protoDUNE photon Detector MC

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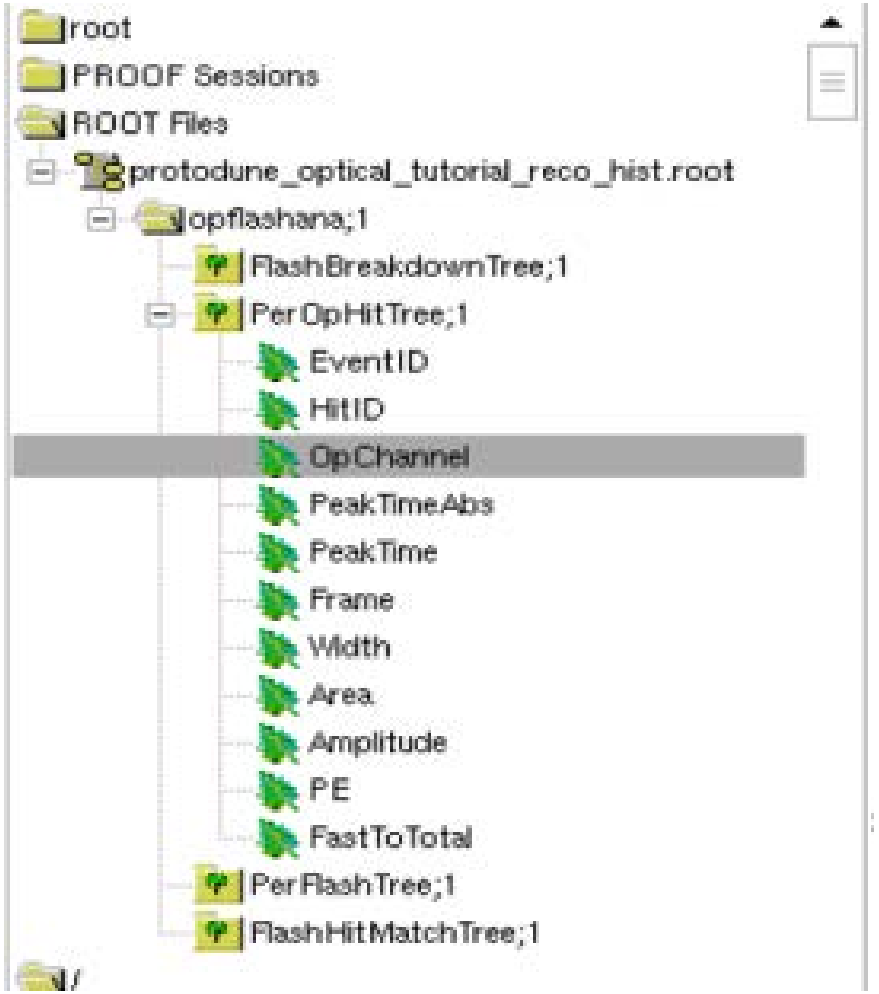
Some MC notes

- Based on wiki for photon detector MC tutorial
  - https://cdcvs.fnal.gov/redmine/projects/dunetpc/wiki/Photon_Simulation_Tutorial
- Using dunetpc v08_14_00 (fixed a +-X swap mapping to OpChannels)
- Instead of using “DUNE” version as in the tutorial, use protoDUNE version of fcl(s) found in the protoDUNE subdirectory
- In /srcs/dunetpc/dune/PhotonPropagation/Tutorial/protoDUNE/
- My example in:
  - /dune/app/users/mualem/pdune_201903/srcs/dunetpc/dune/PhotonPropagation/Tutorial

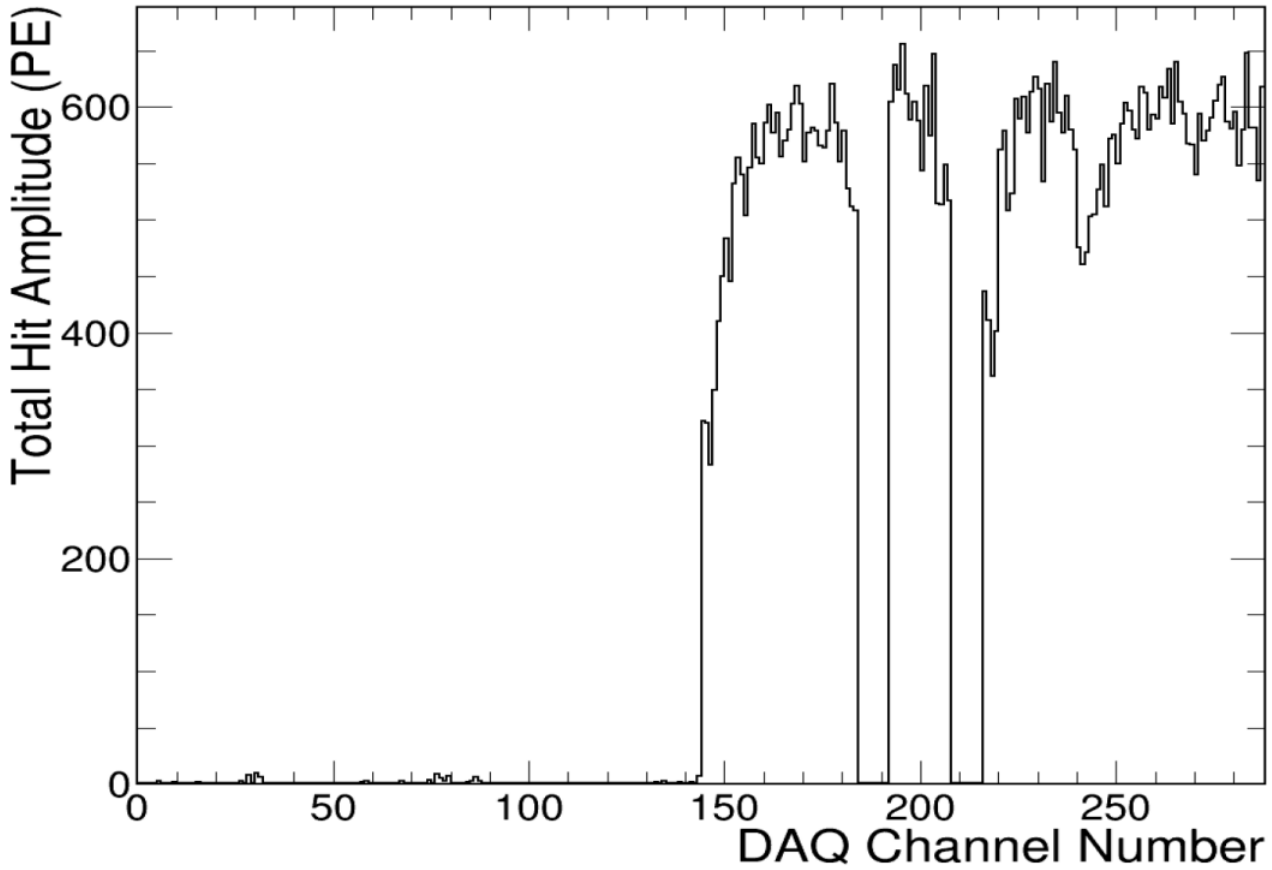
Some MC notes

- root –l protodune_optical_tutorial_reco_hist.root
- TBrowser mine;
- Navigate to OpChannel



Along Faces of APA 5,6,4 in sequence

- 100 10 GeV/c Mu+
- Along Z axis
  - ThetaXZ=0
  - ThetaYZ=0
- Near APA non-beam drift (X=300)
- Centered Top to Bottom (Y=300)
- Start at beam face (Z=0)

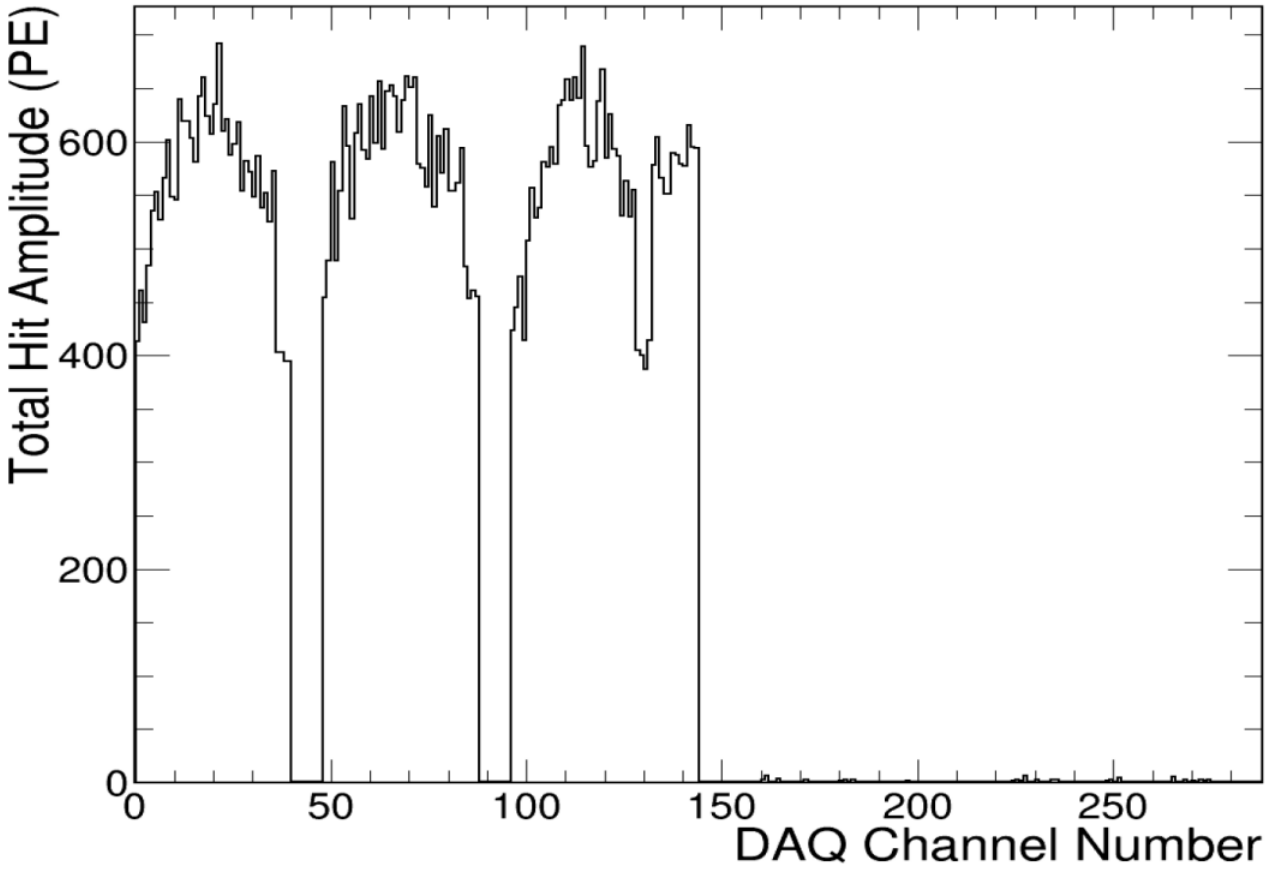


- All (almost) Hits on non-Beam, some leakage out the side reduces APA 1

Along Faces of APA 3,2,1 in sequence

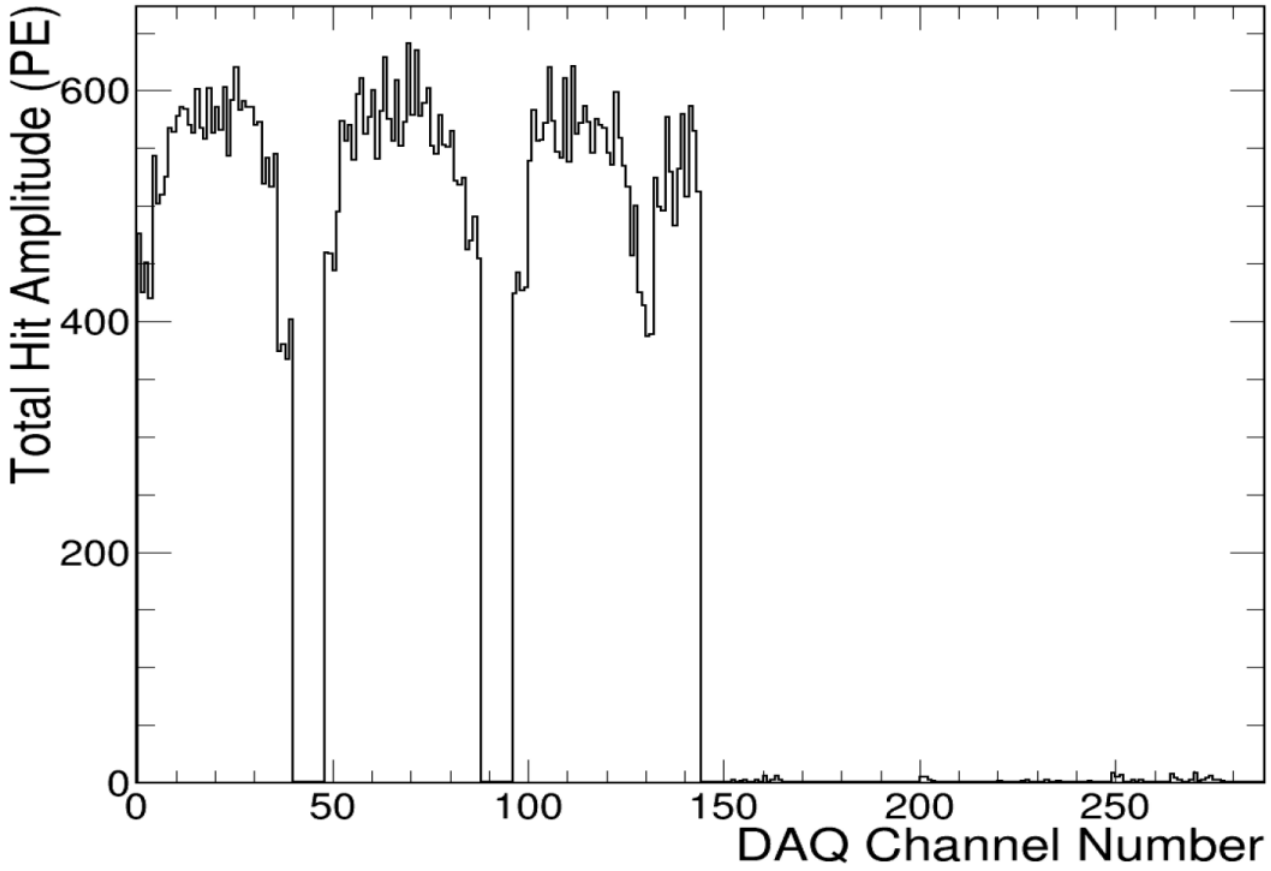
- 100 10 GeV/c Mu+
- Along Z axis
  - ThetaXZ=0
  - ThetaYZ=0
- Near APA beam-side drift (X=-300)
- Centered Top to Bottom (Y=300)
- Start at beam face (Z=0)

- All (almost) Hits on Beam-side
- Equal APA distribution
- Small leakage across CPA



Mid-Drift in front of APA 3,2,1

- 100 – 10 GeV/c Mu+
- Along Z axis
  - ThetaXZ=0
  - ThetaYZ=0
- Centered in beam-side drift (X=-180)
- Centered Top to Bottom (Y=300)
- Start at beam face (Z=0)

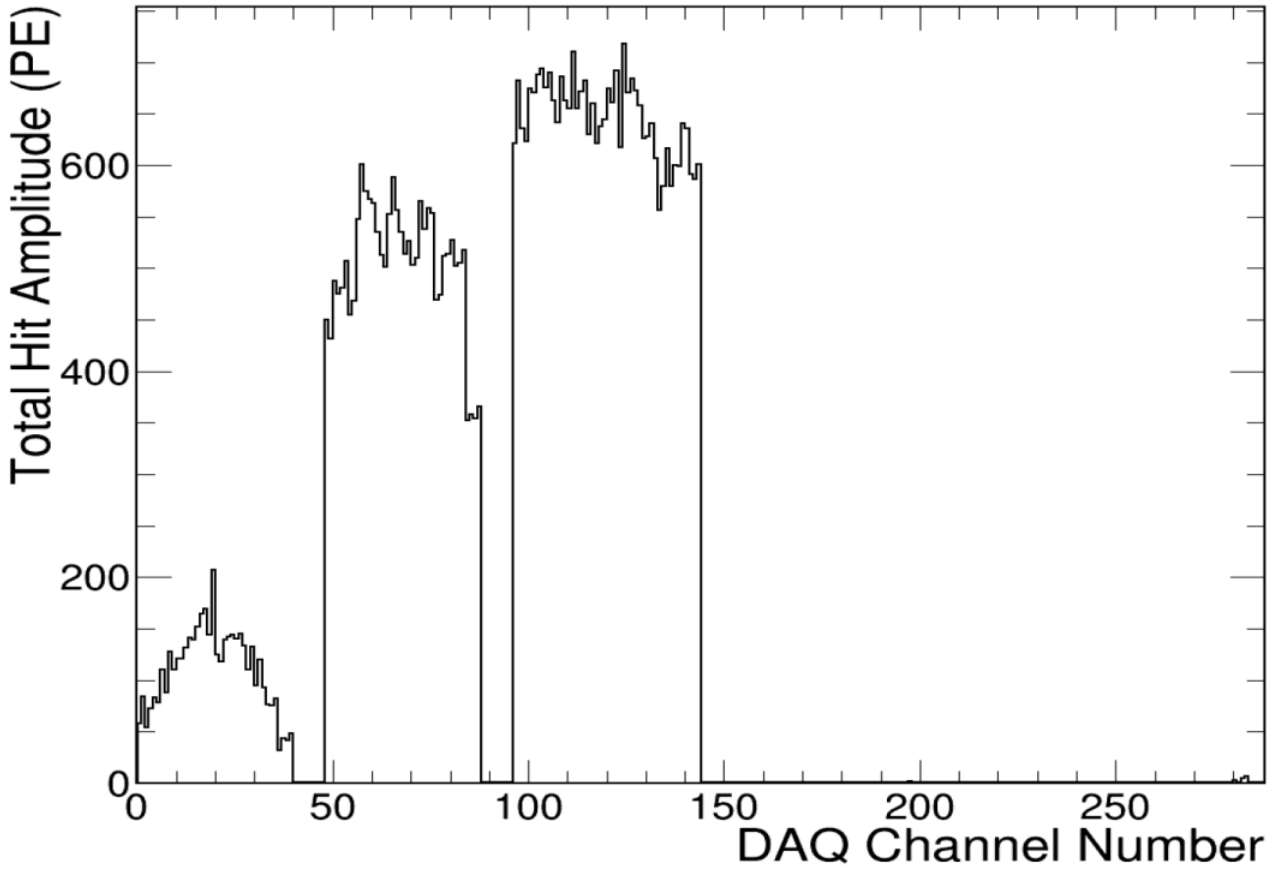


- Almost all hits on beam side, small leakage to non-beam, probably 1 of 100 muons had photon cross the CPA

Down Face of APA3

- 100 10 GeV/c Mu+
- Along Y axis
  - ThetaXZ=0
  - ThetaYZ=-90
- Near APA beam-side drift (X=-350)
- Start At Top (Y=600)
- Mid-APA3 (Z=110)

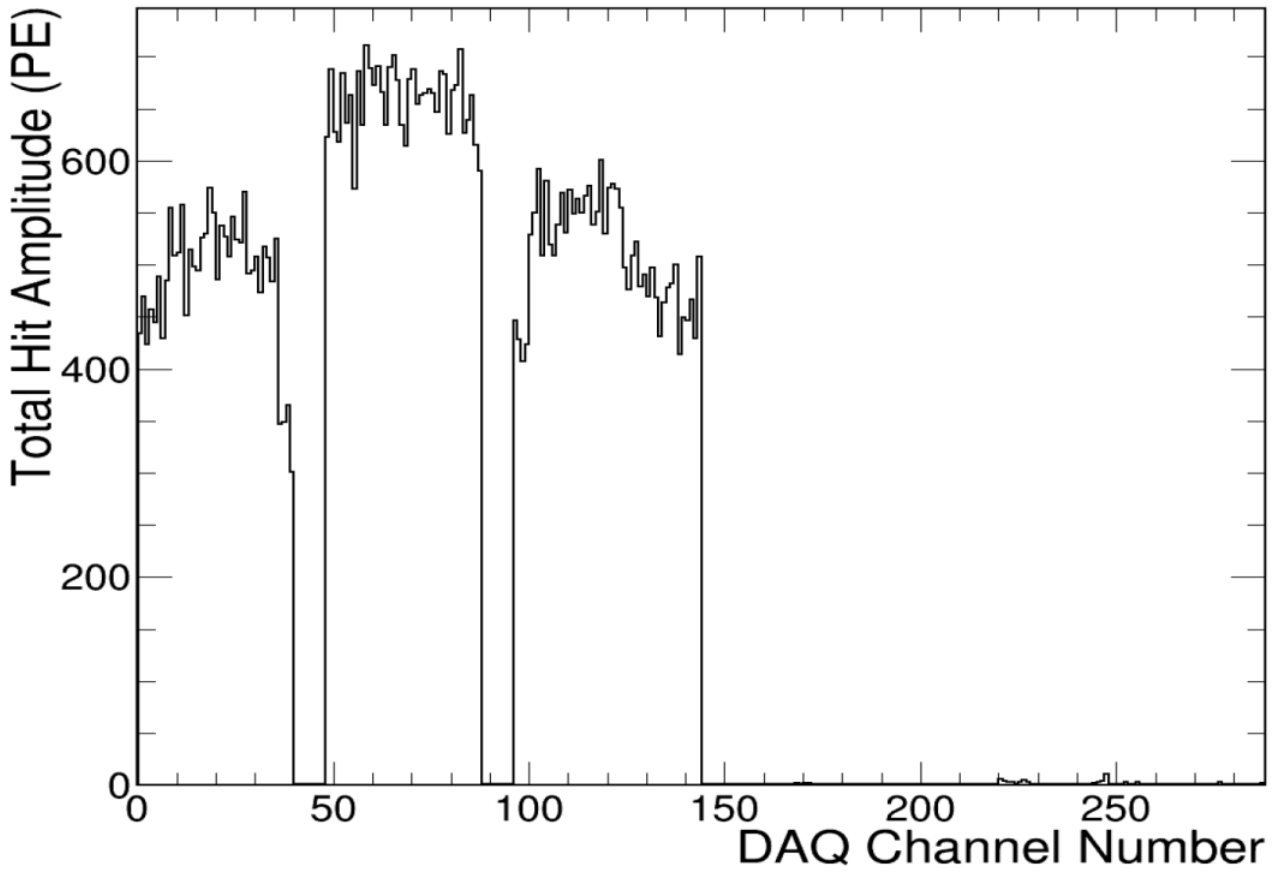
- Largest hits on APA3
  - less on APA2
    - Least on APA1



Down Face of APA2

- 100 10 GeV/c Mu+
- Along Y axis
  - ThetaXZ=0
  - ThetaYZ=-90
- Near APA beam-side drift (X=-350)
- Start At Top (Y=600)
- Mid-APA3 (Z=330)

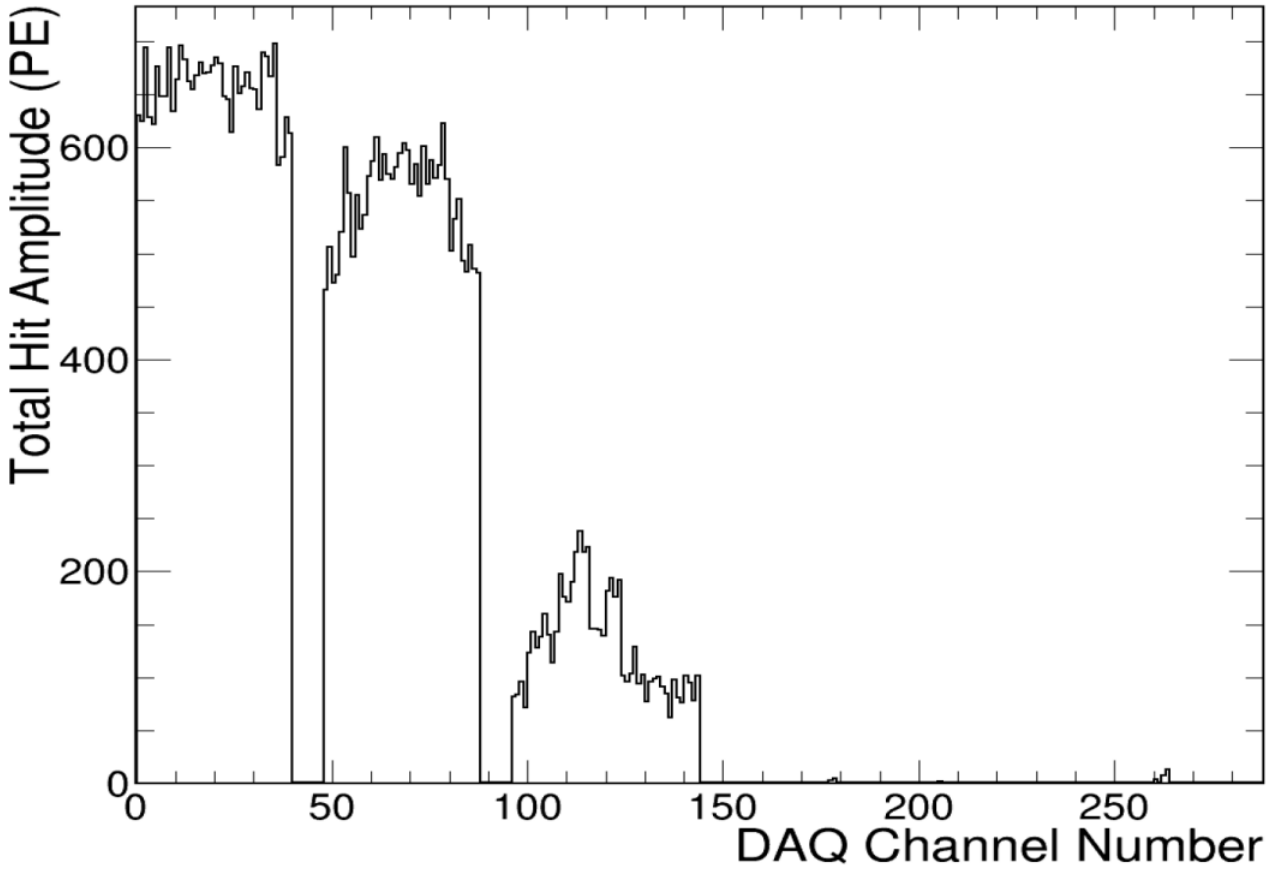
- Largest hits on APA2
  - less on APA3 = ~APA1



Along Face of APA1

- 100 10 GeV/c Mu+
- Along Y axis
  - ThetaXZ=0
  - ThetaYZ=-90
- Near APA beam-side drift (X=-350)
- Start At Top (Y=600)
- Mid-APA3 (Z=550)

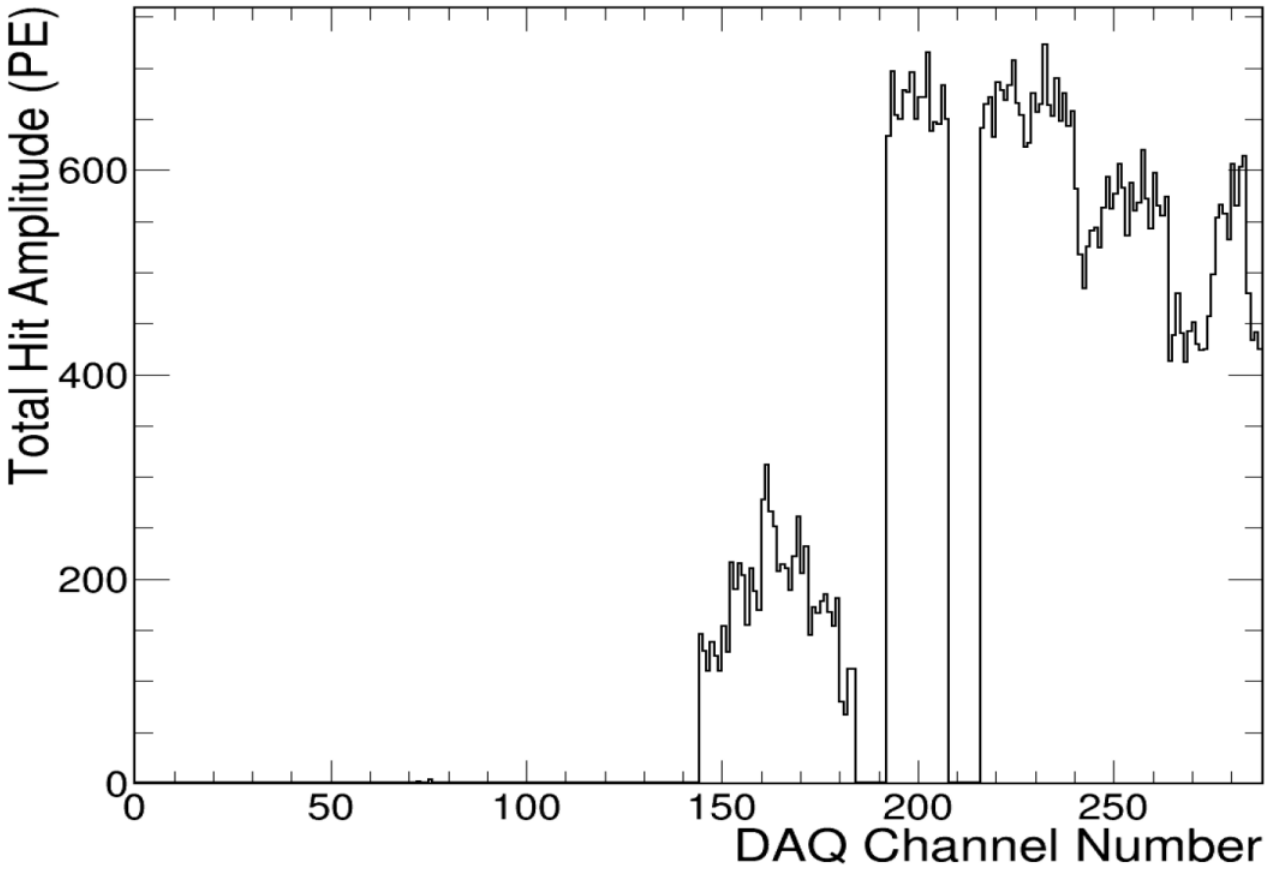
- Largest hits on APA1
  - Less on APA2
    - Least on APA3



Along Face of APA5

- 100 10 GeV/c Mu+
- Along Y axis
  - ThetaXZ=0
  - ThetaYZ=-90
- Near APA beam-side drift (X=350)
- Start At Top (Y=600)
- Mid-APA5 (Z=110)

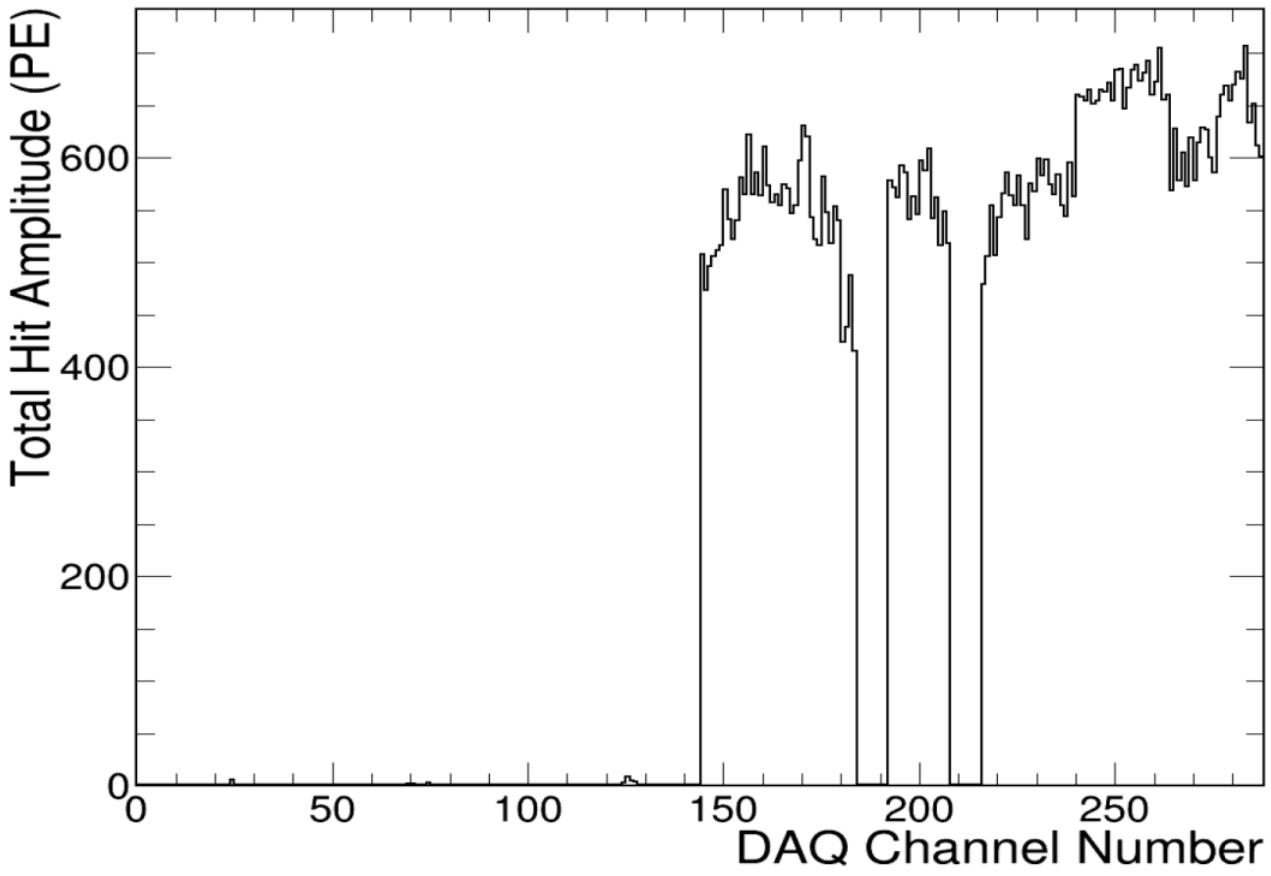
- Largest hits on APA5
  - Less on APA6
    - Least on APA4



Along Face of APA6

- 100 10 GeV/c Mu+
- Along Y axis
  - ThetaXZ=0
  - ThetaYZ=-90
- Near APA beam-side drift (X=350)
- Start At Top (Y=600)
- Mid-APA5 (Z=330)

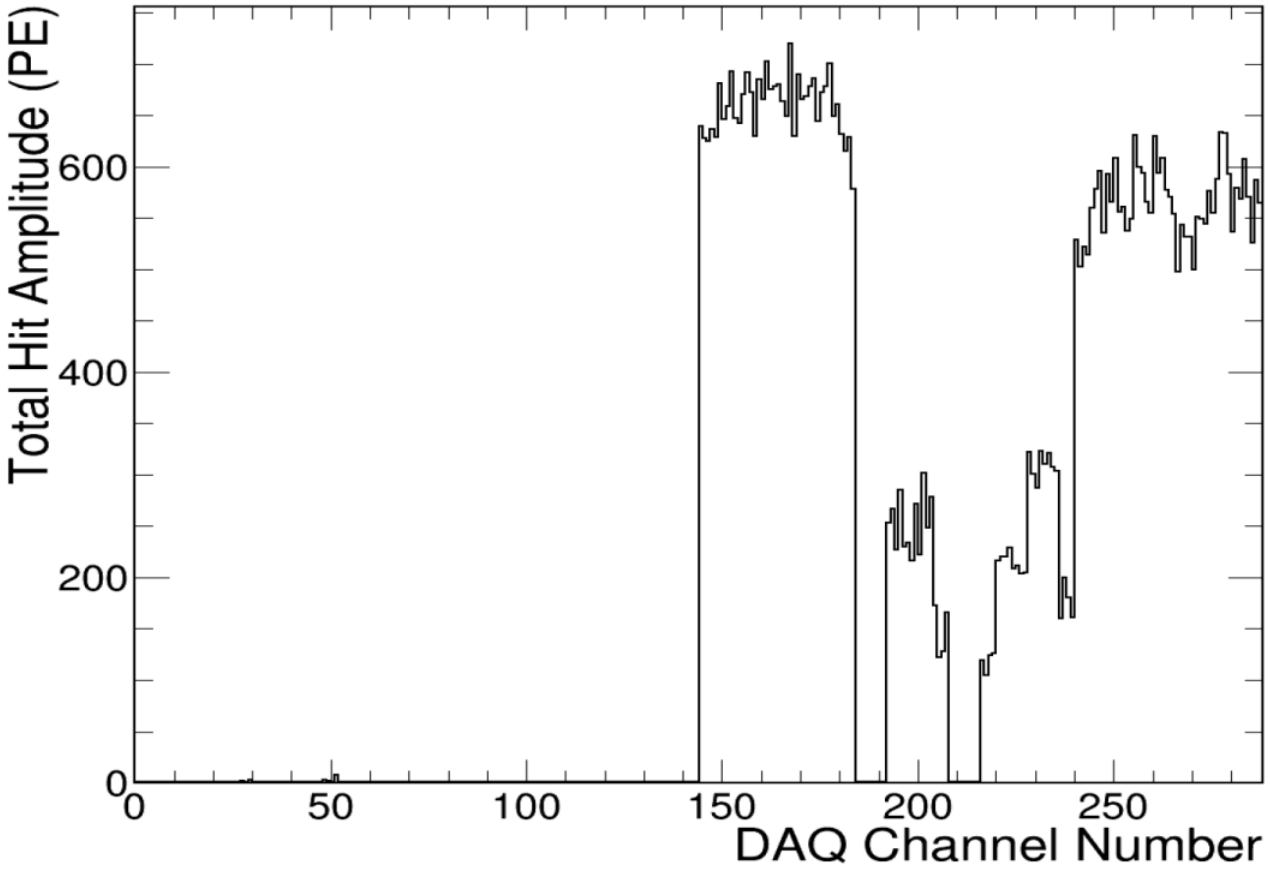
- Largest hits on APA1
  - Less on APA2
    - Least on APA3



Along Face of APA4

- 100 10 GeV/c Mu+
- Along Y axis
  - ThetaXZ=0
  - ThetaYZ=-90
- Near APA beam-side drift (X=350)
- Start At Top (Y=600)
- Mid-APA5 (Z=550)

- Largest hits on APA4
  - Less on APA5
    - Least on APA6 (furthest away)



Conclusions

- Re-Checked the correspondence of channel map in MC to Data.
- Versions now agree, in prior versions channels were swapped in X
  - (any earlier MC needs re-digitizing)
- Geometry of the MC looks consistent with reality
  - +Y axis = up and origin ~ bottom of CPA/APA
  - +X axis = toward beam left, Jura, origin at ~CPA plane
  - +Z axis = along the CPA plane, origin ~upstream end of APAs
    - Caveat: did not test to cm or mm precision

BACKUP Details on how to run (possibly out of date)

Some MC notes

- Based on wiki for photon detector MC tutorial
  - https://cdcvs.fnal.gov/redmine/projects/dunetpc/wiki/Photon_Simulation_Tutorial
- Instead of using “DUNE” version as in the tutorial, use protoDUNE version of fcl
- In /srcs/dunetpc/dune/PhotonPropagation/Tutorial
- My example in:
  - /dune/app/users/mualem/pdune_201809/srcs/dunetpc/dune/PhotonPropagation/Tutorial

Some MC notes

- testgen.sh in that directory runs each step sequentially
- Successfully ran up to about 5000 events. (files get too big if I recall)

```
#
lar -c protoDUNE/protodune_optical_tutorial_sim.fcl -n 10000
lar -c protoDUNE/protodune_optical_tutorial_digi.fcl -s protodune_optical_tutorial_sim_gen.root -n 10000
lar -c protoDUNE/protodune_optical_tutorial_reco.fcl -s protodune_optical_tutorial_digi_gen.root -n
10000
#root -l protodune_optical_tutorial_reco_hist.root
```

- Sim – Particle production, interaction, energy deposits, …. (GEANT bascially)
- Digi – Take particle tracks, energy deposits and make into waveforms
- Reco – Take waveforms and make hits, flashes, energy deposits in OpChannels
- Each stage above produces file “gen” (big, all info) and “hist” (small, summary info)

Some MC notes

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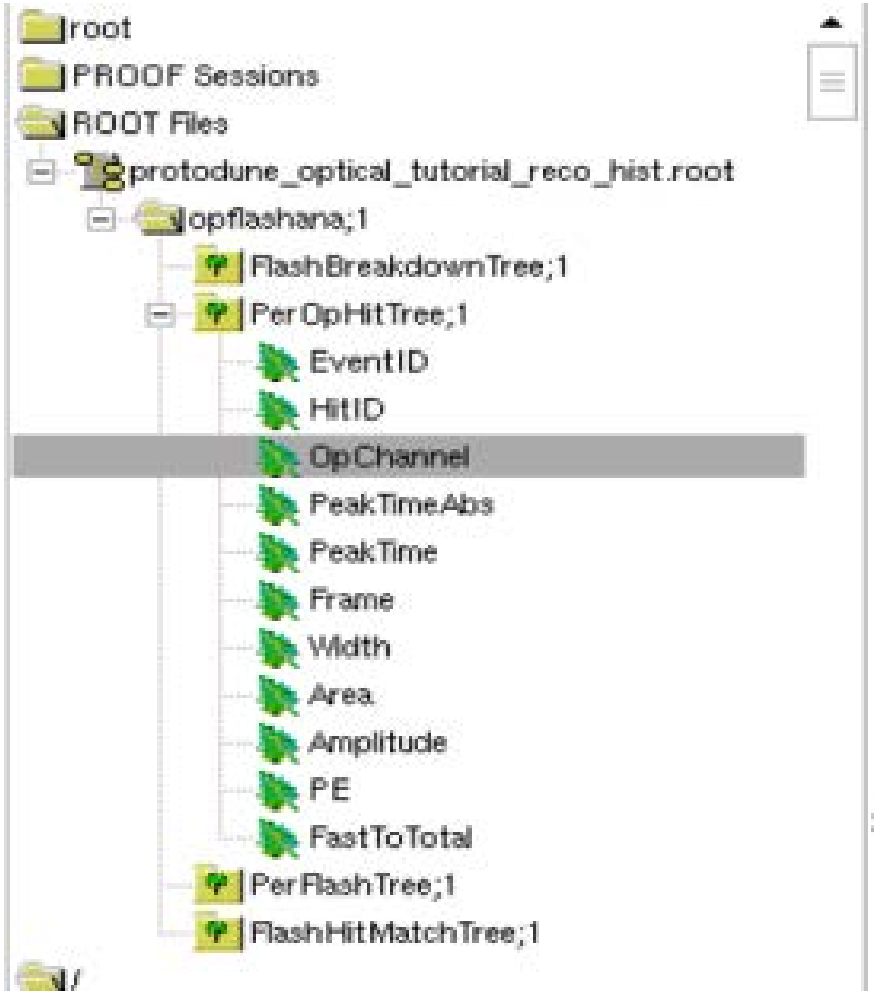

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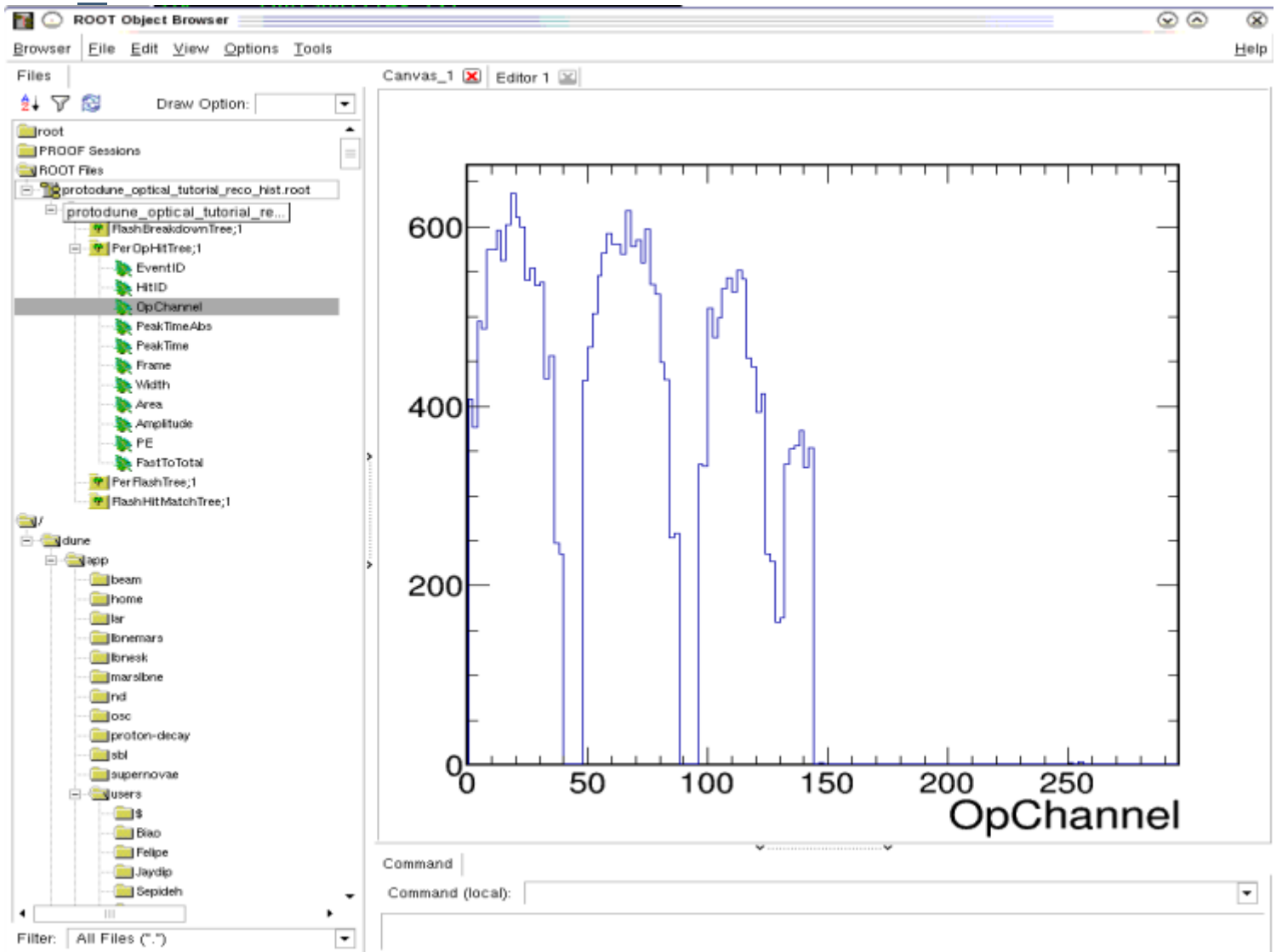

Some MC notes

- Particle hints:
  - /dune/app/users/mualem/pdune_201809/srcs/dunetpc/dune/PhotonPropagation/Tutorial
  - …protoDUNE/protodune_optical_tutorial_sim.fcl
  - Particle type:

```
# In this example, which primary particle(s) we'll focus on in an event.
    # PDG code 13 = mu-.pi+ = 211 proton = 2212 mu+ = -13
    PDGcode:        211
```

  - Particle Momentum:

```
physics.producers.generator.P0: [3.0]
```

Some MC notes

- Geometry hints:
  - /dune/app/users/mualem/pdune_201809/srcs/dunetpc/dune/PhotonPropagation/Tutorial
  - …protoDUNE/protodune_optical_tutorial_sim.fcl

```
# positive x axis
# physics.producers.generator.Theta0XZ: [ 90 ] # degrees angle in xz plane from z axis ?
# physics.producers.generator.Theta0YZ: [ 0 ] # degrees angle in yz plane from z axis ?
# positive z axis
# physics.producers.generator.Theta0XZ: [ 0 ] # degrees angle in xz plane from z axis ?
# physics.producers.generator.Theta0YZ: [ 0 ] # degrees angle in yz plane from z axis ?
# negative z axis
# physics.producers.generator.Theta0XZ: [ 0 ] # degrees angle in xz plane from z axis ?
# physics.producers.generator.Theta0YZ: [ 180.0 ] # degrees angle in yz plane from z axis ?
# vertically down
# physics.producers.generator.Theta0XZ: [ 0 ] # degrees angle in xz plane from z axis ?
# physics.producers.generator.Theta0YZ: [ -90.0 ] # degrees angle in yz plane from z axis ?
```

  - We believe origin at upstream (wrt beam) bottom edge of cathode plane (maybe lowest wires?)

Beam Plug position?

- Possibly the beam plug location – Paola probably knows best

```
# This block defines starting parameters for beam window 3 ( with beam plug) in protodune_v4.gdml geometry
physics.producers.generator.PosDist: 0   # Position distribution (0=uniform, 1=gaussian)
physics.producers.generator.X0: [7.966]         # Starting position (cm)
physics.producers.generator.Y0: [460.84]
physics.producers.generator.Z0: [-191.60]
physics.producers.generator.SigmaX: [0.0]
physics.producers.generator.SigmaY: [0.0]
physics.producers.generator.SigmaZ: [0.0]

physics.producers.generator.AngleDist: 0         # Angle distribution (0=uniform, 1=gaussian)
#physics.producers.generator.Theta0XZ: [-11.844] # Starting angles (degrees)
# Flip the angle for the photon detectors. UGH!
physics.producers.generator.Theta0XZ: [11.844] # Starting angles (degrees)
physics.producers.generator.Theta0YZ: [-11.107]
physics.producers.generator.SigmaThetaXZ: [0.]
physics.producers.generator.SigmaThetaYZ: [0.]
```