Simulation and design studies of ALICE Forward Calorimeter

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Introduction

ALICE experiment at CERN is devoted to study strongly interacting matter and quark gluon plasma. Results from HERA and recently from RHIC experiment shows the potential in exploring small-x physics such as parton distributions at small-x, initial state effects like gluon saturation, color glass condensate, final state effects like parton energy loss in highly dense medium through gamma-jet or jet-particle correlation study. A new forward electromagnetic calorimeter is being considered as an upgrade of the ALICE experiment at CERN-LHC. The calorimeter will be able to extend the small-x physics capabilities to a large extent.

We had studied different possible configuration for the calorimeter. As one of the possibility, we had studied a multilayer sampling type calorimeter in which there are three high granular ($1mm^2$ si-pixel detectors) layers along with 18 course ($1cm^2$ si-pad detector) layers.

In high-energy physics experiments, calorimetric data reconstruction requires very good energy and position resolution along with a suitable clustering technique especially in ALICE like high multiplicity density environment. In this abstract we will discuss the capability of the calorimeter in reconstructing the pi0 mass for different energies along with its efficiency of finding closely spaced clusters.

Data reconstruction:

We had done our simulation using GEANT4 geometry and tracking toolkit for single gamma, electron and neutral pions of different energies. For the reconstruction of clusters (produced from electromagnetic showers of electron and photons at consecutive layers) we had used Fuzzy clustering technique along with its modified version. It has been found that two overlapping clusters with their centers separated by 3mm (which is the case for separation b/w two photon clusters coming from decay of pi0 of energy about 200GeV and above) can be reconstructed safely. For the sake of simplicity we had used only three high granular layers of the calorimeter in reconstructing the data. Proper calibration of the deposited energy with the incident energy was taken care of.

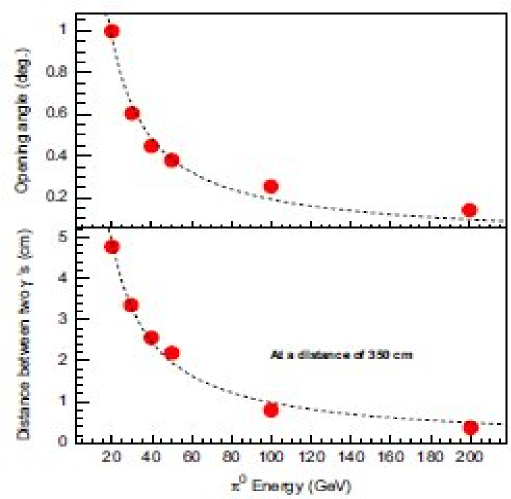

Fig. 1 Reconstruction opening angle (top panel) and two photon separation (bottom panel) *vs.* incident pi0 energy at a distance of 350cm away from interaction point.

Results:

Reconstruction of neutral pions, pi0-gamma separation, electron-gamma discrimination etc are few of the major aim of the calorimeter in terms of data analysis. The distance between two decayed photons decreases with the increase in energy of pi0. The opening angle and the distance b/w two decayed photons (Fig-1) had been calculated at a distance of about 350 cm away from the interaction point using data from the high granular layers only.

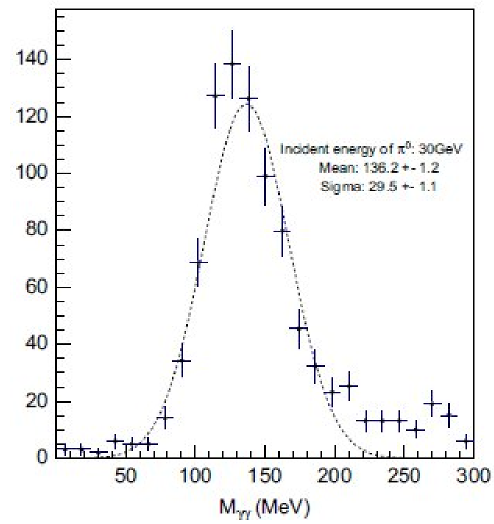

Fig. 2 Reconstruction of Invariant Mass of pi0 of energy 30GeV.

The reconstruction of photon showers needs to be accurate in order to calculate the tracks and deposited energy of photons or electrons properly. Using FCM clustering technique, cluster positions, tracks and deposited energy had been found which was used to reconstruct invariant mass (Fig-2 shows such a result for 30 GeV pi0 reconstruction) for pi0. Fig-3 shows reconstructed invariant mass vs. incident energy for pi0 with different energies. The granularity of the detector and the limitations of the clustering algorithm restrict the reconstruction of pi0. With the present configuration the algorithm can work fine up to 100GeV pi0 energy. Beyond that it starts deviating.

Apart from pi0 reconstruction, the efficiency of the algorithm in finding closely spaced (overlapping) clusters had been studied. With a known set of 1000 events of eight clusters, the efficiency of the algorithm with the present granularity was found to be about 80% in finding 8 (+-1) clusters.

Details of characterization of the calorimeter and reconstruction of the simulated data with the FCM algorithm are intended to be presented.

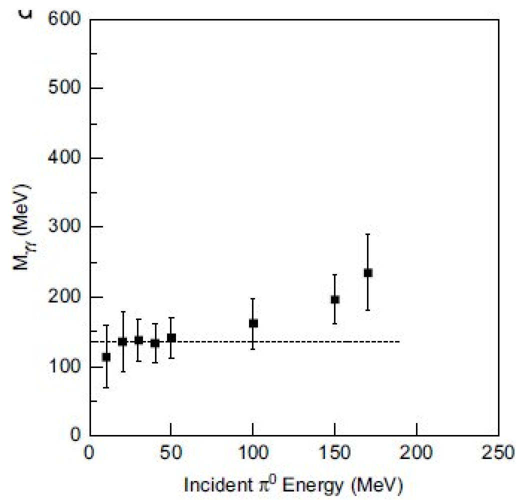

Fig. 3 Invariant Mass of pi0 Vs. Incident energy of pi0.

References:

[1] Radha P. Sandhir, Sanjib Muhuri and Tapan Nayak, Nuclear Instrument and Methods in physics Research A 681 (2012) 34-43.

[2] STAR Collaboration, Forward Neutral Pion Production in p+p and d+Au Collisions at $\sqrt{s_{NN}}$=200GeV: Phys. Rev. Lett. 97, 152302 (2006) [6 pages].

[3] S. Muhuri, Feasibility study of a forward calorimeter in the ALICE Experiment at CERN: proceedings of DAE Symposium on Nuclear Physics, Vol-55.

[4] Gerardus Nooren, Taku Gunji, Sanjib Muhuri, Martijn Reicher, A Forward Calorimeter (FoCal) as upgrade for the ALICE Experiment at CERN; Contribution ID-421; QM2010.

[5] Susanta Kumar Pal, Nuclear Instrument and Methods in physics Research A 626 (2011) 105.

[6] Sanjib Muhuri, and Tapan K. Nayak, Physics and Design Studies for a Silicon-Tungsten Calorimeter for the ALICE experiment at CERN: Proceedings of the DAE Symp. on Nucl. 56 (2011).