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.

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.

LDMX 3.00 GeV Single-Event 2d-Cluster Centroids

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.

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. 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.

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.

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

<table>
<thead>
<tr>
<th>Version/Parameters</th>
<th>Version #1</th>
<th>Version #2</th>
<th>Version #3</th>
<th>Version #4</th>
<th>Version #5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed Energy Threshold</td>
<td>0.10 MeV</td>
<td>0.10 MeV</td>
<td>0.10 MeV</td>
<td>0.10 MeV</td>
<td>0.10 MeV</td>
</tr>
<tr>
<td>Neighboring Strip Energy Threshold</td>
<td>0.01 MeV</td>
<td>0.50 MeV</td>
<td>1.00 MeV</td>
<td>0.01 MeV</td>
<td>0.01 MeV</td>
</tr>
<tr>
<td>Number of Neighboring Strips</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

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.