Two-Particle Position Resolution Study from Backward HCal

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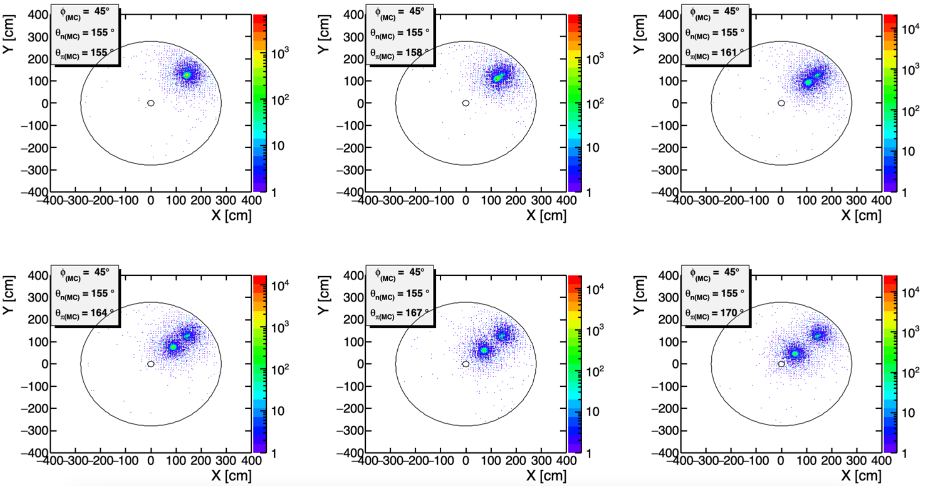
Setup

Objective *: Use clusters to distinguish between neutron/pion shower reconstruction.*

- (1 n + 1 π^-) / event. ---- ***Standalone ddsim***
- φ = 45°
  - θ_n = 155° (η = -1.51) ------ ***fixed***
  - θ_π = 155° (η = -1.51), 158° (η = -1.64), 161° (η = -1.79), 164° (η = -1.96), 167° (η = -2.17), 170° (η = -2.44)

- Only Backward HCal was taken into account [not the whole ePIC geometry – scattering effects neglected]
- $-4.14 < \eta < -1.18$
- Alternating Steel and Scintilator slices
- 10 cm. x 10 cm. Polystyrene tiles

Cluster Positions (xy coordinates)



Cluster (x,y) are shown along with simulated angular coordinates

p = 1 GeV/c

[neutron showers in outer region; pion showers in inner region]

Distributions are becoming more distinguishable as (θ_π - θ_n) increases…

Clustering Correction (Neutral hadron detection)

- Tests of a particle flow algorithm with CALICE test beam data, 2011
  CALICE Collaboration (https://doi.org/10.1088/1748-0221/6/07/P07005)
- Particle flow calorimetry and the PandoraPFA algorithm, 2009
  M.A. Thomson (https://doi.org/10.1016/j.nima.2009.09.009)

The previous four stages of the PandoraPFA algorithm are found to perform well for jets with energy less than about 50 GeV. At higher energies the jet energy resolution degrades due to the increasing overlap between the hadronic showers from different particles. It is possible to detect such reconstruction failures by comparing the charged cluster energy, E_C, with the momentum of the associated track, p. A possible reconstruction failure is identified if $|(E_C - p)/\sigma_{E_C}| >$ ChiToAttemptReclustering [3.0]. In this case the PandoraPFA algorithm attempts to find a more self-consistent clustering of the calorimeter hits. If, for example, a 10 GeV track is associated with a 20 GeV calorimeter cluster, shown schematically in Fig. 5(a), a potential reconstruction failure is identified. One possible approach would be to simply remove hits from the cluster until the cluster energy matched the track momentum. However, this does not use the full information in the event. Instead, the clustering algorithm is modified iteratively

Not done in this study

https://www.hep.phy.cam.ac.uk/~thomson/pandoraPFA/

Charged Particle Correction

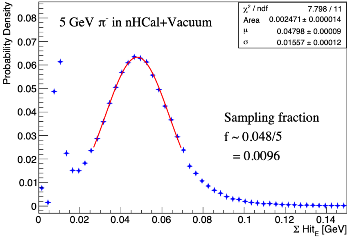
$$|(E_C - p)/\sigma_{E_C}| > \texttt{ChiToAttemptReclustering}\ [3.0].$$

Condition to determine possible reconstruction failure and make charged particle correction

E_c = Energy of the cluster that is matched to a track

p = Momentum obtained from tracking

σ_{E_c} = uncertainty on the cluster energy due to hadronic nature of energy deposition



Charged Particle Correction

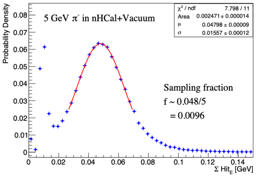
$$|(E_C - p)/\sigma_{E_C}| > \texttt{ChiToAttemptReclustering}\ [3.0].$$

E_c = Energy of the cluster that is matched to a track → Energy of Pion Cluster based on ClusterMCParticleAssociation

p = Momentum obtained from tracking → Momentum of generated Pion

σ_{E_c} = uncertainty on the cluster energy due to hadronic nature of energy deposition →

$$\sigma_{E_c} = \frac{\sigma f_p}{f_{EICrecon}} E_c$$



Uncertainty in sampling fraction (f) depending on the momentum (p) of the track

Charged Particle Correction

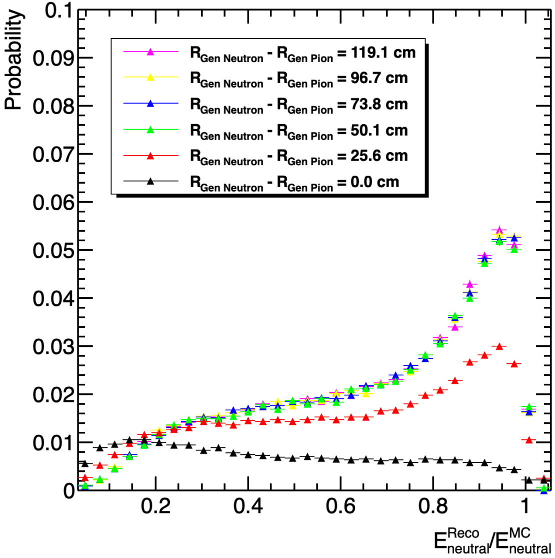
If $|(E_C - p)/\sigma_{E_C}| >$ `ChiToAttemptReclustering` [3.0].

$$E_{neutral}^{Reco} = E_{total}^{Reco} - p$$

Energy hijacking
(aka "confusion")
was involved

Else, $E_{neutral}^{Reco} = E_{total}^{Reco} - E_{charged}^{Reco}$

Charged Particle Correction



When, $|(E^{Reco}_{charged} - p)/\sigma_{E^{Reco}_{charged}}| > 3.0$

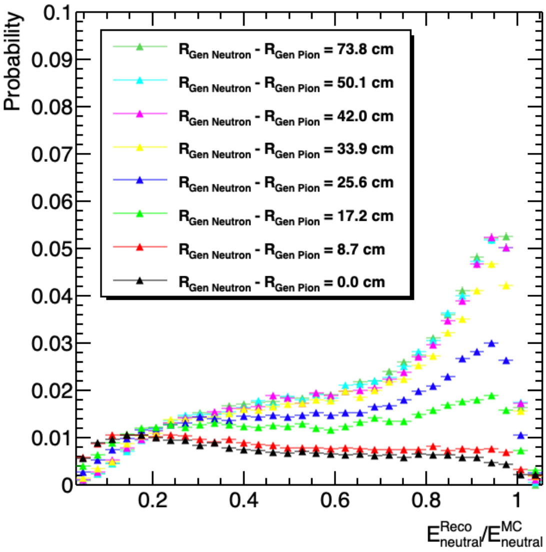
$$E^{Reco}_{neutral} = E^{Reco}_{total} - p$$

Otherwise,

$$E^{Reco}_{neutral} = E^{Reco}_{total} - E^{Reco}_{charged}$$

$E^{MC}_{neutral}$ = MC energy deposition by neutron

Charged Particle Correction



When, $|(E^{Reco}_{charged} - p)/\sigma_{E^{Reco}_{charged}}| > 3.0$

$$E^{Reco}_{neutral} = E^{Reco}_{total} - p$$

Otherwise,

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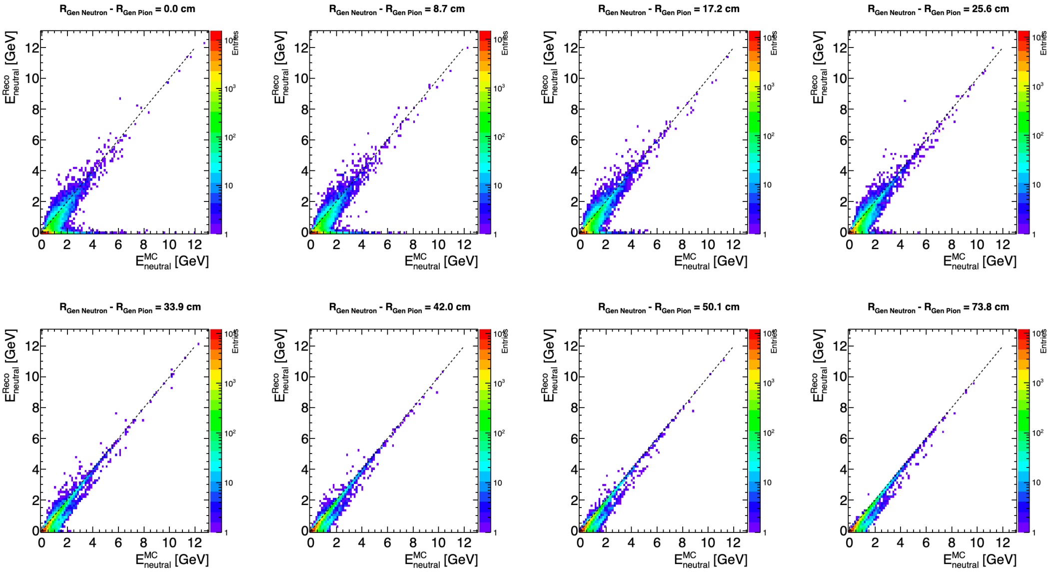
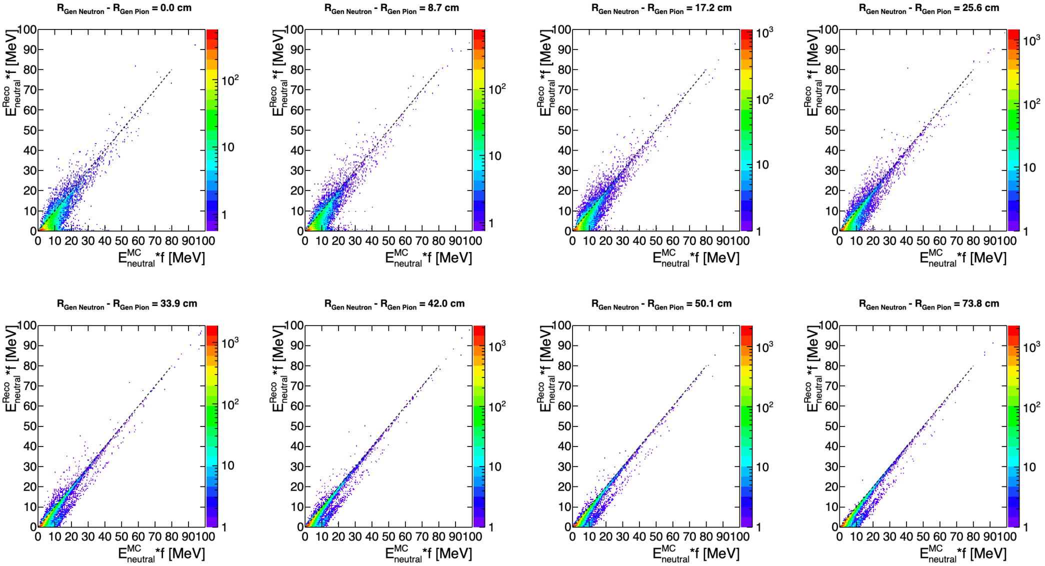
Charged Particle Correction



Charged Particle Correction



Backup

Charged Particle Correction

E_c = Energy of the charged cluster obtained from EICrecon

$f_{EICrecon}$ = Sampling fraction incorporated in EICRecon

$f_{EICrecon}\, E_c$ = Uncorrected energy of cluster corresponding to actual energy deposition without the sampling fraction correction.

Lets call it $E_c^{uncorrected}$

Objective : To find out the error in E_c due to uncertainty in sampling fraction.

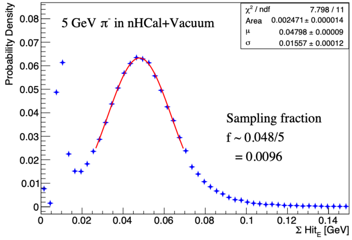
$$E_c^p = E_c^{uncorrected} / f_p$$

p = momentum of the track matched to the cluster

$$\frac{\sigma E_c^p}{E_c^p} = \frac{\sigma f_p}{f_p} \Rightarrow \sigma E_c^p = \frac{\sigma f_p}{f_p} E_c^p$$

$$\sigma E_c^p = \frac{\sigma f_p}{f_p^2} E_c f_{EICrecon} \approx \frac{\sigma f_p}{f_{EICrecon}} E_c$$

f does not change much with p



Charged Particle Correction

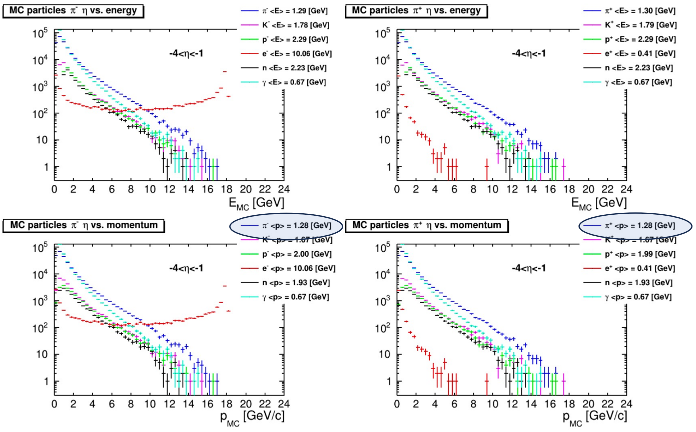
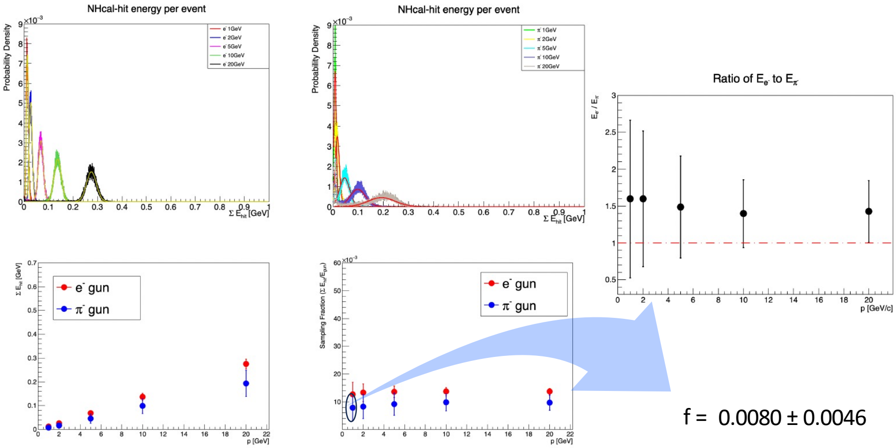


Figure 8.105: Top: Primary, generated particle E distributions in nHCal acceptance $-4.0 < \eta < -1.0$. Bottom: Primary, generated particle p distributions in nHCal acceptance $-4.0 < \eta < -1.0$.

Recap – e/h study

Steel/Scint = 10:1; 10 layers [40 mm Steel + 4 mm Scint]



f = 0.0080 ± 0.0046

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