Liquid He cyropanel test for the K150 cyclotron

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This year, the K150 cyropanel was tested with liquid nitrogen and liquid helium for the first time since its installation in 2013. The cyropanel is shown in Fig. 1, while it was under construction. The cyropanel is made of copper and consists of an inner chamber intended for liquid helium surrounded by an outer chamber intended for liquid nitrogen. The cyropanel has a large surface area and is placed in the cyclotron in such a manner as to allow the removal of residual gases throughout the cyclotron chamber. At temperatures less than 20 K, achievable with such a device, the cyropanel can pump and remove any residual oxygen, nitrogen and argon present in the cyclotron chamber and thus improve the transmission for heavy ion beams.

Fig. 1. The K150 cyropanel during its construction.

The K150 cyropanel was tested in September through November of 2022 with two different configurations and two different heavy ion beams of interest. A summary of the tests is shown in Table I and II. The first configuration for the cryopanel was the originally intended one: cooling the inner chamber with liquid He and the outer chamber with liquid nitrogen. In this mode, the cyropanel improved the measured cyclotron chamber vacuum from $9.0*10^{-7}$ torr to $6.0*10^{-7}$ torr and consumed about 2-3 L/hr of liquid He. This setup was tested with two beams: $^{129}Xe^{31+}$ at 6.3 MeV/u and $^{197}Au^{37+}$ at 3.0 MeV/u. For ^{129}Xe, the beam transmission improved by nearly a factor 2 vs. when the cryopanel was not cold. For ^{197}Au, the beam transmission improved by a factor of 3.

Table I. Results of cyropanel tests with 129Xe31+ at 6.3 MeV/u.

Date	Cryopanel Configuration	K150 Vacuum	FC02 Reading
9/27/22	Warm	$9.0*10^{-7}$	1.4 nA
9/27/22	Liquid N_2 outer chamber, Liquid He, inner chamber	$6.0*10^{-7}$	2.2 nA
10/22/22	Warm	$9.0*10^{-7}$	0.7 nA
10/22/22	Liquid He, both chambers	$1.1*10^{-7}$	2.0 nA

Table II. Results of Cyropanel Tests with 197Au37+ at 3.0 MeV/u.

Date	Cryopanel Configuration	K150 Vacuum	FC02 Reading
11/3/22	Warm	$9.0*10^{-7}$	7 pA
11/3/22	Liquid N_2 outer chamber, Liquid He, inner chamber	$6.0*10^{-7}$	20.5 pA
11/3/22	Liquid He, both chambers	$1.1*10^{-7}$	170 pA

The second configuration tested was with both chambers of the cyropanel cooled with liquid He. In this configuration, the entire surface area of the cyropanel was cooled to less than 20K. In this mode, the measured cyclotron chamber vacuum improved from $9.0*10^{-7}$ torr (cyropanel warm) to $1.1*10^{-7}$ torr and consumed about 18-20 L/hr of liquid He. This setup was tested with the same two heavy ion beams as in the previous test. For ^{129}Xe, the beam transmission improved by a factor 3. For ^{197}Au, the beam transmission improvement was more dramatic; it improved by more than a factor of 20! This test demonstrated what was possible with the increased pumping capacity provided by the cyropanel, at the cost of higher liquid He consumption.

In conclusion, the liquid He cyropanel for the K150 cyclotron was tested and shown to improve both the cyclotron vacuum and heavy ion beam transmission for the K150. However, the available intensity for the heavy ion beams also depended on the production of high charge states by the ECR2 ion source. The combination of a higher frequency, higher power ECR ion source and the improved vacuum of the K150 cyclotron will allow the production of new heavy ion beams at higher intensity for future experiments and SEE line testing.