

The CRYRING@ESR Project

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The low energy storage ring LSR shall provide low energy, highly charged ions and antiprotons at FAIR used by two collaborations, SPARC and FLAIR, for precision experiments. The LSR is a Swedish in-kind contribution to the FAIR facility in Darmstadt,

The LSR [1] evolves from the heavy-ion storage ring CRYRING, which has been operated at the Manne Siegbahn Laboratory in Stockholm until 2010. Instead of storing the ring components until installation at the Facility for Antiproton and Ion Research, FAIR, the immediate installation behind the existing Experimental Storage Ring, ESR, has been proposed and worked out in detail by a Swedish-German working group. The estimated efforts for installation and operation of CRYRING at the ESR have been summarized in a report [2] published by that working group in 2012.

A schematic overview of the storage ring and its facilities is shown in fig. 1. CRYRING can decelerate, cool and store heavy, highly charged ions down to a few 100 keV/nucleon. It provides a high performance electron cooler as well as a gas jet target. It is equipped with its own injector and ion source, to allow for standalone commissioning.

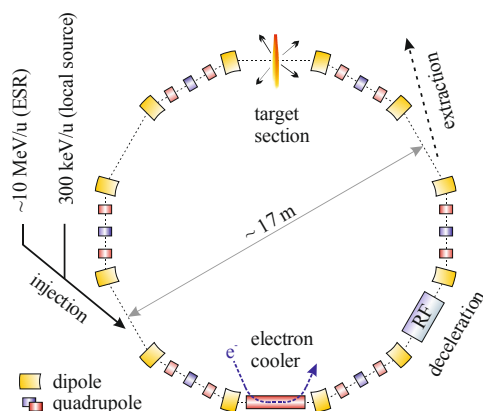


Figure 1: CRYRING at ESR.

The ions are kept in orbit by twelve 30° magnetic dipoles and a number of magnetic quadrupoles and sextupoles (not shown in the figure) in six of the twelve straight sections. The other six sections house an injection and an extraction system, the deceleration and acceleration section, and the electron cooler. One section is used for experimental installations as for instance a gas target.

The storage ring is capable of accelerating ions with mass to charge ratio below four injected at only 300 keV/nucleon from the off-line ion source to the max-

imum rigidity of 1.44 Tm. It also decelerates ions injected at the maximal rigidity down to the lower rigidity limit of 0.054 Tm. The magnets are designed for fast ramping, such that the whole decelerating (accelerating) process could be done in only 150 ms.

One of the key features is an electron cooler with adiabatic expansion of the electron beam. This yields about 100 times lower transversal electron temperature than in the ESR and yields directly higher resolution in recombination spectroscopy with merged ion – electron beams.

The proposed installation behind the ESR in combination with its own injector makes CRYRING@ESR the perfect machine for FAIR related tests of diagnostics, software and concepts on one hand, and atomic physics experiments with heavy, highly charged ions stored at low energy on the other hand.

The new control system of FAIR will be implemented for the first time in a machine that delivers beam and hence will be the perfect occasion to test not only the cooperation of the design concepts but also the performance of the system. Since the ring can be operated any time it is the perfect training ground for operators on the new control system and this allows for valuable feedback on the operational concept well in advance before the commissioning of FAIR's key machines.

Physics applications range from “classical” atomic physics experiments like the determination of the lamb shift using X-ray spectroscopy, but with increased resolution, over measurements at the borderline of atomic and nuclear physics for instance to determine the charge radius, to a yet unexplored energy regime for astrophysically interesting nuclear reactions. The details of planned experiments are laid down in the “Physics book” that is close to completion [3].

Most components have been shipped by now to GSI and on-site tests are on going. CRYRING@ESR will be installed in the existing Cave B and the necessary reconstruction work has been started.

References

- [1] H. Danared, et al. (2011) “LSR - Low-energy Storage Ring, Technical design report”, Manne-Siegbahn Laboratory, Stockholm University, version 1.3.
- [2] M. Lestinsky, et al. (2012) “CRYRING@ESR: A study group report”, Project study, GSI, Darmstadt, https://www.gsi.de/fileadmin/SPARC/documents/Cryring/ReportCryring_40ESR.PDF
- [3] M. Lestinsky, et al. (2013) “Physics Book: CRYRING@ESR”, in preparation.