Updates on EICrecon And PCB board generation

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Gerbers scripts*

First script: GenerateLayoutH4.ipynb:

- Determines the positions of the edges of the boards
- Determines the positions of the SiPMs and centers of the cells
- Writes out to .csv files

Second script: GeneratePCB.ipynb

- Based on pcbflow library**
- Creates Gerbers files for the PCB-carrying boards
- 25 different layouts for 120 different boards (60 layers x L/R)

*https://github.com/sebouh137/InsertDesign
**https://github.com/michaelgale/pcbflow

Gerbers scripts (continued)

What's new since I last worked on this last summer/fall

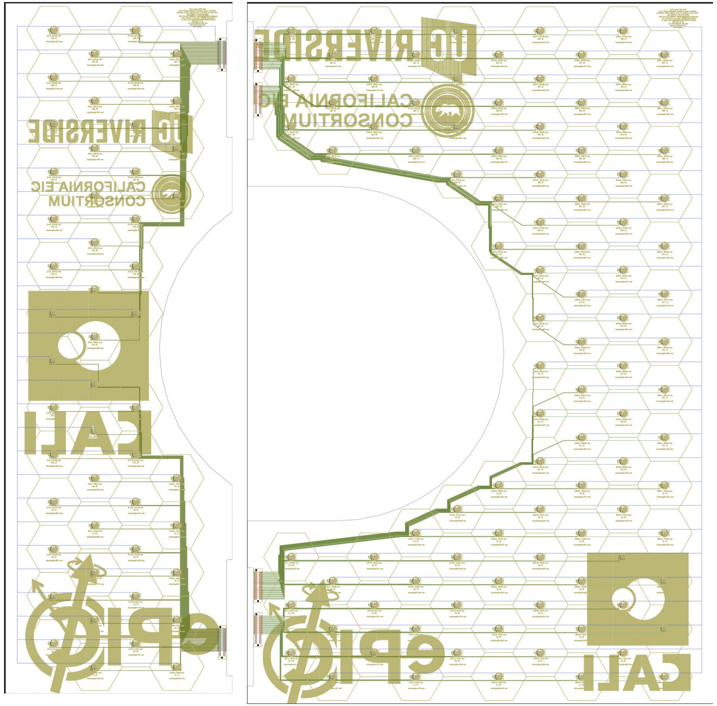
- Separated these scripts from a much larger package
- Removed the LEDs and their resistors.
- Added numbers for the lengths of the traces

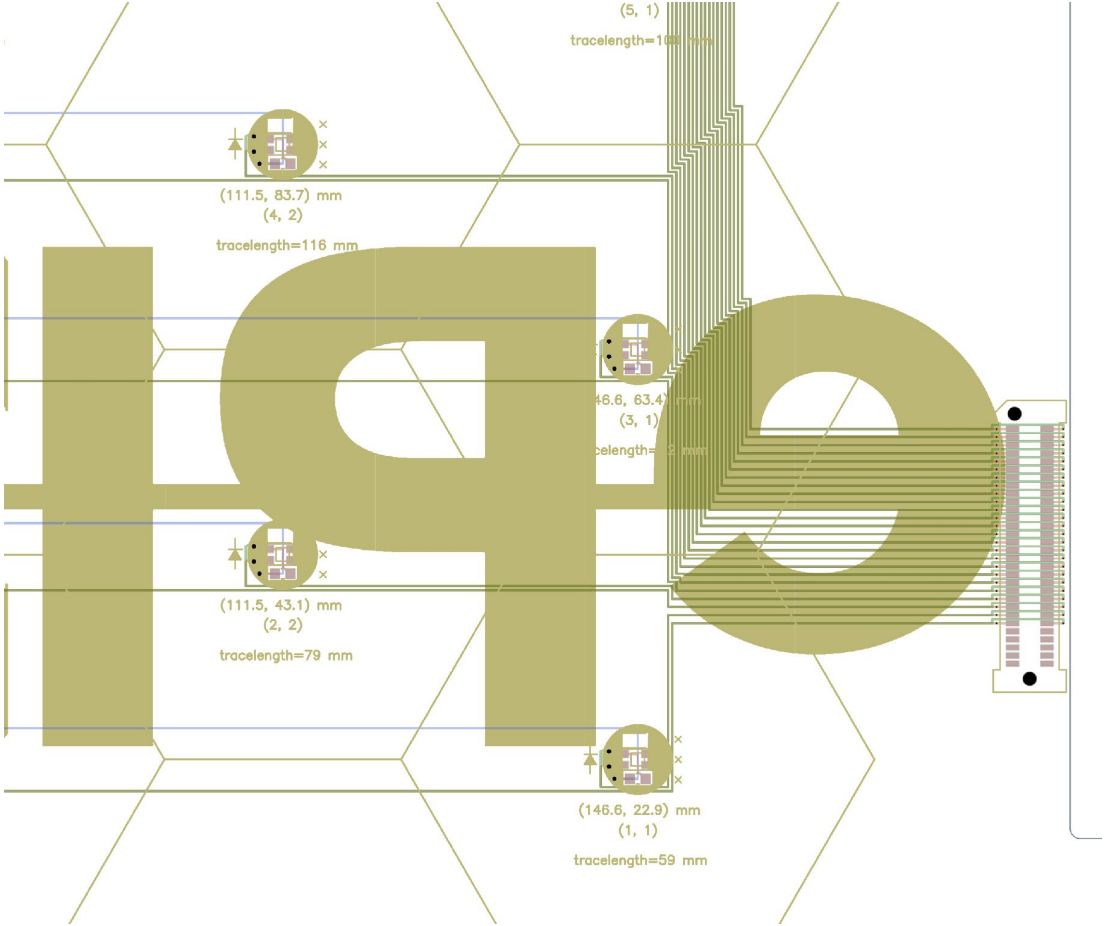
TO DO:

- Manually check that the traces don't collide with one another
  - Algorithm needs to be patched to avoid collisions in boards R1;5 and R13
- Use edgecards instead of socket connectors on the SiPM-carrying boards?

https://github.com/michaelgale/pcbflow

Gerbers Scripts





EICrecon: Lambda reconstruction in ZDC

- Added two algorithms
  - “Neutrals” reconstruction:
    - Small clusters close to the front of the detector are considered “photon” candidates
    - All other clusters are combined to form neutron candidate
  - Lambda recon:
    - Uses IDOLA algorithm* to produce reconstructed lambda and its decay products in the CM frame

Feasibility Study of Measuring $\Lambda^0 \to n\pi^0$ Using a High-Granularity Zero-Degree Calorimeter at the Future Electron-Ion Collider

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Abstract

Key measurements at the future Electron-Ion Collider (EIC), including first-of-their-kind studies of kaon structure, require the detection of Λ^0 at forward angles. We present a feasibility study of $\Lambda^0 \to n\pi^0$ measurements using a high-granularity Zero Degree Calorimeter to be located about 35 m from the interaction point. We introduce a method to address the unprecedented challenge of identifying Λ^0s with energy $O(100)$ GeV that produce displaced vertices of $O(10)$ m. In addition, we present a reconstruction approach using graph neural networks. We find that the energy and angle resolution for Λ^0 is similar to that for neutrons, both of which meet the requirements outlined in the EIC Yellow Report. Furthermore, we estimate performance for measuring the neutron's direction in the Λ^0 rest frame, which reflects the Λ^0 spin polarization. We estimate that the neutral-decay channel $\Lambda^0 \to n\pi^0$ will greatly extend the measurable energy range for the charged-decay channel $\Lambda^0 \to p\pi^-$, which is limited by the location of small-angle trackers and the accelerator magnets. This work paves the way for EIC studies of kaon structure and spin phenomena.

1. Introduction

The Electron-Ion Collider (EIC) [1] physics program will enable groundbreaking measurements of the structure of hadrons and atomic nuclei by facilitating the first-ever collisions of polarized electrons with polarized protons and light nuclei, as well as collisions involving polarized electrons and heavy nuclei. This program will be carried out using a detector system called

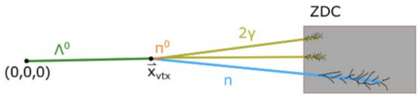
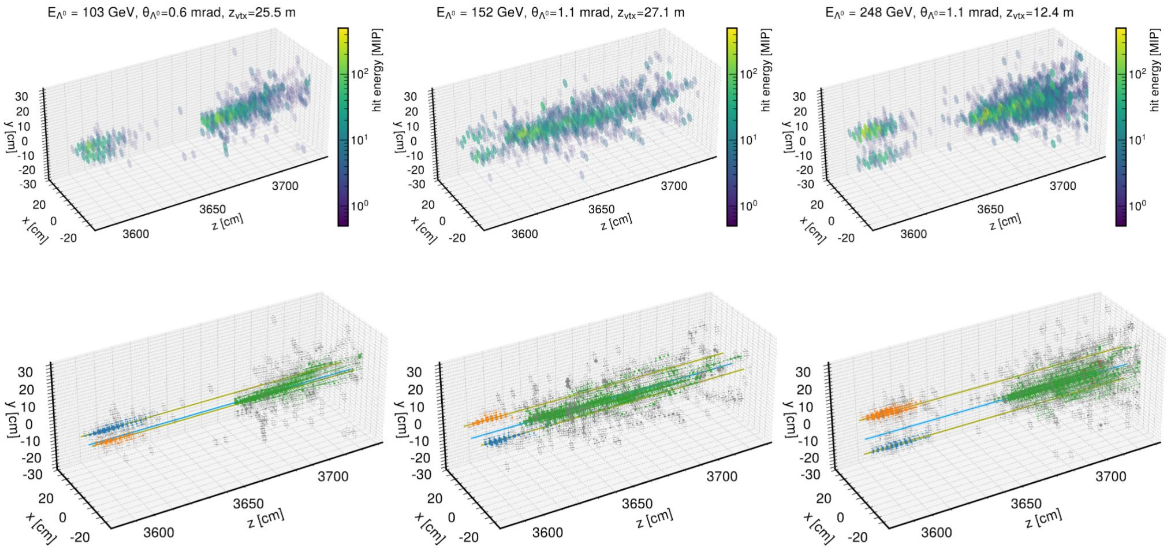


Figure 1: Topology of Λ^0 decay in neutral-channel decay. Not shown to scale.

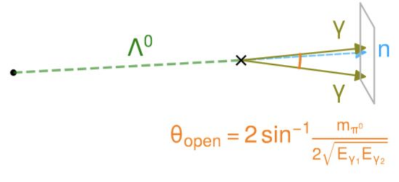
https://github.com/eic/EICrecon/pull/1731
https://arxiv.org/abs/2412.12346

EICrecon: Lambda reconstruction

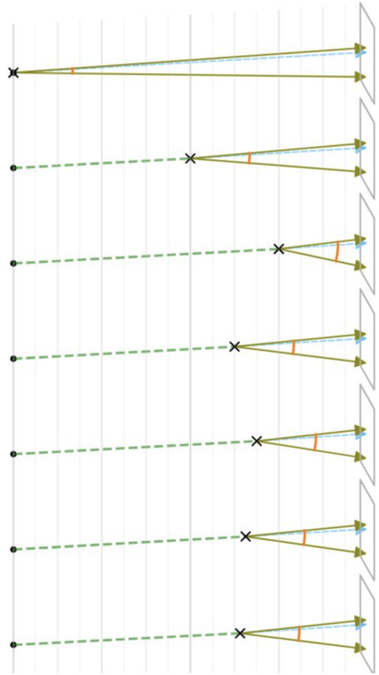


Truth event:

$f \equiv \frac{z_{vtx}}{z_{ZDC}} = 0.64$



Iter.	f
1	0.00
2	0.50
3	0.75
4	0.62
5	0.69
6	0.66
7	0.64



EICrecon: topo-clustering (in progress)

- Added functionality for string-based definitions of “neighbors”
- Example:
  - “abs(layer_1-layer_2)<=1 && abs(lx_1-lx_2)<16 && abs(ly_1-ly_2)<14”
  - No more than one layer apart from one another, and no more than 16 cm (14 cm) apart in local x or local y.
- Copied implementation of this from the existing island-clustering code into the topo-clustering code
- While testing this, I found that this is over 200x slower than using the normal method of checking for neighbors

Draft of pull request:
https://github.com/eic/EICrecon/pull/1732

EICrecon topo-clustering (continued)

- Why is it so slow?
  - Every time the algorithm checks if two hits are neighbors, it first converts the information from both hits into a mapping from strings (names of readout fields and the local position) to floats (values of those readout fields and the local position).
  - This must be done many times per event
- What can be done to fix this?
  - At initialization of the algorithms, replace variables in the string like “layer_1” with “params_1[0]”
  - Create a mapping from calorimeter hits to vectors which contain the values of readout fields, local positions, global positions, etas/phis, etc.
  - Run the string-based method on the *vectors* not on the hit objects themselves.

Summary

- Generator for Gerbers files for SiPM-carrying boards is now on github
    - Trace routing will need some tweaking to avoid collision in a few of the boards
- EICrecon functionality for lambda reconstruction in ZDC has been implemented and pull requested
- String-based neighbor determination in EICrecon needs more work to make it run within a reasonable amount of time.