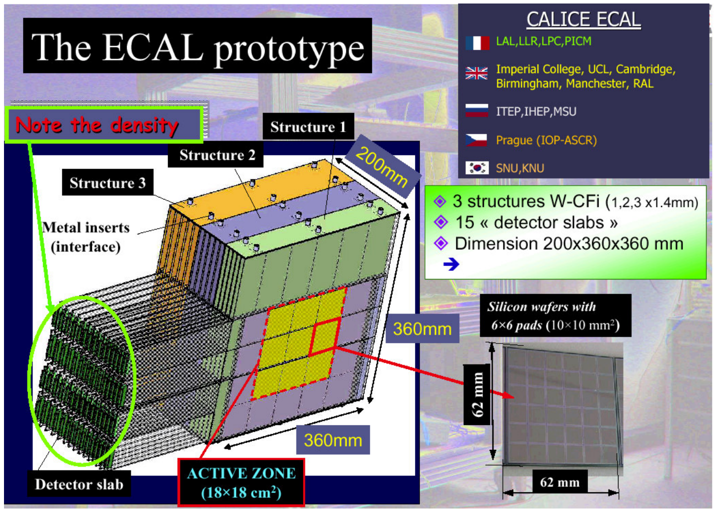
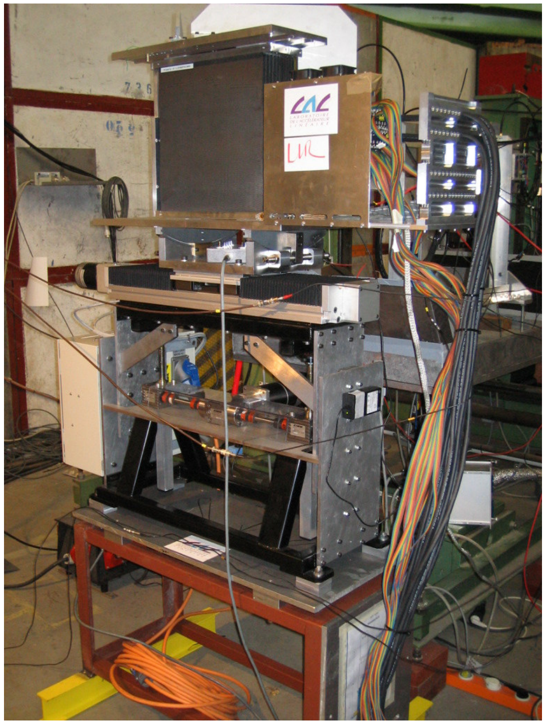
Data/MC comparisons

David Ward

- Compare these test beam data with Geant4 and Geant3 Monte Carlos.
- CALICE has tested an (incomplete) prototype Si-W ECAL in DESY electron test beam in February 2005.
- Trying to use “standard” Calice software chain (LCIO, Marlin etc), even though much is still under development.
- Work in progress – no definitive conclusions

ECAL prototype at DESY





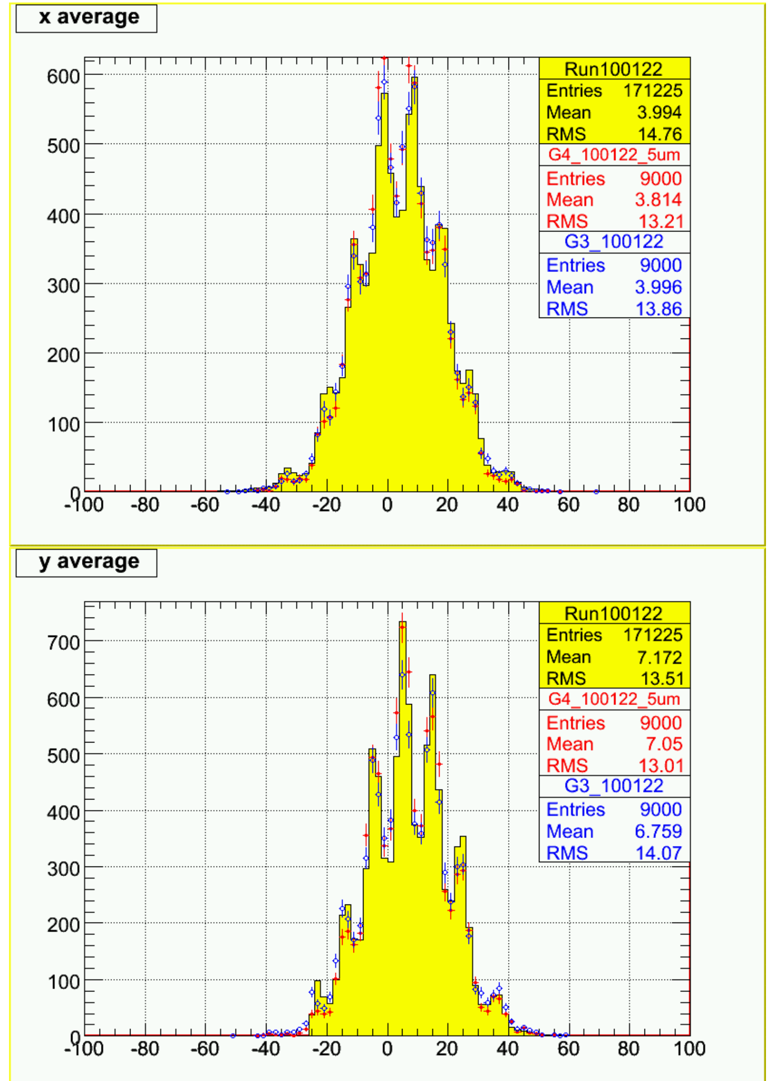
- Prototype tested so far at DESY had 14 layers (~$7X_0$) out of 30 planned, and 18x12 1cm^2 Si pads compared to 18x18 planned.
- Tested with 1-6 GeV electrons incident at various points over the front face, and at normal incidence and at 10º, 20º, 30º.
- Will focus on 1 GeV normal incidence sample unless otherwise stated.
- Further details shown in calorimeter session talks.
- Data (calibrations etc.) still preliminary

Monte Carlo

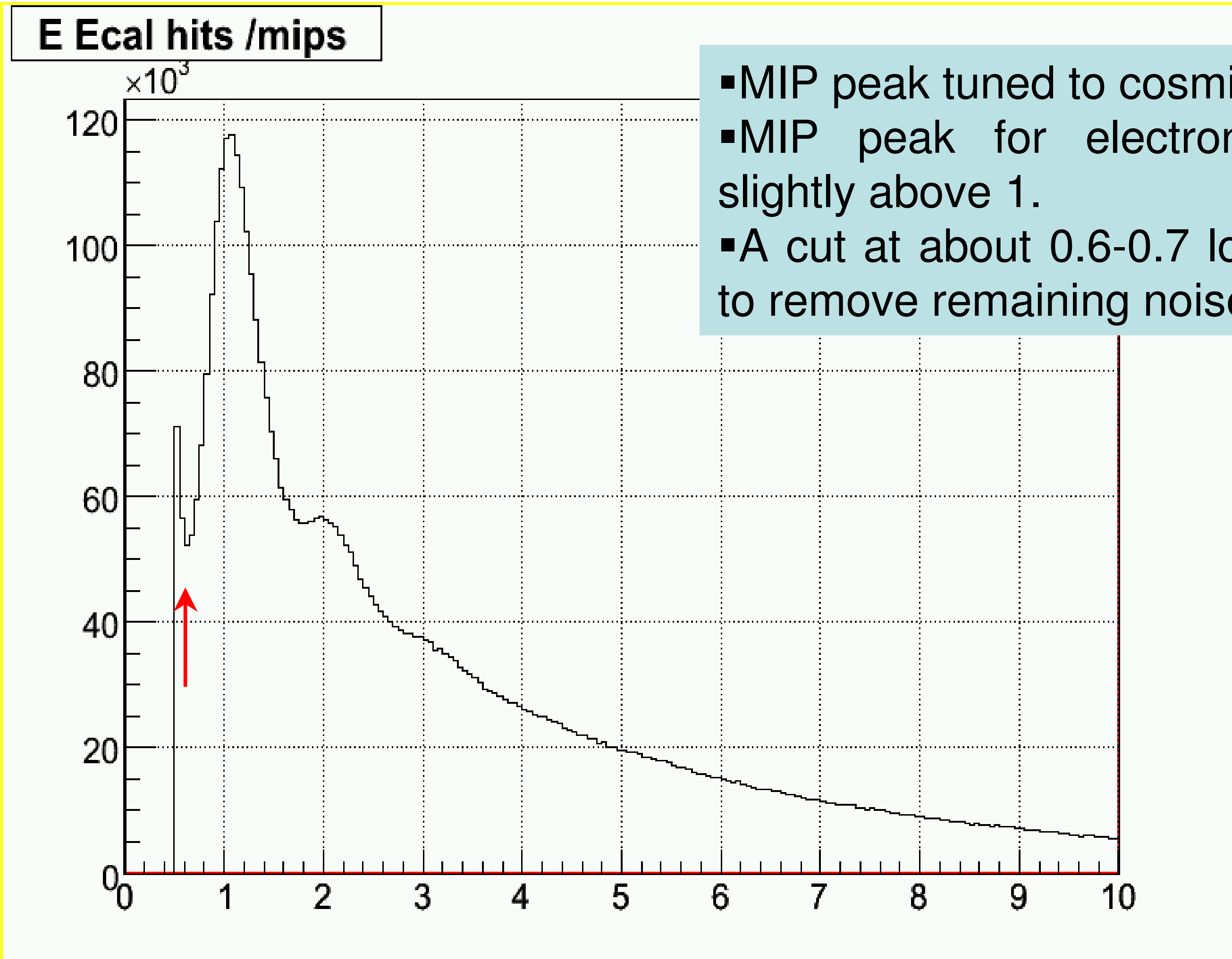
- Mokka (Geant4) contains detector geometries for Calice Test Beam. For this purpose, have been using the ProtoDesy0205 model up to now. This contains 30 layers; 9 wafers/layer, so remove non-existing ones in software.
- Code versions – Mokka 5.1 and Geant 4.7.1
- Also Geant3 MC – Caloppt. Uses hard coded geometry, identical to Mokka (A.Raspereza).
- Both write out LCIO SimCalorimeterHits, which contain the total ionization energy deposit in each Si pad.
- Test beam data converted to LCIO format, and after calibration are in the form of CalorimeterHits

MC generation

- Use Mokka 5.1 with monochromatic electron beams at normal incidence.
- Gaussian beam spread of width chosen to roughly match profile in data.
- In analysis, add in 0.12MIP of noise to each channel (reflecting pedestal width in data).
- No noise in empty channels yet; no cross-talk. So the “digitization” simulation is very primitive as yet.

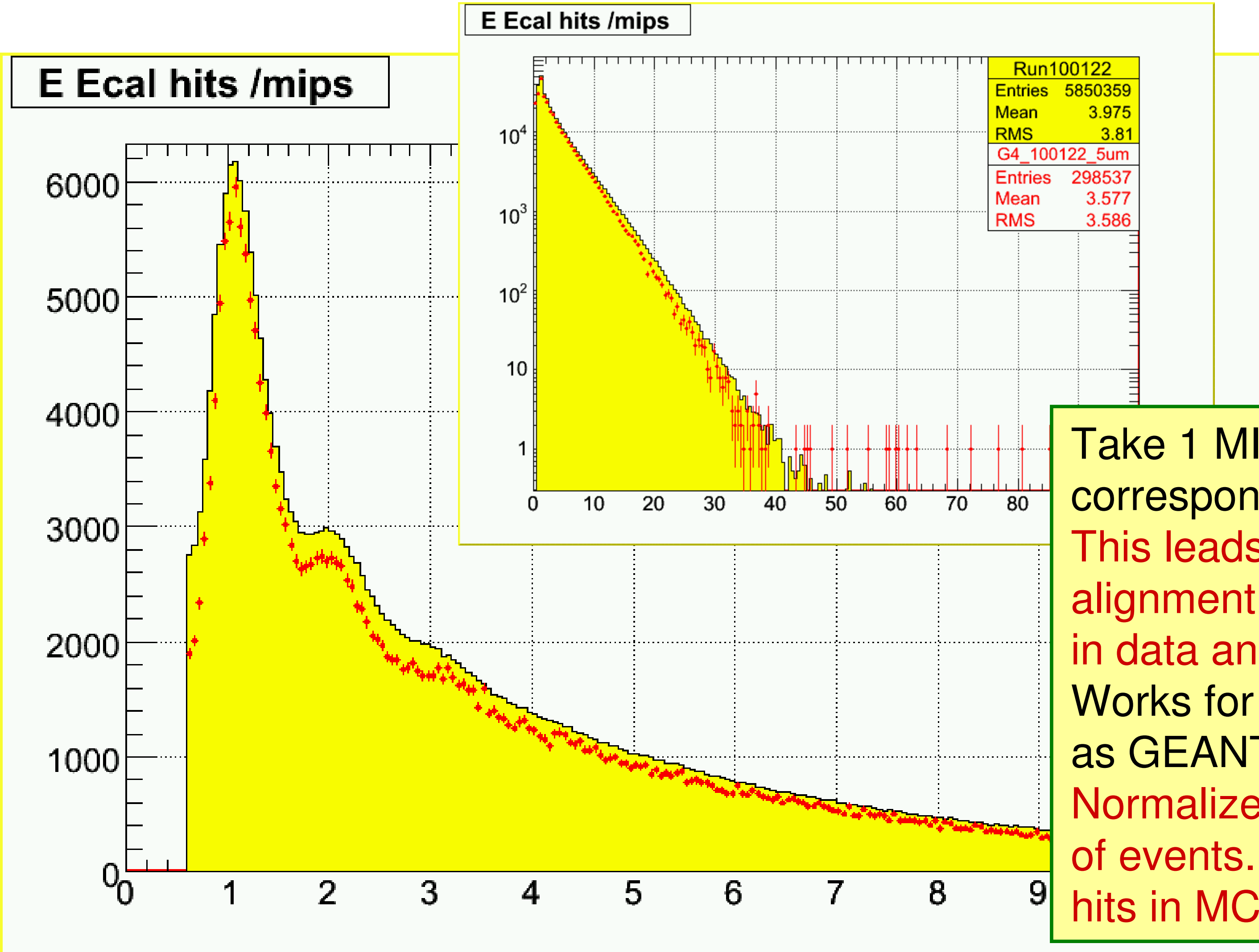


MIP peak in data



- MIP peak tuned to cosmics.
- MIP peak for electron <u>showers</u> lies slightly above 1.
- A cut at about 0.6-0.7 looks appropriate to remove remaining noise. Use 0.6

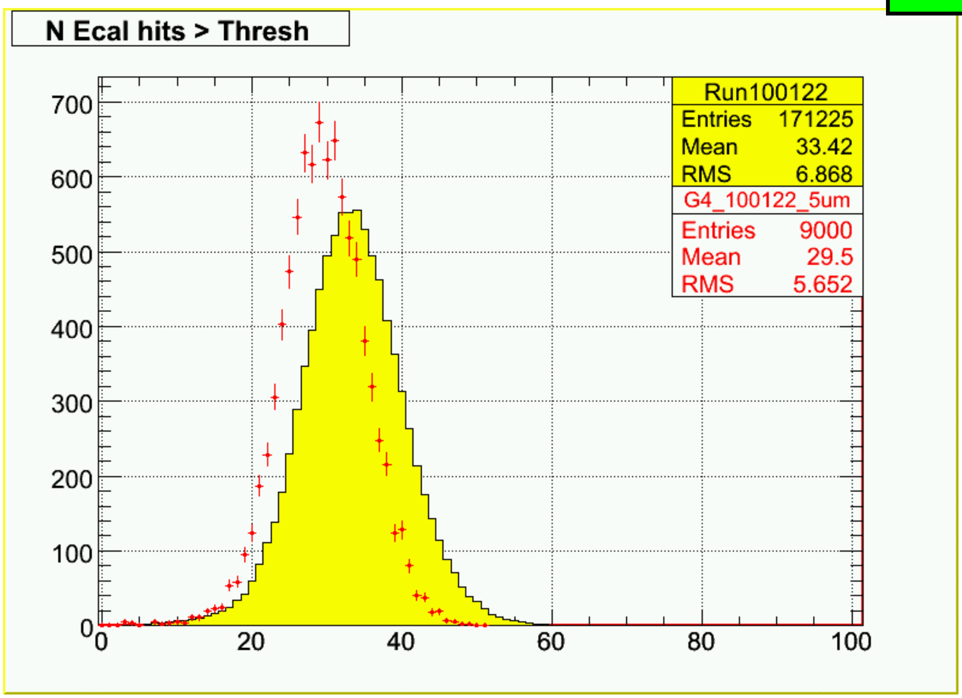
MIP peak : data c.f. Geant4

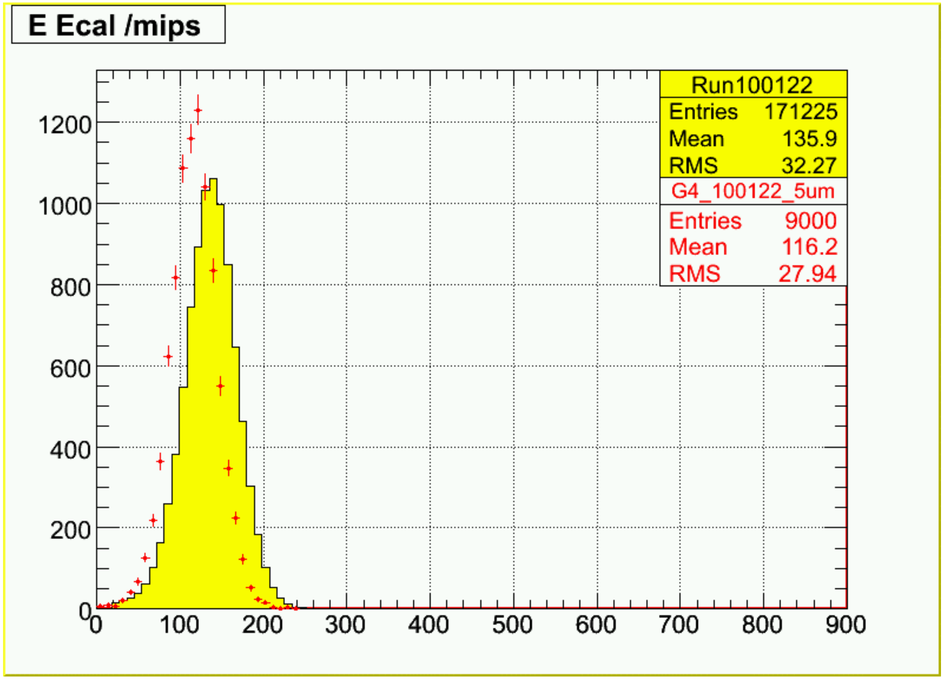


Take 1 MIP in MC to correspond to 0.16 MeV
This leads to satisfactory alignment of the MIP peaks in data and MC.
Works for Geant3 as well as GEANT4
Normalized to number of events. Clearly, fewer hits in MC than data.

hits above threshold   Total energy /MIPs

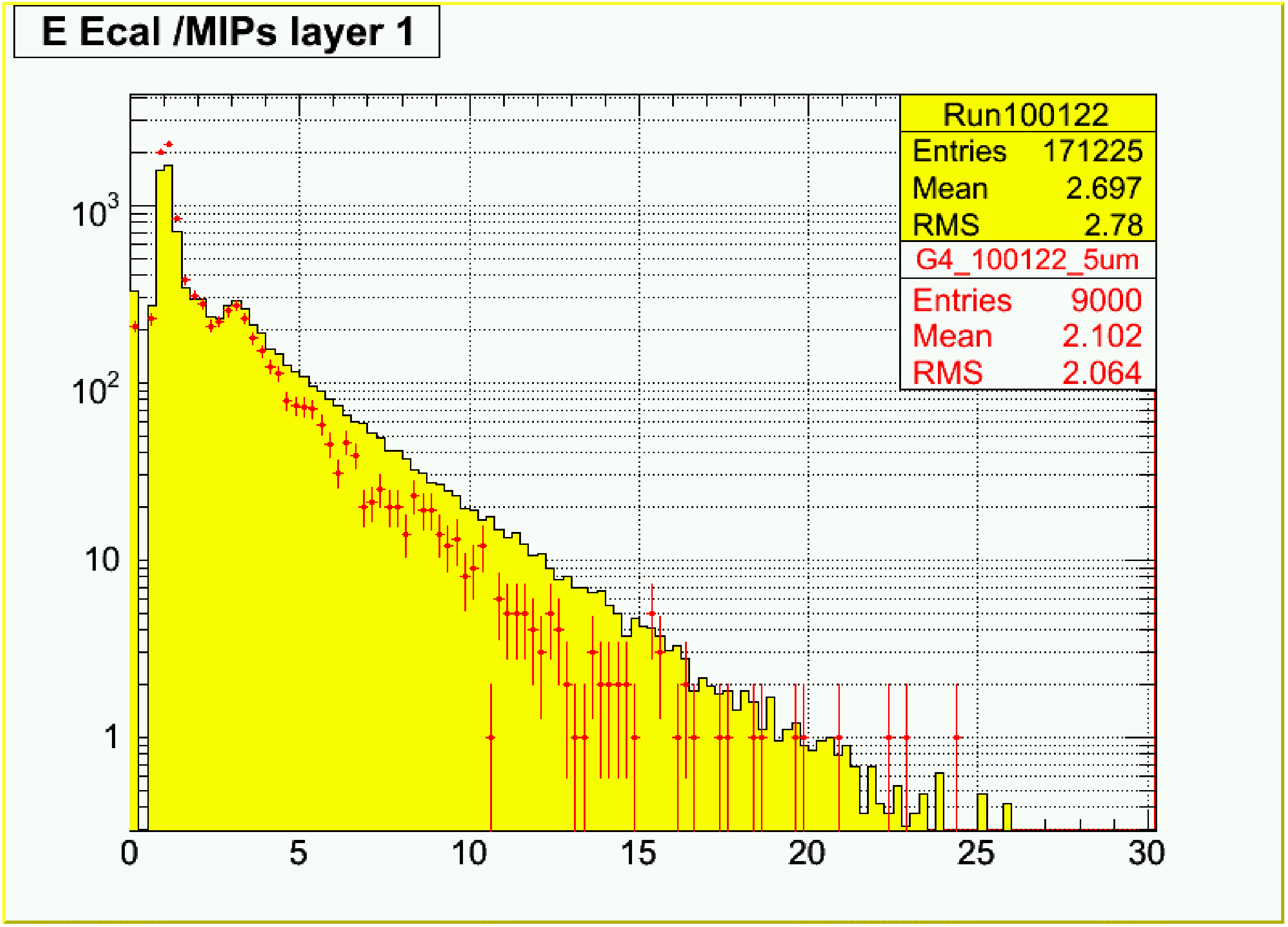
1 GeV e^-





- ~13% discrepancy in # hits.
- ~17% discrepancy in energy scale. Fractional width OK.

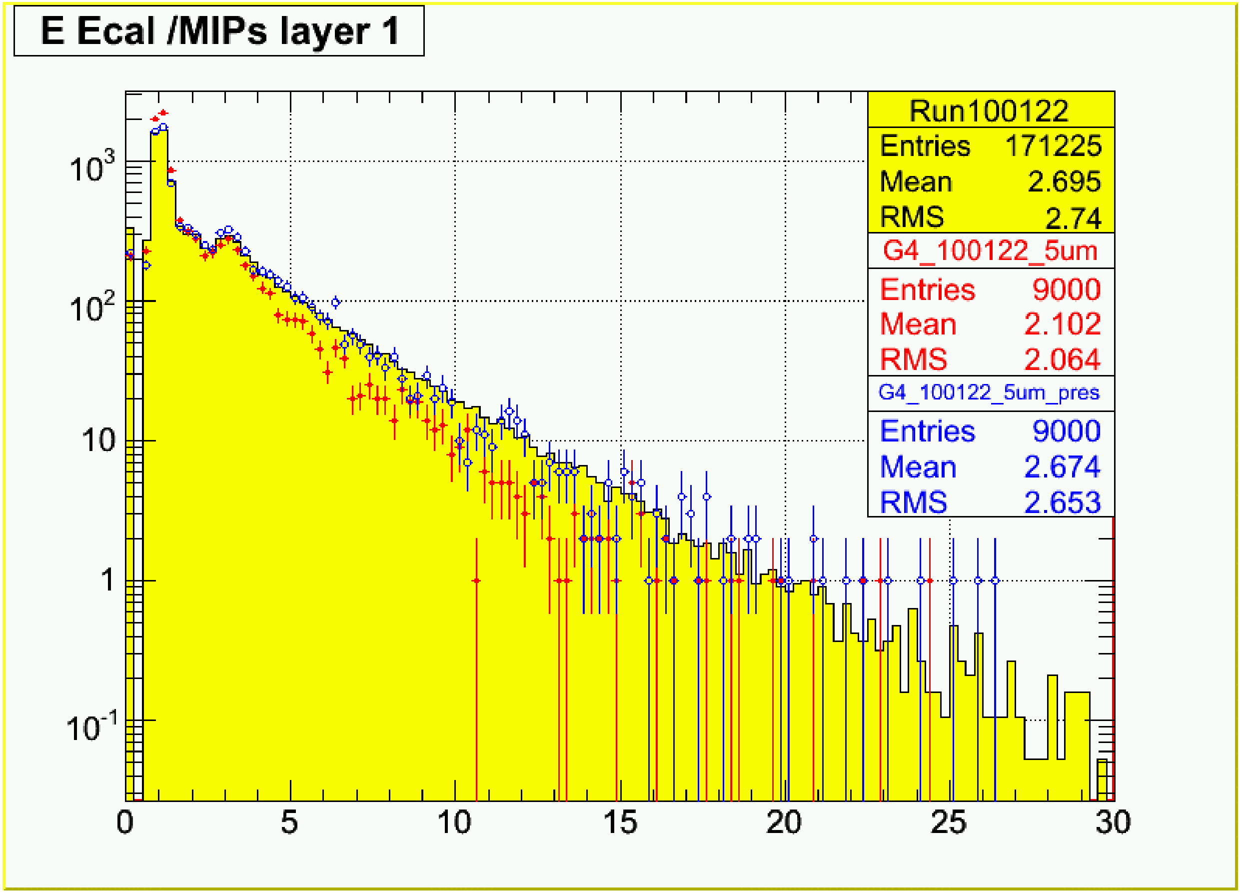
Energy in first plane



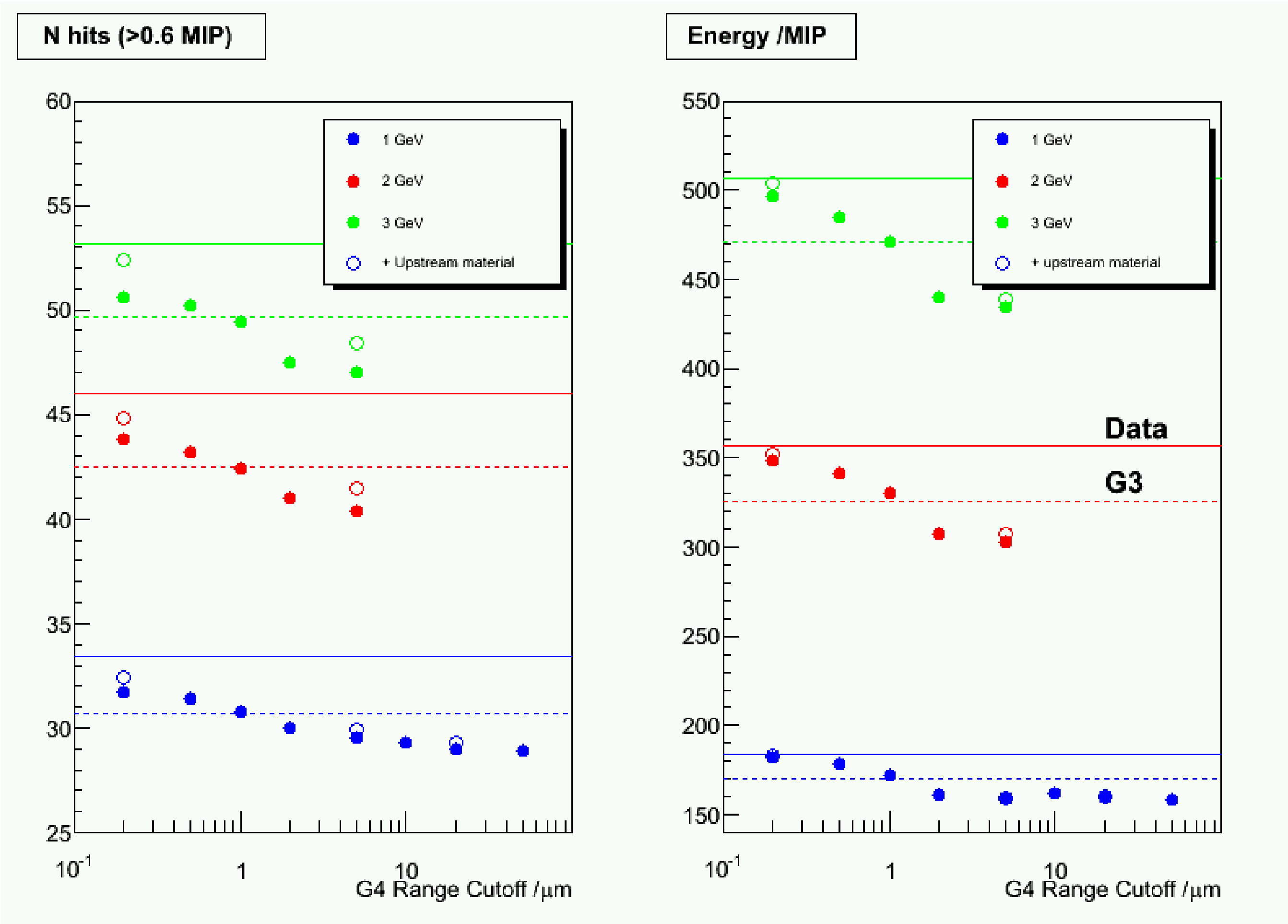
Data shows more energy in first plane than MC; fewer single MIPs

Energy in first plane

Could patch up energy in first plane by introducing ~0.15X_0 of upstream material.
But effect on total energy and no. of hits is small (1-3%).



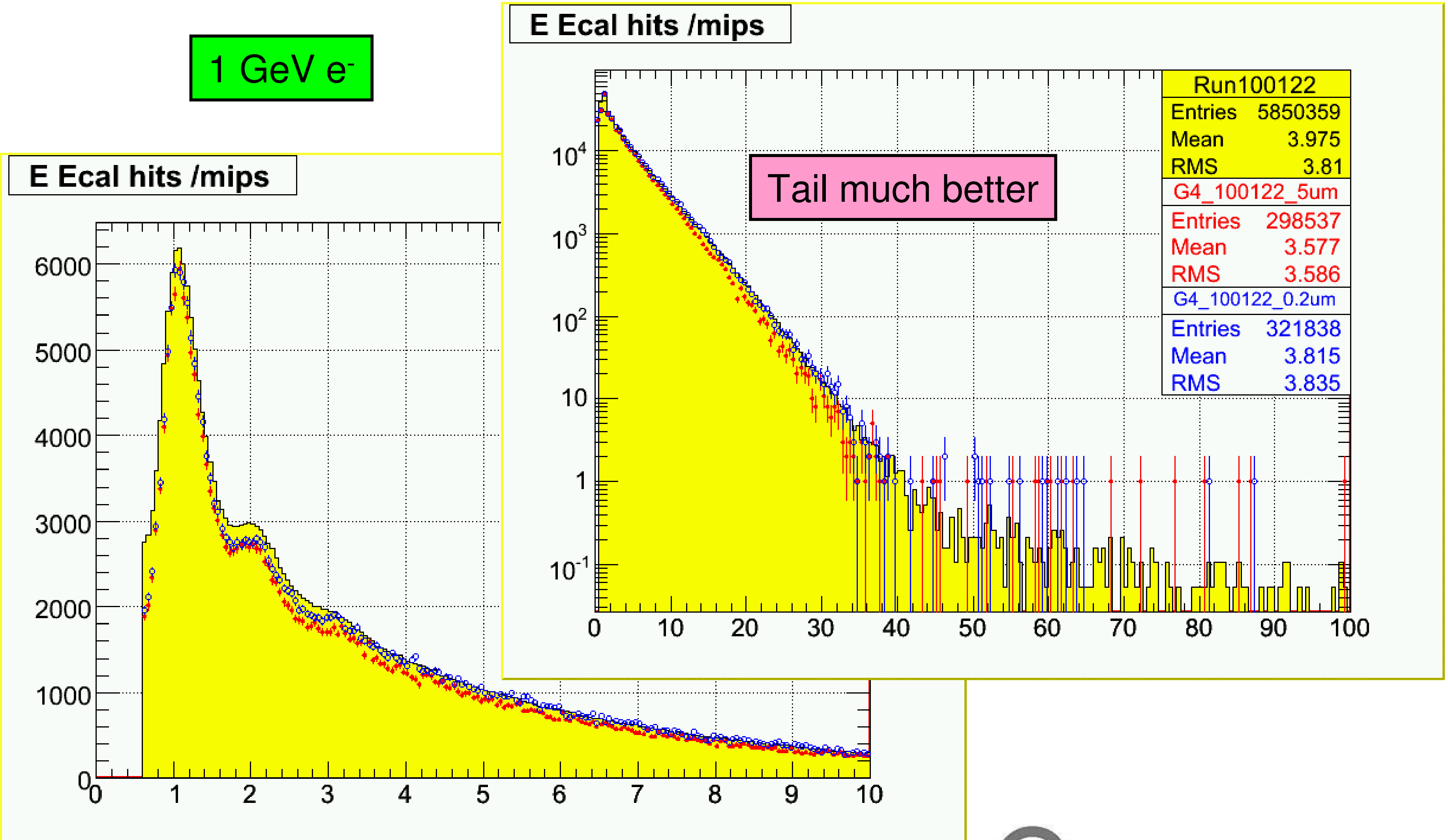
Dependence on tracking cut?



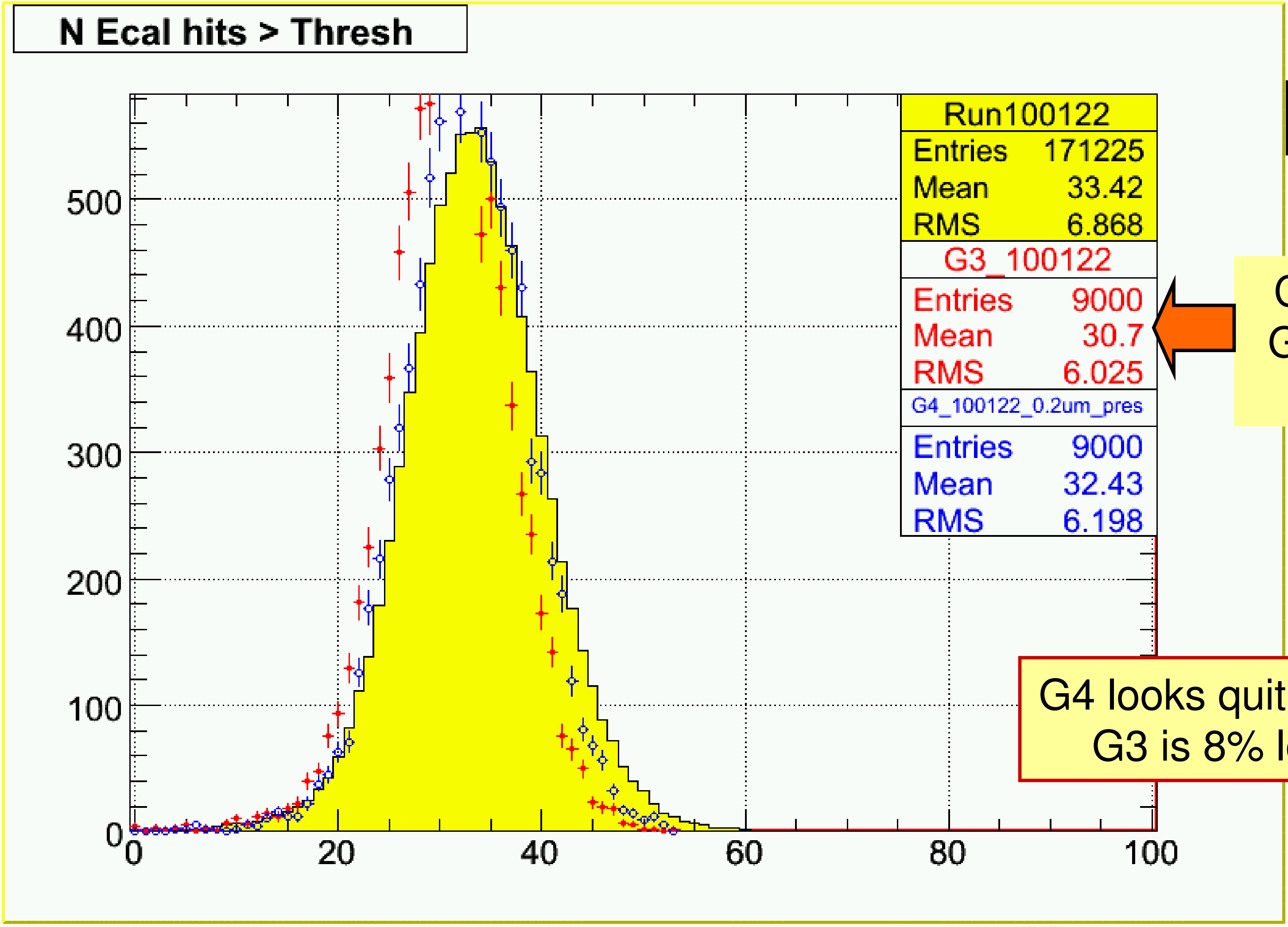
- G4 operates with a cut on range (5 μm default in Mokka)
- Reduction to 0.2μm improves agreement with data
- **But** slows program down by a factor ~20
- G3 (cutoff 100 keV) equivalent to G4 with cutoff of ~ 1 μm

MIP distribution vs tracking cutoff

1 GeV e⁻



N hits vs tracking cutoff

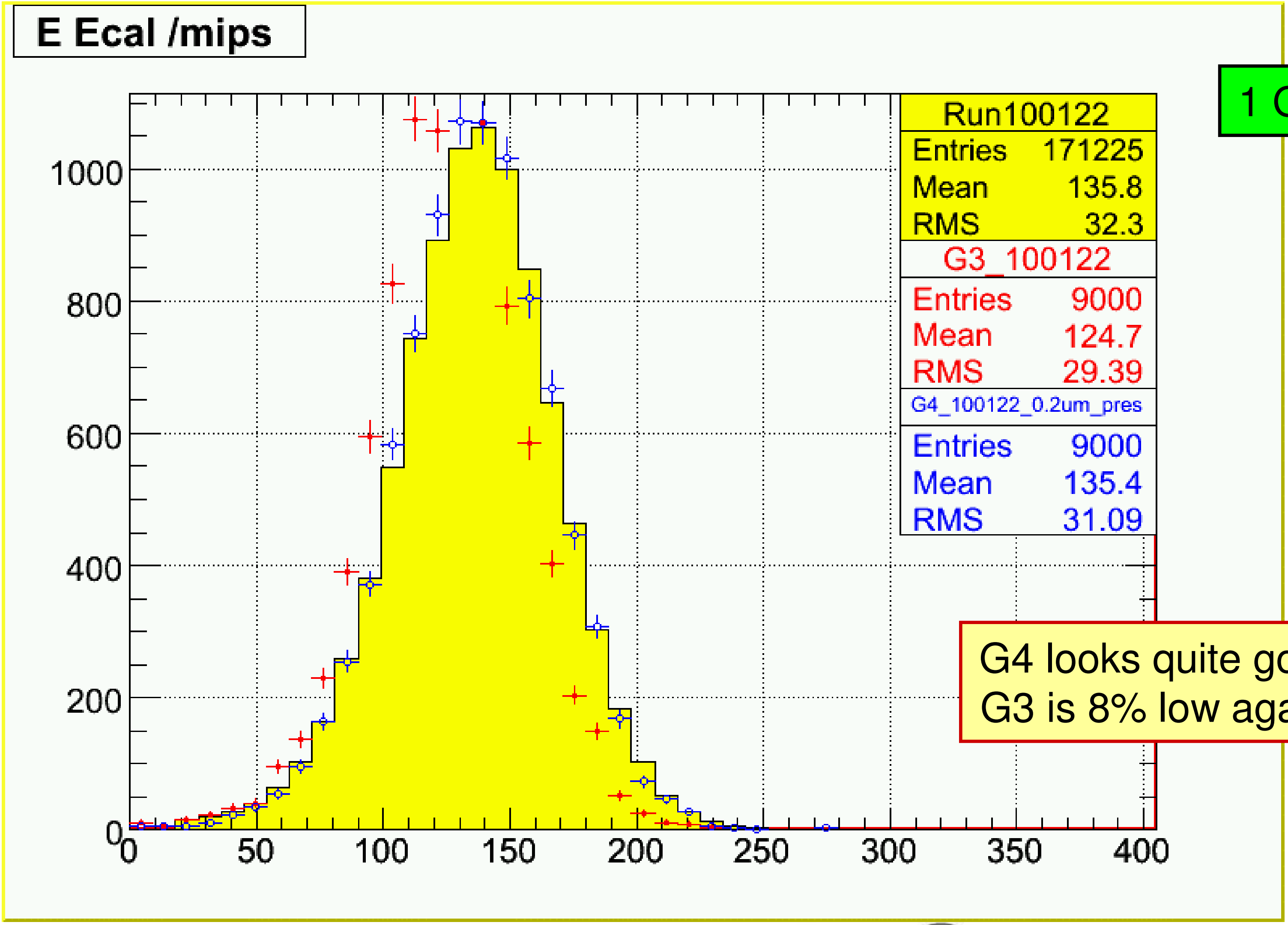


1 GeV e^-

Compare with G3 sometimes from now on

G4 looks quite good
G3 is 8% low

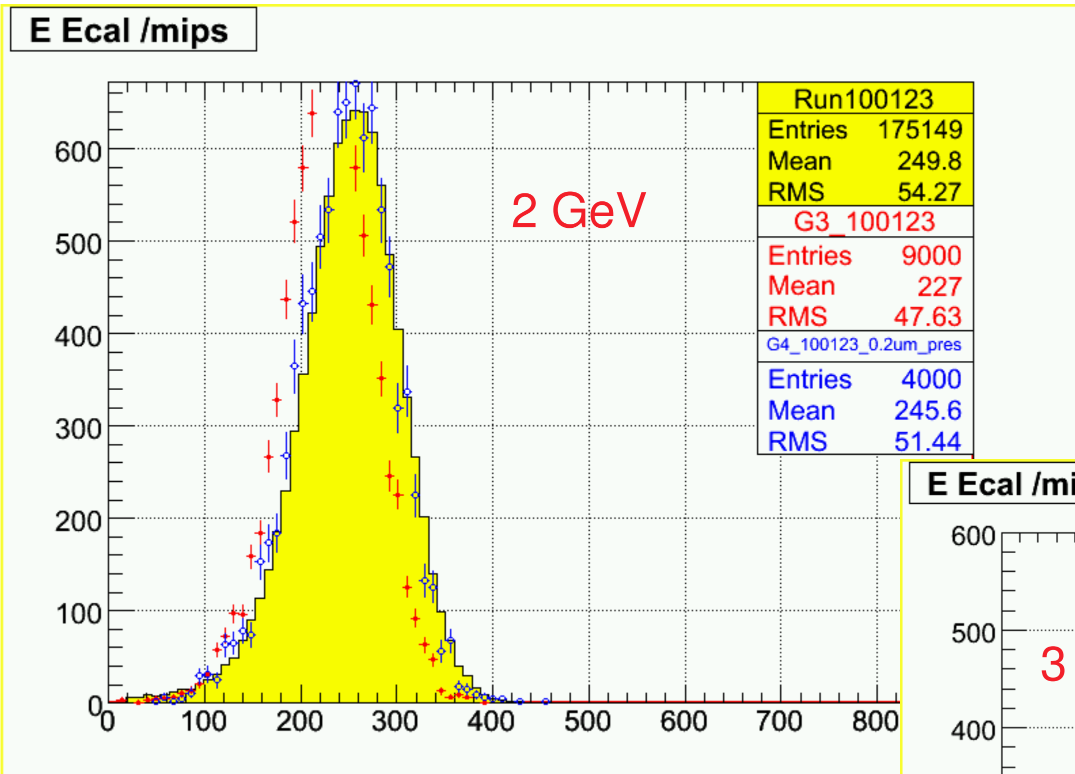
Etot /MIPs vs tracking cutoff



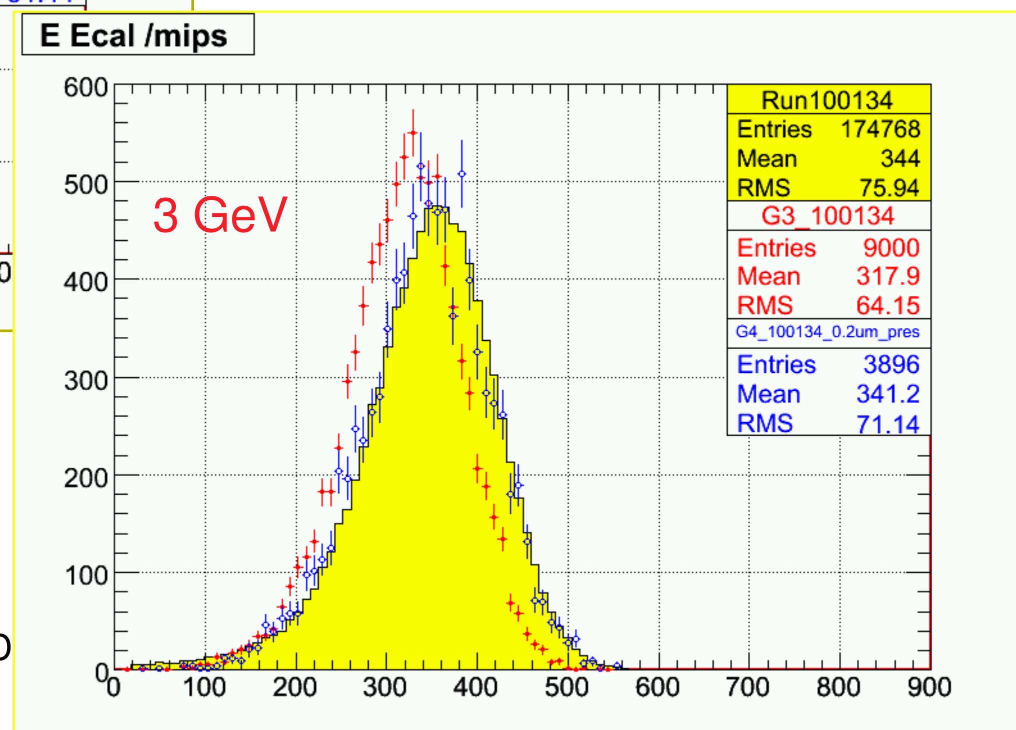
1 GeV e^-

G4 looks quite good
G3 is 8% low again

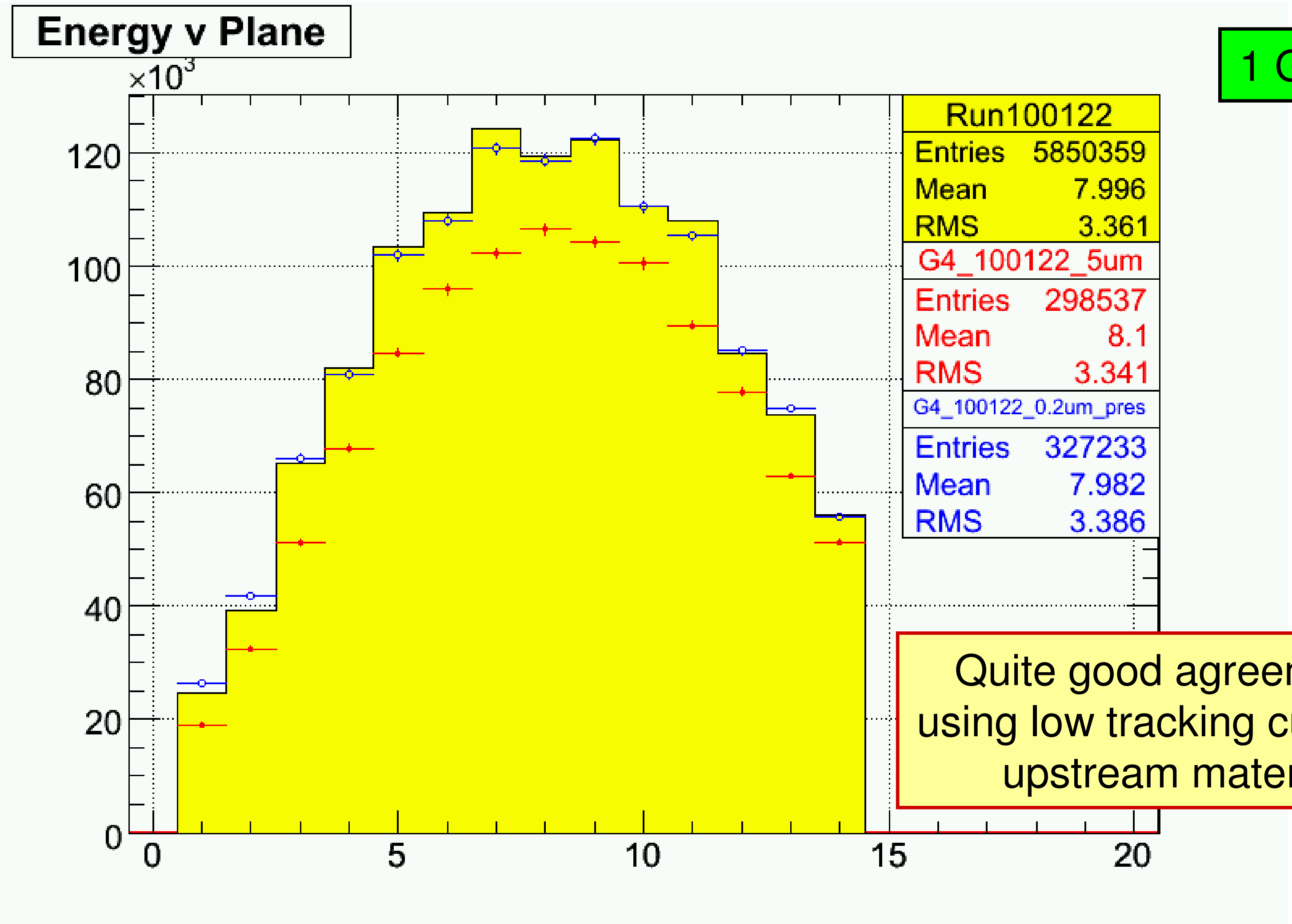
2GeV and 3GeV samples



G4 looks quite good in each case
G3 is consistently 8% low again



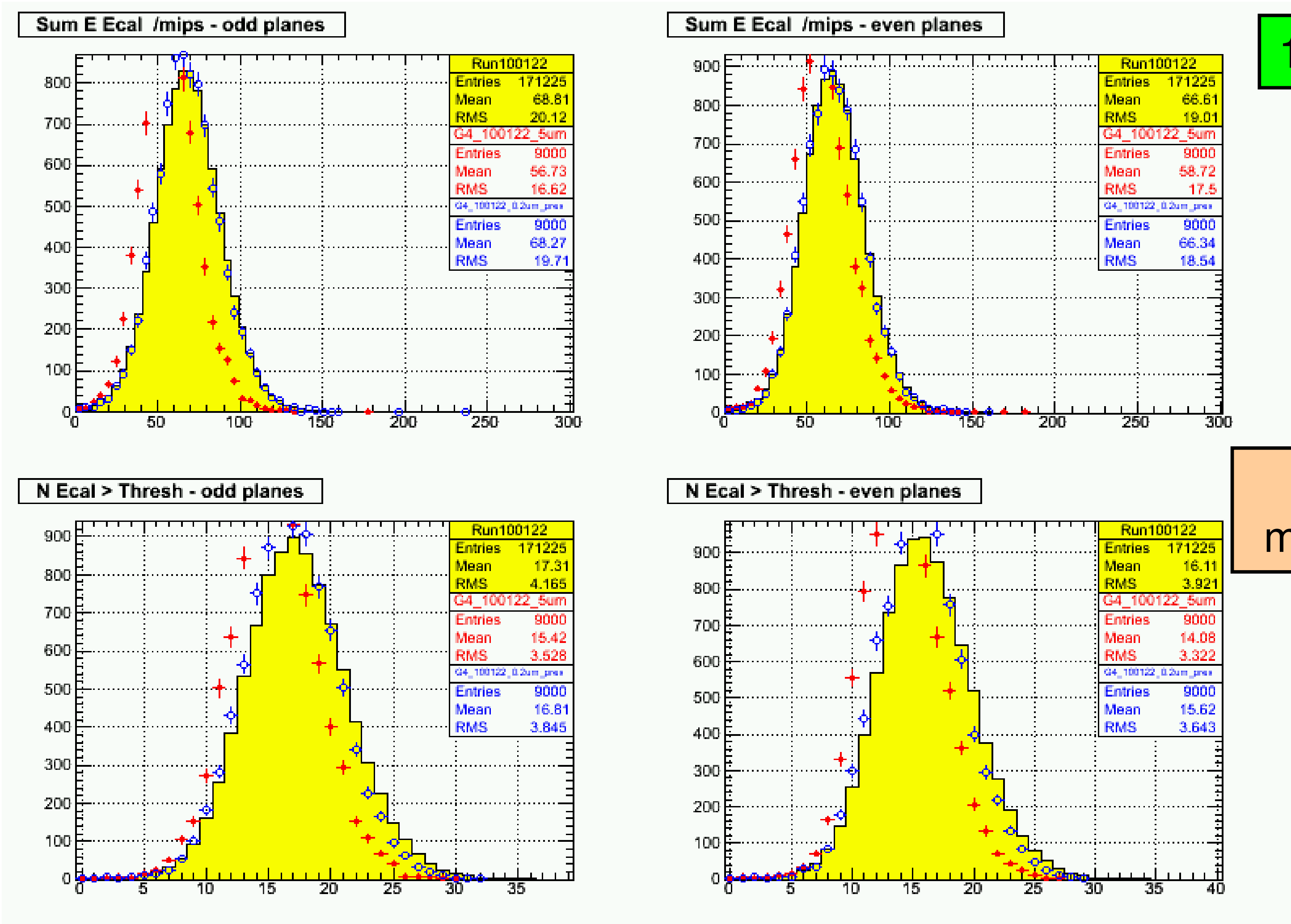
Longitudinal shower profile



1 GeV e^-

Quite good agreement, using low tracking cuts *and* upstream material

Even-odd plane differences

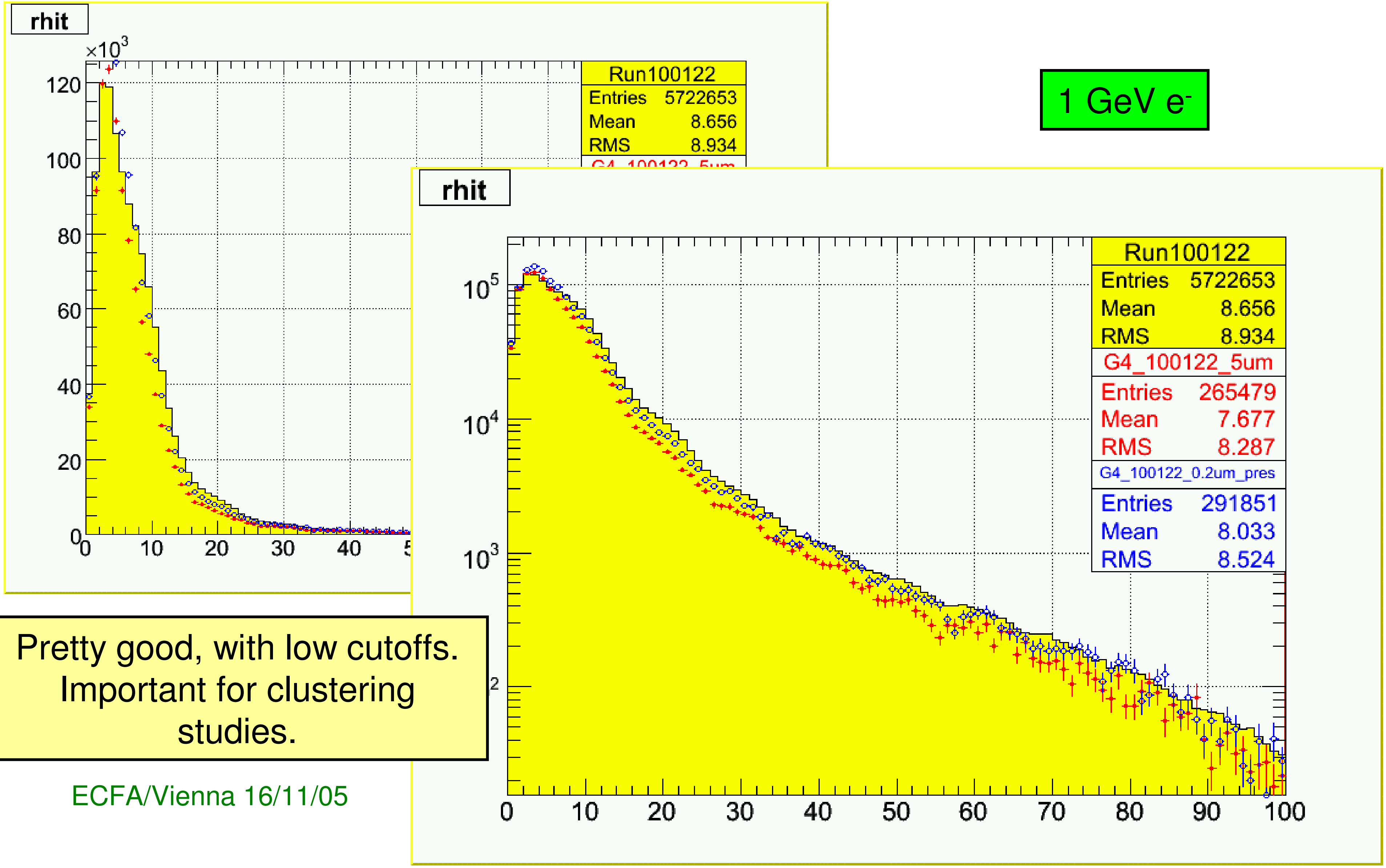


1 GeV e^-

Well modelled

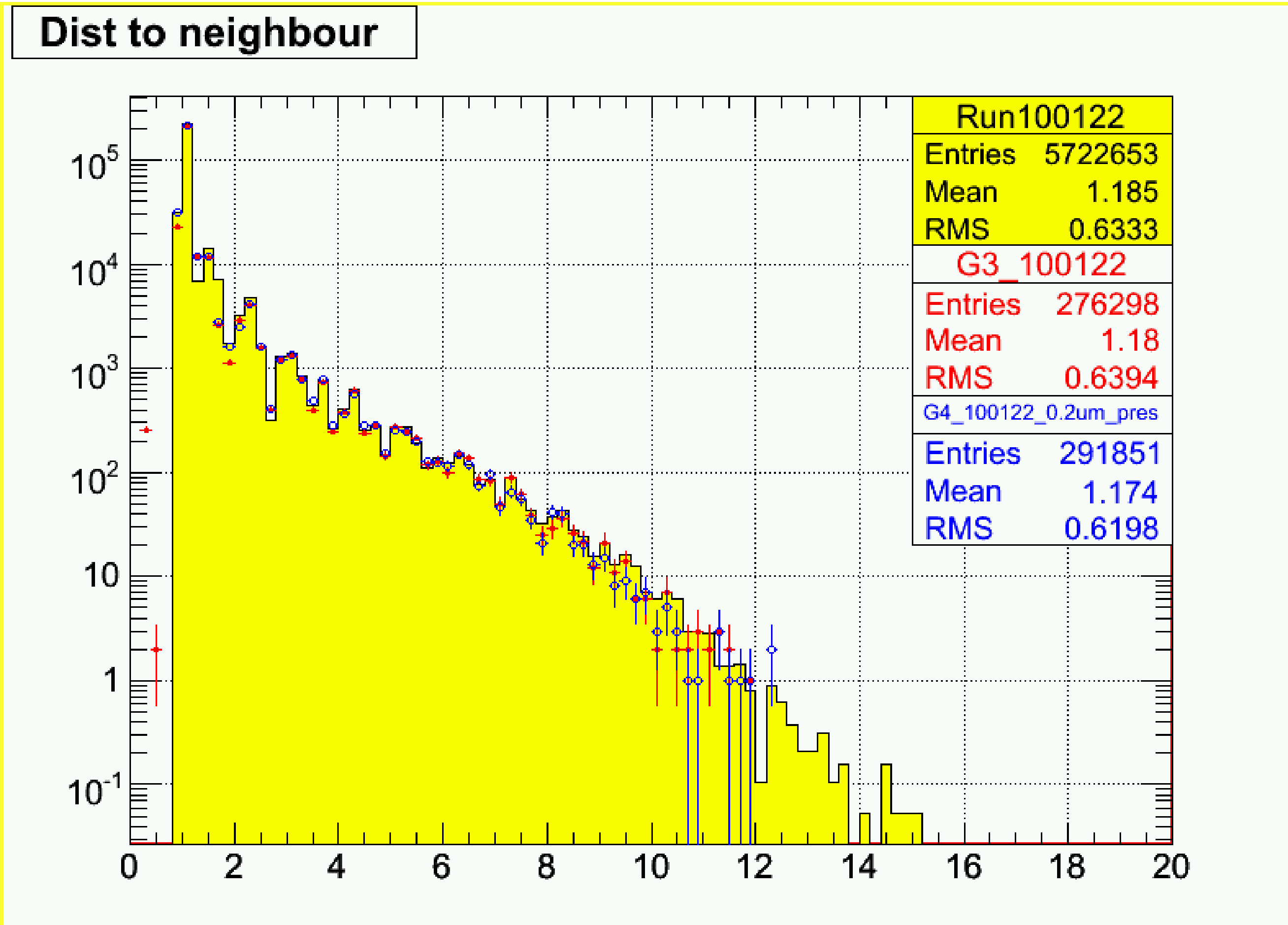
Transverse profile (w.r.t. barycentre)

1 GeV e^-



Pretty good, with low cutoffs. Important for clustering studies.

Distance of hit to nearest neighbour?



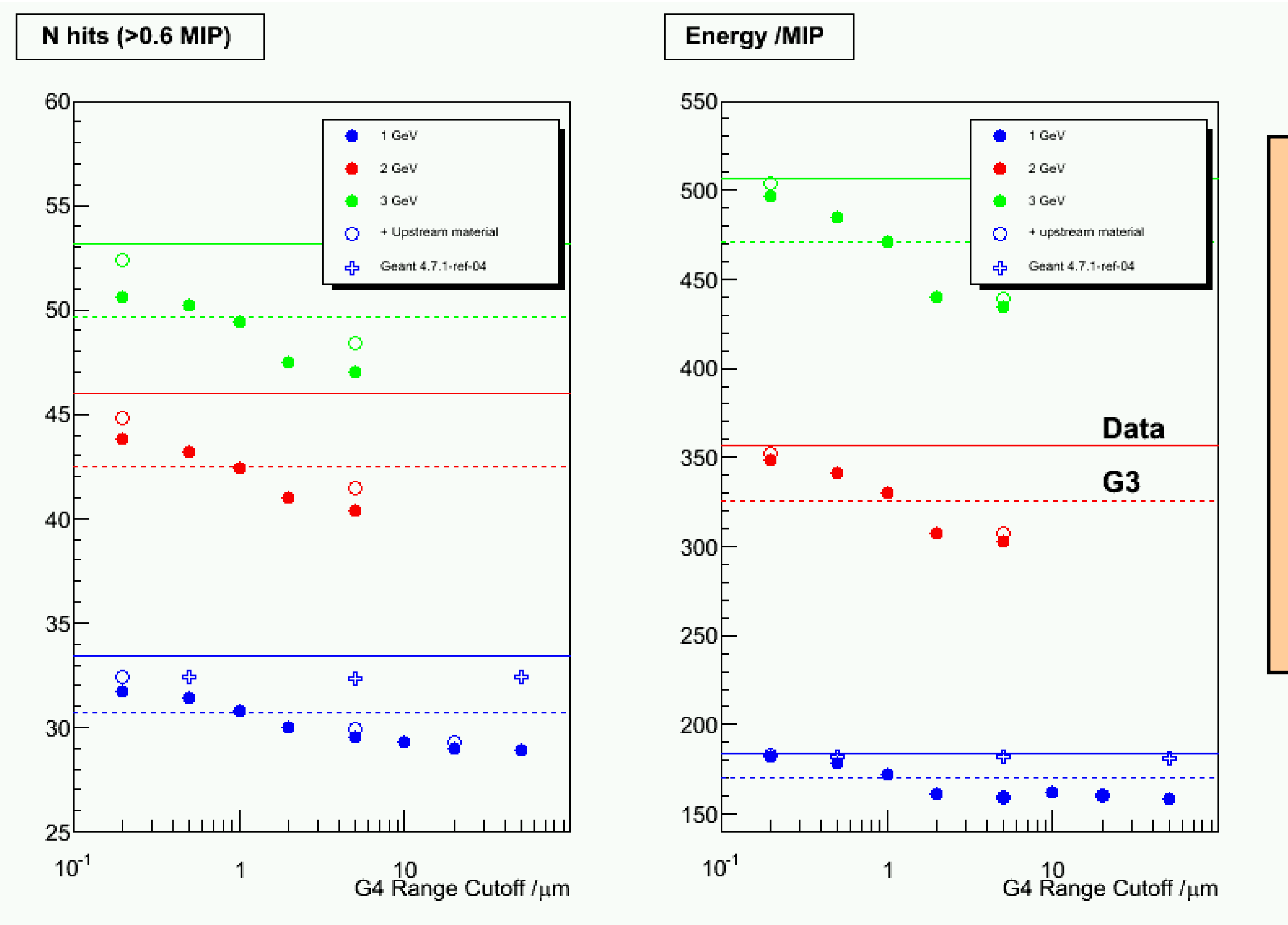
1 GeV e^-

Relevant for clustering?
Units – cm in (x,y); layer index in z.

Some recent developments

- Mokka 5.2 allows different tracking cutoffs in Si, W, G10 etc.
- Tests indicate that reducing the cutoff in Si only doesn't help (slightly worse if anything). Cutoff in tungsten is what matters. This doesn't help to improve the speed of the program.
- After recent LDC meeting N.Graf alerted us to new developments in GEANT4 (M.Maire+L.Urban), aimed at reducing cutoff-dependence.
- Installed GEANT 4.7.1-ref-04 (from CVS).
- First results with this version of G4, still using Mokka 5.1. Look encouraging…

Cutoff Dependence

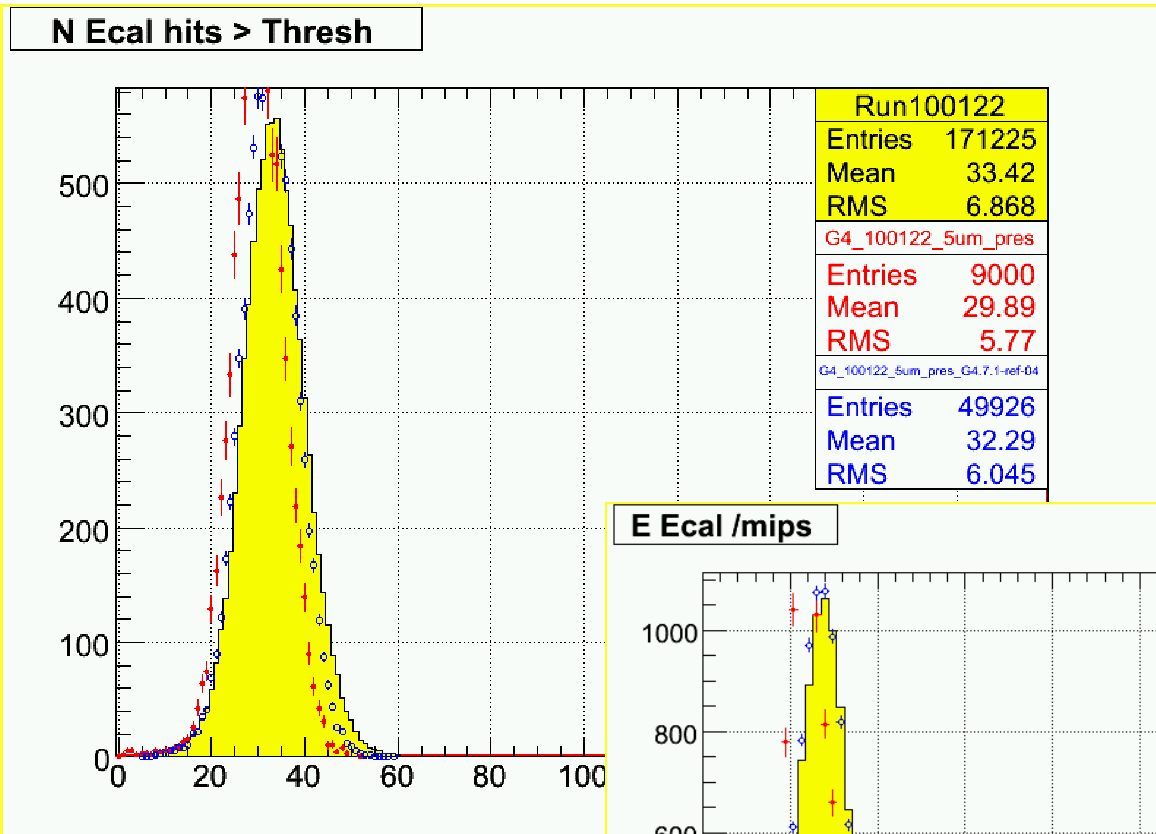


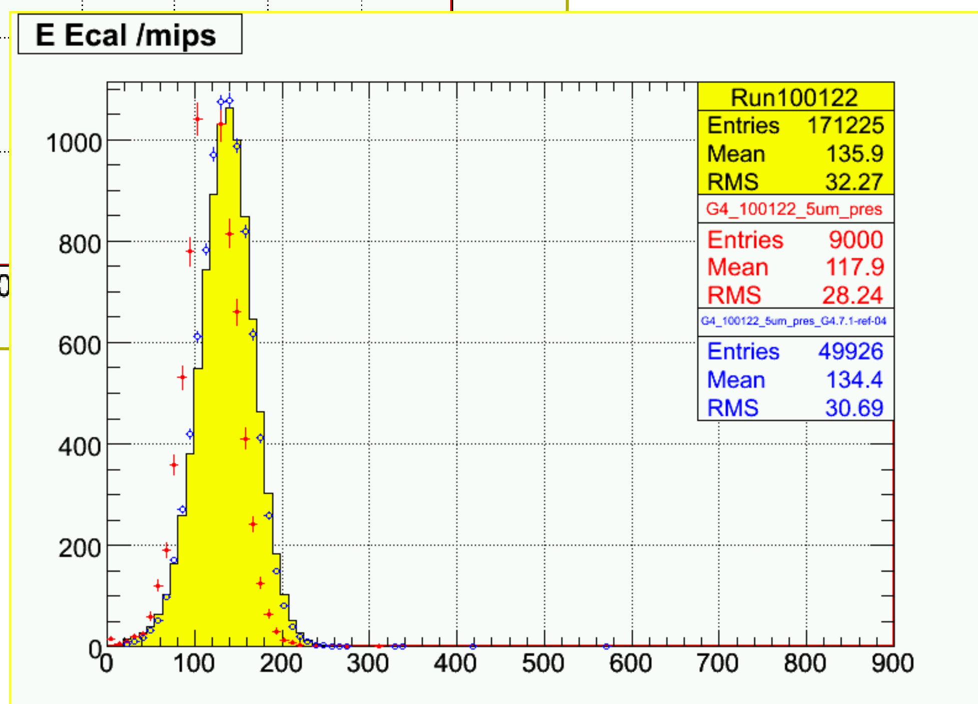
Now almost no dependence on cutoffs.

Speed of program largely unaffected.

A few more plots…

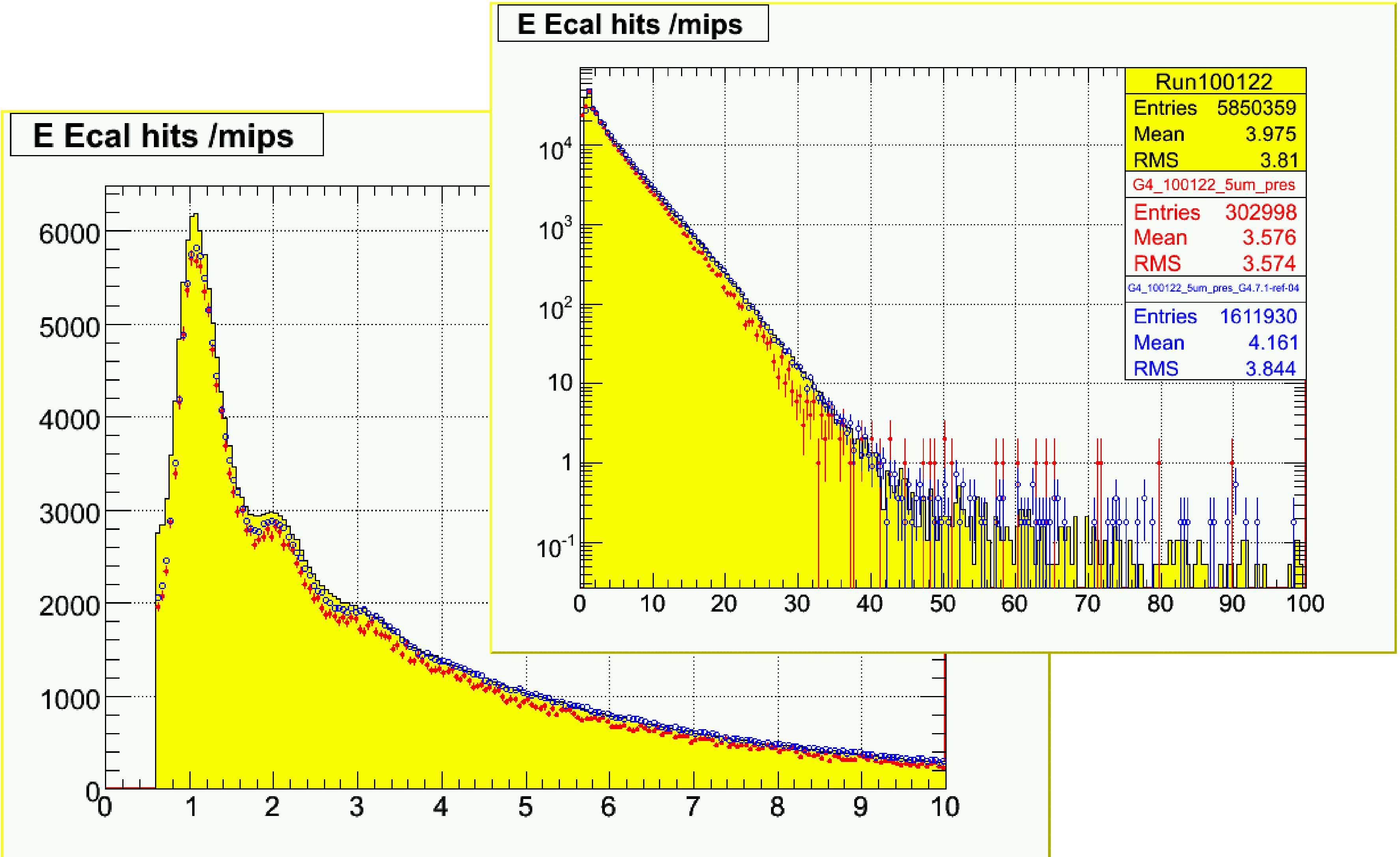
Hits; total energy





Looks pretty good, with 5µm tracking cuts

Hit energies



Summary

- Appears necessary to reduce tracking cutoffs in Geant4.7.1 to describe data. I don't yet understand physics of what is going on here.
- Unfortunately, G4 almost prohibitively slow under these conditions.
- Luckily, G4 authors seem to have addressed this in the next release. Could have significant effect for PFlow?
- Recent modifications in Mokka (G. Musat) allow different cutoffs in Si and W. Turns out that it is the tungsten which is important.
- Still need to look carefully at effects of noise and crosstalk in Calice data. But even without, G4 can model the data fairly well.
- Further detector effects (e.g. edge effects) to be taken into account?
- Understand more precisely effects induced by upstream material.
- G3 is faster, but can't easily push tracking cutoffs below 100 keV.
- Can learn a lot of useful things about modelling the data using the February Calice run.