Development of a Stopping Chamber and a Radio-Frequency Quadrupole Ion Guide for the SHIPTRAP Project ◊

J. Ott, H. Backe [a], J. Dilling [b], T. Faestermann, D. Habs, P. Kienle, H. J. Körner, A. Kolbe, W. Lauth [a], R.B. Moore [c], U. Schramm, M. Sewtz [a], P. G. Thirolf, H. F. Wirth, and the SHIPTRAP Collaboration

[a] Universität Mainz, Institut für Kernphysik, Becherweg 45, D-55099 Mainz
[b] GSI, Postfach 110552, D-64220 Darmstadt [c] McGill University, Montreal, H3A 2B1, Canada

1. The SHIPTRAP project

In order to extend the scope of various experiments in chemistry, atomic and nuclear physics to transuranium elements a letter of intent 'Precision mass measurement of radioactive ions in a Penning trap after mass separation, deceleration and cooling' had been submitted to the Experimentierausschuß of GSI. It is already approved and the collaboration was strongly encouraged to continue.

An overview of the planned facility is shown in Fig. 1 and a more detailed description is given in ref. [1]. The system consists of a stopping chamber, an ion extraction system, an ion bunching system and an ISOLTRAP [2–4] like double Penning trap mass spectrometer. The ions coming from the velocity filter SHIP are thermalized in the noble gas within the stopping chamber (similar to that described in ref. [5]) and come to rest with an abundance of about 80 % as singly charged ions. These are guided by electric fields outside the chamber into the extraction system. This is essentially an open quadrupole four rod structure which confines the ions to its axis. The axial transport of the ions towards the bunching system is performed with an additional axial DC field [6]. This part (operated at a noble gas pressure of about 1 mbar) also represents the first stage of a differential pumping system, in which the pressure has to be lowered from about 100 mbar in the stopping chamber to 10^{-5} mbar in the purification trap. The second pumping stage is again an axially segmented quadrupole rod system, but of lower aperture and operated at 10^{-3} mbar, similar to that which presently is developed for the ISOLTRAP facility [7]. The end segments of this structure are designed to provide a 10 V deep potential trap which is used to collect the ions and inject them as (preliminary) bunches into a cylindrical Penning trap. In this purification trap the contaminating isotopic and isobaric background is suppressed by a factor of up to 10^5 with a mass resolving power of up to 10^5 [3].

The pulsed beam leaving this first Penning trap is very pure and has low emittance. It can be either injected into a second (hyperbolic) Penning trap for high precision mass measurements or guided by electrostatic deflectors to other experimental set-ups, e.g. Laser spectroscopy or chemistry.

2. Developments in Munich

At the Munich accelerator laboratory prototypes of the stopping chamber and extraction system will be built and tested. The design goals for the prototype stopping chamber are to stop A≈115 ions within a spherical volume of about 25 mm diameter and transport them within a millisecond and a total efficiency of more than 50% through the nozzle. The ion cloud size in the chamber is determined by a planned major modification of the SHIP ion optical properties which will provide a beam spot of about 20×20 mm^2 at the entrance window and the straggling of the stopped ions. The design value for the mass number is given by the fact that the reaction ^{58}Ni + ^{58}Ni with calculated cross sections of up to more than 100 mbarn will be a good first test measurement at GSI. The transport efficiency of the quadrupole structure is expected to be more than 95%.

With this prototype design it will be possible to investigate nuclei in the vicinity of the doubly magic nucleus ^{100}Sn. Later on the stopping and extraction system will be adopted for the requirements of heavy and super heavy element research. Thus in the long term such a set-up also may be used at the Munich fission fragment accelerator [8].

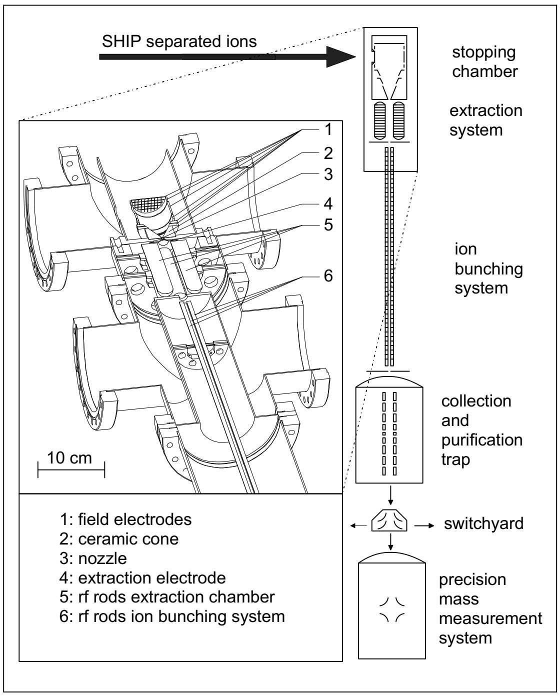

Fig. 1: Overview of the SHIPTRAP facility. The insert shows the stopping chamber and extraction system in more detail. These parts will be built and tested in Munich.

References

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◊ This work is supported by the European Commission under TMR contract ERB4062PL975008