

AHCAL analyses overview

Erika Garutti

List of ongoing analyses targeted to the upcoming publications

List of upcoming publications

short term (<6 months)

- 1) HCAL response to muons (Andrea, BORIS, Lars)
- 2) HCAL response to electrons (Nanda, SERGEY, Philipp)
- 3) Digitization and EM validation (KATJA, Sergey)

medium term (<1 year)

- 4) AHCAL hadronic resolution (Katja, FRANK)
- 5) Pion shower profile analysis (ANGELA, Alex, Beni, Riccardo)
- 6) Pion/Proton shower analysis (MARINA, Beni)

longer term

- MC validation (Beni, ALEX, Nils)
- Shower leakage (BENI, Kurt, Ivan)
- Low energy pion (NILS)
- Shower separation (SANDRA)
- Deep analysis of hadron showers (Sergey)

1) AHCAL response to muons

Calibration:

- Cell equalization using MIP signals (CERN+FNAL data)
 - efficiency of MIP detection, detector noise
- T & V dependence of SiPM response (CERN+FNAL data)

Detector response:

- uniformity for muons
- stability in time
- layer by layer alignment using muons

This paper/analysis defines a new calibration set
→ see talk from Nils on status of AHCAL calibration constants
! Thanks to all calibration team for the huge effort !

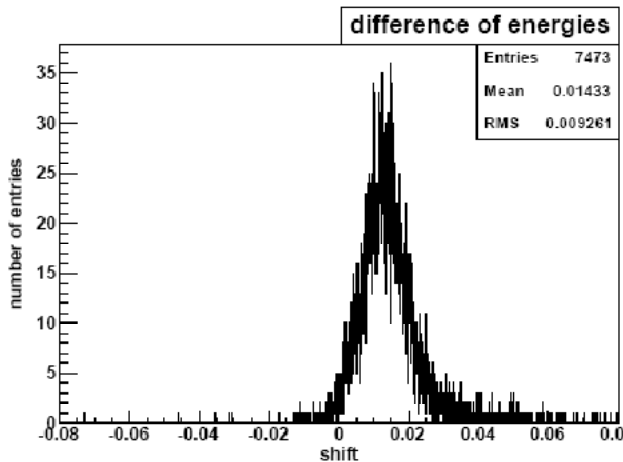
Muon physics:

- Energy and angular dependence of muon response
- Muon production probability in hadronic shower
- ...

1) AHCAL response to muons

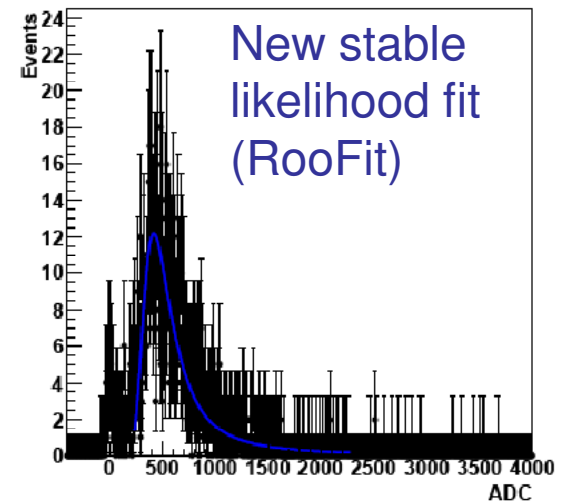
Calibration:

- Cell equalization using MIP signals
 - efficiency of MIP detection, detector noise
- T & V dependence of SiPM response



Comparison to default MIP calibration

- 7473 cell calibrated
- ~3% shift in energy
- <1% spread between constants



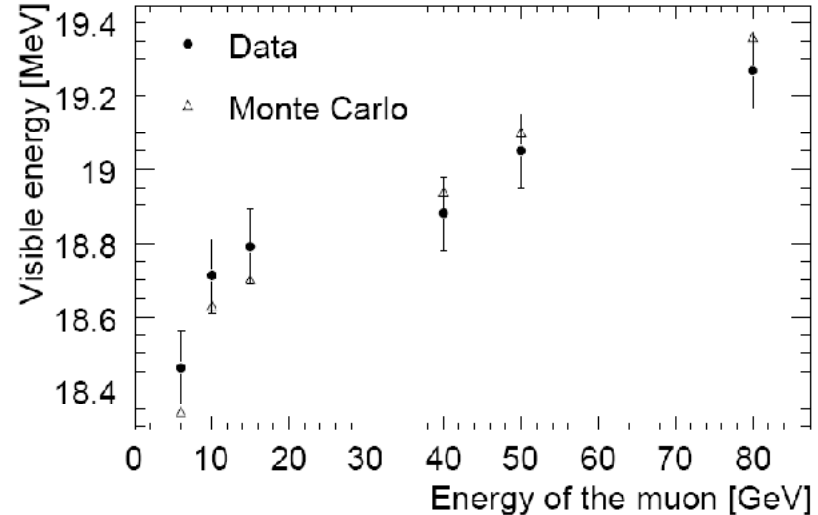
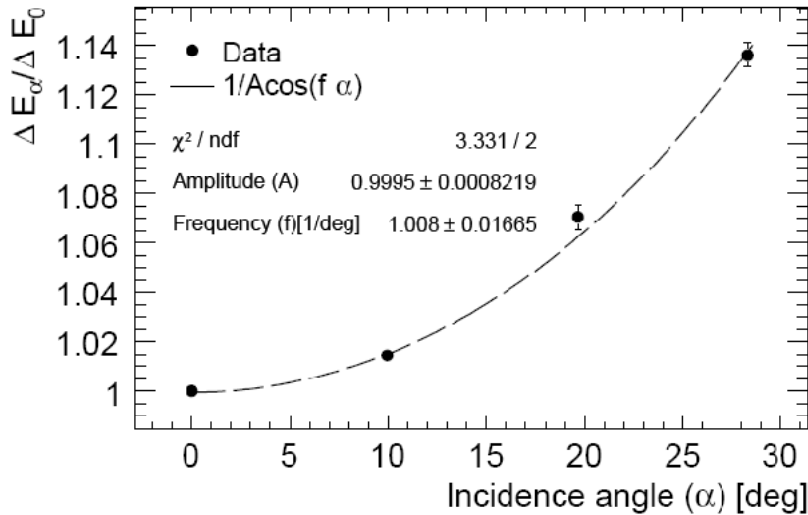
from Boris
(see Nils talk)

temperature slopes ($\frac{1}{A} \times \left. \frac{dA}{dT} \right|_{\frac{\%}{K}}$), comparison with previous

approach	slope	rms of slope	entries(min slope -0.08)
line, CERN2007	-3.5	1.7	6473
line, FNAL2008	-3,7	2.3	6024
line, merged	-3.6	1.6	6378
plane, merged	-3.7	1.2	7031
previous results	-3.7	1.1	-

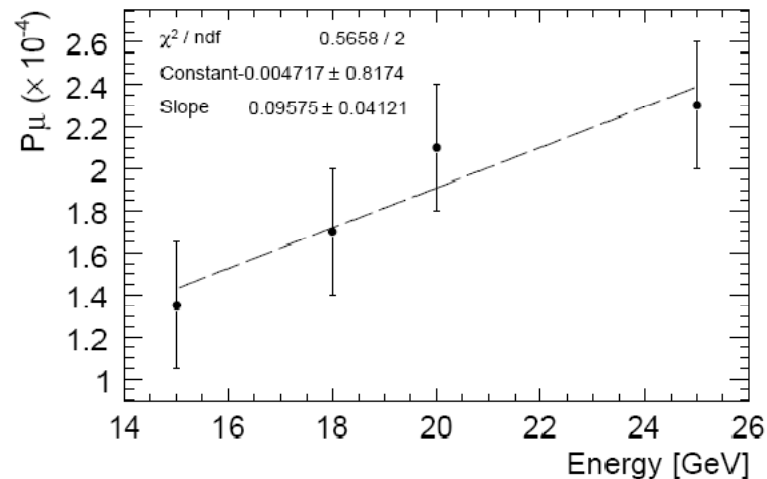
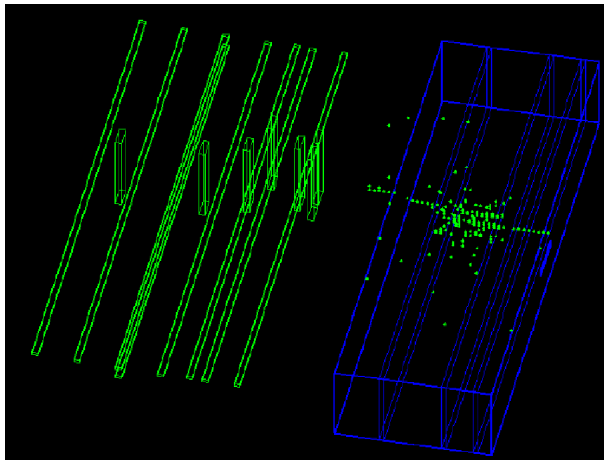
Muon physics

Angular and energy dependence of muon visible energy



from Nicola D'Ascenzo thesis

Probability of muon production in a pion shower



2) AHCAL response to electrons

Calibration to EM scale:

- Saturation corrections

Detector response:

- uniformity of AHCAL core response to electrons
- homogeneity of tiles
- stability in time

Electron “physics”:

- Response linearity
- Lateral and longitudinal profile (w.r.t theory, no MC!)
- angular dependence
- e/mip , e/μ
- ...

Benchmark to establish the final calibration set

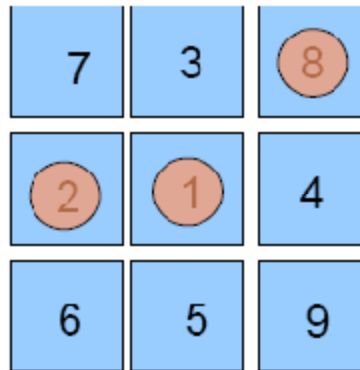
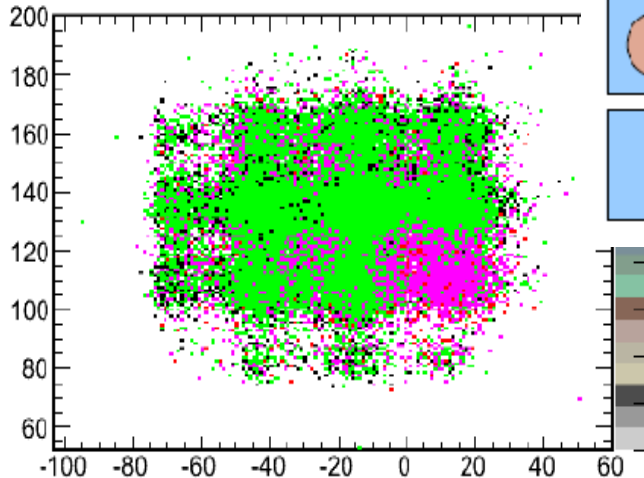
2) AHCAL response to electrons

Calibration to EM scale:

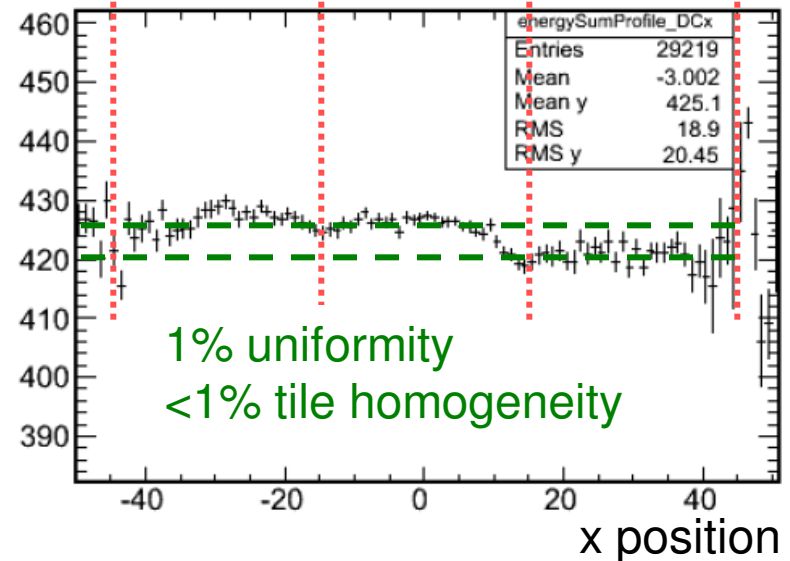
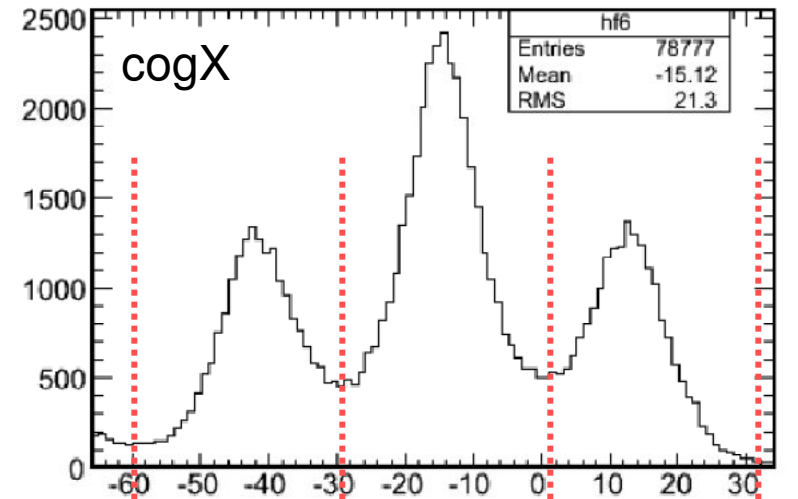
- Saturation corrections
- ➔ new fits from Niels
- ➔ single parameteriz. (Nanda)

Detector response:

- uniformity of AHCAL core response
- homogeneity of tiles
- stability in time



Sergey analysis



2) AHCAL response to electrons

Calibration to EM scale:

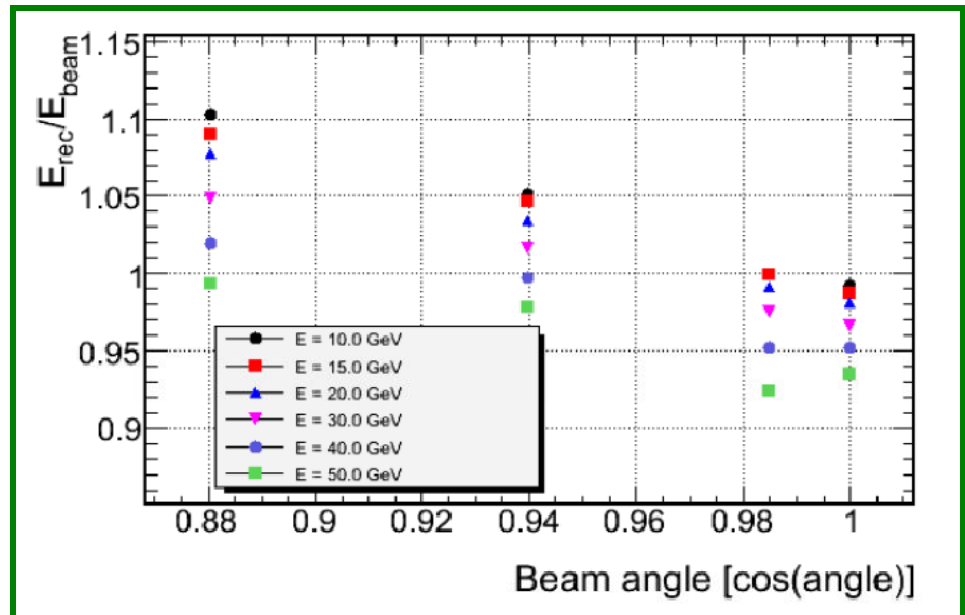
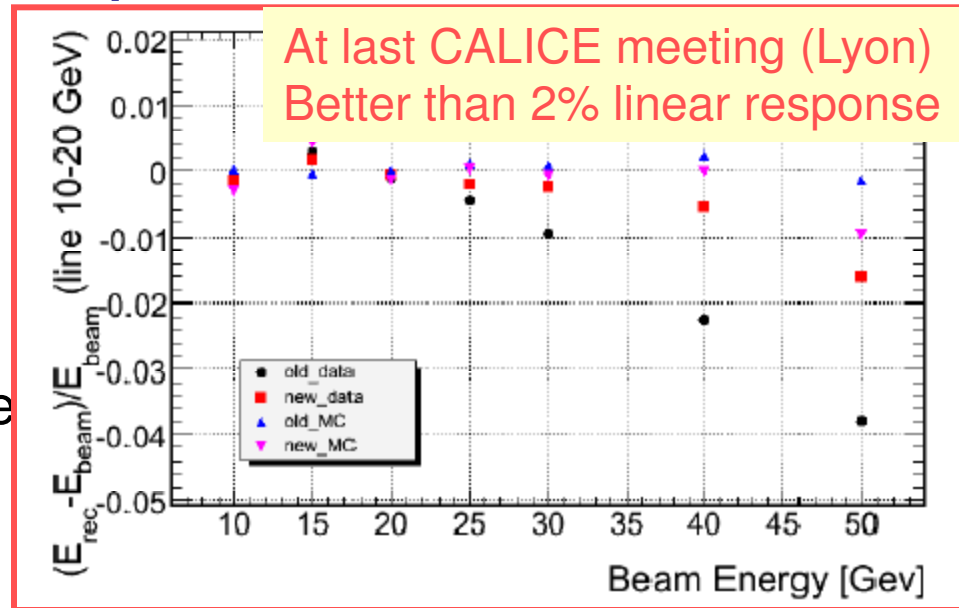
- Saturation corrections

Detector response:

- uniformity of AHCAL core
- homogeneity of tiles
- stability in time

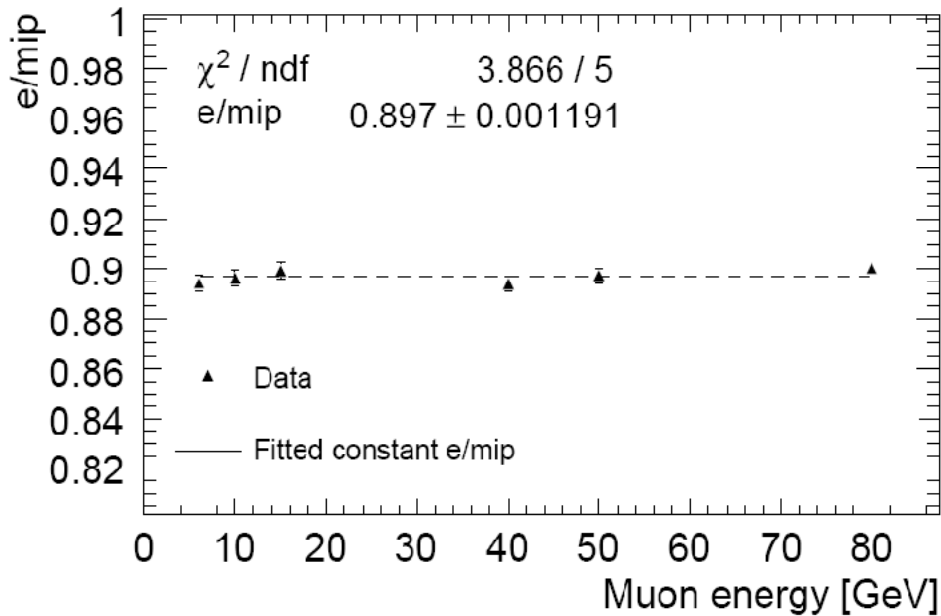
Electron “physics”:

- **Response linearity**
- Lateral and longitudinal profile
- **angular dependence**
- e/mip , e/mu
- ...



2) AHCAL response to electrons

From N. D'Ascenzo thesis



$$\frac{e}{mip} = \frac{Sf_e}{Sf_{mip}} = \frac{\overline{E}_e^{vis} \overline{E}_{mip}^{tot}}{\overline{E}_e^{tot} \overline{E}_{mip}^{vis}}$$

Electron “physics”:

- Response linearity
- Lateral and longitudinal profile (w.r.t theory, no MC!)
- angular dependence
- e/mip , e/mu
- ...

3) Digitization and EM validation

Validation of digitization procedure

- In addition to data calibration chain: energy scale, optical cross-talk, dead channel mapping, noise, additional smearing

Electron “physics”:

- Energy scale
- Lateral and longitudinal profile data/MC
- Energy resolution
- ...

➔ see Katja talk for latest status

3) Digitization and EM validation

Validation of digitization procedure

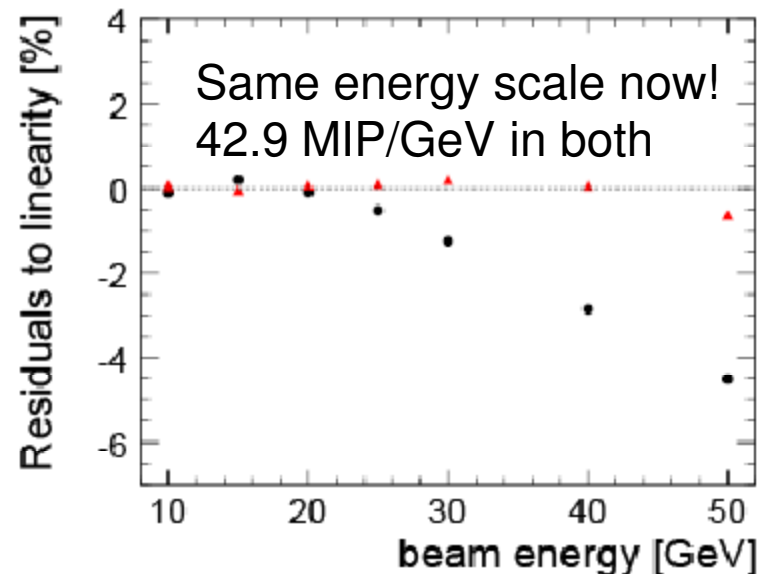
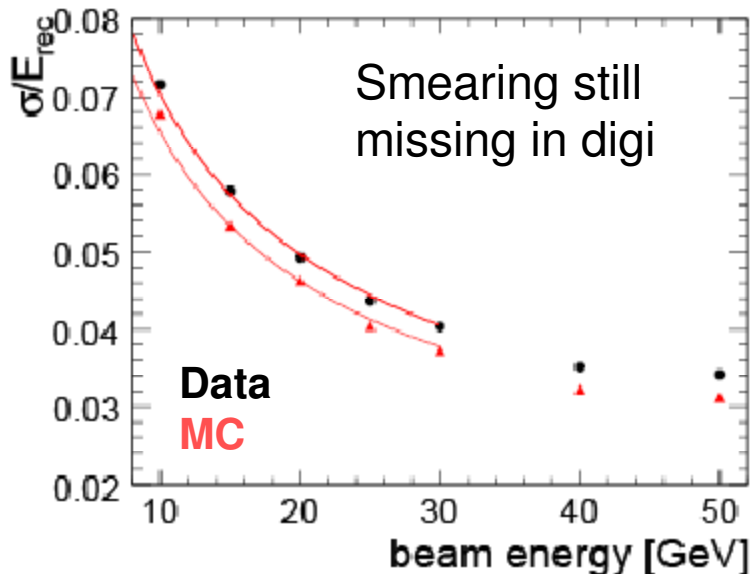
- In addition to data calibration chain: energy scale, optical cross-talk, dead channel mapping, noise, additional smearing

→ many improvements / bug fixes

Electron “physics”:

- Energy scale
- Lateral and longitudinal profile data/MC
- Energy resolution

Katja analysis

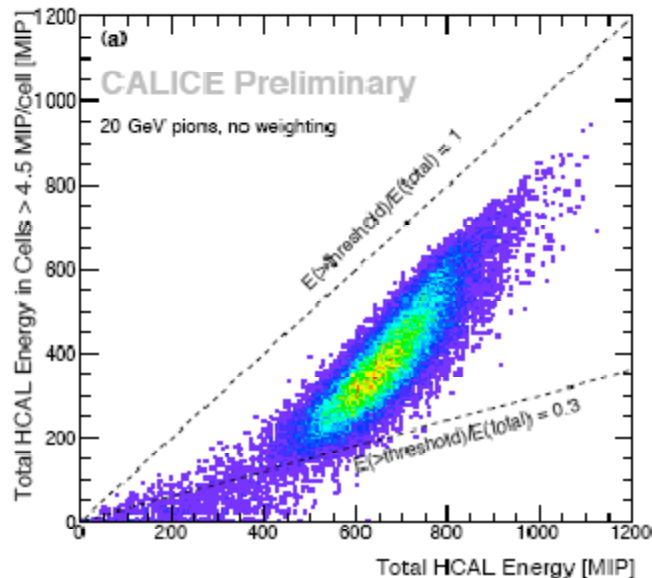


4) AHCAL hadronic resolution

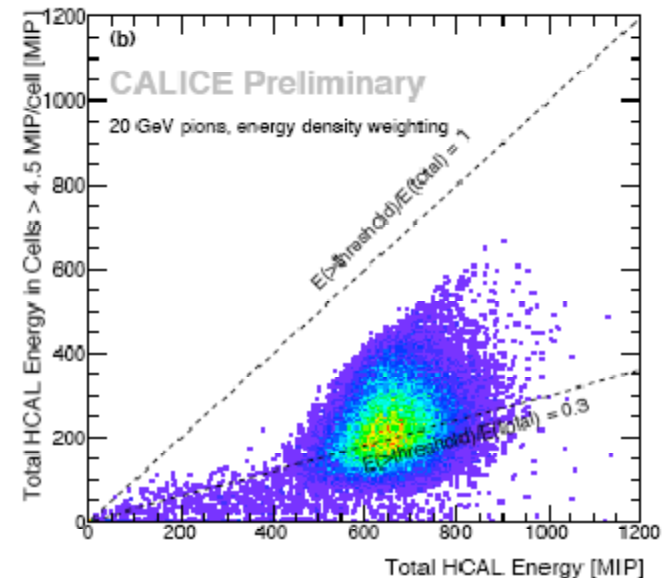
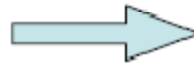
Response of the HCAL to hadrons (pions)

- Linearity of response
- Energy resolution for contained showers
- Improvement with weighting technique

CAN-015 from Frank and Katja



cell-by-cell
weights



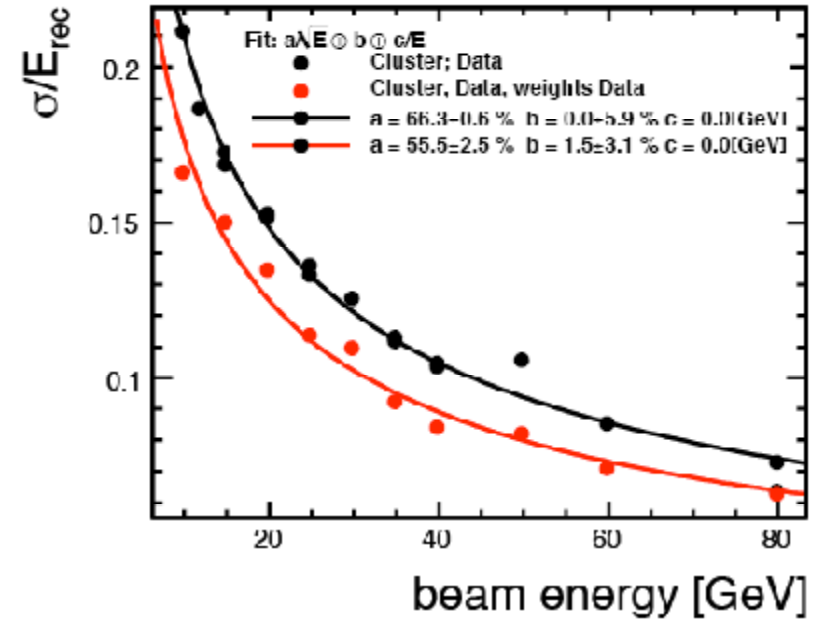
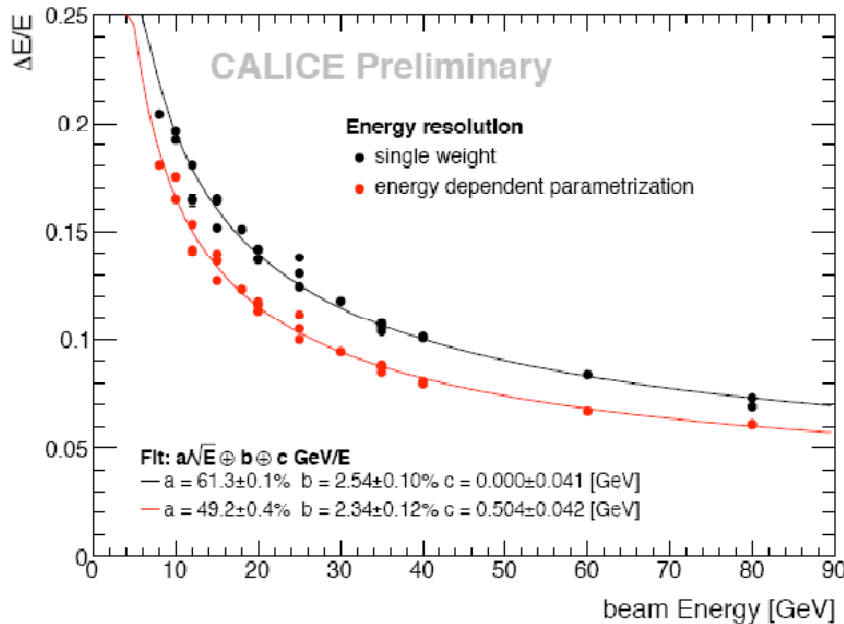
Minor improvements expected with new calibration set

➔ has to wait for EM analysis paper

4) AHCAL hadronic resolution

Response of the HCAL to hadrons (pions)

- Status: CAN-015



Using simple cluster algorithm

61% → 66%

+ weights from data 55%

alternatively + weights from MC 45%
(see Katja talk at analysis meeting 07.12.09)

Neural network analysis in progress

Improvement in stochastic term
from 61% (true AHCAL resolution)
to 50% with energy density weighting

5) Pion shower profile analysis

Show the high granularity potential of the AHCAL

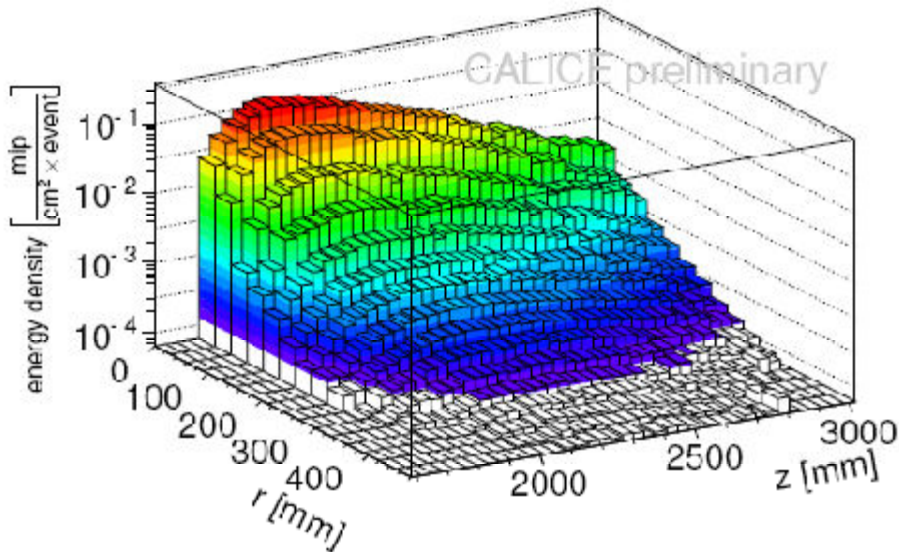
- 3D shower development
- Longitudinal profiles
- Lateral profiles
- First data/MC comparison (carefully phrasing the non-conclusive validation, i.e. not enough observables)

Significant improvements expected with new calibration set
→ has to wait for EM analysis paper & MC validation paper

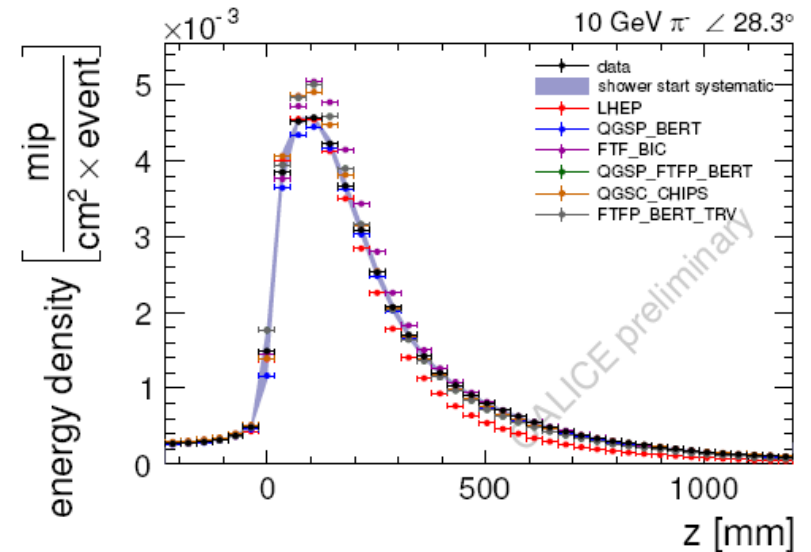
4) Pion shower profile analysis

Show the high granularity potential of the AHCAL

- 3D shower development
- Longitudinal profiles



CAN-011d from Beni

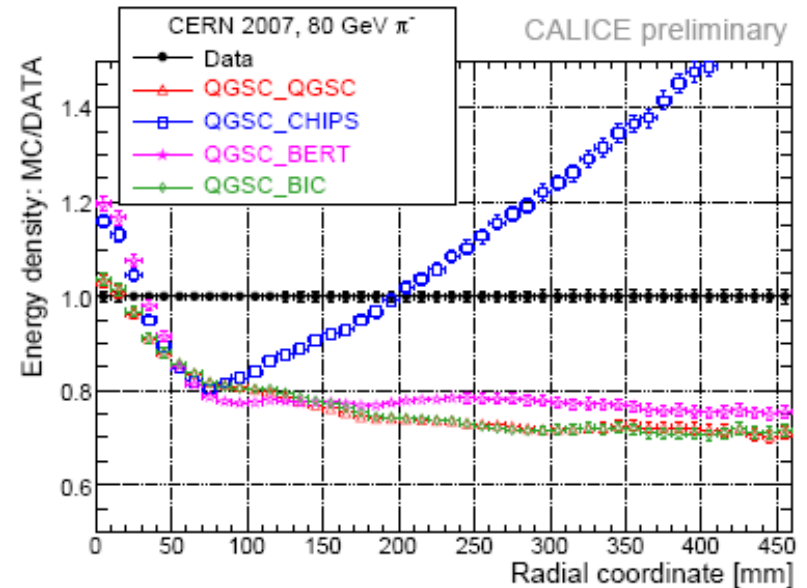
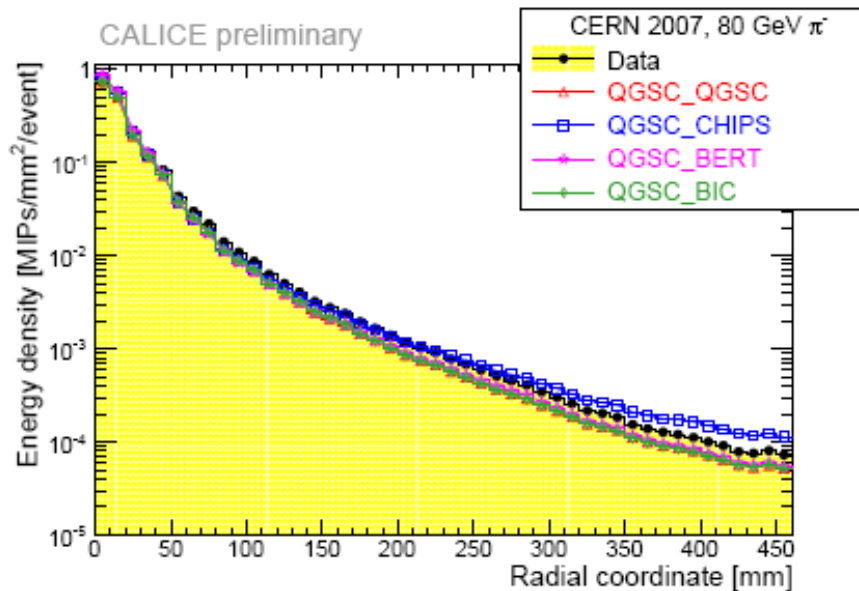


4) Pion shower profile analysis

Show the high granularity potential of the AHCAL

- 3D shower development
- Longitudinal profiles
- Lateral profiles

CAN-011e from Angela

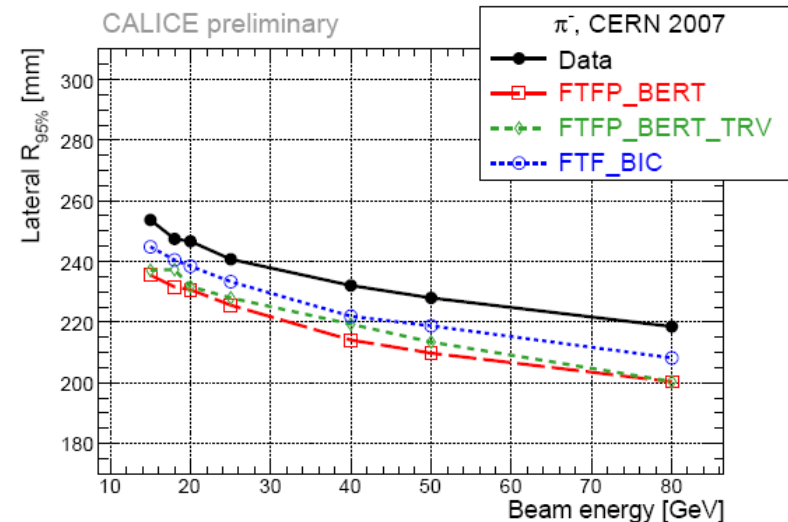
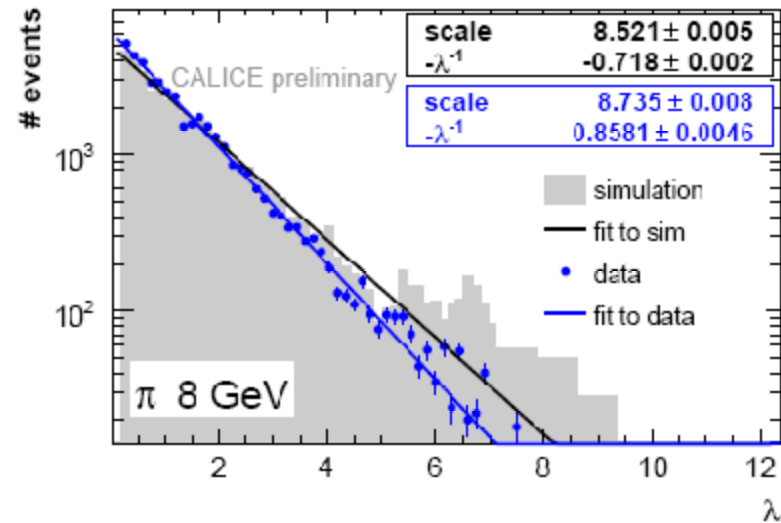


→ See talk from Angela for current status

4) Pion shower profile analysis

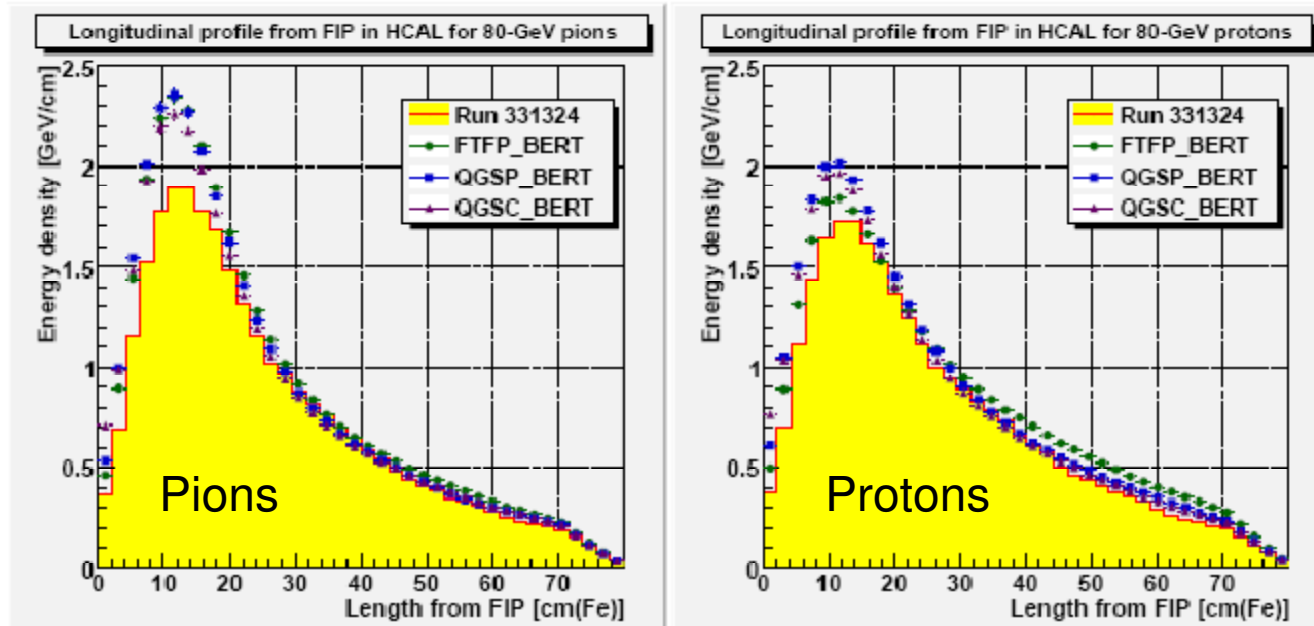
Show the high granularity potential

- 3D shower development
- Longitudinal profiles
- Lateral profiles
- First data/MC comparison
 - ➔ additional plots like:
 - shower starting point & shower max
 - shower attenuation
 - lateral radius
 - 95% containment (long & lateral)



6) Pion/Proton shower analysis

Extension of pion shower profile paper to include proton response
From Marina talk at CALICE meeting in Lyon



Still to be done: use latest version of official code for both data/MC
systematic of shower starting point definition

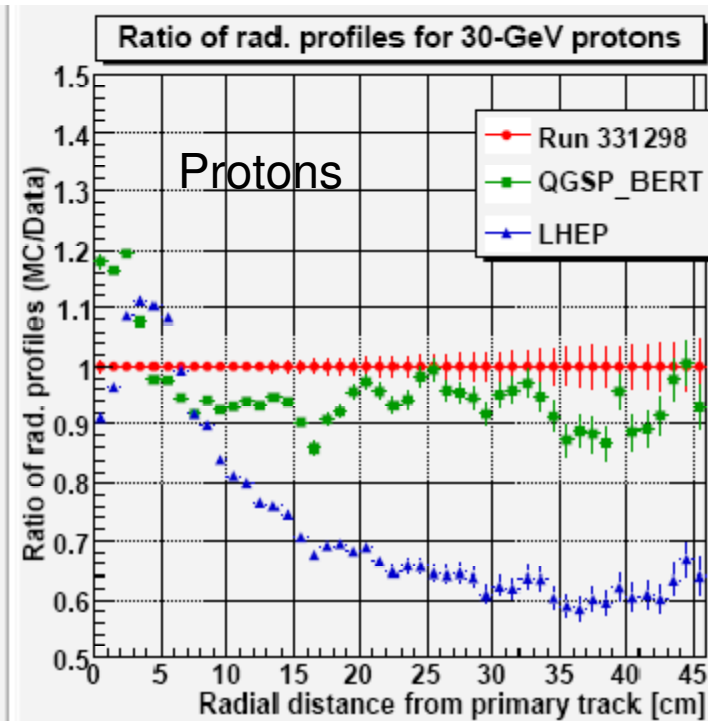
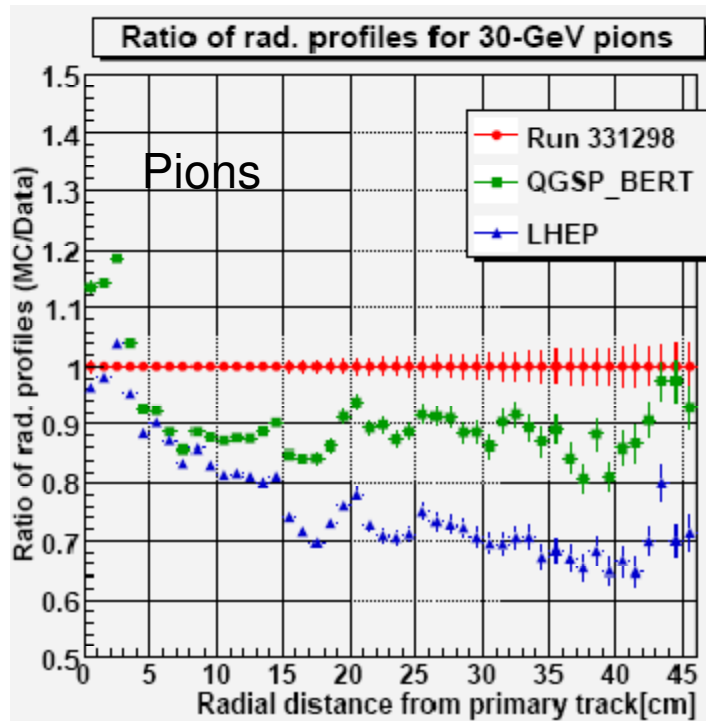
Significant improvements expected with new calibration set
→ has to wait for EM analysis paper & MC validation paper

6) Pion/Proton shower analysis

Extension of pion shower profile paper to include proton response

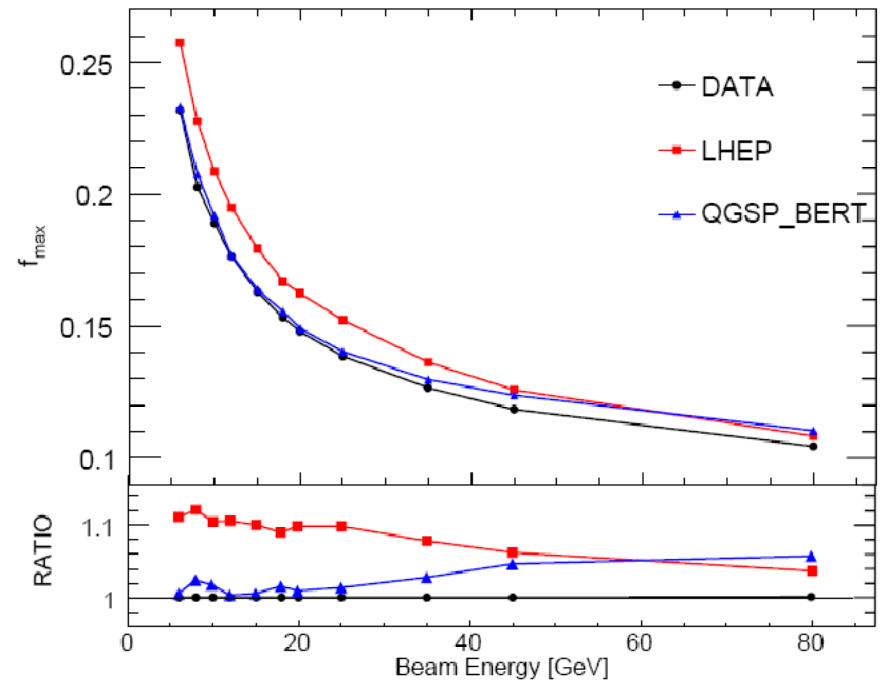
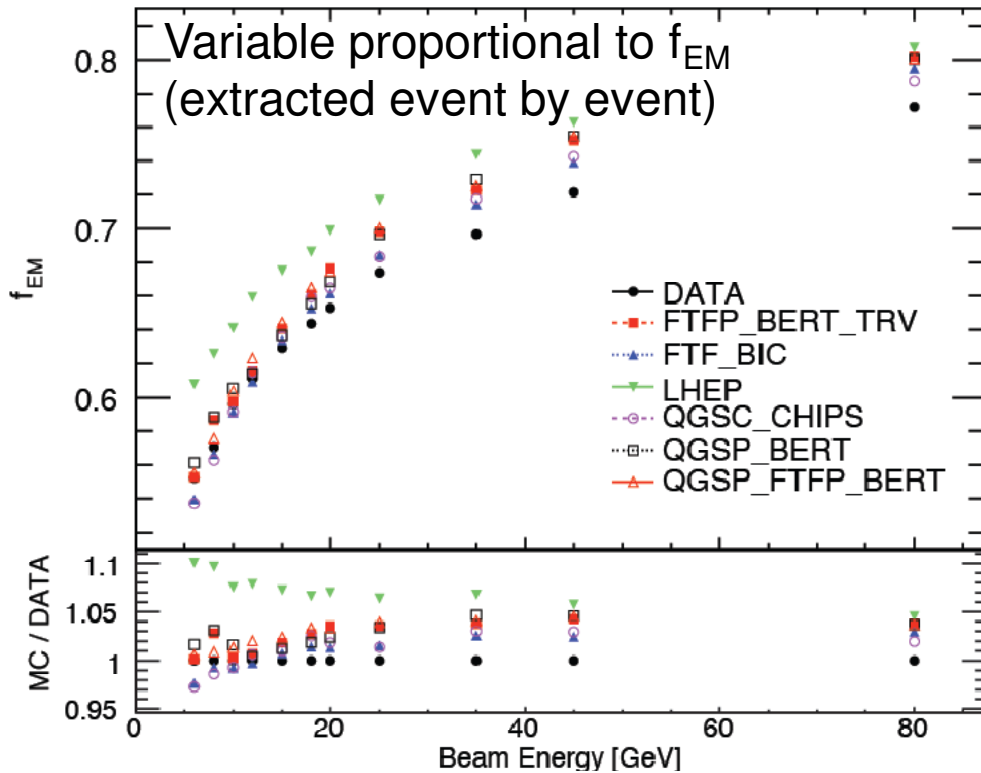
Radial shower profile confirms Angela observation

→ analysis feature or true issue in G4 ?



Additional ongoing analysis → future publications

Alex: Search of discriminating variables for more comprehensive & conclusive MC validation



Fraction of energy deposited in shower maximum layer

Still preliminary results, follows ATLAS & CMS experience + use high granularity
Eventually extend to include also deep analysis clusters

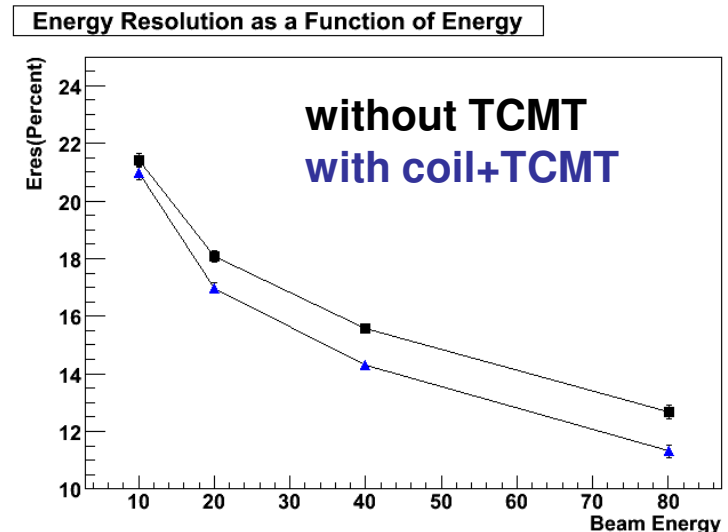
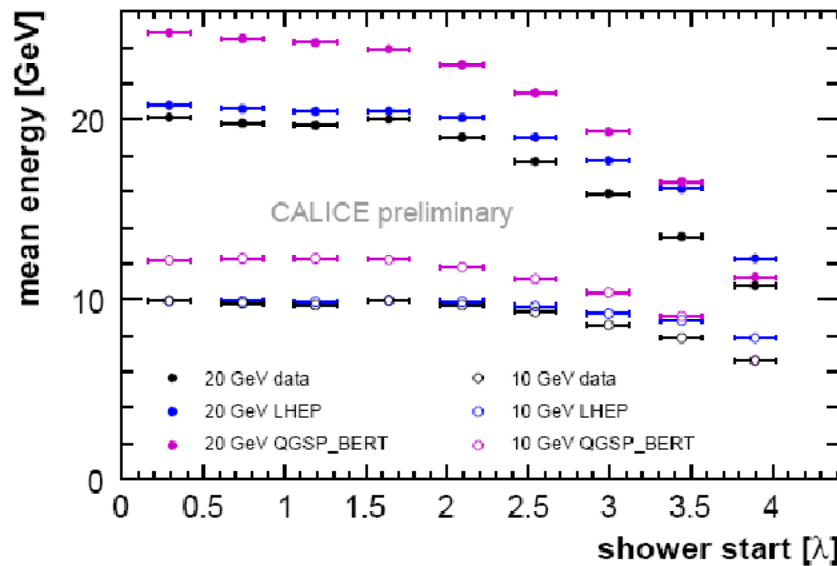
Additional ongoing analysis → future publications

Beni/Kurt/(Ivan): shower leakage studies

Two CAN-NOTES: 011a (Beni) and 016 (Kurt) to be turned into publications

1) Quantification of leakage

- effect of leakage on E_{res}
- improvements to E_{res}



2) Effect of “ILD-like” coil

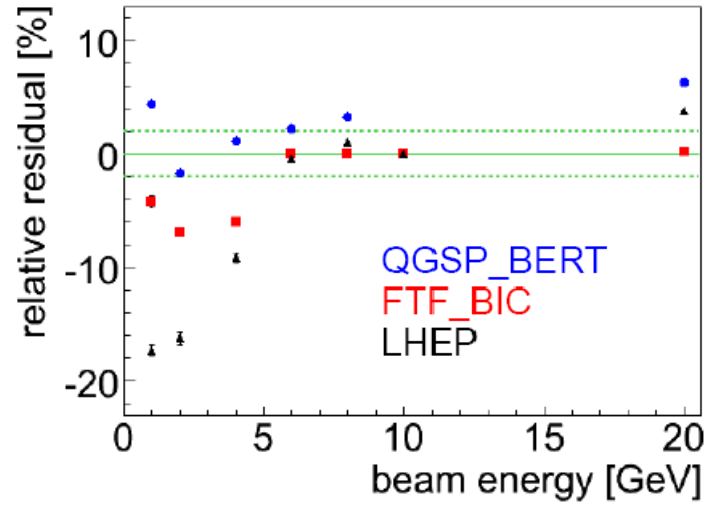
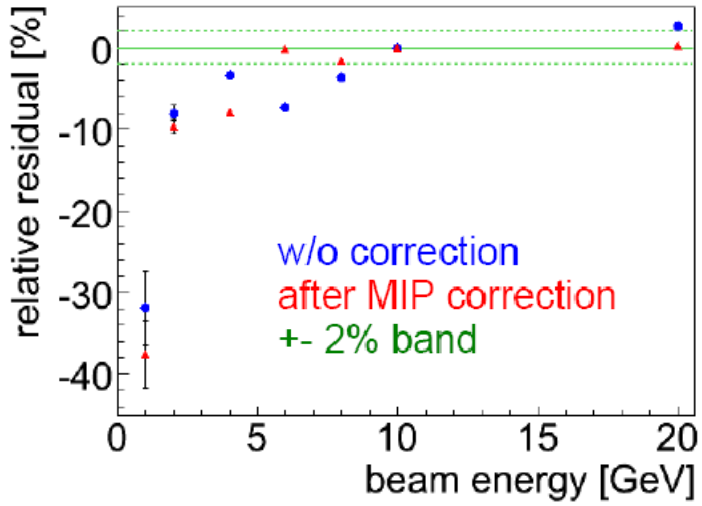
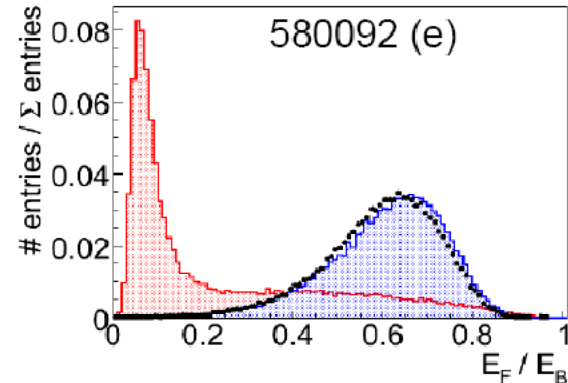
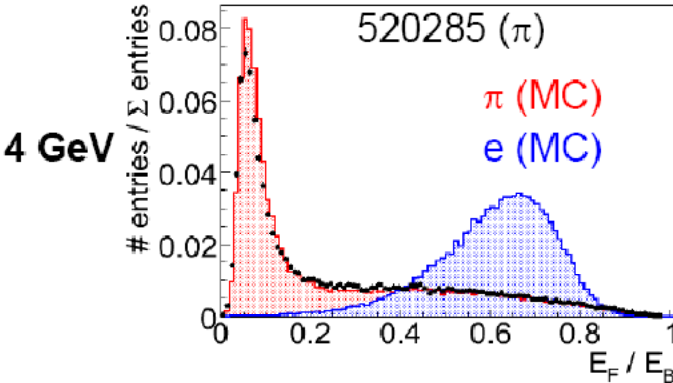
3) Advantage of a TCMT after the coil

- see Kurt talk

Missing: new calibrations, data/MC comparison, muon finder in TCMT, validation of shower starting point

Additional ongoing analysis → future publications

Nils: Low energy
FNAL pions

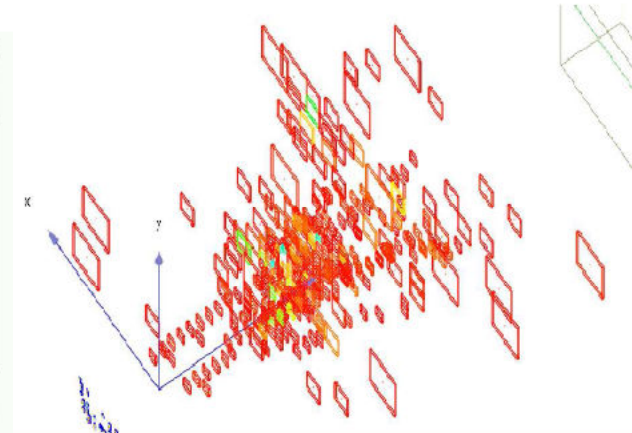
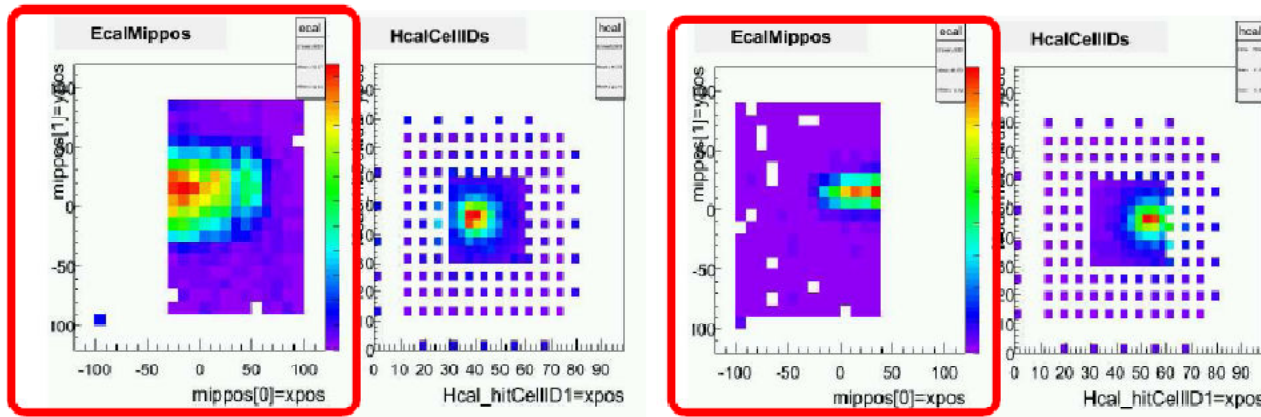
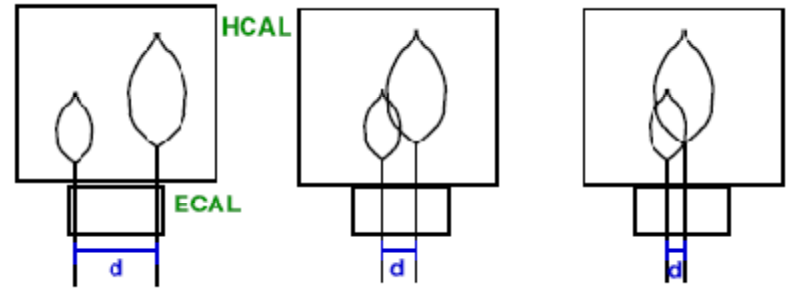


Still preliminary results, using mostly online calibration
→ Will greatly profit from calibration task force effort

Additional ongoing analysis → future publications

Sandra: shower separation

Event selection based on track in ECAL
Still problems with geometry for some files
→ Currently fixing software



Adapting existing private code (Jorgen) to official frame
Apply track-wise clustering
Repeat CAN-011 analysis + MC + larger distance (d)

List of upcoming publications

short term (<6 months)

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- 2) HCAL response to electrons (Nanda, SERGEY, Philipp)
- 3) Digitization and EM validation (KATJA, Sergey)

medium term (<1 year)

- 4) AHCAL hadronic resolution (Katja, FRANK)
- 5) Pion shower profile analysis (ANGELA, Alex, Beni, Riccardo)
- 6) Pion/Proton shower analysis (MARINA, Beni)

longer term

- MC validation (Beni, ALEX, Nils)
- Shower leakage (BENI, Kurt, Ivan)
- Low energy pion (NILS)
- Shower separation (SANDRA)
- Deep analysis of hadron showers (Sergey)

→ More combined analysis (ECAL+HCAL+TCMT) !!!