# GSimple neutrino flux generation using Dk2Nu ntuples

Far detector simulation meeting
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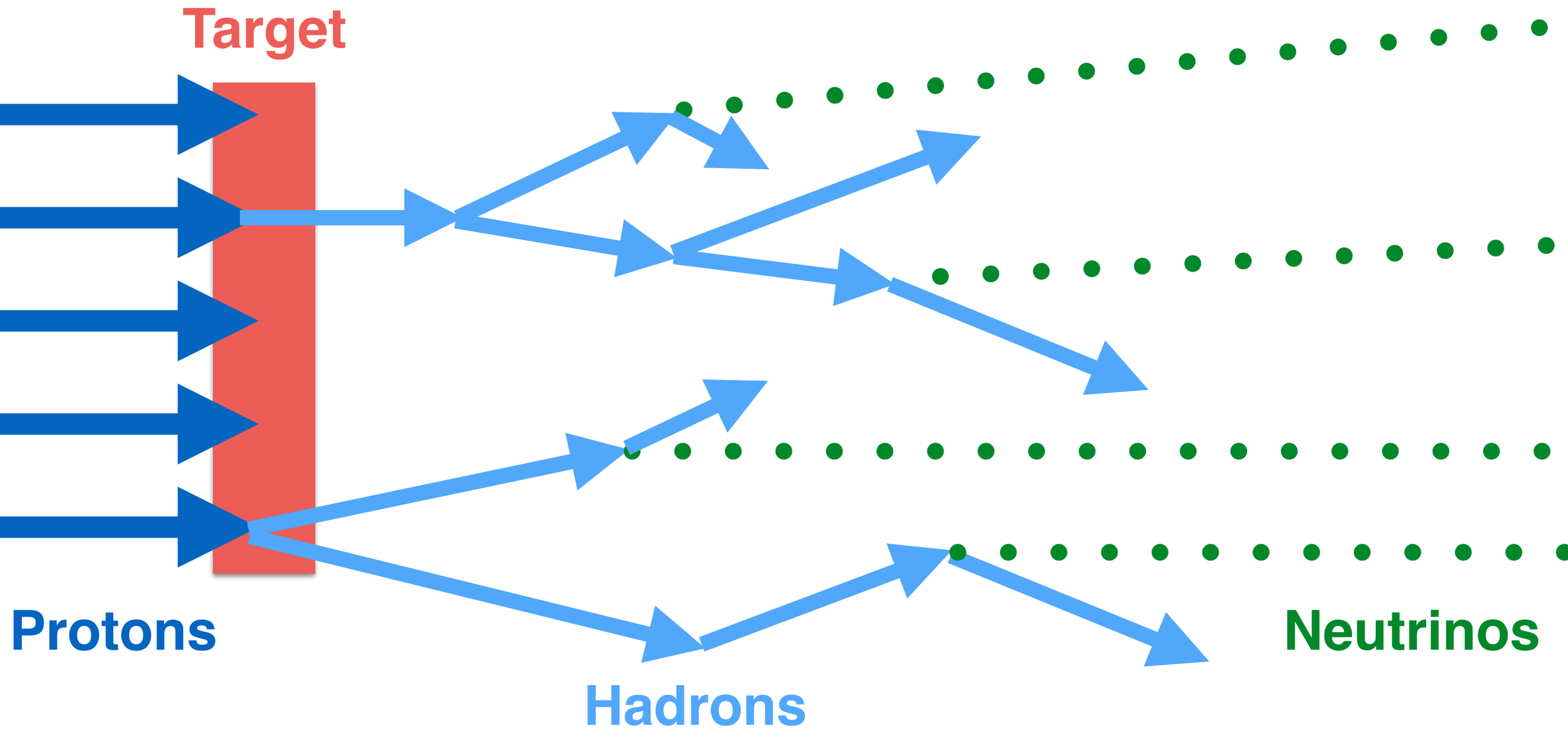
**Thanks to R. Hatcher and the beam sim. group**

# What we want to do

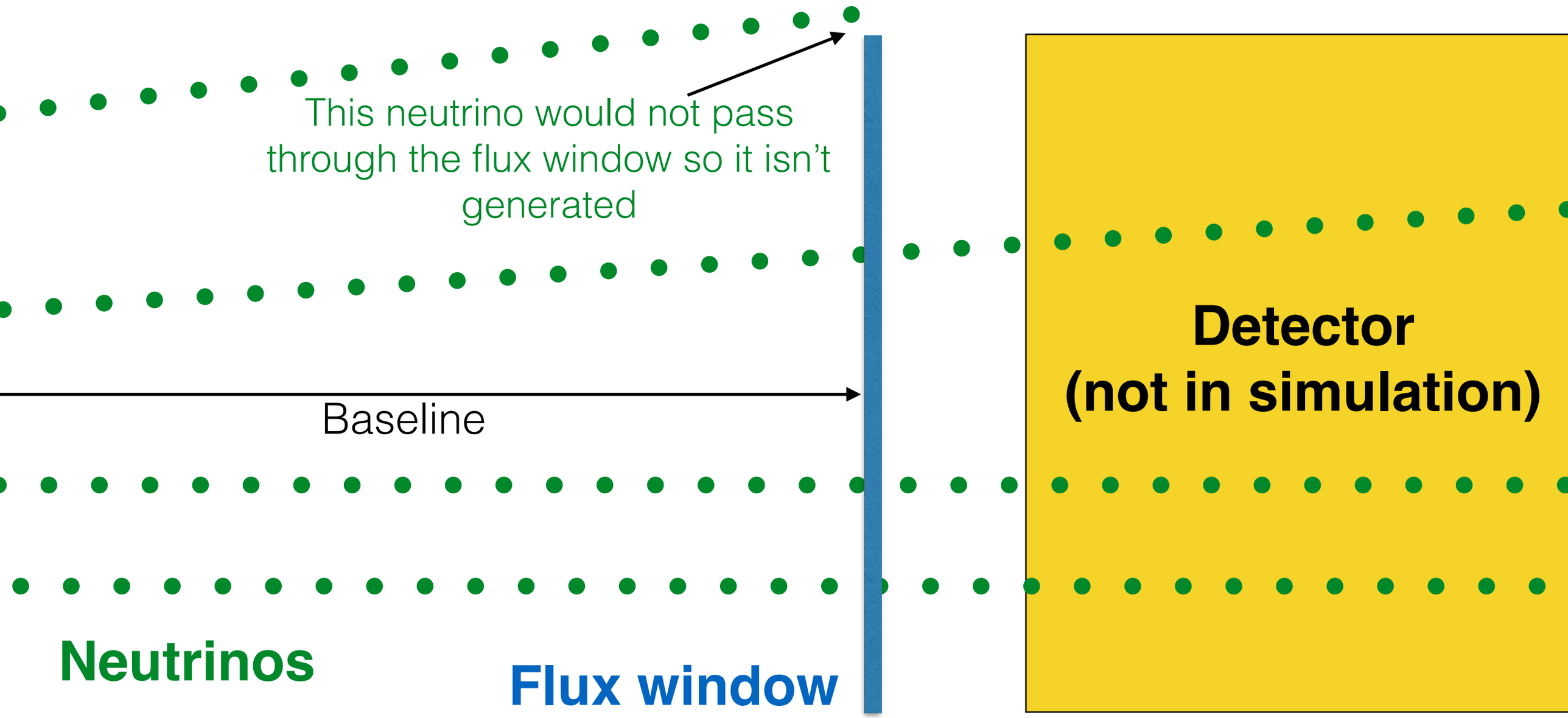
- So far, neutrino events in the far detector MCC have been generated using simple flux histograms
- We want to move to a more realistic simulation of the neutrino flux
- In recent times, there has been a push to move neutrino flux generation in numi to a unified format called **Dk2Nu**
  - Dk2Nu files are ntuples which contain the decays of numi product hadrons which create neutrinos
  - Entries contain full ancestor chain from numi proton all the way to the neutrino
- What we need to do is take the numi-decay neutrinos and propagate the neutrino rays to the far detector.  The output files containing the rays are called **gsimple** flux files
  - The Dk2Nu->gsimple conversion is done using the gsimple converter (R. Hatcher)
  - https://cdcvs.fnal.gov/redmine/projects/genie/wiki/Generating_GSimpleNtpFlux_files

# Dk2Nu




The Dk2Nu files contain the full chain from protons to final-state neutrinos

# gsimple conversion

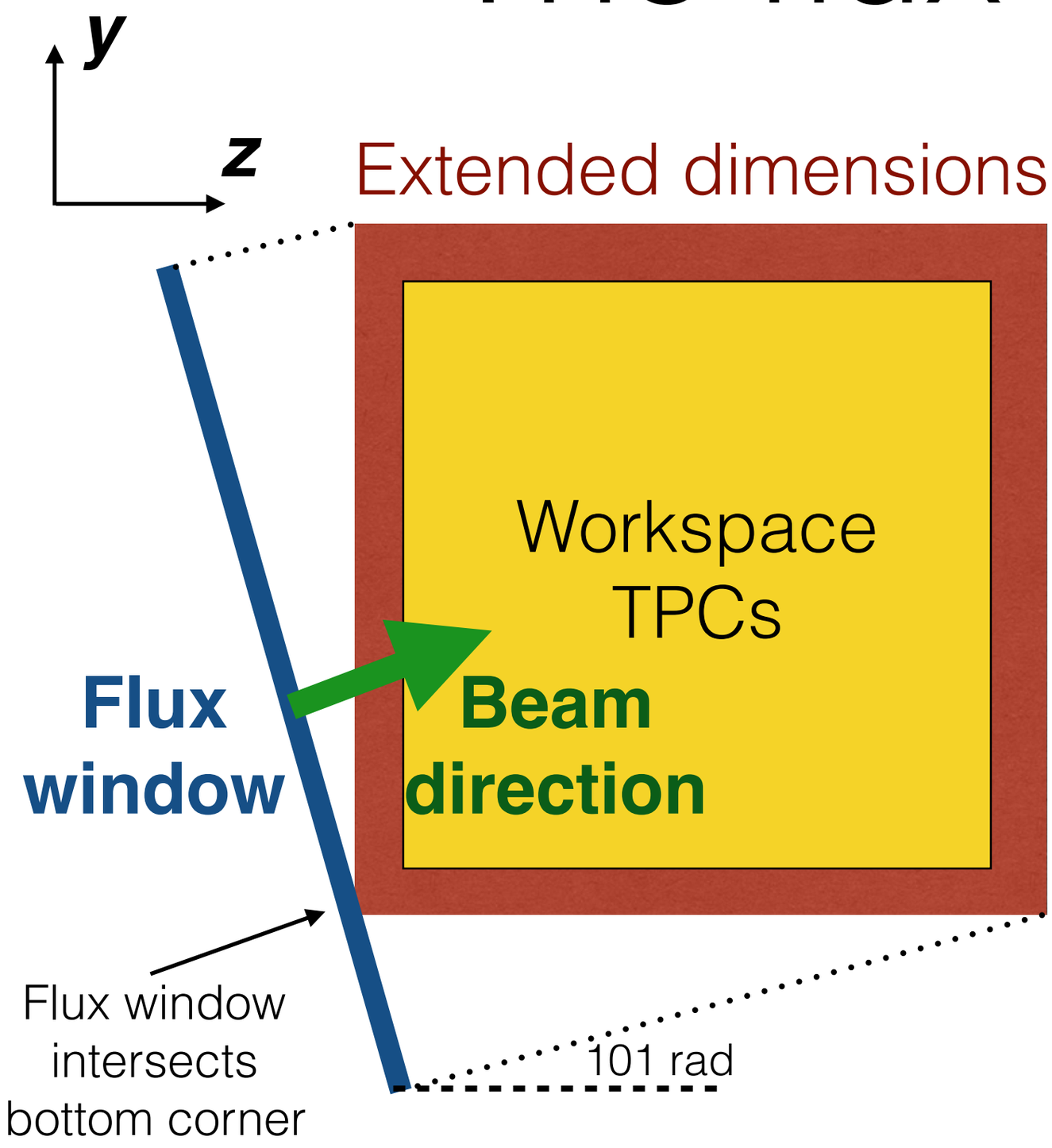


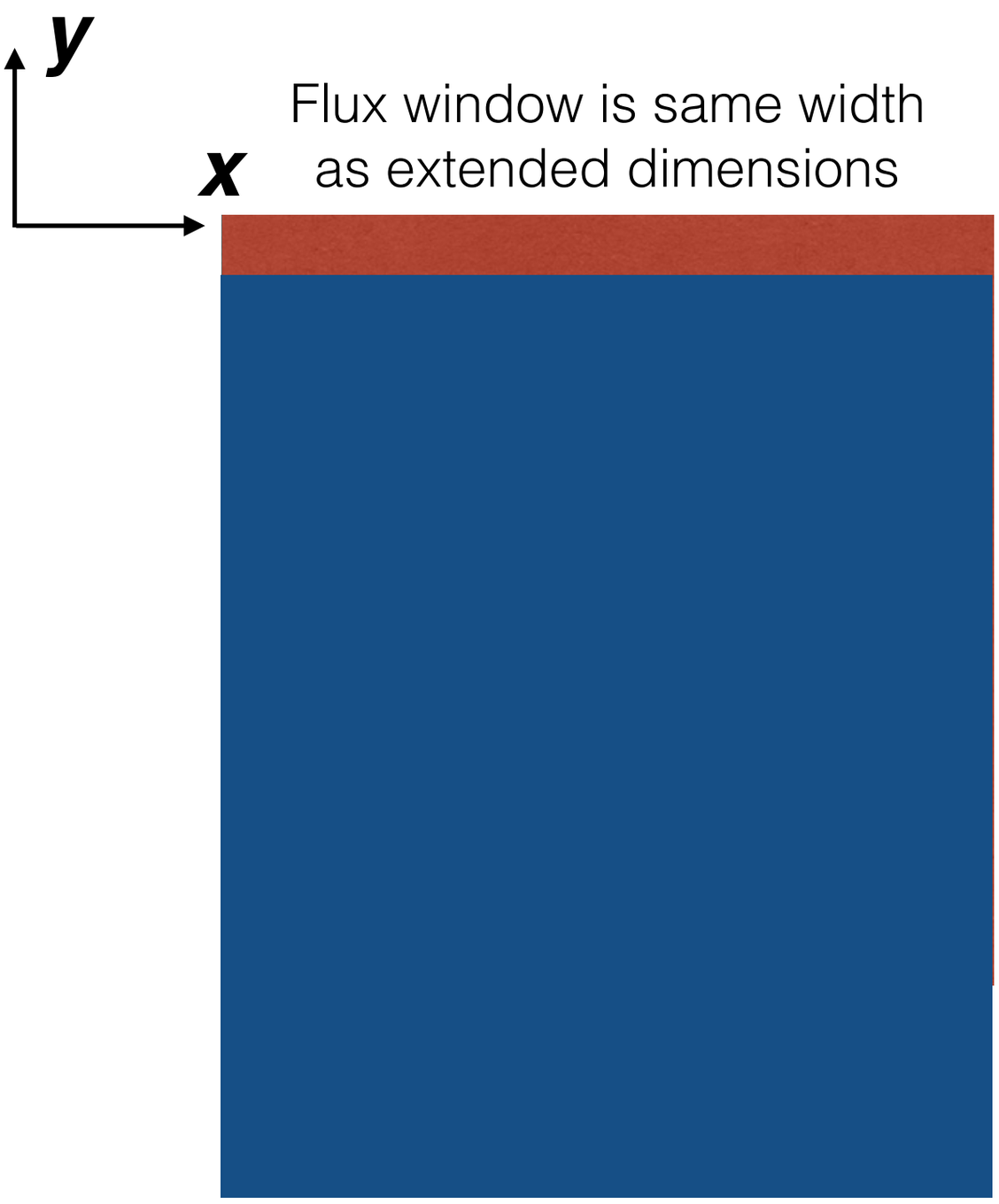

The gsimple converter uses a 2D flux window to generate the neutrino rays off
The trick is calculating the flux window so it adequately covers your detector

# Generating gsimple files for the FD workspace geometry

- The FD workspace TPC dimensions are x:[-3.6,3.6]m, y: [-6,6]m, z:[0,4.6]m but we should extend the the dimensions by 20%
    - Dimension extension allows us to simulate Out Of Fiducial Volume (OOFV) events
- The flux window should be perpendicular to the beam direction
    - The beam direction is rotated 0.101rad (upwards) around the x-axis
- The flux window should be just large enough to cover the detector dimensions that we specify
    - A window that is too large will create neutrinos which will not pass near the TPC
- The neutrino rays are very forward going
    - Every neutrino is parallel to the beam direction

# The flux window



# The gsimple beam xml configuration

- All of the beam configuration is done via xml which is then passed to the converter

- The one made for the workspace geometry is below

```
 1 <gnumi_config>
 2   <param_set name="LBNE-FarDet_Workspace">
 3     <units> m </units>
 4     <beamdir type="series">
 5       <rotation axis="x" units="rad"> +0.101 </rotation>
 6     </beamdir>
 7     <beampos> (0, 0, 0 ) = ( 0, 0, 1300000.0 ) </beampos>
 8     <window>
 9       <point coord="det"> -3.96, -7.75374, -0.403882 </point>
10       <point coord="det"> -3.96,  7.05360, -1.904530 </point>
11       <point coord="det">  3.96, -7.75374, -0.403882 </point>
12     </window>
13     <enumax> 120. 1.05 1.05 2500000 </enumax>
14     <reuse> 10 </reuse>
15   </param_set>
16 </gnumi_config>
```

# The gsimple converter xml configuration

- The converter takes a request file which contains the location of the Dk2Nu files, the beam config, output path, random seeds, the total POT and max. number of rays to generate

- Full usage instructions are here, provided by R. Hatcher

- https://cdcvs.fnal.gov/redmine/projects/genie/wiki/Generating_GSimpleNtpFlux_files

```
 1 # loc = LBNE-FarDet_Workspace
 2 # inpath = /lbne/data/users/ljf26/fluxfiles/g4lbne/v3r3p8/QGSP_BERT/DK2Nu/200kA/flux/Dk2Nu
 3 # outpath = /lbne/data/users/dbrailsf/flux/job/files_10000rays_1e12pot
 4 # xml = /lbne/data/users/dbrailsf/flux/job/lbne_fd_workspace.xml
 5 # pattern           seed   pots  nentries
 6 g4lbne_v3r3p8_QGSP_BERT_DK2Nu_200kA_Dk2Nu_001.root 0 1e12 10000
 7 g4lbne_v3r3p8_QGSP_BERT_DK2Nu_200kA_Dk2Nu_002.root 1 1e12 10000
 8 g4lbne_v3r3p8_QGSP_BERT_DK2Nu_200kA_Dk2Nu_003.root 2 1e12 10000
 9 g4lbne_v3r3p8_QGSP_BERT_DK2Nu_200kA_Dk2Nu_004.root 3 1e12 10000
10 g4lbne_v3r3p8_QGSP_BERT_DK2Nu_200kA_Dk2Nu_005.root 4 1e12 10000
11 g4lbne_v3r3p8_QGSP_BERT_DK2Nu_200kA_Dk2Nu_006.root 5 1e12 10000
12 g4lbne_v3r3p8_QGSP_BERT_DK2Nu_200kA_Dk2Nu_007.root 6 1e12 10000
```

# Output files

- The output gsimples files are located here:
  - /lbne/data/users/dbrailsf/flux/200kA/fd_workspace/10000rays/nominal
- Total number of files: 250
- Number of neutrino rays per file: 10,000
- Total number of rays: 250 x 10,000 = 2500000
- The gsimple files can be read in by genie (via fhicl) to generate events

# genie fhicl file

- Minor alteration to the prod_genie_common.fcl file
- The important ones are:
  - FluxType # needs to be “simple_flux”
  - FluxSearchPaths # Full directory path to where the flux files are located
  - FluxFiles # The name of the flux files (can be wild carded)

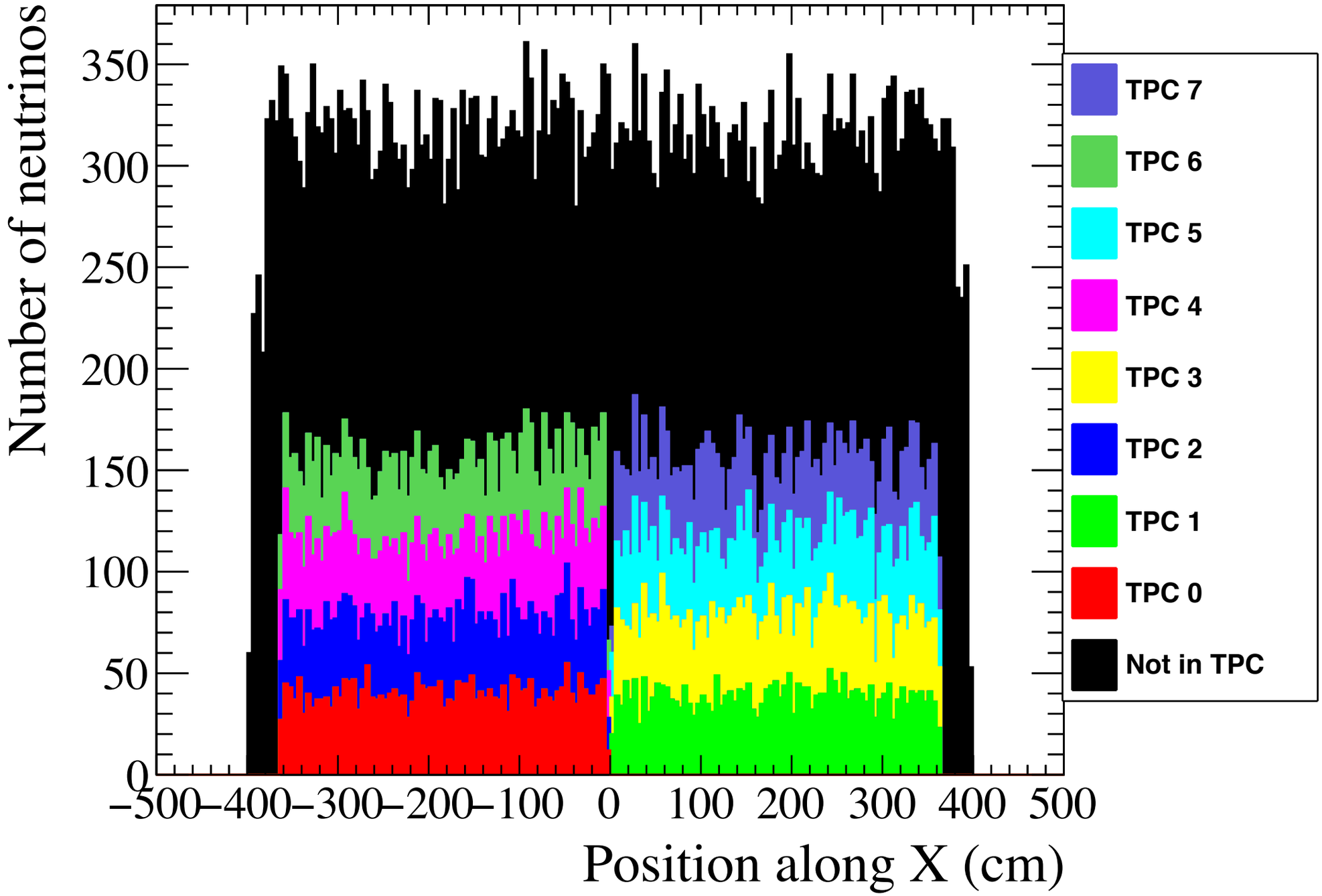
```
physics.producers.generator.FluxType: "simple_flux"
physics.producers.generator.FluxSearchPaths: "/lbne/data/users/dbrailsf/flux/
physics.producers.generator.FluxFiles: ["gsimple_LBNE-FarDet_Workspace_Rotate
physics.producers.generator.FluxCopyMethod:  "IFDH"
physics.producers.generator.MaxFluxFileMB:  2000
physics.producers.generator.TopVolume: "volDetEnclosure"
```

# Neutrino event generation

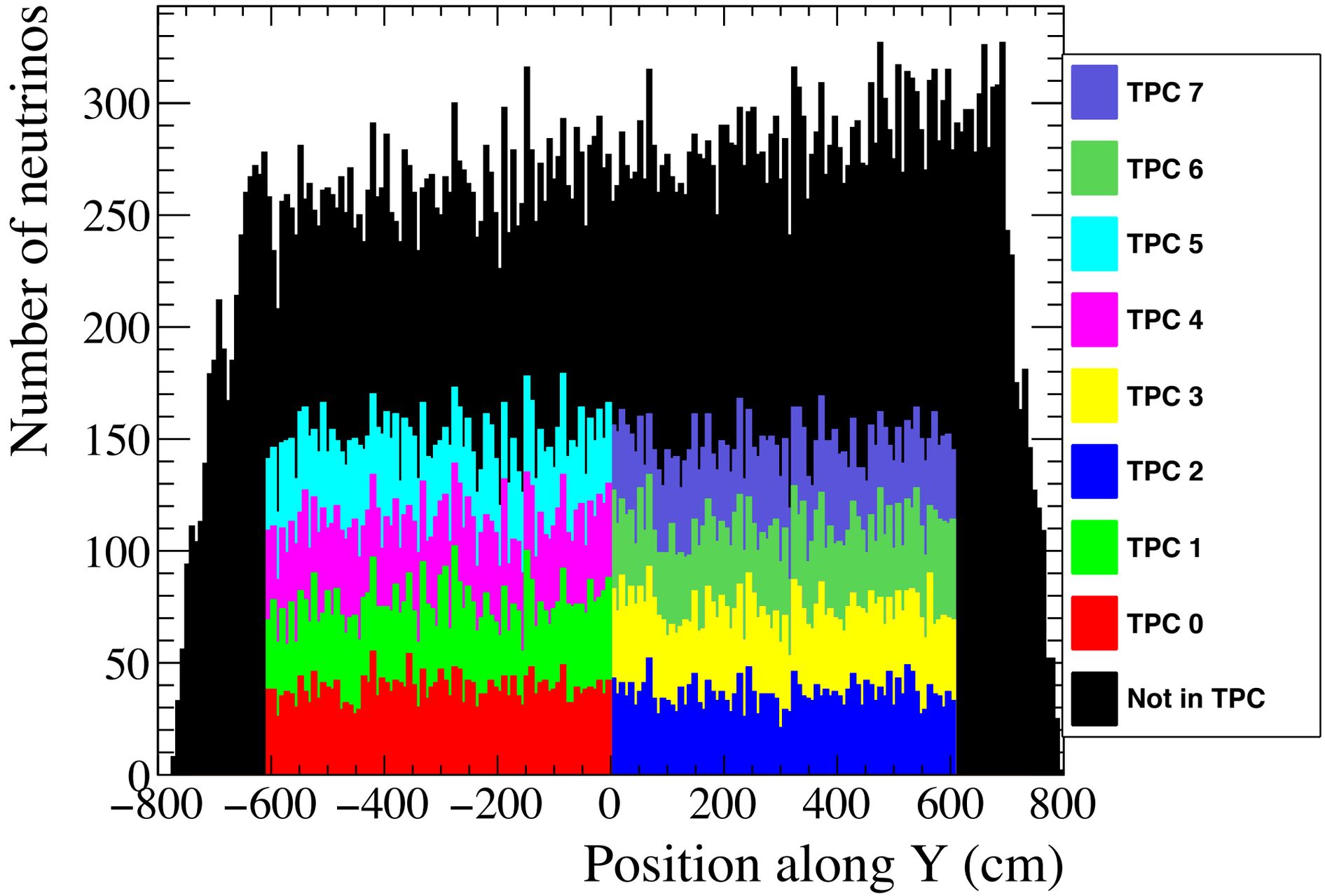
- Generated 10,000 genie events in the FD workspace geometry using volDetEnclosure volume

- To check that the flux window is adequately sized, there should be interactions in all of the TPCs and outside of it

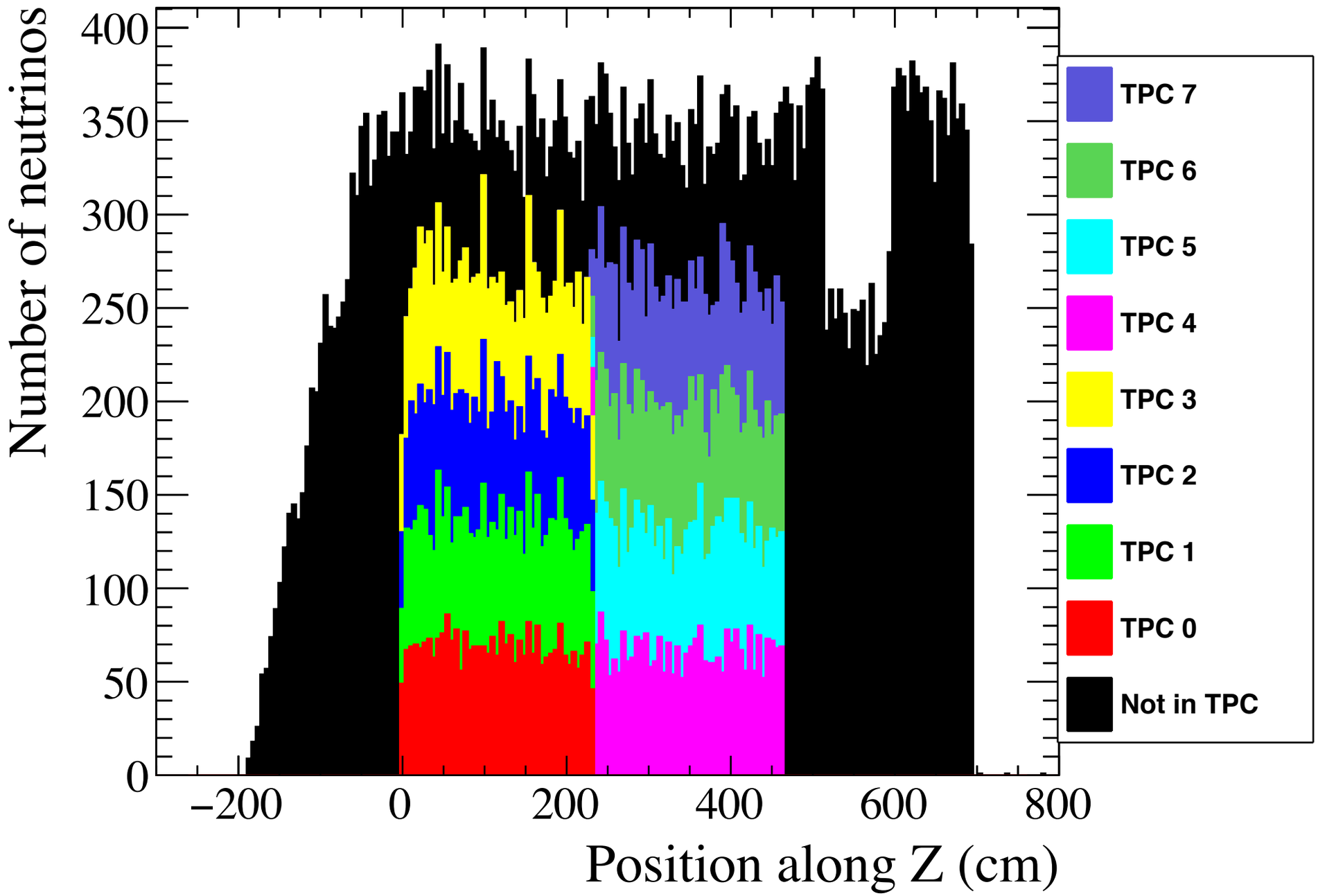
# Neutrino interaction position (X)



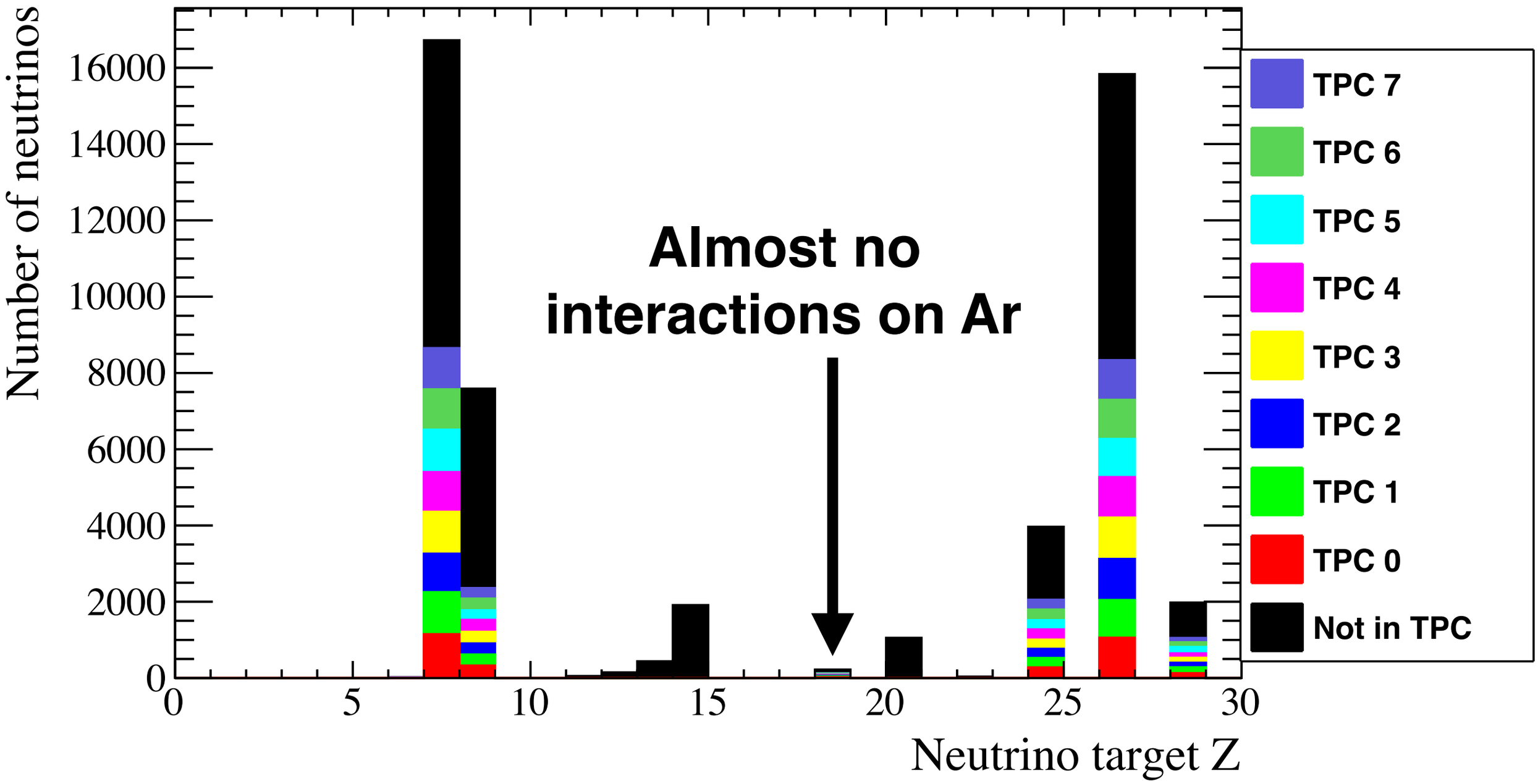
# Neutrino interaction position (Y)



# Neutrino interaction position (Z)

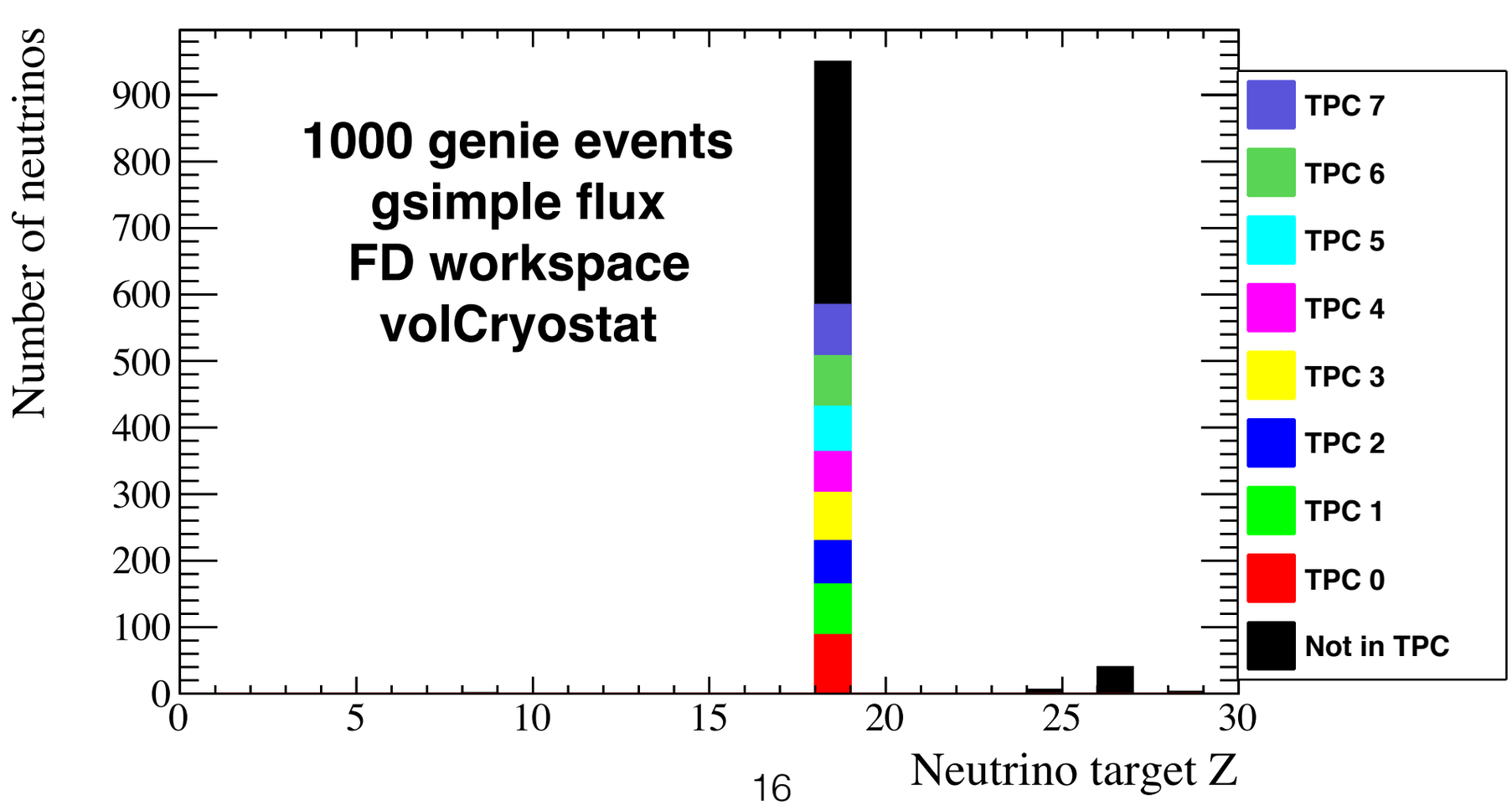


# Neutrino target Z (possible bug)



# Neutrino target Z (possible bug)

- During investigation of this issue, I generated 1000 additional neutrino events using the gsimple flux files on the FD workspace geometry but using the volCryostat volume
- In this volume, Ar is the dominant target
- This is still being investigated



# Summary

- With the unified Dk2Nu format, we have to convert the hadron decays into gsimple neutrino rays

- A total of 250 gsimple files, each containing 10,000 neutrino rays, have been generated for the FD workspace geometry
  - /lbne/data/users/dbrailsf/flux/200kA/fd_workspace/10000rays/nominal

- Validation genie events show that the flux window adequately covers the FD workspace geometry

- There is a possible bug in the genie generation which affects the target Z
  - This “bug” could very easily be me doing something stupid