Luminosity Determination at ANKE with the Spectator Detector

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During the ANKE beam time in September, 1999 the prototype of the silicon detector system for the detection of low energy spectator protons has been tested with the deuterium cluster target [1] at beam energy of 2 GeV. The telescope-like set-up consisted of 3 layers: a 18 μm surface-barrier silicon detector and two silicon-strip detectors of 300 μm and 5 mm thickness were placed inside the vacuum chamber. Particles emitted from the target in the polar angle range of 77°-110° were detected. With a finite length of the target of 15 mm along the beam direction, different kind of particles emitted in forward and backward directions were clearly separated by the strip detectors. The good separation of protons and deuterons was achieved in ΔE/E correlation spectra of these detectorsas well. In the forward direction both, protons and deuterons, were observed (Fig. 1) but in backward direction only protons were detected. So, the selection of deuterons yields immediately the **pd** elastic-scattering process which can be used for the luminosity determination.

The energy-position correlation of deuterons

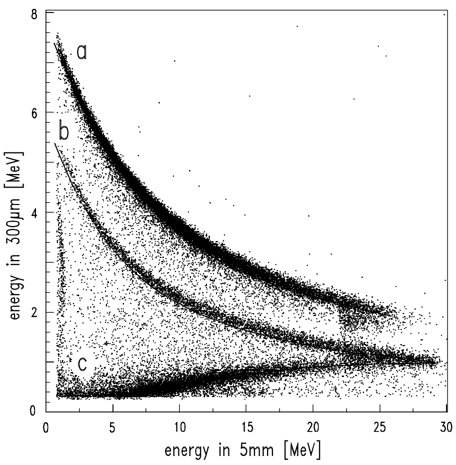

Figure 1: ΔE/E distribution in the strip detectors. Calculated dependences are shown by curves.

(Fig. 2) is actually related to the energy-angle dependence of the elastic scattering: particles of a certain energy are emitted from the target edge at a certain angle. Positions where such deuterons are expected to be detected in the 5 mm thick detector are shown by lines. The calculated image of a sharp target edge without the influence of the multiple scattering in the 300 μm detector is presented by the solid curve. The dashed curve takes this effect into account. Some shift (1-1.5 mm) seems to be due to the displacement of either the target or the detector along the beam direction. Nevertheless, the shape of the upper border of the experimental distribution is in a good agreement with the expected one with very few entries outside this range. The negligible background of deuterons coming not from the target has also been seen. It can be identified by the coordinates of deuterons in the two planes of the silicon strip detectors.

The luminosity was determined by the expression:

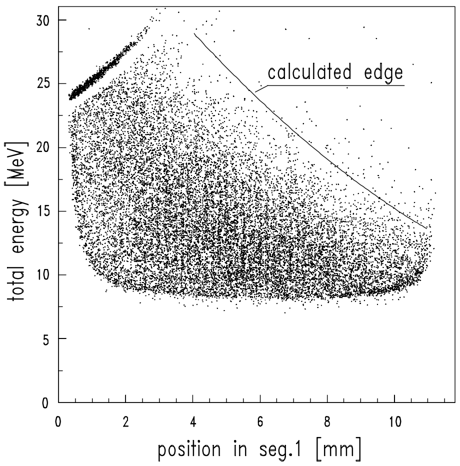

Figure 2: The distribution of deuterons with the total energy E_d along the 5 mm strip detector.

$$L = Y_d \cdot k_l \cdot DT \cdot (\Delta t \cdot \int_{\Delta\Omega} d\Omega \frac{d\sigma}{d\Omega})^{-1}$$

where Y_d is the measured yield of deuterons with energies 16-18MeV. This energy range was chosen in order to minimize the uncertainties due to the multiple scattering, the inefficiency of detectors and in order to simplify the calculation of the acceptance.
$k_l = 2.5$ is the correction factor due to the only partially seen target length (Due to the space limitation of the actual ANKE target chamber, the target can not be fully seen by this luminosity monitor).
DT and Δt are the dead time of the data acquisition system and the duration of the data taking, respectively, obtained from the ANKE system scalers.
$\int_{\Delta\Omega} d\Omega \frac{d\sigma}{d\Omega} = 1.38 \cdot 10^{-29} cm^2$ is the **pd** elastic cross section for the selected deuteron energy range. The value of the cross section was taken from [2].

RUN	$\frac{Protons}{bunch}$	DT	Δt, s	Y_d	$L, \frac{10^{29}}{cm^2 \cdot s}$
1849	$5.5 \cdot 10^9$	2.707	3493	695	1.0(3)
1853	$5.5 \cdot 10^9$	2.278	10294	2300	0.9(2)
1856	$9.5 \cdot 10^9$	2.929	2080	650	1.7(4)
1857	$9.5 \cdot 10^9$	12.39	2719	200	1.7(4)

References:

[1] H. H. Adam et al., IKP/COSY Annual Report 1998, FZ-Juelich, 25 (1998) and contribution to this report.

[2] J. Bystricky et al., in "Numerical Data and Functional Relationships in Science and Technology", v. 9, Springer-Verlag, 1980.

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Energy deposit in 5 mm detector, keV

Fig. 1 ΔE/E distribution in strip detectors. Calculated dependences are shown by curves.

Position in the 5 mm detector, μm

Fig. 2. The distribution of deuterons with the total energy E_d along the 5 mm strip detector.