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PROPOSAL TO STUDY 50,000 $\Sigma^- n$ MULTIPRONG EVENTS AT ~240 GeV/c BY MEANS OF THE 15' BUBBLE CHAMBER

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1. INTRODUCTION

In contrast to the large amount of data accumulated in non strange baryon - baryon interactions, there is only a limited amount of information available on ΣN interactions. As a $\Sigma^- p$ experiment at 240 GeV/c has already been approved with the 15', we propose to complete this experiment by studying the $\Sigma^- n$ interactions at the same incident momentum. This will allow us to make a comparison between $\Sigma^- n$ and $\Sigma^- p$ reactions and to detect thus the isospin influence on the ΣN interactions. Furthermore, as previous bubble chamber experiments at F N A L have shown that four constraint reactions can be studied, the use of a neutron target will give us access to four constraint final states which cannot be obtained from the $\Sigma^- p$ experiment. The utilization of a deuteron target will of course complicate somewhat the data analysis. Nevertheless this is a convenient method to study the pure $I = 3/2$ ΣN isospin state as $\Sigma^+ p$ experiments are more difficult to carry out than $\Sigma^- n$. In a first step we would like to have a statistics corresponding to 50,000 multiprong events, i.e., events having more than two prongs.

The 15' bubble chamber is particularly well adapted for the proposed experiment. Indeed its large size will increase the probability to observe the decays of strange particles which will be produced abundantly because of the $S = -1$ strangeness value of the initial state. Apart of this mean feature other advantages are connected with the use of the 15' i.e. :

- The possibility of measuring momenta with a good accuracy
- The high probability of observing secondary interactions facilitating thus the identification of the outgoing particles
- The high γ - ray conversion rate allowing to obtain information on π^o and Σ^o production

In the following we will discuss the most important physics aspects which can be studied with the proposed experiment. As will be seen below the present experiment will allow us to bring a significant contribution to the field of the ΣN physics.

2. PHYSICS INTERESTS

a). Topological cross sections and multiplicities

The proposed experiment will offer us the possibility to measure topological cross sections and also the statistical momenta of the charged multiplicities. Comparisons between ΣN and pp or $\bar{p}p$ data will allow to evaluate the importance of the s-channel quantum numbers on the quantities mentioned above. In particular it will also be of interest to see whether or not the $\Sigma^- p$ and $\Sigma^- n$ interactions are distributed on a same curve whenever they are plotted in the KNO form. The comparison between charged multiplicities of the $\Sigma^- n$ and $\Sigma^- p$ interactions is expected to lead to a better understanding of the isospin influence on the production of charged particles.

b). Correlation

The two particle correlation features are often used in high energy reactions for analysing the production process. Such a study will also be made here for inclusive, semi-inclusive and exclusive reactions. A comparison with other hadron-hadron reactions will be carried out.

c). Correlation between the production of neutral and charged particles

Recently the production of the average number of neutral pions as a function of the charged multiplicity has been studied[(1)] giving information about the multiparticle production mechanism[(2)]. Profiting from the relatively high γ-ray conversion ($\sim 20\%$) in the 15' bubble chamber, we will study the above mentioned correlation. We plan also to make similar studies when the neutral particle will be this time n, $\bar{n}$, Λ, $\bar{\Lambda}$, K^o and $\bar{K}^o$. We will here benefit from the large size of the chamber. Indeed some outgoing n, $\bar{n}$ will be identified through their secondary interactions whereas the strange particles will be recognized whenever they decay in the bubble chamber.

The $\bar{p}p$ data examined until now indicate that the average number of π^o [$\langle n_o \rangle$] is related to the charged multiplicity n through a linear rule : $\langle n_o \rangle = \alpha n + \beta$[(1)] (at least for moderate n). Here α and β are parameters depending on the available c.m. energy. One possible explanation of this linear relation has been proposed considering the production as an interplay of two different

mechanisms[3]. One of them leads to pion production concentrated around an average depending on the available c.m. energy while the other results from the constraints introduced by isospin conservation. In this approach differences between $\Sigma^- p$ and $\Sigma^- n$ data should be observed. In any case we will study quantitatively the influence of isospin effects on the mentioned correlation.
The same analysis will also be made with other neutral particles as n, $\bar{n}$, Λ, $\bar{\Lambda}$, K^o and $\bar{K}^o$.

d). Inclusive reactions

Because of the size of the bubble chamber an important fraction of the produced strange particles will decay in the chamber. This will allow us to study in particular the inclusive reactions :

$$\Sigma^- n \rightarrow \Sigma^{\pm} X$$
$$\rightarrow \Lambda X$$

(where X means anything). The comparison of the inclusive reactions obtained from the $\Sigma^- N$ with the pp data will be carried out. This will permit among other things to check the factorization properties of the inclusive reactions (i.e., by comparing for instance $pp \rightarrow pX$ with $\Sigma N \rightarrow pX$ or $\Sigma p \rightarrow \Sigma X$).

e). Diffraction dissociation

We also intend to study the diffraction dissociation of the incoming Σ^- and n particles which appears to play an important role in high energy production processes. Similarly to the dissociation of the $p \rightarrow N^*$ seen in pp interactions, it is expected that the $\Sigma^- \rightarrow Y_1^*$ will be produced abundantly. This will offer us the possibility of studying the production of resonances having the same isospin as the incoming Σ^- and to search for the SU(3) partner of the $N^*(1470)$. In fact, it has been predicted ky Lipkin in a recent work[4] that there should be Y_1^* resonances not discovered as yet, which are primarly produced in the diffraction dissociation processes. As the incoming $\Sigma^- N$ system is exotic (in the sense that the baryonic number B = 2) the contribution of the leading exchange degenerate Regge trajectories are expected to cancel and the interactions will be dominate by Pomeron exchange. Then if the Pomeron is a pure SU(3) singlet the transition octet → decuplet will not be allowed by diffractive dissociation. Thus the study of $\Sigma^- N$ interaction may bring some additional information about the SU(3) nature of the Pomeron. Finally let us also point out that the proposed experiment will also allow us to see if helicity is conserved in the s or t channel. Furthermore as Λ will be present in some of the final states, polarization measurements of the Λ will lead to further information about diffraction dissociation mechanisms.

We intend also to study the diffraction dissociation of the neutron target. The high probability of an outgoing neutron to make a secondary interaction will also permit to study dissociated systems containing an outgoing neutron.

f). Exclusive reactions

The results obtained from hybrid experiments carried out with the 30 inch bubble chamber have shown that one can handle the four constraint events. Here where the precision of the momentum measurement will be comparable to that of the hybrid system we will also be able to study the four constraints events or those having a strange particle decaying in the chamber. Some of these reactions are listed below ($m \geq 0$).

$$\begin{aligned}
\Sigma^- n &\to \Sigma^- p \pi^- m\pi^+ m\pi^- \\
&\to \Sigma^+ p 3\pi^- m\pi^+ m\pi^- \\
&\to \Sigma^- \Lambda K^o m\pi^+ m\pi^- \\
&\to \Lambda p \, 2\pi^- m\pi^+ m\pi^- \\
&\to ppK^- 2\pi^- m\pi^+ m\pi^- \\
&\to \Xi^- n K^o m\pi^+ m\pi^-
\end{aligned}$$

Any information on these channels will be of interest in itself because of the scarcity of existing data. Among other things a study of Y^* and Ξ^* production will be carried out. The Y^* resonances are expected to be abundant in the final state since in $\Sigma^- N$ interactions Y^* can be produced without strangeness exchange. We also expect an important Ξ production rate. In addition a search for Λp resonances, for which some evidence for their existence han been reported[(5)], will be made (such resonances may for instance populate the $\overline{10}$ SU(3) multiplet).

Although exotic resonances are predicted to be primarily coupled to the $\overline{N}N$ system[(6)] the proposed experiment is particularly suitable for searching exotic $\Sigma^-\pi^-$ resonant systems[7]. For this one can for example use the simplest channel $\Sigma^- n \to \Sigma^- p\pi^-$ in which an outgoing $\Sigma^-\pi^-$ system appears. Furthermore a search for exotic t-channel exchange is particularly suitable in reactions having Σ^+ in the final state.

As an additional physics interest we can also mention that the reaction $\Sigma^- n \to \Sigma^- p\pi^-$ will permit obtaining information about $\pi\Sigma \to \pi\Sigma$ scattering if π exchange contributes to the $\Sigma^- p\pi^-$ production. Finally we also expect to study some of the production features of the one constraint events.

g). Coherent production

A fraction of $\Sigma^- d$ interactions will lead to reactions coherently produced on deuterium. The study of coherent production phenomena, will allow us to analyse the systems emitted in a pure isospin $I = 1$ state : i.e., those recoiling against the deuteron. An estimation of the cross sections can be made assuming that coherent production phenomena are nearly independent of the type of the incident particle and incident momentum. This in any case appears to be verified by the $pd \to pd\pi^+\pi^-$ and $\bar{p}d \to \bar{p}d\pi^+\pi^-$ reactions in the 5.5 – 15 GeV/c incident momentum region[8]. Using then the $\bar{p}d \to \bar{p}d\pi^+\pi^-$ cross section at 15 GeV/c, we will have available about 600 $\Sigma^- d \to \Sigma^- d\pi^+\pi^-$ events (see below).

h). Strange particle production

One of the most striking results obtained from the experiments with the 30" bubble chamber is the rapid raising of the strange particle production in hadron - hadron interactions[9]. If one assumes that strange particles are also copiously produced in ΣN interaction we would be able to study reactions having three strange particle in the final state. This will facilitate the search of resonances decaying into strange particles.

i). Multiparticle production phenomena

At high energy the multiparticle production contribute to an important part of the inelastic cross section. Except for the multiplicity distribution already discussed above we will also study these production phenomena using, among other things, multivariable techniques as proposed some years ago[10]. In the same manner as made for lower $\bar{p}p$ incident momenta[11] we will search for multivariable distribution sensitive to the production mechanism. To do this we need to know at least the momenta of the charged tracks. The 15' chamber will allow us to proceed with such an analysis using in particular the four constraint events.

j). Miscellaneous

As a by product of the proposed experiment, we will also measure the $\Sigma^- d$ elastic scattering. Information about the $\Sigma^- n$ scattering will be obtained by analysing the $\Sigma^- d \to \Sigma^- d$ and $\Sigma^- d \to \Sigma^- pn$ reactions[12]. Information on total $\Sigma^- n$ and $\Sigma^- d$ cross will also be obtained[13].

3. NUMBER OF EVENTS AND SHEDULE OF THE ANALYSIS

The total cross section [σ_t] for $\Sigma^- N$ interactions can be estimated from the relations

$$\sigma_t(pn) - \sigma_t(\Sigma^- p) = \sigma_t(\pi^+ p) - \sigma_t(K^- n)$$

$$\sigma_t(pn) - \sigma_t(\Sigma^- n) = \sigma_t(\pi^- p) - \sigma_t(K^- p)$$

deduced from the quark model[14]. Using the total cross sections at 240 GeV/c given in reference (15) one obtains that $\sigma_t(\Sigma^- p) \simeq \sigma_t(\Sigma^- n) = 36$ mb. If one assumes that the fraction of two pronged events in $\Sigma^- p$ interactions is equal to that obtained in pp interactions at ~ 200 GeV/c one obtains a cross section of about 27 mb for $\Sigma^- p$ reactions having more than two outgoing charged particles. Taking also this value for the $\Sigma^- n$ multiprong cross section we can estimate the number of photographs needed to have 50,000 $\Sigma^- n$ multiprong events. Using a fiducial region of 2.8 m and assuming that one can have 5 Σ^-/ burst we will need about 57,000 photographs. This value is obtained by taking also into account the path length attenuation due to the decay of the incident Σ^- in the chamber. Although 1/3 of the 50,000 events will have a visible spectator proton stopping in the chamber we intend also to use the events with invisible spectator for studying - the general features of the $\Sigma^- n$ interactions.

The participating groups intend to make a great effort (if this proposal would be approved) in order to analyse rapidly the data. About 20 (half time) scanners will work on this experiment. Programmers from both groups will work on the 15' foot software and may spend some months at F N A L . The Hydra system being already used by one of the groups the adaptation of the 15' software could be rapidly carried out. In addition a few physicists intend to come for a few months to operate the beam.

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