Tracking muons and pions in the SiW ECAL

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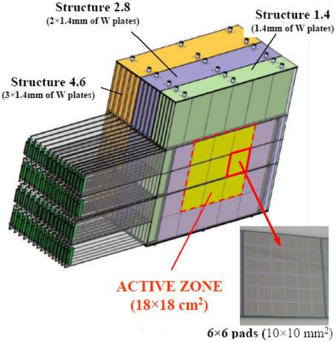
The SiW ECAL in 2008 : overview of the detector

Figure: Si-W ECAL prototype used at FNAL : 30 layers fully equipped



ECAL = sandwich of Si (detector) and W (absorber) layers

- $1 \times 1\ cm^2$ Si pixels ~ 10000 channels
- 1 layer of $1.4mm = 0.4X_0$
- 3 different W depths
- depth $= 24X_0 = 1\lambda_I$

MIPs / Tracking in the ECAL ?

Why do we look for MIPs ?

- *My study :* hadronic showers at low energy (FNAL'08 data), the initial part is a MIP
  ⇒ find a MIP in the first layers of the ECAL
  + interaction point (not discussed today)
- Possibility to use it to :
  ⇒ determine the beam's quality
  ⇒ calibrate the ECAL with MIPs (ADC counts / MIPs)

Algorithm developped : *MipFinder* (a Marlin processor).

- based on *MipSelect.hh/cc* developped by Götz Gaycken in *calice reco* tools, already used to calibrate the ECAL with MIPs
- *Today :* detailed study

The MipFinder in a nutshell

The MipFinder looks for MIPs in a given layer range.
Criteria to merge hits and/or clusters :

- distance D_{max} between hits and/or straight clusters
- angle θ_{cut} between straight clusters
  did not exist in MipSelect and avoids problems like backscattering

If some layers are not hit, others are added to help creating good clusters.

To count the number of entering particles: $0 \leq layer \leq 4$ and clusters where $N_{hits} \geq 3$, $D_{max} = 12$ mm and $\theta_{cut} = 0.1$ rad.

Remark: Can be applied to the last layers to determine the number of outgoing MIPs.

Efficiency using simulated samples of muons

Efficiency to find one single particle :
η_1 = nb of 1 particle events / nb of total events, as given by the MipFinder.

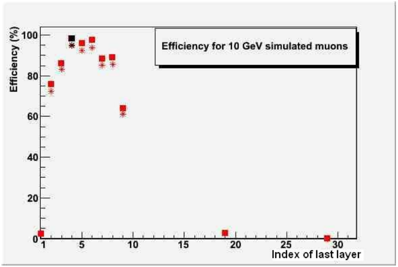


Figure: η_1 vs last layer taken to count the number of entering particles. Red : QGSC, black : QGSP BERT. Results are similar with the 2 physics lists.

Cross is without T_{cut}, squares are for $T_{cut} < 0.2$. *Wait for it...*

The parameter T_{cut}

$$T_{cut} = \Sigma_{N_{hits}} \frac{d_{XY}^2}{\sigma^2} / N_{hits}.$$

σ = cellsize = 10 mm, d_{XY} = distance between the hit and the cluster axis (z is fixed).

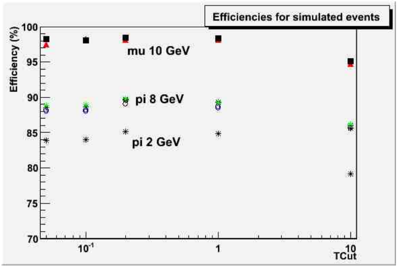
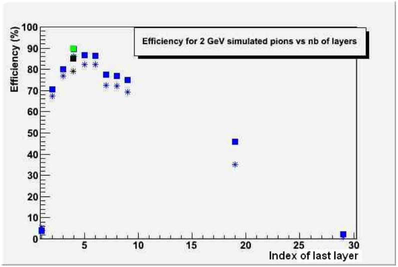


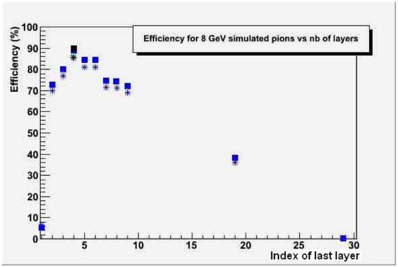
Figure: η_1 vs Tcut for 10 GeV muons, 8 GeV pions, 2 GeV pions. (Red : QGSC, black : QGSP BERT, blue : LCPhys, green : LHEP) Results are similar between physics lists. Best for $T_{cut} < 0.2$.

Efficiency using simulated samples of pions

Figure: Efficiency for 2 GeV pions vs last layer taken into account. Black : LHEP, red : LCPhys, green : QGSP BERT.

Figure: Efficiency for 8 GeV pions vs last layer taken. Black : LHEP, red : LCPhys, green : QGSP BERT.





The results are slightly worse with QGSP BERT than the other models (earlier interactions at lower energies)

Efficiency using overlayed muons

Efficiency to find two particles :
η_2 = nb of 2 particle events / nb of total events, as given by the MipFinder.

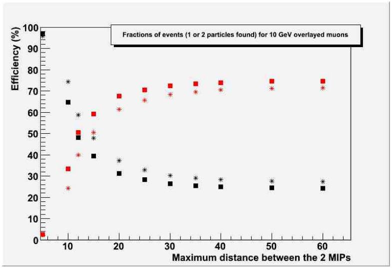


Figure: Efficiencies for 10 GeV overlayed muons. Red : η_2, black : η_1.

$D_{max} = 12$ mm. Here, the change of efficiencies is around these 12 mm and the stable region is reached at $\sim 2 \times 12$ mm.

Inefficiencies

Why ?

Simulated muons

- special case, to be discussed
- no hit before layer $\sim$ 10

Simulated pions

- special case, to be discussed
- strange distribution
- 2 particles !!
- no hit before layer $\sim$ 10

These inefficiencies will be much reduced next time.

Inefficiencies : no hit in the first layers

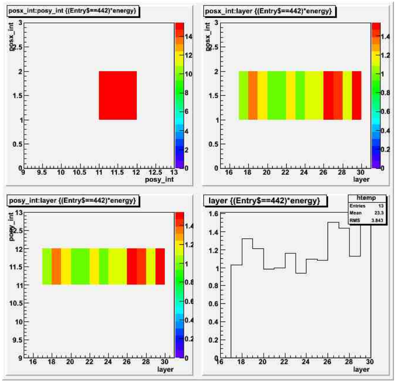


Figure: 2D histograms of the energy deposition in the ECAL - no hits in the first layers : there is nothing to count here

Solution: start counting in the first HIT layer

Inefficiencies : special case

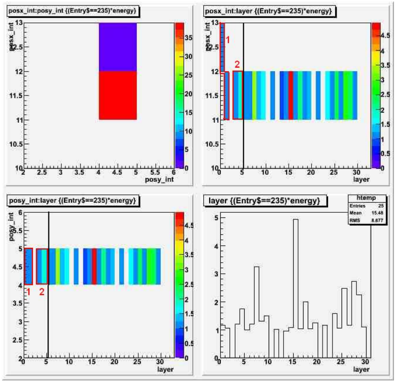


Figure: 2D histograms of the energy deposition in the ECAL - special case

The clusters are constructed and the angle is too high to merge them. Solution: any idea ?... ($\sim 1/2$ of the inefficiencies)

Inefficiencies : strange distribution

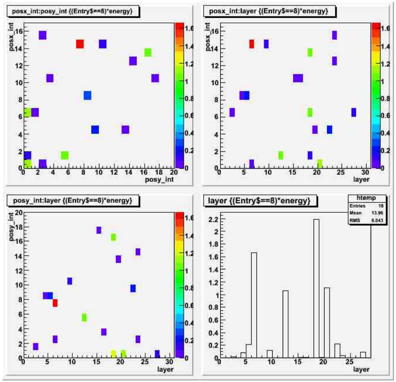


Figure: 2D histograms of the energy deposition in the ECAL - strange distribution

Solution: any idea ?... (very small fraction of events : can be kept at the moment)

"Inefficiencies" : 2 particles

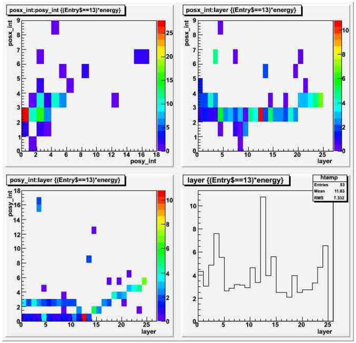


Figure: 2D histograms of the energy deposition in the ECAL - 2 particles seem to enter the ECAL

Maybe a backscattered particle or a problem in the simulation ?

Results with FNAL'08 TB data - pions

Estimation of the quality of the beam : use the MipFinder to count the particles entering the ECAL. The uncertainty is given by the inefficiency shown with simulated samples.
Real data : $\eta_i \Rightarrow f_i$, fraction of events with i particles.

For muons at 32 GeV :
$f_0 = 10.8\%$, $f_1 = 83.6\%$,
$f_2 = 5.1\%$, $\pm 1.8\%$
(from muon inefficiencies in simulations).

Maybe problems with the Cherenkov trigger $\Rightarrow f_1$ may be underestimated (TB data).

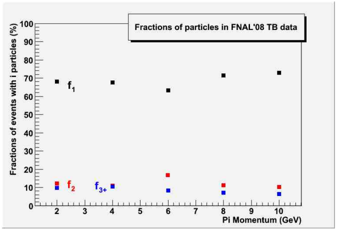


Figure: Fractions of i entering particles vs momentum (TB data). Black : f_1, red : f_2, blue : f_{3+}. Inefficiencies from simulation O(10%).

Inefficiencies in the TB data

- 2 real particles $\Rightarrow$ input on the quality of the beam
- pre-showering
- special case...

Inefficiencies in TB data : pre-showering

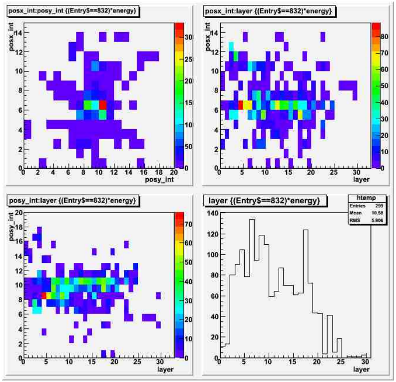


Figure: 2D histograms of the energy deposition in the ECAL - pre-showering

Solution: ask for Energy in 5 first layers < 20 MIPs (allows ~ 4 entering particles).

Conclusion and Outlook

- Good efficiency of the MipFinder to count the entering particles with simulated particles
- Most of the inefficiencies are understood and will be addressed
- Efficiencies reasonable with TB data and input on the beam's quality

To do:

- Remove the inefficiencies !
- Switch to the description of the interaction region of the pions
- Compare this algorithm with the Hough transform used by Cristina

Thank you for your attention, any comments are welcome.