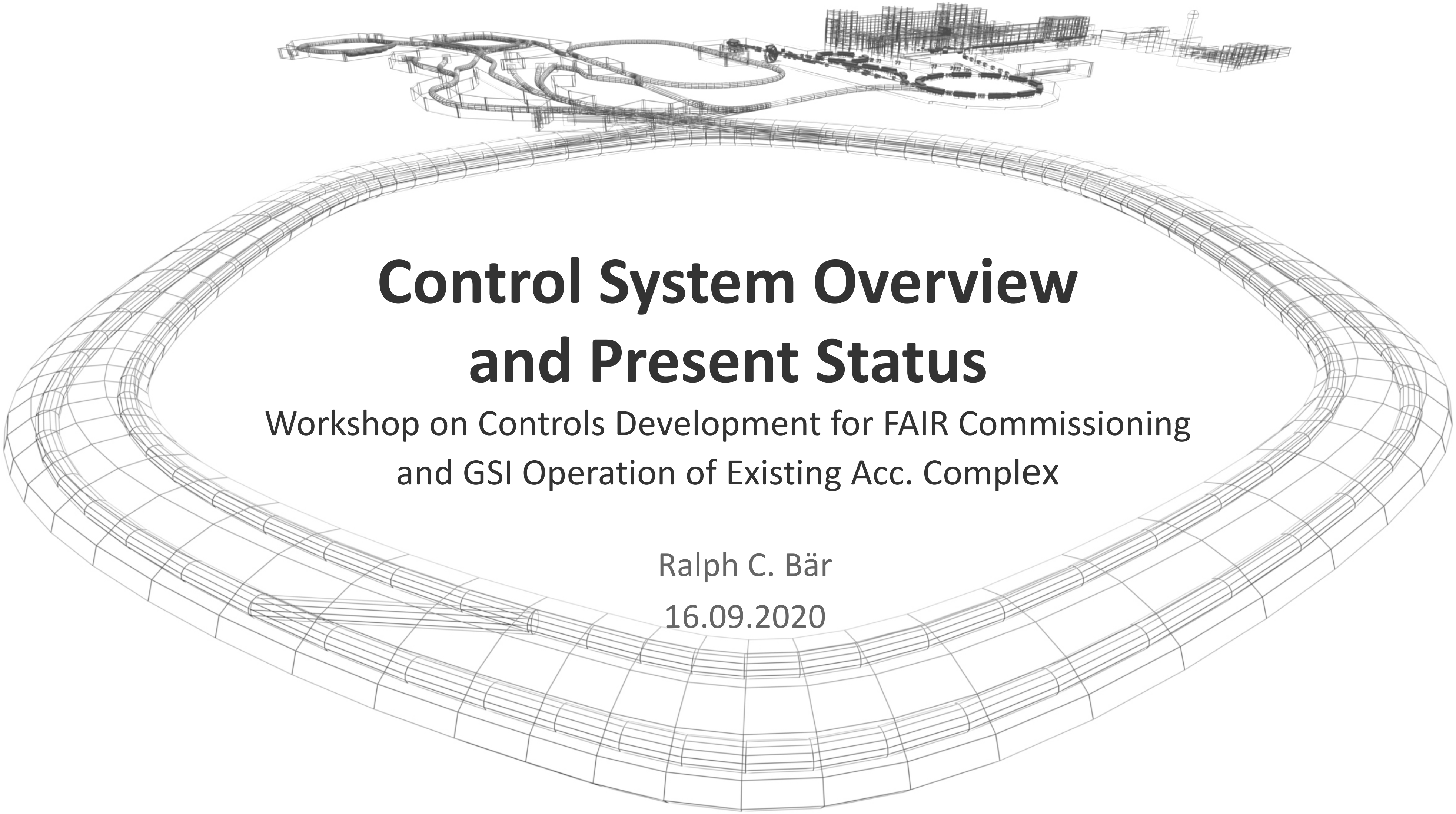

Control System Overview and Present Status

Workshop on Controls Development for FAIR Commissioning and GSI Operation of Existing Acc. Complex

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16.09.2020

Topics Overview

1. **About this Workshop**
2. **Strategic Approach for Control System Development**
3. **Control System Overview and Status**

Intention of this Workshop

- Proposed by the TI (Technical Integration) team and the FAIR Project Lead
- Asked for by several SPL, Operation and some technical departments

The new FAIR/GSI control system has already been developed for several years now:

- Basic developments are completed (frameworks, architecture, hardware platform, system services, major features)
- System has been successfully operated in two major beamtime campaigns (2019, 2020)

Project will move soon to next phase phase => FAIR hardware and beam commissioning

- Control system needs to be prepared well for these upcoming challenges
- SPL/MC need to be informed about the status and development roadmap

Intention of the workshop: Present and discuss…

- controls aspects of FAIR (hardware) commissioning
- requests from beam operation with the existing accelerators (FAIR injectors)
- Start a comprehensive collection of requests
- Refine, confirm and/or optimize the Controls development roadmap
- Align with our overall objectives (FAIR, Operation, Upgrades) and resources
- Prepare a refined implementation/commissioning plan and priorities

Intention of this Workshop

Workshop Day 1:

- Presentations on present status => everbody on the same page
- Presentation of further Controls development roadmap (when do we plan to do what)
- Presentation of Controls (hardware) commissioning preparations (tools, organisation, …)

Workshop Day 2:

- Presentations on Controls requests by the FAIR Sub-Projects
- Presentation on Activities and Controls Requests by the existing Machines
- Presentations on Requests by other stakeholders
- Presentations on Requests by selected Technical Subsystems

Optionally:

- Additional discussion on Friday 09:30 (Zoom only)

Control System Development

Strategic Considerations for New Control System Development

- **Design as Open Distributed System**
  - The CS is designed as an open distributed system, so that other technical groups can contribute to the development and bring in their specific expertise, e.g. the physics modelling of the accelerators (LSA), development of equipment classes (FESA), development of operational applications, beam-based control loops.
  - CS shall provide open interfaces to users, e.g. to Archiving, Settings Management

- **Collaboration Approach**
  - Profit from collaborations as much as possible (➔CERN): reliable, tested solutions and focus to extend/enrich/develop features specific for GSI/FAIR. ➔ e.g. LSA (setting management), FESA (front end system architecture), cmw (controls middleware), UNICOS (industrial controls), White Rabbit (timing).

- **Testing & Implementing the FAIR control System at GSI first**
  - Testing at new Integration System (INT)
  - Testing at CRYRING (testbed machine)
  - Get operational experience & feedback at existing GSI accelerators

- **Slovenian in-kind Contribution**
  - Some subsystems and components developed by Slovenian consortium

Strategic Considerations for New Control System Development

- Common sense: Never commission a new control system **and** a new accelerators in parallel (FAIR is big and complex!) ➔ de-couple controls and machine commissioning for FAIR

- Reliability for FAIR: get robustness and reliability as high as possible not to impede fast and efficient commissioning of FAIR (reliability of whole chain is product of availability of injector chains)

- Identify possible design flaws, bottlenecks, problems as early as possible in order to mitigate (the later, the worse) ➔ Troubleshooting, debugging asap, iron out problems

- Get operators and users involved and trained in the new system as early a possible, incorporate feedback and achieve (earn) confidence into the system

Drawback of this approach: Existing facility and users...

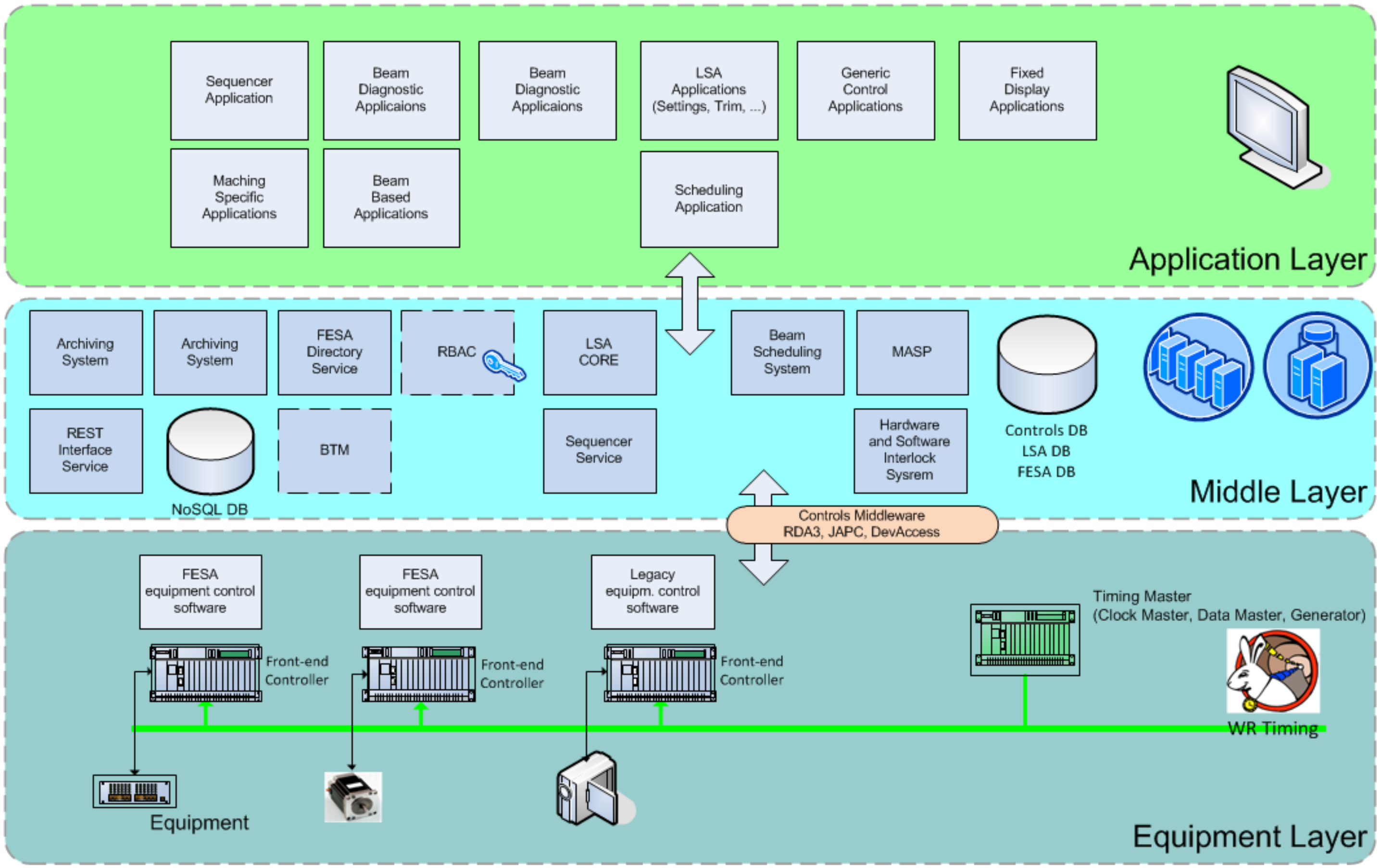
- Naturally: new control system is initially more unstable and lacks well known feature of a mature system
- In transition, operators/users suffer from degraded performance, bugs & troubleshooting (typical 2-3 years), but compensated by new features & functions

The FAIR Control System Stack

Presentation Tier

Middle Tier
powerful
servers

Resource Tier
FESA



- Standard 3 tier model; distributed OO system
- Modular design with well defined interfaces

General Status: Control System in Operation

- For SIS-18/HEBT/ESR/CRYRING the basic feature-set of the CS is considered complete (however, many functions are cumbersome and not „nice“ to use, but are there)
- Achieved for BT 2020: Storage ring functions for ESR added, allow interactive operation and physics program, operation is presently based on expert tools

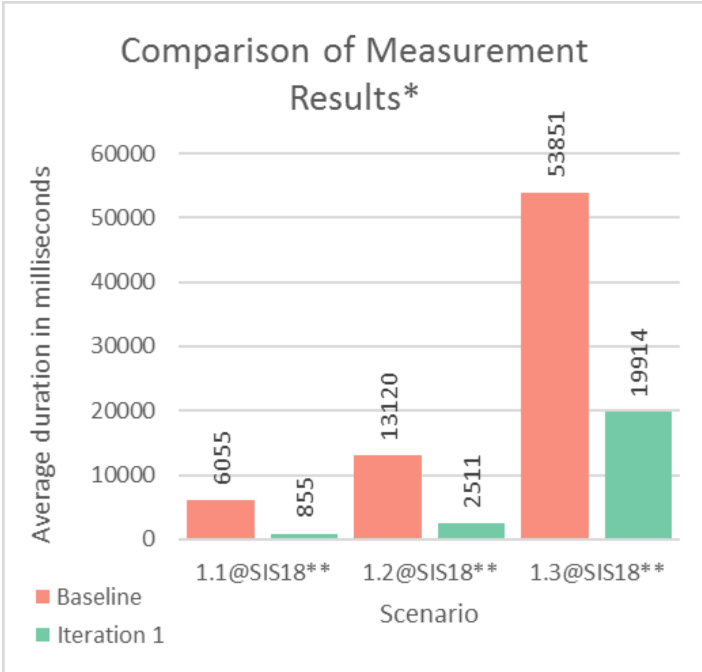
- Robust operation of central CS subsystems: LSA, BSS, Timing, Interlocks, …
- Stable operation of UNILAC & CRYRING vacuum control system (UNICOS based)

- Reproducibility of LSA settings is good (loading a pattern ➔beam is there)
- Reliable setting and optimization at several consoles in parallel, e.g. independent optimization of 3 beam-lines possible

- Major issue:
  - Performance: System response times for settings/trims is poor
    (not acceptable on the long run)
    addressed by ➔ Task Force Performance (TFP) established in 04/2020

Task Force Performance achieved significant results after iteration 1 already

- Establishing a cross-department task force proved beneficial for defining goals, setting priorities and improving mutual understanding
- The scenario-based approach ensures that optimization is targeted at real-world use cases, results are verifiable and implementation can be carried out efficiently
- Implementation phase is still ongoing. For individual trim scenarios already optimized, an improvement of ~75% on average compared to the baseline measurements has been realized
- Iteration 2 will focus on optimizing concurrent trims and ensuring that improvements manifest in operators experience during day-to-day operation



* Please keep in mind that due to changing system environments, measurement methods and external factors, measurement runs performed at different points in time are not fully comparable. Consequently, this diagram should only be considered a rough indicator of to-be-expected performance.

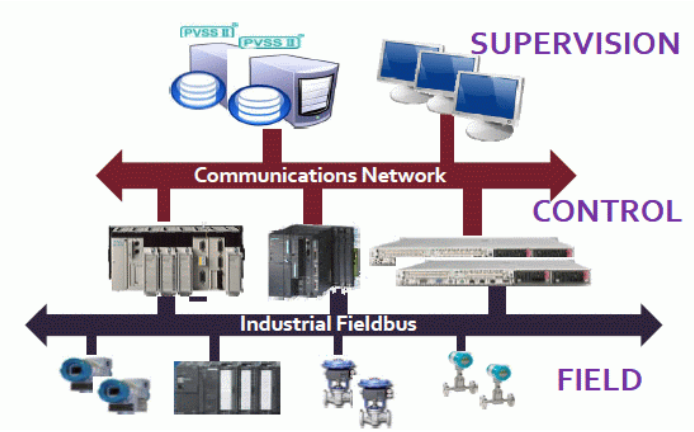
** Baseline measurements are available for scenarios 1.1 to 1.3 at SIS18 only.

All TFP meeting minutes, technical documentation and results are available in the Controls Wiki (ACC account needed).

Most TFP objectives will be met. However, an ongoing effort is needed

- Task force members are confident that at the end of the project, the measures implemented will result in substantially improved operation efficiency. Also, considering requirements for the future FAIR facility, no fundamental flaws in control system design or architecture have been found so far
- Measurements show that all machines operated with the FAIR control system will benefit. However, due to limited resources, some requirements affecting specific machines may not be realizable within the project's scope. These should be considered for ongoing performance improvement efforts and need to be prioritized in relation to other requested features
- Due to the optimization efforts, measures to reduce technical debt in affected systems had to be partly postponed. However, these are still necessary to ensure future extensibility and have to be considered in project planning
- After the project's conclusion, performance will be monitored during the coming beam times. A dedicated reevaluation should be foreseen after transactions for setting changes have been implemented (currently planned for 2023/24)

Industrial Controls
Vacuum and Cryogenic Controls



Some technical subsystems are not time-critical and highly industrial related: Cryogenics Controls, Vacuum Controls, Personnel Safety.

CERN **UNICOS** (Unified Industrial Control System) selected

- Framework with methods to design and develop complete industrial control applications
- Based on Siemens PLCs and commercial SCADA system (WinCC OA, TIA portal)
- Tools to automate the instantiation of devices and generate logic code

Development of the UNICOS system for Vacuum and Cryo is already quite advanced
The following systems are already in operation (FAIR type):

- CRYRING vacuum control & bake-out
- UNILAC vacuum controls (successfully replaced in 2019, operated in Beam Time 2020)
- Cryo controls already in use for R3B and TCF20 (Cryring e-cooler) LHe plant/distribution

Vacuum control system for FAIR is mainly Slovenian in-kind contribution!

➔Presentation by Christine Betz (this Workshop)

Present Activities (2020)

Next Steps

- Control System technical consolidation phase in 2020 (removing technical debts in all systems)
- Top priority in 2020: Performance optimization (TFP)
- Preparation and support for SIS-100 String Test (end-2020)
- Development of key services for FAIR commissioning and operation (Sequencer, Archiving) and general Middle-Tier System Architecture (MiTSA) framework

Implementation of New Features for Operation/FAIR (not existing in the old system)

- Archiving system: operation, improvement of DAQ features and data retrieval / processing and visualization features ➔ Presentation by Vitaliy Rapp (this Workshop)
- Sequencer System (automatic procedures, important for FAIR commissioning, repetitive tests, …)
  ➔ Presentation by Stefan Krepp (this workshop)
- Digitization-Project: High-quality analog signals digitizer systems
- BPM Concentrator (orbit data) implemented, operational GUI under development

Injector Controls Upgrade Project ➔ Presentation by Peter Gerhard (this Workshop)

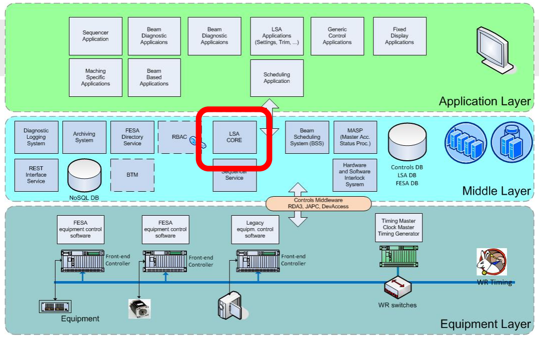
- Life-sustaining measures for UNILAC operation
- Retrofit of UNILAC control system towards FAIR standard (Timing System, upper system layers)

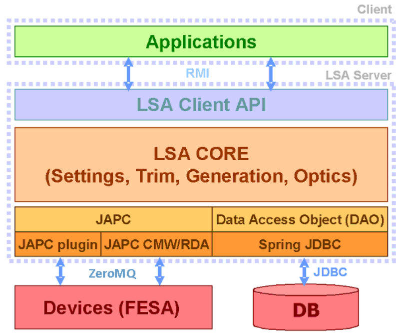
thank you!

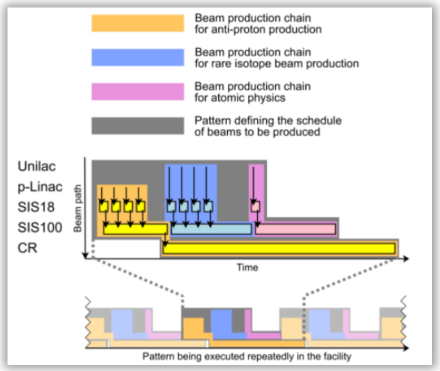
Setting Generation and Management

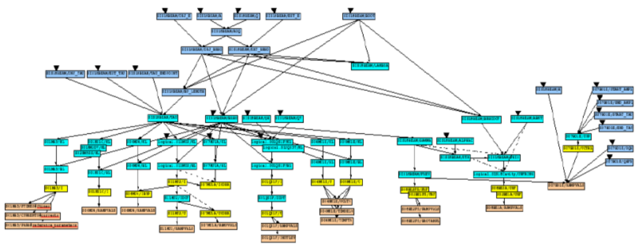
Status

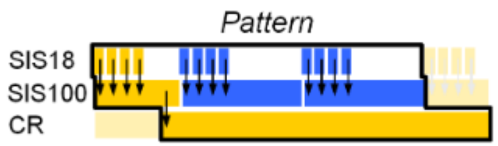
- LSA is ***the*** core component of the FAIR Control System, used for settings generation and management
- Well developed framework for CERN and FAIR accelerators (maintained in collaboration)
- Provides consistent settings on all levels, contains optics, accelerator model(s) and parameters (hierarchy from physics to devices)
- All accelerators (CRYRING injector & ring, SIS-18, HEBT, ESR have successfully been modelled in LSA and operated
- LSA core was extended by several components for the beam scheduling system (pattern management, beam requester, MASP status processor) and for the FAIR Timing System (Schedule supply fully implemented)
- Central system architecture and new concepts have proven to be adequate for facility operation, no showstoppers identified.

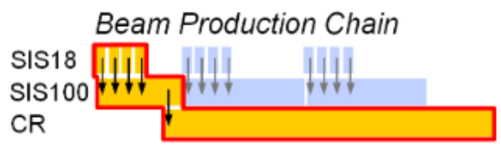




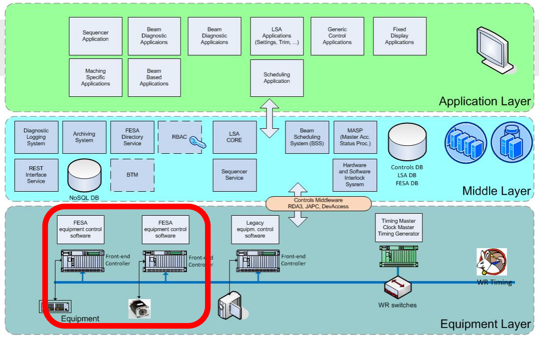






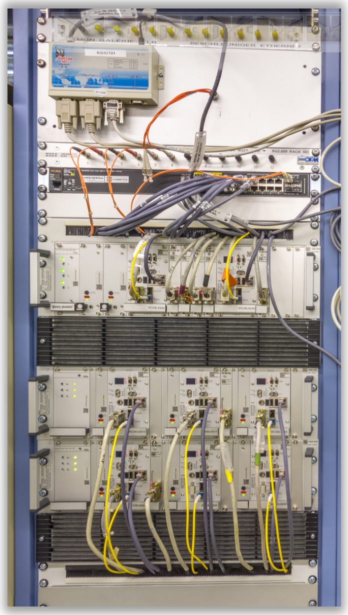


Equipment Control
Front-End Electronic and Software



Hardware Status
- SCU modular eco-system for FAIR further developed (SCU host controller, several types of slave boards, feature several types of interfaces DIO/AIO Cu/FOC IF, integrated WR FTRN
  ➔ 150 units already in operation at GSI facility
- SCU3 production ongoing, SCU4 revision under development

Software
- FESA equipment control software developed for several types of equipment (FAIR type and retrofitted): Power Converters, Ring-RF, linac RF, Chopper, CRYRING devices, …



Retrofitted controls rack controlling power supplies

Analog Signals Digitizer Systems
- Hardware Platform for Time- and Frequency-Domain Acquisitions
- Electro-mechanical system integration
- Prototype Time-Domain FEC-Integration
- Several user-level GUIs

- Missing: Frequency-domain SW integration