# FAIR@GSI progress in 2013

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In April 2012 the GSI advisory board requested GSI to establish a line management structure that focuses on the in-kind contributions of GSI to the FAIR project. The result is FAIR@GSI, which was established in August 2012. FAIR@GSI is responsible for the technical supervision of all FAIR accelerators, for the upgrade and operation of the existing GSI accelerator facility and for the procurement of the equipment GSI will provide in-kind to the FAIR accelerators and experiments. In 2013 FAIR@GSI is running with its seven divisions, which cover the accelerator sections and the according experiments as well as project coordination and the cross functional machine tasks. The focus on the project is the scientific and technical work on the work packages defined by the work breakdown structure (WBS). This comprises the technical supervision of all FAIR accelerators, the design and the construction of the systems and components GSI delivers in-kind and the upgrade and development of the GSI accelerator facility. FAIR@GSI delivers the project management for the sub project accelerator. The project coordination organizes the project planning, financial and procurement control, quality assurance, interfaces to the other sub-projects and the documentation and the data handling of project relevant information. In 2013 a solid resource loaded schedule of the project has been established.

In 2013 the collaborations with our partner institutes did progress. MoUs have been established with Budker institute concerning the design and technical supervision on the collector ring (CR) which will be shared in the future. As a start of the collaboration on the CR machine two GSI - BINP workshops have already been held this year, the first one in April and the second one in June 2013. During these workshops, many experts from BINP have visited GSI and discussed together with GSI experts the technical aspects of the CR magnets, the vacuum system design and the power supplies. CEA Saclay is already working on the proton sources and LEBT of the p-linac and will take over the technical supervision of the Super-FRS dipoles. The test infrastructure for the Super-FRS magnets at CERN is progressing due to the substantial support of CERN. The collaboration with Dubna on the SIS100 quadrupole modules and the testing of the quadrupole units is detailed out and contracts are in preparation or have been signed. Finally the collaboration with KVI in Groningen is another strong pillar, supporting the construction of the Super-FRS.

## The superconduction (S.C.) magnets for the FAIR synchotron SIS100

In June the Babcock-Noell GmbH (BNG) delivered the First Of Series (FOS) superconducting (S.C.) dipole magnet for the FAIR synchrotron SIS100. The delivery of the dipole was the first step in the production phase of the heavy ion synchrotron SIS100, the primary beam driver accelerator of the FAIR project. According to the schedule, more than 112 dipole magnets will be produced and delivered to GSI in the next three years. The factory acceptance test (FAT) was successful and therefore the magnet has been prepared for site acceptance test (SAT) at GSI. However about 95 points have been identified in the FAT, which need to be adjusted for the series magnets. The magnet has to undergo a significant number of tests including cols tests. End of 2013 the magnet was tested for the first time at cryogenic temperatures (4 K) under pulse operation conditions. The magnet did exceed its designed performance and quench training went very well.

The ion optical lattice of SIS100 comprises 108 dipole modules and 83 quadrupole modules arranged in the 1086 m long SIS100 accelerator. The 83 quadrupole modules are split into 13 different configurations of arrangements of internal sub-devices. One configuration, appearing in the arc sections of SIS100, was selected to be designed up to a level ready for production. Based on the need of increasing operation safety of the SIS100 machine to a maximum, a consequent reduction of internal interfaces is required. Hence the concept of an integrated quadrupole doublet module was developed at GSI. Within one module two s.c. quadrupole magnets are integrated into a common cold mass, together with further corrector magnets, collimators, bus bar and current lead systems the cold mass is covered in a quadrupole doublet cryostat.

## Magnet test facilities

The tests of the several hundred S.C. magnets cannot be done in a single facility. Therefore the different magnets will be tested in three different locations. Prototype magnets and all dipole magnets of SIS100 will be tested at GSI. Significant upgrades to the GSI test facility were needed in order to be ready to test the FOS superconducting dipole. The power converter had to be upgraded to double its maximum current (now up to 20 kA) adjusting its output voltage to the particular SIS100 and SIS300 magnets. High temperature super conductor (HTS) current leads were needed due to the limited cooling capacity of the cryogenic infrastructure at the prototype test facility of GSI. The power converter was optimized and commissioned with a test load. The security off-switch has already been integrated in the power converter. The current leads were delivered to GSI on the 10th of October and then mounted into the feed boxes. The preparation of the series test facility including procurement of the 2 kW cryo plant and the construction of the building for the cryo plant has been significantly pushed forward in 2013.

The S.C. quadrupole units of the SIS100, will be produced at JINR/Dubna. The quadrupole units are combinations of a main quadrupole with a BPM, a sextupole or a steerer. To guarantee conformity of each of the 175 quadrupole units to the technical specifications they have to be subjected to detailed cold tests and measurements that certify the required performance. The according test infrastructure will be developed, manufactured and commissioned at JINR/Dubna. The units of the SIS100 superconducting quadrupole doublet modules (QDM) will be cold tested. This test facility will be available for testing superconducting magnets of the NICA accelerators as well and demonstrates the synergy of the common effort.

The huge Super-FRS magnets, dipoles and multiplets, will be tested at CERN in a collaboration of GSI, CERN and CEA Saclay. CERN will install a test facility with all infrastructure serving three test benches in hall 180. First cleaning and installation work on the infrastructure in this hall has been performed by CERN.

## Preparation for the FAIR rf-systems

The rf-systems of SIS100 comprises (in the start version) 14 acceleration cavities, 9 bunch compressor cavities and one cavity for barrier bucket operation. For all cavity types, procurement has been started in 2013. A new rf-cavity was developed and realized in the framework of the SIS18-upgrade program in order to increase possible beam intensities for FAIR. The so-called „h=2-system“ was developed for the high current operation of SIS18 to flatten the ion density distribution in the bunch and therewith reducing the space charge forces acting on the particles in the bunch. It is essential for the later booster operation for the SIS100 with its high repetition and ramp rate. The “h=2”-cavity has been installed in the shutdown period of 2013 including all infrastructure installations required for the cavity operation. Based on the limited space in the synchrotron tunnel it was necessary to place the high-power-rf-amplifiers (weighting 1 ton) directly on top of the cavity. Due to that the height of the ring tunnel has been enlarged at the location of the cavities. Originally the new rf-system was installed and operated (without beam) in the testing-hall. This required serious efforts, because the supply devices, like the electrical supply from the common net, the oil cooling installation for one unit and the cooling water supply for the other unit, have been installed there additionally.

## Beam cooling in the storage rings

The collector ring (CR) serves the fast stochastic cooling of antiproton and rare isotope beams. The FAIR Council has allocated the CR stochastic cooling system to GSI as an in-kind contribution. Intensive engineering, manufacturing and procurement activities on various system components have been done in 2013 at GSI. One of the main technical challenges is the cryogenic movable (plunging) pick-up electrodes. After extensive engineering design work, two novel water-cooled linear motor drive units have been assembled in the mechanical workshop and the existing prototype pick-up tank has been modified to accommodate them. These units are easier to maintain and made from aluminium, which is lighter than the previously used stainless steel. Their maximum range of plunging is now 70 mm.

In order to enhance the signal to noise ratio, which is the main challenge for the stochastic cooling of antiproton beams, the movable pick-up electrode modules are thermally coupled to flexible sheets, which are cooled by 2 helium cryoheads to about 30 K. The cryoheads also cool an intermediate cryoshield at 80 K.

## Reconstruction started in cave-B for the CRYRING installation

In July 2013, the Transport & Installation department (CSTI) has successfully removed the FOPI superconducting magnet from cave-B. The removal of this magnet was an important step for the remodelling of cave-B as a future home of CRYRING@ESR, a Swedish in-kind contribution to FAIR. CRYRING@ESR is a heavy-ion storage ring and will be served with ion beams from ESR or from an independent ion injector. It will first deploy several key technologies for FAIR and serve as an experiment facility on low-energy highly-charged ions. After the move of the magnet the complete reconstruction of cave-B has already started.

## Digital mock-up (DMU) of the FAIR machines

A very important task is the work in the digital model of the whole accelerator facility, which allows the check for interfaces, collisions with the building infrastructure and the proper alignment of the beam lines to the ion optical lay-out (IOL). This digital mock-up (DMU) is an essential part of the configuration management of FAIR@GSI and is a very successful example for excellent project work at GSI. A 3D-model for the IOL prepared with the beam optic program “Mirko” serves as the backbone for the representation of the beam lines. One of the main jobs of the DMU-team of the mechanical integration (ENMI) department is the visualization of results which have been developed by differenz scientific and technical departments. Many data types have to be transferred into the format of Catia.

As an example the normal conducting (N.C.) magnets are delivered by the magnet and alignment department (ENMA) as 3D-models which will be included in the DMU of the beam lines. After this, the vacuum chambers and diagnostic boxes will be chosen and positioned and collisions will be checked. Defining interfaces for components of different suppliers is one of the major tasks in the developmental stage. Cables, tubes and their ducts and trays towards the components, alignment concept, references, installation space, accessibility, fixation and many more things have to be cleared before the specifications can be released.


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