IMB DETECTOR - THE FIRST 30 DAYS*

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ABSTRACT

A large water Cherenkov detector, located 2000 feet below ground, has recently been turned on. The primary purpose of the device is to measure nucleon stability to limits 100 times better than previous measurements. The properties of the detector are described along with its operating characteristics.

INTRODUCTION

In this talk I shall describe the properties of the IMB detector and summarize the first 30 days of operation.

Figure 1 shows a schematic diagram of the detector. It consists of a rectangular volume of water bounded by six planes of photomultiplier tubes, 2048 in all. The tubes have hemispherical photocathodes, 5" in diameter. The spacing is about 1 meter. The volume of water contained within the six planes is 6800 m^3, while the volume held by the cavity is somewhat larger, $\sim$ 8000 m^3.

The cavity was hewn from the rock and salt of the Fairport Mine of the Morton-Thiokol Corporation. It is lined with a double layer of black, high density polyethylene sheet, each 2.5 mm in thickness. A pump-out between the two layers removes the small amount of water which leaks out of the inner liner, about 10 gal. per hour. The cavity is at a depth of 1940 feet (1600 meters water equivalent).

SUMMARY OF DETECTOR PROPERTIES

The detector operates by sensing the Cherenkov light emitted by charged particles with velocities in excess of β = .75. Each photomultiplier (PM) tube senses the intensity and time of arrival of the Cherenkov wave front. This information is recorded and may be used to reconstruct the position and direction of the tracks of charged particles. The gamma rays from π° decay produce electromagnetic showers of $e^\pm$ in the water and are thus detected. The detector is therefore well-suited for the detection of proton decay to $e^+\pi^\circ$.

The properties of the detector are summarized in the following table:

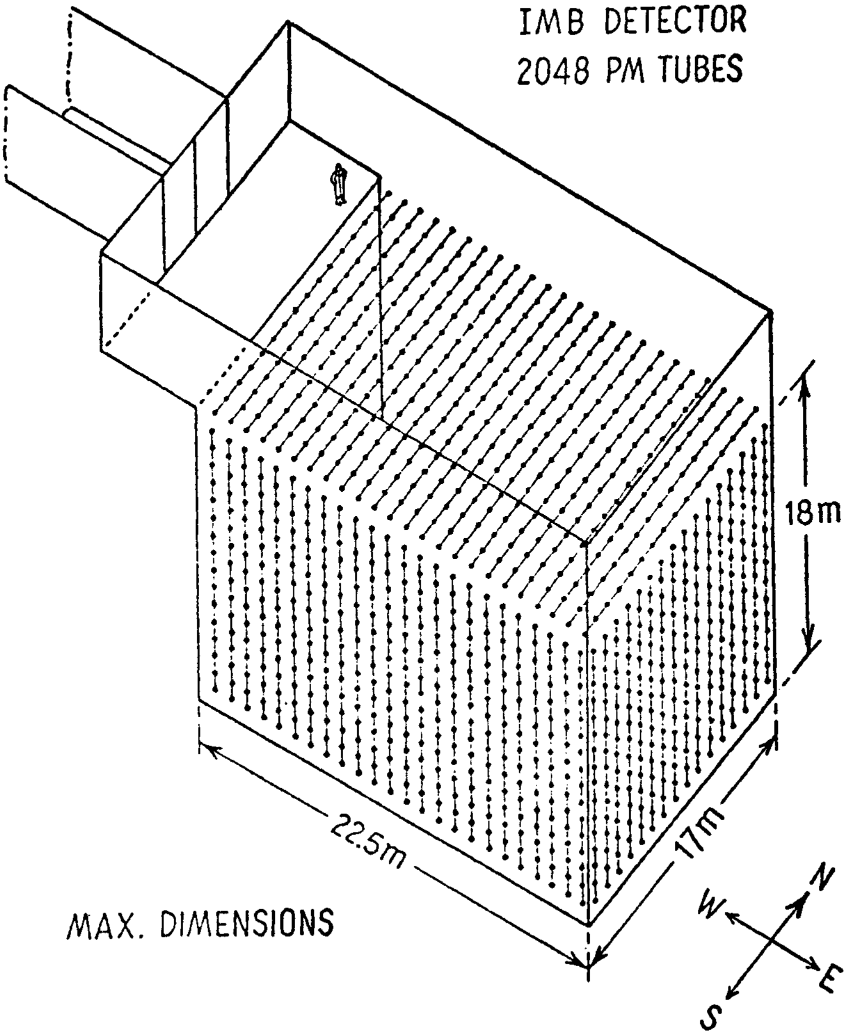

Figure 1. A schematic view of the IMB detector.

TABLE 1. PROPERTIES OF THE IMB DETECTOR

SIZE:

Between PM-tube planes: 4×10^{33} nucleons
Estimated fiducial volume: 2×10^{33} nucleons

ENERGY RESOLUTION:

500 MeV shower: $\sigma = 11\%$
500 MeV $\pi\pm$, $\mu\pm$: $\sigma = 15\%$
1 GeV shower: $\sigma = 8\%$

VERTEX LOCALIZATION:

Two tracks, wide opening angle: $\sigma \sim .5$ m
Single track: $\sigma \sim 2$ m

ANGULAR RESOLUTION:

Showers ($e\pm$, π°): $\sigma = 10°-20°$
Charged tracks: $\sigma = 5°$

TRIGGERING:

Noise triggers: $\lesssim 1\%$
Cosmic rays: 2.7 ev./sec.
Energy threshold: ~ 30 MeV

OPERATION OF THE DETECTOR

The detector was filled with water in July '82 and the PM tubes were installed immediately thereafter. Serious data taking had started by the end of August. At the time of this talk (Sept. 28, '82) the detector has taken 30 days of data suitable for the study of nucleon decay. This corresponds to a duty cycle of ~ 70%. All but 1% of the PM tubes are working. The quality of the data is excellent, corresponding closely with our Monte Carlo simulations.

A. TRIGGERING

The discriminator threshold for each PM tube is set at a level corresponding to ~ .5 of the pulse height for a single photoelectron. The trigger logic divides the detector into 32 patches, each patch consisting of 64 PM tubes in an 8 x 8 square. A patch trigger consists of a discriminator pulse from 3 PM tubes in the same patch within a 50 nsec coincidence. A detector trigger consists of <u>either</u> 2 patch triggers in 150 nsec coincidence <u>or</u> 10 PM tubes anywhere in the detector in 50 nsec coincidence.

The trigger rate is due almost entirely to cosmic rays and is normally 2.7 triggers/sec. Noise triggers are usually less than 1%.

The minimum energy necessary to trigger the detector is 30 MeV if the particle is an electron.

B. RECORDED DATA

For each PM tube the following is recorded:

1. The time of the pulse. There are two time scales:

   a. T_1 scale; 0-512 nsec in 1 nsec intervals.
   b. T_2 scale; 0-7.5 nsec in 15 nsec intervals.

2. The charge (Q) collected from the photocathode. The Q scale ranges from 1 to 512 and this corresponds approximately to the range 1 to 50 photoelectrons though it is very non-linear.

C. CALIBRATION

The T_1, T_2 and Q scales are calibrated by means of a pulsed light source located at the center of the detector. This light source consists of a diffusing ball connected via an optical fiber to a nitrogen laser. This laser produces pulses of u.v. light (λ = 330 nm) whose time variance is less than 1 nsec. The intensity of the light may be varied by the insertion of neutral filters. With this system we obtain for each PM tube:

1. Absolute time calibrations of the T1 and T2 scales for different light intensities.

2. Relative Q calibrations in the range 1 to 50 pe.

A single overall constant is needed to provide the absolute Q calibration. This is obtained by computing the total Q expected from vertical muons traversing the center of the detector and comparing this with the data for such muons.