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SBND: Status of the Fermilab Short-Baseline Near Detector

Nicola McConkey for the SBND collaboration

Department of Physics and Astronomy, University of Sheffield, Hicks Building, Hounsfield Road, Sheffield, S3 7RH, UK

E-mail: n.mcconkey@sheffield.ac.uk

Abstract.

SBND (Short-Baseline Near Detector) will be a 112 ton liquid argon TPC neutrino detector located 110m from the target of the Fermilab Booster Neutrino Beam. SBND, together with the MicroBooNE and ICARUS-T600 detectors at 470m and 600m, respectively, make up the Fermilab Short-Baseline Neutrino (SBN) Program. SBN will search for new physics in the neutrino sector by testing the sterile neutrino hypothesis in the 1 eV^2 mass-squared region with unrivaled sensitivity. SBND will measure the un-oscillated beam flavor composition to enable precision searches for neutrino oscillations via both electron neutrino appearance and muon neutrino disappearance in the far detectors. With a data sample of millions of neutrino interactions (both electron and muon neutrinos), SBND will also perform detailed studies of the physics of neutrino-argon interactions, even in rare channels. In addition, SBND plays an important role in an on-going R&D effort within neutrino physics to develop the LArTPC technology toward many-kiloton-scale detectors for next generation long-baseline neutrino oscillation experiments. The design details and current status of the detector is presented here.

1. Introduction

The Fermilab Short-Baseline Neutrino (SBN) program will measure neutrino oscillations in the Booster Neutrino Beam (BNB), using three on axis Liquid Argon (LAr) Time Projection Chambers (TPC). The neutrino beam will be measured by the Short Baseline Near Detector (SBND), MicroBooNE, and ICARUS-T600 detectors at distances of 110m, 470m, and 600m respectively from the BNB target [1].

The current status of the SBND TPC, light collection system, and external cosmic ray tagger system is presented here, and the application to future larger volume LAr TPC technology is highlighted.

2. The SBND detector

The SBND detector is a single phase LAr TPC with an active mass of 112 tons. It will operate inside a membrane cryostat, leveraging the same technology as ProtoDUNE and DUNE, as developed for the DUNE 35t prototype [2]. SBND is currently in the design and construction phase. Prototyping and testing of components is underway, and manufacture and procurement of components has recently started in the US, UK and Switzerland.



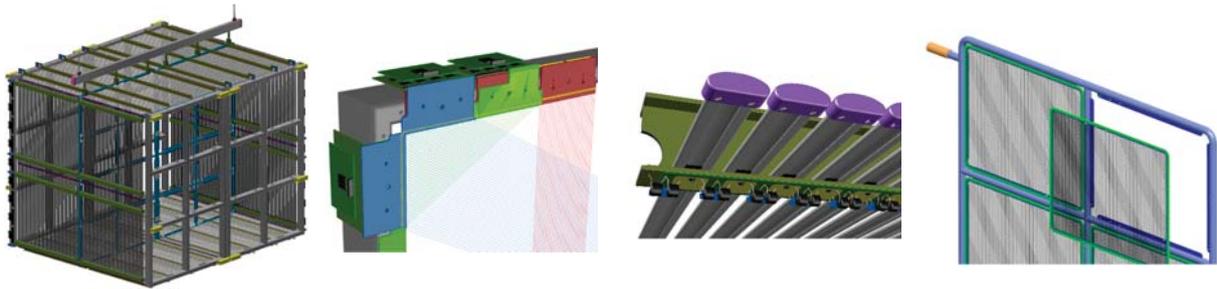


Figure 1. Left to right: SBND TPC overview; the three anode wire planes mounted on an APA frame; roll-formed field cage bars with UHMW PE end caps; the CPA frame with mesh inserts.

2.1. Time Projection chamber

The SBND TPC, as shown in figure 1 has an active volume of $5\text{ m} \times 4\text{ m} \times 4\text{ m}$. A central Cathode Plane Assembly (CPA) divides the TPC into two drift regions, and ionisation charge is read out by wire anodes. Each anode plane consists of three wire planes at 3 mm spacing. The wire spacing is 3 mm, which is identical to that used in the T600 and MicroBooNE. This enables electron / photon separation with very similar efficiencies [1]. Figure 1 shows the wire plane layouts: a vertical collection plane (Y), and two induction planes (U,V) at $\pm 60^\circ$ angles to the vertical. Each Anode Plane Assembly (APA), is composed of two interconnected APA wire support frames of $2.5\text{ m} \times 4\text{ m}$.

The construction of the APAs is currently underway. The four stainless steel APA frames have been welded, and are being machined in preparation for attachment of wires. A wire-winding prototype has been built and tested on a small prototype frame. This prototyping work has demonstrated the functionality of the wire placing technology, as well as testing placement and alignment of wire carrier boards. Construction of full scale wire-winding setups is currently in progress in both the UK and US.

Figure 2 shows a welded full size APA frame and the prototype frame, demonstrating excellent alignment of corner boards, and wrapped wires for the interconnected APA section.

The CPA, as shown in figure 1 is composed of two welded and electropolished stainless steel frame assemblies each holding eight mesh frames. The mesh is bolted together and held flat by outer mesh frames, preventing high fields at mesh edges.

The cathode is held at a nominal bias of -100kV, which is inserted into the cryostat through a high voltage feedthrough, and connected via a high voltage cup to the cathode. There are currently two feedthrough designs under manufacture and testing. Both have a coaxial design and are made of Ultra High Mass Weight (UHMW) Polyethylene (PE) insulator with a stainless

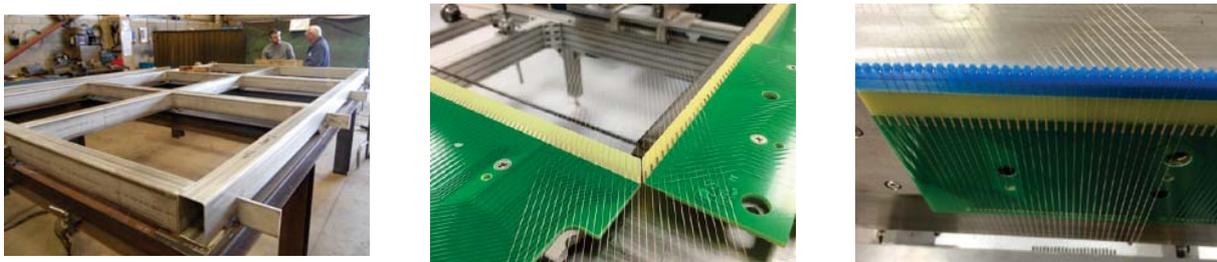


Figure 2. Left: APA frame in welding jig. Centre, right: Prototype APA frame with wired geometry boards.

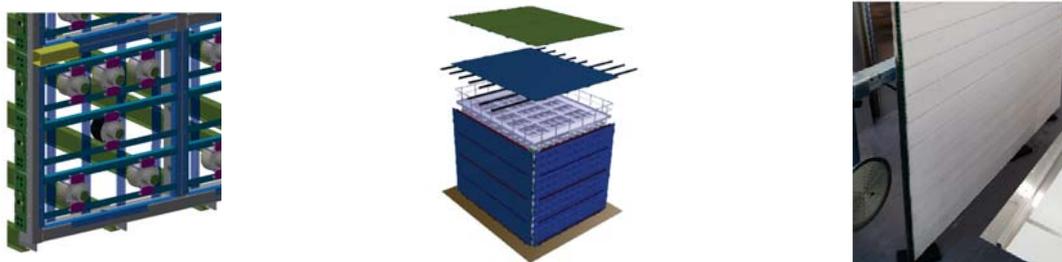


Figure 3. Left: Photon detection system modules mounted to the back of an APA. Centre: Cosmic ray tagger system plane locations. Right: Cosmic ray tagger module.

steel core and grounding sheath.

The SBND drift field will be 500V/cm, and the TPC field cage, shown in figure 1 will be made from roll-formed stainless steel profiles, of a design analogous to that envisaged for DUNE and for ProtoDUNE [3]. The roll-formed profiles will be covered by UHMW PE caps at the ends, in order to minimise high electric field edge effects. A prototype fieldcage piece has recently been demonstrated to hold a bias of 100kV in liquid argon without discharge.

2.2. Light detection system

The SBND Photon Detection System (PDS) is composed of two complementary technologies: Photomultiplier Tubes (PMT) coated in Wavelength-Shifting (WLS) tetraphenyl butadiene, and acrylic WLS bars read out by Silicon Photomultipliers (SiPM). These PDS modules are mounted to the APA frames behind the wire planes, as shown in figure 3. The mounting, bases and frames are currently under design.

There are a total of 120 Hamamatsu R5912 8" PMTs, and 80 WLS bars across both readout planes. The inclusion of WLS foils at the cathode to improve uniformity of light collection across the detector is under discussion [4]. The opportunity to test different PDS approaches side-by-side is an important one for the goal of informing an optimized design for use in future LAr detectors for long-baseline neutrino physics.

2.3. Cosmic Ray tagger

The Cosmic Ray Tagging system (CRT) is a tool to mitigate the cosmic ray background in the SBND detector. It detects cosmic ray muons and measures their crossing time and coordinates relative to events internal to the TPC. The CRT consists of seven planes surrounding the detector, as shown in figure 3. These consist of extruded scintillator strips read out by Hamamatsu S12825 MPPC photo-diodes. Production and testing of front end electronics boards, and assembly of the first plane is now underway [1].

3. Summary and Timeline

SBND not only has an exciting physics program, but also provides a great opportunity for detector development towards future large liquid argon detectors for long-baseline neutrino experiments. SBND is currently in the design and construction phase, with a view to first beam data taking in 2018.

4. References

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- [4] Szelc A M *et al.* (SBND), *JINST* **11**, *LIDINE 2015 proceedings*