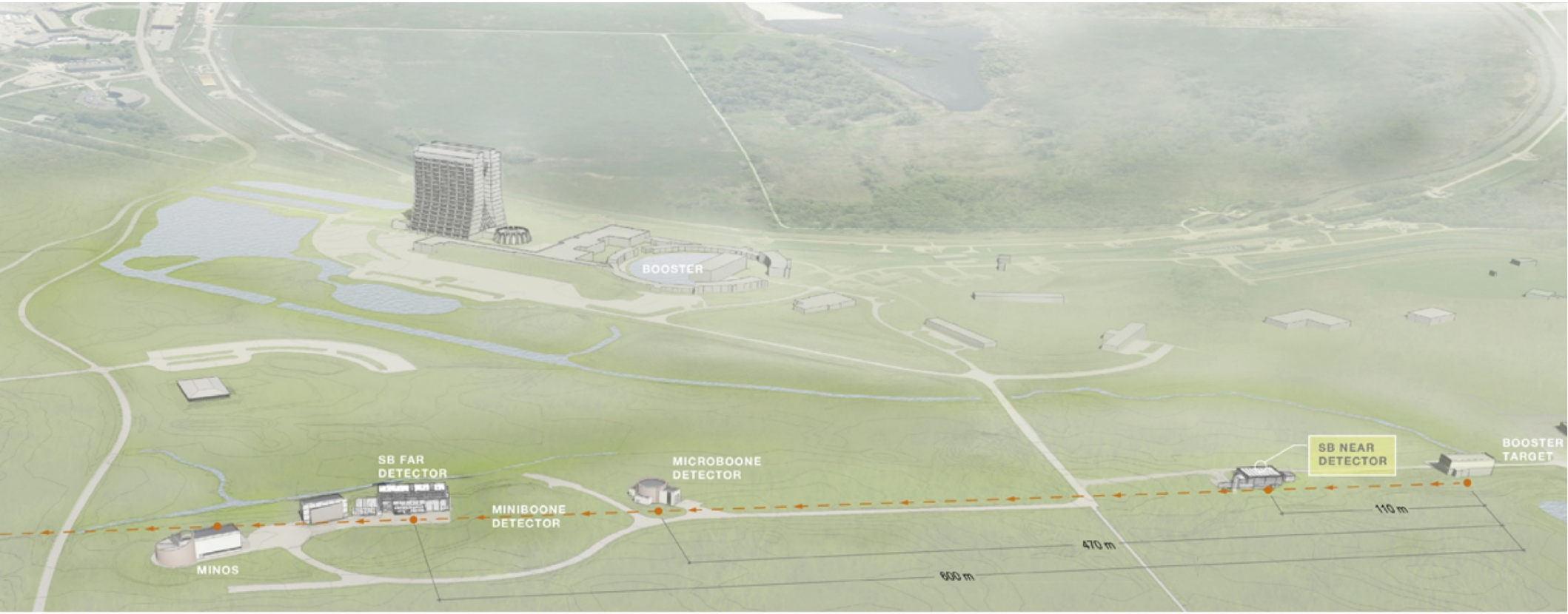


SBND: Neutrino Interactions at Fermilab's Short Baseline Near Detector

Corey Adams, Yale University

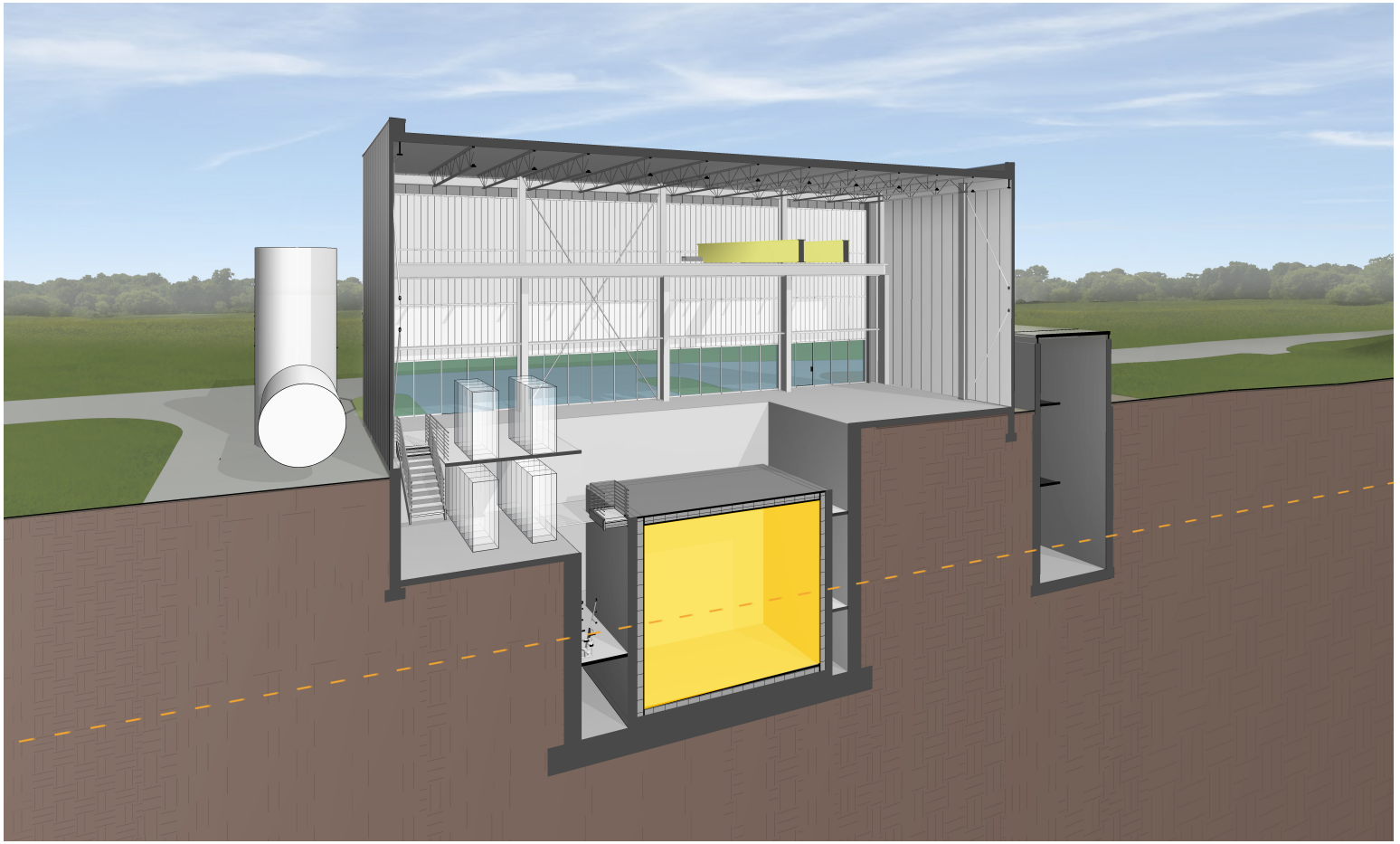
SBND in the SBN-Program

The Short Baseline Program offers a broad yet precise venue to resolve outstanding short baseline oscillation anomalies.

Broad: multiple oscillation channels over many orders of magnitude in oscillation parameters.

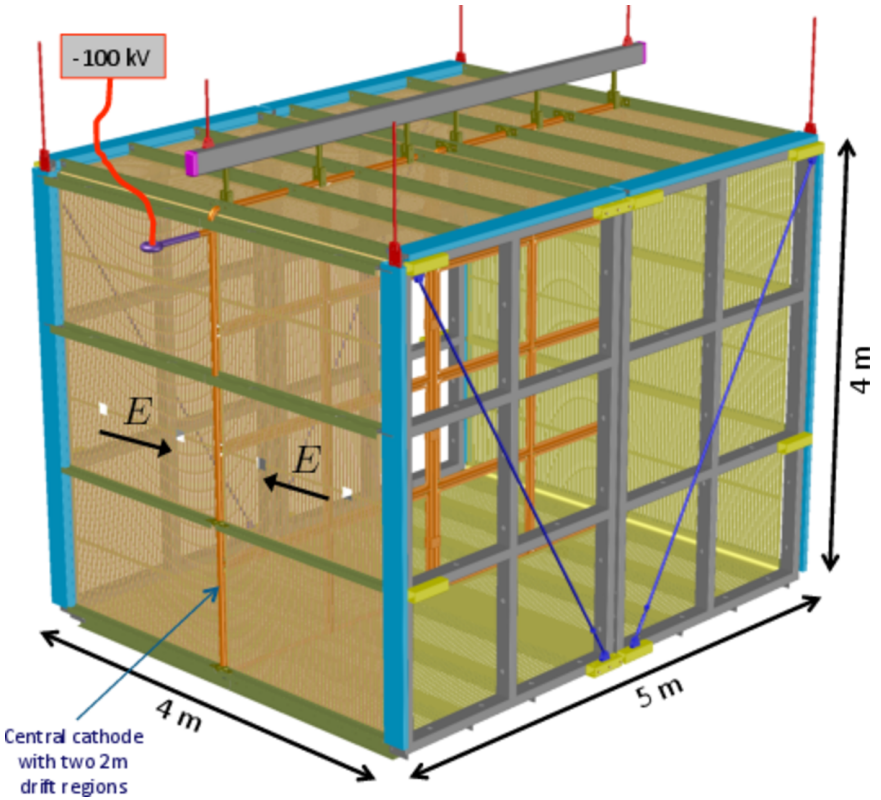
Precise: Three functionally identical detectors along a very well known beam line, many uncertainties cancel.

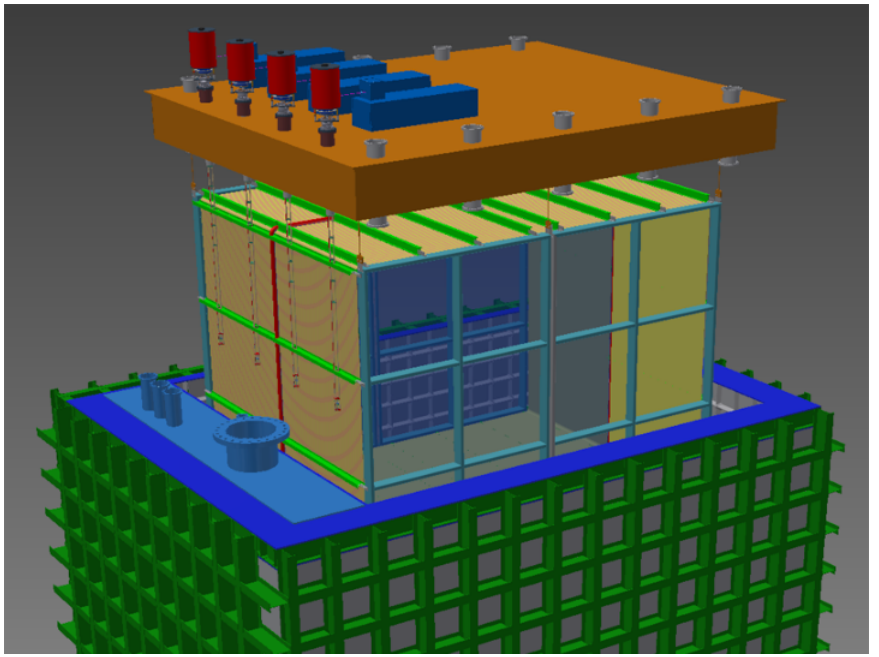
What is SBND?



The first of three (along the beam, not in time!) Liquid Argon Time Projection Chambers along the Booster Neutrino Beam

SBND Design



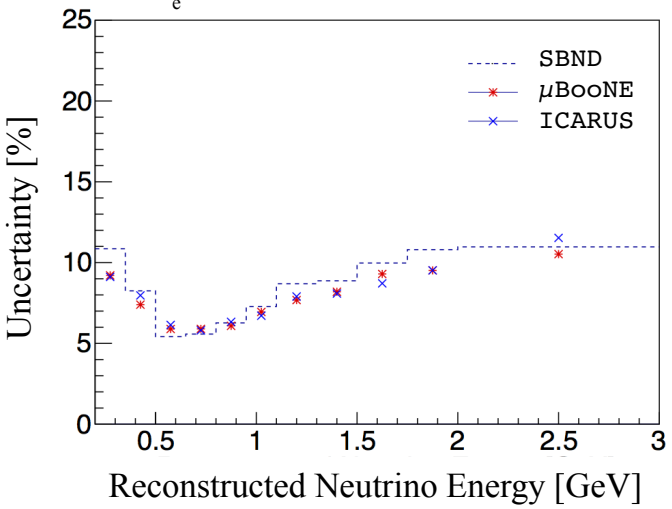


Short Baseline Near Detector

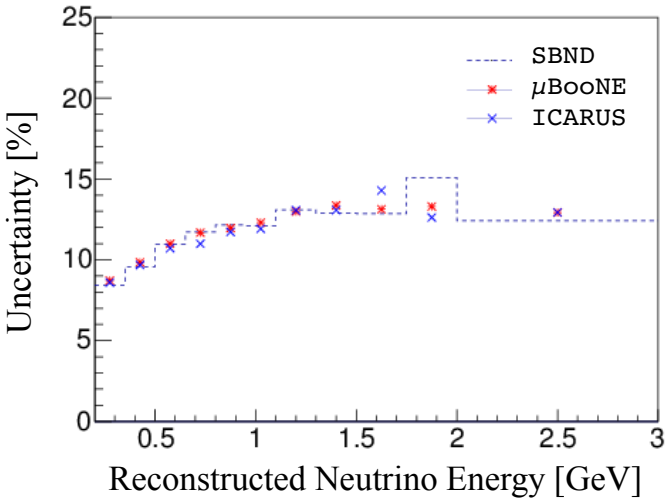
Design is mature, assembly starting soon.

Reducing Uncertainties

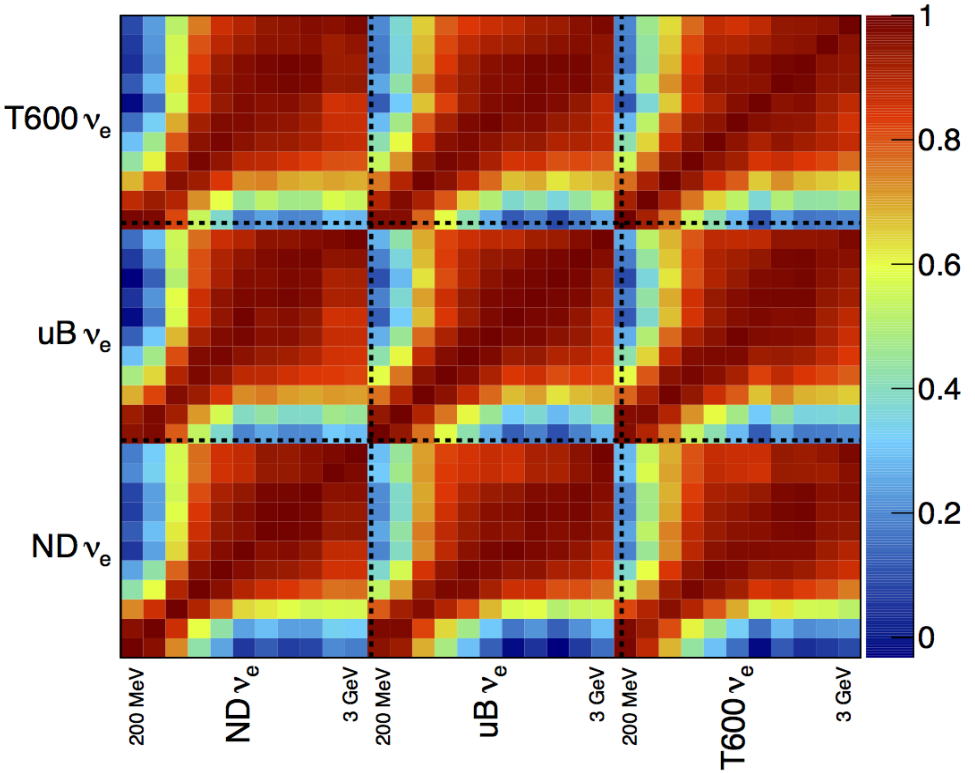
ν_e Flux Fractional Uncertainties



ν_e Cross Section Fractional Uncertainties

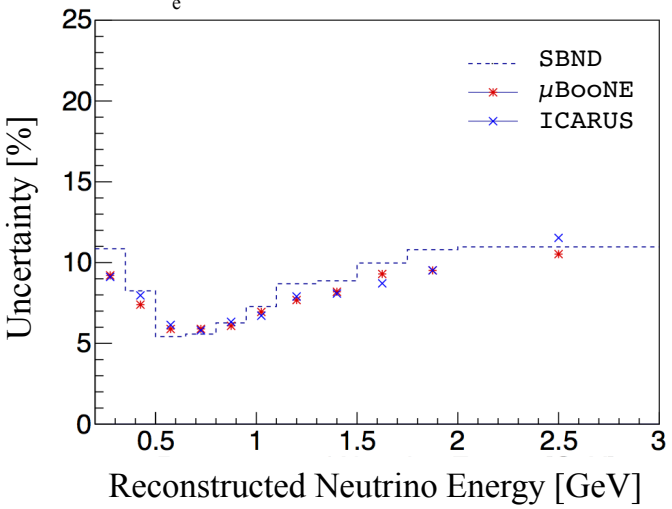


Correlation Matrix

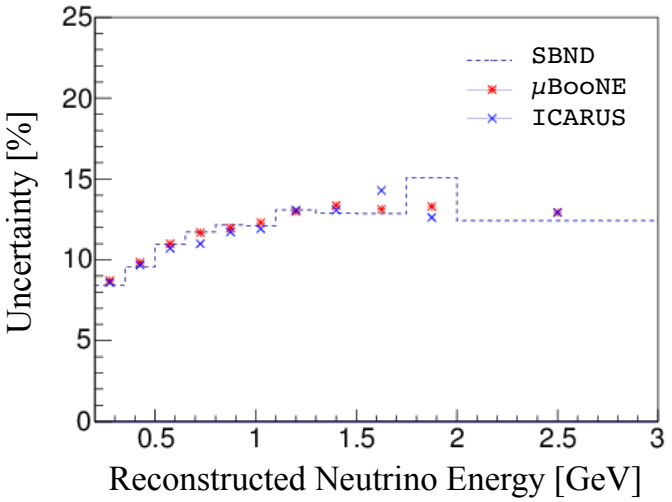


Reducing Uncertainties

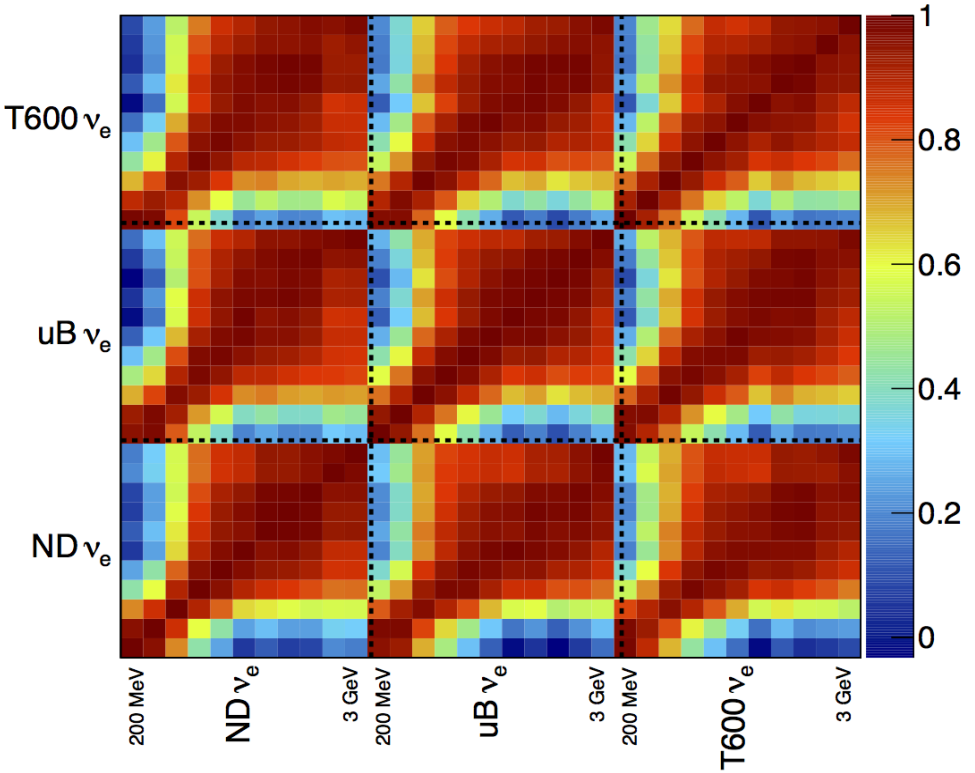
ν_e Flux Fractional Uncertainties



ν_e Cross Section Fractional Uncertainties

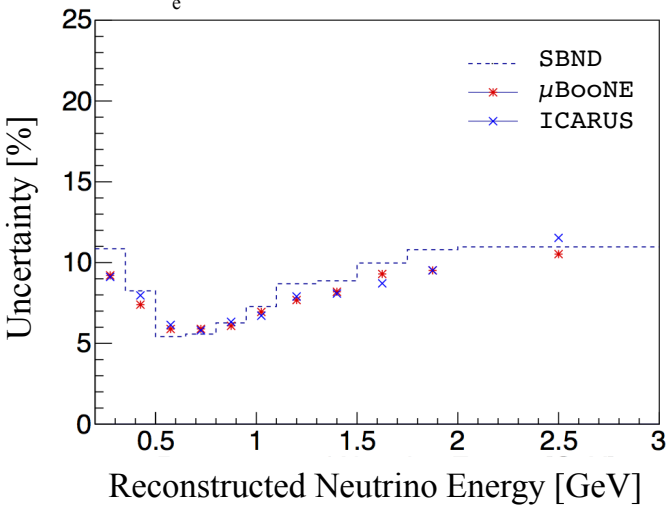


Correlation Matrix

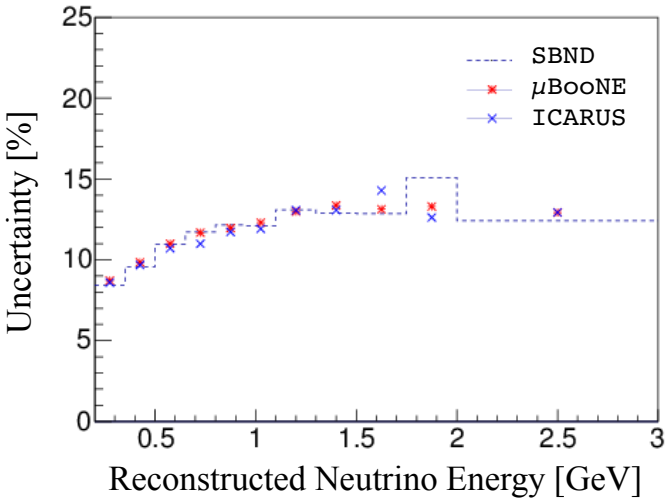


Reducing Uncertainties

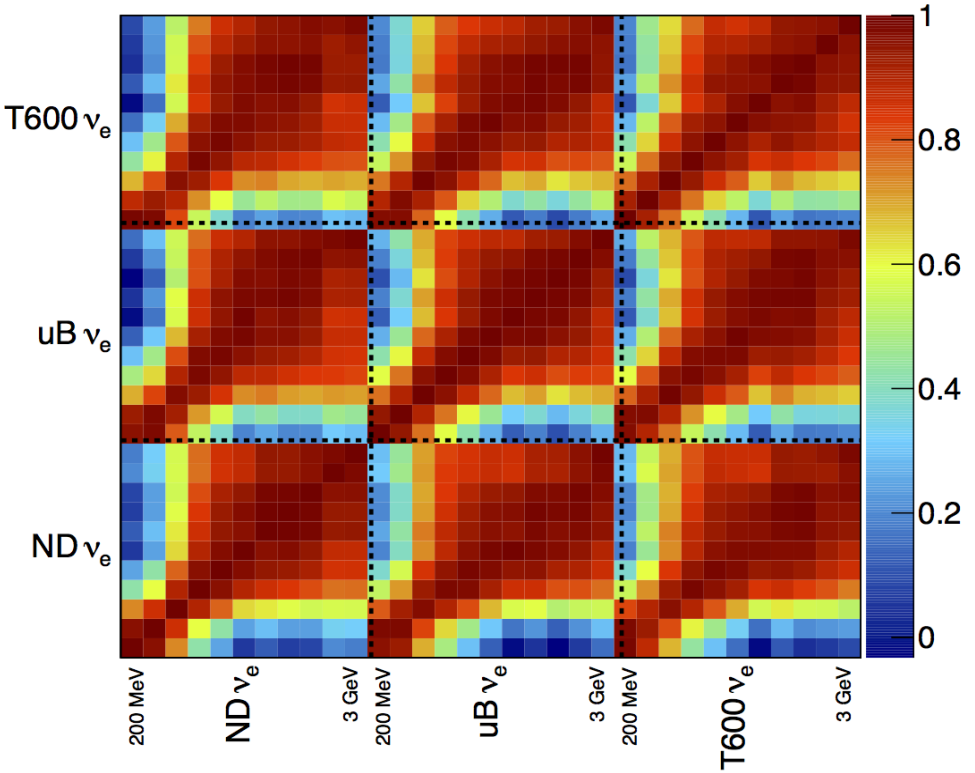
ν_e Flux Fractional Uncertainties



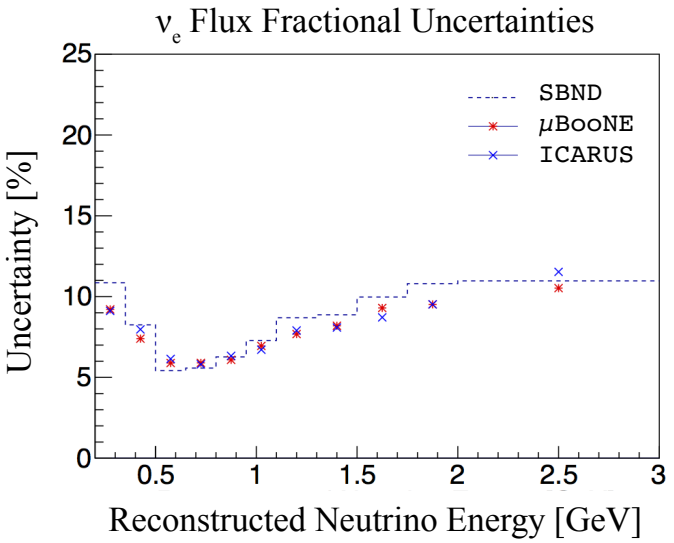
ν_e Cross Section Fractional Uncertainties

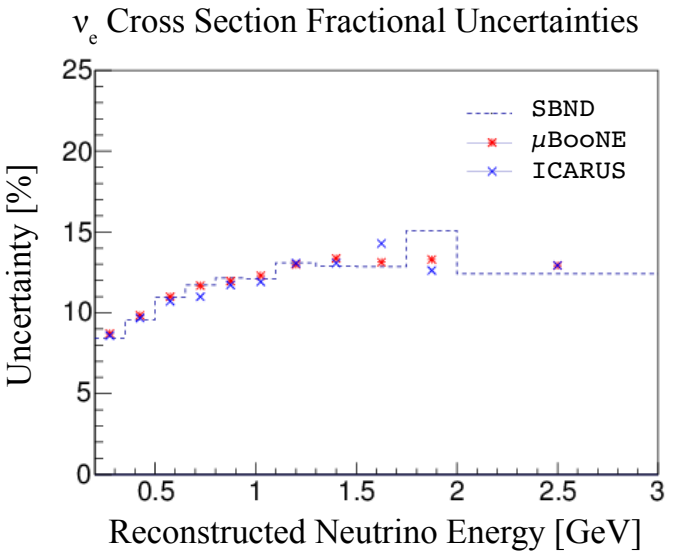


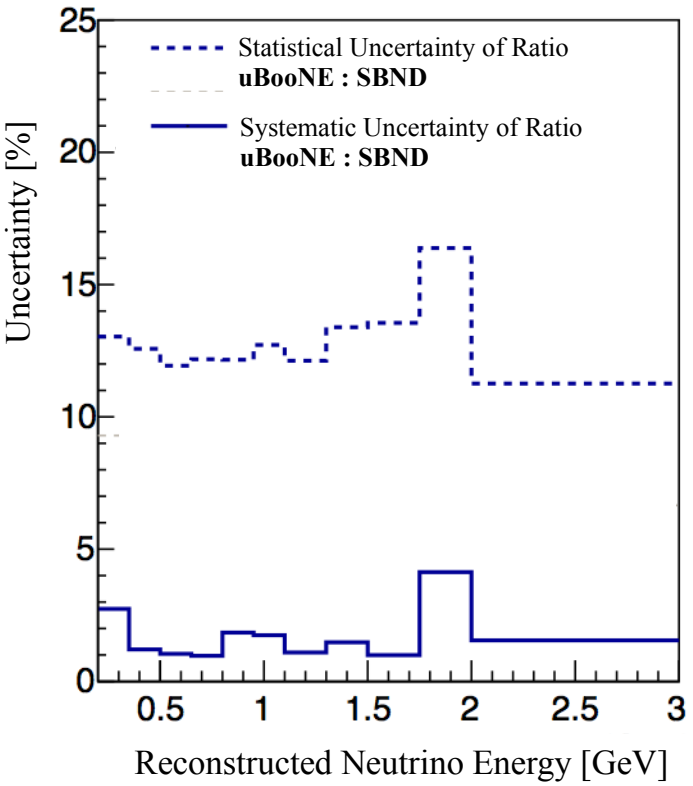
Correlation Matrix



Reducing Uncertainties

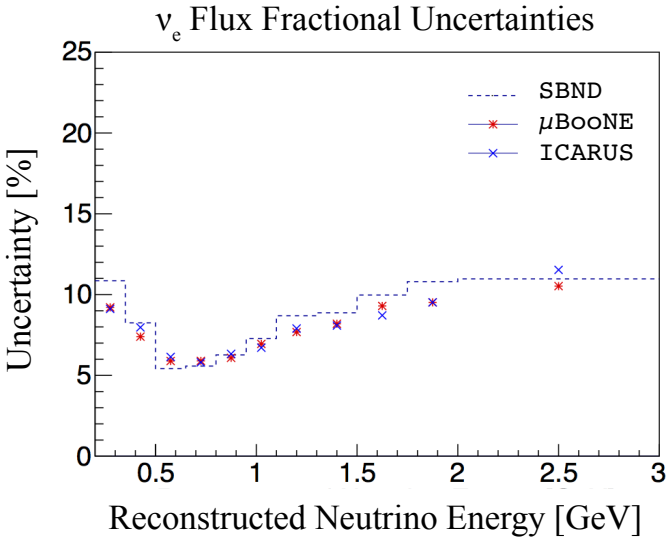


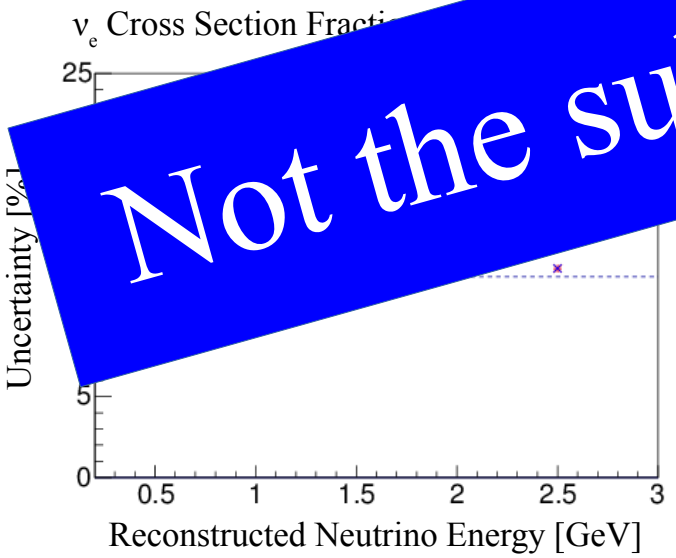


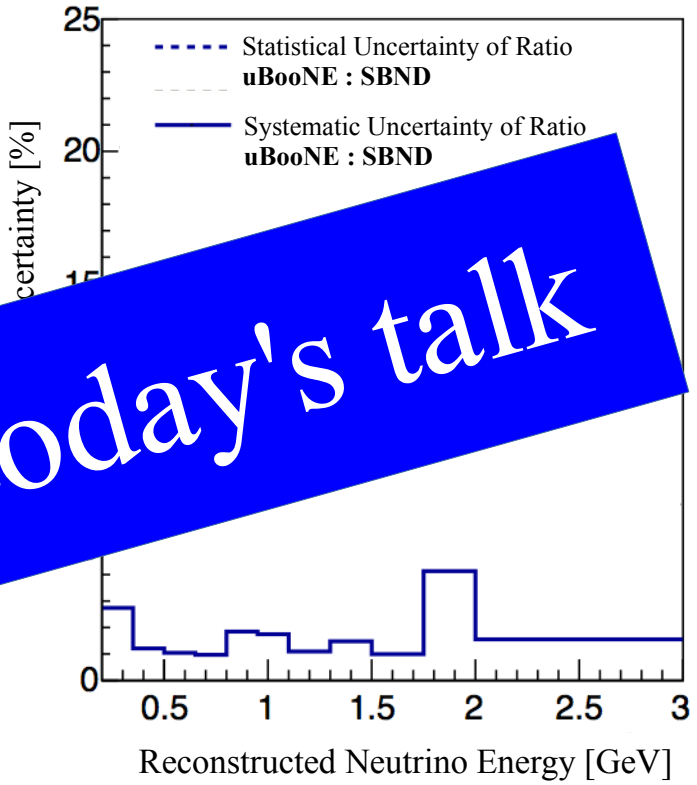


Large correlations in systematic uncertainties lead to large cancellations

Reducing Uncertainties







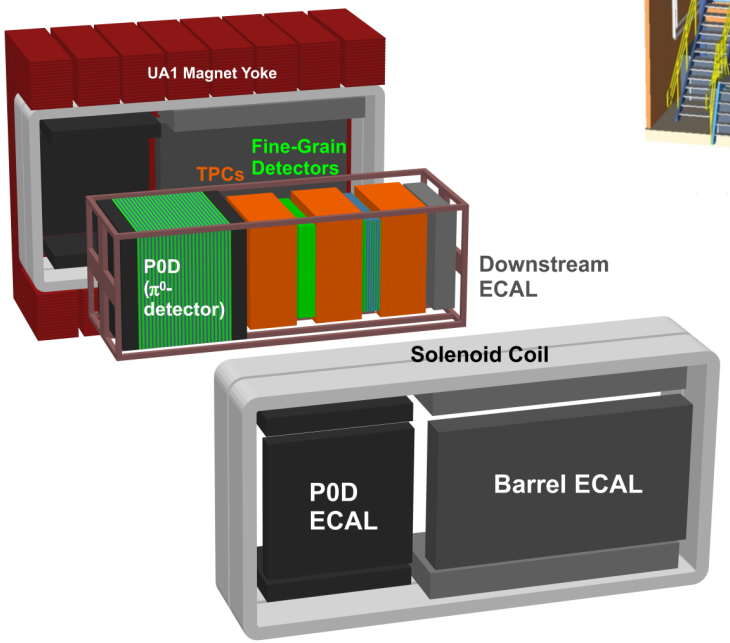
Not the subject of today's talk

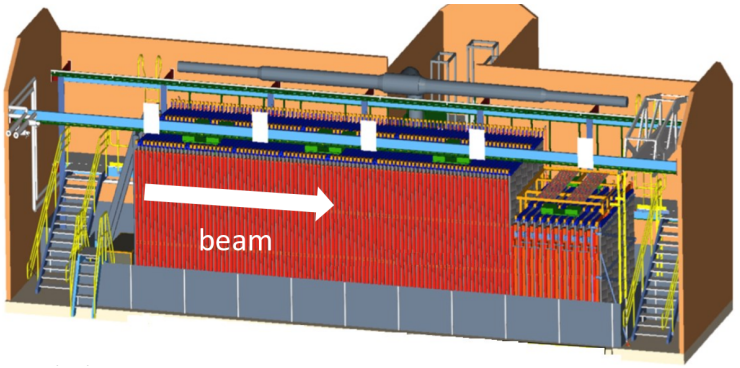
Large correlations in systematic uncertainties lead to large cancellations

What About Cross Sections?

Near Detectors have a history of excellent cross section measurements

ND280



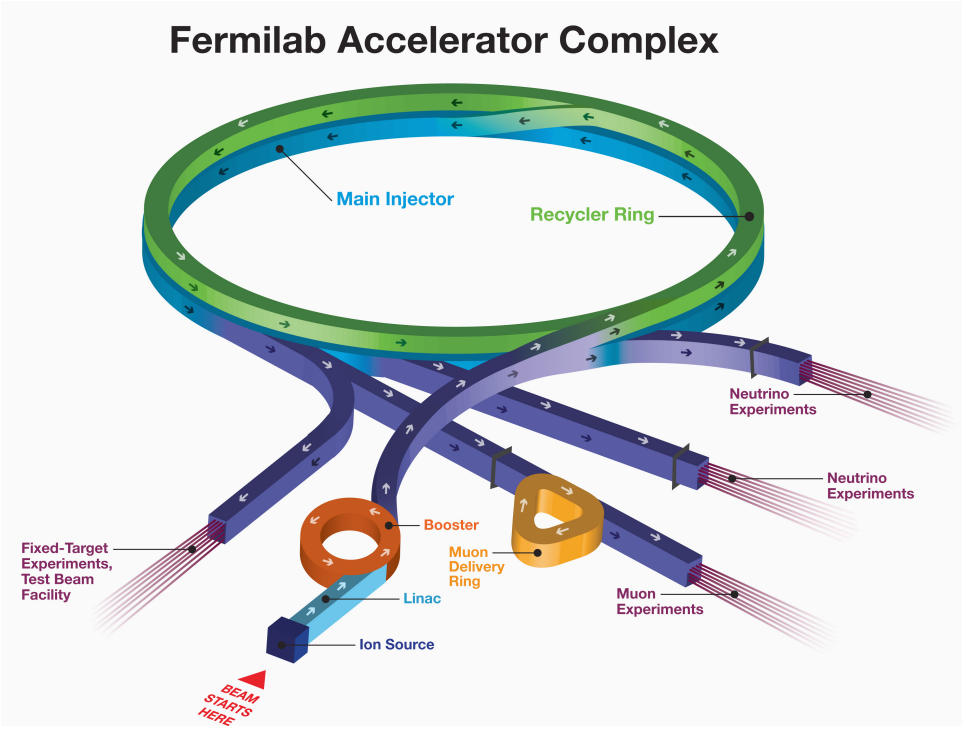


Nova Near Detector

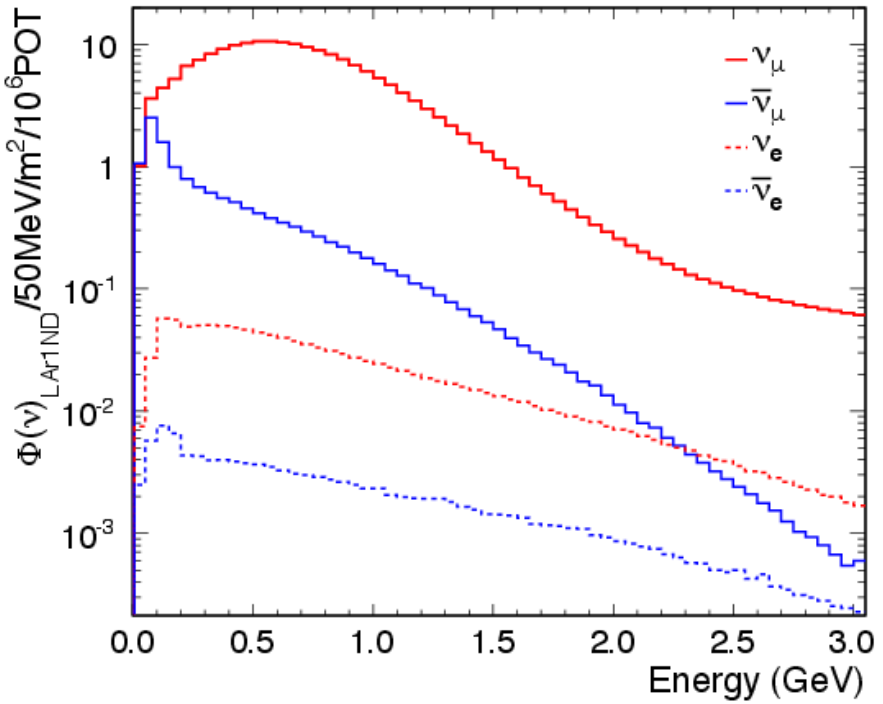
Minos Near Detector

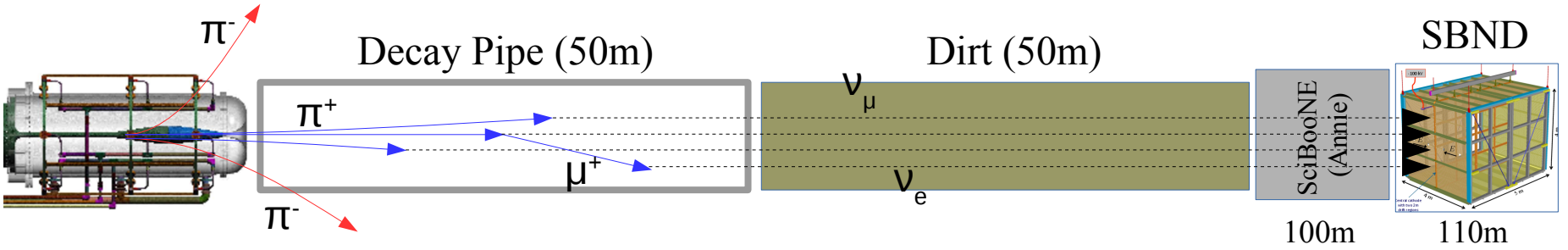
This talk: What can SBND do for Nuint?

Neutrino Flux at SBND

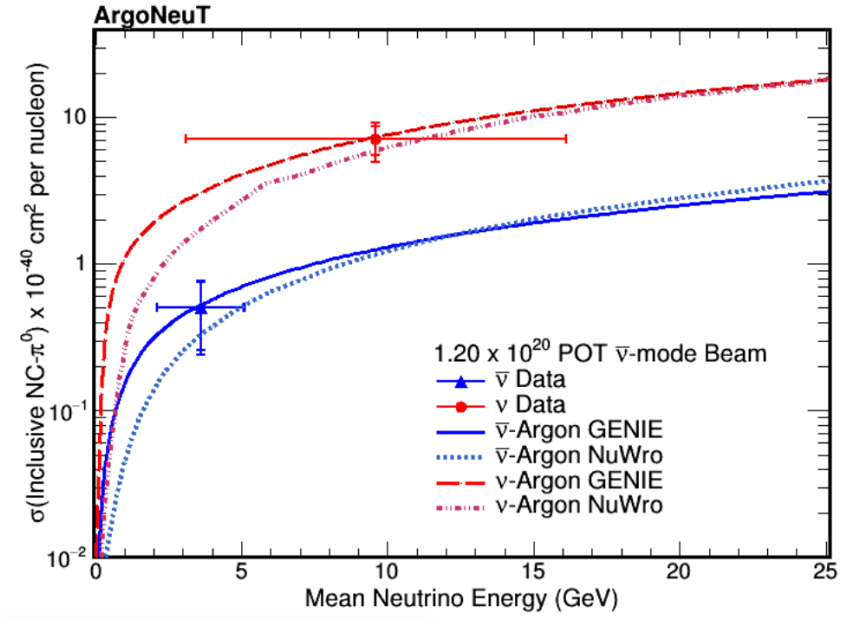


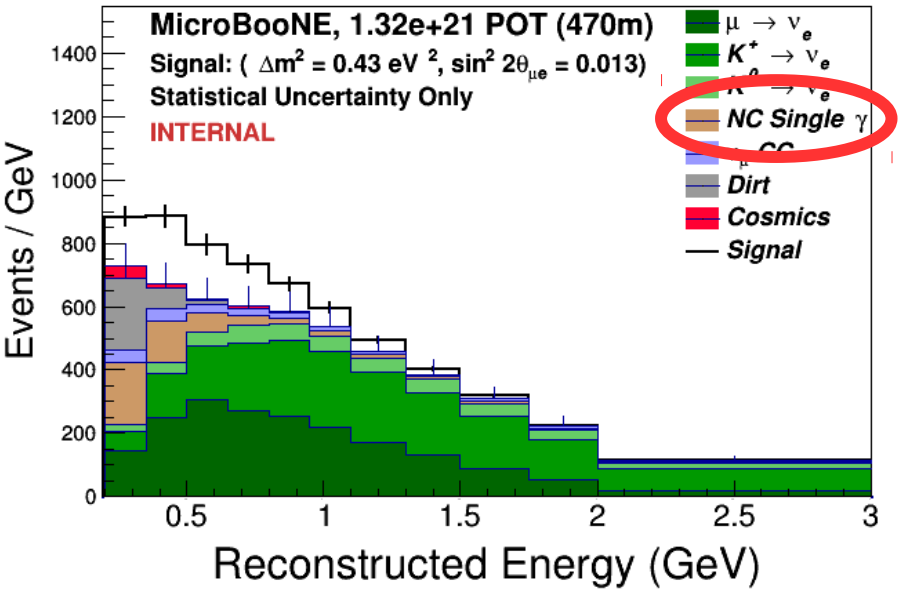
~30x MicroBooNE Flux

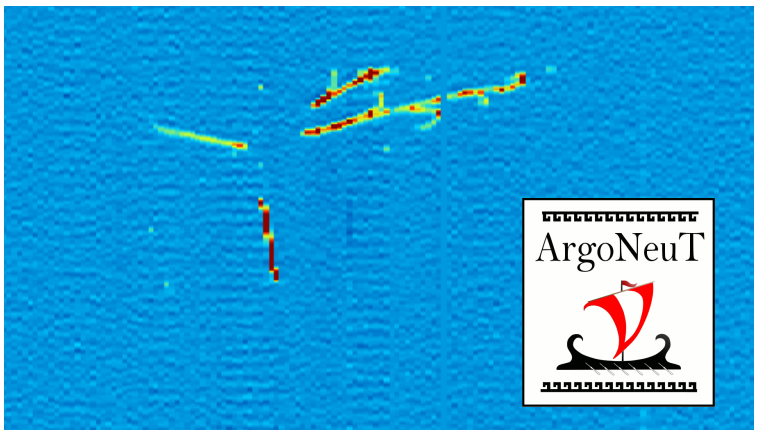




Neutral Current Backgrounds



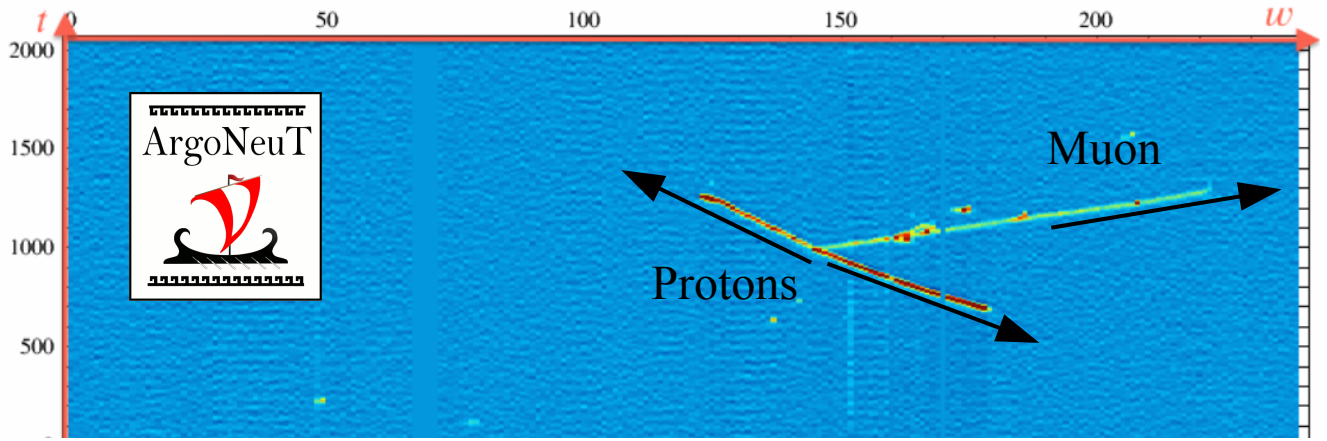




Charged Current Neutral Pion Expectations (GENIE estimate, rounded)

	1 Month	1 Year	3 Years
CC + 1 pi0	14,000	166,000	498,000
NC + 1 pi0	10,000	120,000	358,000

Final State Interactions



Physical Process

Detector Signature

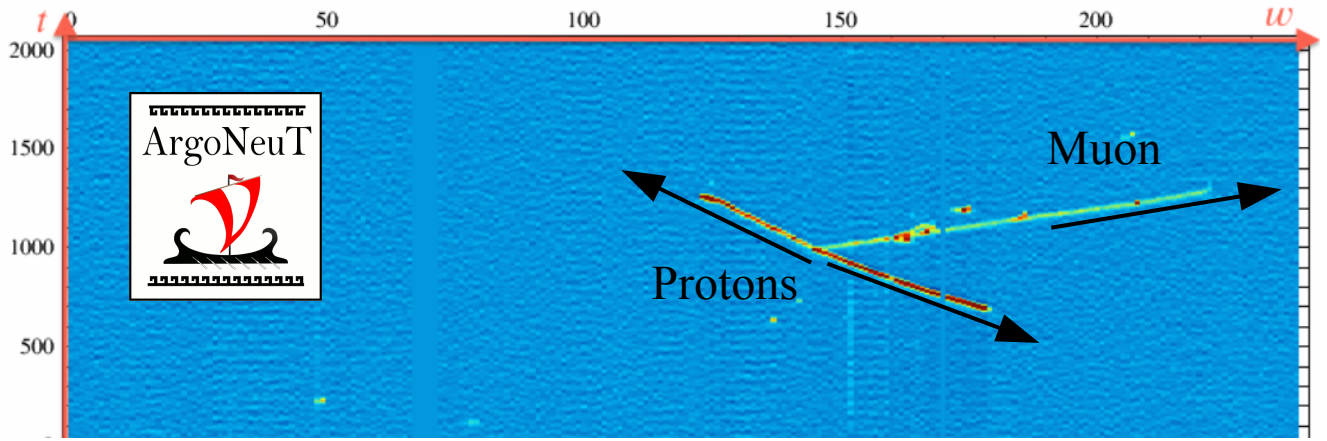
Quasi-Elastic → $\mu + p$

Resonance → $\mu + \pi + p$

Deep Inelastic → $\mu + N\,\pi + N\,p + \ldots$

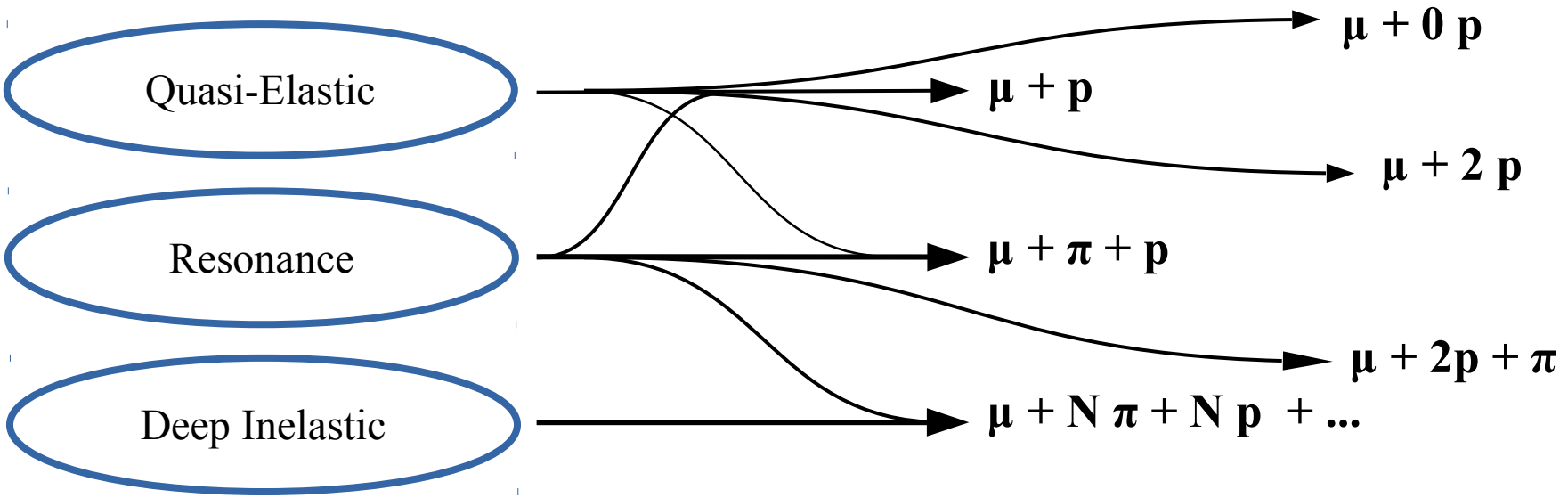
Phys. Rev. D 90, 012008 (2014)

Final State Interactions



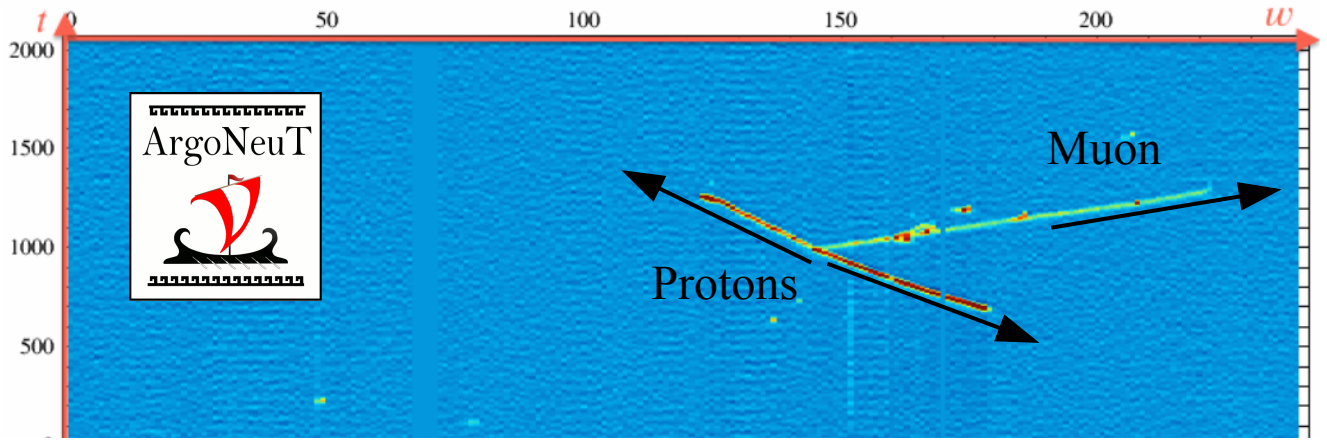
Physical Process

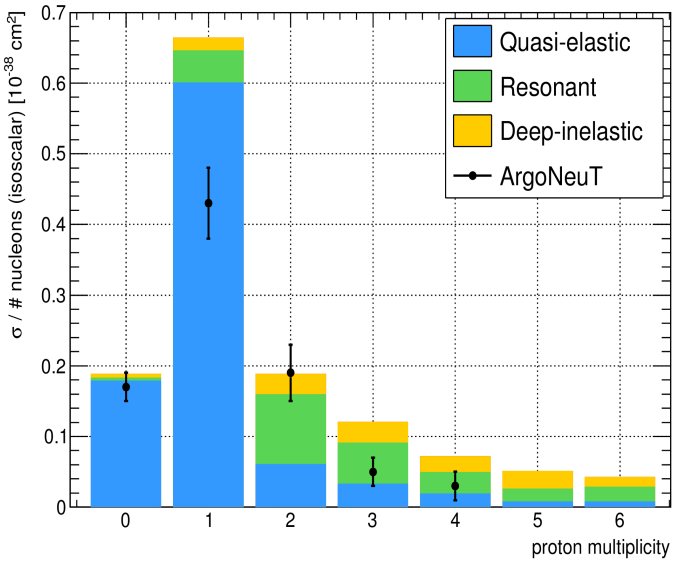
Detector Signature



Phys. Rev. D 90, 012008 (2014)

Final State Interactions





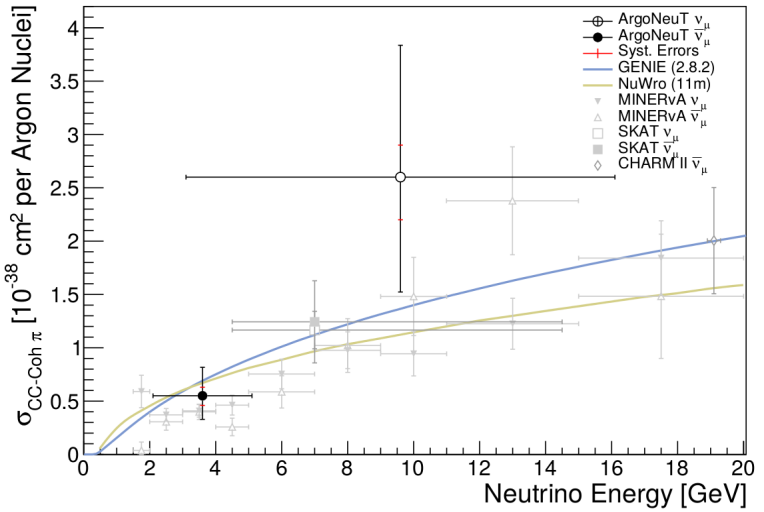
Charged Current Zero Pion Expectations (GENIE estimate, rounded)

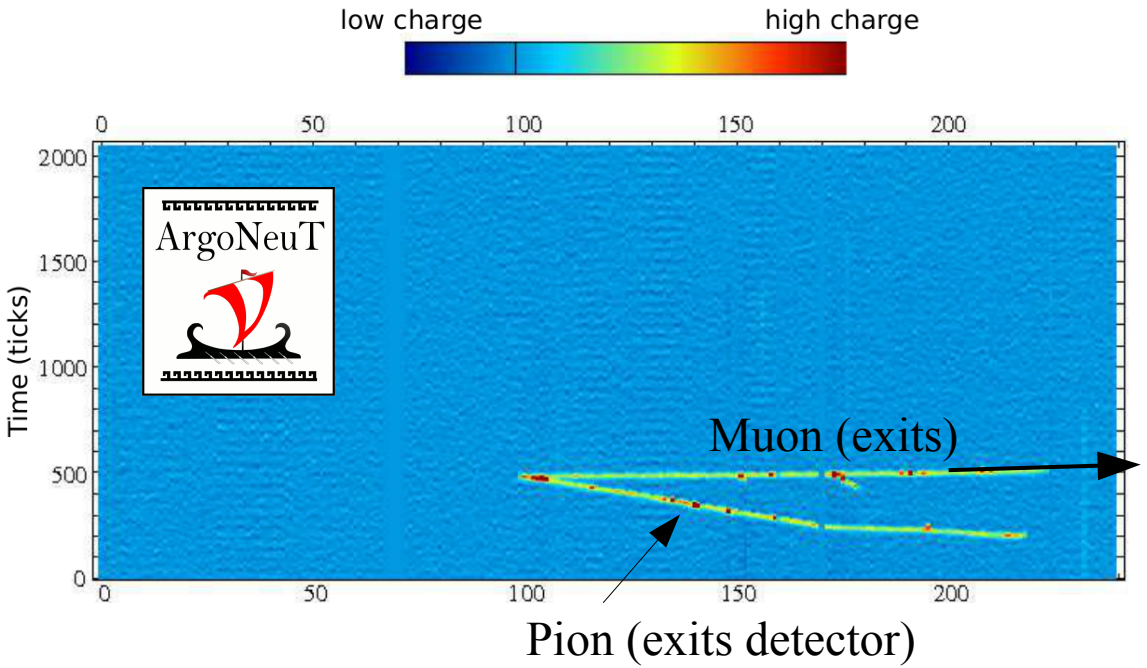
	1 Month	1 Year	3 Years
CC + Np	97,000	1,170,00	3,500,000
CC + 0p	22,000	260,000	790,000
CC + 1p	56,000	667,000	2,000,000
CC + 2p	10,000	120,000	360,000
CC + >3p	10,000	120,000	370,000

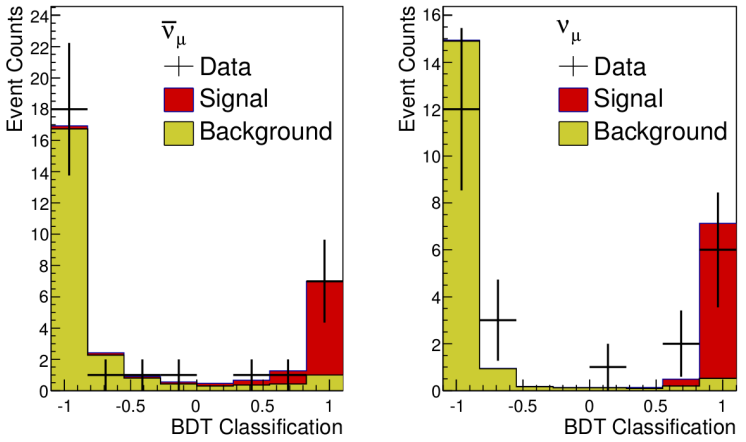
Coherent Pion Production

$$\nu_\mu + A_{g.s.} \rightarrow \mu^- + \pi^+ + A_{g.s.}$$

$$\bar{\nu}_\mu + A_{g.s.} \rightarrow \mu^+ + \pi^- + A_{g.s.}$$





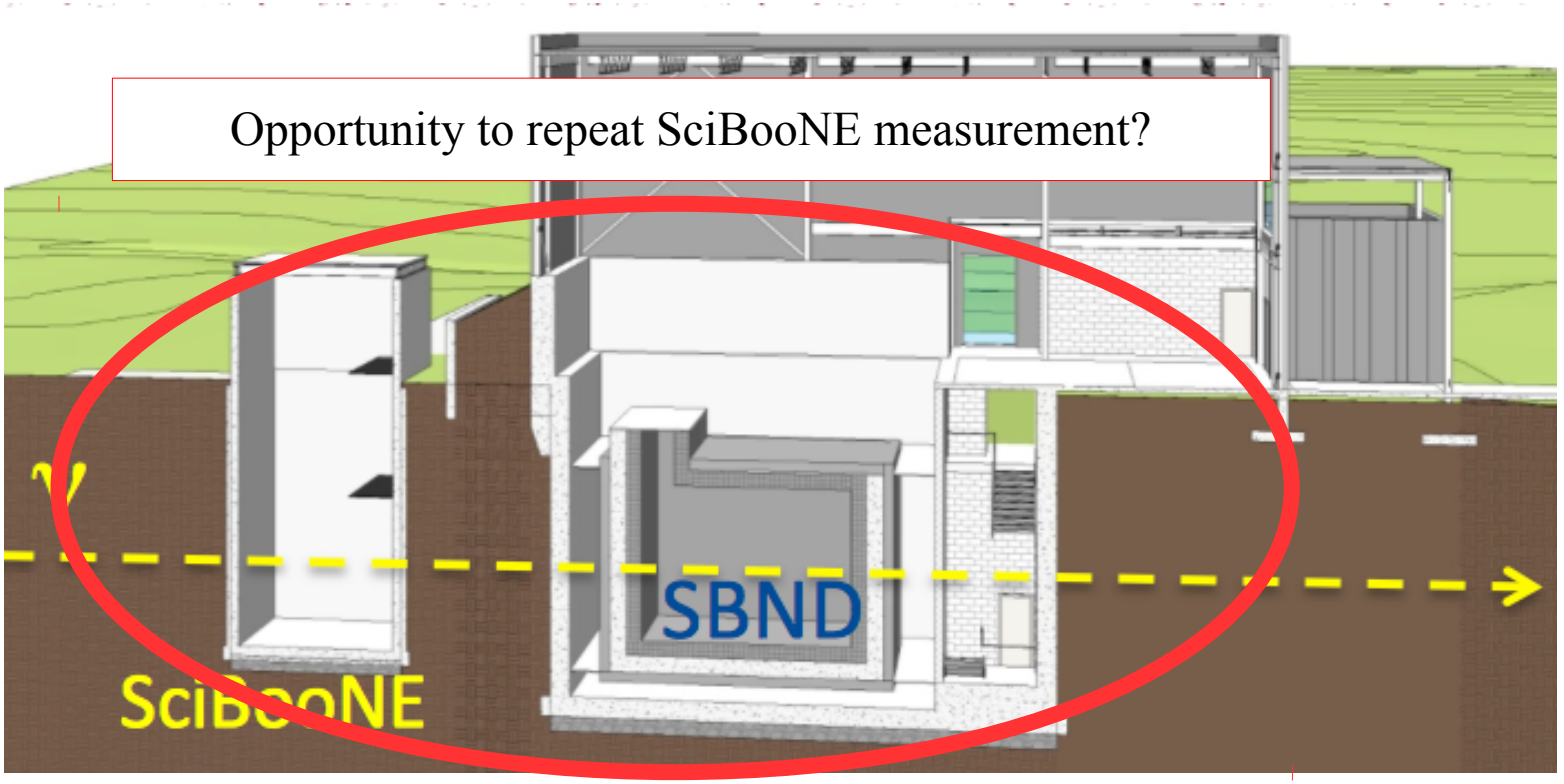


Phys. Rev. Lett. 113, 261801 (2014)

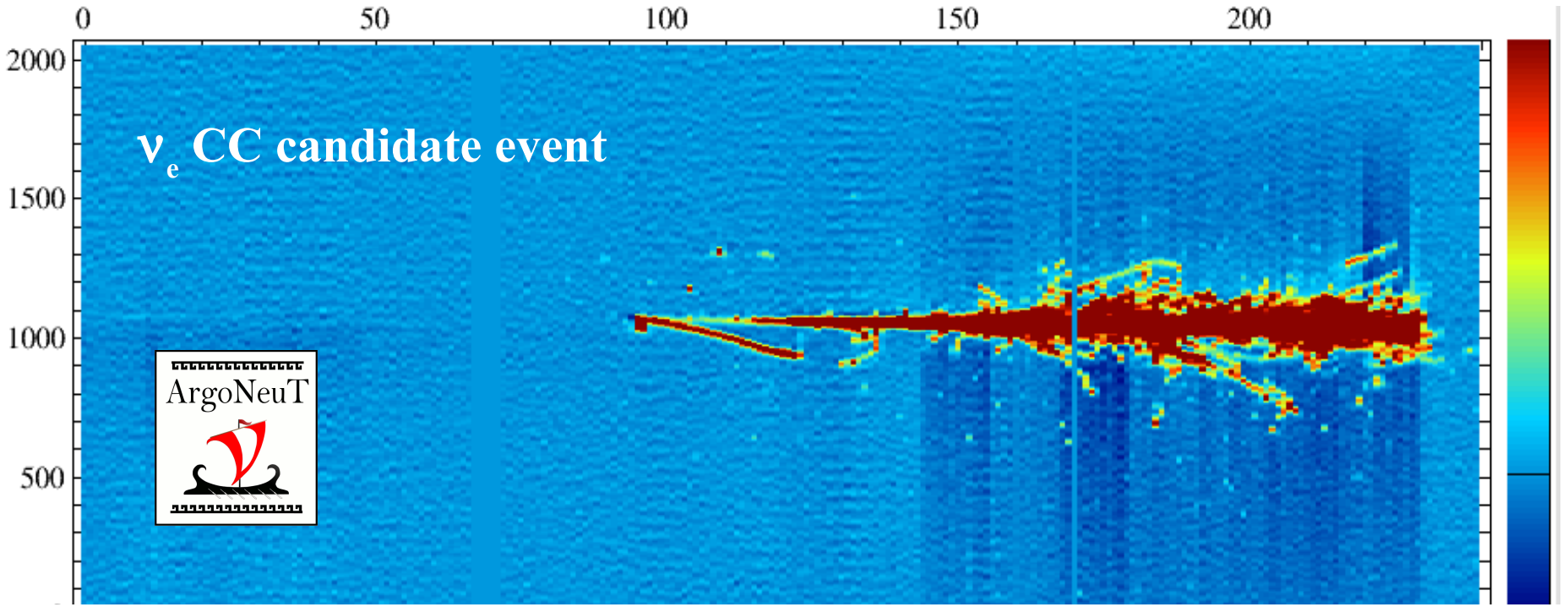
Coherent Pion Production

Charged Current Coherent Pion Expectations
(GENIE estimate, rounded)

	1 Month	1 Year	3 Years
CC Coherent	500	6,300	19,000



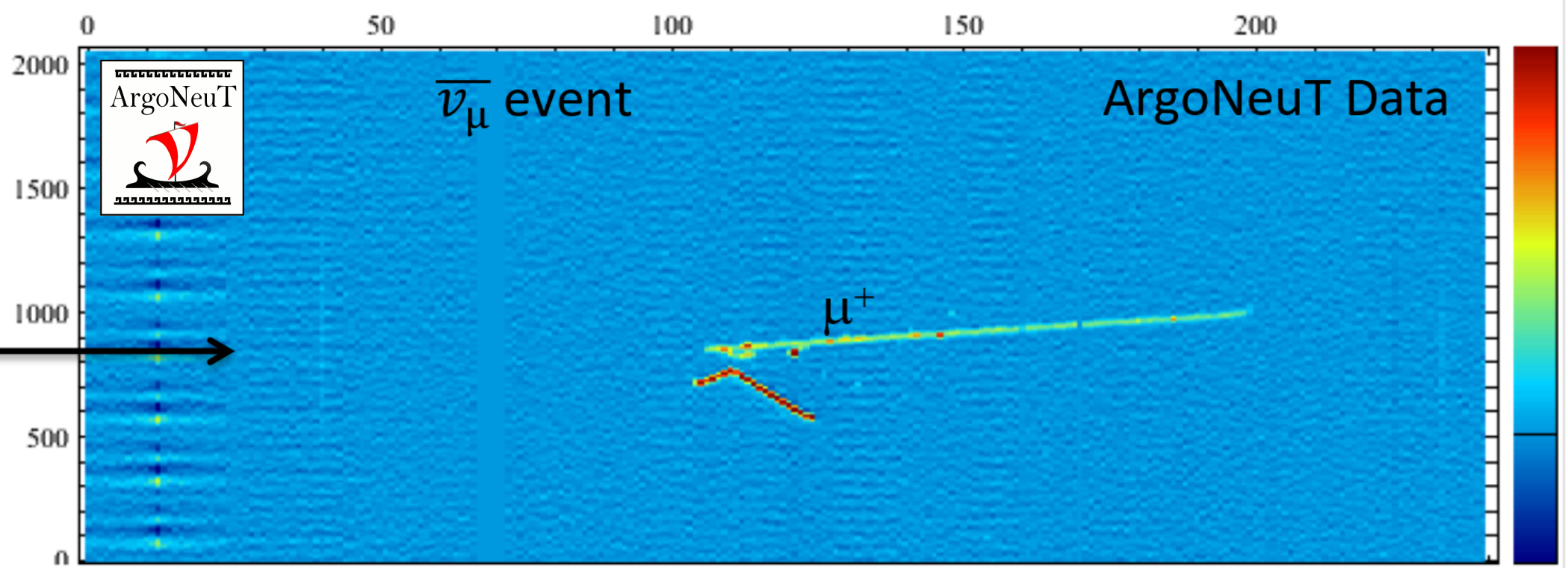
Electron Neutrinos



	1 Month	1 Year	3 Years
CC ν_e	1,000	12,000	37,000

The high statistics electron neutrino sample will be **hugely** beneficial to both SBN and DUNE physics programs

Rare Channel Searches

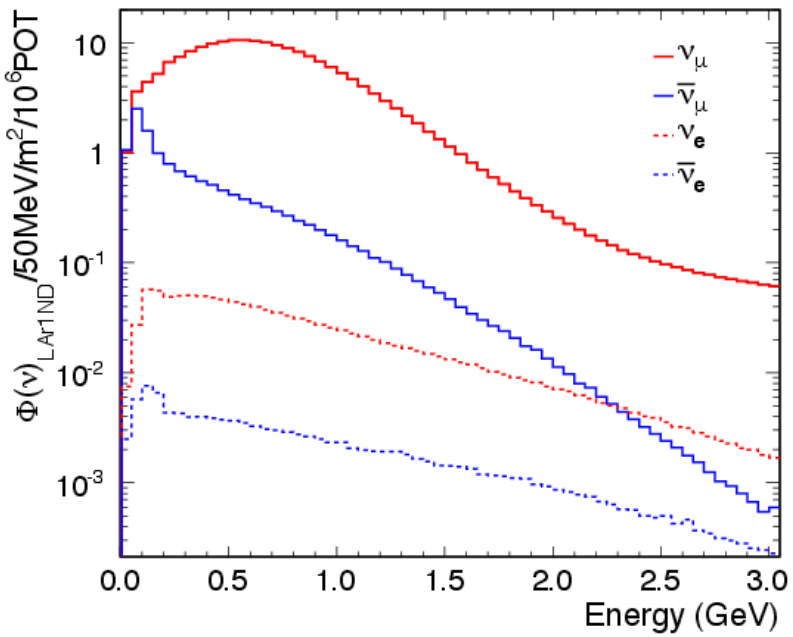


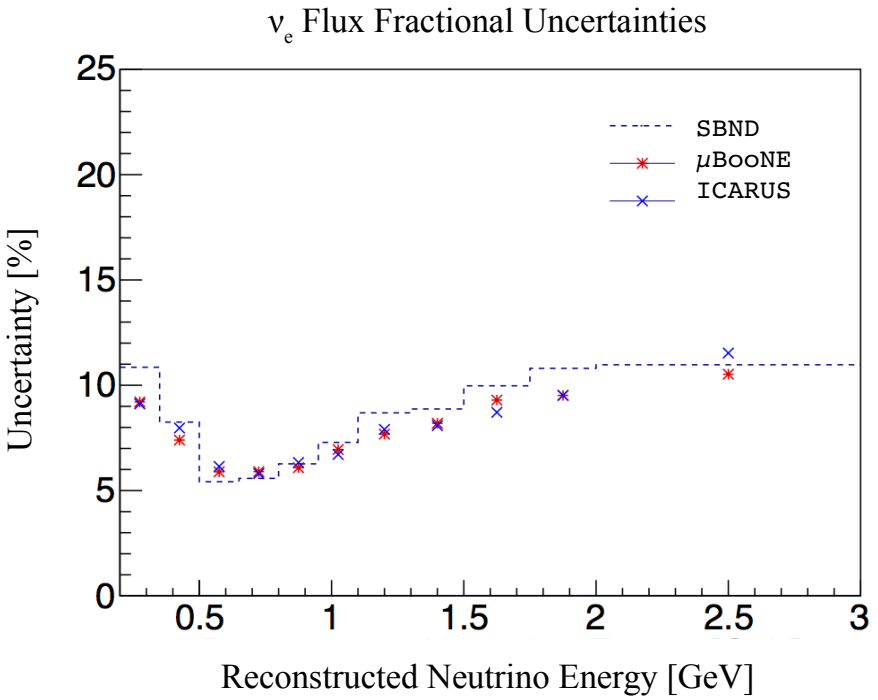
Hyperon Production Expectations (CC + NC)
(GENIE Expectations)

	1 Month	1 Year	3 Years
Λ^0 Production	200	2,600	8,000
Σ^+ Production	125	1,500	4,500

SBND opens the door to high statistics, high precision, rare neutrino interactions.

Flux Uncertainty

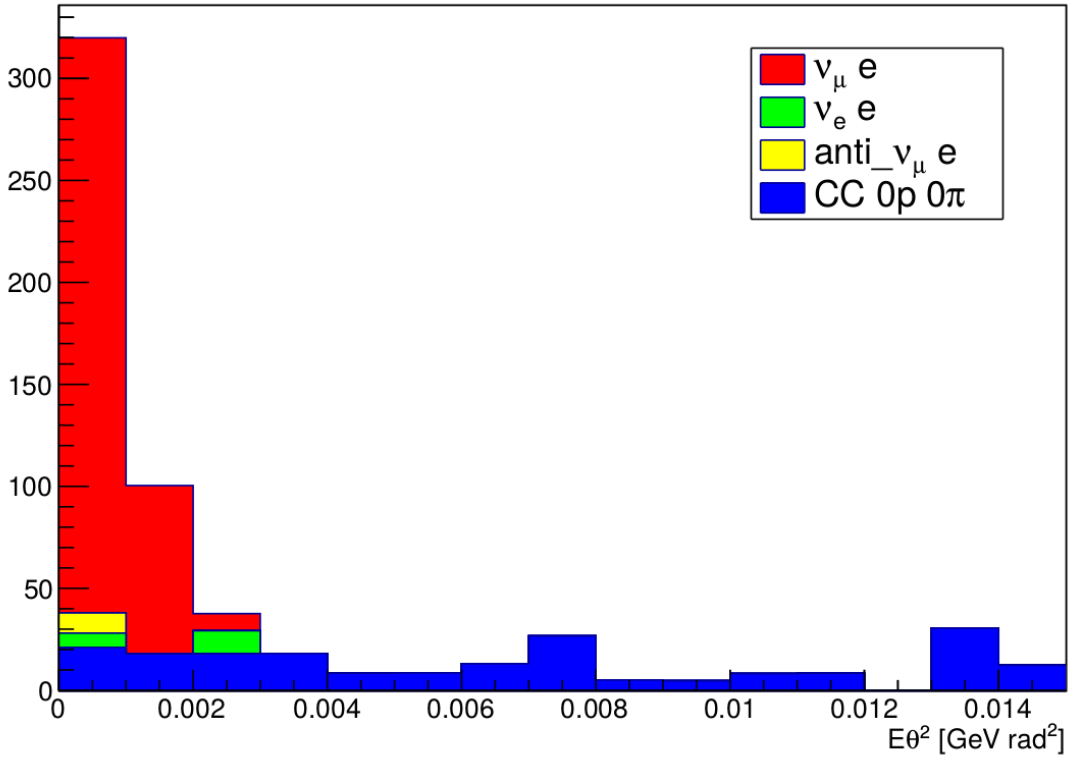




Many analyses shown here will be systematics limited in just months of data.

(Accumulate statistics of ArgoNeuT in just 2 days!)

Electron Neutrino Scattering



$$\nu + e \rightarrow \nu + e$$

Detector Signature:

1) Very forward electron

2) No activity around vertex

LArTPC technology is ideally suited for this.

Event rate (~300 events expected) provides a constraint on flux normalization.

SBND Timeline

- Design is mature and nearly final (December 2015)
- Construction starts January 2016
- Assembly begins Summer 2016
- Ground breaking imminent
- Detector Operations begin 2018
- SBND will be a “Future Experiment” for one more Nuint Meeting
- Stay updated at our website!

Thanks

- **Argonne National Lab**: Zelimir Djurcic (IB), Ranjan Dharmapalan, Gary Drake, Maury Goodman, Steve Magill
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- **Indiana University:** Stuart Mufson (IB), Denver Whittington
- **Lancaster University:** Andy Blake, Peter Livesly, Ian Mercer, Jarek Nowak (IB), Peter Ratoff
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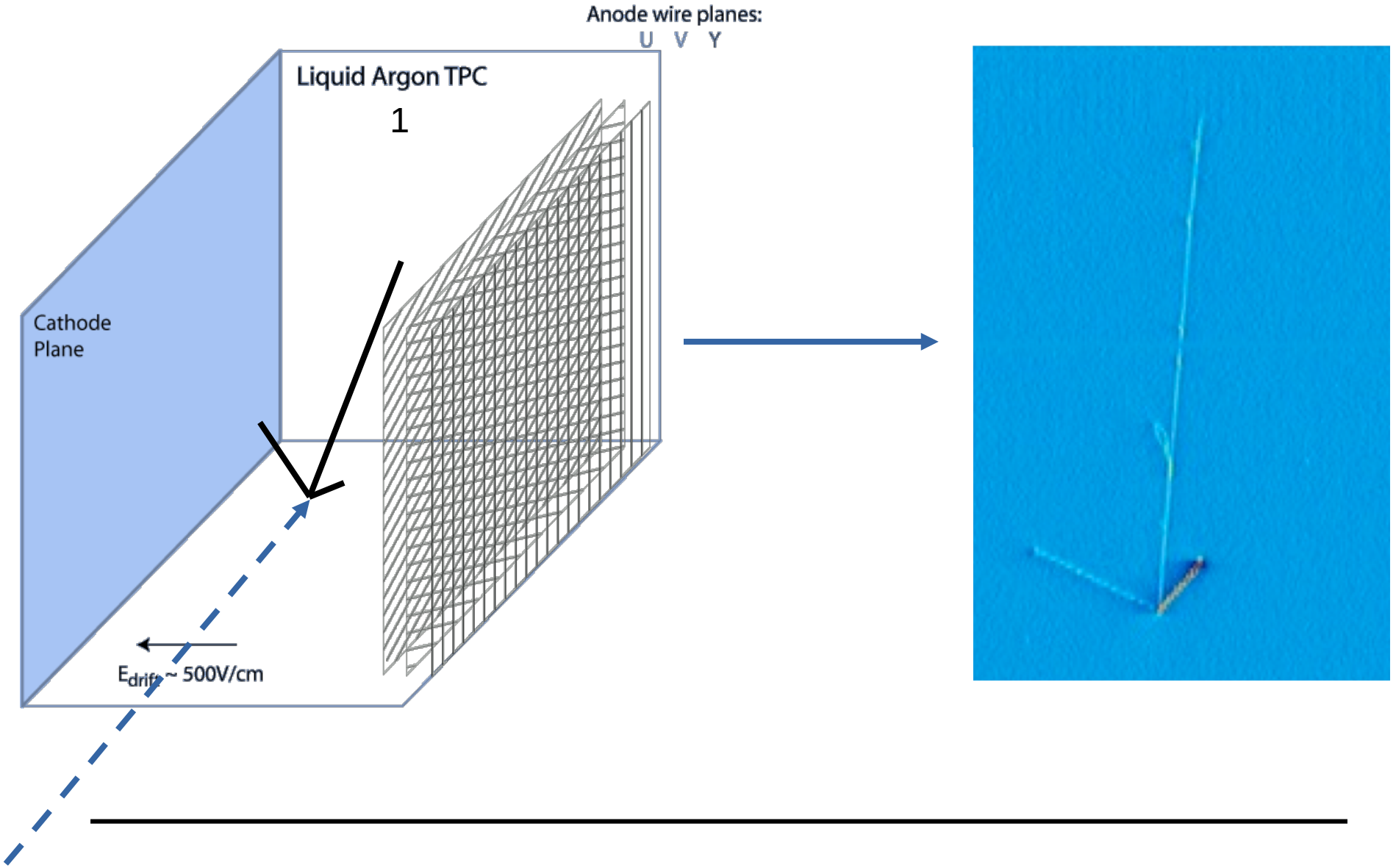
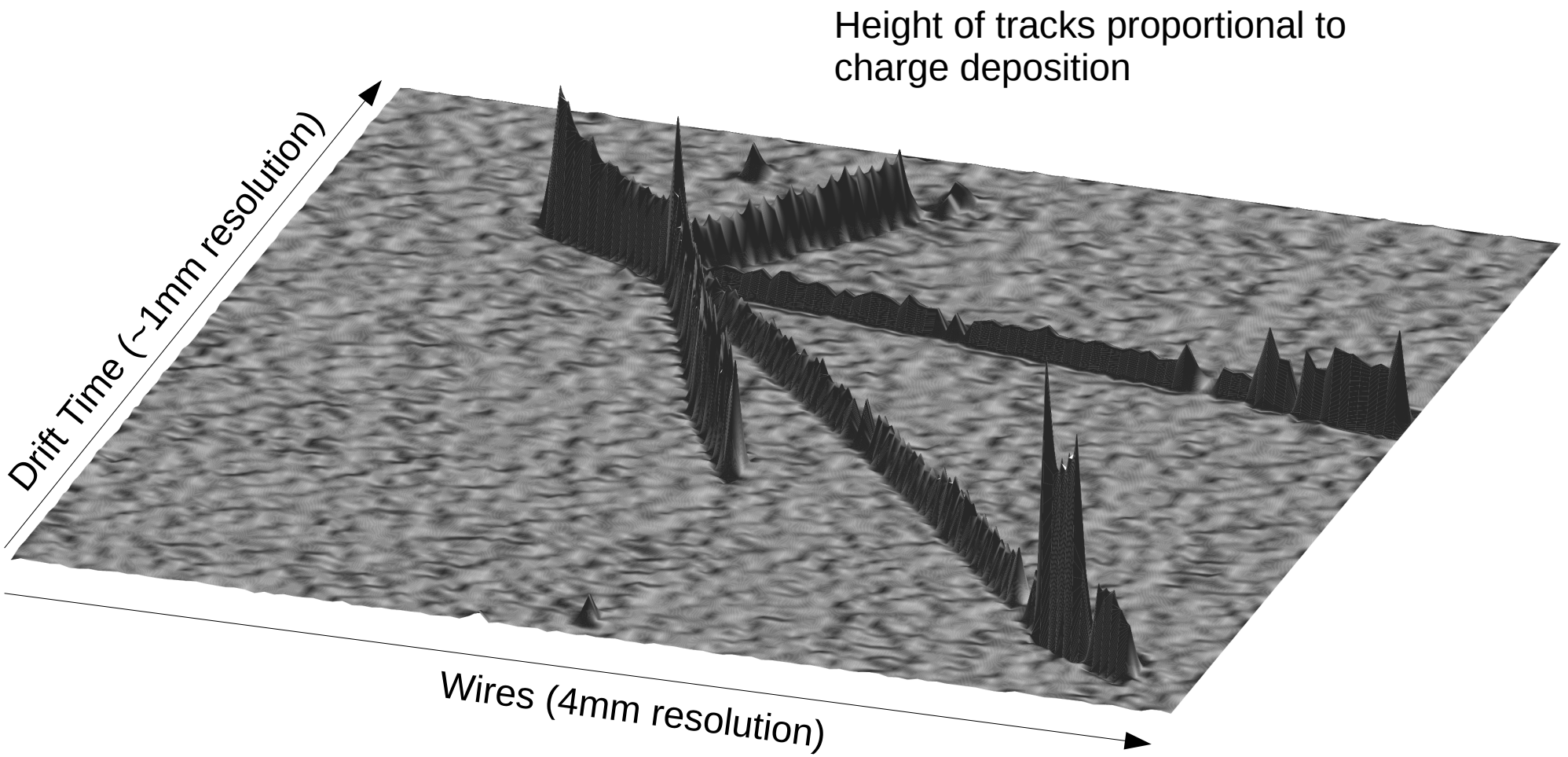
- **University of Oxford:** Matt Bass, Roxanne Guenette (IB)
- **Pacific Northwest National Lab:** Eric Church (IB)
- **University of Pennsylvania:** Nuno Barros, Josh Klein (IB)
- **University of Puerto Rico:** Hector Mendez (IB), Samuel Santana
- **University of Sheffield:** Trevor Gamble, Vladimir Kudryavtsev, Nicola McConkey, Sumanta Pal, Jonathan Perkin, Martin Richardson, Neil Spooner (IB), Matthew Thiesse, Lee Thompson
- **Syracuse University:** Jessica Esquivel, Greg Pulliam, Mitch Soderberg (IB)
- **University of Texas Arlington:** Jonathan Asaadi (IB)
- **University College London:** Michele Cascella, Anna Holin (IB)
- **Virginia Tech:** Artur Ankowski, Chun Min (Mindy) Jen, Leonidas Kalousis, Camillo Mariani (IB)
- **Yale University:** Corey Adams, Bonnie Fleming (IB), Elena Gramellini, Ariana Hackenburg, Brooke Russell, Serhan Tufanli

Backup Slides

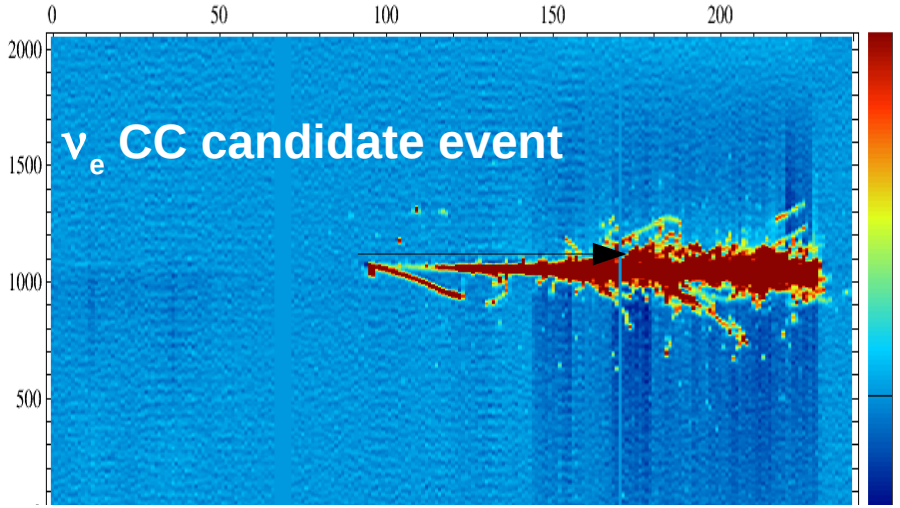
Liquid Argon Time Projection Chamber

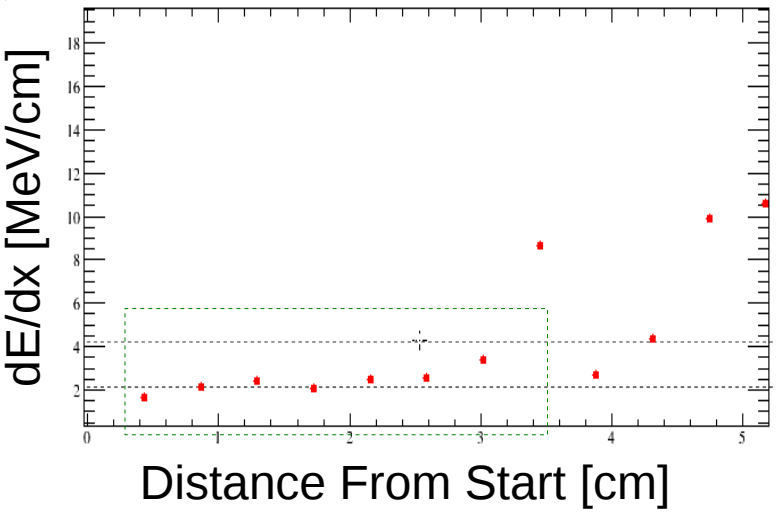


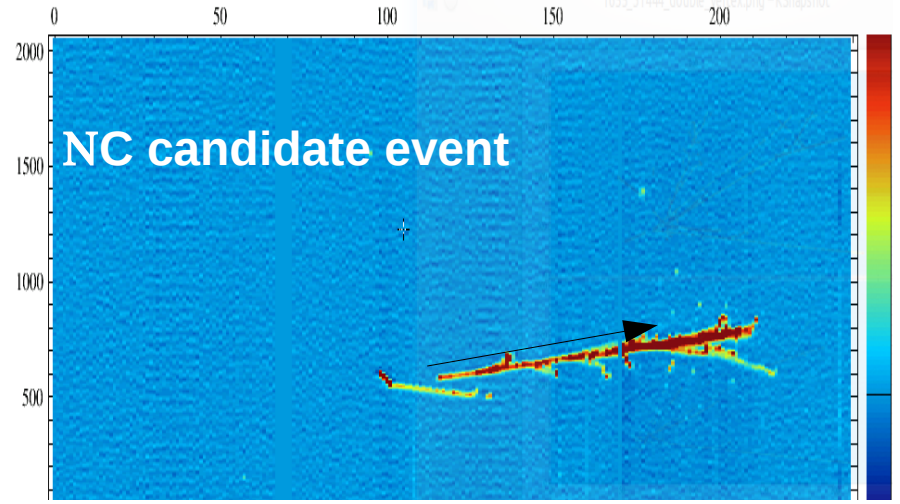
Precision Imaging AND Calorimetry

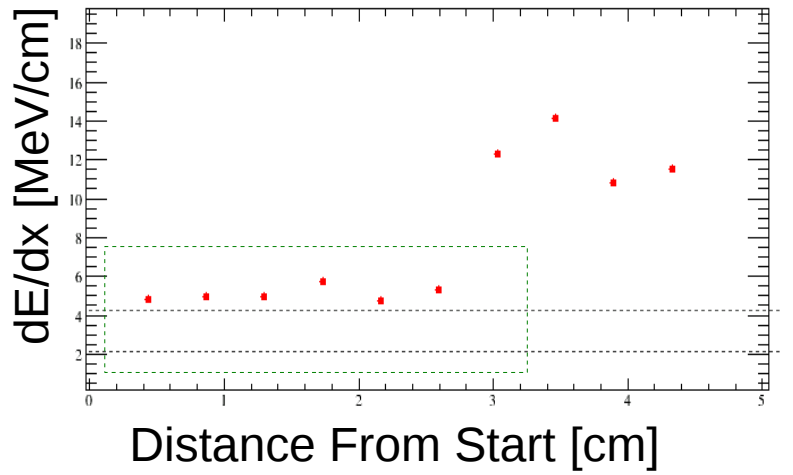


Electron/Photon Separation



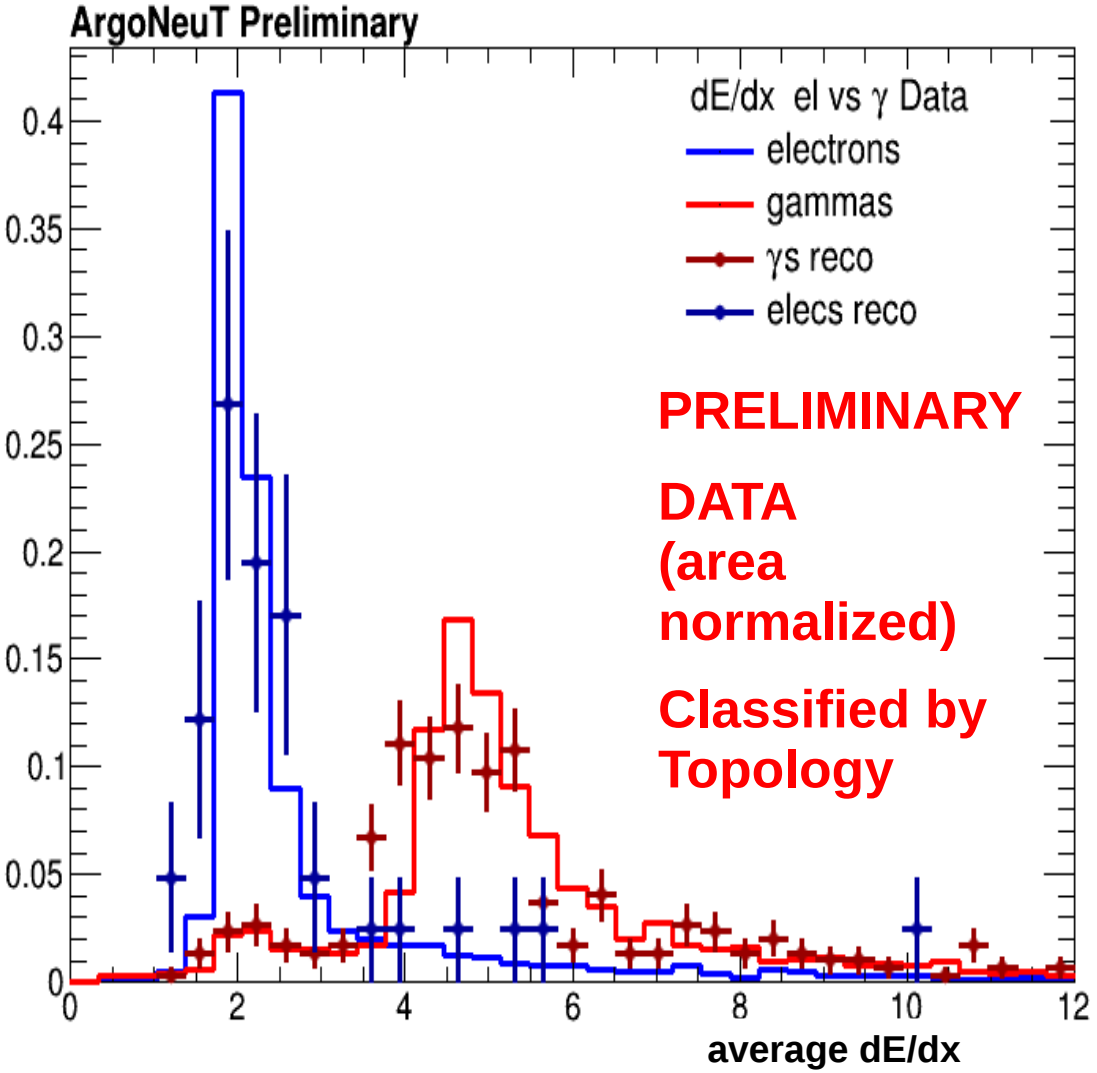






Electron/Photon Separation

Electron/single gamma separation



Immediate applications in MicroBooNE to resolve the MiniBooNE anomaly