Development of a new configuration for the liquid hydrogen target

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This study reports the development of a new configuration for the liquid hydrogen target, using a cryogenic proton and alpha target system (CRYPTA).[1)] We study the complete kinematics of p(^{10}Be, pd) reactions at 230 MeV/nucleon. Recoil protons and deuterons exhibits a large scattering angular range (0°–70°). To cover these particles, we develop a new configuration for the liquid hydrogen target system located inside the CAesium iodide array for γ-ray Transitions in Atomic Nuclei at high isospin Asymmetry (CATANA)[2)] frame.

Figure 1(a) shows the conceptional image of the new configuration and (b) shows the internal structure of the vacuum chamber. A 70-cc copper (Cu) buffer tank is connected to the first stage of a Gifford-McMohon cycle refrigerator (ULVAC R20) using a 45-cm long Cu pipe. A SUS O-ring is used to avoid leakage, and a small Cu ring is inserted to improve heat conductivity. The target cell is made of oxygen-free Cu and connected to the buffer tank by two Cu tubes, which are used for inlet (green) and outlet (magenta), respectively. Havar foil with a thickness of 6.5 μm was glued to the Cu window of the target cell and sandwiched by a Kapton ring. Figure 1(c) shows the size of the target cell. The thickness of the target cell is 15 mm. The deformation of the Havar foil was measured to be 2 mm with a difference of 1.2 atm. In the new configuration, the target cell is located at the downstream side of the vacuum chamber near the exit window (Fig. 1(b)). The chamber will be inserted into the CATANA frame. As a result, the center of the target is 25 cm more downstream than the center of the cryogenic head along the beam direction, thus covering a solid angle of approximately 2π.

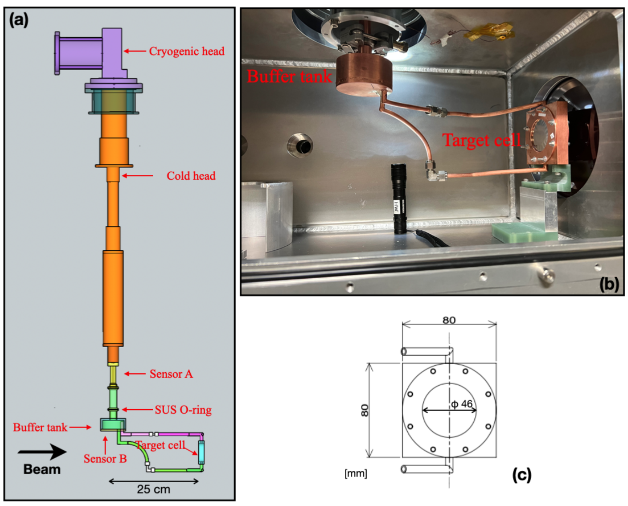

Fig. 1. New configuration: (a) conceptional image; (b) inside of the vacuum chamber; (c) the size of the target cell.

Temperature is monitored using two silicon diode thermometers (Scientific Instruments Si410AA). The thermometers are labeled as "Sensor A" (SA) (placed below the heater) and "Sensor B" (SB) (placed at the bottom of the buffer tank) (Fig. 1(a)). Figure 2 shows the variation in temperature and pressure with cooling time in a cooling test. The target cell and buffer tank was firstly pumped out at room temperature. It took less than 3 hours to cool SA from room temperature to 20 K, whereas SB was at 25 K. Then the heater started to operate and SA was maintained at 20 K. SB was cooled down to approximately 24 K with vacuum, and the system achieved dynamic equilibrium. Hydrogen gas was filled into the cell at 1650 hPa and liquefied near the cold head. Liquid hydrogen flew down gradually and cooled the system down to 21 K (Fig. 2(b)). Finally, the pressure was stabled at 1111 hPa, which is 33% lower than the pressure at which hydrogen gas was filled, indicating that the buffer tank and target cell was fully filled by liquid hydrogen. It took approximately 1.5 hours to completely filled the buffer tank and target cell. In the new configuration, it takes 4.5 hours to cool down and fully fill the system with liquid hydrogen.

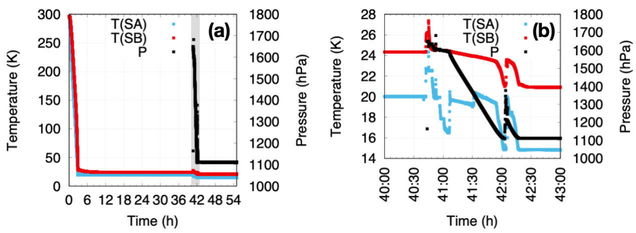

Fig. 2. Variation in temperature and pressure with time in a cooling test: (a) overall variation; (b) zoom-in view of the hatch area illustrated in (a).

In summary, we have developed a new configuration for the liquid hydrogen target system based on CRYPTA. By implanting the buffer tank, the target cell is placed near the center of CATANA. The system will be used first in the SAMURAI-53 experiment. Moreover, such a new configuration can be applied to the DALI2 array to study in-beam γ-ray spectroscopy.

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