

T. Jenegger, R. Gernhäuser for the R<sup>3</sup>B Collaboration

TUM School of Natural Sciences, Physics Department, E62, Technical University of Munich, Garching, Germany

**CALIFA – Detection of gammas and light charged particles @ R<sup>3</sup>B**

**R<sup>3</sup>B - Reactions with Relativistic Radioactive Beams**

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

**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:

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

**CALIFA**

**Endcap:** CEPA: > 112 CsI(Tl) crystals

**iPhos:** > 480 CsI(Tl) crystals

**Barrel:** 1952 CsI(Tl) scintillator crystals

**Hit observables:**

- Energy deposit E
- Polar angle  $\theta$
- Azimuthal angle  $\phi$
- Hit-time t

**Simulated CALIFA event with three true clusters**

**Cluster reconstruction from 2.1 MeV simulated gammas**

Interaction process photons – scintillator material

Legend: photoelectric (red), compton (green), pair production (blue), total (black)

Annotations: ① Photopeak, ② Single escape peak, ③ 511keV from escape peak, ④ Overlapping photon clusters

**Agglomerative Clustering**

Hit – time is integrated as radius  
3D hit:  $\theta, \phi, r(\text{time})$

cluster size threshold

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

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

**Pairwise hit comparison (i, j)**

**12 input features:**

 $E_{ij}, \theta_{ij}, \phi_{ij}, t_{ij}, \Delta E_{ij}, \Delta \theta_{ij}, \Delta \phi_{ij}, \Delta t_{ij}$ 

**Edge Detection NN Architecture**

Implemented via: PyTorch

**RESULTS**

**True positive**

**False negative**

Hit not merged into its true cluster

**False positive**

Hit incorrectly merged into a cluster

**False mixed**

Hit incorrectly merged and detached from true cluster

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
- Aggro + Edge (with time)
- Data preclustered via Agglomerative Clustering → input into the Edge model

