

Control System & Applications

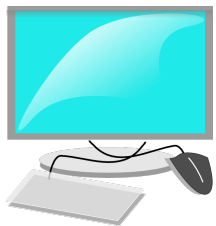
Jutta Fitzek, *Hanno Hüther*
13.09.2017

- Control System Overview
- Patterns & Beam Production Chains
- Applications
- Outlook

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Control System Overview

Tier 1: Application / Presentation



FAIR Facility Overview
('Page 1')

Applications
(Java)

Exp. Apps.
(Java)

Tier 2: Business Layer



Controls
DB

SCADA
(Vacuum
/ Cryo)

LSA
(Settings
Management)

LSA
DB

Archiving

LSAAPI

JAPC

Tier 3: Industrial Control & IT

Timing
(FESA, HW, C++)

Prop. HW
(non-FESA)

Front-End
(FESA, C++)

Front-End
(FESA, C++)

White Rabbit

actual HW

actual HW

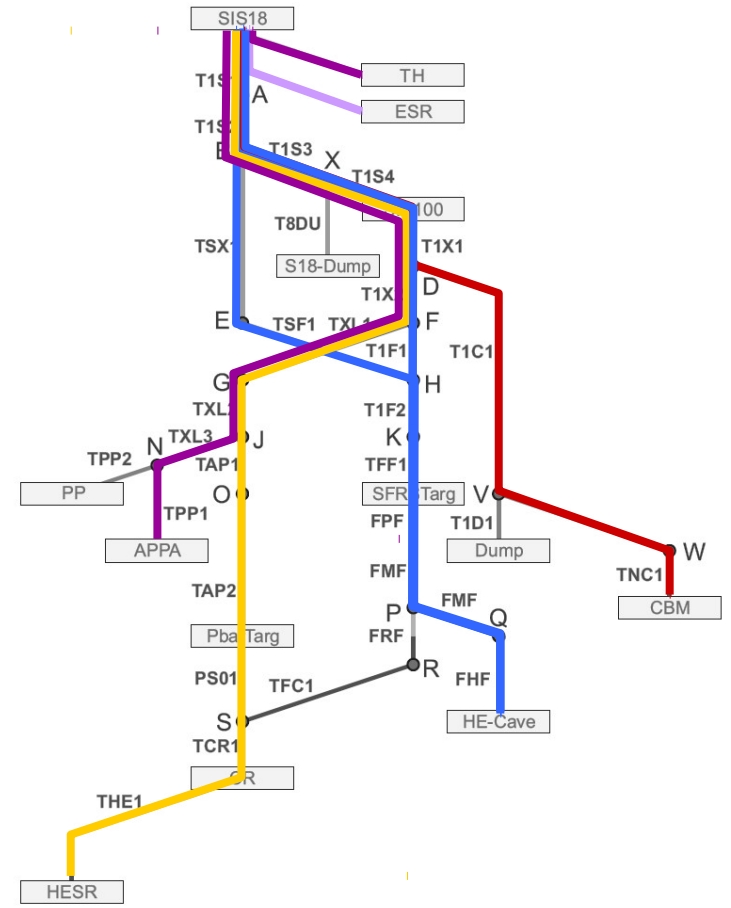
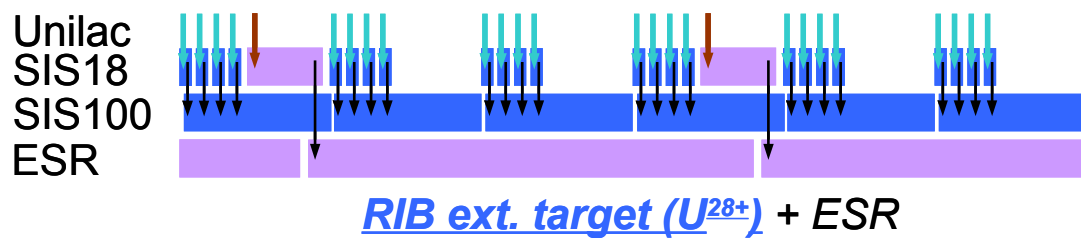
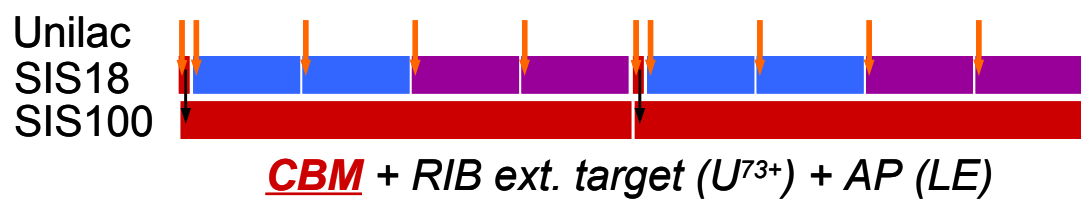
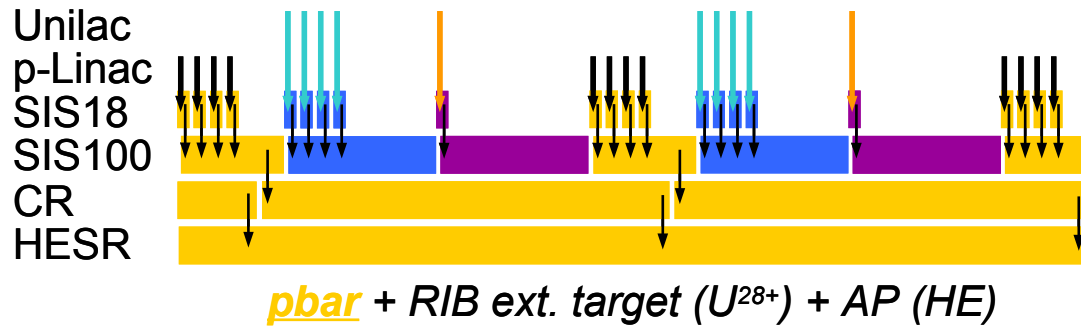
actual HW

Machine-Protection, Interlocks, MASP
Transmission Monitoring, Post-Mortem

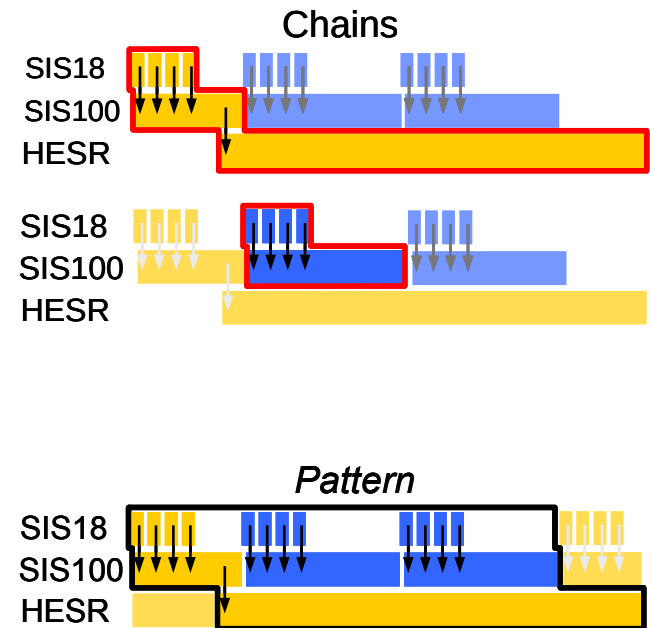
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FAIR Operation Scenarios

Examples for periodic Patterns, each dominated by one main experiment



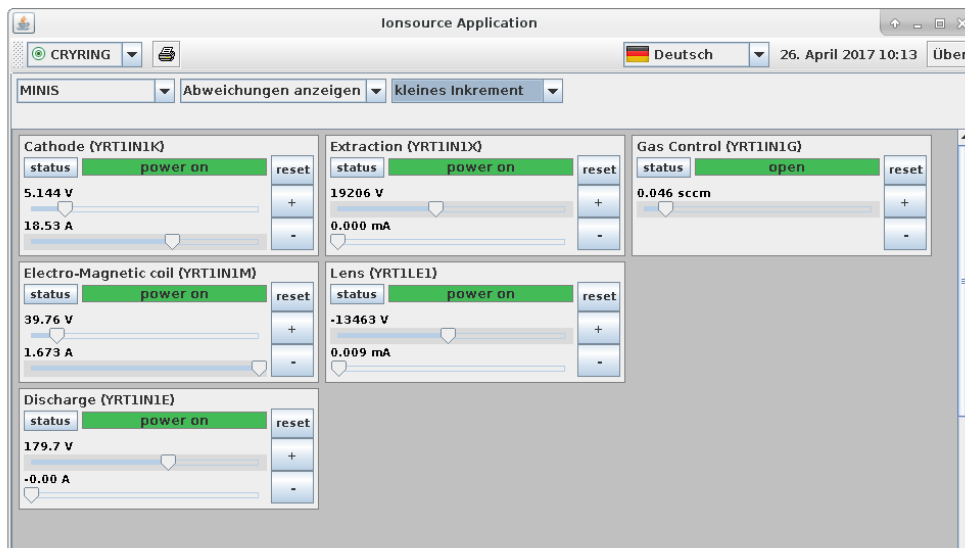
- Beam Production Chain (BPC)
 - Organisational structure to manage parallel operation and beam transfer through FAIR accelerator facility
 - Defines sequence and parameters of beam line from the ion-source up to an experiment
- Pattern
 - Grouping of Beam Production Chains that are executed periodically
- For 2018
 - One BPC per Pattern
 - Multiple Patterns in Round Robin
 - Similar to working with Virtual Accelerators



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Ionsource Application

- Generic Ion Source Program for FAIR, used at CRYRING (operational) and Unilac North/South (as prototype)



CRYRING | Deutsch | 26. April 2017 10:13

MINIS | Abweichungen anzeigen | kleines Inkrement

Cathode (YRT1IN1K)
 status: power on
 5.144 V
 18.53 A

Extraction (YRT1IN1X)
 status: power on
 19206 V
 0.000 mA

Gas Control (YRT1IN1G)
 status: open
 0.046 sccm

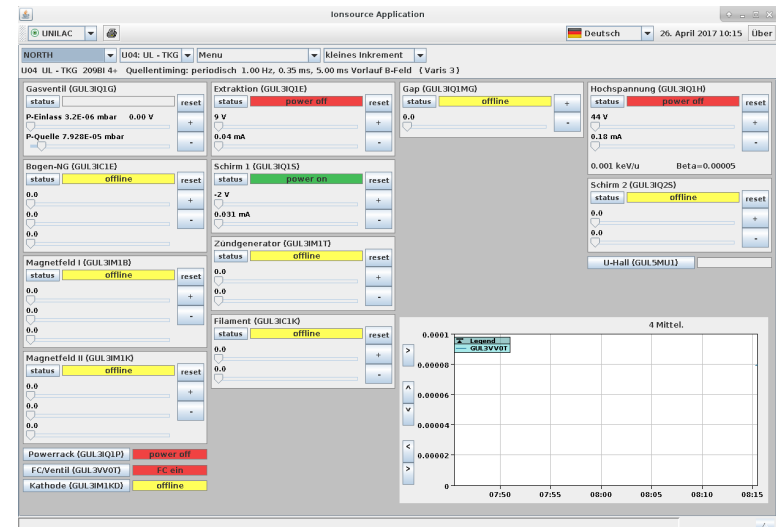
Electro-Magnetic coil (YRT1IN1M)
 status: power on
 39.76 V
 1.673 A

Lens (YRT1LE1)
 status: power on
 -13463 V
 0.009 mA

Discharge (YRT1IN1E)
 status: power on
 179.7 V
 -0.00 A

Abweichungen anzeigen

	set value	read value	difference	set value	read value	difference
YRT1IN1K	7.000 V	5.144 V	26.51 %	18.503 A	18.53 A	0.17 %
YRT1IN1M	50.01 V	39.76 V	20.50 %	0.880 A	1.673 A	146.10 %
YRT1IN1E	180.00 V	179.7 V	0.12 %	0.300 A	-0.00 A	100.00 %
YRT1IN1X	19401 V	19206 V	1.00 %	1.000 mA	0.000 mA	100.00 %
YRT1LE1	13500 V	13463 V	0.28 %	1.000 mA	0.009 mA	99.07 %
YRT1IN1G	0.0460 sccm	0.046 sccm	0.43 %			



UNILAC | U04: UL - TKG | Menu | Kleines Inkrement | Deutsch | 26. April 2017 10:15 | Über

U04 UL - TKG 20961 4 - Quellentiming: periodisch 1.00 Hz, 0.25 ms, 5.00 ms Vorlauf 8-Feld (Varis 3)

Gasventil (GUL3Q1G)
 status: power off
 9 V
 0.04 mA

Extraktion (GUL3Q1E)
 status: power off
 0.0
 0.031 mA

Gasventil (GUL3Q1G)
 status: offline
 0.0
 0.0

Schirm 1 (GUL3Q1S)
 status: power on
 -2 V
 0.031 mA

Schirm 2 (GUL3Q2S)
 status: offline
 0.0
 0.0

Zündgenerator (GUL3M1T)
 status: offline
 0.0
 0.0

Filament (GUL3C1K)
 status: offline
 0.0
 0.0

Magnetfeld I (GUL3M1B)
 status: offline
 0.0
 0.0

Magnetfeld II (GUL3M1K)
 status: offline
 0.0
 0.0

Powerrack (GUL3Q1P)
 status: power off

FC/Ventil (GUL3V01T)
 status: FC ein

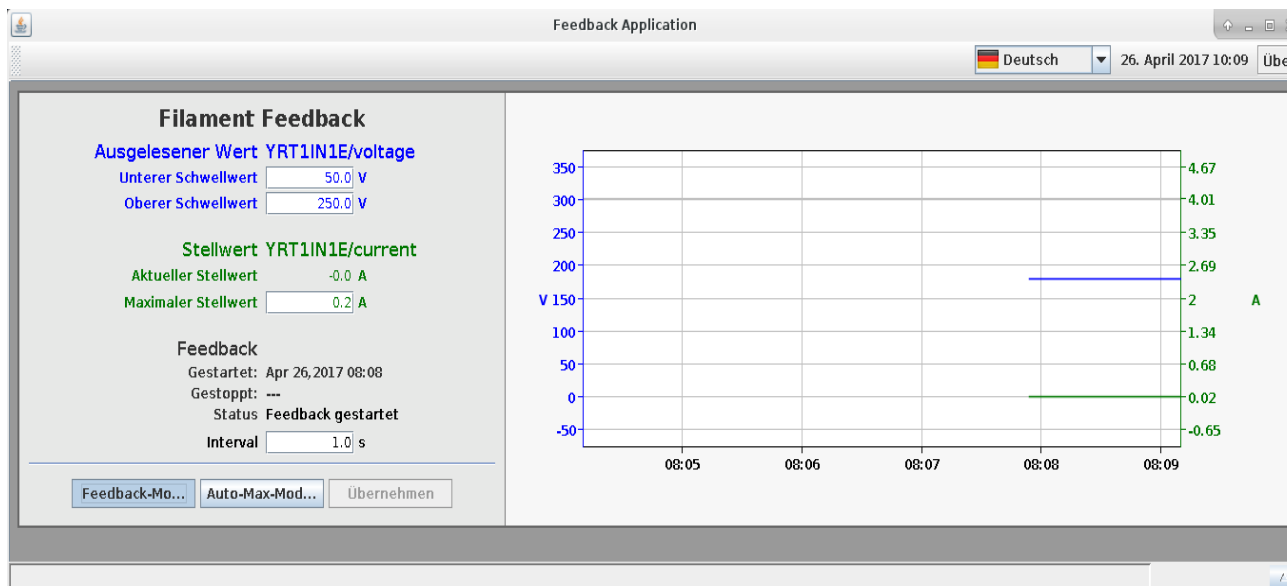
Kathode (GUL3M1K3)
 status: offline

Hochspannung (GUL3Q1H)
 status: power off
 44 V
 0.18 mA
 0.001 keV/u Beta=0.00005

U-Hall (GUL3MU1)

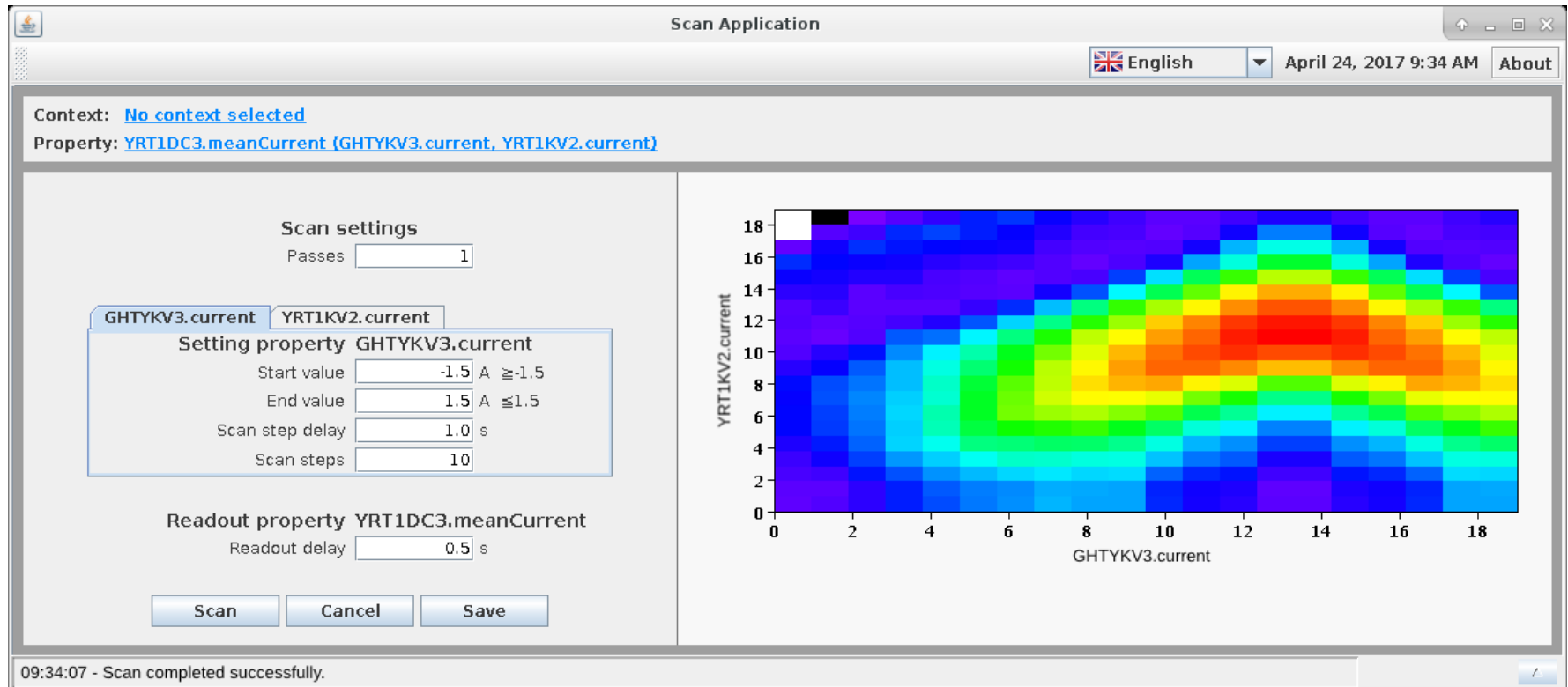
4 Mittel.
 Legend: GUL3V01T

- Remake of an existing Crying Ion Source Feedback Program from Sweden
- Collect ideas for a more generic feedback program for other ion sources



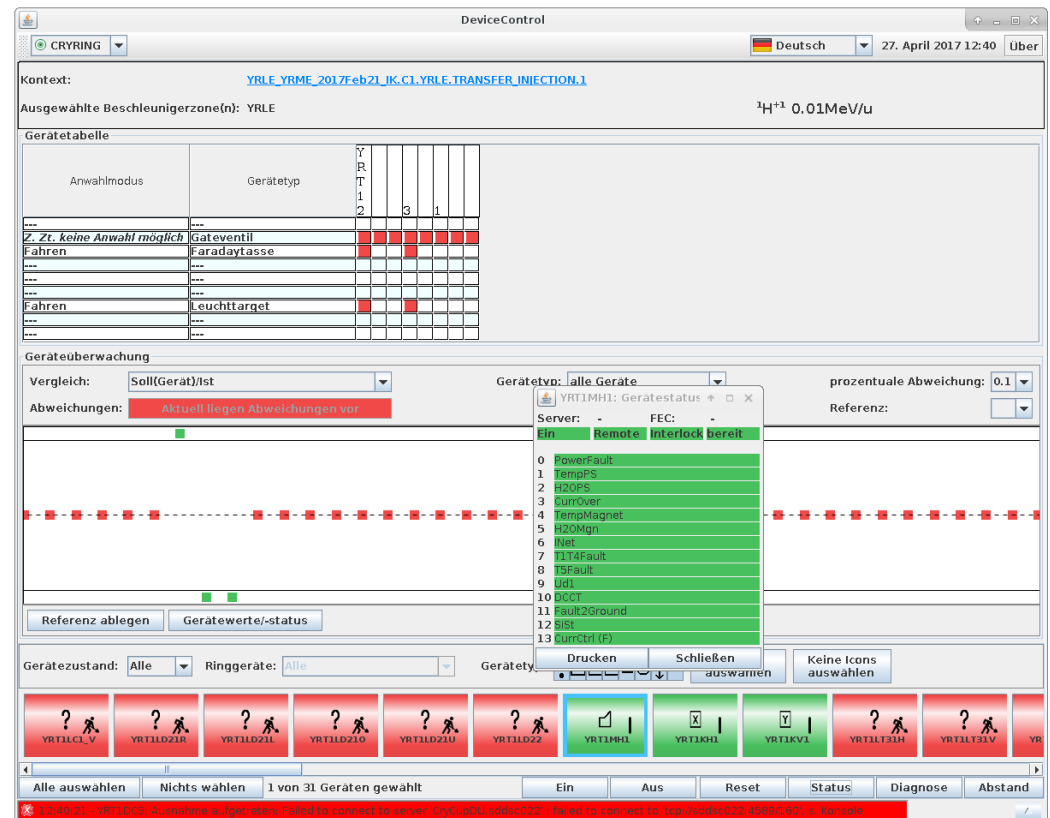
Scan Application

- Prototype of a generic scan application
- 1-/2D parameter scan



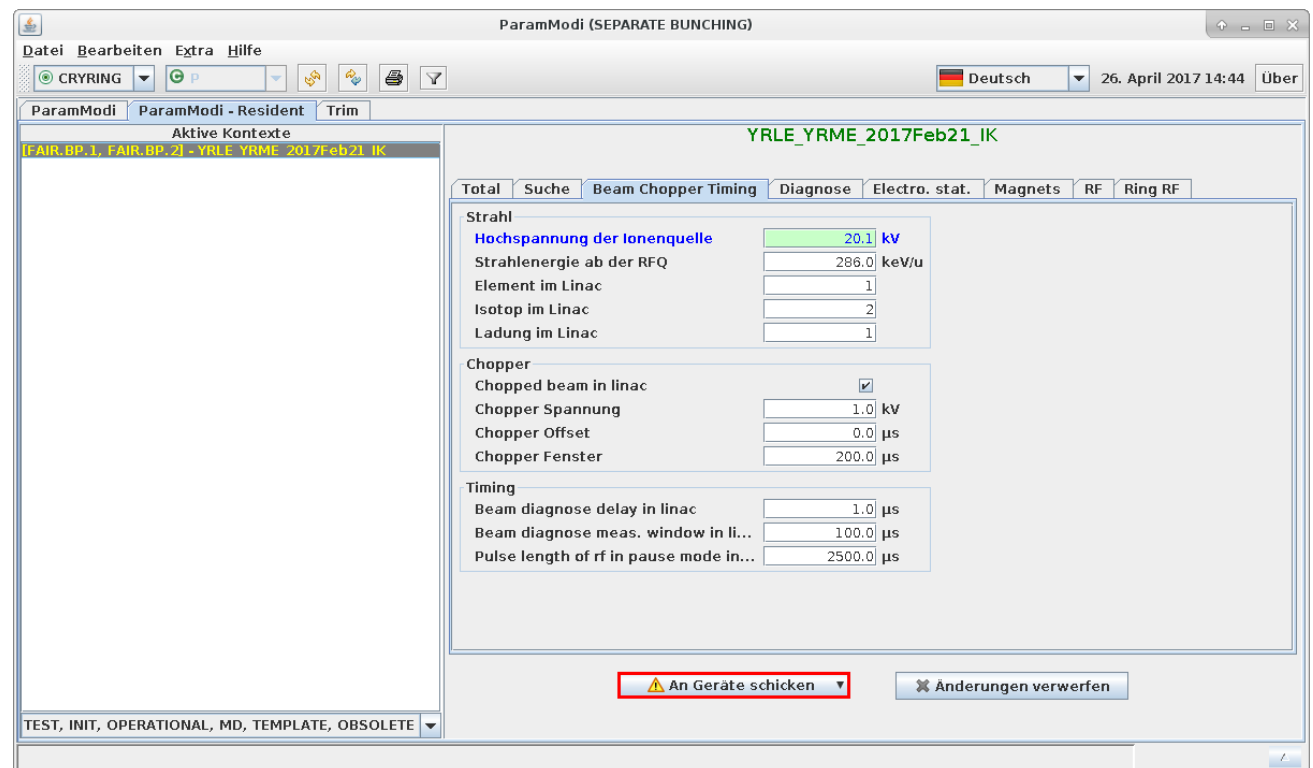
The screenshot displays the 'Scan Application' window. At the top, it shows the language set to 'English' and the date 'April 24, 2017 9:34 AM'. The main area is divided into two sections. On the left, the 'Scan settings' panel includes a 'Passes' field set to 1. Below this, there are two tabs: 'GHTYKV3.current' (selected) and 'YRT1KV2.current'. The 'Setting property GHTYKV3.current' section contains four fields: 'Start value' (-1.5 A), 'End value' (1.5 A), 'Scan step delay' (1.0 s), and 'Scan steps' (10). Below these is the 'Readout property YRT1DC3.meanCurrent' section with a 'Readout delay' field set to 0.5 s. At the bottom of the settings panel are 'Scan', 'Cancel', and 'Save' buttons. On the right, a 2D heatmap shows the relationship between 'GHTYKV3.current' (x-axis, 0 to 18) and 'YRT1KV2.current' (y-axis, 0 to 18). The heatmap features a central region of high intensity (red/orange) that tapers off towards the edges, indicating a peak in the scanned parameter space. A status bar at the bottom left reads '09:34:07 - Scan completed successfully.'

- Control on device level
 - Reading status
 - Comparing set and actual values
 - Switching on / off
 - Driving step motors
 - ...

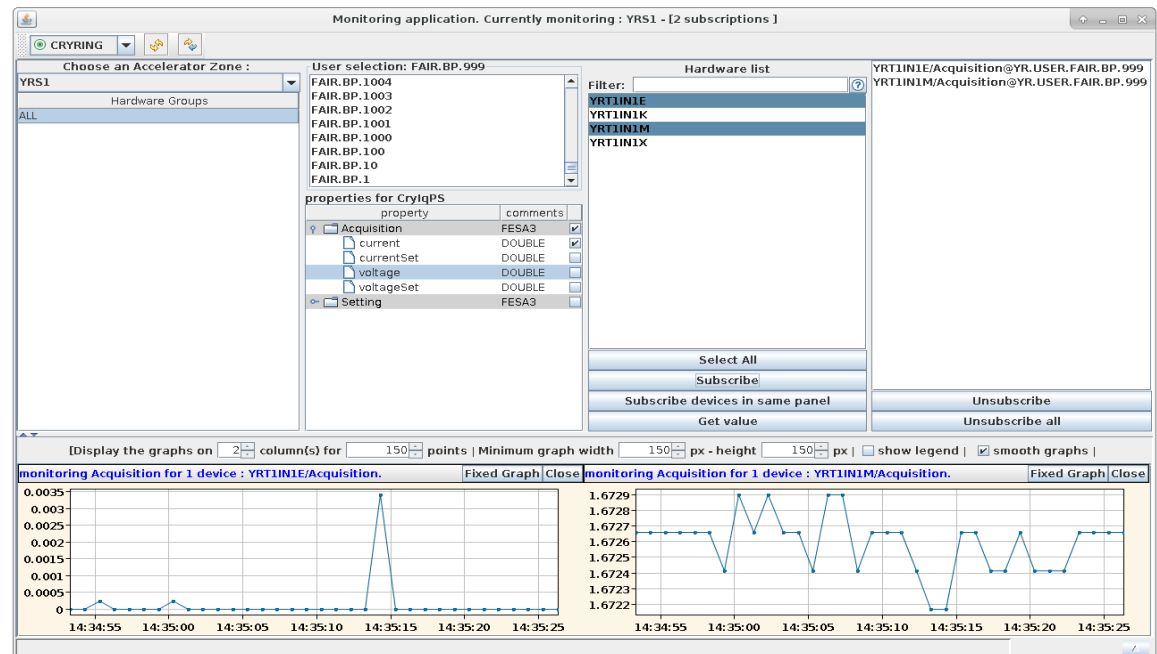


The screenshot shows the 'DeviceControl' software interface. At the top, it displays the context 'YRLE_YRME_2017Feb21_JK.C1.YRLE.TRANSFER_INJECTION_1' and the selected acceleration zone 'YRLE' with a beam energy of $^3\text{H}^{+1}$ 0.01MeV/u. Below this is a 'Gerätetabelle' (Device Table) with columns for 'Anwahlmodus' (Selection Mode) and 'Gerätetyp' (Device Type). The table lists various devices like 'Gateventil', 'Faradaytasse', and 'Suchttarget' with their respective status indicators. A 'Geräteüberwachung' (Device Monitoring) section shows a comparison of 'Soll(Gerat)/Ist' (Set/Actual) values and a list of monitored parameters such as 'PowerFault', 'TempPS', 'H2OPS', etc. The interface also includes a status bar at the bottom with buttons for 'Alle auswählen', 'Nichts wählen', and '1 von 31 Geräten gewählt'.

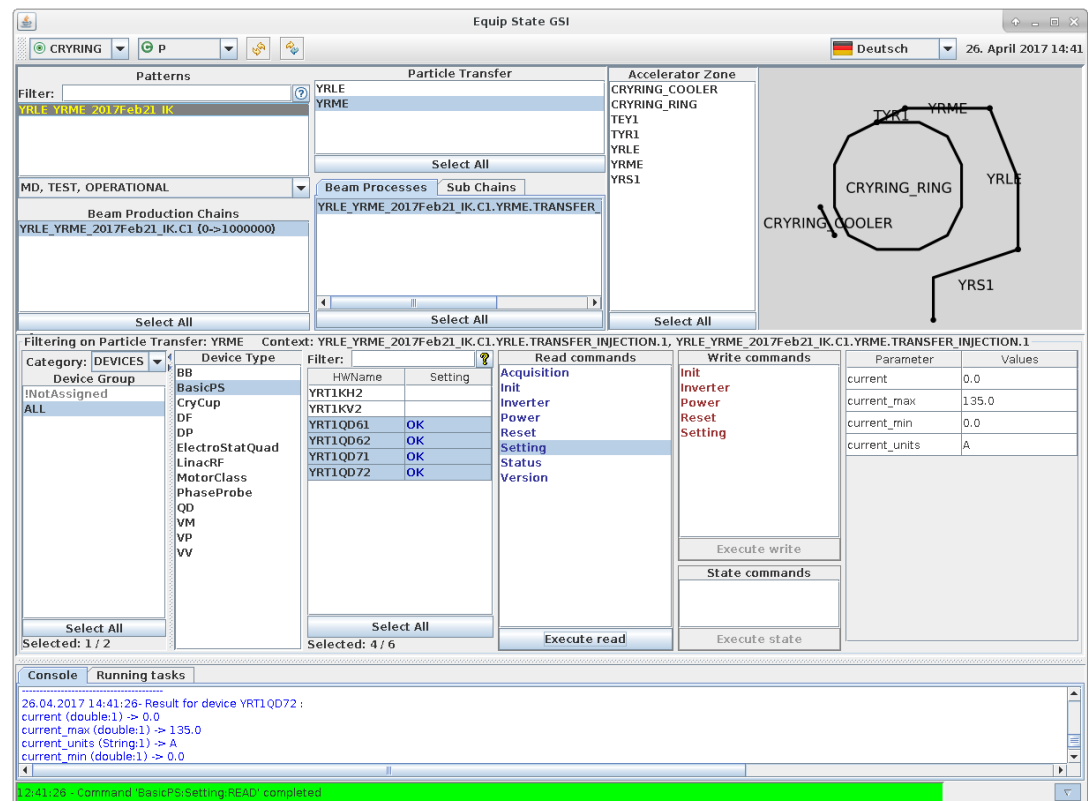
- Central application for manipulating setting values
- View the settings on all levels of the hierarchy (plus expert trim)



- EquipMonitor: Subscribe to all properties of the devices
- Will be replaced in the future by the Archiving System GUI



- EquipState: Set/Read all properties of the devices (comparable to FESA Explorer, bit less „low-level“)



The screenshot displays the EquipState GSI software interface. The top bar shows the application name and system information like language (Deutsch) and date (26. April 2017 14:41). The main area is divided into several sections:

- Patterns:** A list of patterns with a filter field. One pattern, "YRLE_YRME_2017Feb21_IK", is highlighted.
- Particle Transfer:** A list of particle transfer components including YRLE and YRME.
- Accelerator Zone:** A list of zones including CRYRING_COOLER, CRYRING_RING, TEY1, TYR1, YRLE, YRME, and YRS1.
- Beam Production Chains:** A list of beam production chains, with "YRLE_YRME_2017Feb21_IK.C1 (0->1000000)" selected.
- Filtering on Particle Transfer:** A section for filtering devices, showing a list of device types (BB, Device Group, ALL, NotAssigned, etc.) and a table of hardware names and settings.
- Read commands:** A list of read commands including Acquisition, Init, Inverter, Power, Reset, Setting, Status, and Version.
- Write commands:** A list of write commands including Init, Inverter, Power, Reset, and Setting.
- Parameter Values:** A table showing parameters and their values for the selected device.
- Console:** A log window showing the results of a read command for device YR1QD72, displaying current, current_max, current_units, and current_min.

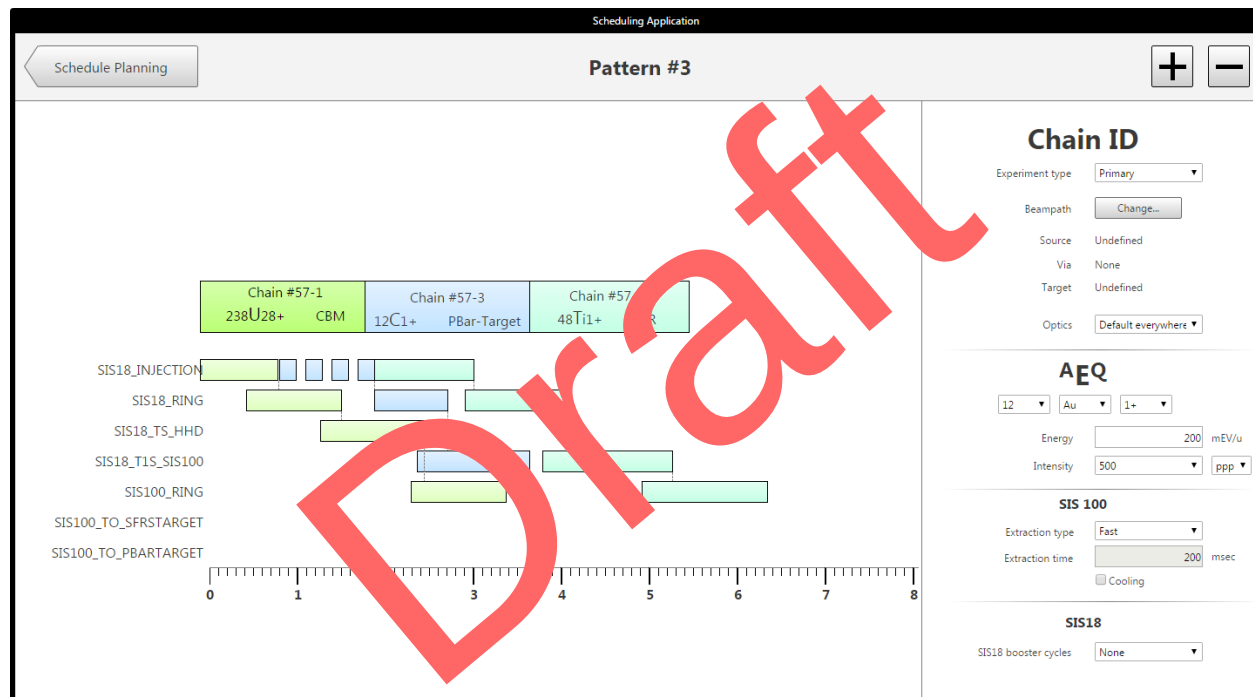
Parameter	Values
current	0.0
current_max	135.0
current_min	0.0
current_units	A

```
26.04.2017 14:41:26 - Result for device YR1QD72 :
current (double:1) -> 0.0
current_max (double:1) -> 135.0
current_units (String:1) -> A
current_min (double:1) -> 0.0
```

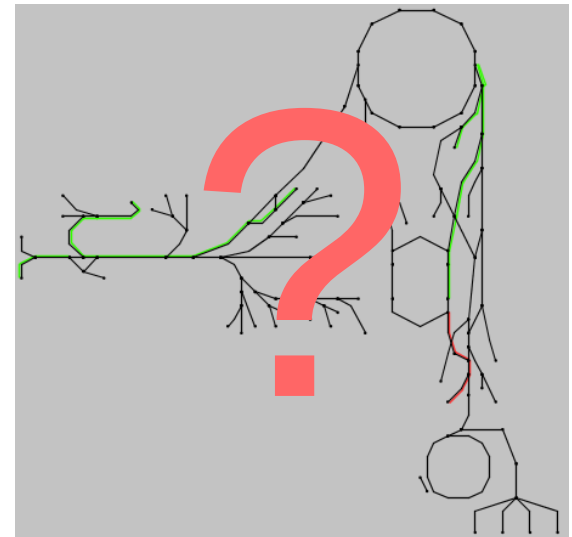
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Outlook: Scheduling Application

- Plan and execute patterns
- Comparable to “Init” application



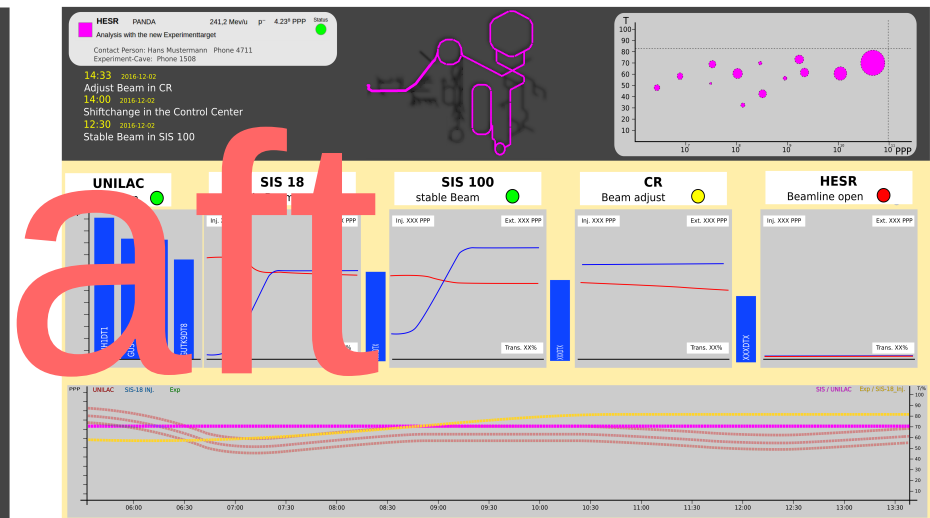
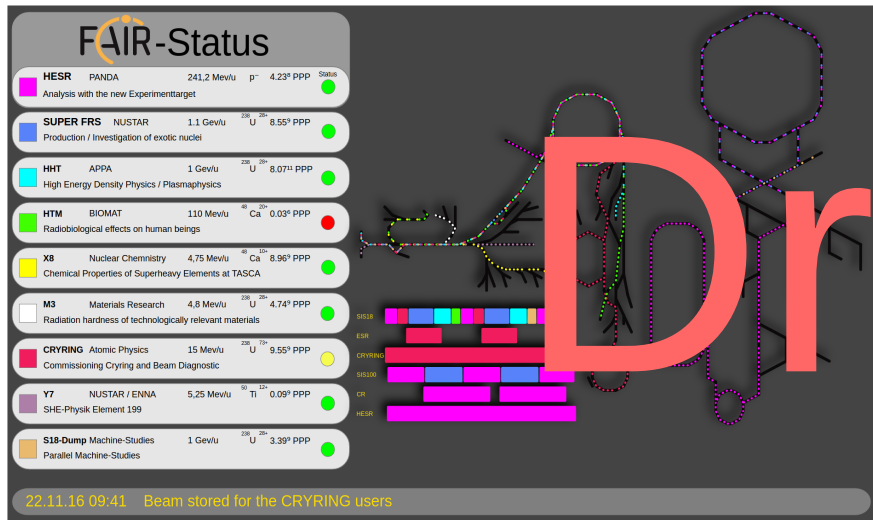
- Based on MASP (Master Accelerator Status Processor)
- Displays the status of the whole machine with clear indication of current problems
 - Current Status of all machines
 - Interlocks, Alarms, ...
 - Accelerator Modes
 - Clear indication of current problems



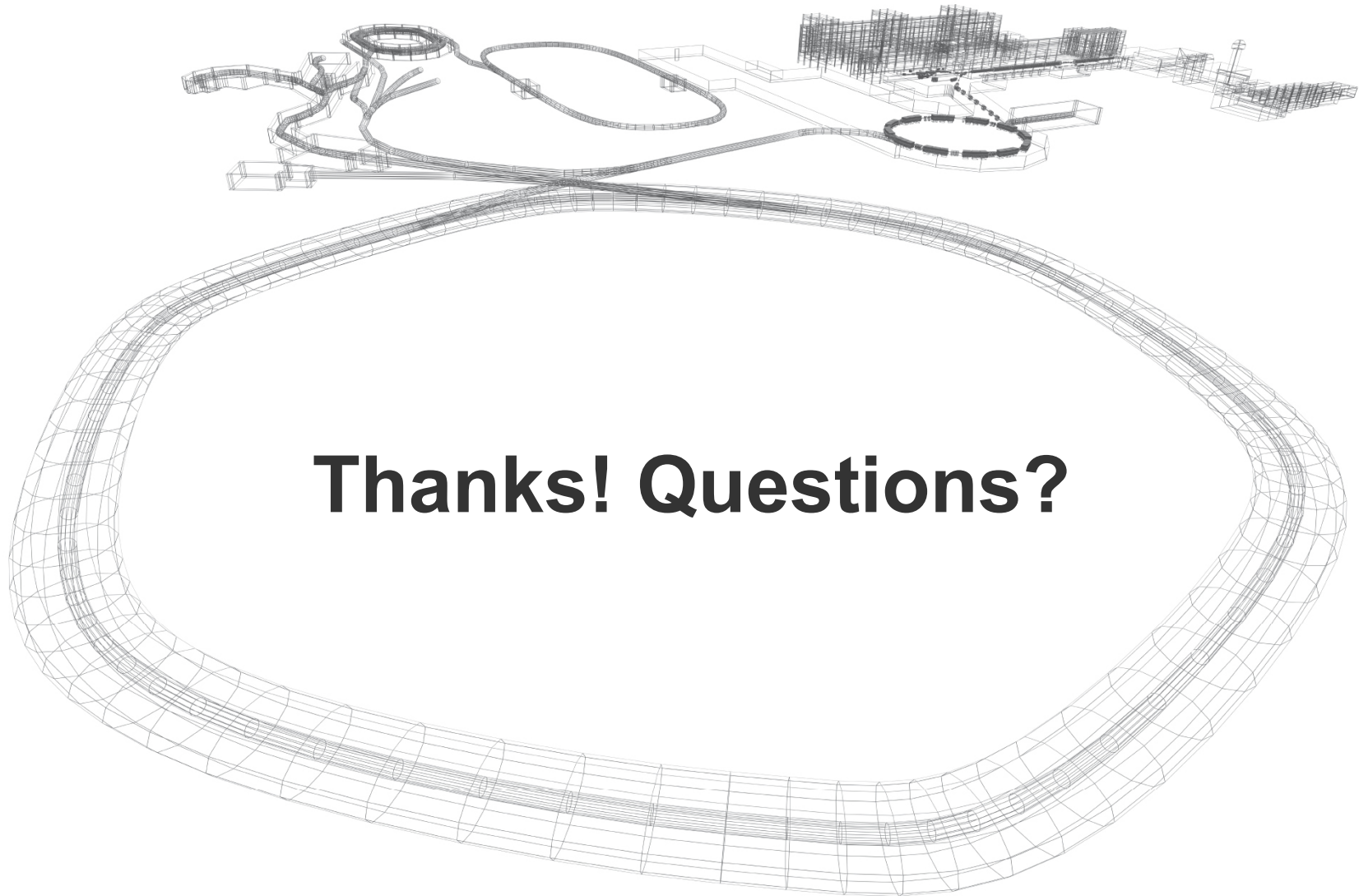
Outlook: Facility Overview

- HKR / FCC Overview Application

- Which beams are running?
- What is their status?
- Transmission, history
- => fixed / detailed version for the control room,
short (possibly rotating) version for the canteen



- Beam Transmission Monitoring Application (spec draft)
- Beam-based feedbacks together with machine physicists
 - LSA-based Orbit Feedback (proof-of-concept during beamtime 2016)
 - LSA-based Macro-Spill & Harmonics Control (proof-of-concept 2016)
- Requestor Application

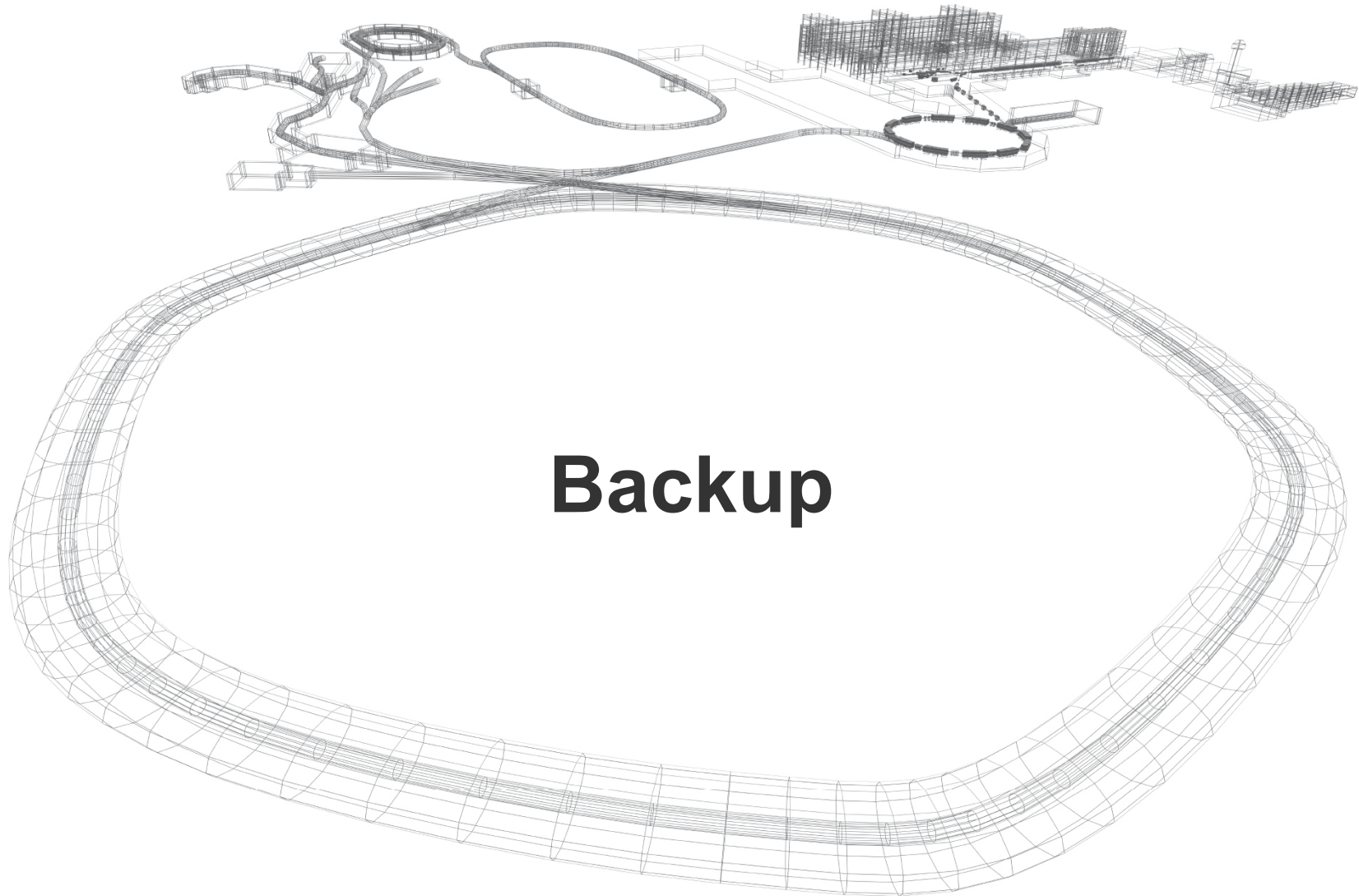


Thanks! Questions?

A complex wireframe model of a roller coaster track, featuring multiple loops, curves, and a large oval track that frames the central text. The track is rendered in a light gray wireframe style.

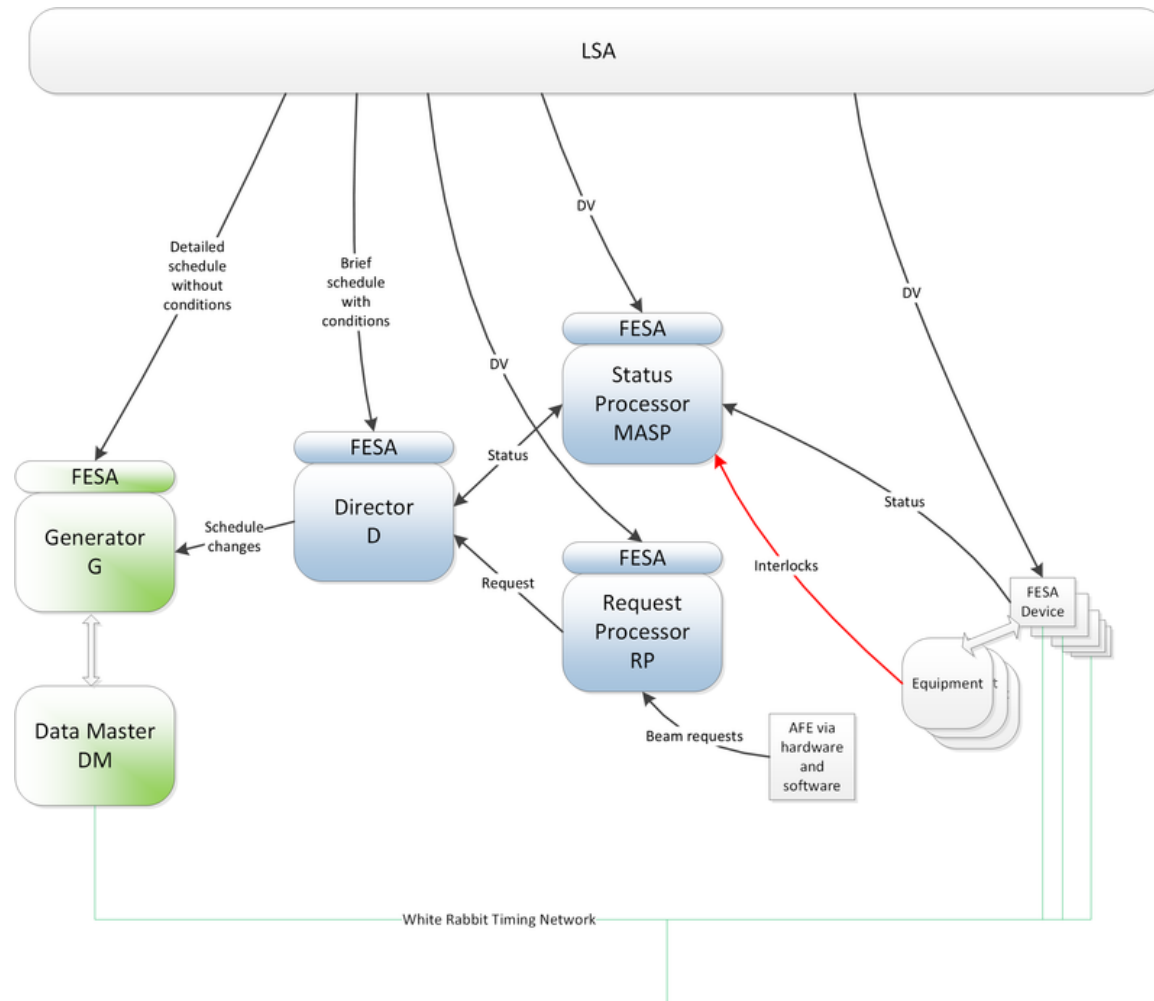
Thanks! More questions later?

Drop by anytime! Also interesting:
[Control System Glossary](#)



Backup

Beam Scheduling System (BSS)



Equipment Controller: SCU

SCU (Scalable Control Unit): Development of a custom and cost-effective solution for equipment control

- base board with powerful FPGA for time-critical functions (e.g. timing receiver, function generators)
- COM Express module with Intel Atom CPU
- primary interface: SCU Bus (16-bit wide parallel bus)
- option: high-speed serial connectors (>500 MBit)
- 2 SFP slots on base board (timing),
1 GbE for communication

Used as central Front-end controller for FAIR:

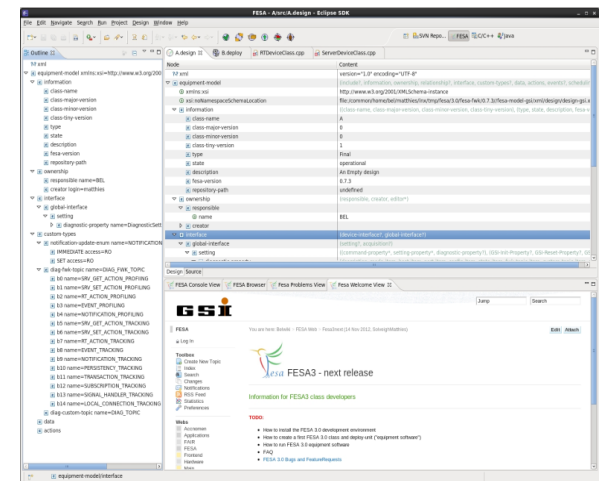
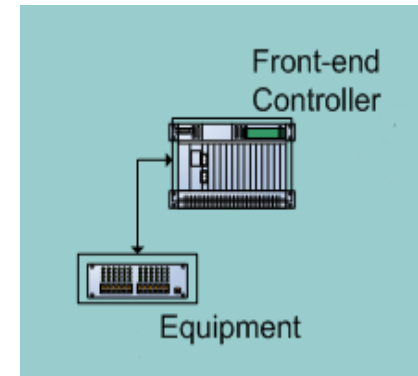
- about 1500 units for power converters, RF, etc
- integrated in equipment (e.g. power converter cabinet)
- form factor / bus system evolution for compatibility / upgrade



Equipment Control Software: FESA

FESA (Front-end Software Architecture) will be the core component of the "FEC Software Framework" for the FAIR accelerator complex

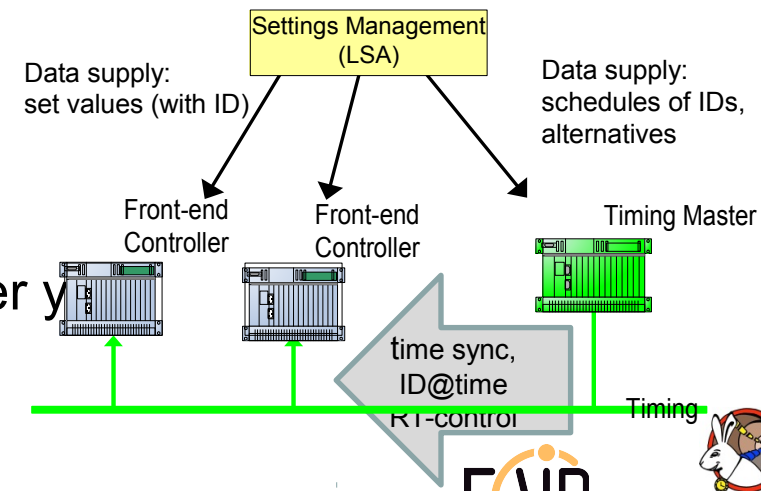
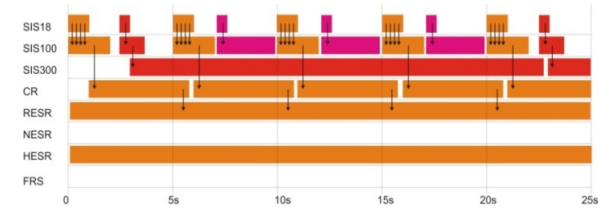
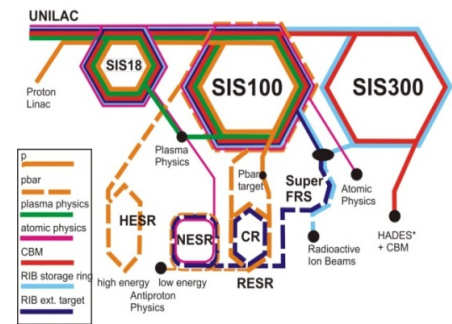
- developed and maintained in collaboration by CERN and GSI
- allows to develop standardized and coherent equipment software for accelerator operation
- development tool is integrated into Eclipse IDE: code generation, building+linking, debugging, documentation, SVN integration, deployment
- XML-description of the device interface
- object-oriented C++-sources are generated
- target system is a Front-end operating with Linux (currently Scientific Linux), e.g. the SCU



Timing System

GMT (General Machine Timing System)

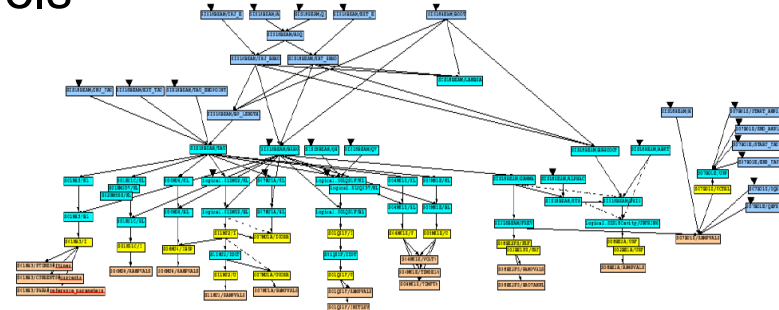
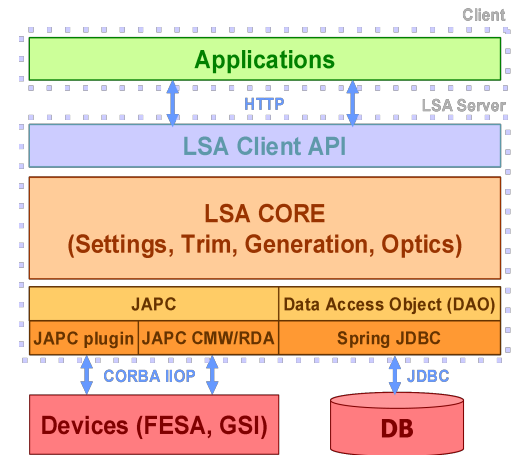
- parallel execution of beam production chains
- cycles: 20ms to hours
- trigger and synchronize equipment actions
- 1 μ s precision in 99% of all cases
- few ns precision for kickers
- (few ps for rf-systems: BuTiS)
- many rings
- >2000 devices connected to timing system
- large distances
- robustness: loose at most one message per year



Settings Management: LSA

LSA (LHC Software Architecture) will be the core component for the accelerator settings management

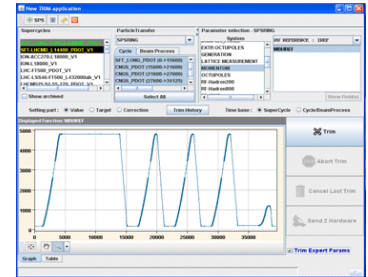
- well developed framework for CERN accelerators, now maintained and enhanced in collaboration
- highly data driven
- DB is the master, contains optics, devices, cycles, etc. for all accelerators
- parameters are organized in hierarchies (from physics to HW)
- consistent settings management on all levels
- devices are accessed using an abstraction layer that hides middleware



Applications

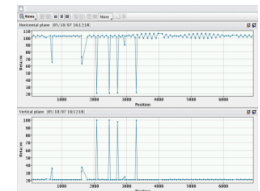
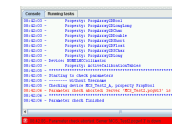
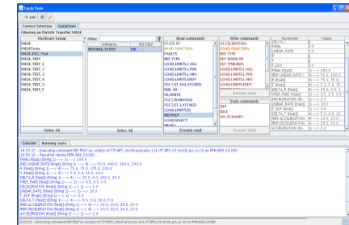
Applications provided by CO will cover all standard operation software used in the central and local control rooms of FAIR

- modular and distributed SW architecture
- all processes are data driven
- separation of concerns, MVC, logic in central or distributed services
- usage of code templates, libraries, widgets, prefilled components
- Java with Swing / JavaFX as GUI technology



Console environment:

- coherent work environment for operators
- central mechanisms for context switching
- supports different views on the facility:
e.g. focus on beams or accelerators



Industrial Controls

Industrial Controls will be used for slow control subsystems such as:

- Vacuum Control

- for CRYRING: 12 x 28 bake out heating channels,
 - 20 vacuum valves, 8 ion sputter pumps,
 - 10 hot cathode extractor gauges, 10 wide range gauges

- Cryo Control

- Personnel Safety System

- Interlock System

UNICOS framework from CERN is based on PLC (Siemens) and SCADA (WinCC OA) and will be used as basis for development

System consists of three layers:

1. field layer: sensors, actors => PLC Remote I/Os
2. control layer: PLC logic
3. supervision layer: SCADA logic and visualization

