Heavy ion guide: beam transport and diagnostics

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Our present plans for a heavy-ion guide system are based on developments at Argonne National Laboratory (ANL) [1]. For the heavy-ion guide, preselection of ions will be done using a superconducting solenoid similar to that being used now in the BigSol spectrometer. Earlier tests with a 1 m long gas cell at low input intensities (below 10^7 ion/sec) have been carried out at ANL with beams up to 4 MeV/A and at GSI with initial beams of 280 MeV/A to check the stopping efficiency. Consistent results with stopping and extraction efficiencies close to 40% have been obtained in both tests with realistic pressures of 100 to 200 mbar and helium pumping speeds less than 3000 m^3/hr. Similar results, but with significantly higher load, up to 10^9 ion/sec, were obtained on a modified ANL gas catcher (RIA gas catcher prototype) [2]. This is very important result, since using deep inelastic collisions, we expect high production rates for a large range of secondary ions [3]. Currently complete set of parts for two similar gas catchers are being manufactured for ANL and TAMU.

After extraction from the gas cell 1+ ions will be delivered to the charge breeding ECR source where they will be stripped to a high charge state and then the highly charged ions will be injected into and accelerated by the K500 cyclotron. Starting from the original production of radioactive species and after, including collection, extraction and transport to the injection point, we need to control the efficiencies of each stage.

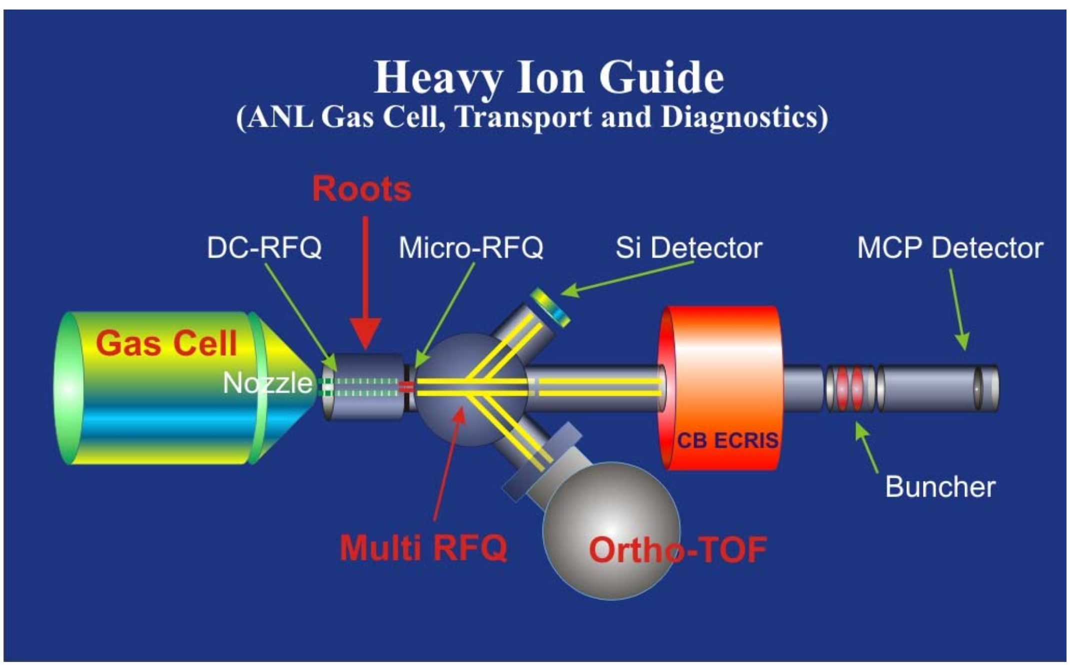

Figure 1. Schematic of heavy ion guide (ANL gas cell, transport and diagnostics).

Fig. 1 schematically shows a suggested secondary beam transport and diagnostic system. After extraction the secondary beam enters a Multi-RFQ beam transport system where the exit direction is defined with the help of three mobile central branching segments of the RFQ (see Fig.2) [4]. The beam can go straight or be deflected 45^{o} relative to the central axis. There are two curved and one straight segment and their position can be adjusted with the help of a remotely controlled elevator. One of 45^{o} branches will be connected with the orthogonal electrostatic time-of-flight mass spectrometer (Ortho-TOF) shown in Fig. 3.

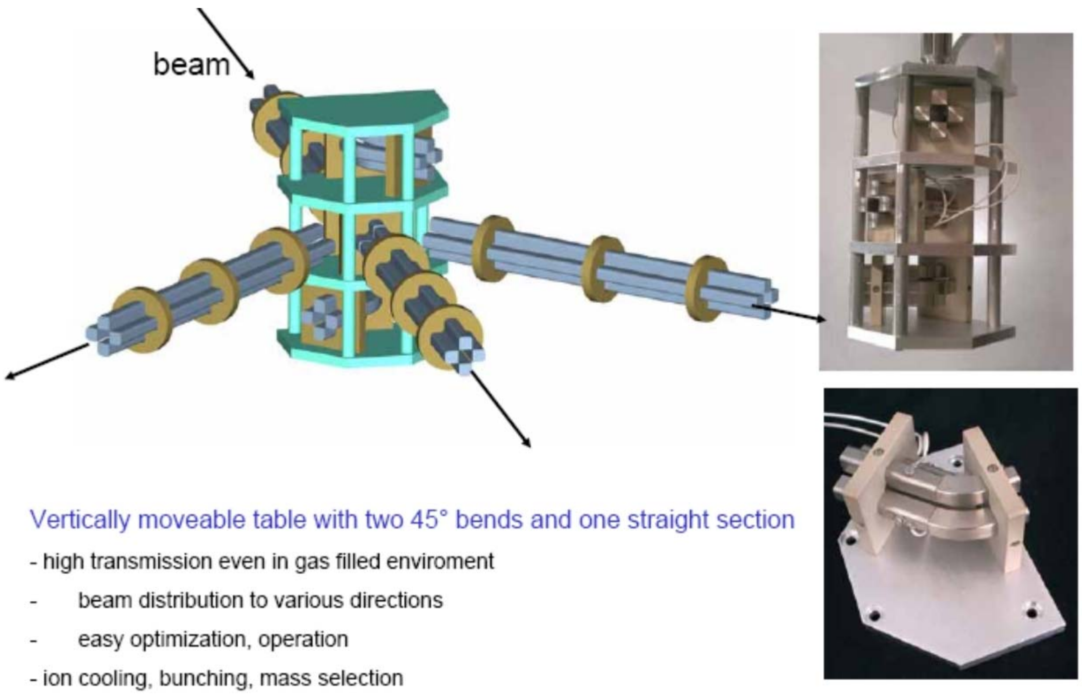

Figure 2. Multi-RFQ beam transport system.

After entering the Ortho-TOF, 1+ ions will be accelerated up to 6 keV energy via a pulsed electrostatic accelerator and will travel towards the bottom of the 1.7 m long cylinder. At the bottom of the cylinder, using double stage electrostatic reflector, ions will make a U-turn and move up to the microchannel plate (MCP) timing detector located in the same plane as the accelerator. By measuring time-of-flight we can determine the masses of the ions. The Ortho-TOF has a resolution of one part in 5000 at ,inimum, which is more then enough to determine masses of the ions with an accuracy of better then 1 a.e.m. On the other 45 degree branch a solid state Si detector will be mounted, which also allows to define the yield of the radioactive ions by measuring decay curves of short lived ß activities. Ortho-TOF coupled with Multi-RFQ system was earlier designed at Giessen University and experimentally proved itself as a precise and easy to operate tool [5].

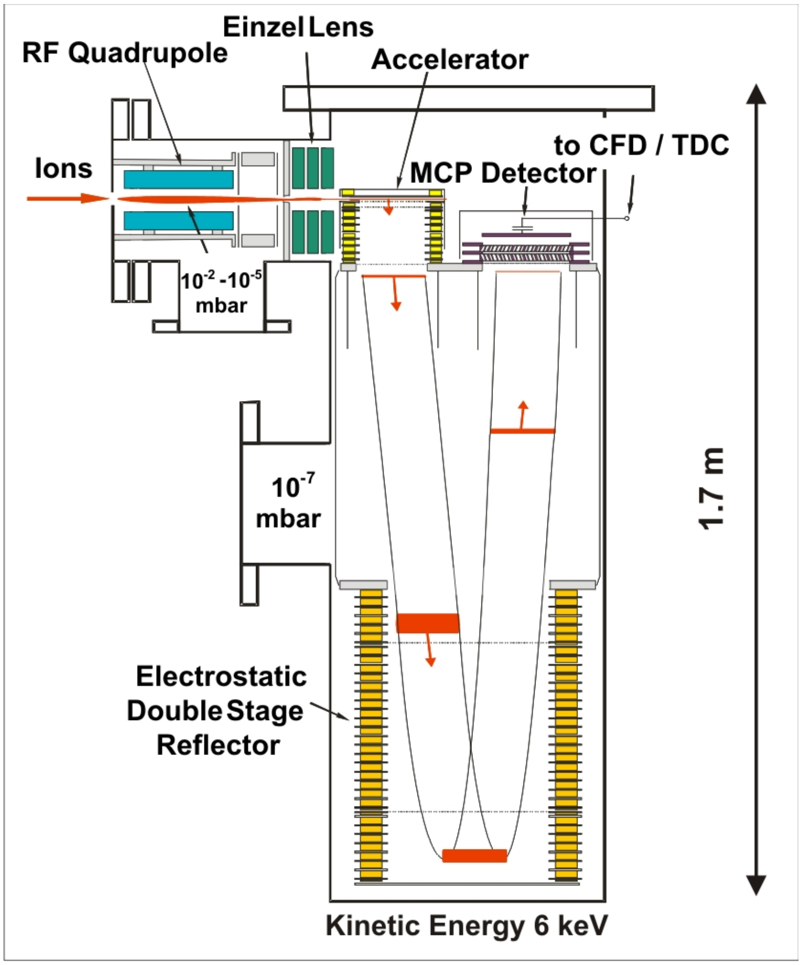

Figure 3. Layout of the orthogonal electrostatic time-of-flight mass spectrometer.

It is also very important to find out final number of recharged secondary radioactive ions after the Charge Breeder. Due to the long flight path from the Charge Breeder to the injection point and very low velocity of the radioactive ions time-of-flight system may be used. This is possible to achieve by placing beam buncher right after the Charge Breeder and removable MCP timing detector close to the injection point.

The Heavy Ion Guide is a product of close collaboration between TAMU Cyclotron Institute, Argonne National Laboratory, Giessen University-GSI and NSCL Michigan State University.

1. G. Savard *et al.*, Nucl. Instrum. Methos Phys. Res. **B204**, 582586 (2003).
2. G. Savard (private communication).
3. G. A. Souliotis *et al.*, Nucl. Instrum. Methods Phys. Res. **B204**, 166 (2003).
4. W. R. Plass (private communication).
5. S. Eliseev, PhD Thesis, Justus-Liebig University, Giessen, 2004.