WireCell Signal Processing with DNN ROI Finding at SBND

Mun Jung Jung

Lar-WireCell Meeting

August 29th, 2024

THE UNIVERSITY OF CHICAGO

Introduction

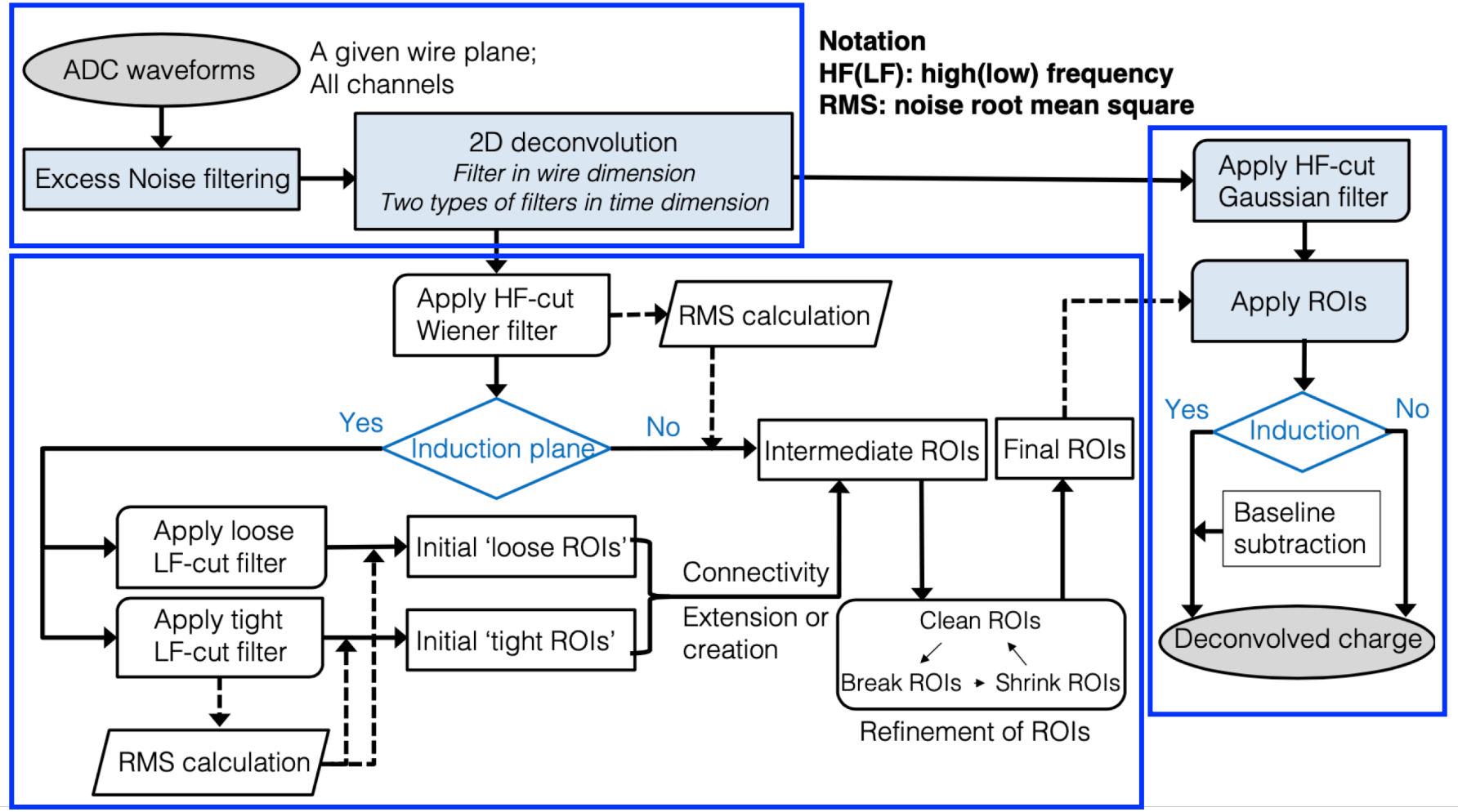
- WireCell signal processing for SBND docdb 36134
  - Filters values were optimized using charge extraction metrics
  - There's corner cases where the traditional SP struggles: prolonged tracks, busy vertices, …
- DNN ROI finding docdb 34162
  - Provides faster optimization
  - Improves performance for these corner cases
  - Uses multi-plane matching information
- We're working to get DNN ROI implemented for both SBND and ICARUS
  - Expected to be especially helpful for ICARUS where induction planes are noisy
  - Will contribute towards consistent 2-detector analysis docdb 37187

WireCell Signal Processing

1. 2D Deconvolution

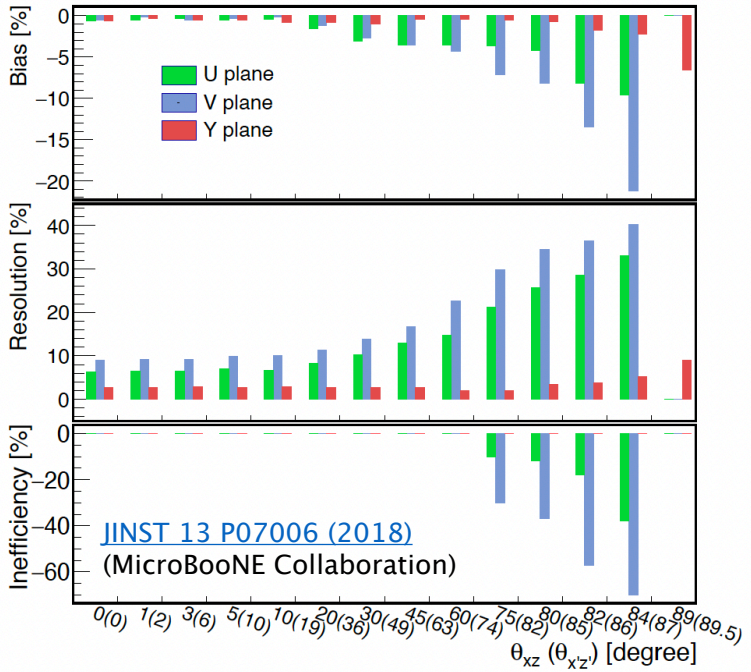
2. ROI Finding

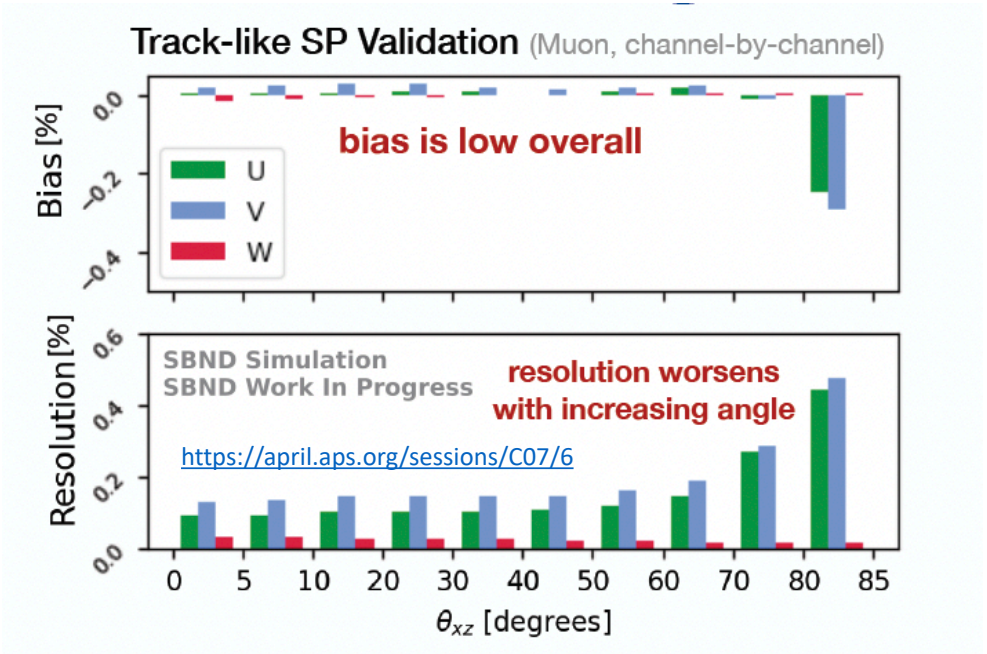
3. Charge Extraction



Limitations of the Traditional Method

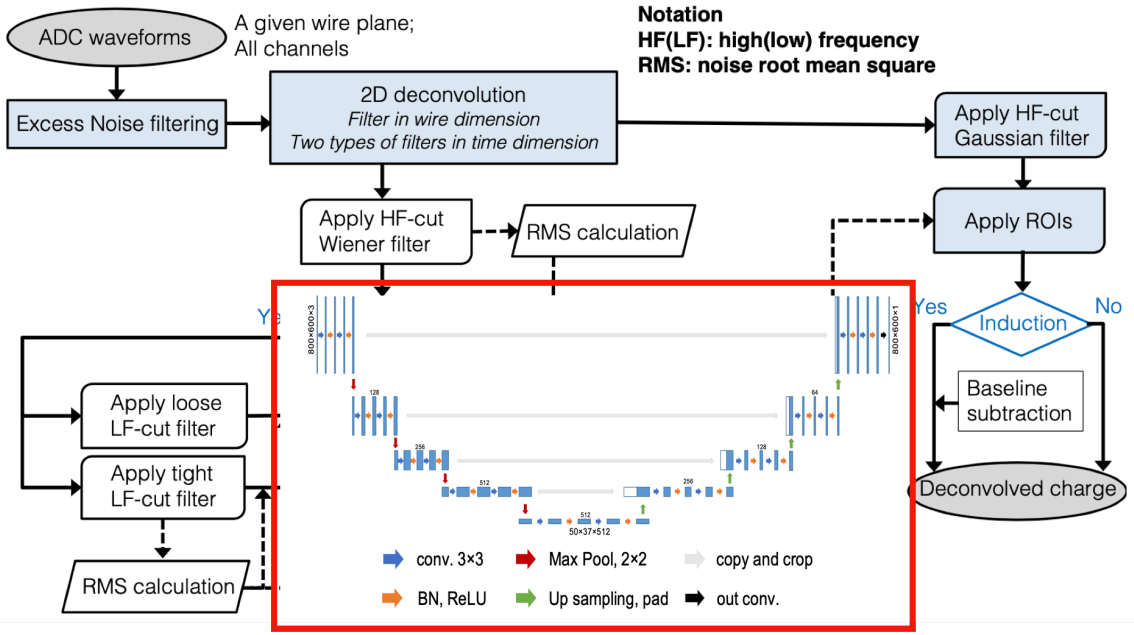
- Procedure for the optimization of the traditional ROI finding algorithm is nontrivial and computationally challenging
  - filters are simultaneously optimized by coordinate descent approach
  - decision of filter values from evaluation on different samples by eye
- Limited performance for some cases ex. prolonged tracks





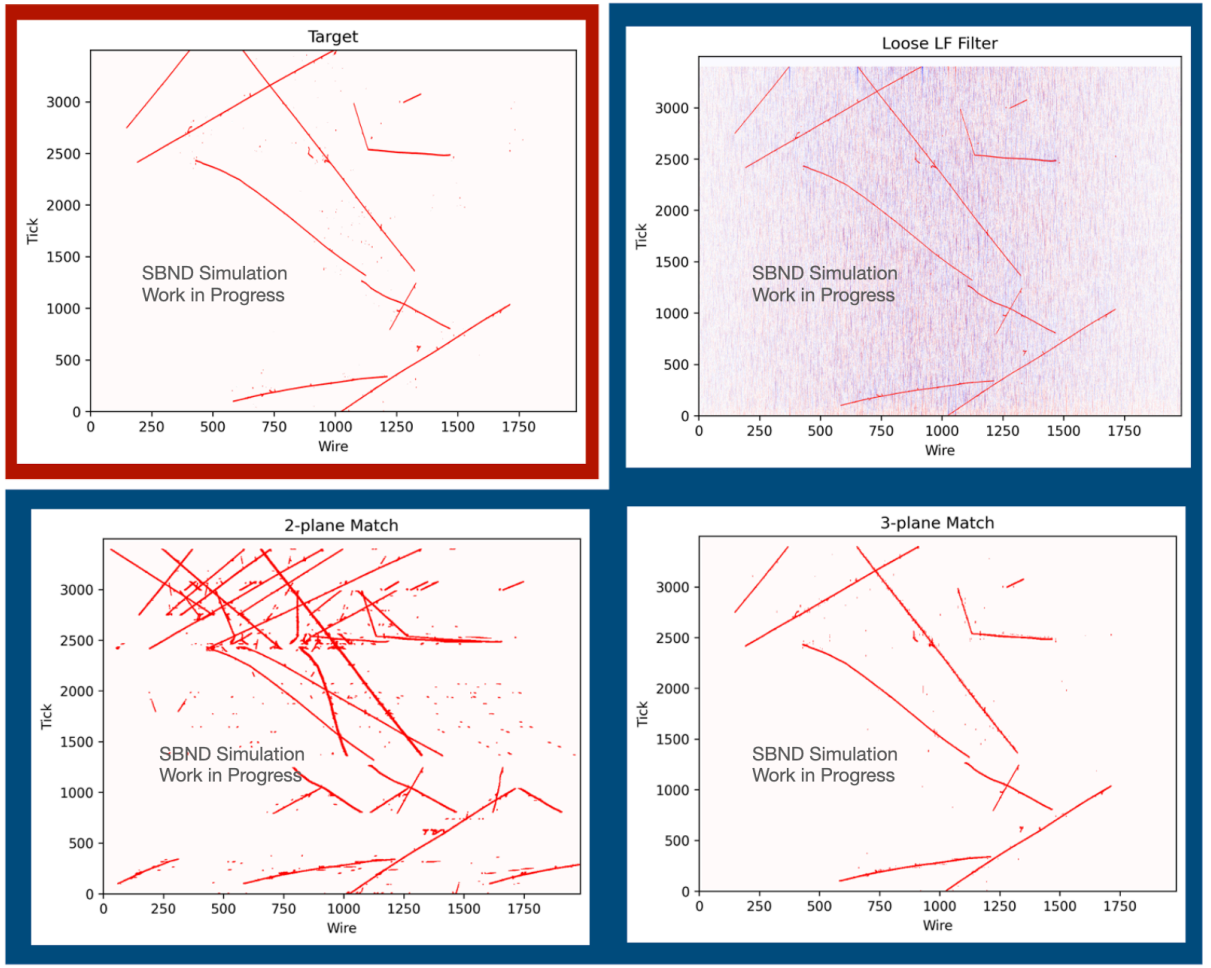
DNN ROI Finding

- DNN tool to address the limitations of the traditional method
  - network learns and recognizes features of prolonged tracks from images
  - faster and easier optimization process
- Tool developed by the protoDUNE experiment (JINST 16 P01036)
  - Integration into the data signal processing workflow is work-in-progress at SBND and protoDUNE



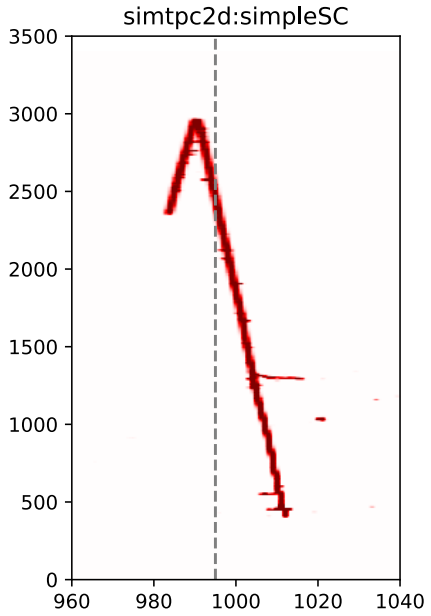
Training Samples

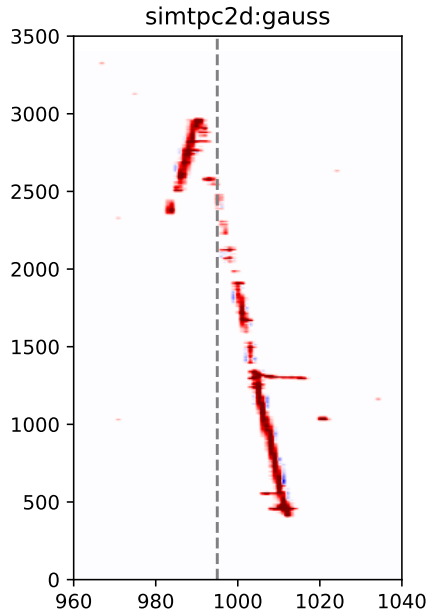
- Training images made from simulated neutrino events
  - **target images** is made from setting a threshold on simulated charge deposit
  - **input images** are made from intermediate stages of the traditional signal processing chain
    1. Loose LF filter: preserve prolonged track signals that are washed out my tighter filters
    2. 2-plane match
    3. 3-plane match: multiplane match outputs to inform network of geometric constraints from other planes



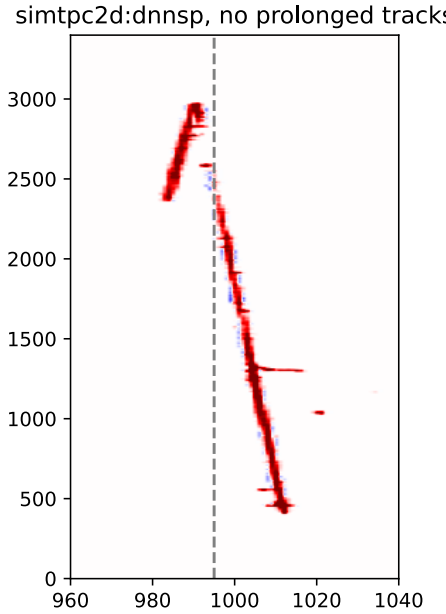
DNN ROI @ SBND SP - MC

- UResNet trained for SBND

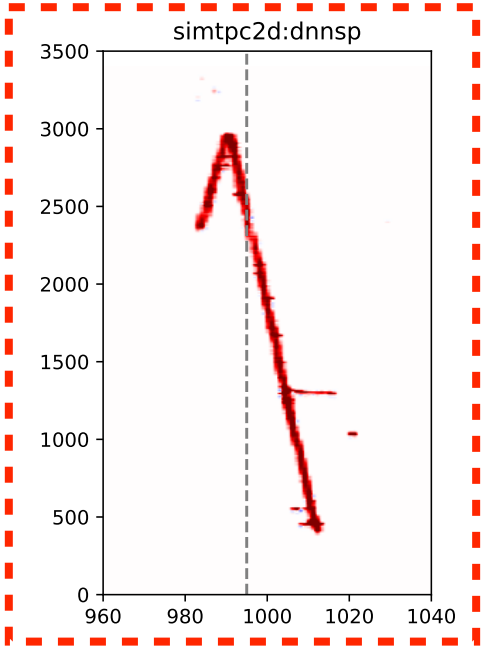


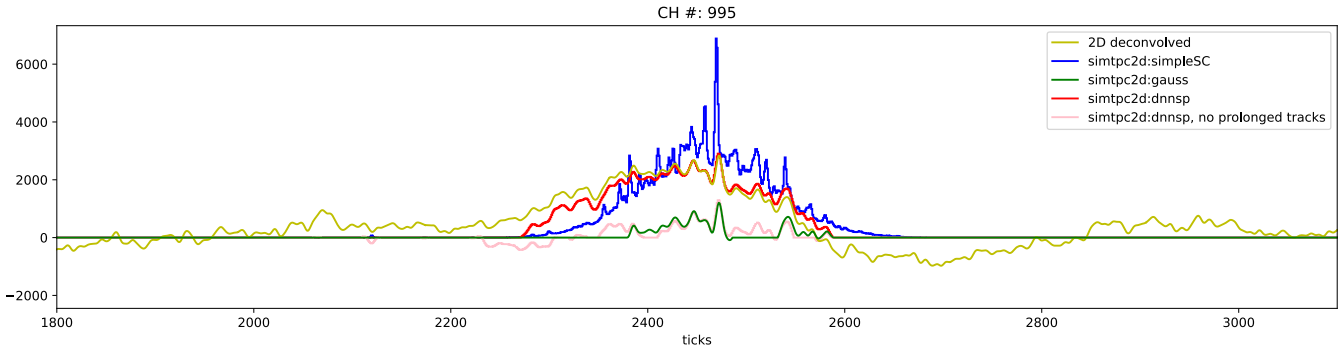


Trained on BNB nu & cosmics (2000 events)



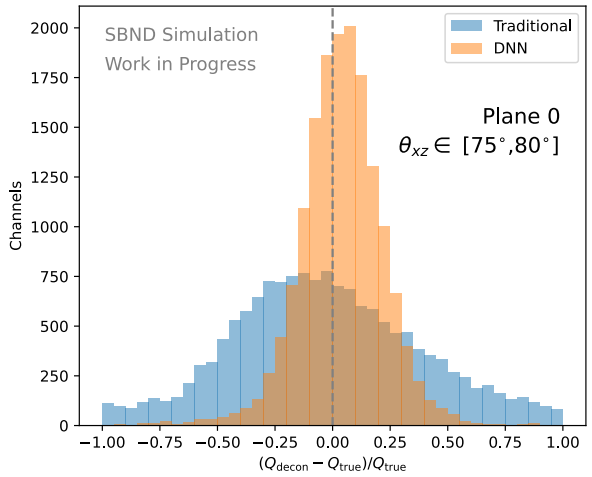
Trained on BNB nu & cosmics (2000 events) + prolonged tracks (200 events)

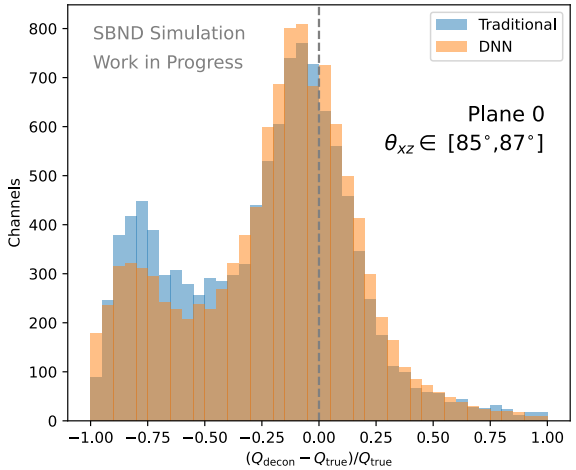


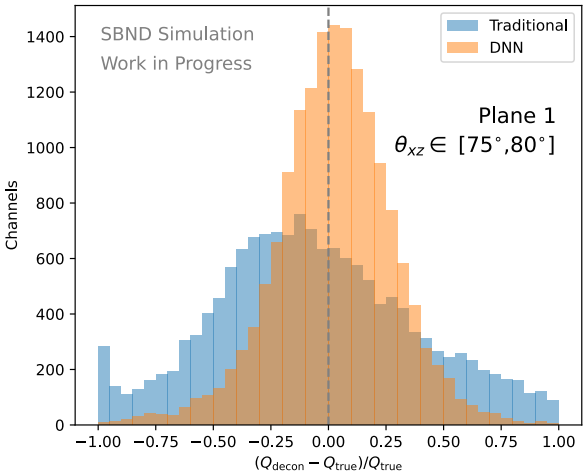


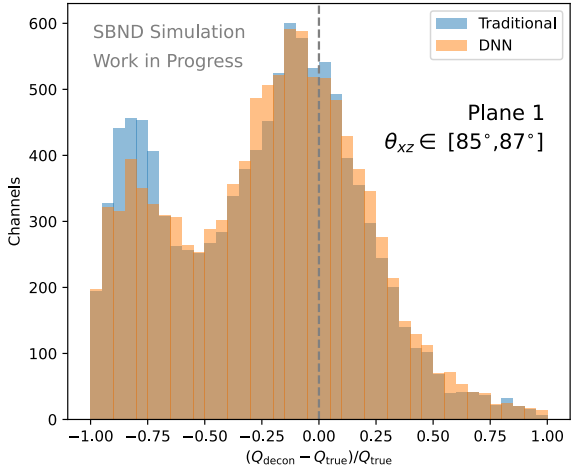
DNN ROI @ SBND SP - MC

Trained on BNB nu & cosmics (2000 events)

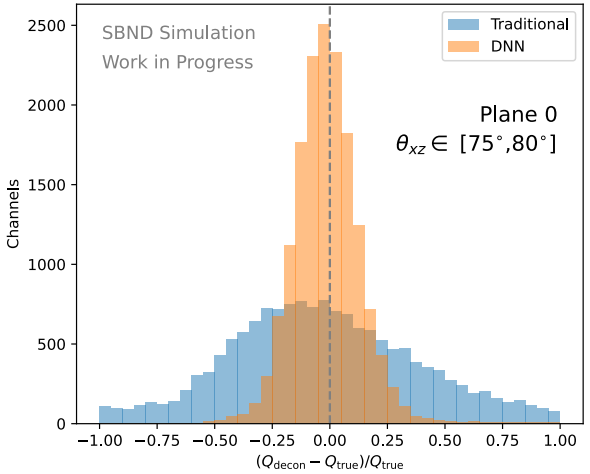


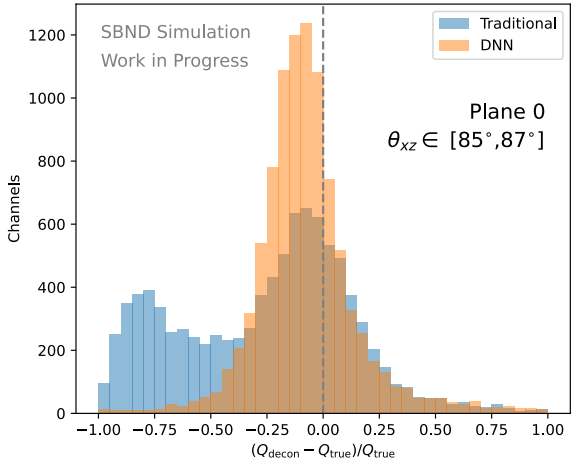


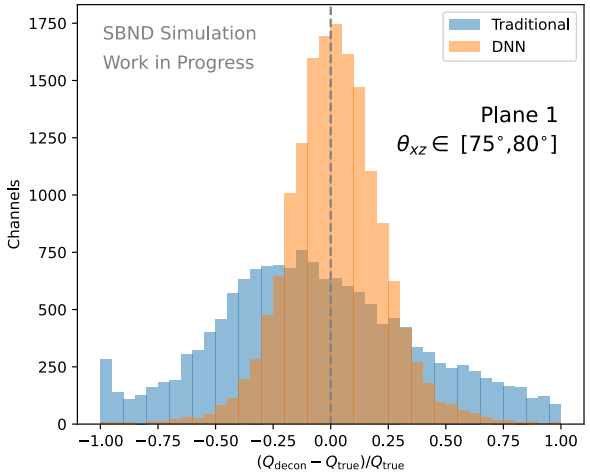


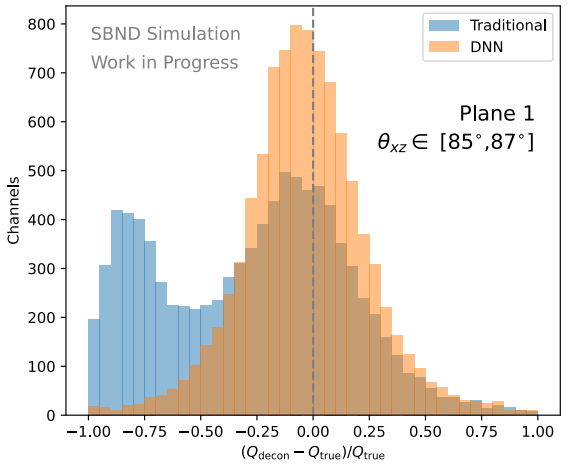


Trained on BNB nu & cosmics (2000 events) + prolonged tracks (200 events)



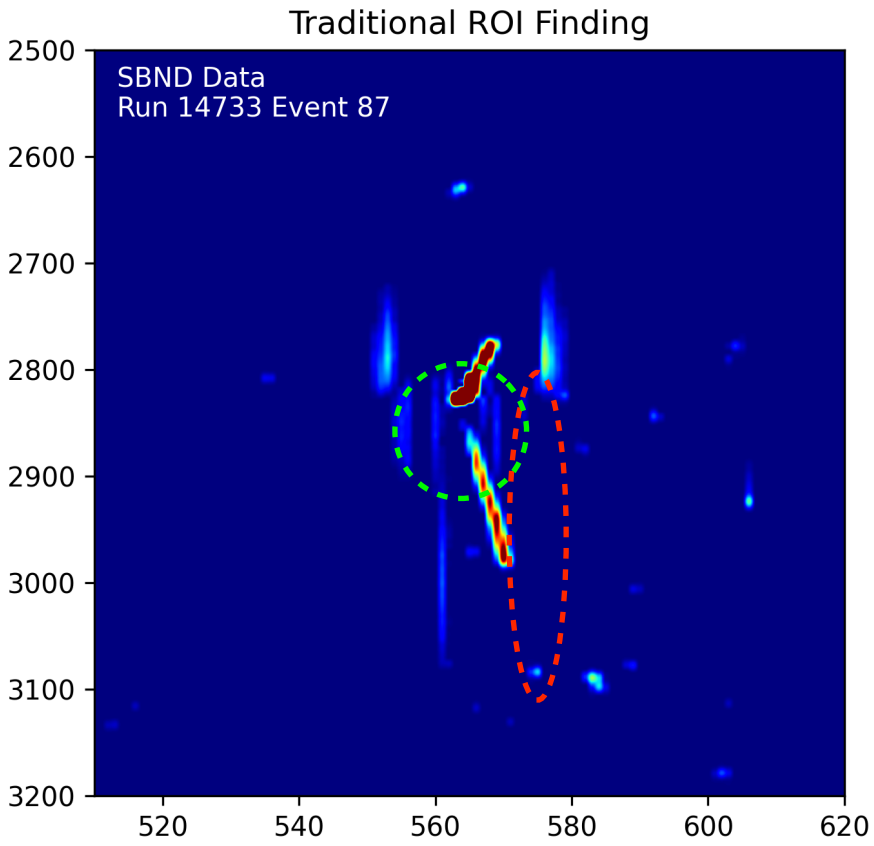


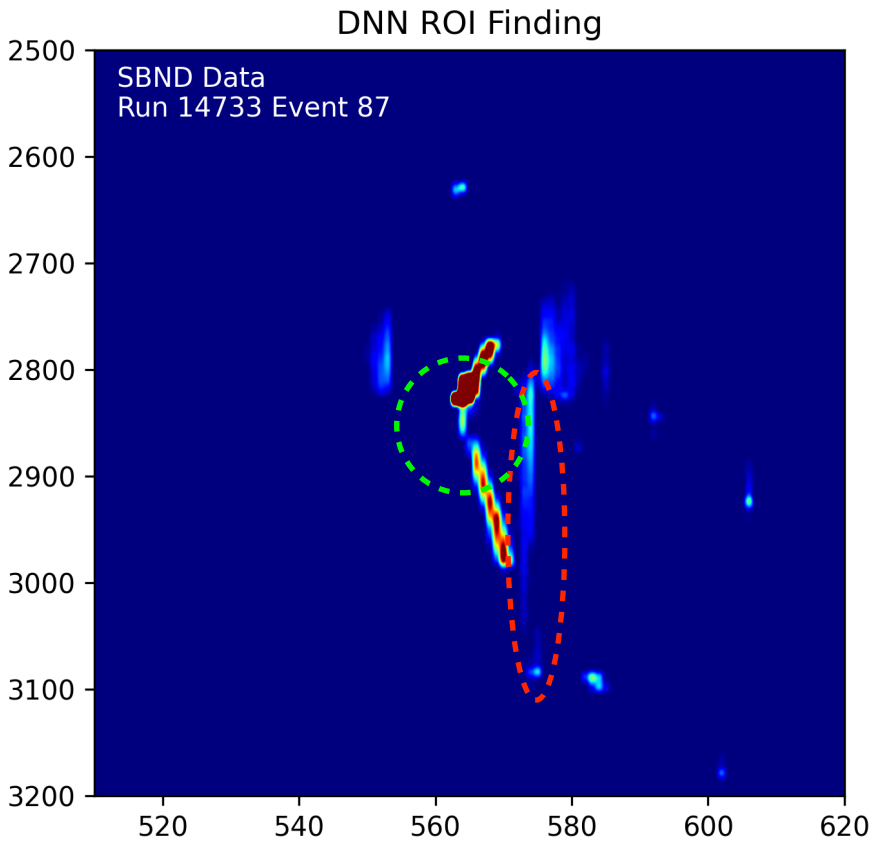




DNN ROI @ SBND SP - Data

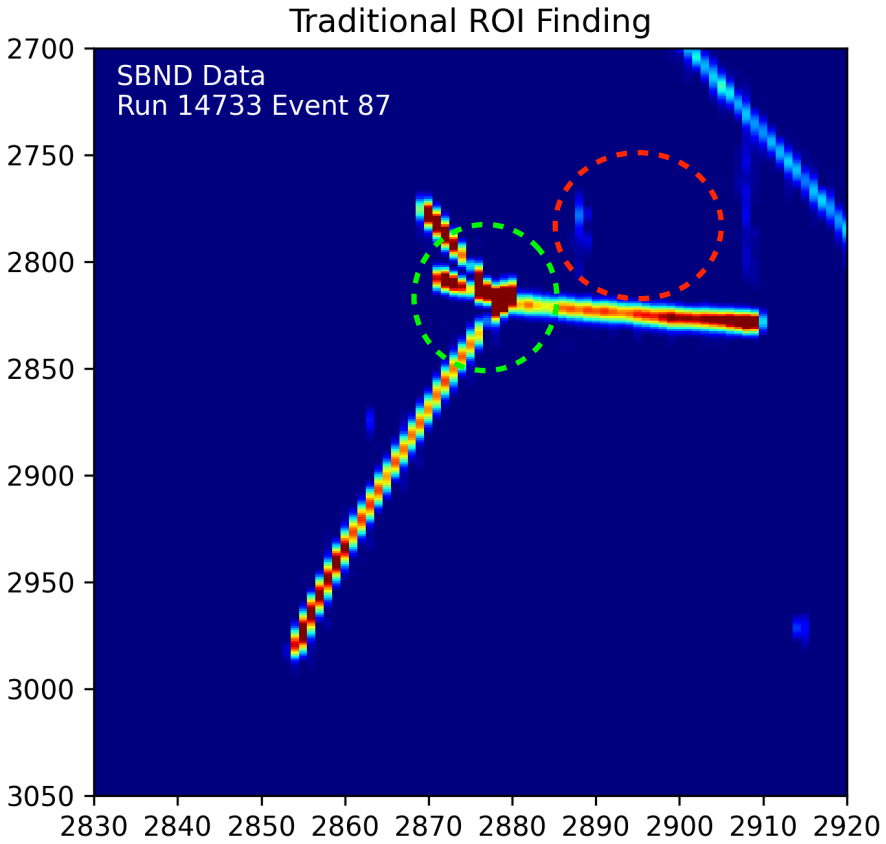
- ν_μ CC Np Candidate

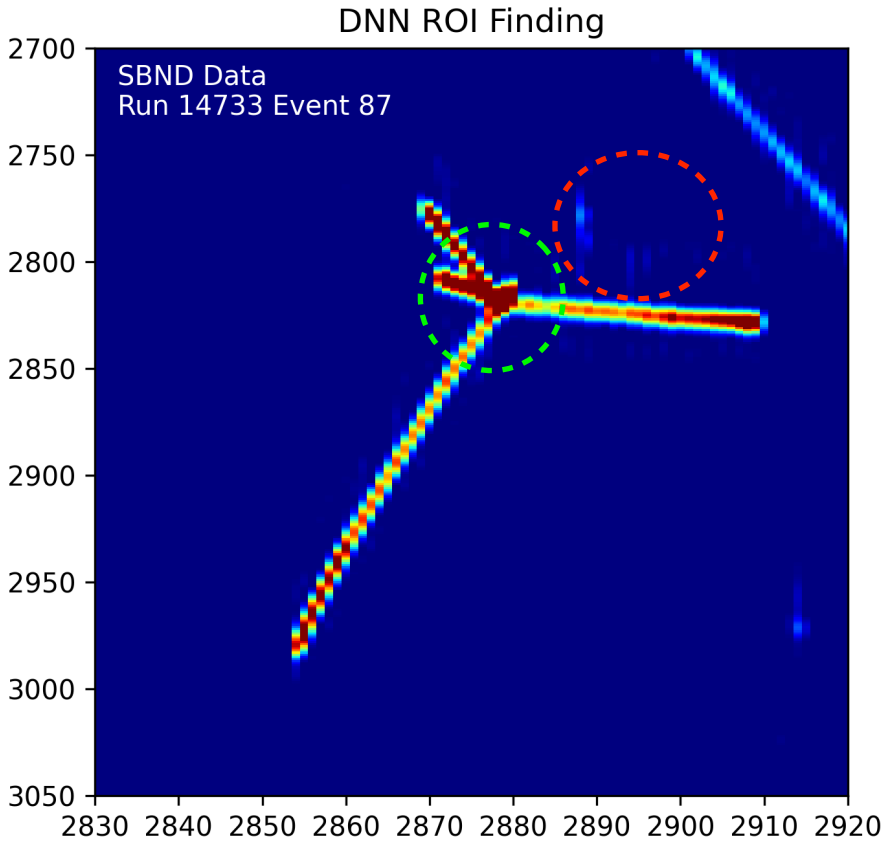




DNN ROI @ SBND SP - Data

- ν_μ CC Np Candidate

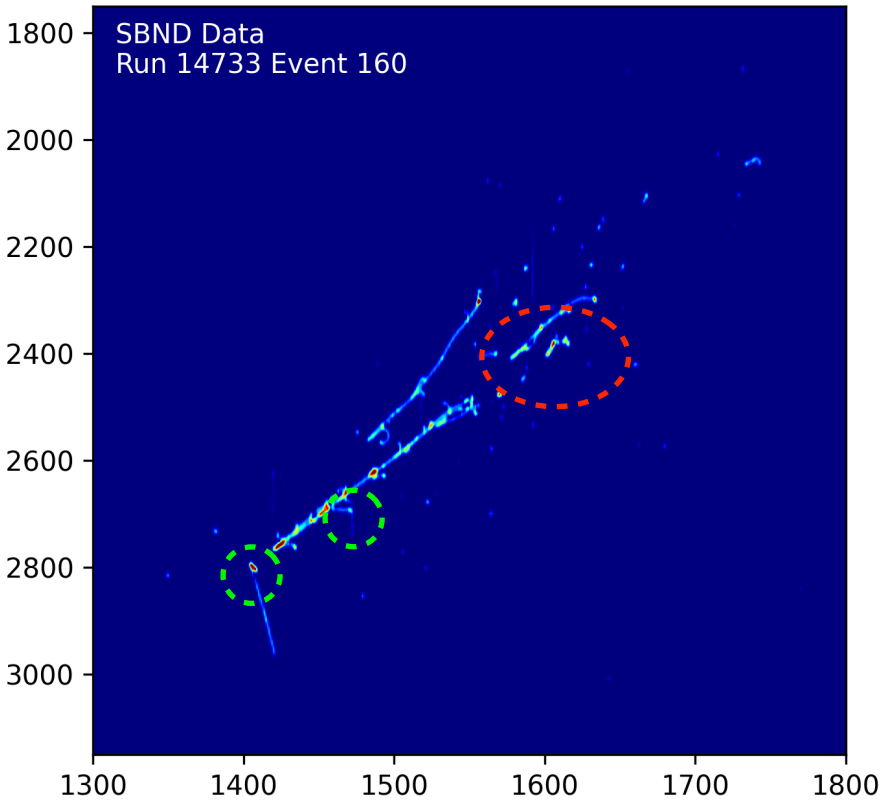




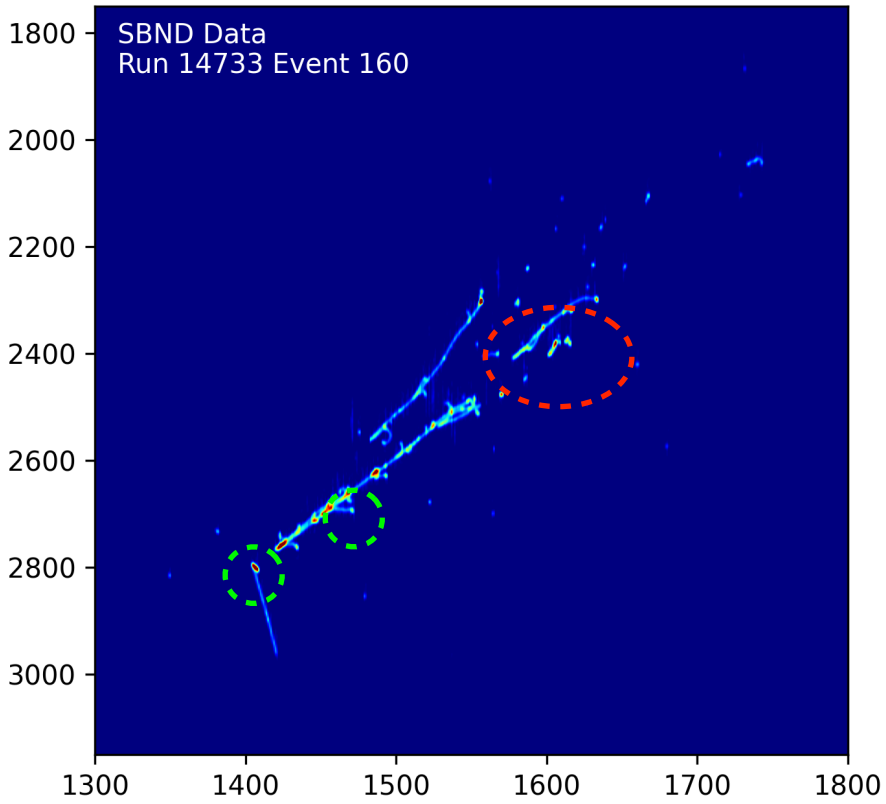
DNN ROI @ SBND SP - Data

- ν_μ CC 1μ1p1π^0 Candidate

Traditional ROI Finding

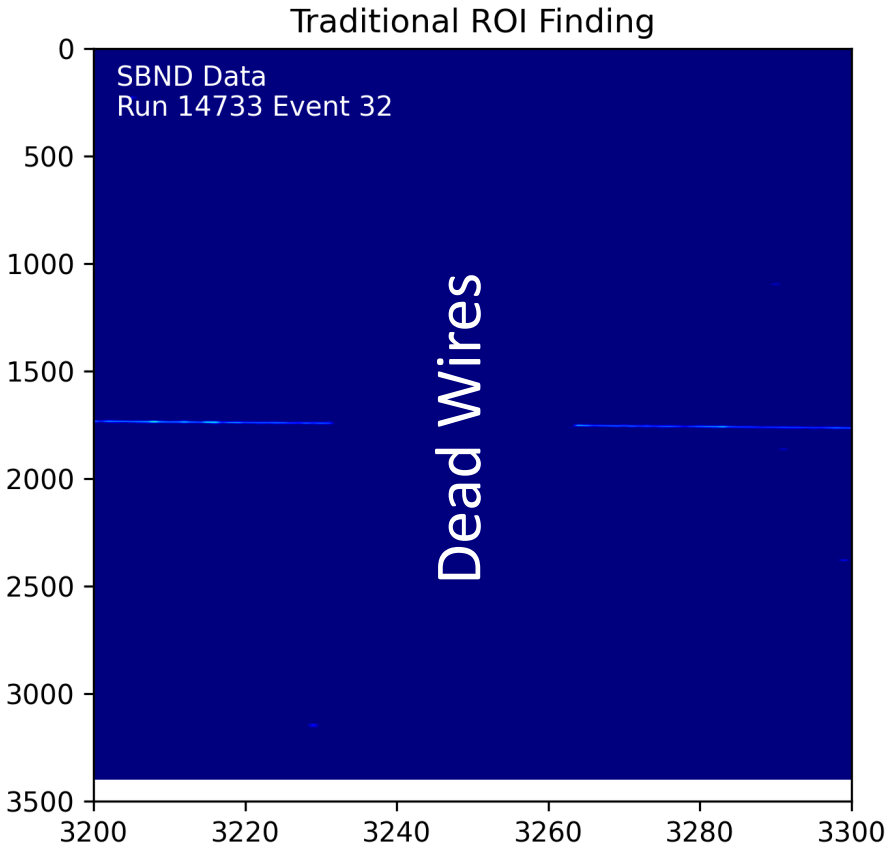


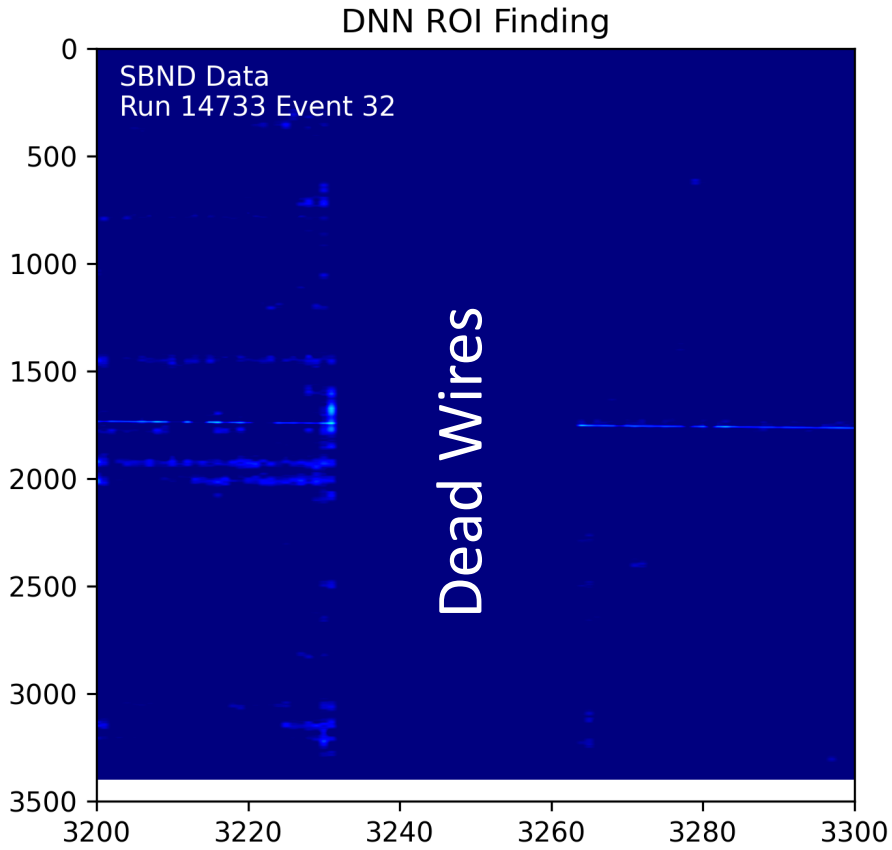
DNN ROI Finding



DNN ROI @ SBND SP - Data

- DNN is confused by dead wires that don't exist in MC



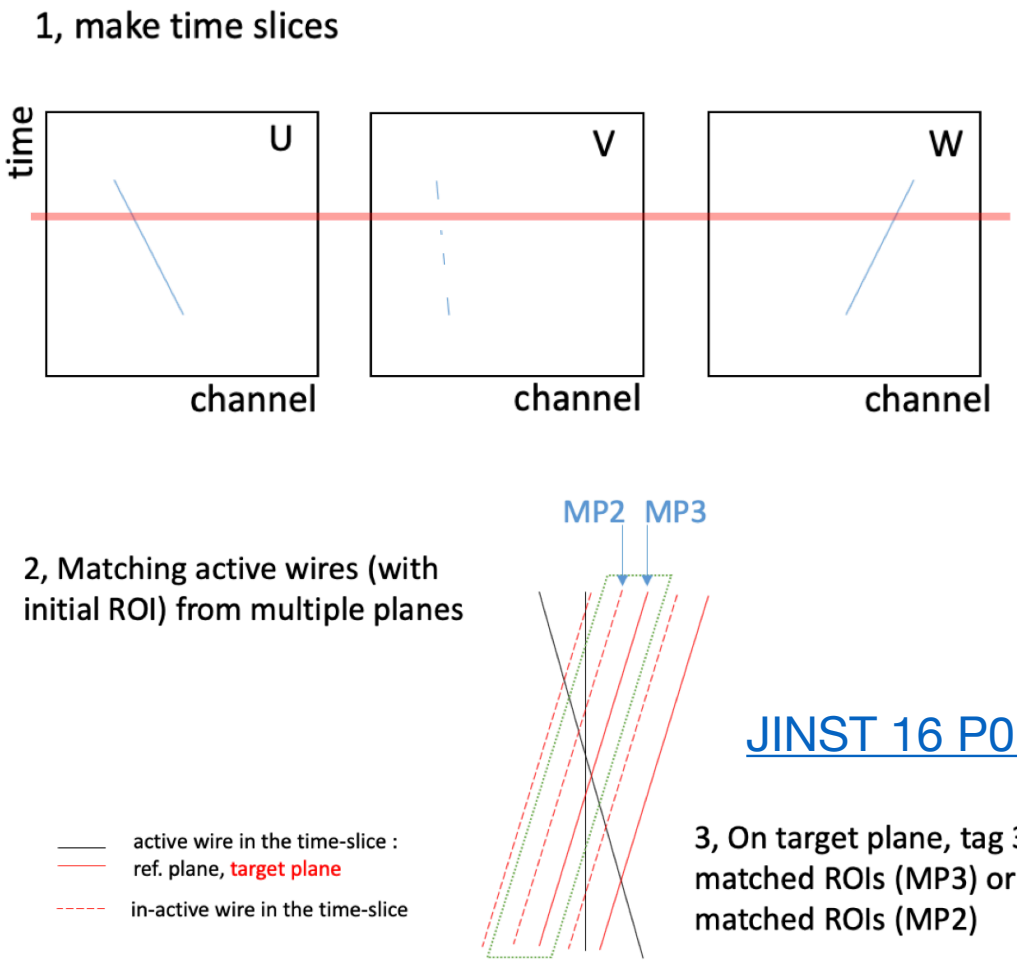


Summary & Outlook

- DNN-based ROI finding looks promising for improving signal processing performance on some corner cases ex. prolonged tracks, busy regions, etc.
- SP using DNN ROI finding is integrated into the SBND workflow
- Remaining questions
  - Is there tradeoff between performance improvement on different corner cases? — Avinay
  - Is the resource usage reasonable for integration into the workflow? — Haiwang, Nate, Gray
  - How to evaluate the performance on data?
  - How to make the method robust to detector variations, MC/data discrepancy?
    - dead wires

Training Samples

- Training images made from simulated neutrino events
  - **target images** is made from setting a threshold on simulated charge deposit
  - **input images** are made from intermediate stages of the traditional signal processing chain
    1. Loose LF filter: preserve prolonged track signals that are washed out my tighter filters
    2. 2-plane match
    3. 3-plane match: multiplane match outputs to inform network of geometric constraints from other planes



JINST 16 P01036