NAL PROPOSAL NO. 185

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# PROPOSAL TO STUDY pn INTERACTIONS AT 205 GeV/c BY MEANS OF THE 30" DEUTERIUM FILLED BUBBLE CHAMBER

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October 13, 1972

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# PROPOSAL TO STUDY pn INTERACTIONS AT 205 GeV/c BY MEANS OF THE 30" DEUTERIUM FILLED BUBBLE CHAMBER

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A b s t r a c t -

We propose to carry out a pd experiment at 205 GeV/c using the 30" deuterium filled bubble chamber. We show that a representative sample of events allowing the study of pn interactions can be obtained. A comparison between pp and pn interactions at 205 GeV/c will then be made and may be helpfull to study the various dissociation models. We plane to measure the various topological cross sections and to study the single particle distribution for the $\pi^-$ and the p emitted backward in the c.m. system. Results on inclusive $pn \rightarrow \pi^- X$, $m\pi^- X$, $\pi^- pX$, $m\pi^- pX$ reactions ($m \geq 2$) and on two particle correlation will also be obtained. Elastic $pd \rightarrow pd$ scattering will be studied and in certain cases we may be able to extract some information on other coherent pd channels.

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## 1.- INTRODUCTION

Recently data have been reported on pp interactions at 205 and 303 GeV/c incident momenta[1,2]. We are interested in complementing these investigation by studying the pn interactions. Although some pd experiments have already been submitted to N A L it seems that the groups involved have decided to focus first their interest on pp interactions[3]. We propose to carry out a pd experiment at 205 GeV/c allowing us to study the pn interactions and to compare the results with those obtained from the pp data at 205 GeV/c.

We would like to obtain 50,000 photographs (we prefer the 35 mm format) using the 30" deuterium filled bubble chamber. By requiring that the proton spectator has to be visible in the chamber, the statistics of the proposed experiment will be of the same size as the data given in reference (2). We will thus be able to measure partial cross sections with an acceptable statistical accuracy[2]. In fact, as shown below, the situation is slightly better because we can also use the events having an odd number of prongs(i.e. those where the track lengths of the proton spectator are too short to be detected) for studying the pn interactions.

The way of selecting the events and the main physics interests of the proposed experiment will be discussed in the next sections.

## 2.- SELECTION OF pn EVENTS

In order to study the pn interactions we have to identify an outgoing track of low momentum as being a proton spectator. Since the kinematical fit to the production, as made in the usual bubble chamber analysis, cannot be carried out at this high energy, the identification of a proton spectator may present some difficulty. We distinguish essentially two cases :

(1) The positive track has a length too small to be detected in the chamber (events with odd number of prongs)

(2) The track has a length which can be measured, giving then a measurement of the momentum through a range-energy relation if a mass assignement can be made (events with even number of prongs)

In what follows we do not consider the one or two prong events which are difficult to handle although information about elastic pd → pd scattering can be obtained from the two prong events as will be discussed in Section 3 f.

(1) The sample obtained in the first case contains mainly events with unseen proton spectator and a small contribution from coherent pd events. An estimate of the percentage of coherent events can be made by a Monte Carlo calculation using the steep t dependence of the coherent production mechanism, t being the four momentum transfer between the incident and outgoing deuteron. Indeed the sample of coherent events having nonvisible outgoing deuteron tracks in the chamber corresponds to events for which $|t| < 0.025 (GeV/c)^2$. This t cut is reflected in the $t' = |t - t_{min}|$ distribution where $|t_{min}|$ is the smallest possible t value obtained with the effective mass value of the system recoiling against the deuteron. Low energy data[(4)] indicate that the t' distribution is of an exponential form even for low t', which is the region affected by the t cut. Therefore the knowledge of the slope (b) of the t' distribution, and of the partial coherent pd cross sections will allow us to estimate the number of coherent events with non visible outgoing deuteron and hence those which will be classified in the odd prong events. In fact a Monte Carlo calculation shows that to a good approximation this number is practically independent of the inelastic coherent pd channel.

There exist of course no value for the pd → pdmπ cross section at 205 GeV/c. However based on low energy data we consider that 20 % of the total pp cross section is an upper limit for the total inelastic cross section for coherent processes. Using then the measured value of $\sigma_{pp}$ at 205 GeV/c and assuming $b \sim 18 (GeV/c)^2$, we obtain that less than 3 % of the odd prong events will be due to inelastic coherent channels.

(2) Among the even prong events we can increase the ratio of pn to pd coherent events by only taking events for which the cosine of the laboratory emission angle of the stopping track is less than 0.7. Using the same estimate as above a Monte Carlo calculation shows that we then obtain a sample containing about 85 % pn events.

Although the estimations made above are rather crude they seems to indicate that we will be able to collect a representative sample of pn events.

## 3.- PHYSICS OBTAINED FROM THE STUDY OF pn INTERACTIONS

### a). Topological cross sections

The proposed experiment will allow us to measure $\sigma_n$, the topological cross section for n charged particles in the final state. These results in addition to those obtained from the pp experiment at 205 GeV/c will give a better estimate of the variation of $\sigma_n$ as a function of n. In particular, one could see wether or not $\sigma_n \sim 1/n^2$ for large n, as predicted by the various fragmentation models(5). Also the measurement of the second moment $f_2 = \langle n(n-1) \rangle - \langle n \rangle^2$ for an odd number of charged particles will be of interest because of its sensitivity to the production mechanism(6).

### b). Single particle distributions

By using the Mura bubble chamber and our measuring devices we expect to be able to measure tracks having momenta up to 15 GeV/c(7). Due to the limited transverse momenta of the secondaries ($p_T^2 \lessgtr 0.2(\mathrm{GeV/c})^2$) we see from Fig.1 that even with this 15 GeV/c cut we will obtain an unbiased sample of $\pi$ emitted in the backward c.m. hemisphere ($q_\ell^* < 0$). As the negatively produced particles are mainly pions, we will be able to study the single $\pi^-$ distributions for $\pi^-$ emitted in the backward hemisphere. From Fig. 1 one also sees that we can measure $d^2\sigma/(dq_\ell^* dp_T^2)$ around $q_\ell^* \sim 0$ which is a rather useful quantity. Indeed, if scaling is valid this $[d^2\sigma/(dq_\ell^* dp_T^2)]_{q_\ell^* = 0}$ should be independent of $\sqrt{S}$, the c.m. energy. In addition a study of the shape of the $d^2\sigma(dq_\ell^* dp_T^2)$ can be made as function of the multiplicity.

In Fig.1 we also indicate which part of the $x = 2q_\ell^*/\sqrt{S}$, $P_T$ scatter plot is accessible to protons having momenta smaller than 15 GeV/c. In fact the situation is better than shown by this graph because of the expected peripherality of the pn reaction at 200 GeV/c. Then the outgoing baryon associated with the target neutron vertex has a small laboratory momentum and can then be identified if it is a proton. This can be seen more precisely by using a Monte Carlo method to generate $pd \to p_s p N m \pi$ $(m > 2)$ events according to a $e^{bt_1} \times e^{bt_2}$ momentum transfer dependence. Here $t_1$ ($t_2$) is the four momentum transfer between the initial p (n) and the outgoing p (N). We took the value of $b = 5(\mathrm{GeV/c})^{-2}$ which is assumed to give a realistic description of the peripherality. (At 7 GeV/c(8) one obtains a slope of $6.1 \pm 1.0(\mathrm{GeV/c})^{-2}$ from the $pn \to pp\pi^-$ reaction).

The laboratory momentum distributions obtained from this Monte Carlo generation for different values of m show that if N is a proton it essentially always has a laboratory momentum less than 1.2 GeV/c and may thus be measured and identified. We will then be able to study the single particle distribution associated to the proton emitted in the backward c.m. frame.

c). Diffraction dissociation

Several attempts have been made to describe high energy production by means of single and double diffraction dissociation of the incoming particles[(6,9)]. The ratio of the cross section of double to single diffraction dissociation (D/S) is a parameter of the model which may be determined from the experimental data[(6)]. In particular the n/p production rate, which depends directly on this D/S ratio, can be measured here for the diffraction dissociation of the incoming n. As stated above the emitted baryon has then a small momentum and a proton can only be recognized among the low momentum tracks. The number of neutron events are simply those in which a low momentum proton was not identified.

The results of the proposed experiment and those obtained from the pp data will permit a direct comparison of the n and p diffraction dissociation.

d). Inclusive reactions

As discussed in b). we will be able to measure the $\pi^-$ and the proton emitted backward in the c.m. system. In this region of phase space we study the following inclusive processes :

$$pn \rightarrow \pi^- X$$
$$pn \rightarrow k\pi^- X \qquad (k = 2\,;3\,,\ldots)$$
$$pn \rightarrow \pi^- pX$$
$$pn \rightarrow k\pi^- pX$$

where X means anything while k represent the number of recorded $\pi^-$.

e). Correlations

The study of the two particle correlation in the rapidity space can be carried out if one uses the $y' = \ln \mathrm{tg}(\theta_{lab}/2)$ variable which for fast particle reduce to the usual rapidity variable $y = 0.5 \ln[(E + q_\ell)/(E - q_\ell)]$. ($E$ and $q_\ell$ are respectively the energy and the longitudinal momentum of the particle which is considered while $\theta_{lab}$ is its emission angle). As the negatively charged particles are assumed to be mainly pions we will be able to collect some $2\pi^-$ correlation information by measuring only the $\theta_{lab}$ values. However for $\pi^-$ emitted in the backward c.m. hemisphere, for which the momentum can be determined, additional information can be obtained by using other kinematical variables. In the same manner it will also be possible to study the $p\pi^-$ correlation for the p being emitted in the backward c.m. hemisphere.

f). Coherent events

Based on the momentum measurement of the recoil particle it was possible as shown in reference (1) to collect a sample of elastic $pp \to pp$ events. By a similar method we will study the elastic $pd \to pd$ scattering for which there is no information at all in the 205 GeV/c region.

A crude estimate of the coherent cross section can be obtained by comparing the number of events having their stopping track greater and smaller than $\cos\theta = 0.7$ (See 1.2).

## 4.- SCHEDULE OF THE ANALYSIS

If the proposed experiment would be carried out all the effort of both groups would be devoted to this experiment. The collaboration will be able to utilize 6 scanning tables and 5 conventional measuring machines. This is sufficiant to analyse the films in a very short time. Thus we plane to obtain the topological cross section about six weeks after we get the film. On the other hand the events needed for studying the physics described above will be measured within two months.

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$P_T$ VERSUS $x = 2q_L^*/\sqrt{s}$ FOR FIXED LABORATORY MOMENTUM

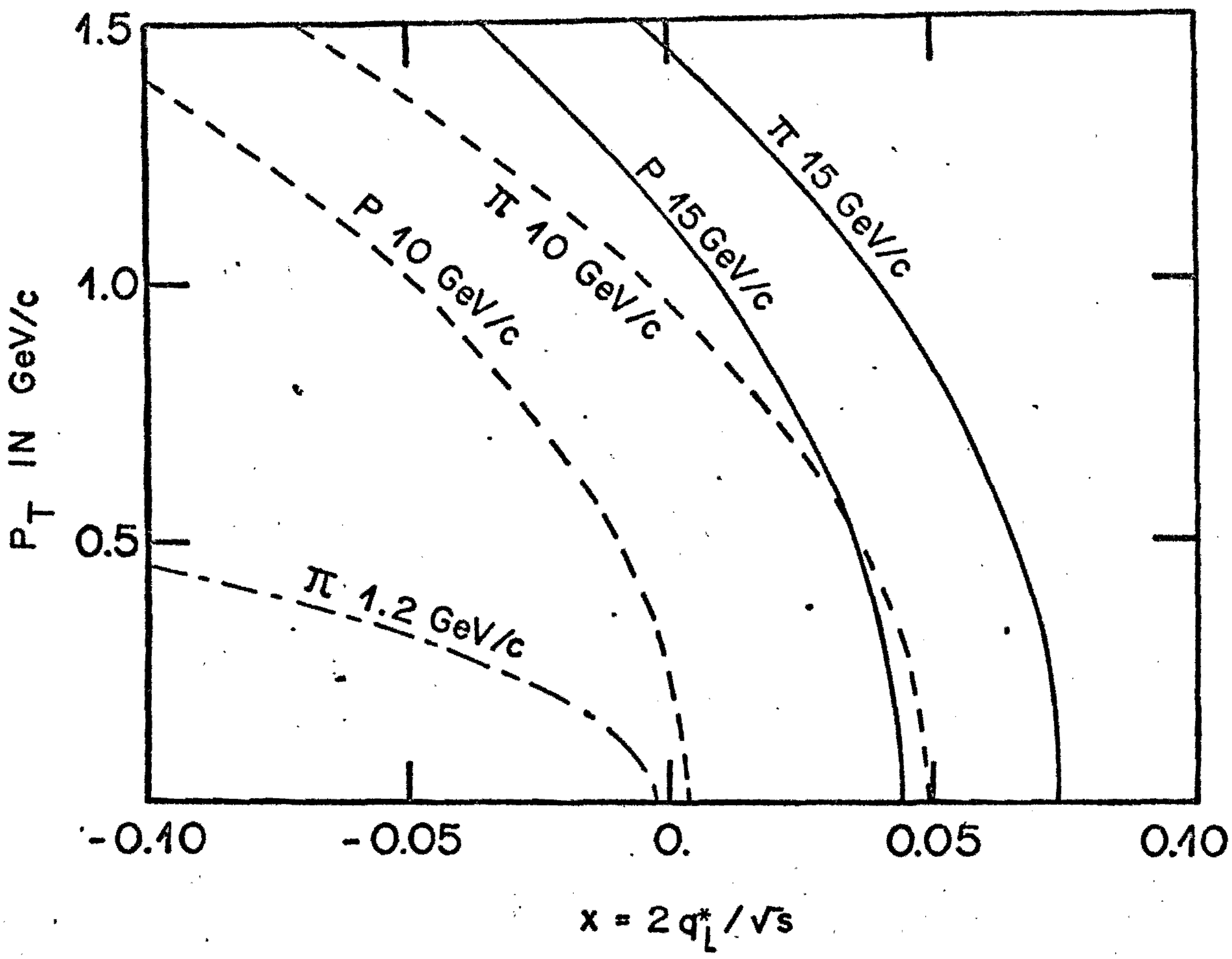


Figure 1