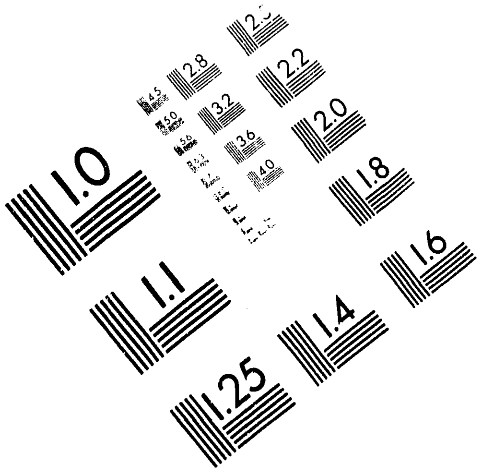

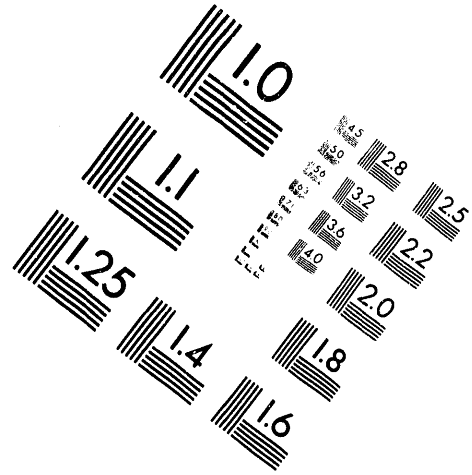

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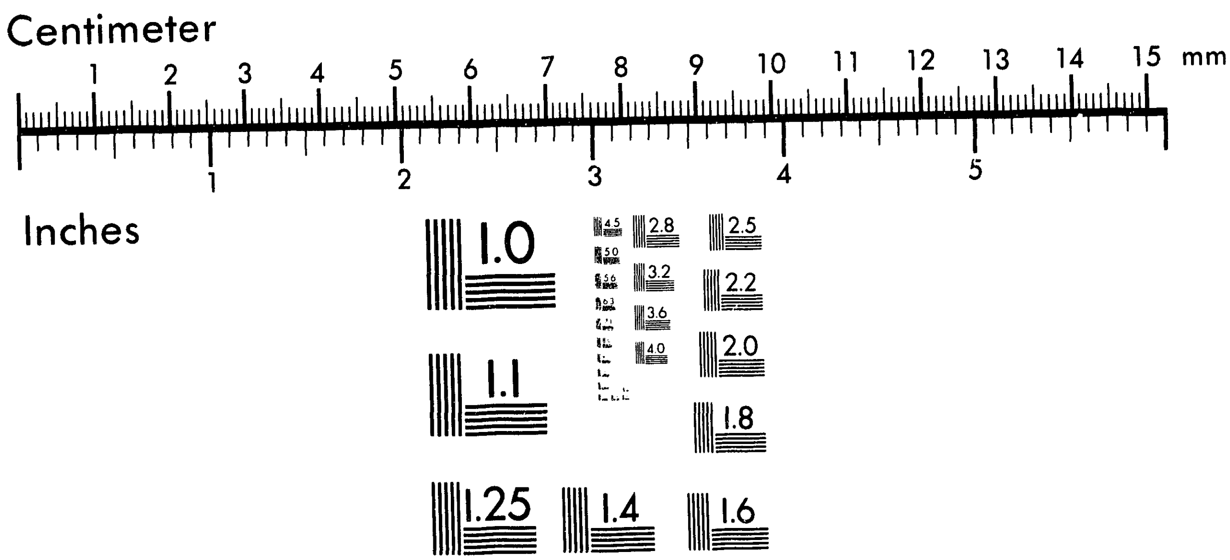

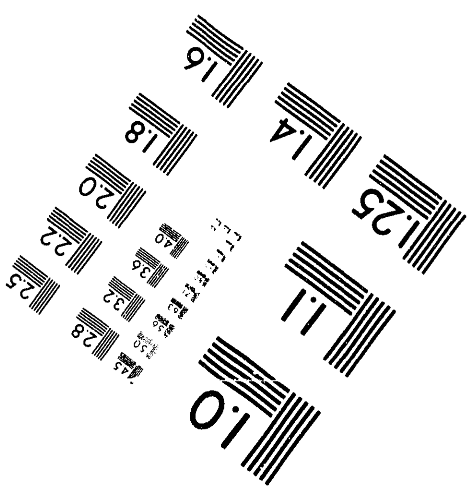

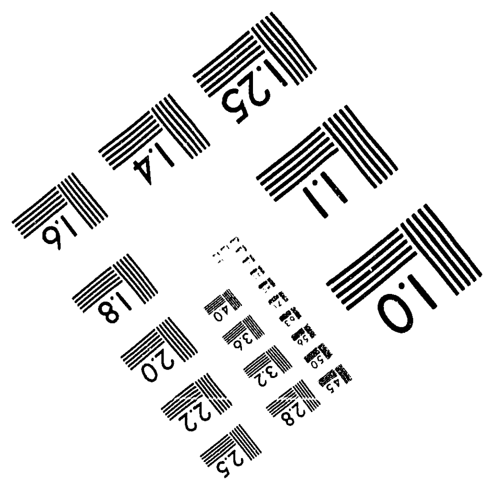

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Contained ν Events Observed in Soudan 2*

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1. Introduction

Atmospheric ν_μ and ν_e are created in cosmic ray interactions in the atmosphere, and can be detected in underground detectors. The Kamiokande and IMB water Cerenkov detectors have found fewer ν_μ interactions (relative to ν_e) than are expected.[Hirata, Casper, Berger, Aglietta] Results are usually expressed by the ratio:

$$R \equiv \frac{(\nu_\mu/\nu_e)_{measured}}{(\nu_\mu/\nu_e)_{predicted}} \quad (1)$$

with R found to be less than 1. The Soudan 2 detector is an iron calorimeter, which has different systematic effects than the water Cerenkov counters. Results from the Frejus and NUSEX calorimeters do not suggest a deficit of ν_μ's in iron, implying that perhaps there is a systematic effect in Cerenkov detectors or some unexpected nuclear effect. Here we report on a preliminary analysis of 0.5 kton-year of data in Soudan 2. We are presently analyzing our second 0.5 kt-year of data, and will present new results at the meeting.

2. Data Analysis

The Soudan 2 contained event analysis chain has been described elsewhere[Roback]. The detector is a tracking drift calorimeter that will

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consist of 224 modules each weighing 4.3 tons. Eight hundred twenty six tons are operating at present (March 1993) and detector installation will be completed this year. During the first 0.5 kt-year of data, the detector grew from 269 tons to 538 tons. The calorimeter is surrounded by a cavern-liner proportional-tube active shield.

Processing of 17 million triggers yielded 25,000 possible contained event candidates which were scanned by physicists. Containment is defined as no track coming closer than 20 cm to the outside of the detector. The next step was to classify the topology of the contained events as single track, single shower or not being due to a quasi-elastic interaction($\overline{QE}$). The single track and single shower events are mostly (72%) quasi-elastic interactions according to our Monte Carlo simulation. In this separation an observed recoil nucleon or muon decay was ignored. Events which appeared to be neutral current or inelastic interactions were classified as $\overline{QE}$.

Certain kinds of noise in the detector can appear to be similar to low energy showers. We have identified and eliminated such events. Nevertheless at this stage we have applied an additional cut that showers must have more than 200 MeV of visible energy.

Contained events with hits in the active shield are due to interactions of neutral particles produced by muon interactions in the surrounding rock. A study of such events indicates that the efficiency of detecting at least one charged particle passing through the active shield is high. The shield efficiency and random rate is continuously monitored using the 0.2 Hz of throughgoing muons. The final sample contains 38 0-shield-hit (neutrino candidate) events and 23 1-shield-hit events which we use to estimate the background. In the 0-shield-hit events we identify 13 tracks, 14 showers and 11 $\overline{QE}$'s. In the 1-shield-hit sample there are 16 tracks, 5 showers and 2 $\overline{QE}$'s. The neutrino event counts have been corrected for losses due to random shield hits and contamination due to shield inefficiencies, giving a final sample of 11.0 tracks, 13.9 showers and 11.5 $\overline{QE}$'s.

In a Monte Carlo exposure of 3.17 kton-years, analyzed in an identical manner, we identified 20.8 tracks, 14.5 showers and 16.9 $\overline{QE}$ events, after normalizing to our exposure. Scanners correctly identified 96% of the single tracks and showers.

3. Discussion

The track/shower ratio is $11.0/13.9 = 0.79 \pm 0.39$ (stat). The Monte Carlo ratio is 1.43. Major systematic uncertainties at this stage are 15% for the Monte Carlo simulation, 14% from the statistics of the Monte Carlo, and 6% from the uncertainty in shield efficiency. Combining these errors in quadrature, we obtain:

$$R' = \frac{(track/shower)_{measured}}{(track/shower)_{predicted}} = 0.55 \pm 0.27(stat) \pm 0.10(sys) \qquad (2)$$

For the neutrino oscillation hypothesis $\nu_\tau \rightarrow \nu_\mu$, this ratio R' must be corrected to obtain R in Equation 1 because 16% of the single track events are due to neutral current interactions, which are unaffected by oscillations. After this correction, $R = 0.46 \pm 0.23$. We note that the correction of R' to R in equation 1 is strongly model dependent and different for each detector.

Acknowledgements

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