Electrons in the ATLAS LAr Barrel Calorimeter and Comparisons to G4 Monte Carlo Simulations

Tancredi.Carli@cern.ch

03/05

Test-beam 2002 of the LAr Barrel Calorimeter:

Aim: Test uniformity, linearity and resolution -> on-going data analysis

-> preliminary:

achieved linearity of ~1 permille using calibration scheme where calibration parameters are extracted from G4 and applied to data

For this accuracy a fit to data is not possible, since too many effects have to be controlled !

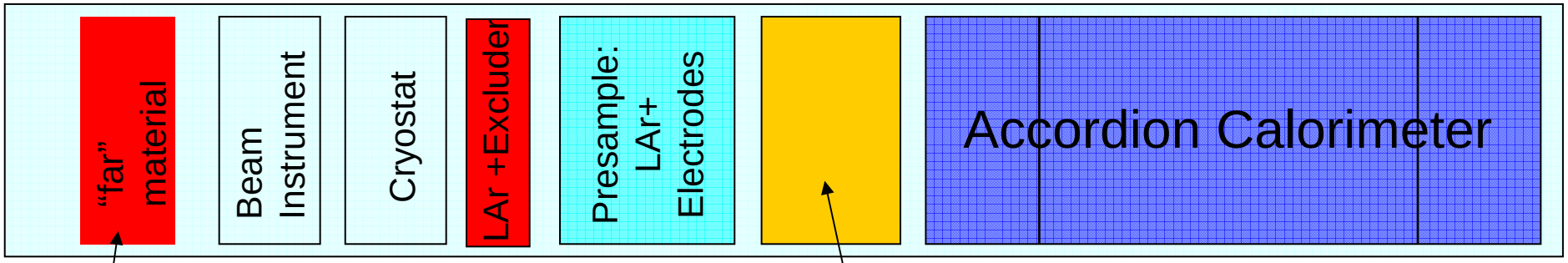
…is G4 good enough ?

-> during the analysis many deficiencies in the detector description have been found (no real problem with G4 so far…)

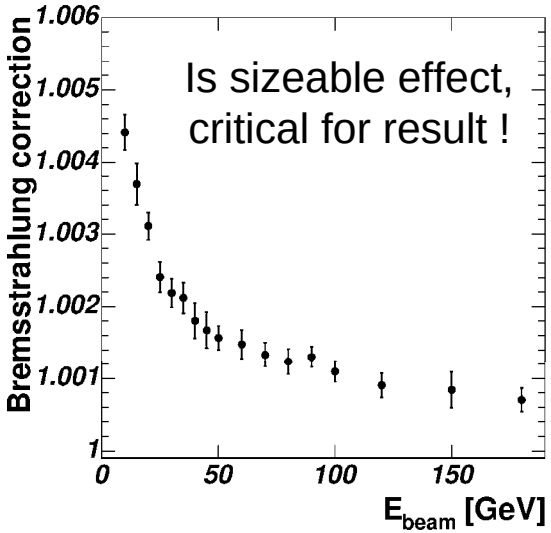
general difficulty to distinguish possible problems in physics or detector description

Using version: G4: 4.06-02 QGSP 2.8

ATLAS LAr Barrel Calorimeter – TB 2002 Set-up



Photons produced In „far" material do not reach the calorimeter -> Bremsstrahlung correction needed:



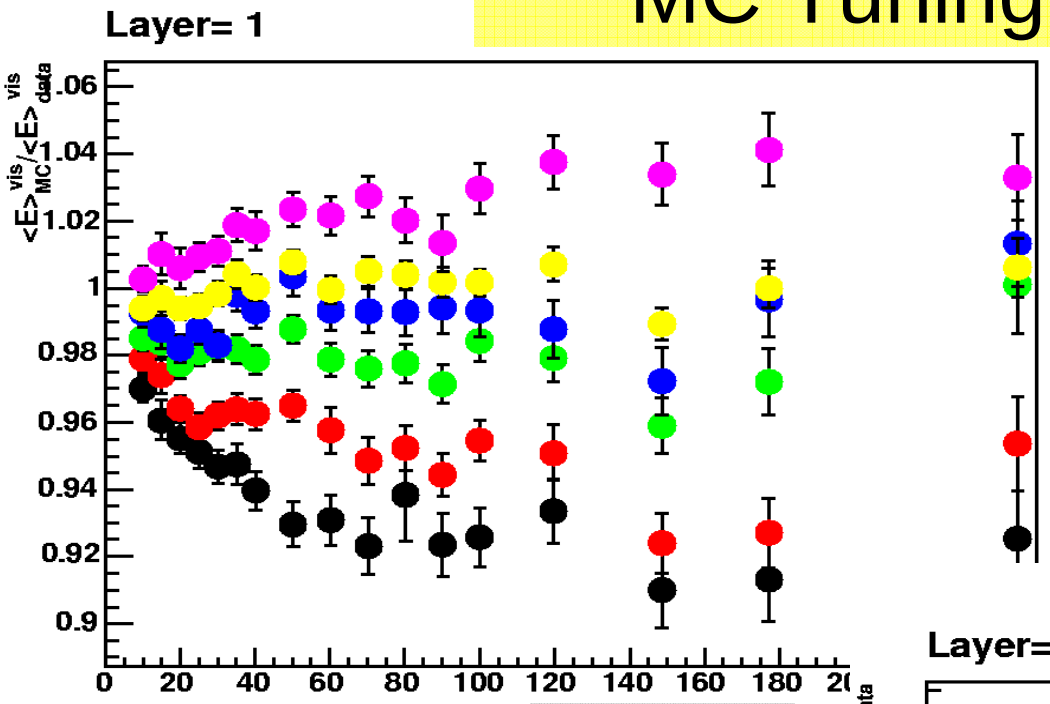
Amount of LAr not very well know. Tune by MC/Data comparison.

Material PS/Strips:
cables, electronics, support structures
description should be correct
within ~0.1 X0 (after a lot of work…)

…amount of "far" material and
of Lar in front of PS remains uncertain.
-> needs to be tuned to data !
(look at energy dependence)

"far" material (air, mylar windows etc.)
effectively simulated with sphere of 3.5mm Al

MC Tuning

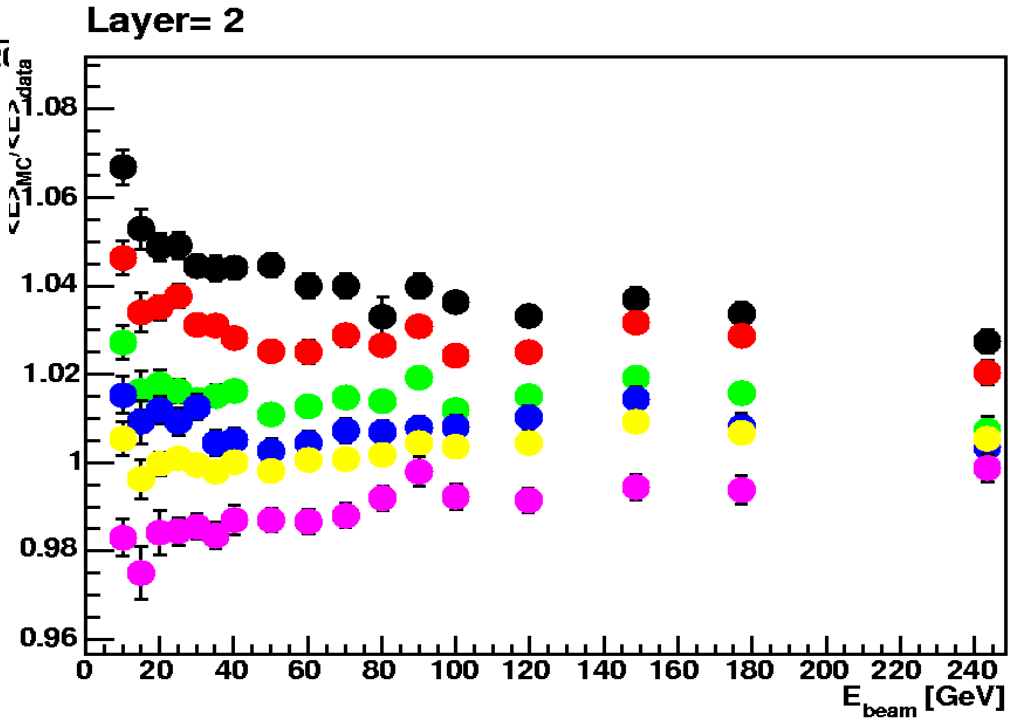


Idea:
correct detector geometry
gives flat energy dependence
when MC is compared to data

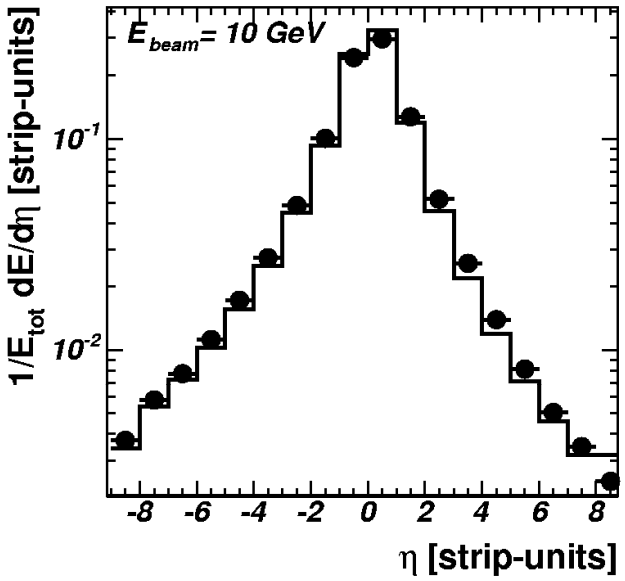
Assume:
G4 gives correct description
of physics processes

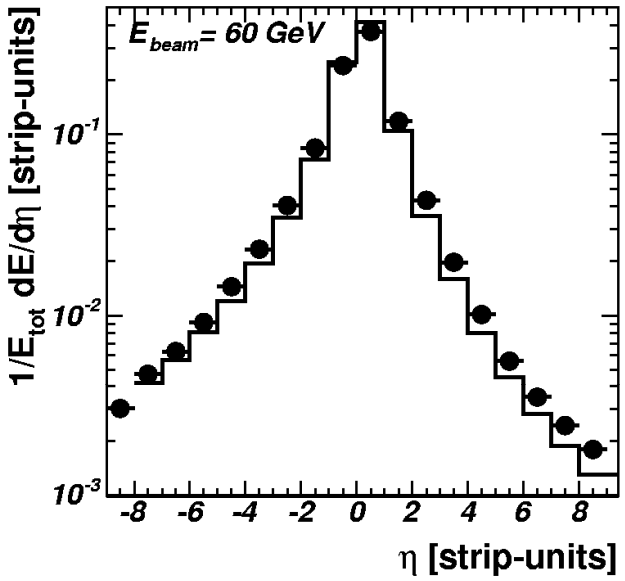
Note:
absolute normalisation
not precisely known.
2.0-3.0 cm Lar
in front of PS
seems reasonable

4.0 cm
3.0 cm
2.5 cm
2.0 cm
1.0 cm
0.0 cm

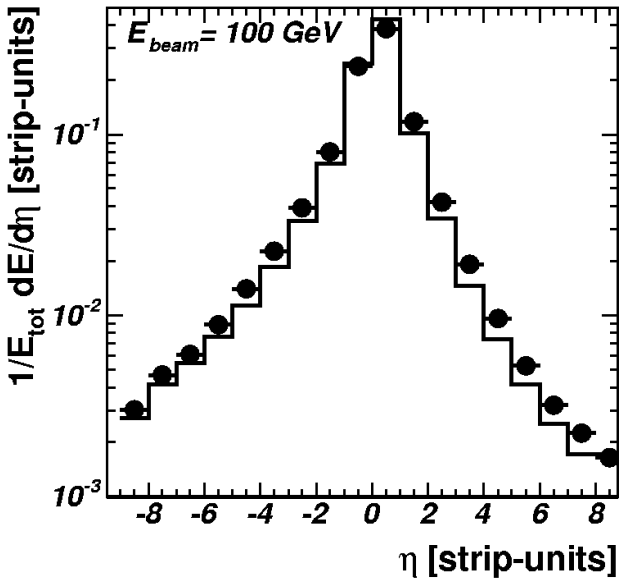


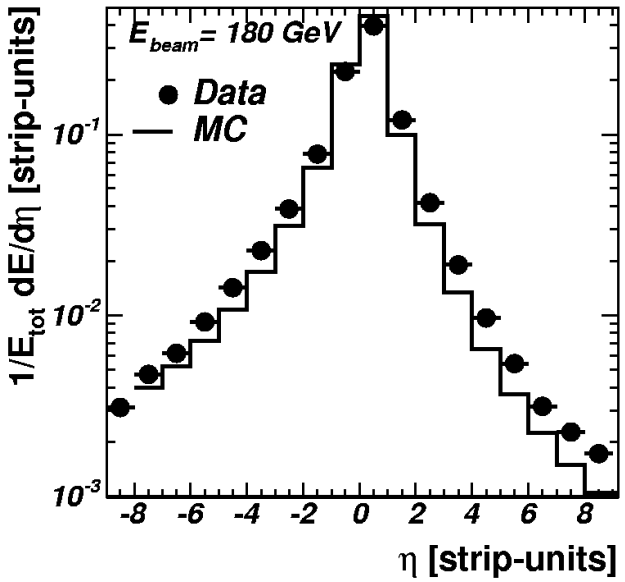
Lateral Shower Profile





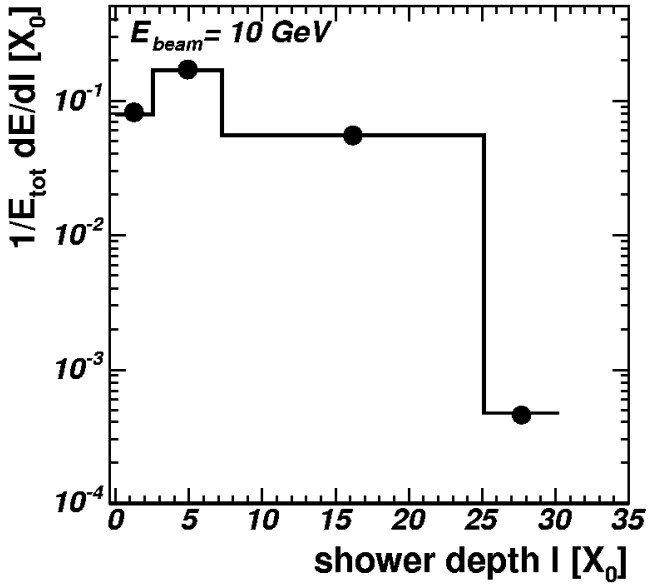
Layer 1 has fine radial granularity in one direction

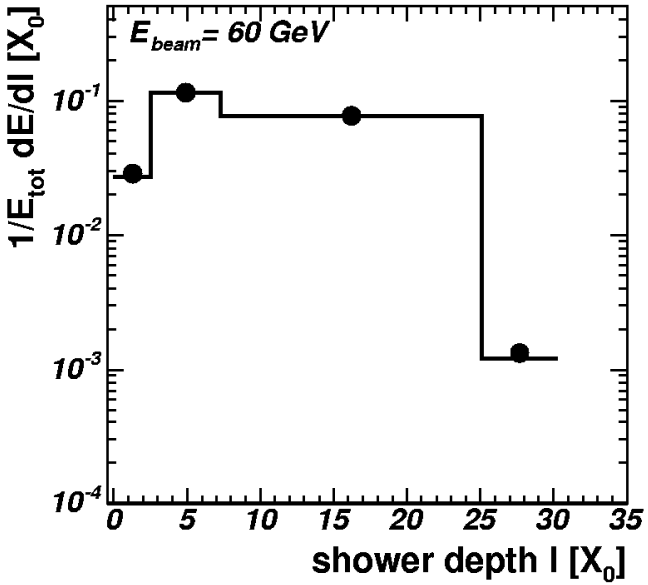


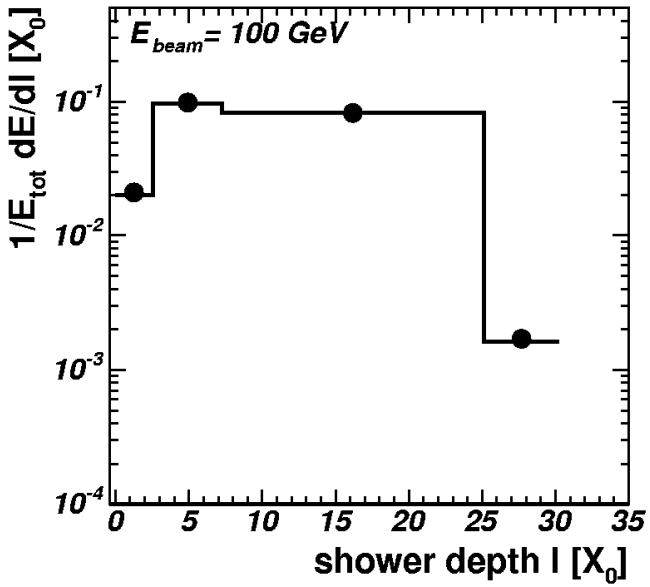


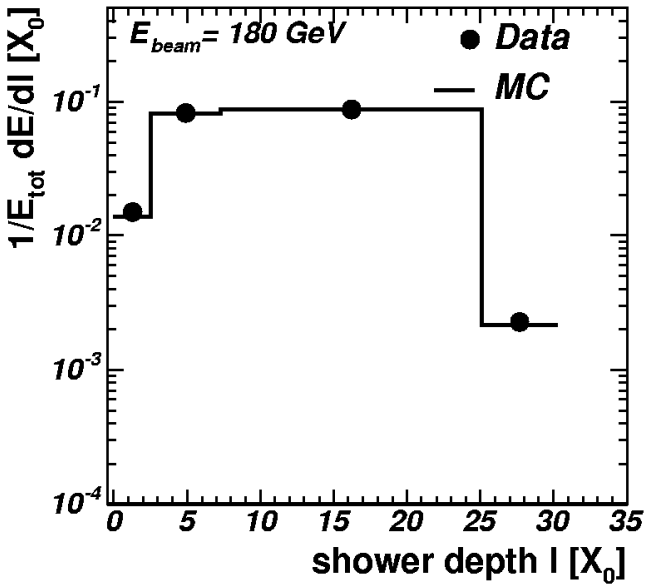
Shower wider in data
due to insufficient G4 ?
due to insufficient description of beam line/profile ?

Longitudinal Shower Profile



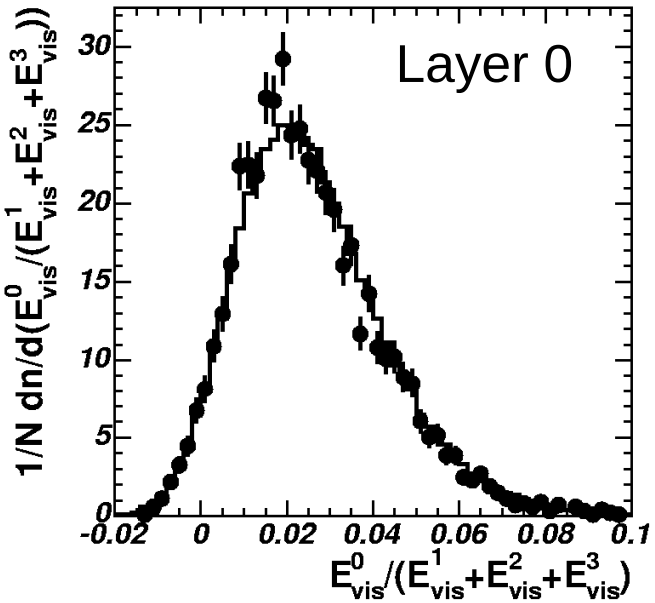


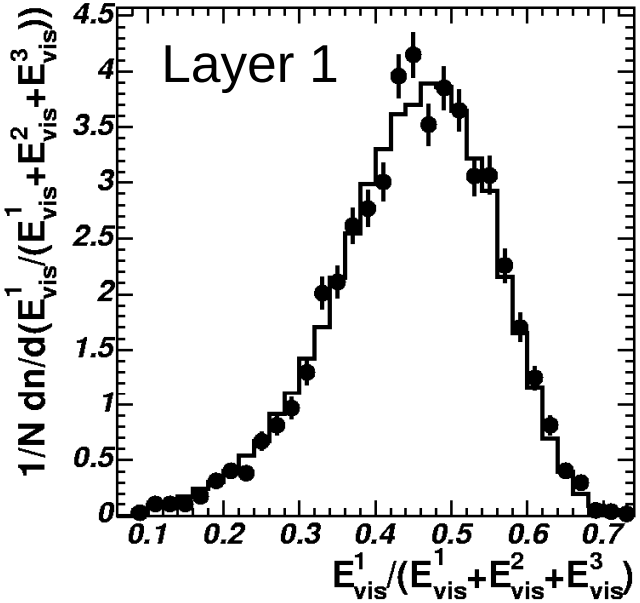


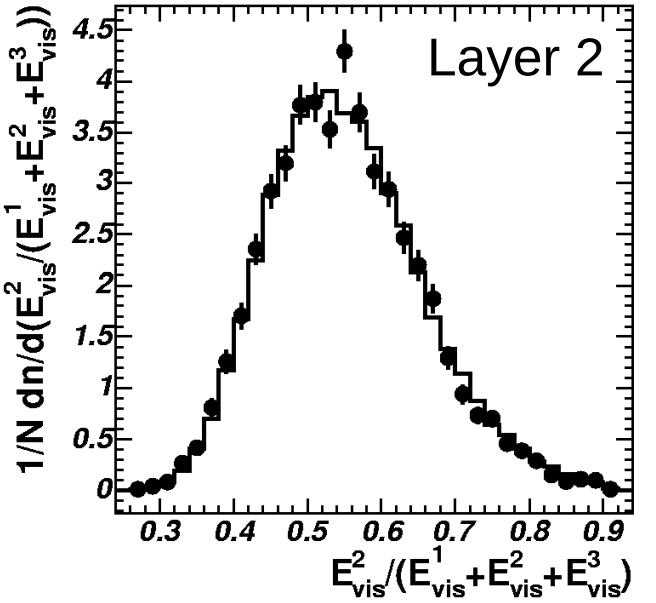


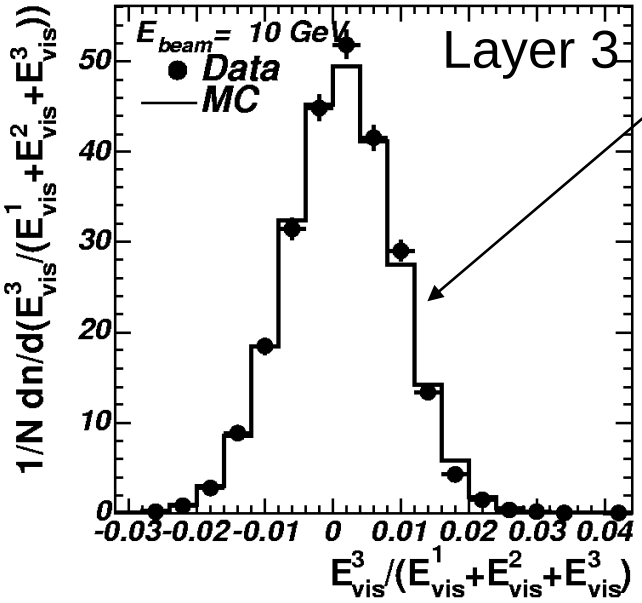
excellent !

Layer Energy Fractions:





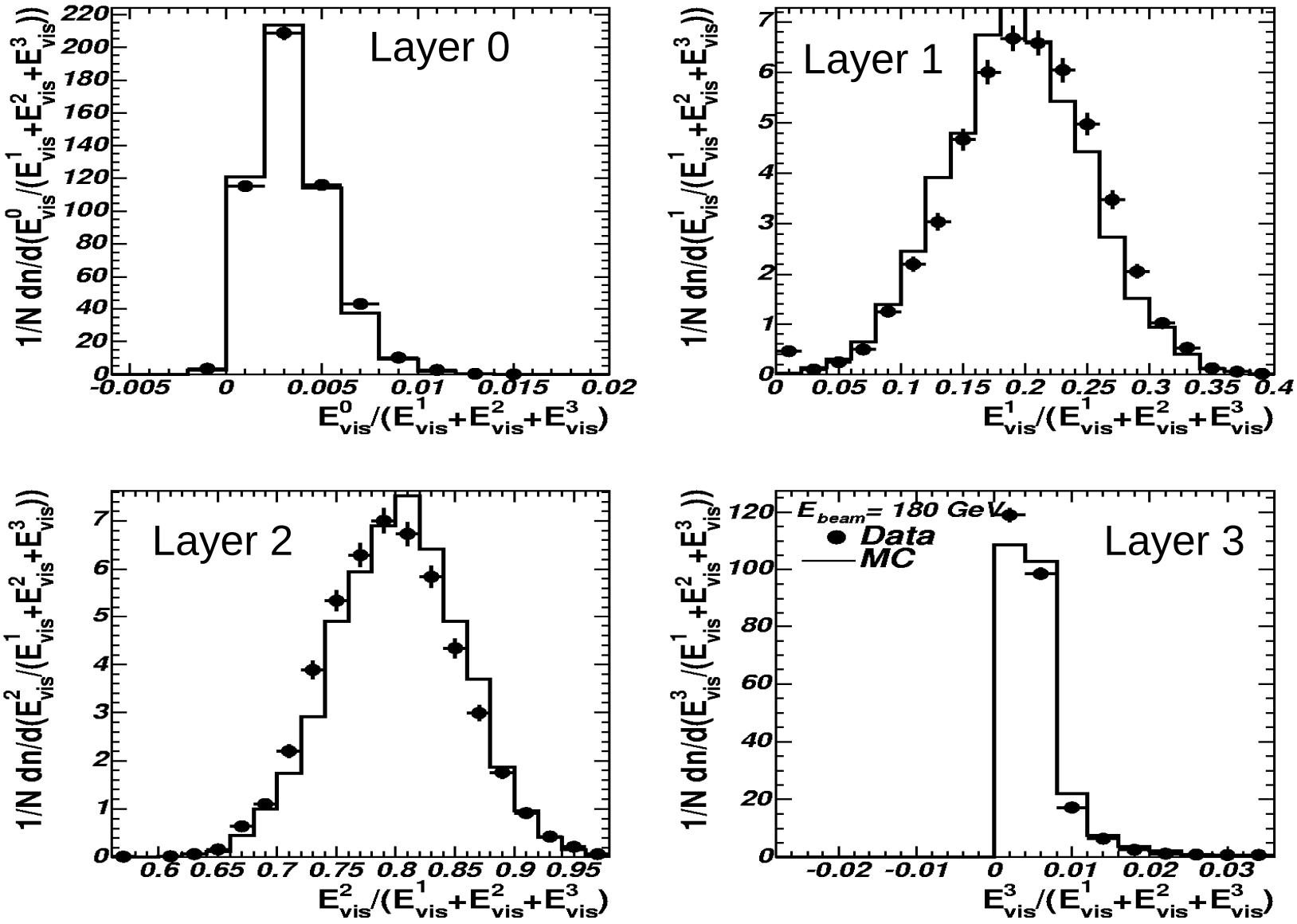




Only noise !

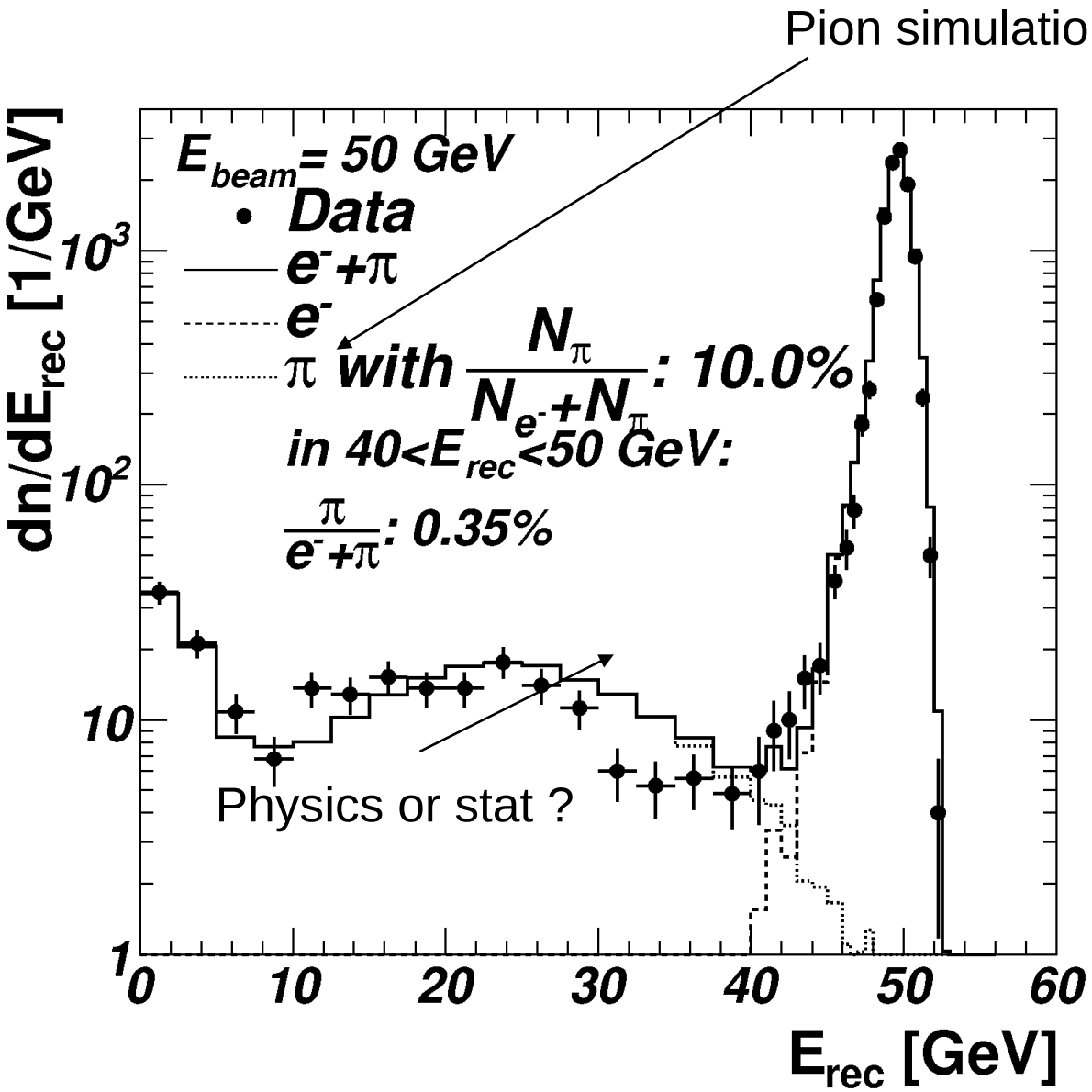
excellent !

Layer Energy Fractions:



This problem has been solved meanwhile (length of layer 1 was wrong by 1mm…)

Study Effect of Pion Contamination using G4:

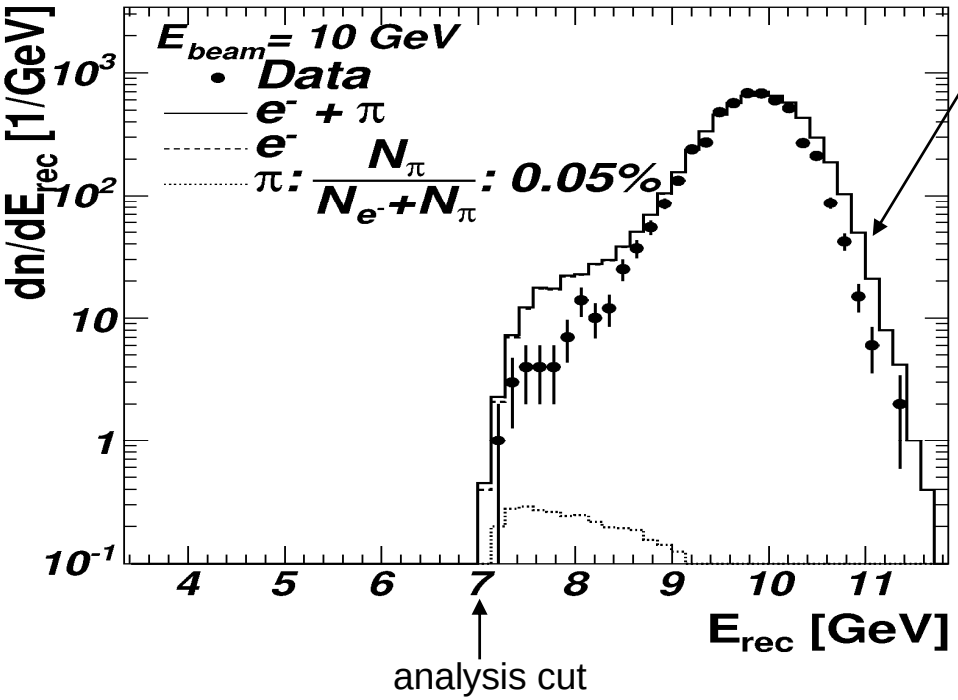


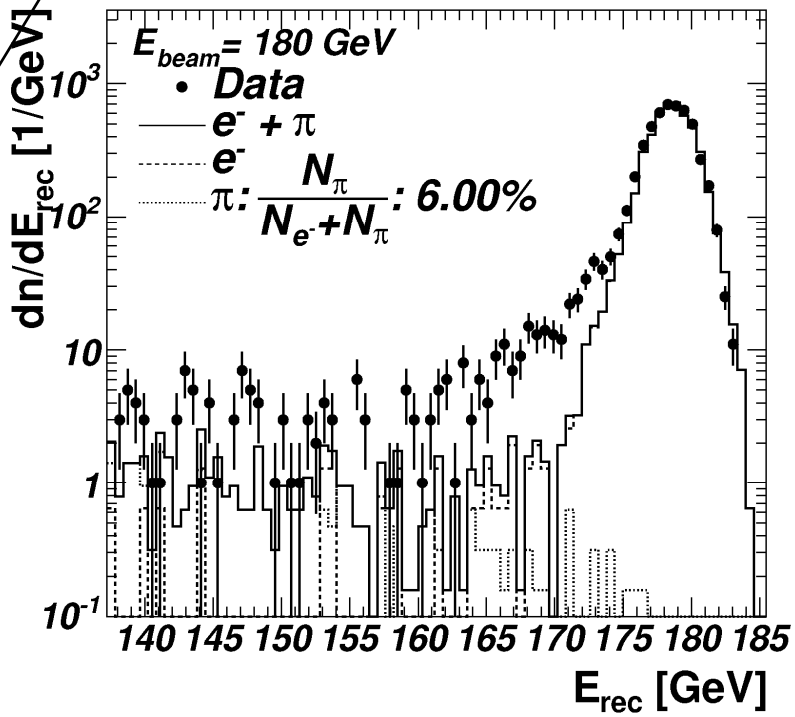
MC gives acceptable description of data…

For 40 < Erec< 50 GeV:
0.35% of events are pions

Tails of Energy Distribution:

Noise simulation needs to be improved



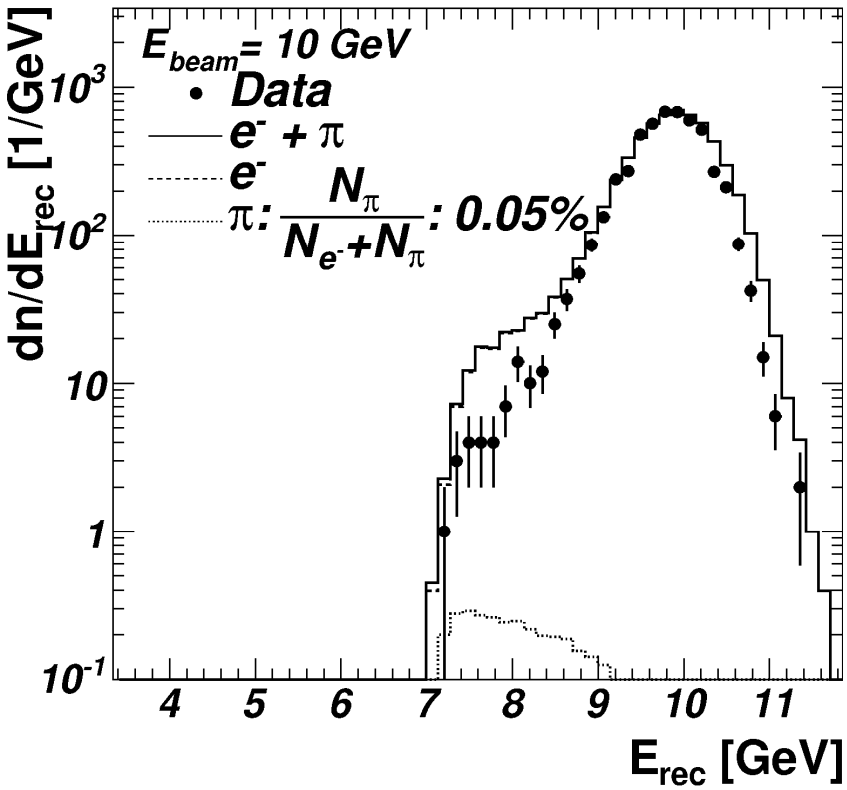


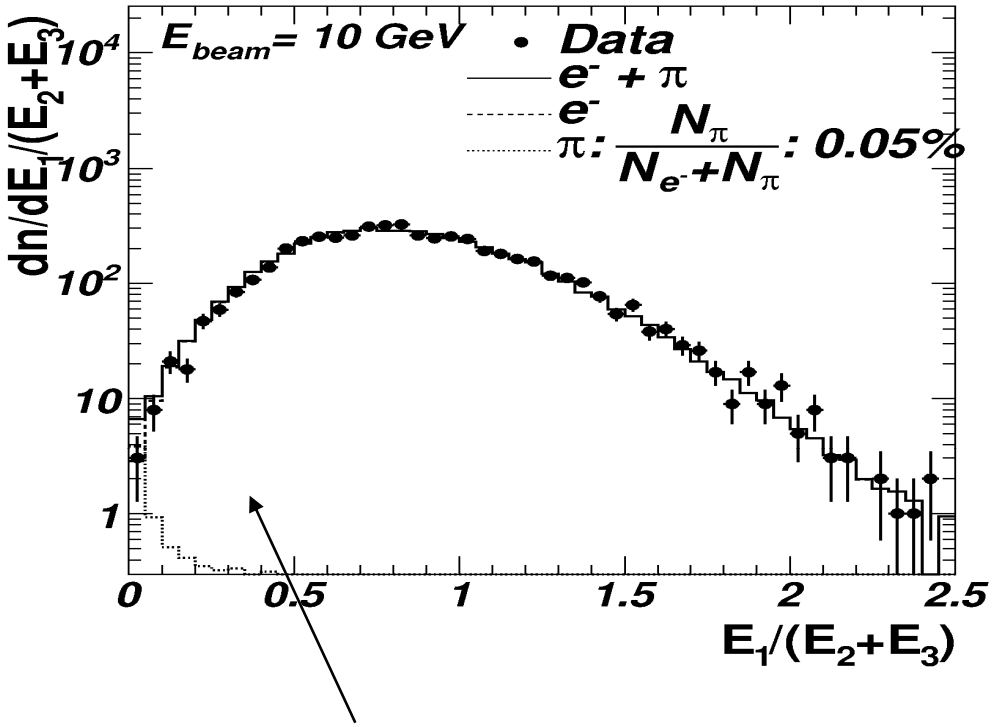
o) Remaining problem to describe the energy distribution

- at 10 GeV: noise overlay needs improvement (RMS to wide)
  but also tail to large (too much material in beam ? Effect of beam transport ?)
- at 180 GeV:
  low energy tail ? can not be explained by pions, see later
  beam spread ? Effect of beam transport ?

Beam transport presently looked at by beam experts

Tails of Energy Distribution and Pion Contamination E=10 GeV:

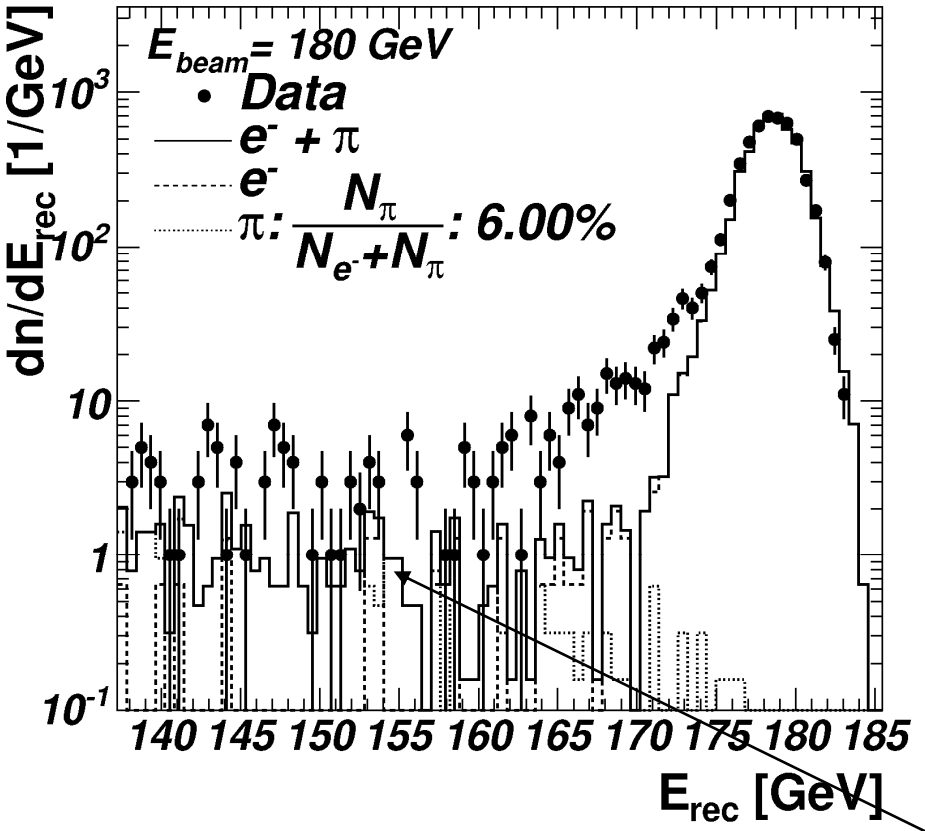




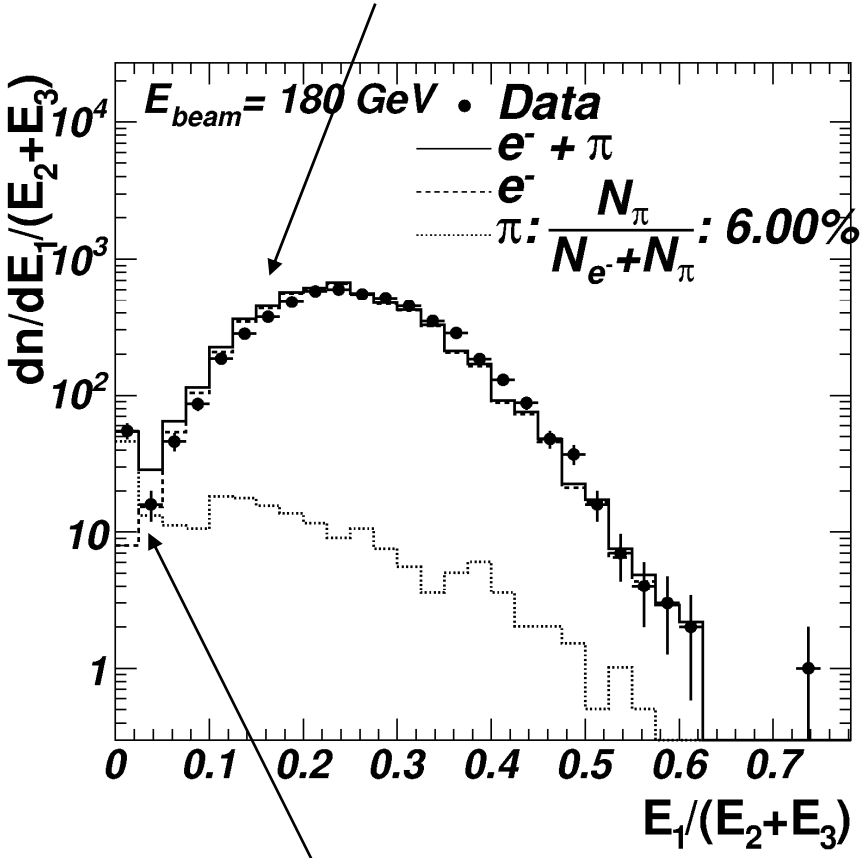
Excellent description by G4 !

At 10 GeV about 3% of the pions
deposit E>8 GeV in the Lar, i.e.
they interact mosty electromagnetically
These pions can be reduced by a factor of 2
by cutting on E1/(E2+E3), i.e. late showers

Tails of Energy Distribution and Pion Contamination E=180 GeV:



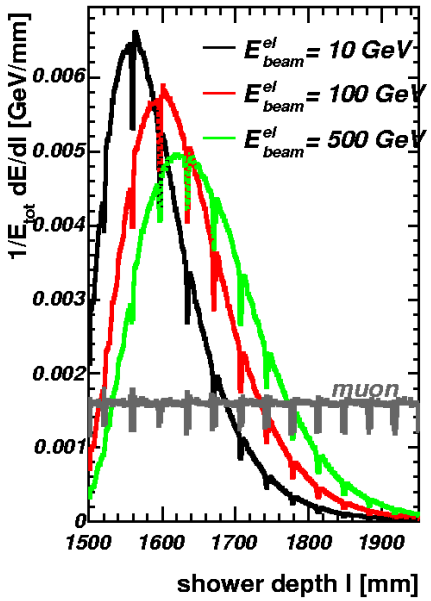
Excellent description by G4 !

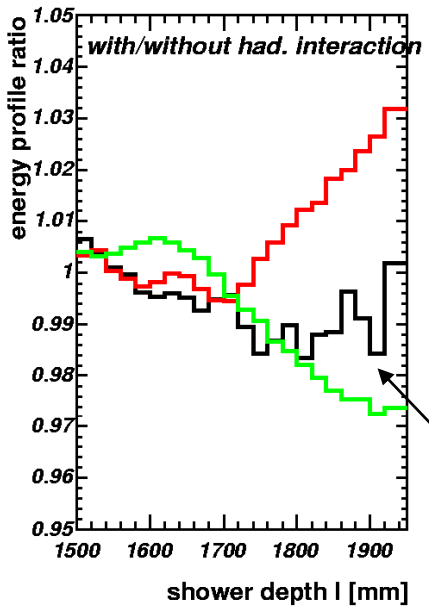


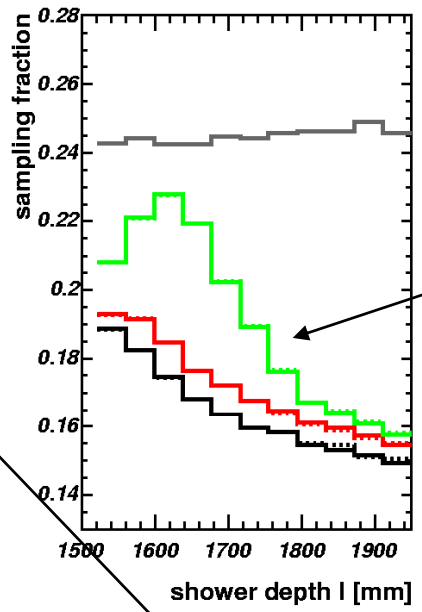
Here are some pions !
…but can not explain low energy tail

Beam transport presently looked at by beam experts

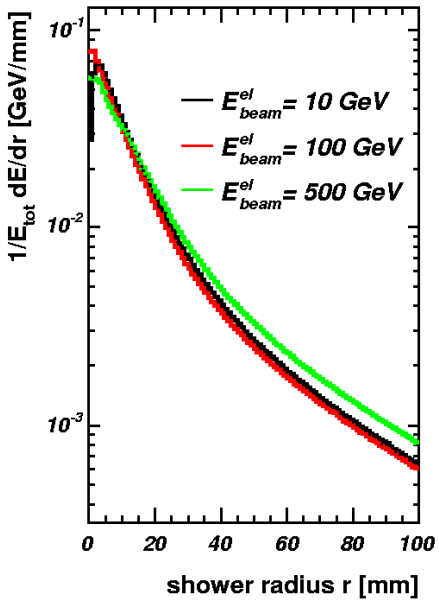
Hadronic Interactions in e.m. showers

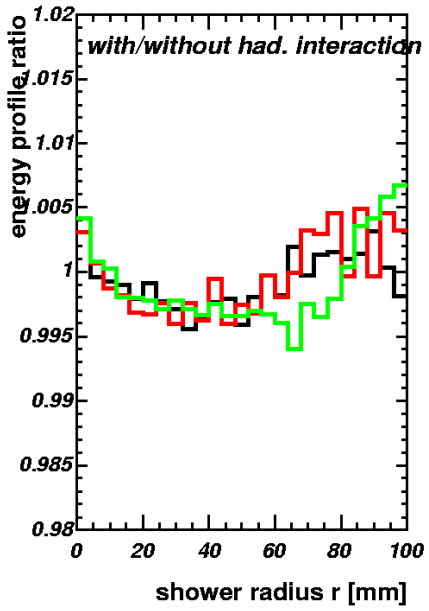






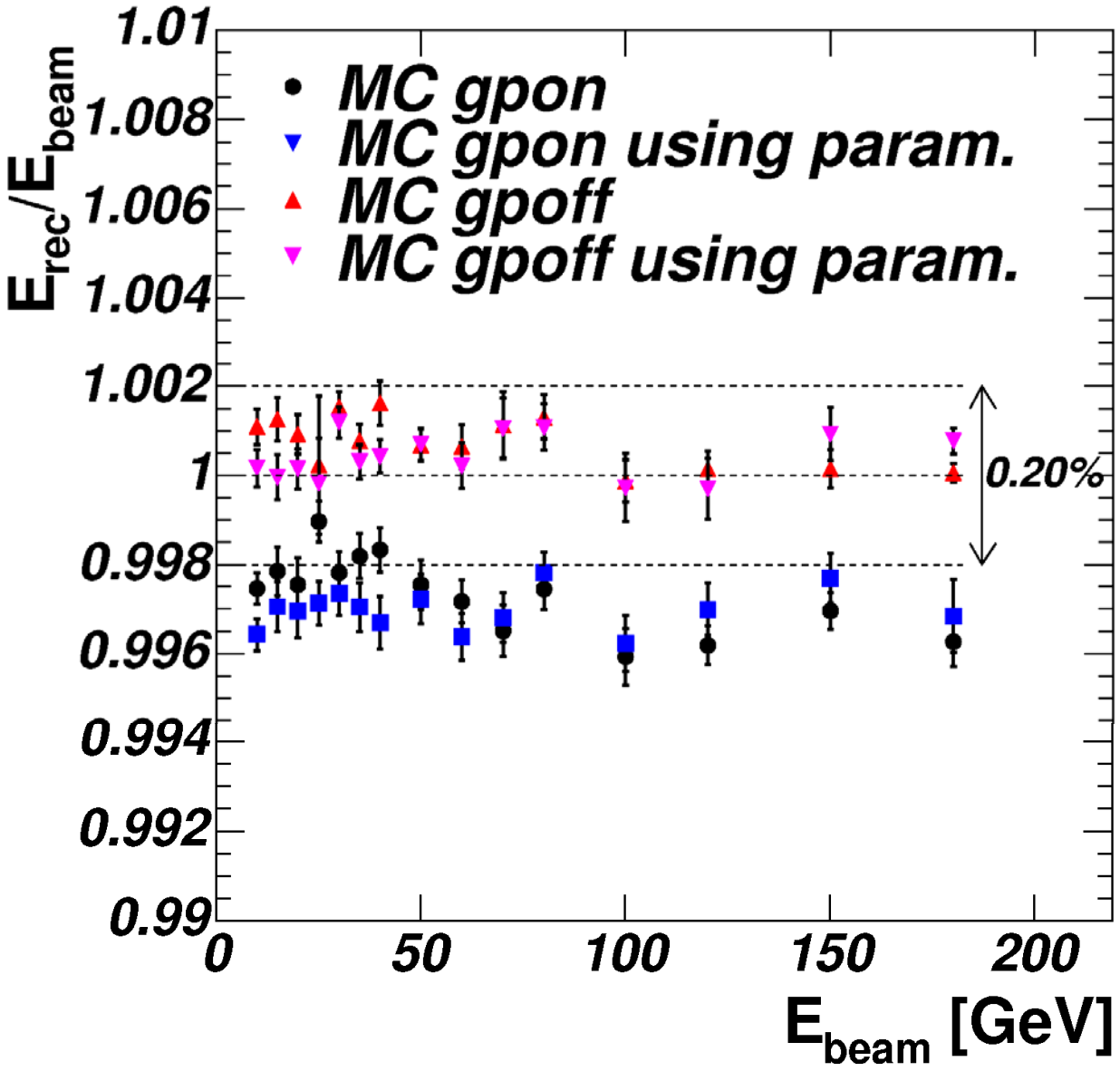
Is this correct ?





energy behaviour correct ?
Need to be rechecked

Hadronic Interactions in e.m. showers



- statistical accuracy: 0.1%
- With hadronic interaction on, 0.2% of the energy is lost (in the detector)
- linearity is not changed by hadronic interactions in e.m. showers, but they need to be taken into account for the relative normalisation of layer 1 and layer 2 (not shown here)

Conclusions

ATLAS plans to base e.m. calibration and hadronic calibration
on calibration parameters extracted from the MC simulation
and validated on data to be able to correct effect-by-effect.
In the test-beam for electrons this works within 1 permille
(encountered limitations are the limited knowledge of the test-beam set-up
and residual uncertainties in the detector calibration…
Is G4 good enough ? How can we validate that we can reach 0.1 permille ?