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

**

Summary.

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

\[ dd \rightarrow ddmπ \]
\[ dd \rightarrow N_sNdmπ \]
\[ dd \rightarrow N_sN_sNNmπ \]

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 following 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 → ddmπ reactions will allow us to investigate the $I=0$ nn system. In the case of the dd → ddmπ+π− channel we can thus obtain information on the $I=0$ ππ interactions (the cross section for the ddmπ+π− final state is estimated to be $\sim 30 \mu$b, corresponding hence to 500 events; see Table I). In general by using the dd → ddmπ reaction one can also investigate any $(m-I)$ 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 peripheral phase space.

We also intend to study the $d^*$ (or double $d^*$) production and the d → ddmπ diffraction dissociation process. Apart of the dd → ddmπ+π− case at 3 and 7.9 GeV/c\(^{(1,2)}\) nothing is known on the value of the dd → ddmπ 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

\[
\begin{align*}
\text{nd} &\rightarrow (p_s)pdm\pi^+(m+1)\pi^- \quad (1) \\
\text{pd} &\rightarrow (n_s)pdm\pi^+m\pi^- \quad (2)
\end{align*}
\]
the former belonging to the class of four constraint reactions.

The reactions \((l)\) 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 \(nd + (p_s) ndm\pi\) events can be added to the \(pd + (n_s) pdm\pi (m \geq l)\) events. Then if \(\alpha\) 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 \(\alpha\) 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 \(Nd + Nd m\pi\) reactions the present experiment is particularly well adapted for investigating the inclusive \(dd + dX\) 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 \(nn + ppm\pi\) 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 discrepancies 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 nucleons. 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 (6) (π⁻d at 200 GeV/c) appear to be independent on the charged multiplicity.

6. MISCELLANEOUS

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 sub-systems produced in definite isospin states. The states to which one has access can be summarized as follows:

\[
\begin{align*}
\text{dd} & \rightarrow \text{d}X & I(X) &= 0 \\
\text{dd} & \rightarrow \text{dd} \pi & I(\pi \pi) &= 0 \text{ and } I((m-1)\pi^-) = 1 \\
\text{Nd} & \rightarrow \text{Nd} \pi & I(N \pi \pi) &= 1/2 \\
\text{nd} & \rightarrow \text{pd} \pi^+ (m+1)\pi^- & I((m-1)\pi^+ (m+1)\pi^- p) &= 3/2 \\
\text{nn} & \rightarrow \text{pp} \pi & I(m \pi) &= 2
\end{align*}
\]
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 \(\bar{p}d\) experiment at 9 GeV/c\(^{(5)}\) since the \(\bar{p}d\) 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.
References

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


   CERN Yellow report CERN 74-18

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.

<table>
<thead>
<tr>
<th>reaction</th>
<th>cross section (mb)</th>
<th>number of events</th>
</tr>
</thead>
<tbody>
<tr>
<td>$dd + dd\pi^+\pi^-$</td>
<td>0.03</td>
<td>$\sim 450$</td>
</tr>
<tr>
<td>$dd + \ N_sNd m\pi$</td>
<td>$\geq 2.0$</td>
<td>$\geq 60,000$</td>
</tr>
<tr>
<td>$dd + \ N_sNd \pi^+\pi^-$</td>
<td>0.3</td>
<td>4,400</td>
</tr>
<tr>
<td>$dd + \ p_spd\pi^-$</td>
<td>0.9</td>
<td>$\sim 12,000$</td>
</tr>
<tr>
<td>$dd + \ p_sp_p\pi\pi\pi$</td>
<td>$\sim 2.5$</td>
<td>36,000</td>
</tr>
</tbody>
</table>
TABLE II - Approximative effective mass ranges (obtained with peripheral phase space) in which there are enough events to search for resonance production in \( \text{dd} + \text{ddm\pi} \) reactions at 14 GeV/c

<table>
<thead>
<tr>
<th>final state</th>
<th>effective mass combination</th>
<th>mass range (GeV/c(^2))</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{dd2}\pi )</td>
<td>( \text{d}\pi )</td>
<td>2 - 2.5</td>
</tr>
<tr>
<td></td>
<td>( \text{d}\pi\pi )</td>
<td>2.4 - 3.0</td>
</tr>
<tr>
<td></td>
<td>( 2\pi )</td>
<td>0.30 - 0.72</td>
</tr>
<tr>
<td>( \text{dd4}\pi )</td>
<td>( \text{d}\pi )</td>
<td>2 - 2.6</td>
</tr>
<tr>
<td></td>
<td>( \text{d}\pi\pi )</td>
<td>2.3 - 3.0</td>
</tr>
<tr>
<td></td>
<td>( 2\pi )</td>
<td>0.18 - 0.60</td>
</tr>
<tr>
<td></td>
<td>( 3\pi )</td>
<td>0.52 - 0.92</td>
</tr>
<tr>
<td></td>
<td>( 4\pi )</td>
<td>0.72 - 1.24</td>
</tr>
</tbody>
</table>