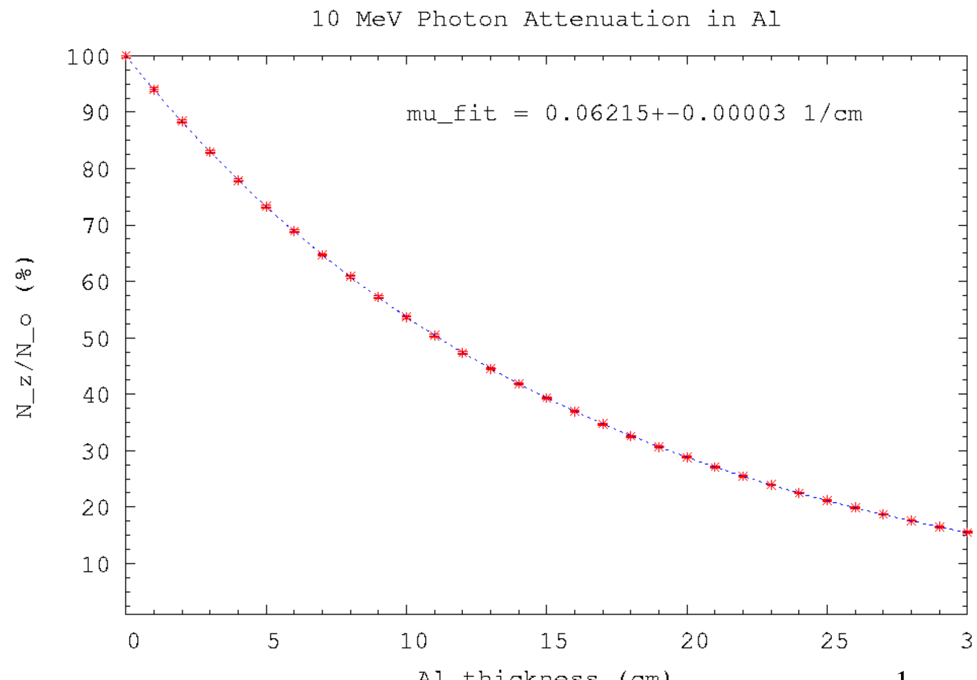
WS 2005-2006: Medizinische Physik I (Übungen)

# Results assignment 03: photon attenuation in aluminum



# Photon attenuation in aluminum

monoenergetic beam (homogenous)
pencil beam (parallel geometry)

| E (MeV) | $1^{st}$ HVL (cm) | $2^{nd}$ HVL (cm) | H ($1^{st}$ HVL / $2^{nd}$ HVL) |
|---|---|---|---|
| 0.05 | 0.8 | 0.8 | 1.00 |
| 0.1 | 1.6 | 1.5 | 1.07 |
| 1 | 4.25 | 4.1 | 1.04 |
| 10 | 11.0 | 10.95 | 1.00 |

**Histogram Analysis**

| E (MeV) | $\mu$ (1/cm) | $\Delta\mu$ (1/cm) | HVL (cm) | $\Delta$HVL (cm) | $\mu/\rho$ ($g/cm^2$) | X-Ray mass attenuation table $\mu/\rho$ ($g/cm^2$) | Diff. (%) |
|---|---|---|---|---|---|---|---|
| 0.05 | 0.8966 | 0.0001 | 0.7731 | 0.0001 | 3.322E-01 | 3.68E-01 | -9.75 |
| 0.1 | 0.4342 | 0.0002 | 1.5964 | 0.0007 | 1.609E-01 | 1.70E-01 | -5.59 |
| 1 | 0.16543 | 0.00008 | 4.190 | 0.002 | 6.129E-02 | 6.15E-02 | -0.27 |
| 10 | 0.06215 | 0.00003 | 11.153 | 0.005 | 2.303E-02 | 2.32E-02 | -0.66 |

$\rho_{Al} = 2.699\ g/cm^3$

# Photon attenuation in water

monoenergetic beam (homogenous)
pencil beam (parallel geometry)

**Histogram Analysis**

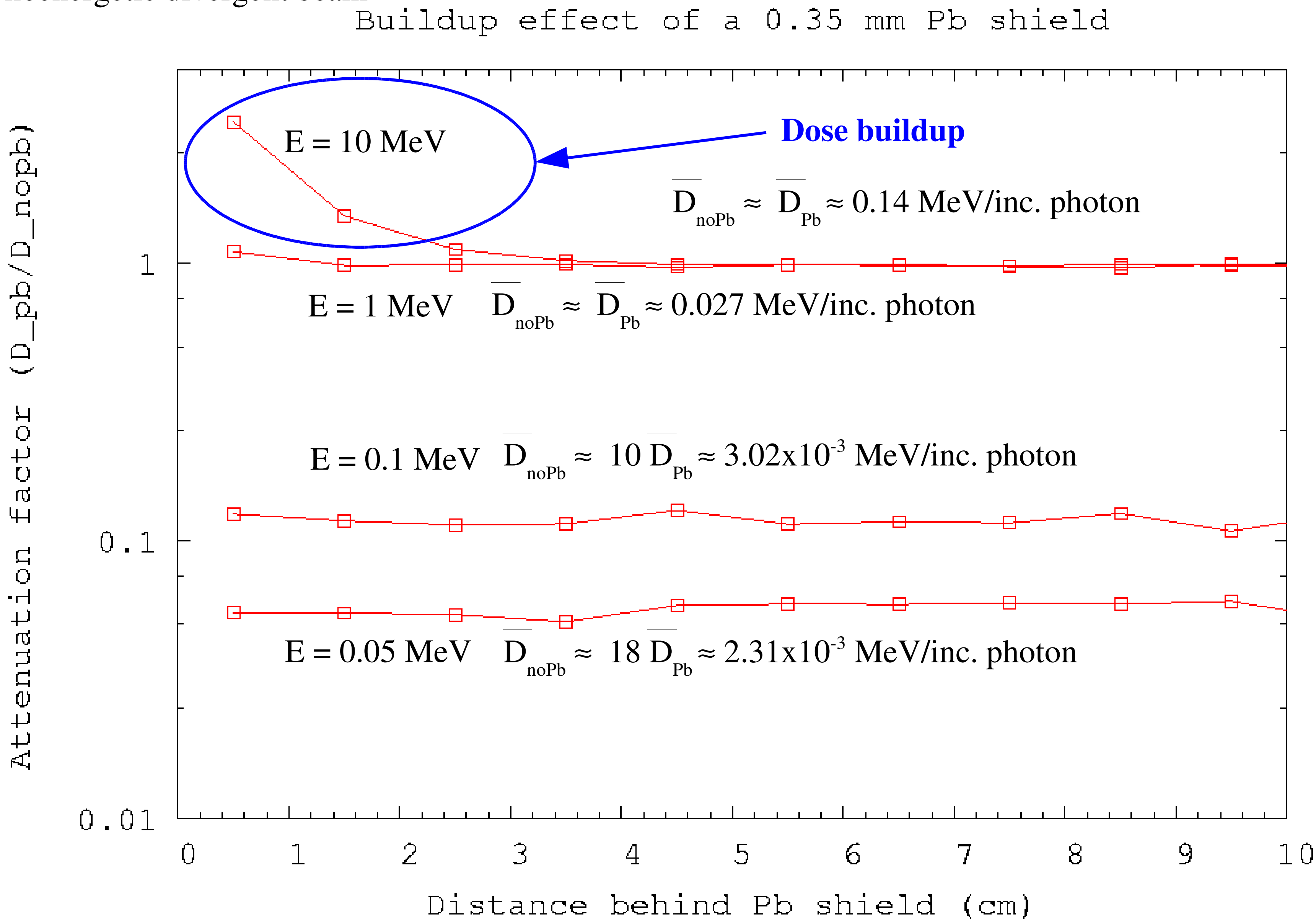
| E (MeV) | $\mu$ (1/cm) | $\Delta\mu$ (1/cm) | HVL (cm) | $\Delta$HVL (cm) | $\mu/\rho$ (g/cm$^2$) | X-Ray mass attenuation table $\mu/\rho$ (g/cm$^2$) | Diff. (%) |
|---|---|---|---|---|---|---|---|
| 0.05 | 0.2139 | 0.0001 | 3.241 | 0.002 | 2.139E-01 | 2.269E-01 | -5.74 |
| 0.1 | 0.16757 | 0.00004 | 4.136 | 0.001 | 1.675E-01 | 1.707E-01 | -1.83 |
| 1 | 0.07070<br>0.0703 | 0.00002<br>0.0003 | 9.803 | 0.003 | 7.070E-02 | 7.072E-02 | -0.02<br>-0.59 |
| 10 | 0.022176<br>0.02195 | 0.000008<br>0.00006 | 31.26 | 0.01 | 2.218E-02 | 2.219E-02 | -0.06<br>-1.08 |
| 20 | 0.01782<br>0.01793 | 0.00006<br>0.00005 | 38.89 | 0.14 | 1.178E-02 | 1.813E-02 | -1.70<br>-1.10 |

$\rho_{H2O} = 1.0$ g/cm$^3$

In red: values obtained from percentage depth dose curves of pencil beams, assignment 02.

# Results assignment 03: buildup effect due to a Pb shield

monoenergetic divergent beam



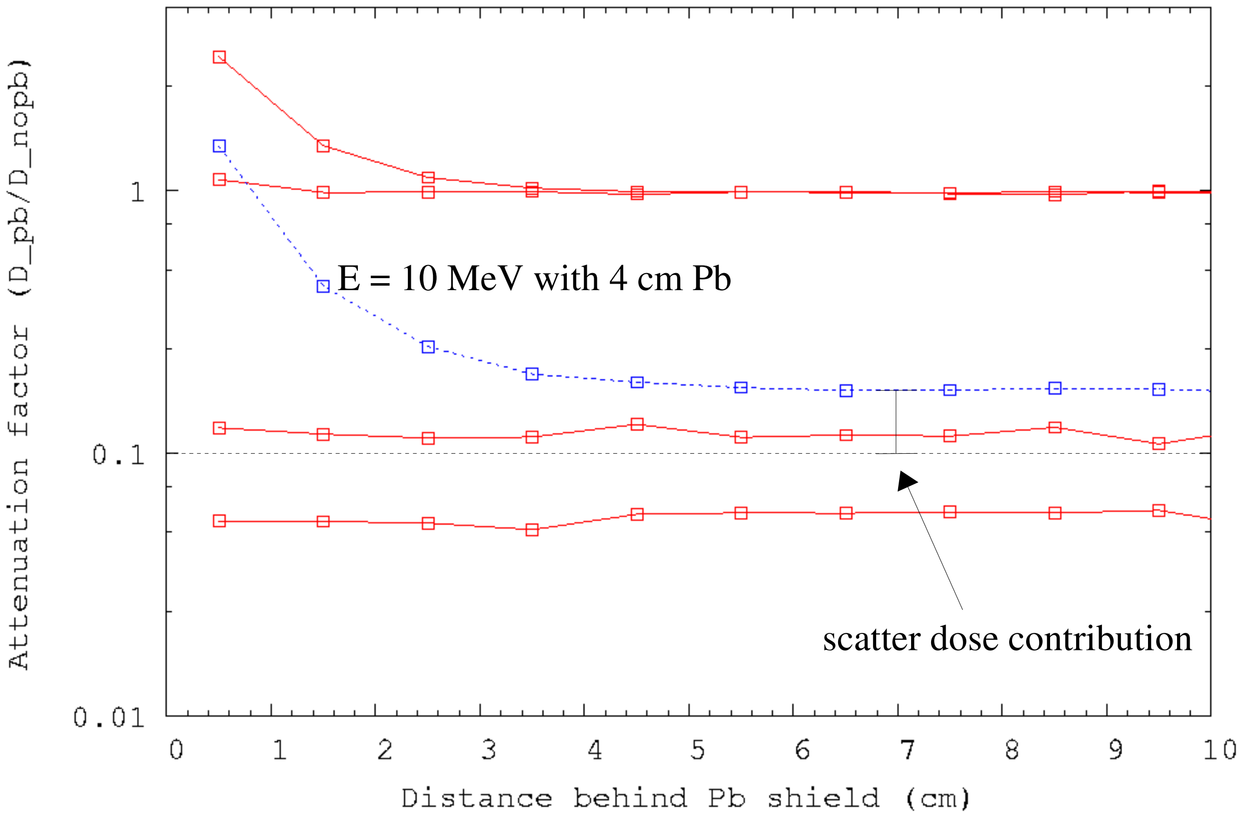

Source to water phantom distance: 100 cm

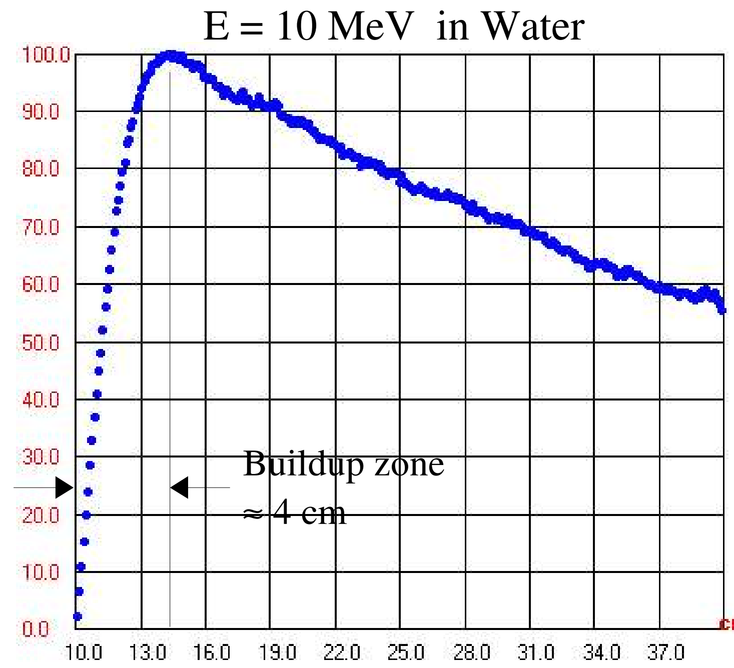
# Results assignment 03: buildup effect due to a Pb shield

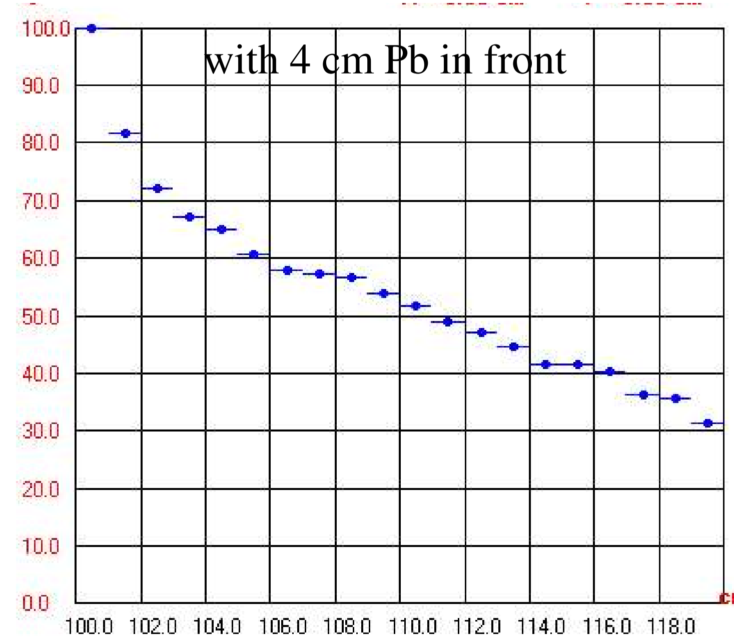
from Tables, we have that for lead:

$$\frac{\mu}{\rho} = 4.972\, x\, 10^{-2} \frac{cm^2}{g} \qquad \rho = 11.35 \frac{g}{cm^3} \qquad \mu = 0.564 \frac{1}{cm}$$

$$\frac{I}{I_o} = 0.1 = e^{-\mu x} \Rightarrow x = -\frac{\ln(0.1)}{\mu} = 4.1\, cm$$



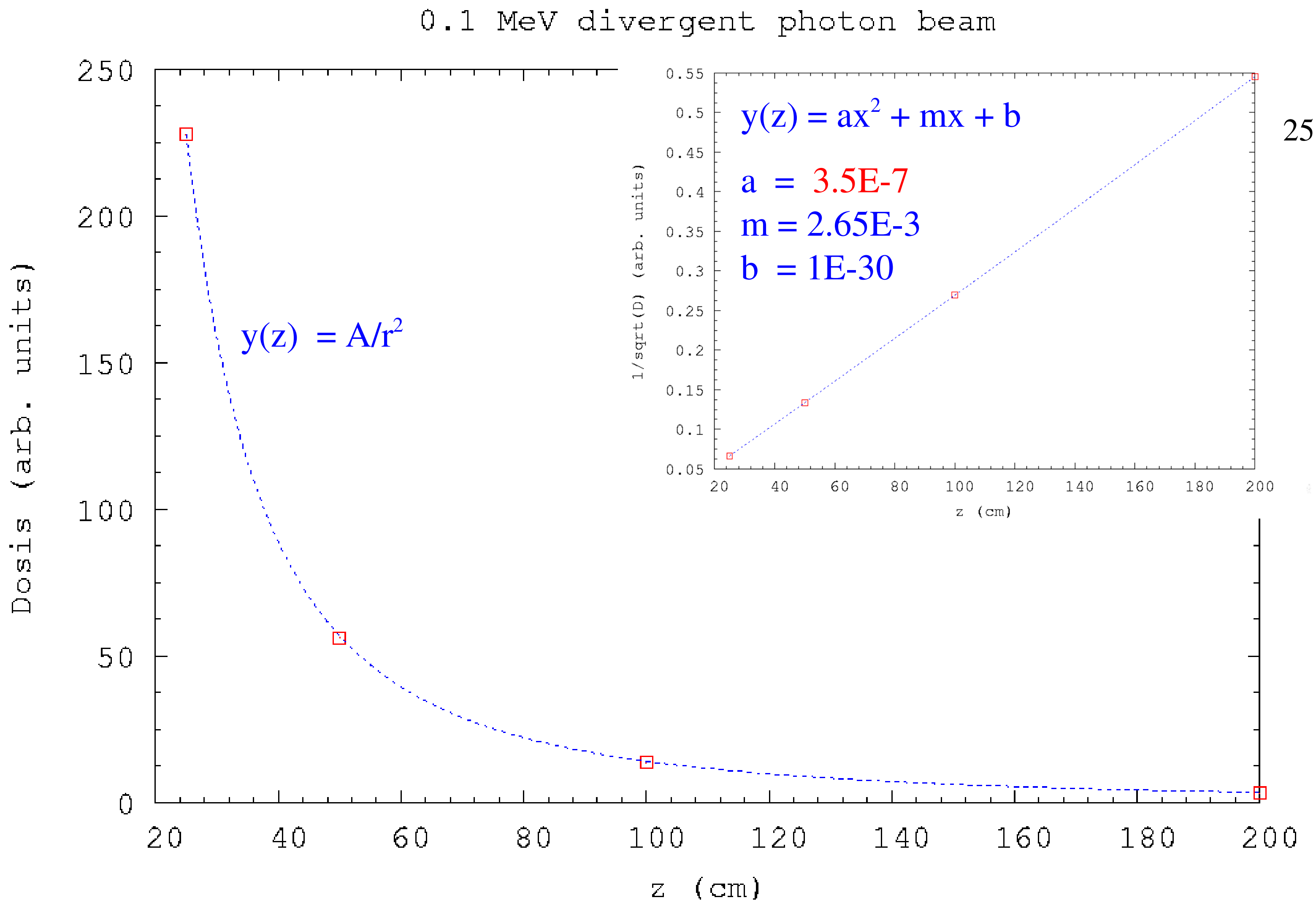



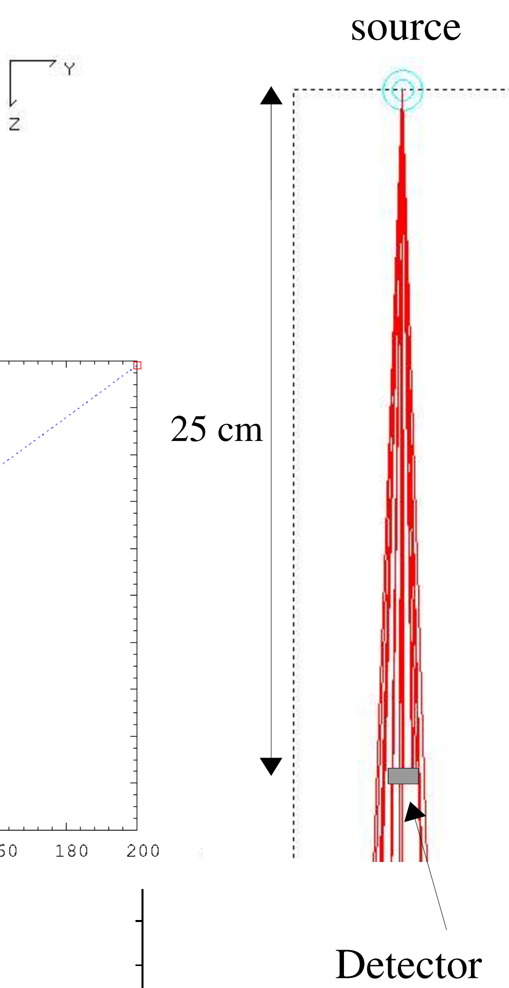
# Inverse square law ($1/r^2$)

Divergent homogenous photon beam. Energies 0.1, 10 MeV

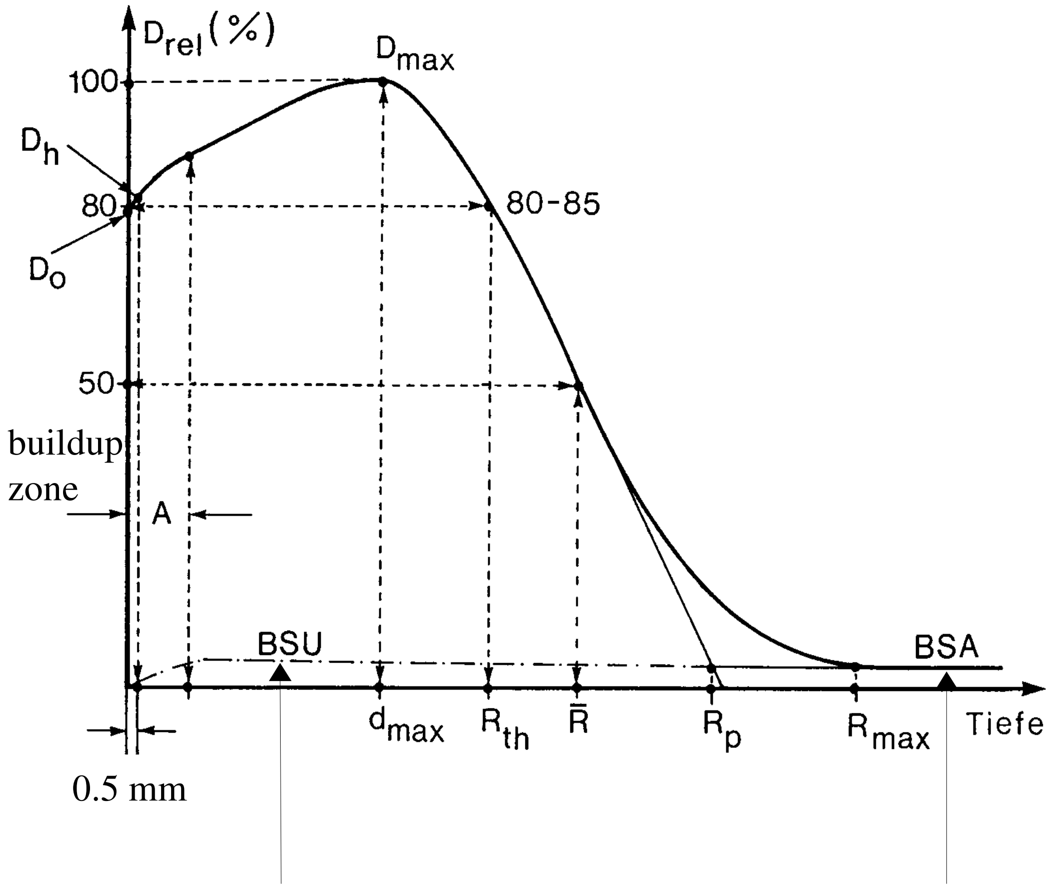
Source to detector distance: 25, 50, 100, 200 cm

Detector: Pb



# Percentage depth dose curve of electron beams




$\bar{R}$: mean range (mittlere Reichweite)

$R_p$: practical or extrapolated range (praktische Reichweite)

$R_{max}$: maximum range (maximale Reichweite)

$R_{th}$: therapeutical range (therapeutische Reichweite)

$D_o$: surface dose (Oberflächendosis)

$D_h$: skin dose (dose at a depth of 0.5 mm) (Hautdosis)

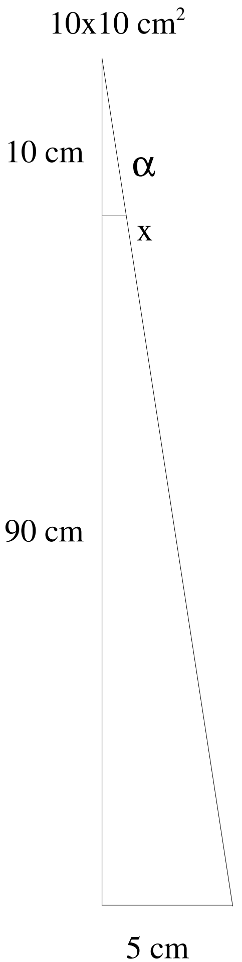
$d_{max}$: depth of maximum dose (Dosismaximumtiefe)

bremsstrahlung background: proportion of the energy dose due to bremsstrahlung at $d_{max}$. (Bremsstrahlungsuntergrund, BSU)

bremsstrahlung contribution: relative doses due to bremsstrahlung at $R_p$. (Bremsstrahlendosisanteil, BSA)

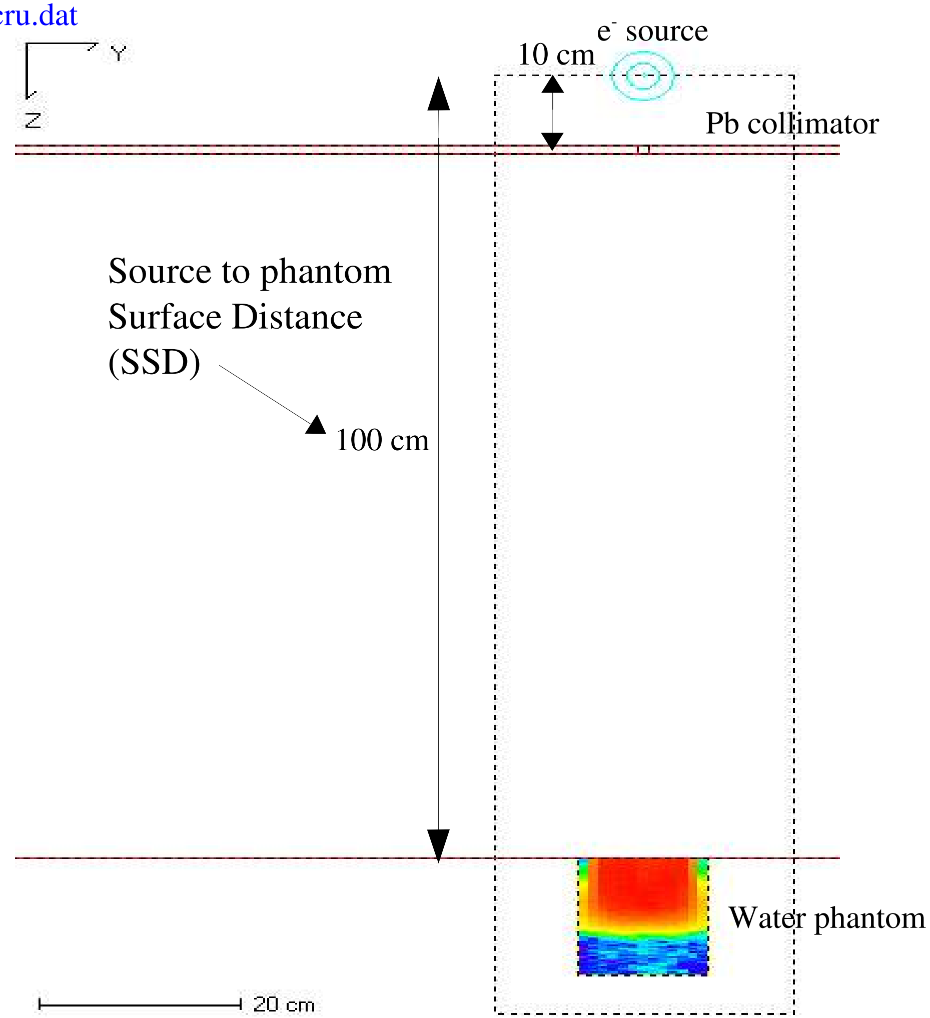
# EGS-Ray: field size of divergent electron beams

monoenergetic beam




$$\tan\alpha = \frac{x}{10} = \frac{5}{100}$$

Daten
D:\EGSRay\Mediendaten\521icru.dat
Randomseed
1802 9373
Punktquelle
0. 0. 0.
Richtungsbereich
-1 1 -1 1 0.99 1
Elektronen
Energie
20.511
Rechenraum
-15 -15 0 15 15 120
Scoringraum
-6.5 -6.5 100 6.5 6.5 115
Voxelgröße
1 1 0.2
Platte
PB521ICRU
2 9.0 10
Box
AIR521ICRU
-0.5 -0.5 9.0 0.5 0.5 10
Halbraum
H2O521ICRU
2 100 1
Histogramm
2 100
Presta




Field sizes: 4x4 cm²
10x10 cm²
20x20 cm²

# Assignment 04: absorption of homogenous electron beams

Electron absorption (1):

Simulate: parallel monoenergetic electron beam: E = 20 MeV
Field size: 10x10 $cm^2$
Phantom: $H_2O$

Analysis: Determination of $\bar{R}$, $R_p$, $R_{max}$, $R_{th}$, $D_o$(%), $d_{max}$(cm),
bremsstrahlung contribution (%).
Comment the electron spectra at several depths.

Electron absorption (2):

Simulate: a) divergent monoenergetic electron beam: E = 20 MeV
Field sizes: 4x4, 10x10, 20x20 $cm^2$
Source to phantom surface distance (SSD): 100 cm
Phantom: $H_2O$

Analysis: dependence of R and $R_p$ with field size.

b) divergent monoenergetic electron beam: E = 20 MeV
Field size: 10x10 $cm^2$
Source to phantom surface distances (SSDs): 50, 100, 150 and 200 cm

Analysis: Average dose at 5 cm depth. Inverse square law. Is it valid?

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