ISBN: 978-3-95450-168-7 doi:10.18429/JACoW-IPAC2015-THPF012

STATUS OF THE HIGH ENERGY BEAM TRANSPORT SYSTEM FOR FAIR

F. Hagenbuck*, L. Bozyk, S. Damjanovic, A. Krämer, B. Merk, C. Mühle, S. Ratschow, B.R. Schlei, P.J. Spiller, B. Walasek-Höhne, H. Welker, C. Will
GSI, Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Abstract

The overall layout of the High Energy Beam Transport (HEBT) System of the Facility for Antiproton and Ion Research (FAIR) [1] did not change since its last presentation in 2008 [2]. All necessitated adaptions as for example due to the introduction of the Modularized Start Version (MSV, module 0-3) of FAIR [3] could be smoothly implemented. In the meanwhile the HEBT system is in its realisation phase with the procurement of its main components in progress.

In the following adaptions of the system layout not yet covered in [2] are summarized and an overview of the technical system design and procurement status are presented.

ADAPTIONS OF THE HEBT SYSTEM LAYOUT

Since its last presentation in 2008 [2] it has been confirmed several times that the HEBT system will be able to fulfill all requirements imposed on it. A new direct connection from SIS18 to the CR was included into the HEBT system without difficulties. For this the section TSN1 was modified in a way that the beam coming from SIS18 can be either injected straight via TSR1 into the end part of the Super-FRS ring branch (which is connected to the CR via the sections TFC1 and TCR1) or guided directly to the NESR as before via TSN2, see Fig. 1, 2. The new connection to the CR was included into the planning of the MSV, whereas the beam line to the NESR belongs to module 6. Modifications in the building planning were not required.

The RESR is not part of the MSV. As mitigating measure the transfer line to the HESR starts now at the CR (THS1) which could be implemented smoothly. After RESR is built in module 5, THS1 will be removed and replaced by a new transfer line from CR to RESR and a new beam line from RESR to HESR (TRH1). All components from the transfer line from CR to HESR can be reused for the connection from RESR to HESR. Dipole magnets will be operated with different bending angles by means of field adaption, merely their vacuum chambers have to be replaced.

Plasma physics (PP) and atomic physics (AP) experiments will share a common building (APPA building), which replaces the former PP and AP caves and will contain two beam lines. The eastern beam line, see Fig. 1, serves atomic physics, biophysics and material research experiments, the western beam line plasma physics experiments. As before the PP beam line provides the option for a perpendicular beam from SIS18 onto the same target.

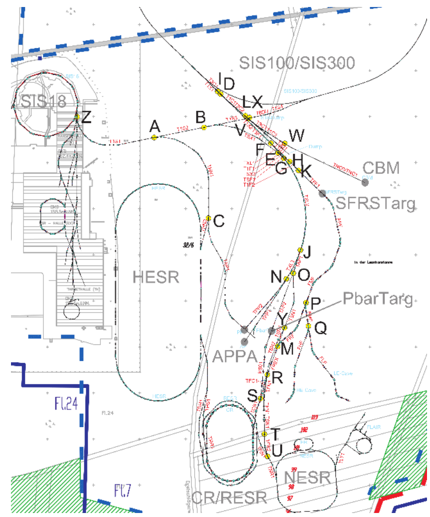

Figure 1: Top view of the beam line topology of FAIR (module 0-6).

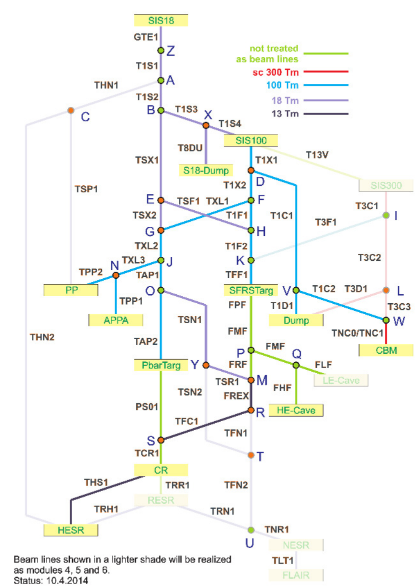

Figure 2: Beam line connection scheme.

The Super-FRS ring branch is not in line with the end of the Antiproton separator. The offset will be carried out now by use of in total four (module 0-6) dipole magnets similar to the ones used in the CR (different bending angle), which allows to use syneregies in magnet production, instead of two dipole magnets at two different bending angles, which turned out to be unpractical because their good field region

* f.hagenbuck@gsi.de

ISBN: 978-3-95450-168-7 doi:10.18429/JACoW-IPAC2015-THPF012

would have to be made much wider. This change could also be conducted without any influence on building parameters.

Necessary adaptions due to changes in the injection into SIS100 were implemented without difficulties. Furthermore a beam dump for set value generation of the beam line from SIS18 to SIS100 was foreseen in front of SIS100. The beam dump is located 5.6 m below SIS100 at the end of the 21.6 m long extension T8DU of the 15 ° inclined section T1S3 of the injection beam line. The beam line section T1D1 (T3D1) leading to the SIS100 (SIS300) machine setting dump was deflected downwards for better radiation shielding. The concept to use this dump also as SIS100 emergency dump for light ions and protons was discarded. Instead a dedicated emergency dump situated below the magnetic septum #3 in SIS100 was designed [4].

A halo collimation system for the CBM/HADES experiment was worked out. Although the beam line from SIS100 to the CBM cave is very compact the required collimators can also be integrated in the sections T1C1 and T1C2 at, from ionoptical point of view, adequate positions. Moreover studies on safety beam plugs (diffusors) were performed. To ensure safe operation they will provide redundancy to interlock magnets. The diffusors are mobile blocks which intercept unwanted beam. Thereby the radiation level in accessible neighbouring areas remains acceptable low in case of malfunction. For diffusors in several beam line sections detailed FLUKA studies were performed for accidental beam deposition, see Fig. 3, to determine the expected radiation level and optimize lengths and material of the beam diffusors [5]. For the MSV 10 diffusors are foreseen which can be integrated additionally into the HEBT system without any problem.

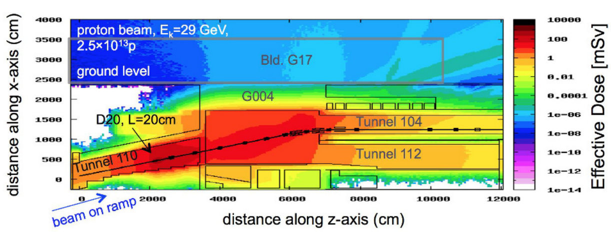

Figure 3: Effective dose for one beam pulse hitting the diffusor D20 (iron cylinder, length = 20 cm) placed along the sloped beam line section T1X2 [5].

TECHNICAL SYSTEM DESIGN

A 3D (CATIA) model of the complete HEBT system (module 0-6) was developed over the past years. Drawings with all relevant geometrical information were derived from it and were used in the specifications of the magnets, vacuum chambers, supports, beam diagnostics vacuum chambers, etc. Moreover the 3D model is indispensable for the integration check of the beam line components and serves as main basis for checking the 3D models of buildings and technical infrastructure. From the engineering point of view the most complex situation is given in the central transfer building H0705A, see Fig. 4, which is the branching and crossing point for 8 beam lines in the full version of FAIR (module 0-6). Here the beam lines reveal a complicated 3D structure, some are inclined, run partly parallel and/or on top of each other. Furthermore a height difference in the floor levels of 7.4 m has to be bridged by a support structure carrying the two 10 ° inclined beam lines going towards the Super-FRS, pbar and APPA, see Fig. 5. With respect to this a first concept of assembly-, alignment and disassembly processes for the beam lines in H0705A as well as for a transportation unit for assembly and disassembly on the injection and extraction ramp were worked out in two advanced design projects with the department of computer integrated design of the TU Darmstadt. Currently the specifications for the support structure as well as for the transportation units are under preparation.

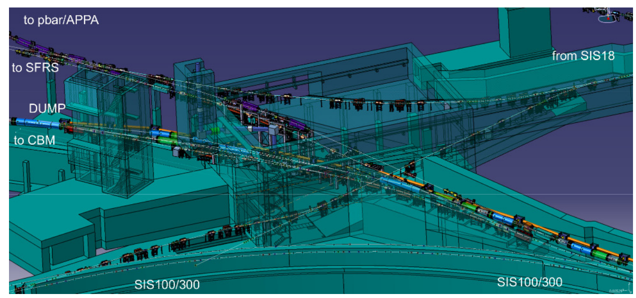

Figure 4: Central transfer building H0705A.

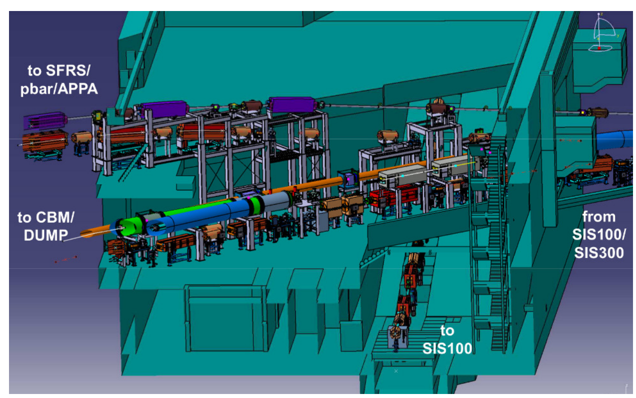

Figure 5: Support structure in building H0705A.

PROCUREMENT STATUS OF HEBT

Referred to costbook values at present 62% of the HEBT system are assigned to international in-kind (or collaboration) partners, 20% to GSI and 18% can still be assigned or will be procured by FAIR tender.

Magnets and Vacuum Chambers

Almost all HEBT magnets (331/365) needed in the MSV were assigned by FAIR Council resolutions to the Efremov Institute (NIIEFA, St. Petersburg, Russia). The remaining magnets are assigned to the Budker Institute (BINP, Novosibirsk, Russia; 2 dipole, 5 quadrupole magnets) and GSI (11

ISBN: 978-3-95450-168-7 doi:10.18429/JACoW-IPAC2015-THPF012

Super-FRS quadrupole magnets) or are still to be assigned (16 magnets for sections TSN1, TSR1). All related vacuum chambers as well as all general vacuum chambers for the beam pipe vacuum system shall be built by BINP. A first contract on the production of 51 dipole magnets including supports and vacuum chambers (batch1) was closed between FAIR and NIIEFA in July 2013 and BINP in December 2012. Meanwhile the production of two pre-series dipole magnets (types dip1s_0 and dip13_0) is running. For dip1s_0 (used in 18 Tm beam lines) the coils are produced, see Fig. 6, all laminations punched and currently the yoke halfs are stacked. Magnet assembly is expected to be finished in May 2015, magnetic measurements will be performed until end of June and the vacuum chamber will be installed into the magnet in July at NIIEFA. The magnet and the vacuum chamber will be delivered to FAIR/GSI site in August 2015. For the second pre-series magnet dip13_0 (used in 100 Tm beam lines) punching of the laminations was recently started. Delivery of the magnet and the vacuum chamber are scheduled for November 2015, the last magnet of batch1 will arrive at FAIR/GSI at the end of 2017.

The specifications for a second batch (17 dipole, 95 quadrupole, 80 steering magnets and vacuum chambers) are released and the contracts are under negotiation with NIIEFA and BINP. The specifications for a third batch (7 dipole, 81 quadrupole, 16 steering magnets and vacuum chambers - magnets and vacuum chambers for TSN1 and TSR1 included) are supposed to be available shortly which enables to negotiate batch3 together with batch2.

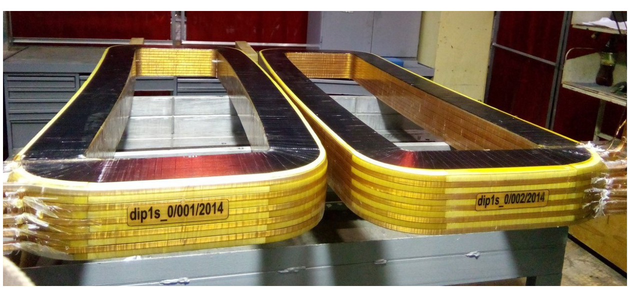

Figure 6: Set of coils for pre-series dipole magnet dip1s_0.

Beam Instrumentation

In Table 1 the beam diagnostic devices foreseen in the HEBT system are summarized whereat CCCs and BIFs/IPMs are not supposed to be availabe for commissioning of the beam lines (day zero). Most of the detailed specifications required for the day zero beam diagnostics are released. All technical documents for the standard diagnostic vacuum chambers (11 types, 57 pieces) were provided to the Indian shareholder Bose Institute (Kolkata), currently a provider is selected by an Indian committee. In November 2014 a contract between FAIR, the Slovenian shareholder (Ministry of Education, Science and Sport) and Tehnodrom (provider) was closed, comprising HEBT BPM pre-amplifiers, data acquisition (for BPM, BLM system and beam current transformer) and pressured air drives and control. Furthermore several beam instrumentation developments applicable in the HEBT system were successfully concluded in the past as for example the test production of the first FAIR-type beam diagnostic chamber, pneumatic drive and RT/FCT, the pre-series production and test of new MWPC and SEM-Grid electronics or a new system for scintillating screen based diagnostics [6].

Table 1: Beam Diagnostic Devices Used in the HEBT System

Device	Measured Parameter	Intercept./ non-intercept.	Extr.	Remark	N (MSV)
Resonant Transformer (RT)	beam current	non-intercept.	fast		25
Fast Current Transformer (FCT)	bunch charge/ time structure	non-intercept.	fast		11
Particle Detector Combination (PDC)	current	intercepting	slow	low intensities	16
Cryogenic Current Comparator (CCC)	current	non-intercept.	slow	high intensities	4
Beam Position Monitor (BPM)	centre-of-mass		fast		39
SEM-Grid (PG)	transverse profile	intercepting	fast	profile & position	51
Scintillation Screen (SCR)	transverse profile	intercepting	fast & slow	profile & position	18
Multi-Wire Proportional Chamber (MWPC)	transverse profile	intercepting	slow	profile & position	34
Beam Induced Fluorescence (BIF)/ Ionization Profile Monitor (IPM)	transverse profile	non-intercept.	fast & slow	profile & position, high intensities	15
Beam Loss Monitor (BLM)	beam loss	non-intercept.	fast & slow		30

Power Converter

In the MSV 329 power converters (PC) are required for the HEBT magnets, splitting into 53 PCs of 18 types for dipole, 180 PCs of 12 types for quadrupole and 96 PCs of 3 types for steering magnets. A first contract comprising 78 quadrupole PCs was signed in May 2014 between FAIR, the Bose Institute and the provider ECIL (Electronics Corporation of India Limited). This contract covers all quadrupole PCs needed for the standard quadrupole magnets (type quad2) in the 18 Tm and 13 Tm beam line sections of the MSV (except TSN1, TSR1) and includes two pre-series PC types whose factory acceptance test is scheduled for September 2015. At present a second contract also between FAIR, Bose Institute and ECIL is under preparation. This contract will comprise all PCs needed for the quadrupole magnets in the 100 Tm beam line sections and all PCs needed for the standard steering magnets (type s18) in the 18 Tm and 13 Tm beam line sections (except TSN1, TSR1), in total 74 quadrupole PCs and 44 steerer PCs. All PCs of these two contracts will be delivered to FAIR/GSI according to the prioritization at FAIR@GSI between February and December 2018.

REFERENCES

[1] FAIR Baseline Technical Report (FBTR), GSI 2006.

[2] S. Ratschow et al., "The High Energy Beam Transport System for FAIR", Proc. of EPAC08, THPP104, Genoa, Italy (2008).

ISBN: 978-3-95450-168-7 doi:10.18429/JACoW-IPAC2015-THPF012

[3] FAIR Green Paper - The Modularized Start Version, October 2009.

[4] C. Omet et al., “Risk analysis and machine protection of SIS100”, Proc. of IPAC14, THPME058, Dresden, Germany (2014).

[5] S. Damjanovic et al., "FLUKA Simulations of the FAIR HEBT System: Optimization of the Safety Beam Plugs”, GSI Scient. Report 2014, (2015).

[6] B. Walasek-Höhne et. al et al., "CUPID: New system for Scintillating Screens based Diagnostics”, Proc. of IBIC14, TUP06, Monterey, USA (2014).