Hadronic interactions in the SiW ECAL (with the 2008 data)

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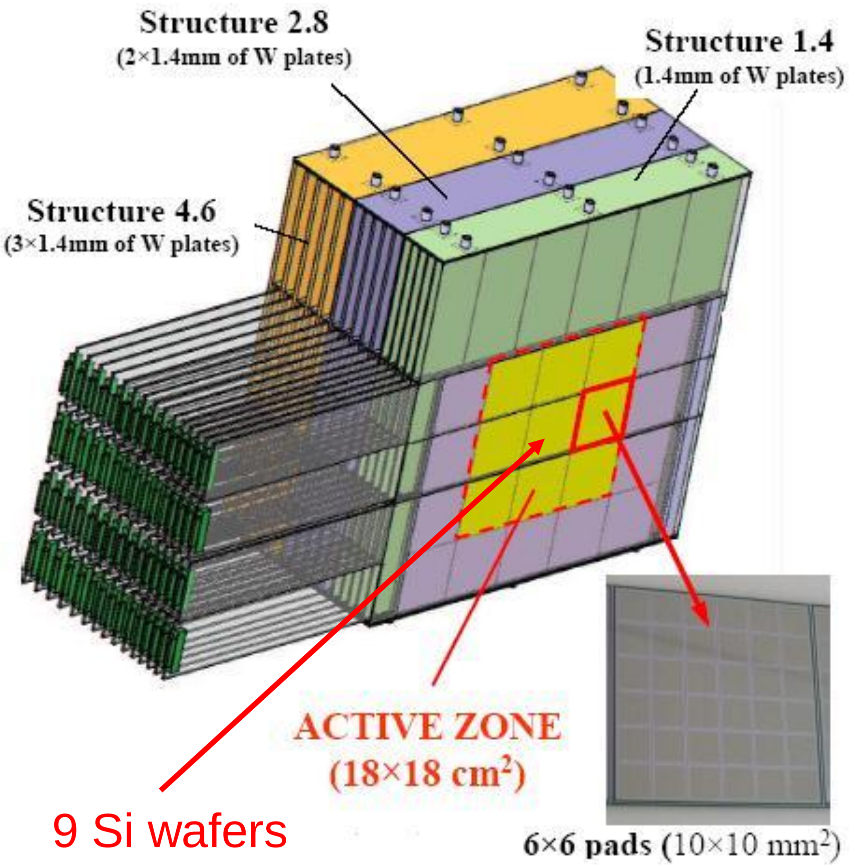
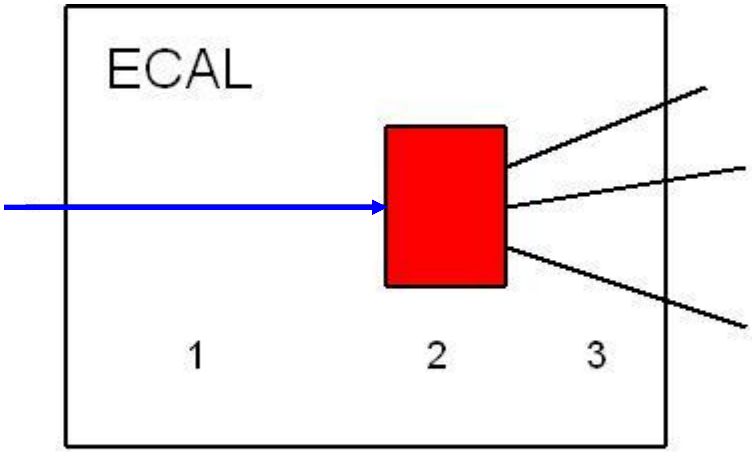
LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

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: more than half of the hadrons interact
  - 1x1 cm² pixels: tracking possibilities
  - 30 layers with 3 different W depths



Procedure



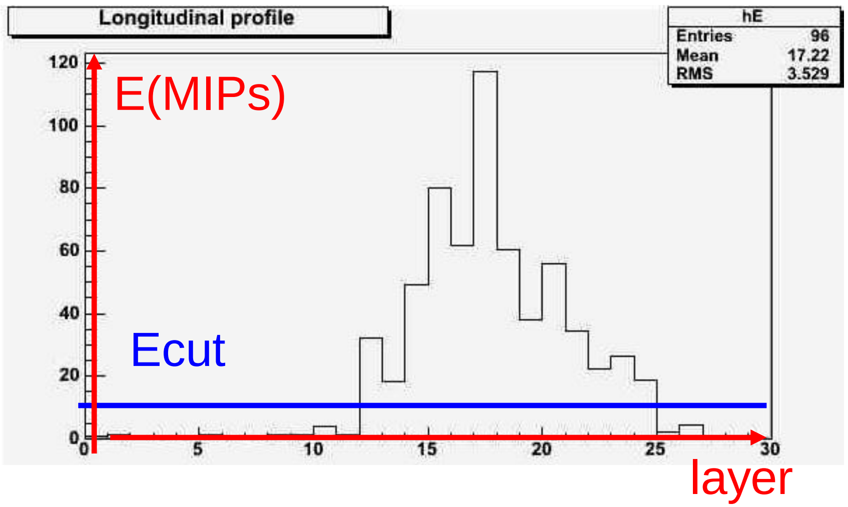
1. Follow the MIP track
2. Find the interaction layer
3. Distinguish the types of interactions

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

Finding an interaction

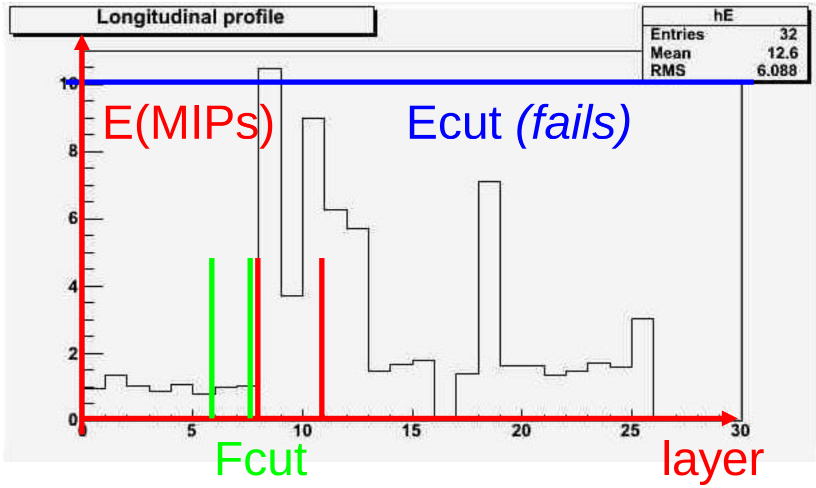
- Looking at the energy profile in the ECAL
  1. For « strong » interactions

$$E_i > \mathrm{Ecut}\ ,\ E_{i+1} > \mathrm{Ecut}\ ,\ E_{i+2} > \mathrm{Ecut}$$



  2. For interactions at smaller energies

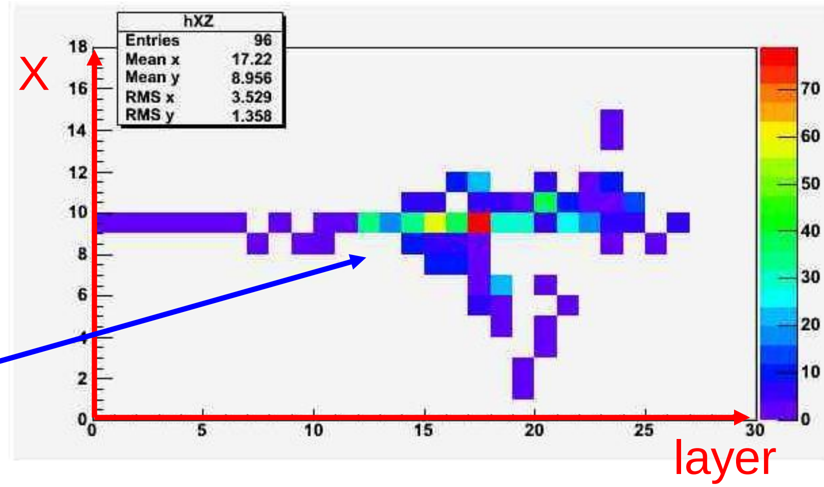
$$\frac{E_i + E_{i+1}}{E_{i-1} + E_{i-2}} > \mathrm{Fcut\ and}\ \frac{E_{i+1} + E_{i+2}}{E_{i-1} + E_{i-2}} > \mathrm{Fcut}$$



– Plus classification

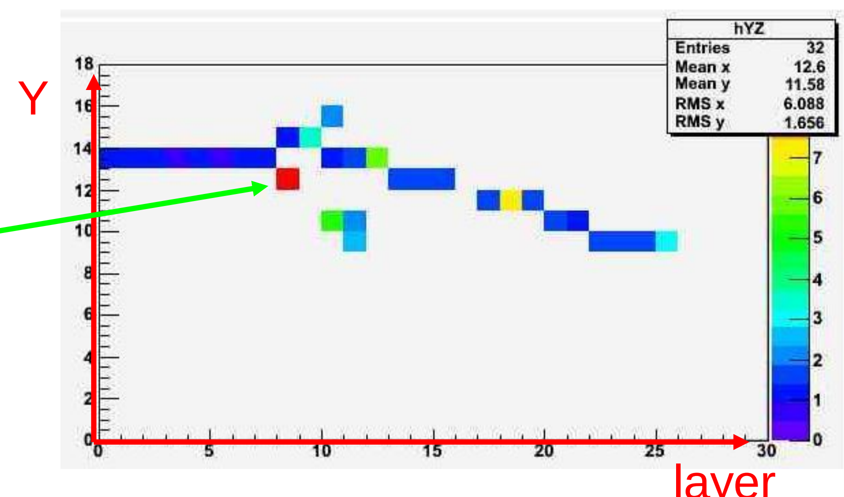
First type: « FireBall »

- For inelastic scattering
  - High energy deposition at rather high energies (Ecut) 10 GeV here



$$E_i > \mathrm{Ecut}\ ,\ E_{i+1} > \mathrm{Ecut}\ ,\ E_{i+2} > \mathrm{Ecut}$$

  - Or relative energy increase at smaller energies (Fcut) 2 GeV here

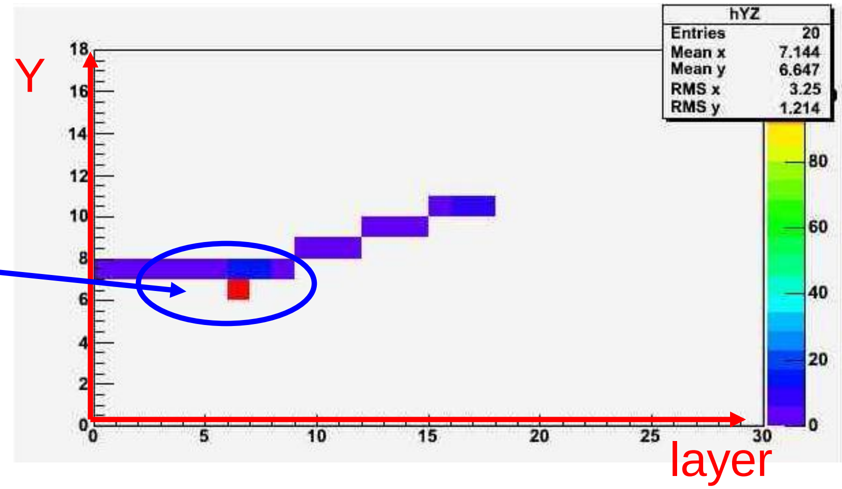


$$\frac{E_{i+2} + E_{i+3}}{E_{i-1} + E_{i-2}} > \mathrm{Fcut} \quad + \quad \frac{E_{\mathrm{around},i}}{E_i} > 0.5$$

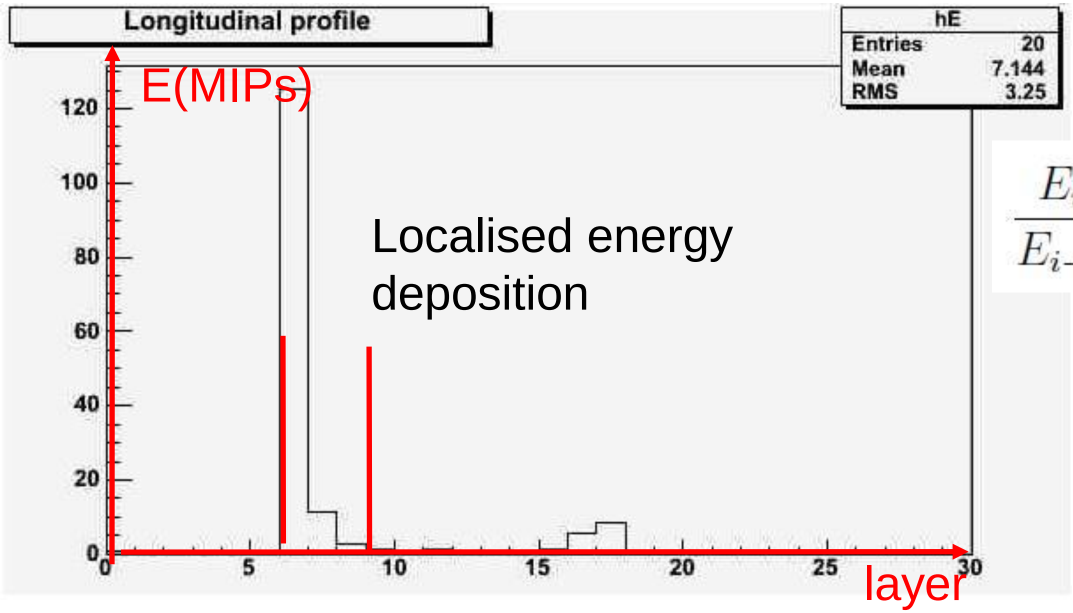
Near the track

Second type: « Pointlike »

- For spallation reaction
  - Local relatively large energy deposition



Pointlike interaction: πp scattering

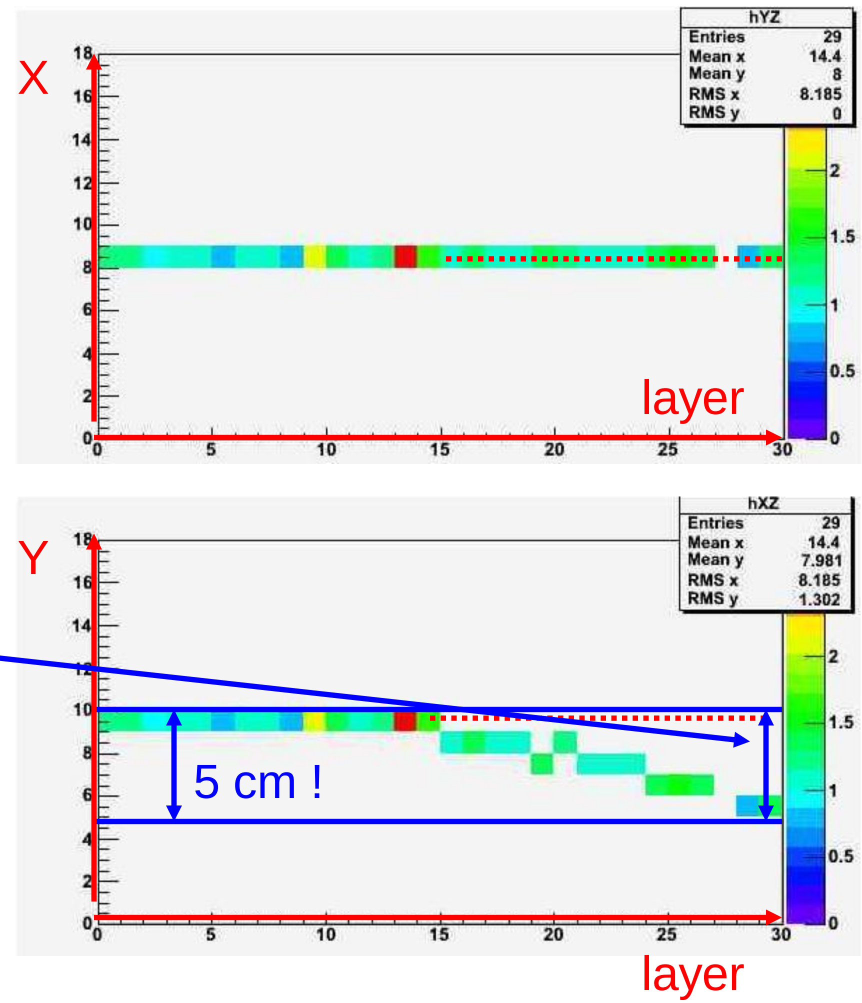


$$\frac{E_i + E_{i+1}}{E_{i-1} + E_{i-2}} > \text{Fcut and } \frac{E_{i+1} + E_{i+2}}{E_{i-1} + E_{i-2}} > \text{Fcut}$$

$$+ \quad \frac{E_{i+2} + E_{i+3}}{E_{i-1} + E_{i-2}} < \text{Fcut}$$

New type introduced: « Scattered »

- Other non interacting events contain two kind of events
  - Type « Scattered »: pion scattering using the extrapolated incoming MIP and last outgoing hit 2 cells away or more
    → Interesting for Pflow !
  - Type « MIP »

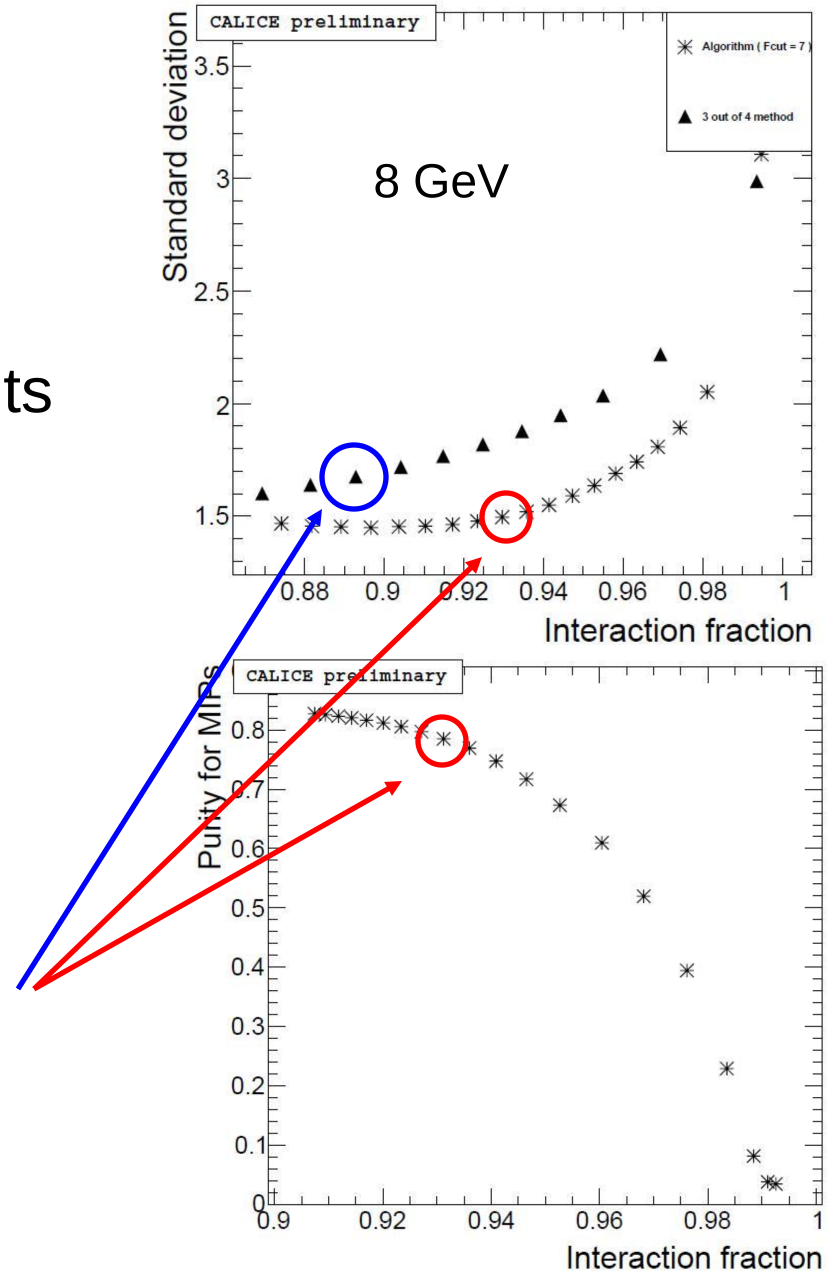


Optimisation of the cuts (using MC)

3 parameters used:

- Standard deviation of the distribution « layer found – true »
- Interaction fraction = events found / events with an interaction
- Purity with non interacting events = events with no interaction found / events with no interaction

- Compromise between those 3 and comparison with David’s method



After optimisation

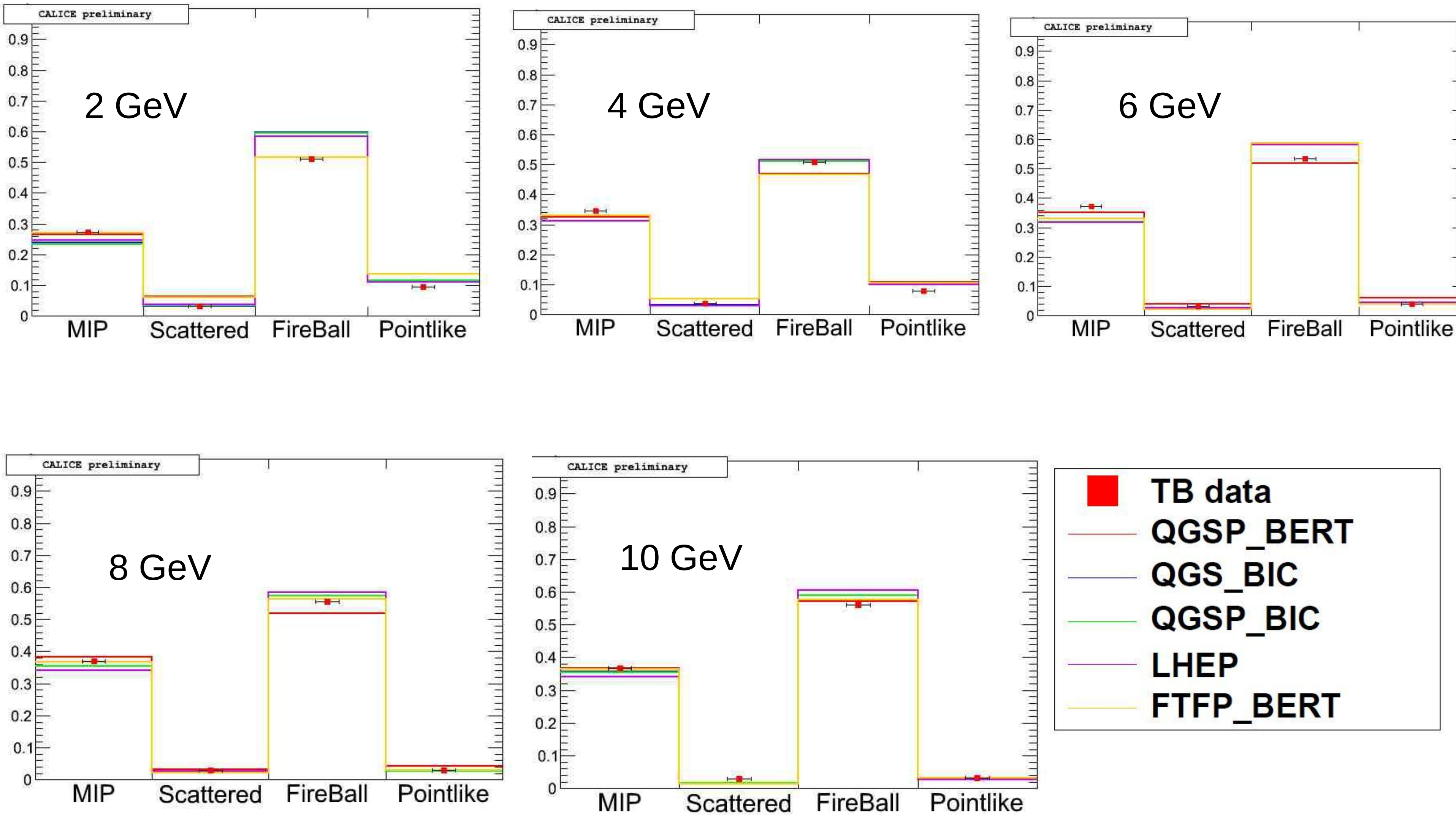
- We care about the interactions found within +/- 1 layer (+/- 2 layers) w.r.t. the interaction layer in the MC

	+/- 1 layer	+/- 2	David +/- 2
2 GeV	56%	67%	28%
4 GeV	60%	73%	61%
6 GeV	62%	76%	69%
8 GeV	64%	78%	71%
10 GeV	72%	84%	76%

David Ward's results:

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 (5 lists)



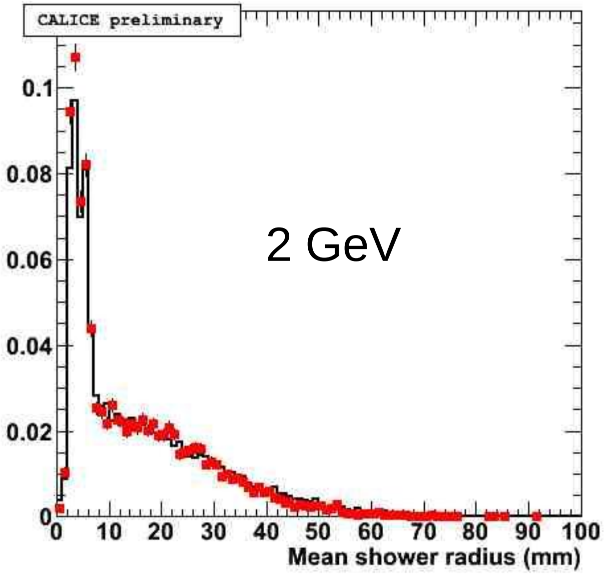
Mean shower radius

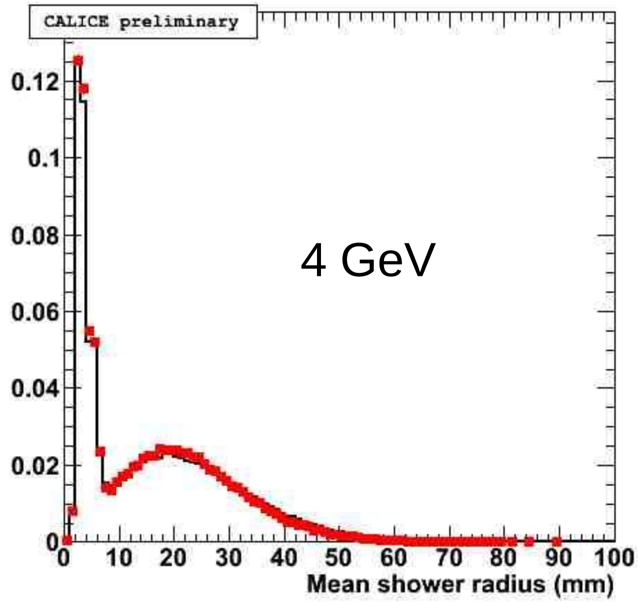
- Transverse size is calculated from the interaction layer (the first for non interacting events):

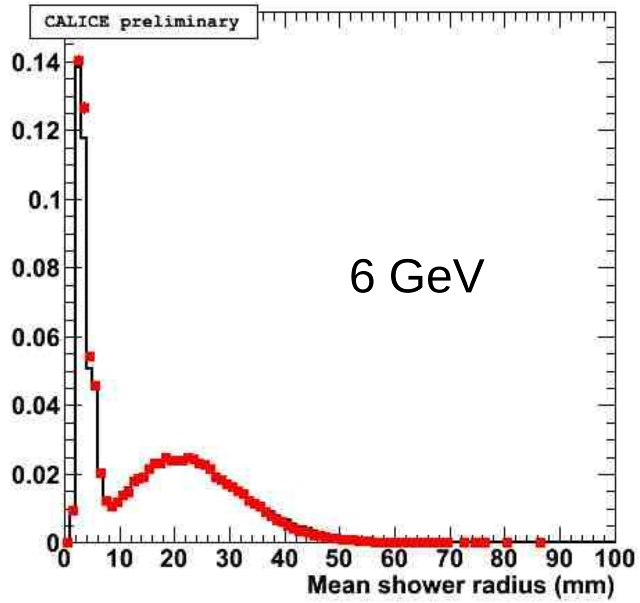
$$<\mathrm{r}>_{\mathrm{E}} = \sqrt{\sigma^2_{\mathrm{E,x}} + \sigma^2_{\mathrm{E,y}}}$$

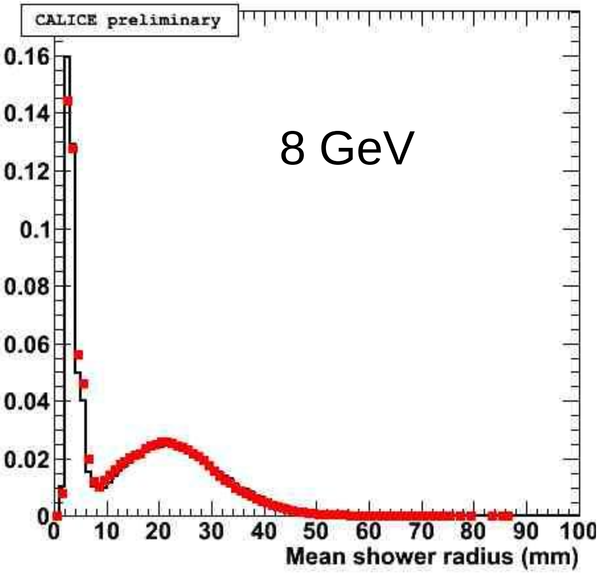
$$\sigma^2_{\mathrm{E,x}} = \frac{\sum\limits_{\mathrm{hits}} x^2_{\mathrm{hit}} E_{\mathrm{hit}}}{\sum\limits_{\mathrm{hits}} E_{\mathrm{hit}}} - \left(\frac{\sum\limits_{\mathrm{hits}} x_{\mathrm{hit}} E_{\mathrm{hit}}}{\sum\limits_{\mathrm{hits}} E_{\mathrm{hit}}} \right)^2$$

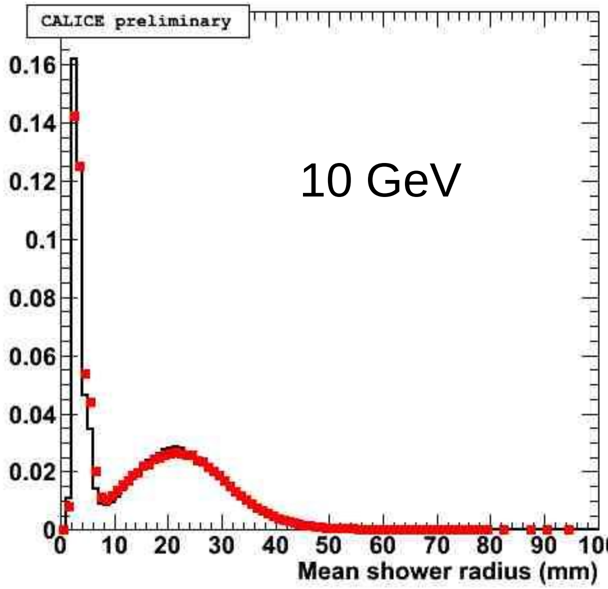
All events with different energies









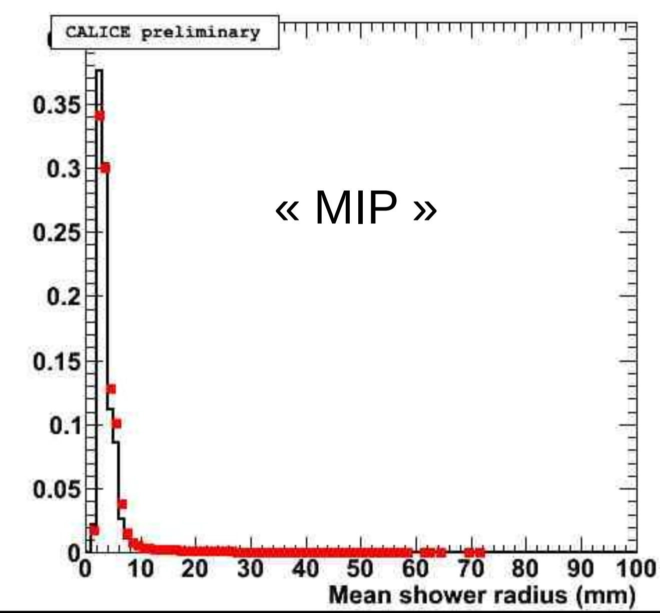


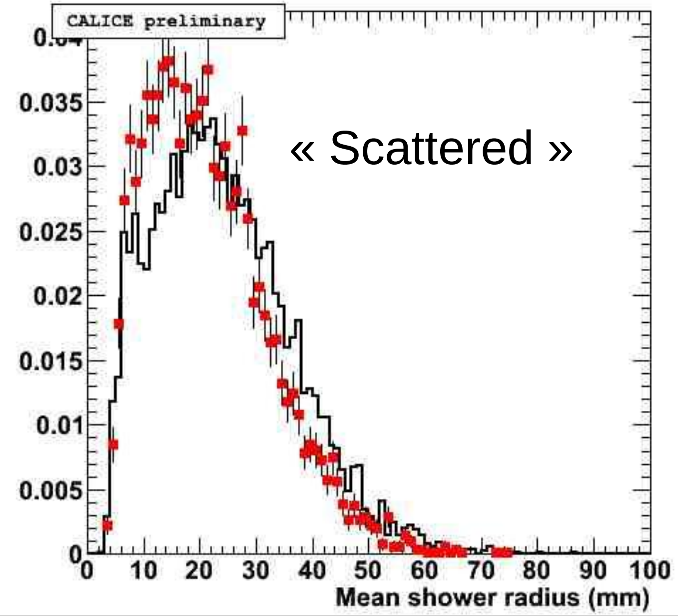
Reference physics list:
QGSP_BERT

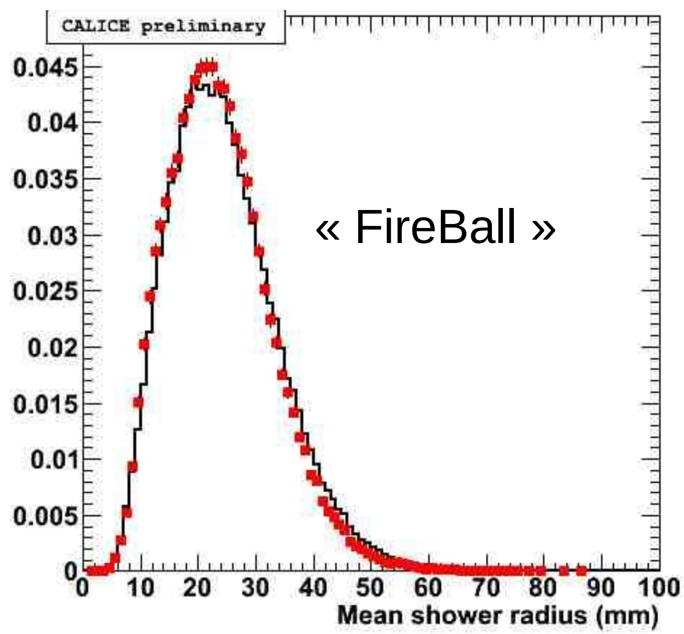
Very good agreement.

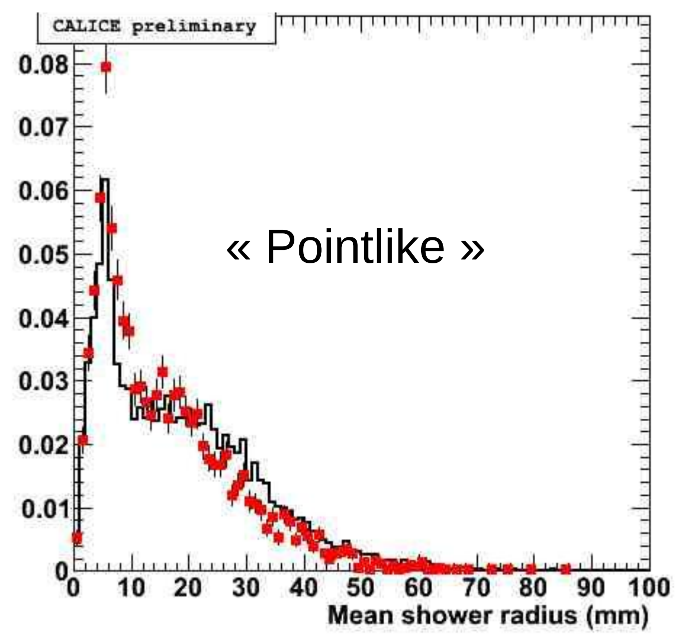
2 GeV starts to have a very different behaviour from other energies.

Classification at 8 GeV

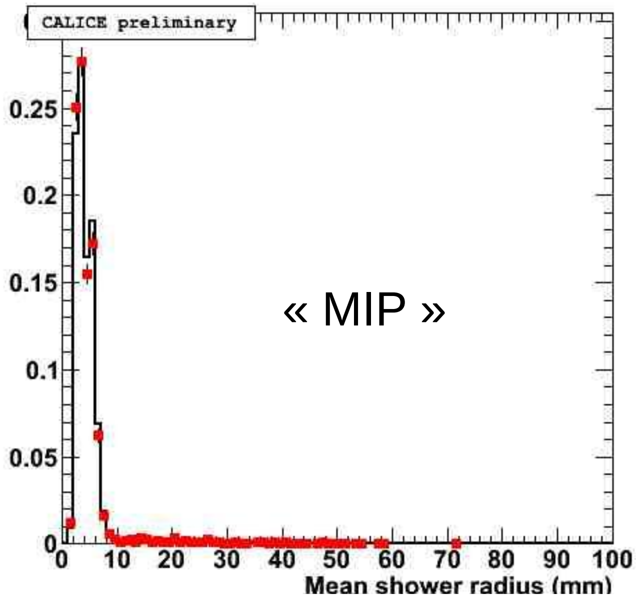


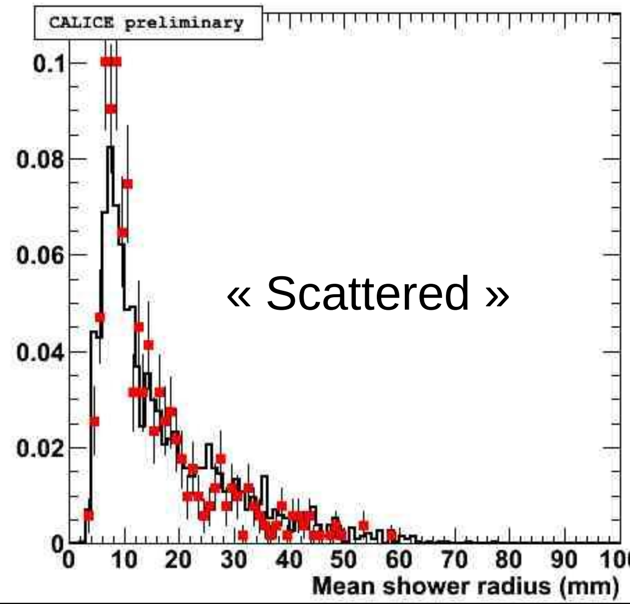


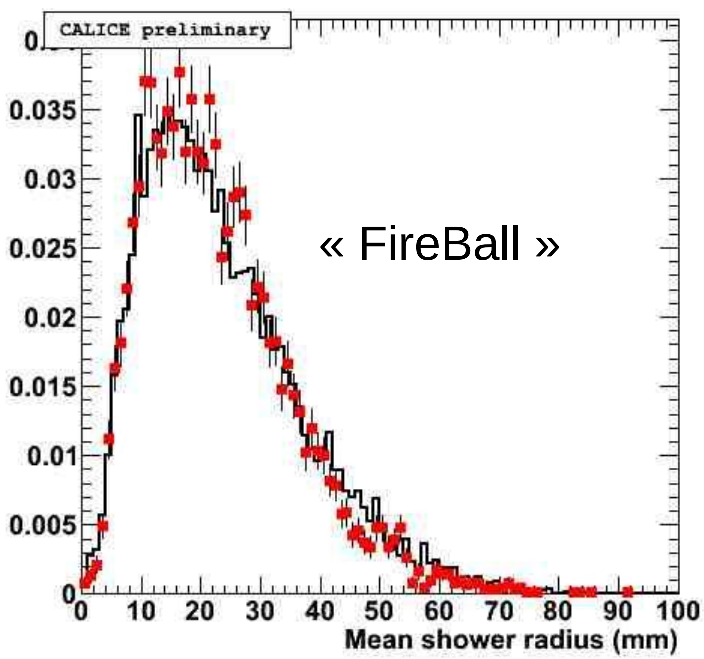


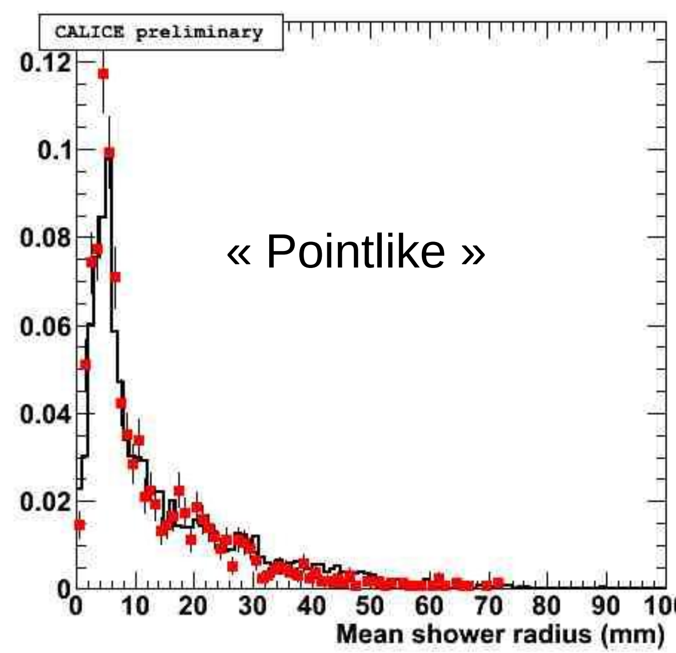


Classification at 2 GeV









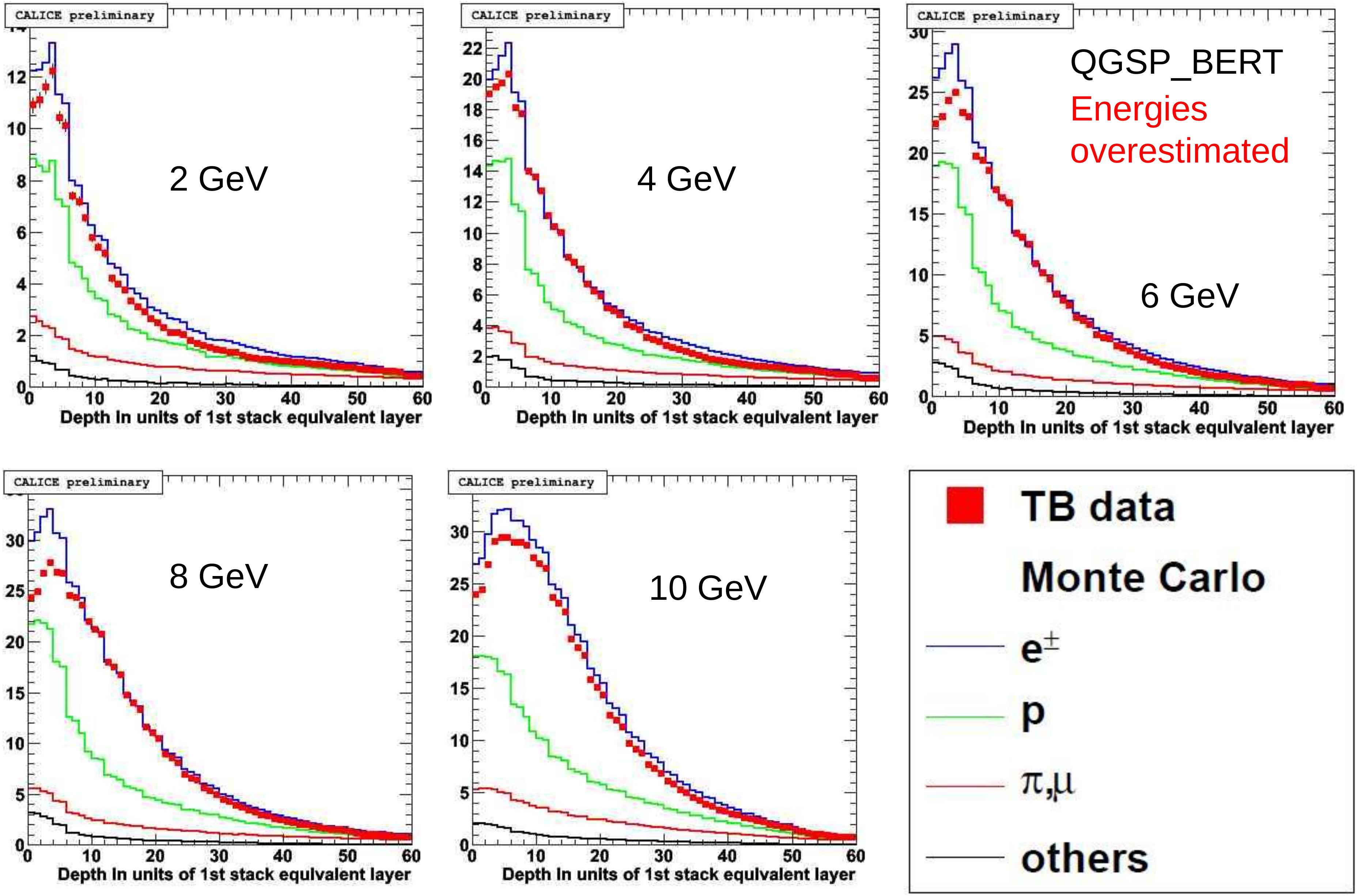
Longitudinal profiles

- 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)

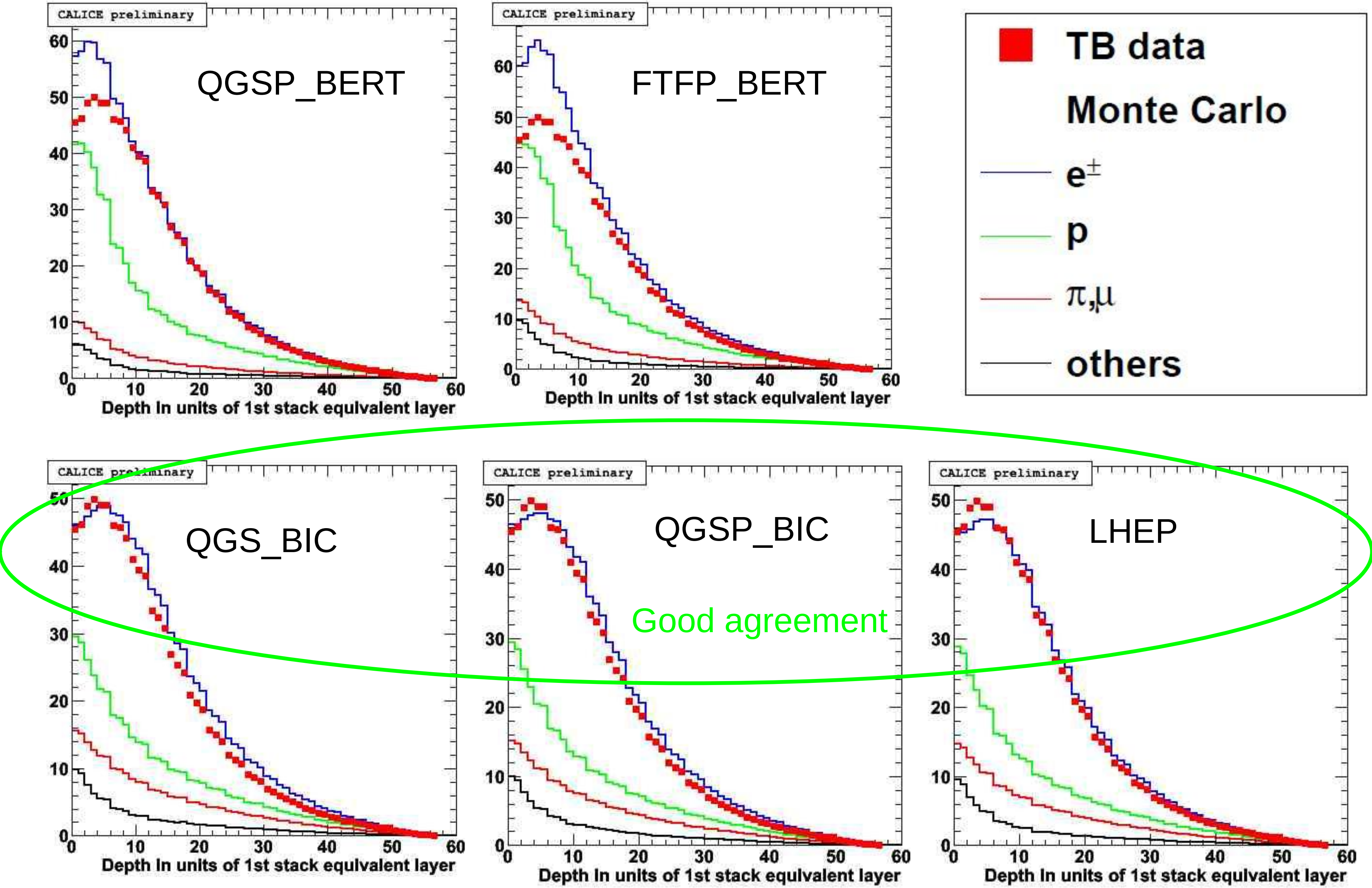
- Layer 0 is the interaction layer (set to 0 for non interacting events)

- The energy deposited in the layer is decomposed in the MC between various secondary particles' contributions

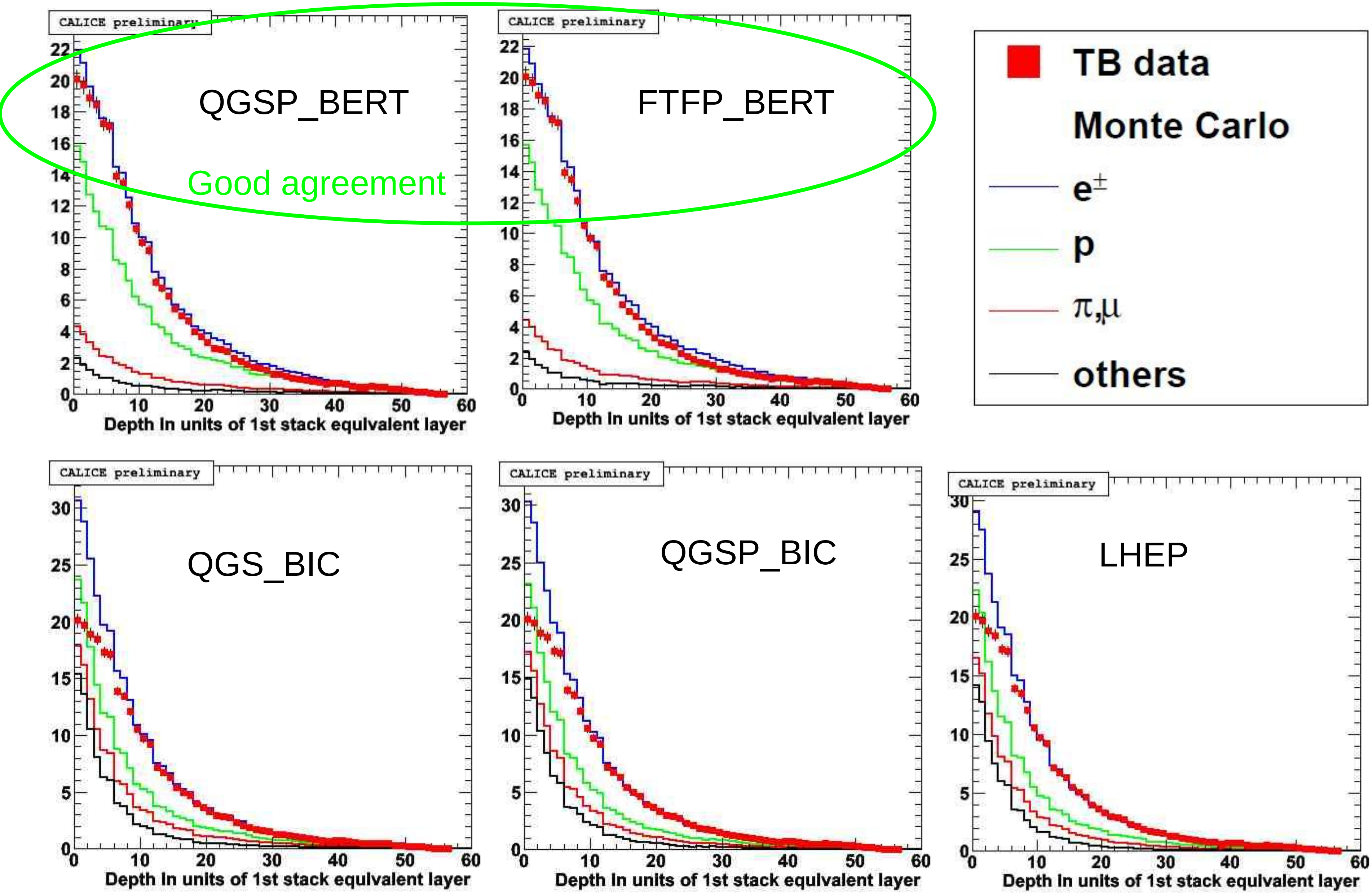
All events at different energies



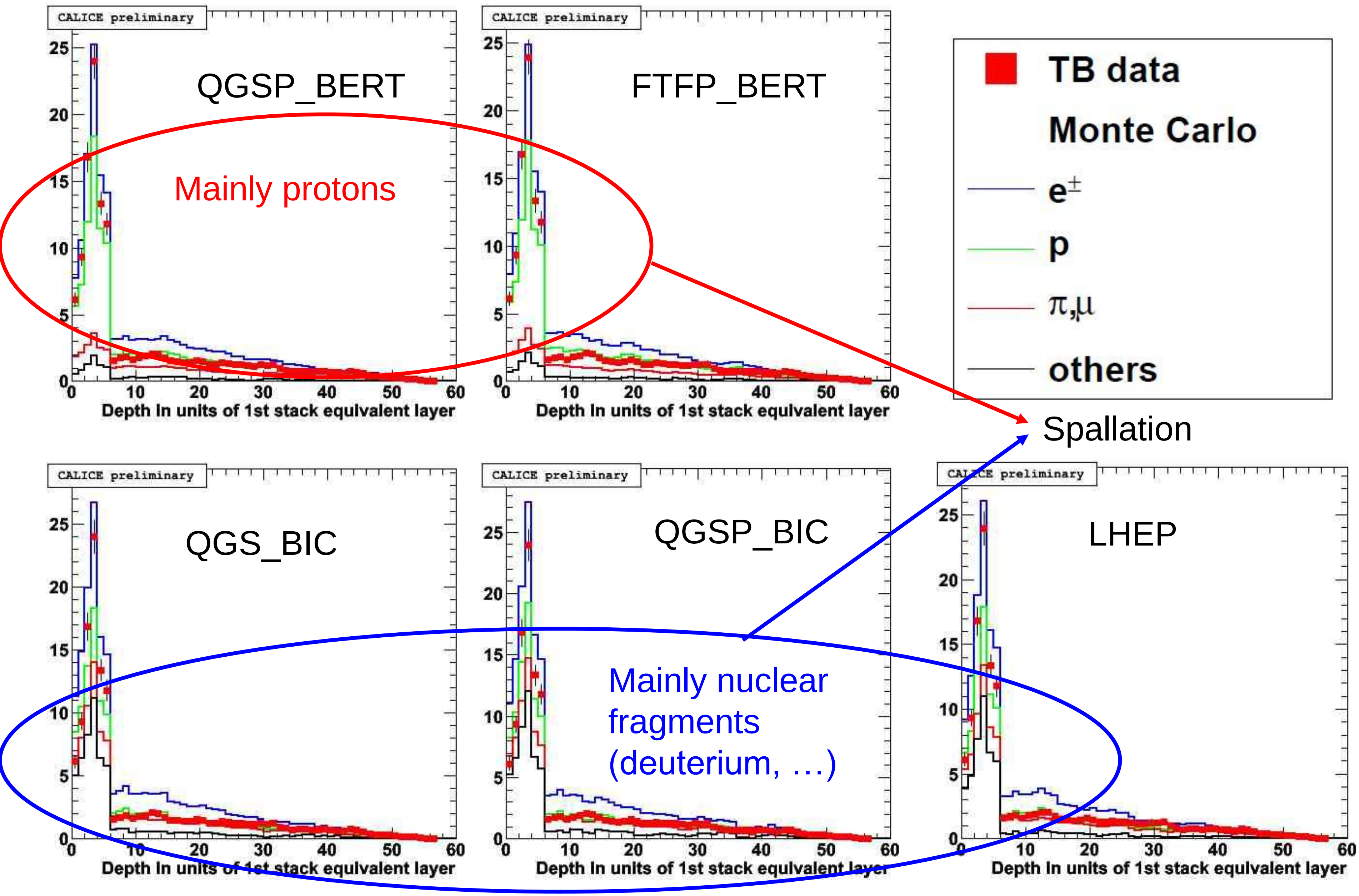
FireBall at 8 GeV for different lists



FireBall at 2 GeV for different lists



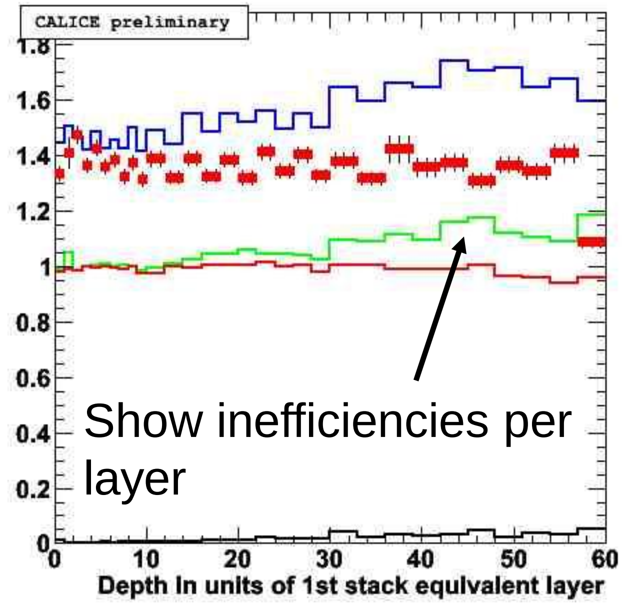
Pointlike at 2 GeV for different lists

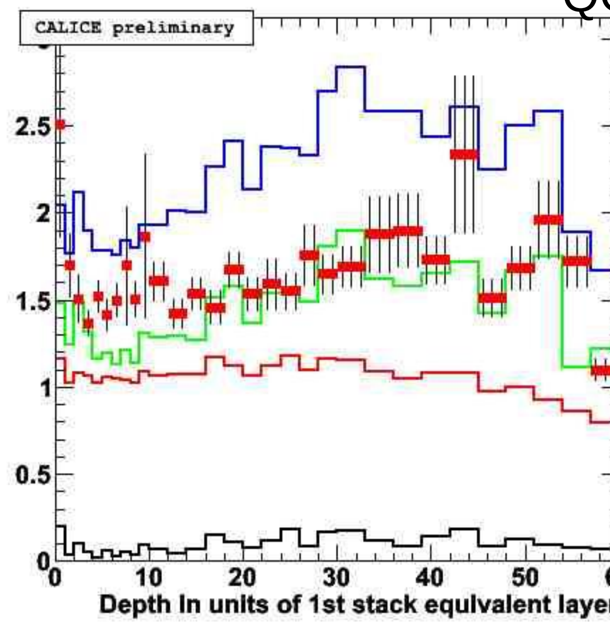


« MIP » and « Scattered » profiles

QGSP_BERT

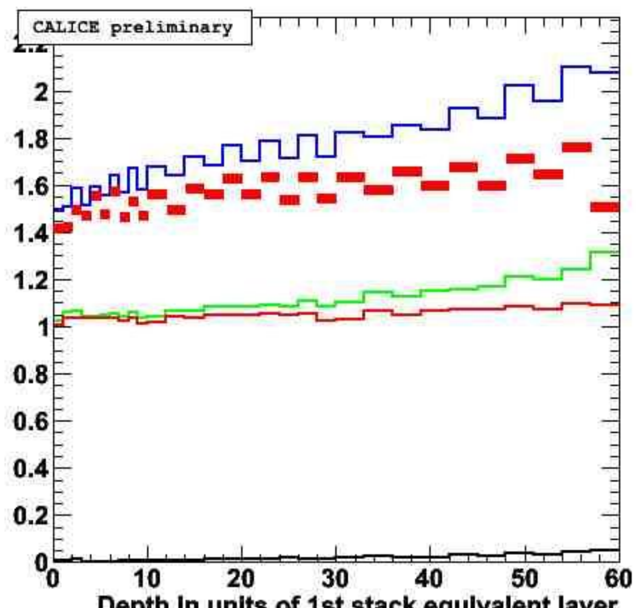
2 GeV

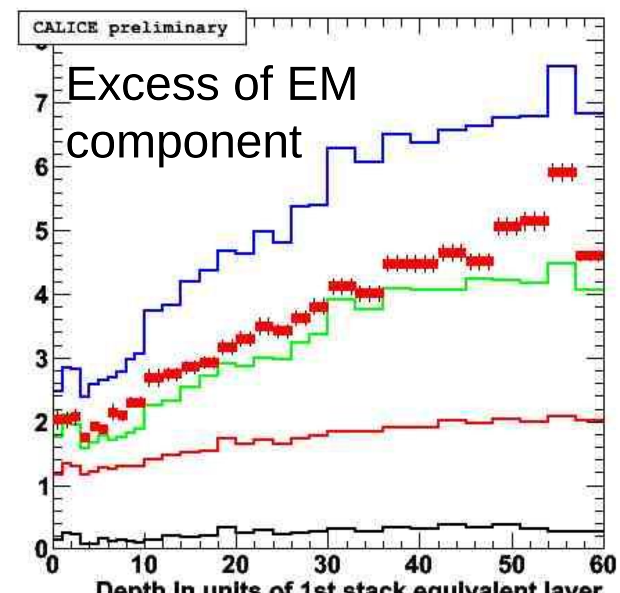




2 GeV

8 GeV





8 GeV

Conclusion

- We combine energy and high granularity to classify hadronic interactions and even see them clearly
  - The mean shower radii agree very well
  - The longitudinal profiles show differencies between physics lists
  - 4 types of interaction allow to separate clearly the profiles and show points of improvement for the lists
- Showers of types « FireBall » and « Pointlike » to be investigated
- Type « Scattered » very promising for particle flow studies (to be improved – ex: angular distribution studies)
- Results stable obtained with official releases

Pointlike at 8 GeV for different lists