Realization of a Concept for Scheduling Parallel Beams in the Settings Management System for FAIR

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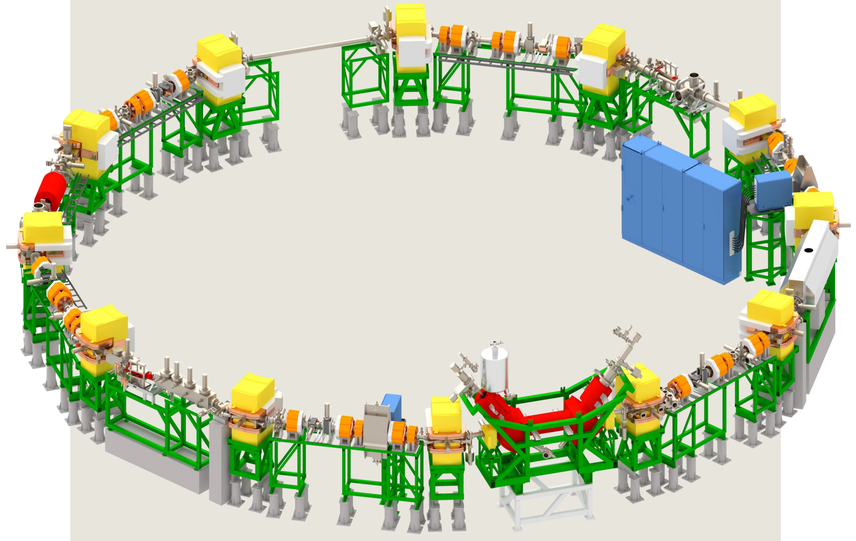
Abstract

Approaching the commissioning of CRYRING, the first accelerator to be operated using the new control system for FAIR (Facility for Antiproton and Ion Research), the new settings management system will also be deployed in a production environment for the first time. A major development effort is ongoing to realize requirements necessary to support accelerator operations at FAIR. The focus is on the pattern concept which allows controlling the whole facility with its different parallel beams in an integrative way. Being able to utilize central parts of the new control system already at CRYRING, before the first FAIR accelerators are commissioned, facilitates an early proof of concept and testing possibilities. Concurrently, refactorings and enhancements of the commonly used LSA (LHC Software Architecture) framework take place. At CERN, the interface to devices has been redesigned to enhance maintainability and diagnostics capabilities. At GSI, support for polynomials as a native datatype has been implemented, which will be used to represent accelerator settings as well as calibration curves. Besides functional improvements, quality assurance measures are being taken to increase code quality in prospect of productive use.

Commissioning of CRYRING at GSI

- ✓ **Installation nearly complete, very few additional components to be integrated**
- ➔ **Commissioning of hardware ongoing, deployment and testing of whole control system stack is about to commence**
- ➔ **Major milestone from a controls perspective, as CRYRING will be the first machine solely operated via the new FAIR control system**



Overview of the CRYRING storage ring as setup at GSI (injection lines not shown), W. Geithner, GSI.

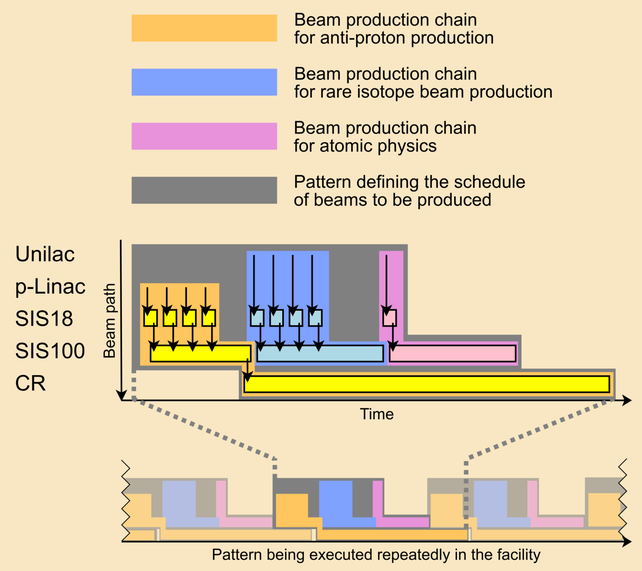
Status of the FAIR Settings Management System

- ℹ **Development is currently focused on CRYRING and implementing the parallel beam scheduling concepts**
- ✓ **Reference settings for CRYRING successfully calculated using the pattern scheduling mechanisms**
- ➔ **Integration tests with the other control system components are being conducted**

Parallel Beam Scheduling Concepts for FAIR

- ◎ **Optimize the number of concurrent research programs**
  - Up to five beams in parallel
  - Pulse-to-pulse switching between different particle types
- ◎ **Allow for great flexibility**
  - Change the parallel operation schemes on a daily basis

- 💡 **A beam-oriented approach to settings management and scheduling that enables consistent operation planning across the whole FAIR facility**
- ℹ **Beam production chains and Patterns are the central technical concepts to fulfill these requirements**
  - A beam production chain describes the order of all procedures (e.g. injection, ramp, extraction) necessary for producing a certain beam, providing settings for all machines involved, from the source up to the target
  - To be able to coordinate multiple beams traversing the facility in parallel, beam production chains are grouped into patterns



Example for parallel beam operation showing scheduling of beam production chains into patterns. HESR accumulating the anti-protons is omitted.

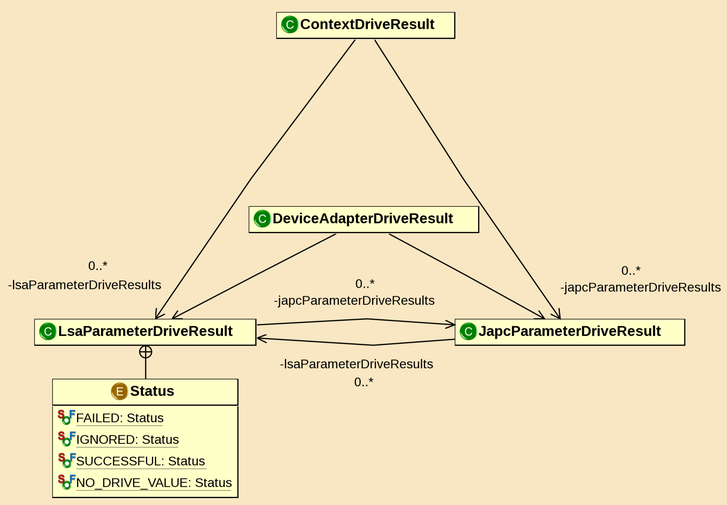
Recent Enhancements of the Framework

Polynomial data types

- ℹ Before polynomials were available, all functions data had to be provided in a discretized form
- ✓ Truly continuous while consuming less memory as they are represented by coefficients instead of x-y-pairs
- ✓ Both calibration curves (from the magnets group) and settings (e.g. for ramped devices) are supported

Data supply subsystem

- ◎ Core motivation was to improve diagnostics capabilities of the system
- ℹ Joint effort between CERN and GSI
- ℹ Data supply results were formerly presented in a flat structure for the whole process
- ✓ New hierarchic result classes allow operators to trace errors down to individual parameters, e.g. in case a set value is rejected by a front-end controller
- ✓ Particularly beneficial when supplying large numbers of devices and for handling error states during commissioning



Class diagram showing the refactored LSA data supply results structure.

Quality Assurance Measures

- **Facilitate focus, correctness and test coverage for mission-critical components**
  - ✓ Implementation of the parallel beam scheduling concept and the data supply system overhaul was carried out using a test-driven development approach
- **Minimize potential errors during commissioning of CRYRING**
  - ✓ Intensive code reviews of machine model
  - ✓ Automated integration test suite using mock-up front-end device controllers

Test-Bed for the new FAIR Control System

- ◎ **Validate concepts and technologies under real-world conditions**
  - CRYRING is equipped with its own injector line, so it can operate independently of the existing accelerator chain
  - CRYRING does not imply the same requirements as FAIR will, but core concepts can nevertheless be tested
- ➔ **Parallel beam scheduling concept will be utilized at CRYRING for the first time**

Outlook

- ◎ **Enhanced CRYRING operation**
  - Synchronization between previous and new control system to be able to transfer beams from ESR to CRYRING
  - Beam manipulation during the cycle for experimentation phases
- ◎ **Towards full FAIR operation**
  - Scheduling a beam production chain multiple times as a sub-chain to consistently model e.g. SIS18 in booster mode for SIS100
  - Multiple active patterns to serve experiments that require beam on demand