Response of SDHCAL to Mips

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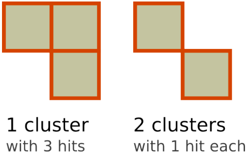
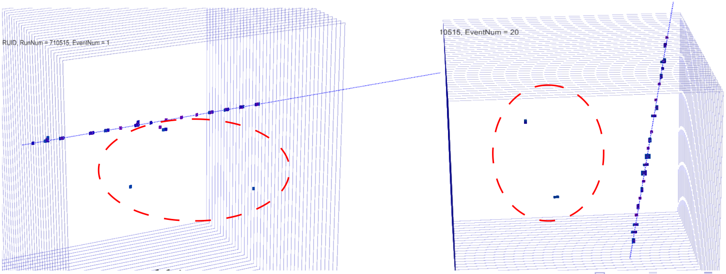
Outline

- Test beam data analysis
- Only run for Aug/Sep and November periods are used here.
- GRPC uniformity measurement & fine structure.
- Threshold scan & Digitizer input.
- This presentation is an update of muon and cosmic analysis. see my presentations at Cambridge CALICE 20&21/09/2012 at Cambridge & 03/2012 at Shinshu.
  http://indico.cern.ch/getFile.py/access?contribId=2&resId=1&materialId=slides&confId=197404 http://ilcagenda.linearcollider.org/getFile.py/access?contribId=13&sessionId=8&resId=0&materialId=slides&confId=5686 https://ilcagenda.linearcollider.org/getFile.py/access?contribId=59&sessionId=4&resId=0&materialId=slides&confId=5484

track reconstruction steps

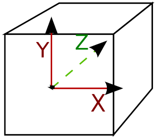
- Clustering of hits performed in each layer using closest neighbor clustering.
- The position of the cluster is taken as center of gravity of the contained hits. The error on this position is calculated as X and Y spread divided by $\sqrt{12}$. The errors are obtained by calculating the variance of flat distribution for which $\sigma_{x,y} = l_{x,y}/\sqrt{12}$ ($l_{x,y}$ is the length of the cluster in each direction)
- Clean the event by removing the farther hits.
- The Mip's track reconstruction is based on the χ^2 minimization.
- The Track are supposed the straight lines with 4 parameters.

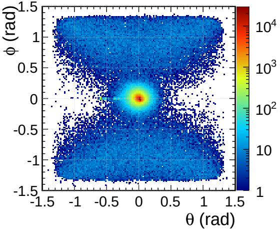


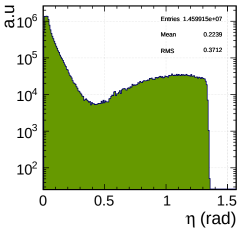


Angular distribution

- Using the parameters of the reconstructed track, its angles can be calculated.
- θ & ϕ are the angles on the (X,Z) and (Y,Z) plane respectively.
- η is defined as the angle between the reconstructed track and the normal of the detector layer.







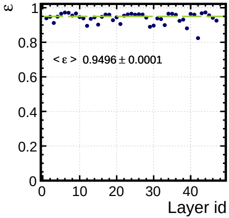
Cut List

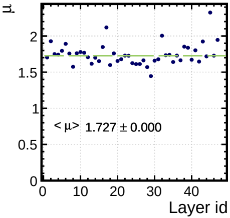
Several cuts are used for Mip's selection : for Layer

- $N_{layer}\left(K < 10\right) \geq 5$ and $N_{layer}\left(K > 40\right) \geq 5$ (for penetrating Mons).
- For Layer i : $N^{i}_{cluster} \leq 1$ (remove the track making interactions).
- $\chi^2 < 20$ (track goodness)
- $N_{hit} < 200$ (exclude e / π ..)
- For cluster j : $N^{j}_{hit} < 5$
- $\left(\Delta x^2 + \Delta y^2\right)^{1/2} < 2cm$ (for efficiency measurement)
- no Alignment correction !
- following runs was taken for the threshold scan from Sptember 2012 period : 715766 ,715772 ,715776 ,715779 ,715782 ,715785 ,715773 ,715777 ,715780 ,715786 ,715770 ,715775 ,715781 ,715784 ,715787 ,715768 ,715783 ,715778
- for the other studies we was take muons from energy scan run Aug/Sep 2012 period : 715480, 715511, 715593, 715596, 715671, 715693, 715491, 715531, 715594, 715612, 715675, 715694, 715493, 715551, 715595, 715651, 715692, 715695

efficiency & Multiplicity estimation

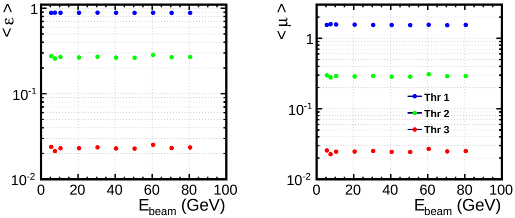
- The local efficiency and multiplicity were measured by using the other chambers to reconstruct particle tracks and determining the expected hit position in the considered one. The multiplicity μ is defined as the number of fired pads within 2 *cm* of the expected position.
- The efficiency ε is the fraction of tracks with $\mu \geq 1$.
- The efficiency errors are calculated using the binomial errors ($\sigma_\varepsilon = \frac{\varepsilon(1-\varepsilon)}{N}$)





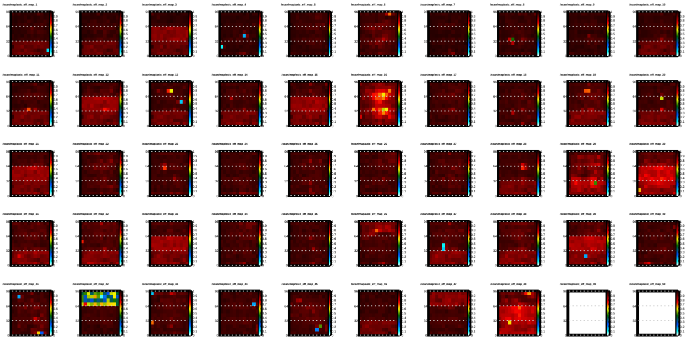
Efficiency & Multiplicity stability with muons energy

- Muons from the Pions runs.
- The μ and ε stable over the energy scan.



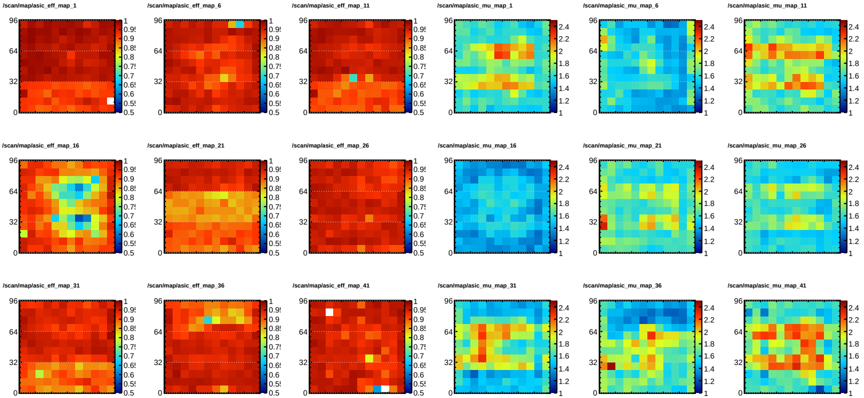
Multiplicity maps/ASIC's

- ASIC efficiency measurement for each plate.



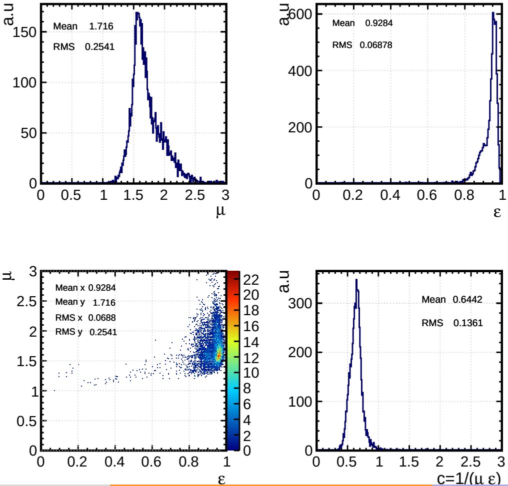
Efficiency maps/ASIC's

- Example of ASIC's efficiency & Multiplicity maps for few layers.



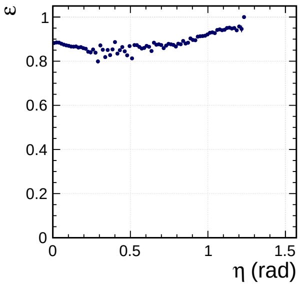
Systematic

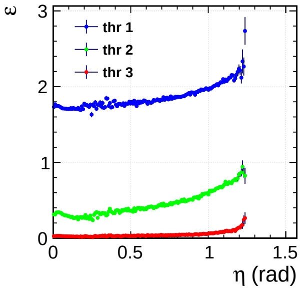
- The efficiency & multiplicity distribution per ASIC's.
- the inhomogeneity correction factor $c_i = 1/(\mu_i \varepsilon_i)$ is determined for each ASIC.



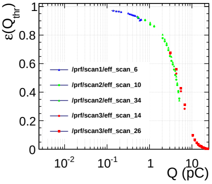
Angular dependencies

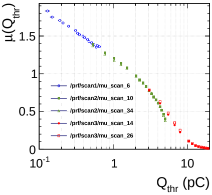
- The multiplicity increases with angle. At large angles, the particle path is longer and more ionisation and hence charge is expected. This rather in higher efficiency.





Charge threshold scan





- Threshold scan for efficiency and multiplicity.
- for each run, the value of the threshold 1, 2 and 3 are changed in the same time for different chamber (3 chambers each).

Threshold	chamber no
t1	6, 18, 30
t2	10, 22, 34
t2	14, 26, 38

- the color correspond the scanned threshold.
- DAC vs Q is not linear at the end of 1st and 2nd threshold.

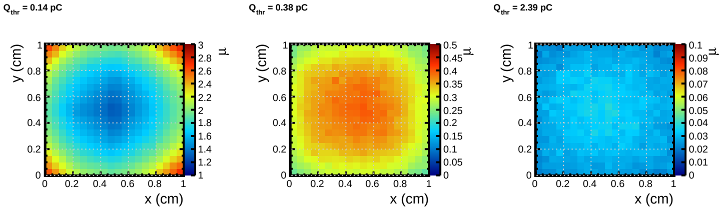
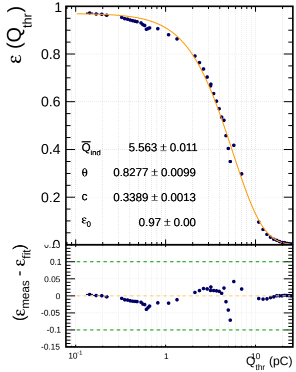


FIGURE: Distribution of the multiplicity on function of position of reconstructed on the pad.

Charge threshold scan



- The polya function can be write simply :

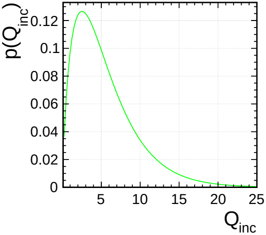
$$\mathrm{P}(q;\theta,\bar{q}) = \left(q\frac{(1+\theta)}{\bar{q}}\right)^{\theta} \exp\left\{-q\frac{(1+\theta)}{\bar{q}}\right\} \qquad (1)$$

$\bar{q}$: mean charge.
θ : free parameter related to the width of $\mathrm{P}(q;\theta,\bar{q})$.

- The efficiency measurement by increasing the threshold means that your integrating the polya function as (polya-CDF function),

$$\varepsilon(q_{thr}) = \varepsilon_0 - c\int_0^{Q_{thr}} p(q;\theta,\bar{q})\mathrm{dq} \qquad (2)$$

ε_0 is the detector efficiency when the threshold on 0 pC and c is the normal



Charge Shape measurement

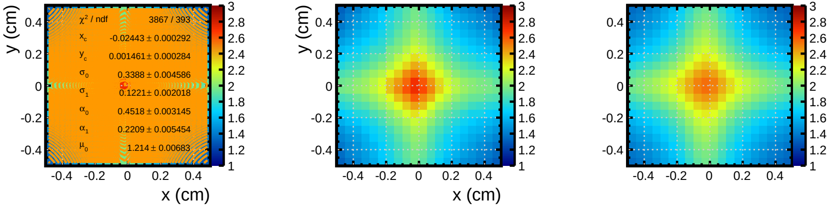


FIGURE: left : fit, middle : data ,right : fitted shape

- The scan cross the pad for multiplicity provide the induced charge space distribution. 2D-fit of this distribution are applied using the following function,

$$f(x,y;\mu_0,\alpha_0,\alpha_1,\sigma_0,\sigma_1) = \mu_0 + \alpha_0 g(x,y;\sigma_0) + \alpha_1 g(x,y;\sigma_1) \tag{3}$$

- where $g(x,\sigma_i)$ is defined as,

$$g(x,y;\sigma_i) = exp\left(\frac{(x-x_c)^2}{\sigma_i^2}\right) + exp\left(\frac{(y-y_c)^2}{\sigma_i^2}\right) \tag{4}$$

- σ_i is an approximation of the e^- avalanche size.

Conclusion & perspectives

- Preliminary results on muons response were shown.
- the local response of the detector (by ASIC's) and the calibration factor were determined.
- The (ε, μ) are stable over the energy scan.
- The Polya distribution parameters were extracted from the threshold scan $\Longrightarrow$ digitizer input.

Next steps ;

- Apply the correction by ASIC's to reduce the detectors inhomogeneity response.
- Check the stabilty of the performance over the time.
- Tune The digitizer with polya function and charge induced shape parameters.