Abteilung für Medizinische Strahlenphysik
Inselspital, Universität Bern, Schweiz
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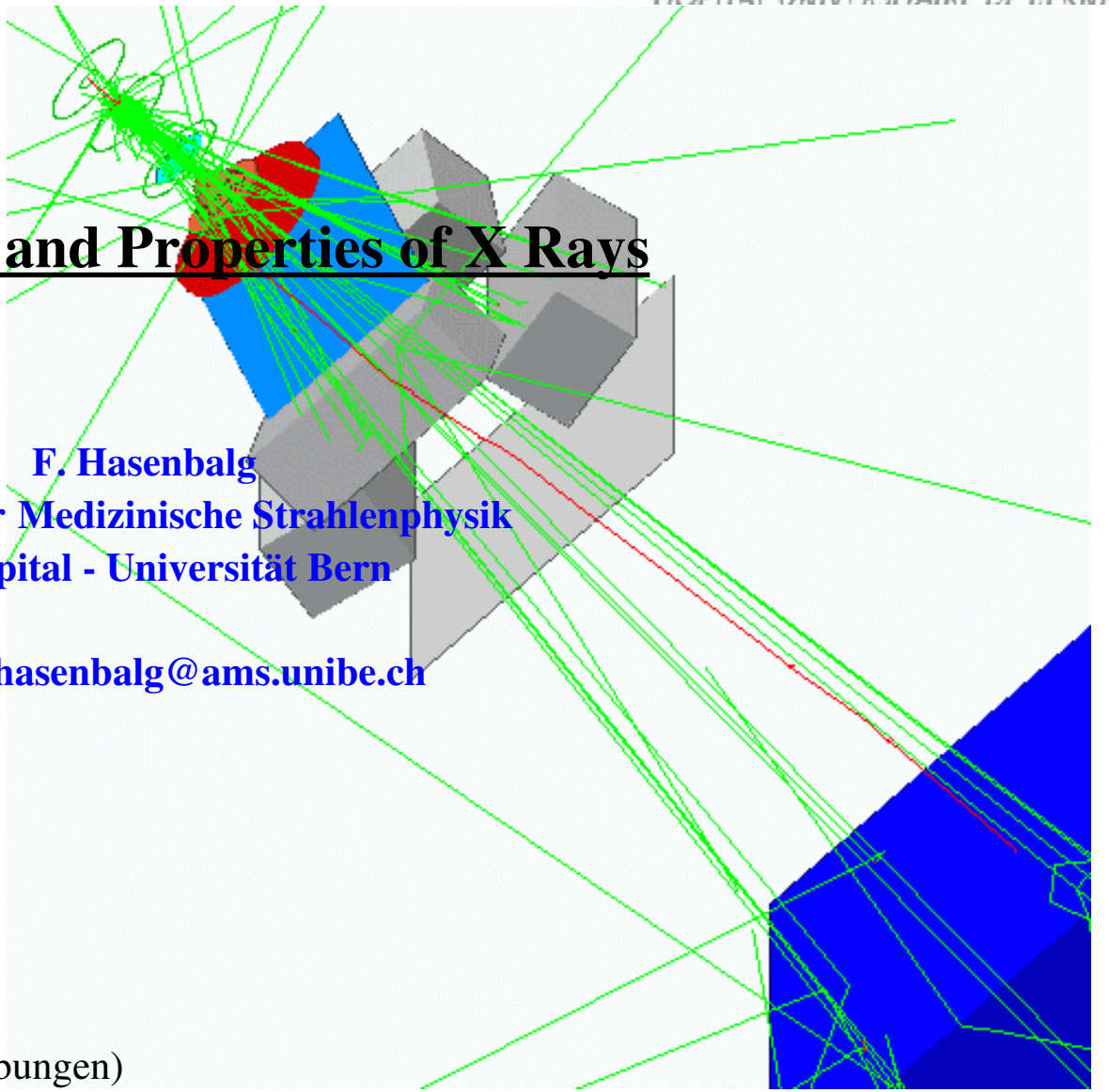
Production and Properties of X Rays



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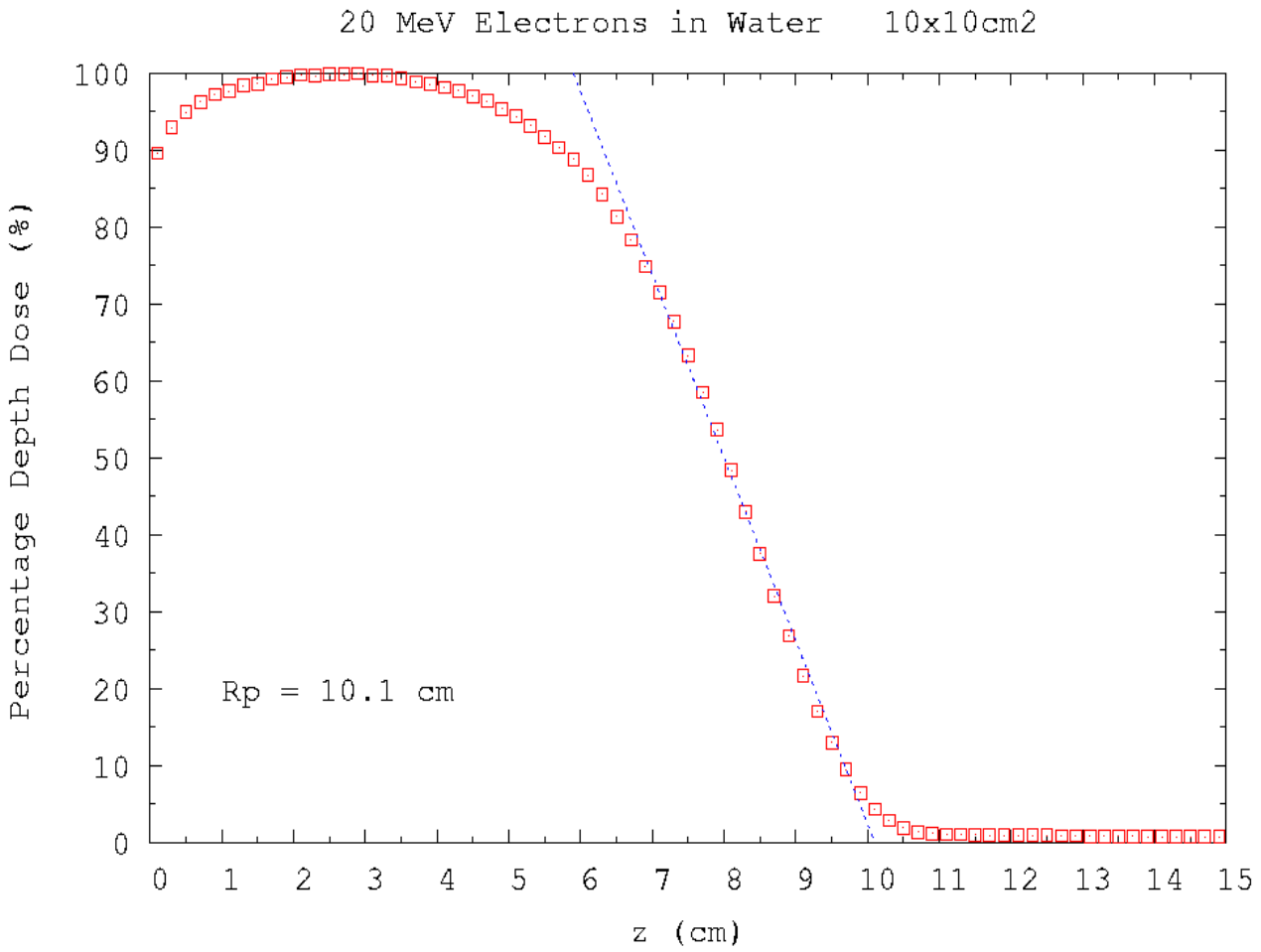
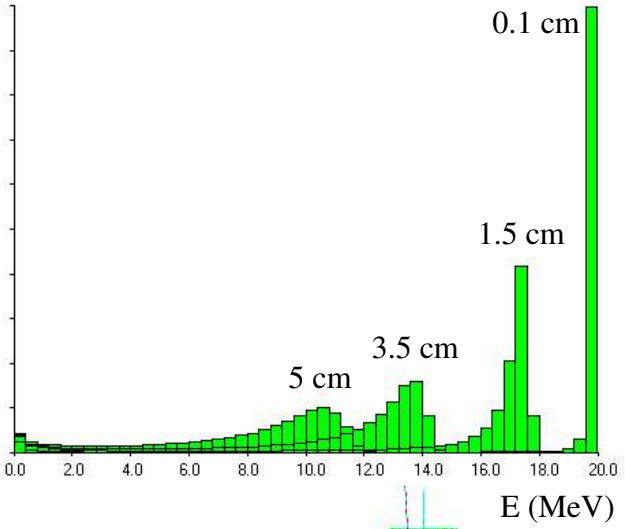
Results assignment 04: electron parallel beam

monoenergetic electron beam: E = 20 MeV
source to phantom (H_2O) surface distance: 100 cm
field size: 10 x10 cm^2

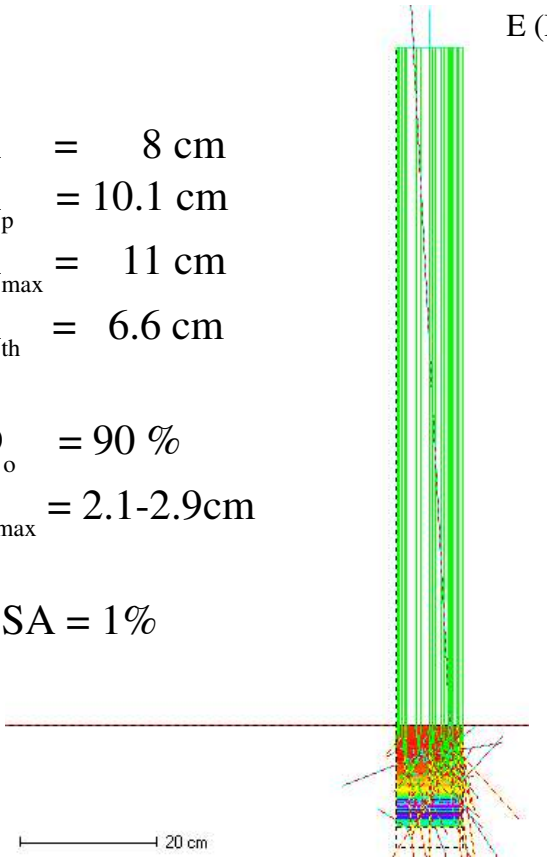




$\bar{R}$ = 8 cm
R_p = 10.1 cm
R_{max} = 11 cm
R_{th} = 6.6 cm

D_o = 90 %
d_{max} = 2.1-2.9cm

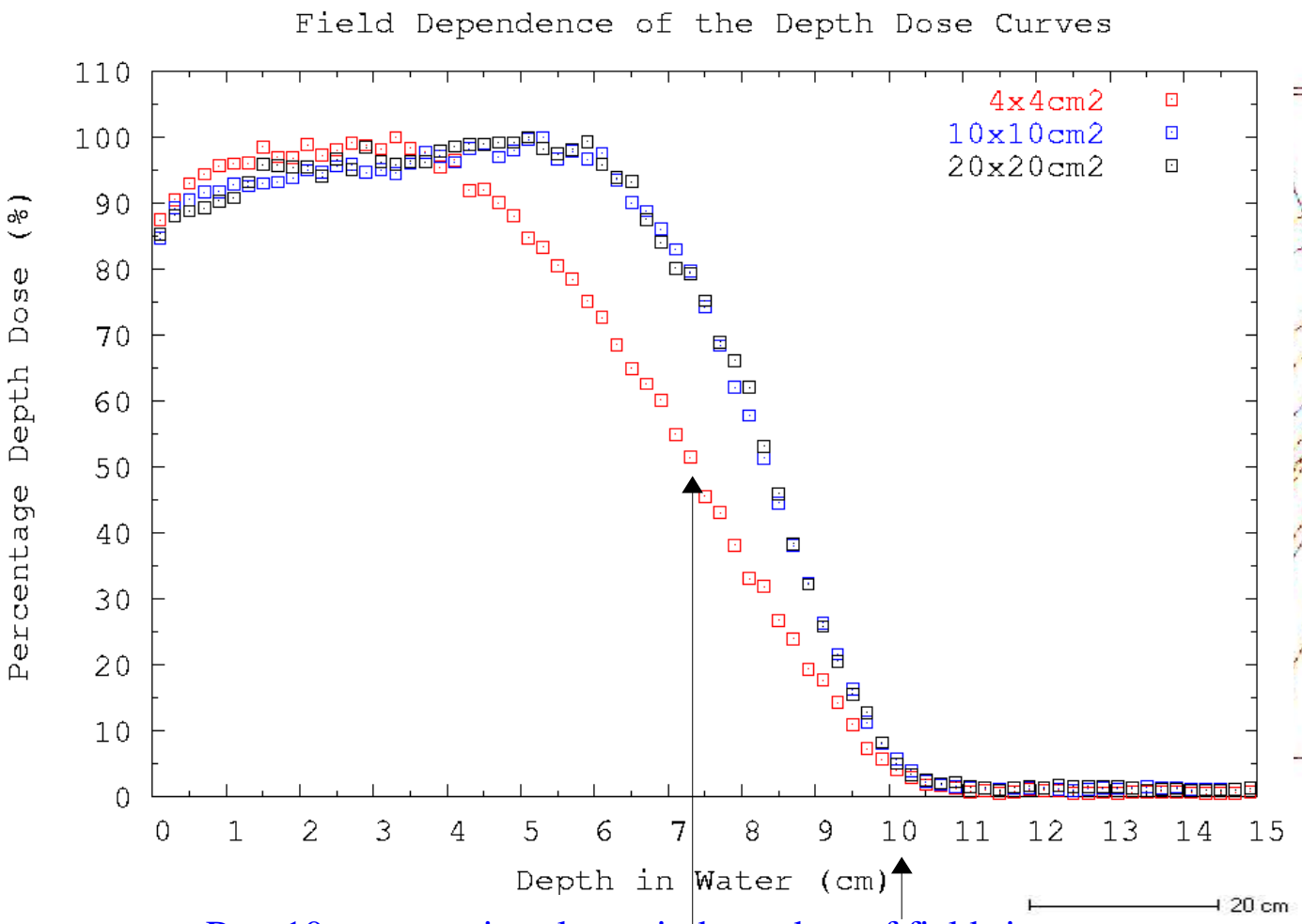
BSA = 1%

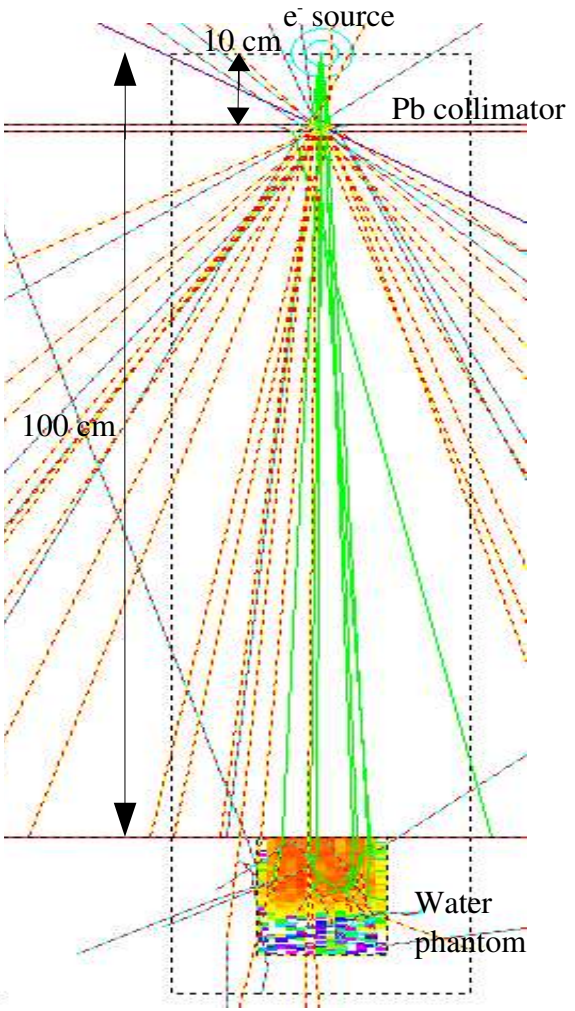


Electron beam: dependence on field size

monoenergetic beam (homogenous) E = 20 MeV fields: 4x4, 10x10 and 20x20 cm^2

source to phantom (H_2O) distance: 100 cm divergent beam





R_p ≈ 10 cm, remains almost independent of field size

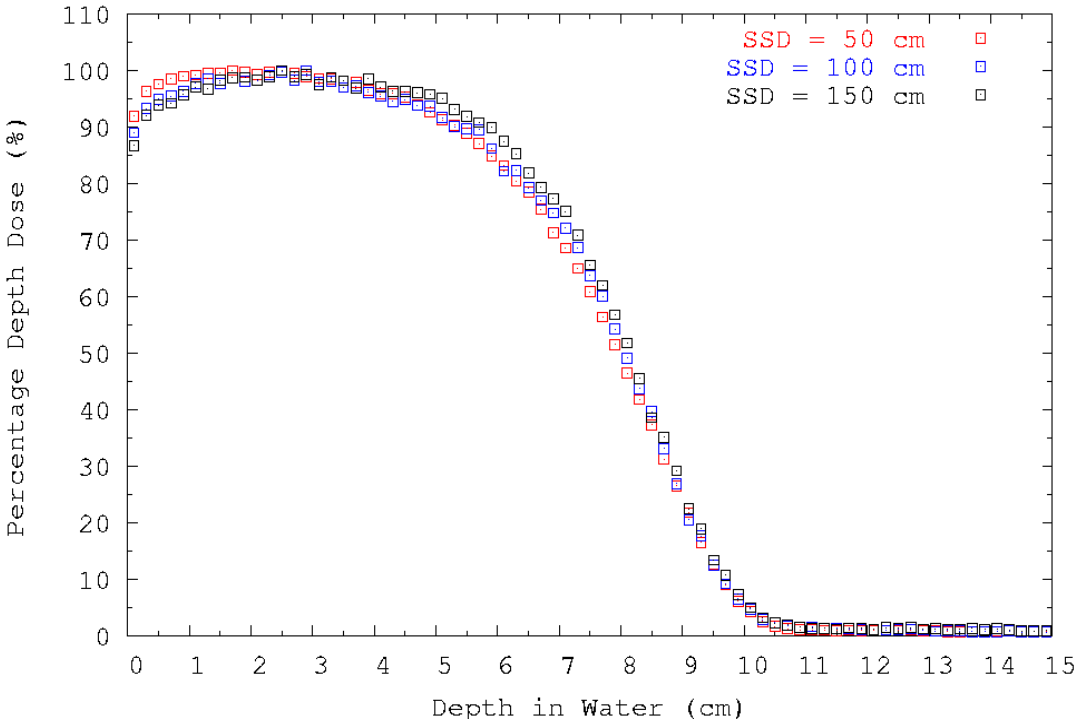
R depends more strongly on field size

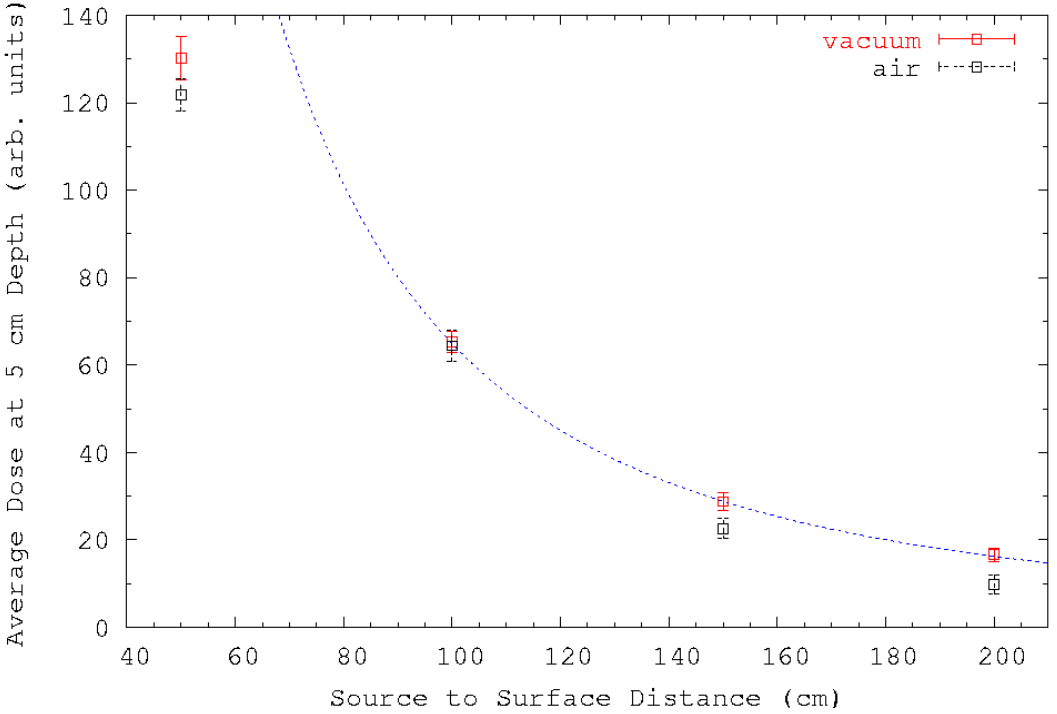
=> R_p is a better parameter to determine the beam energy

Saturation effect due to limited range of e^- (≈ 10 cm)

Field sizes: 4x4 cm^2
10x10 cm^2
20x20 cm^2

Electron beam: dependence on source to phantom surface distance



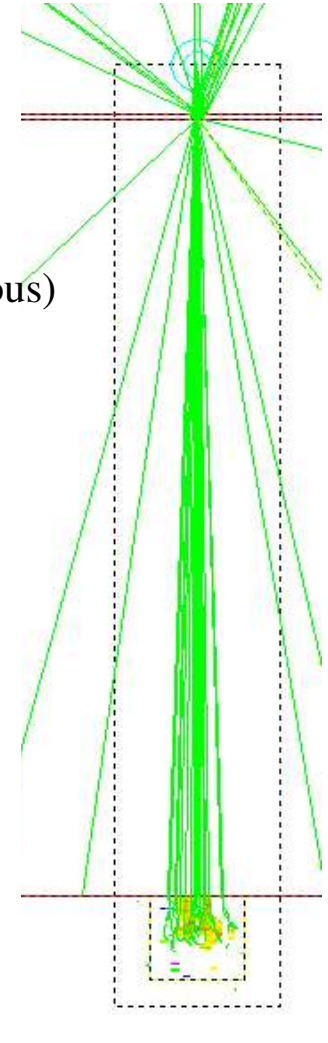


divergent beam

monoenergetic (homogeneous) beam
E = 20 MeV
field: 10x10 cm^2

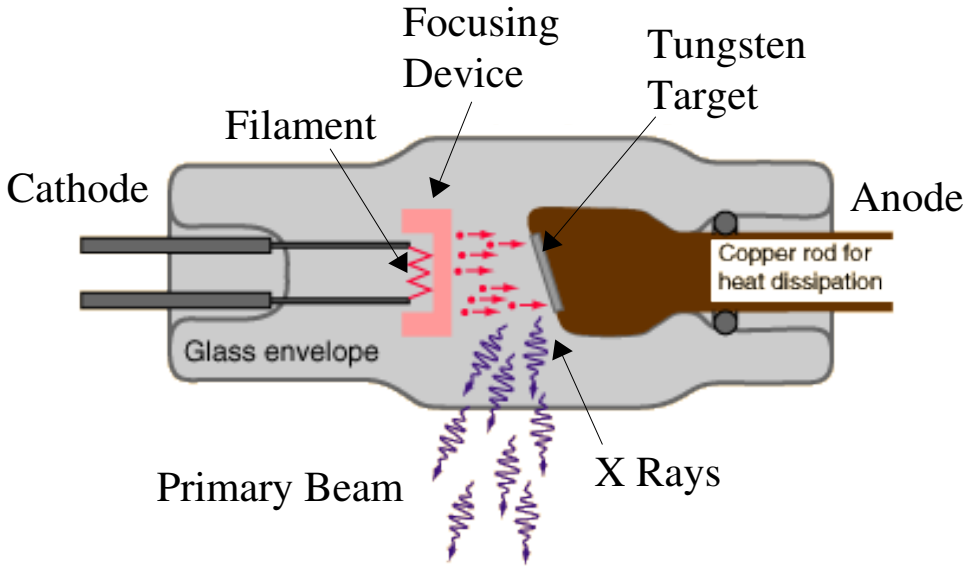
source to phantom (H_2O)

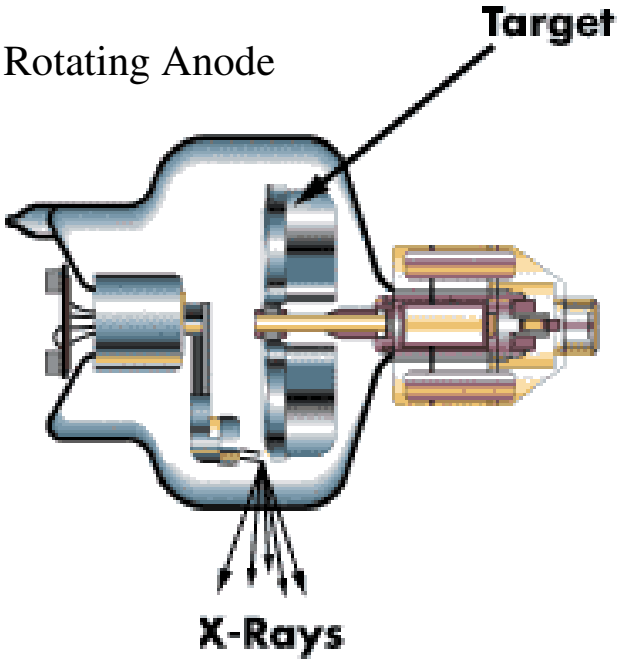
surface distances (SSDs):
50, 100, 150 and 200 cm

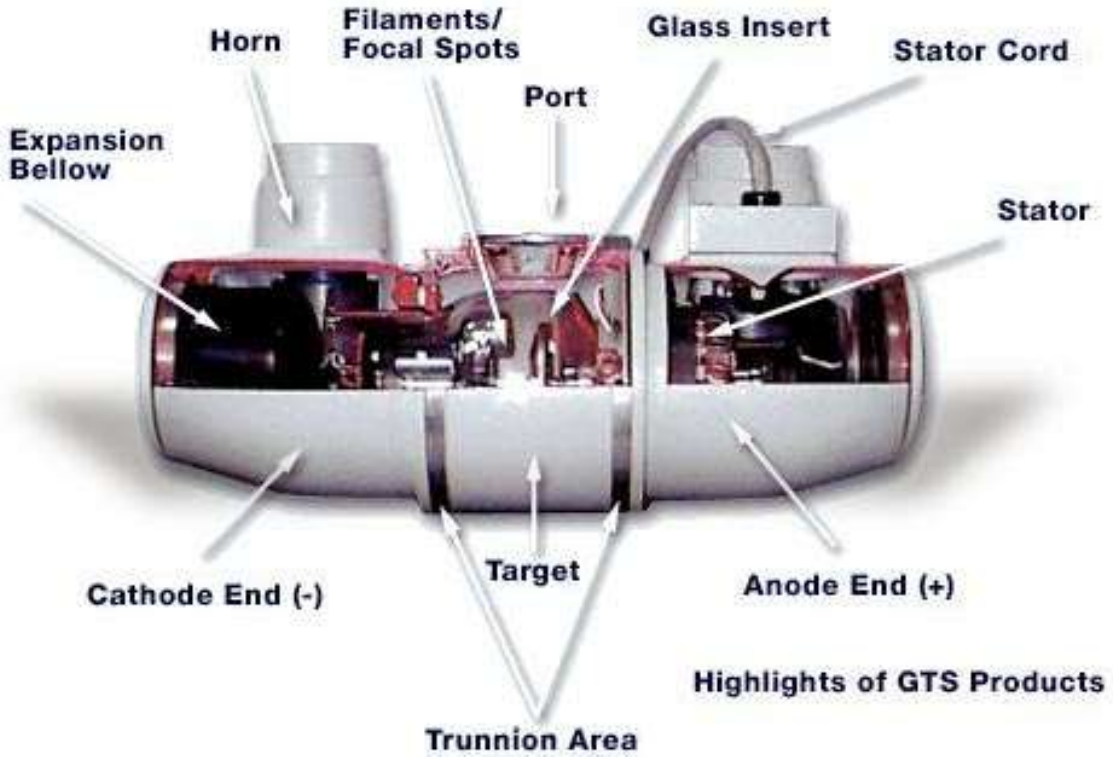


$1/r^2$ not a good approximation in air!

X-Ray Tubes

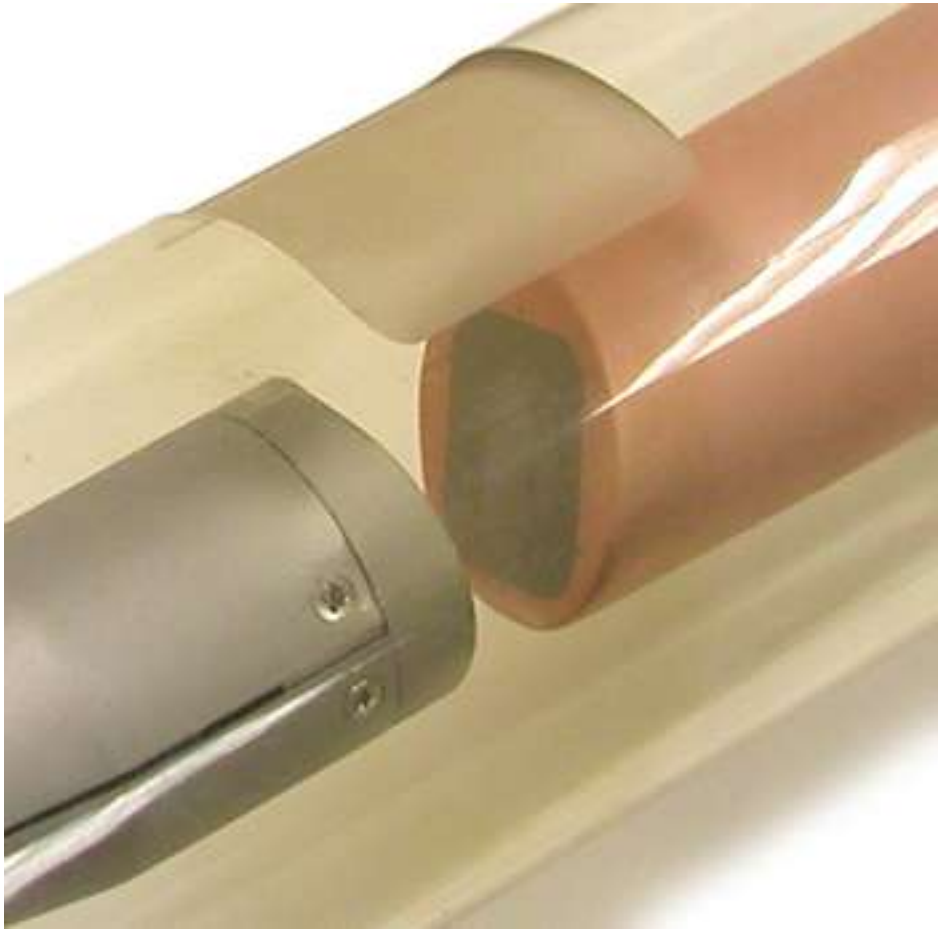






Filaments / Focal Spots

General Electric XP-2-4.5 Tube (ca. 1930)



Collimated Low Energy Therapy Tube (ca 1930)

Machlett FDX 1-2 Rotating Anode Tube (ca 1960)

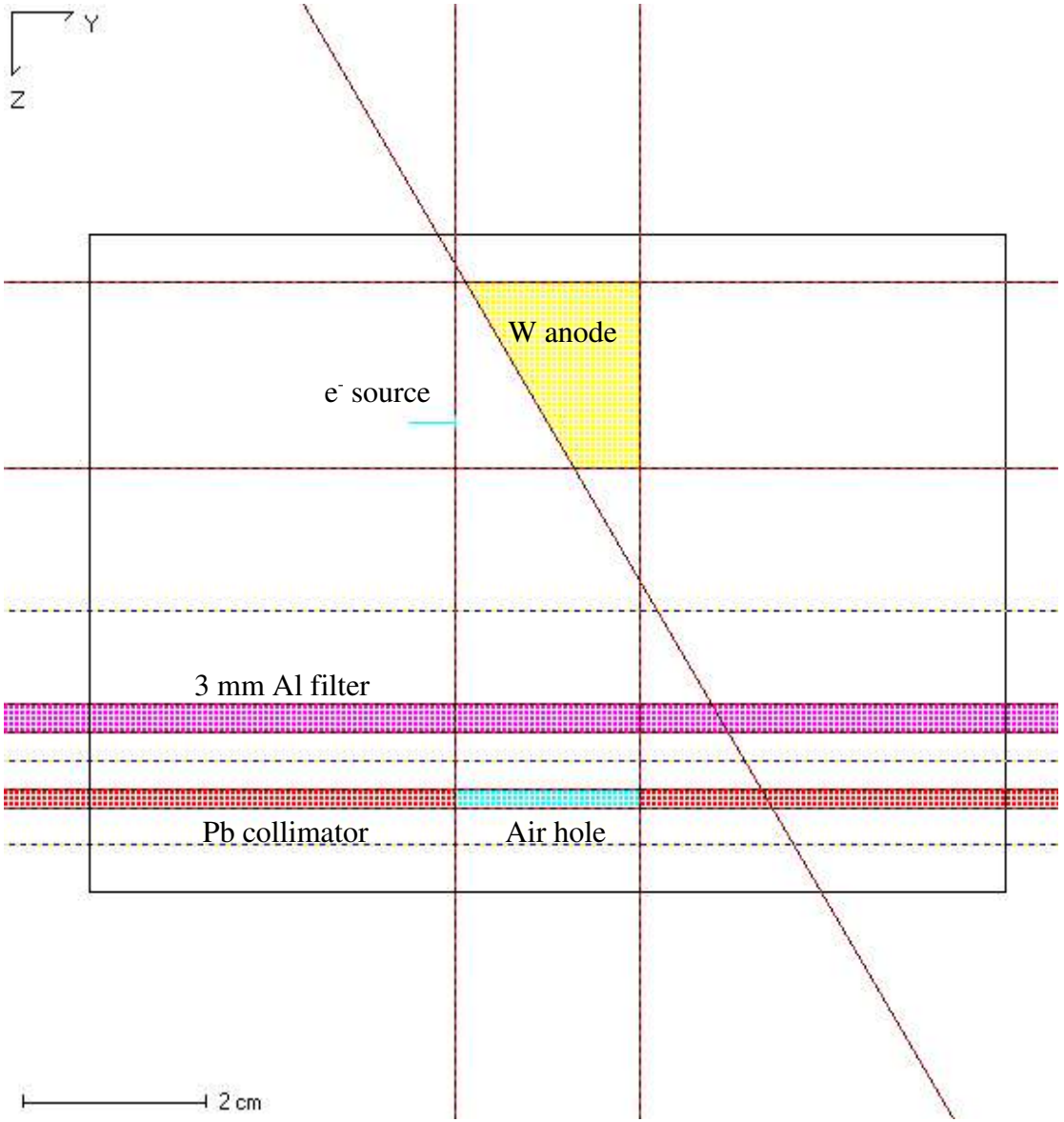
EGS-Ray: simulation of an X-ray tube

Anode tension: 125 kV
with and without
3 mm Al filter

Mean energy of
photon spectra before
and after collimator

```
Daten
D:...Mediendaten\521icru.dat
Randomseed
1802 9373
Histories
10000000
Feld
0. -1. 0          e- source
0. 0. 0.1
Richtung
0. 1. 0.
Elektronen
Energie
0.636             125 keV
Rechenraum
-5 -5 -2 5 5 5
Scoringraum
-5. -5. -2.  5.  5.  5.
Voxelgröße
2  2  2
keine Dosis
```

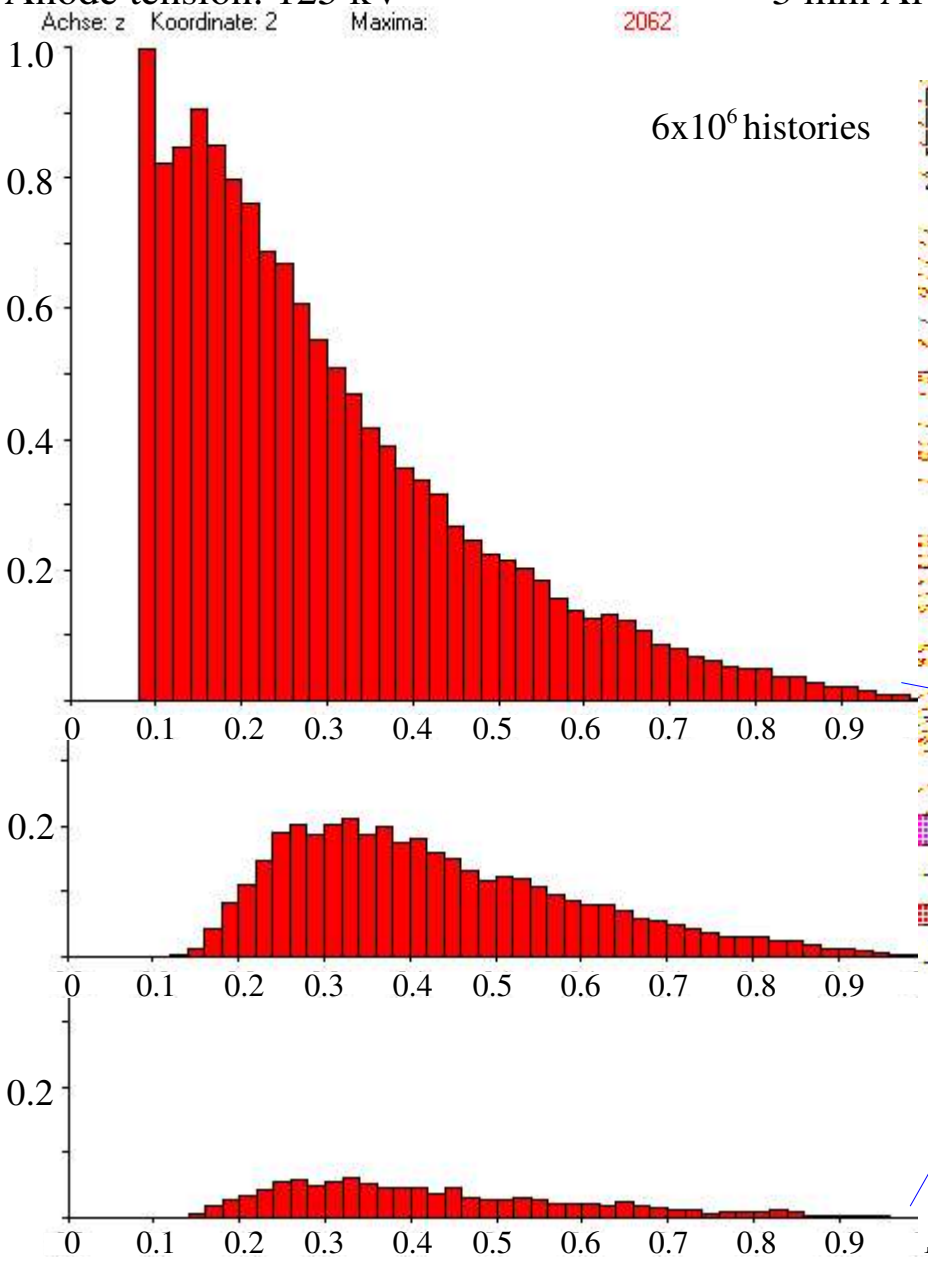
```
Flächenobjekt
W521ICRU
0. 0.7 0.
7.
Wand
1 -1
Wand
1 1               W anode
Wand
0 -0.5
Wand
0. 0.5
Wand
2 -1.5
Wand
2 0.5
Fläche
0 0 0  -0.5 0.3 0.5   0.5 0.3
0.5
PLatte            3 mm Al filter
AL521ICRU
2 3 3.3
Histogramm
2 2
Histogramm
2 3.6
Platte            Pb collimator
PB521ICRU
2 3.9 4.1
Box               Air hole
AIR521ICRU
-3 -1 3.9 3 1 4.1
Histogramm
2 4.5
Presta
```



EGS-Ray: simulation of an X-ray tube

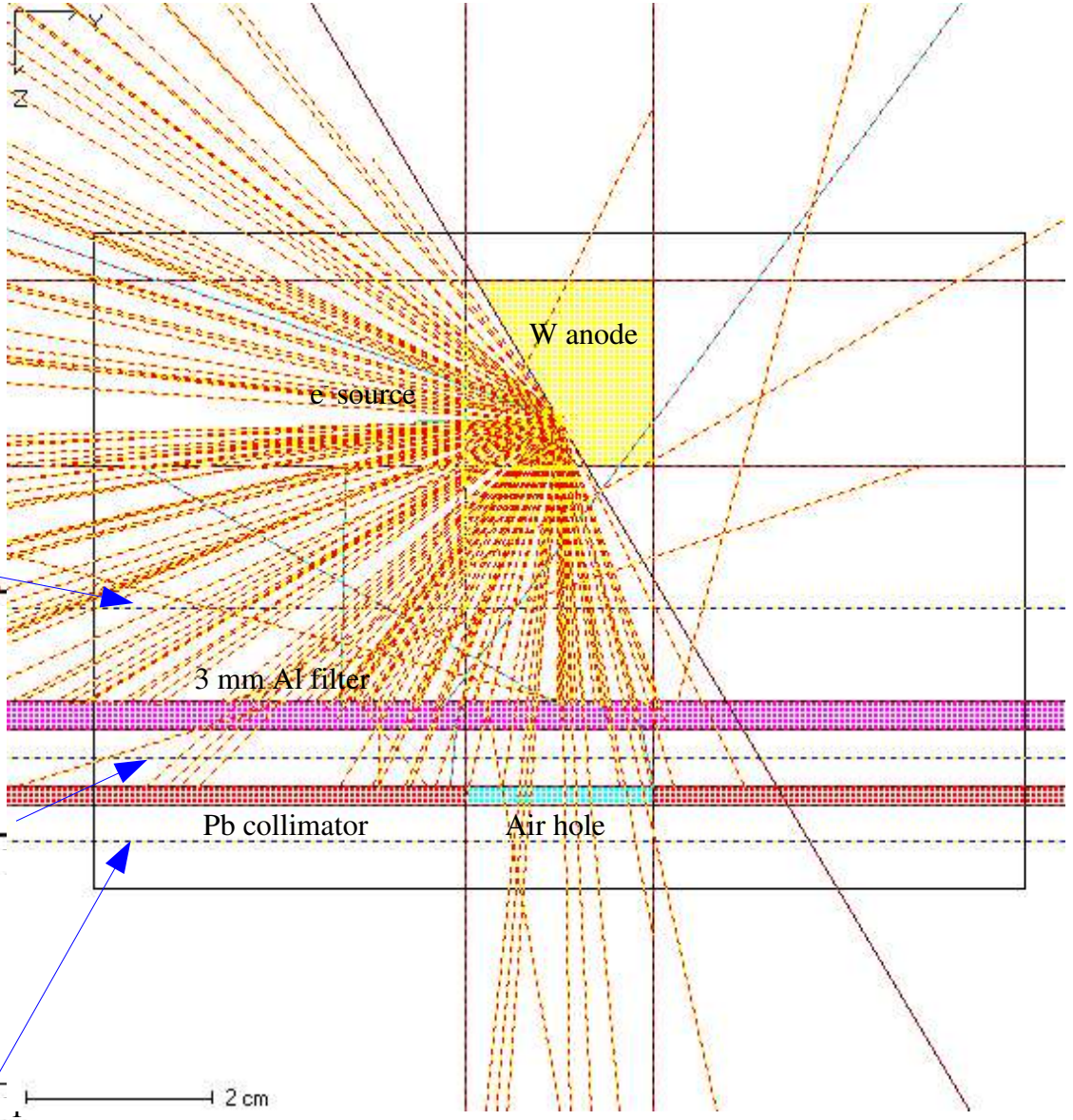
Anode tension: 125 kV

3 mm Al filter



$6x10^6$ histories

Bremsstrahlung photons



Geant 4.6 x-ray tube simulation

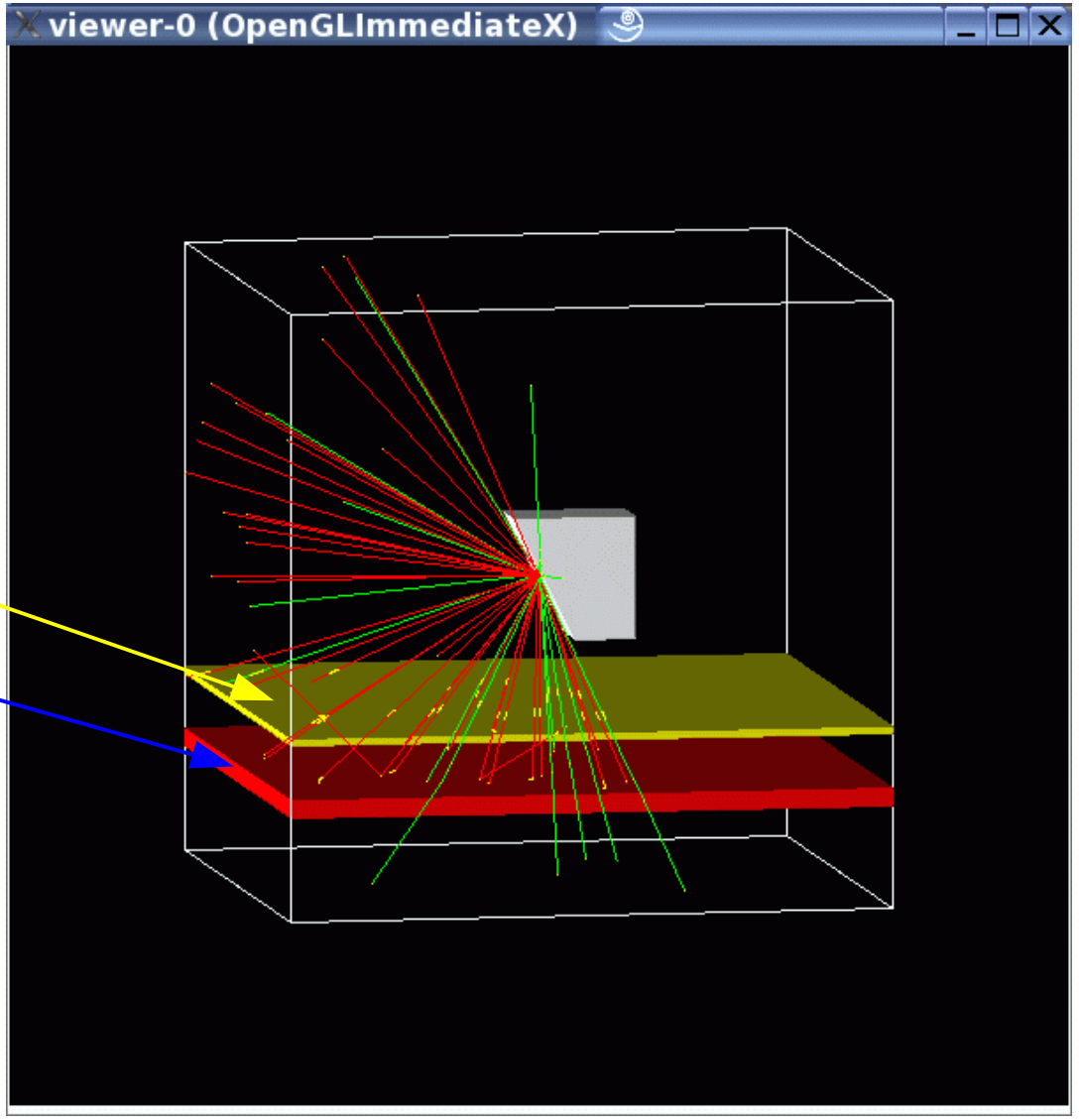
mono energetic electrons
impinging on a tungsten target

low energy extension

scoring plane

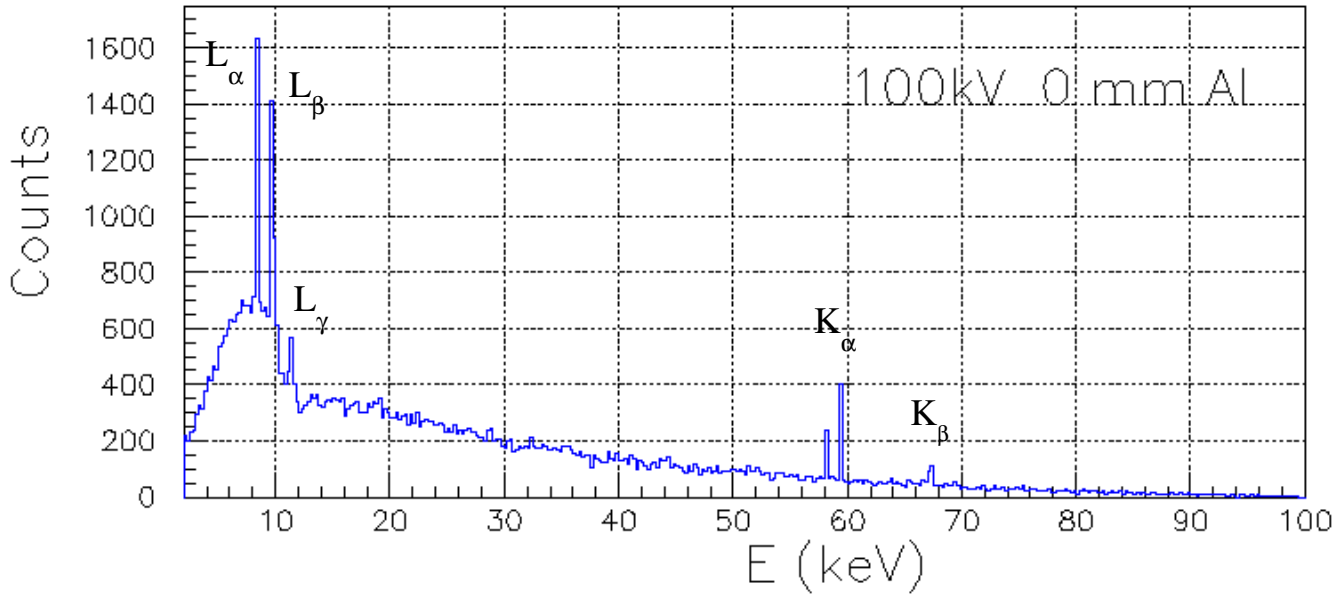
3 mm Aluminum filter

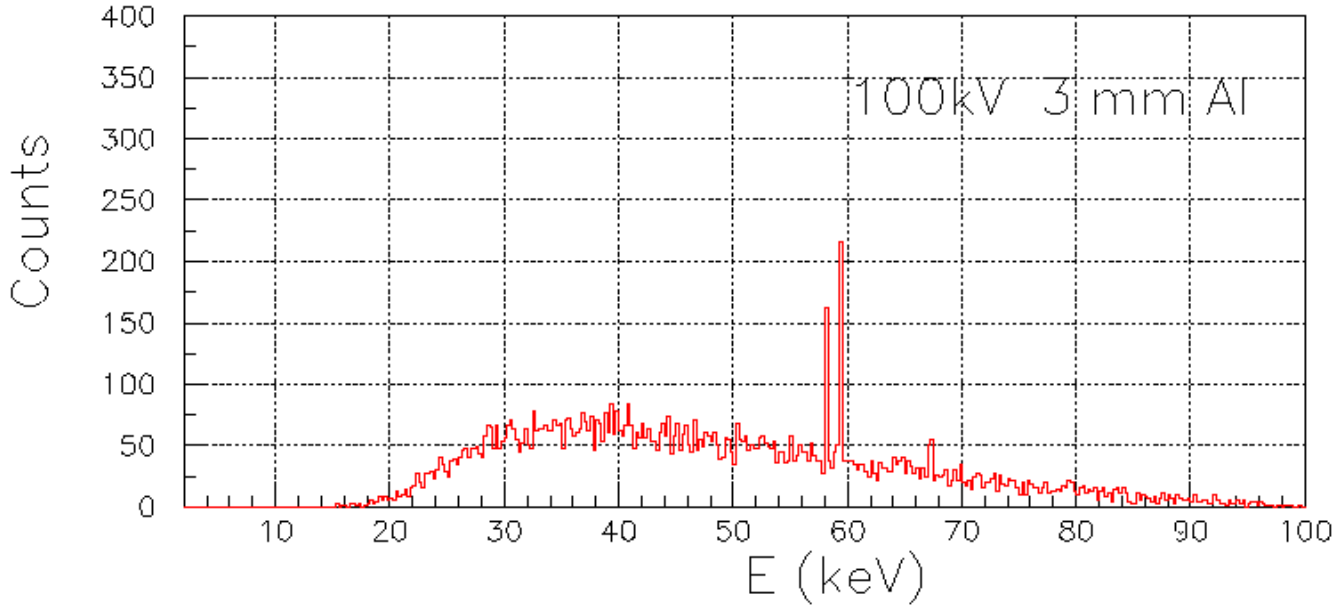
electrons
photons



Geant 4.6 X-ray spectra

100 kV mono energetic electrons impigning on a W target
low energy extension 10^7 primaries Range cut = 1 μm (1.64 keV) in W

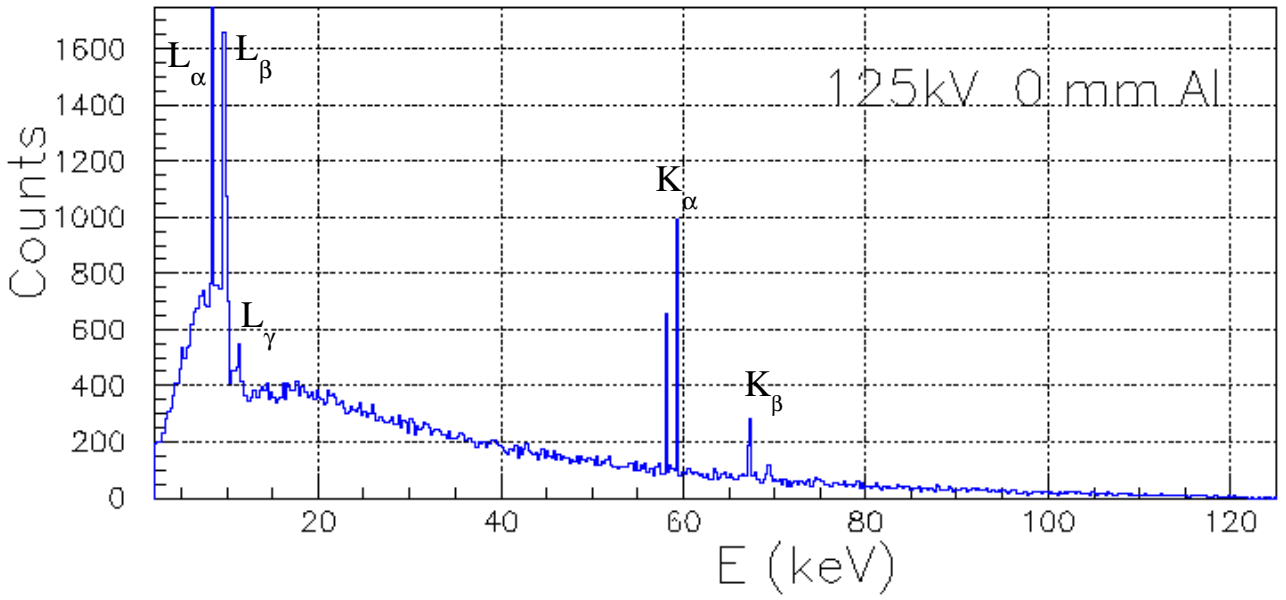


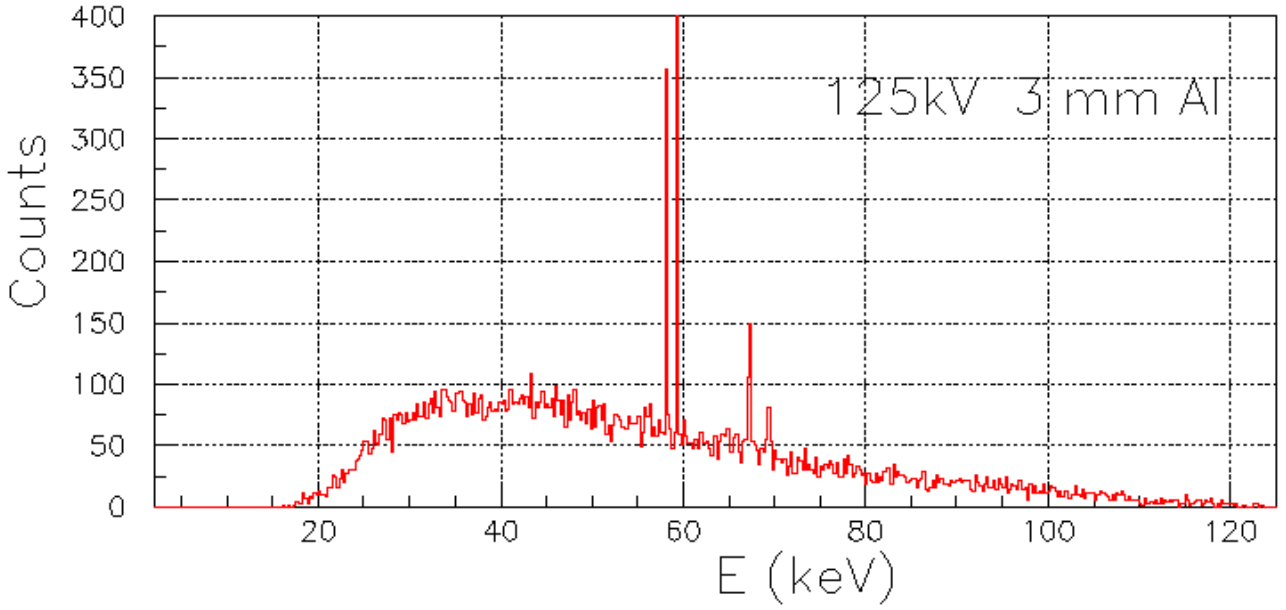


Line	E (keV)	Rel. Int. (%)
$K_{\alpha 1}$	59.318	100
$K_{\alpha 2}$	57.981	57
$K_{\beta 1}$	67.245	22
$K_{\beta 3}$	66.951	11
$L_{\alpha 1}$	8.398	10
$L_{\alpha 2}$	8.336	11
$L_{\beta 1}$	9.673	52
$L_{\beta 2}$	9.962	22
$L_{\gamma 1}$	11.287	9

Geant 4.6 X-ray spectra

125 kV mono energetic electrons impigning on a W target
low energy extension 10^7 primaries Range cut = 1 μm (1.64 keV) in W

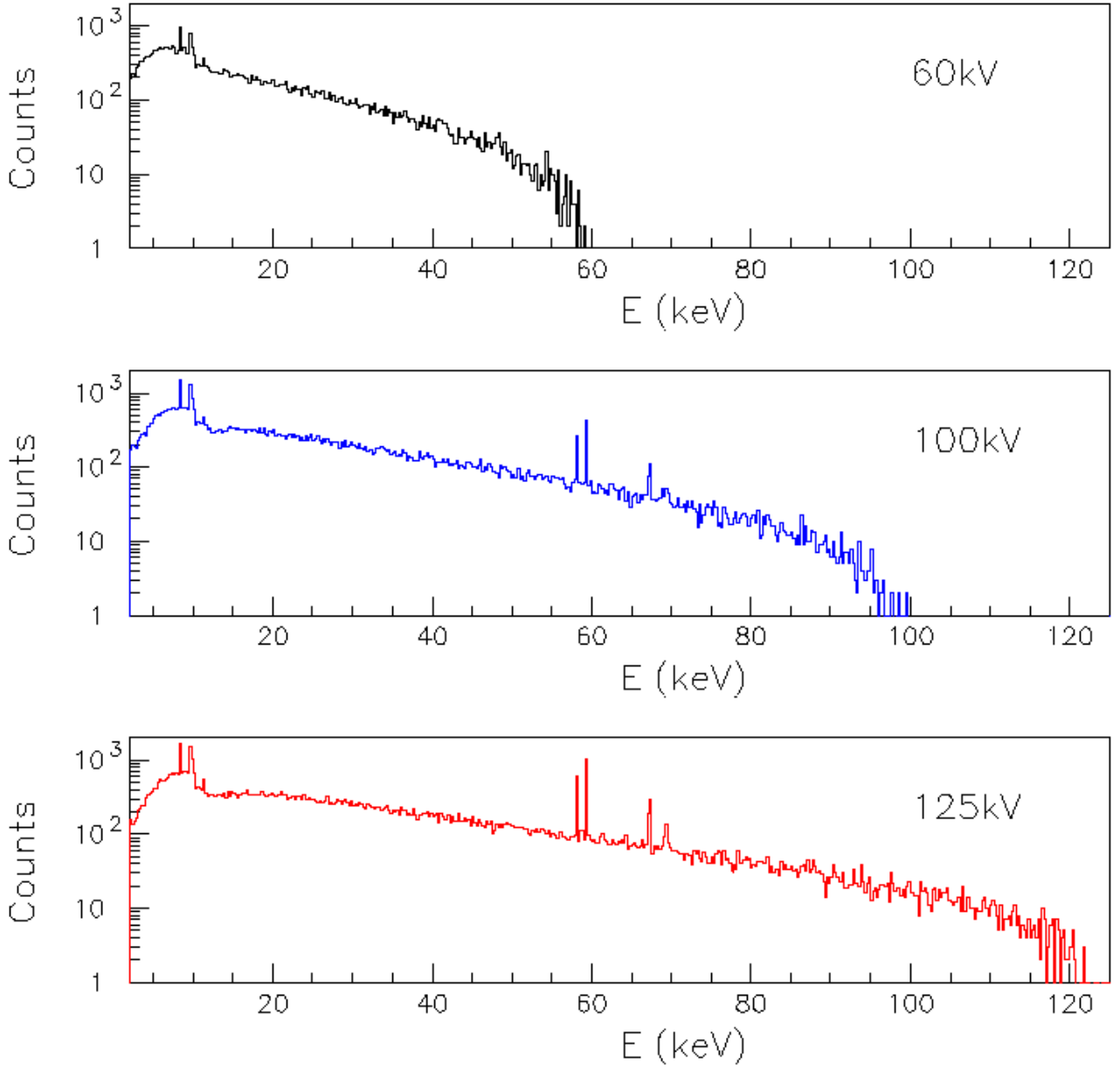




Line	E (keV)	Rel. Int. (%)
$K_{\alpha 1}$	59.318	100
$K_{\alpha 2}$	57.981	57
$K_{\beta 1}$	67.245	22
$K_{\beta 3}$	66.951	11
$L_{\alpha 1}$	8.398	10
$L_{\alpha 2}$	8.336	11
$L_{\beta 1}$	9.673	52
$L_{\beta 2}$	9.962	22
$L_{\gamma 1}$	11.287	9

Geant 4.6 X-ray spectra for various electron energies

mono energetic electrons impigning on a W target
low energy extension 10^7 primaries Range cut = 1 μm (1.64 keV) in W



Assignment 05: X-Ray Production

X Rays:

Simulate: a conventional X-ray tube with and without 3mm Al filter for:
100 kV
and 125 kV

Analysis: Determine the mean energies of the unfiltered and filtered spectra
Determine the shape of the spectrum numerically from
the energy histogram. This will be needed for the next assignment

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