Study of Angular Coordinate Resolution from nHCal and nECal

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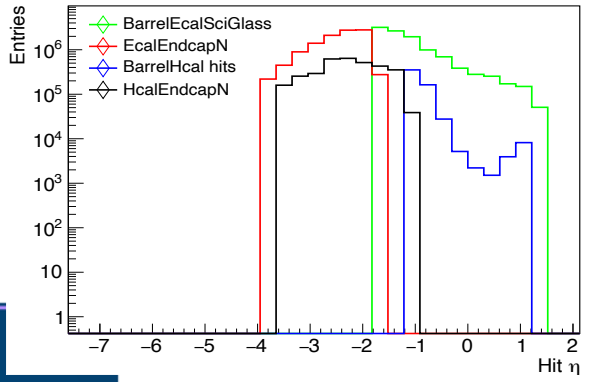
ePIC calorimetry meeting

May 17, 2023

Acceptance overlap between calorimeters



HcalBarrel

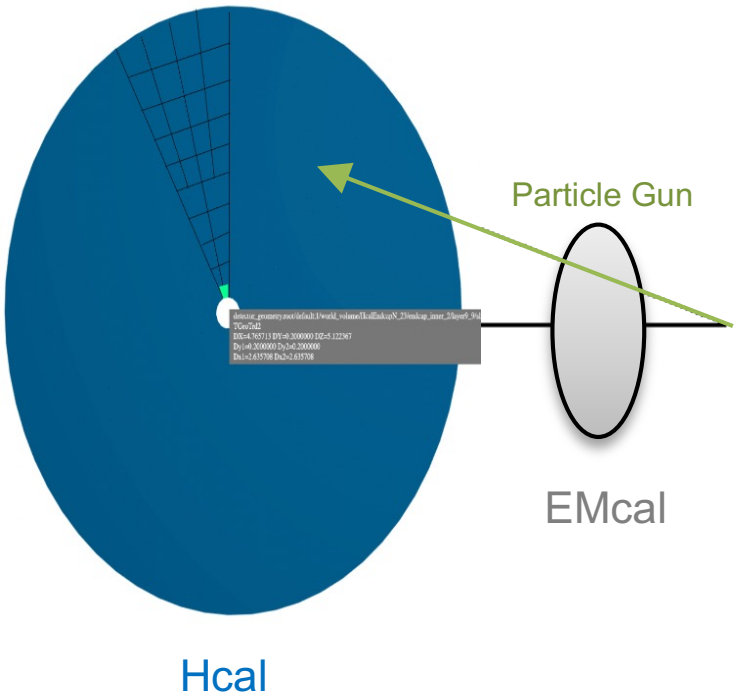
Solenoid

HcalEndcapN

EcalEndcapN

EcalBarrel

Position Resolution Study

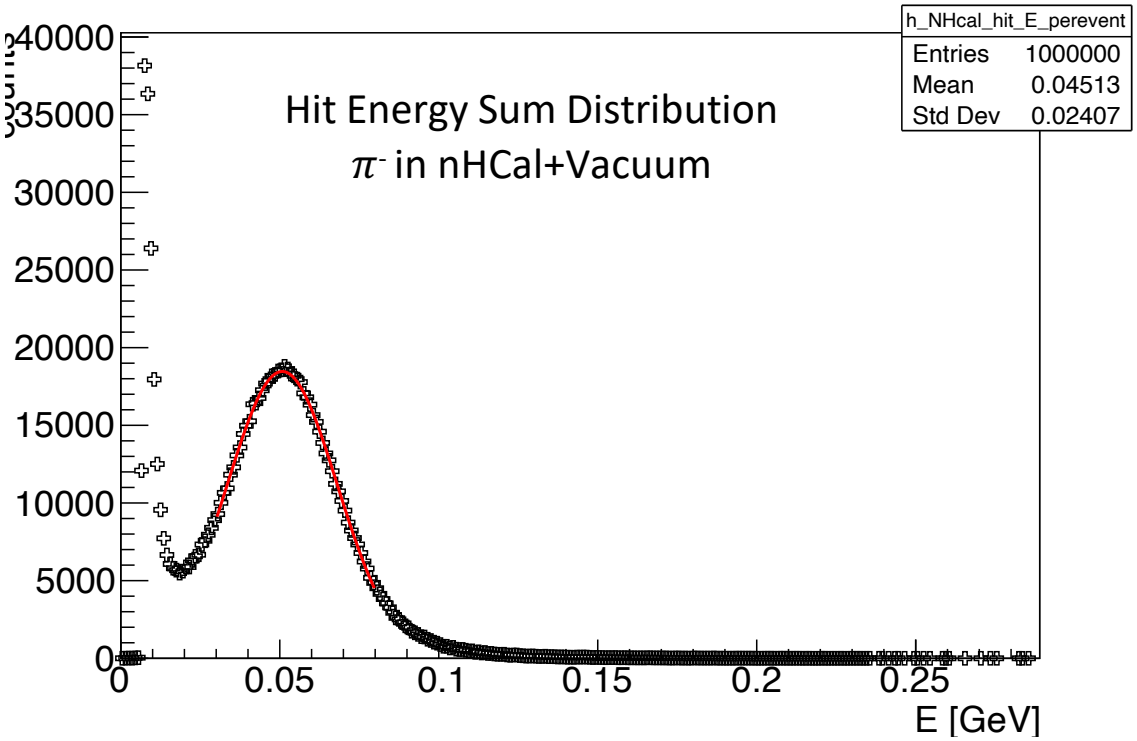


- Neutrons are generated using the particle gun of ddsim
- 1 neutron/event, 1mill events and p=5 GeV
- **θ = 170◦ and φ = 45◦**

Objective : *Use truth clusters to investigate the angular resolution for neutron shower reconstruction*

Detector Calibration

1. Sampling Fraction of nHCal



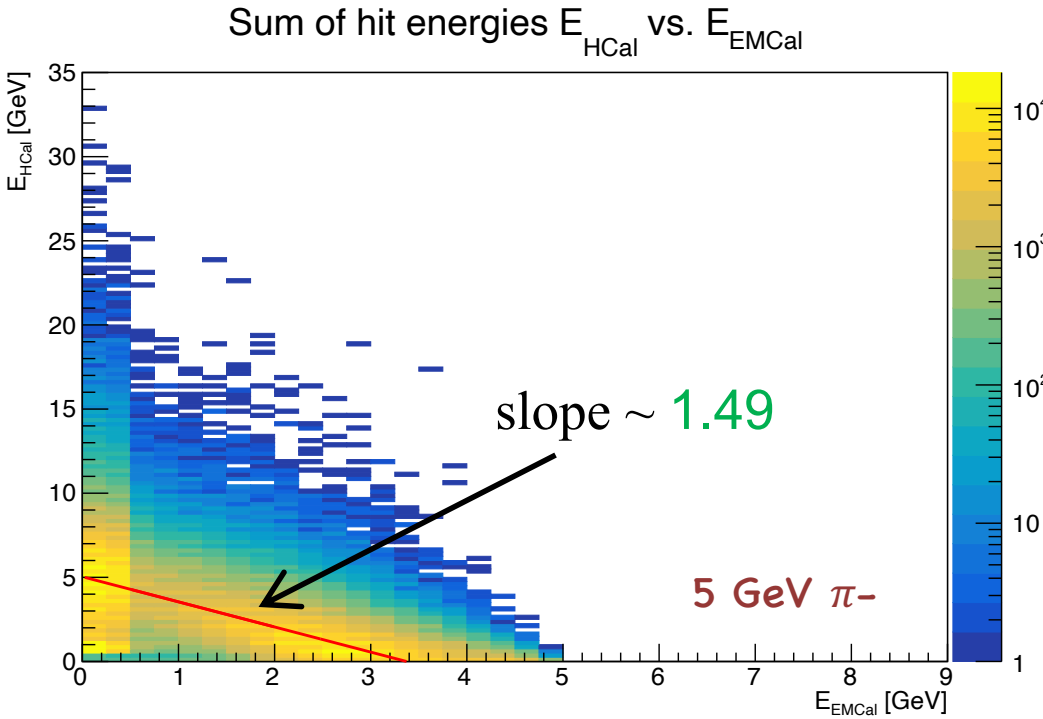
NAME	VALUE	ERROR
Const.	1.84670e+04	3.06670e+01
Mean	5.07752e-02	3.21477e-05
Sigma	1.72697e-02	3.89786e-05

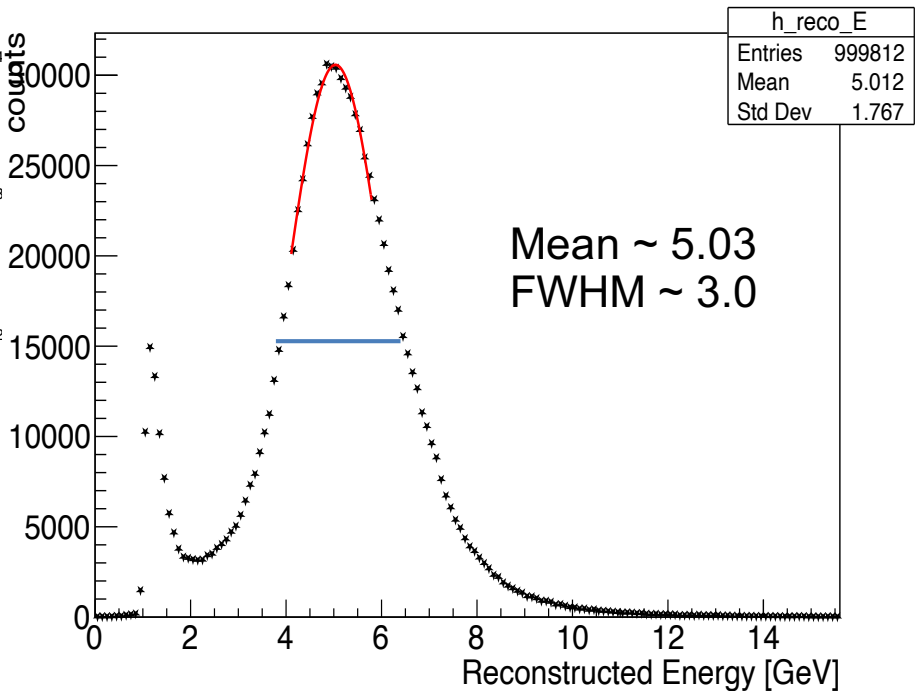
- nHCal is calibrated using π^-
- 1 π^- /event, 1mill events and p = 5 GeV
- θ = 170◦ and φ = 45◦

Sampling Fraction (f)
= 5.07752e-02/5.05
= 0.010054495
~ 0.01 +/- 6.36e-06

Detector Calibration

2. nECal+nHCal response to π-





$E_{reco} = 1.49*E_{EMCal} + E_{HCal}$

Fitted a linear function to E_{HCal} vs. E_{EMCal} histogram to extract the energy sharing parameters

* $E_{Hcal}/f \equiv E_{HCal}$

Angular Coordinate Study

Reconstructed Θ and φ Coordinates

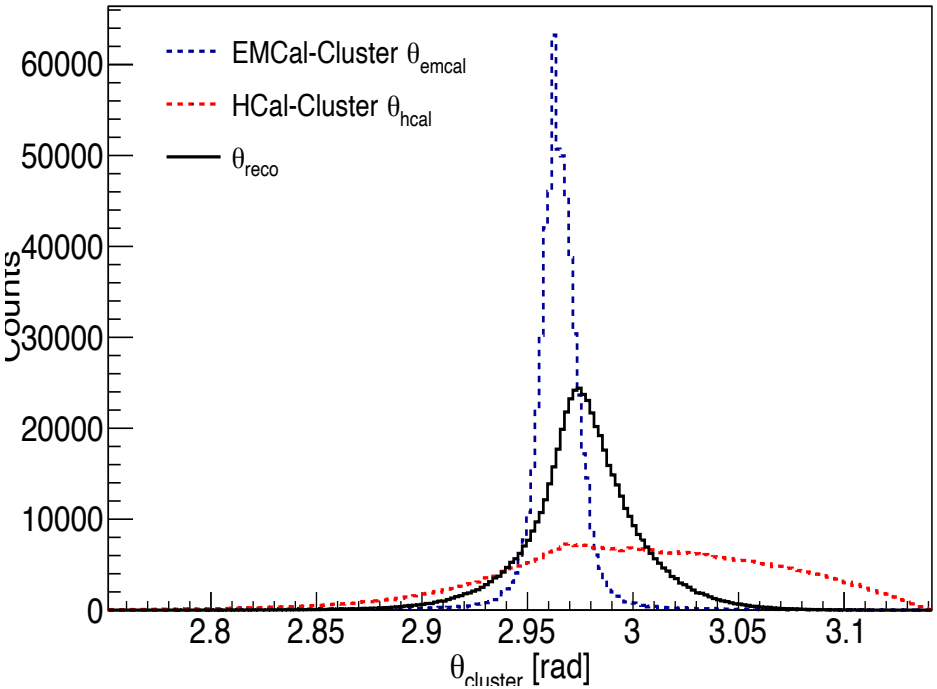
$$\Theta_{reco} = (w_{EMCal} * \Theta_{EMCal}) + (w_{HCal} * \Theta_{HCal})$$
$$\phi_{reco} = (w_{EMCal} * \phi_{EMCal}) + (w_{HCal} * \phi_{HCal})$$

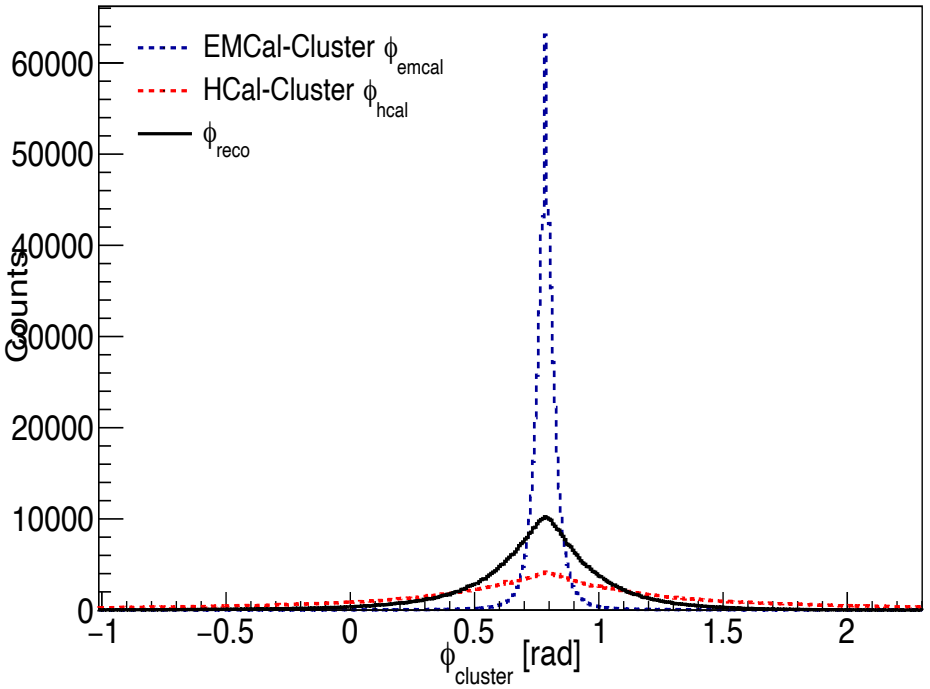
$$w_{EMCal} = \frac{1.49 * E_{Emcal}}{E_{reco}} \; ; \; w_{HCal} = \frac{E_{Hcal}}{E_{reco}}$$

$$E_{reco} = 1.49 * E_{EMCal} + E_{HCal}$$

Used reconstructed energy fractions as weights to combine truth cluster positions

Cluster Angular Coordinates

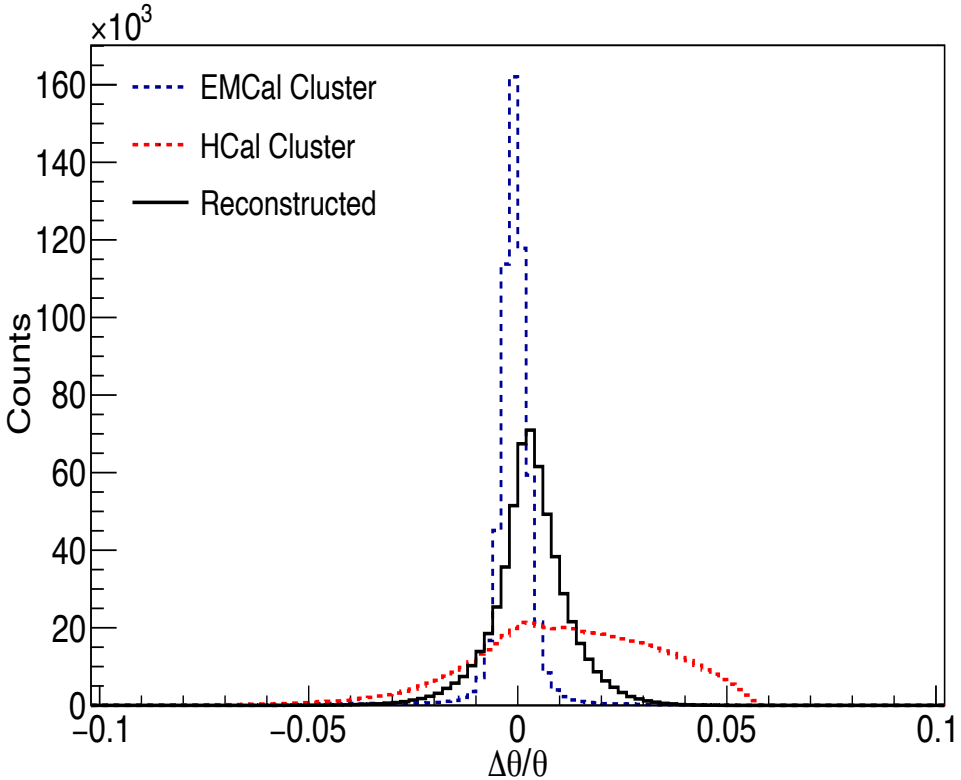


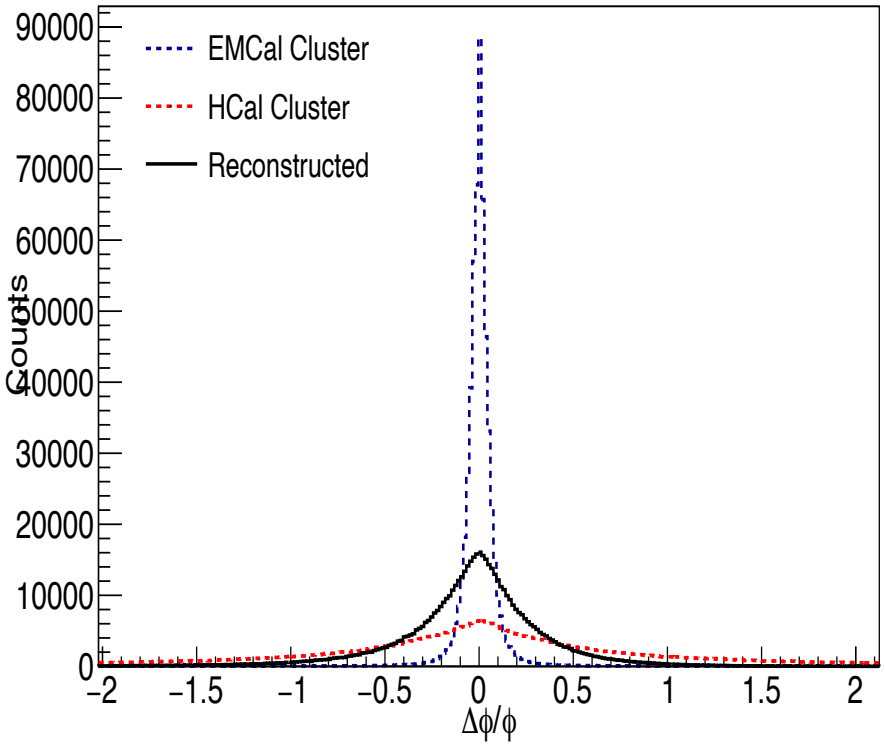


- 1 neutron/event, p=5 GeV
- **θ = 170◦ (2.967 rad) and φ = 45◦ (0.785 rad)**

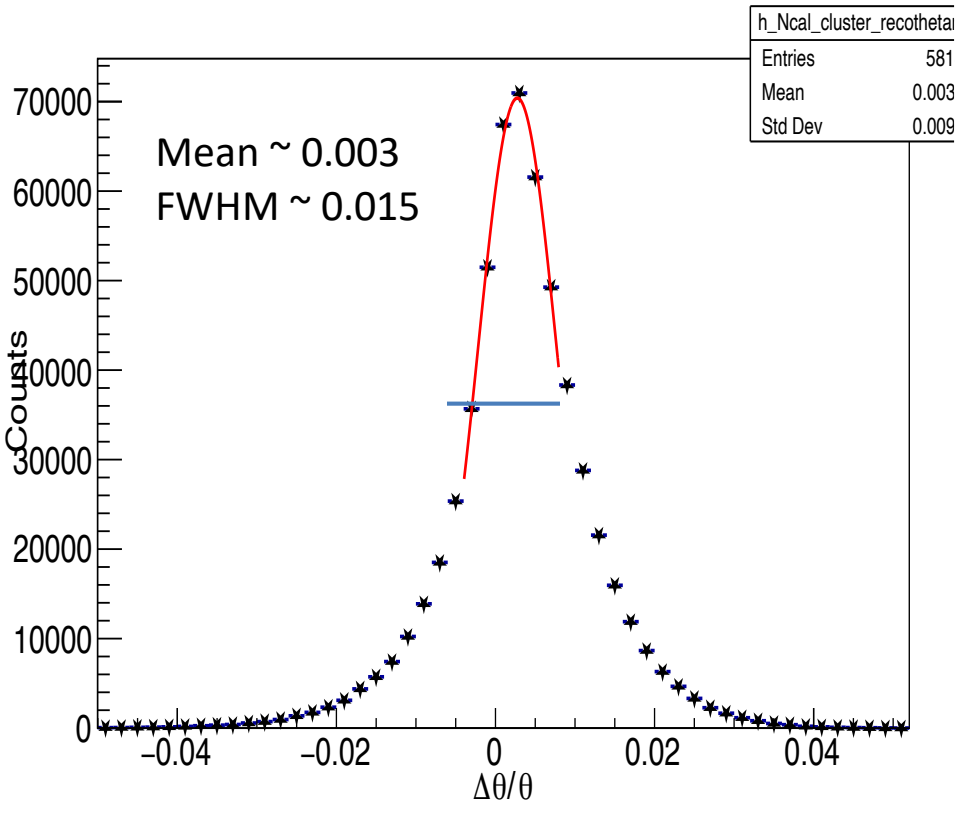
Angular Coordinate Study

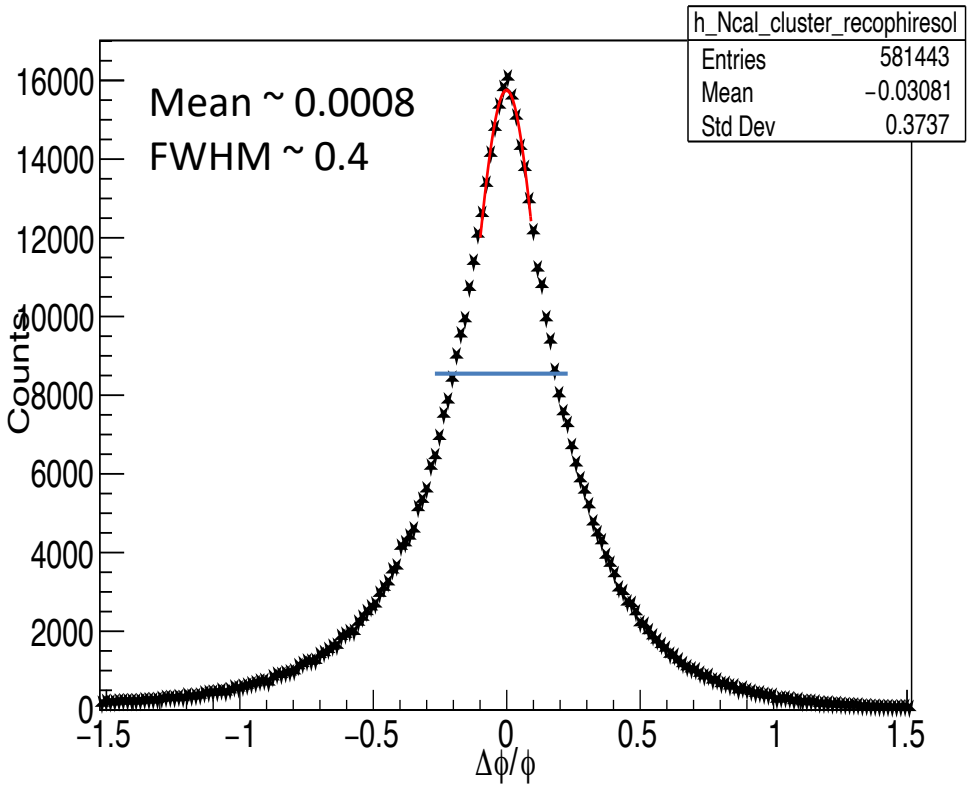
Resolution





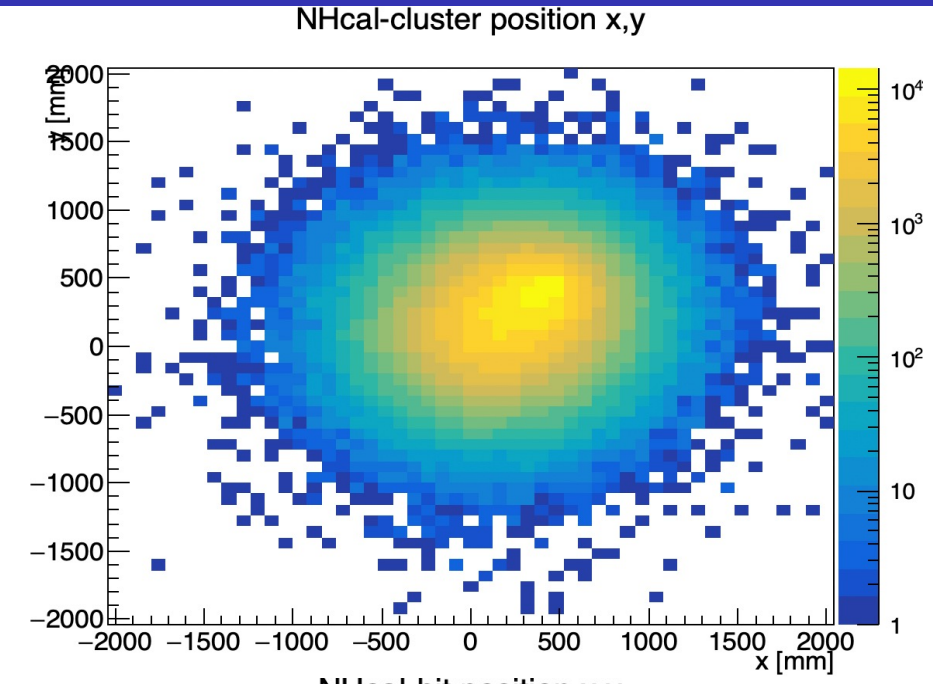
Resolutions (nHCal+nEMCal)

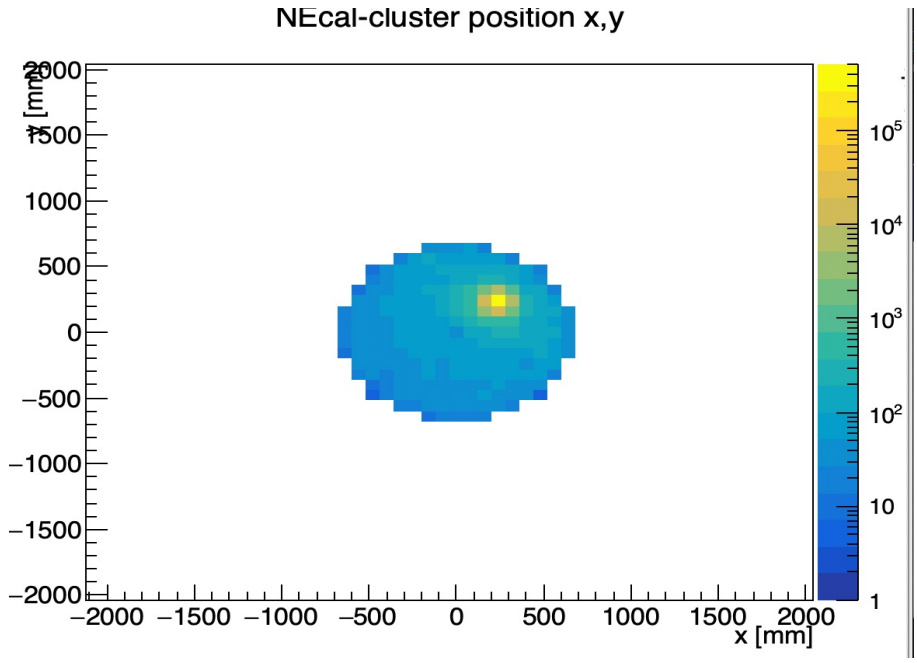


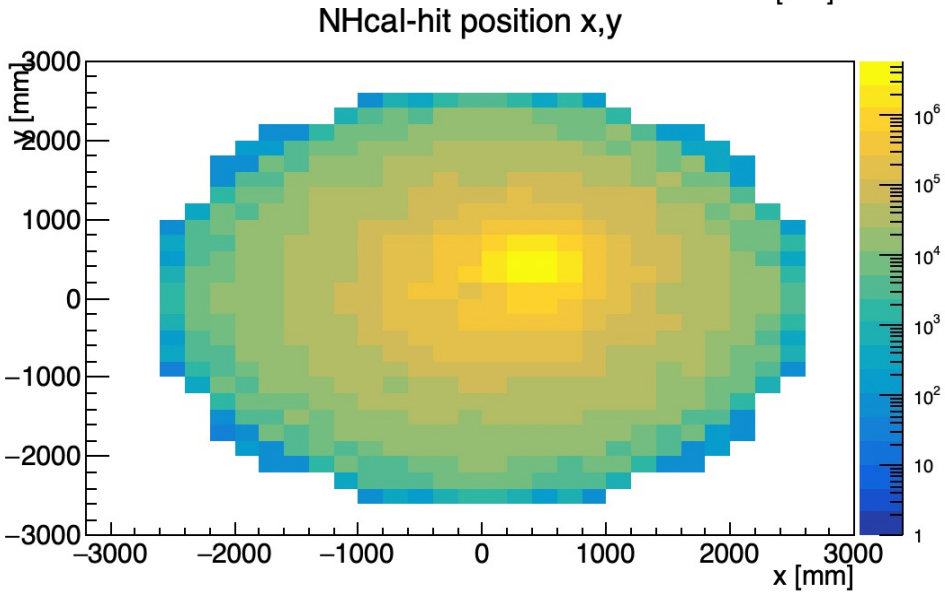


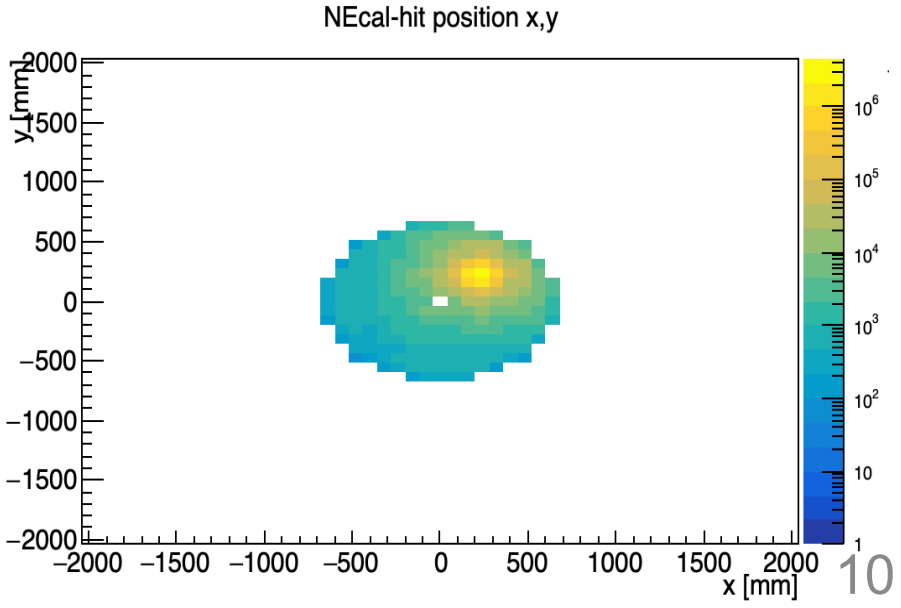
- Gaussian fits work only in a narrow range
- Much worse resolution in the ϕ direction - may be due to proximity to beam

Cluster and Hit Positions

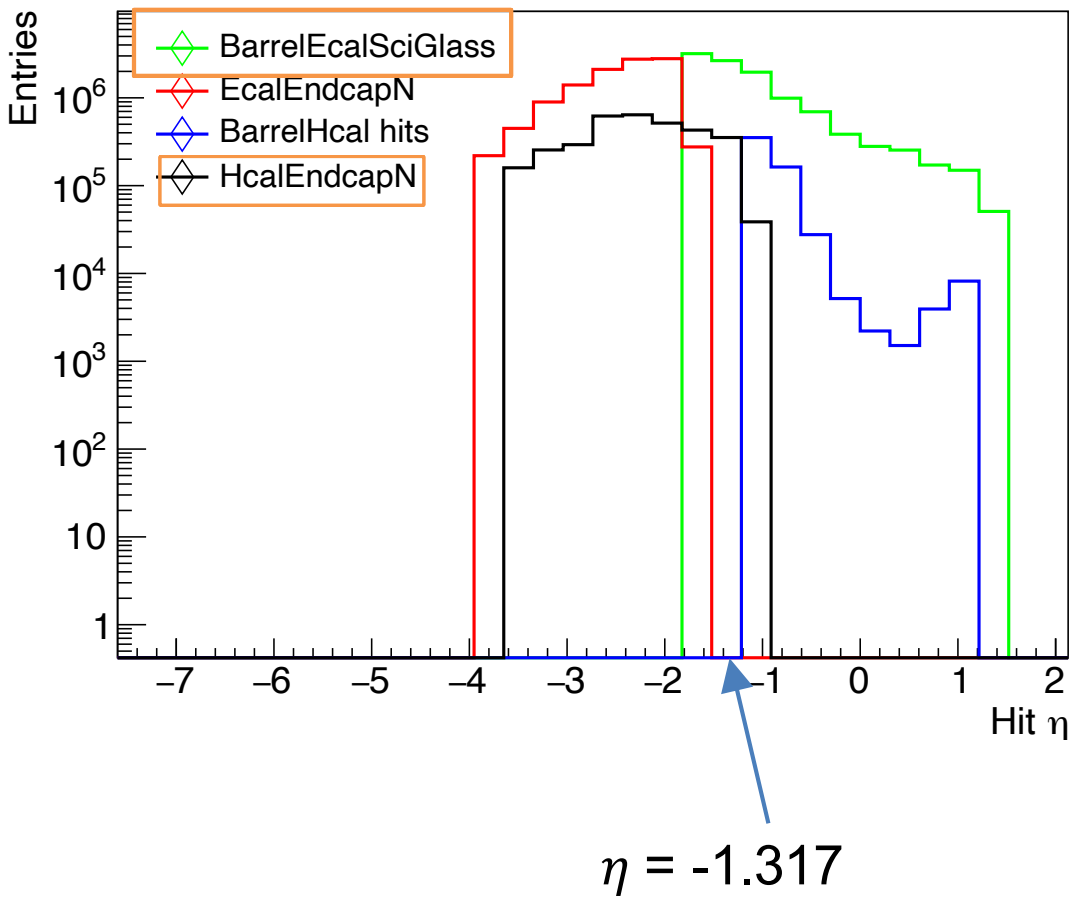




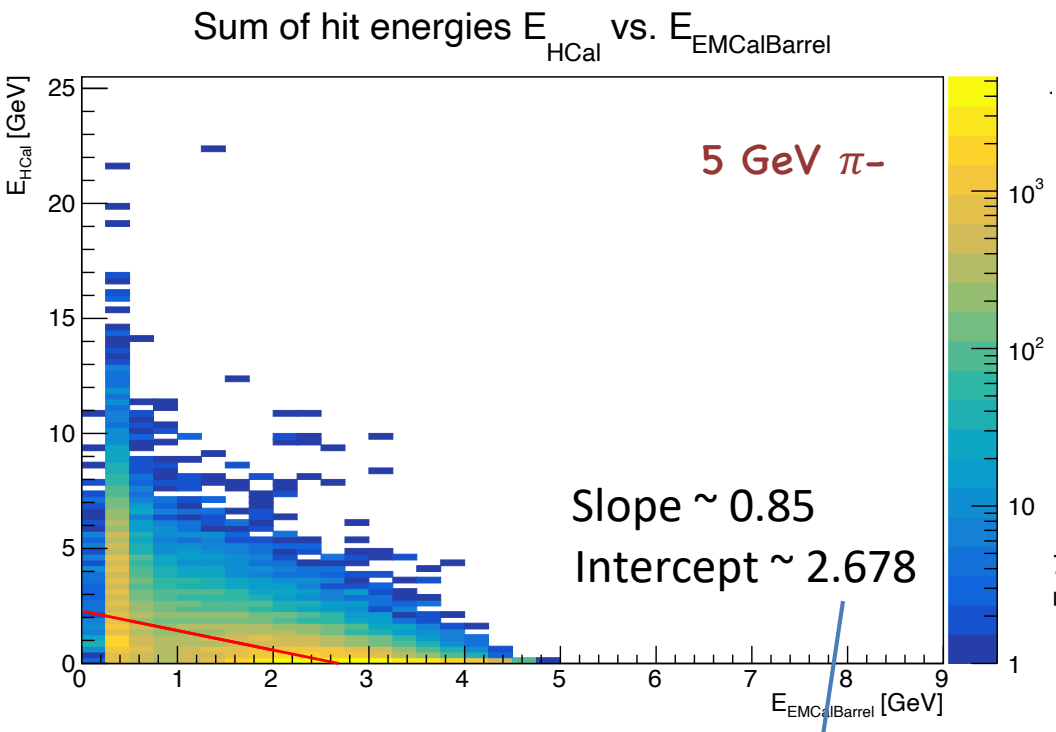




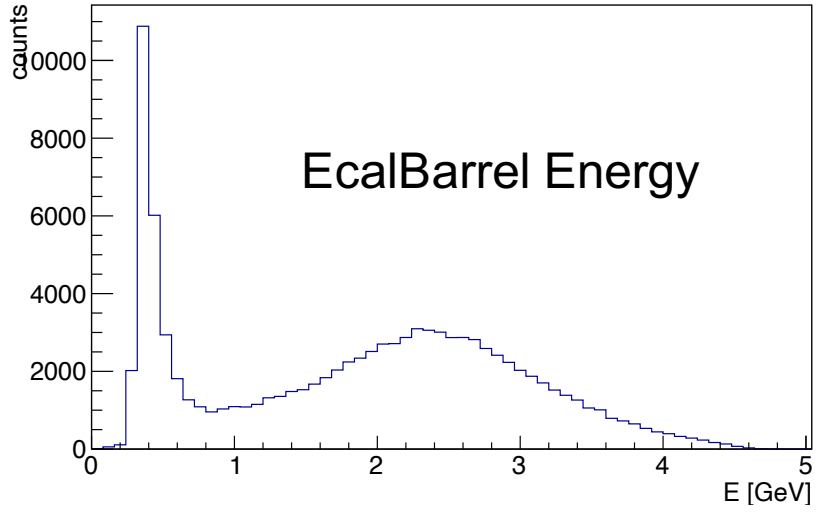
Another attempt at θ = 150◦

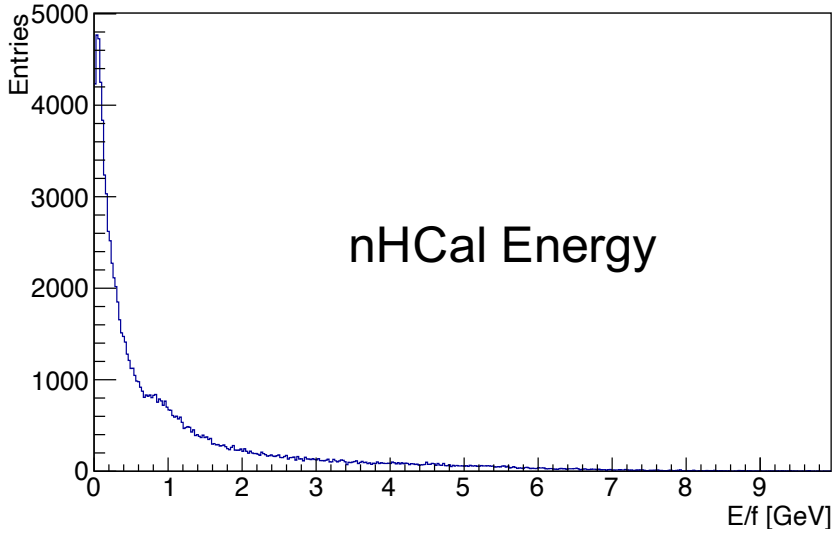


Energy Sharing b/w nHcal and EcalBarrel

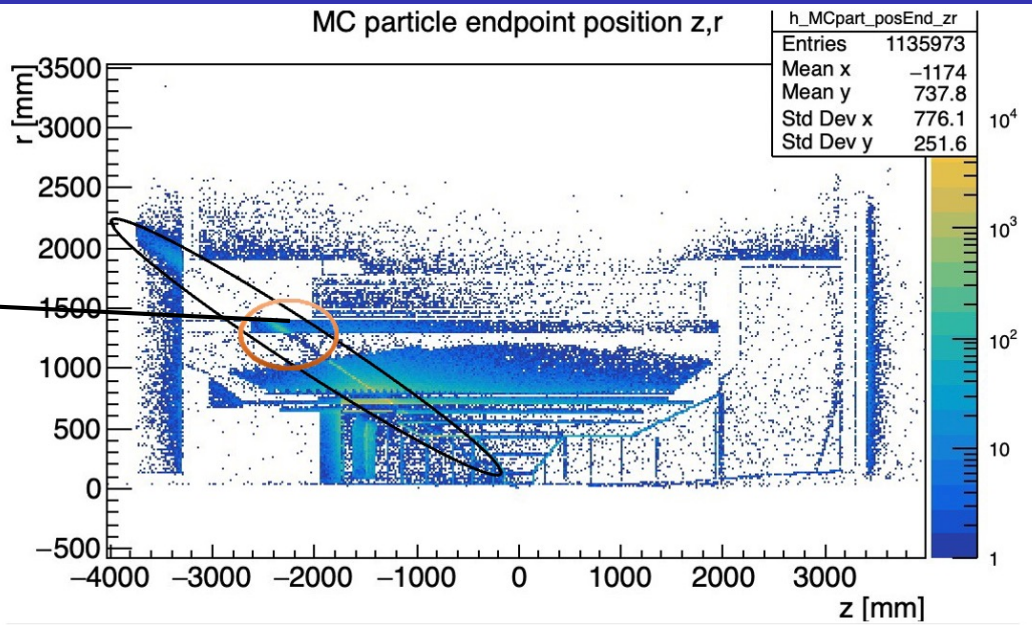


Missing some part of the original E (5.05 GeV)



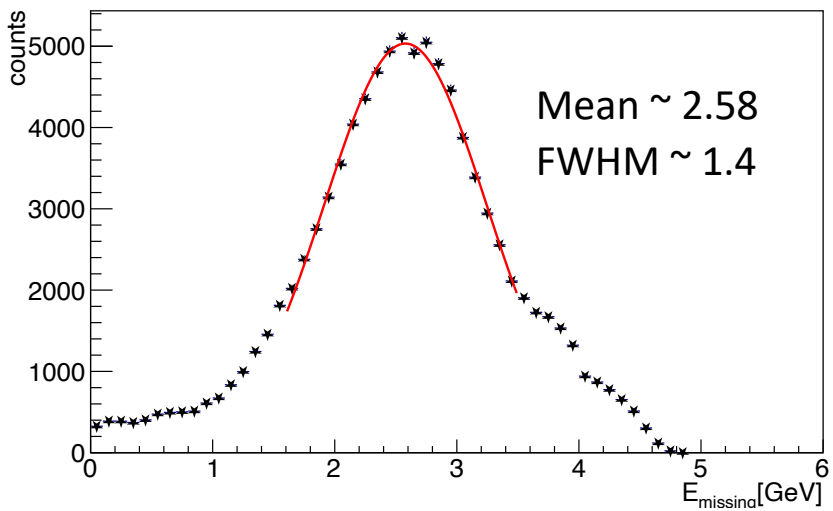


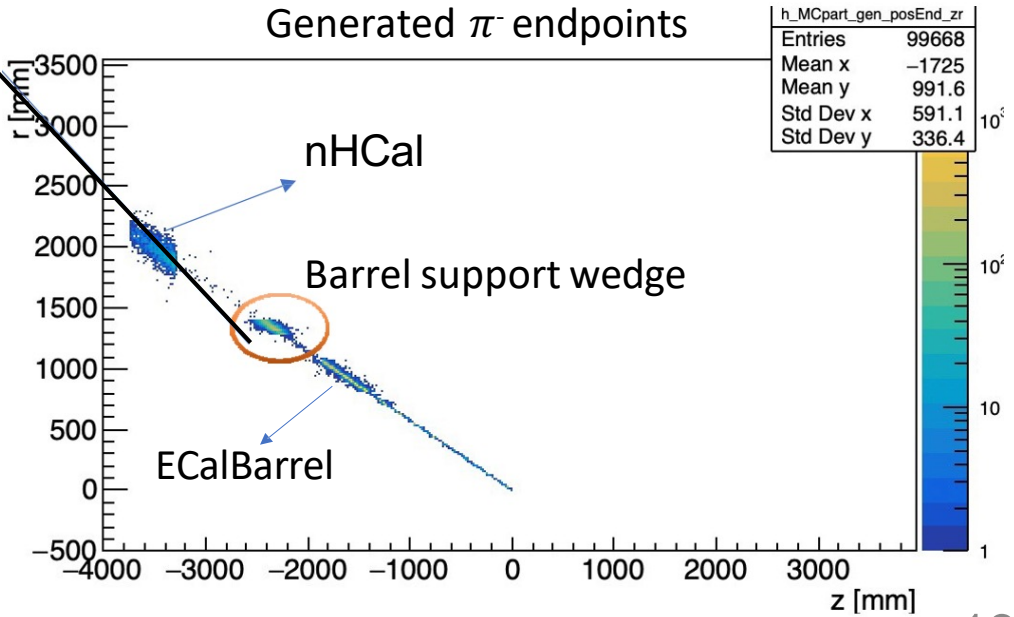
Missing Energy Deposition



Missing Energy Deposition (not stored in hits)

$E_{missing} = E_{sim} - (0.85*E_{EMCal} + E_{HCal})$



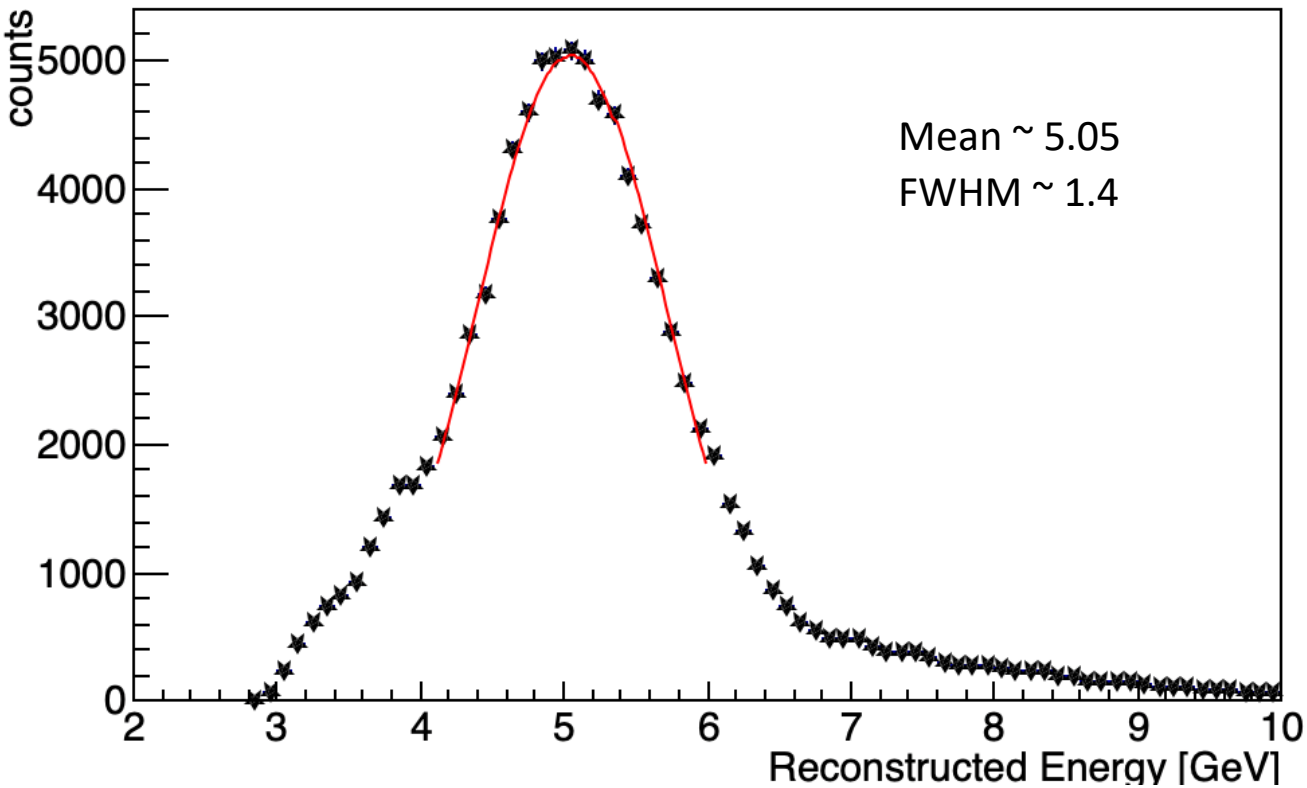


Reconstructed Energy

Slope of $E_{HCal\ VS.}\ E_{EMCal}$

$$E_{reco+miss} = 0.85 * E_{EMCal} + E_{HCal} + 2.58\ GeV$$

$< E_{missing} >$



Adding missing energy recovers the incident energy - OK!

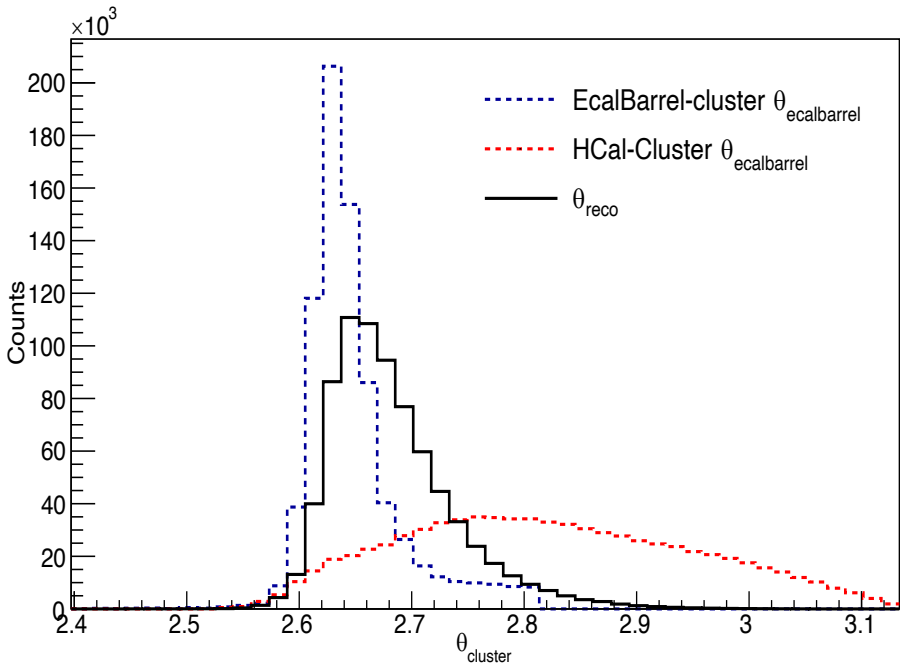
Reconstructed Θ and φ Coordinates

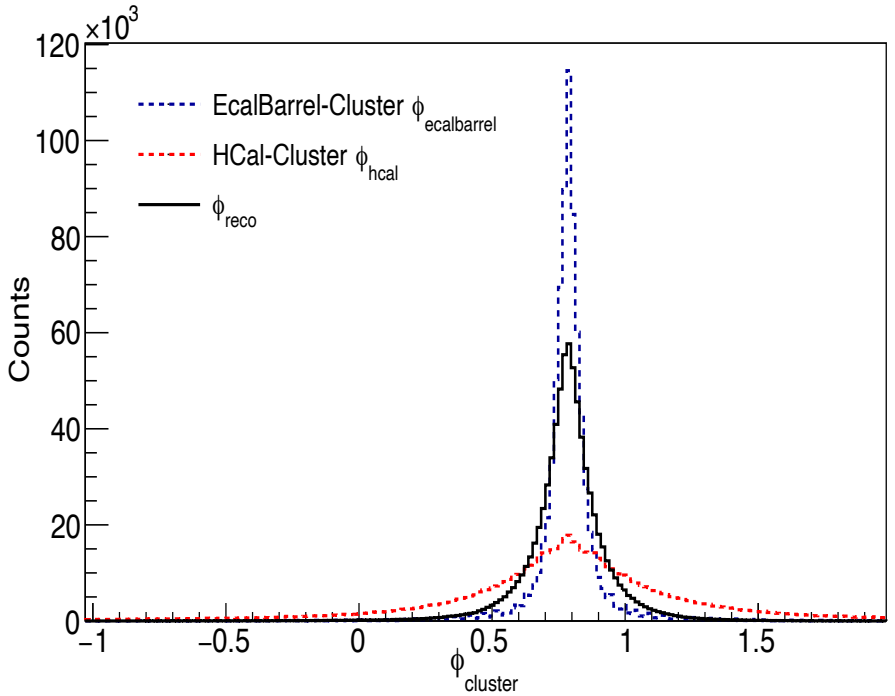
$$\Theta_{reco} = (w_{EMCal} * \Theta_{EMCal}) + (w_{HCal} * \Theta_{HCal})$$
$$\phi_{reco} = (w_{EMCal} * \phi_{EMCal}) + (w_{HCal} * \phi_{HCal})$$

$$w_{EMCal} = \frac{0.85 * E_{Emcal}}{E_{reco}} \; ; \; w_{HCal} = \frac{E_{Hcal}}{E_{reco}}$$

$$E_{reco} = 0.85 * E_{EMCal} + E_{HCal}$$

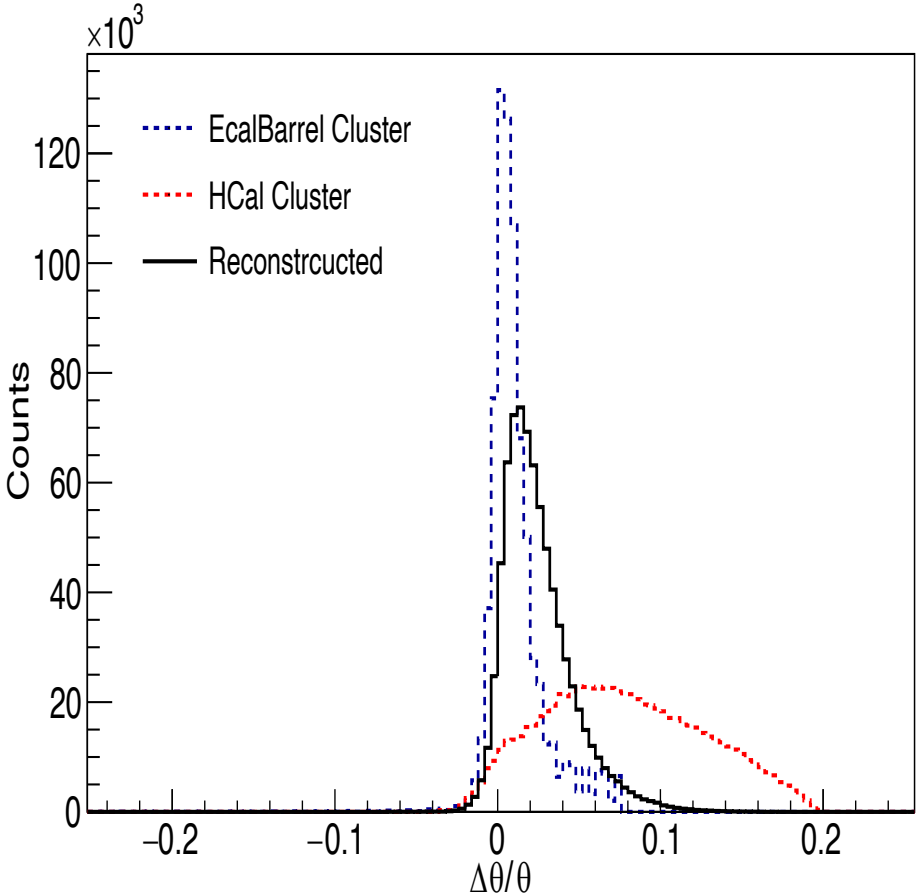
Angular Coordinate Study

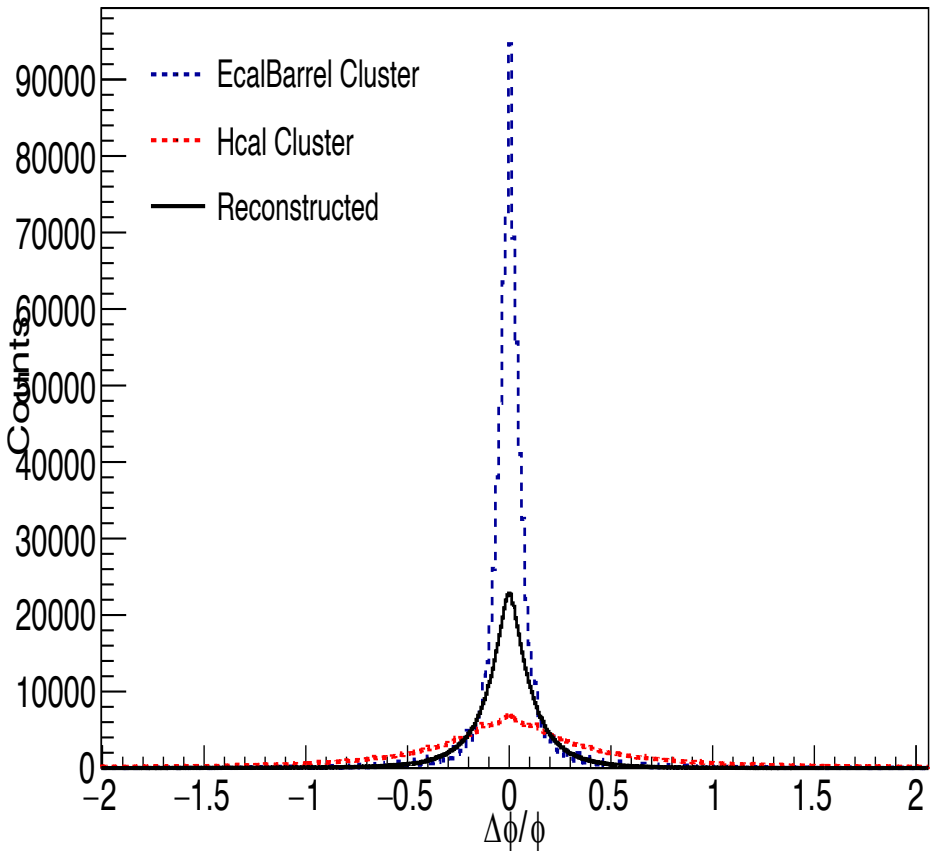




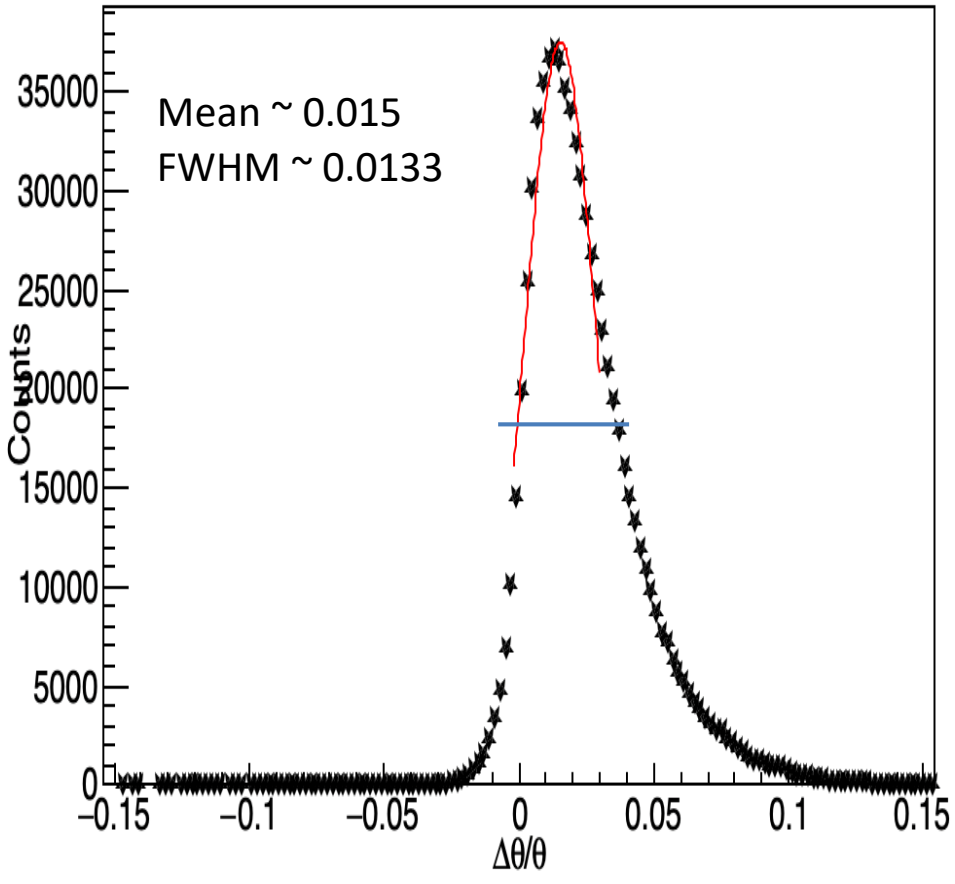
- 1 neutron/event, p=5 GeV
- **θ = 150◦ (2.618 rad) and φ = 45◦ (0.785 rad)**

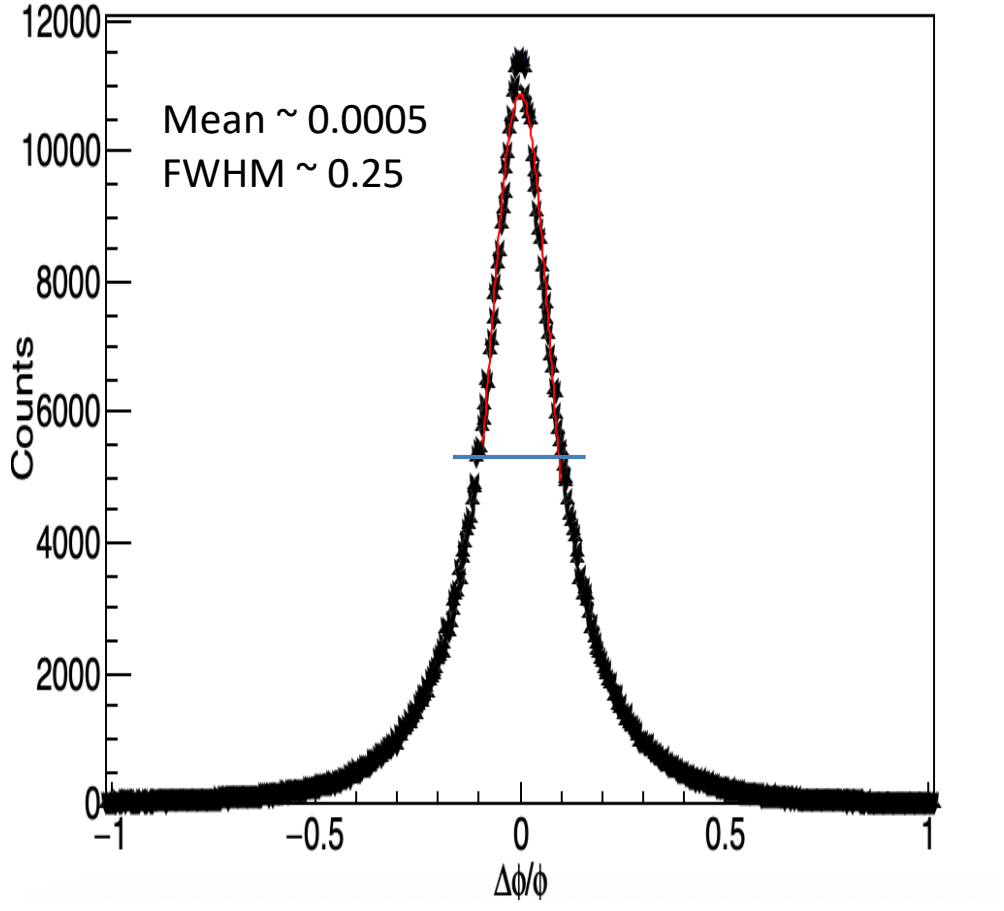
Angular Coordinate Resolutions





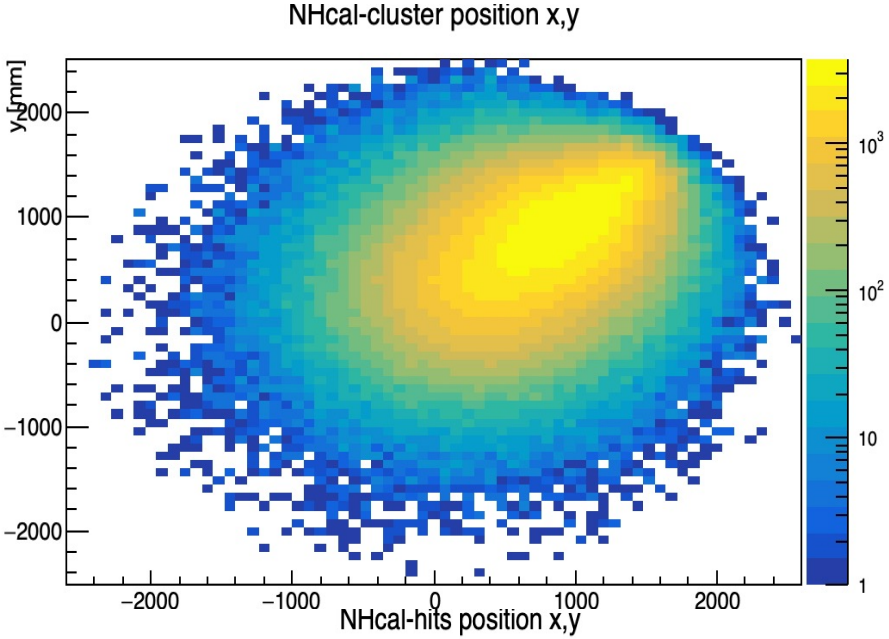
Resolutions (nHCal+EMCalBarrel)

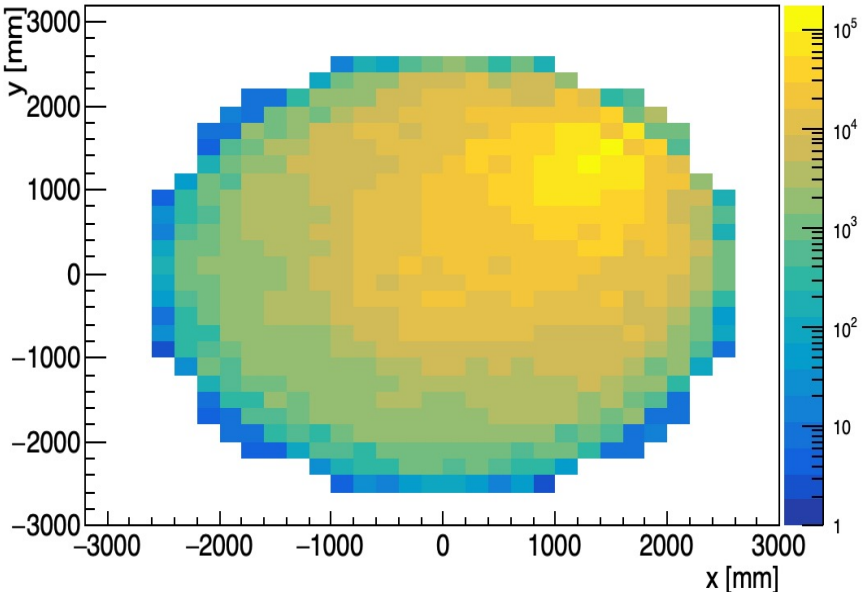


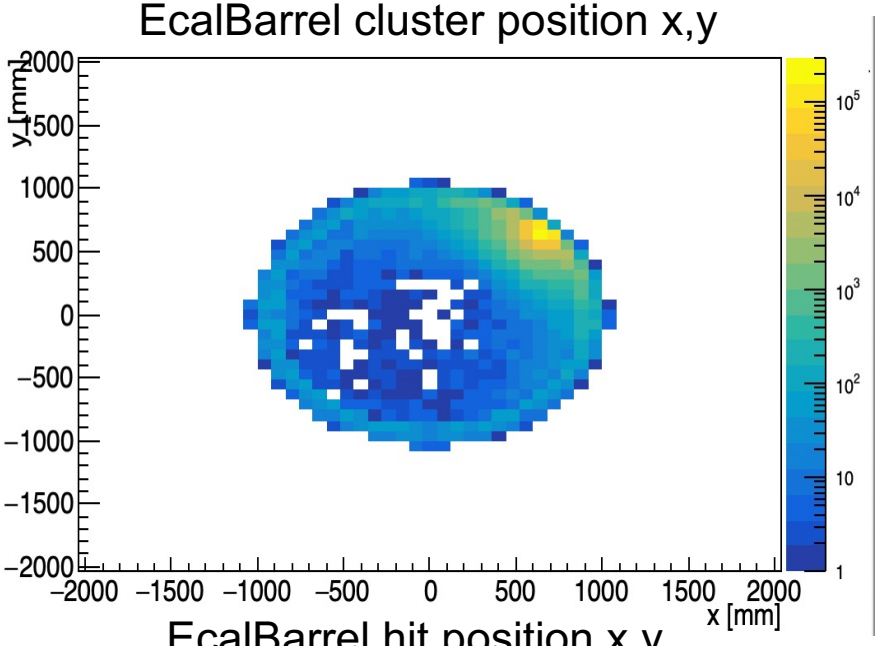


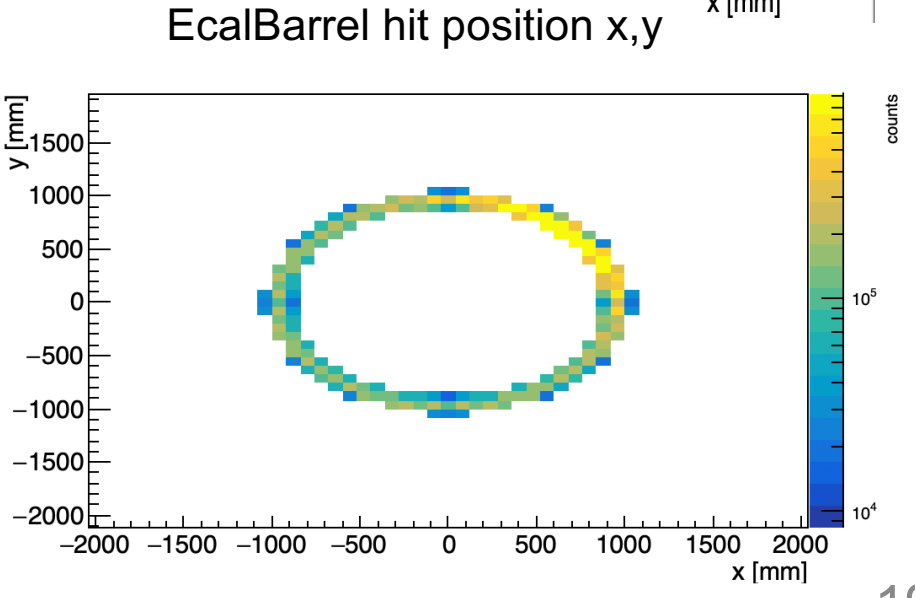
Away from the beam, resolution in the φ direction improved

Cluster and Hit Positions









Summary

- Test of angular resolution study performed with nHCal and both endcap and barrel EMcals
- Resolution is worse in the ϕ direction than η direction

Next Steps

Update geometry to reflect 30deg sector arrangement

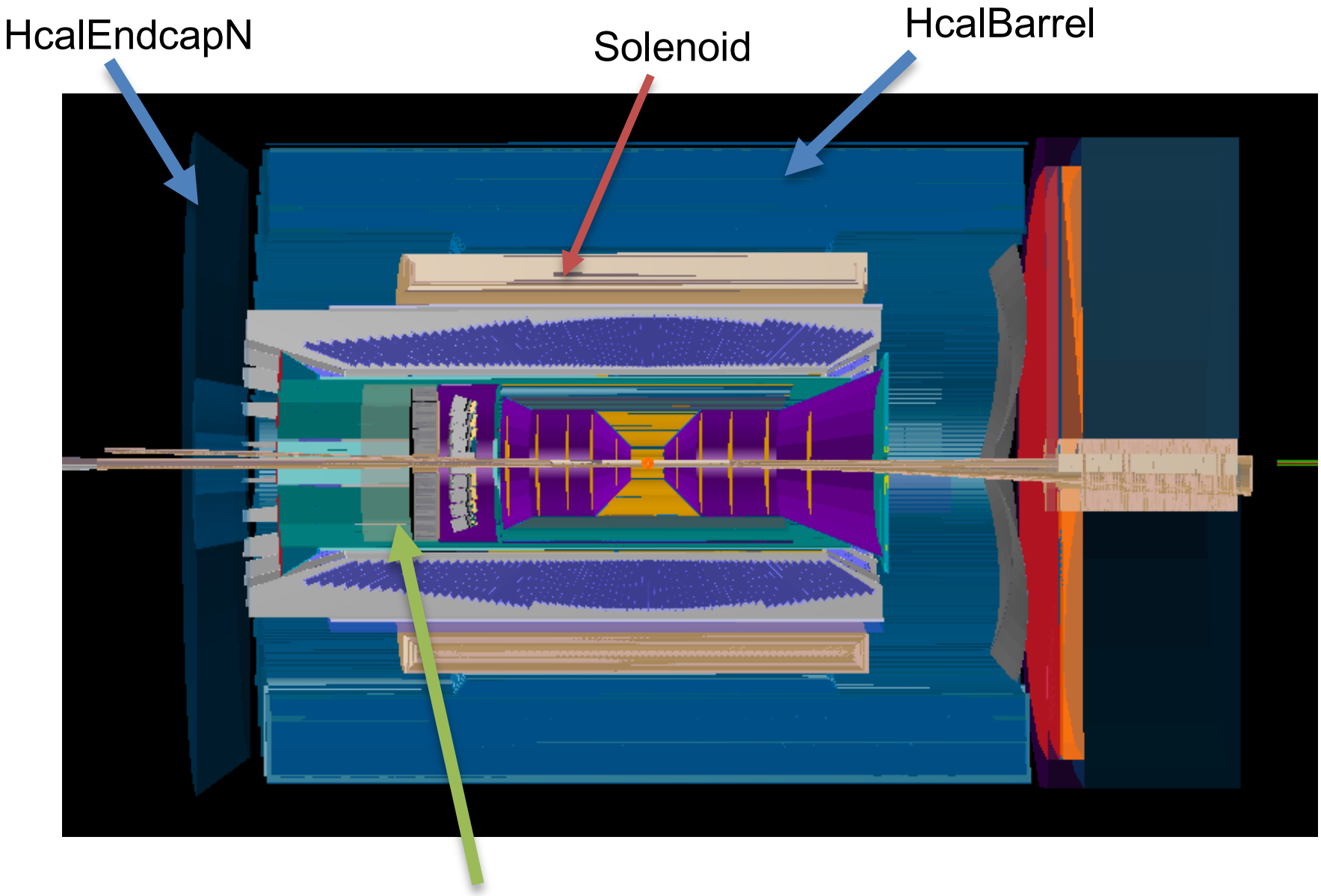
- Perform a full of detector scan vs. η and ϕ

- Use reconstructed (island) clusters to study the resolution

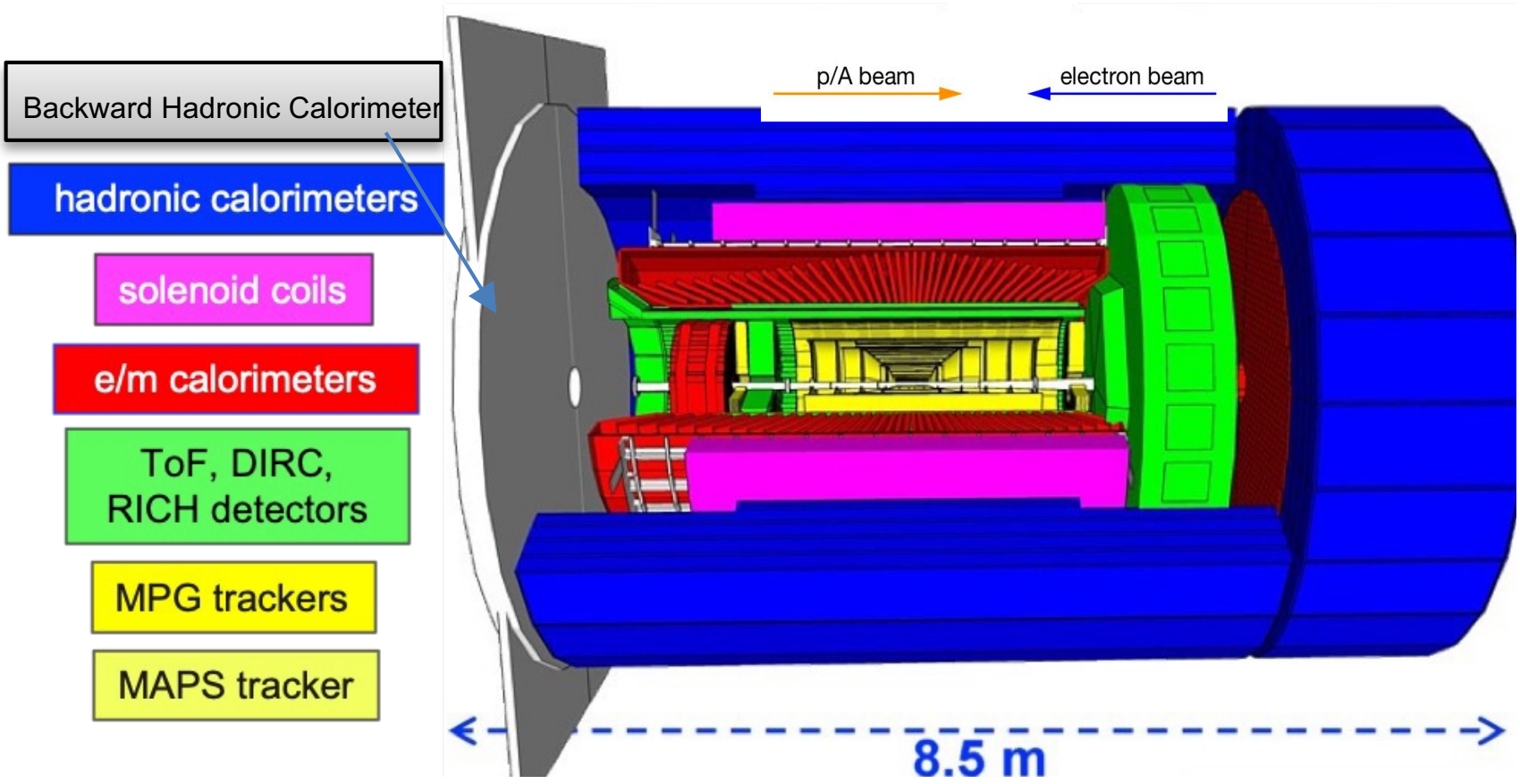
- Merge the geometry with the main branch to be ready for the simulation campaign (can skip above steps if needed)

Thank You

BACK UP

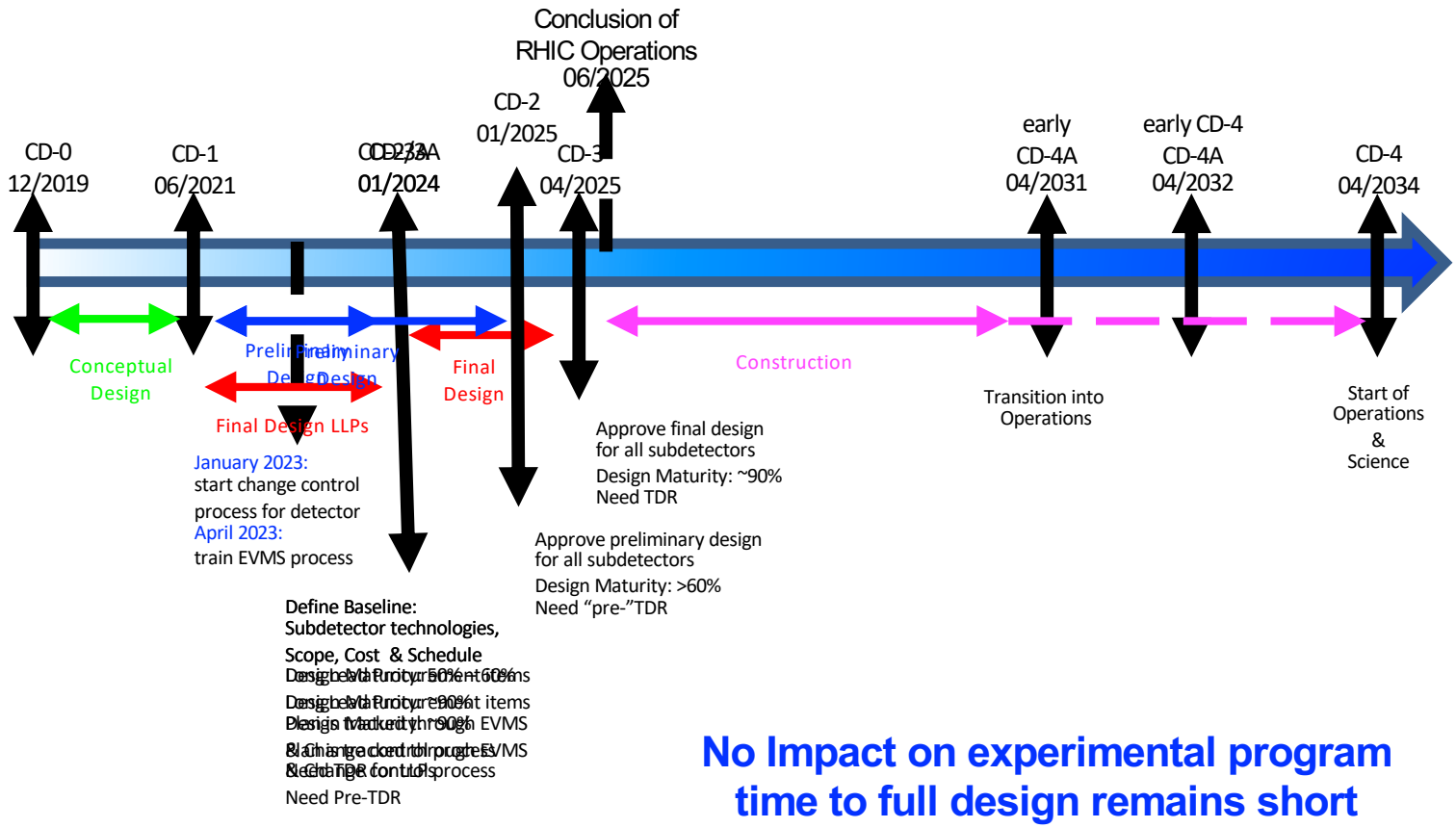

HcalEndcapN
Solenoid
HcalBarrel
EcalBarrel
EcalEndcapN

The ePIC Detector



https://wiki.bnl.gov/EPIC/

Schedule Now



No Impact on experimental program time to full design remains short

Elke Aschenauer and Rolf Ent, ePIC Collaboration Meeting January 9th 2023

Hadronic showers

Hadronic interaction:

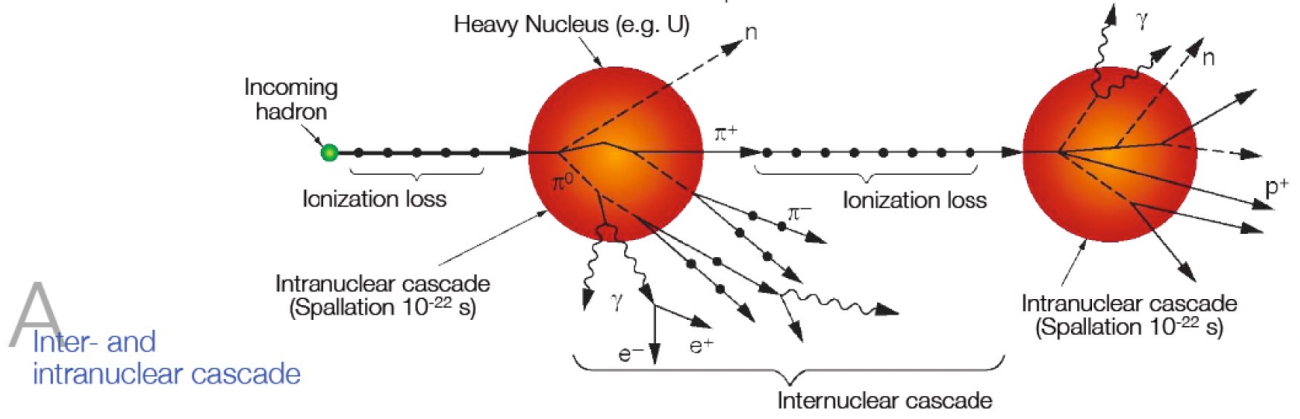
Elastic:

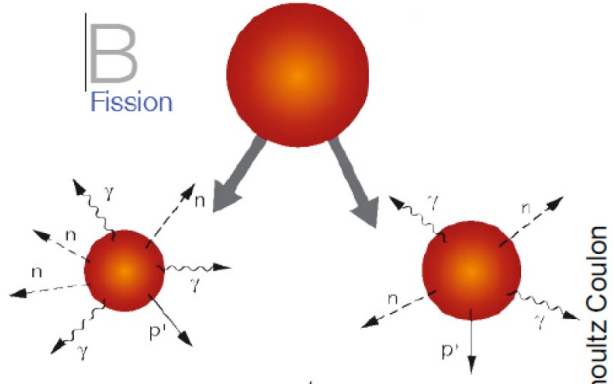
$$p + \text{Nucleus} \rightarrow p + \text{Nucleus}$$

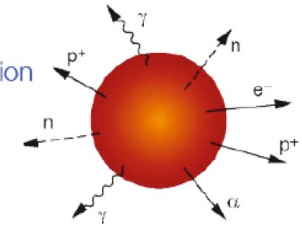
Inelastic:

$$p + \text{Nucleus} \rightarrow \pi^+ + \pi^- + \pi^0 + \ldots + \text{Nucleus}^*$$

$$\left[\begin{array}{l} \text{Nucleus}^* \rightarrow \text{Nucleus A} + n, p, \alpha, \ldots \\ \qquad\quad \rightarrow \text{Nucleus B} + 5p, n, \pi, \ldots \\ \qquad\quad \rightarrow \text{Nuclear fission} \end{array}\right.$$







Courtesy of H. C. Schoultz Coulon