LUXE Participation in FCAL Beam Test

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Outline

- Introduction
- Design of experimental setup at EU.XFEL
- Possible FCAL detectors application at LUXE

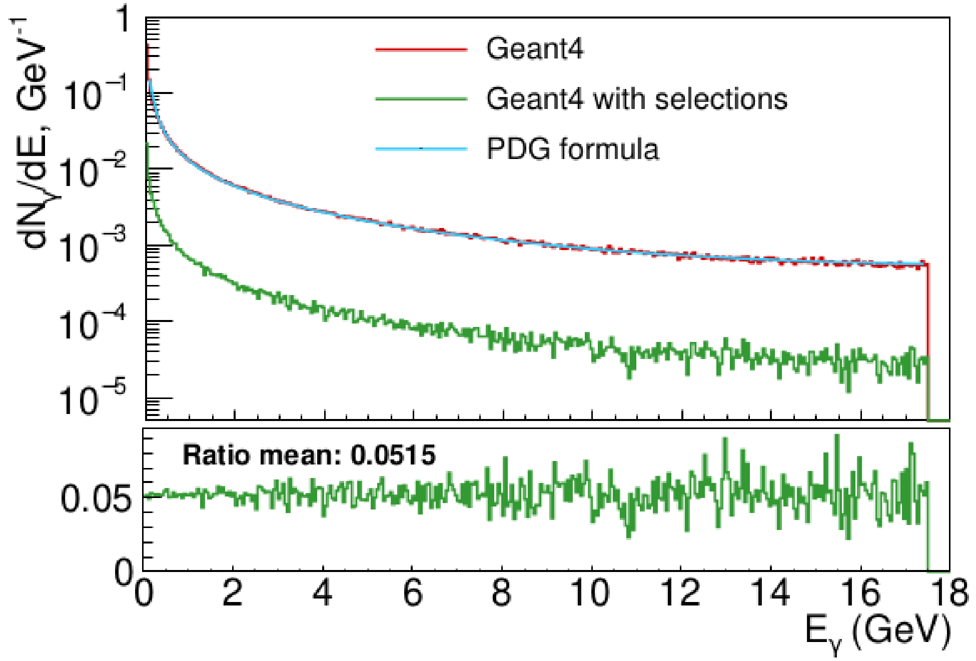
Bremsstrahlung production: Geant4 vs PDG formula

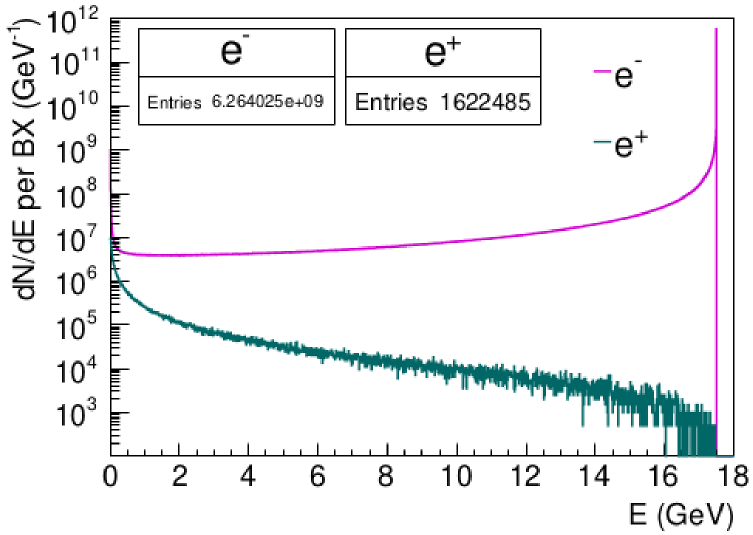
PDG recommended formula for thin targets for bremsstrahlung production:

$$\omega_i \frac{\mathrm{d}N_\gamma}{\mathrm{d}\omega_i} \approx \left[\frac{4}{3} - \frac{4}{3}\left(\frac{\omega_i}{E_e}\right) + \left(\frac{\omega_i}{E_e}\right)^2\right] \frac{X}{X_0}$$

It is used to calculate integral on slide 3 to get the pair production rate.

- The formula does not take into account angular distribution of bremsstrahlung photons
- Geant4 simulation:
  - accounts for laser beam transverse size
  - and thick targets to optimize the photon flux.





- Gaussian beam;
- Tungsten target 1%X0 (35um), 2m from IP;
- 10M electrons
- Two histograms are compared:
  - |x| < 1mm and |y| < 1mm;
  - |x| < 25um and |y| < 25um.

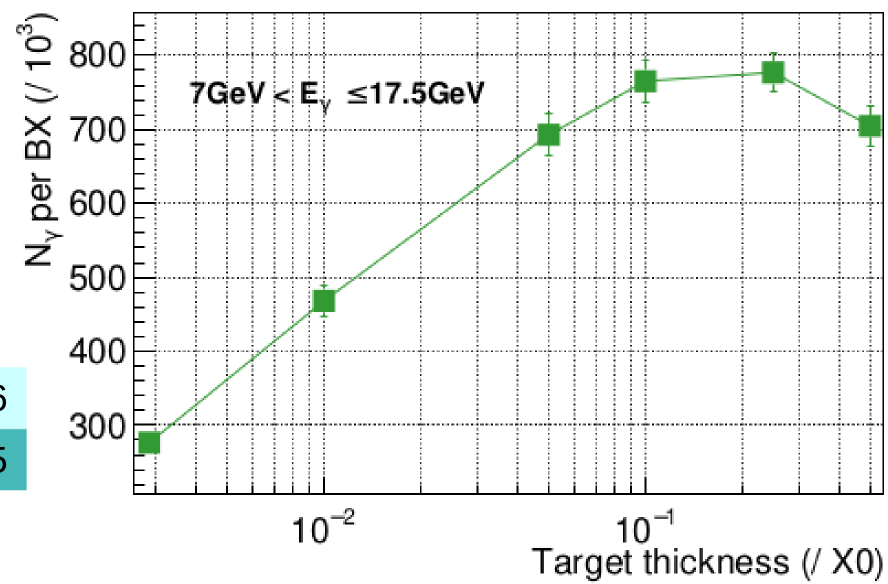
Geant4 simulation with different target thickness and different physics lists

- Gaussian beam, focused on IP;
- Tungsten target 1%X0 (35um) thickness
- 5 m from IP;
- 6.25 M electrons (BX/1000);
- Production cut: 1 µm.

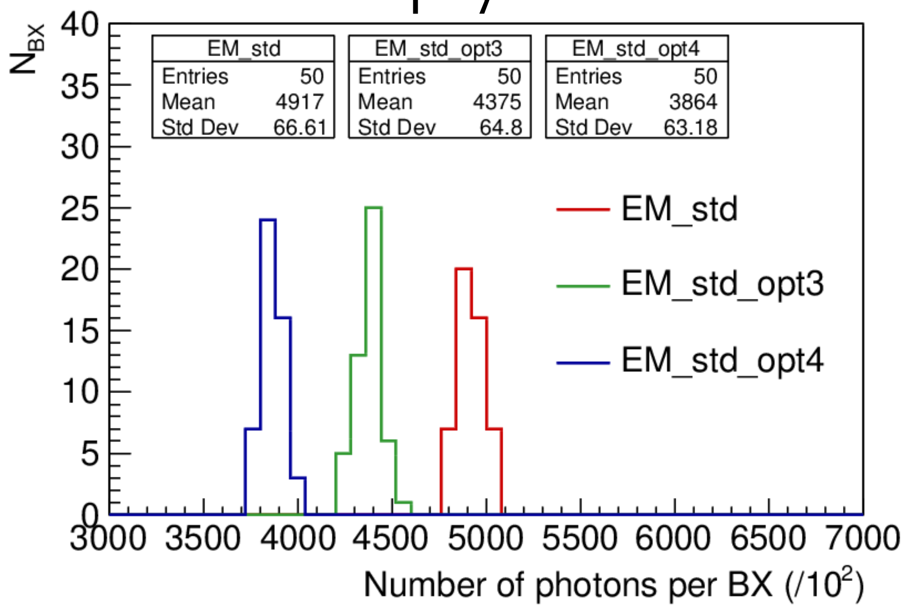
Number of photons inside |x|<25um and |y|<25um;

Nγ	4.91E+06
Nγ, E >7GeV	4.66E+05

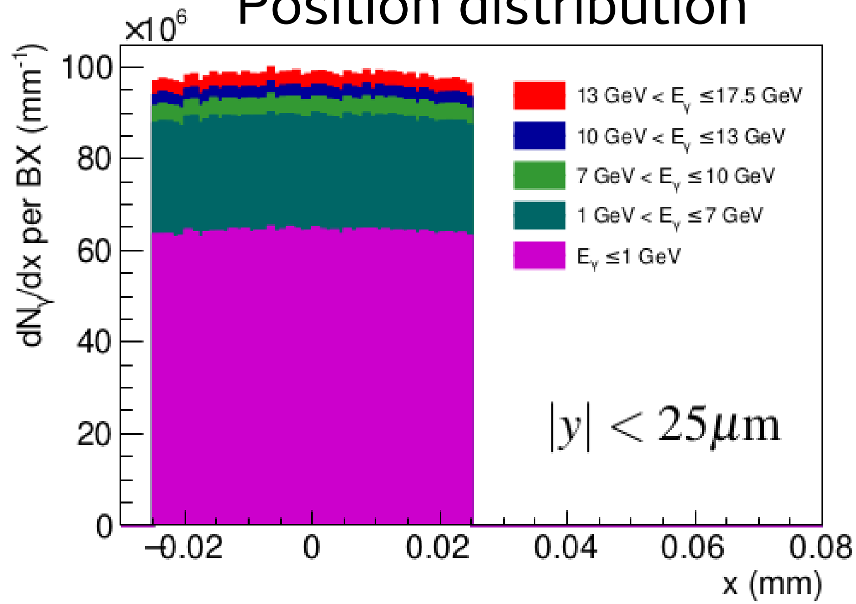
Different target thickness



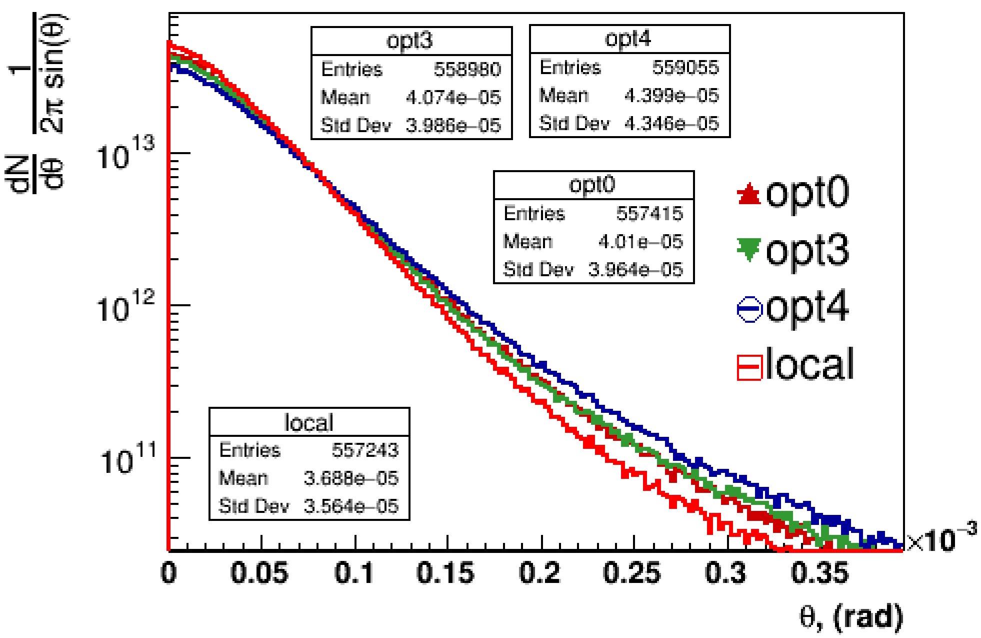
Different physics lists

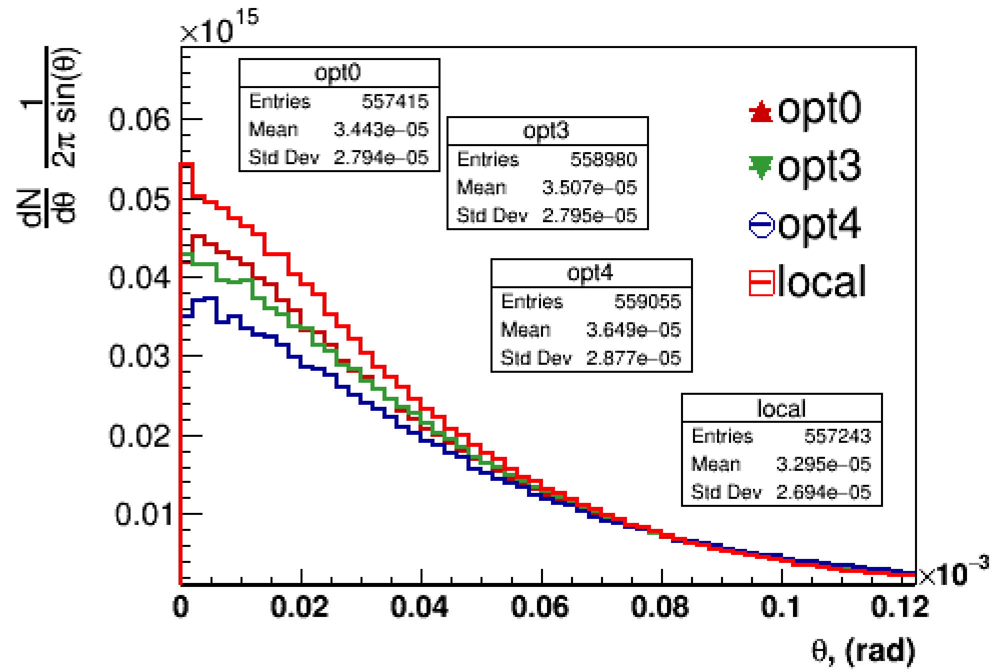


Position distribution



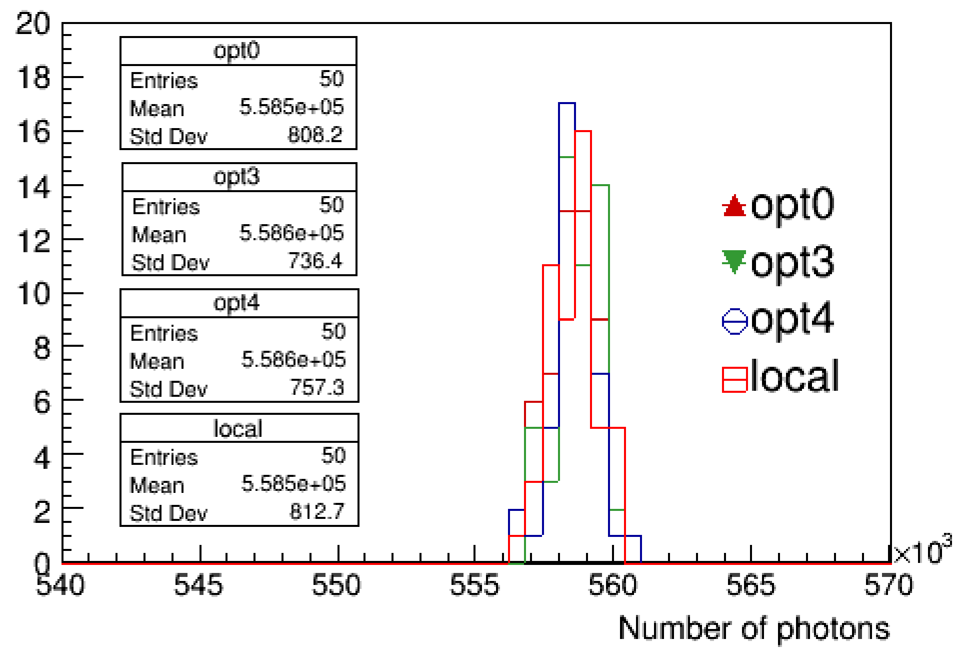
γ angular distribution for different physics lists



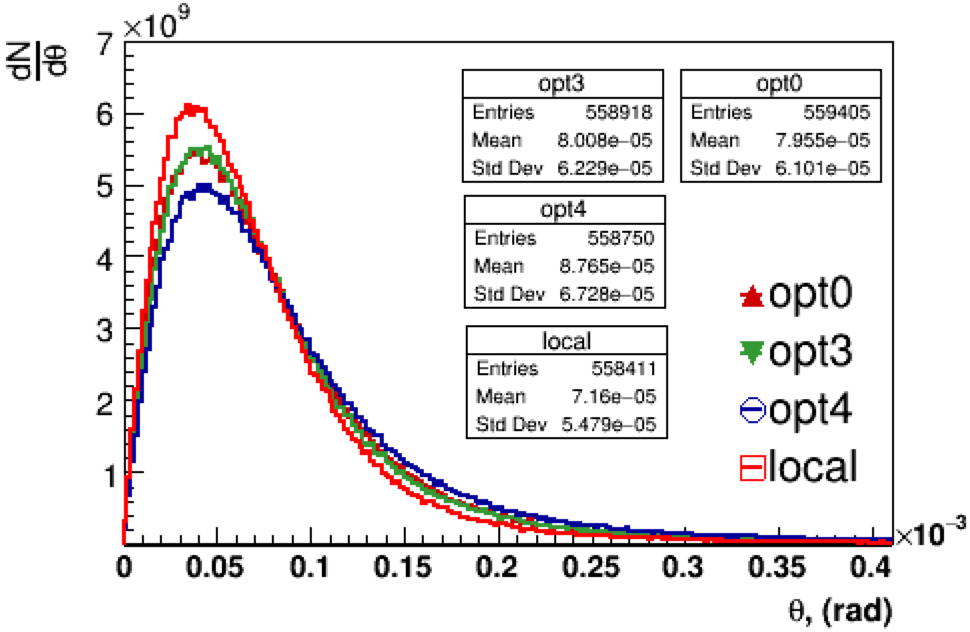


- Angular distribution is the widest for option_4 physics list and the narrowest for the local one.
- Angular distribution explains bottom right plot on previous slide.
- Total number of photons in forward region is identical for all physics lists.

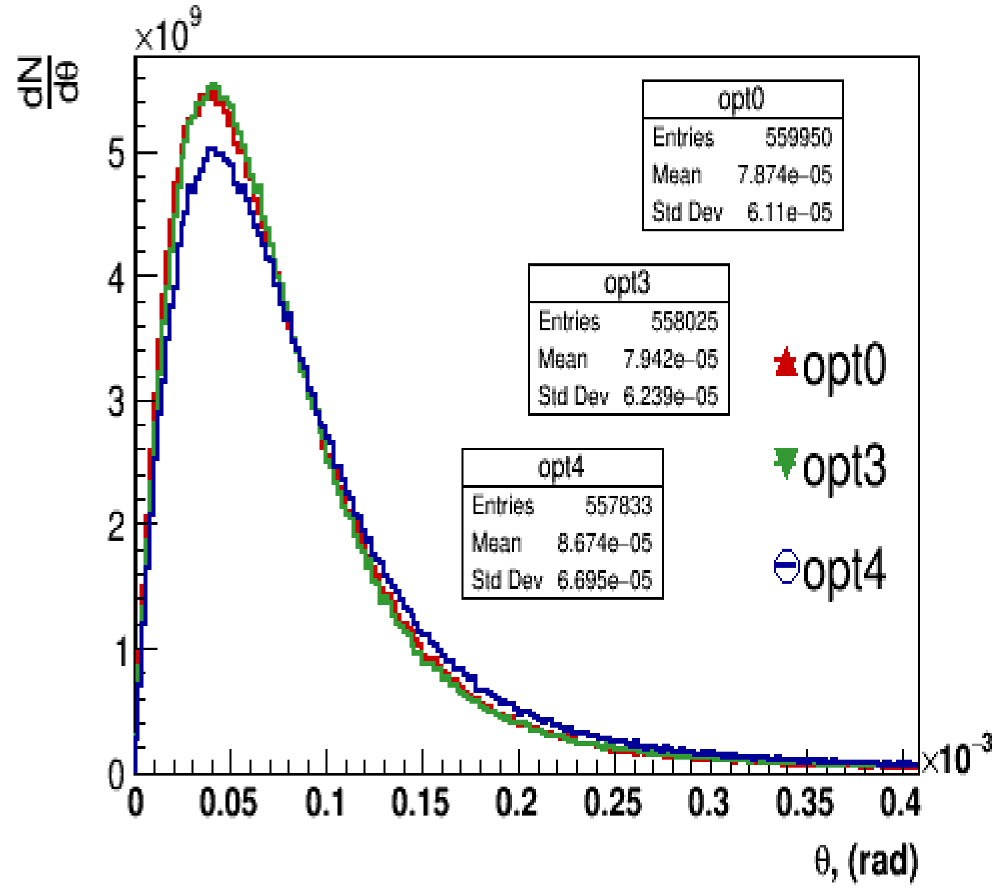
Number of photons inside
|x|<1.5 m and
|y|<1.5 m

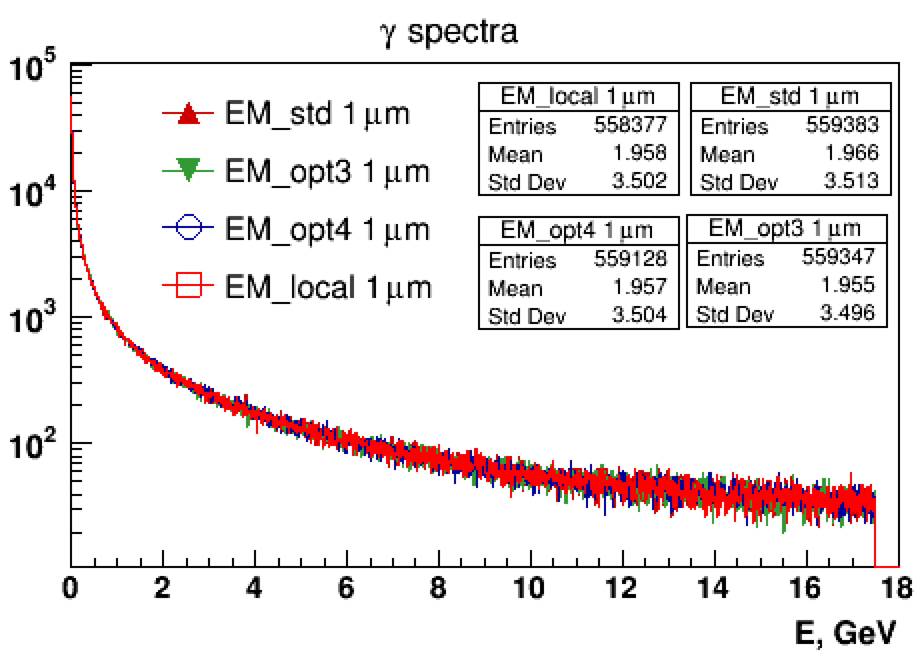


Polar angle distribution and spectra



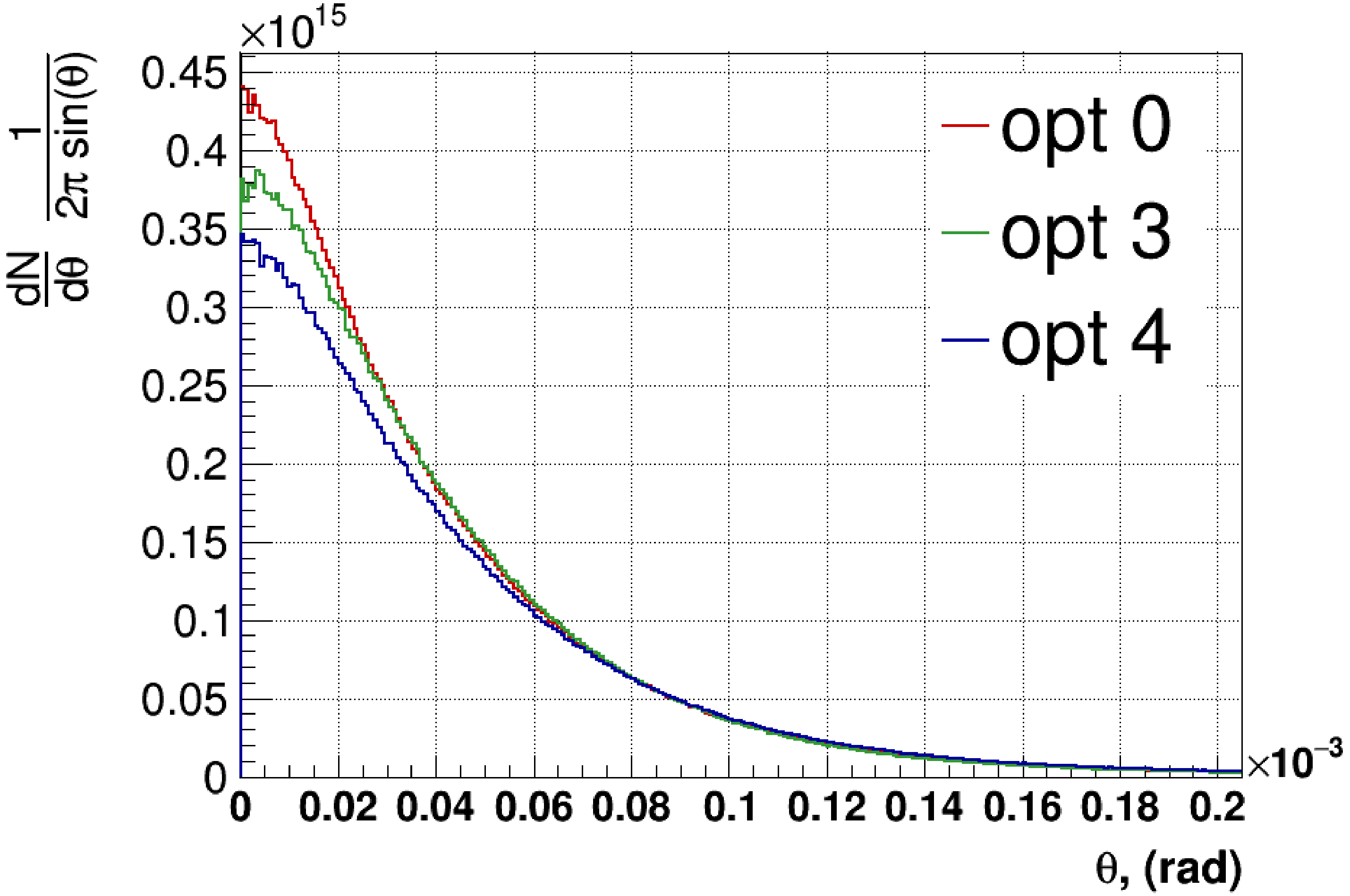
Unidirectional beam:
x=y=px=py=0



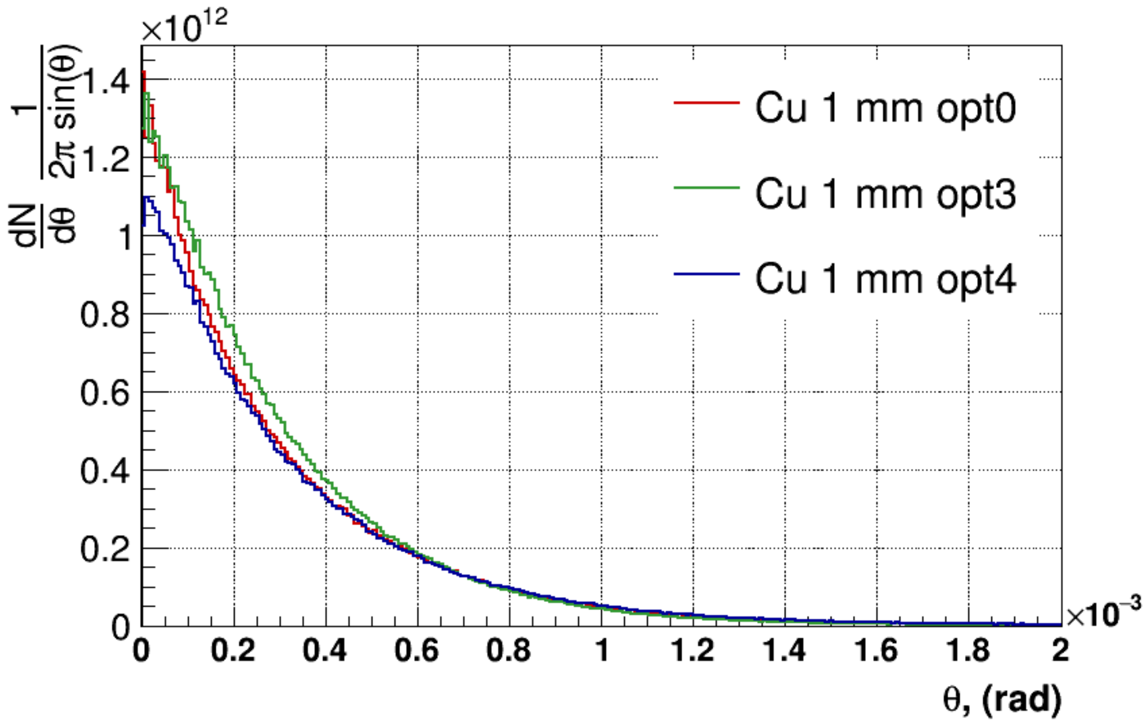


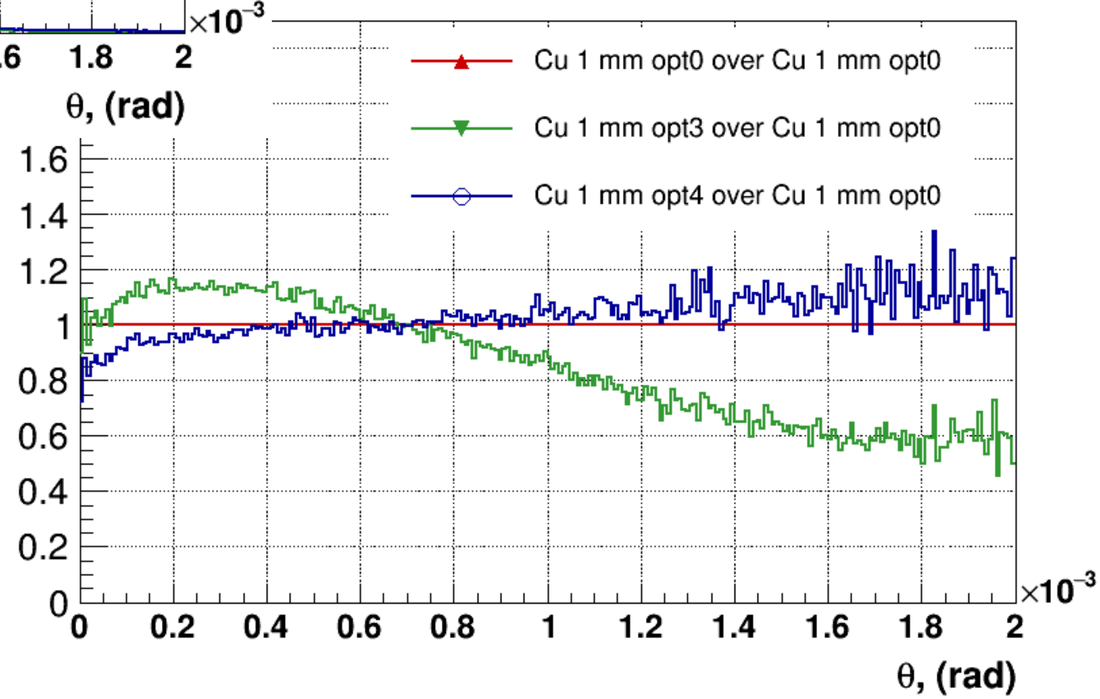
W, 17.5 GeV. Photons

- Beam, x=y=px=py=0;
- Tungsten target 1%X0 (35um) thickness
- 2 m from IP;
- Production cut: 1 μm.



Copper target 1 mm. Photons





$$\frac{\int_{0}^{7\times10^{-4}} N(\theta)\, d\theta}{\int_{7\times10^{-4}}^{1.8\times10^{-3}} N(\theta)\, d\theta}$$

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Ratio: 0.106622
Ratio: 0.0850311
Ratio: 0.11863
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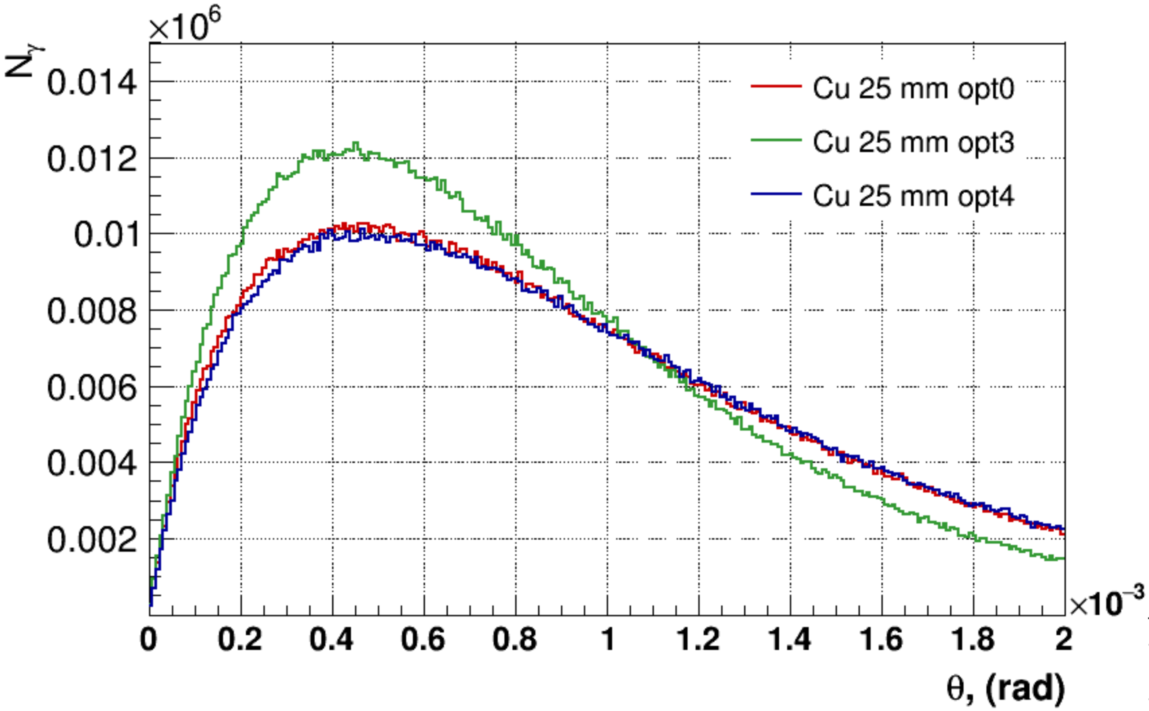
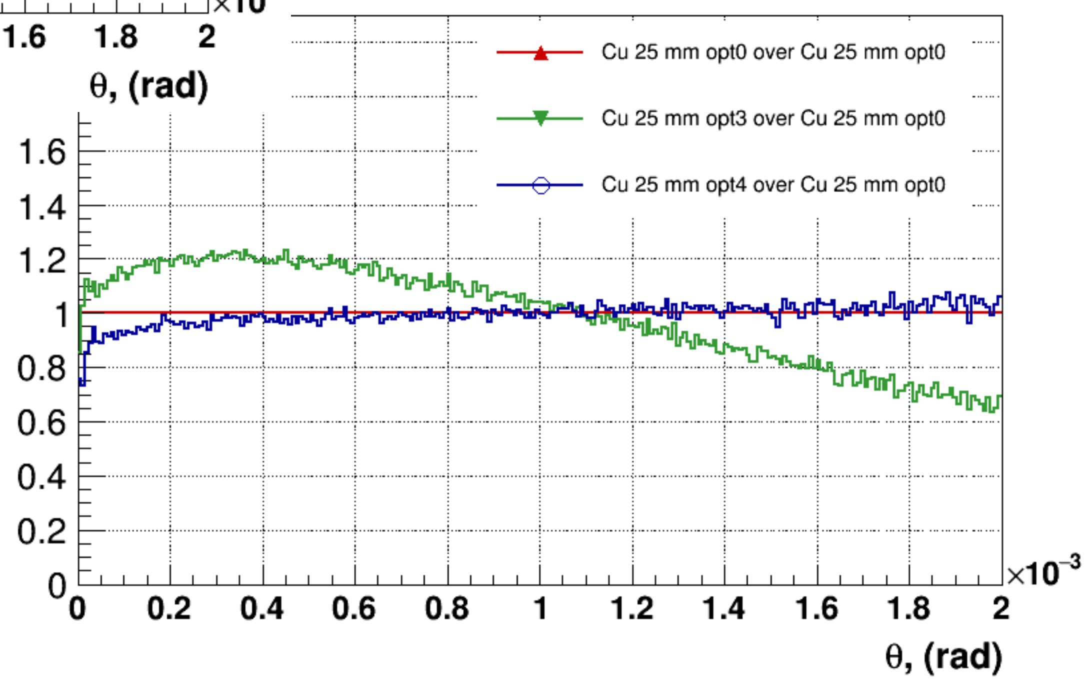
Copper 2.5 mm. Photons

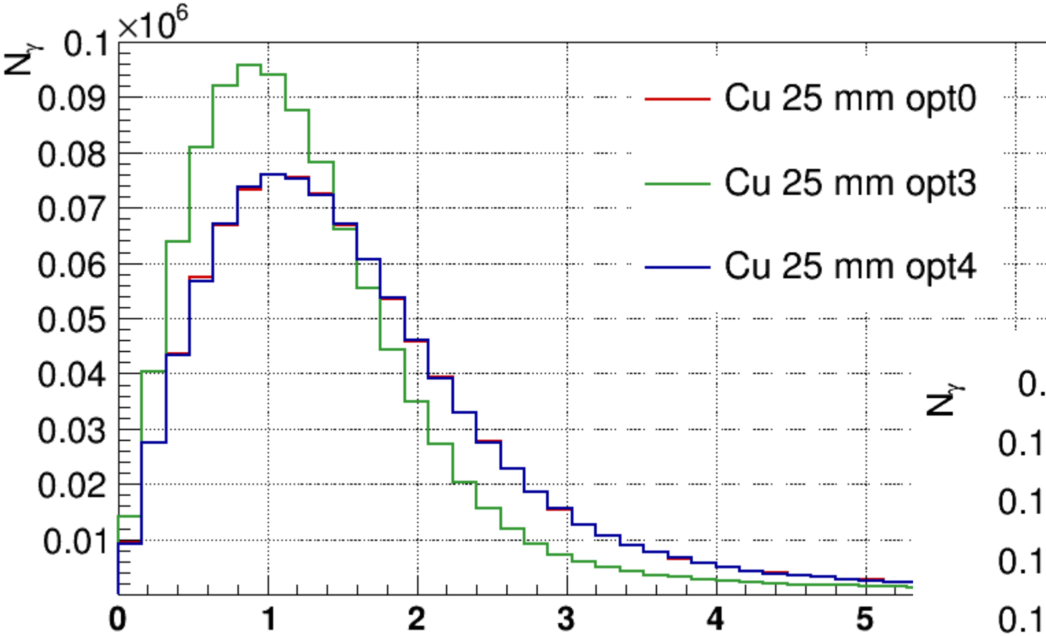


$$\frac{\int_{0}^{1.1\times 10^{-3}} N(\theta)\, d\theta}{\int_{1.1\times 10^{-3}}^{1.8\times 10^{-3}} N(\theta)\, d\theta}$$

Ratio: 0.35302
Ratio: 0.269642
Ratio: 0.36518

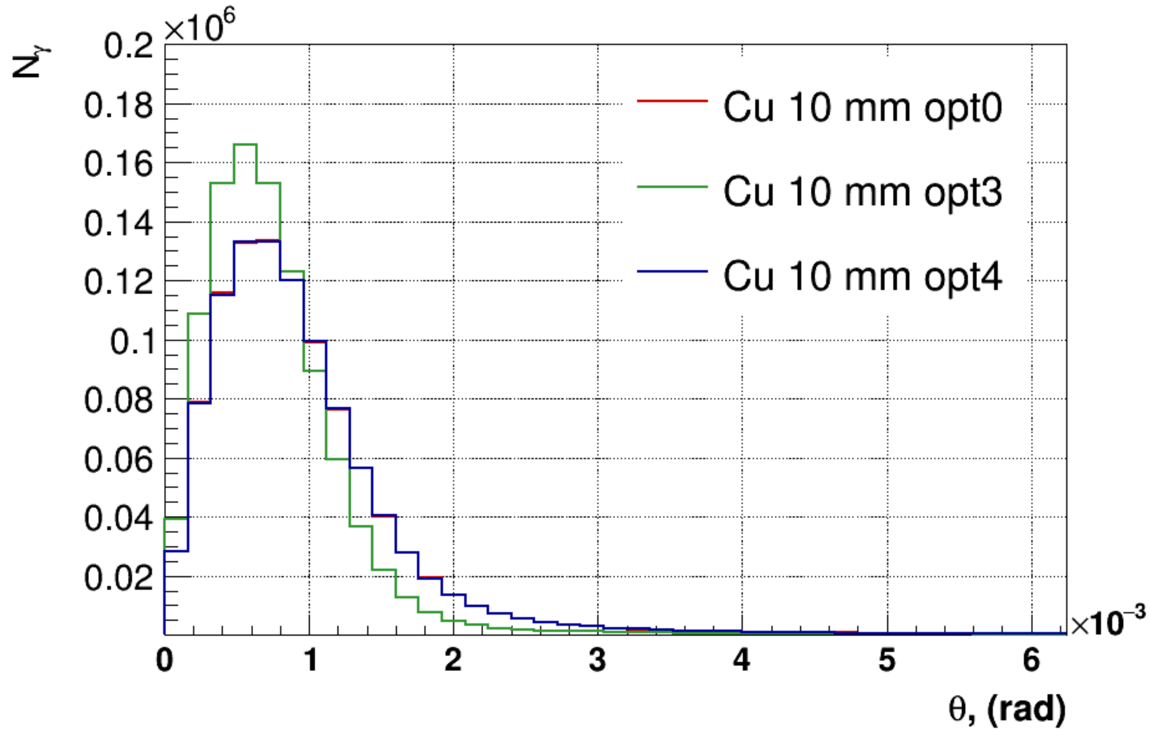


Copper 2.5 mm, Electrons 5 GeV



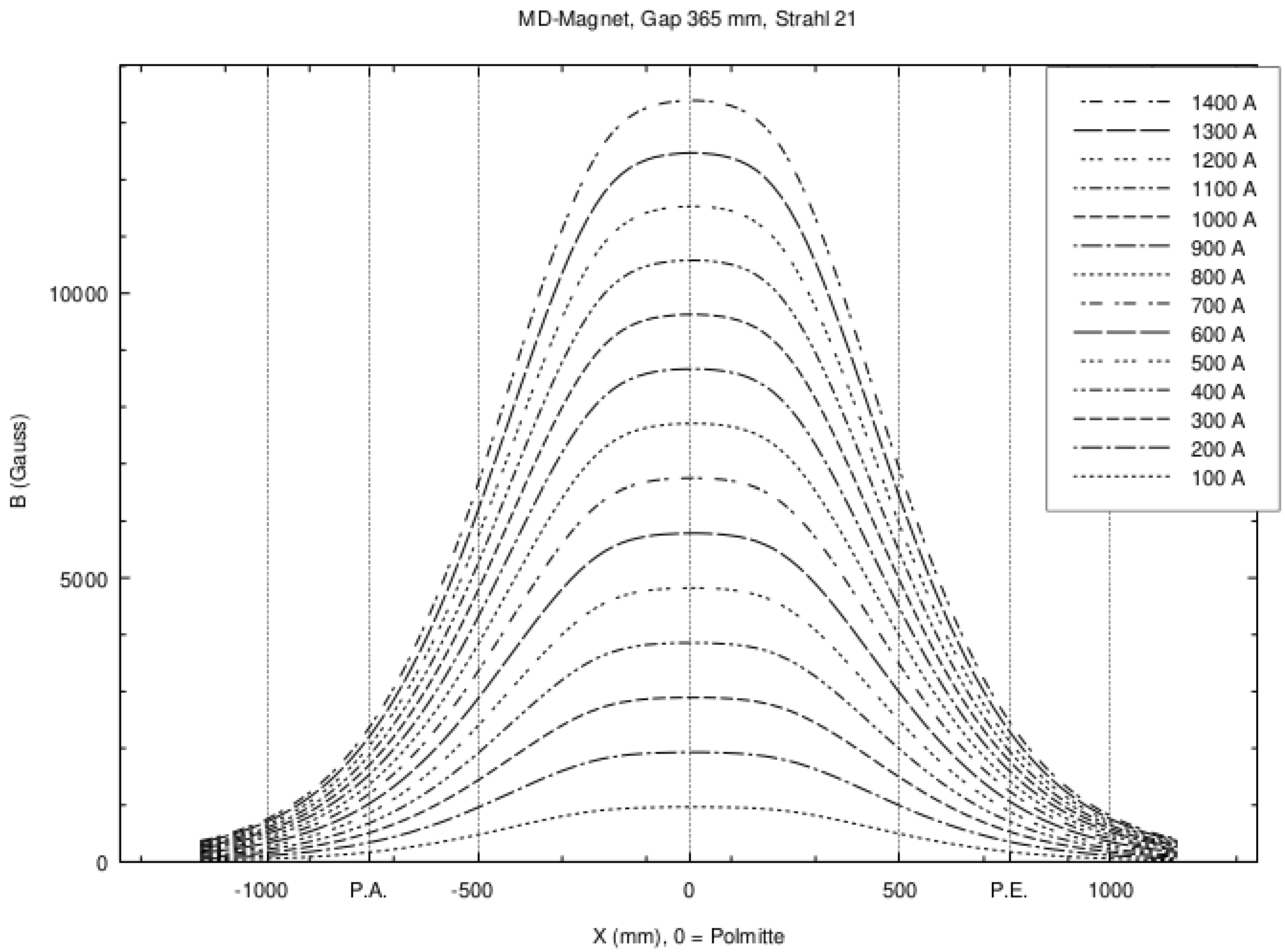
Ratio: 0.692759
Ratio: 0.37029
Ratio: 0.693171

$$\frac{\int_{0}^{1.5\times10^{-3}} N(\theta)\,d\theta}{\int_{1.5\times10^{-3}}^{5\times10^{-3}} N(\theta)\,d\theta}$$



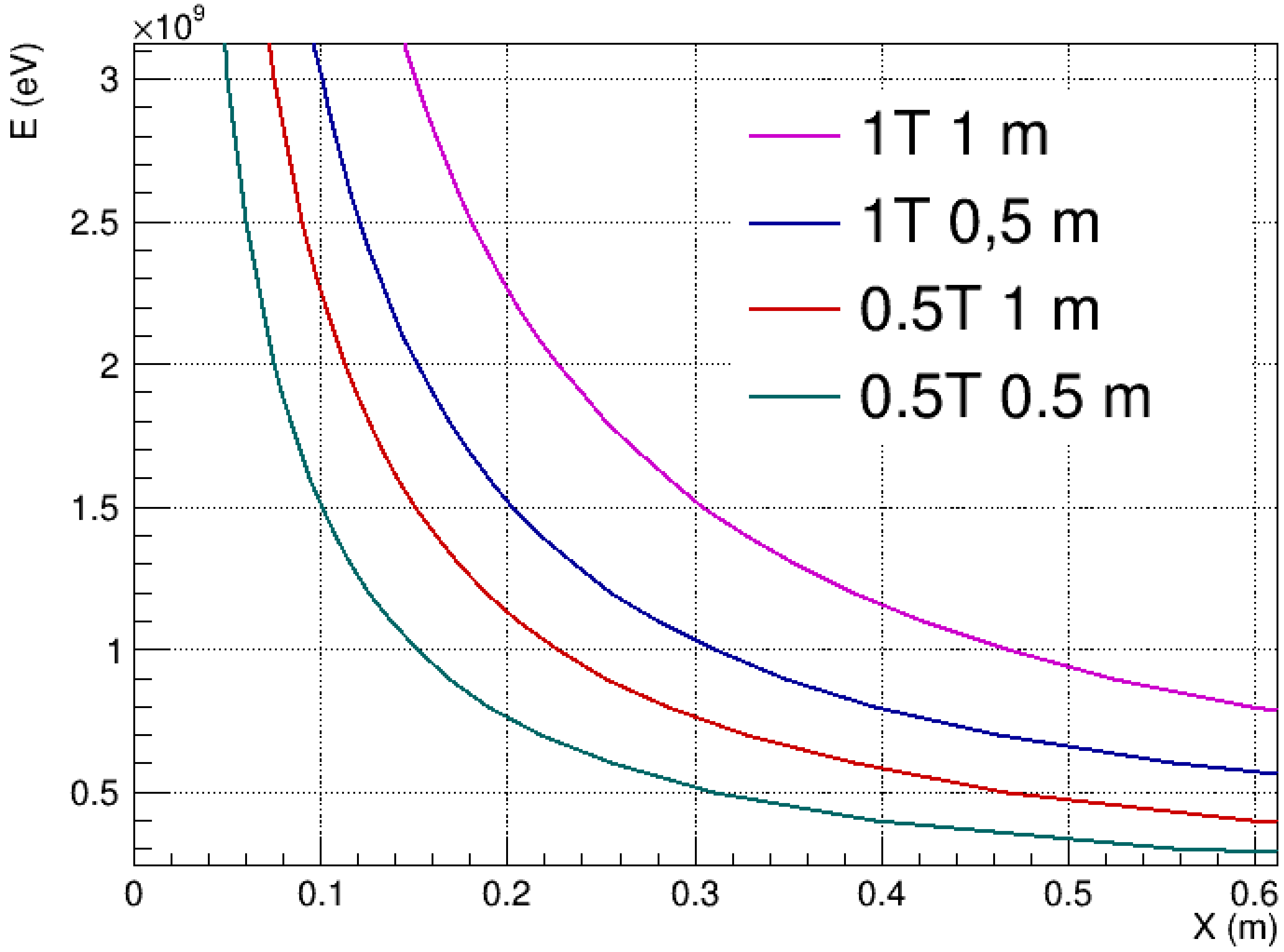
Ratio: 0.39941
Ratio: 0.195003
Ratio: 0.399752

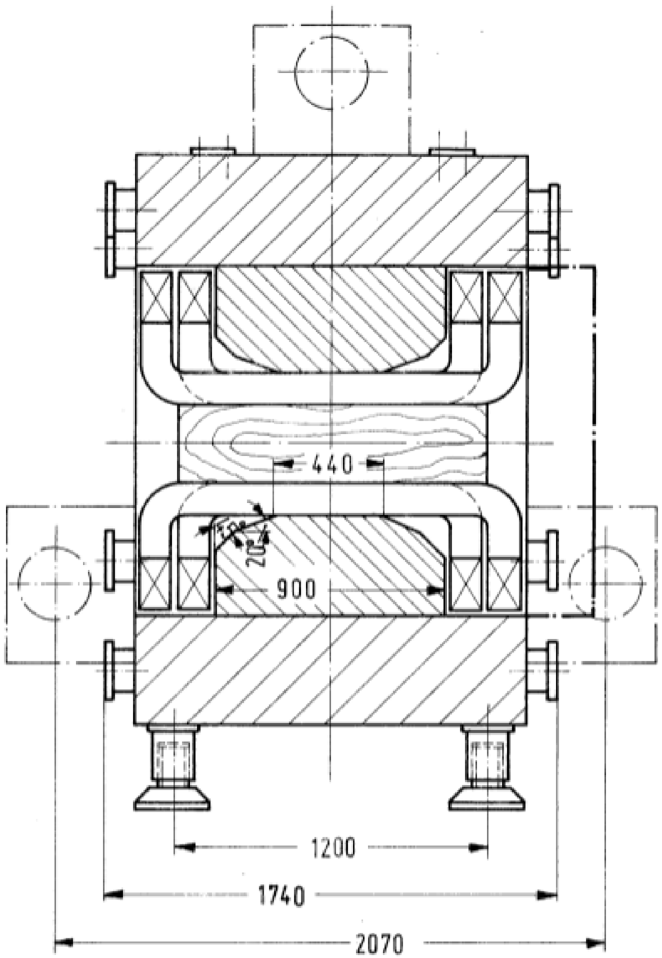
TB Magnet



MD-Magnet, Gap 365 mm, Strahl 21
1400 A
1300 A
1200 A
1100 A
1000 A
900 A
800 A
700 A
600 A
500 A
400 A
300 A
200 A
100 A
10000
5000
0
B (Gauss)
-1000
P.A.
-500
0
500
P.E.
1000
X (mm), 0 = Polmitte

TB Magnet Drawing





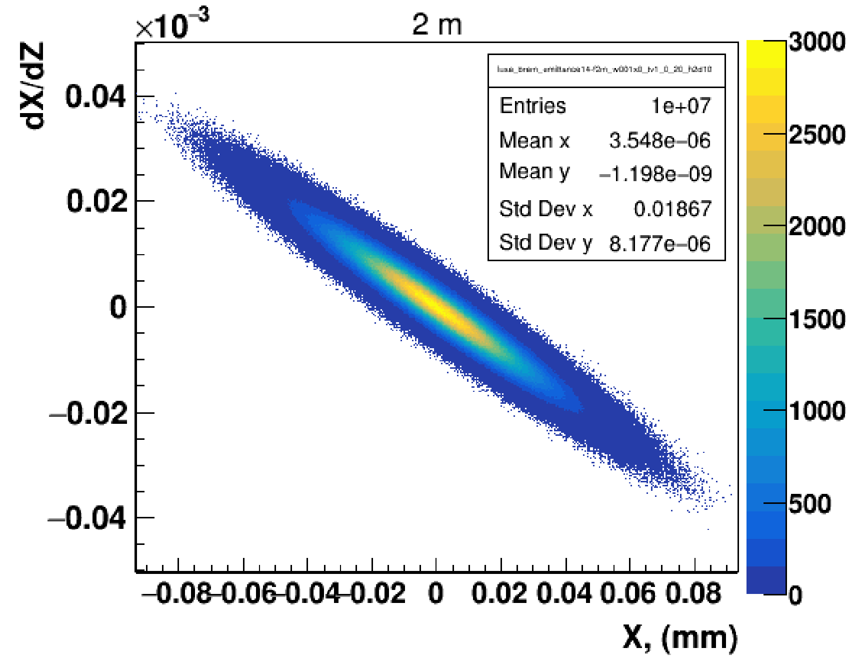
Back up

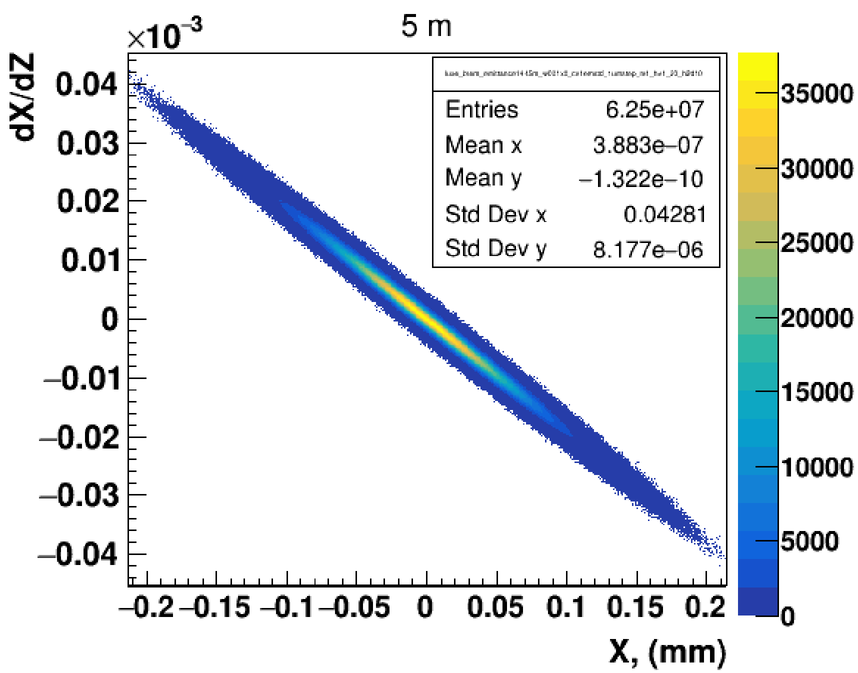
Initial electron phase space distribution. Target 2 m, 5 m and 12 m upstream of IP

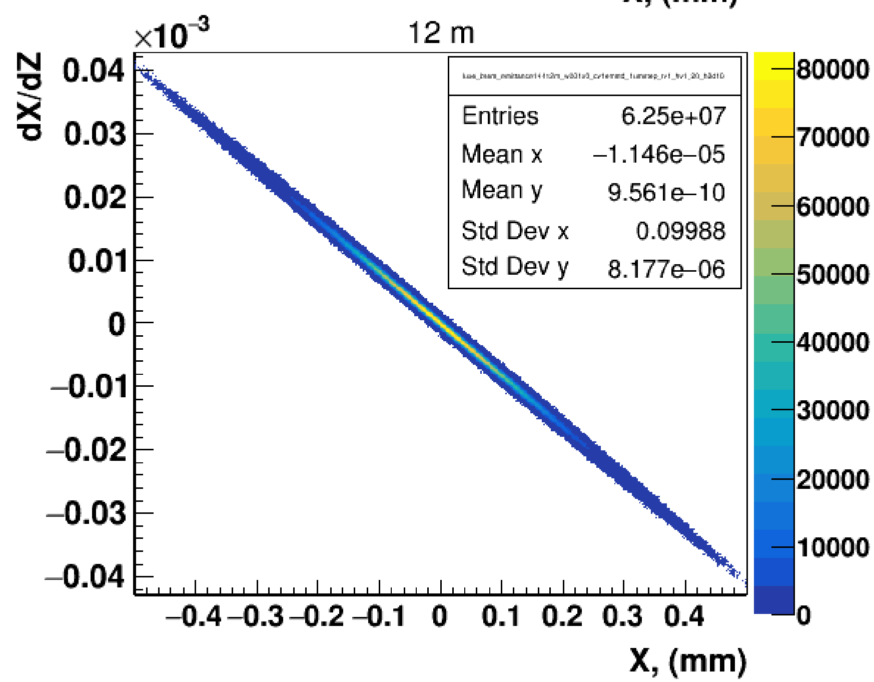
- 2 m: σx = 19 μm;
- 5 m: σx = 43 μm;
- 12 m: σx = 100 μm;

$\sigma_{x,\,y}$ at IP: 5 μm;

Normalized emittance 1.4 mm mrad;







Electron and laser beam parameters

E_pulse, µJ	Crossing angle, rad	Laser σxy, µm	Laser σz, ps	N Electrons	Electron σx, mm	Electron σy, mm	Electron σz, ps
3.5*10^6	0.3	10	0.035	6.25E+09	0.005	0.005	0.08

- Laser wavelength = 800.00 nm (1.5498 eV);
- Circular polarized.