SPARC experiments with highly charged ions at the HESR of FAIR

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Synopsis One of the aims of the SPARC collaboration [1] at FAIR is to perform precision atomic physics experiments with highly charged heavy ions at the High Energy Storage Ring (HESR). An internal target is indispensably an integral part for many such experiments. Ions with different charge states, which are obtained as a result of interaction of an ion beam with the target, need to be effectively separated and detected. In this work we present ion optical studies unambiguously showing the feasibility of SPARC experiments at the HESR.

The SPARC collaboration at FAIR [1] aims at atomic physics research with highly charged ions (HCI) in energy domains previously not accessible for precision experiments [2,3]. Here, the High Energy Storage Ring (HESR) will allow for storing stochastically and/or electron cooled HCIs up to energies of ~5 A GeV.

The missing dipole concept in the HESR enables an installation of internal target stations [4] in two arcs (ROI 1 and 2) [5] (see Figure 1).

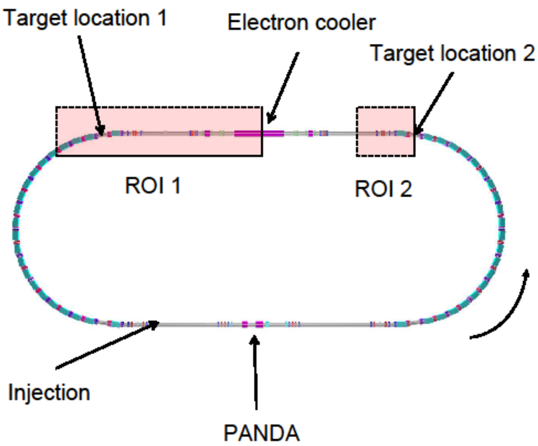

Figure 1. Two target locations in the HESR and the corresponding regions of interest (ROI) can be seen.

The experimental conditions in the ROI 1 region, which was initially proposed for the SPARC target location [6], have a complication: ions, recombined in the electron cooler and the rest gas along the long straight section, will produce an unwanted background. This situation is avoided in the ROI 2 case resulting in much cleaner experimental conditions. However, only one dipole magnet is then available for charge state separation [5]. Figure 2 shows a separation of the primary fully ionized $^{238}U^{92+}$ uranium beam (2-sigma emittance) and two charge states obtained after the reaction in the target (ROI 2). The ion optical computations prove that the resolution of the charge states at the particle detector, which is placed 3 m after the last defocusing quadrupole, is more than sufficient. For experiments with lighter beams, the separation improves further since ΔQ/Q increases [5]. As a conclusion, the experiments with internal target, placed in the missing dipole gap in ROI 2, are feasible [7]. Examples of the growing number of the proposed precision experiments in the HESR, which thus be enabled can be found in [8-14].

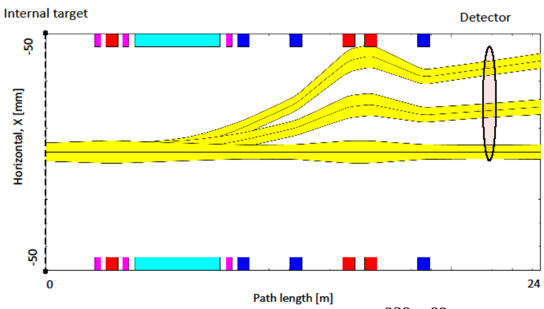

Figure 2. Propagation of primary ($^{238}U^{92+}$) and secondary charge exchange reaction products ($^{238}U^{91+}$, $^{238}U^{90+}$) after interaction with the target. The dipole magnets, focusing and defocusing quadrupoles are shown by cyan, red and blue colors, respectively [5].

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