Preliminary comparison of ATLAS Combined test-beam data with G4: pions in calorimetric system

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Physics Validation of LHC Simulation
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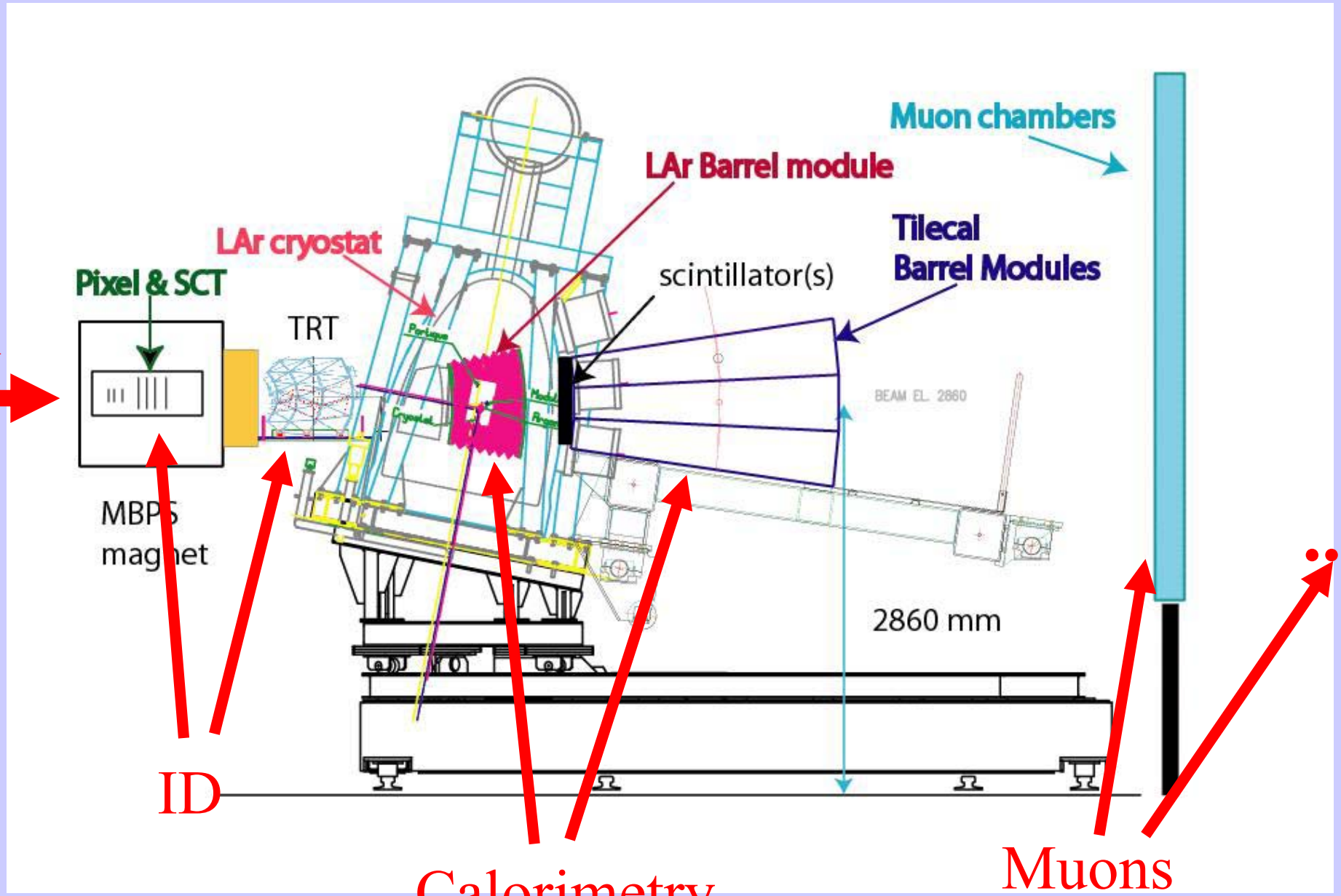
Outline:

- ATLAS CTB Setup
- Brief description of CTB Data and G4 data
- Summary of results for different energies, eta values and analysis methods
- Conclusions
- Work to be done before mass production

ATLAS CTB Setup



Only first chamber is shown

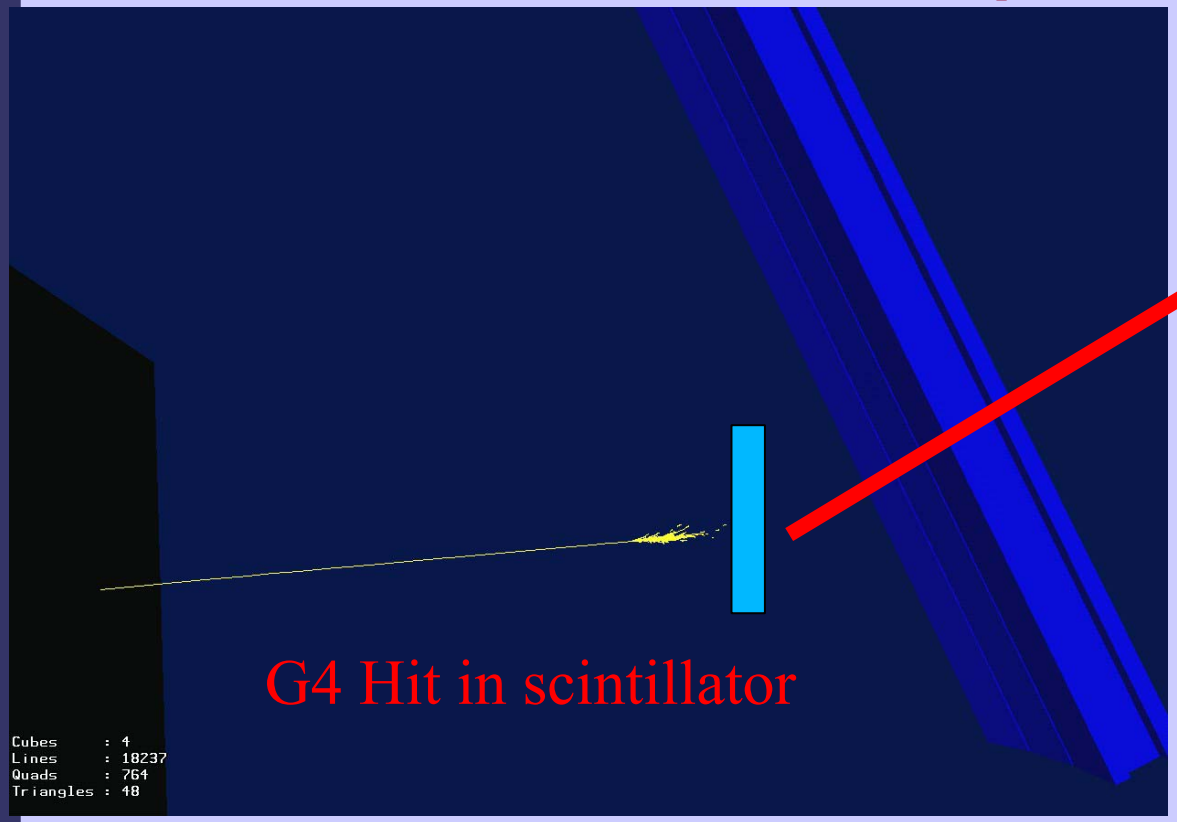
CTB Data Set

- Considered a "good" run list
- π at η= 0.35 and η= 0.2 energies from 20 to 350 GeV
- Fit method to reconstruct energy in TileCal, cubic fit for energy reconstruction in LArg (this is not "perfect" for LArg, it is only a backup solution, while waiting for the Optimal Filter method)
- Used LArg information to separate e/π, MuTag (scintillator)+ TileCal to identify muons, beam line instrumentation (quality cuts)

G4

- G4 data simulated with the ATLAS/CTB Sw release for preproduction studies
- Physics list QGSP_GN (for standalone 2002 studies: QGSP2.7, small difference between the two expected <1%)
- Energy in LArg and Tile reconstructed with Optimal Filter method (not the same reconstruction methods as for the data)
- No photostatistics applied for Tile (small effect expected)
- Not fully optimized to the CTB setup (beam divergence, momentum smearing)
- Noise is applied (at the level of samples)
- Exactly the same cuts used on data have been applied

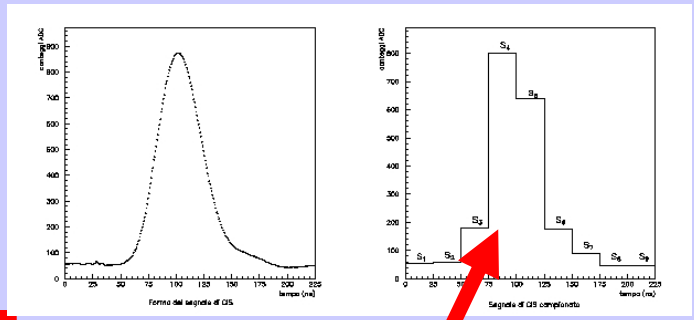
More details on Energy Reconstruction (TileCal as example)



Signal (charge) in TileCal:
factors from both data and MC

$Q=f_{em}*pC/GeV*E_{hit}(MeV)$

Signal Shaping:
shape obtained by calibration system



This is what we have in real data

Energy Reconstruction Algorithm

Energy Reconstruction: analysis

First study: simple approach

The energy is reconstructed summing all the cells in a small eta phi region (± 0.1) around impact point

Second study: noise cut and cryo correction

The energy is reconstructed summing all the cells with $0<\eta<0.7$ if $E>2.2\sigma$

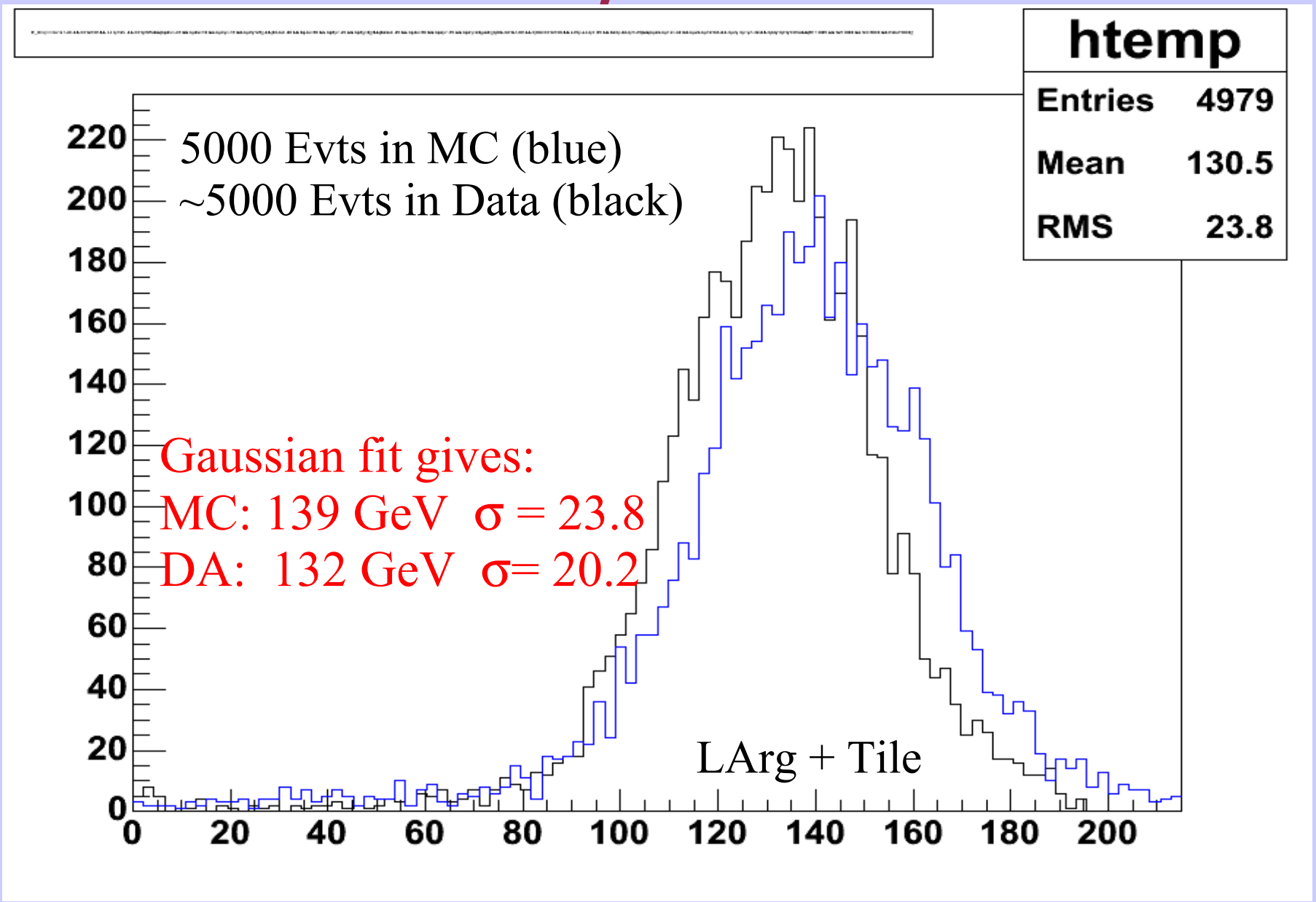
2.2 obtained from electrons contamination: the value for which we obtain the best linearity (20 – 180 GeV). The pions reconstructed energy doesn't depend too much on the noise cut.

Correction for energy lost in cryo added

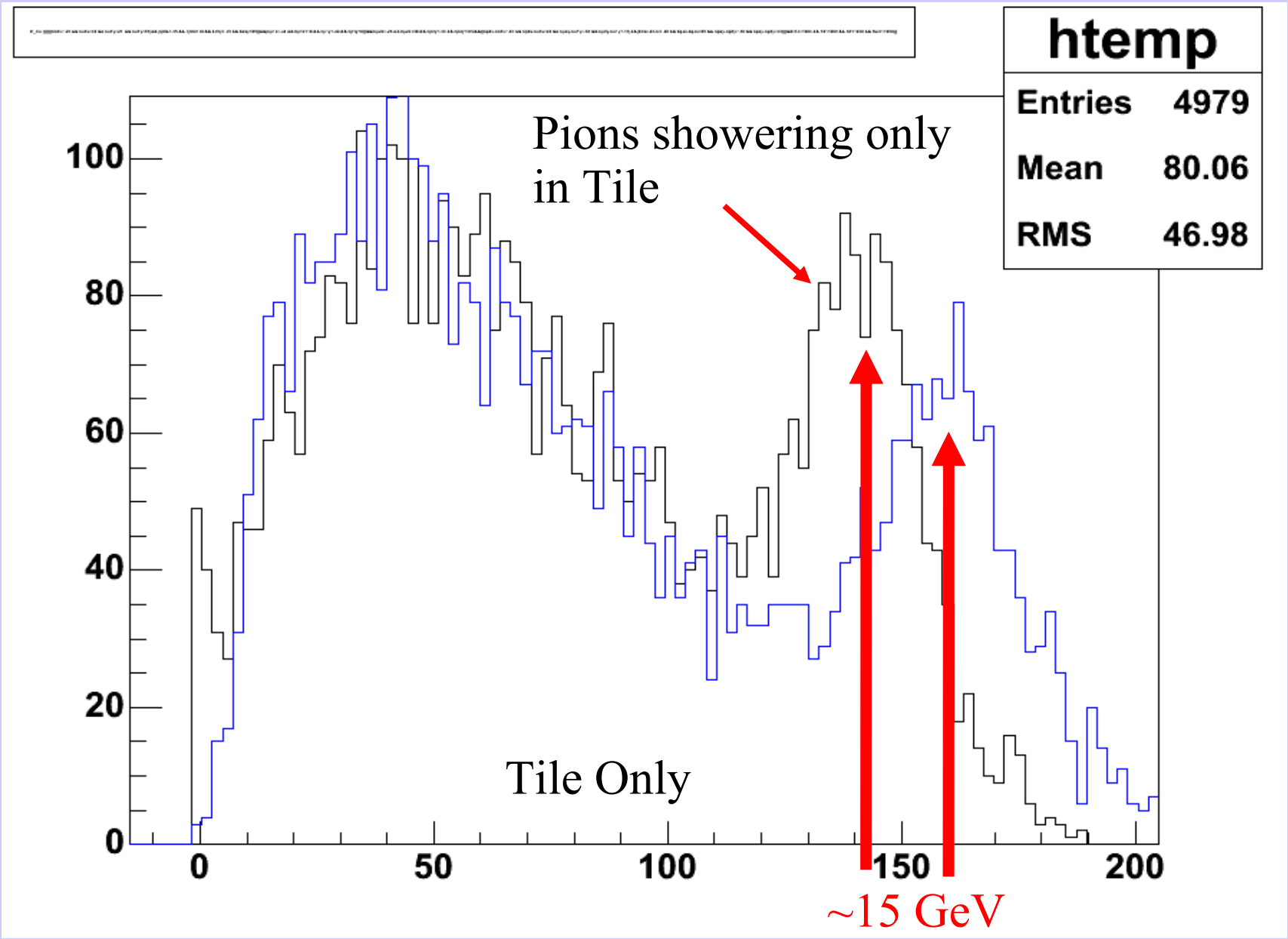
$E_{cryo} = \mathrm{sqrt}(E_{back} * E_{tileA})$

The two analysis give very similar results.

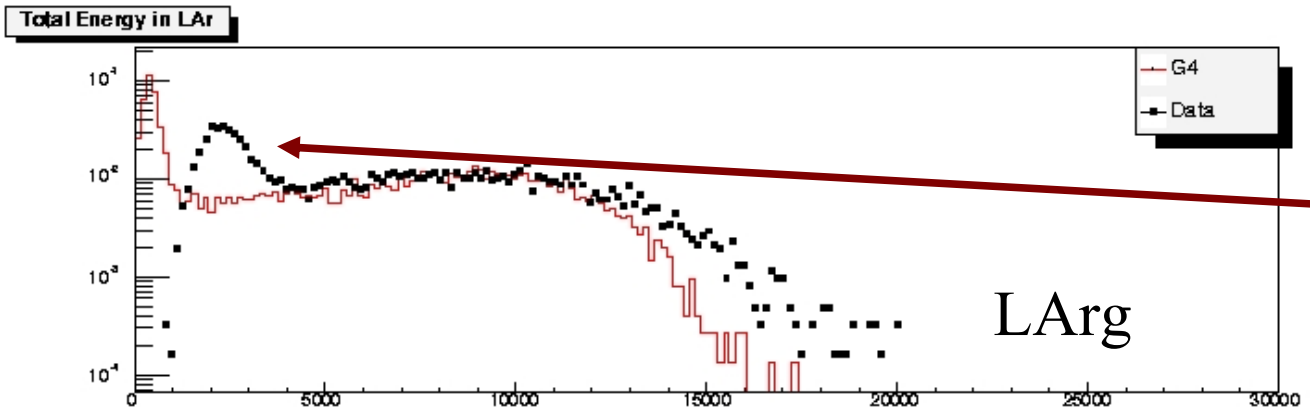
Sum in eta phi region: 180 GeV η=0.2



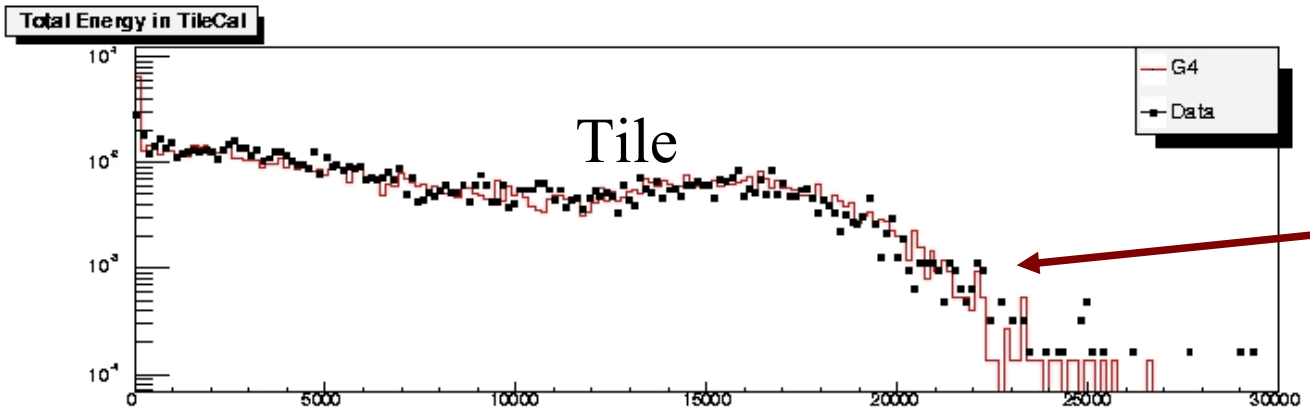
Sum in eta phi region only TileCal: 180 GeV η=0.2



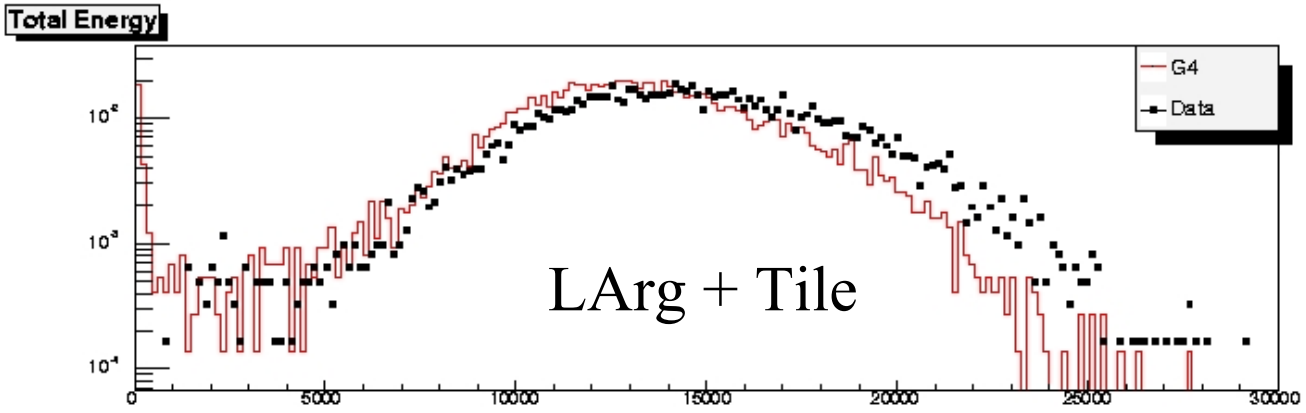
Sum of cells above noise: total energy worst case for LArg (20 GeV) η=0.35



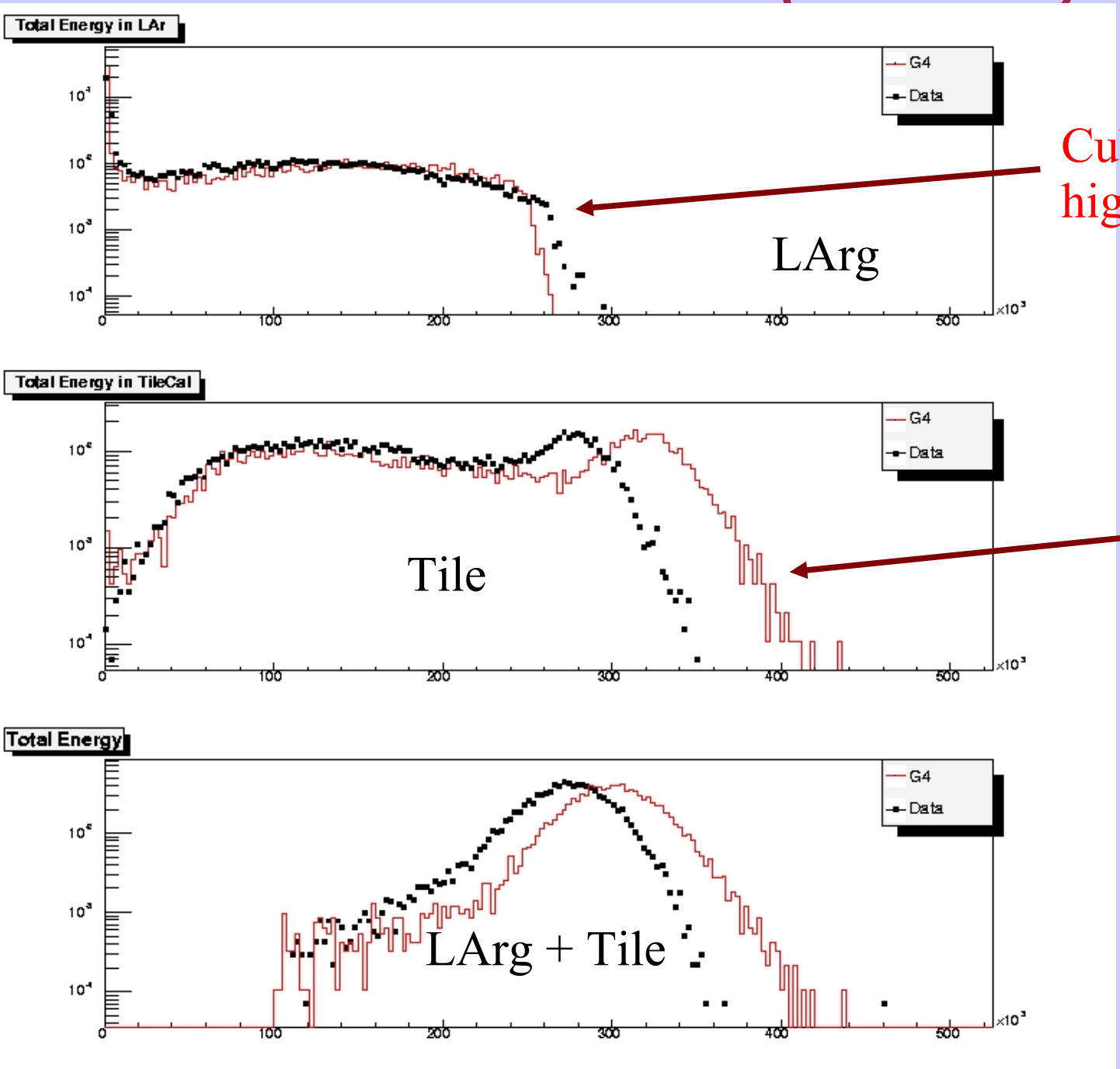
Cubic fit is not precise enough?



Good agreement with Tile



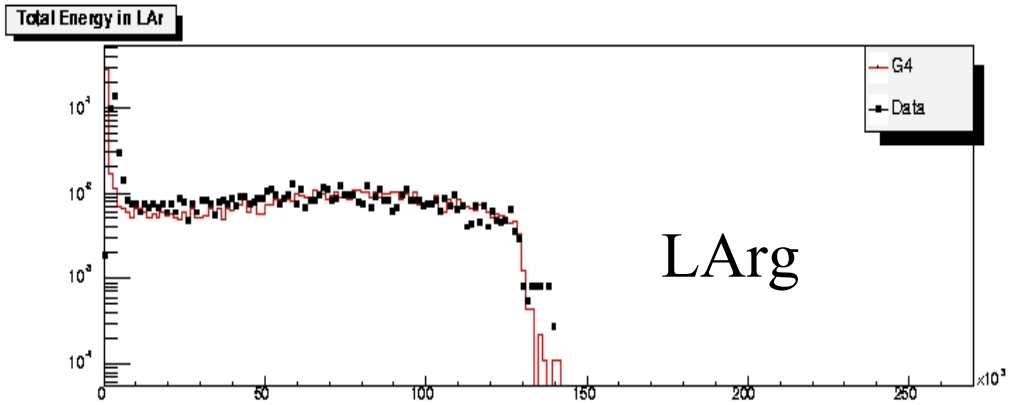
Sum of cells above noise: total energy worst case for Tile (350 GeV) η=0.35

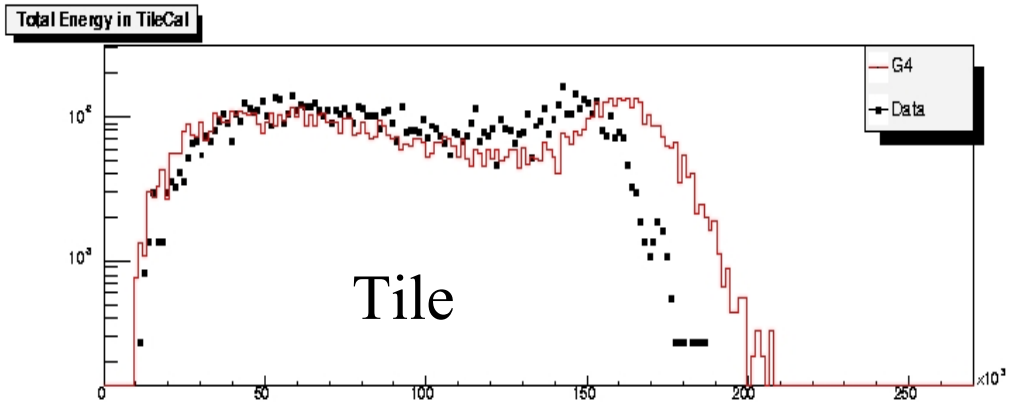


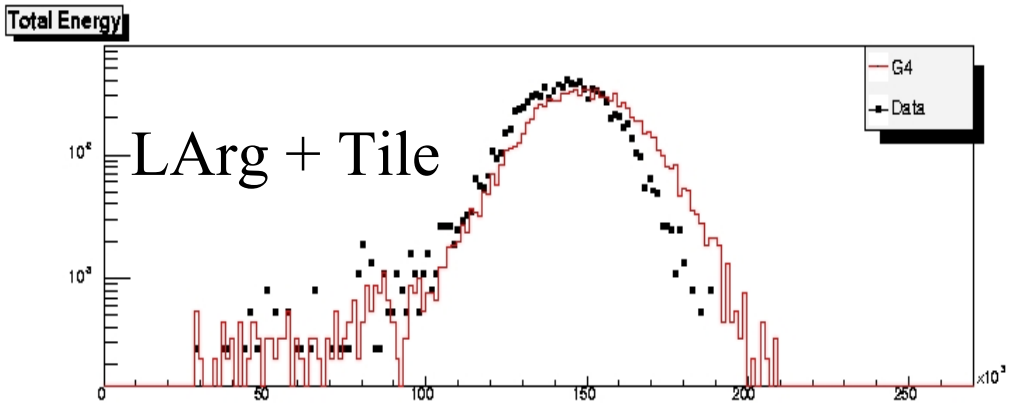
Cubic fit is better at high energy

Poor agreement with Tile: too much energy in G4

Sum of cells above noise: total energy middle case (180 GeV) η=0.35





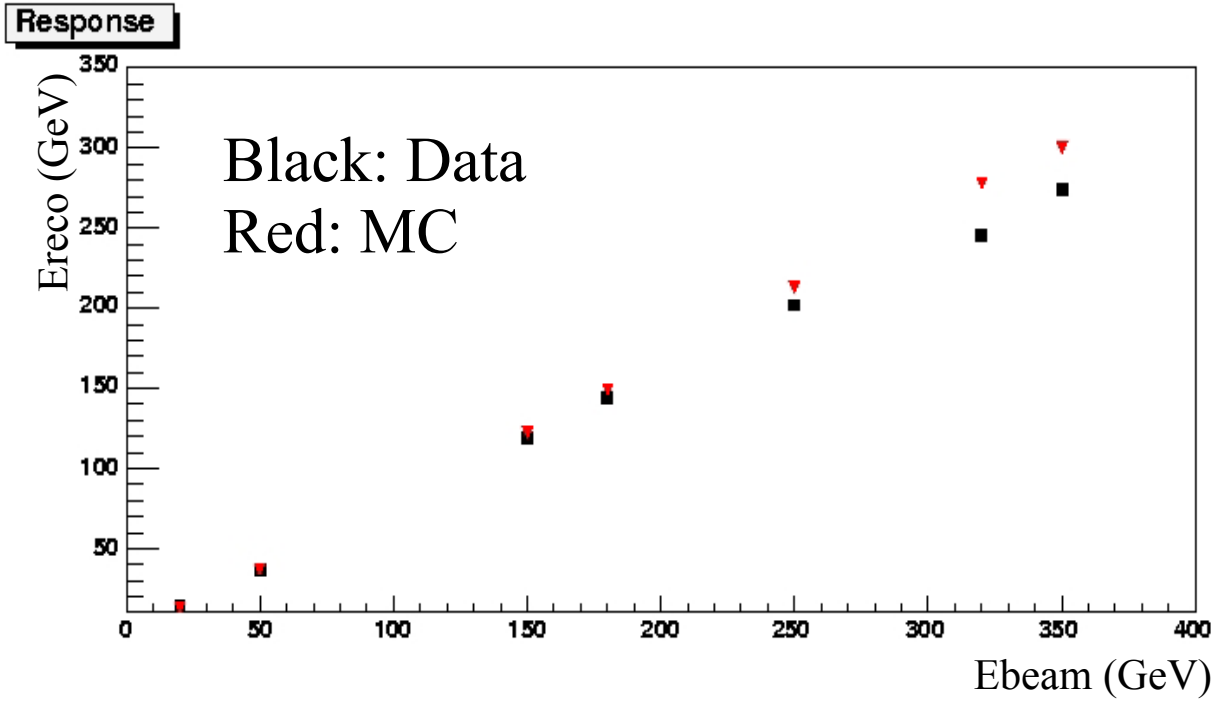


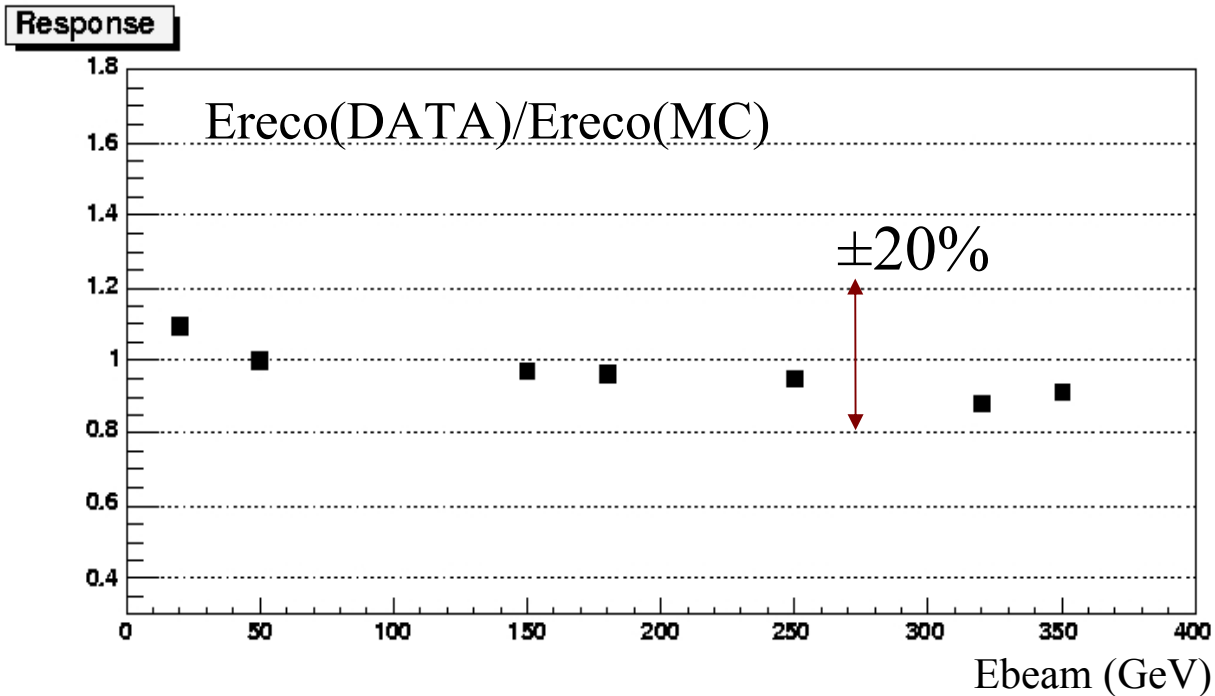
Two factors can play a role in the disagreement:

1 – The differences in the energy reconstruction. But the effect should be small for Tile. We shall try to use the same energy reconstruction algorithms

2- The physics list doesn't describe precisely the energy scale. TileCal participated in QGSP/LHEP validation (see: CERN-LCGAPP-2004-10) can we expect differences in G4 since then? different physics lists (QGSP2.7 vs QGSP_GN) and G4 versions 5.2 vs 6.2). Can also be a mixture of the two effects

Response to pions h=0.35





The agreement is poor: agreement between data and
G4 is ±10%

Another study (Gia Khoriauli) using Calo Calibration Hits shows a better agreement.
Summing nonEM+EM energy from all hits (scintillator+absorber+...) the agreement is ~5%.
Is this and indication that the problem is in energy reconstruction (from hit to reco energy)?
Note: Gia is using topo_clusters for data

Comparison with 2002 Standalone: preliminary

- We approximated e/π (Tile standalone) with E_{beam}/π and fitted the peak of pions showering only in Tile obtaining for the point at 180 GeV:
  - e/π (CTB) = 1.23
  - e/π (CTB-G4) = 1.12
  - e/π (2002) = 1.23
  - e/π (2002-G4) = 1.2

We obtain the same value for data, but the difference in G4 is 7%. Indicates a problem in G4 simulation or in the energy reconstruction method

Conclusions

- For previous study (standalone TB) ±5% agreement between G4/Data was reached (and was considered sufficient). Still lot of work has to be done. We need to improve both in analysis and the simulation
- At this stage it is difficult to verify in details the shower development simulation (it was the main concern in standalone comparison)
- We need to disentangle G4 and energy reconstruction method to verify each step in the simulation
- The disagreement between G4/Data depends on the energy (LArg simulation is better at high energies, the opposite for TileCal)

Work to be done:

- Important step: check all the constants and methods that reconstruct energy starting from a G4-Hit: sampling fraction, pC/GeV, noise contribution, ...
- Select pions showering in TileCal in G4 data and compare the results with standalone simulation results (we want to obtain the same level of agreement ±5%)
- Reconstruct events with same algorithm of data (for LArg use parabolic fit while waiting for OFC), try different combinations
- Compare G4/Data for e/π and e/h ratios
- Check Shower Profile