Analysis of W-AHCAL data

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Introduction

2010 data

- W-AHCAL: **30 layers**
- Energies: 1-10 GeV
- Dedicated muon runs in CERN T7
- Mixed runs (e, π, μ, p) in CERN T9

2011 data

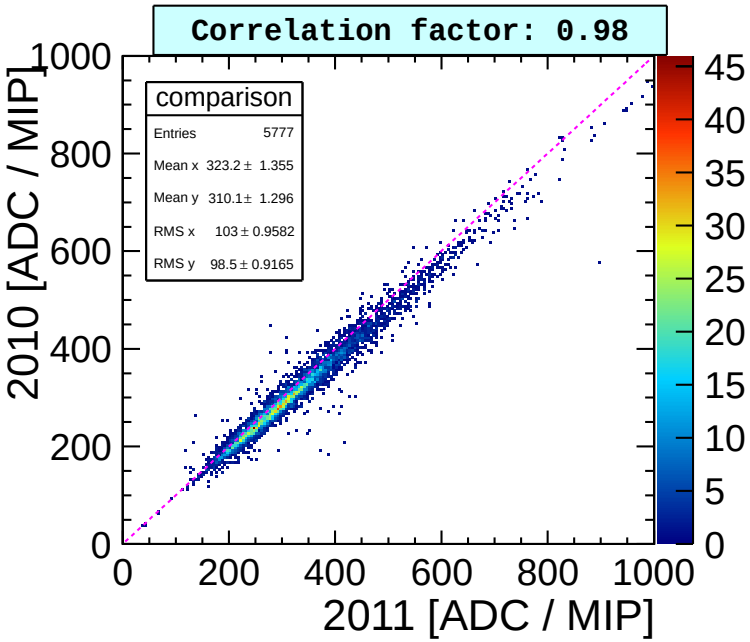
- W-AHCAL: **38 layers**
- TCMT added
- Energies: 10-300 GeV
- Mixed runs (e, π, μ, p, K) in CERN PS and SPS
- Dedicated muon runs, detector scans

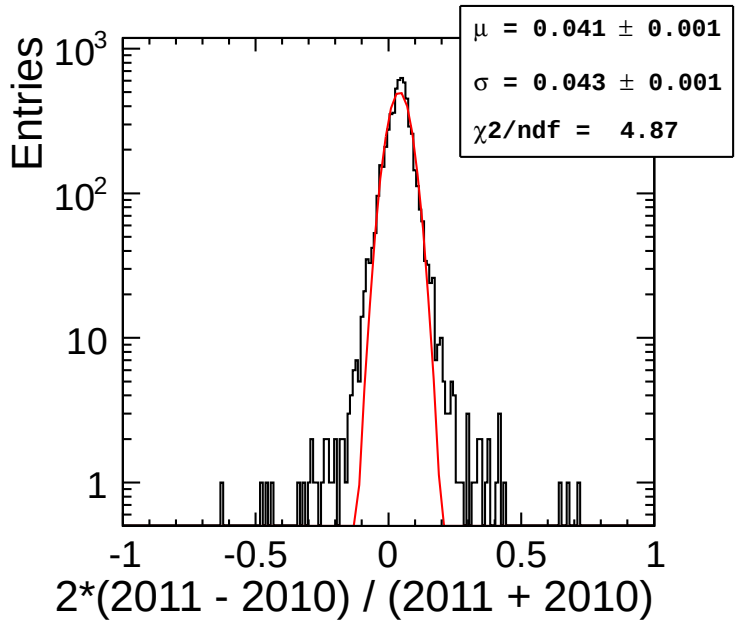
Analysis strategy

- Final goals:
  - Energy resolution
  - Shower shapes
  - Comparison with GEANT4 models
    $\Rightarrow$ analysis note/paper
- Combine 2010/2011 data
- Start with e^+/e^- (electromagnetic showers are theoretically simple, good tool for checking the calibration)
- Once calibration validated, continue with hadrons

MIP calibrations

- AHCAL response calibrated using **muons as MIPs**
- Two calibration data sets: 2010 and 2011 ⇒ need to check:
  - Quality of MIP determination
  - Consistency between the 2 sets
- **Quality**: cleaned MIP values by visual scan and rerunning the fit when possible (see examples in ▸ my talk in HCAL main meeting Dec. 2010)
- After clean up, the 2 sets are well correlated





- Still a 4% shift (maybe due to differences in hold values)

Temperature correction

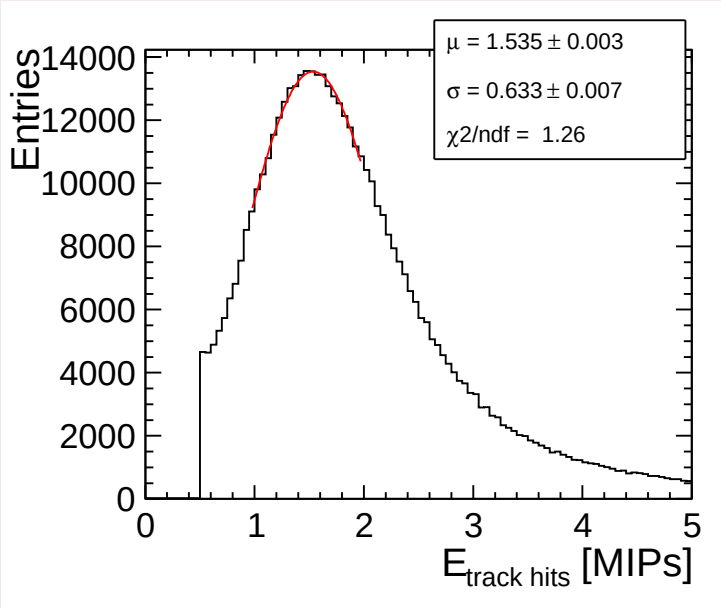
- How to correct for T?
  - SiPM response depends inversely linear with $T \Rightarrow$ measure slopes and use them for correction

How to measure MIP T slopes?

- Reconstruct data (without T correction)
- Find muons
- Look at the variation of the muon energy with T

How to measure muon energy?

- Find muons hits with `PrimaryTrackFinder` (other methods tried, but results not so stable), with additional cuts see here
- Fit single hit energy spectra (Gaussian, limited range)

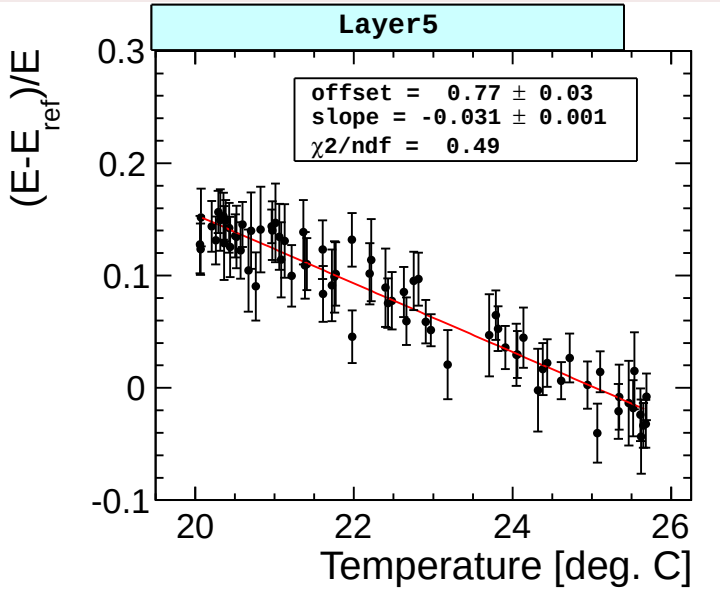


Temperature correction: 2010

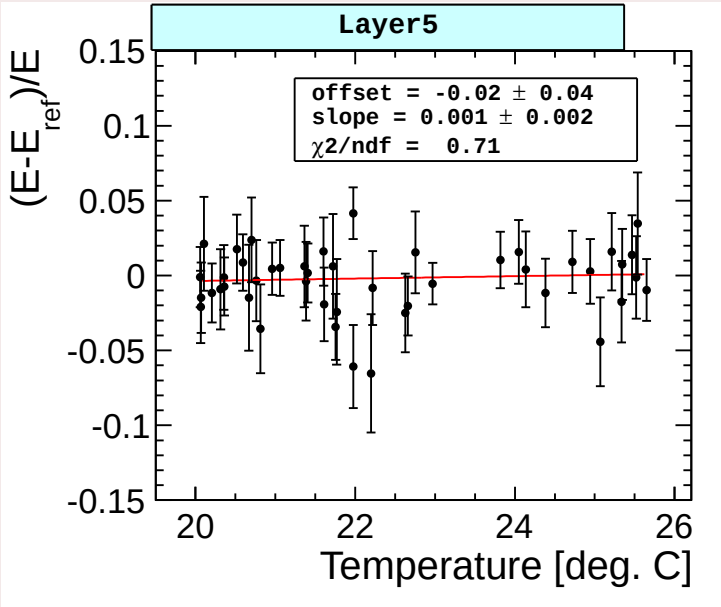
- MIP variation with temperature is corrected for by applying a **relative slope per layer**

Example: layer 5

- Before T correction



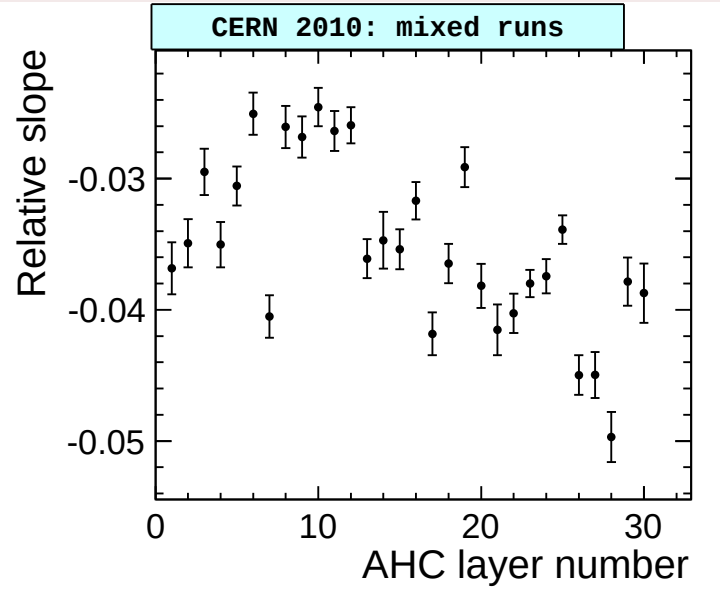
- After T correction



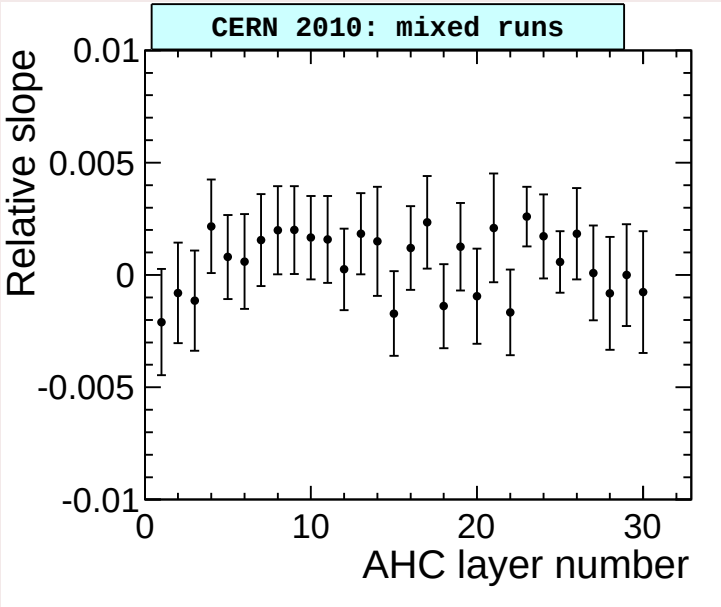
Temperature correction: 2010

All layers:

- Before T correction:
  average = -3.5%



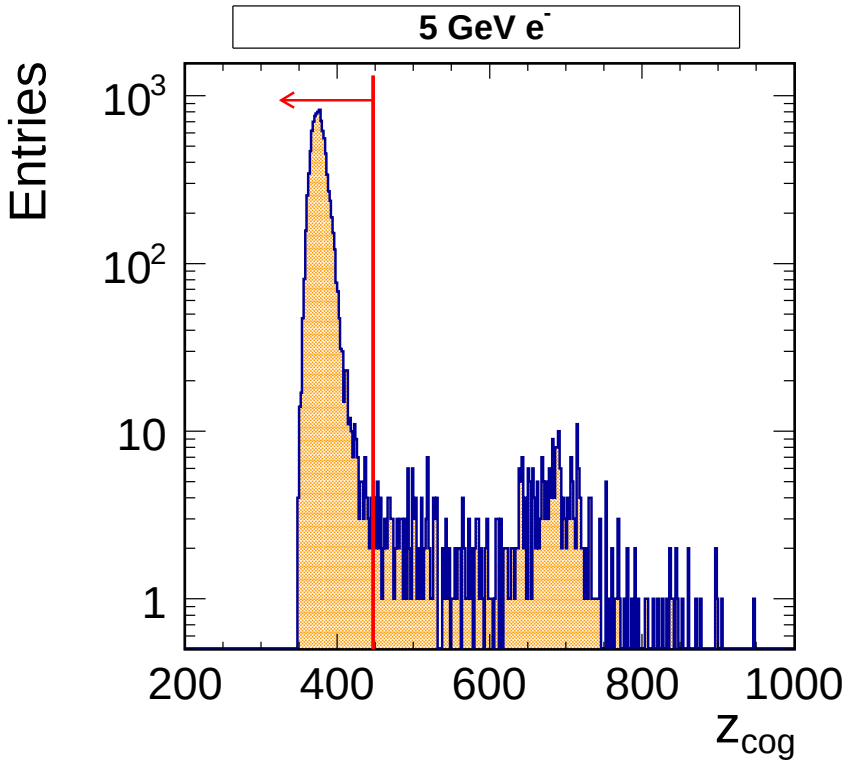
- After T correction:
  average = 0.%



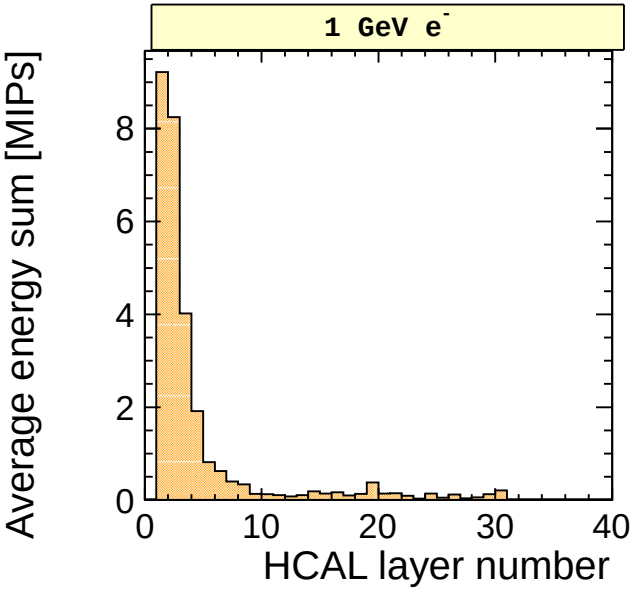
- 2010: relative slopes ok, can be used for analysis

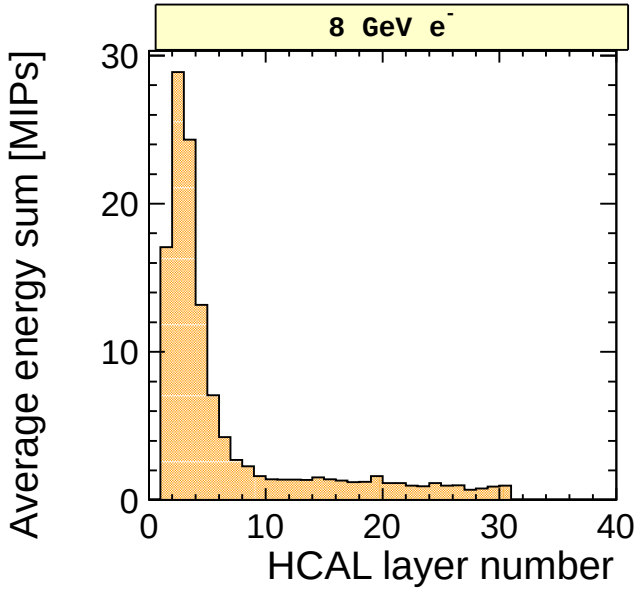
2010: Selection of e^-/e^+ events

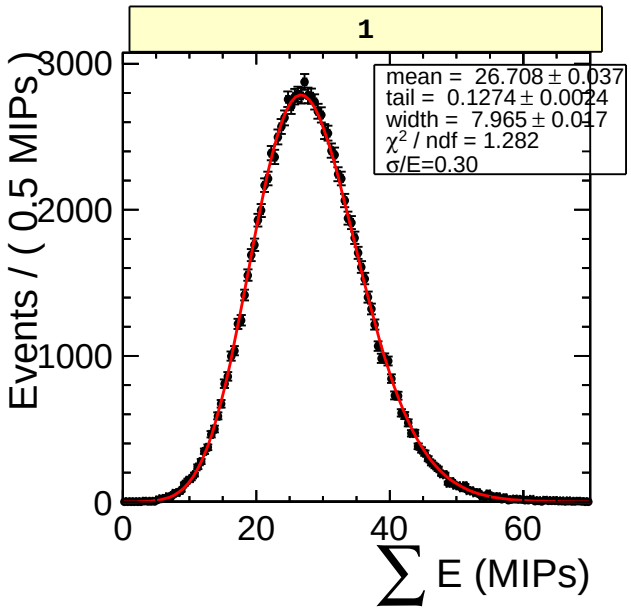
- First: identify particles based on Cherenkov triggers
- But: still muon (and some pion) contamination
- Select e based on $z_{cog} = \frac{\sum z_i \cdot E_i}{\sum E_i}$

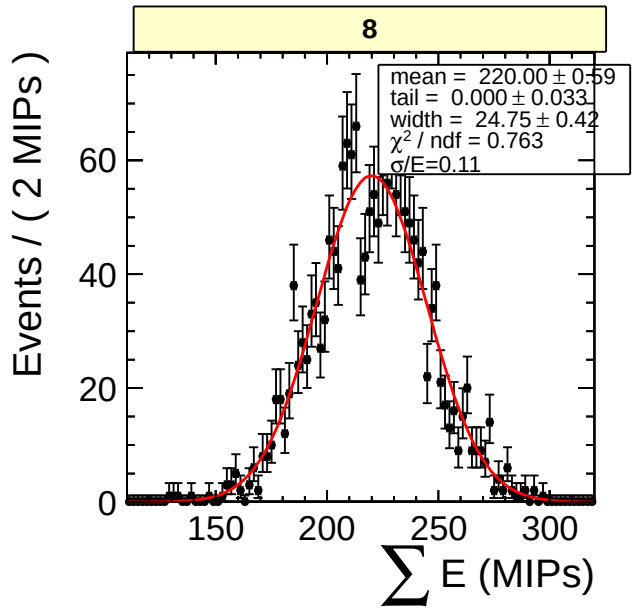


2010: Selection of e^-/e^+ events









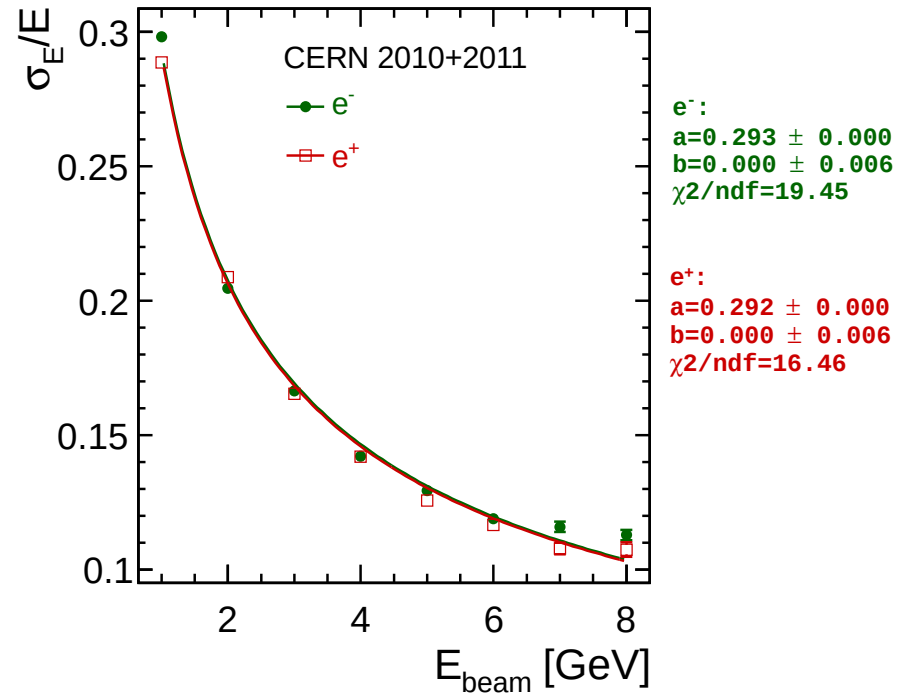
2010: Electromagnetic energy resolution

Fe-AHCAL

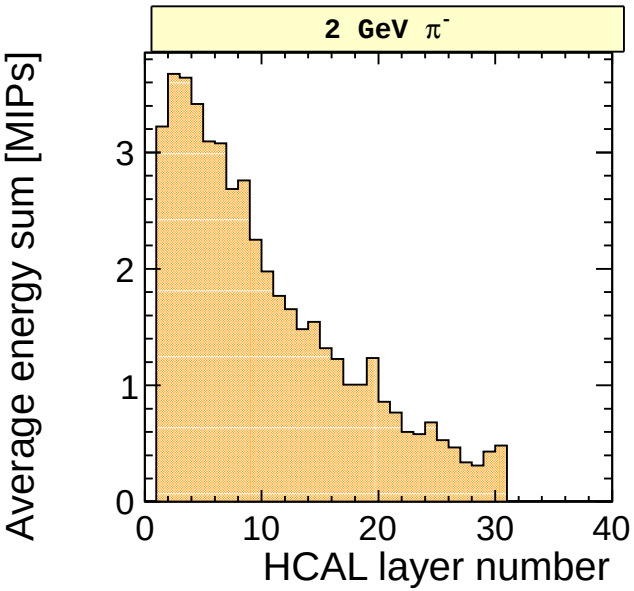
- One layer: $16 + 2 + 2$ mm Fe $\approx 1.14\ X_0$
- arXiv:1012.4343 $\frac{\sigma}{E} = \frac{21.9\%}{\sqrt{E}} \oplus 1.0\% \oplus \frac{0.0058}{E}$

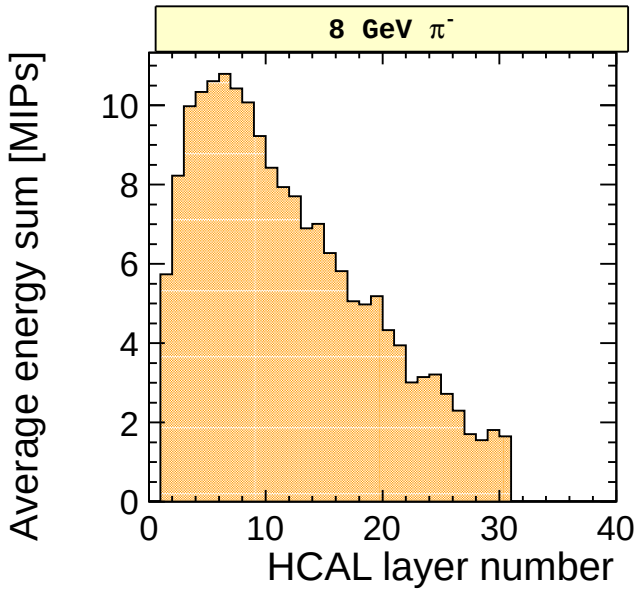
W-AHCAL

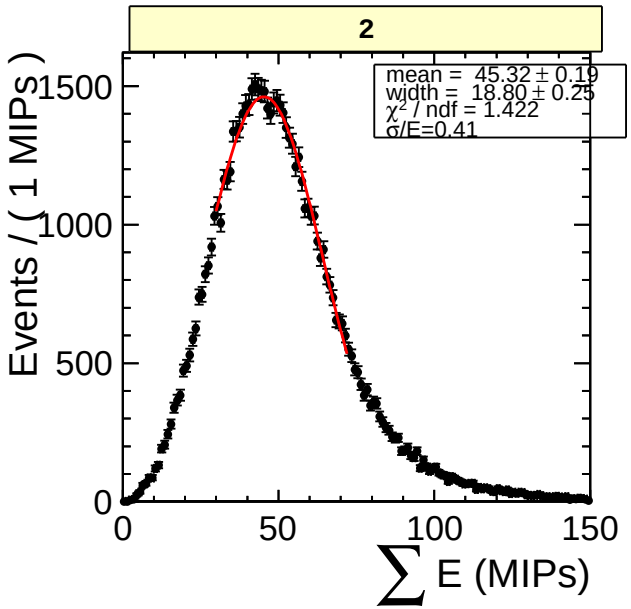
- 2010 data: e^-/e^+ content at $E > 5$ GeV very low, show only up to 8 GeV
- One layer: 10 mm W + $+4$ mm Fe $\approx 3.13\ X_0$
  $\Rightarrow$ expect "worse" EM resolution
- Fit: $\frac{\sigma}{E} = \frac{a}{\sqrt{E}} \oplus b$
- Noise term to be added
- Not final numbers

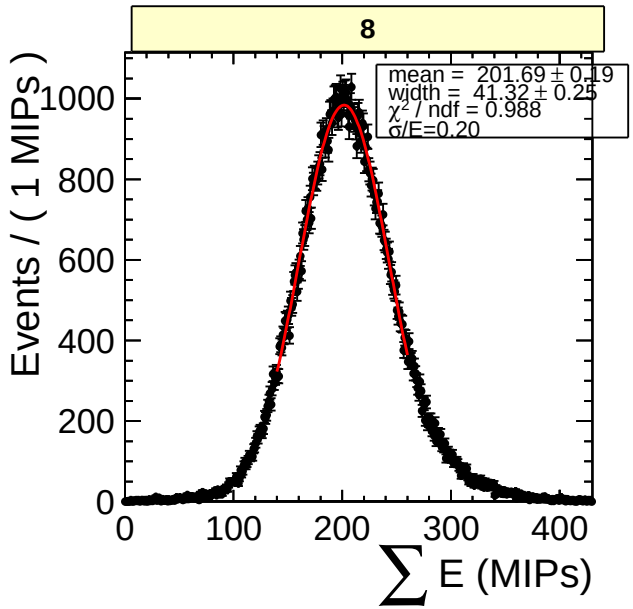


2010: Selection of π events









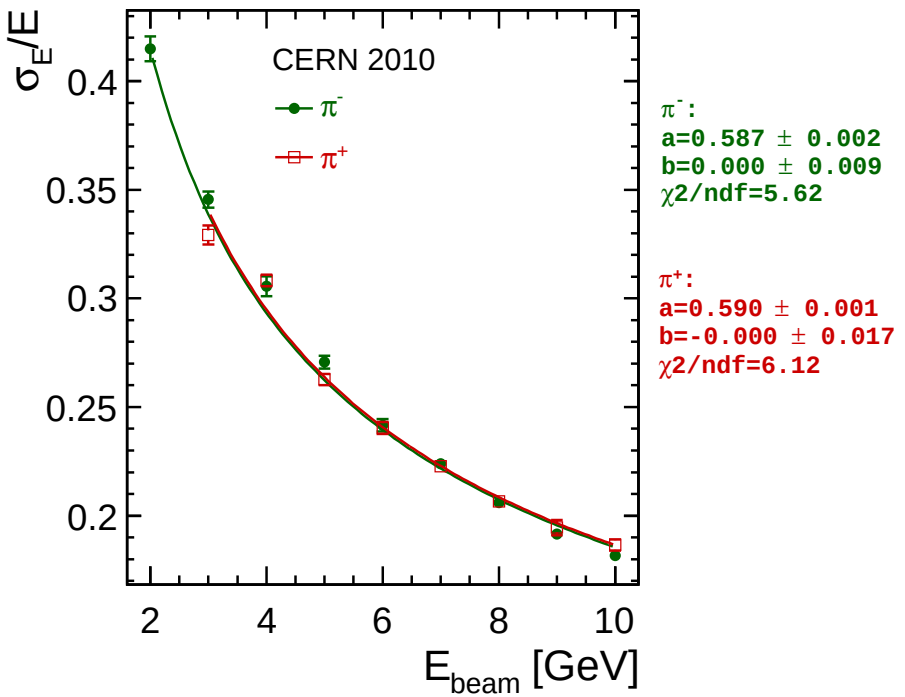
2010: π^-/π^+ energy resolution

Fe-AHCAL

- One layer: 20 mm Fe $\approx 0.1\ \lambda_I$
- CAN-035 Without software compensation $\frac{\sigma}{E} = \frac{57.6\%}{\sqrt{E}} \oplus 1.6\% \oplus \frac{0.18}{E}$

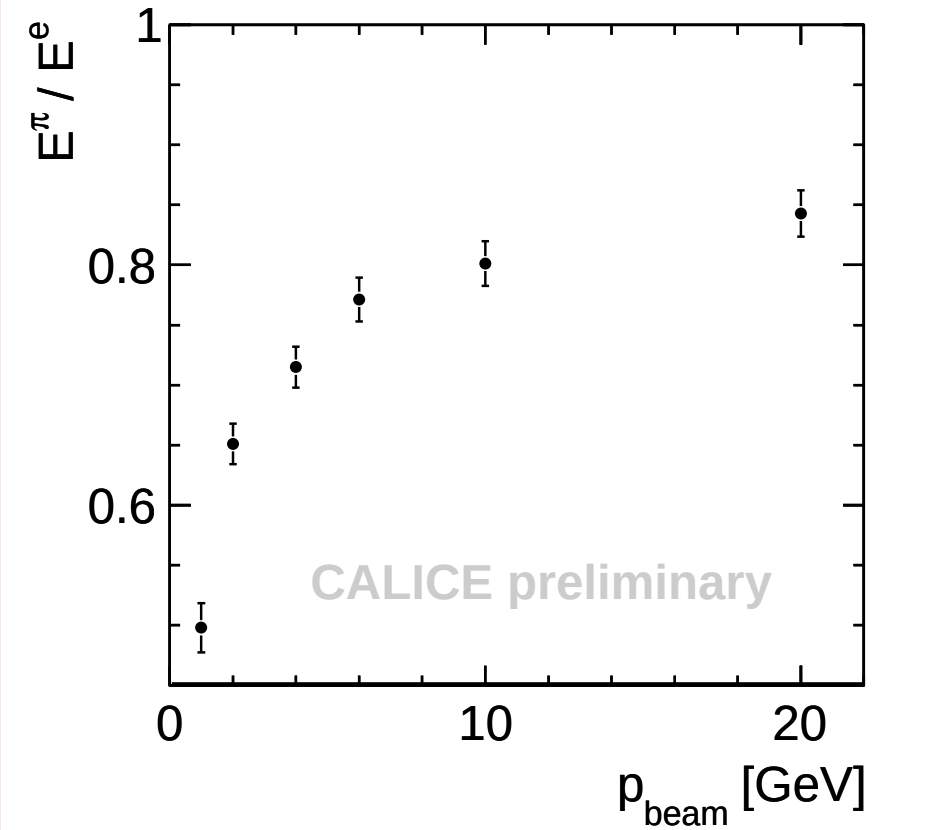
W-AHCAL

- One layer: 10 mm W + +4 mm Fe $\approx 0.1\ \lambda_I$
  $\Rightarrow$ expect similar π resolution
- Fit: $\frac{\sigma}{E} = \frac{a}{\sqrt{E}} \oplus b$
- Not final numbers

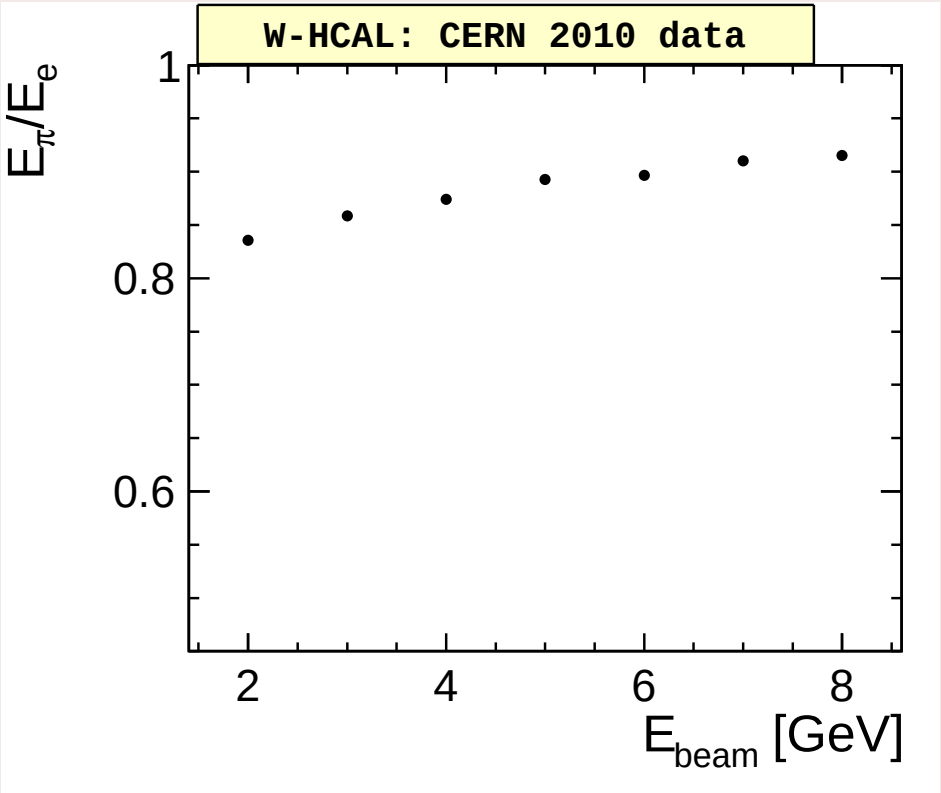


2010: π/e ratio

Fe-AHCAL (▸ CAN-034)



W-AHCAL



- Errors: statistical only (not visible)

Summary and conclusions

- Cleaning of MIP fits/constants done
- Developed tools for measuring MIP slopes per layer
- Problematic AHCAL layers (25-30) when looking at the muon energy vs temperature:
  - 2010: separate bands for pure muon runs and mixed runs
  - 2011: effect due to a few very central tiles, present for almost all the runs
- Energy resolution:
  - Electrons: lower than for Fe-AHCAL (as expected)
  - Pions: comparable to Fe-AHCAL
  - Protons and kaons: to come
- Comparisons with Monte Carlo: on the way
- You can follow developments by looking at the W-AHCAL analysis meetings on the CERN indico page: ▸ http://indico.cern.ch/categoryDisplay.py?categId=2533

Backup

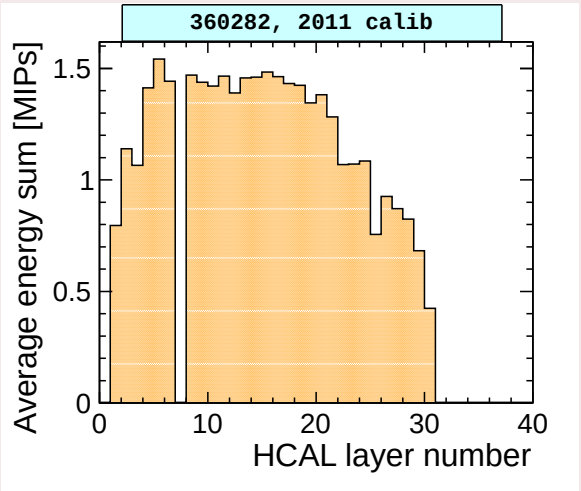
Muon selection improved

Improved muon selection with additional cuts (after `PrimaryTrackFinder`):

- Maximum 2 hits per layer
- At least 20 hits in an event
- At least 20 active layers
- Reject punch-through pions with: $energyPerLayer < 3 \cdot median$, where $median = TMath :: Median(30, energyPerLayerArray)$

▸ Go back to talk

W/O cuts



With cuts