SPARC at Storage Rings of FAIR*

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The FAIR project will be realized in stages as determined by the Modularized Start Version (MSV) [1]. Since the New Experimental Storage Ring (NESR), which is the main instrument for SPARC experiments in FAIR [3], is not within the first stage of the MSV, its realization will inevitably be delayed. Therefore, the MSV has triggered substantial efforts to investigate alternatives enabling unique experiments in the realm of atomic physics using stored and cooled ion-beams already within the MSV. Apart from the MSV program at a dedicated fix-target experimental hall, APPA-Cave, and laser-cooling experiments in SIS-100, these plans include the installation of the CRYRING at the presently operating ESR [2] and the realization of an experimental program with relativistic ions beams in the High-Energy Storage Ring (HESR) [4].

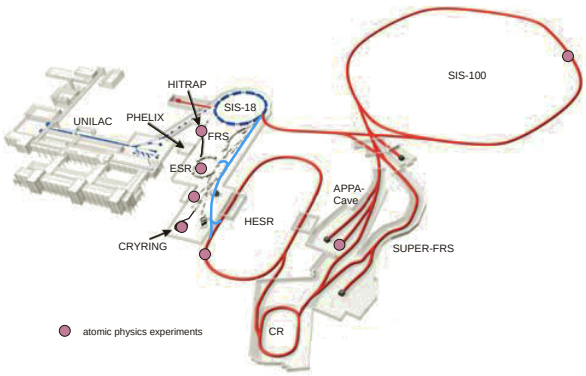

Figure 1: Schematic view of the presently operational accelerator facility at GSI (gray) and the initial phase of the future FAIR facility (red). The main locations of SPARC experiments are indicated, including the HITRAP, which is being commissioned at the ESR, and CRYRING, which is presently under construction. Possible beam lines for transport of protons and ions from SIS-18 directly to the HESR and of antiprotons and ions from HESR to the ESR are shown with light-blue color. These beam lines are currently subject of detailed investigations.

The latter was described in a dedicated feasibility study [5]. Since then the conditions for SPARC experiments were further investigated in a close collaboration with researchers from FZ Jülich. Stochastic and electron cooling of heavy ions has been studied in very detail. It was shown that – by using the available system [6] – stochastic cooling of ion beams will be possible at the injection energy of 740 MeV/u [7] as well as at the highest energies of a few GeV/u [8]. Furthermore, adding an available barrier bucket voltage will allow for a sufficient cooling of the ions also with dense internal targets [9]. The simulation of the full cycle SIS-100 → CR → HESR including bunching, cooling and acceleration has been performed [10]. These studies have shown that the SPARC experiments even with highest target densities can be performed in the HESR without any additional modifications of the HESR stochastic cooling and RF systems.

To facilitate the commissioning of the various machines of the FAIR facility, a direct beam line connecting SIS-18 and HESR could be imagined [11]. This would allow for an easier commissioning of the HESR on the one side. On the other side, since the HESR is capable to efficiently accelerate the stored beams, this would enable the exciting SPARC physics program [12] at a very early stage of FAIR, even before the commissioning of the complex accelerator chain SIS18-SIS100-CR-HESR is completed. A possible location of such a beam line is indicated in Figure 1.

With CRYRING@ESR two fully commissioned storage rings will be available, and, by installing an anti-proton transfer line, the physics program of the FLAIR collaboration could be realized at a very early stage. A possible beam line could connect the HESR with the ESR as, e.g., indicated in Figure 1. In such a case the cooled and slowed-down antiprotons would be extracted from the HESR at 9.5 Tm towards the ESR, where they would further be cooled and slowed-down to about 1.4 Tm, the injection rigidity of the CRYRING, and transferred to CRYRING.

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