Particle Identification with EMCAL

(via shower shape)

- Status
- Results for Low flux parametrisation
- Results High flux parametrisation

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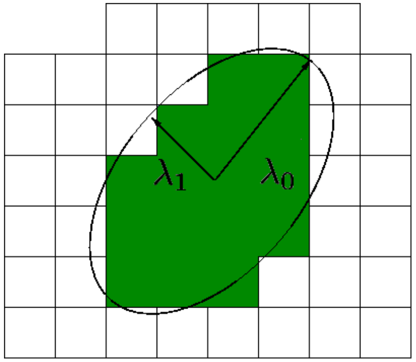
EMCAL PID & new parametrisations

EMCAL PID: based on shower shape analysis + bayesian
Shape of clusters λ_0^2 (main axis of the cluster ellipsoide) +
Bayesian analysis to determine probability for a cluster to be originating from (γ, π^0,, hadron)



In AliRoot now: based on clusters λ_0^2 distributions determined for
- old pp clusterisation parameters and thresholds.
- Nothing for the Pb Pb parameters and thresholds case.

Old pp clusterisation thresholds :
Tower minimum energy cut: fMinECut = 0,01 (10 MeV)
Minimum cluster energy cut : fClusteringThreshold = 0,1(100MeV)

Actuals thresholds	**pp** LowFlux	**Pb Pb** HighFlux
fMinECut =	**0,01 (10 MeV)** ,	**0,45 (450 MeV)**
fClusteringThreshold: =	**0,2 (200MeV)**,	**0,5 (500 MeV)**

PID determination

Principle from AliESDCaloClusters

-1- Parametrisation of shower shape (λ_0^2) distribution for each kind of particle γ, π^0, hadron at different energies.

-2- Determination for each cluster (given its λ_0^2, and energy) of the probability to be from each kind via Bayesian method:

$$W(i) = \frac{P(\lambda_0^2, i)}{\Sigma_i P(\lambda_0^2, i)} \qquad i = \gamma, \pi0, \text{ hadron}$$

Implementation in AliEMCALPID Class called during reconstruction:

The W(i) are then filled during reconstruction and stored in AliESDCaloClusters
Via AliESDCaloCluster::SetPID() Method.

But: 3 particle species differentiation by showershape; AliEMCALPID
11 particle species in standart AliPID
To assure the sum of probabilities equal to 1 the W(i) are distributed from 3 species to 11 species:

kElectron:	fPIDFinal[0] = W(γ)/2	kPhoton :	fPIDFinal[5] W(γ)/2
kPi0:	fPIDFinal[6] = W(π0)		
kMuon:	fPIDFinal[1]= W(hadron)/8	kNeutron:	fPIDFinal[7] = W(hadron)/8
kPion:	fPIDFinal[2] = W(hadron)/8	kKaon0:	PIDFinal[8] = W(hadron)/8
kKaon:	fPIDFinal[3] = W(hadron)/8	kEleCon:	fPIDFinal[9] = W(hadron)/8
kProton:	fPIDFinal[4] = W(hadron)/8	kUnknown:	fPIFFinal[10]= w(hadron)/8

1rst STEP: Parametrisation of λ_0^2

Simulations with (AliRoot-V4.16.Rev06)

-10000 events with 1 γ /event
-10000 events with 1 π /event
-10000 events with 1 K^0_L/event

- 80°<ϕ<190° -0.7<η<0.7
- Pt (GeV)= 10, 12, 14 16 18, 22, 24, 26, 28,30 32 34 36 38 40 42 44 46 48 50
- Pt (GeV)= 60, 80 100 (in addition for K^0_L see later to get parametrisation also for high reconstructed energy (up to 50 GeV as other particles)

- ➢ Only EMCAL material.
- ➢ pp LowFlux clusterisation parameters /PbPb HighFlux

  - ✓ **Selection of clusters: with nb of cells >2**
  - ✓ **Selection of events with 1 and 1 only cluster reconstructed**

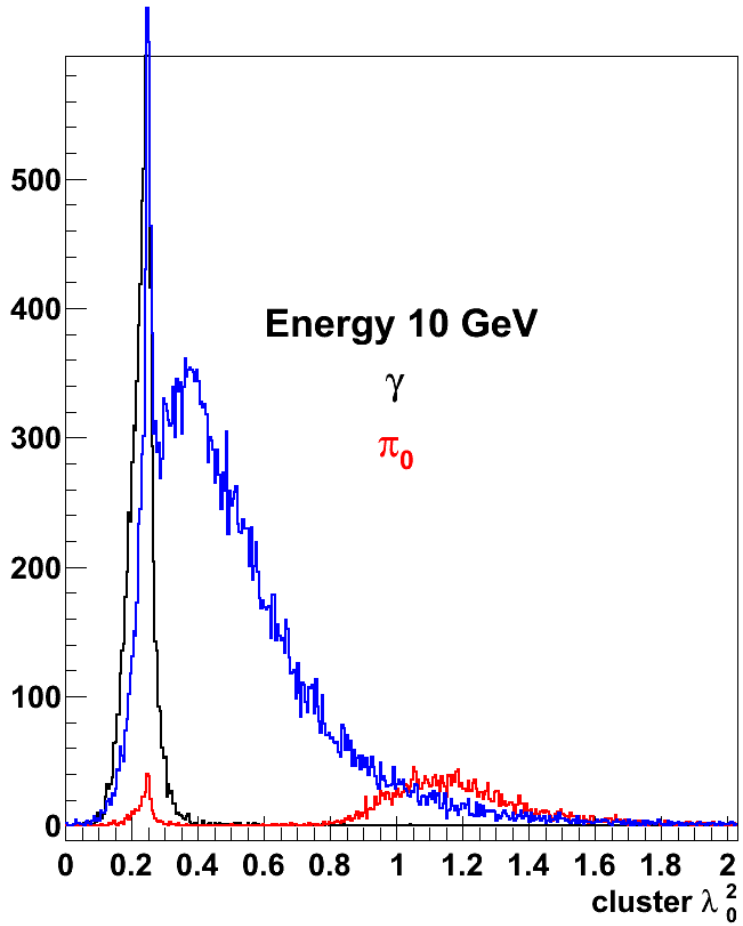
FIT of λ_0^2 distributions

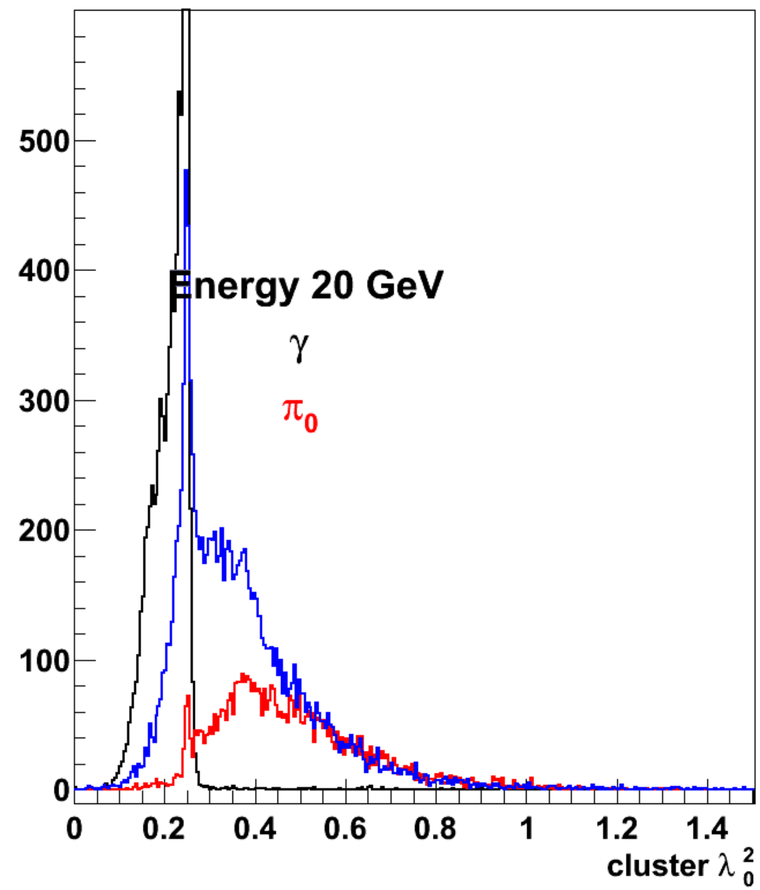
Root Fit of : Gaussian + landau Distribution (or inverted landau for γ,)
Gaussian: $Norm_G$ * TMath::Gaus(λ_0^2 ,m_G,σ_G) : 3 parameters
Landau : $Norm_L$* TMath::Landau(λ_0^2 ,m_L,σ_L): 3 parameters

Evolution of each parameter with Energy is fitted by:

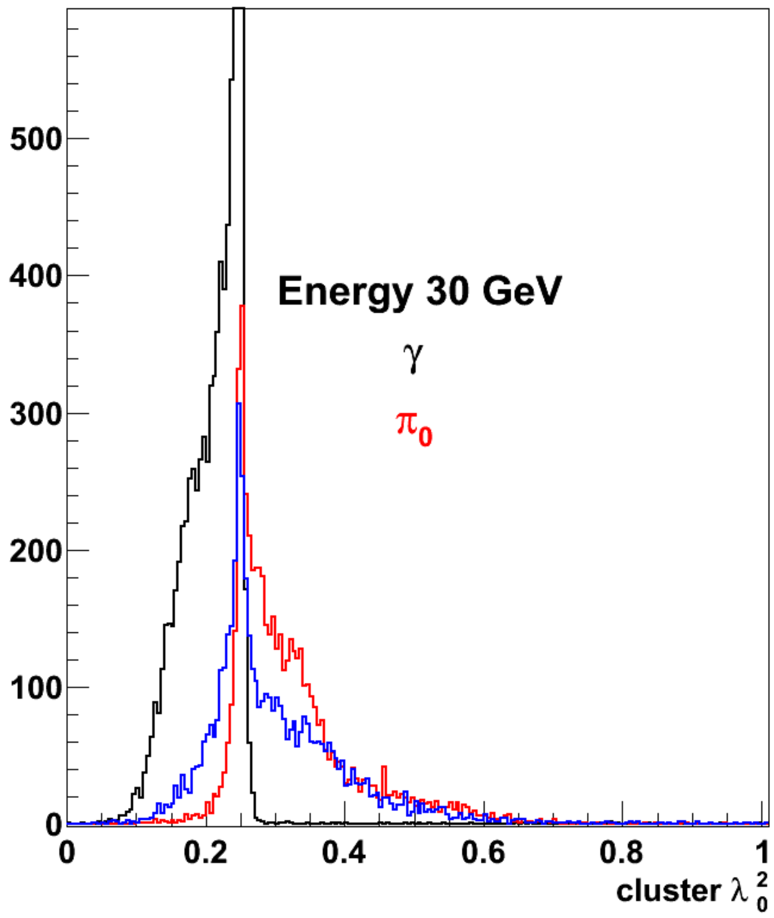
$$Param (E(GeV)) = p_0E^{-2} + p_1E^{-1} + p_2 + p_3E + p_4E^2$$

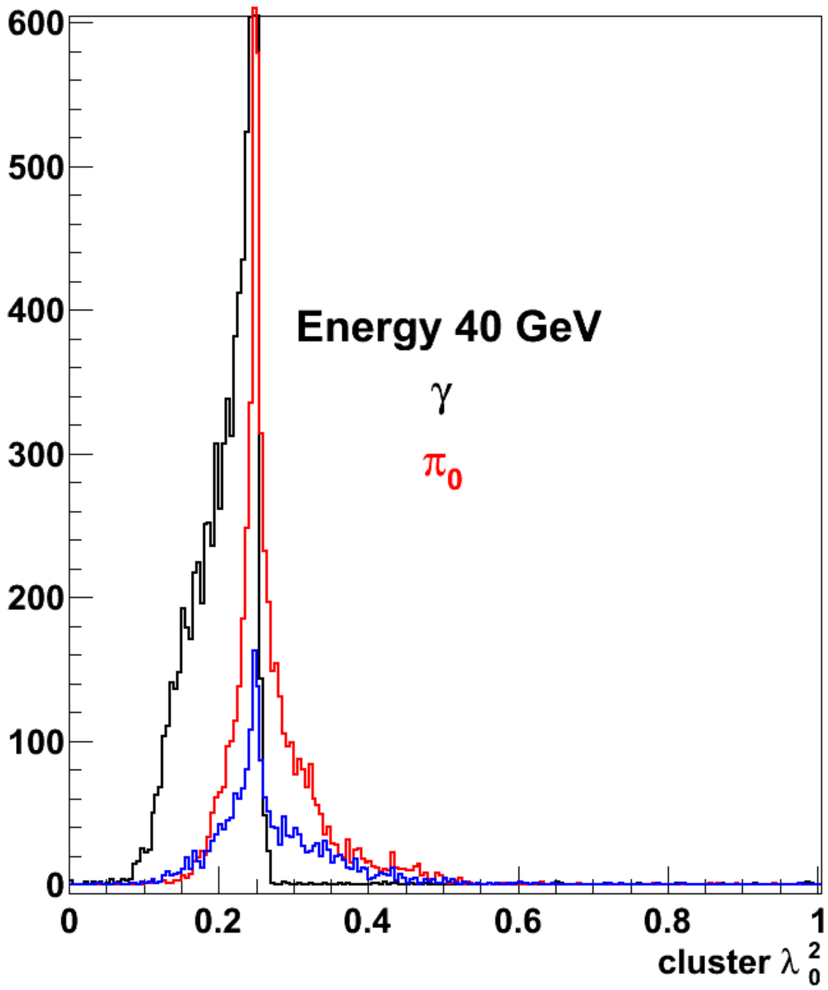
λ_0^2 distributions (pp)



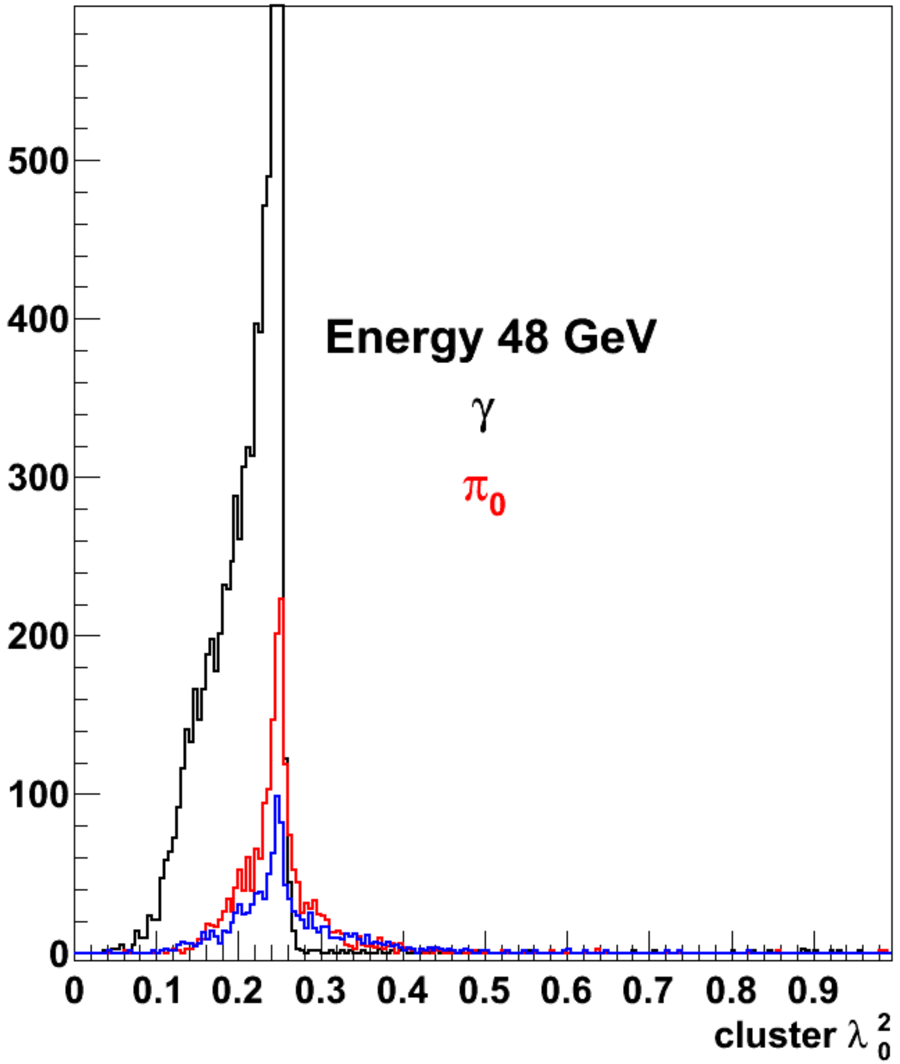


λ_0^2 distributions (pp)





λ_0^2 distributions (pp)



PID Quality/ efficiencies

Simulations: 1 particles from each kind γ,π^0, π^+, π^- at fixed energy /event

Cluster mean multiplicity in EMCAL from Pythia ~ 4

- « merged with »: **pp:** Pythia kPyJet Jet-jet events with JetEtRange[30-100GeV]

- « merged with »: **PbPb:** for Pb Pb Hijing à 5.5 TeV (0-5fm)
  Cluster mean multiplicity in EMCAL from Hijing ~ 20
  poor statistic/bining for the moment

Only EMCAL in
Reconstruction & PID with new LowFlux parametrization for pp case and HighFlux for Pb Pb

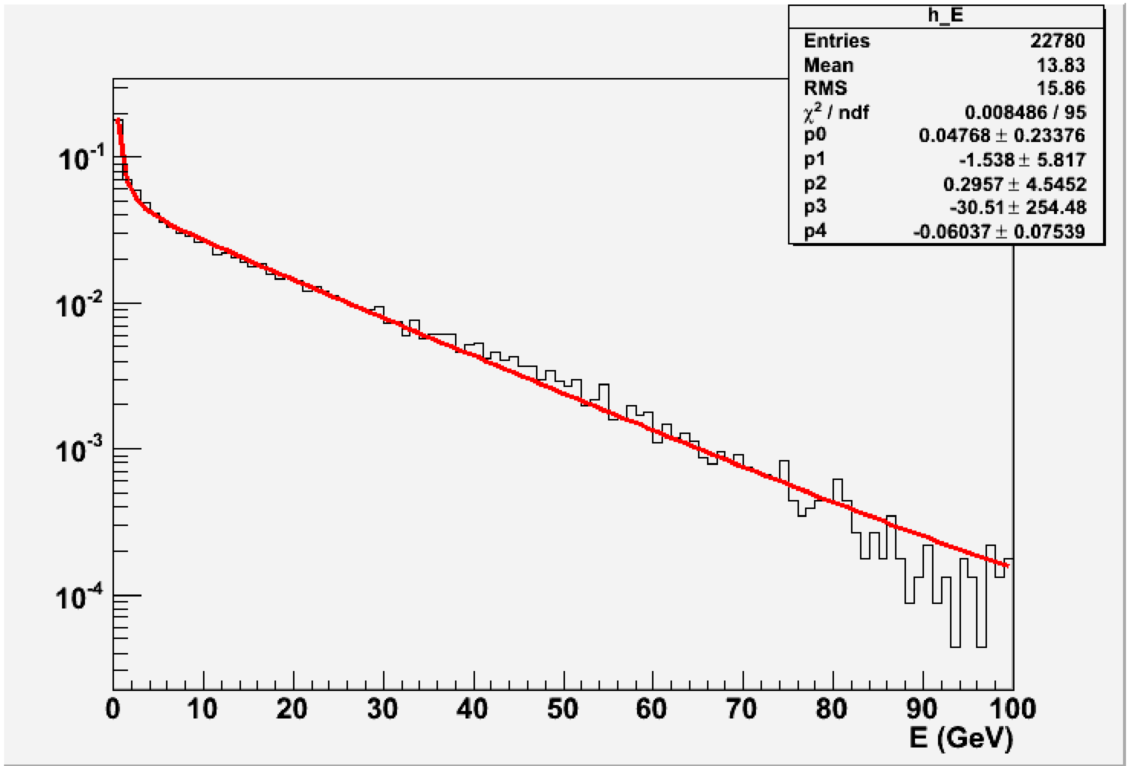
Hadron Energy Ponderation

Pb of hadron « correction »: Energy deposited in EMCAL mainly MIPS.
For showershape/ we require at least 2 cells multiplicity or clusters
(MIP peak is avoided and we have just the tail of the energy distribution)

π/K0 simulation in EMCAL
40000 single particles Flat E distribution between 0.5-100 GeV
Reconstructed Energy distribution

Ponderation of the probability for a given cluster with E and λ_0^2 to be a hadron by the probability to have deposited E

Fit by the fct:
Powerlow+expo
$p_0.E\hat{}p_1+p_{2.}exp(E-p_3)*p_4$

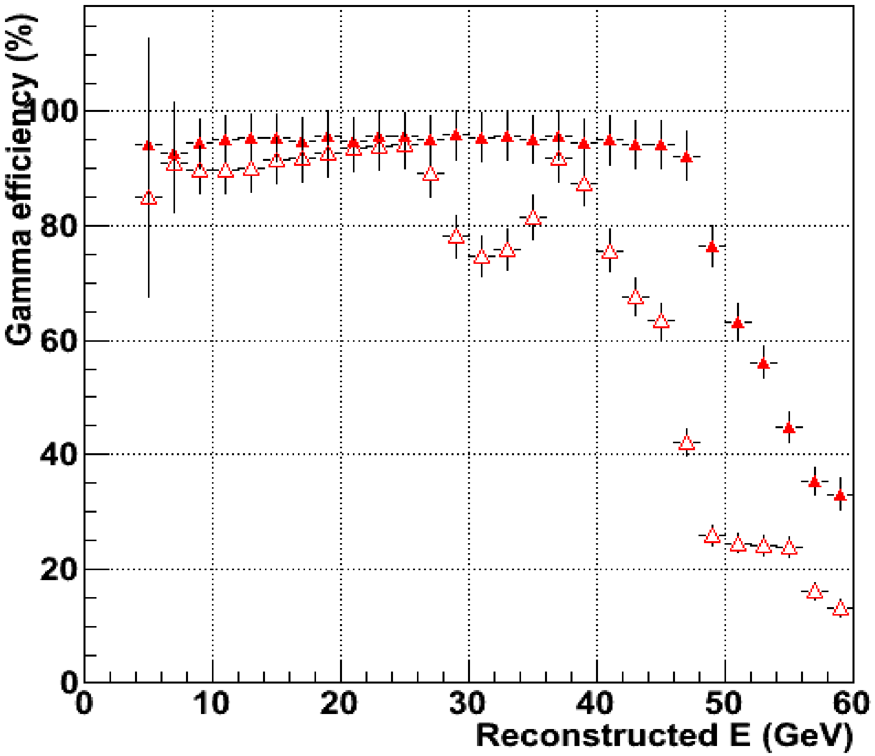


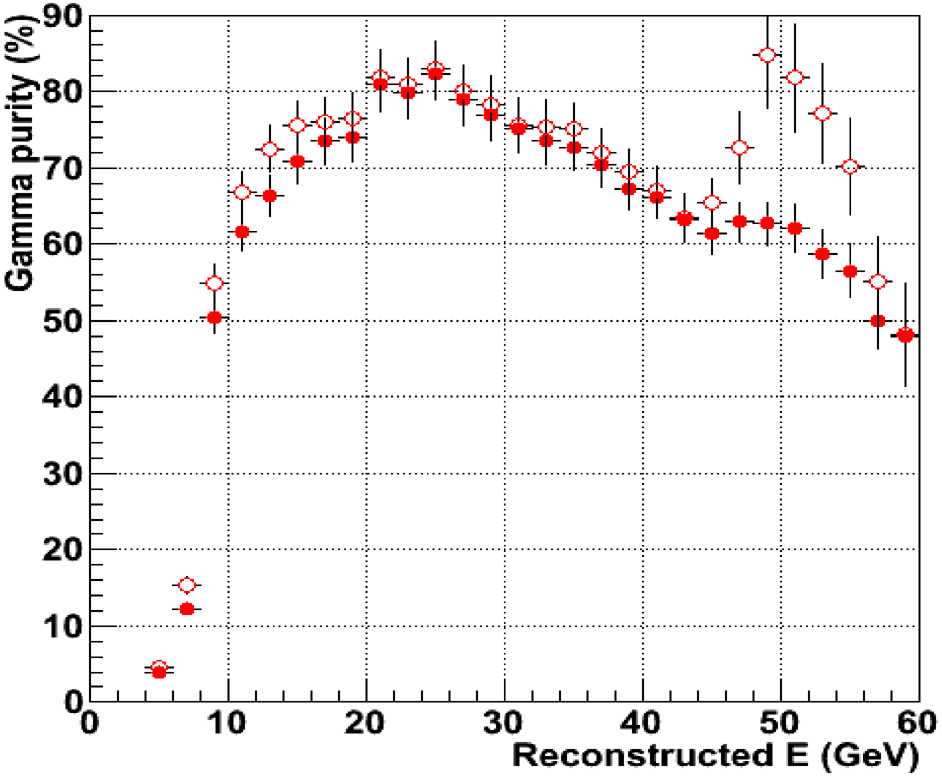
γ merged in Pythia pp

PID criteria: probability >0.5

$$\text{Eff} = \frac{\#\text{ of } \gamma \text{ identified as } \gamma}{\#\text{ of real } \gamma}$$

$$\text{pur} = \frac{\#\text{ of } \gamma \text{ identified as } \gamma}{\#\text{ of part identfied as } \gamma}$$





Open symbol : hadron probability No weighted (E)
Plain symbol: hadron probability Weighted (E)

π^0 merged in Pythia pp

$$\text{Eff} = \frac{\#\text{ of } \pi^0 \text{ identified as } \pi^0}{\#\text{ of real } \pi^0}$$

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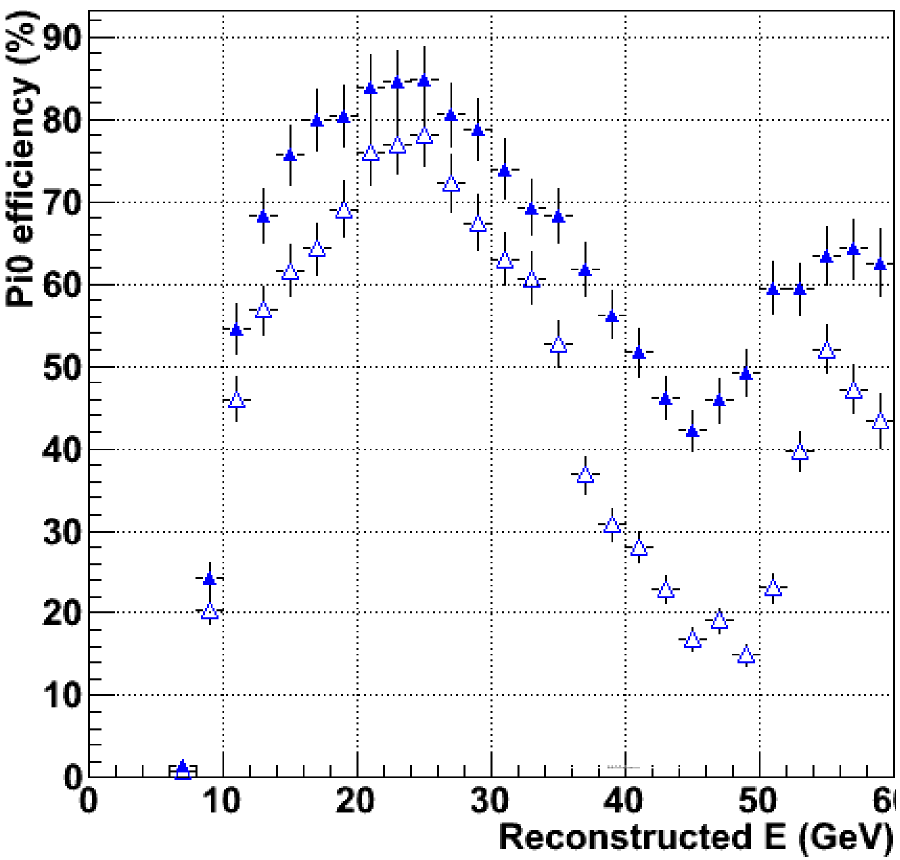
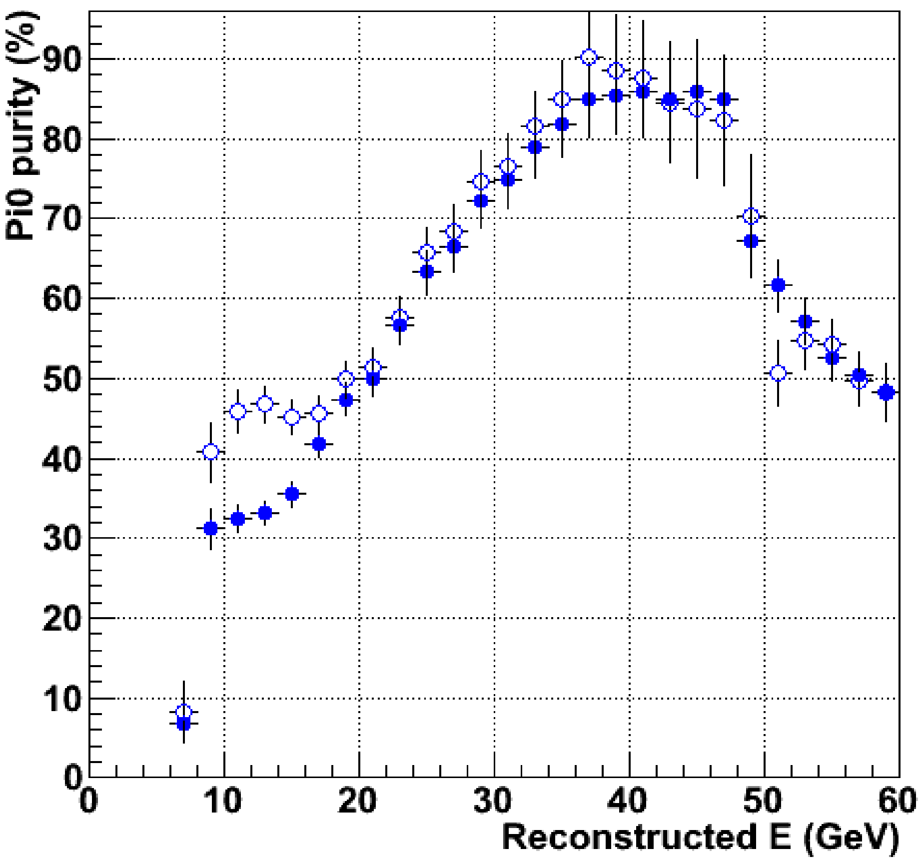




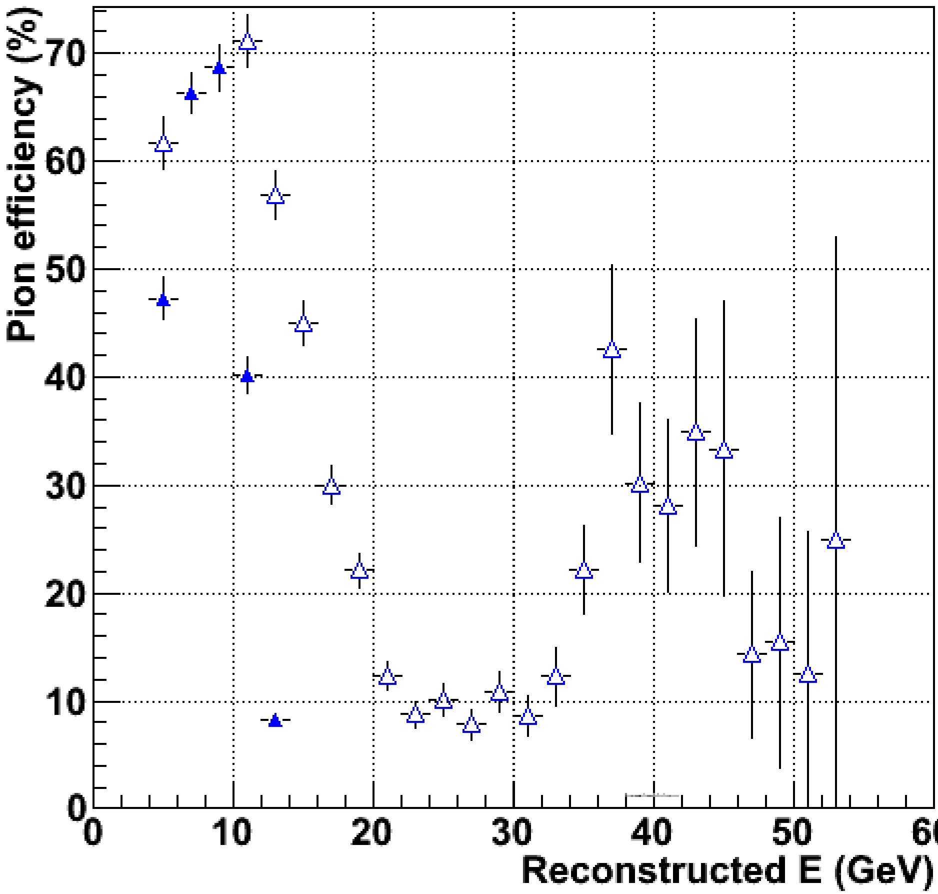
Open symbol : hadron probability No weighted (E)

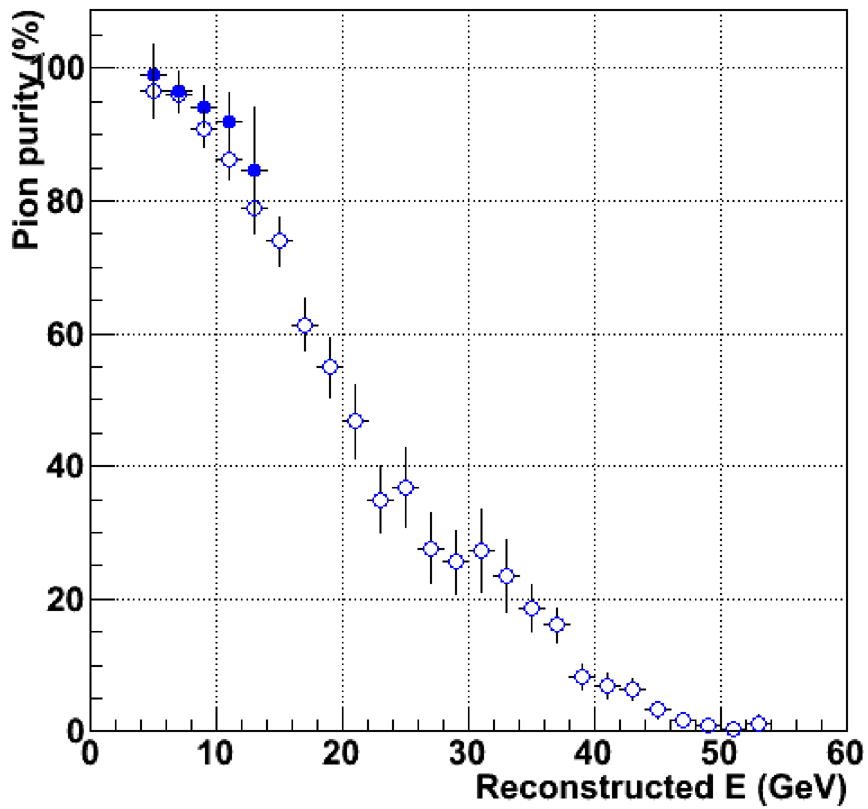
Plain symbol: hadron probability Weighted (E)

charged π merged in Pythia pp

Eff = # of π identified as hadron / # of real π

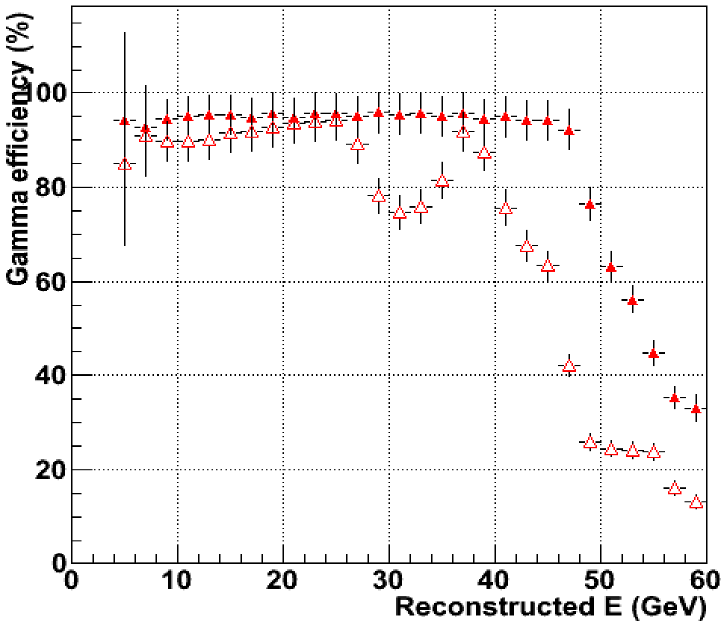
pur = # of π identified as hadron / # of part id hadron





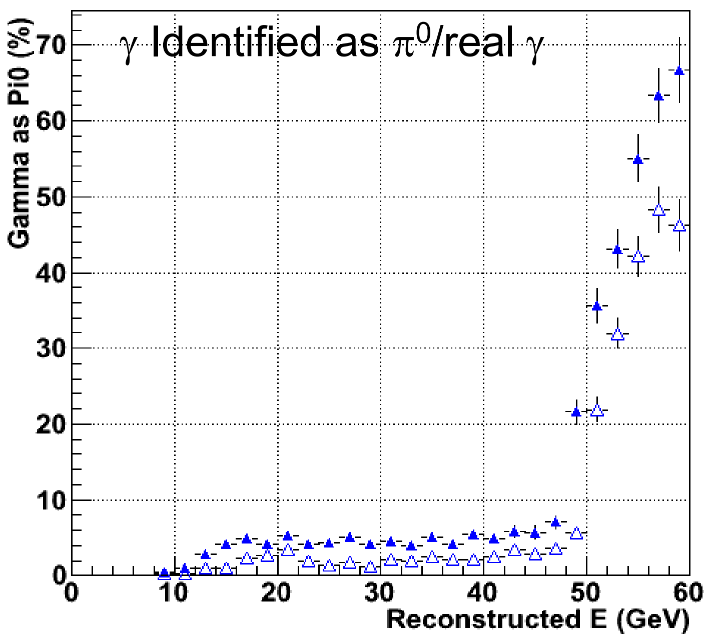
p p LowFlux parametrisation

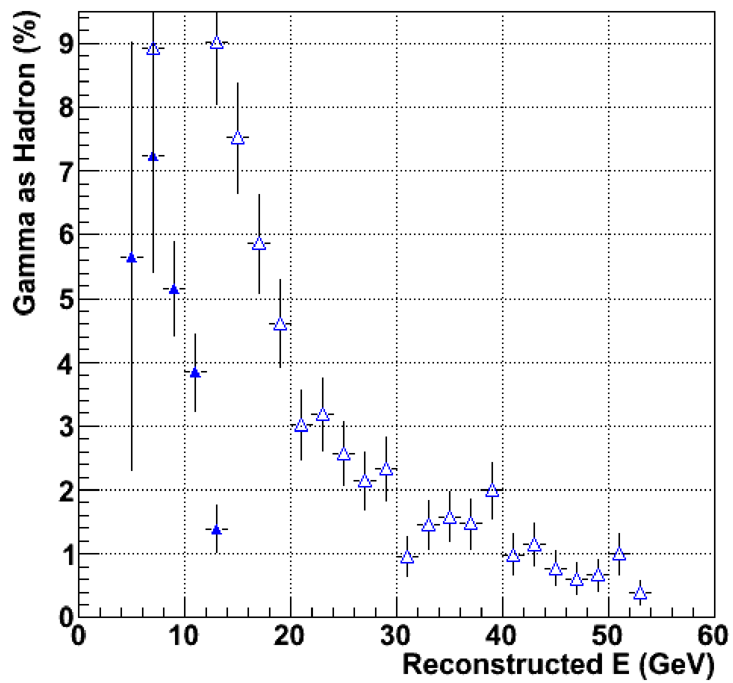
γ Identified as γ/real γ



γ efficiency: different

γ Identified as hadron/real γ

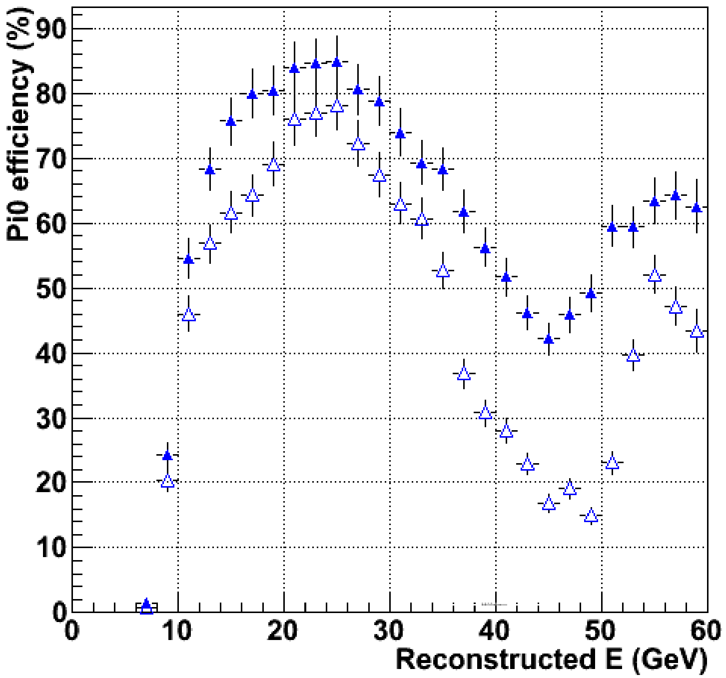


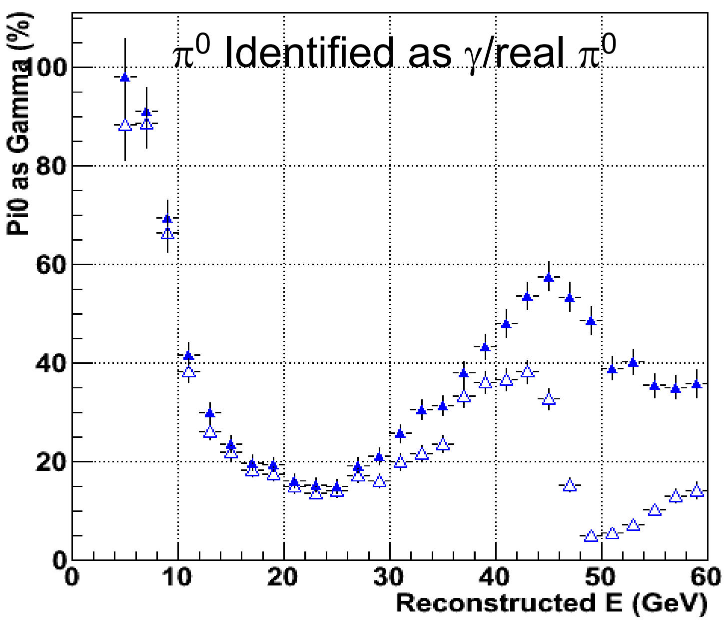


p p LowFlux parametrisation

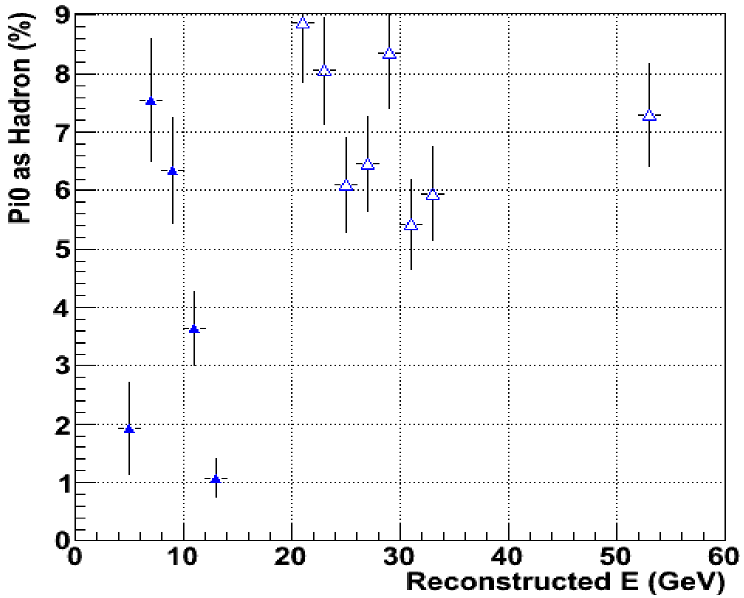
π^0 efficiency: different contributions

π^0 Identified as π^0/real π^0





π^0 Identified as hadron/real π^0



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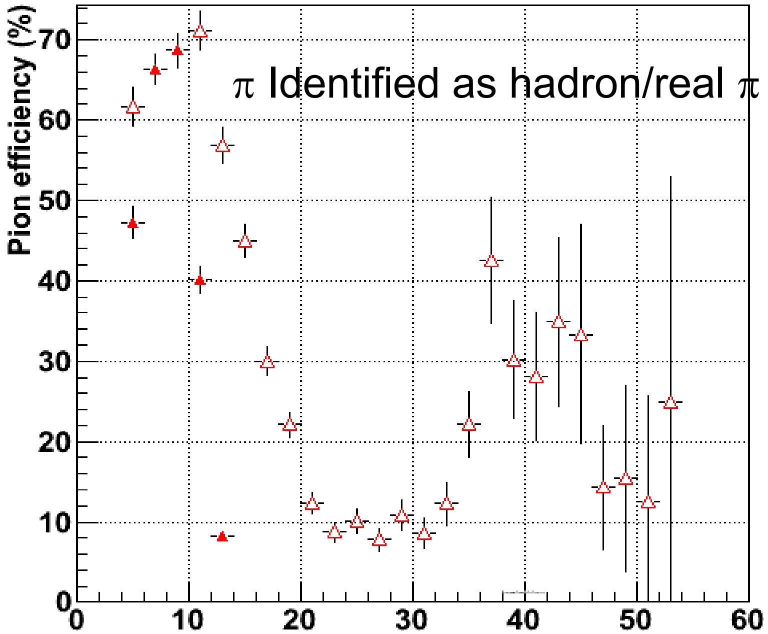
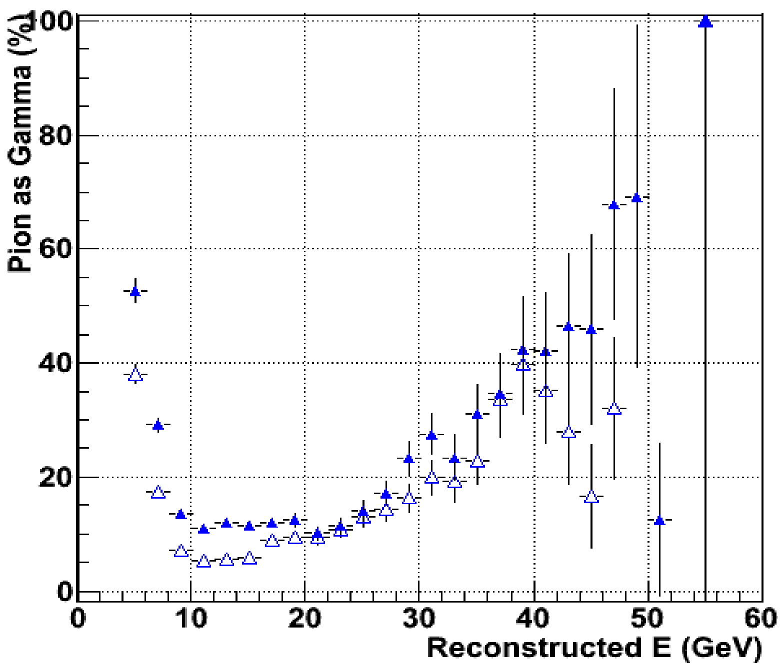
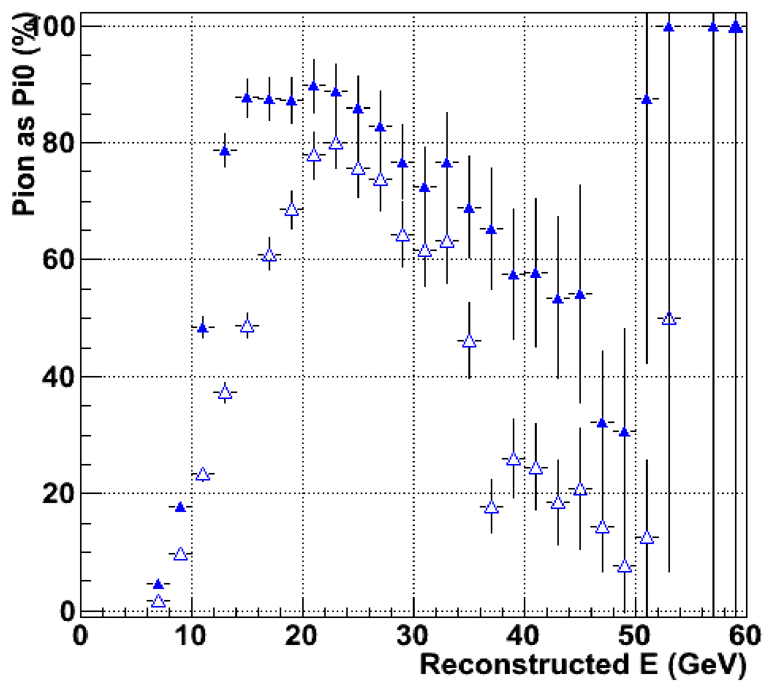


$\pi^{+/-}$ efficiency: different contributions



π Identified as π^0 /real π



γ merged in PbPb@ 5.5 TeV (HIJING central)

PID criteria: probability >0.5

$$\text{Eff} = \frac{\#\text{ of }\gamma\text{ identified as }\gamma}{\#\text{ of real }\gamma}$$

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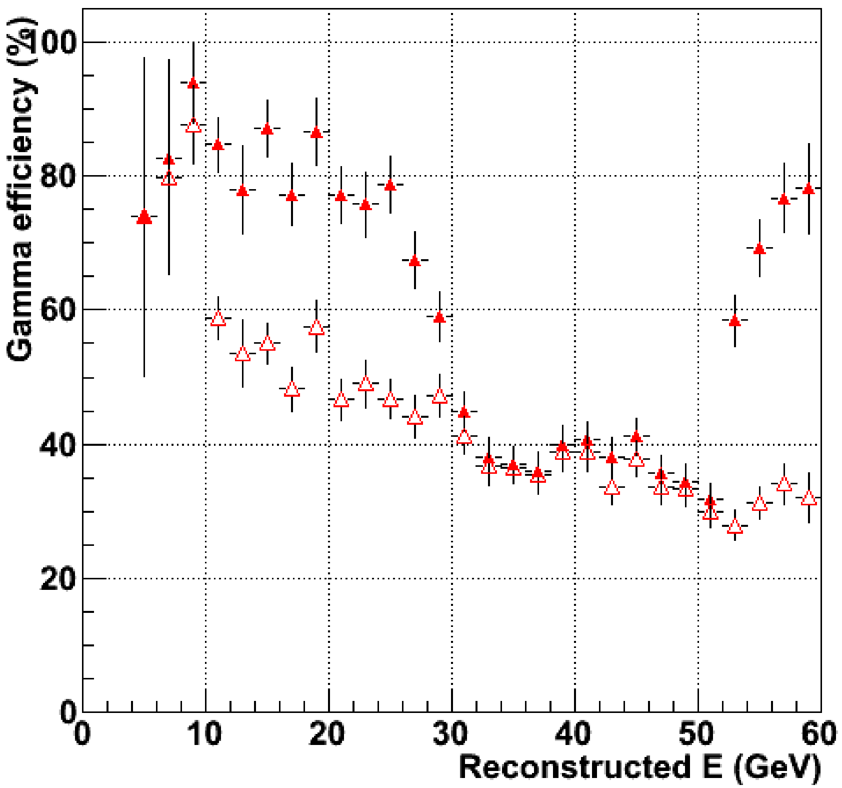

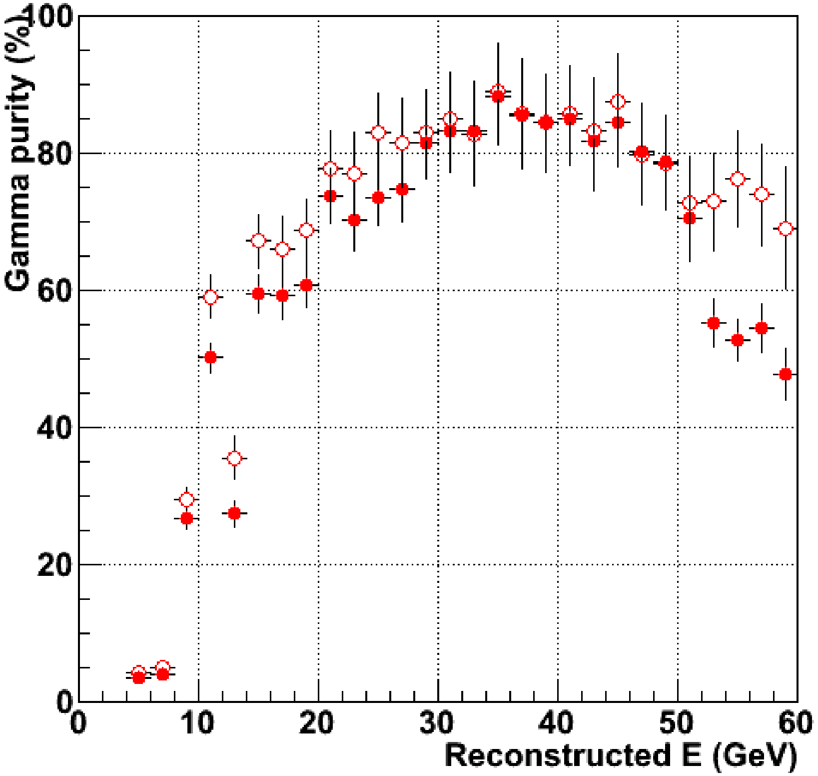

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π^0 merged in PbPb@ 5.5 TeV (HIJING central)

$$\text{Eff} = \frac{\#\text{ of } \pi^0 \text{ identified as } \pi^0}{\#\text{ of real } \pi^0}$$

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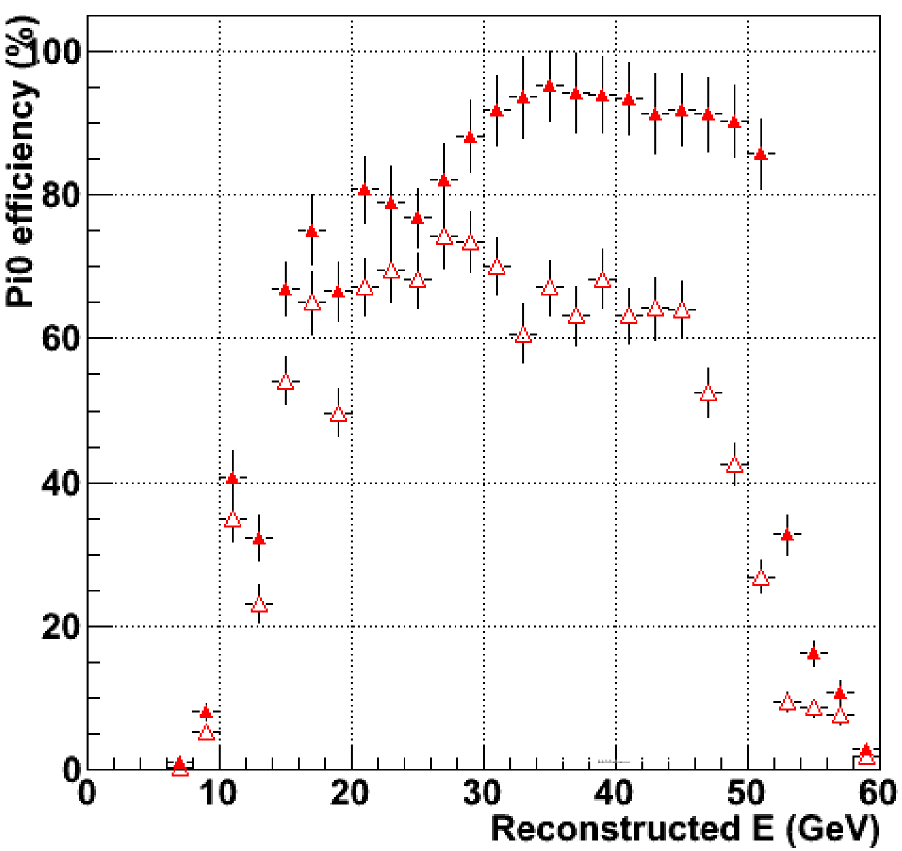

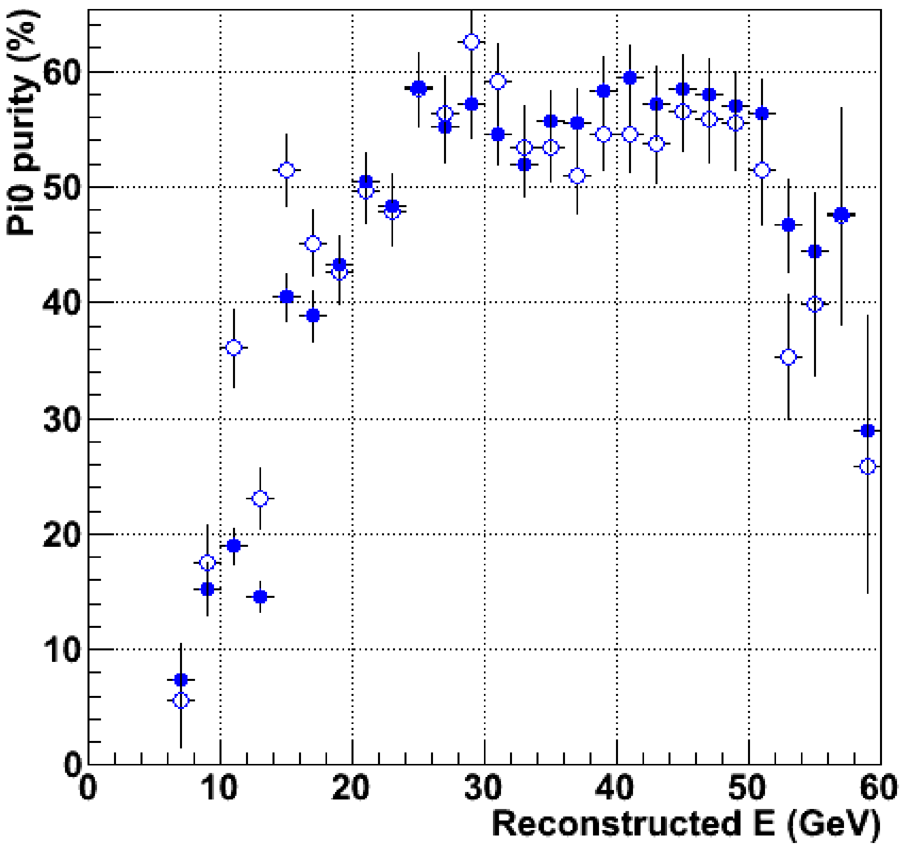

Open symbol : hadron probability No weighted (E)

Plain symbol: hadron probability Weighted (E)

charged π merged in PbPb@ 5.5 TeV (HIJING central)

$$\text{Eff} = \frac{\#\text{ of }\pi\text{ identified as hadron}}{\#\text{ of real }\pi}$$

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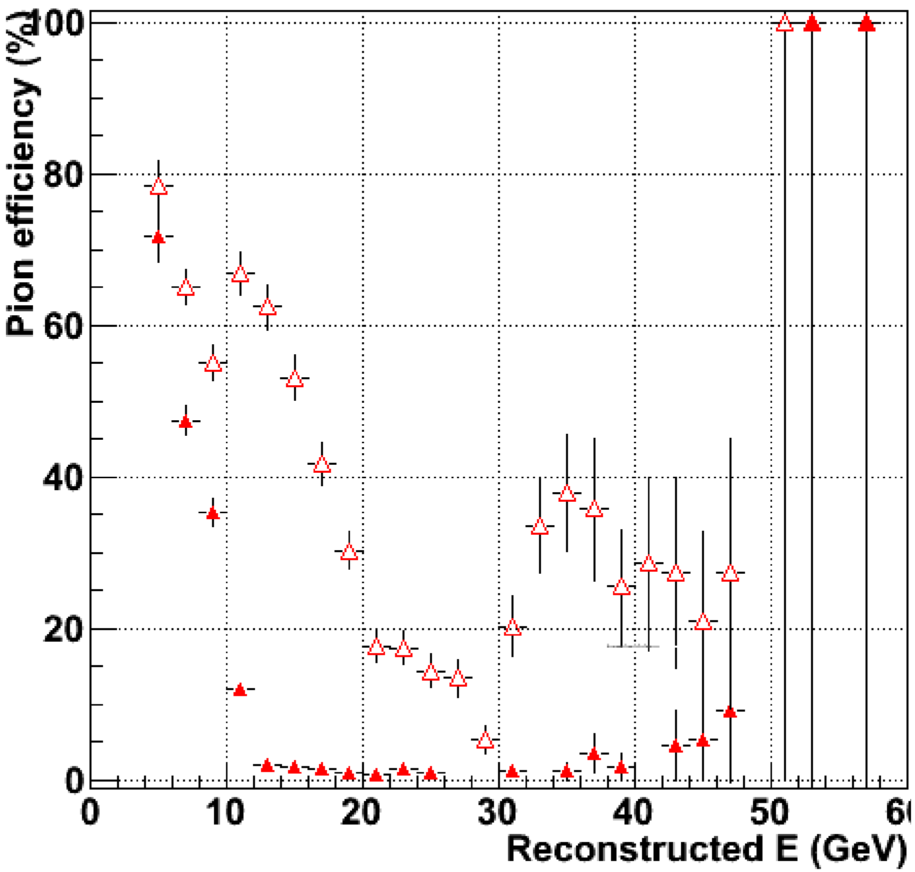
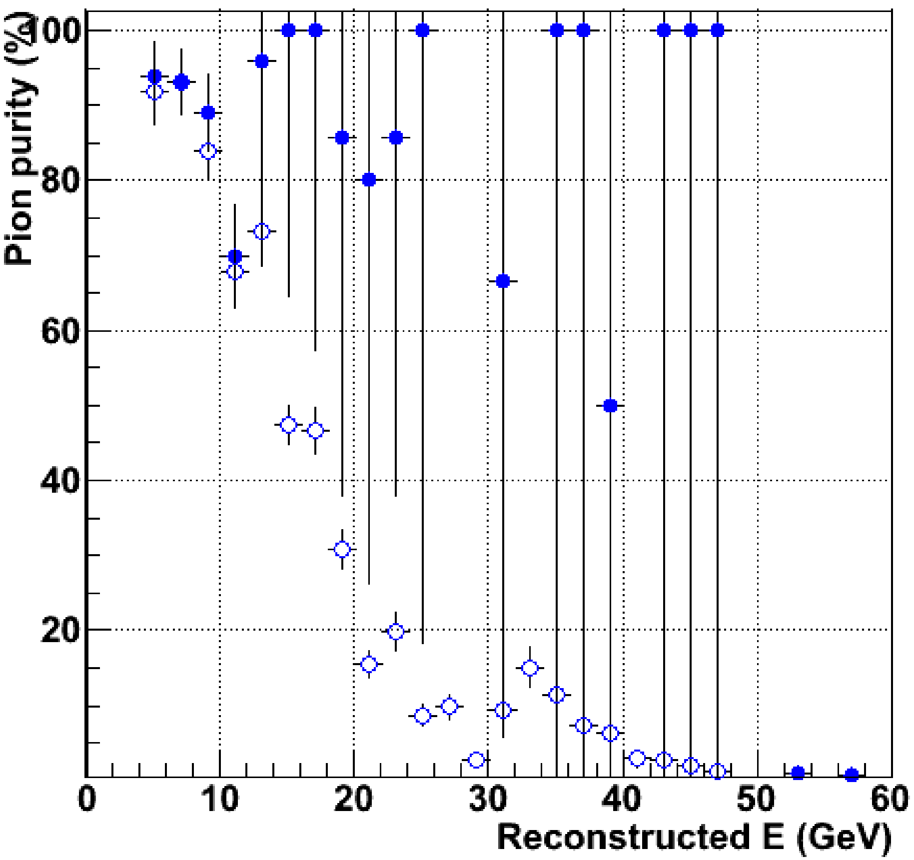
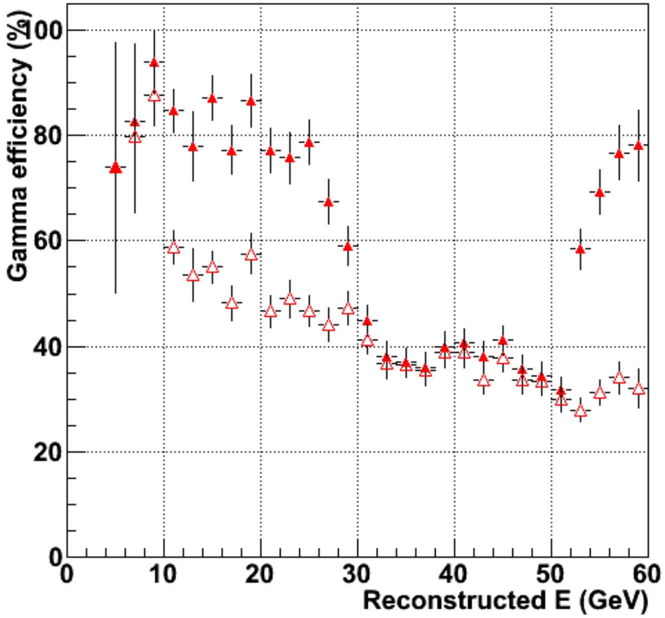


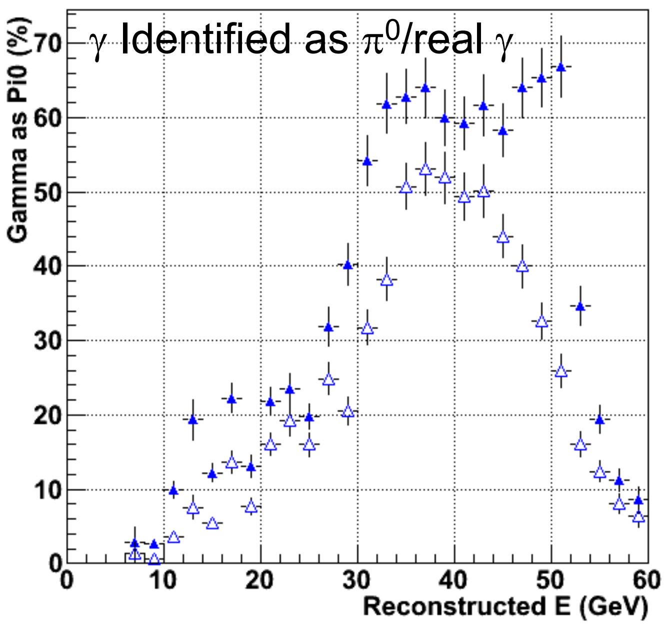


PbPb High Flux parametrisation

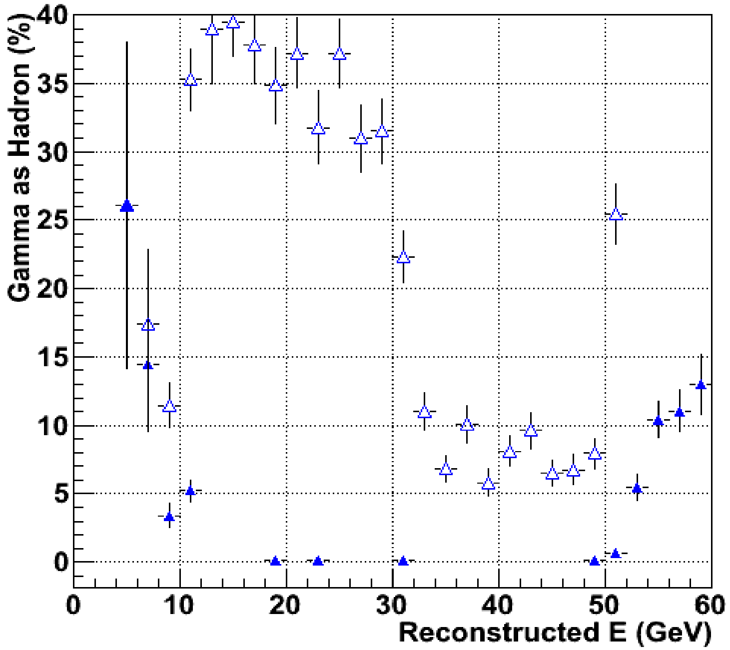
γ Identified as γ/real γ



γ efficiency: different



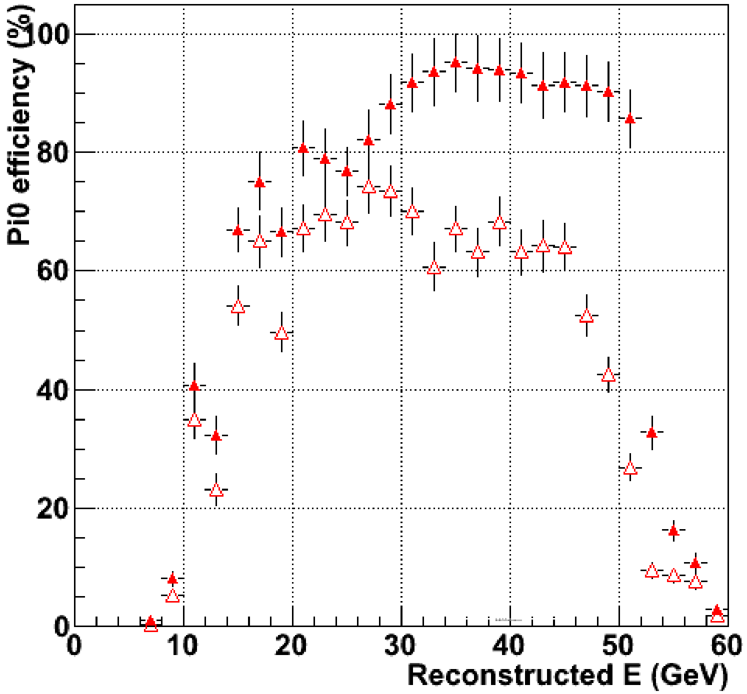
γ Identified as hadron/real γ

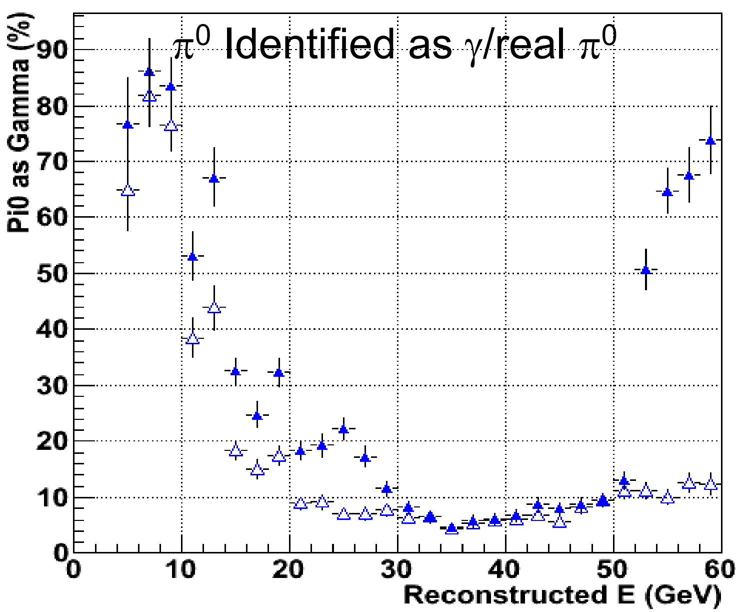


PbPb High Flux parametrisation

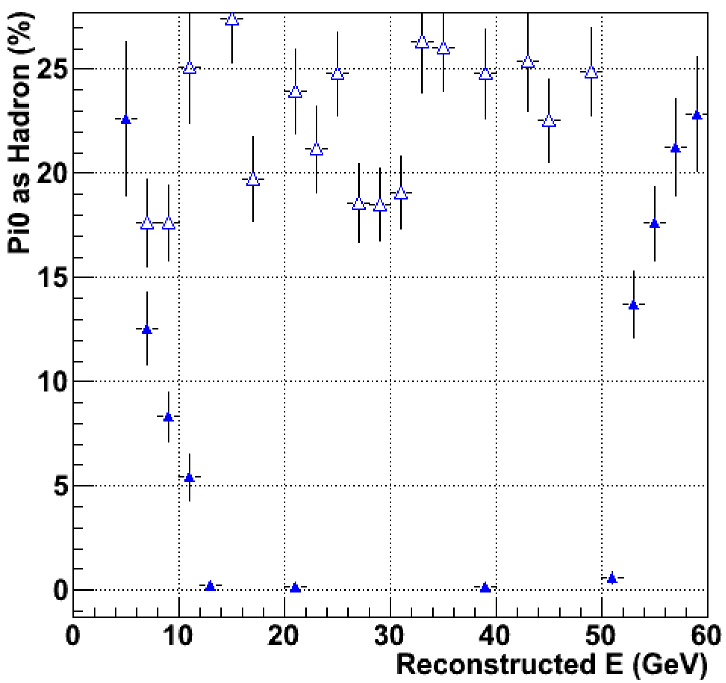
π^0 efficiency: different contributions

π^0 Identified as π^0/real π^0



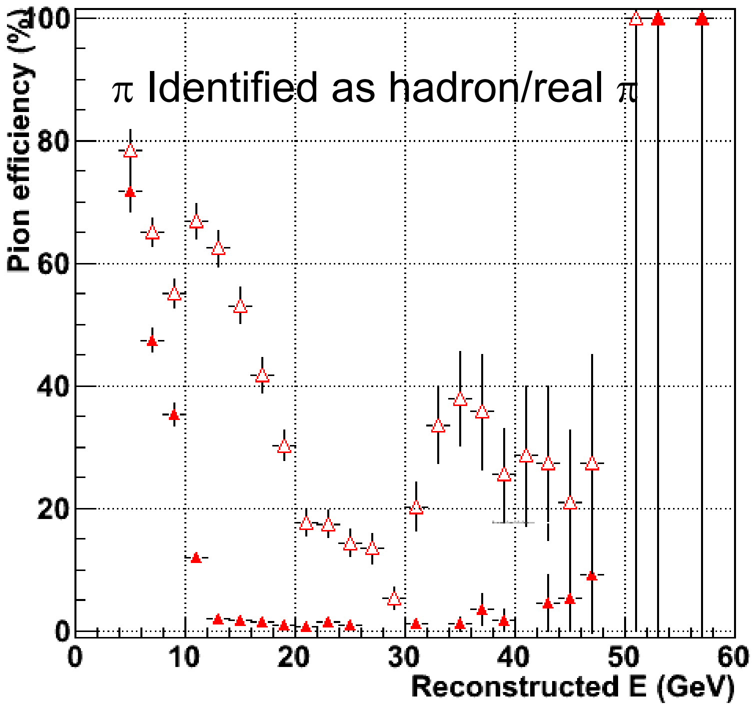


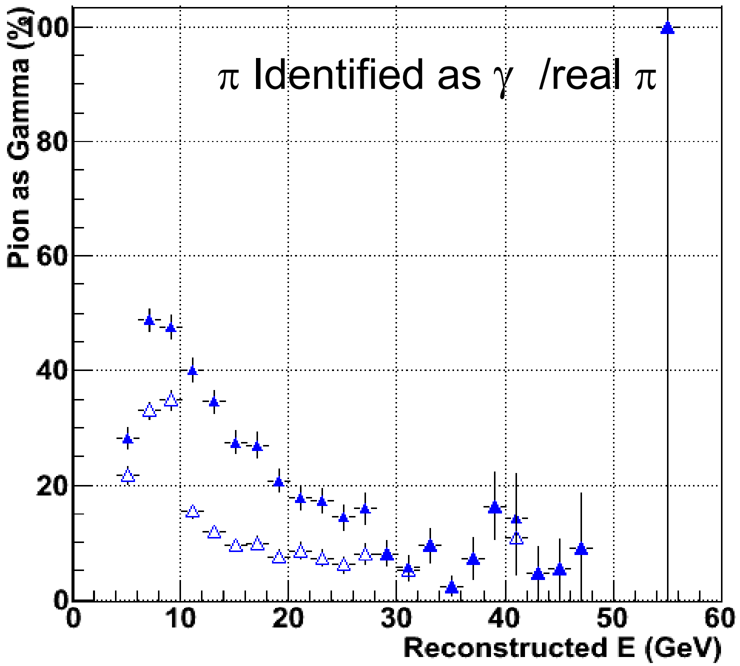
π^0 Identified as hadron/real π^0

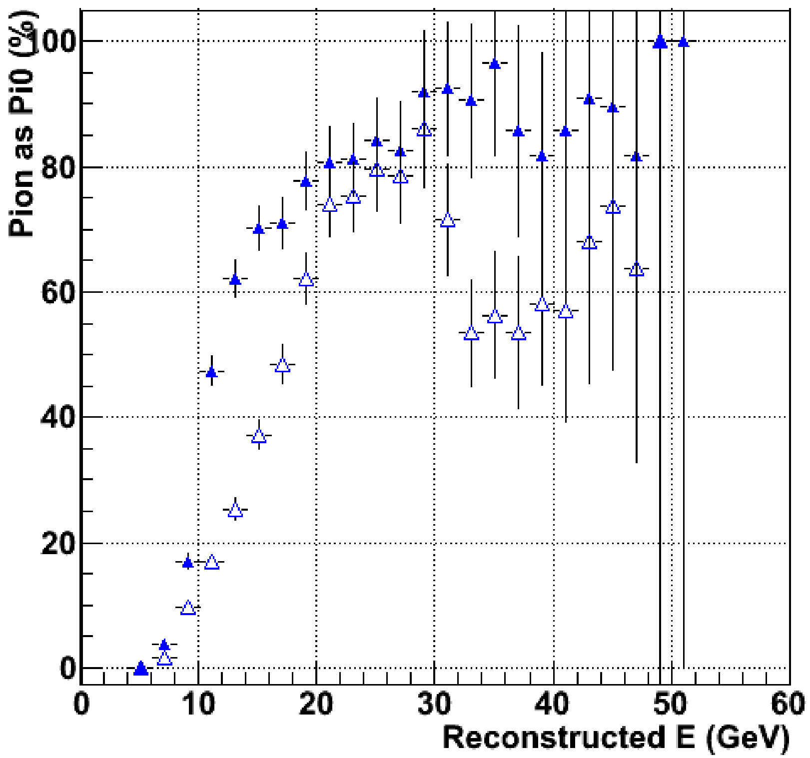


PbPb High Flux parametrisation

$\pi^{+/-}$ efficiency: different contributions







Conclusions

γ π^0 hadron discrimination in low flux with EMCAL shower shape only:

γ identification:

Energy : 5-40 GeV:

PID efficiency >50% very good (hadron probability weight helps)

purity > 60 %

π^0 identification

Energy : 10-40 GeV:

PID efficiency >50%

purity >60%

hadron/ γ discrimination

Up to 10 GeV charged pions discriminated with lower than 10% contamination

γ π^0 hadron discrimination in High flux with EMCAL shower shape only:

Not well tuned for the moment (the hadron energy ponderation was based on simulations with low flux

AliEMCALPID class updated to take into account hadron (and others) energy weight.

Standalone class implementation for running PID after reconstruction: Ready

To do:

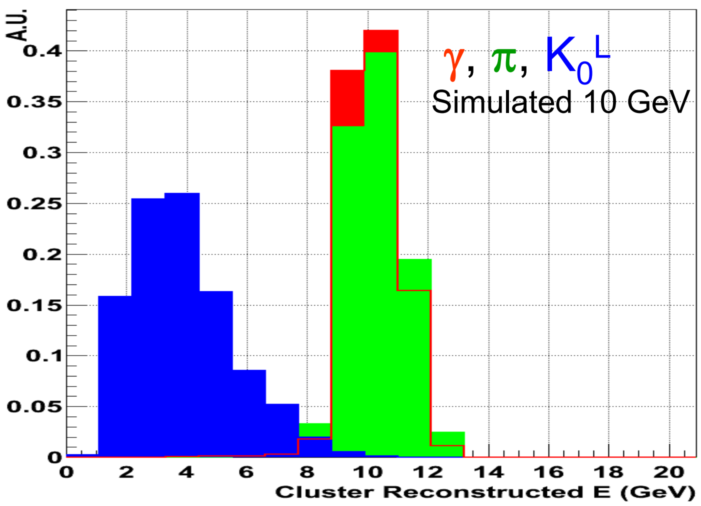
More precise evaluation for Pb Pb

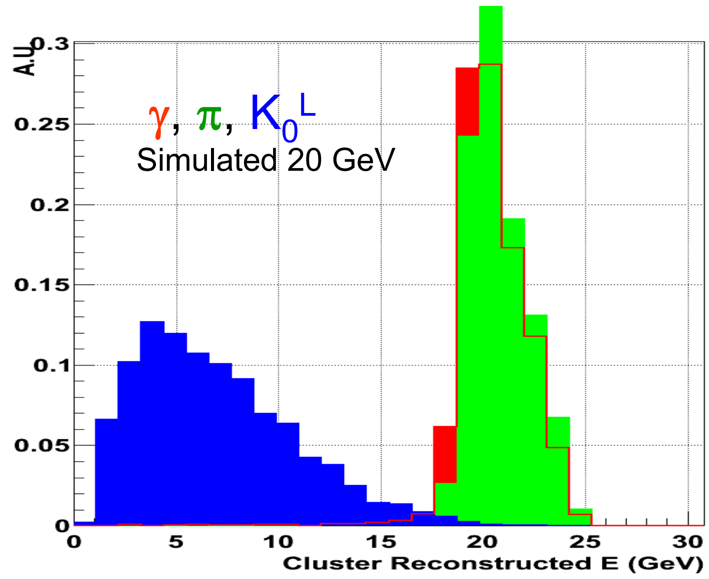
Energy ponderation: for hadrons ÕK for the moment (redo with PbPb param)

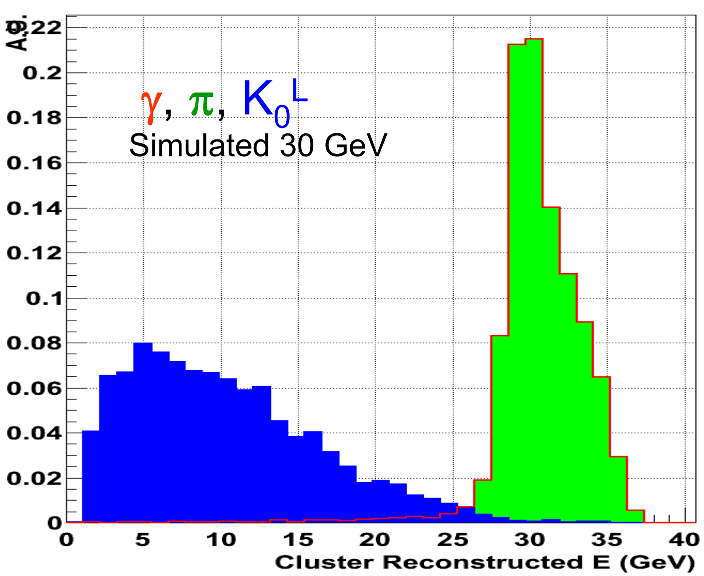
Extend to realistic Xsection ponderation ? for hadron, γ π^0 depends of the realistic spectra

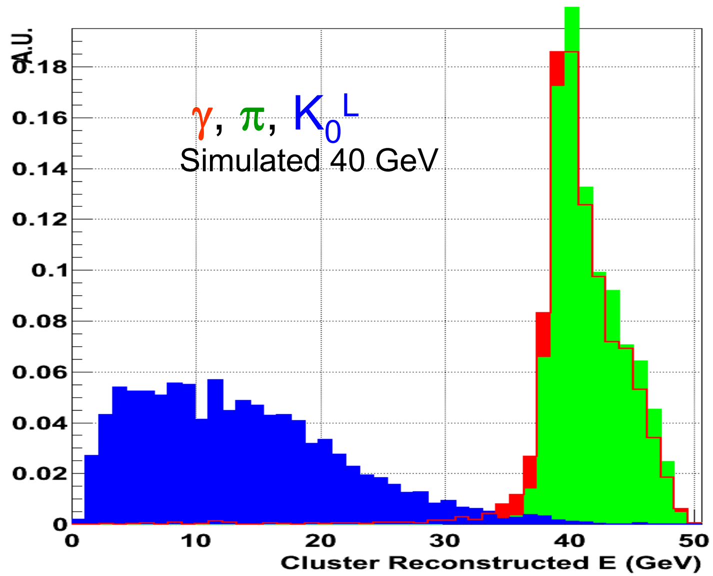
Not sure we have to do it in the showershape PID discrimination.

Reconstructed energy distributions (High flux clusterization parameters)









Reconstructed energy distributions (low flux clusterization parameters)