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ANTIPROTON-PROTON ELASTIC SCATTERING AT 3.55 GeV/c

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ABSTRACT

Antiproton-proton elastic scattering has been measured at 3.55 GeV/c
in the c.m. angular range from 20° to 77° and from 109° to 160°. Forward
pp elastic scattering shows a structure near $t = -0.5 \text{ (GeV/c)}^2$. In the
backward region two events are observed.

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As part of an experimental programme to study the elastic scattering of hadrons on protons, we present in this letter the results of a measurement of the elastic scattering of antiprotons on protons at 3.55 GeV/c. The experiment was performed at the CERN Proton Synchrotron. The characteristics of the optical spark chamber system, and the digitization and analysis procedures have been described in previous publications\(^1\).

A negative unseparated beam with a momentum dispersion of \(\pm 0.5\%\) around the central value of 3.55 GeV/c, which was known to \(\pm 50\) MeV/c, was used. The beam contained 0.5\% \(\bar{p}\), 1.7\% \(K^-\), and 97.8\% \(\pi^-\), \(\mu^-\), and \(e^-\). Three threshold Čerenkov counters\(^2\) were used in the incident beam, two of which were set to record pions, and their signals were used in anti-coincidence. The third Čerenkov counter was set to count kaons and pions, and the information from this counter was displayed on a data-box\(^1\). In this way the elastic scattering of \(K^-\) and \(\bar{p}\) was studied during the same run. The results presented here are based on a total of 92,000 spark chamber photographs. The acceptance of the system permitted observation of elastic scattering events at c.m. scattering angles from 20° to 77° \([0.16 < -t < 2.0 \text{ (GeV/c)}^2]\) and from 109° to 160° \([3.0 < -t < 5.0 \text{ (GeV/c)}^2]\).

The results are given in Table 1 and Fig. 1, where we have also plotted the results of Katz et al.\(^3\). Quoted errors are statistical. There is an over-all uncertainty of scale of \(\pm 20\%\), arising mainly from an uncertainty of the abundance of antiprotons in the incident beam.

In Fig. 2 the energy dependence of forward \(\bar{p}p\) elastic scattering is shown with data from several publications. We list here some of the prominent features, which have been noted by other authors:

i) The forward peak expands with energy (anti-shrinkage).

ii) There is a dip in the angular distribution, which shifts from \(t = -0.4 \text{ (GeV/c)}^2\) at low energy to \(t = -0.6 \text{ (GeV/c)}^2\) at high energy.

iii) The amplitude of the secondary maximum at about \(t = -0.8 \text{ (GeV/c)}^2\) decreases with energy.

These features are qualitatively accounted for by models for elastic scattering involving a superposition of amplitudes due to an infinite-energy diffraction process\(^4\) and the exchange of meson Regge-poles\(^5\).
The two elastic events found in the backward direction correspond to a differential cross-section of $5 \pm 4 \text{ mb}/(\text{GeV}/c)^2$. This is of the same order of magnitude as for backward elastic $K^-p$ scattering\textsuperscript{1}) but smaller than the backward differential cross-section for $K^+p$ and $\pi^\pm p$ elastic scattering\textsuperscript{1}).
REFERENCES


Table 1
Antiproton-proton elastic differential cross-sections at 3.55 GeV/c. Listed errors are statistical. There is an over-all uncertainty of scale of 20%. \( S = 8.65 \text{(GeV)}^2 \), \( p_{c.m.} = 1.13 \text{ GeV/c} \), and \( t_{\text{min}} = -5.13 \text{ (GeV/c)}^2 \)

<table>
<thead>
<tr>
<th>( \cos \theta_{c.m.} )</th>
<th>(-t) (GeV/c)(^2)</th>
<th>(\Delta t) (GeV/c)(^2)</th>
<th>No. of events</th>
<th>(d\sigma/dt) mb/(GeV/c)(^2)</th>
<th>(d\sigma/d\Omega) mb/sr</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9298</td>
<td>0.18</td>
<td>0.04</td>
<td>96</td>
<td>23.7 ± 2.4</td>
<td>9.69 ± 0.99</td>
</tr>
<tr>
<td>0.9142</td>
<td>0.22</td>
<td>0.04</td>
<td>53</td>
<td>13.9 ± 1.9</td>
<td>5.78 ± 0.78</td>
</tr>
<tr>
<td>0.8908</td>
<td>0.28</td>
<td>0.06</td>
<td>50</td>
<td>9.4 ± 1.3</td>
<td>3.84 ± 0.54</td>
</tr>
<tr>
<td>0.8596</td>
<td>0.36</td>
<td>0.08</td>
<td>19</td>
<td>3.04 ± 0.70</td>
<td>1.24 ± 0.28</td>
</tr>
<tr>
<td>0.8294</td>
<td>0.44</td>
<td>0.08</td>
<td>4</td>
<td>0.25 ± 0.13</td>
<td>0.10 ± 0.05</td>
</tr>
<tr>
<td>0.7895</td>
<td>0.54</td>
<td>0.12</td>
<td>16</td>
<td>0.68 ± 0.17</td>
<td>0.28 ± 0.07</td>
</tr>
<tr>
<td>0.7271</td>
<td>0.70</td>
<td>0.20</td>
<td>34</td>
<td>0.74 ± 0.13</td>
<td>0.30 ± 0.05</td>
</tr>
<tr>
<td>0.6491</td>
<td>0.90</td>
<td>0.20</td>
<td>30</td>
<td>0.75 ± 0.14</td>
<td>0.31 ± 0.06</td>
</tr>
<tr>
<td>0.5711</td>
<td>1.10</td>
<td>0.20</td>
<td>10</td>
<td>0.39 ± 0.12</td>
<td>0.16 ± 0.05</td>
</tr>
<tr>
<td>0.4542</td>
<td>1.40</td>
<td>0.40</td>
<td>8</td>
<td>0.21 ± 0.07</td>
<td>0.09 ± 0.03</td>
</tr>
<tr>
<td>0.2982</td>
<td>1.80</td>
<td>0.40</td>
<td>1</td>
<td>0.07 ± 0.07</td>
<td>0.03 ± 0.03</td>
</tr>
<tr>
<td>-0.5477</td>
<td>4.0</td>
<td>1</td>
<td>2</td>
<td>0.005 ± 0.004</td>
<td>0.002 ± 0.002</td>
</tr>
</tbody>
</table>
**Figure captions**

Fig. 1: The angular distribution of antiproton-proton elastic scattering at 3.55 GeV/c measured in this experiment. Also shown are the results of Katz et al.\(^3\)) at 3.66 GeV/c.

Fig. 2: Forward \(\bar{p}p\) elastic scattering as function of \(t\), the four-momentum transfer squared. Data at 1.4 GeV/c from Berryhill and Cline\(^6\)); 2.7 GeV/c, Domingo et al.\(^7\)); 3.55 GeV/c, this experiment; 5.8-5.9 GeV/c, K. Böckmann et al.\(^8\)) and D.P. Owen et al.\(^9\)); 16 GeV/c, D. Birnbaum et al.\(^10\)). The curves are hand-drawn through the data points to guide the eye.
\( \bar{p}p \rightarrow \bar{p}p \)

- W.M. Katz et al. 3.66 GeV/c
- This experiment 3.55 GeV/c

FIG. 1
\( \bar{p}p \rightarrow \bar{p}p \)

\[ \frac{d\sigma}{dt} \frac{mb}{(GeV/c)^2} \]

- Berryhill et al. 1.4 GeV/c
- Domingo et al. 2.7
- This experiment 3.55
- Owen et al. 5.8
- Böckmann et al. 5.7
- Birnbaum et al. 16

FIG 2