Uniformity Correction using Mip's & Energy resolution

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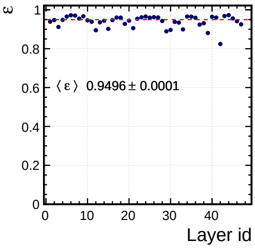
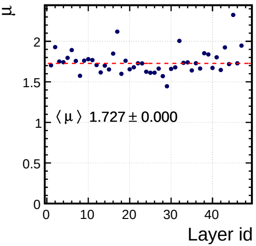
Outline

Mip reconstruction

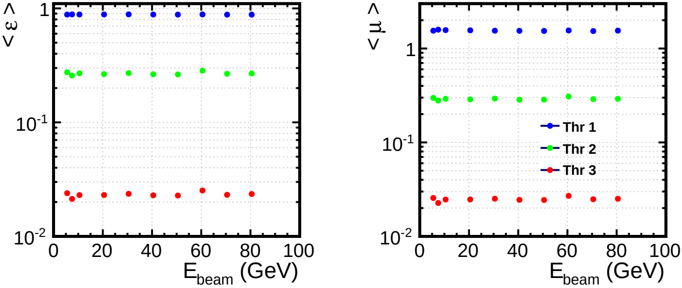
- Use muon reconstructed tracks
- Reconstruction steps
  - Hits clustering in each layer using nearest neighbor clustering
  - Center of gravity of hit on each cluster
    $\Rightarrow$ The position of cluster
  - Isolated clusters are dropped
  - Track reconstruction based on χ^2 minimization
  - Only tracks with
    - $\chi^2 < 20$
    - $N_{cluster} \leq 1$
    - $N_{hit}(cluster) < 5$
- Efficiency & multiplicity estimation
  - Efficiency = presence of at least one hit within 2 cm-radius around the projected impact point
  - Multiplicity = number of hit
  - This estimation is done for each layer using the clusters of other layers to reconstruct the track





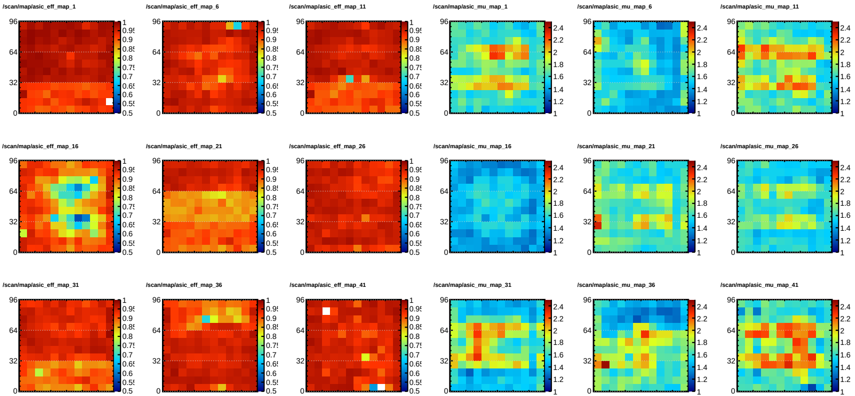
Efficiency & Multiplicity stability with muons energy

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



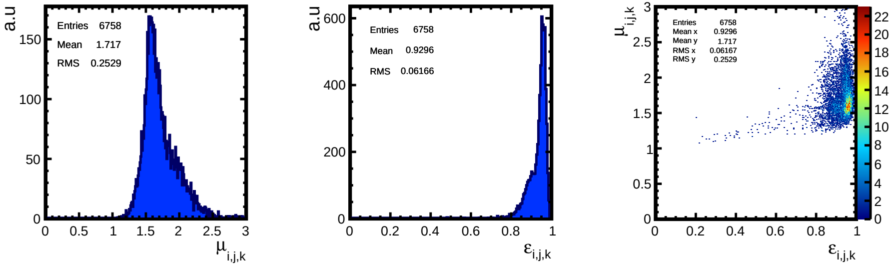
Efficiency maps/ASIC's

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



Few Systematic

- The efficiency & multiplicity distribution per ASIC's.



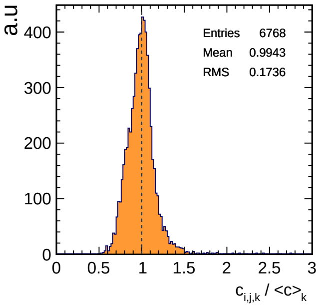
Correction Method

- The idea :
  - Use the mip's taken during the pion runs
  - Estimate the effciency and multiplicity by ASIC.
  - The correction : $c_{i,j,k} = 1/(\mu_{i,j,k} \cdot \varepsilon_{i,j,k})$
- Raw response $\rightarrow$ $R_{raw} = N_{hit}$
- Corrected response can be defined by,

$$R_{cor} = \sum_{k}^{N_{layer}} \frac{1}{<c>_k} \sum_{(i,j)}^{N_{asic}^{k}} N_{i,j,k} \cdot c_{i,j,k}$$

where $N_{i,j,k}$ number of hit in ASIC (i, j, k)

- Now we have to apply this method in pion samples.

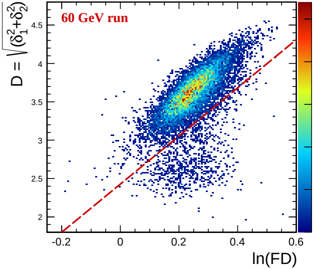


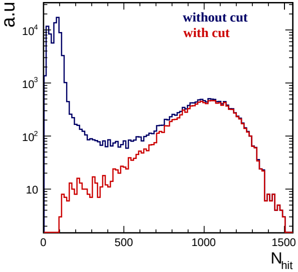
Particle identification (PID)

- Hit density
  - Local hit density $\delta^1_{i,j,k}$ = number of first neighbor hits.
    $\delta^2_{i,j,k}$ =number of first and second neighbor hits
  - Average local density : $\bar{\delta}_a = \frac{1}{N_{hit}} \sum_{i,j,k} \delta^a_{i,j,k}$
- Fractal dimension
  - $FD = \langle \frac{\ln N_\alpha}{\ln \alpha} \rangle$ with N_α number of hit at the scale α
- First interacting plate (FIP)
  - $FIP \equiv$ the first plate with $N_{hit} \geq 5$
  - 3 following plate must have $N_{hit} \geq 5$ if the FIP not found $FIP = -1 \rightarrow$ muons
- Center of gravity in each axis weighted by the hit density $cog_{a \in \{x,y,z\}}$.
- Number of fired layer N_{layer}
- shower radius
  - $R = \frac{1}{n} \sqrt{\sum_{i=0}^{n} (x_i - cog_x)^2 + (y_i - cog_y)^2}$

Basic pion selection

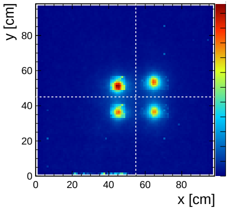
- muon rejection
  - $FIP > 0 \rightarrow$ muon rejection
  - $R > 3.5\text{cm}$ interacted muons rejection
- electron rejection & leakage reduction
  - $N_{hit}/N_{layer} > 3$
  - $D = \sqrt{((\delta_1^2 + \delta_2^2))} > 2.4 + 3 \cdot \ln(FD)$ $\rightarrow$ electron rejection
  - $cog_z < 100$ cm leakage reduction





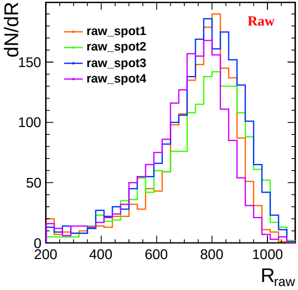
First Test

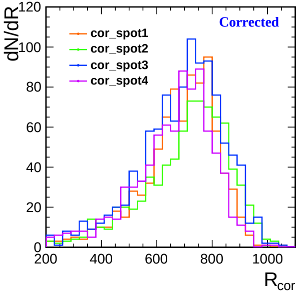
- First test of the method → May data (4 spots in the detector)
- 4 spots in the detector →



- apply the correction for pion in each spot ;

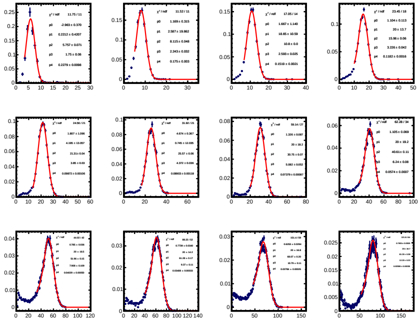
	$< R_{raw} >$	$< R_{corrected} >$
spot1	738.743	684.251
spot2	754.586	707.601
spot3	747.457	689.801
spot4	703.21	660.592
rms	19.7	16.7





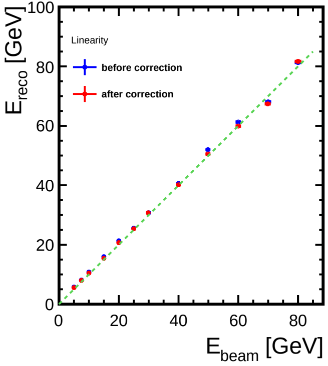
Energy reconstruction

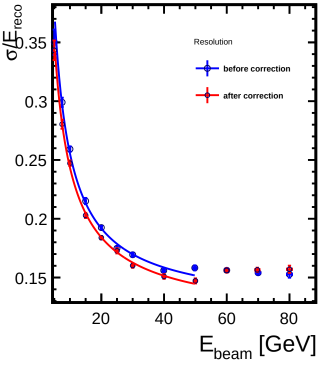
- Use only the first threshold → binary mode
- The reconstructed energy function : $E_{reco} = (C + D \cdot R) \cdot R \rightarrow R$ calorimeter response (raw and corrected)
- A χ^2 minimization over all events is used to get C and D $\chi^2 = \sum_{i}^{event} (E^i_{beam} - E^i_{reco})^2 / E^i_{beam}$
- A Crystal ball fit is applied for each energy.



Energy reconstruction

- Linearity restored for both responses.
- Energy resolution $\equiv \sigma(E)/E$ ($\sigma(E)$ = width of the Crystal-ball)





- Fit in the range $[0, 50]\mathrm{GeV} \rightarrow$ saturation effect at $E > 50\mathrm{GeV}$
- Amelioration of 6% in energy resolution.

Conclusion & perspectives

- A method for energy repose correction using mip's is proposed $\rightarrow$ Efficiency and multiplicity maps by ASIC are used.
- An improvement on the energy resolution is observed in the binary mode.
- This is a very preliminary results

Next steps ;

- Apply the same method in multi-threshold mode.

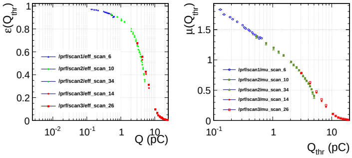
Back Up

Mips Cut Flow

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

- $N_{layer}(K < 10) \geq 5$ and $N_{layer}(K > 40) \geq 5$ (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 : $N^{j}_{hit} < 5$
- $(\Delta x^2 + \Delta y^2)^{1/2} < 2cm$ (for efficiency measurement)
- no Alignment correction !
- 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

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.

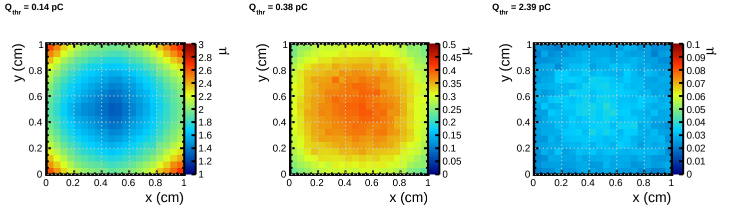
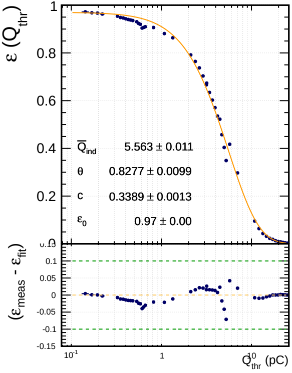


FIGURE: Distribution of the multiplicity on function of position of reconstructed on the pad.

Charge threshold scan



- The polya function can be write simply :

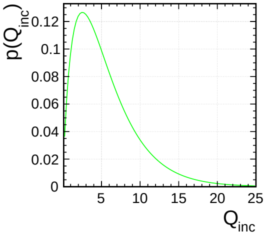
$$\mathrm{P}(q;\theta,\bar{q}) = \left(q\frac{(1+\theta)}{\bar{q}}\right)^{\theta} \exp\left\{-q\frac{(1+\theta)}{\bar{q}}\right\} \quad (1)$$

$\bar{q}$: 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),

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

ε_0 is the detector efficiency when the threshold on $0\ pC$ and c is the nor



Charge Shape measurement

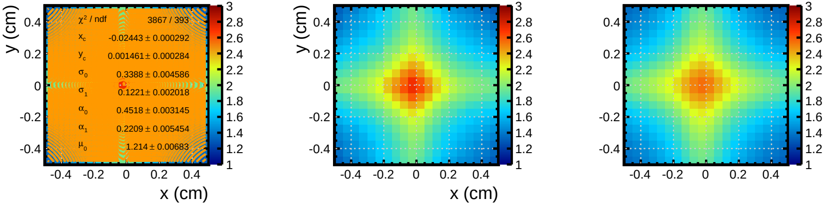


FIGURE: left : fit, middle : data ,right : fitted shape

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

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

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

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

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