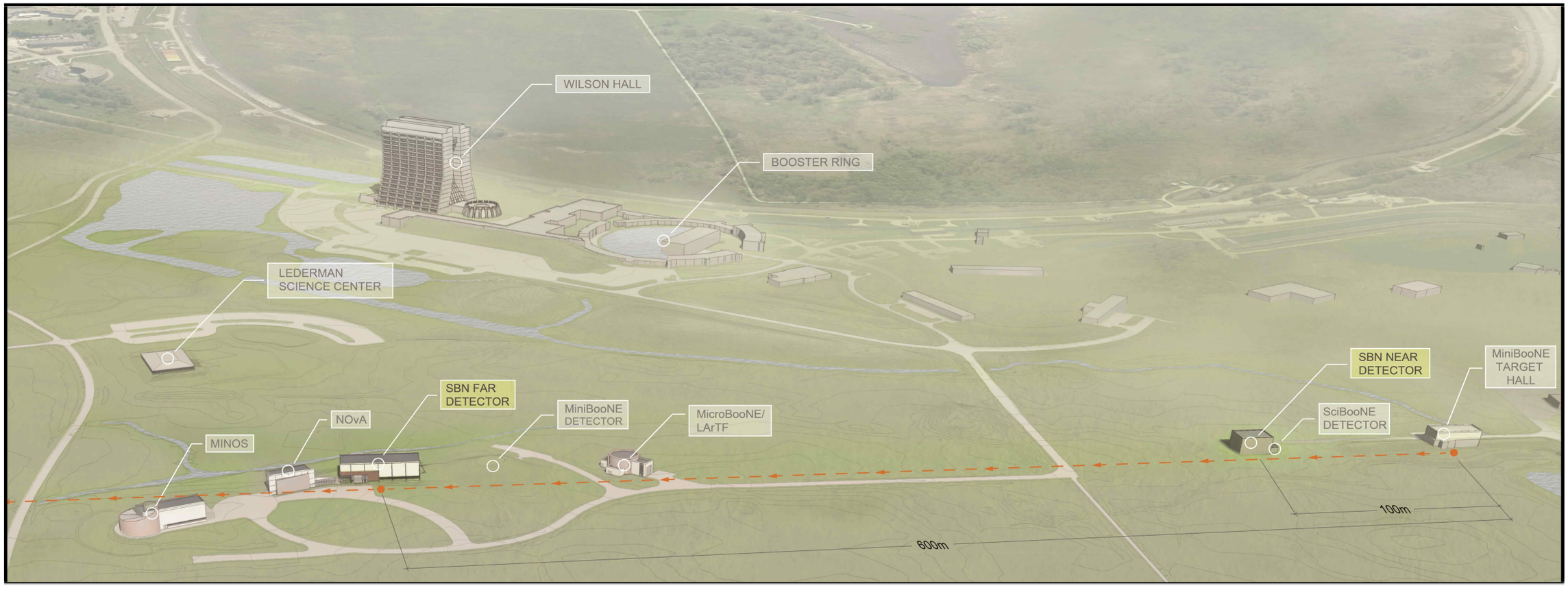


FNAL Short-Baseline Program

Roxanne Guenette
University of Oxford

NNN 15
October 30th 2015

Outline

- Why a Short-Baseline Neutrino Program?
- Description of the SBN Program at FNAL
  - Experiments (MicroBooNE - SBND - ICARUS)
  - Physics goals
  - Current status
- Summary

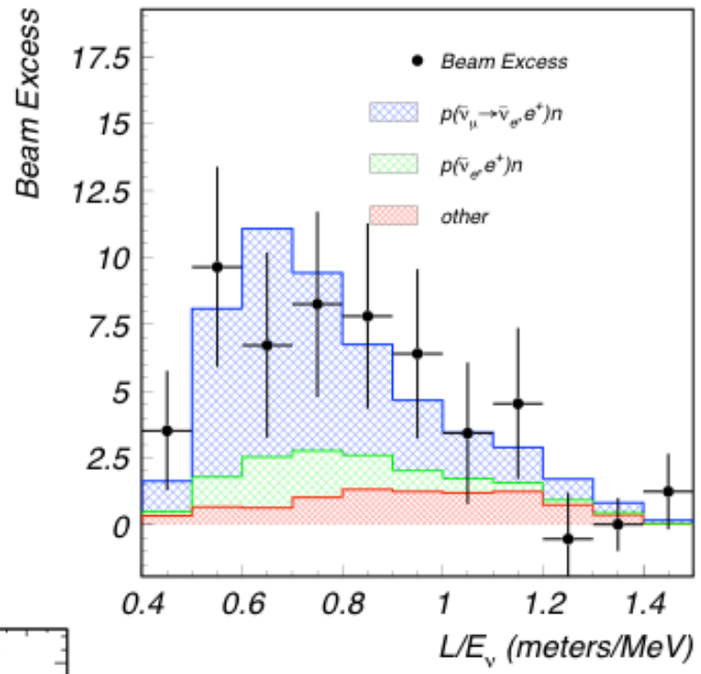
Why a Short-baseline neutrino program?

Many SB anomalies

- LSND anomaly (3.8σ)

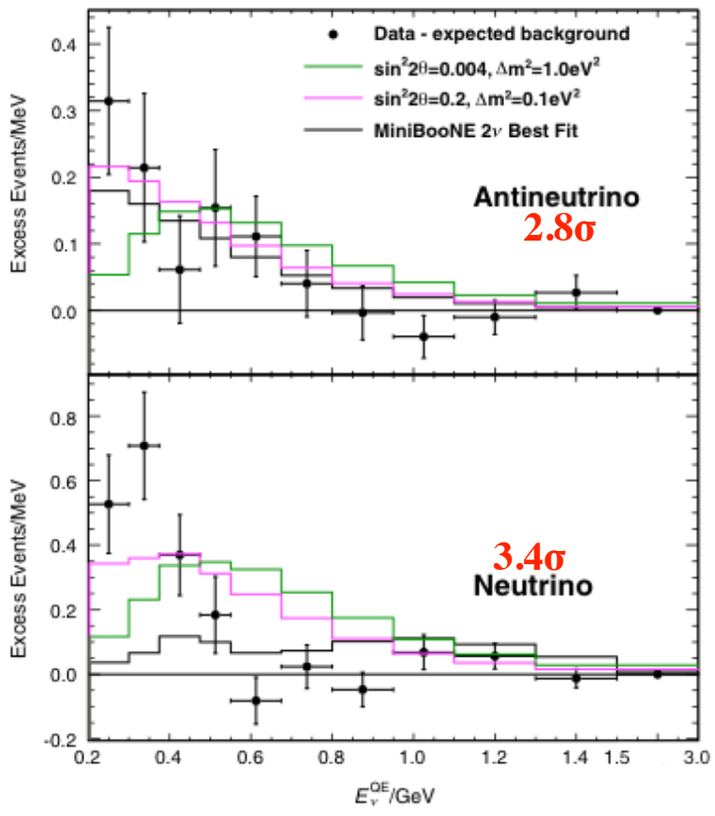
- MiniBooNE low-energy excess (~3σ)

LSND



Phys. Rev. **D64** (2001)

MiniBooNE

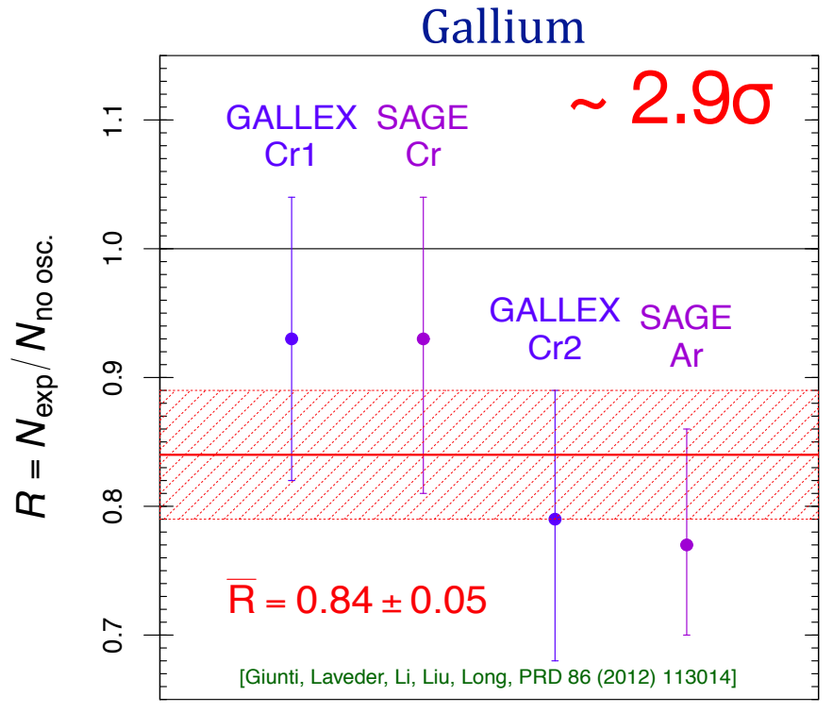


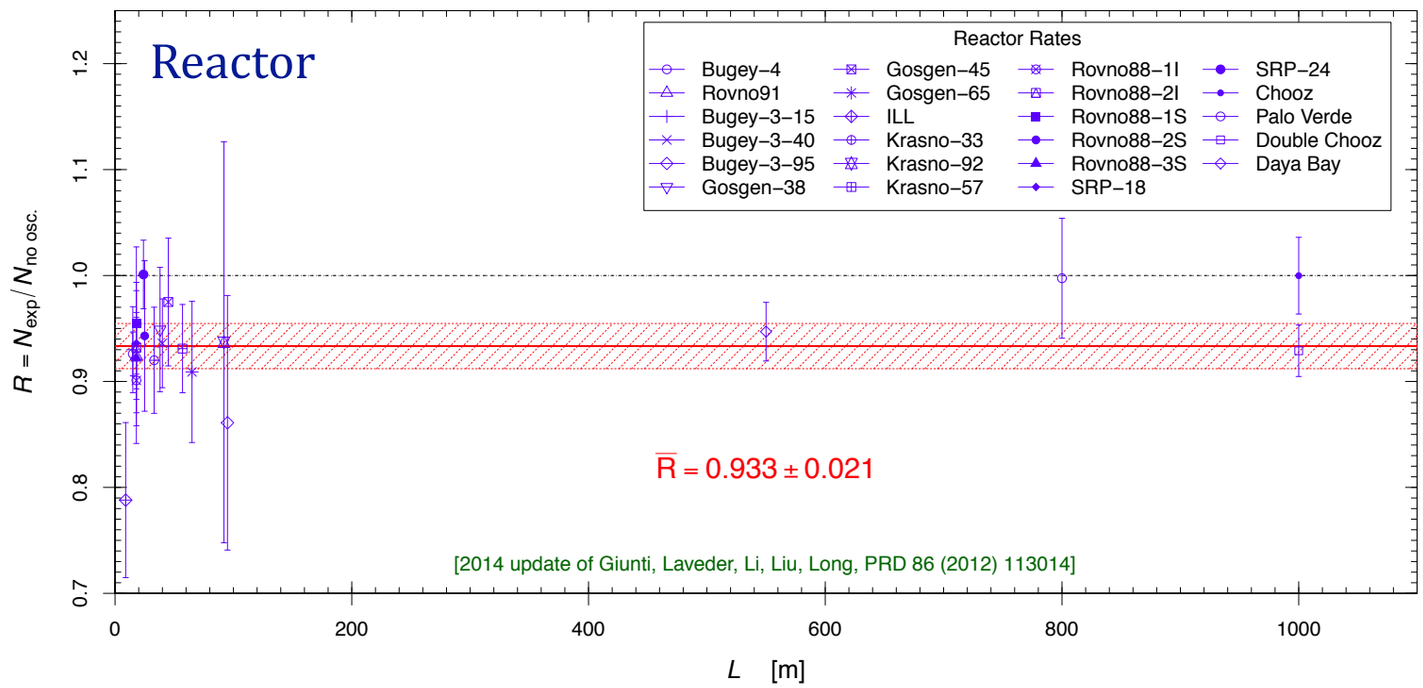
Phys. Rev. Lett. 110, 2013

Why a Short-baseline neutrino program?

Many SB anomalies

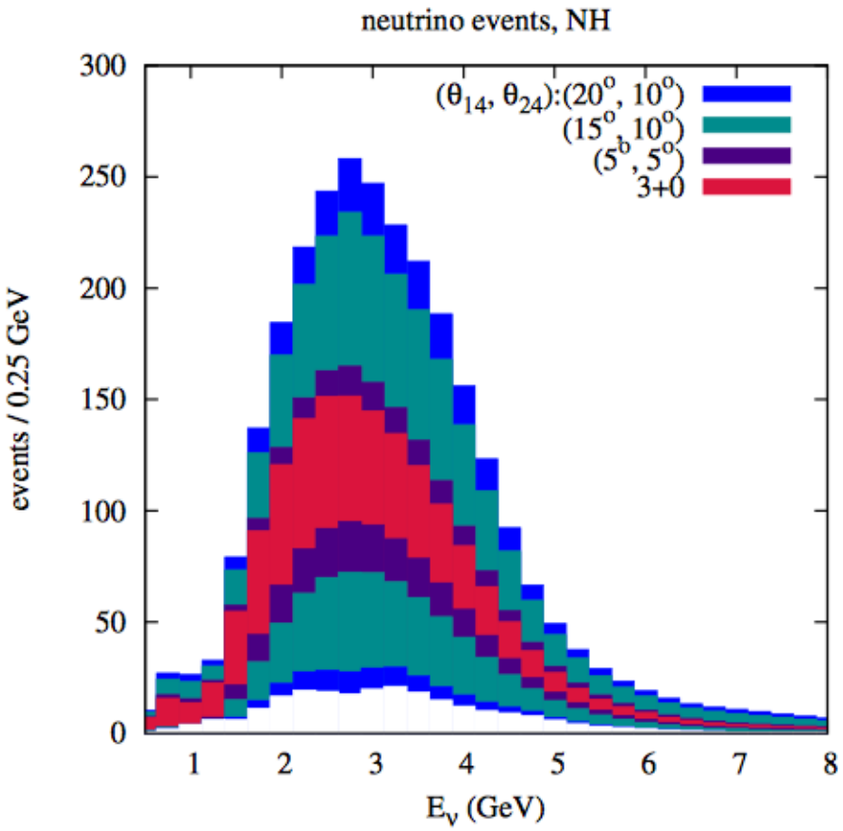
- Gallium anomaly (~3σ)
- Reactor anomaly (~3σ)

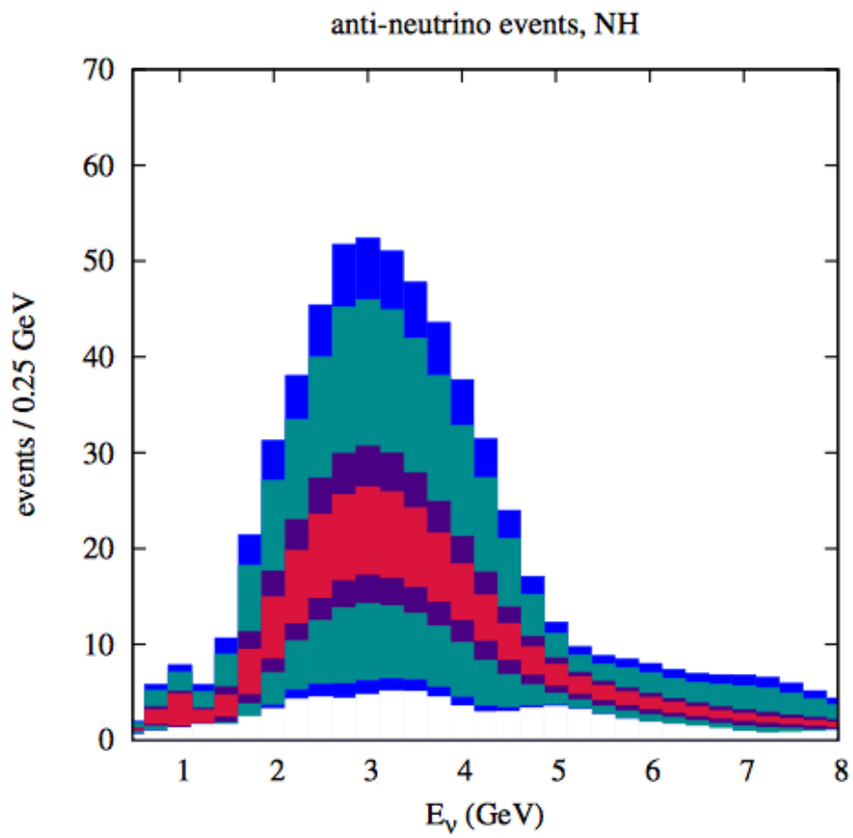




Why a Short-baseline neutrino program?

Impact on flagship measurement of long-baseline experiments: CP Violation





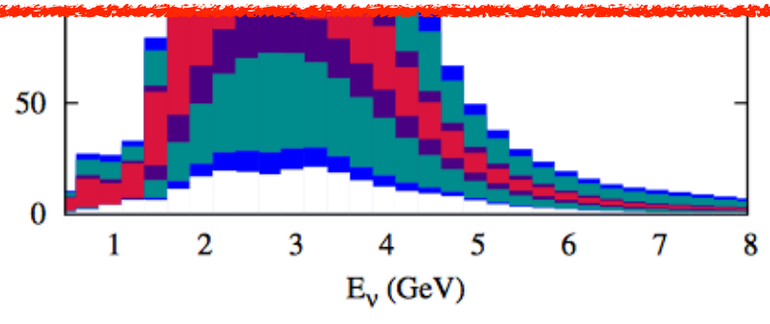
R. Gandhi, B. Kayser, M. Masud, S. Pakrash, arXiv:1508.06275

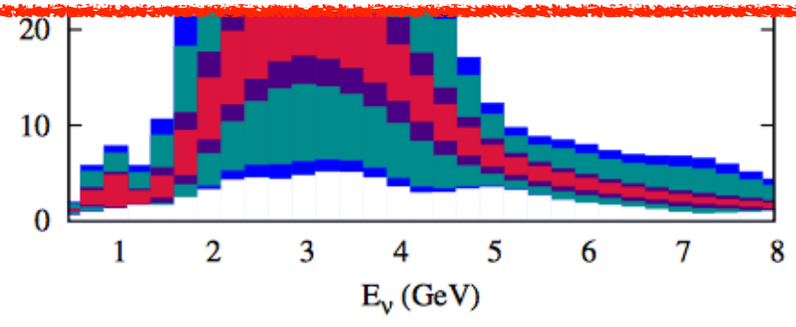
Why a Short-baseline neutrino program?

Impact on flagship measurement of long-baseline experiments: CP Violation

"… any data indicating the violation of CP cannot be properly interpreted within the standard paradigm unless the presence of sterile states of mass O(1 eV) can be conclusively ruled out. "

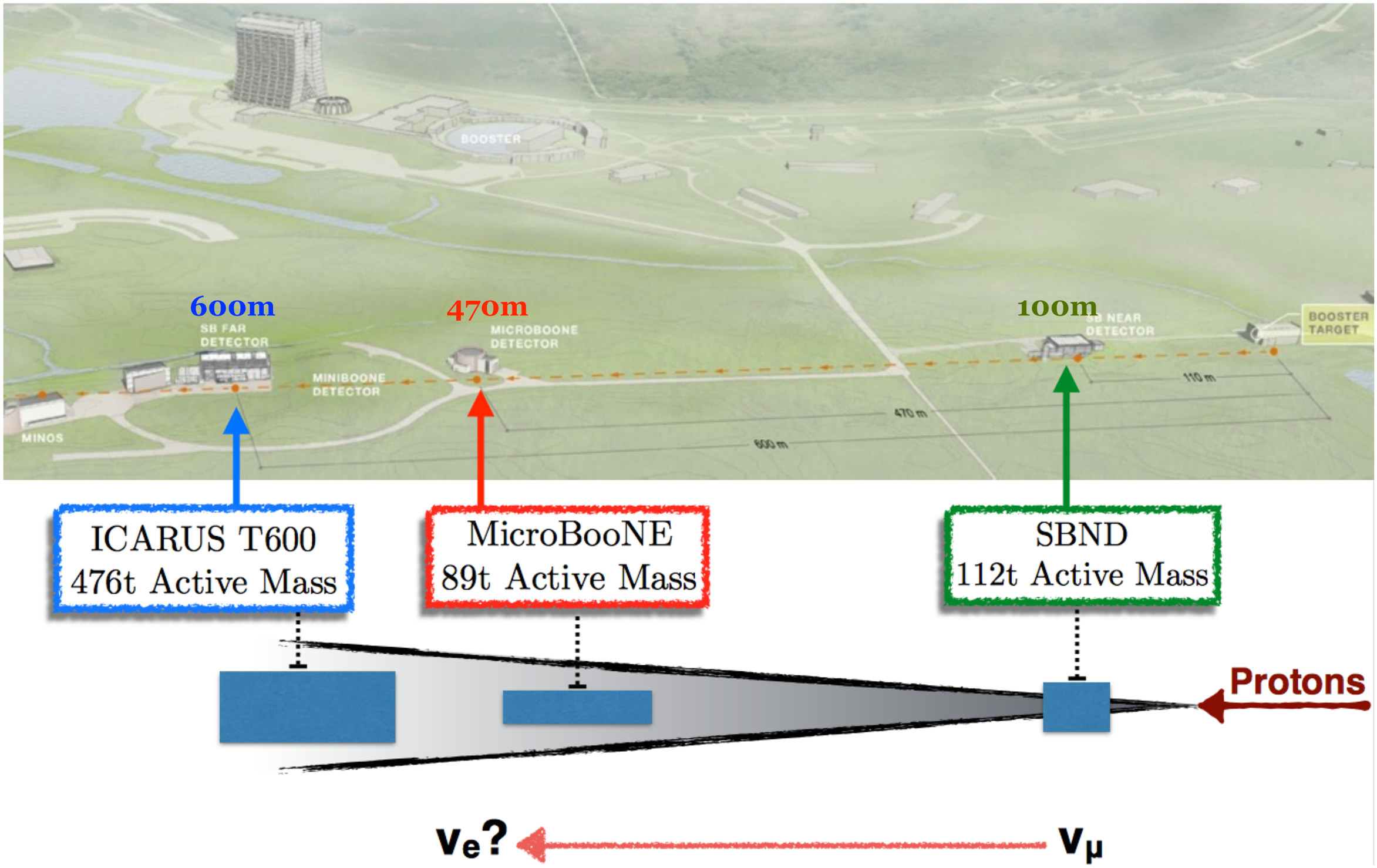
R. Gandhi, B. Kayser, M. Masud, S. Pakrash, arXiv:1508.06275



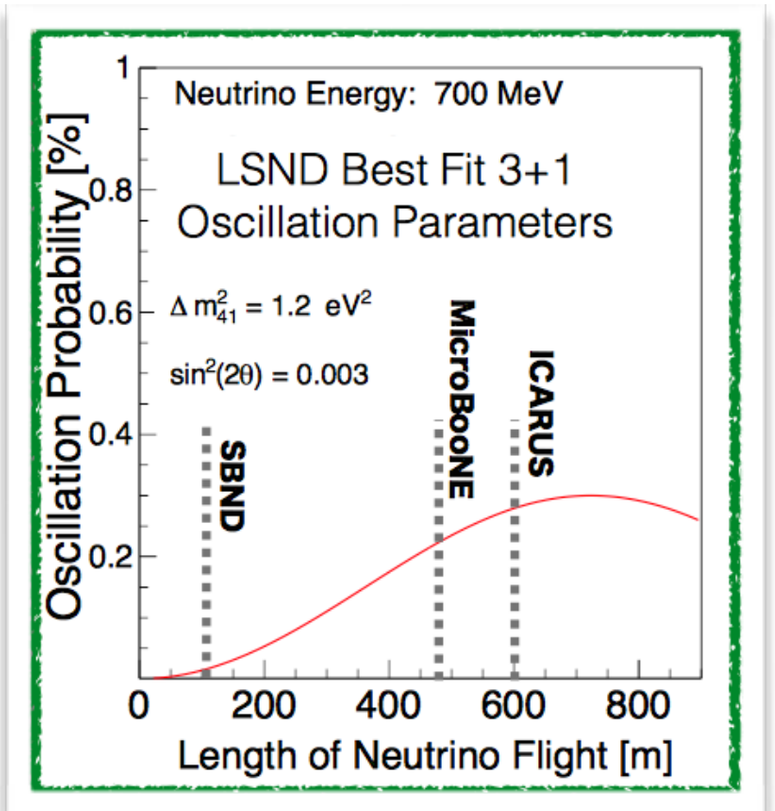


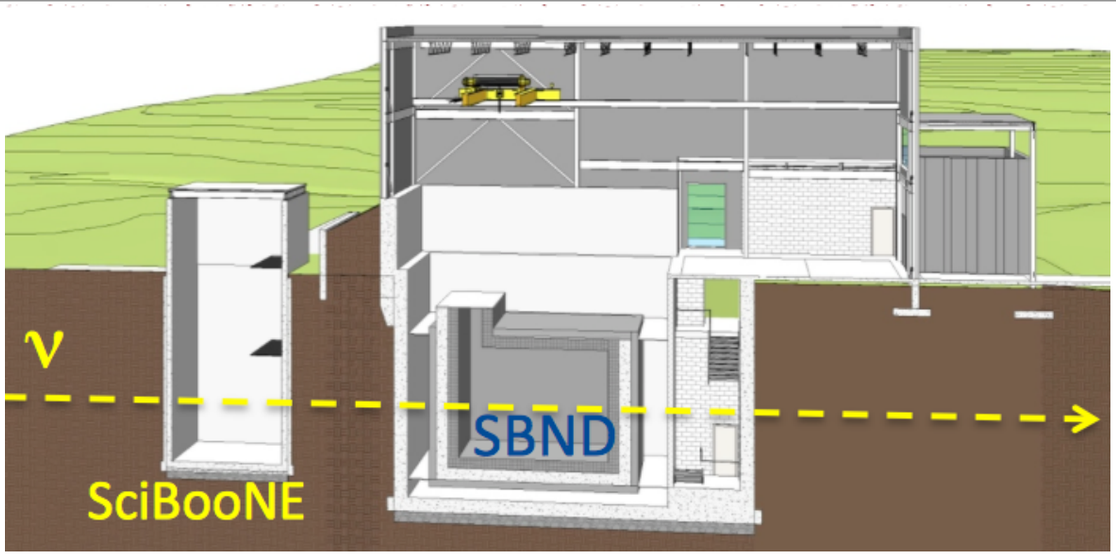
R. Gandhi, B. Kayser, M. Masud, S. Pakrash, arXiv:1508.06275

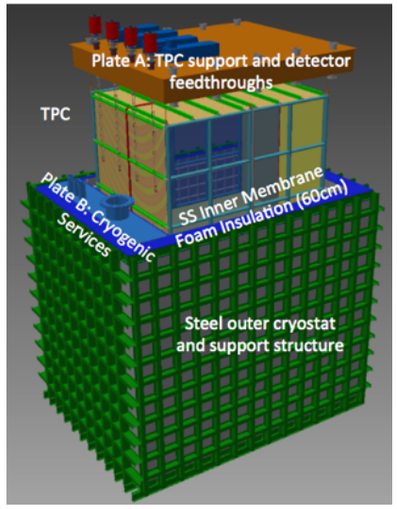
The SBN Program at Fermilab

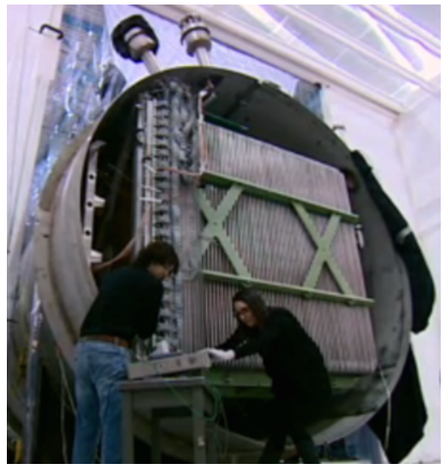


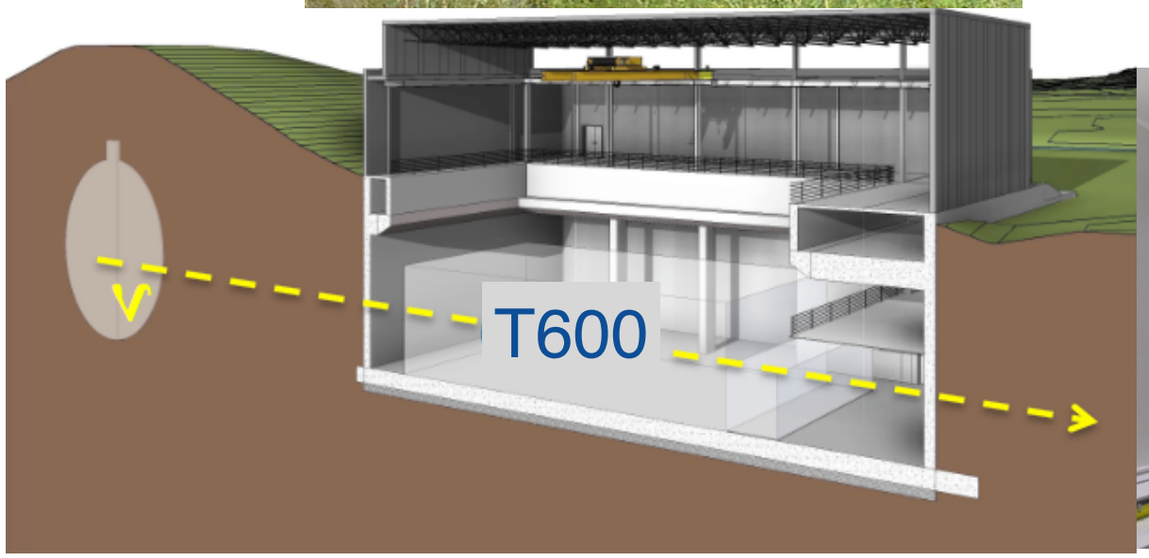
The SBN Program at Fermilab

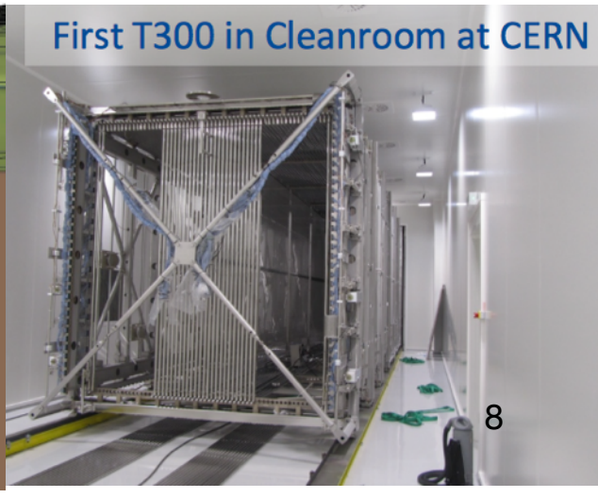










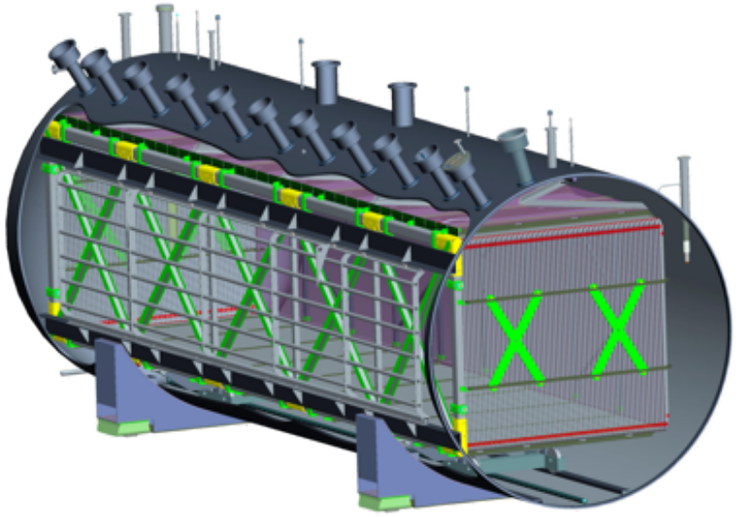


Why three detectors?

- Each experiment has its own unique physics strategy
- SBN focus:
  - ✓ MicroBooNe will lead the way by looking for an excess and will identify it: e or γ ?
  - ✓ SBND will provide a detailed beam characterisation with ~ no signal contamination (great reduction of systematics)
  - ✓ ICARUS will allow to cover the lower Δm^2 regions to study large fraction of LSND allowed region
  - ✓ MicroBooNE offers additional coverage of the higher Δm^2 regions

MicroBooNE

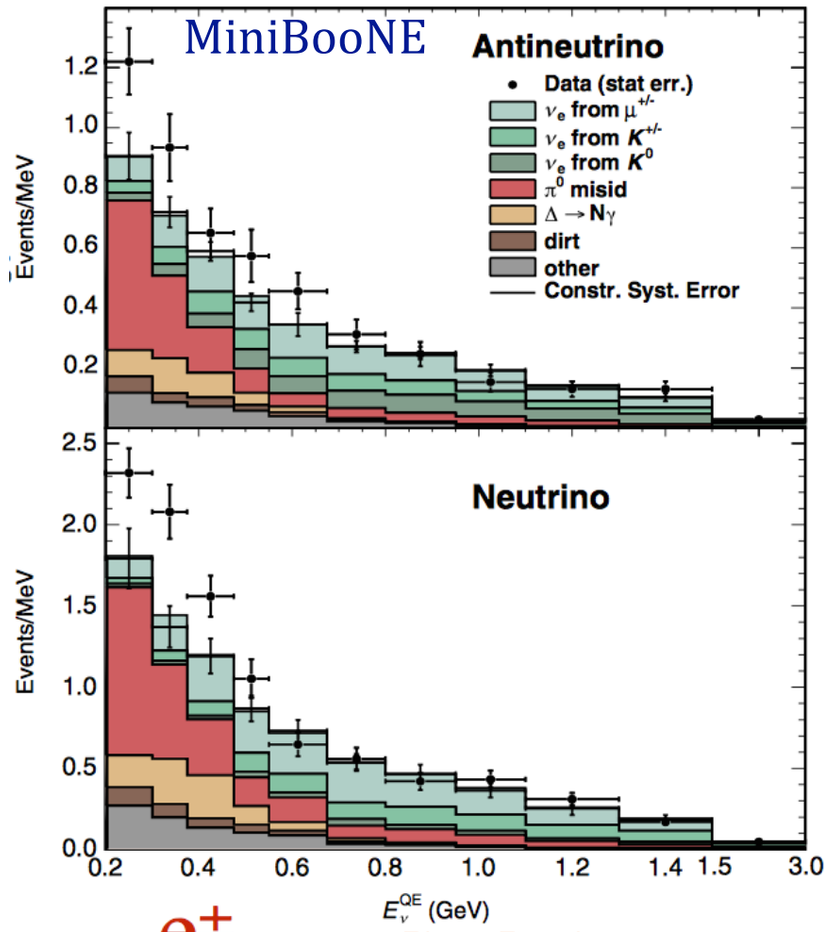
- Proposed in 2007 to address the MiniBooNE low-energy excess
- Part of the US LAr development program (Physics and R&D goals)
- 89 ton Active Volume LArTPC



See Ben Carls' talk this morning!

MicroBooNE Physics

- Address the MiniBooNE low-energy excess
  - Look for excess
  - Identify signal (γ or e^- ?)
- Oscillation physics study (appearance/ disappearance)
- Cross-section measurements
- Astroparticle and Exotic physics

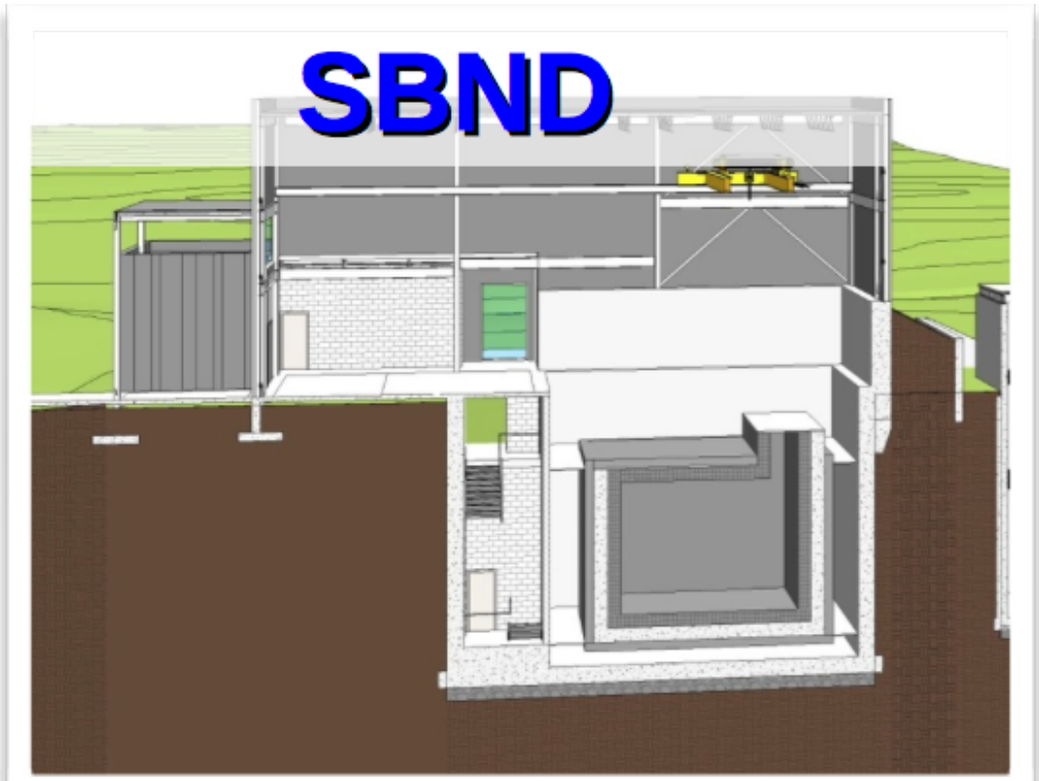


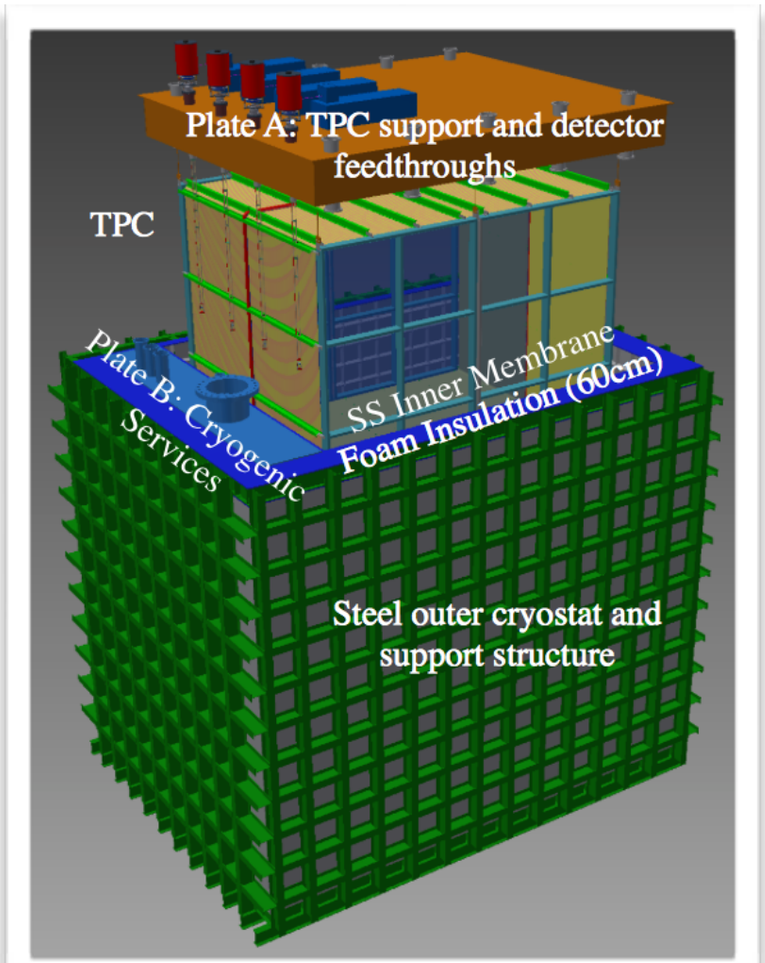
Phys. Rev. Lett. 110, 2013

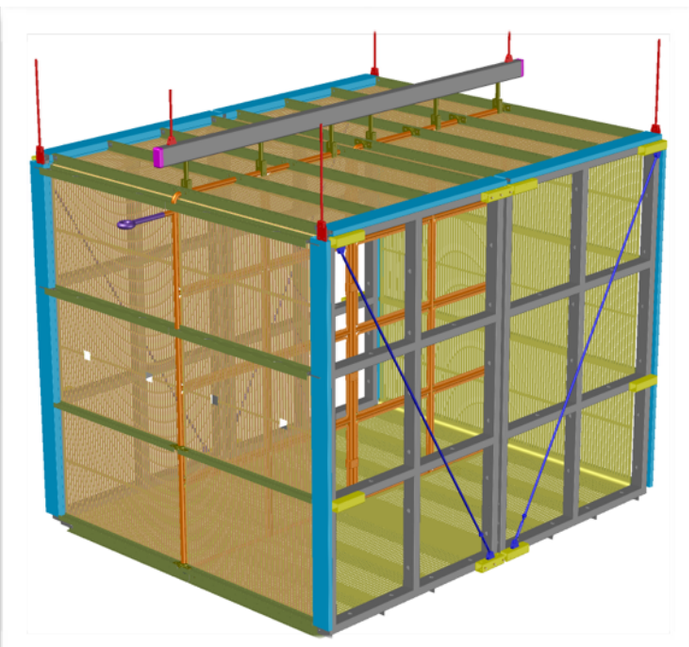
courtesy of T. Miceli

SBND

- First proposed as LAr1ND (2013 arXiv:1309.7987) (became SBND Spring 2015)
- Clear significant impact on physics with near detector







SBND Physics

- Crucial to identify the *source* of a potential excess in MicroBooNE

- Provide unoscillated spectrum for ν_e appearance searches

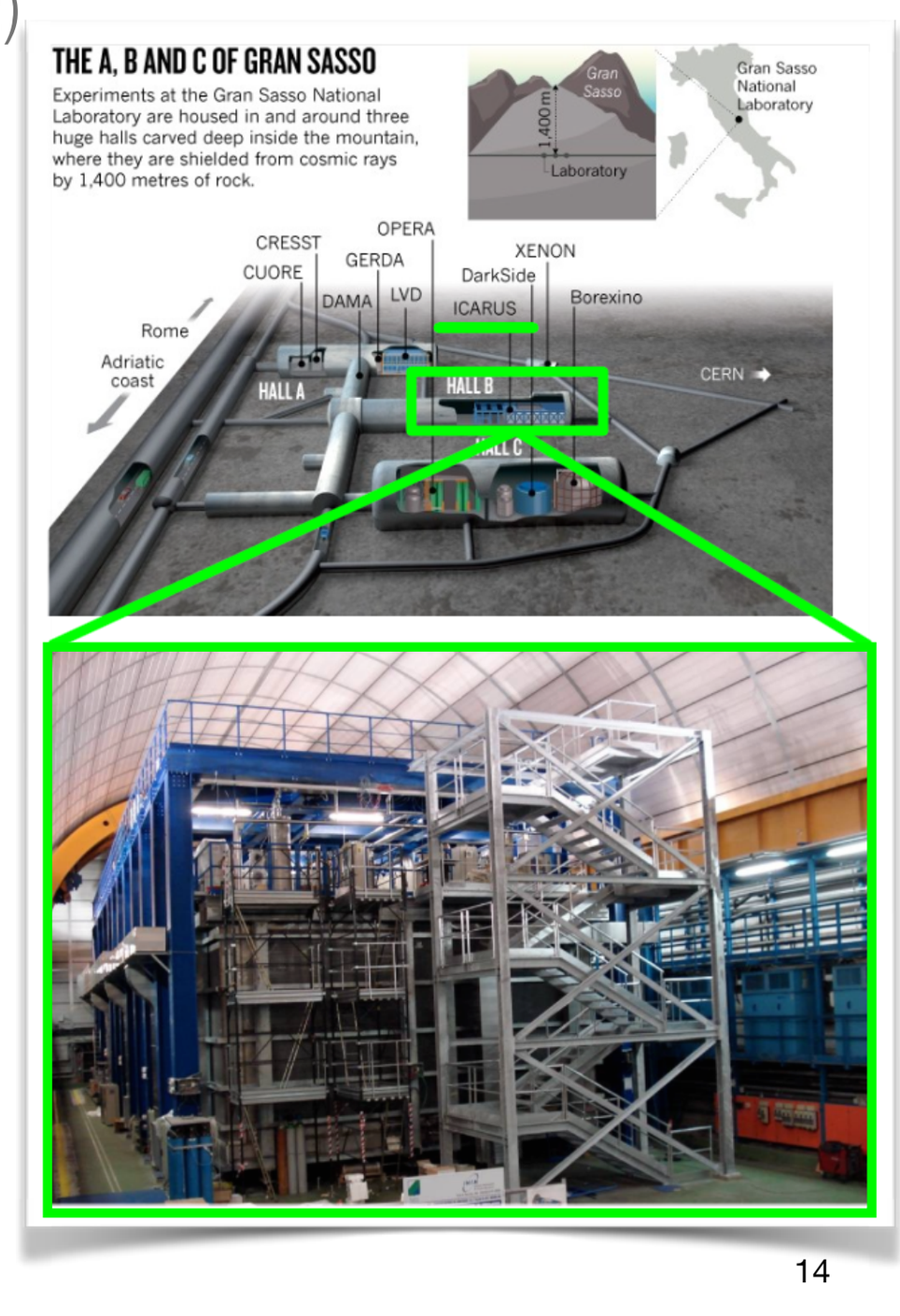
- Great cross-section measurement site

Process		No. Events	Events/ ton	Stat. Uncert.
	ν_μ Events (By Final State Topology)			
CC Inclusive		5,212,690	46,542	0.04%
CC 0 π	$\nu_\mu N \to \mu + Np$	3,551,830	31,713	0.05%
	$\cdot\ \nu_\mu N \to \mu + 0p$	793,153	7,082	0.11%
	$\cdot\ \nu_\mu N \to \mu + 1p$	2,027,830	18,106	0.07%
	$\cdot\ \nu_\mu N \to \mu + 2p$	359,496	3,210	0.17%
	$\cdot\ \nu_\mu N \to \mu + \geq 3p$	371,347	3,316	0.16%
CC 1 $\pi^\pm$	$\nu_\mu N \to \mu +$ nucleons $+ 1\pi^\pm$	1,161,610	10,372	0.09%
CC $\geq 2\pi^\pm$	$\nu_\mu N \to \mu +$ nucleons $+ \geq 2\pi^\pm$	97,929	874	0.32%
CC $\geq 1\pi^0$	$\nu_\mu N \to \mu +$ nucleons $+ \geq 1\pi^0$	497,963	4,446	0.14%
NC Inclusive		1,988,110	17,751	0.07%
NC 0 π	$\nu_\mu N \to$ nucleons	1,371,070	12,242	0.09%
NC 1 $\pi^\pm$	$\nu_\mu N \to$ nucleons $+ 1\pi^\pm$	260,924	2,330	0.20%
NC $\geq 2\pi^\pm$	$\nu_\mu N \to$ nucleons $+ \geq 2\pi^\pm$	31,940	285	0.56%
NC $\geq 1\pi^0$	$\nu_\mu N \to$ nucleons $+ \geq 1\pi^0$	358,443	3,200	0.17%
	ν_e Events			
CC Inclusive		36798	329	0.52%
NC Inclusive		14351	128	0.83%
Total ν_μ and ν_e Events		7,251,948	64,750	
	ν_μ Events (By Physical Process)			
CC QE	$\nu_\mu n \to \mu^- p$	3,122,600	27,880	
CC RES	$\nu_\mu N \to \mu^- \pi N$	1,450,410	12,950	
CC DIS	$\nu_\mu N \to \mu^- X$	542,516	4,844	
CC Coherent	$\nu_\mu Ar \to \mu Ar + \pi$	18,881	169	

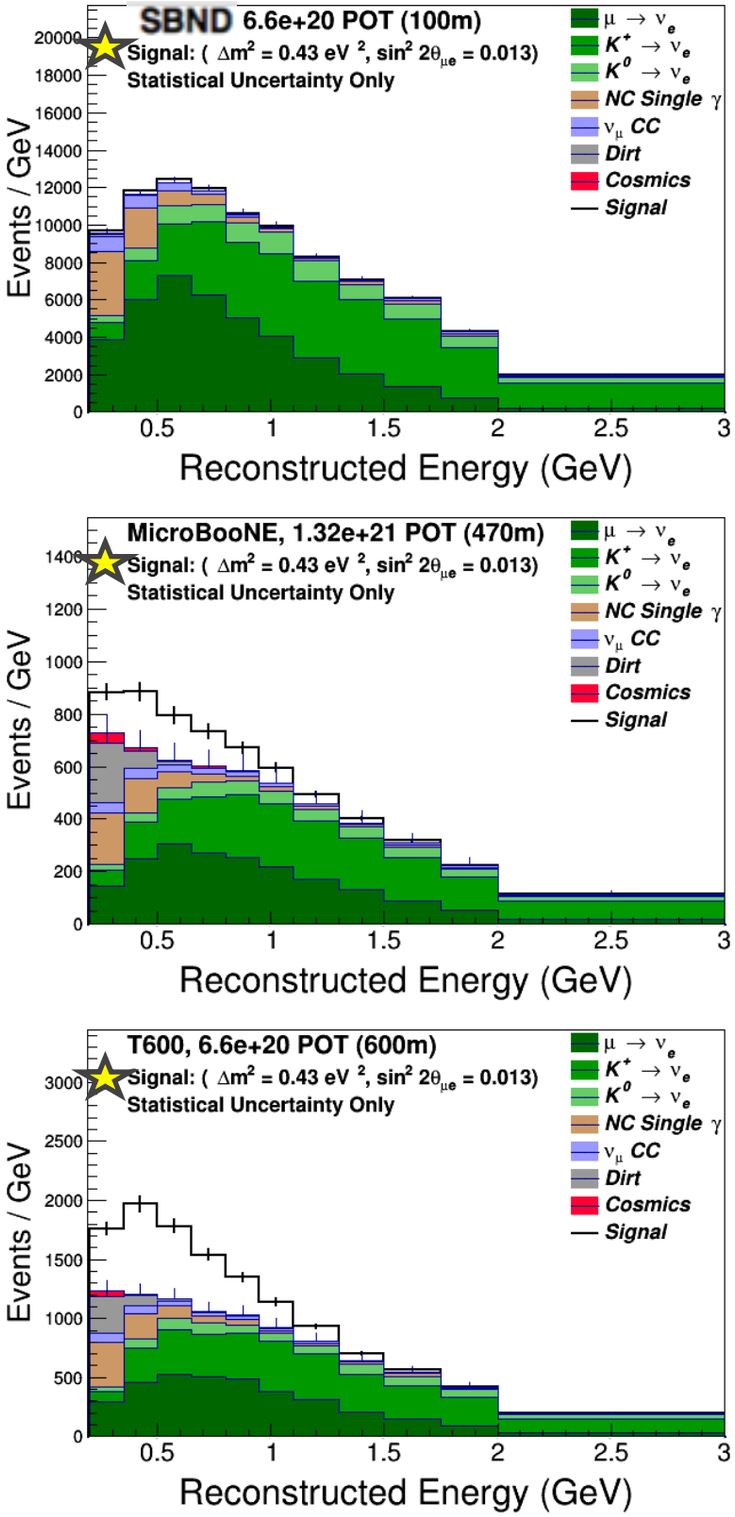
Millions of events!
High statistics
High Precision

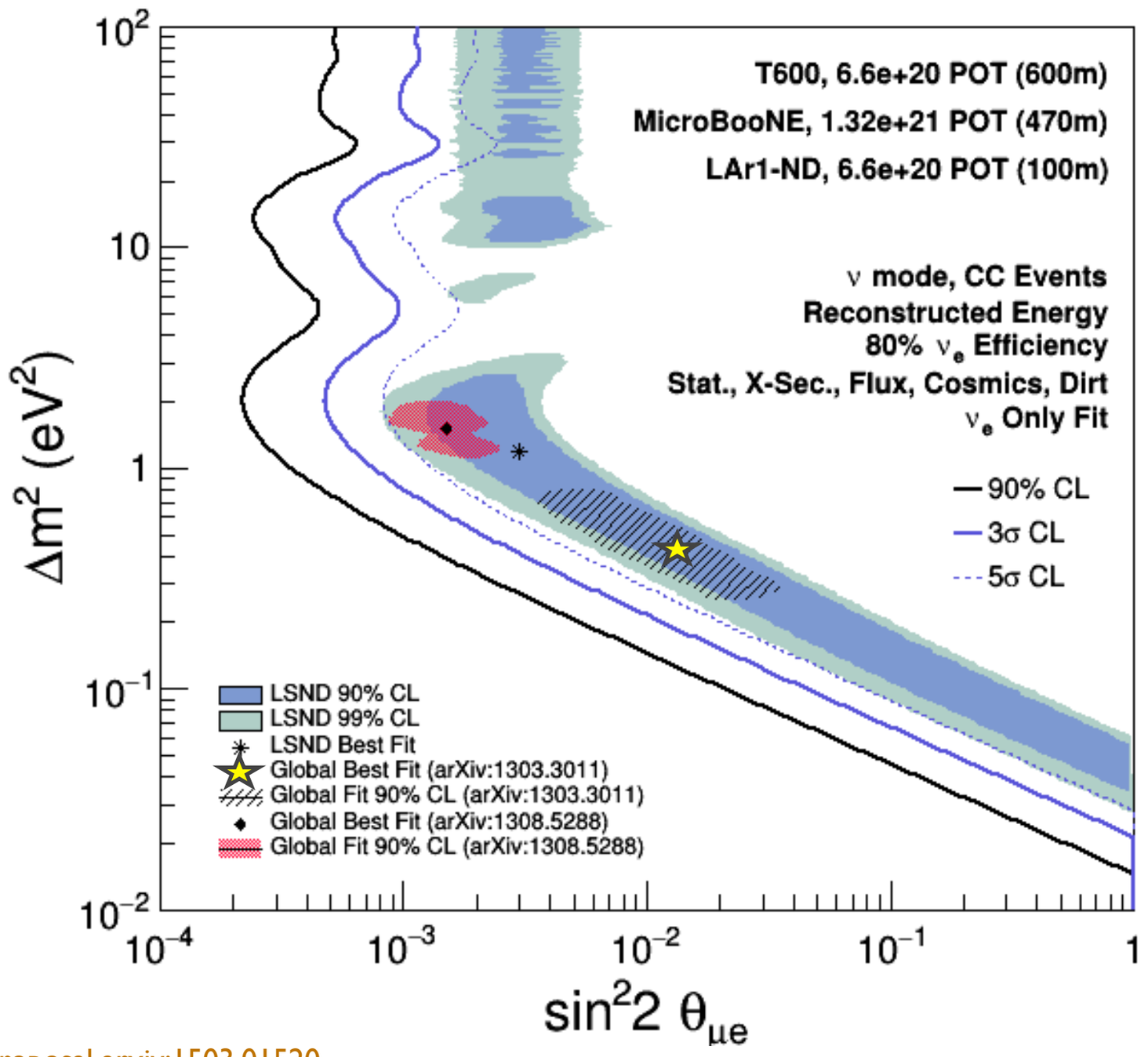
ICARUS

- T600 detector (the largest LArTPC to date!)
- Ran at Gran Sasso from 2010 to 2013



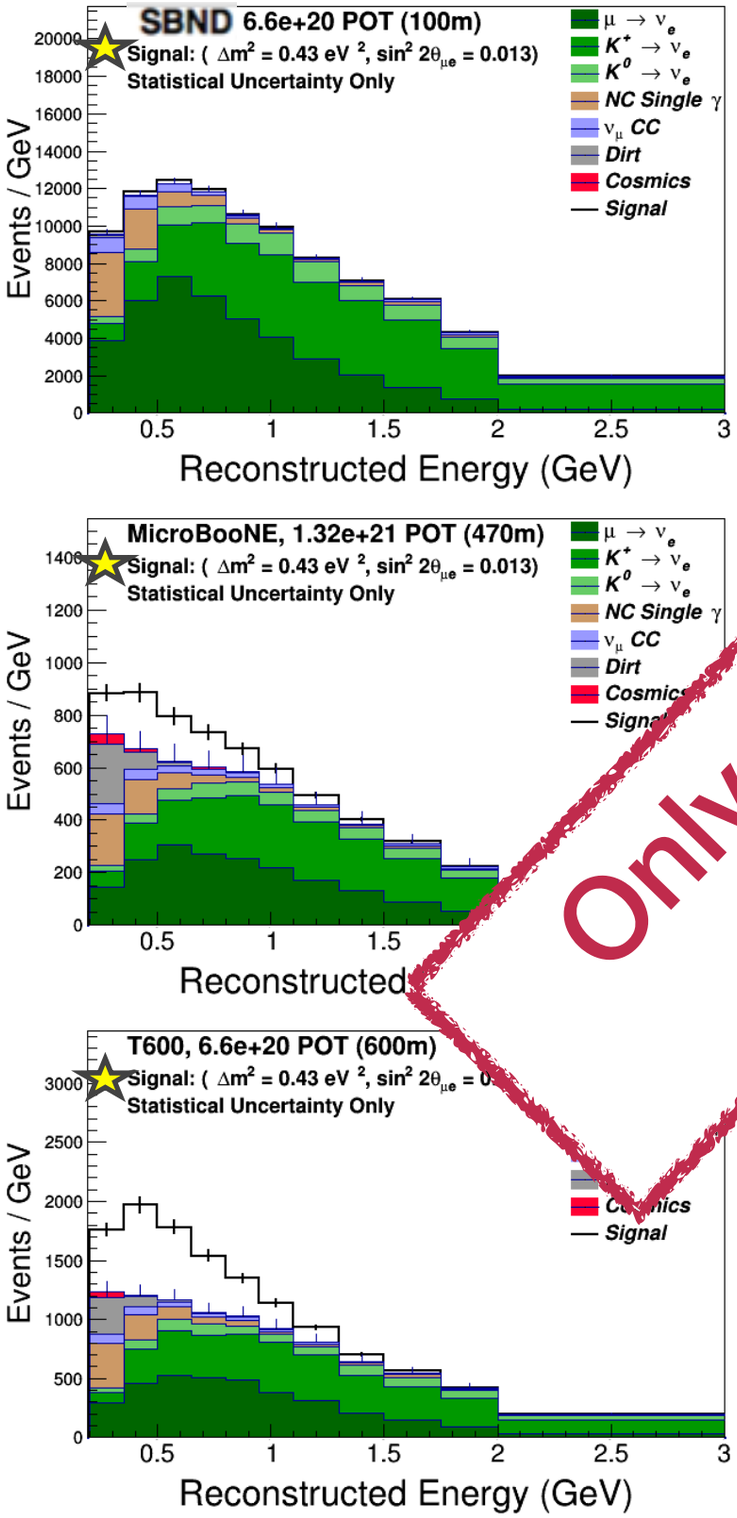
The SBN Program

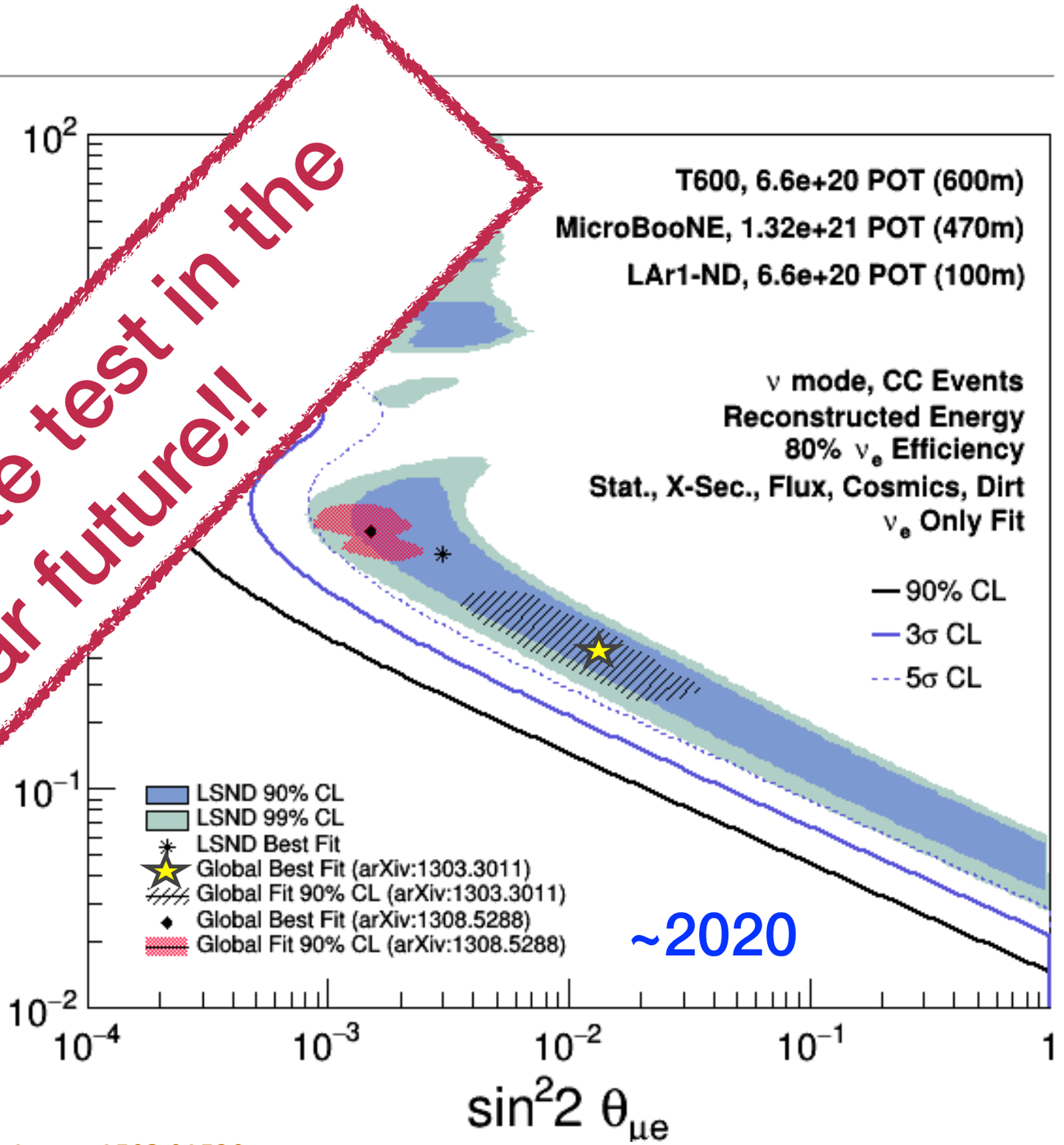




SBN proposal arxiv:1503.01520

The SBN Program





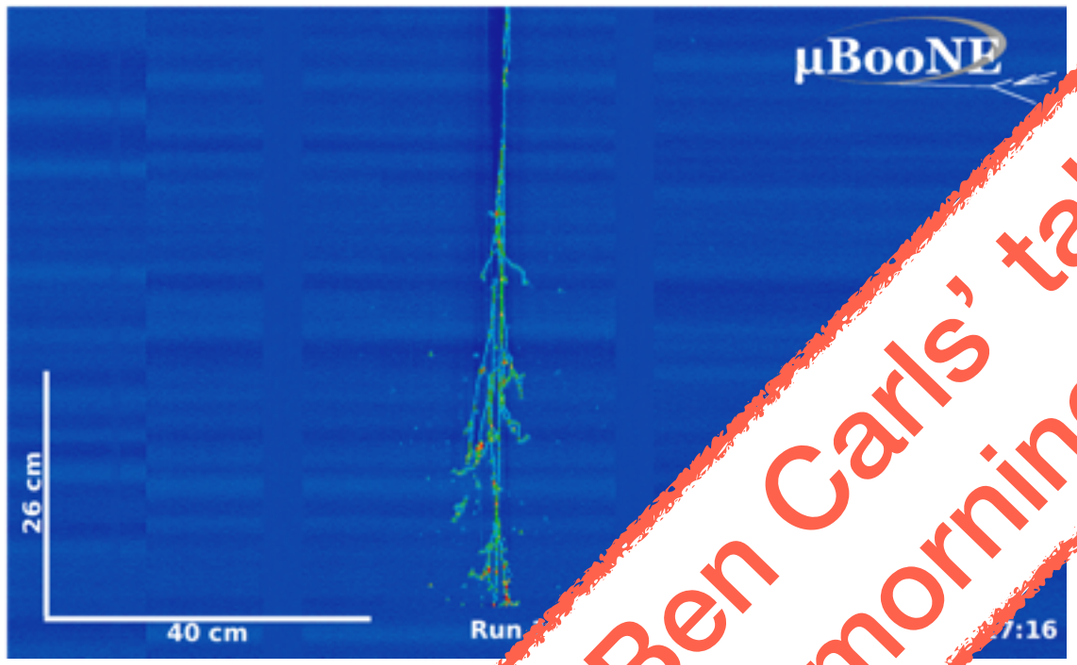
Only definite test in the near future!!

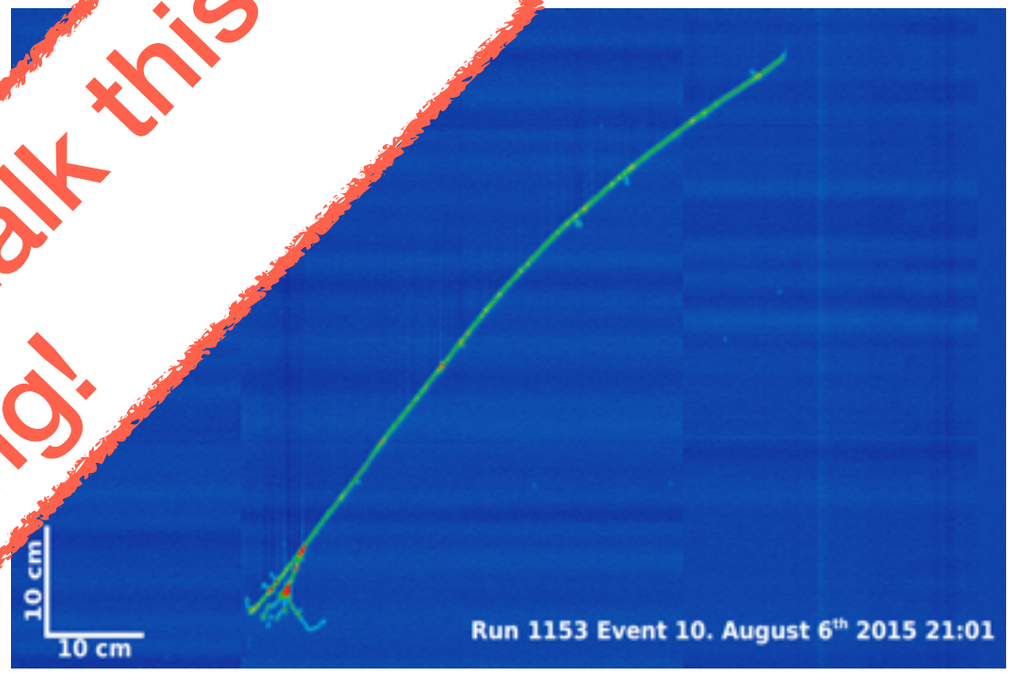
SBN proposal arxiv:1503.01520

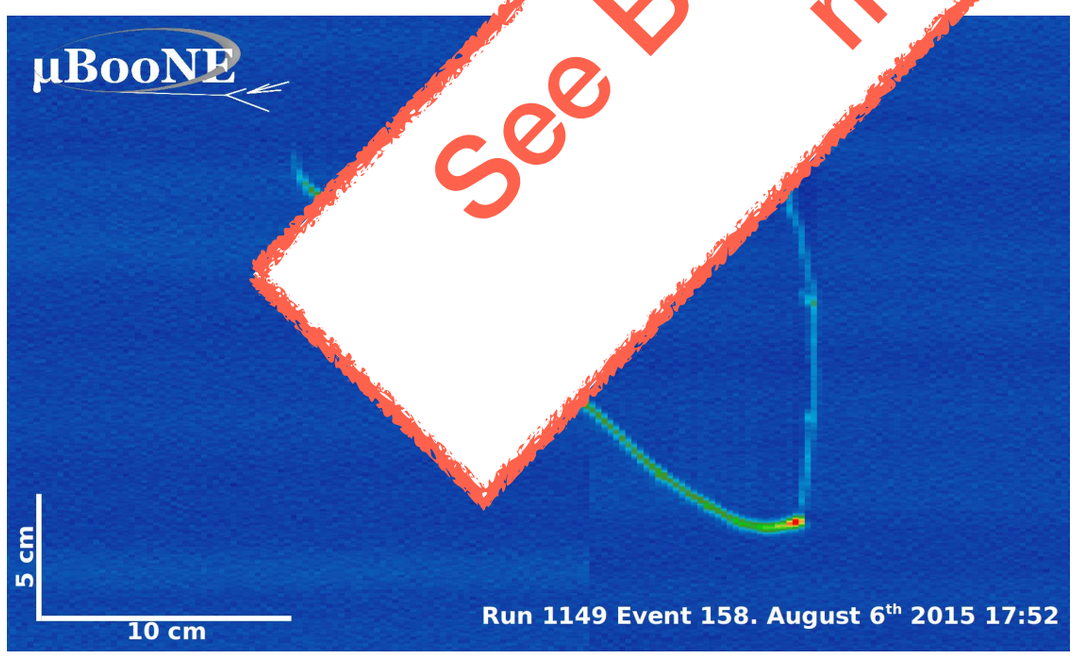
Current Status of the Program

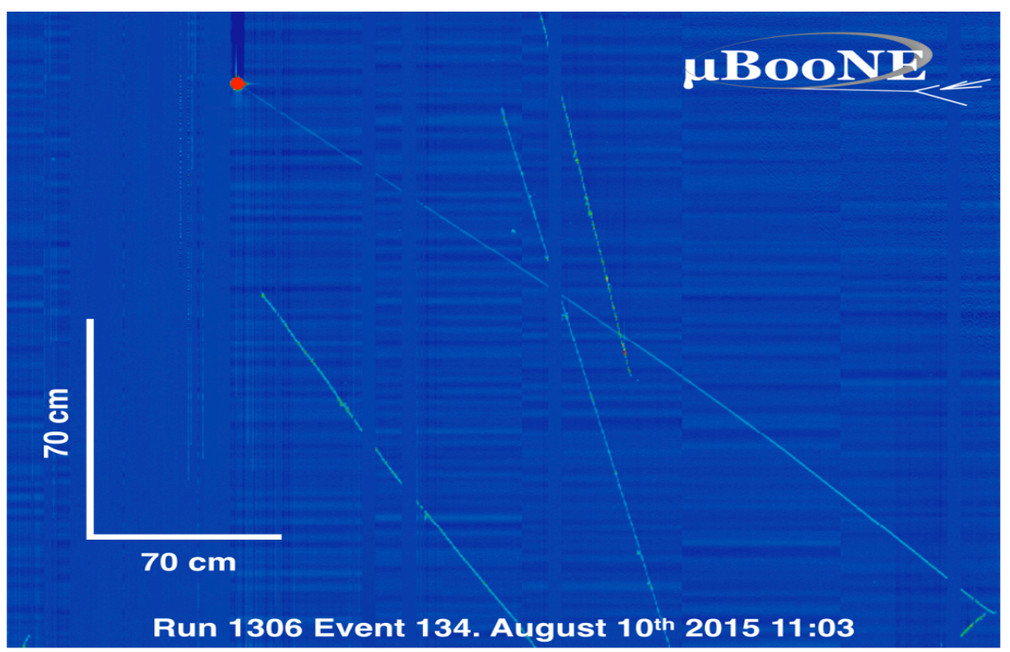
MicroBooNE Status

- First tracks!





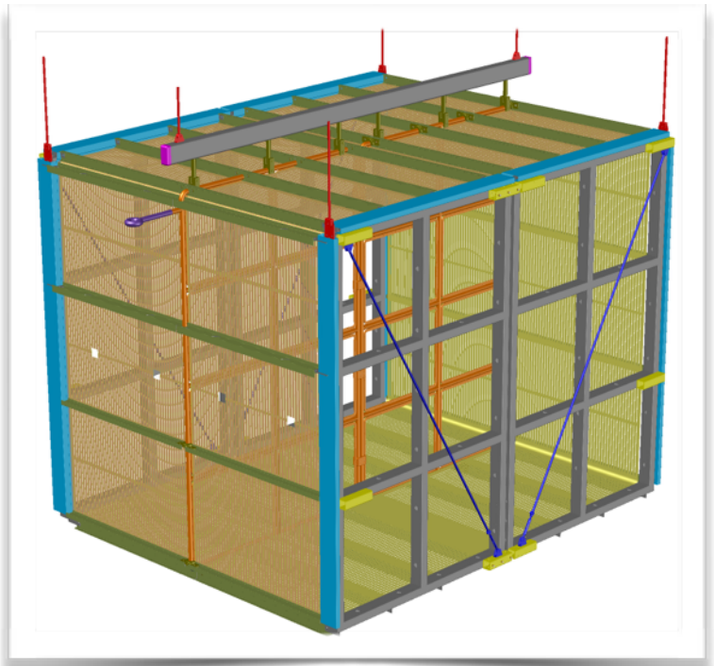




See Ben Carls' talk this morning!

SBND Status

- Stage 1 Approval from FNAL Director: February 2015
- Building Design complete
- Building Construction soon
- Detector Design Fall 2015
- Detector Construction 2016
- Data taking 2018



ICARUS Status

- T300 modules are at CERN being refurbished
- First T300 refurbishment end of 2015
- Building Design Completed
- Building Construction started
- Modules moved to FNAL 2017
- Data taking 2018

Conclusions on SBN

- MicroBooNE has turned on
- MicroBooNE will answer the MiniBooNE low-energy excess
- SBND will address the source of a MicroBooNE excess (if any)
- SBN will give a definitive answer to LSND/MiniBooNE anomaly
- SBN has the perfect timescale to provide important physics inputs to DUNE