# Simulation and Reconstruction of SSRI: A Tutorial

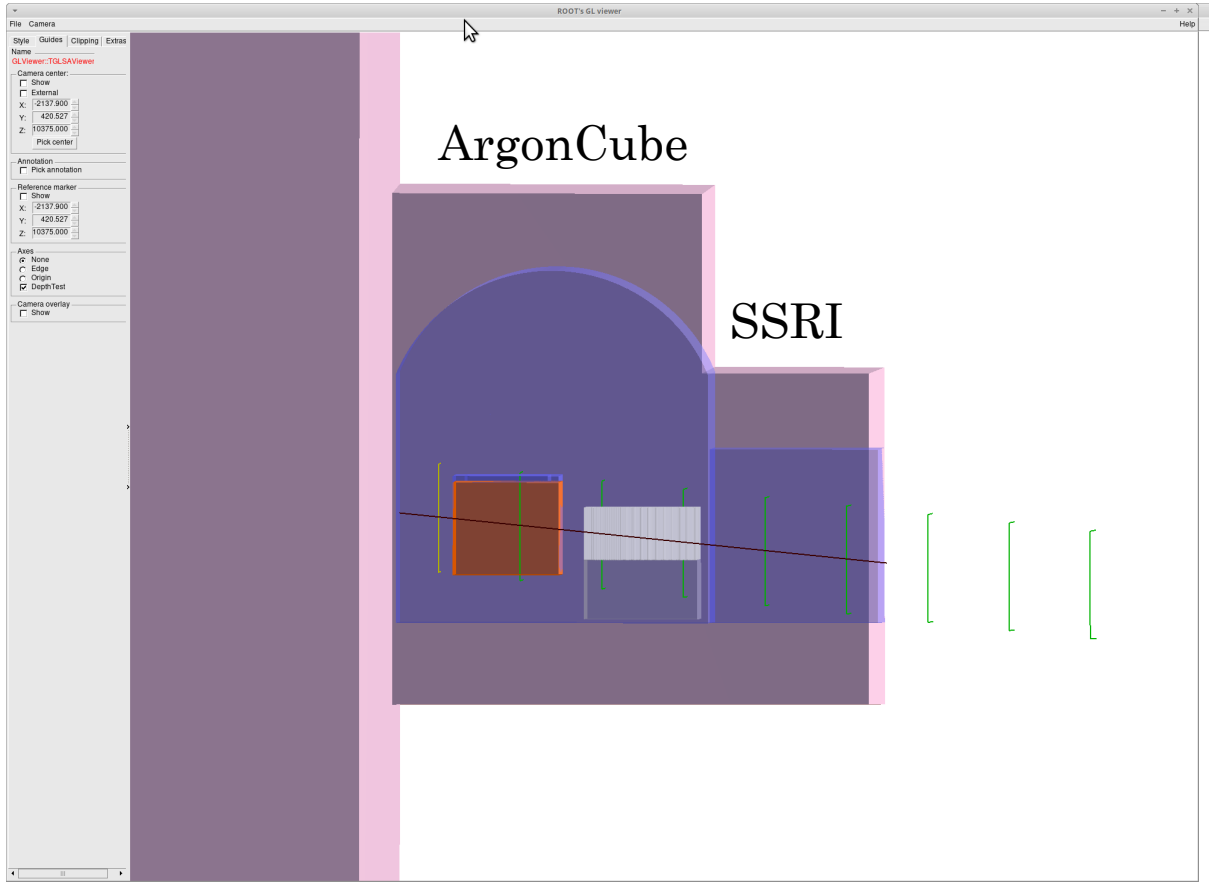
*"sign-selecting range indicator"*

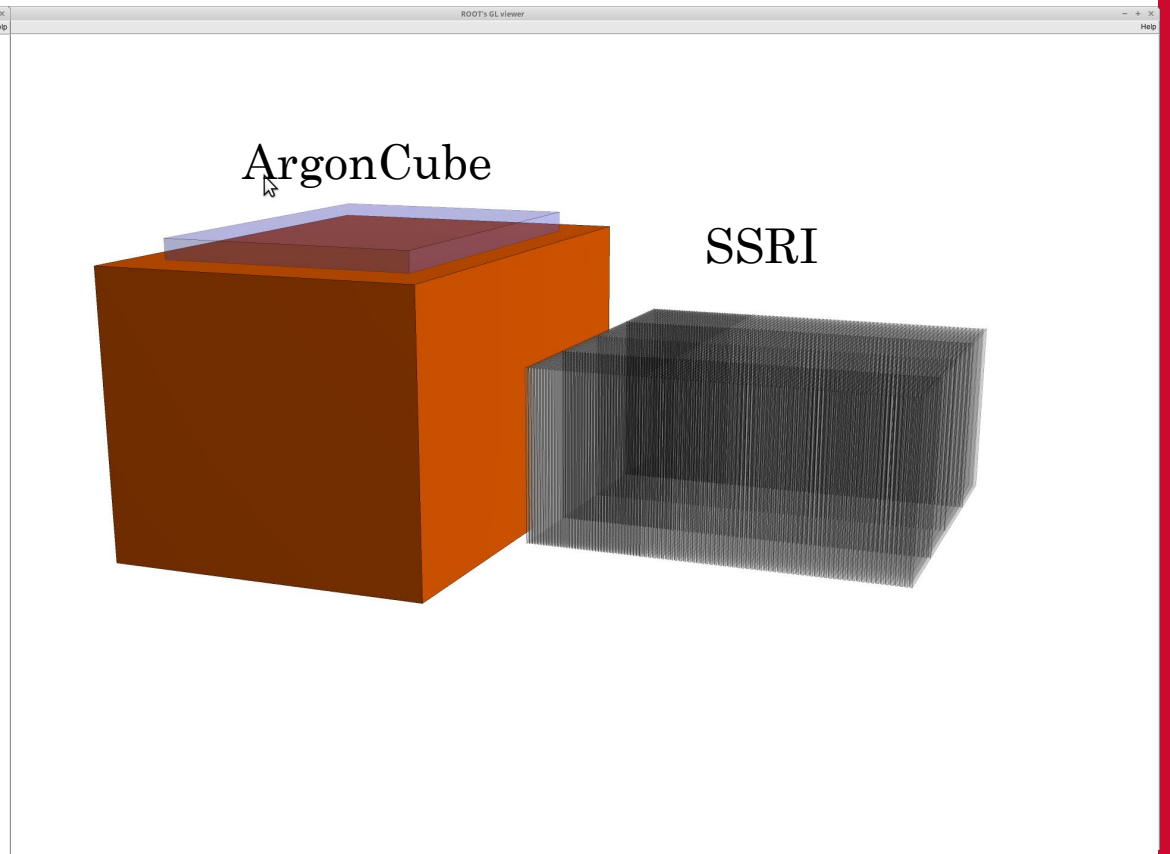
**Gavin S. Davies**

**With credit to the main code architect, Chris Marshall**

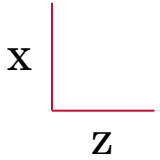
# SSRI – Sign-Selecting Range Indicator

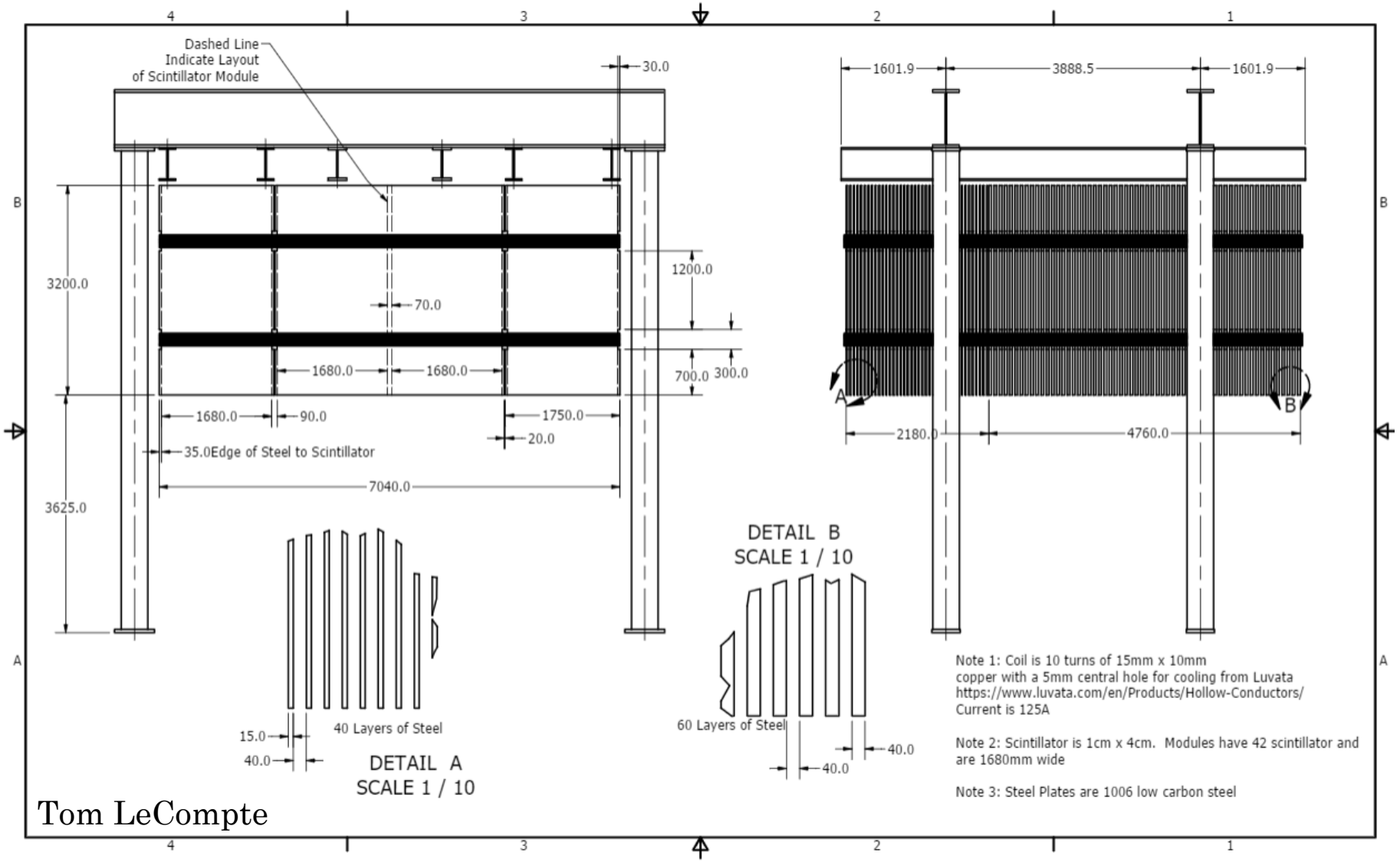
- DUNE Near Detector (at Fermilab) contingency characterization study
  - Simple muon spectrometer downstream of ArgonCube Liquid Argon (LAr) detector
    - Interleaved scintillator/steel layers



# SSRI – Concept 1b




Tom LeCompte

# Initial setup

```
# In your $HOME/.profile:
    alias emacs='emacs -nw '
    export EDITOR='emacs -nw'
```

*# Pick your favourite DUNE gpvm:*

*% ssh dunegpvmXX@fnal.gov*

*% cd /dune/app/users/<your-kerberos>*

*% git clone https://github.com/gavinsdavies/dune-ssri.git*

*#git help -- https://cdcvs.fnal.gov/redmine/projects/cet-is-public/wiki/Git_flow_quick_start#For-particular-development-tasks*

*# Setting up external software*

*% source <your-dir>/dune-ssri/setup/setup_ssri_ana.sh*

*% source <your-dir>/dune-ssri/setup/interactive.sh # Only if you're going to do interactive simulation tests*

*# Security certificates – for accessing files, submitting grid jobs*

*% kx509;*

*% voms-proxy-init -noregen -rfc -voms dune:/dune/Role=Analysis;*

*(consider adding to setup script; if this works you are setup to run GRID jobs)*

# Simulation

Need a better naming scheme! Can we change rmms→ssri?

- Starts with the geometry – a gdml* file (Palash/Mat provide this)
  - <your-dir>/dune-ssri/gdml/nd_rmms_sens_scint_w_mag_field.gdml
  - Defines all the volumes, positions etc.
  - Key is defining the "sensitive" (aka active) detector volumes – "rmmsvol" and "ArgonCube"

- With gdml in hand, need to produce maxpl.xml file
  - Explore the geometry to determine upper-limit on material pathlengths
    - Used to scale cross-sections for efficient generation

- We generate by running 100,000 flux rays through the geometry to be used for later generation
  - **gevgen_fnal** GENIE** standalone application generates the events
    - https://cdcvs.fnal.gov/redmine/projects/genie/wiki/Running_gevgen_fnal
    - Initial setup script got us setup for genie and genie_xsec etc. but we need a couple more tweaks for local running….

* Geometry Description Markup Language [XML-based]

**[GENIE: Event Generator & Global Analysis of Neutrino Scattering Data]

# Simulation: the maxpl file

% cp /dune/data/users/gsdavies/ssri/tars/gevgen.tar.gz <your-dir>/gevgen.tar.gz

% tar -xzf gevgen.tar.gz; cd gevgen/; # put your new gdml file in this directory!

% chmod +x copy_dune_ndtf_flux

% ./copy_dune_ndtf_flux --top /pnfs/dune/persistent/users/dbrailsf/flux/nd/gsimple/v2_8_6d --output <some_dir>/local_flux_files --flavor ${MODE} --base OptimizedEngineeredNov2017 --maxmb=60

**Let's not all do this step right now! For now we'll use my local flux file copies:**
/dune/data/users/gsdavies/ssri/local_flux_files

```
gevgen_fnal \
    -f /dune/data/users/gsdavies/ssri/local_flux_files/gsimple*.root,DUNEND \
    -g nd_rmms_sens_scint_w_mag_field.gdml \
    -t volArgonCubeActive \
    -m "+nd_rmms_sens_scint_w_mag_field.volArgonCubeActive.maxpl.xml" \
    -S "+100000" \
    -L cm -D g_cm3
    -n 1 \
    --seed 0 \
    -r 0 \
    -o neutrino \
    --message-thresholds Messenger_production.xml \
    --cross-sections $GENIE_XSEC_DIR/data/gxspl-FNALsmall.xml \
    --event-record-print-level 0 \
    --event-generator-list Default+CCMEC
```

Files saved where you stated --output.

Also makes local .list, .list.match and .list.match.shuffle files. You don't need these

MODE options: "neutrino" or "antineutrino"

OK, we now have the maxpl file so can move to the next step in generation…

# Generating events!

First, interactively (i.e. on local gpvm to test)

1

```
gevgen_fnal \
    -f /dune/data/users/gsdavies/ssri/local_flux_files/gsimple*.root,DUNEND \
    -g nd_rmms_sens_scint_w_mag_field.gdml \
    -t volArgonCubeActive \
    -m nd_rmms_sens_scint_w_mag_field.volArgonCubeActive.maxpl.xml \
    -L cm -D g_cm3 \
    -n 10 \
    --seed 0 \
    -r 0 \
    -o neutrino \
    --message-thresholds Messenger_production.xml \
    --cross-sections $GENIE_XSEC_DIR/data/gxspl-FNALsmall.xml \
    --event-record-print-level 0 \
    --event-generator-list Default+CCMEC
```

10 events

Different command (-m slightly modified) and no -S option)
Output should be **neutrino.0.ghep.root**

2

Convert the genie output to rootracker:

```
gntpc \
    -i neutrino.0.ghep.root \
    -f rootracker \
    --event-record-print-level 0 \
    --message-thresholds Messenger_production.xml
```

3

Run edep-sim*

```
% cp neutrino.0.gtrac.root input_file.gtrac.root
# because that's what edep-sim expects
```

```
edep-sim -C \
    -g nd_rmms_sens_scint_w_mag_field.gdml \
    -o edep.0.root \
    -u \
    -e 10 \
    dune-nd.mac
```

**Congratulations!** You've now got 10 simulated neutrino events with detector energy deposits to look at!

*https://github.com/ClarkMcGrew/edep-sim

An energy deposition simulation based on G4

# Grid submission

Don't just make lots of files.
Let's coordinate any submissions

- You've got the new gdml file, maxpl.xml and are happy with local tests. Ready to submit!

% setup jobsub_client

```
jobsub_submit \
    -N 100 \
    --OS=SL6 \
    --group=dune \
    --resource-provides=usage_model=DEDICATED,OPPORTUNISTIC \
    --expected-lifetime=8h \
    --memory=2000MB \
    file://<your_dir>/dune-ssri/grid/run_gevgen_edepsim_no_ntuple.sh FHC 0 10000 <geom_name>
```

**BUT!! You need to make some edits of the grid submission first and some pnfs setup**
**Edit:**
TOPDIR="/pnfs/dune/scratch/users/<your-dir>" # you may need to make it first
Also, in this directory, you need a copy of the gevgen.tar.gz that **includes the new gdml and maxpl**
**As well as a copy of the edep-sim.tar.gz**

**At end of the script also is a modified output dir. Will fix for user input!**

# Analysis

Will make these take i/o args
And less me-centric!

```
% python dumpSSRITree.py \
    --topdir /pnfs/dune/scratch/users/gsdavies/ssri/outputs/edep/orig \
    --first_run 0 \
    --last_run 0 \
    --outfile test.root
```

# Runs over run 0 from the output simulation and creates ntuple
Currently can run over up to 99
I tend to run in batches so not to swamp the VM, so say 0 -> 19 for example

```
% python <your-dir>/dune-ssri/ana/fill_histos.py
```

Reads tree and makes histograms
Edit “topdir” and “tree.Add("%s/dump_cmfix_allnu-v1.root" % topdir )” # this is the input tree

```
% python <your-dir>/dune-ssri/ana/make_plots.py
```

Plots the histograms
Edit “topdir” and “tf = ROOT.TFile( "%s/dumpall_cmfixhistos.root" % topdir )”

# Track Length

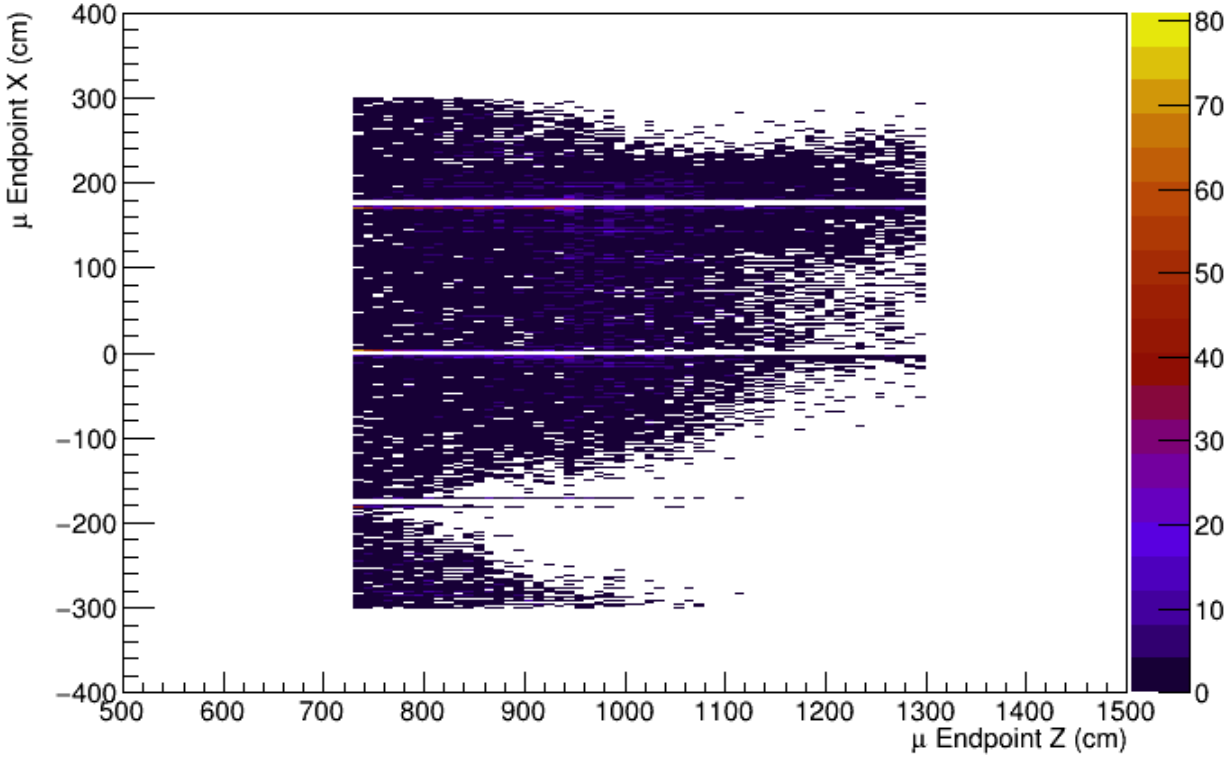
Chris updated my tracking with more accuracy, correctly accounting for differing regions;

- 3 cm air + 1 cm scintillator + 1.5 cm steel [region 1], Z < 950 cm
- 3 cm air + 1 cm scintillator + 4 cm steel [region 2], Z > 950 cm
- Also includes nplanes cut of 8 planes (more on this in a sec)

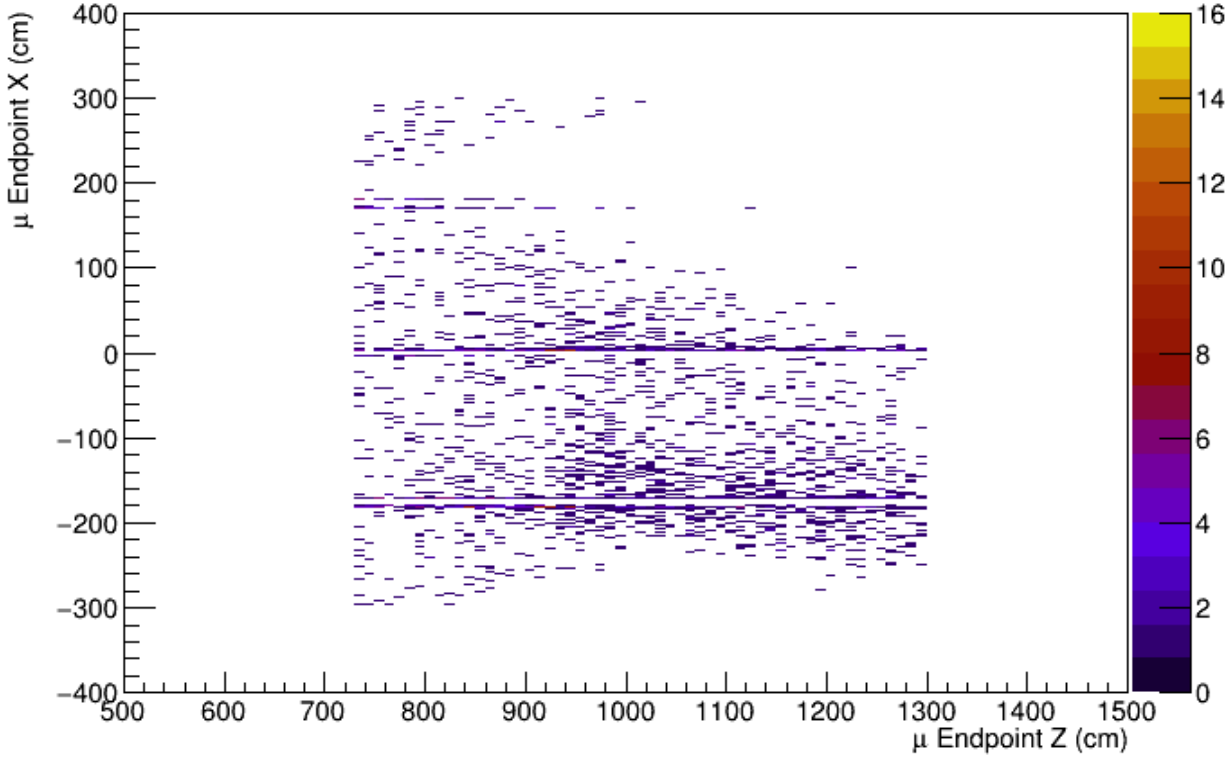
Plot versus Kinetic Energy (taken to be KE of last hit in Lar)

- In progress: correct for KE loss between Lar active and SSRI first layer – edep-sim limitations

Neutrino



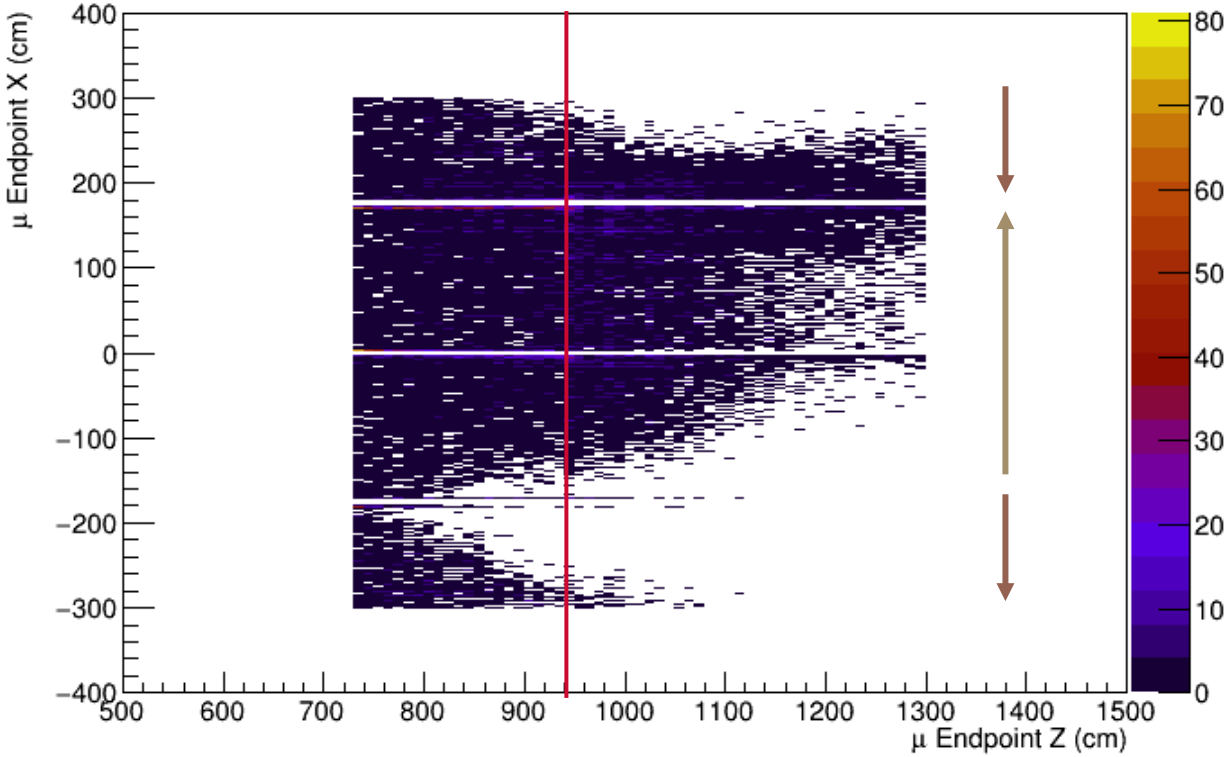

Antineutrino



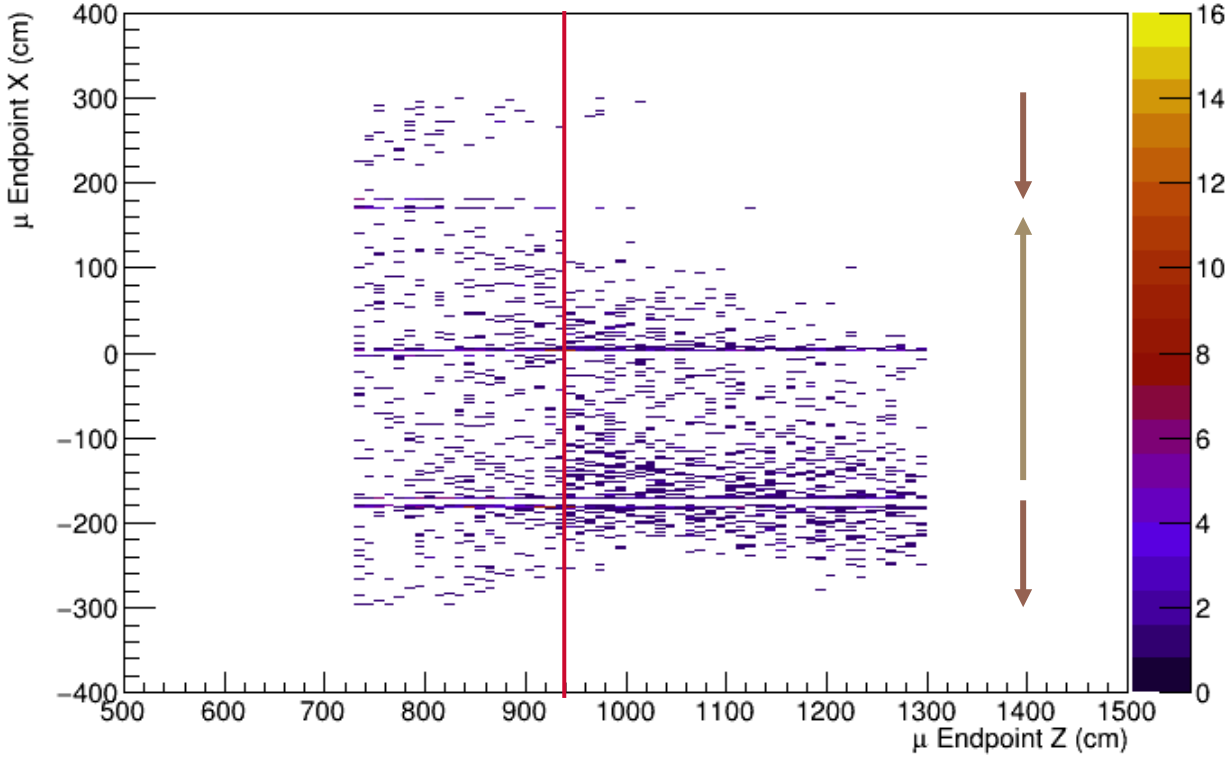
# Track Length Cleanup

- Extended nplanes cut to 8. Initial 4 plane restrictive because of the empty layers in the structure.
  - SSRI containment based on last hit position, front-entering muons

Neutrino



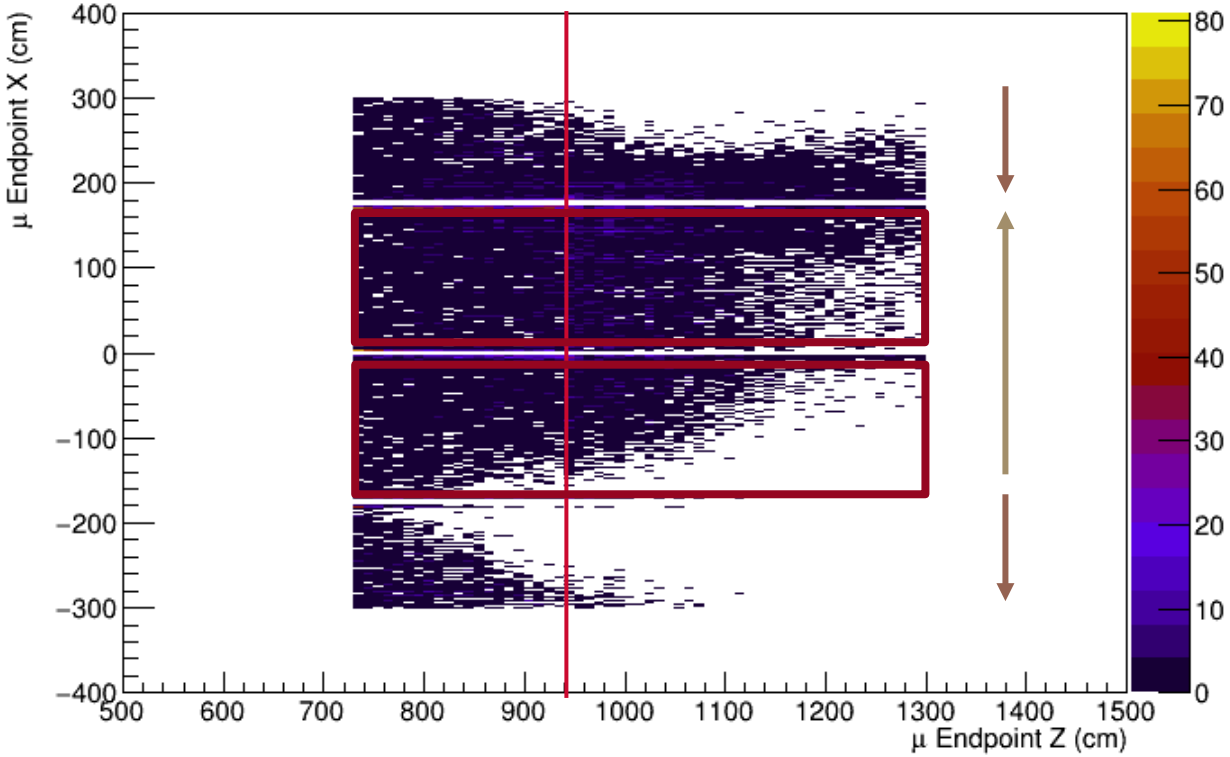

Antineutrino



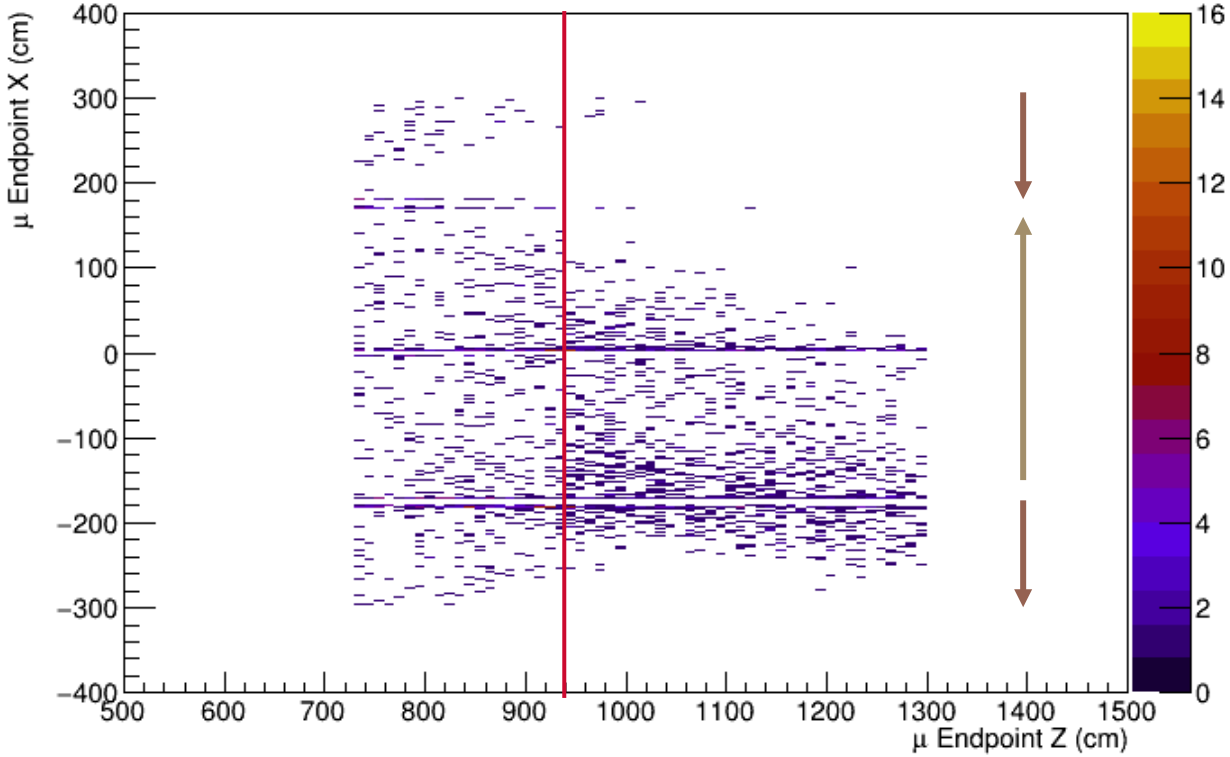
# Track Length Cleanup

- Extended nplanes cut to 8. Initial 4 plane restrictive because of the empty layers in the structure.
  - SSRI containment based on last hit position, front-entering muons
  - Cut on events in the uniform region

Neutrino



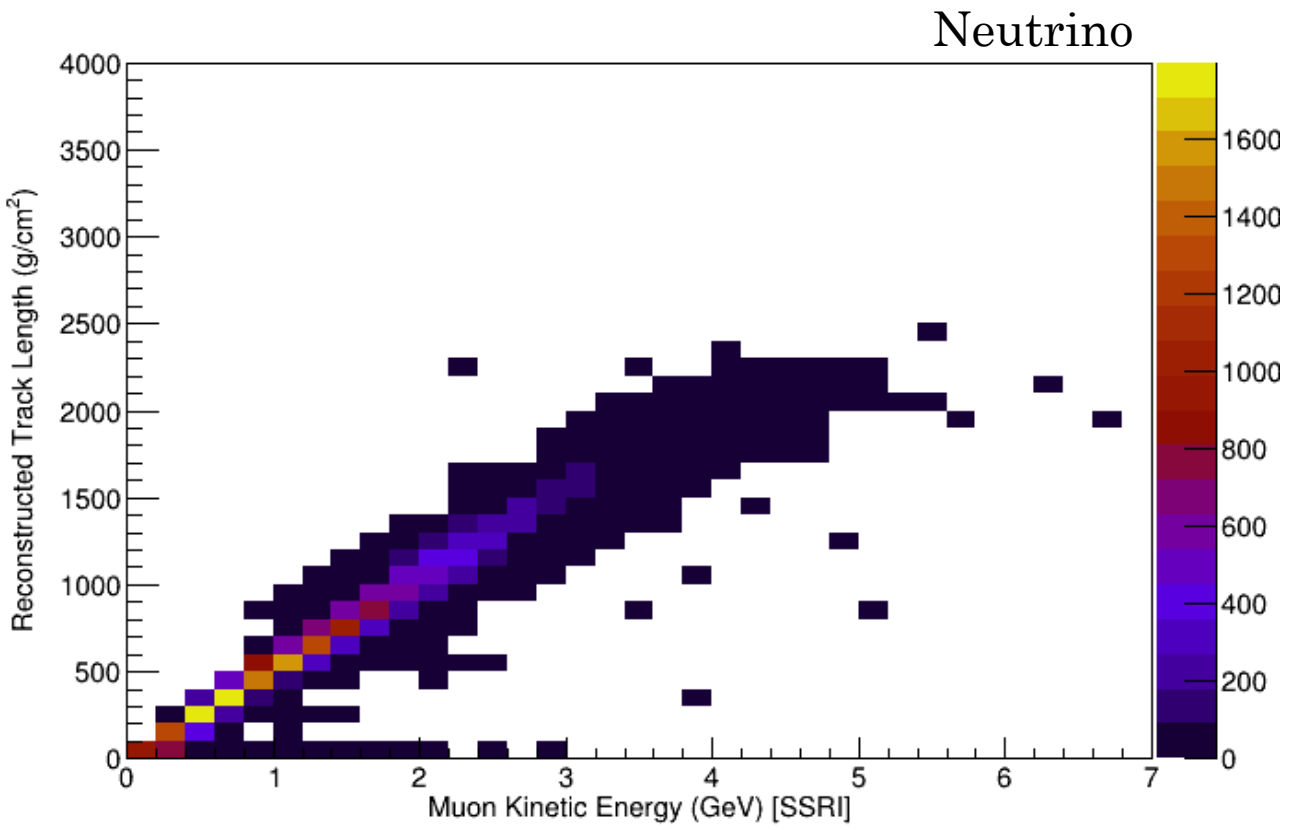

Antineutrino

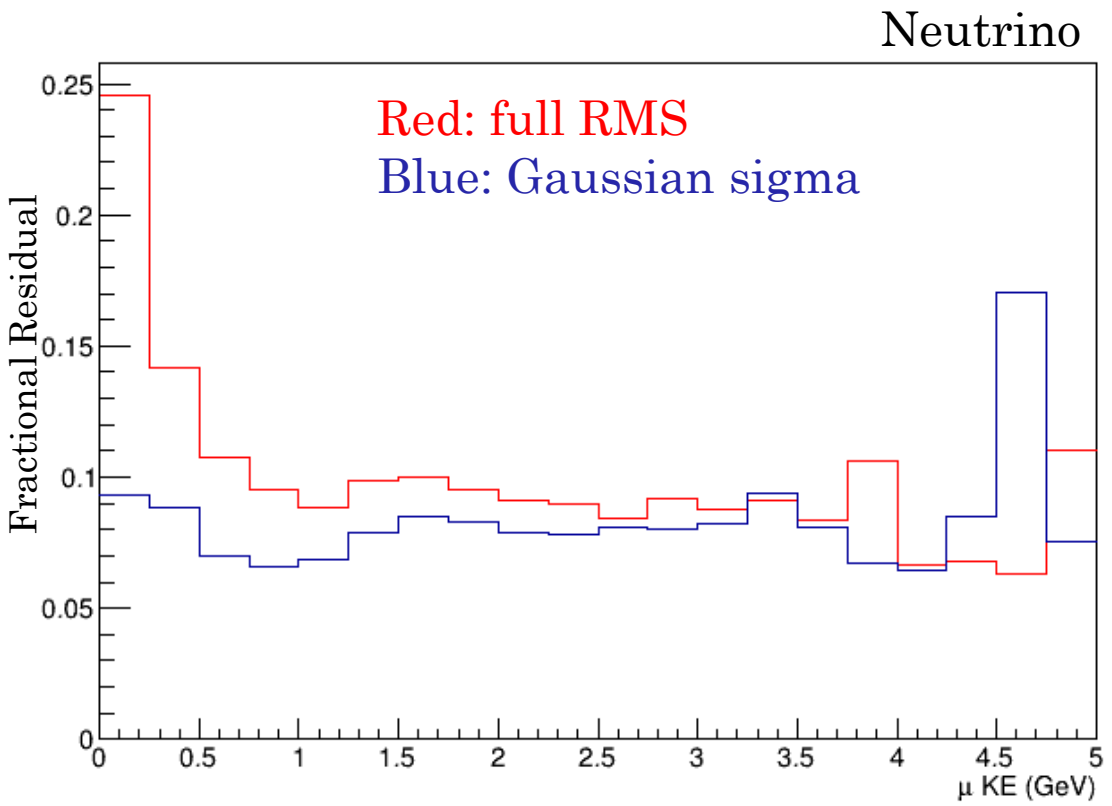


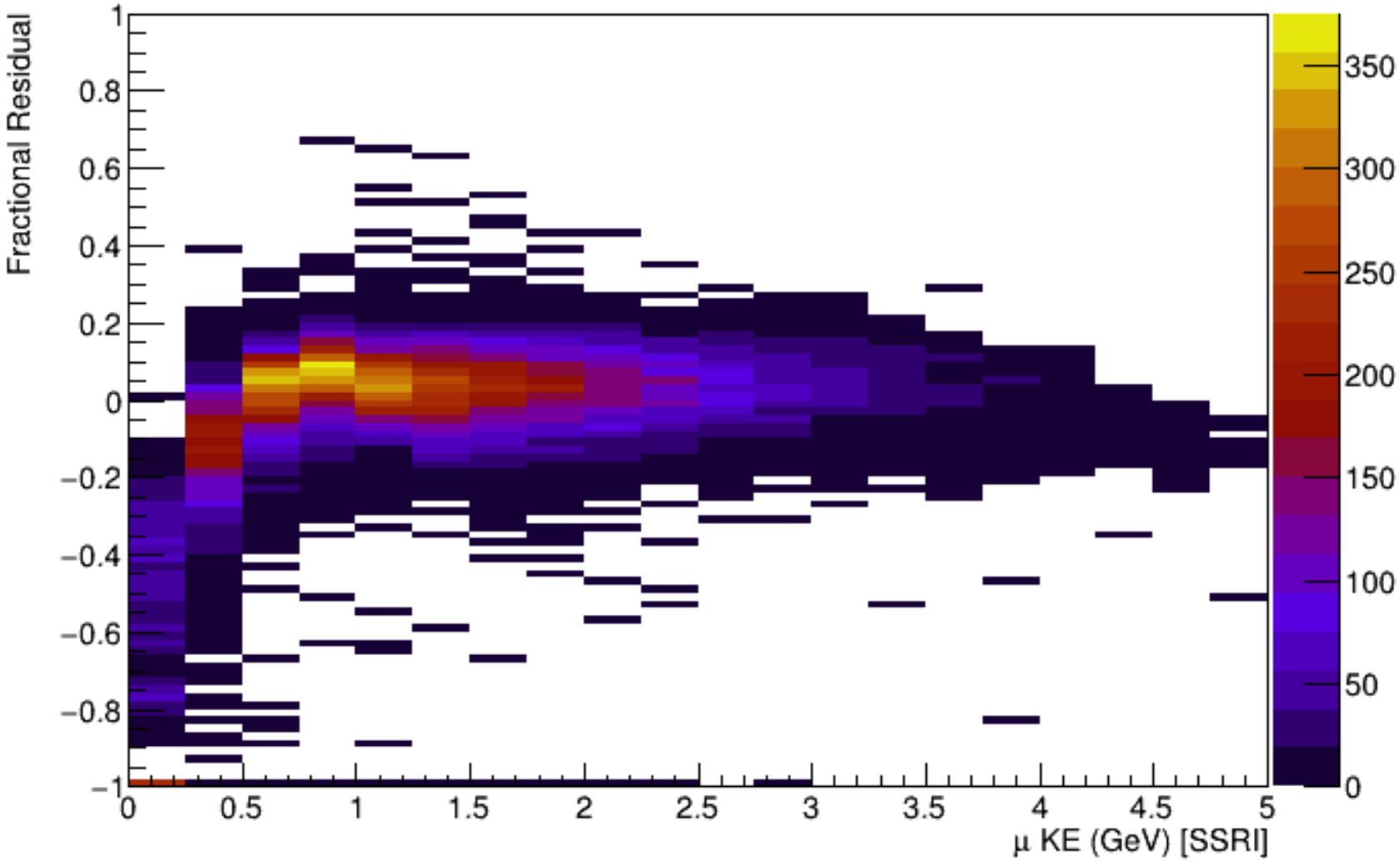
# KE vs. Track Length

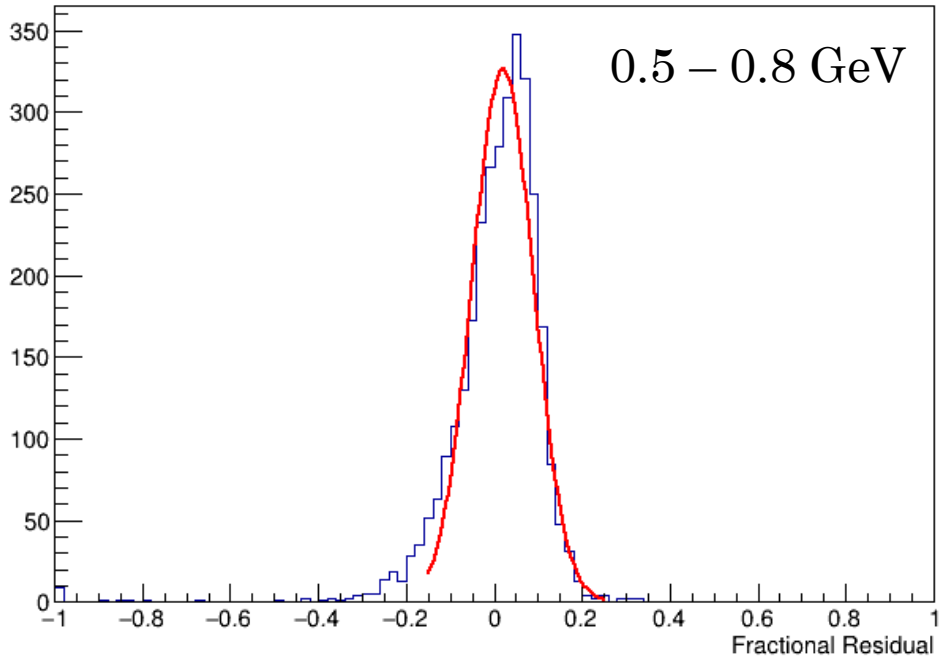
Correction for KE may clean up (currently KE of last hit in LAr)

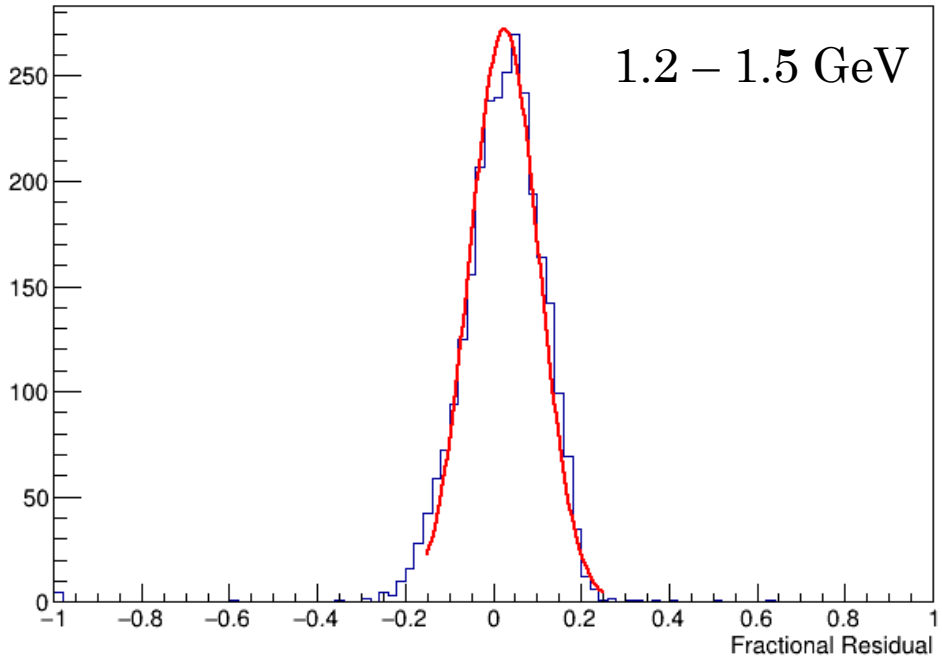
- need average material traversed between Lar active and SSRI first layer

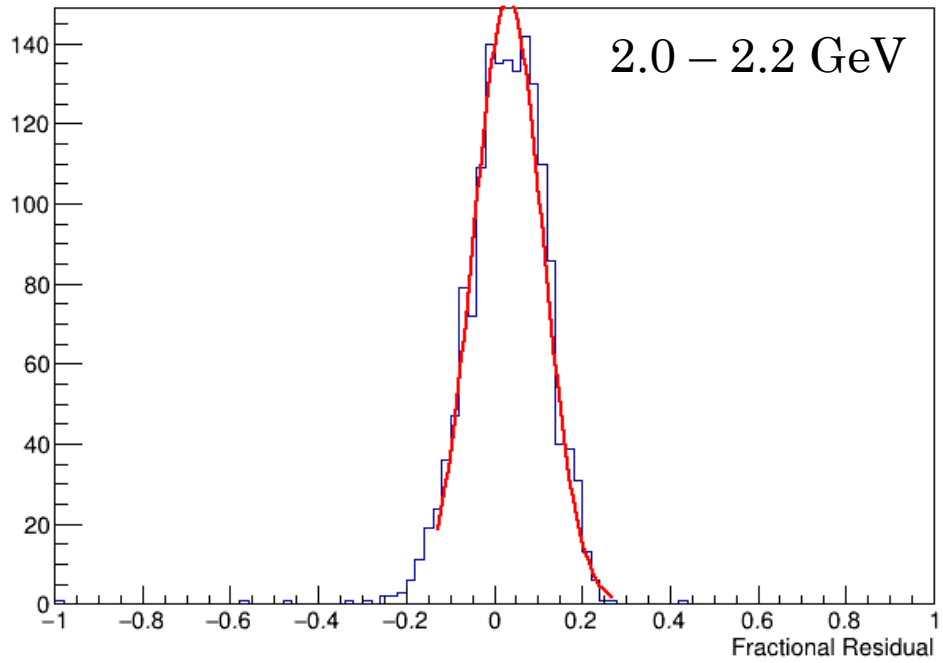


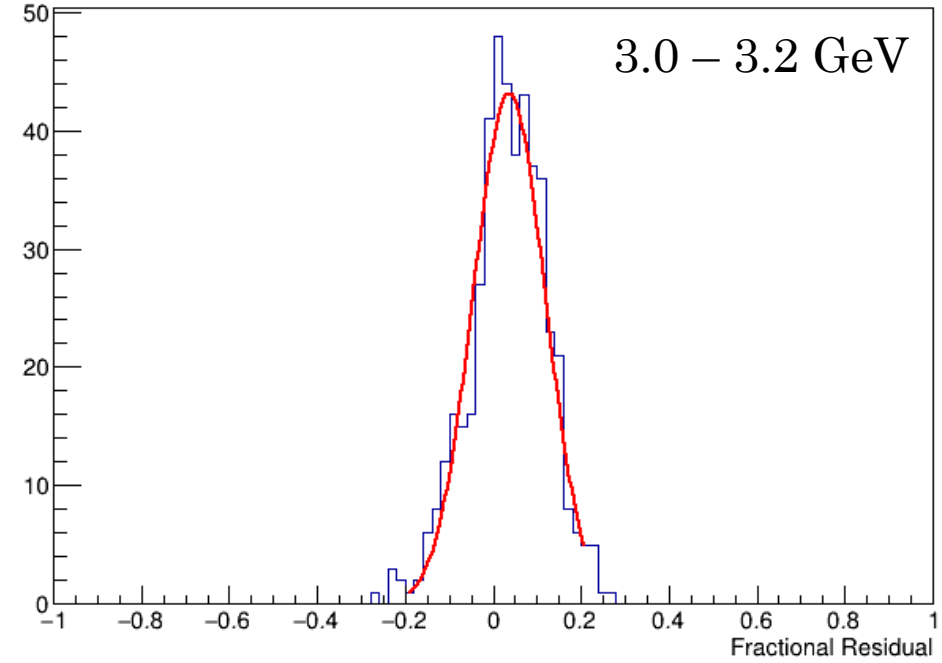



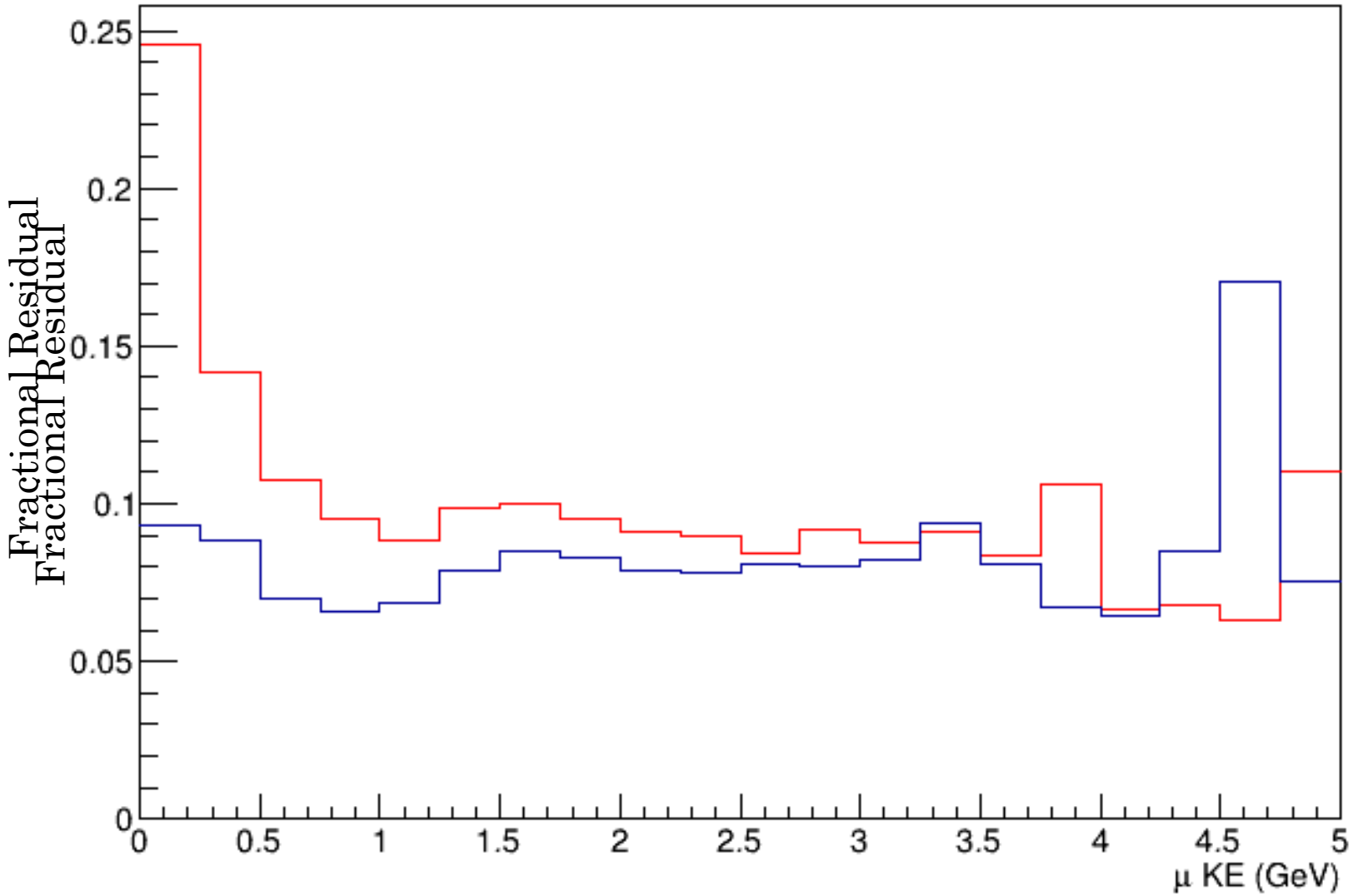

Fractional Residual
1
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
μ KE (GeV) [SSRI]
350
300
250
200
150
100
50
0


0.5 – 0.8 GeV
Fractional Residual


1.2 – 1.5 GeV
Fractional Residual


2.0 – 2.2 GeV
Fractional Residual


3.0 – 3.2 GeV
Fractional Residual


Fractional Residual
Fractional Residual
0.25
0.2
0.15
0.1
0.05
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
μ KE (GeV)

# Some git tips

Made some changes:

% git status # check what is different

% git add <file>

% git commit -a -m “message” # or don’t use -m option and let git open your editor!

# Please make your commit message nice and clear what you’ve done

% git push  # push your changes to the repository

Create your own branch to work without affecting others (or in your own github account you can fork the repository and then submit pull request later):

% git branch <feature_branch>

% git checkout <feature_branch>

% git push origin <feature_branch> # add and commit as normal but push here