# Gamma Monitor using backscatters

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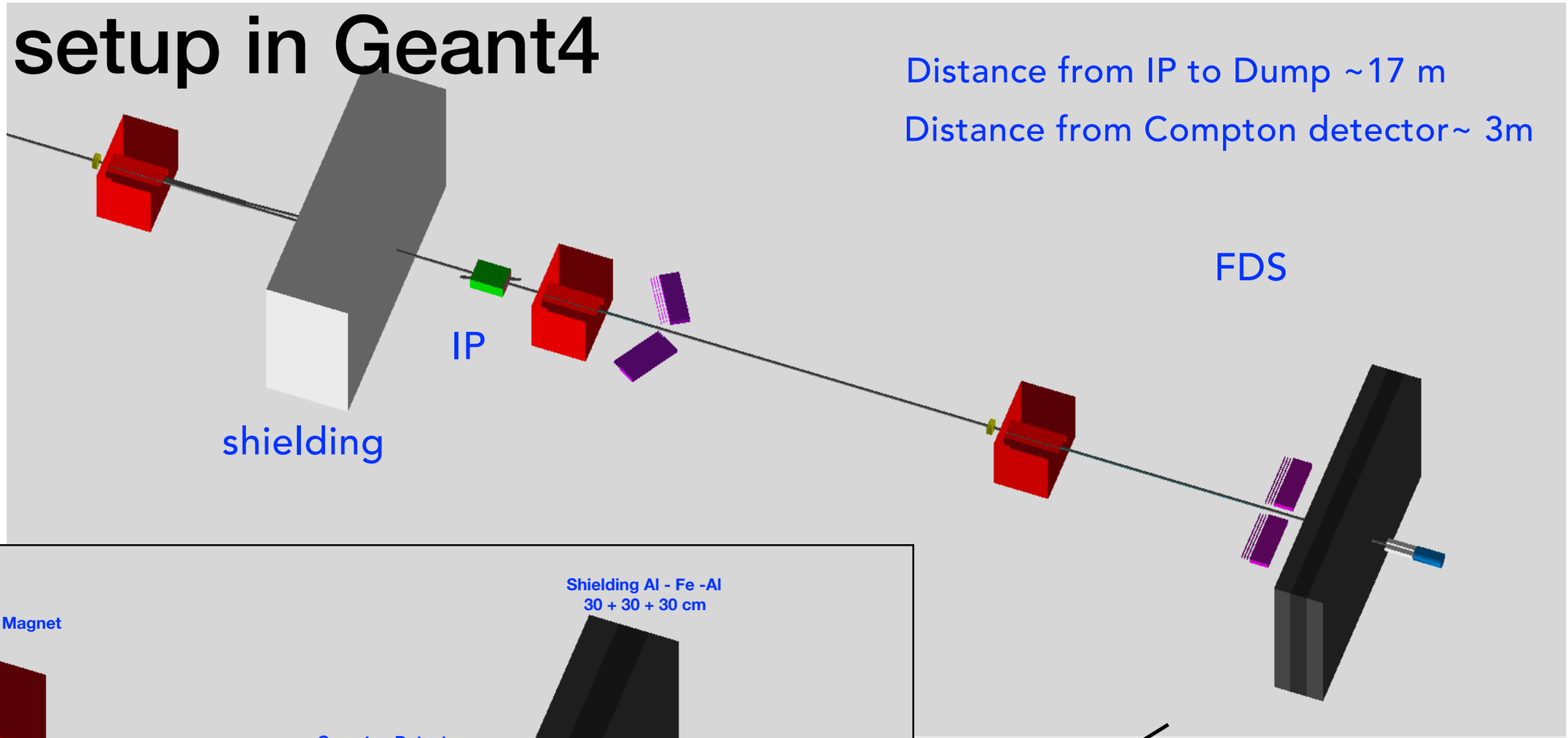
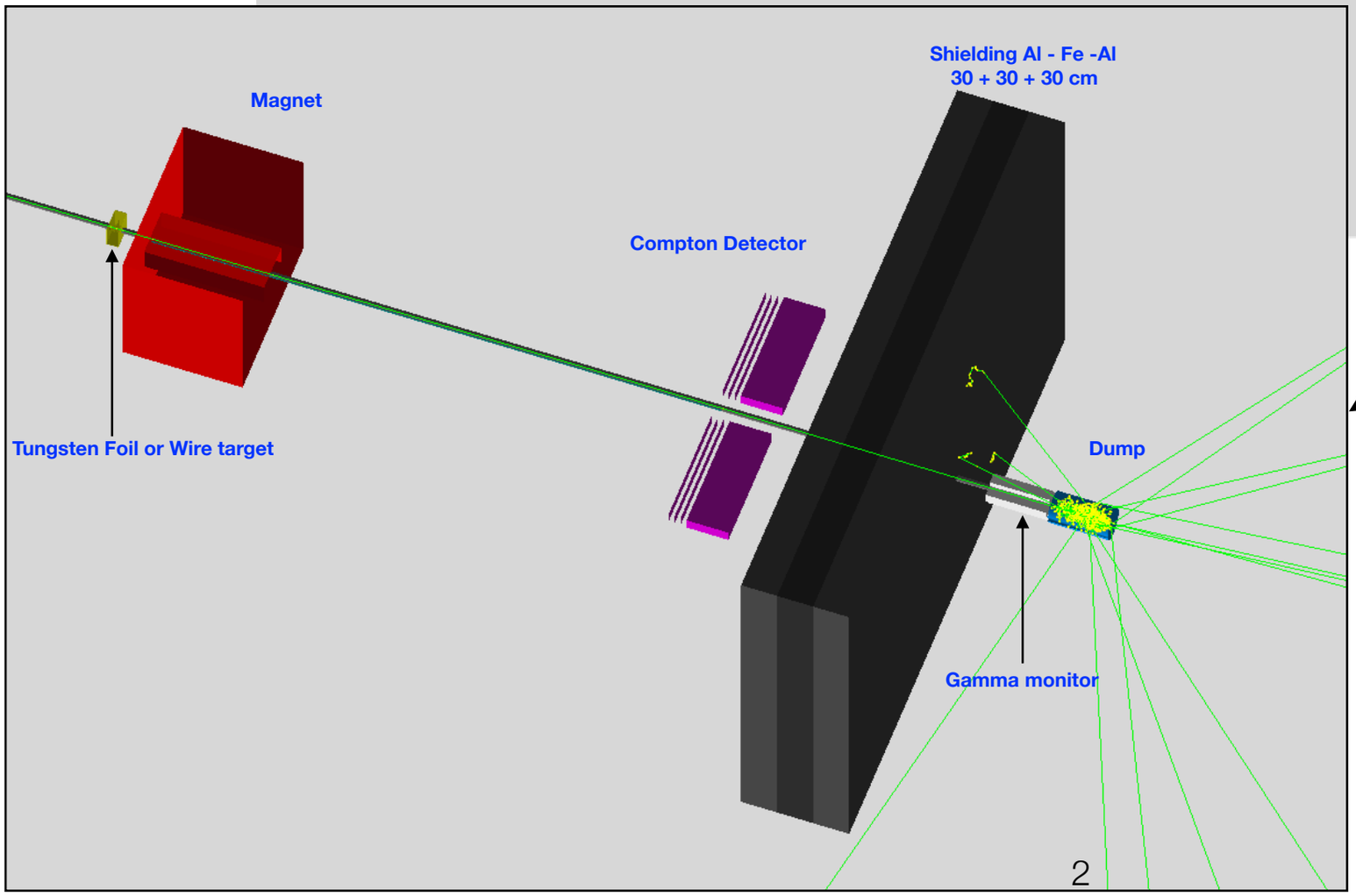
30/01/20

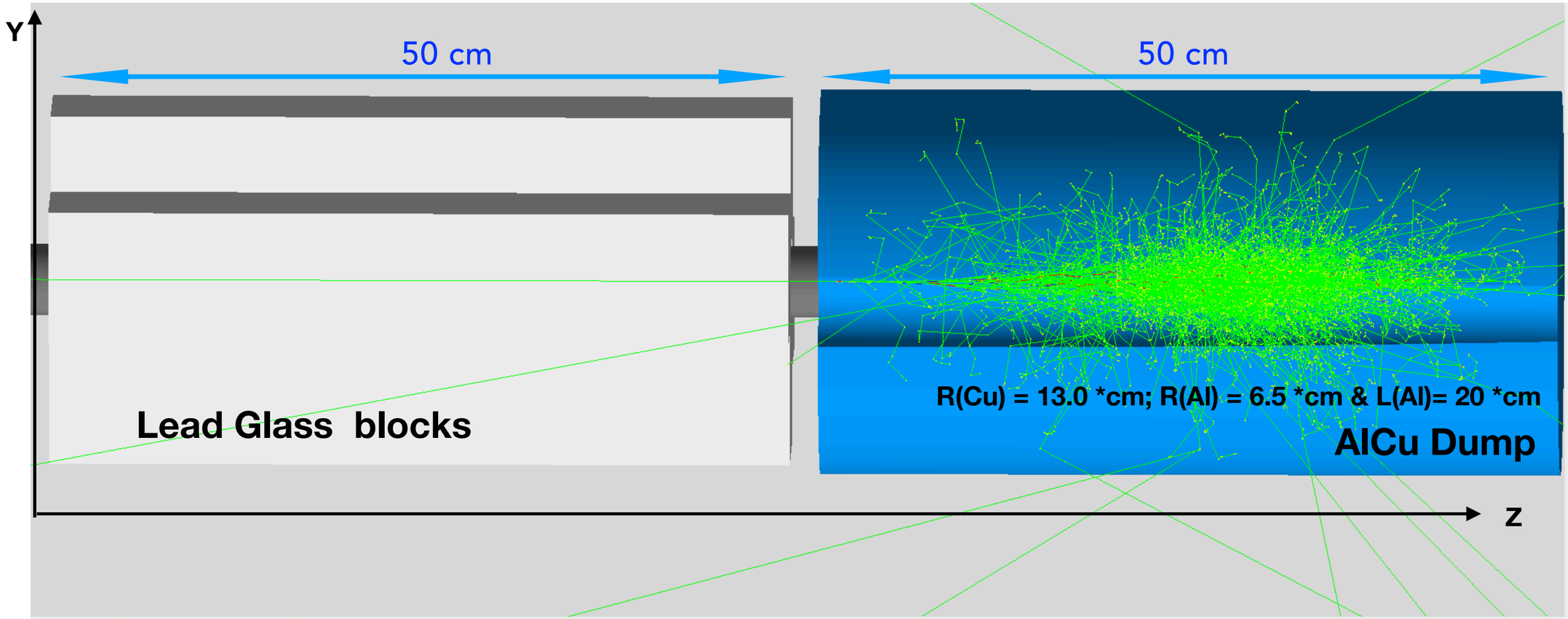
LUXE technical meeting

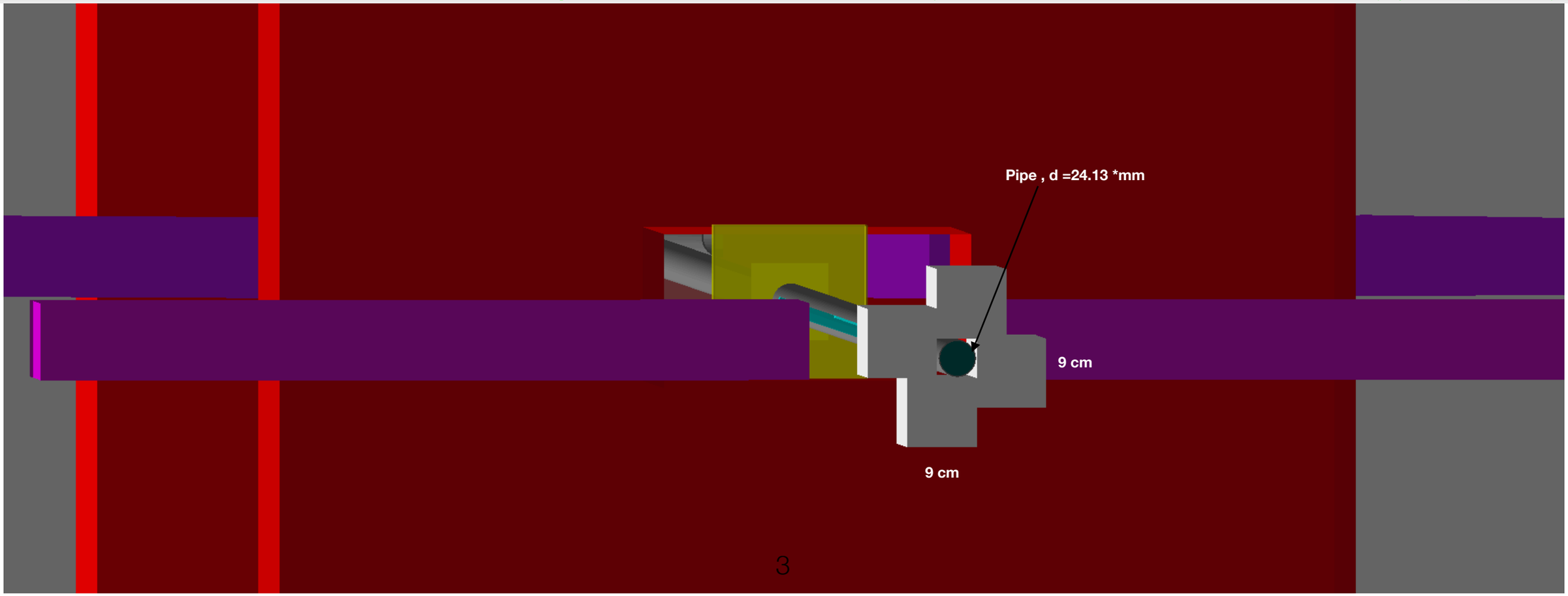
DESY Hamburg

# Gamma Monitor made of 4 Hermes LG blocks in Luxe setup in Geant4

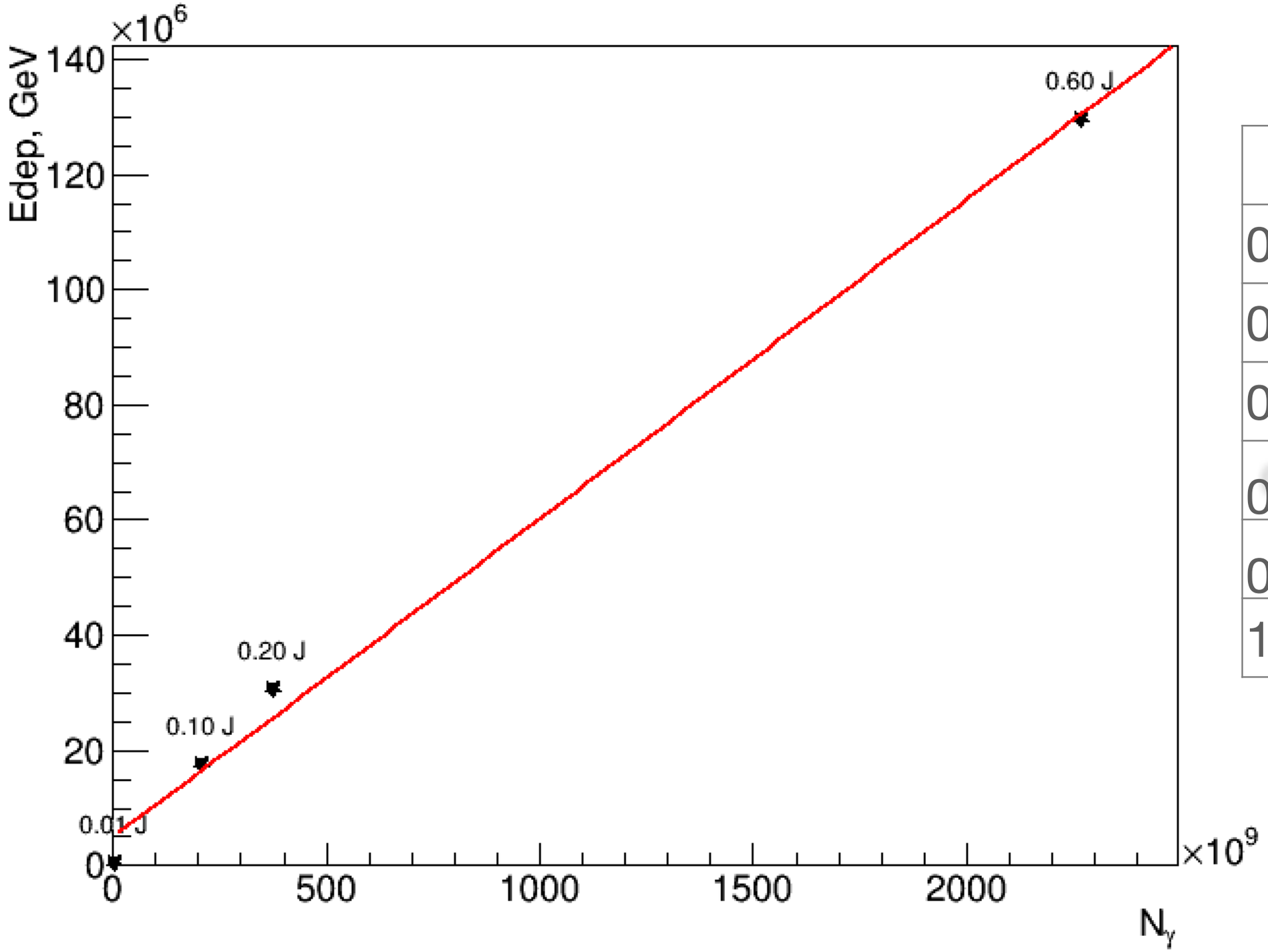



Y
50 cm
50 cm
Lead Glass blocks
R(Cu) = 13.0 *cm; R(Al) = 6.5 *cm & L(Al)= 20 *cm
AlCu Dump
Z


Pipe , d =24.13 *mm
9 cm
9 cm

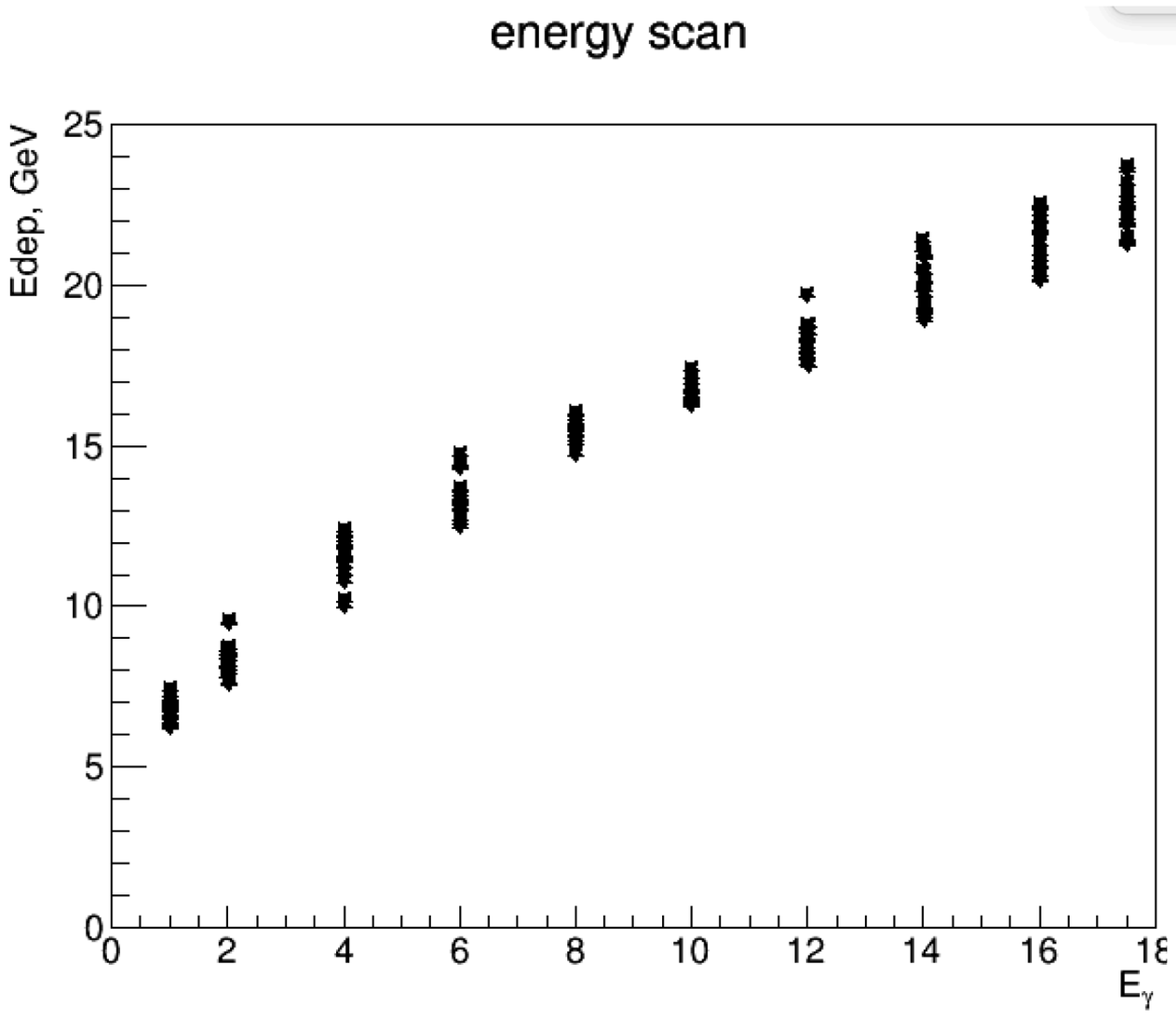
# The deposited energy of 100 BX for different laser intensities

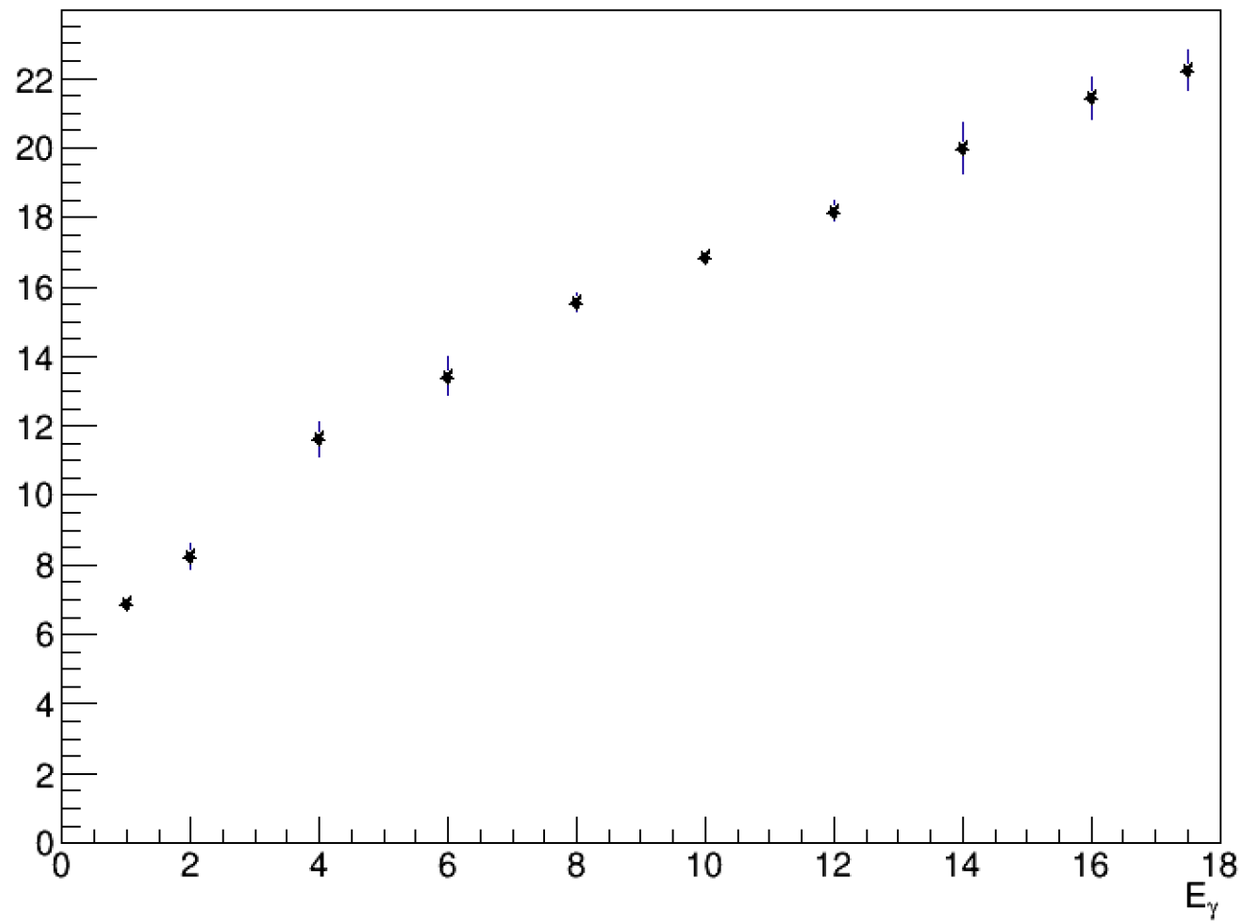



| J | ξ |
|---|---|
| 0.01 | 0.26 |
| 0.1 | 0.82 |
| 0.2 | 1.16 |
| 0.35 | 1.54 |
| 0.6 | 2.02 |
| 1.0 | 2.6 |

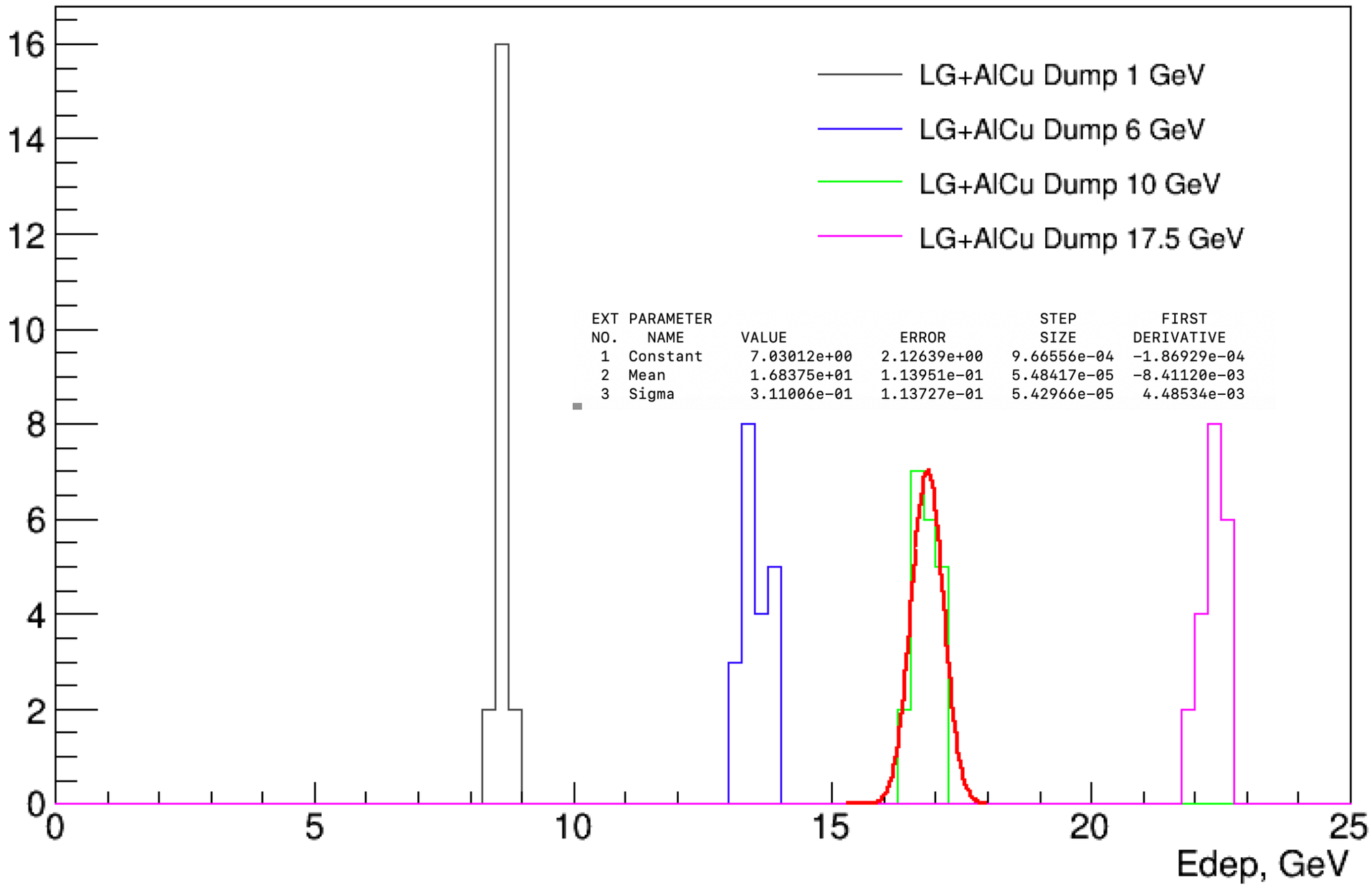
# Energy dependence of deposited energy in Gamma monitor

**20 Runs* 100000 photons with mono energies: 1,2,4,6,8,10,12,14,16 and 17.5 GeV**



# Energy deposit distributions for  1, 6, 10 and 17.5 GeV



# Lead glass blocks from Hera Experiment

- **New TF-1 LG blocks! Not irradiated, w/ measures 3.8 × 3.8 cm², length is 45 cm , ~50**
- **Will give the possibility to determine precisely coordinates and energies**
  - **Found in Hera West thanks to Sergey Schuwalow**
- **There is a preliminary agreement to move it to the LUXE Lab**

# Chemical Composition of TF-1 LG

Table 1. Chemical composition and physical properties of the TF-1[10].

| Chemical composition (weight %) | | Fractions atomic units |
|---|---|---|
| PbO | 51.2 | Pb-0.082232 |
| $SiO_2$ | 41.3 | Si-0.246406 |
| $K_2O$ | 3.5 | 0-0.608358 |
| $Na_2O$ | 3.5 | K-0.038057 |
| $As_2O_3$ | 0.5 | NA-0.023135 |
| Radiation length (cm) | 2.50 | AS-0.001812 |
| Density ($g/cm^3$) | 3.86 | |
| Critical energy (MeV) | 15.57 | |
| Refraction index | 1.6476 | |

# Outlook

- **Gamma monitor studies:**

✳**The implementation in Luxe geometry  the LG Gamma Monitor made of Hermes LG blocks in front of Al-Cu Dump**

✳**Gamma Monitor was studied in GEANT4 w/ LG Monitor in front of Al-Cu Dump for the for mono beams with different energies**

✳**There is a slight dependence of  deposited energy on incident energies.**

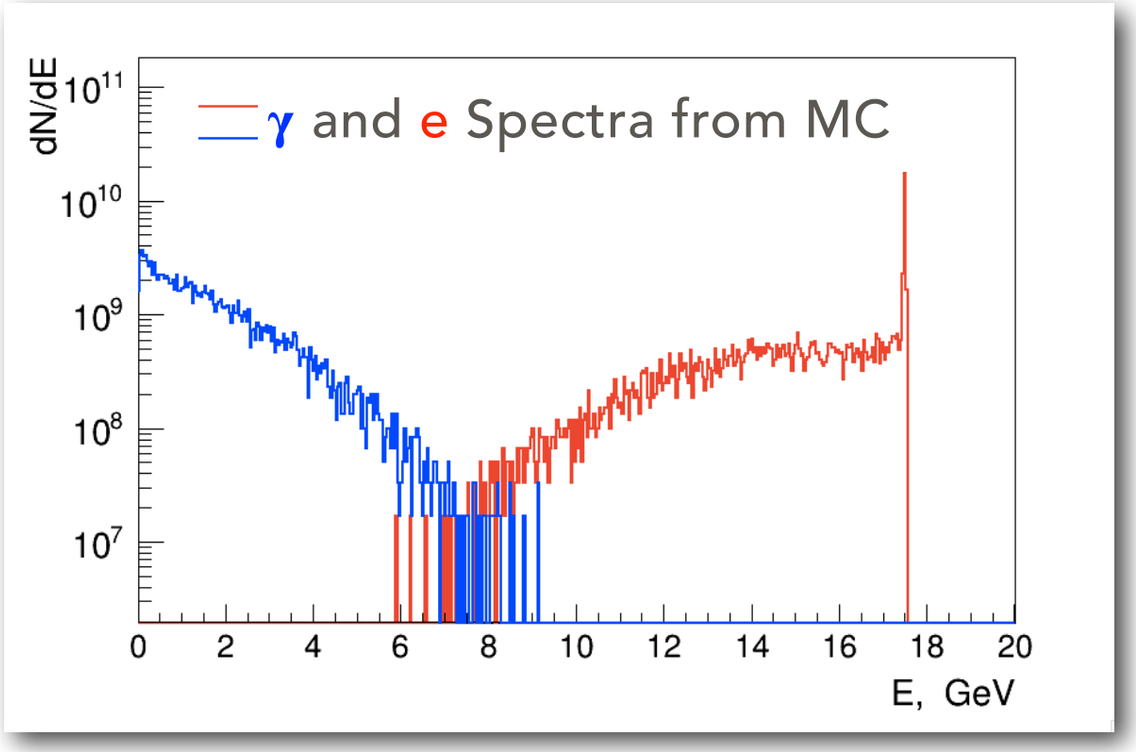
✳**New, irradiated LG block are found and could be wrapped and used for GM.**

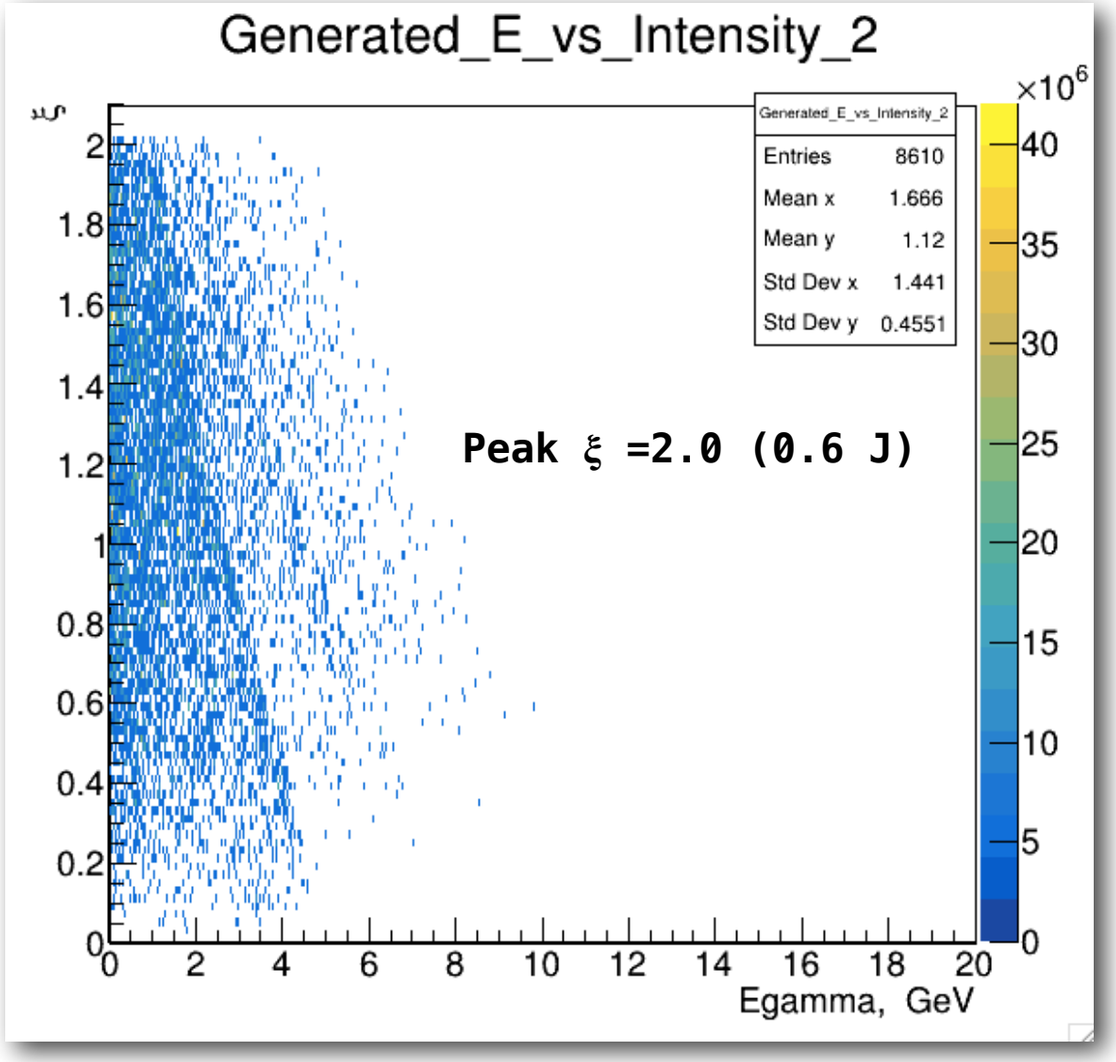
**Further studies:**

**To implement the simulation of the electromagnetic shower and the resulting Cherenkov photon production**

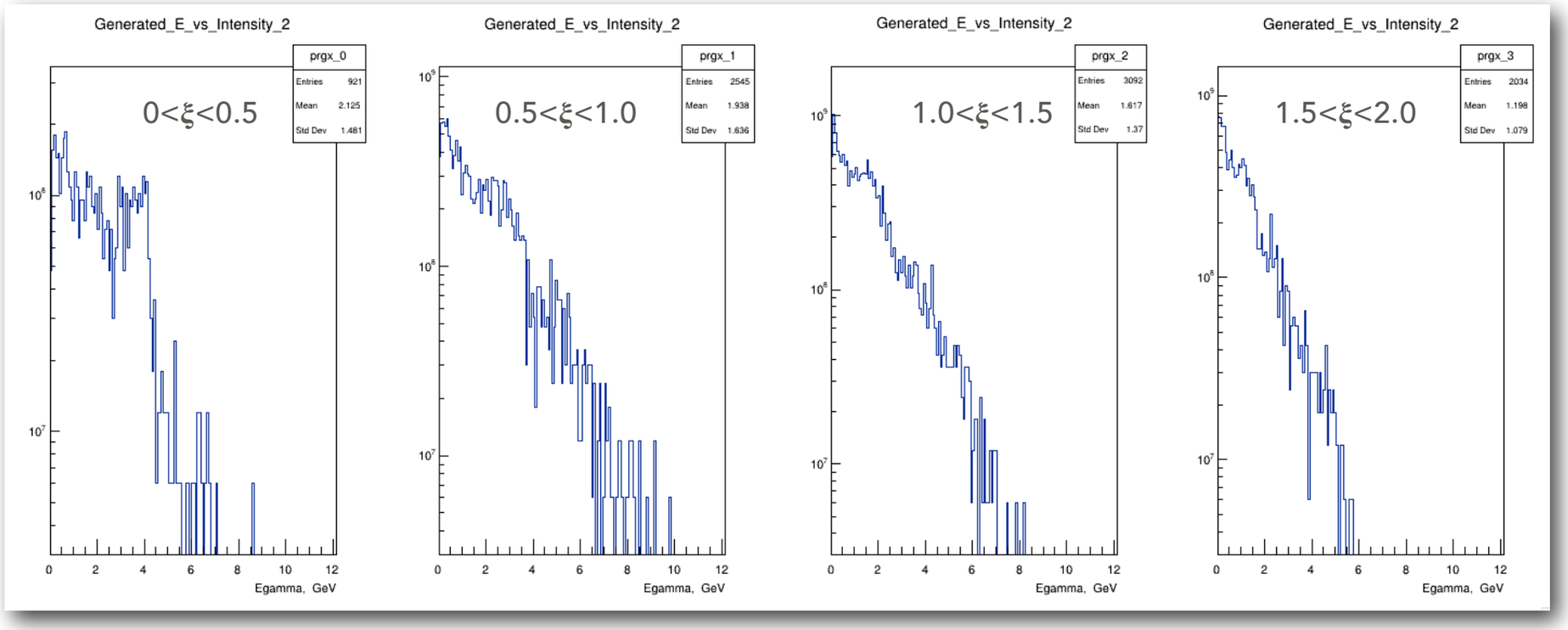
# Back up

# ξ vs Eγ FROM MC



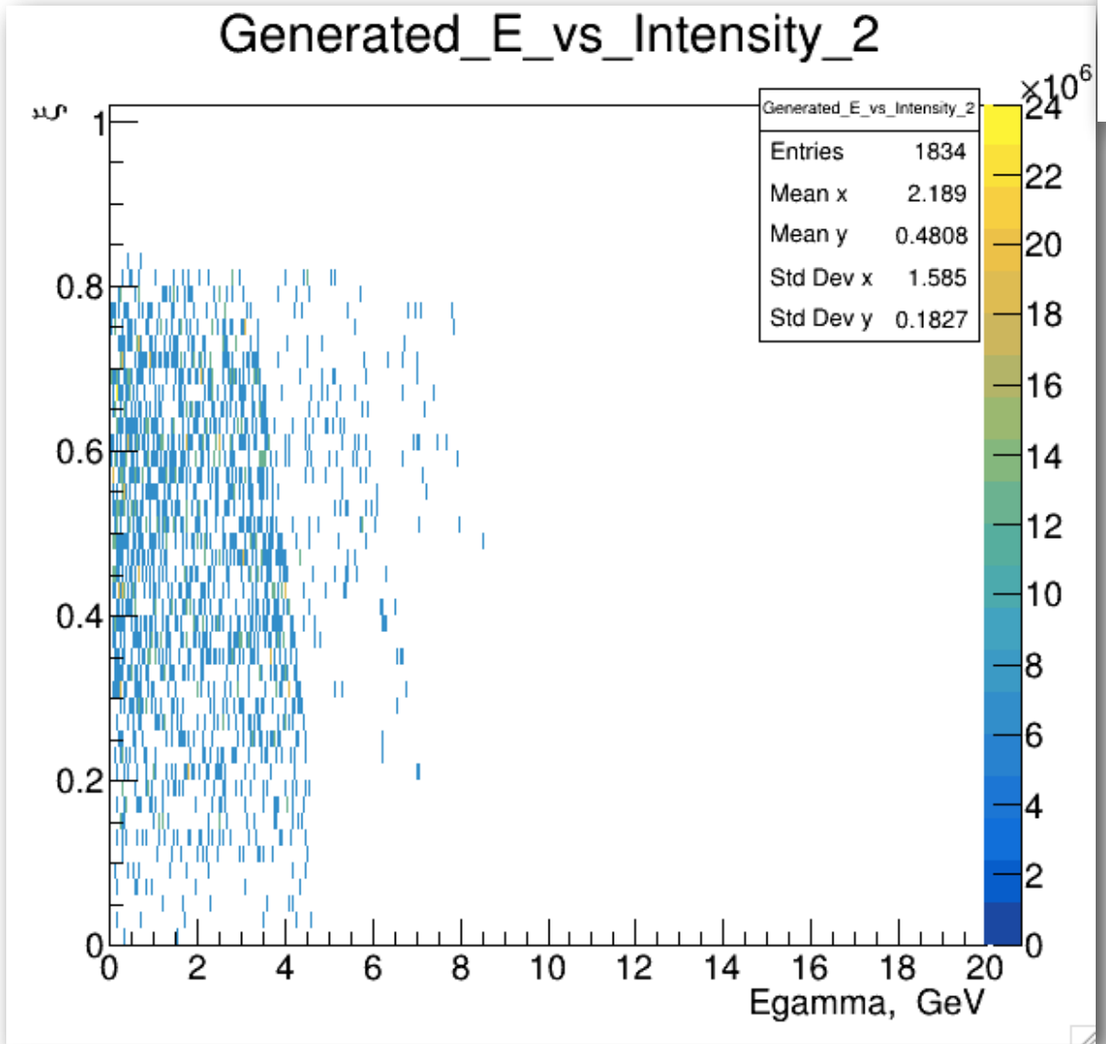

- Laser Intensity (ξ) is not uniform
- This makes the kinematic edges from different *n* not visible
- ξ distribution might be reconstructed by fitting measured spectra w/ convolution of HICS xsection & ξ trial distribution

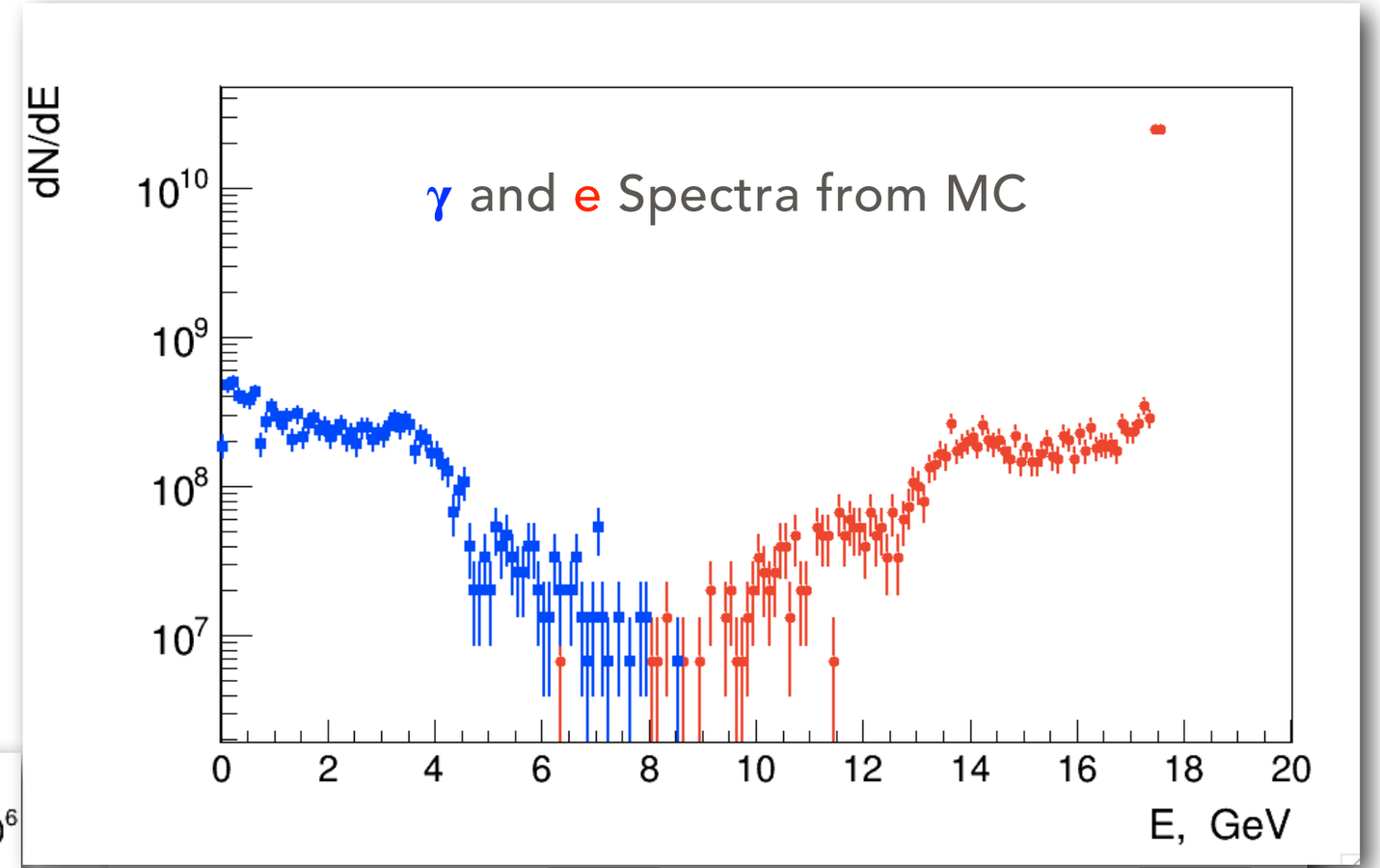


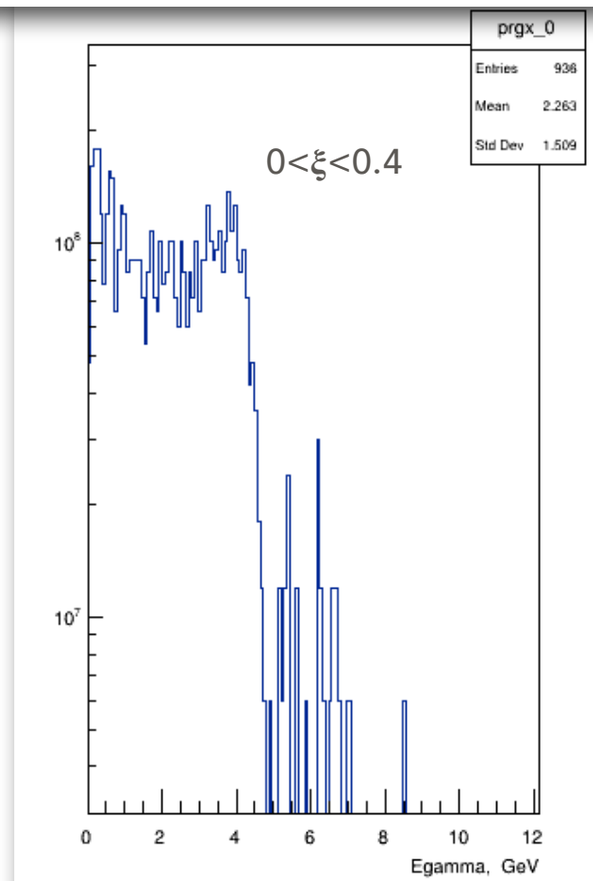
# ξ vs Eγ FROM MC

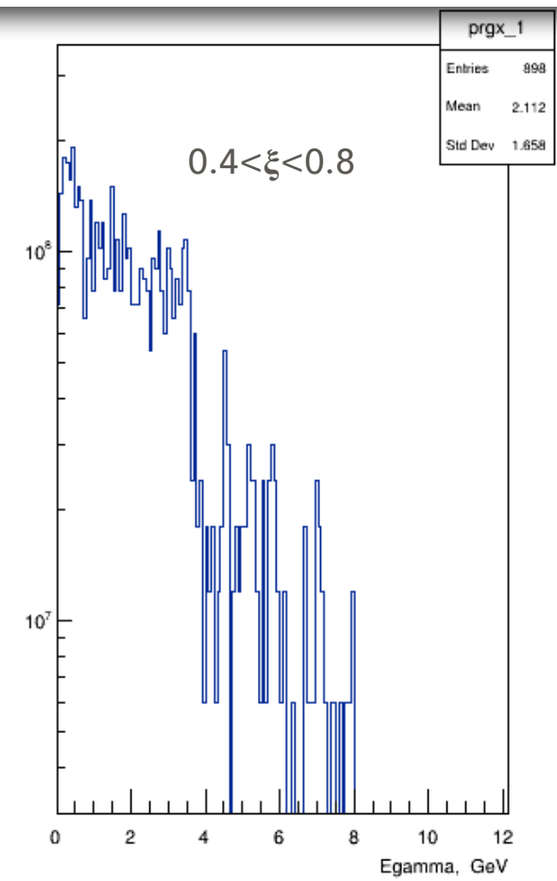
**Peak ξ = 0.8 (0.1J)**

The kinematic edges can be seen at the low intensity.

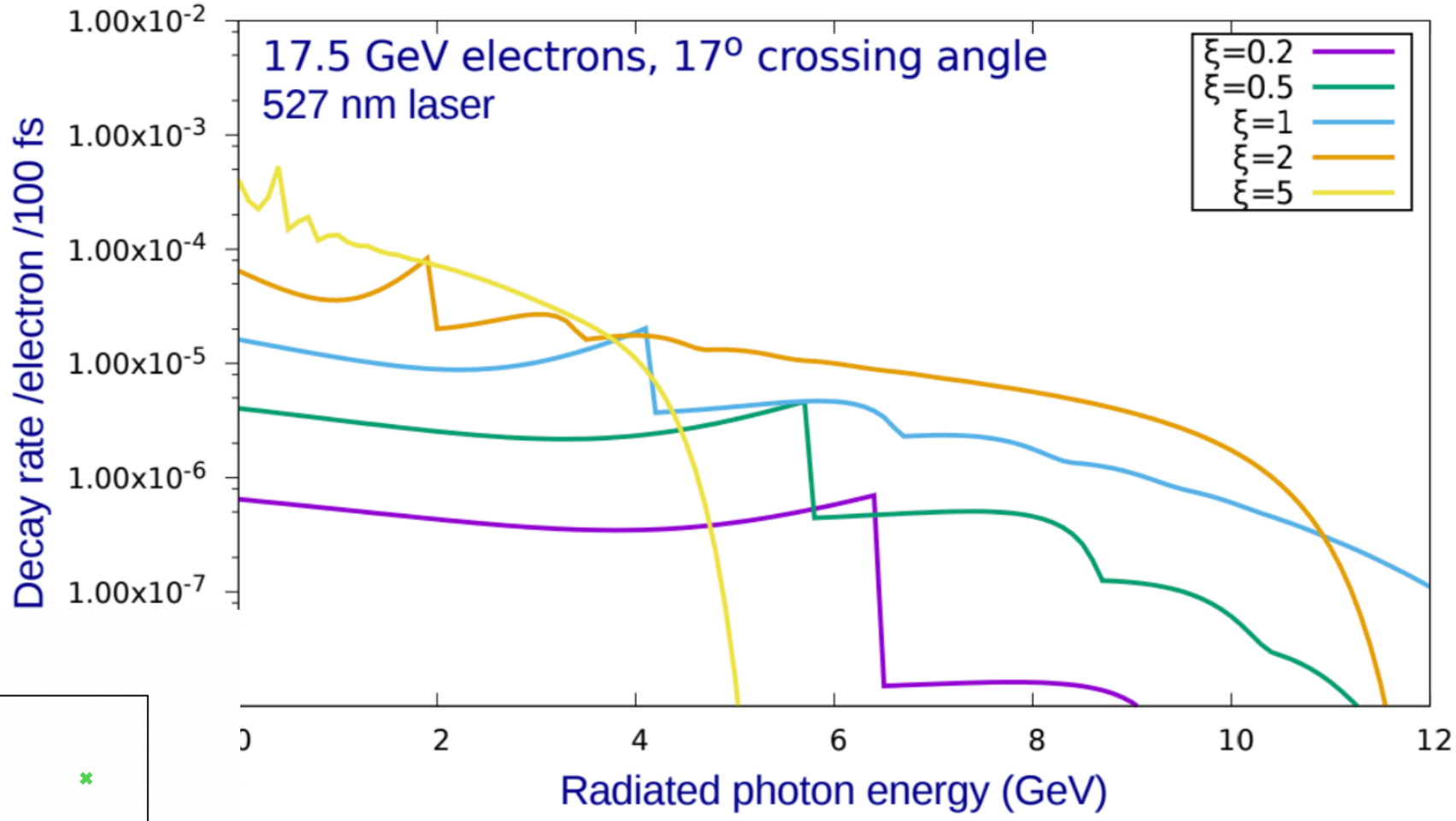


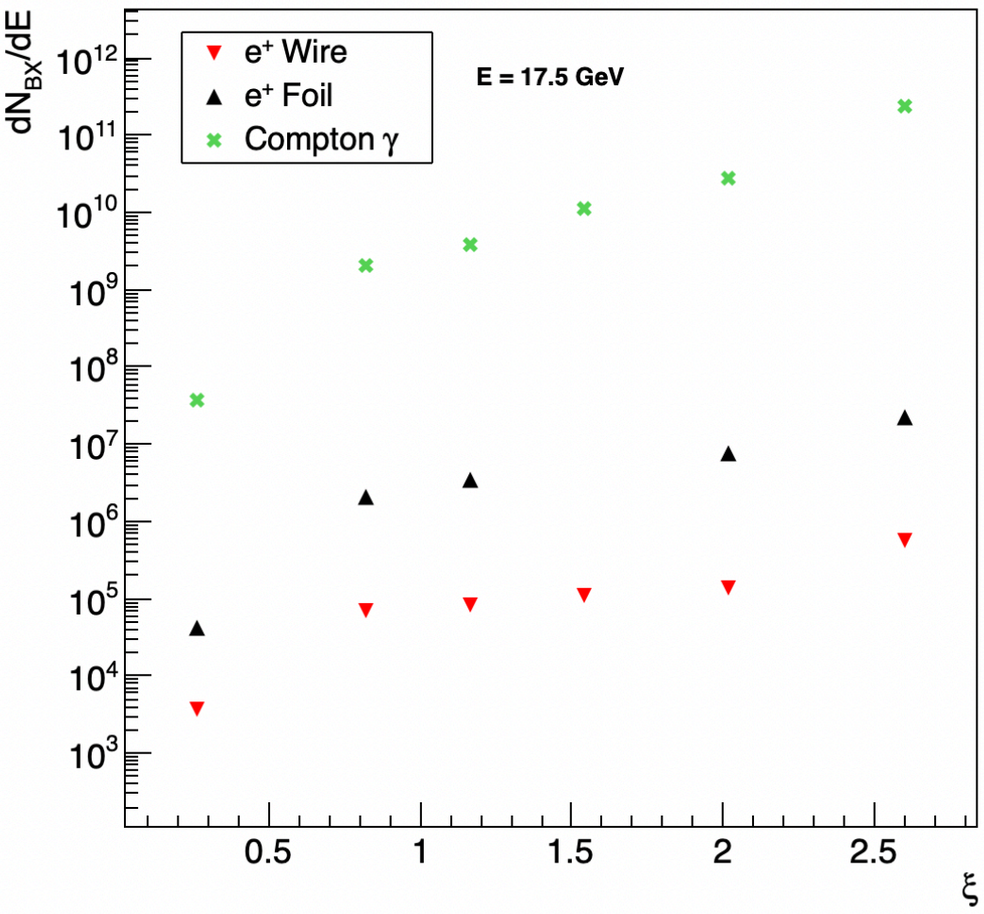



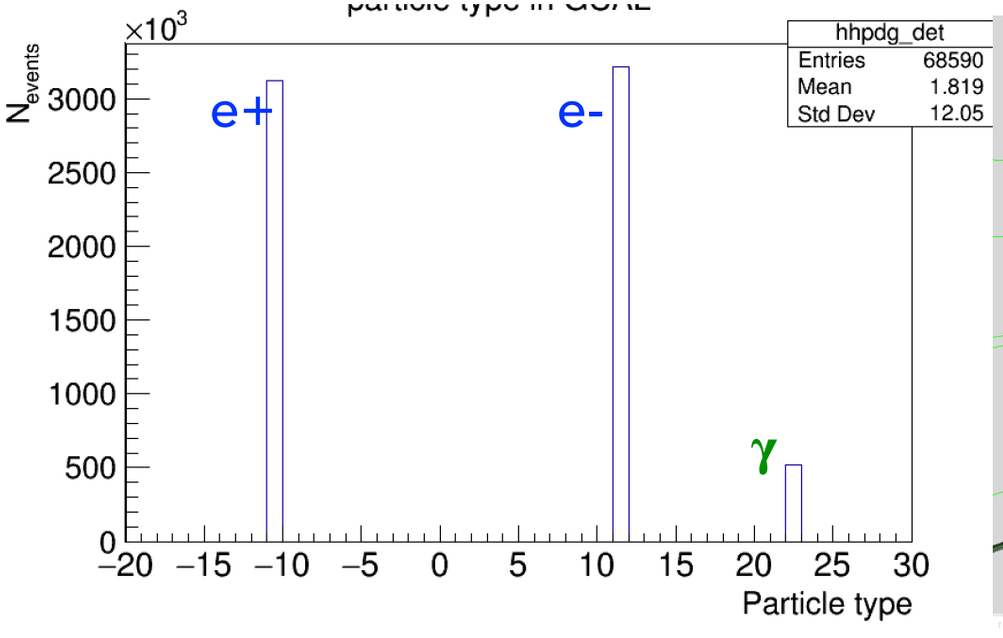



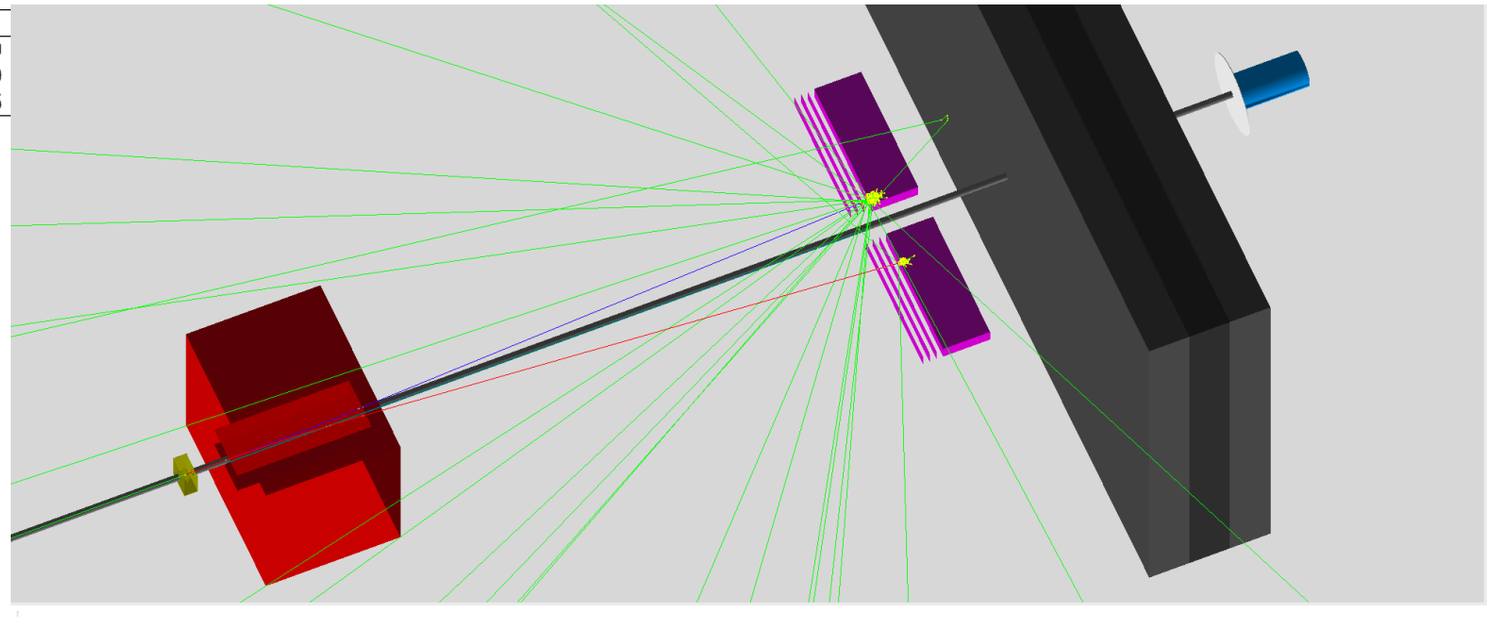
# HICS for 17 GeV electrons, intensity sweep

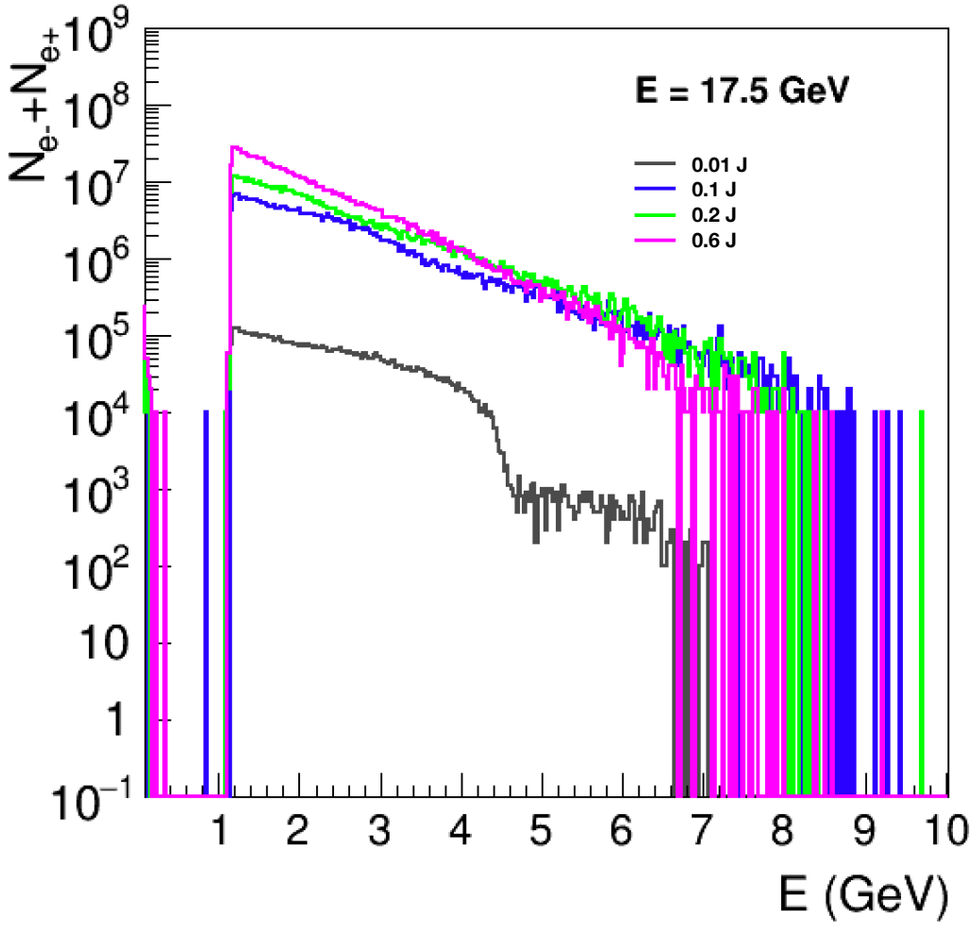


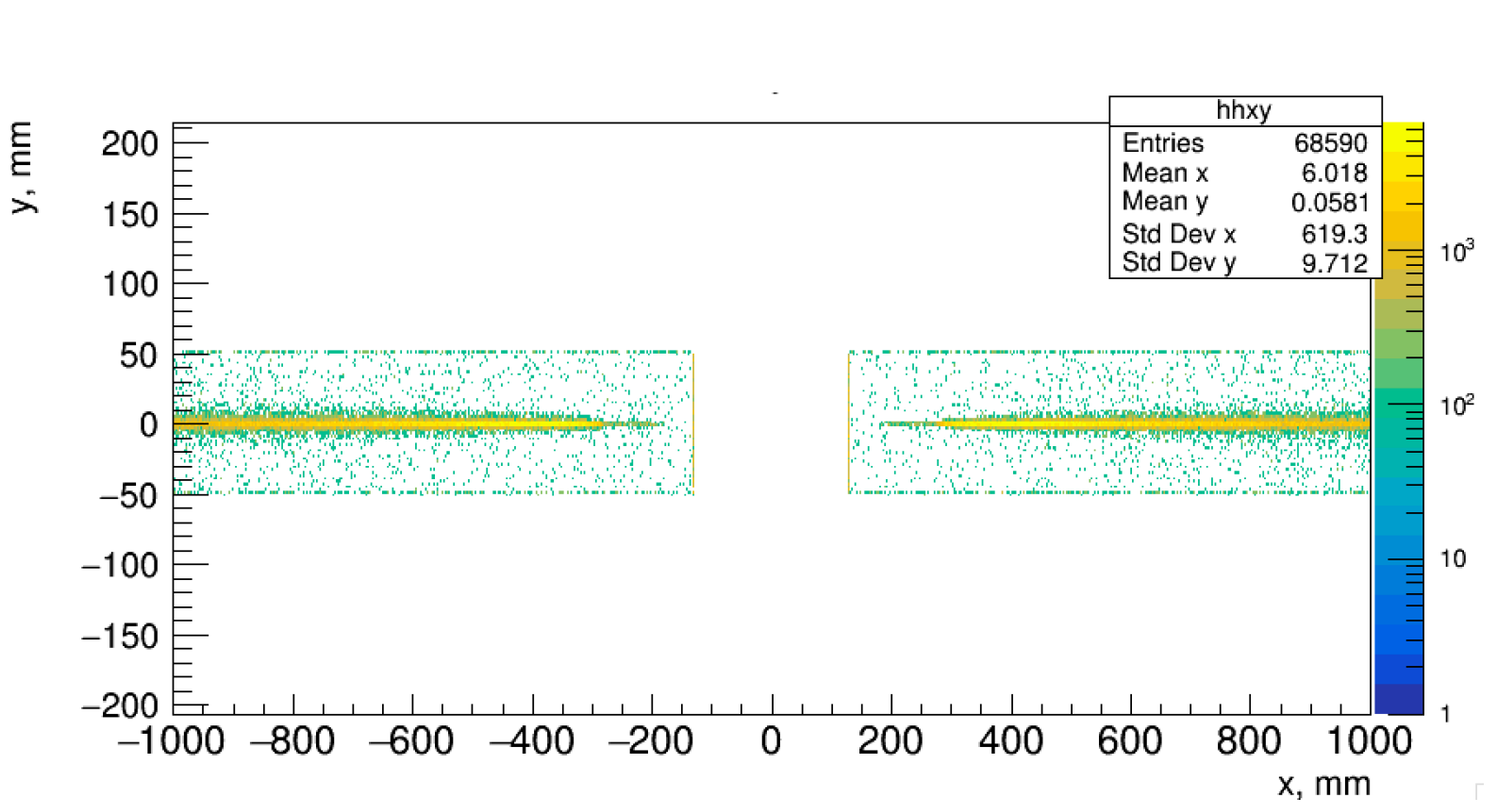



# Compton detector



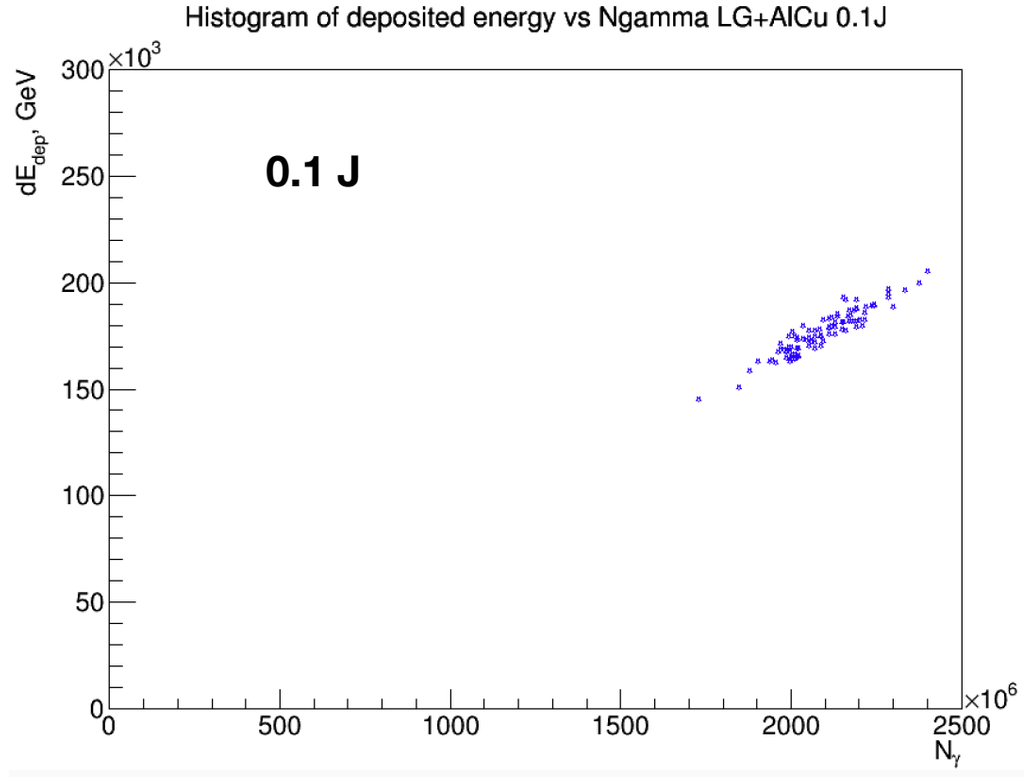



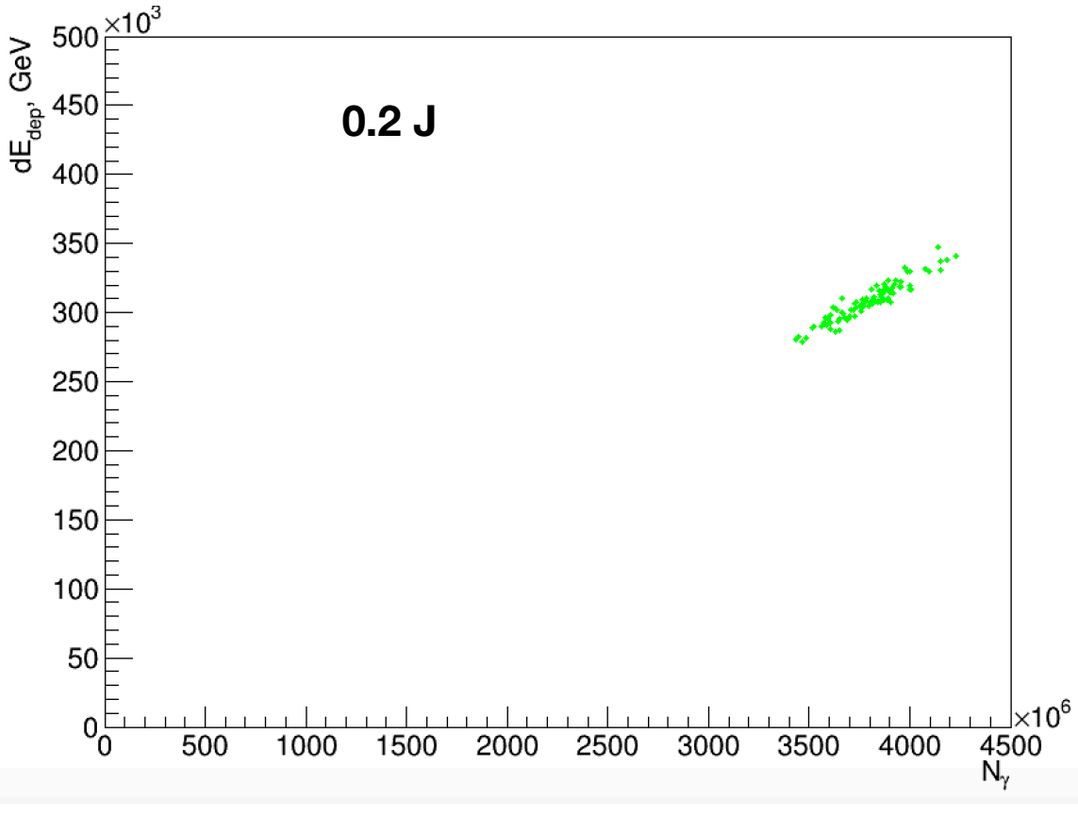


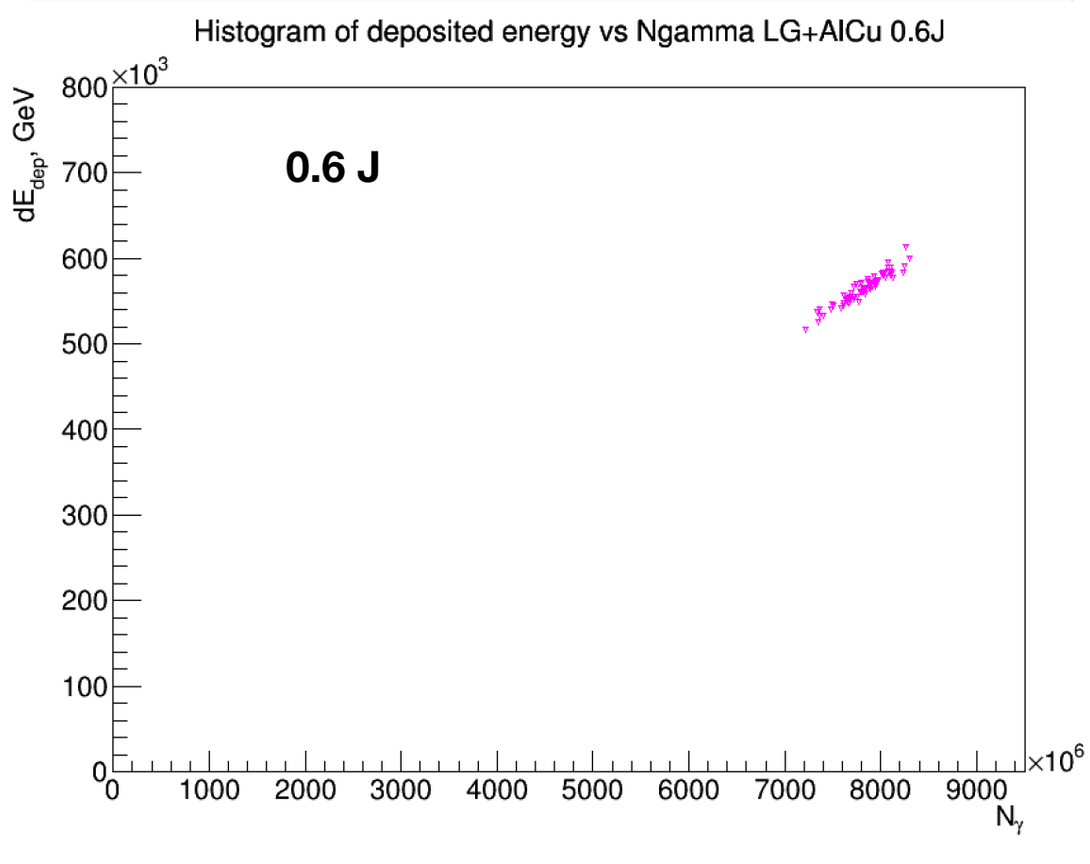



# The dependence of deposited energy on number of incoming photons per BX for LG Gamma monitor and AlCu dump



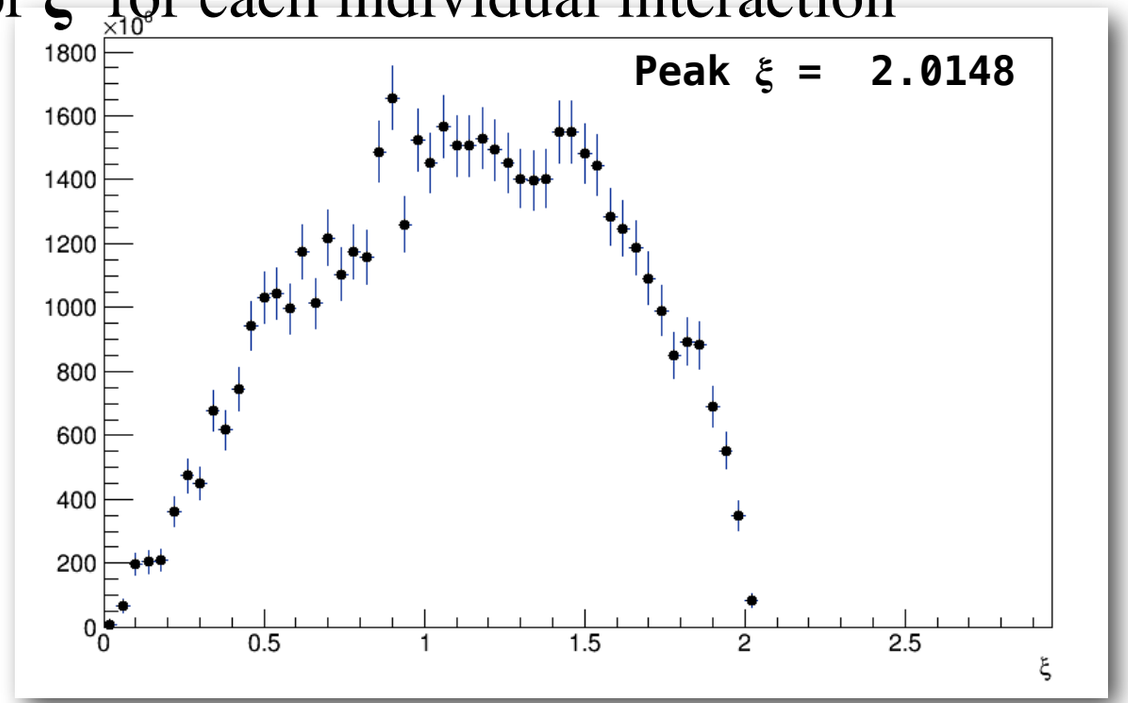



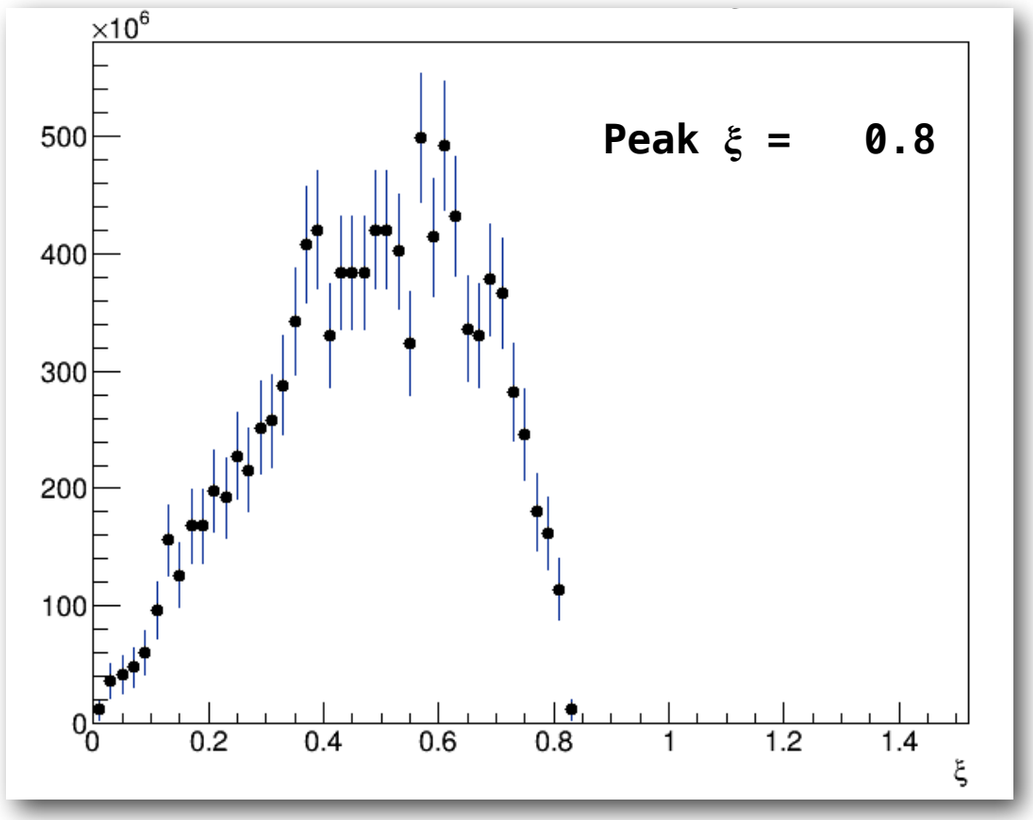



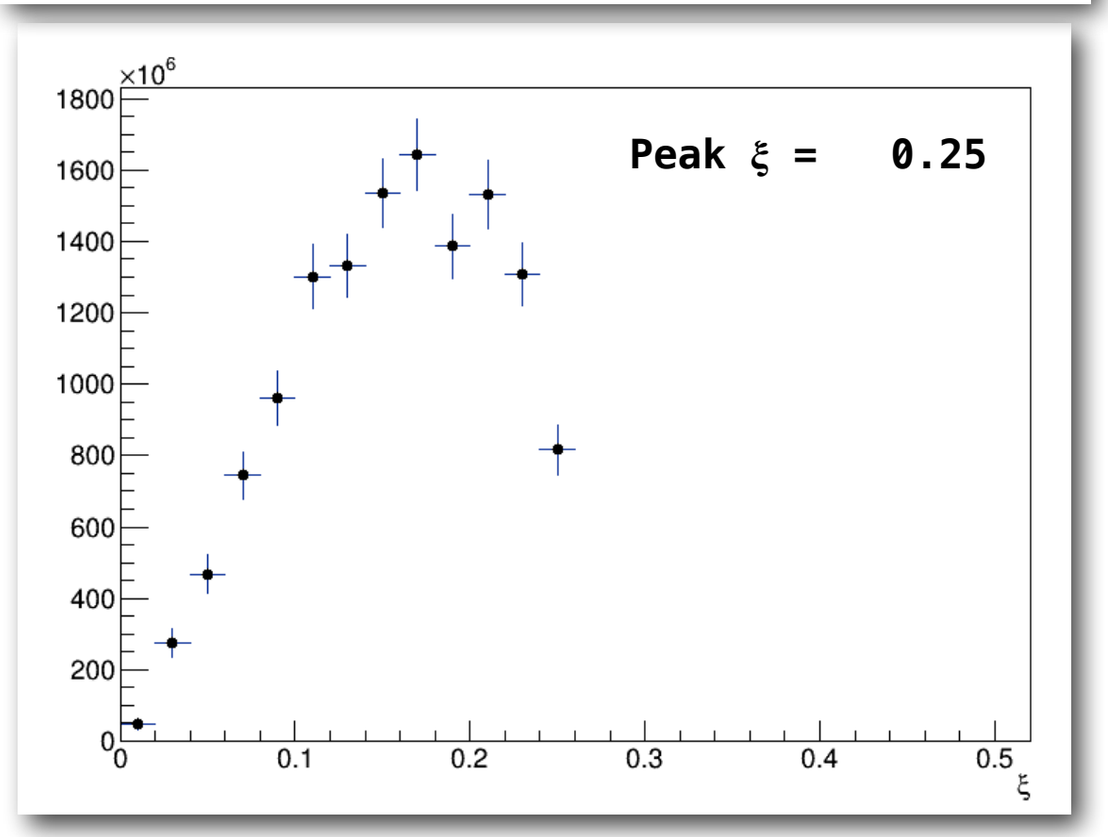
# Laser Intensity

MC simulation provides information for $\xi$ for each individual interaction

- Realistic simulation of laser pulse intensity distribution.
- The field is not the same across the laser pulse.



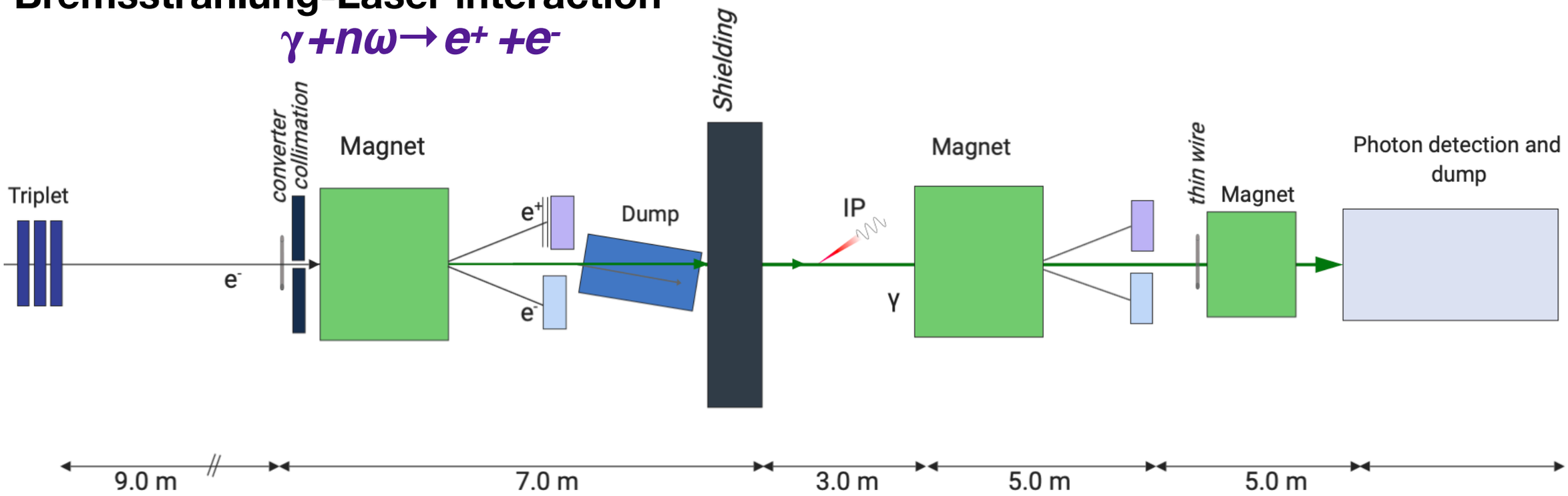



# LUXE Set Up

## Bremsstrahlung-Laser interaction

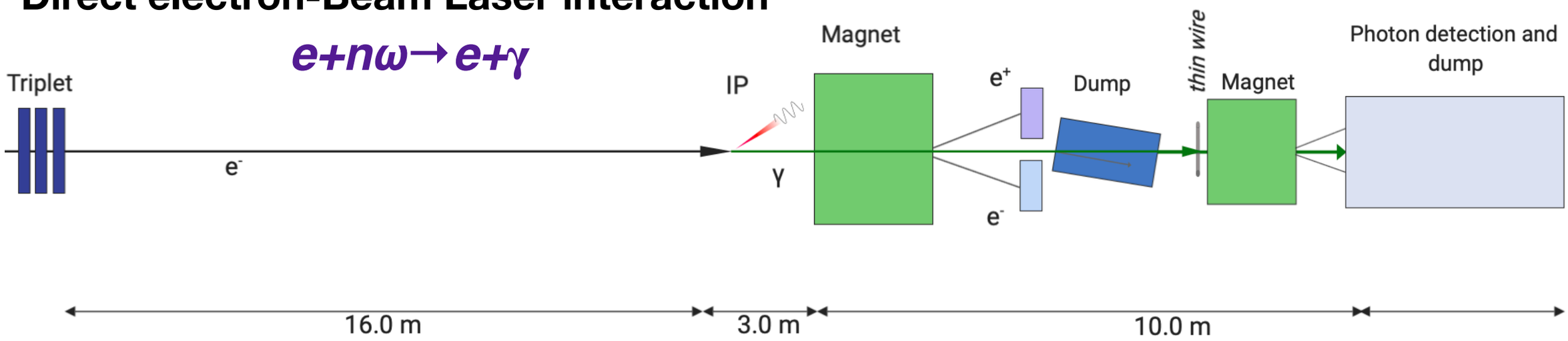
$\gamma + n\omega \rightarrow e^+ + e^-$




the non-linear pair-production process

## Direct electron-Beam Laser interaction

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



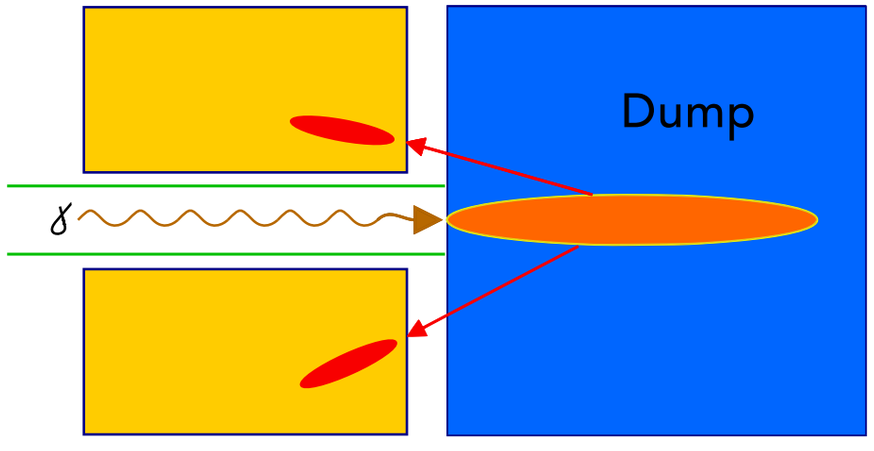

one-step and two-step trident
the non-linear Compton processes

# Rates from LOI

## For 6.0e9 electrons in BX w/ E= 17 GeV

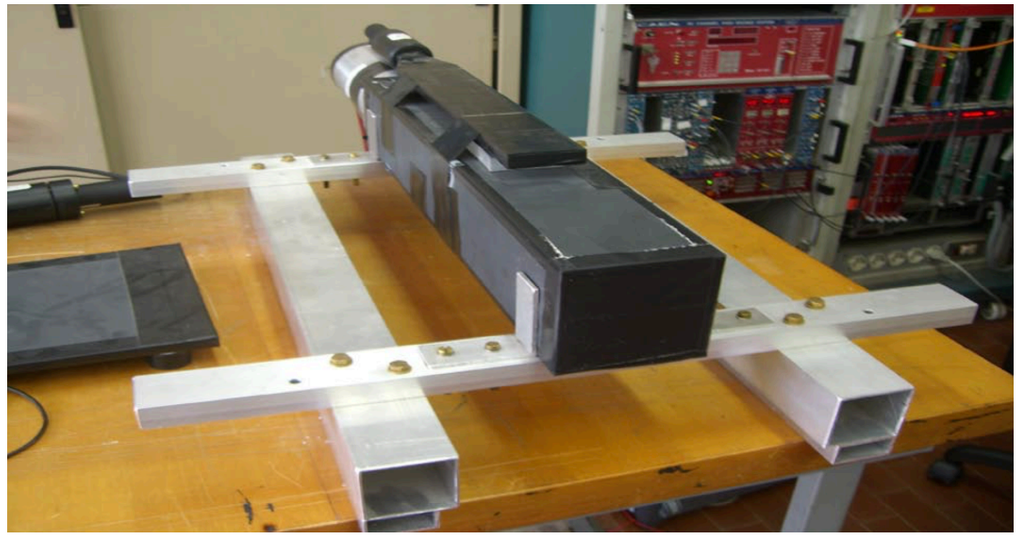
| Location | particle type | rate for ξ=2.6 | rate for ξ=0.26 |
|---|---|---|---|
| e– detector | e–, E <16 GeV | **5.9e+9** | **2.4e+07** |
| e+ detector | e+ | **61.07** | **0.0** |
| Photon detector | γ | **2.4e+11** | **3.8e+07** |
| Photon detector | e+ and e– | **2.3e+07** | **4.2e+04** |
| Photon detector | e+ and e– | **5.8e+5** | **3.8e+03** |

## The Idea:



# Lead glass blocks from Hermes Experiment

Available: 6 calorimeter blocks  w/ measures $9 \times 9$ cm$^2$, length is 50 cm

| Chemical composition (weight%) | |
|---|---|
| $Pb_3O_4$ | 51.23 |
| $SiO_2$ | 41.53 |
| $K_2O$ | 7.0 |
| $Ce$ | 0.2 |
| Radiation length (cm) | 2.78 |
| Density ($g/cm^3$) | 3.86 |
| Critical energy (MeV) | 17.97 |
| Moliere radius (cm) | 3.28 |
| Refraction index | 1.65 |
| Thermal expansion coefficient ($C^{-1}$) | $8.5 \cdot 10^{-6}$ |

Table 1: Chemical composition and physical properties of the F101 LG

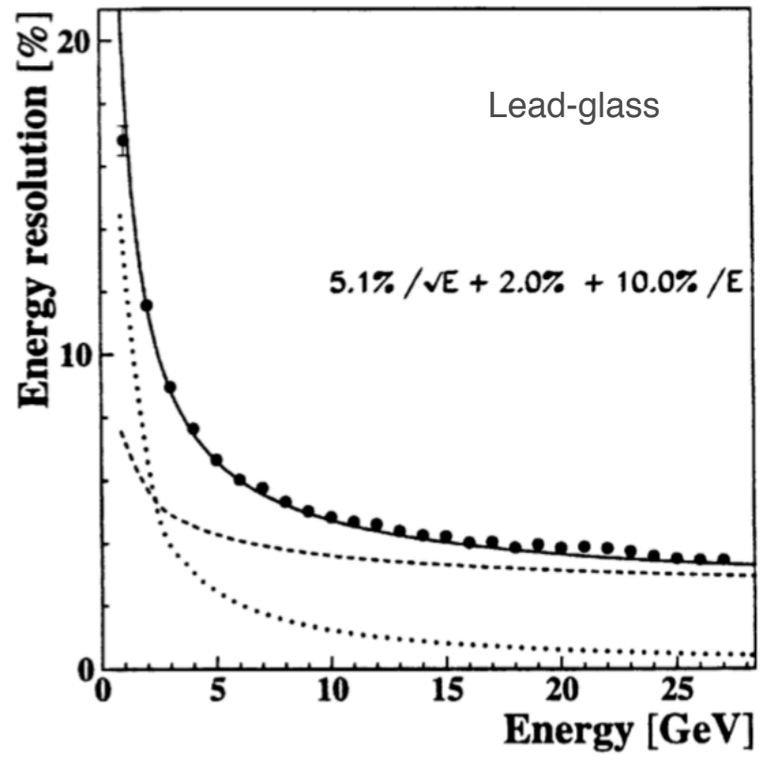
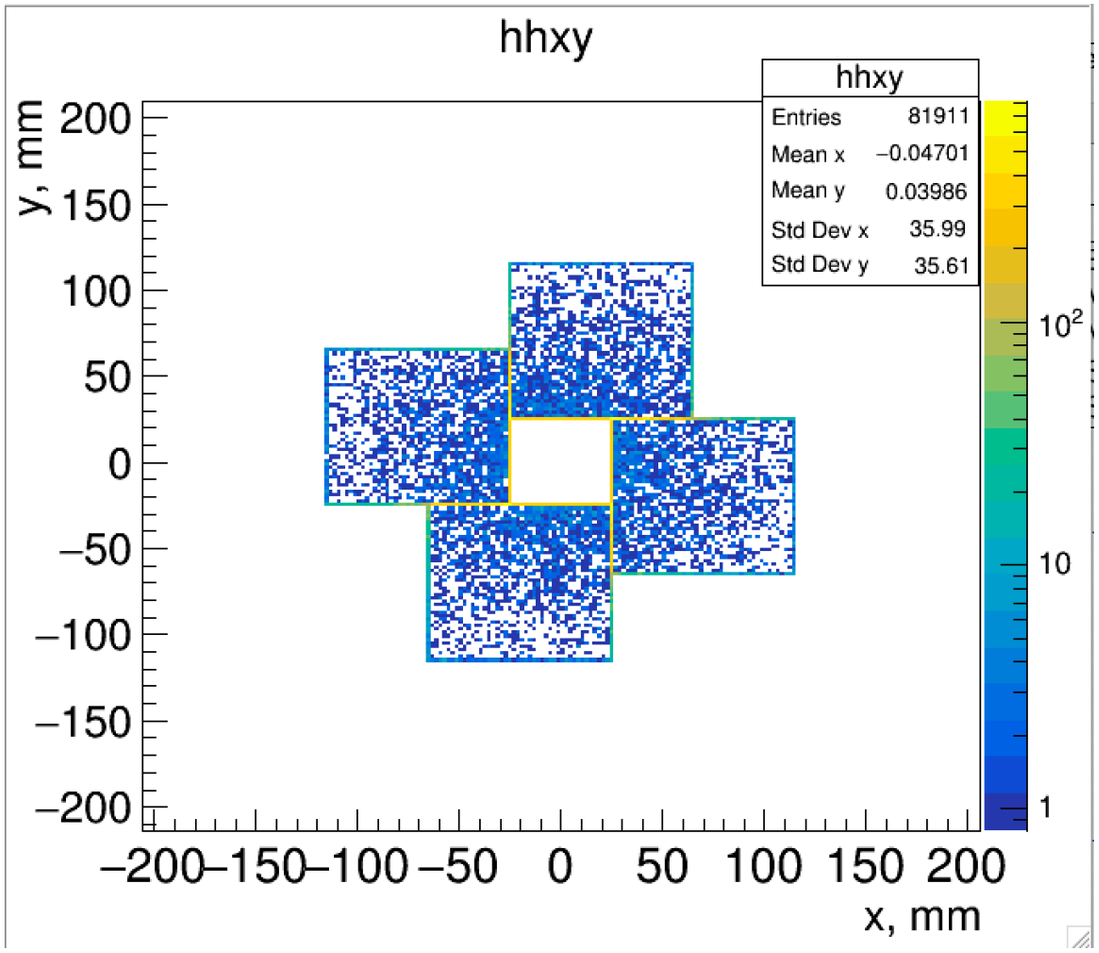
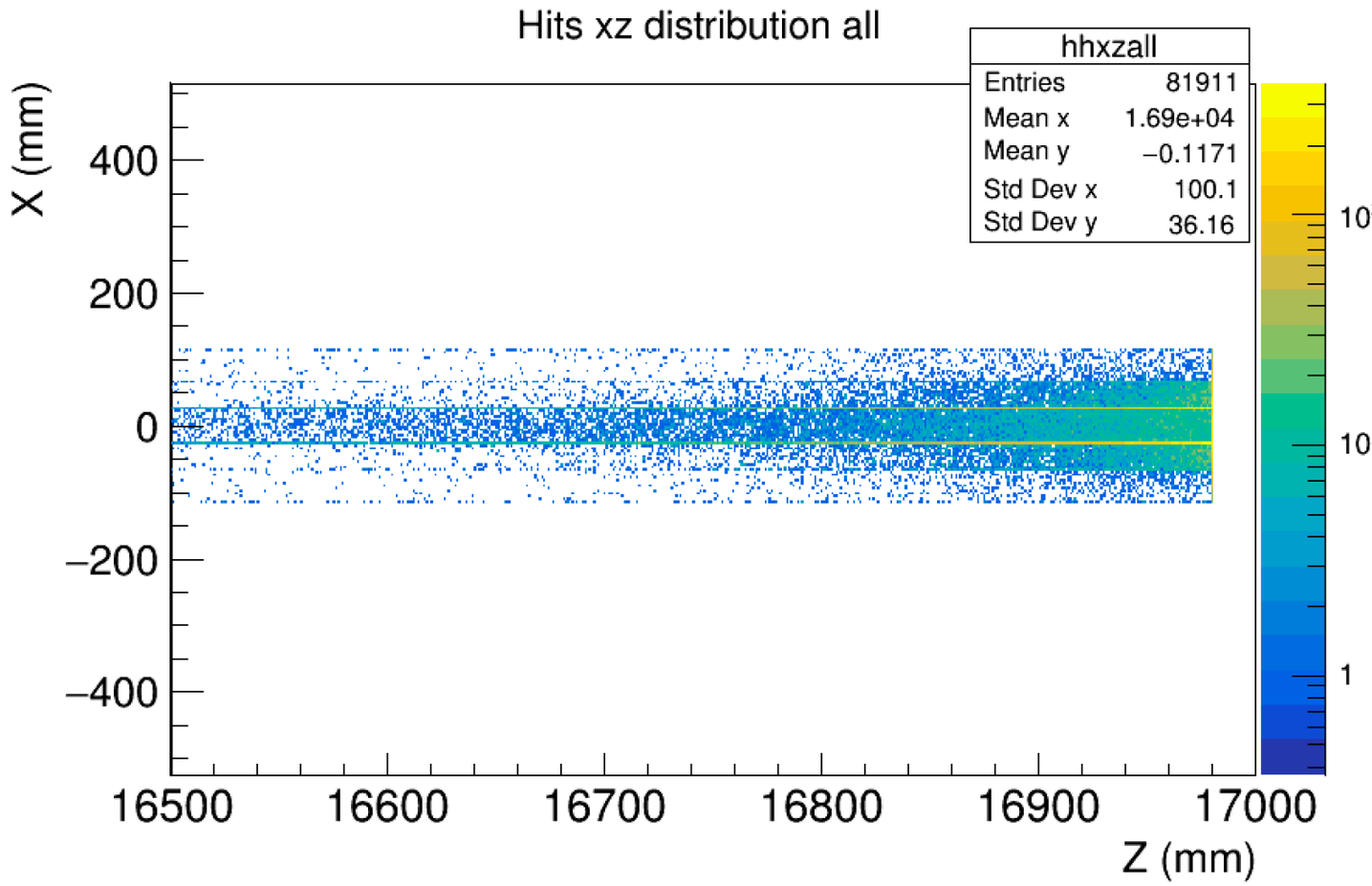
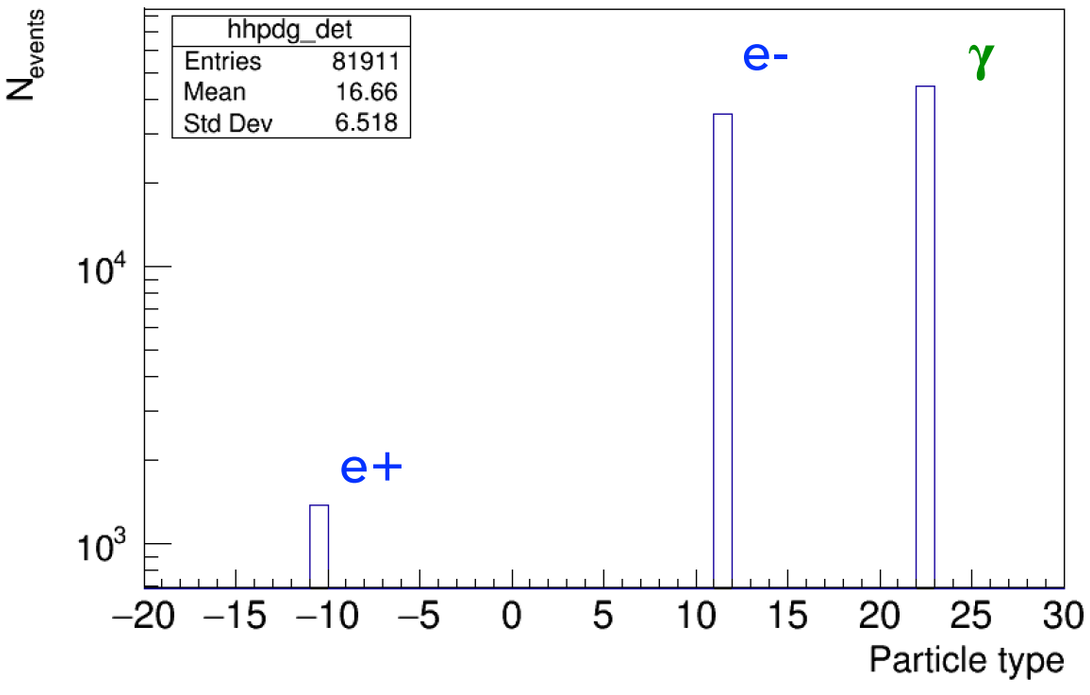



Fig. 5. Energy resolution of the calorimeter; the circles correspond to the 1996 data, the solid curve is the sum of the contributions from the lead-glass (dashed curve) and from the pre-shower (dotted curve) provided at test beam measurement [7].

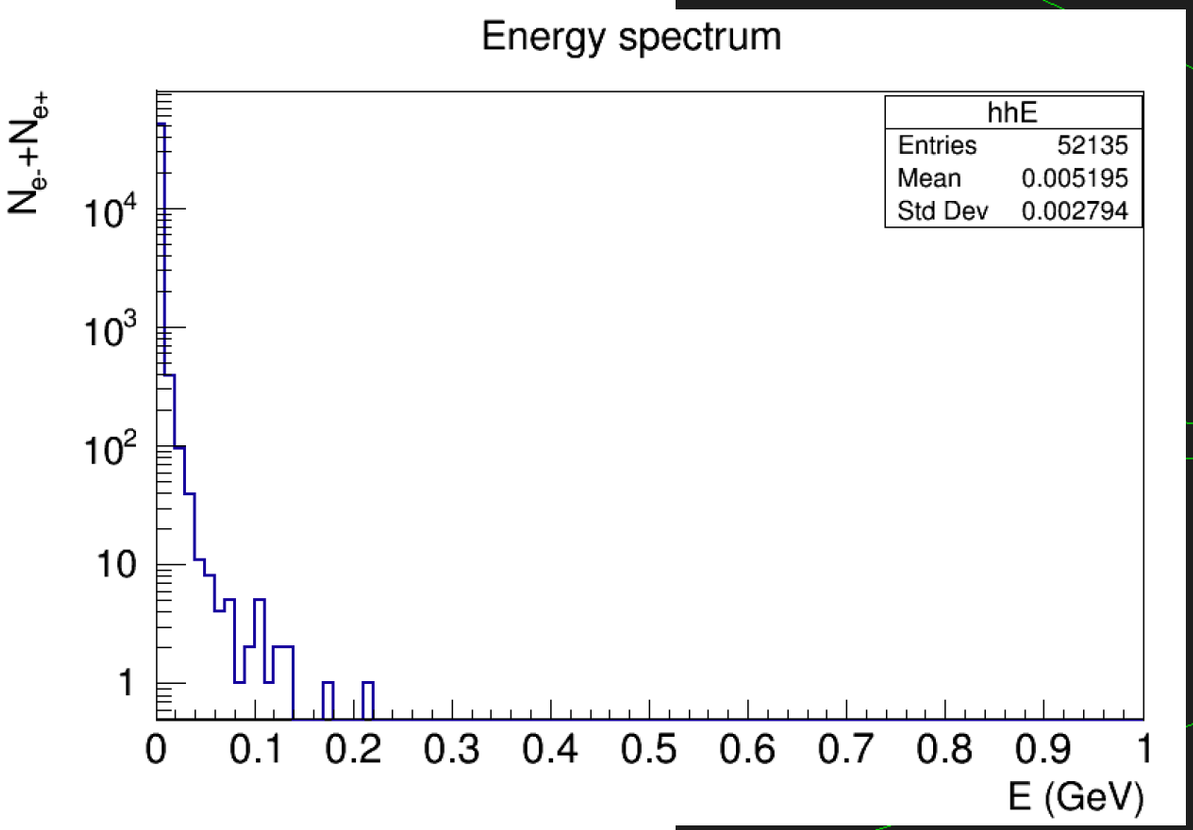
# Control plots for LG monitor



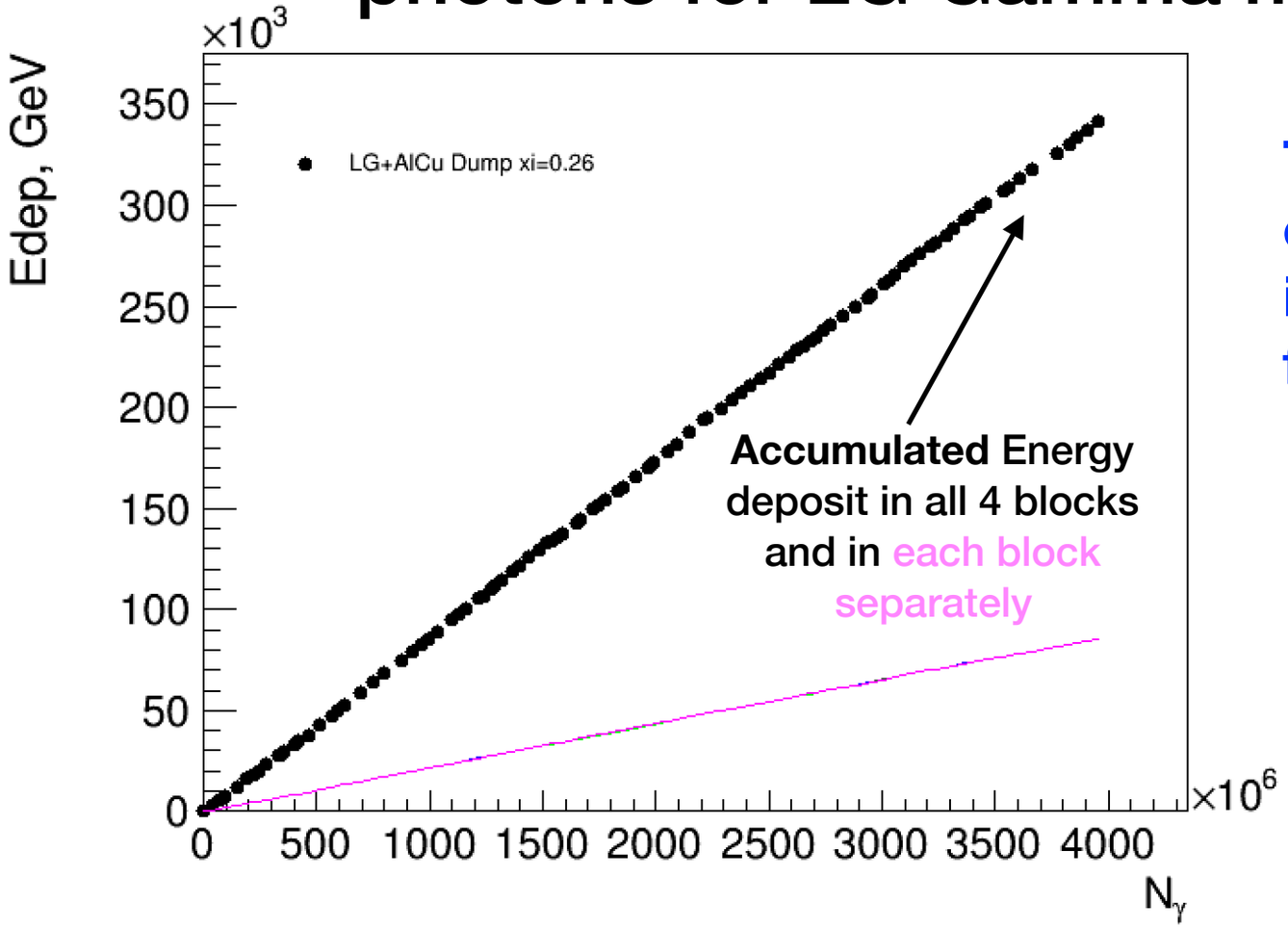




**The distribution of hits of particles entering LG Gamma monitor in XY and XZ planes**

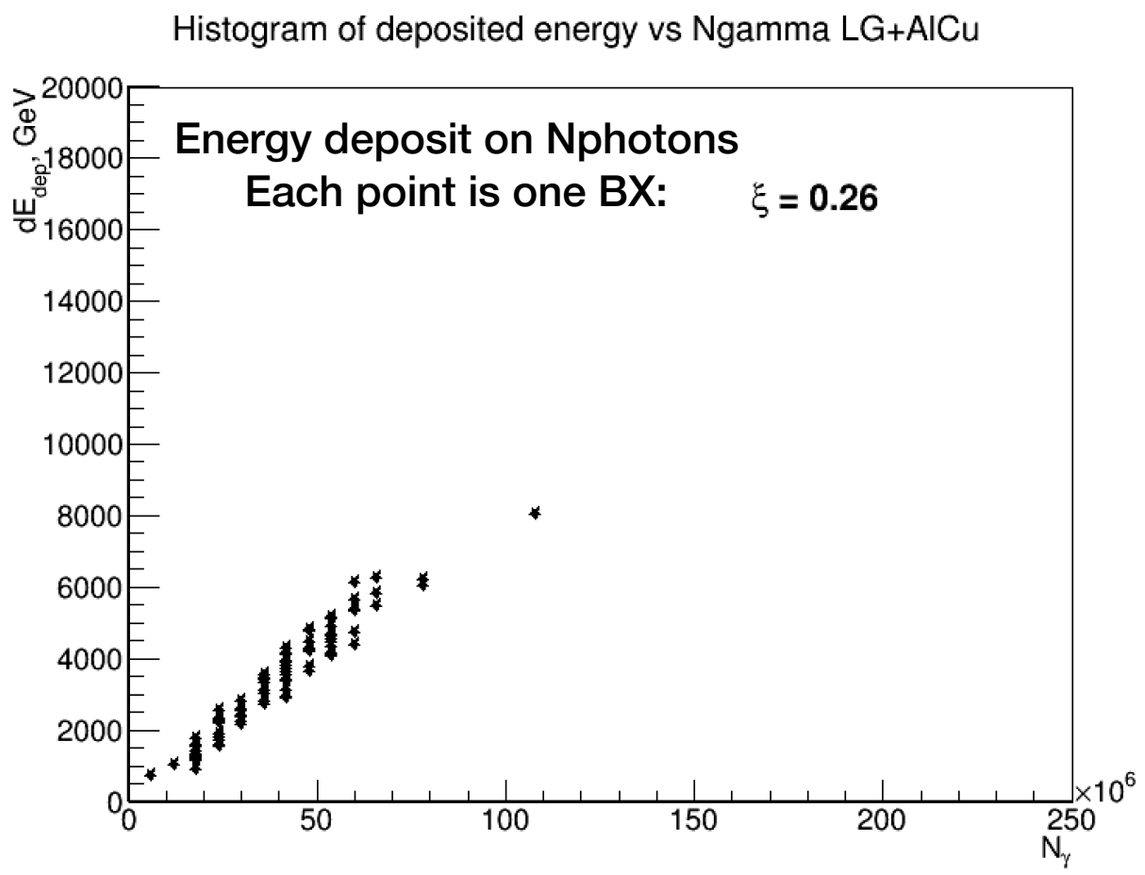

Energy spectrum
hhE
Entries 52135
Mean 0.005195
Std Dev 0.002794
$N_{e^-}+N_{e^+}$
$10^4$
$10^3$
$10^2$
10
1
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1
E (GeV)

e- with 0.2 GeV

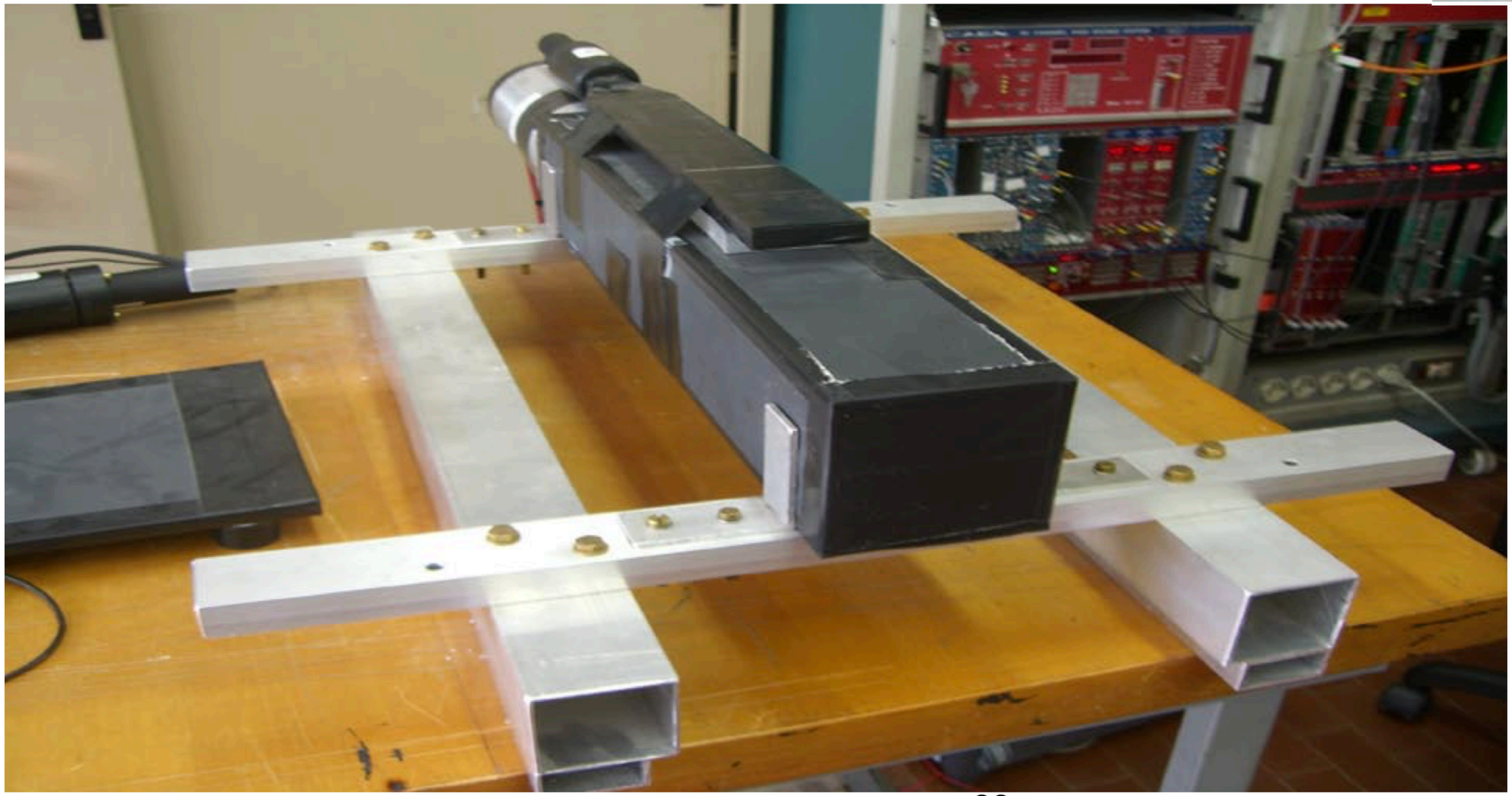
# The dependence of deposited energy on number of incoming photons for LG Gamma monitor and AlCu dump




**The linear dependence of deposited energy on number of incoming photons in LG allows the usage of backscatters for estimating the photon flux**

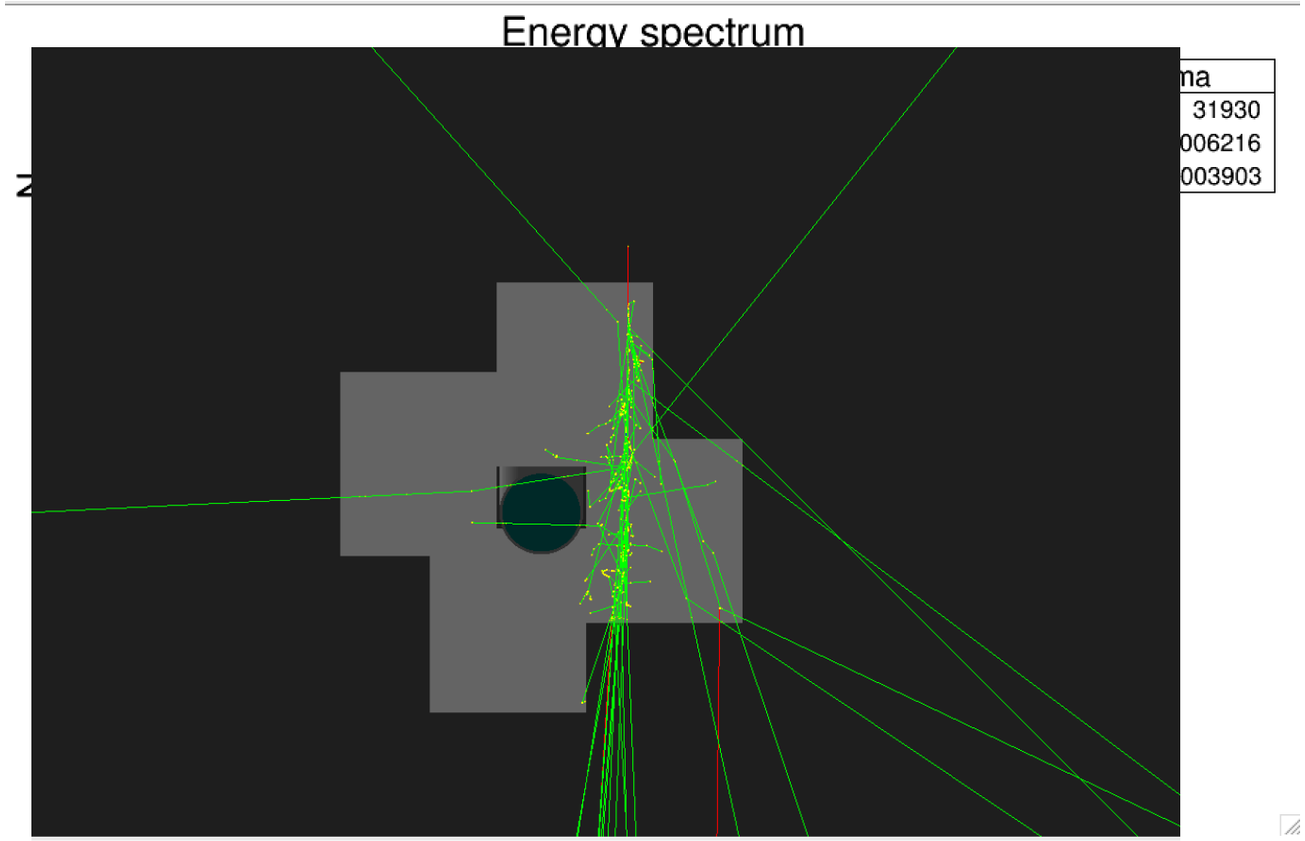


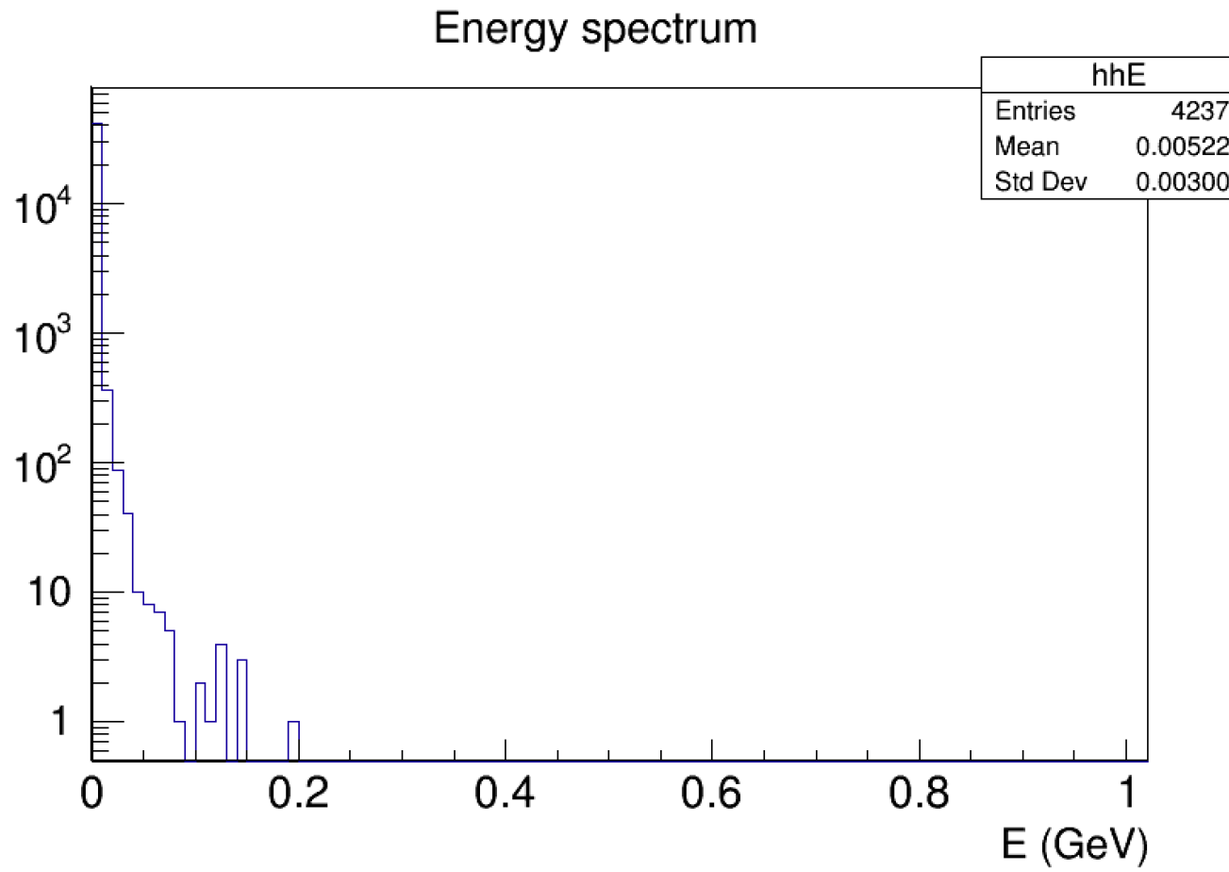
# Wrapped LG block

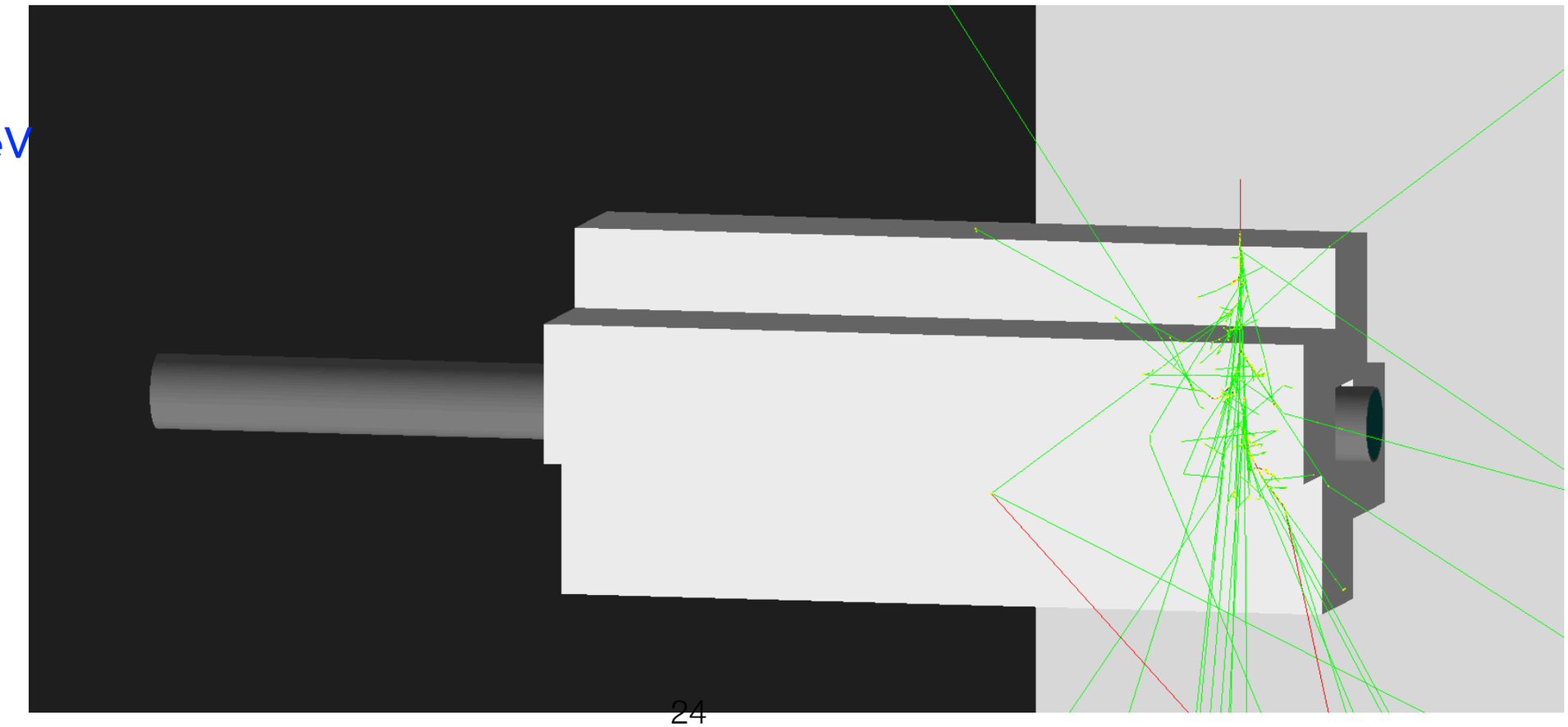



**blocks are wrapped with an aluminized mylar foil to reflect the Cherenkov photons, and a tedlar foil to make the blocks light tight.**

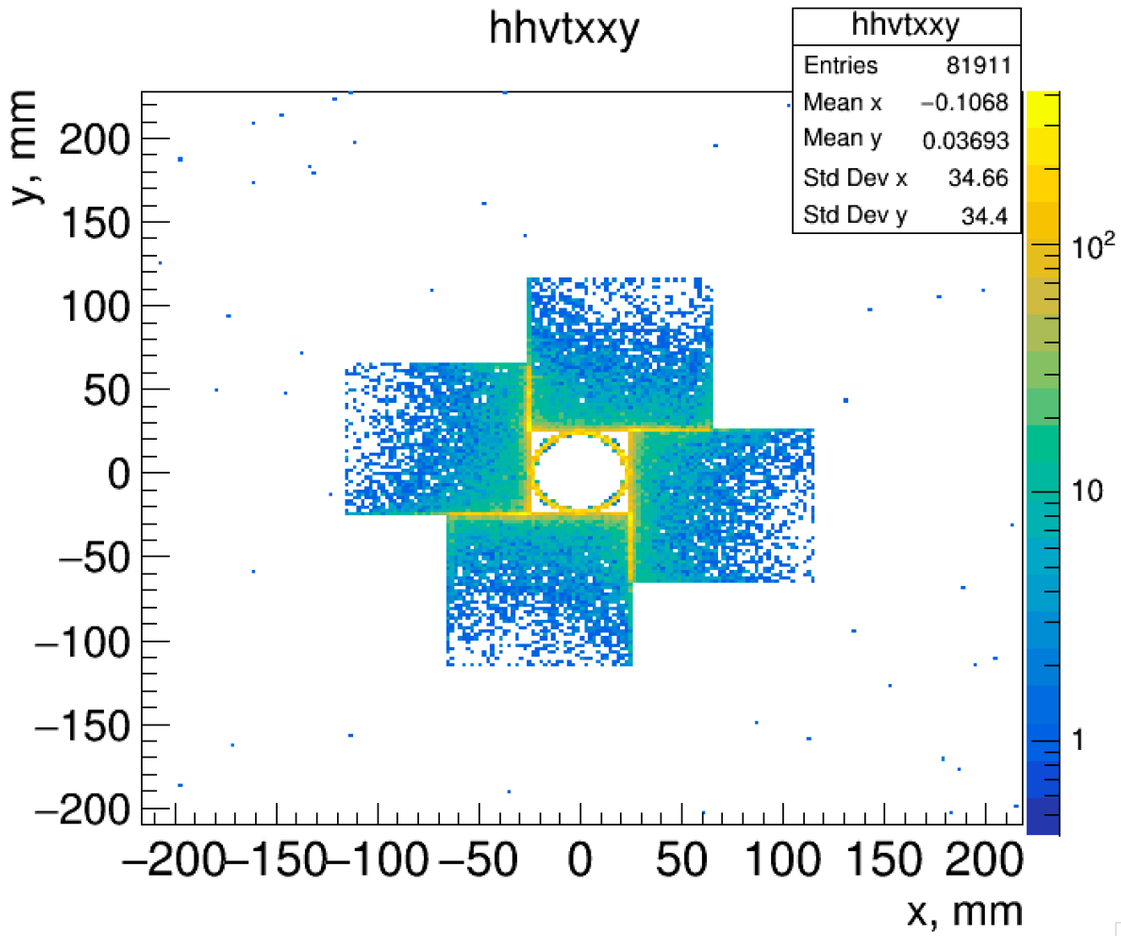
e- with 0.5 GeV

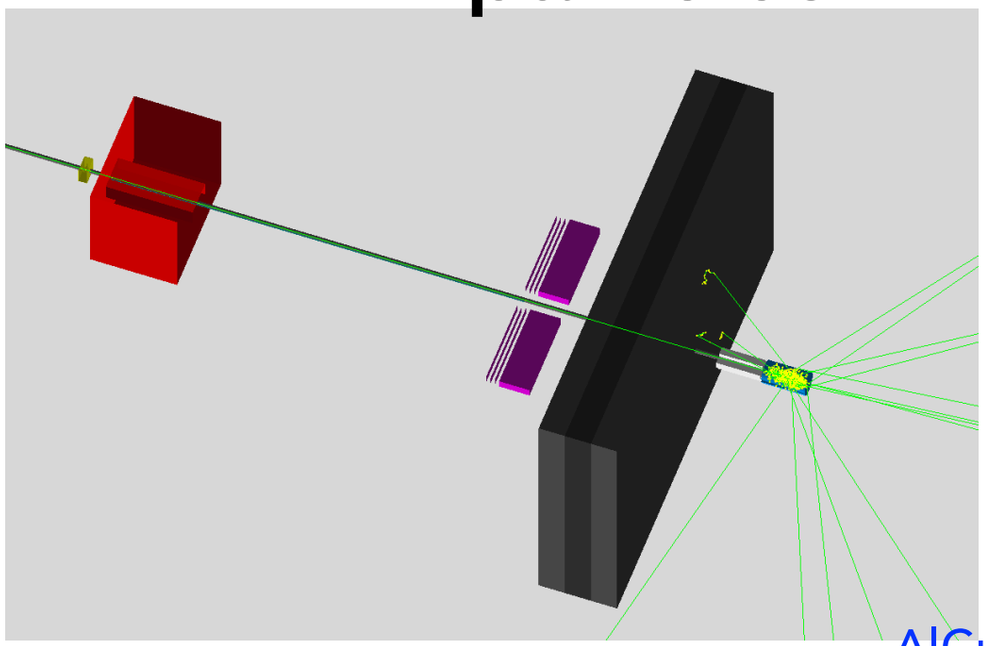

Energy spectrum
ma
31930
006216
003903


Energy spectrum
hhE
Entries 4237
Mean 0.00522
Std Dev 0.00300
$10^4$
$10^3$
$10^2$
10
1
0
0.2
0.4
0.6
0.8
1
E (GeV)



# Vertexes of the particles

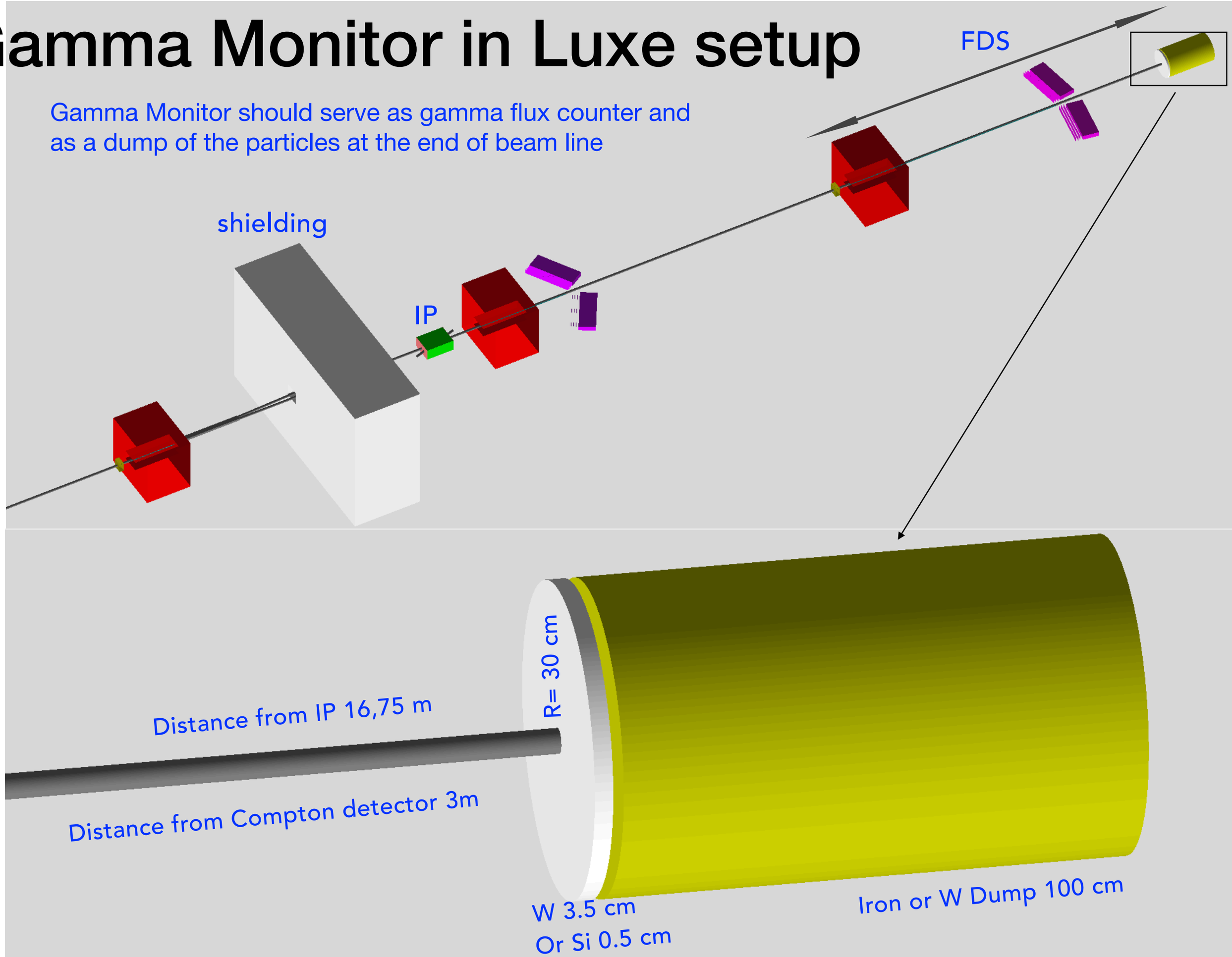


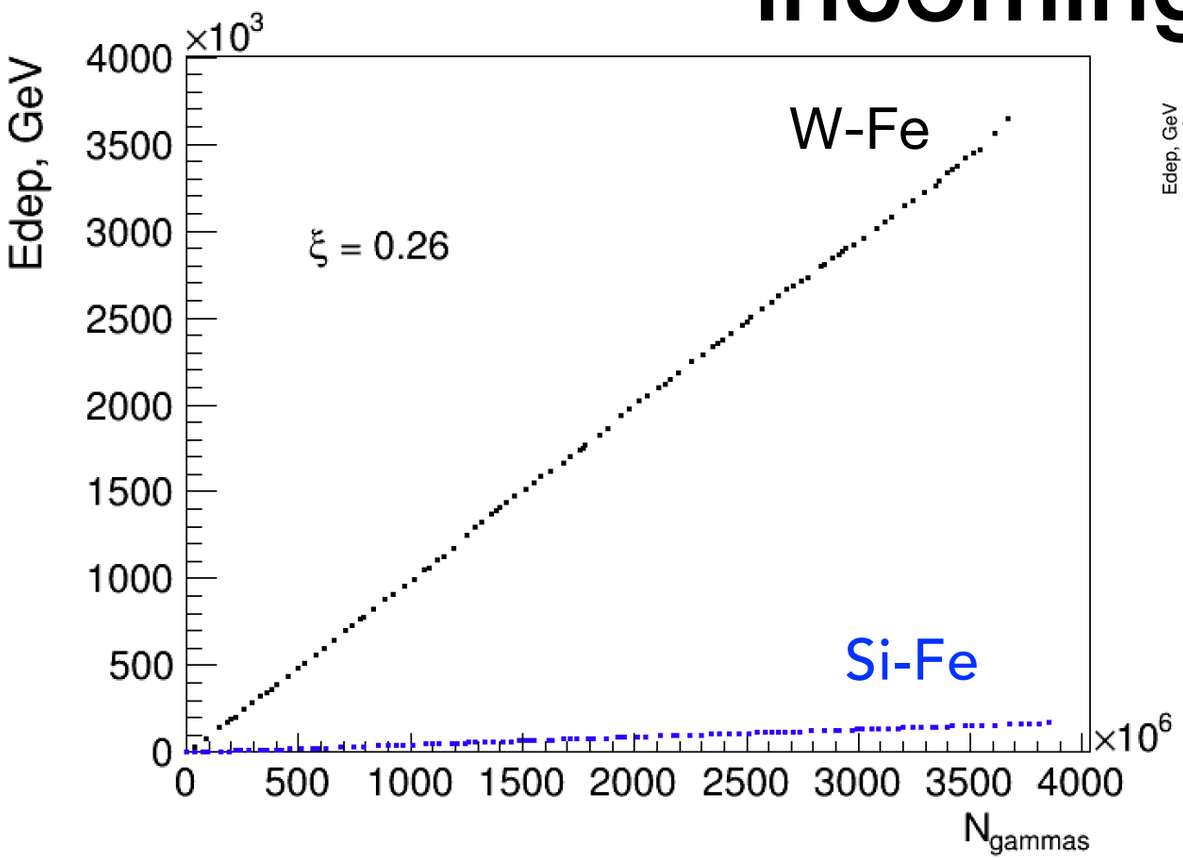
Vertex Z

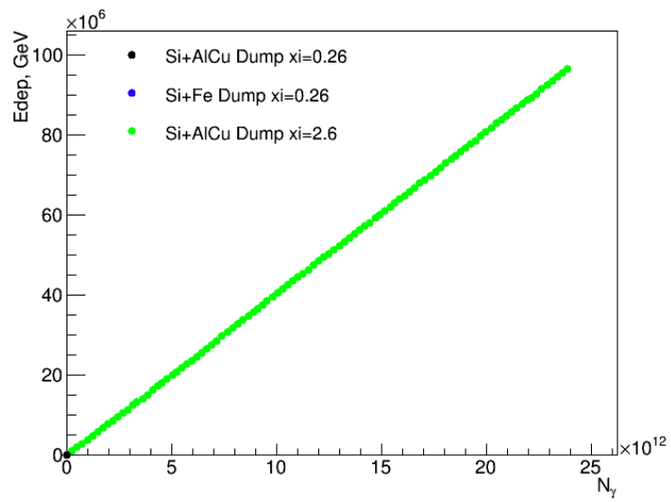
# Gamma Monitor in Luxe setup

Gamma Monitor should serve as gamma flux counter and as a dump of the particles at the end of beam line

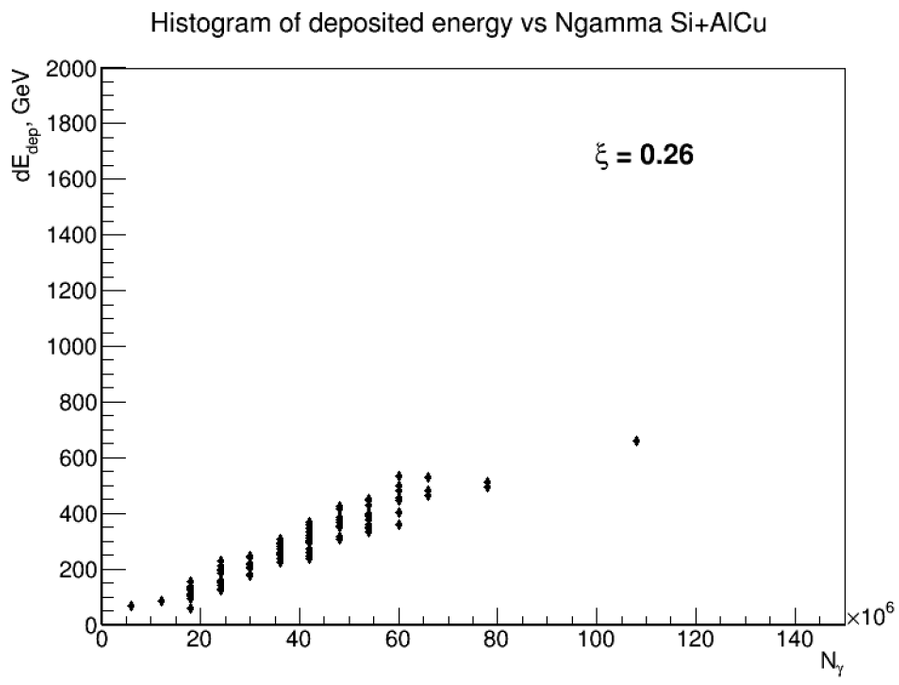


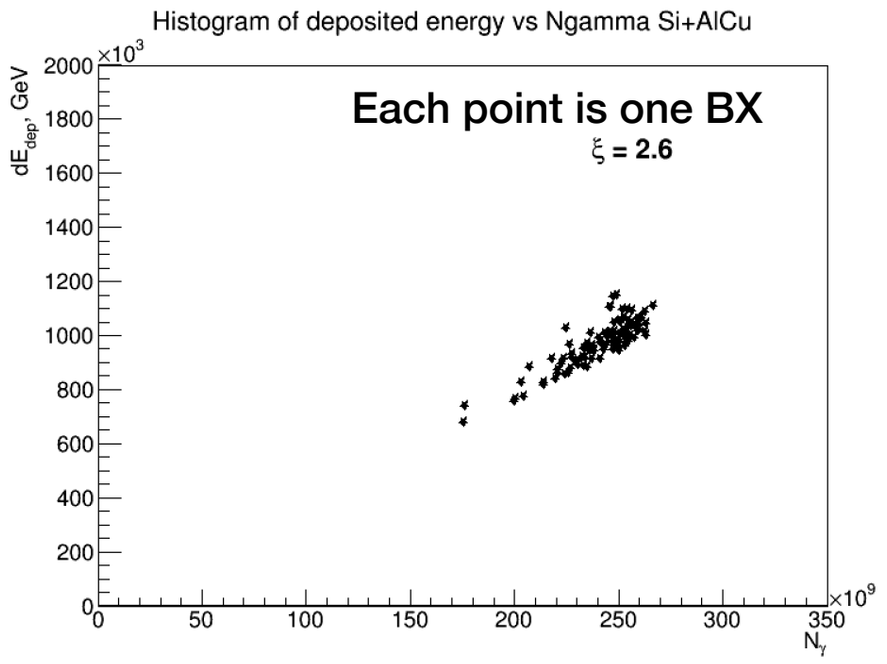
# Energy dependence on number of incoming photons



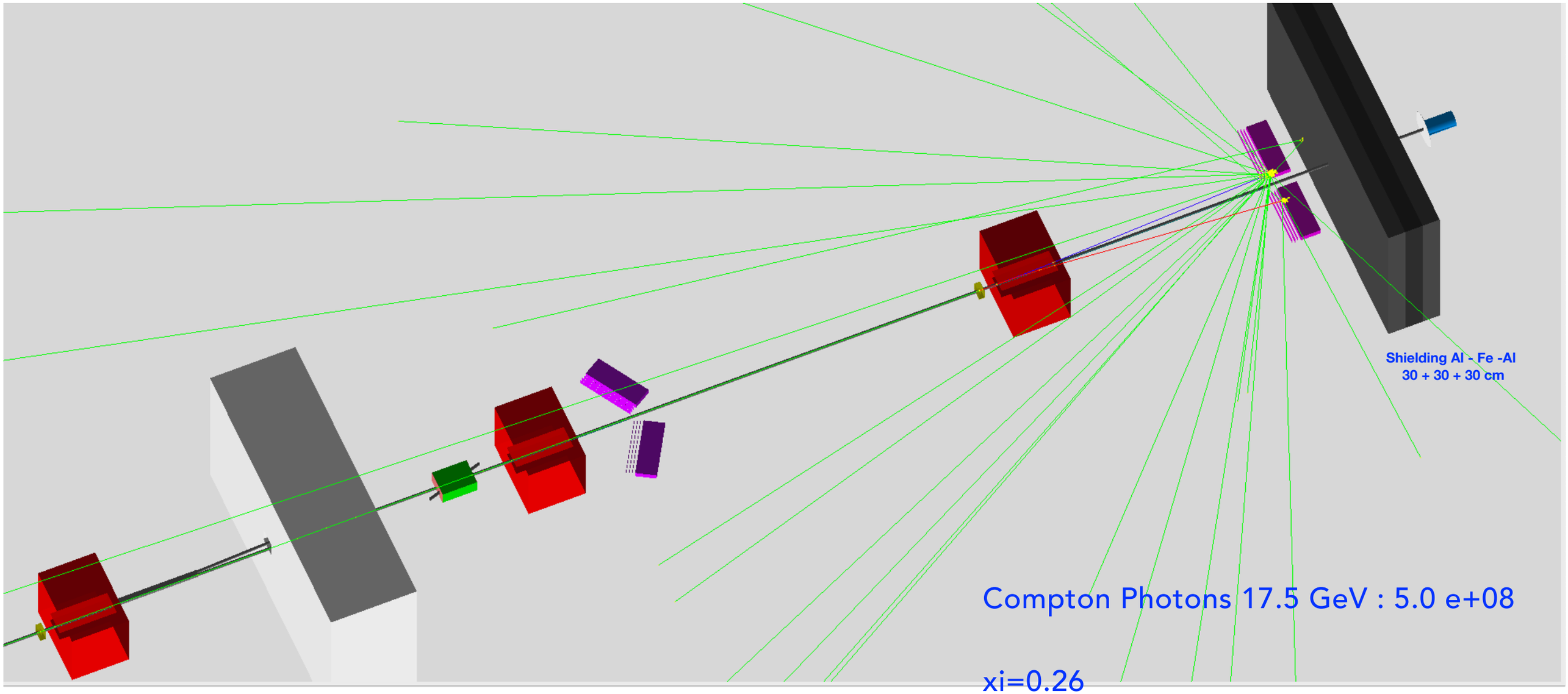

The linear dependence of deposited energy on number of incoming photons allows the usage of backscatters for estimating the photon flux



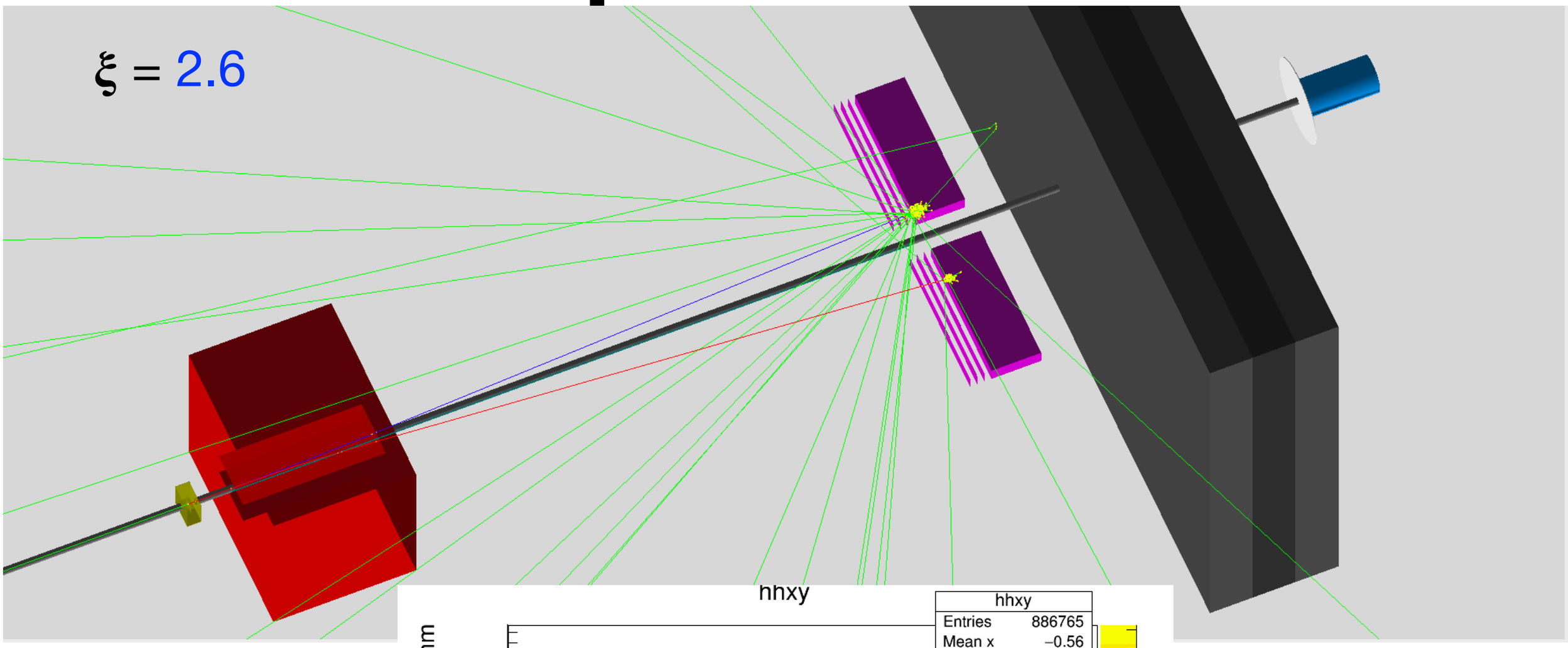



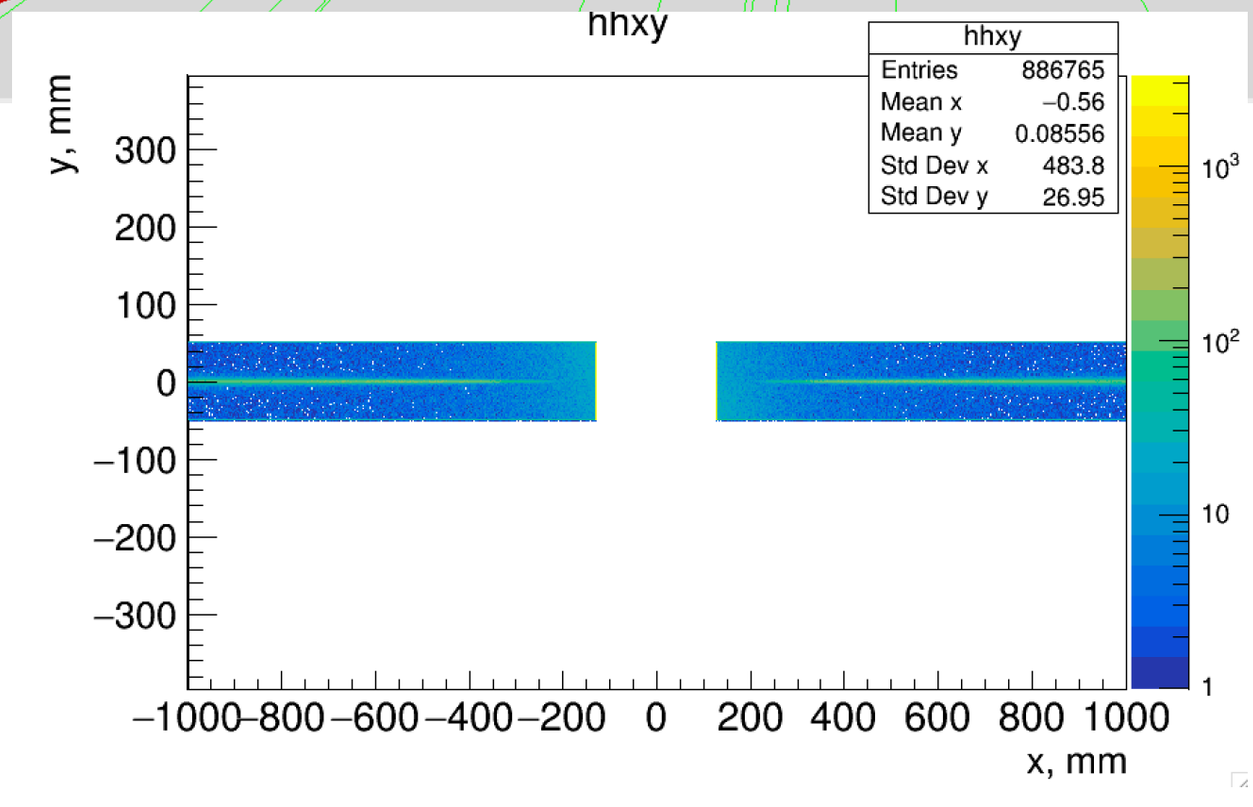

In average one γ deposits ~1 keV; w/ the sigma 0.2 keV

# Luxe setup with non-tilted Compton Detector

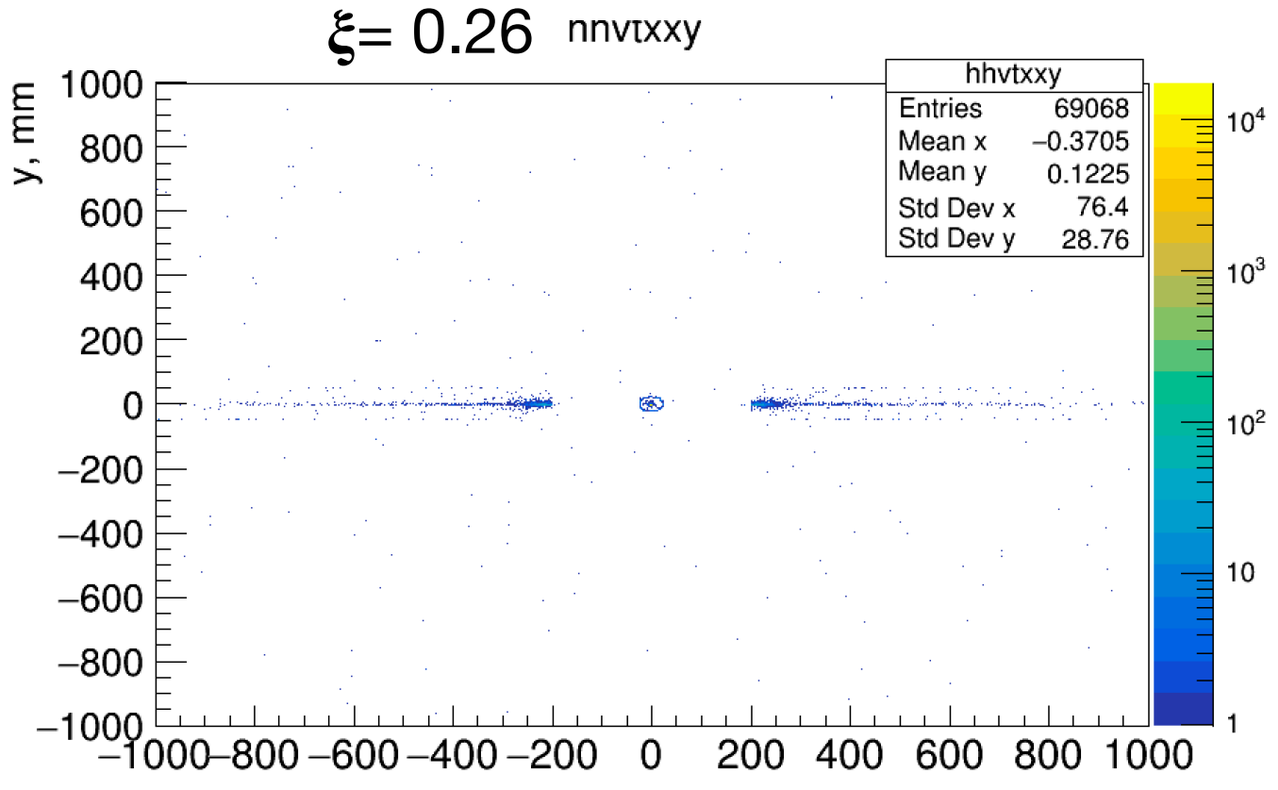


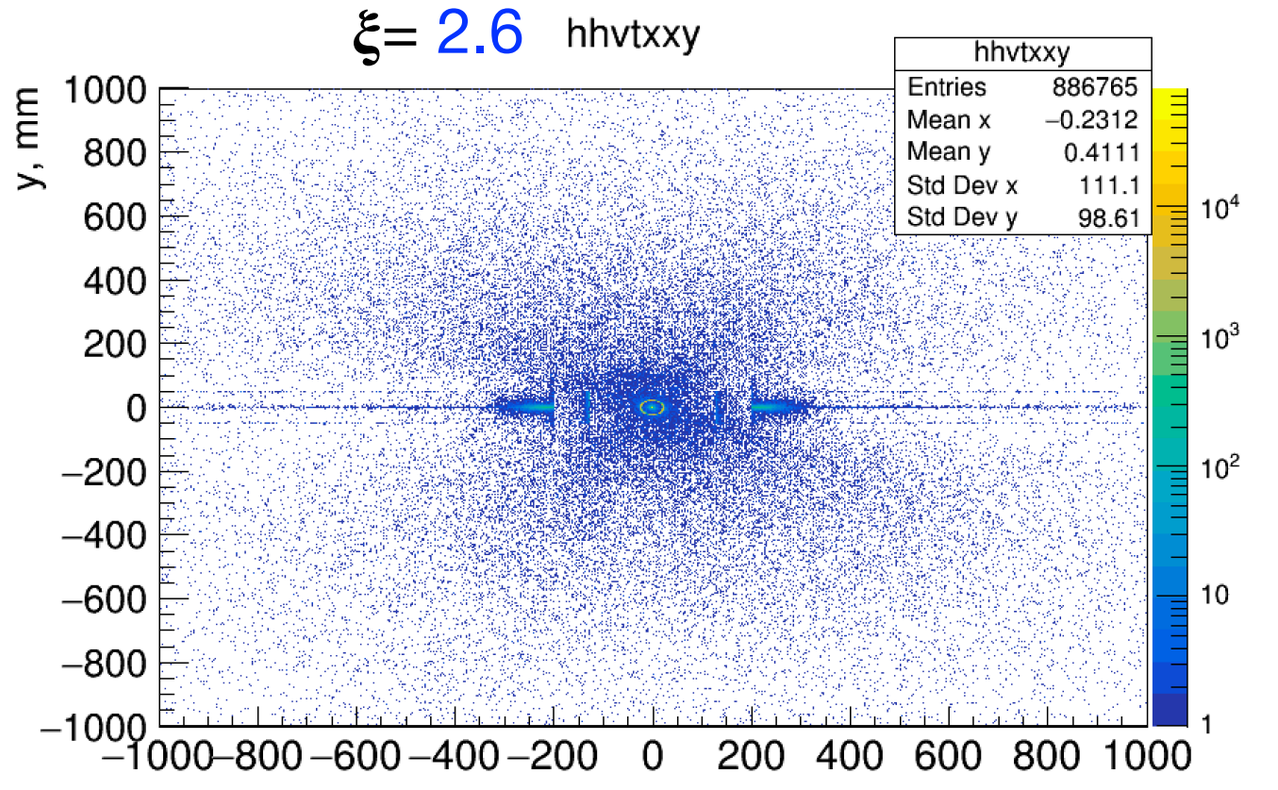
# Compton detector

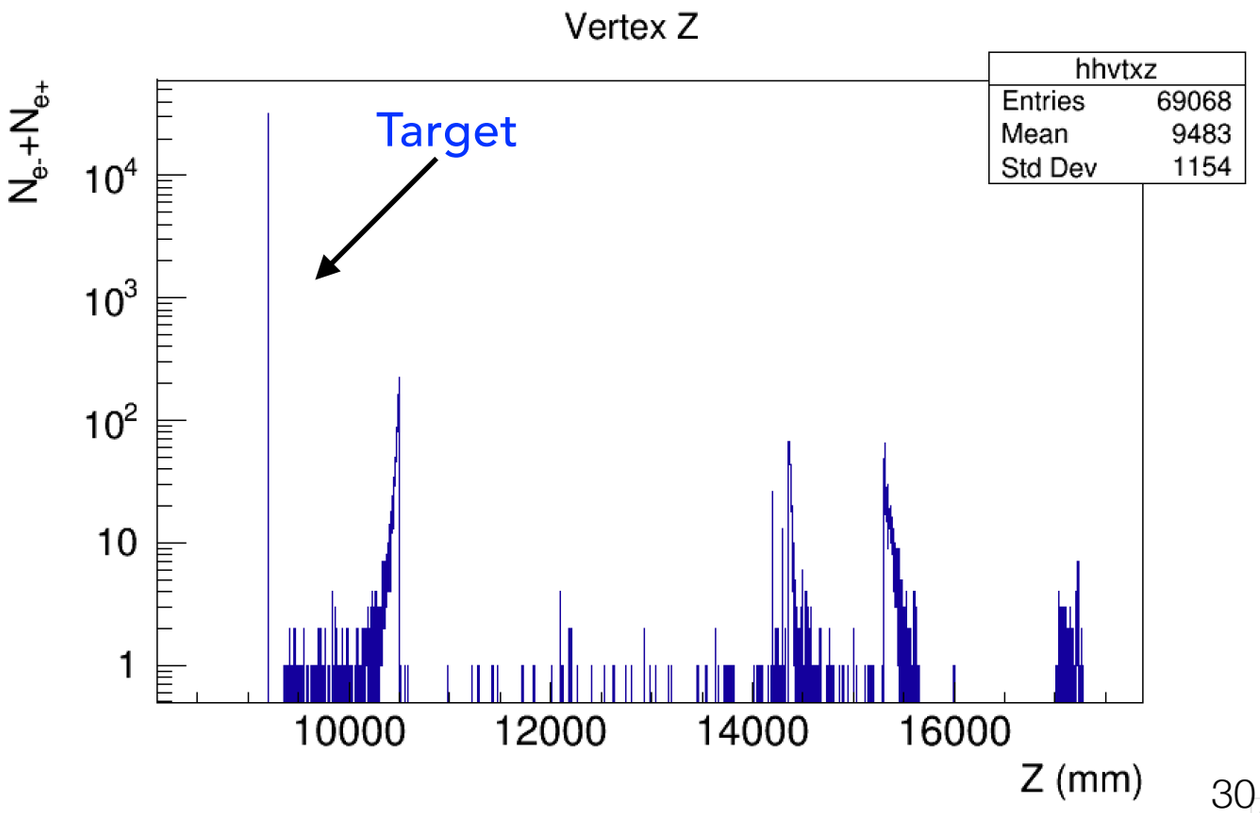


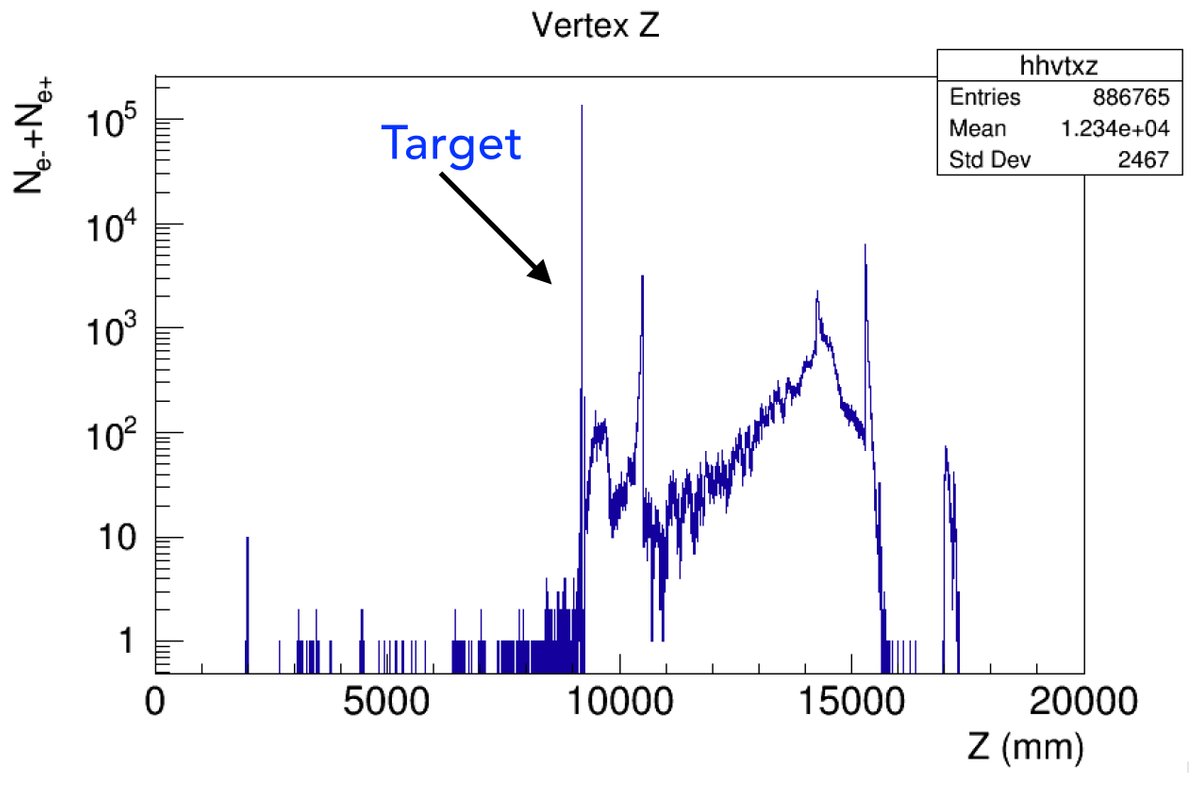



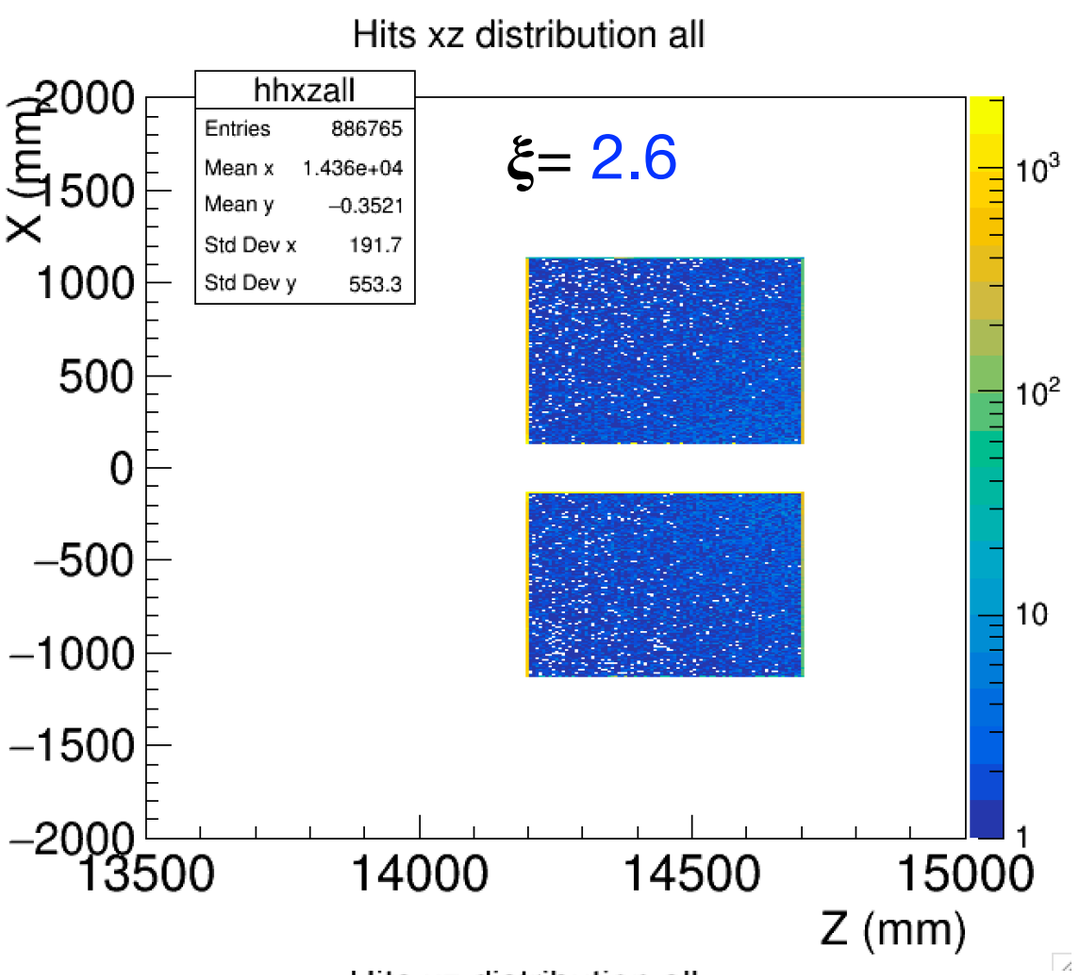
# Vertexes in Compton detector

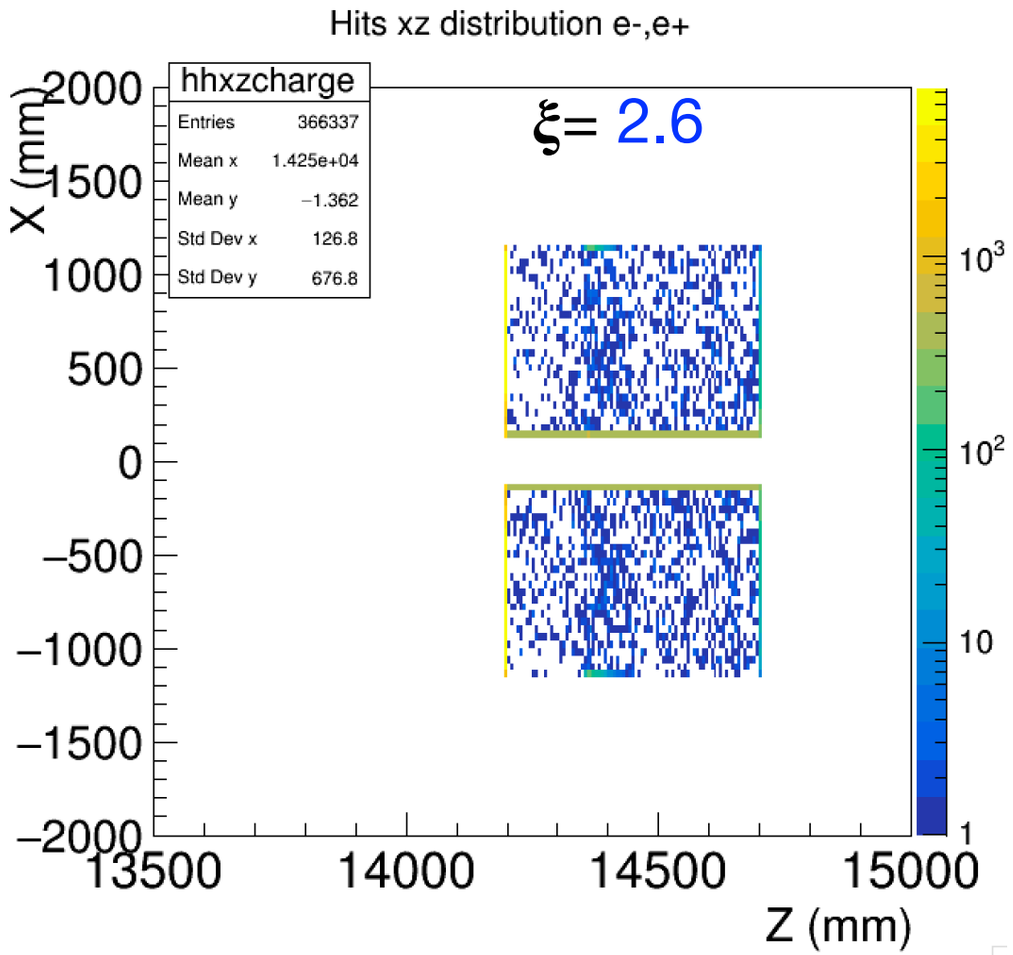


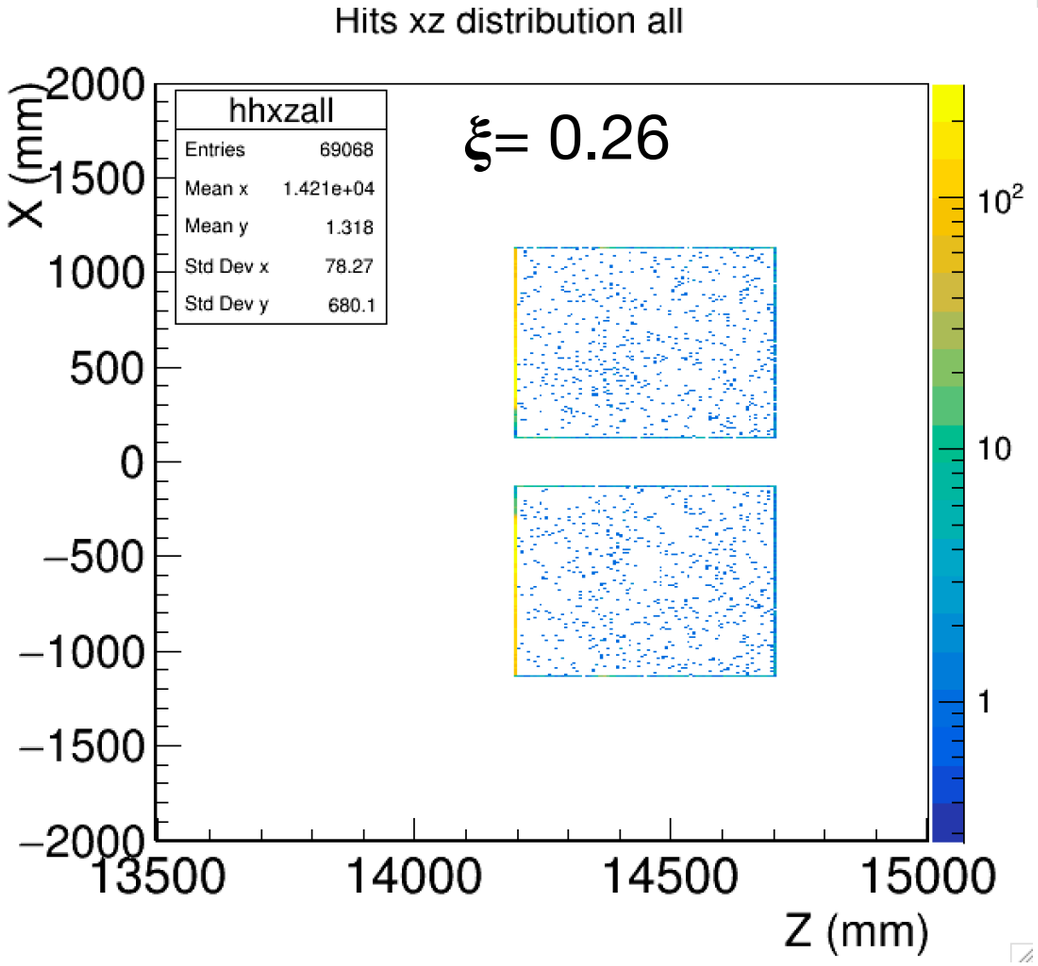



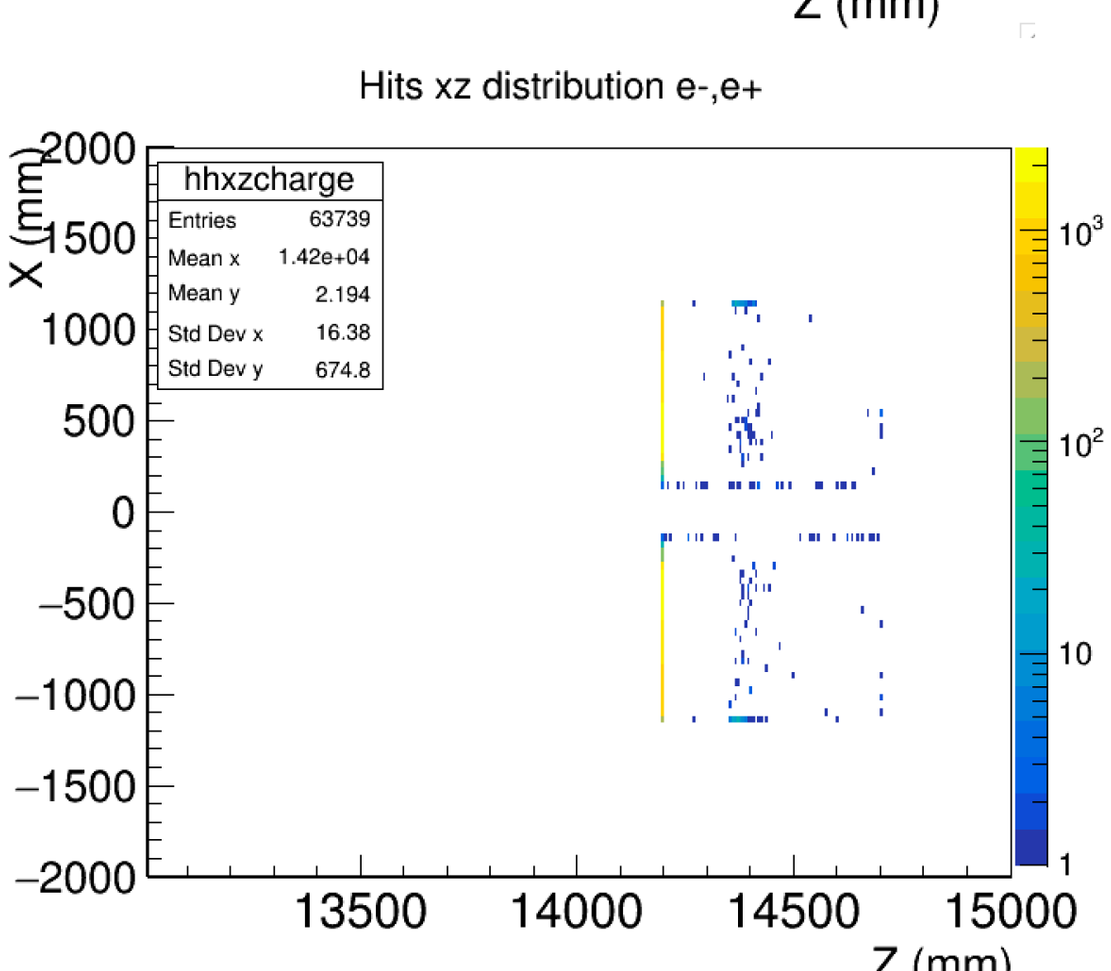



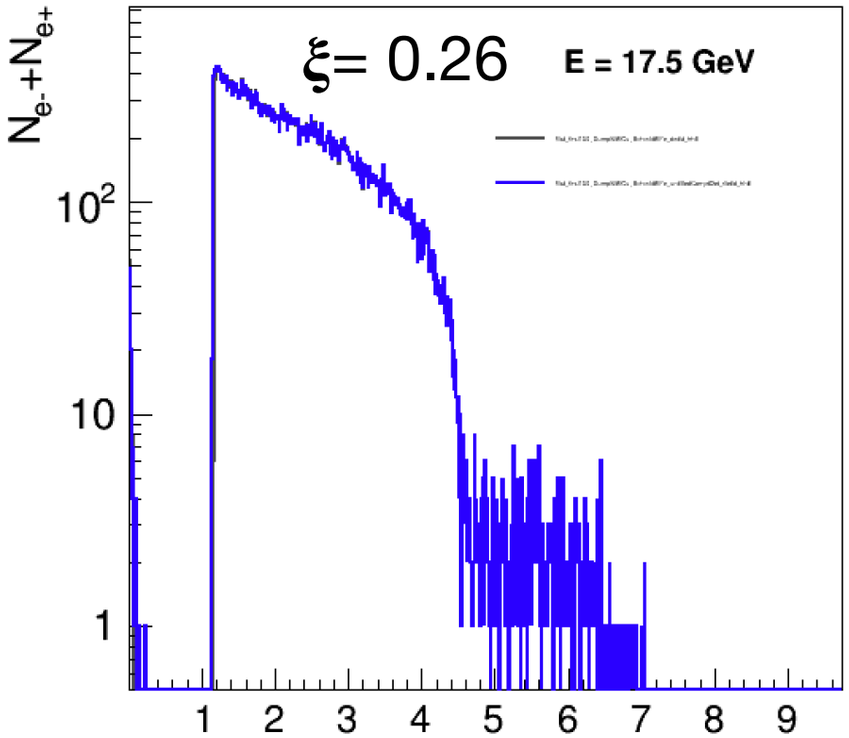

Hits xz distribution all
hhxzall
Entries 886765
Mean x 1.436e+04
Mean y −0.3521
Std Dev x 191.7
Std Dev y 553.3
ξ= 2.6
X (mm)
Z (mm)

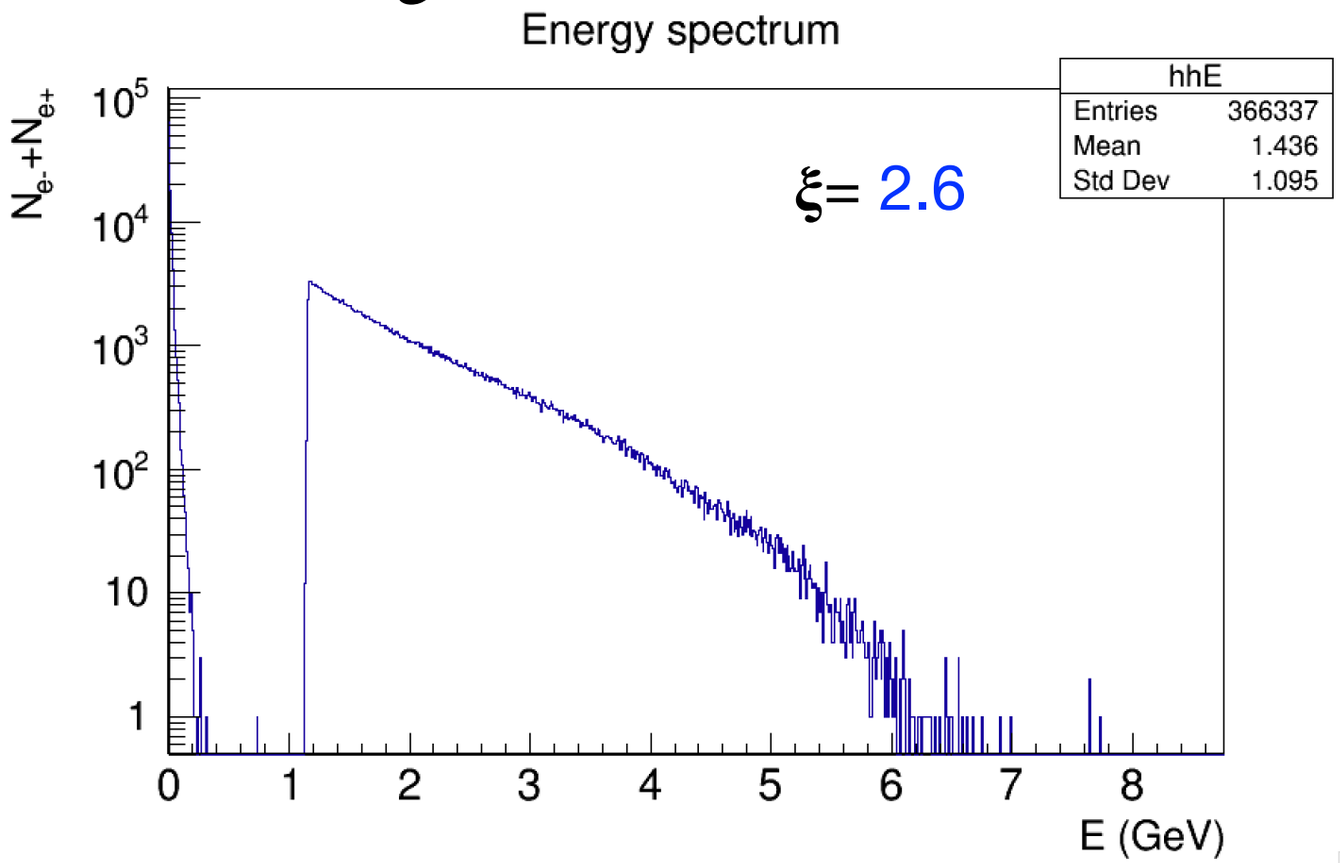

Hits xz distribution e-,e+
hhxzcharge
Entries 366337
Mean x 1.425e+04
Mean y −1.362
Std Dev x 126.8
Std Dev y 676.8
ξ= 2.6
X (mm)
Z (mm)

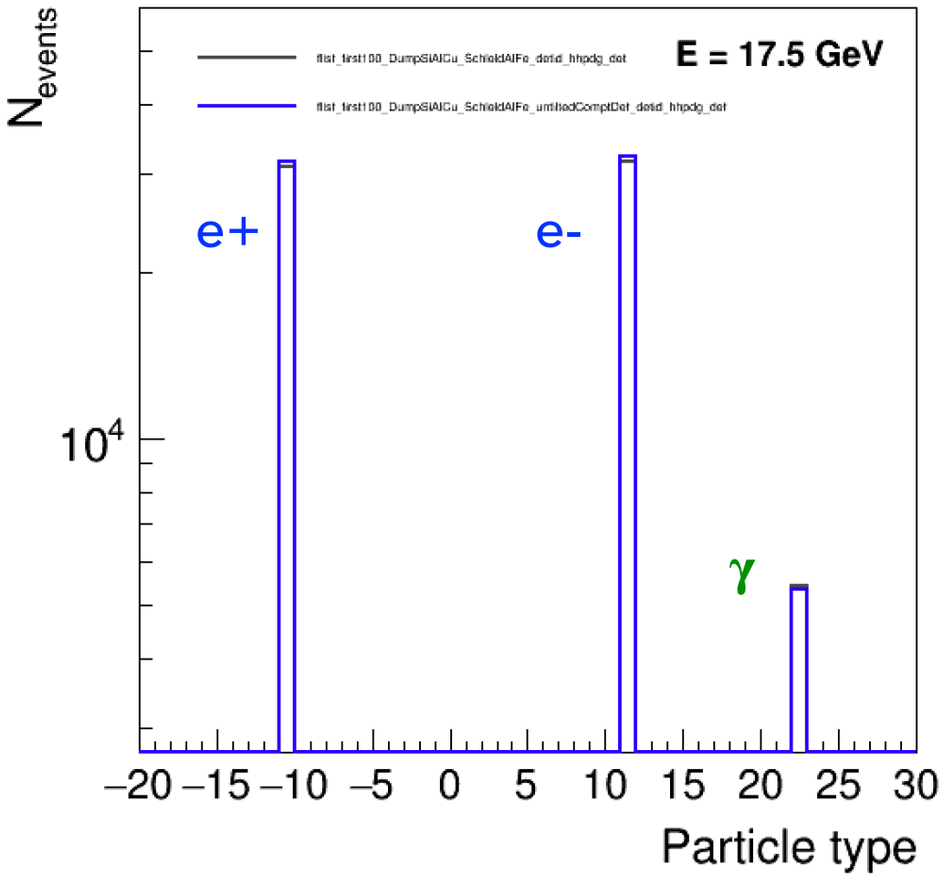

Hits xz distribution all
hhxzall
Entries 69068
Mean x 1.421e+04
Mean y 1.318
Std Dev x 78.27
Std Dev y 680.1
ξ= 0.26
X (mm)
Z (mm)


Hits xz distribution e-,e+
hhxzcharge
Entries 63739
Mean x 1.42e+04
Mean y 2.194
Std Dev x 16.38
Std Dev y 674.8
X (mm)
Z (mm)

# Compton detector: ξ= 2.6 vs 0.26



Edep, GeV

$\times 10^6$

140
120
100
80
60
40
20
0

LG+AlCu Dump 0.6J
LG+AlCu Dump 0.1J
LG+AlCu Dump 0.2J
LG+AlCu Dump 0.01J

0
500
1000
1500
2000

$\times 10^9$

$N_\gamma$