

Luminosity Determination in Proton-Deuteron Scattering Experiments at COSY-11

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The near threshold production of η and η' 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].

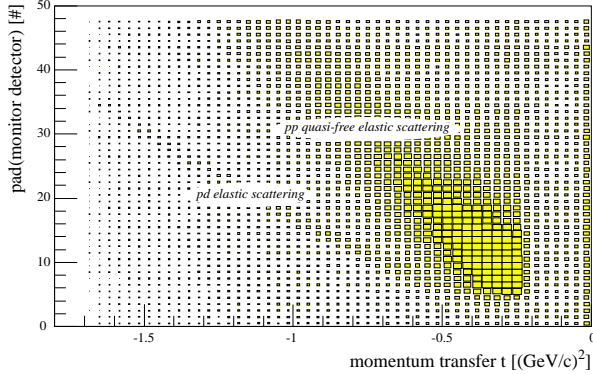


Fig. 1: Identification of the pd elastic scattering. The hit position of scattered deuterons in the monitor detector is shown as function of the momentum transfer of the protons [6]. Additionally to the fine lower band arising from the proton-deuteron scattering, there is a broad distribution resulting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

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 $pd \rightarrow {}^3\text{He} X$ reactions measured at COSY-11 (solid lines).

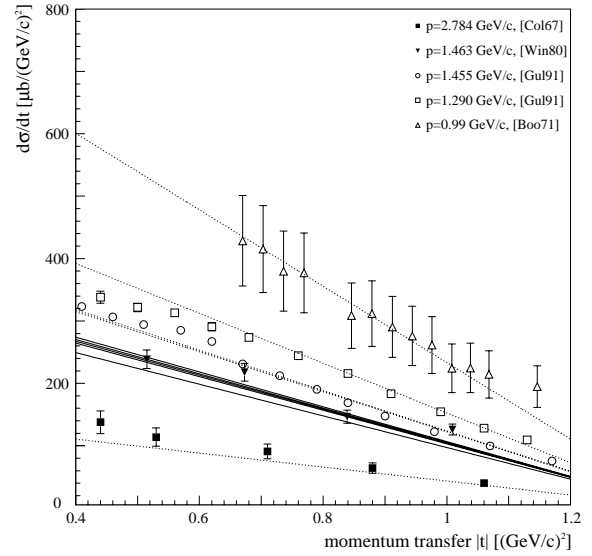


Fig. 2 Differential cross sections of the pd elastic scattering as function of the momentum transfer, references apply to [7]. Dashed lines indicate the reproduction of literature data sets generated from the parameterization. Solid lines represent the prediction for the beam momenta used in $pd \rightarrow {}^3\text{He} \eta$ 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 $pd \rightarrow {}^3\text{He} \eta$ measurements at given beam momenta. The quoted error is purely statistical, additionally there is a systematical error of $\sim 10\%$.

Beam momentum	Integrated luminosity
1.581 GeV/c	47.21 1/nb \pm 3.6%
1.593 GeV/c	57.88 1/nb \pm 3.6%
1.602 GeV/c	54.62 1/nb \pm 3.6%
1.612 GeV/c	53.53 1/nb \pm 2.8%
1.655 GeV/c	53.61 1/nb \pm 5.0%

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