Recent Progress on Wire-Cell Tomographic Event Reconstruction for LArTPCs

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Abstract: Event reconstruction is one of the most challenging tasks in analyzing the data from current and future massive liquid argon time projection chambers (LArTPCs) and its performance is critical to achieve physics goals. A novel tomographic event reconstruction method, Wire-Cell, is under development and applied in MicroBooNE data. In this poster, we will describe the principle of Wire-Cell tomographic event reconstruction, which incorporates the time, charge, geometry, and sparsity, connectivity, information to reduce the ambiguity from wire readout and reconstructs the 3D image of ionization electrons independent of topology.

Tomographic nature of the LArTPC
- **Time**: when ionization electrons arrive at the anode wire planes [Tomography cross section]
- **Charge**: how many ionization electrons along each wire [Tomography radiograph]
  - Noise filtering [1], robust signal processing [2, 3], particularly for induction planes
- **Geometry**: which wire is hit by ionization electrons [Tomography 1D projective view]
  - Wire readout ambiguity: 1D projective position for each wire plane
  - Anode plane 2D geometry information is absent from \( O(\tau^2) \) to \( O(\tau) \)

3D image of ionization electrons = 1D time + 2D anode plane position
- Three 1D projective views
- Robust time, geometry, and charge
- No topology (pattern recognition) involvement

Principle of Wire-Cell Tomographic Imaging

Realistic Issues & Solutions
Issues (gaps in the detector):
- 10% dead wires in MicroBooNE
- Induction plane inefficient charge extraction for prolonged (large inclination to anode plane) tracks

Solutions:
- [Increase volume efficiency] Imaging in the regions where two (27% volume) or three (70% volume) plane active
- [Bridge gaps] Initial clustering solely based on connectivity + further clustering based on directionality

Bridging of gaps
Key: directionality + distance
Challenge: Huge amounts of 3D space points.

Application with MicroBooNE data & Support:
- A novel tomographic method independent of topology
- The projections of the 3D image are strictly consistent with the original measurements (i.e. solution to the first principle equation)
- Realistic issues, e.g. 10% dead wires, are properly addressed
- Good performance was qualitatively demonstrated by hand scan of thousand events & quantitative evaluation/optimization is ongoing

Explore more in B. Russell’s poster “Towards automated neutrino selection at MicroBooNE using tomographic event reconstruction”

References: