Luminosity determination for the deuteron breakup experiment

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During the pd breakup beam time (February 2001) experimental data were obtained with deuteron cluster target at incident proton beam energies of 600, 700, 800, 950, 1350, and 1900 MeV. The luminosity was calculated using pd forward scattering at low transferred momenta with one proton registered in the ANKE Forward Detector (FD).

The pd scattering cross section is composed of elastic and inelastic contributions. It is not possible to separate them experimentally in ANKE FD, due to the very similar kinematical parameters of forward scattered protons and the limited FD momentum and angular resolution. Therefore, theoretical calculations of differential cross sections were carried out [1] in Glauber-Sitenko diffraction theory approximation. The calculations are within 10% with existing experimental data.

The event selection of pd forward scattering was done among single track events in the data taken with FD trigger. (Multiple track events are rare.) For track reconstruction the first and third FD MWPC were used. The horizontal and vertical limitations of the track coordinate on the exit window of the D2 magnet and the FD scintillation counter were applied together with a vertical cut on the target position [2].

The particle type selection was done by particle mass calculated using energy losses in two planes of FD scintillation counters and the particle momentum. In Fig. 1a the particle mass in the first plane of the scintillation hodoscope is plotted vs the mass in the second plane.

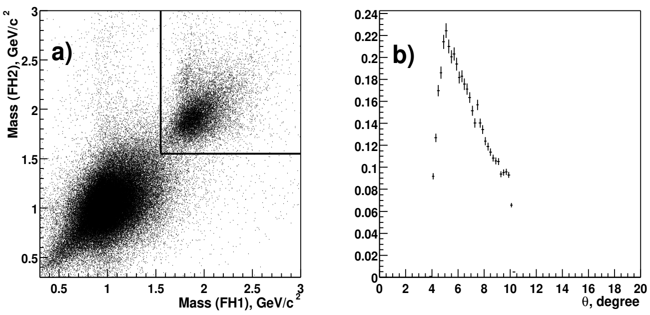

Fig. 1: Particle mass calculated from energy loss in the first layer of FD hodoscope vs mass calculated from energy loss in the second layer (a), FD angular acceptance (b).

After selection of protons from energy loss vs momentum for different polar angle intervals (1 degree bins) for $\theta_{lab} = 5\ldots10^\circ$, the data were fitted by the sum of a gaussianand an inclinded line. Events were selected within 2σ from the fitted average momentum value. In Fig. 2a an example of such a fit is shown.

The determination of the efficiency of the FD MWPCs is described in [3]. For each event the track efficiency was calculated and a correction to the analyzed momentum was applied.

The FD acceptance was calculated using a GEANT-based simulation program. The events with pd elastic kinematics were generated within the polar angle range of $0-20$ degree of the forward emitted proton, with ϕ randomly distributed over 2π. The probability to hit the FD was obtained as a function of polar angle (Fig. 1b). The limiting values of θ coincide well with the experimental data.

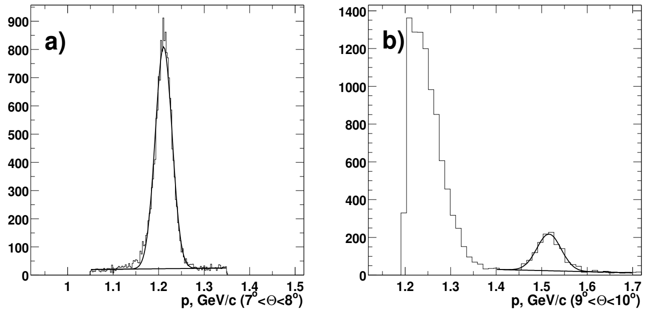

Fig. 2: Momentum distributions of protons from pd forward scattering (a) and deuterons from pd backward scattering (b).

The luminosity was calculated for individual polar angles. In Table 1 the mean values of the luminosity averaged over all angles is listed. The errors correspond to rms value. Errors of this type are one source of systematics. A second source is the accuracy of the theoretical calculation of the cross section, estimated to be $\approx 10\%$. The statistical errors are negligible in comparison with the systematic ones.

Table 1. The luminosity determined using pd forward and backward scattering.

T_p [MeV]	L_{forw} [cm^{-2}s^{-1}]	L_{back} [cm^{-2}s^{-1}]
600	$(0.540 \pm 0.030)\cdot 10^{30}$	$(0.45 \pm 0.09)\cdot 10^{30}$
700	$(0.298 \pm 0.017)\cdot 10^{30}$	$(0.30 \pm 0.06)\cdot 10^{30}$
800	$(0.350 \pm 0.015)\cdot 10^{30}$	$(0.34 \pm 0.07)\cdot 10^{30}$
950	$(0.305 \pm 0.010)\cdot 10^{30}$	
1350	$(0.399 \pm 0.010)\cdot 10^{30}$	
1900	$(0.516 \pm 0.019)\cdot 10^{30}$	

The method was tested by comparing the results with the luminosity determined from the $pd \to dp$ process with the deuteron registered in the ANKE FD. After track and energy loss selection, clear peaks in the momentum spectra are seen for beam energies of 600, 700, and 800 MeV (Fig. 2b). Using existing experimental data [4] and calculations similar to those described in [5]. The luminosity was determined for these energies (third column of table 1). The results are in good agreement with results obtained from the pd forward scattering process.

References:

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