Analyses of W-HCAL data at CERN

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Introduction

- About 870 runs, with energies from 2 to 10 GeV, taken in October and November 2010 at CERN (T7 and T9) with the CALICE WHCAL
- Please see run list on CALICE twiki
- People from the CERN LCD group working on the WHCAL data:

People	Task
Erik van der Kraaij	gain
Martin Killenberg	dead and noisy channels
Christian Grefe	MIPs
Astrid Münnich	tracking
Dominik Dannheim, Wolfgang Klempt	particle identification
Angela	conversion and reconstruction

- People working on tools:

Person	Task
Jacopo Nardulli	simulation of WHCAL
Peter Speckmayer	CALICE Pandora

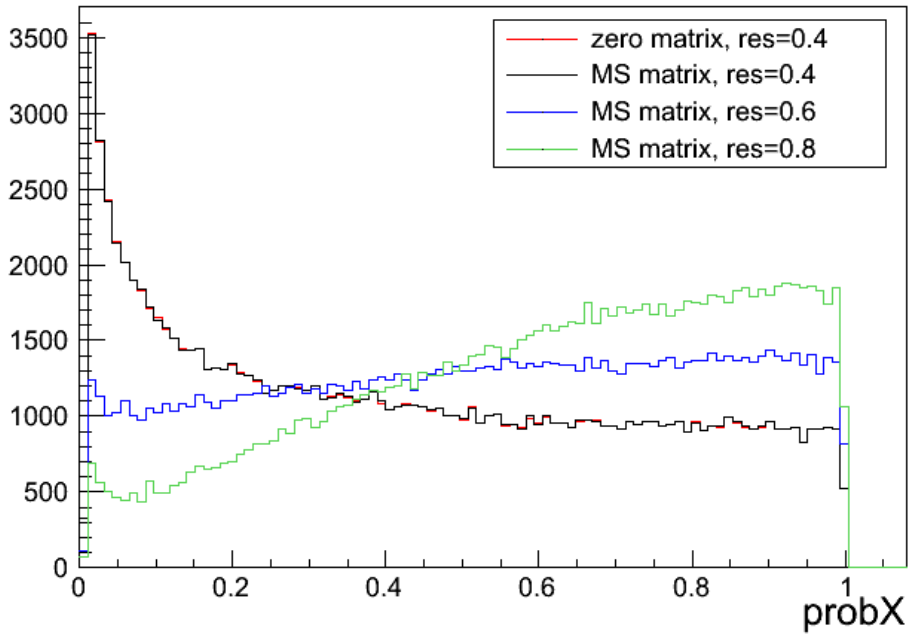
Tracking

- Calibration of the used 3 drift chambers and adaptation of the code done by **Astrid Münnich**
- Very nice progress within few weeks
- Unclear yet: chamber efficiencies $\geq 95\%$, but track efficiency $\approx 70\%$

Input to the track finding:

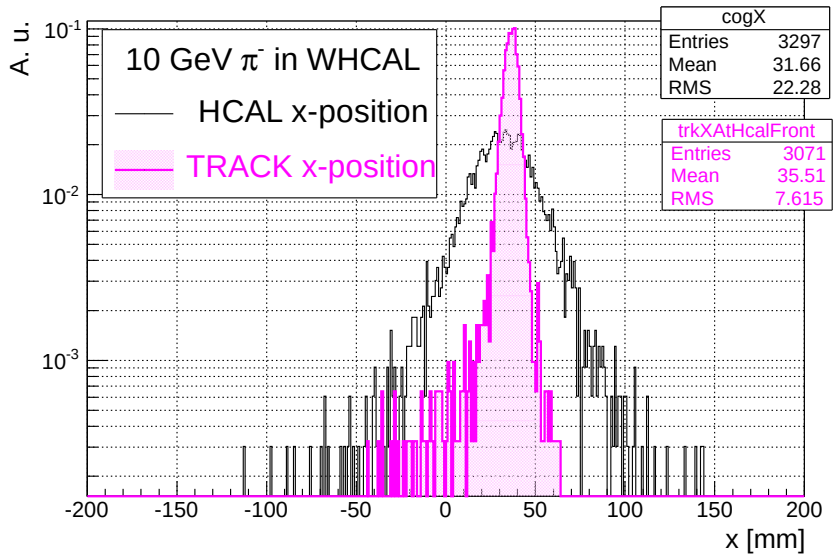
- Error matrices (once correct values, little impact)
- Resolution of the chambers: 0.4 mm expected, but it seems to be rather 0.5 or 0.6 mm (flat probability)

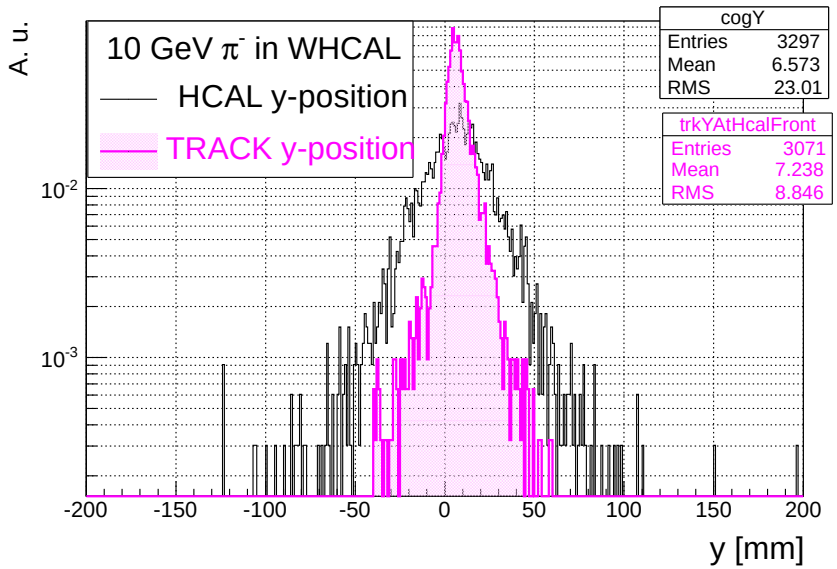
- Example of track probability for a -4 GeV run



Tracking (continued)

- Conclusion: tracking in a good shape ($\Delta x \approx 4$ mm, $\Delta y \approx 0.5$ mm)



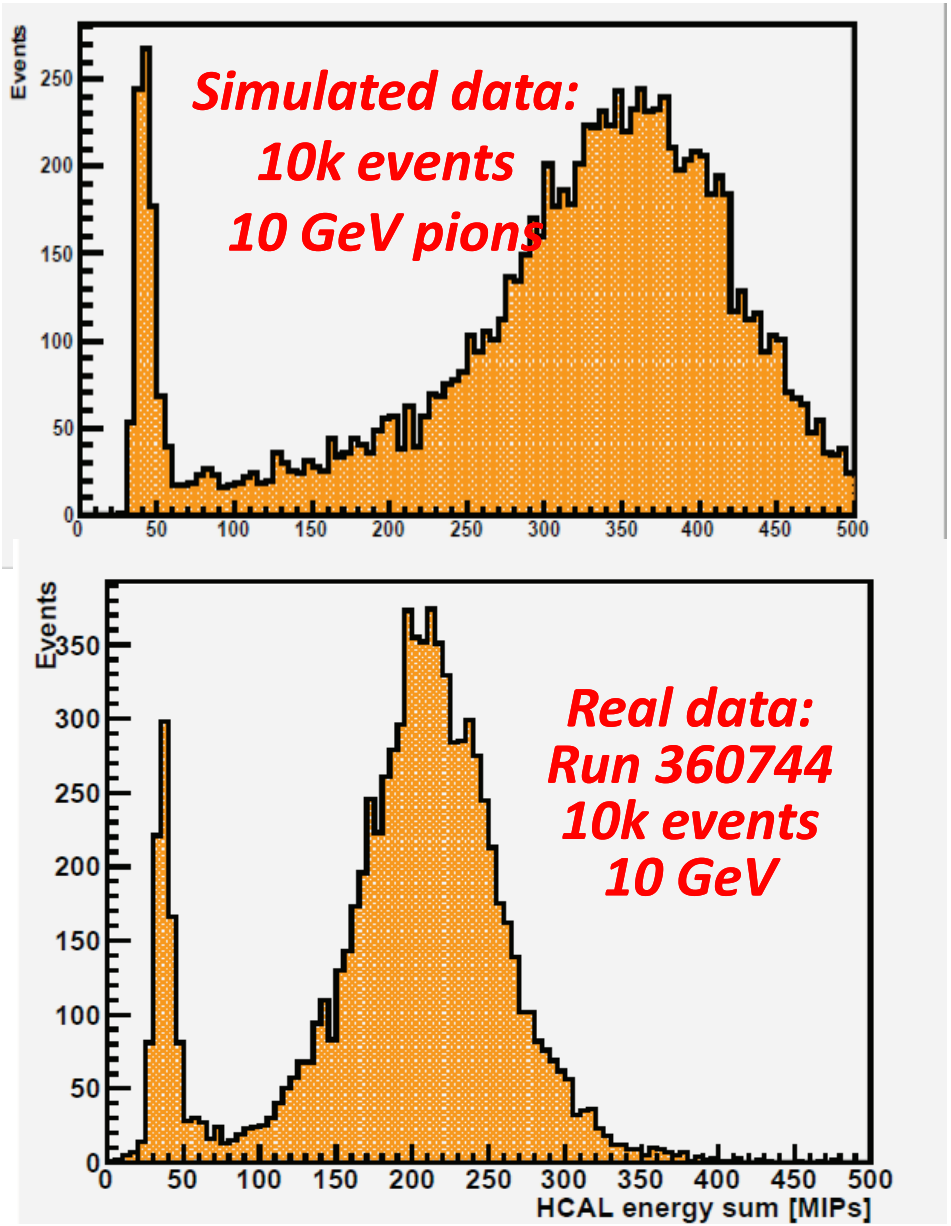


- Still to do: finalise work on track digitisation (first version of simulation constants in the data base, but still checks of applied energy cuts in the GEANT4 simulation needed)

W-HCAL in Mokka

- Work done by **Jacopo Nardulli** with help from Gabriel Mușat (Mokka developer)

- First look at the energy sum in data and in Monte Carlo indicate (scaling?) problem (pion peak much higher in MC)



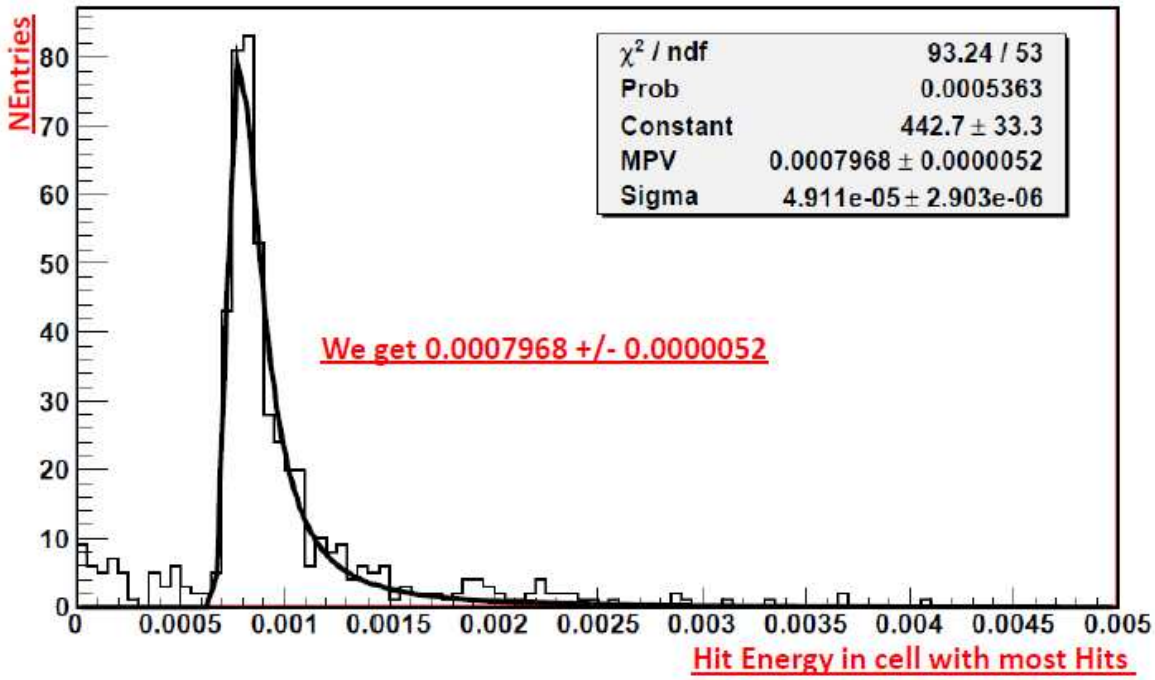
W-HCAL in Mokka (continued)

- First assumption was that the MIP to GeV scaling factor used in digitisation is wrong (measured for Fe-HCAL)

- Unfortunately after using the correct value for the W-HCAL case, the situation did not improve (no significant change in the mean of the energy sum)

- Factor for 80 GeV muons in Fe-HCAL: 816 keV

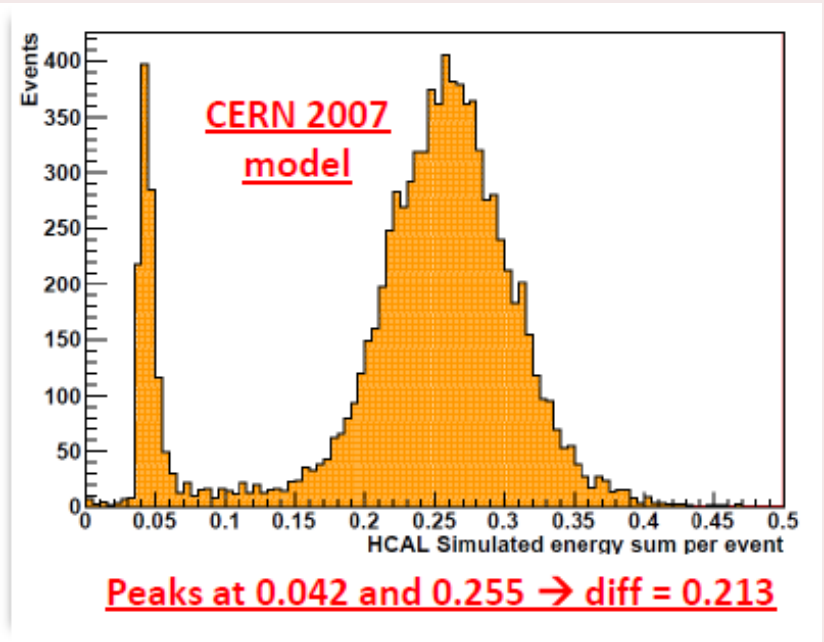
- MIP to GeV factor for 10 GeV muons in W-HCAL:



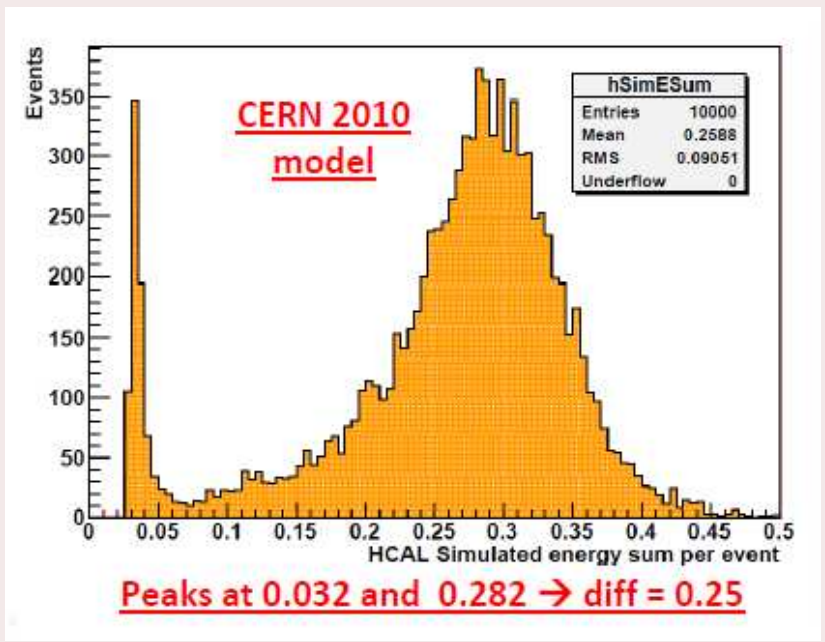
W-HCAL in Mokka (continued)

- We then went back to the Mokka output ⇒ generate 10000 events with 10 GeV pions using different configurations

CERN 2007 Mokka model



CERN 2010 Mokka model



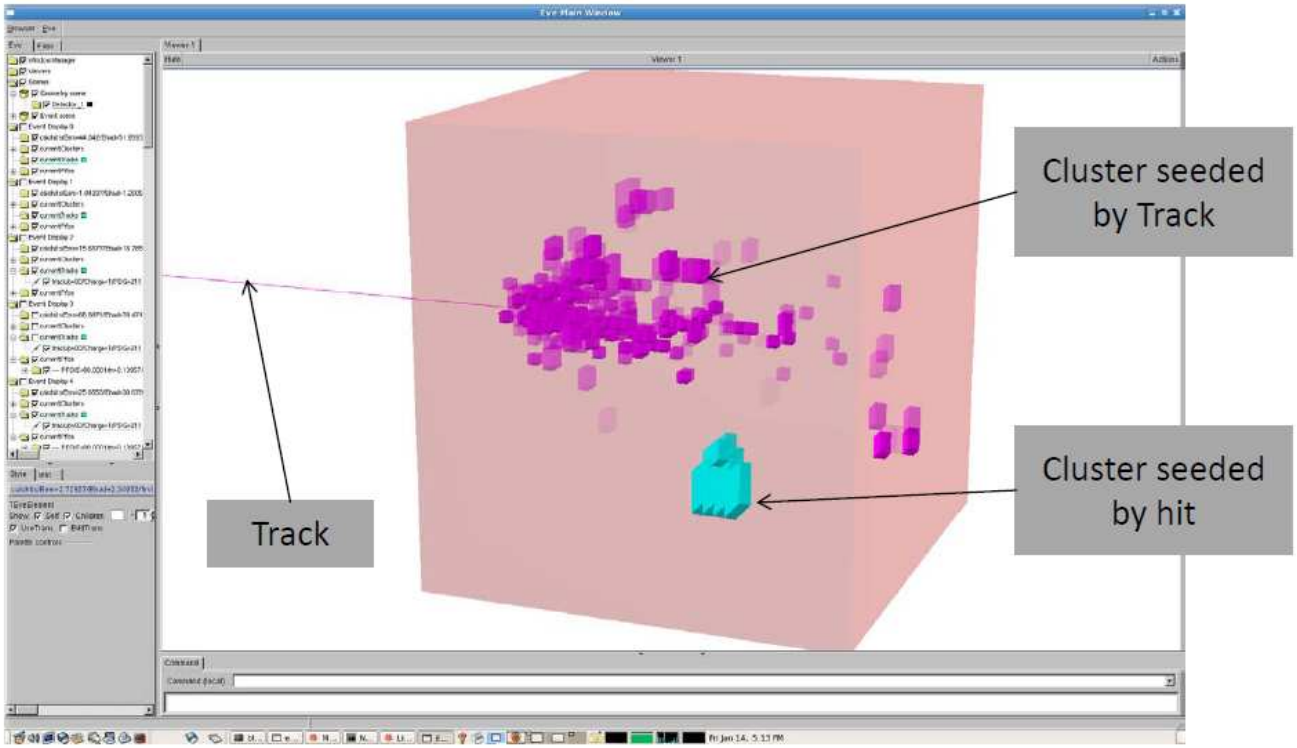
- No obvious mistake here
- No solution yet, need to look at each single step individually (maybe some overlooked aspect of digitisation?)

CalicePandora

- Idea: apply Pandora PFA algorithm on test beam data to test validity
- Already done by our Russian colleagues, see CAN-024, but with old implementation of the PFA algorithm, and with translation of the CALICE geometry into LDC geometry
- Recent work started by **Peter Speckmayer** to apply PFA to the CALICE data:
  - Uses the latest Pandora PFA implementation (help from John Marshal)
  - Uses *PandoraMonitoring* for visualisation
- Several technical difficulties:
  - No GEAR geometry information for CALICE test beam Mokka drivers; created xml file by hand in the moment for the HCAL (to be added for the ECAL and for the TCMT), will be committed to Mokka
  - Tracking: we have our *TBTrack* but Pandora expects *LCTracks*. In the moment, tracks created by hand, but should be converted to LCIO format, in view of overlaying events
- But: cell sizes taken from the CALICE data base (based on Beni's implementation)

CalicePandora

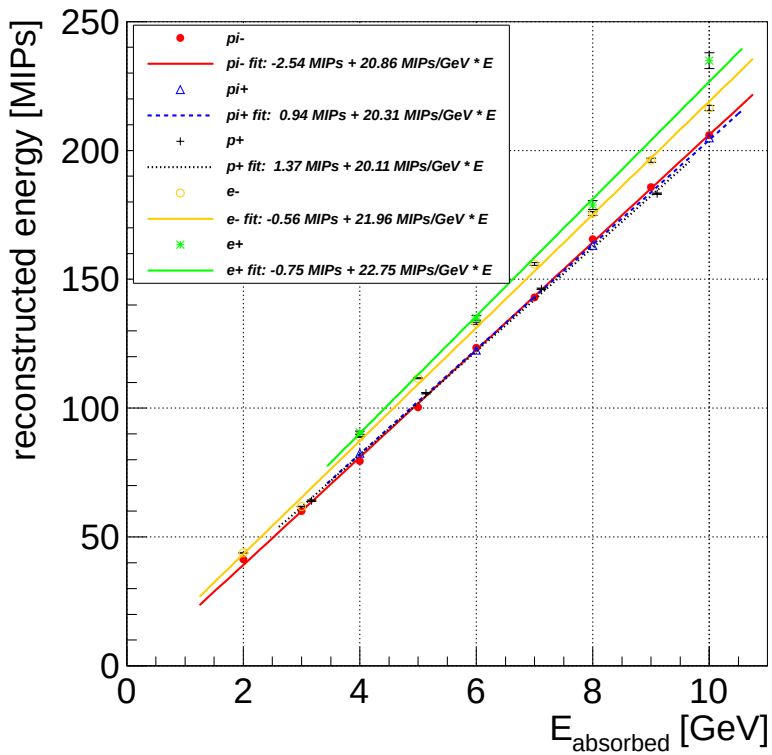
- Example of an 80 GeV π^- event from CERN 2007 (more examples on */afs/cern.ch/user/s/speckmay/public/CalicePandoraPlots*)



- We have some technical problems due to the recent reorganisation of the *PandoraPFANew* code, but
- Hope to have a first working version at the end of February (including the ECAL and the TCMT)

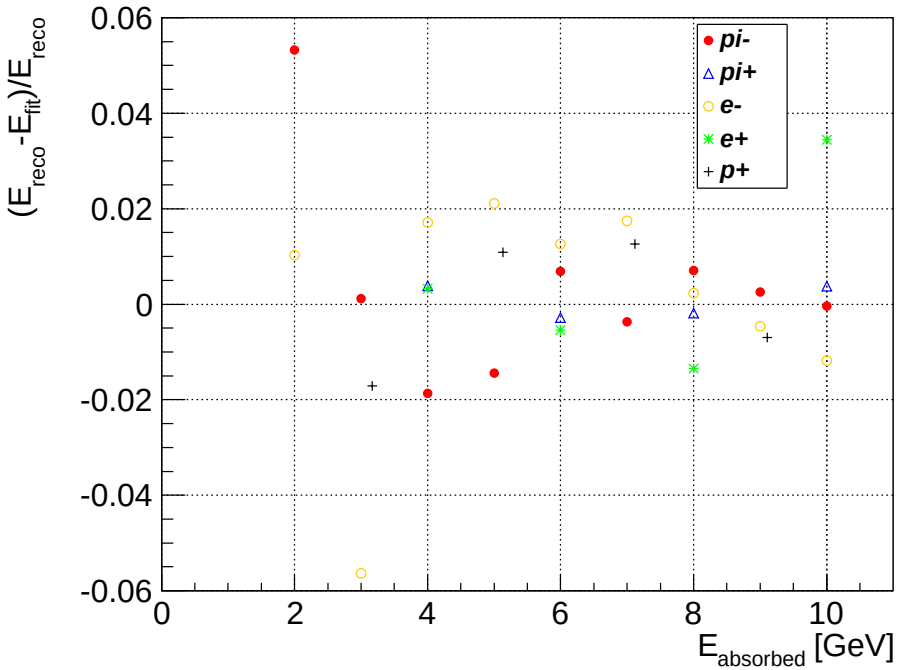
Energy reconstruction

- Particle identification based on Cherenkov triggers
- For tips on Cherenkov selection, please see talk from Dominik
- What has changed from the last presentation of Cherenkov analysis: for fitting we use a Gaussian function convoluted with a Landau (instead of a simple Gaussian)
- Reconstructed vs beam energy (for protons, the rest mass energy is subtracted):

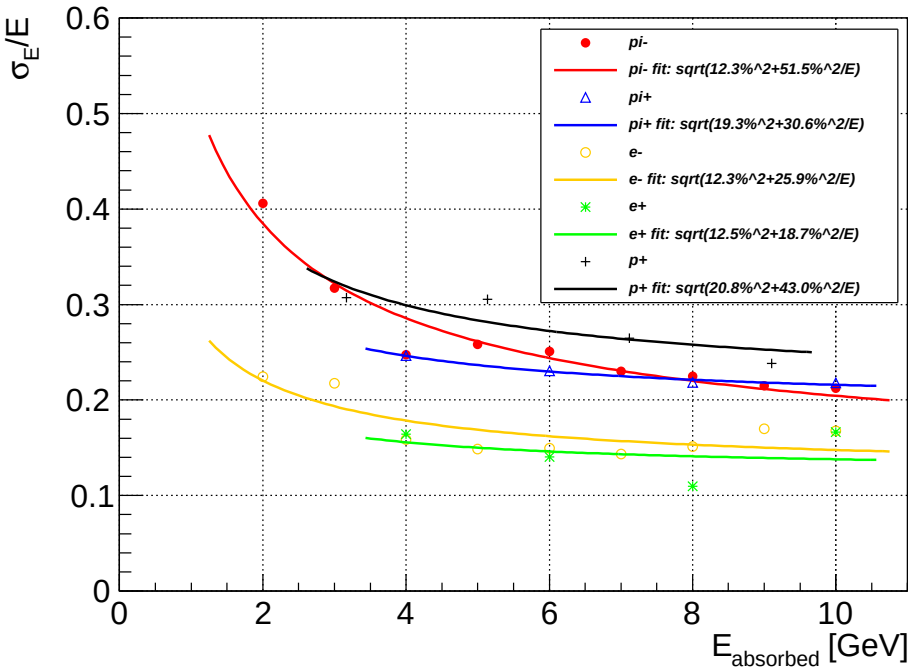


Energy reconstruction (continued)

- In general, the results are worse with the new fitting function
- Deviation from linearity:



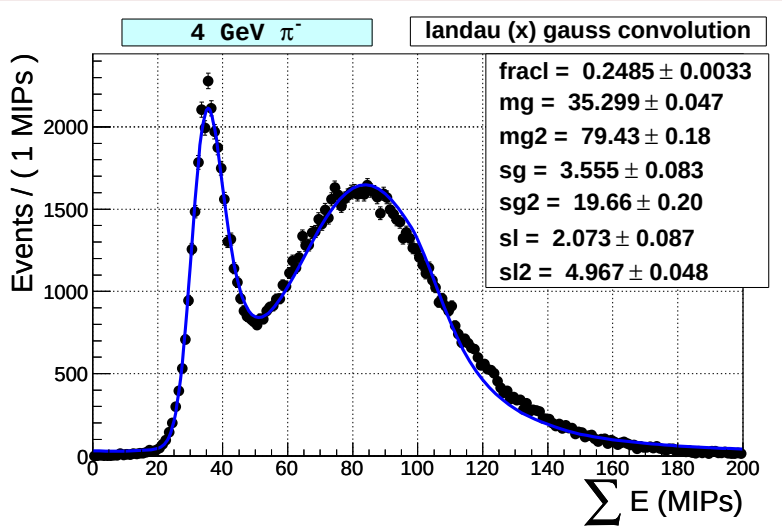
- Electron energy resolution is better than for hadrons, as expected, but (very) low statistics

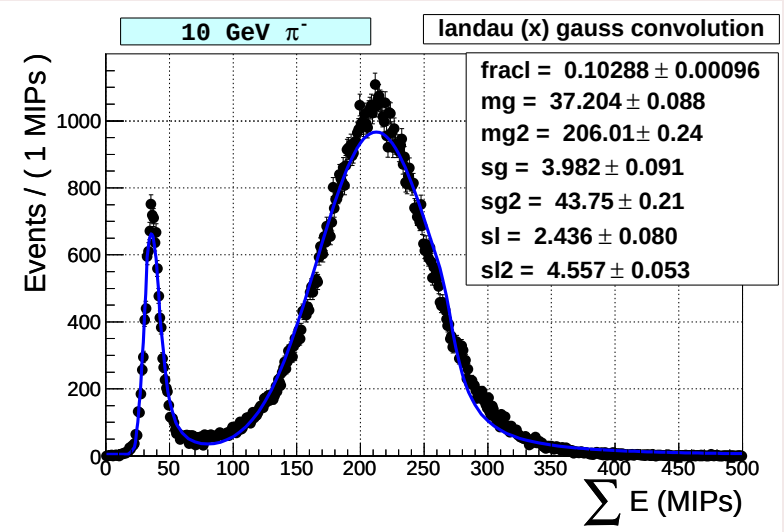


- We need to see if you can refine the fitting procedure and improve the data selection

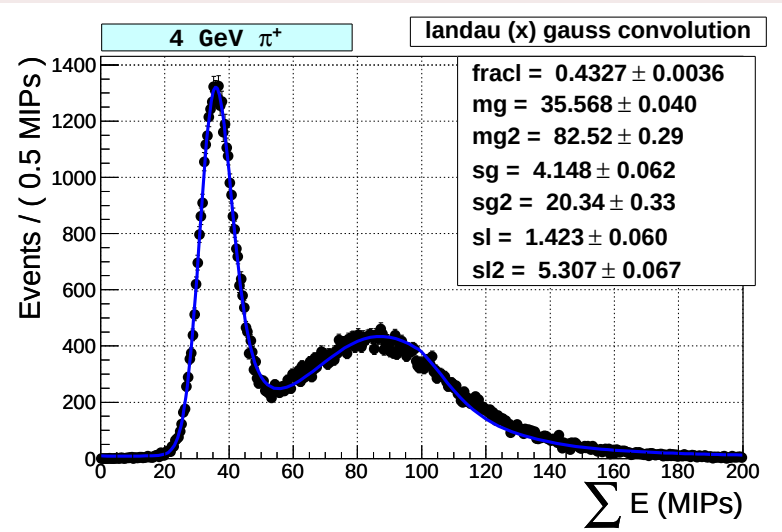
Particle ID: Fit examples at 4 and 10 GeV

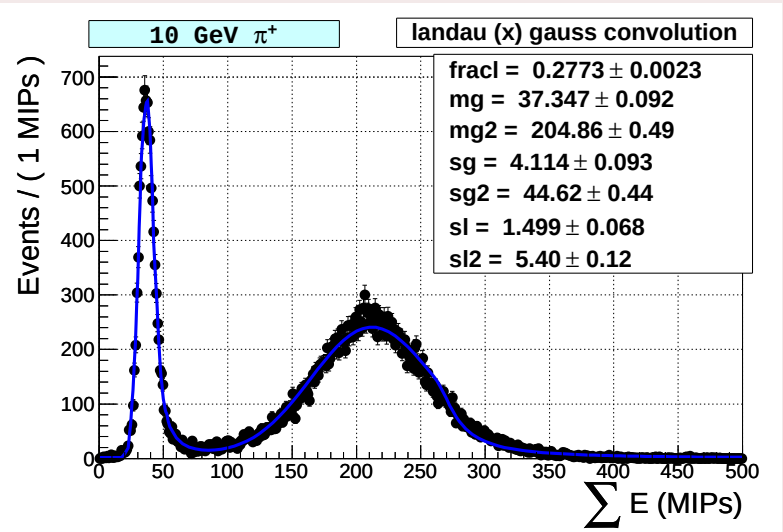
π^-





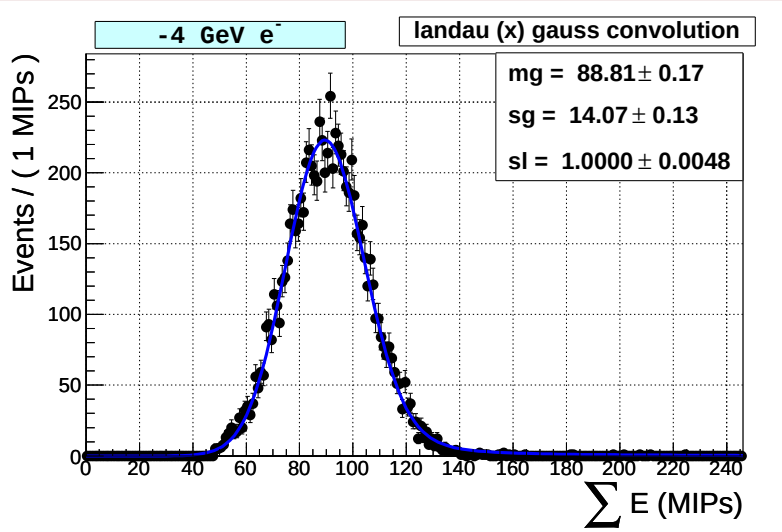
π^+

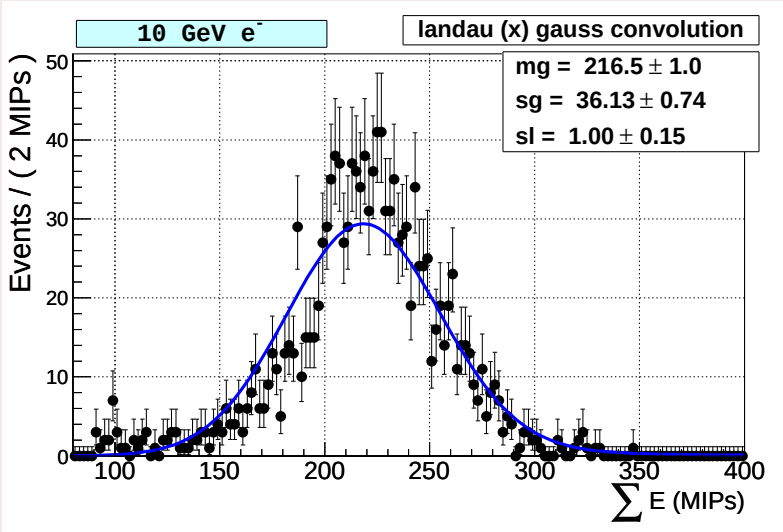




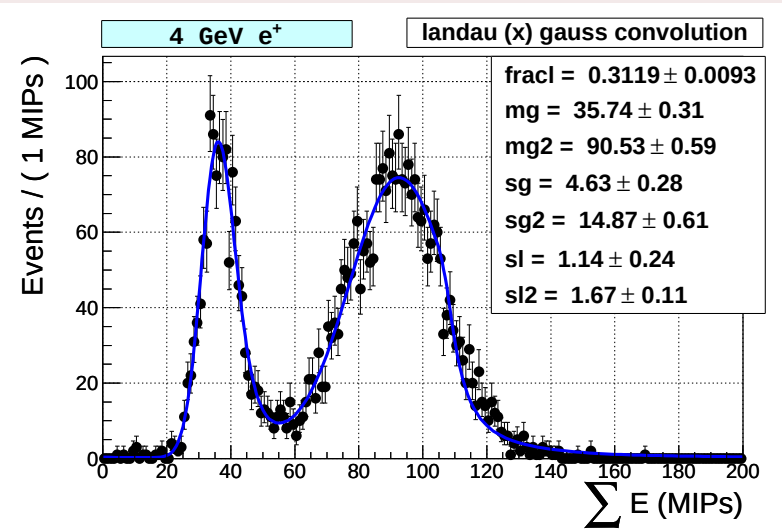
Particle ID: Fit examples at 4 and 10 GeV

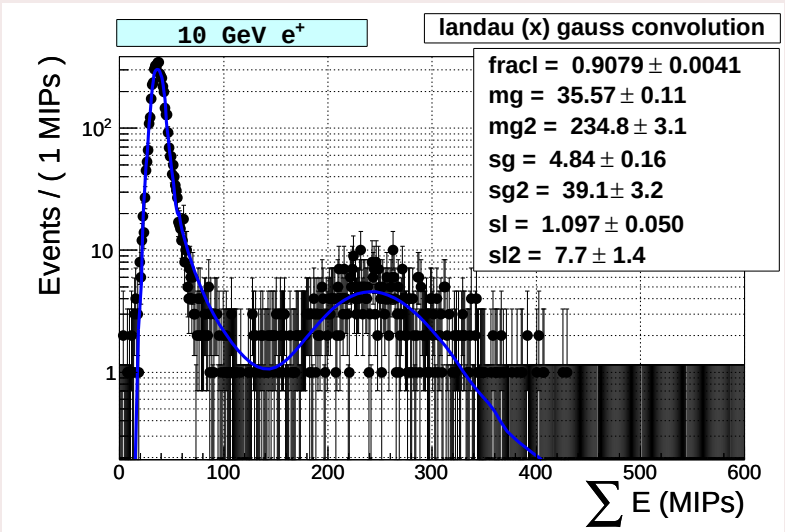
e^-



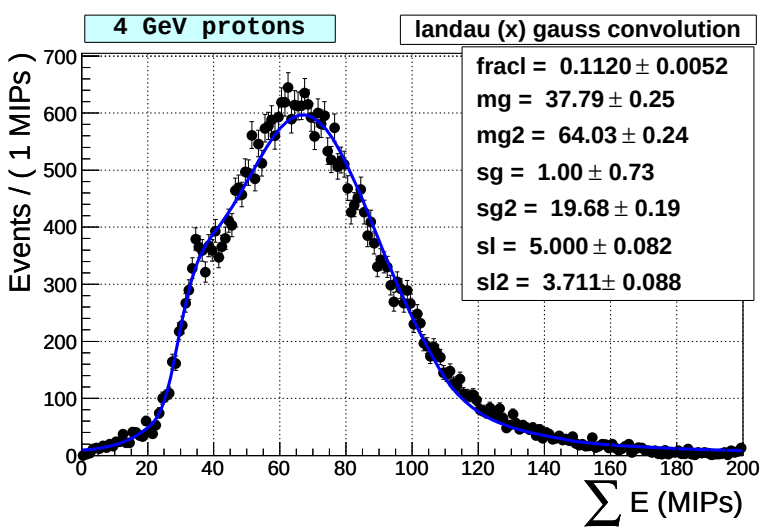


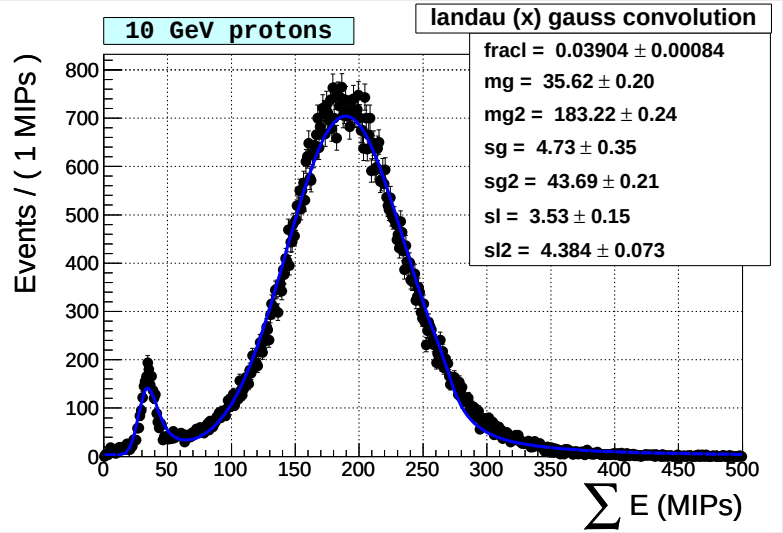
e^+





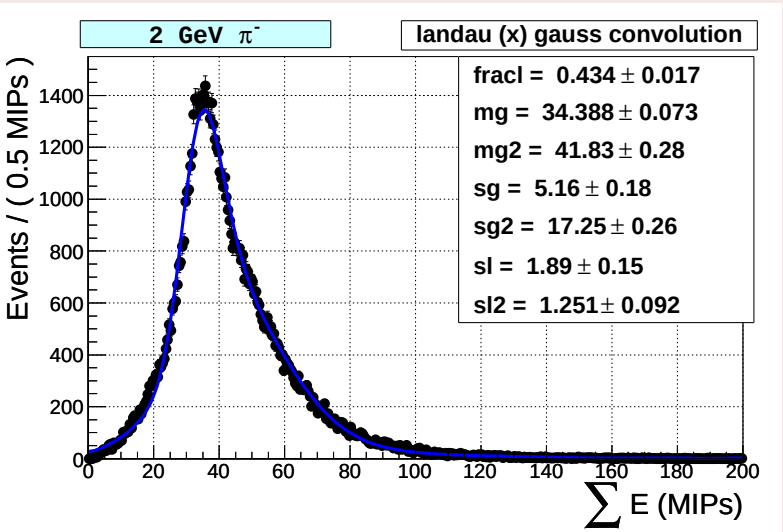
Protons at 4 and 10 GeV





π^- at 2 GeV

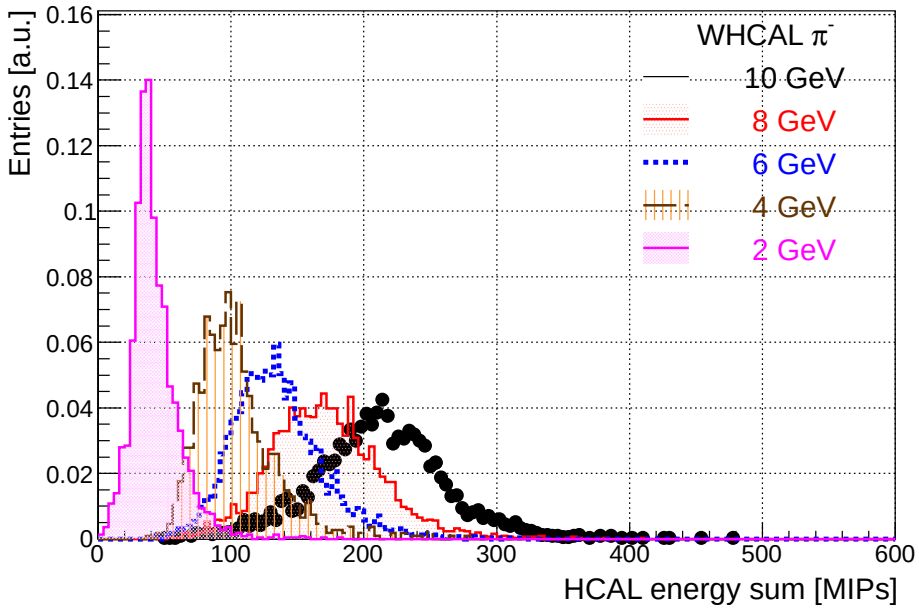
- Muon and pion peak overlap
- Fit at 2 GeV pretty stable (fixing the fit parameters for the muon has little impact)



Analysis of a few π^- runs

- Many runs already reconstructed with old (CERN 2007) calibration constants, and can be found on the grid: */grid/calice/users/lucaci/reco*
- For more details, please check this list
- Had a look at some basic quantities for a few runs

Energy	Run number
10 GeV	360744
8 GeV	360770
6 GeV	360771
4 GeV	360774
2 GeV	360782

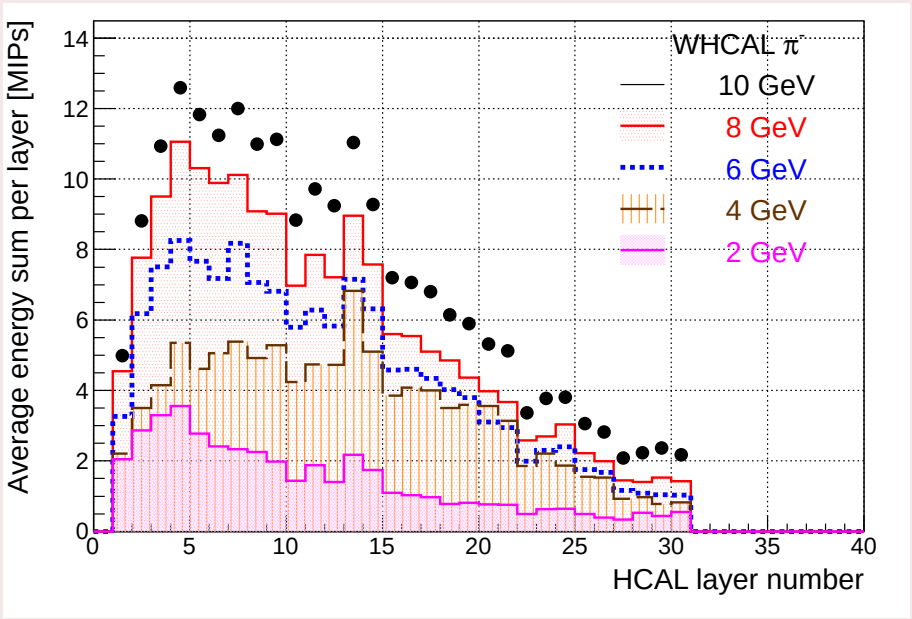


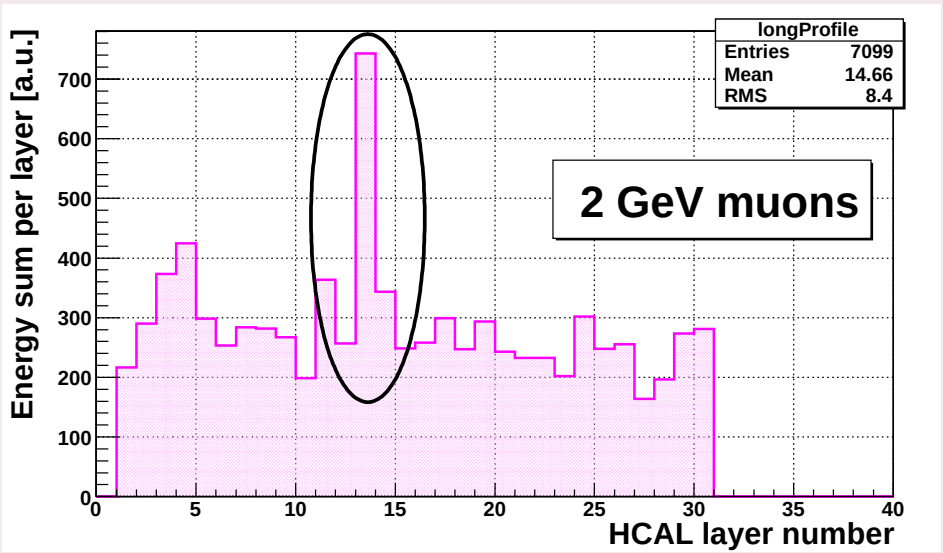
- Used Cherenkov selection as used by Dominik and Wolfgang
- For $E > 4$ GeV, brute pion selection with number of hits in HCAL > 55

Analysis of a few π^- runs

HCAL longitudinal profile

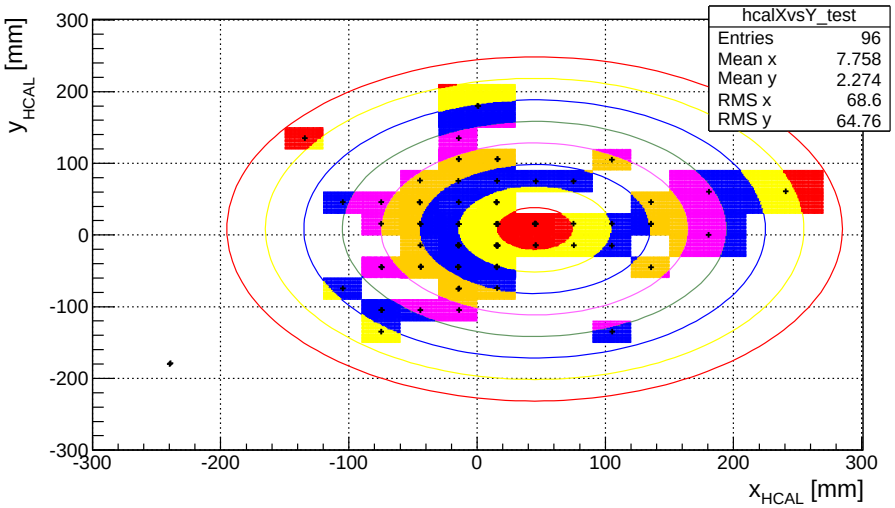
- Problematic layer 13, seen also in the muon longitudinal profile (calibration?)

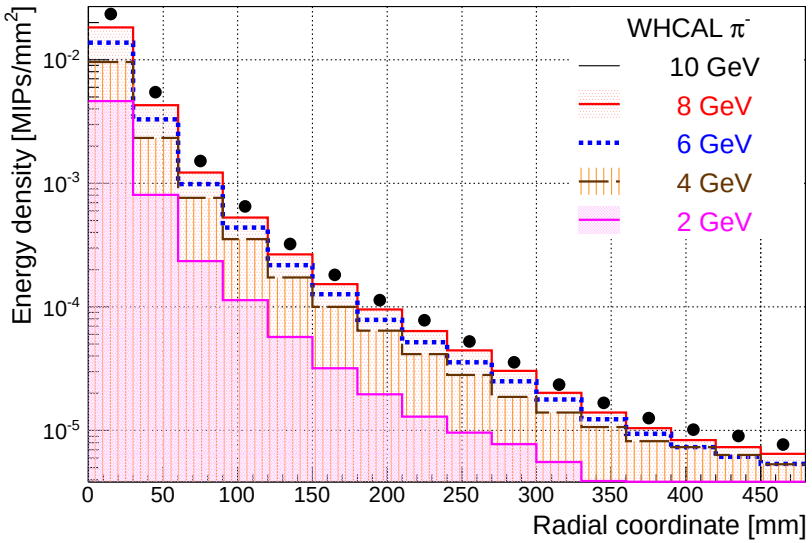




Analysis of a few π^- runs: Radial profile

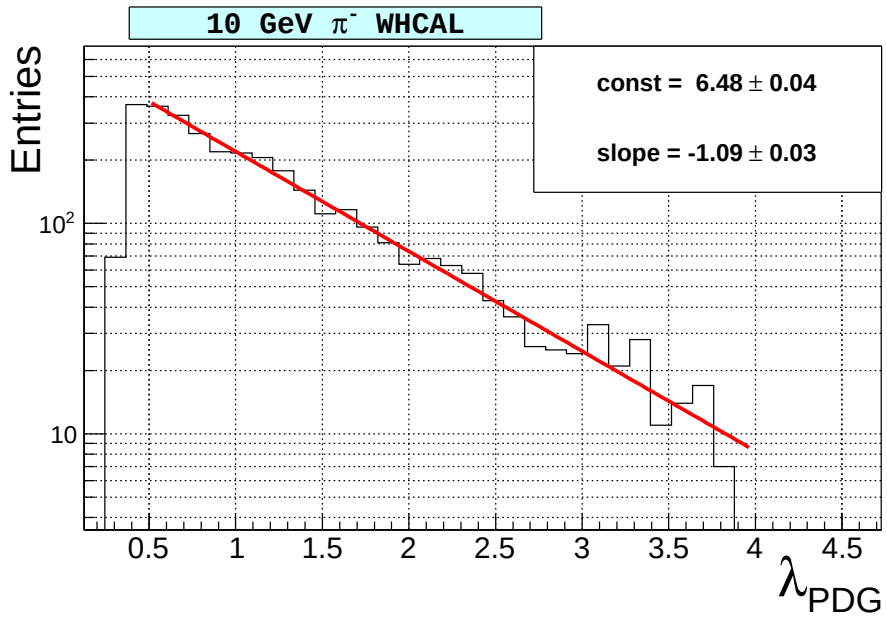
- Measured as described in CAN-011e
- Radial coordinate is the distance between the position of the HCAL hit and the shower axis (given by the track)





Analysis of a few π^- runs: Measurement of the interaction length

- Just for fun: looked at the distribution of the shower start layer (obtained with Marina's track finder)
- No adaptation of the track finder
- Considered only the absorber material (approximation)
- Obtained $\lambda_I/\lambda_{PDG} = 1.09 \pm 0.03$



Conclusions

- Considerable progress within several weeks from the data taking period
- Several preliminary analyses done on CERN 2010 runs reconstructed with old calibration constants (will be repeatead as soon as the new calibrations are available)
- Hopefully to be finalised soon:
  - MIP calibration
  - Mokka model of the W-HCAL
- Planning to do analyses at CERN: Astrid (track matching, shower start, profiles), Erik (particle identification), Angela
- You are very welcome to contribute

Thank you