

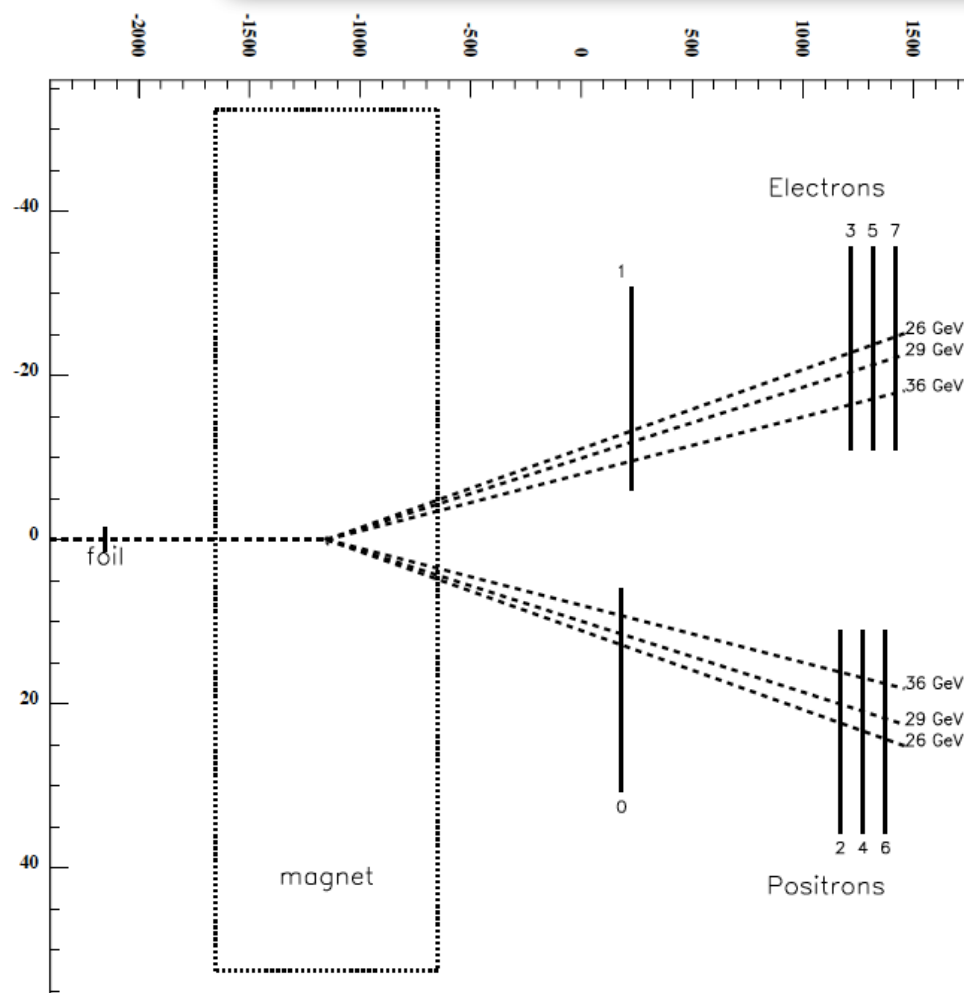
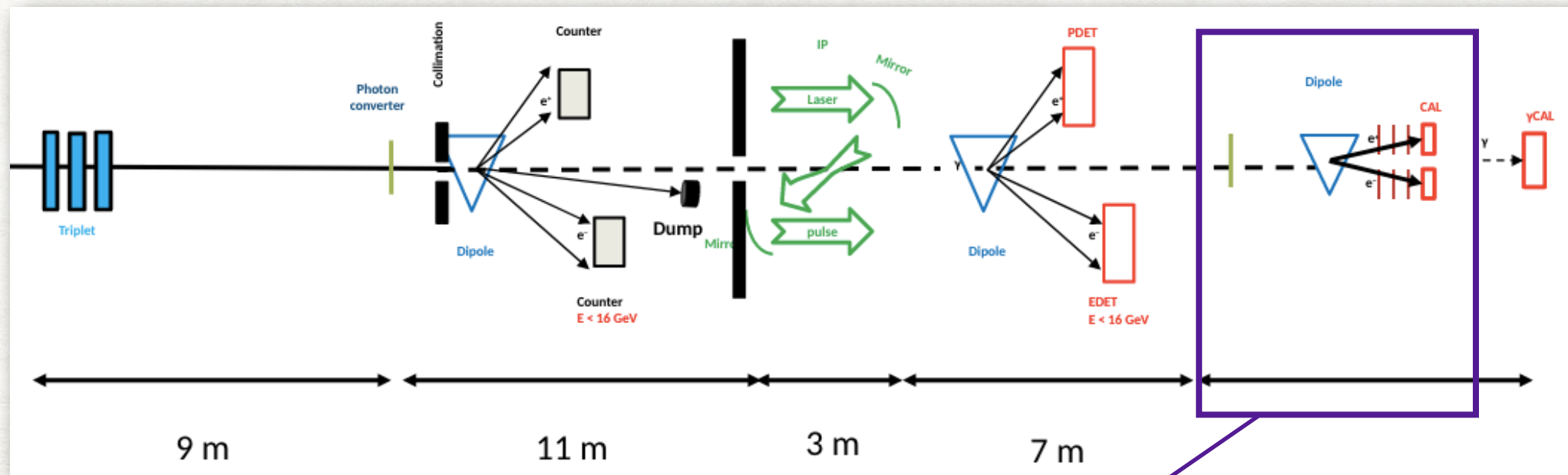
FORWARD PHOTONS

Borysova Maryna

27/01/19

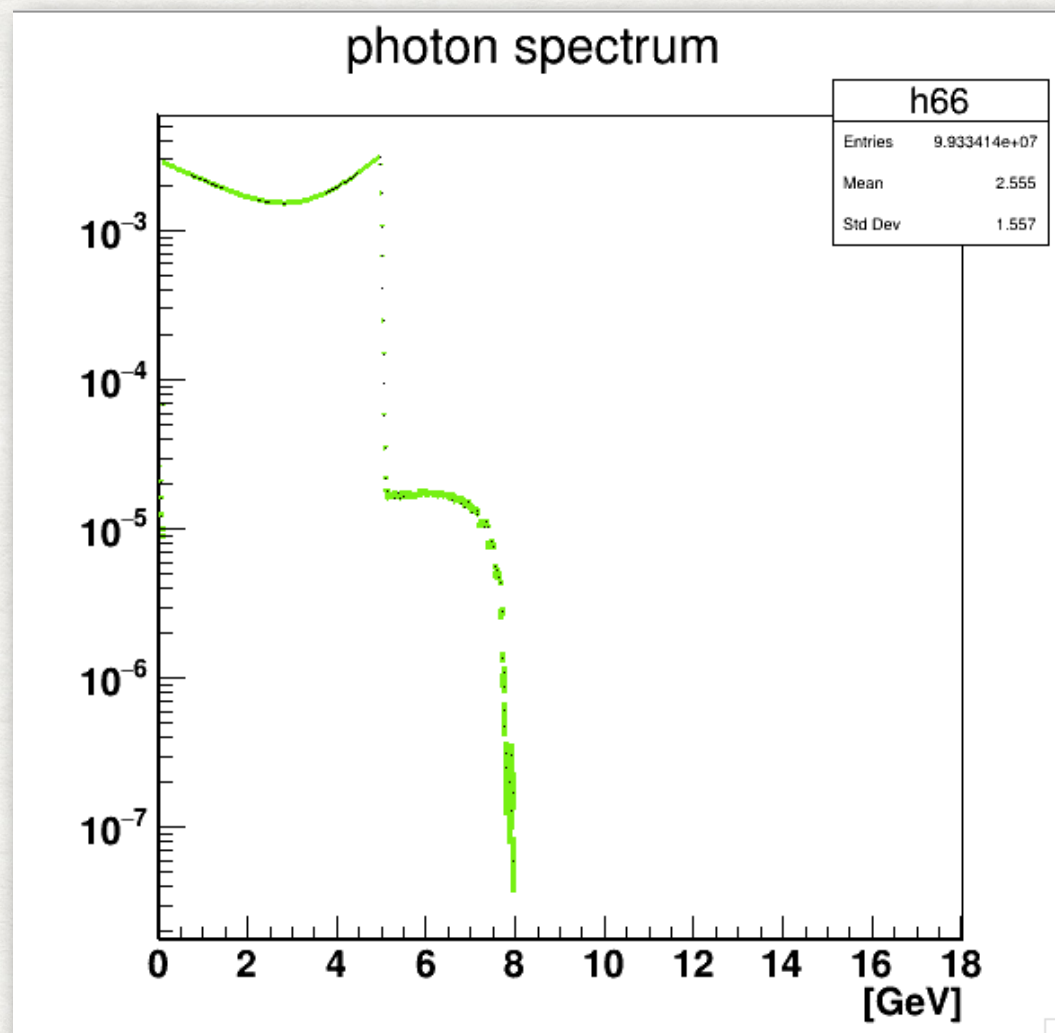
LAYOUT FOR THE LUXE EXPERIMENT

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



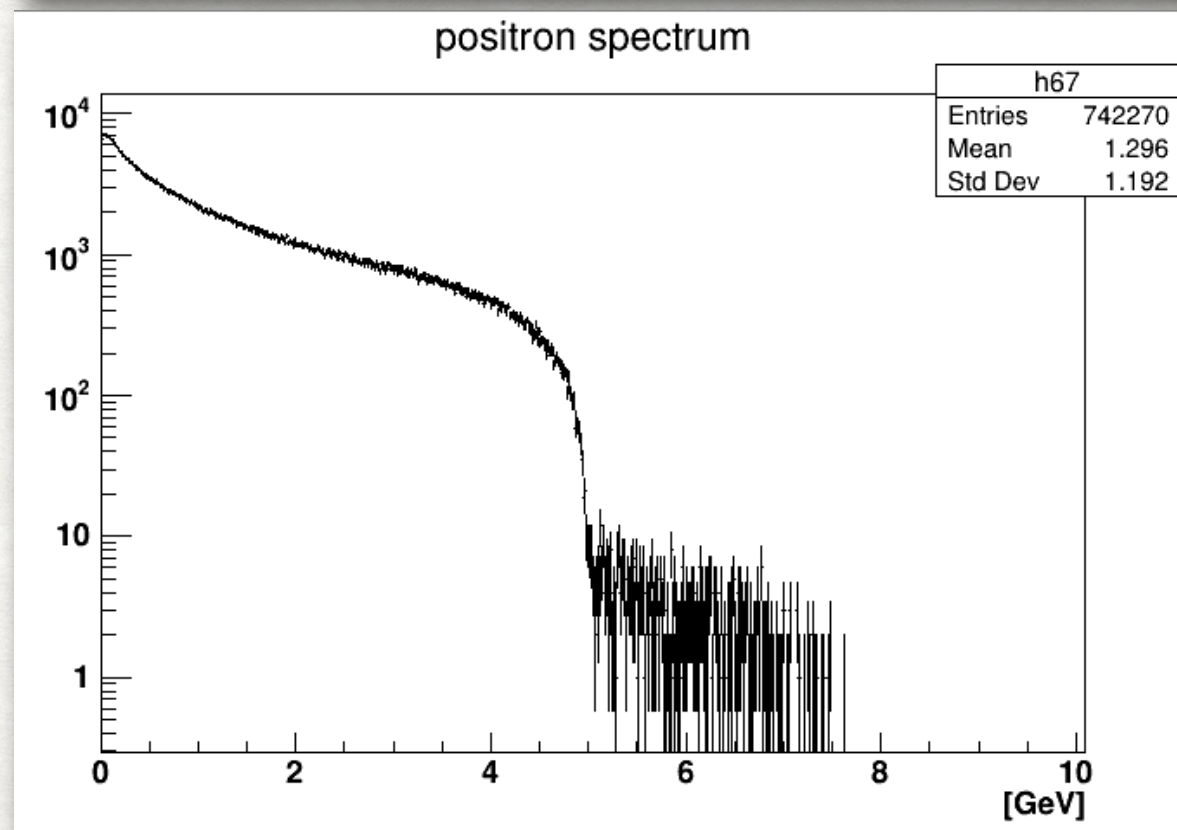
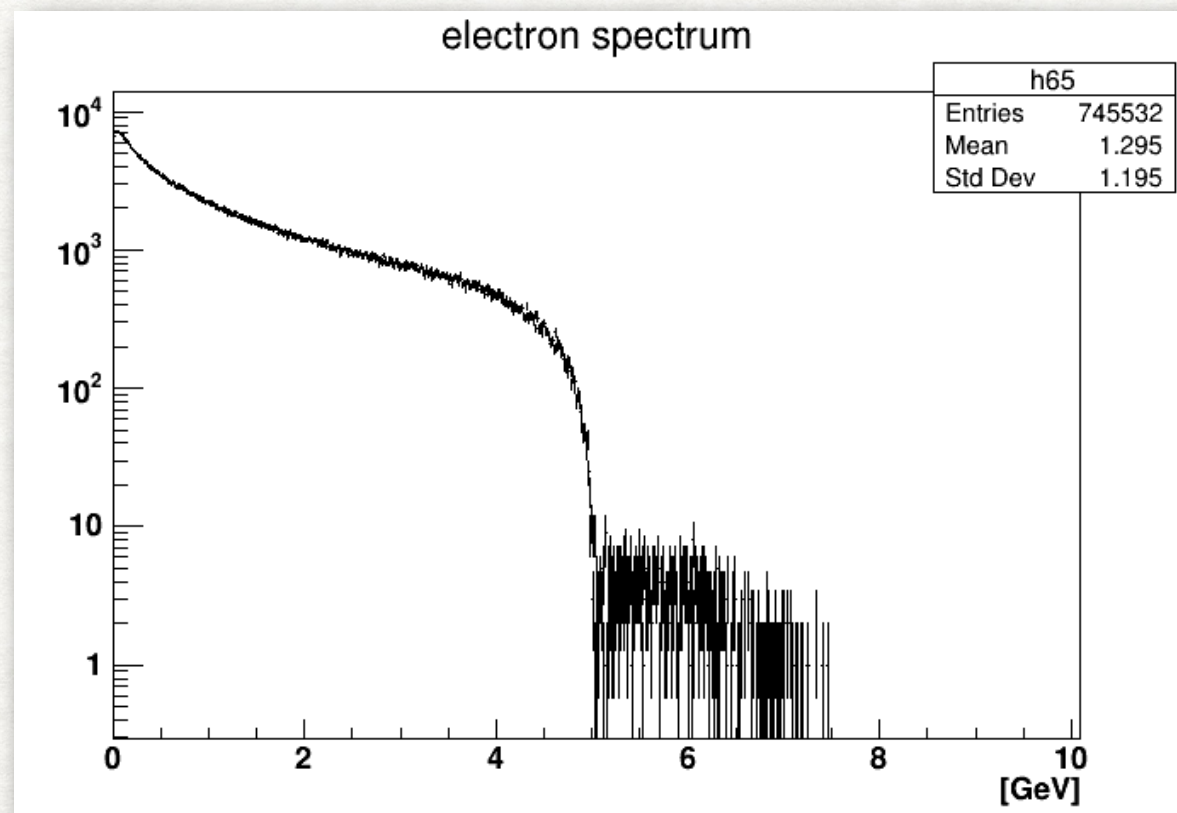
In E144 the data in the two arms of the spectrometer were analyzed independently, and then combined the reconstructed single-particle momentum spectra for comparison to a model spectrum calculated by convolving the simulated photon spectrum with the Bethe-Heitler pair spectrum

FORWARD PHOTONS IN GEANT4



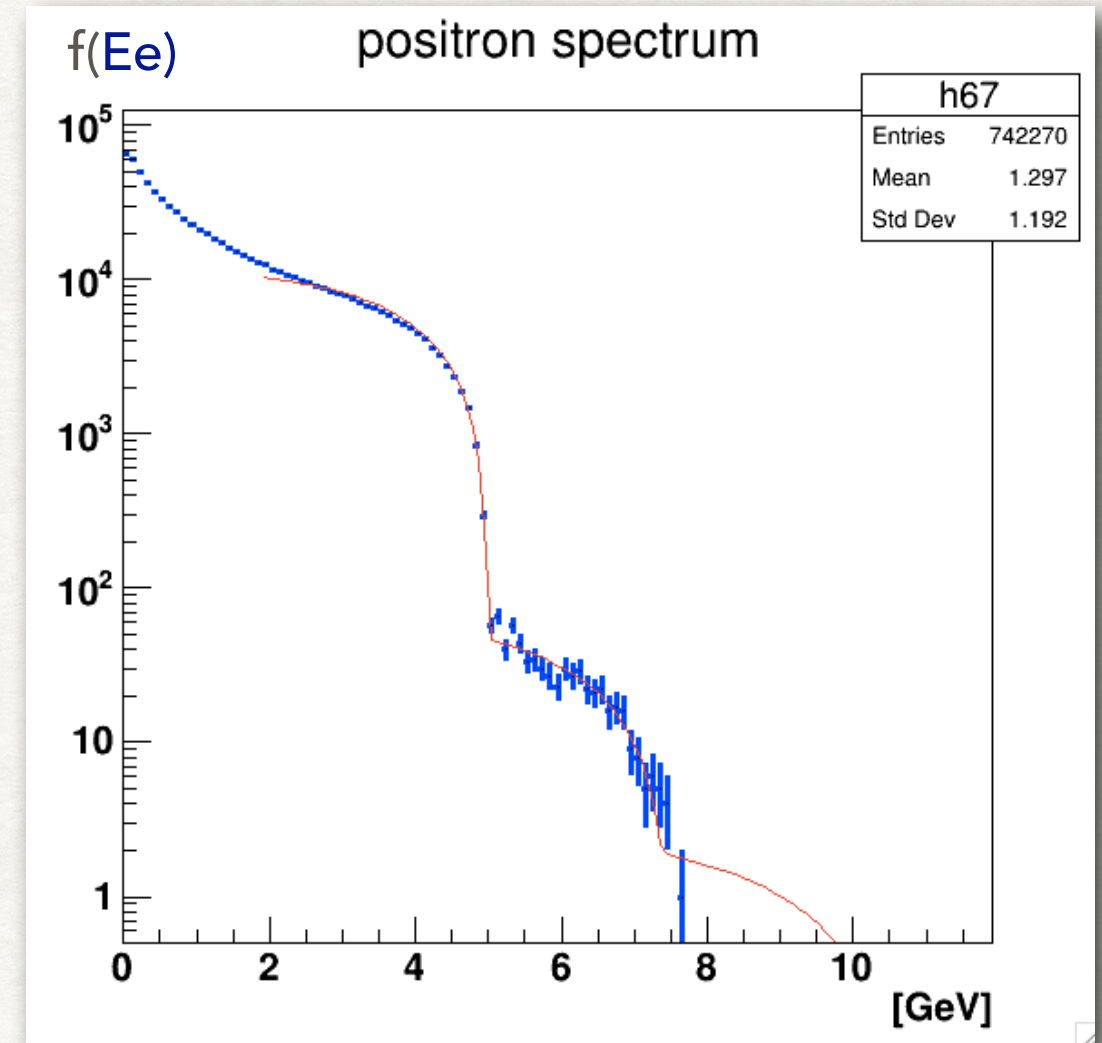
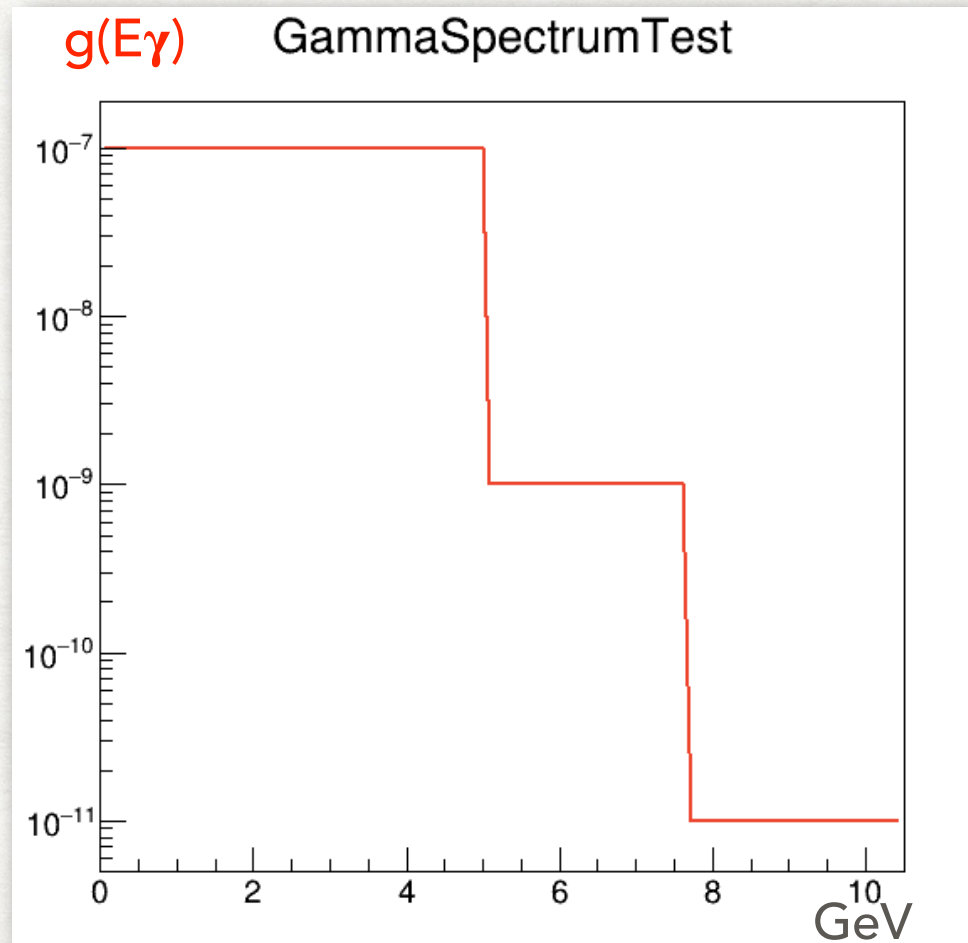
Code from Sasha

target: Tungsten, 0.35 μm
1e8 photons



TESTING: COMPTON-LIKE

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



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

fitting allows finding the parameters quite well :

FCN=1309.19 FROM HESSE STATUS=OK				39 CALLS		442 TOTAL	
EDM=9.77144e-09				STRATEGY= 1		ERROR MATRIX ACCURATE	
EXT NO.	PARAMETER NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE		
1	p0	0.00000e+00	fixed				
2	p1	3.71863e-05	1.18274e-07	7.47299e-08	-9.55179e+00		
3	p2	5.00872e+00	2.75457e-03	2.31805e-06	2.53148e-02		
4	p3	0.00000e+00	fixed				
5	p4	1.02419e-07	7.39607e-09	7.48765e-08**	at limit **		
6	p5	7.38500e+00	8.55688e-02	1.42343e-05	-1.88485e-03		
7	p6	2.16581e-09	1.14383e-09	3.41734e-06	8.55195e-03		

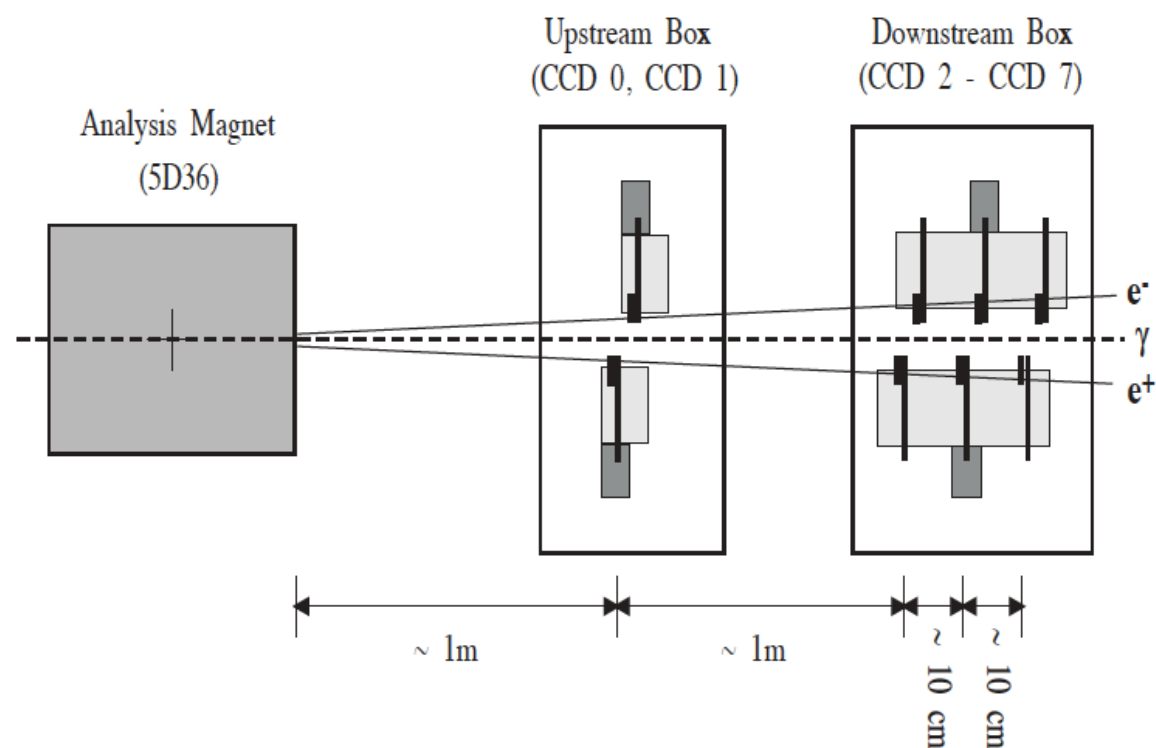
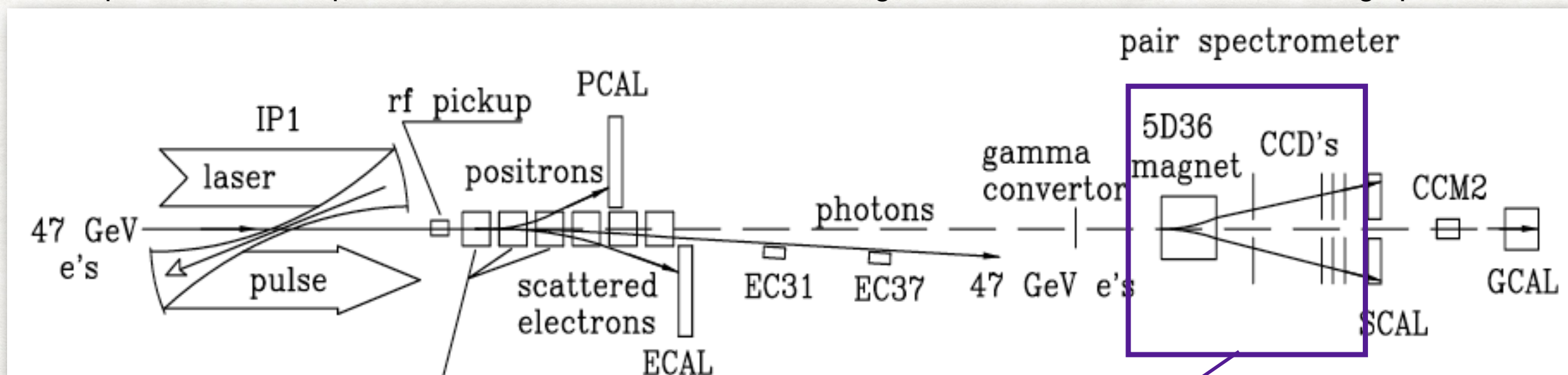
WHAT'S NEXT

- 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



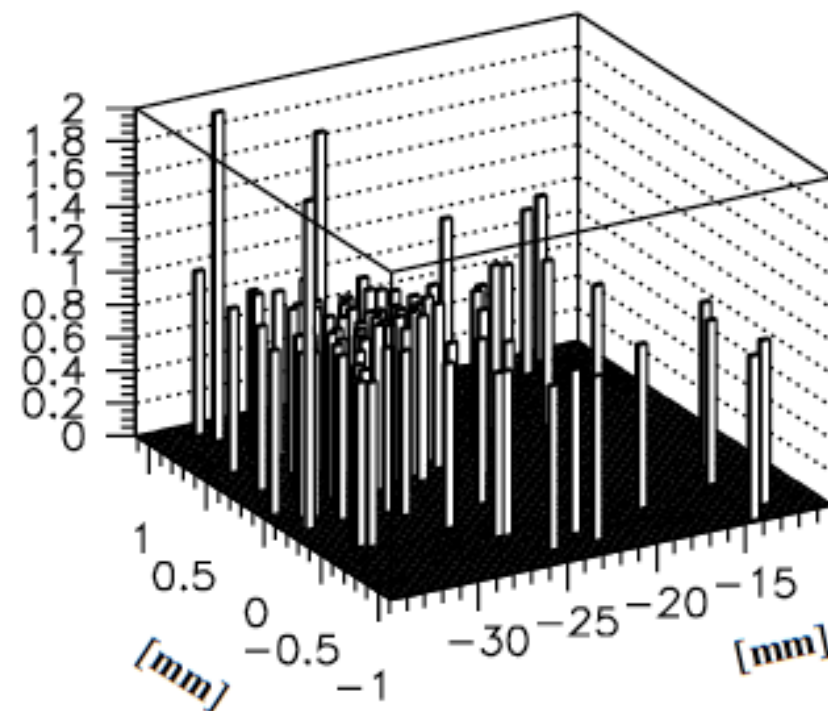
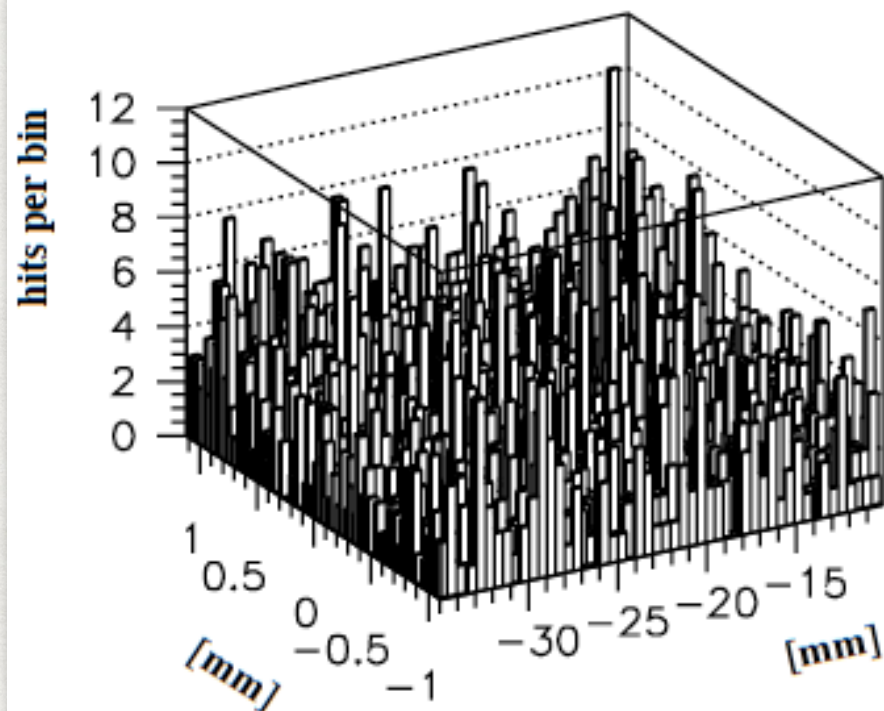
e^-/e^+ tracks were reconstructed using the 3 back planes of CCD's. All triplets of points from the back CCD planes of a given arm were tested to see if they fit a line intercepting a region near the center of the spectrometer magnet. This set of candidate tracks included many "fake" tracks from thermal 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 $22.5 \times 22.5 \mu\text{m}$

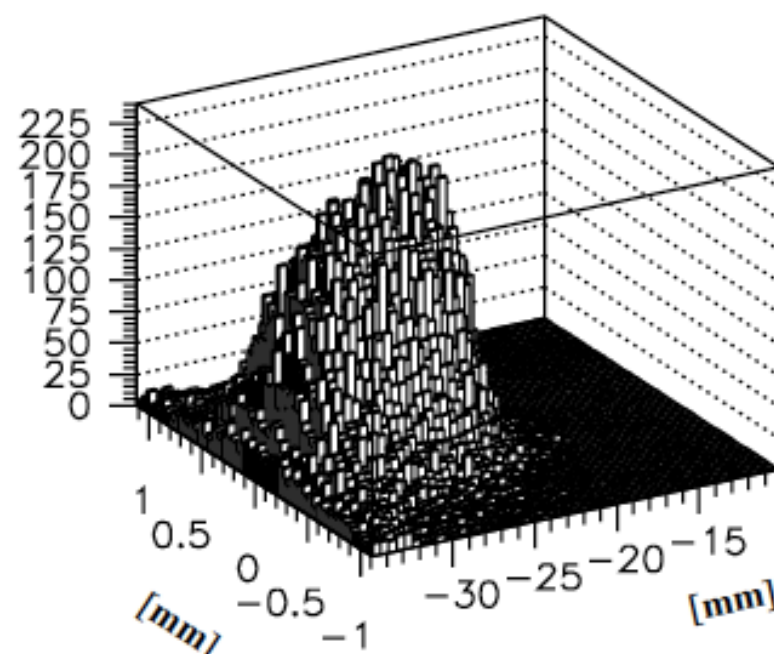
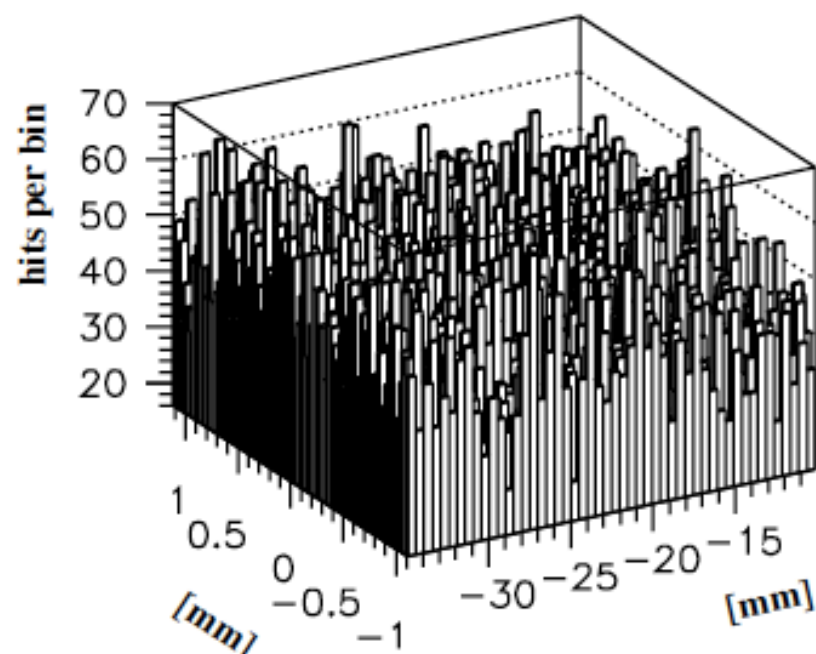
[EEV, 1242*1152].

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.

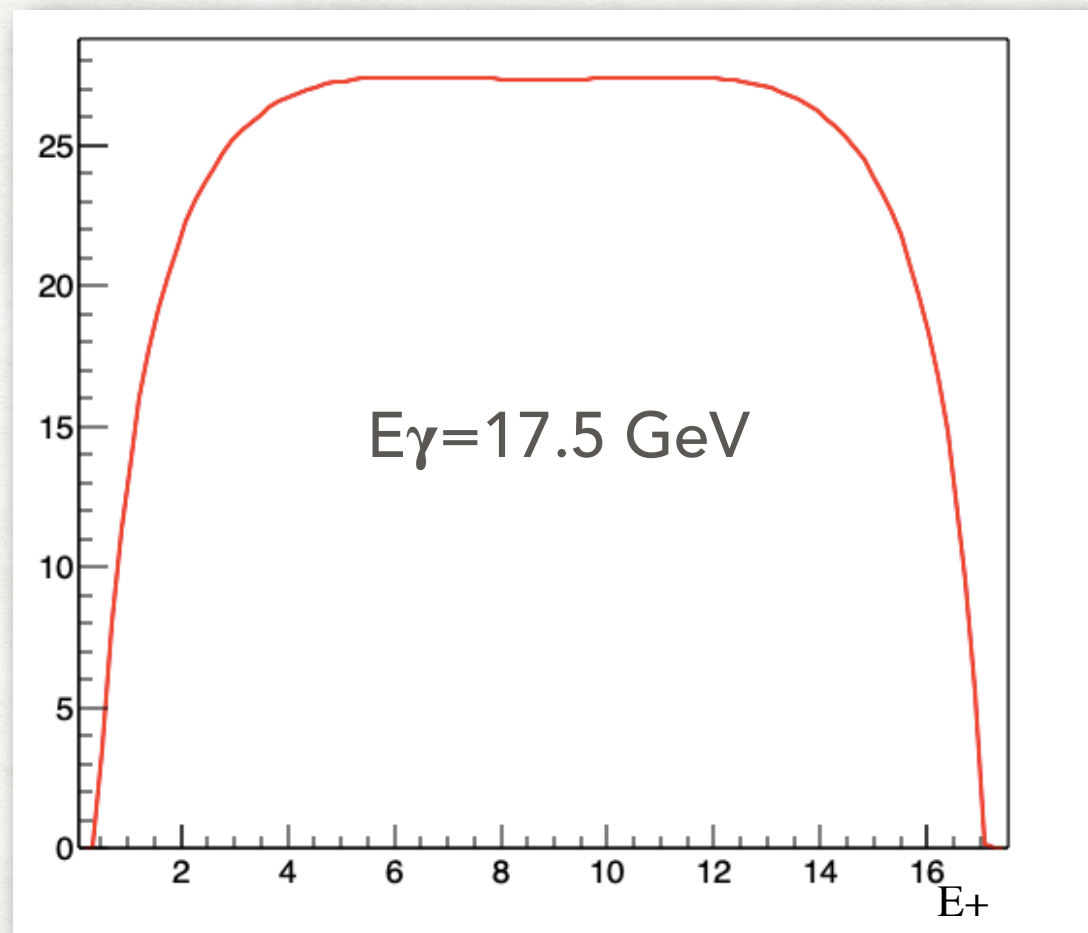
THE CLASSICAL BETHE-HEITLER PAIR SPECTRUM

The classical Bethe-Heitler formula is currently used:

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

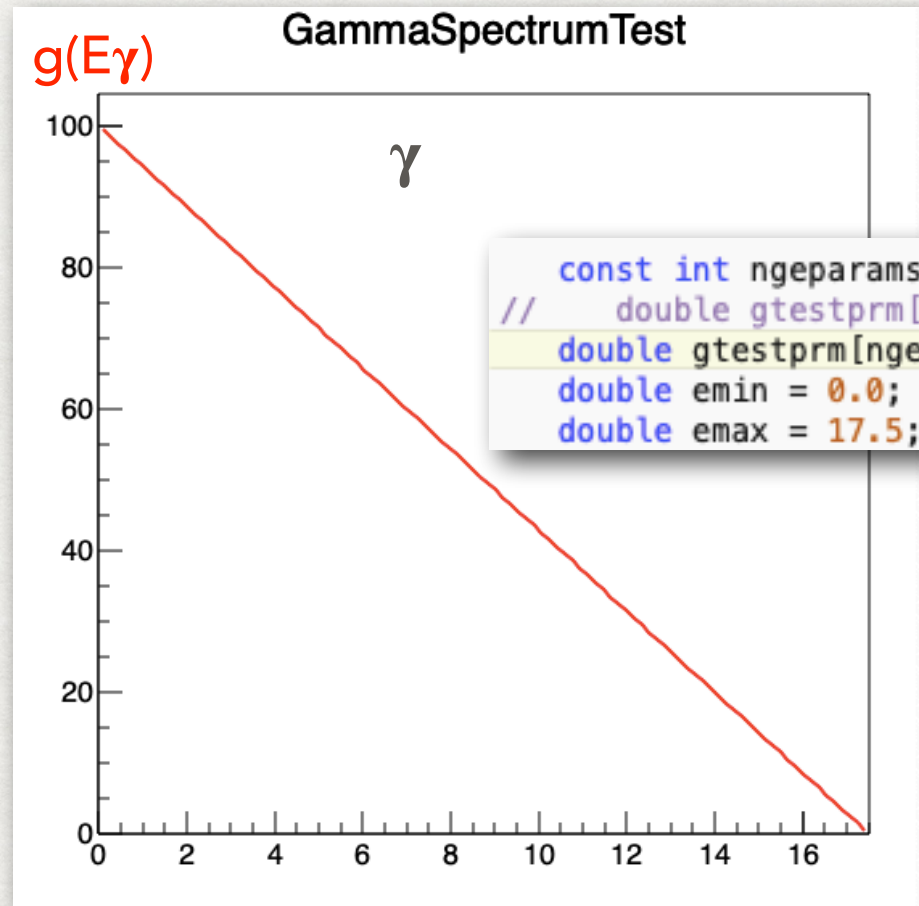
$$\Phi(E_0) dE_0 = \frac{Z^2}{137} \left(\frac{e^2}{mc^2} \right)^2 4 \frac{E_0 + 2E_+^2 + \frac{2}{3}E_0E_+}{(h\nu)^3} dE_0 \left(\log \frac{2E_0E_+}{h\nu mc^2} - \frac{1}{2} \right).$$

energies involved are large compared with mc^2



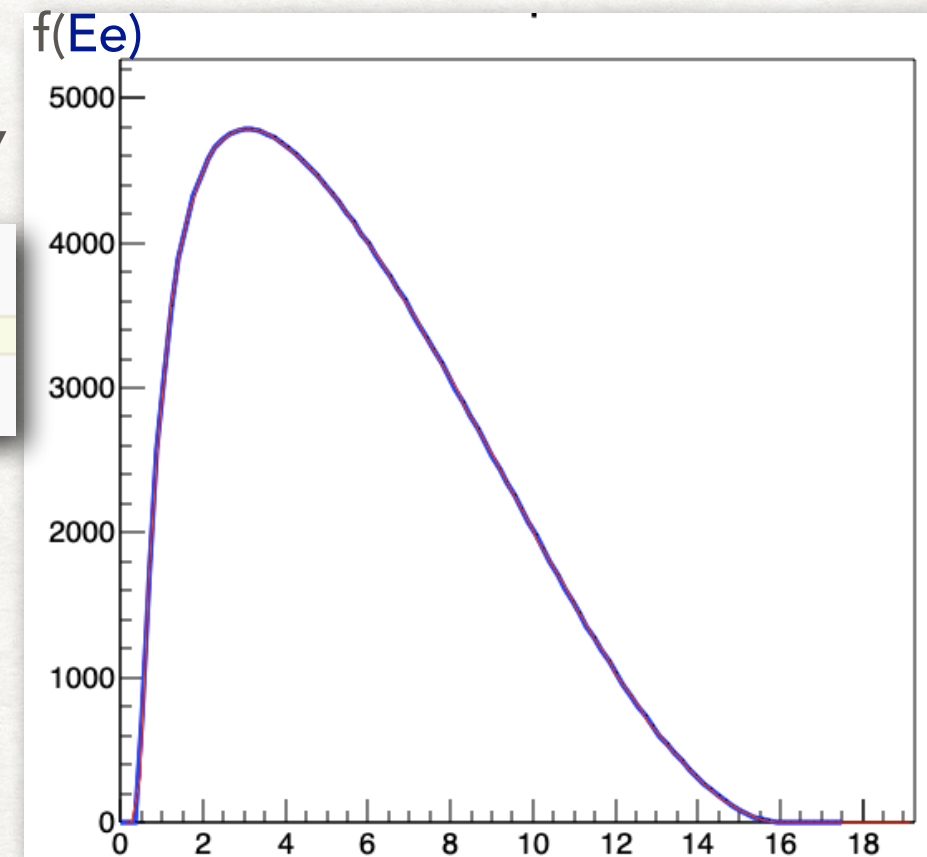
The idea - to check if in a toy model any photon spectrum could be restored if we have the classical BH distribution and characteristic shapes of photon spectrum

TESTING: LINEAR



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

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

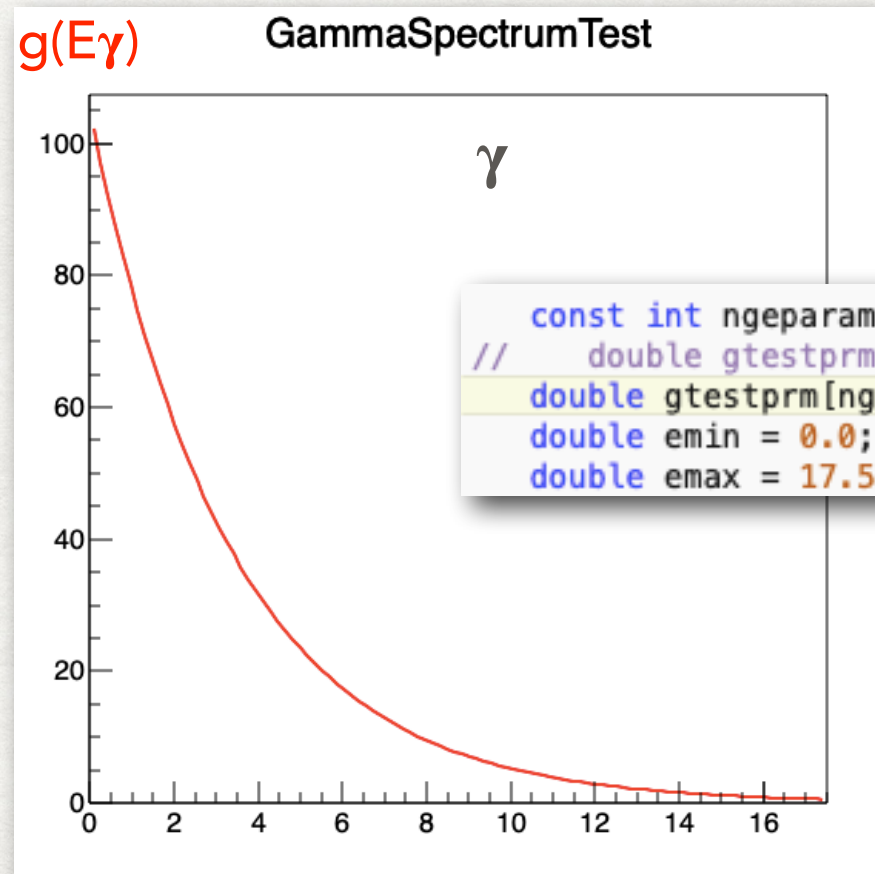


$$\int \sigma(E_\gamma, E_e) g(E_\gamma, p_1, p_2) dE_\gamma$$

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
```

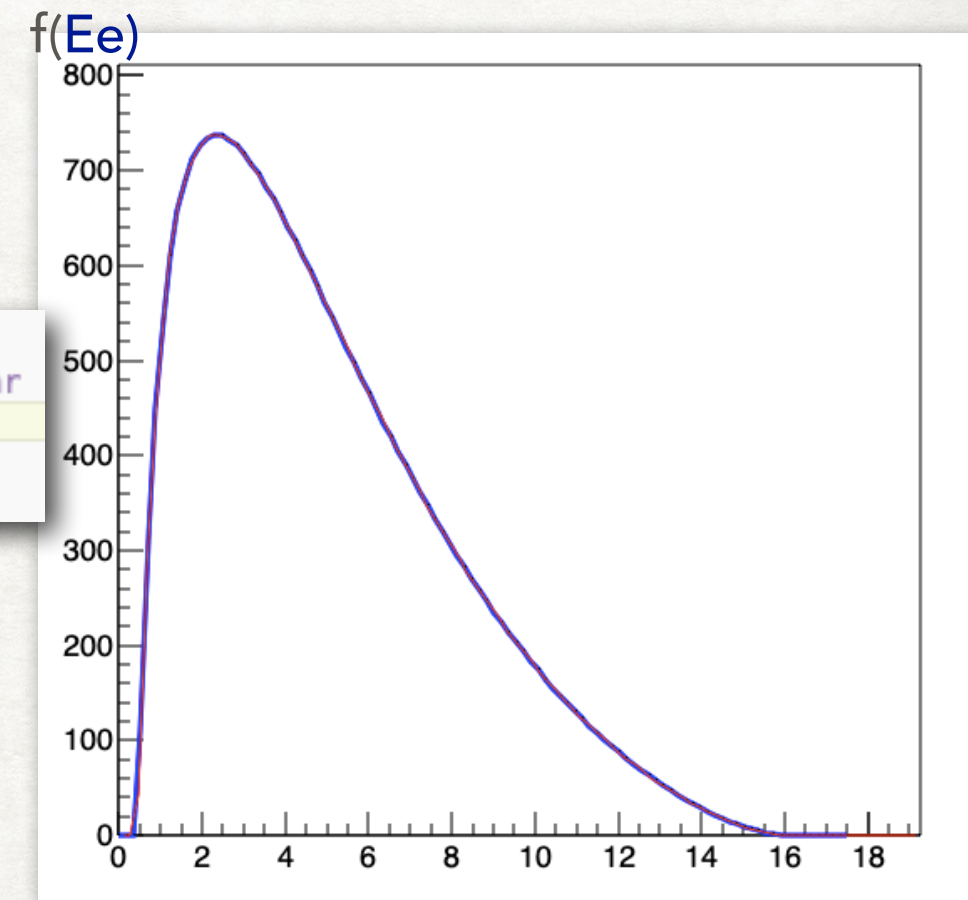

TESTING: EXPONENTIAL



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

BH

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

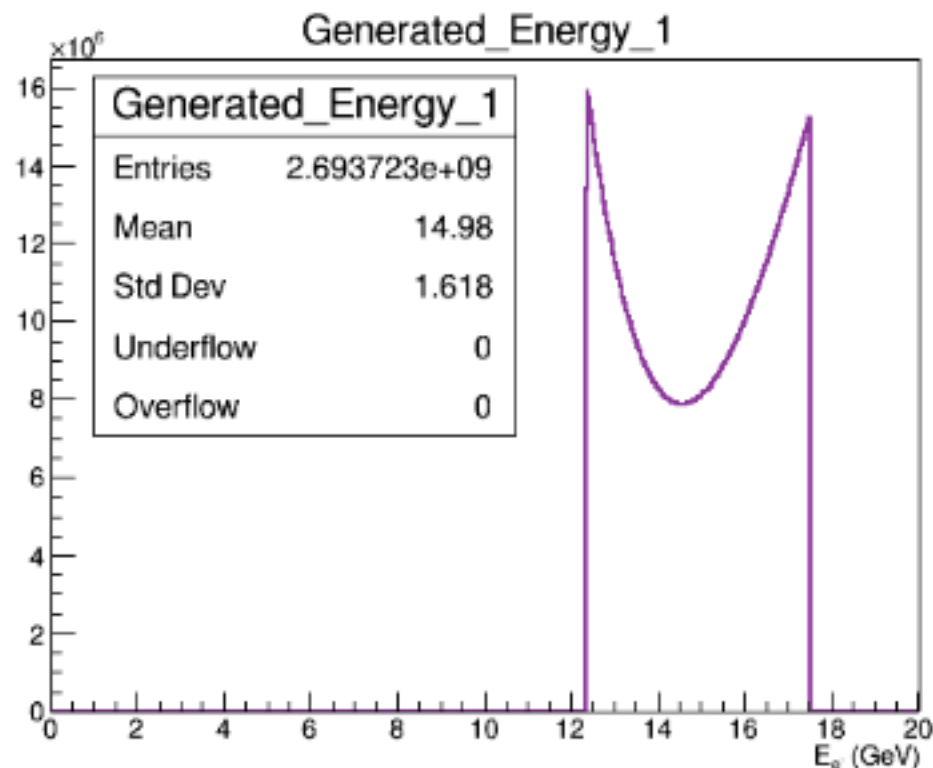
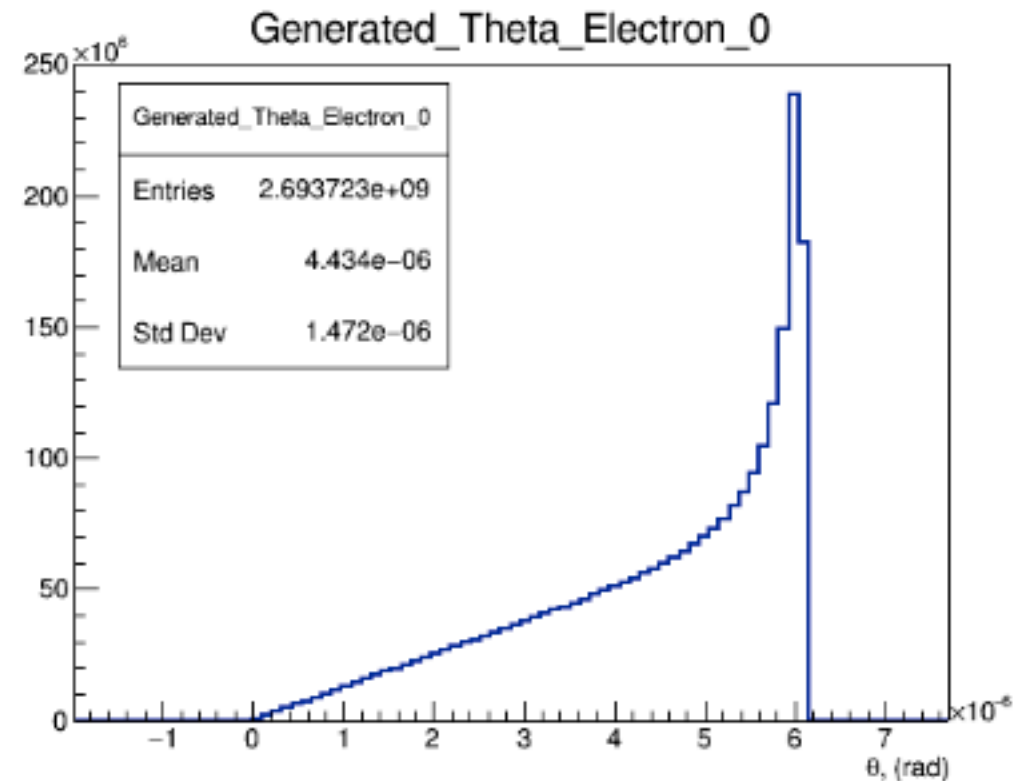
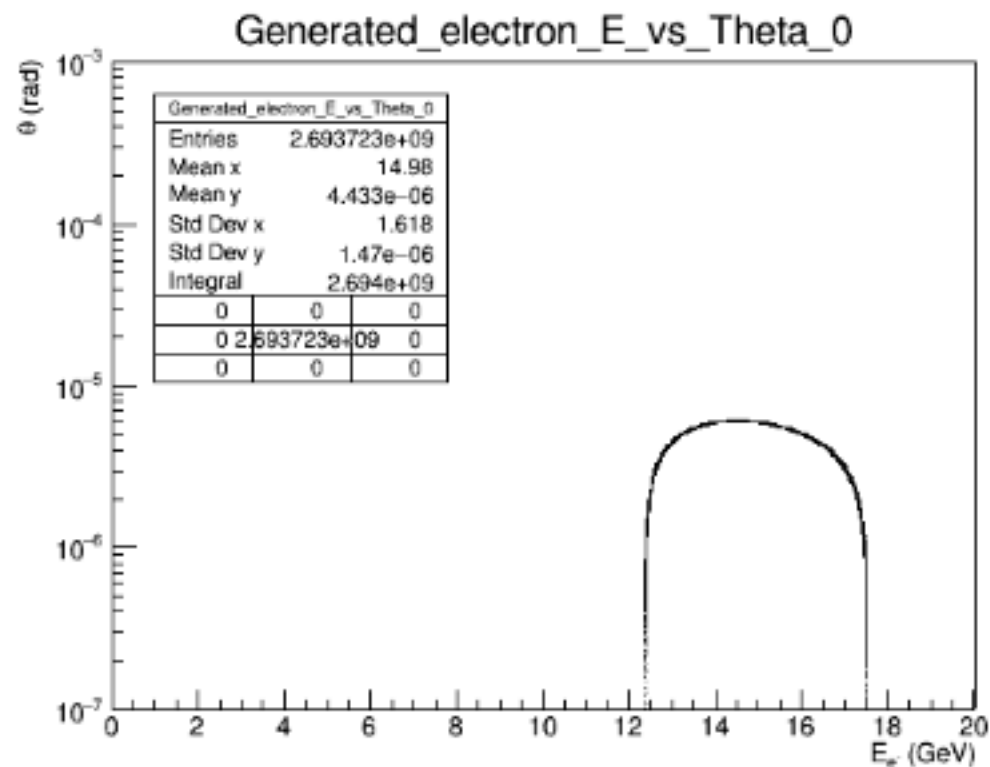


$$\int \sigma(E_\gamma, E_e) g(E_\gamma, p_1, p_2) dE_\gamma$$

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



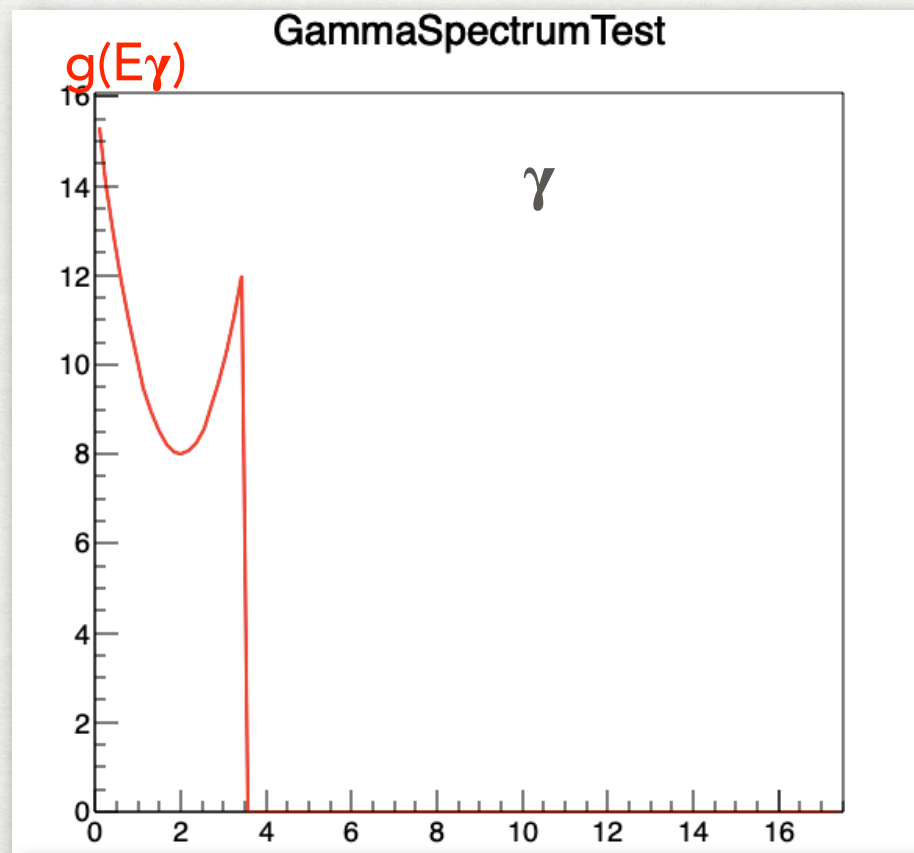
Integrated over azimuthal angle

Compton events in simulation

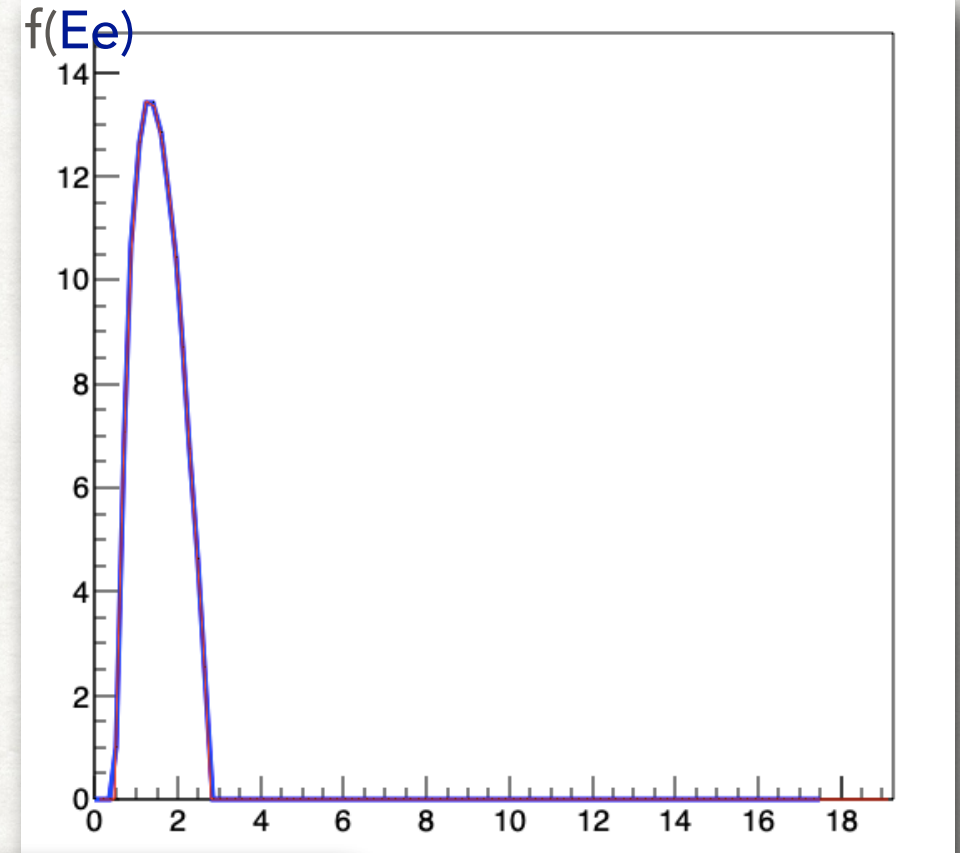
Oleksandr Borysov

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
```

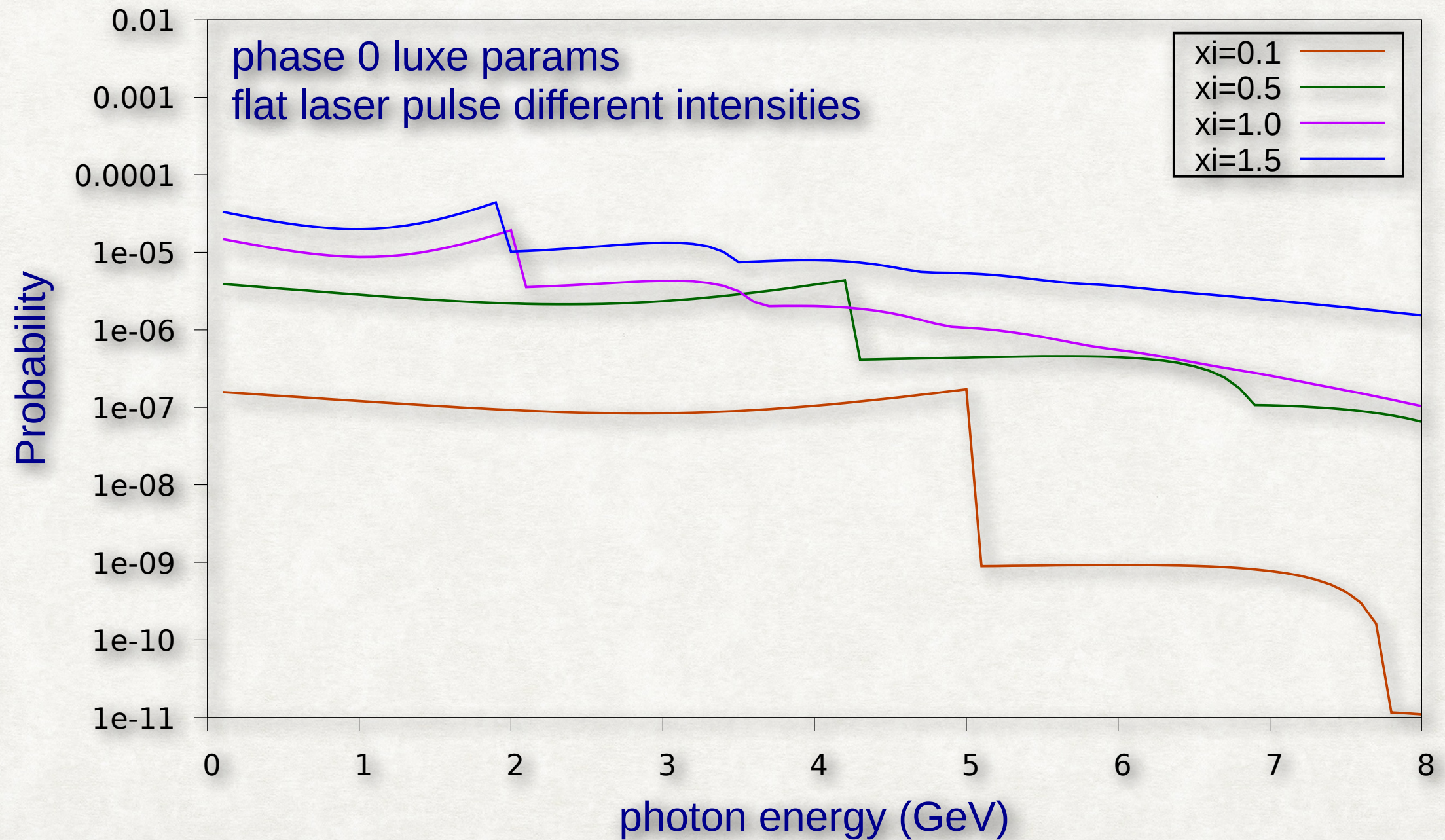
$$\int \sigma(E_\gamma, E_e) g(E_\gamma, p1, p2) dE_\gamma$$

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
```

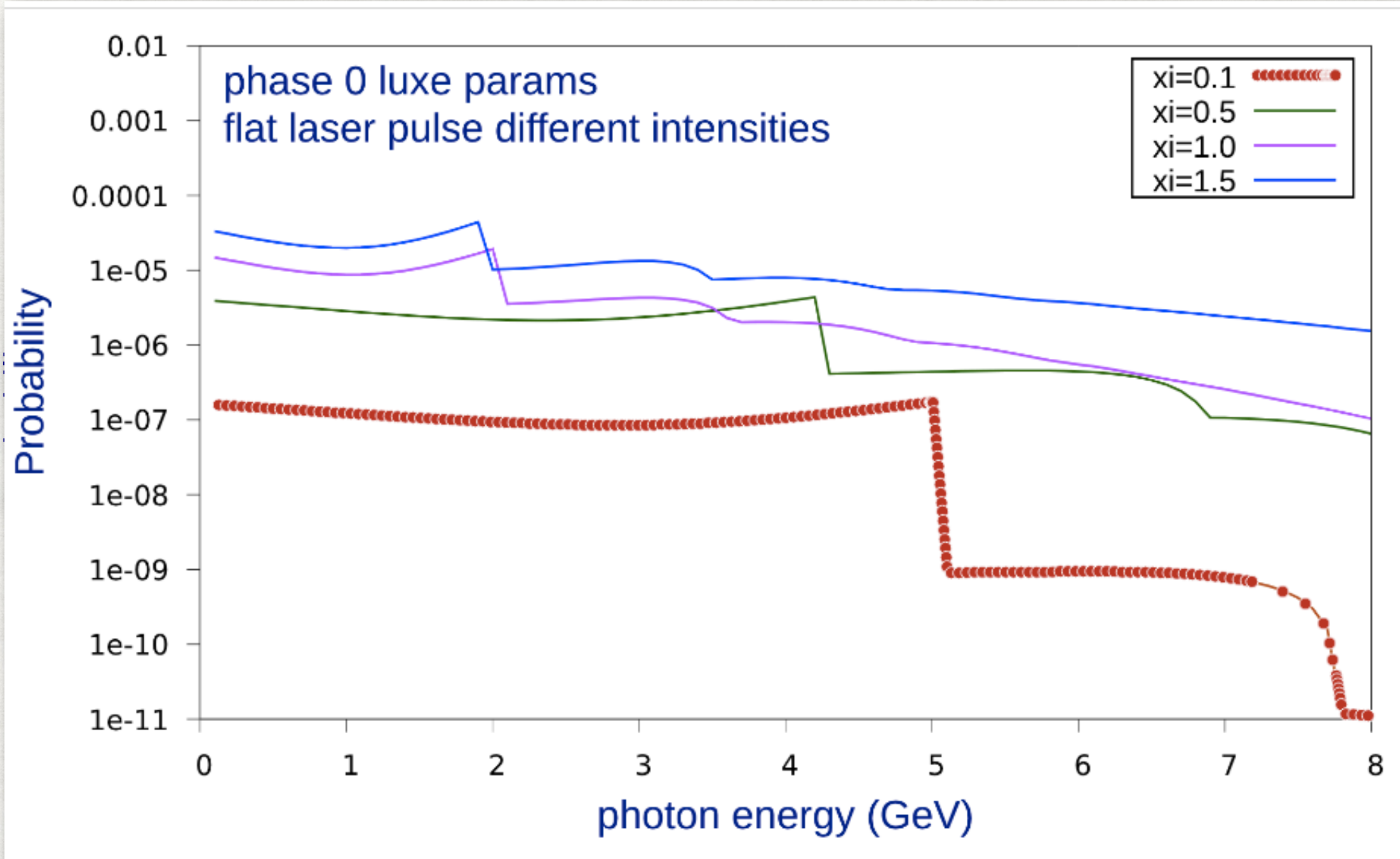

PHOTON SPECTRA VS LASER INTENSITIES

• plot from Tony



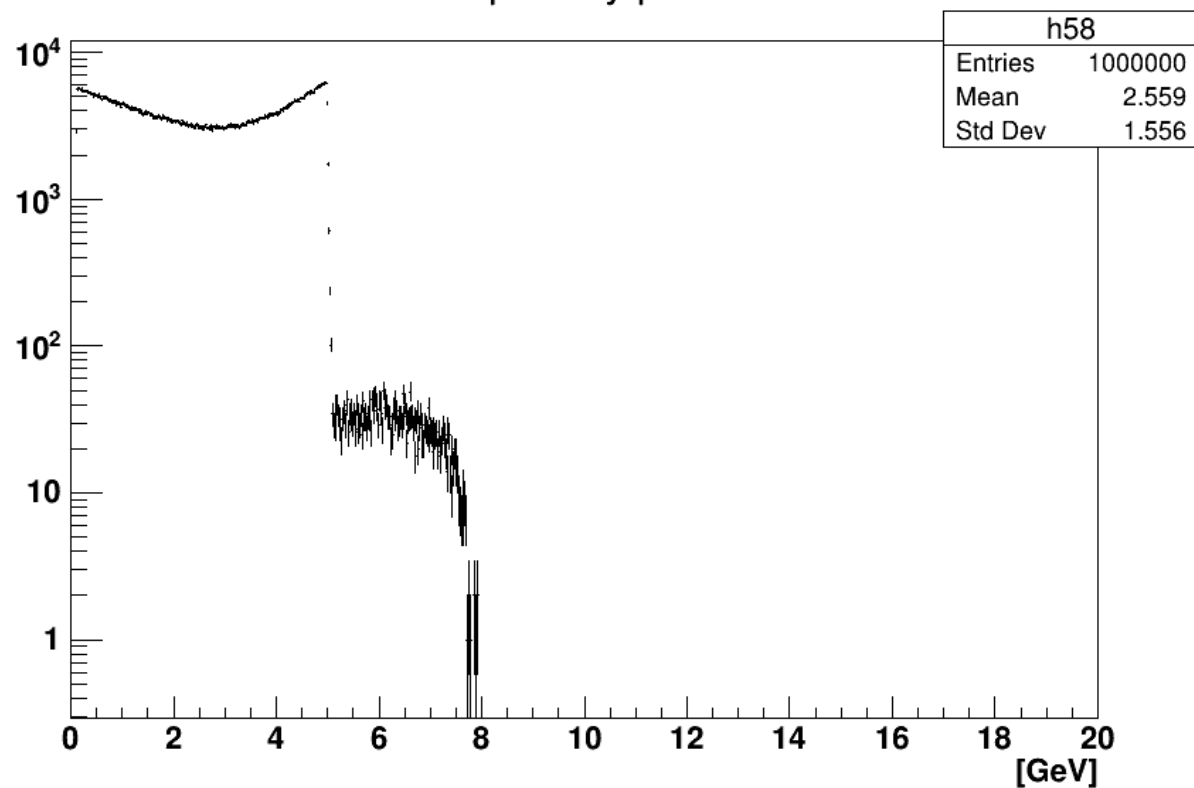
PHOTON SPECTRA VS LASER INTENSITIES

- plot from Tony



FORWARD PHOTONS IN GEANT4

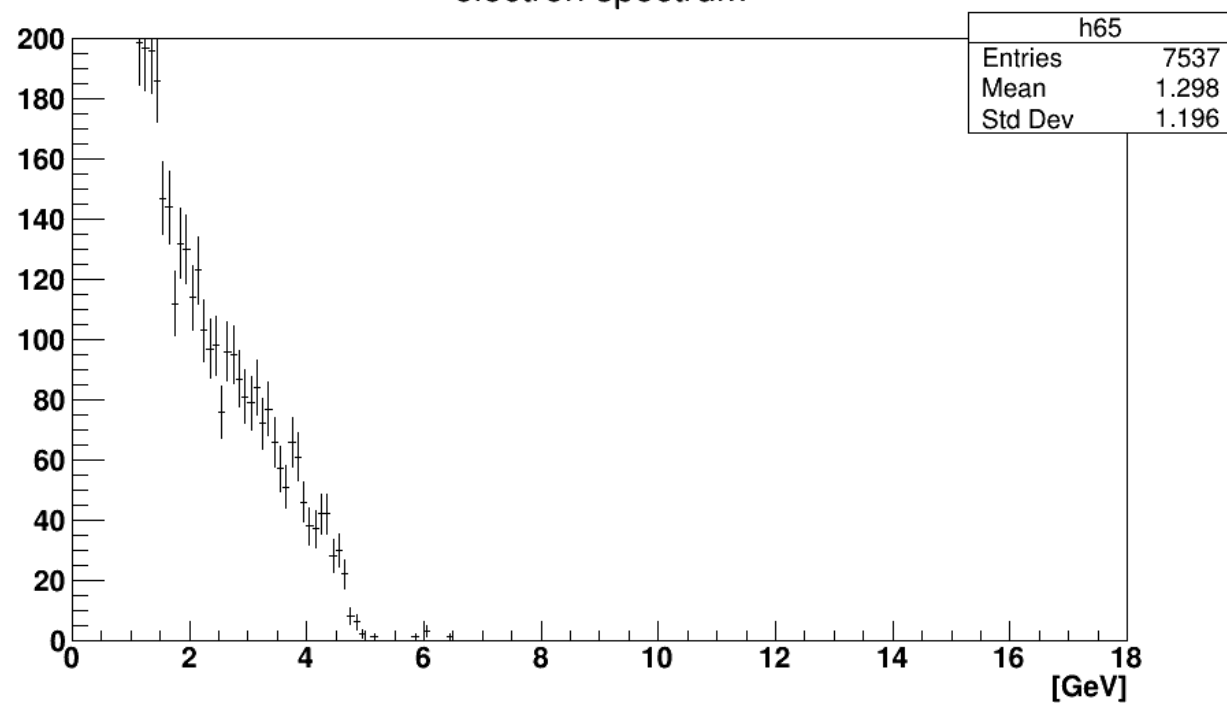
PZ of primary particles



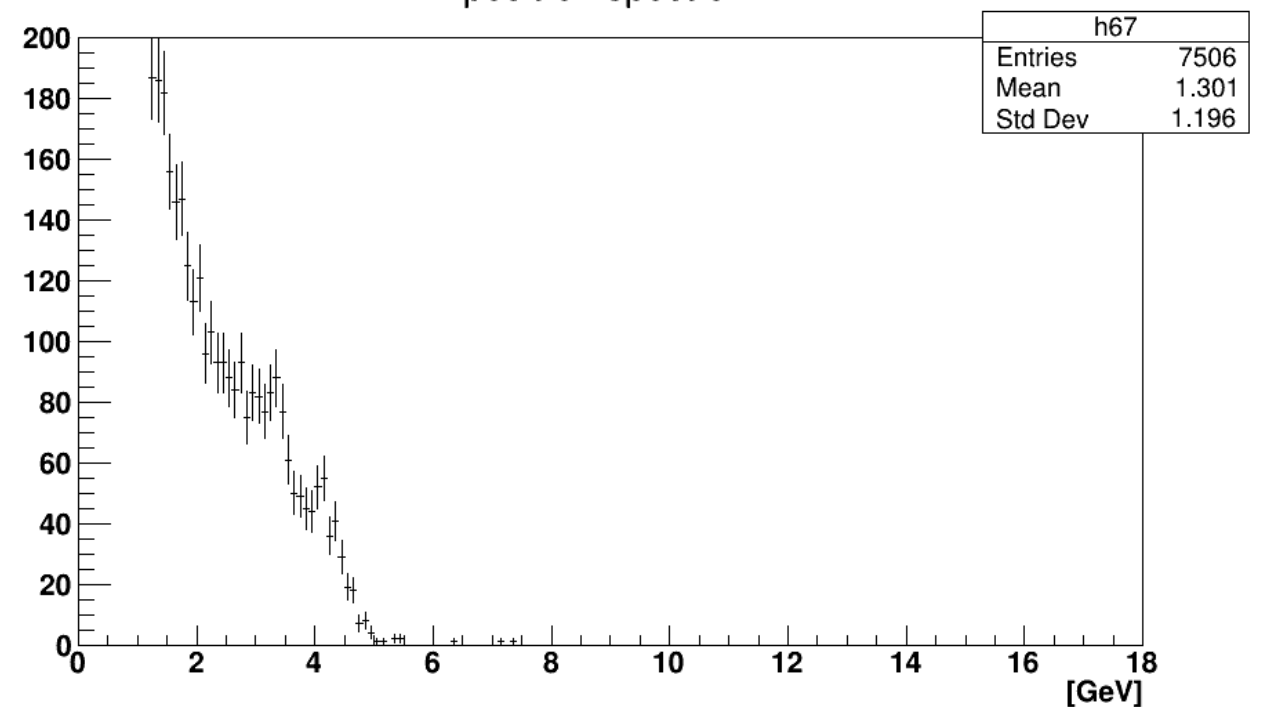
Code from Sasha

target: Tungsten, 0.35 um
1e6 photons

electron spectrum



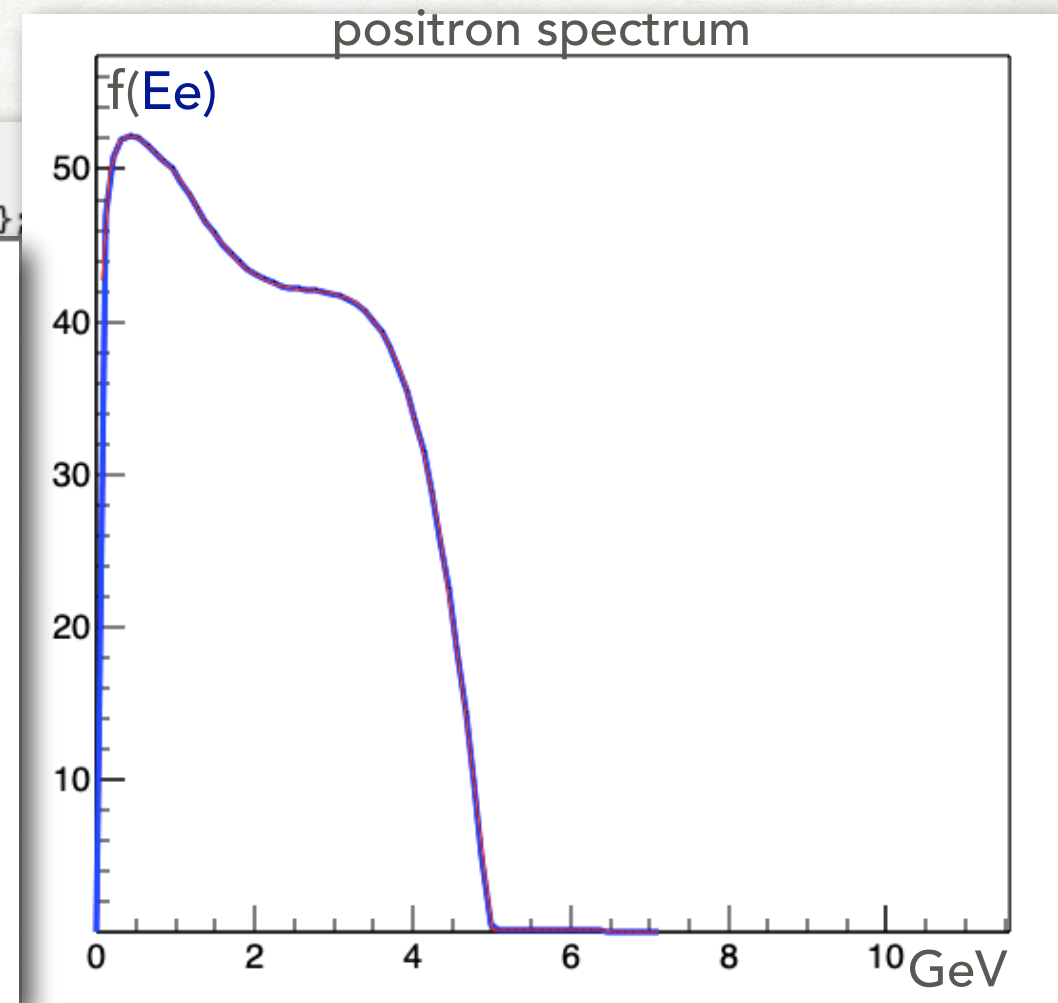
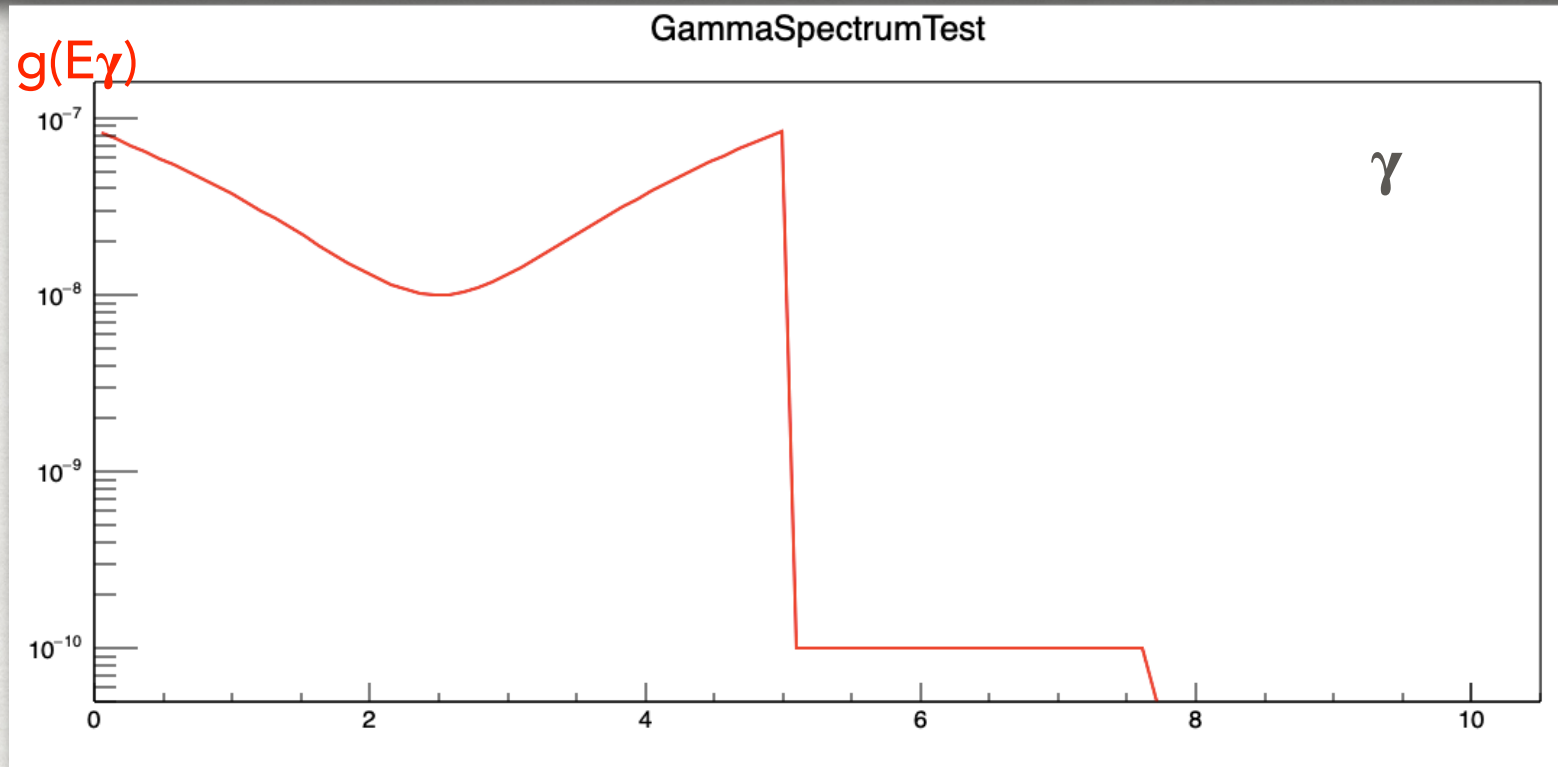
positron spectrum



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 = 5; double gtestprm[ngeparams] = {1.2e-8, 2.5, 1e-8, 0.0, 1e-10};
```



$$\int \sigma(E_\gamma, E_e) g(E_\gamma, p_1, p_2) dE_\gamma$$

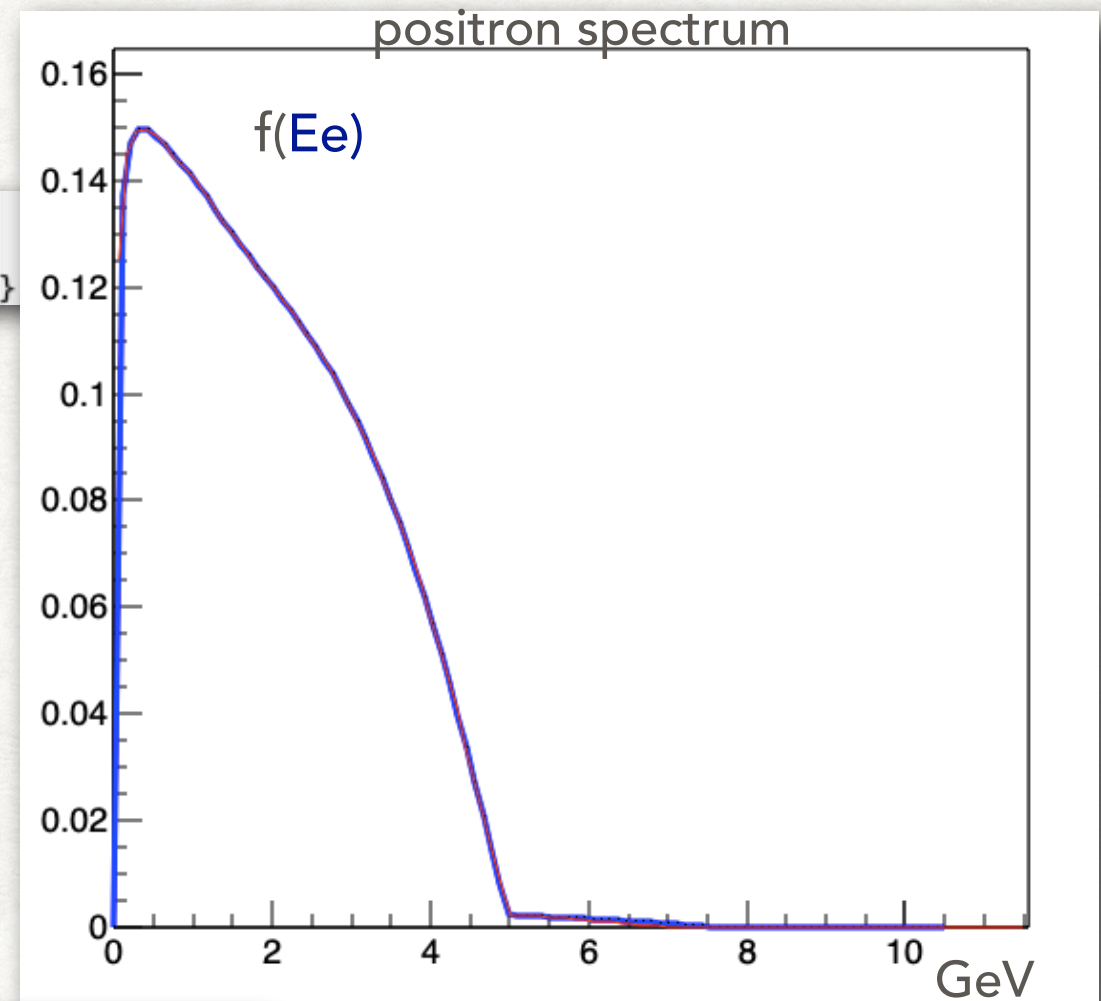
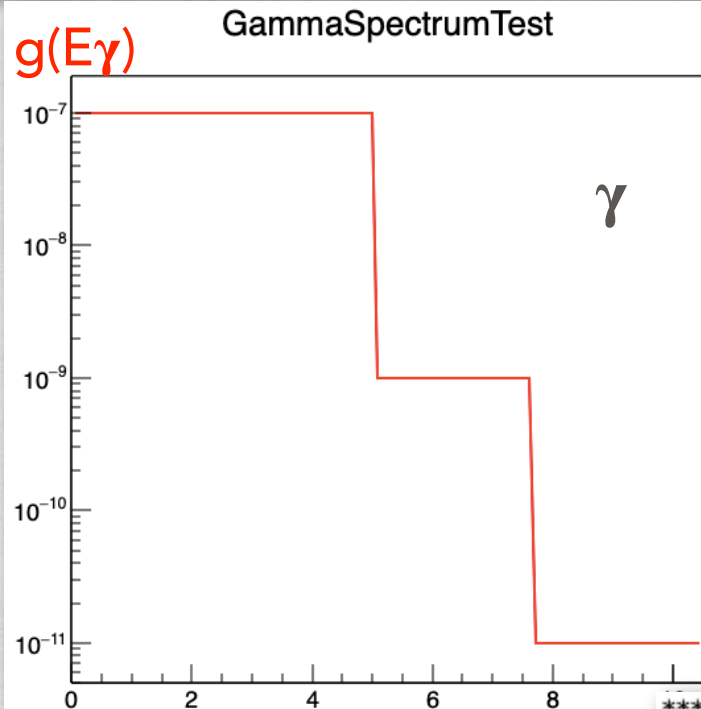
fitting allows finding the parameters quite well :

```
*****
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

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

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

$\int \sigma(E_\gamma, E_e) g(E_\gamma, p1, p2) dE_\gamma$
fitting allows finding
the parameters quite
well :