Fermilab SBN Program – Task Force Status and Planning

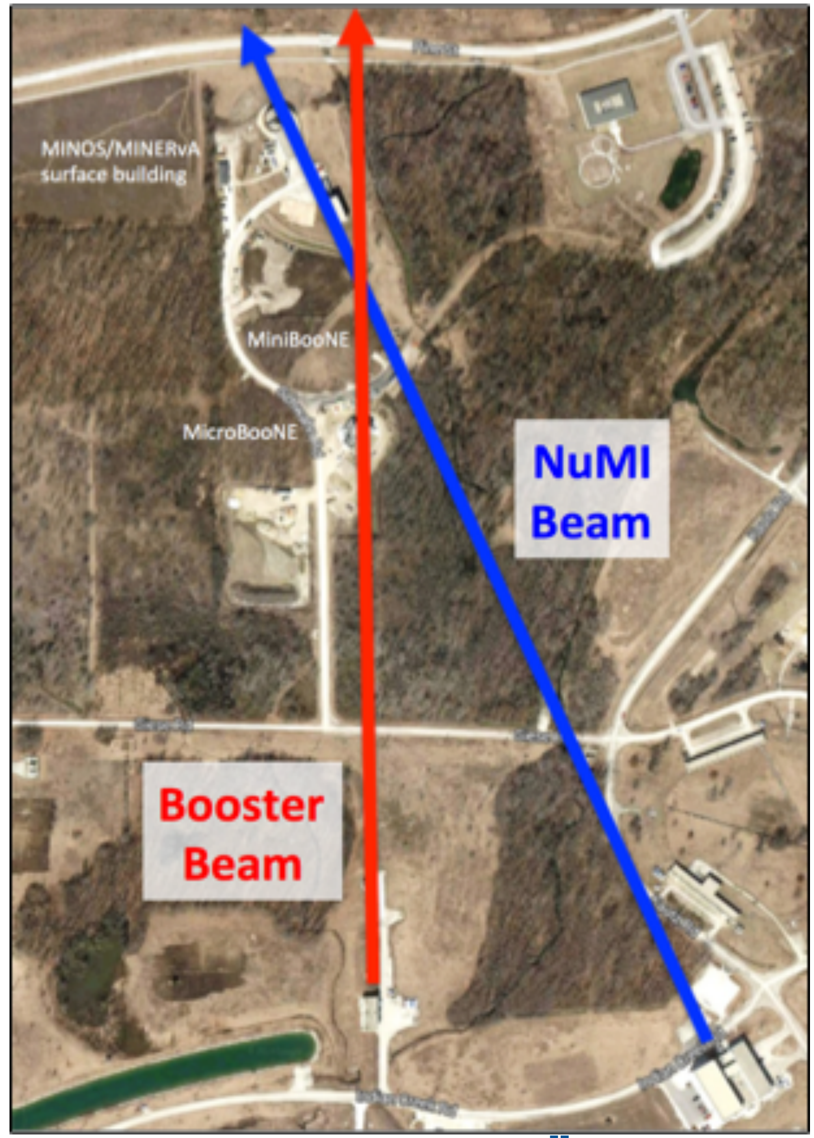
Peter Wilson
SBN Program Coordinator
24 July 2014

Outline

- Motivation – see Steve Brice's talk this morning
- Brief History:
  - LAr1-ND, ICARUS Proposals
  - SBN Task Force and Working Groups
- Current status:
  - Initial Optimization
  - Reference Configuration
- Organization
  - Funding
  - Schedule
  - Organization
  - Approval and review process

Booster Short Baseline Neutrino Beam

- Short Baseline Neutrino Program built on well established existing beamline
  - Robust target and horn system
  - BNB neutrino fluxes well understood due to dedicated hadron production data (HARP experiment @ CERN) and 10+ years of study by MiniBooNE and SciBooNE
  - MicroBooNE detector nearing completion
  - Beam near surface (~10m) => modest civil construction cost



Recent SBN Proposals to Fermilab PAC

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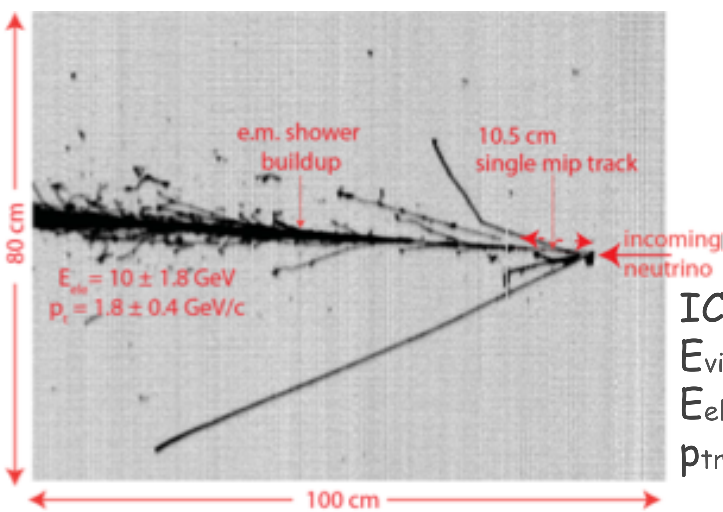
- January 2014 - Two new proposals:
  - P-1052: ICARUS@FNAL
    - Propose relocating an updated ICARUS T600 LAr TPC detector to the BNB as far detector and construct new ¼ scale (T150) detector with same design to serve as a near detector for oscillation searches.

P - 1052: ICARUS at BNB

- ICARUS T600 detector located along the BNB at ~700m from the target
- New T150 detector based on T600 design located at 150±50m from target
- Search for sterile neutrinos
- T600 would also receive ν's from the off-axis NuMI neutrino beam peaked at ~2 GeV with an enriched ν_e flux



ICARUS data event with:
$E_{visible}$ = 11.5 ± 1.8 GeV
$E_{electron}$ = 10 ± 1.8 GeV
$p_{transverse}$ = 1.8 ± 0.4 GeV/c

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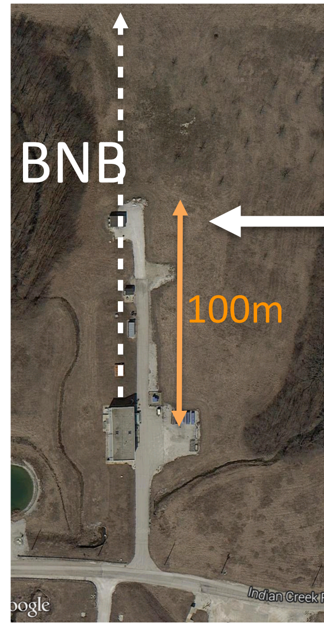
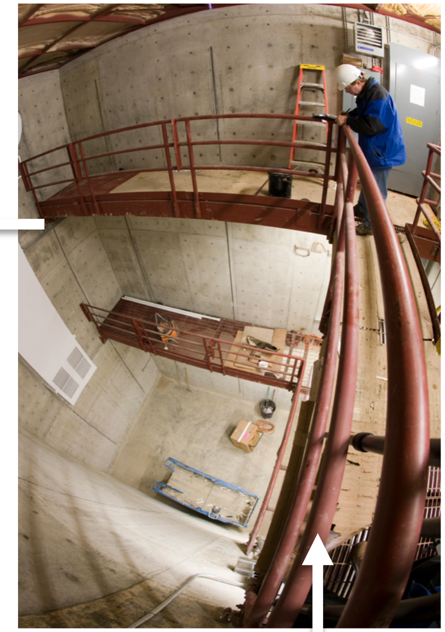
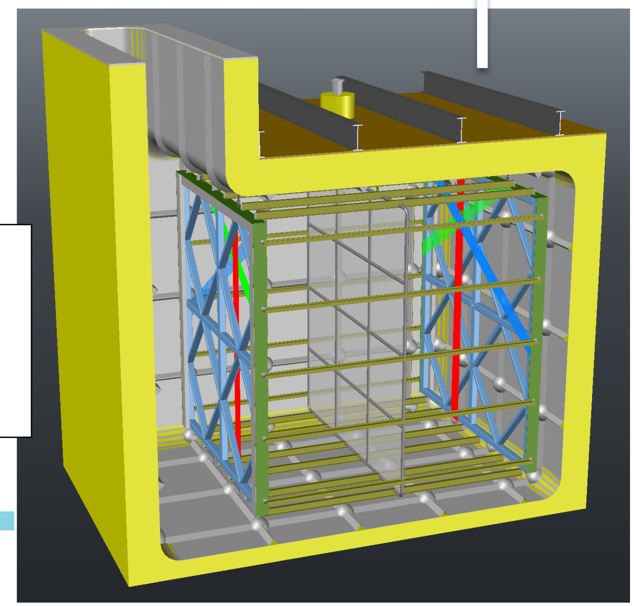
  - P-1053: LAr1-ND
    - Proposed as near detector to MicroBooNE as next phase of SBN program to measure the un-oscillated fluxes.

P-1053: LAr1-ND

- New LAr TPC detector
  - Utilize LBNE far detector design concepts as much as feasible ➔ R&D benefit for Long Baseline
  - Build on experience of T600, MicroBooNE, LBNE 35 ton
  - Locate at 100m in existing SciBooNE enclosure ➔ cost control
- High statistics measurement of intrinsic BNB ν content, combine with far detector
- With MicroBooNE, provide a complete interpretation of the MiniBooNE excess: γ or e? Intrinsic or appearing?
- “Physics R&D”: Reconstruction development and GeV ν-Ar cross sections. ~1M ν_μ events per year, 6,000 ν_e per year!







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  - P-1053: LAr1-ND
    - Proposed as near detector to MicroBooNE as next phase of SBN program to measure the un-oscillated fluxes.
  - *At this stage the PAC is concerned about the coherence of the neutrino program in the context of the Laboratory's strategic direction. The PAC would like to see better integration with the LBNE Collaboration. The PAC encourages the Laboratory management to work with the two groups and the LBNE Collaboration to formulate a common Short Baseline Neutrino Experimental (SBNE) program for FNAL.*

Short Baseline Neutrino Program

- Objectives:
  - Search for sterile neutrinos
  - Further develop LAr TPC technology base for LBN program
  - Build international collaboration on neutrino experiments
  - Have all detectors operational with beam by 2018
- Preliminary configuration
  - LAr1-ND at 100m
  - MicroBooNE at 470m
  - ICARUS T600 at 700m
- To meet tight time frame:
  - Build on existing infrastructure: BNB, MicroBooNE, T600 detector
  - Build buildings using GPP funds (<$10M Far det, <$3M Near det)
  - Near detector constructed as DOE detector R&D activity with contributions from others (e.g. NSF, UK, CERN, CH) ➔ connect with LBN program needs

Steps toward a Program – Coordinator and SBN Workshop

- Short Baseline Neutrino Program Coordinator - …*will work with the contact persons from the three detectors to begin to develop an initial cost, schedule, and requirements package for a short baseline neutrino (SBN) program. (Greg Bock)*
- SBN Workshop @ FNAL (April 30 – May 2)
  - 25 Participants from ICARUS, LAr1-ND, MicroBooNE, LBNE, NESSIE, Fermilab engineering
  - Experiment Configuration:
    - Near detector at 100m, 150m, 200m? ➔ need study of flux systematics
    - Far detector at 700m ➔ 600m due to wetland at 700m
    - Far detector on surface or on beam axis (construction cost)? ➔ need study of cosmic backgrounds
    - Schedule and cost of buildings are drivers of the program
    - Detector sizes: need further study
  - Established connections between collaborations
    - Methods for establishing sensitivity
    - Engineering for cryogenics, design of buildings etc

Steps toward a Program: SBN Task Force

- Charged by Nigel Lockyer, Sergio Bertolucci and Fernando Ferroni:

  A task force is being formed to drive the creation of the CDR. Membership of the task force will include representation from each of the three existing collaborations with Peter Wilson acting as facilitator.

- Task force Members:
  - Alberto Guglielmi (ICARUS, INFN Padova)
  - Mazio Nessi (CERN)
  - David Schmitz (LAr1-ND, Univ of Chicago)
  - Peter Wilson (Coordinator, FNAL)
  - Sam Zeller (MicroBooNE, FNAL)
- Challenging goal: design report by July PAC!
  1. Define/Optimize configuration (eg ND baseline, FD shielding)
  2. Establish sensitivity
  3. Establish cost and schedule

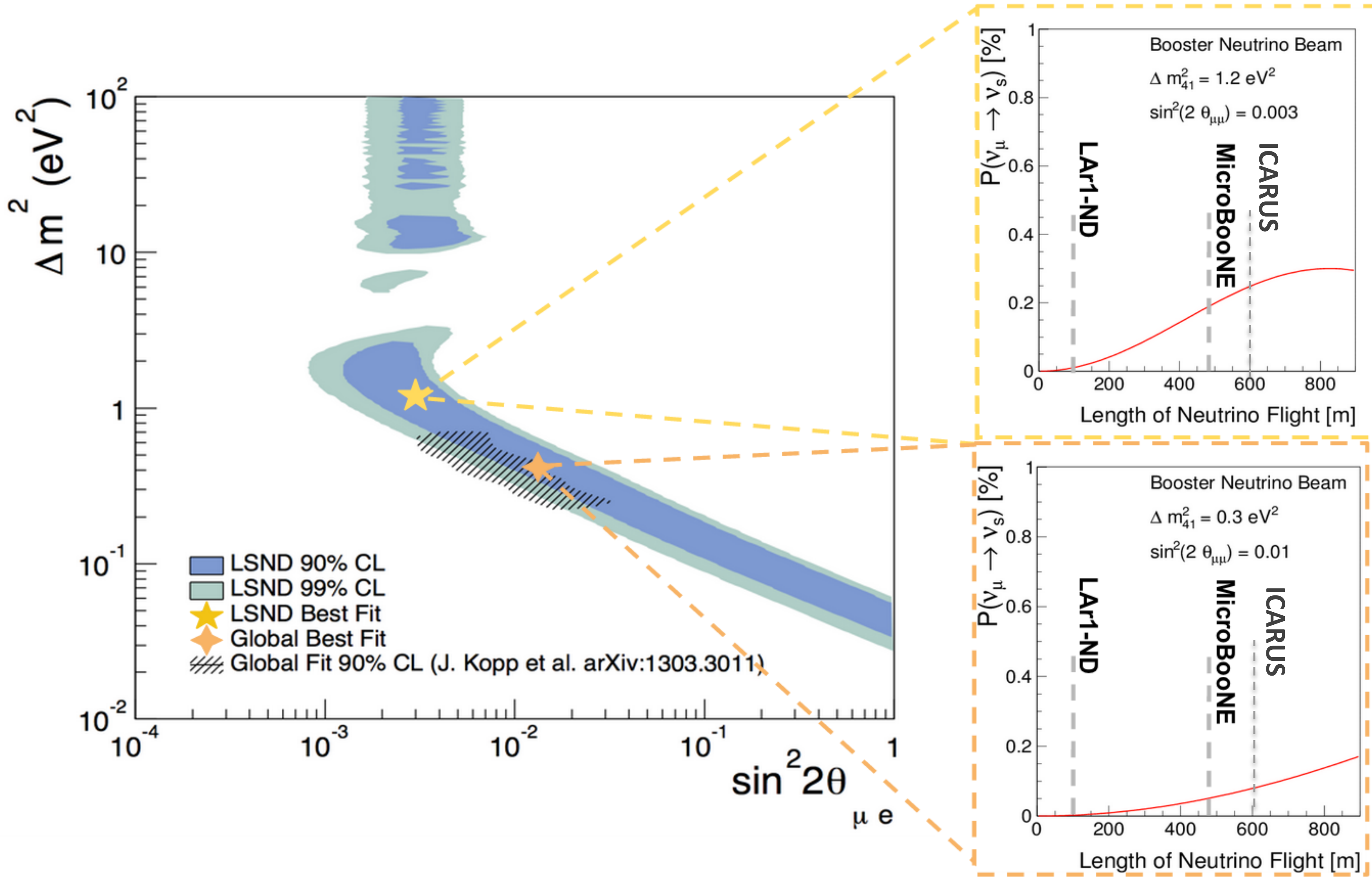
SBN Working Groups

- Four Working Groups formed to address key issues for optimizing the experiment configuration for the conceptual design of SBN program.
  1. Cosmic Backgrounds
     - Impact of cosmic showers on oscillation searches
     - Mitigation strategies
     - Conveners: Paola Sala, Michele Weber
  2. Neutrino Flux and Systematics
     - Optimization of detector location (eg near at 100m, 150m, or 200m?)
     - Possible optimization of BNB for higher flux/proton on target
     - Conveners: Daniele Gibin, Ornella Palamara
  3. Detector Building Configuration and Siting
     - Building requirements
     - Cost and schedule: fit in budget for GPPs (far detector $10M, near detector $3M)
     - Conveners: Alberto Scaramelli, Peter Wilson
  4. Cryostat and Cryogenic System Design and Integration
     - Design of cryogenics including possibility of standardized cryogenics systems for near and far detectors.
     - Optimization of near detector design such as cryostat dimensions.
     - Conveners: Claudio Montanari, Barry Norris
- WGs have each met approximately weekly with several major gatherings
  - WG1 meeting at CERN week of June 16
  - Joint WG 3 & 4 meeting at Fermilab July 2-3
- Work described in status report and in these slides is the product of these WGs.

Initial Optimization

- Design of conventional facilities is on critical path.
- For building designs, need to specify:
  - Baseline of near detector
    - Flux systematics for oscillations ν_e and ν_μ
  - Baseline of far detector
    - Driven by construction cost/schedule, avoid wetland at 700m ➔ locate 600m
  - Far detector on surface or on-axis
    - Flux systematics for oscillations ν_e and ν_μ
    - Cosmic backgrounds
- Two studies:
  1. Flux systematics
  2. First look at cosmogenic photons
- Next step:
  - Optimize detectors

Baseline Example: ν_μ Disappearance



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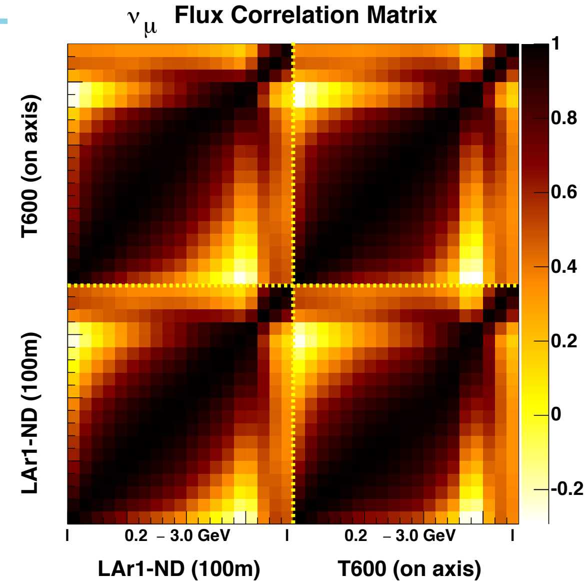
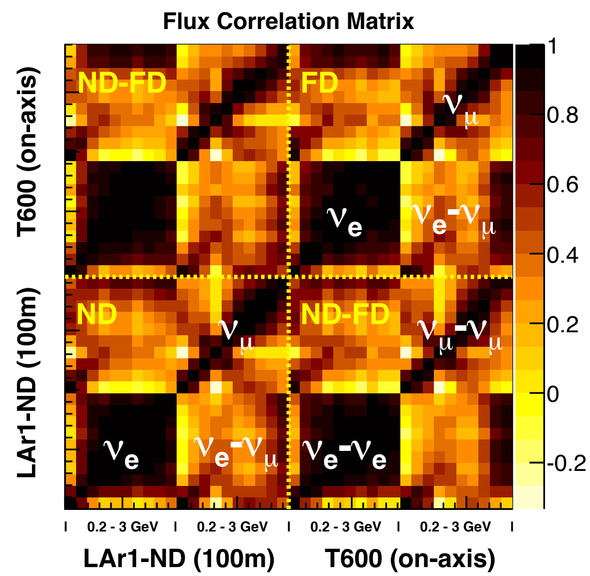
Optimization of Near Detector Baseline

- Statistics vs flux systematics vs oscillated content
- Extreme Case 1: ND close to FD
  - No systematic from flux
  - No sensitivity to oscillation
- Extreme Case 2: ND at target
  - Maximal sensitivity to oscillation
  - Large flux systematic
- Assume factorization of problem:
  - Fix location of far detector (600m)
  - Make *reasonable assumptions* on detectors and performance
  - Other systematics independent of baseline
  - Vary near detector at 100m, 150m, 200m
- Compare sensitivity of ν_μ disappearance, ν_e appearance

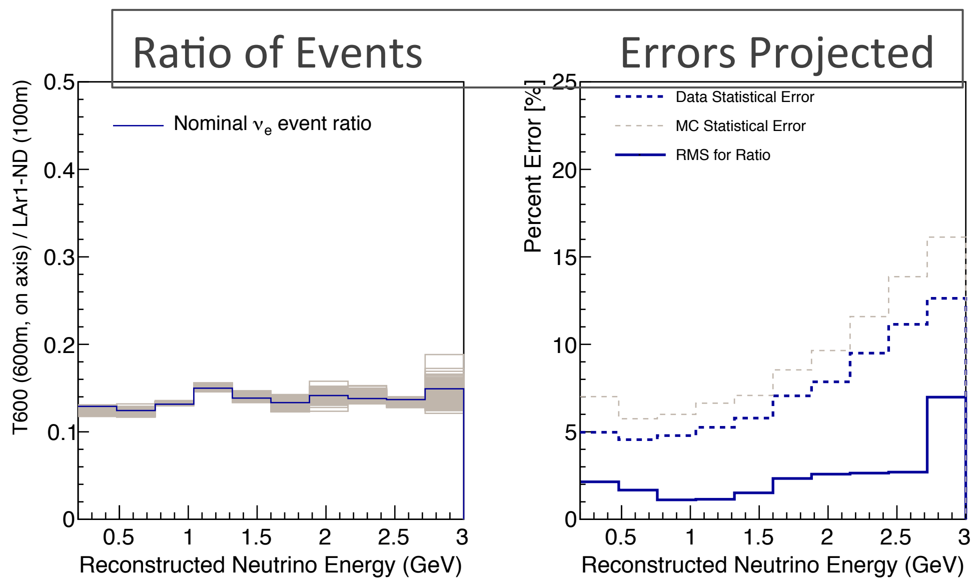




Relative Sensitivities: ν_e Appearance

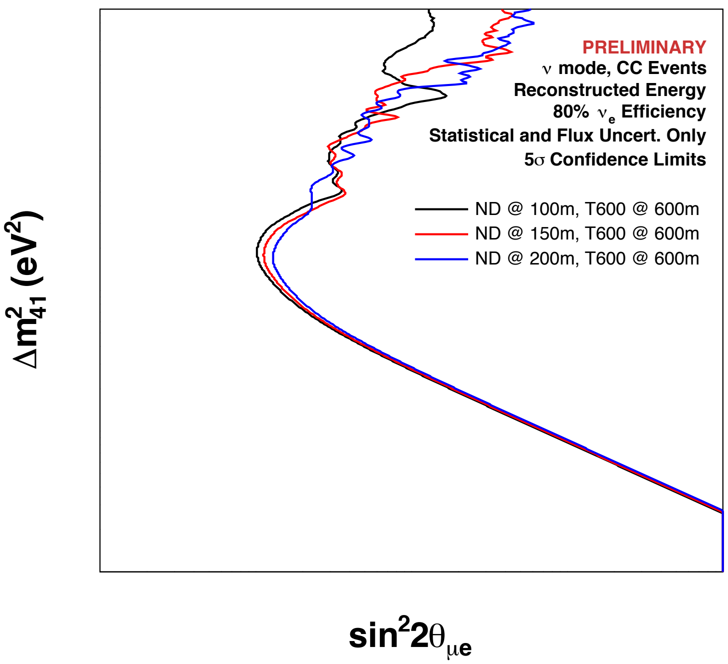
- Calculate sensitivity for three possible experiment configuration
  - Based on well developed MiniBooNE tools including best understanding of BNB beam
  - Use full error correlation matrix
  - Determine 5σ sensitivity in Δm^2_{41} vs $\sin^2 2\vartheta$
  - Given assumptions and current state of studies: Not ready to determine absolute experiment sensitivity
- Cross-check of sensitivities using ICARUS tools in progress

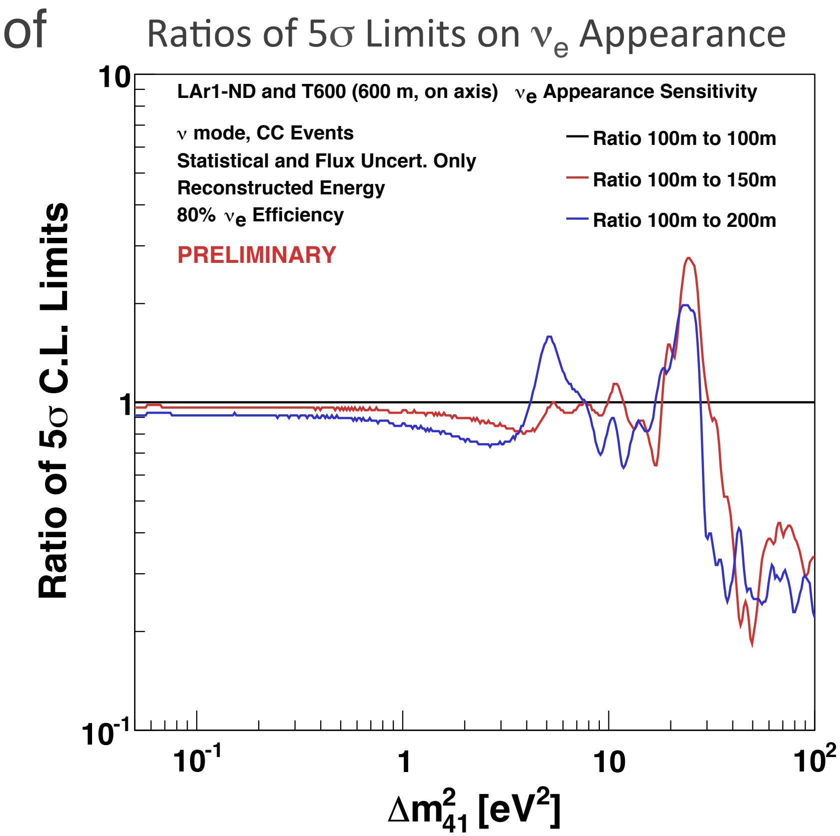
- Assumptions:
  - 6.6E20 P.O.T with nominal detector fiducial volumes (Jan '14 PAC)
  - ν_e CC identification efficiency: 80% in fiducial volume
  - NC π^0, γ rejection factors
  - ν_μ CC + e.m. shower mis-ID rate



Relative Sensitivities: ν_e Appearance

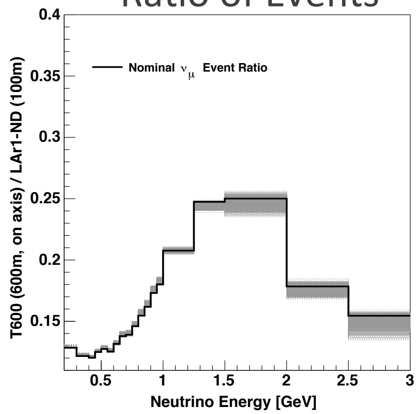
- Difference between three baselines not large, but 100m slightly better
- Cross section physics favors 100m
- Reuse of SciBooNE enclosure as part of near detector facility implies cost advantage to 100m



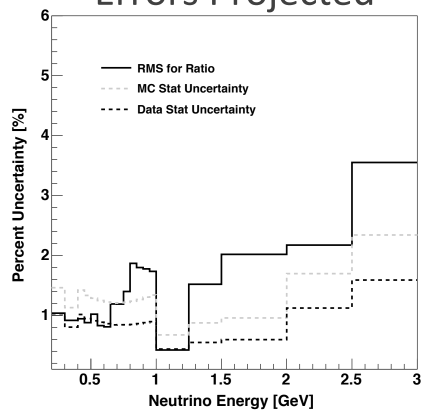


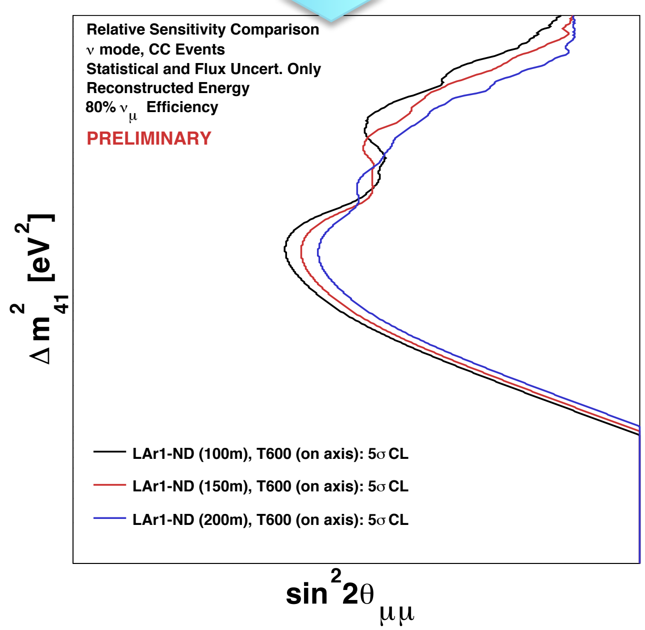
Relative Sensitivities: ν_μ Disappearance

Ratio of Events



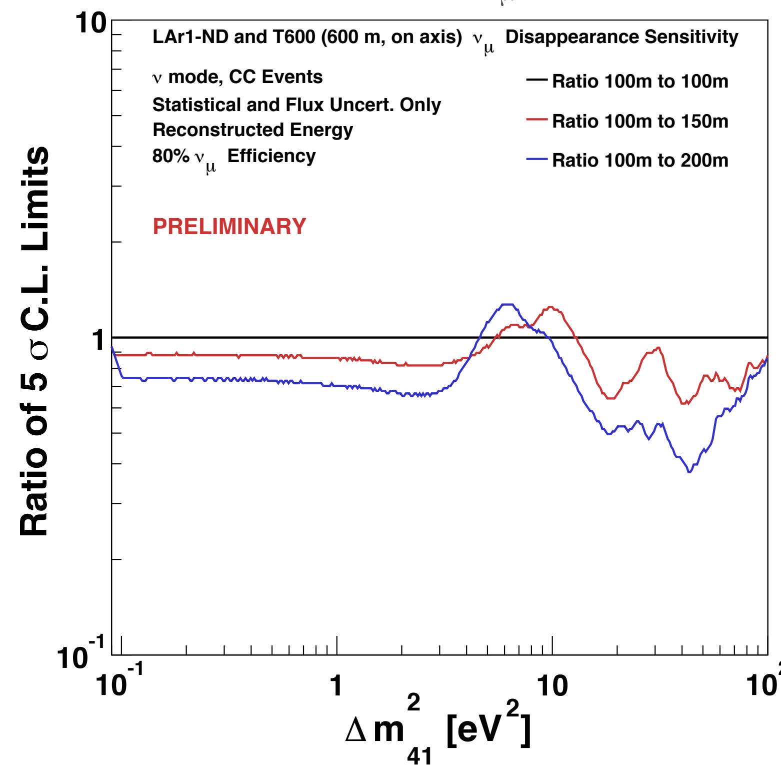
Errors Projected





- Similar assumptions to ν_e appearance
- Same conclusion as ν_e

Ratios of 5σ Limits on ν_μ Disappearance



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Far Detector Position: Cosmic Backgrounds

- Initial focus: cosmogenic γ ➔ Compton e ➔ faking e from ν_e
- Studies by ICARUS, LBNE (10kt surface), MicroBooNE
  - With similar assumptions get agreement to within factor of 2-3
  - Analysis of selection cuts and efficiency just started for ICARUS, MicroBooNE
- Some numbers to keep in mind:
  - Spill time of 1.6μs ➔ total spill time for 6.6E20 P.O.T is 212s (1.3x10^8 spills)
  - Drift time of TPCs ~1000 times longer than spill time
  - ~30 overlapping cosmic μ's /event in ICARUS: present light detection system cannot associate the correct timing to each recorded track as required to automatically distinguish in spill from out-of-spill interactions.
- ICARUS w/ 3m Overburden: N(compton in spill time) ~ N(Intrinsic ν_e) ~ 2000
  - Assumes Timing *can isolate* to spill time
- Mitigation plan:
  1. Install detector on axis with capability of overburden (assumed above)
  2. Explore active veto: external vs internal
  3. Careful study of timing capability (assumed above), selection criteria and efficiency
- Lower event selection efficiency could be compensated by doubling the active mass and/or improvements to the BNB design.

Effect of Cosmogenic Backgrounds

	Detector	MicroBooNE	ICARUS		LBNE	LAr1-ND
1	Cosmic γ Rate	$0.332 \mathrm{m}^{-2}\mathrm{s}^{-1}$	$0.75\ \mathrm{m}^{-2}\mathrm{s}^{-1}$		$0.331 \mathrm{m}^{-2}\mathrm{s}^{-1}$	
2	Active mass	89t	Scaled by area to MicroBooNE	475t	Scaled by area to MicroBooNE	82t
3	Surface (w/o bottom)	$87.5\ \mathrm{m}^2$	$87.5\ \mathrm{m}^2$	$289\ \mathrm{m}^2$	$87.5\ \mathrm{m}^2$	$75.8\ \mathrm{m}^2$
4	$\mathrm{N}_\gamma(\mathrm{E}_\gamma > 200$ MeV), w/o OVB	31680	43296	143000		
5	$\mathrm{N}_{\mathrm{Compton}}(\mathrm{E} > 200$ MeV), w/o OVB	634	1449	4787		549
6	$\mathrm{N}_\gamma(\mathrm{E}_\gamma > 200$ MeV), w/ OVB		15986	52800	4576 (E$>$ 250 MeV)	
7	$\mathrm{N}_{\mathrm{Compton}}(\mathrm{E} > 200$ MeV), w/ OVB		490	1619	137	
8	N_e(Intrinsic ν_e CC, $E > 0$ MeV)	567		2000		17649

Assumes 6.6E20 P.O.T, Count cosmics in time with the spill(212s)

- Mitigation plan:
  1. Install detector on axis with capability of overburden
  2. Explore active veto: external vs internal
  3. Careful study of timing capability, selection criteria and efficiency

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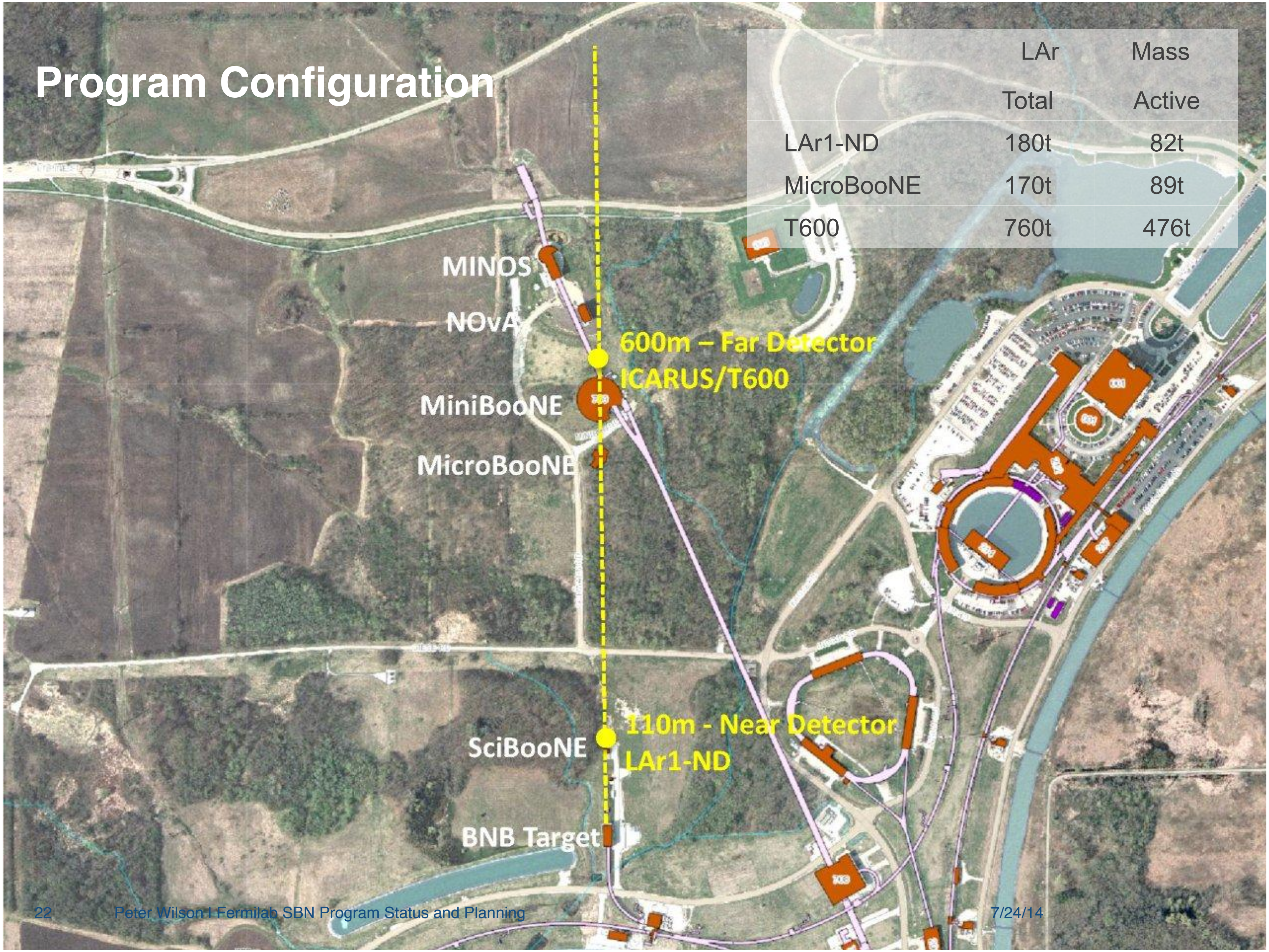
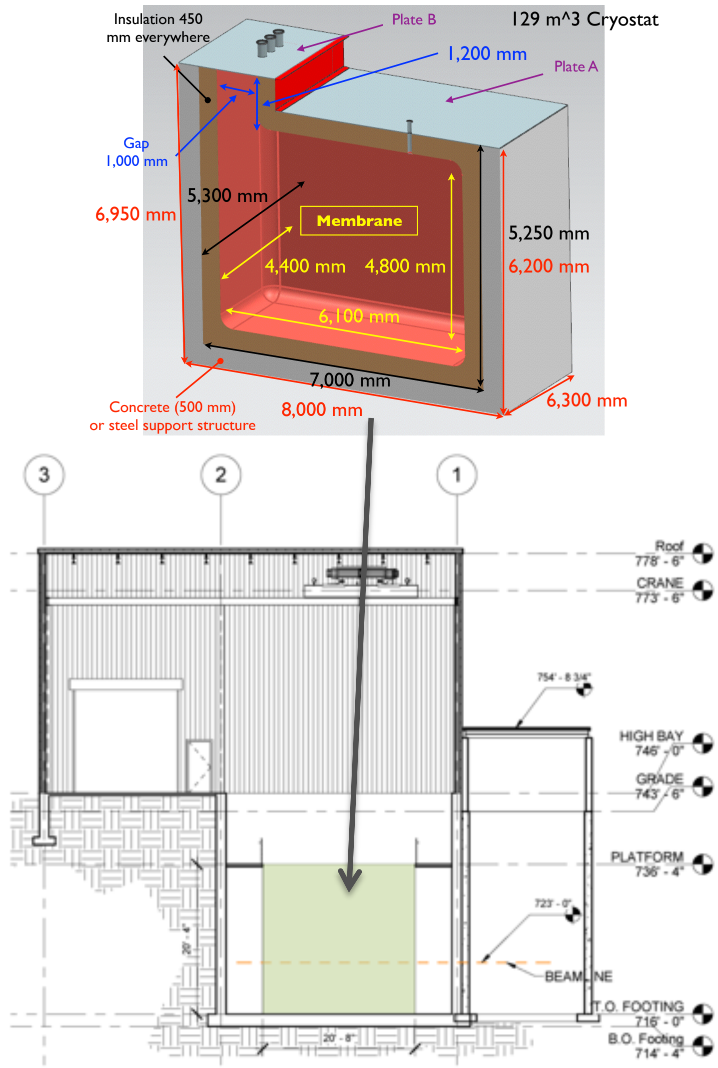
Program Configuration

	LAr	Mass
	Total	Active
LAr1-ND	180t	82t
MicroBooNE	170t	89t
T600	760t	476t



Near Detector Building

- Construct building using GPP funds
  - Budget cap $3M
- New enclosure downstream of SciBooNE (110m)
  - Optimize for easier installation of membrane cryostat.
  - SciBooNE used for Cryogenic system
  - Design to support concrete overburden over detector pit
- Initial costing by A&E firm in August
  - After initial costing, evaluate options on size of ND TPC/Cryostat



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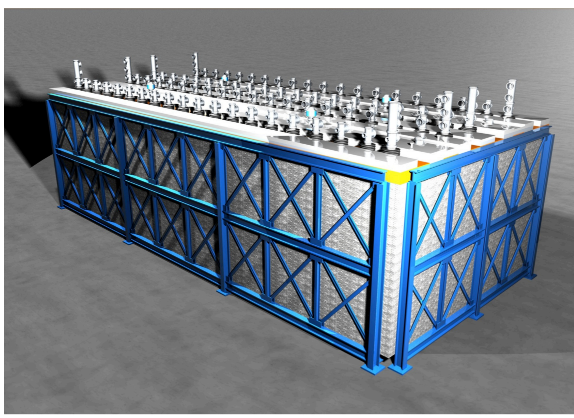
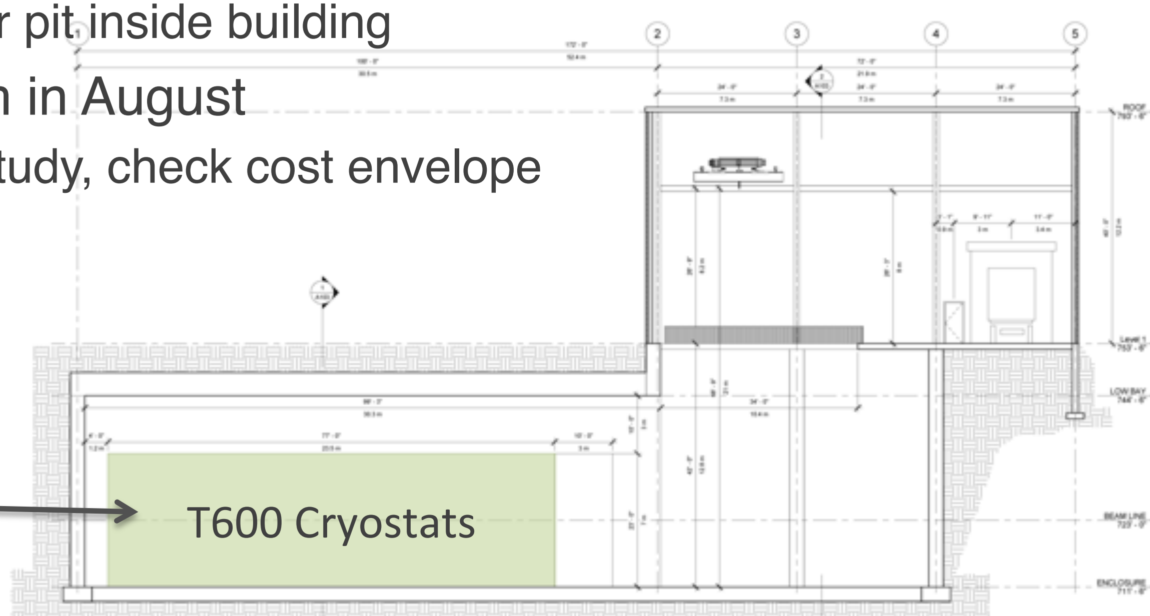
Far Detector Building

- Challenges:
  – GPP limits total cost to <$10M
  – Installing two cryostats each weighing 50t (4m x 4.2m x 20m)
- Two building concepts
  1. Install cryostat in open pit, complete roof over top. Overburden on top of roof
  2. Building with removable roof. Detector installed in completed building. Concrete shielding over pit inside building
- Initial costing by A&E firm in August
  – Larger detector under study, check cost envelope





Concept 1

Optimizations for Design Report

- Near detector
  - Longer TPC: is there significant benefit to justify cost increase?
  - Alignment of design with LBN R&D questions (eg external pump for LAr)
  - Light collection system
  - Veto?
  - Initial discussions between UK and U.S. groups on TPC
- Far detector
  - Light collection system
  - More detailed understanding of cosmics and efficiency
  - Veto system: internal to cryostat vs external (eg scintillator)
- BNB Target and Horn
  - BNB optimized for MiniBooNE detector, could potentially increase productivity given the power of LAr TPC to discriminate against backgrounds
  - Additional production data (HARP) and experience from NuMI system
  - Exploring possibilities of heavier target material (shorter), change in inner conductor, two horn system fitting in existing enclosure

Collaboration on Cryogenics and Cryostats

- A partnership is being established between CERN and Fermilab to develop infrastructure for LAr TPCs
  - Joint specifications
  - Common Designs that can be delivered to CERN, Fermilab etc
- Cryogenic systems: LAr filtration and LN2 for cooling
  - Based concept of standard skids
  - Specified jointly with detailed designs and construction contracted
  - Standardized controls
  - Test at vendor/CERN delivery to experiment
- Membrane Cryostats
  - Access to two vendors : GTT (France) or IHI (Japan)
- New engineering groups formed at CERN and Fermilab
  - Experience from ATLAS, LBNE (35ton), MicroBooNE
- SBN is first demonstration ➔ LBN

Role of MicroBooNE

- MicroBooNE will be the first of the new SBN detectors
  - Operating with beam in early 2015
- MicroBooNE will provide valuable early data on performance of LAr detectors in BNB beam
  - Reconstruction software
  - Measure reconstruction efficiency
  - Cosmic backgrounds: effectiveness of light system, selection criteria, need for overburden
  - Provide input to final designs of LAr1-ND and T600 update
- Provides a two detector system as soon as LAr1-ND or T600 is ready
- Impact of MicroBooNE in three detector program has not yet been fully explored
  - Focus has been on optimization of the other two detectors

Lowering MicroBooNE Cryostat into LArTF

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SBN Funding Sources

- Fermilab/DOE:
  - Building construction/outfitting (GPP)
  - Integrate and install LAr1-ND (R&D)
  - Integrate and install of T600 (OPS)
- CERN, Fermilab/DOE and INFN jointly share cost of Cryogenics and Cryostats
  - LAr1-ND: CERN and Fermilab
  - ICARUS: CERN and INFN
- LAr1-ND detector (TPC, Light system, electronics)
  - NSF/MRI for TPC in final approval
  - UK-STFC for TPC in review
  - Switzerland (BERN)
  - Others? (eg Light system, electronics, active veto)
- T600 Overhaul
  - WA104 collab through MOU w/CERN

	Funding Source		
Component	**DOE**	**NSF**	**Non-US**
LAr1-ND			
Building	X		
Cryostat	X		X
Cryo System	X		X
TPC, Light Detection		X	X
Electronics	X	?	
Integrate and Install	X		
ICARUS			
Building	X		
Cryostat			X
Cryo System			X
TPC, Light Detection			X
Electronics			X
Integrate and Install	X		X

- Requested DOE funding:
  - GPP $9.8M + <$3M
  - R&D $10M over 3 years for ND
  - Operations funds to install FD not yet requested

Schedule and Milestones

- Goal set of having detectors ready for data taking in Spring 2018. This is very challenging but possible.
- Detailed schedule not yet prepared, presented here is a first pass at high level milestones
  - Construction of buildings is on critical path
  - Preparation of CDR must proceed immediately to define requirements of buildings and cryogenics systems
- To achieve this schedule, the work of the Task force and WGs must continue with increased participation and cooperation in the coming months

High Level Milestones

Milestone	Date
Submission of a detailed SBN proposal for peer review	Oct 2014
Final CE requirements ready final building design	Nov 2014
Near detector cryostat engineering study contracted	Nov 2014
T600 at CERN, refurbishing starting	Dec 2014
Cryogenic plants proposal submitted for peer review	Mar 2015
LAr1-ND technical proposal submitted for peer review	Mar 2015
Ground breaking for far detector building	May 2015
Cryogenics procurement plans released and active	Sep 2015
Ground breaking for near detector building	Oct 2015
LAr1-ND cryostat procurement contract issued	Dec 2015
Buildings ready, utilities installation start	Oct 2016
Start cryostat assembly for near detector at Fermilab	Oct 2016
T600 ready at CERN for transport	Nov 2016
T600 detector arrives at Fermilab	Mar 2017
Start LAr1-ND detector installation	Apr 2017
Start cryogenic plant commissioning	Aug 2017
LAr1-ND and T600 installed	Sep 2017
Start detectors cooling and commissioning	Nov 2017
Start data taking with beam	Apr 2018

Organization: Scientific Collaboration

- Three collaborations working together through Task force and working groups to create joint proposal/CDR
  - Waiting to start work until collaboration model is decided would delay preparation of proposal/design report
  - Task force and Working groups can be sandbox for establishing future collaboration
  - Discussion of future organization must continue in parallel
- The Task force and the WGs have representatives from each of the collaborations, however they cannot "approve" for the collaborations
  - There was not sufficient time for the status report or this talk to be approved by all three collaborations
  - This work represents the best effort by the Task force and WGs to represent the interests of the collaborations
  - The Proposal/Design Report to follow will need to have more formal approval
- The three collaborations are very engaged in the process and have all shown great interest in the success of the SBN Program

Organization: Oversight and Review

- Require close coordination between collaborations, CERN, Fermilab, INFN, and other funding stakeholders
  – Similar challenge to LHC experiments but at a different scale
  – LBN faces same challenge at a bigger scale
- Proposed structure for construction
  – Three collaborations responsible for delivery of their detectors at least through commissioning
  – MOUs (or equivalent) between collaborations and Fermilab
- Cost, schedule and technical reviews will be required:
  – Expect SBN Program to be external to DOE CD Process (413.2b)
  – Propose that peer reviewing be organized by Fermilab as Director's Reviews
- Oversight of finances will be required:
  – Propose that Fermilab will organize a Resource Review Board
- Propose a steering group to guide the work: SBN Task force provides an example of a possible organization.

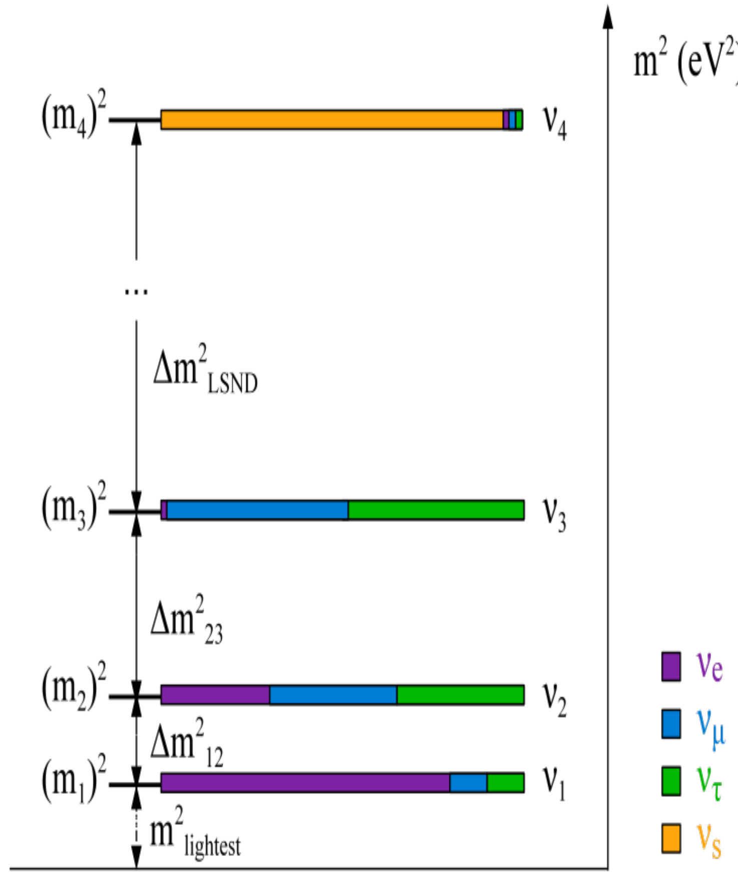
Summary

- Significant progress has been made in establishing the definition of the Short Baseline Neutrino Program.
- A framework for the organization of the program has been established through the SBN Task Force and the Working Groups. These will need to strengthen to achieve the goal of a Conceptual Design in Fall 2014.
- The challenging schedule requires that evaluation of capabilities must proceed simultaneously with establishing technical requirements for the detectors and facilities. Final design of the far detector building must start by December 2014 and have scope that fits in GPP cost envelope.
- There are significant challenges ahead to establish the capability of the program (e.g.): more detailed understanding of cosmic backgrounds and identification efficiency.
- The existing Fermilab BNB combined with LAr TPCs detectors provide an excellent opportunity to resolve hints of new physics of neutrinos at short baseline.

Backup Materials

SBN Physics Program

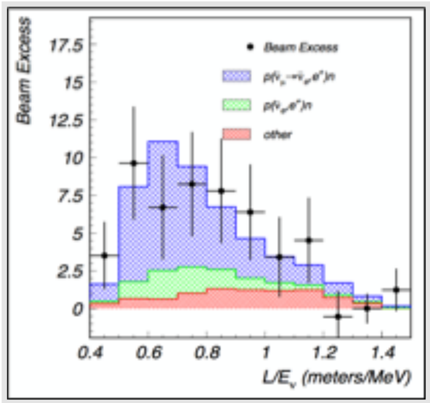
- A Multi-detector program could address these unexplained anomalies which together could be hinting at new physics (see Steve Brice's talk this morning)
  - MicroBooNE will address MiniBooNE low energy excess but not designed explore the complete sterile neutrino oscillation parameter space on its own



Experiment	Type	Channel	Significance
LSND	DAR	$\bar{\nu}_\mu \to \bar{\nu}_e$ CC	3.8σ
MiniBooNE	SBL accelerator	$\nu_\mu \to \nu_e$ CC	3.4σ
MiniBooNE	SBL accelerator	$\bar{\nu}_\mu \to \bar{\nu}_e$ CC	2.8σ
GALLEX/SAGE	Source - e capture	ν_e disappearance	2.8σ
Reactors	Beta-decay	$\bar{\nu}_e$ disappearance	3.0σ

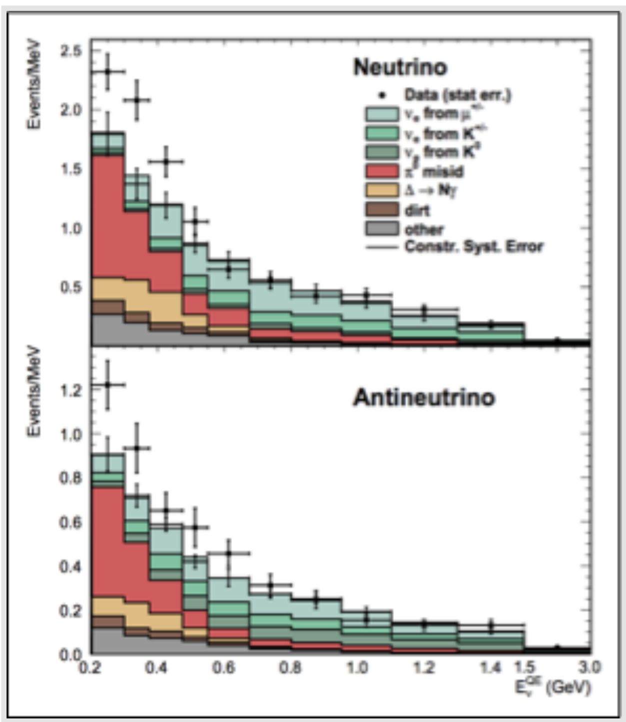
K. N. Abazajian et al. "Light Sterile Neutrinos: A Whitepaper", arXiv:1204.5379 [hep-ph], (2012)

Accelerator Based Anomalies



LSND

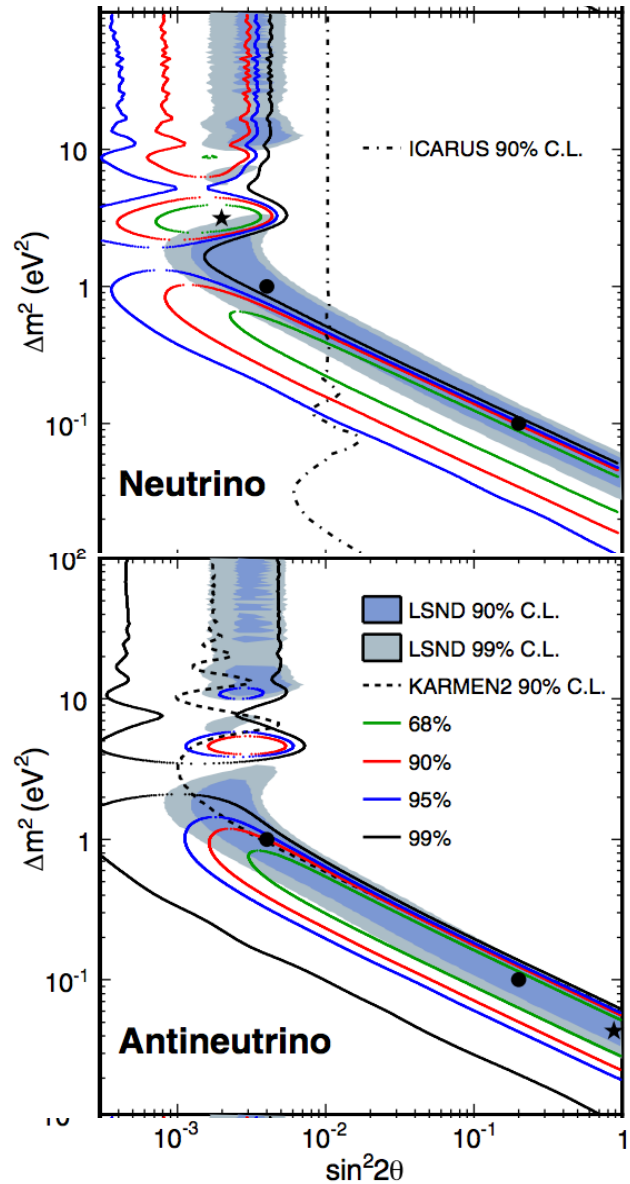
$\bar{\nu}_\mu \rightarrow \bar{\nu}_e?$



$\nu_\mu \rightarrow \nu_e?$

MiniBooNE

$\bar{\nu}_\mu \rightarrow \bar{\nu}_e?$



Fermilab Experiment Schedule

Fermilab Program Planning

Fermilab Accelerator Experiments' Run Schedule

12-Feb-14

		FY 2014 (Q1–Q4)	FY 2015 (Q1–Q4)	FY 2016 (Q1–Q4)	FY 2017 (Q1–Q4)
Neutrino	B	MiniBooNE-DM / µBooNE	MicroBooNE	MicroBooNE	MicroBooNE
Muons	B	OPEN / g-2	g-2	g-2	g-2
Muons	B	OPEN	OPEN	OPEN / Mu2e	Mu2e
Neutrino Program	MI	MINOS+	MINOS+	MINOS+	MINOS+
Neutrino Program	MI	MINERvA	MINERvA	MINERvA	MINERvA
Neutrino Program	MI	NOvA	NOvA	NOvA	NOvA
SY 120	MT	FTBF - MTest	FTBF - MTest	FTBF - MTest	FTBF - MTest
SY 120	MC	OPEN / FTBF - MCenter	FTBF - LArIAT	FTBF - LArIAT	FTBF - MCenter
SY 120	NM4	SeaQuest / SeaQuest	SeaQuest	SeaQuest	SeaQuest / OPEN

- RUN/DATA
- STARTUP/COMMISSIONING
- INSTALLATION/COMMISSIONING
- M&D (SHUTDOWN)
- INSTALLATION & RUNNING

Anticipate mid-year maintenance shutdowns of 6 week + 2 weeks commissioning

NOvA CD-4 end of Nov 2014, MicroBooNE first beam for commissioning July 2014

MicroBooNE "installation" start defined as time when BNB target reinstalled.

g-2 and Mu2e installations defined as starting when buildings ready.

Continued MINERvA & MINOS+ running through FY07 assumed - to be reviewed

SBN Workshop Questions:

1. New alternative proposed layout: MicroBooNE as Near detector and ICARUS T600 as Far (500 m?): what are the benefits on physics reach, time schedule and cost?
2. Sensitivity assumptions: The sensitivities for nue appearance presented by the LAr1-ND and ICARUS collaborations seem to have some differences even when evaluating very similar configurations. In order to converge, it would be helpful to discover what creates this difference. Is it a difference in input assumptions or calculation methods?
3. Neutrino beam spectra at different distances from target.
4. Near Detector size: Do we gain in the physics capabilities by enlarging the ND? What are the cost and schedule implications of such a change?

SBN Workshop Questions (cont):

- Location of ICARUS T600: Is the physics impacted by locating the FD at the surface, amounting to ~10m off-axis? What are the cost savings relative to locating on-axis?
- Far Detector size: Is it possible to increase mass at far detector with new module(s)? What impact would added mass at FD location have on physics reach?

- Think about these questions during today's sessions and consider:
  - Do we already have enough information to come to a conclusion now?
  - If not, what additional information do we need to reach a conclusion?

Effect of Cosmogenic Backgrounds

	Detector	MicroBooNE	ICARUS		LBNE	LAr1-ND
1	Cosmic γ Rate	$0.332 m^{-2} s^{-1}$	$0.75\ m^{-2} s^{-1}$		$0.331 m^{-2} s^{-1}$	
2	Active mass	89t	Scaled by area to MicroBooNE	475t	Scaled by area to MicroBooNE	82t
3	Surface (w/o bottom)	$87.5\ m^2$	$87.5\ m^2$	$289\ m^2$	$87.5\ m^2$	$75.8\ m^2$
4	$N_\gamma(E_\gamma > 200$ MeV), w/o OVB	31680	43296	143000		
5	$N_{Compton}(E > 200$ MeV), w/o OVB	634	1449	4787		549
6	$N_\gamma(E_\gamma > 200$ MeV), w/ OVB		15986	52800	4576 (E> 250 MeV)	
7	$N_{Compton}(E > 200$ MeV), w/ OVB		490	1619	137	
8	N_e(Intrinsic ν_e CC, $E > 0$ MeV)	567		2000		17649

Assumes 6.6E20 P.O.T, Count cosmics in time with the spill(220s)

- Mitigation plan:
  1. Install detector on axis with capability of overburden
  2. Explore active veto: external vs internal
  3. Careful study of timing capability, selection criteria and efficiency

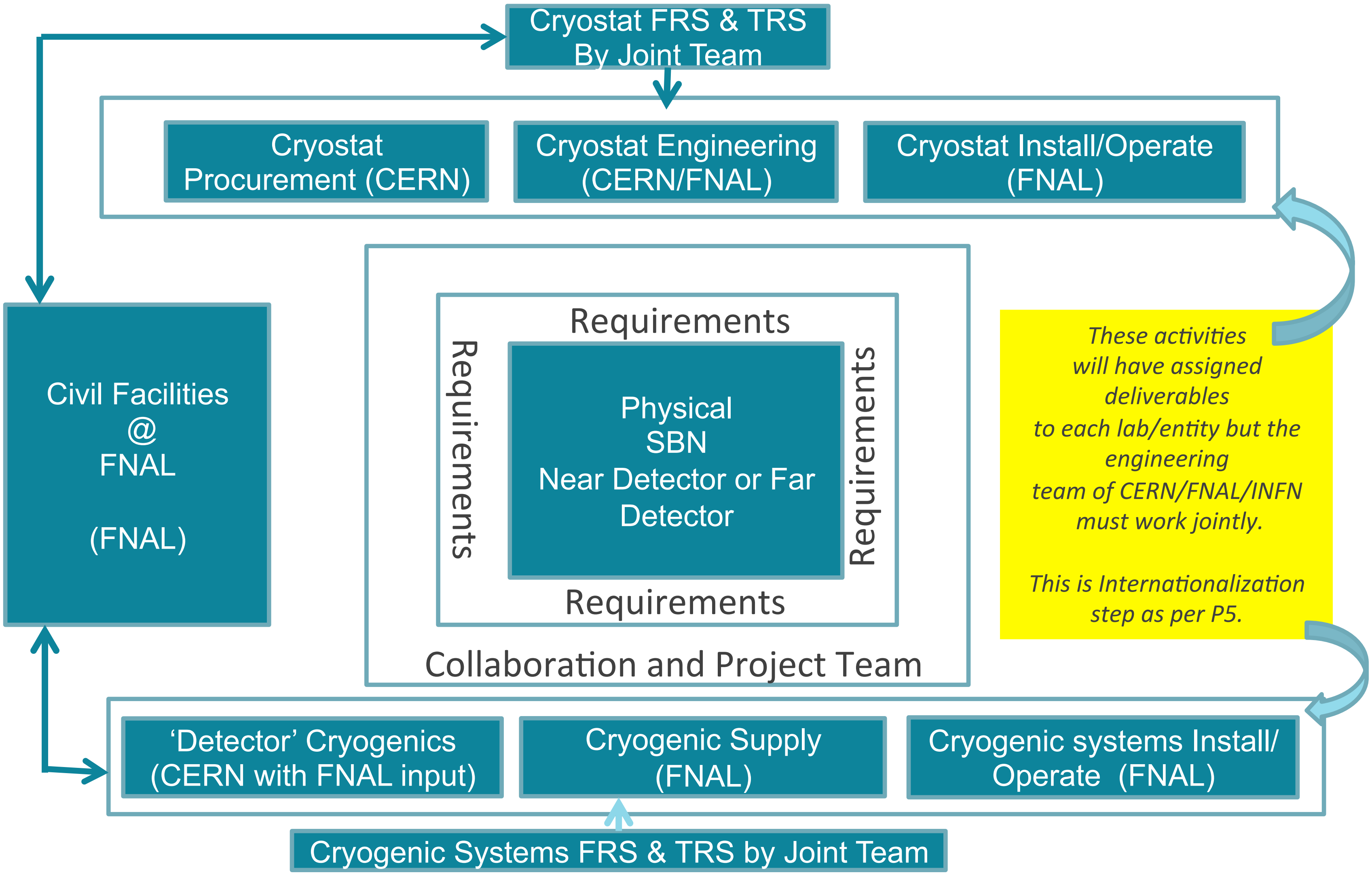
Fermilab

Example LAr1-ND Cryostat Parameters (129m^3)

Parameter	Value
Type of structure	Membrane cryostat
Outside reinforcement	Concrete/steel enclosure with embedded heaters (Floor + Sides)
Fluid	Liquid Argon (LAr)
Inner dimensions (flat plate to flat plate)	4.4 m (W) x 6.1 m (L) x 4.8 m (H)
Depth of liquid argon	4.8 m (All the gas in the "neck" region)
LAr Volume/Mass	129 m^3 / 180 ton
Membrane material	SS 304/304L
Maximum static heat leak	15 W/m^2 ??
Insulation thickness	0.45 m (everywhere)
Primary membrane	SS 304/304L
Operating gas pressure	1.0 psig (~70 mbar)
Vacuum	No vacuum
Design Pressure	3.0 psig (~207 mbar)
Design Temperature	77 K (liquid Nitrogen temperature for convenience)
Metal surfaces in the ullage in ops	< 100K
LAr pumps for continuous purification	Outside tank
Cold penetrations	At least one (HV)
Lifetime	10 years (5 years of run + 5 years potential upgrade)
Thermal cycles	20 complete cycles (cool down and total warm up)

From David Montanari

Example Organization of Cryogenics and Cryostat Effort



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10 US institutions
- 3 DOE National Laboratories
- 6 NSF institutions

8 European institutions
- 6 UK institutions
- 1 Swiss institution
- CERN

11 institutions also on MicroBooNE.
Most also LBNE collaborators.

MicroBooNE Collaboration

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- 3 countries
- 23 institutions
- 134 collaborators (includes project team)

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