Pulsed Neutron Source Analysis Update

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Data Collection

- This analysis uses data taken at the Deuterium Deuterium generator (DD generator) test in July 2020 on ProtoDUNE-SP.

- The DD generator produce 2.5 MeV neutrons: $D+D \rightarrow n+^3He$

- Random Trigger Mode:

  - DDG Off: E = 650 V/cm; 2 Hz Trigger Frequency

  - DDG Off: E = 350 V/cm; 5 Hz Trigger Frequency

  - DDG On: E = 650 V/cm; 2 Hz Trigger Frequency

  - DDG On: E = 350 V/cm; 5 Hz Trigger Frequency

- Pulsed Trigger Mode (Only for DDG On):

  - E = 350 V/cm, 5% duty Cycle, ~175 µs pulse width, ~4 Hz

  - E = 0 V/cm, 5% duty Cycle, ~175 µs pulse width, ~4 Hz

Data Reconstruction

- Use "protoDUNE_SP_keepup_decoder_reco.fcl" to reconstruct the raw data with the following modules:

    - "hitpdune" for reconstructing hits

    - "reco3d" for extracting spacepoints

    - "dbscan3d" for clustering spacepoints

- DBSCAN parameters:

    - epsilon = 2 cm;
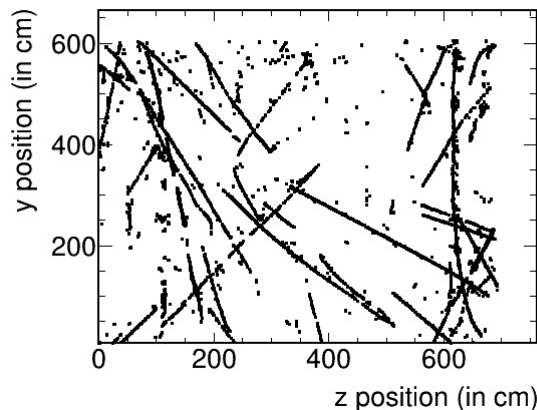
    - Minimum spacepoints per cluster = 3

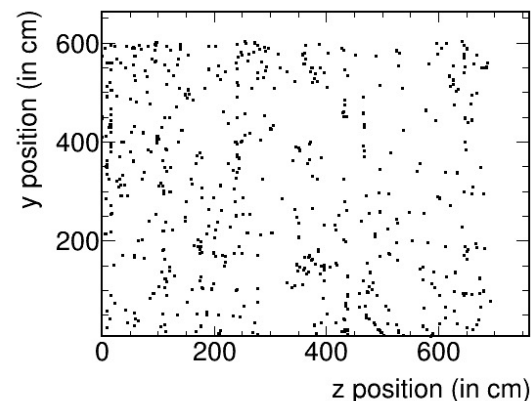### All Spacepoints

Y vs Z plot of DDG-on run (All Space Points)
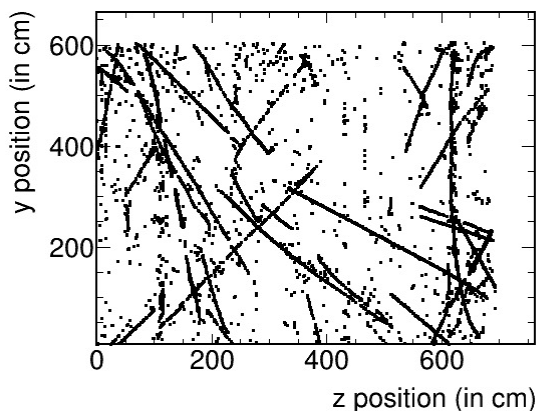
Clustered Spacepoints

Y vs Z plot of DDG-on run (Cluster Space Points)

Unclustered Spacepoints

Y vs Z plot of DDG-on run (non-Cluster Space Points)

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Simulation

- Updated the Geant4 physics list in LArSoft.

- Modified the LArSoft geometry to include the shield.

- Text file generator: 1500 neutrons with 2.5 MeV per event

- protodune_corsika_cmc for cosmic ray

- protodunesp_39ar for Ar39
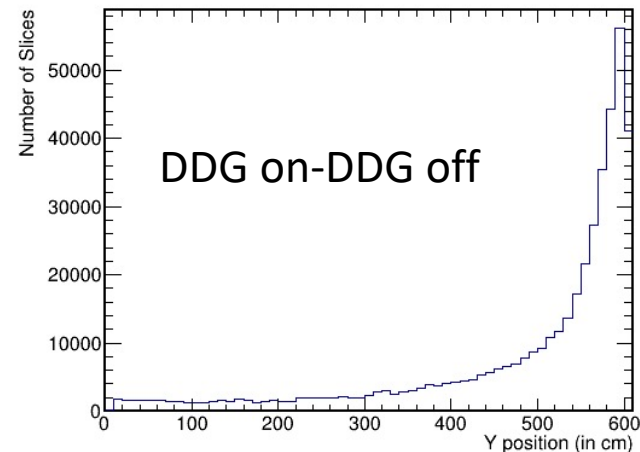
- Same reconstruction chain as data.

Cluster Size Cut

- Neutron capture events can also form relatively large clusters.

- Cluster size cut is set to be 13.
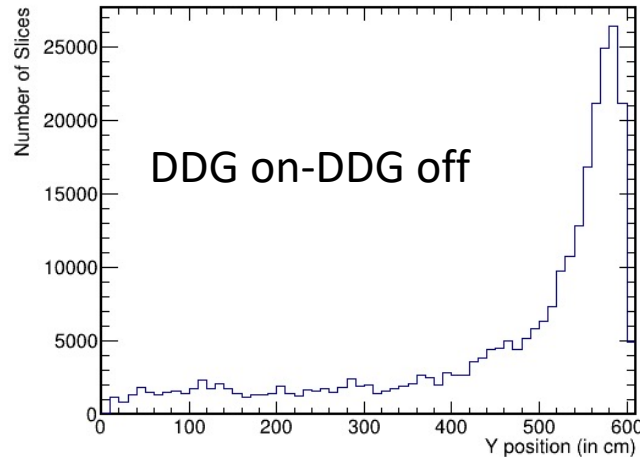

Neutrons Only

Cosmics Only
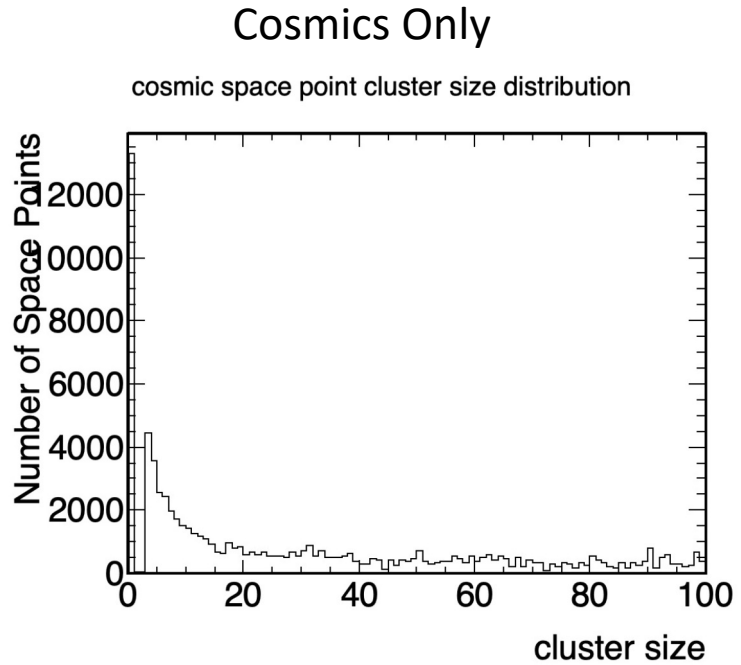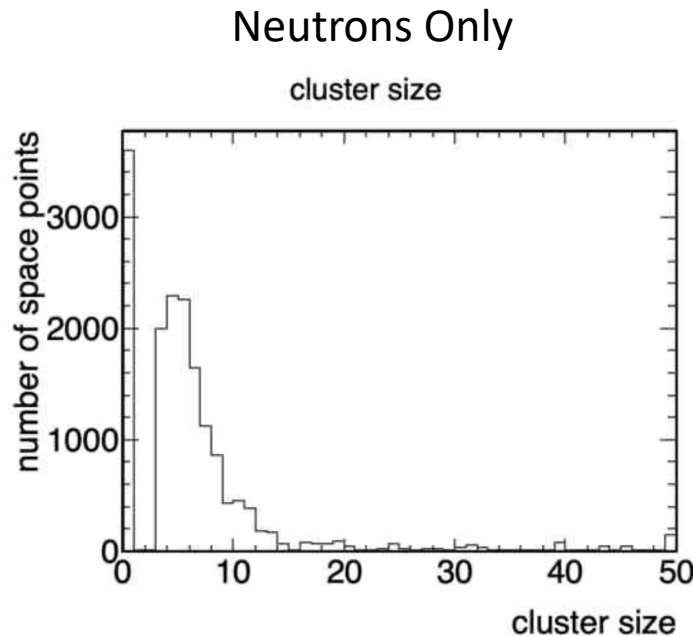
Spacepoint y Position
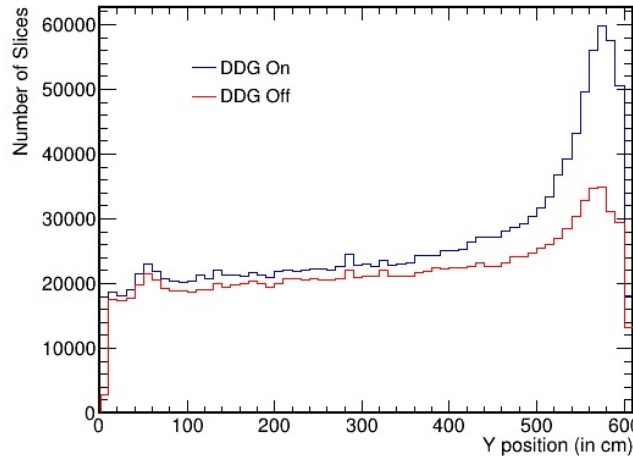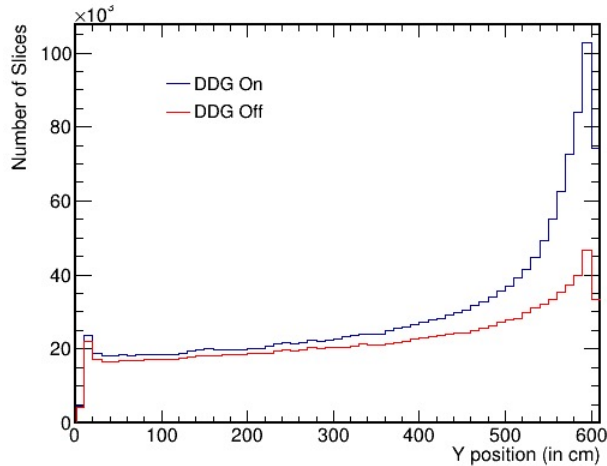
- 5000 events reconstructed and simulated

- DD generator signal seen in both MC and data

- Inefficiency near top of detector observed in data

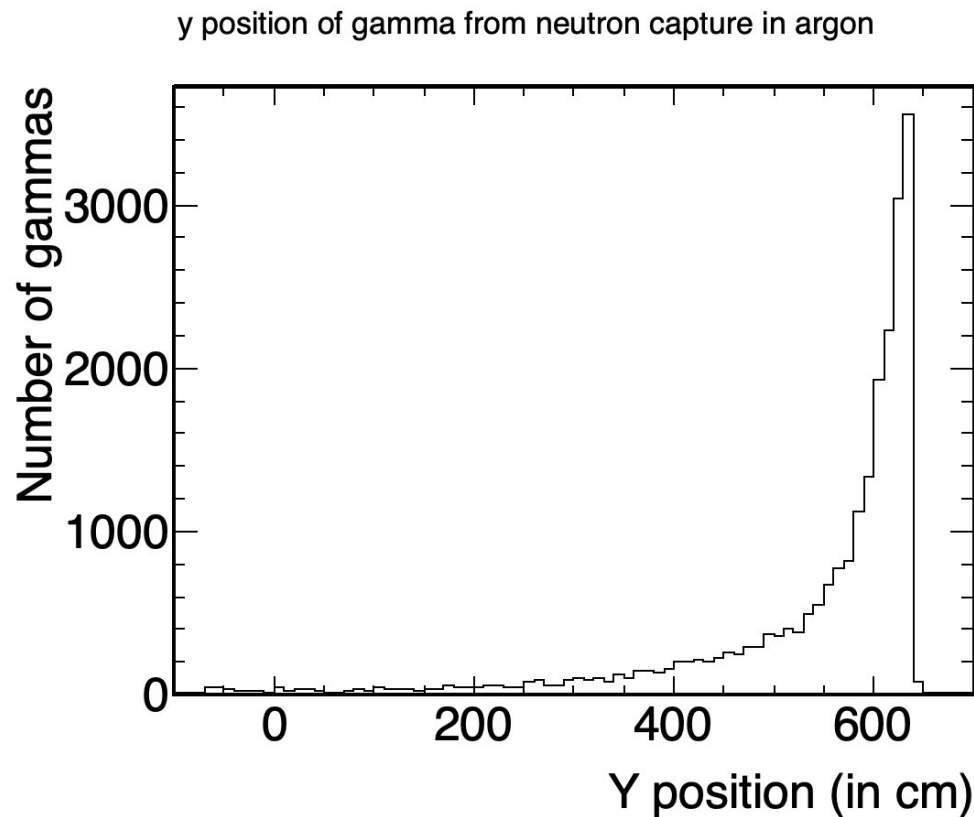- Chi-square minimization used to fit the data with MC simulations

$$\chi^2 = \sum_{i=bins} \frac{\left[(D_{on,i} - D_{off,i}) - \beta\left(MC_{on,i} - MC_{off,i}\right)\right]^2}{D_{on,i} - D_{off,i}}$$

MC   Data

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Neutron capture in simulation

- Simulation confirms that gammas from neutron capture are seen.

y position of gamma from neutron capture in argon

Conclusion

- Good agreement between data and MC, except at the edges

- Gammas from neutron capture are seen.

- MC seems to overestimate the activity in the detector

- Inefficiency near top of detector in data

- The fit parameter, β = 0.74