Conf-930389--12

Workshop of Future Directions in Particle & Nuclear Physics
at Multi-GeV Hadron Facilities
Brookhaven National Laboratory, Upton, NY 11973
March 4-6, 1993

BNL-48832

Polarization and Color Transparency*

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Abstract

Color transparency offers an interesting experimental test of our understanding of hadronic polarization effects which have been seen at high energy. Large polarization effects have been seen for exclusive high momentum transfer reactions which are incompatible with lowest order pQCD. It is proposed to filter these reactions by scattering inside a nucleus. We expect that only color transparent hadrons would survive, and that these should be products of "hard" scattering. If the polarization arrises from a non-perturbative "soft" effect, the nucleus should filter these reaction products away. We should see no polarization remaining after the reaction is filtered by a large nucleus.

1 Color Transparency

If certain physical processes give rise to abnormally small hadrons, these colorless objects can pass through a thick nucleus. This is the idea of color transparency.[2] It is expected that hard exclusive hadron scattering ($Q^2 > 5(GeV/c)^2$) gives small hadrons. This expectation is based on the scaling behavior of fixed large angle exclusive scattering. It is observed that, for example, proton-proton elastic scattering at 90° CM falls with energy as s^{-10}, and this power is predicted from dimensional counting.[3] Dimensional counting presumes that the reaction takes place in a small region of space, and, therefore, the participating hadrons are small at the time of the interaction. These hadrons would remain small for some period of time, since they cannot instantaneously expand to the normal hadronic size. If the interaction took place in a nucleus, the nucleus would be transparent to these colorless hadrons. In this picture a hadron is seen as fluctuating in size, and the hard exclusive scatter can only take place between hadrons which happen to be small when they collide. Scaling for fixed angle scattering has been established for many different processes (pp, πp, ep, etc.), the observed power agrees with the dimensional counting prediction, and the onset of scaling is generally for $Q^2 > 5(GeV/c)^2$. For lower Q^2 the cross sections fall exponentially with energy. This Q^2 onset of scaling corresponds to a distance of 0.1 Fermi, and the reaction Q^2 is the predicted size of the interaction and, thus, the participating hadrons. These small hadrons are expected to remain small for a distance of 5-10 Fermi at AGS energies.

An experiment on color transparency was done at the AGS and it reported a large change in transparency with energy (a factor of 3).[5] An analysis of the data was discussed by Ralston at this workshop (see the Dynamics Section). He and Jain conclude that the effective cross section for p-nucleus scattering depends on Q^2 and is about 15 mb for the Q^2 range of the experiment, compared to the "normal" 36 mb for p-nucleus scattering. There are two new experiments: one on ep scattering at SLAC which has taken data (NE18), and a new AGS experiment on color transparency which will take data this summer (EVA).

2 Filtering

We have just argued that only small hadrons will survive filtering through a nucleus, and that small hadrons are the product of hard exclusive scattering. Therefore, we can use a nucleus to filter reactions, leaving us with only the hard scattering part of the reaction. In general, after filtering, reactions should look more "asymptotic".

There are several phenomena in exclusive large angle scattering which appear to be non-asymptotic. The pp cross section, although it agrees well with the scaling expectations, appears to oscillate about the s^{-10} fall-off.[4] Large polarization effects have been seen for several reactions. Can we filter out this non-asymptotic behavior? Data from the AGS experiment on pp elastic scattering and color tranparency can be used to test whether the oscillations in cross section (about a factor of 2) are reduced when the protons are filtered by a nucleus. Heppelmann has discussed this test in his talk in the Dynamics Section of this workshop. There appears to be less oscillation, but the results are not conclusive. The new AGS experiment should give a clear answer.

3 Polarization and Color Transparency

The first example of a non-asymptotic polarization effect which would be interesting to study with a nuclear filter is large angle $\pi p \rightarrow \rho p$ scattering. An experiment at the AGS observed that, for $\pi^- p \rightarrow \rho^- p$ scattering at 90° CM, $-t = 10 GeV^2$, the $\rho^- \rightarrow \pi^- \pi^0$ decay plane has a large azimuthal dependence.[6] This azimuthal dependence implies either angular momentum (something that was pointed out at the workshop by Myher and Ralston), or the helicity flip of participating quarks. Both explanations imply a larger interaction region, and larger interacting hadrons. Can we filter azimuthal dependence out?

The data are shown in Figure 1, where we see the fitted dependence (solid line) and phase space (dotted lines). The azimuthal dependence is seen for the ρ mass region, but not in the higher mass data. It is also seen in a smaller data sample at higher energy. The dependence corresponds to an off-diagonal spin-density matrix element $r_{1-1} = 0.32 \pm 0.10$.

It is experimentally difficult to study this reaction filtered by a nucleus. The problem is that the target proton has Fermi momentum, and we would need to observe the π^0 from $\rho^- \rightarrow \pi^- \pi^0$ decay. A better reaction is $\pi^+ n \rightarrow \rho^0 p$, where all final state particles are charged. We have studied this reaction and have designed the EVA detector to be sensitive to this reaction, particularly the lower energy pions. We expect to collect data on this reaction this summer, using targets ranging from light to heavy nuclei.

A second large "non-asymptotic" polarization effect is pp elastic asymmetry with one proton polarized transversely, A_N. Data from an AGS experiment[7] is shown in Figure 2. For $(p_T)^2 > 6(GeV/c)^2$, the asymmetry is large. It is expected to be zero from lowest order pQCD. One can do this experiment, filtered, by scattering the AGS polarized proton beam from protons in nuclei. The EVA experiment will propose to do this.

*Work performed under the auspices of the U. S. Department of Energy, the National Science Foundation, and the Basic Research Foundation administered by the Israel Academy of Science and Humanities.

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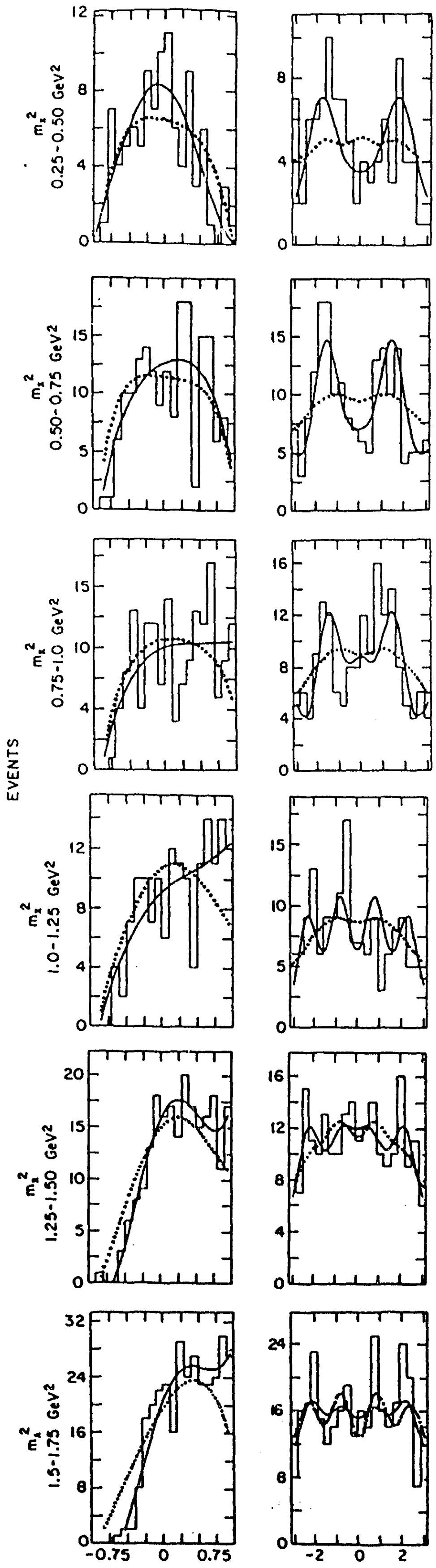

FIG. 1. cosθ and ϕ projections of the decay π^- for the reaction $\pi^- p \rightarrow p + X$, $X \rightarrow \pi^- \pi^0$. The angles are in the c.m. helicity frame of X. The projections are shown for six missing-mass bins (m_X^2). The dots superimposed over the data represent a Monte Carlo simulation of the acceptance and the solid lines are results from the maximum-likelihood fit,

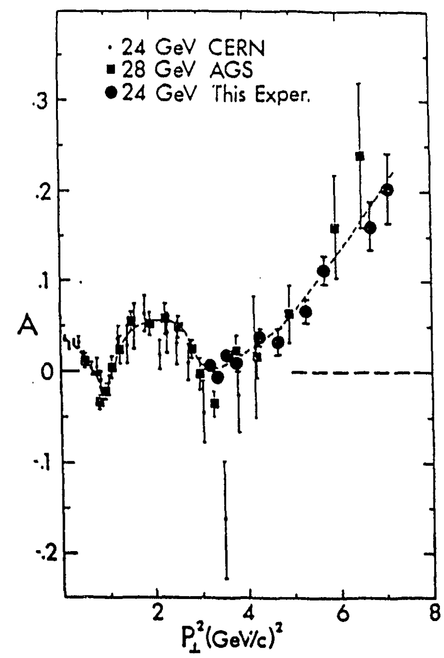

Fig. 2. The analyzing power, A, is plotted against p_T^2, for spin-polarized proton-proton elastic scattering at 24 and 28 GeV/c.

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