Highly charged ions at rest: The HITRAP project at GSI

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The planned HITRAP facility at GSI in Darmstadt will make highly-charged ions up to bare uranium available at very low energy. Later, HITRAP will be a central part in the low energy section, in the facility for low energy antiproton and ion research (FLAIR), at the planned international accelerator facility for research with ions and antiprotons (FAIR). There, HITRAP will not only provide low energy highly charged ions but also low energy antiprotons. First, the ions or antiprotons will be decelerated after production down to 4 MeV/u using the Experimental Storage Ring (ESR) at the present GSI facility and the New Experimental Storage Ring (NESR) followed by the Low Energy Storage Ring (LSR) at FAIR, respectively. This deceleration will be accompanied by electron cooling in the storage ring, such that the emittance of the beam does not grow. Then a linear decelerator will take over. After rebunching the beam will enter an IH structure and will be decelerated to 0.5 MeV/u. Then it will be rebunched again and sent to an RFQ decelerator. The final energy after the Radio-Frequency Quadrupole will be as low as 6 keV/u. There is no transverse cooling applied in the linear decelerator section, hence the emittance grows considerably. The beam after the RFQ will have about $100\,\pi$ mm mrad transversal emittance and an energy spread calculated to be in the order of 6%. In order to further slow down the antiprotons or highly-charged ions, the beam is captured in a Penning trap. There, electron cooling and subsequent resistive cooling will be applied to cool up to 10^5 charged particles.

A cylindrical Penning trap in a magnetic field of 6 T will be cooled to 4 K. This will ensure the best possible vacuum that is needed to store antiprotons or highly-charged ions long enough for the applied cooling. When injected into the strong magnetic field the ions or antiprotons will be decelerated further to energies below 2 keV/u. The strong magnetic field prohibits the transversal blow up of the beam in this phase. After the dynamic capture by closing the trap right in time, the ions or antiprotons will be first cooled by interaction with a dense electron plasma. After about 1 s the ions or antiprotons will be separated from the electrons and stored in a harmonic electric field region. There, resistive cooling will be applied in order to cool the particles to final temperatures close to 4 K, equivalent to energies below 1 meV. Then the ions or antiprotons will be ejected and sent to experiments in either of two ways. Slowly, that means 10^5 particles distributed over up to 10 s or fast, i.e. all particles within a few microseconds.

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