PROPOSAL TO STUDY dd INTERACTIONS AT 14 GeV/c
BY MEANS OF 400,000 PICTURES IN THE 2m DBC

H. BRAUN, D. BRICK, F. ETIENNE, A. FRIDMAN, J-P. GERBER,

E. JEGHAM, P. JUILLOT, G. MAURER, A. MICHALON,

M-E. MICHALON-MENTZER, C. VOLTOLINI

Centre de Recherches Nucléaires de Strasbourg

* * *

S u m m a r y.-

We are proposing to study dd collisions at 14 GeV/c. We intend to investigate the reactions

$$dd \rightarrow ddm\pi$$

$$dd \rightarrow N_s Ndm\pi$$

$$dd \rightarrow N_s N_s NNm\pi$$

which will allow us to study subsystems produced in pure isospin states.

1. INTRODUCTION

We are interested to study dd collisions at 14 GeV/c. The main physics
points which we want to study are exposed below. They are divided in the follow-
ing sections :

- Interactions with two deuterons in the final state.
- Interactions with one deuteron in the final state.
- Multiplicity distributions and statistical moments.
- NN interactions.

2. INTERACTIONS WITH TWO DEUTERONS IN THE FINAL STATE

The $dd \rightarrow ddm\pi$ reactions will allow us to investigate the $I = 0$ $m\pi$ system.
In the case of the $dd \rightarrow dd\pi^+\pi^-$ channel we can thus obtain information on the $I = 0$
$\pi\pi$ interactions (the cross section for the $dd\pi^+\pi^-$ final state is estimate to be
~ 30 μb, corresponding hence to 500 events ; see Table I). In general by using
the $dd \rightarrow ddm\pi$ reaction one can also investigate any $(m - 1)$ system which, because
of isospin conservation, is constrained to have the isospin $I = 1$. In Table II
we indicate the range of the effective masses accessible for various subsystems
produced in this reaction . These ranges were calculated by using a double peri-
pheral phase space.

We also intend to study the d^* (or double d^*) production and the
$d \rightarrow dm\pi$ diffraction dissociation process. Apart of the $dd \rightarrow dd\pi^+\pi^-$ case at 3 and
7.9 GeV/c[1,2] nothing is known on the value of the $dd \rightarrow ddm\pi$ cross section.
Therefore the measurement of these cross sections alone can already be considered
as an interesting task.

3. INTERACTIONS WITH ONE DEUTERON IN THE FINAL STATE

The present experiment is particularly suitable for studying events
with one deuteron in the final state as we are obtaining in the same time nd
and pd reactions. In these cases, one nucleon among the four incoming ones is
a spectator. We will thus be able to investigate the reactions

$$nd \rightarrow (p_s)pdm\pi^+(m + 1)\pi^- \qquad (1) \qquad m \geq 1$$

$$pd \rightarrow (n_s)pdm\pi^+m\pi^- \qquad (2)$$

the former belonging to the class of four constraint reactions.

The reactions (1) have also the interesting properties that the $(m + 1)\pi^-(m - 1)\pi^+p$ subsystem is in the pure $I = 3/2$ isospin state. Thus a study of the $I = 3/2$ baryonic resonances can also be carried out.

With respect to the usual pd interactions the dd collisions enhance the number of events in some of the reactions in which a deuteron appears in the final state. Indeed because of the charge symmetry invariance the $nd \rightarrow (p_s)ndm\pi$ events can be added to the $pd \rightarrow (n_s)$ pdmπ $(m \geq 1)$ events. Then if α is the probability that one of the incident bound nucleon strikes the other incoming deuteron so that it remains unbroken after the collision, the probability to observe an outgoing d in dd collisions for the reactions just mentioned is $2\alpha(1 - \alpha)$. As α is small one obtains nearly twice as much d in dd collisions than with pd collisions. Therefore in addition to the possibility to study the $Nd \rightarrow Nd\, m\, \pi$ reactions the present experiment is particularly well adapted for investigating the inclusive $dd \rightarrow dX$ process.

4. MULTIPLICITY DISTRIBUTIONS AND STATISTICAL MOMENTS

Recently a great deal of stimulating works have been made on multiplicity distributions. In particular multiplicity distributions have been studied on complex nucleus[3]. We intend here to study the multiplicity distributions as well as the statistical moments obtained in dd collisions. A comparison will be made with pd and NN interactions at the same c.m. energy.

5. STUDY OF NN INTERACTIONS

The present experiment will also allow us to study the NN collisions although the presence of two spectator nucleons will complicate the data analysis. Nevertheless the reaction $nn \rightarrow ppm\pi$ presents a great interest as the outgoing $m\, \pi$ system is in a pure isospin $I = 2$ state. It will then be possible to make a systematic search for $I = 2$ boson resonances for which some evidence have been reported some years ago.

The reactions without deuteron in the final state will also allow us to make a detailed study of the validity domain of the impulse approximation scheme. In hadron – deuteron collisions one generally consider that the outgoing

nucleon having the smallest momentum is a spectator one when its momentum is smaller than 0.3 GeV/c. The experimental distributions of this so-called spectator nucleon generally do not really follow the predictions as given by the usual deuteron wave functions. The observed discrepances are usually explained by flux factor corrections or by the influence of the cross section variation in the c.m. energy spread resulting from the Fermi motion of the bound nucleons[4]. For hadron-deuteron interaction it is in any case difficult to make a quantitative study to what extent the impulse approximation can be applied to all the data. The use of dd interactions will allow us to make easily such an investigation. To this end we will study the two particle correlation in the transverse plane (the plane perpendicular to the incoming deuteron laboratory momentum) which has to vanish for two real spectator nucleon. In particular we will investigate the validity domain of the impulse approximation as function of the number of outgoing particles. This may bring some new insight on the double scattering processes in the deuteron which at high energy[8] ($\pi^- d$ at 200 GeV/c). appear to be independent on the charged multiplicity.

6. MISCELLANOUS

As a by product of the proposed experiment we will also measure the total and elastic dd cross section. The differential dd→dd cross section will be analysed in the framework of the Glauber formalism.

6. CONCLUSIONS

As discussed above the proposed experiment will allow us to study subsystems produced in definite isospin states. The states to which one has acces can be summarized as follows :

$$dd \rightarrow dX \qquad\qquad I(X) = 0$$

$$dd \rightarrow ddm\pi \qquad\qquad I[m\pi] = 0 \text{ and } I[(m-1)\pi] = 1$$

$$Nd \rightarrow Ndm\pi \qquad\qquad I[N\, m\pi] = 1/2$$

$$nd \rightarrow pdm\pi^+ (m+1)\pi^- \qquad\qquad I[(m-1)\pi^+ (m+1)\pi^- p] = 3/2$$

$$nn \rightarrow ppm\pi \qquad\qquad I(m\pi) = 2$$

In Table I we give estimates of cross sections and the corresponding number of events for some specific channels. The cross sections for reaction (1) was obtained by assuming that it is nearly incident momentum independent as suggested by dd data obtained at 3 and 7.9 GeV/c[1,2]. For reactions (2) through (4) we estimated the various cross sections using our p̄d experiment at 9 GeV/c[5] since the p̄d and pd coherent reactions appear to be nearly equal[6,7]. The values for (5) has to be considered only as a rough guess as we used factorization in a c.m. energy where its validity may be dubious.

R e f e r e n c e s

1). J. Debaisieux et al., Nucl. hpys., 70, 603 (1965)

2). A.T. Goshaw and J.M. Bazin, Phys. Rev. Letters, 25, 50 (1970)

3). W. Busza et al., Phys. Rev. Letters, 34, 836 (1975)

4). A. Fridman, Fortschritte der Physik, 23, 243 (1975).

5). Study of charged multiplicity distributions in $\bar{p}n$ interactions at 5.55, 9.3 and 14.6 GeV/c, A. Fridman et al., Strasbourg, Rutgers - Stevens, Case Western Collaboration, to be published in Phys. Rev. (1975)

6). D. Brick et al., Nuovo Cimento, 24A, 202 (1974)

7). A. Fridman, Proceeding of the Antiproton Symposium, p. 248 (1974) CERN Yellow report CERN 74-18

8). K. Dziumkowska et al., Krokow - Seattle - Warsaw - Davis Collaboration, VIL - PUB 25 preprint, October 1975

TABLE I - Rough estimates of cross sections and number of events for some specific channels. The number of events were calculated using 10 d per picture and 400,000 photographs

reaction		cross section (mb)	number of events
$dd \rightarrow dd\pi^+\pi^-$	(1)	0.03	~ 450
$dd \rightarrow N_s Ndm\pi$	(2)	$\gtrsim$ 2.0	$\gtrsim$ 60,000
$dd \rightarrow N_s Nd\pi^+\pi^-$	(3)	0.3	4,400
$dd \rightarrow p_s pd\pi^-$	(4)	0.9	~ 12,000
$dd \rightarrow p_s p_s pp\pi^-\pi^-$	(5)	~ 2.5	36,000

TABLE II – Approximative effective mass ranges (obtained with peripheral phase space) in which there are enough events to search for resonance production in dd → ddmπ reactions at 14 GeV/c

final state	effective mass combination	mass range (GeV/c^2)
dd2π	dπ	2 − 2.5
	dππ	2.4 − 3.0
	2π	0.30 − 0.72
dd4π	dπ	2 − 2.6
	dππ	2.3 − 3.0
	2π	0.18 − 0.60
	3π	0.52 − 0.92
	4π	0.72 − 1.24