\( \bar{p}p \rightarrow \Delta^{++}\Delta^{++} \) AT 5.7 GeV/c

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I would like to make two remarks about \( \bar{p}p \rightarrow \Delta^{++}\Delta^{++} \) at 5.7 GeV/c, concerning the channel cross-section and the forward structure in \( d\sigma/dt \) distribution. Some results on the analysis of 10,970 events of \( \bar{p}p \rightarrow \bar{p}p\pi^+\pi^- \) were published by Atherton et al.\(^1\) and were mentioned in Yamagata's talk at this meeting.

It is well known that the gross features of the \( \bar{p}p\pi^+\pi^- \) final state are given by \( \Delta^{++}/\Delta^{++} \) production, i.e., by channels

\[
\begin{align*}
\bar{p}p &\rightarrow \Delta^{++}\Delta^{++}, \\
\bar{p}p &\rightarrow \Delta^{++}\bar{p}\pi^-, \\
\bar{p}p &\rightarrow \Delta^{++}p\pi^+,
\end{align*}
\]

and a small non-\( \Delta \) contribution:

\( \bar{p}p \rightarrow \bar{p}p\pi^+\pi^- \).

The amount of the resonance production is difficult to establish because we do not know how to describe the background.

Let us start from the probability density function at fixed \( s \)

\[
\frac{d^3\rho}{d\nu dm_1 dm_2} = \sum_{i=1}^{\infty} \frac{\alpha_i}{\int \int f_i(v,m_1,m_2)Res_i(m_1,m_2)PS \left| d\nu dm_1 dm_2 \right| PS},
\]

where \( m_1 \) (\( m_2 \)) is the effective mass of \( p\pi^+ \) (\( p\pi^- \)); \( v \) is the four-momentum transfer \( t \) or the c.m.s. scattering angle \( \cos \theta \); index \( i \) goes over channels (1), ..., (4); \( Res_i(m_1,m_2) \) stands for the Breit-Wigner terms; \( f_i(v,m_1,m_2) \) are the squares of amplitudes for production of clusters with masses \( m_1, m_2 \); \( PS \) is the appropriate phase-space element; and \( \alpha_i \)'s give fractions of processes (1), ..., (4).

Now we make an assumption which is often made, namely that \( f_i(v,m_1,m_2) \) do not depend on the masses \( m_1 \) and \( m_2 \)

\[
f_i(v,m_1,m_2) = f_i(v).
\]

This is a correct assumption about \( f_1 \) because the Breit-Wigner weight keeps \( m_1, m_2 \) close to the resonance masses of \( \Delta^{++}, \Delta^{++} \), but it is not straightforward for \( f_2, f_3, \) and \( f_4 \). Let us remember that Eq. (6) is not fulfilled for OPEM models where the vertex functions depend both on \( t \) and \( m \). The practical advantage of Eq. (6) is that it enables us to extract \( f_i(v) \) from data, fitting Eq. (5) to small
intervals of $v^{2,3}$). Taking for $v \cos \theta$ or $v$, we get for the density distribution on the mass scatterplot (7) and (8), respectively

$$\frac{d^2p}{dm_1dm_2} = \sum_{i=1}^{4} \alpha_i \int \int \frac{R_i(m_1,m_2)PS}{R_i(m_1,m_2)PS dm_1dm_2}$$  \hspace{1cm} (7)

$$\frac{d^2p}{dm_1dm_2} = \sum_{i=1}^{4} \alpha_i \int \int \frac{F_i(m_1,m_2)R_i(m_1,m_2)}{F_i(m_1,m_2)R_i(m_1,m_2)PS dm_1dm_2}$$  \hspace{1cm} (8)

where $F_i(m_1,m_2) = \int f_i(t) dt$.

In Eq. (7) we get LIPS for the background [the peripherality is contained in $f_i(cos \theta)$ not contributing to the scatterplot]. In Eq. (8) the background is described by the peripheral phase space $F_i(m_1,m_2)PS$. Both formulae when applied to data give different values of $\alpha_i$'s (see Table 1). As there is no a priori reason for the choice $v = \cos \theta$ or $v = t$, we can use only statistical criteria to find out which choice data prefer.

Table 1

<table>
<thead>
<tr>
<th>$P_{lab}$ (GeV/c)</th>
<th>$v = \cos \theta$</th>
<th>$v = t$</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.6</td>
<td>85 $\pm$ 6</td>
<td>63.8 $\pm$ 4.6</td>
<td>2</td>
</tr>
<tr>
<td>5.7</td>
<td>62.7 $\pm$ 1.3</td>
<td>50.0 $\pm$ 1.0</td>
<td>1</td>
</tr>
<tr>
<td>12.0</td>
<td>34.0 $\pm$ 1.6</td>
<td>27.1 $\pm$ 1.4</td>
<td>2</td>
</tr>
</tbody>
</table>

In our data at 5.7 GeV/c $^1$ we did not get a good fit using formula (7) ($\chi^2/ND = 1144/974$). The comparison with Eq. (8) is just being made.

The other remark concerns the forward spike in $d\sigma/dt$ distribution for $t' < -0.06$ GeV$^2$ in the channel (1). The results of the maximum likelihood fit to the formula

$$\frac{d\sigma}{dt'} = \begin{cases} \exp(b_1t') & \text{for } t' \in (t_b',0) \\ \exp(b_2t') & \text{for } t' \in (-0.5,t_b') \end{cases}$$  \hspace{1cm} (9)

are given in Table 2 and in Fig. 1.
Table 2

Values of exponential slopes $b_1$, $b_2$ and the break value $t'_b$ for three mass cuts on $m_1$, $m_2$

<table>
<thead>
<tr>
<th>Mass cut (GeV)</th>
<th>$b_1$ (GeV$^{-2}$)</th>
<th>$b_2$ (GeV$^{-2}$)</th>
<th>$t'_b$ (GeV$^2$)</th>
<th>$\chi^2$/ND</th>
<th>Fig. 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.136-1.336</td>
<td>$12.83 \pm 0.96$</td>
<td>$5.80 \pm 0.18$</td>
<td>$-0.065 \pm 0.003$</td>
<td>29.6/48</td>
<td>a</td>
</tr>
<tr>
<td>1.156-1.316</td>
<td>$13.10 \pm 1.01$</td>
<td>$5.85 \pm 0.19$</td>
<td>$-0.064 \pm 0.003$</td>
<td>36.2/48</td>
<td>b</td>
</tr>
<tr>
<td>1.176-1.296</td>
<td>$14.21 \pm 1.36$</td>
<td>$5.86 \pm 0.22$</td>
<td>$-0.058 \pm 0.003$</td>
<td>40.8/48</td>
<td>c</td>
</tr>
</tbody>
</table>

In this region the dip or peak structure was observed for many other two-body reactions dominated by $\pi$ exchange. We tried to understand this phenomenon, at least qualitatively, in the language of the strong absorption model. Using the arguments given by Dar$^{4}$ we get the following rules for the high-energy behaviour of vertex functions:

i) the vertex $N\pi\Delta$ prefers to conserve helicity,

ii) the vertex $N\pi N'$ changes helicity.

The behaviour of $d\sigma/dt'$ at $t' \approx 0$ is given$^{4}$ by

$$
\frac{d\sigma}{dt'} \propto \frac{1}{(m^2 - t')^2} \sum_{\Delta\lambda} C_{\Delta\lambda} (t')^{\Delta\lambda/2},
$$

$$
\Delta\lambda = |(\lambda_c - \lambda_a) - (\lambda_d - \lambda_b)|,
$$

where $C_{\Delta\lambda}$ is the sum of contributions from vertex functions with the total helicity change $\Delta\lambda$. If $C_0 = 0$ then $d\sigma/dt'$ has a dip, otherwise a peak, because of the presence of the propagator. Using (i) and (ii) we summarize the forward behaviour of $d\sigma/dt'$ for different $\vec{p}(p)$-induced reactions with $\pi$ exchange in the following rules:

a) for double $\Delta$ production: spike,
b) for single $\Delta$ production: dip,
c) for charge exchange with no $\Delta$: spike.

The data do not contradict these conclusions.
REFERENCES


