The stability of the liquid hydrogen target system during the SAMURAI 30 experiment

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The charge-exchange (p,n) reactions in inverse kinematics are powerful tools to study the spin-isospin response of light nuclei. In general, Polyethylene (CH_2) is used as the hydrogen target to induce the (p,n) reactions, because it is easy to handle and has uniform thickness. However, the background generated from the carbon in CH_2 is serious.

In the SAMURAI 30 experiment, a thick liquid hydrogen target (LHT)[1] was used to perform the measurements of the (p,n) reactions with a high reaction rate and lower background from carbon. It was required to keep the temperature of the target cell below the boiling point of hydrogen during the measurement. In this report, the stability of the temperature and pressure of the LHT system during the SAMURAI 30 beam time is reported.

The setup of the LHT system is described in Ref. 1). A Gifford-McMahon cycle (GM) refrigerator was used to keep the target cell at a low temperature in order to liquefy the hydrogen. A heat shield covered by aluminum foil was installed around the target cell to prevent heat inflow from the room temperature environment. A Cu tube was used to connect the target cell to the GM refrigerator, to which a heater was attached to control the temperature.

The temperatures of the target cell and the Cu tube were measured using a Si diode thermometer. In the SAMURAI 30 experiment, hydrogen gas with a pressure of 812 hPa was filled into the cell after cooling down the system. The pressure decreased to around 500 hPa when the hydrogen gas was liquefied. Under such conditions, the temperature of the target cell should be kept lower than 18 K during the measurement in order to keep the hydrogen in liquid form.

Figure 1 shows the variations of the temperature and gas pressure with time after the hydrogen gas was liquefied. The temperature was found to be instable during the first 8 hours. The temperatures of the target cell and the Cu tube increased steadily. In order to lower the temperature, the temperature of the water in the chiller was decreased from 22°C to 8°C. However, it was found that this operation had almost no influence on the temperature of the LHT system. The temperature increased gradually, as shown in Fig. 1, but the liquid phase was maintained at just below the boiling point. The temperature of the target cell stabilized at 18.3 K after the pressure of the hydrogen was added to 710 hPa. However, for some reason, a rapid decrease in temperature and pressure was observed 4 hours later. When the temperature of the Cu tube decreased to 14.7 K, the heater started working. The temperature of the target cell was kept at about 15 K and the gas pressure was stable at 705 hPa. The LHT system was maintained at a stable temperature and pressure for more than 8 hours.

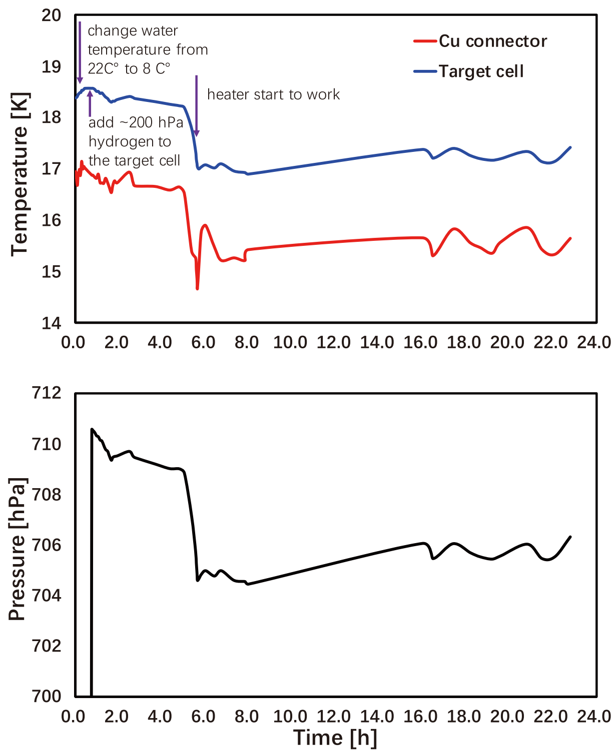

Fig. 1. Variations of the temperature (top panel) and gas pressure (bottom panel) with time. The temperature was measured for both the target cell (blue line) and the Cu connector (red line).

In summary, in the SAMURAI 30 experiment, the instability of the LHT system was observed during the first 8 hours of the beam time. During the rest of the beam time, the fluctuation of the temperature and pressure of the LHT system were less than 1.5% and 1%, respectively. Further investigation is necessary to achieve stable control of the system temperature and pressure for a long time.

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Reference

1) H. Ryuto *et al.*, Nucl. Instrum. Methods Phys. Res. A **555**, 1 (2005).