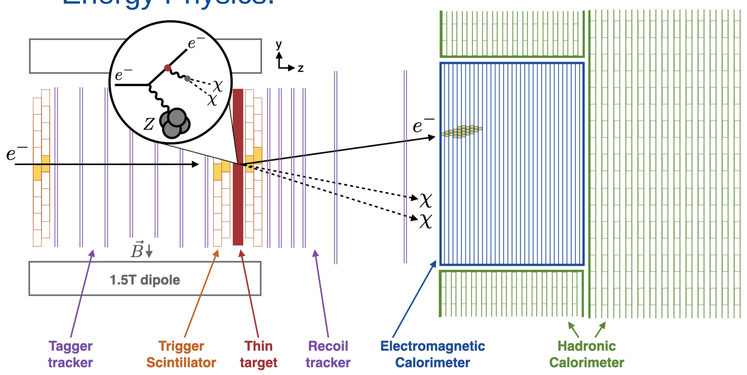
FERMILAB-POSTER-22-137-STUDENT

Clustering High-Energy Neutron Hits in the LDMX Hcal

Jonathan Rositas, University of Chicago – SULI Intern | Cristina Ana Mantilla Suarez, Fermilab

This manuscript has been authored by Fermi Research Alliance, LLC under Contract No. DE-AC02-07CH11359 with the U.S. Department of Energy, Office of Science, Office of High Energy Physics.



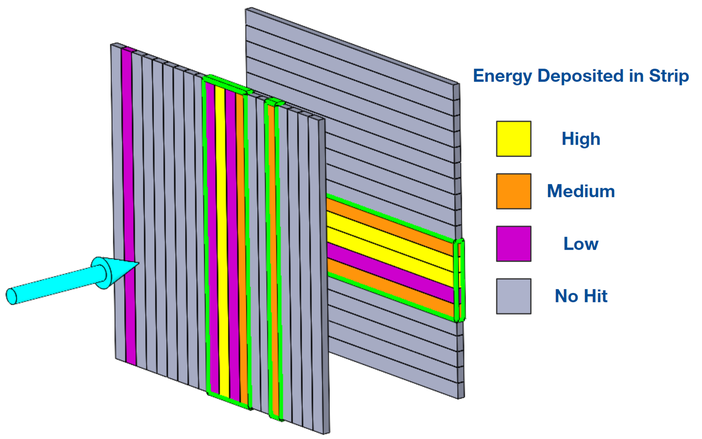


Fig. 1. Depiction of 2 Layers in the Hcal. The blue arrow points in the positive z-direction and is the direction of travel of particles as they enter the detector. Here, a 2D clustering algorithm is being used according to the following parameters:

- **Seed-Energy Threshold: Medium**
- **Neighboring Strip Energy Threshold: Low**
- **Number of Neighboring Strips: 4**

Clusters are denoted by a green border around all clustered strips.

Background

The Light Dark Matter eXperiment (LDMX) is a missing momentum search for Dark Matter (DM) at hitherto untested low energies from 0.5 MeV – 0.5 GeV.

Motivation

When neutrons interact with the Hcal, they produce a shower of particles that are detected as "hits" in the detector strips. In order to reconstruct the momentum of the parent neutron, these hits must be clustered.

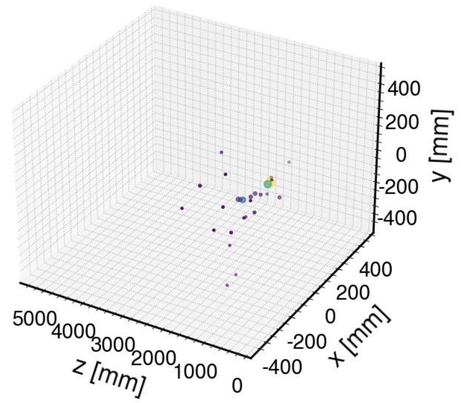


Fig. 2. 3D Plot Showing Centroids of 2D-Clusters for a single event with one 3.00 GeV Neutron.

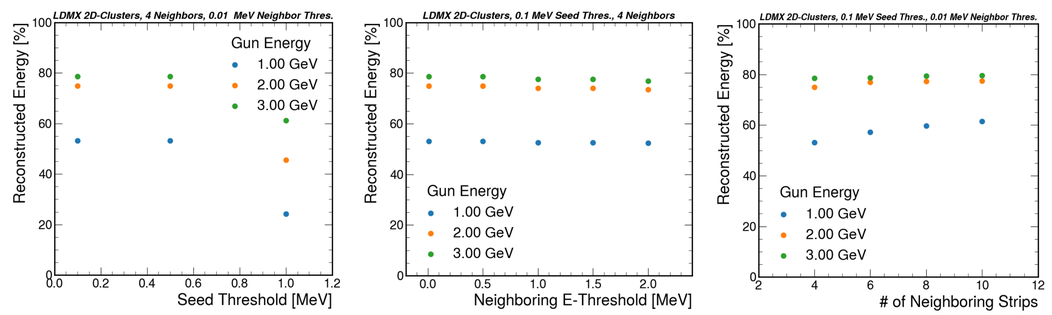
Clustering Explanation

There were 3 parameters that could be adjusted.

- **Seed Energy Threshold:** The minimum energy that must be deposited in a strip for it to be considered as a location for the clustering algorithm to begin.
- **Neighboring Strip Energy Threshold:** The minimum energy a neighboring strip must have to be included in the cluster.
- **Number of Neighboring Strips:** The number of adjacent strips that will have their energy tested for inclusion in the cluster.

Version/Parameters	Version #1	Version #2	Version #3	Version #4	Version #5
Seed Energy Threshold	0.10 MeV	0.10 MeV	0.10 MeV	0.10 MeV	0.10 MeV
Neighboring Strip Energy Threshold	0.01 MeV	0.50 MeV	1.00 MeV	0.01 MeV	0.01 MeV
Number of Neighboring Strips	4	4	4	6	8

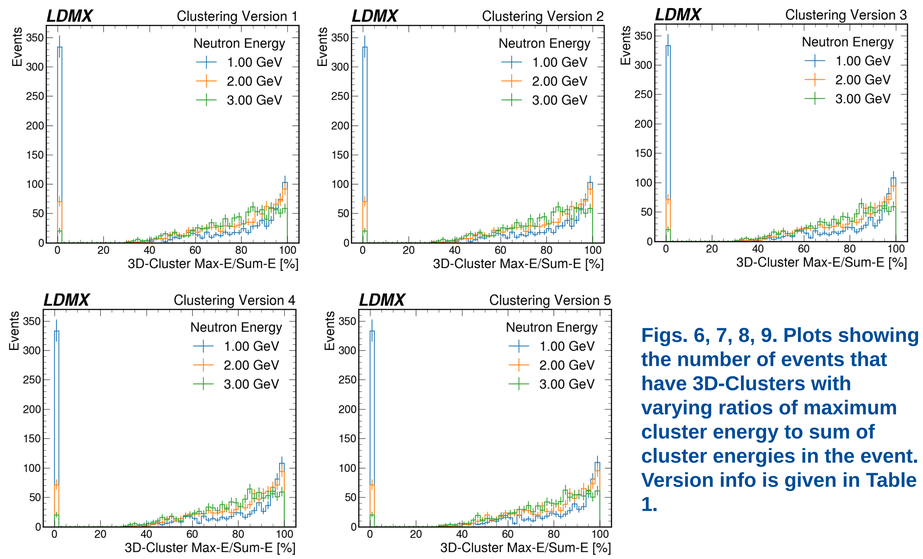
Table 1. Parameter info for first 5 versions of the clustering algorithm.



Figs. 3, 4, 5. Plots showing the percent of energy reconstructed plotted against varying parameters in the clustering algorithm. Only the parameters being plotted against varied between the versions used for each graph. Reconstructed energy percentage is determined by correcting the sum of energies for the sampling fraction, and then dividing by the energy of the gun.

Methods

Using GEANT 4 10.2, a simulation was run where neutrons of varying energies were fired at the Hcal. Plots of reconstructed energy values (figs. 3, 4, 5) and 3D-Clustering efficacy based on energy capture (figs. 6, 7, 8, 9) were generated for 10 versions.



Figs. 6, 7, 8, 9. Plots showing the number of events that have 3D-Clusters with varying ratios of maximum cluster energy to sum of cluster energies in the event. Version info is given in Table 1.

Results

Analysis of the energy reconstruction and efficacy plots indicates that a seed-energy threshold of 0.50 MeV is optimal while a neighboring energy threshold between 0.10 – 2.00 MeV has little effect on the quality of the clusters and the number of neighboring strips has a consistent positive correlation with clustering efficacy.