Fermilab Proposal #386

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Research Proposal for the Fermi National

Accelerator Laboratory

A SEARCH FOR LOW ENERGY NEUTRAL PARTICLES AND PARTICLE INTERACTIONS INVOLVING SMALL ENERGY EXCHANGES IN THE NEUTRINO BEAM

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SUMMARY

A proposal is presented to search for any new type of low energy neutral particles capable of passing through the large neutrino shield and producing nuclear interactions in a stack of nuclear emulsions. The experiment exploits the capability of the nuclear emulsion to detect interactions involving energy exchanges of the order of several MeV which could not be detected with other instruments.

INTRODUCTION

In the year 1968 we carried out a nuclear emulsion experiment at SLAC which was, in many ways, similar to that proposed herein. A site was selected 720 feet behind the beam dump and a stack of emulsions was located within one milliradian of the direction of the beam line. Charged particles from the beam could penetrate only about 120 feet so that only neutral radiations could reach the emulsion detector. Shielding from the cosmic rays and scattered radiation from the accelerator was provided by about three feet of iron. In addition, the emulsions were coated at the site and never moved, even during the time of development. Thus tracks associated with the beam direction could be distinguished from those due to cosmic rays with a very high degree of discrimination.

The plates were exposed for a two week period during which the beam intensity at the dump was about 50-60 Kw. The purpose of the experiment was to search for events due to any new type particle or radiation not presently known. Needless to say, all events found could be interpreted as being due to known processes.

Recently we coated a few nuclear emulsions at Ray Davis's underground laboratory in the Homestake Gold mine. Again the purpose was to look for very low energy processes which would be missed by conventional detectors. In the course of scanning 64 cm^3 of the emulsion, 7 low energy events have been found which cannot be explained and would not be detected with electronic instruments. The events are described in Appendix I, an abstract for the 14^{th} Int. Cosmic Ray Conference.

The events discussed in Appendix I represent energy exchanges only about 1.5 times greater than that due to natural radioactivity. The high resolving power of the emulsion made it possible to detect the events out of a background of 10^6 alpha particle tracks from natural radioactivity. Three of the events were produced by neutral particles or radiations and their number is about 10^4 time greater than could be explained from cosmic ray neutrinos.

PROPOSED EXPERIMENT

We would like to get a site near the end of the neutrino shield and in line with the beam where a search could be made for new particles of low energy or processes involving small energy exchanges. This experiment obviously is not intended to compete with the large scale neutrino experiments in progress but it aimed at the search for several MeV interactions which could not be detected by conventional means. In addition, the experiment could be carried out with negligible interference with other experiments.

A crude shelter would be needed near the end

of the neutrino shelter in order to keep the emulsions out of the weather as well as to provide an area where the emulsions could be coated. Shielding would be required to the extent of providing a box of about 1 ft^3 surrounded by a shield of several feet of iron or concrete. In the same manner as at SLAC, the coated emulsions would not be disturbed for several weeks of running time. We would try to keep emulsions in the beam for all periods when large beams are striking the target.

APPENDIX I

Abstract for 14th International Cosmic Ray Conference
August 15-29, 1975

ANÓMOLOUS STOPPING PARTICLES AT GREAT DEPTHS UNDERGROUND

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Theoretical ☐ Experimental ☒ Both ☐

In carrying out a series of measurements on the primary muon flux and its associated secondary fluxes of slow particles at various depths underground and underwater, we have prepared, and developed a stack of G-5 photographic emulsions in the Solar Neutrino Laboratory, which is 4500 feet underground in the Homestake Gold Mine, South Dakota. The exposure time for this stack overlapped that time during which Lande recorded what may have been a series of anti-neutrino pulses. In our scan of a part of this stack which was exposed for 250 days (64 grams with 400 square centimeters total surface area), we found 7 tracks with minimum lengths of from 110 to 210 microns which had one end located in the emulsion volume. Four of these tracks appear to be alphas ($E_{min} \sim 15 - 20$ MeV) while the other three look like protons or possibly muons or pions. These events will be described and possible interpretations of them presented.