High p_T π^0 identification in pp collisions at the LHC measured with ALICE EMCal

Haitao Zhang (Central China Normal University & University of Bergen) for the ALICE collaboration

Introduction/Motivation

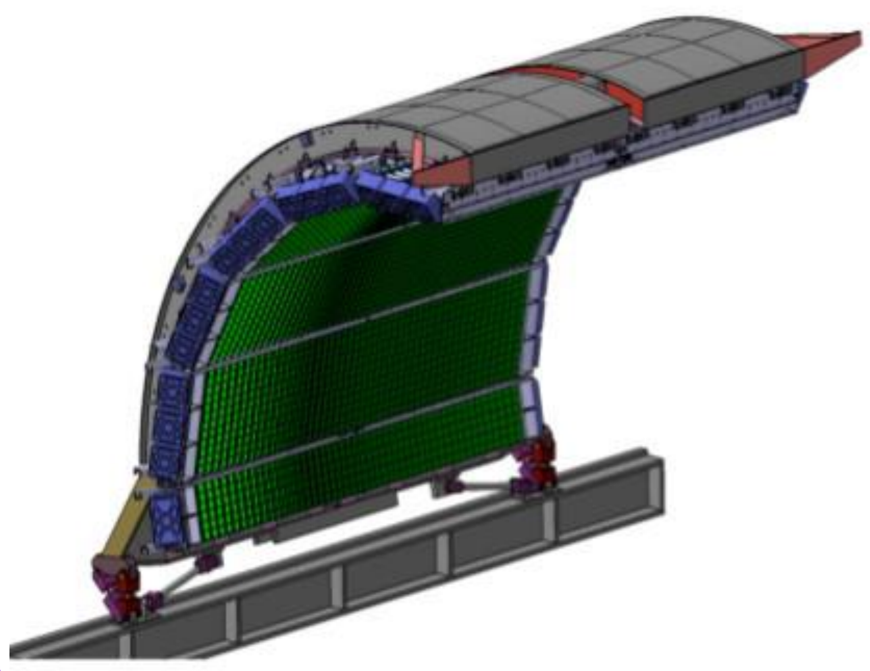
This poster shows the measurement of neutral pion in pp collisions at 2.76 TeV. Much higher energy of the π^0 is reached via merged cluster splitting method with the ALICE Electromagnetic calorimeters(EMCal). Unlike the invariant mass method of two separate clusters, this merged cluster method focuses on high energy π^0, whose decay photon pairs fall into a single large and elongated cluster in EMCal. In order to identify such π^0, several selection criteria are applied including the shower shape of the cluster, the splitting of the cluster into two sub-clusters, and thus the invariant mass of the two sub-clusters and their energy balance.

The measurement of neutral meson spectra in pp collisions at LHC energies is a key measurement to test and constraint perturbative QCD calculations such as gluon fragmentation function, and provide a reference to study the scaling properties of hadron production at LHC energies, such as the nuclear modification factor R_{AA}

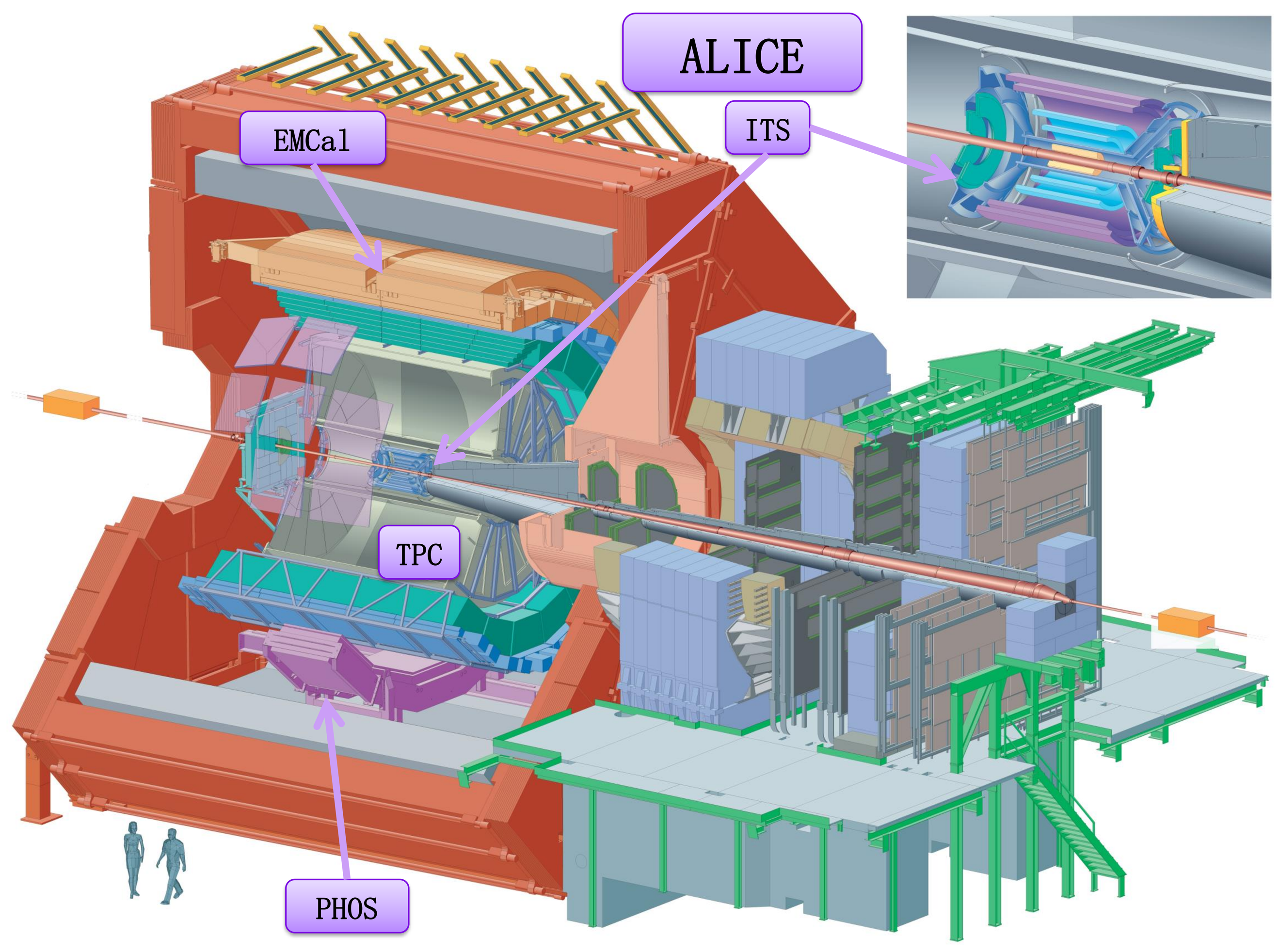
EMCal

ElectroMagnetic Calorimeter

- Active element:
  tower of 77 layers,
  1.4 mm lead +1.7 mm scintillator,
  6×6×25 cm3
- Geometry:
  10 modules, 24×48 towers each;
  distance to IP 450 cm
- Aperture:
  |η|<0.7, 80°<φ<180°

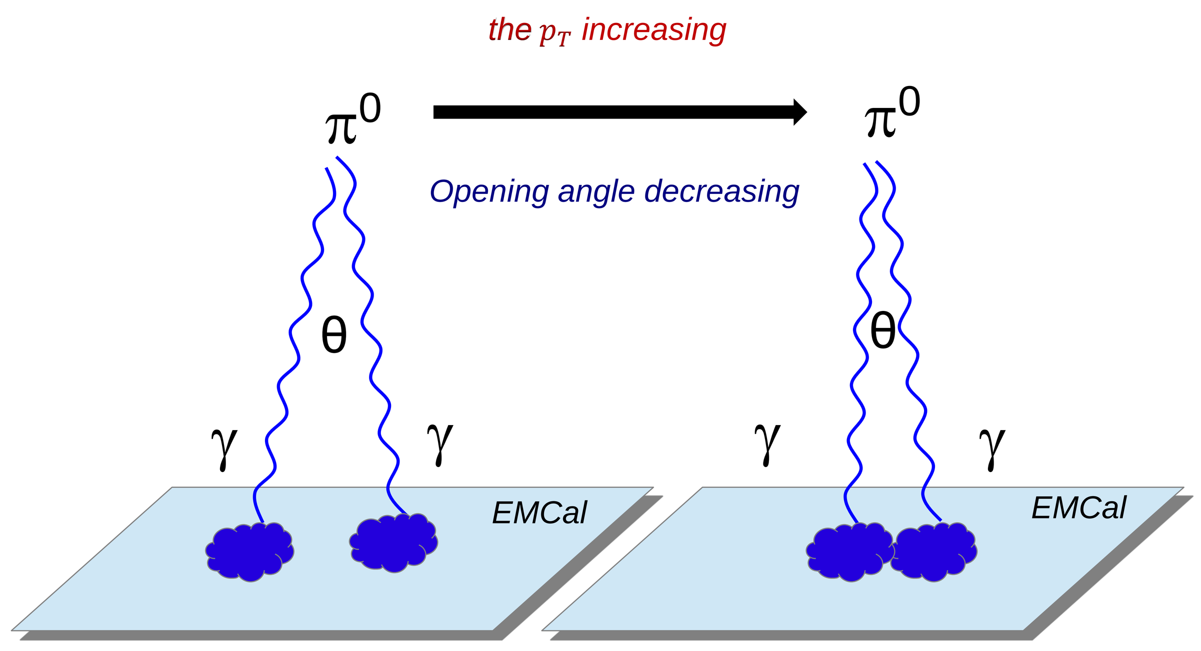


ALICE



π^0 decay kinematics

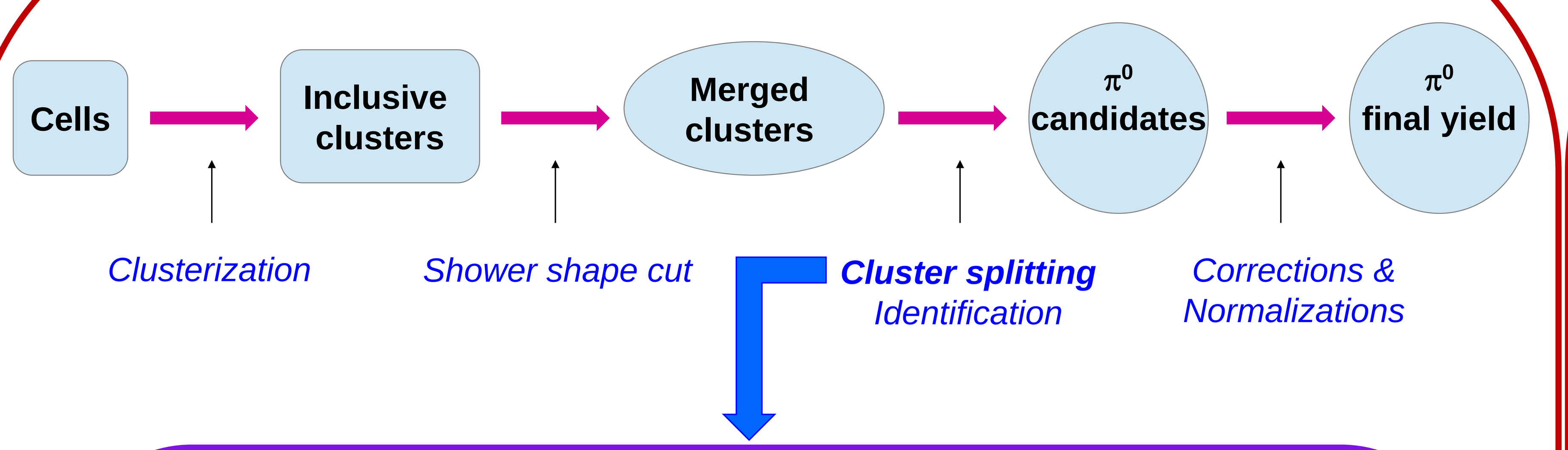
- π^0 decay kinematics shows that the opening angle of the two decay photons gets smaller with increasing π^0 energy due to Lorentz boost
- High energy π^0 whose decay photons overlapped which can be identified by using the cluster shower shape criteria and cluster splitting.

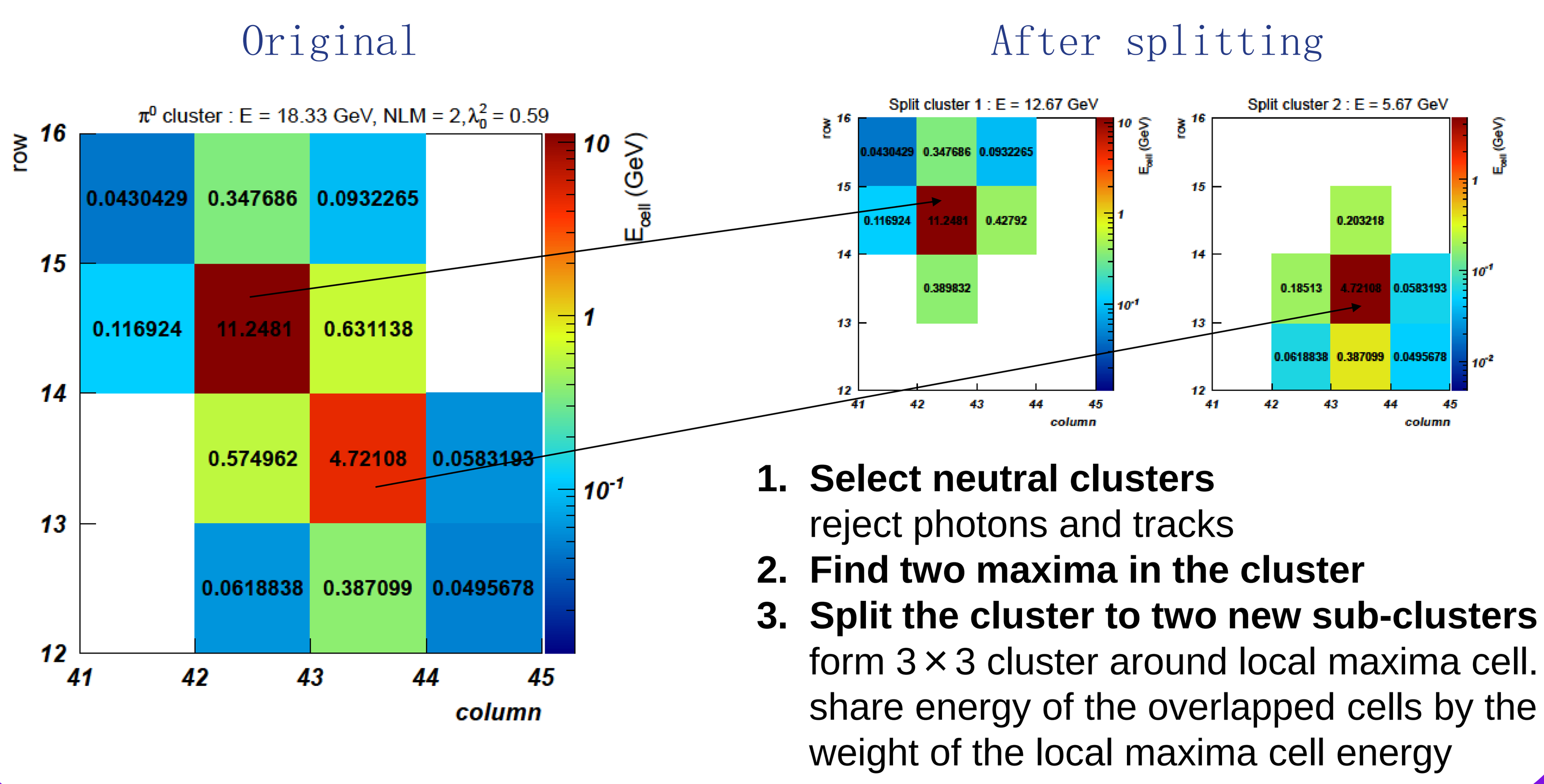


(1) di-cluster analysis: for π^0 p_T < 10 GeV/c

(2) Merged cluster analysis: for π^0 p_T > 10 GeV/c

Analysis Strategy

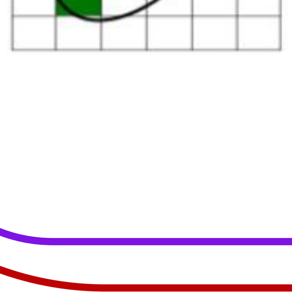




1. **Select neutral clusters**
   reject photons and tracks
2. **Find two maxima in the cluster**
3. **Split the cluster to two new sub-clusters**
   form 3×3 cluster around local maxima cell.
   share energy of the overlapped cells by the weight of the local maxima cell energy

Cluster shower shape ellipse axis definition

The shower shape of a cluster can be described using an ellipsoidal parametrization by the axis of the shower surface ellipse. This surface can be represented by a covariance matrix with 4 terms representing the average cluster position in Φ and η direction in calorimeter plane, and weighted logarithmically by the cell energy.
The diagonalization of the covariance matrix gives the shower surface ellipse axis λ_0 (long axis) and λ_1 (short axis). The calculation of such parameters is the following equations:



$$\lambda_0^2 = 0.5(\delta_{\phi\phi} + \delta_{\eta\eta}) + \sqrt{0.25(\delta_{\phi\phi} - \delta_{\eta\eta})^2 + \delta_{\eta\phi}^2},$$

$$\lambda_1^2 = 0.5(\delta_{\phi\phi} + \delta_{\eta\eta}) - \sqrt{0.25(\delta_{\phi\phi} - \delta_{\eta\eta})^2 + \delta_{\eta\phi}^2},$$

where $\delta_{\phi\phi}$, $\delta_{\eta\eta}$ and $\delta_{\phi\eta}$ are weighted coefficients by the cell energy:

$$\delta_{\alpha\beta} = \sum_i \frac{w_i \alpha_i \beta_i}{w_{tot}} - \sum_i \frac{w_i \alpha_i}{w_{tot}} \sum_i \frac{w_i \beta_i}{w_{tot}},$$

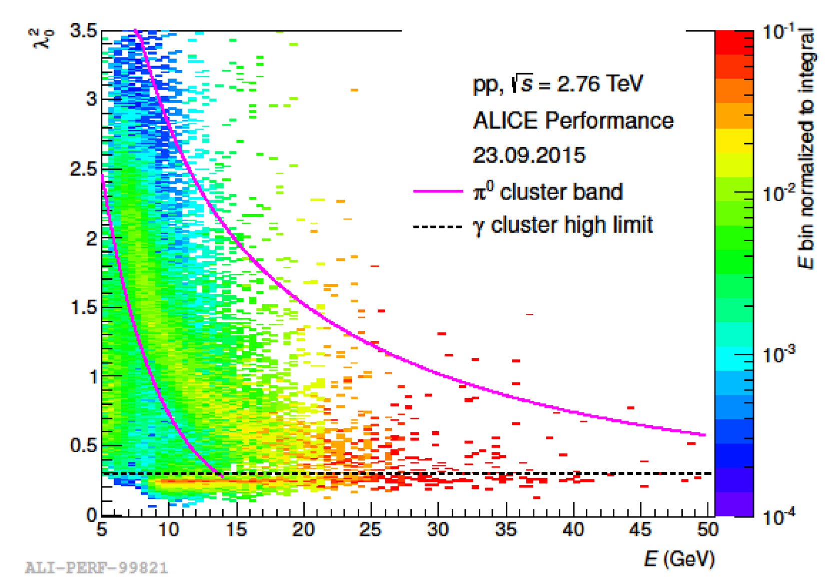
$$w_i = TMath::Max(0, w_0 + \ln(\frac{E_i}{E_{cluster}})),$$

$$w_{tot} = \sum_i w_i,$$

π^0 identification

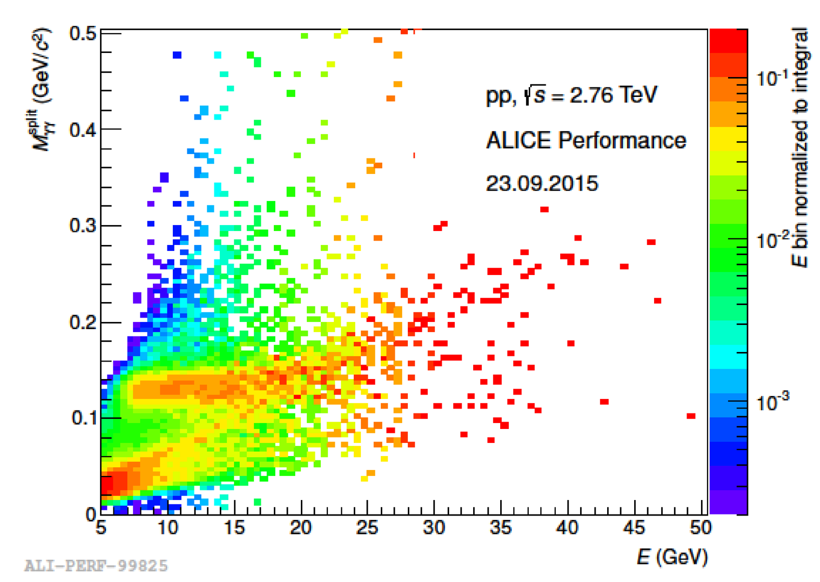
• *Shower shape of the merged clusters*

Clusters produced by one or two photons can be distinguished cutting on the main axis of the shower shape ellipse.
The shower shape cut for selecting neutral clusters as the π^0 candidates is a band in the λ_0^2 vs energy two dimensions distribution.



• *Invariant mass of the merged clusters*

Using the cluster splitting, two split sub-clusters can be formed, then the invariant mass of the pair can be calculated.
In the Mass vs E plot we can clearly see a region populated in the expected π^0 mass value, which helps π^0 identification.



Conclusions

- The Invariant mass method is limited by the photon overlapping. Merged cluster splitting method can identify high energy π^0.
- By using the cluster splitting, the π^0 identification can provide a measurement with the possible energy reach up to 50 GeV/c.

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