The near threshold production of $\eta$ and $\eta'$ mesons has been measured in proton-deuteron collisions at different beam momenta [1,2,3] at COSY-11 [4]. To gain total and differential cross sections it is necessary to determine the integrated luminosity. While in proton-proton reactions it is a standard procedure at COSY-11 to extract the luminosity by measuring a reaction with well known cross section simultaneously to the reaction of interest, the procedure is more difficult for the proton-deuteron case [1].

In proton-proton experiments the elastic scattering $pp \rightarrow pp$ is taken as reference reaction, being clearly selectable by a coincident detection of both ejectiles and profit by the wealth of high-precision data available from EDDA [5]. The same trigger condition is applicable to the reaction $pd \rightarrow pd$. However, in addition to the desired proton-deuteron elastic scattering, also the quasi-free proton-proton scattering, where the target neutron acts as a spectator only, has to be taken into account (Figure 1). Another difficulty is the lack of literature data for $pd$ elastic scattering in the energy region of interest.

These two obstacles can be overcome by a carefully filtering of the experimental data to separate the $pd$ elastic scattering events from the dominant background [6] and a reasonable parameterization of the available literature data. This parameterization has to take into account the momentum transfer dependence of the differential cross sections of the $pd$ elastic scattering at a fixed beam momentum, as well as the beam momentum dependence.

Based on the limited data sets close to the beam momenta of interest, it was possible to perform a parameterization, which succeeds to describe both the shape and the absolute scale of the differential cross section of available literature data, as demonstrated in figure 2 (dashed lines). With this parameterization it is possible to make predictions of the differential cross section for $pd$ elastic scattering for beam momenta used in $pd \rightarrow ^3He X$ reactions measured at COSY-11 (solid lines).

**Fig. 1**: Identification of the $pd$ elastic scattering. The hit position of scattered deuterons in the monitor detector is shown as function of the momentum transfer of the protons [6]. Additionally to the fine lower band arising from the proton-deuteron scattering, there is a broad distribution resulting from quasi-free proton-proton scattering events.

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**Fig. 2**: Differential cross sections of the $pd$ elastic scattering as function of the momentum transfer, references apply to [7]. Dashed lines indicate the reproduction of literature data sets generated from the parameterization. Solid lines represent the prediction for the beam momenta used in $pd \rightarrow ^3He \eta$ experiments at COSY-11.

This allows to compare the measured $pd \rightarrow pd$ momentum transfer distributions to the predictions based on literature data and therefore, to extract integrated luminosities with a systematical error of only 10% in total (Table 1) [7].

**Table 1**: Integrated luminosities for $pd \rightarrow ^3He \eta$ measurements at given beam momenta. The quoted error is purely statistical, additionally there is a systematical error of ~10%.

<table>
<thead>
<tr>
<th>Beam momentum</th>
<th>Integrated luminosity</th>
</tr>
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<tbody>
<tr>
<td>1.581 GeV/c</td>
<td>47.21 nb ± 3.6%</td>
</tr>
<tr>
<td>1.593 GeV/c</td>
<td>57.88 nb ± 3.6%</td>
</tr>
<tr>
<td>1.602 GeV/c</td>
<td>54.62 nb ± 3.6%</td>
</tr>
<tr>
<td>1.612 GeV/c</td>
<td>53.53 nb ± 2.8%</td>
</tr>
<tr>
<td>1.655 GeV/c</td>
<td>53.61 nb ± 5.0%</td>
</tr>
</tbody>
</table>

**References:**


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