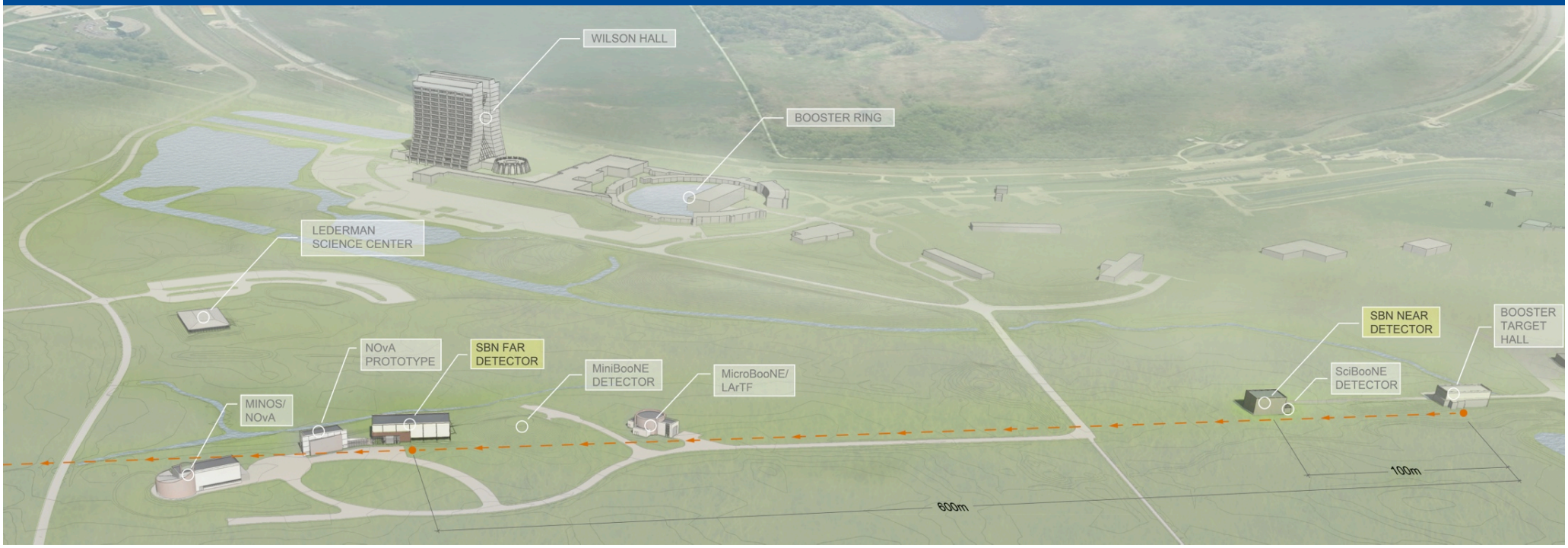

Short-Baseline Neutrino Program Discussion

Michael Kirby – SCD

5 April 2017

Outline

- SBN Program Layout
- Experiment Timelines
- Physics Goals and Sensitivity
- Minerva Timeline and Physics Goals
- LArIAT
- Short discussion

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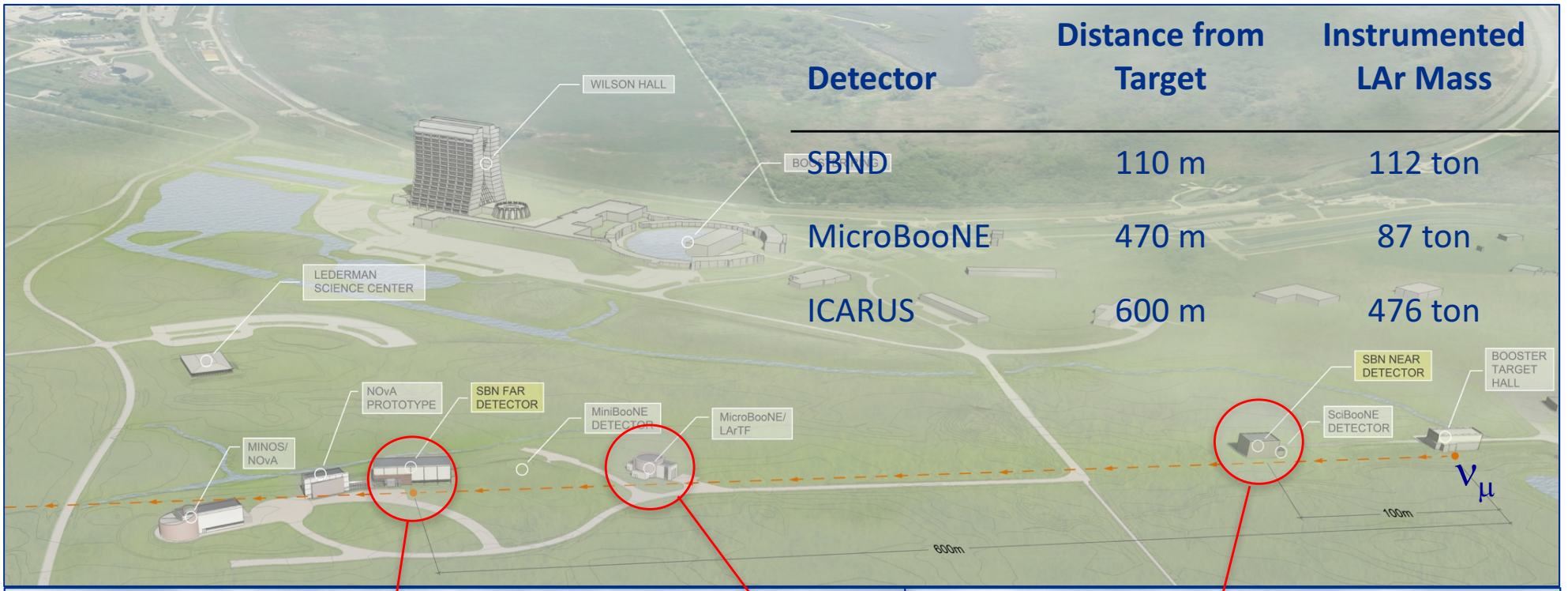
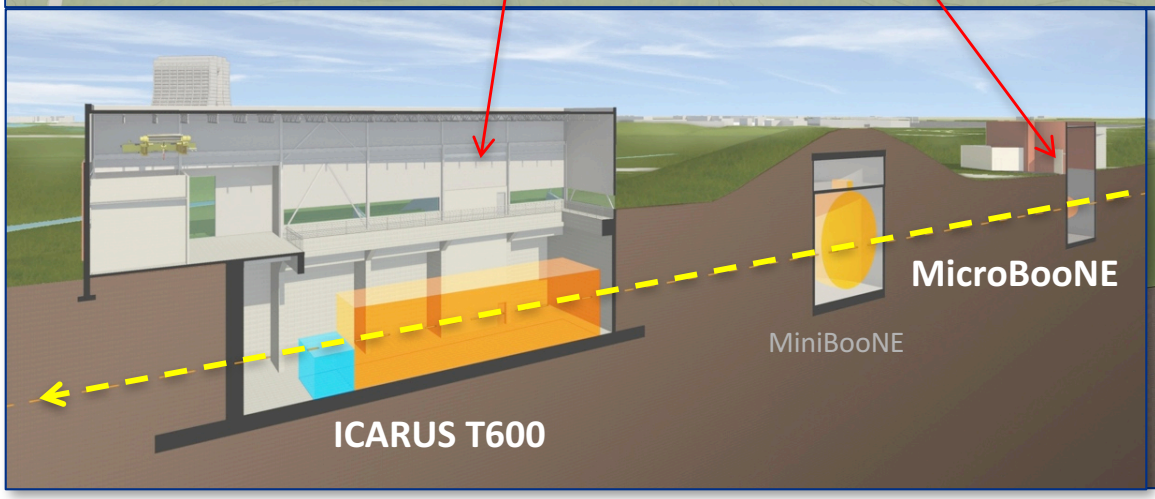
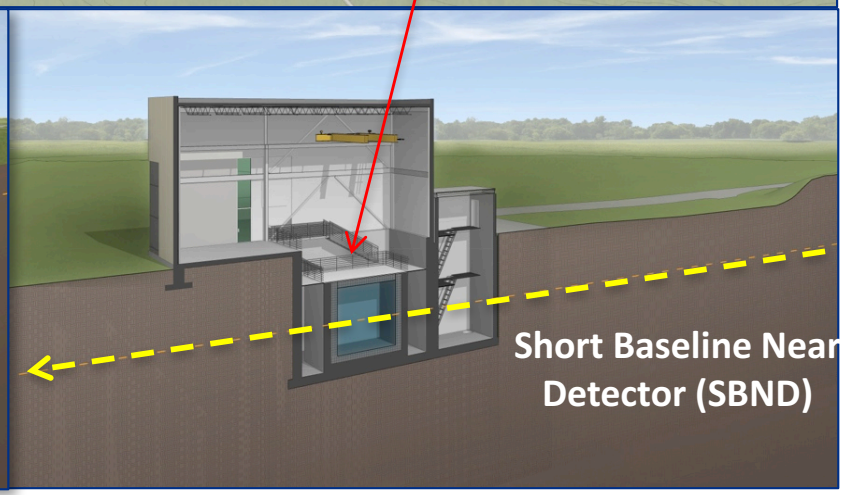
Thanks to Laura Fields, David Schmitz, and Peter Wilson for slides!

SBN Program: Three LAr TPC Detectors

Detector	Distance from Target	Instrumented LAr Mass
SBND	110 m	112 ton
MicroBooNE	470 m	87 ton
ICARUS	600 m	476 ton



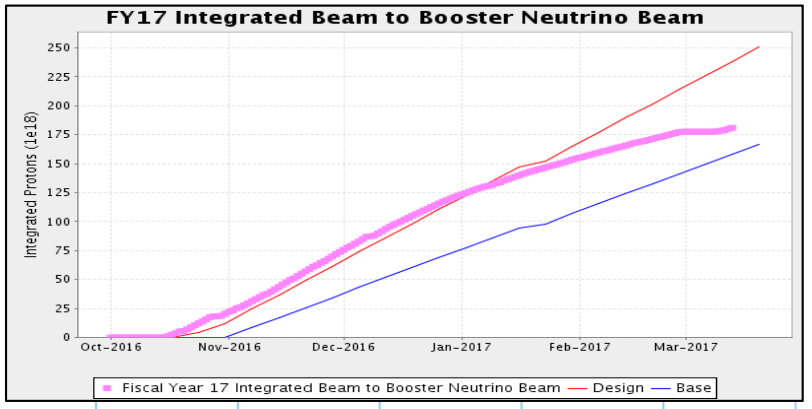




Simplified Timeline

MicroBooNE Timeline

- First 17 months of running very successful
  - Collected ~80% of initial beam request
  - Booster setting intensity records
  - 97% detector uptime with beam
  - Argon purity – ~ inf. lifetime for 2.5m drift
  - Signal/noise ratio > 40 (collection plane)



Not all activities shown

TPC Move

Readout Electronics

Cryogenics

CRT Top Design & Fabrication & Installation

Lar Fill

Commission

Operate

2Q 2014 3Q 2014 4Q 2014 1Q 2015 2Q 2015 3Q 2015 4Q 2015 1Q 2016 2Q 2016 3Q 2016 4Q 2016 1Q 2017 2Q 2017

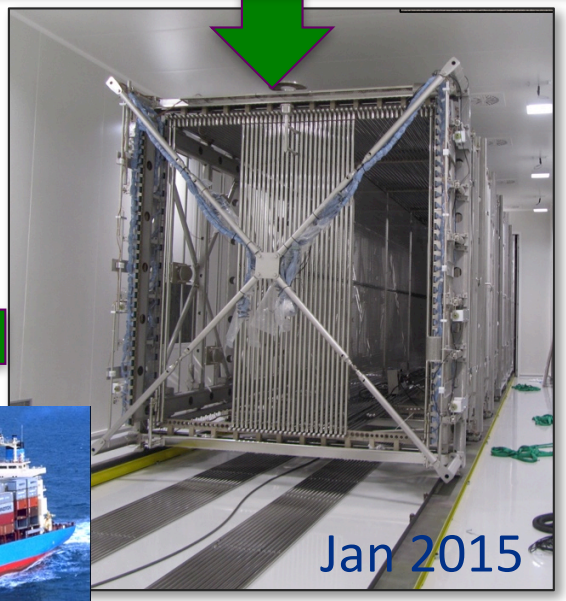
Oct 15, 2015

Timeline – Calendar year

ICARUS: Gran Sasso to Fermilab via CERN

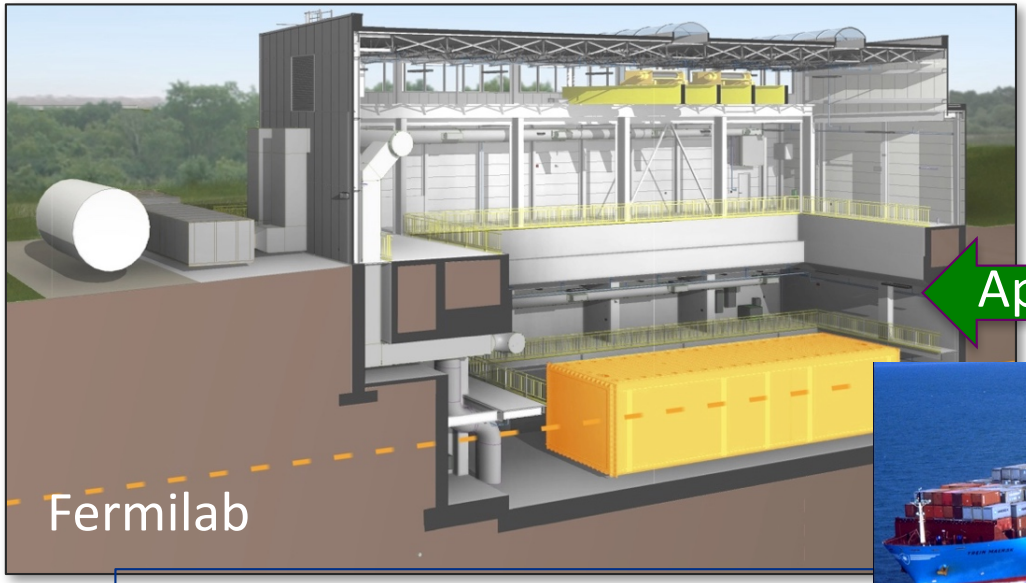
Removing from Gran Sasso

On the road to CERN



In Cleanroom @ CERN

April 2017



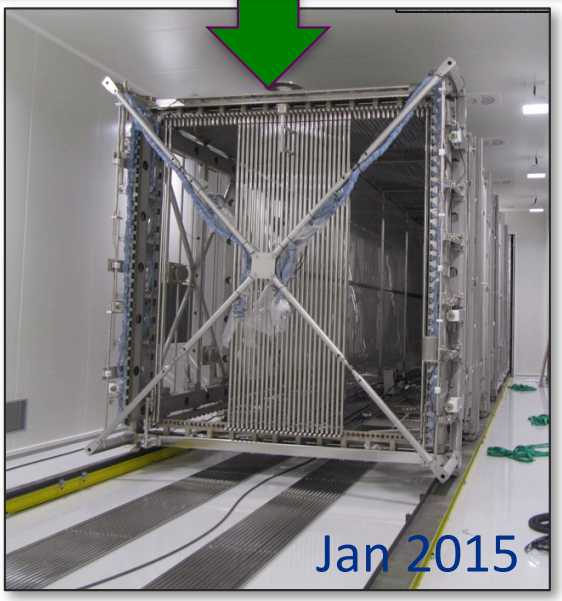
New Building at Fermilab

Fermilab

ICARUS: Gran Sasso to Fermilab via CERN

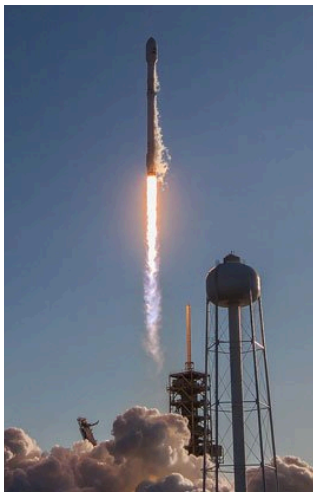
Removing from Gran Sasso

On the road to CERN



In Cleanroom @ CERN

April 1, 2017



A bright, sunshiny day for ICARUS

March 31, 2017

Share Tweet G+1 Email

Steve Brice

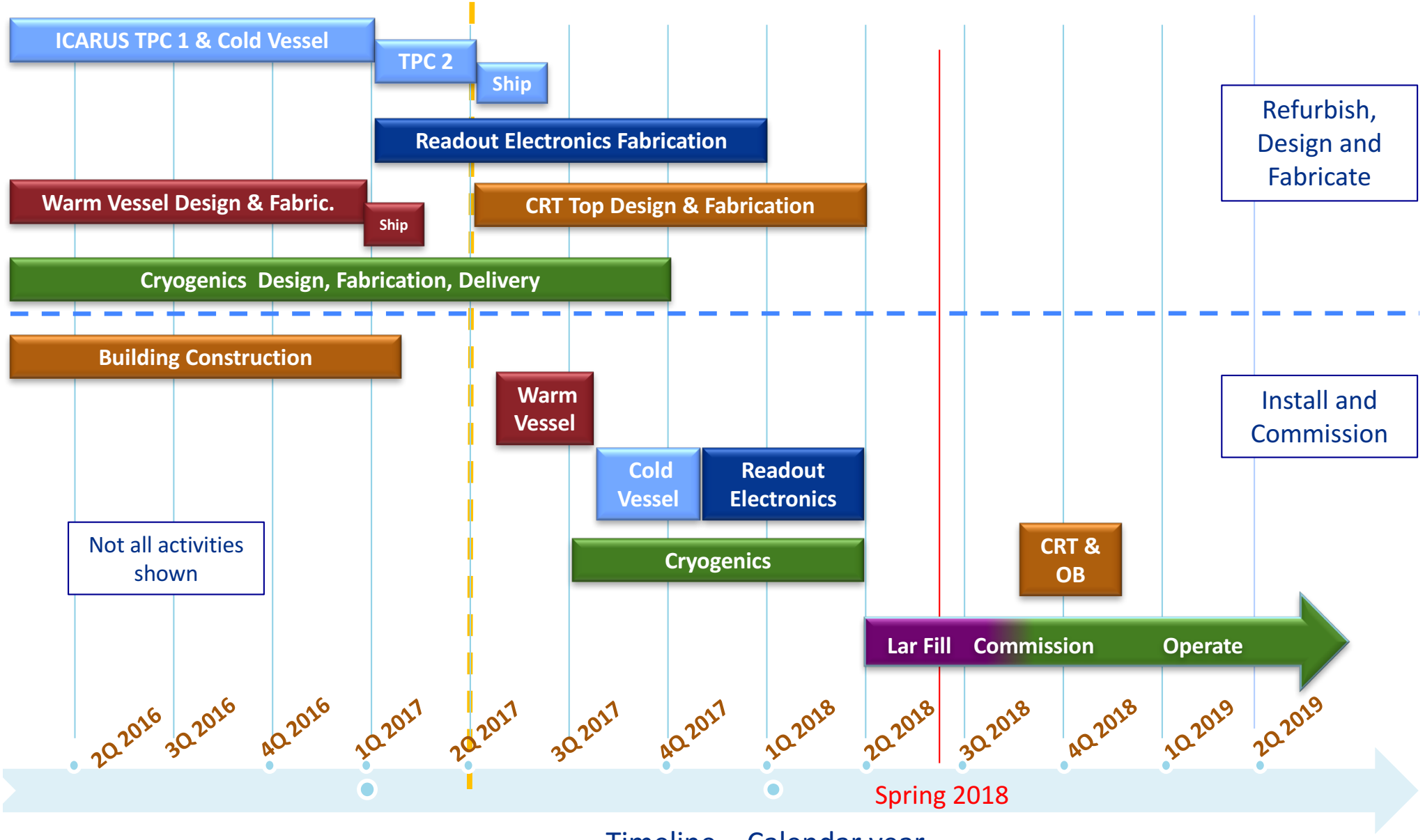
After many months of planning, preparation and proofs of promising performance, the ICARUS neutrino detector, which CERN has been refurbishing for Fermilab's Short-Baseline Neutrino Program, is making its way across the Atlantic Ocean.

And we have an exciting announcement: Because of ICARUS' soaring achievements in tests, the Fermilab Physics Advisory Committee has recommended it be used not only to look for sterile neutrinos as planned, but also for solar neutrinos. So we're renting a rocket to send the ICARUS detector 1.5 million kilometers above Earth's surface to better understand both neutrinos and the workings of the sun.

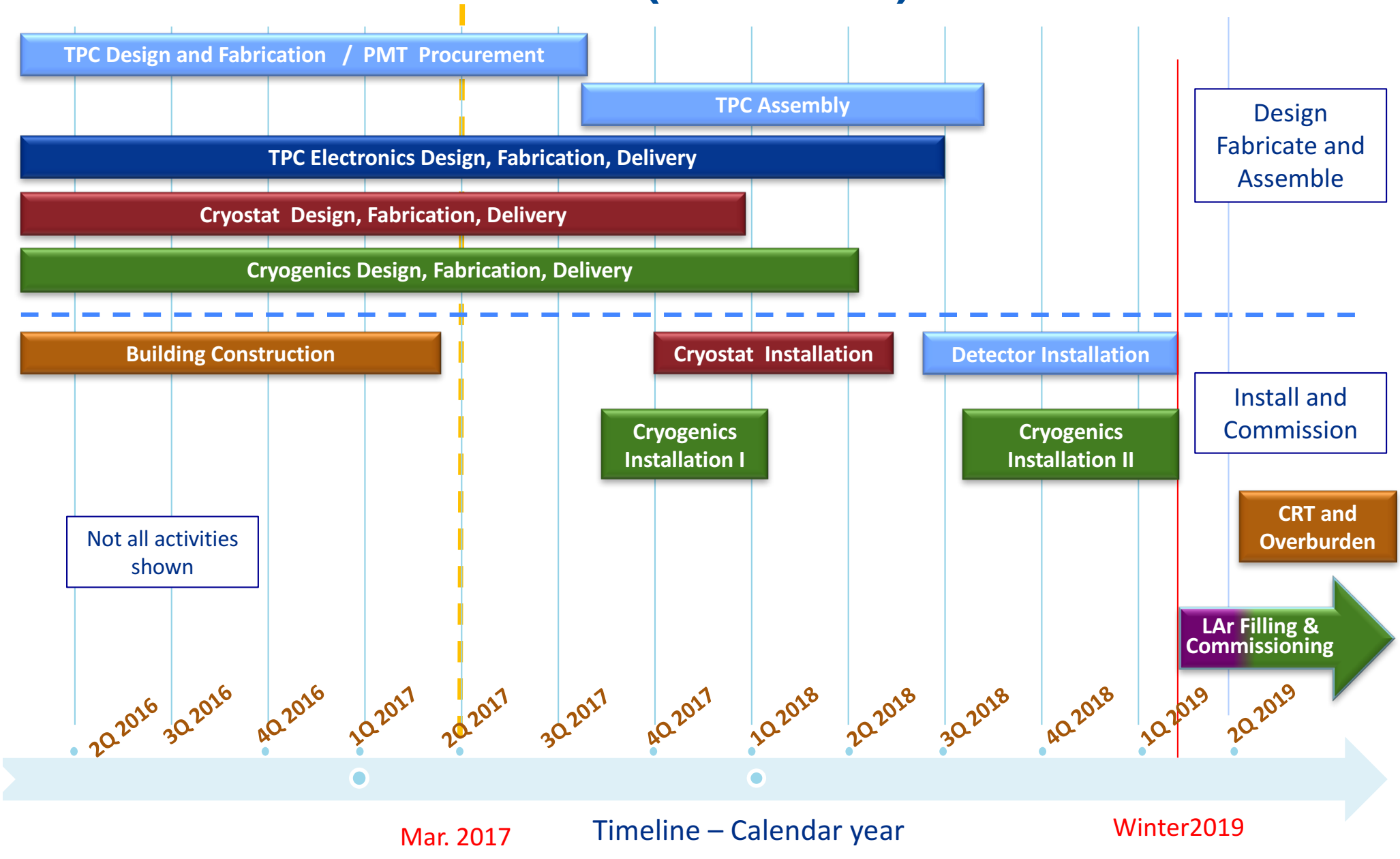
We're sending ICARUS just shy of L1, a gravitationally stable sweet spot between the sun and Earth. It's the closest to the sun any neutrino

Fermilab

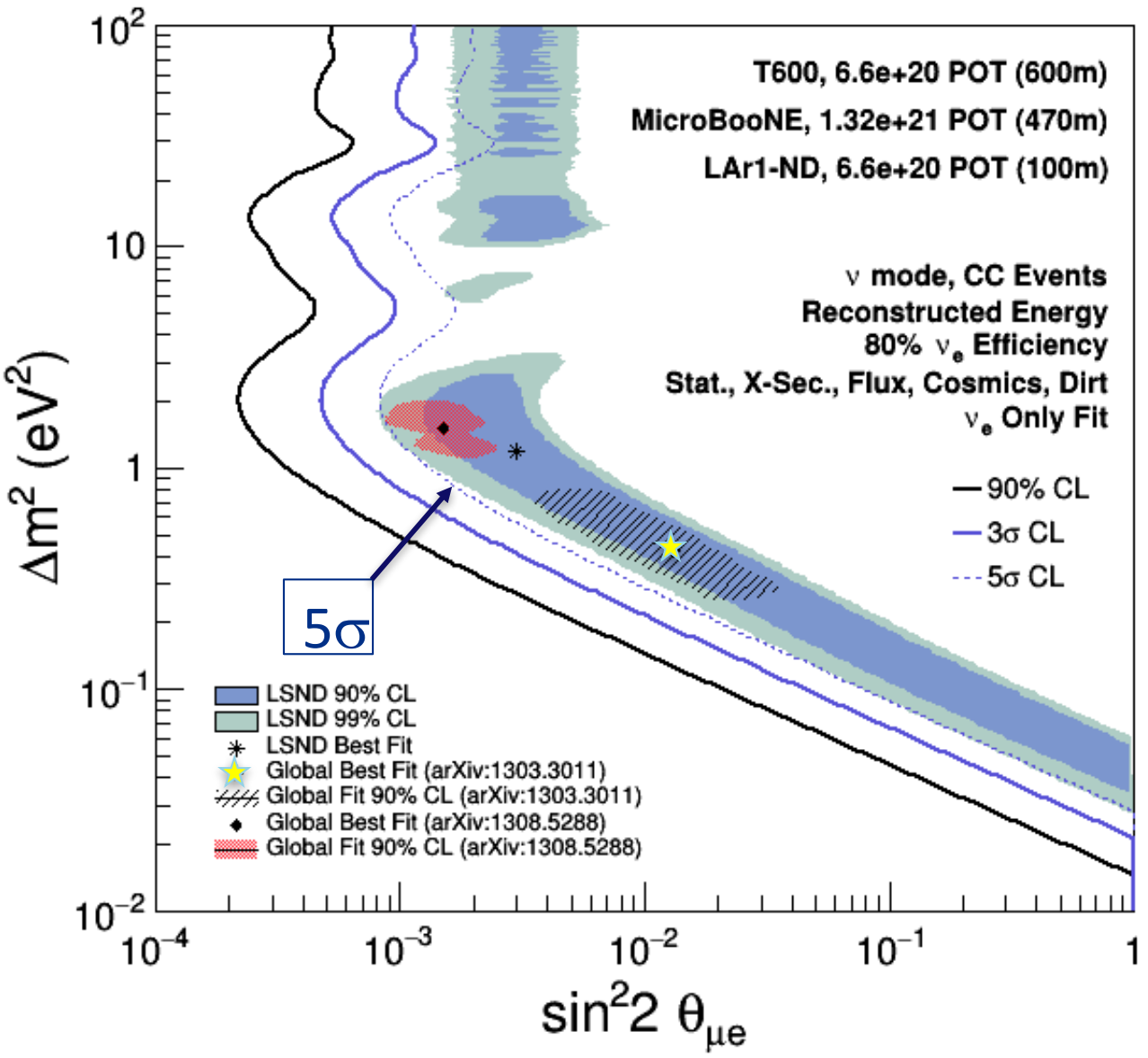
Far Detector Timeline (March 2017)

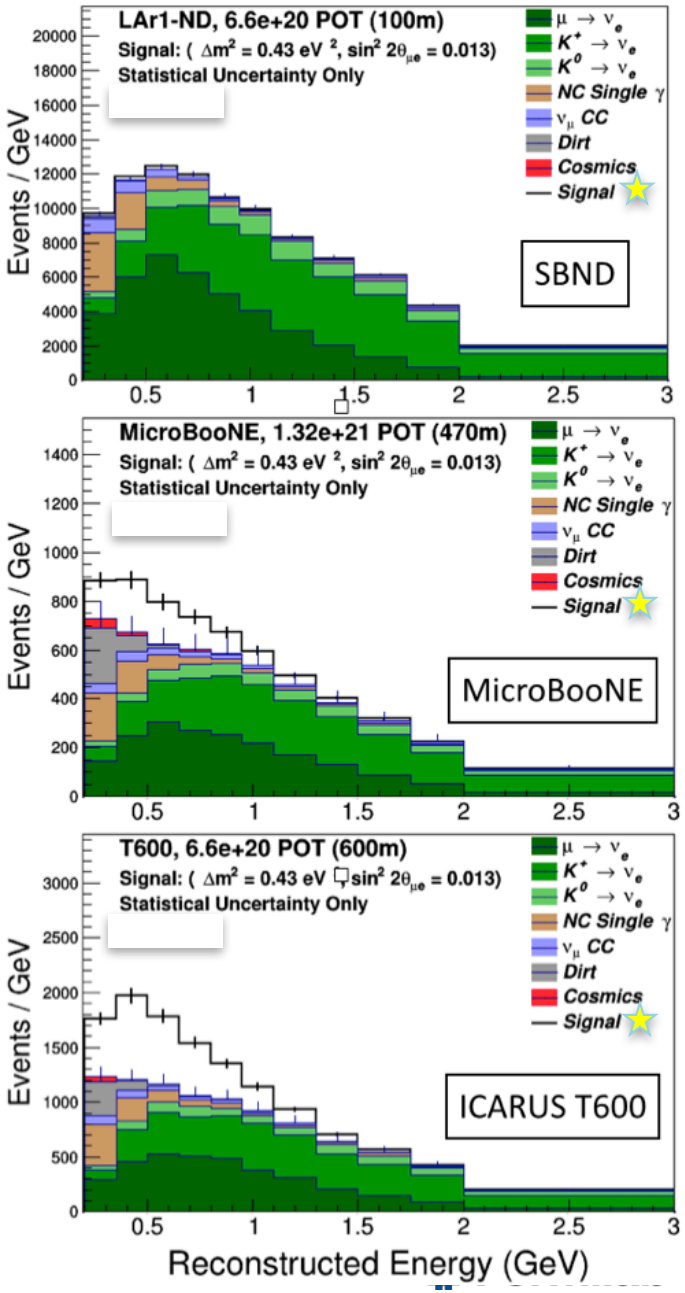


Near Detector Timeline (Dec 2016)

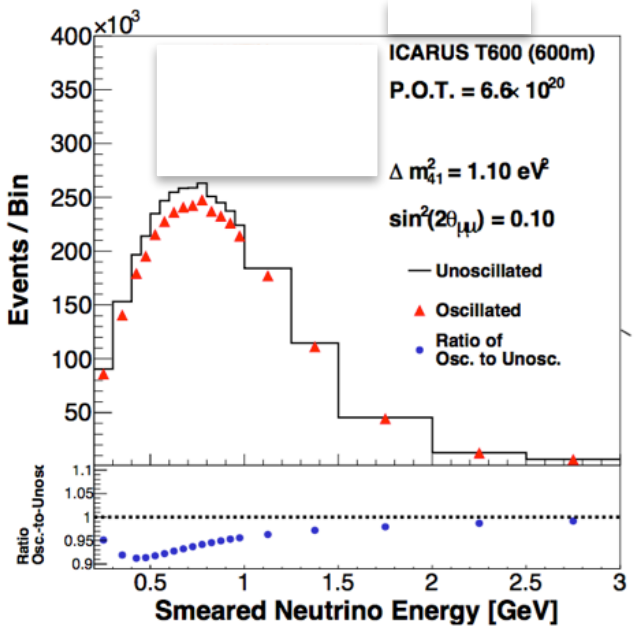


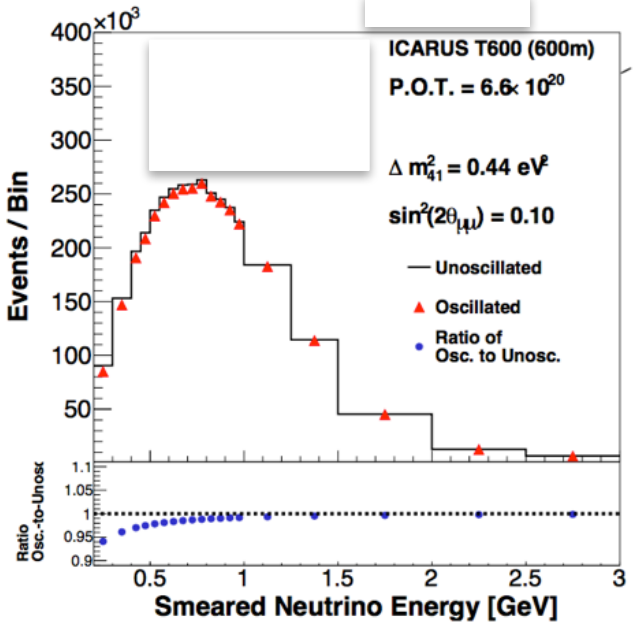
SBN $\nu_\mu \rightarrow \nu_e$ Oscillation Sensitivity

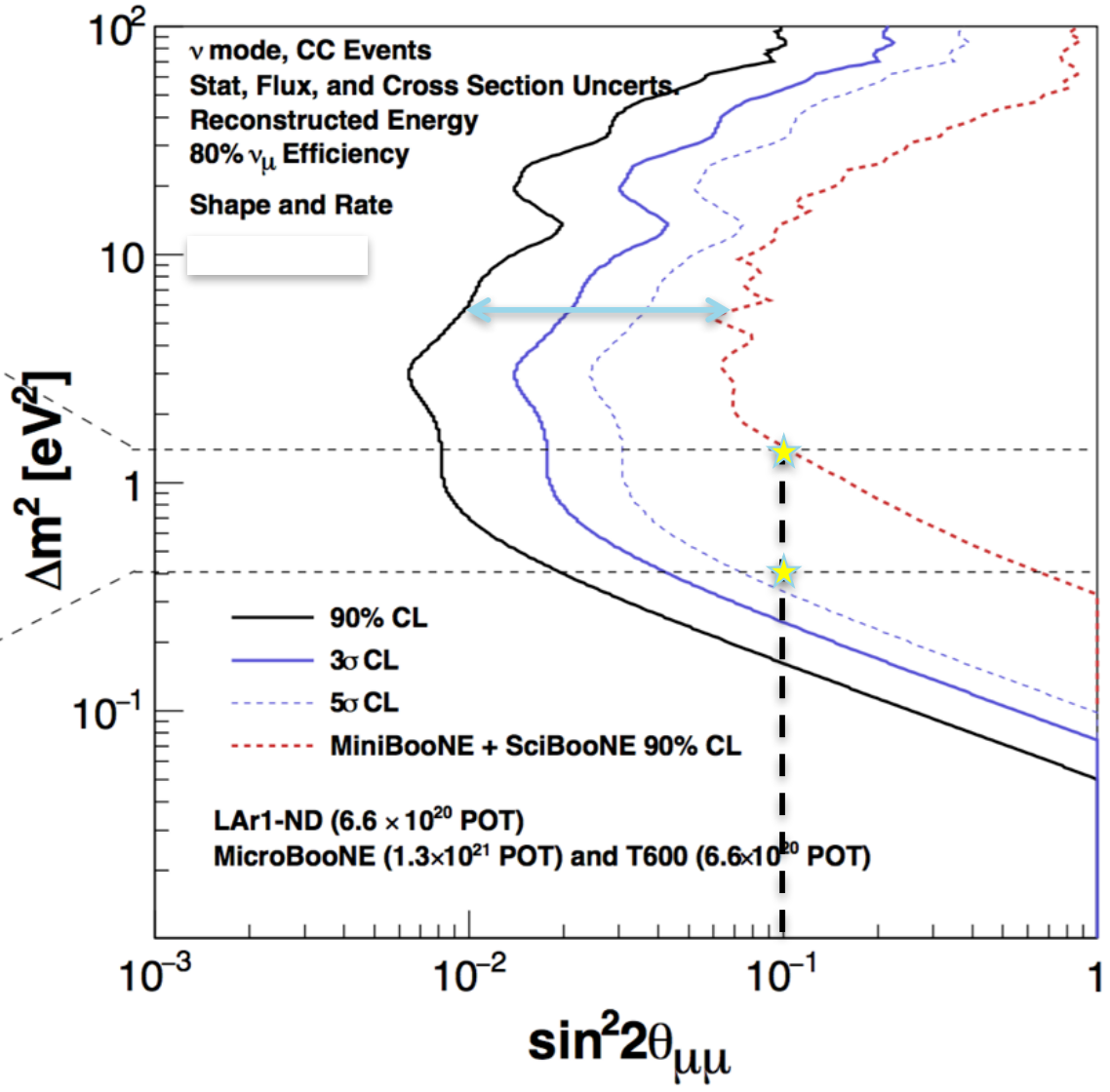




SBN ν_μ Disappearance Oscillation Sensitivity





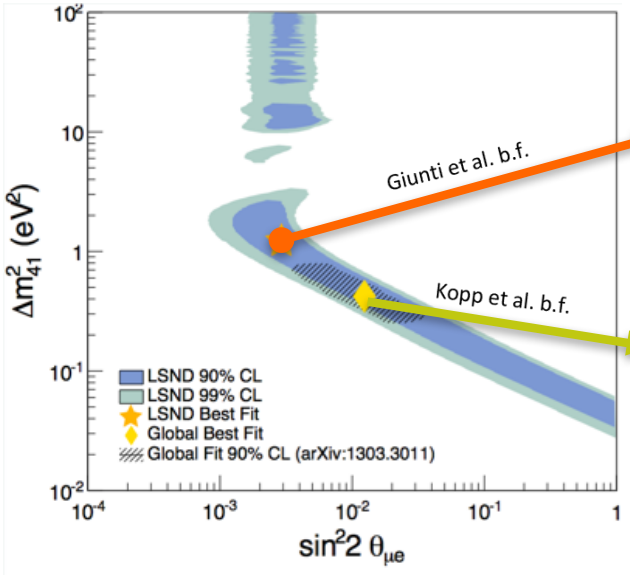


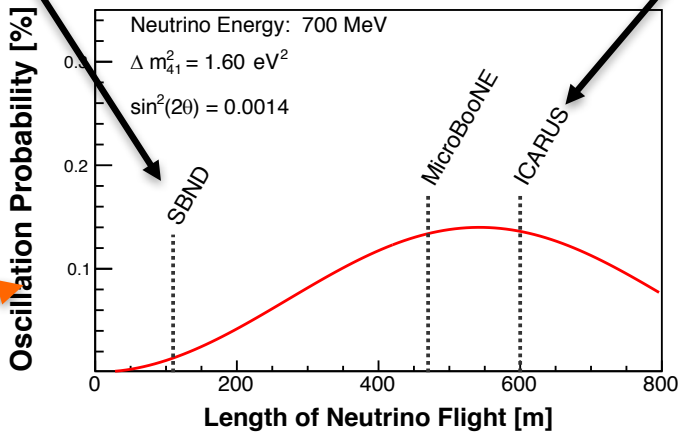
Very little background. Near detector key to controlling flux and cross-section uncertainties.

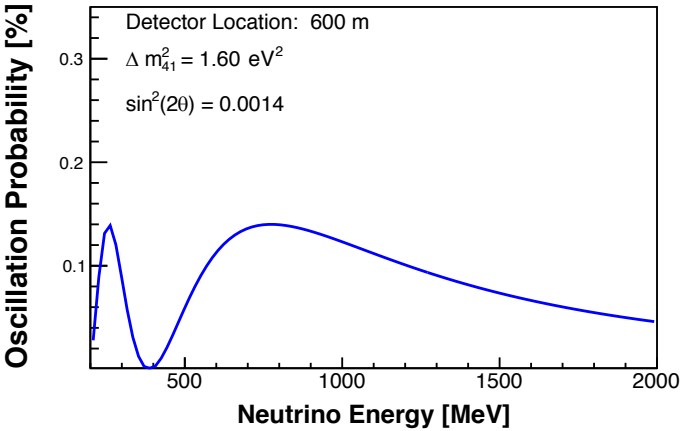
control **systematics**

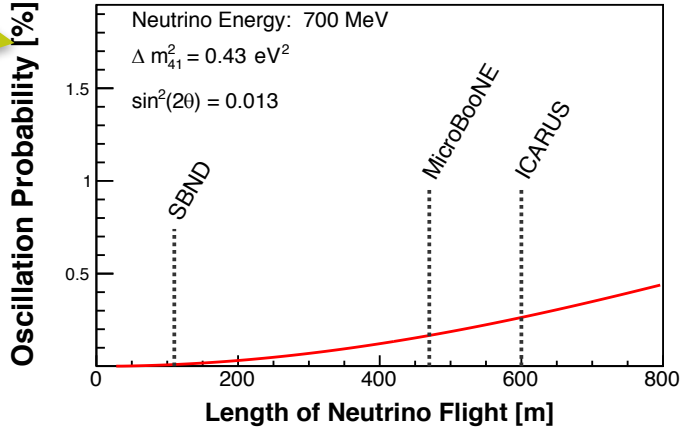
increase **statistics** of signal

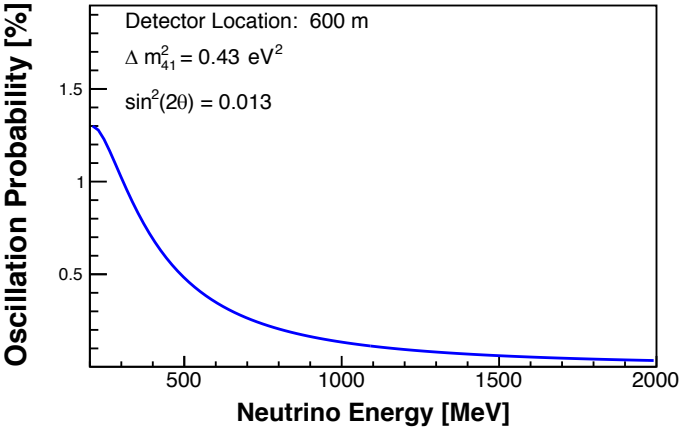
Oscillation Physics

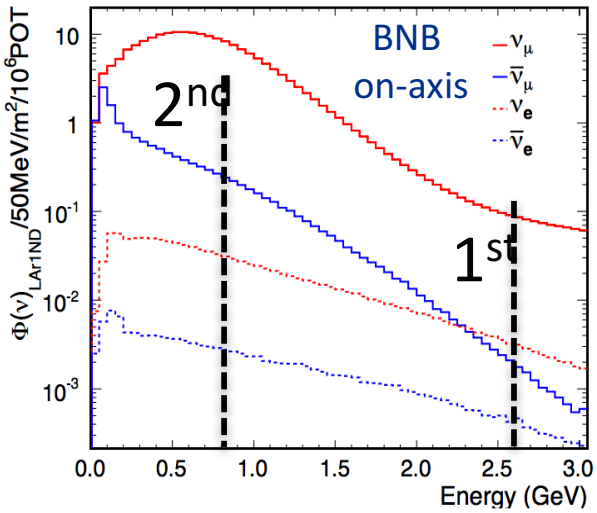












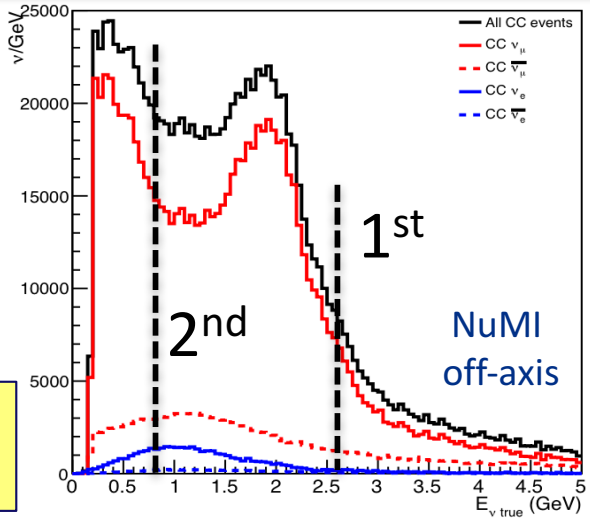
SBND: **1.5M** ν_μ CC/year, **12k** ν_e CC/year

+ low rate channels - e.g. coherent (10^4), strange prod (10^3), neutrino-electron (10^2)

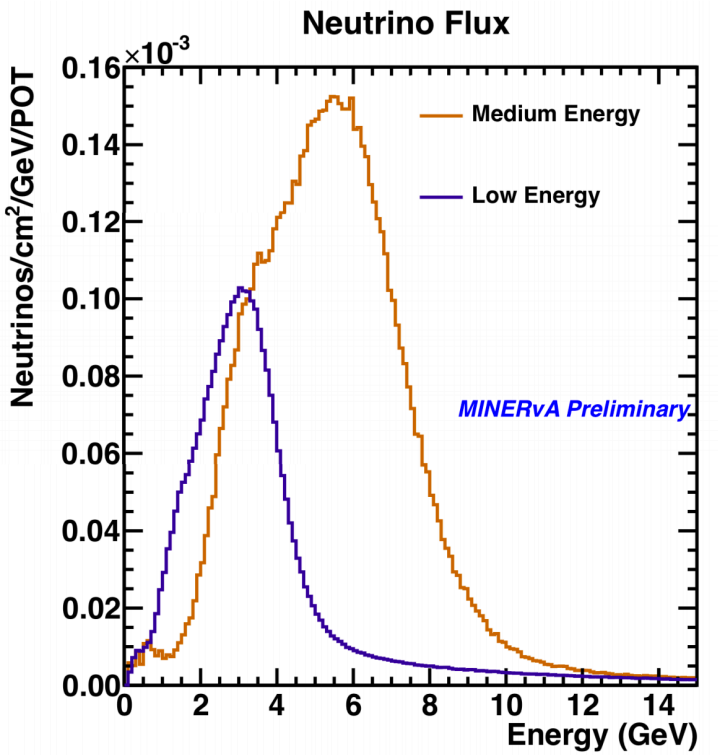
Neutrino Interaction Physics

ICARUS: **10^5** NuMI off-axis events/year

many at the DUNE 1st osc. max



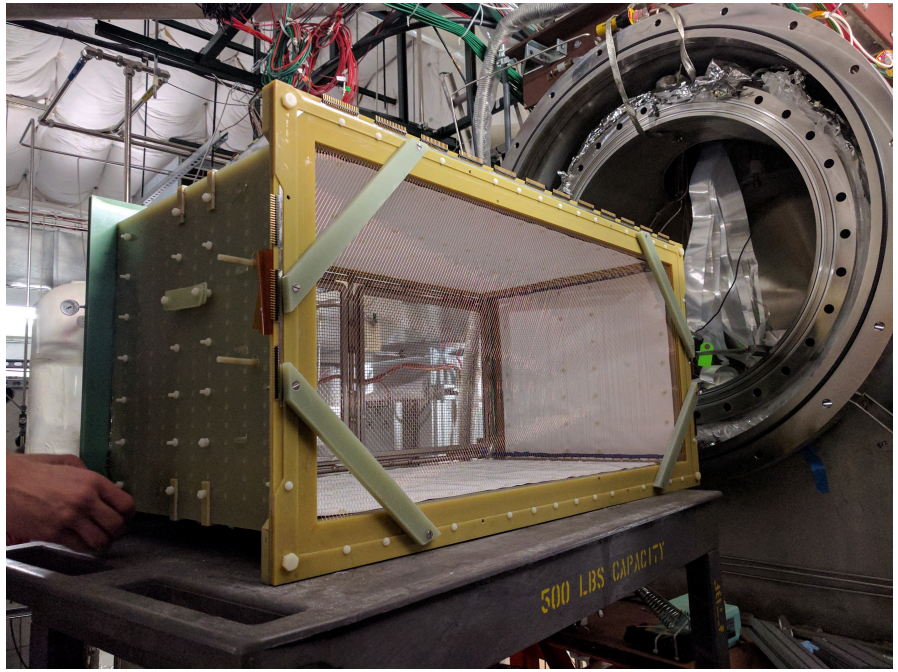
Minerva – Physics Goals



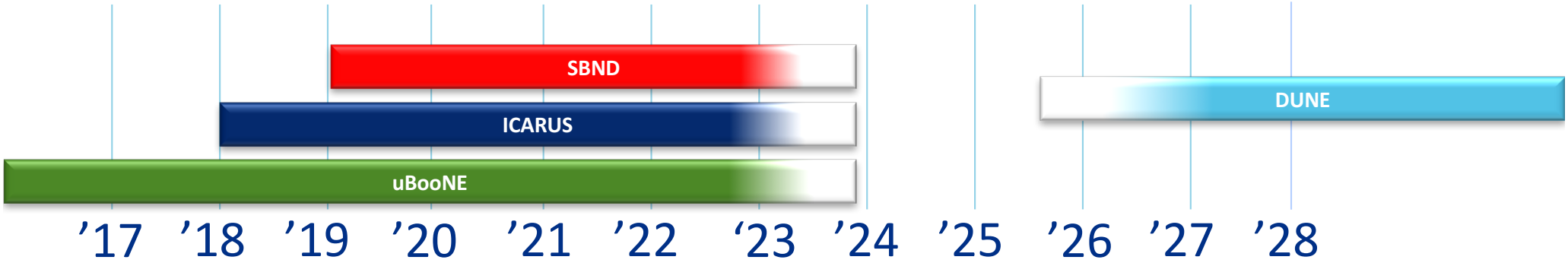
- Completing last Low-Energy Cross Sections Measurements
  - Quasi-Elastic studies: double-diff, improved reconstruction
  - Cross-section ratios: Pb/CH, Fe/CH
- Currently collection Medium-Energy
  - Much higher event rate
  - Accumulated 3x exposure of LE neutrino mode dataset
  - Expect similar anti-neutrino exposure through FY18
  - Will be able to probe nuclear effect for several channels, especially the Deep Inelastic Scattering
- Currently unique coverage of DUNE flux
- Plan for final analyses after beam ends

LArIAT – “the little cryostat that could”

- Run III has begun – continue to operate and take beam until June 23, 2017 scheduled start of summer shutdown
  - Utilization of FTBF has been very successful
- Measurement of charged particle cross sections on Ar
- Particle identification efficiency and separation
- Determine reconstruction eff and calorimetric resolution
- R&D on detector parameters
  - TPC wire spacing
  - Light collection devices
  - Mesh cathode
- Useful for simulation tuning
- Analysis of Run I and Run II datasets continue
- publications are on the way

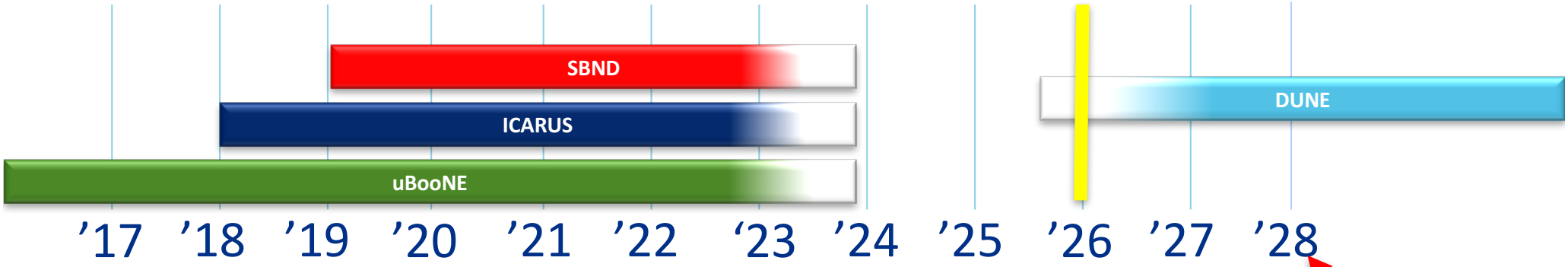


The Future for Short-Baseline Neutrino



- Focus on the next 10 years – DUNE is the following 10 years
  - Is there anything
- Minerva and MicroBooNE – data archival and final cross sections
- Important to interface with theory and generators
- LArIAT – how long does it keep chugging along?
- What direction to take when SBN Program is successful?
  - Discovers a sterile neutrino signal?
  - Excludes sterile neutrino signal throughout LSND region?
  - SBND cross sections for DUNE
  - ICARUS cross sections for DUNE
- What is missing? Where are the gaps in scientific interests?

The Future for Short-Baseline Neutrino



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Peter retires

Can't rely on him forever – young scientists need to express their ideas.

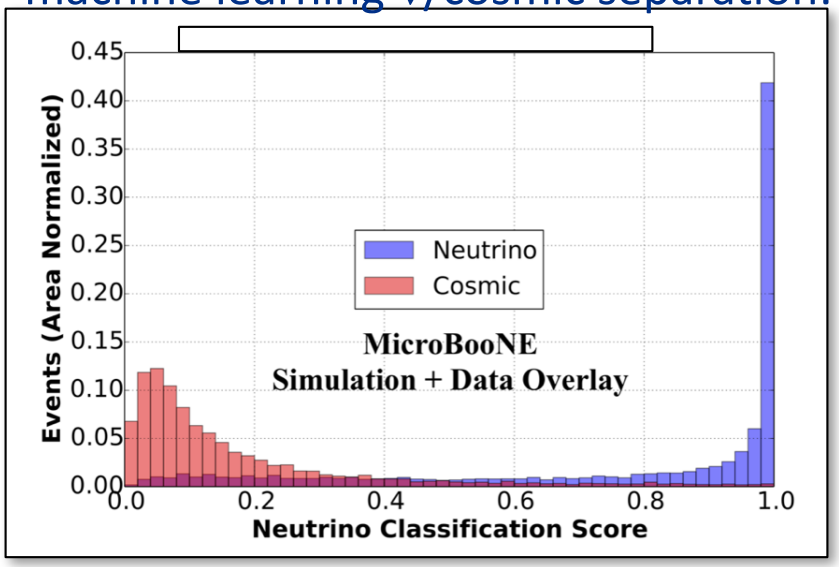
Backup Slides

MicroBooNE Physics

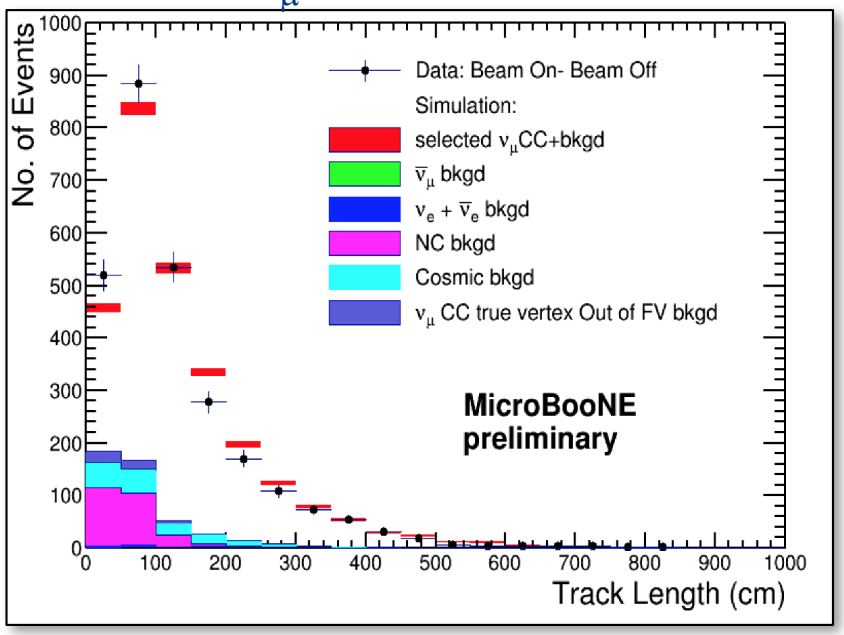
- MicroBooNE has several publications this year with more in the pipeline:
  - *Design and Construction of the MicroBooNE Detector,* JINST 12, P0217 (2017)
  - *Convolutional Neural Networks Applied to ν Events in a LAr TPC,* JINST 12, P03011 (2017)
  - *Determination of Muon Momentum in the MicroBooNE LAr TPC Using an Improved Model of Multiple Coulomb Scattering",* submitted to JINST arXiv: 1703.06187 (https://arxiv.org/abs/1703.06187)
- 3 more papers currently in internal review:
  - Michels, μ tracking efficiencies, signal/noise
- 16 public notes
  - describing detector performance, reconstruction techniques, and initial physics analyses

http://www-microboone.fnal.gov/publications/publicnotes

machine learning ν/cosmic separation:



ν_μ CC interactions:



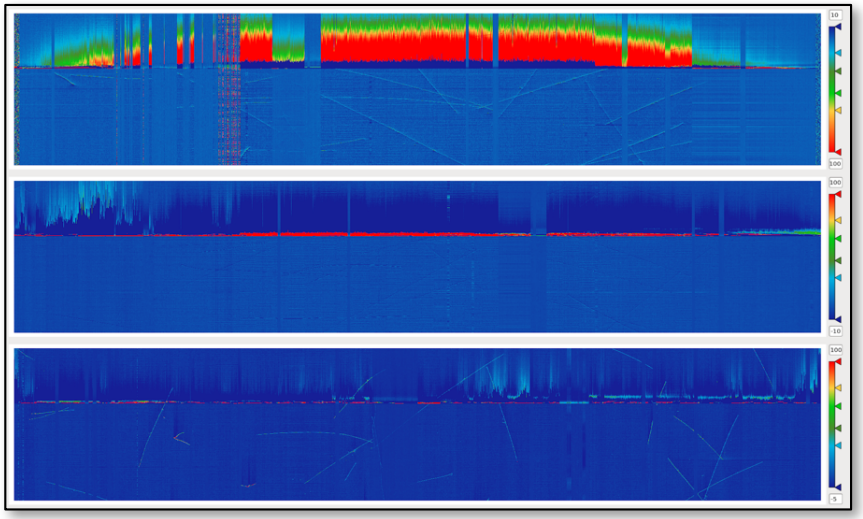
Fermilab

MicroBooNE R&D (we are learning a lot)

Recent example: drift HV feed-through to cathode connection problem

- Significant instabilities observed in HV system and on anode planes (large "burst" events) at the end of January, which made data taking impossible
- Systematically ruled out causes outside of the cryostat first
- Used anode planes to diagnose cathode instabilities (first time this has been done)
- Removal of ice ball on HV feed-through and adjustment of HV feed-through bellows brought system back into a stable running state
- In the process → developed new monitoring techniques and test configurations for diagnosis
- Passing on lessons learned (SBN/DUNE satellite workshop before next DUNE collaboration meeting)
  - HV feedthrough/cathode connectivity in LAr TPCs deserves more attention

"burst events"



flange housing the drift HV feed-thru

- ***Have been running smoothly since Feb 29th***

Fermilab

Fermilab: International Neutrino Laboratory