Towards an ECAL e^- analysis paper?

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- Would like to aim to progress from LCWS note to published paper(s). Envisage two papers:
  - 1. Hardware, calibration, technical performance (gain, noise, stability etc). Anne-Marie to coordinate.
  - 2. Electron response (linearity, resolution, uniformity etc.)
- Schedule – drafts by the end of 2007???
- Basic topics much as in the LCWS note.
- Several problems to be addressed before we can be ready. Will mainly discuss these.
- Comments on systematics.

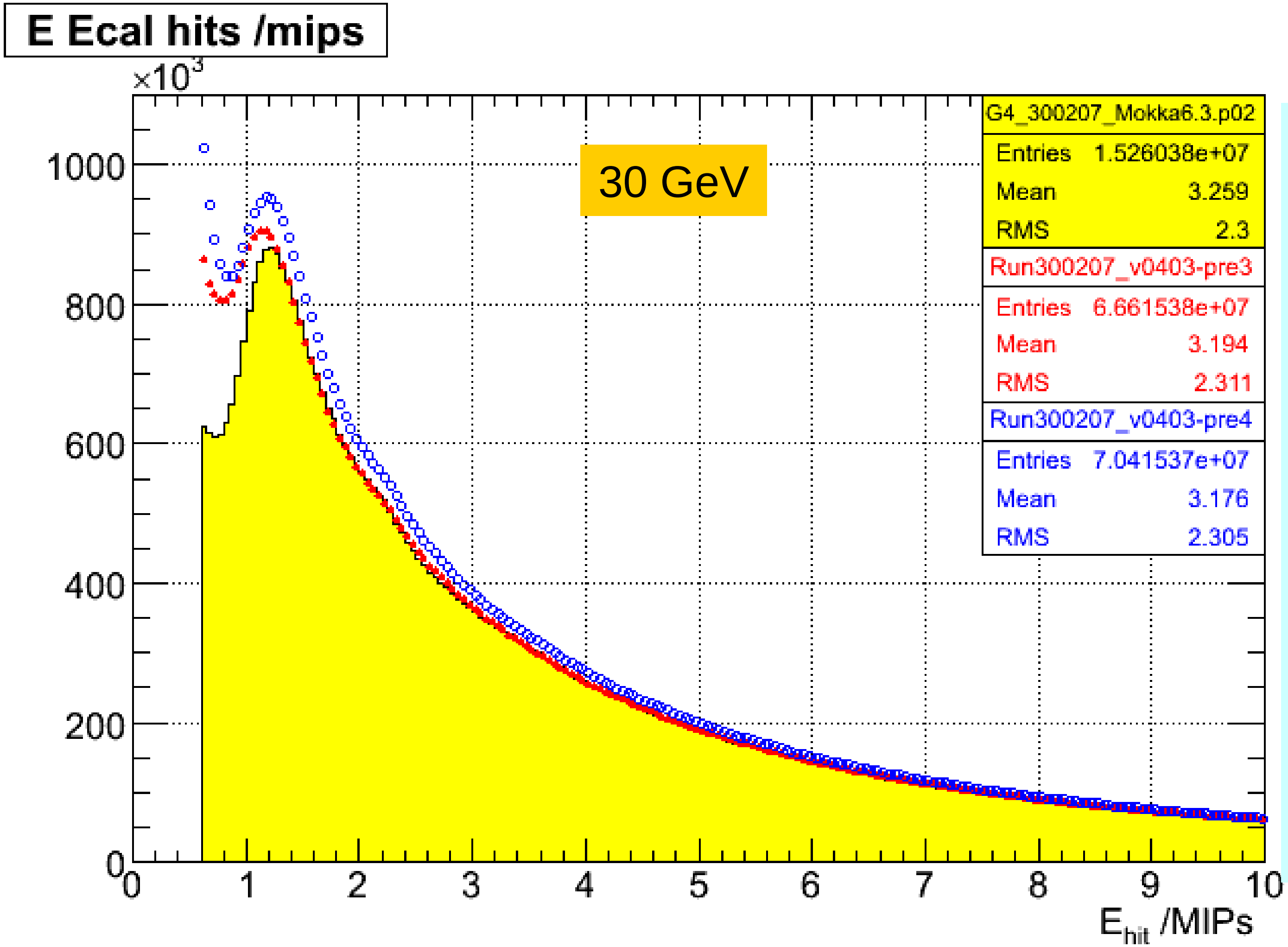
Content of analysis paper?

- Energy response
  - Linearity; uniformity (gap correction); angle dependence.
- Energy resolution
  - As a function of energy, angle, impact of gaps…
- Shower longitudinal profile
- Shower transverse profile
  - Effective Molière radius
- Position resolution
  - Using tracking
- Angular resolution
  - Using tracking
- 2-shower separation
  - Using double events/superimposed events
- All of the above compared with MC simulation.

ECAL problem areas

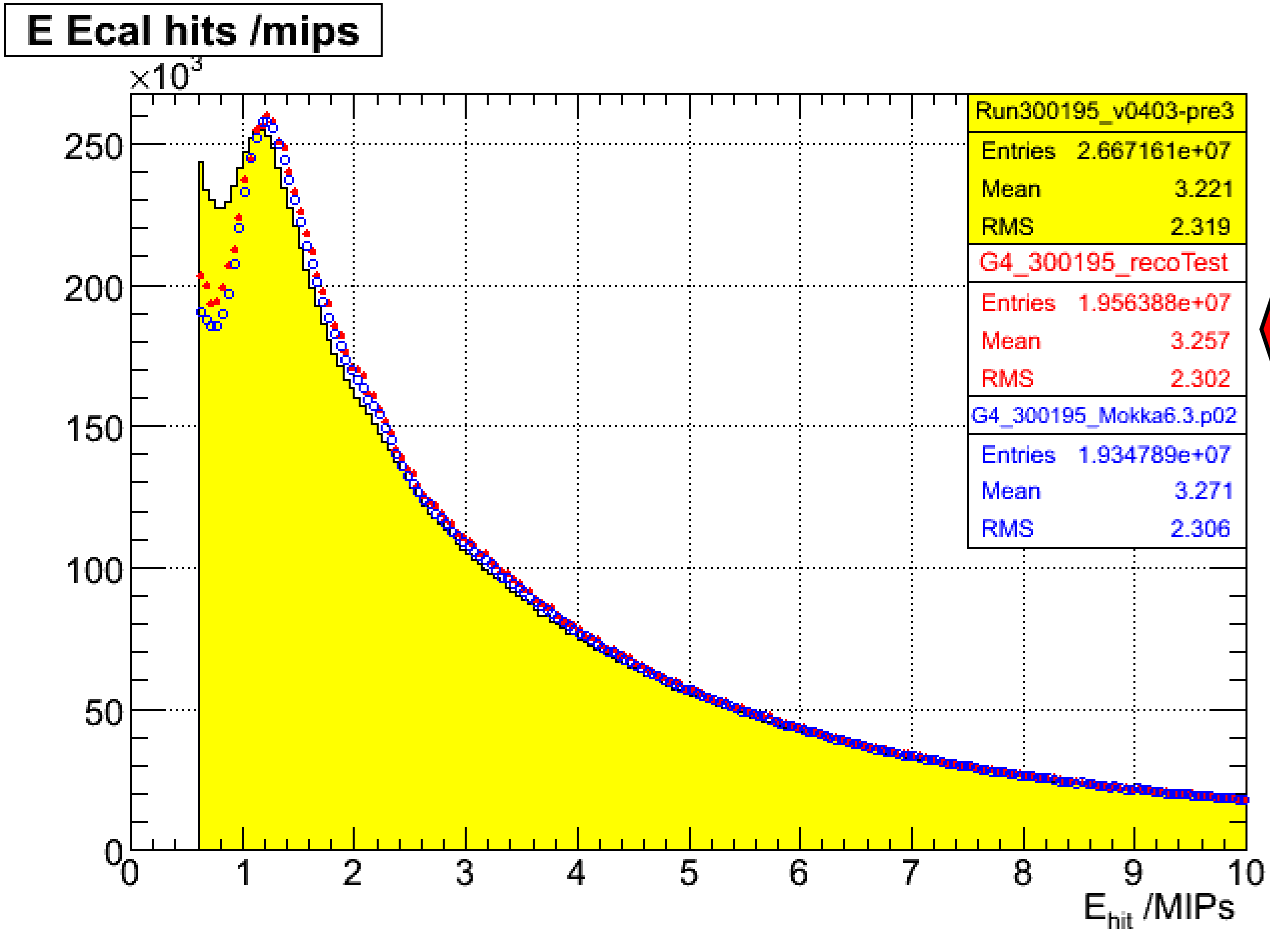
- There are several problematic areas, where we see discrepancies between data and Monte Carlo.
- Some at least may be partly interconnected.
  - Low pulse height hits
  - Number of hits.
  - Interwafer gaps (effect of guard rings etc)
  - Transverse shower shape ($\sim$ 10% higher in data)
  - Shower depth (understanding of beam line, upstream material?)
  - Mismatch of energy scale ($\sim$ 3%) between CERN and DESY

Low energy hits



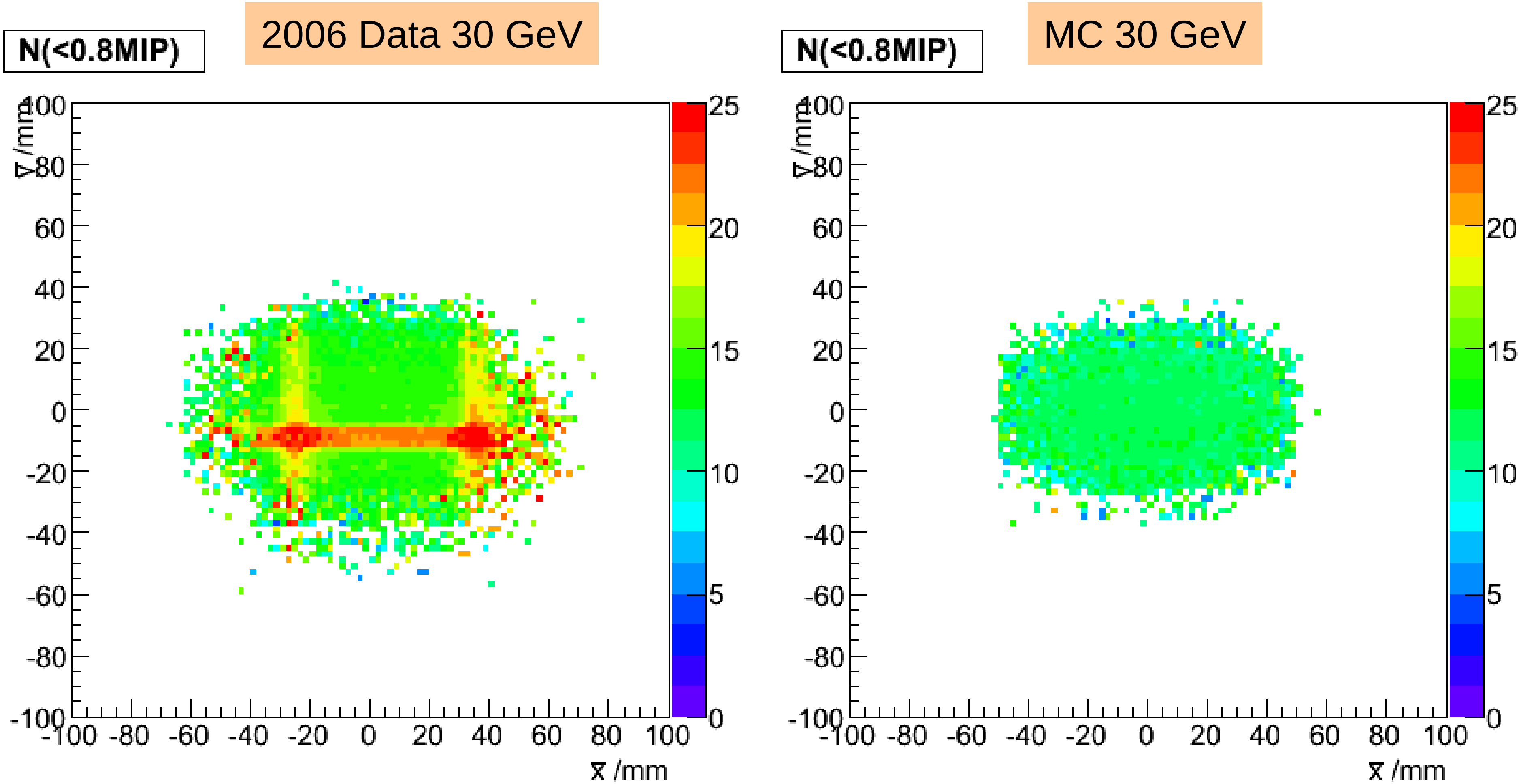
- Pre3 processing agrees with MC quite well down to 1.2 MIPs
- Pre4 processing (SIPS correction) gives extra hits; agrees less well with MC.
- Effect grows with increasing energy.
- Anne-Marie's MC digitization and reconstruction doesn't have any significant effect (next slide…).
- Similar in 2007 data; possibly a bit worse

Effect of MC digitization (45 GeV)

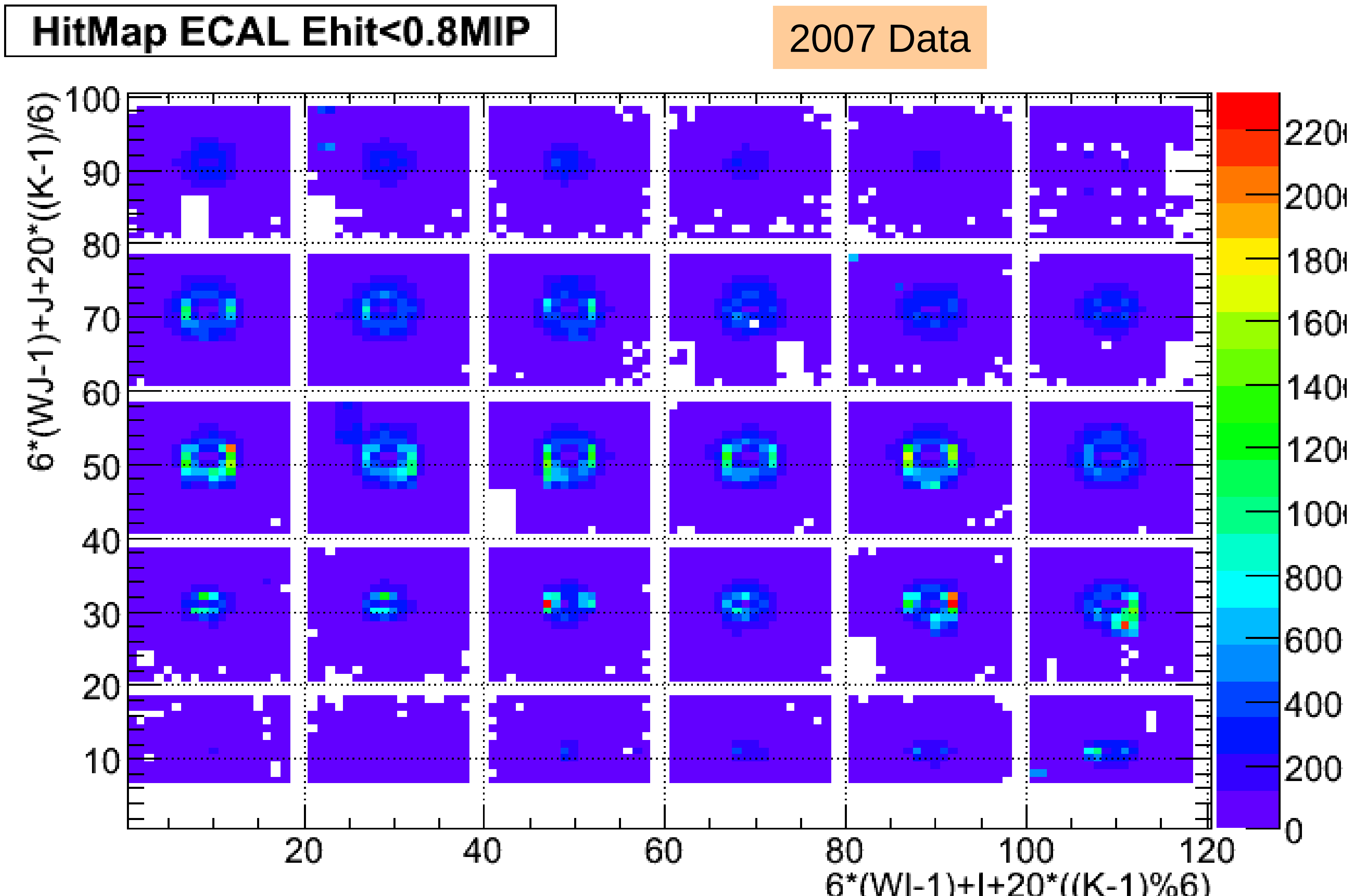


After MC digitization

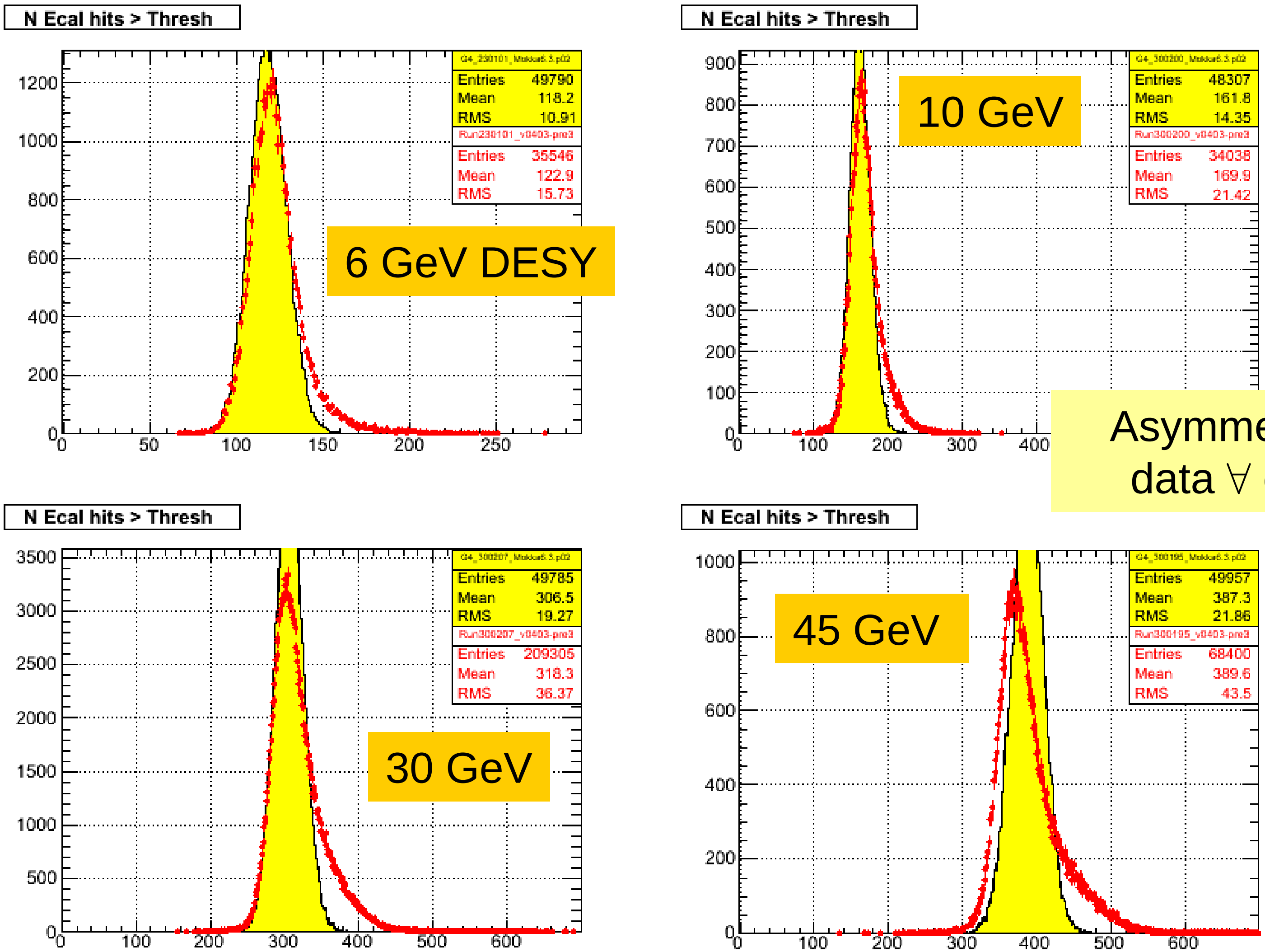
Correlated with shower position



HitMap of hits below 0.8 MIP

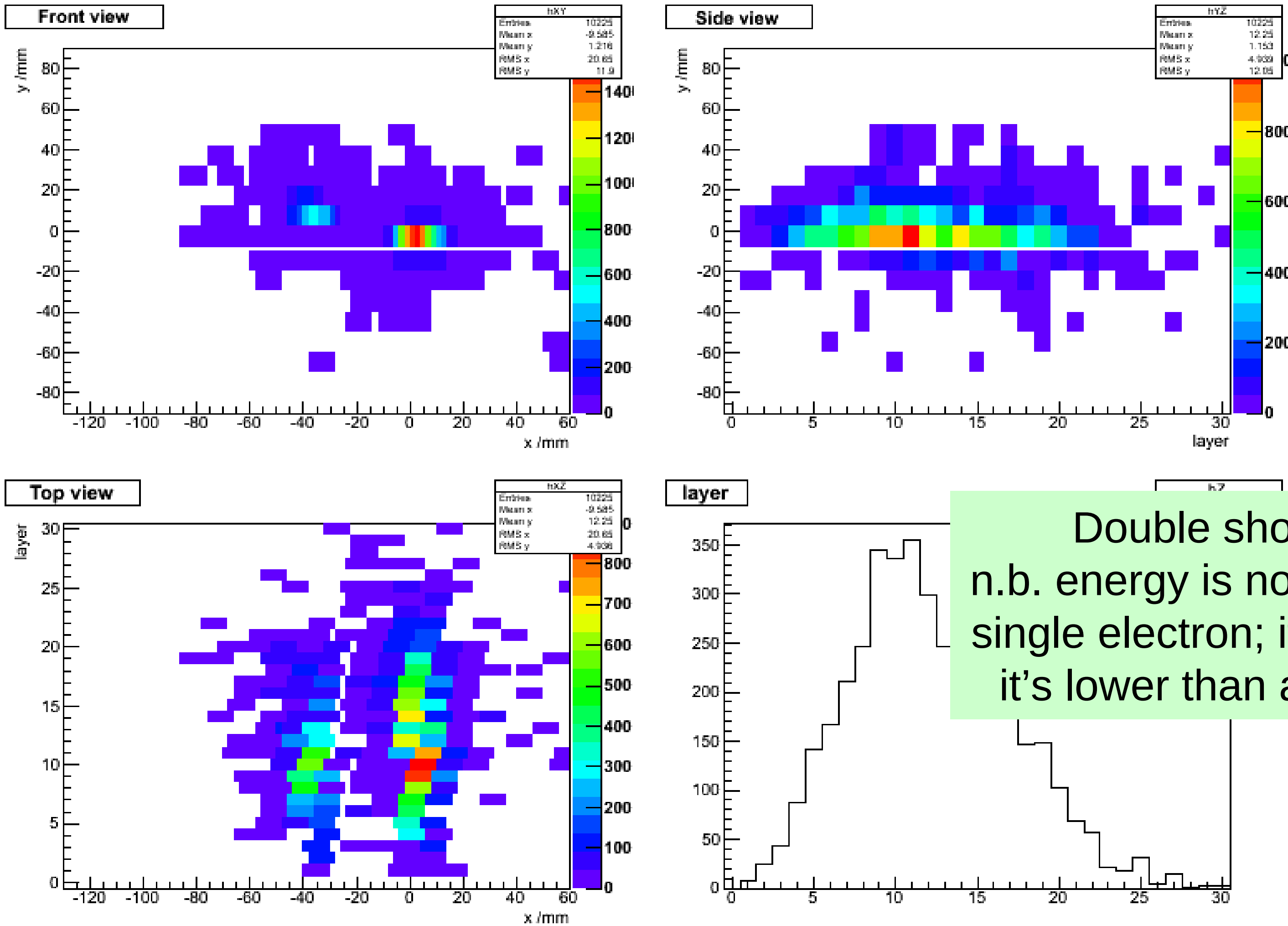


Number of hits (above threshold)

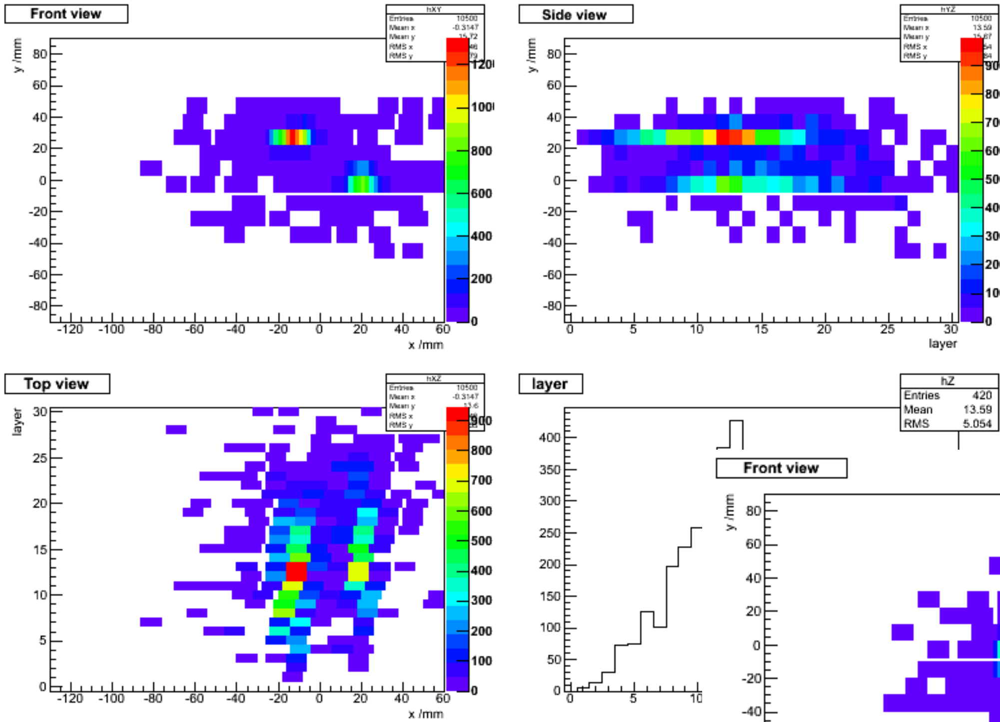


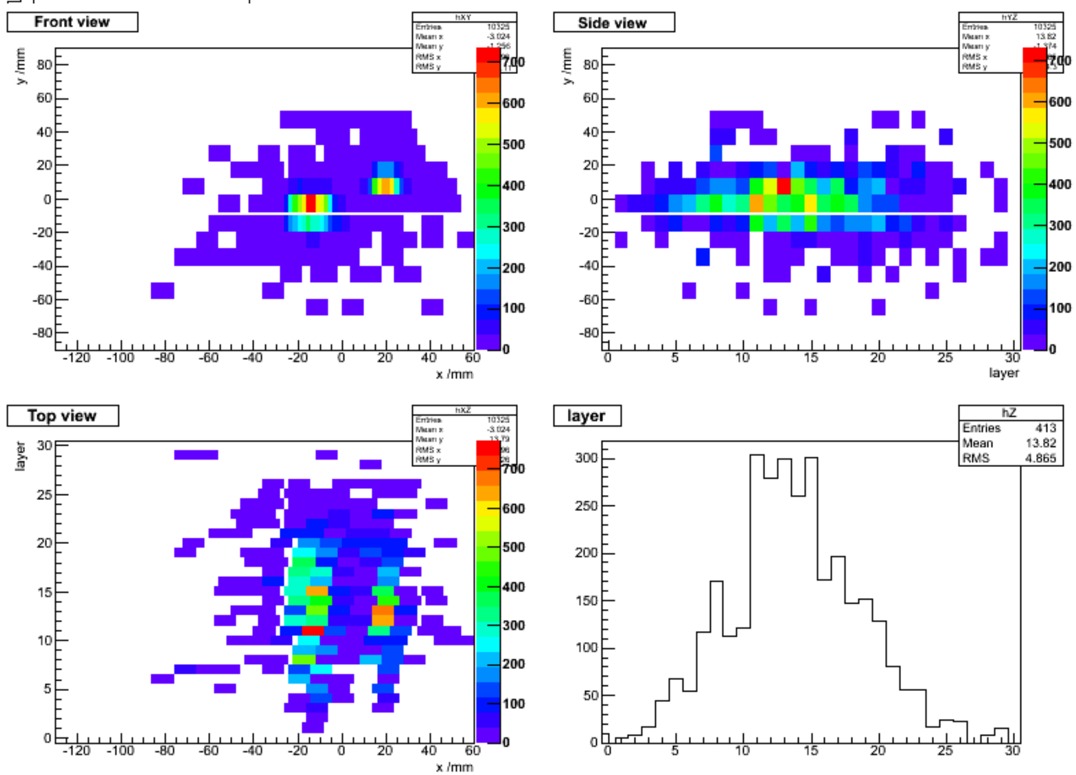
Asymmetric tail in data ∀ energies

Look at events in the high tail in data



Double shower.
n.b. energy is normal for a single electron; if anything it's lower than average.

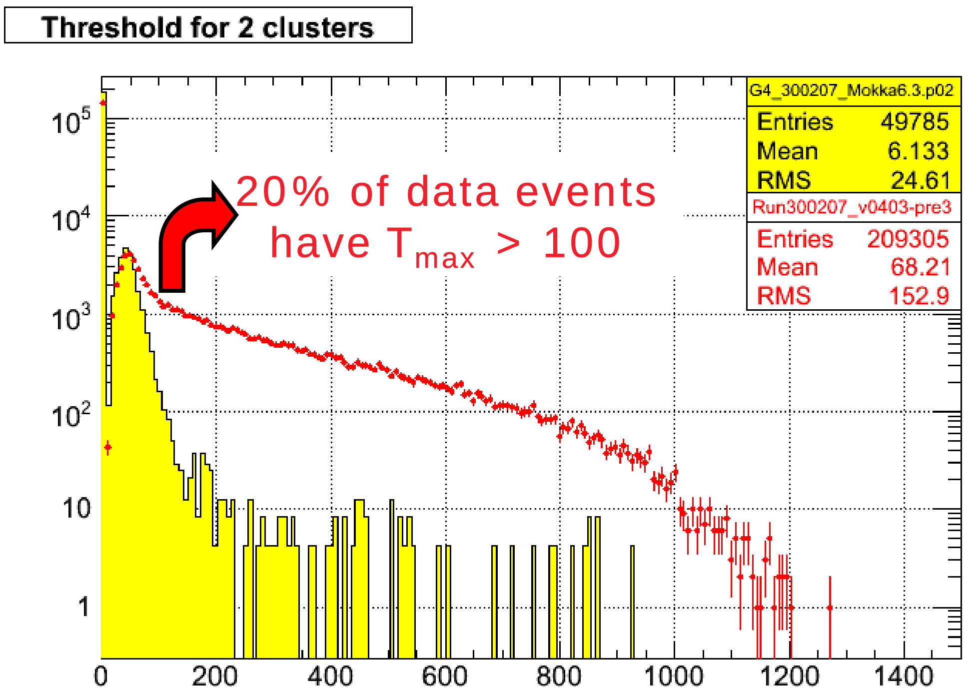




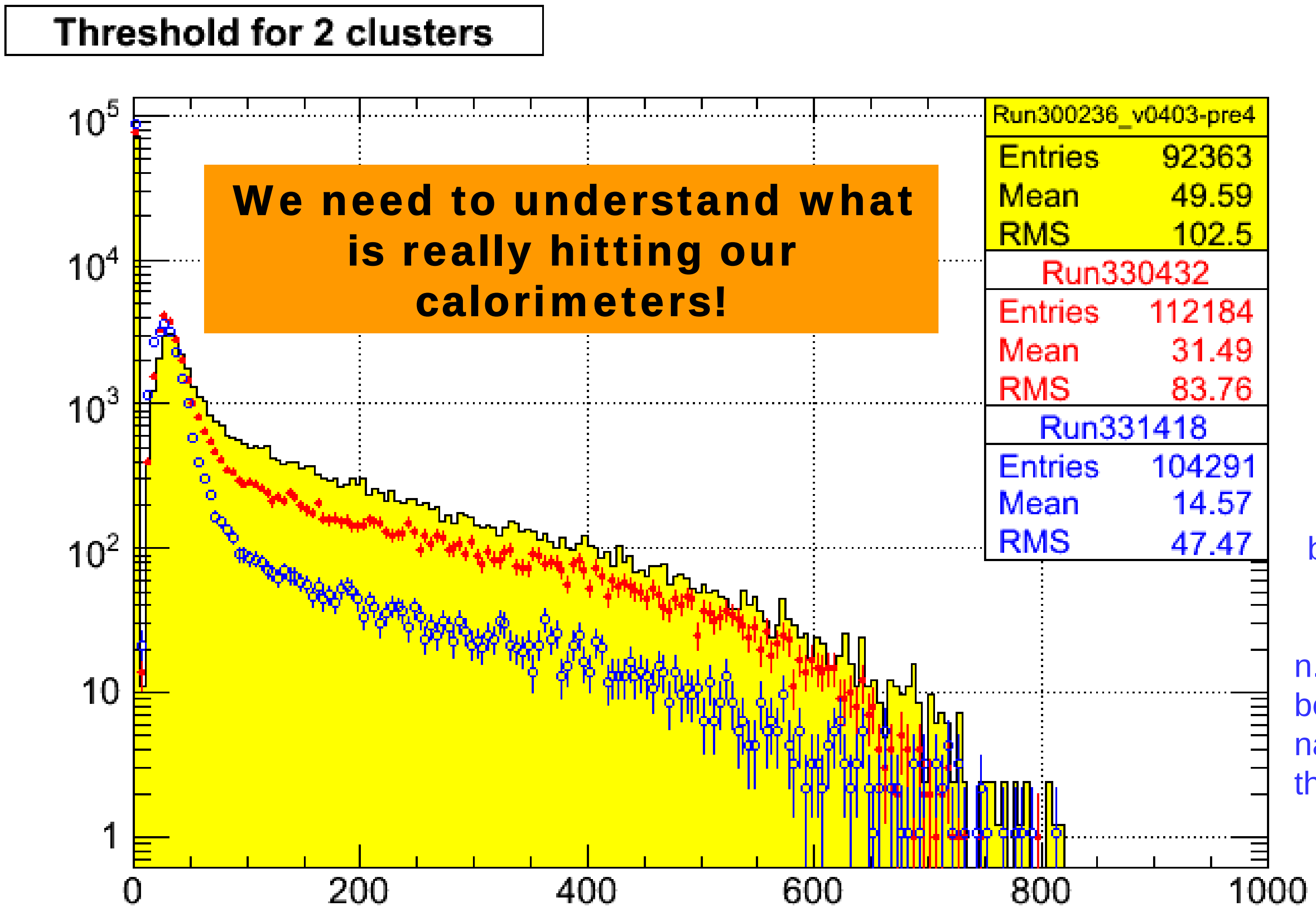
Such events are essentially not simulated at all in Mokka.
There is much still to understand about the beam!

Cut against double events

- Simple algorithm: form *x-y* projection of all 30 layers.
- Apply Threshold *T*
- Perform naïve nearest-neighbour clustering of cells above threshold.
- Find T_{max} below which two or more clusters first appear.
- Dramatic difference between data and MC
- Cut T_{max}<100 to remove (most) double events.



Compare with 2007 data (20 GeV)



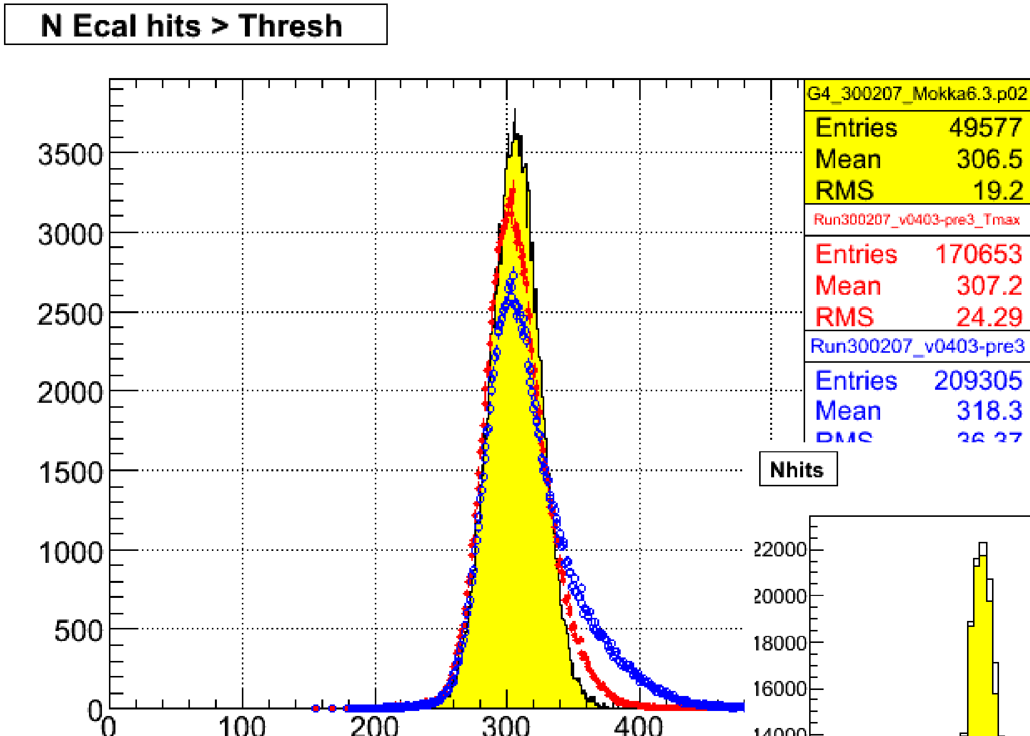
2006

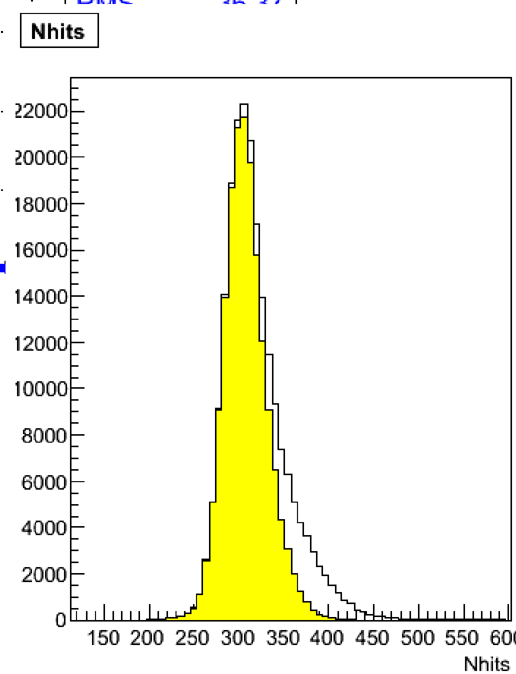
2007 e-
Better, but other runs worse

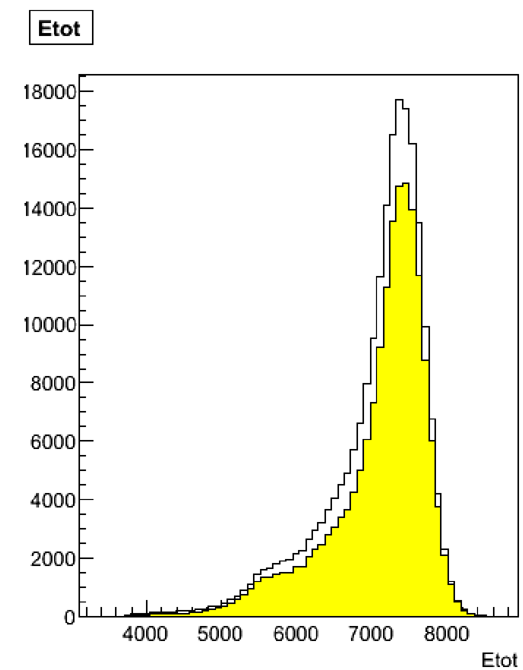
2007 e+
Much better, but still worse than MC

n.b. the e+ beam is much narrower than the e- beam

Effect of cut against double showers

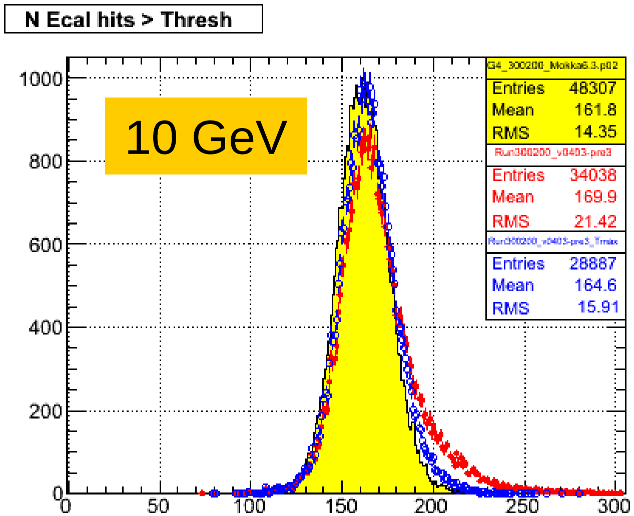


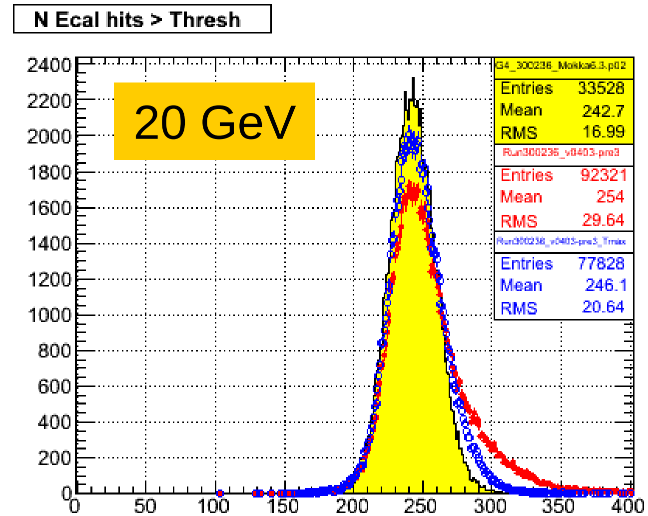




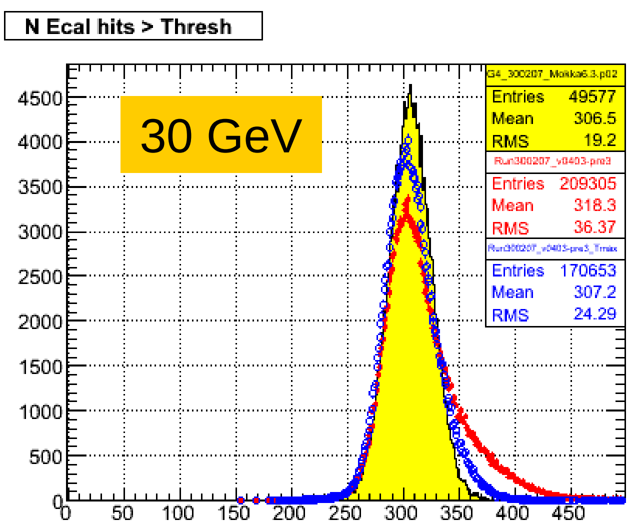
Helps with N_{hits}, but doesn't fully solve the problem.
Little effect on E_{tot}.

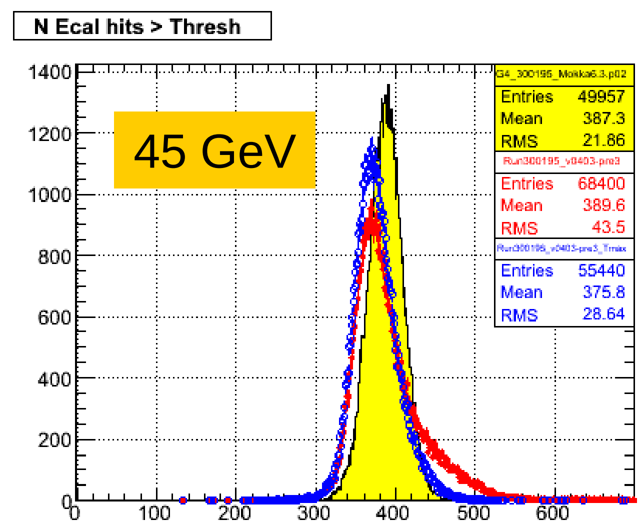
Other energies?



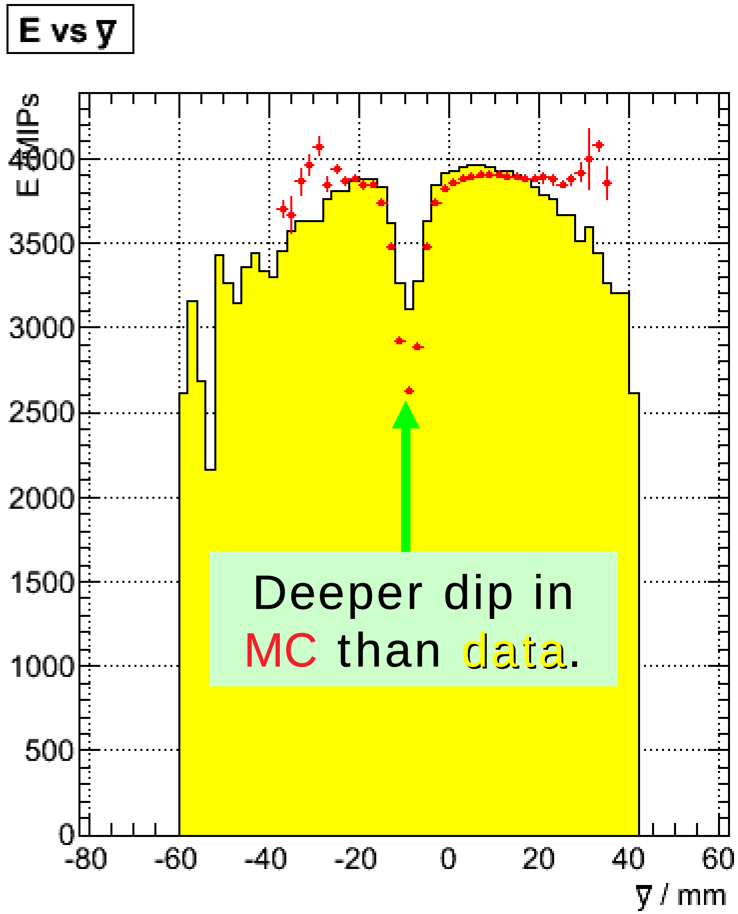


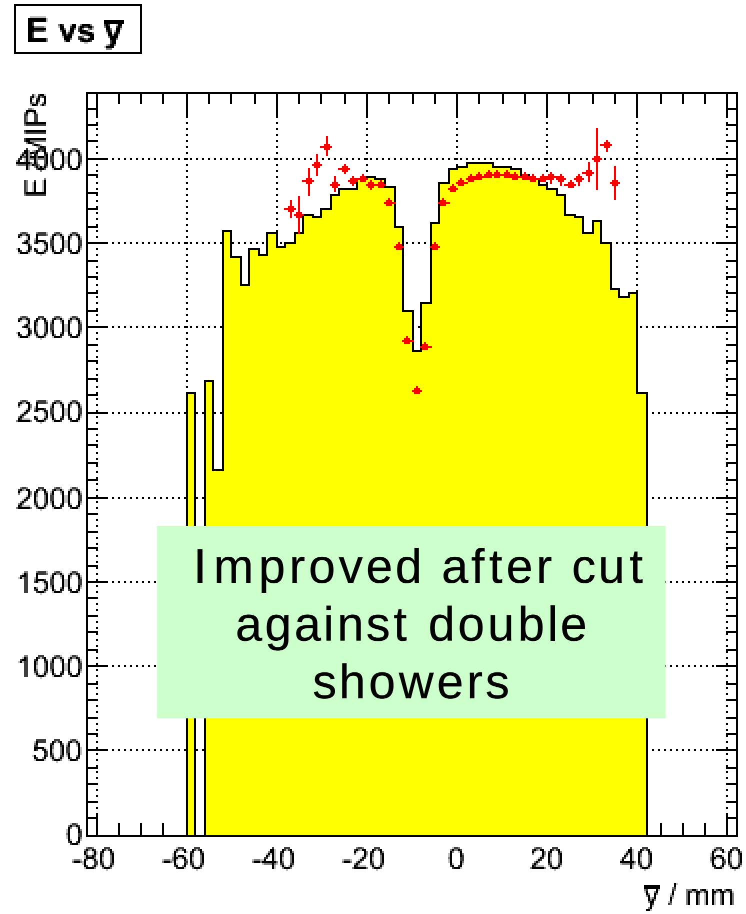
Peak position vs. energy is still a issue





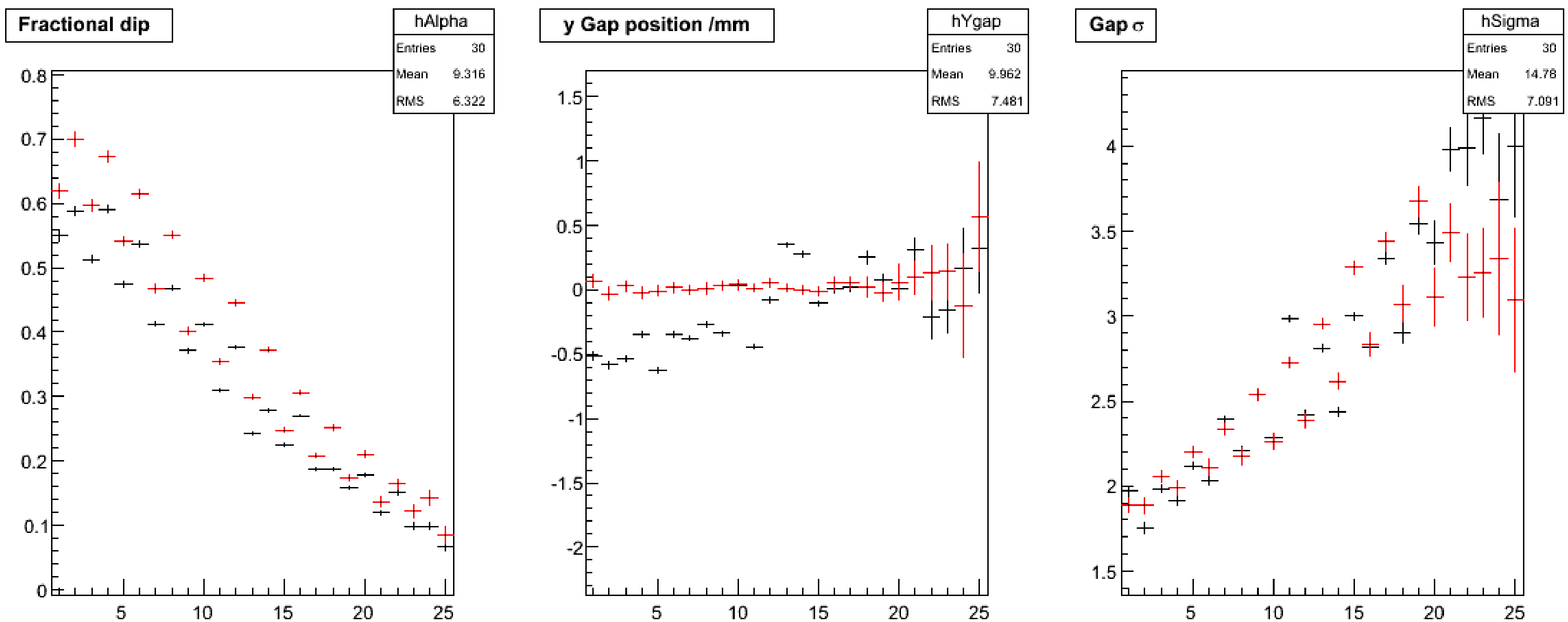
Interwafer gaps; 30 GeV e^-





Dip vs. Layer; 30 GeV e^-

Fit dip in energy vs y in each layer to a Gaussian.
Plot fractional depth of dip, position and σ, for data and MC

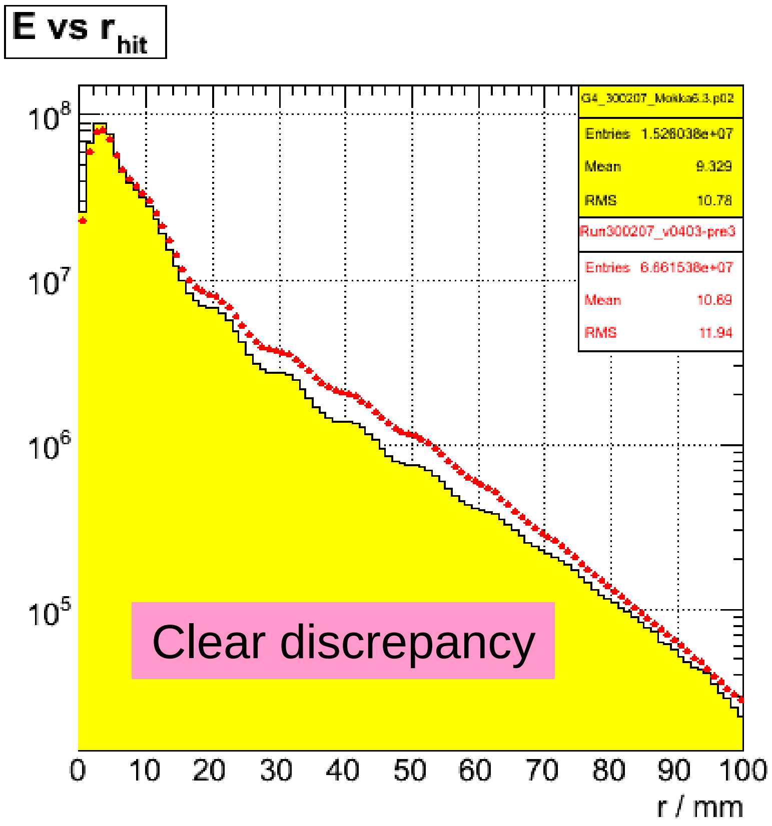


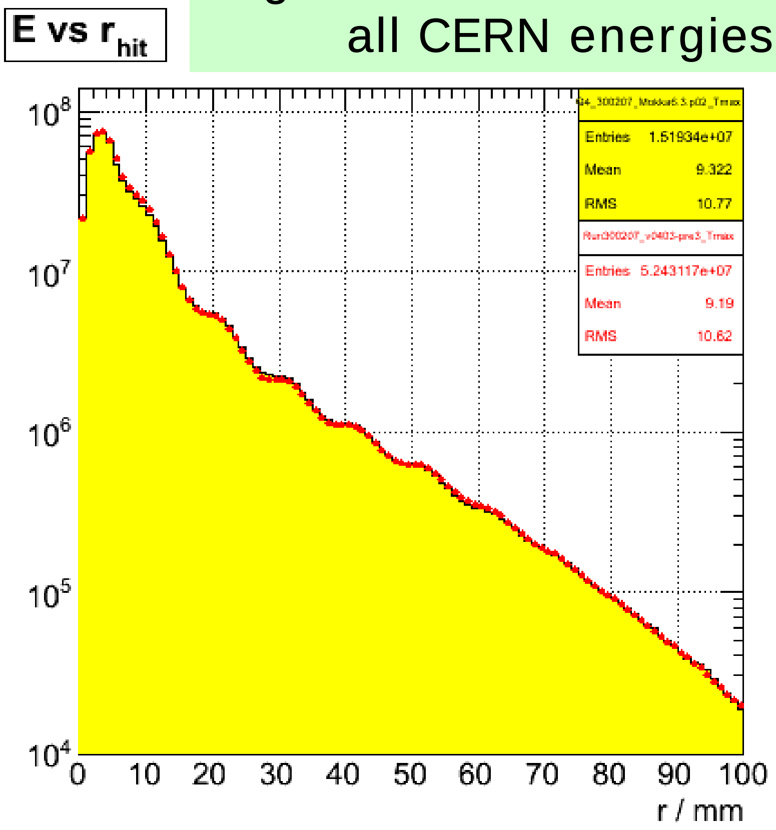
Dip in MC still slightly deeper than in data

Beam inclined in data? Alignment issues?

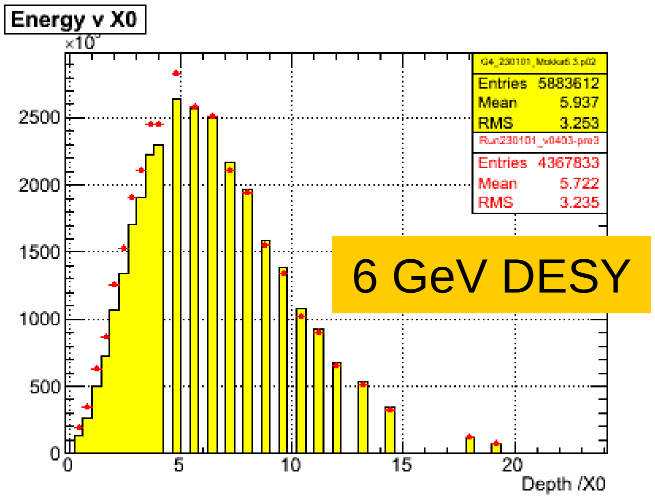
Radial energy distribution

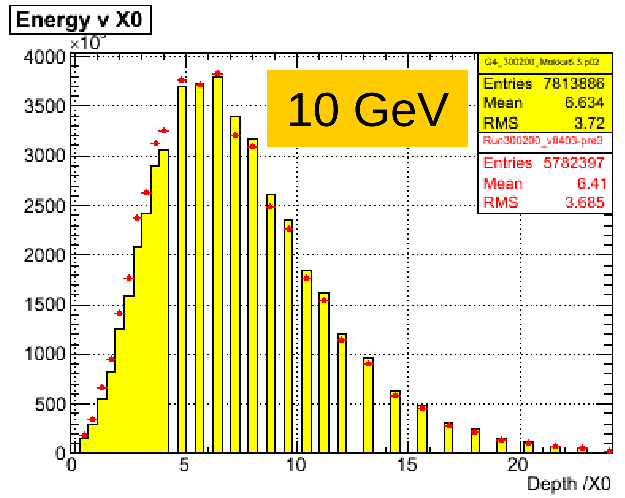
Greatly improved by cut against double showers; at all CERN energies

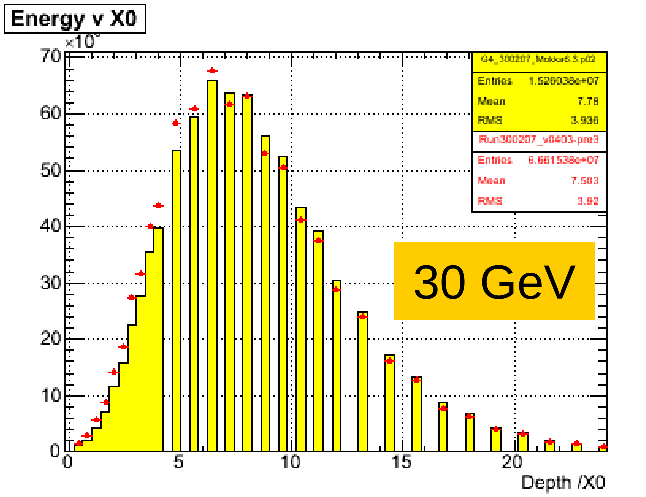


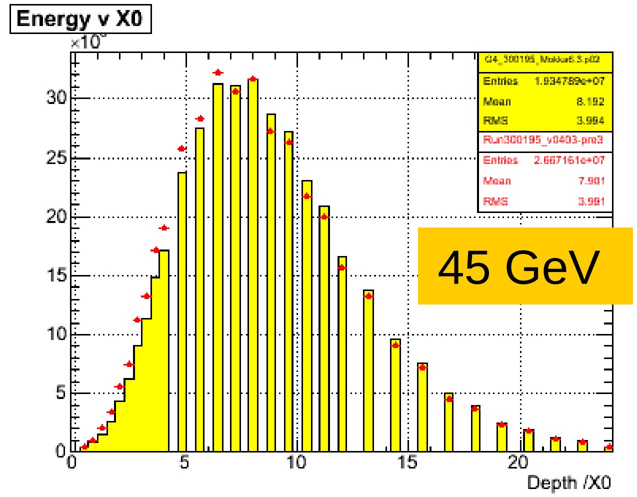


Shower depth



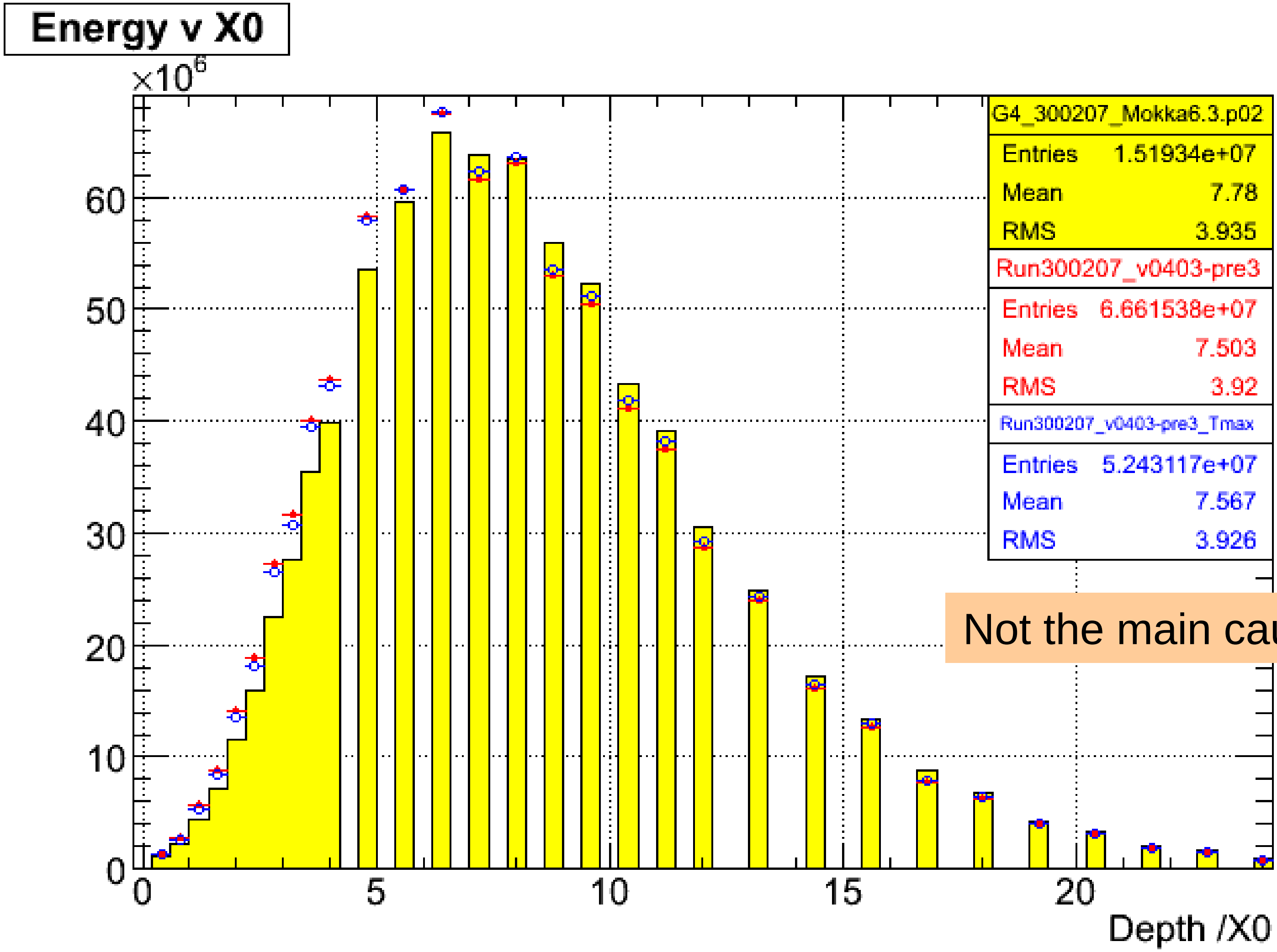






- Shower depth consistently » 0.2-0.3 X_0 deeper in MC than data.
- R.M.S. seems quite well modelled.
- Suggests problem with modelling the beam line rather than the material of ECAL?

Shower depth – effect of double shower cut



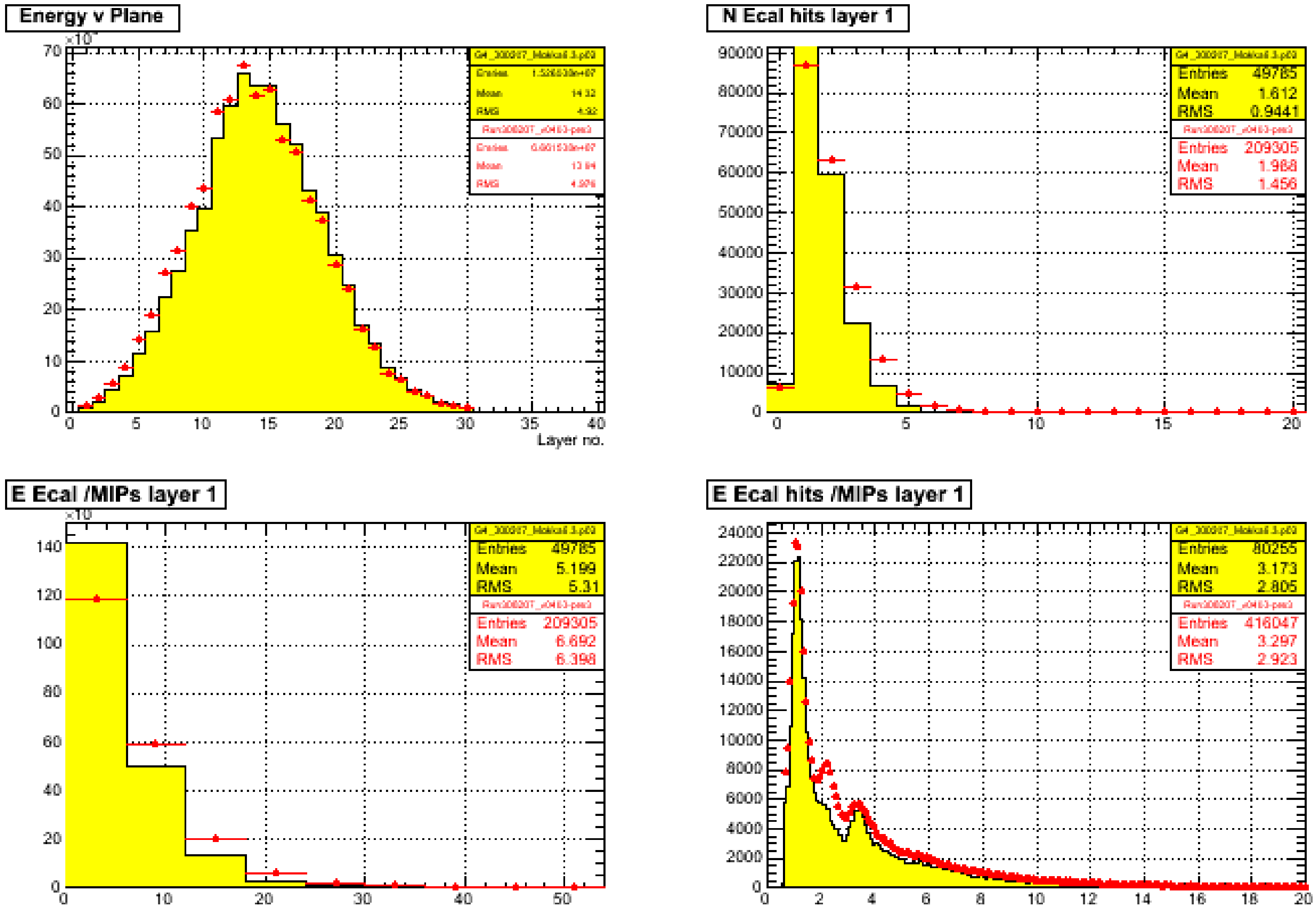
MC 7.78

Data 7.50

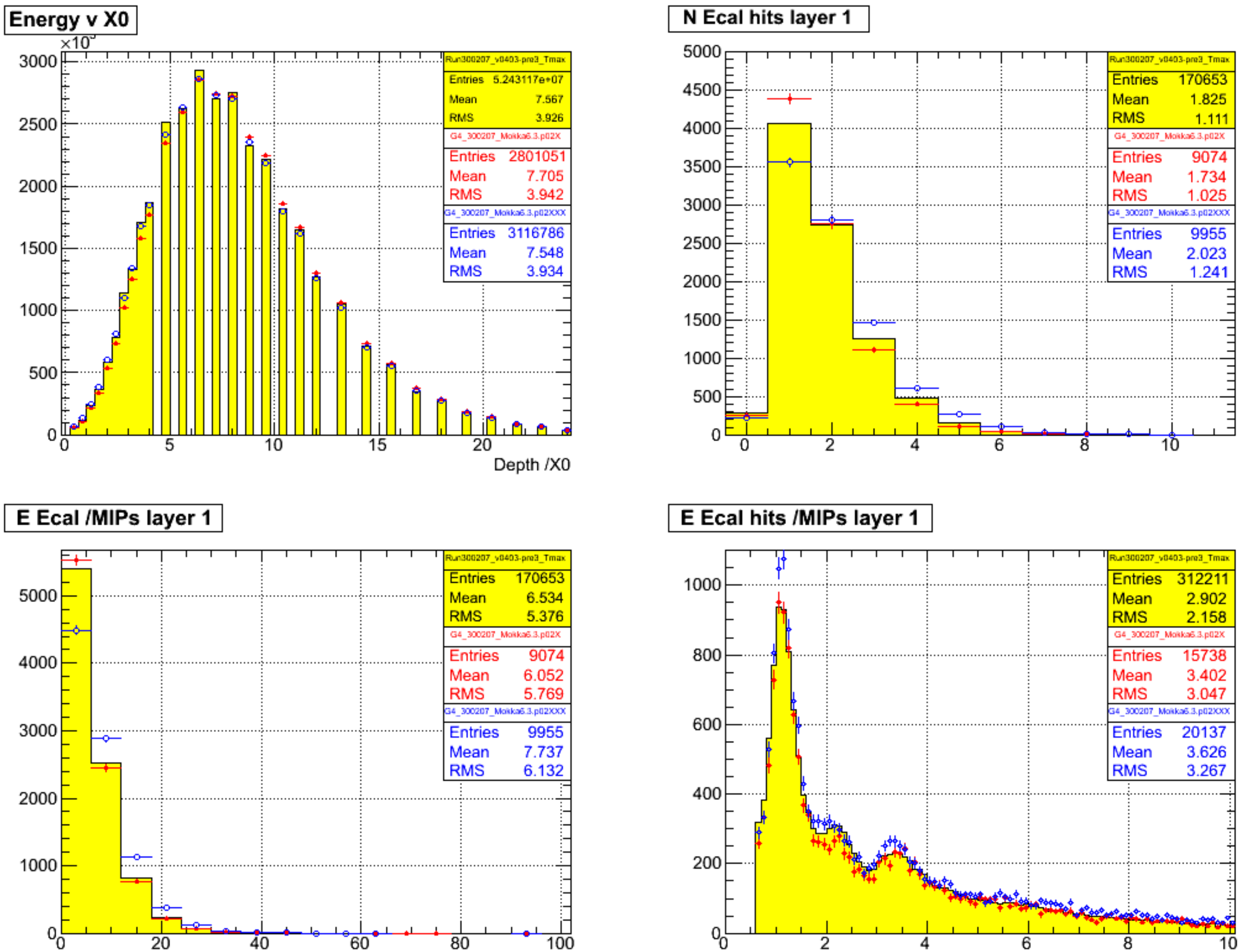
After T_{max} cut 7.57

Not the main cause of the problem.

Hits in Layer 1 only (30 GeV e^-)

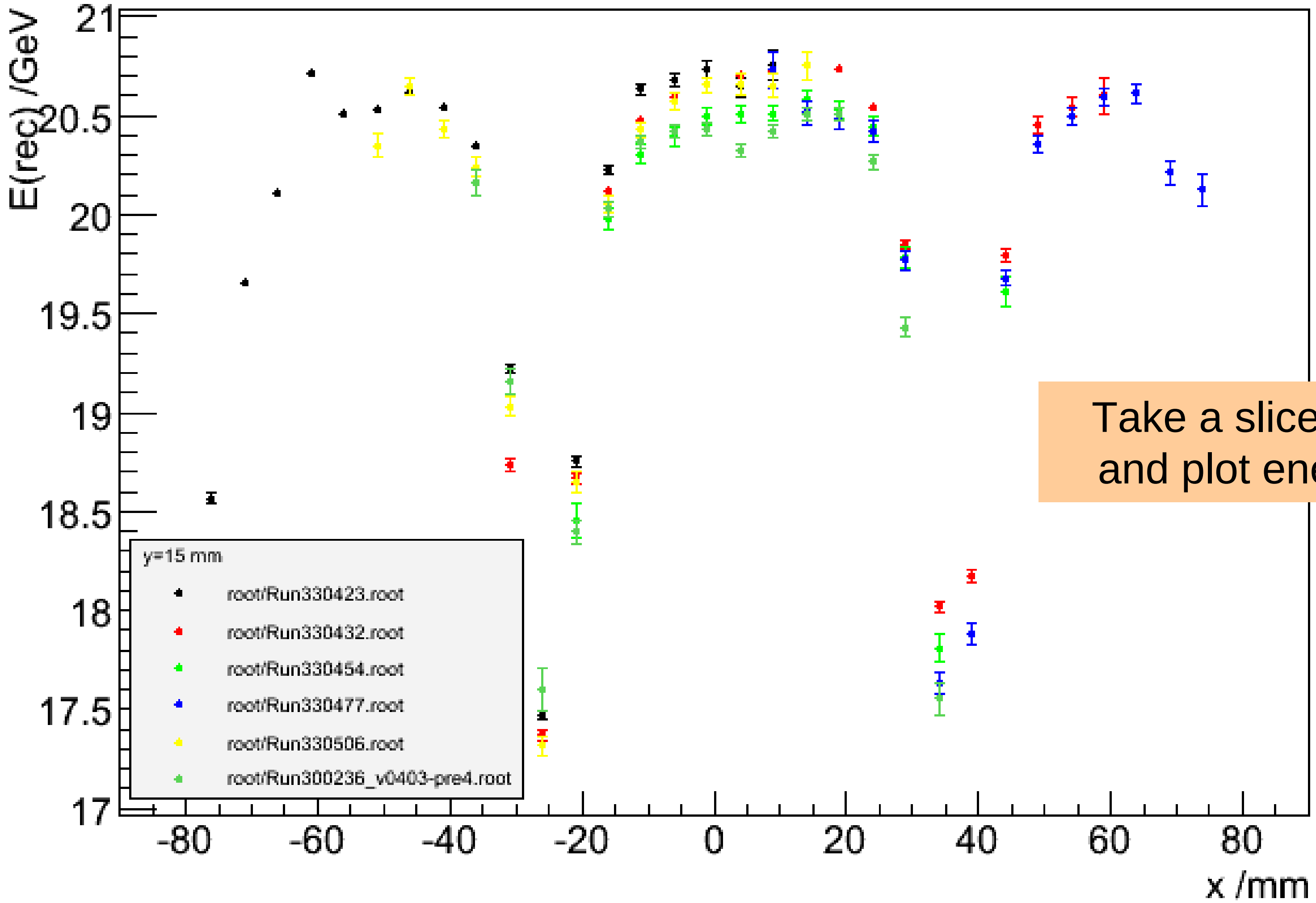


Increase material in beam



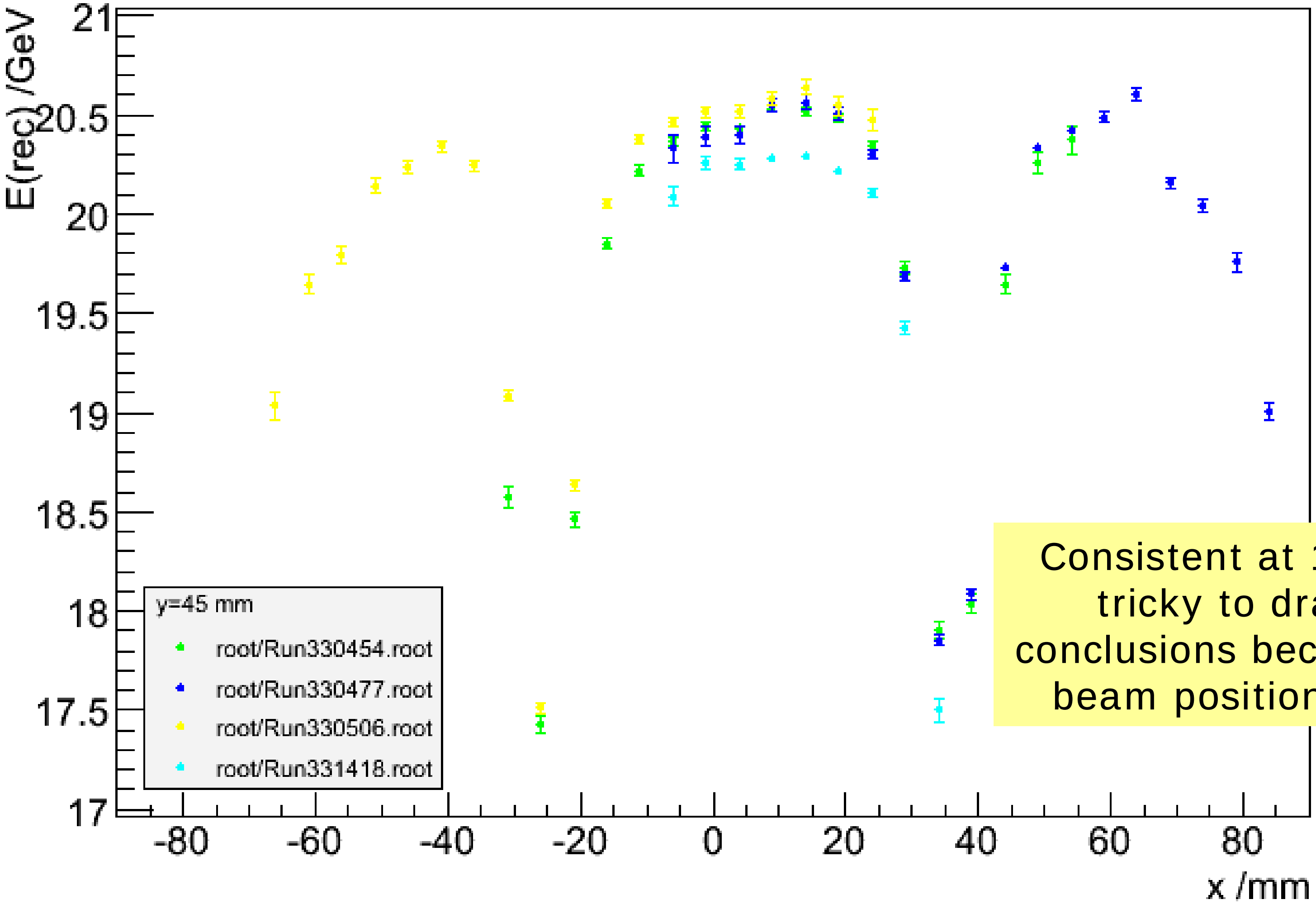
- Try increasing material in beam by 10% or 20% X_0
- Technically done by doubling or trebling thickness of scintillators.
- Obviously too crude, but suggests $\sim$ 10-20% X_0 upstream material would be needed.
- Seems improbably much?
- Emphasises the need to understand the beam better.

Uniformity across detector in 2007 data



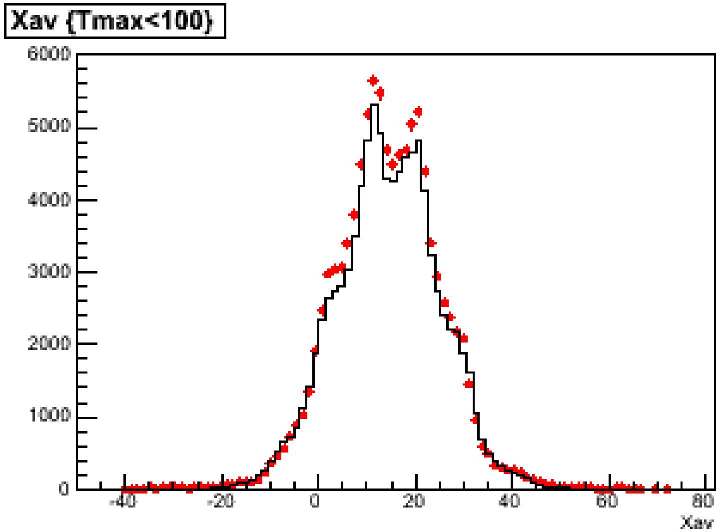
Take a slice 10<y<20 and plot energy vs x.

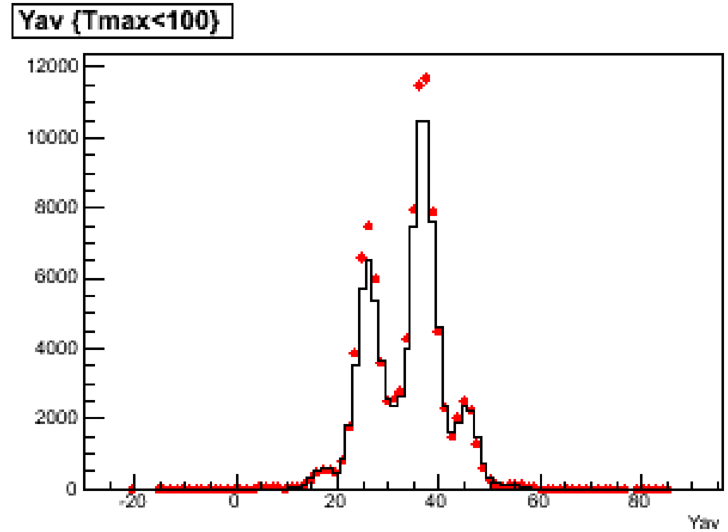
Another slice (40<y<50)

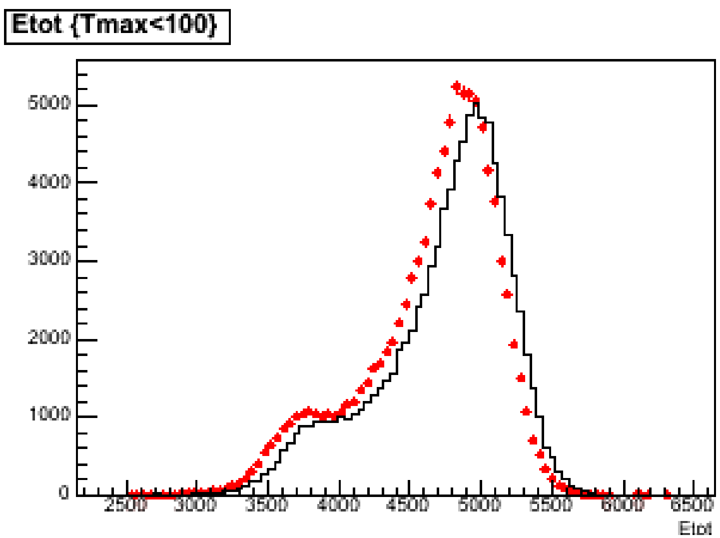


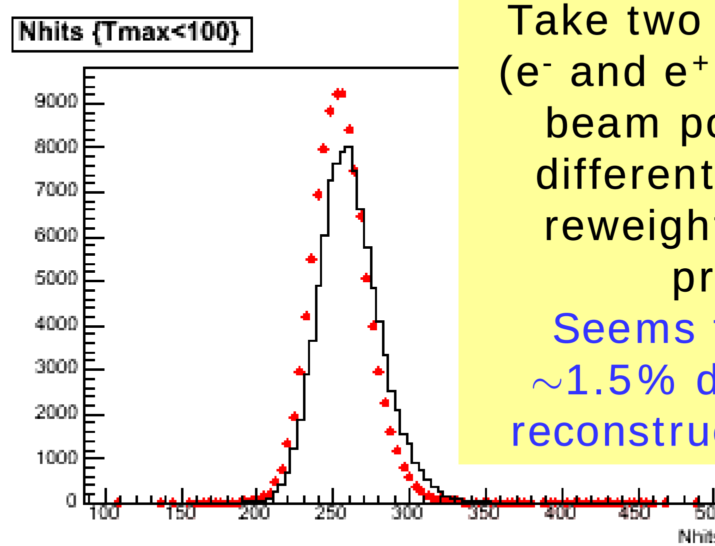
Consistent at 1-2% level, but tricky to draw definitive conclusions because of different beam positions and profiles.

Reweight two 20 GeV runs to same beam profile







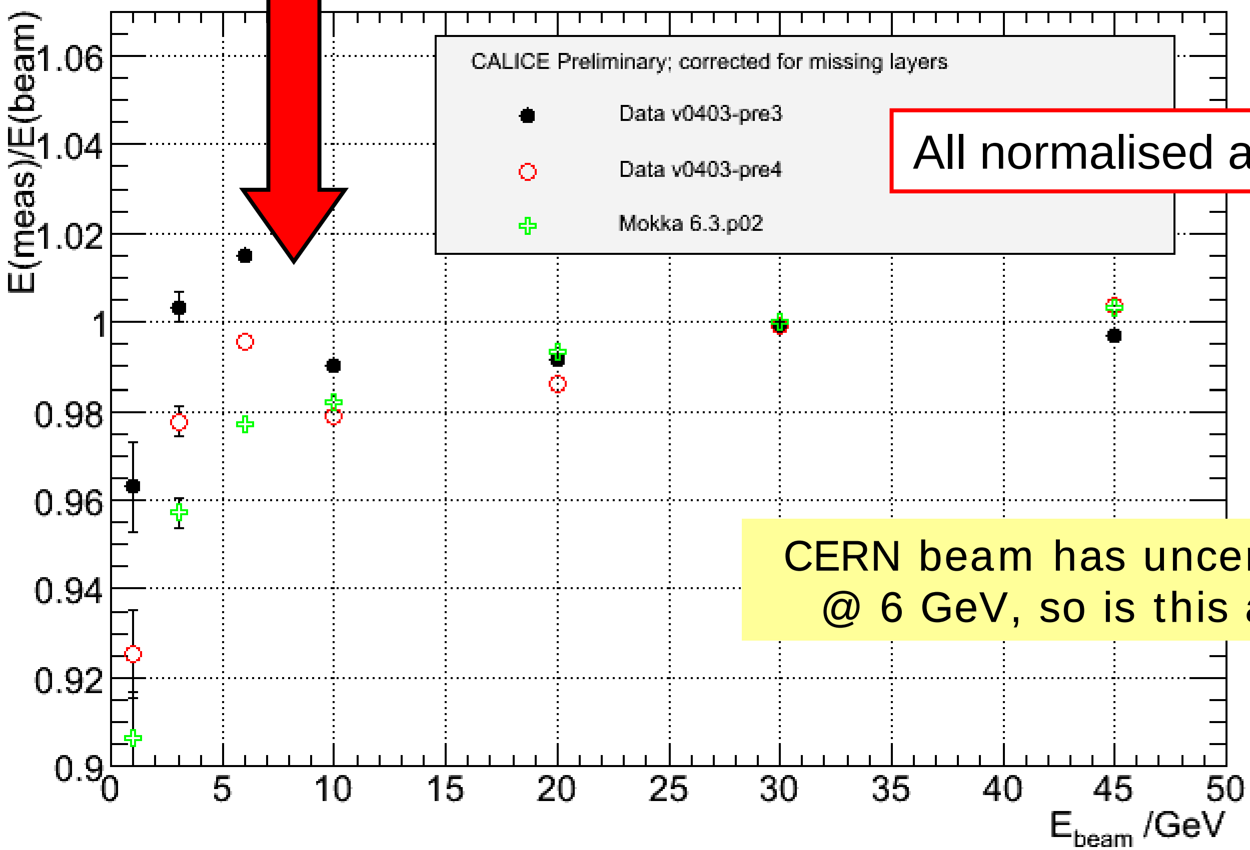


Take two 20 GeV runs (e^- and e^+) with similar beam position, but different width, and reweight to ∼same profile.

Seems to be clear ∼1.5% difference in reconstructed energy.

Energy scale CERN *c.f.* DESY

Glitch in data after correction for missing slabs; not simulated.



All normalised at 30 GeV

CERN beam has uncertainty ~ 2.5% @ 6 GeV, so is this a real worry?

Thoughts on systematic errors

- A major deficiency in what we've presented so far.
- Think what we might need to do, and whether software framework is adequate at present. Comments welcome.
  - Vary threshold cut.
    - Is the signal/noise cut in data reconstruction adequate?
  - Vary calibration constants within their statistical errors.
    - Reprocess using database? Or just smear? Or simulate using MC?
  - Vary cuts for selecting good $e^{\pm}$ events.
  - Compare runs at same nominal energy.
  - Vary fit procedure/range for extracting response/resolution
  - Different inter-wafer gap corrections?
  - Intrinsic beam energy uncertainty ($0.5\% \oplus 150$ MeV/p) and spread (typically 0.5%).
- I think most of these could be done (or approximated well enough) using the existing reconstructed files.
- ...

...Continued...

- Would be good to add to the reconstructed files info about the beam (energy (nominal or “true”?), spread, position, angle, magnet currents?).
- Needs for the Monte Carlo?
  - Correct calorimeter geometry.
    - Including misalignments?
  - Dead cells (especially for 2007)
  - Signal-related crosstalk/pedestal shift, if we can understand the effect well enough.
  - More realistic simulation of the beam.
    - Spread of energy/position/angle; correlations between these.
    - Upstream material and showering.
    - Do we need a full beam line simulation?

Summary

- Do we go for publication of 2006 data soon, or wait till we understand 2007 data?
- Should we split up topics into smaller papers?
- Do we combine the DESY and CERN data?
- Big questions to resolve:
  - Understand/simulate the beam more correctly
  - Treatment of energy loss in inter-wafer gaps, in a way that is angle-independent.
  - Characterise/correct/simulate "square events" and other coherent signal-related effects, e.g. SIPS.
- Think realistically about systematics. We are not making precision SM measurements, but we do have to assess the reliability of anything we measure.