Machine Learning for the Cluster Reconstruction in the CALIFA Calorimeter at R³B

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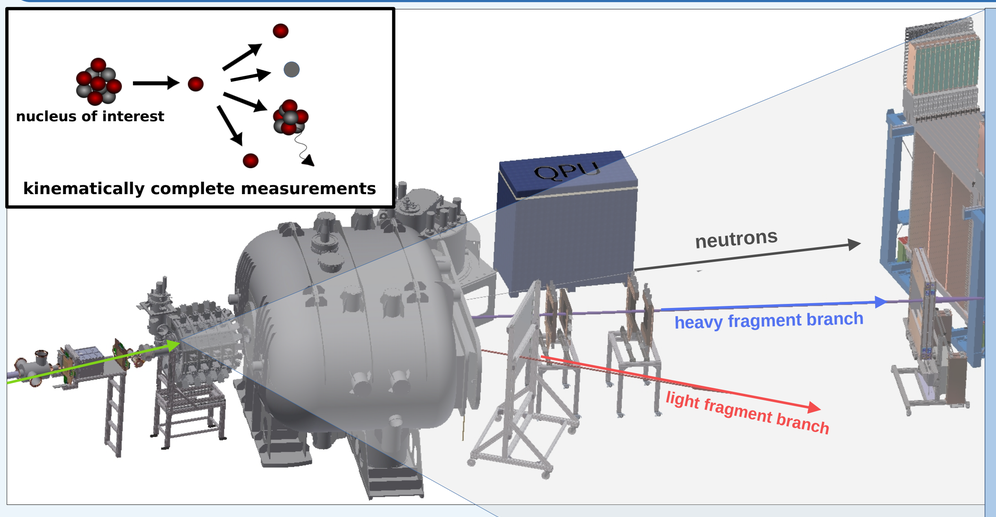
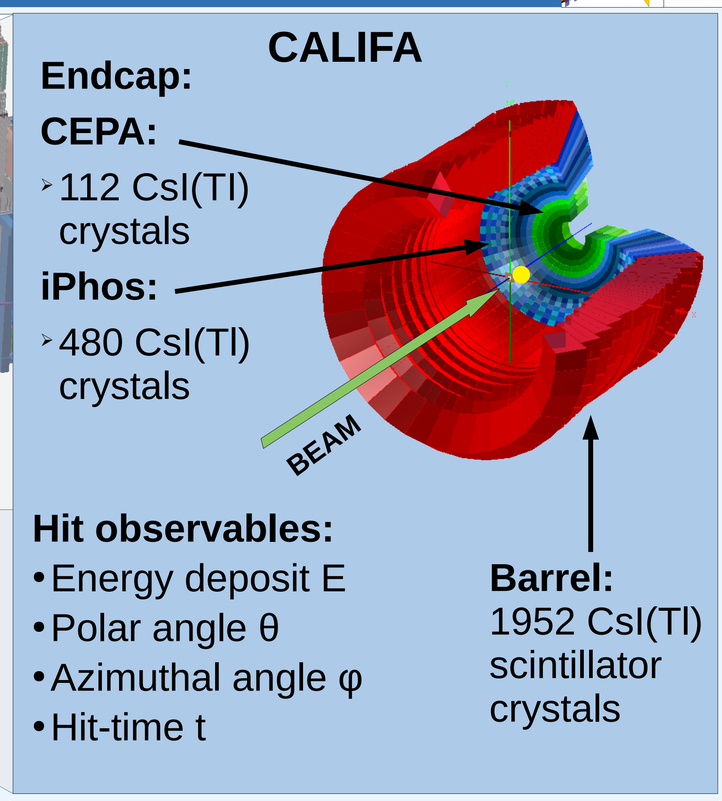
CALIFA – Detection of gammas and light charged particles @ R³B

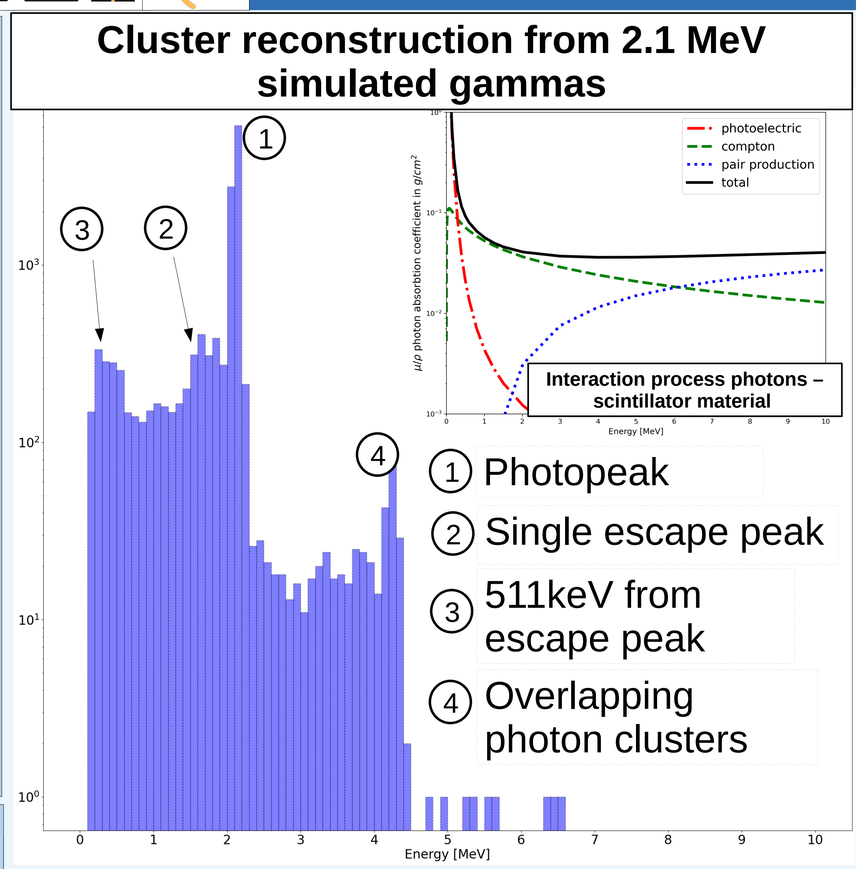


R³B - Reactions with Relativistic Radioactive Beams

- Studies of exotic nuclei far from stability
- Focus: nuclear structure and reaction dynamics

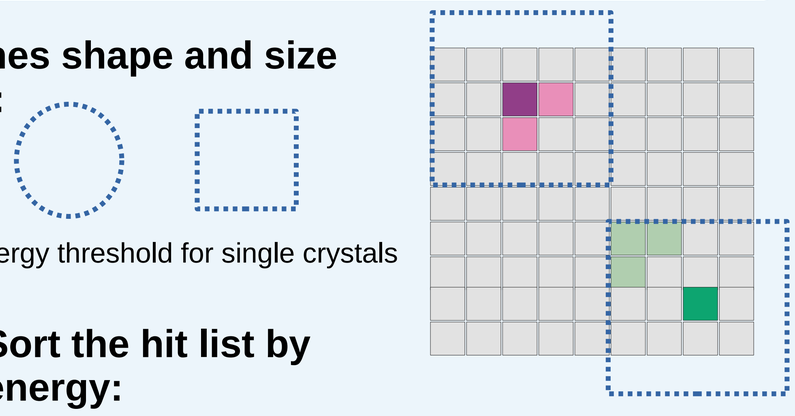


Hit observables:
- Energy deposit E
- Polar angle θ
- Azimuthal angle φ
- Hit-time t



Constant Geometry Method (CGM)

User defines shape and size of cluster:



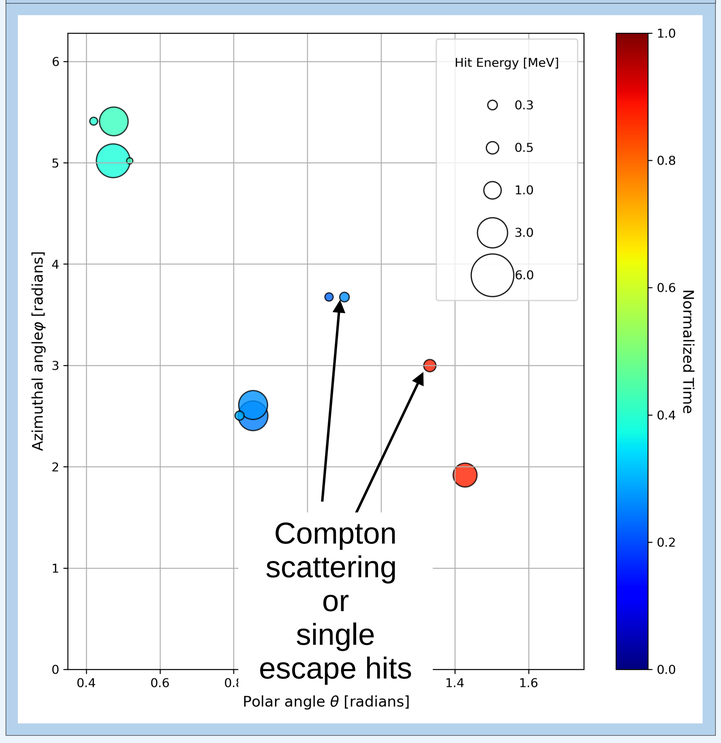
and set energy threshold for single crystals

3.1 MeV
2.2 MeV
2. MeV
1.5 MeV
0.7 MeV
0.5 MeV
0.3 MeV

Sort the hit list by energy:

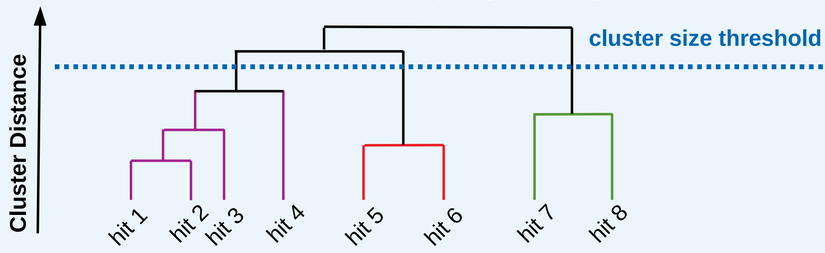
1. Create cluster centered around first hit
2. Loop over all hits in list
   - if hit inside cluster add it and remove it from the list
3. Do this procedure until list is empty

Simulated CALIFA event with three true clusters

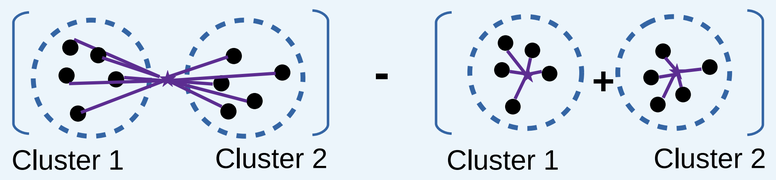


Agglomerative Clustering

Hit – time is integrated as radius
3D hit: θ,φ,r(=time)



– Ward linkage as distance measure – minimize sum of square error (SSE)



Subtract the sum of intra-cluster SSE from joint clusters SSE

Edge Detection Neural Network

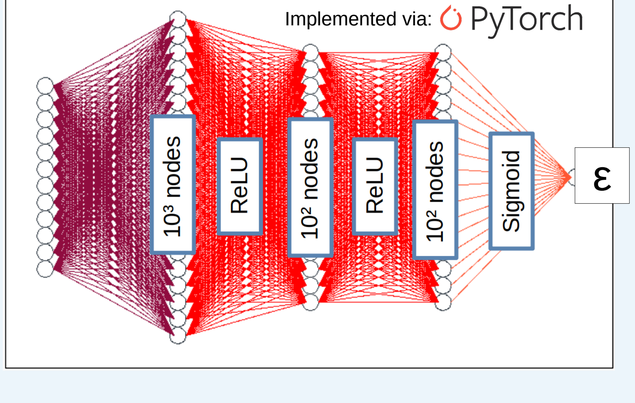
Pairwise hit comparison (i , j)

12 input features:

$E_{i,j}$, $\theta_{i,j}$, $\varphi_{i,j}$, $t_{i,j}$, ΔE_{ij}, $\Delta\theta_{ij}$, $\Delta\varphi_{ij}$, Δt_{ij}

Edge Detection NN Architecture

Implemented via: PyTorch

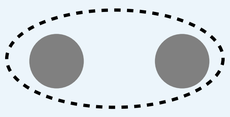


Single node output layer with score ε within [0 , 1]

If ε < merge cut

independent hits

elif ε > merge cut



merge hits

RESULTS

Various Edge Detection NN models analyzed:

- Edge model without time information
- Edge Model with time information
- R3B + Edge (without time)

  Data preclustered via Standard R3B Clustering → input into the Edge model
- Agglo + Edge (with time)

  Data preclustered via Agglomerative Clustering → input into the Edge model

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