Inclusive π^0 production studies for SPD

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Goal of study

- To estimate π^0 reconstruction efficiency (N_{RC}/N_{MC}) as a function of momentum *p* and polar angle θ .
- To evaluate contributions of different factors determining the efficiency.

Event sample

- SpdRoot v4.1.4
- Pythia8: SoftQCD (without elastic)
- $\sqrt{s} = 27 \, \text{GeV}$
- 100 000 events
 - (~ 0.03 s of data taking)

(p, θ) distribution of π^0 [MC]

primary π^0 : p vs θ (MC)



 $p = 0.4 ... 3.0 \text{ GeV/}c, \quad \Delta p = 0.2 \text{ GeV/}c$ $\theta = 0 ... 0.5 \cdot \pi, \qquad \Delta \theta = 0.1 \cdot \pi$

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 $E_{cluster} > 200$ MeV 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.

Procedure of π^0 reconstruction

• Invariant mass distribution is fitted by function:

$$f(m) = \frac{I}{\sigma\sqrt{2\pi}} \exp\left[-\frac{(m-\mu)^2}{2\sigma^2}\right] + \underbrace{(a_0 + a_1m + a_2m^2)}_{\text{background}}$$

• The procedure described above is applied for each p- θ bin.



Example: π^0 invariant mass, $0.000 < \theta < 0.314$



π^0 mean mass and sigma



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 $\boldsymbol{\gamma}$
- 3. ECAL cluster reconstruction
- 4. Rejection of multi-shower clusters associated with charged particle(s)
- 5. Cut on cluster energy ($E_{cluster} > 200 \text{ MeV}$)
- 6. Mis-reconstructed particle energy \Rightarrow wrong invariant mass

Feed down



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Geometrical acceptance + γ loss: γ



----- 0.314 < θ_ν < 0.628 • 0.628 < θ_{γ} < 0.942 0.942 < θ_y < 1.257 1.257 < θ_y < 1.571</p> p [GeV/c] N(γ : passed behind ECAL) / N(γ) [γ from all π^0] --- 0.000 < θ_y < 0.314</p> - 0.314 < θ_y < 0.628</p> - 0.628 < θ_{γ} < 0.942 0.942 < θ_ν < 1.257</p> 1.257 < θ_ν < 1.571</p> 15 2.5 p [GeV/c]

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Geometrical acceptance + γ loss: π^0

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



ECAL cluster: γ

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



ECAL clusters: complicated cases

- However, one reconstructed cluster may be produced by more than one closely flying particles (*«multi-particle clusters»*), especially in the endcaps.
- On the contrary, one particle may produce *several clusters*.
 This typically happens in the area of **overlap of barrel and** endcaps.





Change

titles !!!

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 γ (from π^0) : E^{RC} vs E^{MC}



energy is overestimated



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. $(\pi^+ \gamma)$. Such cases are excluded.



Cut on ECAL cluster energy

For both γ particles from π^0 decay require that $E_{\text{cluster}} > 0.2 \text{ GeV}$.



Mis-reconstructed energy / invariant mass



Mis-reconstructed energy / invariant mass

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



Correction factors





Correction factors

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



Conclusions

- Detailed analysis of various factors affecting the π^0 reconstruction efficiency was performed.
- Multi-shower reconstruction algorithm for ECAL clusters is needed, especially for the endcaps.
- Also, it would be nice to have an algorithm for matching clusters in overlap area of ECAL barrel and endcaps.
- Cut on E_{cluster} is subject to optimization.

backup slides

Comparison

ECAL geometry in SpdRoot

BARREL: $\theta_{min} = 0.53$ rad

ENDCAP: $\theta_{max} = 0.71$ rad

π^0 kinematical distributions [MC]

π^0 kinematical distributions [MC]

Invariant mass (cut $E_{cluster} > 200 \text{ MeV}$)

Invariant mass *ռուշտո*ւուն, շեղը նշերը լա_նները է աներաներությունները է աներաները al neutral all γ γ from the same π^0 ν'n. m [MeV/c²]

Invariant mass (no cut on E_{cluster})

π^0 reconstruction efficiency

