# Localisation of volatile isotopes on cryotraps ◇

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Neutron-induced fission of uranium enables the production of highly intense neutron-rich radioactive ion beams. Since large amounts of unwanted volatile radioactive species are also produced, an efficient method to avoid the contamination of beamline and vacuum system of the facility has to be applied. The performance of a cryotrap system (cryopanel), designed to localise gaseous radioactivity close to its origin, has been studied in the framework of radioprotection studies within the MAFF project [1] at the FRM II in Garching. These studies considering $10^{14}$ fiss/s provide important radioprotection information for the planned EURISOL facility [2] with envisaged $10^{15}$ fission events per second. The design of the cryotrap considers besides geometric requirements also activity distribution calculations. Two cryotrap prototypes has been set up for validating the simulation results.

The so-called large cryopanel (GP) was designed considering the geometry of the MAFF beam tube and consists of a double-walled tube with a length of 1 m, an outside diameter of 169 mm and a gap width of 4 mm. The six inside channels (for the cooling medium helium) show a spiral structure in order to guarantee the mechanical stability. For manufacturing the panel the thermal shrinking method was applied using Al 6061 T6 (cryogenic specification) as material. Temperature and deformation distributions of the large panel were simulated using Solid Works (finite elements method).

The small cryopanel (SP) was set up only for test purposes and for a comparison with the large panel and consists of a single bent stainless-steel tube. In order to enlarge the active pumping area the panel tube was sandwiched between two paddles. The surface ratio between large and small panel amounts to ∼18, not including the paddles.

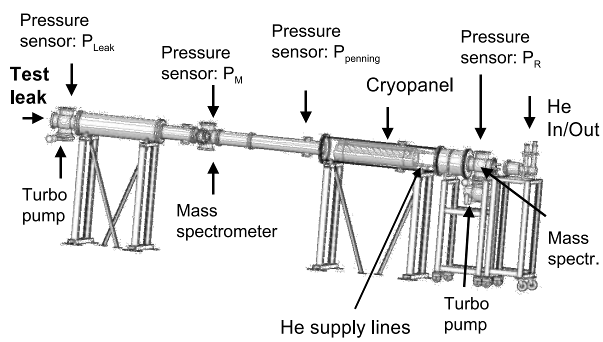


Fig. 1: Schematic view of set-up used for the tests with the cryotrap.

In Fig. 1 a schematic view of the set-up used for the tests with the cryopanel is shown. The system represents a mock-up of the MAFF beam tube. Different pressure sensors and two QMS (Quadrupole Mass Spectrometers) on both sides of the panel were used for the determination of the local residual gas pressures and different partial pressures, respectively. The cryopanels were coupled to the helium liquifier in hall 3 of the Maier-Leibnitz-Laboratorium which was operated in cold-gas mode at 10 K (required cooling power ∼380 W at 10 K).

Calculations of the radioactivity distribution in the beam line were done using the code MOVAK3D. With this Monte Carlo code simulations of trajectories of particles after their emission from their source in 3-dimensional arbitrary geometries are possible. For the MAFF beam tube geometry the calculations resulted in a retention capability of 99.98%.

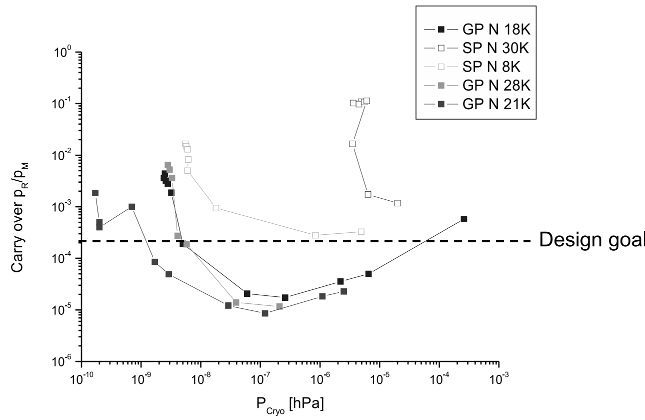


Fig. 2: The "carry over" as a function of the inlet pressure of the test leak and the panel temperatures. Indicated is the calculated retention capability/carry over of 99.98%/0.02%.

The test measurements with both panels (GP/SP) were performed using a calibrated test leak with different gases (nitrogen, argon, krypton). The plot in Fig. 2 shows the resulting "carry over" $P_R/P_M$ (corresponds to the complement of the retention capability) for different temperatures of the panels. Clearly visible is the result for the large panel (GP), showing that for realistic operational pressure values the calculated retention capability (99.98% $\equiv$ carry over $\sim 2\cdot10^{-4}$) of the cryopanel could be verified. The tests showed also that an operation below a temperature of 20 K is not needed, nevertheless a thermal shielding is favourable in order to ensure a homogeneous pumping capability of the cryopanel. Concerning the mechanical stability of the large panel one result of the tests was an appearing internal leakage most likely due to a welding seam developing this leak under thermal stress. In addition to this mechanical effect the large panel showed temperature inhomogeneities due to the gas flow characteristics inside resulting from the spiral structure (affirmed by simulations). Therefore, the next prototype cryopanel which is presently under construction shows a simplified design in order to avoid these inhomogeneities.

## References

[1] D. Habs et al., Nucl. Instr. Meth. B204 (2003), 739.
[2] The EURISOL report, *http://www.ganil.fr/eurisol/Final_Report.html*.

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