Efficiency of a Faraday cup in the WS scattering chamber for a 200 MeV proton beam

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We have been measuring elastic scattering of protons from nuclei using the magnetic spectrometer Grand Raiden (GR) in the WS course [1]. In these experiments, we have used a 300 MeV polarized proton beam because the proton has the longest mean free path in a nucleus at this energy. By analyzing data with polarized observables and by using charge density distributions measured by electron scattering, we have succeeded in extracting neutron density distributions. In order to investigate the density distributions precisely, it is important to know absolute values of cross sections. Therefore, we needed to measure efficiency of the Faraday cup in the WS scattering chamber (SCFC) and the efficiency of the GR trigger scintillators for protons at 300 MeV [2]. Usually, these efficiencies are not equal to 100% due to the escape of electrons from SCFC and reaction loss in these materials. Recently, we have proposed an experiment to extract proton and neutron density distributions simultaneously from measurements of proton elastic scattering at 200 and 300 MeV [3] without using the electron scattering data. For the simultaneous extraction, we also need to measure these efficiencies for protons at 200 MeV. In this report, we describe experimental results for the efficiency of SCFC.

The experiment was performed by the same method as the previous experiment [2]. During the measurement, we used unpolarized 200 MeV proton beams, energy resolution of which was about 200 keV, with beam intensities of 1–20 nA. The beam current from SCFC was measured with a current integrator (Model 1000C, Brook heaven instruments corporation). The accuracy of the current integrator was confirmed by using a calibrated precise current source (263, Keithley). In order to define the absolute beam current, we also measured the beam current with a large Faraday cup (LFC) placed just behind the scattering chamber. We assume that the large volume and the structure of LFC are enough to capture all charges. In order to calibrate slight difference of the beam current between the measurements of SCFC and LFC, we used the existing two beam line polarimeters (BLP1 and BLP2) in the beam line. The eight scintillators of each BLP were placed at angles of $34°/53.24°'$ (left-and-right pairs) and $59°/28.485°$ (up-and-down pairs), respectively. The count of the current integrator was monitored by comparing with the number of elastic and quasi-elastic events scattered from an 100-μm-thick Aramid film at BLP, applying the kinematic coincidence of the paired scintillators to select these events.

Figure 1 shows the measured efficiencies as a function of the beam intensity. Because the efficiency does not depend on the beam intensity, we determined the efficiency for a 200 MeV proton beam by averaging the data. The weighted average is 101.47 ± 0.08 (stat.) ± 0.14 (sys.)%. The statistical error is determined by the propagation of error. The systematic error is evaluated by the sample standard deviation. The obtained value is the almost same as the value, 101.41 ± 0.08 (stat.) ± 0.13 (sys.)%, for a 300 MeV proton beam.

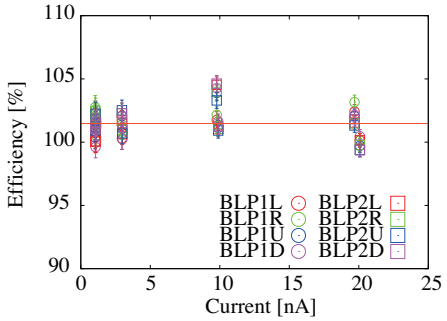

Figure 1: Efficiencies of SCFC for 200 MeV proton beams. A red line indicates the weighted average.

References

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