MANCHESTER 1824
The University of Manchester

μBooNE

Measurement of the $\nu_e + \bar{\nu}_e$ Charged Current Inclusive Cross Section on Argon in MicroBooNE

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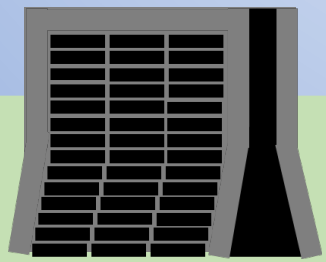
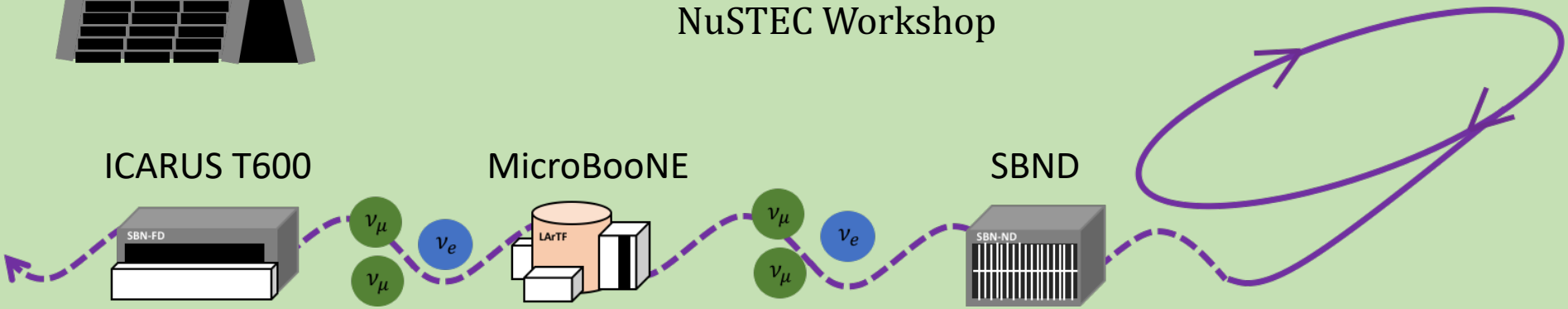
on behalf of the MicroBooNE Collaboration

15 March 2021

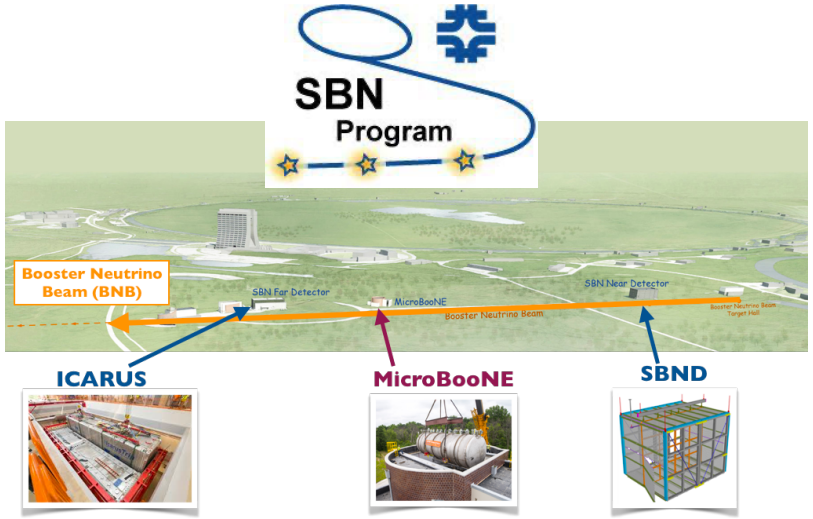


New Directions in Neutrino-Nucleus Scattering (NDNN)
NuSTEC Workshop



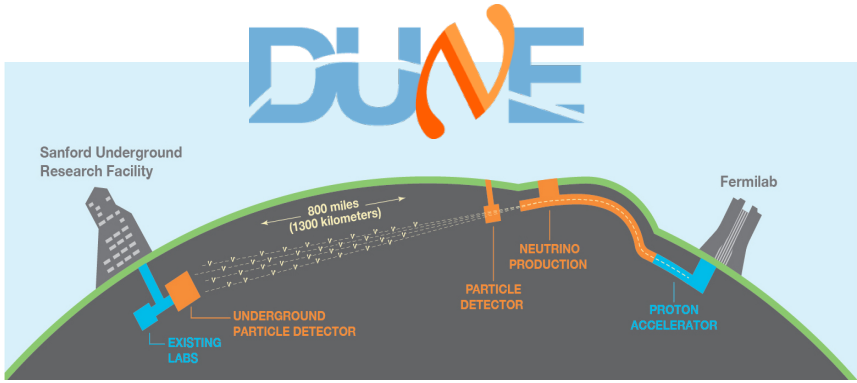
Importance of the ν_e-Ar cross section

- MicroBooNE + SBN Program + **DUNE**
  - ↠ Employ Liquid Argon Time Projection Chambers (**LArTPC**s)



arXiv:1503.01520 [physics.ins-det]

- Primary signal channel for these experiments is ν_e – Ar CC interactions



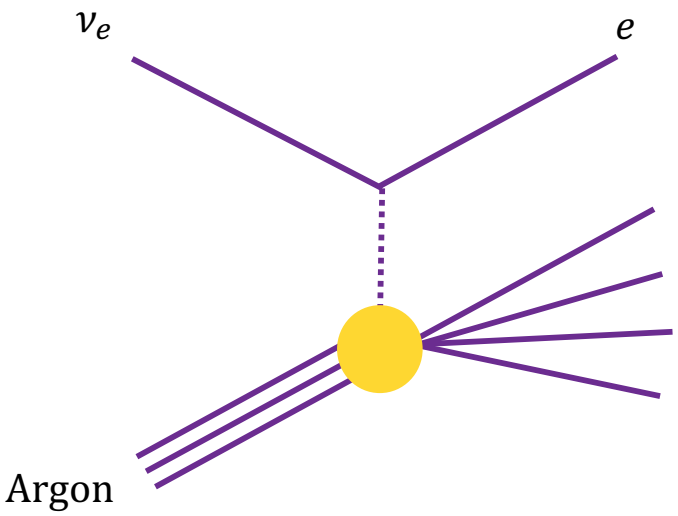
arXiv:2002.03005 [hep-ex]

Building a Picture of ν_e Interactions

ArgoNeuT is the first measurement made on argon

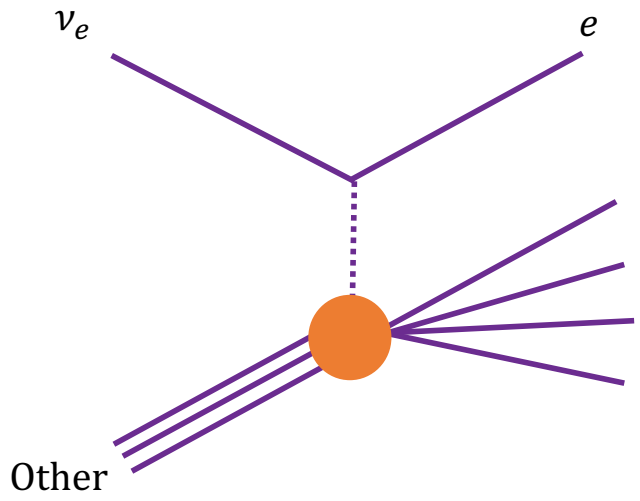
- Sample of 13 selected events

Phys. Rev. D 102, 011101(R) (2020)



A handful of measurements on other nuclei in the hundred MeV to GeV range

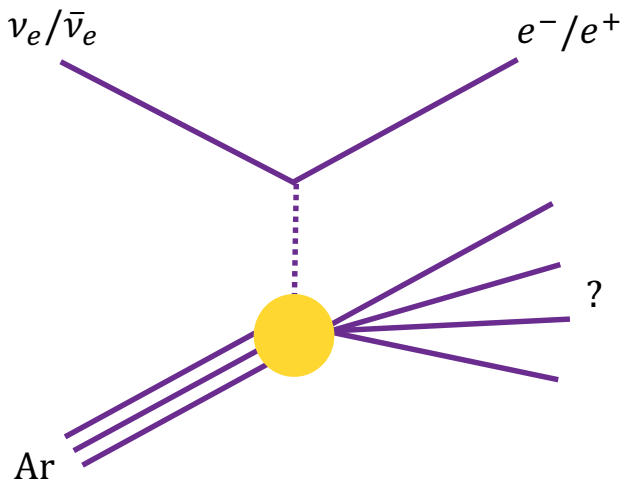
- Gargamelle — Nuclear Physics B 133, 205 – 219 (1978)
- T2K — Phys. Rev. Lett. 113, 241803 (2014); Phys. Rev. D **91**, 112010 (2015); *J. High Energ. Phys.* **2020**, 114 (2020)
- MINERνA — Phys. Rev. Lett. 116, 081802 (2016)

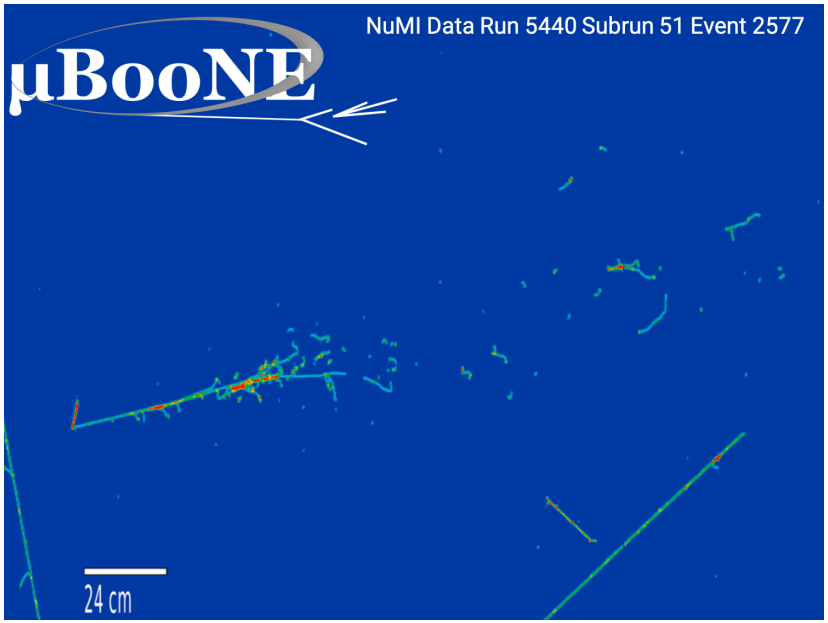


What are we measuring?

- Total $\nu_e + \bar{\nu}_e$ Charged Current (CC) inclusive cross section

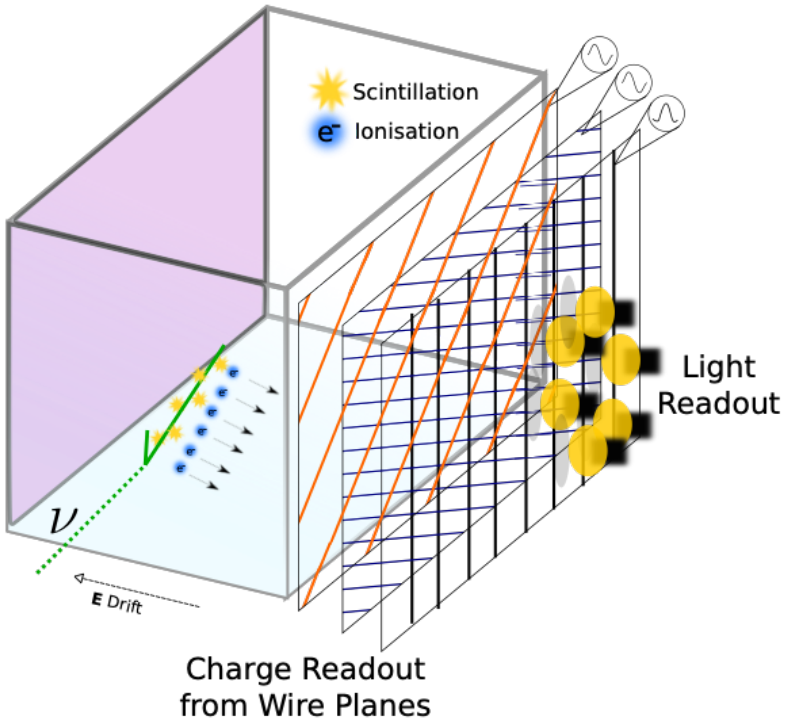
- Signature: the neutrino event contains at least one electron-like shower
  - No requirements on the presence (or absence) of any additional particle
  - Do not differentiate between ν_e and $\bar{\nu}_e$





Inclusive channel is the most straightforward channel to compare to predictions

MicroBooNE

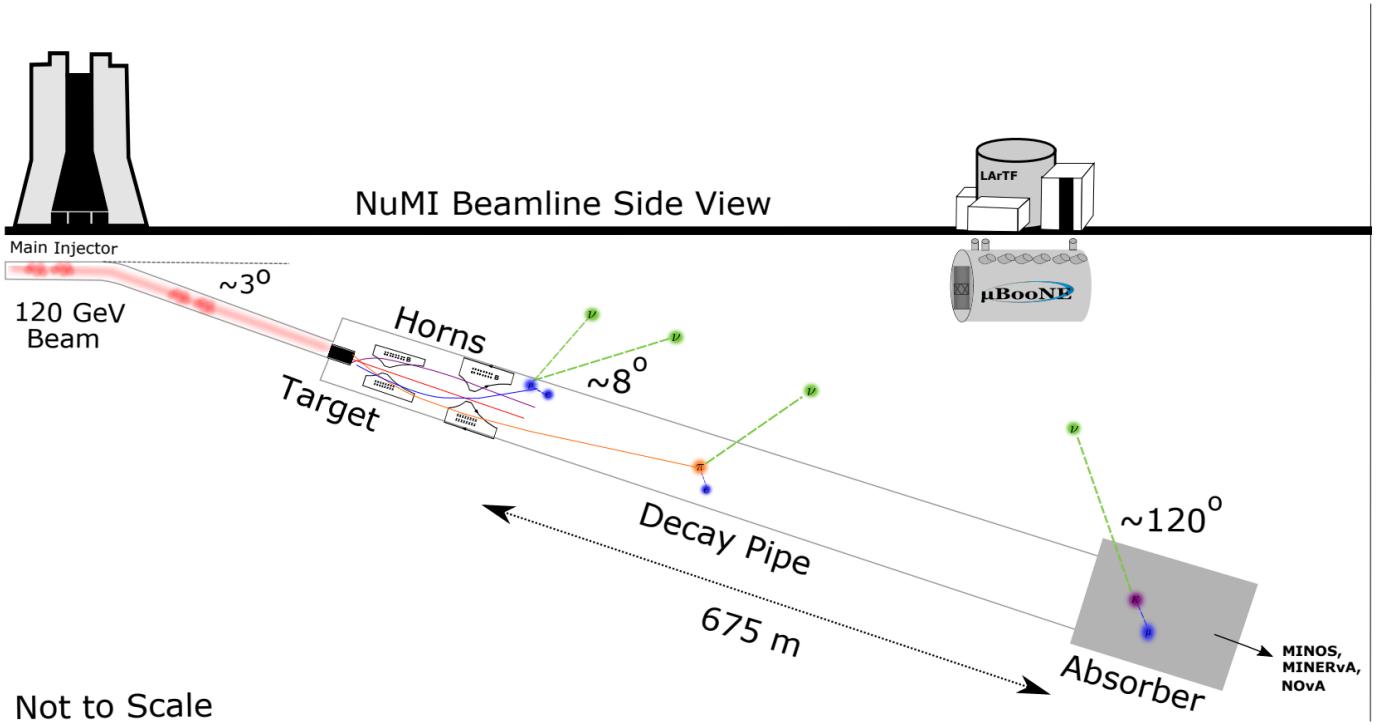


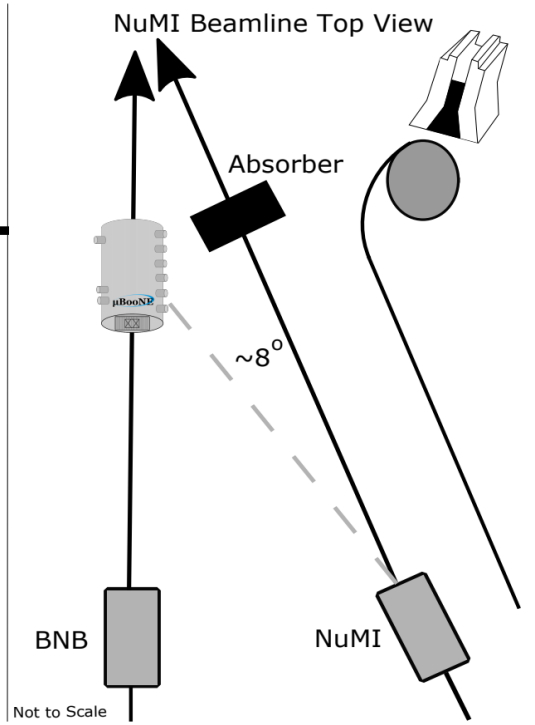
- Measurement is performed using the MicroBooNE LArTPC

- Features of a LArTPC detector:
  - Precise calorimetry
  - 4π acceptance
  - Low detection thresholds

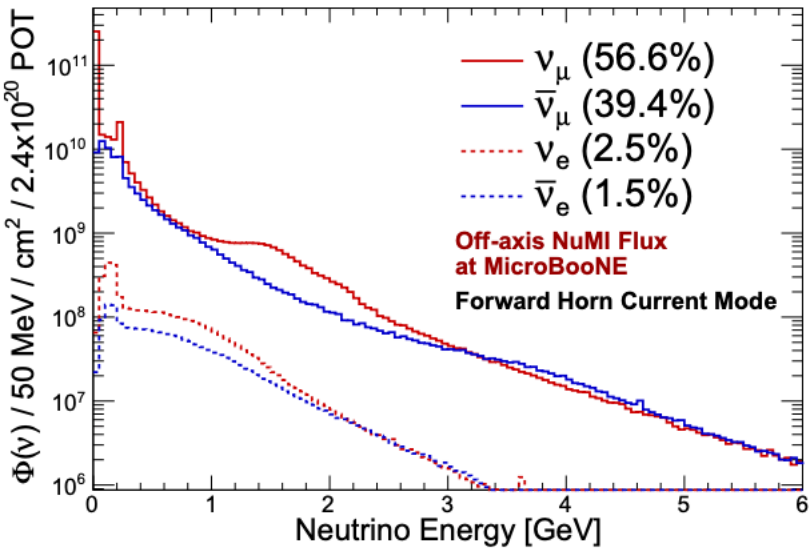
The NuMI Beam

- 120 GeV proton beam
- Off-axis to MicroBooNE
- Majority of selected neutrinos originate from target direction

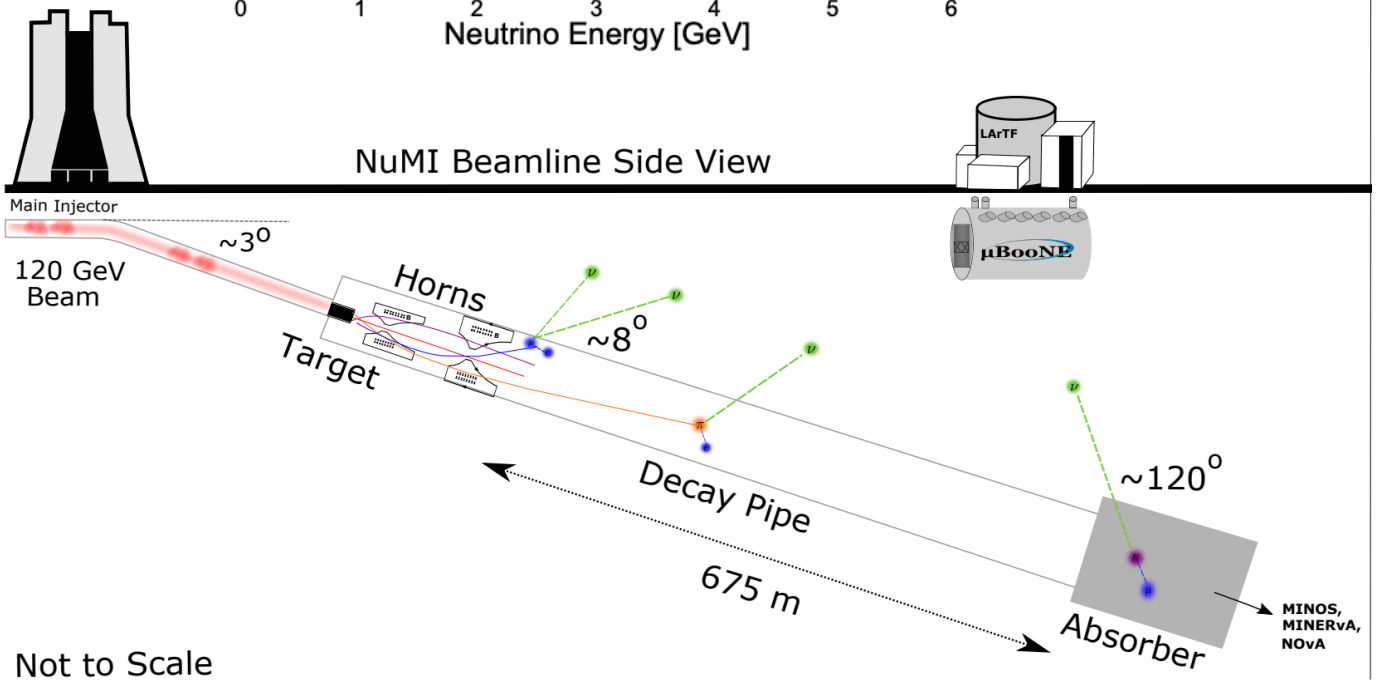


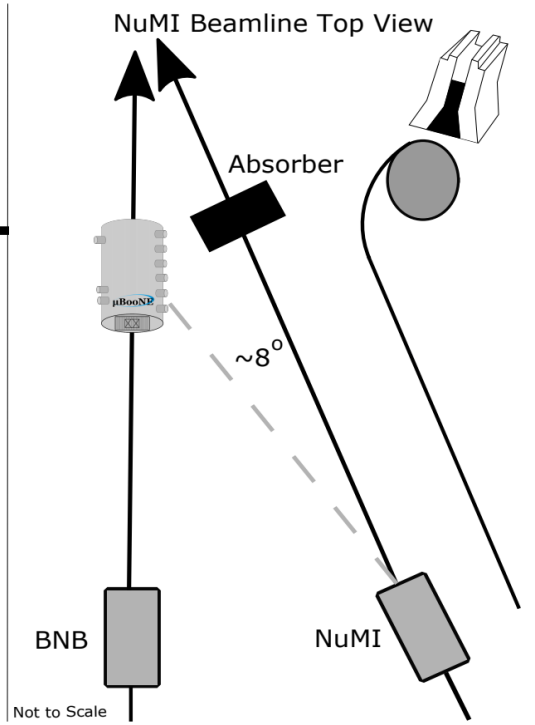


The NuMI Beam

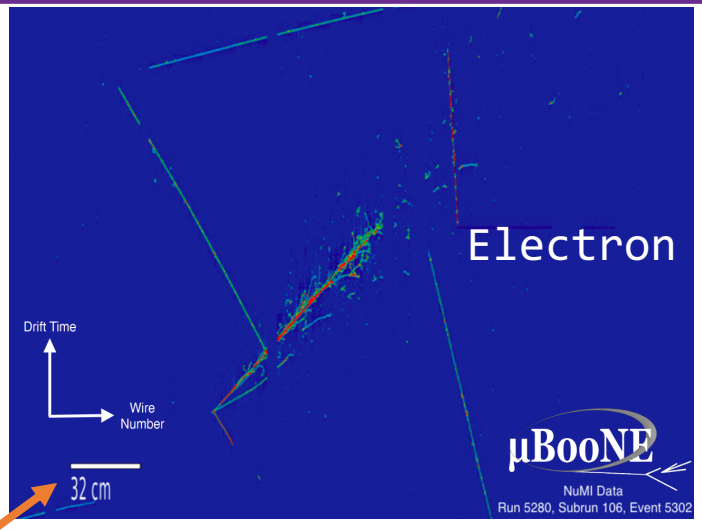


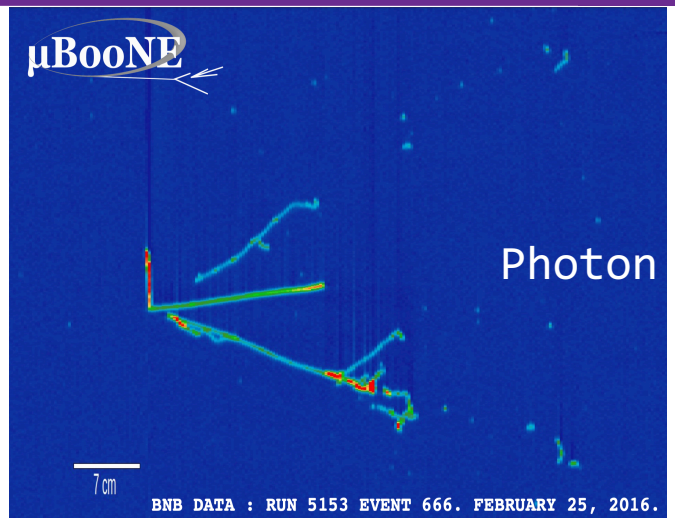
- Flux has a significant fraction of electron neutrinos
- $< E_{\nu_e+\bar{\nu}_e} > \sim 905$ MeV
  - ⇥ $E_{\nu_e+\bar{\nu}_e} > 250$ MeV





Electron-Photon Separation



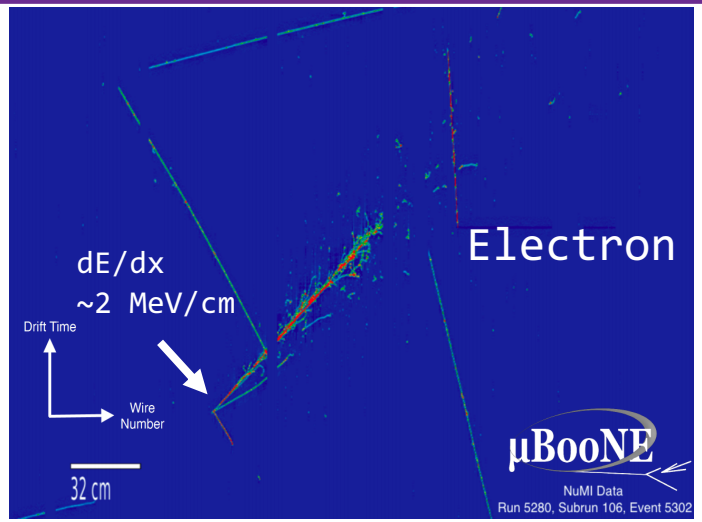


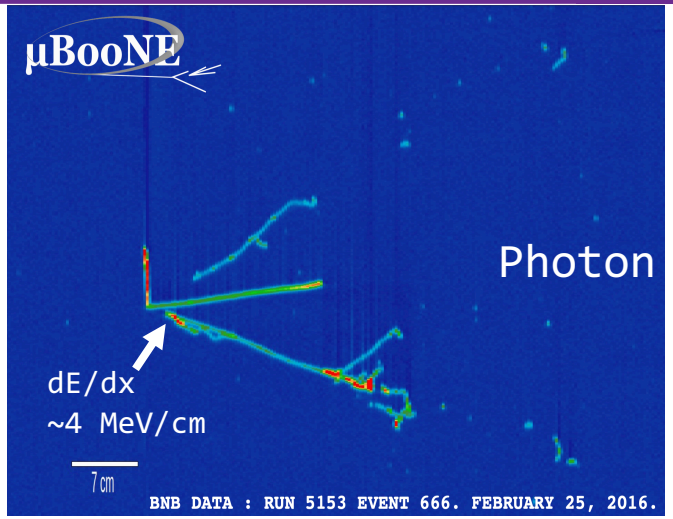
NuMI beam direction from target

- Key backgrounds in this analysis are NC π^0 and ν_μ CC π^0

- Classify the electron-induced shower as the shower with most hits: "leading shower"
  - ⇥ Apply requirements e.g. distance to vertex and dE/dx on this shower to identify if it is electron-like or photon-like

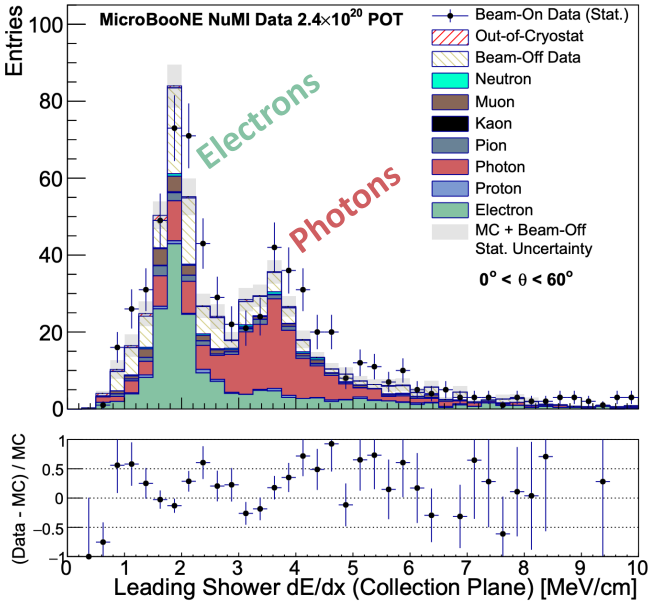
Electron-Photon Separation





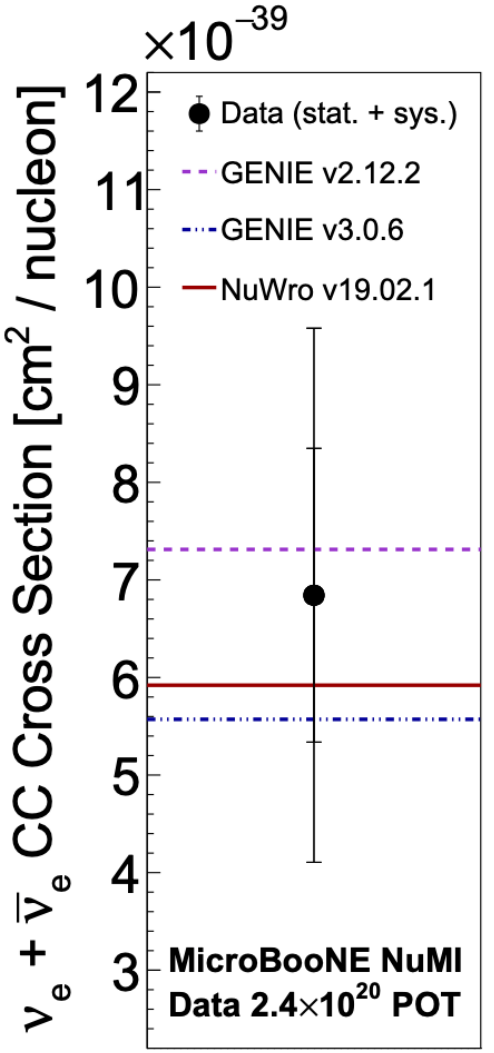
- Demonstrate the **first fully automated discrimination of electron and photon induced EM-showers in a LArTPC**

- Utilize the energy loss per cm (dE/dx):
  - **Electrons**: dE/dx near the start of a EM-shower is ~ 2 MeV/cm
  - **Photons**: dE/dx near the start of a EM-shower is ~ 4 MeV/cm



$\nu_e + \bar{\nu}_e$ Cross Section Measurement

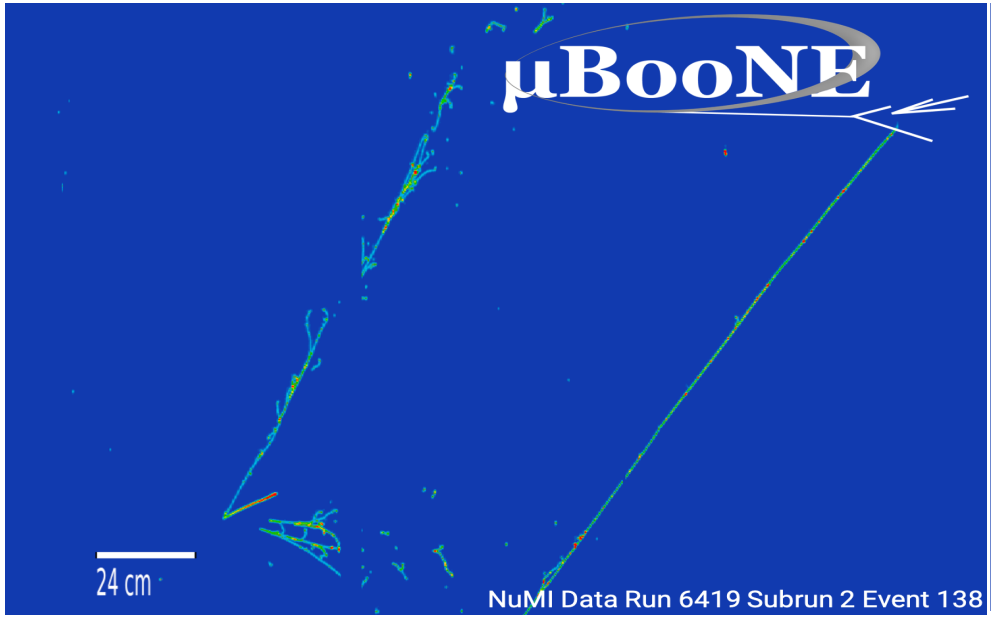
- First $\nu_e + \bar{\nu}_e$ measurement using the NuMI beam from MicroBooNE
  - ↠ 214 selected events
- Final selection purity of 39% and efficiency 9%
- Total cross section is in agreement with the GENIE v2, GENIE v3 and NuWro generators

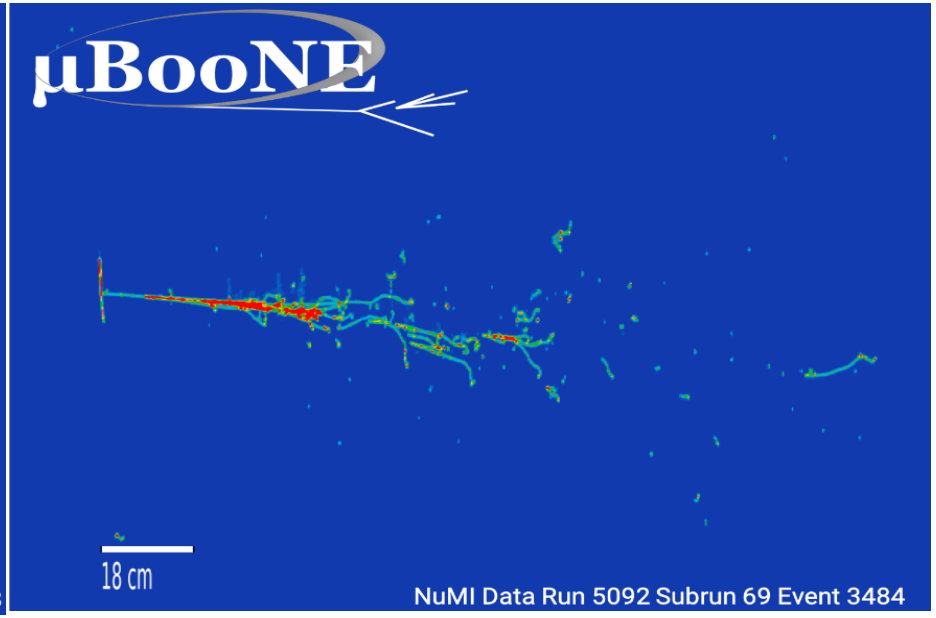


[arXiv:2101.04228]

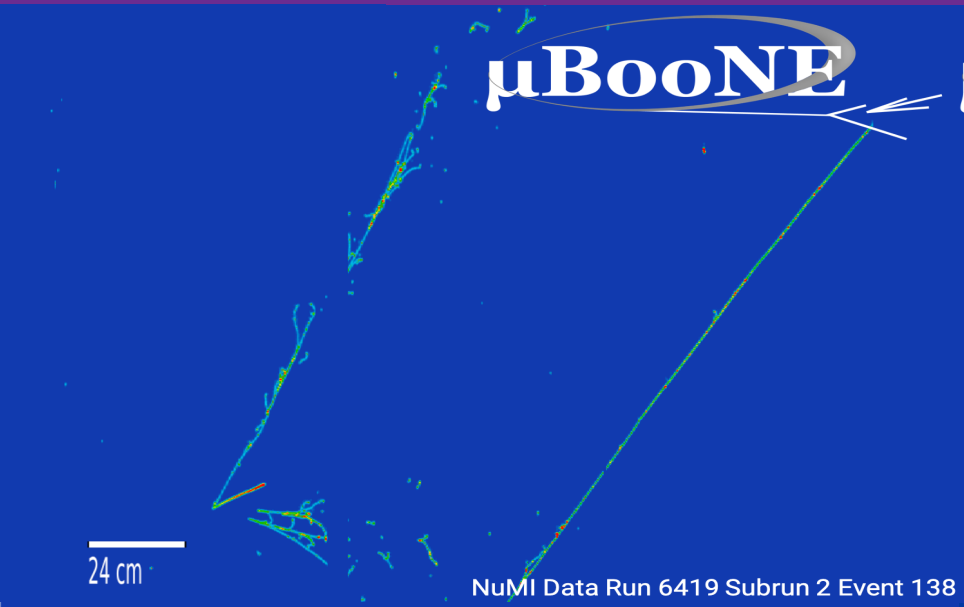
Next Generation of Analysis Soon!

- Next generation of analysis in progress using improvements to simulation
  - Significantly reduced cosmic backgrounds (largest contribution in this analysis)
  - Reduced uncertainties, improved efficiency
  - Coming soon: differential cross section as a function of the outgoing lepton energy and angle!

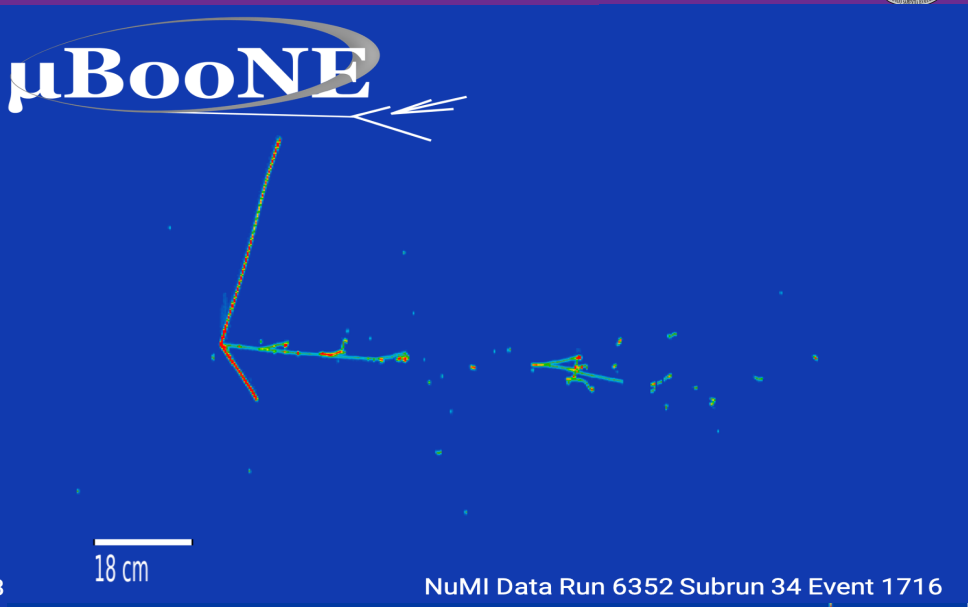




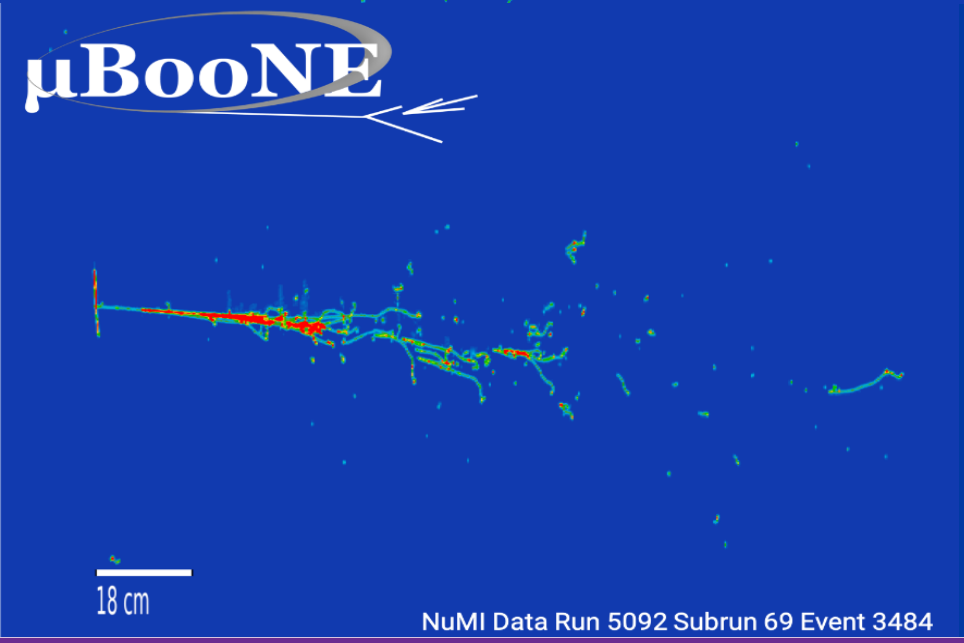
Thanks for Listening!



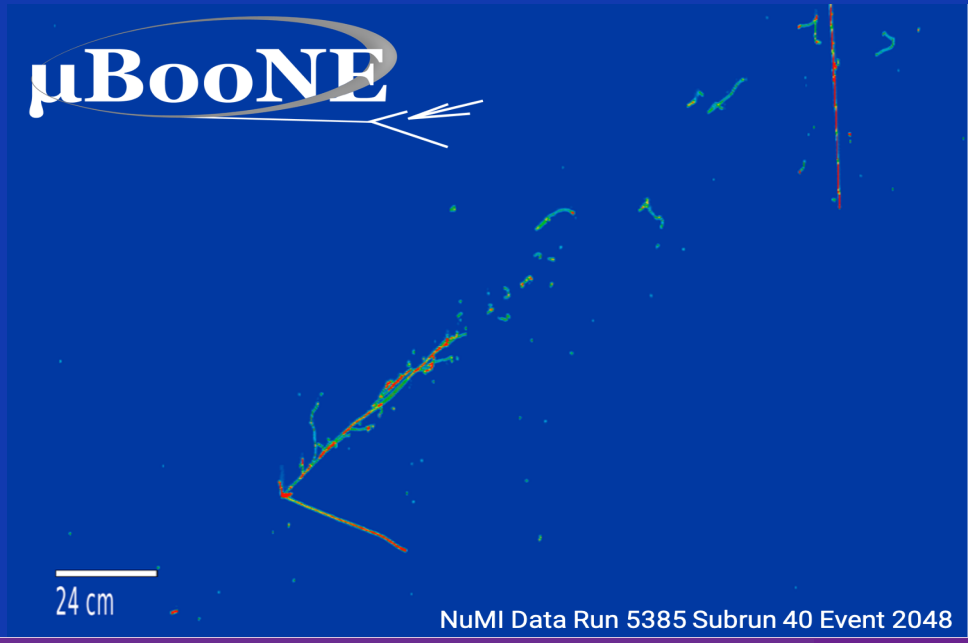
NuMI Data Run 6419 Subrun 2 Event 138



NuMI Data Run 6352 Subrun 34 Event 1716



NuMI Data Run 5092 Subrun 69 Event 3484



NuMI Data Run 5385 Subrun 40 Event 2048