Signal Processing in SBND with a Validated Field Response

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on behalf of the SBND Collaboration

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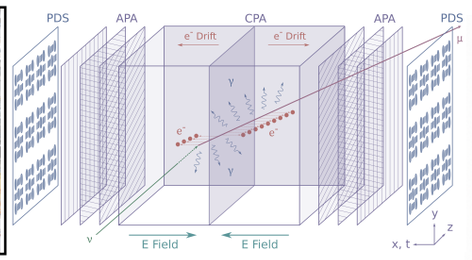
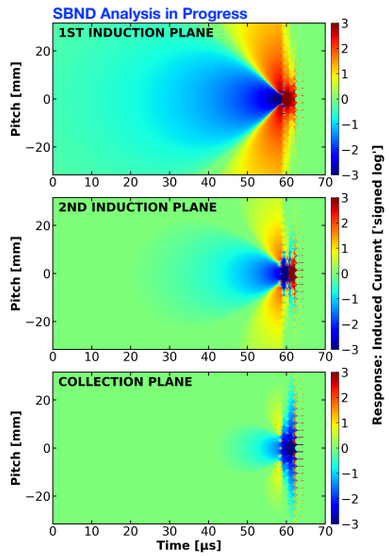
1. SBND Experiment and Detector



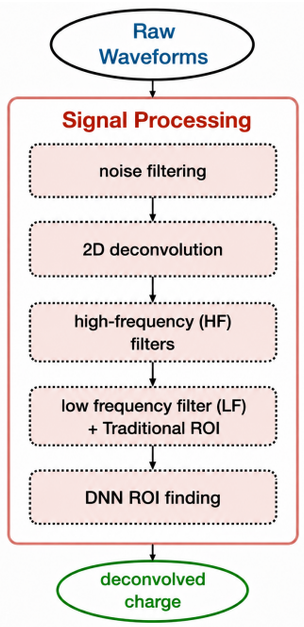
- SBND is a liquid argon time projection chamber (LArTPC) neutrino experiment located 110 m from the Fermilab Booster Neutrino Beam target
- The detector consists of two independent drift regions sharing a common cathode, with each region instrumented by three wire planes
- Charged particles produce scintillation light and ionization electrons that drift to the anode wire planes, inducing signals on the wires
- Signal processing reconstructs the deposited ionization charge from the wire signals
- Accurate signal processing enables particle reconstruction and identification

3. Field Response



- Field response describes the current induced on anode wires by drifting ionization electrons
- Field response is calculated using GARFIELD simulations
- It is essential for waveform simulation and charge reconstruction

2. Signal Processing



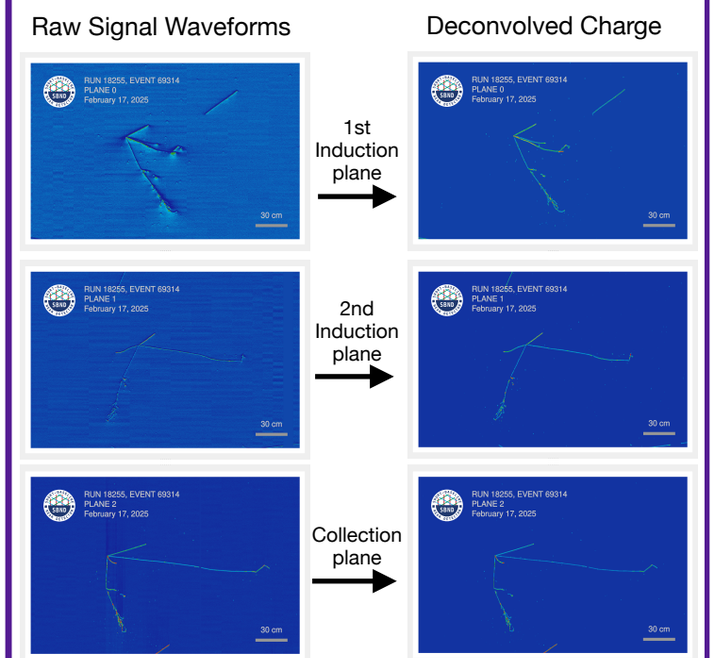
Signal processing reconstructs ionization charge from raw wire waveforms

Raw waveforms are a convolution of ionization charge, field response, and electronics response

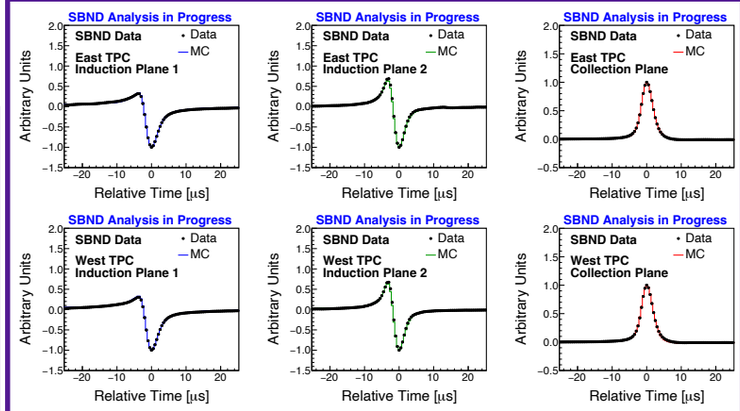
$$S(w,t) = C(w,t) \circledast R(w,t) \circledast E(t)$$

w = wire
t = time

1. Coherent electronic noise is removed
2. Deconvolution corrects for the field and electronics responses
3. Gaussian filtering suppresses high-frequency noise
4. Thresholding identifies Regions of Interest (ROIs) (traditional ROI finding)
5. A DNN-based ROI finder improves showers, extended tracks, and near-perpendicular tracks
6. Deconvolution reconstructs the ionization charge

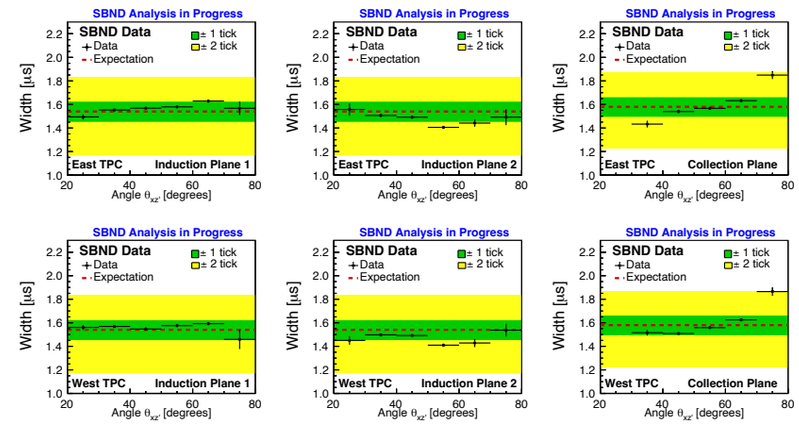


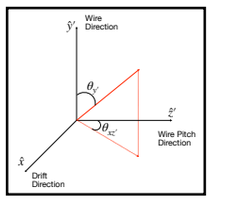
4. Data and MC Signal Waveforms



Cosmic-ray muon waveforms in data and simulation show good agreement across all TPC wire planes, validating the field-response model

5. Results and Conclusions





- Data waveforms are deconvolved with the corresponding simulated waveforms to test the field-response model
- The deconvolved charge width is expected to match the Gaussian filter width
- The charge width is measured as a function of track angle
- **The SBND field-response model is validated to within 1–2 time ticks, corresponding to 0.5–1.0 μs, across all wire planes and track angles**

Acknowledgement

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