The CALICE Tile HCAL

Preliminary Testbeam Results from CERN

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LCWS
2. June 2007

Tile HCAL – Electrons – Pions

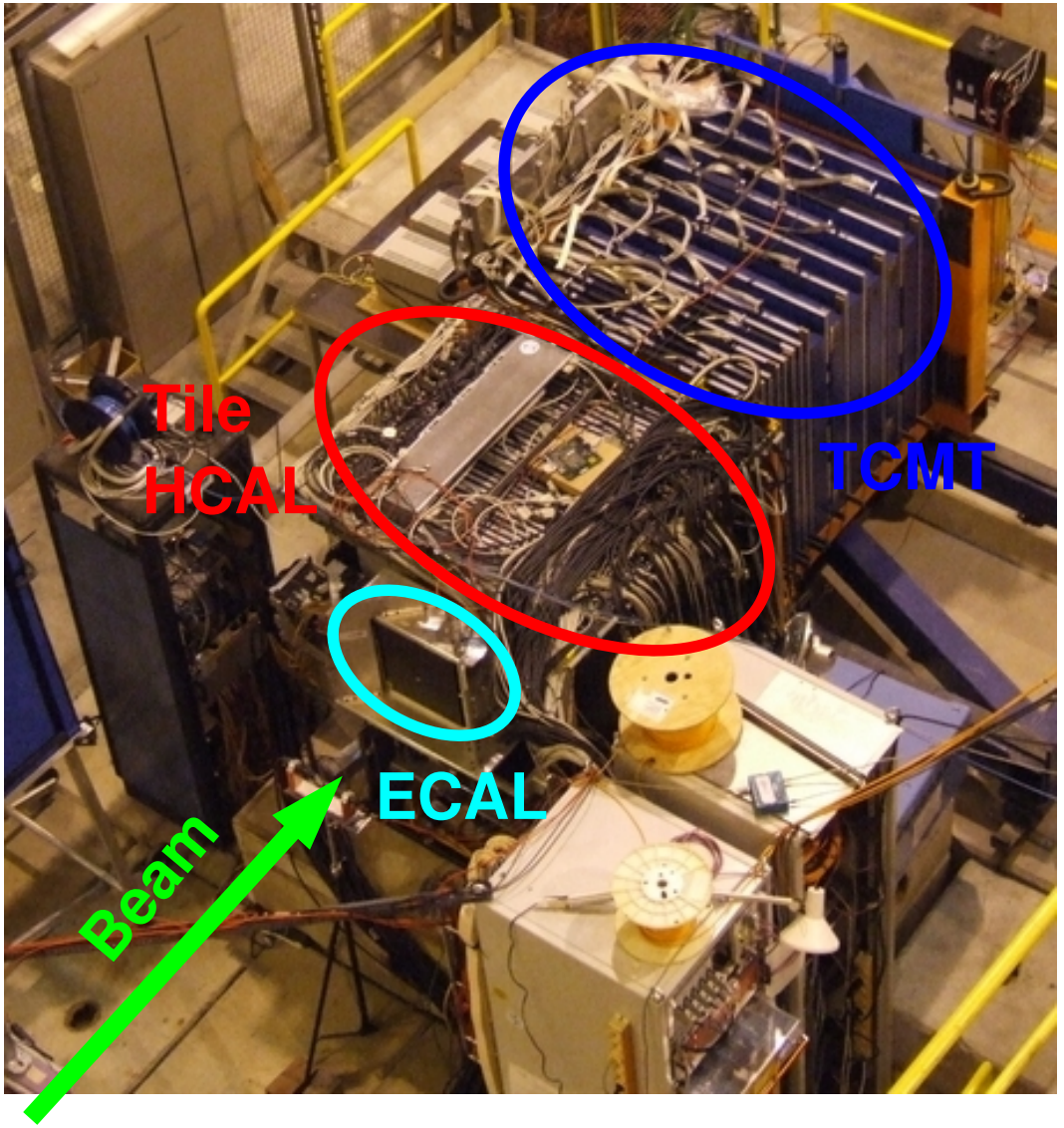
CALICE @ CERN 2006

Testbeam installation with Si-W ECAL, tile HCAL and TCMT

Additonal instrumentation: Ĉerenkov counter, veto scintillator, drift chambers

Pions/electrons from 6 – 80/50 GeV

2x two weeks data taking in summer/fall 2006 with 135M events recorded

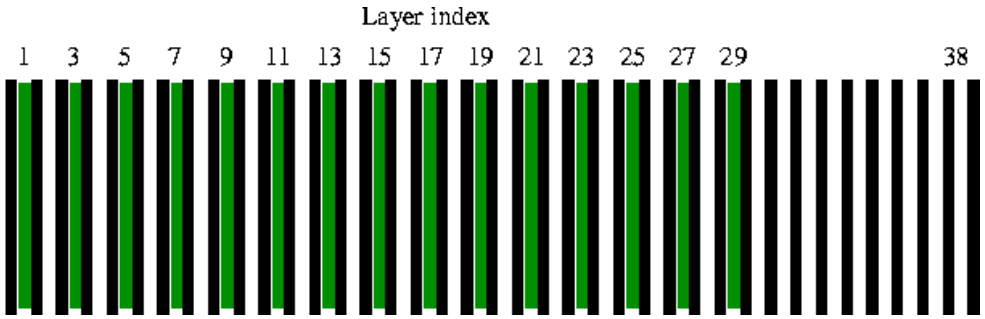


Tile HCAL

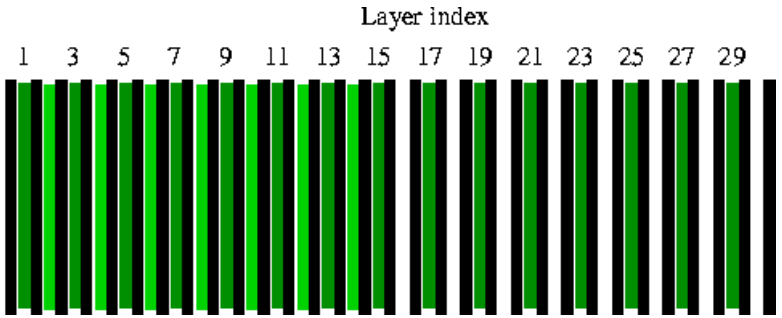
3240/4968 Channels in 15/23 Modules of 216 scintillator tiles with individual SiPM readout

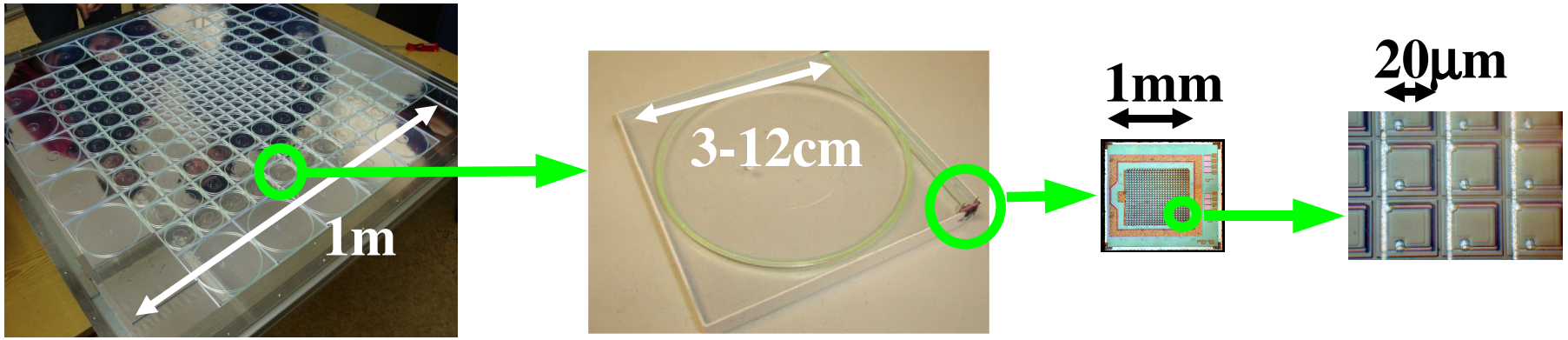
Depth of ~3.5 Λ_0 is instrumented

08/09.06



10.06





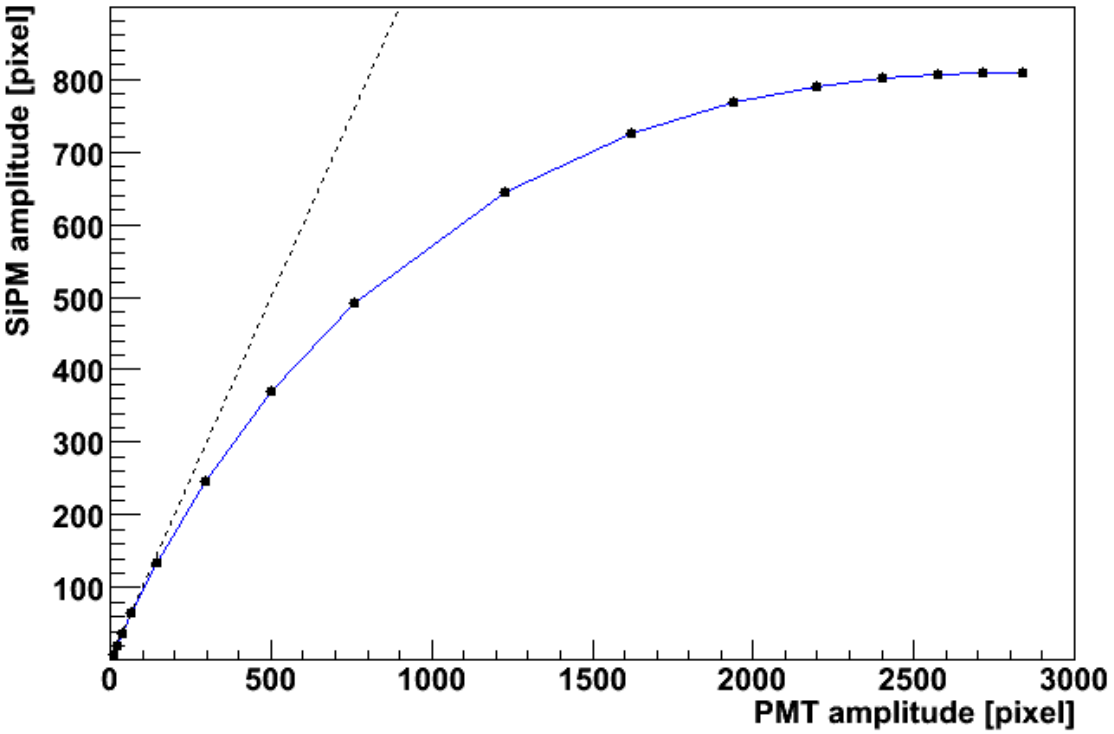
Saturation Correction

SiPM are non-linear due to limited number of pixels plus dead-time

Correction is done with saturation curves measured for each device

Natural scale of saturation is amplitude in pixel

SiPM allow observation of single pixel peaks ⇒ gain calibration from data with light from LED monitoring system



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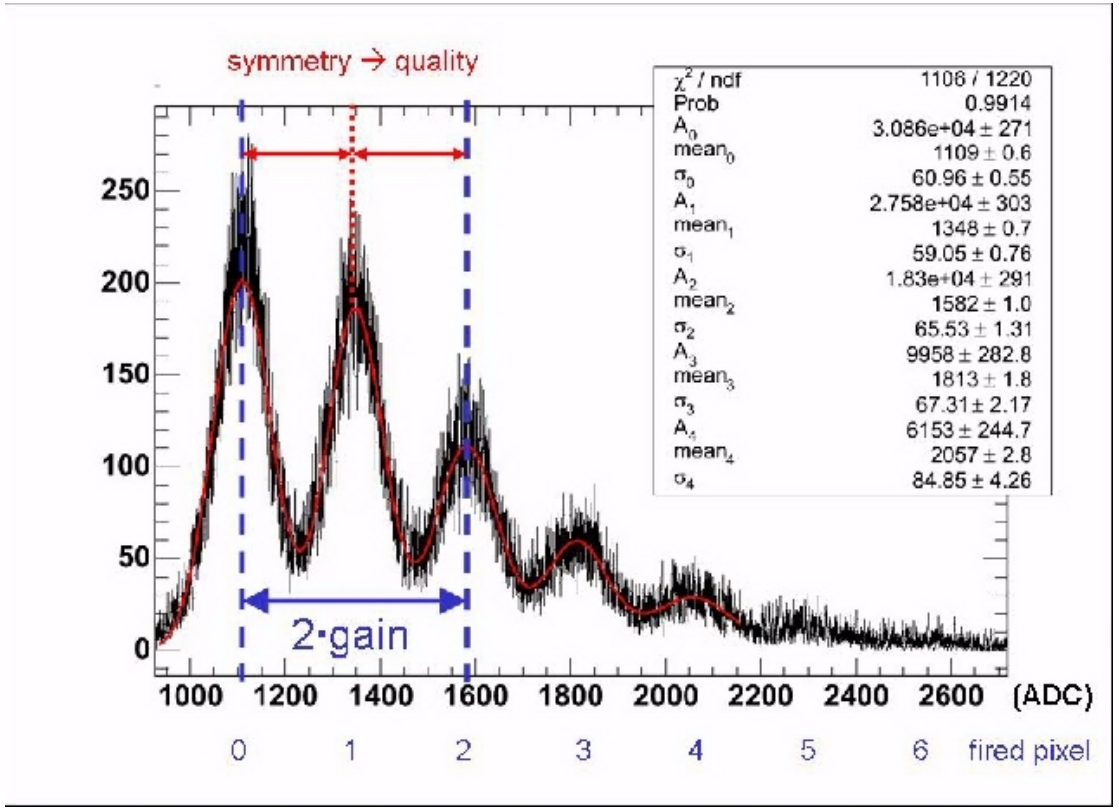
Gain uncertainties only affect size of correction



Mip Calibration

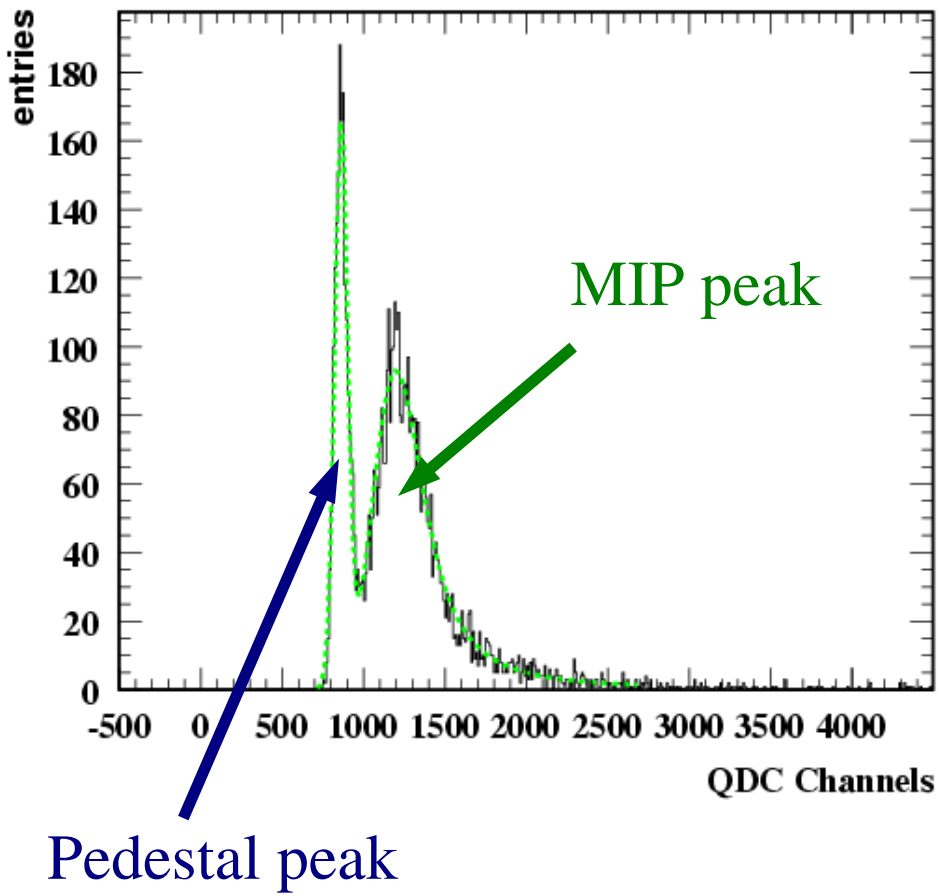
Equalization of all channels done by simple physics process:
Response to passage of minimum ionizing particle

Mip is energy scale and is also accessible in MC

Zero-suppression:
reject hits below 0.5 Mip

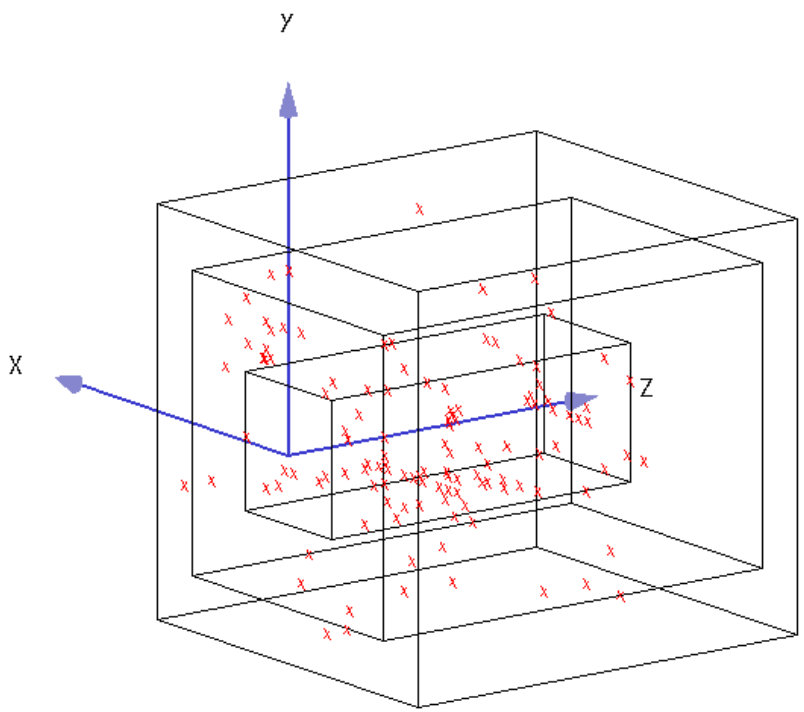
Calibration at CERN:
muons in parasitic running

Mip uncertainties directly affect reconstructed energy



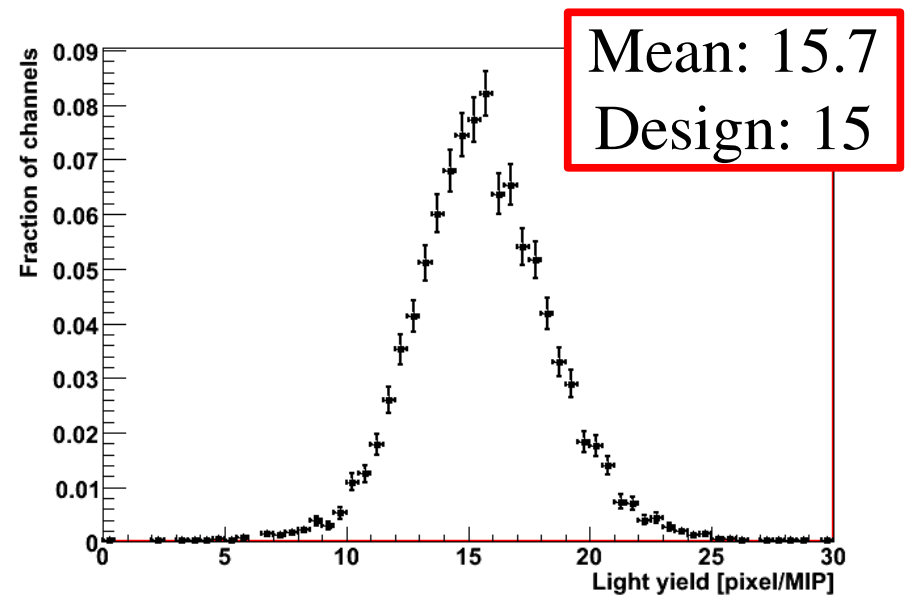
Calibration Summary

	Channels	Mip good	Gain good	Unused
Aug./Sep.	3240	3177	3132	123
October	4968	4639	4818	347



Unused channels in August

Ratio Mip and gain calib. in October

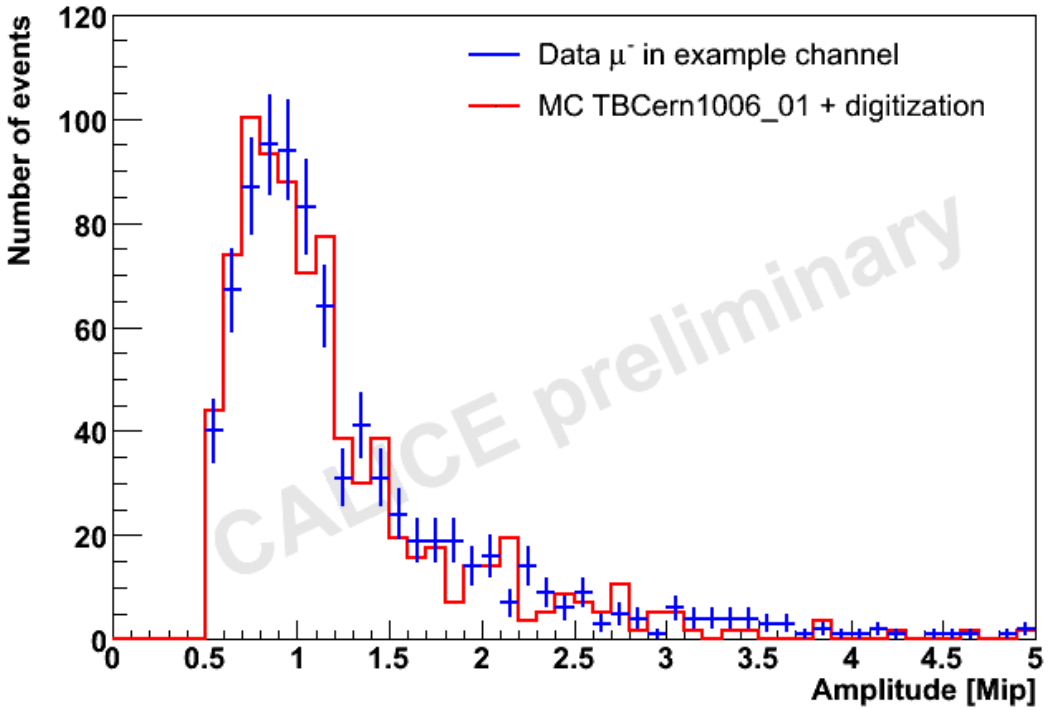


MC Simulations

GEANT 4 / Mokka to simulate energy deposition
+ simulation of light cross-talk and saturation
  using channel-by-channel calibrations and saturation curve
+ overlay of random trigger event
+ same reconstruction as data

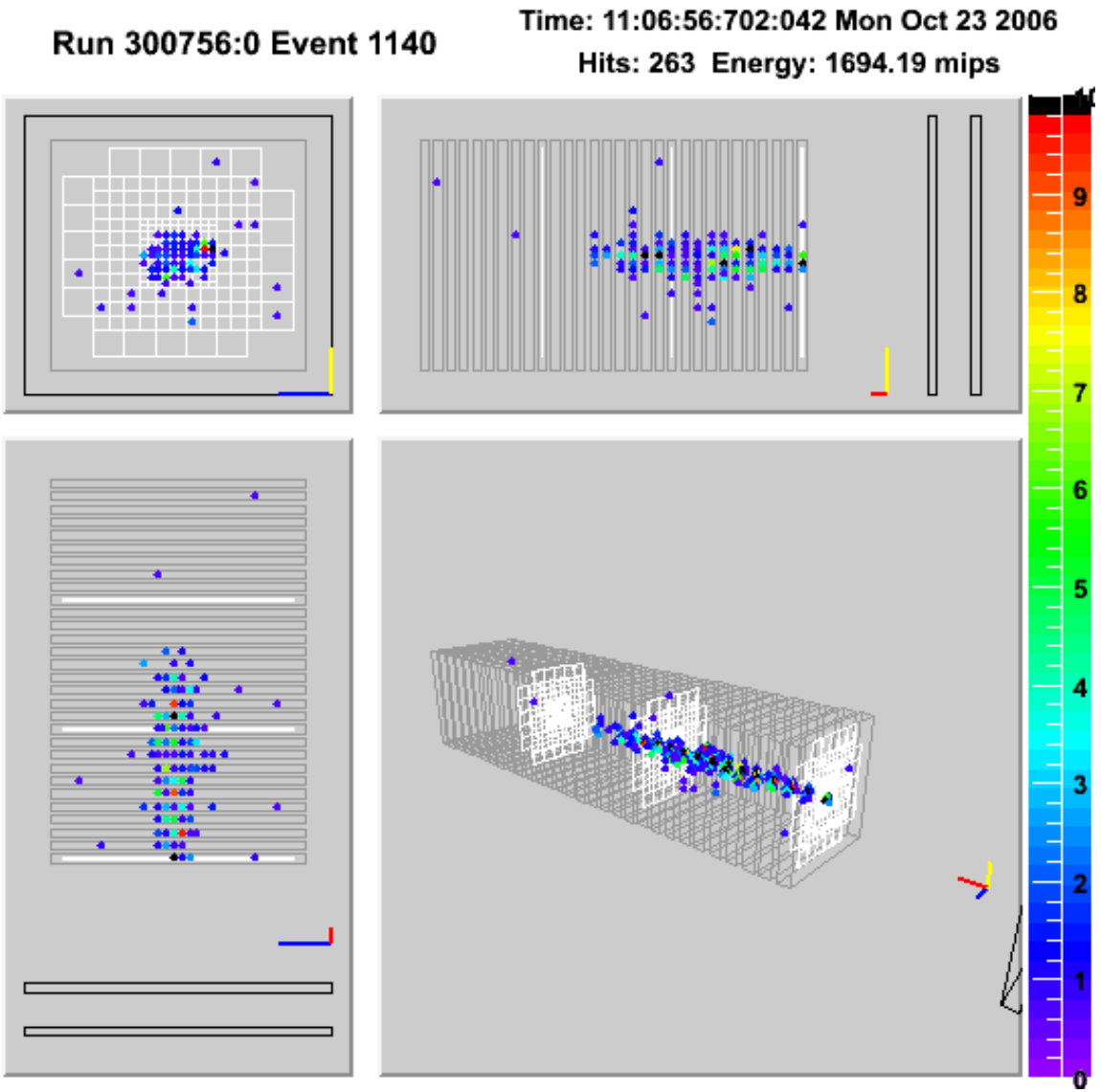
Good agreement between data from muon beam and simulations for individual channels

MC after reconstruction: 'correct' calibrations and saturation correction



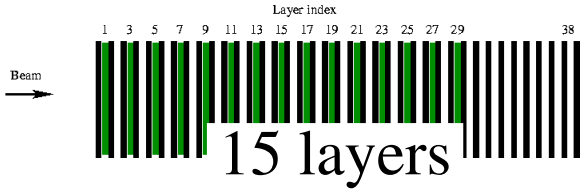
Response to Electrons

50 GeV e^+ shower
in the online display



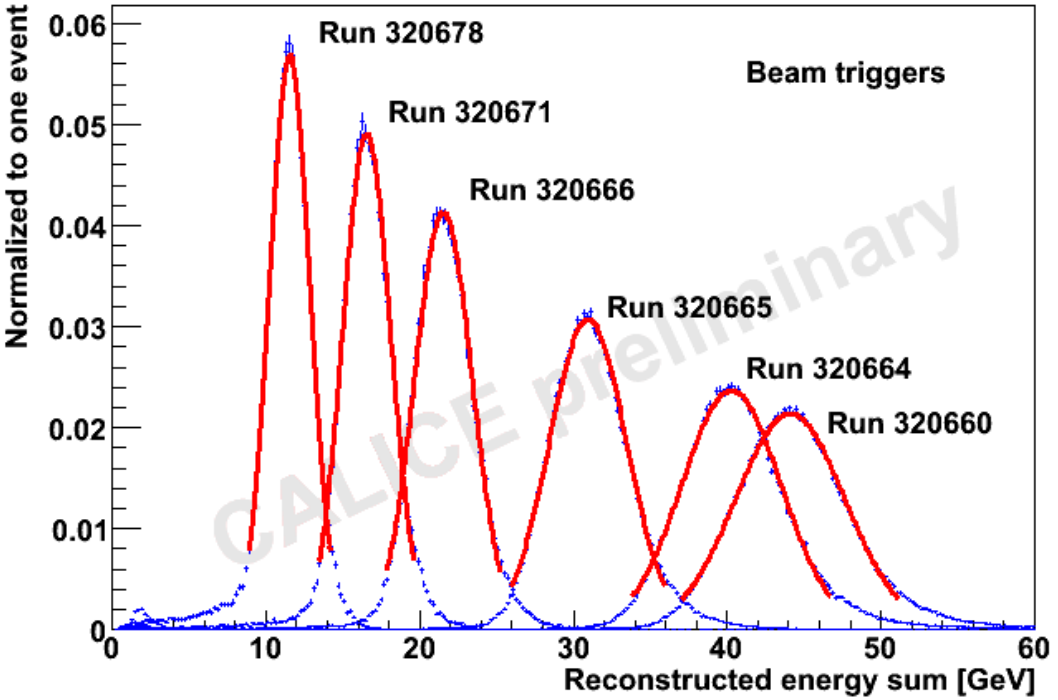
Response to Electrons

Data from first period without ECAL in front, AHCAL with 15 layers in double sampling



Remove hits in uncalibrated cells and all hits below 0.5 Mip

Reconstruct energy sum of whole AHCAL, fit mean response



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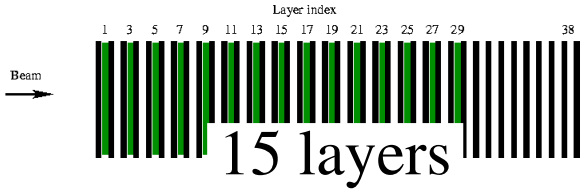

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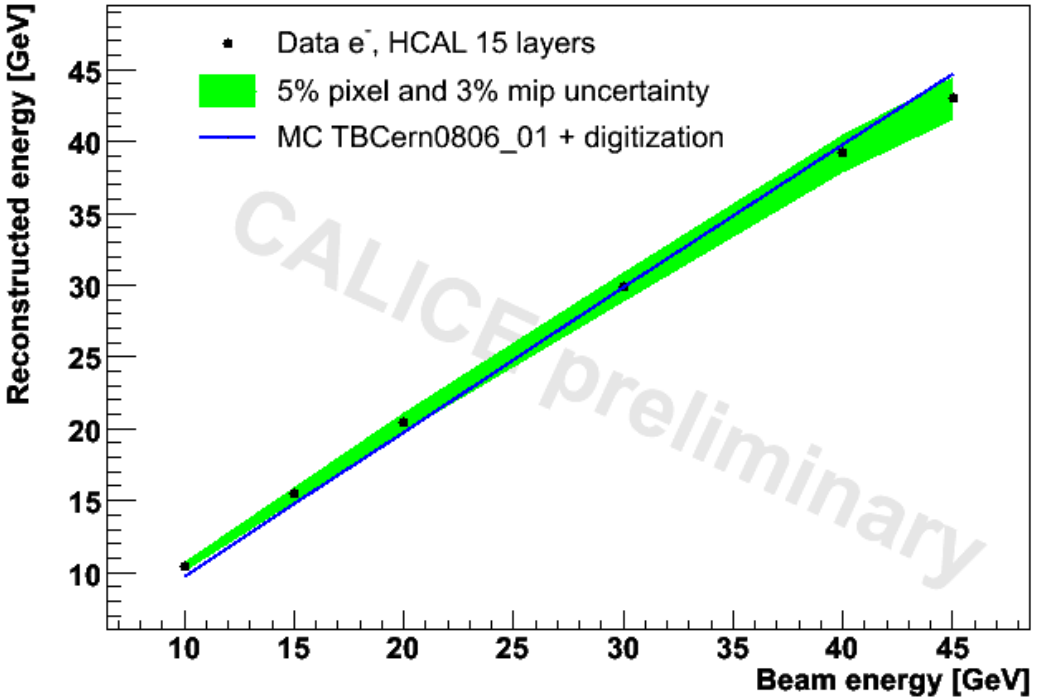
Fix energy scale from difference of 10 GeV and 20 GeV beam

Subtract noise estimate from random trigger events of same run



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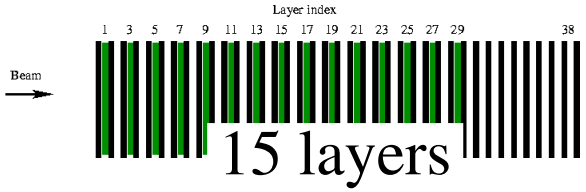

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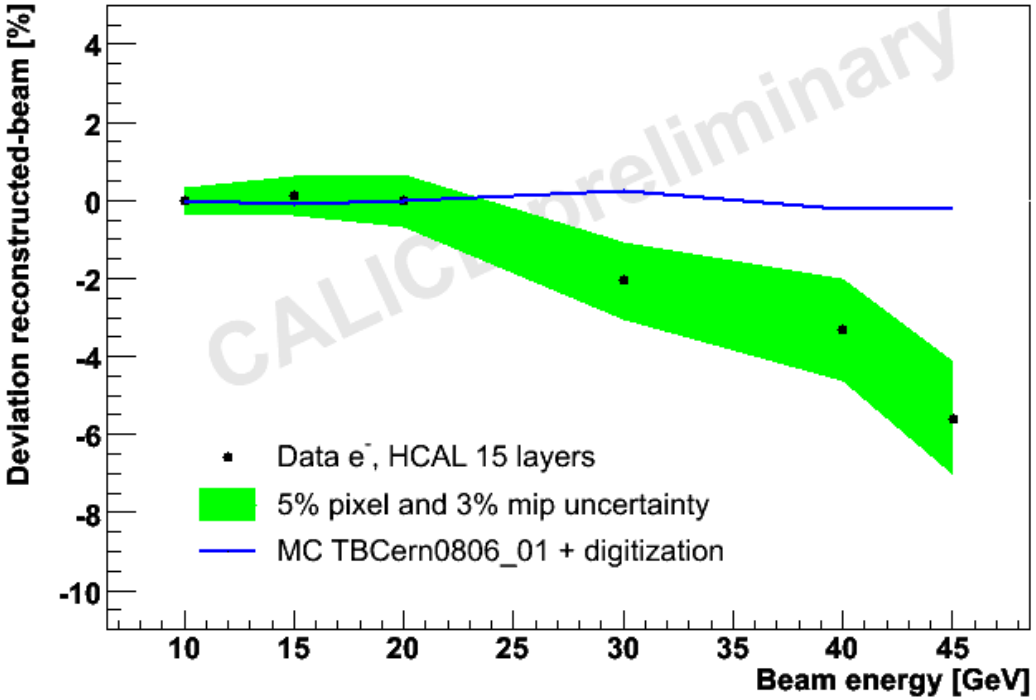
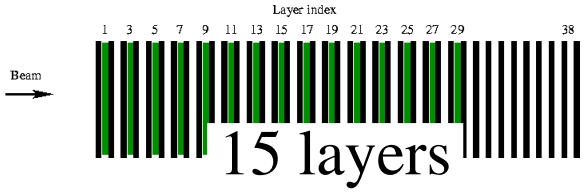
Subtract noise estimate from random trigger events of same run

Linearity better than 6%



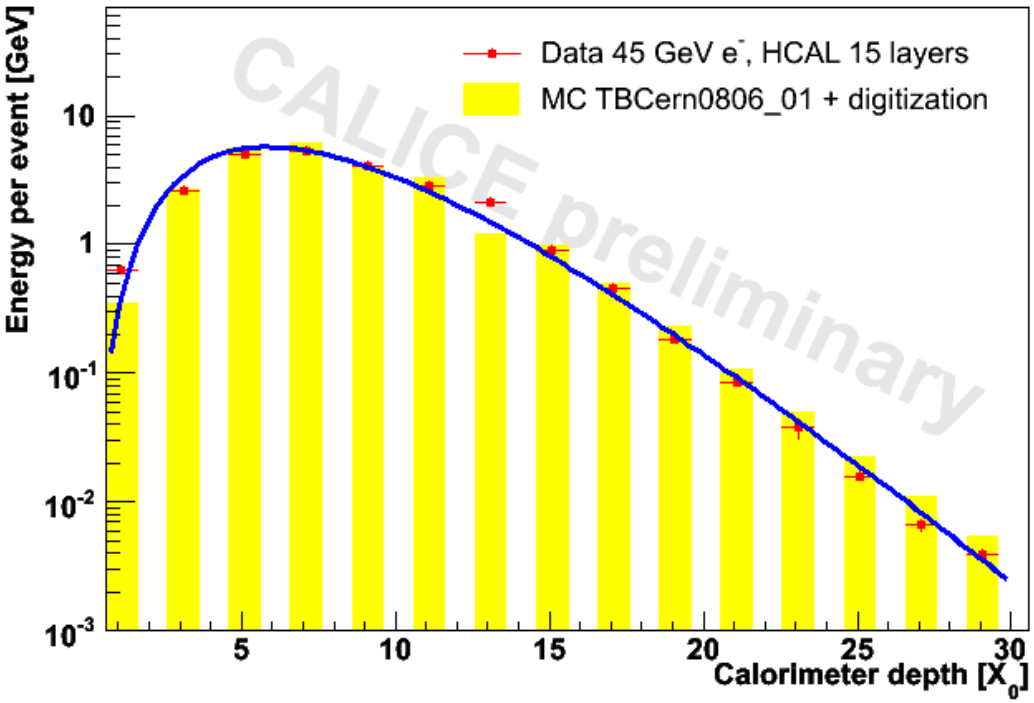
Response to Electrons

Longitudinal energy profile:
example of shower reconstruction

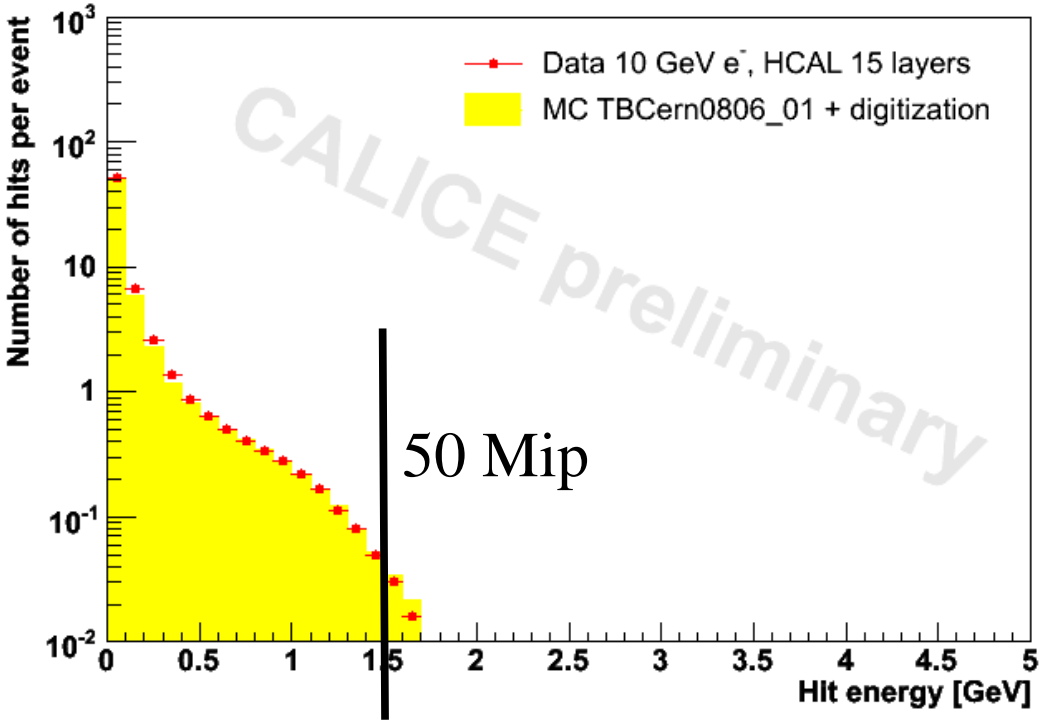


Further corrections needed for detailed shower analysis

- event selection
- omitted cells (leakage)
- remaining non-linearity



Hit Energy Spectra



Perfect data/MC agreement at least up to 50 Mip per hit

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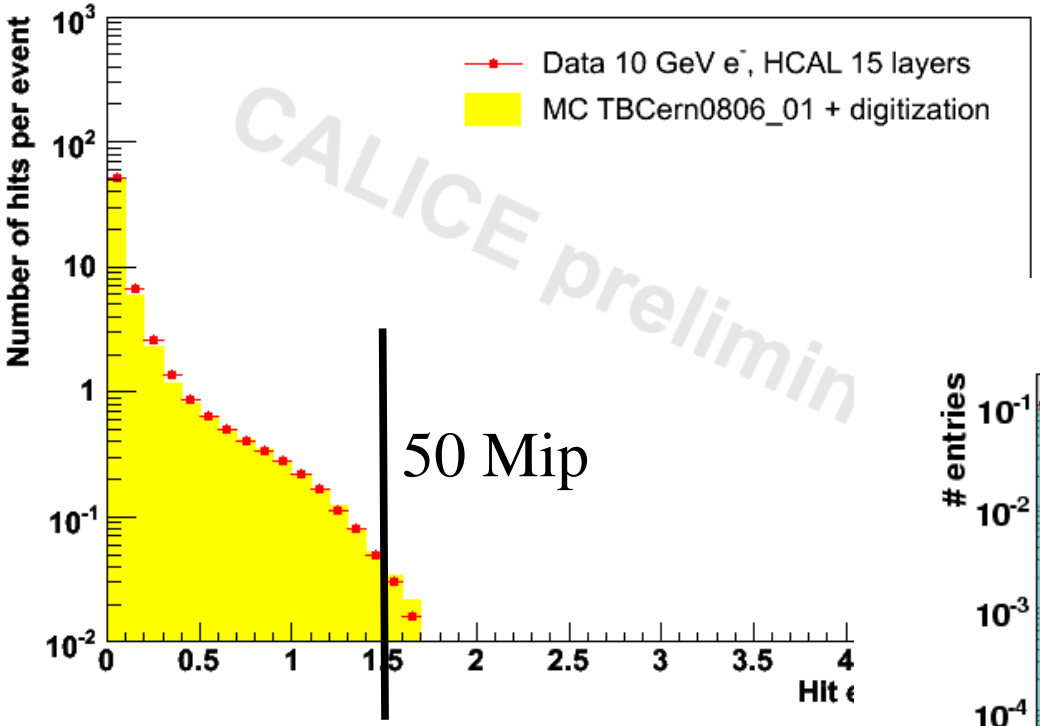
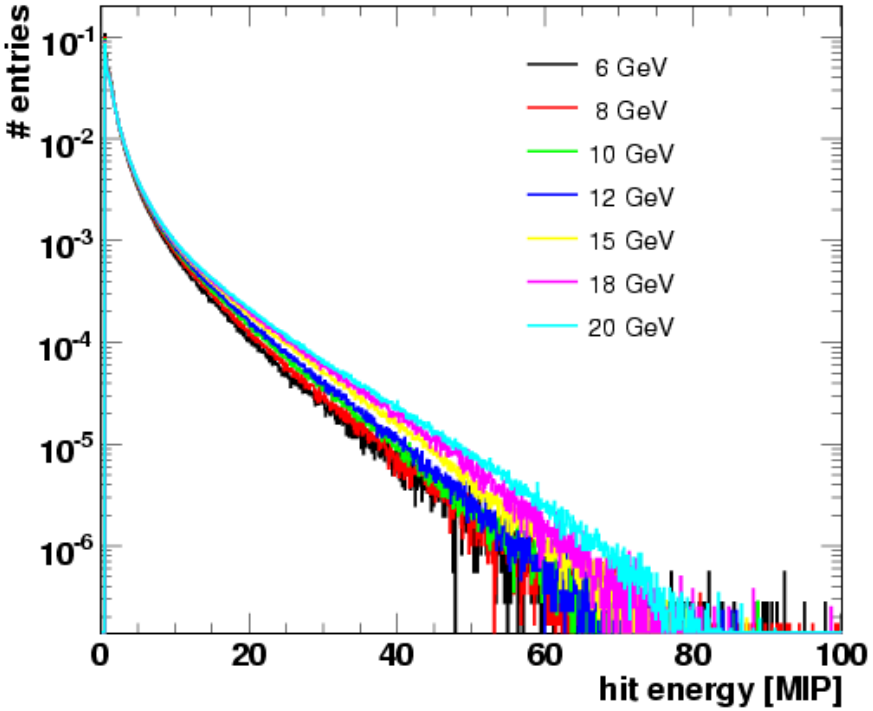


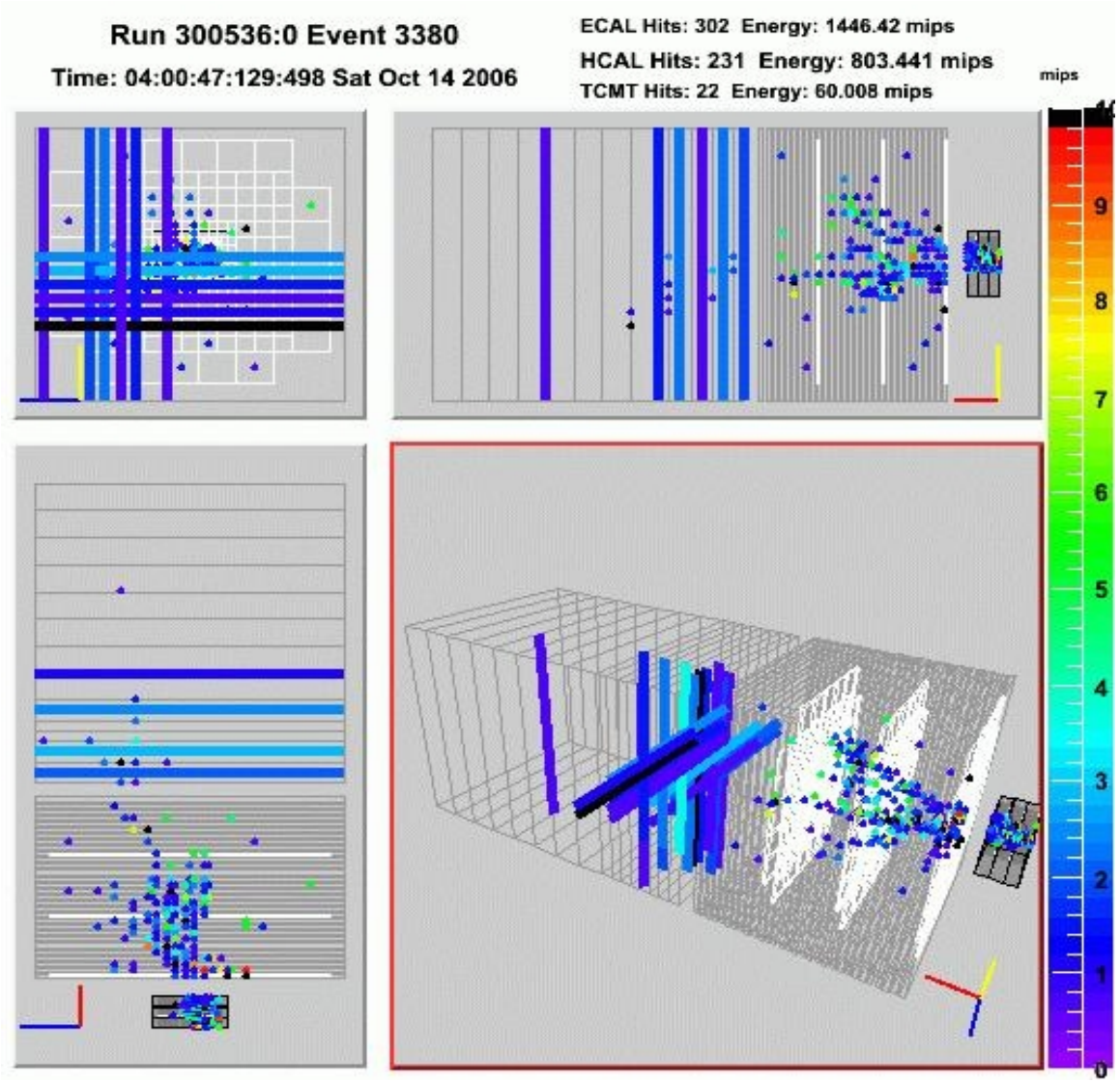


Perfect data/MC agreement at least up to 50 Mip per hit

-> Saturation correction fine for pion data 6 – 20 GeV

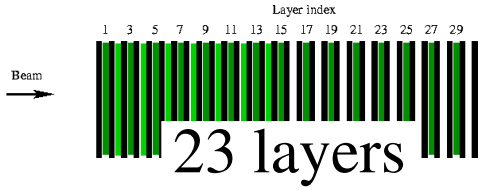
Response to Pions

40 GeV π^- shower
in the online display



Response to Pions

Pion data from October (23 layers) with ECAL

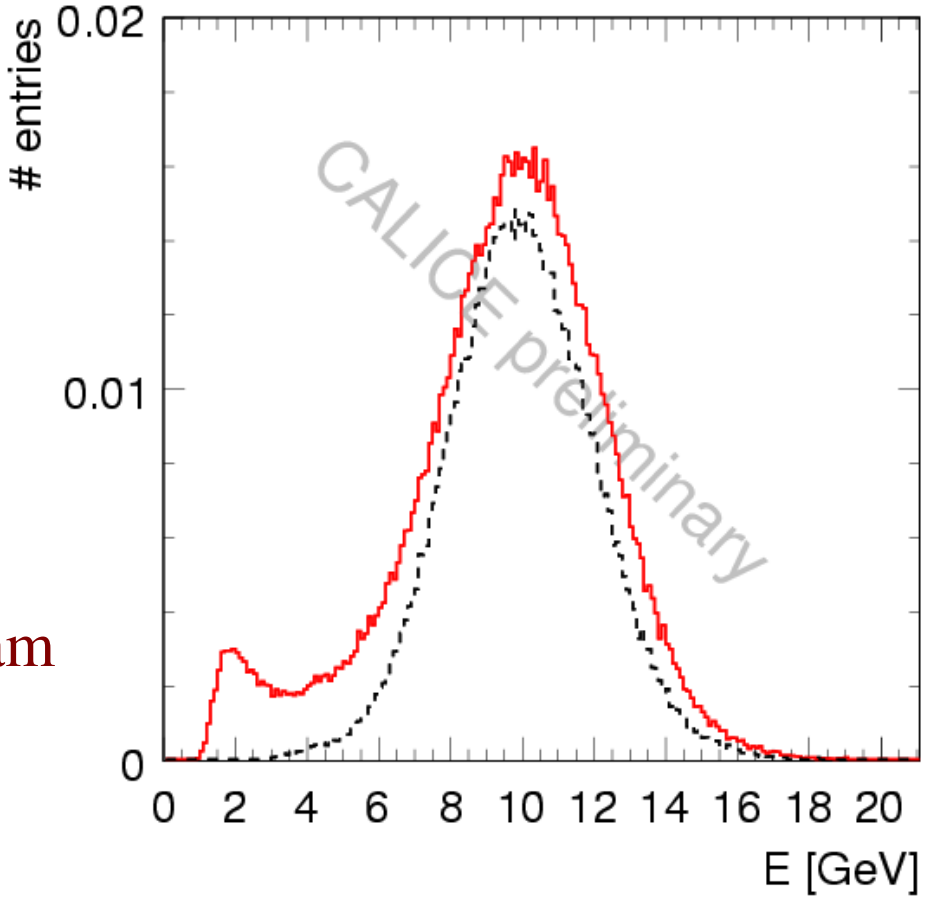


Beam energy 6 – 20 GeV

Cut on ECAL activity to force shower start in AHCAL

Distinguish contained showers (cut on TCMT activity) and all pions in additon

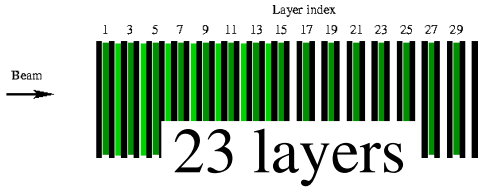
Fix energy scale with 10 GeV beam

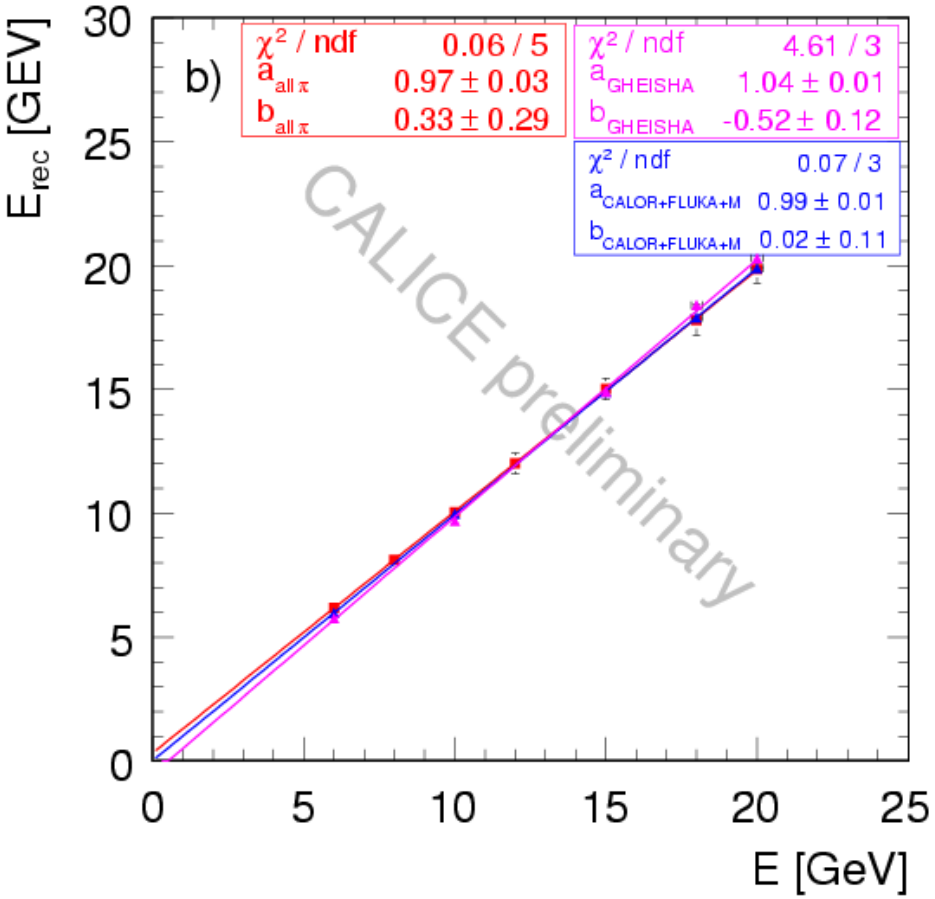


Response to Pions

Energy sum compared between data and MC
– GEISHA (no neutron transport)
– GCALOR+FLUKA+MICAP
(full neutron response)

Linearity established in any case





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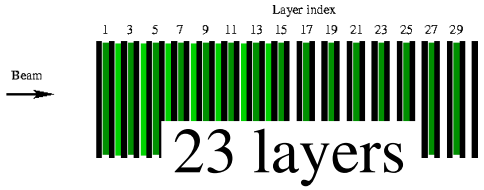
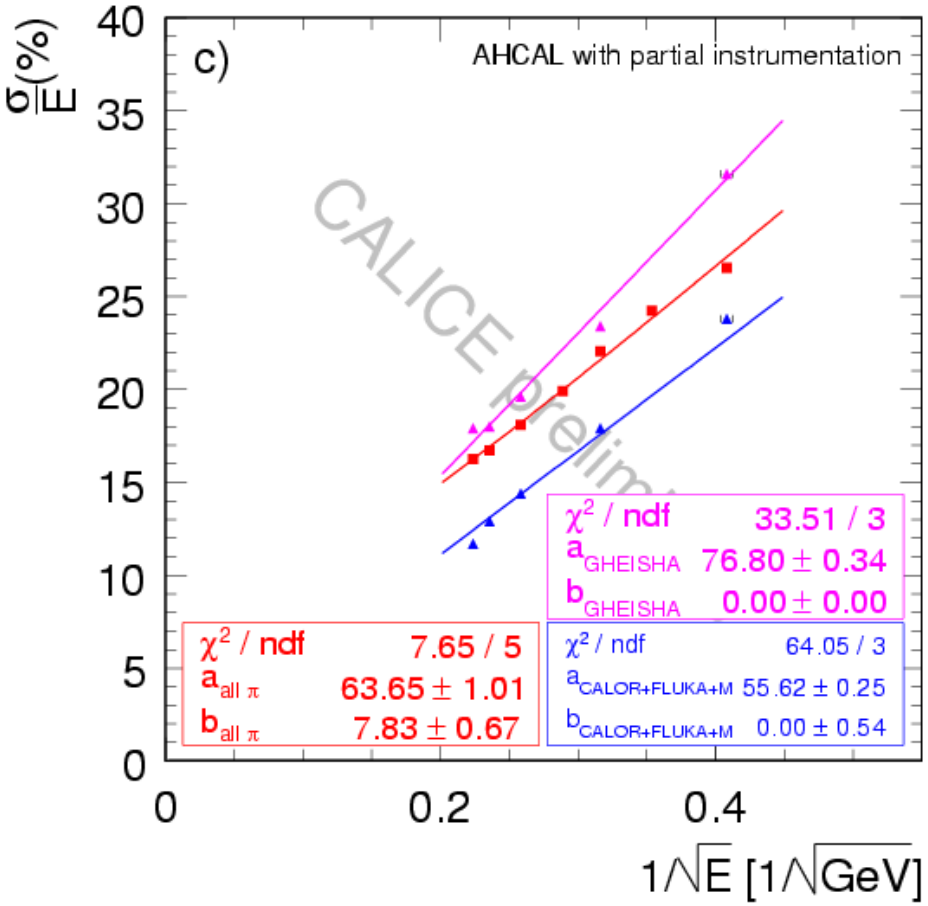


Linearity established in any case

Not fully instrumented, linearity correction only, MC not digitized

- Energy resolution in correct ballpark, but not conclusive, yet



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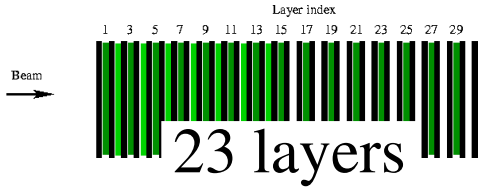

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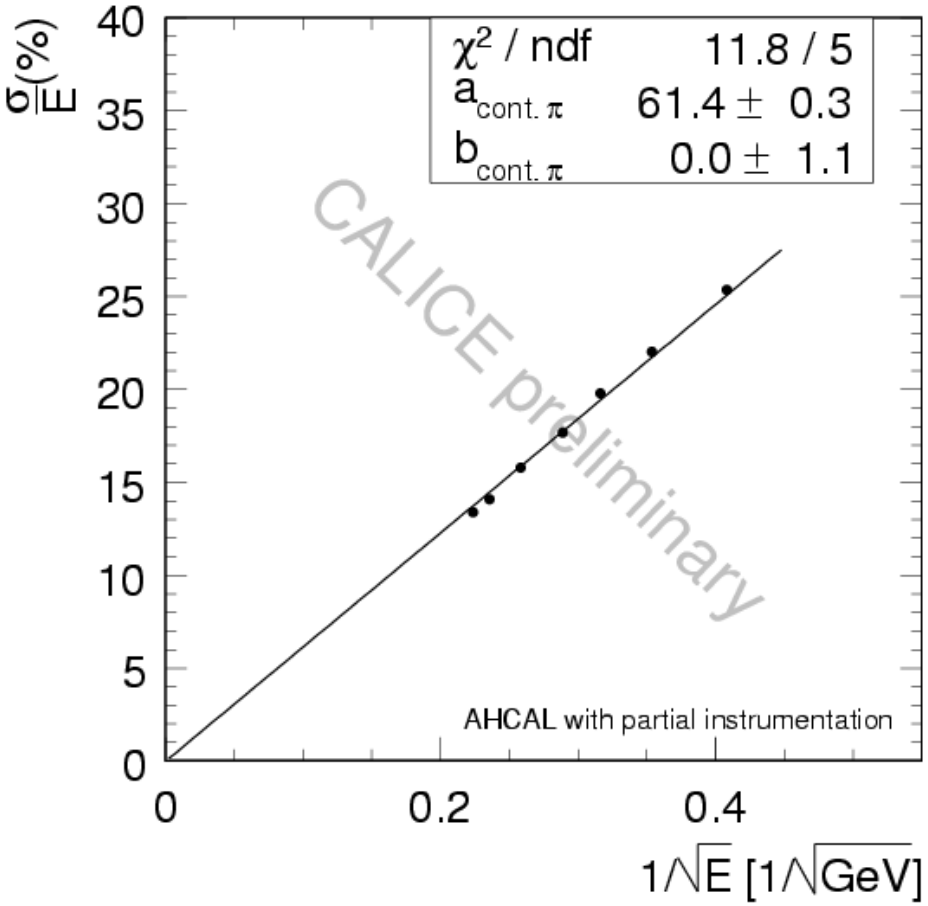
Linearity established in any case

Not fully instrumented, linearity correction only, MC not digitized

- Energy resolution in correct ballpark but not conclusive, yet
- No constant term for contained pions however proofes that the technology is under control



Conclusions

Detailed detector and MC studies with well understood EM showers

- Calibration procedure established for large scale prototype
- Sufficient understanding of SiPM response and saturation correction
- Proof-of-principle of MC digitization
- Further corrections (e.g. leakage from unused cells) under study

Preliminary analysis of pion beam data promising

- Non-linearity correction relyably under control
- Only partly instrumented, so no conclusive results on resolution
- Technology is under control and viable for hadron calorimetry

Future plans

- Optimize reconstruction for realistic results on shower as a whole
- Improve resolution by shower decomposition and reweighting
- And of course continue data taking with full detector...

Backup

Response to Pions

Longitudinal shower development lead to similar conclusion as EM showers:

- general trend is as expected
- Detailed exploration of additional corrections needed for quantitative results