Development of a luminosity monitor system for experiments using the liquid D_2 target

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We developed a luminosity monitor to normalize the thickness of the liquid D_2 target used in the supernarrow dibaryon (SND) search experiment at WS course [1]. This experiment employs the proton inelastic scattering on deuteron at 300MeV to produce SNDs. Since the production cross section of SND is estimated to be as small as 3 $\mu b/sr$ [2], it is essential to perform low background measurements with a reasonably thick deuteron target. In the case of using a CD_2 target, the events of the protons scattered from carbon produce most of background. To eliminate the events from carbon, we use a liquid deuterium target [3]. The target is about 16 mm$^\phi$ $\times$ 3 mm^t in volume and covered by 4 μm^t aramid foils at both sides (Fig. 1). Because the foils swell in vacuum, the thickness of the target can change during the measurement. Therefore we use the luminosity monitor simultaneously to correct the deviation.

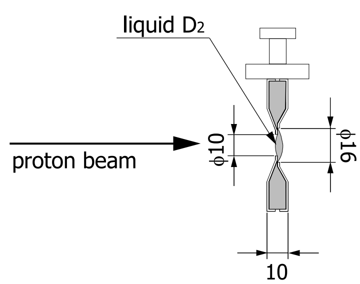

Figure 1: Side view of the target cell for the SND search experiment.

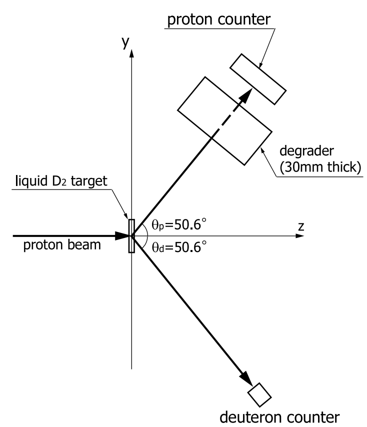

Figure 2: Schematic view of the luminosity monitor. The plastic scintillation counters are placed at 20 cm downstream of the target.

The $p + d$ elastic scattering reaction is used to monitor the luminosity. The scattered protons and the recoil deuterons are detected in kinematical coincidence. The luminosity monitor consists of a couple of NE102A plastic scintillation counters which are placed symmetrically at $\theta_{\mathrm{lab}} = 50.6°$ in up and down directions. The plastic scintillation counters with lightguide are coupled to the photo-multiplier tubes Hamamatsu H7415. The schematic view of the detectors is shown in Fig. 2. To avoid the effect of the beam polarization along the y-axis, the counters are placed in the vertical plane. The dimensions of the plastic scintillation counters for deuteron and proton detection are $8 \times 8 \times 10$ and $32 \times 32 \times 10\mathrm{mm}^3$, respectively.

The size of the proton counter is sufficient to detect all the scattered protons when the recoil deuterons enter the deuteron counter. A 30 mm^t brass block is placed in front of the proton counter in order to prevent protons from the deuteron breakup process and recoil deuterons from entering the counter.

We determined the thickness of the liquid D_2 target and checked the stability of the luminosity monitor in the following way.

1. Using a solid CD_2 target [4], the thickness of which is known as 44 mg/cm^2 [5], we determined the differential cross section of the $p + d$ elastic scattering from the data of GR+LAS coincidence. The beam intensity was obtained from the Faraday Cup at the beam dump. The scattered protons and the recoil deuterons were detected by the GR placed at 70° and the LAS at 38.2° respectively.

2. We made the same measurement with the liquid D_2 target. The thickness was determined by using the differential cross section obtained in step 1. In this experiment, the luminosity monitor was also operated. We obtained the normalization constant between the actual luminosity and the number of the events from the luminosity monitor.

3. With other beam intensities, we repeated step 2 several times to check the stability of the normalization constant.

In the online analysis, the target thickness has been determined as 3 mm^t.

Figure 3 shows two-dimensional plot of the light output of the deuteron and the proton counters. Figure 4 shows the timing information. These plots allow us to separate the $p + d$ elastic scattering events from the backgrounds. The data analysis is now in progress.

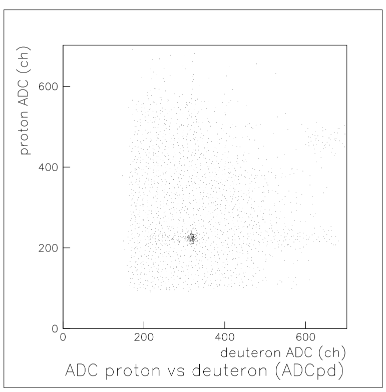

Figure 3: Two dimensional plot of the light output of the deuteron and the proton counters.

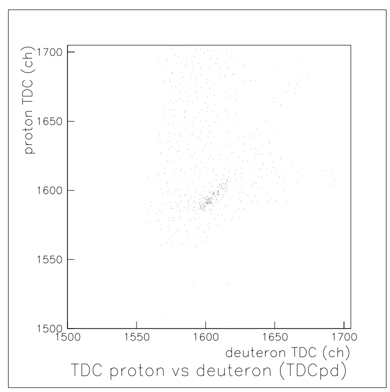

Figure 4: The plot of timing information of the deuteron and the proton counters.

References

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