Control system developments and machine model benchmark for the GSI fragment separator FRS

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1 Introduction

At the GSI facility, the LSA [1] framework from CERN is used to implement a new control system for accelerators and beam transfers. This was already completed and tested for the SIS18 heavy-ion synchrotron. The implementation of experimental rings such as CRYRING and ESR is currently under development. In addition, the fragment separator FRS [2] and - at a later stage - also the superconducting fragment separator Super-FRS at FAIR will be controlled within this framework. The challenge posed by the implementation of the control system for the FRS arises from the interaction of the beam with matter in the beam line and the beam's associated energy loss. This energy loss is determined using input from ATIMA [3] and has been included into the code of the LSA framework. The implemented setting generator was simulated and benchmarked with results of earlier measurements. Furthermore recent development made the modeling of slits and their magnetic rigidity changing properties and modeling of the propagation of charge states and isotopes through matter possible.

2 FRS and LSA

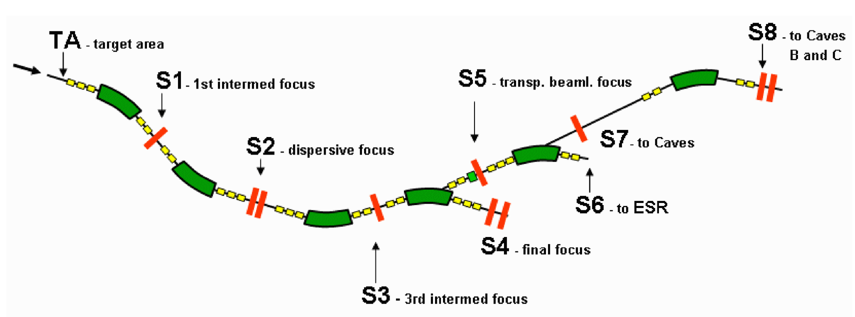

Figure 1: Magnetic setup of FRS and focal planes.

The LHC Software Architecture is used for setting generation and management.It is highly database driven and uses one data model for all accelerators. The LSA-core obeys certain concepts, which are as follows: parameters, settings, cycles, supercycles, beam production chain, pattern, beamprocess.

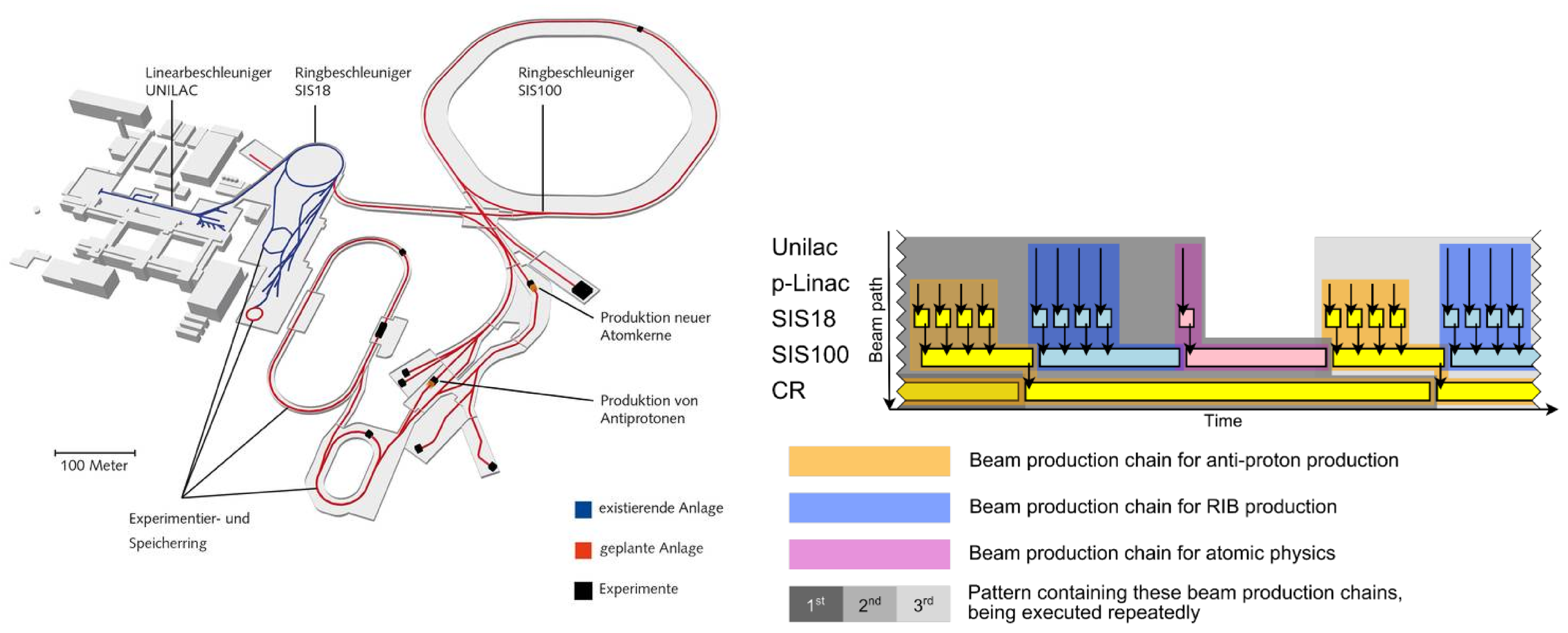

Figure 2: GSI and planned FAIR facilities together with new concepts of LSA.

The software architecture of LSA ,as it is used at GSI, is designed under the concepts of being distributed, modular and layered. These aspects can be found in the 3-tier design of the LSA framework and structure of the LSA-Core.

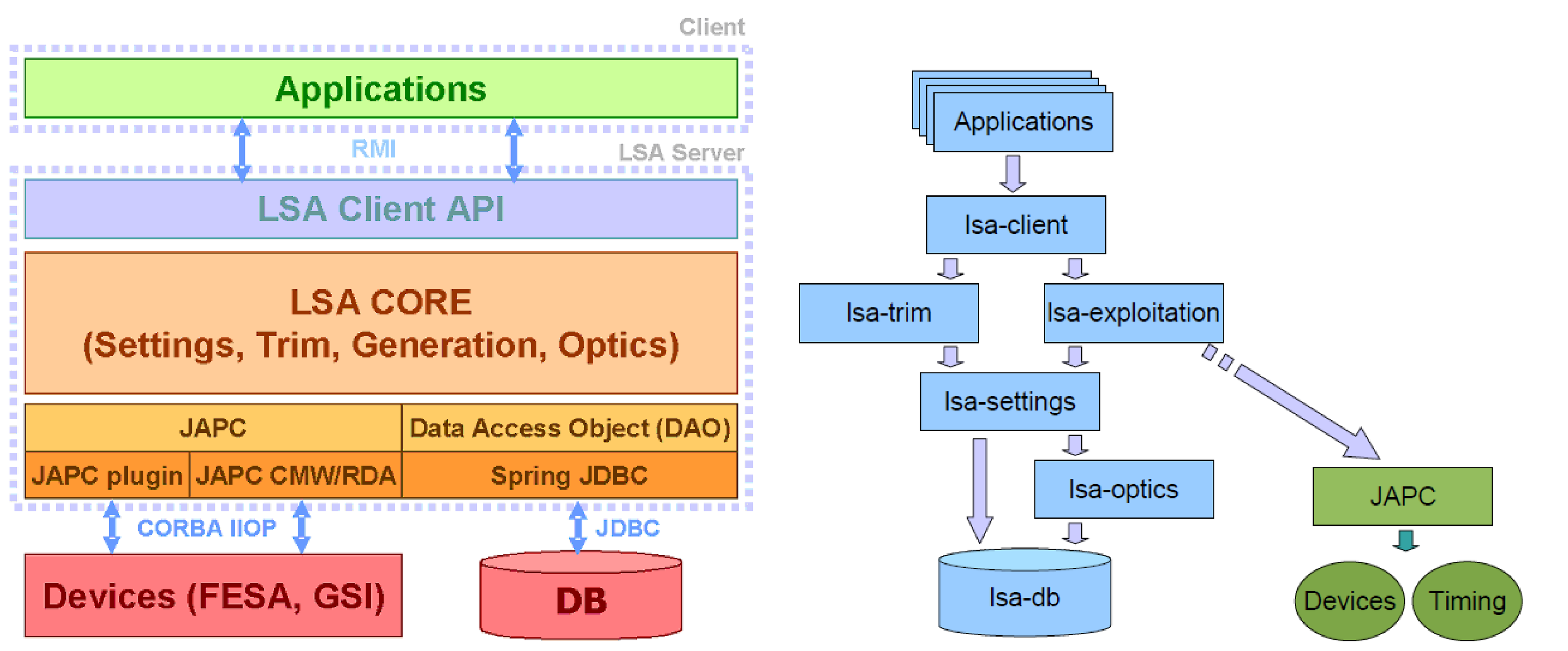

Figure 3: LSA 3-Tier architecture and communication.

3 Recent developments

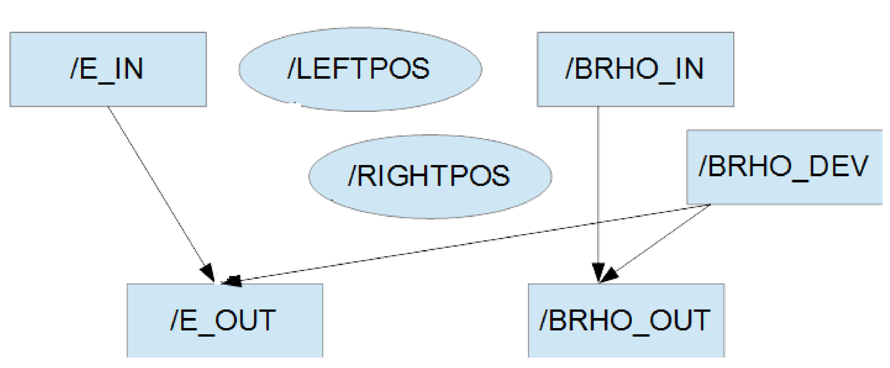

Figure 4: Parameters for horizontal slits.

The LSA machine model for the FRS has been continuously updated and reworked since its early model that was used for benchmarking [4]. Many of these developments can be found in the new design of the parameter hierarchy of matter, slits and slit drives. The slits have been designed accordingly, taking into account the ability to change beam parameters such as the magnetic rigidity and the energy of the beam. This is achieved by introducing a deviation factor for the rigidity which is applied unto the energy by transforming the momentum into an energy factor within the Makerule.

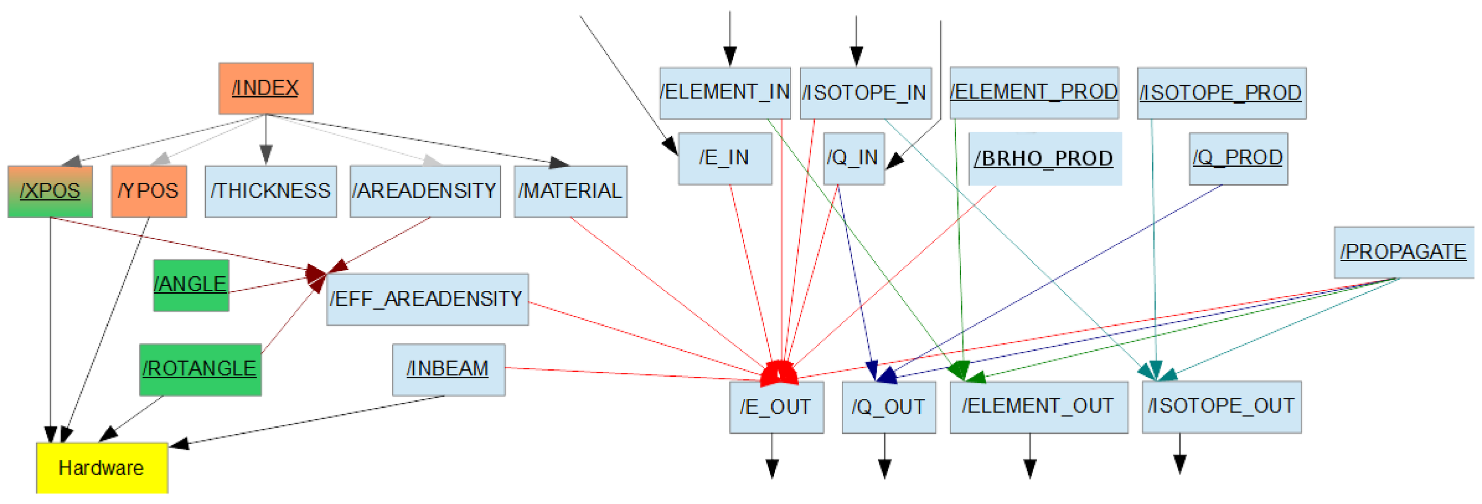

Figure 5: Hierarchy for FRS matter.

A big change for matter is the consideration if the beam is being propagated through matter or if a secondary beam is being produced, here the operator needs to provide additional information about the produced isotope.

4 Benchmark - ^{238}U @ 1 GeV/nuc. primary beam at TA

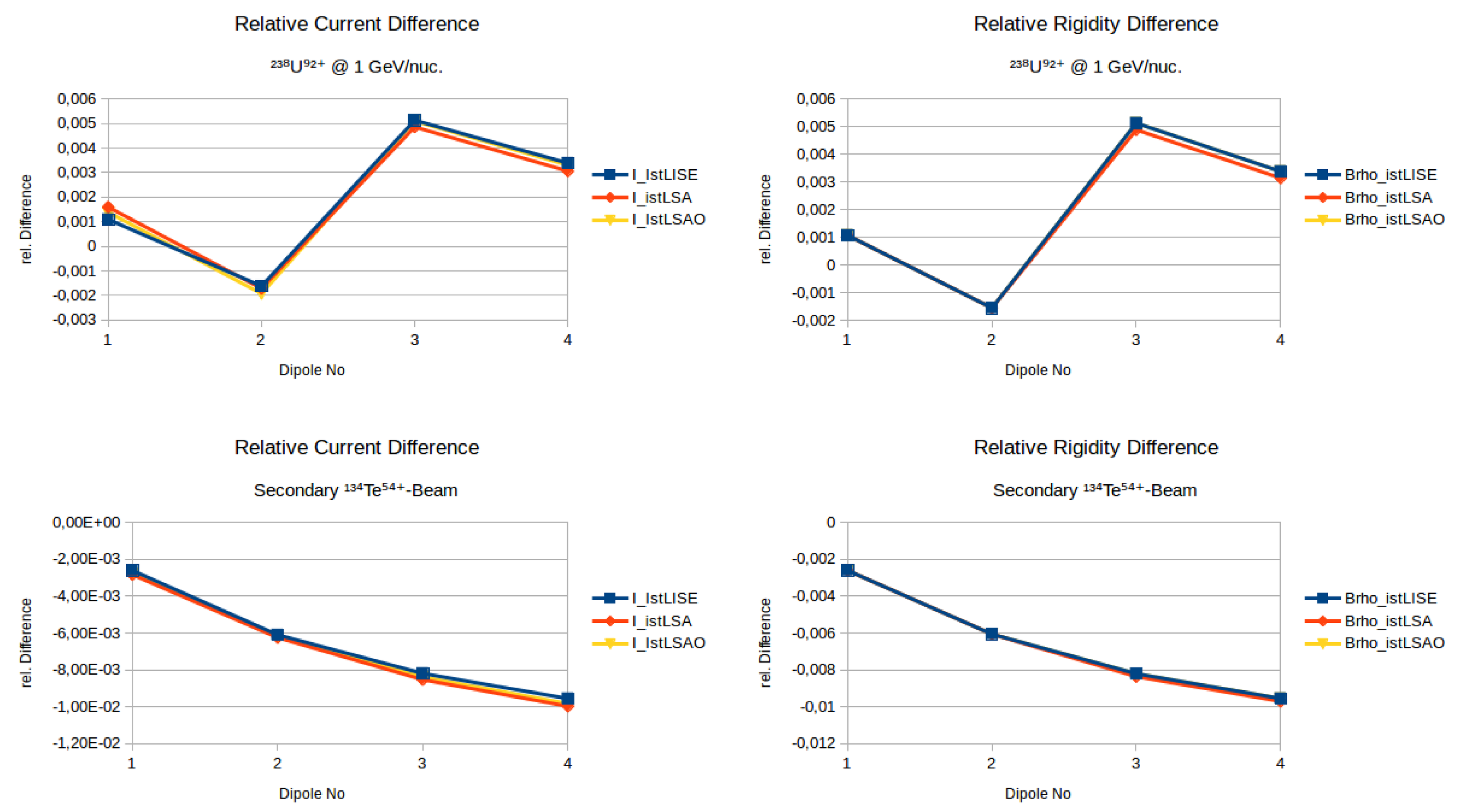

Figure 7: Resulting differences for primary and secondary beams.

Experimental dipole currents and magnetic rigidities compared to calculated values by LISE++ (blue), Bρ Overwrite by LSA (yellow) and new (red, this work) model with a primary beam of ^{238}U with 1 GeV/nuc. on 6333 mg/cm^2 Be + 233 mg/cm^2 Nb at TA and 4200 mg/cm^2 of Aluminium wedges together with standard detector and slit setup at other focal planes. The updated machine model shows a calculated relative accuracy in the range of 10^{-3} for both primary and secondary beams, equivalent to LISE++.

5 Conclusion

It was possible to design the machine model of the FRS with all devices from TA to S8 including matter and detectors in the LSA-Framework, to implement energy-loss calculations and to build new parameter hierarchies for the 5 types of matter encountered inside the FRS: detectors, targets, targetladders, degraders and degraderdisks. The machine model was tested during engineering runs at the GSI facility in April 2019 for the FRS, which showed that it is possible, with the current machine model and control system, to safely operate the FRS and transfer the main beam from TA to S4. Devices and machines, including SIS18, CRYRING and FRS were able to be operated at beamtimes in 2018/2019. A benchmark with former experimental settings showed that the new model is able to reproduce the settings with a relative accuracy in the order of 10^{-3}, equivalent to LISE++ which has been used before. Furthermore updates in ATIMA [3] from Version 1.3 to 1.41 improved the energy-loss calculations at low energies, and new functionalities like hysteresis cycling for dipoles, automatic drive update, target steering, manual overwrite and Bρ selection in slits have been added and proven to work.

6 Outlook

- Implement automation scripts for readout from MIRKO/GICOSY and writing into LSA/LISE++.
- Implement a database for matter and ATIMA splines.
- Adapt developed FRS solution to S-FRS

References

[1] M. Lamont et al., LHC Project Note 368
[2] H. Geissel et al., NIM B 70, 286 (1992)
[3] H. Weick et al., NIM B 164/165 168 (2000)
[4] J.P. Hucka, Implementierung und Test eines Settingenerators fuer den GSI-Fragmentseparator FRS in der LHC Software Architecture LSA (2016), TU Darmstadt