ENGINEERING STATUS OF SIS100

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INTRODUCTION

The heavy ion synchrotron SIS100 is the central part of the new modularized FAIR start version. The 1083 m long lattice of SIS100 is built up of superferric magnets similar to the magnets developed for the NUCLOTRON synchrotron at JINR, Dubna [1]. Through the last years, an R&D program has been successfully performed with a focus on the optimization of the superferric magnets. Aiming for a significantly reduced AC loss, a number of model magnets and prototypes were built and tested.

After reaching the main goals of the magnet R&D and the demonstration of the fundamental understanding of the dynamic behaviour of this type of magnets, the procurement of a first pre-series dipole magnet is now under preparation. The first pre-series dipole will be tendered together with the final dipole cryostat, the bus bar system designed for integration into the SIS100, the connecting cryostats and two types of thin wall, reinforced, cooled vacuum chambers. For the preparation of these specifications, the dipole cryostat environment had to be reviewed and optimized. The cryomagnetic system is one of the most complex technical systems of SIS100. Starting from the design of the main magnets and correctors, the integration of the cryomagnetic systems is being continued as a major activity in 2010. Open integration issues related to the design of other major components and systems, e.g. the injection and extraction devices are under investigation. The integration studies and design considerations are performed with the goal to reach the final device specifications for procurement of all components within one year.

MODIFICATIONS IN THE SIS100 CRYOMAGNETIC SYSTEM

Pre-series Module and Lattice Optimization

With the goal to built and procure the first pre-series unit of the cryomagnetic system of SIS100, the design of the dipole module has been modified and completed. In context with the completion of the design of the dipole module, the overall lattice cell has been optimized with respect to the cryostat interfacing. All cryostat distances could be equalized with the advantage that all connecting cryostats and their heat shields are now the same (figure 1). The longer distance between the two dipoles of each lattice cell improves also the accommodation of the slightly elongated dipole chamber and the connecting beam line bellows. In order to maintain the acceptance of SIS100, the horizontal aperture of the elongated vacuum chamber has been increased from 115 to 120 mm. The new distance enables an installation of the adsorption pumps for hydrogen pumping, which are foreseen in each second lattice cell, in between the dipole magnets. The pre-series dipole magnet itself will feature a new coil design with half of the number of turns and a new high current cable which is being operated at twice the current of the available prototype dipole magnets (~ 13 kA) [2]. In order to minimize the cross talk between the bus bars at the higher operation currents and to account for the increased distances between the magnets, the design of the bus bar system had to be modified. The pre-series dipole module will also address the question of the chamber cooling. Chamber temperatures below 12 K are needed for an effective pumping of heavy residual gas components which are the main origin of ionization beam loss in SIS100. Therefore, two chamber types, one with active cooling by means of cooling tubes and one with contact cooling will be built and tested within the pre-series dipole. The final decision on the requirement for cooled dipole chambers will be taken according to the results of the extended version of the STRAHLSIM code [3]. The new version of this unique code enables the simulation of spatial and time resolved residual gas pressure dynamics and the related ionization beam loss. Thus, it is now possible to evaluate the impact on the dipole chamber pumping relative to the quadrupole chamber pumping on the ionization beam loss in SIS100.

Feed-in and Cold Link

A major change is under consideration with respect to the feed-in- and bypass attachment to the arc cryostat. So far, it was planned to use the missing dipole gap for the He-supply and the feed-in of the s.c. bus bar system, while the bypass lines bridging the warm sections in the straights, have been connected to the arc termination cryostat. The position of the feed-in and supply cryostat is defining the location of the main intersections between the accelerator and the parallel supply tunnel. Thus, this machine-related engineering issue has a major impact on the building planning and must therefore be finally clarified within a few months. Meanwhile, it is under study if the arc termination cryostat, slightly prolongated can be used to attach the bypass line, the bus bar feed-in and the He-supply.

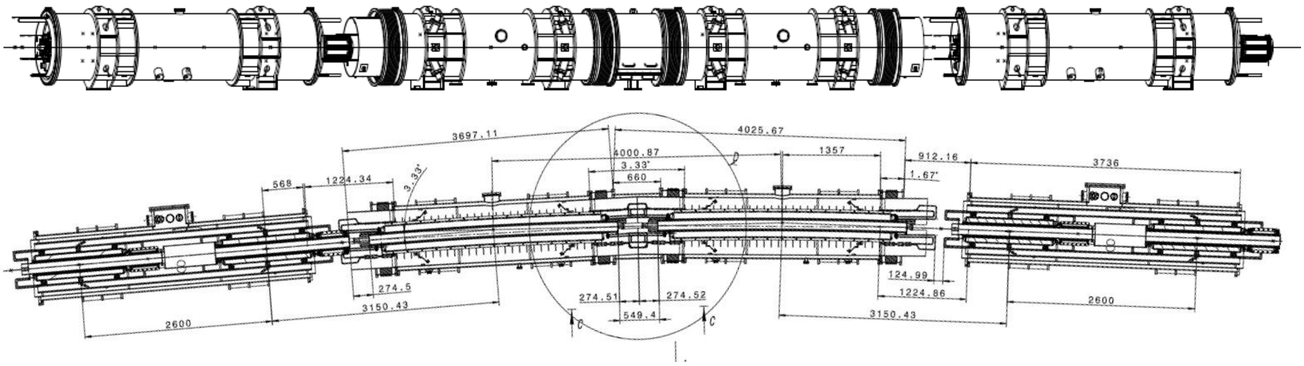

Figure 1: Modified SIS100 lattice providing equalized cryostat distances between the dipole- and quadrupole modules.

CRYOCATCHER INTEGRATION IN THE QUADRUPOLE MODULE

Exemplarily, integration studies are under way for one of the central quadrupole modules of the arc (figure 2). The presently available, however still preliminary design for the quadrupole- and corrector magnets are used for the design of the quadrupole module interior. The main quadrupole modules of the arcs contain two quadrupole magnets, a sextupole- and dipole corrector, a BPM and a cryo catcher. It is assumed that these elements are installed on a common support girder, which can also be used for pre-assembly outside the cryostat. However, the correctors are attached to the quadrupole yokes, respectively. By means of thermo-mechanical studies on the contraction process during cool down, final design decisions, e.g. on the fix points of the individual support structures are prepared.

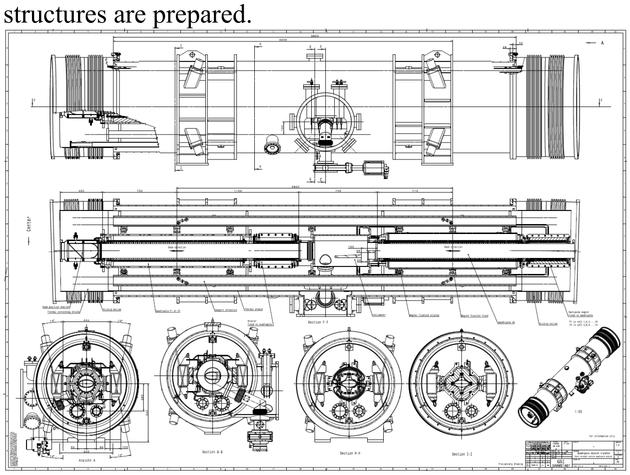

Figure 2: Integration of the cryocatcher chamber into the quadrupole cryostat. The cryocatcher is placed in between the two quadrupoles where the peak of the ionization beam loss is expected. The cryocatcher chamber is also used for pumping the beam pipe vacuum system.

Central element of the quadrupole module is the cryo catcher chamber, which serves as a fix point for the two long UHV chambers and as the main beam pipe pumping port. A prototype of the 60 cryo ion catchers is actually under development [4]. The procurement and testing of the prototype catcher is funded by the COLMAT workpackage within EUCARD. Several engineering aspects are addressed in the frame of this development.

E.g. the temperature stabilization of the catcher on an intermediate temperature level of about 50 K will be realized by a connection to the cooling pipe of the heat shield of the quadrupole cryostat. The prototype tests will proven, that by means of the higher catcher temperature no residual gas will be frozen-out on the catcher which in turn would than be desorbed by the beam ions. The cooling of the main catcher chamber, which shall act as a powerful cryopump, is assured by a copper strap connection to the He-return line. To assure a uniform temperature over the catcher chamber, different techniques are under consideration, e.g. an electroplating of the stainless steel chamber with Copper. The cryocatcher chamber will also be used as the main pumping chamber for the beam pipe vacuum system and is used to attach the quadrupole chambers from each side. The design studies include the cold warm transition for the connection of the conventional pumping system outside. The beam current on the catchers will be measured and serves as an indicator for the development of a vacuum instability and may be used as an interlock driving the emergency beam abort system. The prototype ion catcher which is actually under construction will be installed in a high energy cave at GSI and tested with Uranium beams from SIS18.

INJECTION- AND EXTRACTION DEVICES

Magnetic kicker systems

The integration of the kicker magnets into the available space in the warm section has not been solved so far. Especially the length of the missing dipole gap in front of the beam transfer system to SIS300 was to short for the accomodation of the large number of required kicker modules. In order to meet the demands on the UHV conformity, the outgassing rates of each component connected to the UHV system has to be very low. Therefore, it has been assumed that the ferrits can not be used in the UHV environment and ceramic vacuum chambers must be foreseen for the kicker magnets. However, recent measurements of the out-gassing properties of the desired ferrites have proven their applicability in pressure domains of 10^{-12} mbar [5]. Thus, it became possible to integrate several kicker moduls in a common UHV tank (figure 3). Thereby, the overall length of the kicker systems which are grouped in three per module could be significantly reduced and the integration in the available space in the extraction- and transfer straights enabled.

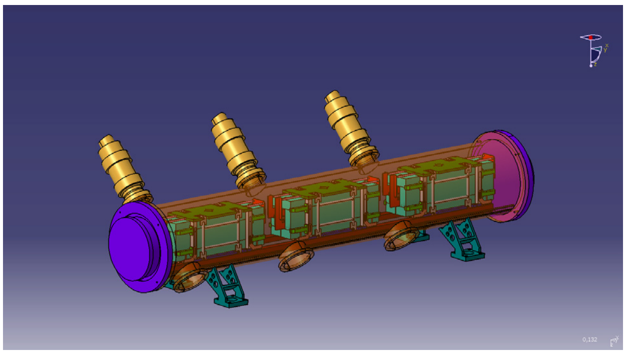

Figure 3: Sketch of the integrated kicker module with the ferrit yokes in the UHV environment.

The pulse power generator of the bipolar kicker system has been studied in detail and an electrical circuit has been proposed which avoids duplication of the PFN. However, one Thyratron is needed for each discharge direction. Remaining questions concerning the breakdown safety of the second Thyratron, at switching of the first one must be clarified experimentally. The final stage of the bipolar, pulse power generator is actually being set-up at GSI for testing.

The more compact kicker arrangement enables a larger displacement of the beam against the beam axis at the position of the magnetic extraction septum. Thus, the thickness of the plate of the first of the three magnetic septa could be increased from 8 mm to 11 mm. At slow extraction the septum must be operated in a steady state mode. At the mean electrical power of 110 kW, cooling is still an issue even with the enlarged plate thicknesses.

Electrostatic septa for high beam intensities

Due to the high specific stopping power of heavy ions ($dE/dx \sim Z^2$), at slow extraction of intense beams the septum wires are exposed to heavy beam load and heated up to temperatures of several thousand degrees.

Therefore, design studies have been performed to find a suitable and safe technical concept for the electrostatic septa. It could be shown, that by using Wolfram-Rhenium wires with a diameter of only 25 µm instead of the presently used 100 µm, the temperature rise can be restricted to values below the melting temperature. However, to account for the low tensile strength at these high temperatures, the pre-tension of each wire has to be very small. Several types of wires were tested by means of an equivalent electrical heating. The wire temperatures measured verified the expected values. A septum sample consisting of an arrangement of different wires is in preparation for installation and testing in the high energy density area at GSI. In this area, which is typically used by the plasma physics department, by means of a strong focussing system high beam densities can be achieved, comparable to the beam current density at slow extraction of SIS100 beams.

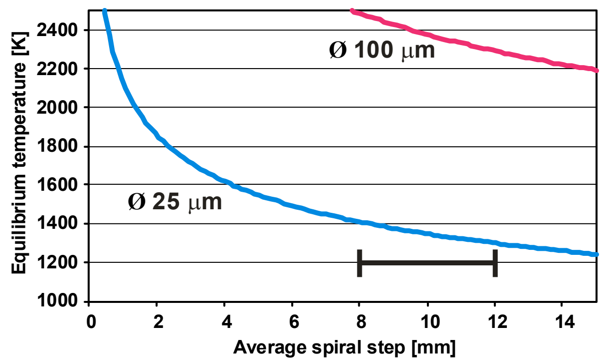

Figure 4: Equilibrium temperature of the septum wires as a function of the average spiral step of resonant particles at the electrostatic septum in SIS100 (blue): Ø25 µm W-Re25%, SIS18 (red): Ø25 µm W-Re3%. Beam: 5×10^{11} U-ions extracted over 1s. Typical spiral step: 8-12 mm.

MODIFICATIONS IN THE FAIR BEAM TRANSPORT SYSTEM

In the frame of the progressing building and civil construction planning, a number of modifications in the FAIR HEBT system were implemented. For a more effective radiation shielding, the beam transport system in front of the machine setting dump has been deflected downwards. The proton beam line has been adapted to the space requirements of the PANDA building and the beam line passing the pbar target towards the NESR, has been rearranged to accommodate radiation shielding for the Super-FRS. In the frame of the new modularization of the FAIR project, several options were studied to accommodate a new APPA target area. Presently, in close interaction with the users, the beam line system is being optimized for the experiment equipment and needs. A slight increase of the distance between the CBM building and the Super-FRS has been proposed, which would allow a later extension of the FAIR facility to the East. For the civil construction planning, major assumptions have been made for the transportation, installation and maintenance of accelerator components. The cross sections of all tunnels, the routes of transportation, the major transportation equipment and cranes were specified and summarized in a HEBT building specification document.

REFERENCES

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