Measurements with the Gas Cell and Extraction RFQ for SHIPTRAP ◇

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1. Set-up

In the SHIPTRAP project the gas cell design together with the extraction RFQ is expected to be one of the critical parts. Therefore a gas cell study program was initiated in Munich and a prototype gas cell has been designed for tests at the Tandem Accelerator in Garching and for first tests at SHIP [1].

1.1 Concept

The prototype of the gas cell for SHIPTRAP follows the concept of extracting the ions via the gas flow and guiding electrostatic fields. These two mechanisms can be simulated separately in first order, due to the special feature of a high transmission grid in front of the nozzle. This grid prevents a loss of ions in the defocusing field inside the nozzle and improves the focusing inside the cell due to a spherical shape. The extraction RFQ separates the ions from the neutral gas.

1.2 Test set-up

The prototype gas cell has a length and a diameter of 100 mm. The guiding field inside the cell is created by three electrodes and a spherical grid covering the supersonic nozzle with an inner diameter of 0.6 mm. The subsonic part of the nozzle has a conical shape to achieve gas velocities high enough to drag the ions through the nozzle [2].

The design of the extraction RFQ and the electronics profits from the work done at ISOLTRAP and GSI in the past three years [3]. Compared to the structures used there the extraction RFQ of SHIPTRAP is a short structure with 12 segments and a total length of 120 mm. The diameter of the rods is 11 mm with an aperture (diameter) of 10 mm. The ions are mass selective detected in a QMS followed by a MSP (Micro Sphere Plate) [4]. The test set-up is shown schematically in Fig. 1.

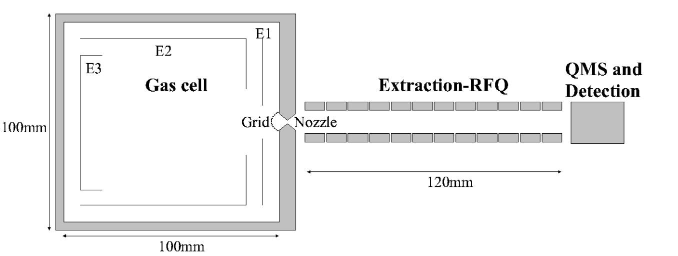

Fig. 1: The SHIPTRAP test set-up consisting of the gas cell with the three electrodes (E1, E2, E3) and a nozzle covered by a high transmission grid, the extraction RFQ as a differential pumping section and the QMS and Detection section for a mass selective ion detection.

2. Simulations

The simulations covered the following topics: stopping of the ions in the gas (SRIM); drag of the ions via the electrical field in the cell towards a supersonic nozzle (SIMION); drag of the ions through the nozzle via the gas flow (VARJET, solving the full system of time dependent Navier-Stokes equations [5]).

First stopping simulations indicate that, whatever gas is used, a majority (50 to 90%) of most radionuclides of interest could be stopped within a spheroid of 40 mm diameter and 70 mm length (for ^{232}Th at 100 keV/u in He at 50 mbar). To these values one has to add the horizontal and vertical SHIP-beam dimensions of 50 mm and 30 mm. These simulations imply the minimum dimensions for the innermost electrode of the final gas cell for SHIPTRAP.

3. Measurements

First measurements with the gas cell showed a clear dependence of the ion focusing towards the nozzle and the grid in front of the nozzle. The grid allows to achieve faster extraction times due to higher voltages applicable in the cell. These higher voltages lead to a stronger defocusing of the ions. However, this drawback can be compensated by the better focusing properties of the grid.

Fig. 2 shows measured TOF's of Ni and Er ions at different pressures and voltages in the cell.

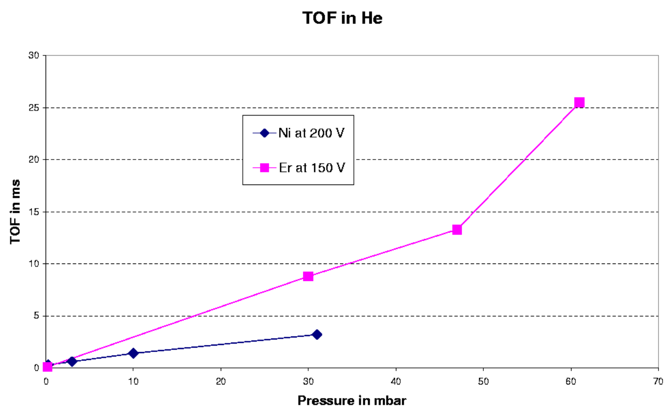

Fig. 2: Measurement of the TOF of Ni and Er ions in dependence of gas pressure and voltage inside the cell (electrode E2).

First measurements with laser ionized Ni and Er in the gas cell were performed to optimize the voltages in the cell and the RFQ. Based on this the extraction times in dependence of the gas pressure and the voltage inside the cell were studied. A voltage difference of 10 V was between the first and last segment of the extraction RFQ together with an rf-voltage of 200V_{pp} at 1.2 MHz was applied to guide the ions to the mass selective ion detection system. An improved gas cell, based on these exp riences is under construction. The new cell will allow higher voltages in the cell and is designed to stop and extract 90% of the ion cloud.

References

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