THE GSI FACILITY AND THE LAYOUT FOR FAIR

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Abstract

The facility for achieving low energy radioactive ion beams or highly charged stable ion beams at GSI is briefly described. Using the HITRAP LINAC, deceleration down to 6 keV/u is foreseen for the collection of ions within an electro-static trap. Based on the present experiences, the layout of the projected FAIR facility is described.

THE PRESENT GSI FACLITY

This paper gives a short overview of the existing GSI facility to prepare the subject for the contribution of this workshop covering installations at GSI. The main purpose of the GSI facility is the acceleration of all ions from proton to Uranium with a very wide spectrum of beam parameters, see Fig. 1. Three ion source locations are operated, fulfilling different requirements concerning pulse length for fixed target beam delivery form the LINAC and the high current operation for the synchrotron SIS. The beams from the ion sources are bunched and accelerated by an RFQ and further accelerated by the efficient drift-tube LINAC of IH type. An increase of the charge state is achieved at a kinetic energy of 1.4 MeV/u e.g. in the case of Uranium from U^{4+} to U^{28+}. After a further acceleration to 11.4 MeV/u within an Alvarez DTL, a second stripping can be used to increase the charge state by a foil stripper, e.g. for Uranium to U^{73+}.

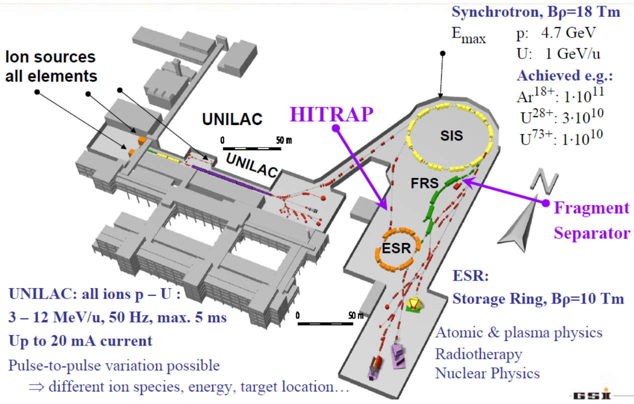

Figure 1: The existing GSI facility comprising of the LINAC UNILAC, the synchrotron SIS, the Storage Ring ESR and the target locations.

For further acceleration the ions are injected into the synchrotron SIS having a maximum magnetic rigidity of 18 Tm. This rigidity corresponds for heavy ions to about 1 GeV/u, where extraction is performed in two different manners: Either the beam is slowly extracted within typically some seconds to fixed target experiments. Namely, the Fragments Separator is used for the generation of a broad spectrum of in-flight Radioactive Ion Beams RIB, which are than investigated with different spectroscopic methods. The detection of beams slowed down by material interaction is discussed within the frame of this workshop [1]. The other extraction method from the SIS is a bunch-to-bucket transfer to the Experimental Storage Ring ESR. The charge state of the ions can be increased by a foil-stripper installed within the transfer line between SIS and ESR, the ion's kinetic energy of 300 to 500 MeV/u is large enough for complete ionization, in the case of Uranium to U^{92+}. Various nuclear and atomic physics experiments are performed with stored highly charged ions at the ESR. Electron and stochastic cooling is applied to decrease the beam emittance significantly.

The deceleration of heavy ions from the injection energy of about 300 MeV/u down to 4 MeV/u in the ESR is of interest for this workshop. Emittance enlargement is associated with the deceleration and beam cooling is required to keep the beam within the acceptance of the ESR. At injection level stochastic cooling is applied, while at an intermediate step of 30 MeV/u electron cooling is most efficient. In total about 60 s are required for the preparation of a beam of about 10^6 to 10^7 highly charged ions at a low energy of 4 MeV/u.

THE HITRAP FACLITY

The deceleration from 4 MeV/u to 6 keV/u is performed by the HITRAP facility [2, 3], for which the stepwise commissioning started in 2007 using different ion beams. This LINAC comprises of two bunchers, an IH-DTl and an RFQ as well as the ion trap are depicted in Fig. 2. The pulse length of the beam extracted within on turn inside the ESR is about 3 µs. Bunches are formed by two bunchers operate at the base frequency of 108 MHz and the 2^{nd} harmonics of 216 MHz. The functionality and a proper efficiency had been demonstrated [4]. The bunched beam is transported to an IH cavity, which is known as an efficient accelerator type for heavy ions. The nominal output is 0.5 MeV/u and deceleration was demonstrated [4]. However, the efficiency is only about 10 % which is lower than expected and a contamination of particles decelerated only to about 2.4 MeV/u was detected. The appearance of different beam energies is caused by the sensitive beam dynamics of the IH-DTL. To isolate the particles with the right energy of 0.5 MeV/u for further deceleration a horizontal dipole magnet will be installed in spring 2010 between the IH and RFQ. After this step the beam-based tests of the RFQ are foreseen with injection of a pure 0.5 MeV/u beam.

The beam diagnostics used at this decelerator is described in further articles at this workshop [5, 6] and in conference proceedings [7]. One has to state that a commissioning of a LINAC with a repetition time of only 60 s is quite unusual and calls for reliable beam diagnostics.

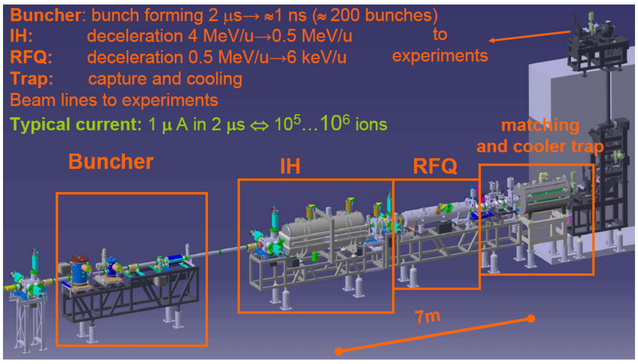

Figure 2: Sketch of the HITRAP LINAC and the Cooler Trap.

THE FAIR FACLITY

The Facility for Antiproton and Ion Research FAIR is the approved future project to be installed at the GSI site [8]. It will be the mayor facility for different communities using stable heavy ions, RIBs or anti-protons. The general layout is shown in Fig. 3. The existing GSI facility with UNILAC and SIS18 will serve as the injector chain delivering high current beams. Due to the scaling of the space charge limit in synchrotrons with the square of the ionic charge q^2, higher currents will be accelerated with low charge states; for the design ion Uranium it will be U^{28+}. To reach the optimal energy for in-flight RIB production of about 1 GeV/u the synchrotron SIS100 with 100 Tm rigidity will be built, equipped with super-conducting dipole and quadrupole magnets. The RIB production will take place at an optimized Super Fragment Separator S-FRS with a larger acceptance and therefore a factor of 100 higher transmission compared to the existing Fragment Separator. The radioactive ions can be investigated at fixed target locations including a low energy branch for slowed down RIBs [1] or the ions can be transferred to the Collector Ring CR or the New Experimental Storage Rings NESR for experimental investigations of stored high energy beams. Moreover, stable isotope beams can be stored in the NESR for various atomic physics investigations with highly charged ions.

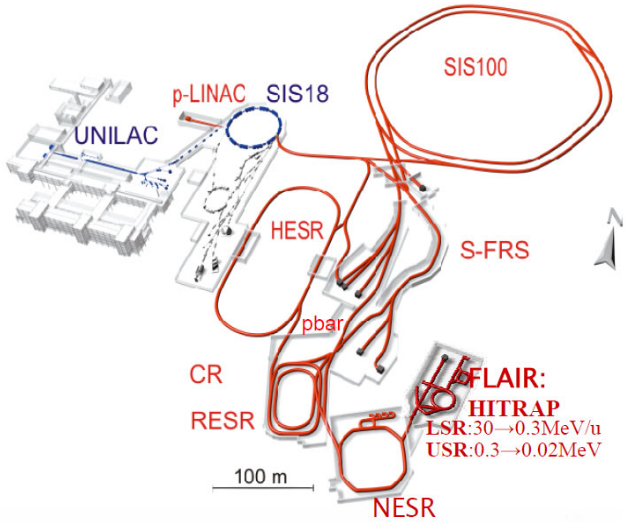

Figure 3: Sketch of the FAIR facility (red) and the existing GSI injector (blue).

Beside the program based on positive charged ions, versatile experiments with anti-protons are foreseen. A new p-LINAC is required because the UNILAC is optimized for large charge-to-mass ratio and will not deliver high currents of protons. After passing SIS18 these protons will be accelerated to 30 GeV in SIS100 and target generated anti-protons of 3 GeV kenetic energy will be stochastically cooled in the Collector Ring CR, the design intensity is 10^7 anti-protons per pulse. They will be either transferred to the High Energy Storage Ring HESR for high energy investigations or to the NESR for further deceleration. The latter branch is of interest here: Inside the NESR the anti-protons should be cooled and decelerated to 30 MeV. They can be transferred to the Low Energy Storage Ring LSR, which might be a re-installation of the existing CRYRING from Stockholm [9]. The task of this ring is further deceleration down to 0.3 MeV and a transfer to the modified HITRAP facility or to the Ultra Low Storage Ring USR, which is basically and electro-static ring, see [10] for more details.

The FAIR complex will be realized within several steps and a modular concept was recently accepted by the contributing international partners.

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