Pion showers in the Si-W ECAL

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(presented by David Ward)

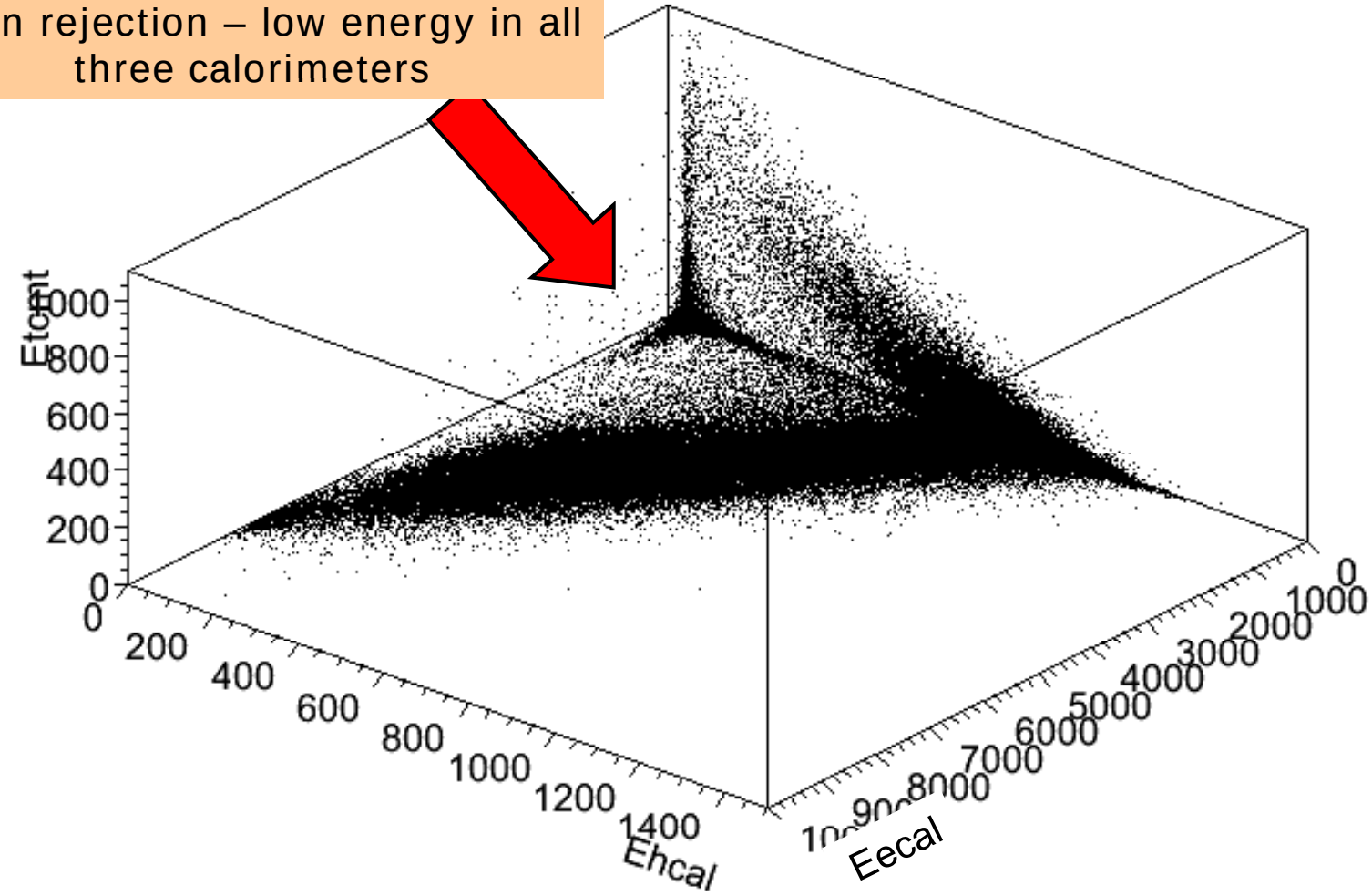
Motivation / Outline

- We have a reasonably good understanding of electromagnetic showers in the ECAL. Effects of noise, digitisation are known to be modest.
- $\pi^{\pm}$ showers usually start in the ECAL; need to validate shower models in ECAL as well as in HCAL.
- May be able to exploit fine ECAL granularity to characterise behaviour of showers at their start.
- This study is based on four runs from CERN 2007 (v0406 reco)
  - 330641 8 GeV π^-
  - 330645 12 GeV π^-
  - 331298 30 GeV π^+
  - 331324 80 GeV π^+
- And we examine three GEANT4 physics lists:
  - LHEP (≈ Gheisha), QGSP_BERT (≈ LCPhys), FTFP_BERT

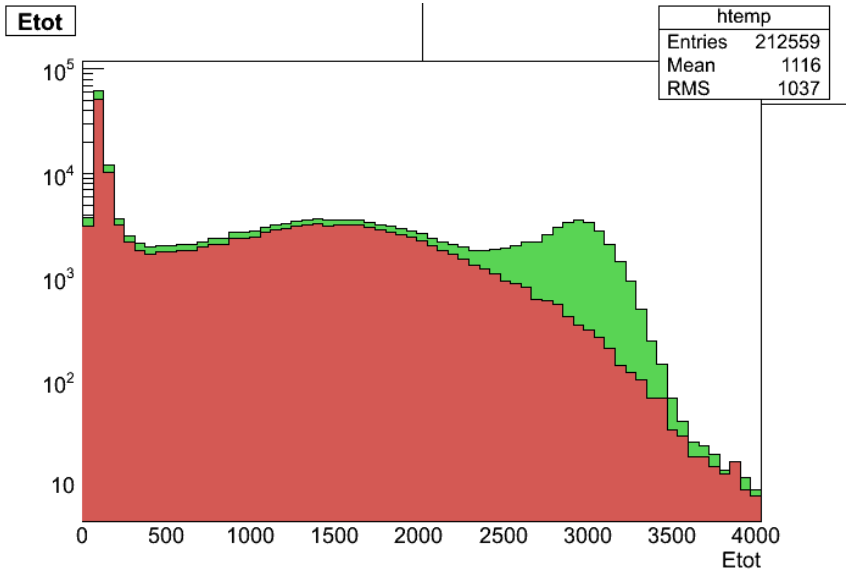
Event selection

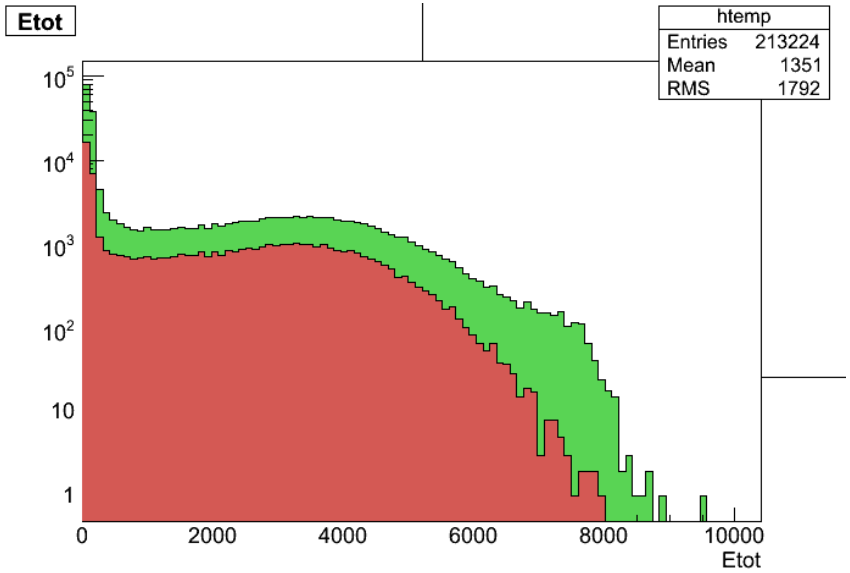
Etcmt:Ehcal:Etot

Muon rejection – low energy in all three calorimeters



Event selection



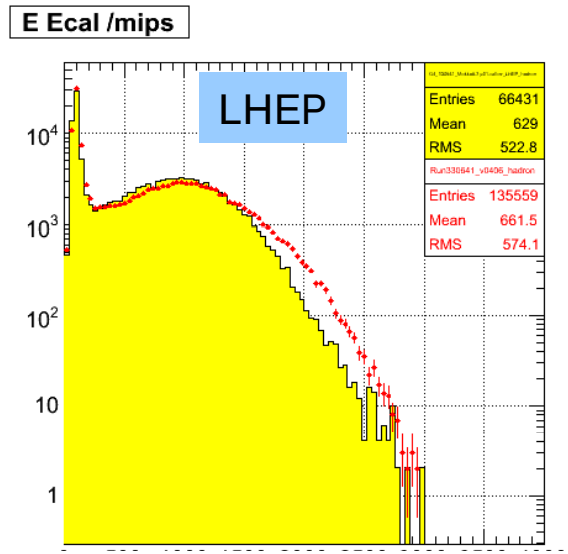


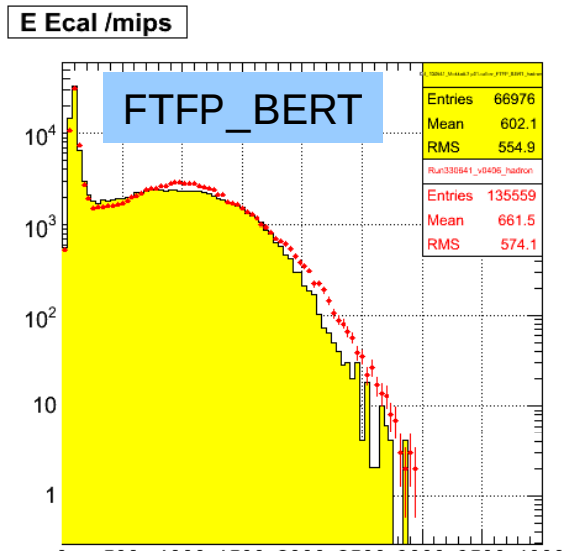
π^- runs : demand Cerenkov **off** to remove e^-

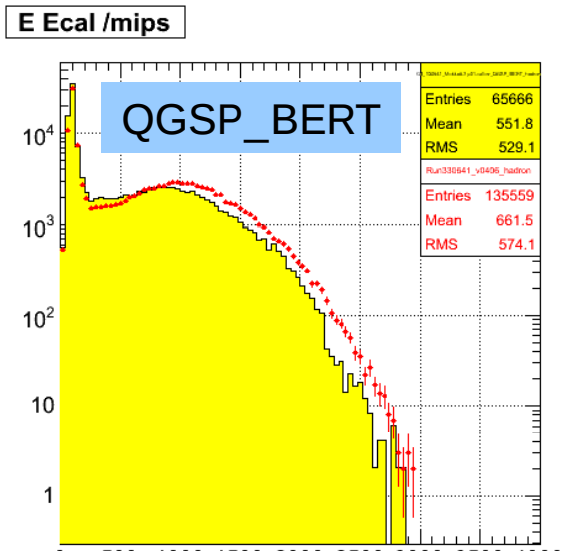
π^+ runs : demand Cerenkov **on** to remove p

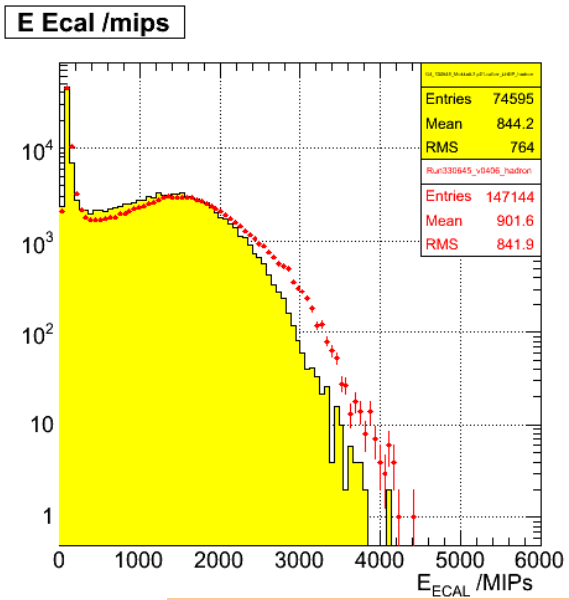
Also, reject event if >50 MIPs in layers 1+2 (upstream showering cut)

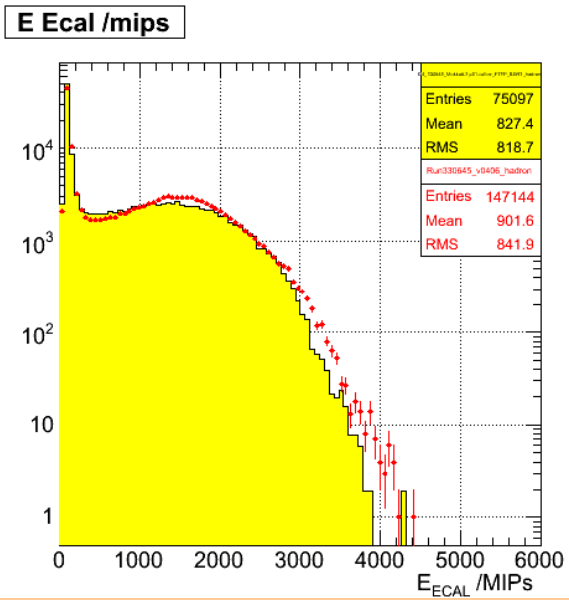
Total ECAL energy; 8 and 12 GeV

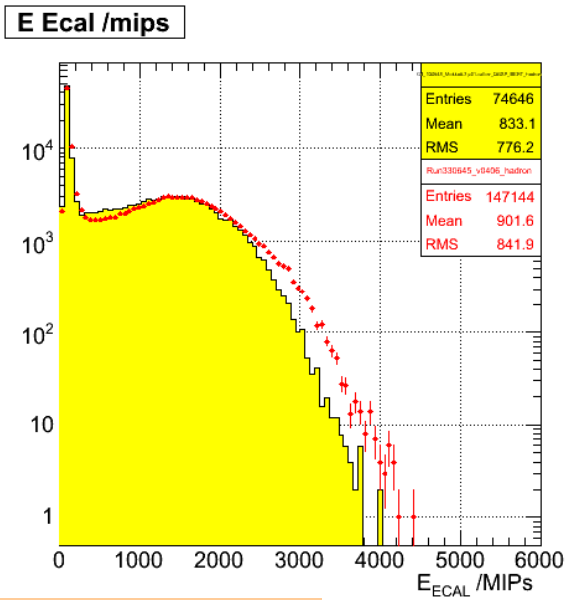






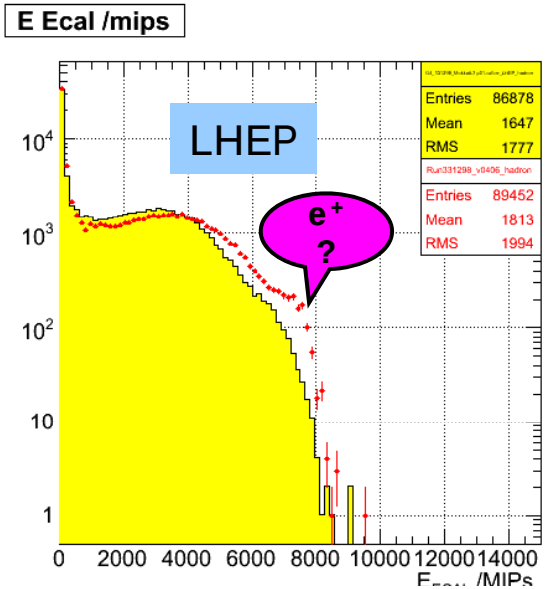


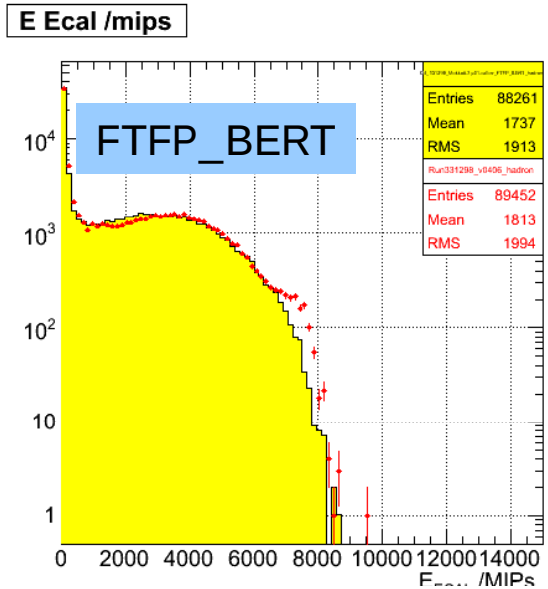


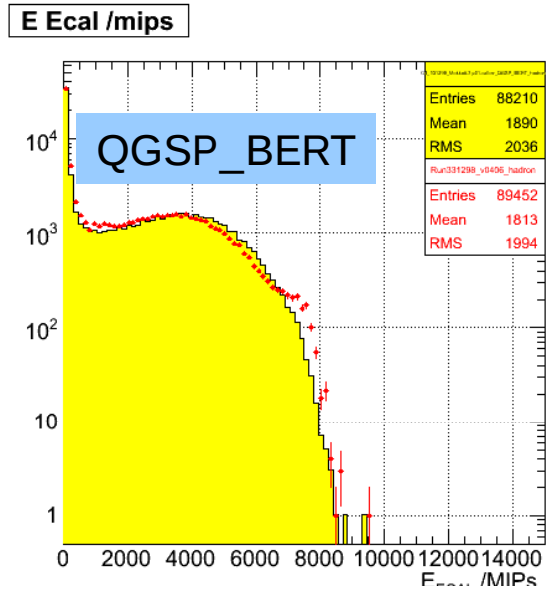


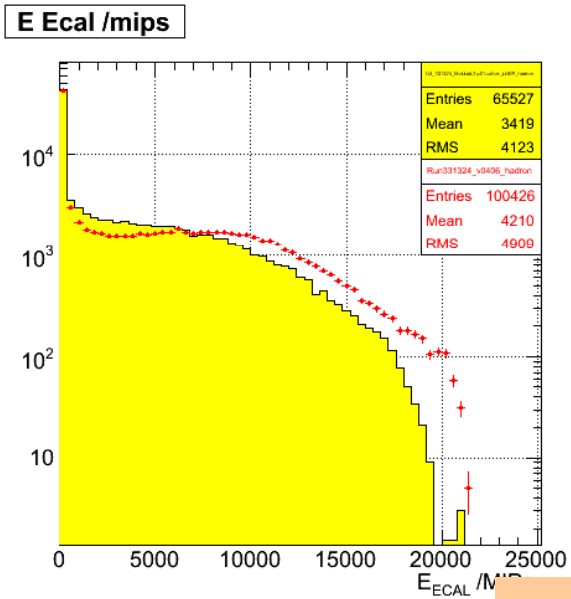
QGSP_BERT worst; FTFP_BERT slightly better than LHEP?

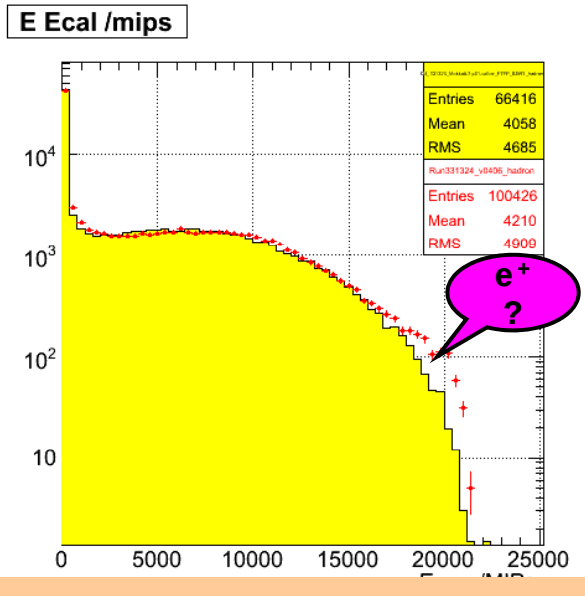
Total ECAL energy; 30 and 80 GeV

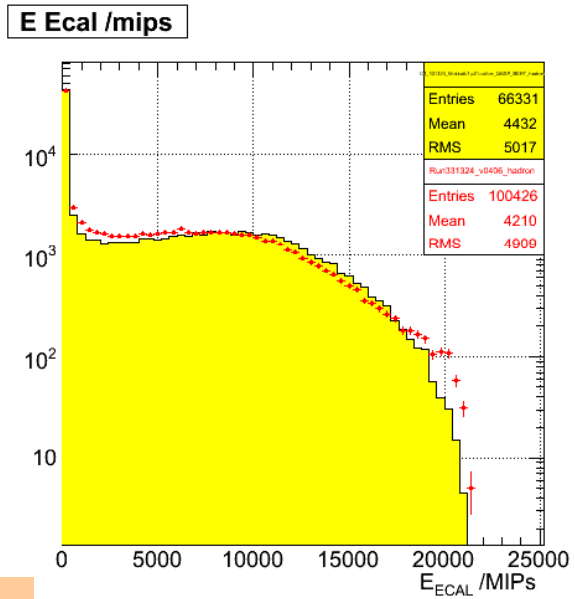






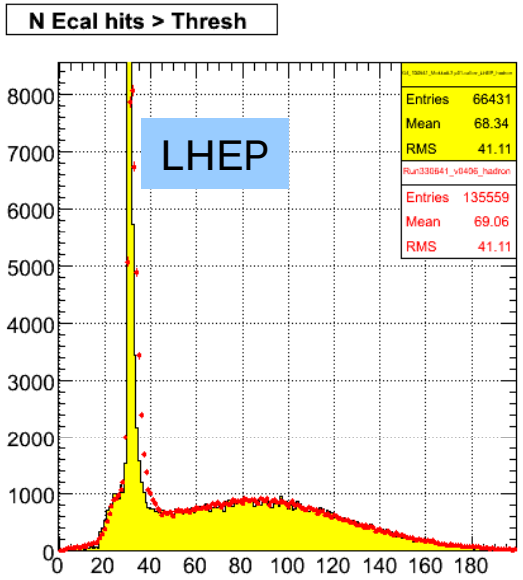


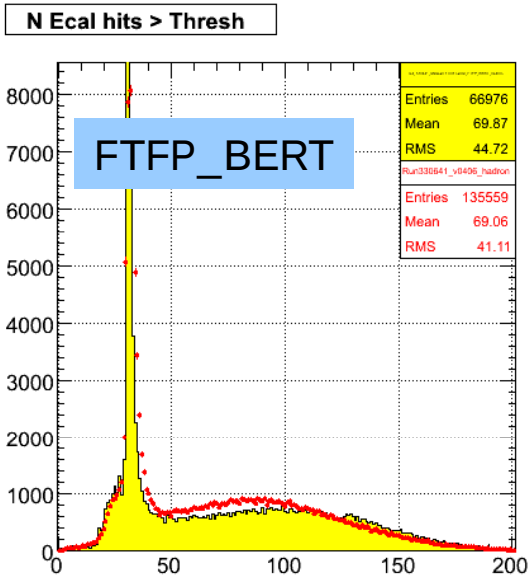


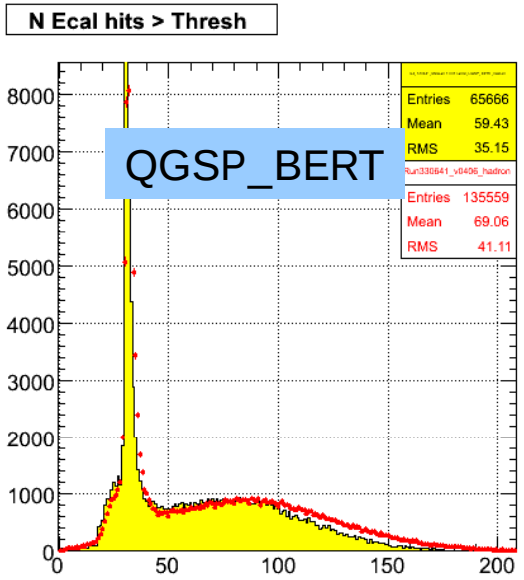


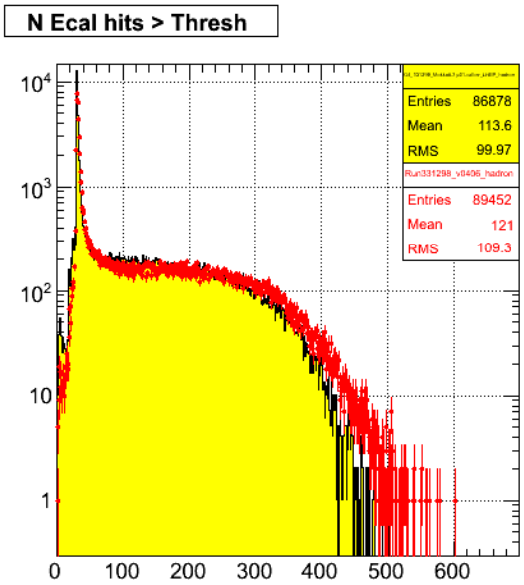
LHEP clearly worst; FTFP_BERT best

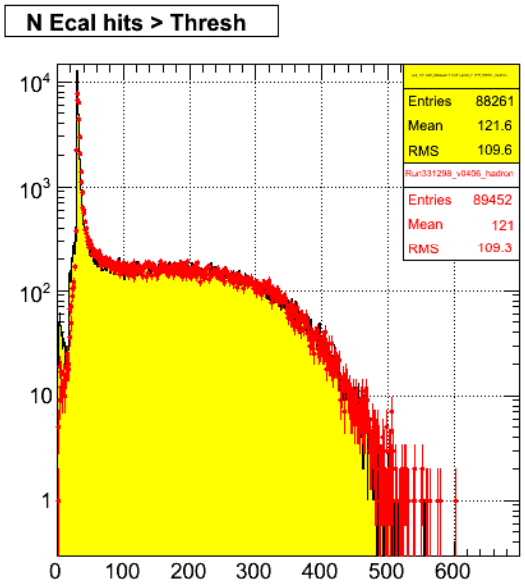
N ECAL hits 8GeV (top) and 30 GeV (bottom)

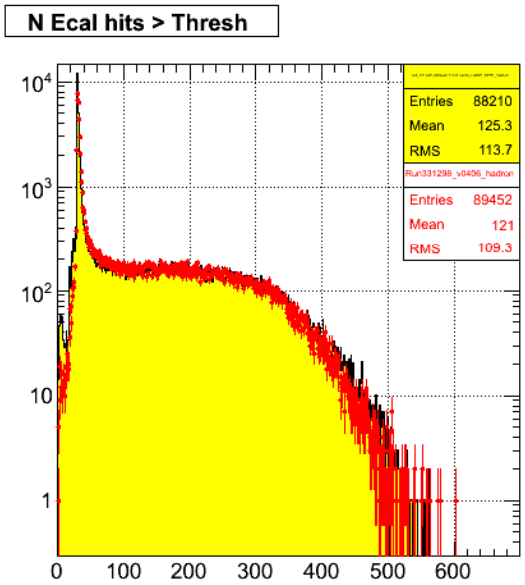






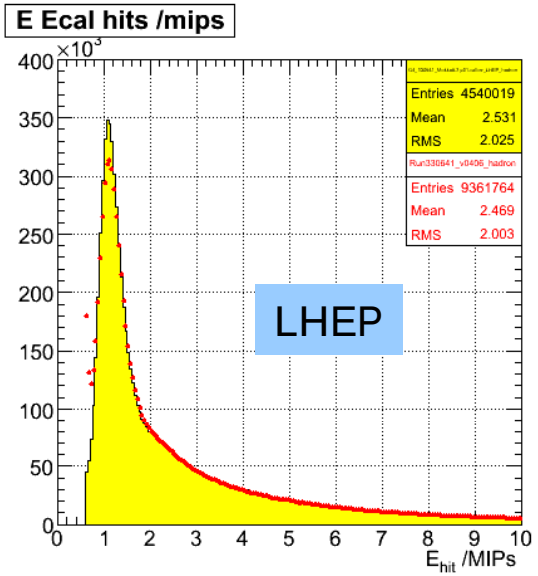


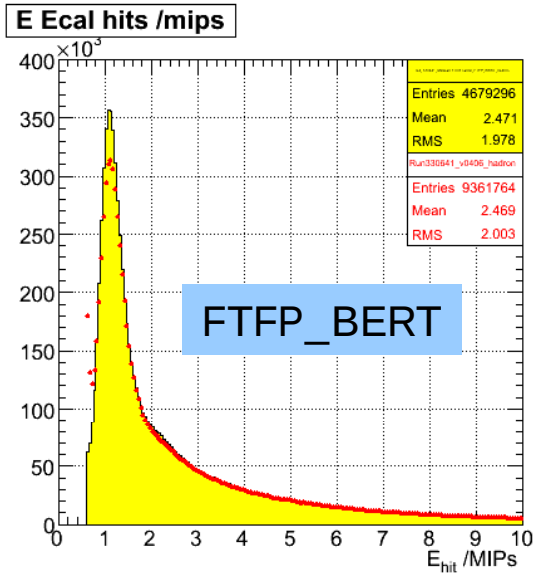


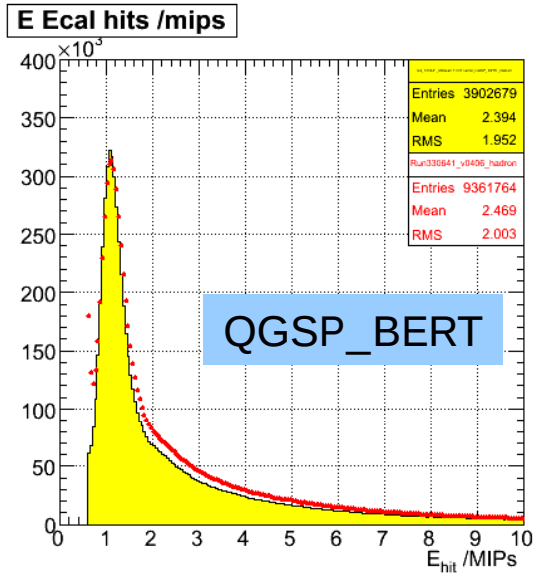


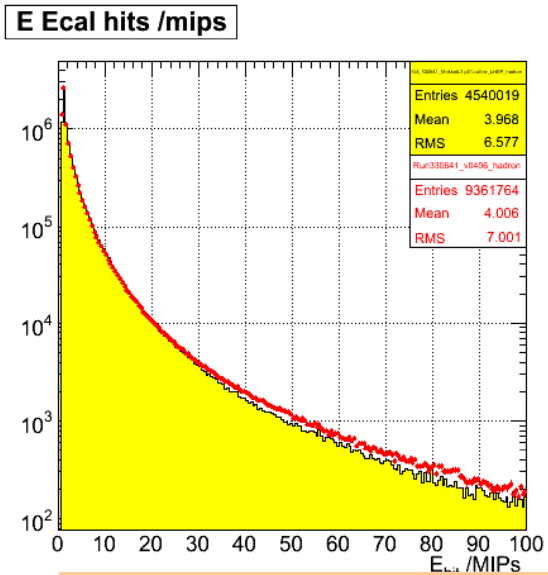
LHEP best @ 8 GeV, worst @30 GeV; FTFP_BERT best @ 30 GeV

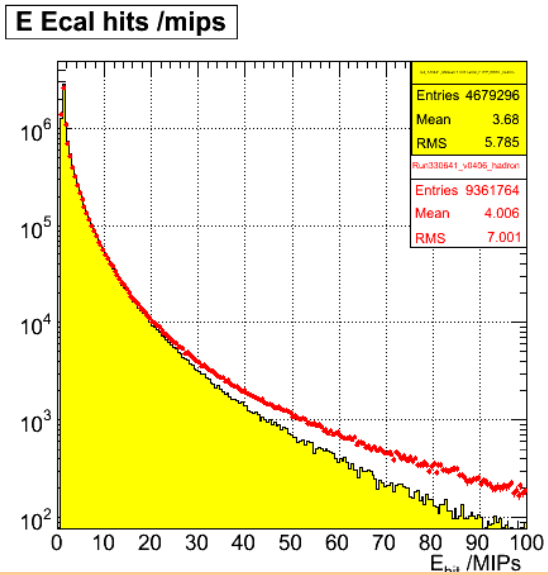
Hit energies 8 GeV

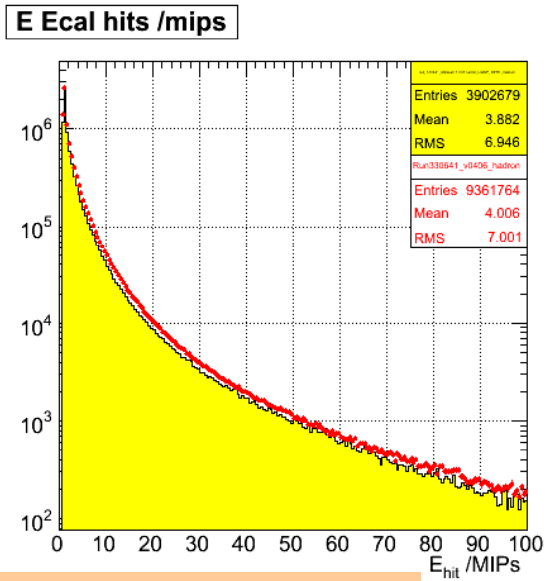






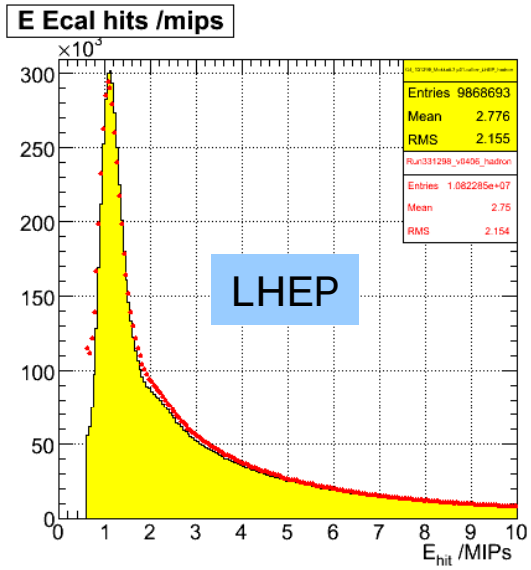


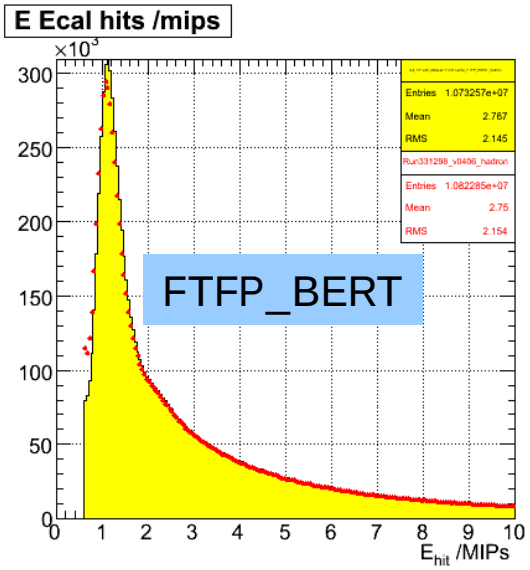


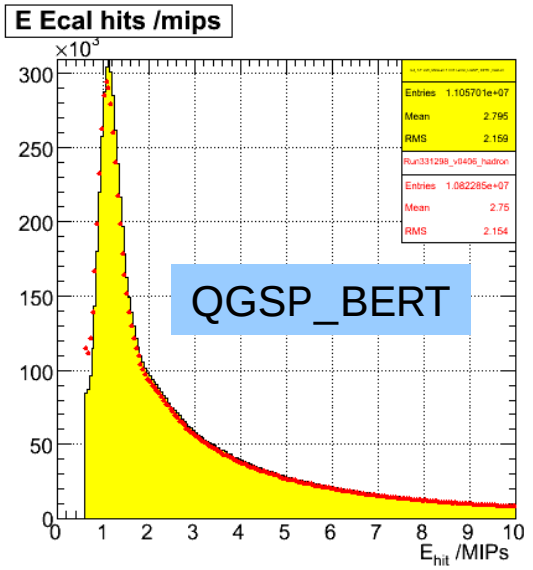


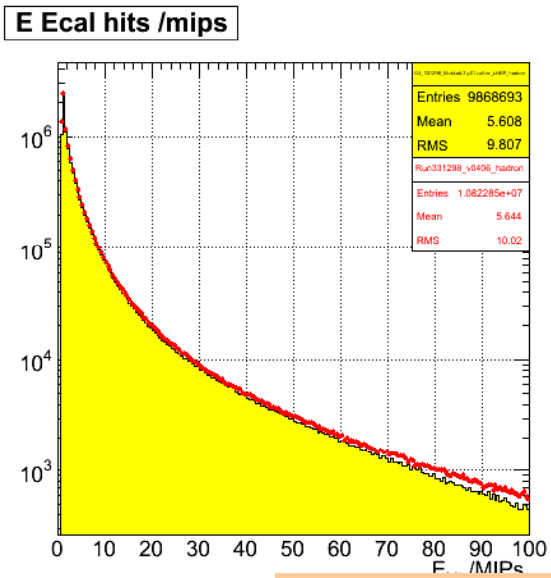
LHEP, FTFP_BERT good in the MIP peak; FTFP_BERT worst in tail

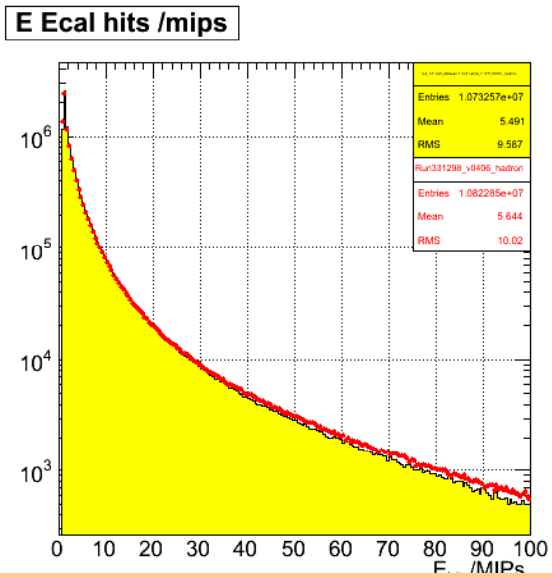
Hit energies 30 GeV

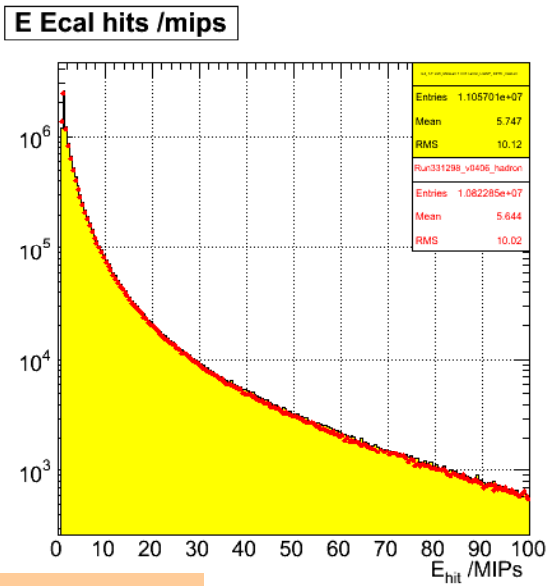






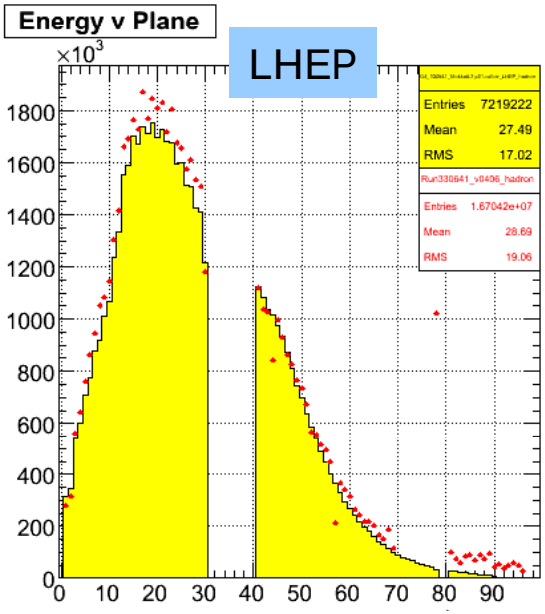


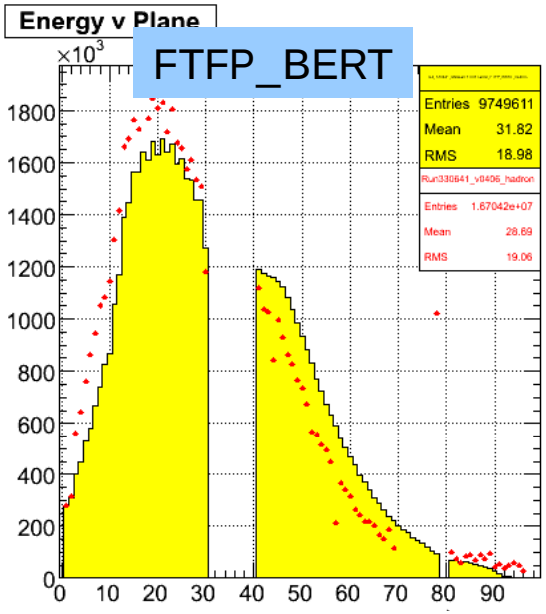


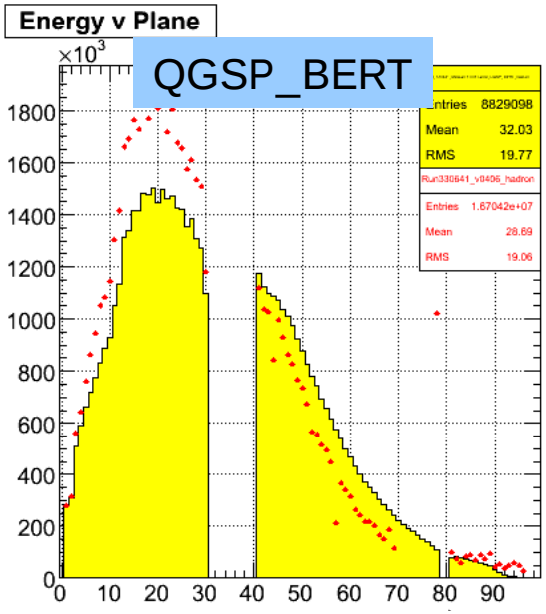


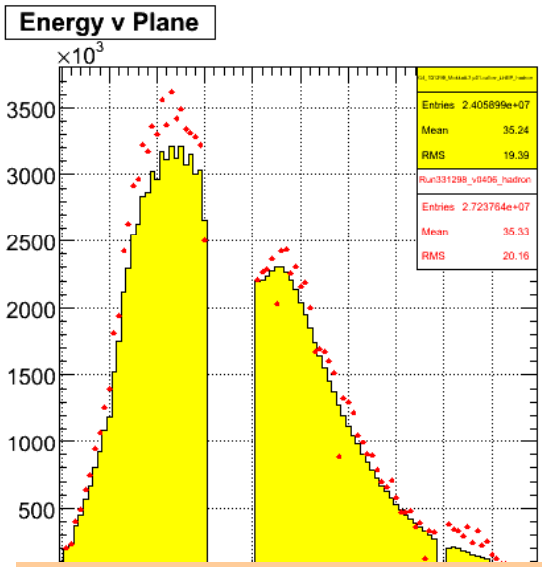
All OK in the MIP peak; QGSP_BERT best in tail

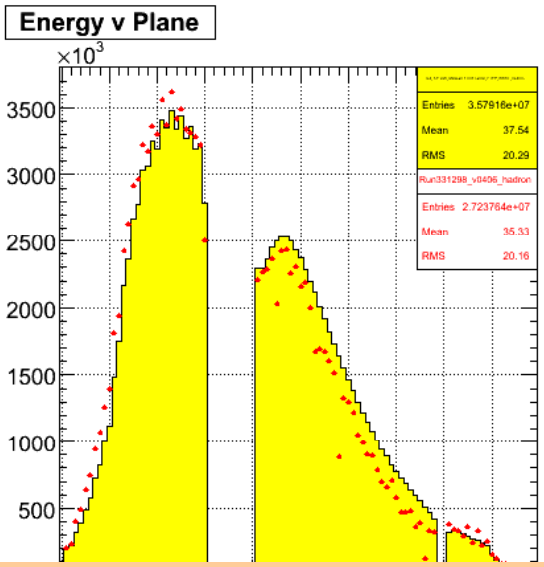
Longitudinal energy profile: 8 and 30 GeV

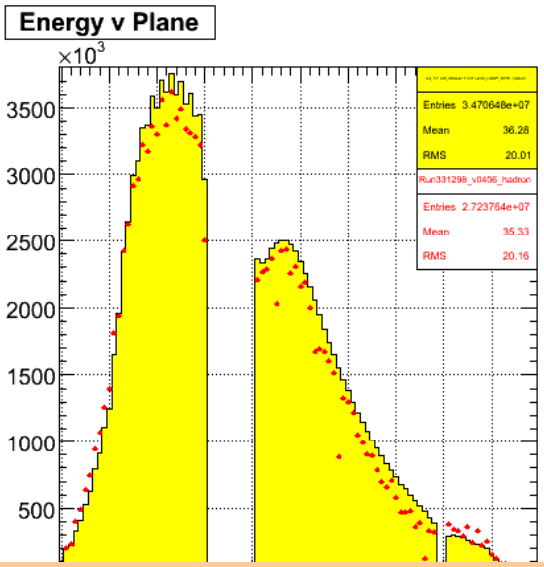






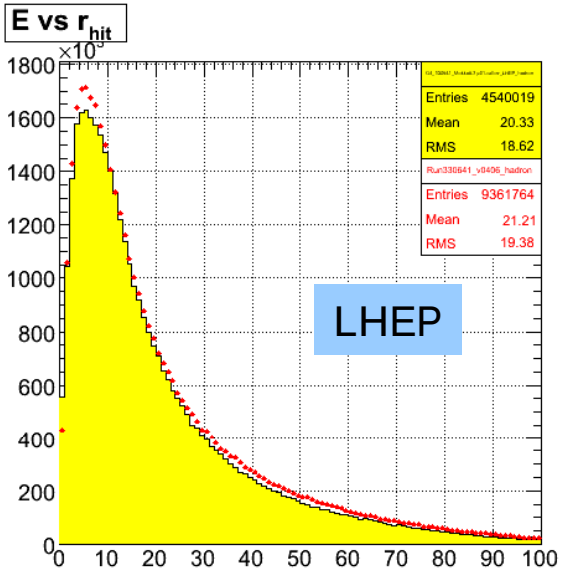


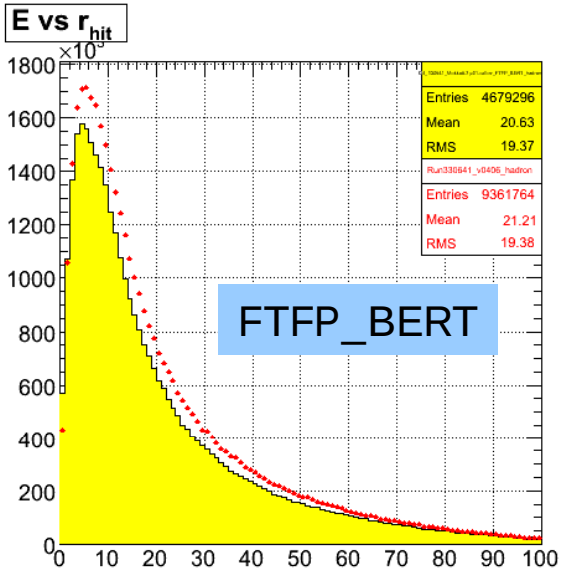


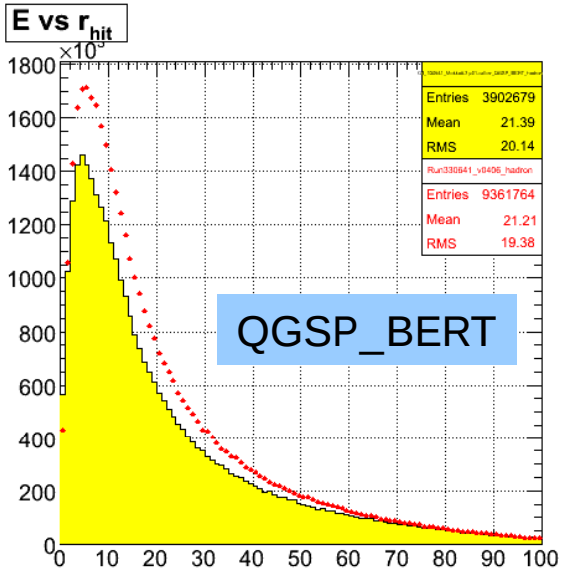


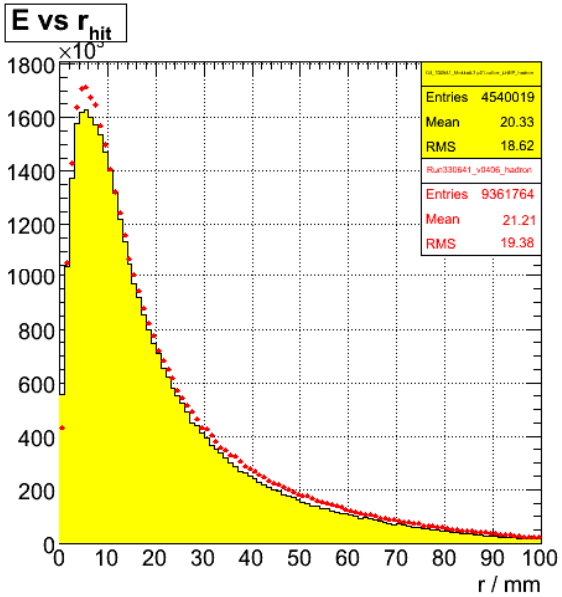
Not very illuminating; mainly see differences in normalisation, not shape

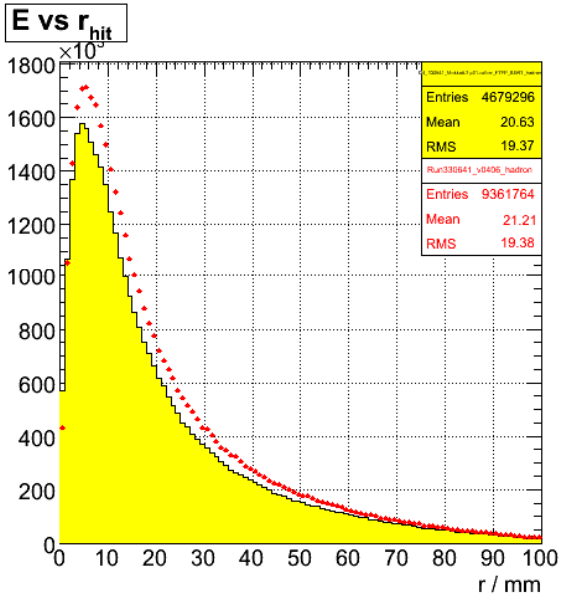
Transverse energy profile: 8, 12 GeV

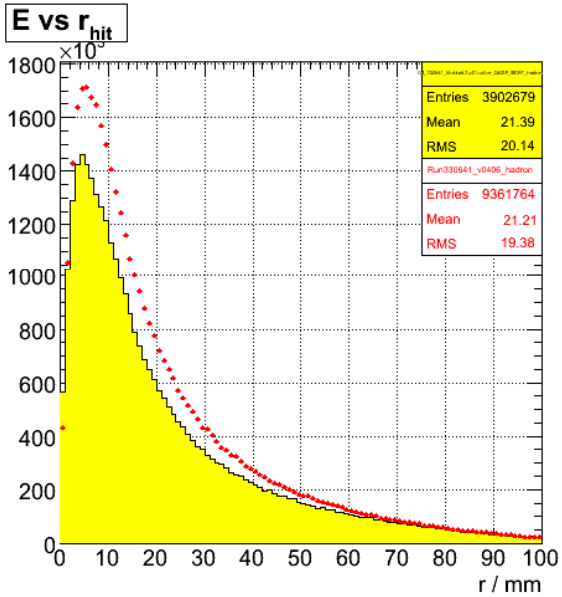






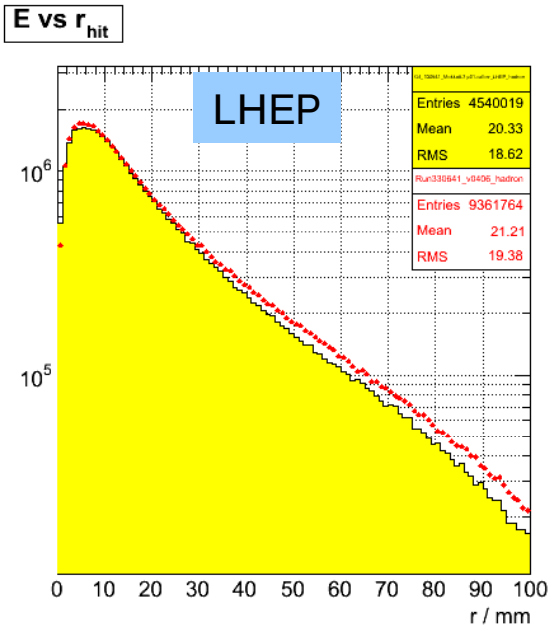


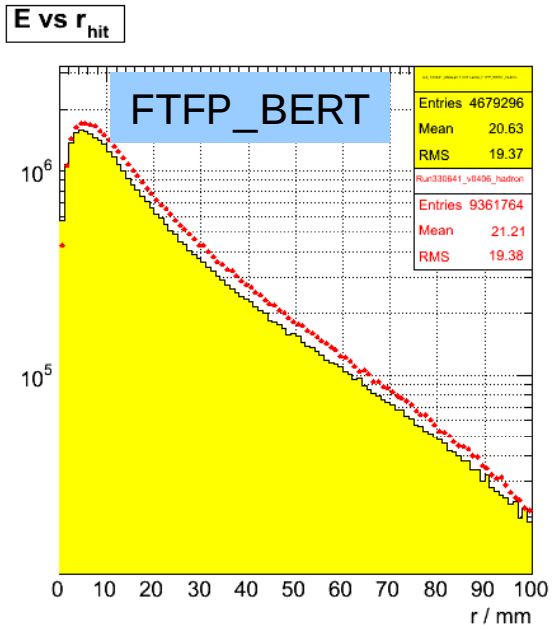


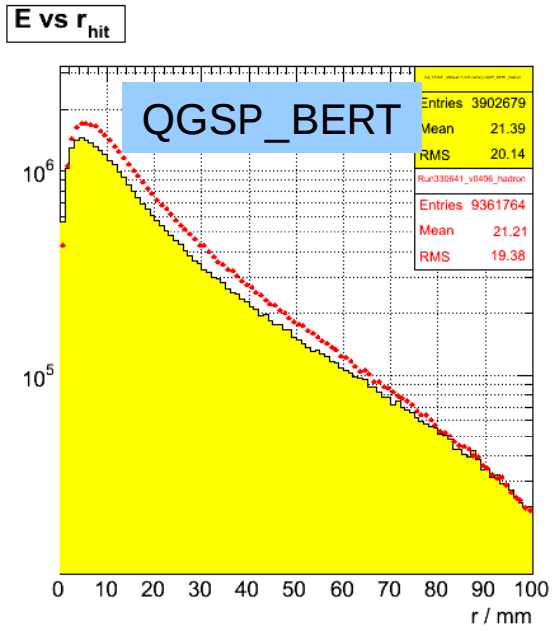


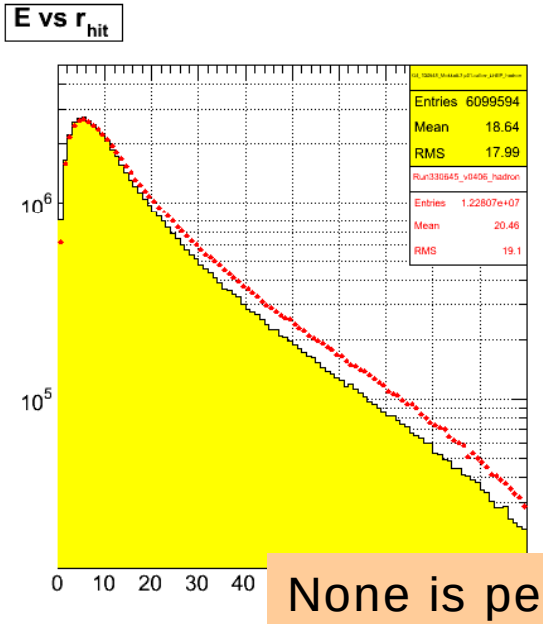
Differences in energy response affect normalisations. Log scale better?

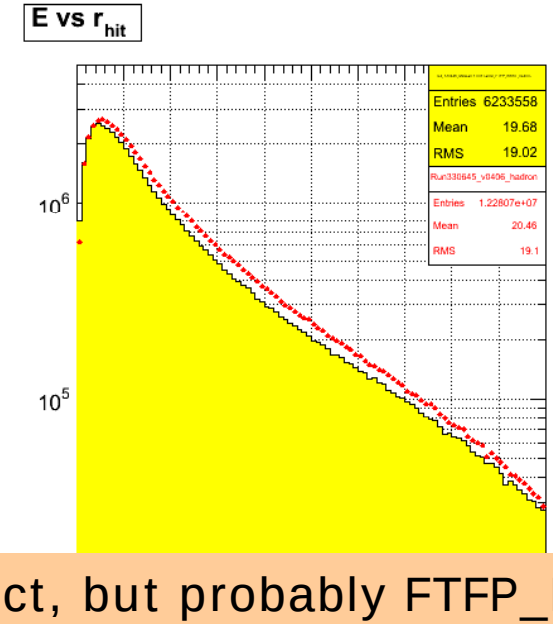
Transverse energy profile: 8, 12 GeV

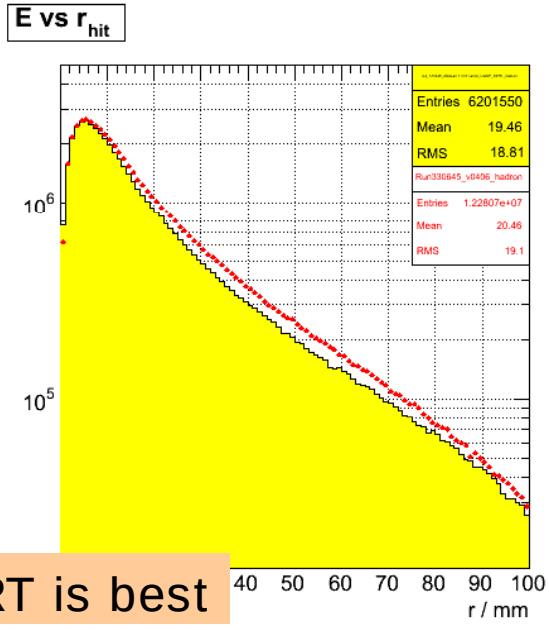






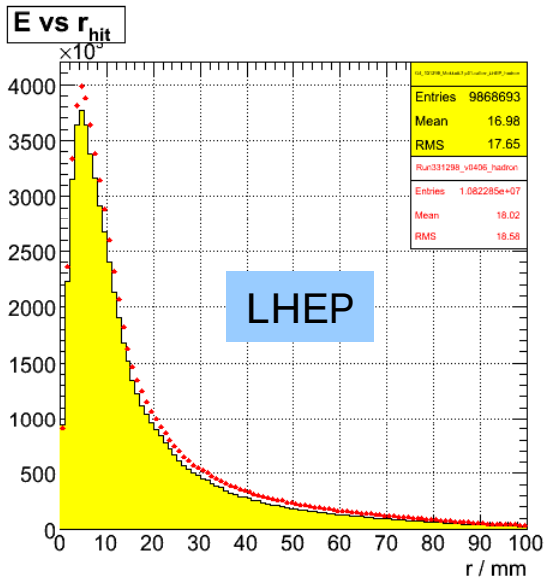


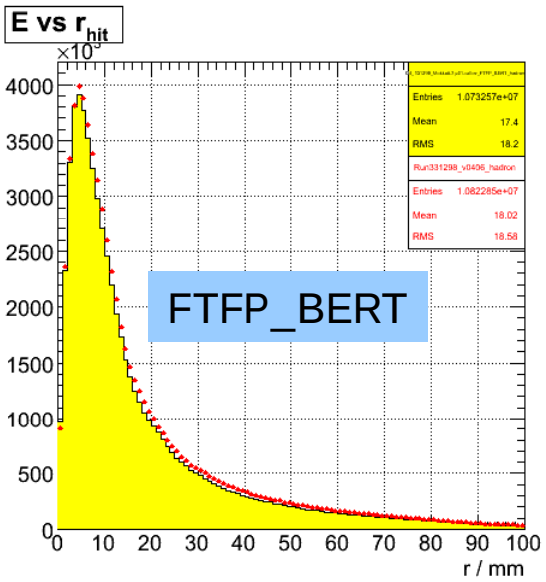


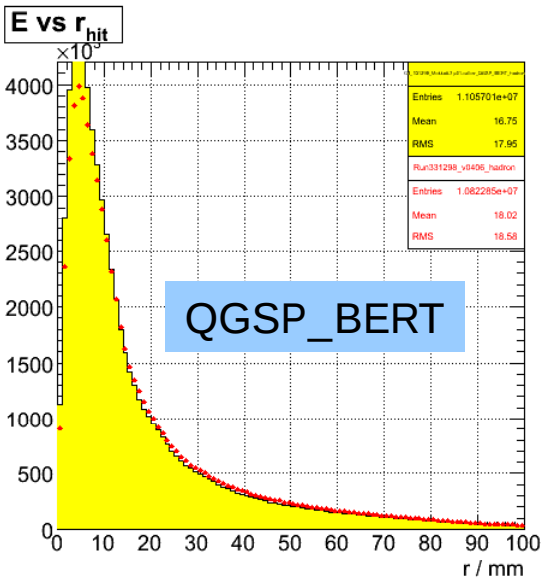


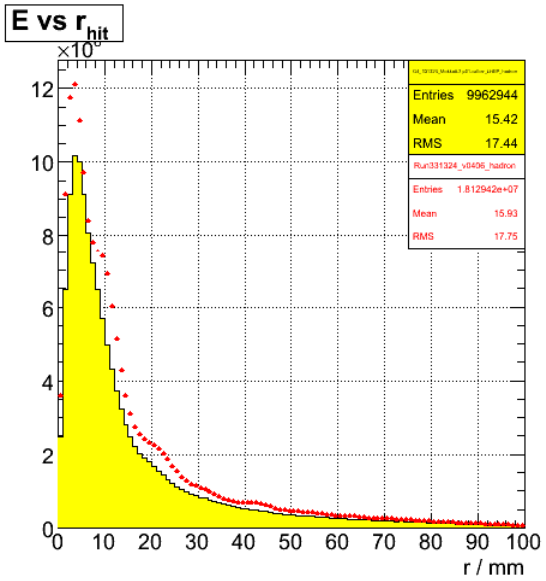
None is perfect, but probably FTFP_BERT is best

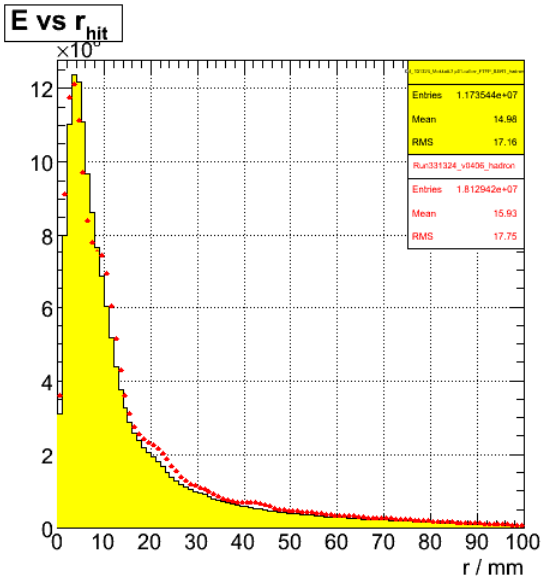
Transverse energy profile: 30, 80 GeV

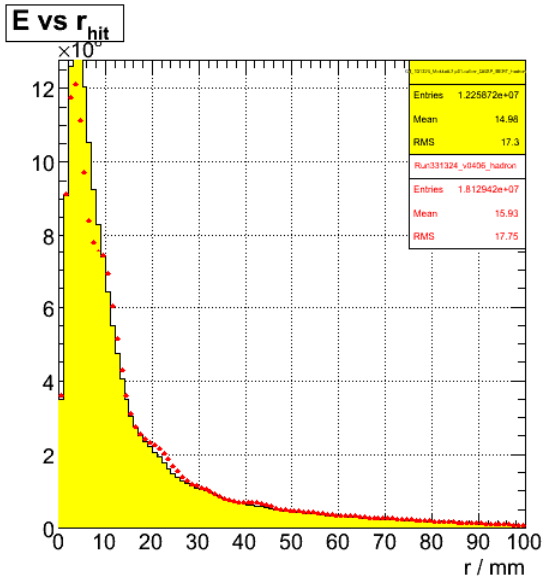






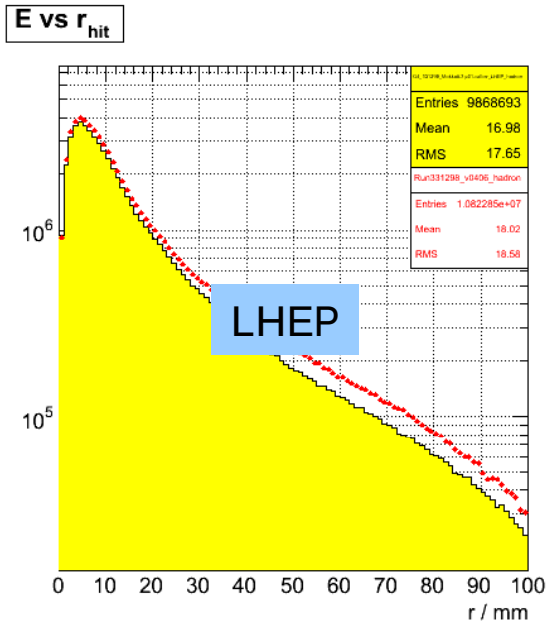


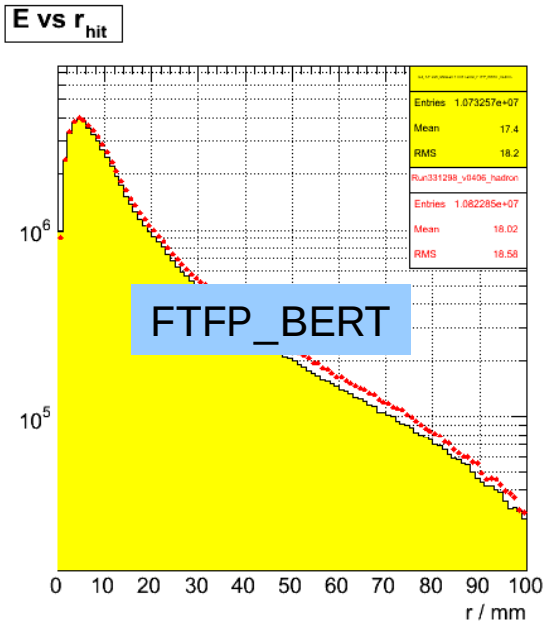


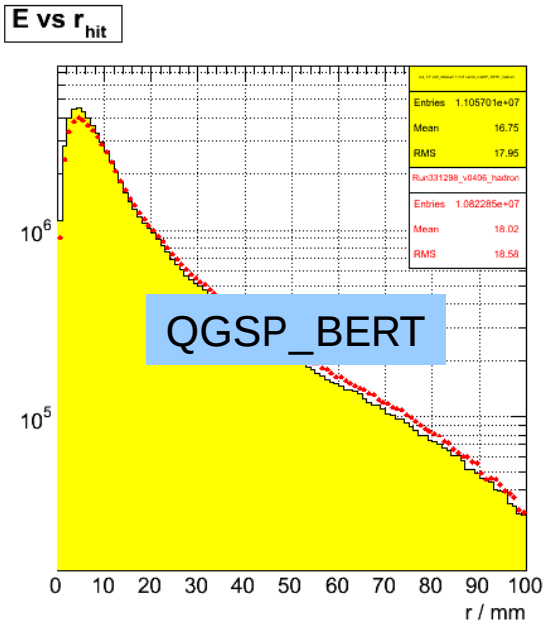


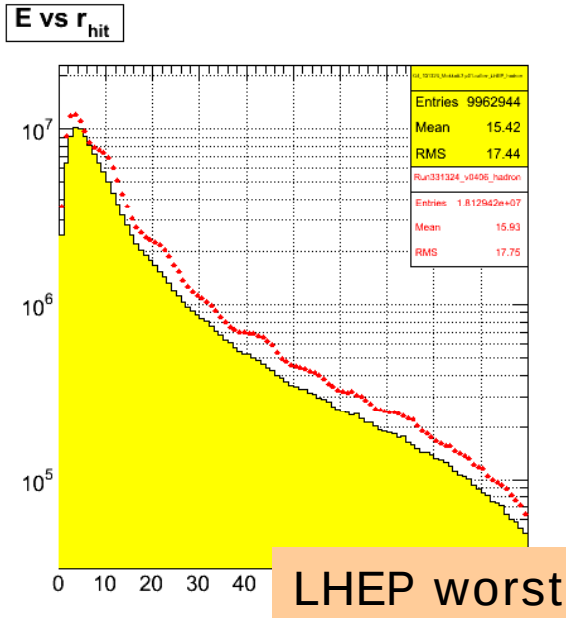
Linear scale not very revealing

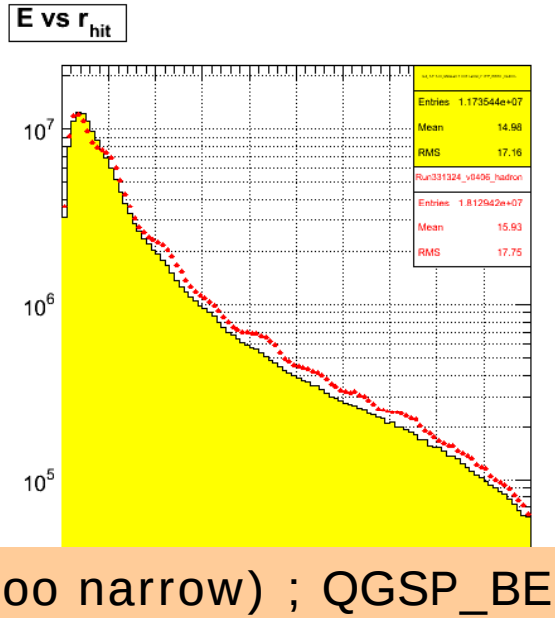
Transverse energy profile: 30, 80 GeV

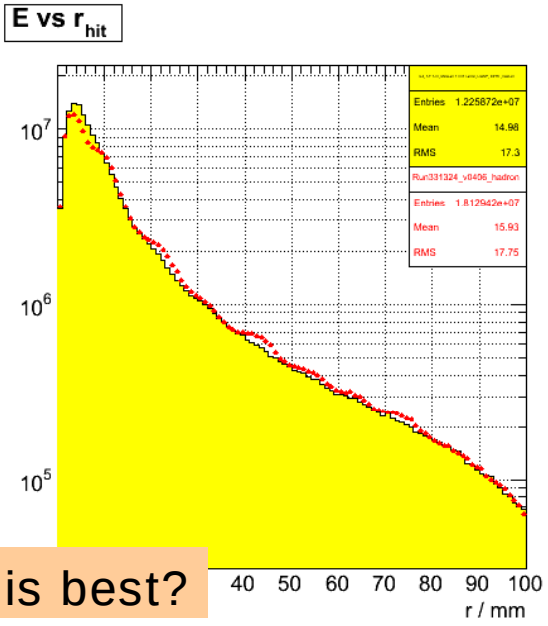






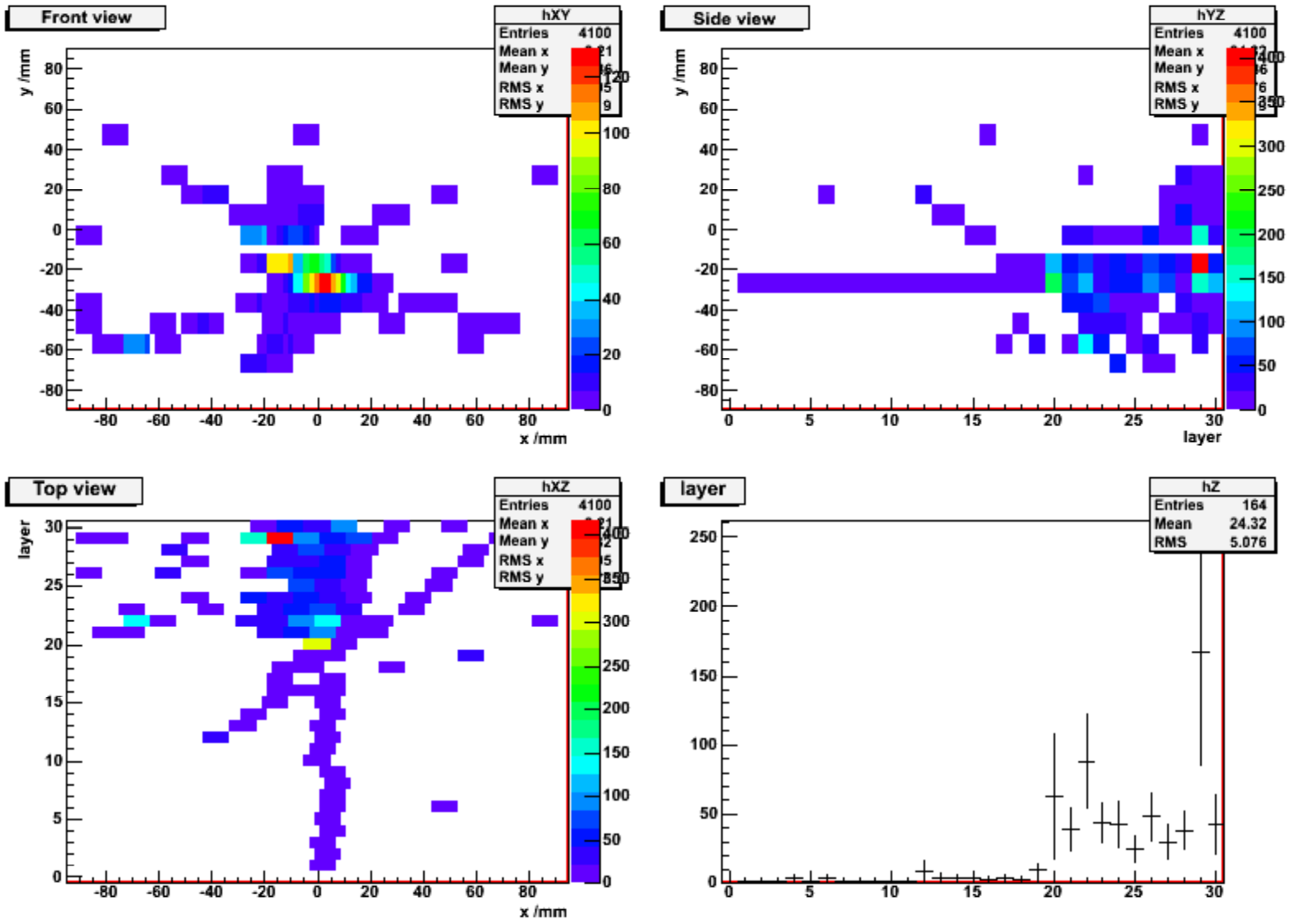






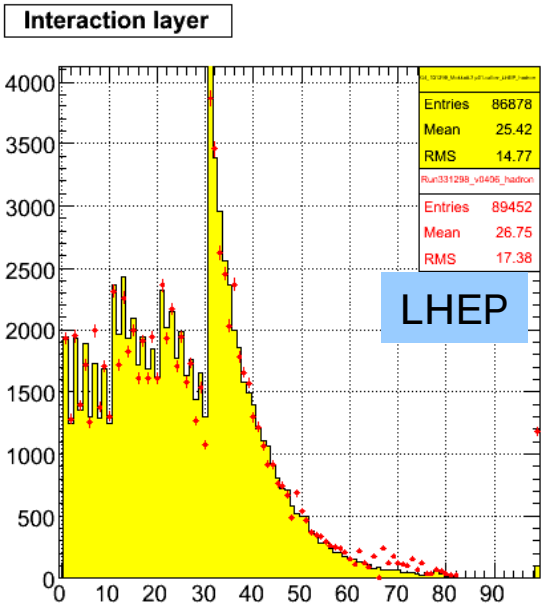
LHEP worst (too narrow) ; QGSP_BERT is best?

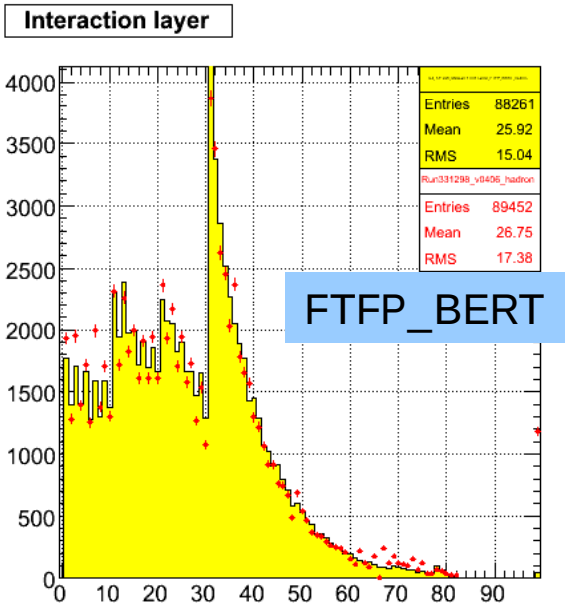
Identify layer of interaction

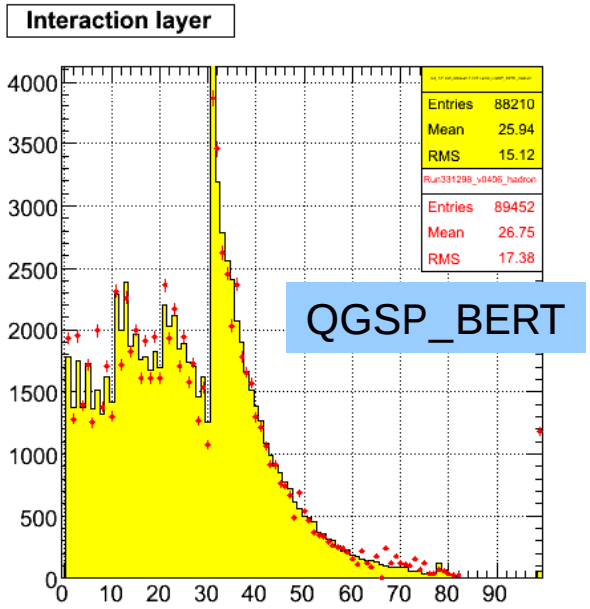


Identify the first layer at which 3 layers out of 4 consecutive layers >10MIPs

Interaction layer 30 GeV

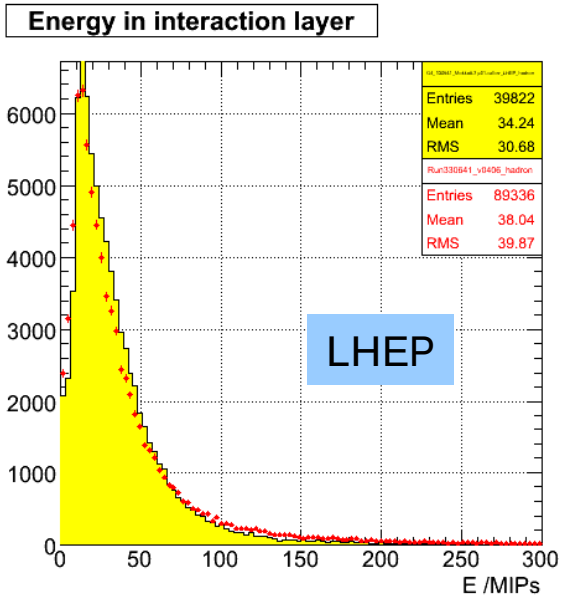


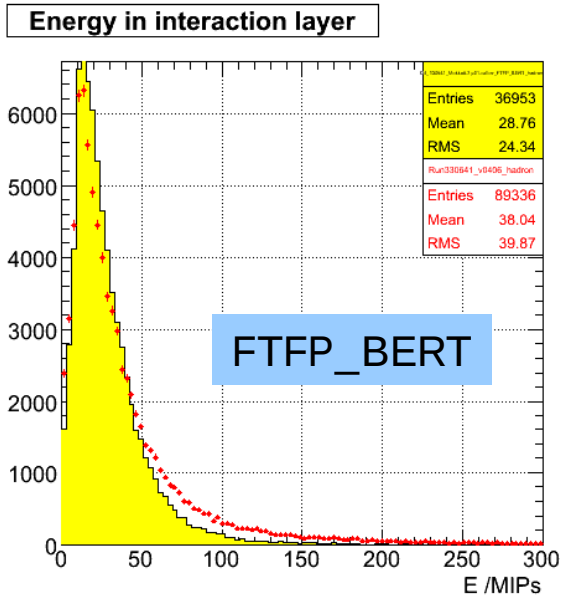


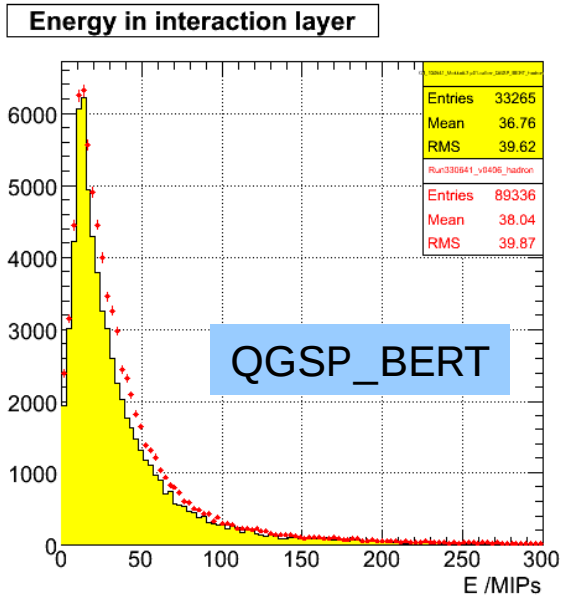


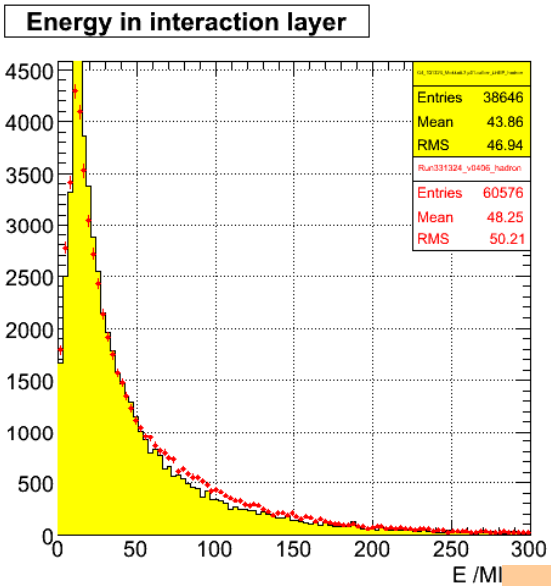
Seems to be well modelled ∀ physics lists and energies
Basically a test of cross-sections and correctness of the gross material modelling

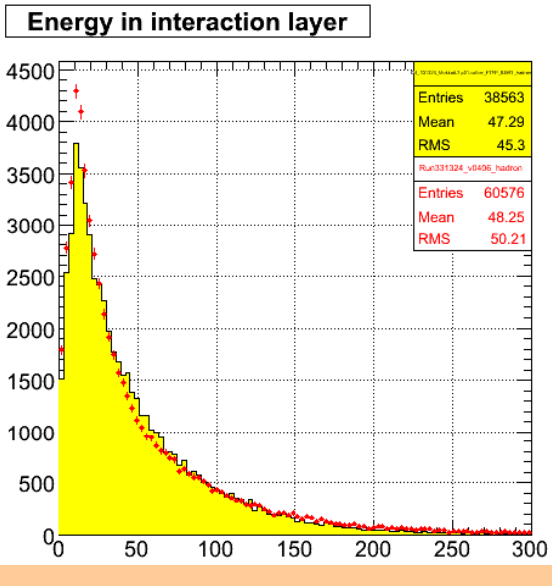
Energy in interaction layer: 8 and 80 GeV

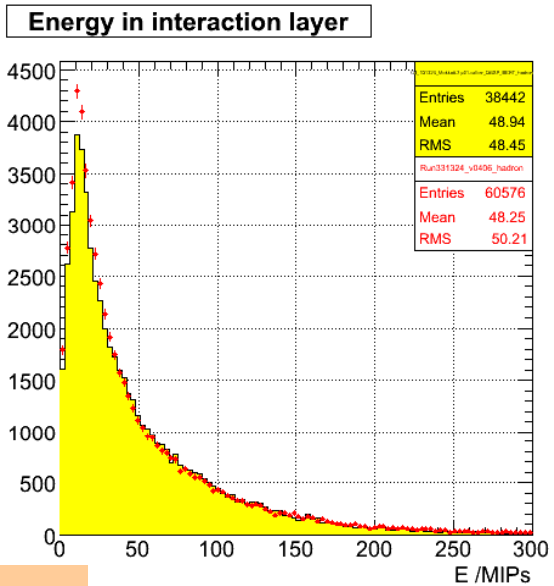






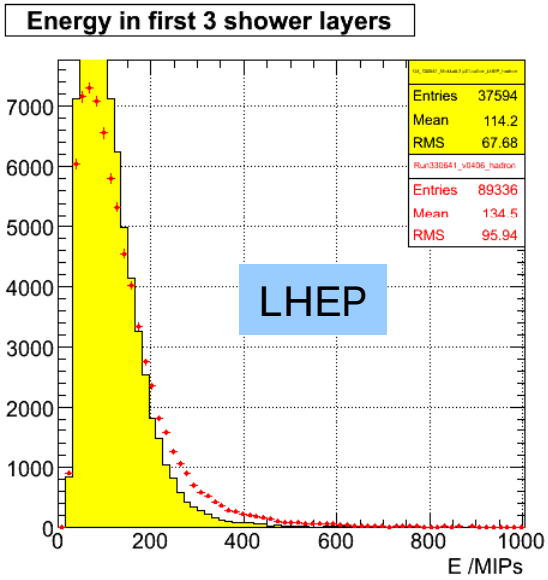


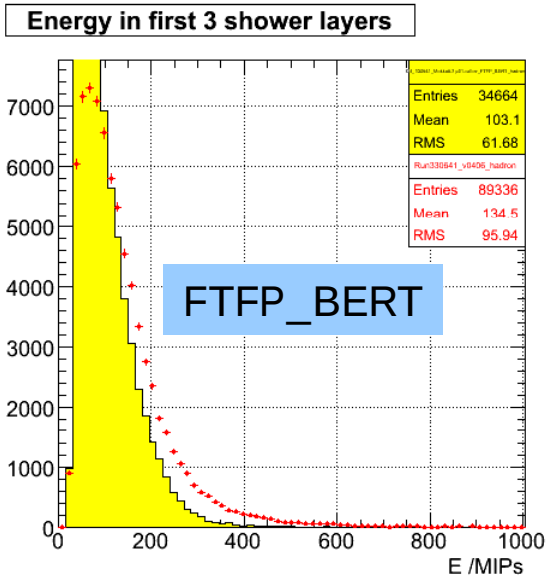


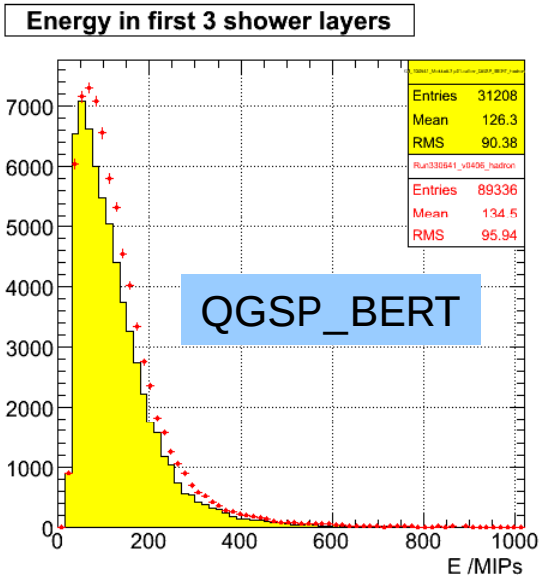


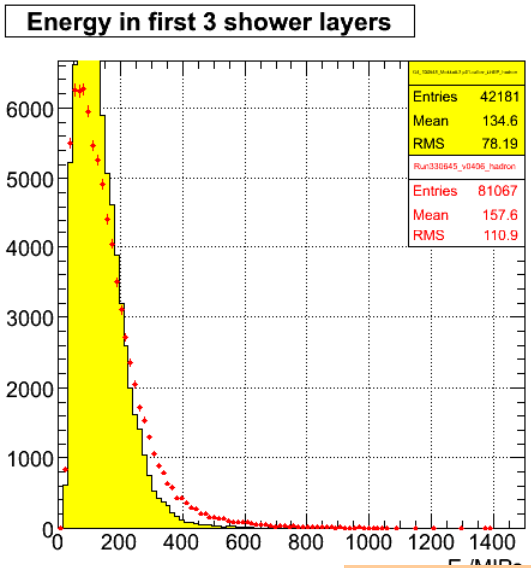
FTFP_BERT not so good @ 8 GeV

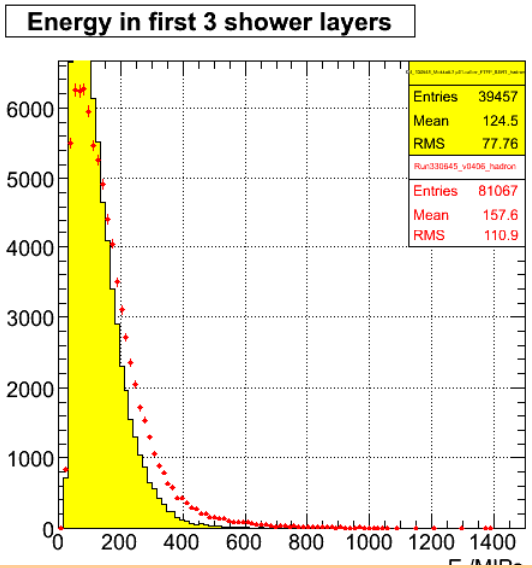
Energy in first 3 shower layers: 8 and 12 GeV

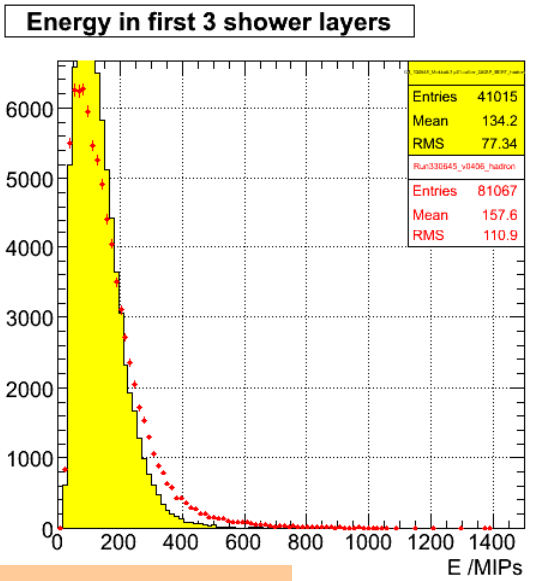






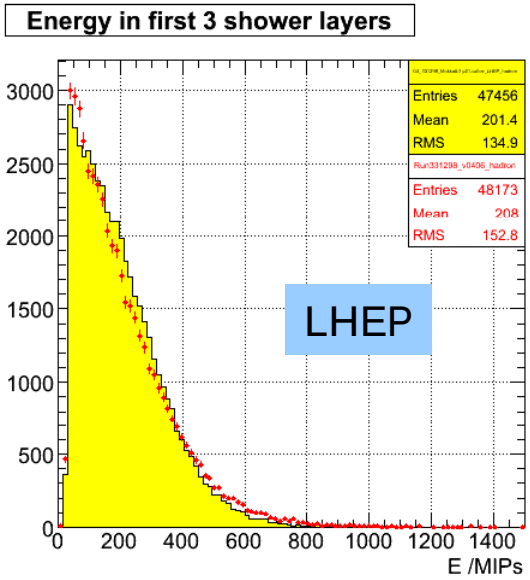


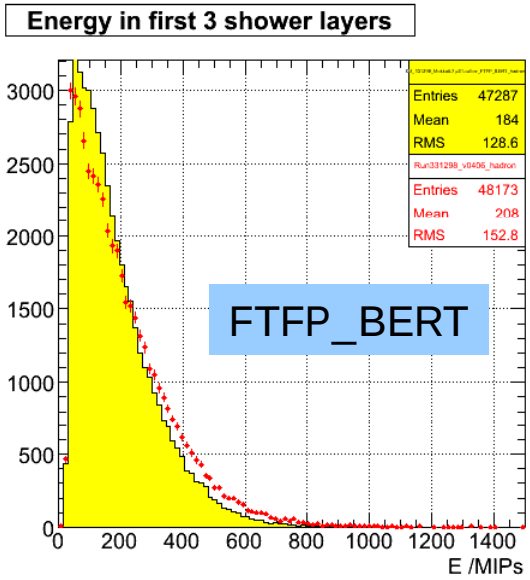


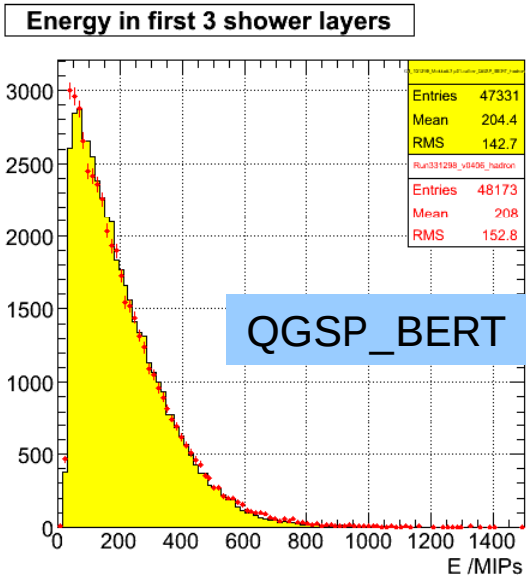


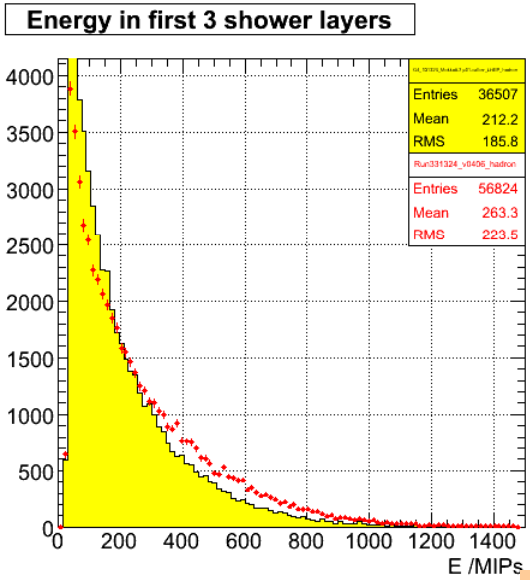
All models lie lower than data; fail to model tail

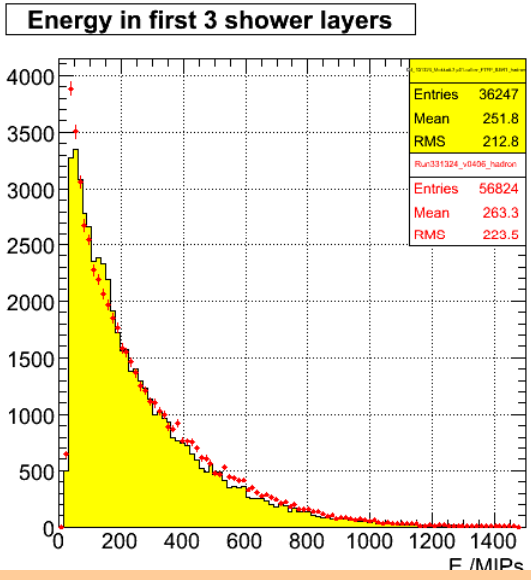
Energy in first 3 shower layers: 30 and 80 GeV

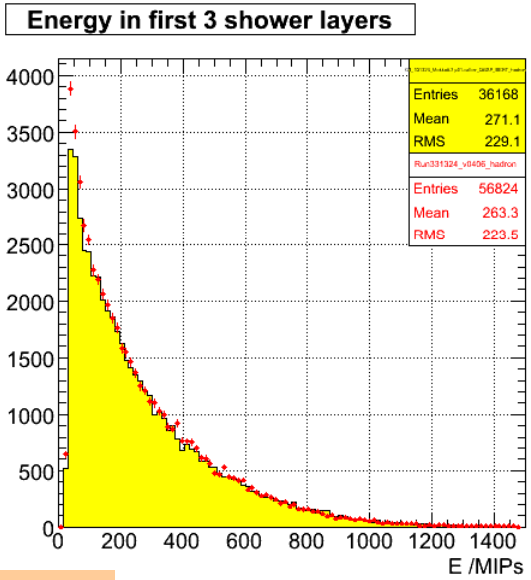












QGSP_BERT best overall for this

Summary

- A lot of information here. Hard to draw firm conclusions.
- The ECAL data do have sensitivity to models, so the study is worth pursuing.
- None of the models is perfect. All have problems at 8-12 GeV. LHEP not too good at higher energies. FTFP_BERT looks an interesting option; is probably the best overall of the models we've been studying.
- Questions to the Geant4 experts:
  - What are the important measurements you would like us to make in order to provide you with useful feedback?
  - What distributions and energies would be best to help us discriminate between models?
  - Should we be trying to produce an improved or tuned physics list for our purposes? Any advice on how we should approach it?