
# Near Detector geometry and rock interaction events.

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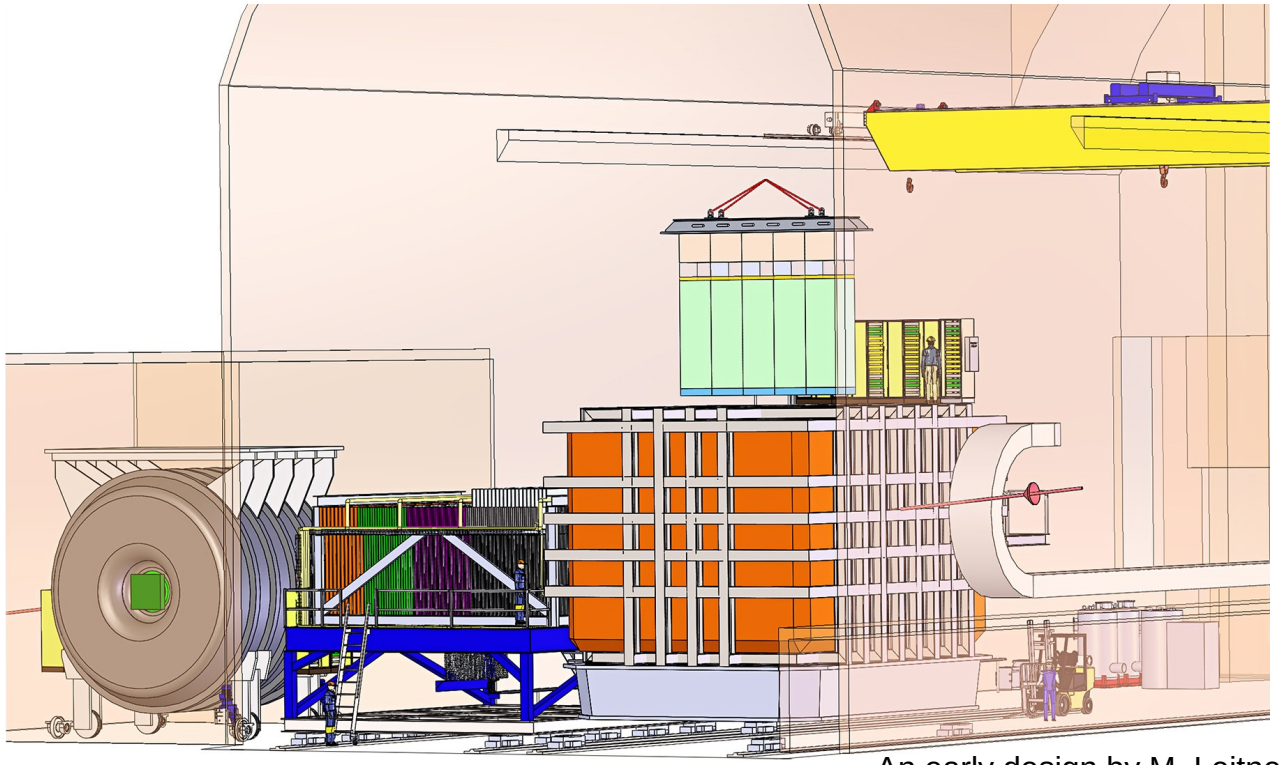
# What is this the ND Temporary Muon Spectrometer?

- The temporary muon spectrometer (TMS) is a magnetized range stack to measure the momentum and charge of muons from the ND-LAr.
- It is meant as an inexpensive option to facilitate day-one ND capabilities for early oscillation physics.
- It will operate for few years and then be replaced by the more capable ND-GAr.



An early design by M. Leitner

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# Performance Goals

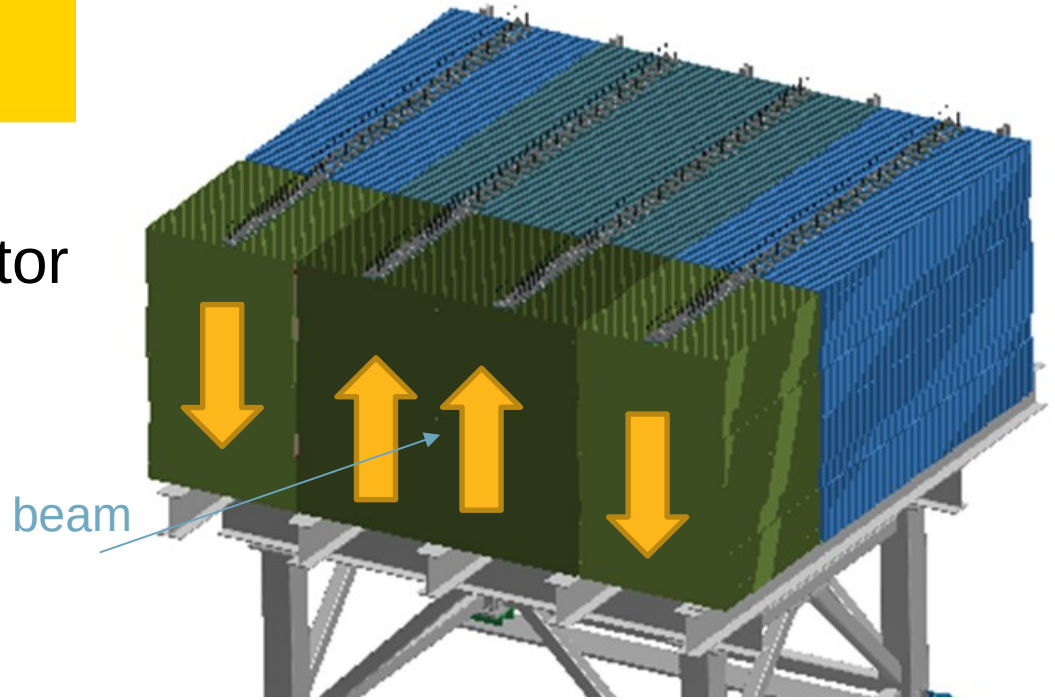
- Determine the momentum of muons escaping the ND-LAr **no worse than the Far Detector** (~4%).
- Determine the neutrino/anti-neutrino beam composition.
- Ensure broad kinematic acceptance of LAr muons.
- Note: These are the initial design goal and they are still under study.

# GEOMETRY

- Dune-ND-GGD a is tool to build geometries for DUNE near detector. Dunendggd is based on the sophisticated package called GeGeDe-python based package.
- It produces GDML files. These files are used by Geant4 or Root application.
- Geometry gdml file was produced by Wichita State University.

# Current Design

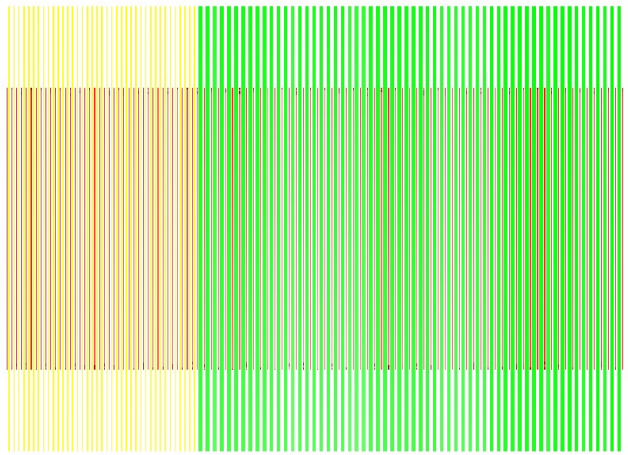
- 100 layers of alternating steel and scintillator
  - 40 layers of 1.5 cm steel
  - 60 layers of 4 cm steel
  - 4 cm gap between layers
  - Each steel layer is comprised of three plates
    - 3.5 m central plate and flanking 1.75 m plates.

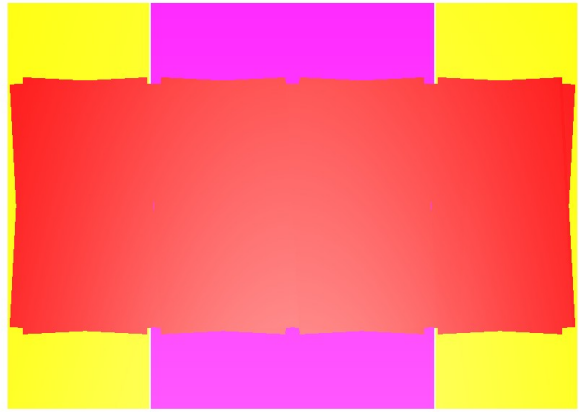



- Each module layer has four panels, each containing 48 MINOS-like scintillator slats, 3.5 cm wide, and spanning the vertical extent of the detector.
- It can move in the x-direction (PRISM)
- The 1 T field in the central plates point opposite the sides plates.
  - Field direction shown in diagram (yellow arrows).

# TMS geometry 2D

40 thick layers





<box name="thinlayerbox" lunit="cm" x="703.5999999999999" y="502.20000000000005" z="1.5"/>

<rotation unit="degree" name="Modrirot" x="0" y="0" z="3"/>
<rotation unit="degree" name="Modleftrot" x="0" y="0" z="-3"/>

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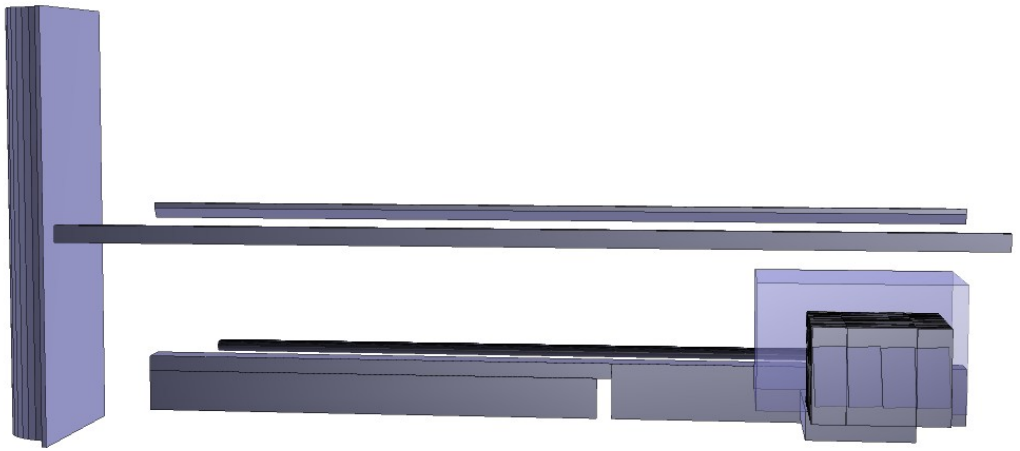
# ND Hall with Lar & TMS

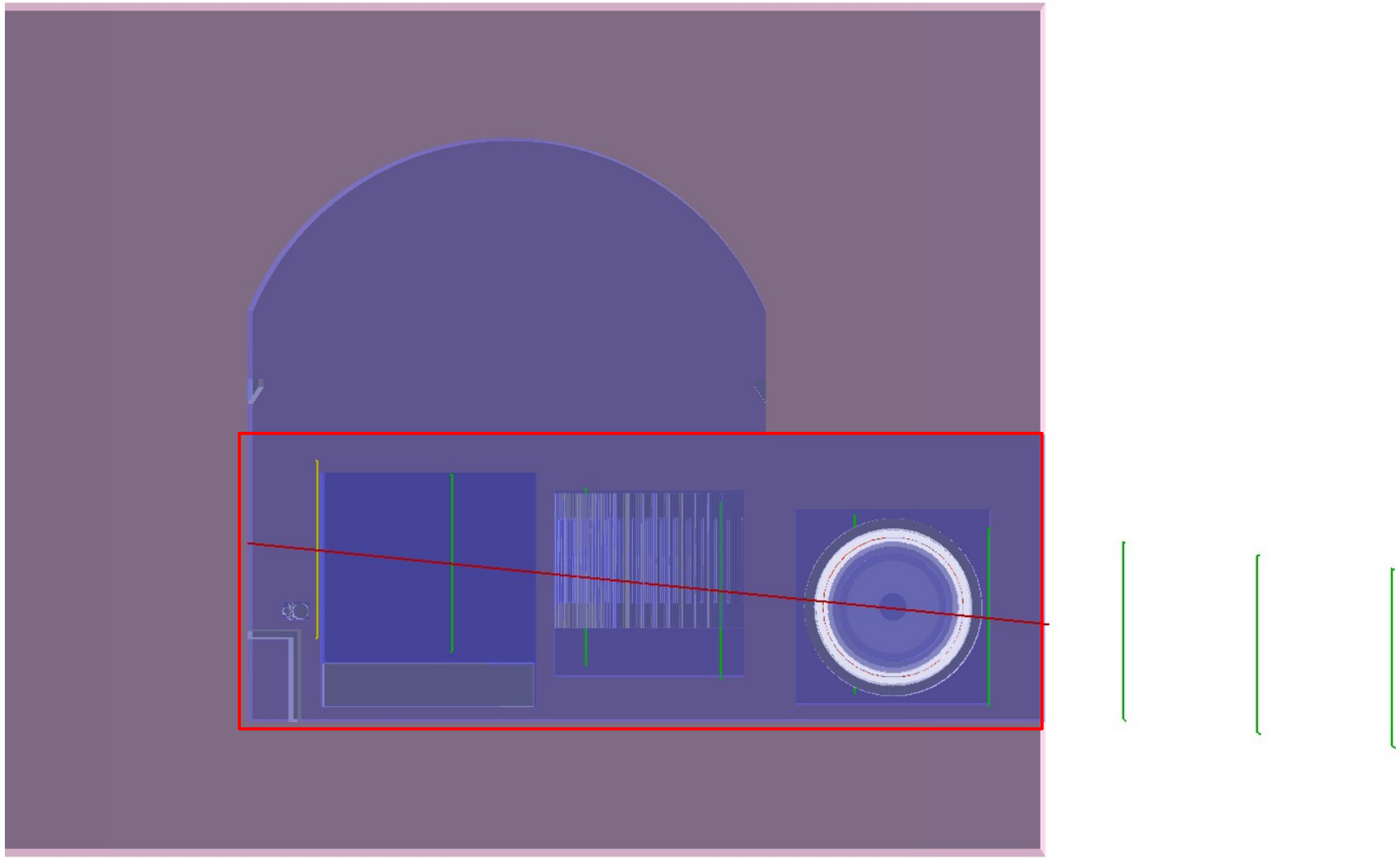


# Rock Interaction Events

- “Rock events” is a term used for neutrino interactions outside the detector hall.

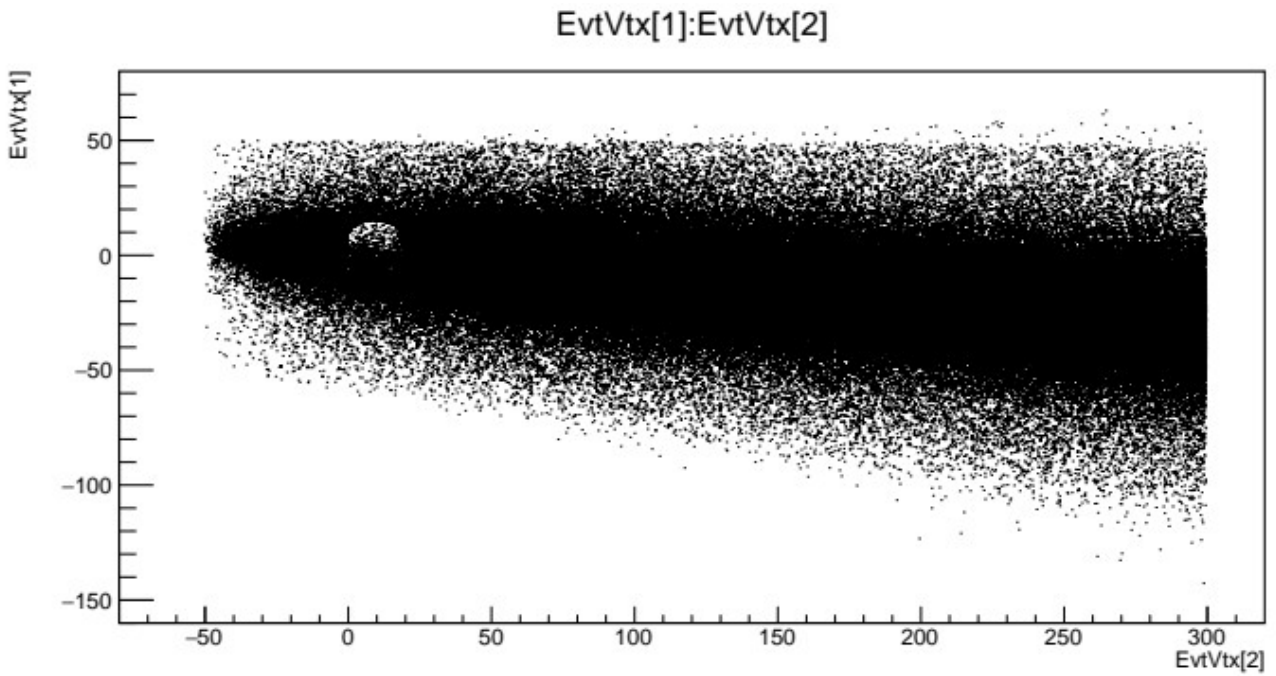
- Rock events usually refer to rock and soil neutrino interactions outside the detector hall and the surrounding materials.
- I am trying to investigate efficiently Genie rock box features.

# Rock Box



# Rock Box

- Generated a common set of GENIE “gntp.*ghet.root files.
- To generate .root files, I used a flux configuration with larger “window” to capture all the relevant interactions that contribute to particles entering the hall.



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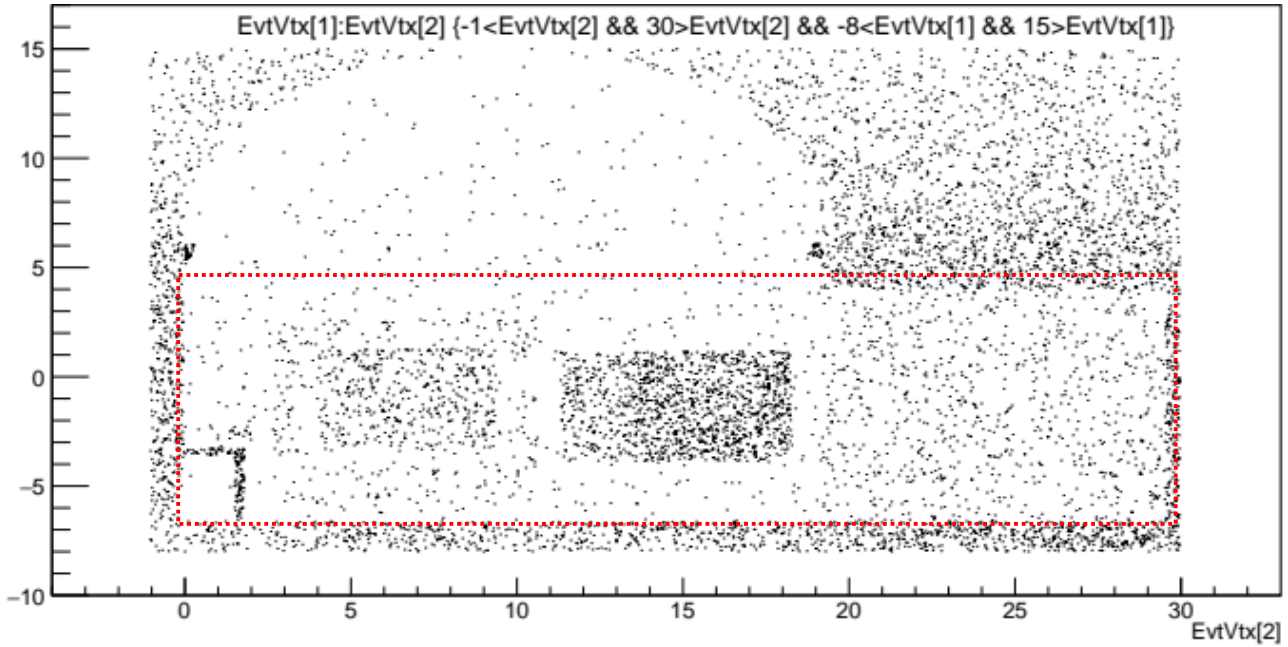
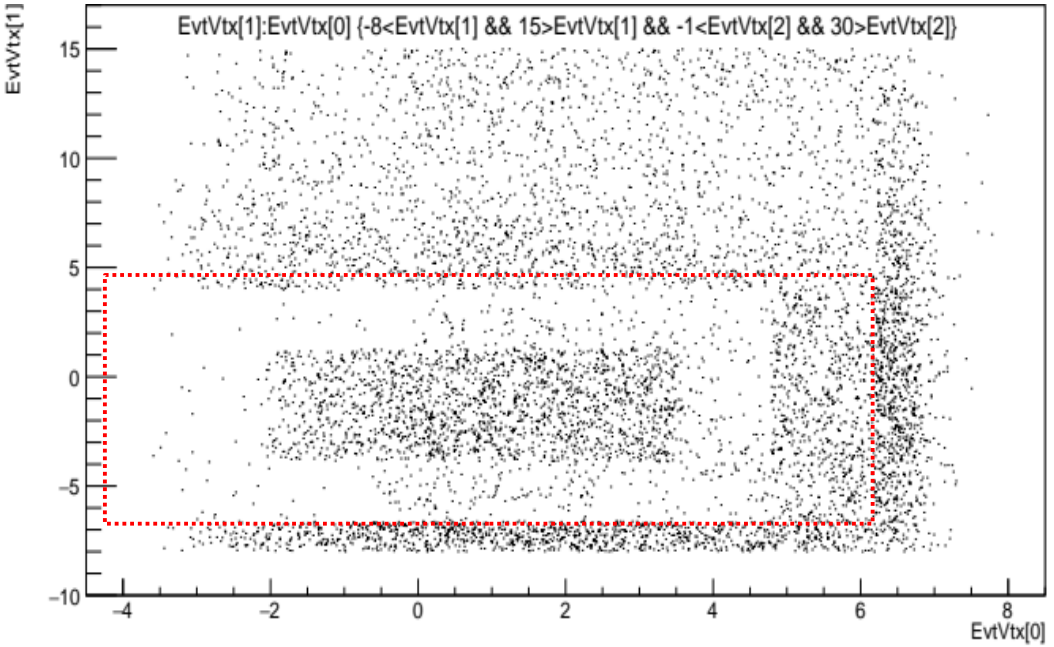
# Rock Event Interaction



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# Rock Interaction Events

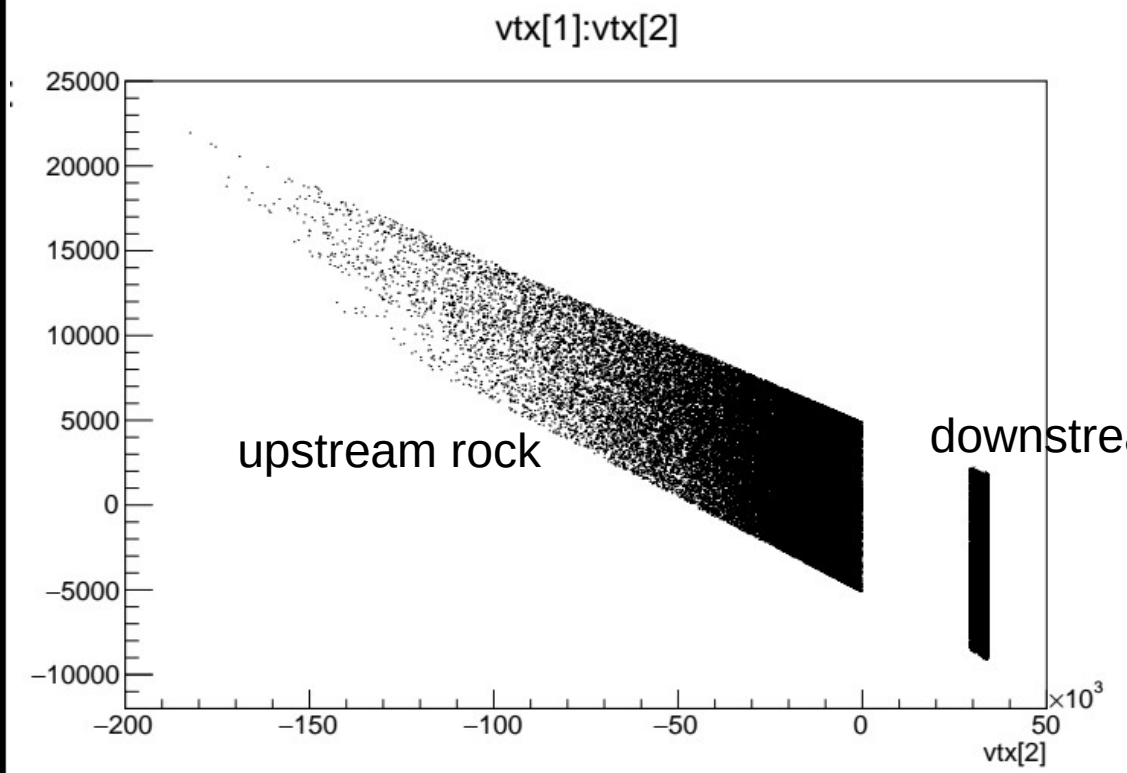
- Selectively keeps GENIE events which are determined to have produced particles likely to reach the hall (defined by a a variable”RockBox”).
- I geneated rock interaction events with POT 1e16

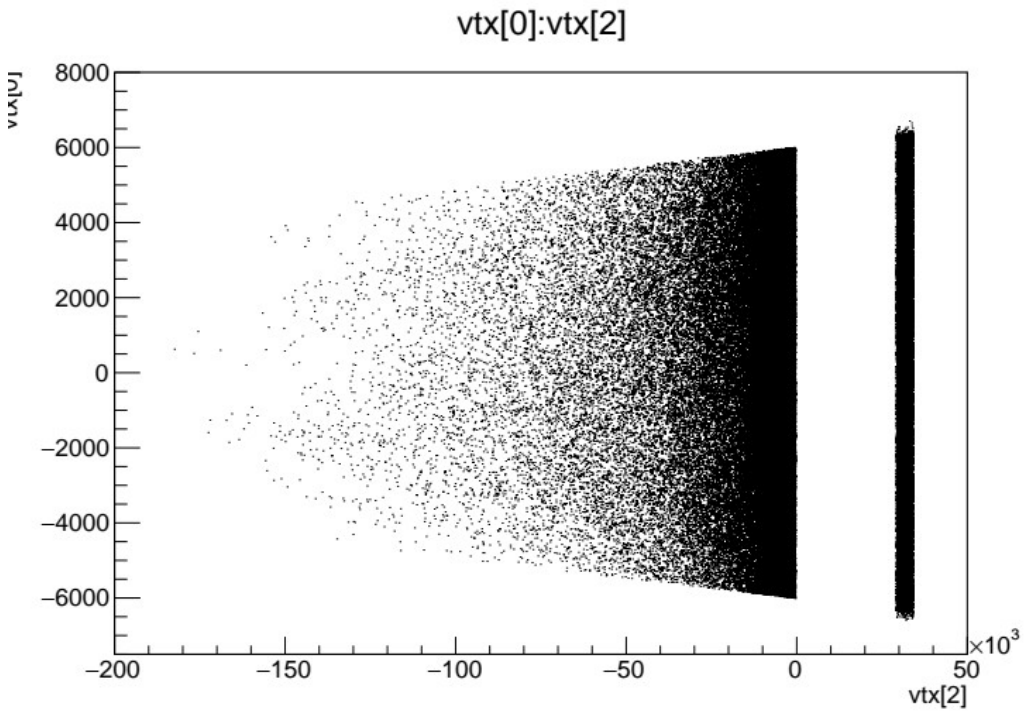
- **rockbox:(xmin,ymin,zmin)(xmax,ymax,zmax),rockonly,wallmin,dedx,fudge,efromw**

```
gevgen_fnal \
    -f flux_files/dk2nu*,DUNEND \
    -g ${ND_PRODUCTION_GDML}/nd_hall_with_lar_tms_nosand.gdml \
    -t volWorld \
    -L cm -D g_cm3 \
    -e 1e+16 \
    --seed ${SEED} \
    -r ${RUN} \
    -o neutrino \
    -F "rockbox:(-6211,-6625,0)(6211,4025,2950),1,500,0.00425,1.05,1" \
    -z -500 \
    --message-thresholds ${ND_PRODUCTION_CONFIG}/Messenger_production.xml \
    --cross-sections ${GENIEXSECPATH}/gxspl-FNALsmall.xml \
    --event-record-print-level 0 \
    --event-generator-list Default+CCMEC
```

# Interaction vertex with rockbox

lots of events apparent close to the hall.

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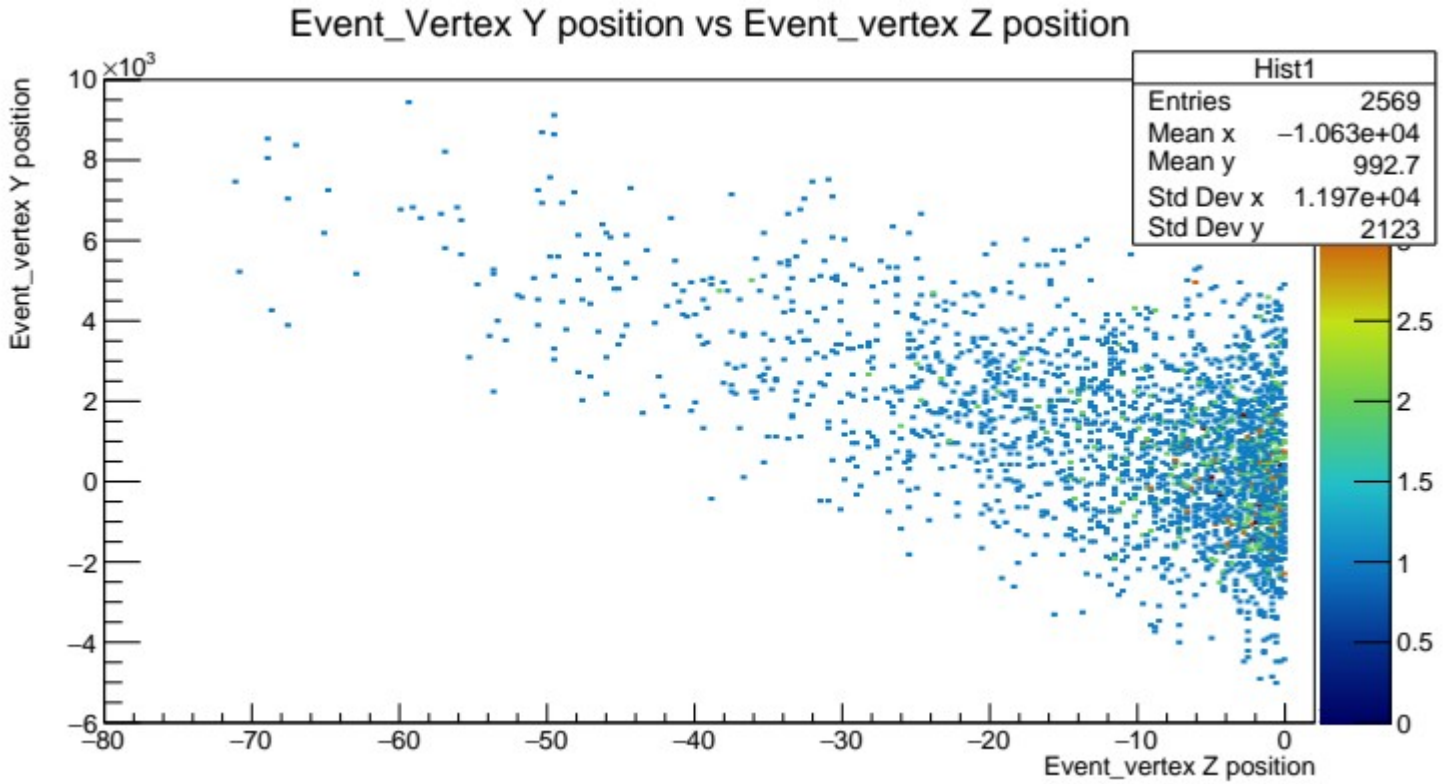
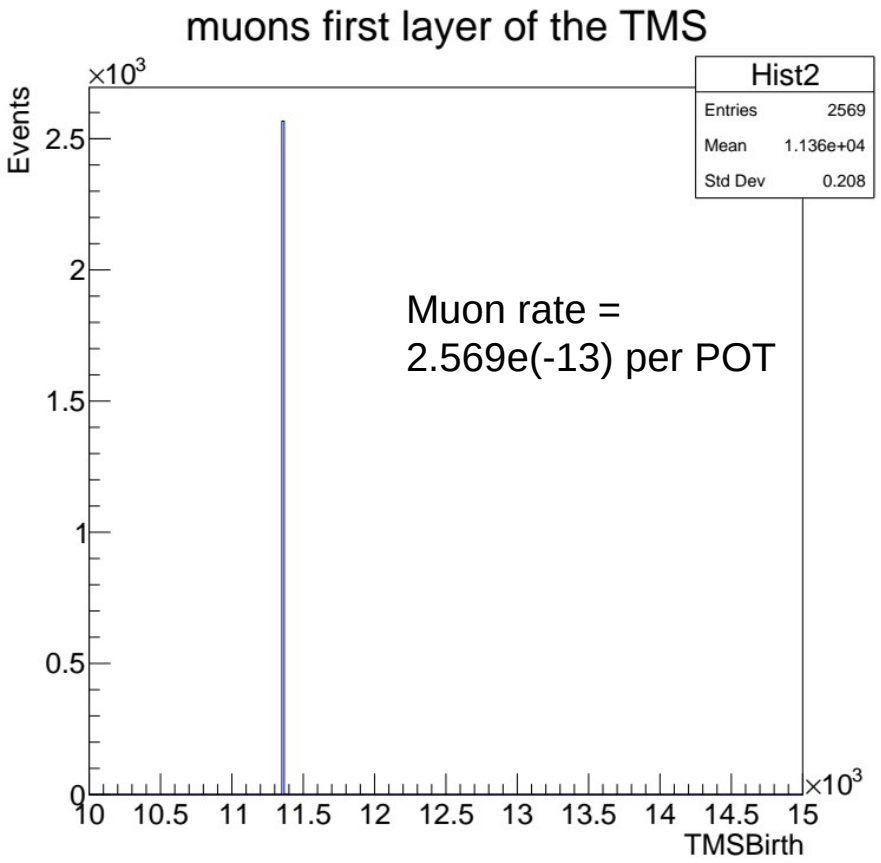
# Interaction vertex with rockbox

Vertex Y position vs Z with first layer scintillator of TMS and upstream rock

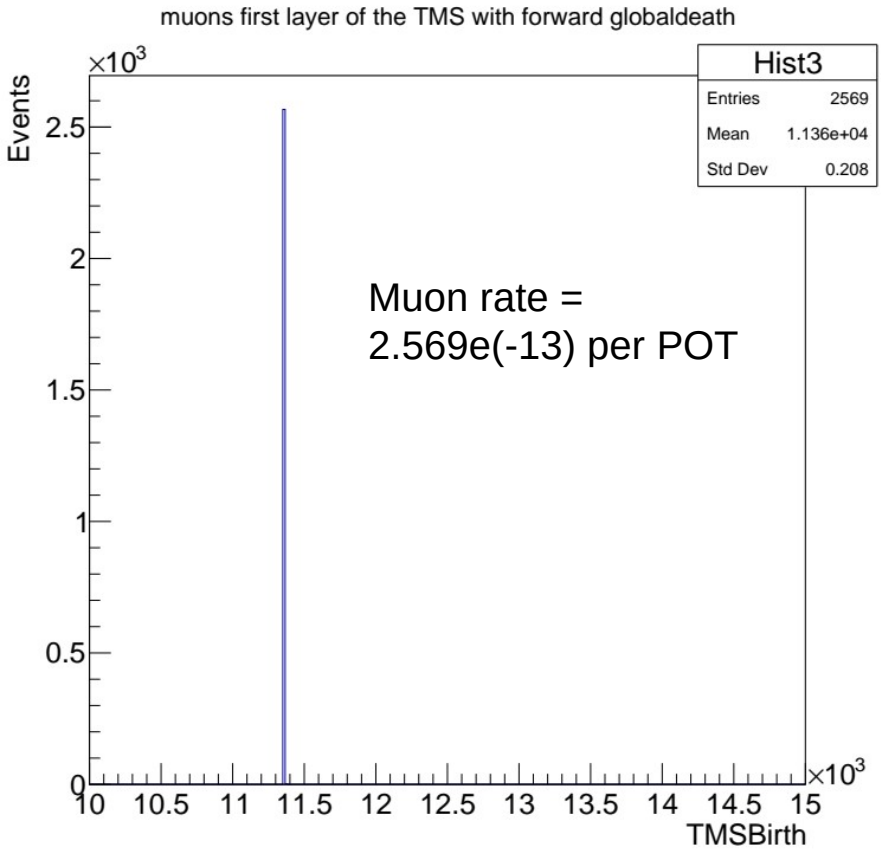


# TMSBirth of Muon in TMS (1e16 POT)

From upstream rock with TMSBirth in first scintillator layer




From upstream rock with TMSBirth in first scintillator layer and forward global death

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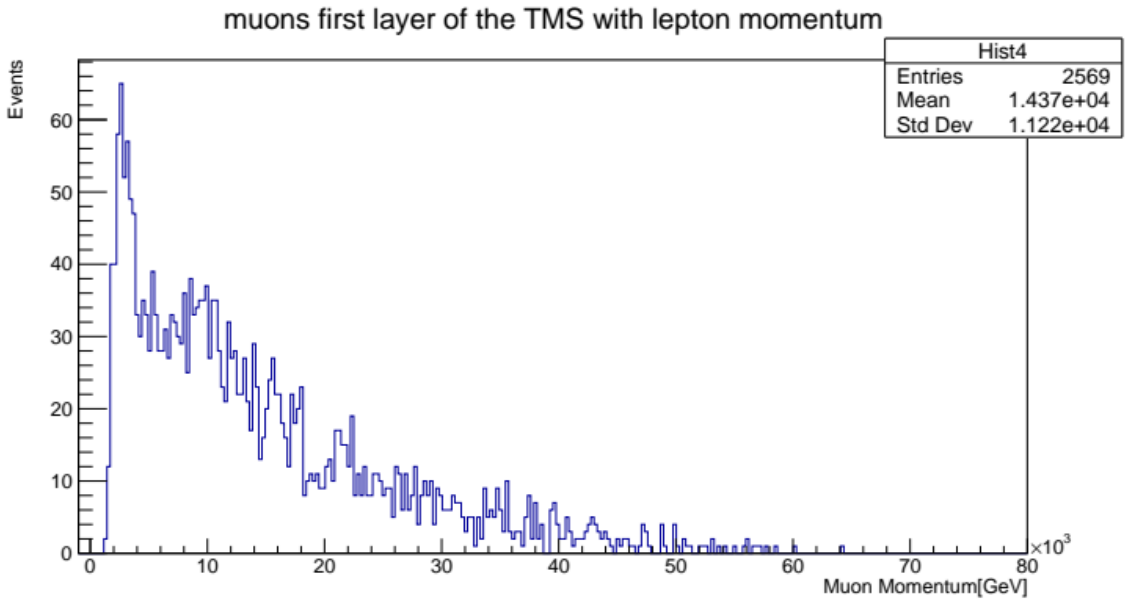
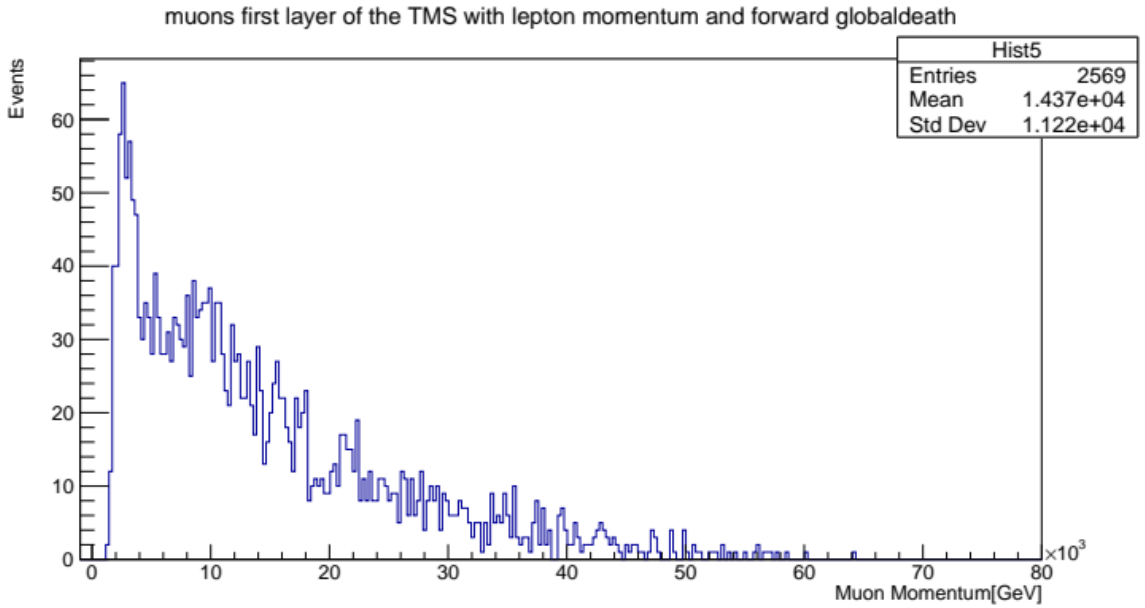
# Foward Muon Momentum for TMS Particles

From upstream rock with muon momentum in first scintillator layer




From upstream rock with muon momentum in first scintillator layer and forward global death

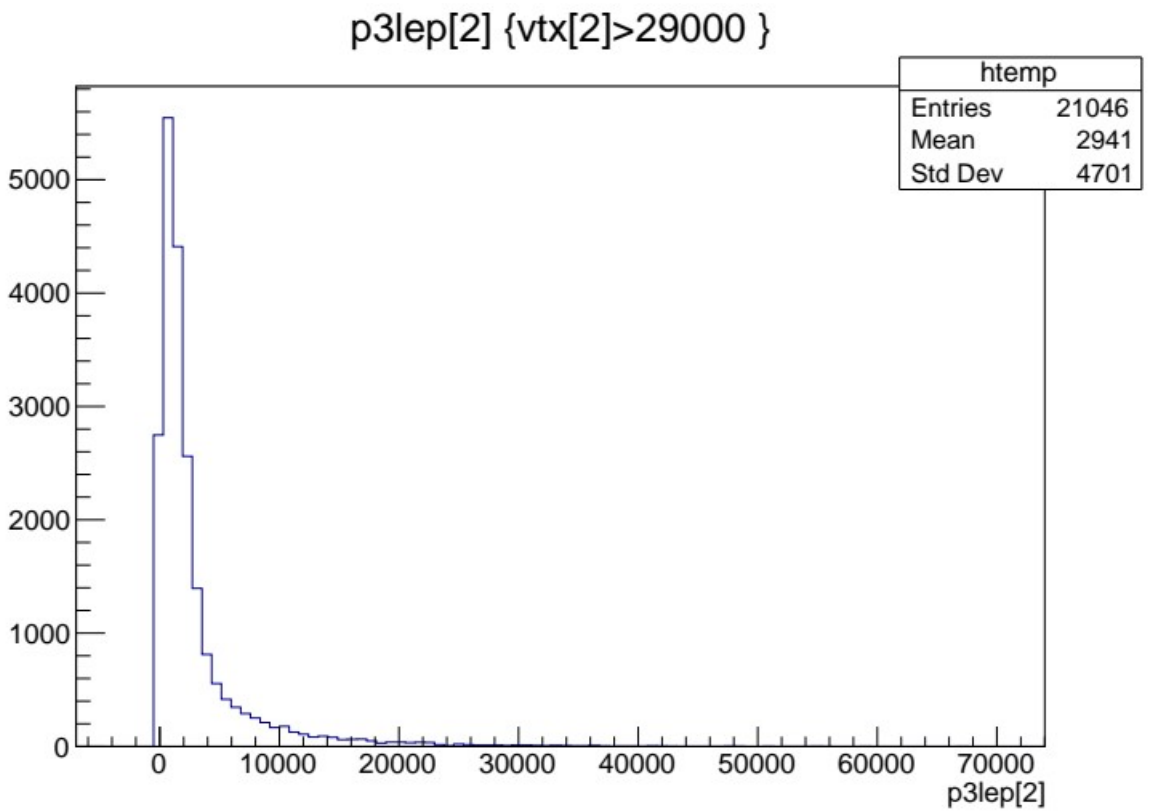


# TMSBirth of backward Muon in TMS

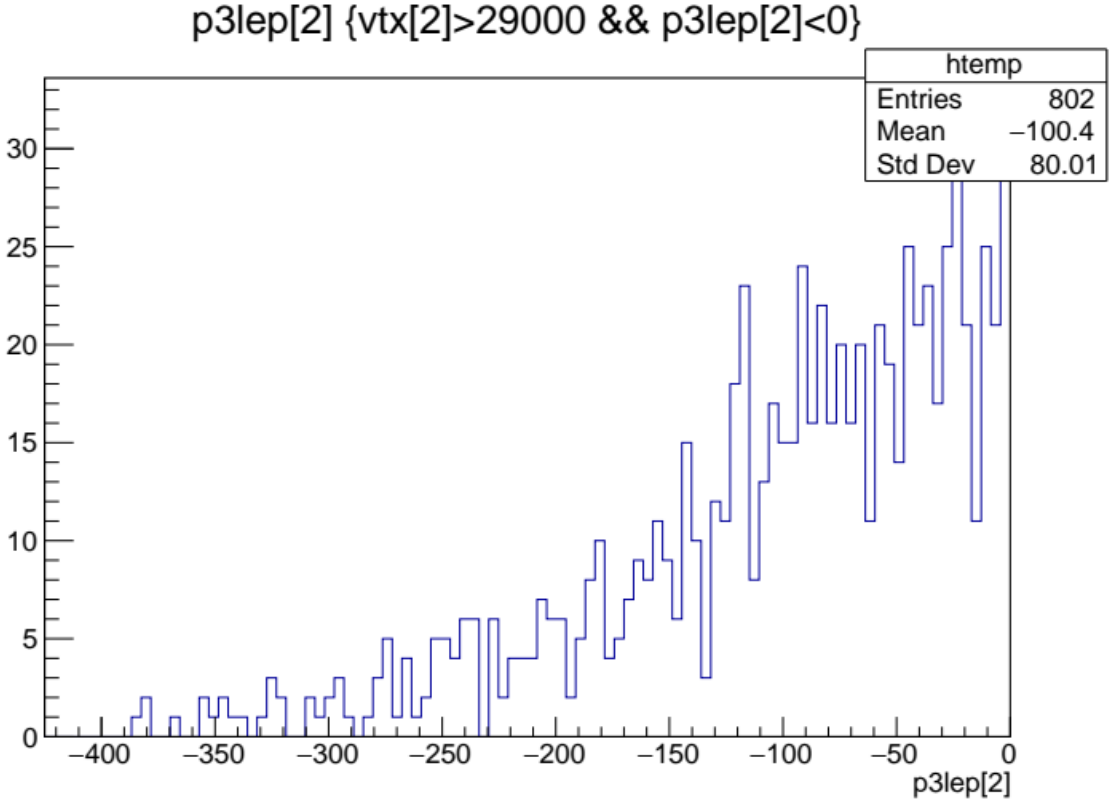
- From downstream rock with TMSBirth in first scintillator layer is empty.
- From downstream rock with TMSBirth  in first scintillator layer and backward global death is empty.

# Backward Muon momentum

From downstream rock with muon momentum

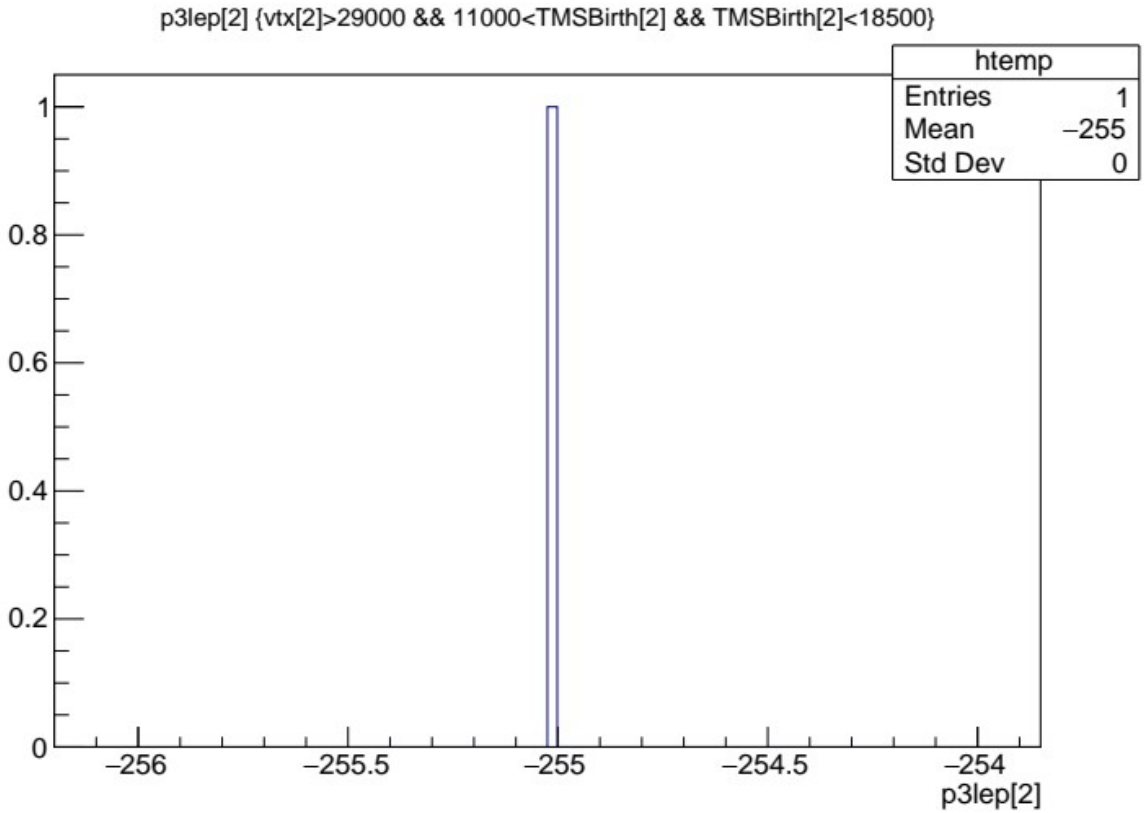



From downstream rock with muon momentum (negative muon momentum)



# Backward Muon momentum for TMS particles

From downstream rock with muon momentum and whole TMS



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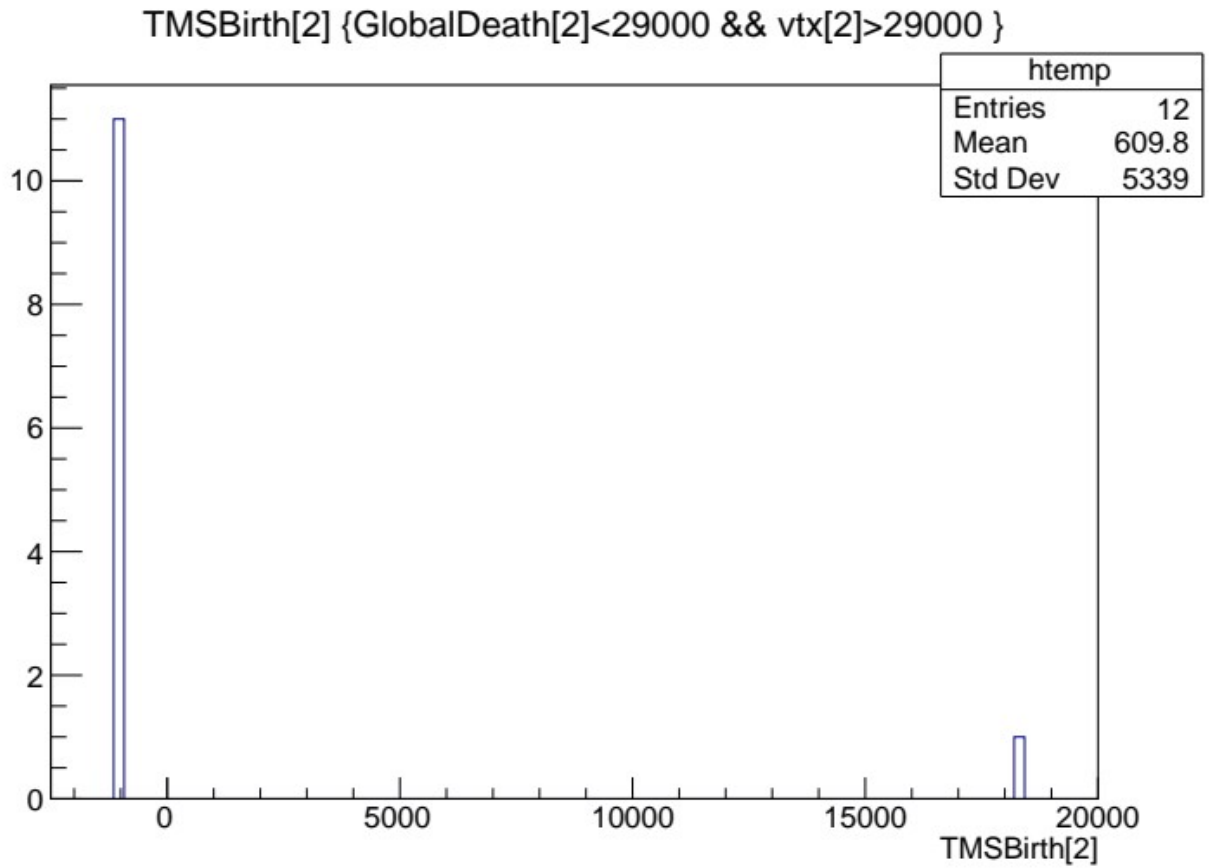
# TMSBirth of Backward Muon in TMS

From downstream rock with TMSBirth and backward global death

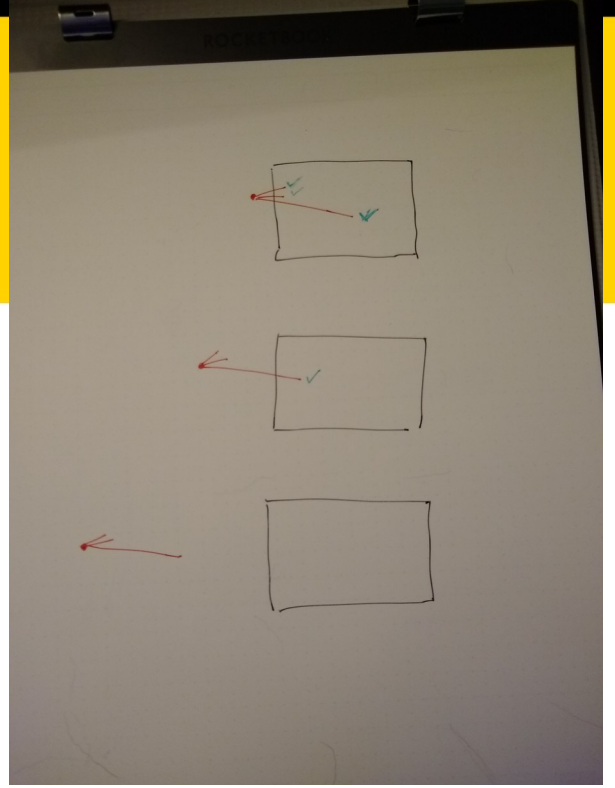


# Next Steps

- add base structure on Geometry.
- add magnetic coil on Geometry.
- Our proposal to eliminating downstream rock.
- We are using the standard flux window. We can play with flux window.
- Integrating ND_Production tool.

thanks

# Rock Events



- In the first case the event is near enough to the hall that all the particle make it and are recorded as they enter -- so the the corresponding "rock_propagated" event has 3 particles as they enter.
- In the second case, only the muon has enough energy to punch through the rock to the hall surface, so while the "genie_rock" event has 3 particles, the "rock_propagated" event only records the one.
- In the third case none are sufficient to make it to the hall and there is no corresponding "rock_propagated" event.

# F flag

- **rockbox:(xmin,ymin,zmin)(xmax,ymax,zmax),rockonly,wallmin,dedx,fudge,efromw**
- (xmin,ymin,zmin)(xmax,ymax,zmax) define the extent of the (inner) reference box in master world coordinates (always)
- **rockonly**
- 1 = generate only outside the reference box [default]
- 0 = also generate events within the reference box (i.e. the detector) by only excluding minuscule bubble
- wallmin minimum size (geometry natural units) beyond reference box size [default=800]
- dedx estimated dE/dx losses, used to convert energy into box size extension [default=2.5*1.7e-3]
- fudge extra fudge factor for box size [default=1.05]
- efromw expand from wall (or outer box) rather than wall just setting a minimum size [default=0 or off]

# F and z flag

- he -F "<fiducial-cut-flag>" to enable the "rock box" scaling of the volume of rock considered for each neutrino ray
- the  -z <setback> flag to start the rays far enough upstream.