# Compton events in simulation

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# Input Parameters

Cross section calculation

```
// Laser variables:
Elaser 1.5498E-9    // photon energy in GeV (800nm -> 1.5498eV)
Epulse 2.5e6        // energy per laser pulse in uJ  (should be 5E6)
alpha 0.3           // crossing angle in radian
sigmaxy 10.         // transverse size of pulse in um(round profile assumed!)
sigmaz  0.025       // longitudinal size of pulse in ps

nbxflip 2           // number of BXs between flips of laser helicity

// // Beam variables:
Ee 17.5           // beam energy in GeV
PX 0.0             // horizontal transverse polarisation
PY 0.0             // vertical transverse polarisation
PZ 0.0             // longitudinal polarisation
nelectron 6.25E+9  // number of electrons per bunch XFEL according to Matthew's talk
nbunch 1          // number of bunches per train
ttrain 1.0e3      // duration of bunch train in ms  (3250 bunches * 200ns bunch spacing)
// XFEL according to Mathew's talk
esigmax 0.030      // horizontal beam size in mm
esigmay 0.030      // vertical beam size   in mm
esigmaz 0.334      // longitudinal beam size in ps  (XFEL sigma_z = 20 um ; t = sigma_z / 300 um  * ps)
```

Luminosity → Number of events

$$\mathcal{L} = \frac{N_1 N_2 f N_b}{2\pi\sqrt{\sigma_{1x}^2+\sigma_{2x}^2}\sqrt{\sigma_{2y}^2+\sigma_{2y}^2}} \cdot S$$

$$S = \frac{1}{\sqrt{1+(\frac{\sigma_s}{\sigma_x}\tan\frac{\phi}{2})^2}} \approx \frac{1}{\sqrt{1+(\frac{\sigma_s}{\sigma_x}\frac{\phi}{2})^2}}$$

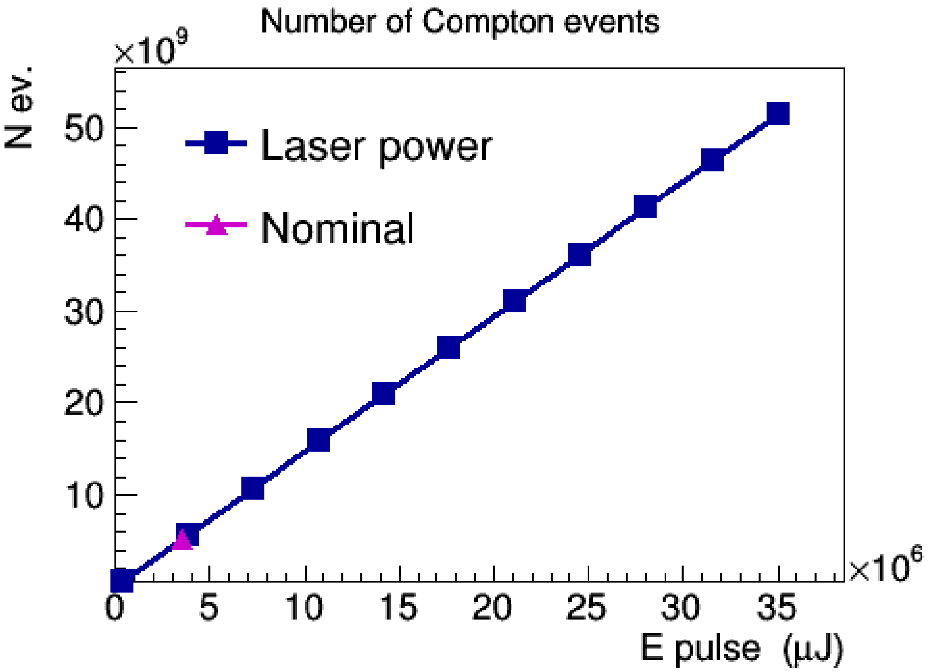
# Number of Compton events

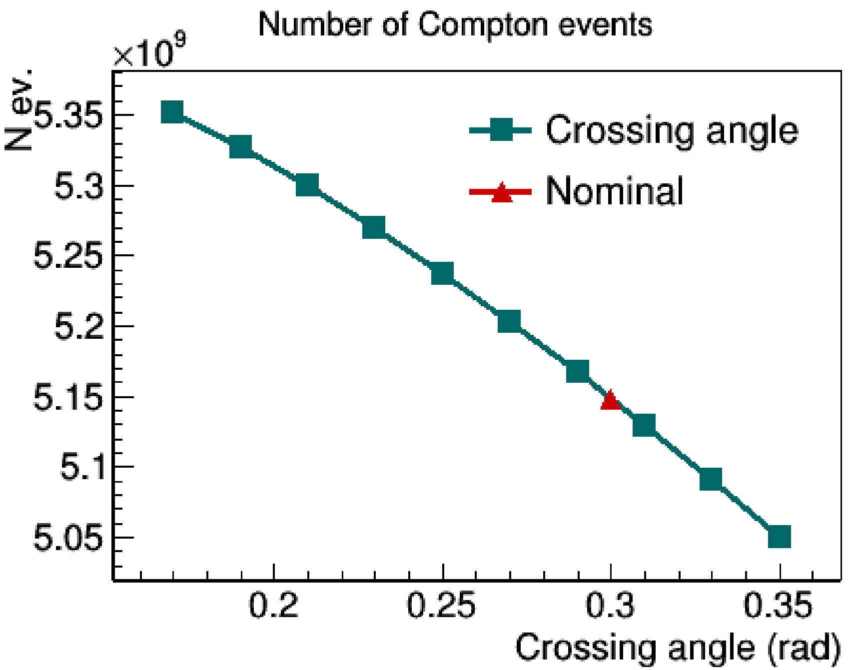
Dependence on beam parameters

| E_pulse, μJ | Crossing angle, rad | Laser $\sigma_{xy}$, μm | Laser $\sigma_z$, ps | N Electrons | Electron $\sigma_x$, mm | Electron $\sigma_y$, mm | Electron $\sigma_z$, ps |
|---|---|---|---|---|---|---|---|
| 3.5*10^6 | 0.3 | 10 | 0.035 | 6.25E+09 | 0.005 | 0.005 | 0.08 |
| 2.5*10^6 | 0.17 | 5 | 0.02 | | 0.001 | 0.001 | 0.05 |
| 35.0*10^6 | 0.35 | 50 | 0.04 | | 0.01 | 0.01 | 0.1 |

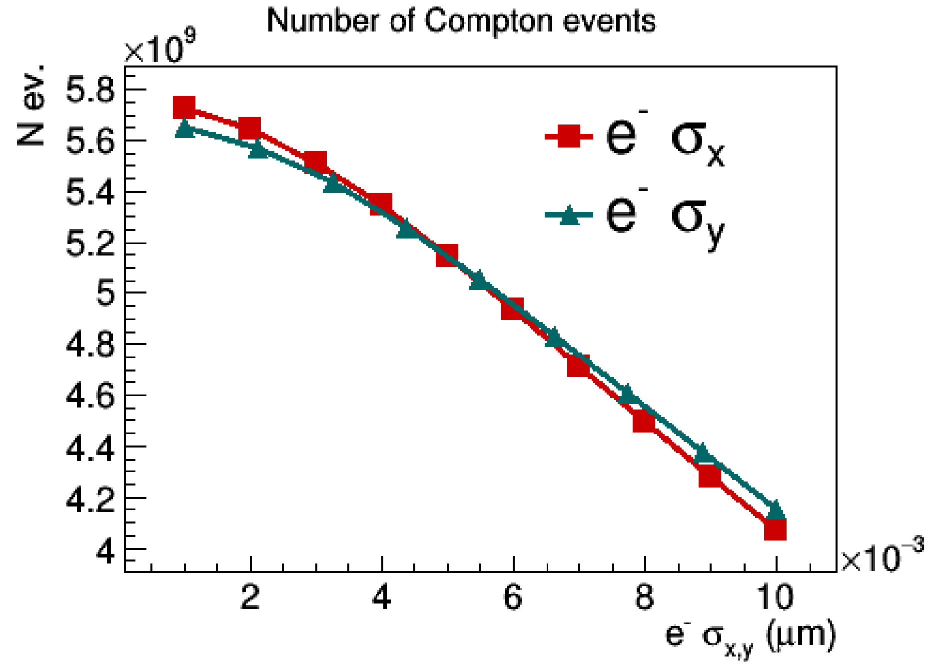
Nominal values

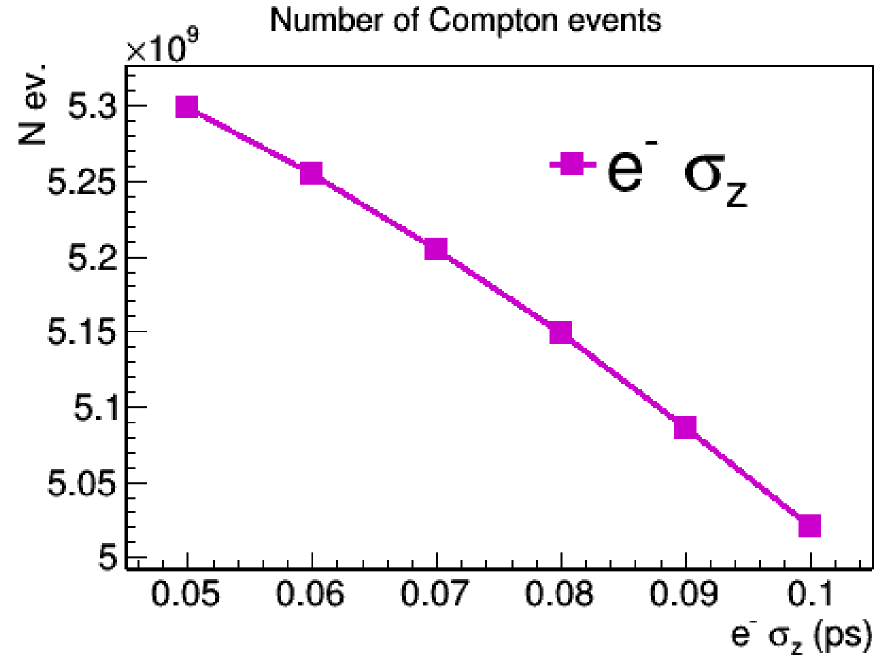
Scan range

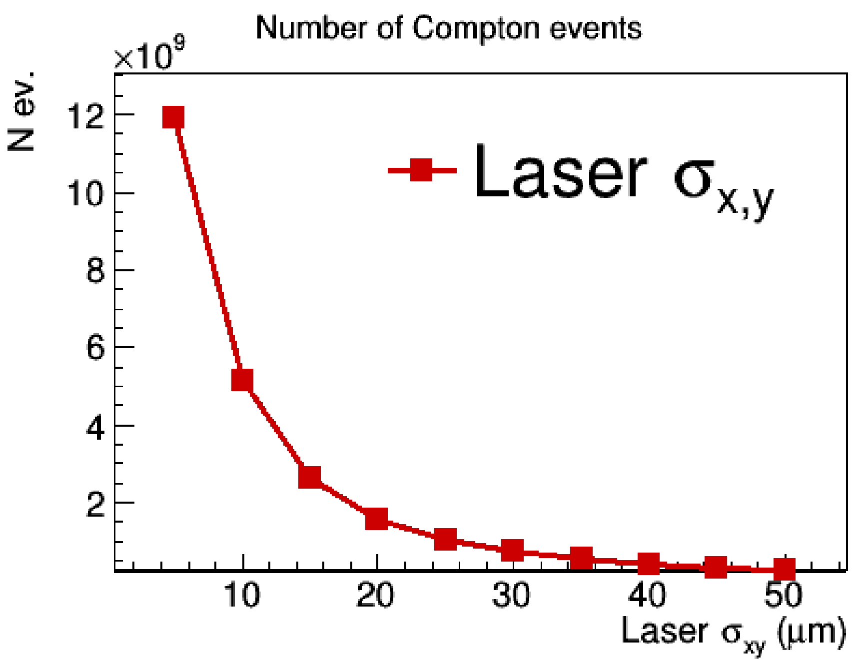


# Number of Compton events



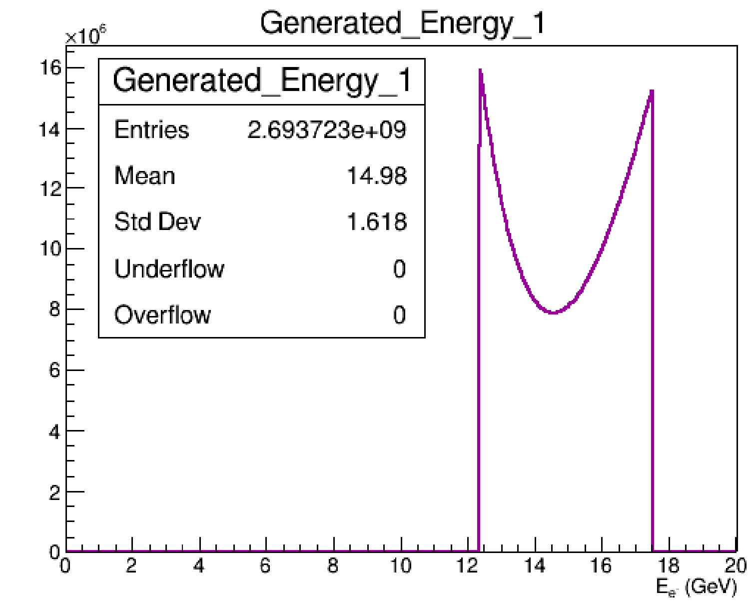



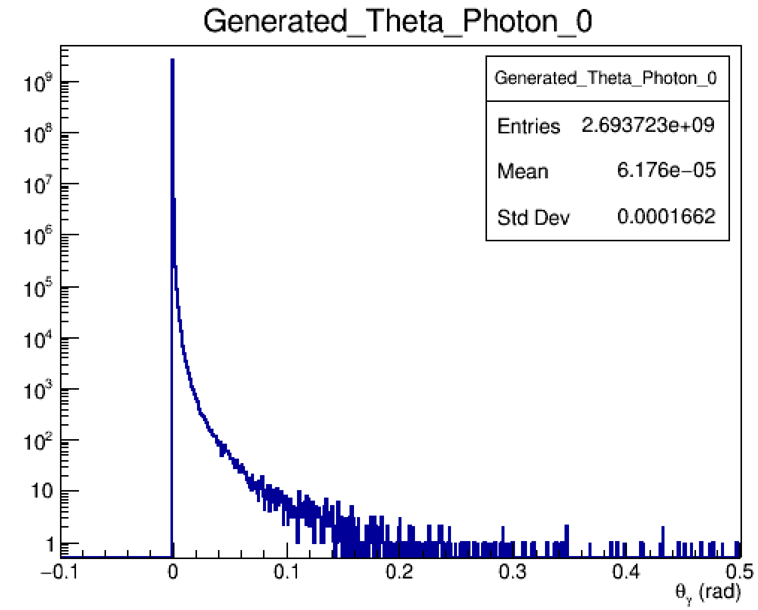

- In present implementation, for the laser $\sigma_x = \sigma_y = \sigma_{xy}$, only one parameter describes transverse size;
- This explains stronger dependence of the number of events;
- Beam displacement is not implemented.

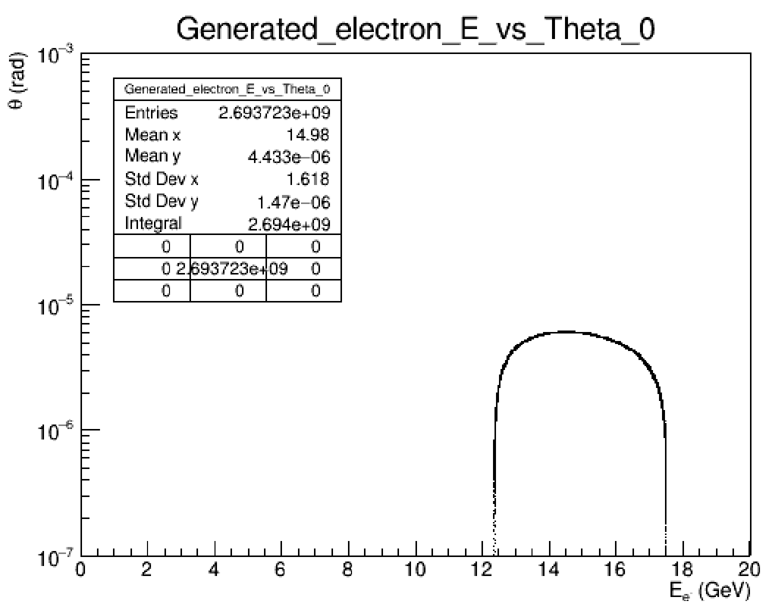
# Electrons after interaction

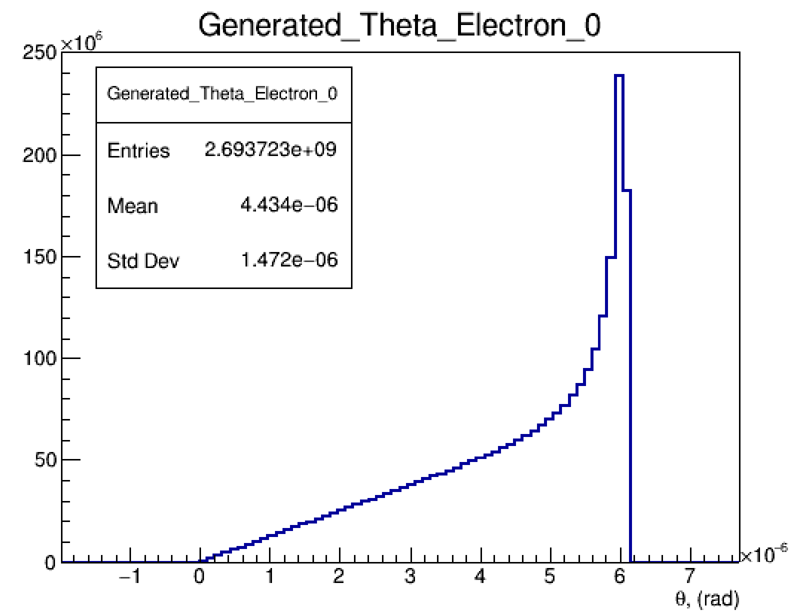
Number of interactions is reduced to speed up calculations

Integrated over azimuthal angle

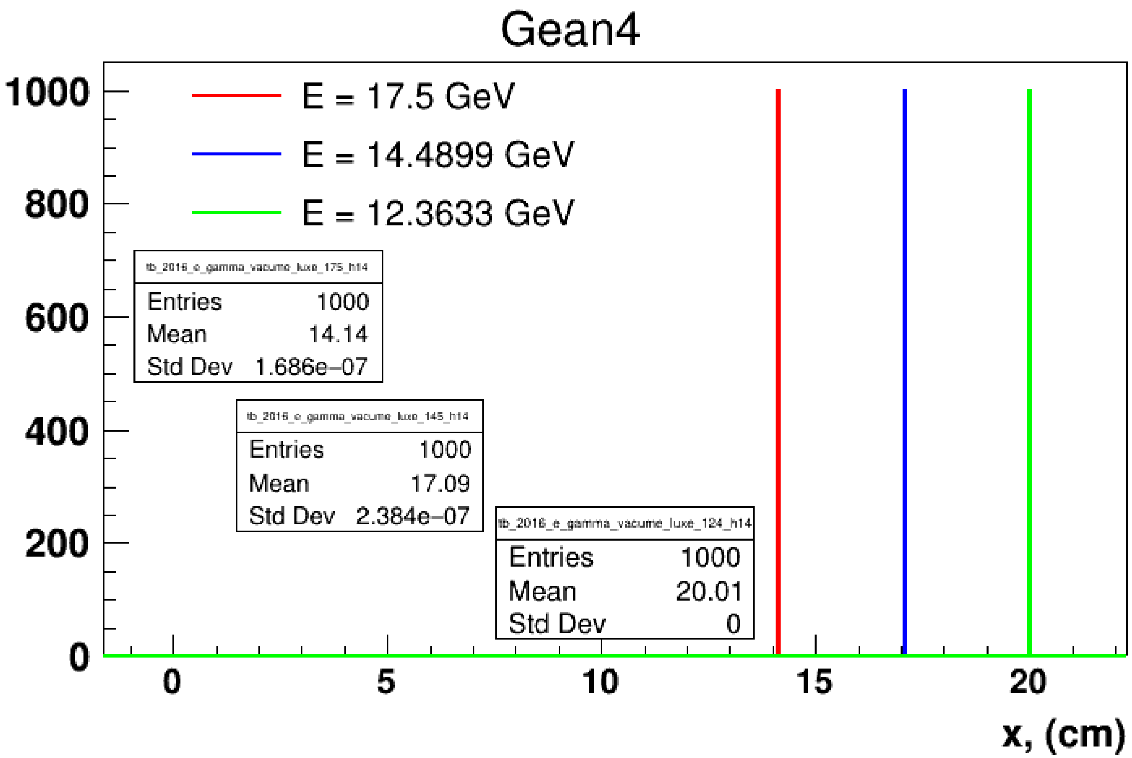


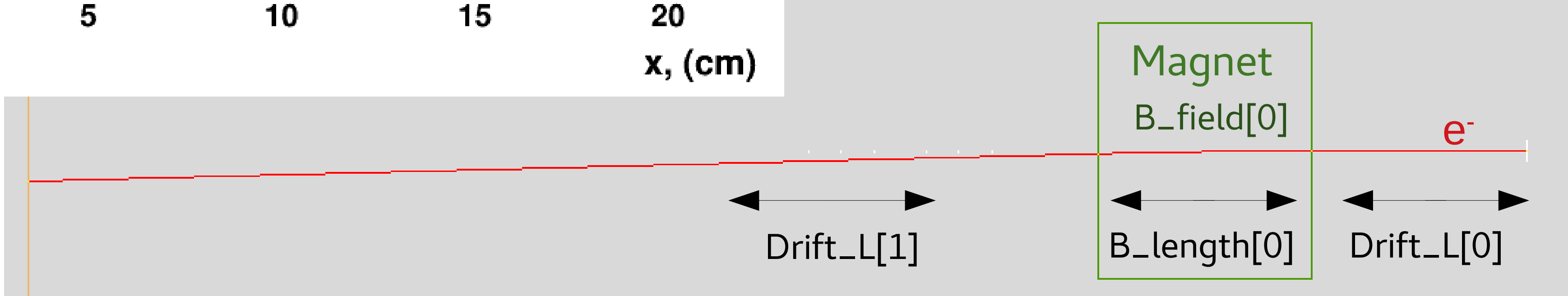



# Test of Electron Transport Performance




- 1 m drift
- 1 m magnet 1.5 T
- 5 m drift




```
ChicaneSpectrometer initialized with 1 Magnets. Elements:
   Drift with length  1 m
   Magnet with length 1 m and field 1.5 T
   Drift with length  5 m
ChicaneSpectrometer: x-offset for electron at nominal energy: 14.1375 cm
```

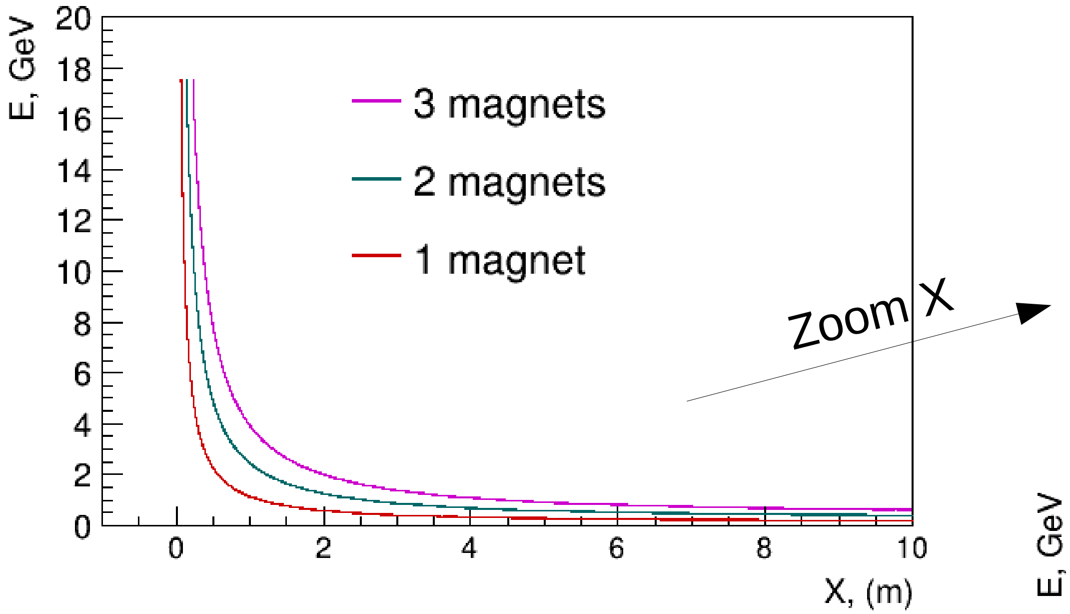
```
xOffset: 0.141375
## nominal position of Compton edge:  x_edge = 20.0177 cm
## nominal position of zero crossing: x_zero = 17.0769 cm
```

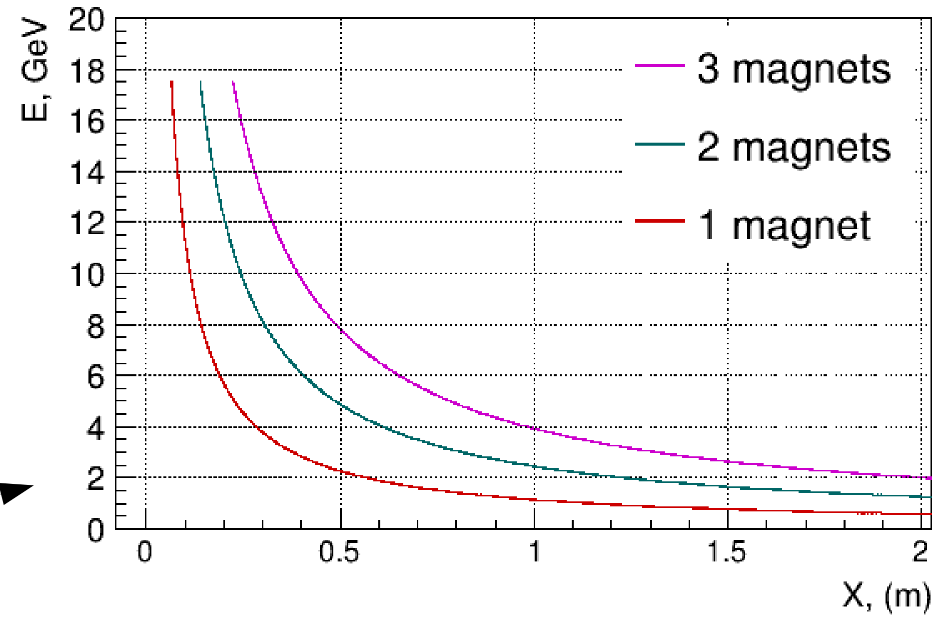
```
Eedge (electron) = 12.3633 GeV
Ezero = 14.4899 GeV
```

# Energy vs Position of electron in detector

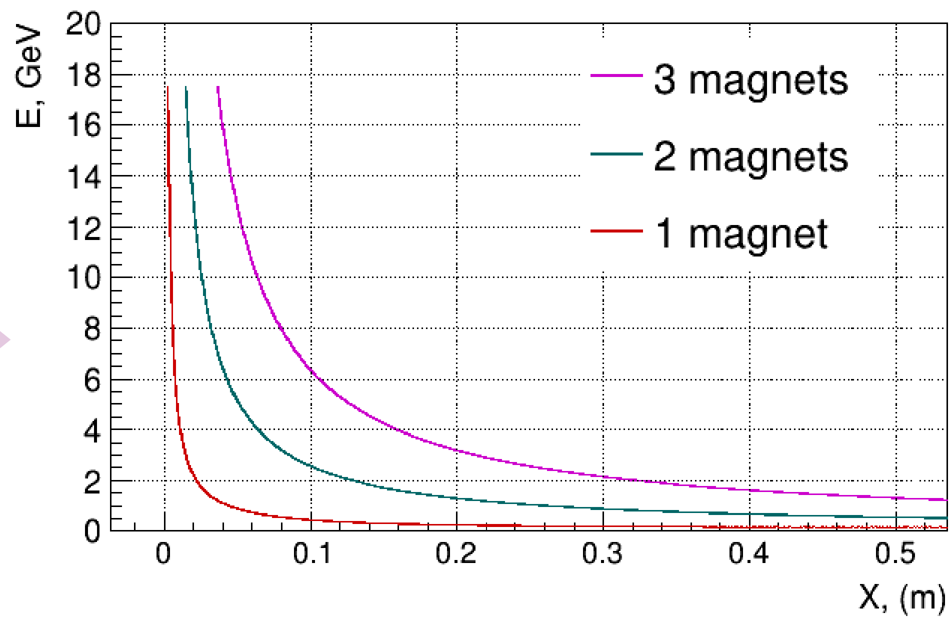
Simulation with 3 dipole magnets

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Drift_L | 1.0 | | 0.5 | | 0.5 | | 6.5 |
| B_length | | 0.5 | | 0.5 | | 0.5 | |
| B_field | | 1.12 | | 1.12 | | 1.12 | |




Position right after last magnet



# Study of the data generated by Anthony

**Implemented processes:**

- HICS (High intensity Compton scattering)
- OPPP (one photon pair production)

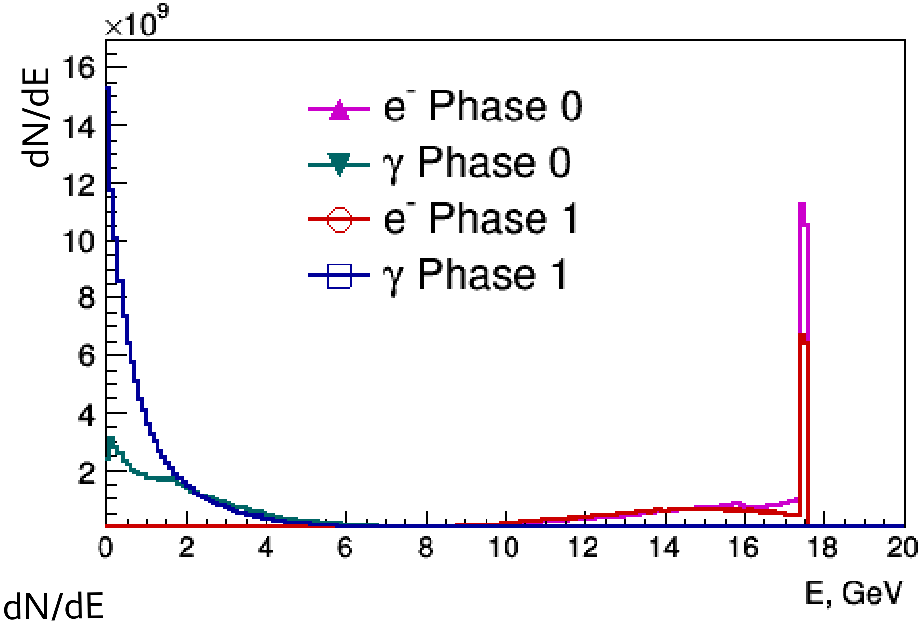
Together, in different time steps, these make the two step trident process.

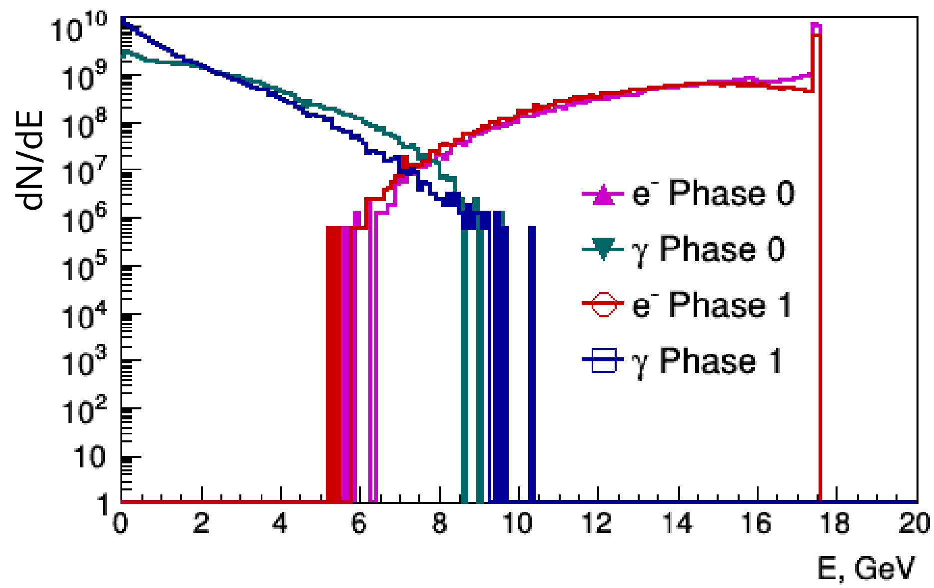
**Future steps from theory side:**

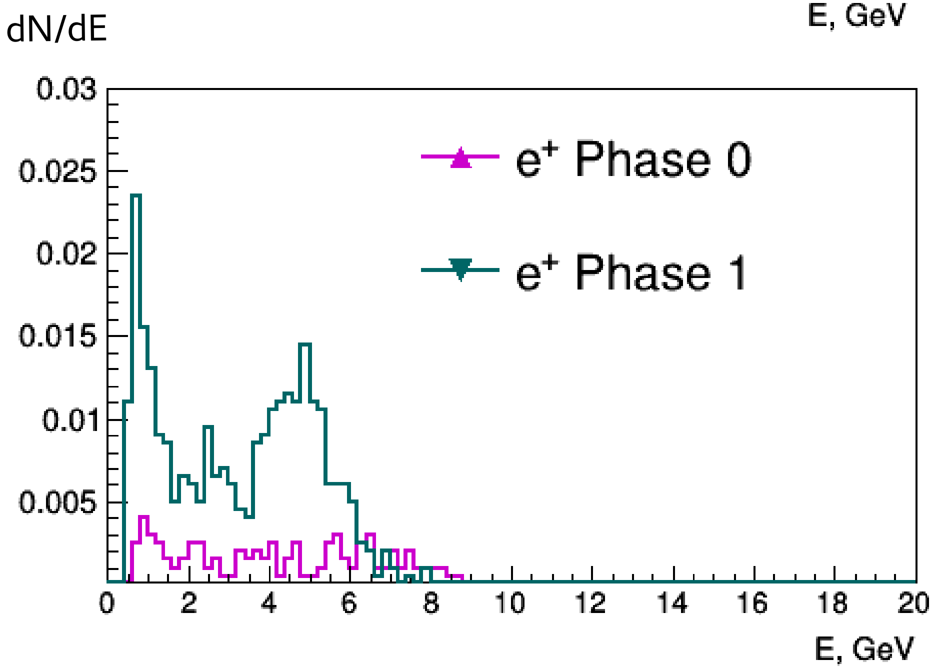
- Implementation of one step trident process (with virtual intermediate photon), this will constitute an extra source of positrons;
- Effect of finite pulse length.

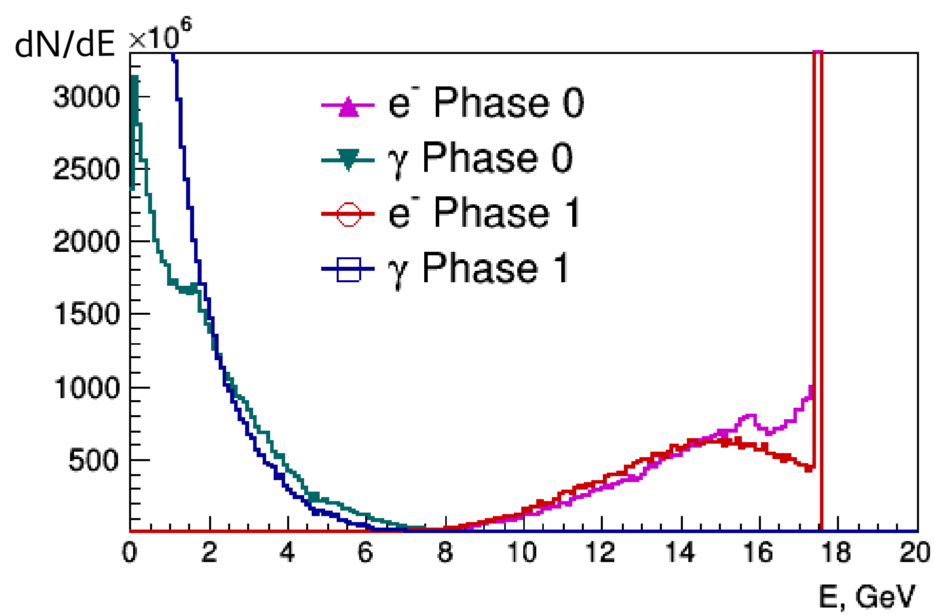
# $e^-$, $\gamma$, $e^+$ spectra for phases 0 and 1

Histograms are normalized to one event and bin width.



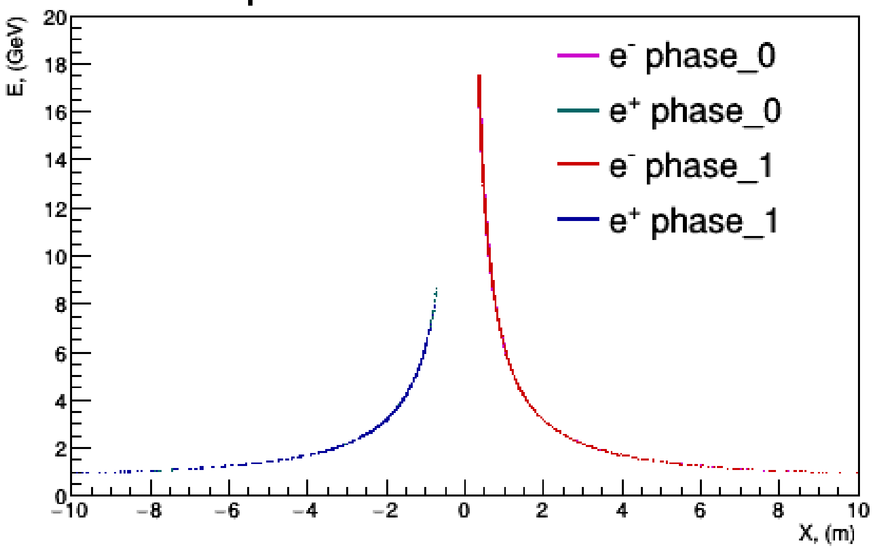



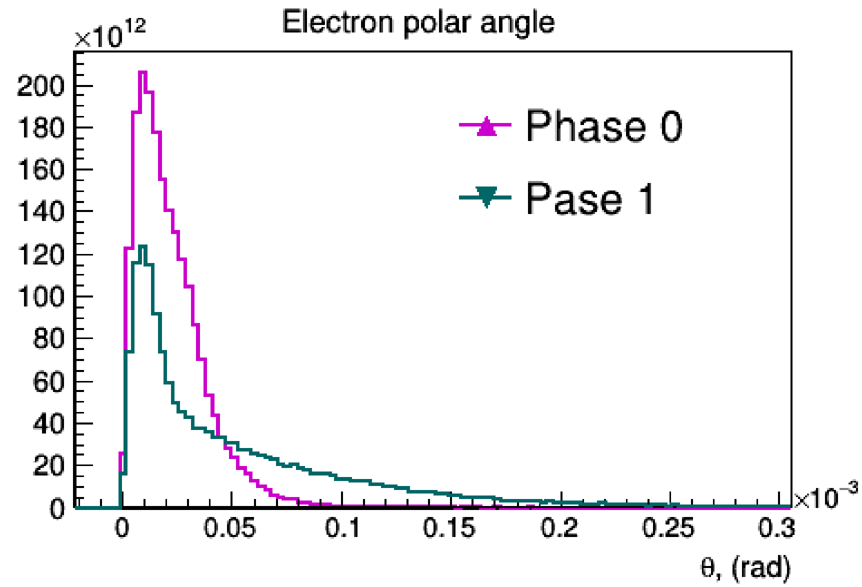



# Particles statistic in selected energy range

| Data | Phase_0 | Phase_1 |
|---|---|---|
| Number of electrons (for 1<E<6 GeV) | 180000 | 240000 |
| Number of electrons (for 6<E<16 GeV) | 2.72E+09 | 2.84E+09 |
| Number of photons (for E>1 GeV) | 3.93E+09 | 4.26E+09 |
| Number of positrons (for E>1 GeV) | 0.0119 | 0.0441 |
| Position of electron with E = 1 GeV (m) | | 8.93458 |
| Position of positron with E = 1 GeV (m) | | -8.86167 |

e-, e+ position in the detector



# Position of e$^-$, e$^+$ in detector

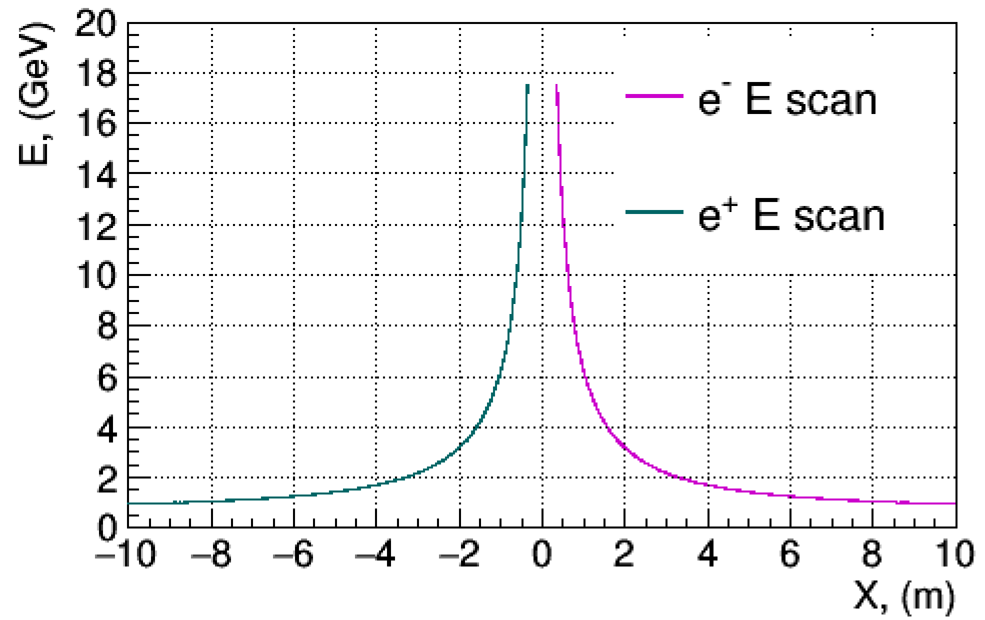
Position of the particles can be determined using energy scan.

| | | |
|---|---|---|
| Drift_L | 1.0 | 8.0 |
| B_length | 1.08 | |
| B_field | 2.24 | |

Position of electron with E = 1 GeV : 8.89636 m

Position of positron with E = 1 GeV : -8.89948 m

Position for E = 17.5 GeV : ±35.42 cm

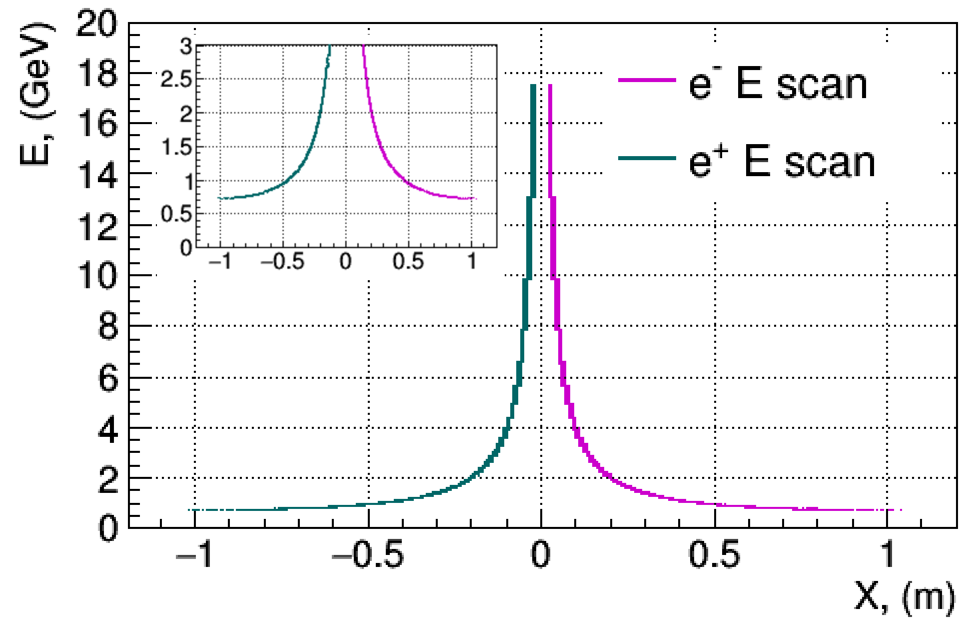



| | | |
|---|---|---|
| Drift_L | 1.0 | 0.001 |
| B_length | 1.08 | |
| B_field | 2.24 | |

Position of electron with E = 1 GeV : 0.465 m

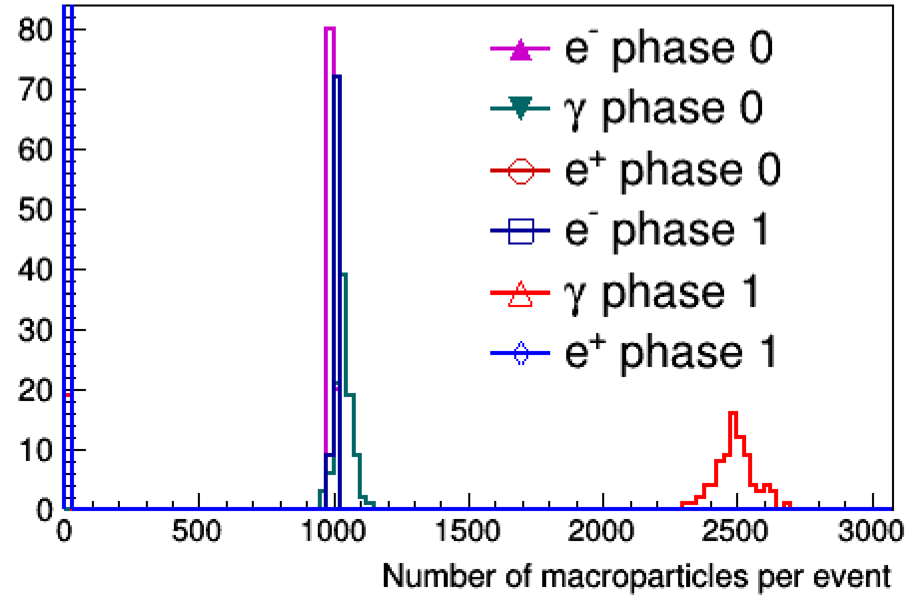
Position of positron with E = 1 GeV : -0.465 m

Position for E = 17.5 GeV : ±2.24 cm



# Summary and plans

- The number of Compton events per bunch crossing with nominal e- beam and laser pulse is ~ 5.1E9.
- It looks barely possible to measure the whole energy range of e-/e+ with a single settings for one rectangular magnet:
  - Change the field and scan the energy;
  - V-shape magnet?
  - Use more than one magnet?
- Number of positrons produced in one collision is 0.01 and 0.04 for phase 0 (0.35J) and phase 1 (3.5J). The energy ranges from 0.4 GeV up to 8 GeV. More statistics might be helpful.
- The implementation of one step trident process is in progress.
- Finalize the code to interface output from generator with possibility to configure program execution via steering file.
- Consider implementation of detector models for fast simulation.



80
70
60
50
40
30
20
10
0
0
500
1000
1500
2000
2500
3000
Number of macroparticles per event
e- phase 0
γ phase 0
e+ phase 0
e- phase 1
γ phase 1
e+ phase 1