THE FAIR SYNCHROTRONS SIS100 AND SIS300 AND THE HIGH ENERGY BEAM TRANSPORT SYSTEM

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Introduction

The heavy ion synchrotrons SIS100 and SIS300 are the central part of the FAIR accelerator facilities [1,2]. The two stage acceleration concept as it will be realized with SIS100 and SIS300, enables an optimisation of both synchrotrons for specific tasks and allows a real parallel experiment supply with beams of different properties. The 1083 m long lattice of SIS100 consists of superferric magnets similar to the magnets developed for the NUCLOTRON synchrotron at JINR, Dubna [3]. Superferric magnets assure a minimum cycle time by means of fast ramping with ramp rates of up to 4 T/s. At a typical SIS100 cycle time of 1.5 s, Uranium beams can be generated with an average intensity of $3x10^{11}$ ions/s. Due to the rather small aperture of superferric magnets, even at the maximum ramp rate the total pulse power does not exceed 26 MW.

Compared to the present intensity levels, the number of heavy ions per cycle has to be increased by two orders of magnitude. Space charge limits and significant beam loss in stripper stages disable a continuation of the present high charge state operation. The FAIR intensities can only be reached by lowering the charge states, e.g. by acceleration of U^{28+}-ions instead of U^{73+}-ions. However, in the energy range of SIS18 and SIS100, the intermediate charge state 28+, which is produced in the first stripper stage of the UNILAC, is typically below the equilibrium charge state. Thus at operation with intermediate charge state heavy ions, ionisation processes driven by collisions with rest gas atoms become the main issue with respect to potential beam loss in the FAIR synchrotrons. Therefore, a new synchrotron design concept had to be developed with the goal to minimize the beam-rest gas interaction and consequently the beam loss by charge change: SIS100 is the first synchrotron which has been optimised for the acceleration of high intensity, intermediate charge state, heavy ion beams [4]. Ionisation beam loss, desorption processes and pressure stabilization were the driving issues for the chosen general system layout and for several technological approaches.

Beside heavy ions, SIS100 in combination with the upgraded heavy ion synchrotron SIS18 [5,6], allows acceleration of beams of all ions from Protons to Uranium. Therefore, the SIS100 lattice has to provide sufficient flexibility to accommodate also for the high gamma operation with high intensity light ion and Proton beams. According to the needs of the different experiments, these beams must be extracted with appropriate time structures. A sophisticated extraction system layout, matching the tight constraints given by SIS300, enables fast and slow extraction and emergency dumping during any time of the acceleration process. A powerful magnetic alloy loaded RF compression system enables the generation of short single ion bunches before extraction.

SIS300 is equipped with low-loss, cos(Θ)-magnets providing ramp rates of up to 1 T/s. SIS300 may be used as a stretcher ring to deliver linac-like, uninterrupted heavy ion beams of intermediate charge states for fixed target experiments or for acceleration of highly charged ions (U^{92+}) to high energies (34 GeV/u). By sharing the acceleration and extraction process between SIS100 and SIS300, the average intensity can be considerably increased and a real parallel beam supply for different experiments is feasible.

A large number of achromatic beam transport systems, connect the three synchrotrons SIS18, SIS100 and SIS300 with the Super-Fragment Separator (Super-FRS), various areas for plasma physics, atomic physics and biophysics experiments and the antiproton production target. These systems contain the two parallel beam lines from the SIS100/300 to the production target for radioactive secondary beams. The production chain for the primary beams assures an optimal beam matching to the targets and the FAIR secondary beam facility.

DESIGN PARAMETERS

The highest heavy ion beam intensity will be achieved by means of lowering the charge states of heavy ions. So far SIS18 has been operated with highly charged heavy ions, e.g. U^{73+}. This charge state is produced by means of two stripper stages; the first stage is situated behind the UNILAC high current injector, the second stage behind the UNILAC ALVAREZ section, just before injection into SIS18. At each heavy ion stripping process, a large fraction of the particle current is lost due to the charge state distribution generated in the stripping process. E.g. at stripping from U^{28+} to U^{73+}at 11.4 MeV/u typically about 85 % of the initial particle current gets lost. Consequently, to reach the intensity goals, the transfer channel stripper will not be used for the FAIR high intensity operation. Thereby, a large fraction of the total stripping loss is being eliminated and furthermore the space charge tune shift after injection into SIS18 and SIS100 is being reduced. Table 1 summarizes the SIS100 beam parameters at Proton and Uranium operation.

Table 1: Design beam parameters for the lightest and heaviest ions in SIS100

SIS100	Protons	Uranium U^{28+}
Number of injections	4	4
Injection method	long. stacking	long. stacking
Number of ions per cycle	2.5×10^{13}	5×10^{11}
Maximum energy	29 GeV	2.7 GeV/u
Ramp rate	4 T/s	4 T/s
Beam pulse length before fast extraction	50 ns	90 - 30 ns
Extraction mode	Fast and slow	Fast and slow
Repetition frequency	0.4 Hz	0.7 Hz

Table 2 summarizes the maximum Uranium beam intensities per cycle and per second, for fast and slow extraction from SIS18, SIS100 and SIS300.

SIS100/300 DESIGN AND R&D STATUS

General System Layout

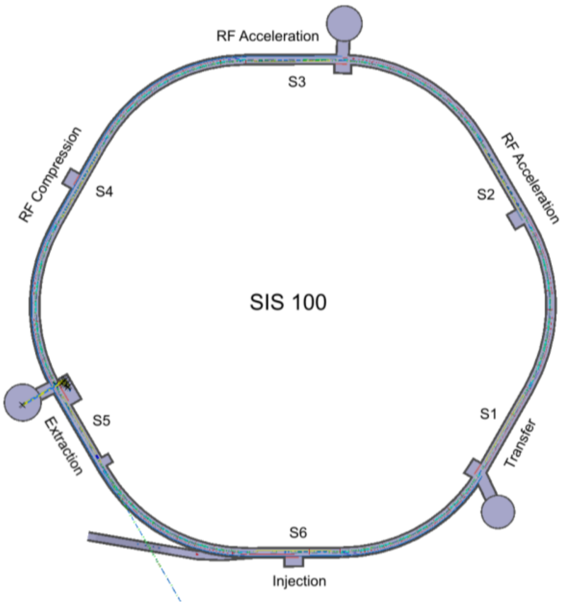

Figure 1: SIS100 with sixfold super-symmetry. The arrangement of the main technical systems is indicated.

Various geometrical structures have been considered for SIS100 and SIS300. The finally chosen sixfold super-symmetry matches the following design criteria:

- Sufficiently long, warm straight sections for the different technical systems
- Reasonable line density in the resonance diagram for large tune shift operation
- Good geometrical matching to the overall FAIR beam line topology

In order to enable an installation of SIS300 on top of SIS100 in a common ring tunnel, the geometry of both synchrotrons with their different lattice structures and different magnet technologies had to be matched carefully. The ratio of the straight section length and the arc length at a fixed circumference of five times the circumference of SIS18, is defined by the required length of warm straight sections in SIS100. E.g. the systems for fast-, slow- and emergency extraction have to fit into one of these sections. For the layout of the extraction systems the following constraints were given:

- The extraction point has to be situated precisely at the same position as the extraction point of SIS300
- The angles of the fast and slow extracted beams from SIS100 have to be the same as the angles of the beams extracted from SIS300
- The SIS100 and SIS300 beams have to continue with a constant distance in the transport lines.
- The vertically extracted SIS100 beam has to bypass the arc of SIS300.

These constraints have led to a final layout for the different extraction- and transfer systems which is based on demanding device specifications.

SIS100 Charge Separator Lattice

The lattice structure has been optimised with respect to the efficiency of a charge scraper system, consisting of six times eleven scrapers situated in the arcs of SIS100. The lattice cells are designed to act as charge separators providing a peaked distribution of ionisation beam loss along the circumference. The peaked loss distribution

Table 2: Maximum Uranium beam intensities per cycle and per second at fast and slow extraction from SIS18, SIS100 and SIS300

Uranium Beam Intensities		
SIS18 (U^{73+})	SIS100 (U^{28+})	SIS300 (U^{28+})
2×10^{10} /cycle	5×10^{11} /cycle	5×10^{11} /cycle
Slow Extraction at 1 GeV/u and 1.4 s Spill		
1.1×10^{10} /s	1.5×10^{11} /s	3.5×10^{11} /s
Fast Extraction at 1 GeV/u		
5.4×10^{10} /s	3.5×10^{11} /s	not foreseen

enables the control of ionisation beam loss by means of specially designed scrapers. A large number of different lattice structures have been investigated with respect to the fraction of ions controlled by the scrapers and the scraper distance from the beam edge. The selected doublet structure assures an almost hundred percent control of single ionised Uranium ions without affecting the synchrotron acceptance.
In addition, the lattice has to accommodate for different beam manipulations, e.g. for the generation of a single compressed bunch or for the acceleration of Protons without crossing the transition energy.
For theses purposes the SIS100 doublet lattice structure provides the following general features [7]:

- Peaked distribution and highly efficient charge scraper system for ionization beam loss
- Maximum transverse acceptance (at minimum three times the emittance at injection) at limited magnet apertures (to restrict the total pulse power and AC loss)
- Vanishing dispersion in the straight sections for high dp/p operation during compression
- Low dispersion in the arcs for high dp/p operation during compression
- Sufficient dispersion in the straight section for slow extraction with Hardt condition
- Variable transition energy (three quadrupole bus bars) for Proton operation
- Sufficient and efficient use of space for the accommodation of all components
- Accommodation of slow, fast and emergency extraction and transfer within one straight.

For the acceleration of Proton beams to 29 GeV with a final γ=32, a dedicated quadrupole setting will be used shifting the transition energy to a very high value (e.g. γ=44). This gamma transition shift is enabled by means of three independent quadrupole families (two F and one D quadrupoles) as it is regularly performed since many years in SIS18.

Ionization Beam Loss and Dynamic Vacuum

The world wide unique operation with high intensity, intermediate charge state heavy ions (e.g. U^{28+}) is one of the most demanding features of the FAIR project. Due to the high cross sections for ionisation in combination with ion induced gas desorption, significant beam loss may result from pressure bumps during the acceleration cycle.
As described before and in [4], the SIS100 lattice has been optimised for the control of ionisation beam loss with the goal to restrict the dynamics of the residual gas pressure. For the simulation of vacuum dynamics and beam loss due to charge changing processes, the program STRAHLSIM has been developed [8]. The accuracy of the STRAHLSIM results in the energy range of SIS100 could continuously be improved during the design phase of SIS100/300. The models for the ionisation cross sections [9] have been extended to relativistic energies. The new cross sections, as well as a scaling law for the desorption yield according to the specific energy deposition $(dE/dx)^2$ [10] were implemented in STRAHLSIM. However, experimental studies which approve these models for high energies are still not available.
Furthermore, the beam scrubbing effect and the dependence of the pumping speed of NEG-coated and cryogenic surfaces as a function of the number of mono-layers of the adsorbed gases have been accounted. Thereby, long term simulations and predictions on the ionization beam loss, the number of extracted ions, the pumping power, the number of monolayer and the mean residual gas pressure have been enabled.
To prepare the booster operation of SIS18 and to verify the STRAHLSIM results, machine experiments with intermediate charge state heavy ions have been started in 2001. The experiments were performed with U^{28+}- or alternatively with Ta^{24+} beams. Beams of both ions can be generated in the UNILAC with almost the same beam current of the order of 2-5 emA. Both ions have comparable cross sections for ionization. The progressing SIS18 upgrade program, which is mainly focused on the dynamic vacuum issue, as described in has meanwhile led to a major increase of the accelerated number of intermediate charge state heavy ions [11]. In the frame of the latest Ta^{24+} machine experiments, more than 10^{10} ions could be accelerated and extracted (see Figure 2).

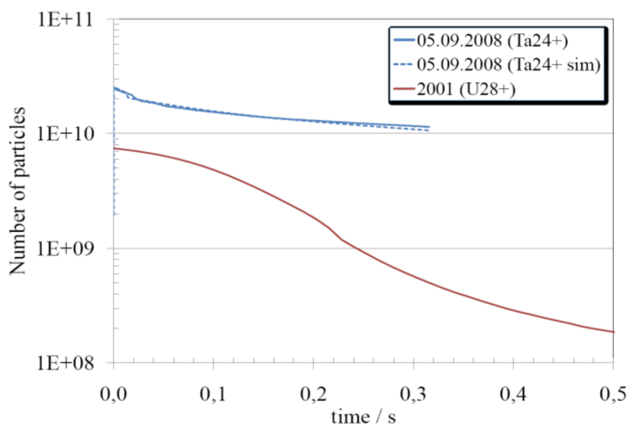

Figure 2: Comparison of the first machine experiments with high intensity intermediate charge state heavy ions in 2001, with the latest experiments performed in 2008. A significant reduction and stabilization of the ionization beam loss and the connected vacuum dynamics has been achieved.

The STRAHLSIM code comprises the following features:

- Linear beam optics with several in- und export filters
- Static vacuum simulations
- Dynamic vacuum simulations
- Beam loss due to charge changing processes

The linear beam optics module enables the calculation of the beam loss pattern due to charge change and the collimation efficiency for a given synchrotron lattice. The static and dynamic vacuum simulations are based on:

- Static pressure and static residual gas components;
- Vacuum conductance;
- Properties and pumping power of conventional pumps;
- An analytic description of the pumping power of cryogenic and NEG surfaces as a function of the pressure and temperature including saturation
- Cross sections for ionisation for different ionization degrees as a function of energy
- Desorption yield scaled with the square of the specific energy loss
- Beam scrubbing
- Coulomb scattering
- Target ionization
- Intra beam scattering
- Beam loss in a realistic accelerator cycle.

The simulations on the dynamic vacuum and the correlated ionization beam loss in SIS100 show clearly that for stable operation conditions, a strong distributed pumping system is require. The pumping power needed to achieve an acceptable low amount of ionization loss, can only be provided by NEG-coated or cryogenic surfaces. In contrary to cryogenic surfaces, the pumping power of NEG-coated surfaces drops fast if more than one monolayer of molecules has been adsorbed. It has been shown that for each additional monolayer the pumping speed drops by half an order of magnitude [12]. However, cryogenic surfaces provide strong pumping powers even for macroscopic thick layers of adsorbed gases [13]. The drop of pumping power is significantly lower. Furthermore, the reactivation of NEG-coated surfaces after saturation can only be repeated about 30 times, while croygenic surfaces can be refreshed as often as required.
Moreover, because of the highest cross sections for ionization, the scraper system is optimized for the most heavy ions. Light ions and ions with intermediate mass and heavy ions after multiple ionization miss the catchers to a certain fraction. Since the cross section for lighter ions is significantly lower, the generated pressure bumps do not create a major beam loss increase, but contributes to the grow-up of monolayers. Therefore, it is expected that the long term pumping properties of a NEG-based pumping system are not sufficient - the amount of ionization loss and generated pressure bumps may increase over time. Under these conditions the life time of the NEG-coatings may be to short and not sufficient for SIS100.

Beam Dynamics
For a better and precise prediction of beam loss driven by high current or high space charge effects the development of adequate high current beam dynamics models and simulations tools have been enforced [14]. Advanced beam dynamics simulations have been performed including non-linear longitudinal and transverse beam dynamics under the influence of space charge and collective effects. Attention has been concentrated on the long accumulation and extraction plateaus with high tune shift operation (dQ= -0.25) and synchrotron motion. Different beam loss processes have been studied carefully in order to approve the magnet quality, to localize machine activation and to prevent residual gas pressure bumps by a suitable halo scraper concept. The following items have been addressed:

- Space charge and cavity beam loading effects during the various parts of the RF cycle.
- Long-term beam loss during accumulation due to the combined effect of magnet errors, synchrotron motion and ‘frozen’ space charge at selected working points.
- The SIS100 resistive wall and kicker impedances.
- The transverse impedance budget with space charge for coasting beams (octupoles are proposed in order to stabilize the beam) [15].

Tracking, ripple and synchronisation tolerances of the synchrotrons have been studied for:

- Synchronization requirements for the quadrupoles with the dipoles
- Power supply ripple requirements for the quadrupoles
- Synchronization and ripple requirements for the dipoles with the RF

Based on the predicted beam losses, life time and activation have been estimated for those technical devices which face unavoidably heavy beam load, e.g. due to the slow extraction process. Special protection measures have been derived for radiation sensitive devices and components which have to be installed in the synchrotron tunnel.

Main Magnets
In SIS100, superferric magnets as developed for the NUKLOTRON synchrotron will be used. Based on this technology, an R&D program aiming for a further improvement of the properties of these magnets has been conducted together with the Joint Institute of Nuclear Research in Dubna. The major goals of the R&D program were:

- Reduction of the AC loss during ramping with 4 T/s
- Improvement of the 2D and 3D field quality
- Long term mechanical stability over $2x10^8$ cycles

The experimental part of the R&D program has been conducted to a large extend at JINR, using a number of available magnets for modifications. The design goal of 13 W/m for the AC has almost been reached by re-designing the yoke, especially the lamination on both ends, the coil loop, the brackets and endplates.

Based on the results achieved in the R&D project phase, manufacturing of a number of SIS100 full length model magnets has been performed [16].

- Straight, full length dipole magnets have been manufactured at BNG (Würzburg) (Figure 3) and at JINR (Dubna) (Figure 4);
- A curved dipole magnet has been produced at BINP in Novosibirsk (Figure 5);
- A prototype quadrupole magnet has been produced at JINR (Dubna) (Figure 6) [17].

The production of both full length magnets at JINR is supported by the EU FP6 DIRAC program.

Although, the lattice itself as described in the "Technical Report" has basically not been changed, some major properties of the main dipole- and quadrupole magnets had to be reconsidered and optimised during the R&D phase [Table 3]. In order to provide a reasonable acceptance for the large emittance heavy ion beams (at minimum three times the KV emittance), quite large apertures were required for the straight dipole magnets. Consequently, the AC loss, which was substantially reduced by the magnet R&D, did not meat the original design goals anymore. Due to the increasing sagitta and beam displacement in the fringe fields, an elongation of the straight dipole magnet could not be considered. Moreover, the required field strength of 2.1 T resulted in a significant increase of the stored energy with consequences for the quench protection system. Due to the high dipole field strength and also quadrupole gradient the field quality in both magnet types was marginal. Therefore, it was decided to reduce the apertures and the maximum field strength and to focus the magnet R&D on an elongated, curved dipole magnet. Making use of a curved magnet instead of a straight allows increasing the length without affecting the beam acceptance. After reviewing the available warm straight section length, the length of the quadruple has also been increased by 10% and in accordance the maximum gradient could be reduced.

For the production of the straight full length dipole magnet with BNG a cable winding machine from the LHC magnet production has been taken over and modified. Thus, a second source for production and delivery of the NUKLOTRON type cable has been established.

The large hydraulic resistance of the two layer coil built in all prototype dipoles does not provide the cooling power for operation with pure triangular cycles. Triangular cycles are considered as fall-back option in case problems connected with high beam loss occure on the long injection flat-top of the reference cycles. The Nuklotron-type coils are made of a s.c. cable consisting of a too long He-pipe with a too small cross section. Therefore, the first pre-series magnet will be equipped with a new single layer coil with slightly increased cross section and a high current cable (13 kA instead of 7 kA).

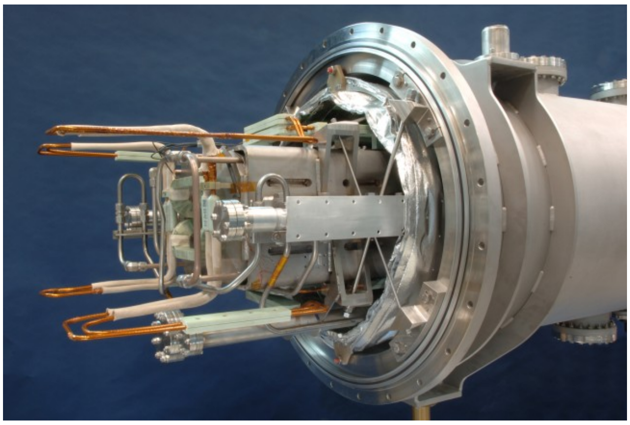

Figure 3: Full length, straight SIS100 model dipole built by BNN, Würzburg, Germany.

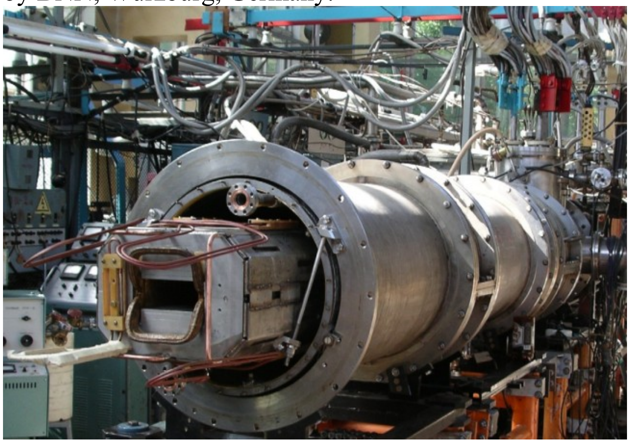

Figure 4: Full length, straight SIS100 model dipole at cold test built by JINR, Dubna

Figure 5: Curved, SIS100 full length dipole model after assembly at BINP

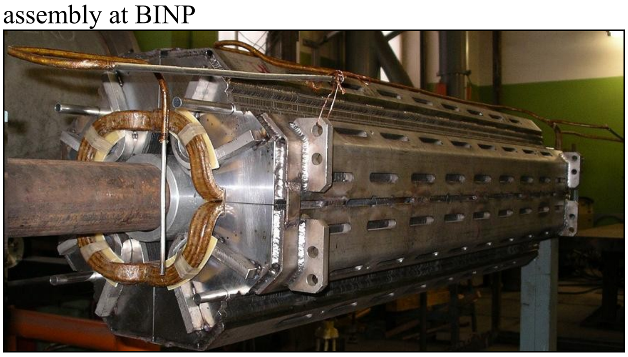

Figure 6: Full size SIS100 quadrupole prototype manufactured at JINR, Dubna

Table 3: Comparison of the modified (TDR) and FBTR main magnet parameters

	Straight dipole (FBTR)	Curved dipole (TDR)
B x L_{eff} [Tm]	5.818	5.818
B [T]	2.11	1.9
L_{eff} [m]	2.756	3.062
Estimated L_{yoke} [m]	2.696	3.002
Bending angle[deg]	3 1/3	3 1/3
Radius of curvature [m]	47.368	52.632
Aperture (h x v) [mm]	130 x 60	115 x 60
Ramp rate [T/s]	4	4
	Quadrupole (FBTR)	Quadrupole elongated (TDR)
B' x L_{eff} [T]	35	35
B' [T/m]	32	27
L_{eff} [m]	1.1	1.3
Estimated L_{yoke} [m]	1	1.2
Aperture (h x v) [mm]	135 x 65	135 x 65
Ramp rate [T/ m s]	67.5	57

For SIS300, the design and R&D of a fast ramped curved 4.5 T dipole magnet has been continued at INFN, Italy [18]. This model development is focused on solving the mechanical problems with the production of a curved coil made of a stiff, low loss cable with stainless steel core and its integration into the collar and yoke. Figure 7 shows the results of a winding test of a curved coil with a standard Rutherford cable.

In parallel, the production of a straight, two layer s.c. 6 T dipole magnet has been completed at IHEP, Protvino. The manufacturing of the 1 m long, two layer coil magnet and the cold testing has been finished in January 2009. Both magnets are optimised for low AC loss and make use of a cable with the bare cable geometry of the LHC dipole outer layer conductor, but with a stainless steel core inside.

Table 4: Main parameters of the short SIS300 dipole model developed by INFN/Ansaldo.

Nominal field [T]	4.5
Ramp rate [T/s]	1
Radius of curvarture [m]	66 2/3
Magnetic length [m]	3.879
Bending angle [deg]	3 1/3
Coil aperture [mm]	100
Max temp. of supercritical He [K]	4.7

Since the ramp rate of SIS300 is much higher than of any other s.c. cos(Θ)-synchrotron and in addition SIS300 is expected to deliver slow extracted beams with very long spills, studies on the influence of transient field errors in the superconducting magnets on the beam dynamics are conducted

Although the specific coil and cable design and the methods applied for reducing the AC loss during fast ramping may help to restrict the persistent current flow, a fast feed back system, similar to the one developed for HERA, is considered. Based on the transient field harmonics measured in the reference string, the feed back system generates set-values for the correction system. Especially under the assumption of a very flexible operation with independent and arbitrary machine cycles, in connection with the stability requirements for slow extraction, the linear and non-linear machine properties must be controlled.

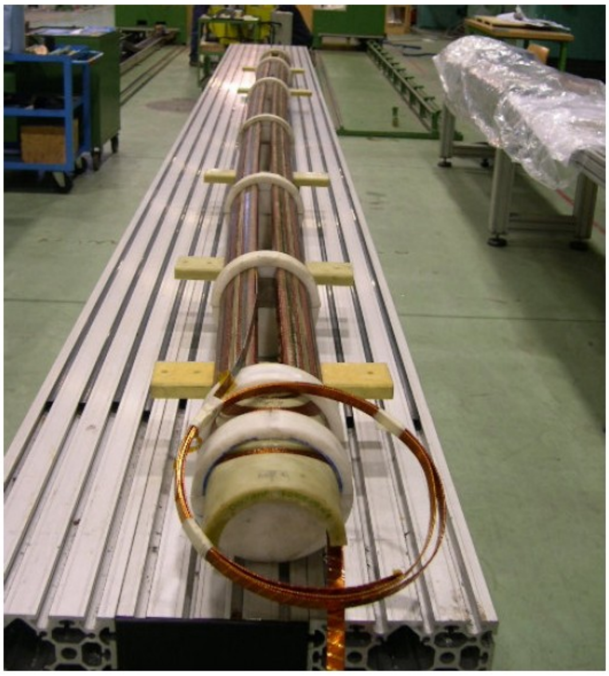

Figure 7: Curved winding tests for a curved coil for the short SIS300 dipole magnet.

Power Converters and Power Connection

In order to minimize the interaction of the fast ramped synchrotrons of GSI and FAIR with the surrounding power grid, a new power connection has been realized. The new 110 kV power line, exclusively used by GSI/FAIR, enables fast ramping with maximum pulse power harmonics as indicated in the power diagram (Figure 8). Especially the fast ramping of SIS18 with 10 T/s up to 18 Tm, as required for the booster operation, with a pulse power of 50 MW is permitted. Due to the small apertures of the superconducting magnets, the pulse power of SIS100, at ramping with 1 T/s is only 26 MW (see Table 4) .

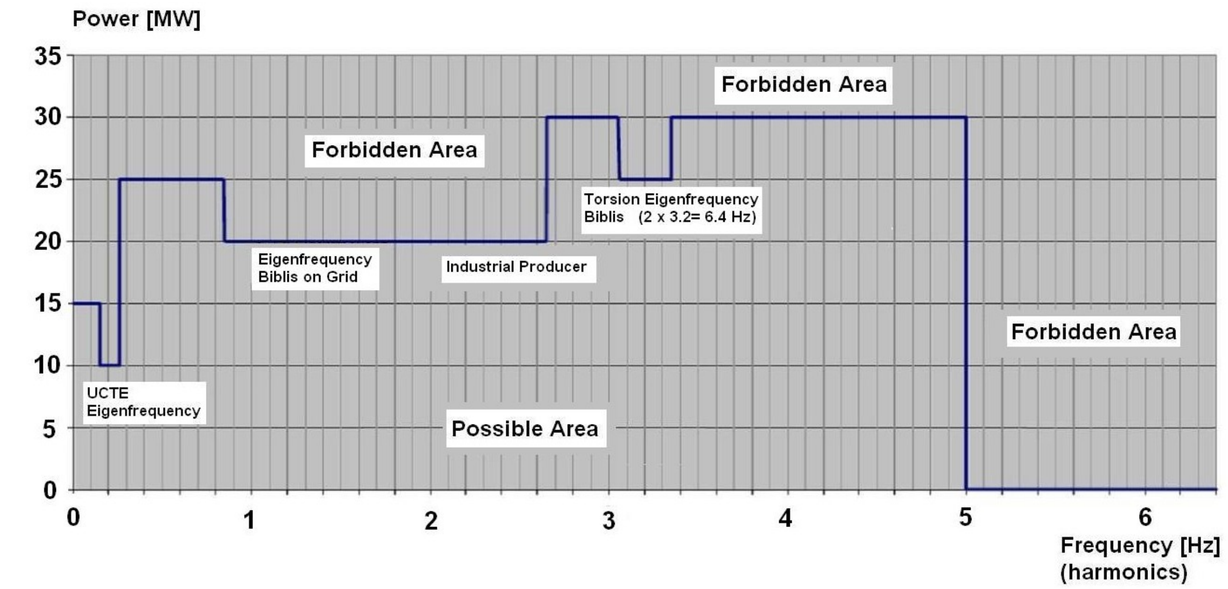

Figure 8: The power diagram shows the allowed area of operation for the GSI/FAIR synchrotrons. It indicates the restrictions for the power harmonics given by the properties of the power grid and the industrial customers.

Equipped with comparable normal conducting magnets, the pulse power of SIS100 would increase to 75 MW and additional compensation effort would be needed on side. The power diagram indicates several frequency dependent restrictions given by the eigenfrequencies of industrial producers and customers, the UCTE and a torsion resonance of the shaft of a large power plant nearby. Table 5 summarizes the pulse power of the GSI/FAIR synchrotrons.

Table 5: Pulse power of the GSI/FAIR synchrotrons during fast ramping

Synchrotron	Pulse Power [MW]	Ramp Rate [T/s]
S18	50	10
SIS100	26	4
SIS300	23	1

A 11 kA power converter making use of a silicon controlled rectifier (SCR) and a switch mode parallel active filter has been built for the s.c. magnet test stand at GSI. The hardware, firmware and software for the digital control of dynamic high precision power converters has been developed and is in practical use in the power converters of the therapy accelerator of HICAT in Heidelberg. Because of the demanding quench protection system of the SIS100 dipole magnets, an electronic 8 kA DC circuit breaker has been developed. A prototype DC circuit breaker is under construction in TU-Darmstadt.

RF Systems

In collaboration with the BINP, Novosibirsk a technical design study has been conducted and meanwhile completed for the ferrite loaded acceleration cavities [19]. The collaboration has been continued with an engineering study with the goal to prepare the tendering process for a prototype production (see Figure 10). The same acceleration cavities as developed for SIS100 will be used in SIS300. The cavity design is close to the existing SIS18 system and the BINP cavity for HIRFL-CSR, Lanzhou, China. Each cavity provides an acceleration voltage of 20 kV in the frequency range of 1.1-2.7 MHz. Twenty cavities are needed to generate an acceleration voltage of 400 kV for ramping with 4 T/s.

No R&D has been performed for the bunch compression systems, assuming that the recently completed bunch compression cavity for SIS18 [20] provides sufficient information for a direct call for tender. For the SIS18 bunch compressor project, GSI has conducted an extensive survey on commercially available magnetic alloy core materials. Figure 9 shows the design (left) and a photograph of the completed SIS18 compression cavity (right) with its amorphous VITROVAC ring cores.

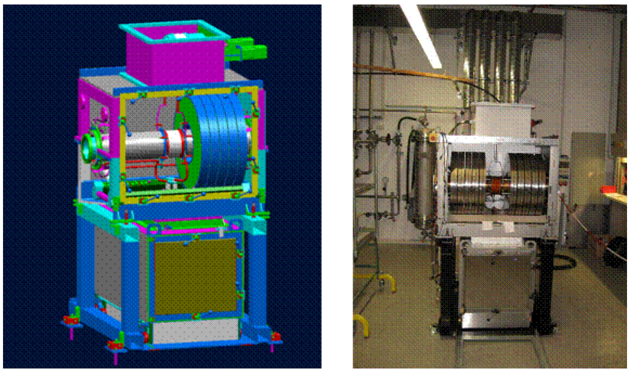

Figure 9: Design (left) and a photograph of the completed SIS18 compression cavity (right) with its amorphous VITROVAC ring cores

Table 6 summarizes the main SIS100 Rf systems.

Table 6: Rf systems of SIS100

	Harm./ Voltage	f /MHz	Numb.	Cavity Technology
Acceleration System	h=10/ 400 kV	1.1–2.7	20	Ferrite loaded, "narrow" band cavities
Compression System	h=2/ 640 kV	0.395-0.485	16	Magnetic alloy loaded, broad band (low duty cycle) cavities
Barrier Bucket System	/15kV	2	2	Magnetic alloy loaded, broad band (low duty cycle) cavities

To accommodate for the official FAIR start version as agreed by the International Steering Committee (ISC) an initial, reduced equipment with RF acceleration and compression systems has been defined. The reduction in RF voltage in both systems leads to a slightly reduced ramp rate and increased bunch length after compression.

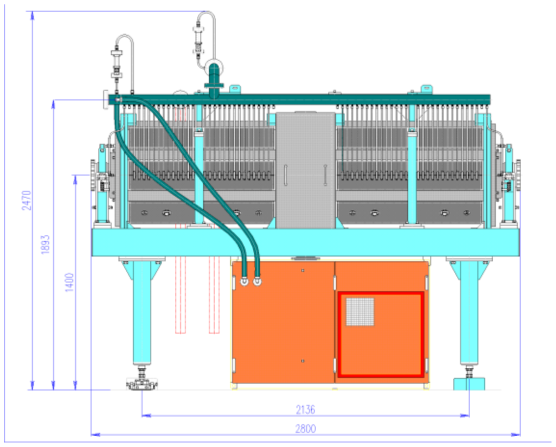

Figure 10: Design study for the ferrite loaded SIS100 acceleration cavity (BINP, Novosibirsk).

HEBT STATUS

The layout of the beam transport system has been revised for normal- instead of superconducting SIS100 beam line magnets [21]. The new overall topology is to a large extent consistent with the original layout for superconducting beam transport magnets as described in the FAIR Baseline Technical Report – no significant change in the overall topology size has resulted from the change in magnet technology. The design of the main warm beam line magnets has been optimized with respect to energy efficiency and operation modes. The layout for the beam diagnostics and correction system has been fixed and integrated into the beam transport structure. The charge stripper system between SIS18 and SIS100 has been integrated into the existing layout of the 90 degree bend behind SIS18 without major modifications. By means of a fast linear induction motor a stripper foil required to generate the high charge state beams (e.g. U^{92+}) for SIS300, will be moved into the beam path in a shot-by-shot mode. The supply buildings, so far matched for the supply of a superconducting HEBT system have been modified for the supply systems of the normal conducting beam lines. Recently, minor modifications of the beam line topology were requested by the progressing civil engineering process and tunnel planning.

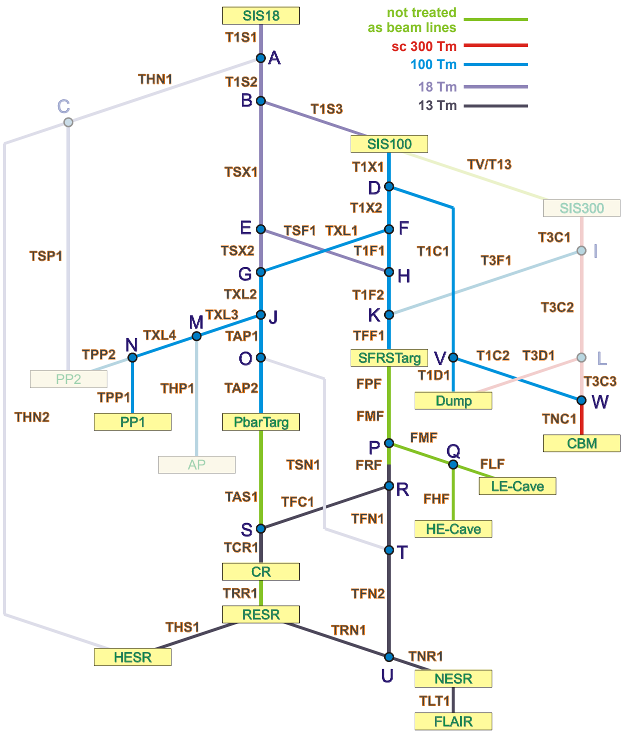

Figure 11: The FAIR beam transport topology. The feint beam line sections are not subject of the official start version.

ACKNOWLEDGEMENT

The results summarized in this paper have been achieved by a collaboration between the GSI FAIR synchrotron department, the GSI technical departments and international project partners.

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