Simulation and Reconstruction in the updated nHCal at epIC

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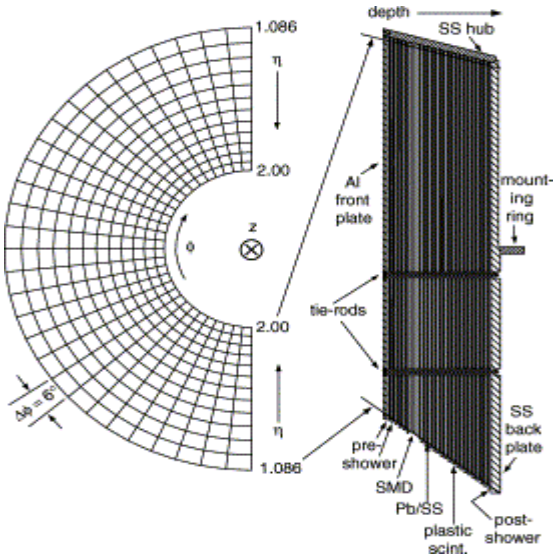
What we had



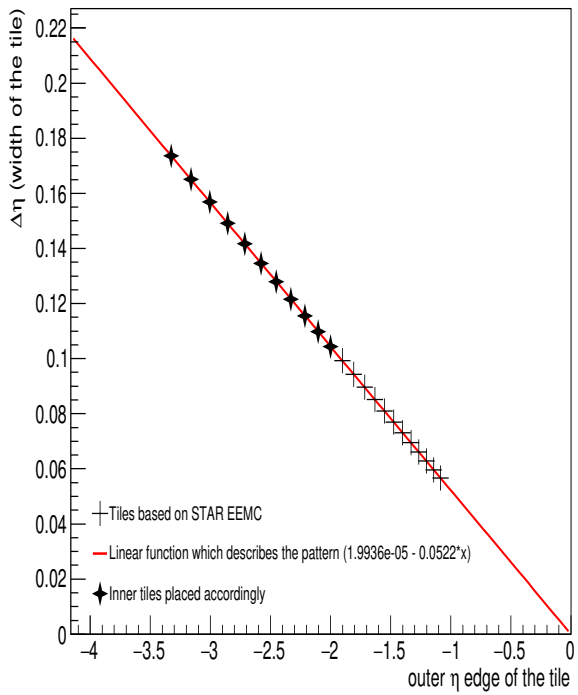
1. nHCal geometry updated with segmentation based on STAR EEMC and then extrapolated to η = -3.5
2. Segmentation implemented with PolarGridRPhi2:
   - 60x6 deg bins in ϕ
   - 12 bins in R

- η edges of tiles are taken from STAR and then used to get the R bins : $R = z/sinh\eta$; z = - 330 cm (position of the nHCal).
- R_{min} = 90.9878 cm, R_{max} = 251.444 cm.

Warning 1: Same tile size in R across the layers (changing z) instead of being same in η – still an approximation

Warning 2: Tiles shaped as parts of a ring instead of trapezoids

Extrapolation method for inner tiles up to η = -3.5



- Plotted $\Delta\eta$ (size of tile) vs. outer η edge of existing tiles
- Performed a linear fit : $\Delta\eta = 1.9936e^{-5} - 0.0522\eta$
- Extrapolated up to η = -3.5
- Recalculated into limits in R using the formula: $R = z/sinh\eta$

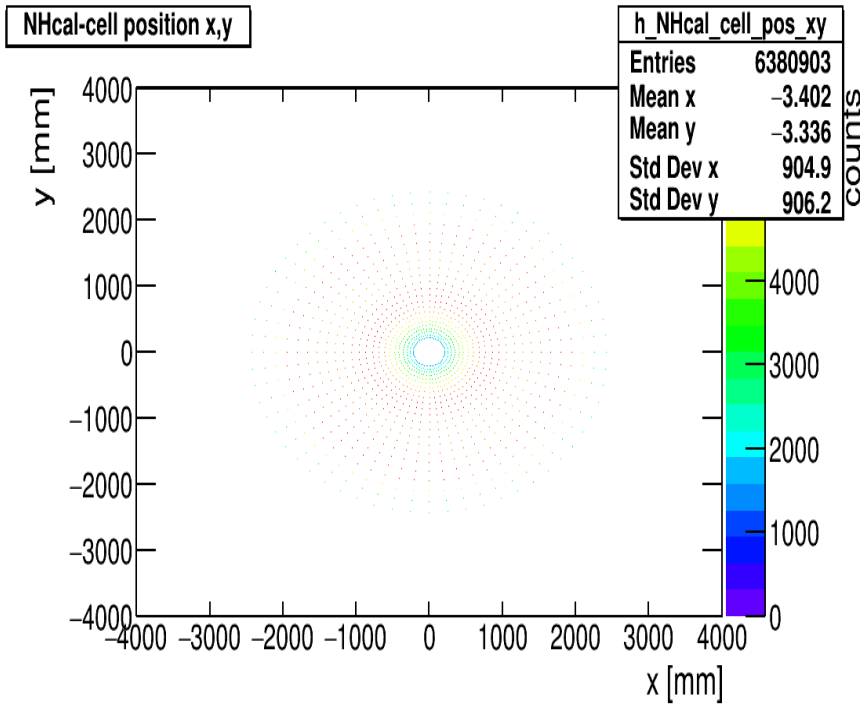
Updates stored in negative-HCal-dev and a merge into the main branch has been approved.

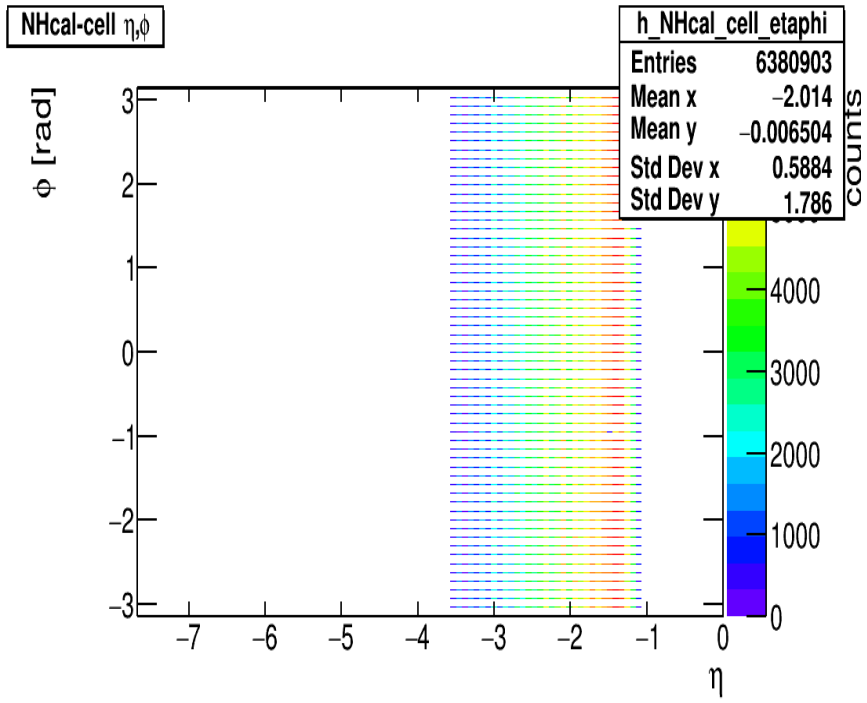
`https://github.com/eic/epic/tree/negative-HCal-dev`

Description of events

- Neutrons are generated using the particle gun of ddsim
- Gun energy 5 GeV
- Generated particles are distributed uniformly within the range $130^\circ < \theta < 177^\circ$
- 100000 events in total and 1 generated particle in each event

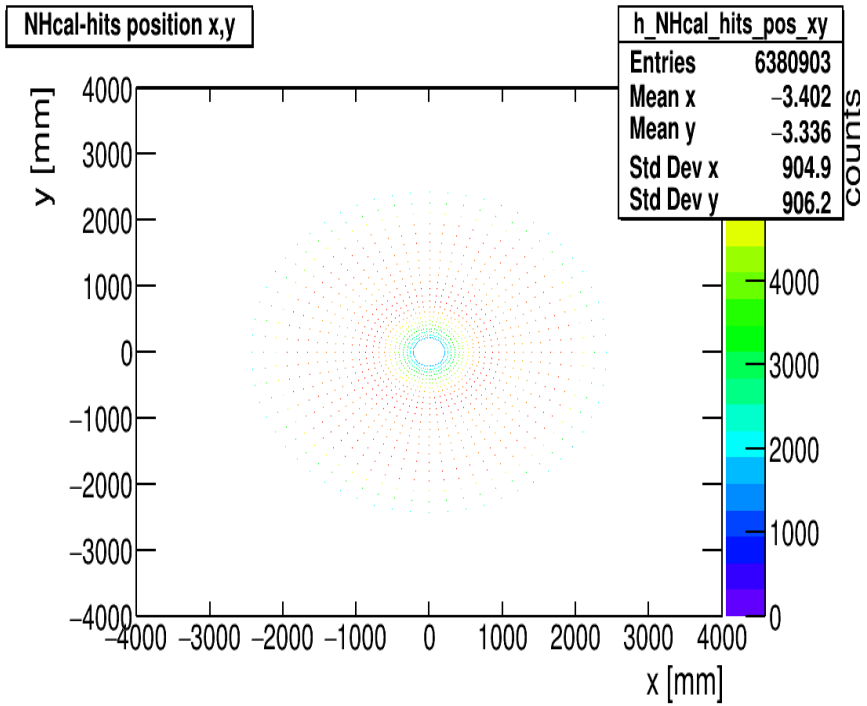
Position of the tiles

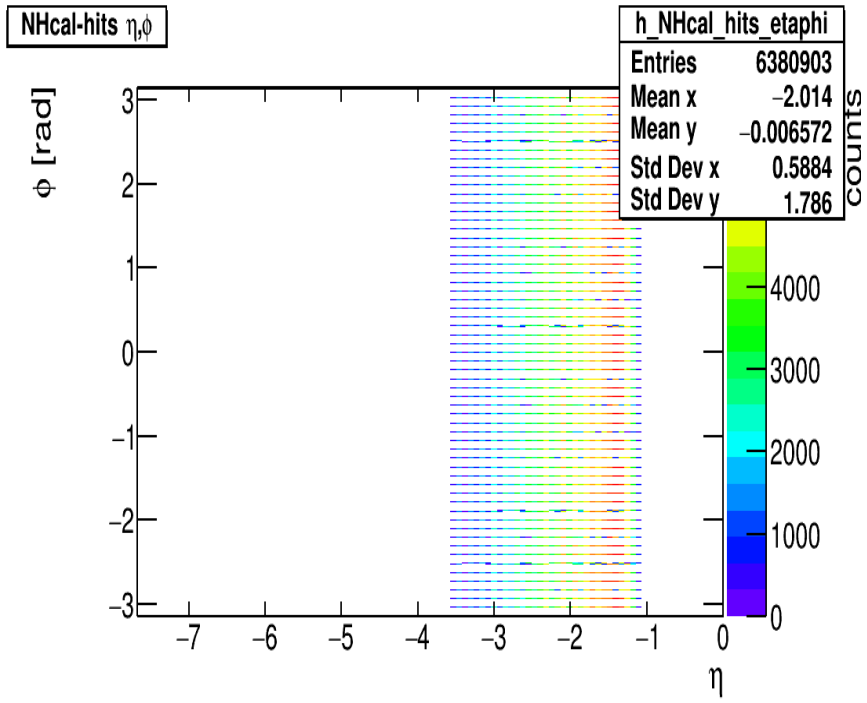




The position of the tiles looks good. The segmentations have worked as expected.

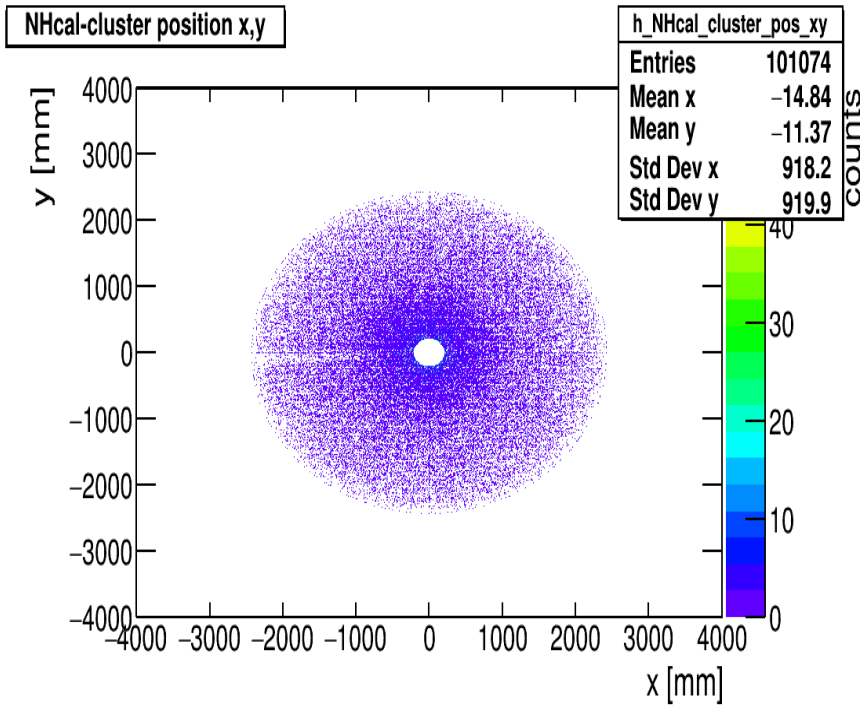
Position of the Hits

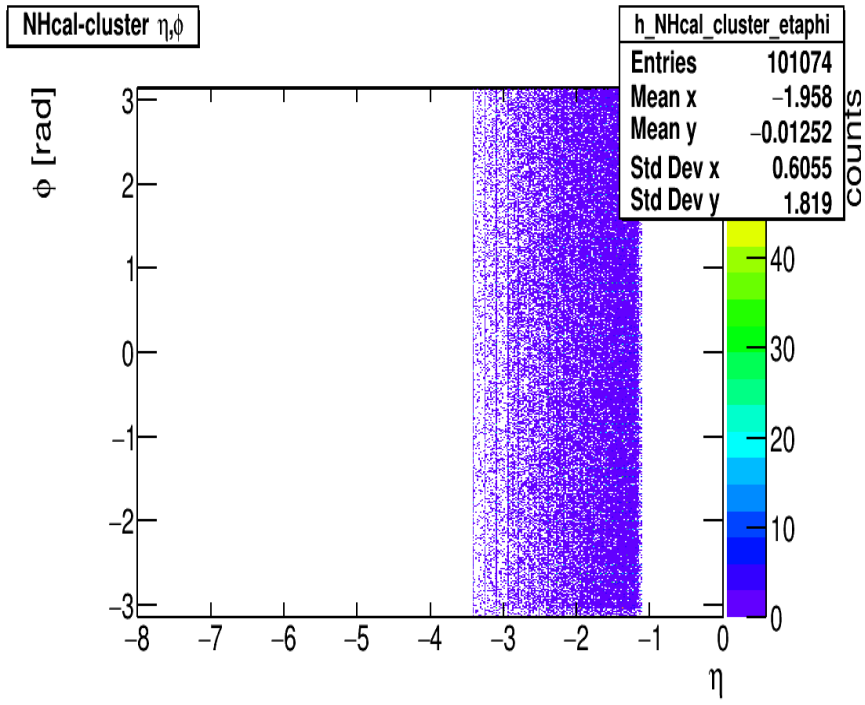




Hits are placed at the center of the tiles.

Reconstructed nHCal cluster position

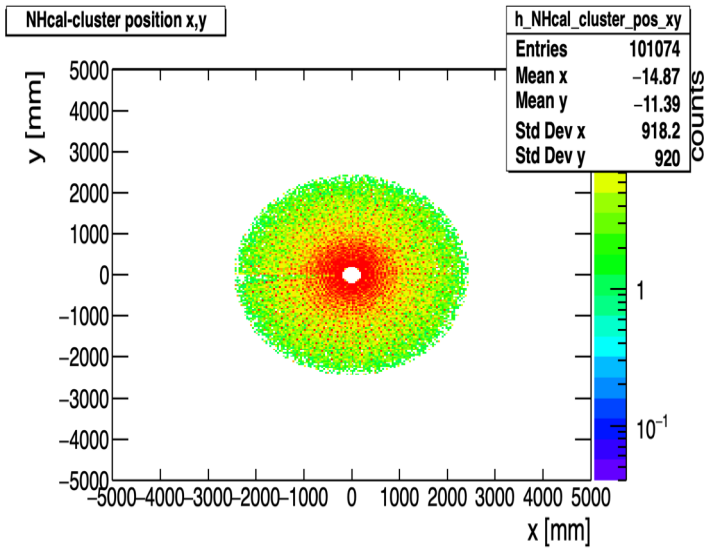




Less no. of clusters along y = 0 in the negative x region. It seems like the Clustering algorithm treats $\phi = -\pi$ and $\phi = \pi$ as separate positions.

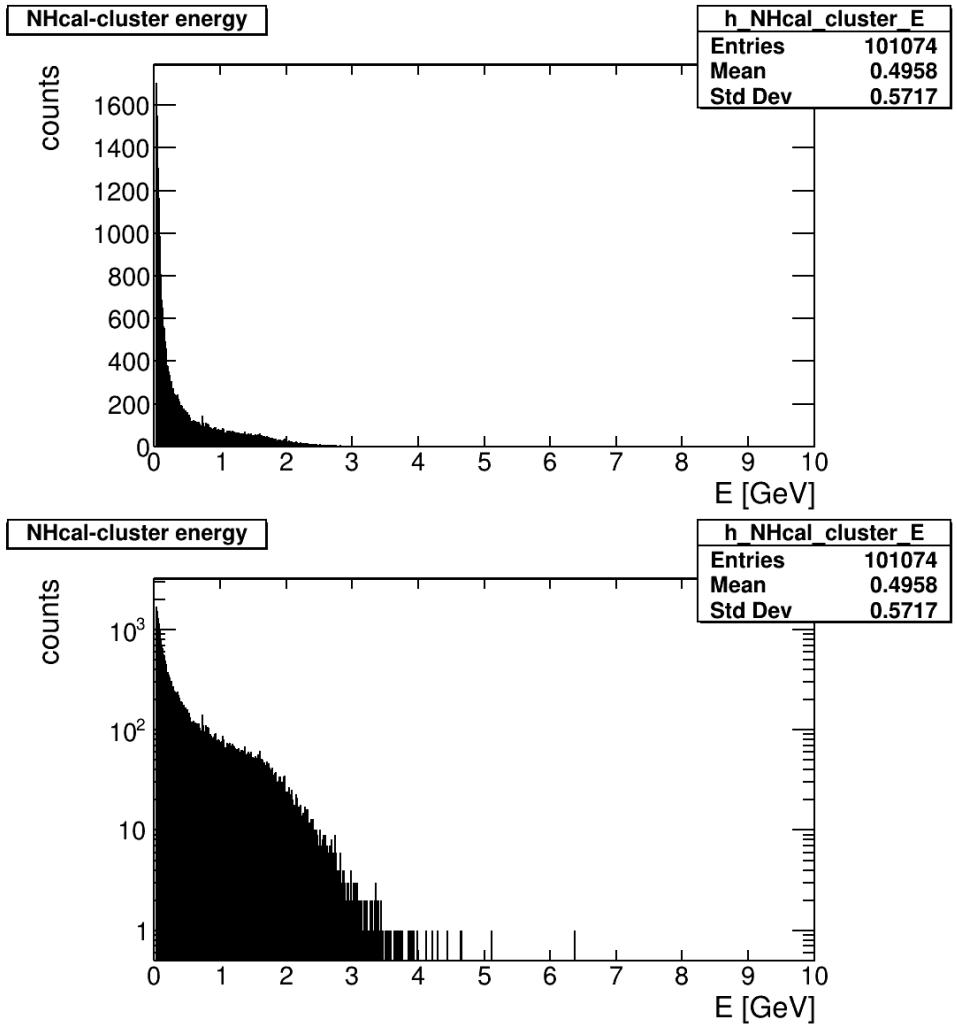
nHCal cluster position

1. The number of clusters (101,074) is more than the number of generated particles (100,000). So, there are some split clusters.
2. As we go from outer R to inner R, the ΔR of the tiles keeps on decreasing. But the corresponding $\Delta\eta$ keeps on increasing.

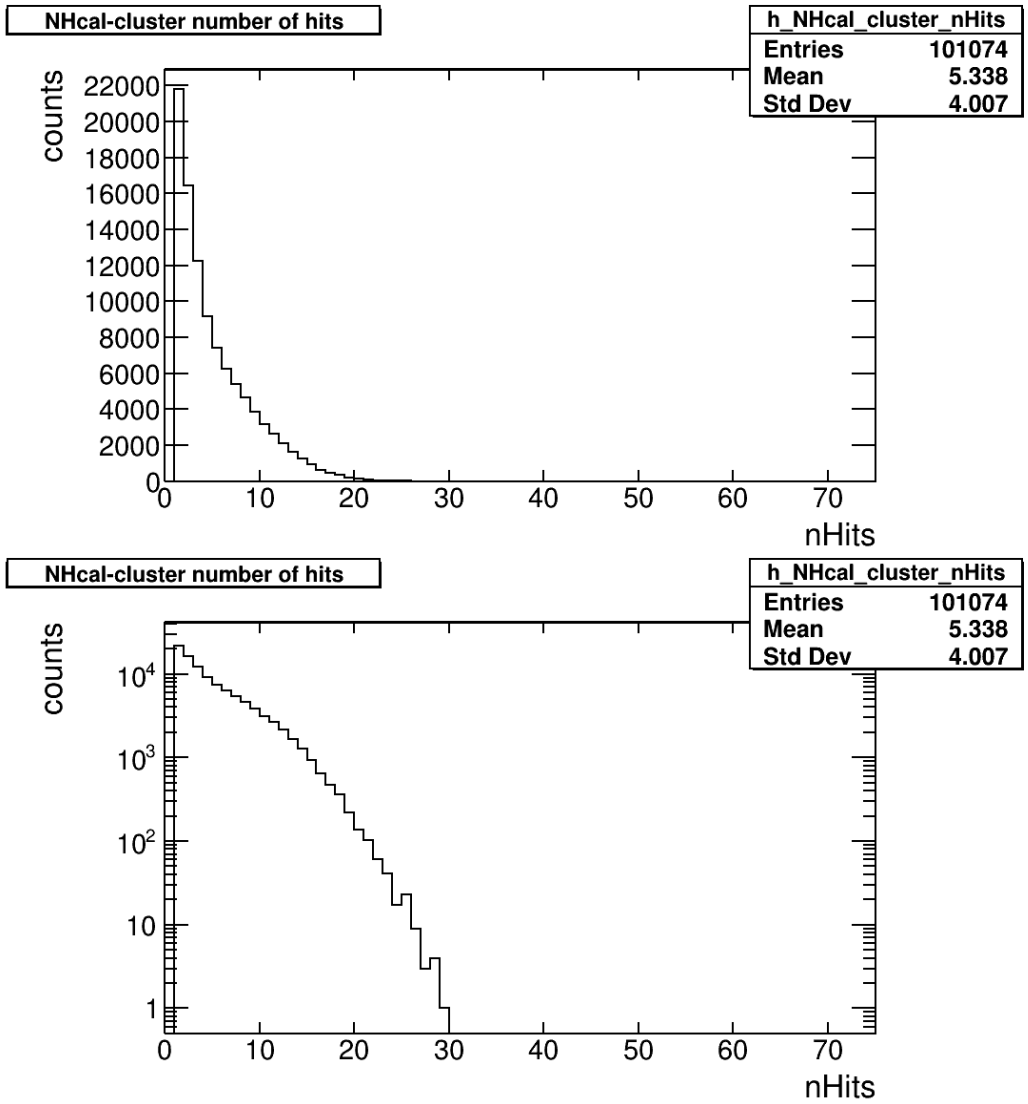


- The η bin used in the clustering algorithm does not work properly for the inner regions.
- Suggestion to use different η bin for different regions of the detector.

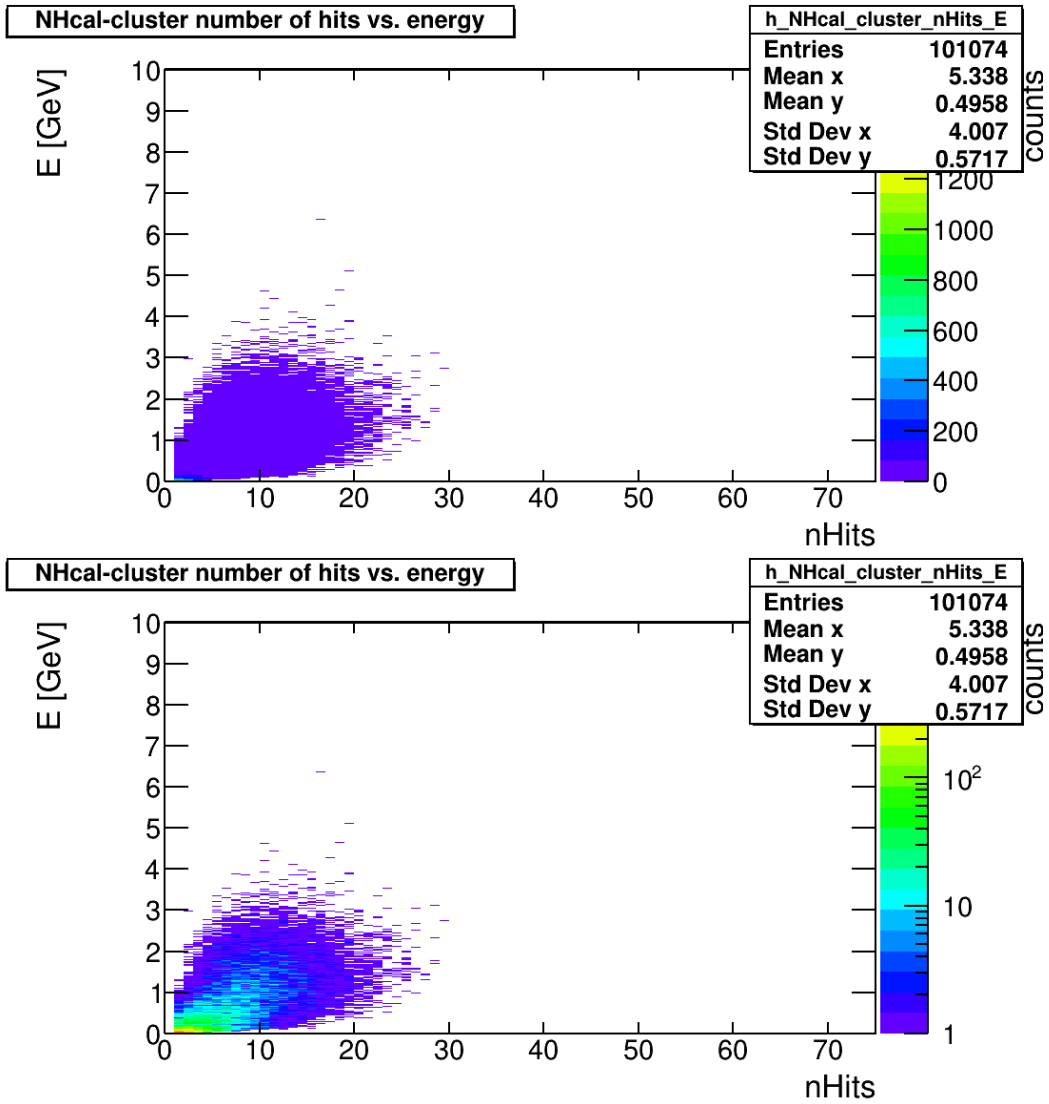
nHCal cluster energy



nHCal cluster nHits



nHCal cluster Energy vs. nHits



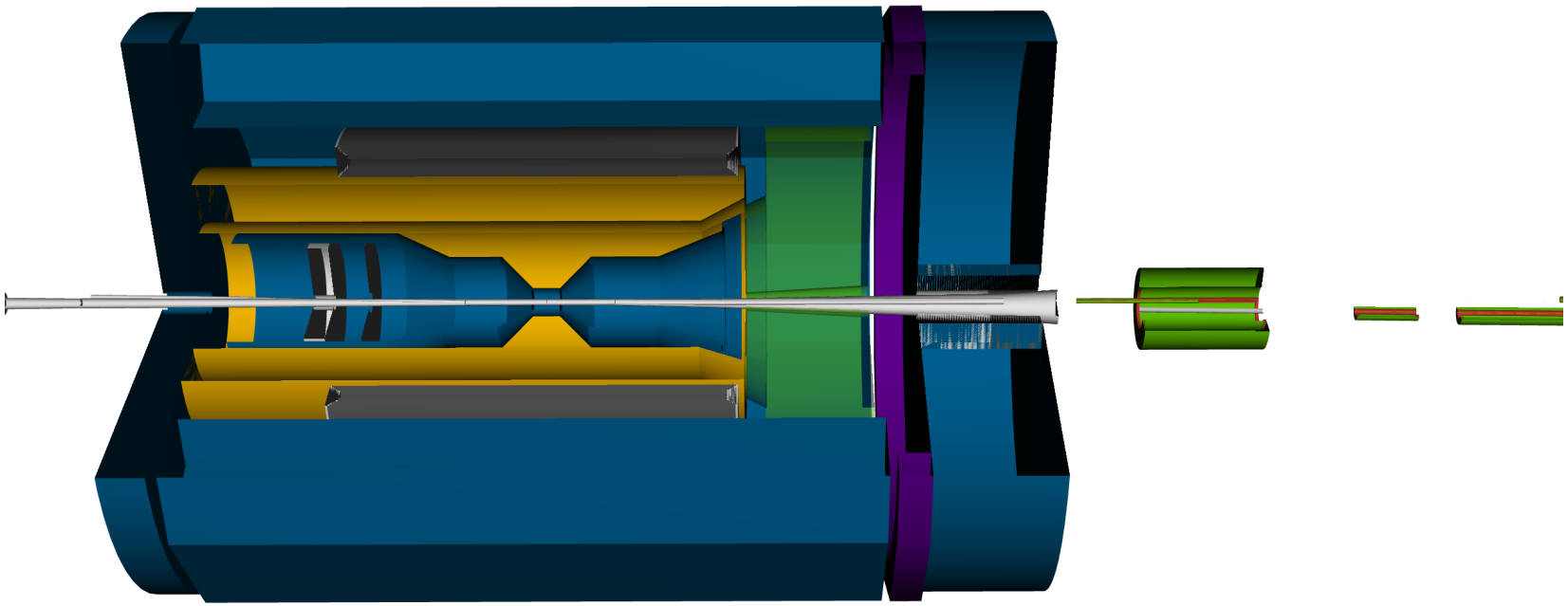
Summary

- Updated nHCal segmentation and geometry - changes approved for merging into main branch
- Basic tests done - ready for simulation campaign

Further steps

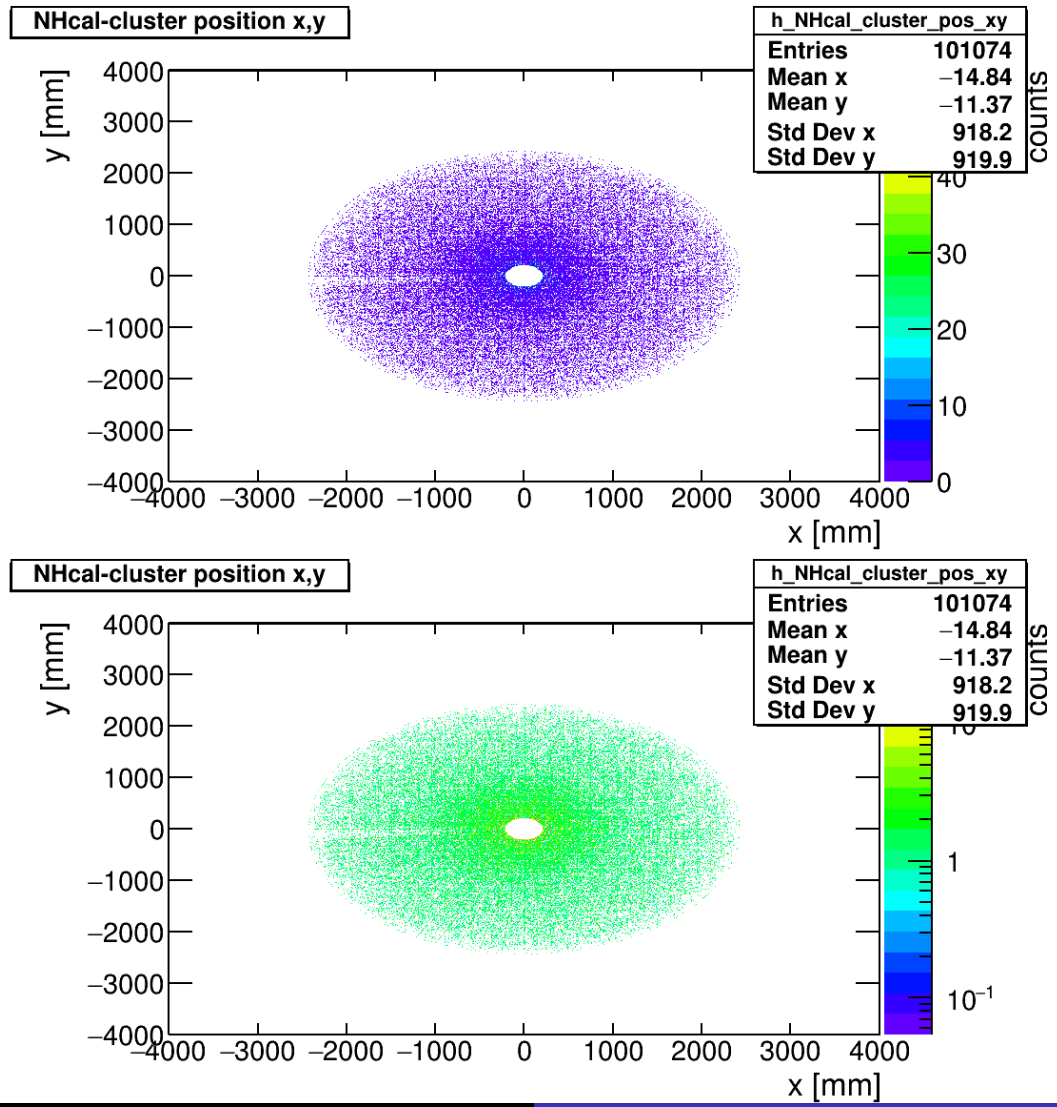
- Tests needed for typical neutron energy - need input from e+p/e+A events simulation
- Need to add charged track projections
- Apply machine learning methods to separate neutral/charged hadrons
- Implementation of more detailed geometry?
- Energy resolution studies?
- Any other checks?

Thank You

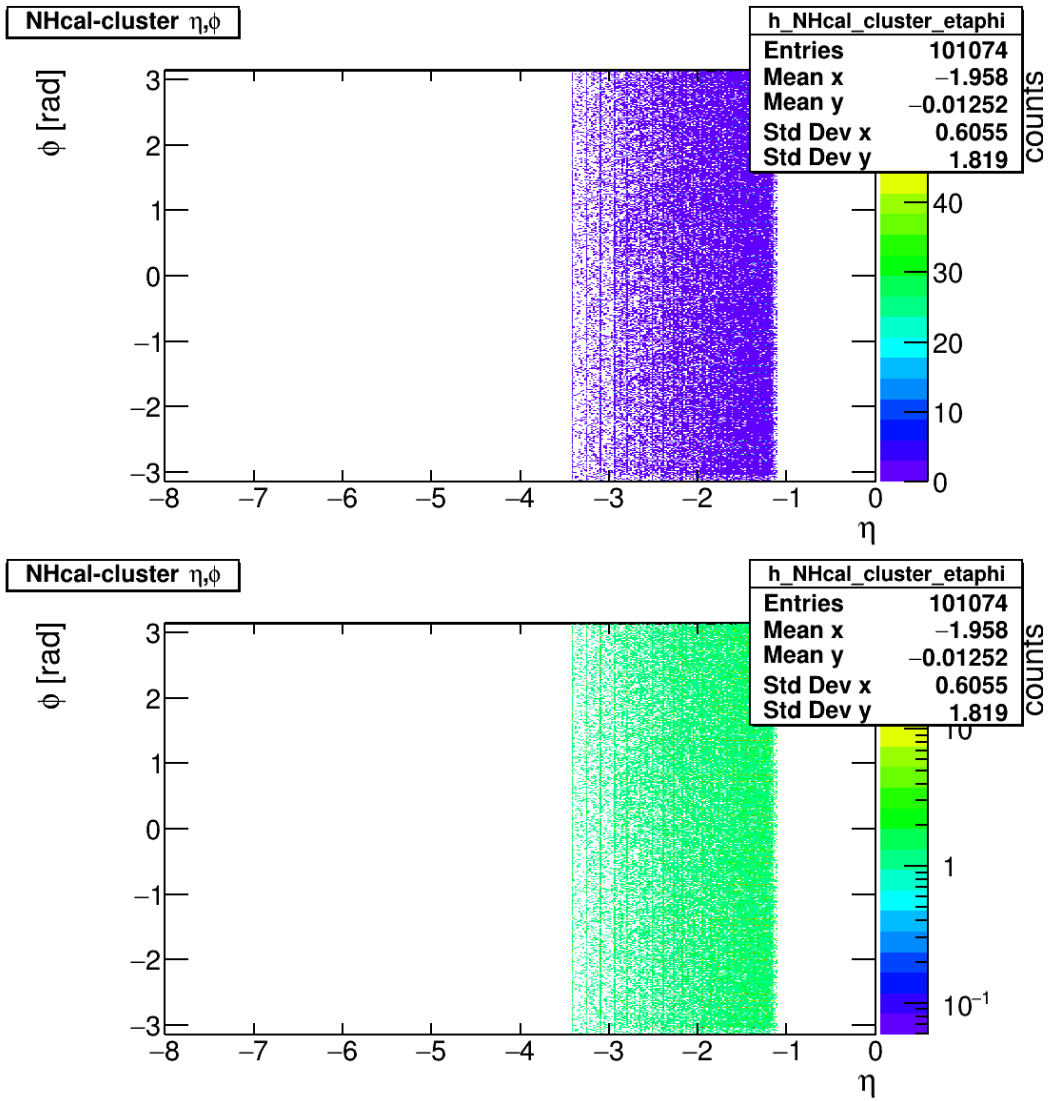


BACK UP

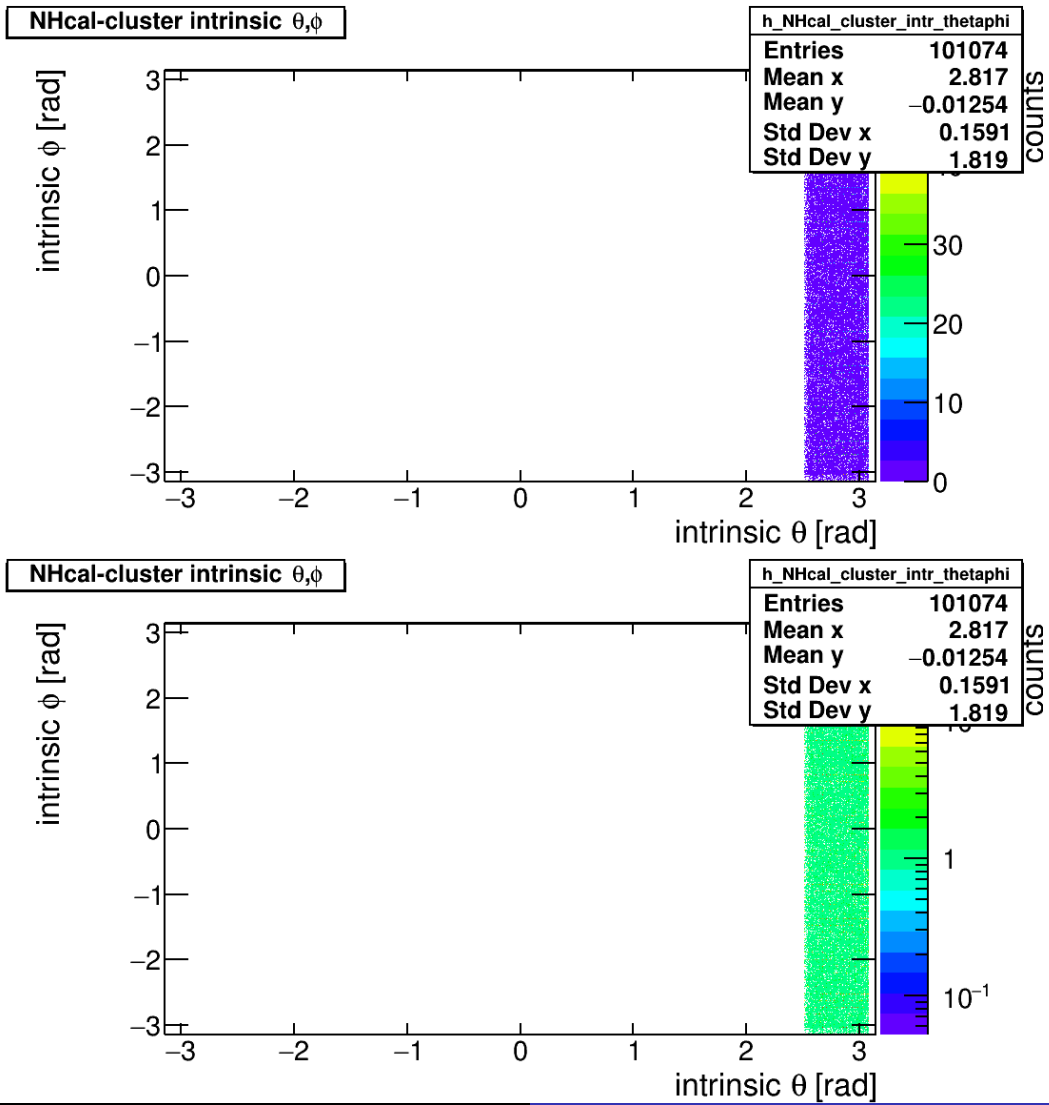
Reconstructed nHCal cluster x-y distribution : Neutron Gun



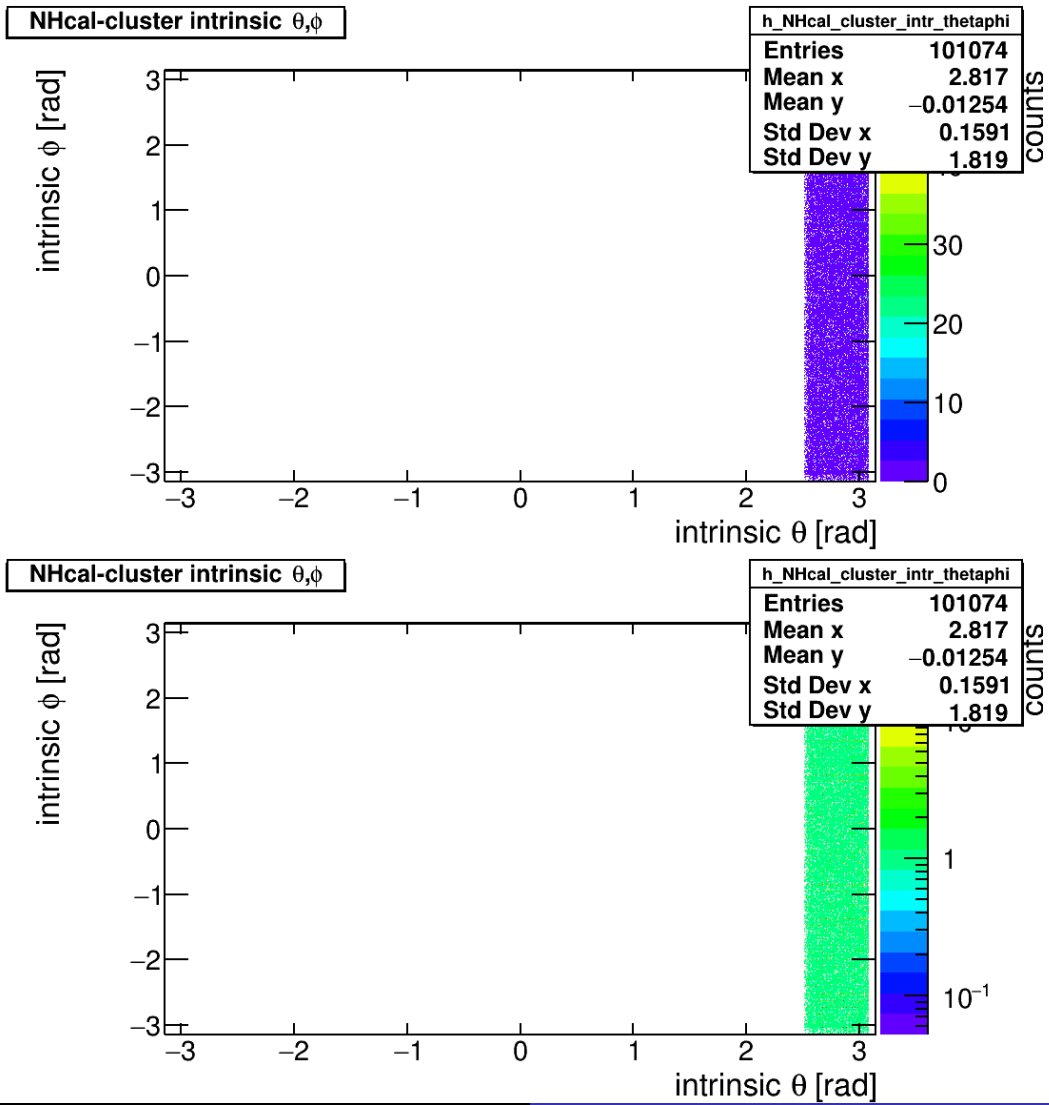
Reconstructed nHCal cluster eta-phi distribution : Neutron Gun



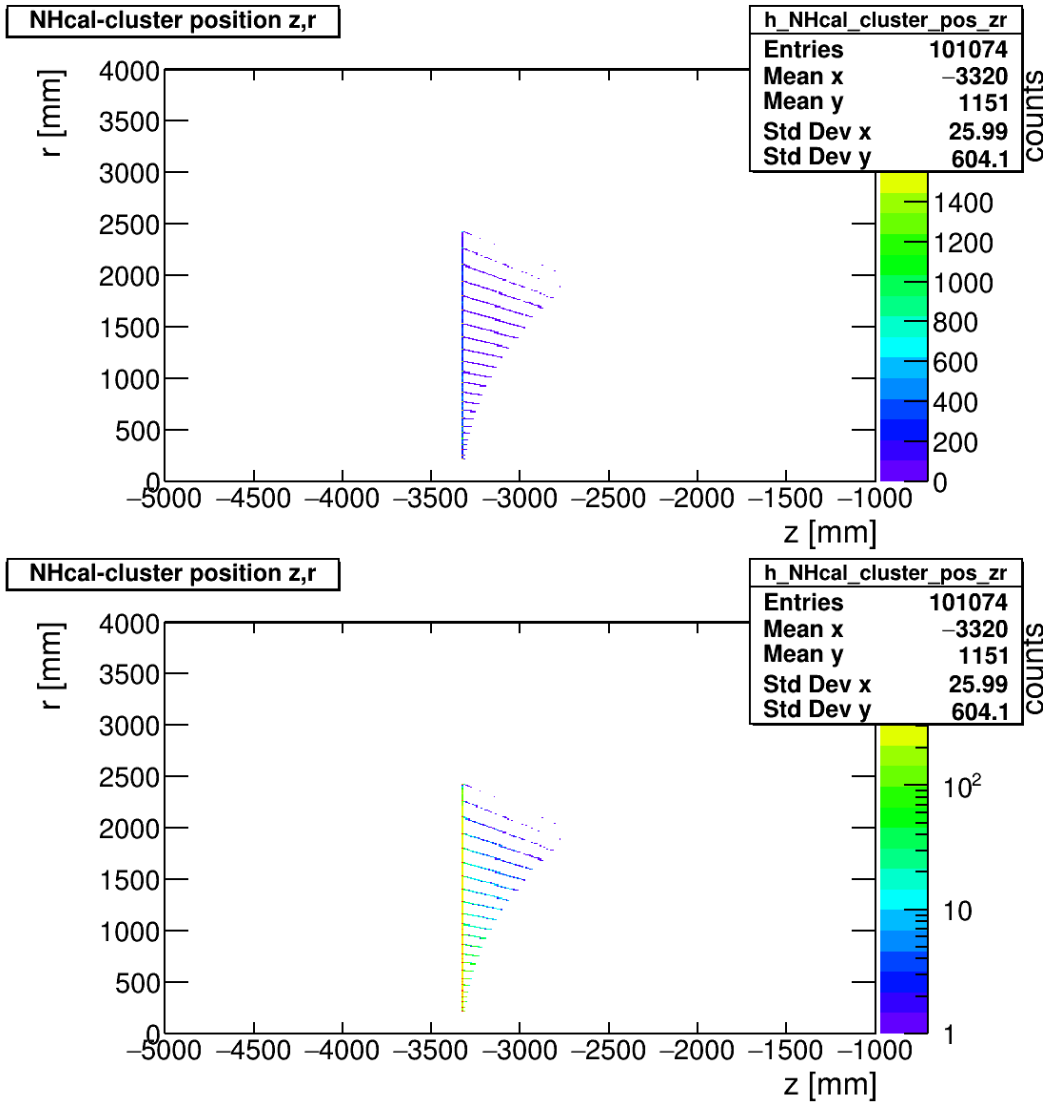
Reconstructed nHCal cluster intrinsic $\theta - \phi$ distribution : Neutron Gun



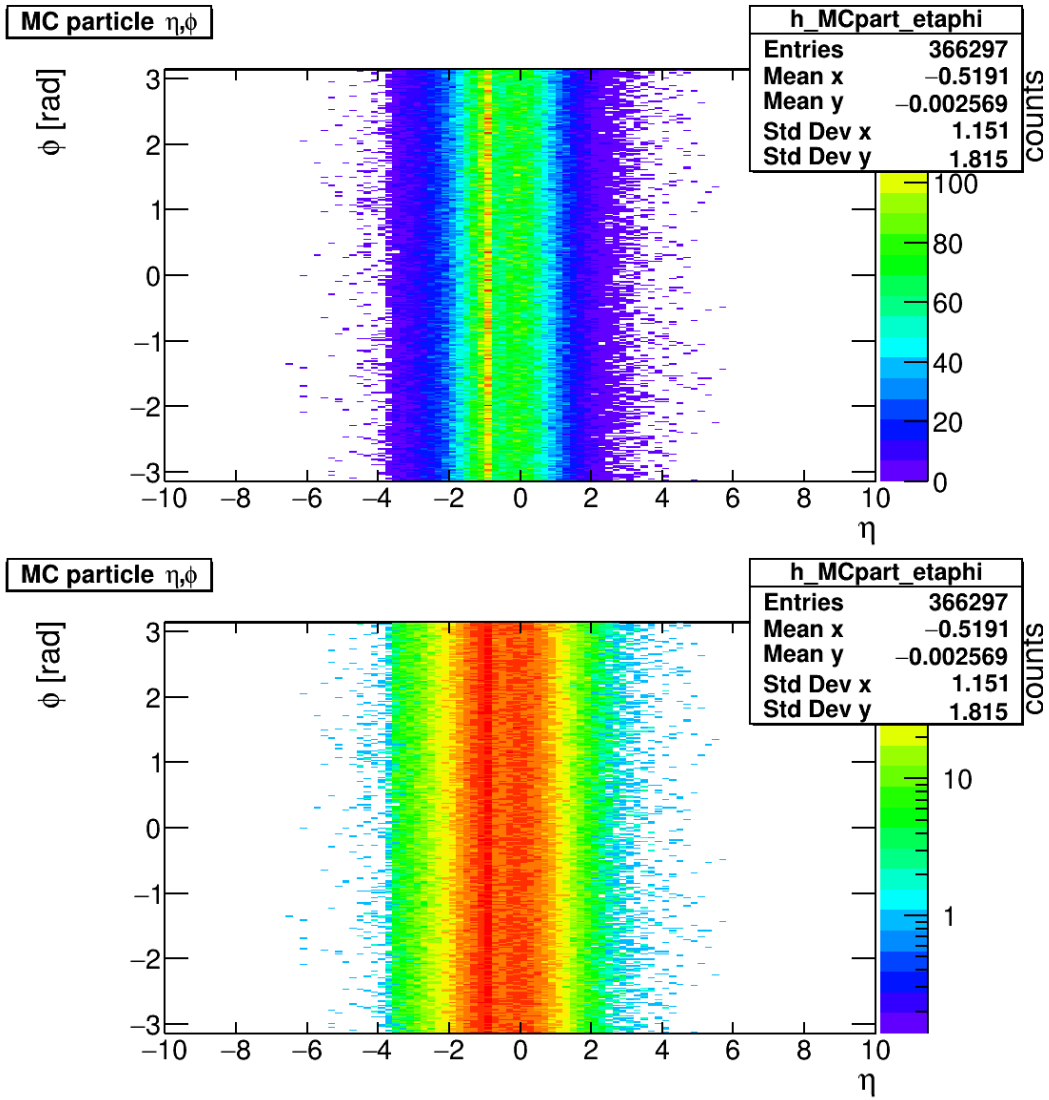
Reconstructed nHCal cluster intrinsic $\theta - \phi$ distribution : Neutron Gun



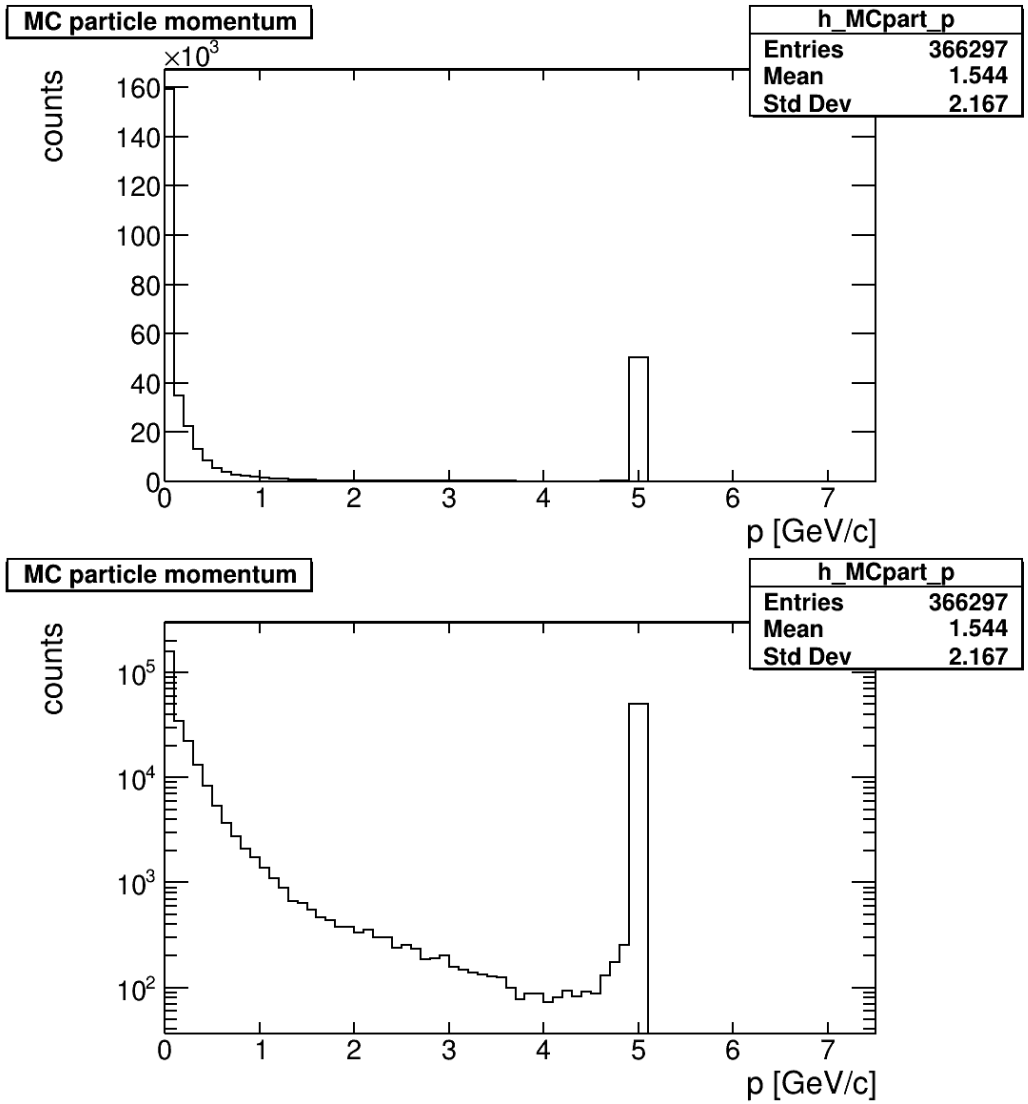
Reconstructed nHCal cluster r-z distribution : Neutron Gun



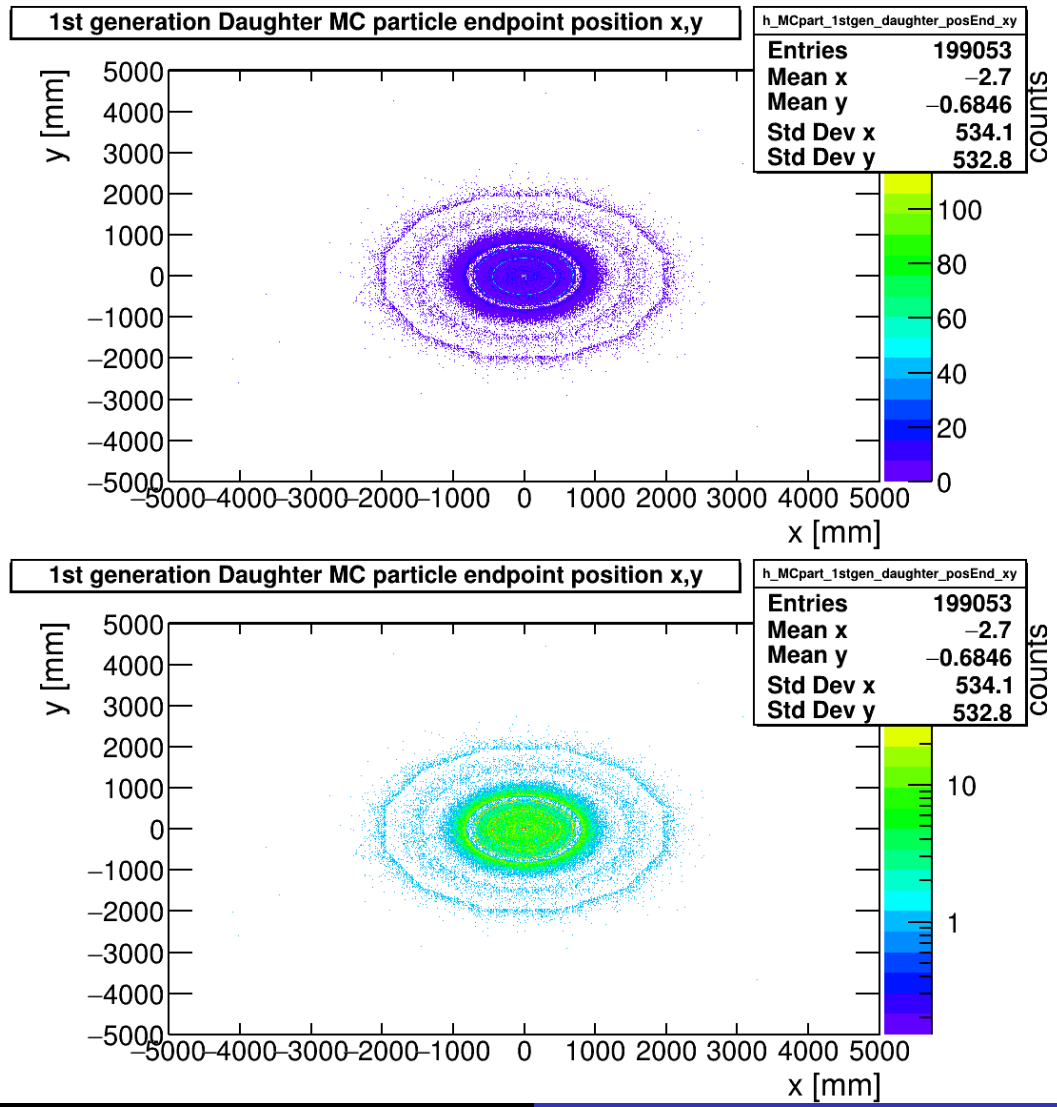
$\eta - \phi$ distribution of MC particles : Neutron Gun



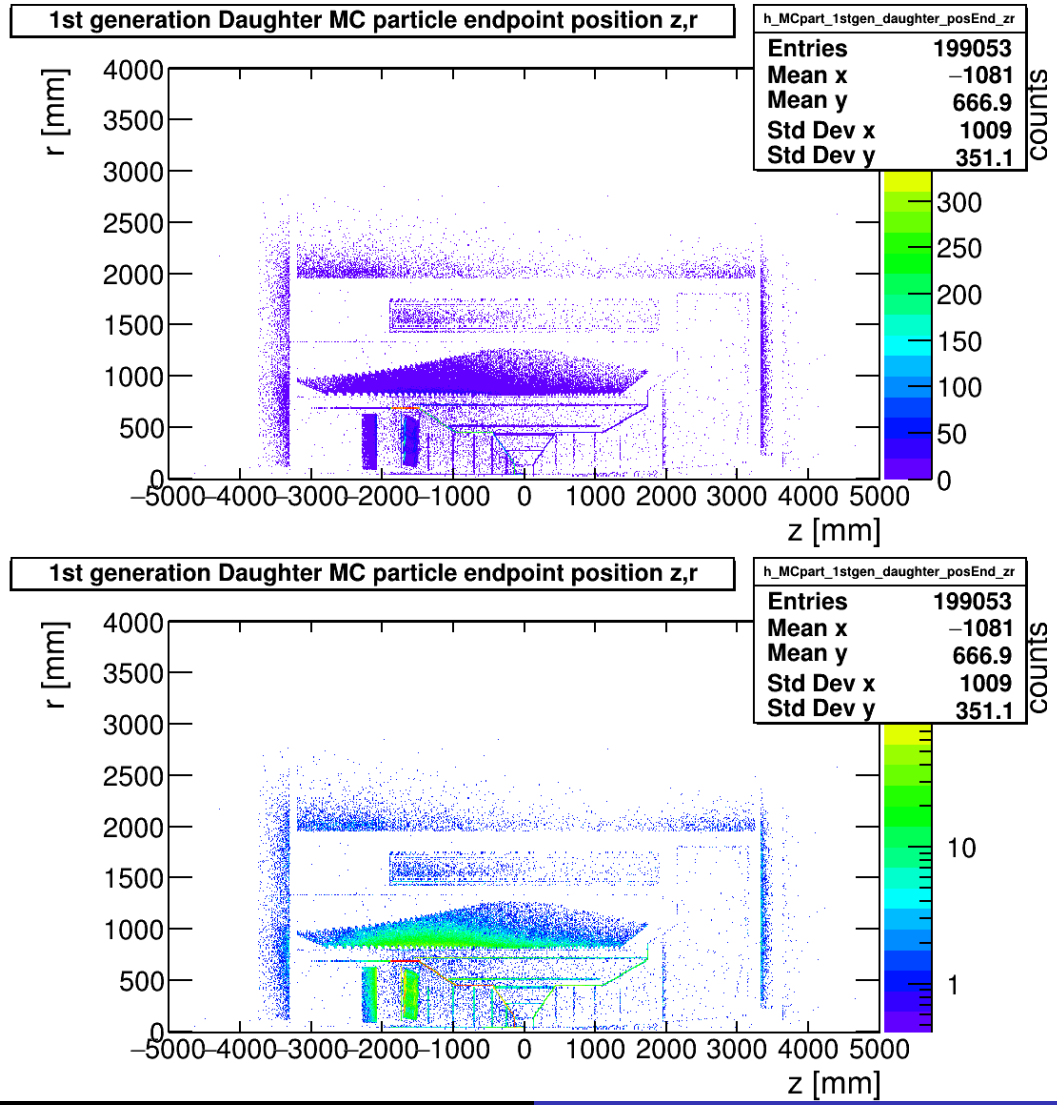
Momentum distribution of MC particles : Neutron Gun



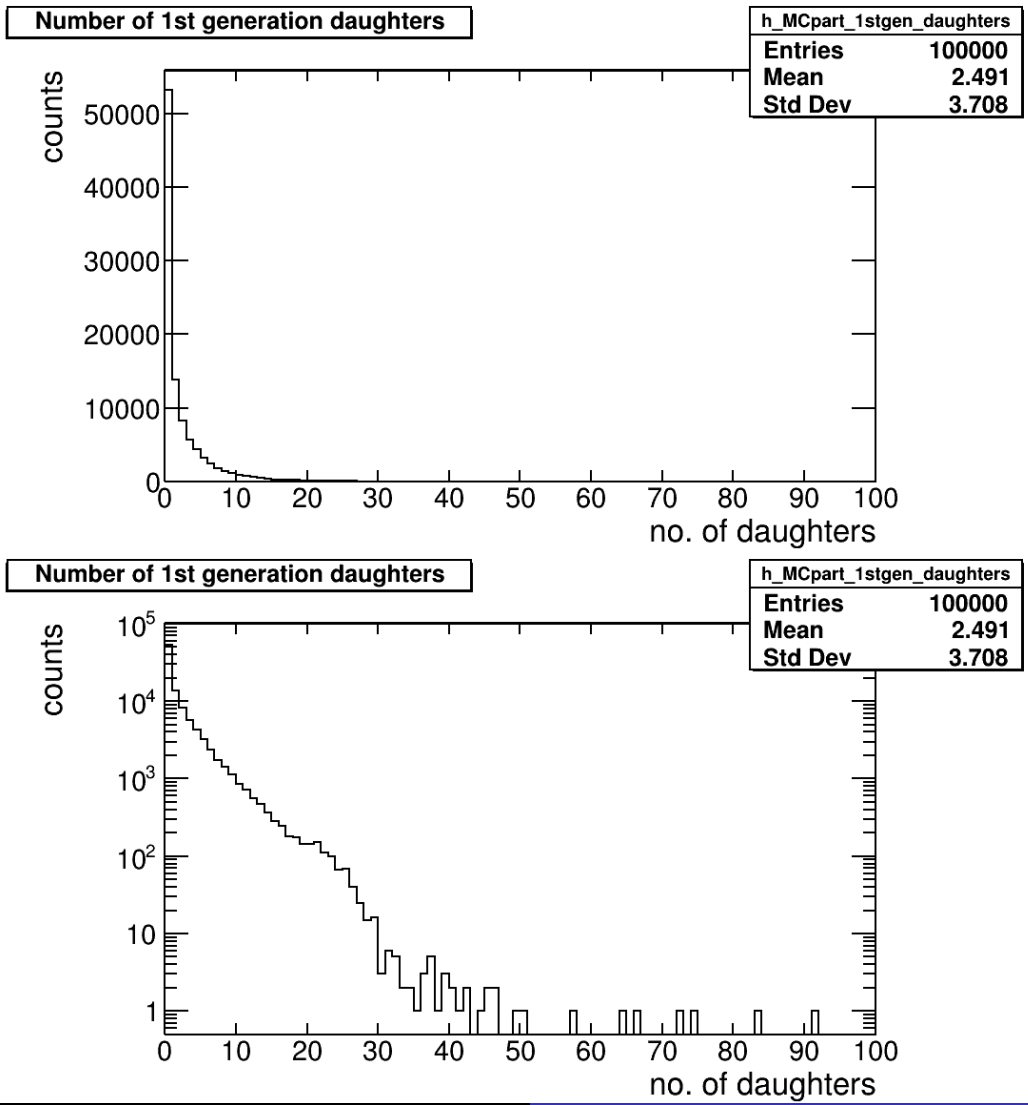
End point of the 1st generation daughter MC particles : Neutron Gun



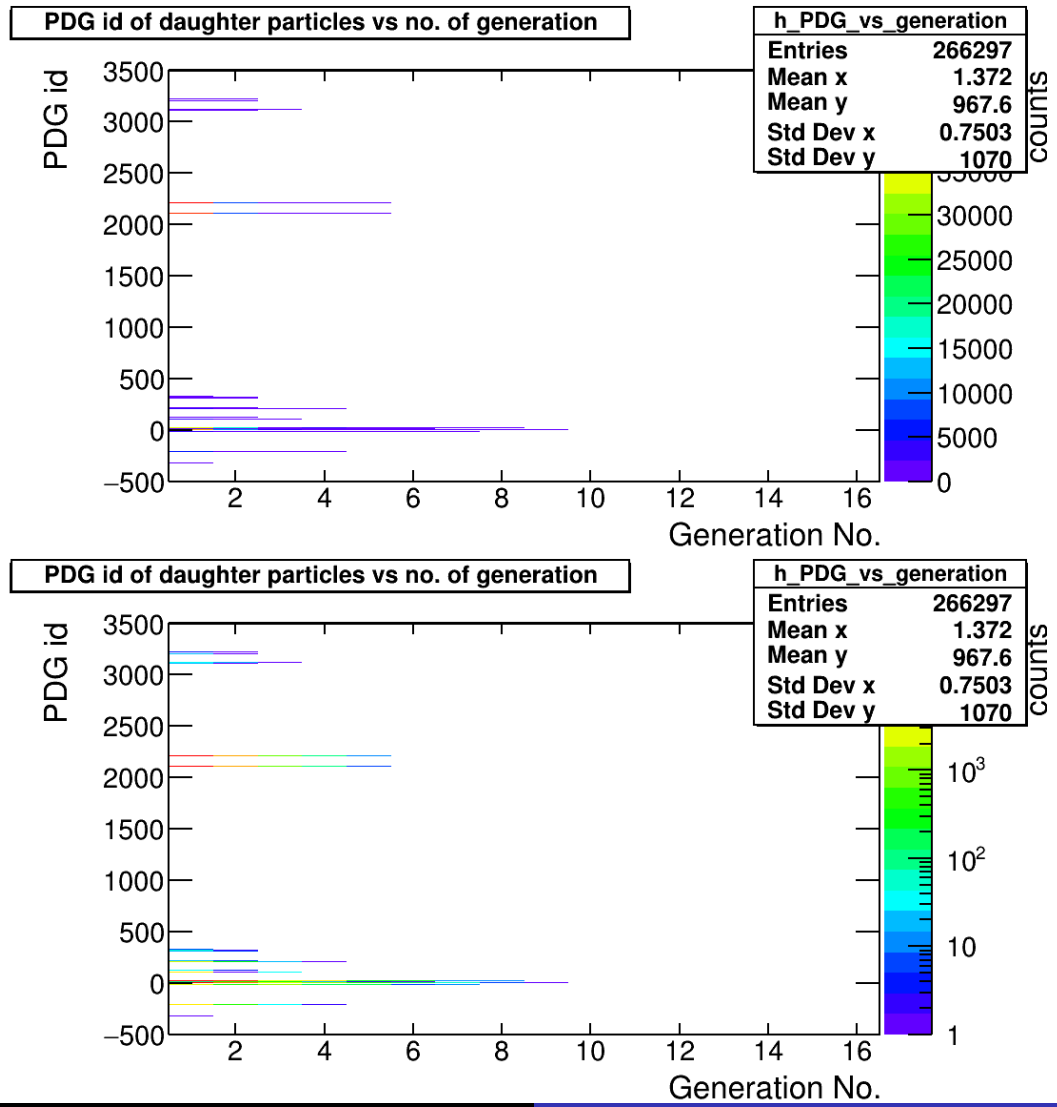
End point of the 1st generation daughter MC particles : Neutron Gun



Number of 1st generation daughter MC particles : Neutron Gun



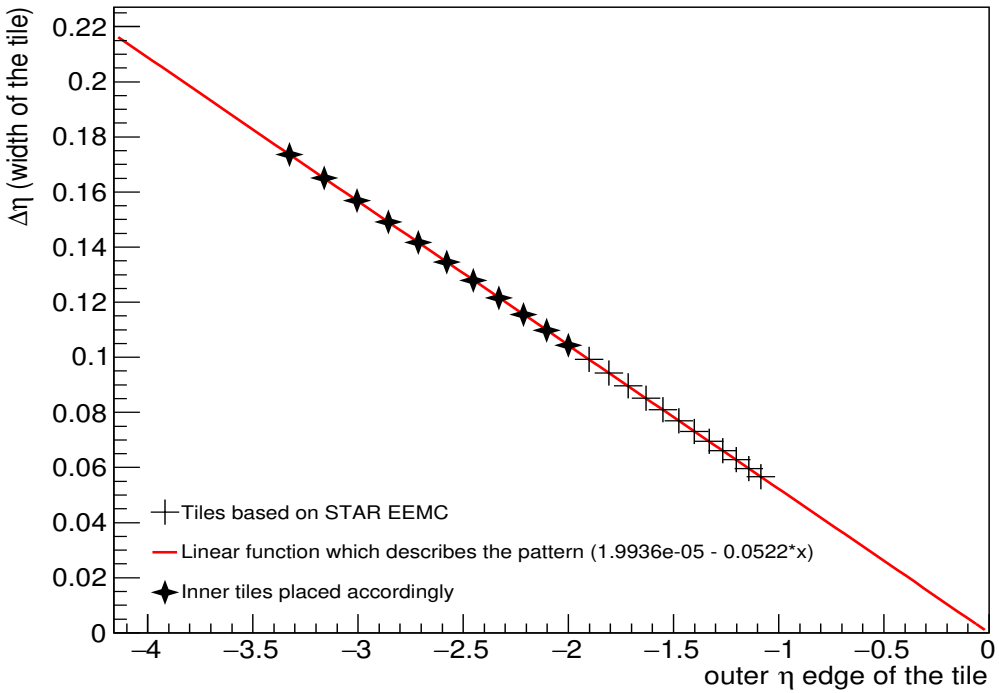
PDG Id of daughter MC particles vs. Generation No. : Neutron Gun



Solution

- Let's find out what pattern is followed by the outer η edges and the η widths.
- Plot a graph of η width vs. outer η edges and fit it.
- A linear fit works reasonably well.
- We get the η width of the tile with outer η edge $=$ -2 and so on.
- We place the tiles accordingly up to $\eta =$ -3.5, which now corresponds to R $=$ 19.9431 cm.

Solution



Current bins in R are defined as follows:

[19.9431 cm, 23.7336 cm, 28.0062 cm, 32.7836 cm, 38.0859 cm, 43.9297 cm, 50.3297 cm, 57.2972 cm, 64.8401 cm, 72.966 cm, 81.6805 cm, 90.9878 cm, 100.89 cm, 111.395 cm, 122.516 cm, 134.229 cm, 146.58 cm, 159.546 cm, 173.155 cm, 187.424 cm, 202.377 cm, 218.019 cm, 234.353 cm, 251.444 cm]