NAL Proposal No. 444

Correspondent: A. J. S. Smith
Department of Physics
Princeton University
P.O. Box 708
Princeton, N.J. 08540

Telephone: 609-452-5590
609-452-4395

A SPECIAL REQUEST FOR HIGH-PRIORITY RUNNING TO MEASURE HIGH-MASS MUON PAIRS

K. J. Anderson, G. G. Henry, K. T. McDonald, J. E. Pilcher, E. I. Rosenberg

Enrico Fermi Institute

University of Chicago

and

J. G. Branson, G. H. Sanders, A. J. S. Smith, J. J. Thaler

Princeton University

September 26, 1975

A Special Request for High-Priority Running to Measure High-Mass Muon Pairs

K. J. Anderson, G. G. Henry, K. T. McDonald, J. E. Pilcher, E. I. Rosenberg
Enrico Fermi Institute
University of Chicago

and

J. G. Branson, G. H. Sanders, A. J. S. Smith, J. J. Thaler
Princeton University

September 26, 1975

ABSTRACT

We request 400 hours (4 weeks) of high-intensity hadron running in the N1 line ($\sim 10^7$ particles/burst), with which we shall survey the dimuon spectrum in the mass range $\sim$1.5 --- 15 GeV, with a sensitivity of $\sim$ 1 event/10^{-36} cm^2/nucleon. Protons, π^+, and π^- of $\sim$225 GeV/c momentum will be used to bombard a carbon target. This choice of interactions will produce significant tests of dimuon production mechanisms and the parton formalism as well. We also list many other exciting physics results we expect to obtain from this 400 hour run. It is crucial that this requested high-intensity run take place before our experiment is torn down to make way for E-398, deep inelastic muon scattering.

INTRODUCTION

Last November, Experiment 331 (DETAILED STUDY OF DIMUON PRODUCTION) was approved for a parasitic run of 400 hours at a beam intensity of $\sim 10^6$ particles/pulse. Since then we have completed an initial shakedown run in which we managed to tune up the spectrometer and accumulate 150 hours of data at $\sim 5\ 10^5$ particles/pulse. This test run has both produced interesting results[1,2,3] and shown conclusively the feasibility of our carrying out a definitive measurement of dimuon production by hadrons. Therefore as suggested by the Program Advisory Committee in the letter of approval of E-331, we request a 4-week period of high-priority running with positive and negative beams with intensities up to 10^7/pulse. The primary machine energy should be 400 GeV or higher, since we need protons and pions of $\sim$225 GeV/c momentum, and possibly 300 GeV protons as well.

It is essential that this high-intensity run take place toward the end of our parasite run which begins this November. Otherwise, for the want of a single month, the enormous advantages and efficiency of exploiting a completely tested and working experiment (including analysis programs) would be lost, since the muon laboratory is soon to be reconfigured for E-398, the deep inelastic muon-scattering experiment. Should our request be approved, the data will be completely analyzed by the summer. We reemphasize that no changes in the <u>spectrometer</u> are required - all we need is sufficient priority. In a separate proposal[4] we propose a longer term continuation of dimuon measurements, which <u>does</u> require substantial modification of the spectrometer, including the installation of a liquid H_2 target. We do not contemplate setting up this latter experiment till E-398 is completed.

JUSTIFICATION FOR THE PROPOSED 4-WEEK RUN

The measurements we plan to make in these 4 weeks were all mentioned in the E-331 proposal; they are if anything even more interesting and urgent now than they were at the time it was written, before the excitement of last November. The spectrometer has performed precisely up to specifications: The trigger rate is completely manageable, the backgrounds from decays and secondary processes are negligible, and the resolution agrees with that predicted by design studies. A few minor modifications we are now constructing will suppress triggers from low-mass dimuons and from various spurious sources, so that we expect only $\sim$10 triggers/pulse at 10^7. The spectrometer has already handled rates of 3×10^6 for a few all-too-brief periods last June when no other experiments were running. There is no foreseeable impediment to handling fluxes of 10^7.

Hence we are in an almost unique position, with a large-acceptance, high-resolution spectrometer placed where it can receive high-intensity proton and meson beams. These beams are available if we are granted the use of the quadrupole triplet train, which increases the beam solid angle by a huge factor over the present parasitic transport, where the first focusing element is more than 1000 feet from the neutrino target. Although installing the triplet imposes constraints on the other neutrino-area programs, it requires only a very modest flux [$(1-2) \times 10^{12}$] of primary protons.

THE PHYSICS

In what follows we outline some of the most important results we can obtain with a 400-hour run at 10^7/pulse.

I. High-Sensitivity Search for New Particles

The exposure we propose is about 50 times as large as that of our test run, in which $\sim$100 J's were found. We can therefore search, to a sensitivity of $\sim$ 1 event per 10^{-36} cm^2/nucleon, for other sources of dimuons up to masses of $\sim$ 15 GeV. Also, as we should get a sample of a few thousand J's, a very significant sample of $\psi(3.7)$ events should also emerge. If there aren't any, a most significant upper-limit will be set. The good resolution of our apparatus is very important here in s parating J's from $\psi(3.7)$'s.

II. Tests of Production Mechanisms of Continuum Dimuons

By conducting the above search with both positive and negative beams and with an isotopically-symmetric target material, such as carbon, we can perform some most interesting tests of the parton formalism as well. For example, the model of Drell and Yan predicts, (assuming the usual fractionally-charged constituents and that the partons of target and projectile are in the valence region) that:

$$(1) \qquad \frac{\sigma(\pi^- + C \to \mu^+\mu^- + X)}{\sigma(\pi^+ + C \to \mu^+\mu^- + X)} = 4,$$

a rather dramatic result.

$$(2) \qquad \sigma(\pi^+ + A \to \mu^+\mu^- + X) >> \sigma\ (p + A \to \mu^+\mu^- + X)$$

(3) If (1) and (2) are satisified, then one can do a scaling test:

$$\frac{d\sigma}{dQ^2} = \frac{1}{Q^4}\ f(Q^2/s)$$

Unfortunately we don't have unlimited freedom to vary s, so some assumptions about f may have to be made.

III. Detailed Study and Comparison of Continuum and J Production:

Because of the large acceptance and good resolution of the spectrometer, we can measure dimuons in both the "valence" and "sea " regions. Thus the region of validity of the parton model should be found. We also have a virtually complete acceptance in cos $\theta^*_{\mu\mu}$, the angle of the decaying muons in the dimuon center of mass frame. This allows us to measure the density matrix of the dimuon, for which definite predictions are made by various models. Comparison of this polarization between J's and continuum may shed light on the mechanism for J production itself.

IV. Like-Charged ($\mu^+\mu^+, \mu^-\mu^-$) events:

Because decay backgrounds are so small, we can use these events to test the hypothesis that J's are produced in pairs via a new associated-production mechanism.

V. Events with >2 Muons

We have a substantial efficiency for such events: J pairs decaying to 4μ's, for example, are detected with 50% of the single $J \rightarrow \mu\mu$ efficiency.

Our present data sample contains five 3-μ events with $\mu^+\mu^-$ pair masses above 1.5 GeV. We plan to investigate the source of these events, as well as any new classes to be observed, in the proposed run.

VI. Kaon-induced muon pairs.

The kaon flux in the N1 beam has been measured recently, and is included in the report FERMILAB-Conf-75/31-EXP 7300.001. One notes that the K^-/π^- ratio is $\gtrsim .04$. This means that a significant measurement of the process $K^- + C \rightarrow \mu^+\mu^- + X$ can be made simultaneously with our π^- running. Should any difference appear between K^- and π^- induced muon pairs, we shall be able to investigate it further.

References:

1. J. E. Pilcher, paper presented to the Lepton-Photon Symposium, SLAC, August 1975.

2. A. J. S. Smith, paper presented to the Annual Meeting of the Division of Particles and Fields, Seattle, Washington, August, 1975.

3. K. J. Anderson, et.al., submitted for publication in Physical Review Letters.

4. K. J. Anderson, et.al., Continued Studies of Hadron-Induced μ Pairs in a Large-Acceptance Spectrometer, NAL proposal submitted for consideration by the PAC at its November meeting, 1975.