Helium filling method for SAMURAI spectrometer†

V. Panin,[*1] S. Chebotaryov,[*1,*2] S. Sakaguchi,[*3] E. Milman,[*1,*2] N. Chiga,[*1] Z. Elekes,[*4] B. Heffron,[*5] S. Leblond,[*6] T. Lokotko,[*6] and H. Otsu[*1]

A helium filling method was developed for the SAMURAI spectrometer and successfully tested in the SAMURAI13 experiment. The method allowed the use of an extra-large exit window to maximize the geometrical acceptance of the spectrometer and preserved the acceptable momentum resolution for charged particles by minimizing multiple scattering in the gas with a small Z number.

A schematic layout of the He-filling system is shown in Fig. 1. The vacuum extension duct, neutron window, and large "megane" flange of the spectrometer were replaced by a large window with a total area of 5.2×1 m^2. The design of the exit window was based on a previously tested prototype.[1)] Two O_2 sensors were placed inside the SAMURAI gap to monitor the concentration of air in a volume of $\sim$10 m^3. Helium was supplied into the gap at a rate of 20 L/min via an injection flange, which also contained feedthroughs for signal cables from the O_2 sensors. In addition, an internal pressure monitor was attached to the injection flange to control gas pressure inside the gap. Another external monitor measured ambient pressure in the experimental area. The data from the O_2 and pressure sensors were monitored and recorded on the external PC. During He injection, the air-He mixture was freely exhausted to the atmosphere via NW25 port. Slow gas ventilation allowed maintaining a pressure nearly equal to atmospheric pressure inside the gap without significant stress on the exit window.

The results are summarized in Fig. 2. The operation was performed in three stages. During the first period ($\sim$11 h), a He concentration of 76% was reached. Subsequently, He injection was interrupted, and the exhaust port was sealed for 11 h to check the leak rate. No leak was observed during this period, and the final ventilation was performed to reach the desired He content of $\sim$95%. The concentration was maintained at this level throughout 13 consecutive days without continuous gas supply and keeping a sealed ejection port. In the following, an insignificant air leak of $\sim$2 L/day into the gap was observed, which was partially compensated by adding small amounts of helium once per two days. No significant changes (<1 mbar) in the internal pressure relative to the exterior were observed during and after the ventilation procedure. Small fluctuations of the absolute pressure coincided with the ambient pressure due to changing weather conditions as can be seen in Fig. 2.

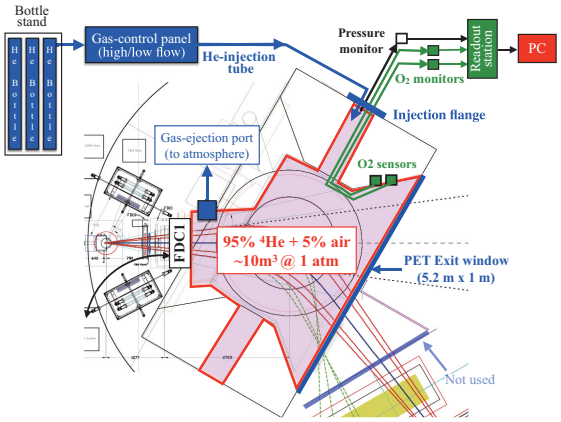

Fig. 1. Schematic layout of the He-filling system. The red shaded area indicates the volume filled by helium.

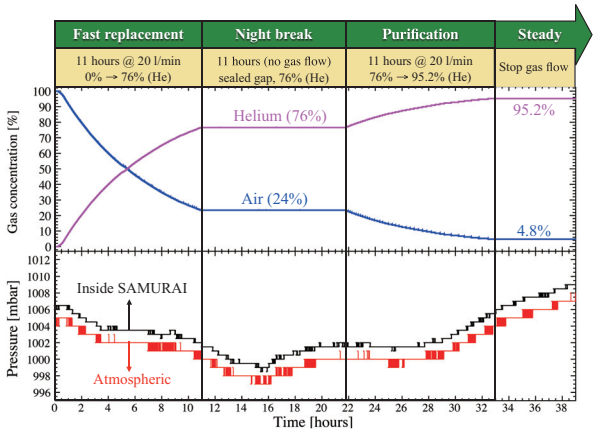

Fig. 2. He-filling performance with SAMURAI. Top figure: gas concentration in the gap as a function of time, estimated from the measurements in O_2 sensors. Bottom figure: data form the internal and external pressure monitors.

The presented results clearly demonstrate the feasibility of the He-filling of the SAMURAI spectrometer. The method can be potentially applied in the upcoming experiments at SAMURAI, for example, in heavy-ion-proton measurements, which require the maximum geometrical acceptance for protons in the focal plane owing to 90° rotation of the spectrometer.

*1 RIKEN Nishina Center
*2 Department of Physics, Kyungpook National University
*3 Department of Physics, Kyushu University
*4 Institute for Nuclear Research, MTA Atomki
*5 Oak Ridge National Laboratory
*6 Department of Physics, University of Hong Kong

Reference

1) V. Panin et al., RIKEN Accel. Prog. Rep. **49**, 168 (2016).