SBN Joint Working Groups

SBN Oversight Board Meeting
FNAL
December 13th 2019
Daniele Gibin

SBN Joint Working Groups

- SBN DAQ and Data Pre-Processing *(conveners: B. Badgett, A. Fava, W. Ketchum, S. Ventura)*
  - *Scope*: Identify areas of common effort on **trigger, data acquisition and data pre-processing**, and coordinate activities in those areas.
- SBN Slow Controls *(conveners: S. Gollapinni, G. Savage)*
  - *Scope*: Develop a **control system** based on **hardware and software interfaces** as much as possible identical for the two detectors.
- SBN Cosmic Ray Tagger *(conveners: U. Kose, I. Kreslo, B. Wilson)*
  - *Scope*: Review the **CRT production status and the installation plans for the two detectors**, develop common CRT **DAQ and data output format** (together with the SBN DAQ WG), develop **common CRT monitoring**.

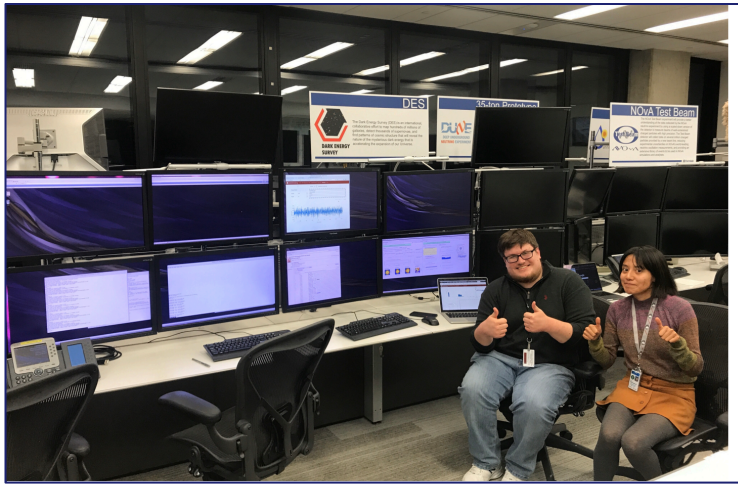
SBN Joint Working Groups

- SBN Data Management *(conveners: W. Ketchum, J. Zennamo (new))*
  - *Scope:* Review computing resources and needs for SBND and ICARUS, and define a **model for SBN computing**. Collaborate with the Fermilab Scientific Computing Division to develop an **implementation of the SBN computing** strategy.
- SBN Analysis *(conveners: D. Gibin, O. Palamara)*
  - *Scope:* Implement a **multi-detector simulation**, the **reconstruction** algorithms/tools and the **analysis tools for the SBN oscillation analysis**.

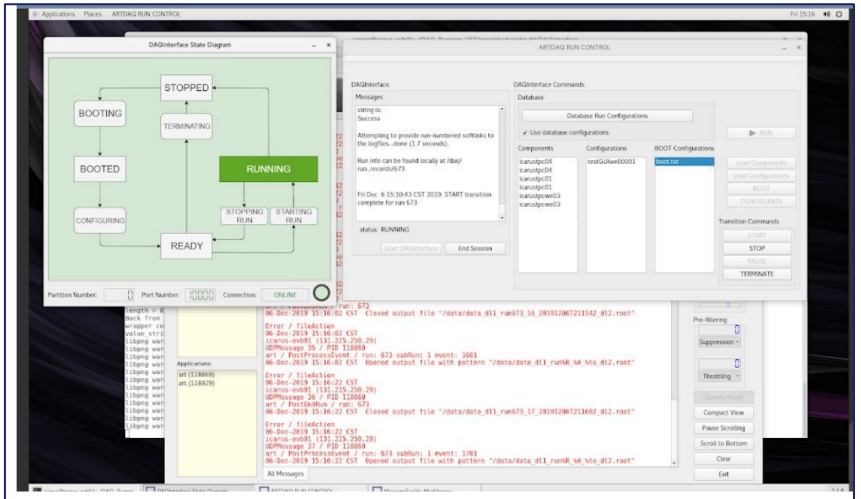
SBN DAQ and Data preprocessing

Much progress, with focus on preparing for data-taking at SBN-FD (ICARUS)!

- Preparing run control in ROC-W for operation of the far detector
  - Updates to RunControl with database
  - Updates to online monitoring
  - Continued development of system integration
    - Important timing studies on CRT DAQ
- This has been a successful SBN-wide effort!



First data taken using CR machines!



VNC to evb-01 machine

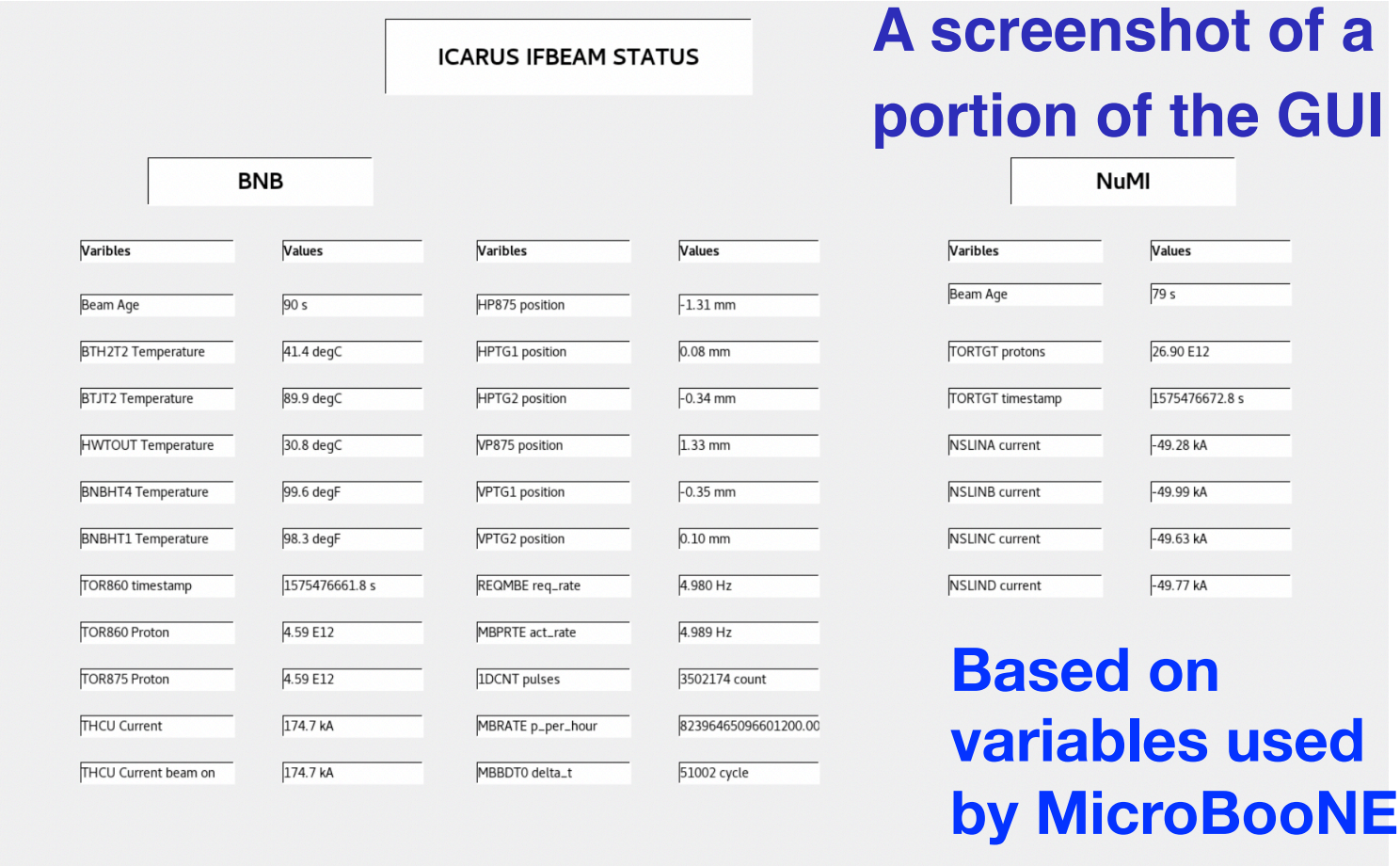
Common SBN Slow Controls WG

Sub-system	Hardware Contact	Hardware Choice/ Manufacturer	Software Protocol
Photon Detection System (PDS)	Robert/Bill	CAEN SY5527 HV, CAEN WV8100VME005	Various protocols for CAEN for EPICS; N2 levels in LAr come from Cryo IFIX
Ground Monitoring	Linda	Similar to uB, custom-built	low-level protocols into EPICS
GPS Timing	Bill	GNSSource-2500	low-level protocols into EPICS
Power Distribution Units (PDUs)	Bill	Schneider Electric rack PDU	NetSNMP to EPICS
CPU hardware monitoring	Wes/Bill	KOI computers; Super-micro parts	IPMI to EPICS
Cameras	Steve Hahn	Axis	custom controls provided by VMS services
Purity Monitors	Trevor N / Anne	same as uB/ICARUS	follow uB model
DAQ Servers (CPU load, memory etc.)	Wes/Bill	KOI computers; Super-micro parts	Grafana to EPICS
DAQ Status	Wes/Bill	—	InfluxDB to EPICS
Cryo Status	Trevor N.	Fermilab Cryogenics	IFIX to EPICS
Beam Status	Tom K.	BNB/NuMI	IFBeamDB to EPICS

Green — done; **Yellow** — ongoing;
Gray — haven't started;

BEAM Status App/GUI (Wei)

- App and GUI are available now for ICARUS IFBEAM systems
- Geoff is checking the possibility of sharing the BEAM App/ GUI among three SBN experiments



ICARUS IFBEAM STATUS

A screenshot of a portion of the GUI

BNB

Varibles	Values	Varibles	Values
Beam Age	90 s	HP875 position	-1.31 mm
BTH2T2 Temperature	41.4 degC	HPTG1 position	0.08 mm
BTJT2 Temperature	89.9 degC	HPTG2 position	-0.34 mm
HWTOUT Temperature	30.8 degC	VP875 position	1.33 mm
BNBHT4 Temperature	99.6 degF	VPTG1 position	-0.35 mm
BNBHT1 Temperature	98.3 degF	VPTG2 position	0.10 mm
TOR860 timestamp	1575476661.8 s	REQMBE req_rate	4.980 Hz
TOR860 Proton	4.59 E12	MBPRTE act_rate	4.989 Hz
TOR875 Proton	4.59 E12	1DCNT pulses	3502174 count
THCU Current	174.7 kA	MBRATE p_per_hour	82396465096601200.00
THCU Current beam on	174.7 kA	MBBDT0 delta_t	51002 cycle

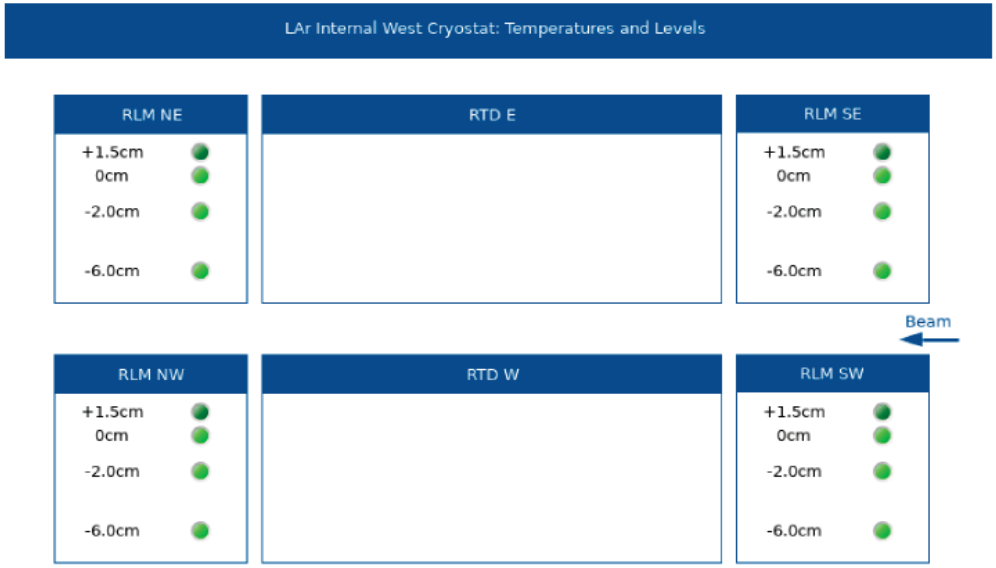
NuMI

Varibles	Values
Beam Age	79 s
TORTGT protons	26.90 E12
TORTGT timestamp	1575476672.8 s
NSLINA current	-49.28 kA
NSLINB current	-49.99 kA
NSLINC current	-49.63 kA
NSLIND current	-49.77 kA

Based on variables used by MicroBooNE

Cryogenic IFIX Status (ICARUS) (Bill, Wei Geoff, Aslin)

- An app and GUI are available based on an initial variable list
- Variable list for ICARUS being finalized now
- Previous 800 IFIX variables are now reduced to ~500
- Planned to look similar to IFIX HMI (from Trevor)



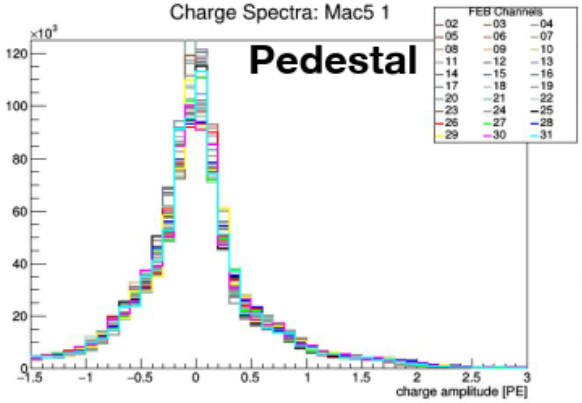
Cryo GUI as of 12/4/19. Temperature information to be added in the future. LEDs will light up as corresponding level meters indicate that LAr has reached each level.

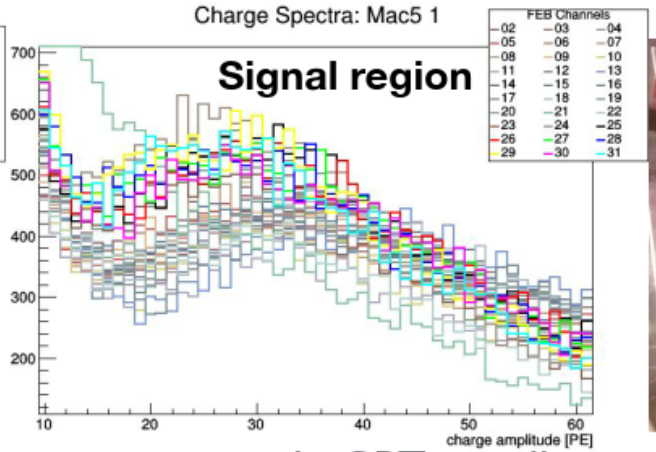
SBN Cosmic Ray Tagger WG: ICARUS Side CRT

SBN-FD Side CRT

- Readout electronics have been installed at the north wall side CRT SBN-FD
  - Reading 240 channels (8 FEBs)
- Commissioning of the north wall is ongoing
- Exercising the DAQ and analyzing the data
- Setting up shifters' instructions and CRT online monitoring

ADC spectral overlays calibrated in PE, inner layer west mezzanine



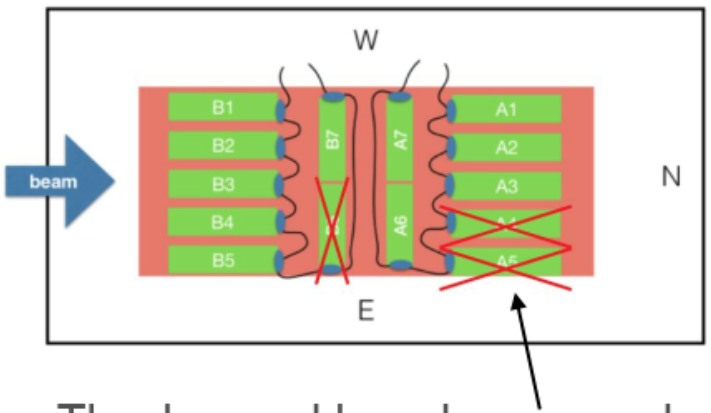


- Installing the support for the remaining side CRT installation

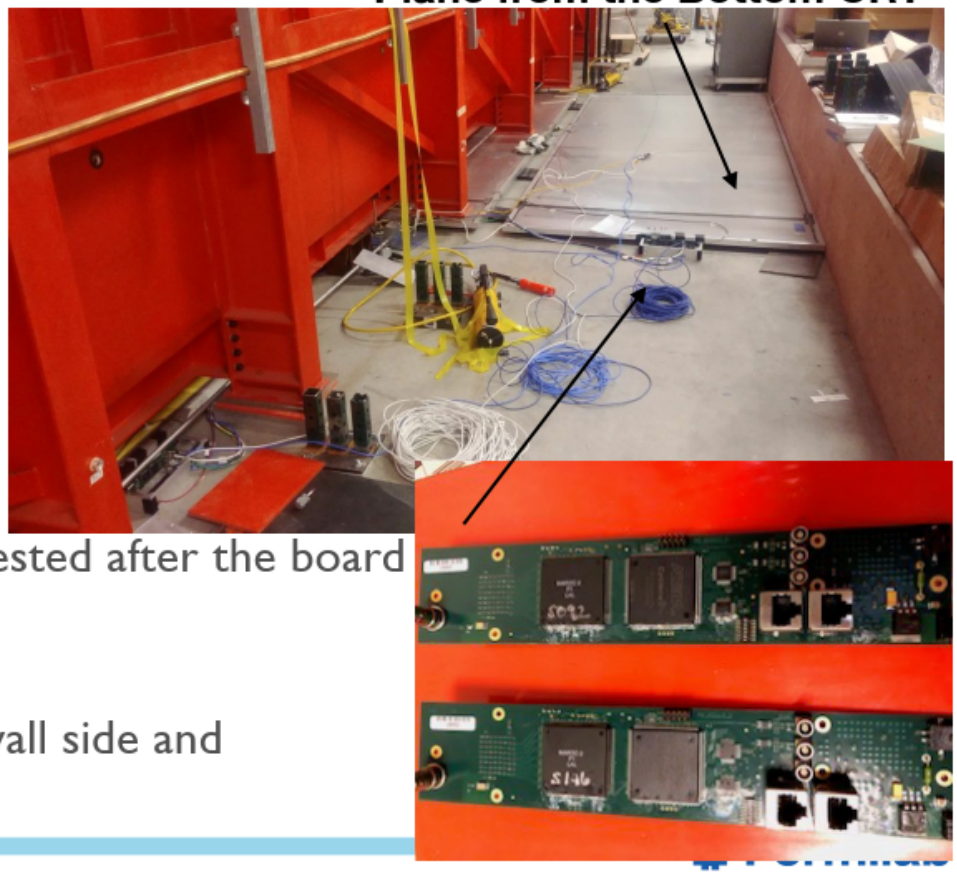
Fermilab

SBN-FD Bottom CRT

- We had a sum pump failure at the SBN-FD building
- The water reached some PMT boards. Three boards were drawing no current from the low voltage supply preventing the remaining (good but daisy chained) boards from working properly

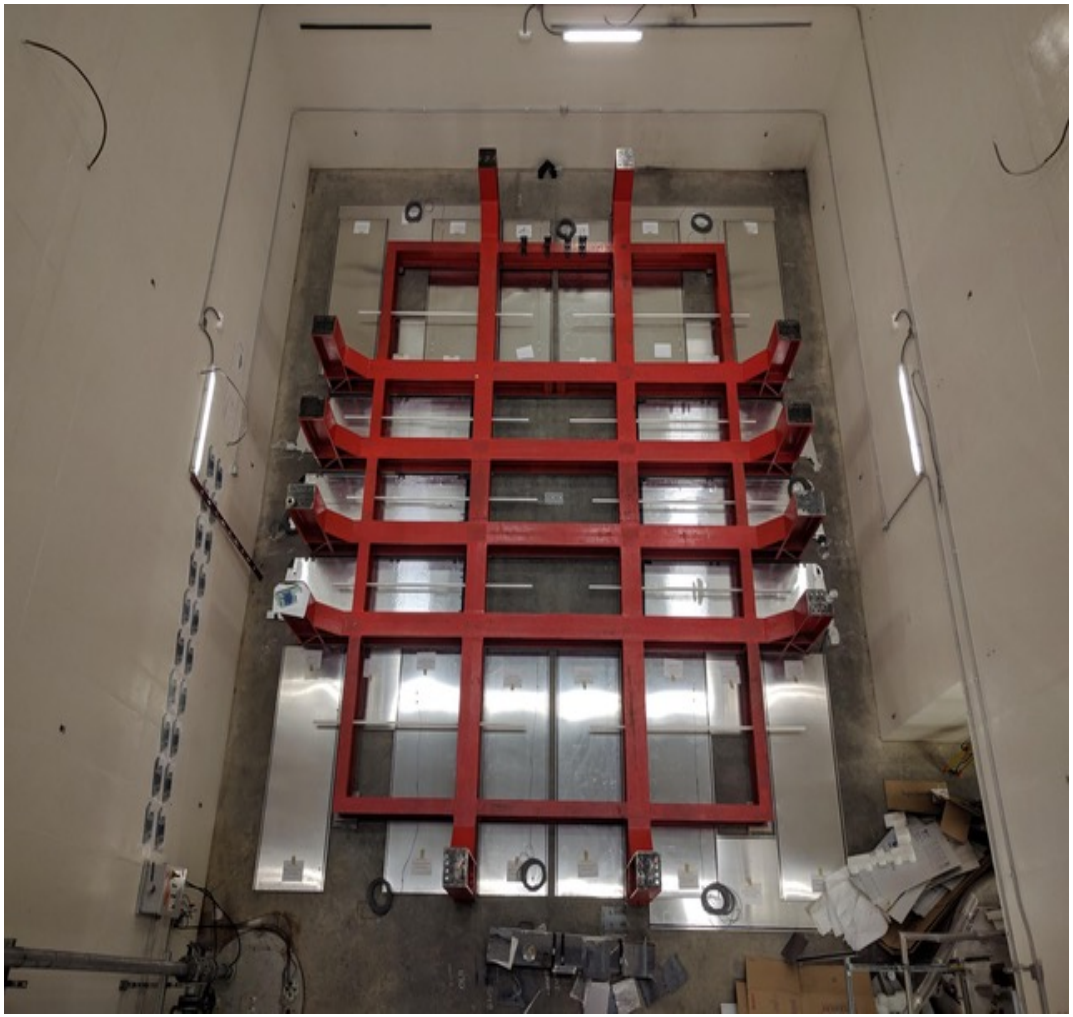


Plane from the Bottom CRT



- The damaged boards were replaced
- Current draw and daisy chain were tested after the board replacement
- Setting up the artDAQ framework
- Preparing to commission the north wall side and bottom CRT at SBN-FD

CRT Bottom layer installed!



- September 22 Lorenzo Meier from Uni-Bern arrived to Fermilab to supervise installation of Bottom Layer CRT
- September 27 the CRT panels successfully installed !
- Commissioning is planned after installation of Side CRT panels in 2020.

SBN Data Management

- Continued focus on the most pressing need: preparing for ICARUS data
  - Online file management and transfer to FNAL central storage being implemented now
    - Help from FNAL SCD on automated file transfer and file cataloguing tools (SAM)
  - Definition of online/keep-up processing chain, including low-level data tier definitions
  - File transfer to CNAF for raw data backup and potentially later data processing
    - Interfaces for file transfer setup and testing bandwidth now → preparing for a data challenge with simulation
    - Planning for use of common cataloguing/data discovery

Broader SBN Data and Analysis Infrastructure

- Data management" is only a (critical) part of broader software and computing to support SBN simulations, reconstruction, and analysis
  - E.g. Data-driven simulations require key coordination to data management and calibration software

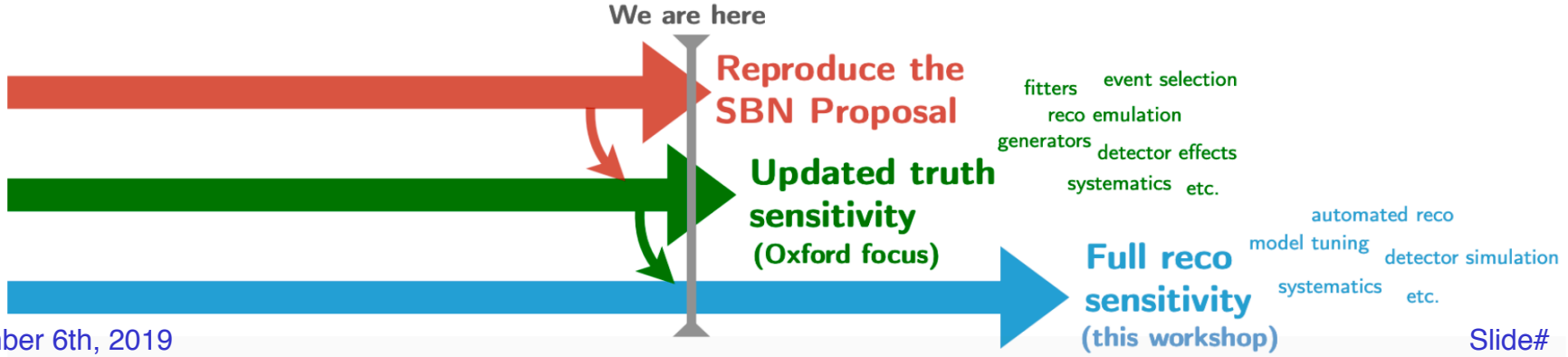
- Propose we can better coordinate infrastructure and resources and build a larger team by incorporating this neighboring scope
  - Production and data resource management
  - Analysis data format and software management
  - Data-driven simulation software management
  - Beam and detector-external interaction simulations

SBN Analysis Group Goals

- Implement a **common analysis scheme** in preparation for real data
  - Data from the different detectors must be analyzed side-by-side together with the analysis/mitigation of all systematic effects
- Work toward updating the projections of **expected physics capabilities** of the SBN program, including
  - reconstruction efficiencies
  - performance and systematic effects
  - background rejection from a full MC simulation of the detectors
- Develop **new analysis methods** and **tools** to perform oscillation analyses
  - combining appearance and disappearance channels, and
  - exploiting different models and exclusive topology measurements
- SBN analysis Group wiki page
  https://cdcvs.fnal.gov/redmine/projects/sbn-analysis-group/wiki
- Several slack channels are also active

IV SBN Analysis Workshop @Fermilab: September 26-30 - 1

- 50 participants with 40 present at Fermilab
- Tutorials in the preceding week, with significant attendance
  - Transition from truth values to as much as possible reconstructed quantities for the event selection and measurement
  - Verifying the sensitivity reach at the present stage of our code
  - Start discussing for the introduction of detector related systematics and for a cross calibration between the detectors
    - Define a list of the dominant systematics
    - Energy resolution for different particles, post calibration
    - Efficiency (correlations) for different event topologies
    - Status/differences in optical systems/simulation/reco



SBN Analysis Workshop @Fermilab: September 26-30 – 2

- Full simulation of consistent samples of events for the near and the far detectors, including single particles, BNB ν and cosmic rays
- Reconstruction of simulated PMT signals in combination with TPC: first implementation of light and charge matching
- Porting of Pandora reconstruction from the near to the far detector with assessment of neutrino vertex reconstruction
- Analysis of the auto-veto probability for the CRT in ICARUS detector and work towards its integration in the SBND detector
- First example of an event display including the CRT detector
- Addressing some sources of systematical differences between the event selection and reconstruction in the near and the far detector
  - Front end electronic noise and event reconstruction
  - Initial study of Michel electrons to be exploited as "standard candles" for detector calibration and systematic assessment
  - Simulation and correction for the space charge effects on the event reconstructiom

Last SBN Analysis Workshop @Fermilab: September 26-30 - 3

- Since the last workshop three groups are working in parallel
  - *Oscillation Sensitivities*
    - Oscillation sensitivity exploiting reconstructed events, mock data challenge, fitter development
  - *Detector systematics*
    - Address main systematics, estimate impact on sensitivities
  - *Event selection (including TPC + Scintillation Light + CRT)*
    - Development of multi-subdetector algorithms, evaluation of efficiency and background rejection, impact on sensitivities
- An end to end analysis of $\nu\mu$ disappearance channel is progressing, combining sub-detectors information and considering overlapping cosmic rays
- Progress in tuning the reconstruction code for the νe event analysis and the suppression of backgrounds

OVERFLOW

SBN Oscillation Analysis Group Organizational Chart

SBN Analysis Working Group

Convener: Daniele Gibin
Convener: Ornella Palamara

Neutrino Event Generators
(Simulation and Tuning on SBN data)
Convener: Jarek Nowak
Convener: Marco Roda

MC production
(Consistent generation of different type of events)
Convener: Maya Wospakrik
Convener: Dom Brailsford

Track reconstruction in TPC
(Consistent clustering, vertexing, track reconstr.)
Convener: Tracy Usher
Convener: Jonathan Asaadi

Shower reconstruction in TPC
(Consistent shower id, vertexing, and reconstr.)
Convener: Yun Tse Tsai
Convener: Dom Brailsford

TPC simulation and Calibration
(Consistent Charge reconstruction, dQ/dx->dE/dx, Lifetime, Space Charge)
Convener: Filippo Varanini
Convener Mike Mooney
Commissioning liasons: Angela Fava, Michelle Stancari

CRT simulation & reconstruction
(CRT signals, timing, CRT-TPC matching)
Convener: Umut Kose
Convener: David Lorca

Light Detection Systems simulation & reconstruction
(LDS signals, timing, LDS-TPC matching)
Convener: Alessandro Menegolli
Convener: Diego Garcia Gamez

sbncode
(General tool for event selection and access to reconstruct. quantities)
Convener: Andy Mastbaum

Event Selection, Cosmic ID and rejection
(consistent combination of TPC, CRT PDS, PID, and cross-validation on exclusive channels)
Convener: Christian Farnese
Convener: Andrzej Szelc

Systematics and Oscillation Sensitivities
(Consistent evaluation of flux, cross-sections and detector systematics, common tools to evaluate oscillation sensitivities)
Convener: Daniele Gibin
Convener: Costas Andreopoulos

- 10 subgroups

SBN Analysis Group – Sub-groups

- SBN Analysis Group Wiki page (in preparation) https://cdcvs.fnal.gov/redmine/projects/sbn-analysis-group/wiki
- Activities progress in parallel within the sub-groups (active also slack channels)
- Sub-groups have regular meetings: documents available in docdb https://sbn-docdb.fnal.gov/cgi-bin/private/ListAllMeetings?eventgroupid=49
- continuous sharing of information with presentations of the status of the activities/discussions at the joint bi-weekly SBN Analysis Group meetings

Deliverables

- Oscillation analysis: three (parallel) intermediate stages:
  - I. *Consistency check* - reproduce the proposal-era SBN oscillation sensitivities with 3 new oscillation fitting frameworks, using truth-level information and the same inputs for beam, reconstruction efficiencies, backgrounds and systematic uncertainties.
  - II. *Update the oscillation sensitivities* - with a full MC simulation, still using the truth-level variable and exploiting efficiencies/ backgrounds and systematic effects more realistically estimated accounting for the available/developed SBN event reconstruction
  - III. *Oscillation physics sensitivity results based on full event simulation and full event reconstruction*

Tentative schedule

- As a tentative schedule:
  - mid March 19: reproduce the proposal sensitivity (fits the next workshop date) for both appearance and disappearance
  - Summer 19: revise the proposal assumptions producing new more realistic estimate of efficiency and backgrounds, implementing a truth based sensitivity study for both appearance and disappearance
  - End of 19 produce an end to end analysis of numu disappearance with as complete as possible event selection and reconstruction
  - Spring 20: produce an end to end analysis of nue appearance with as complete as possible event selection and reconstruction

SBN Analysis Group – Meetings

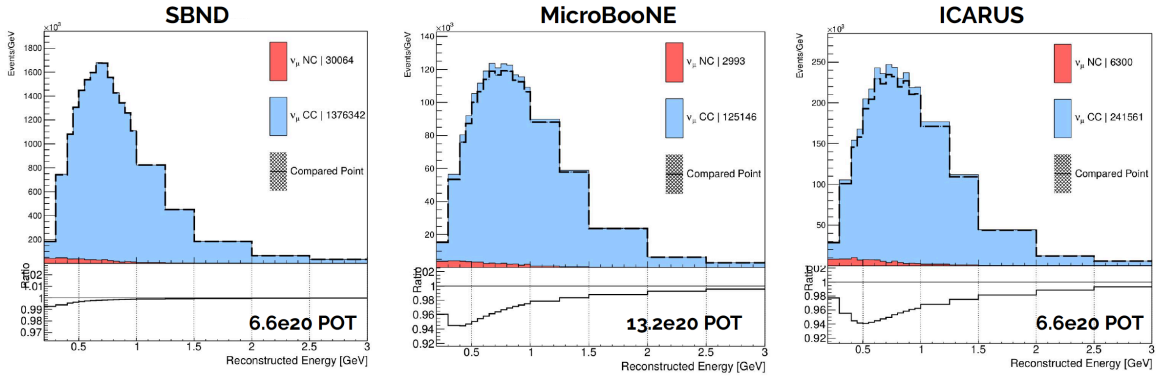
- Bi-weekly meetings of the SBN Analysis Working Group
- SBN Analysis Workshops to facilitate discussion and side-by-side practical work of SBN collaborators
  - Fermilab, Oct 2017 (First useful opportunity of common effort between the collaborators from the different detectors working side-by-side)
  - Padova, March 2018 (work on common reconstruction tools including light and CRT, event selection, n event generation, introduction of SBNCode,)
  - Oxford, March 2019
  - September 2019 at Fermilab
- Fermilab, December 4-5 2018: SBN Analysis Software Workshop/Hackathon
- Typically 30+ participants at the meetings

νμ disappearance sensitivity

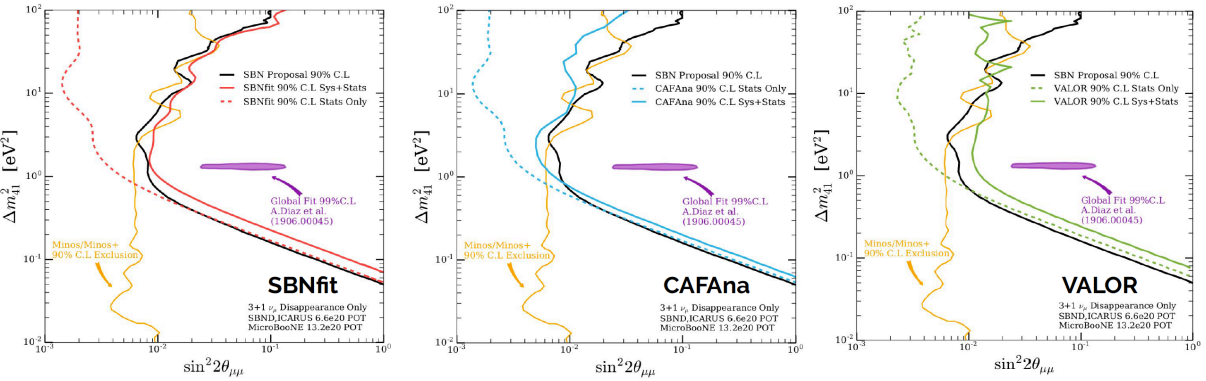
ν_μ Spectra

These are the input spectra to SBNfit, using **version 2.2** proposal sample files, and the SBNreco flattened TTree's within, which *a priori* includes a 3.1% energy shift up.

Shown also is an oscillated spectra for $|U_{\mu 4}|$ = 0.135 and Δm^2_{41} = 1.32 eV² (Recent global best fit, more on this point later) **Sin² 2$\theta_{\mu\mu}$ = 0.07157**



Exclusion Sensitivities: ν_μ Disappearance

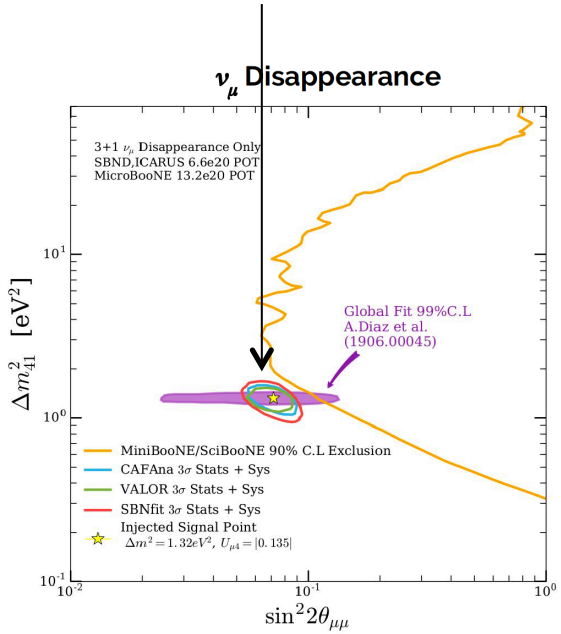


- True neutrino baseline event-by-event for oscillations
- All 25 flux and cross-section systematics from proposal

- Mean neutrino baseline used for oscillations
- All cross section systematics, but missing 5 flux systematics

- Fixed 110m, 470m and 600m baselines used for oscillations
- All 25 flux and cross-section systematics from proposal

Measuring a hypothetical oscillation signal

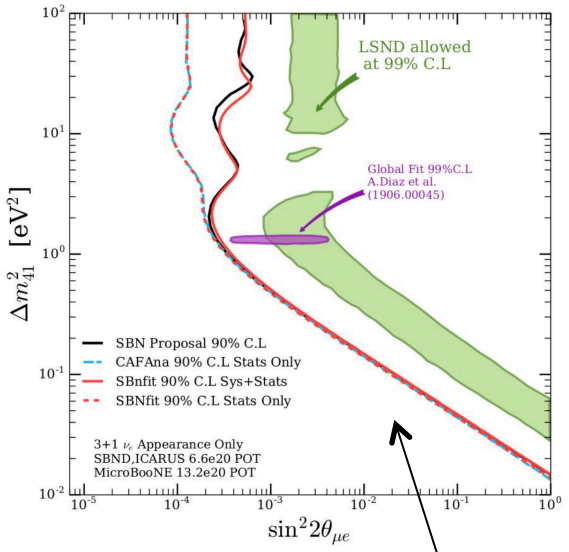


Injected recent global fit https://arxiv.org/abs/1906.00045 Best fit for 3+1 interpretation: $|U_{e4}|$ = 0.116, $|U_{\mu 4}|$ = 0.135 and **Δm^2_{41} = 1.32** eV² (**Sin² 2$\theta_{\mu\mu}$ = 0.07157)**

Mark Ross-Lonergan: SBNFit, CAFAna and VALOR Sensitivity plots, July 18 (docdb https://sbn-docdb.fnal.gov/cgi-bin/private/ShowDocument?docid=13876)

Tremendous progress since April: νe appearance sensitivity

Exclusion Sensitivities: ν_e Appearance



Due to time frame and some issues with ν_e systematics, only SBNfit (stats only and stats+systematics) and CAFAna (stats only) are shown here.

Does *not* include cosmic or dirt component to backgrounds in either case

Oscillating only ν_μ-> ν_e as signal, and no oscillations of backgrounds.

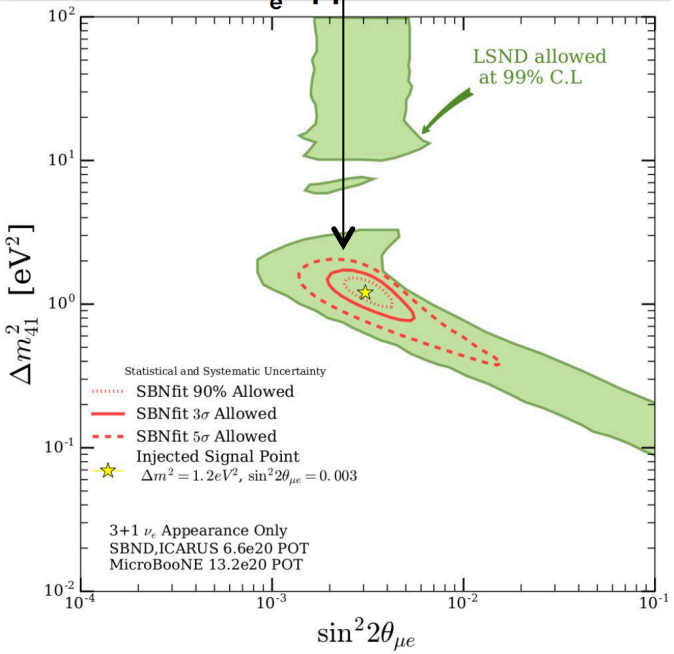
CAFAna and SBNfit stats only contours agree almost perfectly,

SBNfit systematics contour matches proposal excellently with a slight shift in frequency associated second point of maximum exclusion

Calculation of Sensitivity to νe appearance

Measuring the LSND best fit signal

ν_e Appearance



Injected LSND best fit:

$\sin^2 2\theta_{\mu e}$ = 0.003 and Δm^2_{41} = 1.2 eV²

Mark Ross-Lonergan: SBNFit, CAFAna and VALOR Sensitivity plots,July 18 (docdb https://sbn-docdb.fnal.gov/cgi-bin/private/ShowDocument?docid=13876)