The Muon Range Detector at SciBooNE

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Abstract. SciBooNE is a new neutrino experiment at Fermilab. The detector will undertake a number of measurements, principally sub-GeV neutrino cross-section measurements applicable to T2K. The detector consists of 3 sub-detectors; SciBar and the Electron-Catcher were both used in the K2K experiment at KEK, Japan, whilst the Muon Range Detector is a new detector constructed at Fermilab using recycled materials from previous Fermilab experiments. A description of the detector, its construction and software is presented here.

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SciBooNE's principal measurements are sub-GeV neutrino cross-section measurements applicable to T2K [1]. SciBooNE sits in the Booster neutrino beam 100 m downstream from the beam target. As well as carrying out sub-GeV cross-section measurements SciBooNE will also be used as a near detector for the MiniBooNE experiment [2]. The Muon Range Detector (MRD) is one of 3 sub-detectors that make up the SciBooNE detector [3]. It sits downstream of both SciBar and the Electron-Catcher (EC) both originally used in the K2K experiment [4] at KEK, Japan. The Muon Range Detector is made up largely from recycled materials from previous Fermilab experiments including all the PMTs, scintillator, iron absorber and data acquisition (DAQ) electronics.

THE MUON RANGE DETECTOR

The role of the Muon Range Detector is to confine the muons produced in charge-current quasi-elastic (CCQE) interactions, which is the dominant process in SciBooNE. By confining the muon its energy can be reconstructed thus giving a handle on the neutrino energy. The MRD consists of 13 alternating horizontal and vertical scintillator planes, each separated by a 5 cm iron sheet. This results in 60 cm of absorber equivalent to stopping a 1 GeV muon. The first plane is directly downstream of the EC allowing for better track matching and energy reconstruction of π^0 decay photons that escape the EC. Three planes are required to be hit for a track to be reconstructed in the MRD, equivalent to approximately a 180 MeV muon. The total mass of the detector is 60 tonnes, of which approximately 48 tonnes is absorber. See figure 1 for a schematic of the detector.

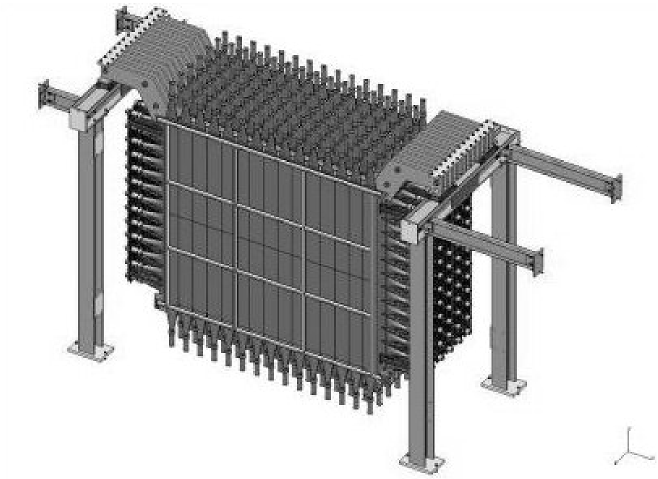

FIGURE 1. Engineering schematic of the MRD. Planes can be moved forward or backward via the use of winches attached to the side of the support frame.

Construction

There are 362 channels in total; 182 horizontal, 180 vertical. Each channel is 20 cm wide and either 155 cm (horizontal) or 138 cm (vertical) long. Planes have active areas of 310×260 cm^2 (horizontal) and 300×276 cm^2 (vertical). Of these 362 channels 5 different photomultiplier tubes (PMTs) are used. The horizontal planes consist of 14 stage EMI 9954KB PMTs from the KTeV experiment, as well as EMI 9839b and 9939b PMTs. The vertical planes consist of 10 stage Hamamatsu 2154-05 PMTs from the NuTeV experiment and RCA 6392A PMTs.

Construction and testing of the first prototype counter started in May 2006 with design approval coming in June 2006. The counter assembly was finished in December, the detector construction began in January 2007, with completion of all planes by March. Cosmic data was taken in the assembly hall prior to installation in the detector hall. The MRD was the first of the sub-detectors to be moved to the hall on April 23rd 2007. By June just over 1 year after initial construction began the fully completed detector saw its first beam events as it started the process of commissioning in the Booster neutrino beam running in anti-neutrino mode.

DAQ and Software

The data acquisition system consists of CAMAC electronics supplied by Fermilab's electronic support, PREP. The electronics consist of LeCroy 4300B ADCs, LeCroy 3377 TDCs and the LeCroy 1440 high voltage system. Unlike SciBar each channel in the MRD has its own TDC. The MRD has a cosmic trigger independent from SciBar and the EC. This allows a greater rate of cosmic data to be taken by the detector. Monitoring the counter efficiencies is crucial for the MRD to check for dead channels and counters that are operating below their plateau voltage. Lightleaks can also be monitored. Figure 2

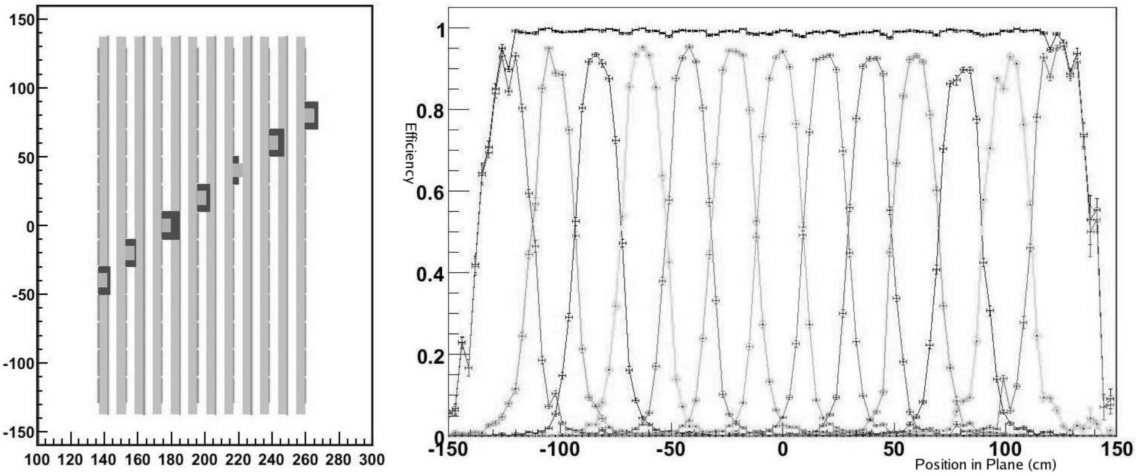

FIGURE 2. (left): Cosmic muon penetrating the MRD (horizontal view), image taken from assembly hall cosmic data run. (right): Efficiency plot of plane 2 (horizontal) showing the efficiency as a function of position over the plane. Both individual counter efficiences and the summed efficiency is shown.

shows an example of a cosmic track in the MRD (left) and an efficiency plot for a half plane in the detector (right). The efficiency of a counter, A, is calculated by summing over all three-fold coincidences between A and two trigger counters either side of A and dividing it by all the two-fold coincidences between two trigger counters either side of A that would involve a cosmic track to pass through A.

SciBooNE has a primary software package that has been developed over the last year. Work is also proceeding in adapting the software developed for the ND280 m detector, the near detector for the T2K experiment. As the composition of the ND280 m detector is similar to that of SciBooNE this will allow analysis tools developed for the ND280 detector to be tested on real data and compared to simulation. The ND280 package is well understood with many developers. Opening up the support and analysis tools of the ND280 software to SciBooNE can only benefit both experiments.

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