NAL PROPOSAL No. 179

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K^+p Multiparticle Production in the 30" NAL Hybrid Chamber at the Highest Possible Energy

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<u>Request</u>: 300,000 "K^+p" pictures using the 30" bubble chamber and downstream wide gap spark chambers.

<u>Special requirements</u>: 20 hours of beam study to determine K^+ energy and intensity requirements. Two targets, for π^- and K^+ production.

<u>Proton intensity</u>: 5×10^{11} protons/burst to 10^{13} /burst, to be determined from a feasibility study at lower intensities.

<u>Proton energy</u>: The highest possible, but 200 GeV/c minimum.

<u>Special equipment</u>: Wide gap downstream spark chambers for K^o detection and upstream Cerenkov counter and kicker magnet. A scintillator beam deflection trigger as used in experiment 2I (Smith et al.).

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INTRODUCTION

One of the unique features of NAL that cannot be duplicated elsewhere (i.e. at CERN-ISR) is the ability to make high energy neutrino beams and high energy meson beams. It appears that meson-proton interactions may have given us some insight into hadron structure because the asymmetry (2 quarks on 3) which one observes[1] in them cannot be seen in proton-proton (3 quarks on 3) interactions. Although the asymmetry can be observed in π p collisions, it is likely that more can be learned if the role played by a single quark or parton can be identified. In K^+p interactions this becomes a possibility because one quark in the K^+ meson carries a strangeness quantum number which has potential for identification after the interaction by means of the K^o decay signature.

BEAM

The most crucial consideration is whether or not a reasonable K^+ beam can be obtained. This appears to be comfortably within the capabilities of the beam line to the 30" bubble chamber. Briefly, the scheme to be used is to strike target number 1 with protons to produce π^-'s. The π^-'s strike target number 2 to produce very high energy K^+'s at almost the same energy as the incident π^-'s. The forward K^+ beam thus should be nearly proton-free. Figure 1 shows that for 25 GeV/c incident π^-'s the π^+/K^+ ratio is as low as 1 or 2. The present Cerenkov counter can then be used to tag the interacting particle in the bubble chamber as a π^+ or K^+ meson for momenta up to about 250 GeV/c.

A realistic case seems to be 10^{12} 200 GeV/c protons per pulse on a Be target. Curves of C.L. Wang (BNL 15893) indicate this will yield 8,000 π^-'s into a 1% momentum bite at 120 GeV/c and a ½ μsr solid angle. This assumes that 50% of the protons interact. Data from π^-p collisions at 25 GeV/c indicate a cross section for producing K's at near beam momentum of 3.0 μbarns/GeV/c in the laboratory. One might ordinarily expect this cross section to decrease as the available momentum range increases unless this is some sort of diffractive process. A sharp spike for K's produced at zero degrees in the center of mass argues that some diffractive process may be involved, but all of these K's are produced in association with backward Λ^o's, and the production mechanism is unclear. However, if one assumes 3.0 μbarns/(GeV/c), 50% beam interactions, and that all of these very fast K's fall in the solid angle of acceptance with a 1% momentum bite, there will be $\sim$10 K^+'s per pulse.

By comparing 7 GeV/c πp and πD data, we find that fast K's are considerably enhanced relative to pions by the use of a deuterium target. If the secondary target is Be rather than hydrogen,one might even hope for 2-4 times more K^+ flux. However, our lack of information about the solid angle of the produced K's could have led us to overestimate the K flux by a factor as large as 100. For this reason some preliminary running time will have to be allotted for a feasibility study.

EQUIPMENT

We would plan to run with the wide gap spark chamber facility behind the 30" bubble chamber. These spark chambers would make identification of the fast, leading K^o decays relatively easy and certain compared to other possibilities such as a bare chamber or digital spark chambers. A downstream detector is necessary because a 100 GeV/c K^o travels about 5 meters before decay.

TRIGGER

In the event that the accelerator is giving a 60 μs spill the following procedure can be used to optimize the number of K^+p events. The average beam intensity will be set at $\sim$15 tracks/pulse. This will yield on the average about 2 interactions/pulse in the hydrogen or associated chamber material. A scintillator deflection trigger used in experiment 2I will identify interactions, and the Cerenkov counter will identify the initiating particle.

If the interaction is K^+p, the upstream kicker magnet will be given a command to remove the remaining beam. This can be done in about 3 μs, less than the average beam particle spacing. If the interaction is π^+p, beam will continue to be admitted. The K^+p event will be marked in the bubble chamber pictures because it will simultaneously appear in the spark chamber which will be triggered only by K^+p interactions. There are, of course, numerous other possibilities for triggering and tagging which depend on machine operating conditions.

EXPOSURE SIZE

Approximately 1/2 of the events will be in hydrogen, 1/2 of these will be in the fiducial volume, and 1/2 to 1/3 of these will be K^+p interactions. Perhaps then one picture in 10 will be a useful K^+p interaction.

If every event produced a K^o, only 1/3 would produce a visible K^o decay. The quark model suggests, among other possibilities, that $\sim 1/4$ of the higher multiplicity events will have leading K^o's. (This latter ratio is one of the things we want to learn from the experiment.) Thus we may expect only about 1/12 of the K^+p interactions will produce a useful K^o final state.

About 1/10 of the pictures will produce inclusive information, momentum spectra, and correlation functions which will be useful. However, the part of the data which is probably unique to the K^+ beam will come from those events with the K^o identified in the final state. A K beam in the 30" chamber is probably the only prospect NAL will have for several years to do a meson-proton experiment which can identify the leading meson and correlate its behavior with the behavior of the entire interaction.

From our experience about 3,000 K^o events would just serve to provide information at a significant level to answer the questions currently being posed in the literature. This leads us to ask for 300,000 pictures. The cost of this experiment is high relative to a simple p-p or π^-p exposure, but there appears to be no other way to obtain this information in the near future.

JUSTIFICATION OF EXPERIMENT

Some of the main reasons for selecting K^+p interactions are listed below.

(1) With reasonable certainty all negative outgoing particles can be assumed to be π^-(not K^- or $\bar{p}$). One can then cleanly study $K^+p \longrightarrow \pi^-$ + Anything, which is an exotic channel by some definitions and might approach limiting behavior at lower energies than others.

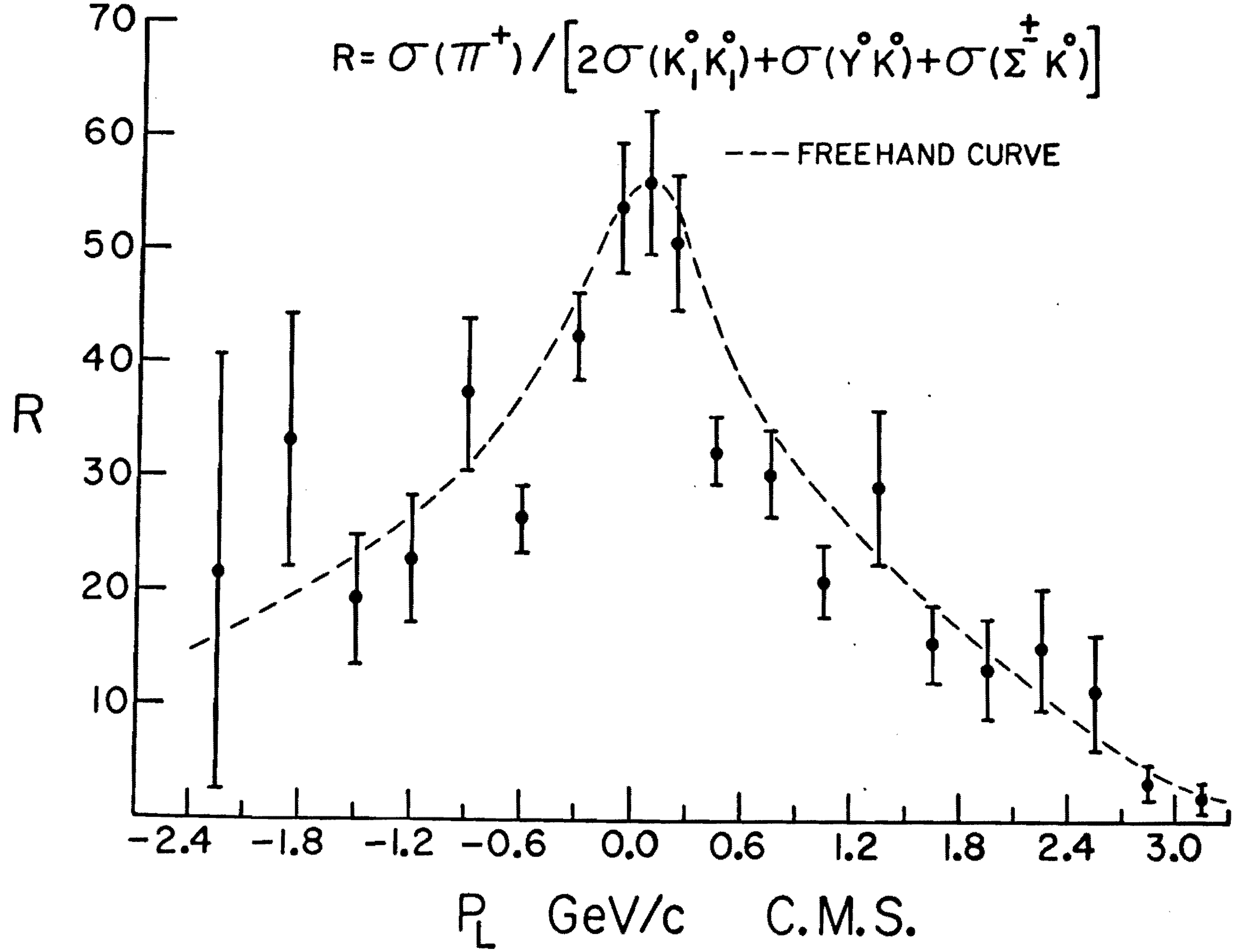
(2) Because the π^- is not an incident particle, it is more likely to be a "produced" particle in the final state, unassociated with "leading" outgoing particles. The choice of two positive particles in the incident state makes the negative pion "definitely" identified in both the forward and backward cms directions.

(3) The use of a strange particle as a projectile offers us the opportunity to study the behavior of a single component (quark?) of hadronic matter. By contrasting the leading K^+ and K^o behavior (ratios) we may see the difference in scattering for the strange and non strange component of the K^+.

(4) The asymmetry ascribed to the quark constituency in the K^+p scattering has been observed at an energy 10 times smaller than proposed for this experiment.[2] The way in which this asymmetry changes with such a significant change in energy should have important implications concerning the quark interpretation.

FOOTNOTES

1. J.W. Elbert, A.R. Erwin, W.D. Walker, Phys. Rev. D3, 2042 (1971).
2. W. Ko and R.L. Lander, Phys. Rev. Letters 26, 1284 (1971).



$R = \sigma(\pi^+) / [2\sigma(K_1^\circ K_1^\circ) + \sigma(Y^\circ K^\circ) + \sigma(\Sigma^\pm K^\circ)]$
--- FREEHAND CURVE
R
70
60
50
40
30
20
10
−2.4
−1.8
−1.2
−0.6
0.0
0.6
1.2
1.8
2.4
3.0
P_L GeV/c C.M.S.