Short-Baseline Near Detector (SBND)

52nd Fermilab Users’ Meeting
June 13th 2019
Nicola McConkey, on behalf of the SBND collaboration
Short-Baseline Neutrino Program

- Three-detector measurement program in the Fermilab Booster Neutrino Beam
  - Low energy: peak around 1 GeV
- Liquid argon Time Projection Chambers (LAr TPC)
  - Same nuclear target and detector technology

<table>
<thead>
<tr>
<th>Detector</th>
<th>Baseline (m)</th>
<th>Active LAr mass (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBND</td>
<td>110</td>
<td>112</td>
</tr>
<tr>
<td>MicroBooNE</td>
<td>470</td>
<td>87</td>
</tr>
<tr>
<td>ICARUS T-600</td>
<td>600</td>
<td>476</td>
</tr>
</tbody>
</table>
SBND’s role in SBN program is to measure the unoscillated neutrino flux

- Crucial for the sensitivity of oscillation measurement
- Highly correlated interactions in near and far detectors
  - Same detector technology and target
  - Decreases effects of neutrino flux and neutrino interaction uncertainties on the measurement
- Controls systematic uncertainties for sterile neutrino search

SBND Physics: neutrino oscillations and sterile neutrinos

[13/06/19 Nicola McConkey | SBND]

[S. Gariazzo et al, arXiv:1703.00860v3]

SBND physics: neutrino-argon interactions

- SBND will make the world’s highest statistics cross-section measurements on liquid argon

- 7 million $\nu_\mu$ interactions in 3 years

- 50,000 $\nu_e$ interactions in 3 years

High interaction rate and LAr TPC technology allows precision measurements of exclusive event topologies

Can quantify nuclear effects in $\nu$-Ar scattering with $\nu_\mu$ and $\nu_e$ CC $0\pi$

Direct experimental quantification of nuclear effects and impact on rates, final states and kinematics

- SBND data will inform neutrino MC generators and discriminate between final state interaction models
- Especially important in low energy (1GeV) regime
SBND Physics Program

- Short-Baseline Neutrino physics: neutrino oscillations and sterile neutrinos
  ICARUS talk, MicroBooNE talk – this session

- Neutrino-argon interaction physics
  Poster: Reconstruction and selection tools for charged-current muon neutrino inclusive cross sections in SBND - Tom Brooks

- Beyond Standard Model physics
The Short-Baseline Near Detector

- A new LAr TPC detector!
  - Neutrino physics and R&D opportunities
  - 112 active tonnes of LAr
  - Active volume: 4m x 4m x 5m
The Short-Baseline Near Detector

High Voltage Feedthrough

Cathode Plane Assembly: (2 frames)

Field cage

Anode Plane Assemblies (4 frames)
Current status

- Work ongoing in 3 locations:
  - TPC assembly, DAQ and cold electronics testing at DAB
  - Cryogenics installation at SBN-ND
  - Cryostat pre-fabrication at CERN

- Major TPC components and DAQ hardware all at Fermilab

- First Cold Electronics at Fermilab and tested

- TPC alignment and transportation frame is under construction

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TPC assembly

1) Install APAs and CPA
2) Install Field cage
3) Install cold electronics
4) Install photon detection system
5) Move to SBN-ND detector hall!

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APA assembly

- Four APA frames produced at 2 wiring sites
- APAs are electrically and mechanically coupled at Fermilab

**Mechanical coupling of the APA**
- Precise alignment of APA frames using laser tracker technology
- Attachment of APA with bolts and attachment blocks

**Electrical coupling of the APA**
- Readout on top and sides: cold electronics readout will be entirely in argon (FE ASIC and ADC)
  - Jumper connectors between APA frames
Electronics, DAQ, Cosmic tagger

- **Cold Electronics**
  - Production concluding at BNL
  - Front End Mother Board testing ongoing at Fermilab
  - Successful integration testing with APA

- **Surface detector with concrete overburden**
  - Tool to mitigate the cosmic ray background

- **Cosmic ray tagger with nearly $4\pi$ coverage of the detector**

- **DAQ test-stand at DAB**
  - Production hardware plus prototypes under test
  - Integrating existing BNL and Nevis systems into shared SBN framework

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Photon Detection System

- Modular photon detection system mounted behind APAs
- Photomultiplier Tubes
  - Wavelength shifter coating on 80%
- Reflector foils to be mounted at the cathode
  - Improves the uniformity of collected light
- ARAPUCA R&D
  - Arapuca
    - A device for “trapping” photons to increase the active area of SiPM
    - Dichroic filters
  - X-ARAPUCA
    - Arapuca concept with wavelength shifting guide for increased detection efficiency
    - Readout electronics R&D

SBND Membrane cryostat

- Currently under construction at CERN
- 3rd generation prototype for DUNE
- Shipment and assembly at FNAL SBN-ND in fall 2019
Summary and outlook

- Exciting physics ahead for SBND!

- Detector assembly ongoing
  - Most major components already delivered to FNAL
  - Completion of SBND TPC construction fall 2019

- Cryostat fabrication is progressing well at CERN.
  - Installation at FNAL starts fall 2019

- ND building cryogenics installation has started

- Commissioning in 2020 and first neutrino data in 2021
APA assembly

- Electrical coupling of the APA
  - Readout on top and sides: cold electronics readout will be entirely in argon (FE ASIC and ADC)
    - Jumper connectors between APA frames
  - QC checks of continuity for both U and V layer across jumpers
    - First plane: all wires connected successfully!
1. High statistics measurement of neutrino-argon interactions:
   - $\nu_\mu$-CC and $\nu_e$-CC and NC interactions
   - Precision studies of neutrino-argon cross section measurements in the GeV region
   - Absolute flux measurement with electron – neutrino scattering
   - Tuning of cross-section models
   - Rare event processes

2. Search for Beyond Standard Model physics
   - Search for millicharged particles
   - Neutrino tridents
   - Dark neutrino sectors
Relevance for DUNE

- Interactions at energies relevant for DUNE oscillation physics

![Graph showing neutrino energies and DUNE oscillation peak](image-url)
SBND Cross sections in context

- Energy of SBND interactions is in CCQE / resonance transition region

[Formaggio, arXiv:1305.7513]
SBN-ND building status

- Cryogenics work at ND building ongoing this summer