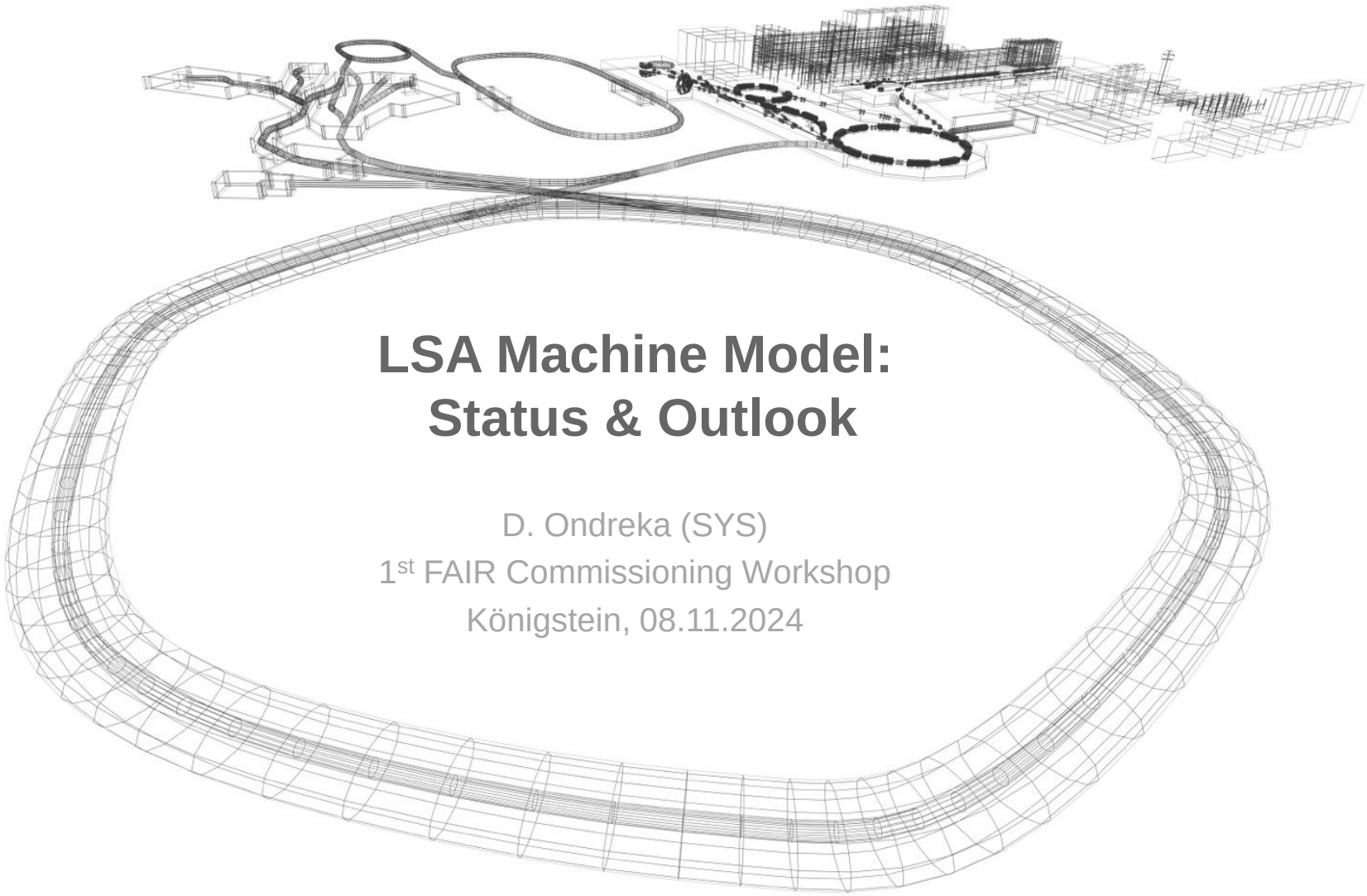


LSA Machine Model: Status & Outlook

D. Ondreka (SYS)

1st FAIR Commissioning Workshop

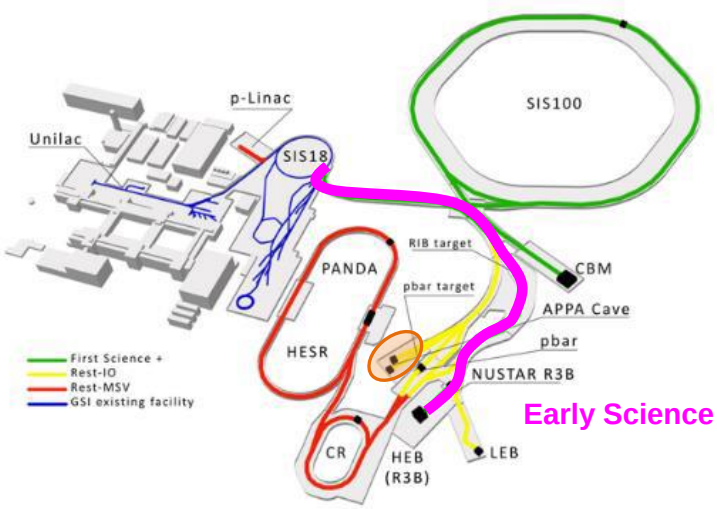
Königstein, 08.11.2024

Outlook

- Role of machine models
- Setting generation with LSA
- Project group “FAIR Data Supply”
- Status and tasks
- Developments for ES and FS
- Timeline
- Summary

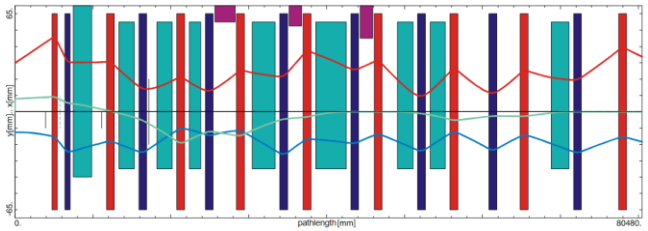
Machine Models

- Early Science
  - Accelerator chain for creating primary beam
    - UNILAC → SIS18 → HEBT → SFRS target
  - Components need to be orchestrated
    - Consistent set values (currents, voltages, …)
    - Consistent timing (beam/RF pulses, ramps, …)
  - Must bring accelerator physics into control system

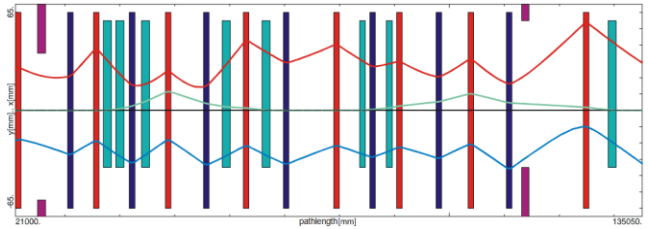


- Physics-driven **machine model**
  - Physics parameters for tuning accelerators
    - Beam parameters: ion type, energy, …
    - Machine parameters: beam optic, tunes, …
  - Translation into consistent set values and timing
  - Applications for managing settings

Beam optic from SIS18 to SFRS (T1S1, T1S2)



Beam optic from SIS18 to SFRS (TSX1, TSF1)

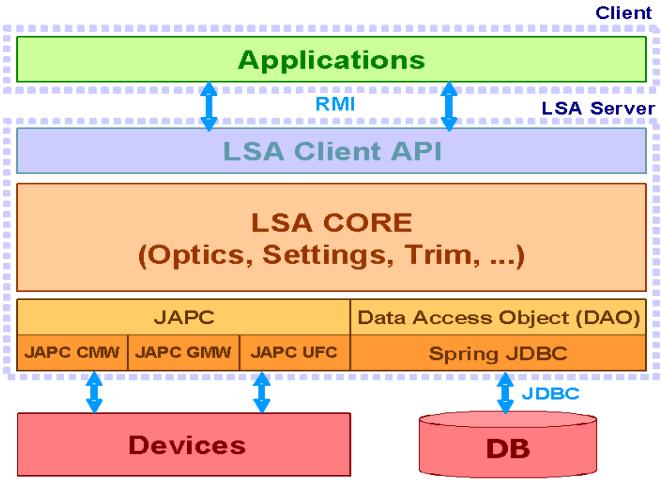


- Relevance for commissioning
  - Assumption: ES model required from phase 3.2
  - Communicate earlier intended use!

LSA Framework

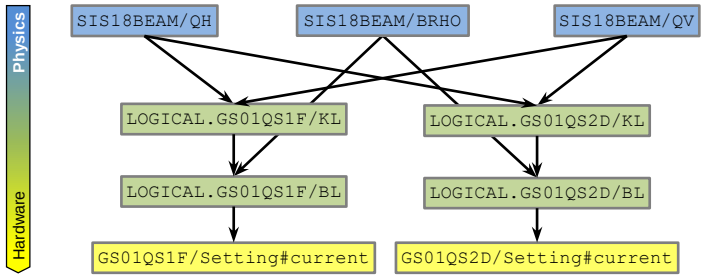
- LSA: Framework for accelerator modeling
  - Invented by CERN, co-developed by CERN/GSI
  - Data-driven system with 3-tier architecture
  - Integral part of FAIR control system

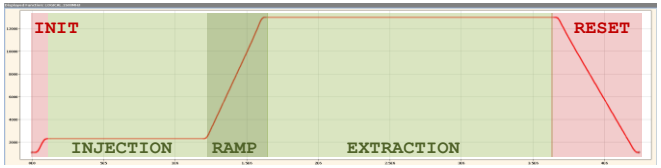
- Separation of expertise
  - Framework maintained by IT experts
  - Convenient hooks for data and physics
  - Responsibility lies with owner of expertise
    - Framework: controls group
    - Model (physics): machine groups
    - Device data: technical groups



Machine modeling with LSA in a nutshell

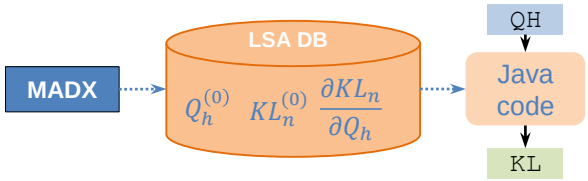
- Machine represented by **parameters**
  - Linked to logical or physical devices
  - **Hierarchy** from physics to hardware
- Cycles organized in contexts
  - Basic unit: **beam process**
  - Grouping into chains and sub-chains
- Values represented as **settings**
  - Value of parameter in beam process
  - Stored in LSA-DB including history
  - HW settings get sent to devices
- Calculations implemented as **rules**
  - Translate from parent to child settings
  - Called by LSA when values change (trim)
  - Java code mostly written by physics experts
  - Accelerator-specific **data** read from LSA-DB





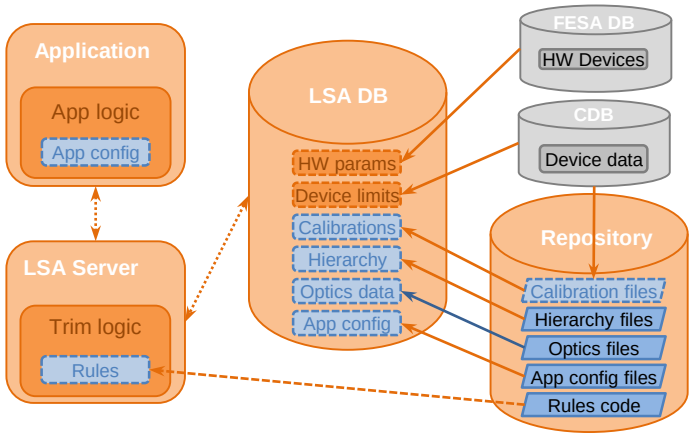
Setting of tune parameter	
Parameter	SIS18BEAM/QH
Beam process	P.SIS18.RING_INJECTION
Value	Constant function = 4.28

$$KL_n = KL_n^{(0)} + \frac{\partial KL_n}{\partial Q_h} \cdot (Q_h - Q_h^{(0)})$$



Organization

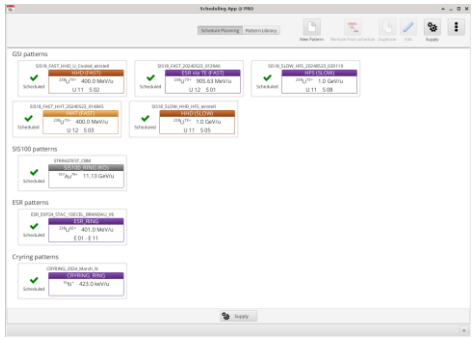
- Project group “**FAIR Data Supply**”
  - Mission: setting generation for FAIR (since 2009)
  - Cross-department organization
    - Maintenance of LSA framework: 1 FTE (ACO)
    - Physics model
      - Core team: 2 FTE model (SYS)
      - Additional contributors from machines, e.g. SFRS
- Modelers’ job: physics
  - Collection of requirements on models
  - Parameter hierarchy and algorithms (rules)
  - Provision of optics data and theory values
  - Configuration of settings applications
- Models needs device data
  - Used to calculate and check set values
    - Calibration curves for all magnets
    - Device limits (min/max values) for power converters
  - Must be provided by technical groups via CDB



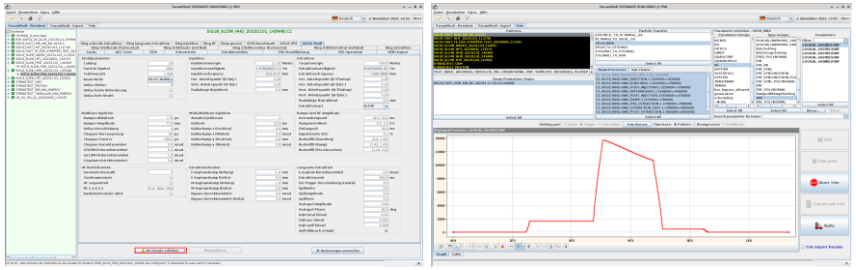
Applications

- Operators need interface to models
  - Applications serve as user interface
- Generic applications
  - Creation of patterns with initial values
  - Manipulation and visualization of set values
  - Import and export of top-level parameters
  - Provided by ACO
- Special purpose applications
  - Provide higher-level functionality
  - Manipulate parameters of the model
  - Can be contributed by ACO or others

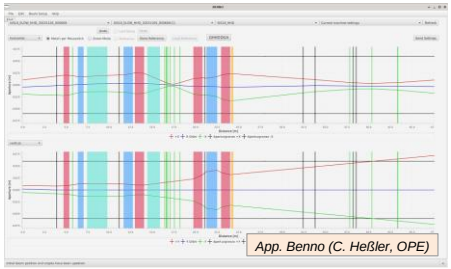
SchedulingApp: Creation of patterns



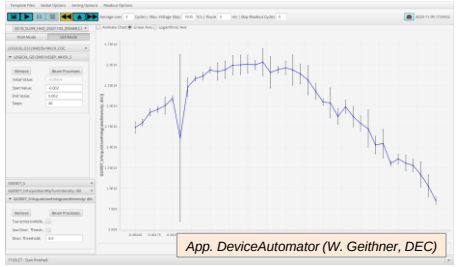
ParamModi: Manipulation and visualization of set values



Special purpose applications for changing set values



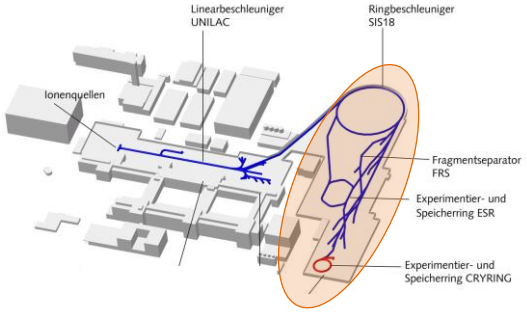
App. Benno (C. Heßler, OPE)



App. DeviceAutomator (W. Geithner, DEC)

Present status and tasks

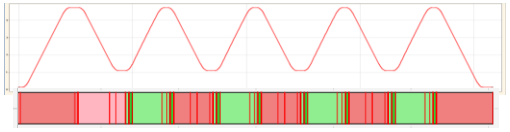
- Status of machine models
  - Production use
    - SIS18, ESR, CRYRING
    - GSI-HEBT, FRS operational
  - Prototype implementations
    - SIS100 (in use for string test)
    - UNILAC (work in progress)



Production use of models	
CRYRING (injector)	2016
CRYRING	2017
SIS18	2018
FRS	2019
ESR	2020
HITRAP	2022
SIS100 (string test)	2023

- Present main tasks
  - Developments for ES
    - Machine model for ES beamline
    - Machine model for SFRS
  - Developments for FS
    - Completion of SIS100 model
    - Booster mode for SIS18
    - Conceptual work for FAIR operation
  - Completion of UNILAC model (mainly ICU team)

SIS18 booster cycle



Parallel operation in FAIR: SIS100-CBM + SIS18-SFRS

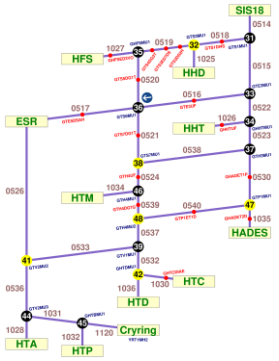
Developments for Early Science

- Machine model for **FAIR-HEBT**
  - Responsibility SYS (I. Kraus)
  - **Includes magnets of SFRS**
  - Model identical to GSI-HEBT
  - Data sources partially different
  - Unified approach for GSI and FAIR in progress
  - ES beamline with mock-data ready spring 2025

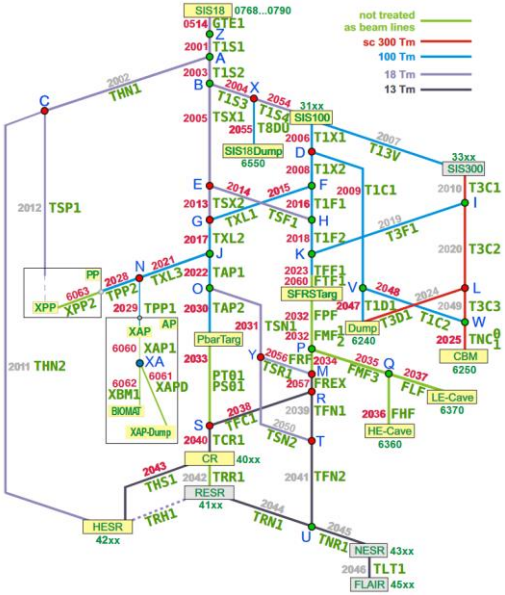
- Machine model for **SFRS**
  - Magnets modeled as part of FAIR-HEBT by SYS
  - **Matter part responsibility of SFR/SFS**
    - Model very similar to FRS at GSI
    - Planned and executed by SFR/SFS personnel
    - Support by data supply group

- Production use requires real device data
  - Models initially tested with mock-data
  - Real data must be in CDB in time for dry runs

Beamlines of the GSI facility



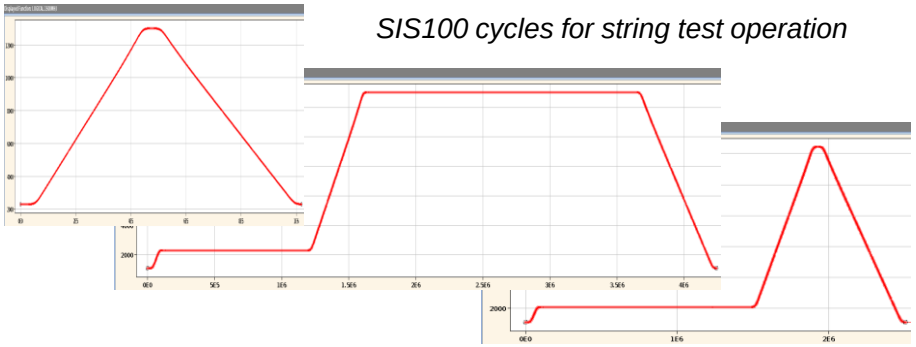
Beamlines of the full FAIR facility



Developments for First Science

- Machine model for SIS100
  - Prototype exists, used at SIS100 string test
  - Completion planned until end 2026

SIS100 cycles for string test operation



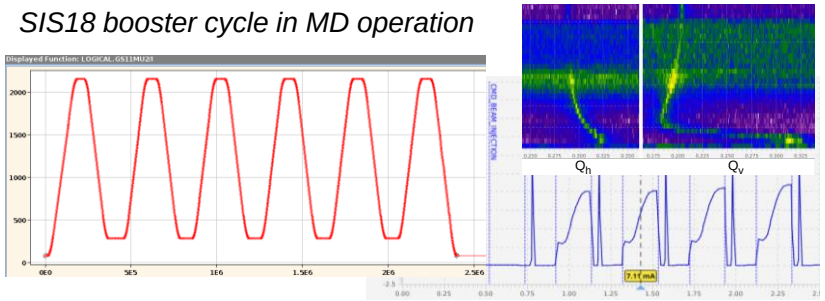
- Modeling of parallel operation
  - Requires concept of periodic patterns
    - Extension of LSA/BSS under responsibility ACO
    - Modelers support development of concept
    - Expected to be available by end of 2026
  - Adaptation of all models planned until end 2027

Periodic parallel operation in First Science+

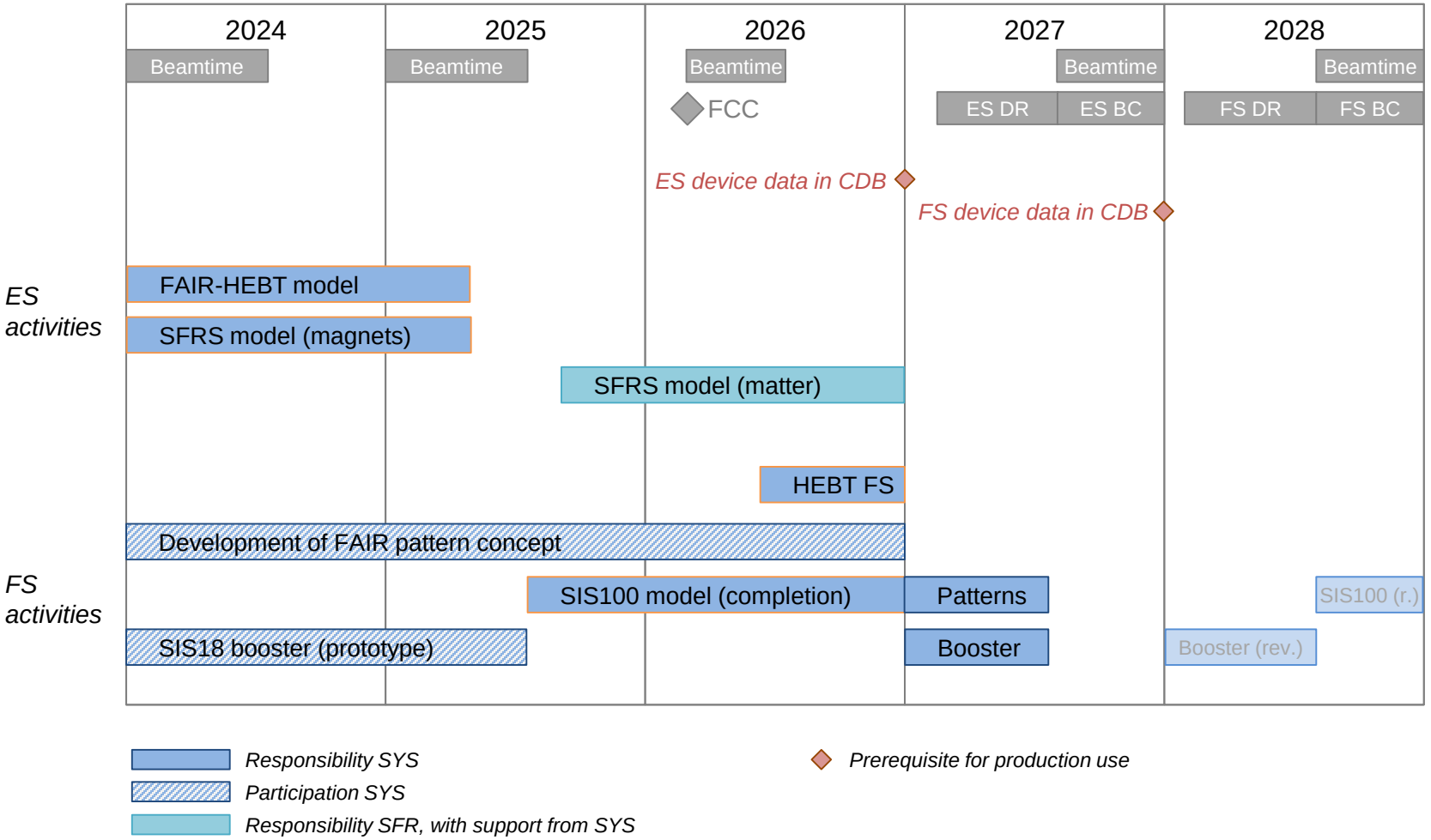
CBM + ***SFRS*** *(SIS18)*

- Implementation of SIS18 booster mode
  - Prototype for machine development exists (wip)
  - Model completion planned until end 2027
    - Integration with new UNILAC timing system
    - Adaptations to FAIR patterns

SIS18 booster cycle in MD operation



Timeline

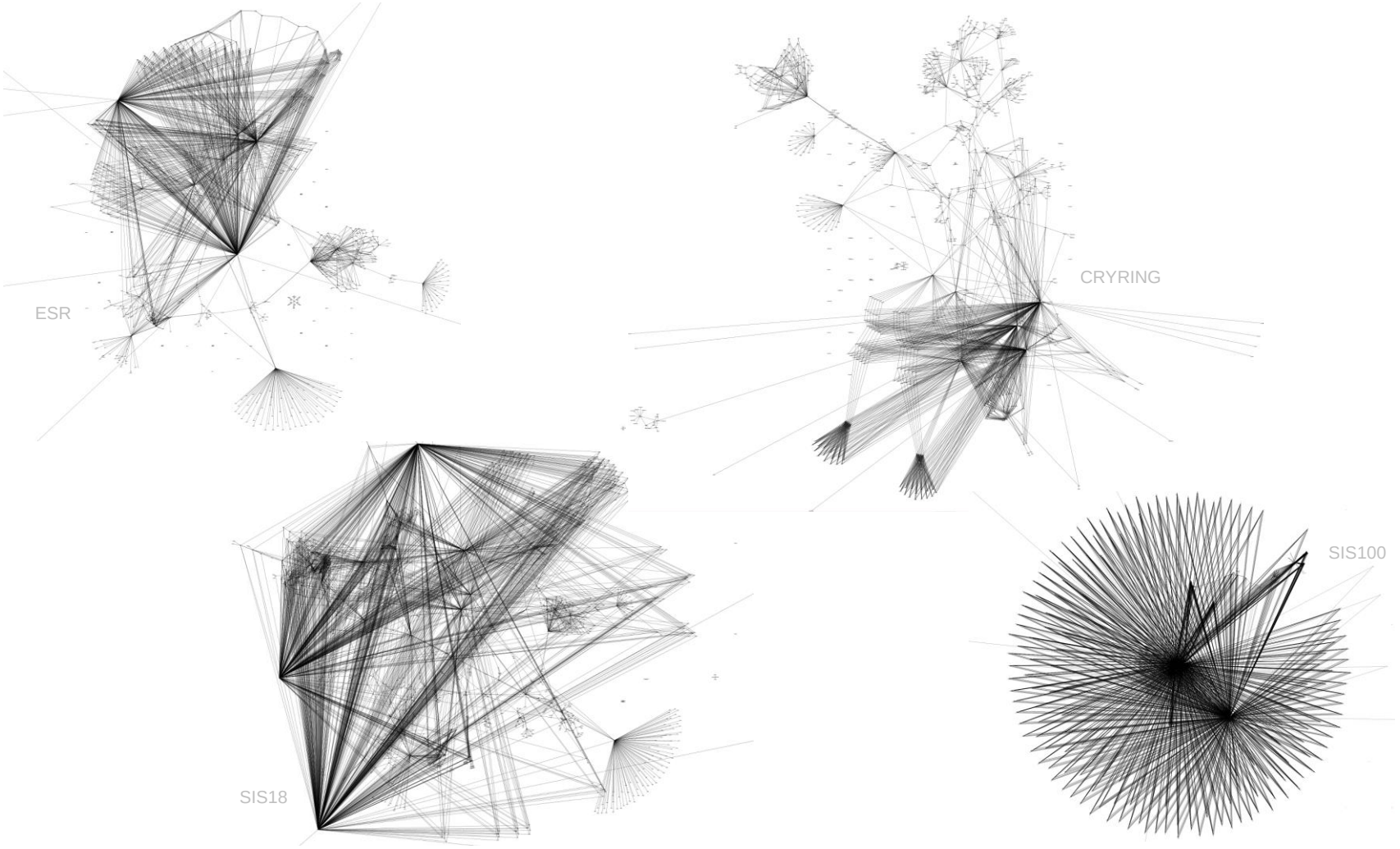

2024
2025
2026
2027
2028
Beamtime
Beamtime
Beamtime
Beamtime
Beamtime
FCC
ES DR
ES BC
FS DR
FS BC
ES device data in CDB
FS device data in CDB
ES activities
FAIR-HEBT model
SFRS model (magnets)
SFRS model (matter)
HEBT FS
Development of FAIR pattern concept
FS activities
SIS100 model (completion)
Patterns
SIS100 (r.)
SIS18 booster (prototype)
Booster
Booster (rev.)
Responsibility SYS
Participation SYS
Responsibility SFR, with support from SYS
Prerequisite for production use

Summary

- Machine models translate accelerator physics to set values for devices
  - Implementation based on LSA framework
  - Project group “FAIR Data Supply”
- Machine models in production use for GSI facility (except UNILAC)

- Model for ES will be ready early
- Production use of ES model requires device data in CDB
  - Responsibility of technical groups
  - Deadline: last control system release before dry-runs (phase 3.2)
- Present assumption: production use of ES model from phase 3.2
  - If set values from model are required earlier, let us know!

Thank you for your attention!



LSA can do dandelions, too, and more…