Study for Stopping and Extraction of SHIP Separated Ions in a Buffer Gas Cell - RFQ Ion Guide System

P.G. Thirolf, J. Ott, P. Reiter, U. Schramm, and D. Habs, Sektion Physik der LMU München
V. Varentsov, V.G. Khlopin Radium Institute, St. Petersburg, Russian Federation
for the SHIPTRAP collaboration

The SHIPTRAP project aims at the delivery of very clean and cooled singly-charged recoil ions from the SHIP facility at GSI [1]. After suppressing the primary beam in the SHIP separator, the recoil ions will be stopped in a buffer gas cell, extracted into an RFQ ion guide system for bunching and cooling and finally injected into a Penning-trap system for precision experiments.
Key element of the setup is the buffer gas cell, where recoil ions from fusion reactions will be stopped in a small volume before being fast and efficiently extracted into the RFQ cooler and buncher channel. Experimental studies and calculations indicate that 50%- 90% of most radionuclides of interest would be contained within a spheroid of 20mm diameter and 50mm length.

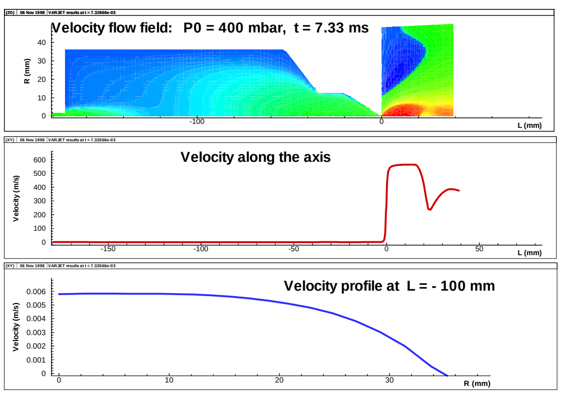

Figure 1: Gas dynamical calculation for a gas cell with 400 mbar Ar and a nozzle diameter of 0.5 mm. The resulting velocity field in the sub- and supersonic region is shown together with the projections in longitudinal and radial direction.

In order to optimize the geometry of the gas cell, gas dynamical calculations have been performed to study the influence of the overall shape, the gas inlet and the extraction nozzle. In these calculations the full set of time dependent Navier-Stokes equations has been solved, taking into account the existence of a Mach disk inside the supersonic gas jet after the nozzle with a subsequent subsonic flow [2]. The calculations have been performed assuming the buffer gas to be a continuous, compressible, viscous and heat conducting medium. In this model precise results can be obtained for the steady gas flow inside the gas cell as well as of the complex shock wave structure in the nozzle and the free jet expansion flow in the extraction chamber regime. Fig. 1(top) displays the velocity field in a gas cell with a pressure of 400 mbar Ar, where the abscissa denotes the distance from the extraction nozzle throat with a diameter of 0.5 mm. The highest velocities occur just after the nozzle, while the darker shaded region at larger radial distances indicates low flow velocities. Due to the negligible flow velocities inside the stopping chamber (middle part of Fig. 1) any design of the gas inlet part of the gas cell can be chosen without influence on the performance of the stopping cell. On the other hand, for a fast and efficient extraction of the stopped ions (forming a supersonic, expanding jet after the nozzle) adequate electrical guiding fields are needed. Due to the high gas pressure the ions will excactly follow the field lines. Using individual potential electrodes raises the problem of a partially defocusing field between two rings, which will lead to ion losses. However, the alternative solution of a cone coated with homogeneous resistivity faces severe technical problems. Once the ions reach the nozzle throat, the ion motion will be dominated by the gas flow, dragging them into a supersonic jet into the vacuum regime. A quadrupole mass spectrometer will be used to detect the extracted ions. Presently an optimized design of the stopping chamber is in progress.
In order to prepare for test experiments a test beamline has been set up at the Munich accelerator laboratory to prepare for in-beam stopping and extraction tests. The presently available pumping speed allows for a gas cell pressure of 100 mbar Ar and a diameter of the Laval nozzle of 0.5 mm, aiming at an ambient pressure in the extraction section of 0.1 mbar. Fig. 2 shows the design study of the gas cell with its entrance window for the recoil ions, the exit nozzle and the first stage of the RFQ ion guide structure.
Since the extraction efficiency from the gas cell is critically dependent on the purity of the stopping gas the design of a high-purity gas-handling system is presently in progress.

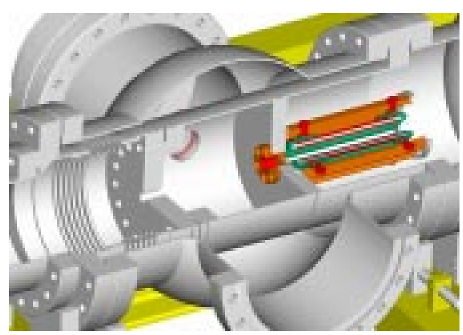

Figure 2: Design schematics of the test setup for the buffer gas cell (with an entrance window to the accelerator beamline), the exit nozzle and the first section of the RFQ ion guide.

References

[1] Proposal for SHIPTRAP (1998)
[2] V. Varentsov et al., Nucl. Instr. Meth.**A413** (1998) 447