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A PROPOSAL TO STUDY SLOW SECONDARY PARTICLE DISTRIBUTIONS

IN π^-p AND pp REACTIONS IN THE 30-INCH BUBBLE CHAMBER

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Abstract:

   A set of runs for the 30" hydrogen bubble chamber for π^- and proton at various

momenta is proposed for a total of 200,000 useable frames. The runs are aimed at

providing quick answers to questions relating to the limiting fragmentation

hypothesis as well as a preliminary survey of multiparticle final states.

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I. <u>INTRODUCTION</u>

We propose an experiment to investigate features of high-energy collisions which can be studied profitably in the 30-inch hydrogen bubble chamber, with particular emphasis on their dependence on the momentum and identity of the incident beam. We are therefore requesting a series of exposures at various momenta using π^- and p beams. Lacking definite knowledge of which beams will be available at bubble chamber turn-on time, we present two possible alternatives for the exposure:

A. If 200 and 400 GeV/c protons can be targeted we would suggest 5 exposures, namely π^- at ∿50, ∿150, and ∿300 GeV/c, and protons at ∿150 and ∿300 GeV/c.

B. If only 200 GeV/c protons were available we would suggest 3 exposures, namely π^- at ∿50 and ∿150 GeV/c, and protons at ∿150 GeV/c.

The total number of pictures requested in either case is 200,000.

The size of the 30-inch chamber clearly limits what can be studied in high-energy interactions. It is also clear that certain aspects of high-energy interactions, on which current theoretical interest is strongly focussed, are accessible. These include:

a) A detailed study of distributions involving particles emitted backwards in the center-of-mass. The bubble chamber is perhaps a uniquely convenient instrument to study in addition correlations among these slow particles, whether they result from the formation of nucleon and meson resonances or from less obvious features of the production mechanism. Some current theoretical speculations predict that at high energy these various distributions should become independent of energy and incident particle identity.[1]

b) Some properties of fast forward secondaries. We clearly cannot measure the energies of fast forward particles, but some simple aspects, such

as charged multiplicities, can be studied.

The proposed experiment will provide direct answers to some interesting questions regarding high energy collisions in a short time. It will also be of considerable value in the design of more elaborate equipment required for more detailed study of multiparticle final states. Finally, we note that as available accelerator energies have increased new and unexpected results have been found. This will certainly be true at NAL, and it is possible that a study such as this proposed experiment may reveal some of them.

II. SINGLE PARTICLE DISTRIBUTIONS

We intend to study inclusive distributions of momentum and direction, or equivalently longitudinal and transverse momentum, $\dfrac{d^2\sigma}{dp_{||}\,dp_{\perp}^2}$, for low momentum secondaries. We will uniquely identify protons whose momentum is below 1.3 GeV/c by the bubble density along their tracks. Similarly, we will distinguish pions from kaons when their momenta lie below 0.8 GeV/c. Thus we can study the distributions of pions, kaons, and protons separately at low momenta. Since particle momenta can be measured accurately at somewhat higher values (at 10 GeV/c the error is only ∿10%) we can study distributions of positive and negative particles in this region.

Some questions of current theoretical interest which can be answered by such data include that of whether limiting distributions are already attained at these incident momenta, and if so whether they are the same for incident pions and protons. We hope to determine whether the distributions are factorizable in terms of longitudinal and transverse momentum, and to what value of secondary momentum these limiting distributions persist.

III. DISTRIBUTIONS FOR GROUPS OF LOW MOMENTUM PARTICLES

The bubble chamber is an ideal instrument for studying groups of particles because of its 4π solid angle and its ability to identify low momentum particles. From the measured momentum and the identification of slow secondaries we can calculate the invariant masses of systems of two or more slow particles. If resonances such as the ρ°, Δ^{++}, N(1470), etc., are produced in significant quantity we can study their distributions as if they were single particles. It would be of great interest, for example, to compare the distribution for N(1470), seen in the $p\pi^+\pi^-$ system, to that for the proton.

In addition, we can study the cross-sections for producing such systems, and at each energy compare them to the total cross-section. Finally, if a significant number of events appear to contain slow particles which are not the decay products of diffractively produced systems, we can profitably study 2-particle distributions. Questions here would include those of whether the distributions were factorizable, or whether the distributions were independent of the angle between the transverse momenta of particles.

Finally, since the net charge of the high momentum secondaries can be inferred from the measurable charges of low momentum particles, we can attempt to correlate any interesting features with the total charge of the high momentum recoils.

IV. MULTIPLICITIES

We believe that meaningful multiplicity information is accessible in the 30-inch chamber. For 30 cm. of outgoing path length we should be able to resolve individual tracks whose azimuthal angles differ by as little as 3 mrad. This corresponds to a downstream separation of 900 μ, or about 3 bubble diameters.

In cases where fast tracks are unresolved they may be counted by a measurement of bubble density. Since events with high multiplicity might be expected to have secondary tracks with a wide spread in momenta there will likely be few cases in which the above technique will fail.

These measurements will provide σ_N, the cross-section for N charged particles. Recent bubble chamber and cosmic ray data [2] appear to support the conjecture that σ_N is essentially a Poisson distribution in pairs of charged particles. Some theoretical models arrive at the same conclusion. An alternative model suggests that at high energies σ_N will display a dip, the lower peak arising from diffraction dissociation reactions and the upper from multiperipheral processes.

IV. BEAM REQUIREMENTS

Since no kinematic fitting will be performed, it is not necessary that $\Delta p/p$ be particularly small. A value of $\pm$ 5%, for example, would be acceptable. In order to facilitate rejection of non-beam tracks the divergence of the beam should be smaller than $\sim \pm$ 0.8 mrad. in both horizontal and vertical planes. We request $\sim$ 10 beam tracks per picture, spread over $\sim \pm$ 3" in the vertical direction.

V. EXPERIMENTAL DETAILS

a) Size of Exposures (based on Case A, five subsamples)

The number of pictures requested reflects a desire for a reasonable number of events ($\sim$ 4000) with slow (p $\lesssim$ 1.3 GeV/c) protons in each of the five subsamples. From the 25 GeV/c $\pi^- p$ data of Erwin, et al. [3] we estimate

the cross section for producing these identifiable protons is 8-10 mb

in π^-p interactions. We further estimate a cross section of 10-12 mb

for producing such protons in pp interactions.

The fiducial volume in which interactions will be measured will be 30 cm

in length, and with 10 beam tracks/picture the desired number of events

will be obtained with $\sim$ 43,000 frames at each pion momentum and $\sim$ 35,000

frames at each proton momentum. The total exposure amounts to 200,000

frames.

The choice of 30 cm of fiducial length allows for at least 30 cm of

outgoing secondary track length. Assuming 60μ setting error for the

measurements and a magnetic field of 28 kgauss, a measuring error of

$\delta p/p \sim 1\%$ results for a 1 GeV/c secondary. (For a 1 GeV/c proton $(\Delta p/p)$

due to multiple scattering $\sim 1.4\%$.) In addition, at least 10 cm of

incident beam track permits an accuracy of $\pm$ 0.8 mr in the measurement

of its angle.

The total measuring load is estimated assuming total cross sections of

40 mb for pp and 25 mb for πp. We expect 30,000 pp events and 33,000 πp

events. The handling of these 63,000 events will be discussed in the

following section.

b) Processing of Data

The $\sim$ 63,000 events to be handled in the experiment can be measured in about

800 hours on DOLLY assuming a rate of 80 events/hour. Using one shift per

day, four months will suffice to measure all the events. This rate assumes

prescanning of the film, which can be performed at least as fast as the

measuring but with a short lead time.

Studies are being performed now to determine whether it is practical
to scan on-line either automatically by DOLLY, or by the DOLLY operator.
In any case, the measuring and scanning load will be light.
Optical constants for the reconstruction program will be determined
during the measuring. Our group has analyzed over 10^6 frames from this
bubble chamber, and we expect no difficulty here. We may realistically
anticipate no more than two months to begin the processing of the measure-
ments. In short, physics distributions will most likely be available
within six months of taking the film.

c) Analysis of Reconstructed Tracks

Since the intent of the experiment is to study all low momentum particles,
each event will be entirely measured. Tracks which have momentum errors
of less than $\sim$ 10% may be useful for subsequent analysis.

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