Analysis of low energy hadrons in the SiW ECAL with the FNAL 2008 data

Philippe Doublet

LAL Orsay

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Plan

1. Introduction
2. Data checks and Cherenkov issues
3. Investigating the hadronic interaction
4. Summary

The SiW ECAL in 2008

- FNAL beam : e, μ, π from 1 to 60 GeV

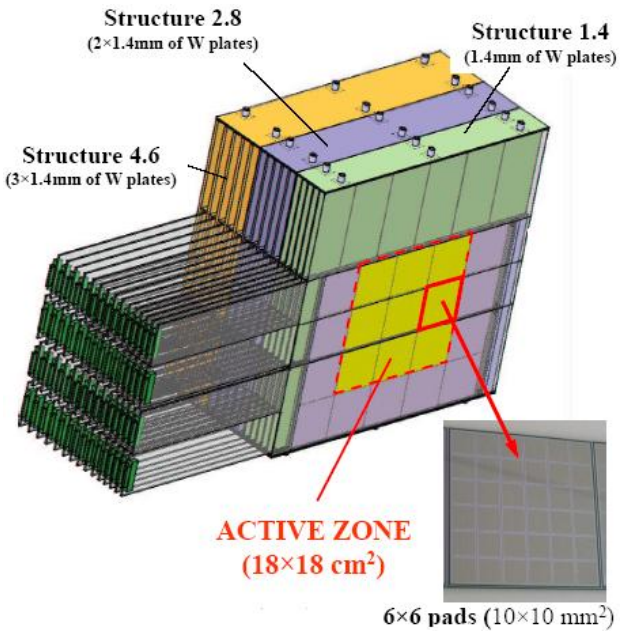
For hadron analysis

- depth $\sim 1\lambda_I$ i.e. 1/3 of the hadron interact
- 1 cm $\times$ 1 cm pixels $\Rightarrow$ tracking possibilities (AHCAL : 3 cm $\times$ 3 cm)

Goal: understand hadronic interactions and their showers
Here: low energy hadrons i.e. from 1 to 10 GeV

- Fully equipped Si-W ECAL

Figure: 30 layers : 1 $cm \times 1$ cm Si pixels $\sim$ 10000 channels, 3 different W depths.



Testbeams at FNAL in May and July 2008

- May: instabilities of the ECAL due to some electronic noise
- July: good and stable running period

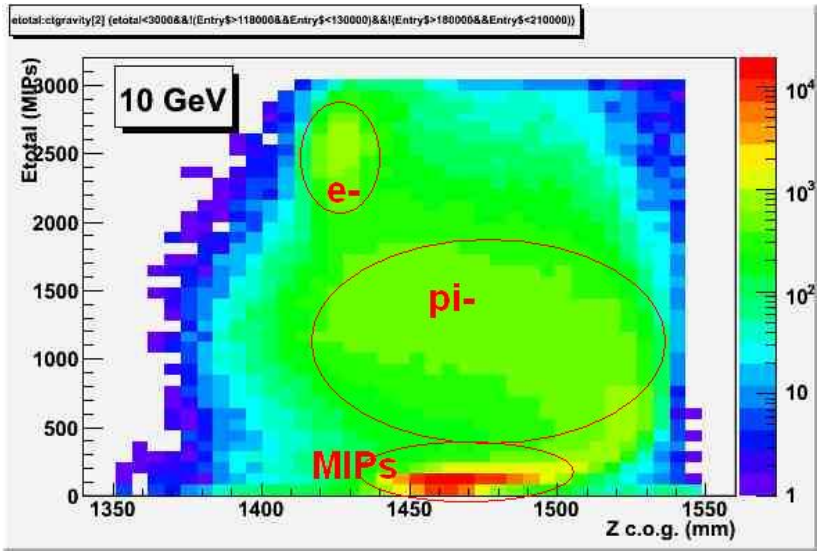
Figure: Installation at FNAL with ECAL, AHCAL, TailCatcher.

N events (triggers)	p (GeV)
460 k (-v22,-v25)	2
820 k (-v24)	4
110 k (-v23,-v27,-v31)	6
540 k (-v27)	8
500 k (-v27)	10

Today : 10, 8 and 6 GeV events (0° angle, all runs).

An overview at 10 GeV

Figure: 2D histogram of the 10 GeV runs showing the total energy deposited in the ECAL versus the center of gravity of the shower.



Thanks to Hengne for preparing the reconstructed data.

Visible information

Possible identification of electrons, pions and MIP particles

Note: 2 e^- events present $\Rightarrow$ trigger inefficiency and polluted beam

Goal here: Remove MIPs and e^-, compare with simulated data.

Major problem: HCAL information not available $\rightarrow$ select the pions with the ECAL

2 appropriate cuts (here, 10 GeV runs)

Electrons interact early: 10 layers $\sim 4X_0$
Difficult for pions: 30 layers $\sim 1\lambda_I$

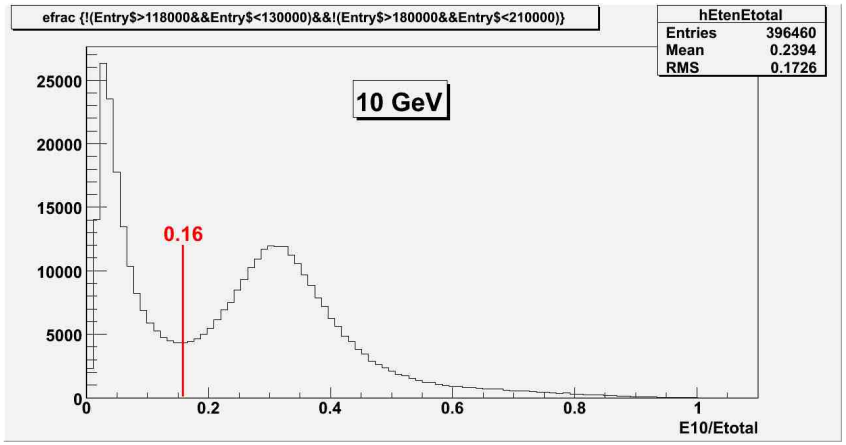


Figure: Fraction of the energy contained in the 10 first layers over the total energy. Cut almost energy independant.

Chosen cuts

Remove MIPs: nhits > 50
Remove electrons:
E(10 layers)/Etotal < 0.16

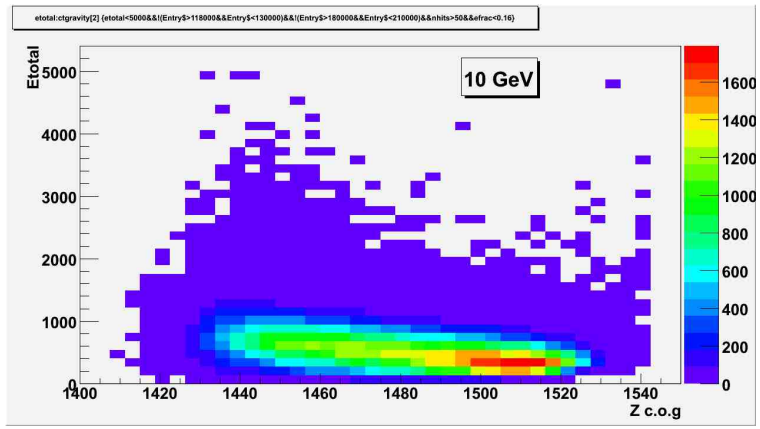
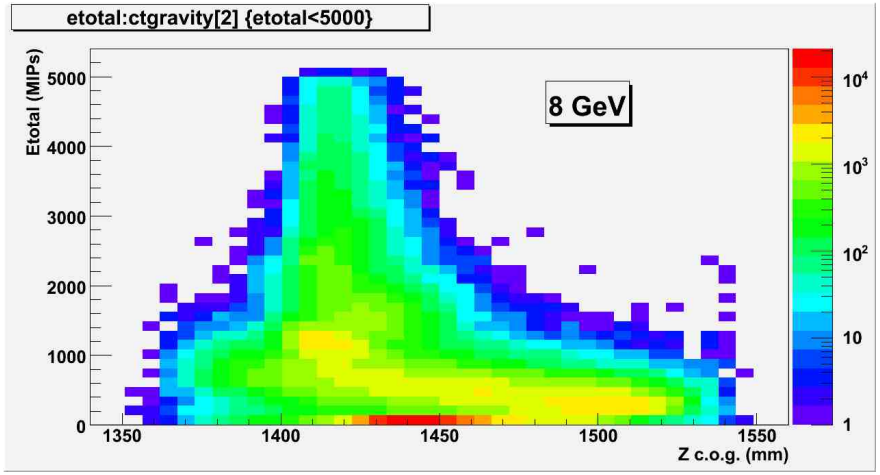
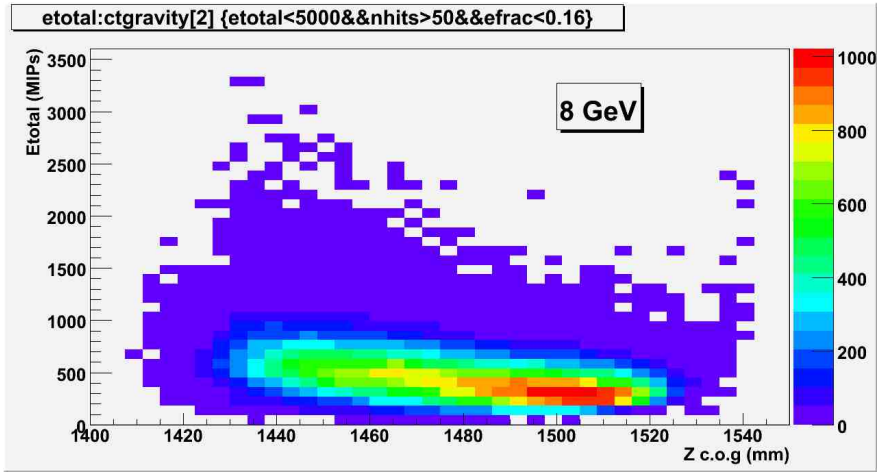
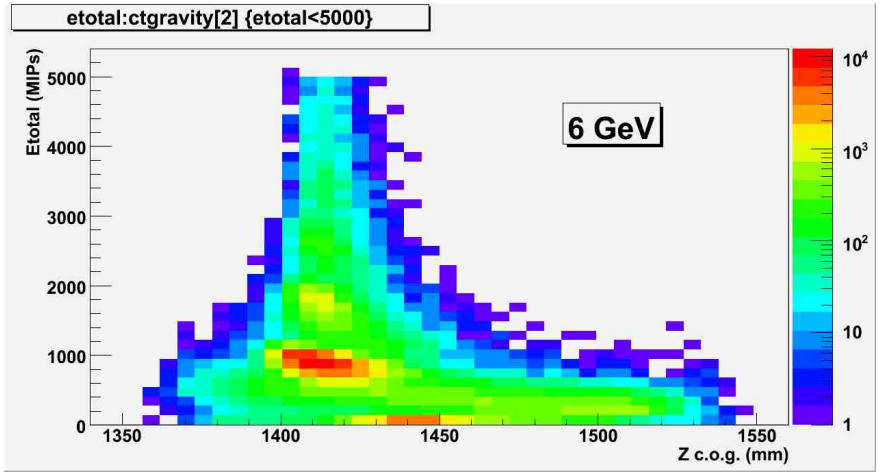


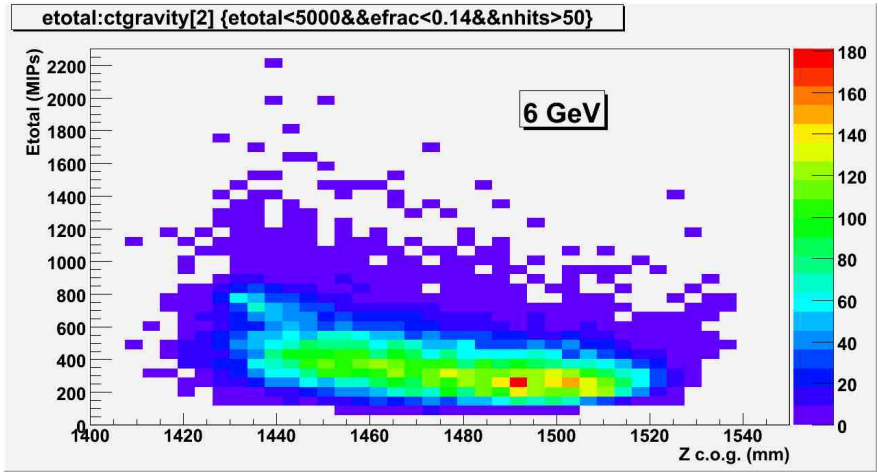
Figure: 2D histogram of total deposited energy versus center of gravity AFTER CUTS

Results of the cuts at 8 and 6 GeV





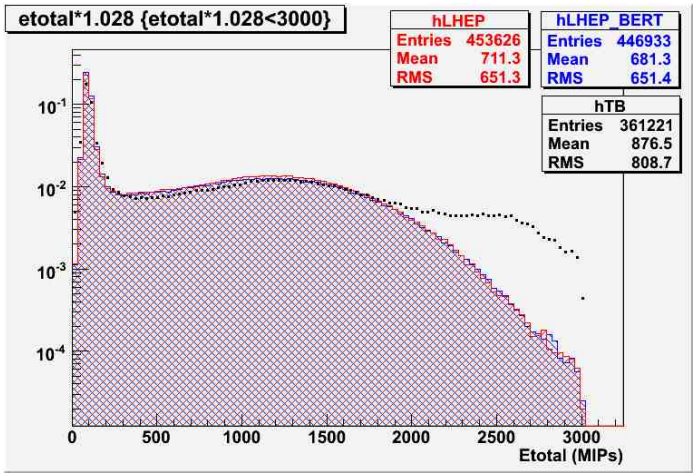


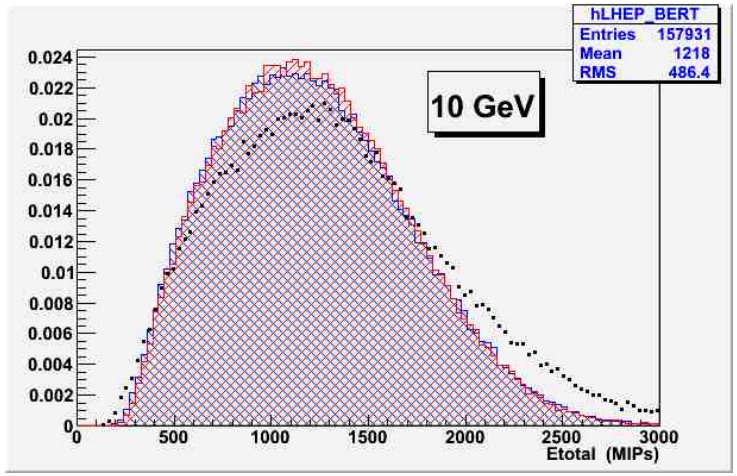


From left to right : before and after the cuts (8 and 6 GeV). Pions seem to be correctly selected.

Comparison with the MC data : effect of the cut at 10 GeV

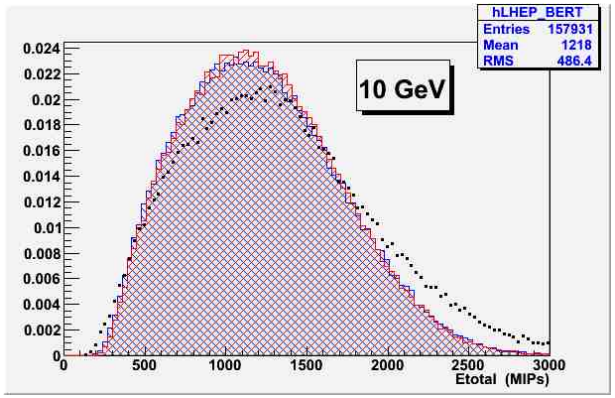
Remark: simulated data from 2006 CERN TB. Total energies of the simulated sample have been scaled so that the MIP peaks correspond to each other with the TB data.

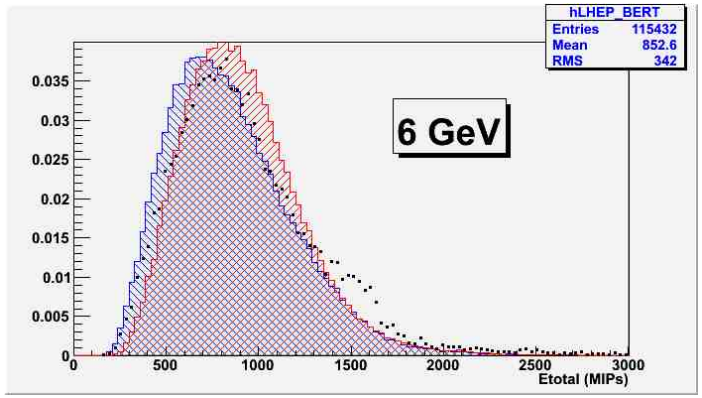




Red=LHEP, blue=LHEP BERT, black dots=TB.

Comparison with the MC data : deposited energy for 10, 8 and 6 GeV





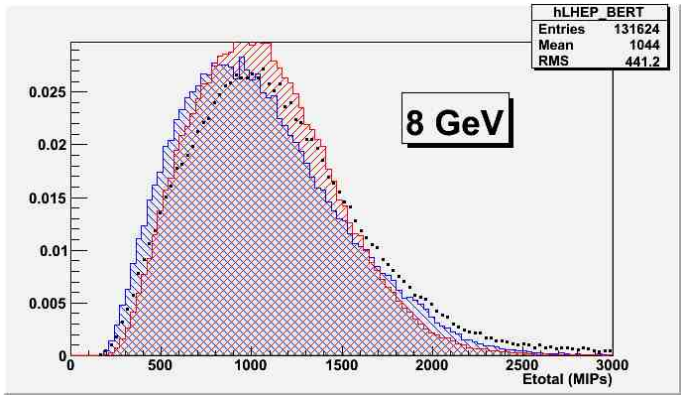
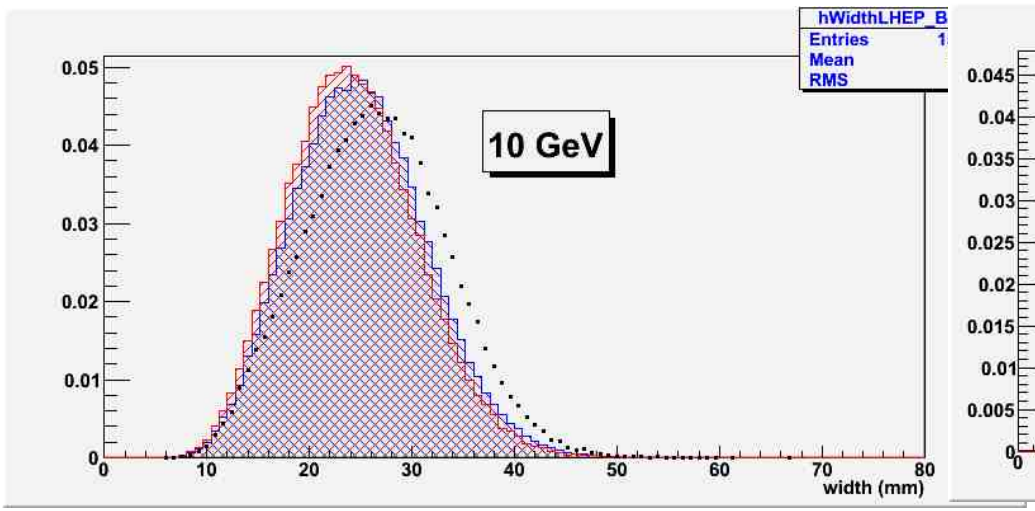
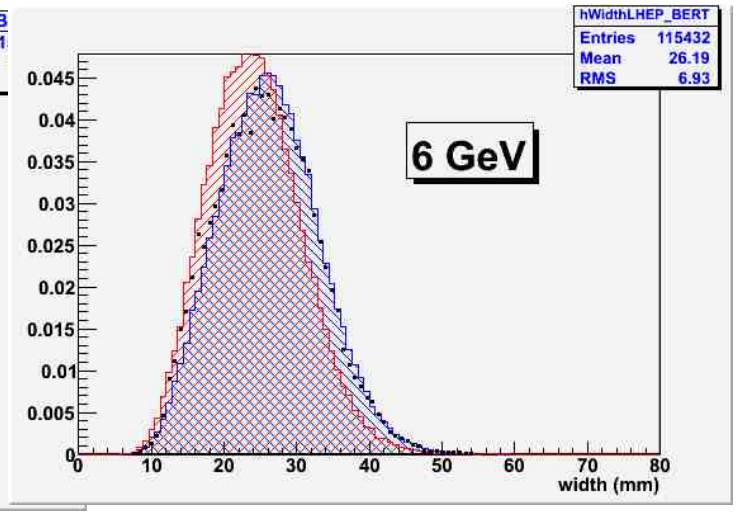


Figure: 10 GeV, 8 GeV and 6 GeV energy deposition with pion cuts. Red=LHEP, blue=LHEP BERT, black dots=TB.

Comparison with the MC data : width of the cluster





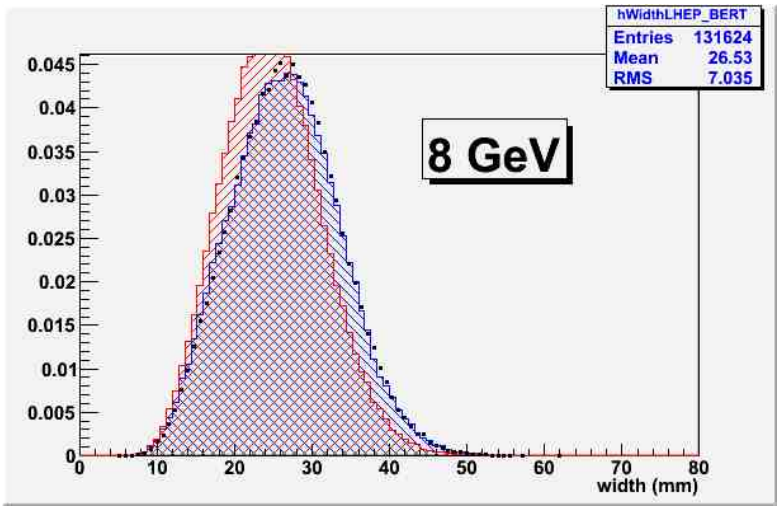


Figure: Width of the cluster in the ECAL after the cuts for pions.

Remark: Low TB statistics at 6 GeV.

Selecting pions with the FNAL Cherenkov

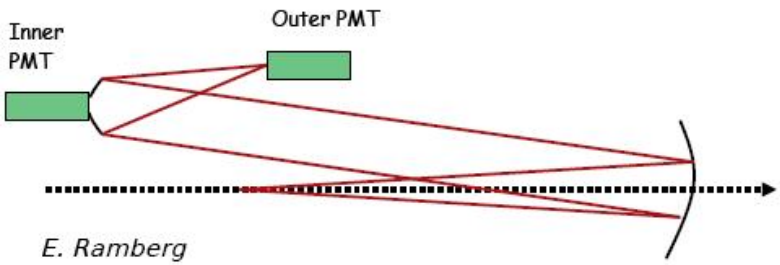


Figure: Scheme of the differential Cherenkov counter used to select particles

$$\cos(\theta) = \frac{1}{\beta n}$$

(Adjust Pressure $\Rightarrow$ n)

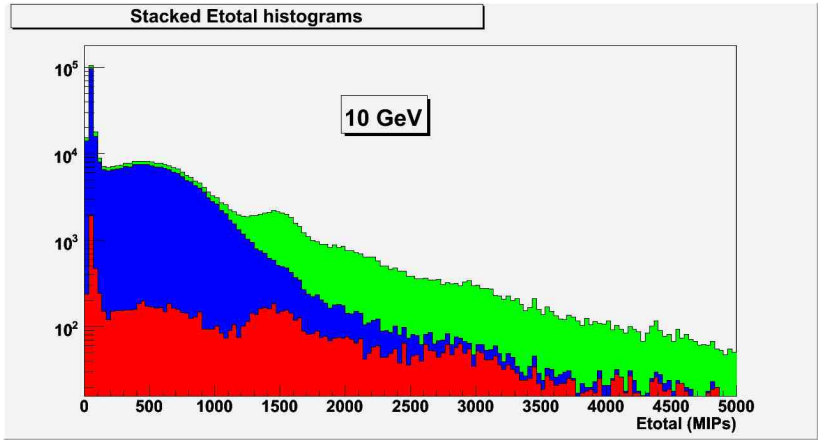
$$\boxed{\Rightarrow \theta_\pi < \theta_\mu < \theta_e}$$

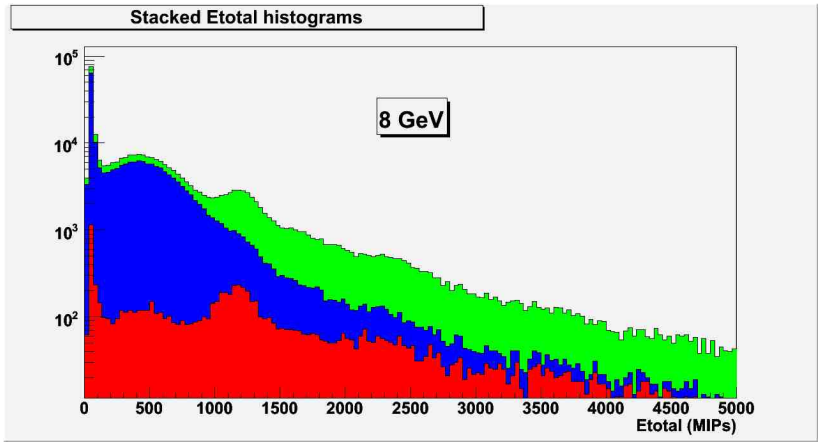
4 cases if pressure was well adjusted and the PMs were perfect

C1	C2	Comment
0	0	Smallest θ: π
1	0	Larger θ: μ
1	1	Largest θ: e
0	1	Not physical

$\rightarrow$ Quantify the efficiency of the Cherenkov w.r.t. previous cuts

Energy distribution with the Cherenkov





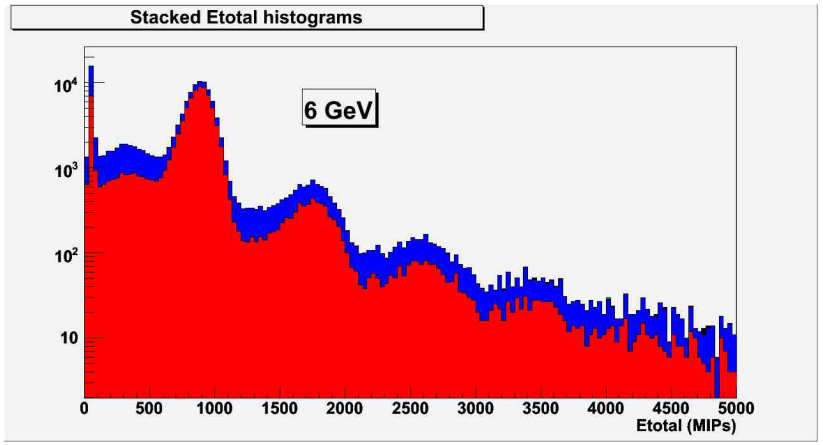


Figure: 6 GeV runs have problems with C2 pressure

Total deposited energy

Green = C1&C2 = θ_{max}

Blue = C1&!C2 = θ_{med}

Red = !C1&!C2 = θ_{min}

Black = !C1&C2 = X

Simple examples

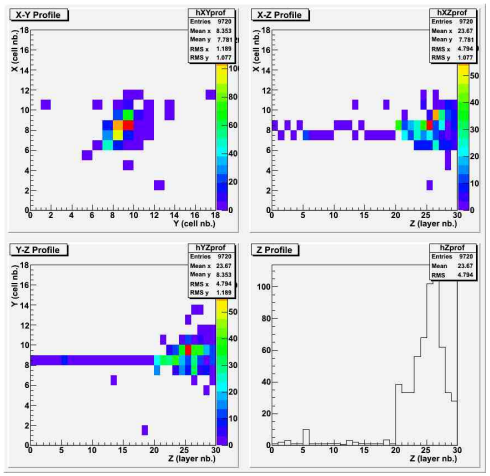


Figure: TB event Projections in the XY / XZ / YZ planes and Z profile of the event. Energies are in MIP.

If we can disentangle with the eyes, we may also do it informatically.

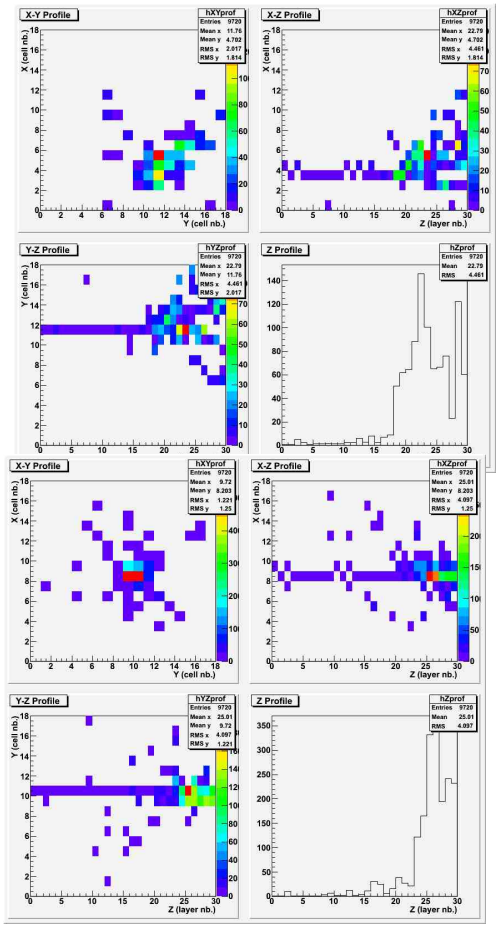
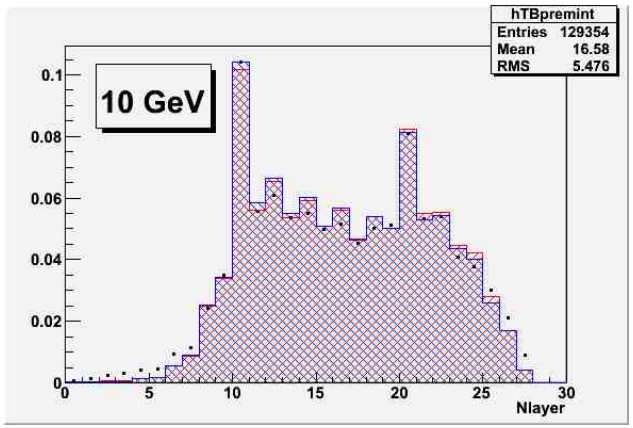
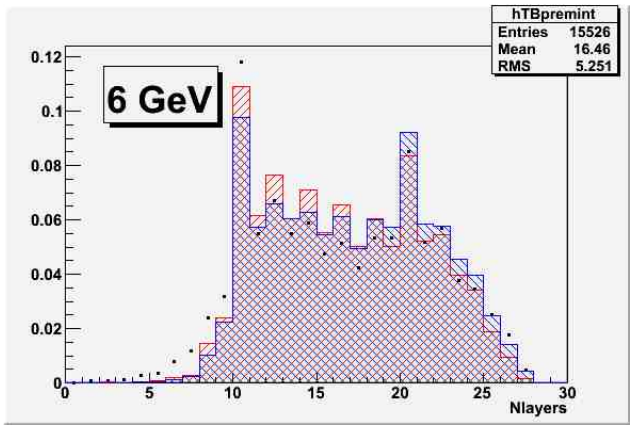


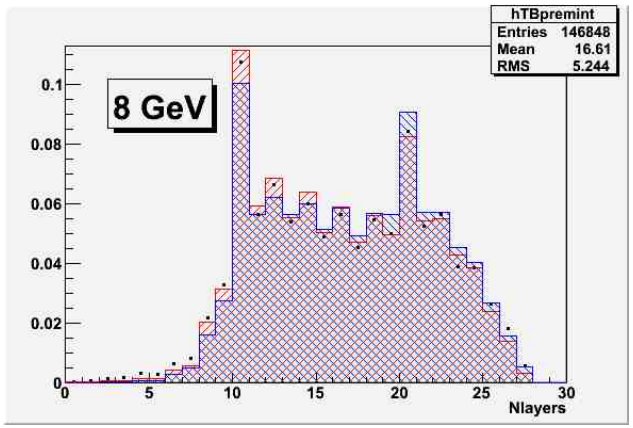
Figure: Simulation : LHEP (top), QGSP BERT (bottom)

Finding the first interaction (PRELIMINARY)

Condition: $E_{layer} > 10$ MIPs for 3 consecutive layers







Two peaks layer 10 and 20: change in the W thickness. Maybe due to W weight: *under investigation*.

Clusteriser algorithm - Developped by Götz Gayken

Goal: develop tracking in the ECAL to find MIPs, multiple particles, and understand the hadronic showers. At the moment : algorithm tested on the 5 first layers to count the number of particles entering the ECAL

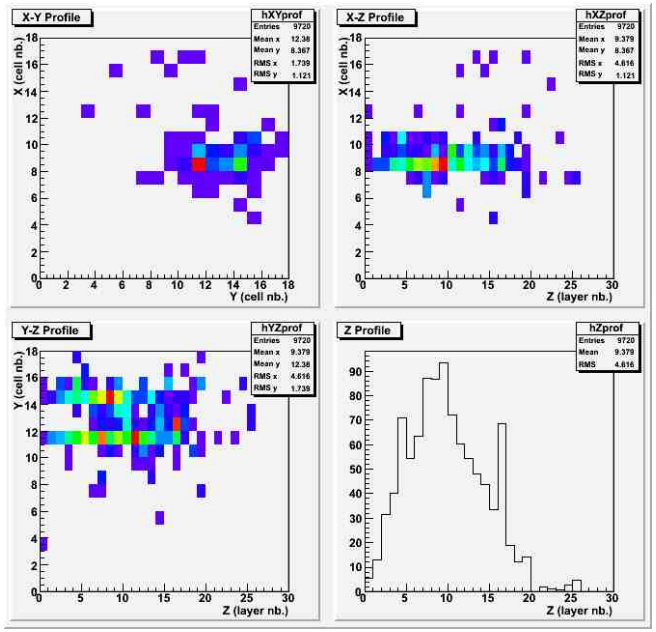


Figure: 6 GeV event showing two electrons interactiong in the ECAL.

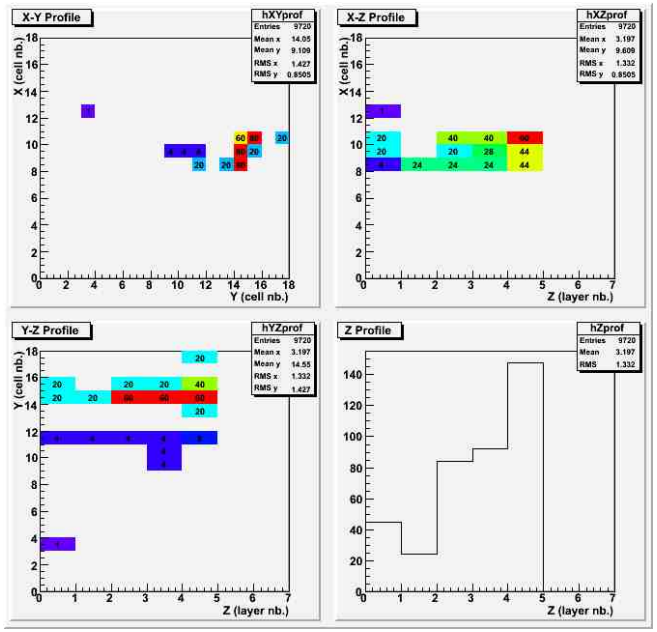


Figure: The clusters in the first 5 layers are shown with their number.

Summary and Outlook

- 2008 data check for pions with $E = 6, 8, 10\ GeV$ started. 2 and 4 GeV to be done.
- Several issues with the Cherenkov. Seem to work at 10 and 8 GeV
- Similar results with 2006 MC samples but differences can be seen (as expected).
- Using the ECAL as a tracker : 1st interaction found, clustering started.

- Get MC samples for 2008 (already asked to Shaojun Lu, they will come).
- Improve the 1st interaction finding.
- Continue the clustering in all the ECAL.

Thank you for your attention, any comments are welcome.