A new particle detector manipulator for ESR, CRYRING and HESR*

C. Brandau[1,2,4], *R. Reifarth*[3], *M. Heil*[2], *A. Müller*[4], *A. Gumberidze*[1,2], *A. Hennig*[2,5], *C. Kozhuharov*[2], *S. Litvinov*[2], *Yu.A. Litvinov*[2,6], *B. Mei*[2,3], *M. Meister*[2], *G. Rastrepina*[2,3], *and T. Stöhlker*[2,7,8]

[1]EMMI/FIAS, Darmstadt; [2]GSI, Darmstadt; [3]Universität Frankfurt; [4]Universität Gießen; [5]Universität Köln; [6]MPI-K, Heidelberg; [7]Helmholtz-Institut Jena; [8]Universität Jena

In a collaboration of GSI, EMMI and the universities Frankfurt and Giessen, a new particle detector manipulator for use at storage rings is presently being designed (Fig. 1). A central feature of this new device is that all detector installations can be completely retracted and can be separated from the ring vacuum using suitable translational motion devices and gate valves. With this design we obtain a high degree of flexibility that allows for easy and quick changes in the set-up between two experiments even with in-vacuum detectors. This new manipulator is ideally adapted to the high vacuum requirements ($\sim 10^{-11}$ mbar) of storage rings such as the ESR, the CRYRING@GSI and the HESR. After opening for service, only the small volume of the bellow has to be heated and not the full ring sector. For the movement of the detector, both, a step motor for slow, fine-tunable movement of the full travel distance, and an additional pneumatic drive for fast short-distance travels (e.g. out/in during injection) are foreseen.

Installation of different modules offers a wide range of applications such as: (i) The use of detector pockets with metal-foil windows for detectors that cannot operate in the ultra-high vacuum of the ring. (ii) In-vacuum window-less detectors for atomic and nuclear collision studies at low ion energies. For example, such a low ion energy is favorable for precision x-ray spectroscopy (low Doppler shift) but also for nuclear reactions around the Coulomb barrier or around the Gamov window. (iii) Arbitrarily positionable scraper or slit systems. (iv) Thin-foil in-vacuum detectors for time-of-flight, particle tracking or even in-ring channeling experiments.

It is planned to have two prototype systems set up, tested and put into operation in the ESR's first dipole magnets in the south and the north arc, respectively, by the end of 2013. Especially for the ESR, the present design allows for the installation of detectors *in* the dipole magnets (C-type). A special optional detector mount enables the placement of a detector in-vacuum on the inside of the ring. A first experiment envisaged at the ESR is the measurement of (p,γ) cross sections in inverse kinematics near or at astrophysically interesting energies for the p-process [1]. The p-process nucleosynthesis is responsible for the production of the rare, proton-rich heavy isotopes (p-nuclei) that cannot be made by neutron-induced processes. It occurs in supernovae, where (p,γ) and (γ,n) reactions modify the seed of s- and r- nuclei at high temperatures. A second immediate application with detectors in the ESR dipole magnets arises for atomic collision studies employing a permanently stochastically cooled ion beam. The electron cooler is then available as a full-time free-electron target for precision

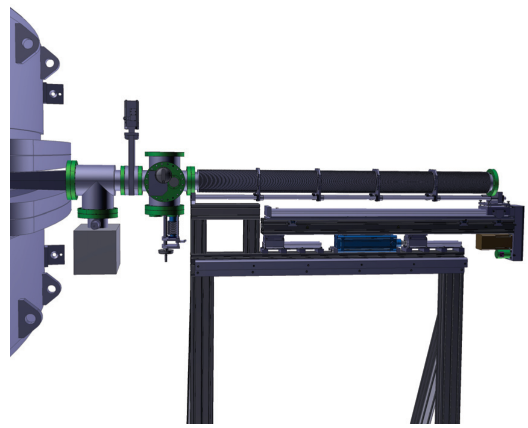

Figure 1: Design study of a detector manipulator for implementation at the ESR, or CRYRING@GSI and HESR. The mobile part of the assembly can be retracted and disconnected from the ring-vacuum by means of gate valves.

collision-spectroscopy experiments [2, 3]. For stochastic cooling the ion beam is stored on an orbit in the outside of the of the ring at a displacement of $\delta p/p = +1\%$. For this setting recombined ions hit the wall before the nominal particle detector positions in the scraper chambers [2]. Therefore, for cooler experiments with such ring settings a detector position inside the first dipole close to the exit of the magnet is required. Experiments with a stochastically cold beam open many new opportunities and significant enhancements over the standard measurement procedure at the cooler (cf. [2, 3]). With stochastic cooling beam losses due to cooling are essentially negligible and the beam lifetime in the ring is hours up to days. For example, this helps to make at least an order of magnitude more efficient use of expensive beams such as radioisotopes and additionally improves the duty cycle by a factor of 2-4. The technique also increases the available collision energy range from 0 up to 200 keV, and appears ideally suited for lifetime studies via recombination resonances. As discussed in [4] it may also be a very important building brick towards experimental verification of the elusive process of nuclear excitation by electron capture (NEEC) [4].

References

[1] Q. Zhong, et al., J Phys: Conf. Ser. **202** (2010) 012011.

[2] D. Bernhardt et al., Phys. Rev. A **783** (2011), 020701.

[3] C. Brandau and C. Kozhuharov, in: Atom. Proc. in Basic and Appl. Phys., Springer, V. Shevelko and H. Tawara (Eds.), (2012) 283ff.

[4] A. Pálffy, et al., Phys. Lett. B **661** (2008) 330.

* Work is supported by BMBF (contracts 06GI911I and 06GI7127/05P12R6FAN), by the Alliance Program of the Helmholtz Association (HA216/EMMI), by the HGF Young Investigators Project VH-NG-327 and by HIC for FAIR.