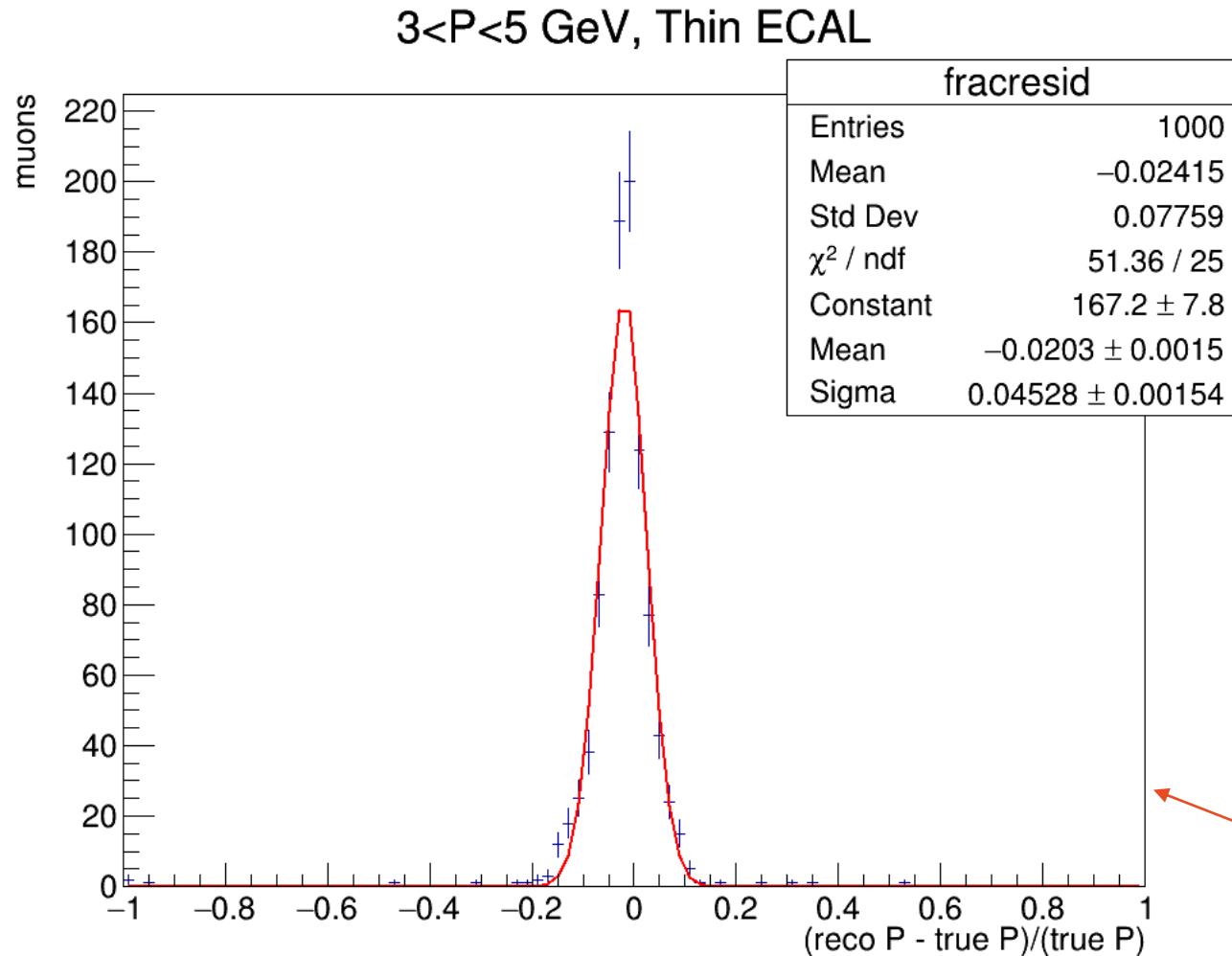


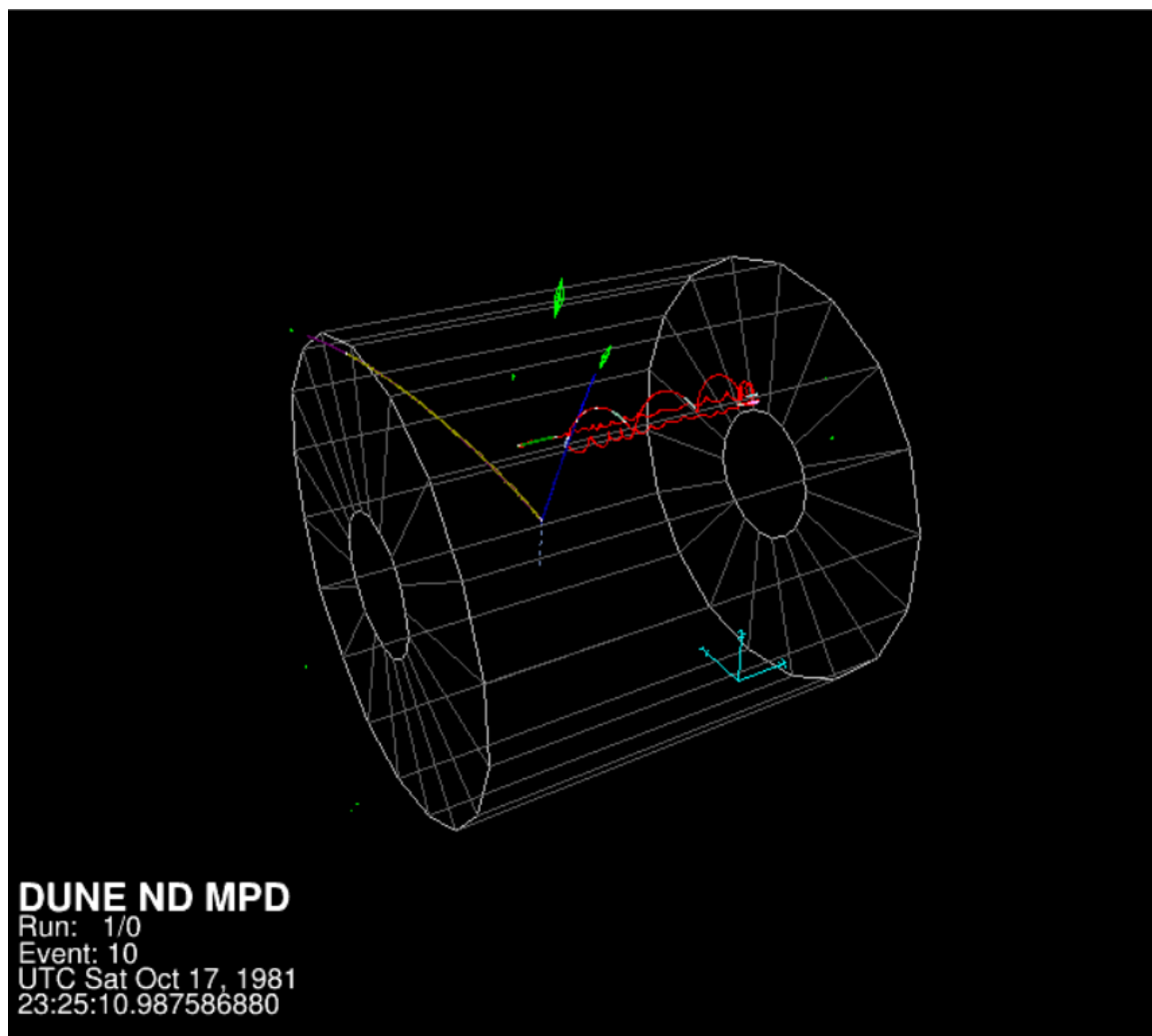
SIMULATION EXERCISE



- **Muon resolution garsoft simulation:** 1000 randomly generated upstream muons entering the Gas TPC with initial momentum $3 < P < 5$ GeV
- **Simulation Goal:** Reconstruct the muon momenta and produce a reconstruction resolution plot
- **Exercise goal:** Reproduce the resolution plot with a new randomly generated muon set

Graph produced with Tom's original hemanatree.root file

THE GARSOFT TUTORIAL

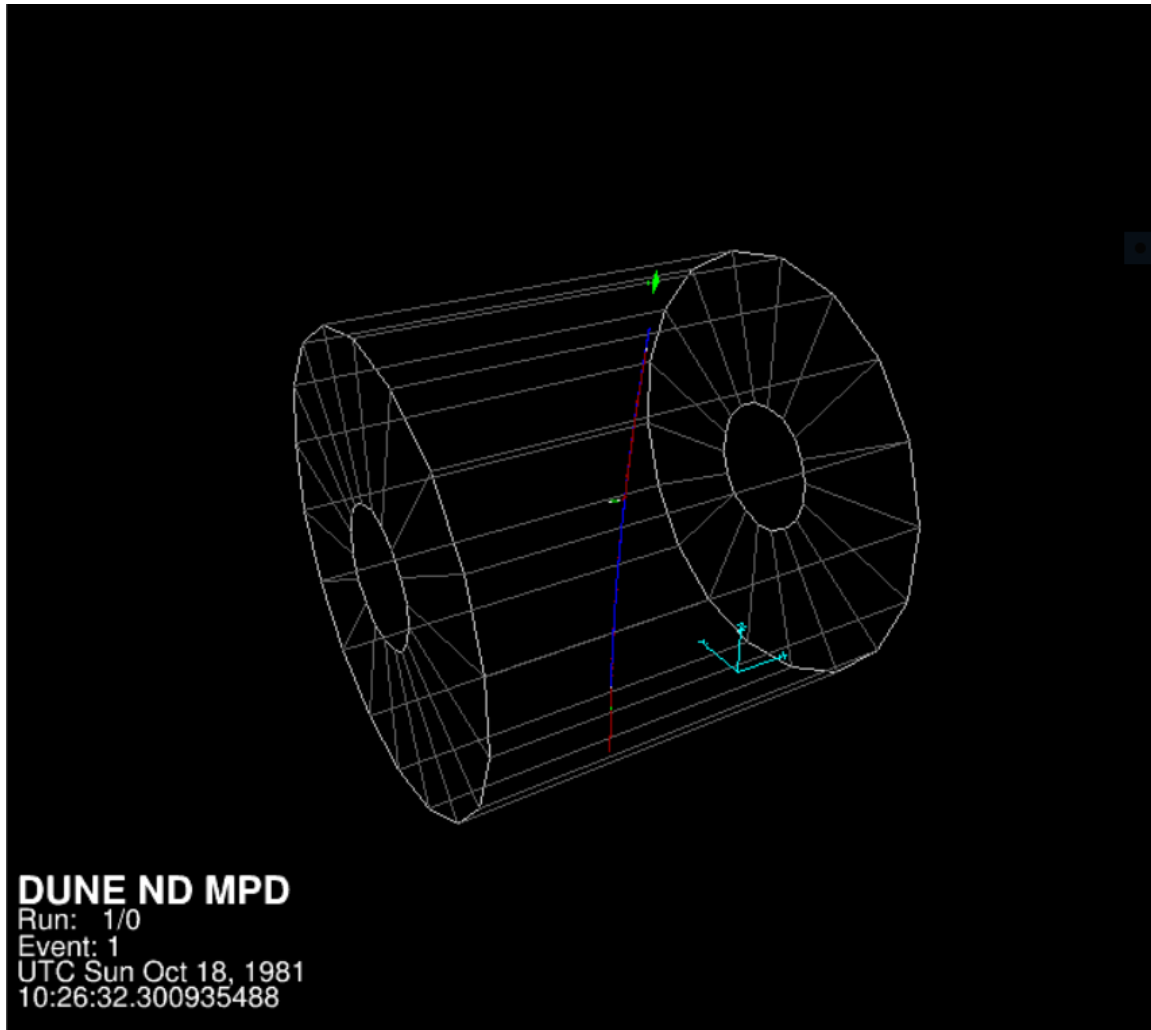


To familiarise with garsoft I firstly followed the garsoft tutorial which consists of four steps:

1. 1000 Event sample generation via GENIE MC generator ([prodgenie.fcl](#))
2. Readout simulation ([readoutsimjob.fcl](#))
3. Reconstruction ([recojob.fcl](#))
4. Creation of a simplified analysis root tree ([anajob.fcl](#))

Event from the tutorial production visualised with garsoft visual display ([evd.fcl](#))

REPRODUCING TOM'S SIMULATION

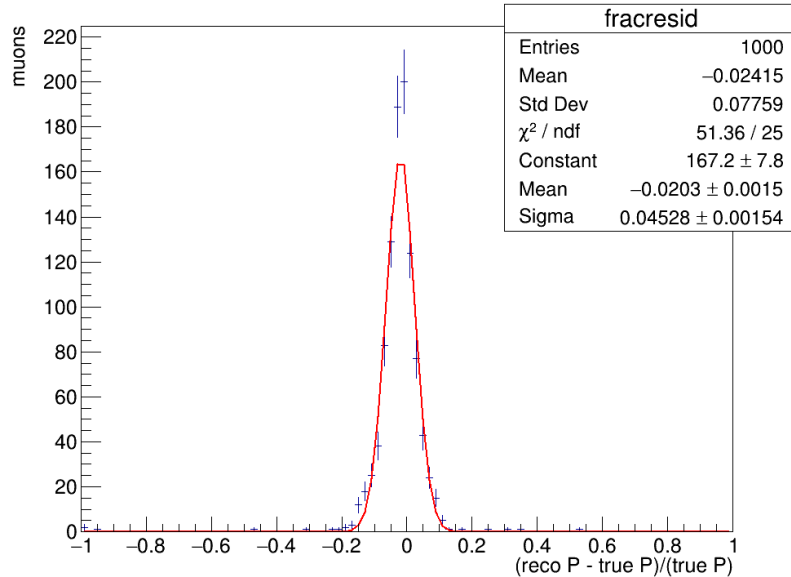


- Generate a text file (using Tom's root macro) with instructions to produce 1000 upstream muons entering the Gar detector : initial momentum on the z direction(i.e. parallel to flux) that varies between 3 GeV and 5 GeV respectively; fixed z coordinate at 1000 cm (in the ND hall coordinates) ; x and y coordinate that vary between -200 and 200 cm and -200 and 0 cm respectively
- Generate simulation using text file (different from Garsoft tutorial)
- Execute readout simulation, reconstruction and convert into analysis tree (same as GarSoft tutorial)
- Use root macro to produce resolution plot and compare with Tom's

Upstream muon visualised with garsoft visual display ([evd.fcl](#))

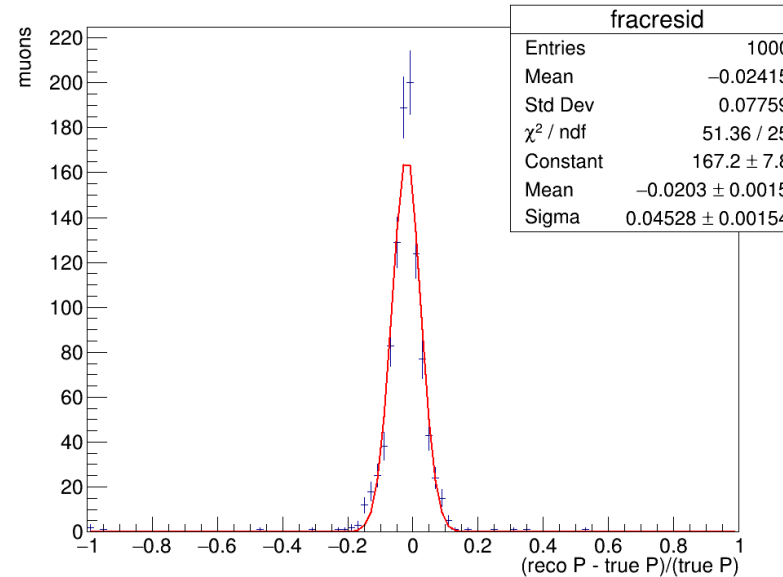
PLOTS COMPARISON

3<P<5 GeV, Thin ECAL



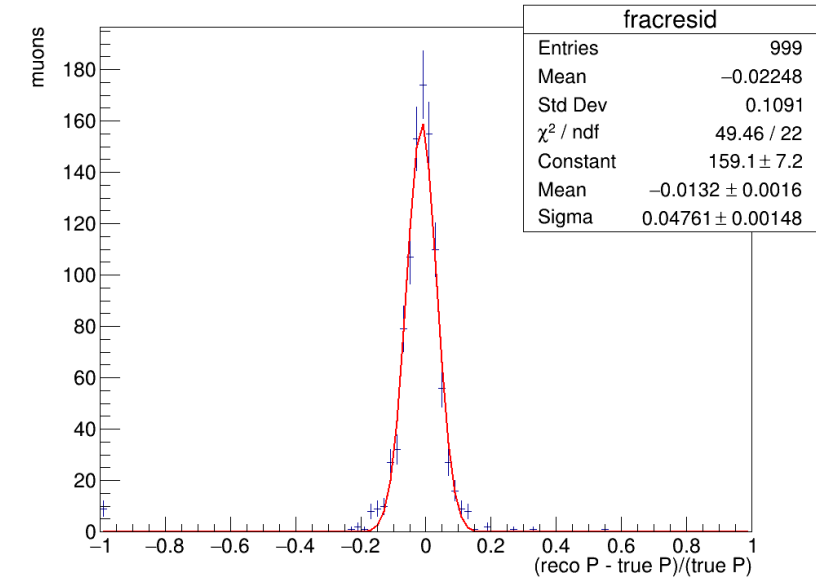
Graph produced with Tom's original hemanatree.root file

3<P<5 GeV, Thin ECAL



Graph produced rerunning Tom's simulation on preinstalled garsoft v2_05 maintaining initial muon sample

3<P<5 GeV, Thin ECAL



Graph produced rerunning Tom's simulation on preinstalled garsoft v2_05 with different random muon sample

BUILD UP TO DATE GARSOFT VERSION

- Tried building **garsoft v3_05_01** with compiler **e19** in **debug** mode following the garsoft getting started guide:

```
source /cvmfs/dune.opensciencegrid.org/products/dune/setup_dune.sh
mkdir <new empty directory>
cd <new empty directory>
export MRB_PROJECT=garsoft
mrb newDev -v develop -q ${COMPILER}:${BUILDTYPE}
source localProducts*/setup
mkdir work
cd srcs
mrb g -d garsoft garsoft-garsoft
cd garsoft
git remote set-url origin ssh://p-garsoft@cdcvs.fnal.gov/cvs/projects/garsoft-garsoft
cd $MRB_BUILDDIR
mrbsetenv
mrbsetenv
mrb i -j4
mrbslp
```

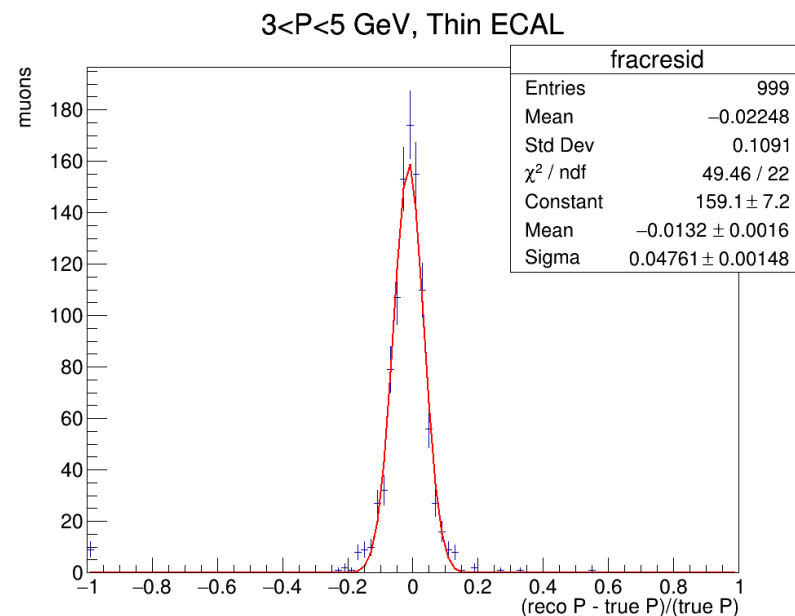
Note: Compiled and built with no errors

BUILD UP TO DATE GARSOFT VERSION

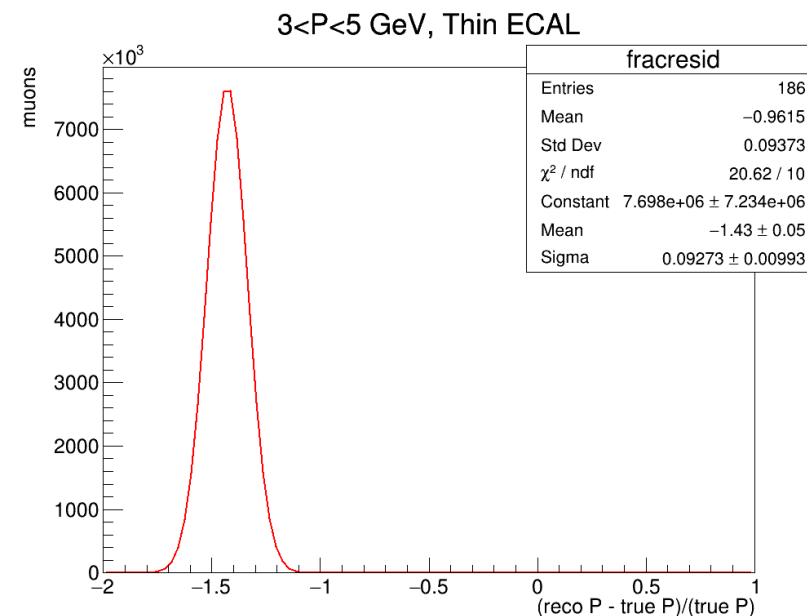
- Repeated the simulation steps getting warning on readout simulation step:

```
Begin processing the 1st record. run: 1 subRun: 0 event: 1 at 02-Sep-2020 03:50:11 CDT
%MSG-w BackTracker_service::RebuildNoSC: ProcessEvent 02-Sep-2020 03:50:11 CDT run: 1 subRun: 0 event: 1 BackTracker_service.cc:175
Unable to find RawDigits in daq; no backtracking in TPC will be possible
%MSG
%MSG-w BackTracker_service::RebuildNoSC: ProcessEvent 02-Sep-2020 03:50:11 CDT run: 1 subRun: 0 event: 1 BackTracker_service.cc:223
Unable to find CaloRawDigits in dacecal; no backtracking in ECAL will be possible
%MSG
%MSG-w BackTracker_service::RebuildNoSC: ProcessEvent 02-Sep-2020 03:50:11 CDT run: 1 subRun: 0 event: 1 BackTracker_service.cc:262
Unable to find rec::Tracks in track; no backtracking of reconstructed tracks will be possible
%MSG
%MSG-w BackTracker_service::RebuildNoSC: ProcessEvent 02-Sep-2020 03:50:11 CDT run: 1 subRun: 0 event: 1 BackTracker_service.cc:296
Unable to find rec::TPCclusters in tpccluster; no backtracking of reconstructed tracks will be possible
%MSG
%MSG-w BackTracker_service::RebuildNoSC: ProcessEvent 02-Sep-2020 03:50:11 CDT run: 1 subRun: 0 event: 1 BackTracker_service.cc:351
Unable to find rec::Clusters in calocluster; no backtracking of reconstructed ECAL clusters will be possible
%MSG
```

PLOTS COMPARISON



Graph produced rerunning Tom's simulation on preinstalled garsoft v2_05 with new random muon sample



Graph produced rerunning Tom's simulation on garsoft v3_05_01 with same new random muon sample (Many events missing and very small reconstructed momentum)

BUILD UP TO DATE GARSOFT VERSION

- Tried with **prof** version (1/09 morning) and got this error:

```
---- Configuration BEGIN
The following were encountered while processing the module configurations:
  ERROR: Configuration of module with label patrec encountered the following error:
---- Configuration BEGIN
  Library specification "tpcpatrec2" does not correspond to any library in CET_PLUGIN_PATH of type "module"
---- Configuration END
  ERROR: Configuration of module with label track encountered the following error:
---- Configuration BEGIN
  Library specification "tpctrackfit2" does not correspond to any library in CET_PLUGIN_PATH of type "module"
---- Configuration END
  ERROR: Configuration of module with label trackpass1 encountered the following error:
---- Configuration BEGIN
  Library specification "tpctrackfit2" does not correspond to any library in CET_PLUGIN_PATH of type "module"
---- Configuration END
---- Configuration END
%MSG
Art has completed and will exit with status 9.
```

Leo found the bug and fixed it

BUILD UP TO DATE GARSOFT VERSION

- Tried again (2/09 morning) and got this new error when trying `mrbsetenv`

```
----- check this block for errors -----  
Error encountered when setting up product: edepsim  
ERROR: Product 'edepsim' (with qualifiers 'e19:prof'), has no v03_0_0 version (or may not exist)  
ERROR: setup -B edepsim v03_0_0 -q +e19:+prof failed  
ERROR: setup of required products has failed
```

- These messages might be related:

```
INFO: cannot find garsoft/v3_05_01/releaseDB/base_dependency_database  
or garsoftcode/v3_05_01/releaseDB/base_dependency_database  
mrbs checkDeps and pullDeps will not have complete information
```

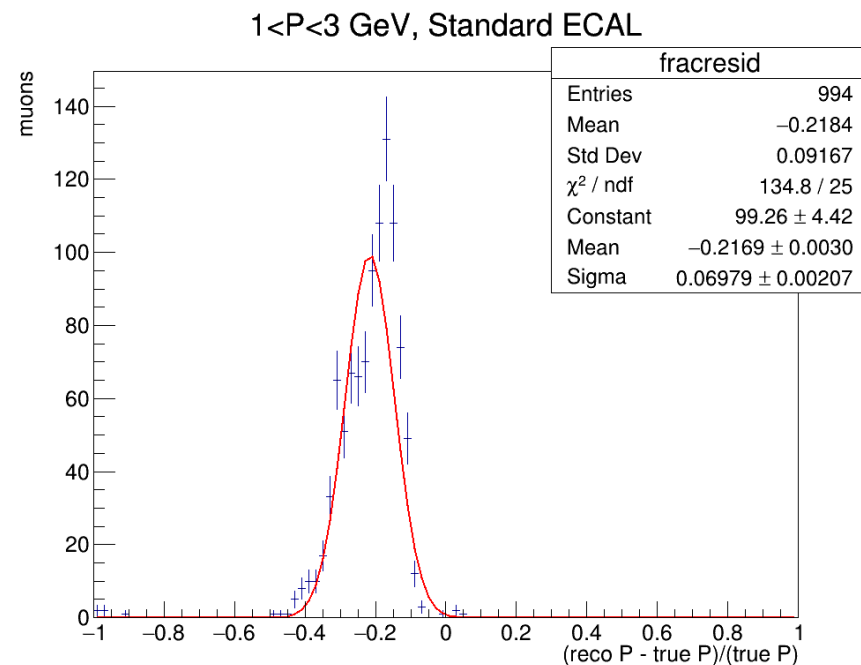
Obtained after:
`mrbs newDev -v v3_05_01 -q e19:prof`

```
INFO: Unable to verify write access for garsoft-garsoft, falling back to read-only.  
Cloning into 'garsoft'...
```

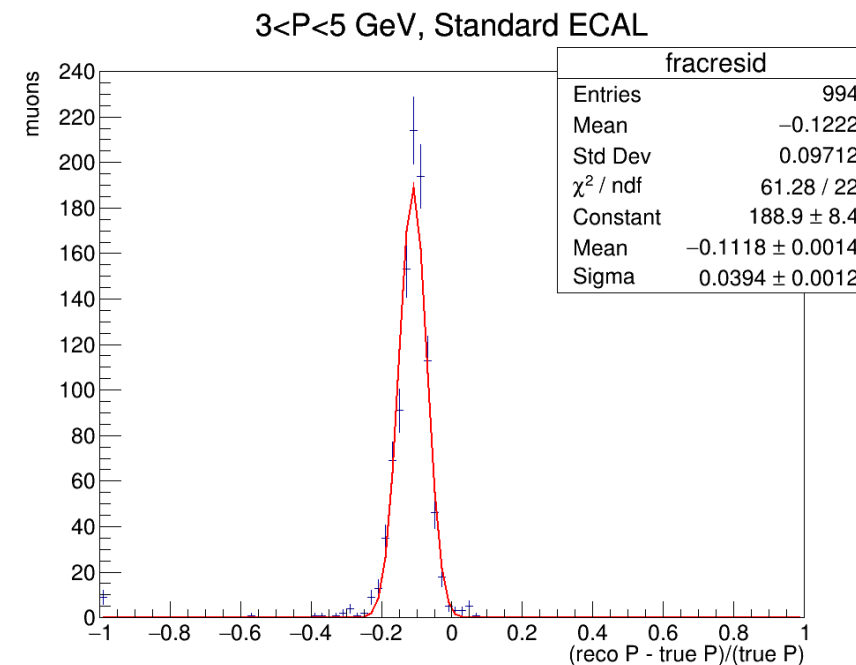
Obtained after:
`mrbs g -d garsoft garsoft-garsoft`

RESOLUTION (SAMPLE OUTSIDE THE DETECTOR)

- Was finally able to install garsoft v3 successfully and to produce these resolution graphs



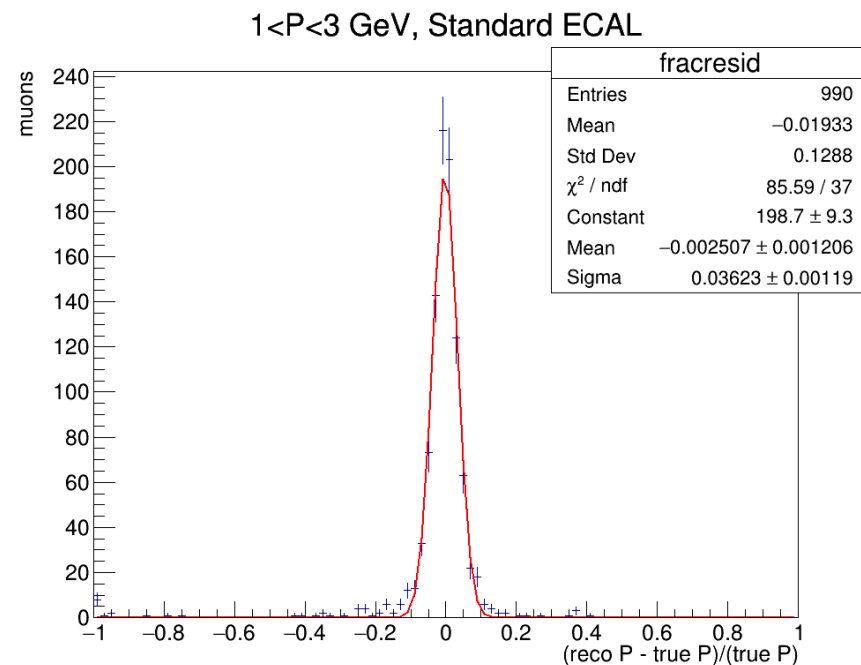
Resolution plot produced on garsoft v3 with random low energy muon sample generated upstream outside the detector (z=-500)



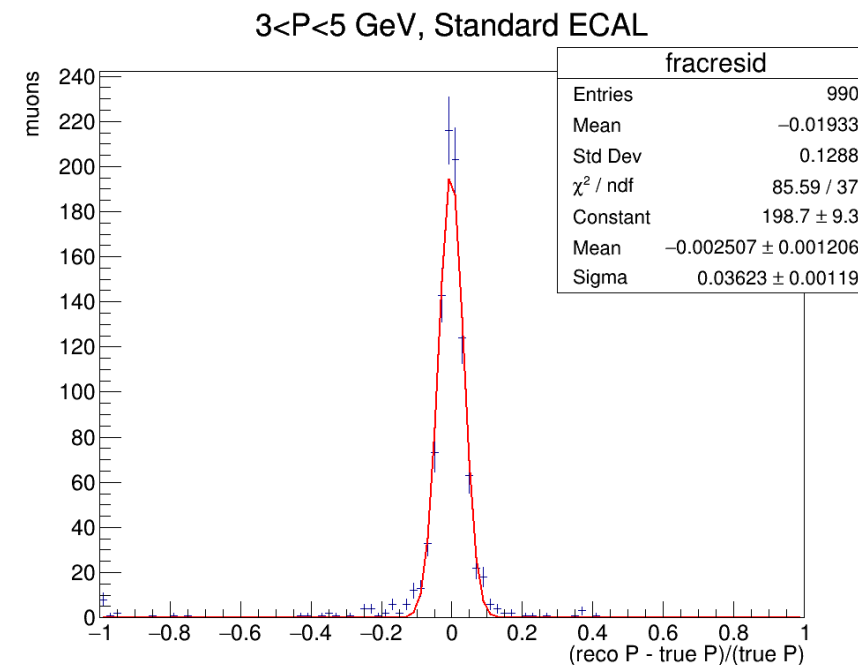
Resolution plot produced on garsoft v3 with random low energy muon sample generated upstream outside the detector (z=-500)

RESOLUTION (SAMPLE INSIDE THE DETECTOR)

- To check if the resolution degradation was due to energy loss in calorimeter, I redid the simulation with a new **muon sample generated inside the gas detector**



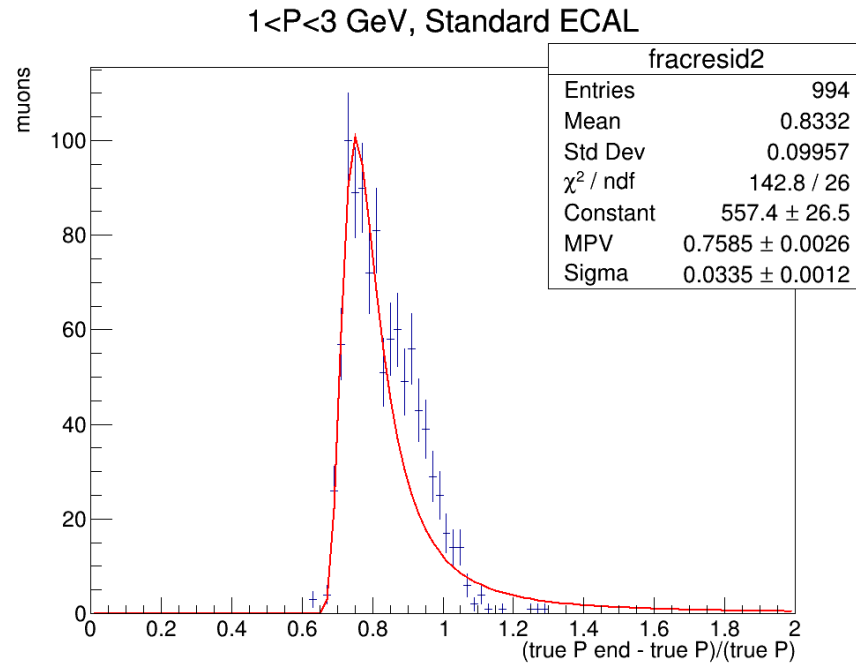
Resolution plot produced on garsoft v3 with random low energy muon sample generated upstream inside the detector (z=-190)



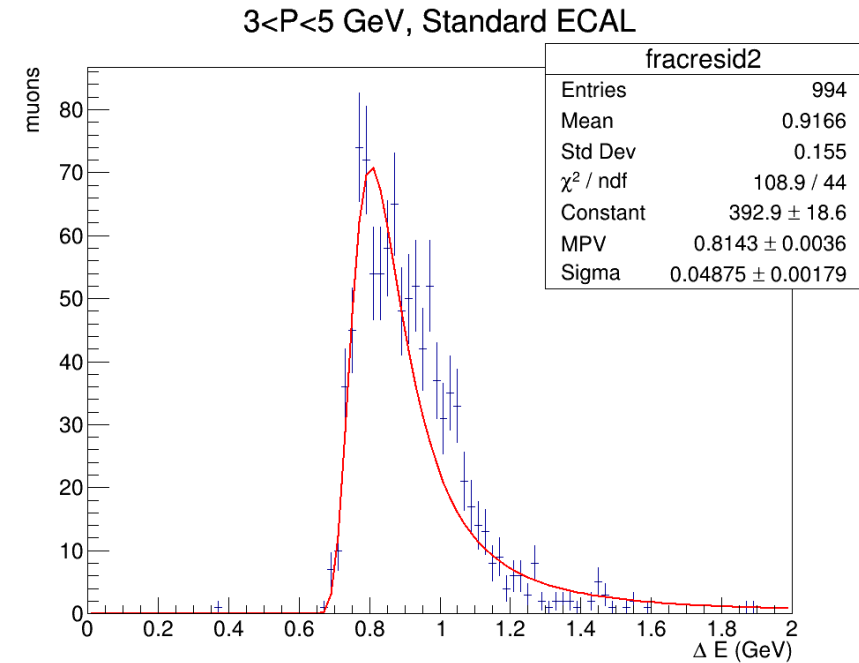
Resolution plot produced on garsoft v3 with random low energy muon sample generated upstream inside the detector (z=-190)

ENERGY LOSS PLOTS

- Graphs for Energy loss distribution for the sample outside the detector



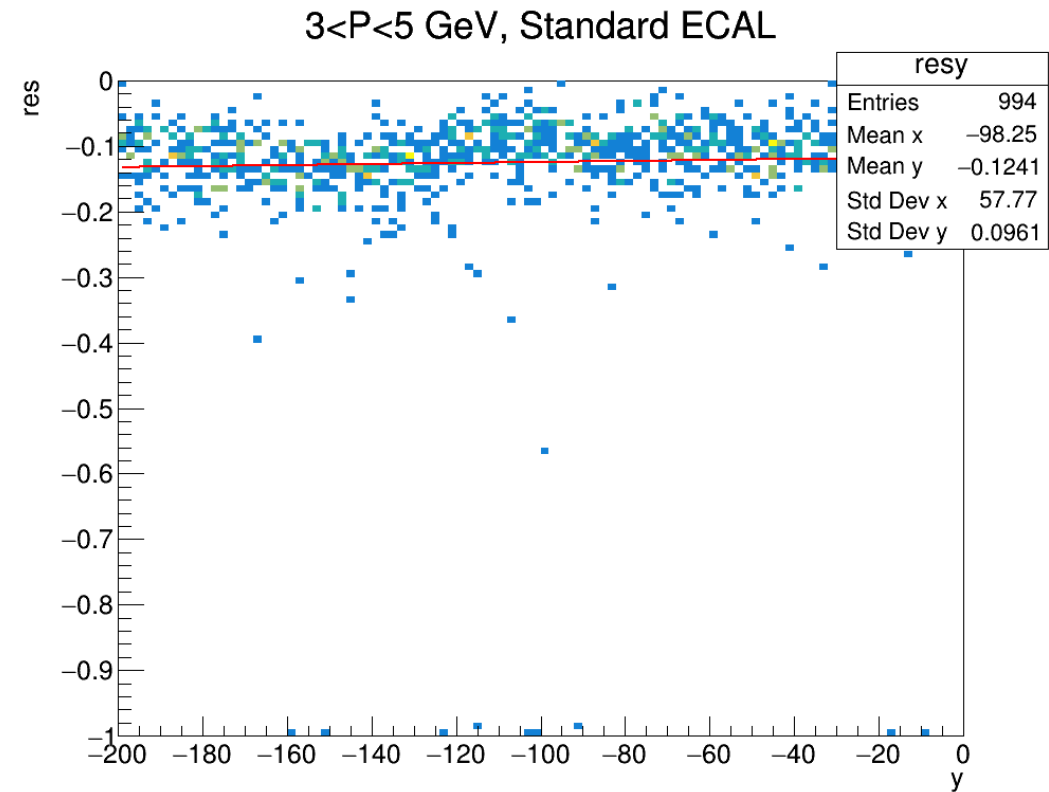
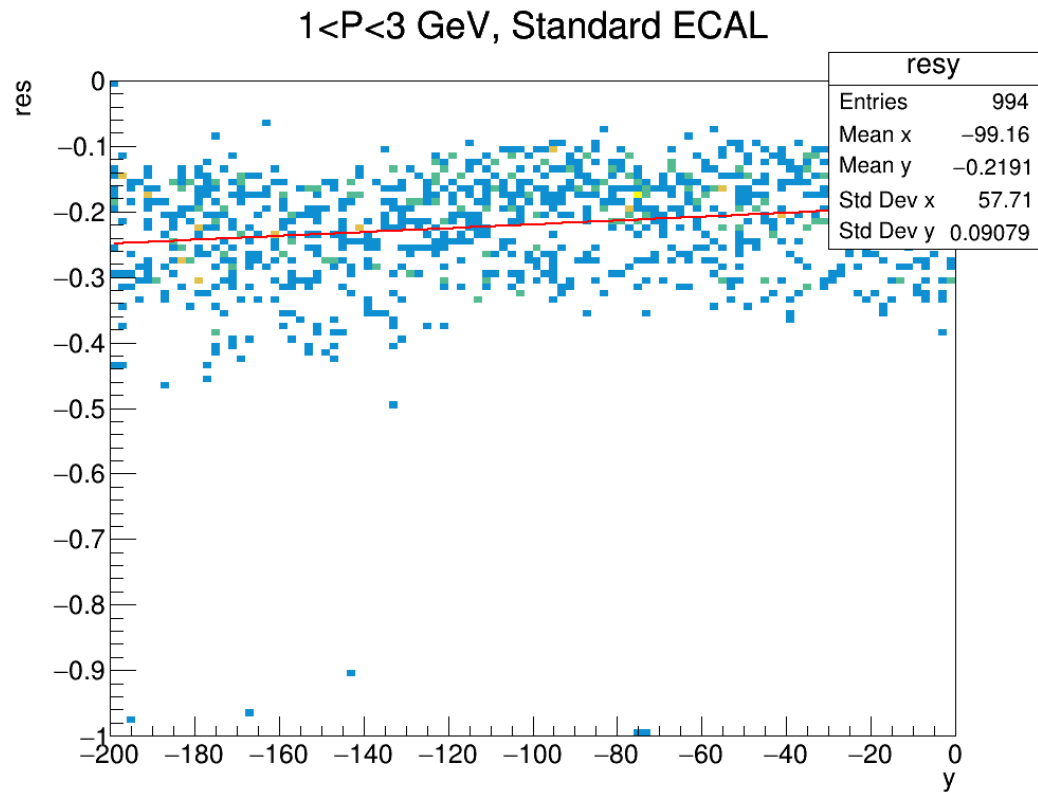
Energy loss plot produced on garsoft v3 with random low energy muon sample generated upstream outside the detector (z=-500)



Energy loss plot produced on garsoft v3 with random high energy muon sample generated upstream outside the detector (z=-500)

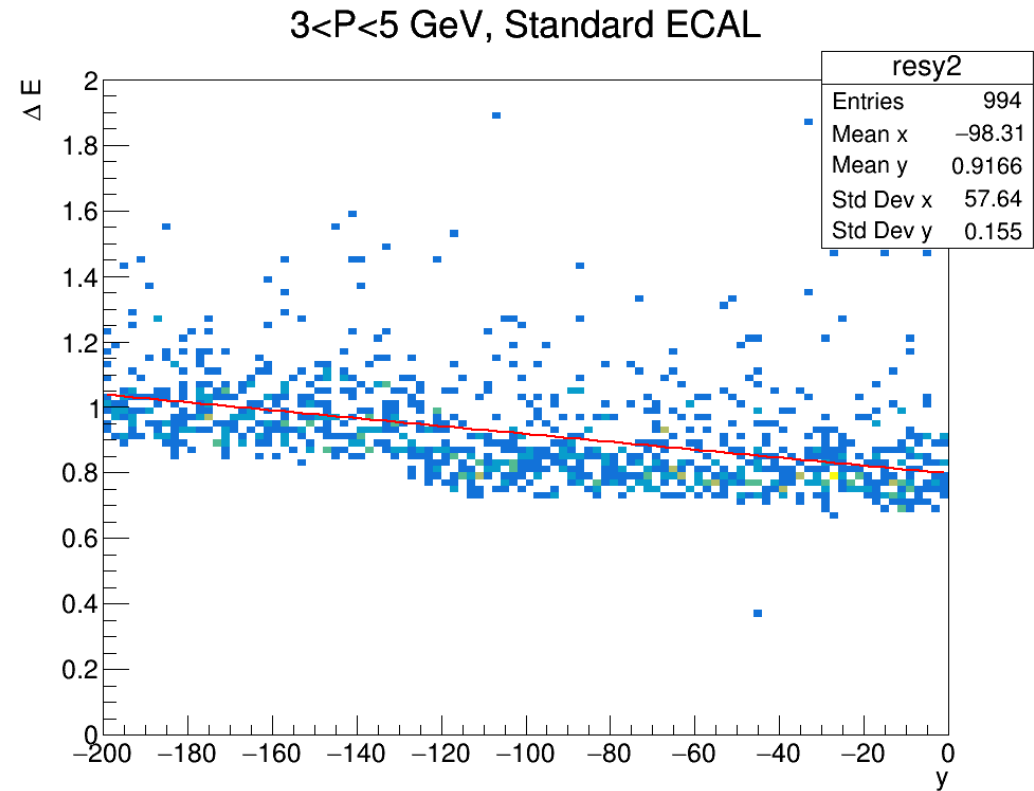
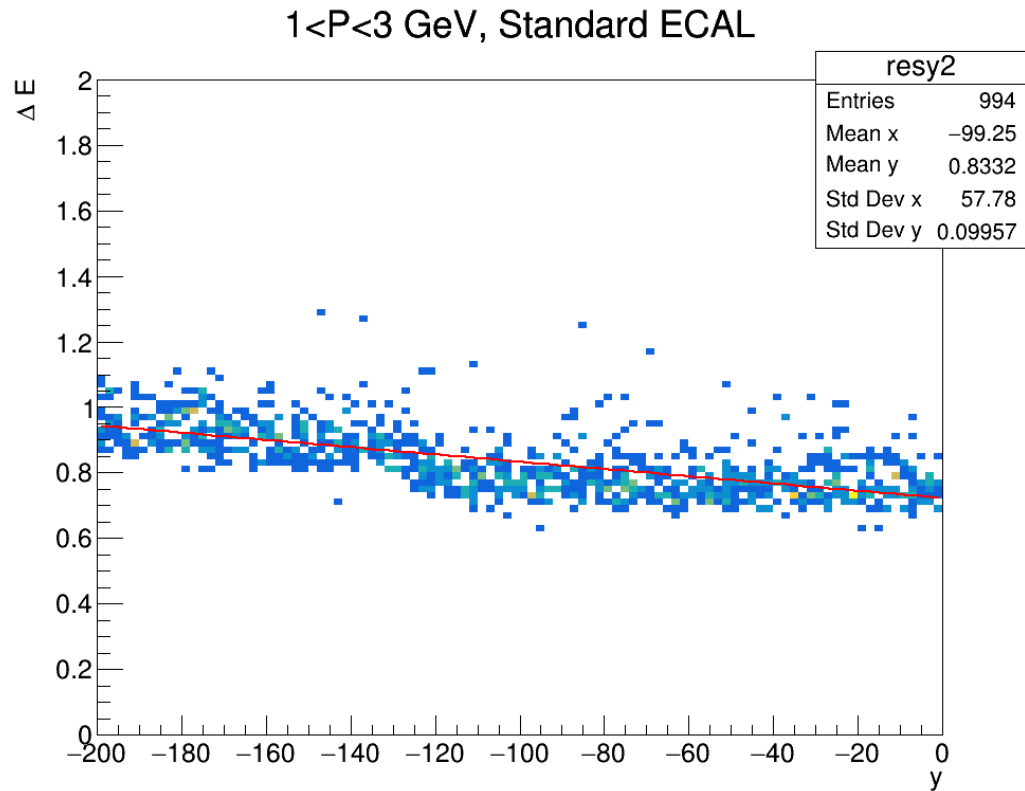
RESOLUTION AS A FUNCTION OF Y

- Plots of resolution as a function of the initial y (vertical) position of the muon (random upstream samples outside the detector $-200 \text{ cm} < y < 0 \text{ cm}$)



ENERGY LOSS AS A FUNCTION OF Y

- Plots of energy loss ΔE (GeV) as a function of the initial y (vertical) position of the muon (random upstream samples outside the detector $-200 \text{ cm} < y < 0 \text{ cm}$)

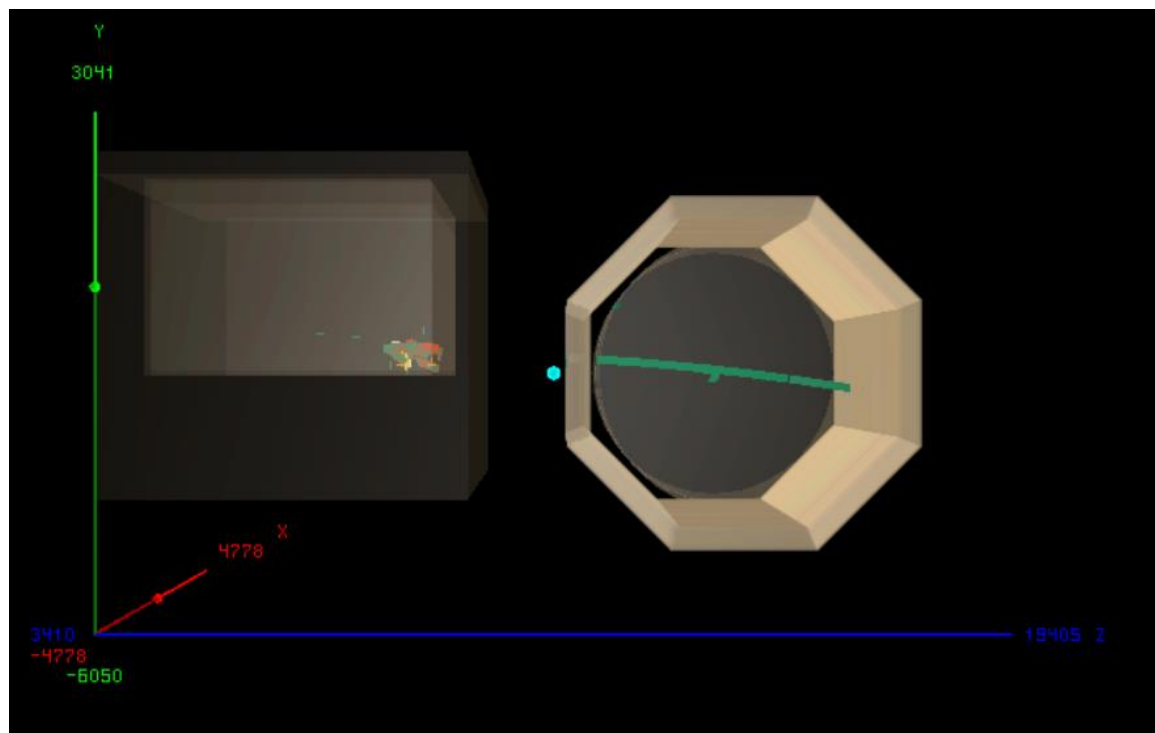


NEXT STEP IN THE SIMULATION

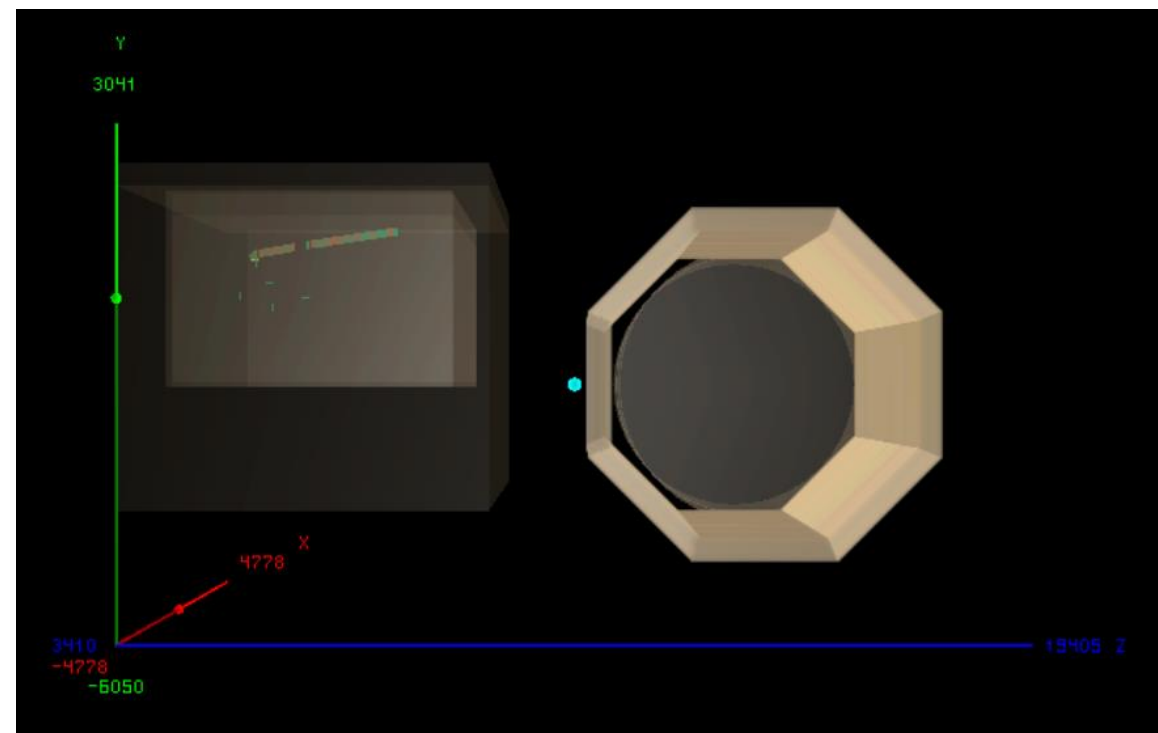
- The next step in the simulation is to produce a sample of muons generated in $\nu_\mu(CC)$ interactions in ArgonCube that have a trajectory such as they enter HPgTPC
- ND simulation chain:
 1. Simulate neutrino interactions with **GENIE** in a ND hall geometry file containing only the liquid Argon detector
 2. Propagate particles using **edep-sim** in a ND hall geometry file containing both ArgonCube and HPgTPC
 3. Convert edep-sim file to root file readable by **GarSoft**
 4. Follow the Garsoft reconstruction chain
- So far have reached point 3, having problems with point 4

EDEP-DISPLAY EXAMPLES

- Two graphical representations of $\nu_\mu(CC)$ interactions in ArgonCube made with edep-sim event display. In one the muon enters the gas TPC, in the other it does not



PASSING MUON



NON-PASSING MUON