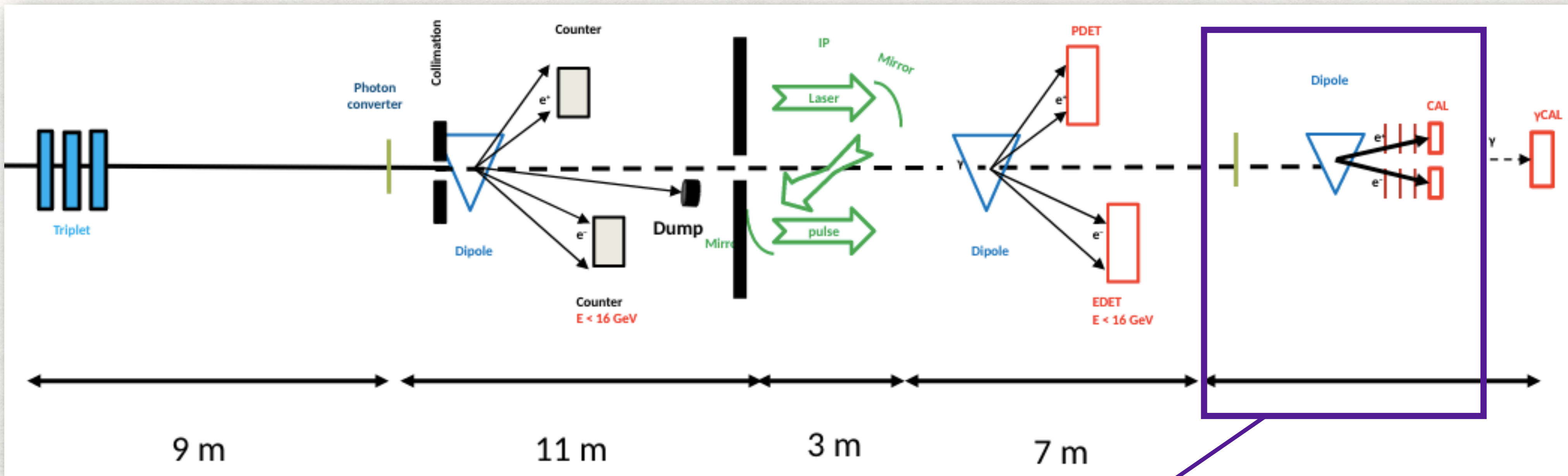
# FORWARD PHOTONS

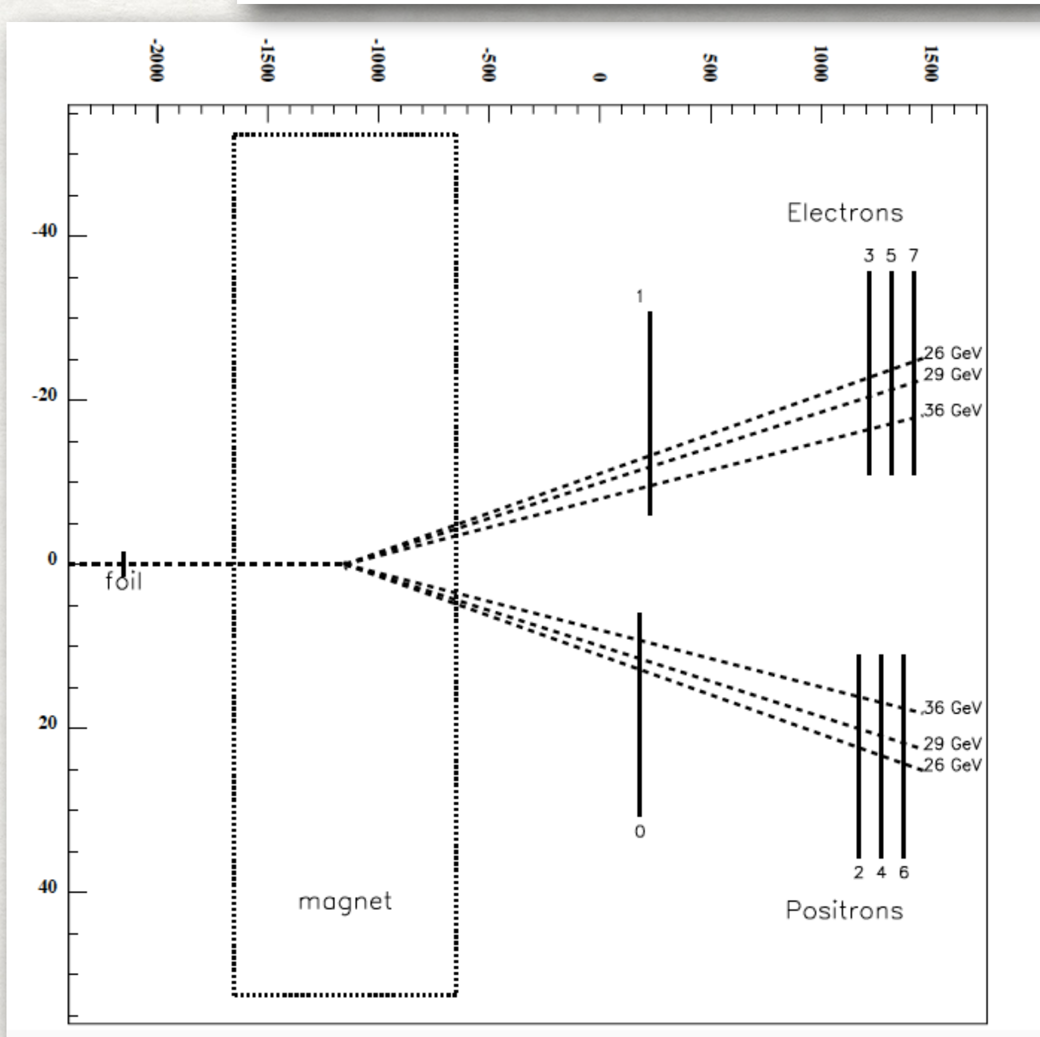
Borysova Maryna

21/01/19

# LAYOUT FOR THE LUXE EXPERIMENT

Photons produced at IP1 proceed down their own beamline through the converter foil and the tracking spectrometer

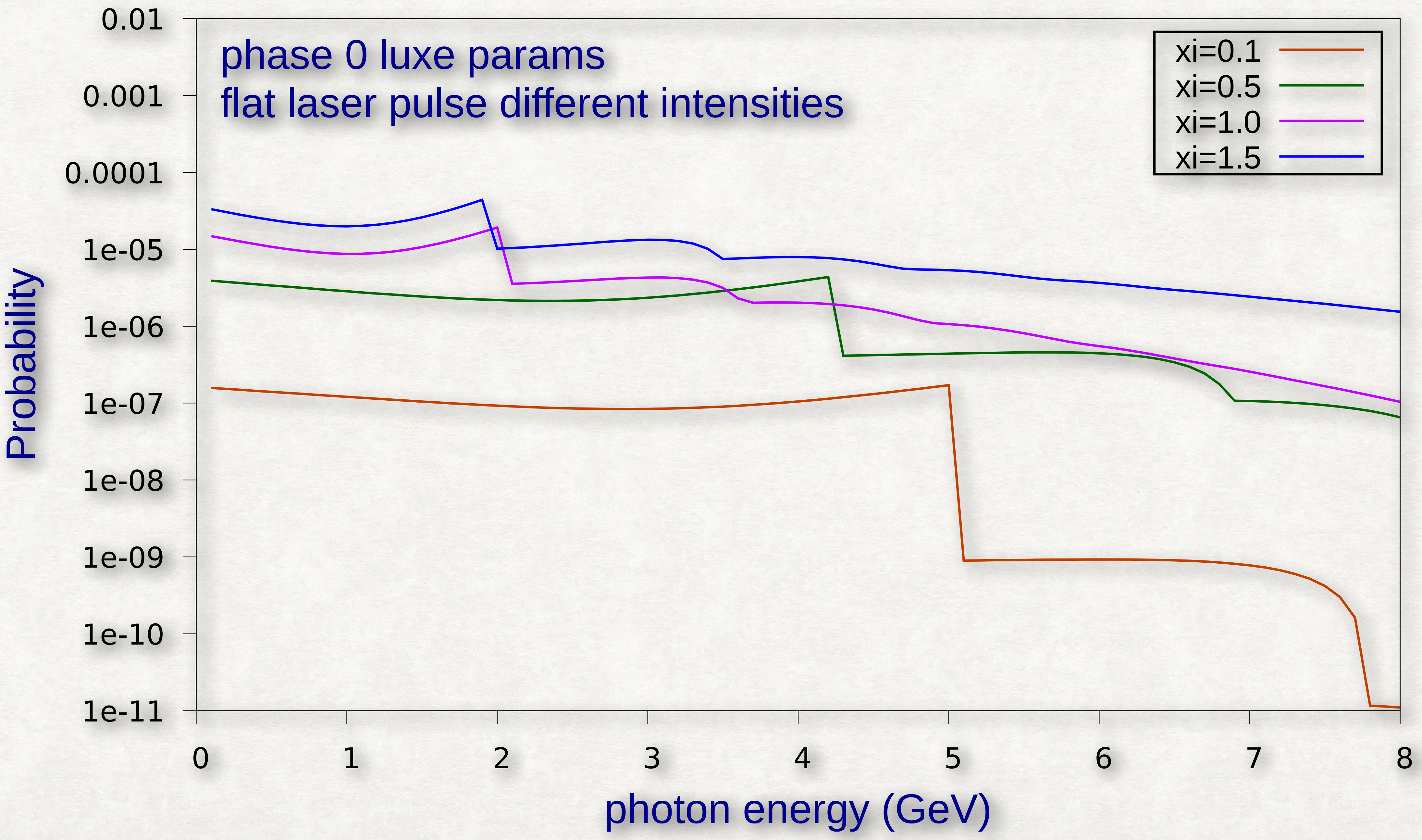



In E144 the data in the two arms of the spectrometer were analyzed independently, and then combined the reconstructed single-particle momentum spectra for comparison to a model spectrum calculated by convolving the simulated photon spectrum with the Bethe-Heitler pair spectrum

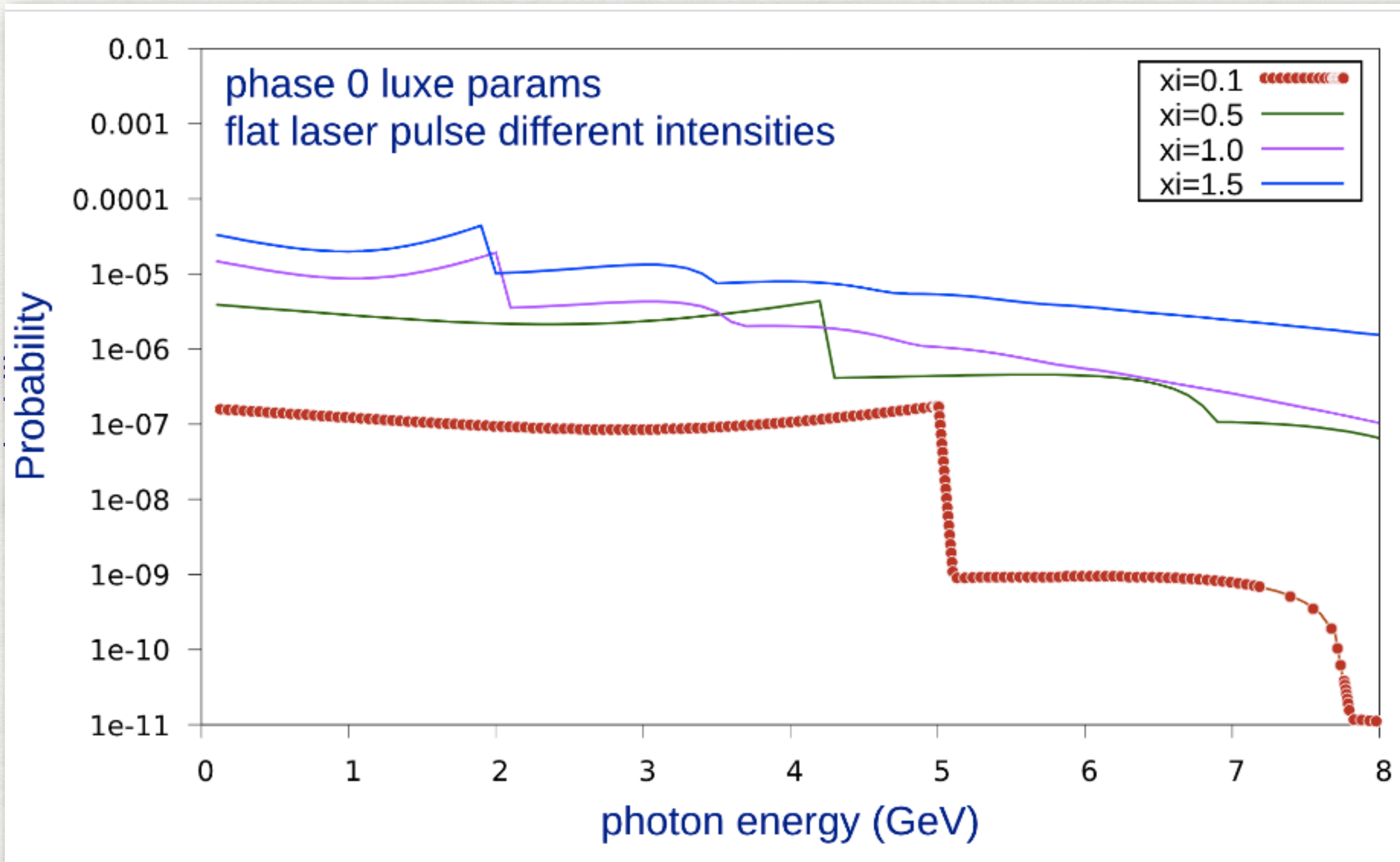
# PHOTON SPECTRA VS LASER INTENSITIES

- plot from Tony

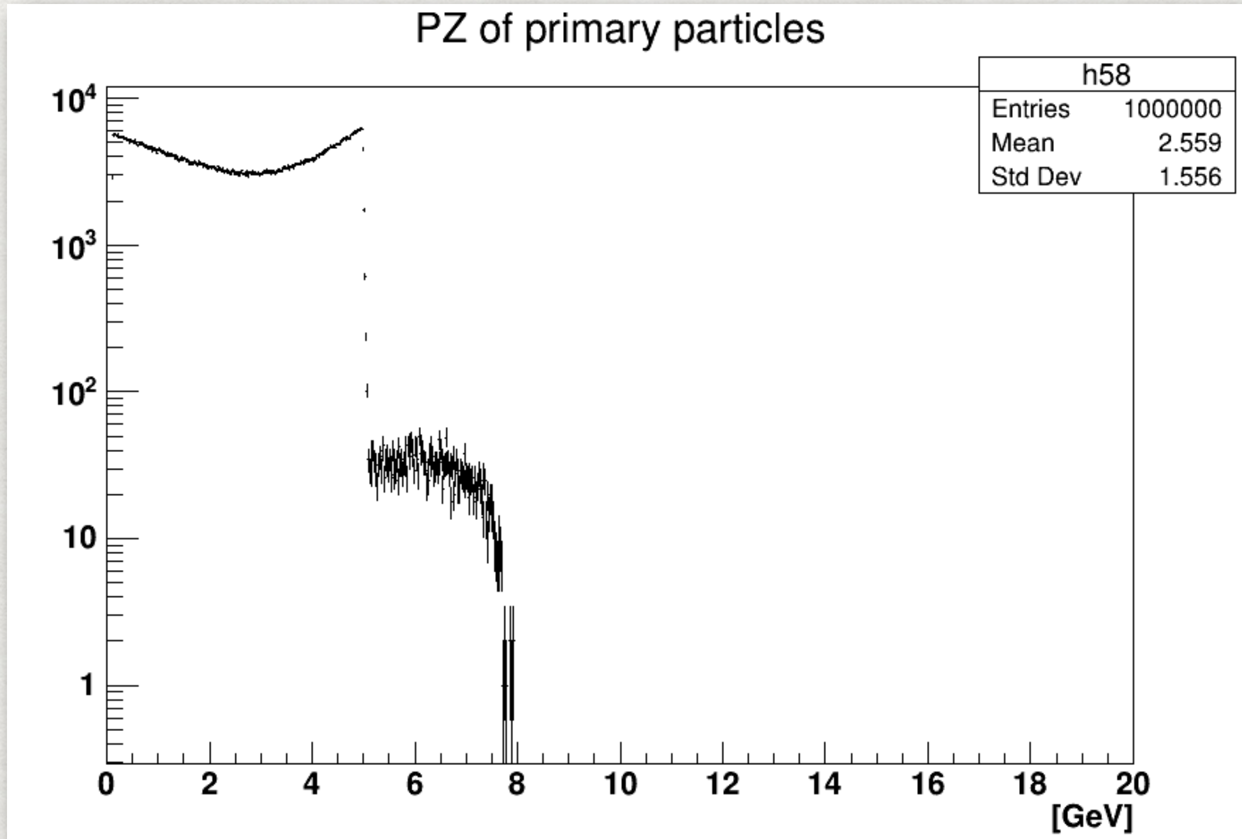


# PHOTON SPECTRA VS LASER INTENSITIES

- plot from Tony

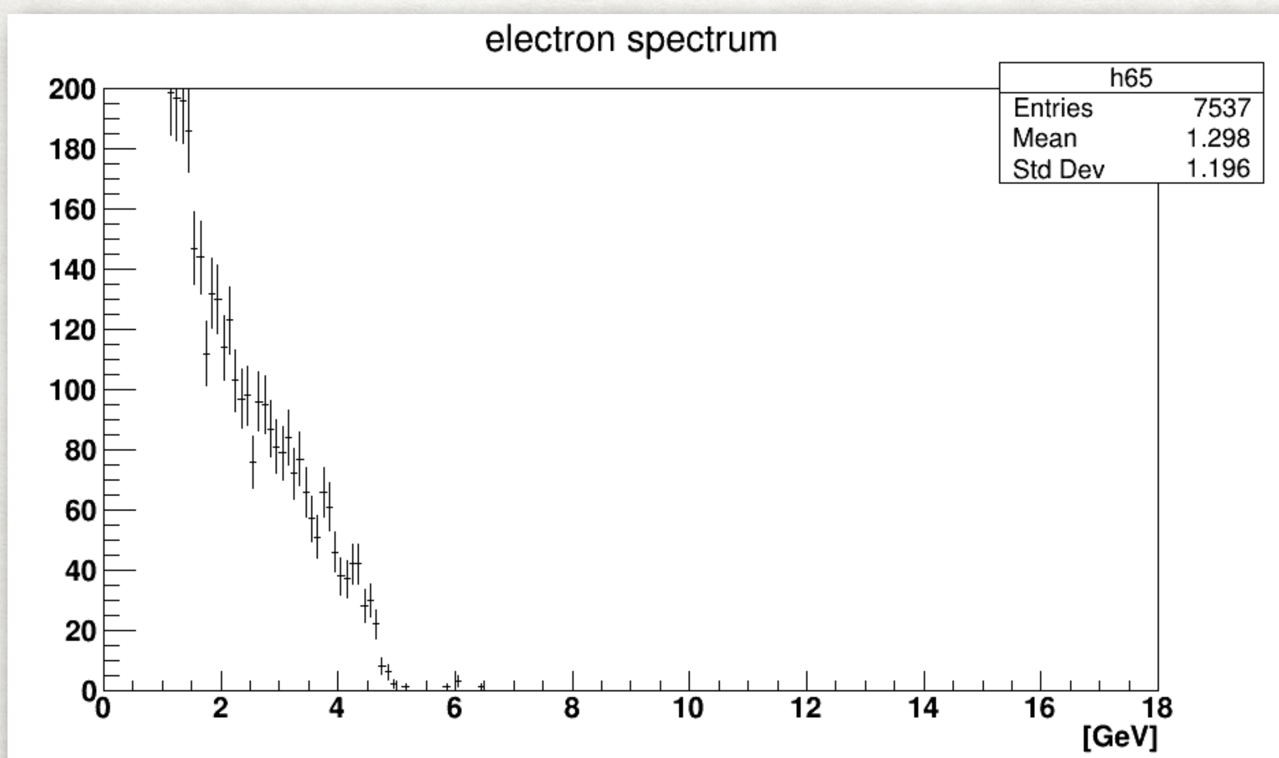


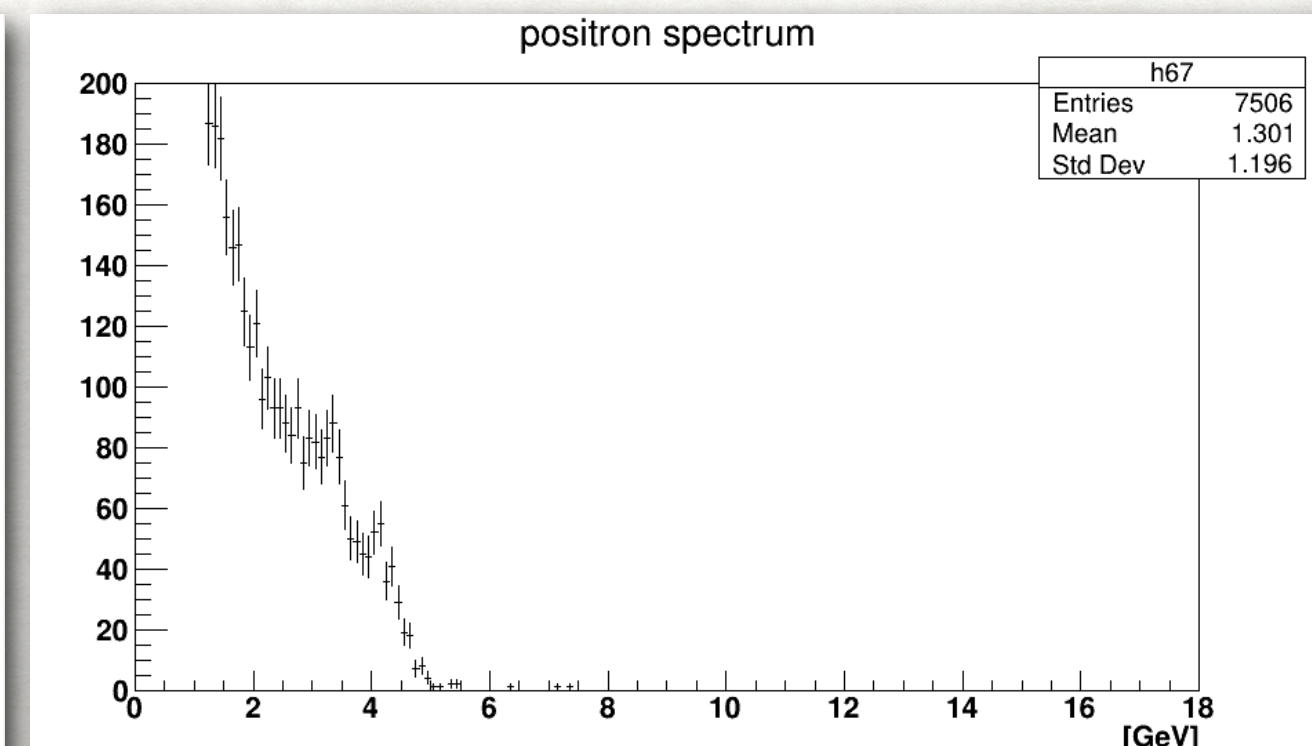
# FORWARD PHOTONS IN GEANT4




Code from Sasha

target: Tungsten, 0.35 um
1e6 photons

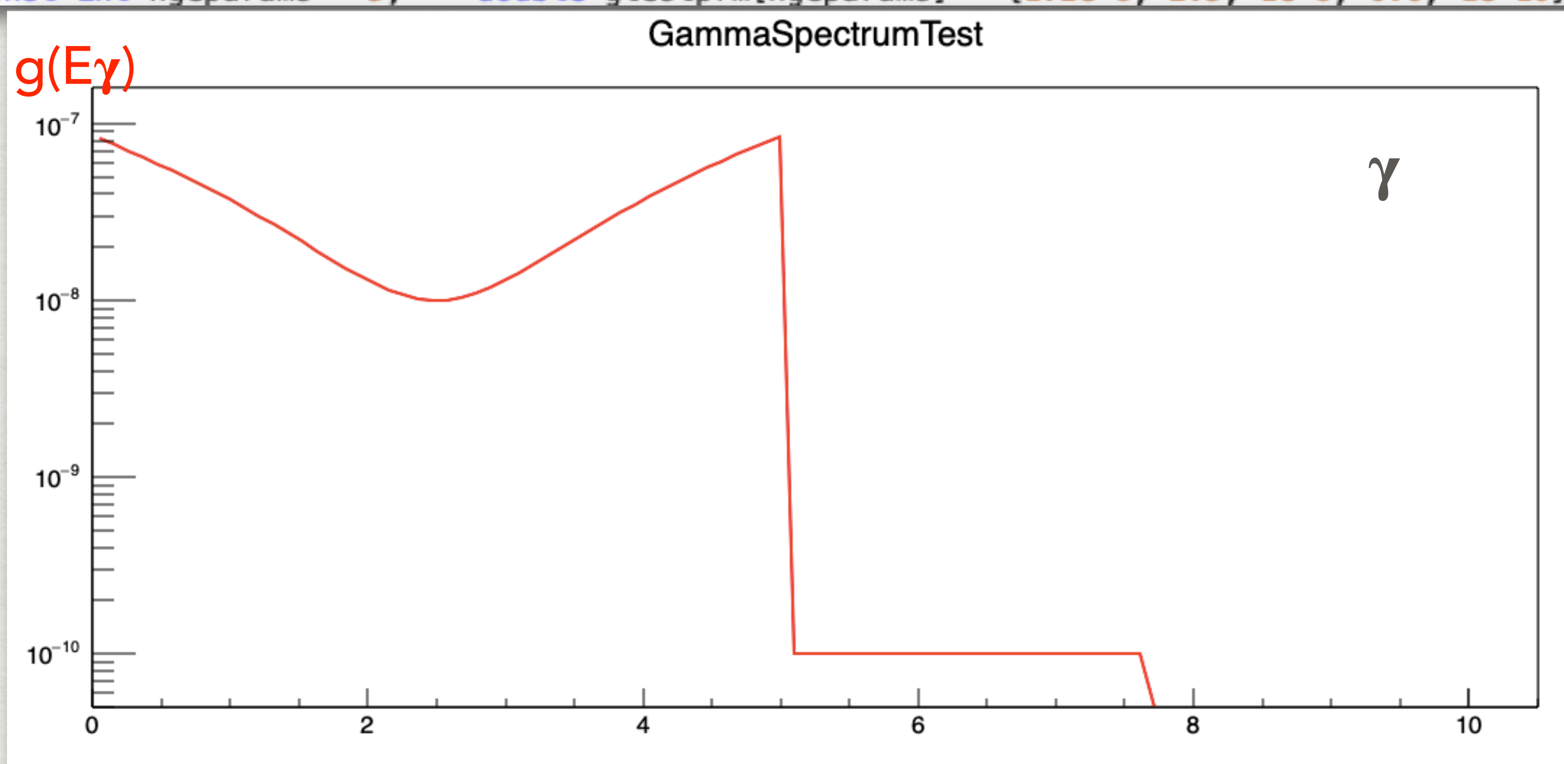


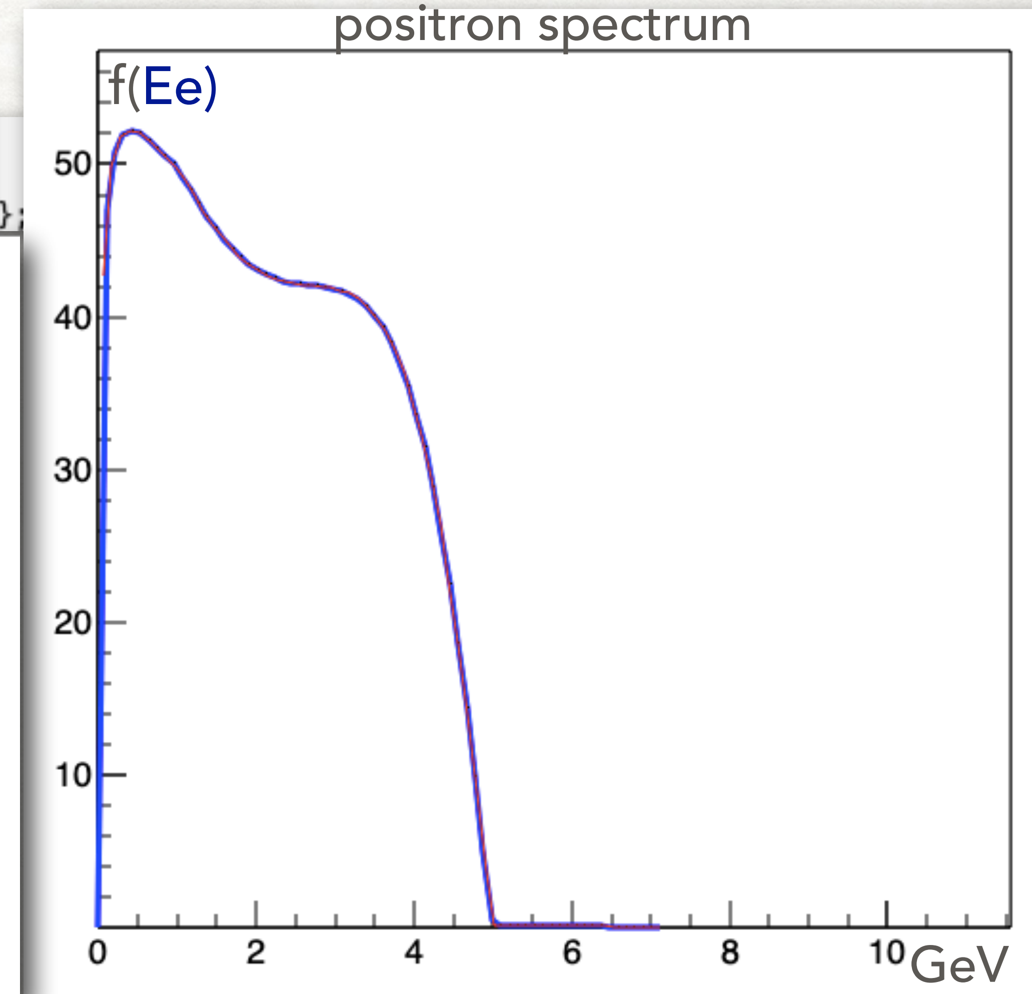



# TESTING: COMPTON-LIKE

Ee=∫σ(Eγ, Ee)g(Eγ)dEγ

```
    double gtestprm[ngeparams] = {100.0, 17.5};  // linear
    double gtestprm[ngeparams] = {105.0, 0.3};   // exp
const int ngeparams = 5;     double gtestprm[ngeparams] = {1.2e-8, 2.5, 1e-8, 0.0, 1e-10};
```




∫σ(Eγ, Ee)g(Eγ,p1,p2)dEγ

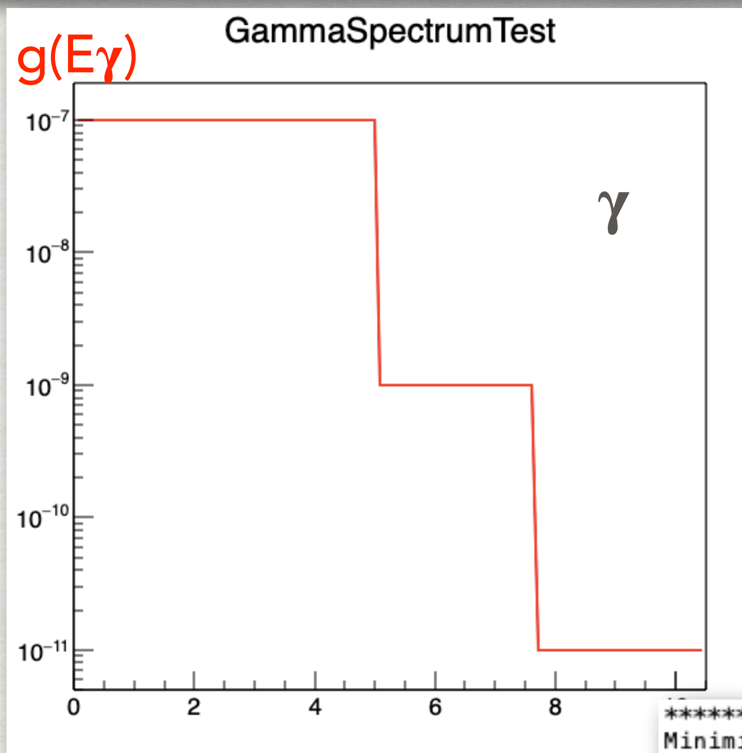
fitting allows finding the parameters quite well :

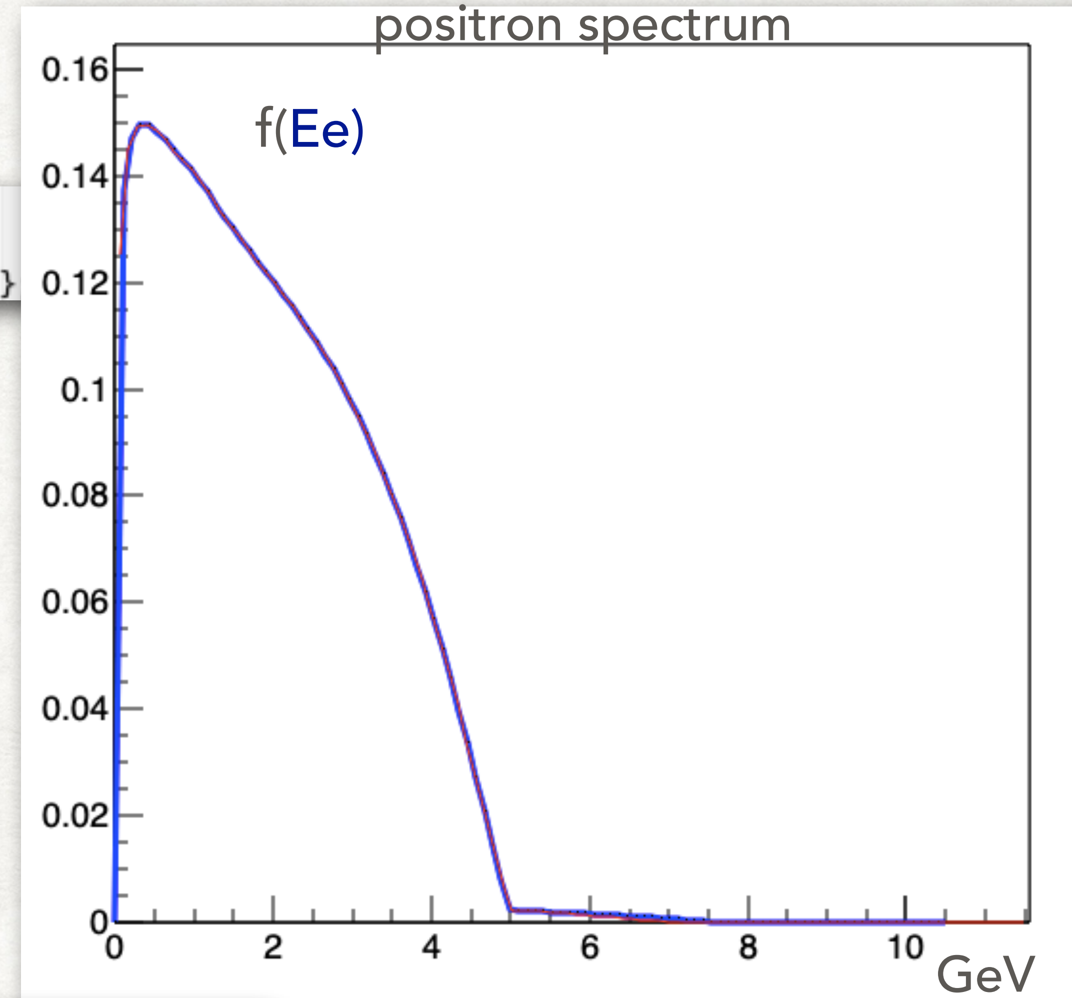
```
****************************************
Minimizer is Minuit / MigradImproved
Chi2                      =  6.09809e-07
NDf                       =           96
Edm                       =  1.21973e-06
NCalls                    =          404
p0                        =  1.20003e-08   +/-   6.73267e-14
p1                        =      2.50003   +/-   5.02686e-06
p2                        =  1.00002e-08   +/-   5.23111e-14
p3                        =            0                       (fixed)
p4                        =  9.99282e-11   +/-   1.04159e-14
```

# TESTING: COMPTON-LIKE+FITTING THE EDGES

Ee=∫σ(Eγ, Ee)g(Eγ)dEγ

```
 double gtestprm[ngeparams] = {100.0, 17.5};  // linear
 double gtestprm[ngeparams] = {105.0, 0.3};   // exp
onst int ngeparams = 5;     double gtestprm[ngeparams] = {1.2e-8, 2.5, 1e-8, 0.0, 1e-10}
```




```
****************************************
Minimizer is Minuit / MigradImproved
Chi2                      =  9.27709e-06
NDf                       =           94
Edm                       =   0.00120974
NCalls                    =          524
p0                        =  7.37899e-12   +/-   9.60965e-08    (limited)
p1                        =  9.99892e-08   +/-   1.10413e-10    (limited)
p2                        =      4.99104   +/-   0.00140731     (limited)
p3                        =            0                        (fixed)
p4                        =   2.4787e-09   +/-   5.8529e-09     (limited)
p5                        =       6.5119   +/-   0.00208994     (limited)
p6                        =  1.16669e-11   +/-   2.65833e-09    (limited)

****************************************
Minimizer is Minuit / MigradImproved
Chi2                      =  3.28284e-06
NDf                       =           96
Edm                       =  2.73614e-07
NCalls                    =          613
p0                        =  7.37899e-12                        (fixed)
p1                        =  9.99892e-08                        (fixed)
p2                        =      4.99869   +/-   0.000832568    (limited)
p3                        =            0                        (fixed)
p4                        =  1.45645e-09   +/-   7.43678e-10    (limited)
p5                        =      7.05114   +/-   0.00130348     (limited)
p6                        =  4.13064e-12   +/-   1.38478e-09    (limited)
```

∫σ(Eγ, Ee)g(Eγ,p1,p2)dEγ fitting allows finding the parameters quite well :

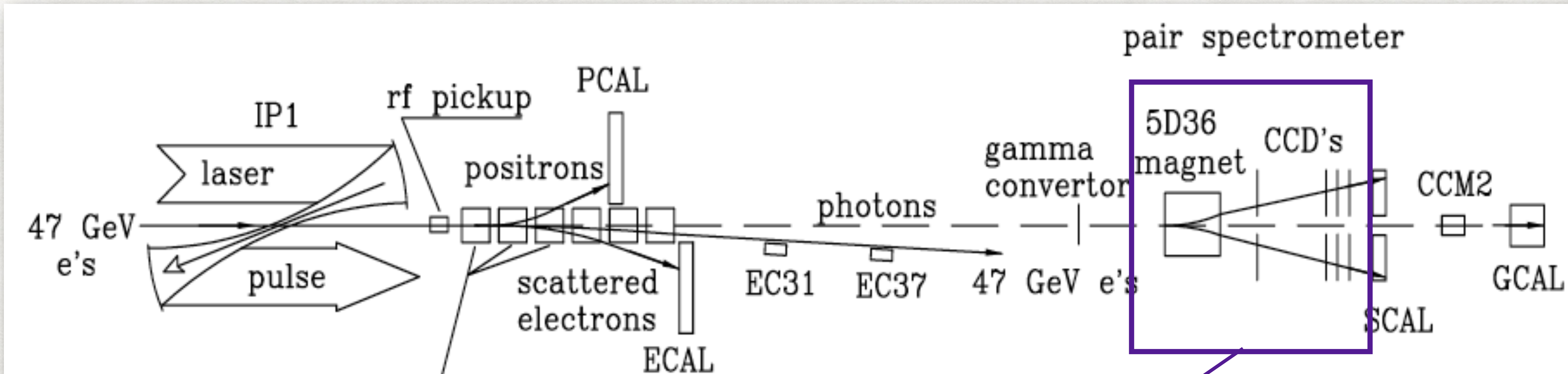
# WHAT'S NEXT

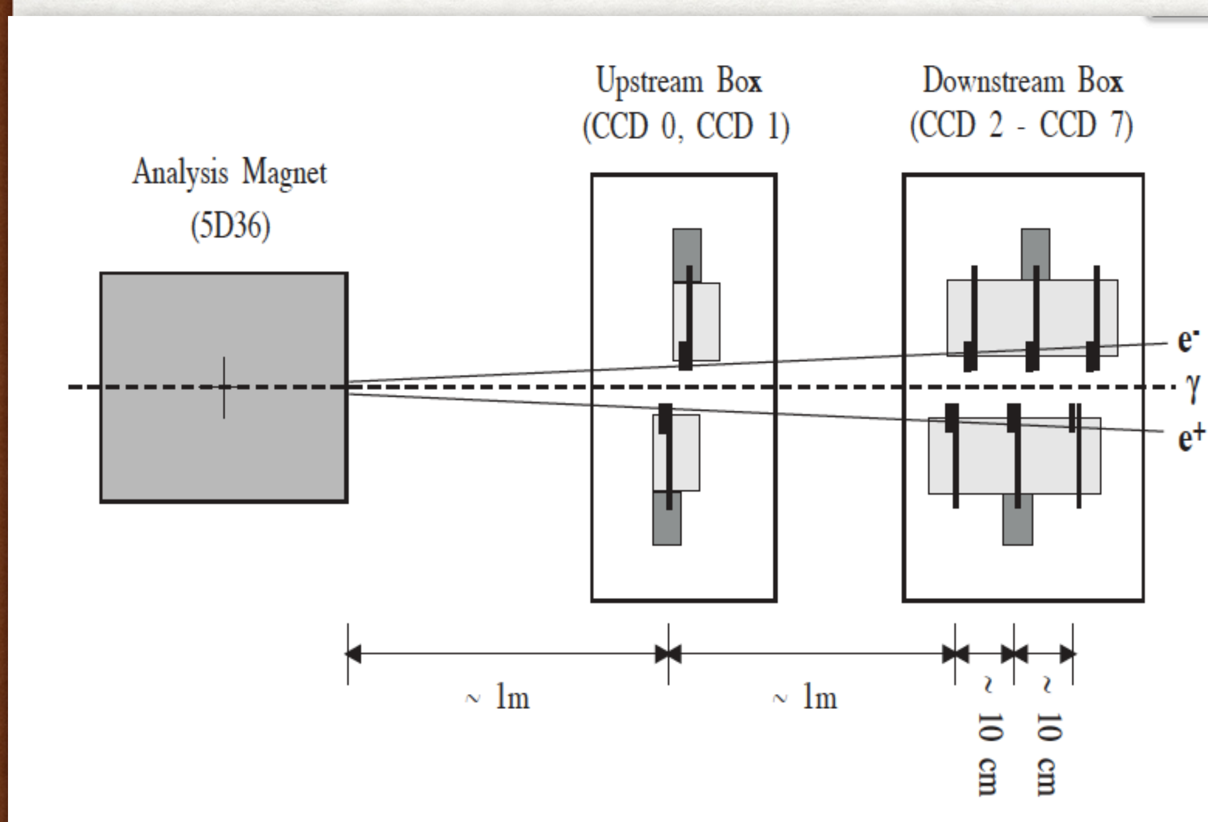
- 1st  draft of code for modeling arbitrary spectrum of primary particles in Geant 4
- test if we could fit and find other parameters describing the process: target material (Z), its thickness.

# BACK UP

# LAYOUT FOR THE E-144 EXPERIMENT

Photons produced at IP1 proceed down their own beamline through the converter foil and the tracking spectrometer




e-/e+ tracks were reconstructed using the 3 back planes of CCD's. All triplets of points from the back CCD planes of a given arm were tested to see if they fit a line intercepting a region near the center of the spectrometer magnet. This set of candidate tracks included many "fake" tracks from thermal noise, and combinatoric background of points from different particles.

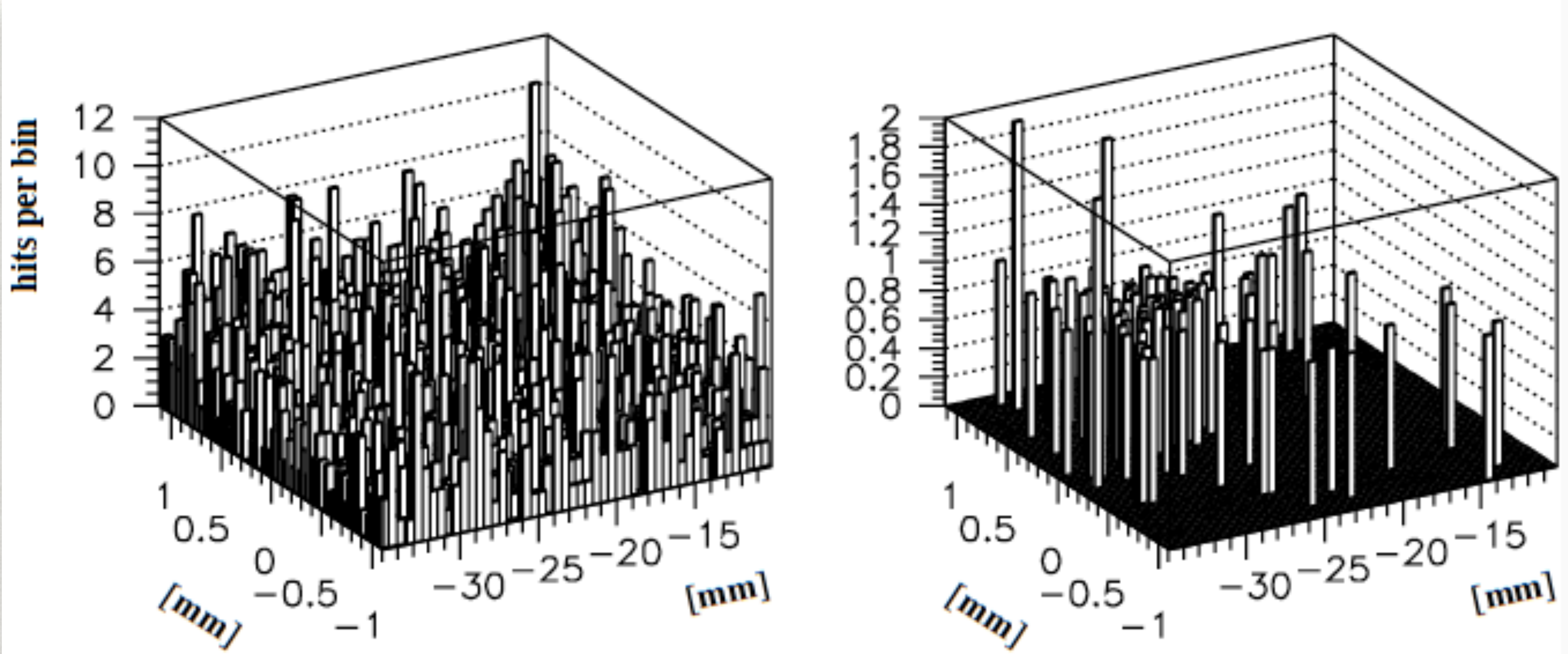
No attempt was made to use the CCDs in the front plane of the spectrometer in this mode, since the high number of hits led to significant ambiguity in the projection from the back planes to the front.

CCD image sensors: pixel size 22.5*22.5 um

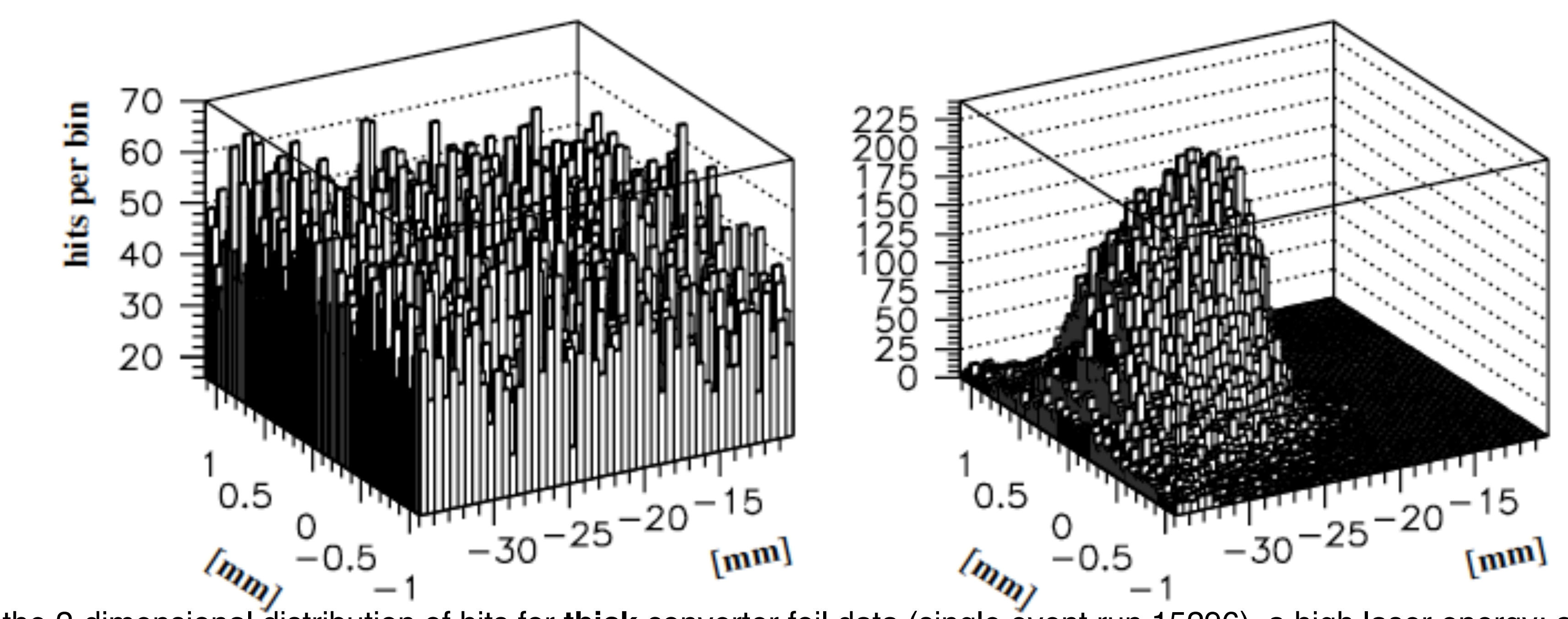
[EEV, 1242*1152].

# SIGNAL HITS IN CCD TRACKING SPECTROMETER OF E-144

each bin is 1 pixel tall and 22 pixels wide.




the 2-dimensional distribution of hits for **thin** converter foil data, modest laser energy: at left, hits which could not be matched with tracks are included, and at right, only hits used to form tracks are used.




the 2-dimensional distribution of hits for **thick** converter foil data (single event run 15296), a high laser energy: at left, hits which could not be matched with tracks are included, and at right, only hits used to form tracks are used.

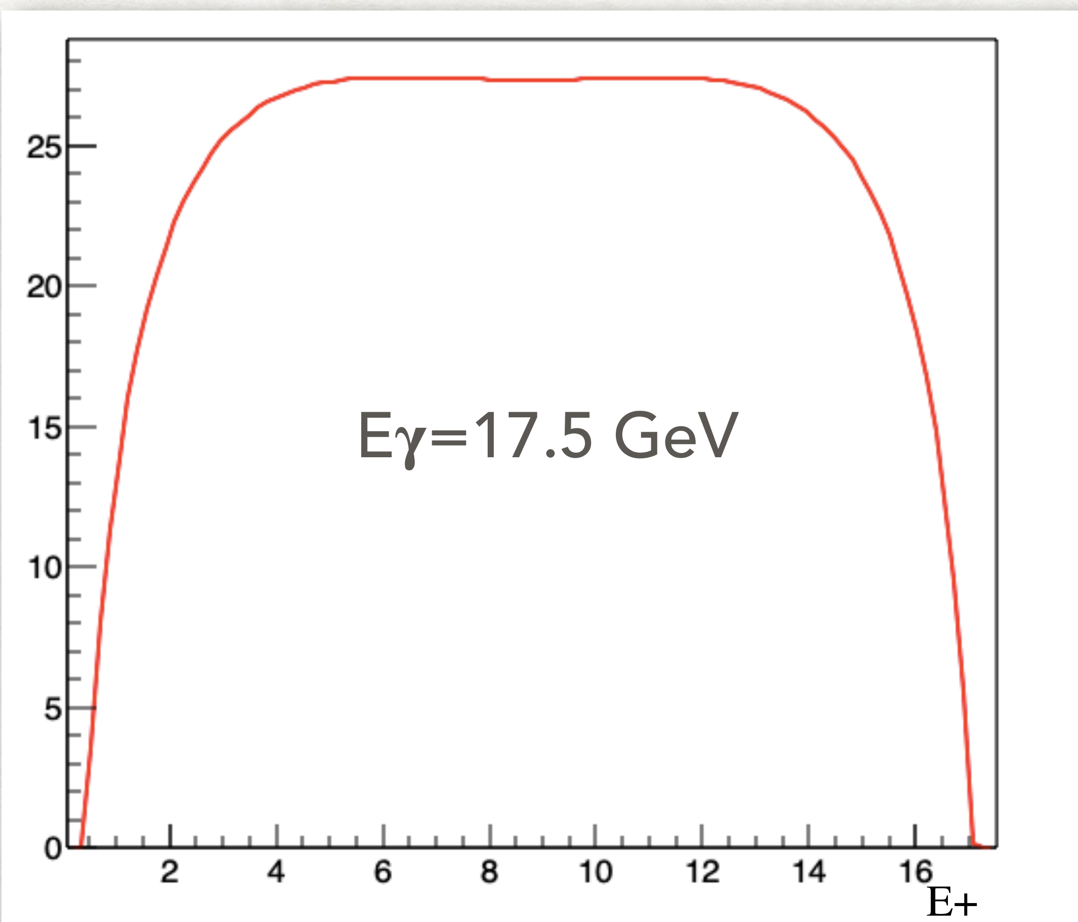
# THE CLASSICAL BETHE-HEITLER PAIR SPECTRUM

The classical Bethe-Heitler formula is currently used:

H.Bethe, W.Heitler, Proc.Roy.Soc.A146 (34)83

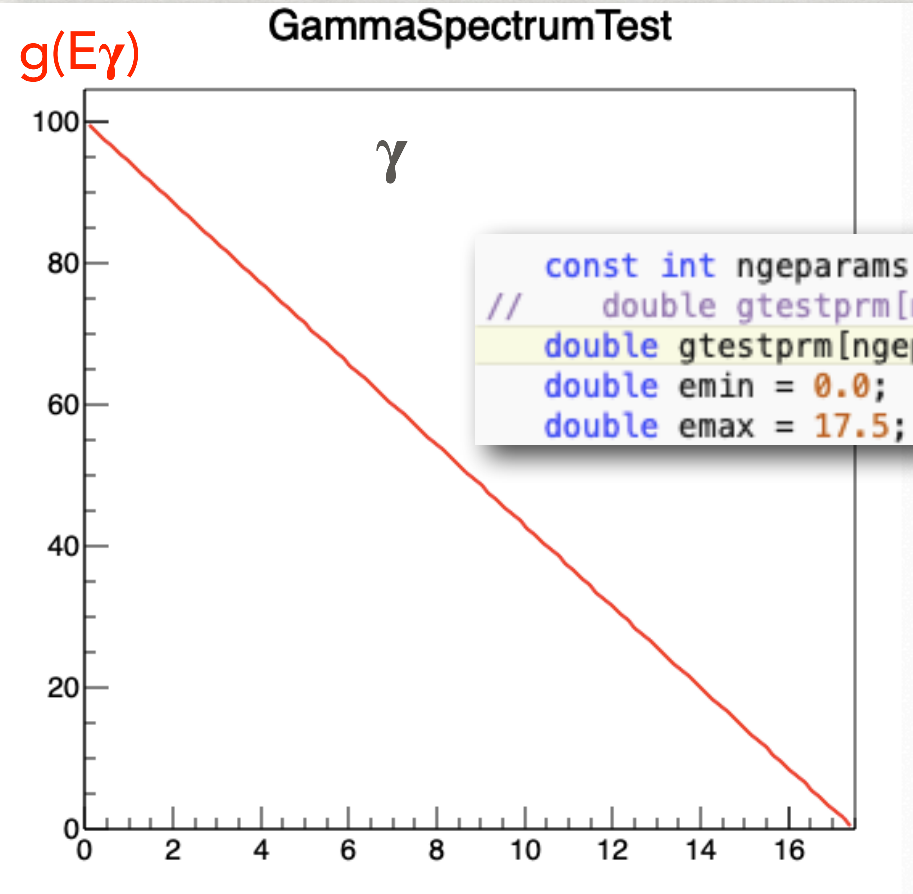
$$\Phi\left(E_0\right) dE_0 = \frac{Z^2}{137}\left(\frac{e^2}{mc^2}\right)^2 4\,\frac{E_0{}^2 + E_+{}^2 + \frac{2}{3}E_0E_+}{(h\nu)^3}\,dE_0\left(\log\frac{2E_0E_+}{h\nu mc^2} - \frac{1}{2}\right).$$

energies involved are large compared with $mc^2$



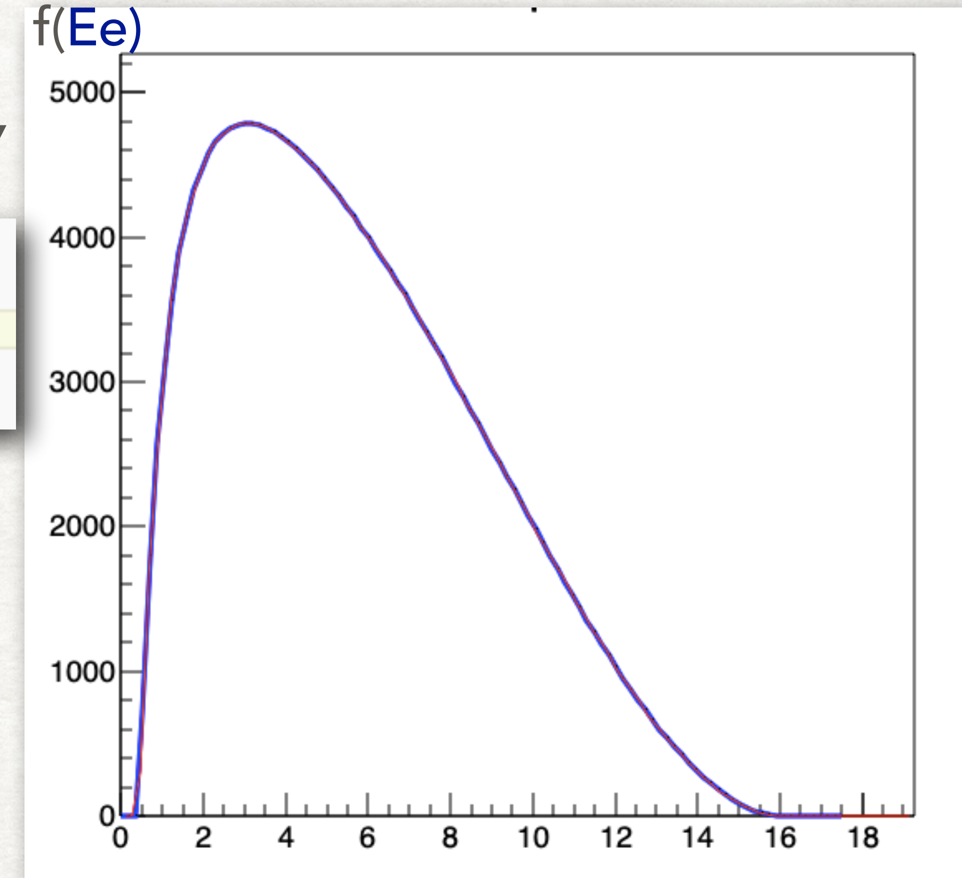

The idea - to check if in a toy model any photon spectrum could be restored if we have the classical BH distribution and characteristic shapes of photon spectrum

# TESTING: LINEAR




$$f(E_e)=\int \sigma(E_\gamma, E_e)\, g(E_\gamma)\, dE_\gamma$$

```
    const int ngeparams = 2;
//    double gtestprm[ngeparams] = {100.0, 17.5};  // linear
    double gtestprm[ngeparams] = {105.0, 0.3};    // exp
    double emin = 0.0;
    double emax = 17.5;
```

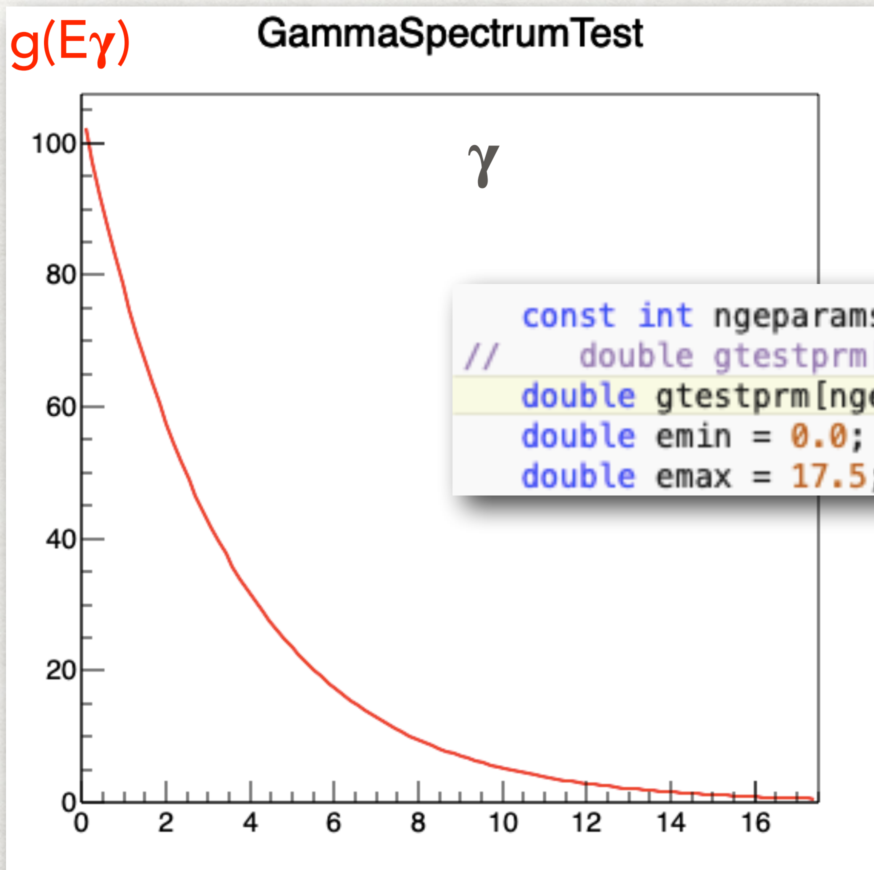



$$\int \sigma(E_\gamma, E_e)\, g(E_\gamma, p1, p2)\, dE_\gamma$$

fitting allows finding the parameters quite well

```
****************************************
Minimizer is Minuit / Migrad
Chi2                      =  5.73475e-09
NDf                       =           98
Edm                       =  1.13143e-08
NCalls                    =          189
p0                        =          100    +/-    1.06734e-07
p1                        =         17.5    +/-    6.94118e-09
```

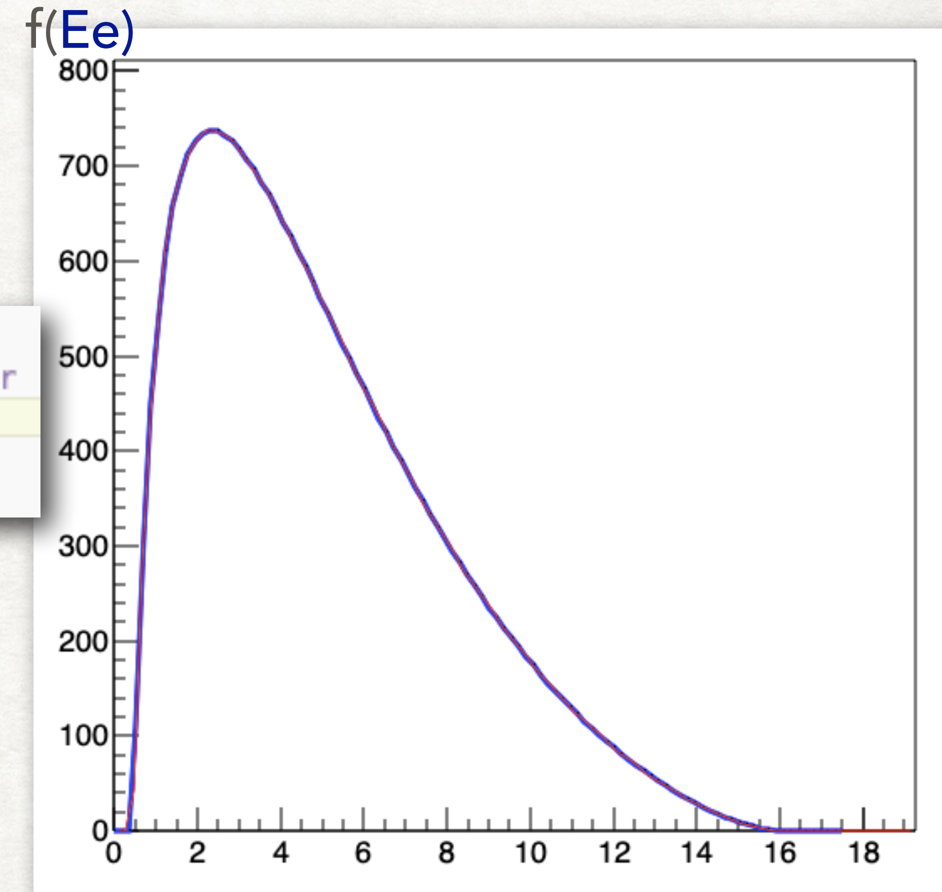
# TESTING: EXPONENTIAL




BH

Ee=∫σ(Eγ, Ee)g(Eγ)dEγ

```
   const int ngeparams = 2;
//     double gtestprm[ngeparams] = {100.0, 17.5};   // linear
   double gtestprm[ngeparams] = {105.0, 0.3};    // exp
   double emin = 0.0;
   double emax = 17.5;
```

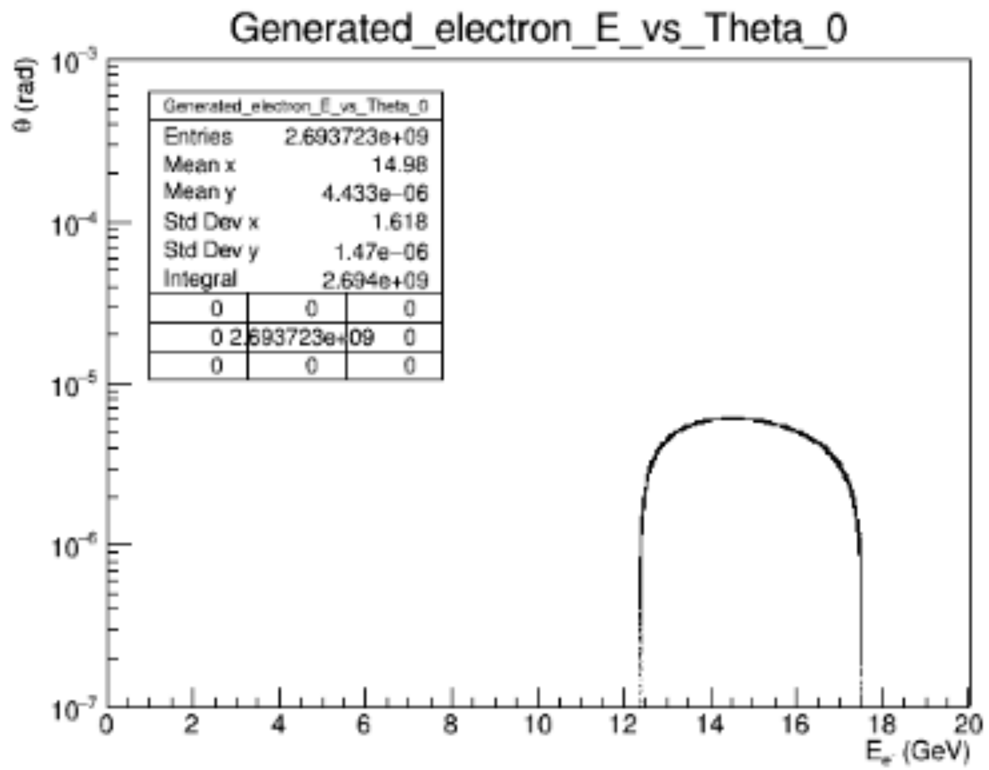


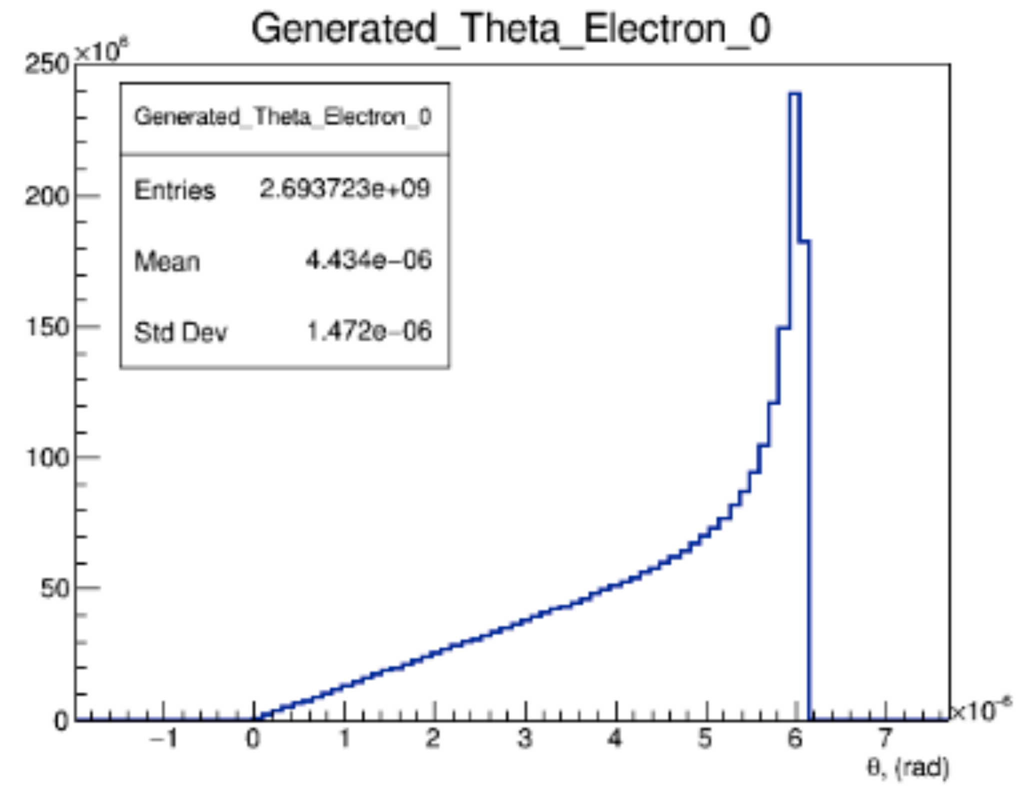

∫σ(Eγ, Ee)g(Eγ,p1,p2)dEγ

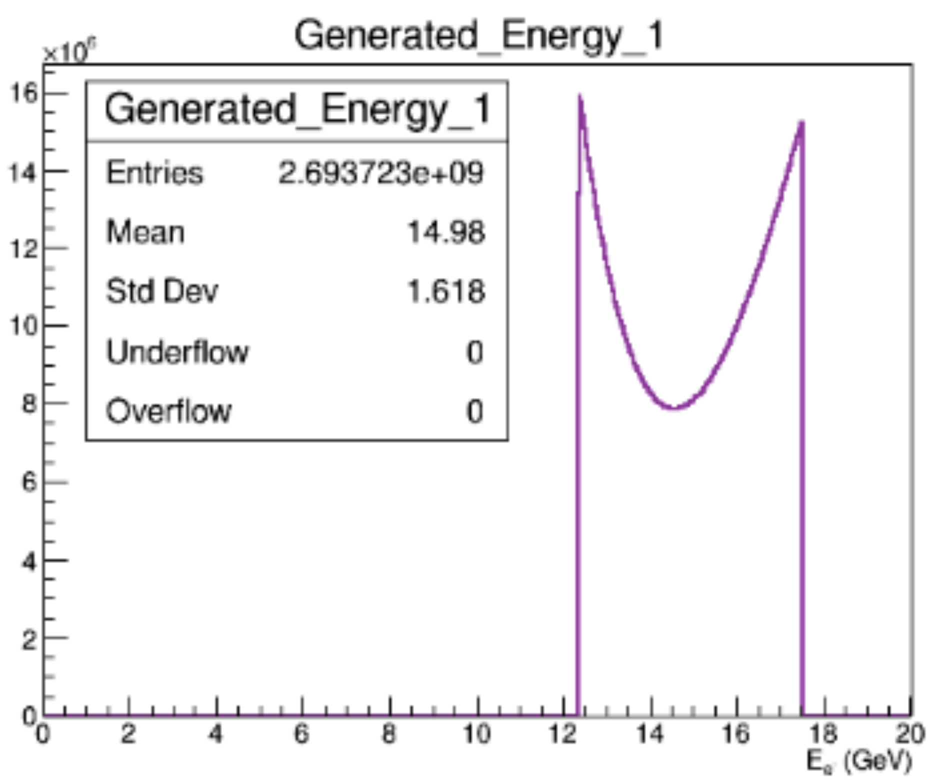
fitting allows finding the parameters with high precision

```
Minimizer is Minuit / Migrad
Chi2                      =  8.52694e-11
NDf                       =           98
Edm                       =  1.70646e-10
NCalls                    =          167
p0                        =          105    +/-    1.72634e-07
p1                        =          0.3    +/-    1.73966e-10
```

# Electrons after interaction



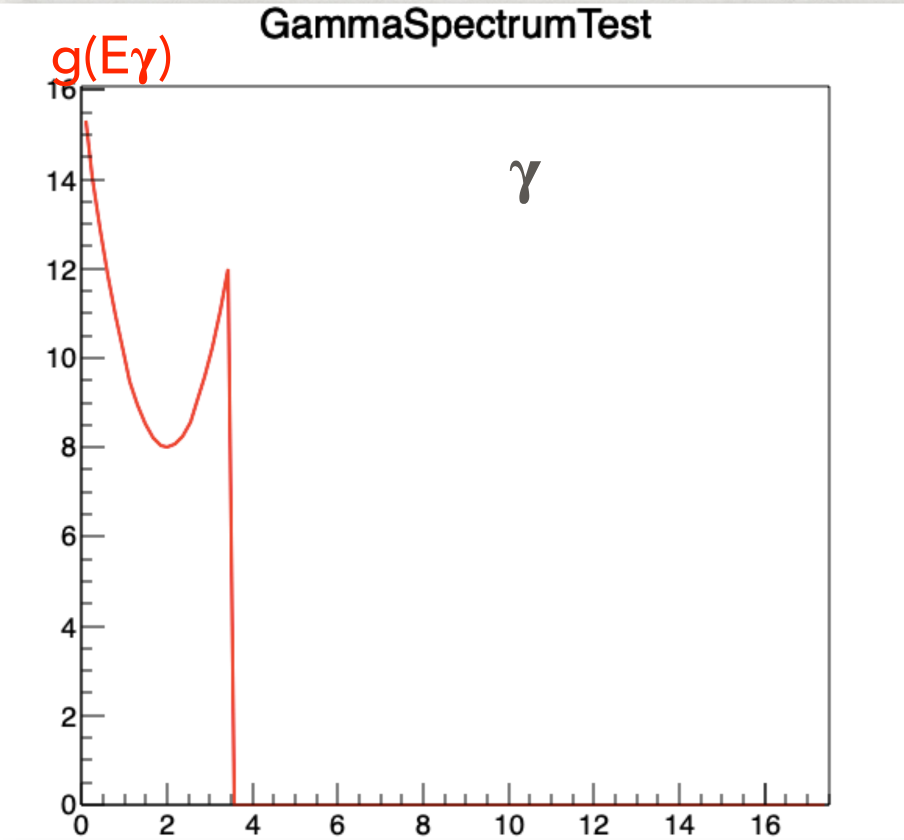

Integrated over azimuthal angle

Compton events in simulation

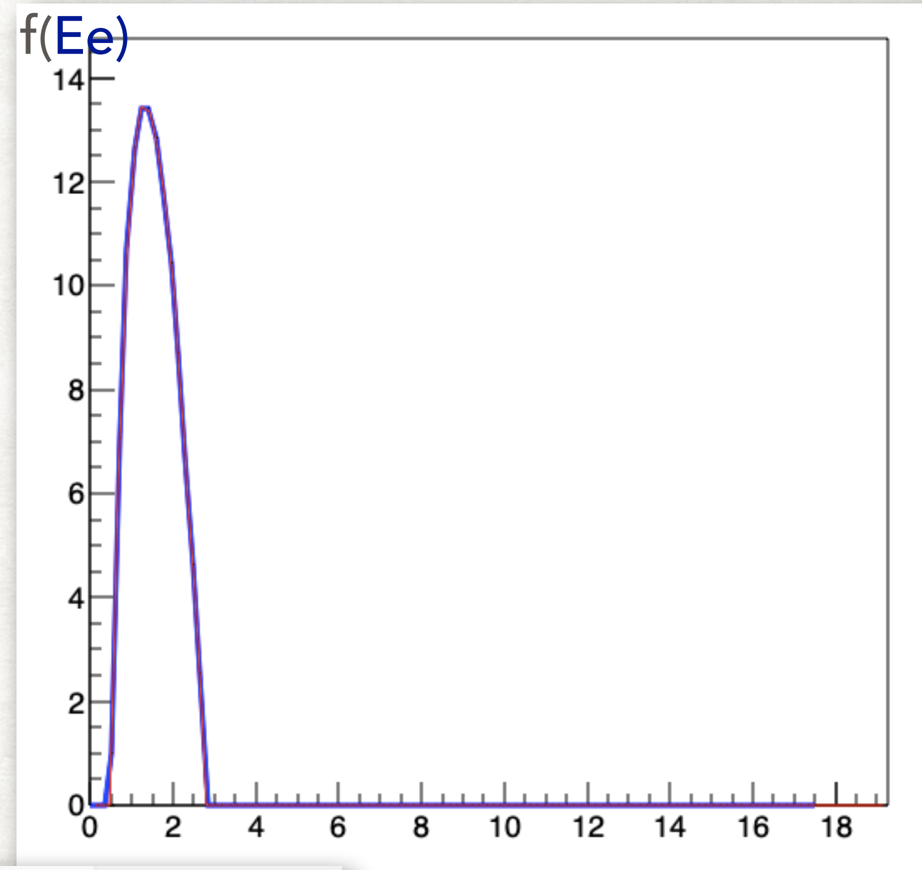
Oleksandr Borysov

LUXE Meeting
September 24, 2018

# TESTING: COMPTON-LIKE




$$E_e = \int \sigma(E_\gamma, E_e)\, g(E_\gamma)\, dE_\gamma$$




```
//    double gtestprm[ngeparams] = {100.0, 17.5};  // linear
//    double gtestprm[ngeparams] = {105.0, 0.3};   // exp
   const int ngeparams = 3;    double gtestprm[ngeparams] = {2.0, 2.0, 8.0};  // parabola like Compton
```

$$\int \sigma(E_\gamma, E_e)\, g(E_\gamma, p1, p2)\, dE_\gamma$$

fitting allows finding the parameters quite well :

```
******************************************
Minimizer is Minuit / MigradImproved
Chi2                      =  5.92197e-07
NDf                       =           97
Edm                       =  1.27179e-06
NCalls                    =          342
p0                        =       1.9899   +/-   0.00109921
p1                        =      1.99569   +/-   0.000468708
p2                        =      7.99435   +/-   0.000639219
```