

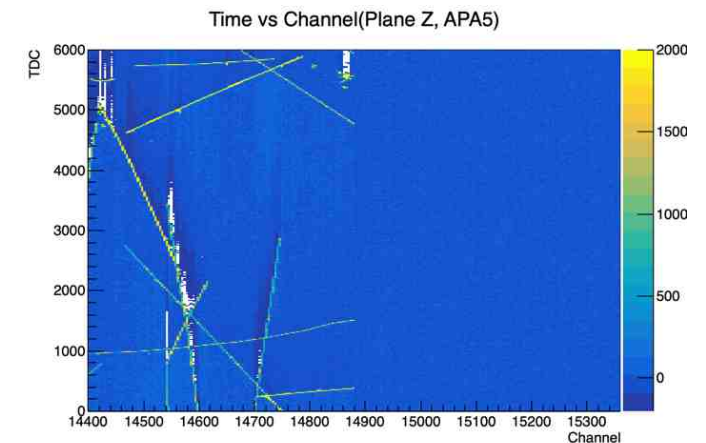
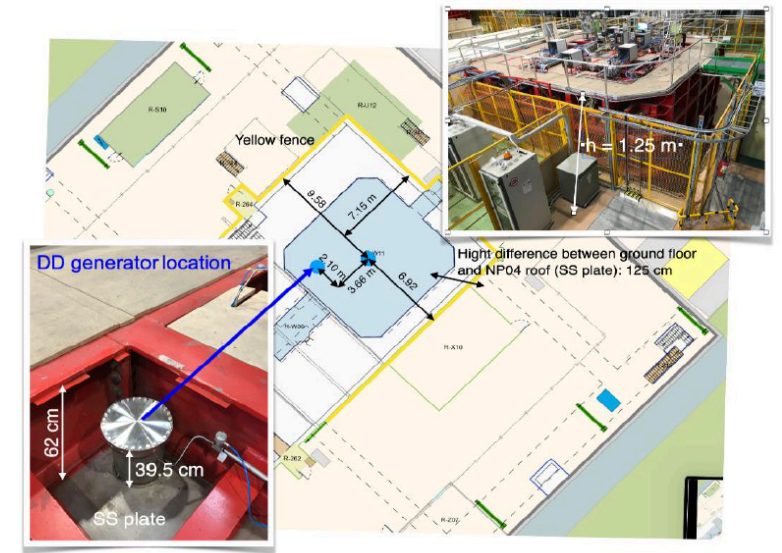
Simulation of Low Energy Events at ProtoDUNE-SP

XIX International Workshop on Neutrino Telescopes
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For the DUNE Collaboration

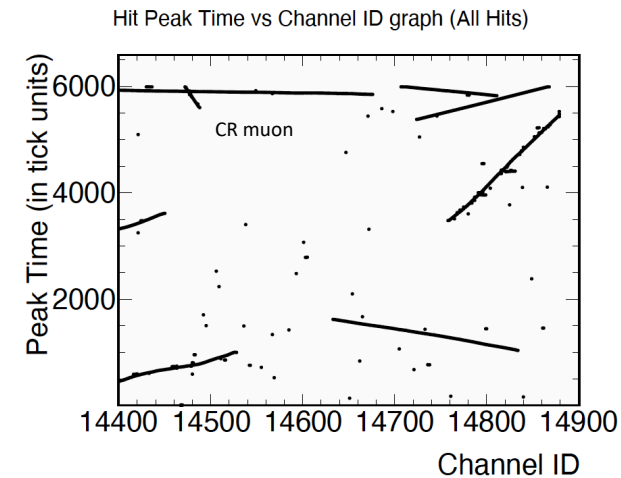
Motivation for the Simulation

- A DD (Deuterium Deuterium) neutron generator test was done on ProtoDUNE-SP (single phase) at CERN in July 2020. More details about the pulsed neutron source (PNS) calibration system for DUNE and DD generator setup was covered in the talk “Neutron Generator Calibration System for DUNE” by Yashwanth Bezawada yesterday: [Link](#)
- Signal Interested: 2.5 MeV neutrons
- Background: Cosmic ray, Ar-39 beta decay
- Yashwanth developed analysis algorithm.
- I ran simulations of neutron and background to compare with real data and test the algorithm.

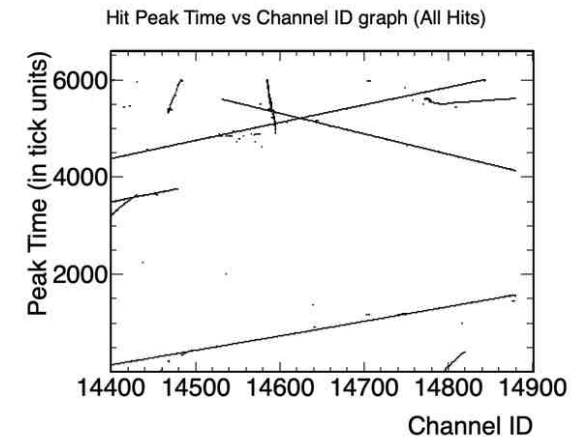


Need to Remove Cosmic Ray Muons

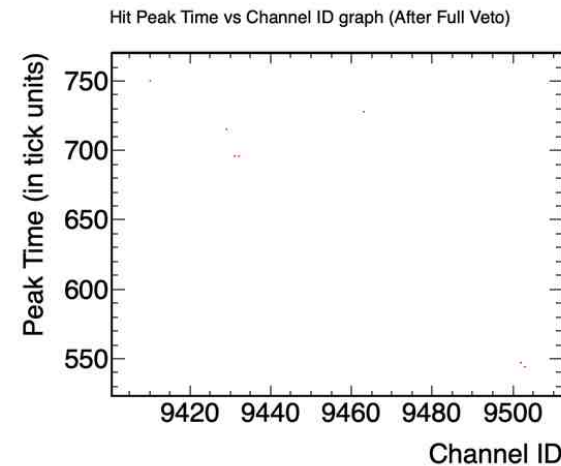
- Plots at right are simulations of one event.
- Simulations are done with DUNE's official software LArsoft. Module for neutrons: NeutronHP.
- In simulation: Separation of neutron and background
- ProtoDUNE standard reconstruction: classify cosmic rays and remove
- Channel ID related to position by pitch 4.7 mm.
- Most cosmic ray hits removed.
- Neutrons can be seen in ProtoDUNE-SP.



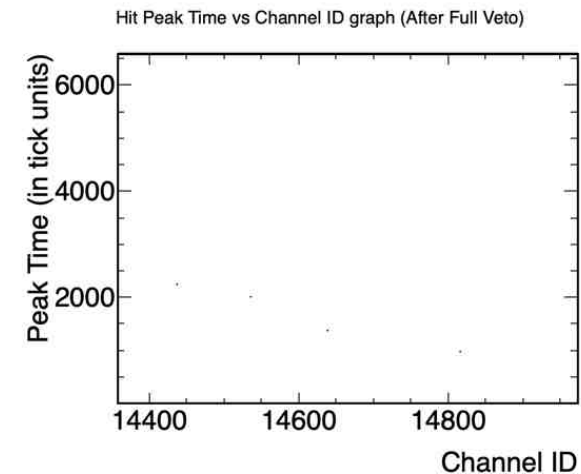
Background and neutrons



Background only



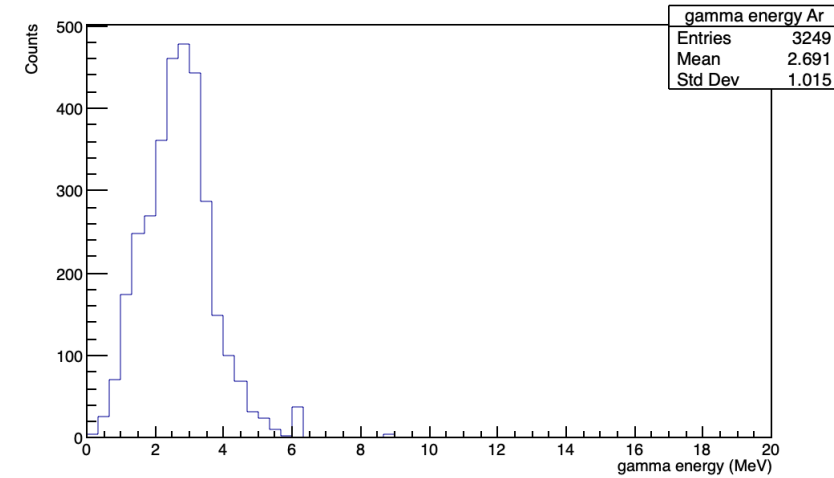
Neutrons only



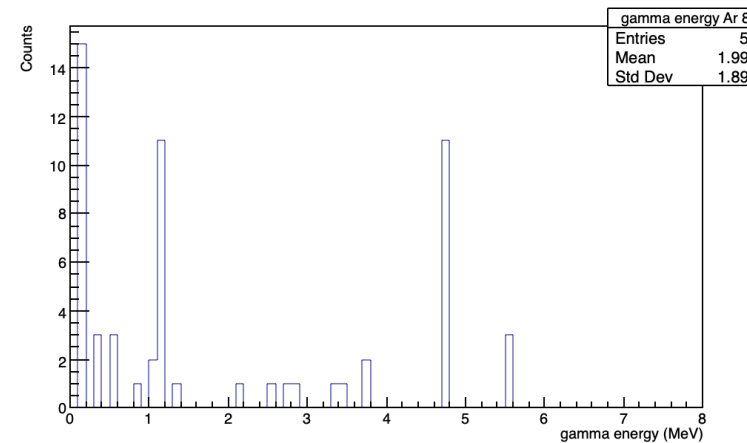
Background after cosmic removal

Neutron Capture Gamma Energy Distribution

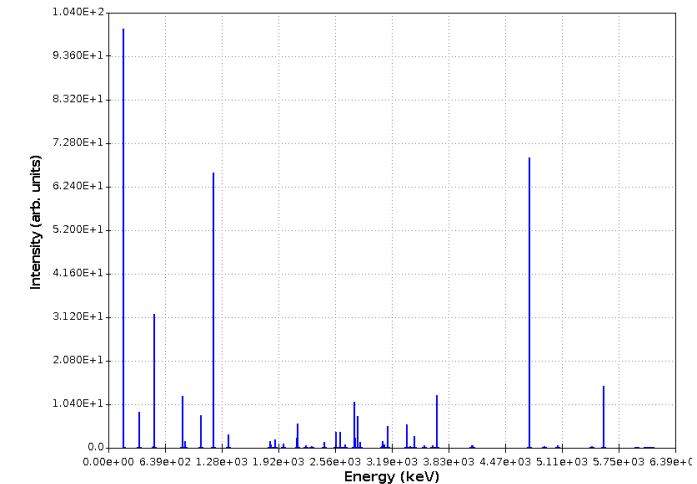
- Identify neutron capture in argon.
- Plots on the right are gamma energy distribution of neutron capture in liquid argon.
- Original GEANT4 gamma energy distribution is wrong. Physics list is: QGSP_BERT_HP
- Fixed to match the NNDC (National Nuclear Data Center) data.



Original GEANT4



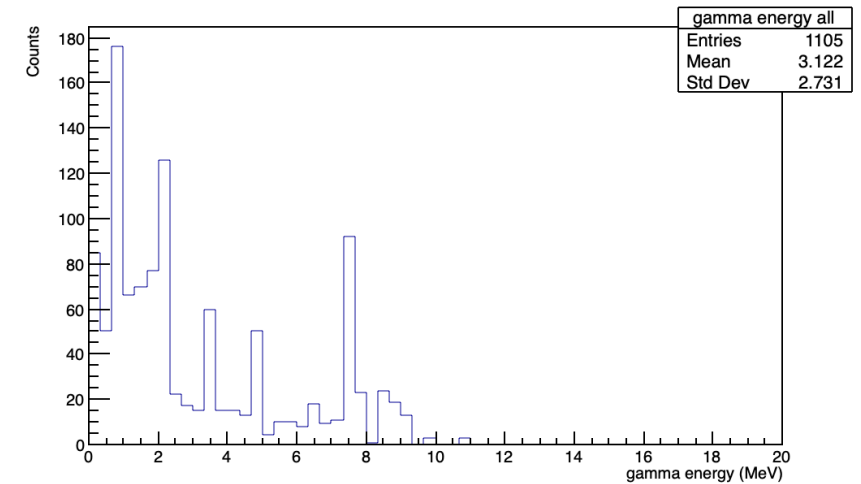
Fixed GEANT4



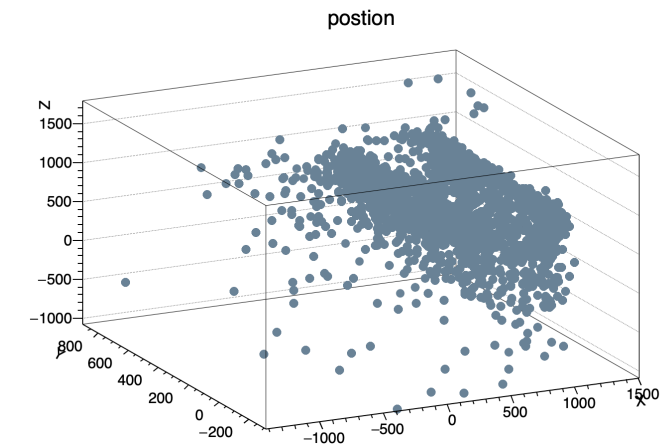
NNDC Data

Neutron Interaction outside Argon

- Neutron capture not only happen in liquid argon, but also in other materials in ProtoDUNE-SP detector. Only about 1% reach the argon active volume, due to non-optimum position of DDG.
- In GEANT4: classify by gamma position, and compare with real data.
- Future plan: energy reconstruction



All neutron capture gammas



3D gamma position distribution

Summary

- Test cosmic ray removal algorithm.
- Verify that neutrons can be seen.
- Fixed GEANT4 neutron capture.
- Identify neutron capture in argon and other materials.

Backup Slides

How to use the fixed simulation

How to use the fix: upgrade to v09_15_00 and change physics list from : QGSP_BERT_HP to MyQGSP_BERT_ArHP