FDS performance

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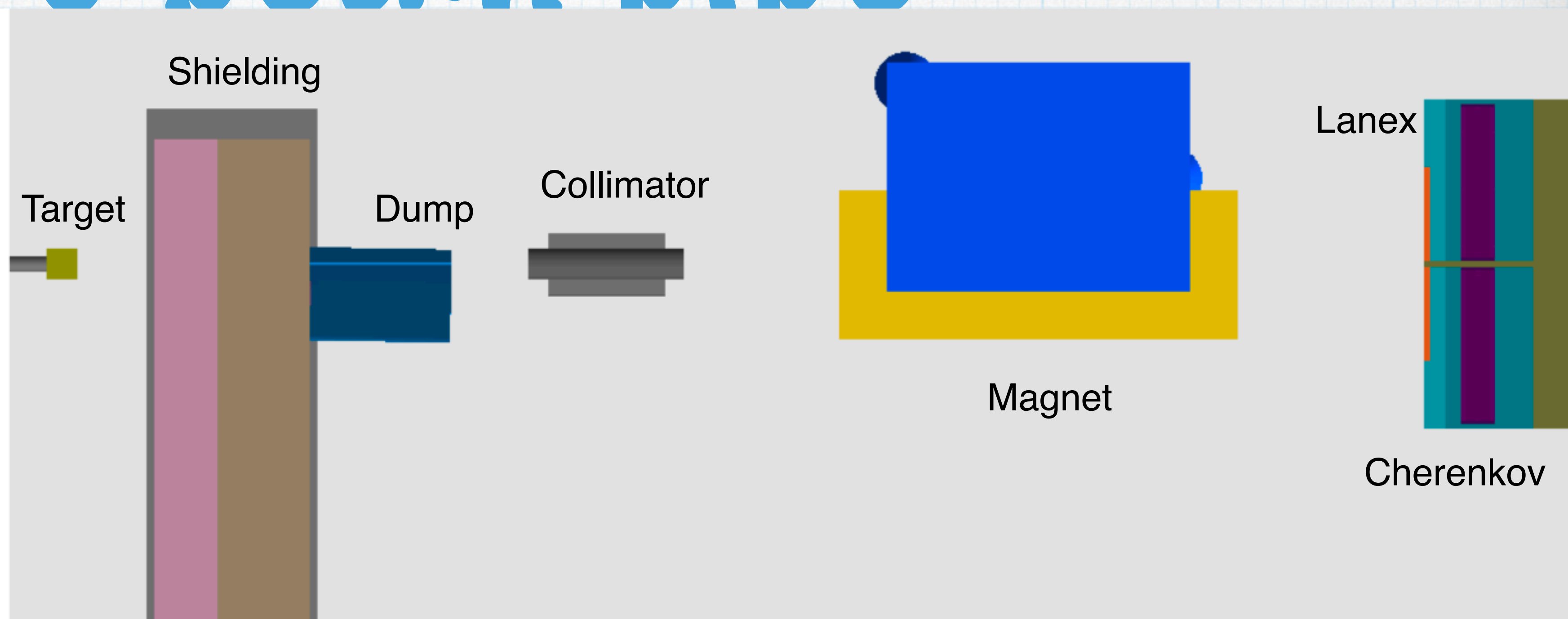
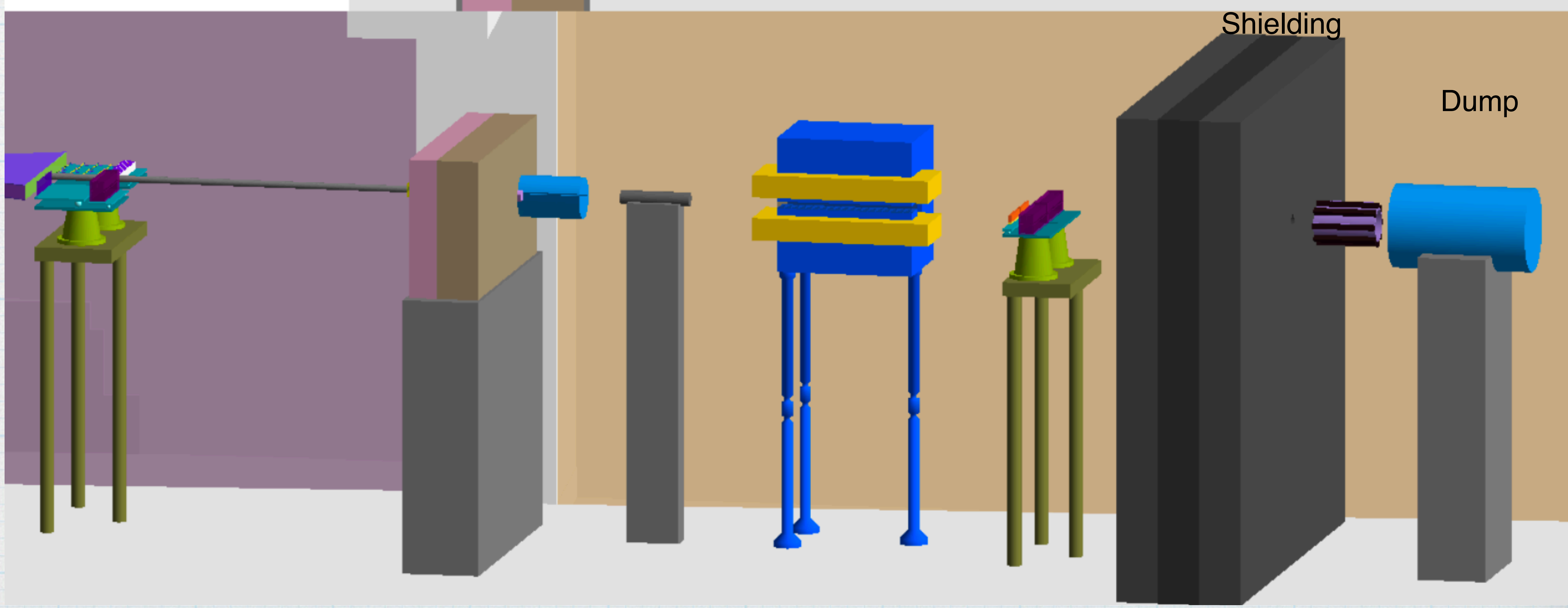
20/10/20
LUXE weekly technical meeting

LUXE

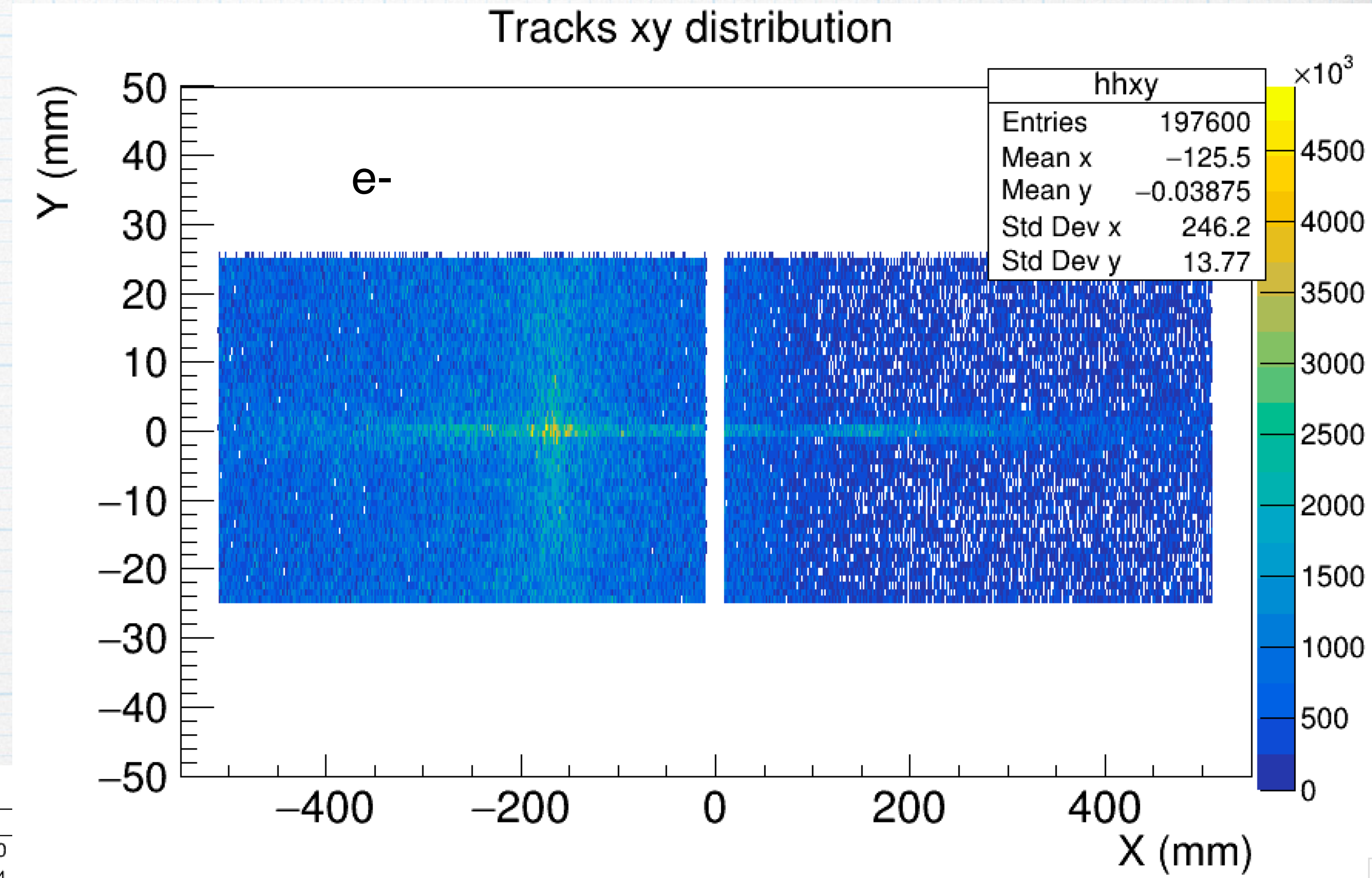
Forward detector system w/o beam pipe

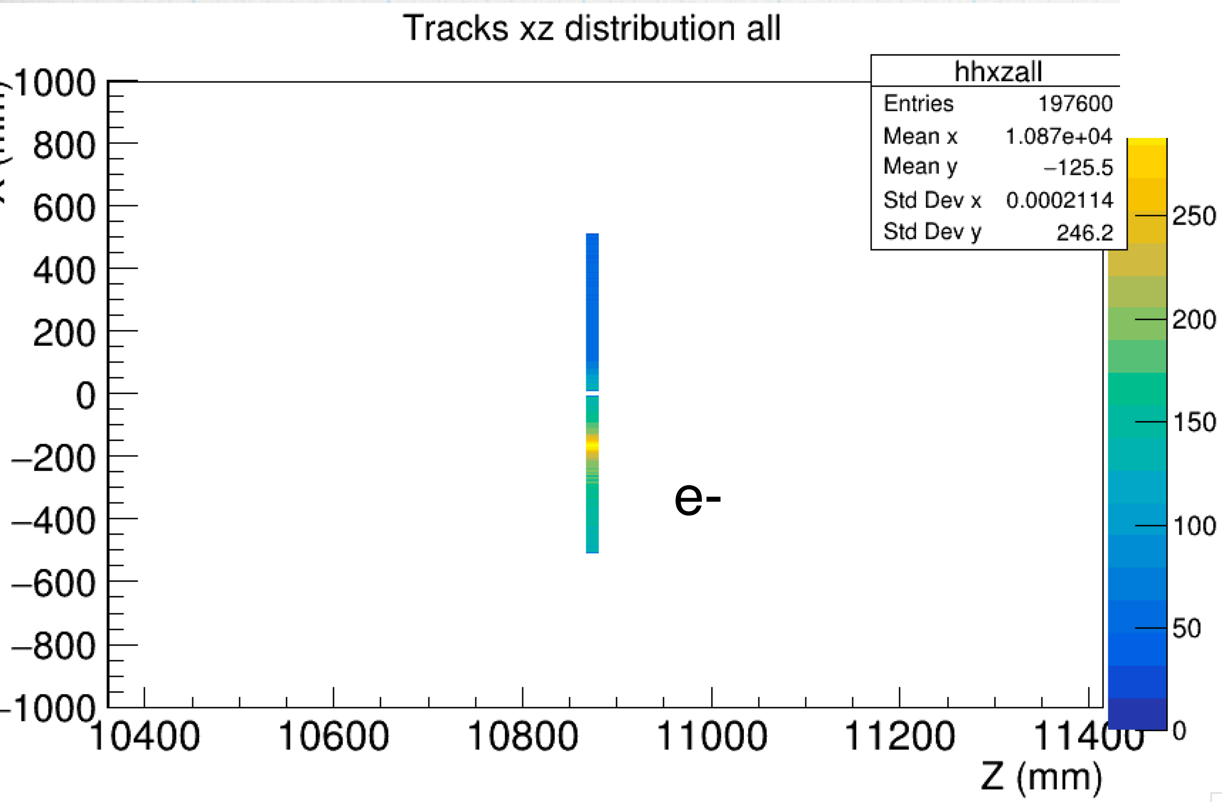
- The screens are modelled as a 30cm x 5cm x 0.5mm (x:y:z) layer of LANEX material
- The number of pixels in the screens 25 x 300.



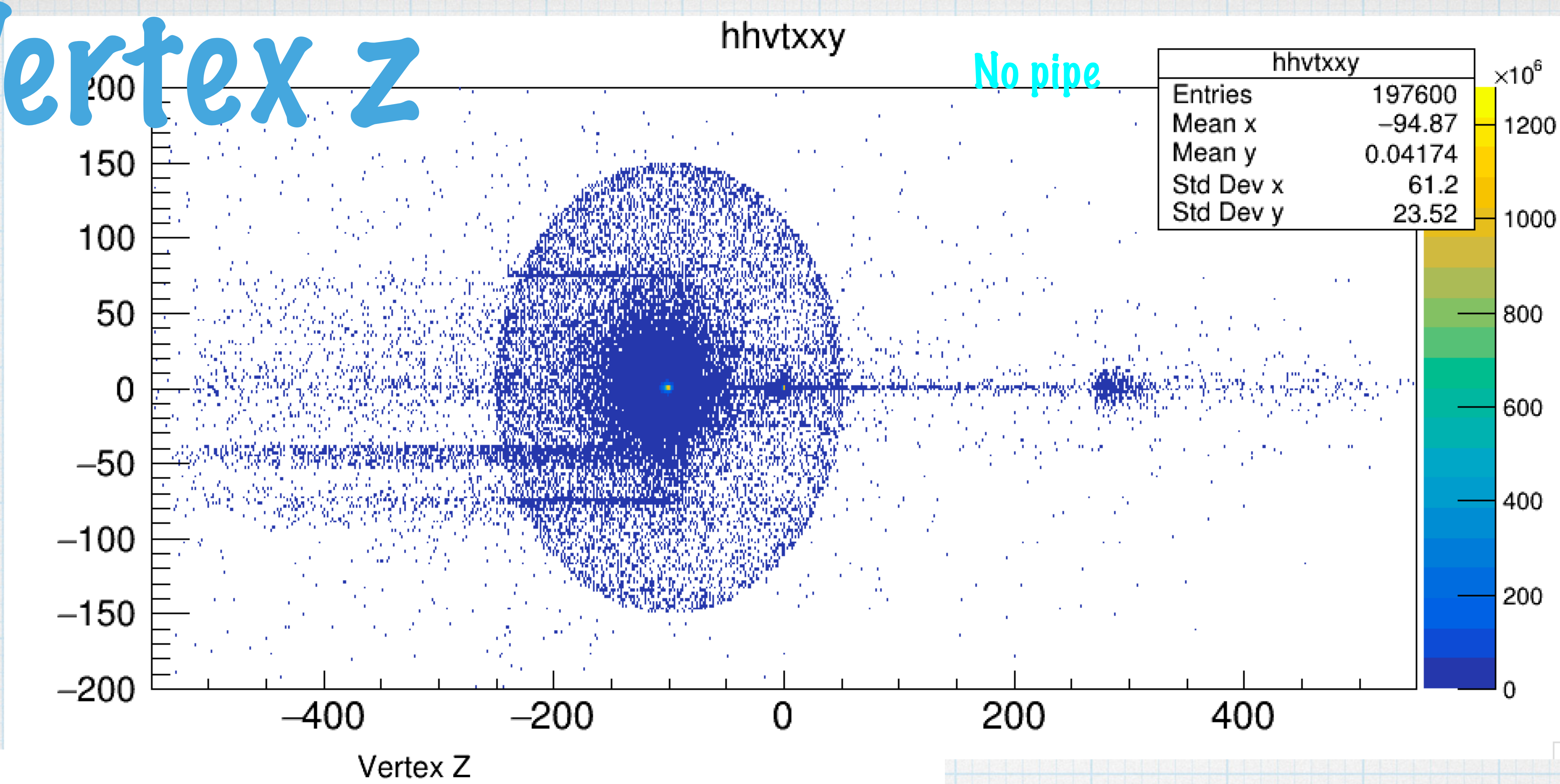


~4700BX out of 5000 BX at the laser intensity xi = 0.3 for 16.5 GeV electron beam

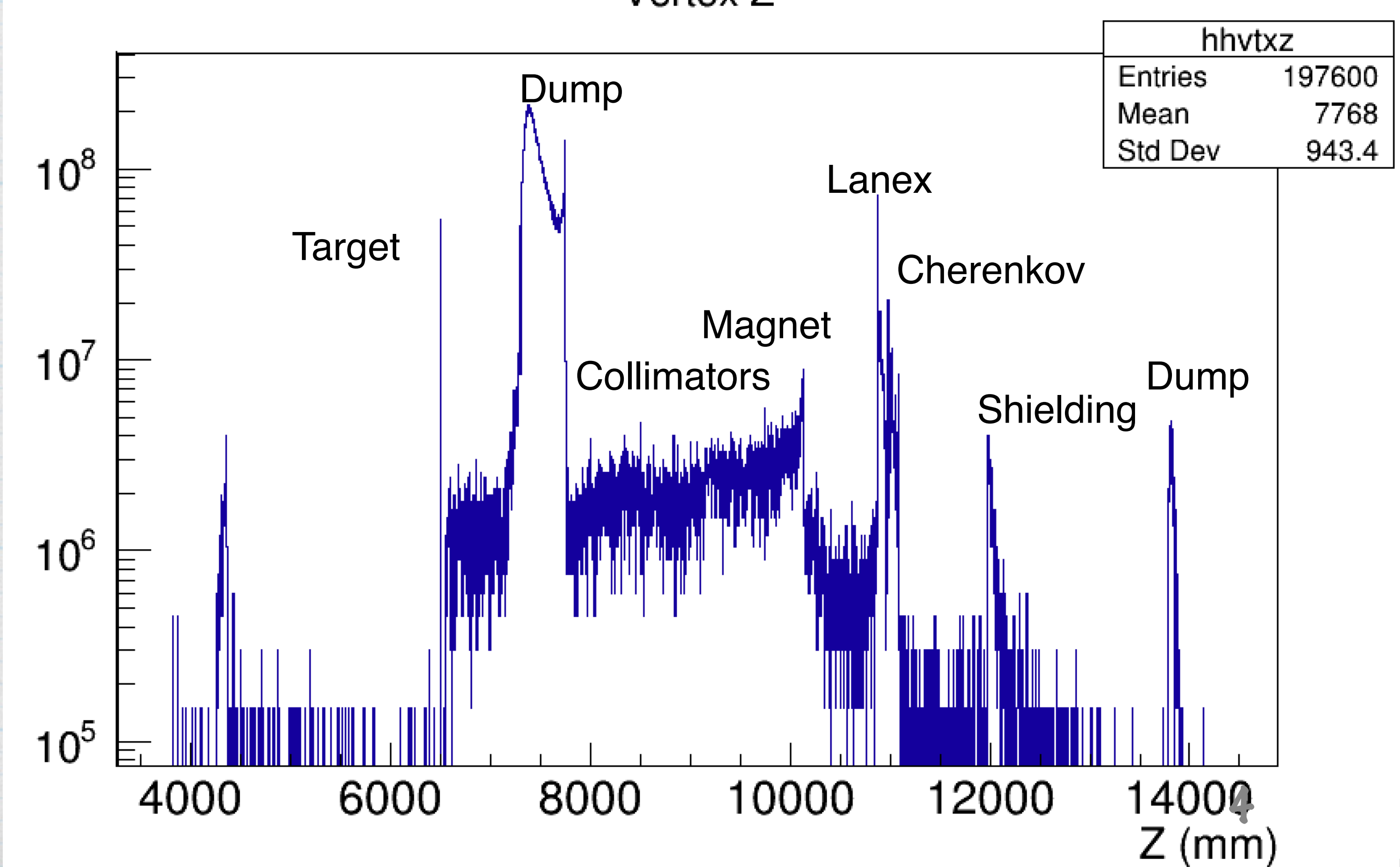




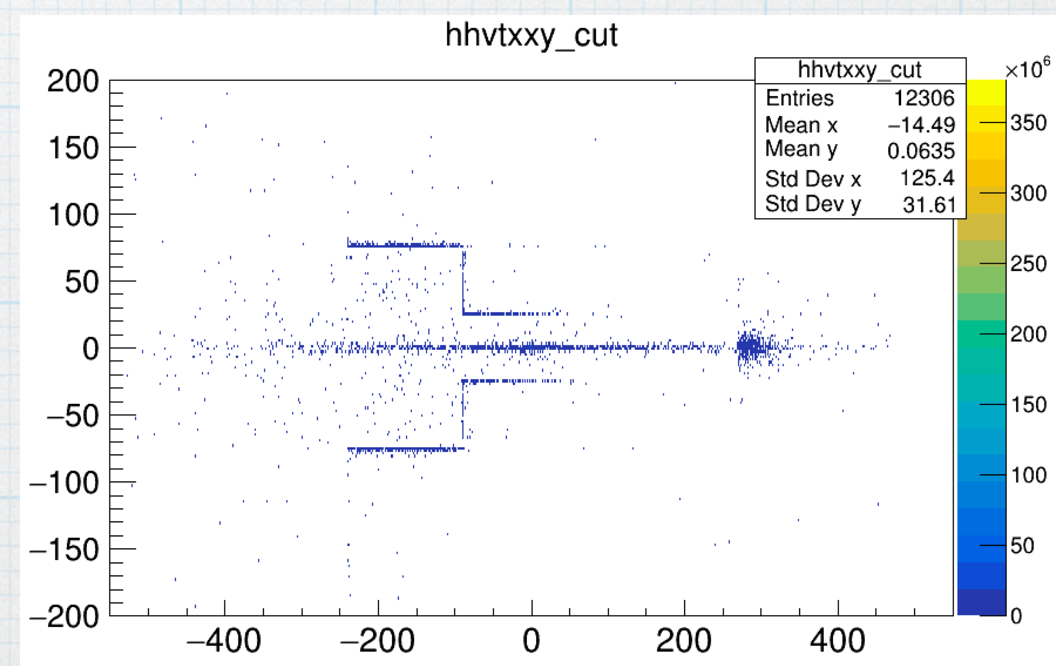
Vertex z



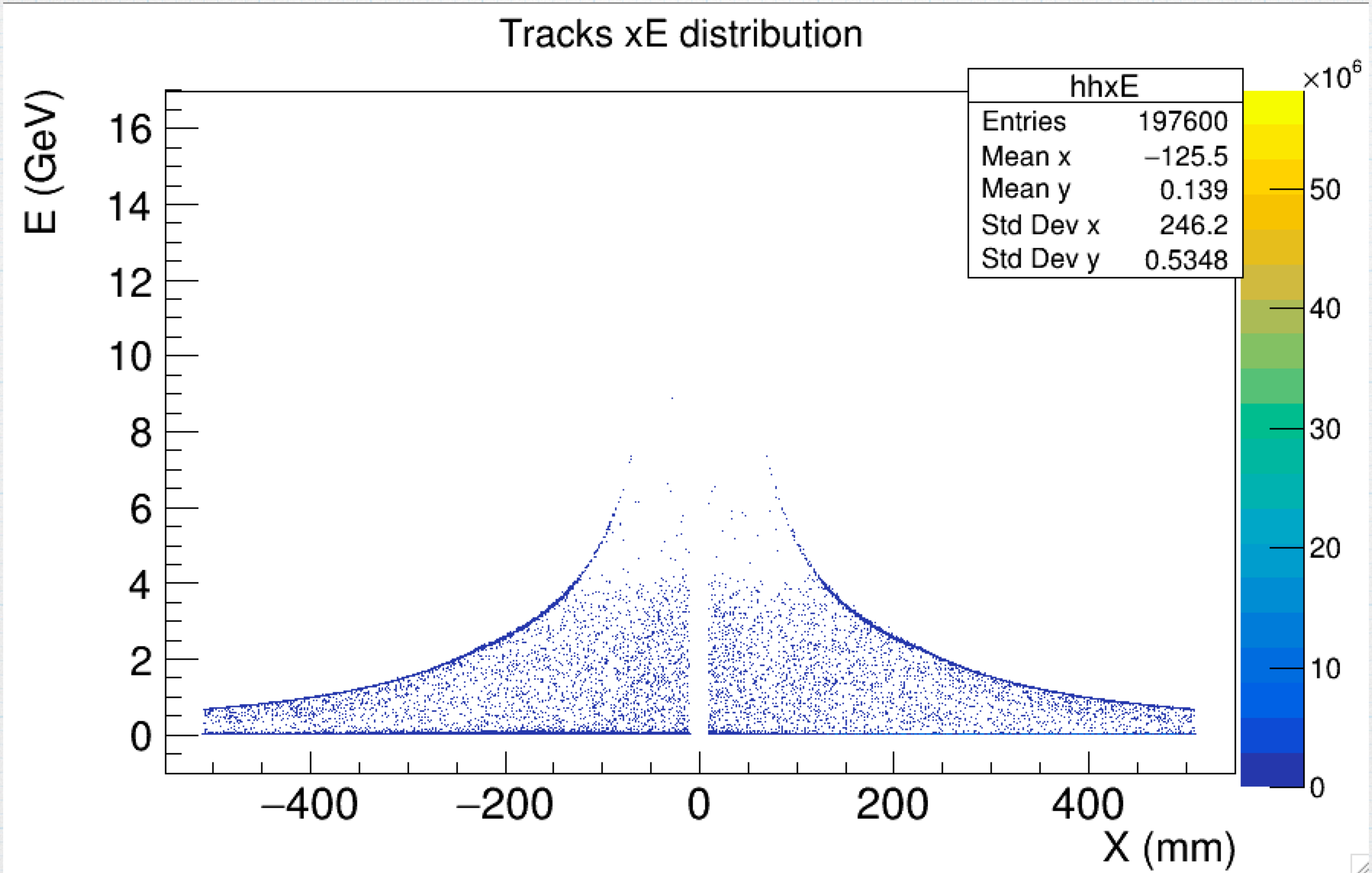
hhvtxxy
No pipe
hhvtxxy
Entries 197600
Mean x −94.87
Mean y 0.04174
Std Dev x 61.2
Std Dev y 23.52
×10^6
1200
1000
800
600
400
200
0
200
150
100
50
0
−50
−100
−150
−200
−400
−200
0
200
400
Vertex Z



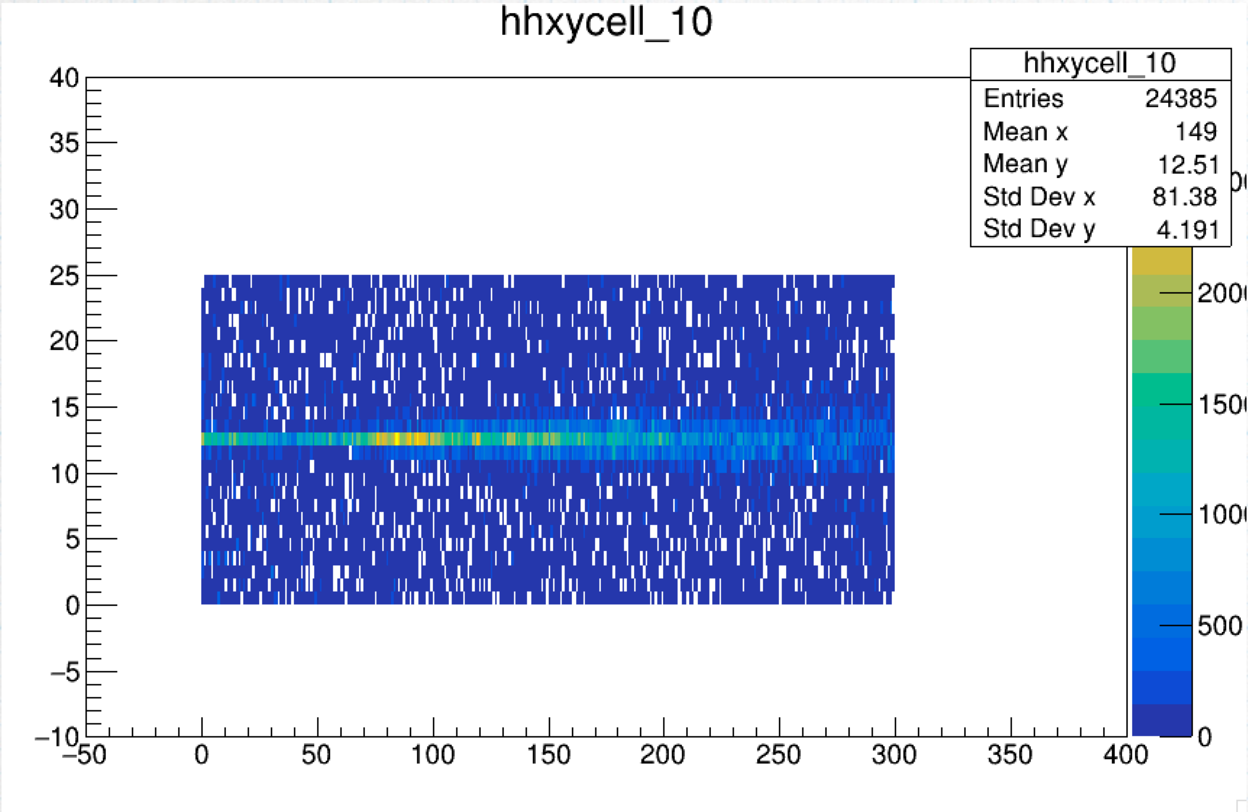
hhvtxz
Entries 197600
Mean 7768
Std Dev 943.4
Dump
Target
Lanex
Cherenkov
Magnet
Collimators
Shielding
Dump
10^8
10^7
10^6
10^5
4000
6000
8000
10000
12000
14000
Z (mm)

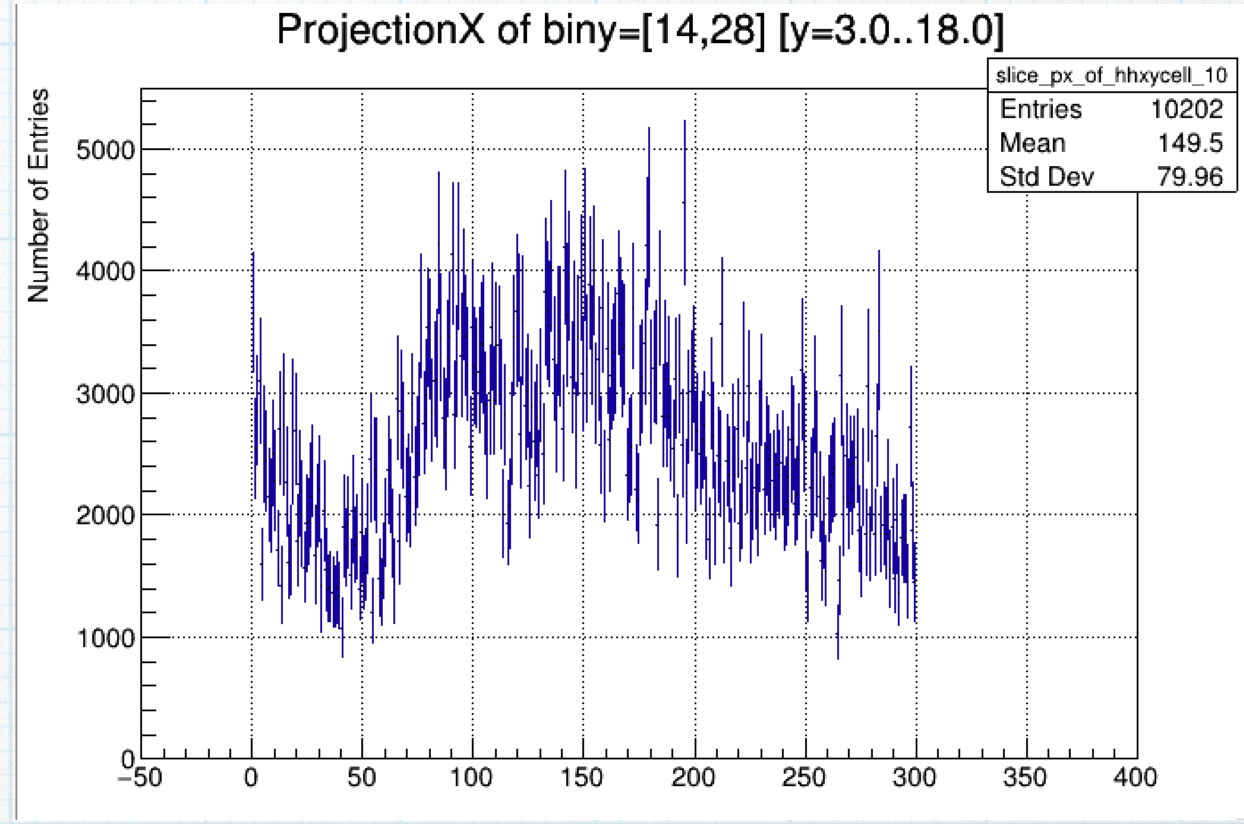


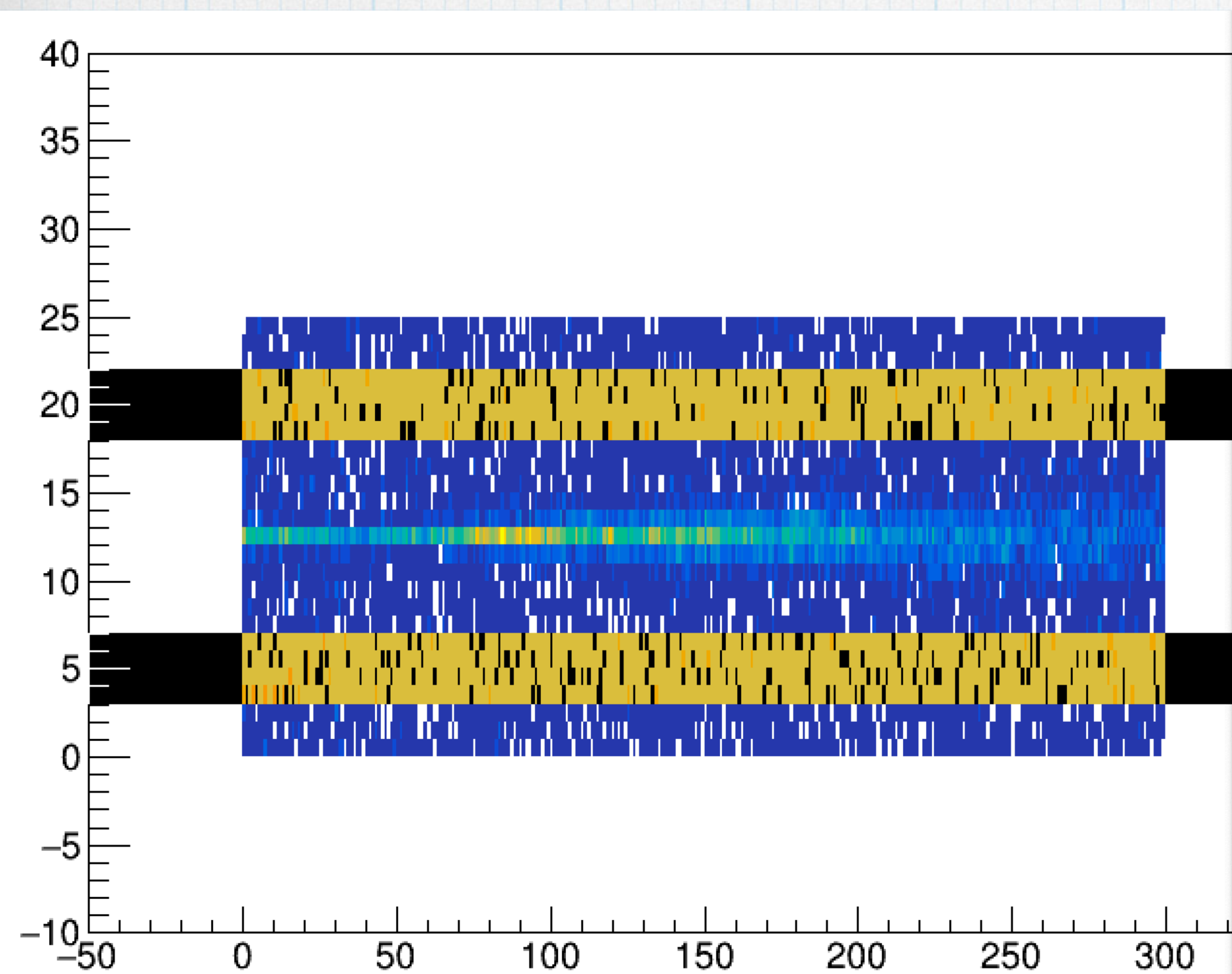
hhvtxxy_cut
hhvtxxy_cut
Entries 12306
Mean x −14.49
Mean y 0.0635
Std Dev x 125.4
Std Dev y 31.61
×10^6
350
300
250
200
150
100
50
0
200
150
100
50
0
−50
−100
−150
−200
−400
−200
0
200
400

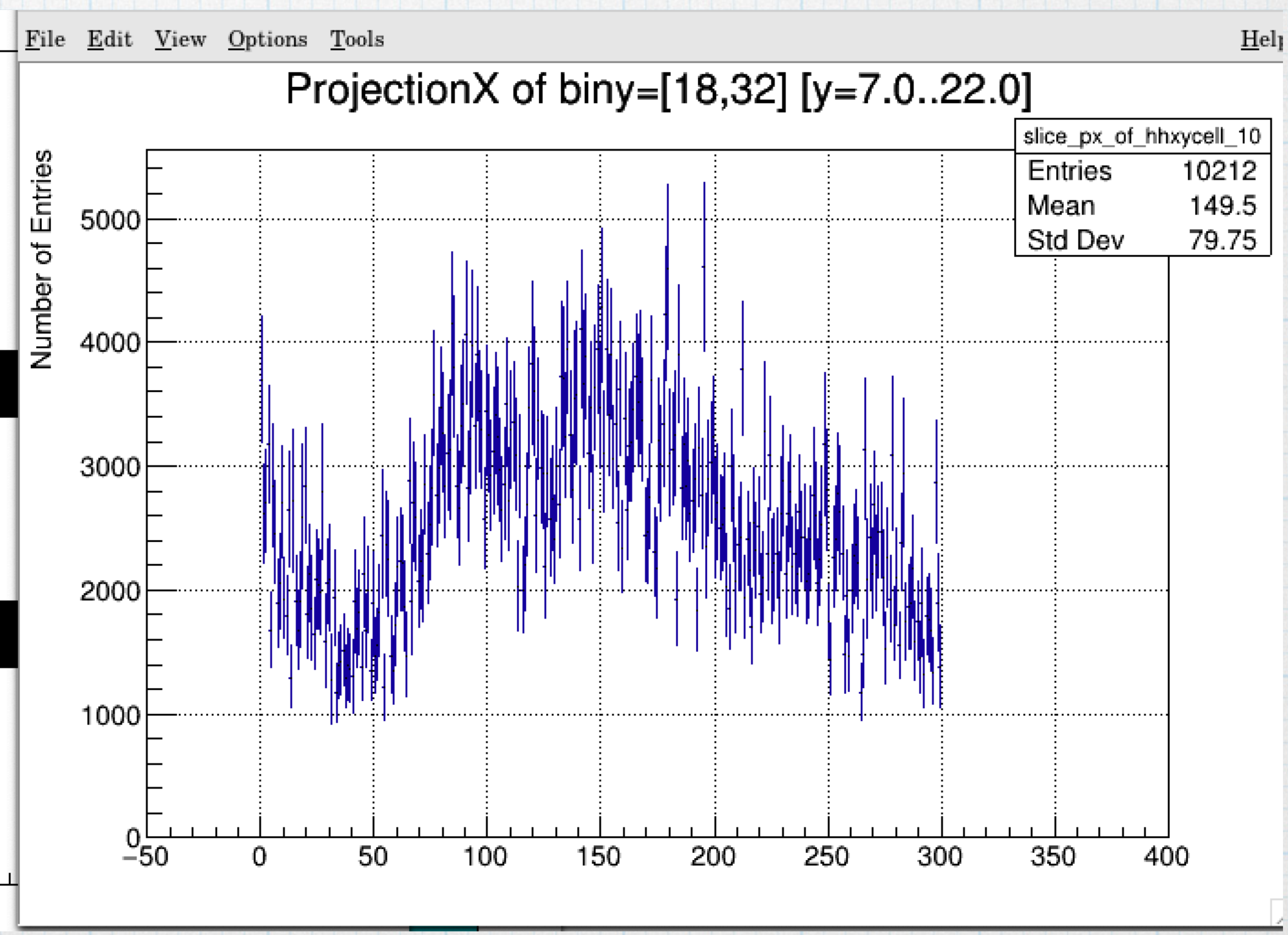


Tracks xE distribution
hhxE
Entries 197600
Mean x −125.5
Mean y 0.139
Std Dev x 246.2
Std Dev y 0.5348
E (GeV)
X (mm)
$\times10^6$
0
10
20
30
40
50
16
14
12
10
8
6
4
2
0
−400
−200
0
200
400


hhxycell_10
hhxycell_10
Entries 24385
Mean x 149
Mean y 12.51
Std Dev x 81.38
Std Dev y 4.191


ProjectionX of biny=[14,28] [y=3.0..18.0]
slice_px_of_hhxycell_10
Entries 10202
Mean 149.5
Std Dev 79.96
Number of Entries




File Edit View Options Tools
ProjectionX of biny=[18,32] [y=7.0..22.0]
slice_px_of_hhxycell_10
Entries 10212
Mean 149.5
Std Dev 79.75
Number of Entries

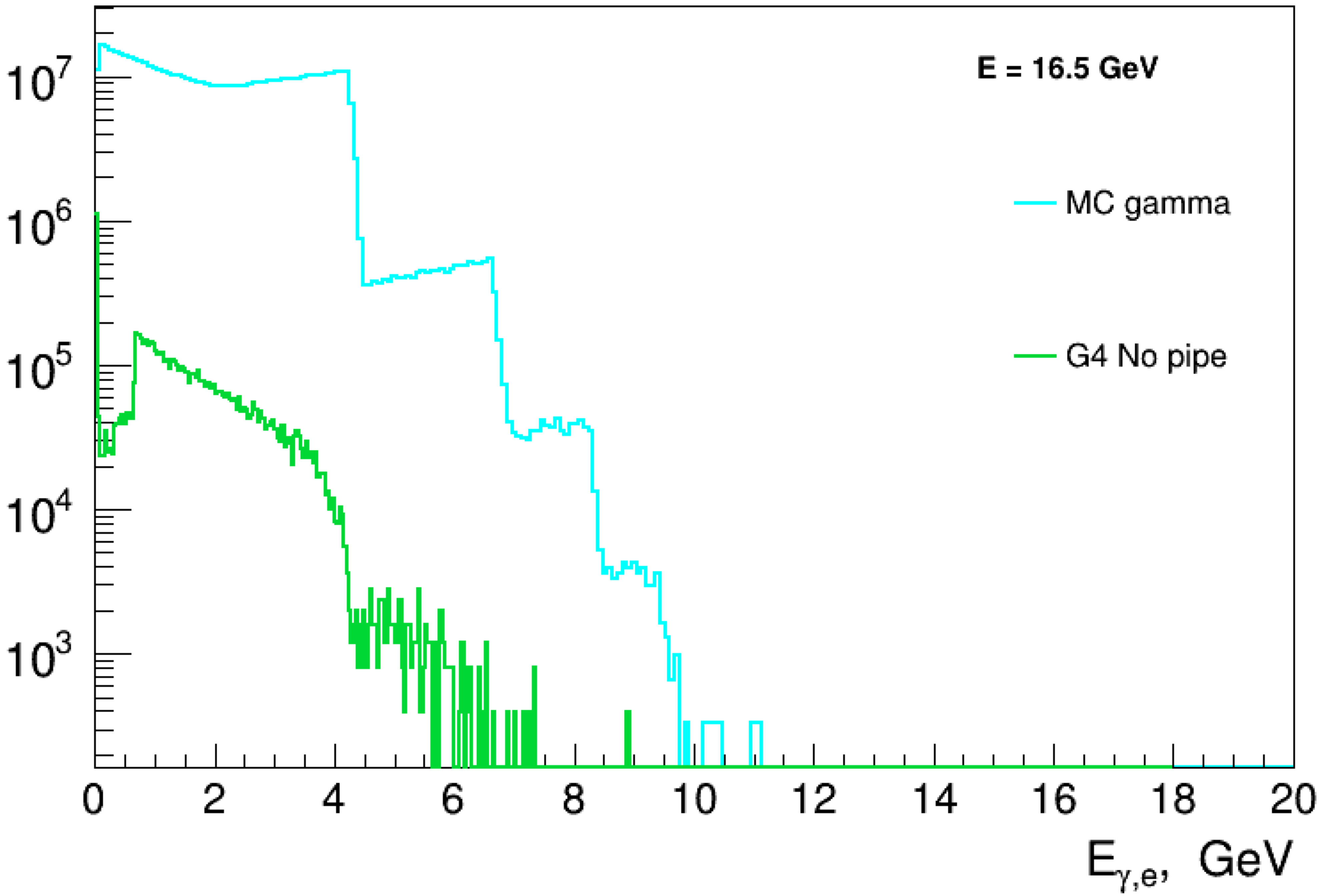
Summary

* The performance of FDS setup w/o beam pipe from the target to Compton detectors was studied

* positron spectrum look reasonable but electron spectrum is very contaminated

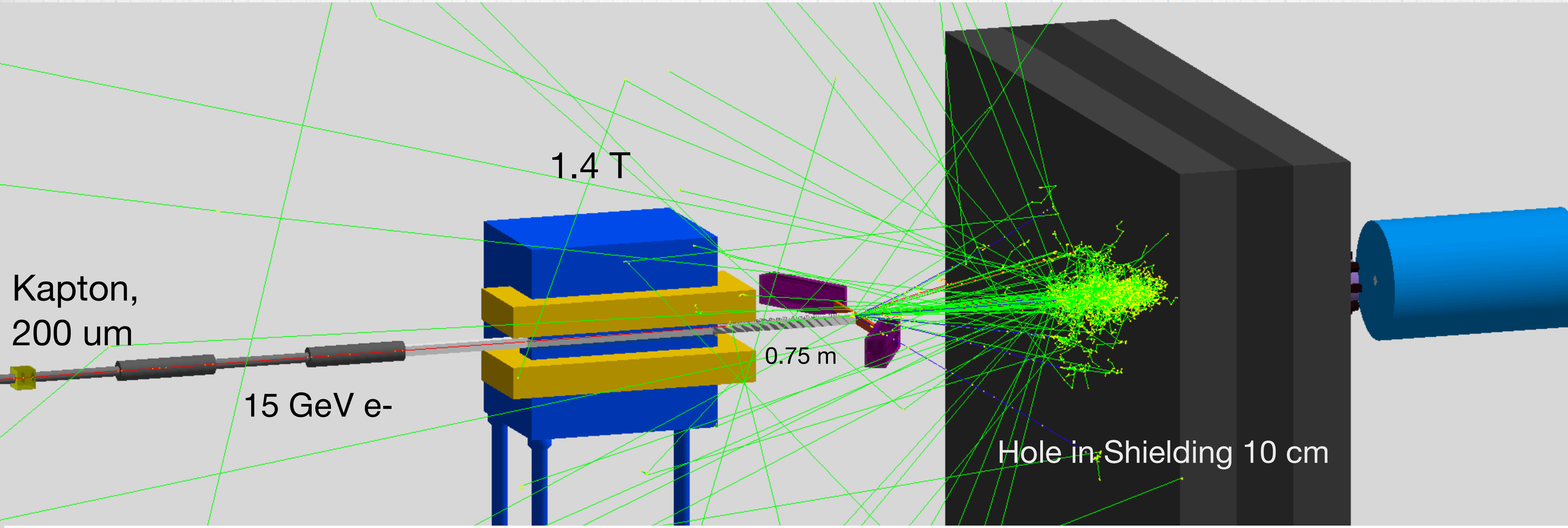
* Not sufficient Shielding w/ electron dump creates substantial background occupancy in Lanex detectors.

Back up



E = 16.5 GeV
MC gamma
G4 No pipe
10^7
10^6
10^5
10^4
10^3
0
2
4
6
8
10
12
14
16
18
20
$E_{\gamma,e}$, GeV

FDS with LYSO calorimeters



Aug 2020 Data Runs, bunch/pulse crossings completed

Experiment Config	$w_0 = 3\mu$m	$w_0 = 3.5\mu$m	$w = 0, 4.0\mu$m	$w_0 = 4.5\mu$m	$w_0 = 5.0\mu$m	$w_0 = 8.0\mu$m	$w_0 = 20.0\mu$m	$w_0 = 50.0\mu$m	$w_0 = 100.0\mu$m
peak SQED ξ	5.12	4.44	3.88	3.45	3.1	1.94	0.78	0.31	0.15
peak SQED χ (16.5 GeV)	0.9	0.79	0.69	0.61	0.55	0.34	0.138	0.055	0.028
JETI40 e-laser 16.5 GeV	10000	1000	1000	1000	1000	1000	500	5000	500

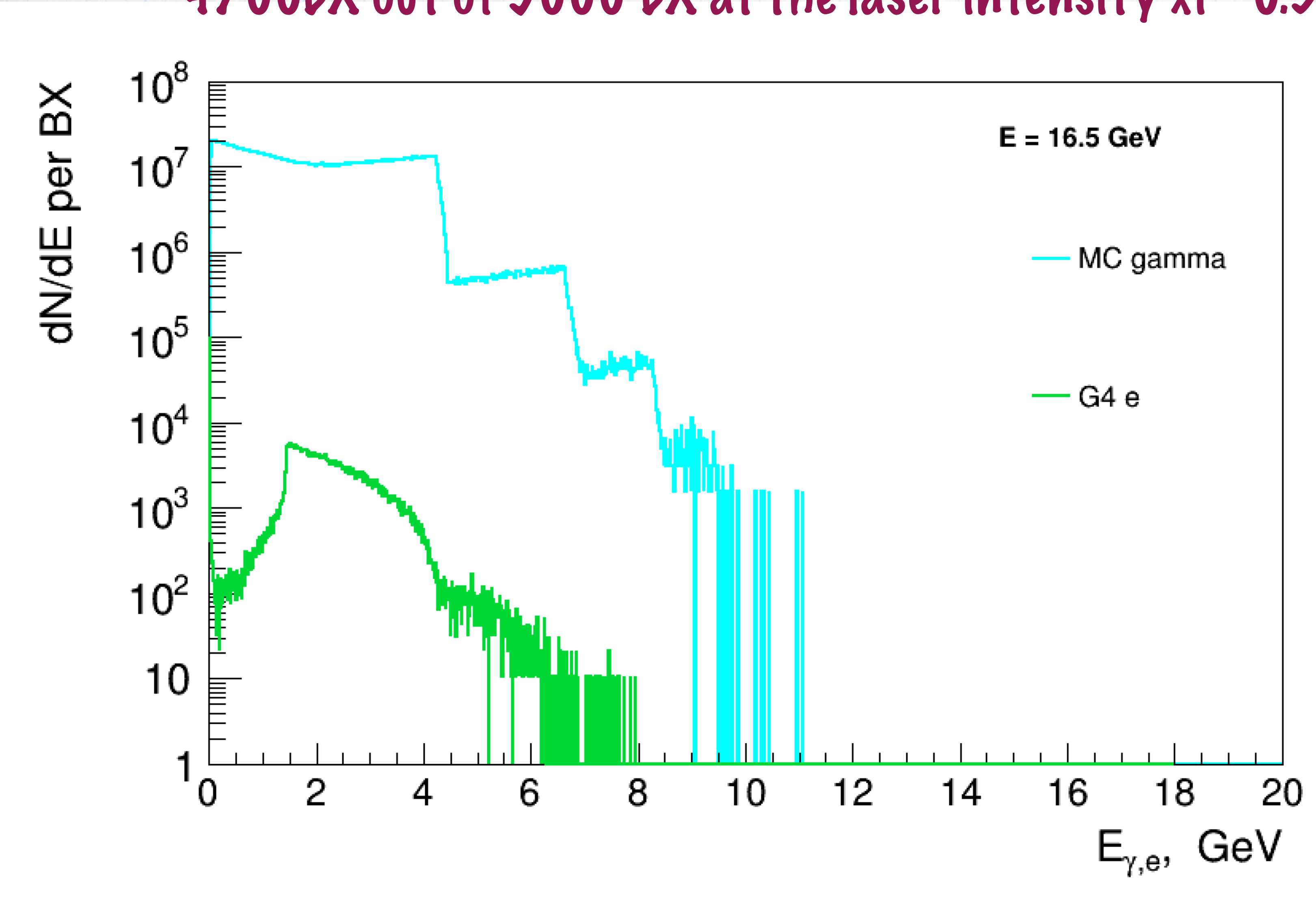
- The scintillators are modelled as a 15x5x2 cm (x:y:z) layer of lyso material
- The crystal (bin) size of the scintillators are 2 x 1 mm (finer segmentation in x; the deflection direction) giving 25 x 300 bins.

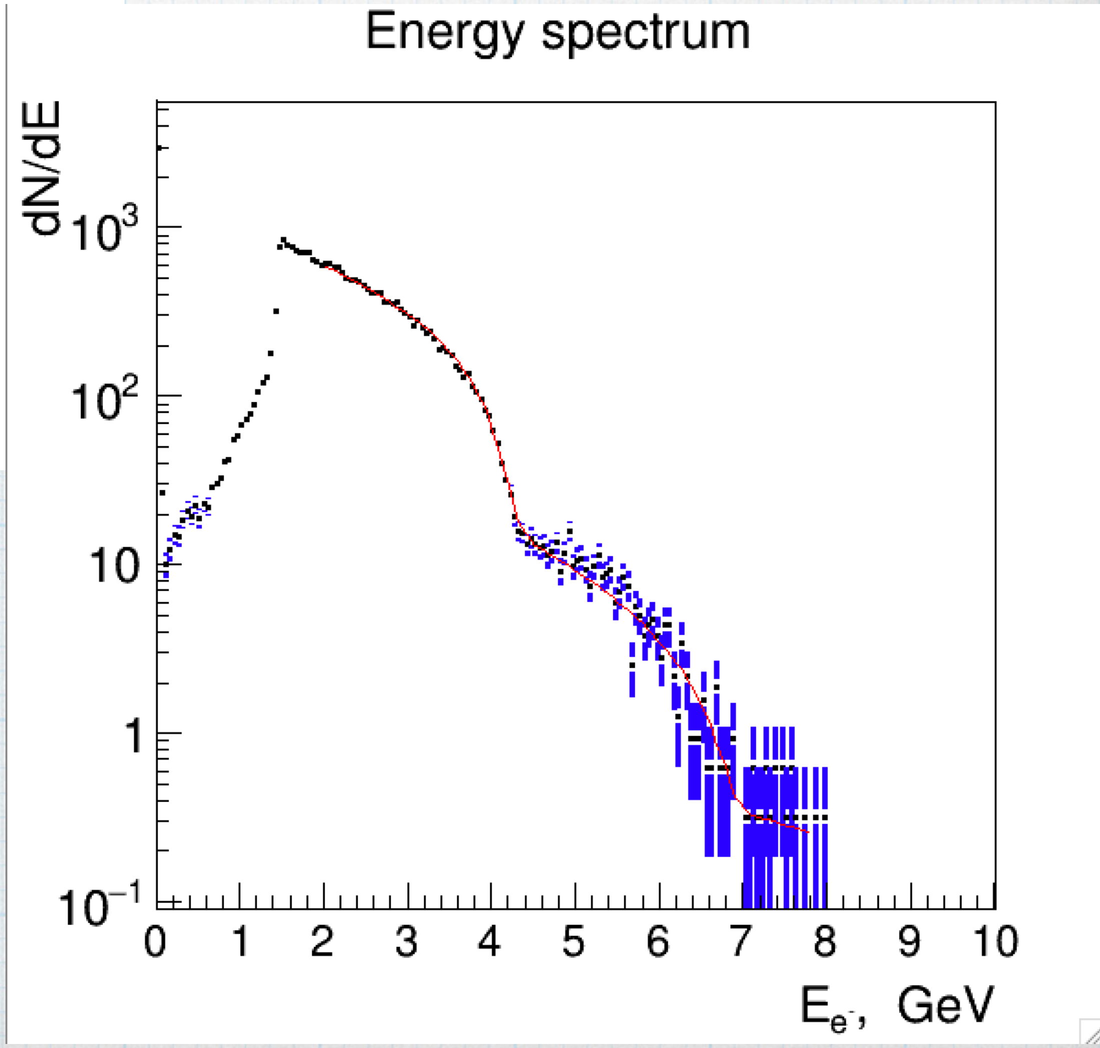
LYSO $(Lu_{1.8}Y_{0.2}SiO_5)$

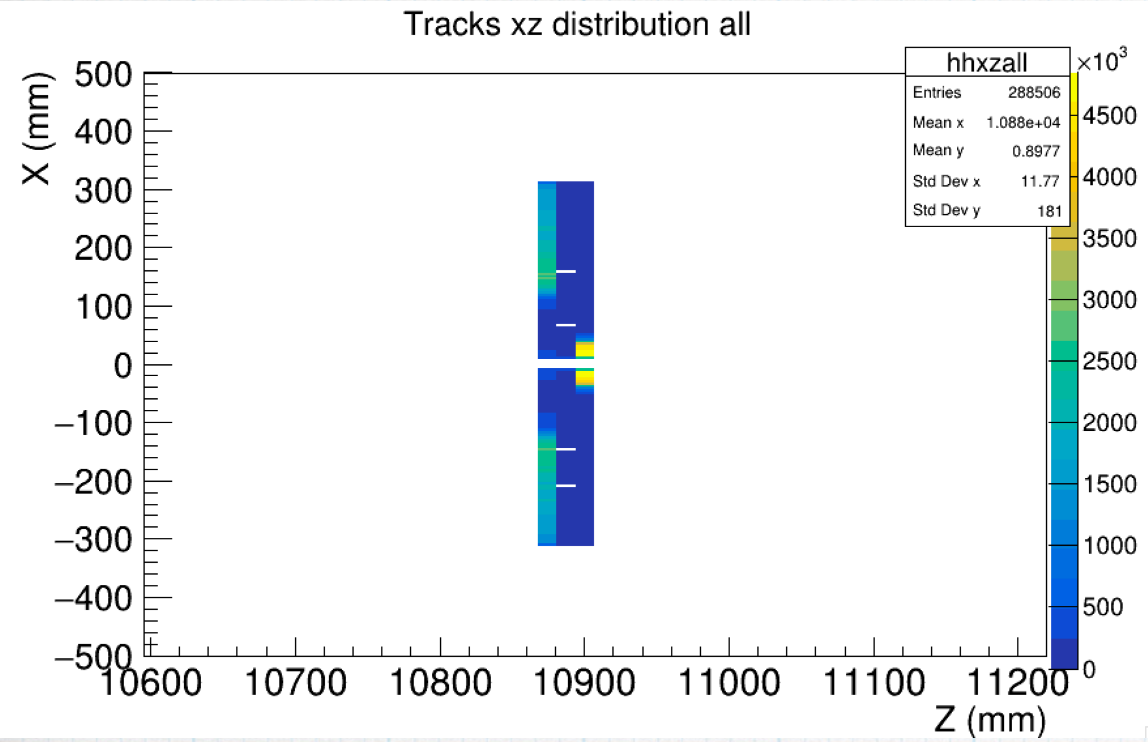
All studies were performed with 5000 BX at the laser intensity xi = 0.3 for 16.5 GeV electron beam

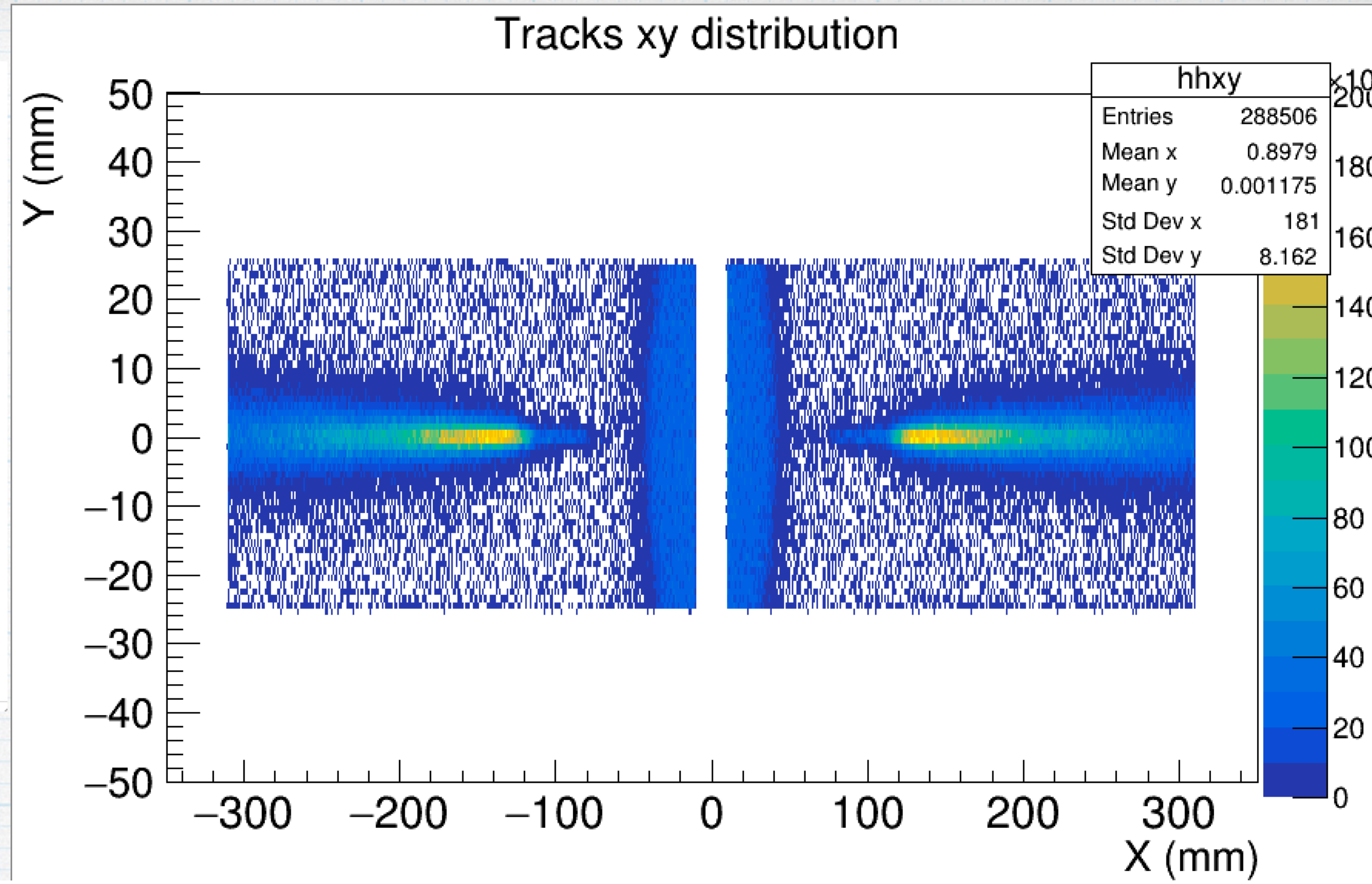
Spectra MC vs G4

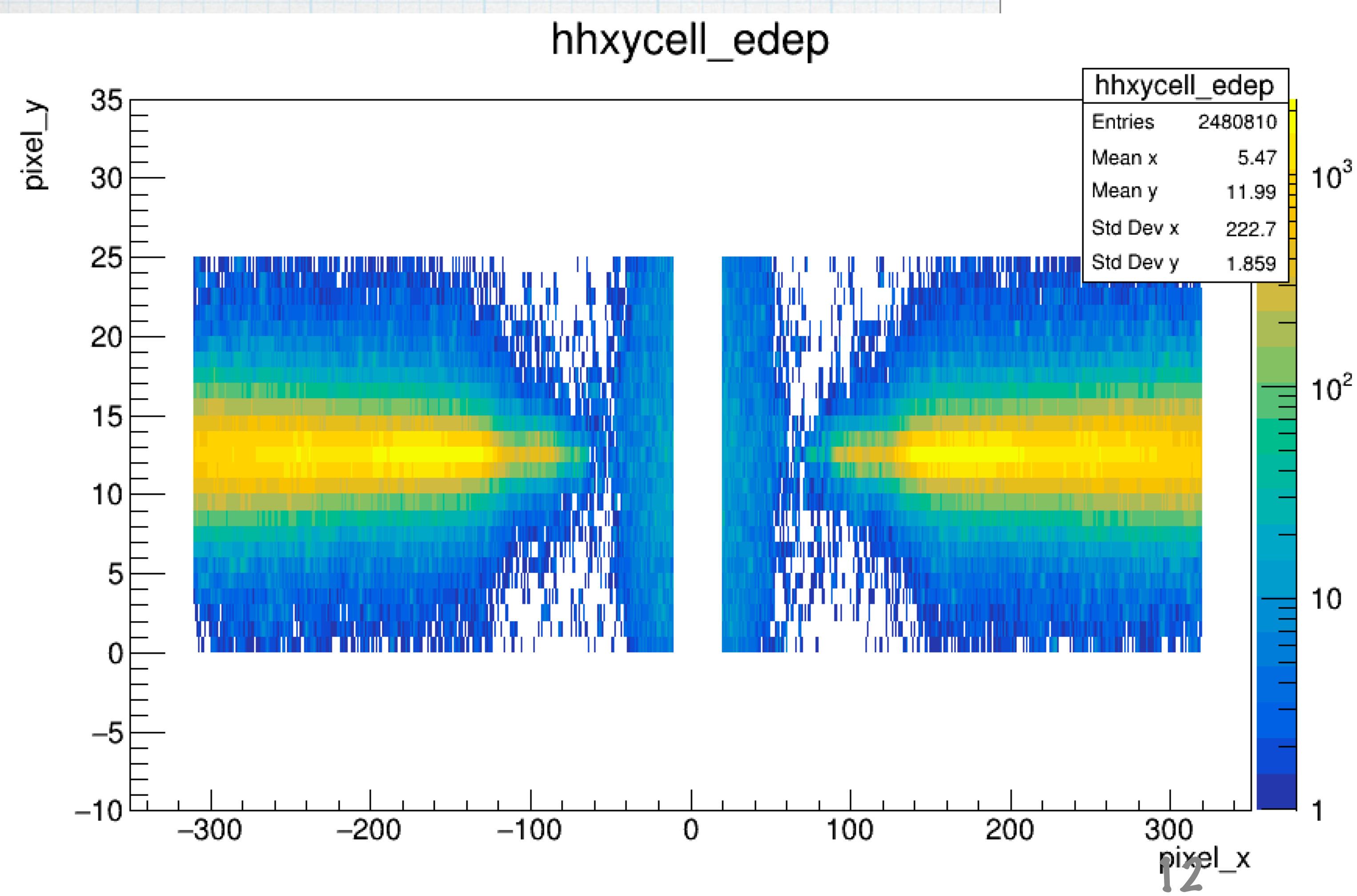
~4700BX out of 5000 BX at the laser intensity xi = 0.3 for 16.5 GeV electron beam

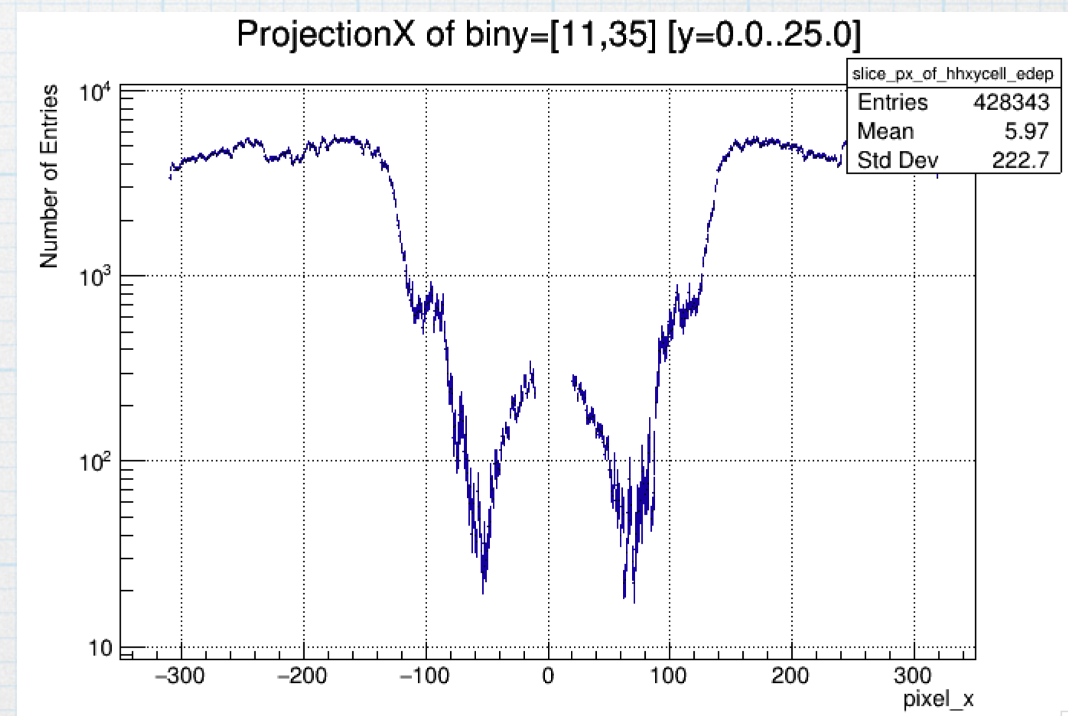





Tracks xz distribution all
hhxzall
Entries 288506
Mean x 1.088e+04
Mean y 0.8977
Std Dev x 11.77
Std Dev y 181
×10^3
X (mm)
Z (mm)


Tracks xy distribution
hhxy
Entries 288506
Mean x 0.8979
Mean y 0.001175
Std Dev x 181
Std Dev y 8.162
×10^3
Y (mm)
X (mm)

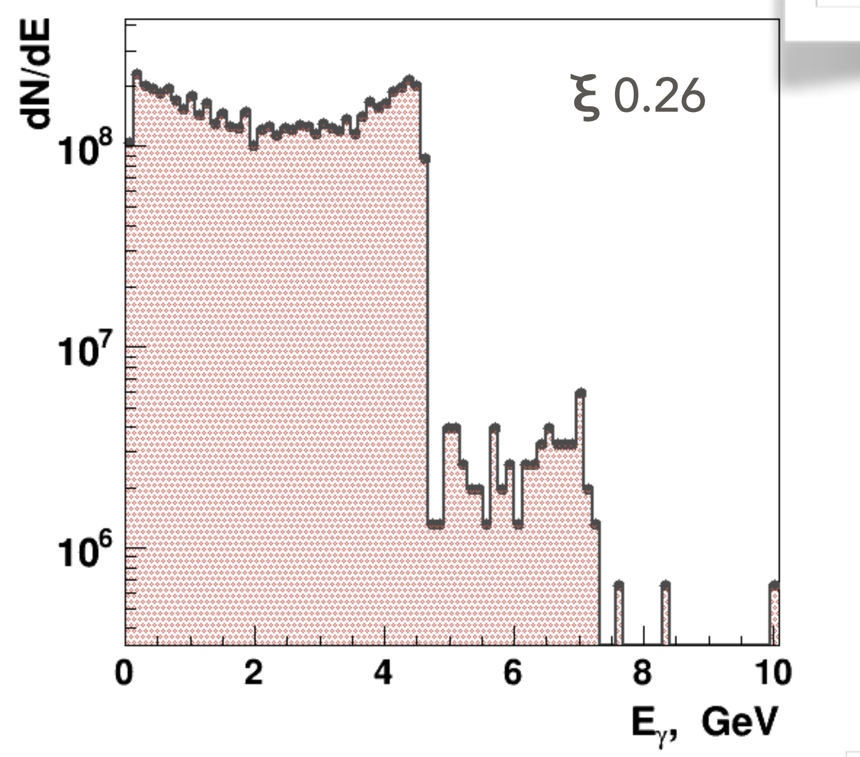

hhxycell_edep
hhxycell_edep
Entries 2480810
Mean x 5.47
Mean y 11.99
Std Dev x 222.7
Std Dev y 1.859
pixel_y
pixel_x


ProjectionX of biny=[11,35] [y=0.0..25.0]
slice_px_of_hhxycell_edep
Entries 428343
Mean 5.97
Std Dev 222.7
Number of Entries
pixel_x

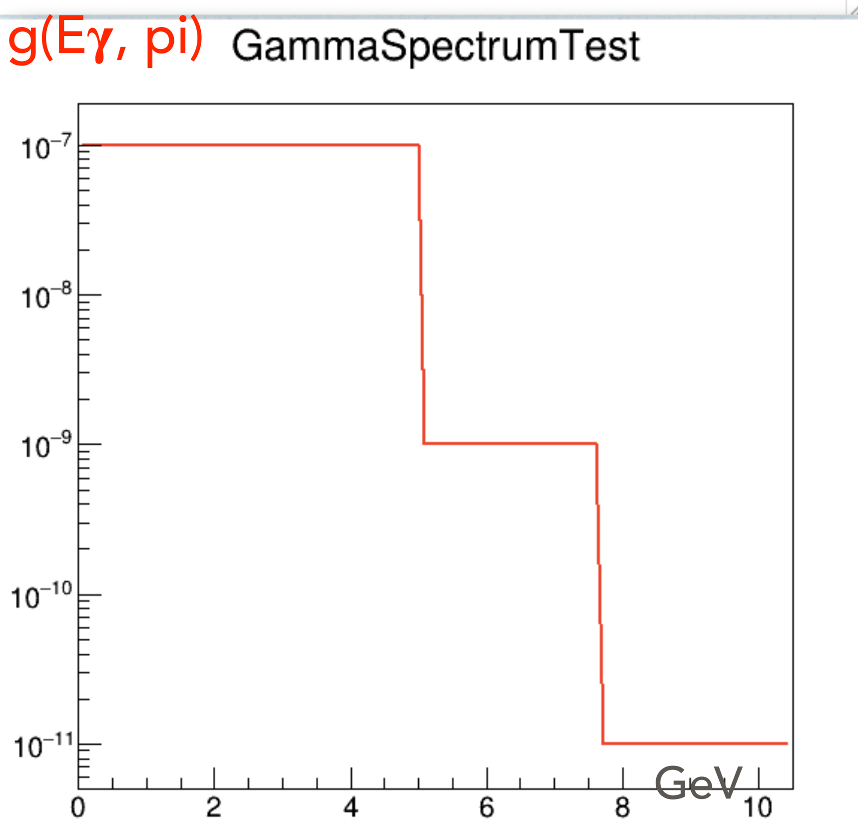
Kinematic edges with accurate pair spectrum

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

g(Eγ)

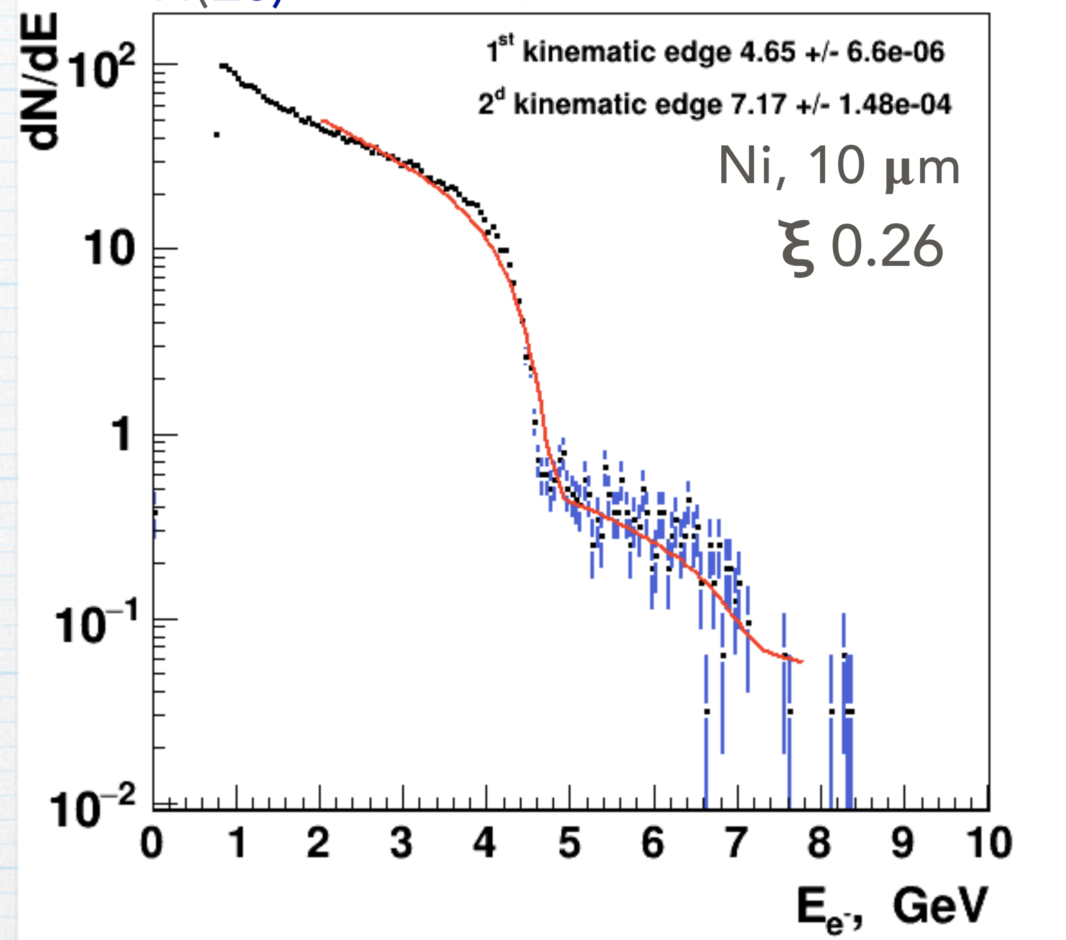


g(Eγ, pi)



The single-particle spectrum obtained in GEANT4 is compared to a **model spectrum** calculated by convolving the trial **photon spectrum** with the **Bethe-Heitler cross section**

N(Ee)



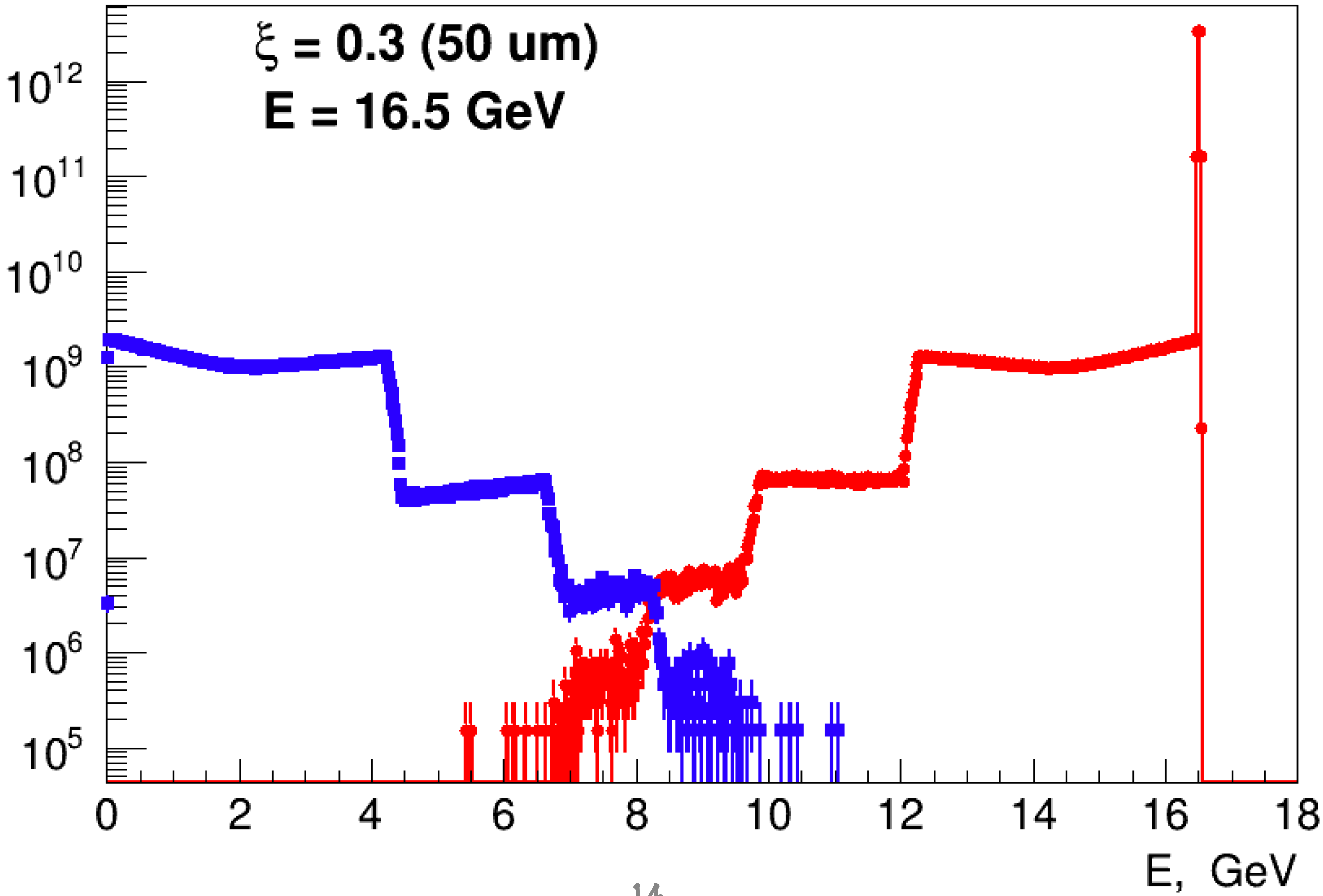
$$\int \sigma(E_\gamma, E_e)\,g(E_\gamma,p1,p2)\,dE_\gamma$$

fitting allows finding **the kinematic edges** quite well

True electron/photon spectra

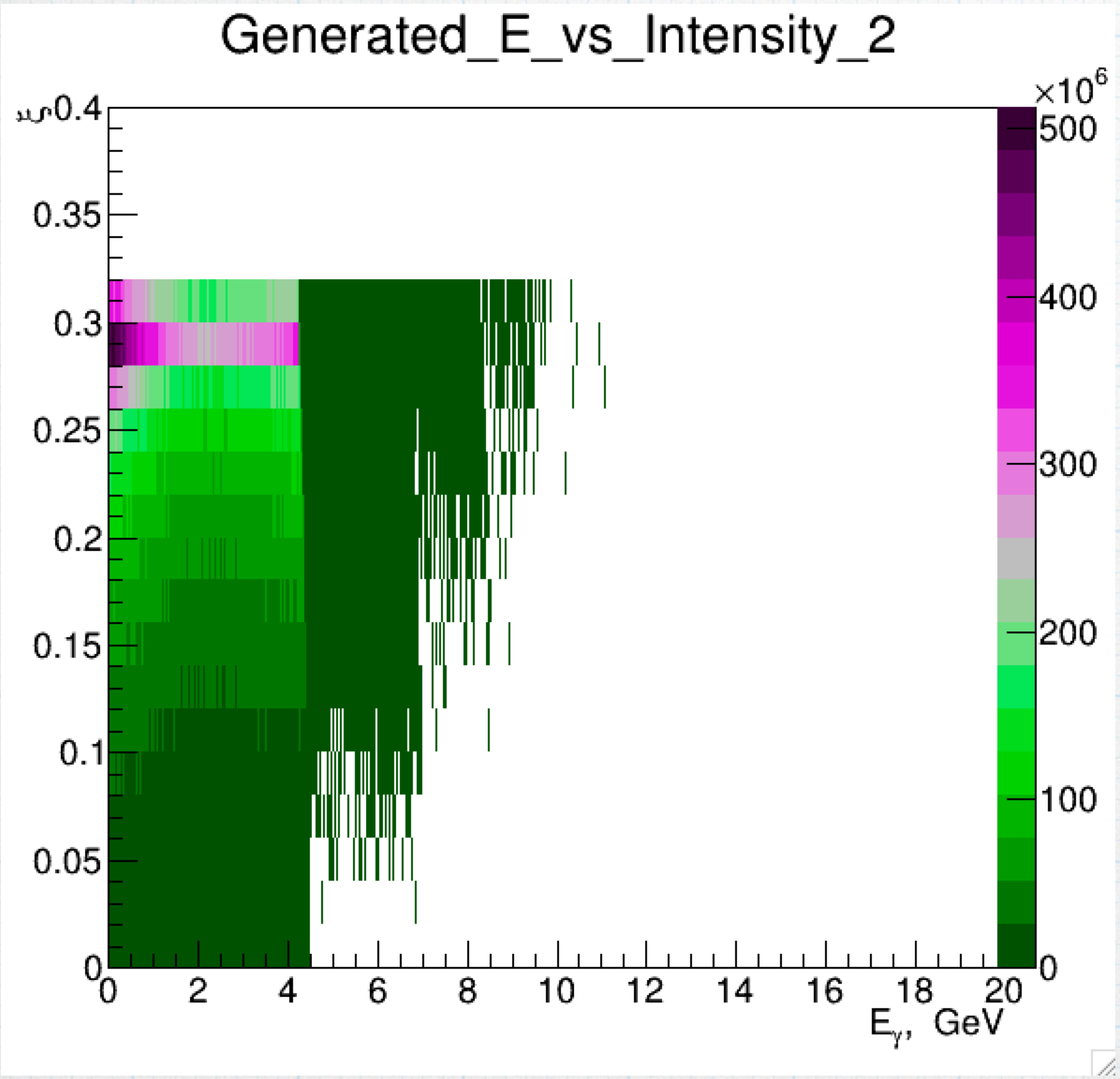
4764BX out of 5000 BX at the laser intensity xi = 0.3 for 16.5 GeV electron beam

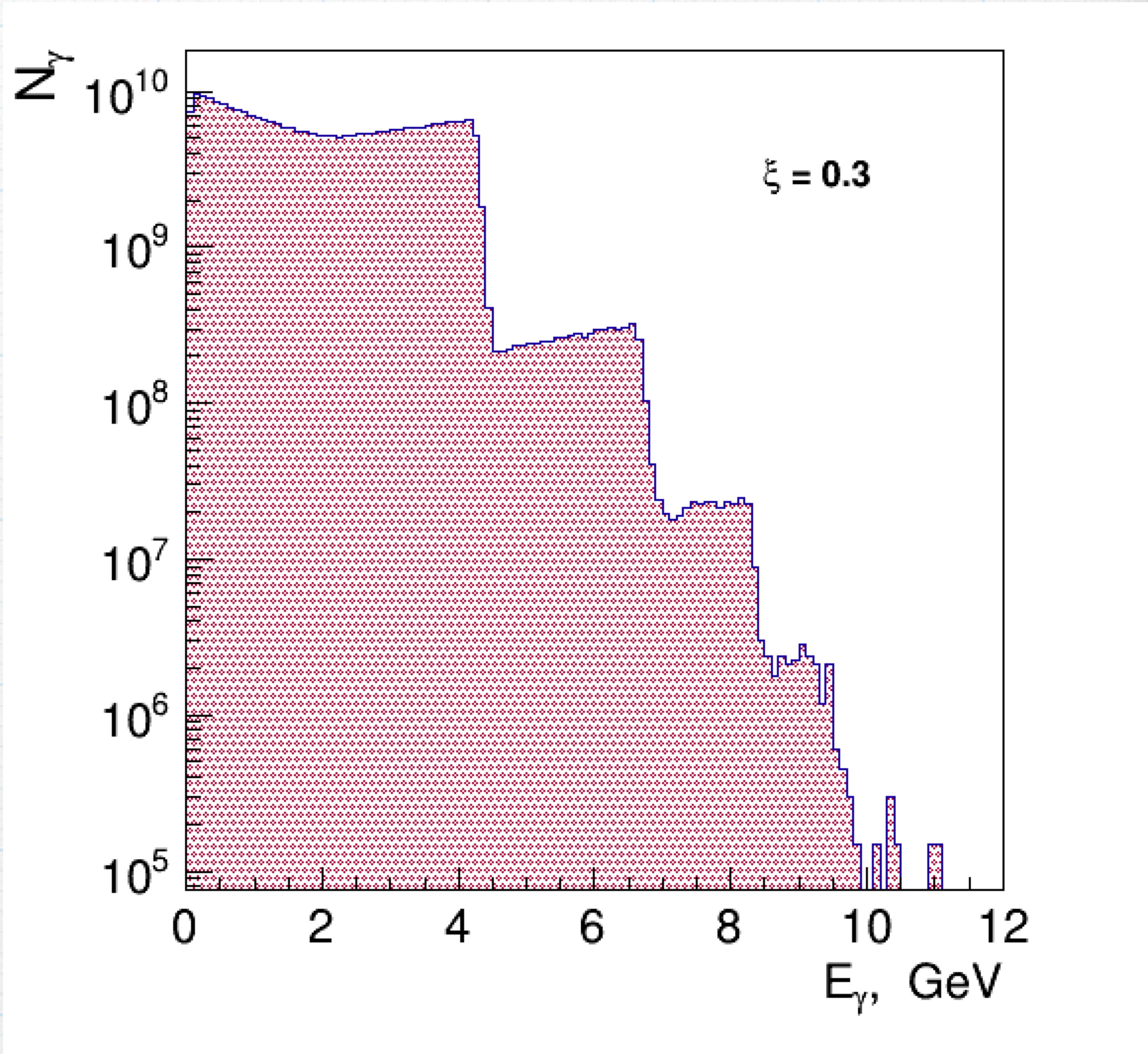
(~5% of files have NaN so they are ignored)



ξ vs photon energy in MC

5000 BX at the laser intensity xi = 0.3 for 16.5 GeV electron beam





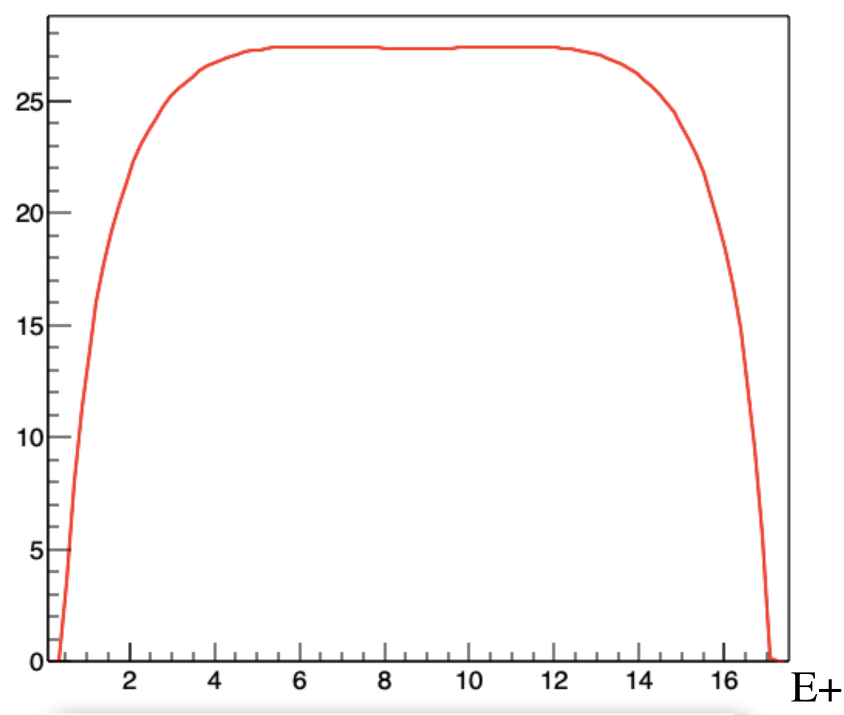
Photon spectra reconstruction using Bethe-Heitler pair spectrum

The classical Bethe-Heitler formula (H.Bethe, W.Heitler, Proc.Roy.Soc.A146 (34)83)

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

energies involved are large compared with mc^2

$\Phi(E+, E_0=E\gamma)$



$\sigma(E\gamma, Ee) = \Phi(E\gamma, Ee) * N_a$ N_a - Number of atoms

- Photon spectra $g(E\gamma)$ can be reconstructed by fitting

  $N(Ee) = \int \sigma(E\gamma, Ee)\, g(E\gamma)\, dE\gamma$

  Where N(Ee) positron/electron spectra measured in detector after the conversion.

- Since $\sigma(E\gamma, Ee)$ depends on number of scatters N_a defined by the thickness of the target the approach can be tested by using the thickness as fit parameter

- Used Bethe-Heitler class from Geant4, with corrections and extended for various effects (the screening, the pair creation in the field of atomic electrons, correction to the Born approximation, the LPM suppression mechanism, etc.) to calculate differential cross-section