Profile measurement of a large target cell of liquid hydrogen

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The (p, n) reaction in inverse kinematics is a powerful probe for studying nuclear isovector responses in unstable nuclei. In May 2018, the SAMURAI 30 experiment was performed using PANDORA[1] and SAMURAI[2] setup with a liquid hydrogen target[3] to study the GT transitions ,including their resonances, in the ^{11}Li and ^{14}Be neutron drip line nuclei.[4,5]

In general, the target thickness along the beam direction is required to obtain the cross sections. However, in the case of a liquid hydrogen target that contains with thin membranes, the target thickness strongly depends on the inflation of the membranes due to the differential pressure between liquid hydrogen and the vacuum in the target chamber.

In the SAMURAI 30 experiment, the target cell was tilted at 45° with respect to the beam direction, so that the recoil neutrons of interest, which were emitted around 90°, did not penetrate the target frame structures. Because the inflated target cell was tilted with respect to the beam line, the evaluation of the target thickness required three-dimensional analysis of the target shape. In this work, we measured the profile of a large target cell of liquid hydrogen by using a laser displacement meter and obtained the effective target thickness along the beam direction by analyzing the profile data.

Figure 1 schematically shows the setup for the target profile measurement. The target cell was filled with N_2 gas, instead of liquid H_2, at 1719 Pa, which corresponds to the differential pressure of 0.72 kPa. A laser displacement meter (KEYENCE LJ-G5000) was used to measure the target profile. The laser vertically irradiated the target cell surface. The configuration of the laser intensity was automatic, and the sampling time was 2 ms. The measurement can decide the absolute value only in the beam direction, while the position information in the horizontal direction can be just obtained as relative values. The scale of the horizontal position was calibrated by adjusting the inner diameter of the target frame to be the designed value, 50 mm. Here, we note that a typical beam spot of an RI beam at the SAMURAI F13 focal plane has a width of ±10 mm and a height of ±20 mm.

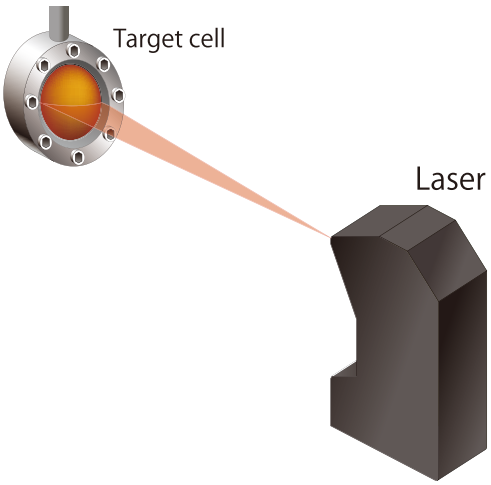

Fig. 1. Schematic of the setup for the two-dimensional profile measurement of the target thickness. The membranes of both sides are irradiated with a laser in the beam direction.

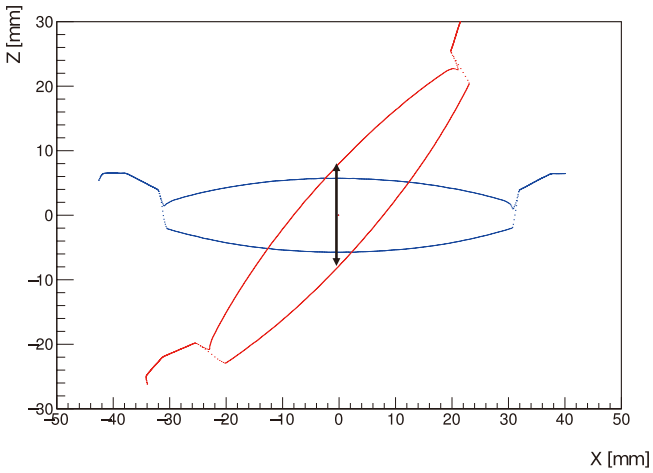

Fig. 2. Profile result of the target shape. The vertical axis indicates the spatial coordinate along the beam direction. The blue and red plots are the original data after the calibration and the data at an angle of 45° respectively.

As a result of the profile measurement, we obtained the target shape data shown in Fig. 2. The blue plots represent original data while the red plots are tilted at an angle of 45°. The profile analysis provided the target thickness after 45-degree rotation as 15.8 mm at the center, 14.3 mm at $x = \pm 10$ mm, and 7.40 mm at $y = \pm 20$ mm.

In summary, we evaluated the target profile in the SAMURAI 30 experiment, taking into account the target tilting with respect to the beam direction through the three-dimensional analysis of the target cell.

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