The spin polarization of proton target in SHARAQ04 experiment

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A (p,2p) knockout reaction was used in the SHARAQ04 experiment to extract the spectroscopic factor of orbital protons, and a spin-polarized proton target was used to extract the analyzing power for distinguishing the spin-up ($J_>$) and spin-down ($J_<$) orbits of the knockout proton. The analyzing power can be determined using the cross section left-right asymmetry and spin polarization. We present the analysis and results of the spin polarization.

The measurement of the spin polarization of the polarized proton target[1,2] was conducted using two methods. The nuclear magnetic resonance (NMR) was used for quick and constant monitoring, and proton-proton elastic scattering was used for measuring the absolute magnitude of the spin polarization.

A 260 MeV pure proton beam was used in proton-proton elastic scattering runs. The spin polarization was reversed during the measurement to eliminate of any systematic asymmetry. A pair of recoil protons was correlated and the opening angle was 180° in the center of mass frame, which is equal to 86.3° to 90° in the laboratory frame. The recoil protons were tracked by two MWDCs[3] located downstream[4]. The MWDCs were arranged 30° to the beam axis and 1022 mm away from the target. The MWDCs covered a forward angle of 20° – 70°, which is equivalent to approximately 40° – 140° in the center of mass frame. The position resolution of the MWDCs is approximately 0.1 mm for X and 0.2 mm for Y.

The NMR method was applied by inserting an NMR coil to surround the target crystal. From the measurement, it was shown that the spin polarization of the spin-down runs was approximately 78% smaller than that of the spin-up runs during proton-proton elastic scattering [2].

The target crystal was made of naphthalene ($C_{10}H_8$). The beam profile was much larger than the size of the target so that significant amount of the beam was incident on the target holder (hydrogen-free plastics) and surrounding structures. These two factors provided us a broad background signal on the opening angle.

By assuming that the reaction point is along the z-axis of the lab frame, we calculated the weighted reaction position (Z-vertex) from the MWDCs' tracking result. The Z-vertex was gated by an opening angle with a central gate (84°-89°) and a side gate (81.5°-84° or 89°-91.5°). The central gate contained the elastic scattering peak and background, while the side gate contained only background because the opening angle is not allowed by kinematics and detector acceptance (Figure 1).

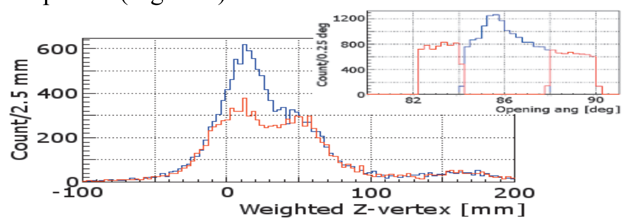

Figure 1. Weighted Z-vertex (reaction vertex on z-axis) with opening angle gate (upper right corner). Elastic scattering runs #7 to #15 were used[2].

We divided the cover angle into five angle sections in the center of mass frame. The yield for each section is

$$Y_x^\beta(\Delta\theta) = f L^\beta \epsilon_x \sigma(\Delta\theta)\Delta\Omega\left(1 + s_x^\beta A_y(\Delta\theta)P^\beta\right)$$

$$L^\beta = N_T \sum N_B^\beta(i)\lambda^\beta(i) \tag{1}$$

$$s_L^\uparrow = s_R^\downarrow = 1 = -s_L^\downarrow = -s_R^\uparrow$$

where x is left or right, β is spin-up or down, f is the fraction of beam on the target, L is the integrated luminosity, N_T is the number of proton in target, $N_B(i)$ is the number of beam protons in the i-th run, λ is the lifetime of the DAQ system, ϵ is the detector efficiency, $\sigma(\Delta\theta)$ is the differential cross section in angle section $\Delta\theta$, $\Delta\Omega$ is the solid angle on the angle section $\Delta\theta$, s is a sign, A_y is the analyzing power and P is the spin polarization of the target. We used the spin-up and spin-down asymmetry to avoid the efficiency non-uniformity of MWDCs. The final spin polarization is a weighted mean from each angle section. The spin-up polarization was 16% ± 14%. The spin polarization is as expected and similar to the results of a previous experiment performed under a similar conditions[5]. An asymmetry of the cross section distribution can be obtained for large statistics.

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