Design work of rf ion guide system at the SLOWRI facility

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We are developing an rf ion guide[1)] gas catcher cell at the SLOWRI facility towards online commissioning in FY2017. We initially designed a large traveling wave rf carpet for the ion transport in the gas cell. The carpet had such a large capacitance due to its large area of 600 cm^2 with 0.28 mm pitch and 0.14 mm separation for stripe electrodes that the resonance frequency was less than 1 MHz to obtain a voltage greater than100 $V_{p.p.}$.

We designed a new configuration that consists of three-stage rf transport electrodes as shown in Fig. 1 so as to reduce the areas of the rf carpets. The first electrode is composed of DC, RF+DC, gap, RF+DC, and DC parts with long strip electrodes. It produces a hemisphere's electrostatic potential to collect thermalized ions onto the central RF+DC parts. When the ions reach close to the electrode surface, they are guided to the gap by the rf ion guide method,[1)] extracted from the gap, and pulled onto the second electrode by electrostatic fields between the first and the second electrodes. We utilize the ion surfing method[2)] to transport the ions downstream with a traveling wave produced with superimposed RF and AF fields. When the ions arrive at the downstream edge, they are again pulled onto the third electrode, transported to an exit hole, and extracted to the outside of the gas cell. We plan to place a block in front of the third electrode to avoid the direct impinging of ion beams on the electrode. This scheme has an advantage in that He ions, which create space charge, produced by beam thermalization can be killed on the first electrode because of the small mobility of He ions. Although the ion surfing method provides faster transport compared with the conventional rf ion guide method, it is more susceptible to a space charge effect. This is why we selectively use the two methods.

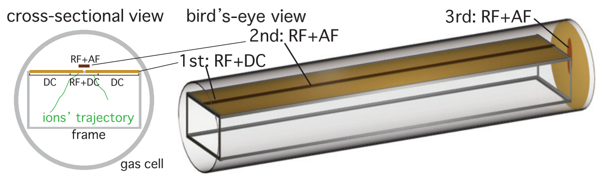

Fig. 1. New design of the rf ion guide system in the gas cell. The size of the cuboid frame is 160×260×1470 mm.

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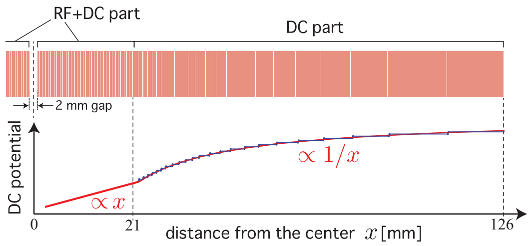

Fig. 2. Enlarged drawing of a part of the first-stage electrode.

The DC potential configuration on the first electrode determines the amount of ions collected in a narrow region, which is important to reduce the area of an RF part. Because the ion's motion simply follows the lines of the electric field, a $\propto 1/x$ potential produced by a point charge would be the best solution to focus ions. In order to emulate such a field, we designed a DC part as shown in the Fig. 2 by changing the width of each electrode. The blue line in Fig. 2 shows the potential with a constant voltage step between the adjacent electrodes and the red line shows a $\propto 1/x$ potential on the DC part and a $\propto x$ potential on the RF+DC part. We also confirmed that the $\propto 1/x$ potential produces the best focusing ion collection among three types of potentials ($\propto 1/x$, $\propto x$, and $\propto \log(x)$) in SIMION simulations. From the simulation result, we set the area of each RF+DC part as 121 cm^2 (25 mm×485 mm) with 0.32 mm pitch and 0.16 mm separation. We expect that the capacitance will be reasonably small and we can apply an rf voltage at several MHz with sufficient voltages for the rf ion guide. We will start an rf test with an actual electrode soon.

Simulations for space charge in this configuration are also in progress. The simulation is based on a state-of-art simulation code "3DCylPIC"[3)] in coorperation with Dr. Ringle from NSCL. In the simulation for the case of the incoming beams in the mid-heavy mass region, preliminary results show that this system will be tolerable to an incoming beam intensity of 10^6 pps.

We finalized the design of the first-stage rf carpet. The designs of the second- and the third-stage electrode will also be finalized soon. We plan to start offline tests of the rf transport system using ion sources from Mar. 2017 and conduct online commissioning in the later half of FY2017.

References

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2) G. Bollen: Int. J. Mass Spectrom. **299**, 131 (2011).
3) R. Ringle: Int. J. Mass. Spectrom. **303** 42 (2011).