Status of the Superconducting Magnets for FAIR*

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Introduction

Within this paper we report shortly on all the many different activities of the group which now is mainly focused on procuring the magnets and associated systems for the FAIR project.

Superconducting Magnets

Rapidly cycling magnets for SIS100

Dipoles – production status and first tests The **F**irst **o**f **S**eries (FOS) dipole has been delivered [1, 2, 3] and its testing has been started. The magnetic field was measured during the first ramp up followed by a first training of the superconducting magnet with the second quench above nominal current and a current of 15.1 kA achieved.

In parallel the different findings and according actions have been discussed with the producer so that the SIS100 dipole magnet series can be produced swiftly as soon as the FOS SIS100 dipole has been qualified.

Quadrupole modules The quadrupole modules house all superconducting magnets of the SIS100 along with the beam vacuum chambers, beam position monitors and cryo-collimators.

The design of the quadrupole magnet and all corrector magnets in the quadrupole modules is finalised toward manufacturing. As the first of the SIS100 corrector magnets, the chromaticity sextupole magnet, has been constructed in collaboration with JINR. The iron yoke had been already prepared in the framework of the BMBF-JINR research contract. The coil will be wound and assembled into the iron yoke in the first half of 2014 at JINR. The test of the magnet will then follow.

In parallel the design of the first of series quadrupole module (type 2.5, see also Fig. 1) has been detailed intensively including all integrated components: the magnets, the support system up to the high temperature superconducting current leads. The suspension rods, connecting the cold mass with the cryostat, were designed to achieve a stability of the beam axis of $\pm$ 125 μm for the main quadrupoles and $\pm$ 175 μm for the associated correctors [4]. The design was further checked and approved to be a pressure vessel compliant with European standards.

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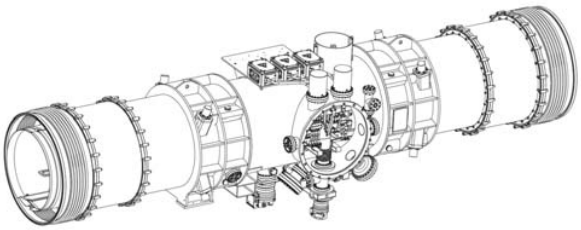

Figure 1: CAD Model of the fully integrated SIS100 quadrupole doublet module, type 2.5, including local current leads located in the central service port.

An order was placed with Babcock Noell for detailing all further quadrupole modules (five arc types, two arc termination types and two straight section types) along with the modules for injection and extraction, which shall be completed beginning of 2015.

Rapidly cycling magnets for SIS300

Magnets with fields up to 4.5 T are needed for SIS300. A first model magnet of the fast ramped $\cos\theta$, 4.5 T SIS300 magnets was developed and tested successfully in collaboration with INFN [5, 6]. It is now awaiting further tests and additional measurements at GSI. A second collared coil, with enhanced field quality and conductor performance [7] is under construction [8]. After successful manufacturing and testing of two prototype quadrupoles and a steering dipole for SIS300, the activities of IHEP (Protvino, Russia) concentrated on the development of wide aperture quadrupoles for FAIRs HEDgeHOB experiment.

Magnets of the Super-FRS

Dipoles A collaboration agreement was signed between GSI and CEA/Saclay concerning the procurement of the superconducting dipoles for the Super-FRS. Saclay will take over the design finalisation next to the technical follow up. FAIR will then tender these dipoles. A ready design is expected mid of 2014 together with a signed production contract in 2014.

Multipletts The specifications of the multiplets of the Super-FRS have been finished and the tendering process was started by GSI. Offers arrived in December. Negotiations with the companies are now under way; a contract should be signed within the first half of 2014. A general

overview over the superconducting magnets of Super-FRS can be found in [9].

Planning for Testing

Prototype test facility activities

The upgrade of the prototype test facility for testing the SIS100 magnets, which has been started in 2012, was finalised by the instalment of the new power converter able to deliver 20 kA at 22 or 66 V next to the HTS current leads. The power converter was brought into operation and tested successfully with a dummy load followed by testing and commissioning the HTS current leads up to 14 kA DC and 17 kA for slow ramps.

Series test facility activities

The procurement of the large scale systems has been started last year and finished with tendering the two power converters. Offers have been received with a tender to be awarded soon. In parallel the refurbishment of the building, the fabrication of the cryogenic infrastructure and the procurement of the current leads has been started.

SIS100 string test

A test string will be set up in the series test facility consisting of a dipole, quadrupole module and cryogenic supply components. Dedicated components are being specified with the assembly of the string foreseen in 2016. The string will provide information on the interplay of the components listed above next to training for the teams building and assembling the SIS100 machine.

Testing Super-FRS Magnets at CERN

The large scale Super-FRS magnets will be tested at CERN. The number of test benches (3), the area and layout of the test facility, have been defined and the measurement program has been evaluated. Based on these achievements the procurement of the infrastructure can start so that the test facility will be ready when the first of series magnets of the Super-FRS arrive.

Current Leads

Dedicated HTS current leads, required for testing the FOS dipole, were developed, procured and successfully tested. This successful test was a clear go for the series of current leads required for the series test facility and the SIS100 machine.

Additionally low current leads are required for the corrector magnets installed within the SIS100 quadrupole module which are based on a conduction cooled warm end and a HTS superconductor connecting them to the cold end. The design of these current leads was completed this year.

Electrical Systems and Magnet Protection

The existing quench detection setup was updated and tuned for testing and operating the HTS current leads and the SIS100 FOS dipole. Moreover the production of the new quench detection system for the dipole series test facility has started now. Further the protection schemes for the SIS100 dipole and quadrupole circuits have been optimised. A set of standard tests and alternative dry tests based on IEC 60851-5 were defined for testing the electrical insulation of superconducting wires.

Conclusion

The procurements of the different superconducting magnets required for FAIR along with the associated auxiliaries has been started. The telegraphic style of this paper reflects the many activities that are undertaken to realise the FAIR project within the given scope and schedule.

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