Update On Cluster Splitting
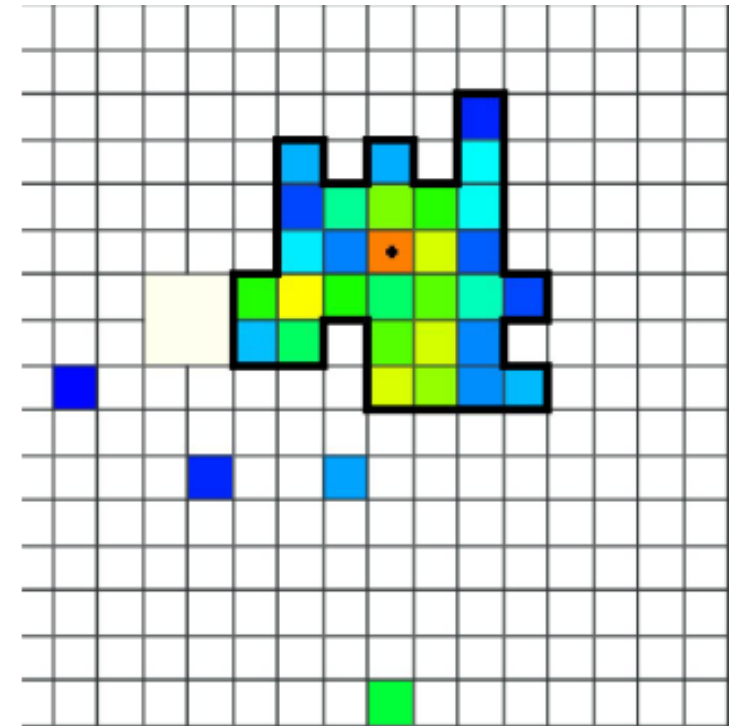
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Island Clustering

- Group all neighboring hits
  - A function to define "neighboring"
  - DFS Search algorithm to iterate all hits
  - Energy threshold for participant hits

- Find local maxima
  - A local maximum: its energy > each neighboring hit's energy
  - Energy threshold for local maximum (cluster center "seed")

Island Clustering

- Split hits group
  - According to the number of local maxima
  - Hits energy shared by every local maxima (with a certain threshold, e.g., > 5%)
  - Weight on distance and energy

- Split a group according to local maxima
  - A separate energy threshold for the center hit
  - Weight on distance and energy
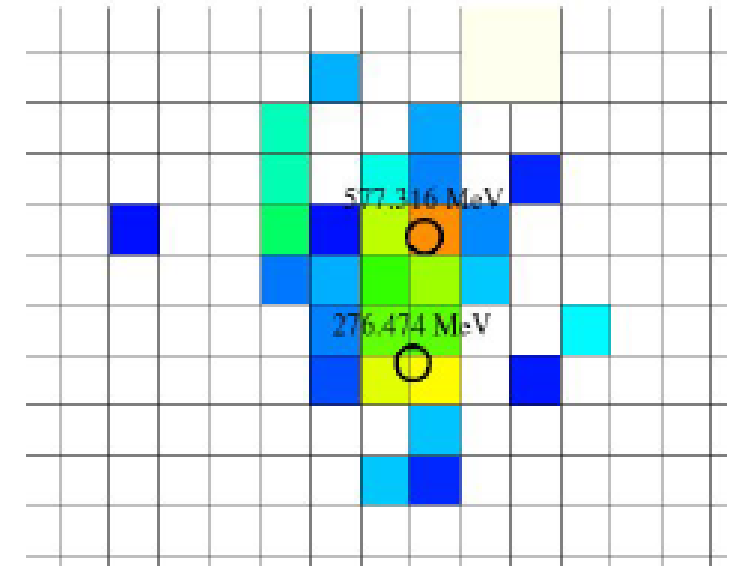
$$w_{ij} = e^{-\frac{D_{ij}}{\lambda}} \cdot E_j \qquad E_{ij} = \frac{w_{ij}}{\sum_j w_{ij}} E_i \qquad \text{For i-th hit and j-th seed}$$

Cluster Reconstruction

- Center of Gravity
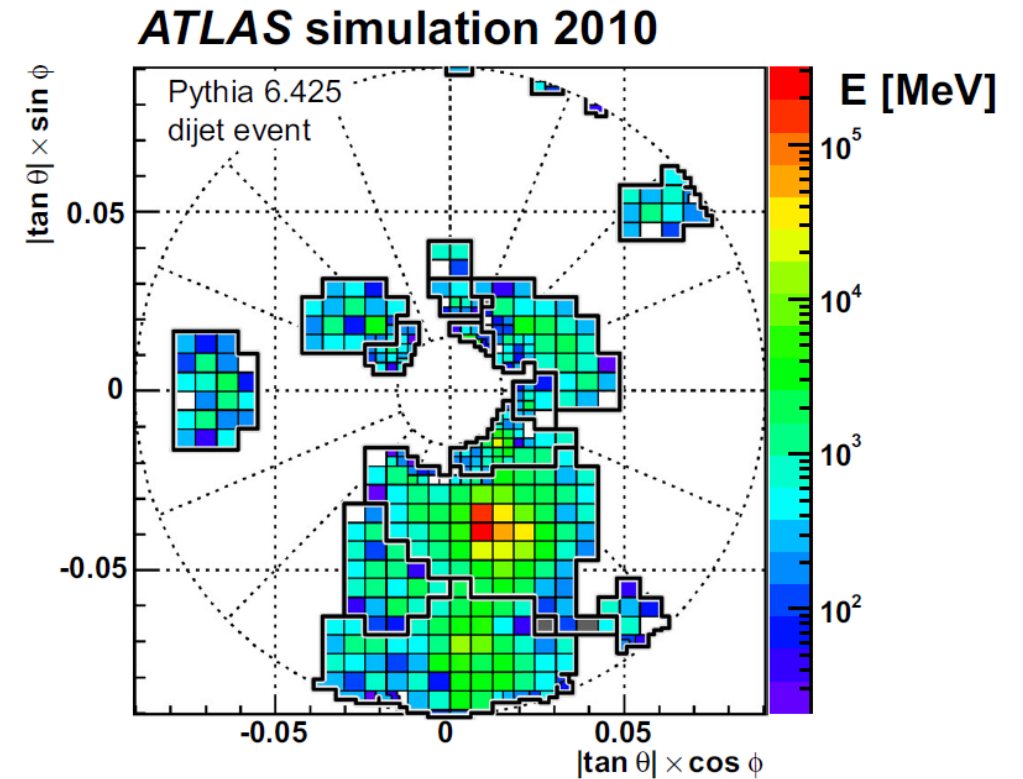 - Logarithmic weighting – approximately exponential shape of radial energy falloff

$$w_i = \max\{0,\ w_0 + \ln\left(\frac{E_i}{\sum_i E_i}\right)\}$$

  - w_0 is an effective threshold for the relative energy
  - $w_0 = 4.6$: a hit must have >1% of the cluster energy to participate in the reconstruction
  - Selecting the high energy core of a cluster to reconstruct its coordinate

Topological Cell Clustering

Aad, G., Abbott, B., Abdallah, J. *et al.* Topological cell clustering in the ATLAS calorimeters and its performance in LHC Run 1. *Eur. Phys. J. C* **77**, 490 (2017).

- Group all neighboring hits
  - Topological connected cells
  - Seeding energy threshold – S
    - as a cluster seed
  - Growth energy threshold – N
    - continue to search for neighboring hits
  - Boundary energy threshold – P
    - stop here

- Very similar to Island cluster
  - One more threshold (P) for growth control

Topological Clustering for Imaging ECal.

https://github.com/eic/EICrecon/blob/main/src/algorithms/calorimetry/ImagingTopoCluster.h

- A generalized version for Island clustering
  - Topologically connected pixels
  - Local x-y distance of pixels in the same sector and layer
  - Global eta-phi distance of pixels in the same sector but adjacent layers
  - Global x-y-z distance of pixels in different sectors

- A separate algorithm because
  - Island splitting does not work for it
  - Reconstruction is also a bit trickier (not exponential fall-off of energy deposit)
  - Still unfinished work on the optimized way for splitting and reconstruction
  - ML maybe a better solution

Ongoing Development

- A viewer script
  - Visualization is important!
  - A viewer script for imaging clusters is available from Juggler (but no splitting info added yet)
  - Pb/Sci will be similar but non-regular grids
    - Space between some layers

- Splitting algorithms
  - Dimension reduction (Imaging: 3D -> 2D, Pb/Sci: 2D -> 1D)
  - Evaluating the performance (wait for the visualization)