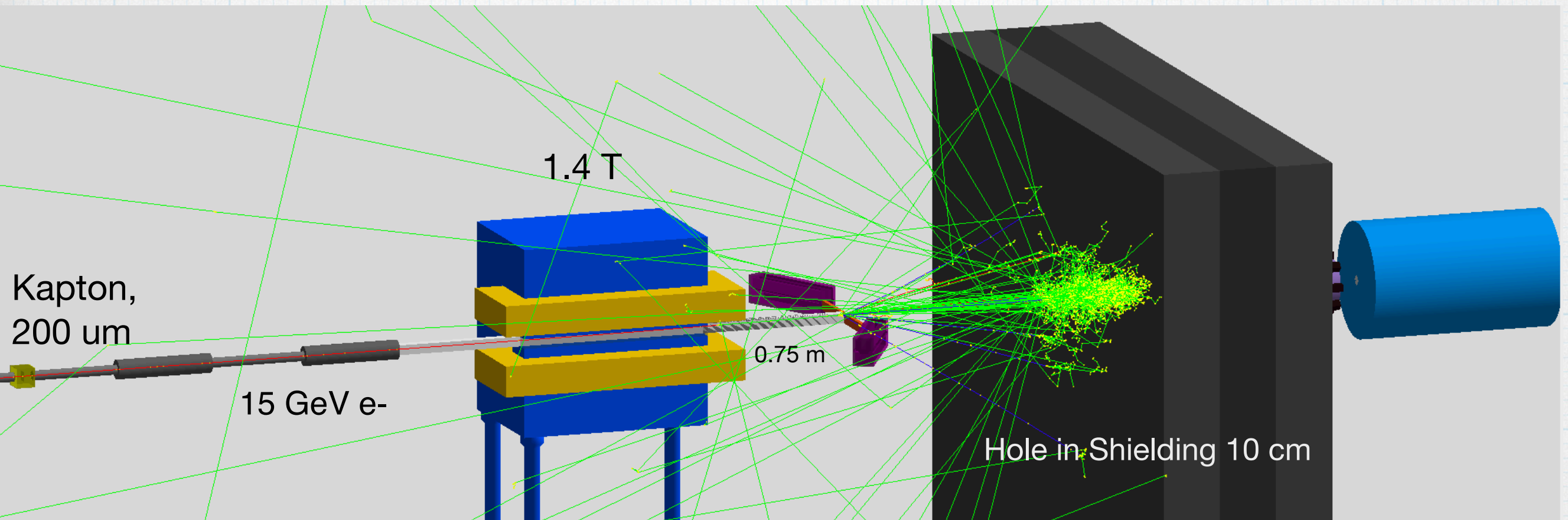


FDS performance w/ Beam pipe

Borysova Maryna (KINR)
06/10/20
LUXE weekly technical meeting

LUXE

FDS with LYSO calorimeters



Aug 2020 Data Runs, bunch/pulse crossings completed

Experiment Config	$w_0 = 3\mu\text{m}$	$w_0 = 3.5\mu\text{m}$	$w = 0, 4.0\mu\text{m}$	$w_0 = 4.5\mu\text{m}$	$w_0 = 5.0\mu\text{m}$	$w_0 = 8.0\mu\text{m}$	$w_0 = 20.0\mu\text{m}$	$w_0 = 50.0\mu\text{m}$	$w_0 = 100.0\mu\text{m}$
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
JET140 e-laser 16.5 GeV	10000	1000	1000	1000	1000	1000	500	5000	500

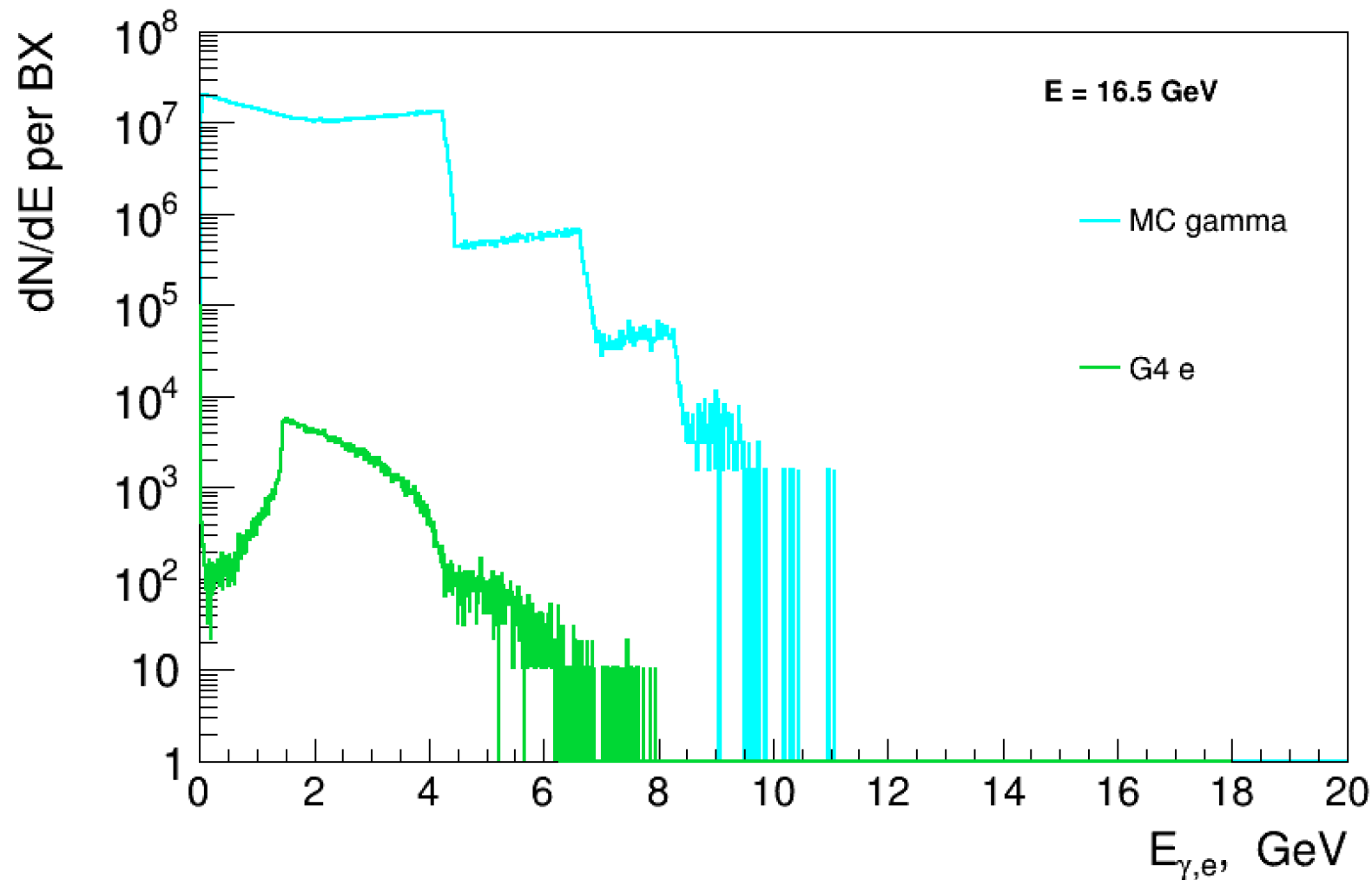
- * The scintillators are modelled as a 15x5x2 cm (x:y:z) layer of lyso material
- * The crystal (bin) size of the scintillators are 2 x 1 mm (finer segmentation in x; the deflection direction) giving 25 x 300 bins.

LYSO ($\text{Lu}_{1.8}\text{Y}_{0.2}\text{SiO}_5$)

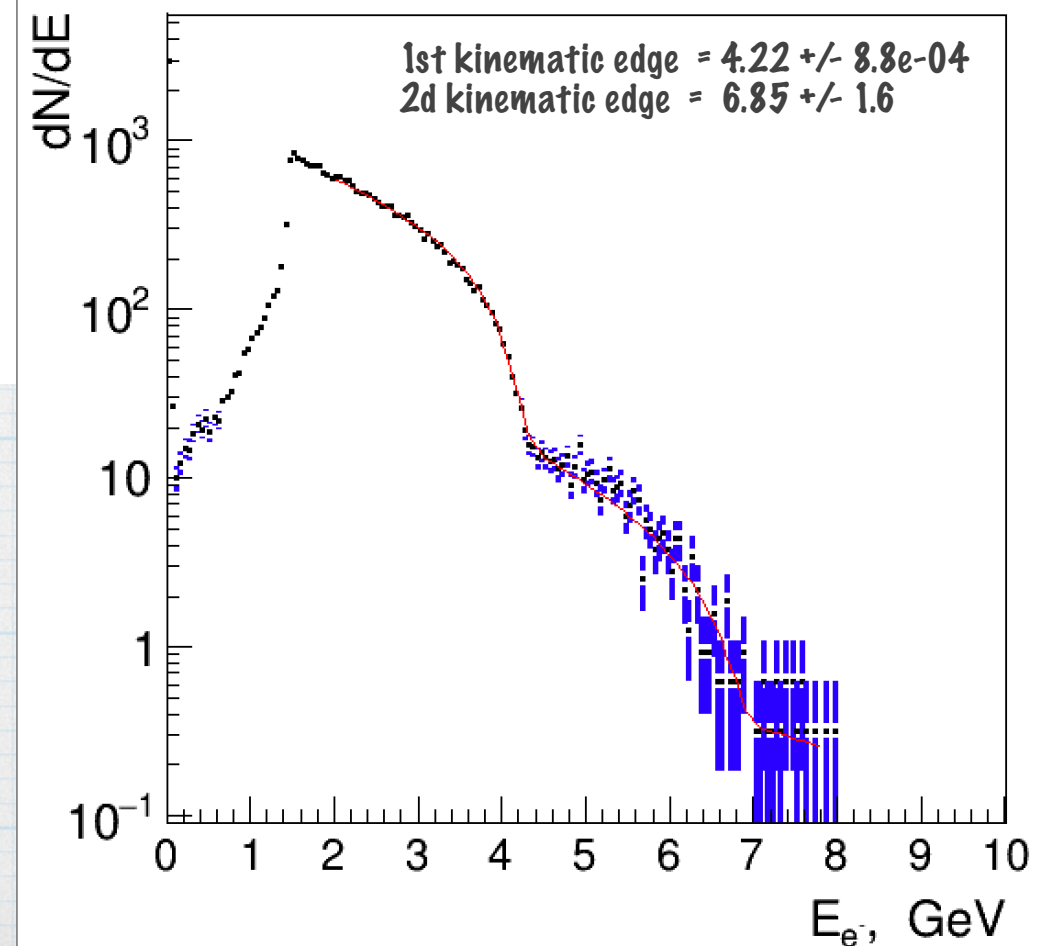
All studies were performed with 5000 BX at the laser intensity $\xi = 0.3$ for 16.5 GeV electron beam

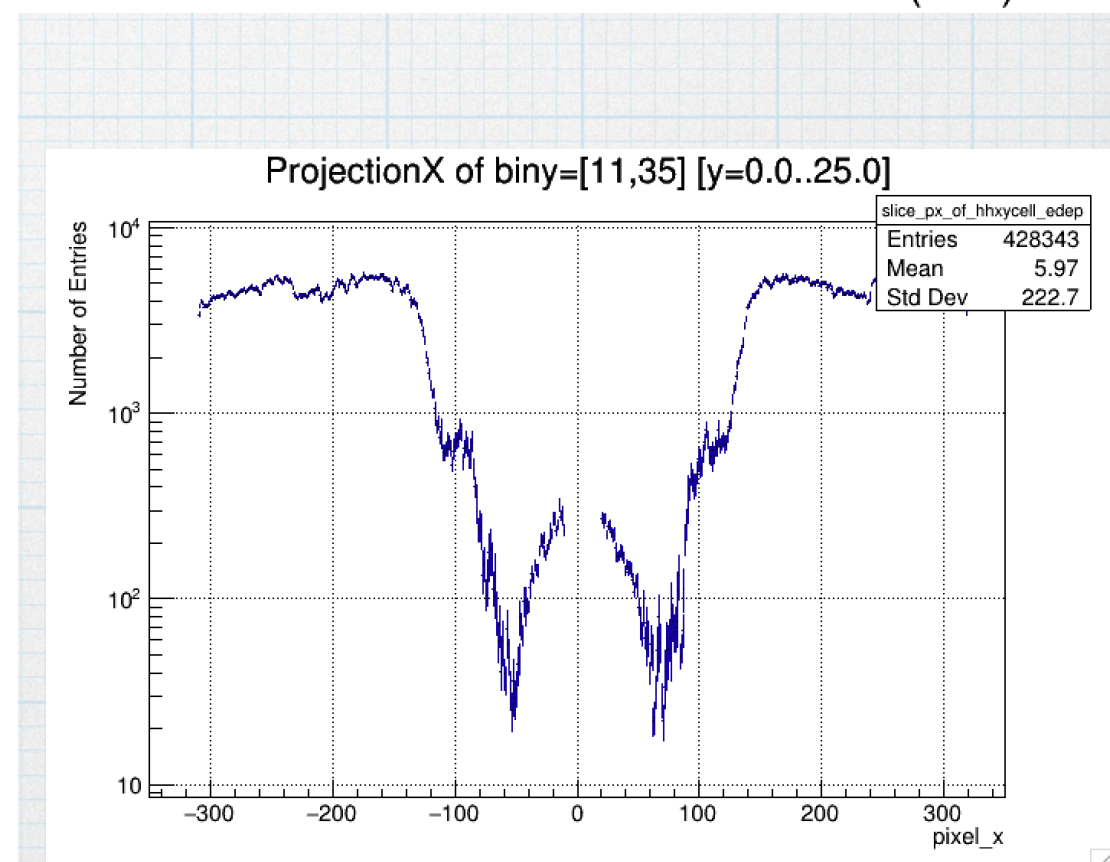
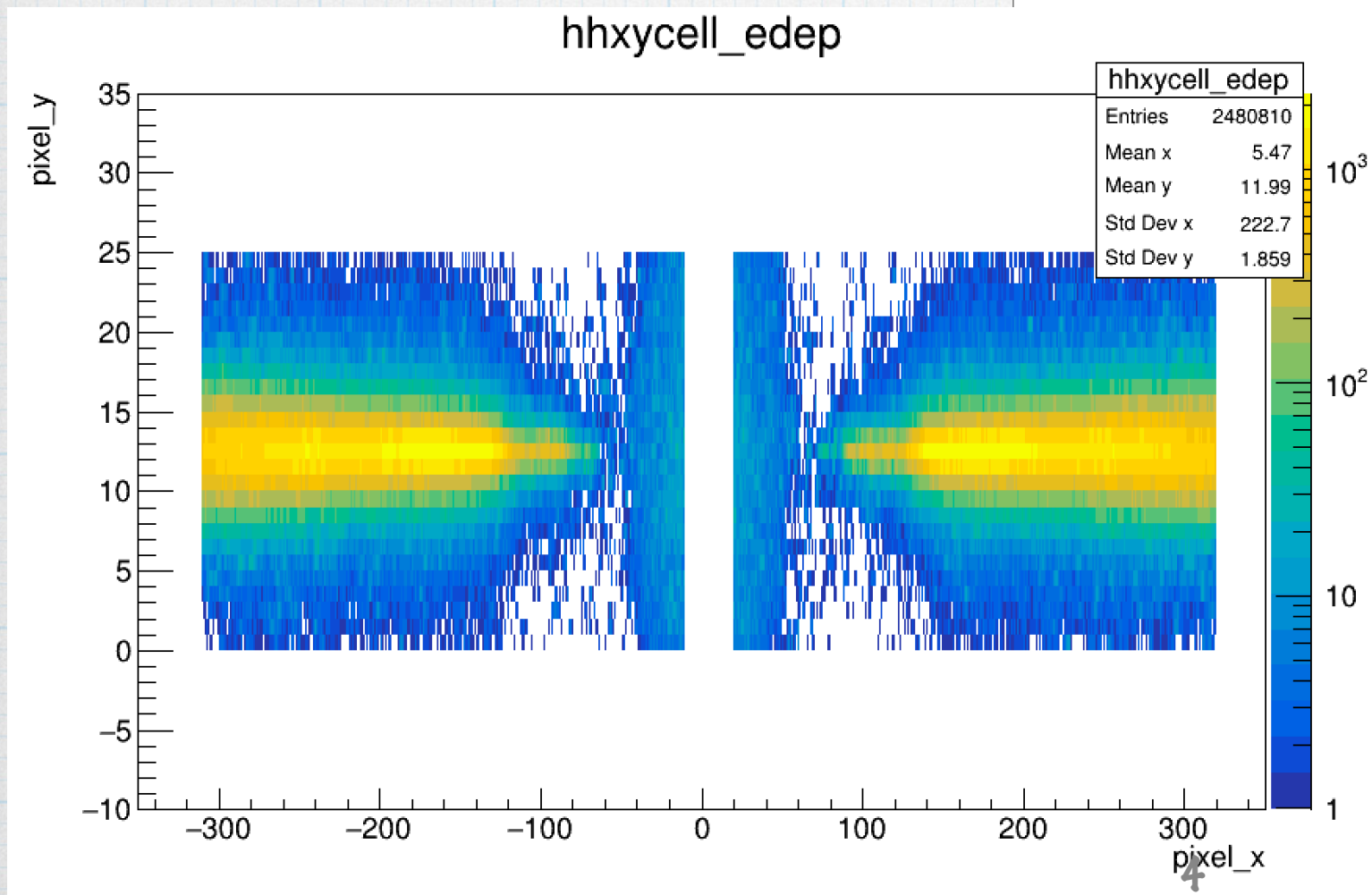
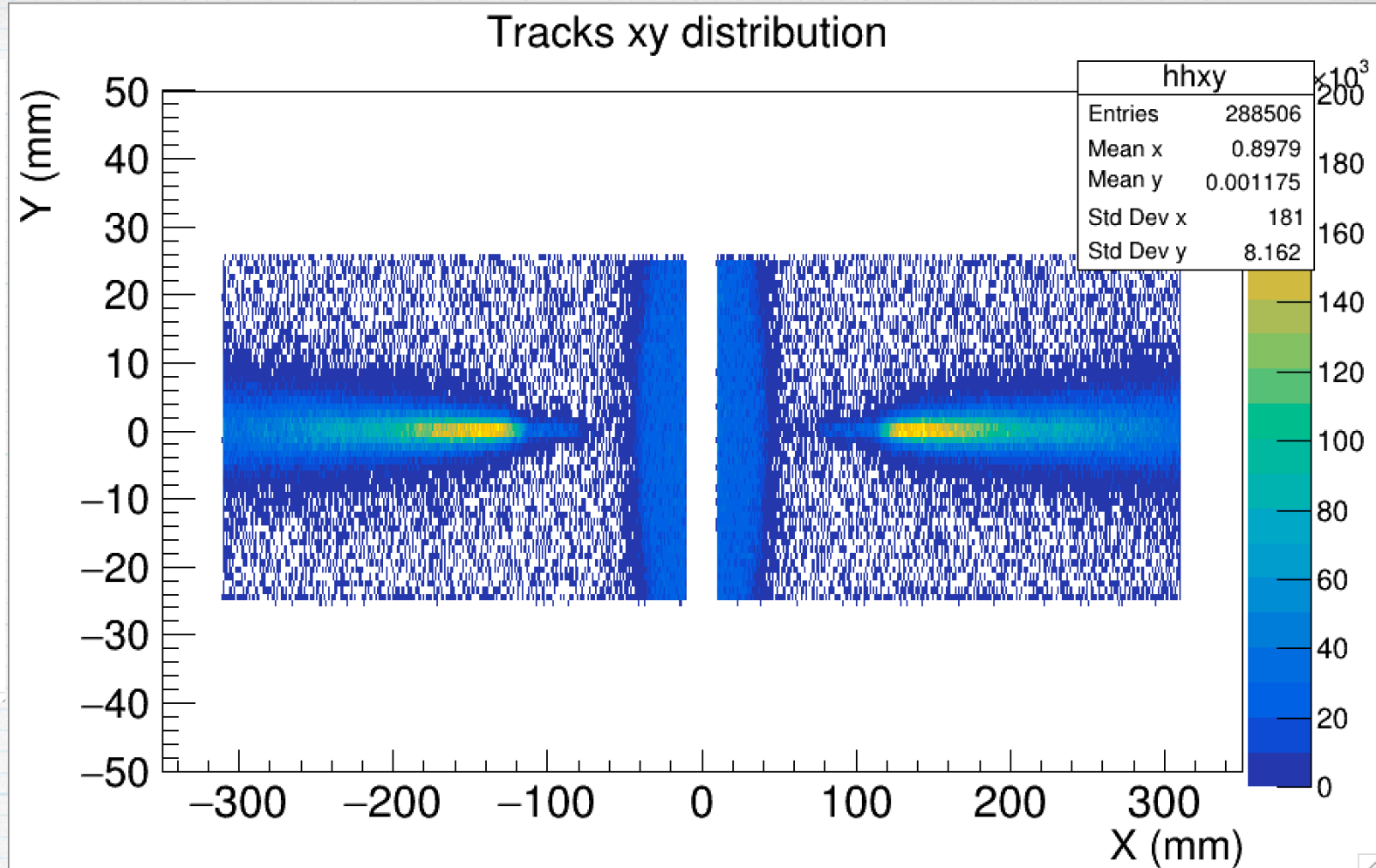
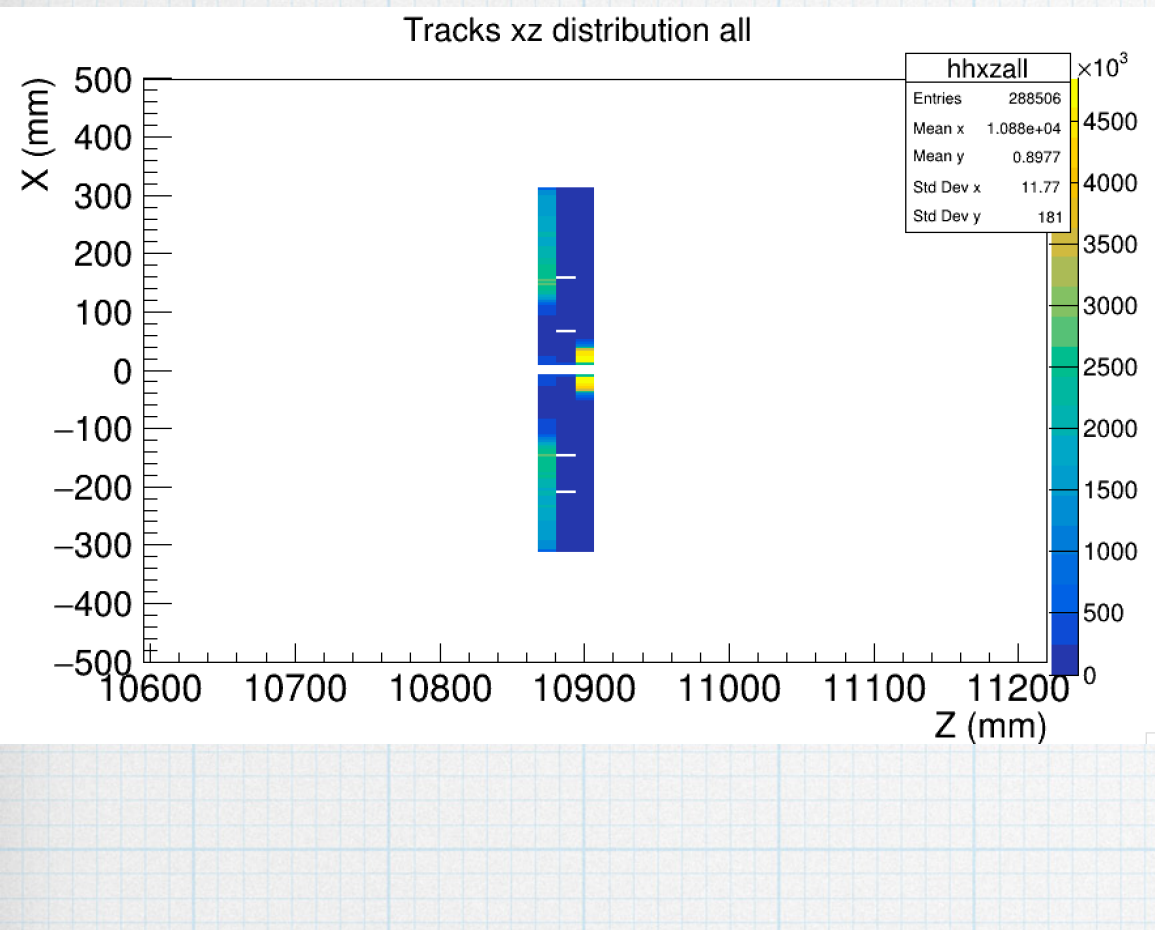
Spectra MC vs G4

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



Energy spectrum





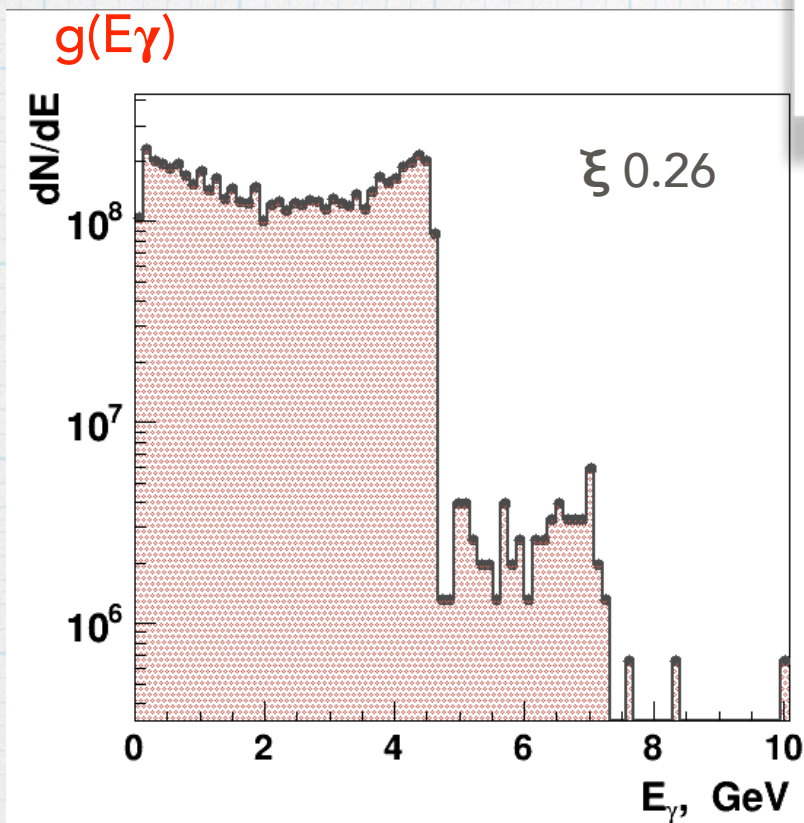
Summary

- * The performance of FDS setup with beam pipe from the target to Compton detectors was studied
- * **electron/positron spectra look reasonable**
- * **Edge finding procedure works reasonable**

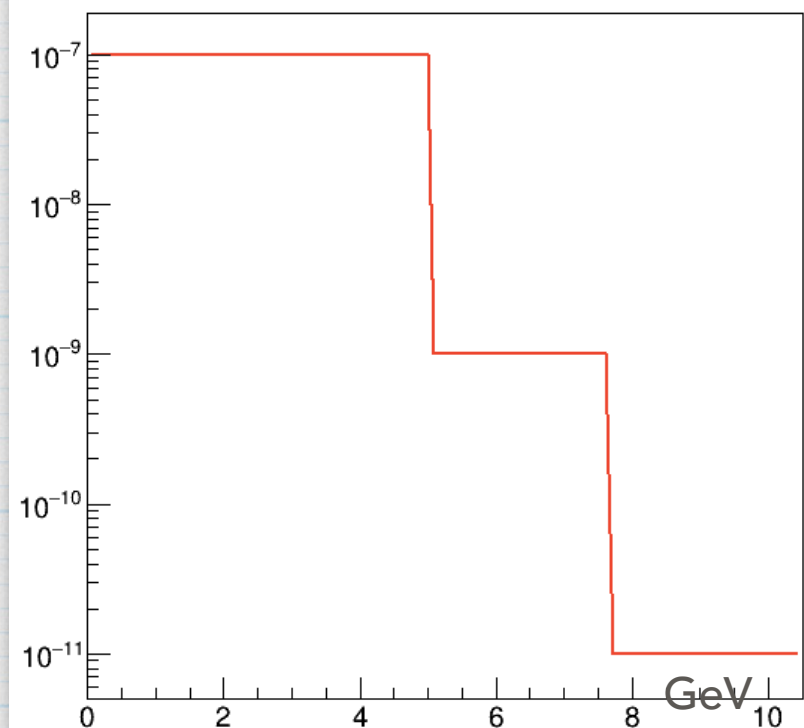
Back up

Kinematic edges with accurate pair spectrum

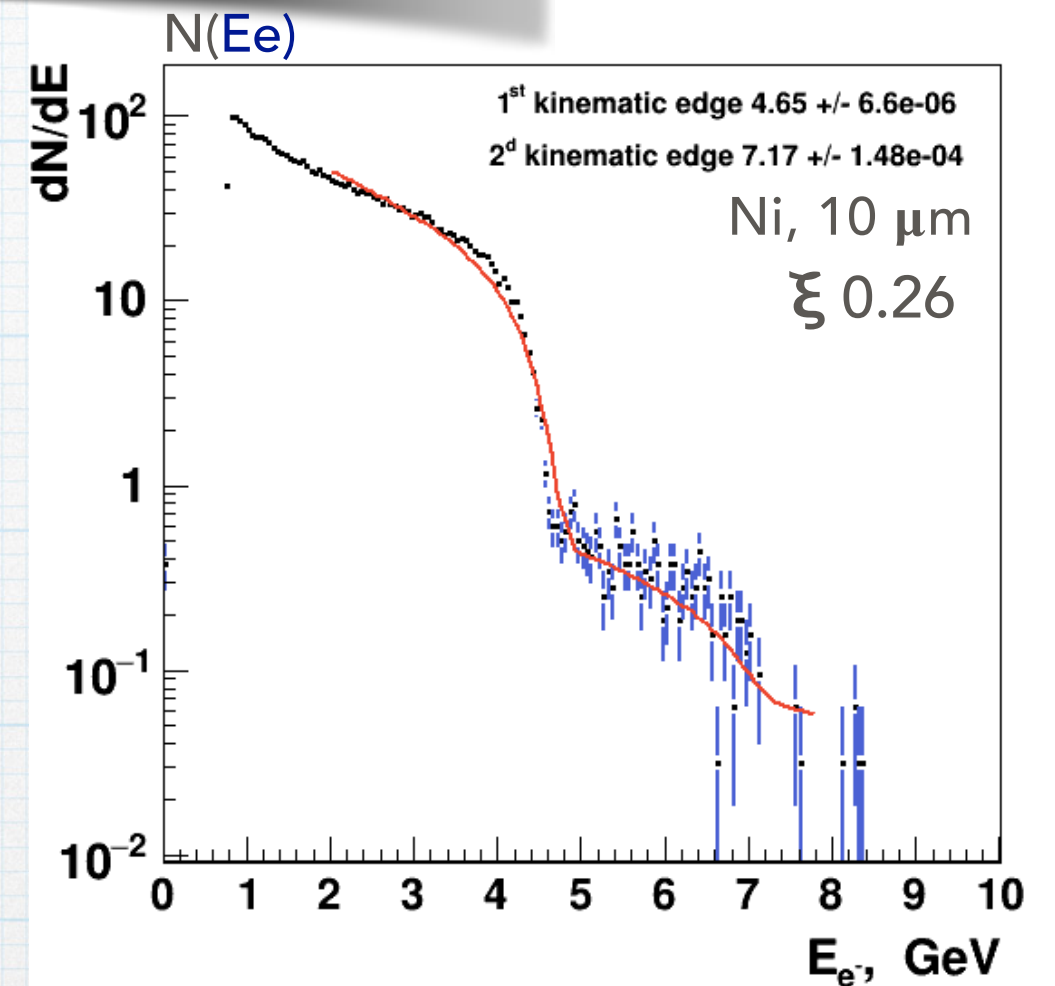
$$f(E_e) = \int \sigma(E_\gamma, E_e) g(E_\gamma) dE_\gamma$$



$g(E_\gamma, \text{pi})$ GammaSpectrumTest



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

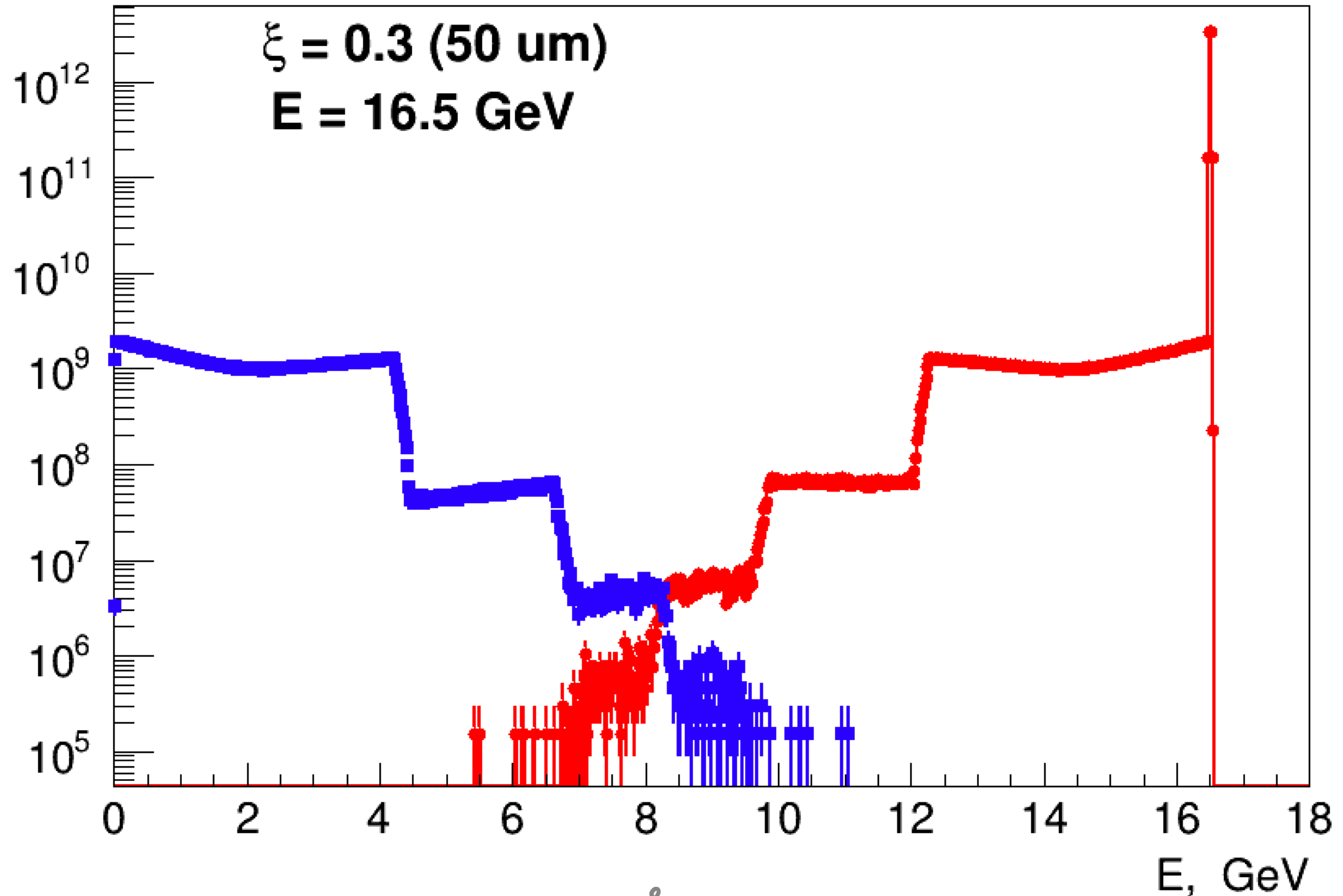


$$\int \sigma(E_\gamma, E_e) g(E_\gamma, p1, p2) dE_\gamma$$

fitting allows finding the kinematic edges quite well

True electron/photon spectra

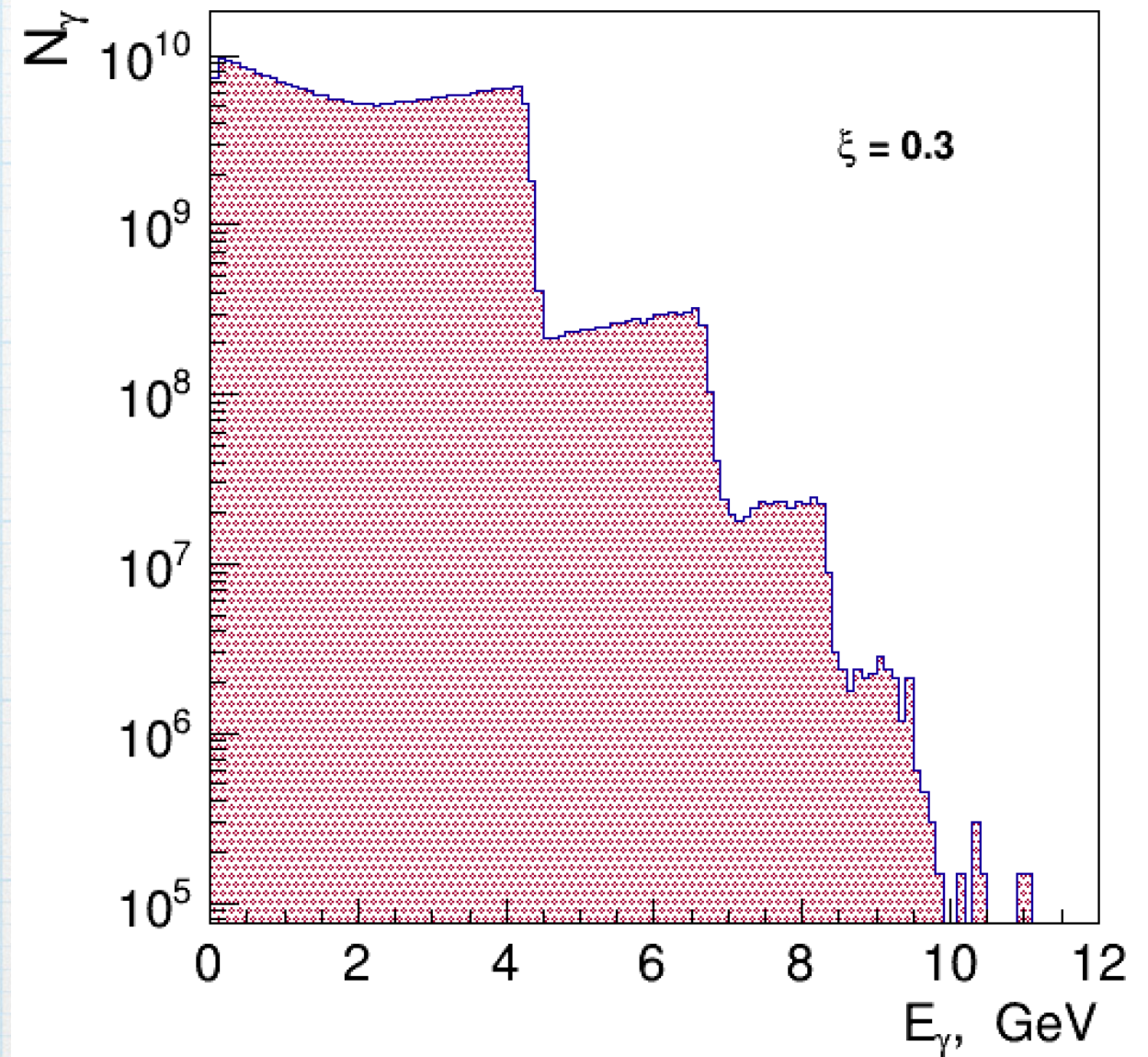
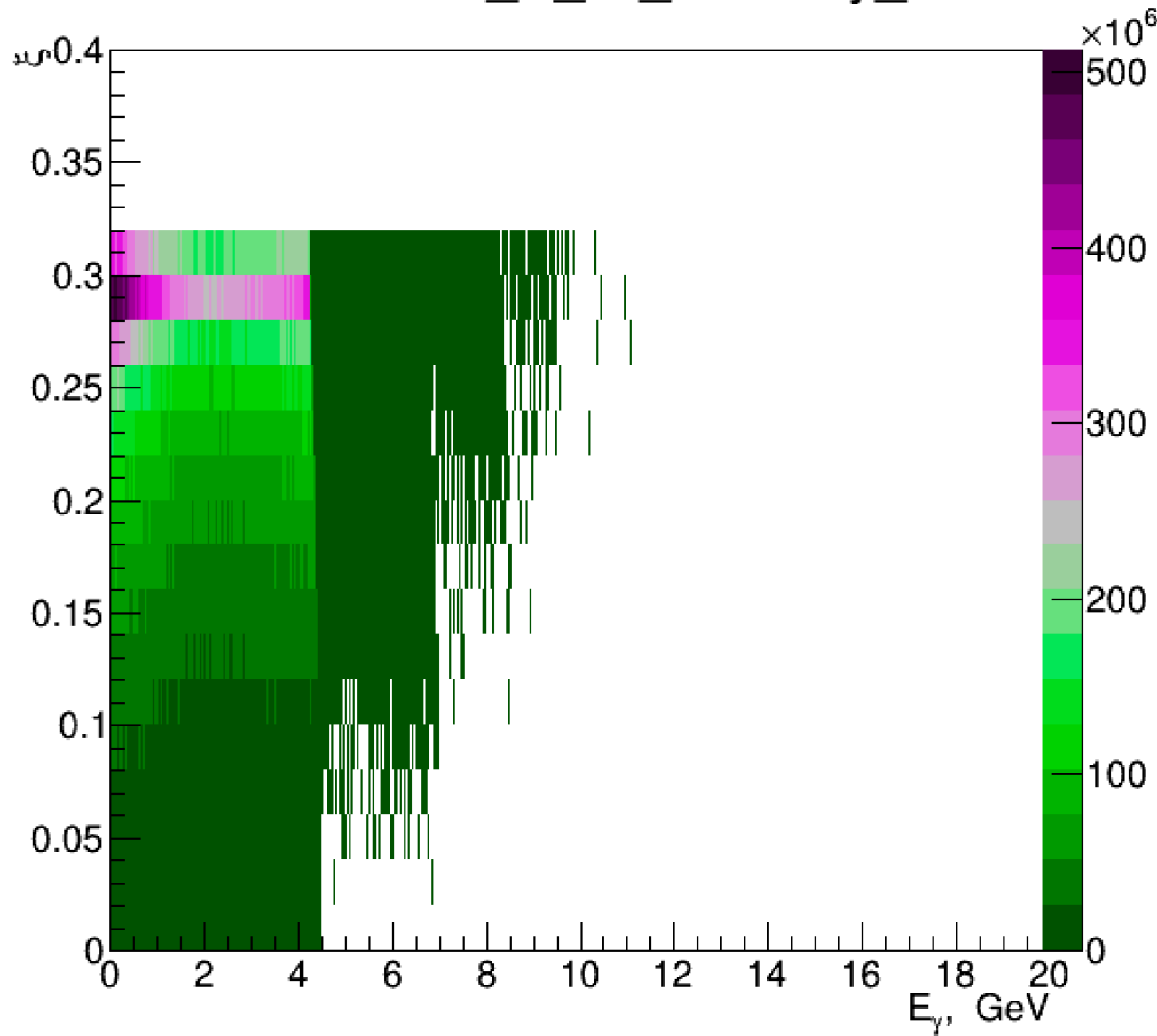
4764 BX out of 5000 BX at the laser intensity $\xi = 0.3$ for 16.5 GeV electron beam
(~5% of files have NaN so they are ignored)



ξ vs photon energy in MC

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

Generated_E_vs_Intensity_2



Photon spectra reconstruction using Bethe-Heitler pair spectrum

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

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

energies involved are large compared with mc^2

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

$$\sigma(E_\gamma, E_e) = \Phi(E_\gamma, E_e) * N_a \quad N_a - \text{Number of atoms}$$

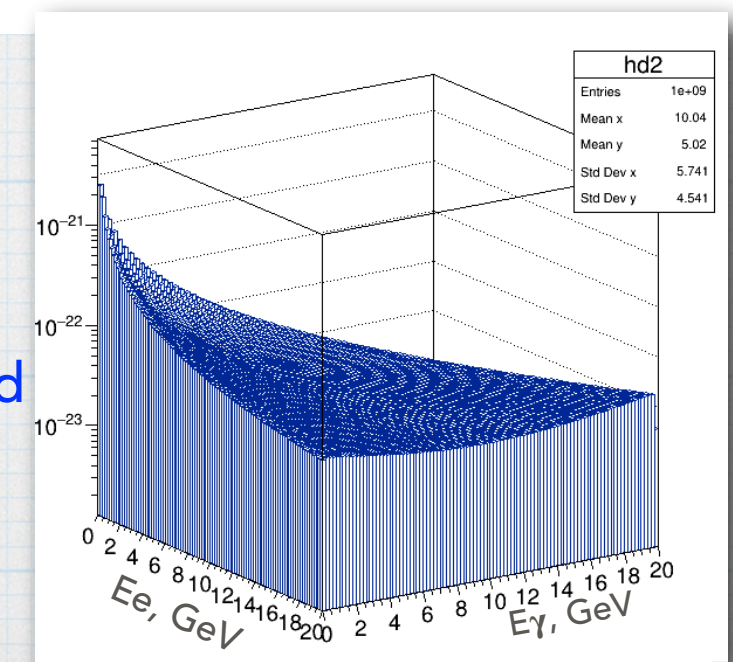
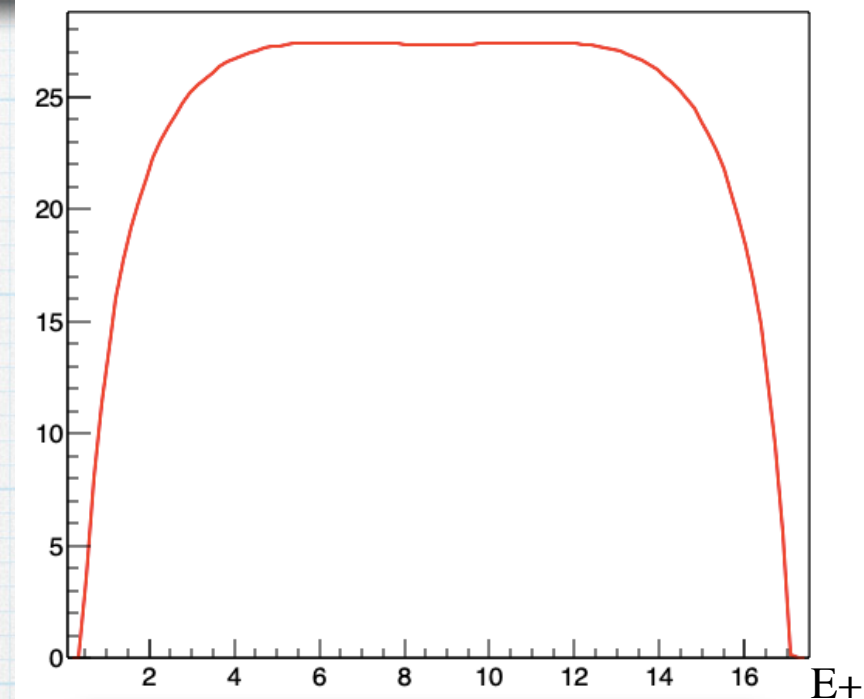
Photon spectra $g(E_\gamma)$ can be reconstructed by fitting

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

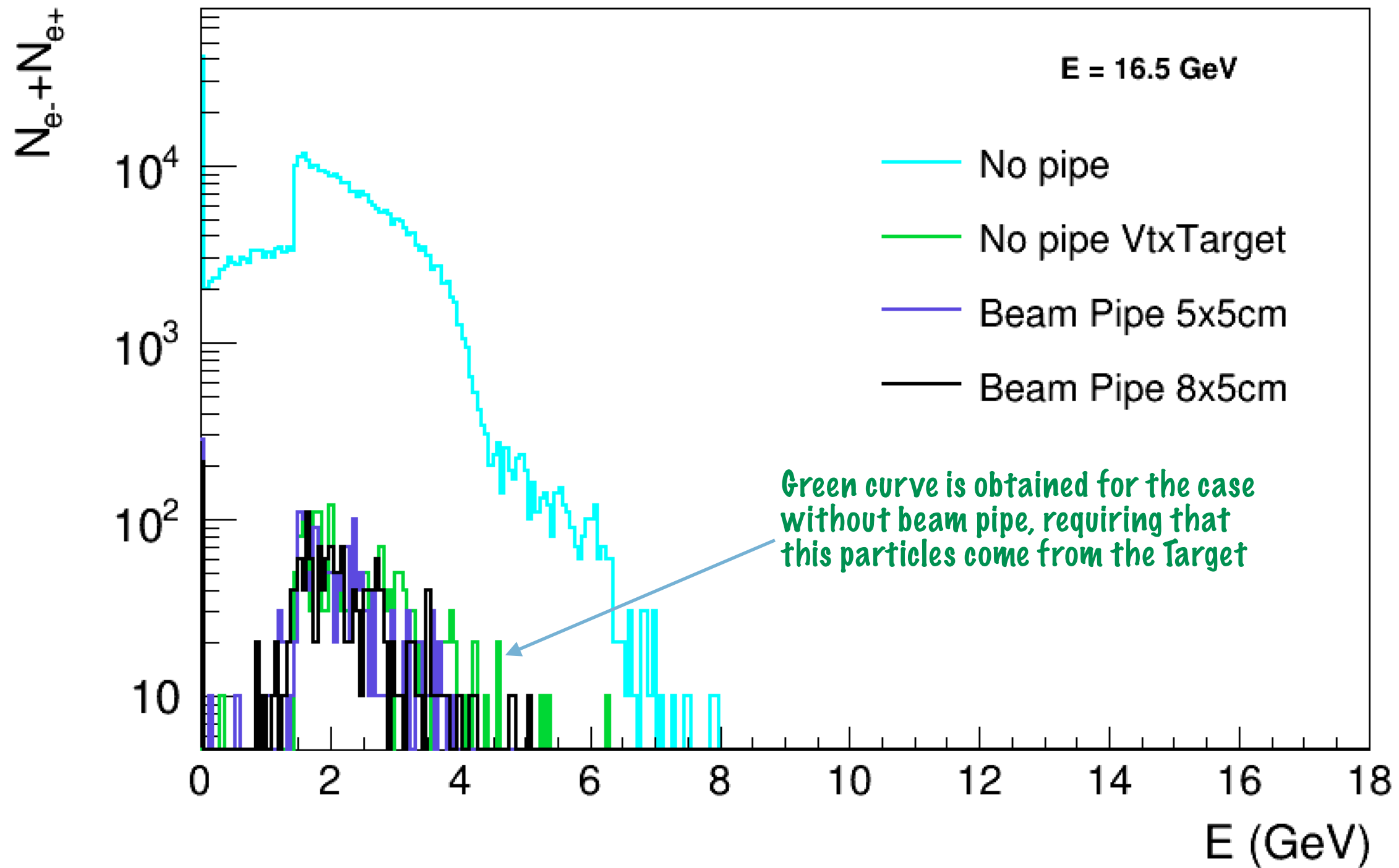
Where $N(E_e)$ positron/electron spectra measured in detector after the conversion.

Since $\sigma(E_\gamma, E_e)$ 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

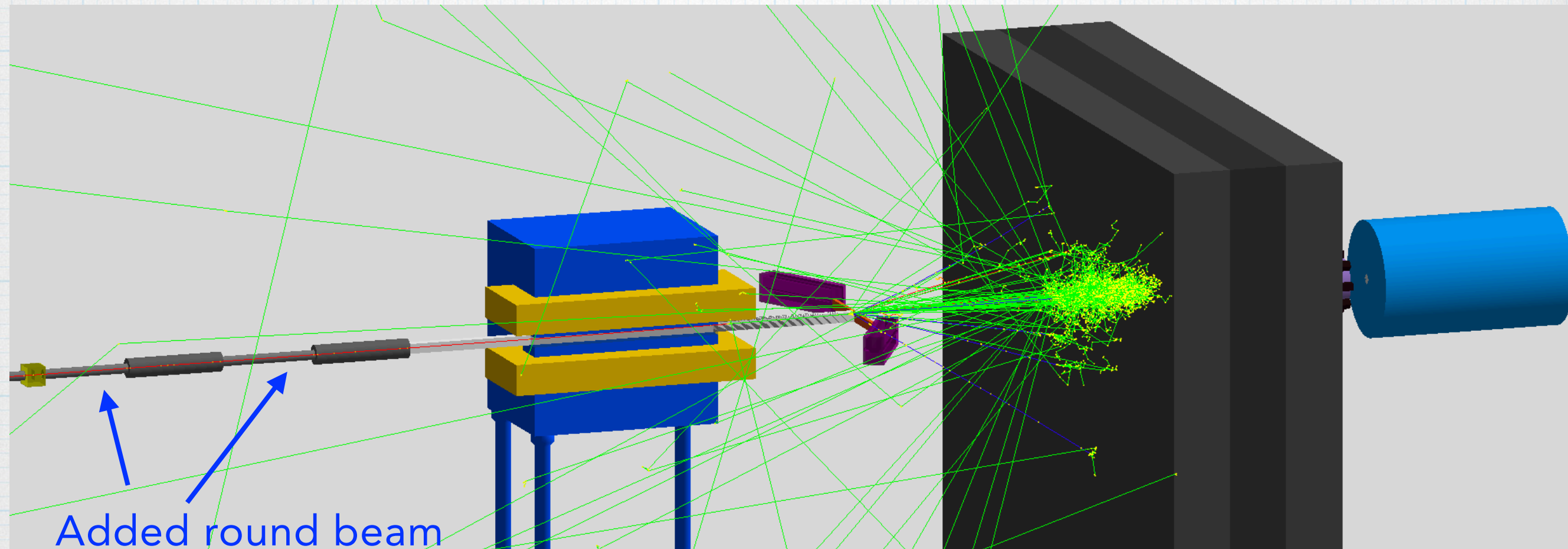


Spectra

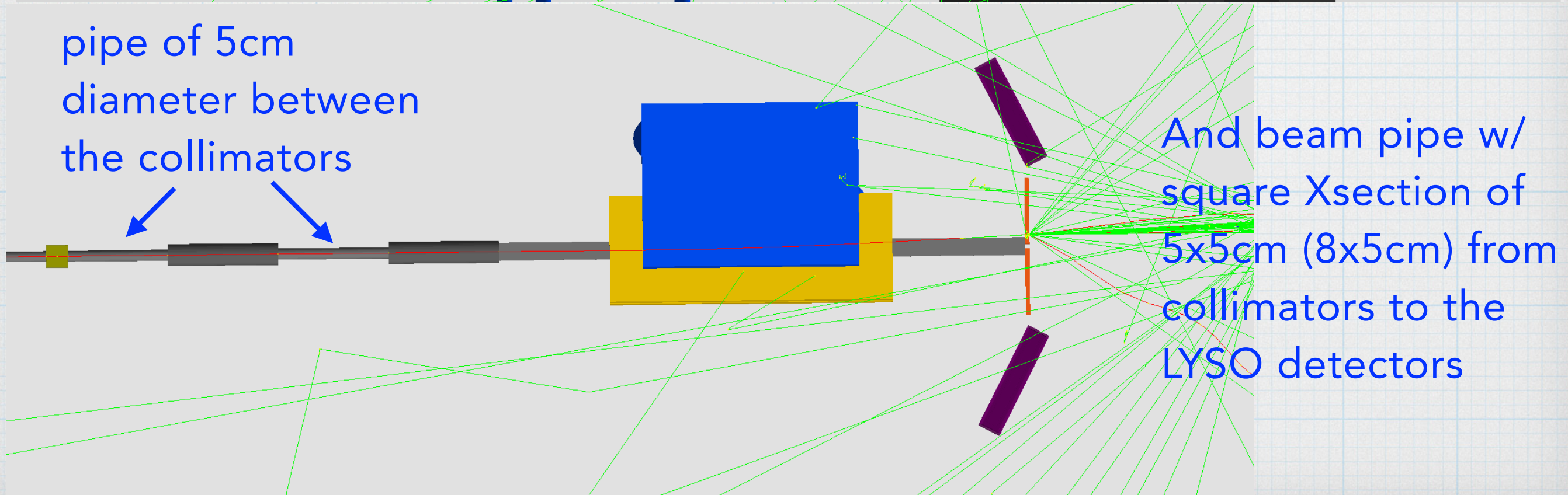


Without beam pipe we measure in Compton detectors a lot e^-/e^+ pairs that were created in the air. Only 4% e^-/e^+ are generated in the Target

Setup with the beam pipe

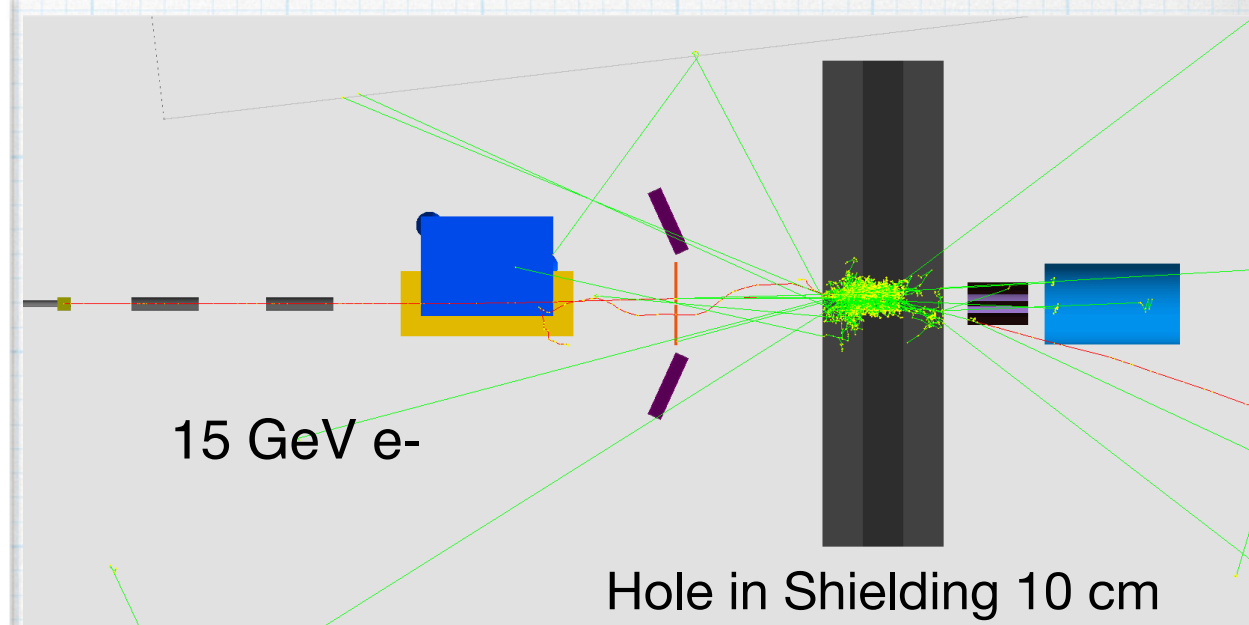
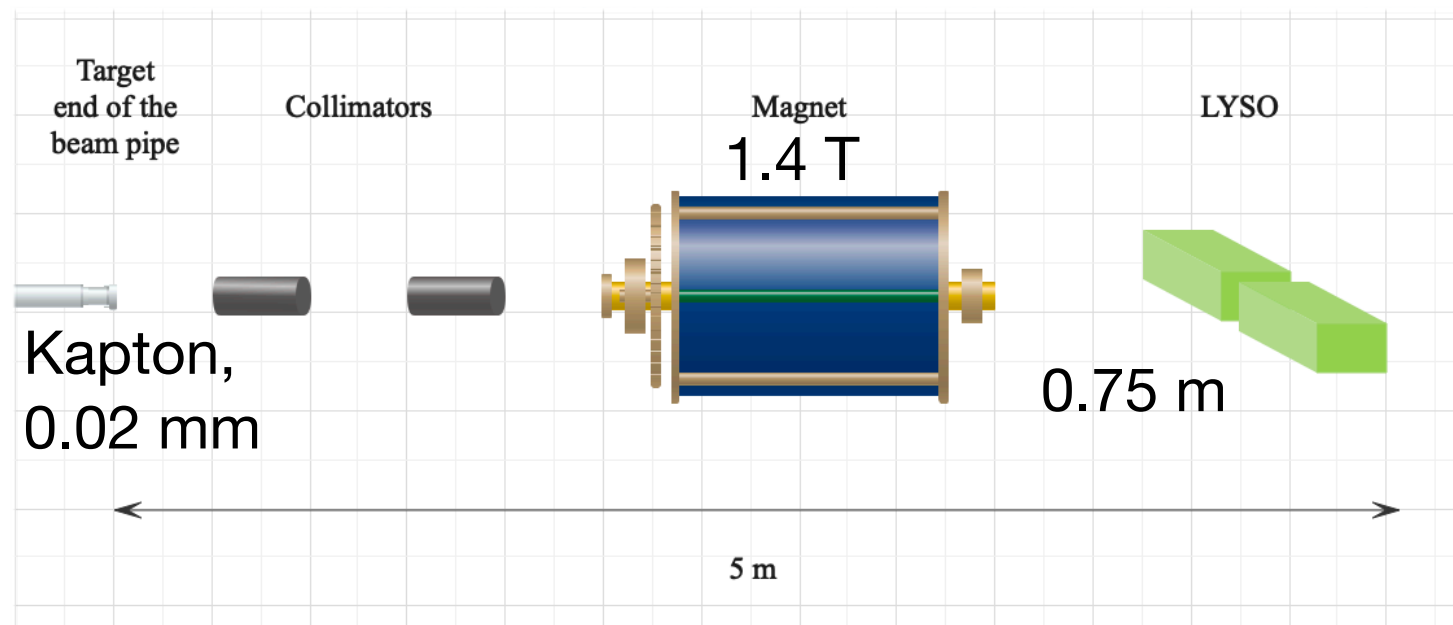


Added round beam
pipe of 5cm
diameter between
the collimators



And beam pipe w/
square Xsection of
5x5cm (8x5cm) from
collimators to the
LYSO detectors

FDS with LYSO calorimeters



Aug 2020 Data Runs, bunch/pulse crossings completed

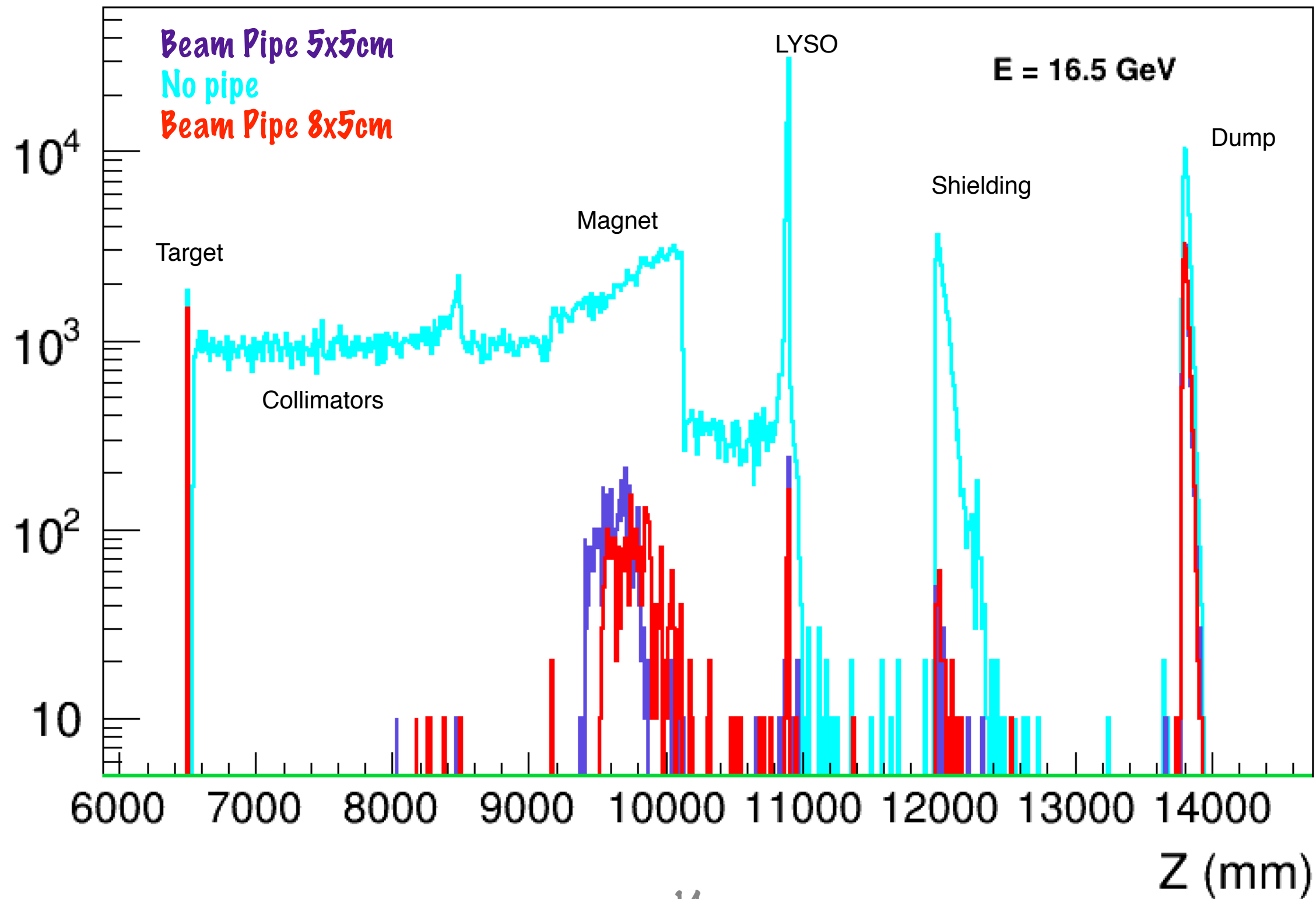
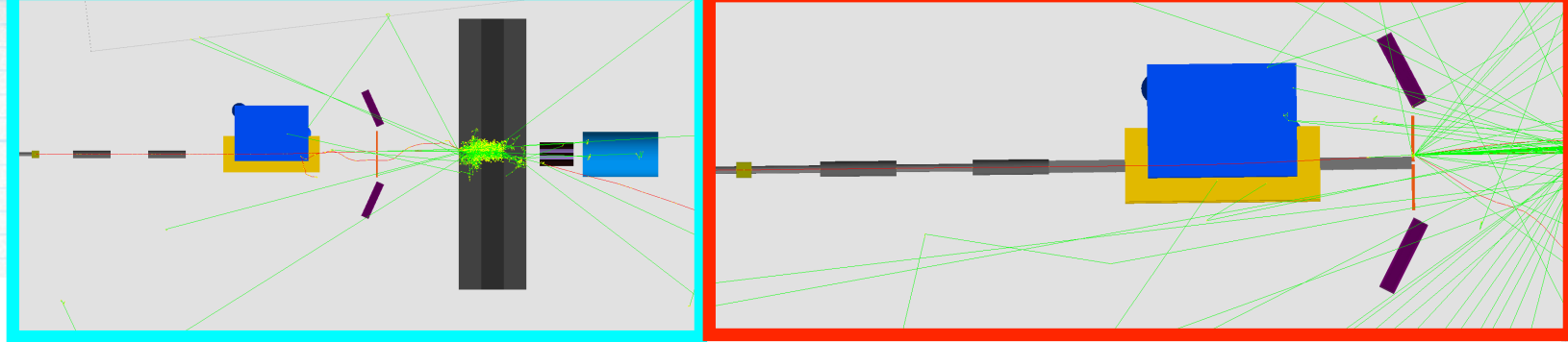
Experiment Config	$w_0 = 3\mu\text{m}$	$w_0 = 3.5\mu\text{m}$	$w = 0, 4.0\mu\text{m}$	$w_0 = 4.5\mu\text{m}$	$w_0 = 5.0\mu\text{m}$	$w_0 = 8.0\mu\text{m}$	$w_0 = 20.0\mu\text{m}$	$w_0 = 50.0\mu\text{m}$	$w_0 = 100.0\mu\text{m}$
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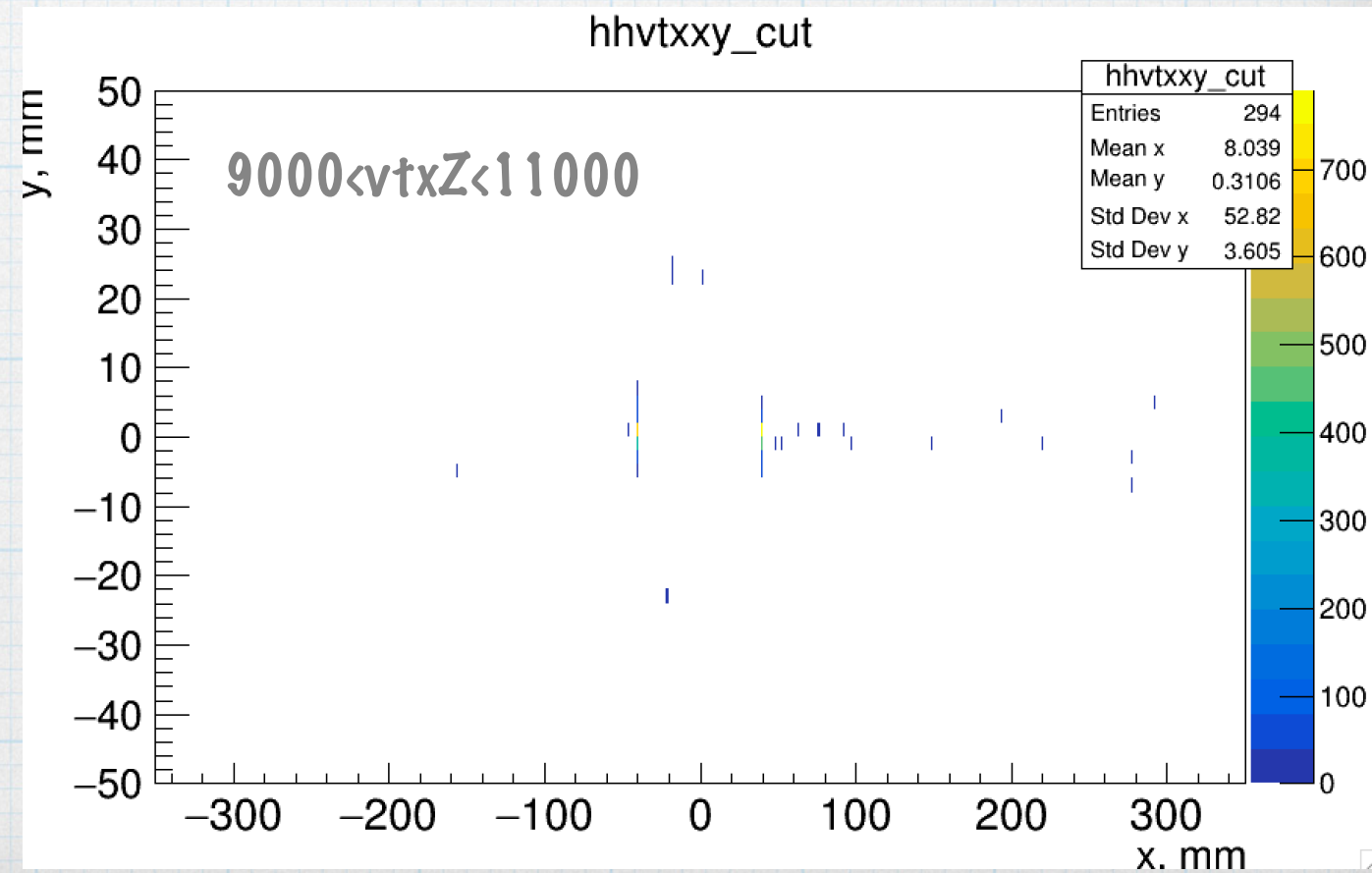
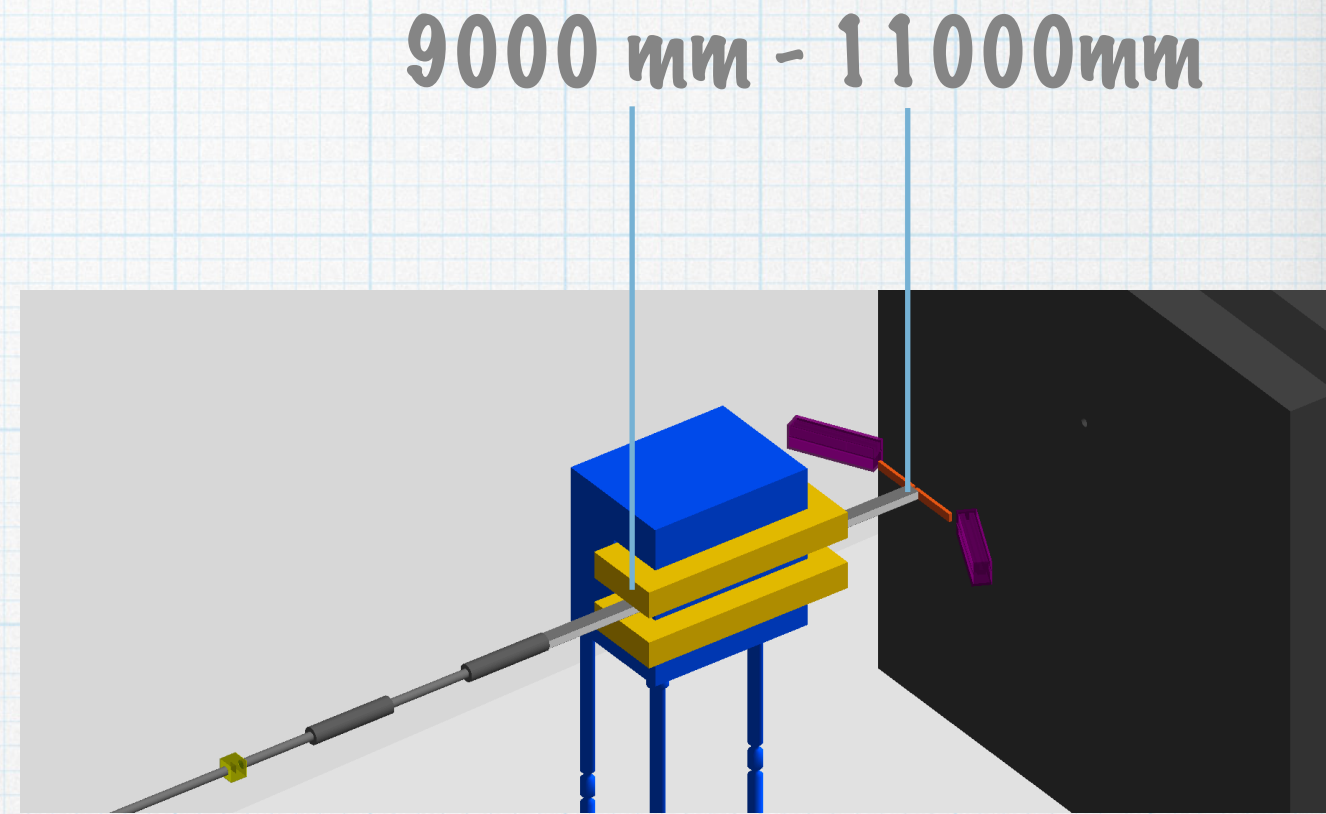
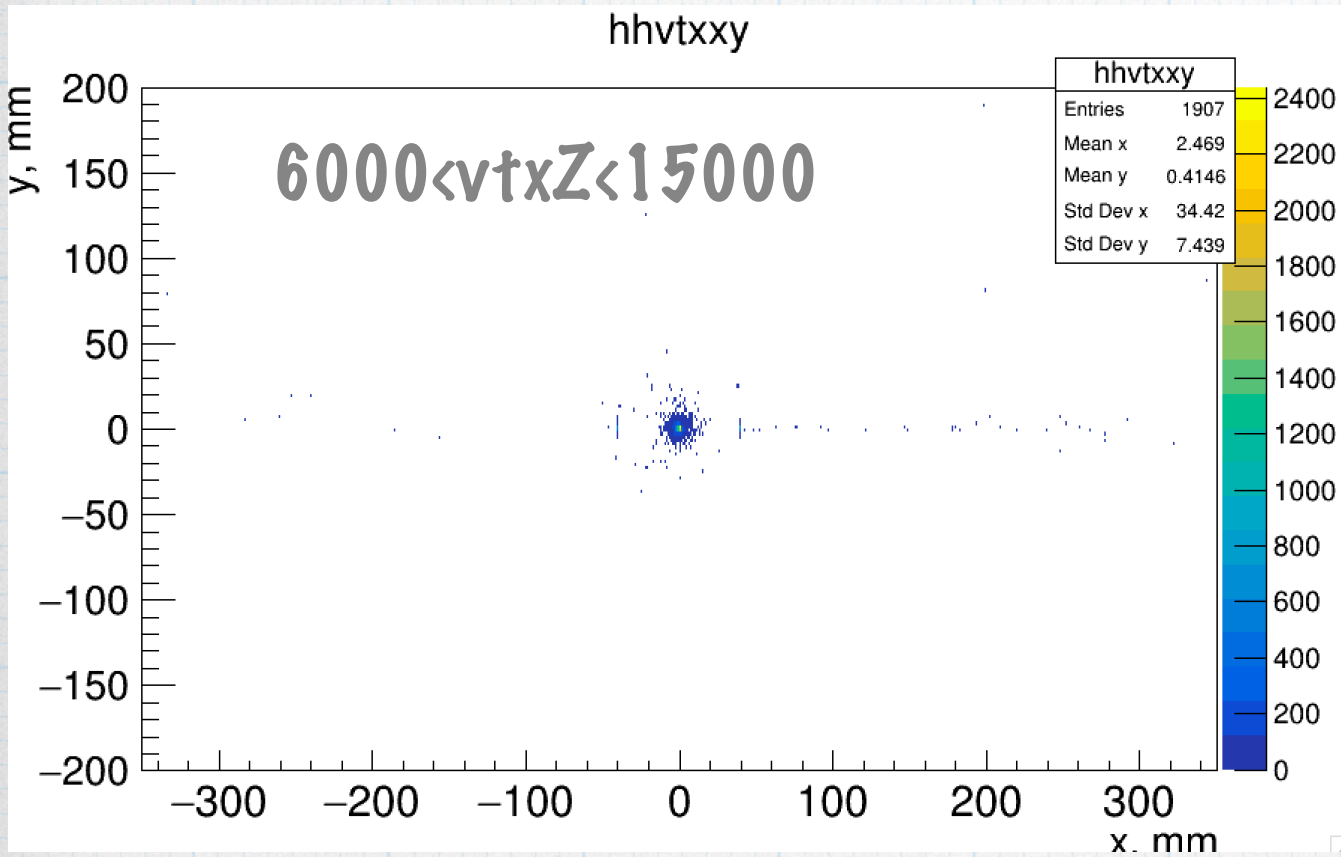
LYSO ($\text{Lu}_{1.8}\text{Y}_{0.2}\text{SiO}_5$)

All studies were performed with 100 BX at the laser intensity $\xi = 0.3$ for 16.5 GeV electron beam

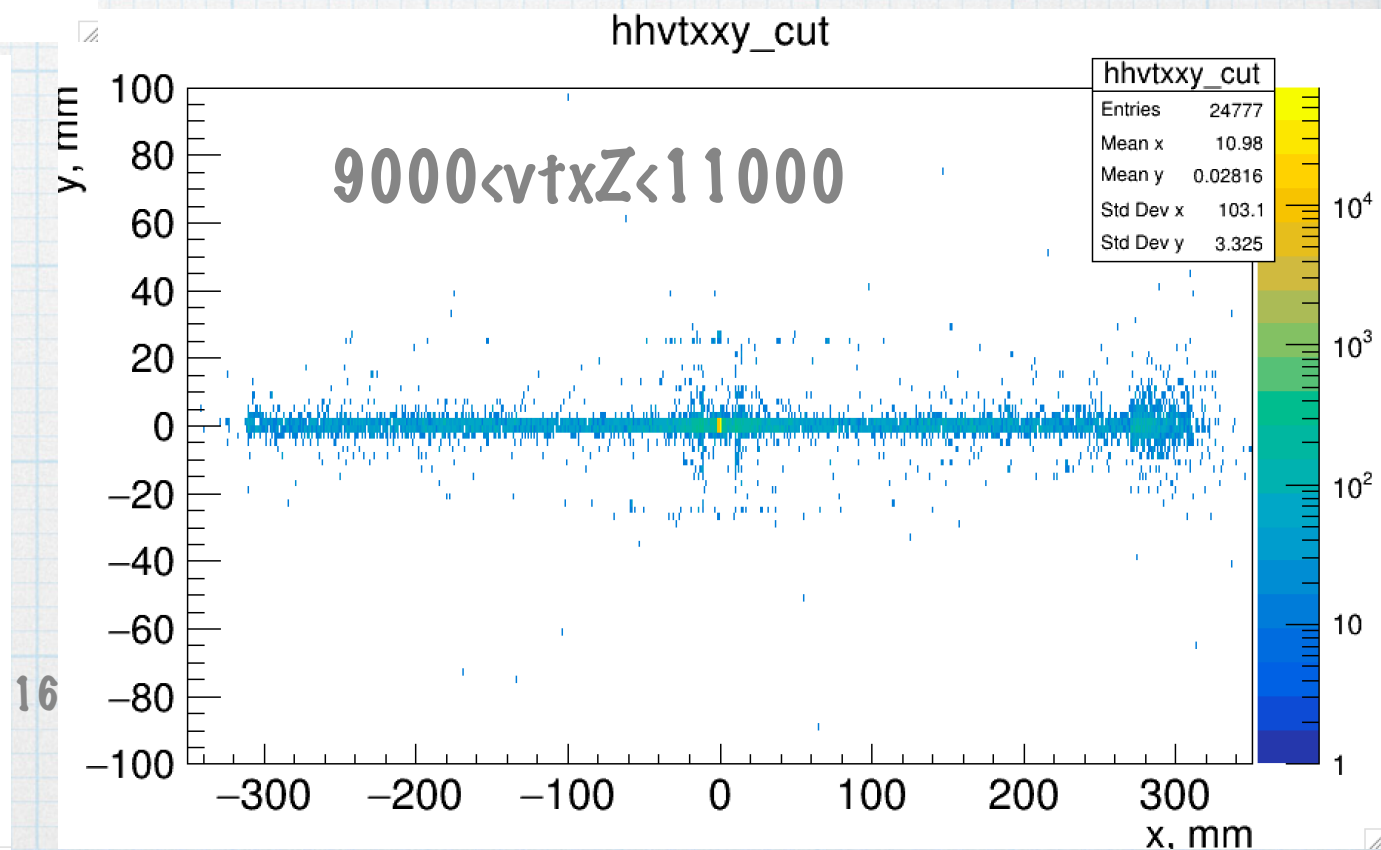
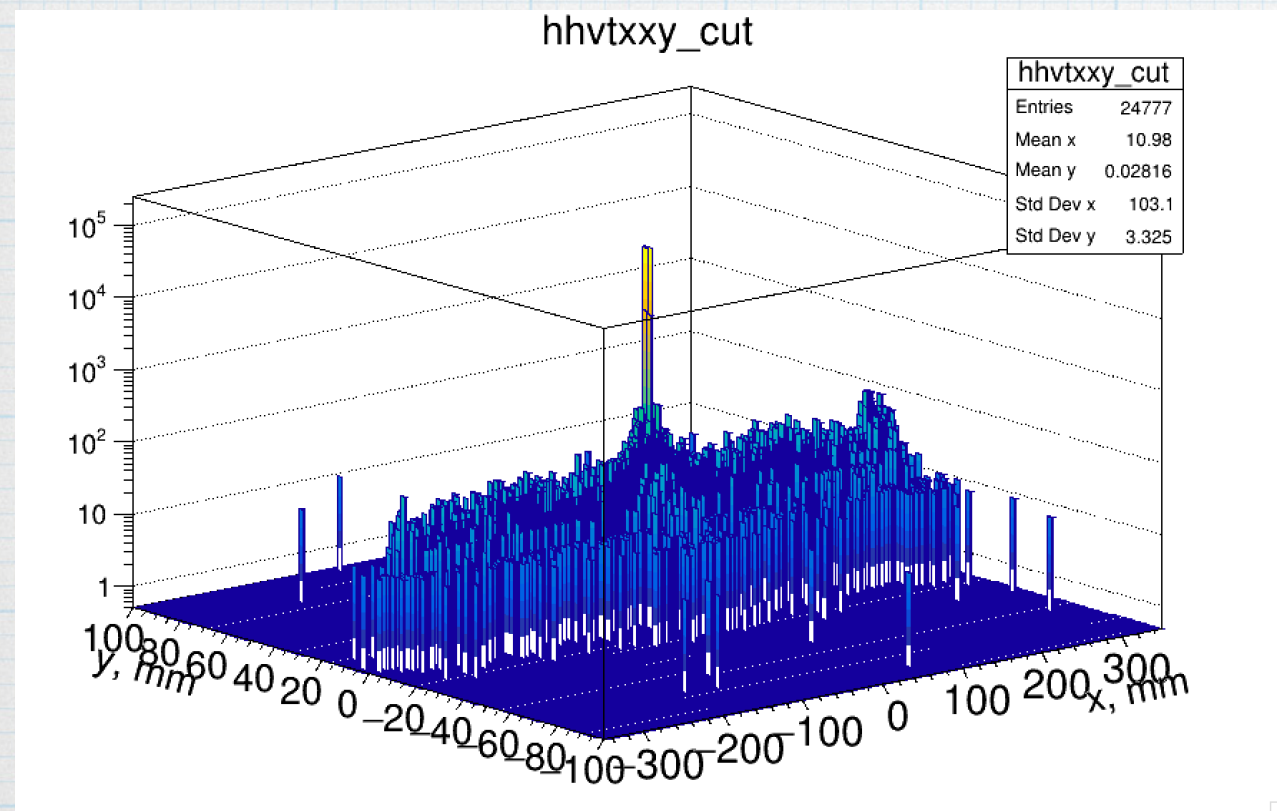
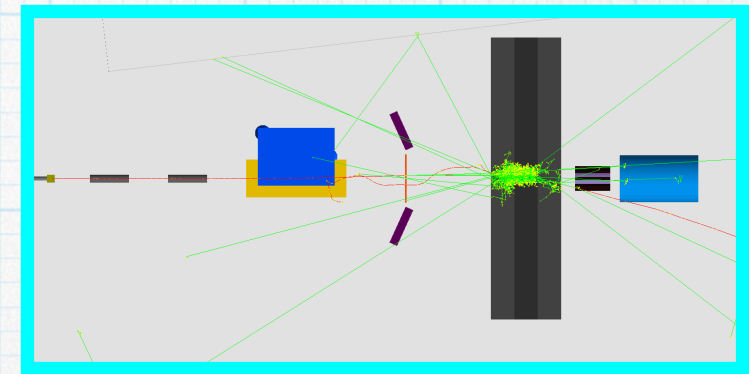
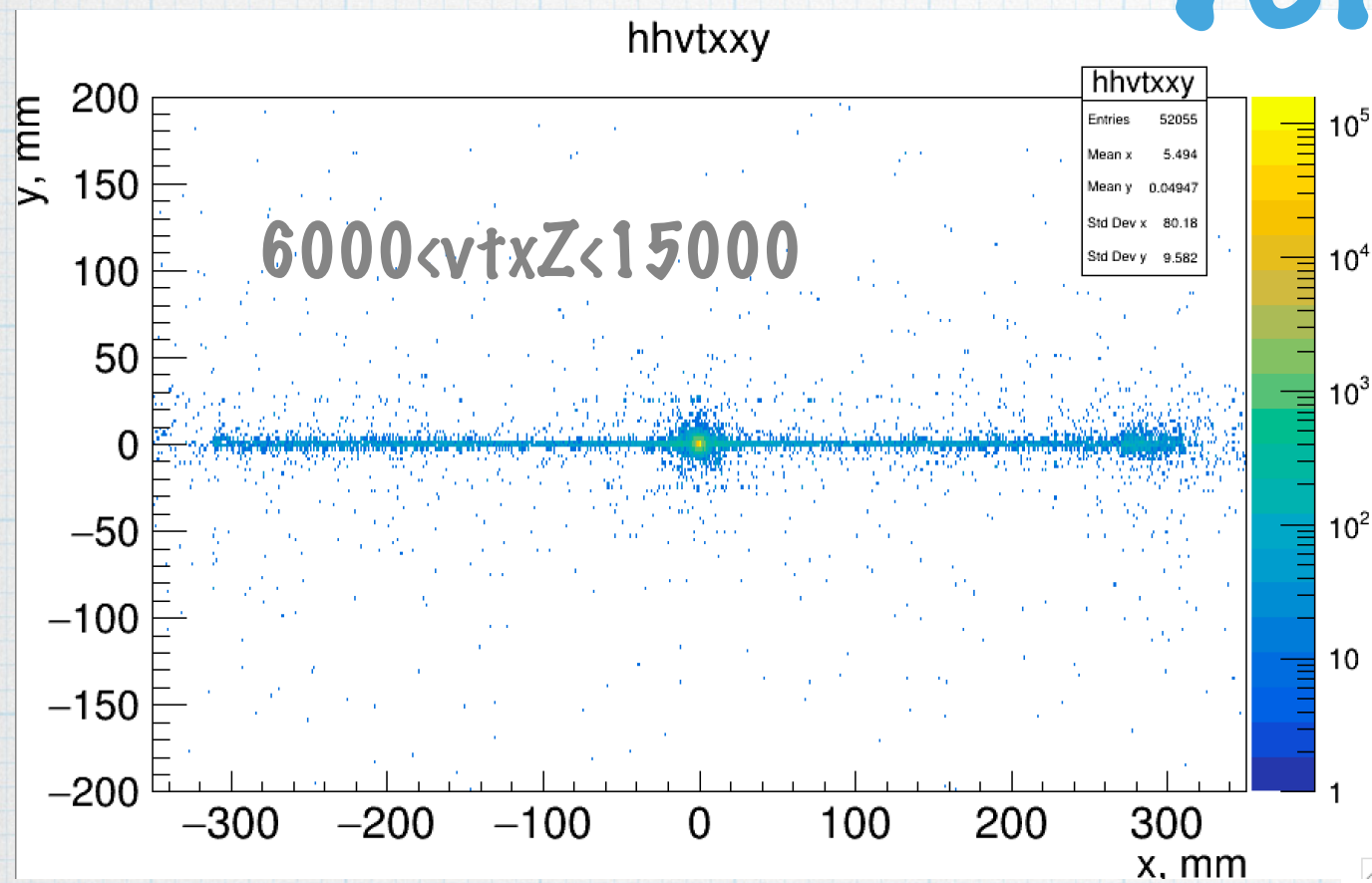
Vertex z



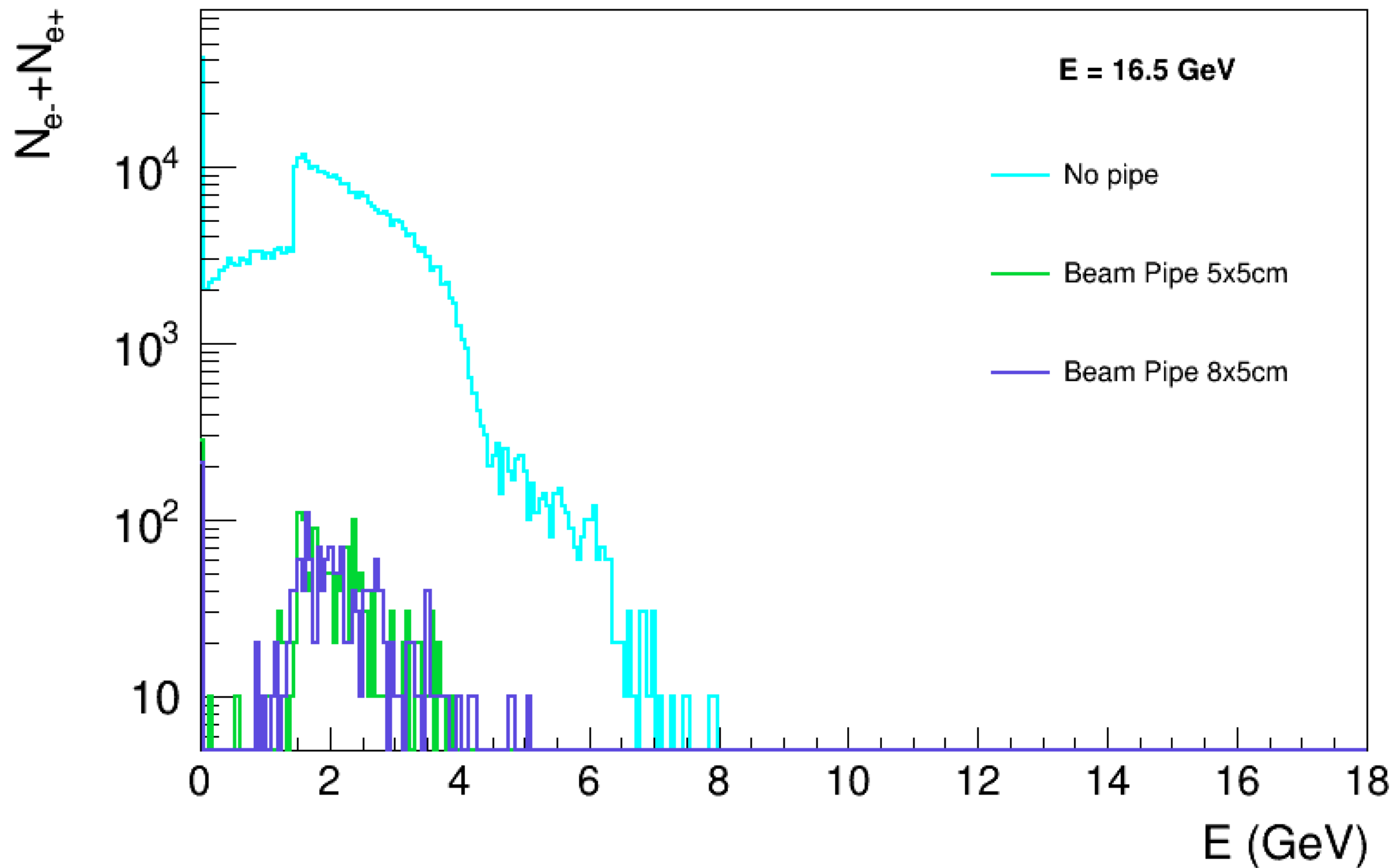
Vertex x-y, beam pipe 8x5



Vertex x-y, no pipe



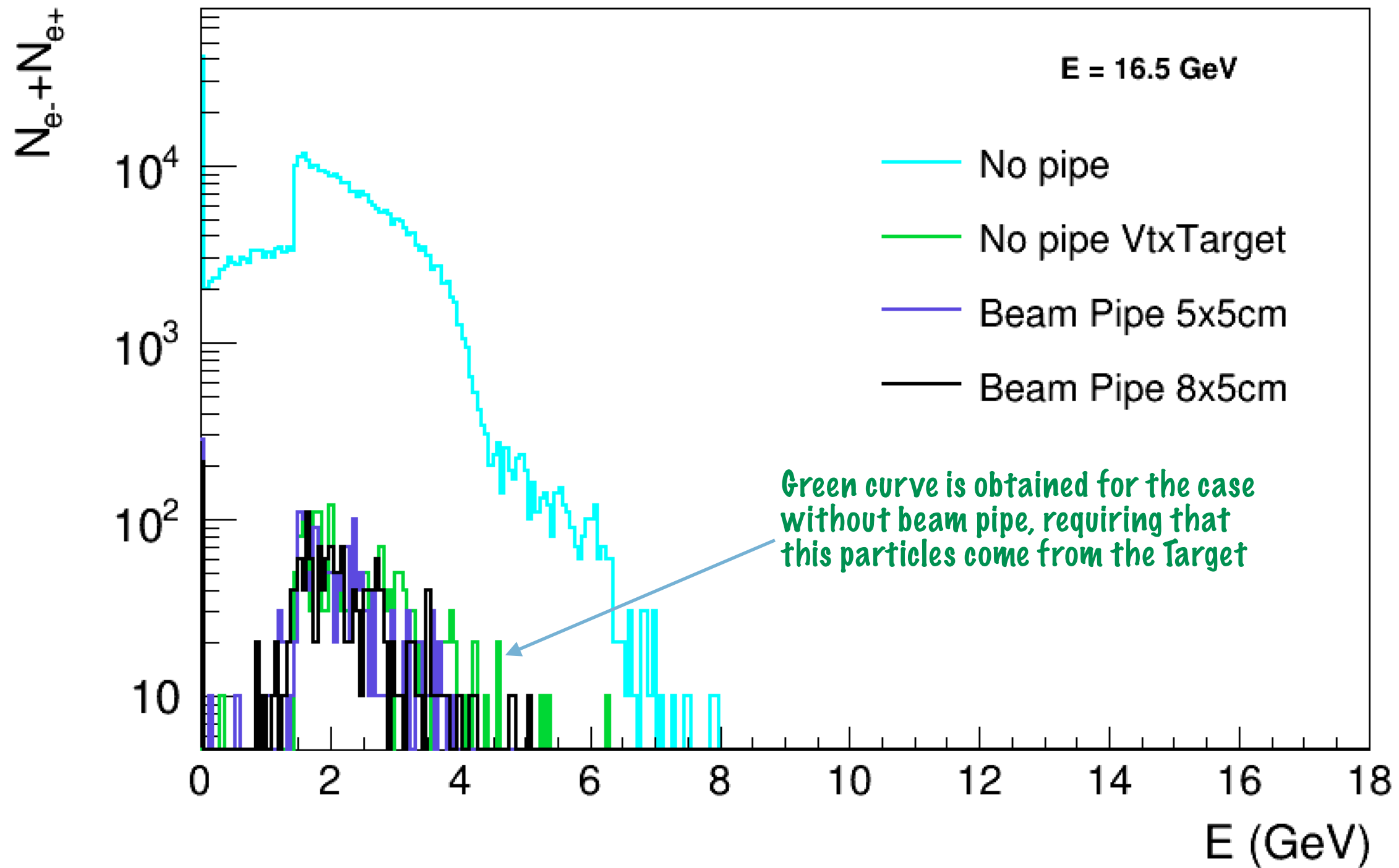
Spectra



Without beam pipe we measure in Compton detectors a lot e^-/e^+ pairs that were created in the air.
Only 4% e^-/e^+ come from the Target

As the laser intensity is low ($\xi = 0.3$), to reconstruct spectra we need more statistics.

Spectra



Without beam pipe we measure in Compton detectors a lot e^-/e^+ pairs that were created in the air.
Only 4% e^-/e^+ are generated in the Target

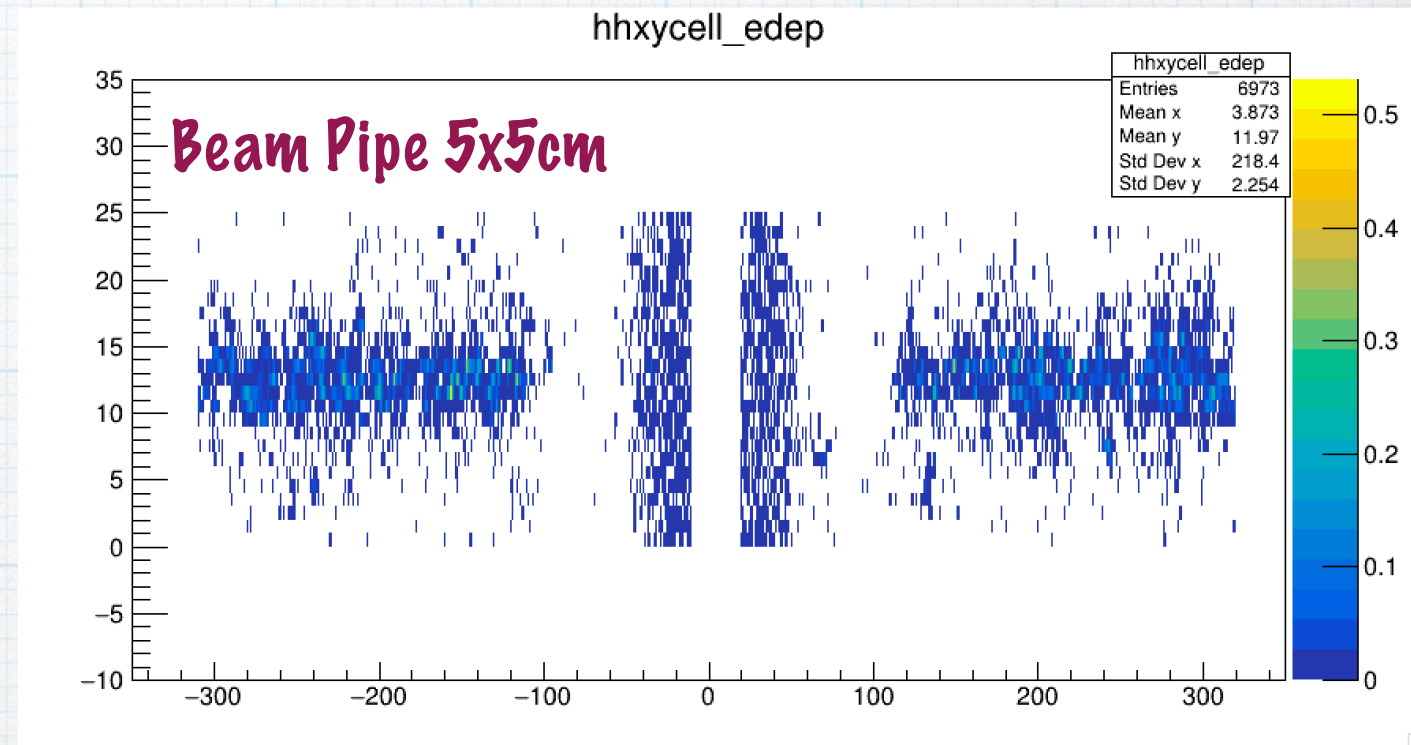
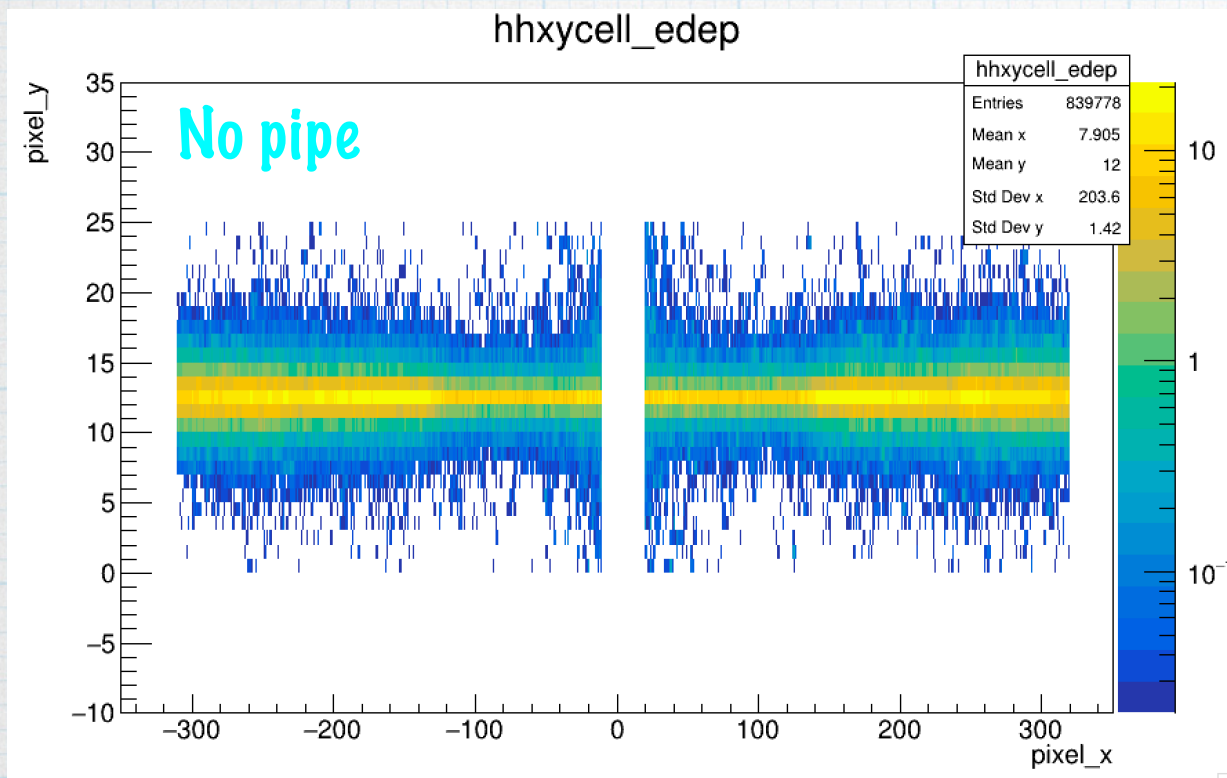
Summary

- * The performance of FDS setup was compared with and without beam pipe from the target to Compton detectors
- * Number of particles per BX hitting LYSO detector is 25 higher without beam pipe
- * Big hole in the Shielding creates substantial background occupancy in LISO detectors.
- * All extra particles are generated in the air. Number of particles generated in the target is identical.
- * In the air the vertexes are distributed almost uniformly all the way from the target to the detectors in case of no pipe.
- * As the laser intensity is low ($\xi = 0.3$), to reconstruct spectra we need more statistics. Asked Anthony to produce more; he runs now 1000BX

Deposited energy per cell

GeV per BX

✿ laser intensity $\xi = 0.32$



Compton MC2020 r for ($\xi=0.32$), 16.5 GeV electrons. G4: Kapton foil of 20 μm as a target, magnet 1.4T and 0.75m distance from magnet to LYSO.

If we take distribution of deposited energy the values around maximum are ~ 10 GeV.

To convert it to Gy, convert it to J: $\sim 1.6 \times 10^{-9} \text{ J}$ and then divide it to the mass of crystals in kg. $\text{Gy} = \text{J/kg}$

The density is 7.1 g/cm^3 , volume $0.1 \times 0.2 \times 2 = 0.04 \text{ cm}^3$. Mass $7.1 \times 0.04 = 0.284 \text{ g}$.

Finally, 5.6×10^{-6} Gy per BX.

Assuming 1 Hz collisions rate we get the dose of 10 kGy in LYSO crystal in about 56 years.

Vertex z

