Possible TB setup for Luxe study

Oleksandr Borysov

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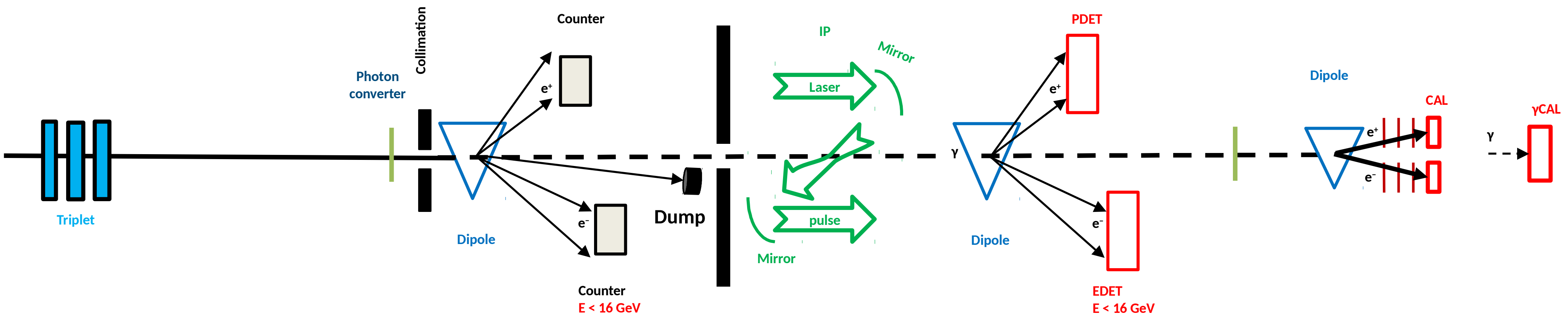
Outline

LUXE – **L**aser **U**nd **X**FEL **E**xpriment

- Introduction
- Possible TB setups for LUXE study

LUXE Setup

Photon-Photon collisions at LUXE



$$\gamma + n\omega \rightarrow e^+e^-$$

One photon pair production (OPPP) at ultra high intensity - non-perturbative physics

European XFEL electron beam:

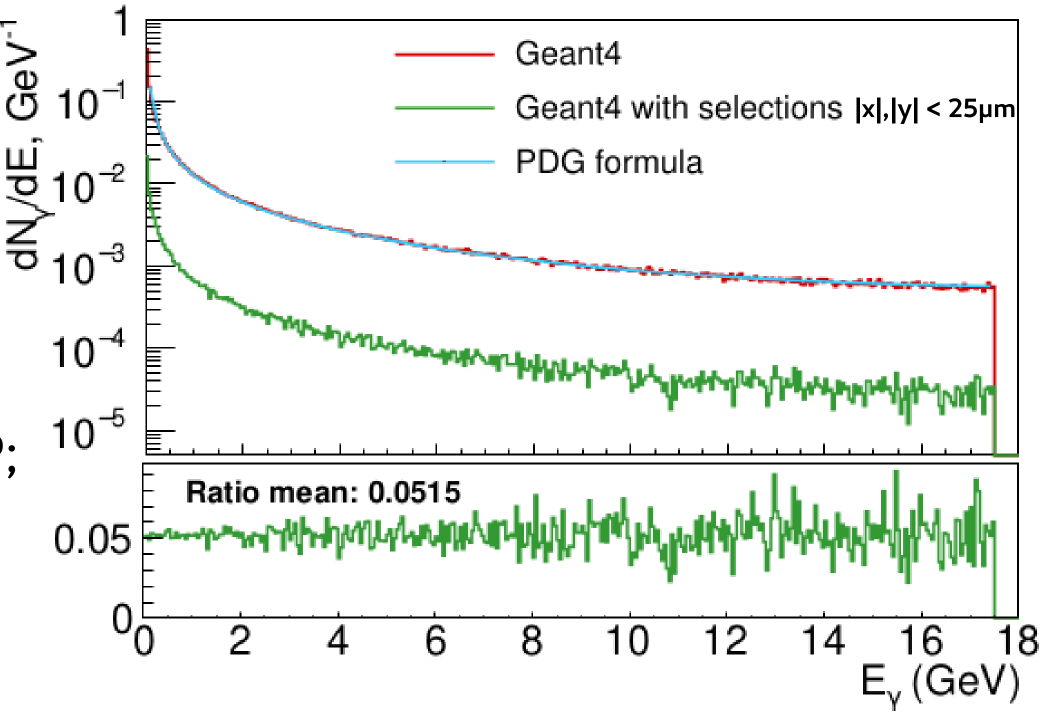
- Energy 17.5 GeV (also possible 10 GeV and 14 GeV);
- Normalized emittance 1.4 mm mrad;
- Repetition rate 10 Hz.

Photons are produced by collisions of XFEL electron beam with tungsten target

Bremsstrahlung Production in Simulation

Bremsstrahlung production (complete screening, thin target):

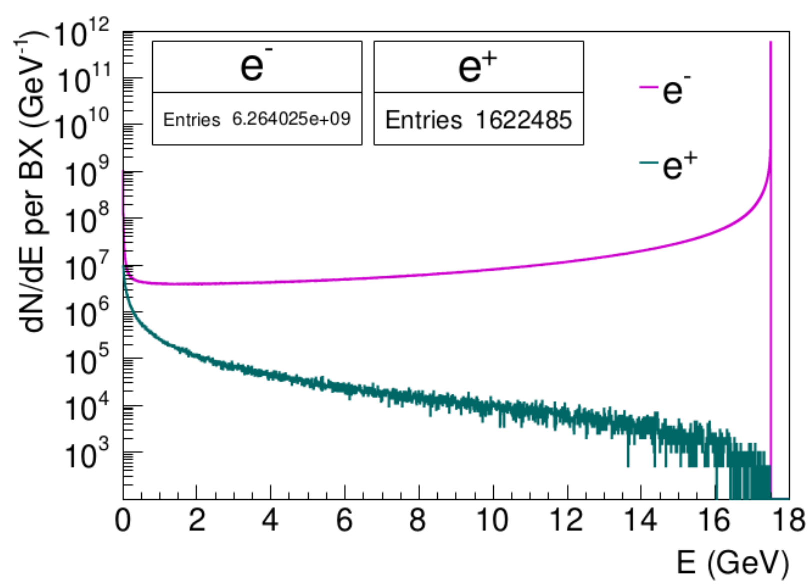
$$\omega_i \frac{dN_\gamma}{d\omega_i} \approx \left[\frac{4}{3} - \frac{4}{3}\left(\frac{\omega_i}{E_e}\right) + \left(\frac{\omega_i}{E_e}\right)^2\right] \frac{X}{X_0}$$



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

- Electrons and positrons observed in forward area behind the target (θ<17°) for one BX.

N e-	6.26E+09
N e-, < 16 GeV	1.80E+08
N e+	1.62E+06



- Can be measured to monitor number of photons.

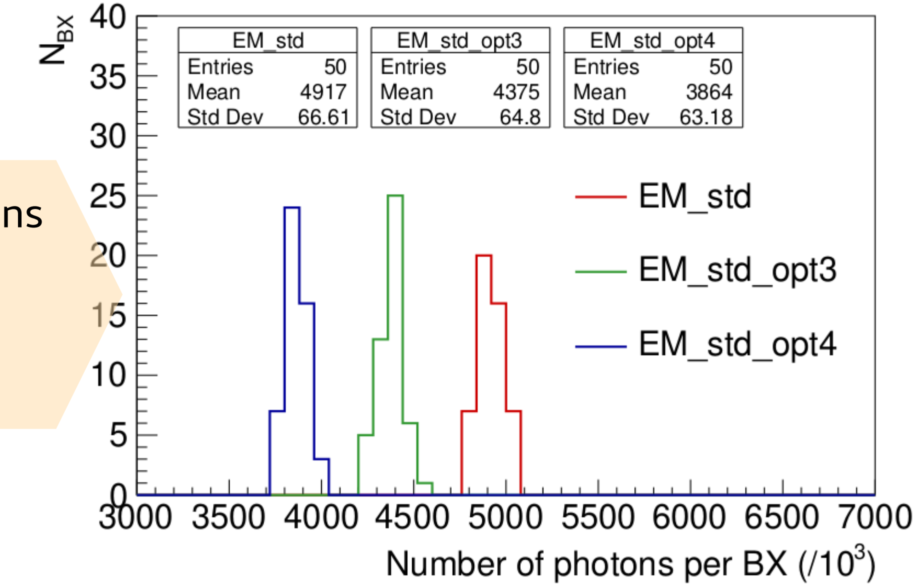
Geant4 simulation with different physics lists

- 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.

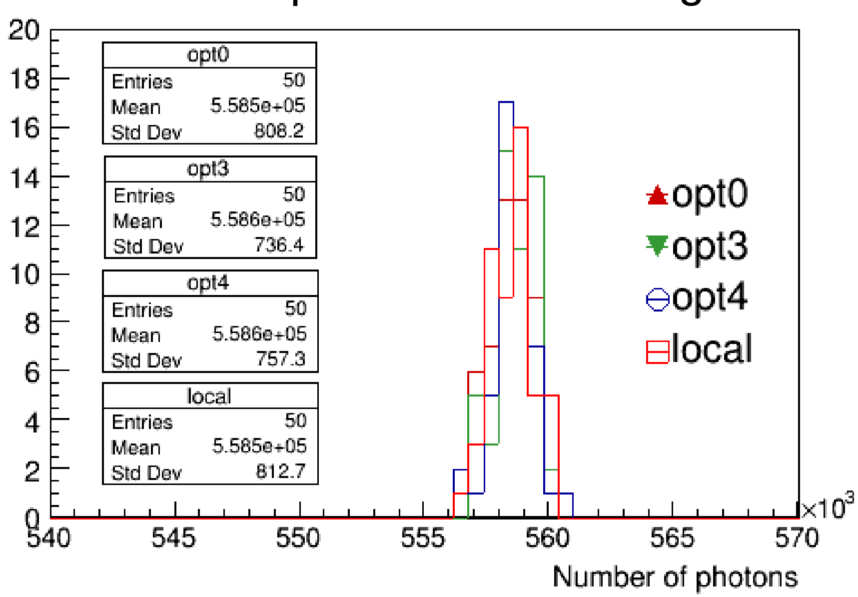
- Angular distribution is the widest for option_4 physics list and the narrowest for option_0.
- Total number of photons in forward region is identical for all physics lists.

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

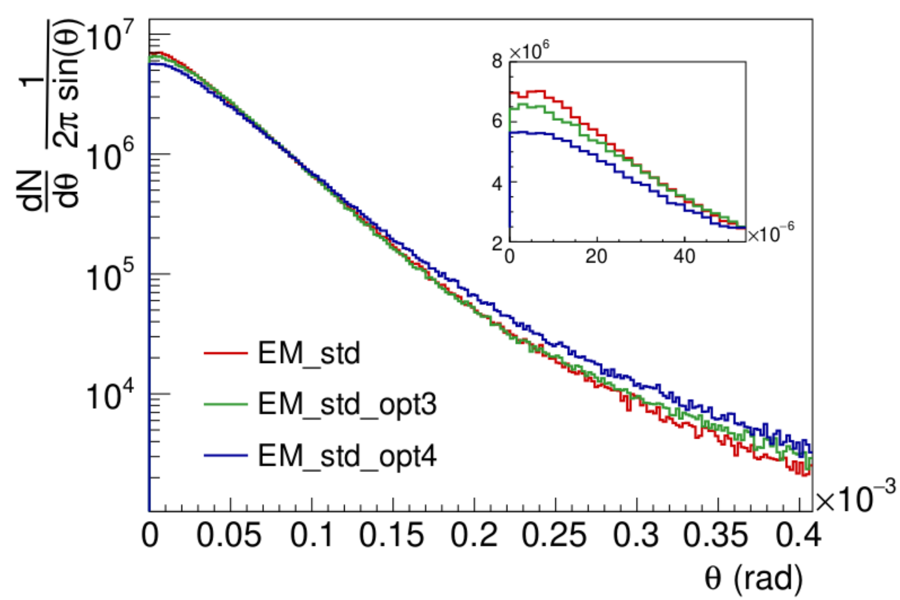
Different physics lists



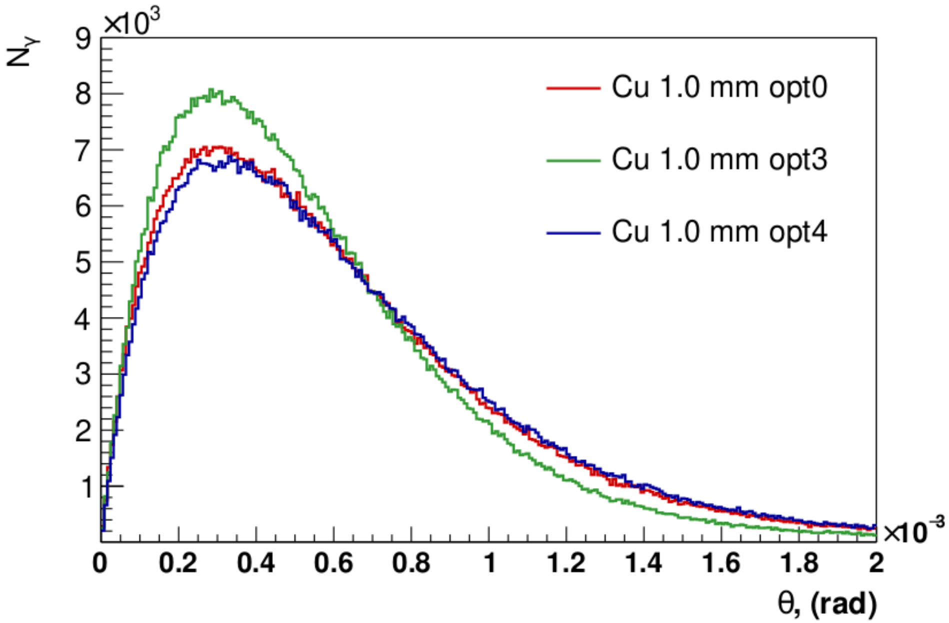
Number of photons in wide rage of θ

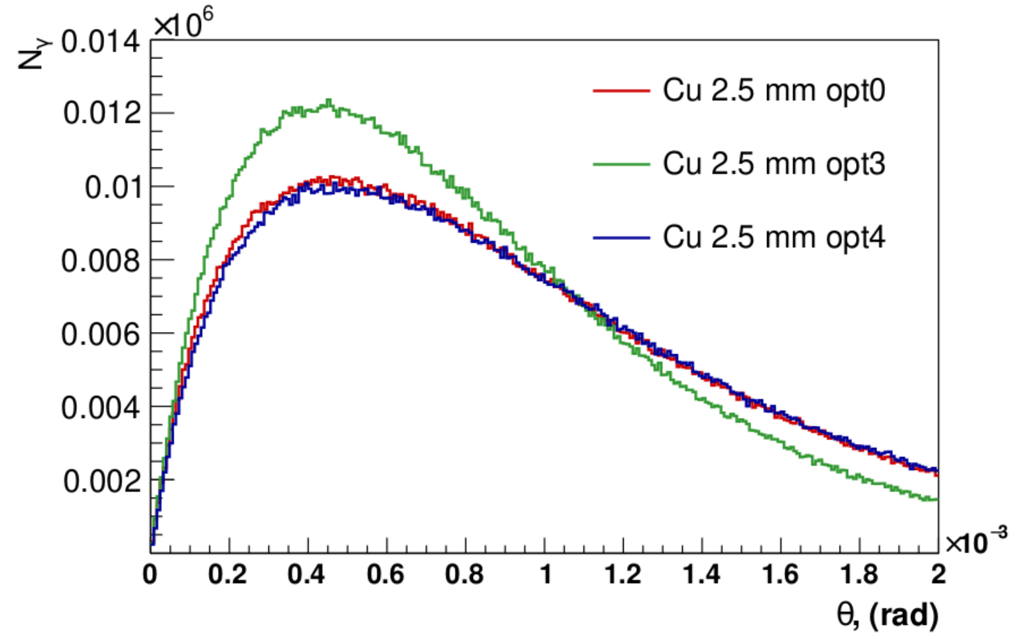


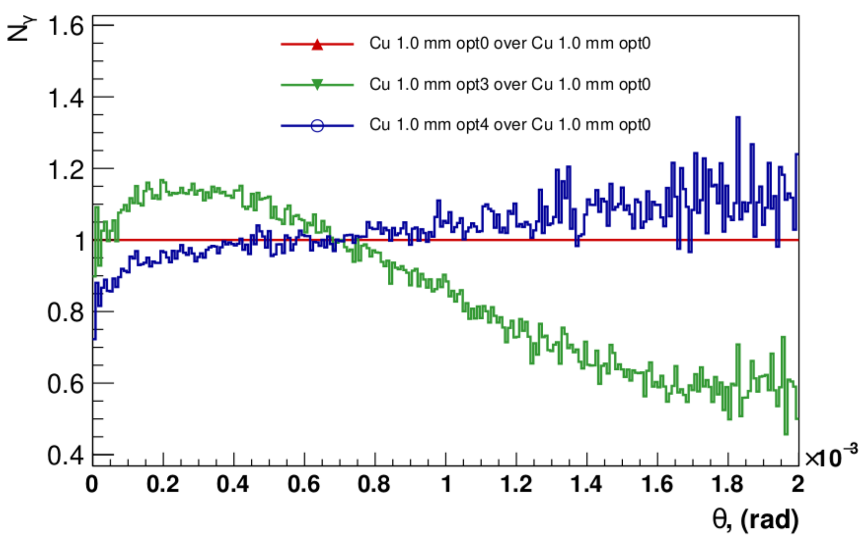
Angular distribution of photons

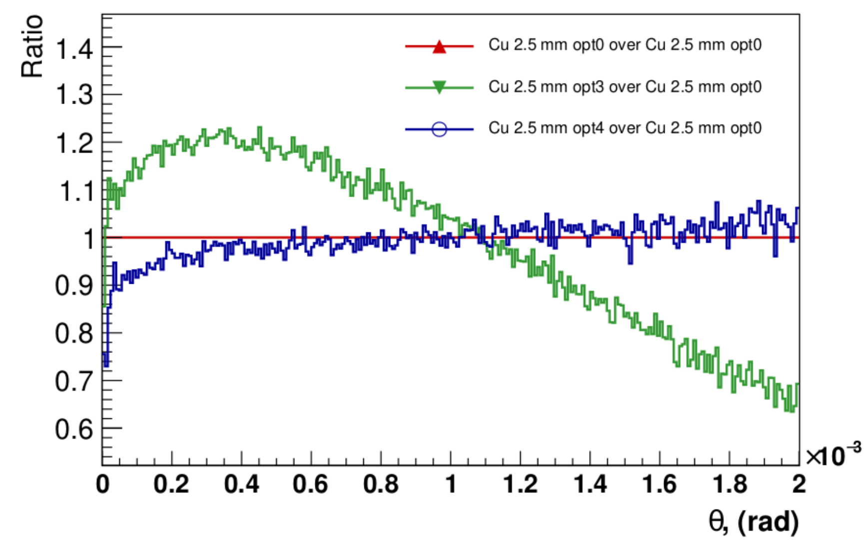


Copper targets 1 mm and 2.5 mm. Photons



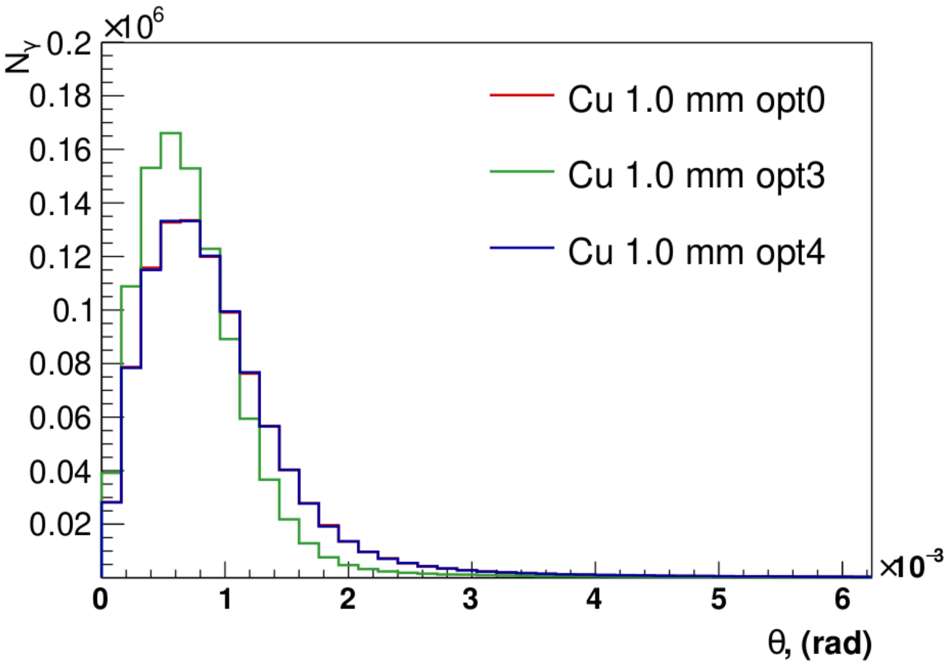


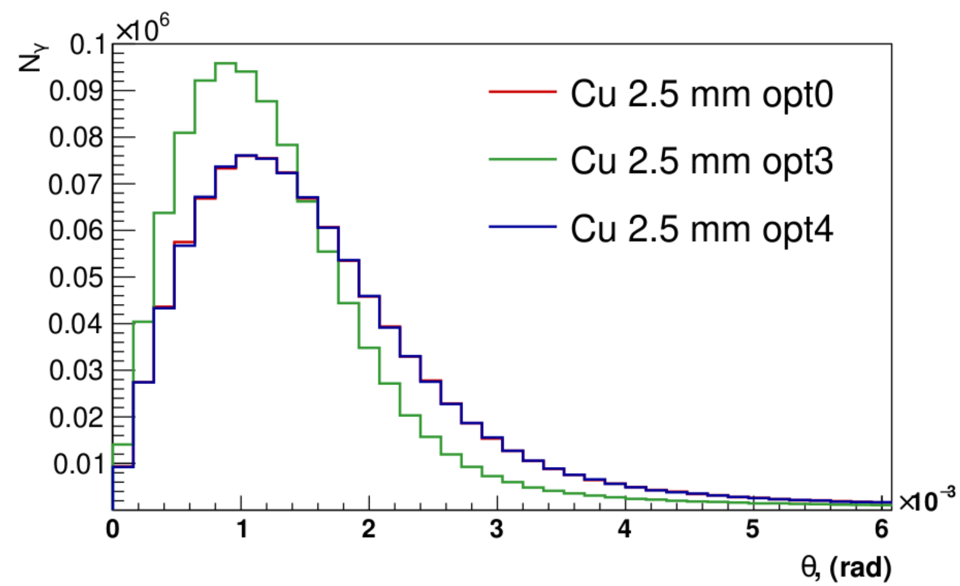




$$\frac{\int_0^{\theta_0} N(\theta)\,d\theta}{\int_{\theta_0}^{1.8\times10^{-3}} N(\theta)\,d\theta}$$

Copper 2.5 mm, Electrons 5 GeV






```
Ratio: 0.39941
Ratio: 0.195003
Ratio: 0.399752
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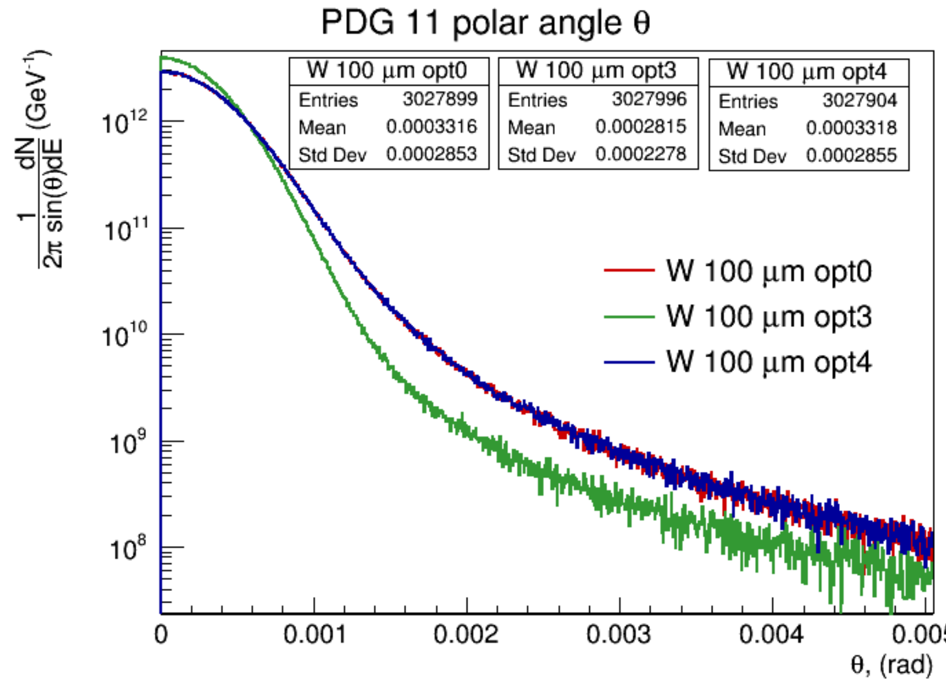
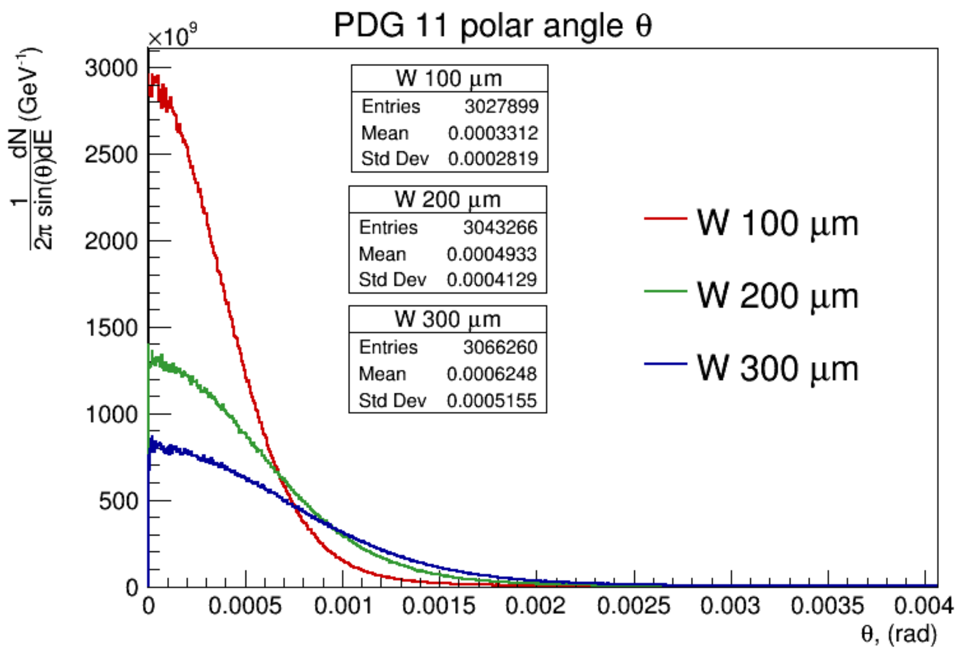
```
Ratio: 0.692759
Ratio: 0.37029
Ratio: 0.693171
```

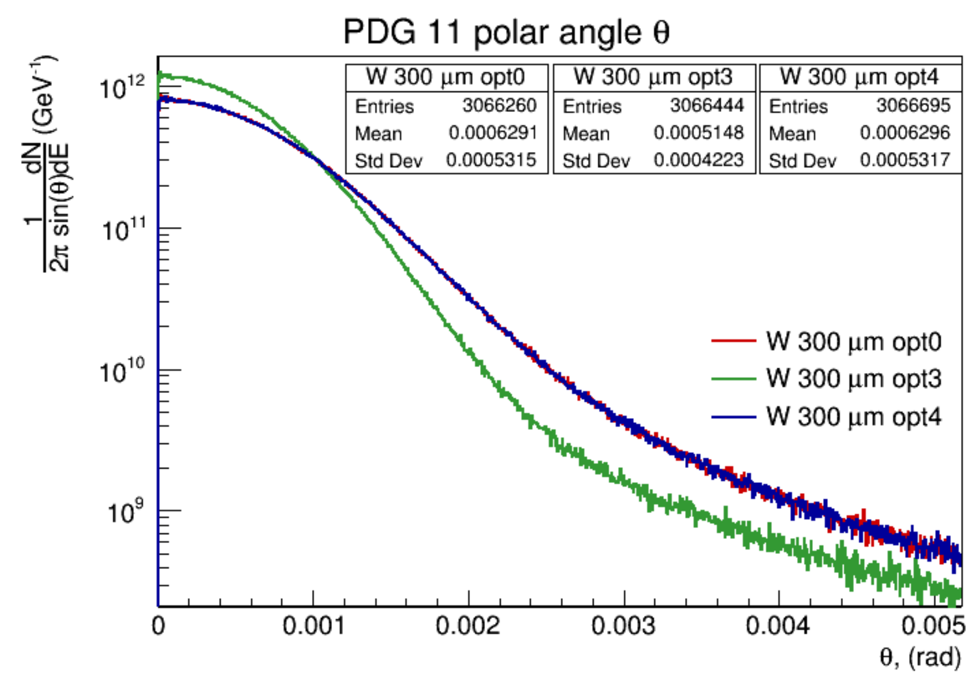
$$\frac{\int_{0}^{\theta_0} N(\theta)\, d\theta}{\int_{\theta_0}^{1.8\times 10^{-3}} N(\theta)\, d\theta}$$

Electrons polar angle after tungsten of different thickness

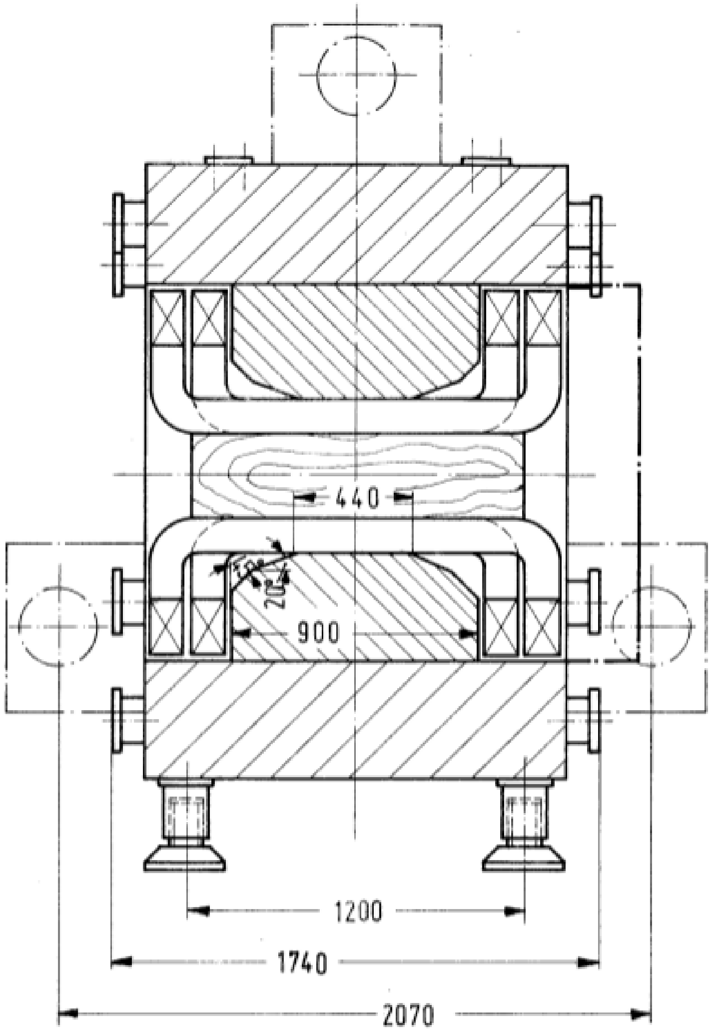
- Angular distributions of electrons after the target are different for different physics lists (opt_0 and opt_3);
- Typical angle where the difference is observed is ~1 mrad;
- For 2 m distance from the target to detector it results in ~2 mm distance;
- ALPIDE sensor with few micron resolution can be capable to measure the difference.



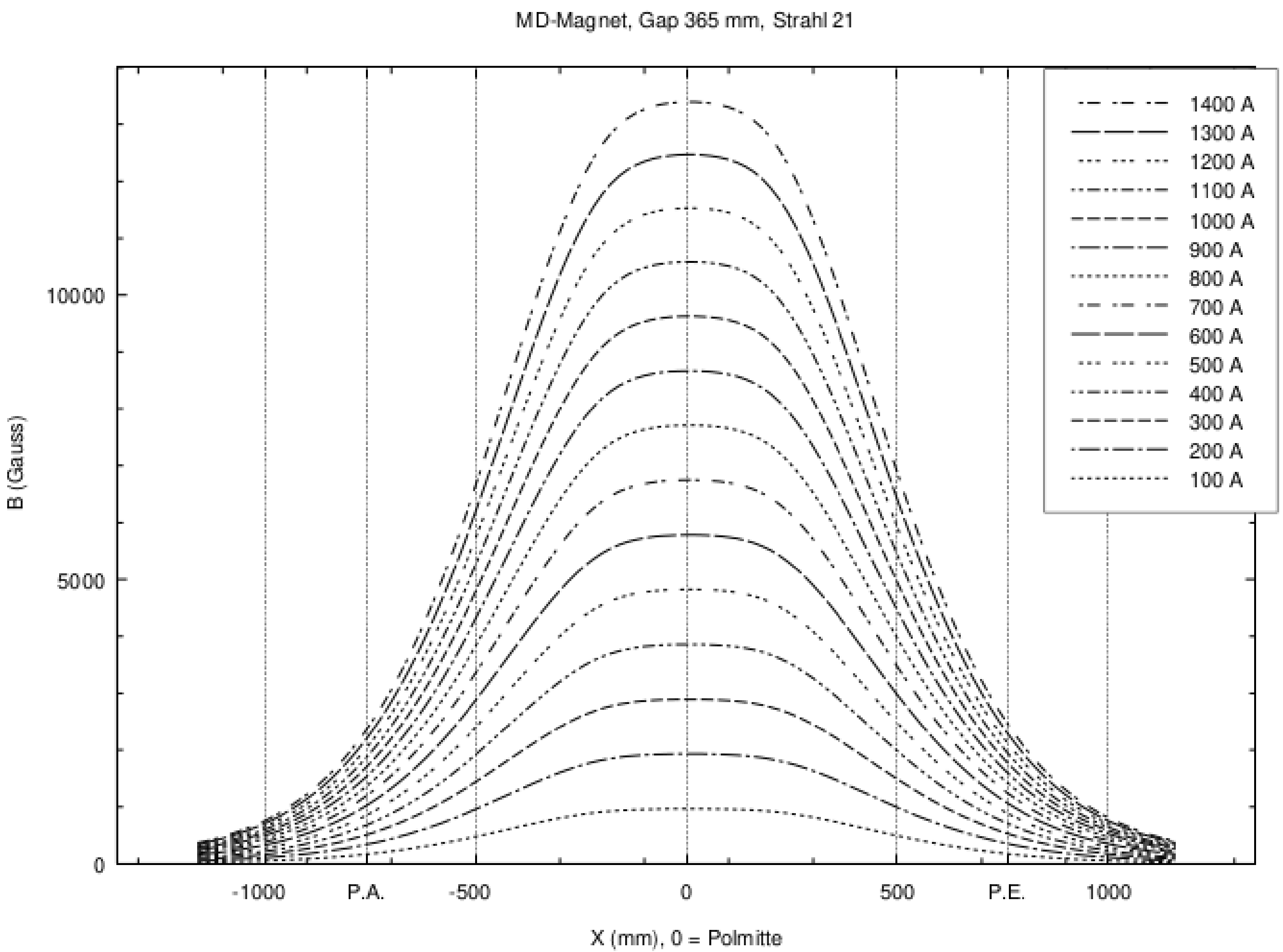




TB Magnet

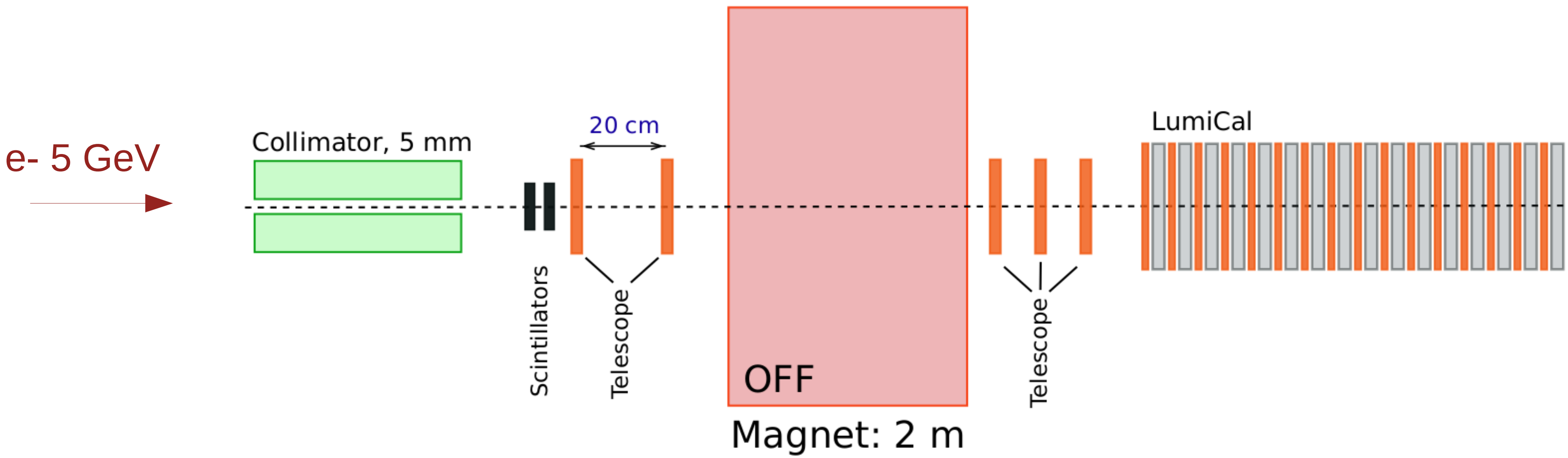


440
20°
900
1200
1740
2070



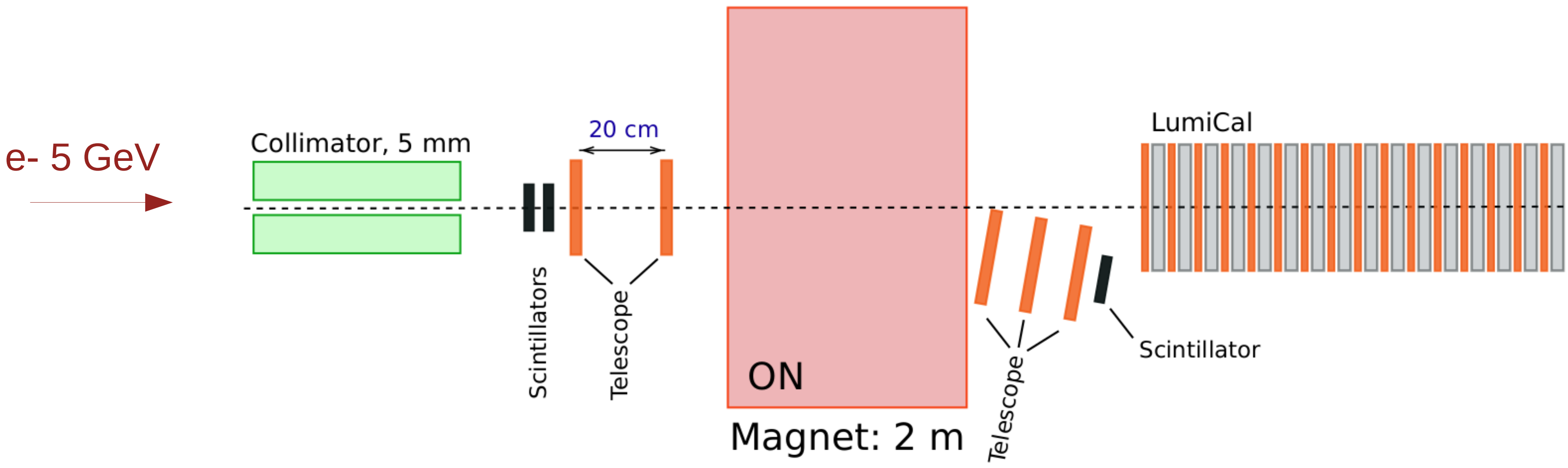
MD-Magnet, Gap 365 mm, Strahl 21
1400 A
1300 A
1200 A
1100 A
1000 A
900 A
800 A
700 A
600 A
500 A
400 A
300 A
200 A
100 A
B (Gauss)
10000
5000
0
-1000
P.A.
-500
0
500
P.E.
1000
X (mm), 0 = Polmitte

Setup 1



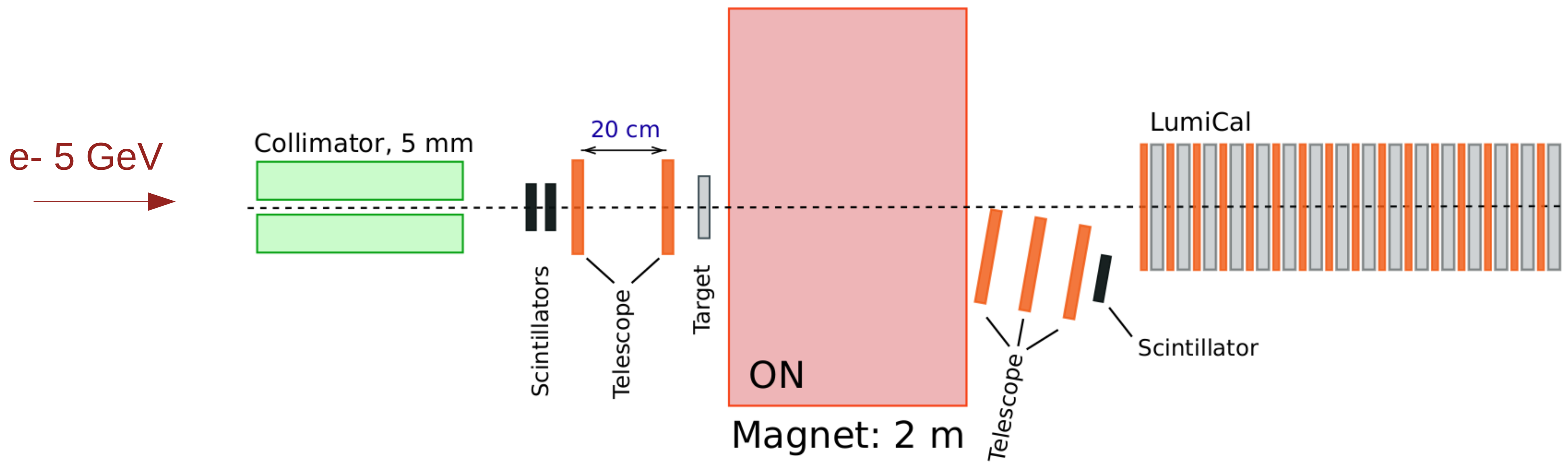
- Measure the effect of the air 2 m.
- Other beam energies?
- Collimator with 5 mm square cross section?

Setup 2



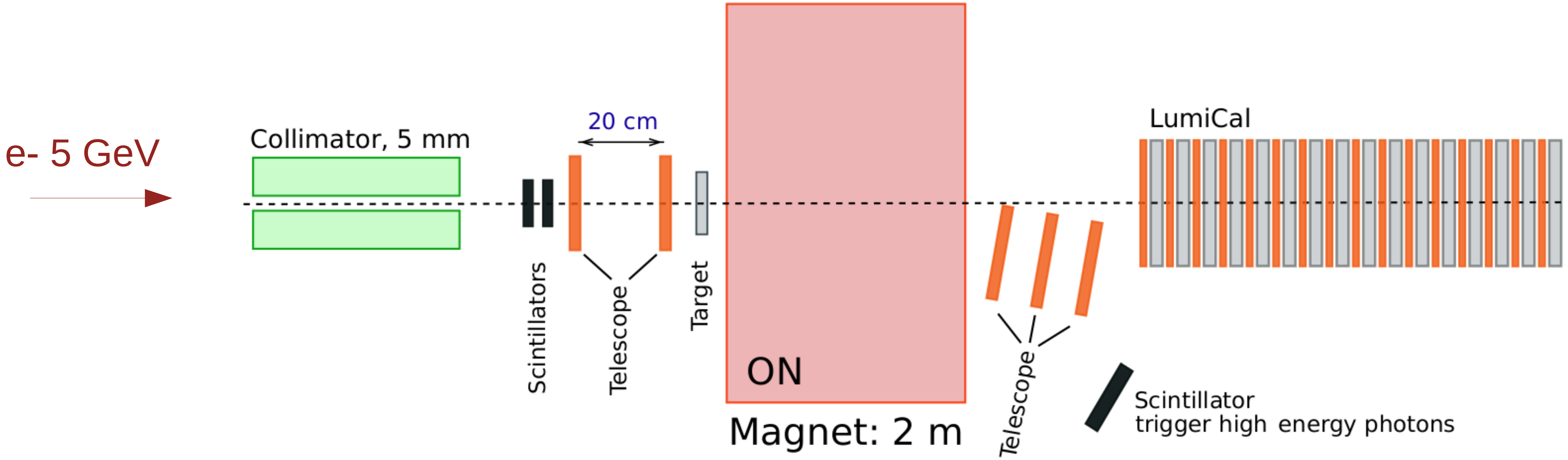
Check and optimize position of the beam after the magnet

Setup 3



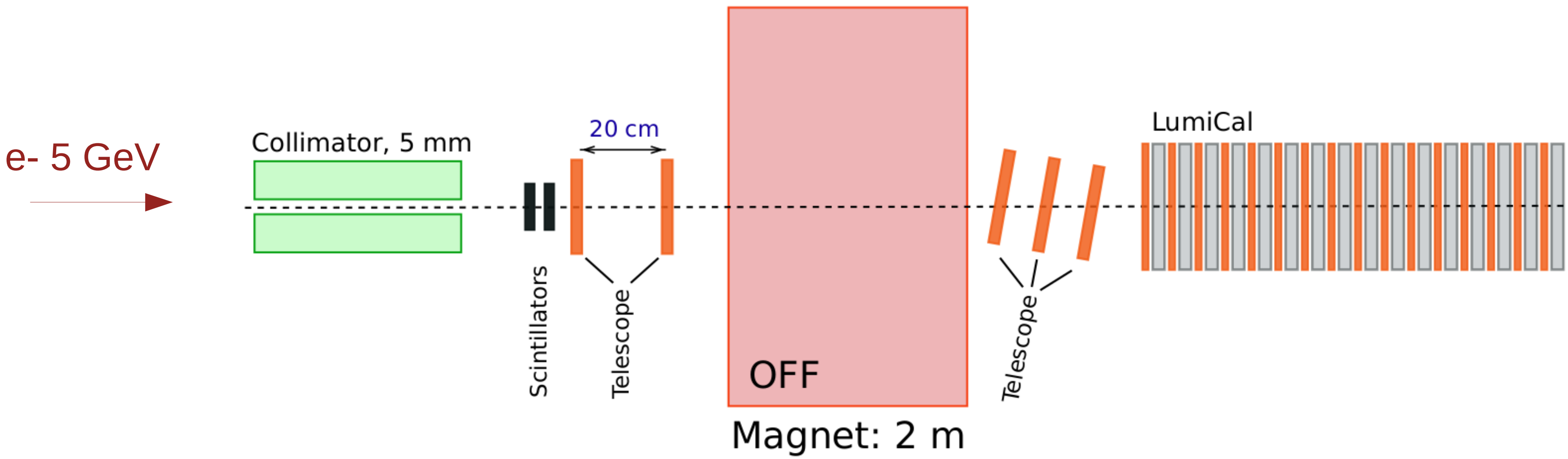
- Tungsten 0.1 mm (3%X0)
- Beam position at front plane of telescope X ≈ 45 mm.
- Telescope sensor size 30 x 15 mm^2;
- Covers electrons 5 GeV – 3.0 GeV;
- Photons: up to 2 GeV;

Setup 4



Collect high energy photons in LumiCal

Setup 1 with modified position of the downstream telescope arm



Beam position after the magnet

```
R[Ee_] = Sqrt[Ee^2 - me^2] / (clight * B)
```

$$\frac{\sqrt{Ee^2 - me^2}}{B\ clight}$$

```
S[Ee_] = R[Ee] - Sqrt[R[Ee]^2 - zm^2]
```

$$\frac{\sqrt{Ee^2 - me^2}}{B\ clight} - \sqrt{\frac{Ee^2 - me^2}{B^2\ clight^2} - zm^2}$$

```
sint[Ee_] = zm / R[Ee]
```

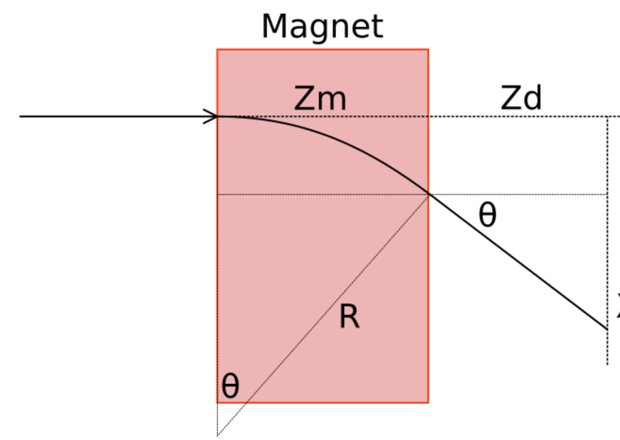
$$\frac{B\ clight\ zm}{\sqrt{Ee^2 - me^2}}$$

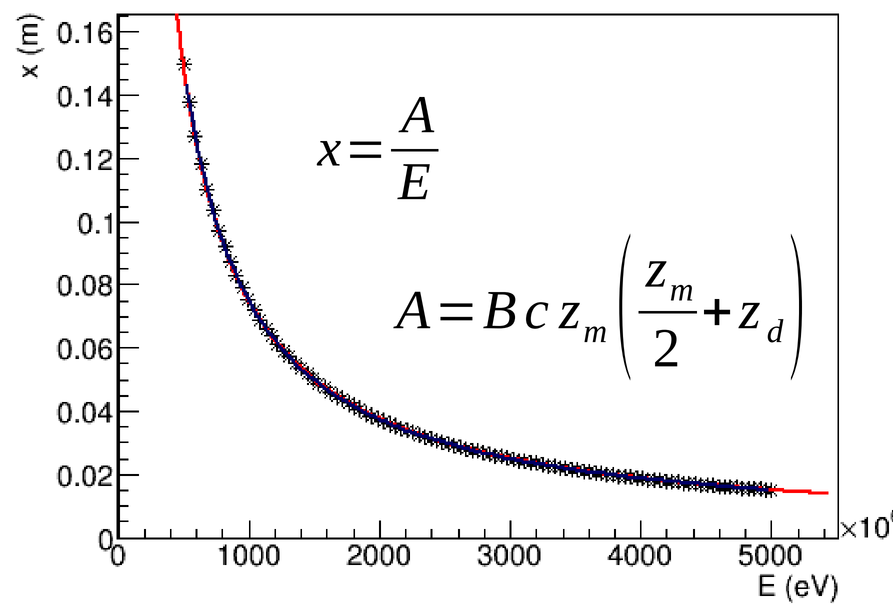
```
tgt[Ee_] = sint[Ee] / Sqrt[1 - sint[Ee]^2]
```

$$\frac{B\ clight\ zm}{\sqrt{Ee^2 - me^2}\ \sqrt{1 - \frac{B^2\ clight^2\ zm^2}{Ee^2 - me^2}}}$$

```
xd[Ee_] = S[Ee] + zd * tgt[Ee]
```

$$\frac{\sqrt{Ee^2 - me^2}}{B\ clight} - \sqrt{\frac{Ee^2 - me^2}{B^2\ clight^2} - zm^2} + \frac{B\ clight\ zd\ zm}{\sqrt{Ee^2 - me^2}\ \sqrt{1 - \frac{B^2\ clight^2\ zm^2}{Ee^2 - me^2}}}$$






```
Minimizer is Minuit / Migrad
Chi2                      =   6.30474e-08
NDf                       =           100
Edm                       =   3.34551e-21
NCalls                    =            15
p0                        =   7.4997e+07   +/-   3870.76
B*c*Zm*(Zm/2+Zd): 7.49481e+07
```

$$E_1 - E_2 = E_1 \frac{\Delta x}{x_1 + \Delta x}$$

5 * 3/(4.5+3) = 2 (GeV)

X_1 is defined by the telescope plane geometry, for ALPIDE it is 4.5 cm.

Number of secondaries per event

Material	Thickness (mm)	Gammas	electrons	positrons	rms proj angle (mrad)
W	0.1	0.3275	0.9524	0.001826	0.4152
W	0.2	0.6722	1.986	0.007265	0.6171
W	0.3	1.029	3.081	0.01666	0.7801
Cu	1	0.9346	11.54	0.01125	0.6802
Cu	1.5	1.403	17.82	0.02469	0.864
Cu	2.5	2.458	31.34	0.06611	1.171