Clustering and Calibration

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5x5 Clustering

- sort hits by decreasing energy
- loop on hits:
  - loop on clusters:
    - if distance(hit,cluster_center)$< 2\sqrt{2}\cdot$cell_size: add hit to cluster (and break loop)
  - if hits doesn't belong to any cluster and distance(hit,clusters_center)$> 4\sqrt{2}\cdot$cell_size: create cluster

$\rightarrow$ drawbacks:

  - cluster can be larger than 5x5
  - some hits are left out

Island Clustering

- sort hits by decreasing energy
- loop on hits:
  - loop on clusters:
    - if hit is a neighbour of the cluster: add hit to cluster
    - if hit belongs to several clusters: dispatch energy following shower profile
  - if hits doesn't belong to any cluster: create cluster
- merge neighbouring clusters depending on χ^2

$\rightarrow$ drawbacks:

- weird shape $\rightarrow$ high χ^2
- merging depends on χ^2 calculation

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- shower profile:

$$
\begin{aligned}
f(dx, dy) &= \frac{E(dx, dy)}{E_{cluster}} \\
&= \frac{a}{2\pi} \cdot (g_f(dx + 0.5, dy + 0.5) - g_f(dx + 0.5, dy - 0.5) - g_f(dx - 0.5, dy - \\
g_f(x, y) &= atan(x/b) + atan(y/b) + atan(x * y/\sqrt{b^2 + x^2 + y^2}) \\
dx, dy &= (x - x_{center})/x_{size}, (y - y_{center})/y_{size}
\end{aligned}
$$

- χ^2:

$$
\begin{aligned}
\chi^2 &= E_{cluster} \sum_{hits+surrounding\ modules} (f(dx, dy) - E_{hit}/E_{cluster})^2/\sigma^2 \\
\sigma^2 &= \alpha \cdot f(dx, dy) + (\beta_1 + \beta_2 \sqrt{E_{cluster}}) \cdot \nabla^2 f(dx, dy) + \gamma/E_{cluster}
\end{aligned}
$$

Coordinate Calculation

- Barycenter with logarithm weight:

$$\vec{r}_{cluster} = \sum_{hits} (cste + log(E_{hit}/E_{cluster}))\, \vec{r}_{hit}$$

  The constant must be adjusted depending on the minimal $E_{hit}/E_{cluster}$ allowed (weight> 0)

- χ^2 minimization (with gradient method) to fit the profile
  $\rightarrow$ not used so far in order to speed up calculations

PRoton Radius

- Not used so far (may need χ^2 minimization)

$$E_{corr} = E_{cluster} / \sum_{hits+surrounding\ modules} f(dx, dy)$$

$\rightarrow$ reject cluster if correction is too important?

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Photon Reconstruction

- Matching right and left TCounter hits
- Merging Tcounter hits from consecutive TCounters
  $\rightarrow$ "Tchannel"
- Merging Ecounter hits from consecutive ECounters
  $\rightarrow$ "Echannel"
- Matching Tchannel and Echannel
  $\rightarrow$ "ETchannel"

Calibration Algorithm

- loop on events:
  - skip bad events (stability) and events with triggers different of 1 or 2
  - get ETchannel $\rightarrow E_\gamma$ (skip if > 1)
  - get hycal clusters
  - loop on clusters:
    - skip if $n_{hit} < 3$, $E_{cluster} < 100$MeV or $\chi^2 > 100$
    - fill histogram for the cluster center module with $E_{cluster}/E_\gamma$
- fit histograms to get the mean value of gaussian $< E_{cluster}/E_\gamma >$
- adjust gains: $gain = gain / < E_{cluster}/E_\gamma >$

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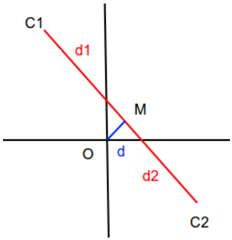
- Moller events:

- look at all pairs of clusters
- select pairs with $d < 5\text{cm}$
- select pairs with $(E_1 + E_2 - E_{beam})/E_{beam} <?$ (depending on the step of the calibration)
- for symetric Moller: $2(E_1 - E_2)/(E_1 + E_2) < 0.1$



- *ep* events: $(E_{cluster} - E_{beam})/E_{beam} <?$ depending on the step of the calibration

Calibration Algorithm

- loop on events:
  - skip bad events (stability) and events with triggers different of 1 or 2
  - get hycal clusters
  - loop on clusters:
    - skip if $n_{hit} < 3$, $E_{cluster} < 50\text{MeV}$ or $\chi^2 > 100$
    - for Moller $cluster1$: fill moller histogram for the $cluster1$ center module with $E_{cluster1} * (d1 + d2)/E_{beam}/d_2$
    - for Moller $cluster2$: fill moller histogram for the $cluster2$ center module with $E_{cluster1} * (d1 + d2)/E_{beam}/d_1$
    - for ep: fill ep histogram for the cluster center module with $E_{cluster}/E_{beam}$
- fit histograms to get the mean value of gaussian $< E_{cluster}/E_{\gamma} >$
- adjust gains: $gain = gain/ < E_{cluster}/E_{\gamma} >$