



Task 12.5: Particle Flow Reconstruction

John Back



on behalf of the Task 12.5 institutes

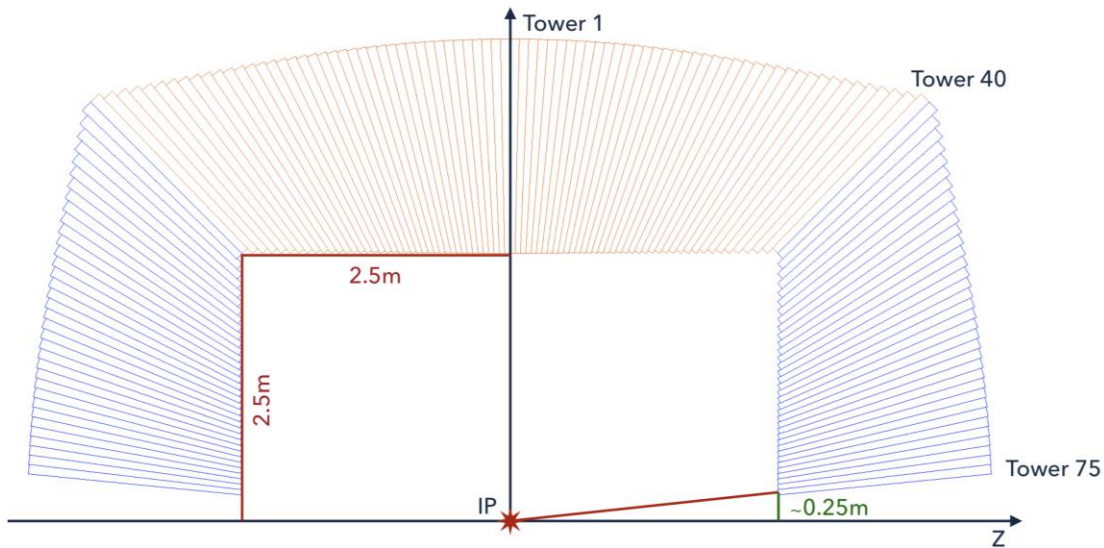
24th June 2021

Updates

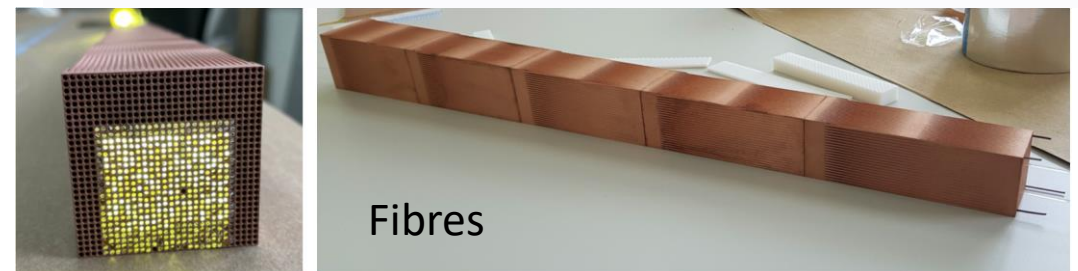
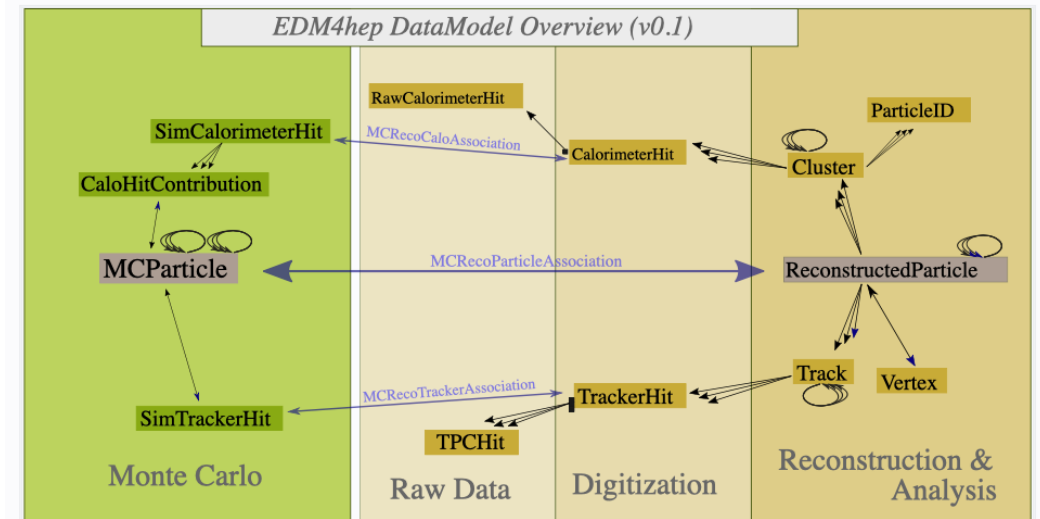
- Dual Readout Calorimeters: simulation & digitisation
 - I. Vivarelli (Sussex), B. Di Micco (INFN Roma-3), S. Vallecorsa (CERN)
- ILC Calorimeters: timing & digitisation
 - G. Grenier (CNRS-IP2I), V. Boudry (CNRS-LLR)
- DUNE Near Detector simulation & reconstruction
 - J. Marshall & J. Back (Warwick), M. Uchida (Cambridge)

Integration of Dual Readout (IDEA) Calorimeter with EDM4hep

- [EDM4hep](#) : **event data model** for Future Circular Collider and Circular Electron Positron Collider frameworks
- **IDEA** (Innovative Detector for Elec-Pos Accelerator) dual readout simulation is routinely producing EDM4hep output
 - [Git IDEA_CALO_FIBER/tree/EDM4HEP](#) simulation code branch includes relevant dependencies
- In parallel, a [digitisation model](#) to include SiPM response from incoming fibre light (**SimSiPM**) was developed by E. Proserpio
 - See talk in <https://indico.cern.ch/event/979160>
- Sensitive elements: **scintillation & Cherenkov** fibres read by SiPM

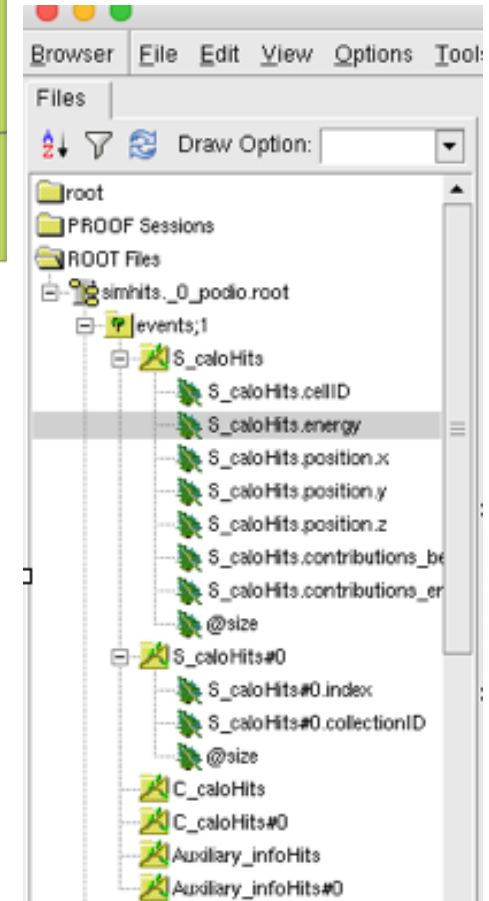
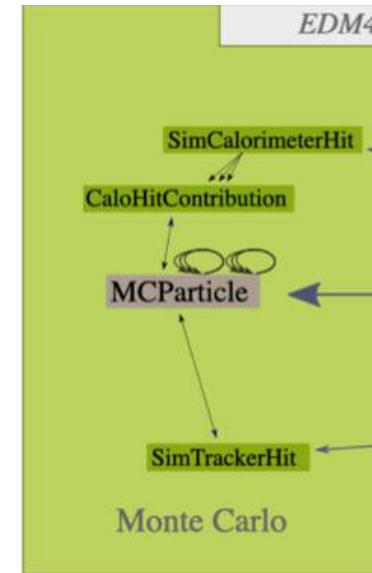


Sketch of single slice of IDEA calorimeter



IDEA calorimeter event simulation

- **SimCalorimeterHit** = 1 fibre (with at least 1 photon)
 - Position, energy (number of photons), list of hit contributions
- **CaloHitContribution** = individual hit
 - Position, energy, photon time of arrival to SiPM
 - Arrival time estimated from global G4 hit time & distance to SiPM
 - 2.8 ns decay time for polystyrene added for scintillation fibre
- Write 2 **SimCalorimeterHit** containers: Scintillation & Cherenkov signals
- Auxiliary container contains information about leakage, total deposited energy etc.



IDEA calorimeter digitisation

- **SimSiPM digitisation code:**

- <https://github.com/EdoPro98/SimSiPM>

- **DRCalo**: fully integrated software package, providing simulation, digitisation and preliminary reconstruction

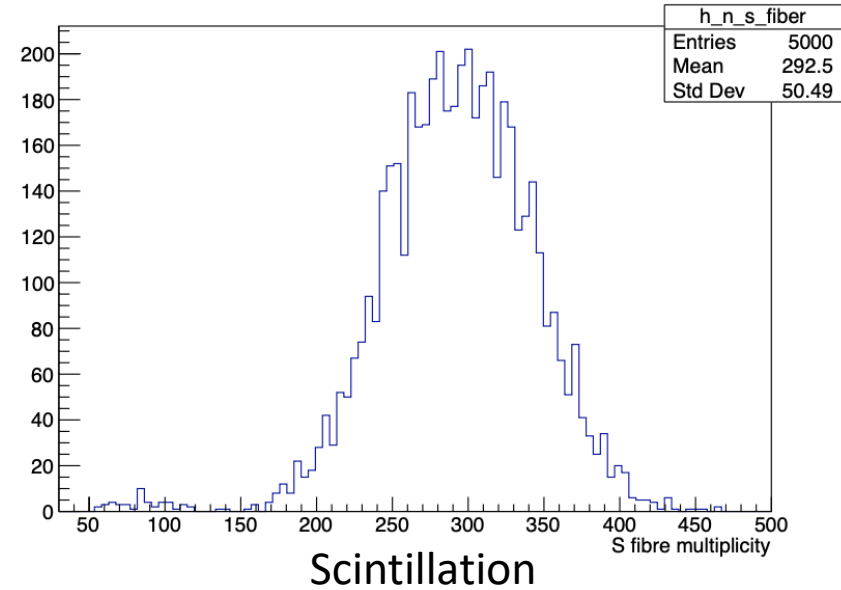
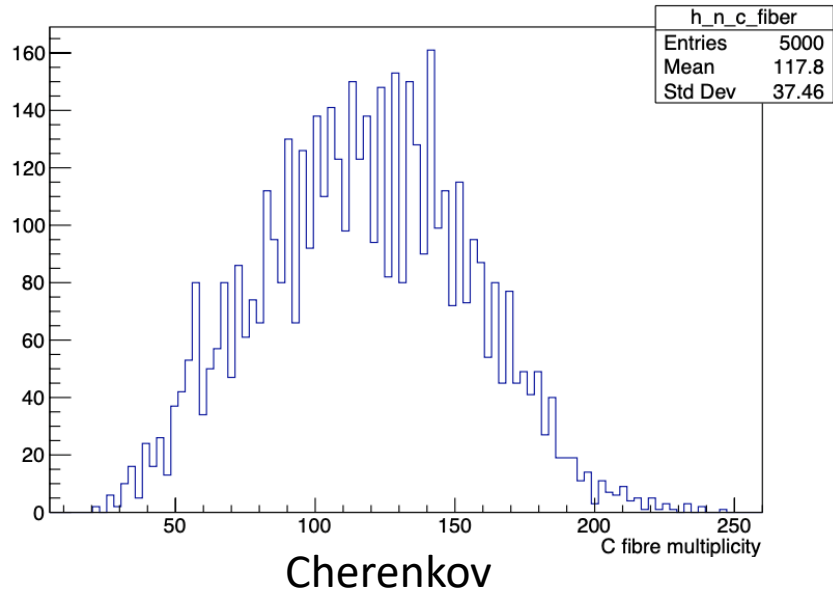
- Applies digitisation directly on **EDM4hep** output
 - Takes **SimCalorimeterHit** containers, applies SiPM simulation & writes out **CalorimeterHit** container
 - Works best directly on top of **key4hep** stack
 - **DRCalo Digitisation** directory: hook to digitisation code, along with run scripts and validation tests (C++ & python)

The screenshot shows a GitHub repository page for 'ivivarel Update README.md'. At the top, it indicates the current branch is 'master', there are 3 branches, and 0 tags. There are buttons for 'Go to file', 'Add file', and 'Code'. Below this, a table lists the repository's contents:

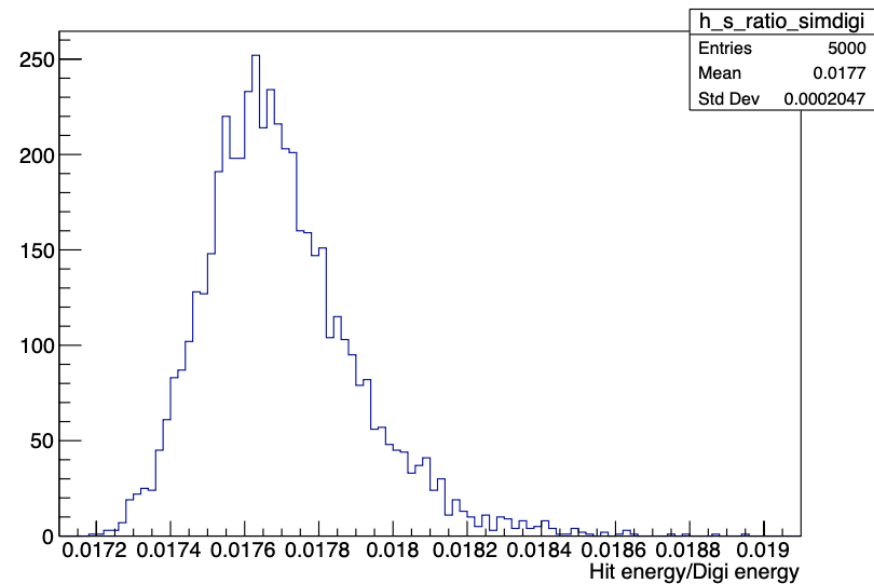
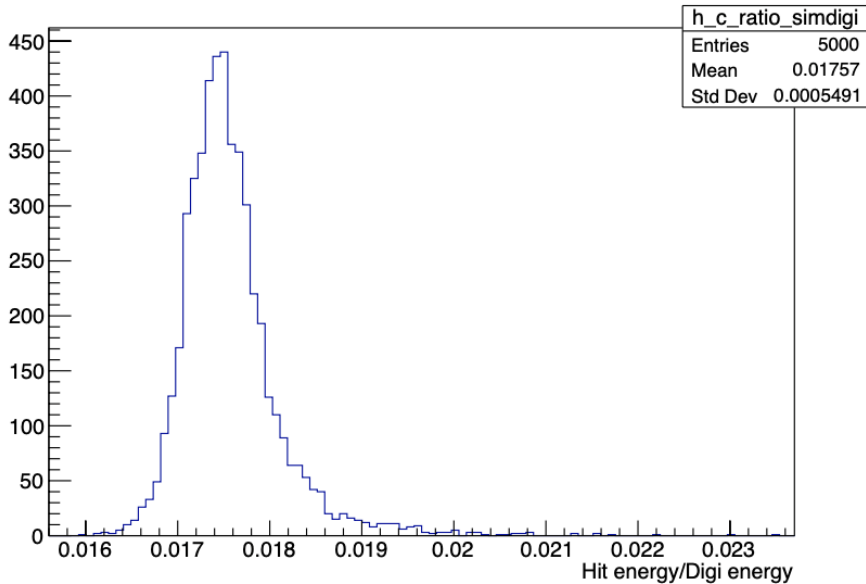
| File/Directory | Description | Last Update |
|-------------------------------|---|---------------|
| AnalysisTools | Working on the cluster calibration now. Developed package DdAndCa... | 2 months ago |
| DR_CMakeTools/scripts | going on with the creation of the common repository | 9 months ago |
| Git_IDEA_CALO_FIBER @ cbcf80f | Copying the include directories for all projects to the build directory | 9 months ago |
| NtupleConverters | Finalised Digitization and Calibration of simulation hits | 2 months ago |
| Reconstruction | Snapshot of teh last version of the software | 18 days ago |
| dual-readout @ b1765bf | Adding the NtupleConverters package | 9 months ago |
| .gitignore | Prepared a setup file and found the first problems with HepMC versio... | 9 months ago |
| .gitmodules | Copying the include directories for all projects to the build directory | 9 months ago |
| CMakeLists.txt | Working on the cluster calibration now. Developed package DdAndCa... | 2 months ago |
| README.md | Update README.md | 2 minutes ago |
| setenv_LCG.sh | Converged on having a setup mechanism | 9 months ago |
| setup_key4hep.sh | Working on the cluster calibration now. Developed package DdAndCa... | 2 months ago |

Below the file list, the 'README.md' content is displayed. It features a link to the repository: <https://github.com/ivivarel/DRCalo>. The title is 'DRCalo'. The text describes the package as an integrated build for the IDEA dual readout standalone simulation, digitisation, and reconstruction. It mentions that simulation and digitisation are introduced as submodules. A section titled 'To use the package (from a machine mounting /cvmfs):' lists two steps: 'checkout the package' and 'source the key4hep stack'. A code block shows the command: `git clone --recursive git@github.com:ivivarel/DRCalo.git`.

IDEA calorimeter example: 5 GeV pions



Fibre multiplicity



Hit E/Digi E

APRIL (Algorithm for Particle Reconstruction @ ILC)

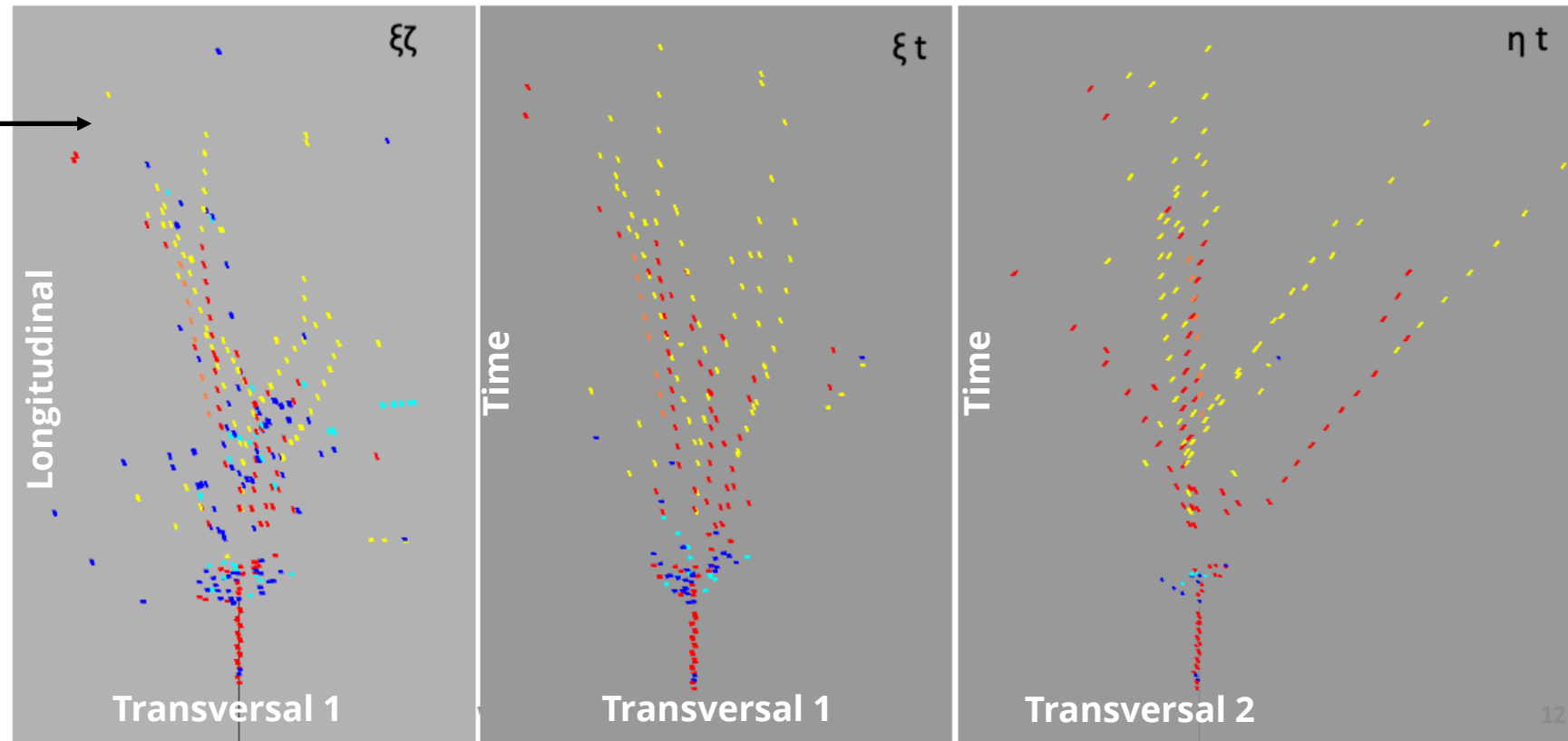
Include timing in PFA

- Preliminary ILD (detector) MC study to include timing in PFA
- Working on digitiser including timing (E and t resolution) for ILD SiW-Ecal and semi-digital Hcal (SDHCAL)
- Looking at CMS HGCal (high granularity) reco for inspiration

APRIL PFA

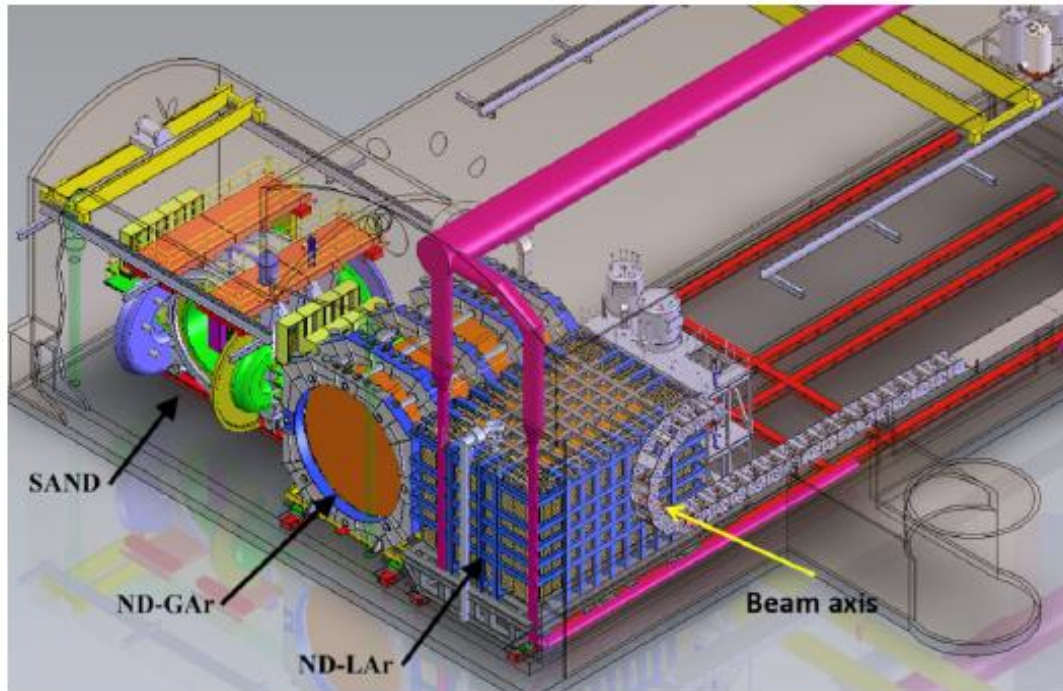
- Developing an algorithm to split big clusters as an alternative to Pandora reclustering method
- Testing the concept on SDHCAL prototype MC simulation will begin soon.

Same shower, different 2D projections (Ecal & Hcal)



Blue electrons, Cyan positrons, Red pions, Orange kaons, Yellow protons

Reconstruction for DUNE Near Detector (ND)



FERMILAB-PUB-21-067-E-LBNF-PPD-SCD-T

Three components: ND-LAr, ND-GAr, SAND.
ND-LAr and ND-GAr can move off axis.

- **ND-LAr**: ν -Ar interactions for comparison to FD. Pixelated readout accommodates high rate.
- **ND-GAr**: high pressure GArTPC surrounded by ECAL, 0.5T magnetic field, muon system.
- **SAND**: magnetised beam monitor - an inner tracker (2 tech options) surrounded by ECAL.

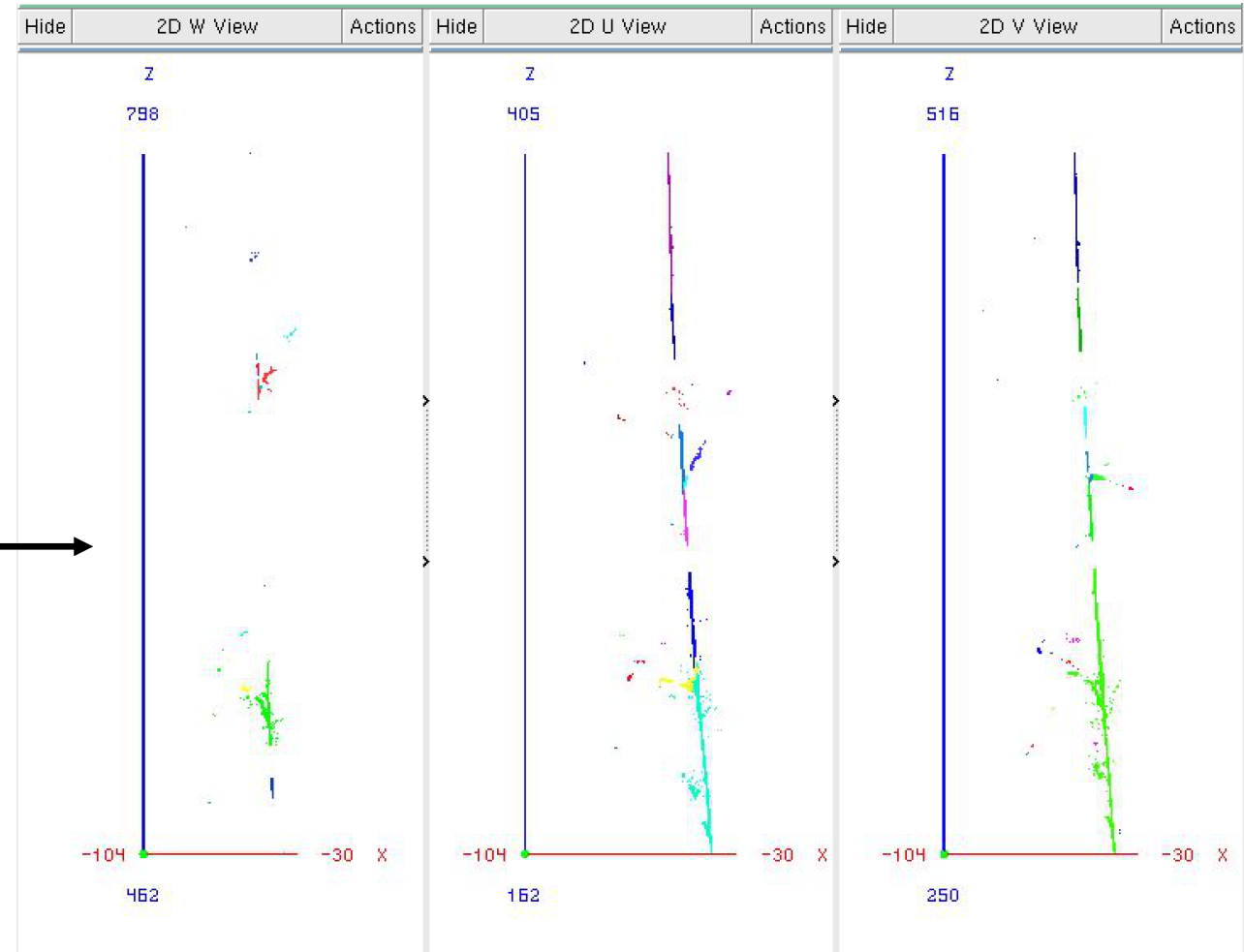
System for on-Axis Neutrino Detection

Day 1: Temporary Muon Spectrometer will be added (MINOS-style steel-scintillator sandwich calorimeter).
Will eventually be replaced by ND-GAr (plans not finalised)

- **Pandora** reconstruction: will initially use LArTPC & ILC algorithms for DUNE ND
- Adapting **2D-view** algorithms (u, v or w with common drift-time coordinate) to work with **native 3D** hits
- Planning to have 0.5 PostDoc working at Cambridge soon (combining with other funds)

LAr calorimeter simulation & reconstruction

- Simulation uses **edep-sim** (<https://github.com/ClarkMcGrew/edep-sim>)
 - G4 hit “segments”: start & stop points
 - Ionization & scintillation processes
 - No hit digitisation
- Can pass these hit lists to Pandora **LArReco**:
 - 3D and/or 2D TPC views u_x, v_x, w_x
where x = drift time coordinate
 - Hit position = $0.5 * (\text{start} + \text{stop})$
- Preliminary **2D LArTPC clustering** →
- Working on **hit voxelisation**
 - Allow basic cleanup (e.g. MIP cuts)
 - Apply energy calibration
 - More points along (start,stop) path to enhance features for reconstruction



10 GeV muon: W, U and V 2D views