Visualizing TopoCluster Algorithms for the Global Trigger

Presidential Undergraduate Research Scholars Program

UNIVERSITY OF OREGON

Abstract

There is a Standard Model of particles and forces that explain the fundamental components of matter. However, this model is incomplete, seeing as we currently understand only about 5% of our universe. The Large Hadron Collider (LHC) is a particle accelerator that collides protons in the hopes of discovering new particles or forces. The LHC will undergo an upgrade in 2026 that will increase its luminosity, meaning there will be an increased number of collisions per second (up to 200 collisions every 25 nanoseconds). After this upgrade, the ATLAS trigger system will need to reduce the data by a factor of 40 within 10 microseconds, so we will need to sort out the interesting events very fast. Our group is designing an algorithm for implementation in firmware in the "Global Trigger" system for ATLAS to help select these interesting events. My research focuses on creating accurate 3-D visualizations of potential algorithms that cluster energies from particle showers in the ATLAS Calorimeters. These visualizations will help us understand the details of the performance of these algorithms.
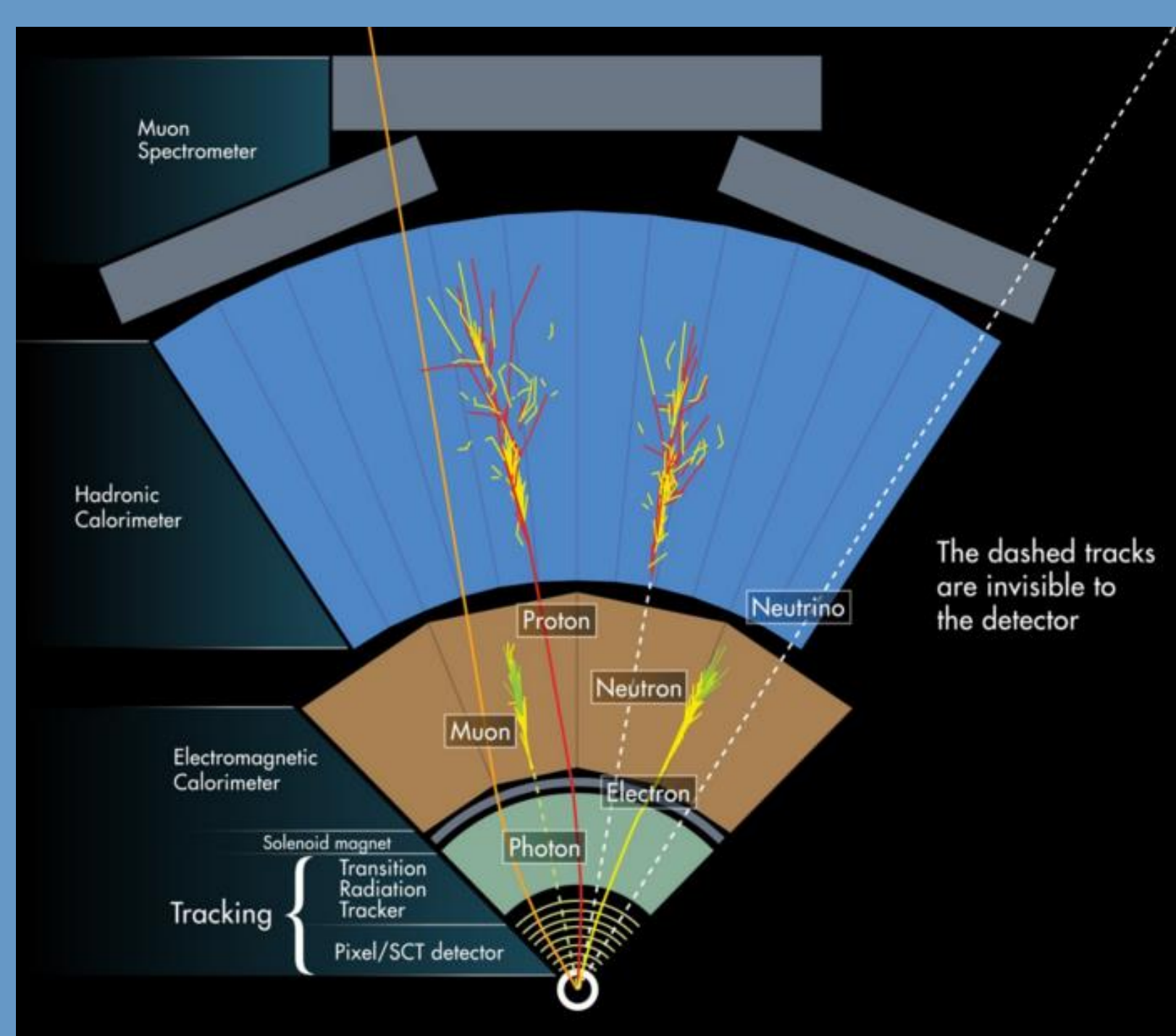
Background

- Explains the fundamental components of matter

- Standard Model of particles and forces- incomplete

- The LHC accelerates protons to near the speed of light in an attempt to fill in these missing pieces

- The LHC will undergo an upgrade that will increase its luminosity, meaning there will be up to 200 collisions every 25 nanoseconds

- The ATLAS Trigger System will need to reduce the amount of data we'll be collecting, so we need to sort out the interesting events very fast

Global Trigger

- ATLAS trigger system for Phase-2 upgrade, 2026

- Selects interesting events within 10 microseconds

- TopoCluster algorithm will help select these interesting events

TopoCluster Algorithm

- Finds cells with $|E_T| > 4\sigma$ (seeds)

- Loops around neighboring cells

- Neighbors that have $|E_T| > 2\sigma$ added to that seed's cluster

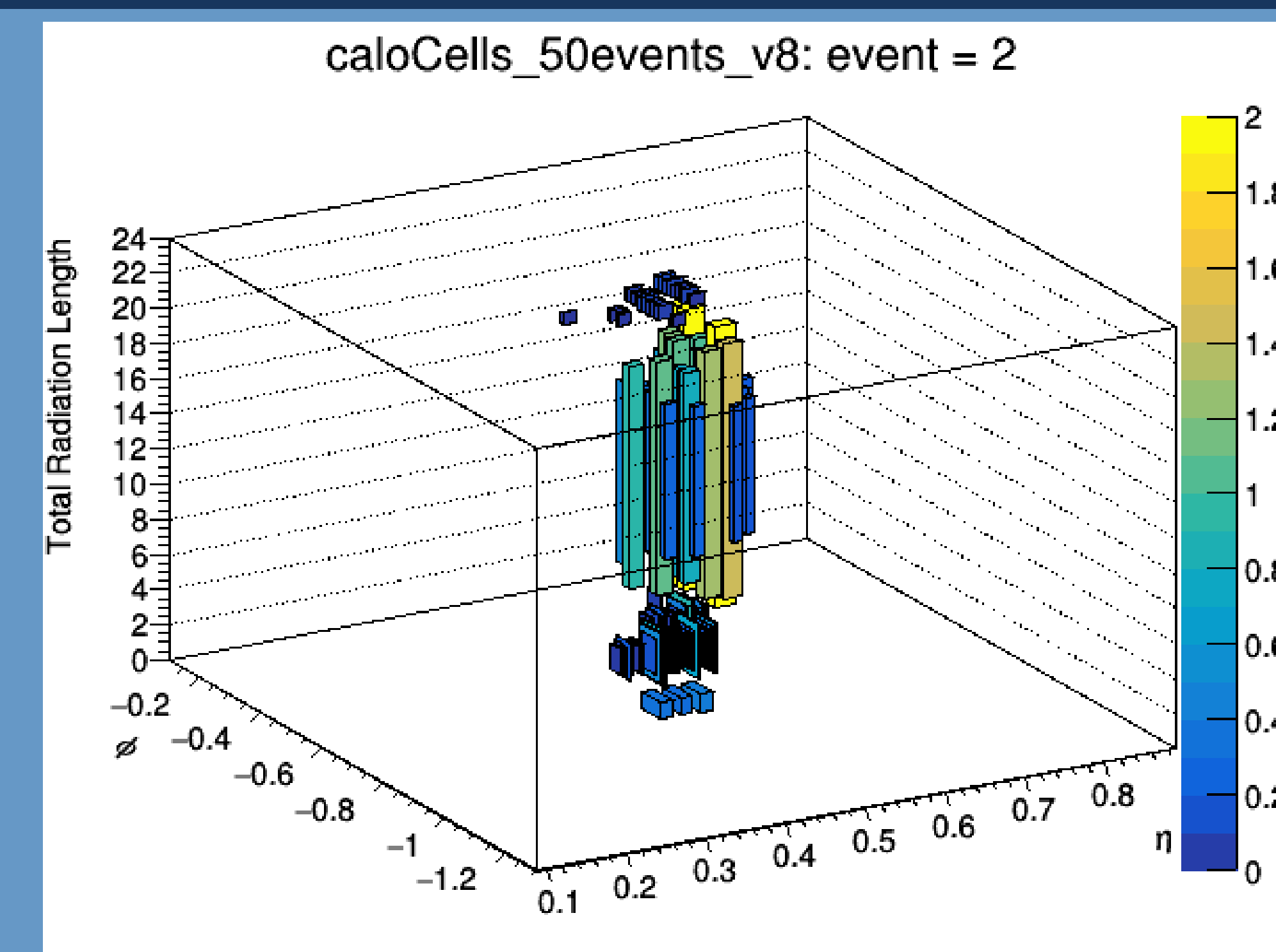- σ is the electronics and pile-up noise added in quadrature
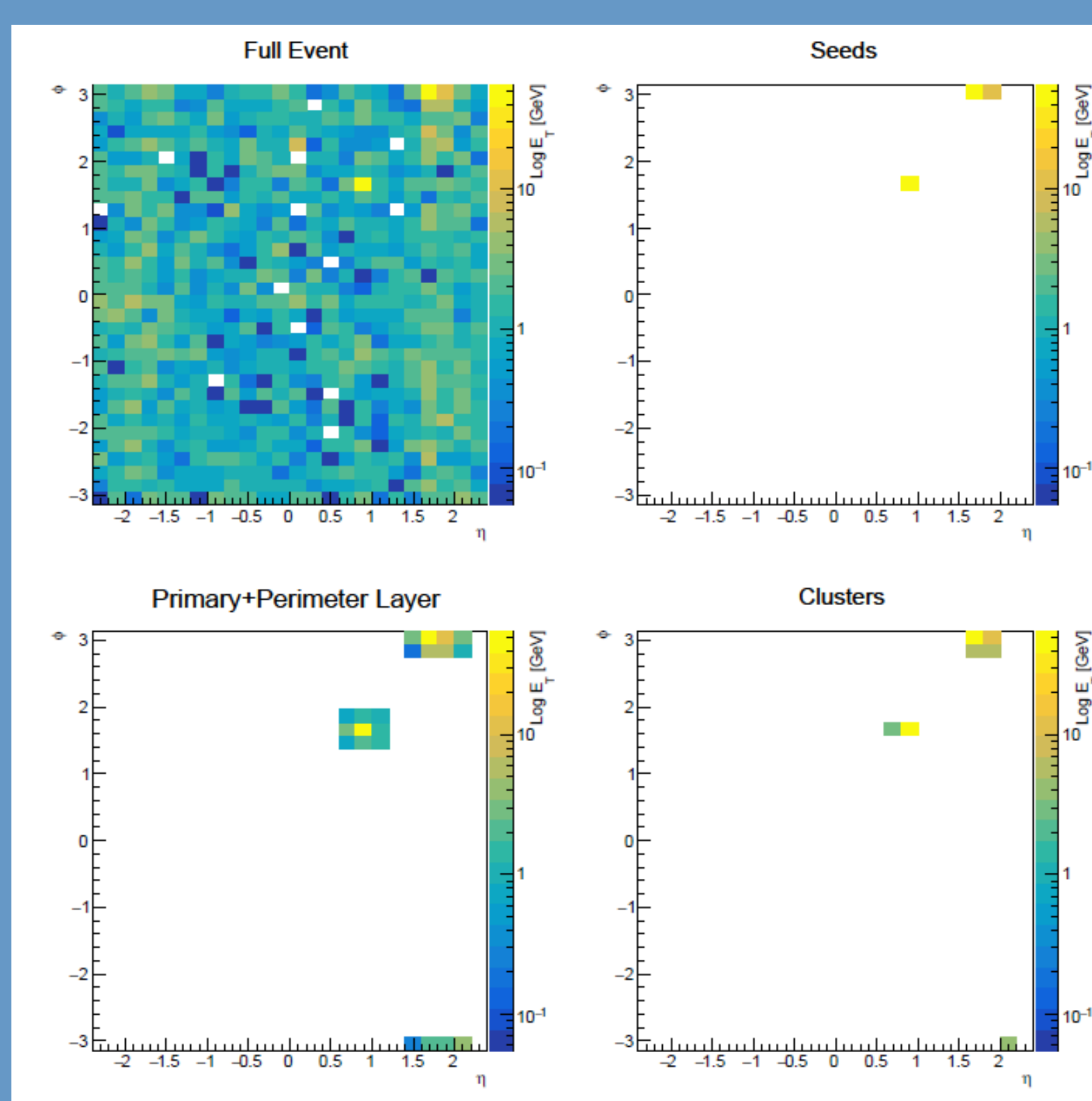
- Clustering algorithm in software, needs adjusting for firmware in trigger system
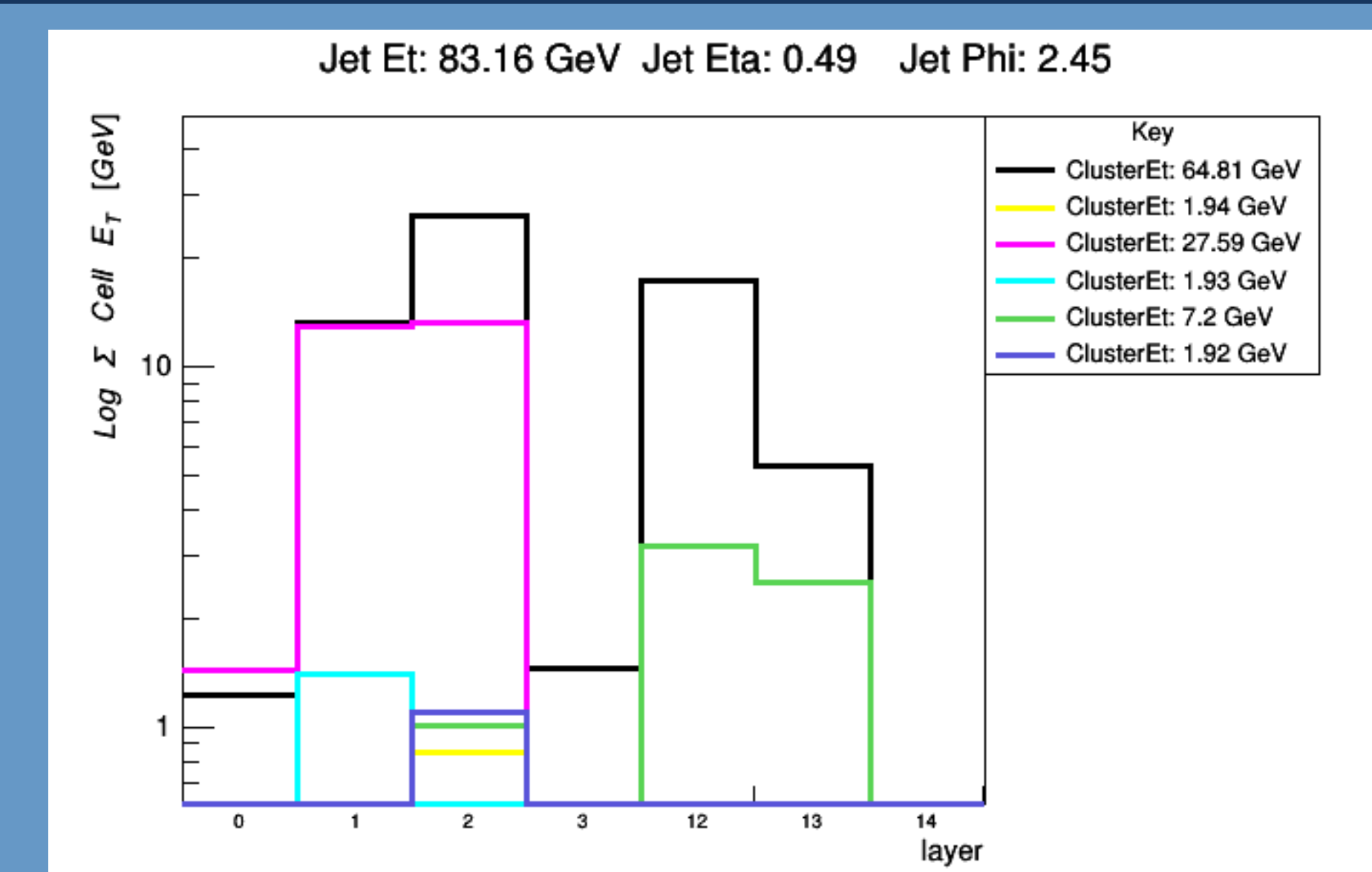
Simulated Signal Event
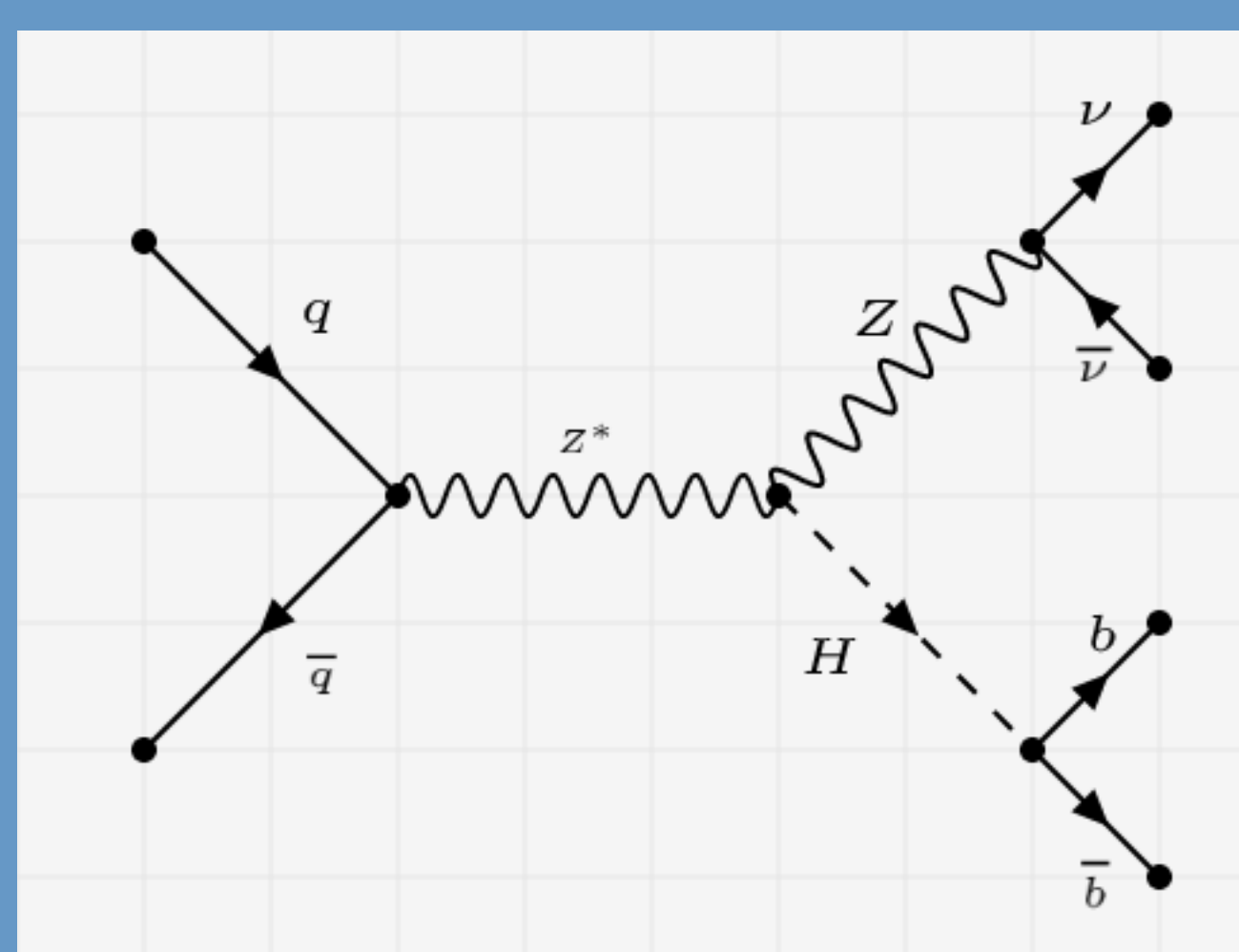
- Understanding simulated data to visualize different algorithms
- Looking at reconstructed hadronic shower from b-quark

Visualizing TopoClusters

caloCells_50events_v8: event = 2

- 3D plot of a cluster of cells in the detector's grid

- Added radiation lengths of layers for variable bins on z-axis

Splitting TopoClusters

Jet Et: 83.16 GeV   Jet Eta: 0.49   Jet Phi: 2.45

Key
- ClusterEt: 64.81 GeV
- ClusterEt: 1.94 GeV
- ClusterEt: 27.59 GeV
- ClusterEt: 1.93 GeV
- ClusterEt: 7.2 GeV
- ClusterEt: 1.92 GeV

- Current TopoCluster algorithm allows clusters to keep growing

- A dip in energy indicates we need Splitting criteria to break up larger clusters

- Will better resemble the parton shower & offline clusters

Next Steps

Investigate how to implement splitting criteria in the TopoCluster algorithm

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ATLAS EXPERIMENT