Update on inclusive π^0 production studies for SPD

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JINR

SPD Physics Weekly Meeting

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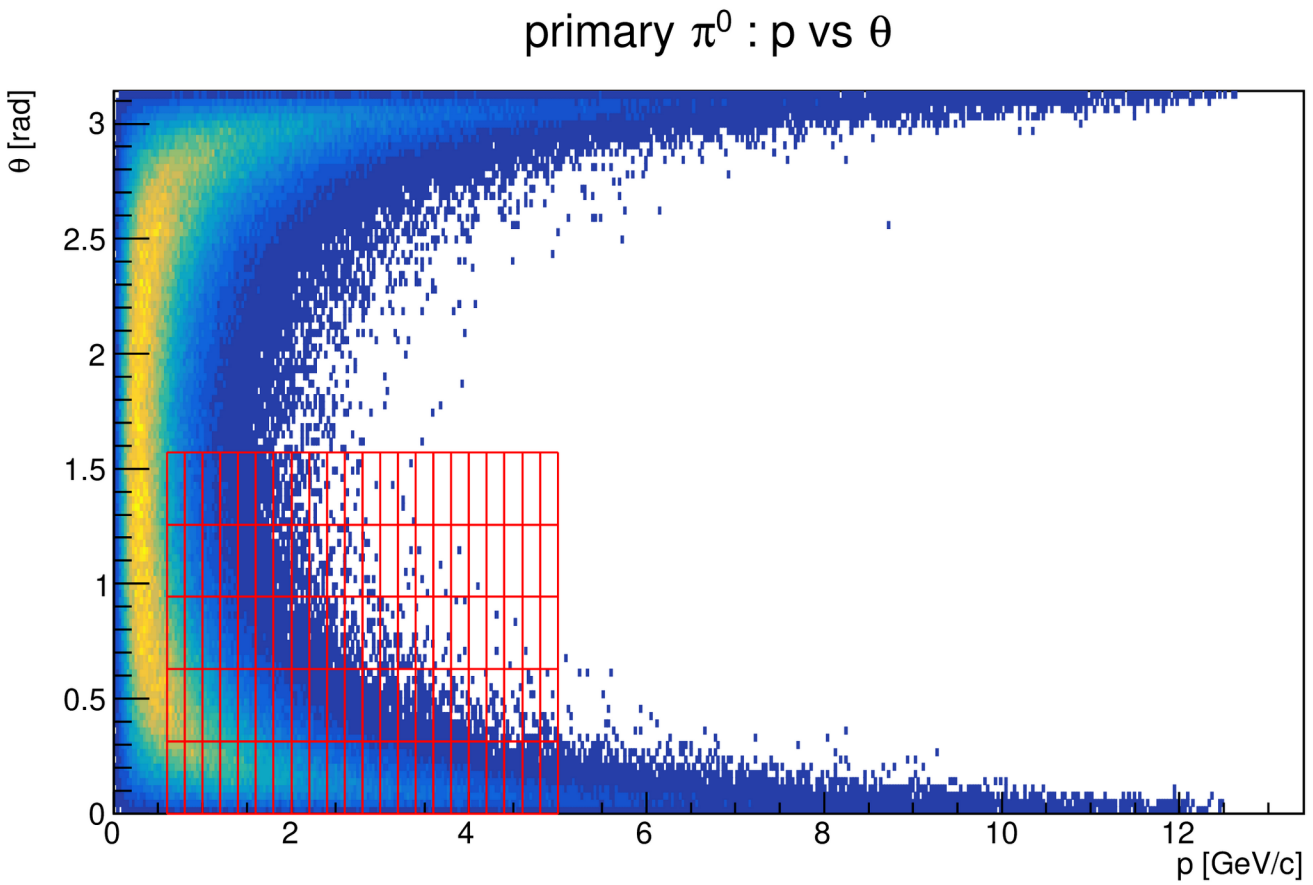
Event sample

- SpdRoot, last version
  (with ECAL geometry changes [size of the hole in ECAL end-caps increased in accordance with TDR, etc.] and reco algorithms updates commited by A. Maltsev in the end of November)
- Pythia8: SoftQCD (without elastic)
- $\sqrt{s} = 27\,\mathrm{GeV}$
- 200 000 events
  (~ 0.06 s of data taking)

(p, θ) distribution of π^0 [MC]



Binning:

p = 0.6 .. 5.0 GeV/c, Δp = 0.2 GeV/c

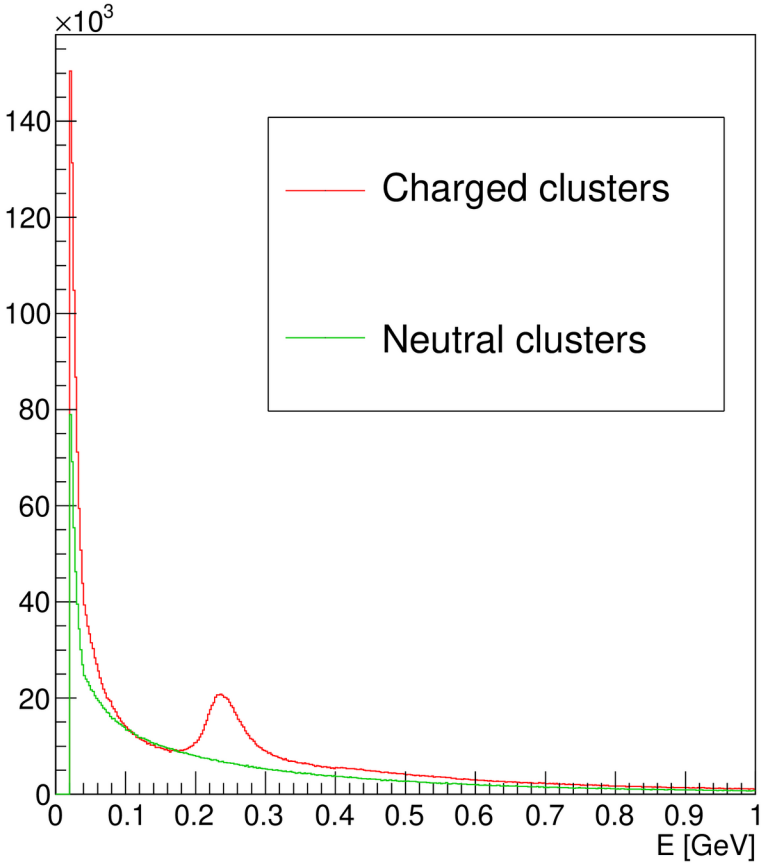
$\theta = 0 .. 0.5 \cdot \pi$, $\Delta\theta = 0.1 \cdot \pi$

Procedure of π^0 reconstruction

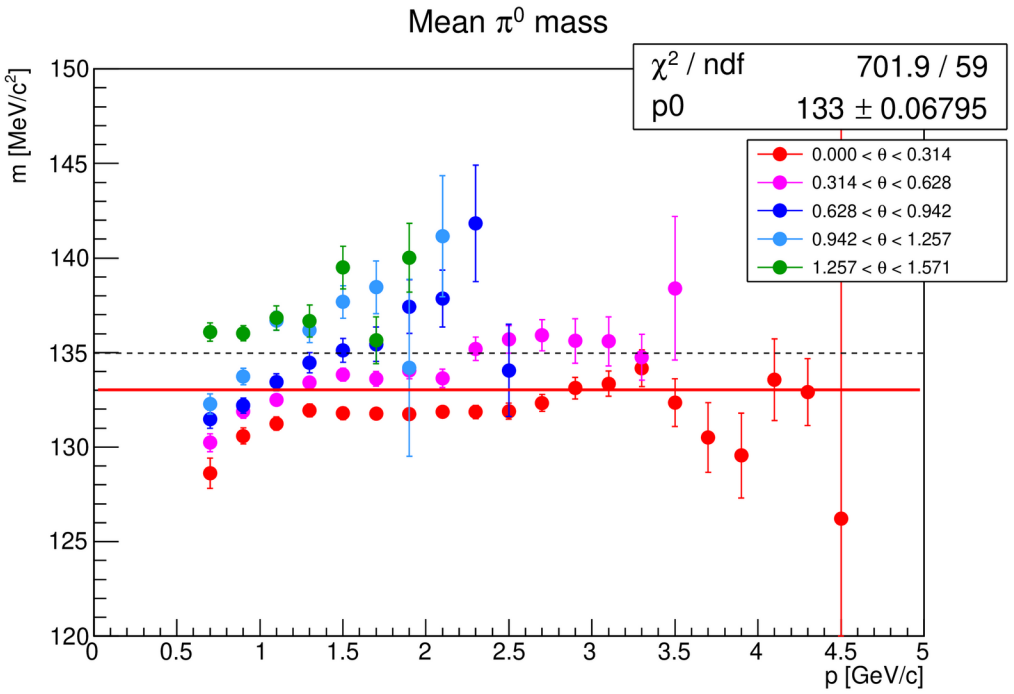
- Loop through all pairs of ECAL clusters.
- Since track association with cluster is not implemented at present, we take information on what particle(s) has (have) created the cluster from the corresponding MC info object, and then exclude clusters associated with charged particles.
- Apply cut $E_{\text{cluster}} > E_{\text{min}}$ to reduce background.
- Calculate the invariant mass for each pair of clusters, assuming that the clusters were produced by photons coming from the primary vertex.
- Invariant mass distribution is fitted by function: $f(m) = \frac{I}{\sigma\sqrt{2\pi}}\exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] + \underbrace{(a_0+a_1 m+a_2 m^2)}_{\text{background}}$
- The procedure described above is applied for each p-θ bin.

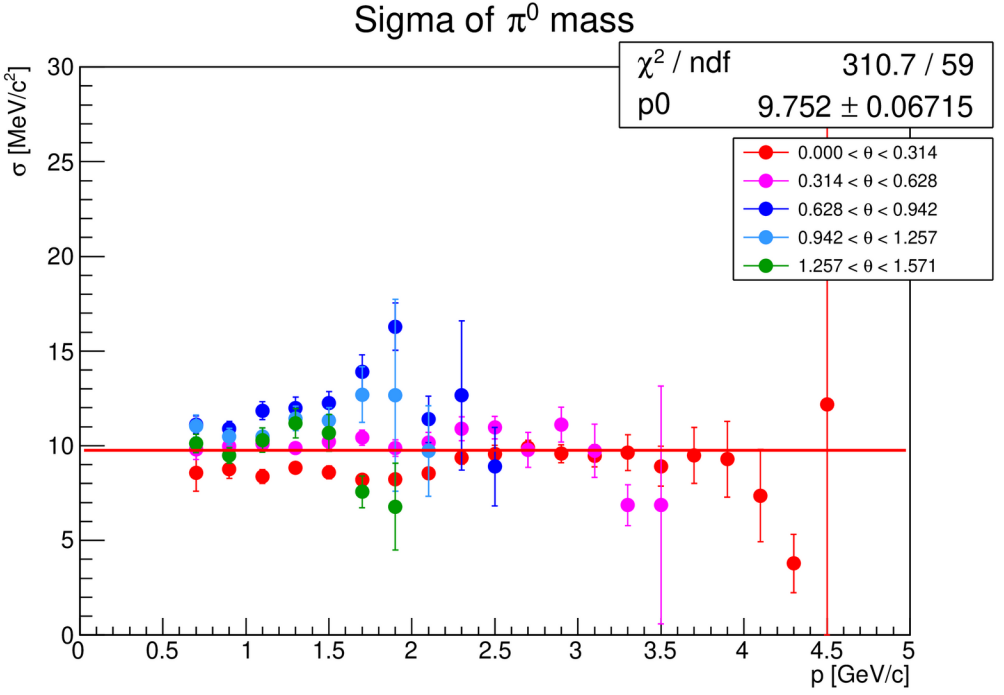
Cut on the cluster energy

- Alexey Guskov noted that cut on the cluster energy E_{min} = 0.2 GeV is not very good because coincides with energy deposition from MIP.
- Now I use E_{min} = 0.3 GeV.



π^0 mean mass and sigma

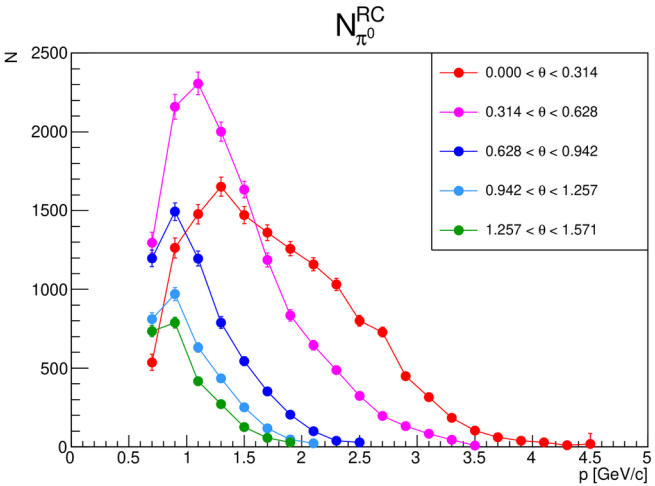


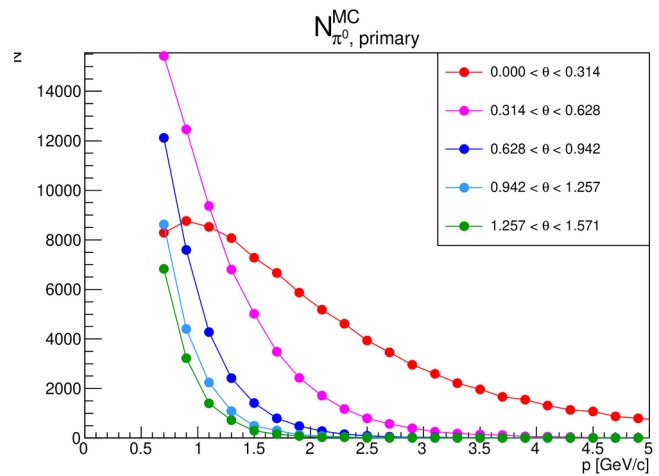


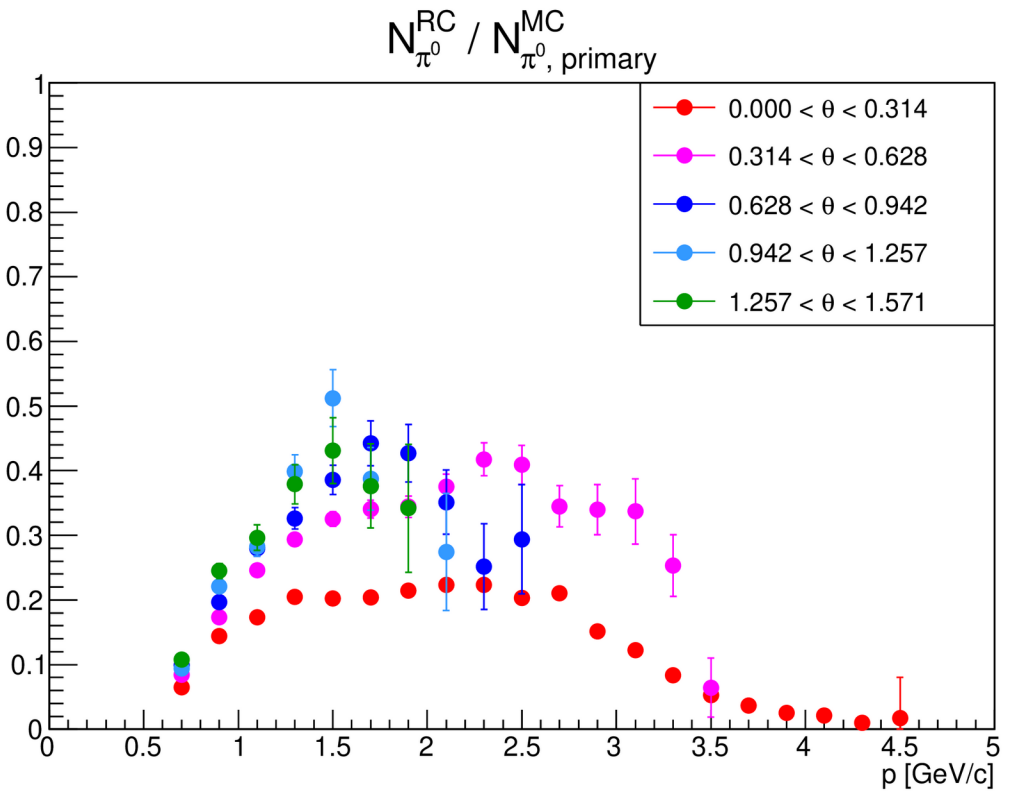
Still deviates from PDG value.

Emin	mean	sigma	note
0.2	*130.7*	*10.0*	*old analysis*
0.2	132.3	10.3	
0.3	**133.0**	**9.8**	
0.4	133.3	9.5	

π^0 reconstruction efficiency





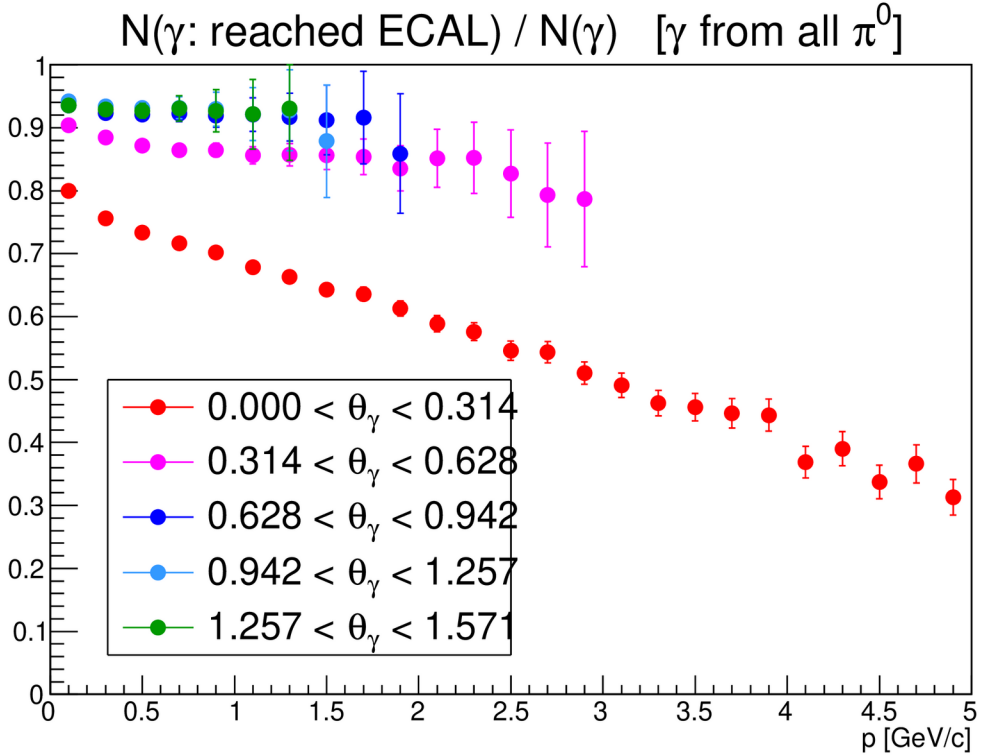


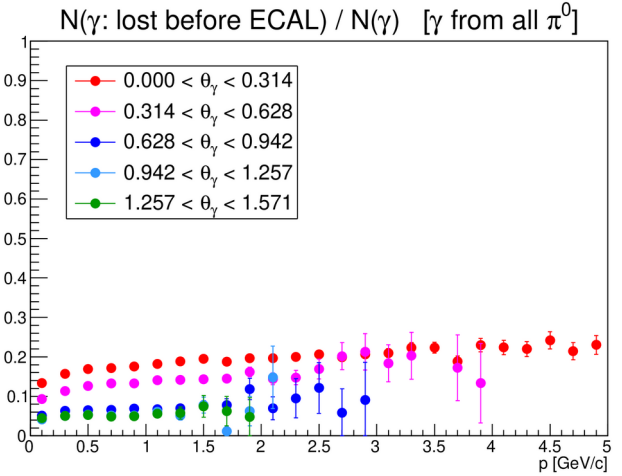
Factors determining π^0 reconstruction efficiency

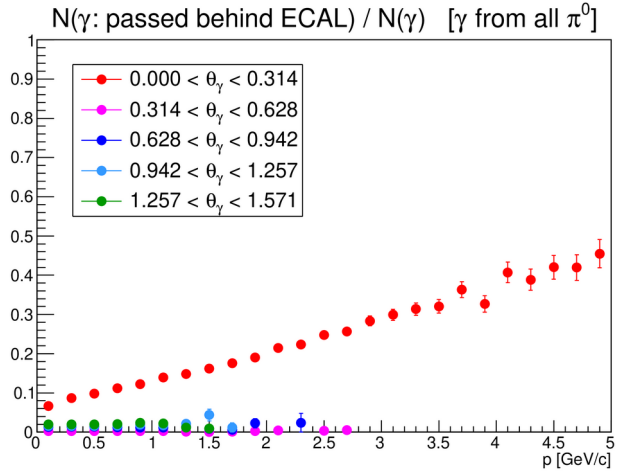
1. Feed down (π^0 from decays and secondary interactions)
2. Geometrical acceptance and loss of γ
3. ECAL cluster reconstruction
4. Rejection of multi-shower clusters associated with charged particle(s)
5. Cut on cluster energy ($E_{cluster} > E_{min}$)
6. Mis-reconstructed particle energy $\Rightarrow$ wrong invariant mass

Geometrical acceptance + γ loss: γ

Look whether γ (from π^0 decay) reached ECAL (via mc-particle → last vertex → det id).

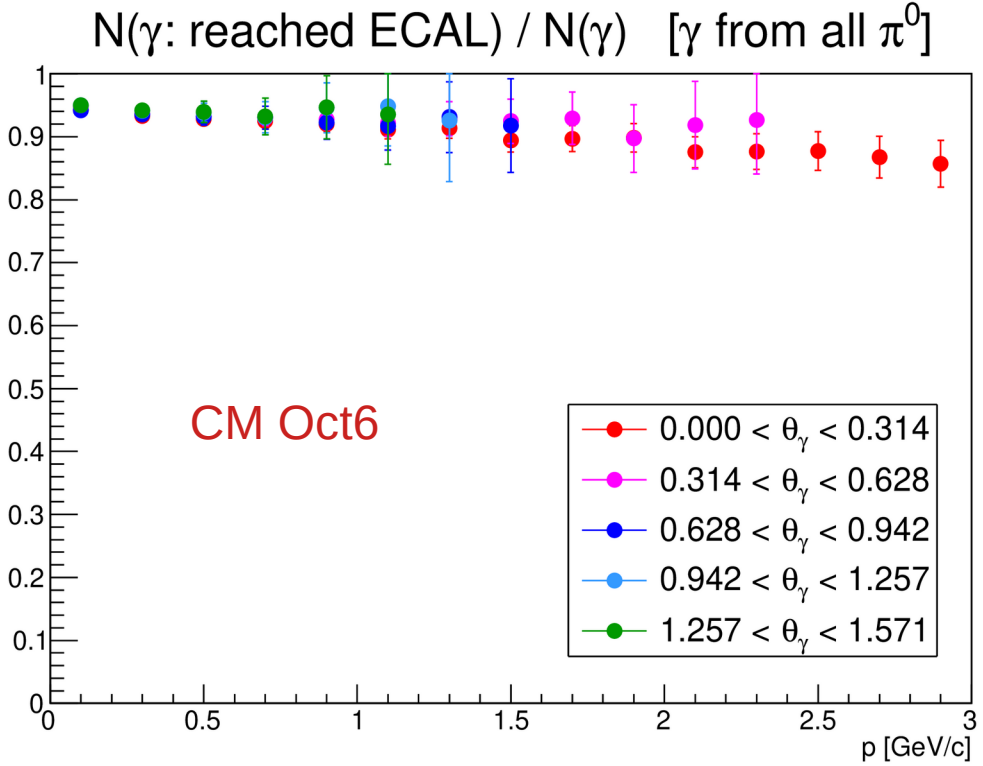


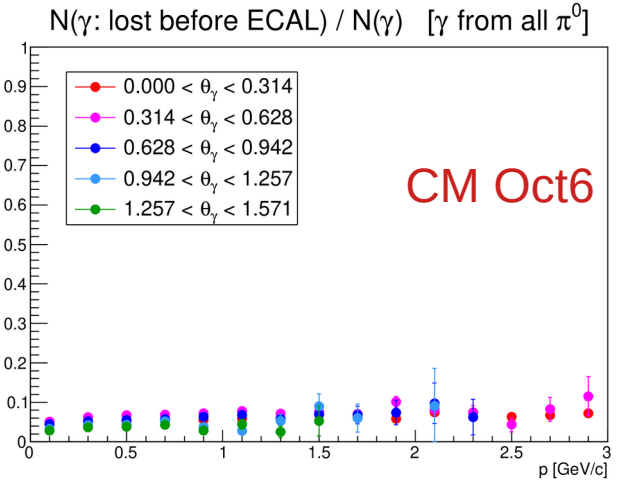


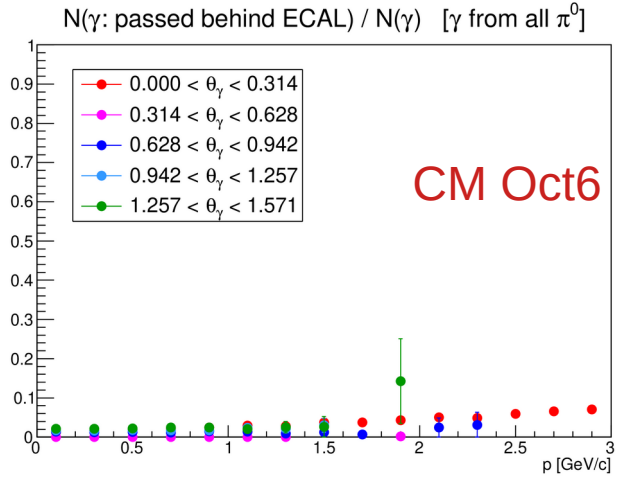


Geometrical acceptance + γ loss: γ

Look whether γ (from π^0 decay) reached ECAL (via mc-particle → last vertex → det id).

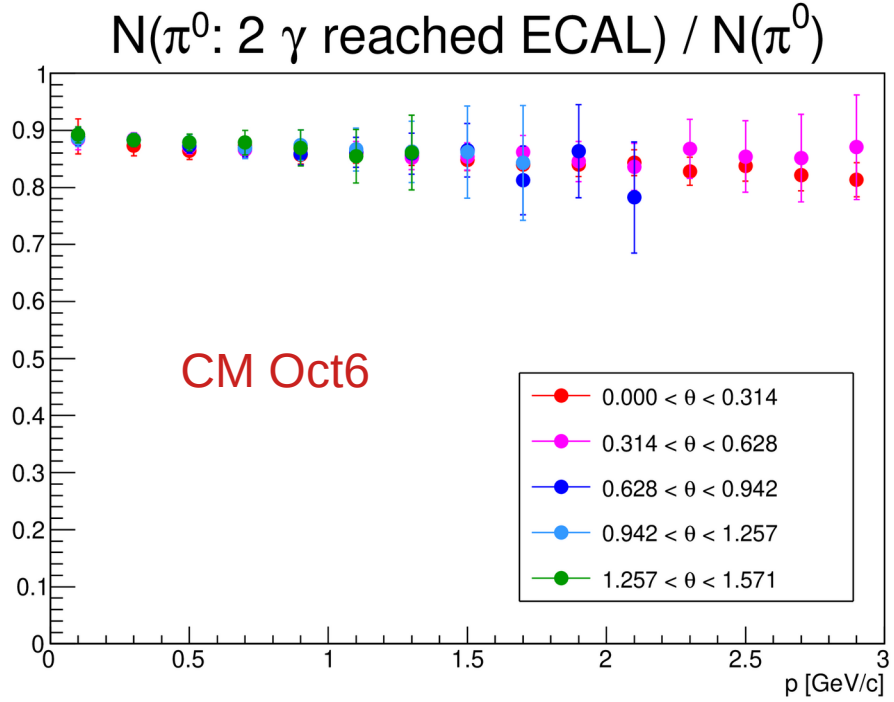


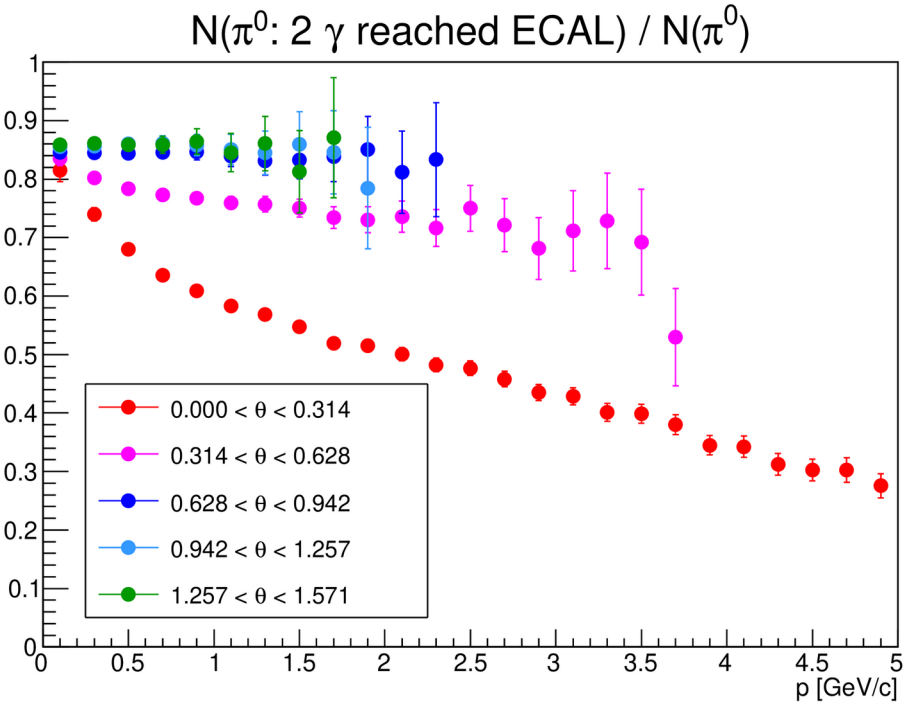




Geometrical acceptance + γ loss: π^0

Look whether both γ particles from π^0 decay reached ECAL.

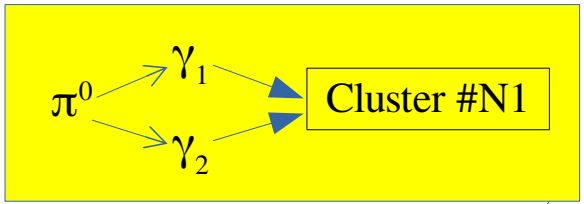


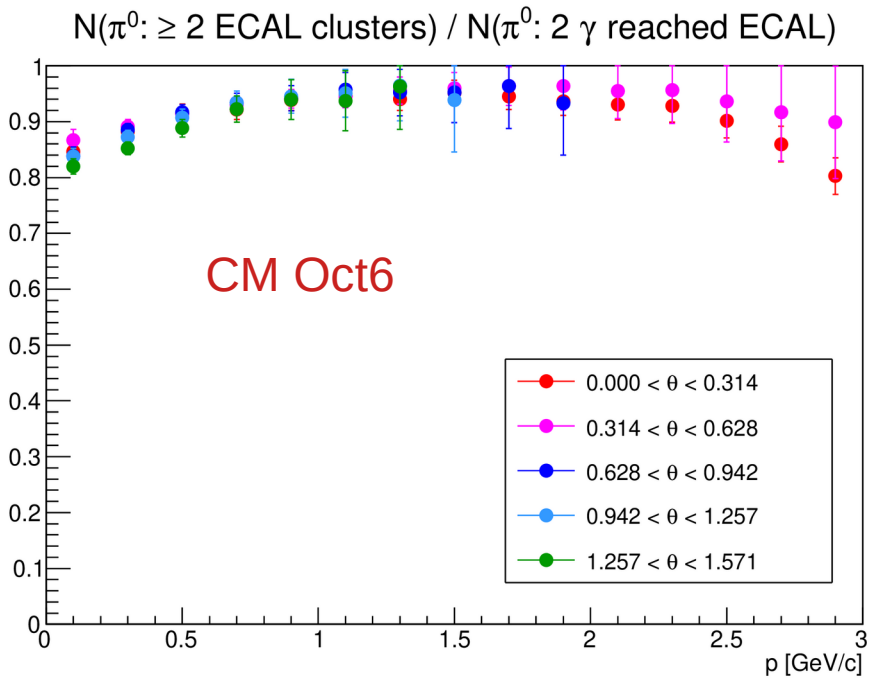


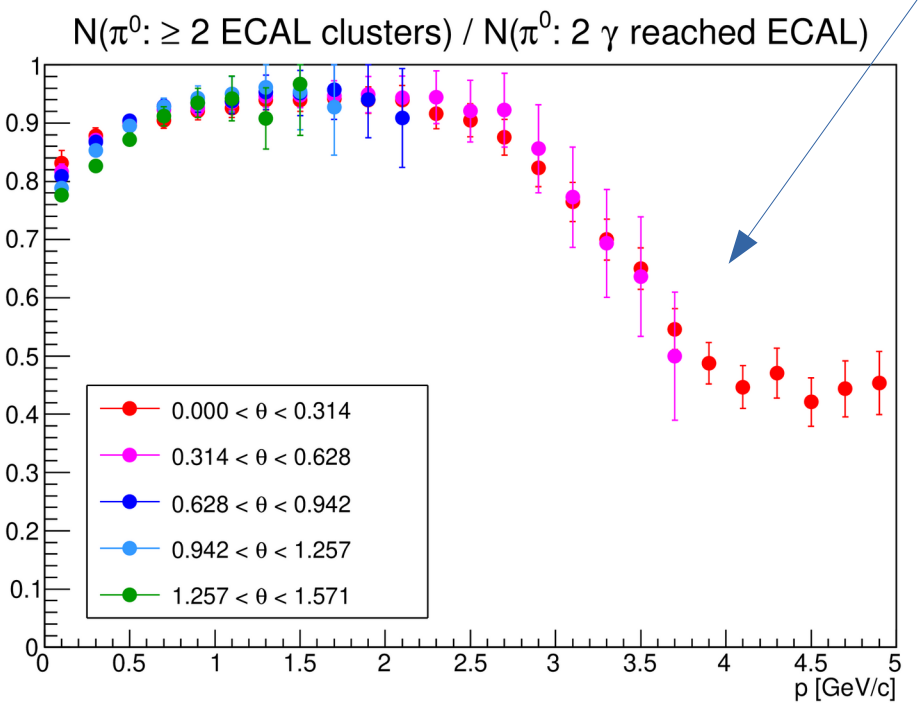
ECAL clusters: π^0

For both γ particles from π^0 decay look if there exist reconstructed ECAL clusters associated with them.

Also check for the special case when both γ belong to the same cluster, and reject such π^0.



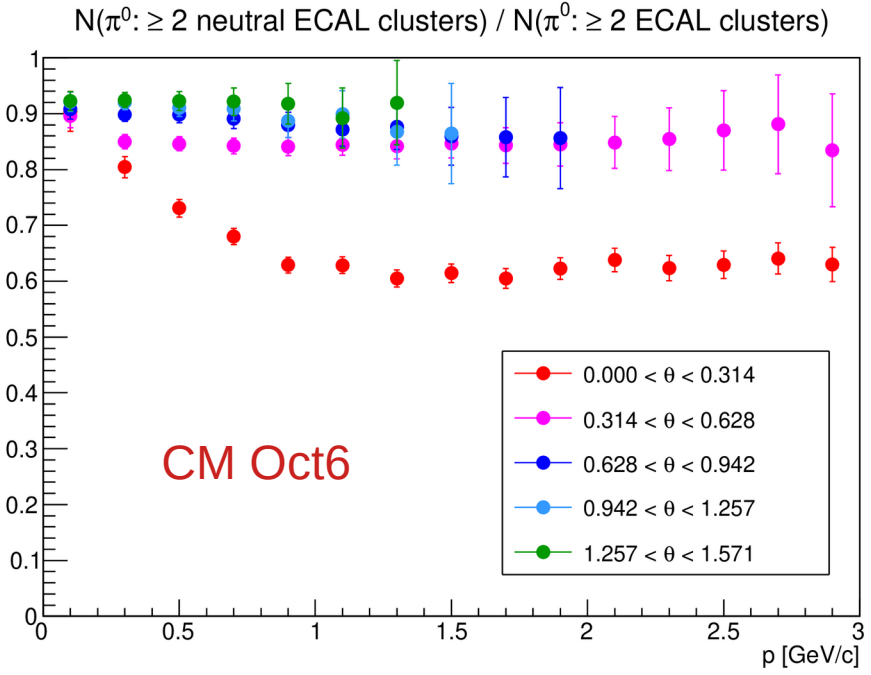


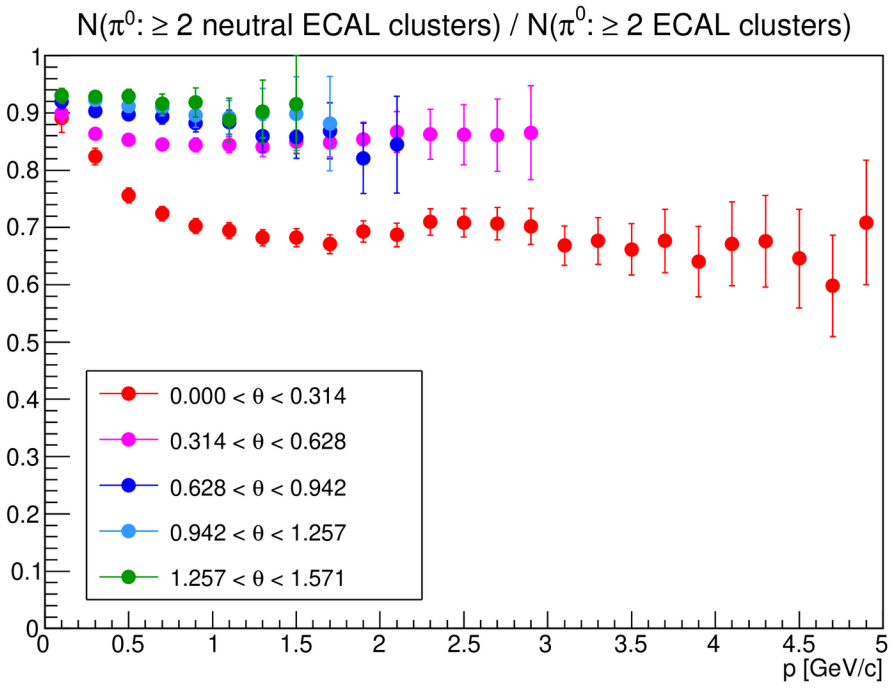


Exclusion of “charged” clusters

Multi-particle clusters may be associated also with a charged particle, e.g. (π^+ γ).

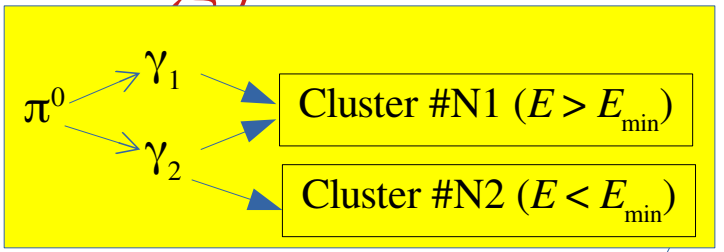
Such cases are excluded.

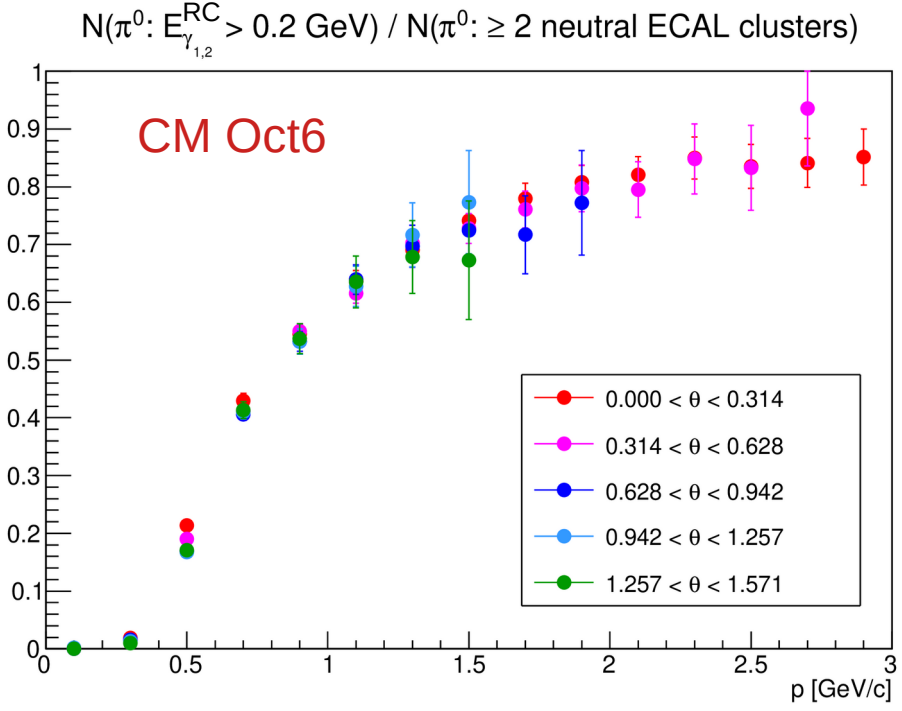


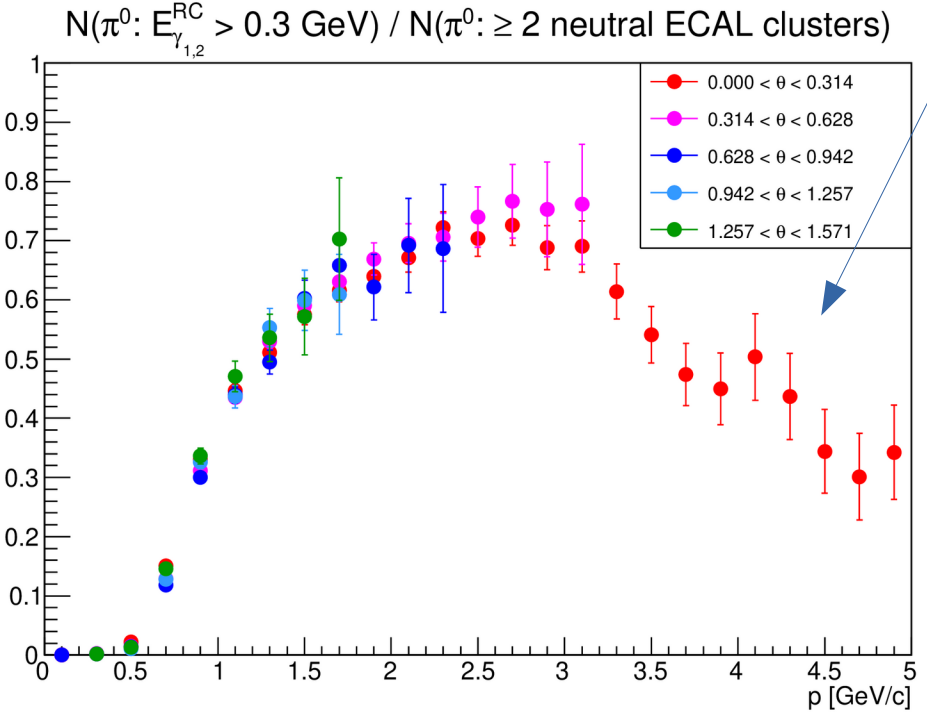


Cut on ECAL cluster energy

For both γ particles from π^0 decay require that $E_{cluster} > E_{min}$.

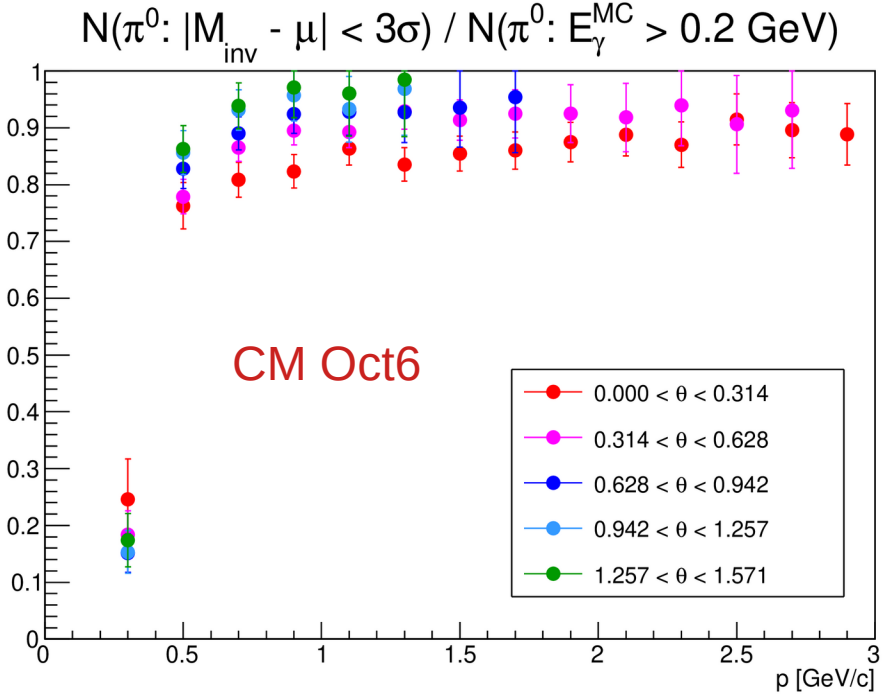


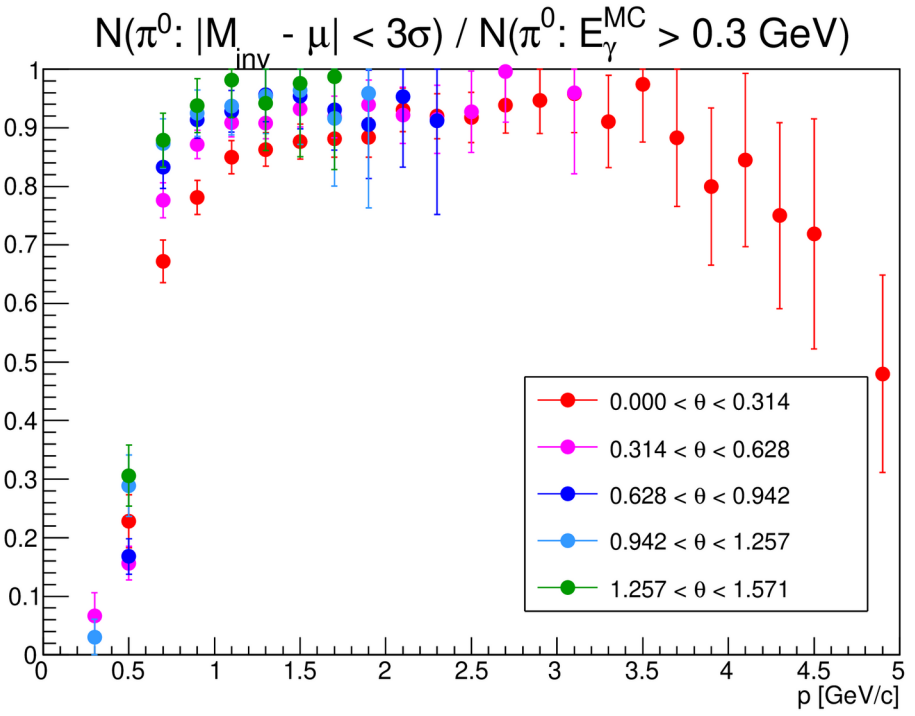




Mis-reconstructed energy / invariant mass

Exclude π^0 mesons with invariant mass outside $[\mu - 3\sigma; \mu + 3\sigma]$ range.





Correction factors

$$c = c_{feed\,down} \cdot c_{geom+loss} \cdot c_{ecalreco} \cdot c_{excl.charged} \cdot c_{Ecut} \cdot c_{misrec}$$

$$c_{feed\,down} = \frac{N(\pi^0)}{N(\text{primary}\,\pi^0)}$$

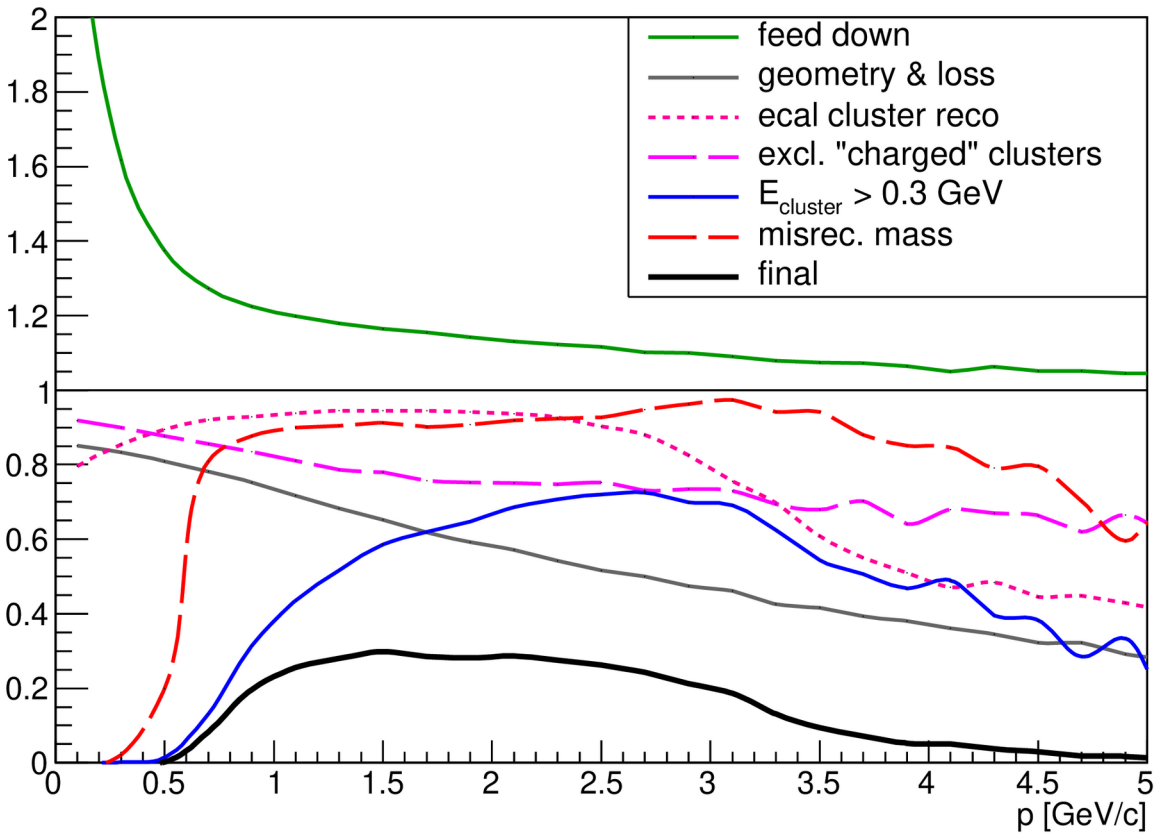
$$c_{geom+loss} = \frac{N(\pi^0 : \text{both}\,\gamma\ \text{reached ECAL})}{N(\pi^0)}$$

$$c_{ecalreco} = \frac{N(\pi^0 : \geq 2\,\text{ECAL clusters})}{N(\pi^0 : \text{both}\,\gamma\ \text{reached ECAL})}$$

$$c_{excl.charged} = \frac{N(\pi^0 : \geq 2\,\text{ECAL neutral clusters})}{N(\pi^0 : \geq 2\,\text{ECAL clusters})}$$

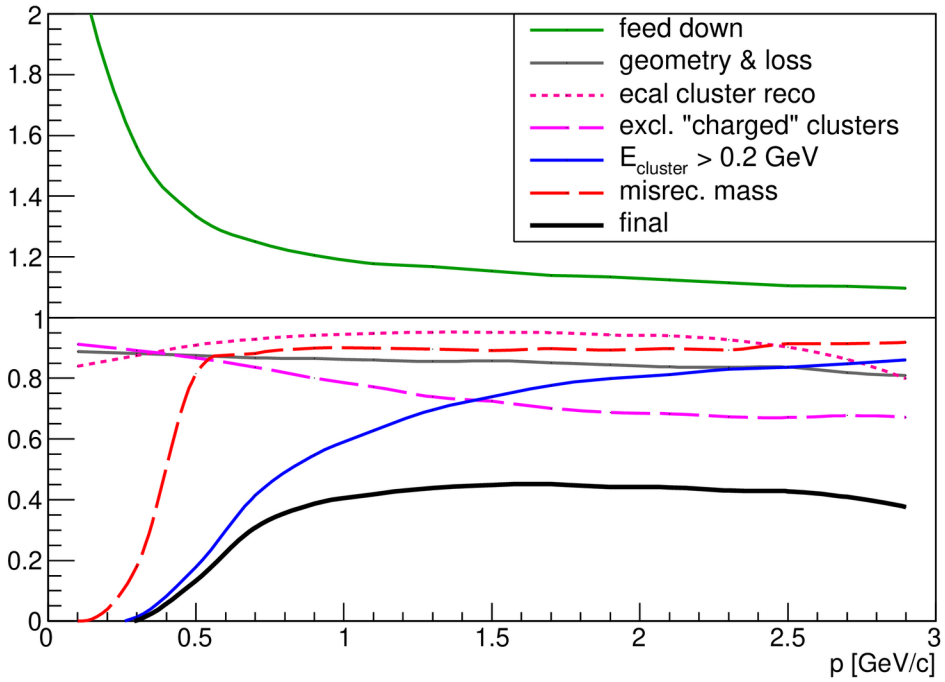
$$c_{Ecut} = \frac{N(\pi^0 : \text{both}\,E_\gamma^{RC} > 0.2\,\text{GeV})}{N(\pi^0 : \geq 2\,\text{ECAL neutral clusters})}$$

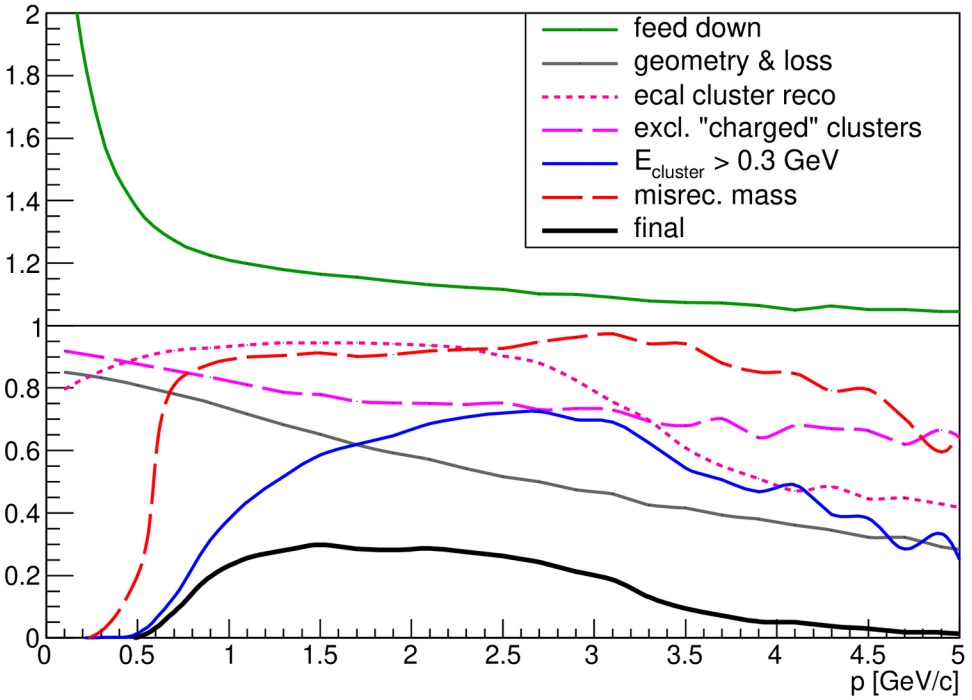
$$c_{misrec} = \frac{N(\pi^0 : |M_{inv} - \mu| < 3\,\sigma)}{N(\pi^0 : \text{both}\,E_\gamma^{RC} > 0.2\,\text{GeV})}$$



Correction factors: comparison

CM Oct6





Conclusions

- Inclusive pi0 production study was performed for the updated ECAL geometry and reconstruction algorithms.
- Because of increased size of the beam hole in the calorimeter end-cap acceptance is reduced.
- For large momenta, the most significant effect affecting pi0 identification is when both gammas belong to the same cluster.

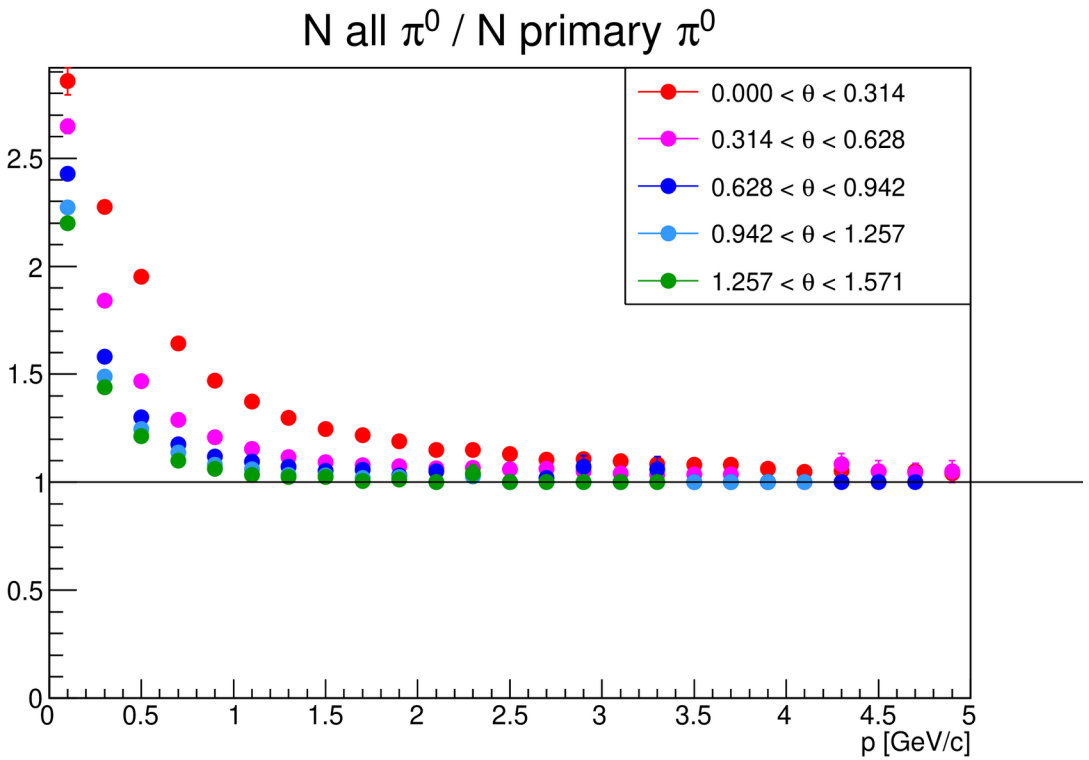
TODO:

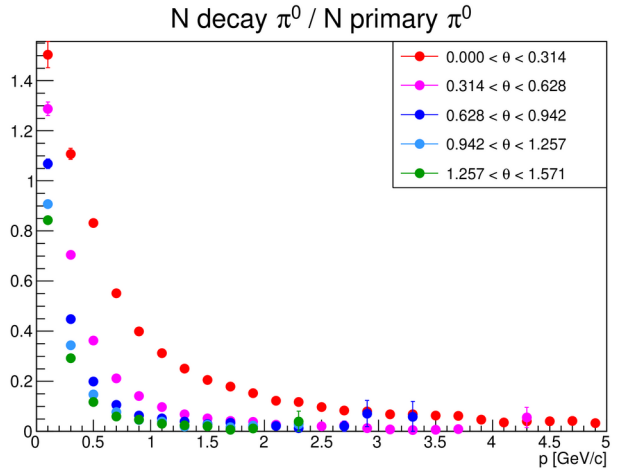
- To increase statistics to explore larger momenta (x_F) values, at least up to $x_F = 0.5$.
- To investigate further the case when both gammas belong to the same cluster.

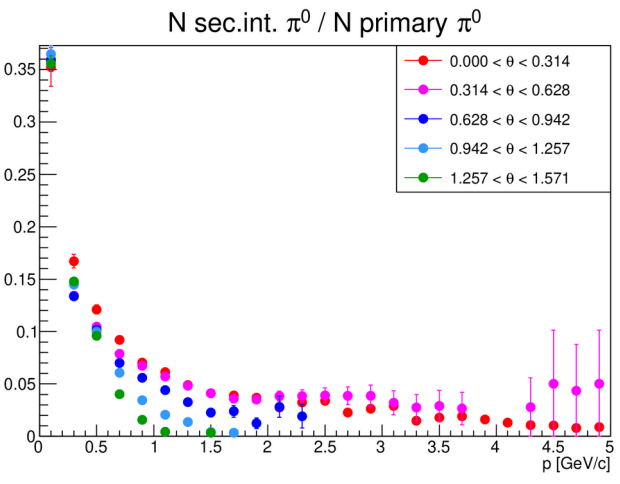
Additional slides

Feed down

$$N_{\text{all }\pi^0} = N_{\text{primary }\pi^0} + N_{\text{decay }\pi^0} + N_{\text{sec.int. }\pi^0}$$

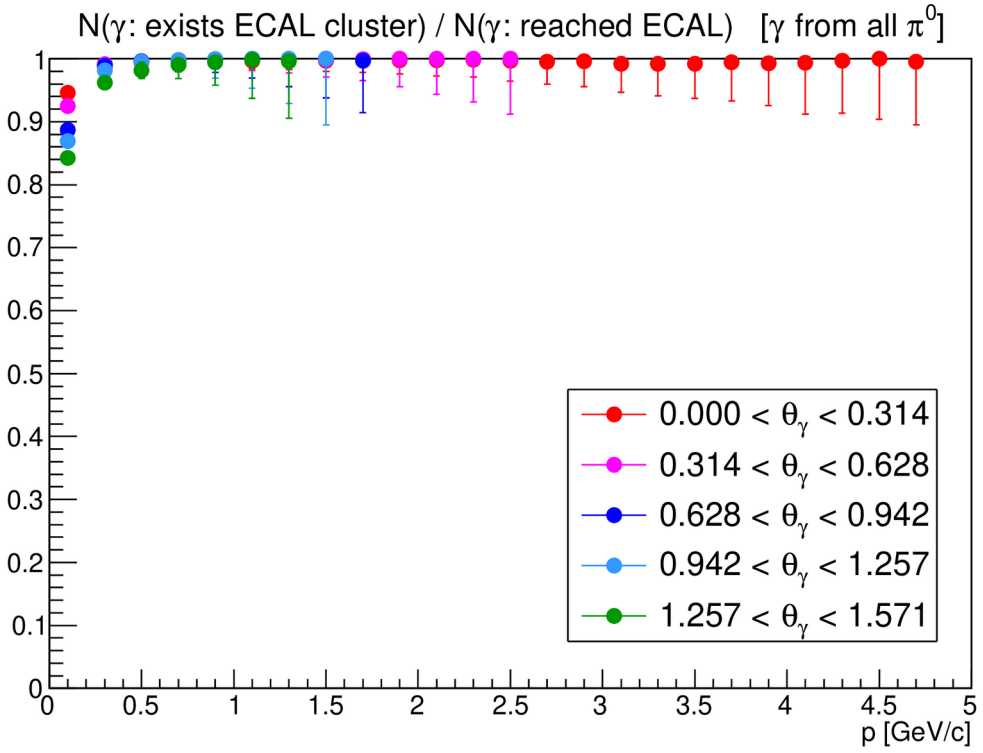




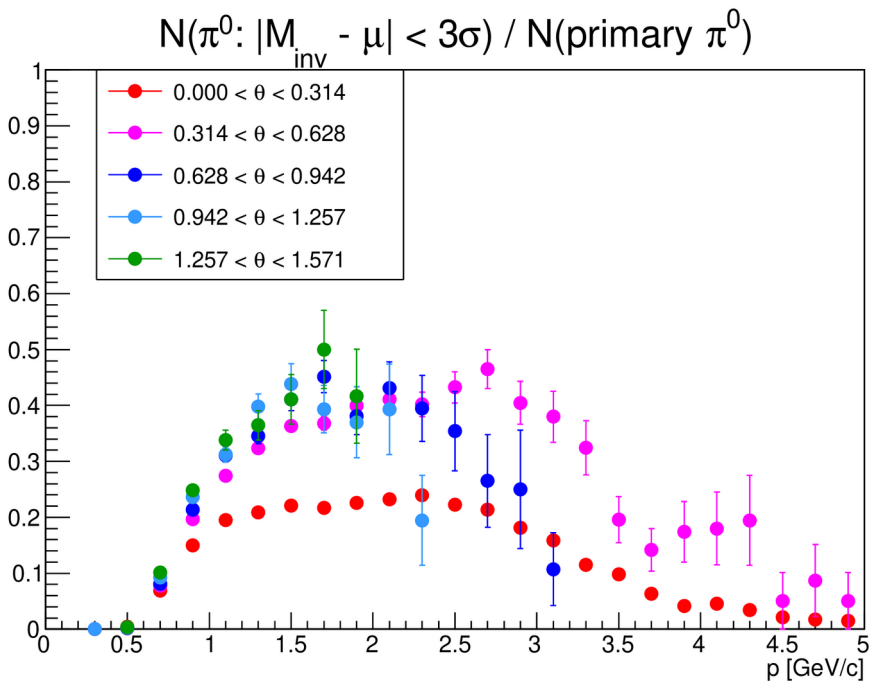


ECAL cluster: γ

For γ (from π^0 decay) look if there exists a reconstructed ECAL cluster associated with it (using `SpdEcalClusterMCInfo`).



Comparison



(from step-by-step procedure)

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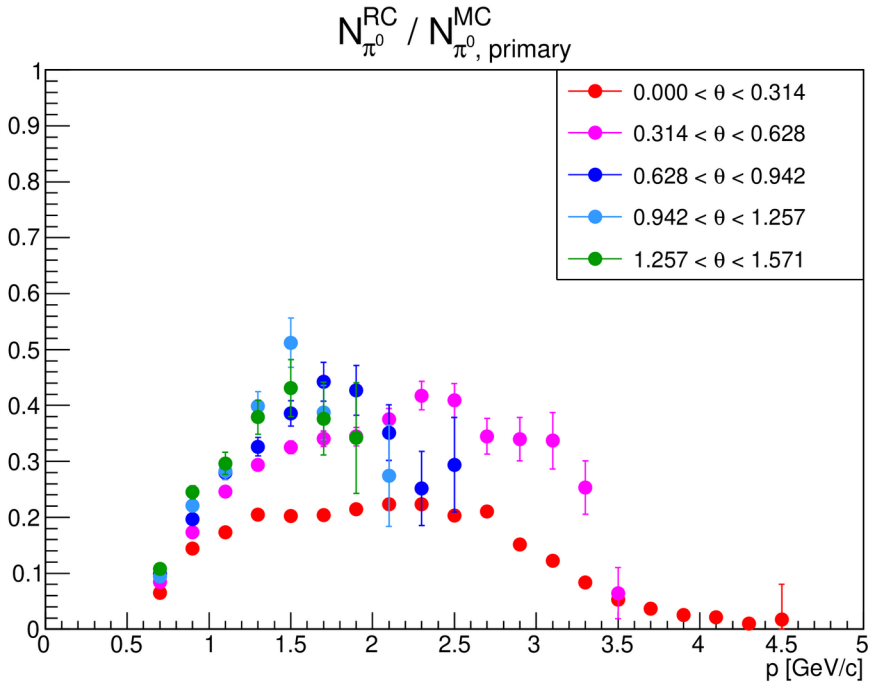
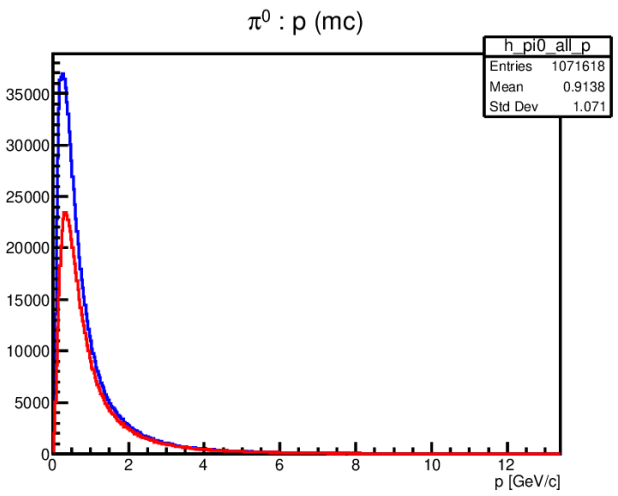
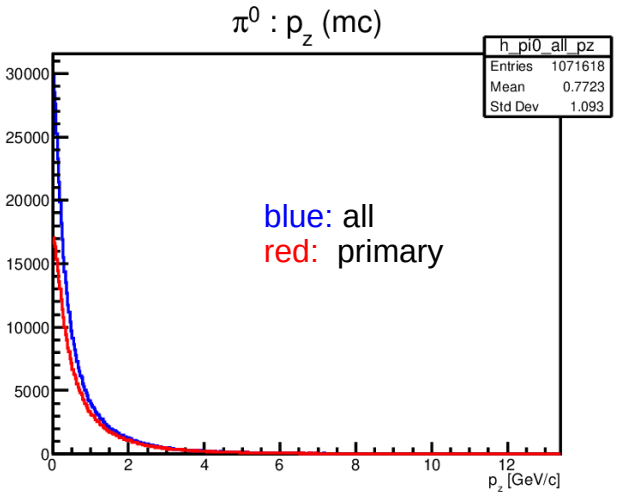


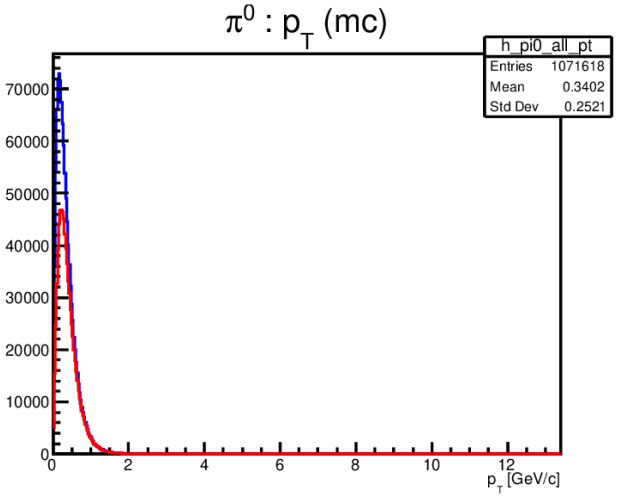
(from fit)

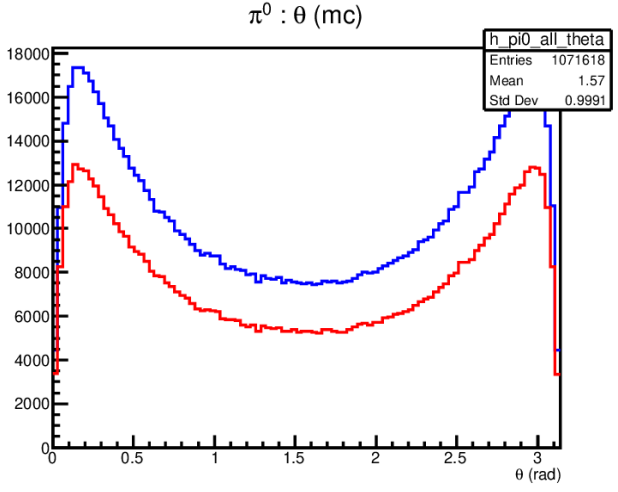
π^0 kinematical distributions [MC]

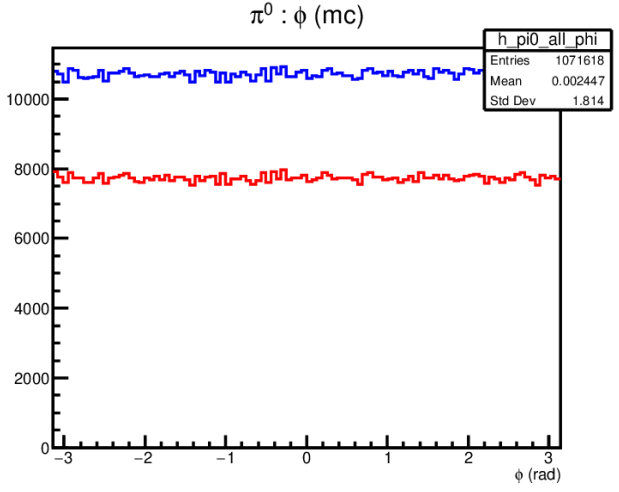


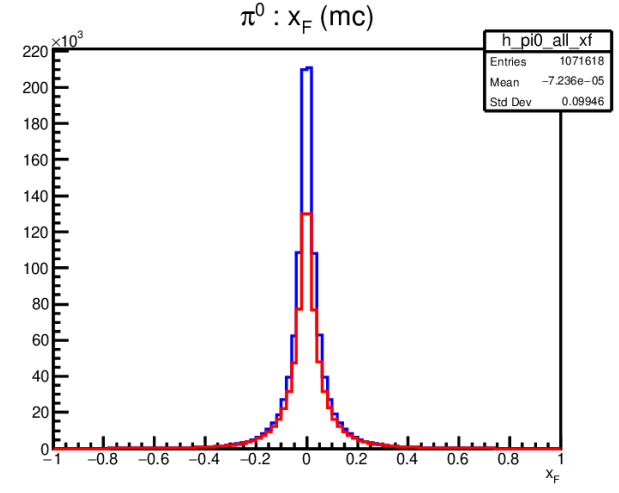


blue: all
red: primary

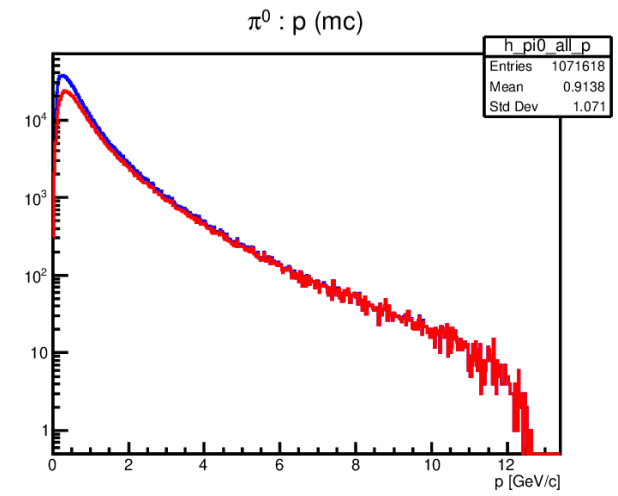


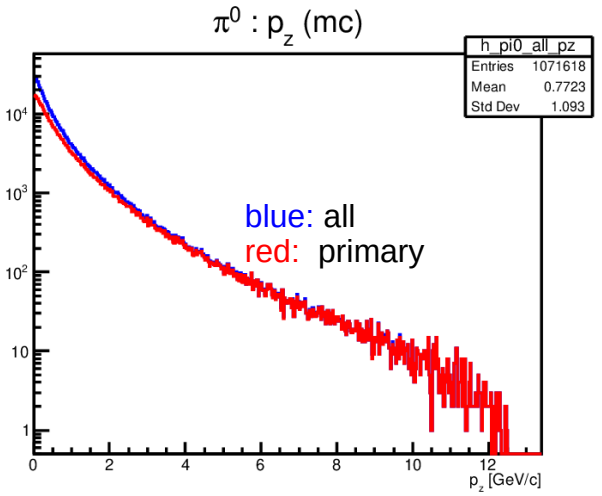


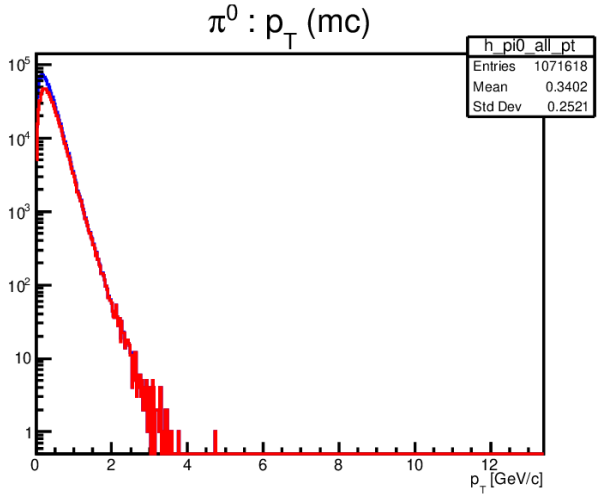


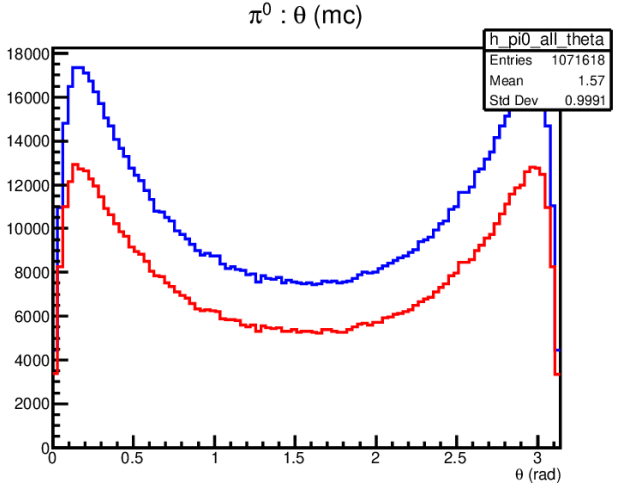


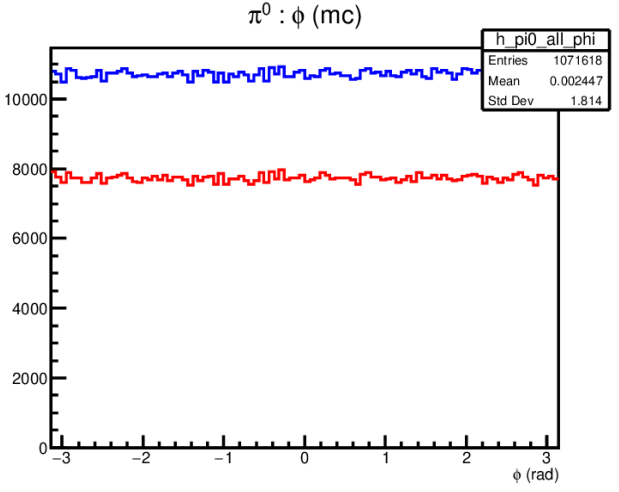
π^0 kinematical distributions [MC]

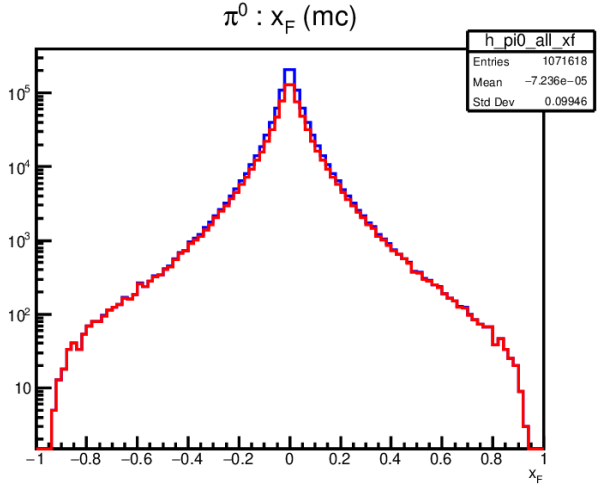




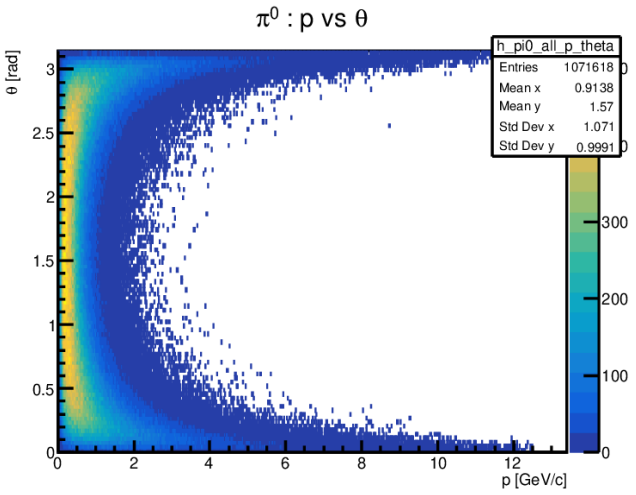


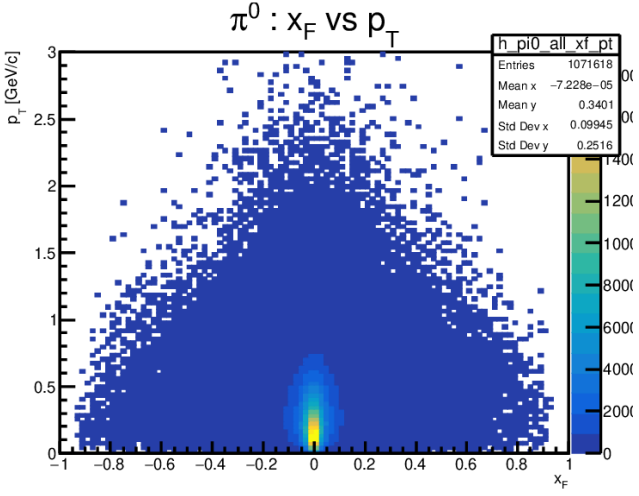


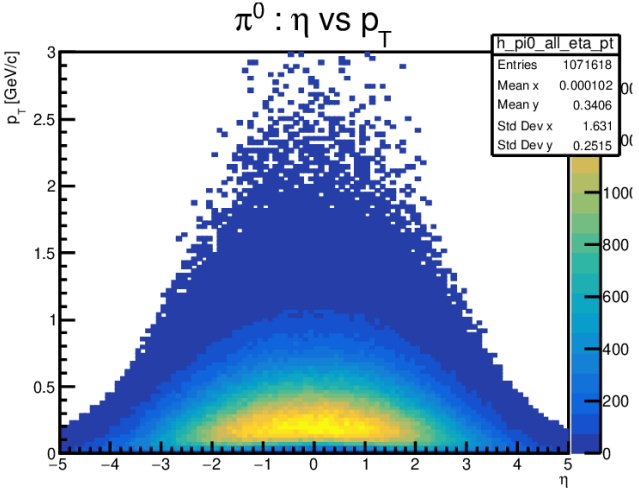


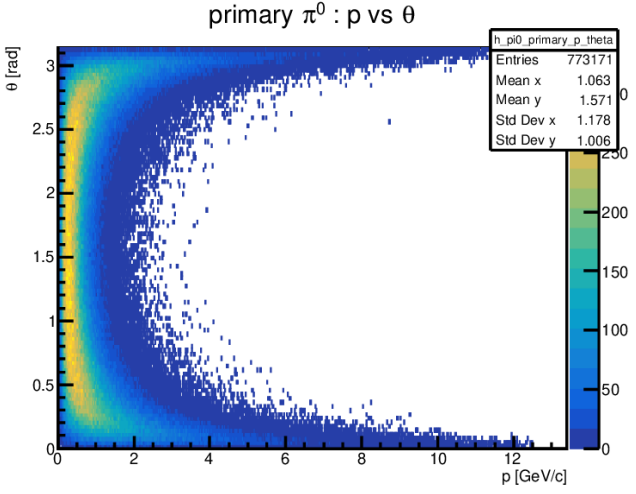


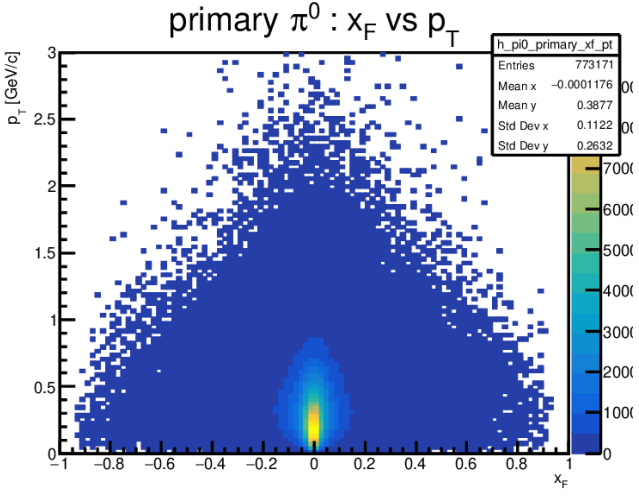
π^0 kinematical distributions [MC]

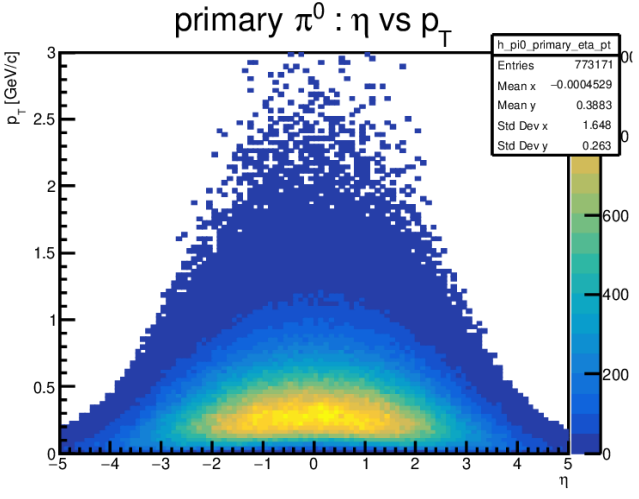












π^0 kinematical distributions [MC]