Particle Flow Algorithm verification with test beam data

Abstract

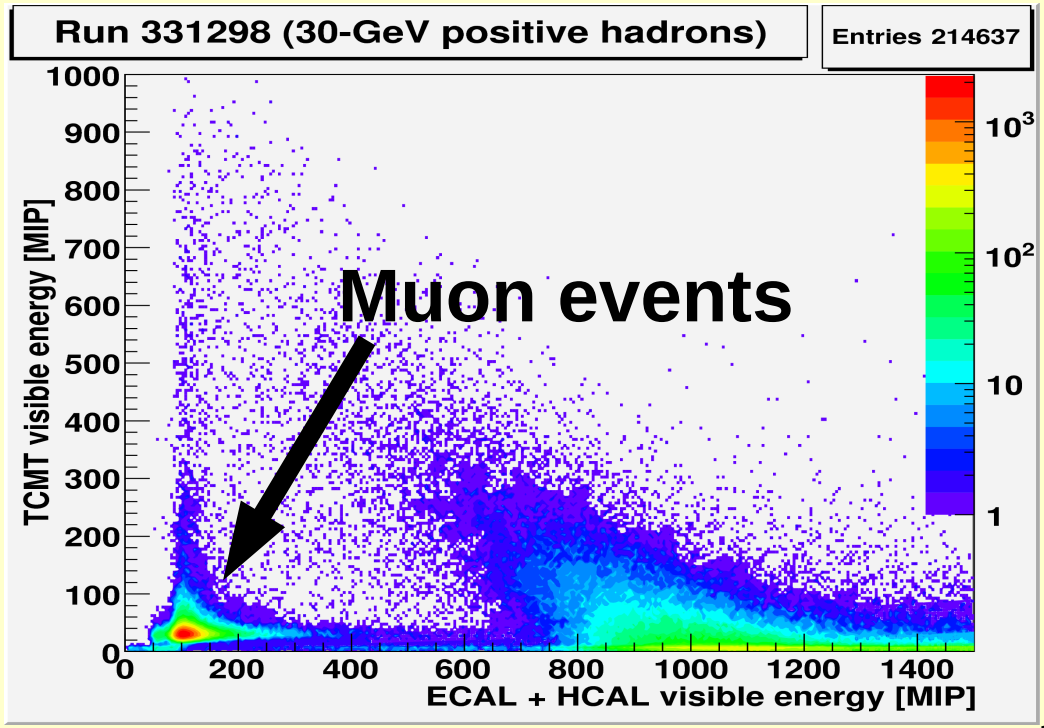
CALICE 2007 test beam data were used to test the Pandora PFA program.
The program capability to recover neutral hadron energy in the vicinity of charged hadron was studied. The impact of hadron showers overlapping on energy resolution was investigated. The overlapping of showers leads to marginal confusion in energies reconstruction. The dependence of this confusion error vs. the distance between charged and neutral hadrons was derived. Reconstruction efficiency was calculated for hadron's energy typical for 100 GeV jet. The comparison of this beam data results with Monte Carlo simulation was done for LHEP and QGSP_BERT physics lists for 10 and 30 GeV charged jet fragments.
The confusion error averaged over possible 100 GeV jet fragments energy has been estimated.

Oleg Markin and ITEP group for CALICE

Events from several runs (from 10 GeV to 30 GeV) has been especially selected

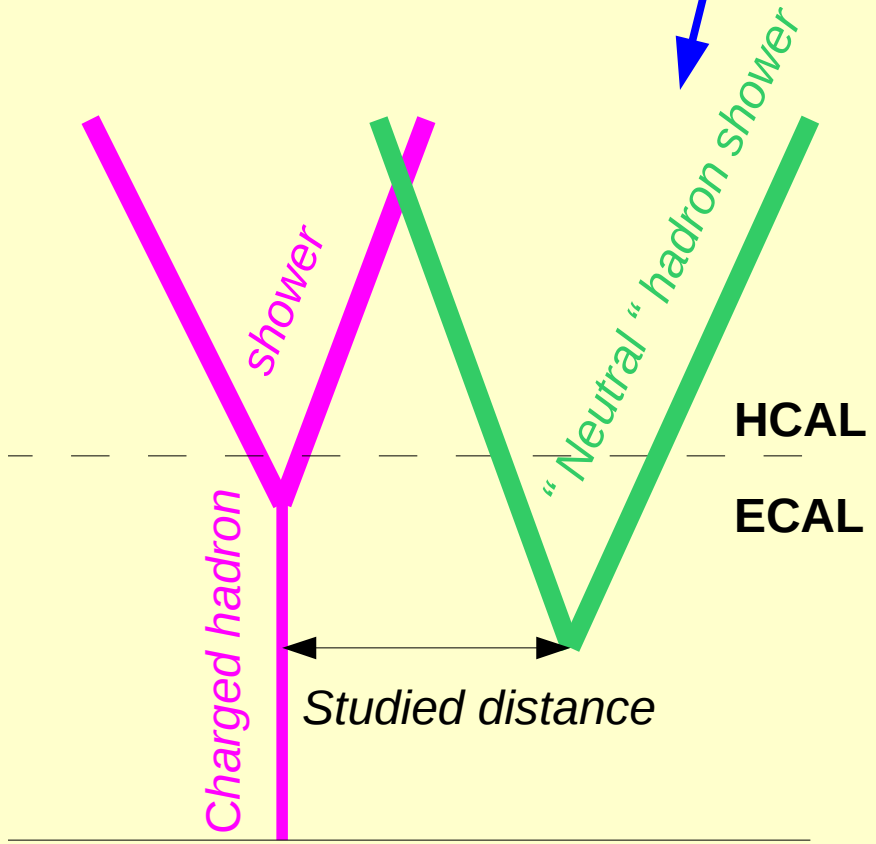
1. pions were separated from other hadrons by Cherencov trigger
2. electron admixture was rejected on the grounds of hits majority in ECAL
3. muon events were separated using the correlation for energy deposited in different units of the detector prototype
4. the garbage has been excluded as follows

- deposited energy >1.5 of beam energy
- deposited energy <0.5 of beam energy
- two or more tracks are found in ECAL
- no hits in ECAL (by pass)



For one of two events from different runs we move all hits at studying distance from their original position, keeping only hits placed behind the shower start. This event imitates the neutral hadron shower.

- We used showers which develop mostly in ECAL and HCAL.
- Beam smearing and ECAL to HCAL alignment have been corrected
- The distance was varied from 5 cm to 30 cm.
- We mapped both event hits to LDC and then made LCIO file for Pandora.



Mapping the CALICE prototype events to LDC leads to slight distortion for the shower shape.

ECAL

- 29 LDC layers instead of 30 prototype layers lead to the few hits loss
- Different absorber thickness layout in the prototype and LDC leads to the ECAL shower longitudinal profile distortion

HCAL

- Local shift for hit positions on the border of 3 X 3 cm and 6 x 6 cm cells is compensated on average from event to event because of beam smearing
- 30 mm step between layers turns to 26 mm step in LDC means that the shower is little bit shorter but wider then in reality

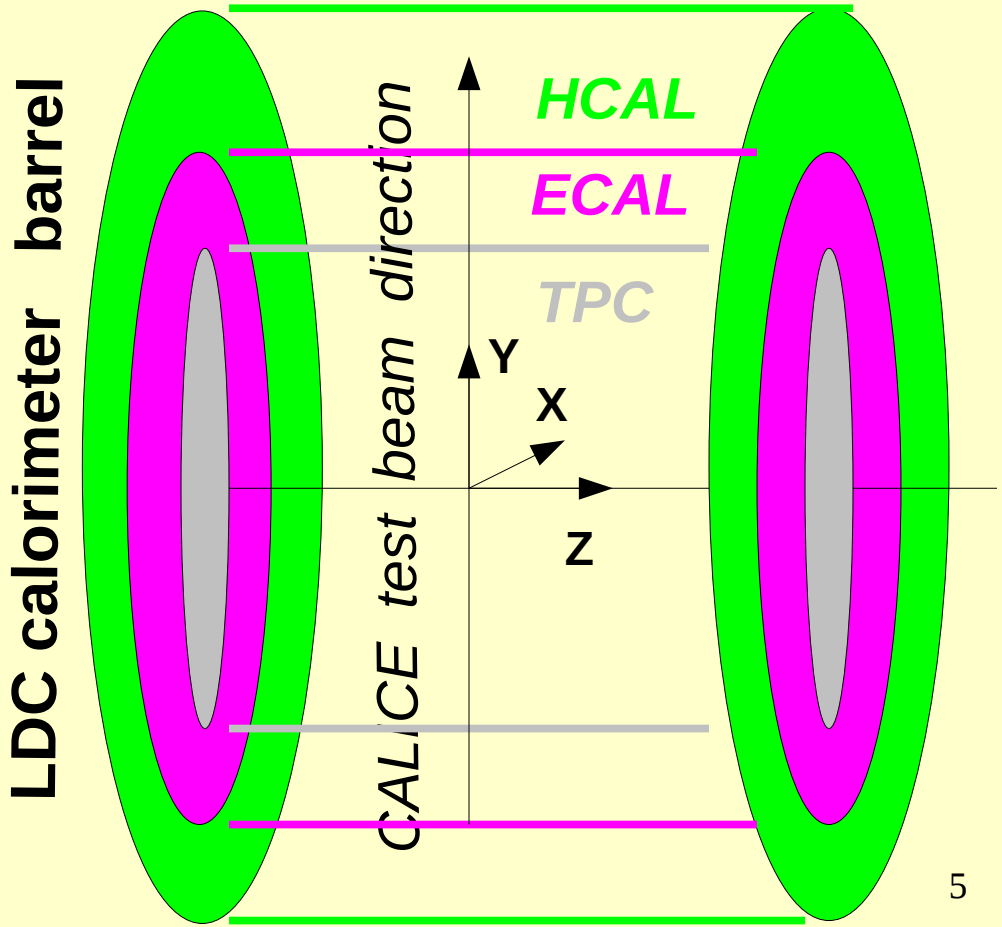
Since these distortions do not change the shower shape considerably they almost do not influence the Pandora performance for our case and hence they have negligible impact on our results

File with two overlapping showers was passed to Pandora PFA Processor which has been adjusted to CALICE test beam configuration. The showers energy *recovered by the program* was compared with the energy *measured by the prototype*

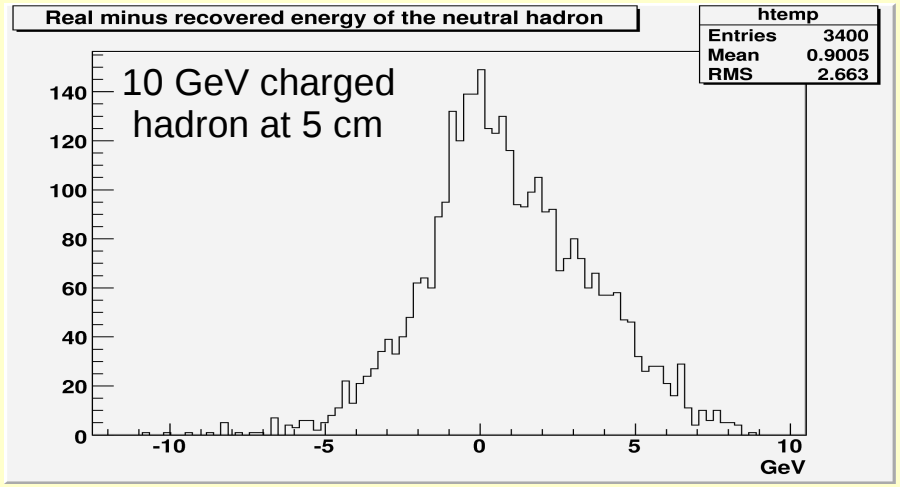
- Instead of helix fit for TPC hits we give to Pandora a straight track at zero XZ position and right angle.

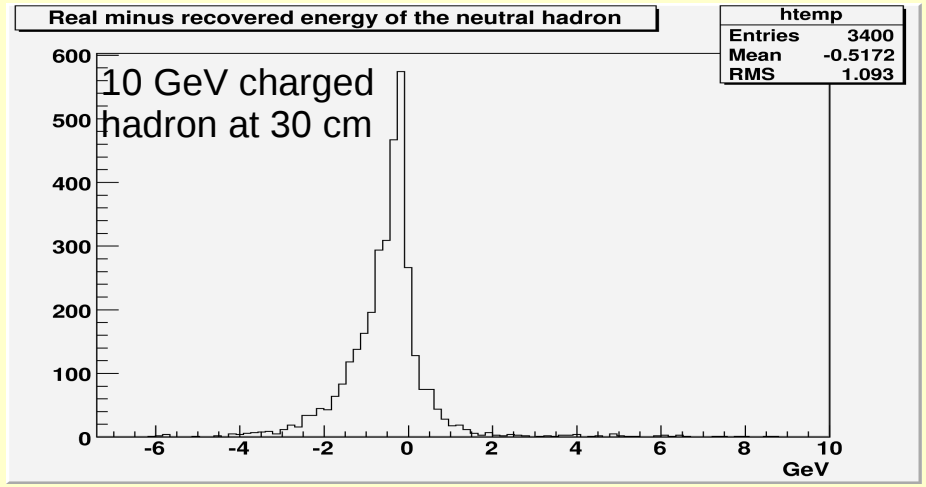
- We include a hit to the neutral hadron shower if Pandora has not include this hit into the charged hadron shower.

- We do not use those section of Pandora which are irrelevant for CALICE configuration.

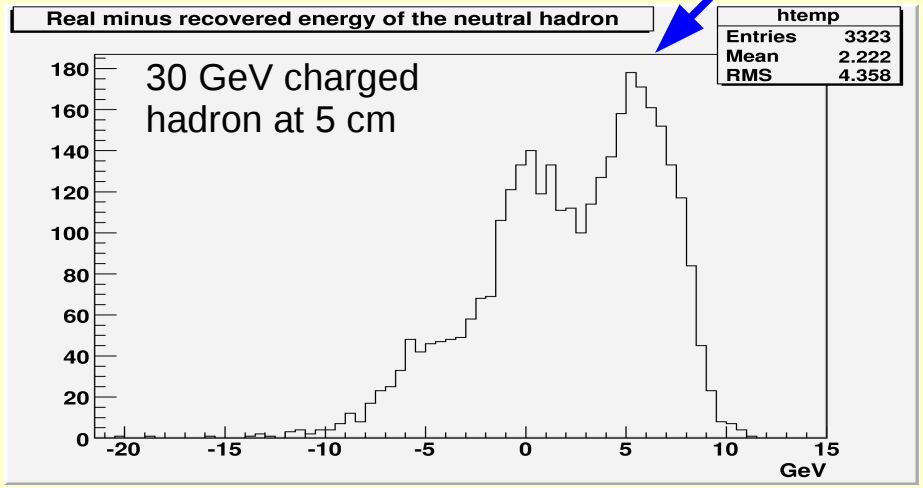


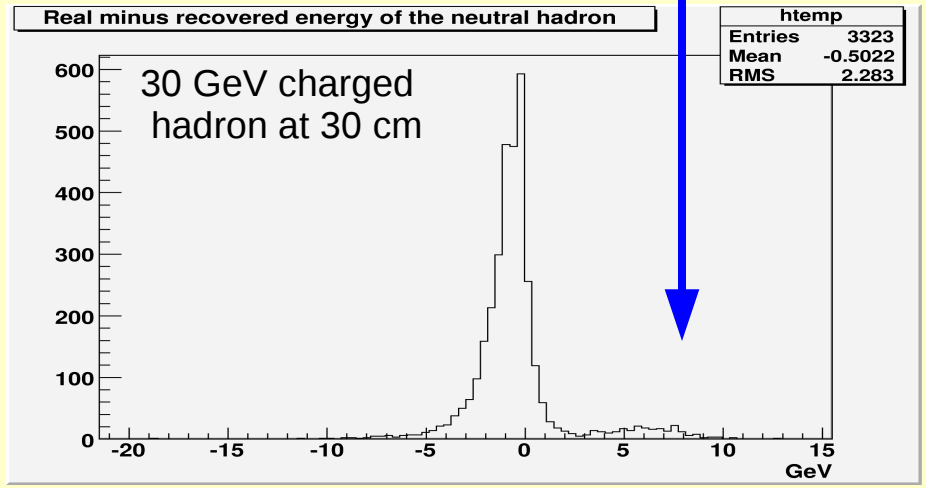
Difference between the *measured energy* and the *recovered energy* for the 10 GeV neutral hadron at different distances from the charged hadron



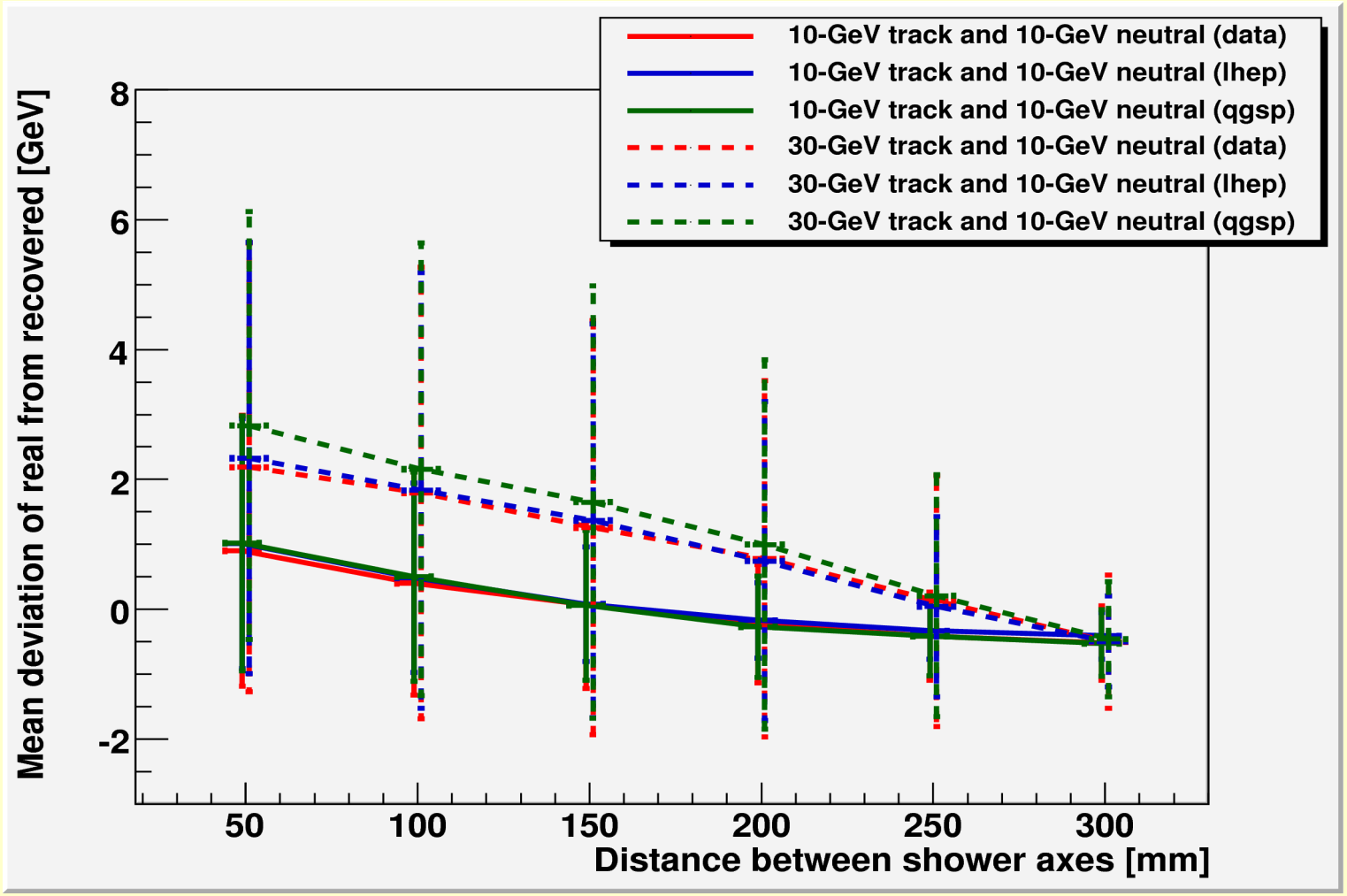


Spike concerned with complete tacking of the neutral shower to the charged shower

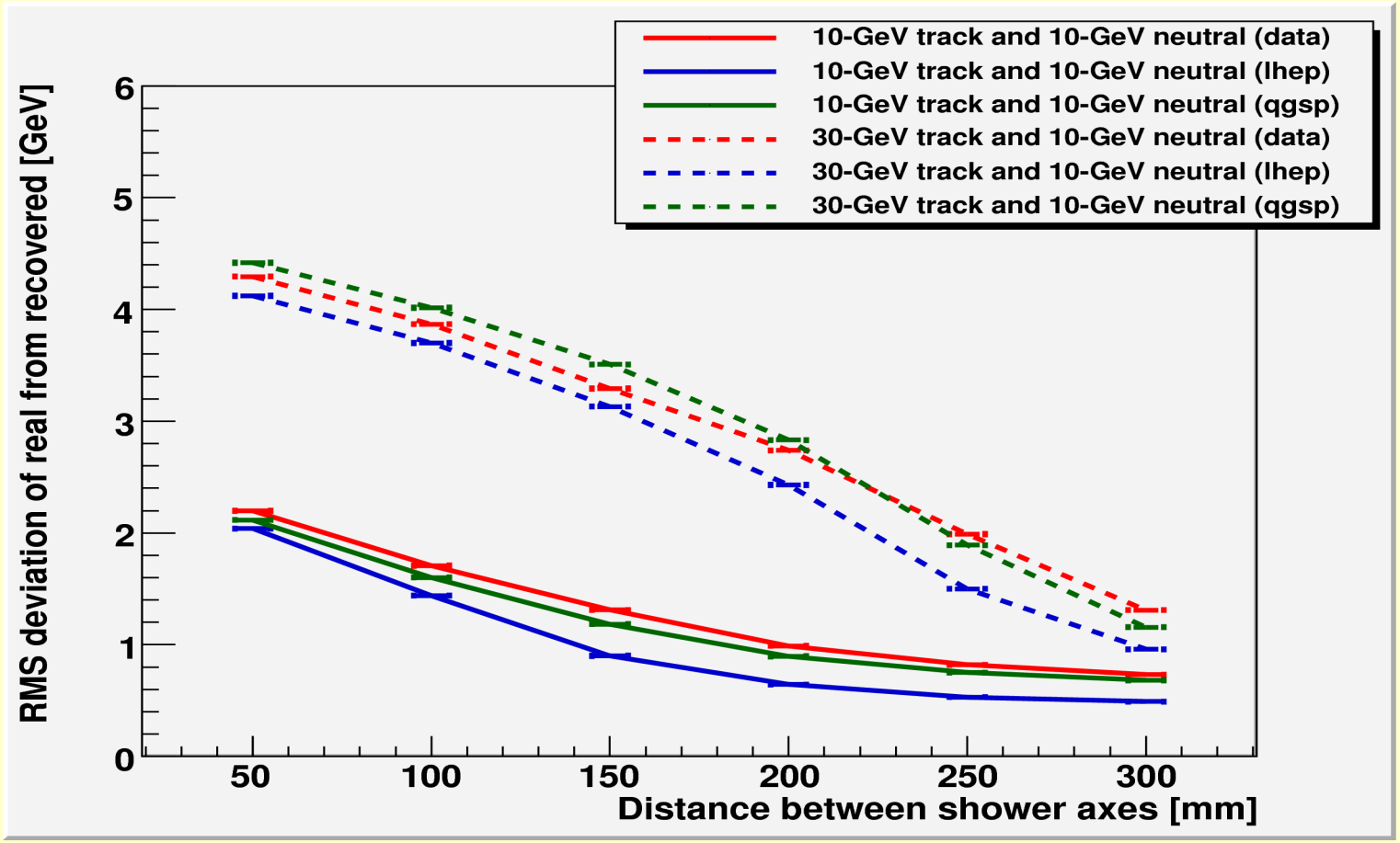




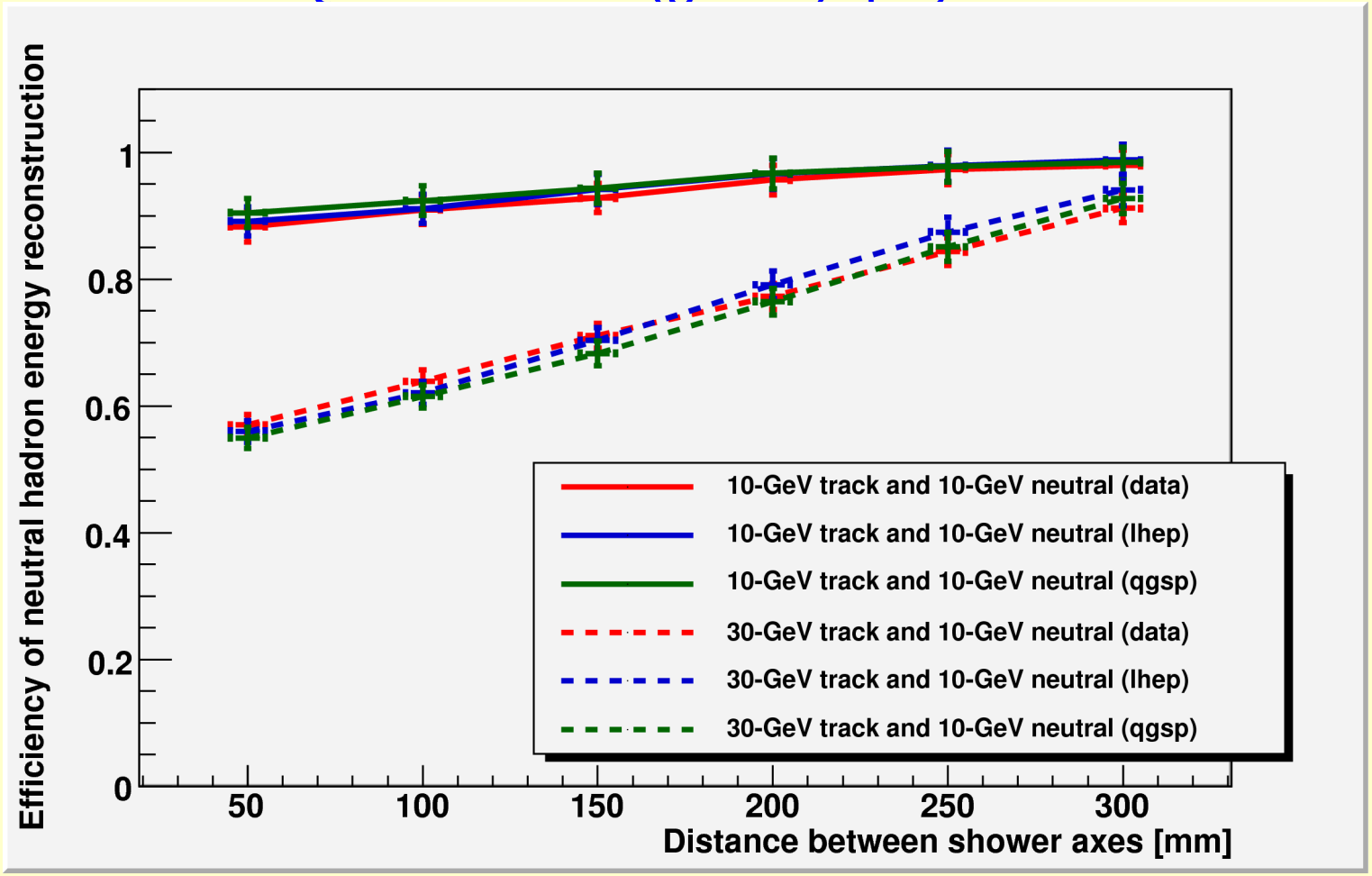
Mean difference between the *measured energy* and the *recovered energy* for the 10 GeV neutral hadron vs. the distance from the 10 GeV charged hadron (continuous line) and the 30 Gev charged hadron (dashed line)



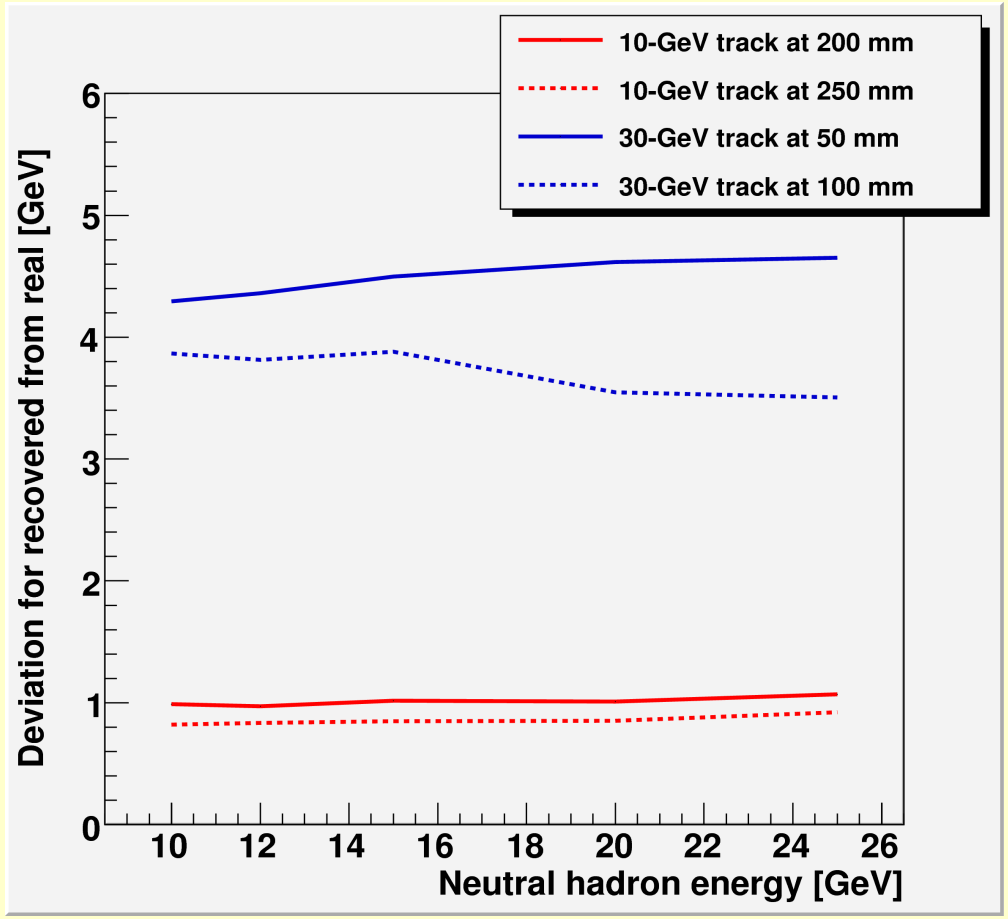
RMS$_{90}$ deviation for the *recovered energy* of the neutral 10 GeV hadron from its *measured energy* vs. the distance from the charged 10 GeV (continuous line) and the 30 GeV (dashed line) hadron for beam data (red) and for Monte Carlo simulated data, for both LHEP (blue) and QGSP-BERT (green) physics lists

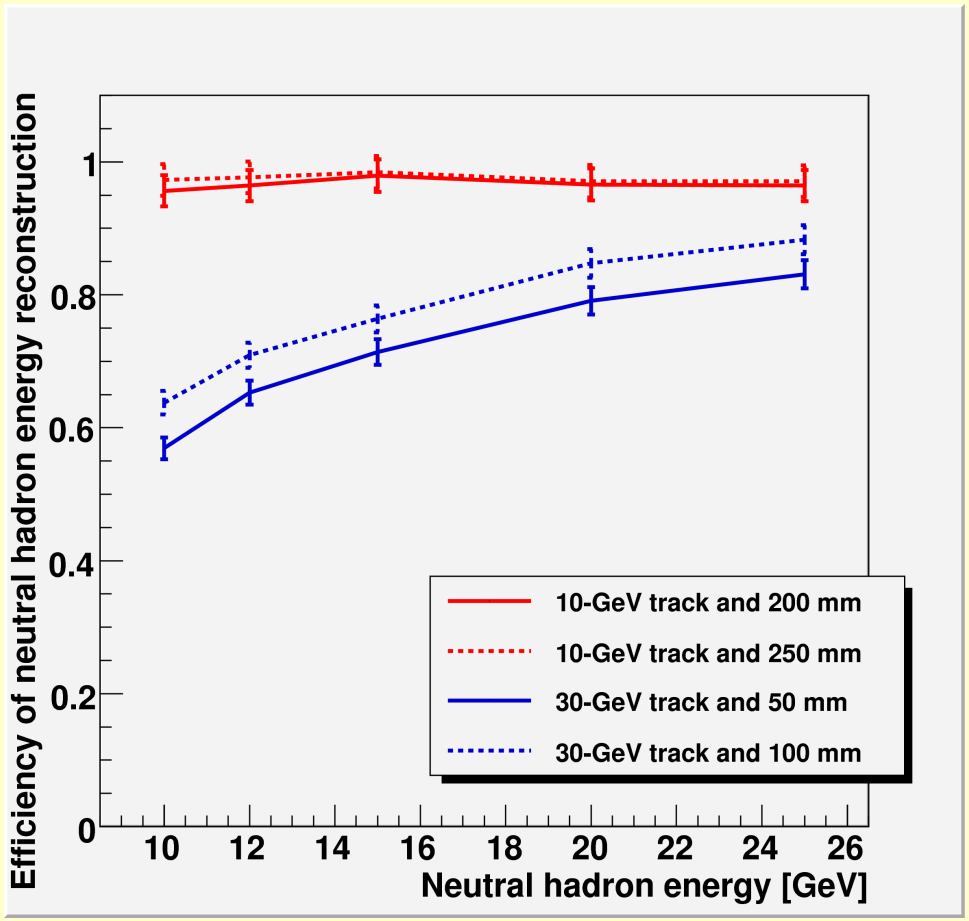


Efficiency of the neutral 10 GeV hadron energy reconstruction within 3 standard deviations vs. the distance from the charged 10 GeV (continuous line) and the 30 GeV (dashed line) hadron for beam data (red) and for Monte Carlo simulated data, for both LHEP (blue) and QGSP-BERT (green) physics lists

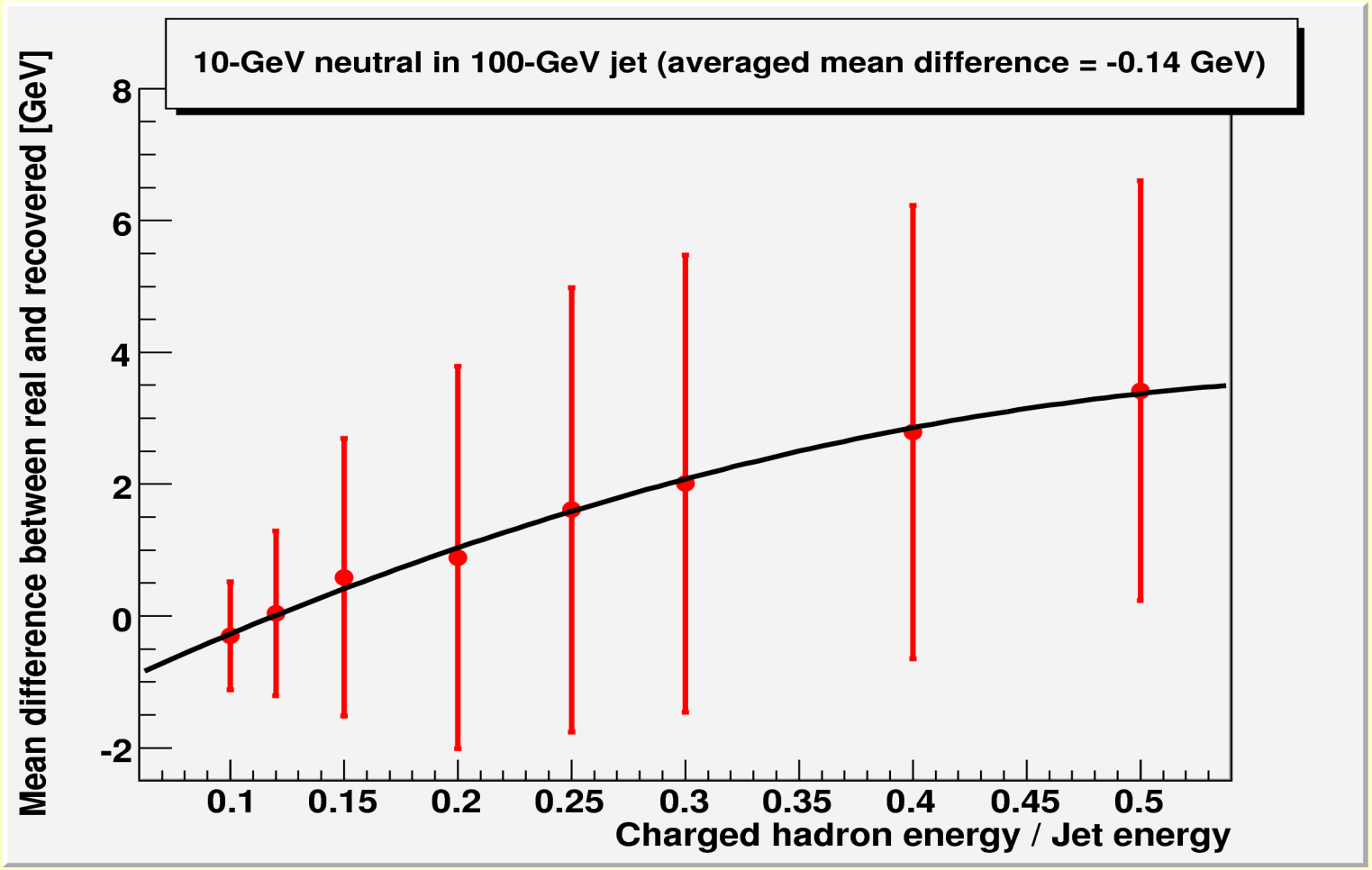


RMS$_{90}$ deviation for *recovered energy* of neutral hadron from its *measured energy* (left) and the efficiency of the neutral hadron energy reconstruction within 3 standard deviation (right) vs the neutral hadron energy in the vicinity of the 10 GeV charged hadron (red lines) and the 30 GeV charged hadron (blue lines) for typical distances between neutral and charged hadrons





Mean difference between *measured energy* and *recovered energy* for the 10 GeV neutral hadron vs. the charge hadron energy in the 100 Gev jet. Integrating this dependence with the probability to find definite charged hadron energy in the jet we get an estimate for the mean difference averaged over jet fragments energy. For RMS_{90} deviation averaged over jet fragments energy the integration gives 1.25 GeV



Conclusion

- Pandora PFA Processor has been adjusted for CALICE test beam configuration.

- Good agreement between beam data results and Monte Carlo results allows to consider the Pandora program as a reliable tool for the real experiment.

- In our study LHEP physics list gives worse prediction for real beam data then QGSP-BERT one.

- For the confusion error between one charged hadron and one neutral hadron we have got the estimate equal to 1.25 GeV.

- Our next step is to pass to Pandora events with several charged hadrons and to estimate the confusion error for whole the jet .