Fermilab Proposal No. 332

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A PROPOSAL TO EXPLORE DI-LEPTON PRODUCTION IN THE LARGE-P_t DOMAIN: DI-LEPTON STRUCTURE, ASSOCIATED HADRON STRUCTURE AND BEAM PARTICLE DEPENDENCE

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ABSTRACT

A detailed study of large-P_t di-lepton phenomena is proposed using the one steradian magnetic spectrometer and 2.7 steradian hadron calorimeter of Experiment #236. Each arm is made sensitive to large-P_t electrons and muons.

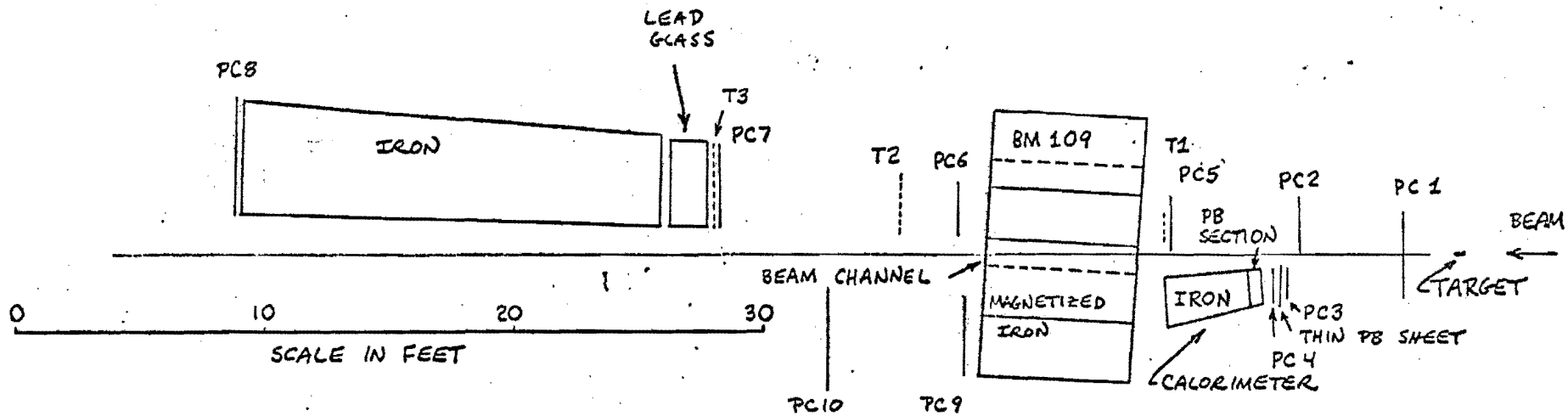
We propose to utilize the large, solid angle spectrometer and calorimeter of our experiment E236 to explore the di-lepton structure and associated hadron structure in the large-P_t domain. Both arms will be upgraded, to distinguish e's and μ's from hadrons, thus allowing a selective trigger. Since we will have the capability to take high data rates (∿ 1 KH_z) without excessive dead time, the trigger can be quite loose to minimize biases.

The upgraded design of the experiment is shown in Figure 1. We have extended the magnet yoke on the calorimeter side so that it will act both as a muon identifier and momentum analyzer. In place of the Cherenkov counters we have added a wall of lead glass to identify electrons and an iron hadron filter for muon identification.

The chambers for detecting muons after penetration of the iron filters will be multi-wire proportional chambers of limited resolution (∿½").

If we assume that the di-leptons approximately conserve P_t between themselves, then we can make a ball park estimate of how many high mass di-lepton events we expect to see. We use a ratio of $(e + \mu)/\pi \sim 2 \times 10^{-4}$ for this estimate and a 2/3 interaction length target. We expect ∿5000 events with $M_{\ell\ell}$>4 GeV in a 600 hour experiment. It should be emphasized that the rate from pions might be much larger.

Since this effort involves a modest increase in the equipment of E236, we believe this experiment could be mounted within a month of the completion of E236.



T1-3 SCINTILLATOR HODOSCOPES
PC 1-10 MULTIWIRE PROPORTIONAL CHAMBER SETS (X,U AND V PLANES)

FIG. 1 LAYOUT OF EXPERIMENT

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Supplement to E332

It is well known that SPEAR I expected to measure the sum of the squares of the parton charges by looking at the rate of $e^+e^- \rightarrow$hadrons. These expectations were, of course, invalidated by the experimental data and there has been some confusion since then in the interpretation of the experimental consequences. However, given the remarkable successes of the quark parton model in the space-like region, one is reluctant to abandon such an attractive theory entirely. We are proposing an experiment in the time-like region which we anticipate may isolate various features of the model. In particular, we believe we have a striking test of the quark parton charge assignments; our experiment proposes to measure $\pi^{\pm}$ C$\rightarrow$ lepton pair + anything.

Our experiment will check scaling and the lepton angular distributions against parton model predictions. However, we anticipate that the mechanisms, perhaps neutral vector gluons, which modified the SPEAR result may well be present here and modify the simple expectations of the theory.

It is known experimentally that there must be something like neutral gluons associated with the partons, since the electro-production data show that the partons carry only half the particle's momentum. Furthermore, from a dynamics standpoint, something must be holding the partons together, hence the name gluons. We would then expect such gluons to give rise to form factors in parton anti-parton annihilation and to final state interactions in parton anti-parton production from e^+e^- annihilation. Why no form factor effects are observed in deep inelastic electron and neutrino scattering is, of course, the real puzzle.

We believe that we can make a significant test of the fundamental quark parton picture in a way which is independent of such gluon effects.

This test stems from the following observations:

(1) The $\bar{u}$ quarks in the π^- must have the same momentum fraction distribution as the $\bar{d}$ quarks in the π^+ from a simple iso-spin rotation.

(2) The u quarks in carbon nuclei must have the same distribution as the d quarks.

(3) Above $x \cong .2$, the non-naive quarks are negligible, where x = momentum fraction carried by the quark. This is required by the value $\sim 1/3$ for the anti-neutrino to neutrino cross-section ratio. Therefore, we conclude that by taking the ratio of the cross sections $\pi^- C \to \ell^+ \ell^- X$ and $\pi^+ C \to \ell^+ \ell^- X$ the effects of gluons will cancel (see Fig. 1). Since at large di-lepton mass ($\sim$5 GeV) non-valance parton effects are expected to be negligible, the ratio of the cross sections should be given by just the square of the u-quark and d-quark charge ratio, namely:

$$\left(\frac{2/3}{-1/3}\right)^2 = 4$$

We believe that this is the cleanest test of the quark-parton picture in the time-like region that can be done at FNAL. It can be made in the present M1 beam of the meson hall and requires only a modest augmentation of our E236 experimental set-up in that beam; this set-up will be in place sometime in early Spring, 1975.

Convincing experimental evidence already exists from the space-like region that the answer will indeed be 4. This comes from a comparison

of the deep inelastic electron and neutrino scattering. After adjustments are made for the relative strengths of weak and electro-magnetic interactions one finds the cross sections are in the ratio of $\sim 5/18$. This is just the result expected from the parton picture, namely $\{(1/3)^2 + (2/3)^2\}/2$.

We propose to look for the other implications of the parton picture, namely, scaling and a $1+\cos^2\theta^*$ lepton angular distribution, but these might very well be modified by the presence of gluons. However, such effects should factor out in the $\pi^-\pi^+$ ratio, and give a believable number regardless of the success of scaling or the lepton angular distributions.

FIGURE CAPTION

Fig. 1 Diagrammatical representation of gluon processes that might modify the Drell Yan rates. This diagram is meant to emphasize the cancellation of these processes in the cross section ratio.

The external quark lines produced by gluons are not expected to contribute to the direct lepton production process at large di-lepton mass or near 90° in the center of mass where the Drell Yan process peaks. These are the wee partons and carry a very small fraction of the particle momentum.

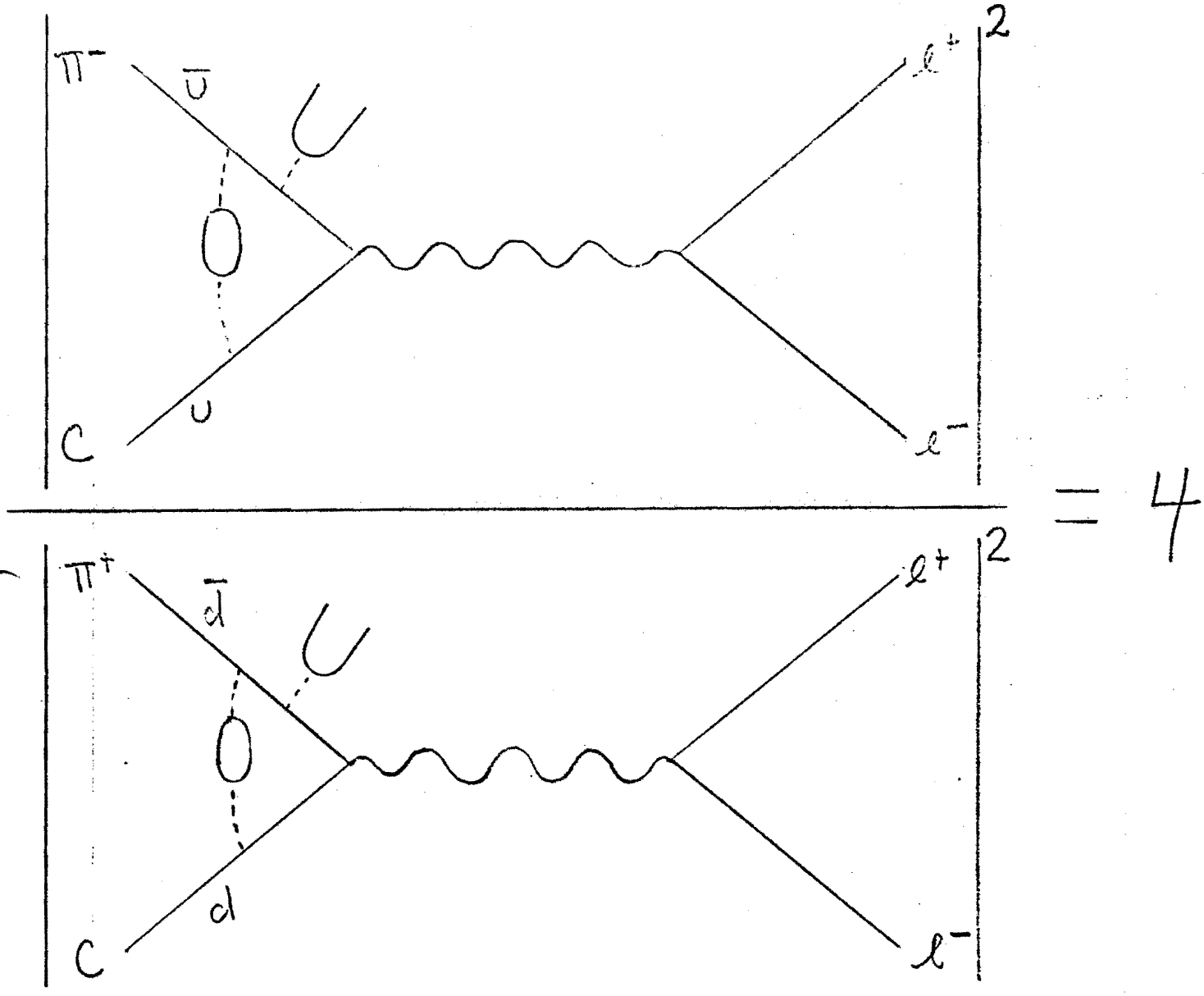

Fig. 1