Measurement of the Polarization of Prompt Muons at $x = 0.14$ at $p_t = 0$ and $p_t = 1.5$ GeV/c

A Proposal to the Fermi National Accelerator Laboratory

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SUMMARY

We propose to measure the polarization of prompt muons produced at a small value of x ($x \approx 0.14$) in the forward direction and at a transverse momentum near 1.5 GeV/c. Such measurements will relate to regions of x and p_t where the most extensive measurements of the anomalously large prompt muon intensity have been made and where the ratio of prompt muons to pions is as large as 10^{-4}. Such measurements will determine as to whether the production of prompt muons is a parity conserving process or whether a non-parity conserving interaction is involved.

These proposed measurements can be considered as extensions of the polarization measurements at a larger value of x ($x \approx 0.45$, $p_t = 0$) which we are now making in Ex. 48. We note that the ratio of prompt positive muons to pions is only about $1.5 \cdot 10^{-5}$ at this energy and exotic processes may not be so important here. The basic equipment and techniques are the same as for Ex. 48 though the polarimeter must be moved from the portacamp which now holds it (1200' from the target) to another portacamp (which is about 400' from the target).

The ratio of prompt positive muons to pions has been measured to be about $8.37 \cdot 10^{-5}$ at $x = 0.14$ and the intensity is sufficient that polarization measurements will require about 100 hrs at a proton intensity of 10^{11} per pulse. Less definitive measurements at $p_t = 1.5$ GeV/c suggest that about 100 hrs at 10^{12} protons per pulse will be required for measurements at this transverse momenta. Altogether, we request 250 hours of beam time, 50 for setup and 200 for the two measurements. We need no additional equipment from FNAL beyond that supplied for Ex. 48.

1. INTRODUCTION

The origin of the large prompt lepton flux produced in proton interactions is still obscure. Prompt leptons appear to be produced at intensities about an order of magnitude greater than might be accounted for by conventional sources and these leptons seem to be produced over a wide range of x (the Feynman variable), p_t and s. Although the ratio of positive to negative leptons is nowhere very different than one -- and, indeed, may be exactly one -- it has not been established that the prompt leptons are produced in lepton-anti-lepton pairs from electromagnetic processes which are parity conserving, or if the leptons are produced in non-parity conserving interactions such as the weak decay of charmed particles, intermediate bosons or heavy leptons. If the production process is indeed parity conserving, the longitudinal polarization of the muons will be zero; if the process is not parity conserving, we can expect a non-zero polarization. Although the degree of polarization to be expected from a non-parity conserving decay will depend upon the precise mode of the decay, for a wide variety of possible processes, the polarization will be almost complete. It is then clear, that measurements of the polarization of the prompt muons are likely to play a crucial part in the attempts to understand this phenomenon.

The proposed experiment is a part of, or extension of, Ex. 48 which is now running in the proton-central beam line. Measurements made in the course of that experiment[1] constitute a basis for the design of the polarization measurements which we propose here. At the present time we are measuring the polarization of the prompt muons where $E \approx 190$ GeV and $x \approx 0.45$. There is some possibility that the prompt muon contribution

at large x might be largely accounted for by conventional processes, but the intensity with smaller values of x are more certainly from an exotic source. We note that our intensity measurements[1] show that the ratio of prompt positive muons to pions is only $1.24 \cdot 10^{-5}$ at $x = 0.57$, which is near the value of $x = 0.45$ where we are now measuring the polarization, while the same ratio was determined to be $8.37 \cdot 10^{-5}$ at $x = 0.135$, which corresponds to the muon energy for the polarization measurement proposed here.

II. EXPERIMENTAL DESIGN

The basic design is very similar to that for Ex. 48 except that the polarimeter is to be placed in one of the portacamps in the upstream pit which has been constructed for Ex. 48. It will be desirable to move that portacamp so the long axis is parallel to the beam and this will probably require some minor modification of the pit. A smaller (20') portacamp would simplify matters here also. We would want the axis of the portacamp to lie about 15' west of the extension of the proton beam line. Between the $p_t = 0$ run and the $p_t = 1.5$ GeV run the bending magnet (in the proton-central hall) will have to be moved a few inches. This placement is suggested in the diagram of Fig. 1. No other modifications of the apparatus used for Ex. 48 are required.

III. EXPERIMENTAL PROCEDURES, DATA HANDLING AND ANALYSIS

All of the procedures, data handling, and analysis methods are the same as for Ex. 48 and have been rather thoroughly tested in the course of those measurements and previous measurements at BNL.[2]

IV. TIME AND EQUIPMENT REQUIREMENTS

We estimate that we will require about 50 hours of beam time to check out the equipment after the move, to set up appropriate triggers, and to adjust the timing requirements. We believe that each run will take about 100 hours, and thereby request a total of 250 hours of beam time. No equipment will be required from FNAL beyond that already provided for Ex. 48.

REFERENCES

1. Leipuner et al., to be published in Phys. Rev. Letters. Paper appended.

2. P.J. Wanderer, Jr., et al., Phys. Rev. Letters 23, 729 (1969)

FIGURE CAPTION

Fig. 1 A schematic view of the experimental setup.