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STATUS OF THE SOUDAN 2 NUCLEON DECAY EXPERIMENT*

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ABSTRACT

Soudan 2 is an 1100-ton fine-grained tracking calorimeter now being constructed to search for nucleon decay. It is distinguished by superior background rejection for a wide variety of decay modes and by a trigger threshold low enough for 100 MeV neutrino-induced muons. A new laboratory large enough for an eventual 3300 ton experiment has been constructed in Minnesota's Soudan mine at a depth equivalent to 2200 meters of water. The detector will be assembled from 256 5-ton calorimeter modules, utilizing corrugated steel sheets and plastic drift tubes to obtain a rather isotropic honeycomb geometry. Data collection will begin in the fall of 1986 and assembly of the 1100 tons will be completed in 1988. Installation progress and the performance of the first 5-ton modules will be described.

INTRODUCTION

The Soudan 2 experiment is being built by a collaboration of five institutions from the USA (Argonne, Minnesota, Tufts U) and the United Kingdom (Oxford, Rutherford). The philosophy of the detector is to use a dense fine-grained tracking calorimeter to detect and measure many properties of nucleon decay events predicted by grand unified theories.¹ Candidate events will be identified by their unique topological properties, compared to the principal backgrounds induced by the interaction of atmospherically produced neutrinos. Soudan 2 is unique in being able to identify particle types and measure energies of each track resulting from a decay or neutrino interaction. This results from the design features which give a measurement of the deposited ionization as a function of track length for each track stopping in the detector. Unique kinematic reconstruction of most recorded events will be possible. The low threshold of the design permits highly efficient searches for decay modes containing many particles in the final state.

THE DETECTOR

The basic detector element of the experiment is shown in Fig. 1. Formed steel sheets 1.6 mm thick are stacked vertically to give a hexagonal close-packed array of holes filled by resistive plastic (hytel) tubes (ID=15 mm, OD=16 mm, length=1 m)

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and enclosed in mylar sheets for insulation. This is shown in the upper inset of Fig. 1. A -10KV electric potential is applied to the central of 17 copper strips to grade the electric field to zero at each tube end. This provides a uniform axial drift field to transport ionization electrons from charged tracks at up to the full 50 cm depth within the module. The transported ionization is detected at each tube end by vertical proportional wires (64) backed by horizontal cathode strips (256) as shown in the lower inset of Fig. 1. The drift velocity using 80/20 Ar/CO₂ is 0.8 cm/usec. Full 3D readout is obtained from the wire and strip locations and multi-hit drift time digitalization. In addition the charge content of each hits is measured with 6-bit flash ADC. A detailed description of the electronics is given in Ref. 2. The tracking resolution is $4 \times 3 \times 2$ mm RMS. The threshold will be 100 MeV kinetic energy for charged particles. The module shown in Fig. 1 is $1\text{m} \times 1\text{m} \times 2.5\text{m}$ and mass 5 ton giving an average density of 2 gm/cm^3 . Two hundred and fifty six will be arranged as 2 high $\times$ 8 wide $\times$ 16 long to provide detector of 1100 metric tons active mass. This main detector will be entirely surrounded by an active shield constructed of a 2-layer array of extruded aluminum proportional tubes.

Fig. 1

MODULE TESTING

As part of the module construction and before installation at the mine site, each module is tested to verify that it meets minimum performance standards. These tests are performed in a cosmic ray teststand on the surface using an external trigger to provide stiff cosmic ray muon tracks. All 640 anode/cathode channels are digitized and readout. Fitted tracks are then used to verify the drift velocity, efficiency, gain uniformity, position resolution, etc. In addition, imbedded Fe^{55} radioactive sources are monitored to obtain an absolute gain calibration and a high precision measurement of the charge resolution. A detailed report of module performance is given in Ref. 3.

THE SITE

The detector will be located on the 27th level of the Soudan Iron Mine, Tower-Soudan State Park, Soudan, Minnesota, USA. Latitude 48°N , Longitude 92°W . The depth of the rock overburden is 700 m, equivalent to 2200 m of water. The rate of cosmic ray muons traversing the main detector will be 0.5 Hz. A new cavity of dimensions 14 m $\times$ 72 m $\times$ 11 m (high) has been excavated. This size is sufficient to accommodate 3300 metric tons of detector, should later expansion be desirable. A steel framework and crane system for mounting the detector modules has been installed. The cavity is currently being outfitted as a physics laboratory with heat, light, power, and enclosures for data acquisition electronics and computers.

SCHEDULE

The first elements of the detector and shield will be shipped to the mine during the summer of 1986. A half wall (8 modules) and overhead shield will be completely installed by the fall of 1986. Sufficient electronics will be installed to test the trigger and observe cosmic rays. We will operate two walls (32 modules, 150 tons) by the firsts of the year 1987. This will provide the first useful fiducial volume for physics. At the time the production rate will be two per week, which will allow the complete 1100 tons to be in operation in the mine by the end of 1988. During the year 1988, approximately 9 modules will be taken to an accelerator laboratory to be calibrated in neutrino and charged particle beams.

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2. J. D. Dawson et al., Proceedings of the 1985 IEEE Nuclear Science Symposium, NS-33, 106 (1986).
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