Beam Loss Studies for the AGS Booster Operation with Intermediate Charge State Heavy Ions

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Introduction

In the context of the planned operation of SIS18 and SIS100 with intermediate charge state heavy ions, the simulation code StrahlSim has been developed which couples the beam dynamics, the atomic physics and the vacuum phenomena. This code was used to carry out a comparison between the current and planned SIS18 operation and the operation of the AGS Booster at BNL [1].

Stabilization of Dynamic Pressure in SIS18

For the stabilization of the pressure dynamics in SIS18 major upgrade measures are in preparation. The upgrade of the UHV system shall lead to a static pressure of $p_0 \approx 1*10^{-12}$ mbar. It is planned to replace the existing dipole and quadrupole magnet chambers by new chambers and to develop a new bake-out system for higher bake-out temperature of 300 °C (the existing one is operated up to 200 °C). In addition, NEG coating of all magnet chambers and the revision of all existing pumps shall provide the required high local and distributed pumping speed. Finally, the upgraded effective pumping speed will be about $2*10^5$ l/s, which is about 100 times higher than the total pumping speed at present.

Moreover, a collimation system is planned for beam losses generated by ionization processes and prevent the desorbed ions and molecules from interacting with the circulating beam. Furthermore, a reduction of systematic beam losses, in particular injection losses to 5% and RF-capture losses to 1% is desired.

All calculations of the beam lifetime and pressure evolution were done using the code StrahlSim. This code includes the simulation of different beam loss mechanisms like coulomb scattering, projectile and target ionization and couples these mechanisms to the induced gas desorption, the desorption collimation system and the resulting vacuum dynamics. Furthermore, realistic numbers for beam loss during injection, RF capture, acceleration and extraction in the AGS Booster and SIS18 acceleration cycle have been included. In order to demonstrate the perspectives, simulations were carried out for higher beam intensities in SIS18 and AGS Booster.

AGS Booster Operation

In fig. 1, a comparison of StrahlSim results with measured beam intensity profiles in an AGS Booster cycle with an initial intensity of $2.6*10^9$ (which is achieved in standard operation) and $6.1*10^9$ ions is plotted. In both cases, measured and simulated beam intensity profiles are in good agreement. No fast pressure measurement does exist for the Au^{32+}-case. However, in machine experiments with beam losses of about $3*10^9$ Au^{31+} ions, a maximum pressure in the order of 10^{-5} Pa was measured in the AGS Booster.

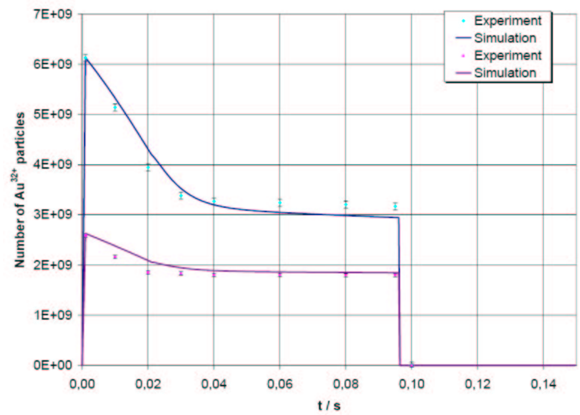

Figure 1: Calculated and measured intensity profiles in an AGS Booster cycle for different initial intensities

The results indicate that the operation with Au^{32+}-beam with an initial intensity of $6*10^9$ Au^{32+} ions can be assumed as a threshold for the AGS Booster.

At higher initial intensities and without any further upgrade measures, tremendous beam loss would occur in both synchrotrons. Due to the different injection energies, the beam lifetime in the AGS Booster is evidently lower than in SIS18. This can be explained by the much higher charge-exchange cross-sections. In SIS18, the dominant process for U^{28+} ions at the injection energy of 11.4 MeV/u is electron loss with cross sections of 10^{-18} to 10^{-17} cm^2/atom. In the AGS Booster the dominant process for Au^{32+} ions at 0.92 MeV/u is electron capture with cross sections of 10^{-17} to 10^{-16} cm^2/atom. At similar base vacuum conditions and also similar and relatively high injection losses this leads to much higher beam losses in the AGS Booster.

Furthermore, the potential operation with higher intensities in the fully upgraded SIS18 and the present AGS Booster has been simulated. SIS18 after reaching the planned upgrade parameters shows quite encouraging results evidently allowing the acceleration of U^{28+}-ion beams with intensities of 10^{11}. On the other side the planned increase of injection energy in the AGS booster will also improve the situation considerably.

References

[1] GSI-Acc-Report-2005-11-001