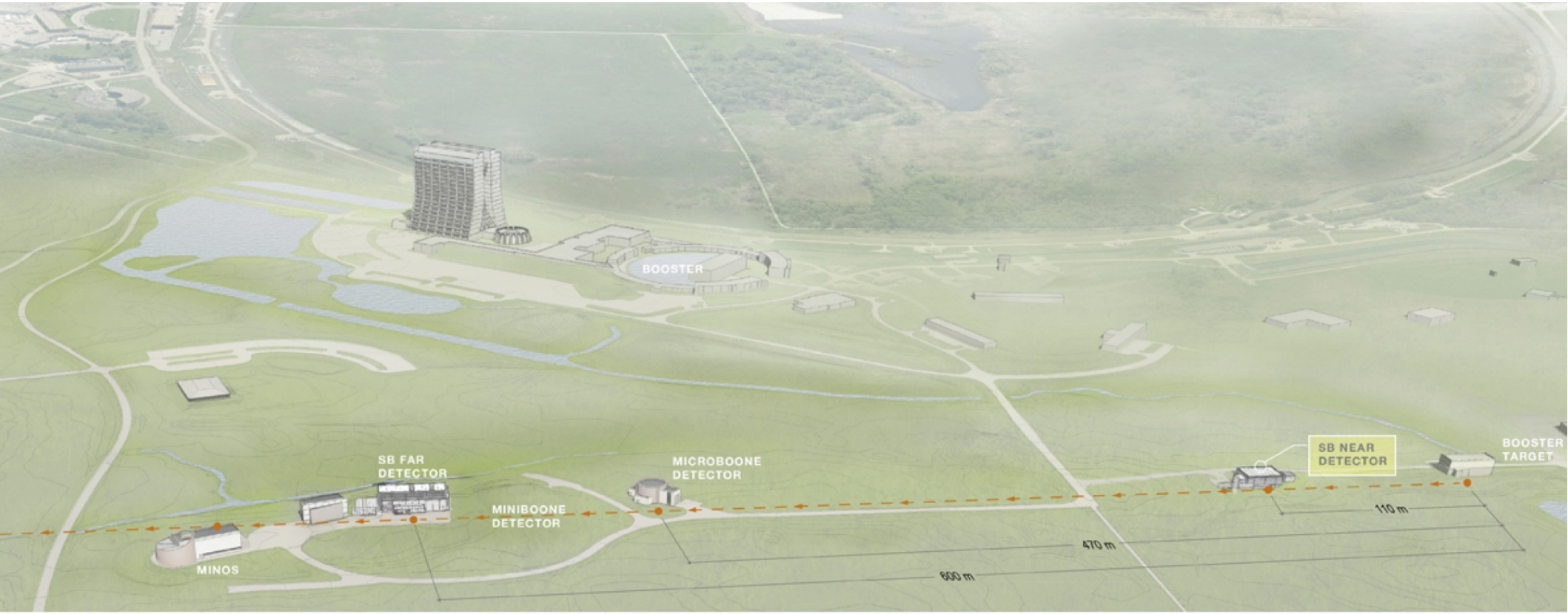
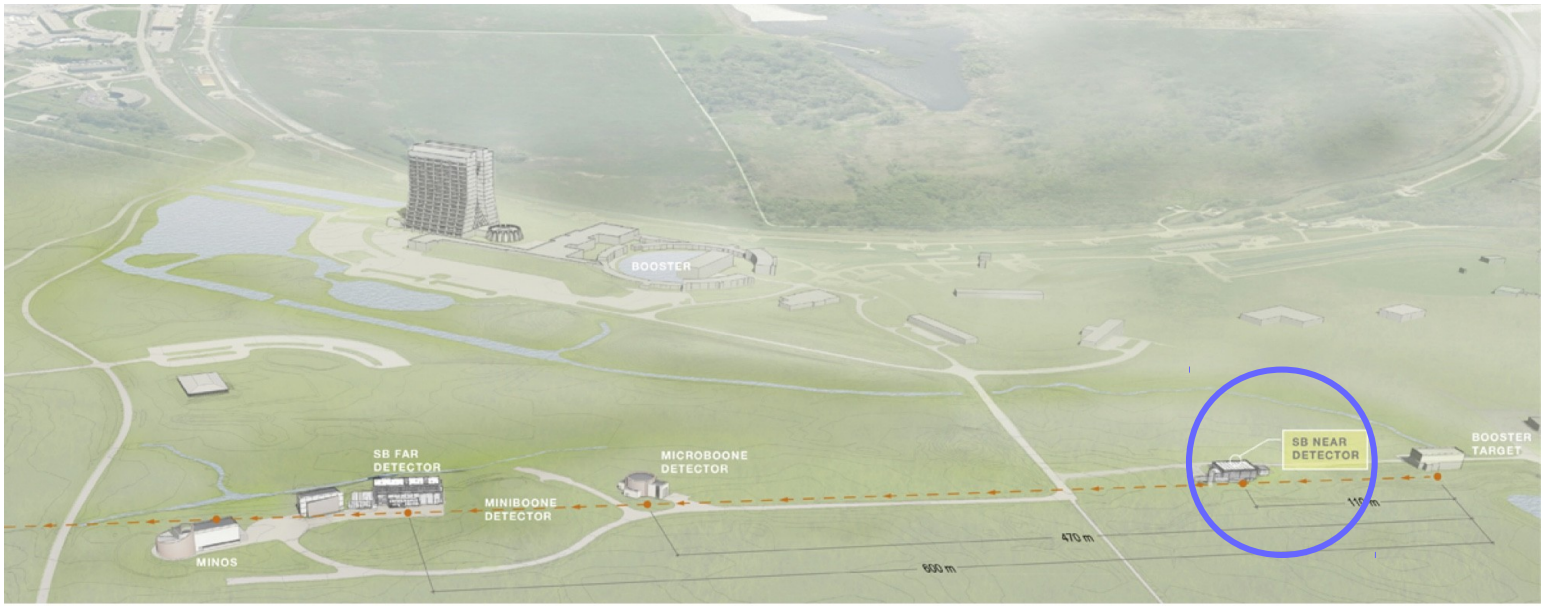


SBND: Neutrino Interactions at Fermilab's Short Baseline Near Detector

Corey Adams, Yale University
On behalf of the SBND Collaboration

SBND in the SBN-Program

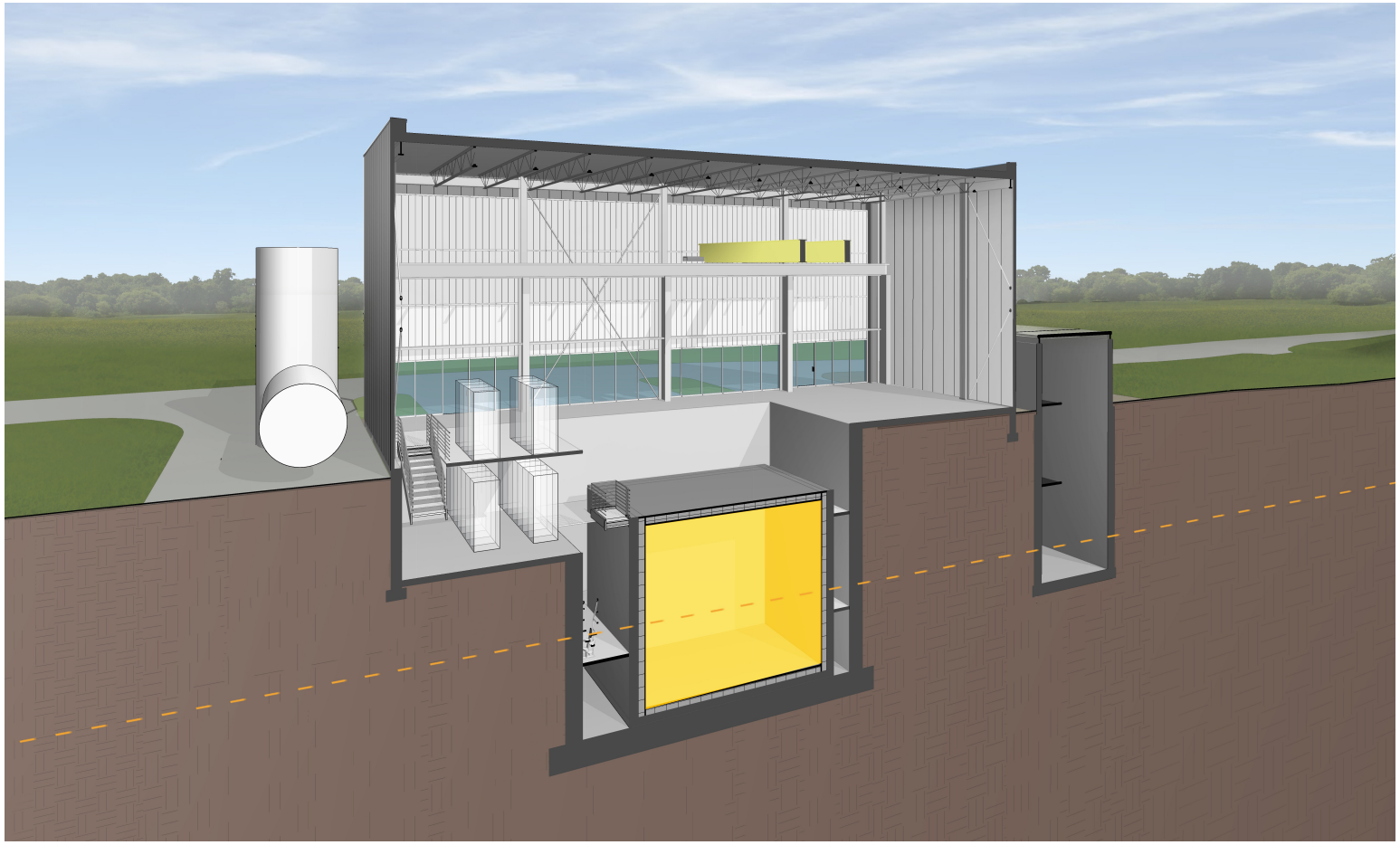


The Short Baseline Program offers a broad and precise venue to resolve outstanding short baseline oscillation anomalies.

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

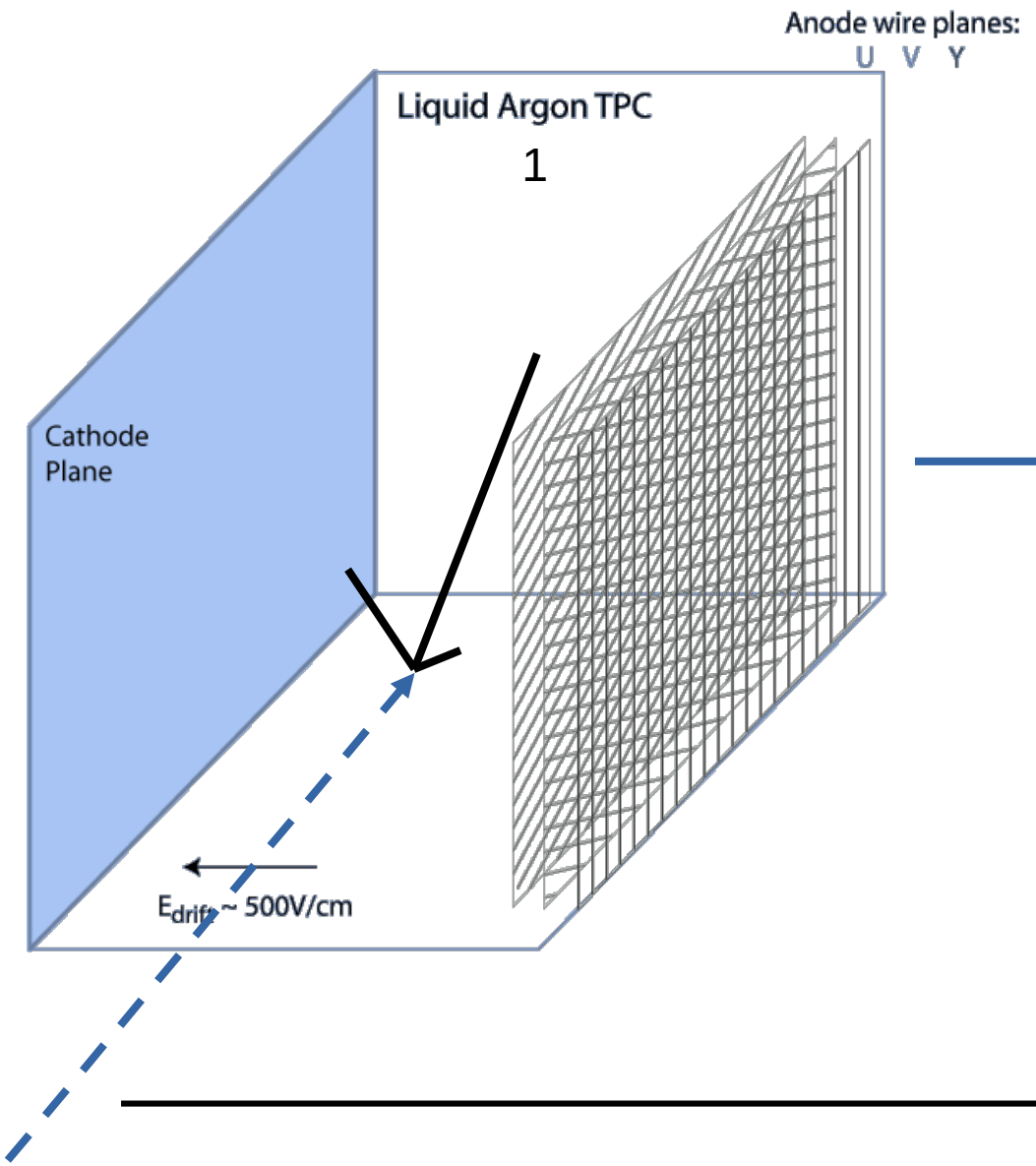
Precise: Three functionally identical detectors along a very well known beam line, many uncertainties cancel.

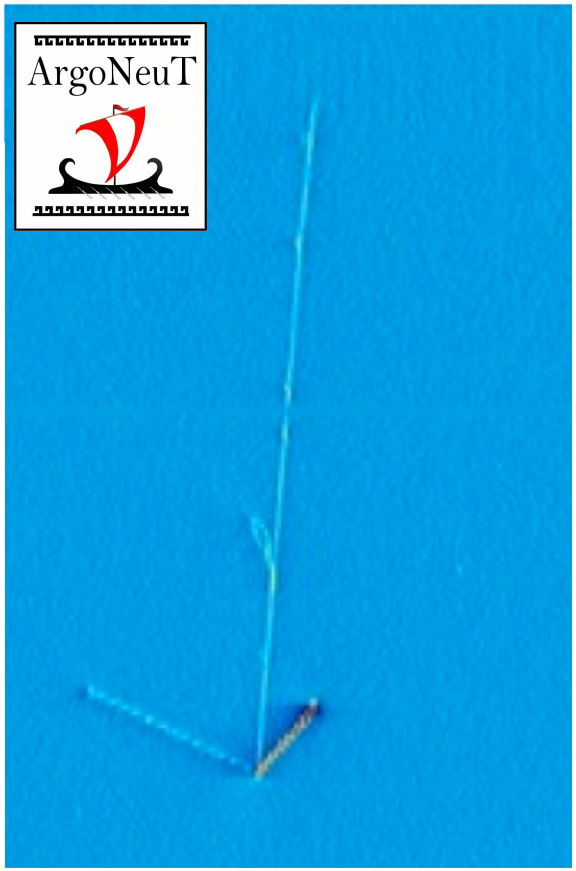
What is SBND?



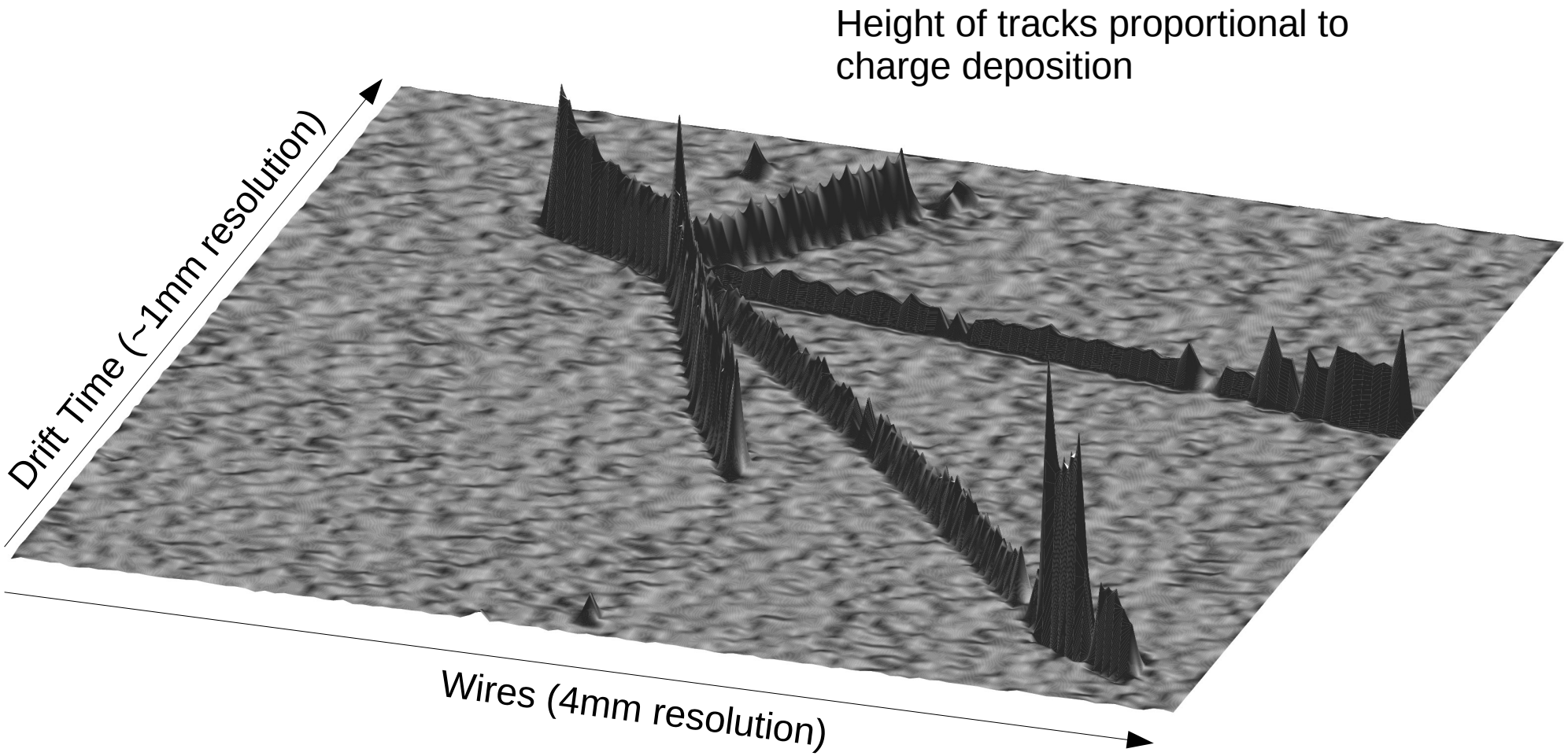
The first of three (along the beam, not in time!) Liquid Argon Time Projection Chambers along the Booster Neutrino Beam

Liquid Argon Time Projection Chamber

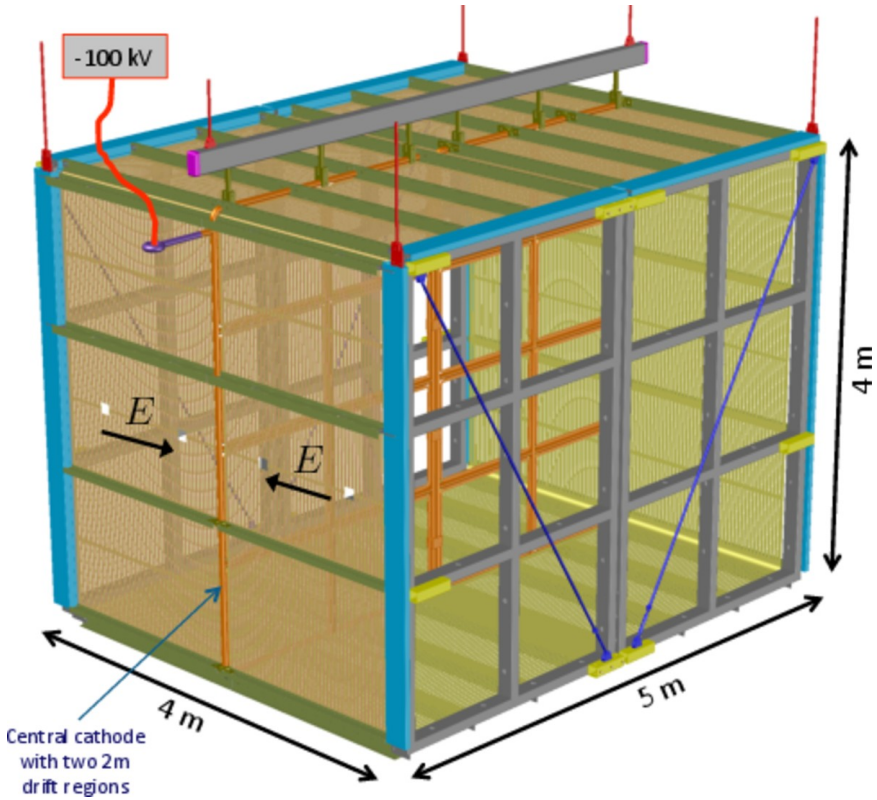


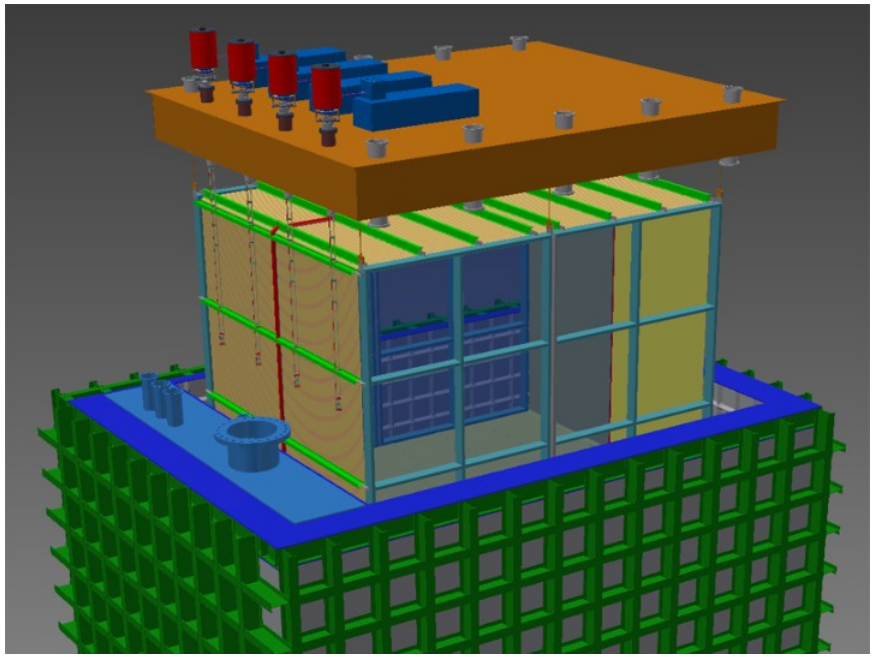


Precision Imaging AND Calorimetry



SBND Design



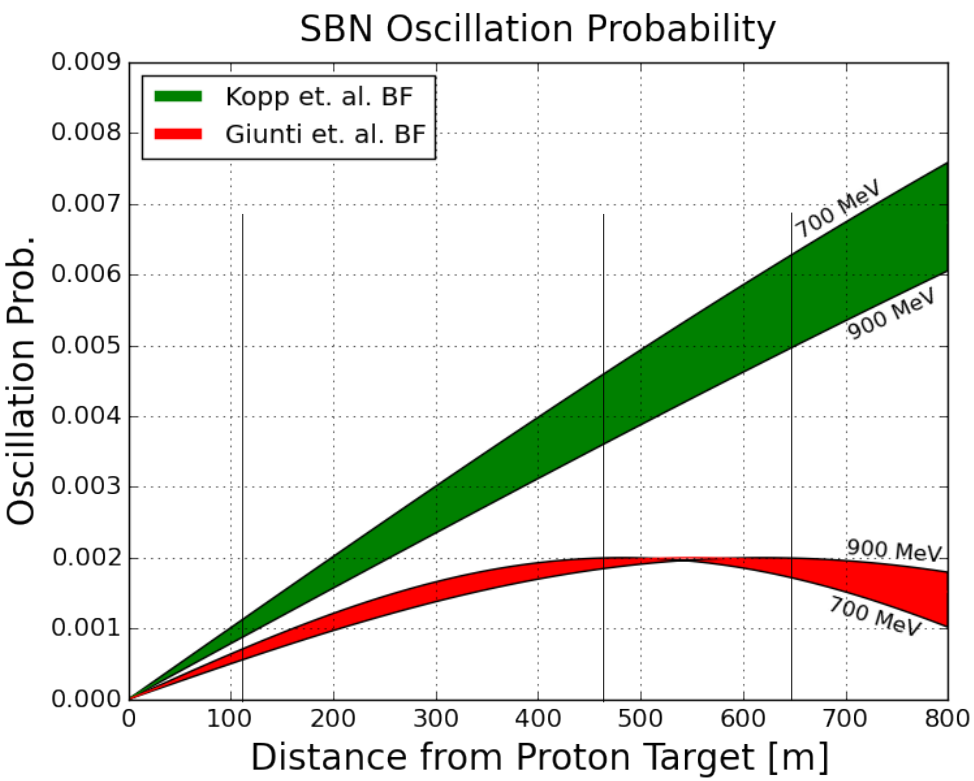


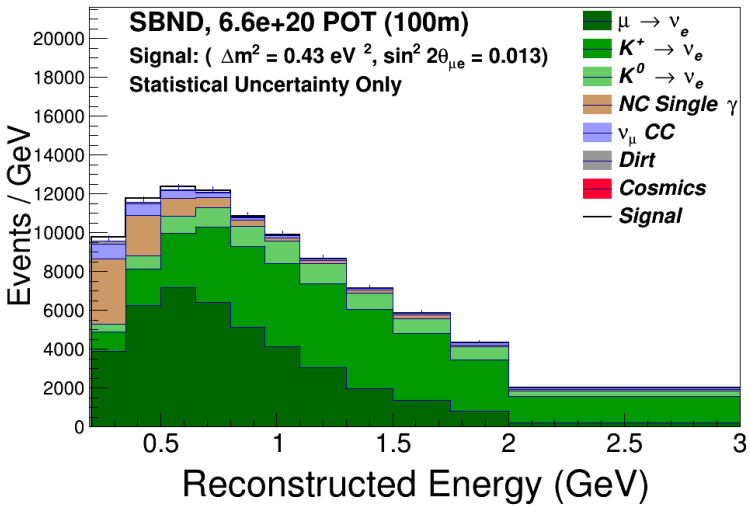
Short Baseline Near Detector

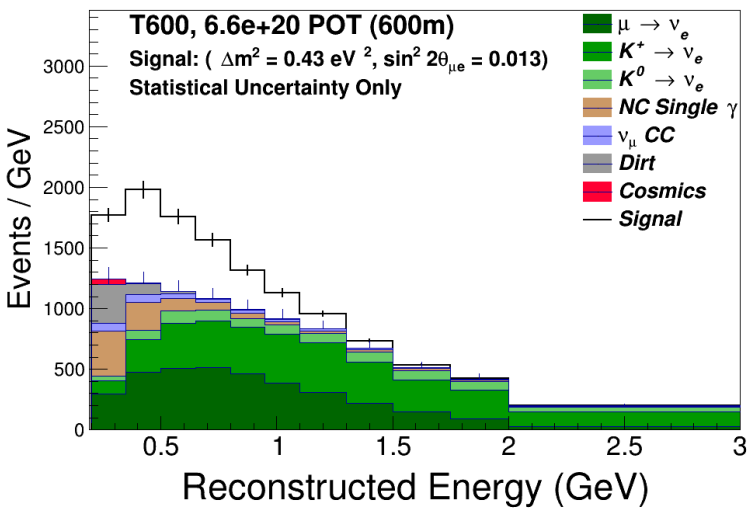
Design is mature, assembly starting soon.

SBN Oscillation Search

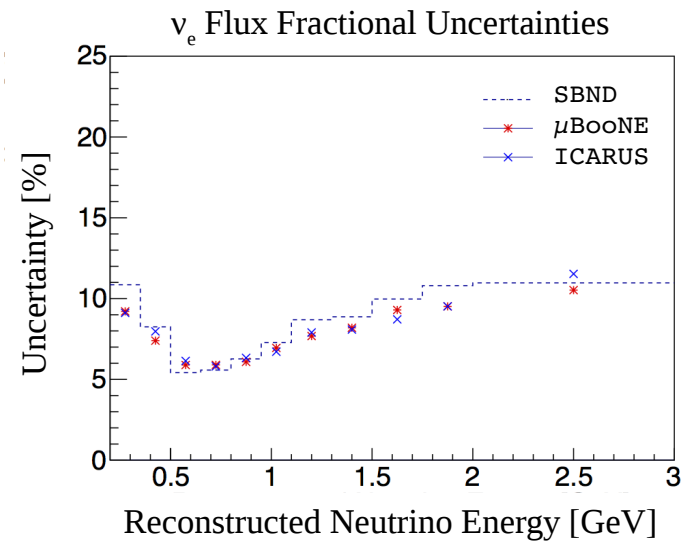
$$P(\nu_\mu \to \nu_e) = \sin^2 2\theta_{\mu e} \times \sin\left(1.267 \frac{\mathrm{GeV}}{\mathrm{eV}^2\mathrm{km}} \frac{L}{E} \Delta m^2_{41}\right)$$

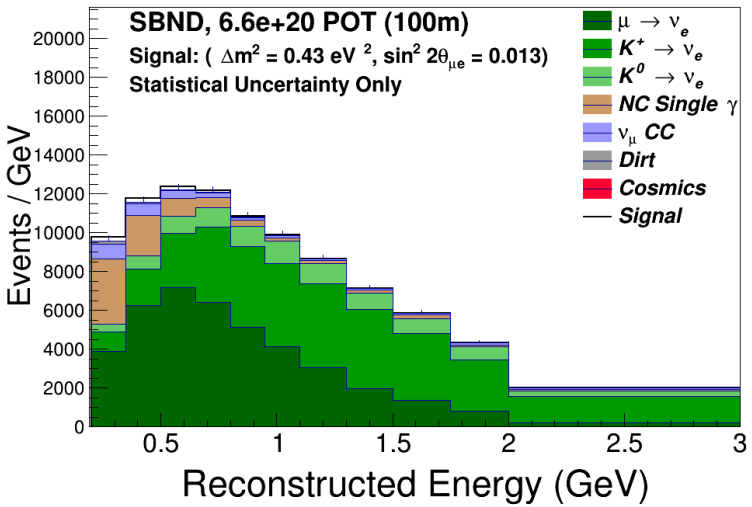


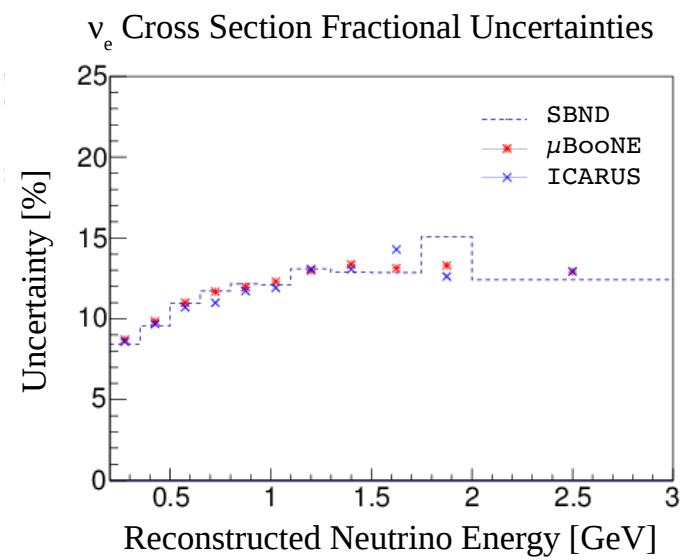


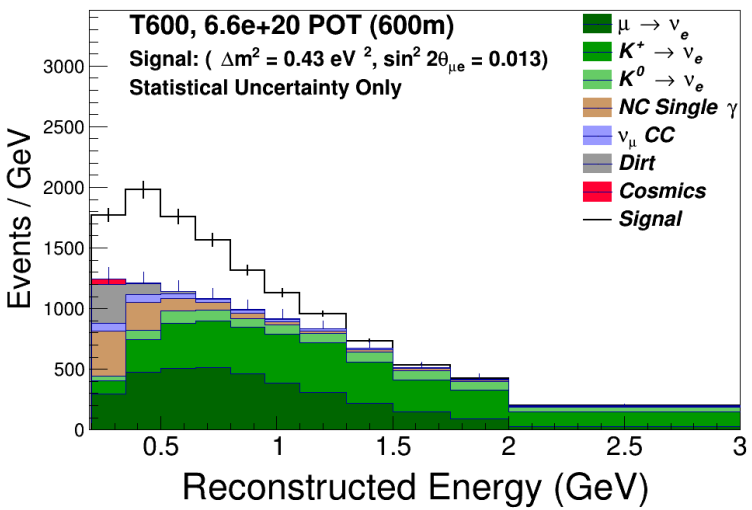


Reducing Uncertainties

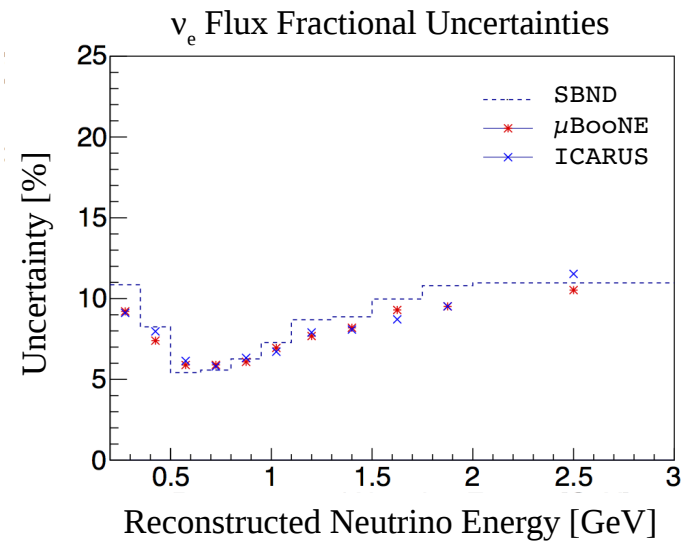


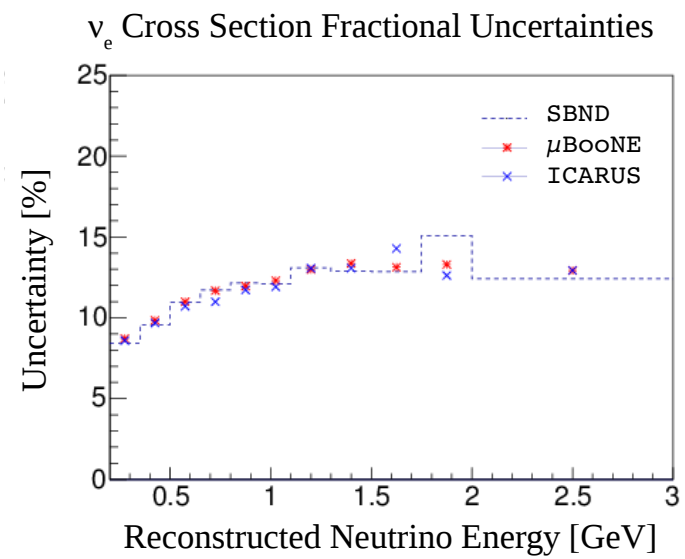






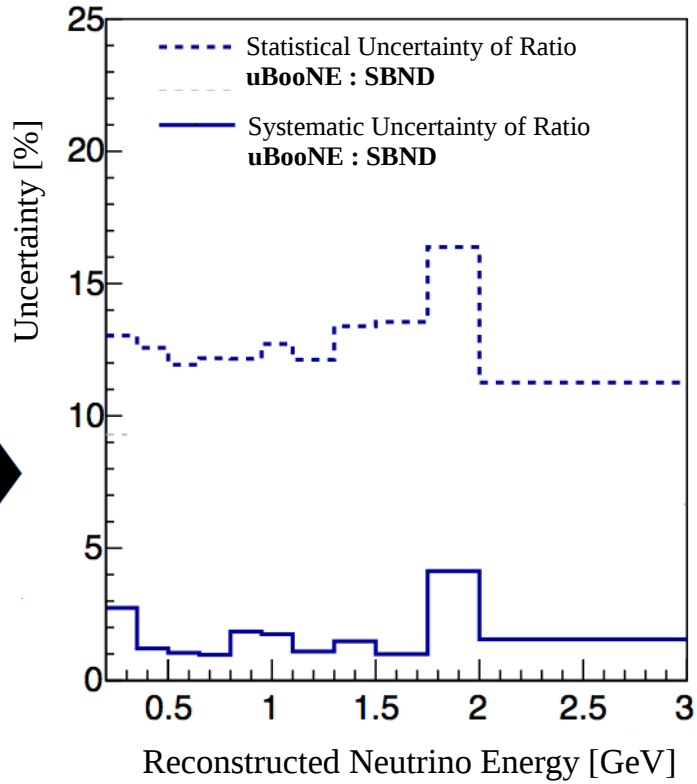
Reducing Uncertainties





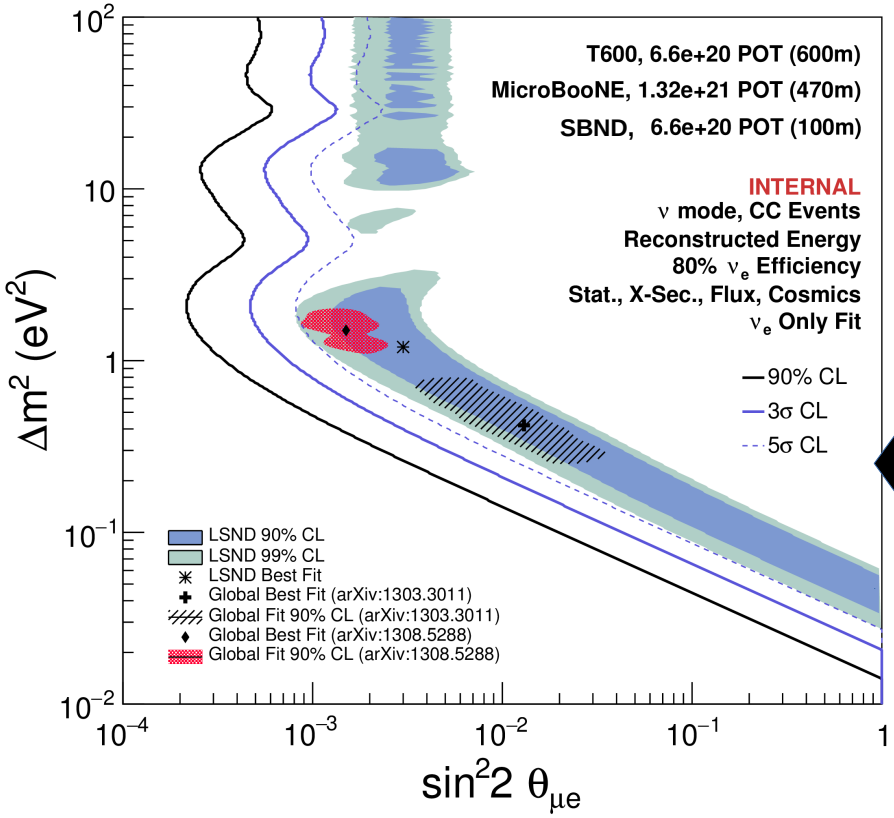
Same Beam

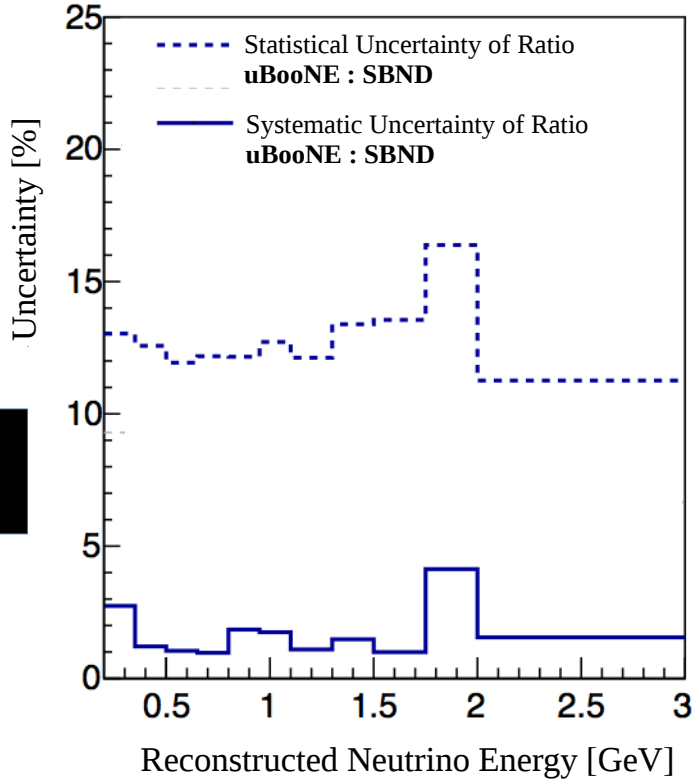
Same Detector



Large correlations in systematic uncertainties lead to large cancellations

Reducing Uncertainties



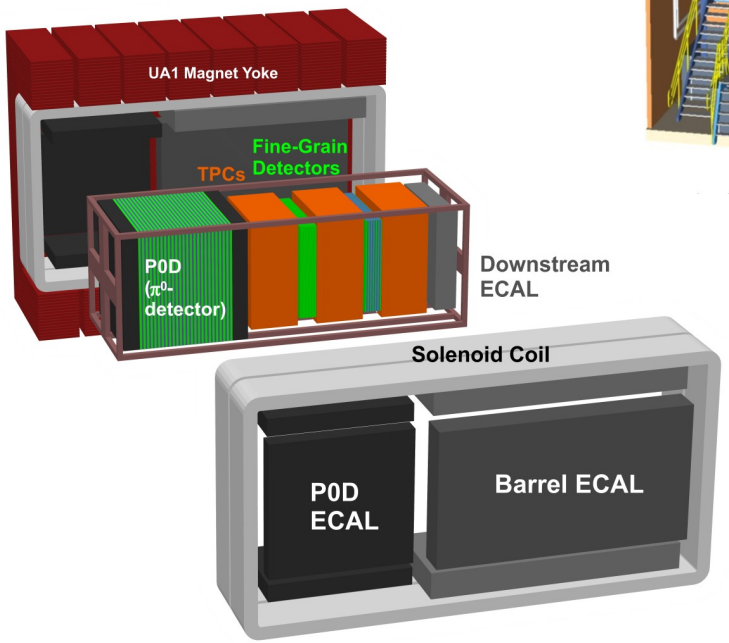


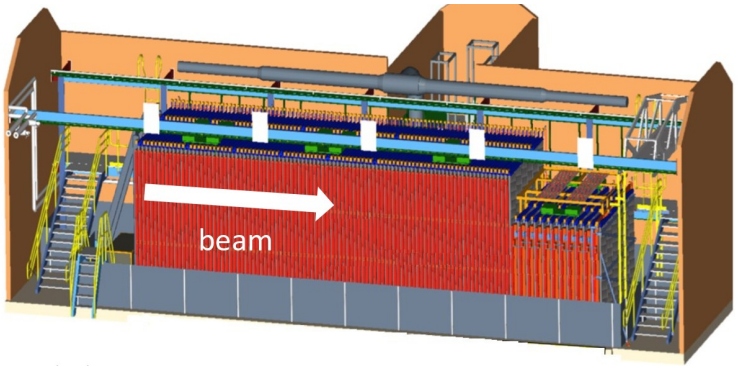
Large correlations in systematic uncertainties lead to large cancellations

What About Cross Sections?

Near Detectors have a history of excellent cross section measurements

ND280



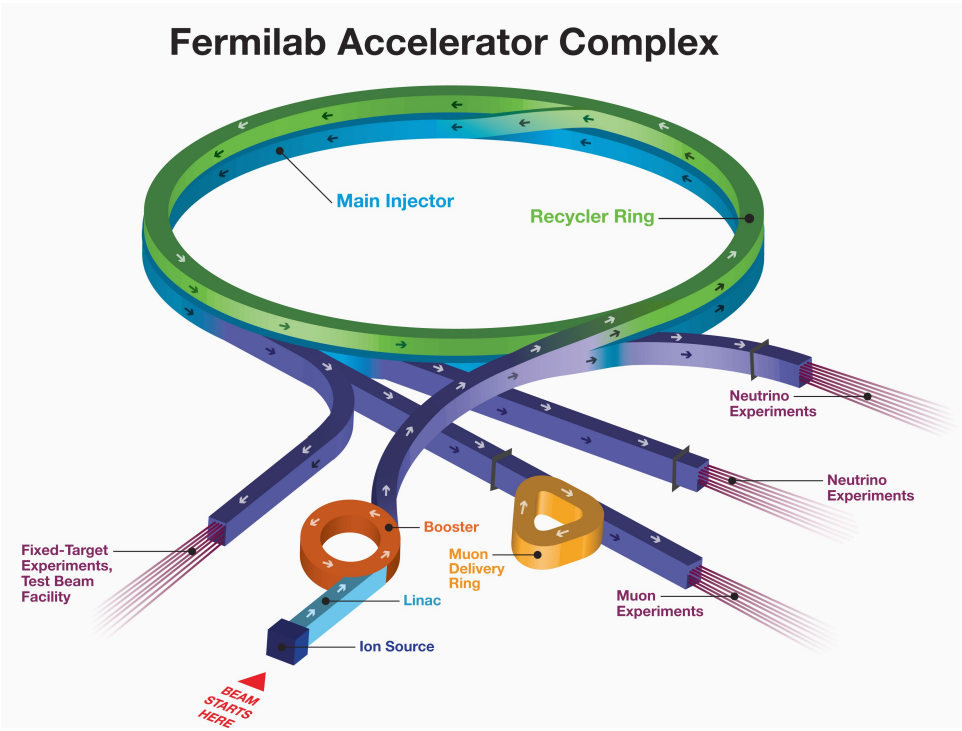


Nova Near Detector

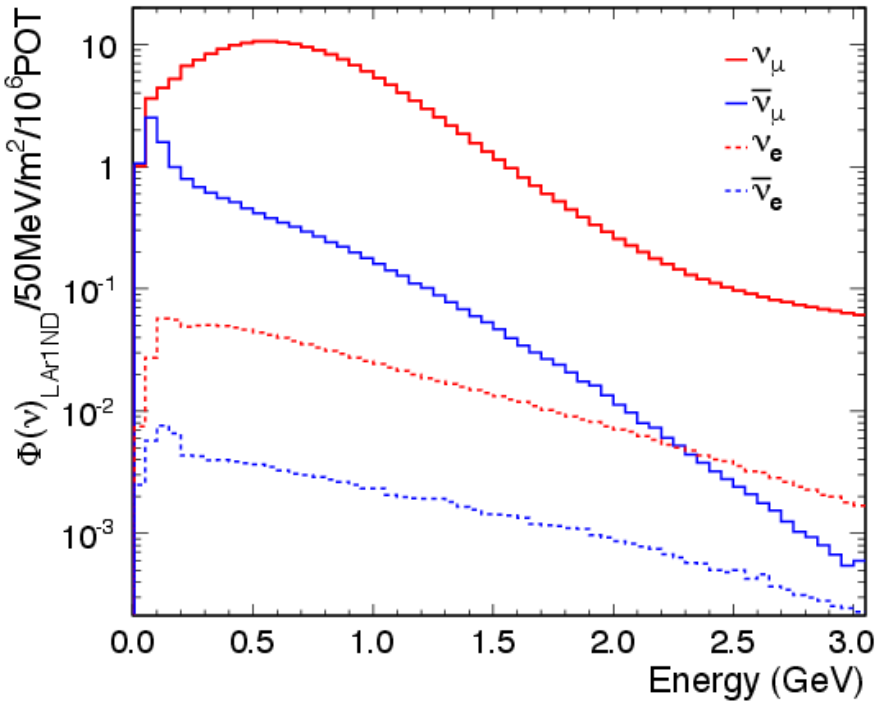
Minos Near Detector

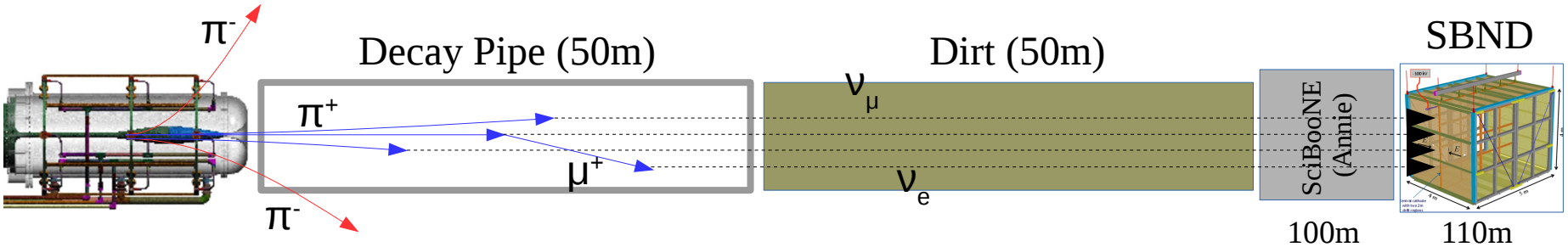
(Not to exclude dedicated experiments like Minerva!)

Neutrino Flux at SBND

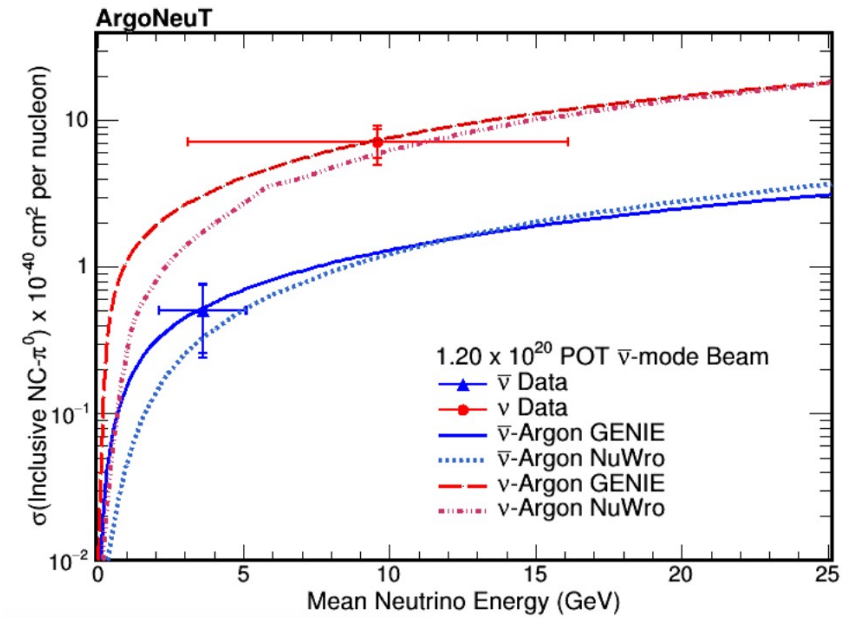


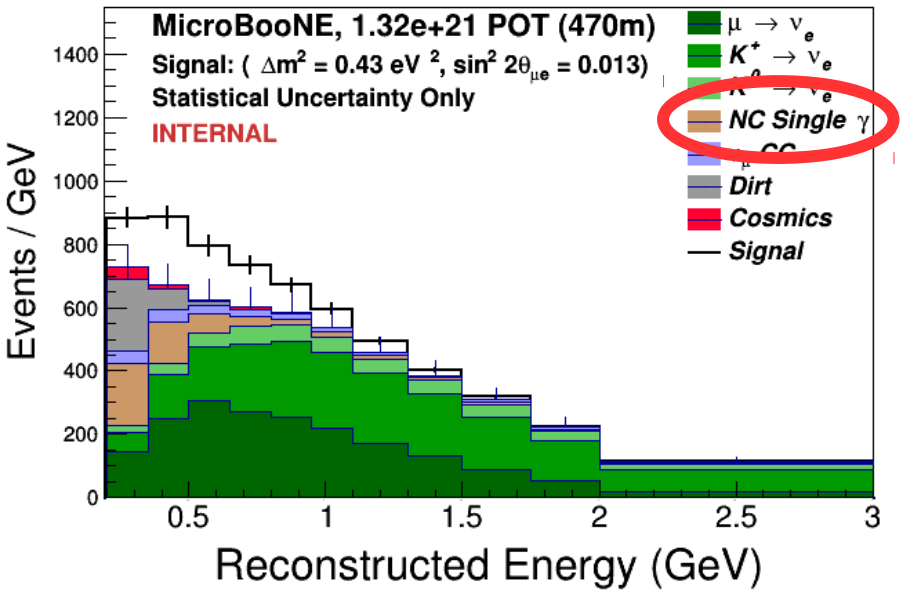
SBND Flux ~30x MicroBooNE Flux

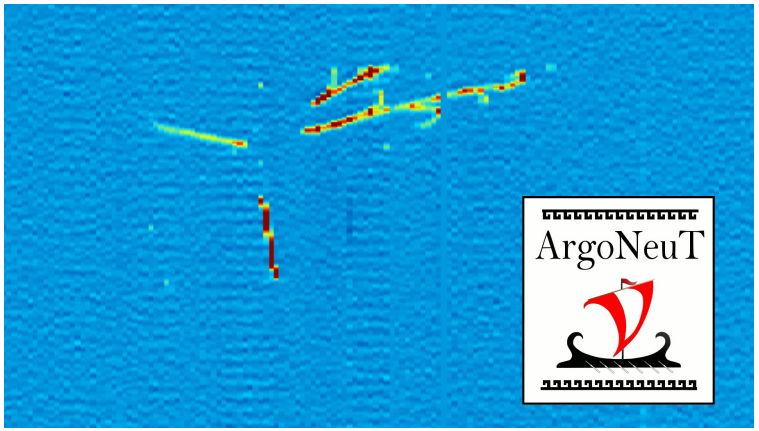




Neutral Current Backgrounds



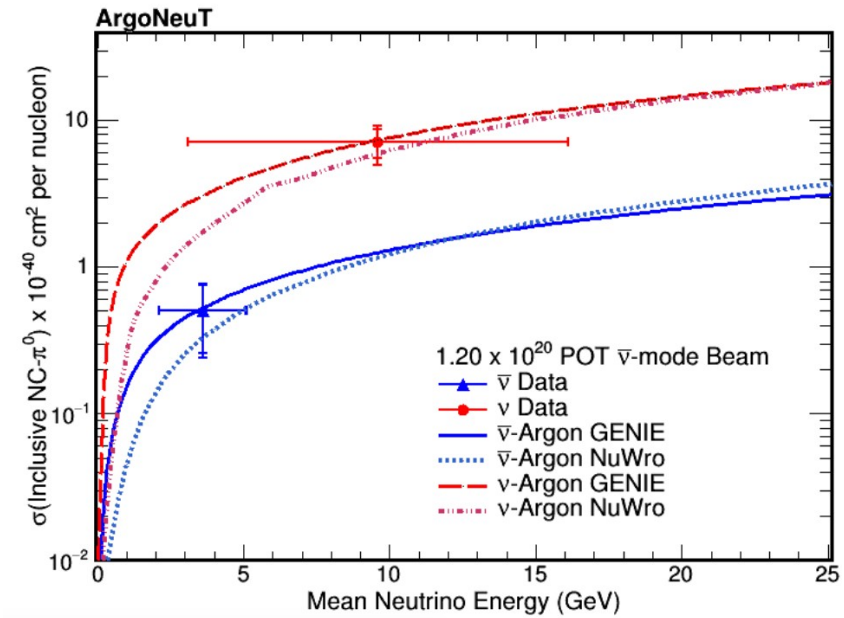


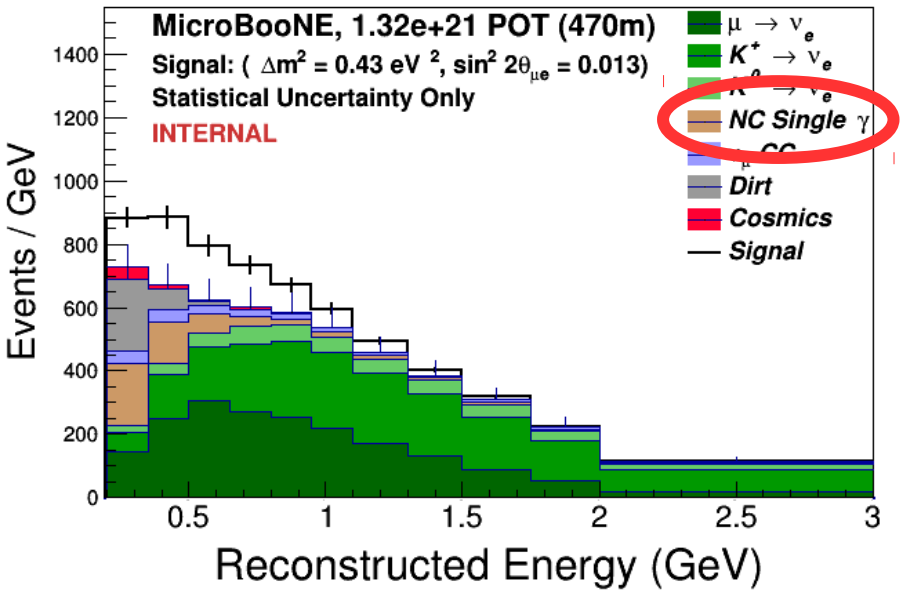


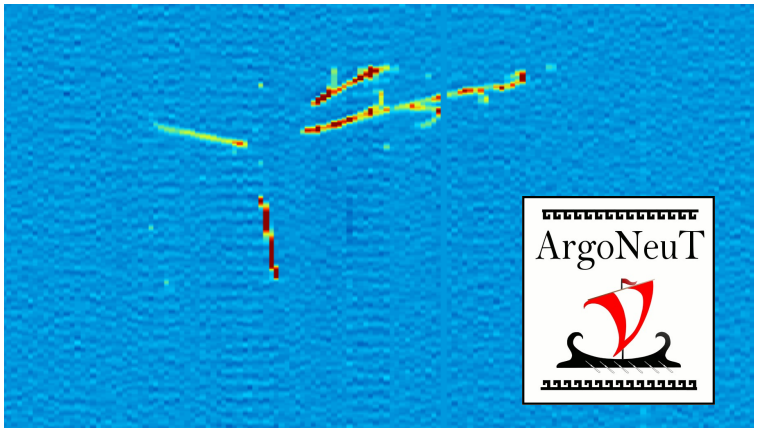
SBND Charged Current Neutral Pion Expectations (GENIE estimate, rounded)

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

Neutral Current Backgrounds







SBND Charged Current Neutral Pion Expectations (GENIE estimate, rounded)

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CC + 1 pi0	14,000	166,000	498,000
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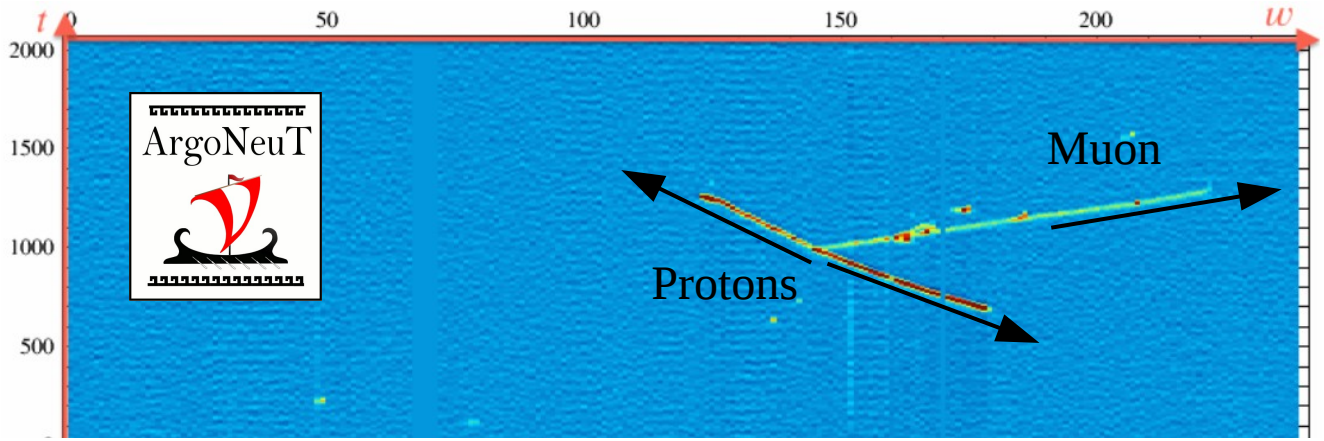
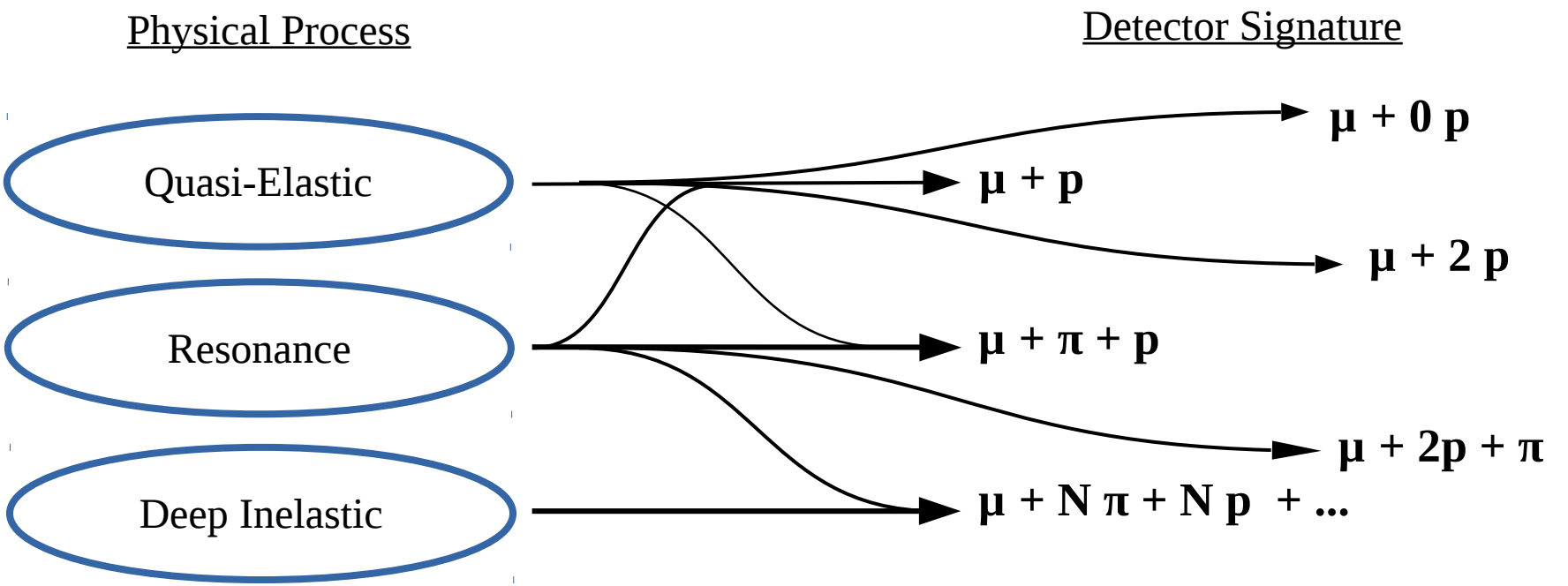
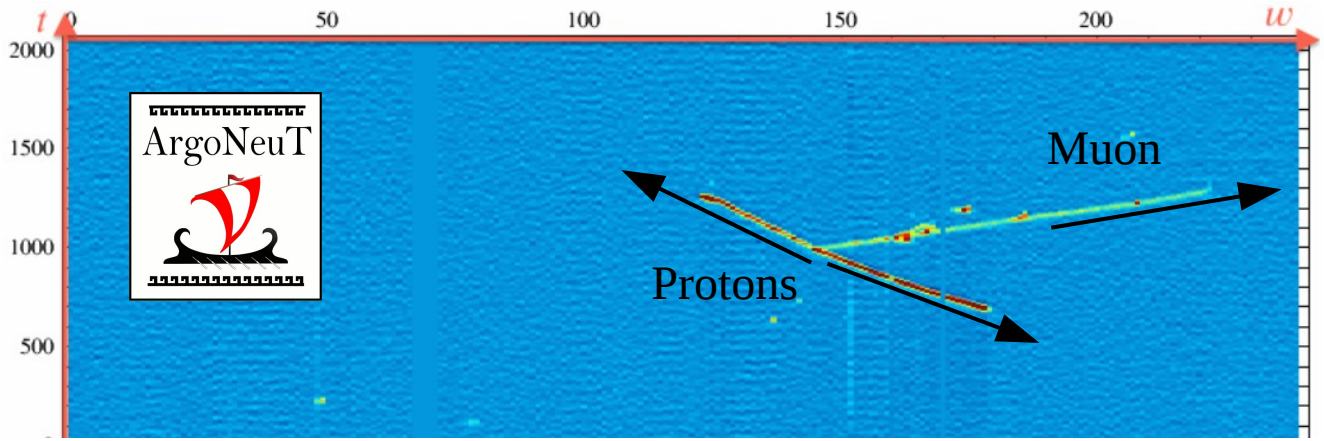
Final State Interactions

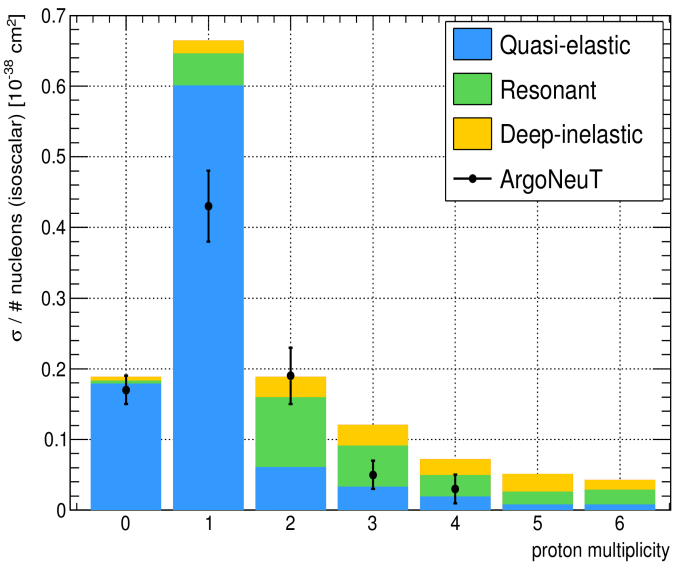




Phys. Rev. D 90, 012008 (2014)

Final State Interactions

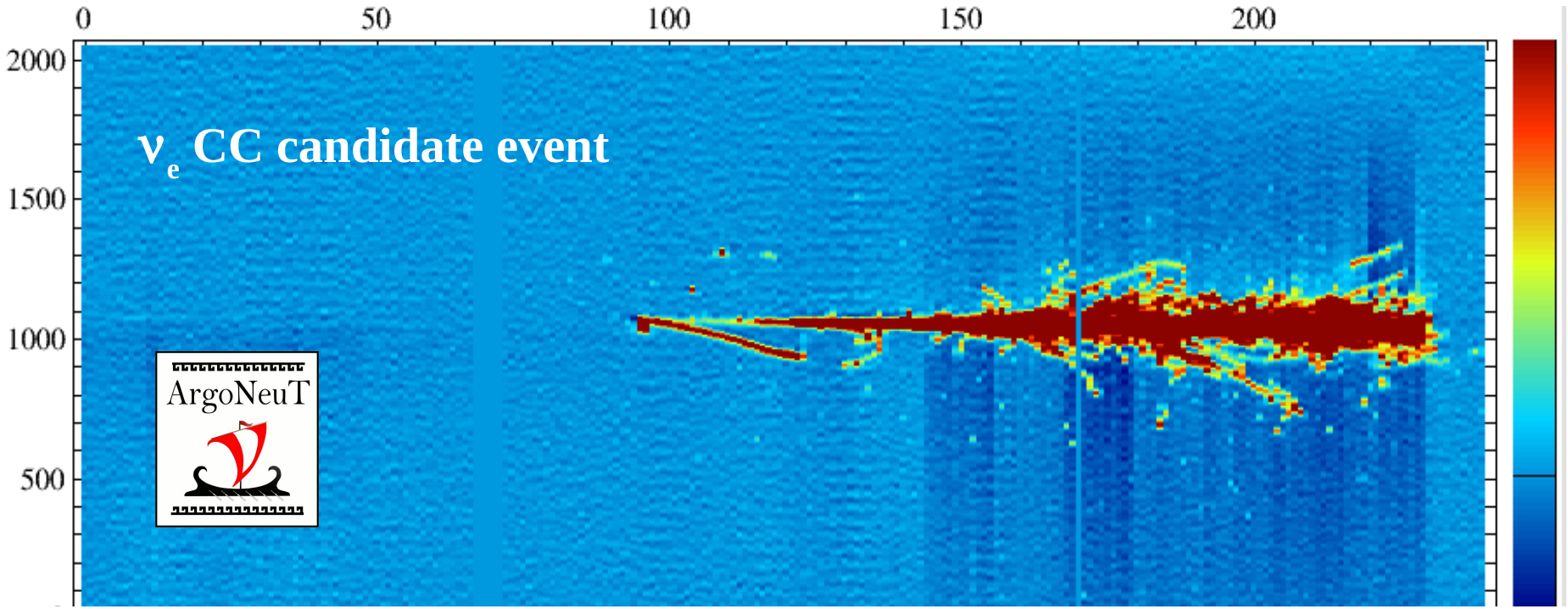




SBND Charged Current Zero Pion Expectations (GENIE estimate, rounded)

	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

Electron Neutrinos

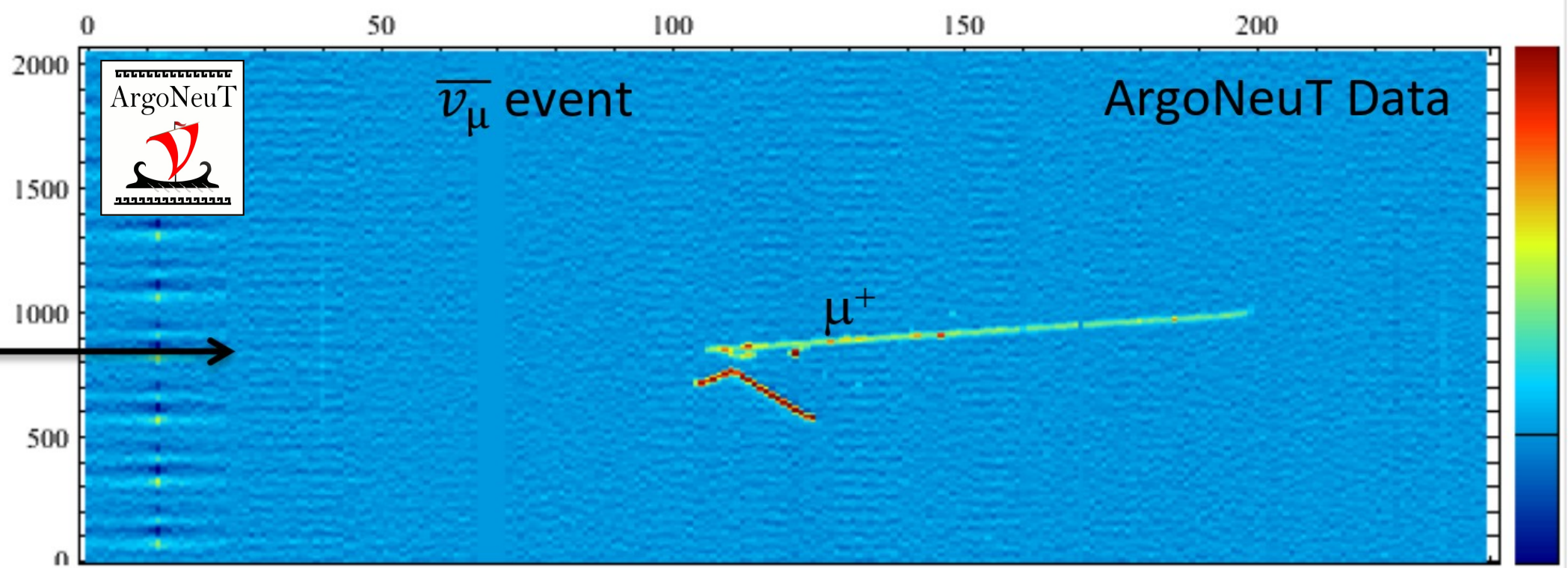


SBND Charged Current Electron Neutrino Expectations (GENIE estimate, rounded)

	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



SBND 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.

SBND Timeline

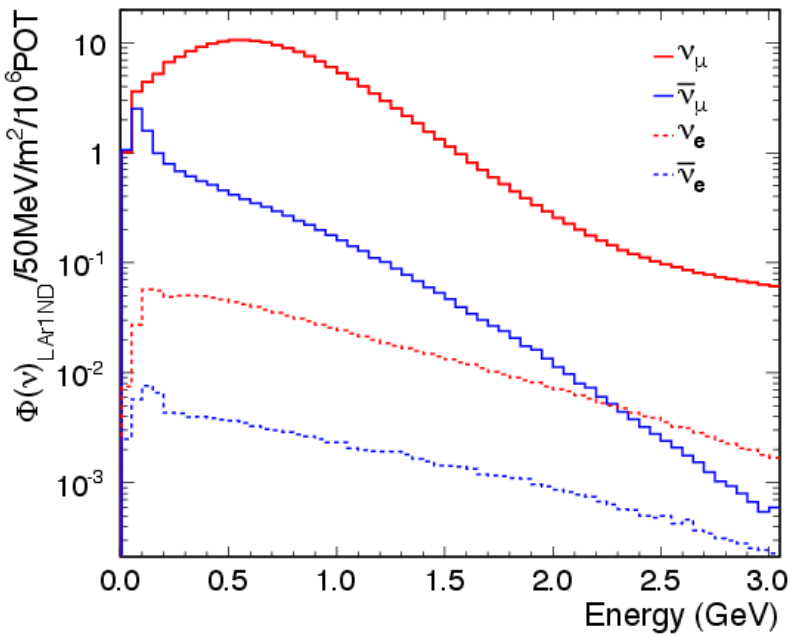
- Design is mature and nearly final (June 2016)
- Ground Breaking for the detector hall April 2016!
- Detector Operations begin 2018
- Stay updated at our website!

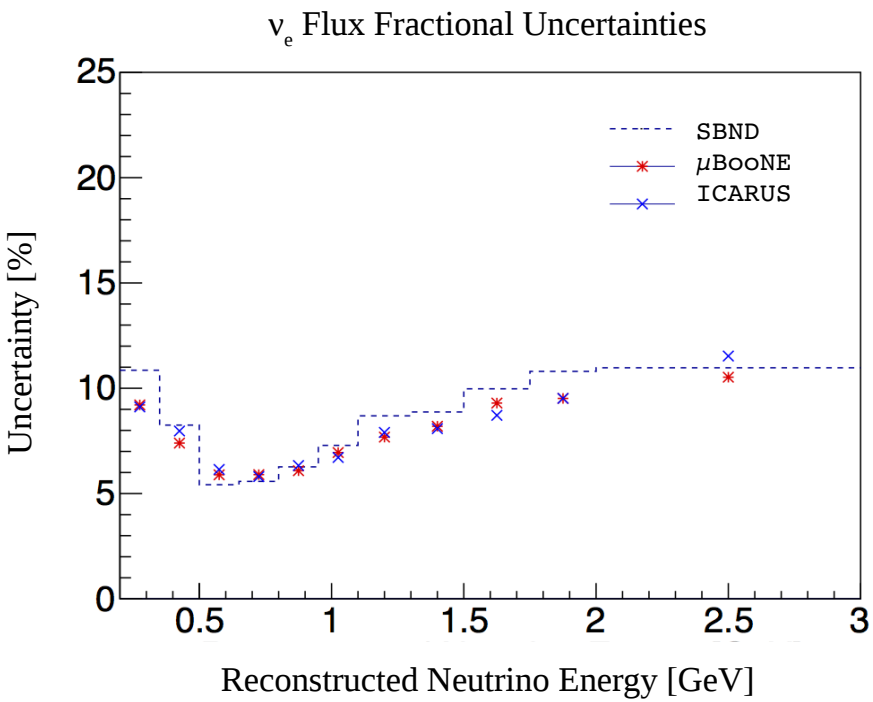
Thanks!

- **Argonne National Lab**: Z. Djurcic, R. Dharmapalan, G. Drake, M. Goodman, S. Magill
- **University of Bern**: M. Auger, A. Ereditato, D. Göldi, R. Hänni, I. Kreslo, D. Lorca, M. Lüthi, C. Rudolf von Rohr, J. Sinclair, M. Weber
- **Brookhaven National Lab**: M. Bishai, H. Chen, J. Farrell, J. Fried, G. De Geronimo, J. Joshi, D. Lissauer, X. Qian, V. Radeka, C. Thorn, E. Worcester, B. Yu
- **University of Cambridge**: M. Thomson
- **University of Campinas – UNICAMP**: C. Castromonte, C. Escobar, E. Kemp, P. Holanda, A. Machado, M. Nunes, L. Santos, E. Segreto
- **CERN**: S. Bertolucci, J. Bremer, U. Kose, D. Mladenov, M. Nessi, F. Noto
- **University of Chicago**: W.M. Foreman, J. Ho, R. Northrop, D.W. Schmitz*, J. Zennamo
- **Columbia University**: L. Camilleri, C. Chi, J. Crespo, V. Genty, M.H. Shaevitz, B. Sippach, K. Terao
- **Federal University of ABC** – UFABC: F. Kamiya, C. Moura, L. Paulucci
- **Federal University of Alfenas** – UFAL: G. Valdiviesso
- **Fermilab**: W. Badgett, L. Bagby, B. Baller, F. Cavanna, S. Dixon, R. Fernandez, M. Geynisman, H. Greenlee, J. Howell, C. James, W. Ketchum, M.J. Kim, T. Miao, D. Montanari, B. Norris, O. Palamara*, Z. Pavlovic, G. Petrillo, R. Rameika, K. Sachdev, M. Stancari, T. Strauss, M. Toups, P. Wilson, G.P. Zeller
- **Illinois Institute of Technology**: J. Echevers, I. Lepetic, B. Littlejohn, D. Martinez,
- **Indiana University**: S. Mufson, D. Whittington
- **Kansas State University**: S. Gollapinni, G. Horton-Smith
- **Lancaster University**: A. Blake, D. Brailsford, J. Cockings, D. Devitt, I. Mercer, J. Nowak, P. N. Ratoff
- **University of Liverpool**: C. Andreopoulos, S. Dennis, K. Mavrokoridis, N. McCauley, D. Payne, A. Roberts, P. Sutcliffe, C. Touramanis
- **Los Alamos National Lab:** G. Garvey, W.C. Louis, G.B. Mills, K. Rielage, R.G. Van de Water
- **University of Manchester**: A. Bitadze, J. Evans, J. Freestone, D. Garcia Gamez, G. Karagiorgi, J. Pater, S. Söldner-Rembold, A.M. Szelc
- **University of Michigan**: J. Mousseau, B. Roe, J. Spitz
- **MIT**: J.M. Conrad, J. Moon, T. Wongjirad
- **University of Oxford**: M. Bass, R. Guenette
- **Pacific Northwest National Lab**: E. Church
- **University of Pennsylvani**a: N. Barros, S. Glavin, J. Klein, D. Rivera
- **University of Puerto Rico**: K. Matias, H. Mendez, S. Santana
- **University of Sheffield**: T. Gamble, V.A. Kudryavtsev, N. McConkey, J. Mercer, F. Mounton, J. Perkin, N. Spooner, M. Thiesse
- **Syracuse University**: J. Esquivel, P. Hamilton, G. Pulliam, M. Soderberg
- **University of Texas, Arlington**: J. Asaadi
- **University College London**: M. Cascella, A. Holin, R. Nichol, D. Waters
- **Virginia Tech**: C.M. Jen, C. Mariani
- **Yale University**: C. Adams, B.T. Fleming, E. Gramellini, A. Hackenburg, X. Luo, B. Russell, S. Tufanli

Backup

Flux Uncertainty

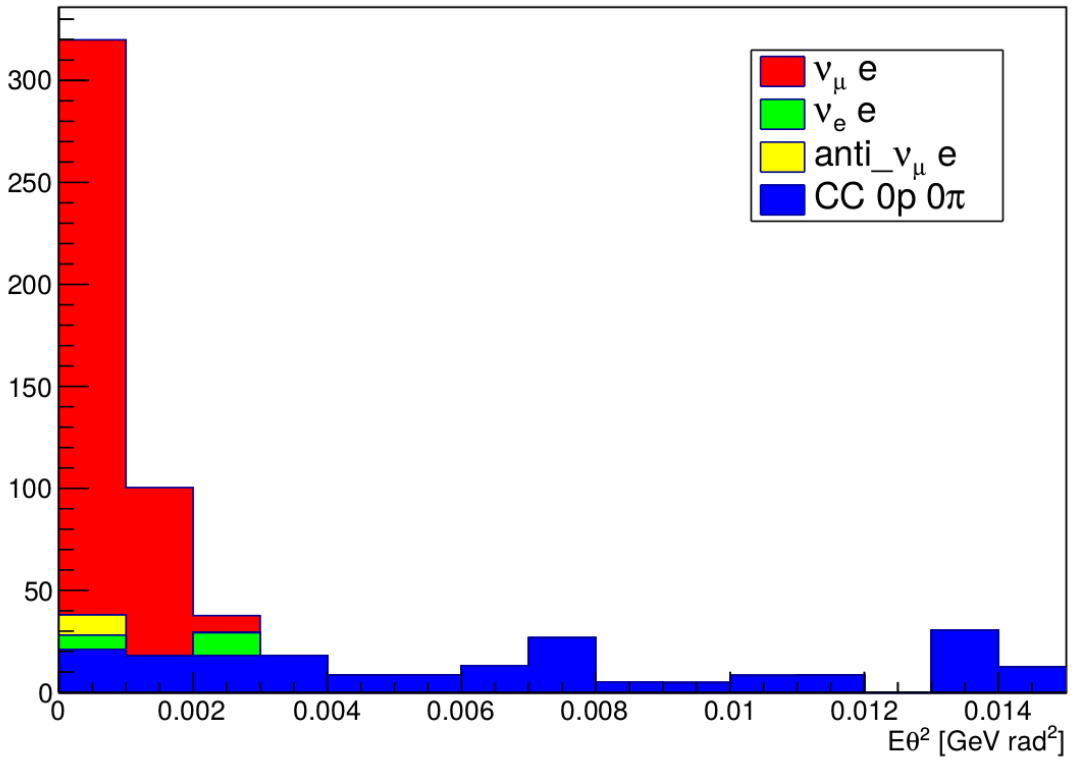




Many analyses shown here will be systematics limited in just months of data.

(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.