CERN-GSI Steering Committee Meeting 2 July 2019

Participants: M.Bai; R.Baer; M.C. Bellachioma; J.Blaurock; O.Boine-Frankenheim; F.Bordry; C.Roux; M.Jimenez; P.Spiller; R.Schmidt; M.Schwickert, H. Simon;

https://indico.gsi.de/event/9035/

Introduction

CERN and GSI/FAIR have an excellent and long lasting collaboration over many decades. The agreement K1727/DG (2010) on "Collaboration in accelerator science and technologies and other scientific domains of mutual interest" has been signed in 2010. Since then, a number of addenda were following.

This meeting is organised to discuss collaboration activities on proposed selected topics with special focus on FAIR.

Various ideas for collaboration topics were distributed prior to this meeting. During the meeting, topics for collaboration in four areas, Magnets, Controls, Beam Instrumentation, and High Intensity Beams were discussed.

Not all collaboration activities require an addendum. For occasional discussion visits, say, a few days per year, the agreement of the management (at CERN the Group Leader) is sufficient. Travel expenses will usually been taken over by the party proposing such visits. For small collaboration activities a lightweight process is suggested. This could be done with a generic addendum covering such activities. Transfer of the required budget from GSI to CERN is straightforward by using the GSI account at CERN.

Addenda for collaboration should always be done for a defined period (e.g. three years), even if the planned collaboration extends beyond this period. It is then possible to extend the addendum or writing a new addendum.

For the collaboration activities, an information about the human resources involved in the different topics is required. At CERN, this information is requested by the Council.

Once per year (if required more frequently) the CERN-GSI Collaboration Steering Board should meet, as it has been done for the collaboration between CERN and ITER for a long time.

Magnets

1. **Existing addendum:** "Magnetic-field Measurement System for the SIS100 Dipoles". Status: Active collaboration, Contact GSI: A. Szwangruber, Contact CERN: S.Russenschuck

   This is an active collaboration described in Addendum #9 for the design and procurement of a magnetic field measurement system for the SIS100 series dipoles. The shafts are operating

in vacuum at a temperature of 4 K. Three systems have been delivered to GSI, and two will still be delivered. The experience with the three system operating in the GSI superconducting test facility for testing SIS100 dipoles is excellent and demonstrates the feasibility of performing such measurement in vacuum at cold. The collaboration is close to completions.

2. **Existing addenda: "**Super-FRS Superconducting Magnet Testing". Several addenda (#2, #4, #5 and #12) were signed for the construction of a test facility and the testing of all SFRS superconducting magnets at CERN as Site Acceptance Tests (SAT). Status: Active collaboration, Contact GSI: K. Sugita, Contact CERN: S.Russenschuck

   The first phase included the refurbishment of the CERN test facility in Building 180, the procurement of a pre-cooler, the quench detection system, survey tooling, integration work and modification of cryo lines, implementation of preparation test bench and control room.

   The second phase includes the tests, with one CERN FTE as test engineer to oversee the functioning of the test facility and 0.4 CERN FTE for the support of equipment groups on best-effort basis. It also includes energy costs, office space and infrastructure. Cryogenics is not included.

   The infrastructure and measurement systems is ready for commissioning of the testing station and testing phase. The first magnet arrived and cool-down is expected soon. A first version of the test plan has been worked out. Delivery schedule of the multiplets is fixed, for the dipoles the delivery schedule is still under discussions. The testing phase is expected to take about 5.5 years.

3. **Proposal for new addendum:** "Simulation of transient effects in the SIS100 superconducting magnet system with CERN software tools (STEAM)". Status: New proposal, high priority, being drafted. Contact GSI: P.Szwangruber, Contact CERN: A.Verweij

   The dynamic electrical behaviour when operating a complex cryo magnetic system with very fast ramp rates will be studied. GSI will provide input data for components and operational scenarios (magnet circuits, power converter, quench detection system, cycling details, 3D models). The strategy for the simulation with the STEAM code will be worked out by CERN. The work will be done by a PhD student or a fellow supervised by CERN staff. The student will be paid by GSI. The personal costs for CERN expert supervision during the first year are about 0.35 FTE, afterwards: 0.1 FTE. CERN resources include supervision and code adaption, guide and training of PhD student / fellow as well as cross-check of simulation results. The addendum is in preparation and should be signed within the next few months.

4. **Proposal for new addendum:** "High-field superconducting septa: magnet development". Status: New proposal, low priority. Contact GSI: C. Sugita, Contact CERN: J.Borburgh

   Conventional iron-dominated septa are limited to 2 T field strength. At GSI, the concept for a cosine-theta septa magnet was developed enabling much higher field strength, e.g. for the Future Circular Collider. Such septa might also be used at other future accelerators (e.g. medical accelerators, …). The next step would be to transfer the concept to an engineering

design. There is an interest from both sides, but a decision should wait until it becomes clear how the studies for FCC will continue.

Controls

GSI and CERN are collaborating in several areas. Both institutes are using the same framework for their control system:

- LSA: LHC software architecture framework for accelerator settings generation and management
- FESA: Front-End System Architecture (accelerator equipment control)
- Timing System – White Rabbit-based high-precision time and event distribution system
- CMW: Controls Middleware (communication fabric)
- SILECS – Software infrastructure for PLC-based low-level equipment controllers
- UI-Development – Graphical user Interface libraries and ACC-Soft common libraries

Collaborations on controls are excellent examples for mutual benefit to both CERN and GSI. However, collaboration activities and responsiveness on CERN-side went down in the last years and could be improved. The human resource effort for collaborating (e.g. for collaboration & design meetings, code revision, management and merge) requires time to be recognized and accepted by management.

It is proposed to organise a collaboration meeting in autumn at GSI/FAIR to discuss the future of the collaboration for these topics.

5. **Proposal for new addendum:** "*Development of Control System Components: Update and finalize the addendum and present it to management for signature, latest in Q4/2019" (GSI: R. Bär,CERN: Eugenia Hatziangeli.*

The draft has been written by both parties, defining rights, obligations, ownership, copyright, licensing, IP, etc. It has not yet been signed. Update and finalize the addendum and present it to management for signature (Q4/19).

6. **Proposal for new addendum:** "Use and further development of UNICOS". Status: New proposal being drafted: Contact GSI: R.Baer, Contact CERN: Peter Sollander, Fernando Rodriguez

GSI/FAIR took a strategic decision to base the control of its Cryogenic and Vacuum Infrastructure for the GSI and FAIR accelerators on the CERN UNICOS framework (Universal Industrial COntrol System). The intention is to continue a long-standing relationship and collaboration with CERN to implement, operate, enrich and further develop the UNICOS framework and related technologies. GSI/FAIR funds a Fellow position for 2 years (initial collaboration phase), will obtain the license for UNICOS and will receive technical support. An

addendum is prepared and negotiated between both parties since November 2018 (IP part needs to be checked by legal services). The process is presently pending, the licensing model is being checked at CERN due to unclear copyright situation of the UNICOS code base. The Addendum should be signed in Q4/2019. The BE/ICS group provides the framework for UNICOS. The two main users at CERN, the vacuum group (TE/VAC) and the cryogenics group (TE/CRG) have the responsibility for the code within this framework, and should be involved in the collaboration. The draft of the addendum should be send to M.Jimenez.

7. **Proposal for new addendum**: "Provide a prototype interlock system based on safety PLCs for the FAIR accelerator". Status: New proposal being drafted: Contact GSI: C.Betz, Contact CERN: Jan Uythoven

   In FAIR, several interlock systems will be required, for equipment as well as for personnel. In many cases, circulating beam has to be stopped, and beam entering into areas of the FAIR complex needs to be prohibited. This has to be done with an adequate safety level (SIL level). One example is the access system for the FAIR accelerator tunnels and experimental areas.

   CERN has experience with safety PLC as well as with interlock systems, and provided a similar system to ITER. CERN will develop a prototype PLC based interlock system that inhibits beam operation on the reception of a number of signals.

   CERN will work out a detailed specification of the system design (modules, structure of the code, Interfaces) and implements a prototype PLC system for one area (safety and non-safety program code). Financial compensation is estimated to be a Fellow position for two years at 50% and expert contribution at 15% FTE. A collaboration was first suggested in 05/2019 and a first version of a Collaboration Addendum drafted for a period of two years.

   The next step is to organize a meeting at GSI with experts from CERN to agree about a basic specification. Further discussions/negotiations between the parties needed, agree on financial compensation, human resources involved and time line.

   Discussions at CERN are required for the respective responsibilities of different CERN teams in this project. The draft of the addendum should be send to M.Jimenez.

Comments for collaboration with controls:

Extensions of collaboration accounts (GSI staff using CERN accounts) is rather heavy, since this is required every year. Could there be a light weight process for such extensions?

One additional suggestion for collaboration is a newly developed digitisation system for analogue signals by GSI.

Beam Instrumentation

Collaboration Activities in the past were the support to FESA software development at CERN by Project Associates from GSI, and the purchase and beam tests of LHC-type Beam-Loss Monitors.

In total, 225 LHC-type Beam Loss Monitors were delivered to GSI, eight BLMs are still required.

Ongoing Collaboration Topics are on Cryogenic Current Comparators, Electron lenses and the development of an Ionization Profile Monitor.

8. **Proposal for new addendum:** "Collaborative support for Cryogenic Current Comparators for AD and ELENA". Status: An addendum will be drafted by M.Schwickert. Contact GSI: M.Schwickert, Contact CERN: R.Jones

   Cryogenic Current Comparators can measure very low beam currents, down to a level of nA. Such detectors were developed between different partners, GSI, CERN, University Jena and TU Darmstadt. One of such monitors is a standard tool used at the CERN AD. Five monitors are required for FAIR and one could be considered for CERN-ELENA. In a collaboration workshop last week the development of a number of CCCs was discussed.

9. **Proposal for new addendum:** "GSI support to CERN e-lens studies". Status: New proposal: Contact GSI: M.Schwickert, Contact CERN: R.Veness. An addendum should be drafted by colleagues from CERN.

   Hollow electron lenses (e-lens) are under development for HL-LHC. For effective operation, very precise alignment between the ion beam and electron beam is required. A beam diagnostics set-up based on an intersecting gas sheet and observation of beam induced fluorescence is under development within a collaboration between CERN, Cockcroft Institute and GSI.

   The existing Addendum #10 has been accomplished: "Delivery of a luminescence profile monitor for observing the interaction of a proton and electron beam with a gas jet target for the High Luminosity Large Hadron Collider". This was mainly in the interest of CERN, profiting from the expertise of GSI in luminescence profile monitoring.

   The next step is to define goals and milestones for a new collaboration agreement. This is a development mainly in the interest for CERN, the addendum should be drafted by colleagues from CERN.

10. **Proposal for Future Collaboration:** "Common developments on FESA integration of beam diagnostic devices (HW + SW), FESA integration of Bunch Structure Monitor (Feshenko-type) and SEM-Grid: Detector and Readout". M.Jimenez will discuss this proposal with R.Jones.

11. **Proposal for Future Collaborations:** "Software development for Ionization Profile Monitor". In the past, mutual technical exchange was based on the ARIES programme. The monitor exists, and the main challenge is the code development for image reconstruction. It is proposed to enhance the existing technical exchange, possibly with a formal collaboration agreement. M.Jimenez will discuss this proposal with R.Jones.

12. **Proposal for Future Collaborations: "**pLinac diagnostics: Bunch Shape Monitor and SEM-Grid profile end emittance measurements".

Bunch Shape Monitor: The hardware for the monitor is a turn-key system purchased from the Russian Institute for Nuclear Research (INR). The functionality of the system has been well proven at CERN, GSI and other institutes. The migration of the complex controls for the system from LabVIEW to FESA and GUI has been done at CERN. A collaboration is proposed for the adaptation of the CERN system to GSI, as well as adding some reconstruction data analysis. Contacts at the engineering level are well established. Next step is to discuss a collaboration agreement for pLinac diagnostics.

Profile and Emittance Measurement: The SEM-Grid for such measurements at the FAIR pLINAC where the beam is smaller than at UNILAC requires a smaller wire distance of 0.5 mm . The readout is not achievable with GSI technology and no FESA compatible version is available. A collaboration is the adaption of CERN system to GSI. Contact at engineering level are well established.

M.Jimenez will discuss these proposals with R.Jones.

High Intensity Beams

Ongoing collaboration: "Collective effects and intensity limitations". The collaboration started many years ago, and it further continuing with a series of workshops (the last workshop in 2017, and the next November 2019). Both sides are very interested in continuing this collaboration (BE/ABP at CERN).

Ongoing collaboration: "Calculations of the impedance of the beam screen of FCC-hh and SIS100". These studies use the same simulation tools. For FCC, the results are being published in the FCC-CDR. The studies should be continued and extended to include Eddy currents. In the past, these studies were financed by EuroCirCol. EuroCirCol funding stopped. In order to continue these studies, other ways of funding need to be identified.

Ongoing collaboration: "Advanced Landau damping for LHC / FCC and FAIR beyond octupoles". For high intensity beams, the understanding of beam stability and the performance limitations is required, as well as to develop mitigation strategies. Ideas for such damping are with pulsed electron lenses or RF quadrupoles. A joint BMBF project funds two PhD thesis students between CERN and GSI, with E.Metral as CERN supervisor. The studies are of interest for both institutes, and for the time being no formal collaboration agreement is required.

13. **Proposal for new addendum:** "Transverse Feedback Systems (TFS) for SIS100". Status: New proposal: Contact GSI: V.Kornilov/U.Blell, Contact CERN: W.Höfle. An addendum will be drafted by O.Boine-Frankenheim and P. Spiller.

    The specifications of the SIS100 system are expected to be very similar to the parameters of the new TFS system in the CERN-PS. A regular exchange between the partners is ongoing and a closer collaboration is desired. CERN support would be very helpful in the preparation of the detailed technical specifications for the SIS100 TFS, which should then be delivered as a Russian in-kind contribution.

14. **Proposal for Future Collaborations:** “High performance beam simulation tools”. Such tools are required to optimise working points and corrections for minimum loss/emittance growth based on realistic beam dynamics simulations for the LHC injector chain (CERN) and SIS18/100 (FAIR).

    The collaboration comprises joint development of high-performance simulation tools, which are hardware accelerated on graphics processing units (GPUs). The project is supported by NVIDIA and E4 computer engineers via the CERN openlab platform: the openlab kick-off meeting in January 2019 was followed by a prototyping phase for the new tool suite within the CERN-FAIR collaboration with support by the NVIDIA engineers. In May 2019, a factor 2000 speed-up for single-particle physics could be reported based on the currently developed (GPU accelerated) SixTrackLib code comparing to MAD-X thin-lens tracking for 1 Mio macro-particles. In June 2019, multi-particle physics have been added by integrating with SixTrackLib the GPU accelerated collective effects code PyHEADTAIL.

    Within the CERN-FAIR collaboration, the potential of this newly established powerful tool suite should now be harvested for detailed high intensity beam dynamics simulations. Next steps comprise modelling the full SIS100 + SPS machines with space charge, with the focus on verifying the physics models as well as experimentally validating predictions. Further code development should consolidate and improve the tool suite based on the initial prototypes as of July 2019. Contacts: A. Oeftiger (GSI) and Y. Papaphilippou (CERN).

Vacuum

Experts from GSI and CERN are exchanging ideas and information. Such exchange can continue without an addendum. As discussed above, for minor activities such as short visits it is sufficient to inform the management (at CERN the group leader). Medium size activities could be covered by a generic addendum.

Summary: Actions

I. STEAM: finalise addendum, latest in Q4/2019 (GSI: P.Szwangruber, CERN: A.Verweij)

II. Development of Control System Components: Update and finalize the addendum and present it to management for signature, latest in Q4/2019 (GSI: R. Bär, CERN: NN).

III. Use and further development of UNICOS: Draft of the addendum should be completed and send to M.Jimenez, latest in Q4/2019 (GSI: R. Bär, CERN: M. Jimenez)

IV. Prototype interlock system based on safety PLCs for FAIR: Draft of the addendum should be completed and send to M. Jimenez, latest in Q4/2019 (GSI: R.Bär/R. Schmidt, CERN: M. Jimenez)

V. Cryogenic Current Comparators for AD and ELENA: Proposal will be drafted and send to M. Jimenez, latest in Q4/2019 (GSI: M. Schwickert, CERN: R.Jones)

VI. GSI support to CERN e-lense studies: An addendum should be drafted by colleagues from CERN, latest in Q4/2019 (GSI: M.Schwickert, CERN: R.Veness)

VII. FESA integration of beam diagnostic devices: Proposal will be drafted and send to M. Jimenez for CERN internal discussion, latest in Q4/2019 (GSI: M. Schwickert , CERN: M.Jimenez, R.Jones)

VIII. Software development for Ionization Profile Monitors: Discussion of a formal collaboration agreement, latest in Q4/2019 (CERN: M.Jimenez, R.Jones GSI: M. Schwickert)

IX. FAIR pLinac diagnostics: Discussion of a formal collaboration agreement, latest in Q4/2019 (CERN: M.Jimenez, R.Jones GSI: M. Schwickert)

X. Transverse Feedback Systems (TFS) for SIS100: Addendum will be drafted, latest in Q4/2019 (GSI: O.Boine-Frankenheim/P.Spiller, CERN: W. Höfle)

XI. High performance beam simulation tools: Proposal for CERN/GSI agreement will be drafted, latest in Q4/2019 (GSI: O. Boine-Frankenheim, CERN: Y. Papaphilippou)

Summarised by R.Schmidt, 8/7/2019, OBF 10/7/2019, CR 11/7/2019