Beam tests and Energy measurement

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For the beam test team

- Energy measurement
- Energy and calibration
- Data/simulation (dis)agreement

Energy measurement

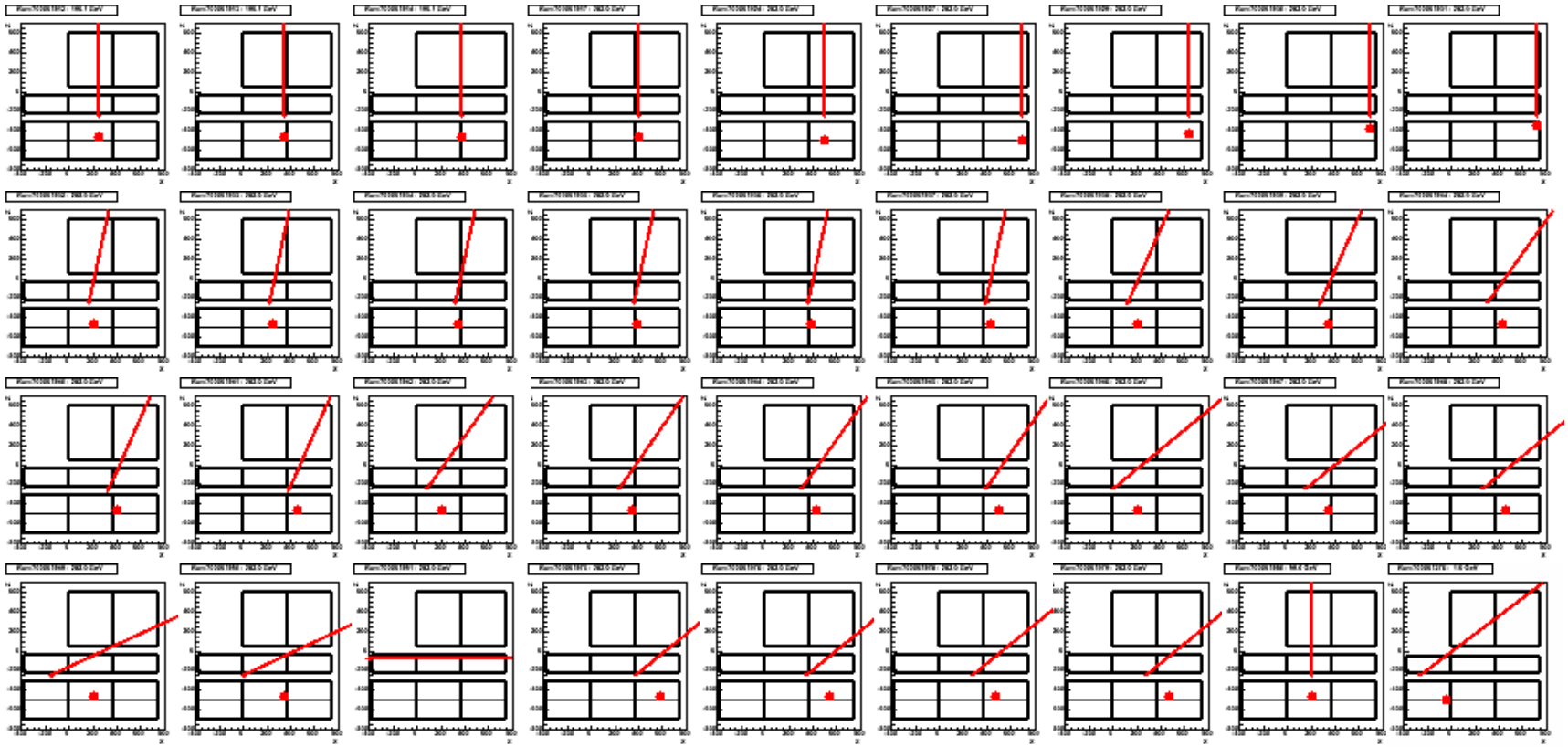
- Dealing with a large phase space :
  - From 10 MeV to 300 GeV
    - Below 1 GeV : importance of the tracker information for E recon
    - Above 1 GeV : the shower is not contained -> longitudinal leakage
  - From 0 to ~90 deg
    - The fraction of energy deposited in the tracker and the longitudinal leakage change with the incidence angle
  - Onto a complex geometry
    - Cracks between towers, between logs,…
- Energy reconstruction
  - 3 algorithms
    - EvtEnergyCorr (Bill's) : centroid and tracker correction
    - CalLkHdEnergy (Pol's) : last layer and tracker correlations (< 50 deg)
    - CalCfpEnergy (Philippe's) : profile fitting (> 1 GeV)
  - + classification trees -> CTBBestEnergy and CTBBestEnergyProb

Energy measurement and beam tests

- Sampling the phase space as much as possible
  - At PS (gammas and electrons)
    - Tagged gammas up to ~2 GeV, many angles and impact points
    - 5 GeV Electrons, crack scans at many angles
  - At SPS (only electrons)
    - 10, 20, 50, 100, 200, 282 GeV
    - Many angles and impact points
- LAT versus CU
  - Flight towers, flight electronics
  - Only 2.5 towers :
    - Lateral direction : an e.m shower is contained within one tower
    - 2.5 towers are enough to test up to 60 deg
    - BUT we can not apply directly and simply the classification tree analysis
- Check the agreement between data and simulation
  - Looking at the raw energies (total, layer, crystals)
  - Looking at the output of the 3 reconstruction algorithms (energy resolution, bias, correlations,…)
- Energy measurement and position measurement with the calorimeter
  - The calorimeter position measurement is used (especially in CalTransRms)
  - A bad position measurement is the sign of a wrong inter-calibration
- If we have agreement between data and simulation in the sampled points of the phase space, we can be confident that we have agreement in the whole phase space.
- If not, life will be more difficult…

Sampling the phase space…

- Angle : 0, 10, 20, 30, 45, 48, 60
- Scans around cracks
- Tower 2 vs tower 3
- Changing the length of the trajectory inside the tracker

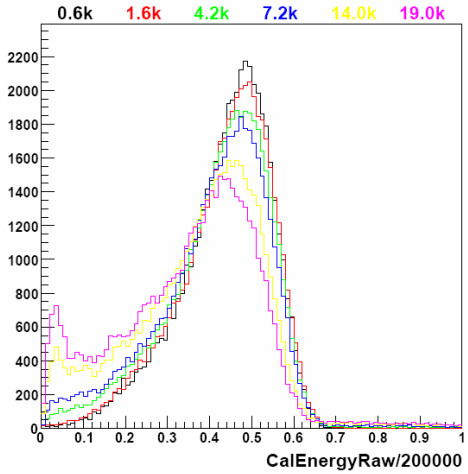


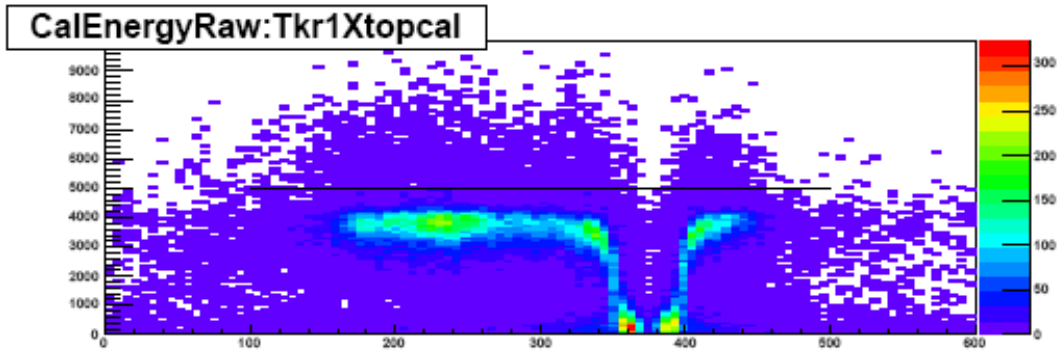
Energy and calibration and simulation

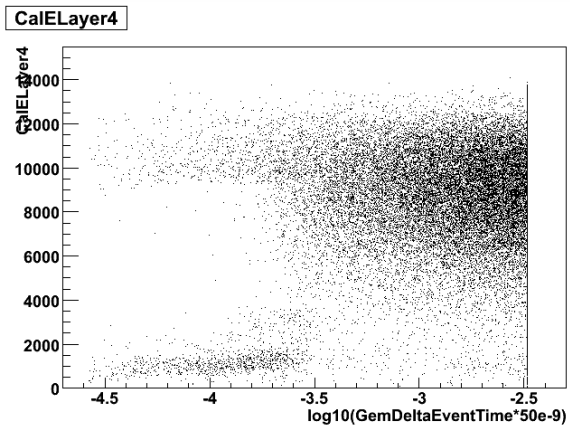
- During SPS we discovered a systematic discrepancy between data and MC (between 5 to 15 %)
- Since then, we have tried to understand this discrepancy and to reach a good agreement :
  - The calibration of the calorimeter has been revised (see Sasha's talk)
  - Check the simulation (Geant3/Geant4, geometry - see Francesco's talk at the C&A meeting yesterday)
- The calibration has been modified several times :
  - The last calibration correction has just been implemented in CalXtalResponse
  - The results shown here do not use the same reprocessing/calibration (sorry for inconvenience…)

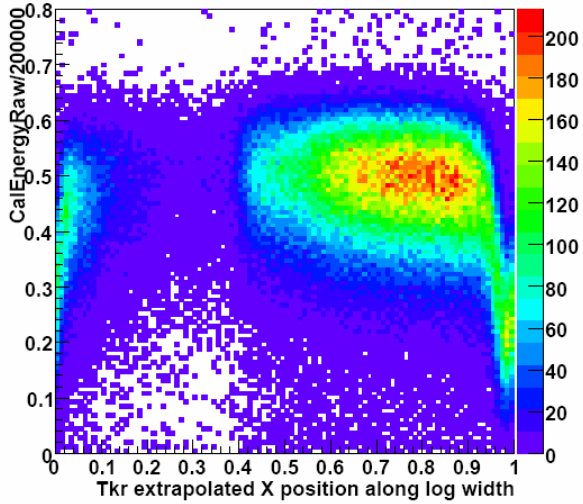
Quality and fiducial cuts

- Remove residual pion contamination
- Electronics and rate : checking time between two events
- Cracks betwen towers but also between logs



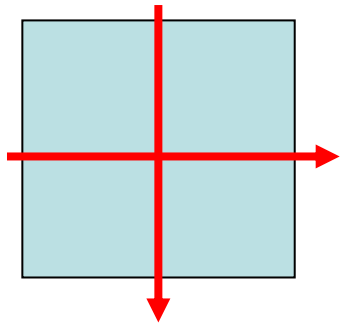


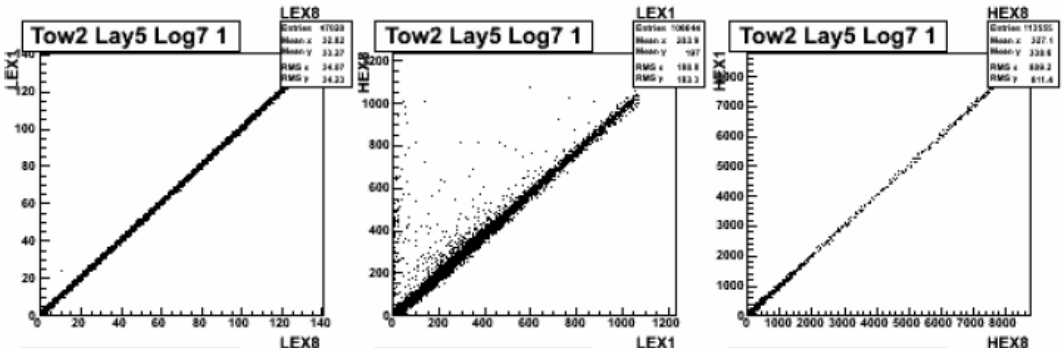


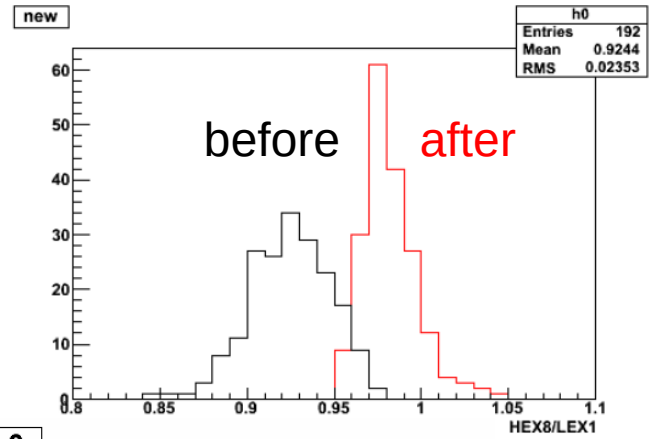


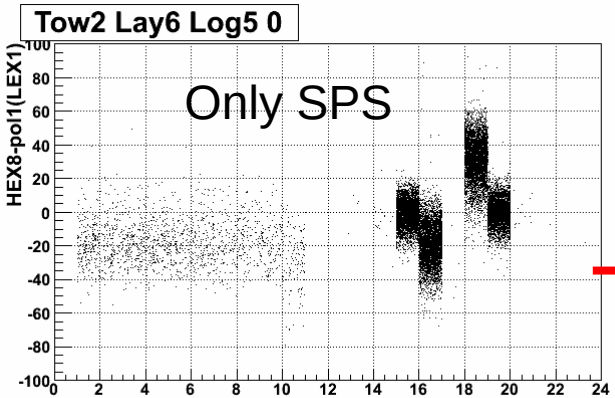
BT16 runs and LE/HE intercalibration

- 12 positions along X and 12 positions along Y
- At PS (5 GeV) and at SPS (100 GeV)
- Sensitive to cross-talk
  - LE diode to HE diode (large diode to small diode)
  - Adjacent crystal
- This is one of the first thing we have to do in orbit for the calorimeter

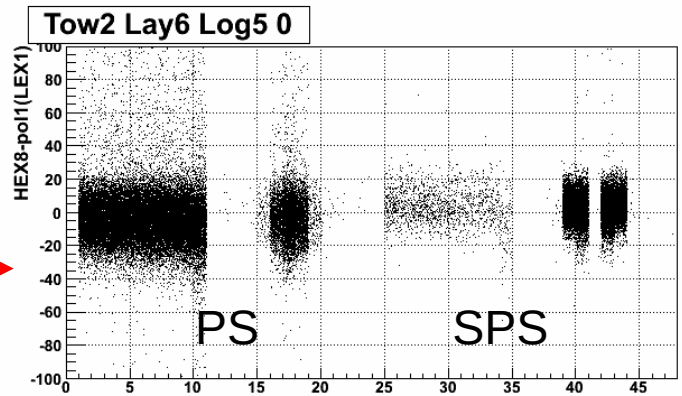






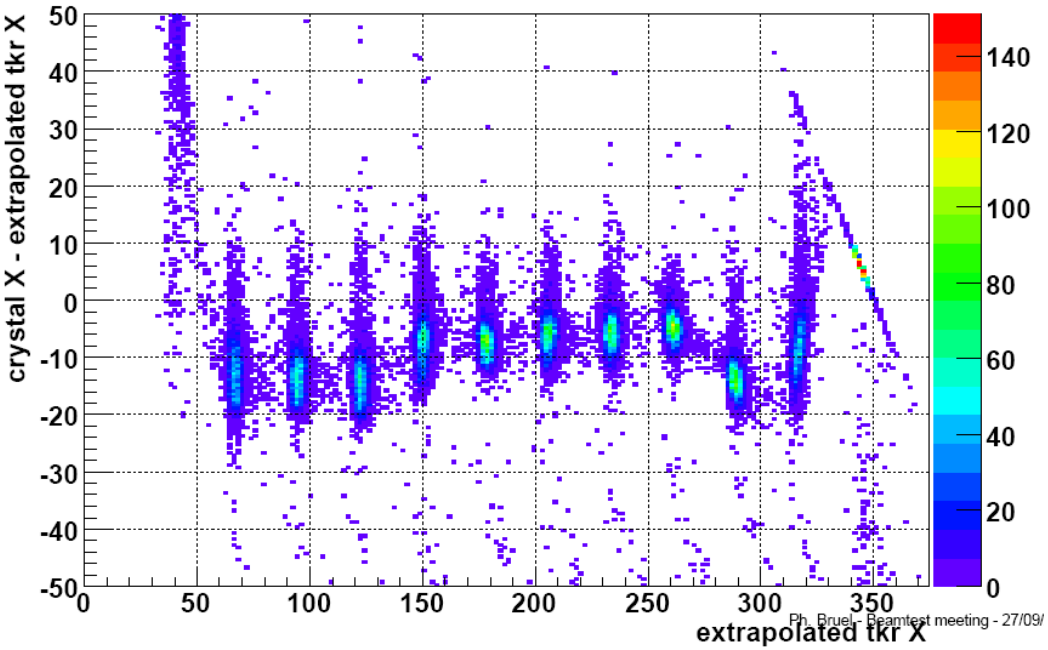


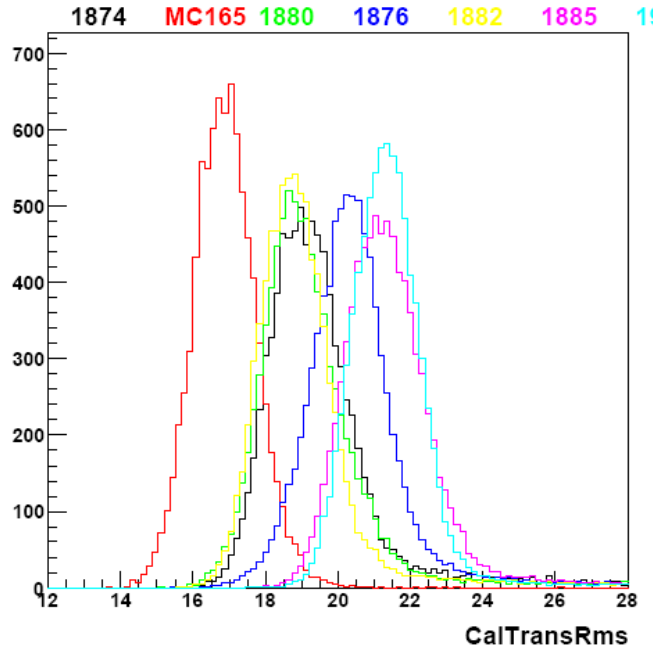
Adjacent Crystal cross-talk Correction



Position measurement

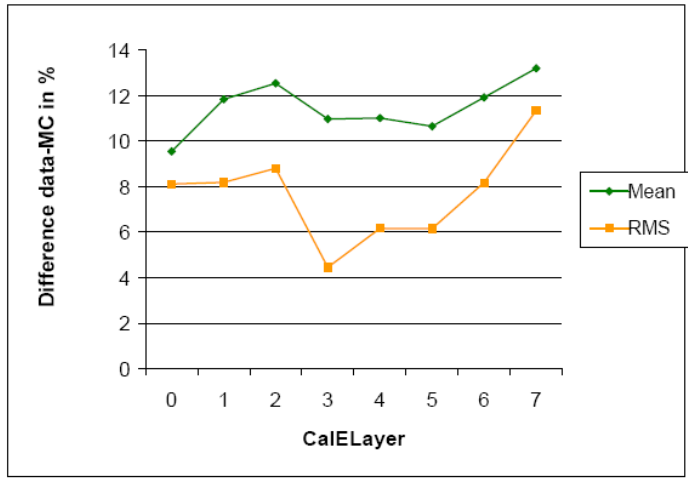
- The position measurement is strongly related to global intercalibration
- 1% calibration error can lead to a 5mm position error
- Consequences on other variables : CalTransRms (used in background rejection)
- It is a way to check the quality of the calibration

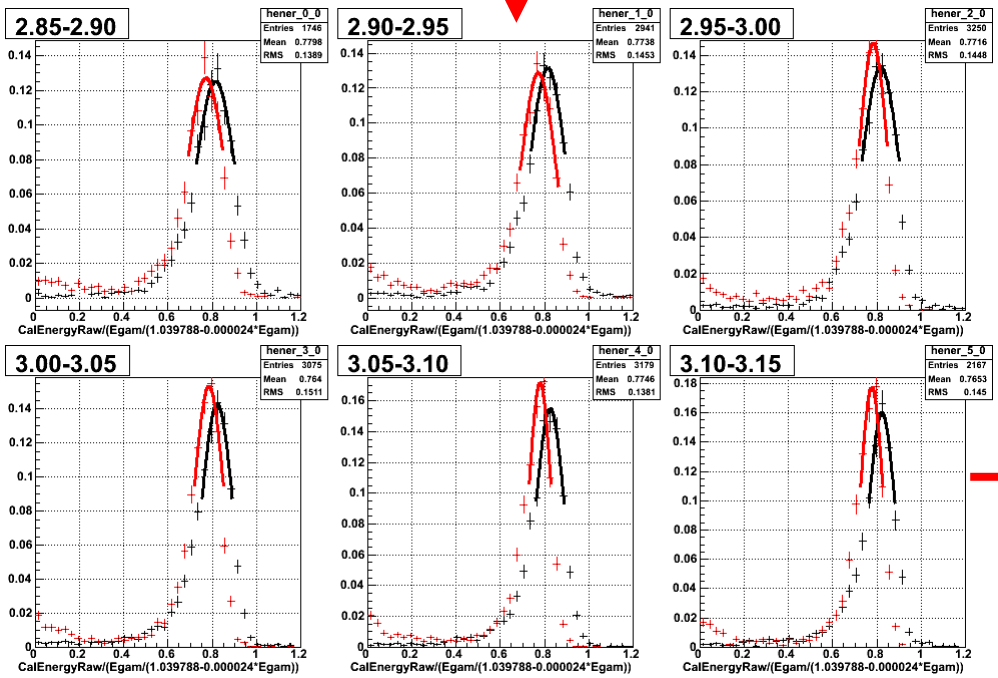


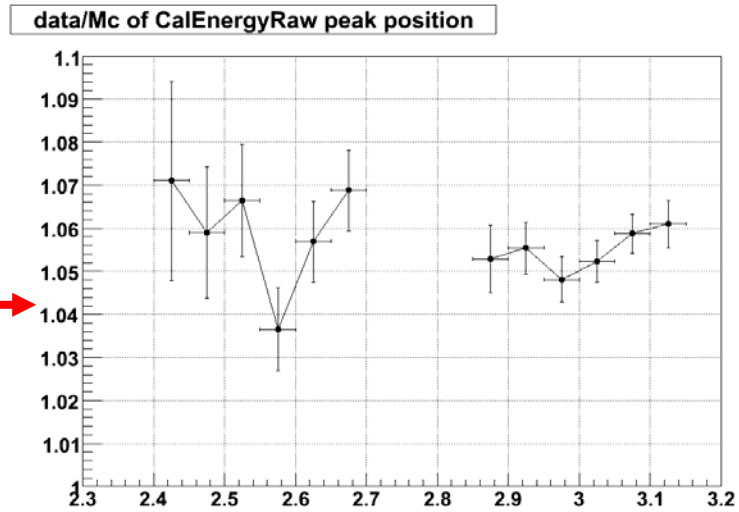


Gammas at PS (<2.5 GeV)

- With full-Brems : data/MC ~ +10%
- With tagged gammas : look at the CalEnergyRaw/Etagger and compare data and MC inside bins in log(Etagger): data/MC ~ +5%

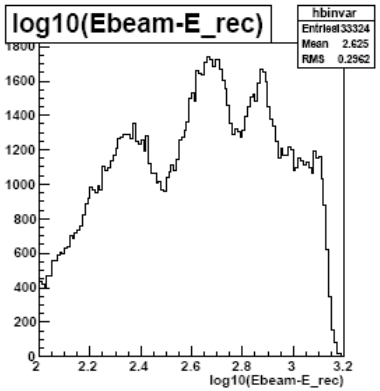


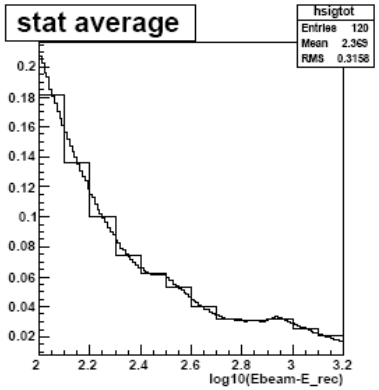


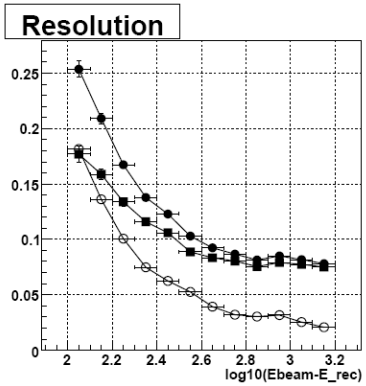


Energy resolution with tagged gammas

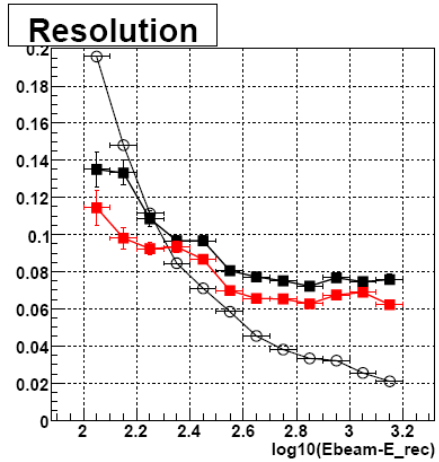
- 4 energy beams : 500, 1000, 1500 and 2500 MeV
- Taking into account the resolution of the tagger which depends on the configuration (Ebeam, Bfield)

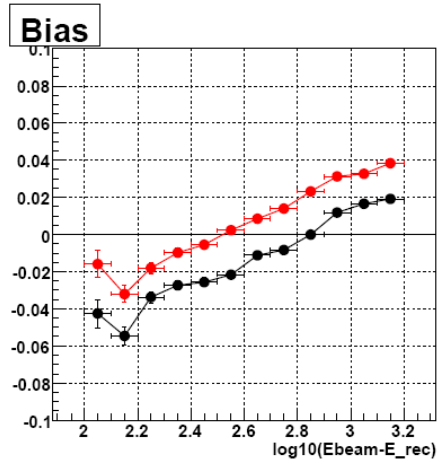






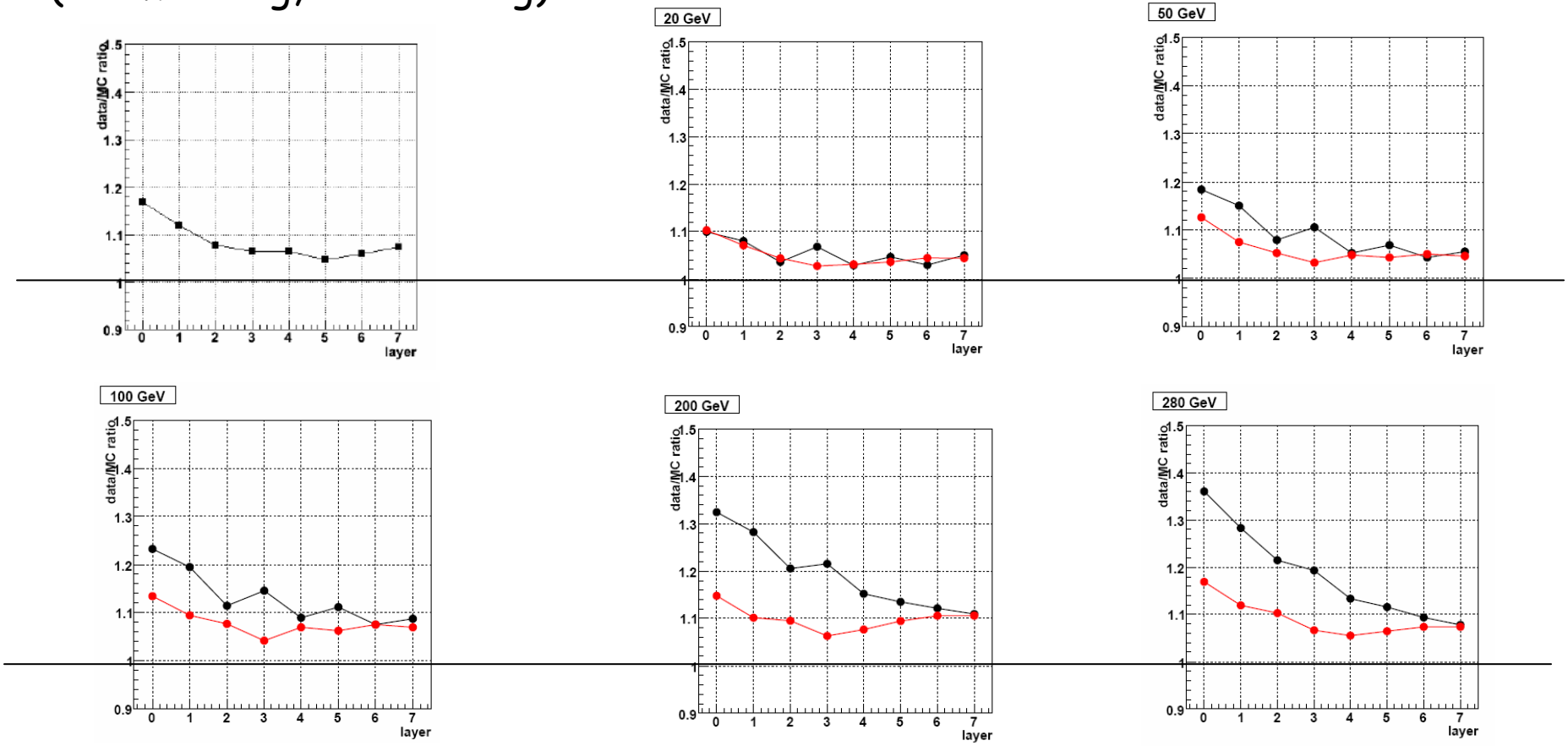
Black : EvtEnergyCorr
Red : CalLkHdEnergy
White : tagger resolution





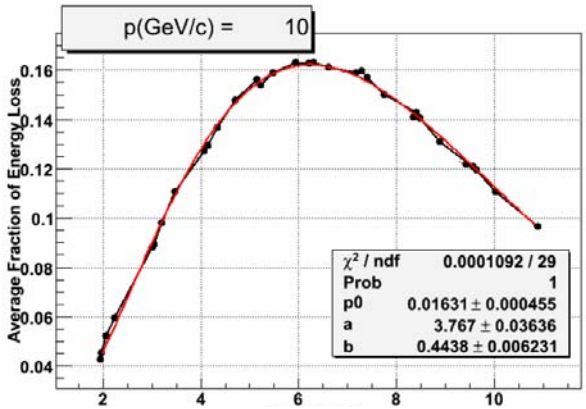
Electrons from 5 Gev to 282 GeV

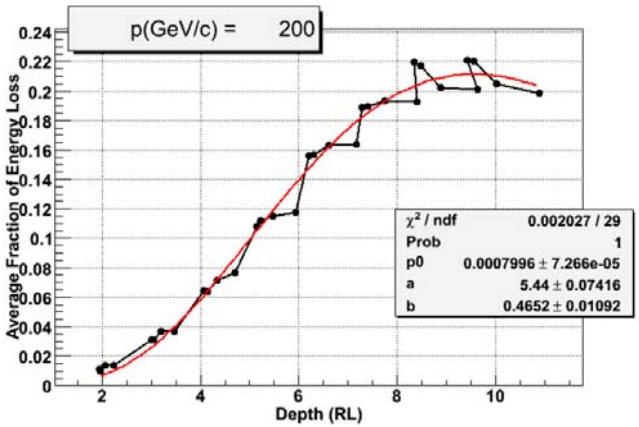
- Comparing the layer energy between data and MC
- Data/MC > 1, but the discrepancy depends on the energy and the angle (black : 0deg, red : 30deg)



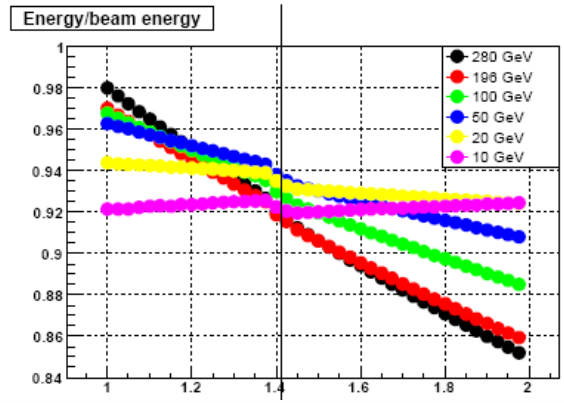
Longitudinal profile of e.m showers

- Sampling the profile with 0, 10, 20, 30, 45 deg runs
- Fitting the profile to look for extra-material upstream the CU
- Checking Geant4 (see Francesco's talk at the C&A meeting yesterday)

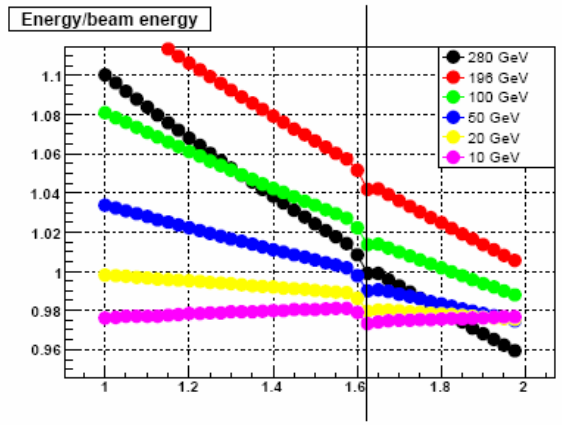




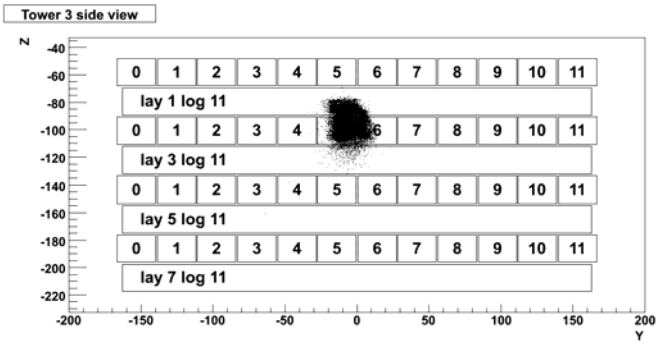
MC

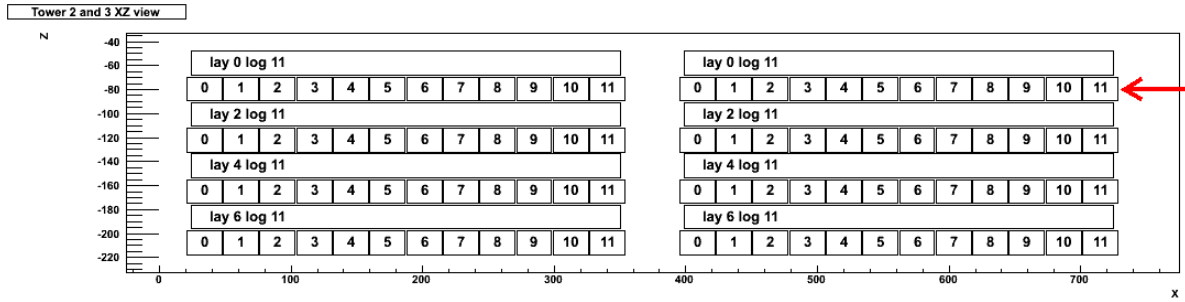


data

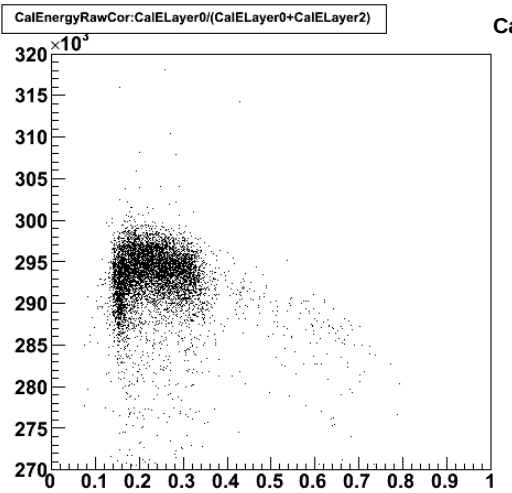


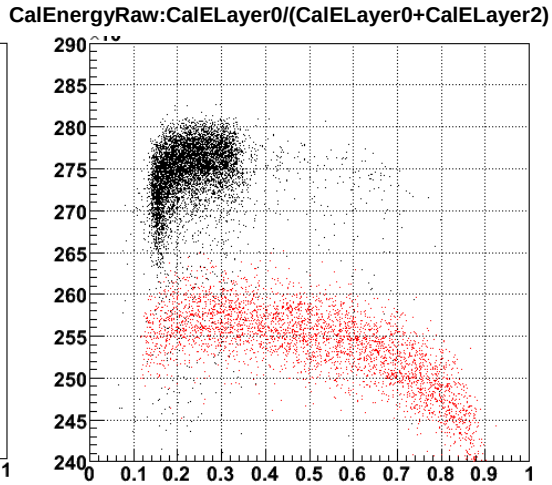
90 deg run (282 GeV) : without the tracker

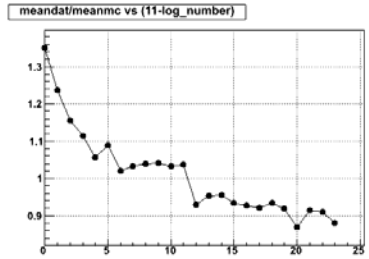


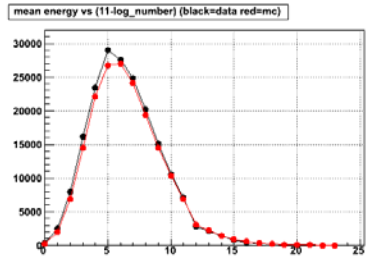


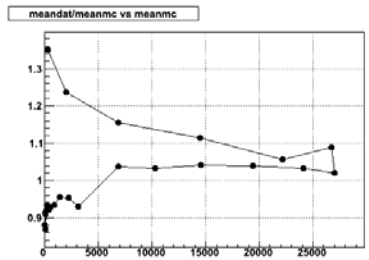
- Corrected CalEnergyRaw / beam energy ~ +3%
- Data/MC ~ +7% and the discrepancy is larger at the start of the shower

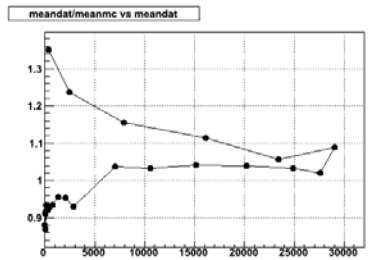






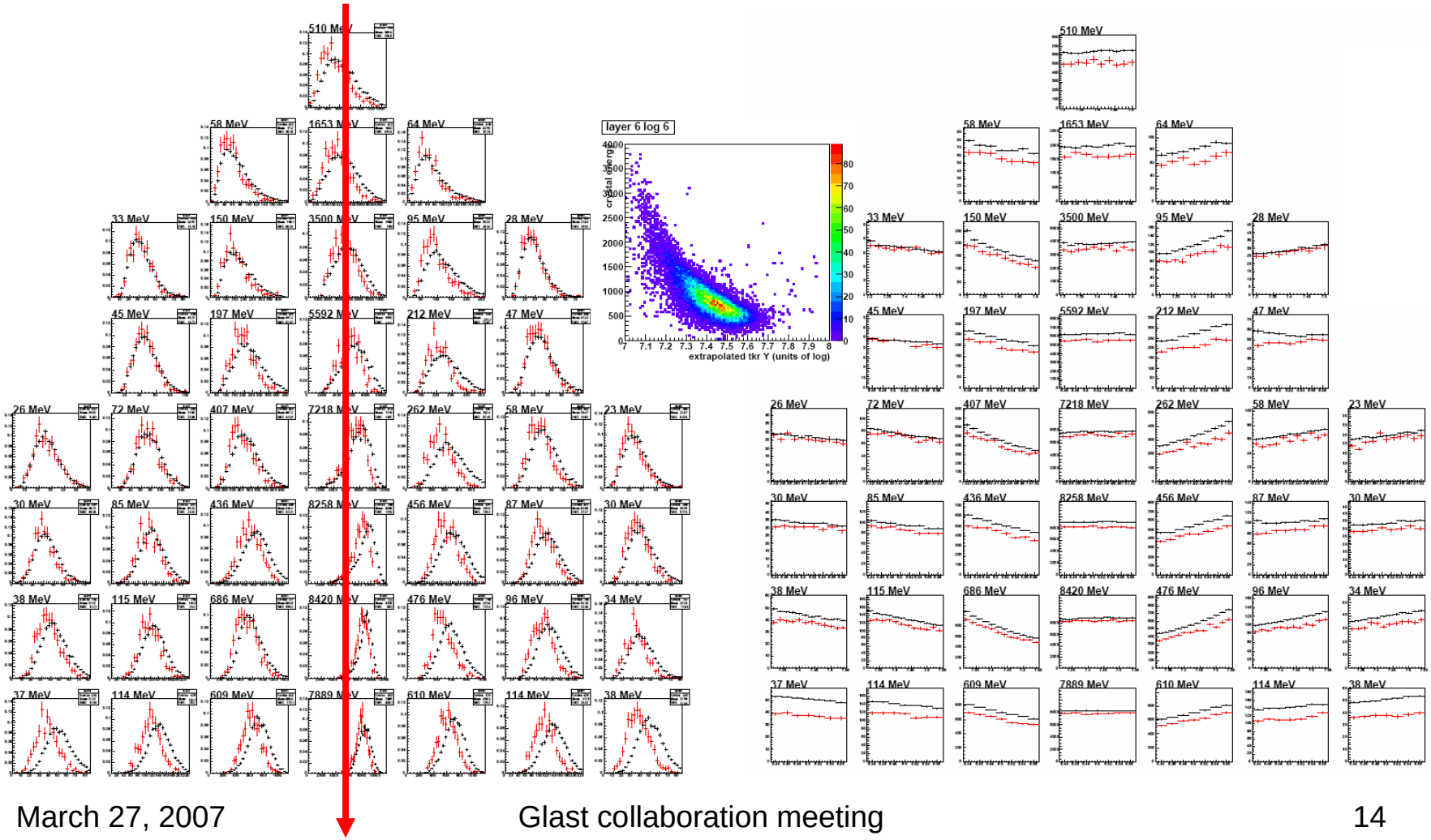




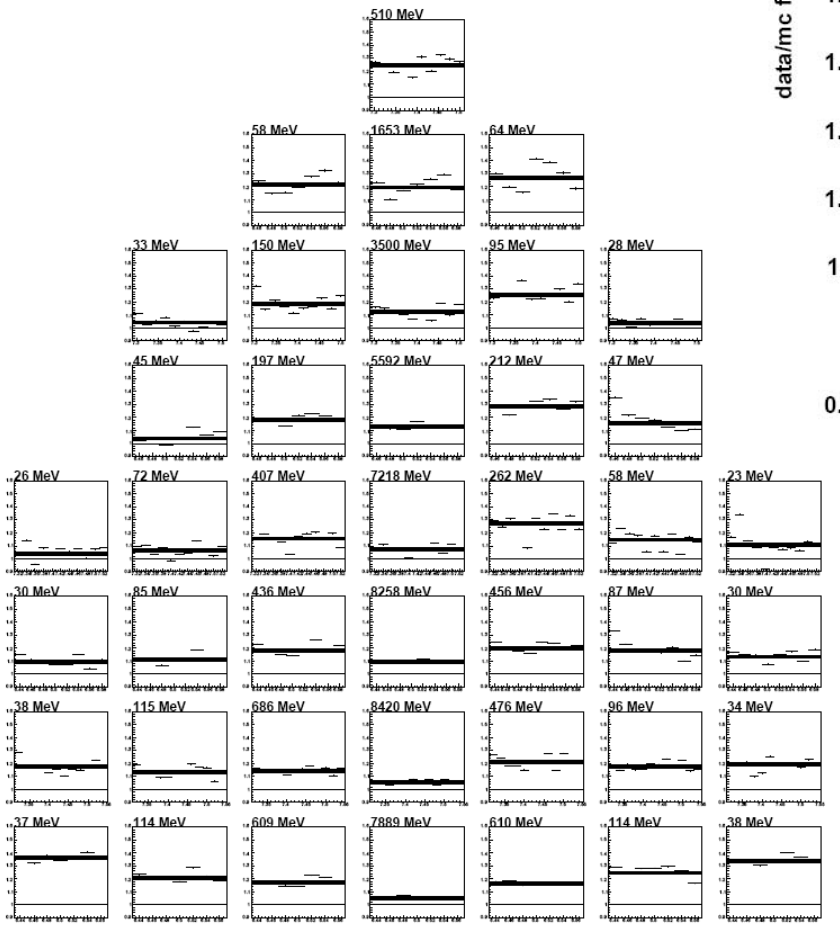


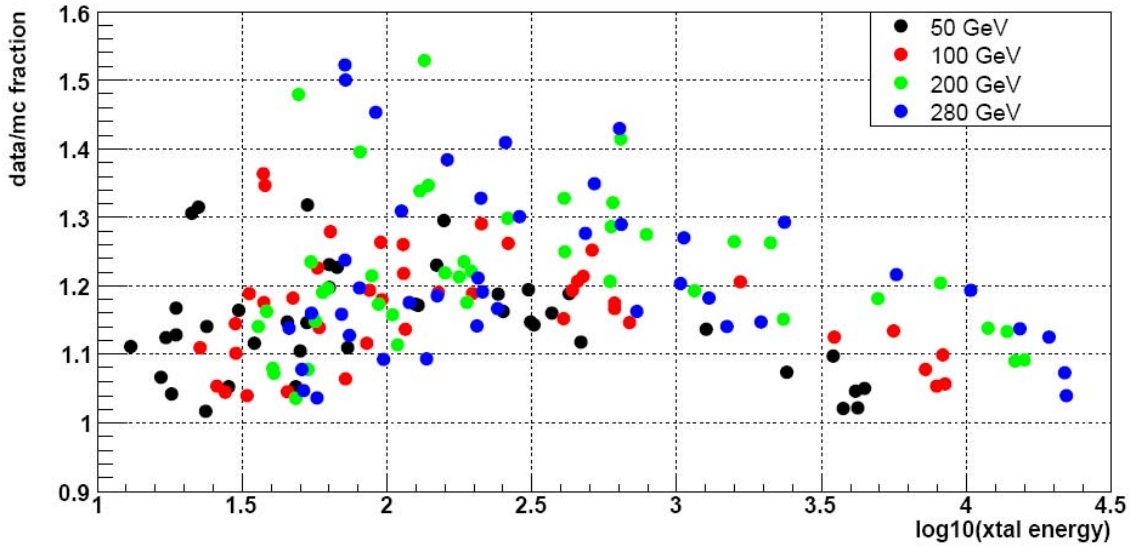
Shower imaging

- Comparing crystal energies and how it varies with position



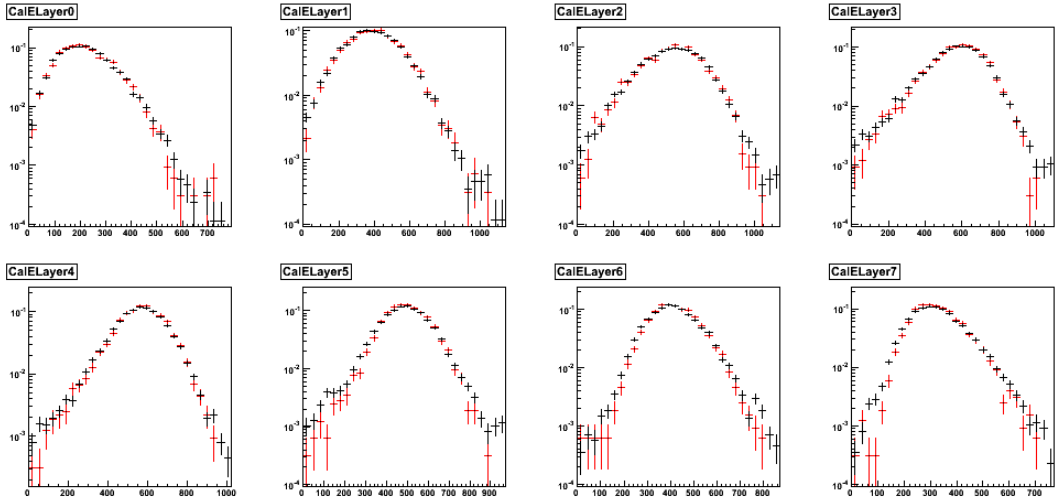
Shower imaging





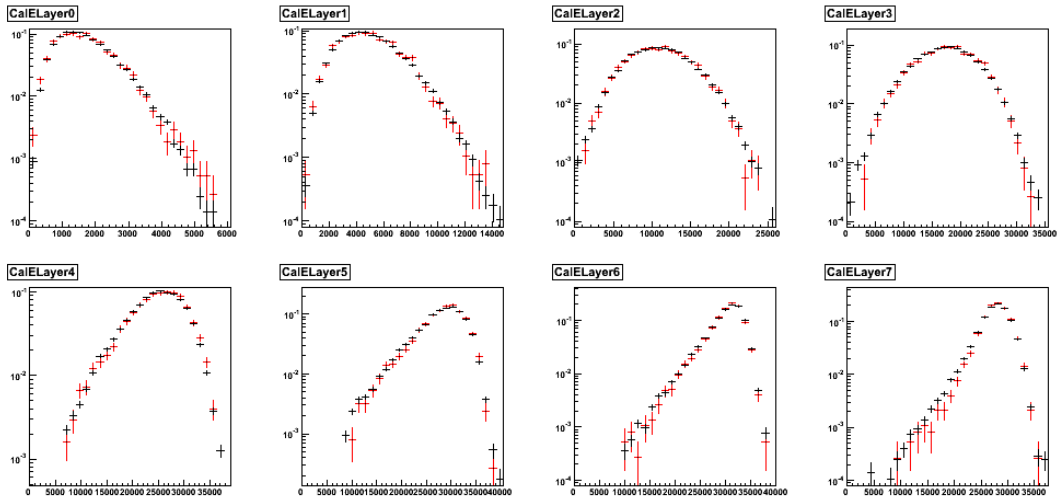
- The dependance with position is well reproduced
- The needed crystal correction is not constant and depends on energy

Layer energy after ad-hoc correction



- After simple ad-hoc correction, the distributions are well reproduced

- 5 GeV
- 280 GeV



Conclusions

- The data/MC discrepancy helped us to revise the calorimeter calibration
- The discrepancy is still there but we have to :
  - Reprocess the data with the last calibration
  - Apply a constant factor correction ?
    - The 11.2 MeV mip cosmic muon is not so accurate
    - Check with protons and pions at CERN
  - Look if extra-material upstream the CU is needed ?
- The shape of the distributions are well reproduced so, at the end, we should get the expected performances (energy resolution)