

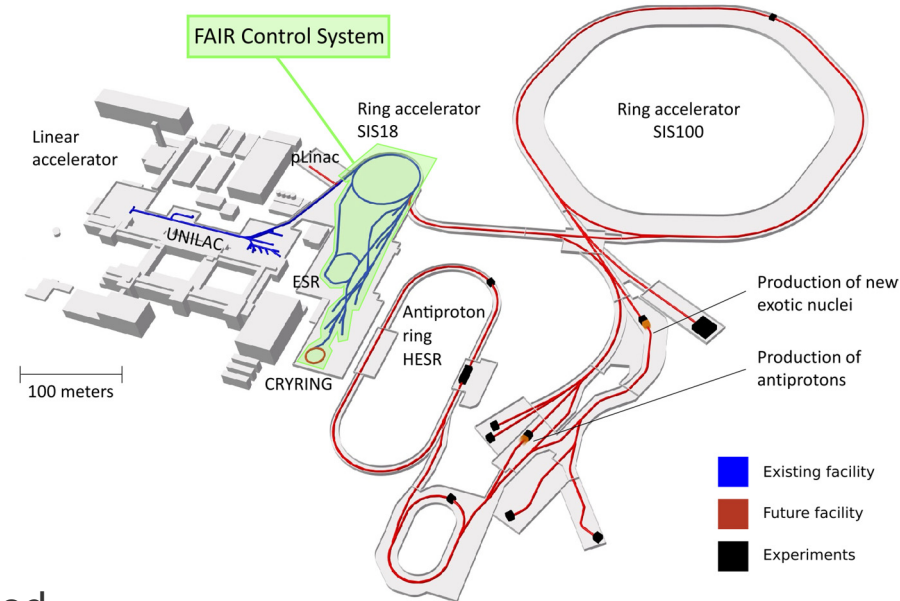
# **Storage Ring Mode for FAIR**

**THPP3 // THP06**

A. Schaller et al., GSI

# New Control System for FAIR

- The new Control System for FAIR is already being used at the existing GSI facility and continuously enhanced
- Since 2015: Synchrotron support
  - Pre-planned schedules
  - Deterministic behavior
- New in 2019: **Storage Ring Mode**
  - Basic blocks of the schedule are pre-planned
  - Interactively controlled execution of the blocks at runtime



## Strong Coupling

- Beam is produced and extracted on request
- Storage ring waits for the injector to produce the beam
- Guarantees beam transfer
- Possibly long idle times for the storage ring

## Weak Coupling (“fire and forget”)

- Injector *always* produces and extracts beam
- Storage ring can serve other experiments while the beam is produced
- Beam may be lost
- Manual synchronization needed

- **Breakpoints:** Pause and continue on user interaction



- **Skipping:** Optionally skip parts of the schedule



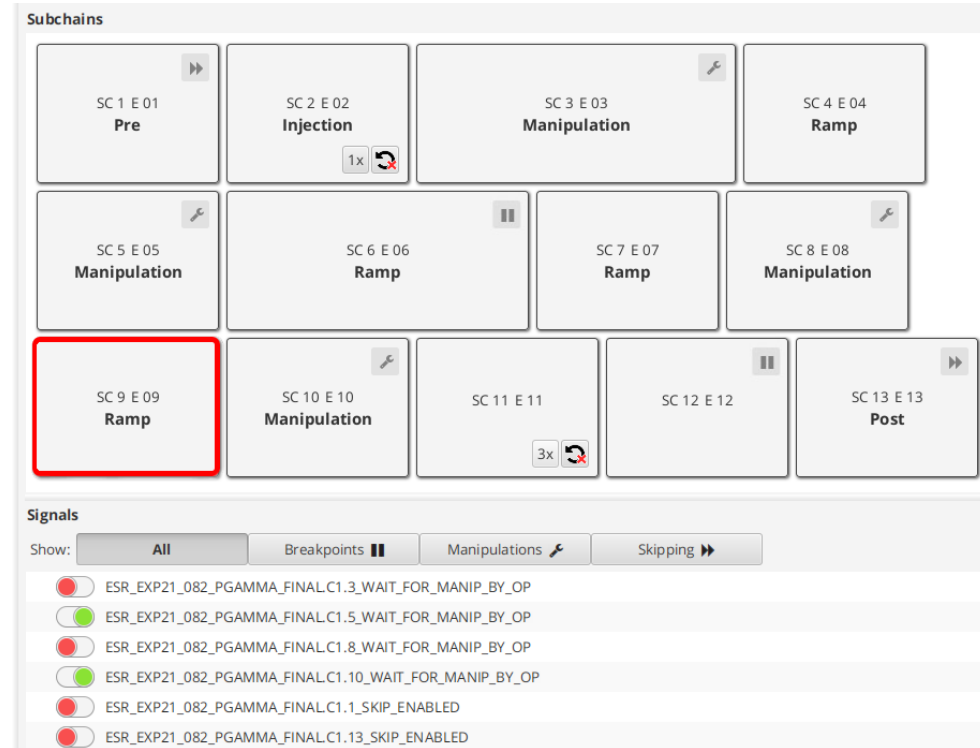
- **Repetition:** Repeat parts of the schedule  $N$  times, can be aborted



- **Manipulation:** Pause execution and modify device settings



- Visualizes current point of execution in the schedule
- Shows which features are available for a block
- Interactive control of the features by the operators



The screenshot displays the 'Subchains' section of the StoRiMo application. It features a grid of 13 subchain blocks, each with a unique ID and a name. The blocks are arranged in three rows: the first row has four blocks (SC 1 E 01 Pre, SC 2 E 02 Injection, SC 3 E 03 Manipulation, SC 4 E 04 Ramp), the second row has four blocks (SC 5 E 05 Manipulation, SC 6 E 06 Ramp, SC 7 E 07 Ramp, SC 8 E 08 Manipulation), and the third row has five blocks (SC 9 E 09 Ramp, SC 10 E 10 Manipulation, SC 11 E 11, SC 12 E 12, SC 13 E 13 Post). The SC 9 E 09 Ramp block is highlighted with a red border. Below the subchain grid is the 'Signals' section, which includes a 'Show:' filter with buttons for 'All', 'Breakpoints', 'Manipulations', and 'Skipping'. Below the filter is a list of six signals, each with a colored circular indicator (red or green) and a text label: ESR\_EXP21\_082\_PGAMMA\_FINALC1.3\_WAIT\_FOR\_MANIP\_BY\_OP (red), ESR\_EXP21\_082\_PGAMMA\_FINALC1.5\_WAIT\_FOR\_MANIP\_BY\_OP (green), ESR\_EXP21\_082\_PGAMMA\_FINALC1.8\_WAIT\_FOR\_MANIP\_BY\_OP (red), ESR\_EXP21\_082\_PGAMMA\_FINALC1.10\_WAIT\_FOR\_MANIP\_BY\_OP (green), ESR\_EXP21\_082\_PGAMMA\_FINALC1.1\_SKIP\_ENABLED (red), and ESR\_EXP21\_082\_PGAMMA\_FINALC1.13\_SKIP\_ENABLED (red).

# Visit us at the Poster Session THP06

- Andreas Schaller, GSI
- Benjamin Peter, GSI

T094

## Storage Ring Mode for FAIR

Andreas Schaller, Jutta Flörke, Hanno Christian Hüfner, Raphael Müller,  
Benjamin Peter, Anette Walker     GSI, Darmstadt, Germany

---

### Abstract

For the FAIR facility for experiments and the Storage Rings, which is currently under construction, a new Control System is being implemented and already used in major parts of the facility. The central component for Facility Management within the FAIR Control System is based on CERN's open-source "TBC Software Architecture" (TBC) and enhanced by FAIR specific features. One of the main goals is to allow the operation of the Storage Rings in a flexible manner. The operation mode allows to manipulate device settings while the beam is circulating in the ring. There are two different types of possible changes in the Storage Ring Mode: skipping, repetition, loadshare and manipulation. The Storage Ring Mode skipping, loadshare and manipulation. The Storage Ring Mode was developed in two first and four test runs in 2018 at the existing heavy ion storage ring FAIR-UP. The construction objectives in 2019 and 2020, the FAIR Control System was enhanced to support Storage Ring Mode operation, using flexible, inverse-time-scheduling and allowing to cycle modifications of operations.

### Motivation

Storage rings have been regularly and routinely operated at GSI since 1988. The new Control System for FAIR has replaced operation of the existing rings using fully pre-planned schedules since 2015. In 2019, the FAIR Control System was enhanced to support Storage Ring Mode operation, using flexible, inverse-time-scheduling and allowing to cycle modifications of operations.

### Storage Ring Mode Coupling Options

The existing beam lines were modified into a storage ring, and different coupling options were developed.

- Strong Coupling
- Medium Coupling
- Weak Coupling (Fire and Forget)
- Manipulation (Fire and Forget)

• Medium Coupling: The beam is captured and stored in the ring. The beam is then accelerated and extracted.

• Weak Coupling: The beam is captured and stored in the ring. The beam is then accelerated and extracted. The beam is then captured and stored in the ring. The beam is then accelerated and extracted.

• Manipulation: The beam is captured and stored in the ring. The beam is then accelerated and extracted. The beam is then captured and stored in the ring. The beam is then accelerated and extracted.

### Strong Coupling

### Weak Coupling

### Storage Ring Mode Key Features

1. Breakpoint: Break and continue on next action.
2. Skipping: Used for optional parts, e.g. measurements.
3. Repetition: Repeat for a predefined number of executions.
4. Manipulation: Pass acceptance and modify settings.

### Timing Graphs for Storage Ring Mode Features

#### 1. Breakpoint

Breakpoint are implemented using a loop in the timing sequence including graph that can be entered or exited by a new signal.

#### 2. Skipping

A branch of events in the timing graph can be skipped upon user input.

#### 3. Repetition

A branch of events can repeat a predefined number of times. As a result, the user can start repeating operations.

#### 4. Manipulation

Manipulation can be used by inserting the perfect step after which the device is allowed to be manipulated or continue the storage ring operation. During the manipulation, the system ensures that the manipulation timing events are executed until the user stops the ring. The user can interrupt and the previous settings for the next beam injection.

### Setting Manipulation (exemplary)

#### Initial Manipulation

Beam extraction process by keeping  $\beta$  value is constant  $\beta$ .

Use change endpoint of F1 from  $\beta = 1$  to manipulation range gun and collect, wait for device and extract early before start.

Value was set, Status F1 and range step for F1. The result is the value change for the next beam injection.

#### Second Manipulation

Use change endpoint of F1 from  $\beta = 1$  to manipulation range gun and collect, wait for device and extract early before start.

Value was set, Status F1 and range step for F1. The result is the value change for the next beam injection.

#### Third Manipulation

Use change endpoint of F1 from  $\beta = 1$  to manipulation range gun and collect, wait for device and extract early before start.

Value was set, Status F1 and range step for F1. The result is the value change for the next beam injection.

### Involved Subsystems

- Storage Ring
- White Rabbit based timing system, extensive custom
- Beam Positioning System (BPS)
- Beam Line: Acceleration of dipole
- Repetitive Timing System
- IOP Software Architecture (IOP)
- Control System: Beamline, injection, detection and BPS
- Storage Ring Mode Application (SRM-App)
- Beam and control Storage Ring Mode System

### Storage Ring Mode in Production

The flexible Application provides an overview of the different parts of a storage ring operation. The red blocks indicate the current part of operation. Small red lines show the status of the Storage Ring Mode System available in this part. The steps below can be reached by the user on the control panel.

### Outlook

Continuing Storage Ring Mode system to Superconducting Mode using low-frequency for diagnostic modules over the beam line, e.g. for spectrometry with multiple modules.