Wire-Cell 3D imaging, clustering, and charge-light matching to select neutrino activities in the MicroBooNE LArTPC

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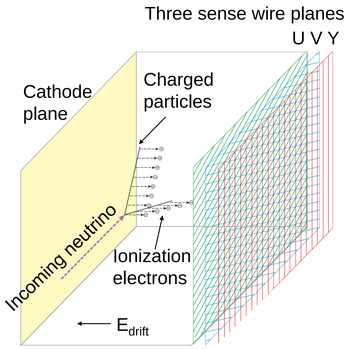
Abstract: An accurate and efficient event reconstruction is an imperative element in realizing the full scientific capability of liquid argon time projection chambers (LArTPCs). The massive LArTPCs in current and future neutrino experiments create a need for new ideas and reconstruction approaches. In this poster, we describe the principles and algorithms of the novel Wire-Cell 3D event reconstruction techniques applicable to LArTPCs with wire readouts, including 3D imaging, clustering of 3D space points, and many-to-many charge light matching. We present their successful applications in MicroBooNE data, as well as a quantitative evaluation of their performance.

3D imaging

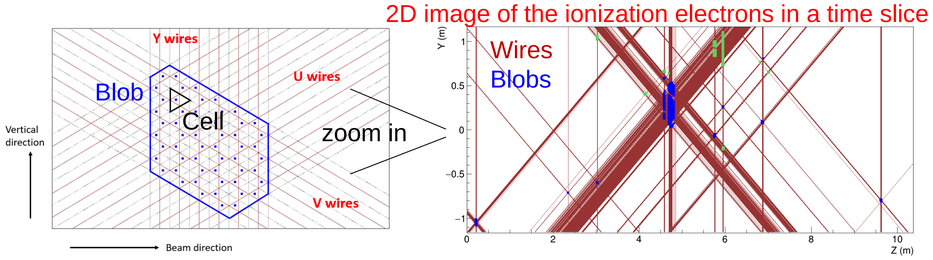


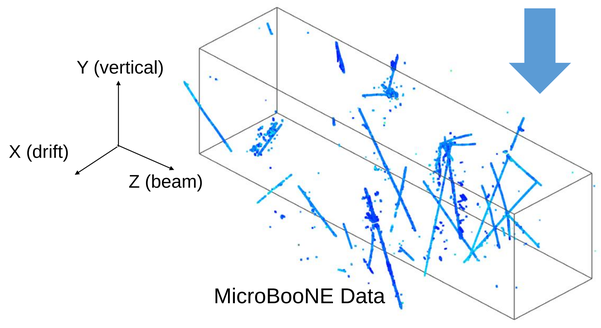
Tomographic nature of the LArTPC
- **Time:** when the ionization electrons arrive at the anode wire plane ***~Tomography cross section***
- **Geometry:** which wires from each wire plane are fired by the ionization electrons **~Tomography 1D projective view**
- **Charge:** how many ionization electrons are measured by the fired wires for each wire plane ***~Tomography radiograph***

3D image of ionization electrons = 1D time + 2D anode plane position

- Compressed sensing (a signal processing technique) to efficiently & rapidly produce the 2D imaging of ionization electrons in a time slice [1]

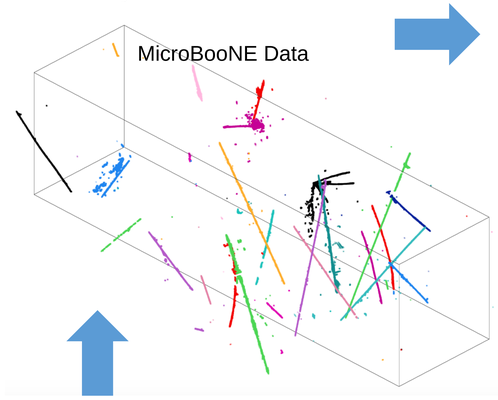
2D image of the ionization electrons in a time slice



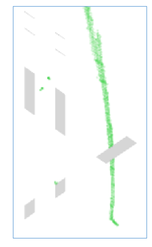


3D clustering

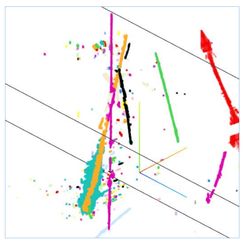
A proper cluster represents a complete TPC object from a cosmic-ray or a neutrino interaction.



Challenges and solutions
- Gaps due to nonfunctional wires, removal of coherent noise, etc. → **Bridge gaps**
- Coincidental overlap → **Separate the clusters**
- Ghost tracks → **De-ghost**



Nonfunctional regions (grey)

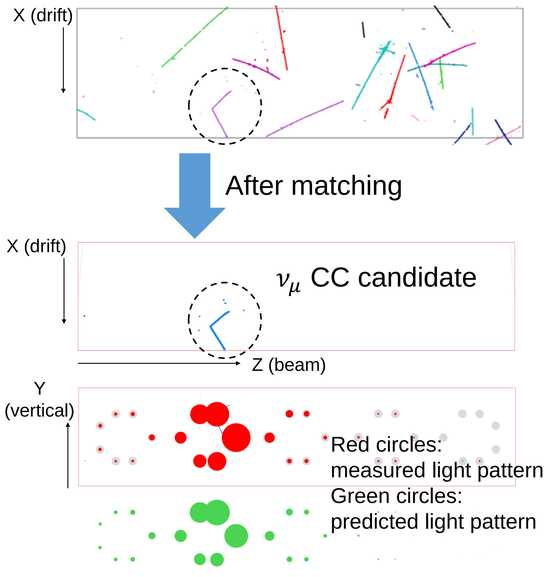


Coincidental overlaps

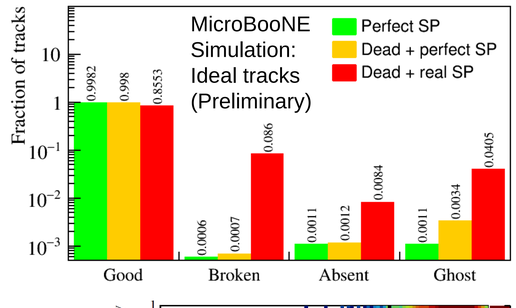
Many-to-many charge-light matching

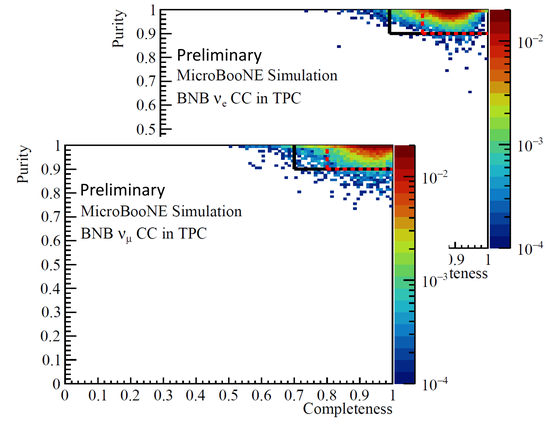
A novel topology agnostic method to identify neutrino candidates and disambiguate neutrino candidate activity from cosmic activity by pairing the 20~30 TPC-clusters to the 40~50 PMT-flashes in an event

Matching procedure:
(1) Hypothesis on matched cluster-flash pairs
(2) Iterative examination of matches
(3) Iterative chi-square fits using the compressed sensing technique



Performance





Conclusion

- Novel Wire-Cell 3D event reconstruction techniques applicable to LArTPCs with wire readouts: 3D imaging, clustering, many-to-many charge-light matching
- High quality 3D image
- Provide a solid foundation to reject the coincident in-beam cosmic-ray muons

Reference: [1] JINST 13, P05032 (2018)
Supporting note: MICROBOONE-NOTE-1083-PUB

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