Hadronic showers in the SiW ECAL (with 2008 FNAL data)

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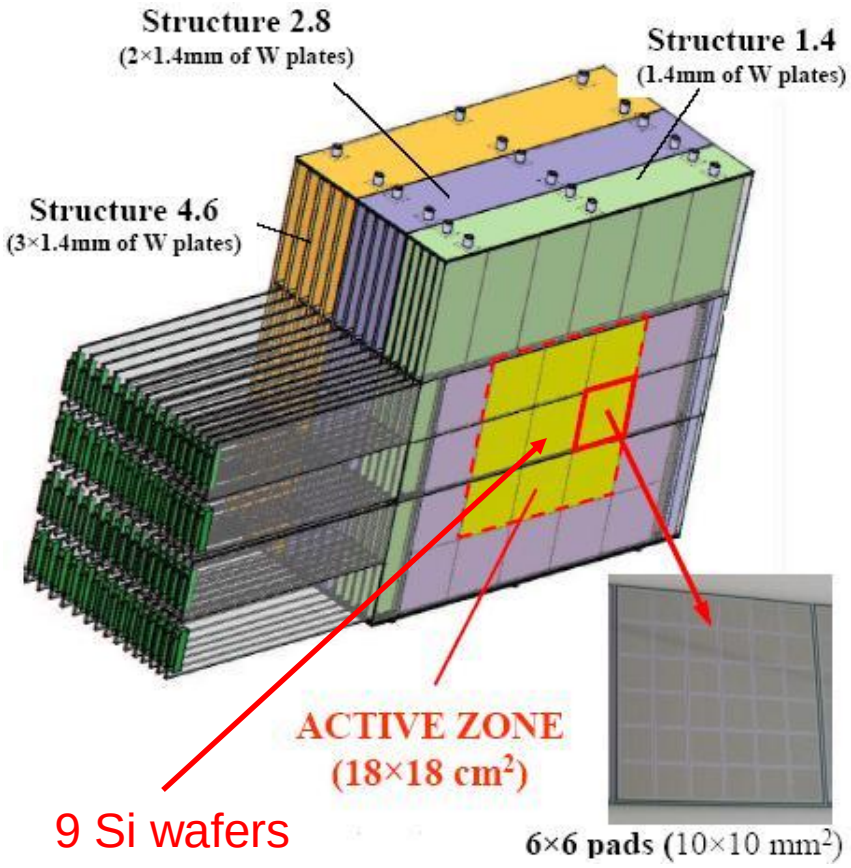
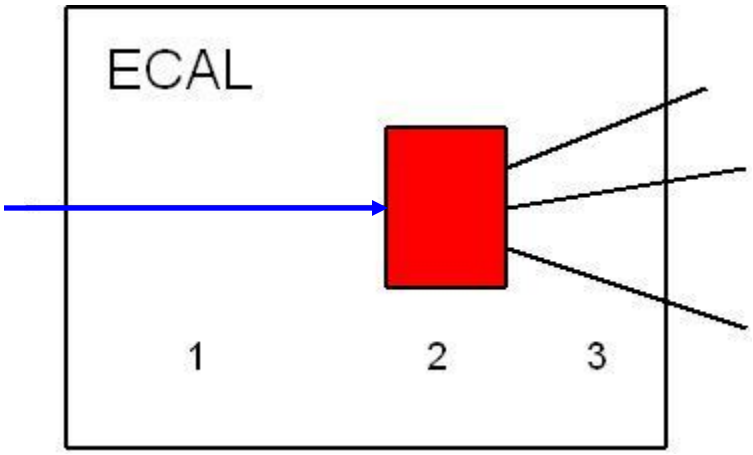
Introduction

- 2008 FNAL data used
  - Pions of 2, 4, 6, 8 and 10 GeV
  - Cuts on scintillator and Cherekov counters
- The SiW ECAL
  - ~1λ_I: ½ of the hadrons interact
  - 1x1 cm² pixels: tracking possibilities
  - 30 layers with 3 different W depths



Procedure

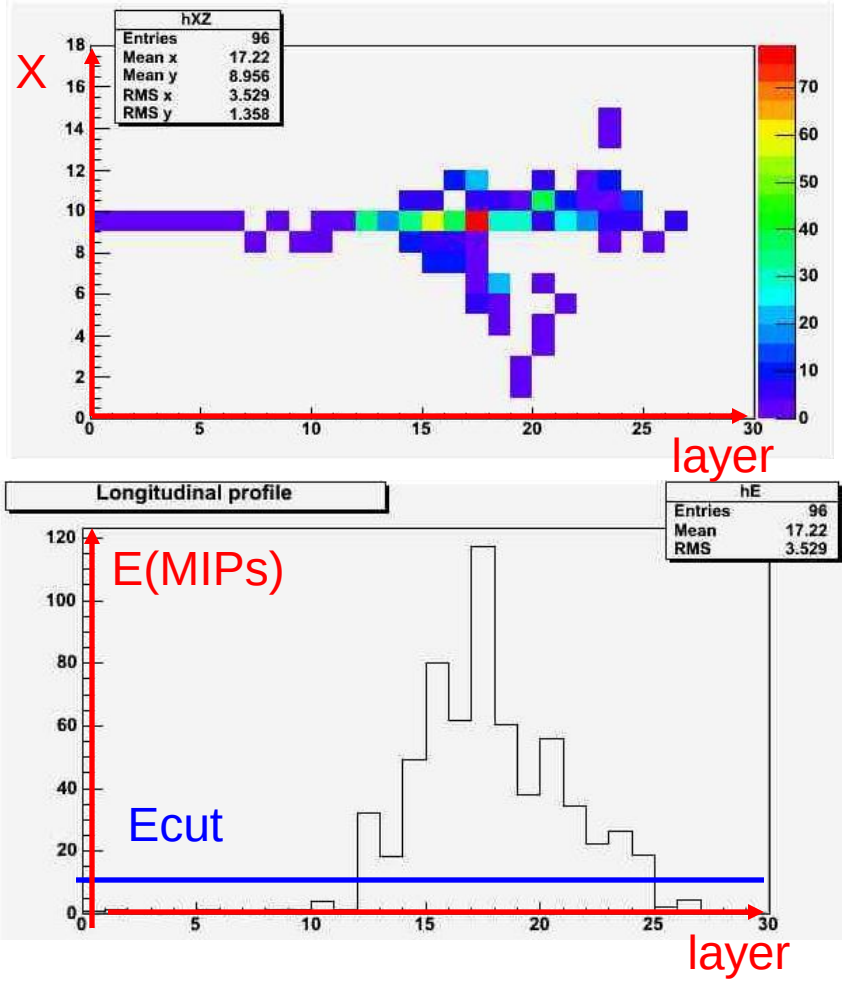


1. Follow the MIP track
2. Find the interaction layer
3. Distinguish the types of interactions

→ At low energies, finding the interaction and its type requires energy deposition and high granularity

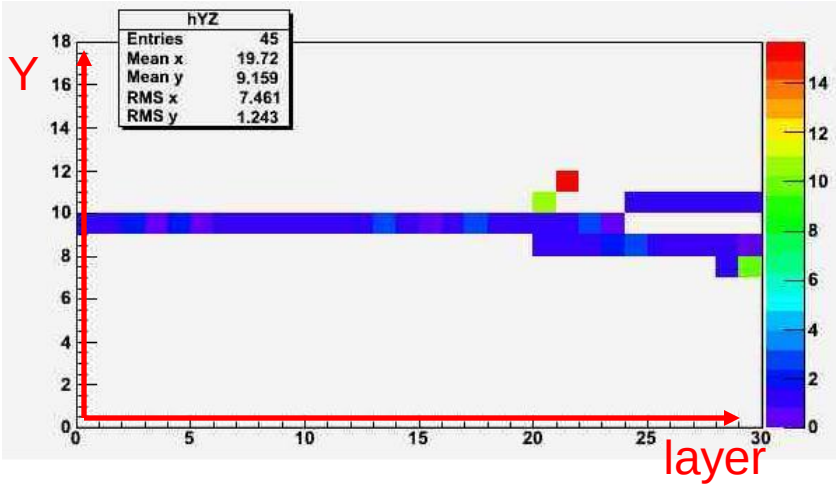
InteractionFinder algorithm 1

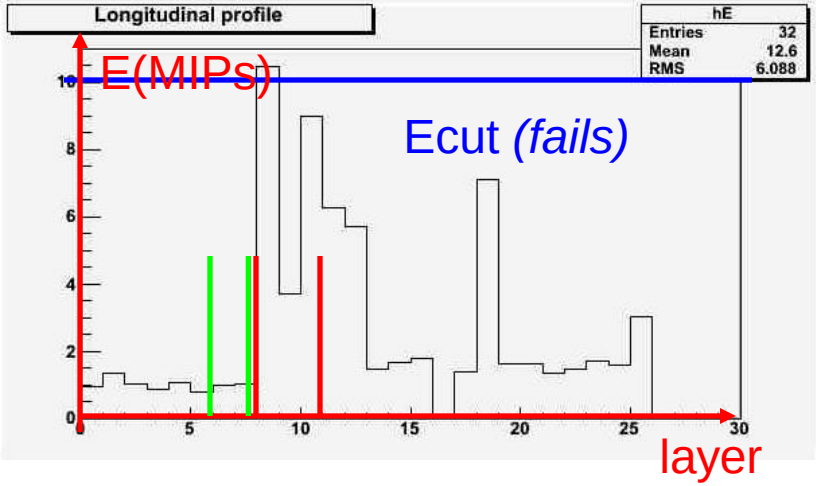
- For « strong » interactions
  - E_i, E_{i+1}, E_{i+2} > Ecut
  - Very simple and works very well at energies ~10 GeV
  - Does not really need high granularity but longitudinal segmentation helps



InteractionFinder algorithm 2

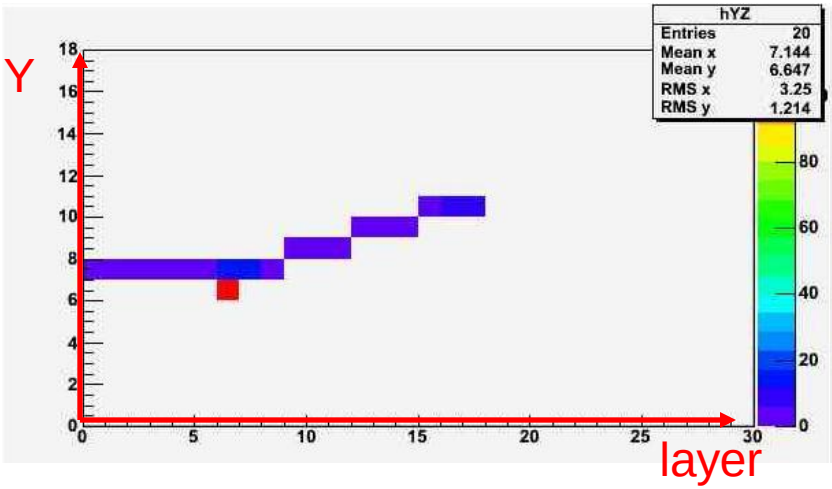
- For « weak » interactions
  - First criteria not satisfying (fails a lot when energy decreases)
  - Use the relative increase of energy:
    - $(E_i+E_{i+1})/(E_{i-1}+E_{i-2}) > Fcut$
    - $(E_{i+1}+E_{i+2})/(E_{i-1}+E_{i-2}) > Fcut$
  - Requires 5 layers: 2 before, 3 after (longitudinal segmentation)

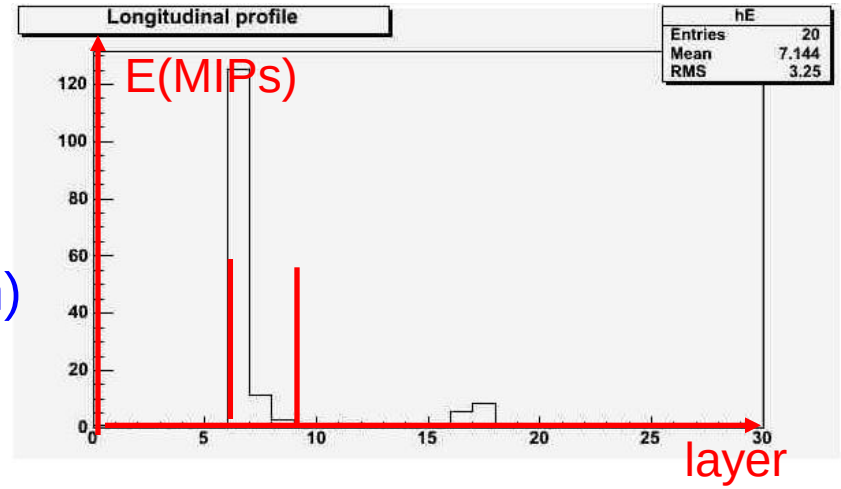




InteractionFinder algorithm 3

- Introduce classification:
  - Strong: « FireBall » class
  - Weak: 2 cases
    1. If $E_i^{\text{MIP-track neighbours}} / E_i > 0.5$ (prevents backscattering) Then « FireBall » class (transverse segmentation)
    2. If $(E_{i+2}+E_{i+3})/(E_{i-1}+E_{i-2}) < \text{Fcut}$ (it was a local increase) Then « Peak » or « Pointlike » class (longitudinal segmentation)
  - If nothing, then « MIP » class

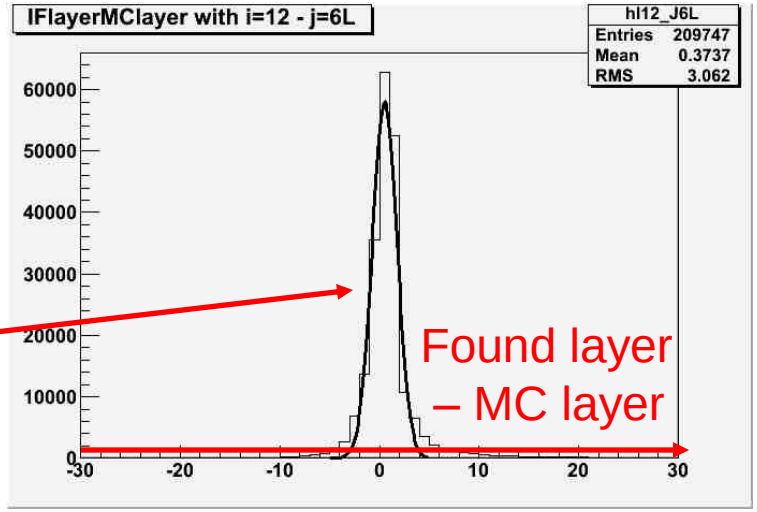


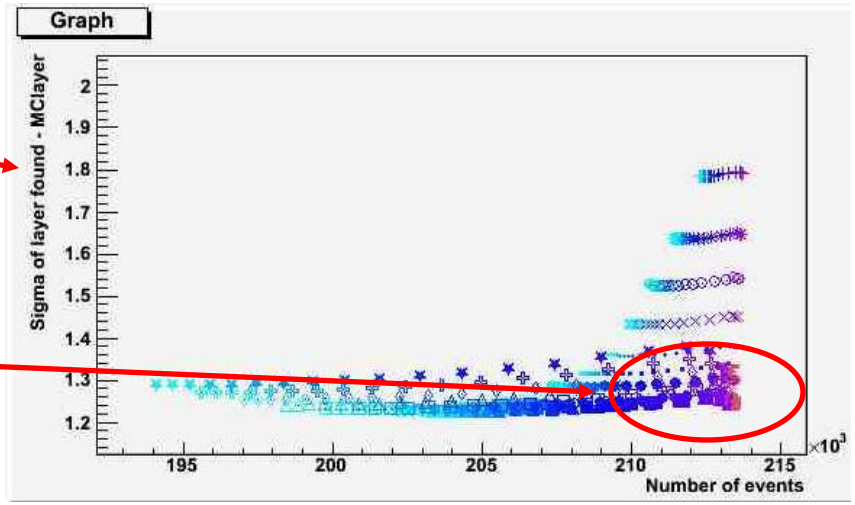


Pointlike interaction: πp scattering

Optimising Ecut and Fcut

1. Try interaction conditions for each event for a set of {Ecut,Fcut}
2. Fit the difference layer found – MC → get σ and N (number of interactions found)
3. Trace for all combinations σ vs N
4. Get the best combination to get a small σ and a high N





After optimisation

- We care about the interactions found within +/- 1 layer (+/- 2 layers) w.r.t. the interaction layer in the MC

	+/- 1 layer	+/- 2 layers
2 GeV	56%	67%
4 GeV	60%	73%
6 GeV	62%	76%
8 GeV	64%	78%
10 GeV	72%	84%

David Ward's results down to 8 GeV:

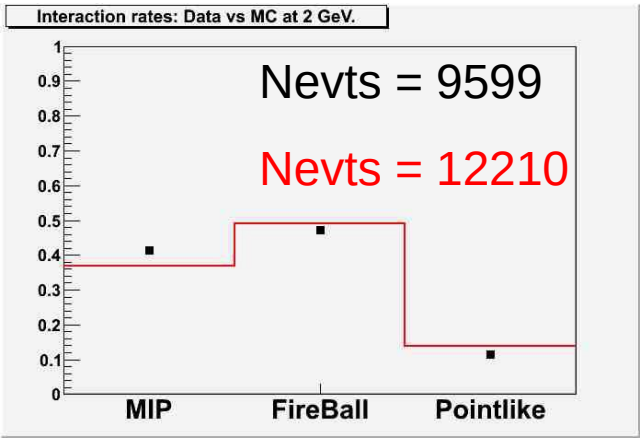
~70% inside +/- 1 layer

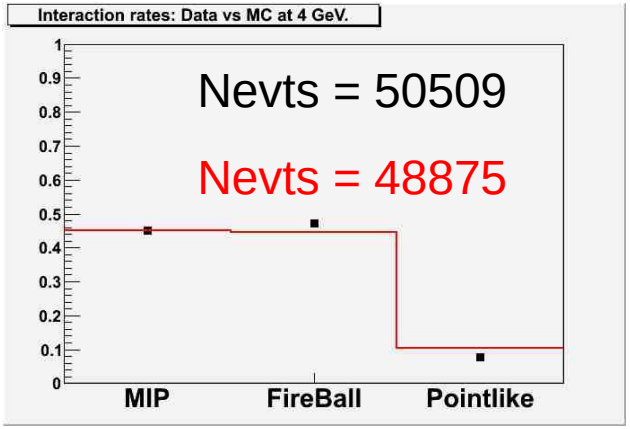
90% inside +/- 2 layers

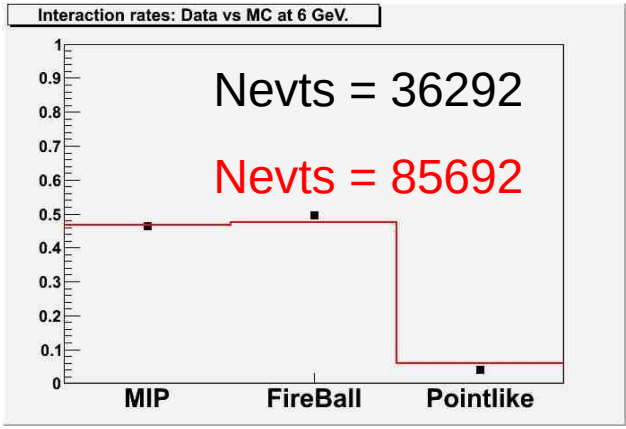
(Ecut criteria made a bit more complex: 3 out of 4 layers must satisfy cut)

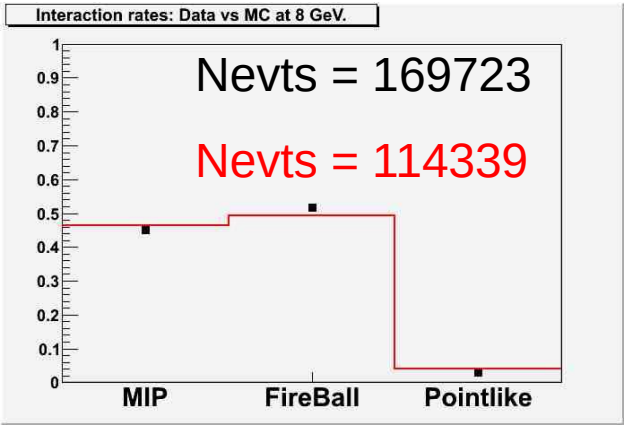
Rates of interaction from 2 to 10 GeV: data vs MC (QGSP BERT)

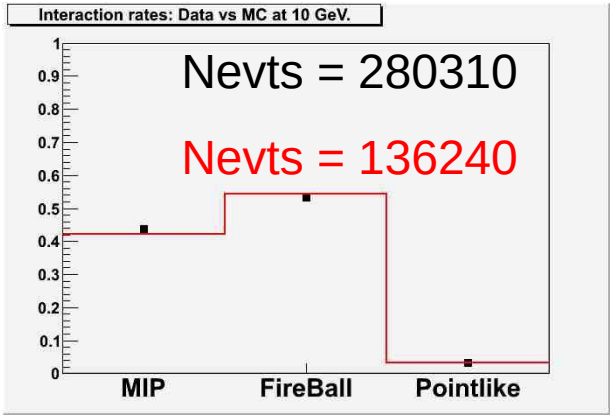
- After optimisation of Ecut and Fcut for each energy











Good agreement between data and MC

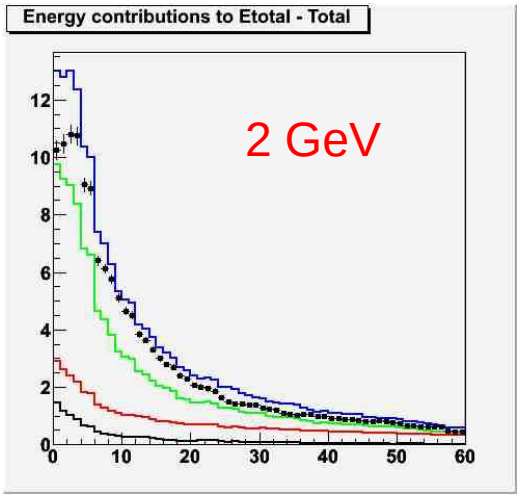
Data reconstruction and MC digitisation are official releases

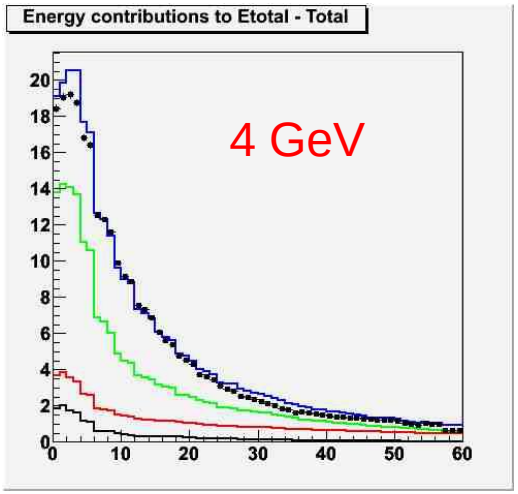
A look at longitudinal and transverse profiles

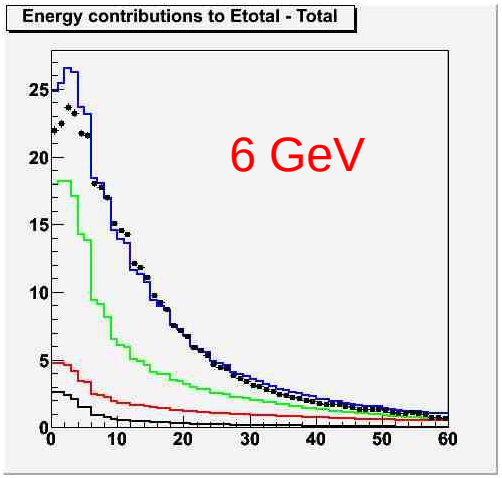
- Longitudinal profiles are drawn with 60 layers equivalent to those in the first stack (i.e. one layer in stack 2 is divided in 2 layers and one layer in stack 3 is divided in 3 layers)

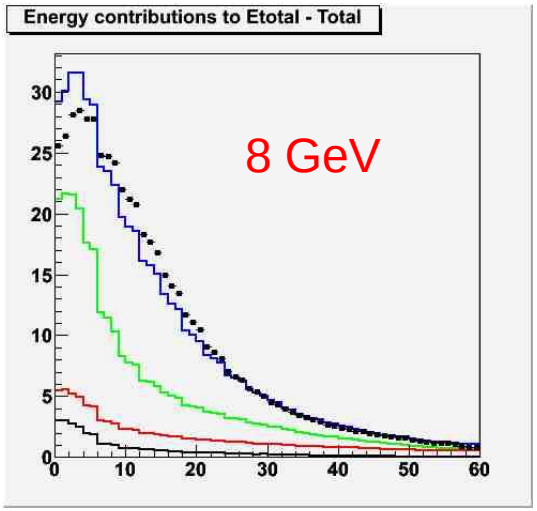
- Transverse size is calculated from the interaction point and weighted by the energy

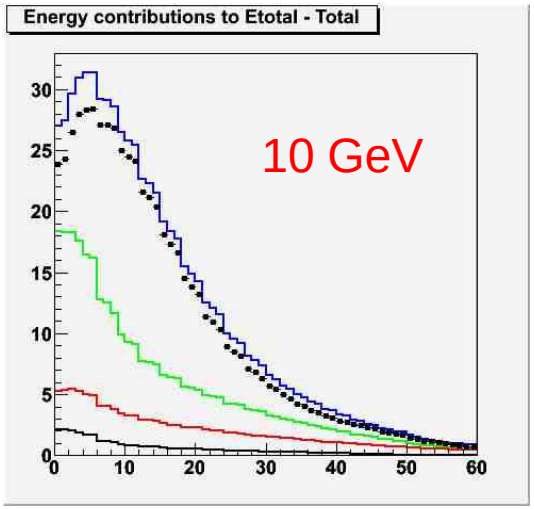
Total longitudinal profiles: data vs MC (with shower structure)











Reasonable agreement is found

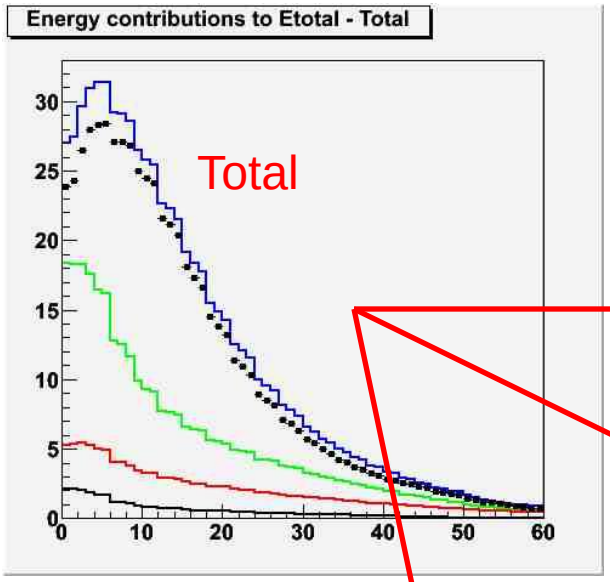
Blue = electrons contributions

Green = protons

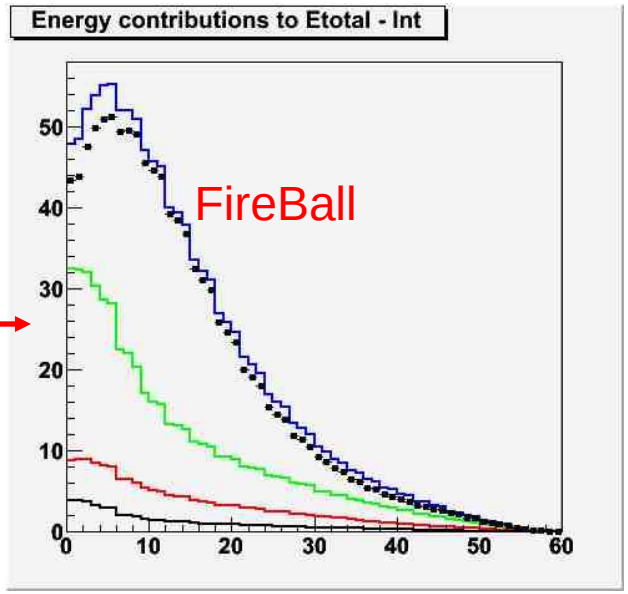
Red = pions

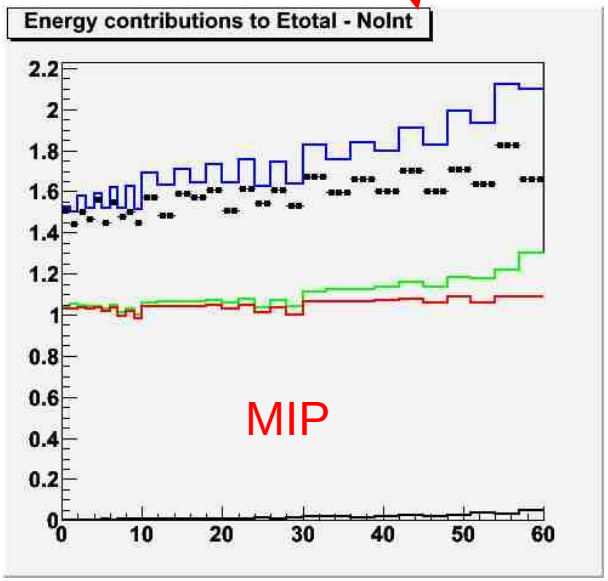
Black = others

Longitudinal profiles sorted by kind



10 GeV

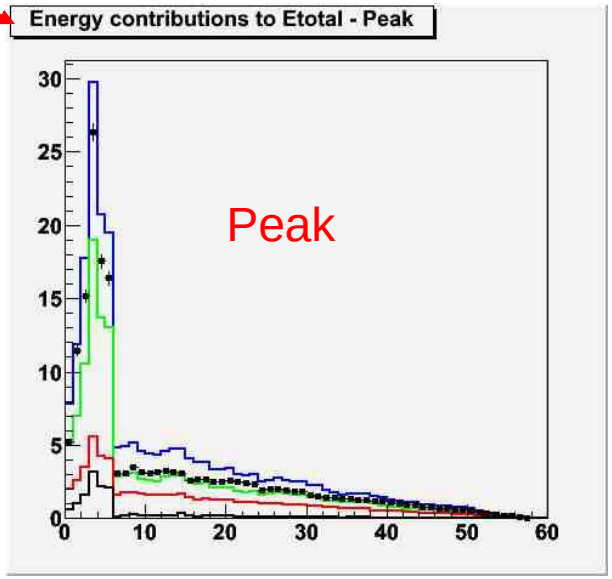




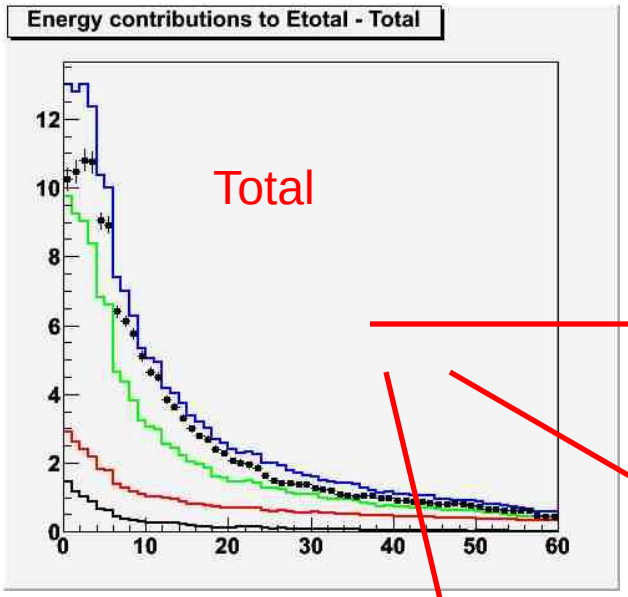
Obvious discrepancy with the MIP energies:

Under investigation

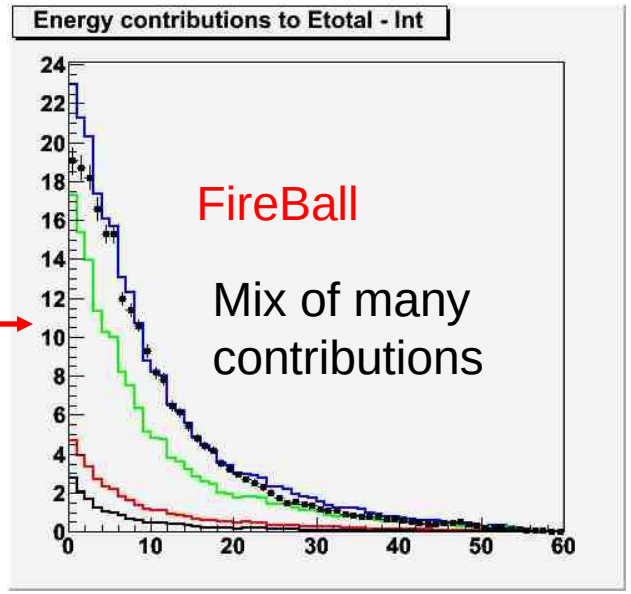
Maybe a problem of conversion MIP→MeV in the official soft

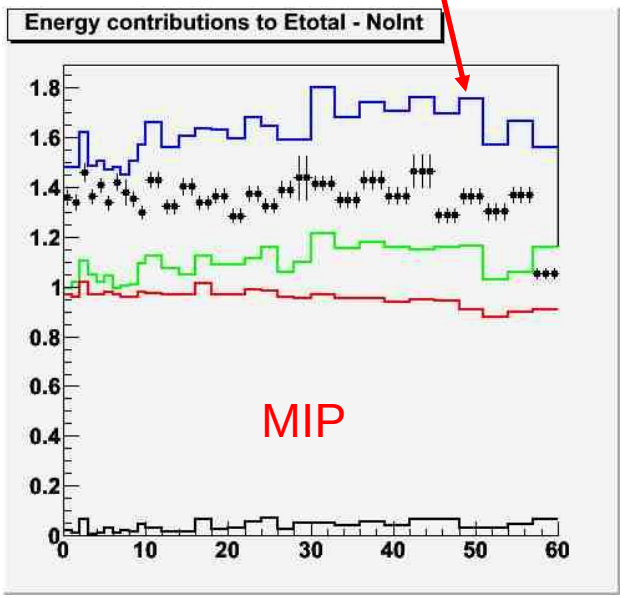


Longitudinal profiles sorted by kind



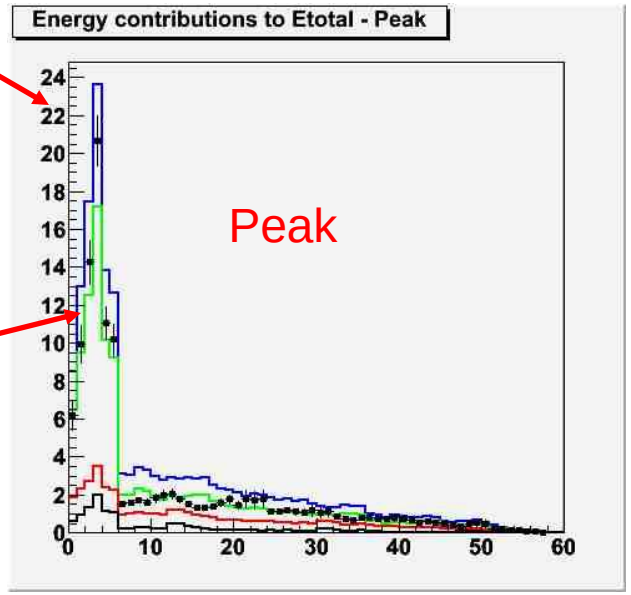
2 GeV



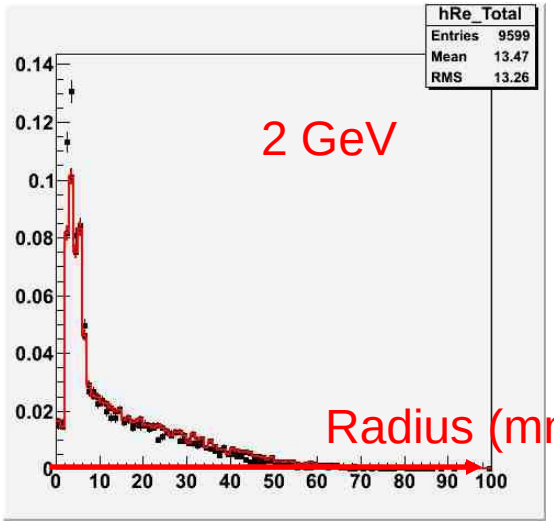


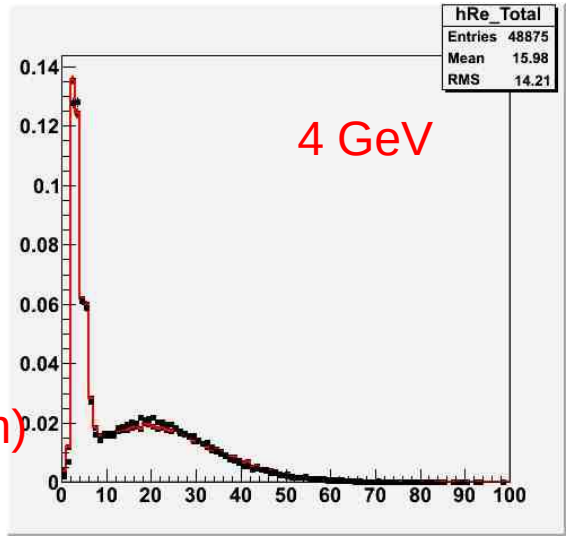
Still a good description at 2 GeV

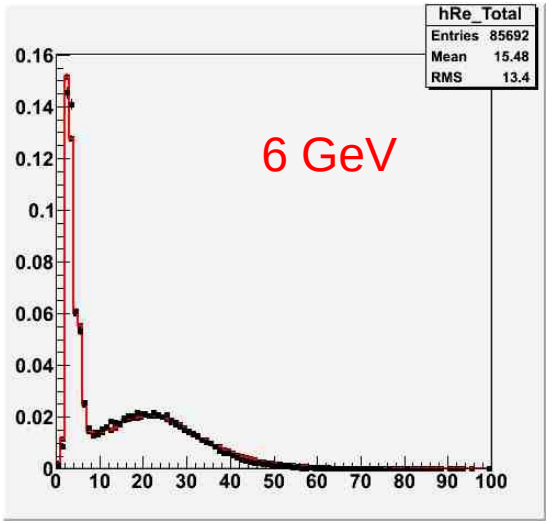
A lot of activity from protons in peak events

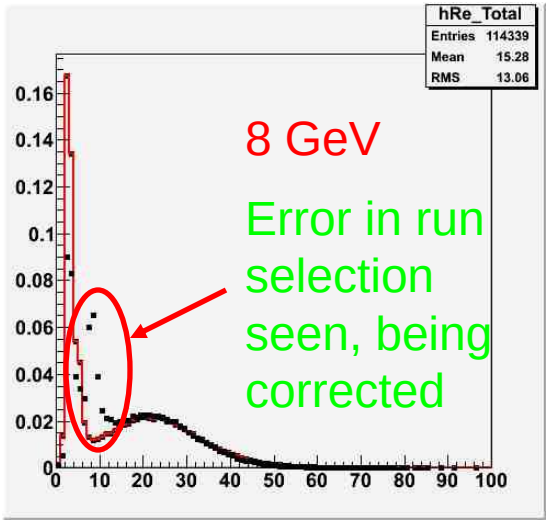


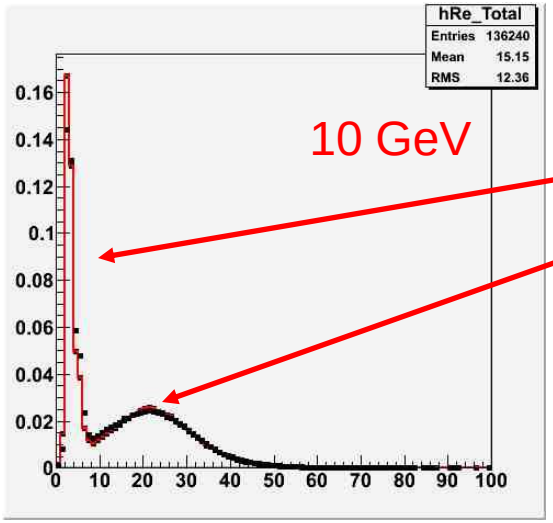
Total transverse profiles: data vs MC (QGSP BERT)







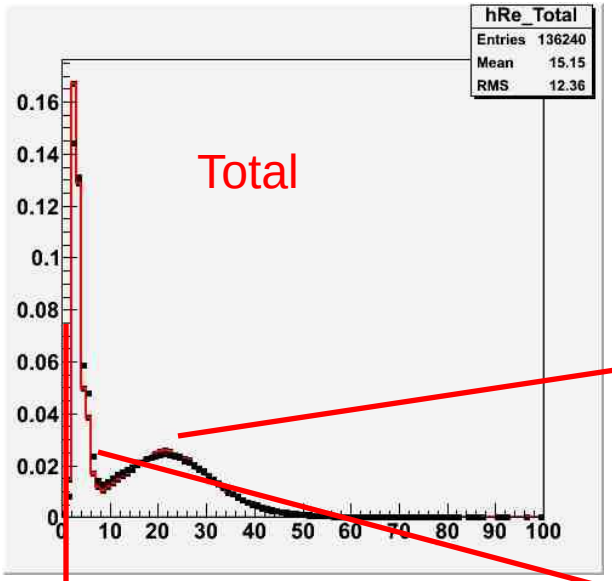




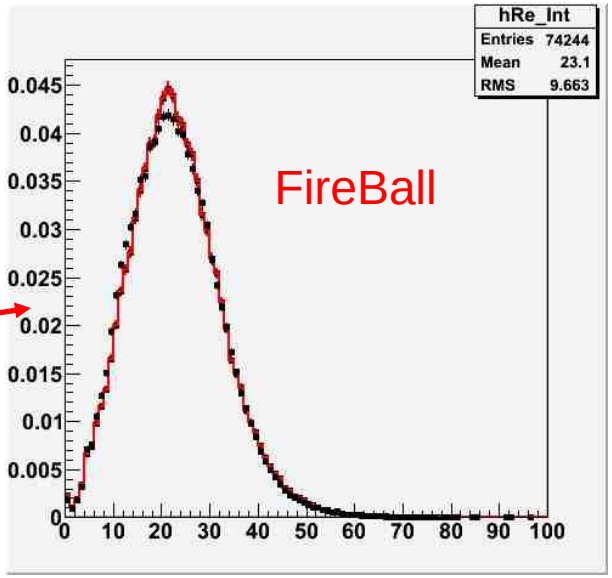
Good agreement:

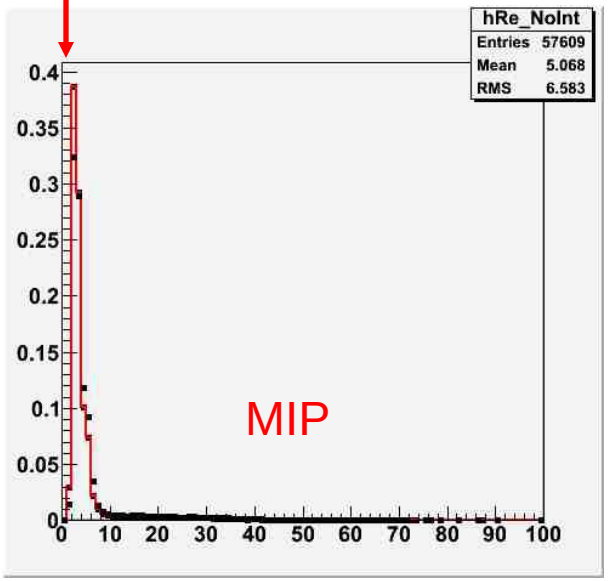
MIP peak and hadron peak clearly well identified

Transverse profiles sorted by kind



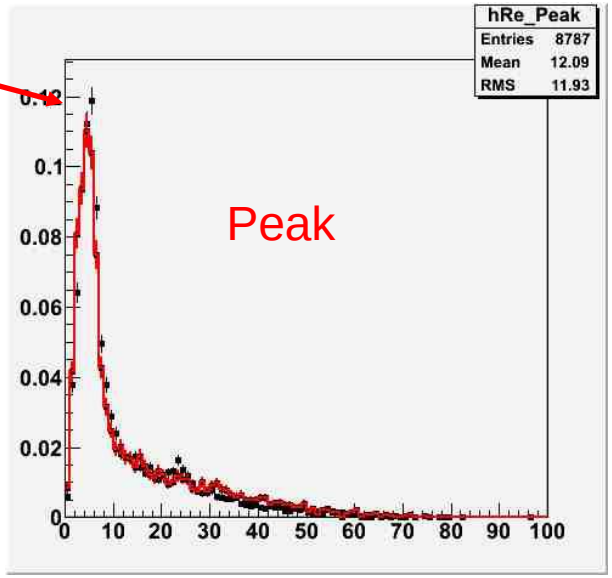
10 GeV



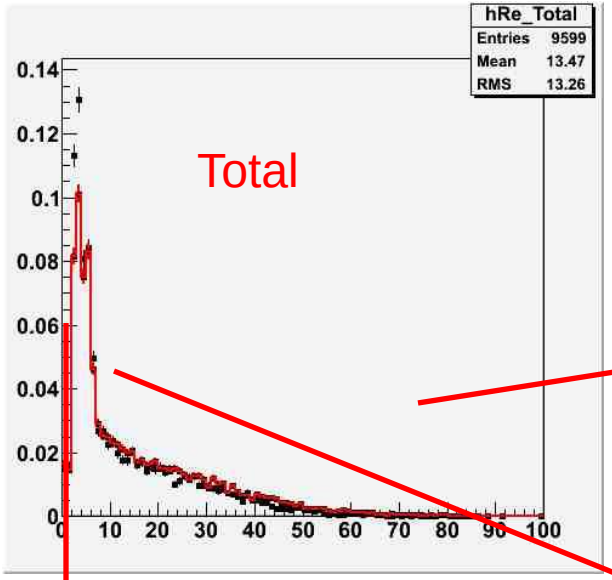


Peaks in the total histogram well separated.

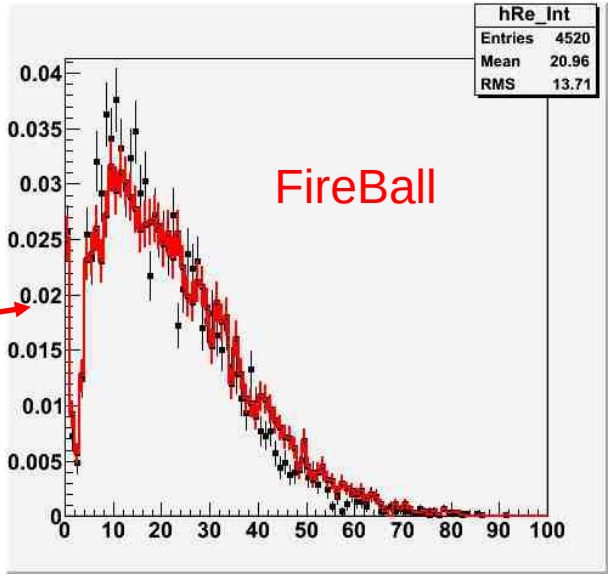
Thanks to granularity « MIP » and « Peak » are distinguished.

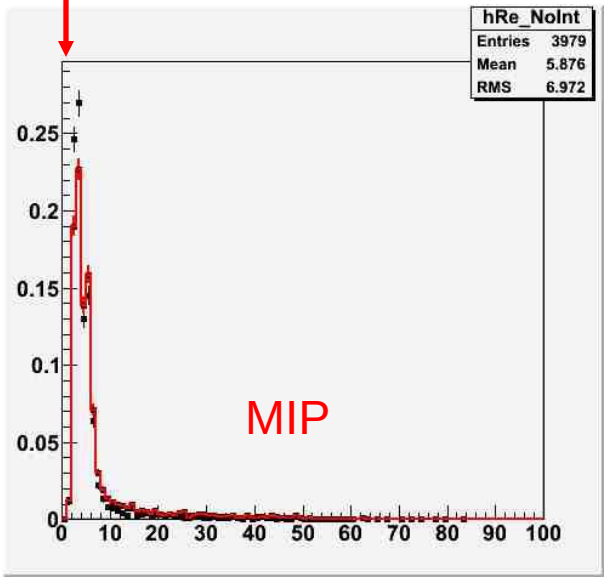


Transverse profiles sorted by kind

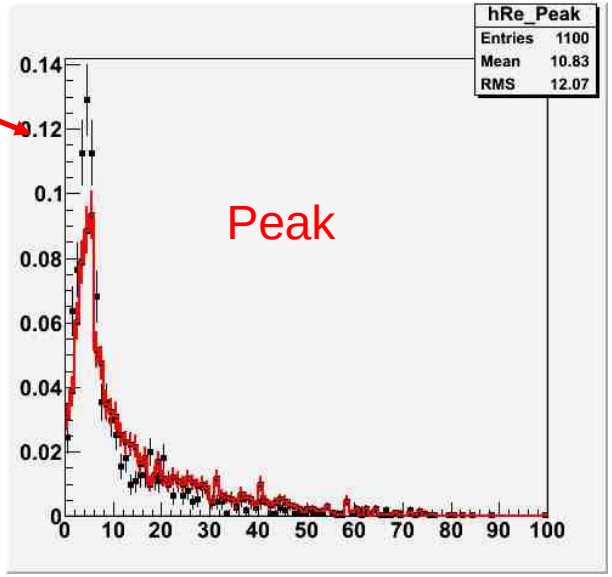


2 GeV



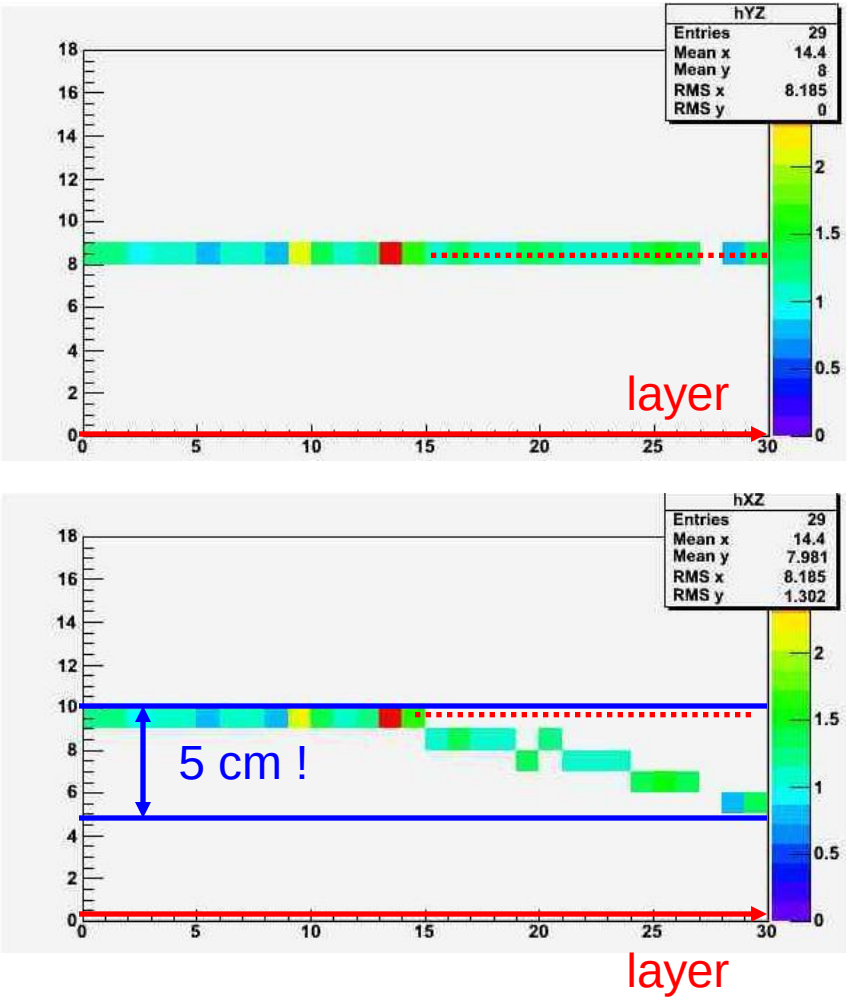


Separation slightly worse but still good at 2 GeV.



Another interesting feature

- « MIP » events contain two kind of events
- They can be separated and classified into REAL MIPs and pion scattering using the extrapolated MIP track (transverse segmentation)
  → development of some particle flow technique seem possible



Conclusion

- We combine energy and high granularity to classify hadronic interactions and even see them clearly
  - The transverse profiles agree very well
  - The longitudinal profiles are slightly higher for MC certainly due to a conversion factor problem
  - The 3 types of interaction allow to separate clearly the profiles and another can even be identified
- Results stable obtained with official releases
- Other physics lists available
- CAN note in preparation to be ready for CALOR2010

Software versions (all official)

- For reconstruction of FNAL runs (done by Alexander Kaplan):
  - Calice_userlib v04-10
  - Calice_reco v04-06
- For digitisation of MC samples (done by Lars Weuste):
  - Calice_userlib v04-10
  - Calice_reco v04-06

→ Same versions