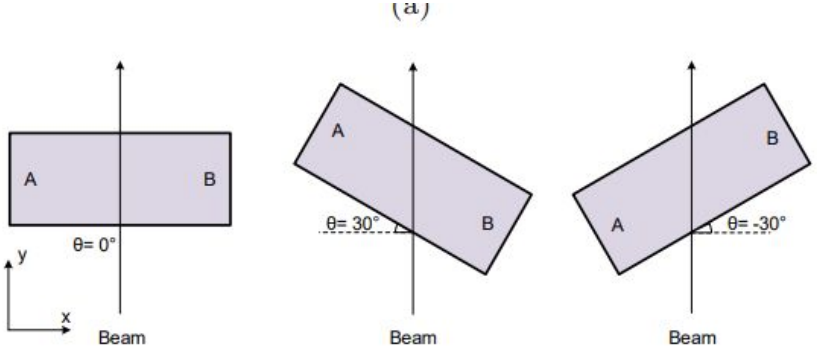
Dual Readout Testbeam simulation

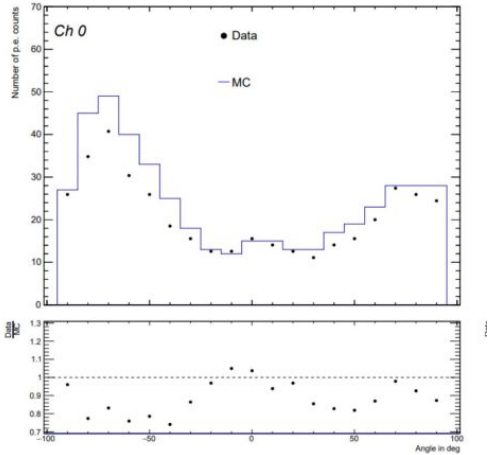
Sarah Eno
19 Dec 2024
SLAC HFCC workshop

Test beam simulation

We are building a publicly available code to do simulations of test beams and in general explore dual readout calorimetry in a stand-alone environment. The code is based in dd4hep (https://dd4hep.web.cern.ch/dd4hep), a wrapper for GEANT4. This is the official code for future colliders. Code developed here should be easy to port back and forth to the full detector simulation discussed later today by Wonyong Chung.

- First code simulated single crystals. Was developed by Mekhala Paranjpe and Sarah Eno. Used in the PbF2 paper https://www.sciencedirect.com/science/article/abs/pii/S0168900224010350
- Very useful for understanding odd angular dependence of light collection and realize the challenges of prompt light collection for Cherenkov light due to its characteristic angle
- Available at : https://github.com/Mekhpar/SingleCrystal_cosmic_ray/tree/main/compact

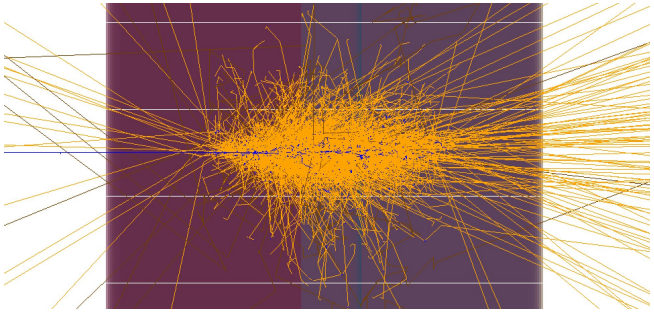


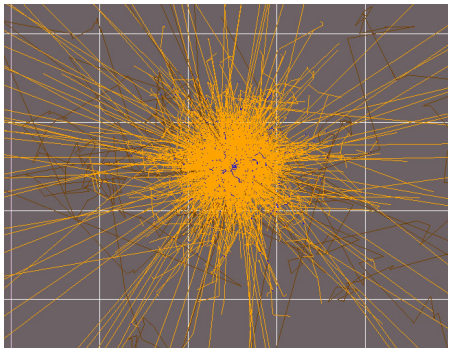


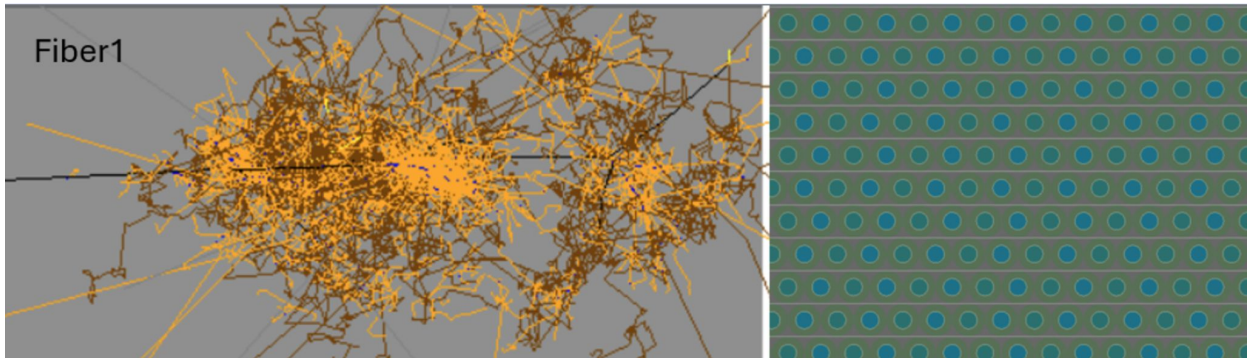
Array with HCAL

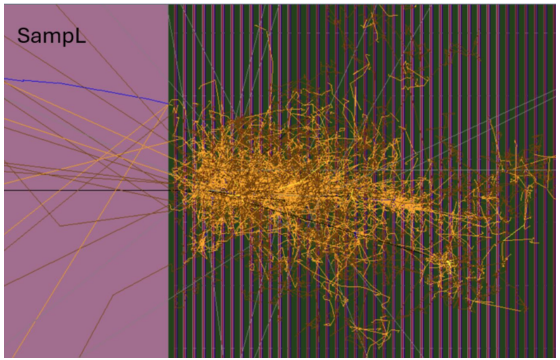
We have updated this to a flexible code allowing different configurations of HCAL + HCAL.

- ECAL currently has 2 crystal segments
- HCAL allows two options: a CMS-HCAL-like sampling calorimeter with scintillating and non-scintillating tile layers for active media and a IDEA-like fiber HCAL with scintillating and non-scintillating fibers in individual absorbers (either tube or square with circular hole).
- General user code at: gitlab
- Beta test version at: https://github.com/saraheno/DualTestBeam







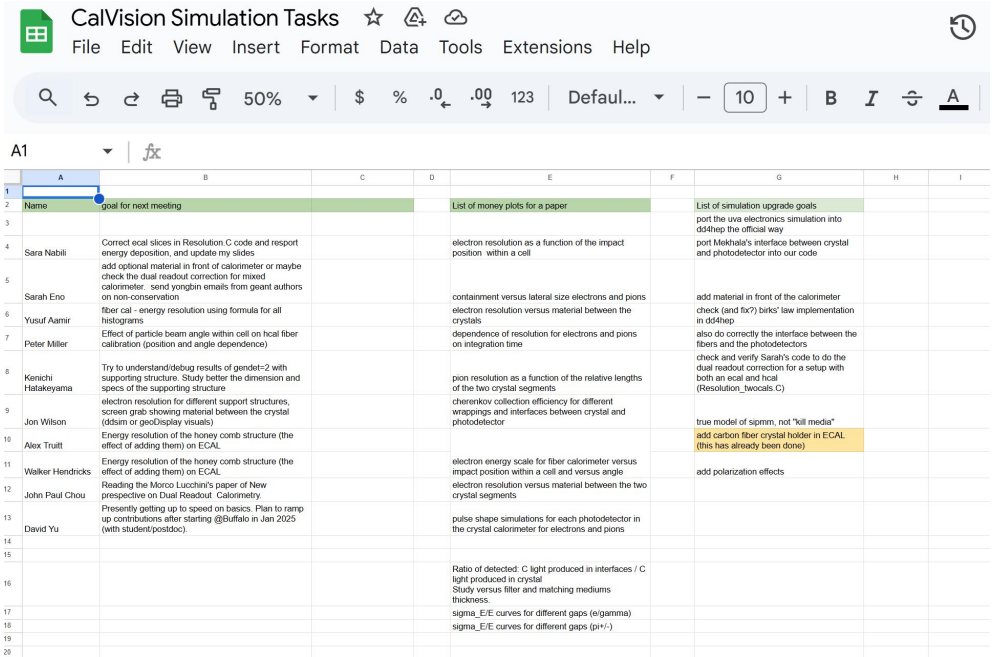


Larger team

- U. Maryland - general code development
- Baylor - ECAL optimization studies
- Rutgers - Dual readout correction for joint ECAL/HCAL test beam

Welcome to join

Working on this code can be a good first project for graduate students. We work in the “standalone simulations of ECAL plus HCAL” thread on the CalVision mattermost. We have weekly meetings, currently Fridays at 3:30 PM Eastern. We have a google sheets where we have a list of projects https://docs.google.com/spreadsheets/d/159vRkuQ4VSZwLp4ARx5AZhcYsIpUfLfnX82SNIcR_Bw/edit?usp=sharing



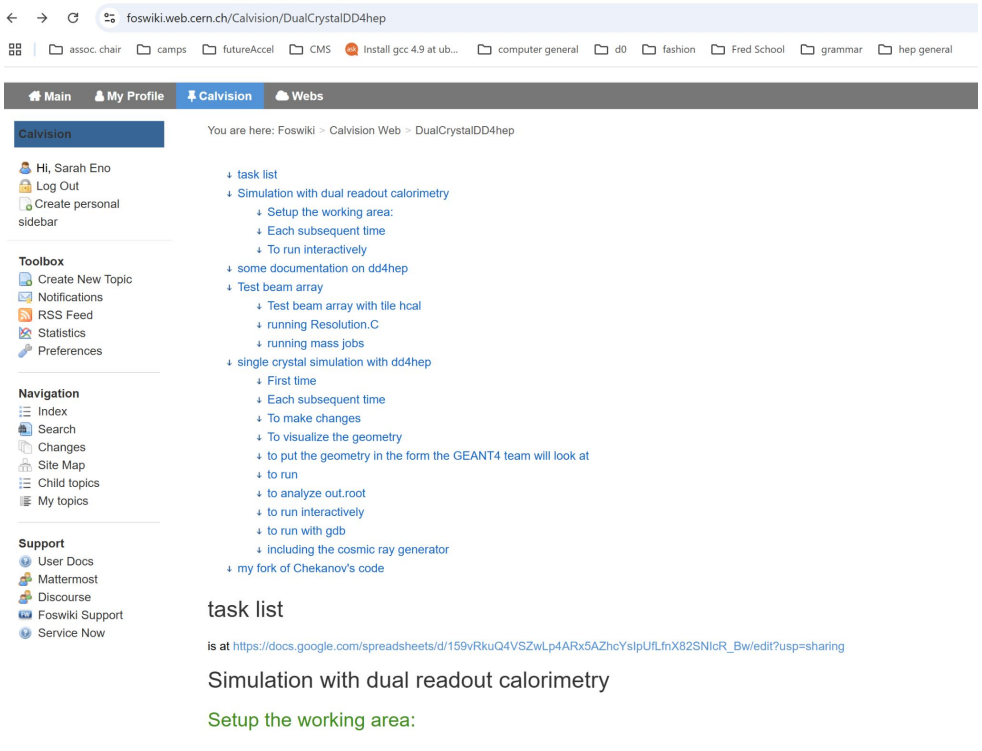
CalVision Simulation Tasks

File Edit View Insert Format Data Tools Extensions Help

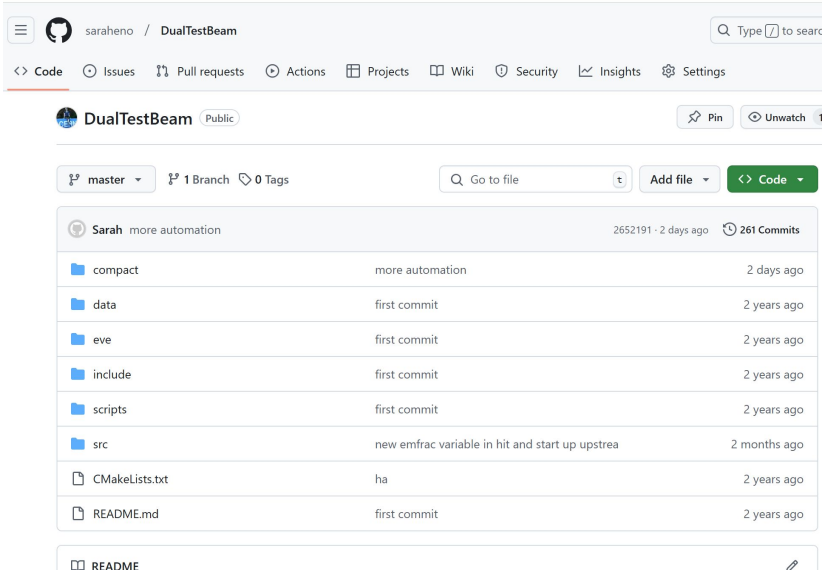
	Name	goal for next meeting	List of money plots for a paper	List of simulation upgrade goals
3				port the uva electronics simulation into dd4hep the official way
4	Sara Nabili	Correct ecal slices in Resolution.C code and resport energy deposition, and update my slides	electron resolution as a function of the impact position within a cell	port Mekhala's interface between crystal and photodetector into our code
5	Sarah Eno	add optional material in front of calorimeter or maybe check the dual readout correction for mixed calorimeter. send yongbin emails from geant authors on non-conservation	containment versus lateral size electrons and pions	add material in front of the calorimeter
6	Yusuf Aamir	fiber cal - energy resolution using formula for all histograms	electron resolution versus material between the crystals	check (and fix?) birks' law implementation in dd4hep
7	Peter Miller	Effect of particle beam angle within cell on hcal fiber calibration (position and angle dependence)	dependence of resolution for electrons and pions on integration time	also do correctly the interface between the fibers and the photodetectors
8	Kenichi Hatakeyama	Try to understand/debug results of gendet=2 with supporting structure. Study better the dimension and specs of the supporting structure	pion resolution as a function of the relative lengths of the two crystal segments	check and verify Sarah's code to do the dual readout correction for a setup with both an ecal and hcal (Resolution_twocals.C)
9	Jon Wilson	electron resolution for different support structures, screen grab showing material between the crystal (ddsim or geoDisplay visuals)	cherenkov collection efficiency for different wrappings and interfaces between crystal and photodetector	true model of sipmm, not "kill media"
10	Alex Truitt	Energy resolution of the honey comb structure (the effect of adding them) on ECAL		add carbon fiber crystal holder in ECAL (this has already been done)
11	Walker Hendricks	Energy resolution of the honey comb structure (the effect of adding them) on ECAL	electron energy scale for fiber calorimeter versus impact position within a cell and versus angle	add polarization effects
12	John Paul Chou	Reading the Morco Lucchini's paper of New prespective on Dual Readout Calorimetry.	electron resolution versus material between the two crystal segments	
13	David Yu	Presently getting up to speed on basics. Plan to ramp up contributions after starting @Buffalo in Jan 2025 (with student/postdoc).	pulse shape simulations for each photodetector in the crystal calorimeter for electrons and pions	
14				
15				
16			Ratio of detected: C light produced in interfaces / C light produced in crystal Study versus filter and matching mediums thickness.	
17			sigma_E/E curves for different gaps (e/gamma)	
18			sigma_E/E curves for different gaps (pi+/-)	
19				
20				

Getting started

Instructions on getting started can be found at:
https://foswiki.web.cern.ch/Calvision/DualCrystalDD4hep



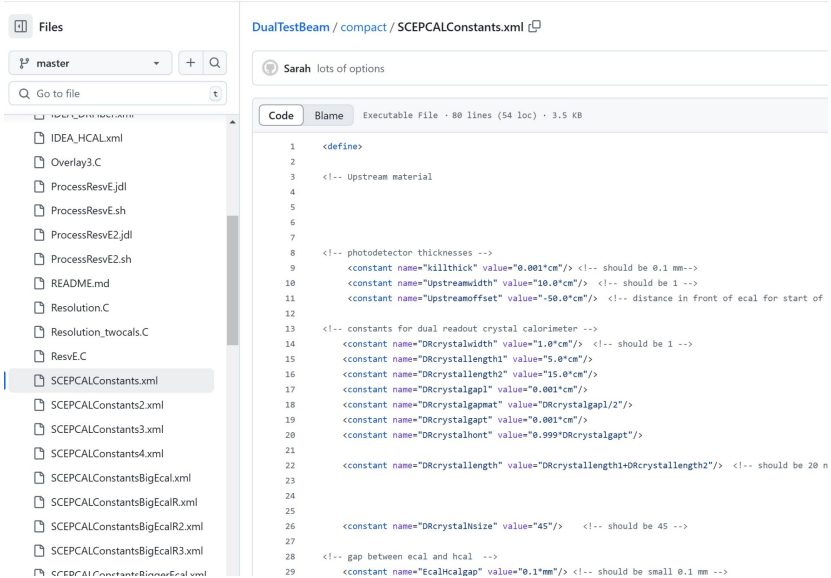
Code structure



The xml files that contain much of the geometry information, code for analyzing the data, and scripts for running the jobs are in “compact”.

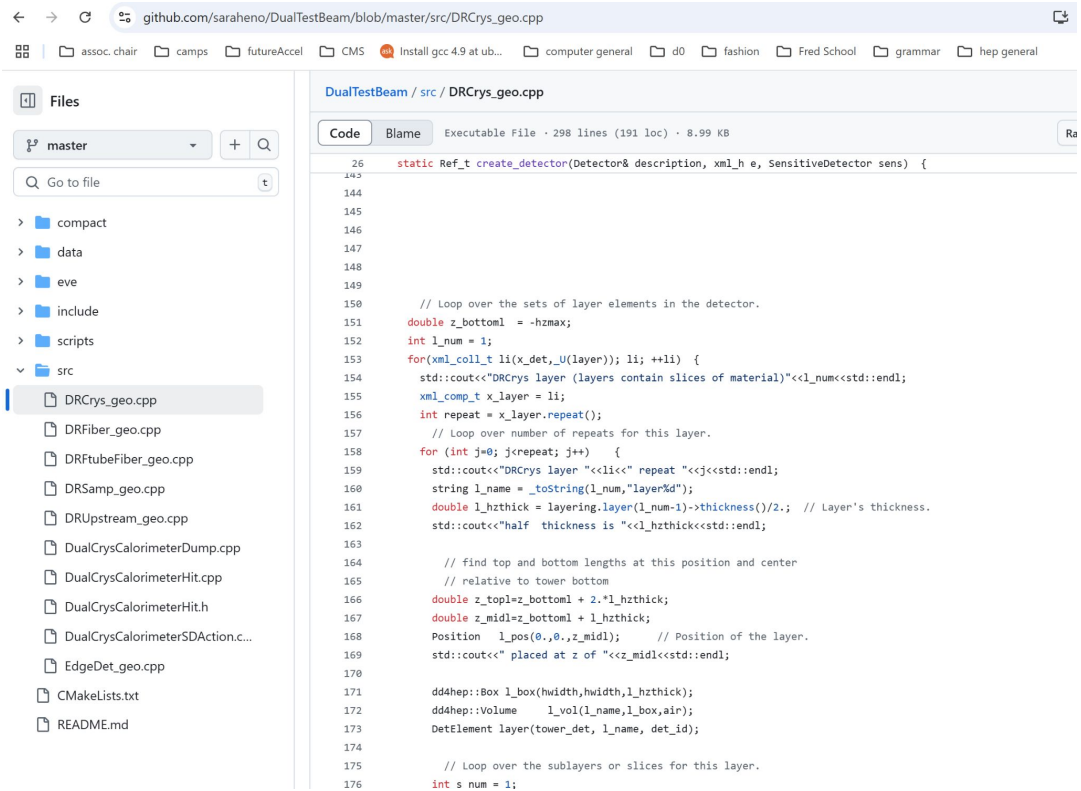
The C++ code that actually builds the detectors is in “src”

Most geometry in 2 xml files, rest in code



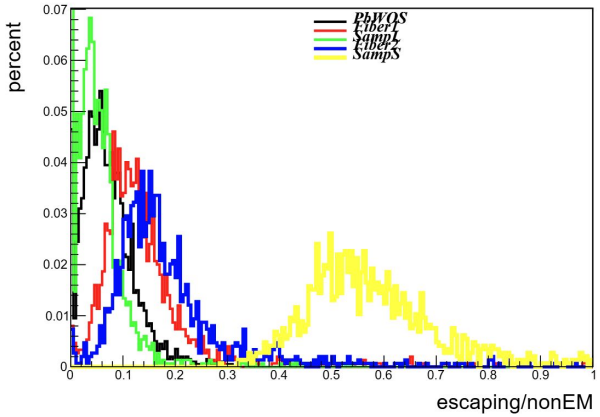
Code structure

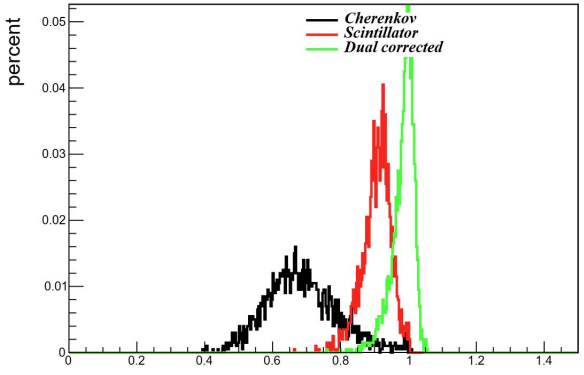
- src
  - DRCrys_geo.cpp
  - DRFiber_geo.cpp
  - DRFtubeFiber_geo.cpp
  - DRSamp_geo.cpp
  - DRUpstream_geo.cpp
  - DualCrysCalorimeterDump.cpp
  - DualCrysCalorimeterHit.cpp
  - DualCrysCalorimeterHit.h
  - DualCrysCalorimeterSDAction.c...
  - EdgeDet_geo.cpp

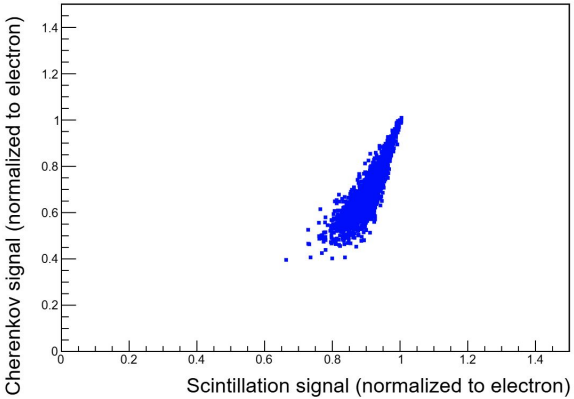


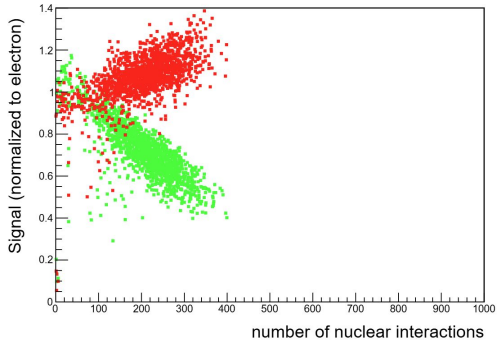
Resolution.C

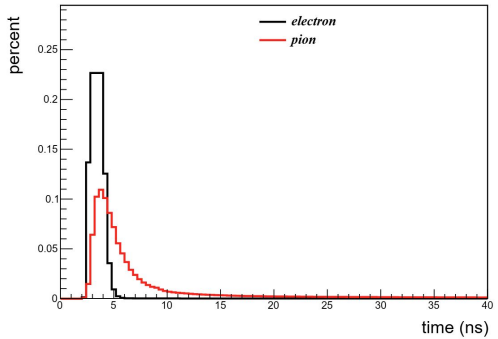
Makes a wide variety of relevant plots (some examples)

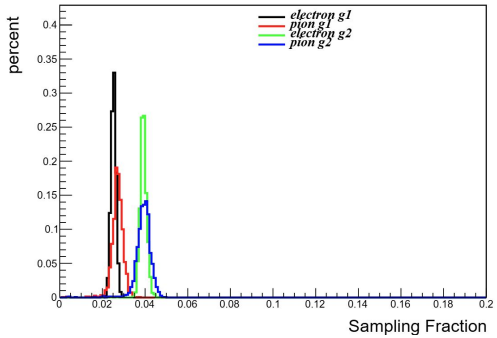












Most pressing needs

- Proper interface between crystal and photodetectors (port from single crystal code)
- Proper simulation of electronics (port from stand alone code by Ledoskoy et al)
- Proper Dual correction implementation for joint calorimeter

Conclusions

- We have a nice sandbox for playing with dual readout calorimetry
- However it still needs development to be ready to be an accurate simulation to help us understand and optimize our array test beam, both with and without a backin HCAL
- dd4hep does have a pretty high entry barrier, but coming to our meetings and working with our team can help overcome this.