Characterisation of the MLL-IonCatcher Performance ◇

J.B. Neumayr, D. Habs, S. Heinz, M. Helmecke, V.S. Kolhinen, M. Sewtz, J. Szerypo, P.G. Thirolf, and the SHIPTRAP collaboration

In parallel to successful highly precise mass measurements at SHIPTRAP with reaction products from the SHIP facility [1], optimisation efforts concerning the efficiency of the used ion-catcher device are going on at GSI, as well as at the MLL. With the MLL-IonCatcher an improved device has been set up for further improvement studies [2] and for a physics program together with the MLLTRAP [3], which is presently set-up at the MLL.

The design of the MLL-IonCatcher, schematically shown in Fig. 1, is based on experiences gained with the SHIPTRAP buffer-gas cell. The stopping chamber has a length of 500 mm and a diameter of 200 mm, while the extraction chamber, containing the RFQ ion guide with a length of 320 mm, is based on a DN150/DN200 cross. Compared to the almost perpendicular ion injection (relative to the extraction axis) at SHIPTRAP, the MLL-IonCatcher was exclusively designed for a parallel injection, resulting in a changed geometry of the stopping volume.

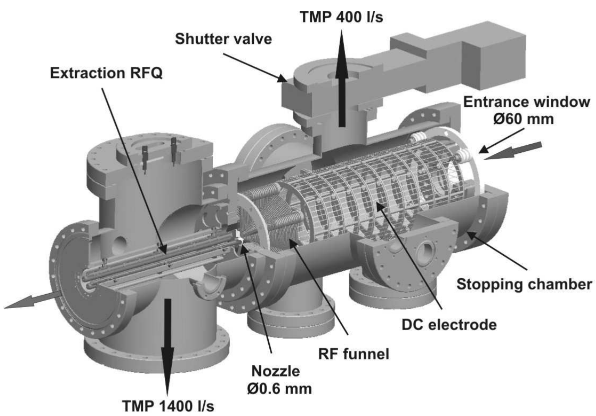

Fig. 1: Schematic view of the MLL-IonCatcher.

Compared to the SHIPTRAP ion catcher, the geometry of the extraction nozzle was not changed and the RFQ and the DC electrode inside the cell were only adapted to the different sizes of the chambers, while several modifications were applied to the RF funnel in order to achieve higher repulsive fields in the electrode region near the nozzle. There the funnel of the MLL-IonCatcher consists of ring electrodes with a thickness/distance of 0.5 mm, while the first funnel of the SHIPTRAP buffer-gas cell (as described in [3]) consisted exclusively of electrodes with a thickness/distance of 1 mm. These modifications were in the meanwhile also inserted into the funnel geometry at SHIPTRAP.

As the SHIPTRAP buffer-gas cell, the MLL-IonCatcher was characterised at the MLL using the Munich test set-up [4], where for the tests ^{152}Er was produced via the reaction ^{121}Sb(^{35}Cl,4n). The number of injected and extracted test ions was determined via the detection of the specific α-decay energy of ^{152}Er. The measurements were performed with helium gas pressures between 40 mbar and 140 mbar and an entrance window (Ti) with a thickness of 3.5 μm. Inside the stopping chamber DC gradients of 2-4 V/cm were used and an RF voltage of 180-200 V_{pp} at 800 kHz was applied to the funnel. The extraction RFQ was operated with an RF voltage between 60-120 V_{pp} at 800-1100 kHz and a DC gradient of 0.2 V/cm. In Fig. 2 the overall efficiency as a function of the buffer-gas pressure is shown exemplarily. A common, non-optimised set of DC and RF voltages was used to find a relative optimum of the stopping efficiency. The maximum efficiency of ∼10.5% for these parameters was reached in the range of 90-100 mbar. Compared to the measurements with the SHIPTRAP buffer-gas cell [3], the efficiency maximum was reached in a higher pressure region (90-100 mbar instead of 40-50 mbar), due to a thinner entrance foil (3.5 μm instead of 4 μm) and an improved transport efficiency of the RF funnel. Based on the optimum gas pressure of around 100 mbar, the optimisation of all other operational parameters resulted in a maximum overall efficiency of the set-up of about 16.4%±1.1%.

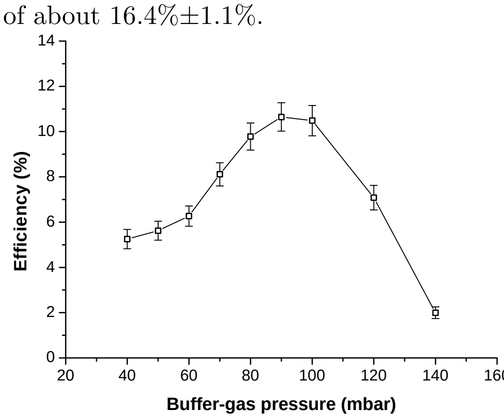

Fig. 2: The overall stopping and extraction efficiency for ^{152}Er ions as a function of the helium buffer-gas pressure.

The improvement of the overall efficiency is also correlated with developments concerning the material of the entrance window. The presently thinnest available metallic foil (Ti) in pinhole free quality (thickness 3.5 μm) limits the transmission through the window to ion energies of ≥180 keV/u (Z∼80). Since experiments foreseen at SHIPTRAP and at MAFFTRAP will require the acceptance of recoil ion energies down to ∼50 keV/u, presently tests of thin (1-3 μm) polyimide foils are performed, where pressure and temperature stability of these foils are studied as well as their impact on the required UHV conditions. Concerning the purity of the system, further optimisation efforts will involve studying the effect of cryopanels inside the cell for the localisation of contaminations.

References

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