Minerva-2x2 simulation overview

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on behalf of the Reco & Sim Minerva 2x2 team

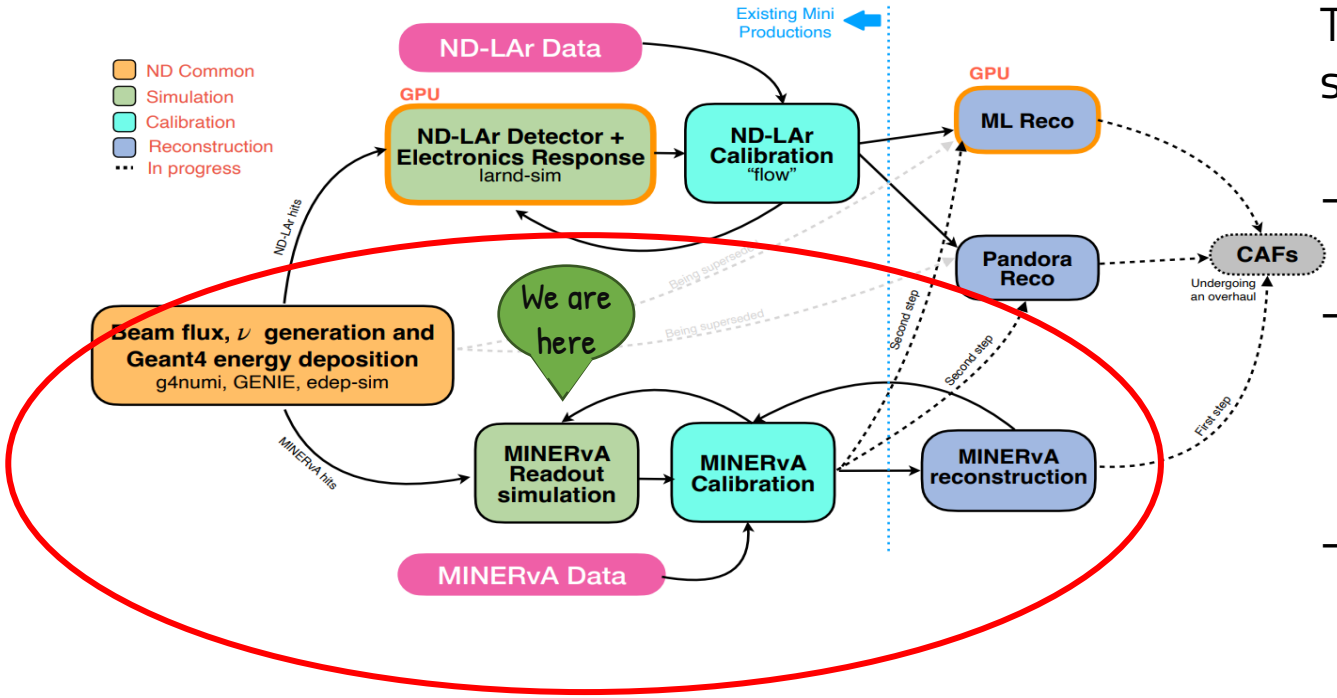
2x2 Workshop – 05/19/2023

YORK U

DUNE DEEP UNDERGROUND NEUTRINO EXPERIMENT

ArgonCube

THE DIAGRAM: A reminder

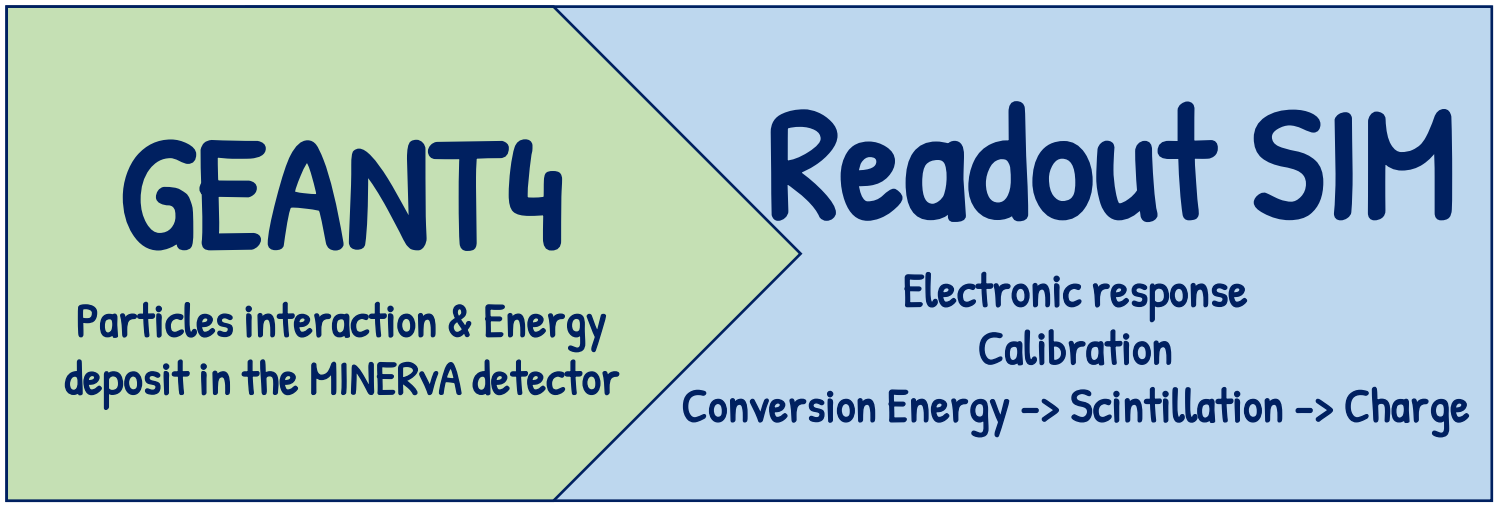


This talk is about the use of MINERvA software for 2x2 simulation.

- All the energy deposits are handled by Edepsim
- We want to use MINERvA framework to readout edepsim hits & reconstruct what's inside MINERvA modules
- Main challenges:
  - MINERvA is not designed to take inputs from the Edepsim framework: different packages, root versions, compiler versions, framework architecture…
  - MINERvA has its own G4 framework
  - 2x2 Geometry is different from the original MINERvA one

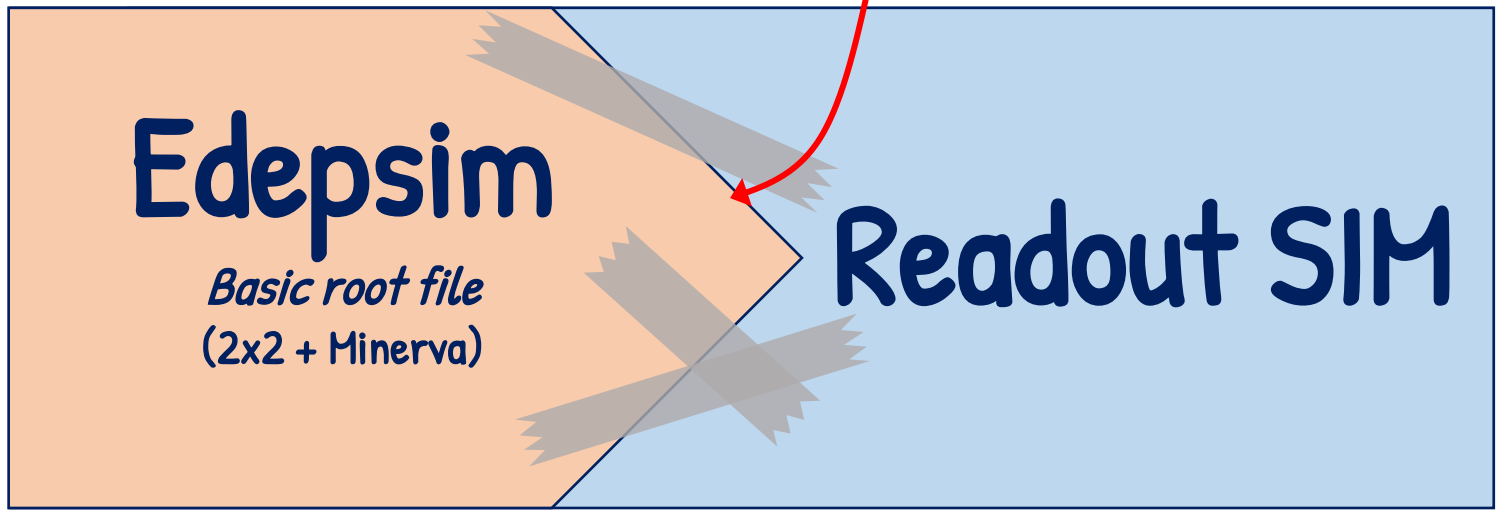
Minerva simulation

Original Minerva Readout sim



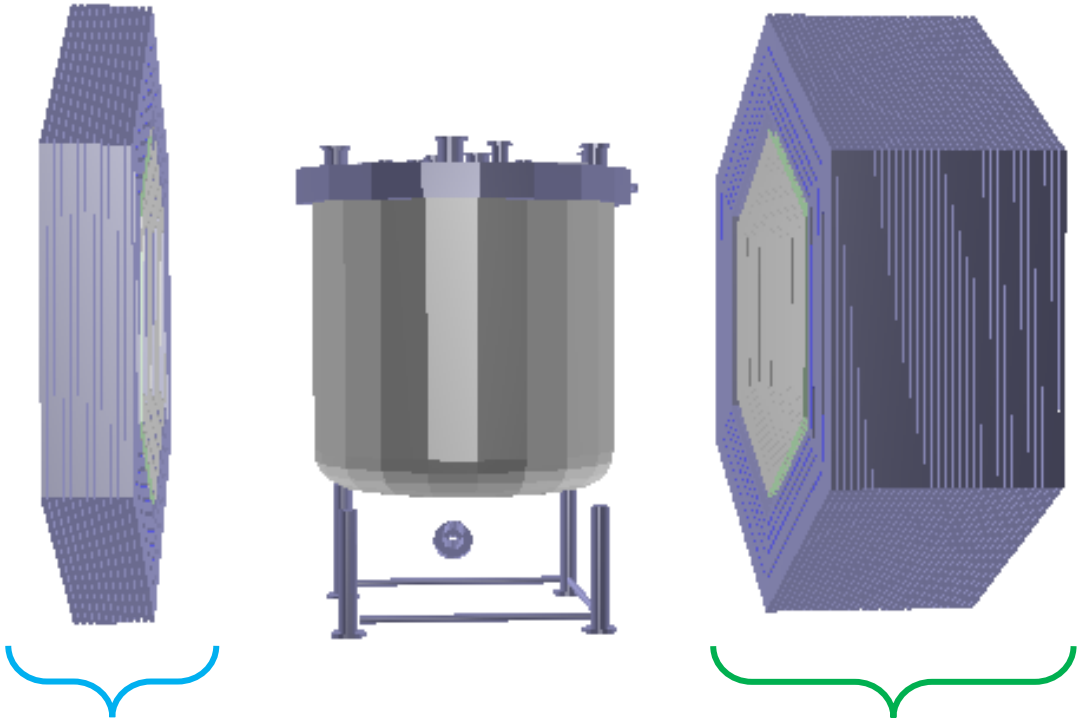
Minerva Readout sim **Updated**

Use the flat root trees to plug Edepsim to the Readout Sim



Geometry included inside

Gdml geometry for Minervax2



Good geometry is now implemented inside MINERvA simulations with the right number of modules and the right distance between the **upstream** and **downstream** part

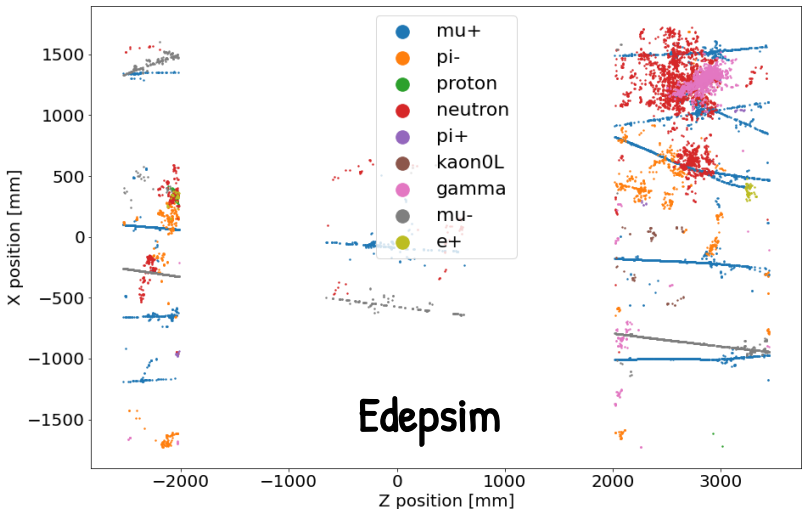
-> Running with fake plex and default calibration

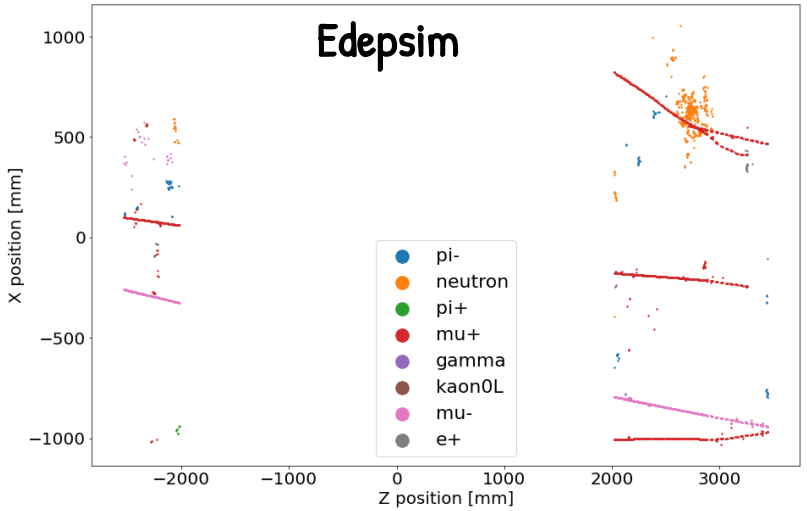
Edepsim to Minerva

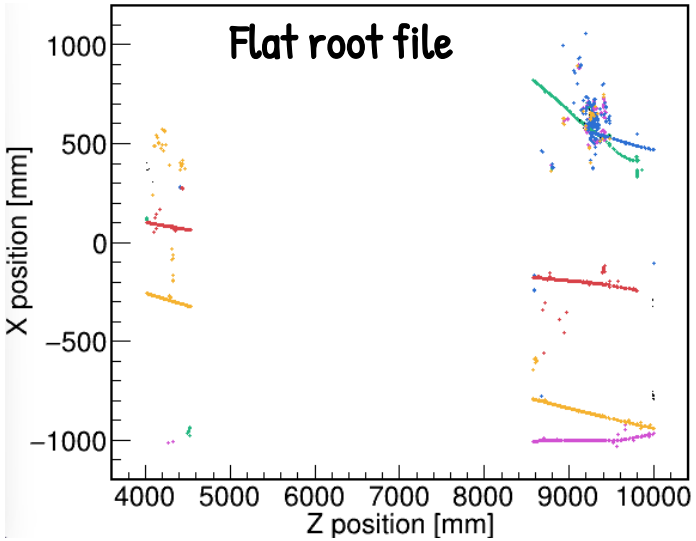
Start with Edepsim type simulation

Extract Hits that are in MINERvA sensitive detector

Bunch all the hits of the same 1.2 s spill time





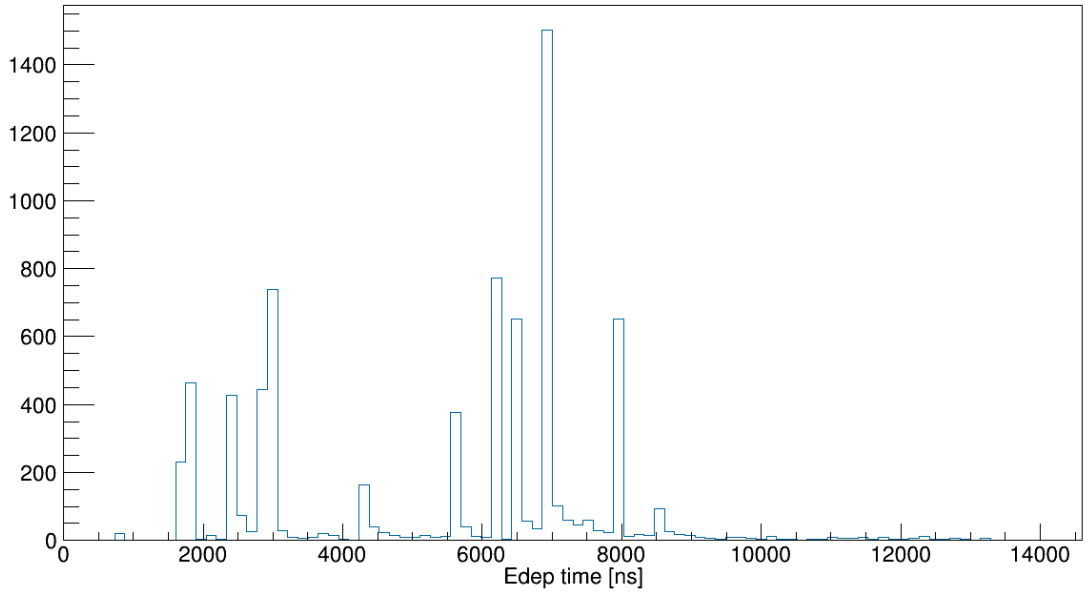


-> All hits positions are shifted in Z and Y position

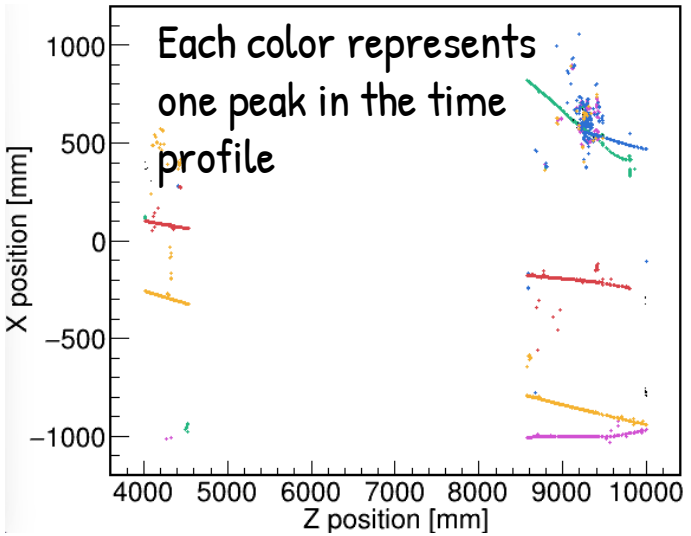
-> All hits timing are shifted with a reset at 0 at each spill for MINERvA software, the spill rate is handled by MINERvA

Per spill timing

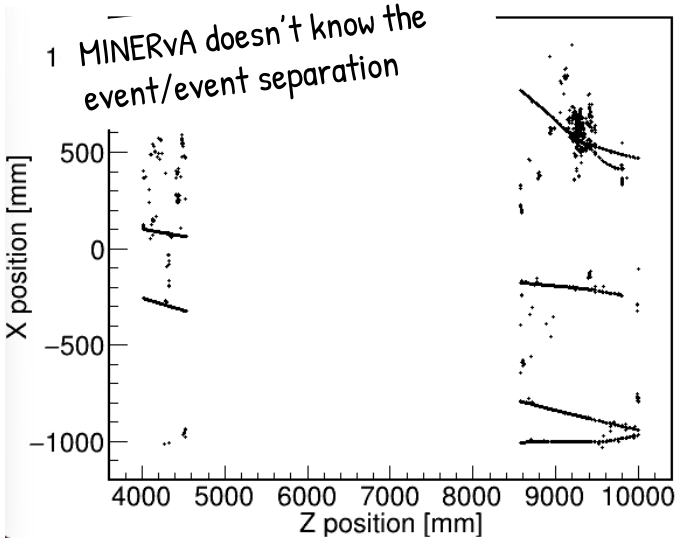
Time distribution of the enegy deposits in the spill



X,Z distribution of the energy deposits

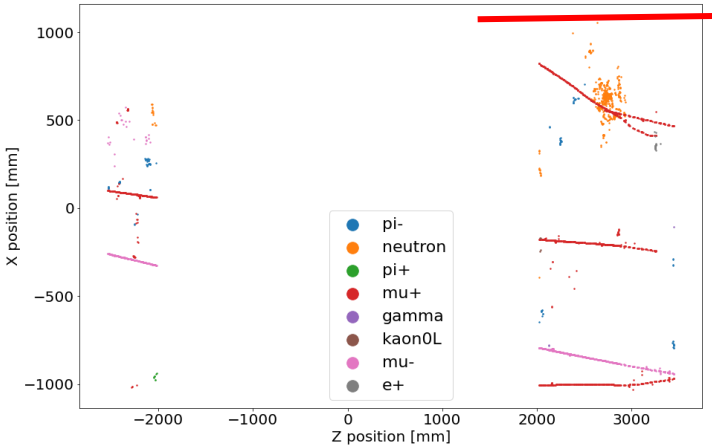


Before running the Readout simulation, we merge all the events of a spill (keep track of IDs for afterwards matching)

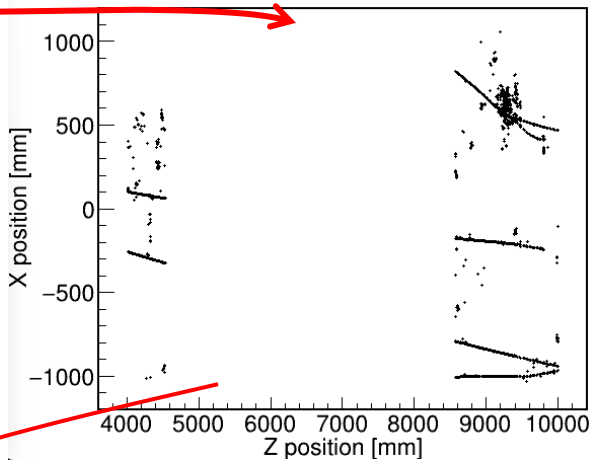


Readout sim & reco in a nutshell

Edepsim energy deposits

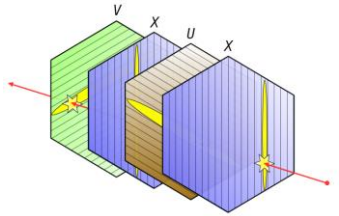


Flat Tree energy deposits

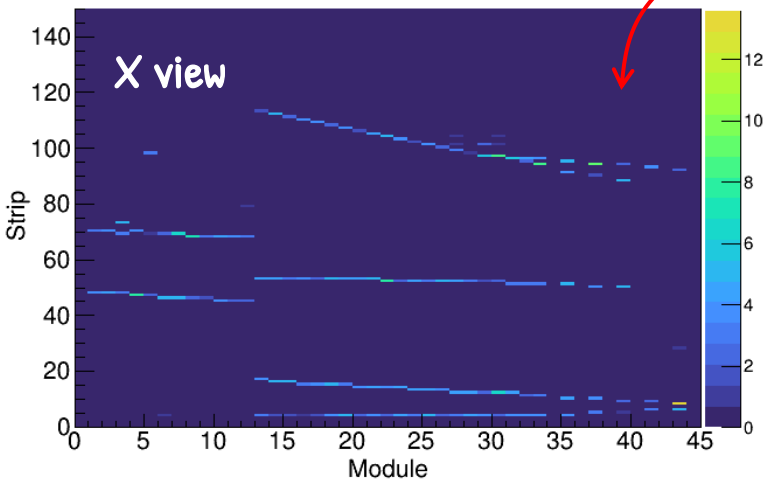


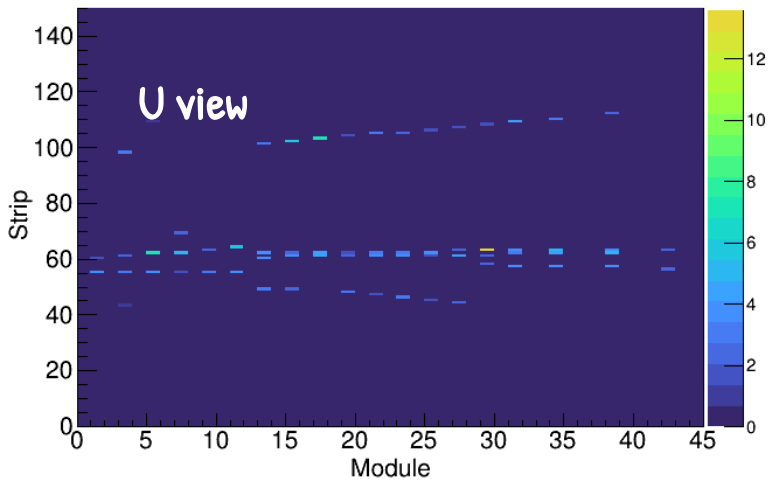
All the energy deposits bunched into spilled.

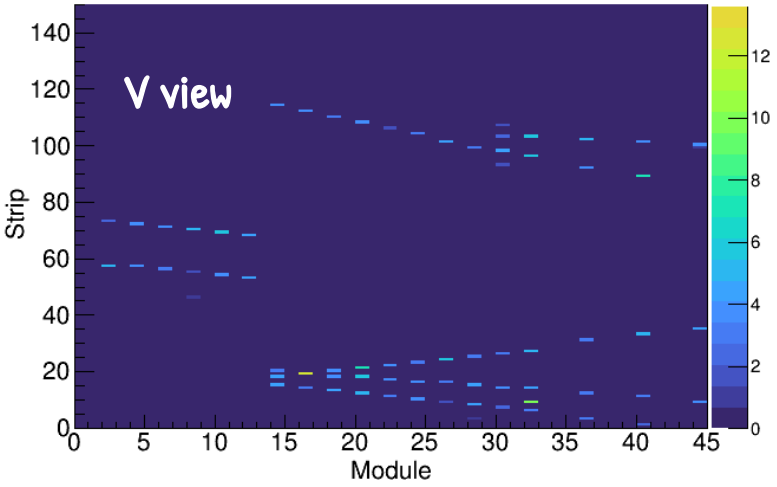
Positions of deposits shifted accordingly to MINERvA ref point.



Reconstructed cluster position vs Energy

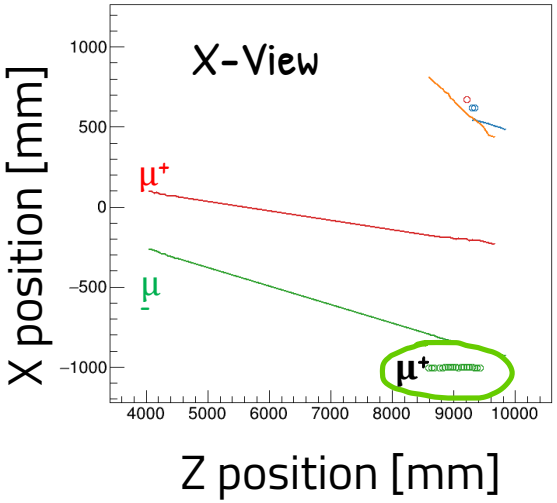


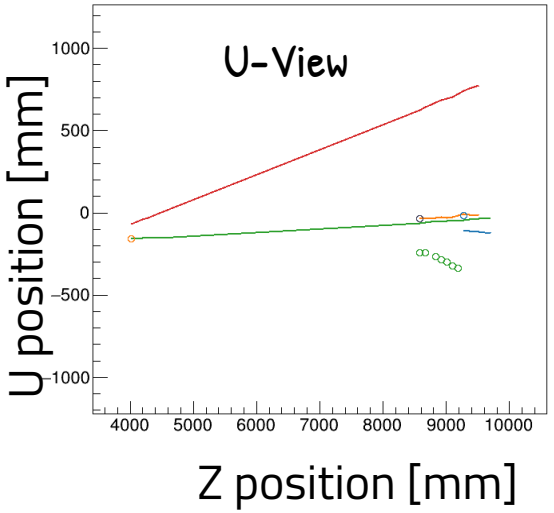


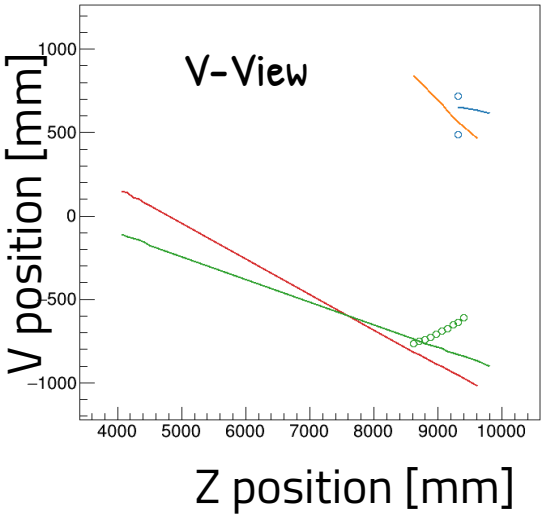


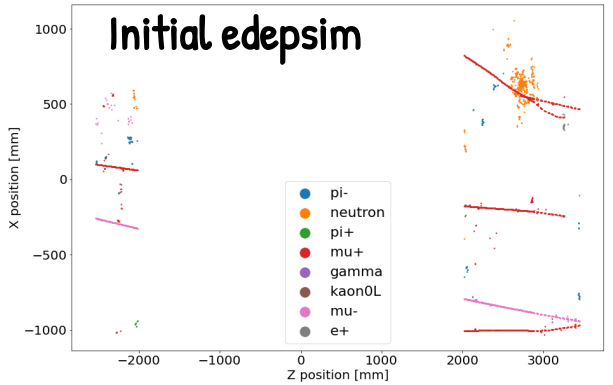
Hits (energy deposits) -> Readout simulation (with default calibration for now): pE channels -> Reconstructed objects.

Reconstructed low level objects : Tracks and Blobs







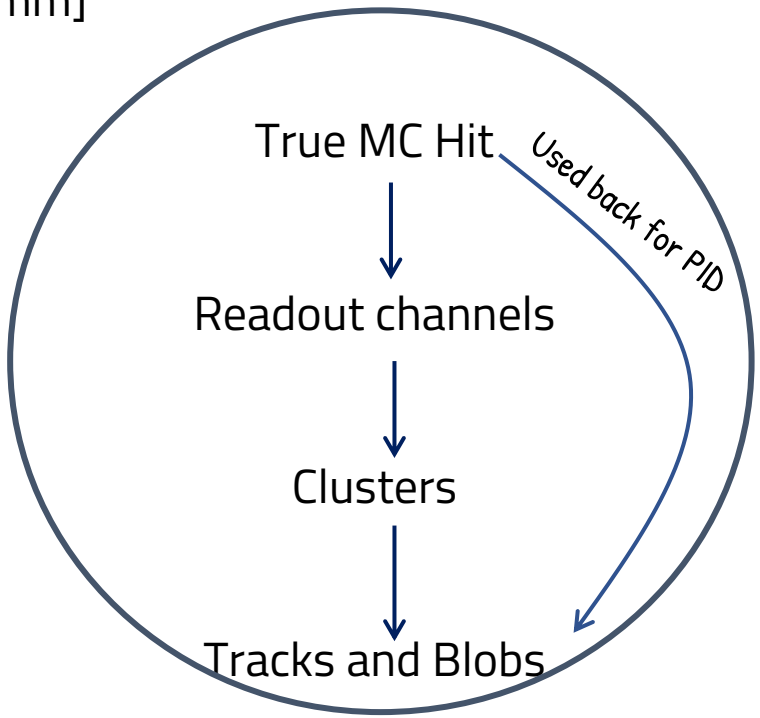


ID 10 - (-13) - Evis 267.0 - Slice 1 - θ 0.21 - ϕ -1.89
ID 30 - (-13) - Evis 75.5 - Slice 2 - θ 0.13 - ϕ -2.98
ID 32 - (13) - Evis 288.8 - Slice 4 - θ 0.16 - ϕ -2.53
ID 43 - (-13) - Evis 172.2 - Slice 6 - θ 0.42 - ϕ -2.56

track parameters

Blob 0 - (-13) - Evis 1.2 - Size 1 - Slice 2 - ID 43 -Type 2
Blob 1 - (-13) - Evis 26.5 - Size 5 - Slice 2 - ID 43 -Type 3
Blob 2 - (-13) Evis 122.4 - Size 36 - Slice 3 - ID 32 -Type 3
Blob 3 - (-13) - Evis 1.9 - Size 1 - Slice 4 - ID 10 -Type 2
Blob 4 - (13) - Evis 2.3 - Size 1 - Slice 6 - ID 32 -Type 2

Blob parameters

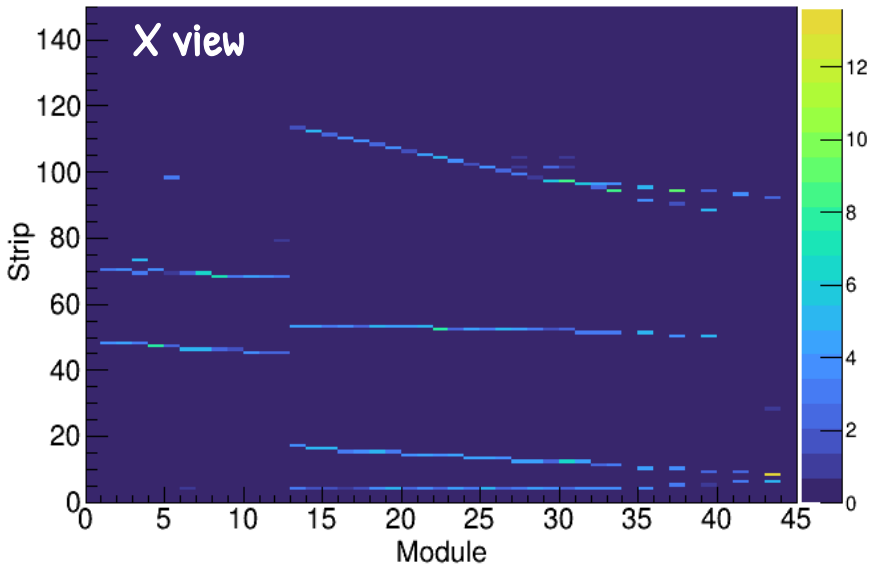


Reconstruction of tracks and blobs (shower like particle)

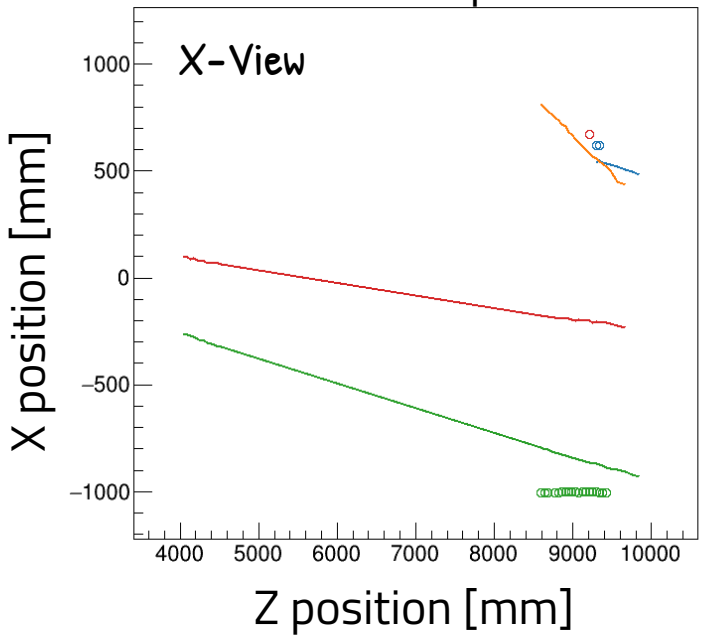
True particle linked to object: particle that contributed the most (energy wise)

Output from MINERvA simulation

Cluster energy vs position



Tracks & Blobs position



-> We store each clusters Strip, Module, Plane position, energy, timing, associated true MC deposits

-> We store each reconstructed Tracks & Blob with position, direction, energy, time, de/dx, each object associated to true MC deposits that contributed

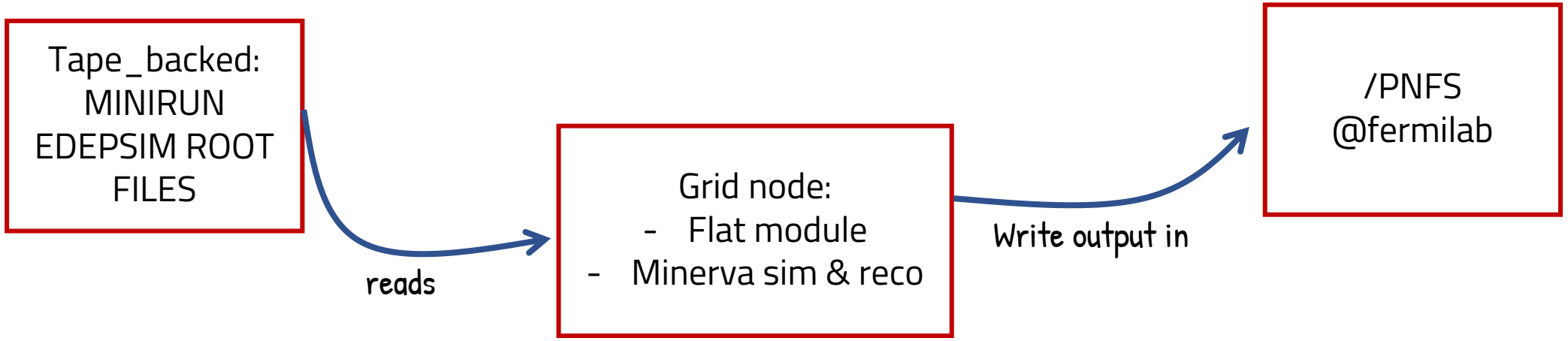
Running the simulation at Fermilab

MINIRUN3 simulation lay here: /pnfs/dune/tape_backed/users/mkramer/prod/MiniRun3/MiniRun3_1E19_RHC/

What we have now for our grid jobs 1 script that:

- loads edepsim on the grid
- run Edepsim_to_flat module
- runs MINERvA simulation & Reco software on the output of the module in local node grid directory
- Transfers Flat file and MINERvA output back to the DUNE PNFS directory

Files are read on pnfs via xrootd with root6.



Timing and Memory usage

- Run on ~1% of the sample (more to come obviously)
- ~20s per file From Edepsim to Flat
- Filesize /21 approximatively (only Hits that are in sensitive material)
- Readout+Reco: ~5min per file (~185 spills)
- Global time for a file is then ~5/6 min (and we have ~1k files). Things now properly run on the grid so not an issue right now
- Filesize ~/20 compared too original Edepsim file
- Run on the MINIRUN3 sample, issues with timing/spill merging found and fixed from our side

Conclusion and next steps

- We have a MINERvA simulation that can readout the Edepsim simulation
  - Proper realistic MINERvA geometry
  - Still running on « fake plex » to have the right number and position of modules
  - Still running on Fake calibration for now

- 1 script that handles all the simulation parts (Edep->Flat root + Minerva) that can be run on the fermigrid with large scale simulation

- Now need to look at the track reconstruction efficiency and the truth matching between edepsim and MINERvA sim with larger dataset

- Still need validation sets of plots

- Currently running on default plex with defaults (de)calibration effects applied. Fine by now but will need to be updated