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Moon/Electron Identification
Tests at KEK

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Preliminary Results From IMB3 Muon/Electron Identification Tests at KEK

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Abstract

A test has been conducted at KEK, Japan using beams of electrons and muons in a 1 kiloton water Cherenkov detector instrumented with IMB3 phototubes and electronics to evaluate IMB's algorithms for identifying electrons and muons. This identification is important because the IMB3 detector's results on the atmospheric neutrino anomaly depend on the proper identification of the electrons and muons produced in neutrino charged-current interactions. Preliminary results are presented.

1 Introduction

One of the outstanding problems in particle physics today is the discrepancy between the predicted and observed ratios of non-showering events to all events in water Cherenkov detectors such as the IMB and Kamiokande detectors. This implies a discrepancy between the predicted and observed ratios of muon neutrinos (which produce non-showering events) to electron neutrinos (which produce showering events).

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The IMB detector[1] recorded the ratio of non-showering events to total events as being $0.36 \pm 0.02(stat) \pm 0.02(syst)$ (see Ref.[2]). Monte Carlo simulation gives the expected ratio of $0.51 \pm 0.01(stat) \pm 0.05(syst)$. Clearly, understanding the systematic error of the experimental measurement is important in determining the significance of this result. The algorithm used in determining the showering or non-showering nature of an event is a possible source of systematic error in the above determination.

2 The Experiment

Data for testing the IMB particle identification techniques was collected at KEK in Tsukuba, Japan using the 12 GeV proton synchrotron as a source of electron, muons and pions. These particles were directed at a 10 meter high, 10 meter diameter tank of pure water instrumented with 342 phototubes and waveshifter plates from the IMB experiment. This tank had been constructed for an earlier test of a similar nature by the Kamiokande III group.

Beams of electrons, muons and pions with momenta from 100 MeV/c to 1 GeV/c were studied. Three bending and eight quadrupole magnets were used to separate the different particle types, and time-of-flight and gas Cherenkov counters were utilized for increased separation ability. The position of the introduction of these particles into the water tank was varied over five beam pipe positions to allow for studies of the position dependence of the particle identification algorithms.

3 The Analysis

The algorithm used in determining whether or not an event is showering is based on the distribution of photoelectrons as a function of the angle between the tube recording the photoelectrons and the track direction. Figure 1 shows a distribution for a sample of electrons and Figure 2 muons with a similar total Cherenkov energy deposition. Note that showering events tend to produce more photons at large angles from the track direction.

The algorithm used to identify the KEK data is derived from the algorithm used in the original IMB3 analysis with minimal modification. Distributions from Monte Carlo events with similar momenta are compared with those of the KEK data. The fractions of photoelectrons falling in the angular ranges $-0.38 < \cos(\theta) < 0.76$ and $0.80 < \cos(\theta) < 0.98$ are determined for both the Monte Carlo and the data. Events having values more closely matching those of showering Monte Carlo events are identified as showers; values closer to non-showering Monte Carlo events are non-showering.

4 Preliminary Results

The above algorithm has been applied to KEK data having known particle types and vertices. The efficiencies for correctly identifying these events as a function of the momentum of the event is given in Figures 3. We will next study the effect of this algorithm on the IMB3 data.

References

- [1] R. Becker-Szendy *et al.*, Nucl. Instr. and Meth. **A324**, 363 (1993)
- [2] R. Becker-Szendy *et al.*, Phys. Rev. D **46**, 3720 (1992)

Figure 1: Distribution of photoelectrons as a function of the angle at the end of the beam pipe between the track direction (assumed to be the direction of beam travel) and the direction of the phototube recording the photoelectron for a sample of 600 MeV/c electrons.

Figure 2: Distribution of photoelectrons as a function of the angle at the end of the beam pipe between the track direction (assumed to be the direction of beam travel) and the direction of the phototube recording the photoelectron for a sample of 800 MeV/c muons.

Figure 3: Efficiency of the particle identification algorithms on samples of electrons and muons from the KEK beam test for one beam pipe position. The x axis is the particle momentum (MeV/c) and the y axis is the probability that a particle was correctly identified (percent).