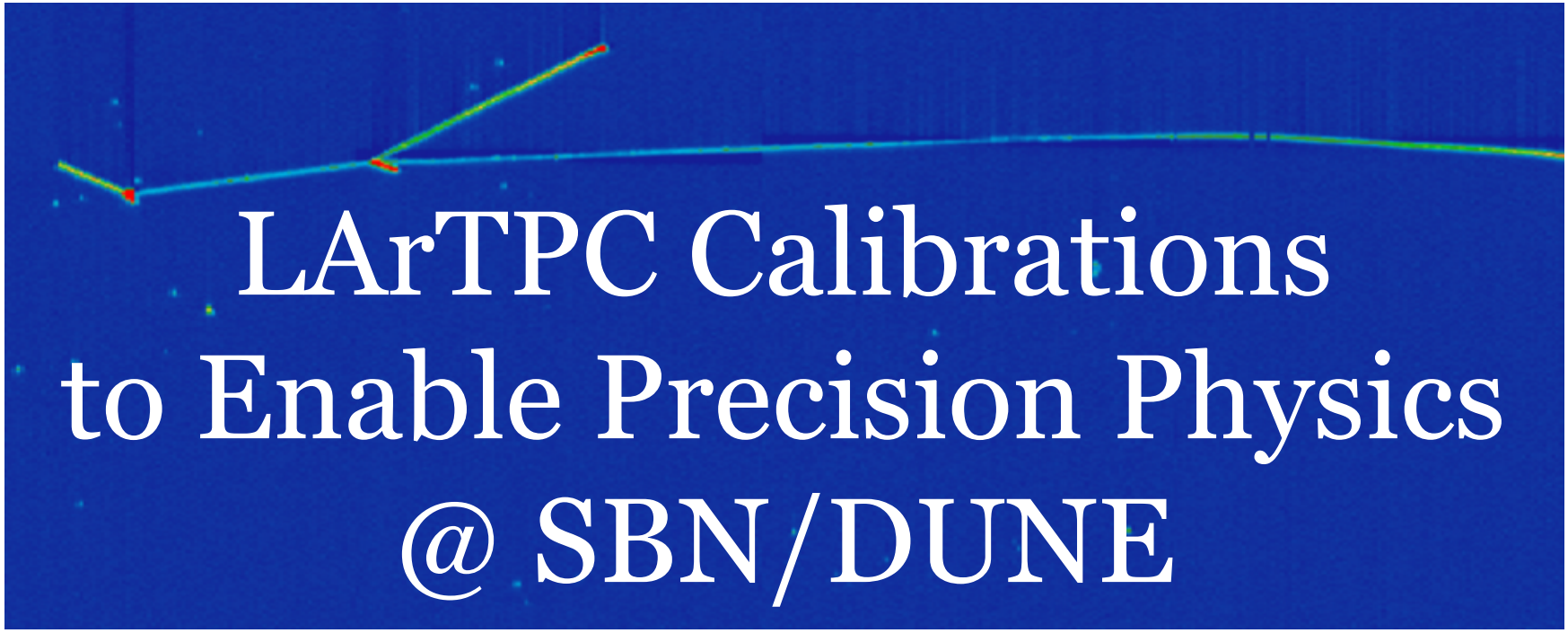

LArTPC Calibrations to Enable Precision Physics @ SBN/DUNE

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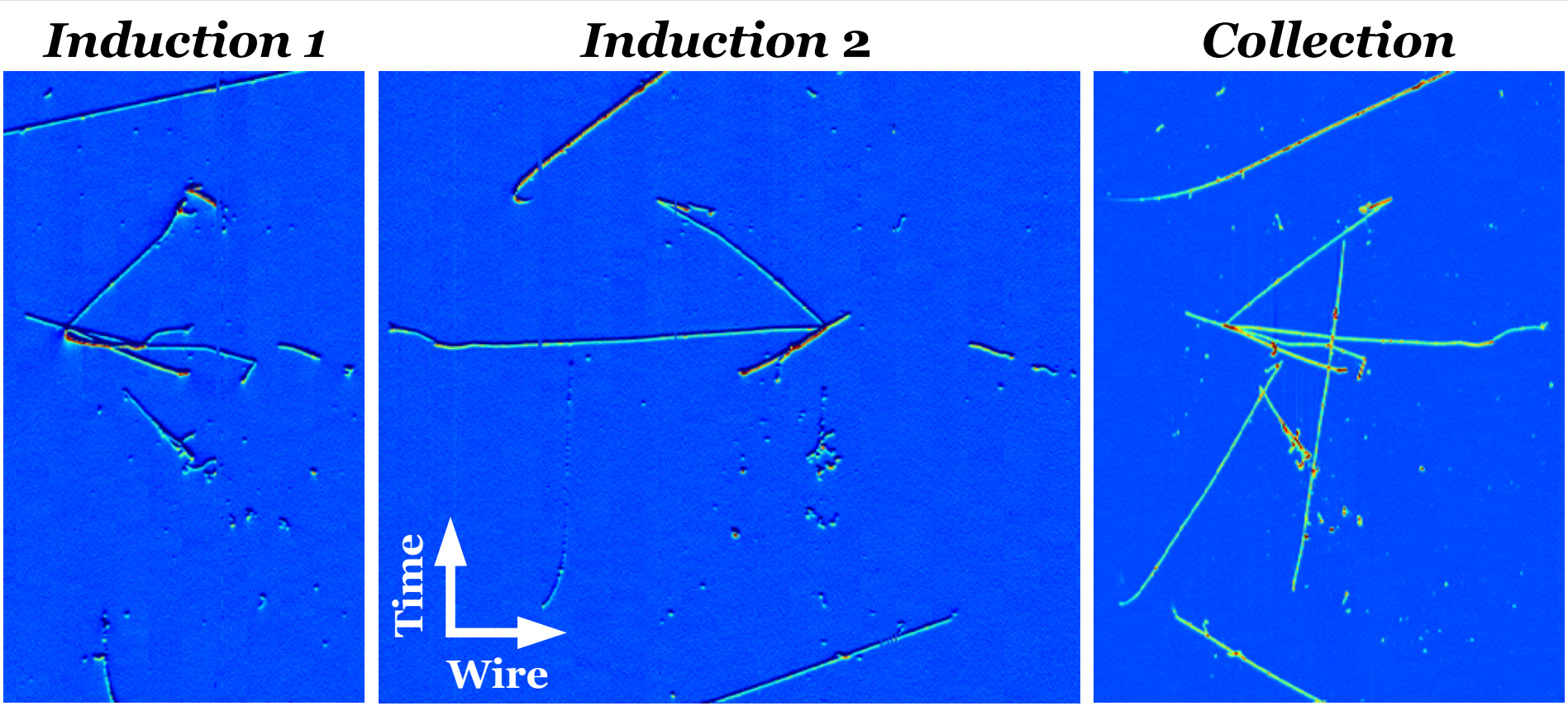
Snowmass 2021 Noble Elements Topical Group Meeting

July 27th, 2020

Introduction

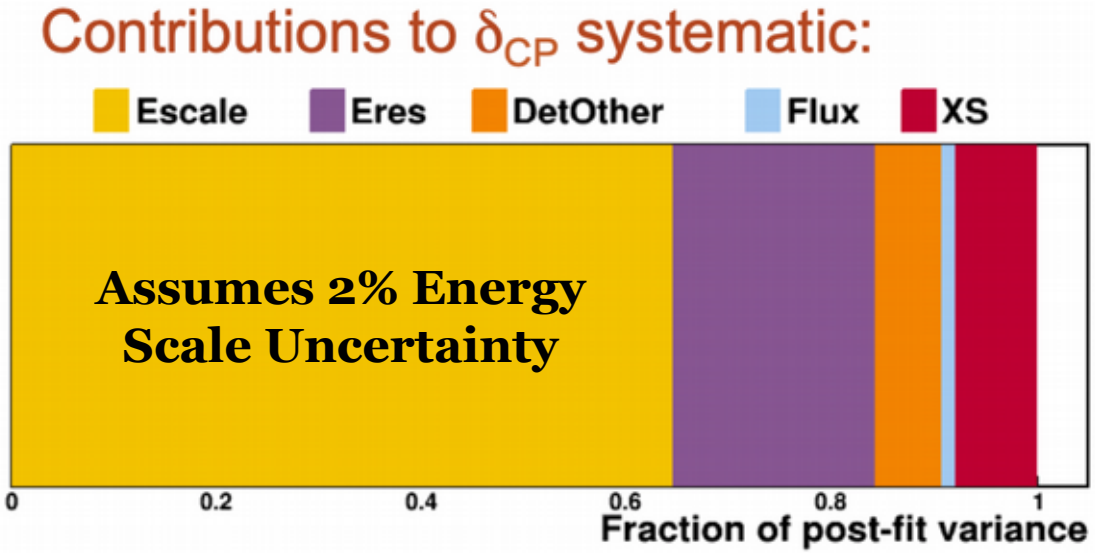
- Two major accelerator neutrino experiments on the horizon in the US, which make use of LArTPC detectors:
  - SBN – first half of this decade
    - Sterile neutrino search, cross section measurements for next-generation experiments (e.g. DUNE)
  - DUNE – later this decade, and beyond
    - Precision measurement of PMNS matrix parameters (including δ_{CP}), neutrino mass ordering, supernova/solar neutrinos, BSM physics (e.g. baryon number violation)
- These experiments make use of the excellent imaging capabilities of the **LArTPC detector**, and so also requires **precision calibration** – not easy!
  - Mooney research group highly involved in this effort

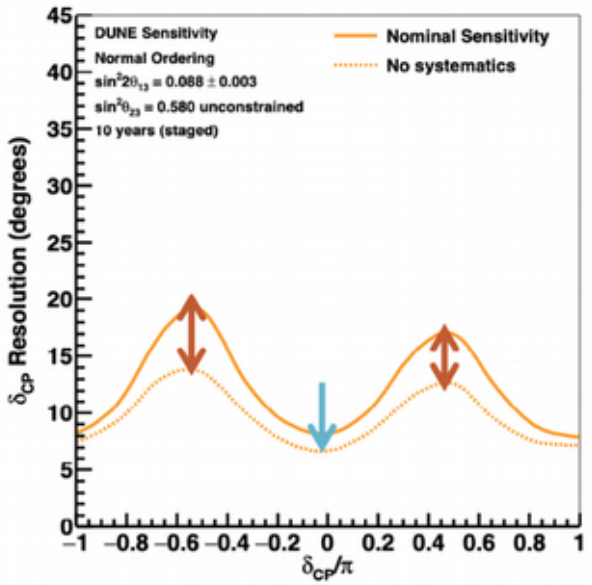
Imaging at LArTPCs



- First beam data events at ProtoDUNE-SP show promising imaging capabilities: arXiv:2007.06722 (submitting to JINST)
- Many MicroBooNE results showcasing new techniques for LArTPC calibrations, detector physics measurements

LArTPC Calibration Needs

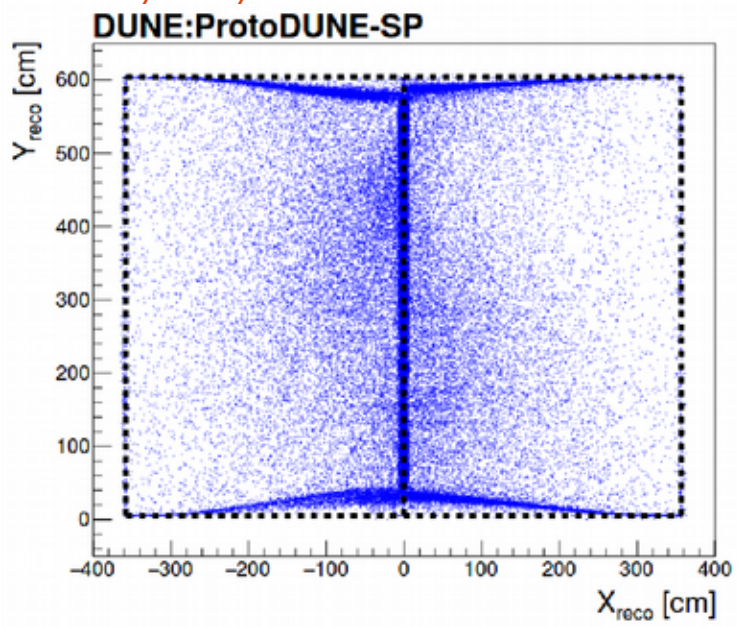




- Studies ongoing at DUNE demonstrate need for precise energy calibrations at all energy scales
  - GeV scale: require **few percent** energy scale/resolution knowledge for PMNS parameter measurements (e.g. δ_{CP})
  - MeV scale: require **5-10%** energy scale/resolution knowledge for e.g. supernova neutrino measurements
- These are challenging requirements – hard work ahead!

Challenges, New Ideas

arXiv:2007.06722



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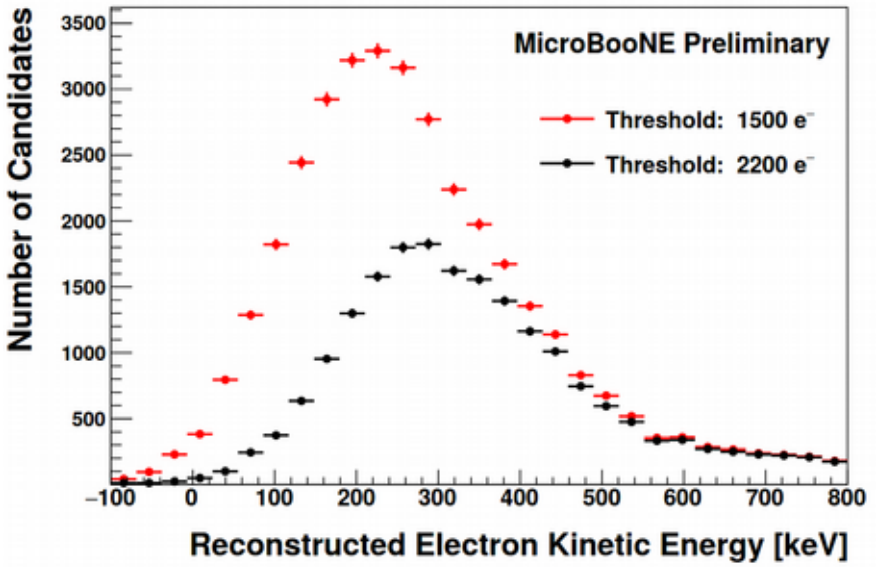

- Some detector effects are very large in LArTPC detectors and require significant calibration efforts
  - In particular SCE (space charge effects) at near-surface LArTPC detectors (ProtoDUNEs, SBN) – can be challenging to deal with!
- New ideas for calibrations of large underground detectors
  - ^{39}Ar beta decays may be critical at DUNE far detector (1 Bq/kg)

Looking Ahead

- "With great power comes great responsibility"
  - Precision physics enabled by precision calibration of precision imaging detectors
- Needs for upcoming LArTPC accelerator neutrino experiments are demanding, but much we can do:
  - **Prepare** – understand if we need dedicated detector physics measurements ahead of DUNE, e.g. small R&D setups
  - **Collaborate** – share knowledge/results across disciplines (neutrino, dark matter, neutrinoless double beta decay, etc.); good example of this is **NEST** (Mooney research group is involved)
- Currently preparing Snowmass LOI summarizing calibration thoughts/needs for DUNE/SBN
  - Let me know if you want to collaborate!