Luminosity determination for $\vec{d}p \to (pp)n$ charge-exchange reaction*

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In order to extract the differential cross section for the $dp \to (pp)n$ charge–exchange breakup reaction [1], the absolute luminosity must be determined. The measurement of the luminosity has been done using the dp elastic scattering reaction. For this purpose only the data sample with the unpolarized beam from the polarized source were used. For the normalization of ANKE data, the KEK results has been used, where the dp total, elastic, inelastic, and differential cross sections have been measured at 10 different beam momenta in the range of p_d = 2.0-3.7 GeV/c and in the angular interval of $\theta^d_{lab} = 4° \div 15°$ [2]. There were no measurements exactly at our momentum $p_d = 2.4$ GeV/c, therefore we used the KEK data for 2.26 GeV/c and 2.46 GeV/c to extract the cross–section for our beam energy in the assumption of linear approximation (see Fig. 1).

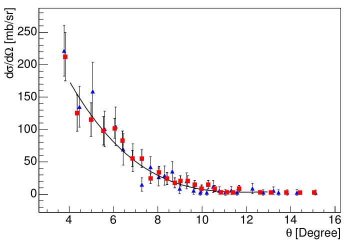

Fig. 1: Thr KEK results for dp elastic cross section [2]: blue triangels are data for p_d = 2.26 GeV/c and red squares are for p_d = 2.46 GeV/c. The solid line is the fit of all data points.

In this experiment we have used only the forward detection (FD) system (three MWPC's and scintillation hodoscope) of the ANKE spectrometer and system was able to detect deuterons in the forward direction for polar angles from 5° to 10°. The dp-elastic process has high cross section and is clearly seen in the one dimensional momentum distribution (Fig 2). The elastic momentum peak is well separated from the other processes. After selecting the peak region in the momentum distribution, the produced missing mass of the selected events clearly sits on the proton mass with almost no background (see Fig. 2).

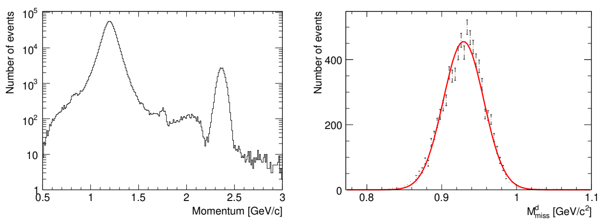

Fig. 2: Identification of the dp elastic reaction at ANKE. Left panel: momentum distribution for single track events; right panel: the deuteron missing mass spectra

For the acceptance calculation of the reaction the data sample of the identifyied events has been divided into the deuteron polar angle bins of 0.5°. After that for each polar angular range, the detector solid angle calculated. Typical spectra for the azimuthal angular distributions are shown in Fig. 3. Finally for each slice of the polar angle the geometrical acceptance was calculated in the following way:

$$A_i = \Omega^{det}_i = \Delta\phi_i[cos\theta_i - cos(\theta_i + 0.5°)], \quad (1)$$

where Ω^{det}_i is the solid angle element of the FD system.

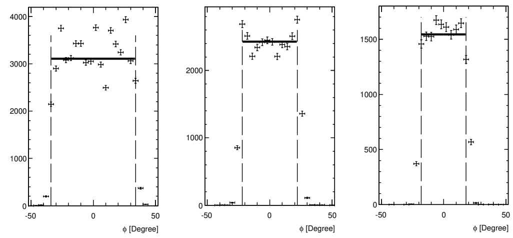

Fig. 3: Typical histograms to define the detector edges in the azimuthal direction for several polar angle bins (from left to right: $\theta = 5.5° - 6.0°$, $7.0° - 7.5°$, $8.0° - 8.5°$.

In these histograms the events are already corrected for the MWPC's efficiencies (around 99%). The number of events where also corrected by the prescaling factor of the FD trigger and by the total DAQ efficiency factor (around 75%).

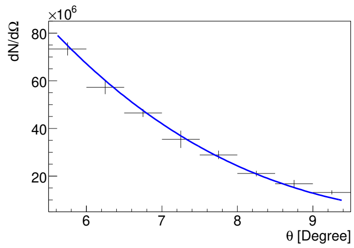

Fig. 4: Acceptance corrected angular distribution for deuterons. The solid line is the fit function find from the Fig.1.

Finally, using the acceptance corrected dp count rates and fitting our angular distribution (see Fig.3) by the one parameter function derived from the KEK differential cross section data, the luminosity for the different polar angular bins was determined and the results has been found consistent. The integrated luminosity for whole beam time is: $L_{int} = (9 \pm 0.04) \times 10^6$ mb^{-1}, which gives the average luminosity of $L = 671 \pm 3$ mb^{-1} sec^{-1}.

References:

[1] D. Chiladze et al. Phys. Lett. B637 (2006) 170.
[2] N. Katayama et al. Nucl. Phys. A438 (1985) 685.

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