FUTURE PLANS FOR THE MP LINE
(Both General and Specific)

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ABSTRACT

This talk consists of three sections. Topics range from suggestions of possible physics, which are presented to provoke thought and discussion about the distant future, to specific goals of E-704 for the next running period. The sections are on physics issues, possible upgrades of the beam and experimental apparatus, and goals for the next running period.

PHYSICS ISSUES

Many of the experiments and issues discussed at this symposium were viewed with renewed interest in light of the recent EMC results concerning the spin distribution functions for quarks in protons at low x.[1] There appear to be major contributions to the overall spin of the proton from either gluon spin or orbital angular momentum. We have heard a talk by Karlinre at this symposium and there are a number of papers and activities in progress.[2]

Polarized proton beams may assume greater importance in the future because the polarized quarks carry color charge which can couple directly to gluons. Deep inelastic scattering utilizing either electrons or muons has been efficacious because of the electrical charge of the quark. Gluons are not electrically charged. We recall that the large x_{BJ} leading quark of a polarized proton is known to carry most of the proton spin,[3] and so is a good probe. The questions which have recently arisen concern only the low x region which is populated with high probability and dominates the overall question of the proton. Electromagnetic probes may be useful in cases such as direct photon production where the information about gluons is not direct but the experimental final state is relatively clean.

We describe one particular reaction only for the sake of illustration. Consider a beam of 200 GeV longitudinally polarized protons. Also, we have a target of polarized protons. At x_{BJ} of .7, a quark in the beam proton will typically be a u quark with about 90% of the protons polarization. A scattering at 90° from a gluon in the target at x of .05 will give $p_\perp$ of 1.7 to both partons. Fragmentation to give hadrons may give a π° as leading particle from the gluon with some probability and a π^+ from the u quark, with z of say .85. What we observe in the laboratory will then be a di-hadron with mass of about 3 and x_F of about .8. If this were a relatively clean way of isolating quark-gluon scattering, we could measure the polarization of the gluon at x of .05 by flipping either the beam or target polarization sign. There are several problems with actually using this. There are other sources of di-pions of moderate mass. The q-squared may be too small to consider it as first-order single scattering. The kinematic constraints are smeared by the probabilistic nature of the hadronization.

A process which has been more seriously proposed by several authors[4] is that of direct photon production from polarized beam and polarized target. In some kinematic regions this is dominated by quark-gluon scattering with bremstrahlung from the quark. A spin dependence in the quark-gluon rate (from spins aligned or opposed) would give a dependence in the direct photon rate. Some typical calculated asymmetries are shown in Fig. 1.

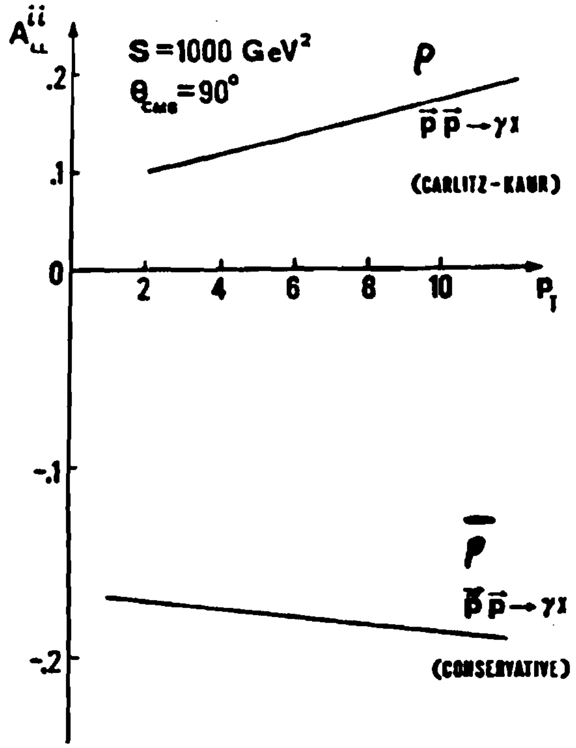

Figure 1

A typical prediction of the asymmetry for direct gamma production with polarized beam and target. This is one way to get the gluon spin structure function.

Other experiments are being considered which also explore the structure of the proton in different ways. One of these is the measurement of dimuon production with polarized beam and target. A comparison of the ψ region with the nearby background would be particularly useful if the dominant production mechanisms in each region are understood, e.g., if ψ production goes dominantly through the χ state. Another possibility is a measurement of parity violation in the total cross section. Calculations with different predictions assume different structure (see T. Goldman, this symposium).

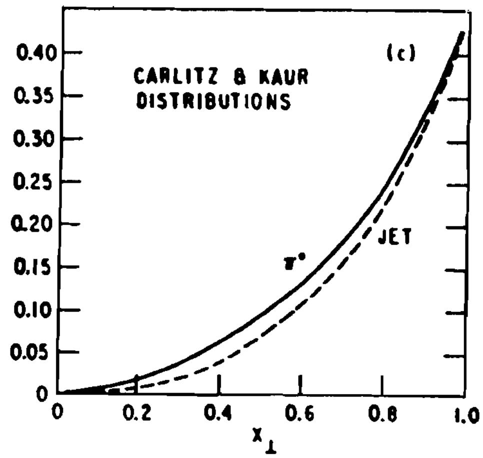

Figure 2 Predictions of inclusive π^0 and jet production asymmetries with both polarized beam and target. This is based on low order QCD and Carlitz-Kaur structure functions.

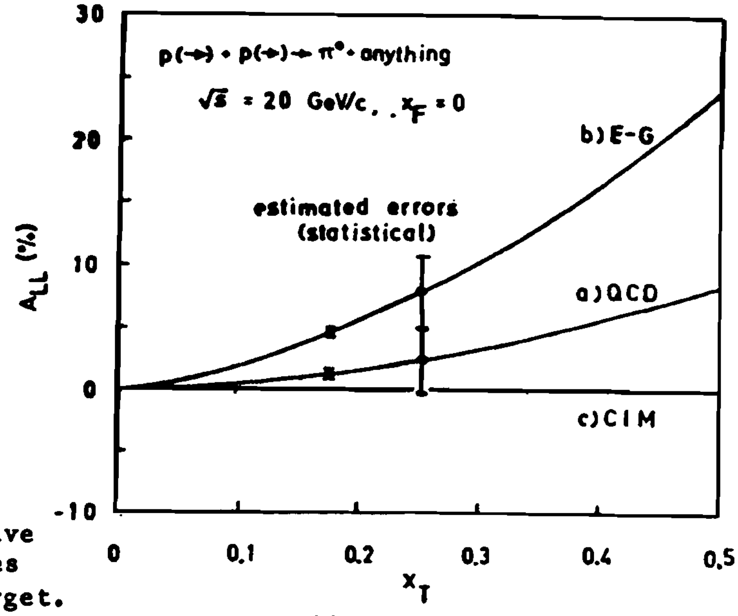

Figure 3 Illustration of the possible error bars in E-704 π^0 measurement.

The reactions presently approved for study in E-704 have more to do with studies of reaction mechanisms and comparison with simple perturbative QCD predictions. Inclusive production of π^0 at small x and large $p_\perp$ is predicted to have a substantial two spin asymmetry (A_{LL}) see Fig. 2. Figure 3 shows our predicted error bars on some typical calculated curves. The large contribution is quark-quark scattering. The single spin asymmetry predicted from single vector exchange is zero but has been measured to be large in several experiments. Figure 4 shows the results from π^0 production from protons on a polarized target in a CERN experiment and Fig. 5 shows the results from pions on a polarized target at Serpukhov.

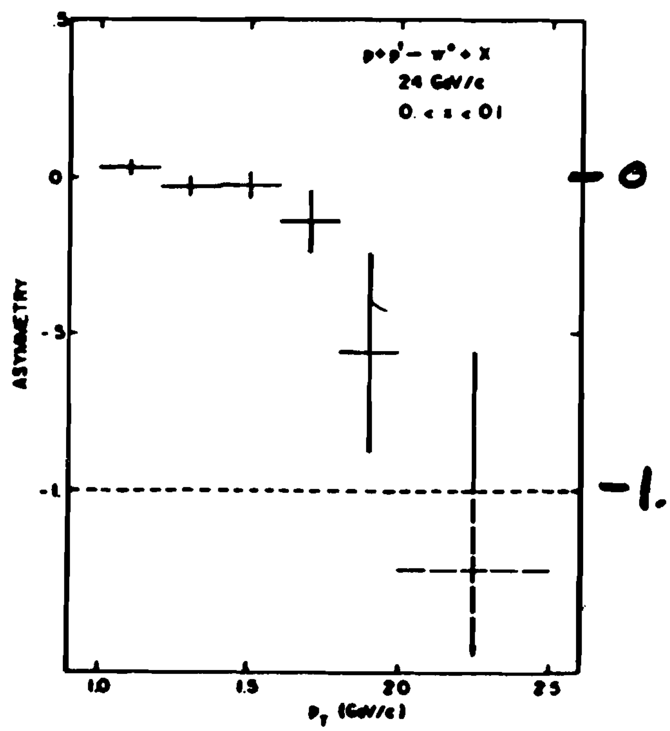

Figure 4 CERN measurement of asymmetry in pp → π^0 x at 24 GeV/c with polarized target over the Xf range 0 to 0.1

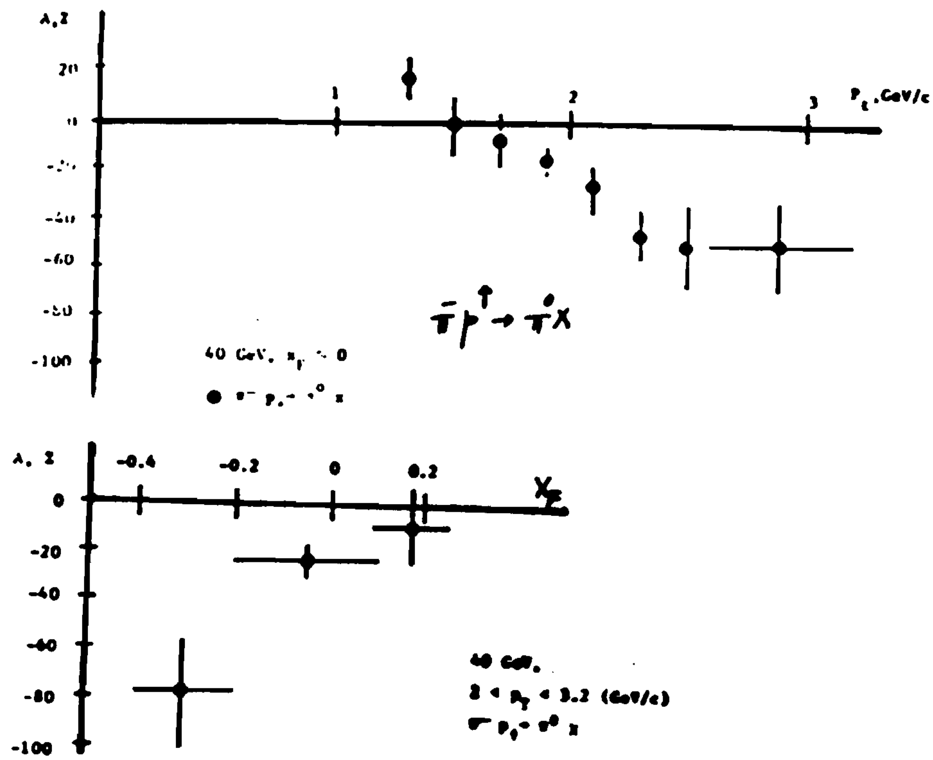

Figure 5 Serpukhov measurement of asymmetry in $\pi^- p \rightarrow \pi^0 x$ at 40 GeV/c shown vs. pt and also vs. Xf.

Another major part of the program is the study of hyperon production at large x and the related study of pions at large x. Recombination models considering di-quarks in the hadrons (and hadron wave functions in general) have some success when combined with some pictures of polarization of strange quarks pulled from the sea (see the talk by M. Nessi in this symposium). There is some discrepancy between model and experiment in the case of Σ^0 and none of the experiments requiring polarized beam have ever been done at high energy (above 22 GeV).

Another topic with many ramifications and some current interest is the total cross section. We will allocate about half of the running time in E-704 to the total cross section difference in pure longitudinal spin states. We can relate this to the rise in the total cross section either in general terms as a combination of helicity amplitudes or specifically as due to mini-jets as described by D. Richards at this symposium. In proton-antiproton there is expected to be a large asymmetry in the annihilation part of the cross section.

POSSIBLE UPGRADES TO THE BEAM AND EXPERIMENT

There are several beam upgrades that have been discussed previously. The appropriate timing for each of them is not yet clear.

1) If we assume that old beamlines never die then we would like a change in the splitting of primary beam in the meson area so that MP can run simultaneously with MC (and ME and other lines). There are various options to be considered such as DC splitting vs. time sharing spill-to-spill. There is also the problem of powering two experiments simultaneously.
2) We can go to somewhat higher energy, perhaps up to 300 GeV/c, by moving existing magnets. We must separate the quadrupoles in each doublet, which leads to a loss in flux. The 6-3-120 momentum selection dipoles must be moved downward. Some experiments may be better off with the higher energy protons, but the antiproton flux peaks around 185 GeV where we are now.
3) We can get both higher energy and higher flux by using large-aperture superconducting quadrupoles. The aperture should be four inches for the upstream group and either three or four inches for the other groups. Each group can be either a doublet (with 2 quads of 10 foot length) or a triplet (with 4 quads of 10 foot length). We would have to augment the two 6-3-120 dipoles to get adequate momentum selection. This upgrade would easily go to 400 GeV and possibly 600 GeV with some other small modifications.
4) We are presently investigating the use of protons from Σ^+ instead of lambda. The polarization would be higher but the flux may be so low that the error bars in experiments would be worse. See talk by Dave Carey.

An upgrade of the experiment applicable directly to E-704 would be a different spectrometer magnet. More aperture would give better acceptance for the lambda studies where the decay is up and down, along the beam polarization direction after the snake. More field integral would be useful for the triggers on lambdas now and on other states in future experiments.

Many people have spent many years at Fermilab developing ways to study particular reactions. We would like to study these reactions with polarized beam and, in many cases, polarized target. Some examples are production of lambda-charmed and, in particular, direct gammas. We must consider whether to try to augment our experimental set-up to study these processes or whether there is some approach which utilizes the experience and hardware already developed.

GOALS FOR THE NEXT RUNNING PERIOD

Tune Beam:

We need to get back to the tune of the previous run with different power supplies and readouts. We need to understand some features in more detail. We would also like to optimize the tune of the primary beam.

Take More Polarimeter Data:

Both the Primakoff and Coulomb-Nuclear measurements suffered from statistics. We would also like to check the polarization of anti-protons.

Polarized Target Runs:

$\Delta\sigma_L$ will be run with protons on protons and also with polarized anti-protons on polarized protons. This is scheduled for 600 hours. We will also tune up the π° measurement in the central region and begin the two spin (A_{LL}) data taking.

Hydrogen Target Runs:

We will also measure both A_N and D_{NN} for Λ° and Σ°, and possibly Σ^+. We will measure A_N for pion inclusive production at large x. We began this measurement for π° during the last running period using a polyethylene target. As mentioned previously, the result was consistent both with energy independence of results at lower energy and with the models used to explain lambda polarization.

REFERENCES

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