The Short Baseline Near Detector

Joel Mousseau
University of Michigan
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Why Build A Near Detector?

• Detectors do not measure neutrinos, they measure (primarily) leptons from neutrino + nucleus interactions.

• Measure cross-section, acceptance, FSI in a near detector to predict an un-oscillated spectrum in your far detector.

• Reality is a bit more complex, typically use a model to extrapolate a near detector spectrum to a far detector.

![Near Detector Spectrum](image1)

![Far Detector Spectrum](image2)

Measured Spectrum

Inferred Spectrum
Location in SBN

Far Det. Flux

SBND Flux

110 m from Neutrino Source
490 m from Far Detector
Building a Better Near Detector

- Ideal case for a near detector: same target nucleus (Ar) and detection technology (TPC) as far detector.
- SBND employs two different drift chambers, shorter drift distance for same volume.
- 4π coverage cosmic tagger (not pictured), reduces largest background
Wire Plane Details

- Cold Electronics boards:
  - Pre-Amp
  - ADCs

- Each anode composed of 12 frames.
- 3 Wire directions per frame.
- 3 mm wire pitch.
Anode Plane Construction

- Wire-Winding currently taking place in US (Yale) and UK (Daresbury).

- First planes from UK expected end of the summer, first from US shortly after.
Scintillation Light Detection

- Light detection used to measure $t_0$ of an event relative to the readout window.
- UV detected with TPB coated PMTs, sit within the wire frame.
Numerous research and development projects in photon detection approved for SBND:

- Reflective Foils
  - Evaporative coating of TPB on highly reflective (R= 0.99) foils.

- Light Bars
  - TPB Coated acrylic bars.
  - Visible light observed by SiPM arrays on bar ends

- Arapucas
  - Trap light via filter + shifter planes.

A. A Machado and E. Segreto, JINST 11 2016
Building a Better Cryostat

- Stainless steel membrane cryostat.
- TPC supported by Cryostat lid.

Same design as DUNE / ProtoDUNE (right).

Photo courteous of Maximilien Brice, CERN
More than a Near Detector!

- As a heavy nucleus \((A=40)\), argon is an ideal laboratory for studying \(A\) dependent effects of neutrino scattering:

\[ W^\pm \]

(a) 2N-SRC

(b) 3N-SRC

Famous ArgoNeut “Hammer” Event

Unprecedented $\nu$-Ar Interaction Statistics

- SBND sits close (100 m) to the neutrino source, provides an immensely intense beam.

- Number of events over 3 years exposure:

\[
\begin{align*}
\text{Inclusive} : \nu_{\mu} + Ar & \rightarrow \mu^- + X & 5M \text{ Events} \\
\text{Single } p^+ : \nu_{\mu} + Ar & \rightarrow \mu^- + 1p & 2M \text{ Events} \\
\pi^\pm : \nu_{\mu} + Ar & \rightarrow \mu^- + N\pi^\pm + \text{nucleons} & 1M \text{ Events} \\
\text{Inclusive} : \nu_{e} + Ar & \rightarrow e^- + X & 37k \text{ Events} \\
\text{Inclusive} : \nu_{\mu} + Ar & \rightarrow \nu_{\mu} + N & 2M \text{ Events}
\end{align*}
\]

Numbers from GENIE Event Generator
Conclusions

• Short baseline near detector provides a data-driven constraint of multiple models necessary for an oscillation result.

• Multiple uses of SBND:
  • Test bed of new optical detection technology
  • Designing future cryostats.
  • Ambitious cross-section program due to intense beam.
  • On pace to begin taking data in 2020.
From all of SBND…

Thank You for your Attention!
The SBND Collaboration

Argonne National Lab: Z. Djurcic, R. Dharmapalan, G. Drake, M. Goodman, S. Magill
University of Campinas – UNICAMP: C. Escobar, E. Funk, M. Guzzo, P. Holanda, M. Nunes, L. Santos, E. Secreto
CERN: S. Bertolucci, J. Breuer, U. Kose, M. Mladenov, M. Nessi, F. Nota
University of Chicago: A. Mastbaum, K. Miller, R. Northrop, G. Putnam, D.W. Schmitz*
Colorado State University: R. LaZur, M. Mooney, I. Terrazas
Federal University of ABC – UFABC: A. Machado, C. Moura, L. Paulucci, L. Quintino
Federal University of Alfenas – UFAL: M. dos Santos, G. Valdivieso
Federal University of Rio de Janeiro: C. Bonifazi
Federal University of Sao Carlos – UFSCAR: F. Marinho
Harvard University: C. Adams, R. Guenette
Illinois Institute of Technology: I. Lepetic, B. Littlejohn
Indiana University: S. Mufson
Kansas State University: G. Horton-Smith
Lancaster University: A. Blake, D. Brailsford, I. Mercer, J. Nowak, P.N. Ratoff
University of Liverpool: C. Andreopoulos, S. Dennis, J. Henzerling, R. Jones, K. Makrakoridis, N. McCauley, D. Payne, A. Roberts,
M. Roda, P. Sutcliffe, J. Tena-Vidal, C. Touramanis
Los Alamos National Lab: J. Boissoevain, G. Garvey, E. Huang, W.C. Louis, K. Rielage, T. Thornton, R.G. Van de Water
University of Manchester: V. Basque, A. Bitadze, J. Evans, J. Freestone, A. Furmanski, D. Garcia Gamez, O. Goodwin, P. Guzowski, C. Hill,
University of Michigan: C. Barnes, R. Fitzpatrick, J. Mousseau, B. Roe, J. Spitz
MIT: J.M. Conrad, J. Moon
New Mexico State University: R. Cooper
Pacific Northwest National Lab: E. Church
University of Pennsylvania: N. Barros, S. Glavin, J. Klein, D. Rivera, R. Van Berg
University of Puerto Rico: K. Matias, H. Mendez, S. Santana
University of Sussex: C. Griffith, I. de Icaza Astiz
University of Tennessee, Knoxville: S. Gollapinni, A. Mogan, W. Tang, G. Yarbrough
University of Texas, Arlington: J. Asaad, A. Chatterjee, A. Falcone, Z. Williams, J. Yu
Tufts University: T. Wongjirad
University College London: M. Cascella, A. Holin, R. Nichol, D. Waters
Virginia Tech: C. Mariani

*Spokespeople

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Including both scientific and technical personnel
The SBND Collaboration

196 Total Collaborators

167 Scientific Collaborators (faculty/scientists, postdocs, students)

36 Institutions

23 US Institutions
   5 DOE national laboratories
   18 US universities
   University of Puerto Rico

13 International Institutions
   CERN
   6 UK universities
   1 Swiss university
   5 Brazilian universities
Detector Construction Status

- **Today 2018**: 1st Wire Planes Finish
- **Fall 2018**: All Wire Planes Finished
- **Mid 2019**: Detector Assembled
- **Late 2019**: Cryostat Installed
- **Mid 2020**: Detector Moved to Cryostat
- **Late 2020**: Data Taking Begins!

### Neutrino Oscillation Parameters

- Neutrino Energy: 700 MeV
- \( \Delta m^2 = 1.2 \text{ eV}^2 \)
- \( \sin^2(2\theta) = 0.003 \)

![Graph showing oscillation probability vs. length of neutrino flight]
Cosmic Ray Tagger

- Cosmic Ray modules (top left) taking data in near detector pit, measuring beam induced neutrons.