SIS Status Report

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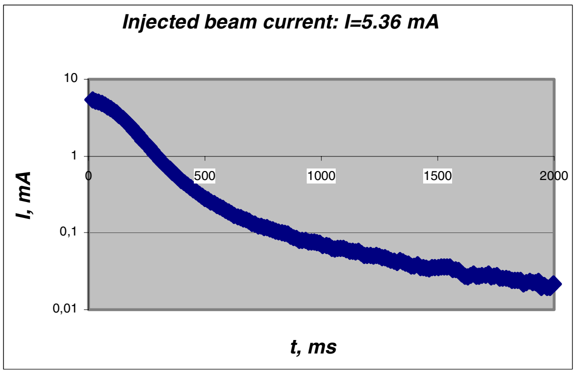
1. Status of Operation

In 2001 twelve different ion species – ^{1}H, ^{2}D, ^{6}Li, ^{12}C, ^{18}O, ^{52}Cr, ^{58}Ni, ^{86}Kr, ^{136}Xe, ^{197}Au, ^{209}Pb, and ^{238}U – were accelerated in the SIS. Altogether 6079 h of beam time were provided for experiments, often with one or more high-energy target experiments and the ESR running in a pulse-to-pulse time-sharing operation mode. Another 350 h were used for accelerator tune-up and development. The total down-time of 266 h (4 % of the total operation time) was to a large part caused by technical failures in the power supplies (59 h), the rf accelerating system (66 h), and in the vacuum system (53 h).

The total user time of 6079 h was distributed to radiotherapy with carbon ions (1313 h or 21.6 %), to production runs for target experiments (4032 h or 66.4 %), and to the ESR (729 h or 12 %).

SIS intensities for heavy ions like U^{73+}-ions were still restricted, since the new high current injector HSI at the front end of the UNILAC has not yet reached the design injection current of 2 to 4 mA. With the available current of 150 to 200 µA the SIS provided about $2 \cdot 10^{9}$ U^{73+}-ions per machine cycle. A comparable beam intensity is available for much lower injection currents using beam accumulation with a series of multi turn injections based on electron cooling.



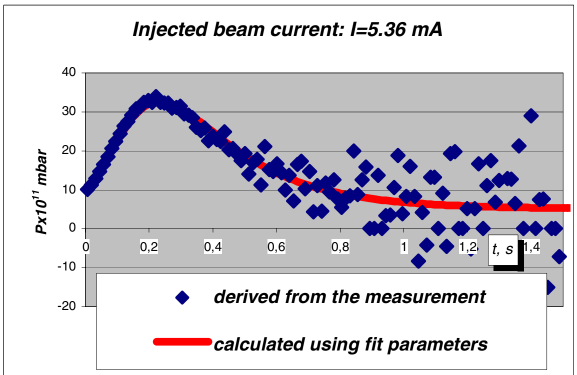


Fig. 1: SIS high intensity operation with $6 \cdot 10^{9}$ U^{28+} ions. The upper diagram shows the current decay and the lower diagram the equivalent pressure bump, which was derived from the intensity curve.

A new record beam intensity of $1 \cdot 10^{10}$ U^{28+}-ions was achieved with an injection current of about 800 µA. However, the first run with high-intensity U^{28+} beams showed strong beam losses immediately after multiturn-injection (Fig. 1). The equivalent beam lifetime was about 200 ms, while for lower beam intensities up to about $2 \cdot 10^{9}$ ions the measured beam lifetime was 3 s. These results correspond to similar observations for the storage of Pb^{29+} ions in the LEIR storage ring at CERN [1]. There it has been shown that one single heavy ion hitting the vacuum chamber can set free about 10^{4} atoms. The desorption of wall atoms leads to a pressure rise, which in case of the SIS experiment with $1 \cdot 10^{10}$ U^{28} ions resulted in an average pressure rise up to $3 \cdot 10^{-10}$ mbar and a corresponding decrease of beam life time.

A new test-facility for the study of wall desorption effects has been designed. In addition, further studies are underway to reduce injection losses as far as possible, to improve local control of beam losses with well-designed collimator systems and with high local pumping efficiency.

2. Development of SIS Machine Operation

It is obvious that the development of high-intensity beams for U^{28+} and U^{73+} ions will play a key role in the future development of SIS machine operation. The beam intensity must be raised to $2 \cdot 10^{10}$ or even $4 \cdot 10^{10}$ U^{73+} ions and to more than $1 \cdot 10^{11}$ U^{28+} ions per machine cycle.

In addition, it will be necessary to develop SIS operation in the SIS12 mode with a ramp rate of 10 T/s for the dipole magnets to approach the high mean intensity of $1 \cdot 10^{12}$ U^{28+} ions per second [2]. In June 2001 a new test run for the SIS12 mode took place. During the test run the effect of the 25 MW GSI pulse load at industrial customers was studied carefully. As shown before in 1988, the results showed again that the high pulse load cannot be tolerated by the power company. The test run was also used to check for the first time beam acceleration at a high ramp rate. Within the short test run of 2 h it could be shown that beam acceleration at a ramp rate of 5 T/s is feasible.

It is planned to provide a connection of the GSI pulse load via a separate 110 kV line to the 380 kV line at the nearby Urberach transformer station for two days in 2002 to further develop SIS12 operation at 10 T/s.

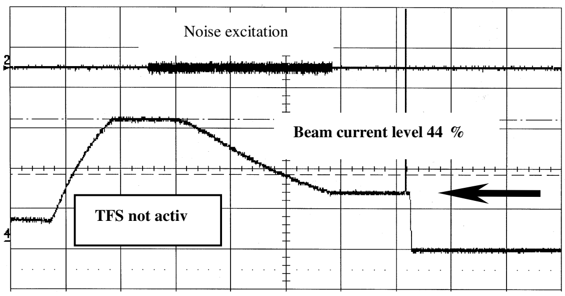
Negotiations with the power companies are under way to check, if a separate 110 kV line can be installed for permanent operation at the high pulse load of 50 to 60 MW that will be required for the SIS12 mode operation and for the proposed New Accelerator Facility.

A newly developed extraction system with an rf-noise-synthesizer locking into the revolution frequency, power amplifiers and the integration in the SIS control system is now ready for routine operation. In this scheme a transverse rf noise voltage is used to knock out ions by excitation of large radial oscillations, which lead into resonance [3]. In comparison to the usual slow-extraction scheme with two fast extraction quadrupoles, which gradually shift the horizontal tune towards the resonance at Q_h = 4 1/3 the new scheme provides excellent position stability for the extracted beam and also an easy way to interrupt the spill and to proceed with slow extraction after a short pause.

The new transverse feedback system will be used to damp coherent transverse instabilities observed during operation with cooled ion beams, e.g. with $2\cdot10^9$ U^{73+} ions. It is planned to extend the range for stable operation with cooled beams to about $5\cdot10^9$ ions. This system with two of the existing position monitor probes as pickup-system, a new feedback kicker, a new DSP processing stage (100 MHz, 12 bit), new power amplifiers, and a closed orbit suppressor system, was tested in coasting beam operation with a low intensity gold beam. Coherent horizontal beam oscillations were induced by the knock out extraction system and then damped by the new feedback system (Fig. 2). The integration of the TFS into the computer control system is underway. The vertical part of the TFS for coasting beam operation and the operation with bunched beams have to be tested.

3. New SIS Machine Components

For the control of coherent longitudinal instabilities a fast feedback in the power amplifiers of the two rf acceleration stations was developed to reduce the impedance from $R_p \simeq$ 3 kOhm to values below 1 kOhm per rf station. These studies have been continued on the test cavity. With a new design of the grid input circuit, the power amplifiers can be driven alternatively via the old low pass solution or the tuneable ferrite grid resonator. Measurements at fixed frequencies showed that the existing driver amplifiers allow reduction of the gap impedance to a value slightly below 1 kOhm. The present feedback concept is being revised to check if vacuum tube feedback amplifiers will be included for safe operation at a high radiation level.



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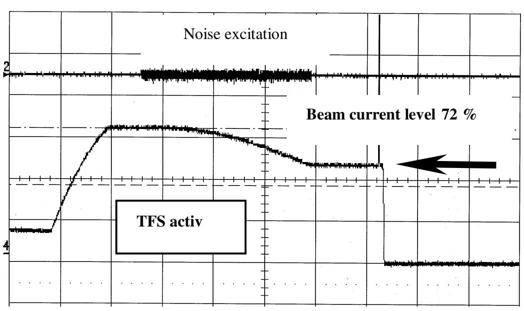

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Fig. 2: Slow resonance extraction using a transverse rf noise voltage to knock out ions by excitation of large radial oscillations, which lead into resonance (top) and damping of horizontal beam oscillations by the new transverse feedback system (bottom).

The production of the set of correction coils was delayed by the manufacturer. Meanwhile the first coils arrived and installation in the SIS will start soon. All necessary power supplies are ready for commissioning. Fig. 3 shows schematically the layout of the correction unit with a three-layer coil arrangement: a skew sextupole on a printed circuit and a skew sextupole in the inner layer and a regular correction quadrupole in the outer layer.

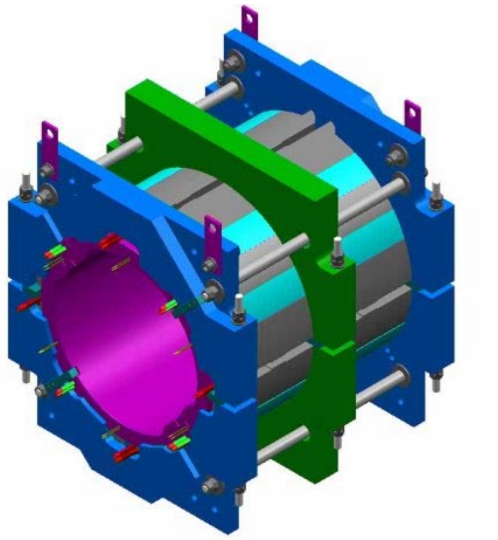

Fig. 3: Schematic layout of the new SIS correction units with a three layer coil arrangement: a skew sextupole on printed circuit board combined with skew quadrupole coils in the inner layer and a correction quadrupole in the outer layer.

For the SIS vacuum system an upgrade program is underway. The vacuum diagnostic system was improved by replacement of extractor gauges and by installation of new residual gas analysers (RGA) to provide precise information on the composition of the residual gas with good time resolution. All ion getter pumps and titanium evaporator pumps were carefully checked in a complete maintenance service.

The four bunch compressor cavities will be installed to produce a short high intensity bunch before fast extraction, e.g. a bunch with up to $2\cdot10^{11}$ U^{28+} ions of 50 ns or 10 m pulse width [4]. Each compressor cavity has an inductive load of twelve cores made of metallic alloy. Measurements on prototype cores, VITROVAC 6030 F from Vakuumschmelze and FINEMET FT-3L from Hitachi showed rf-losses twice as high as shown in the data sheets. Therefore the submission for the complete set of 48 cores had to be postponed. Meanwhile several sets of different small test cores have been developed by Allied Signal (Honeywell) using carefully selected production techniques, which seem to fulfill the requirements. GSI measurements will be available soon. In addition, the production of further test cores is being discussed with the RTI in Moscow and with the AMET Company in St. Petersburg.

References

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