Supporting Flexible Runtime Control and Storage Ring Operation with the FAIR Settings Management System

WEPV047

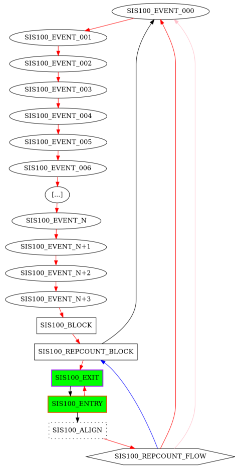
R. Mueller, J. Fitzek, H. Hüther, H. Liebermann, D. Ondreka, A. Schaller, A. Walter,
GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Runtime Control Through Beam Scheduling System

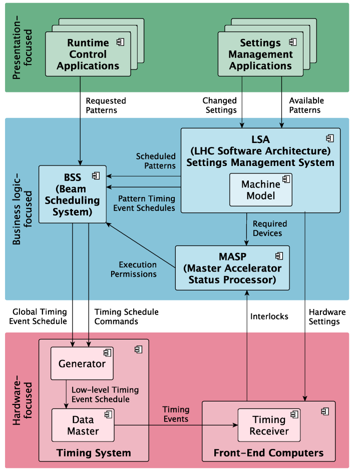
Beam Scheduling System (BSS) Support Implemented in LHC Software Architecture (LSA)

- Machine model (hierarchy) for Timing calculation
  → Chronological order of timing events
  → Schedule graph (DOT) generation
- BSS Signal definition
  → Enables conditional branching in the graph
  → Execution conditions for Patterns
- Pattern repetition count
  → If executed, execute it N times
- Coupling Patterns
  → Synchronize at a specific point, e.g. for beam transfer
- Pattern Groups
  → Which Patterns run alternately and which concurrently
  → Pattern structure provided to BSS

✓ Enables runtime control through BSS's signals and the timing event graph without the need of further interaction with LSA

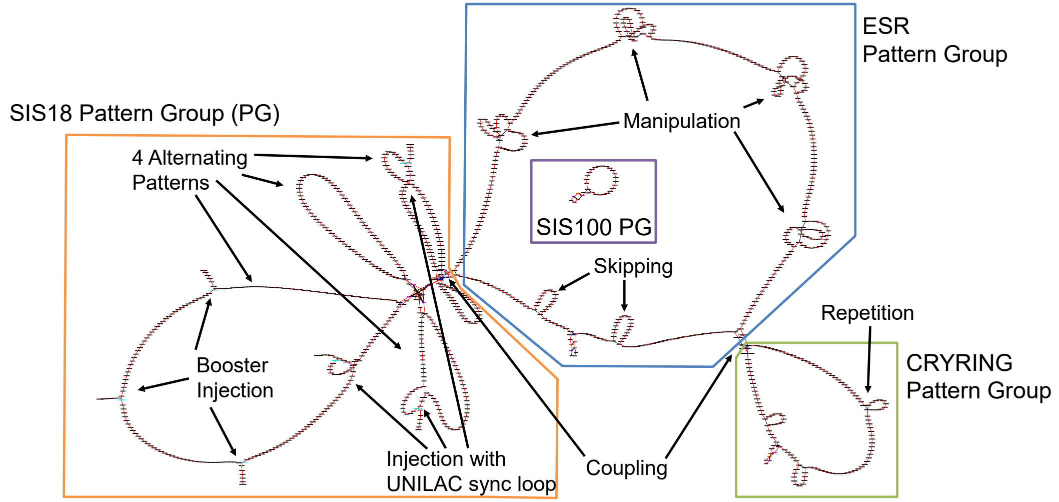


Schematic schedule graph.



Control System interaction diagram.

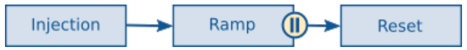
Global Timing Graph (DOT) With Annotations



Storage Ring Mode Features

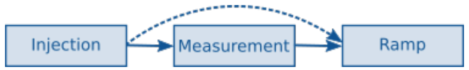
Breakpoint

- Pre-defined points where to pause
- The operator can pause and resume interactively
- Use case: perform measurements, until sufficient data has been collected



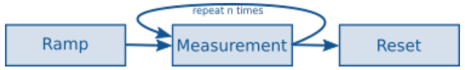
Skipping

- Pre-defined skippable blocks / optional parts
- The operator can decide to skip or not
- Use case: quickly reach the end of a Chain execution in case of unexpected beam loss



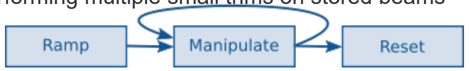
Repetition

- Pre-defined repeatable blocks with a specified number of repetitions
- The operator can define the amount, and can abort currently executed repetitions
- Use case: take a certain number of measurements



Manipulation

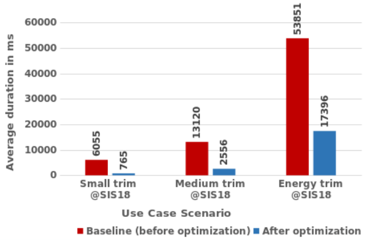
- Pre-defined points where to pause plus the ability to modify the settings
- The operator decides to enter and leave the paused state
- Use case: interactively find good settings by performing multiple small trims on stored beams



Performance Optimization and Outlook

Performance Optimization

- Real-world operating scenarios were defined
- Measuring was introduced through the whole Control System stack
- Optimizations implemented by domain experts and developers across departments
- Measurements before and after optimization showed a speedup between 7.91 for the "Small trim" and 3.1 for the "Energy Trim" scenario



Current Development – Booster Mode

- Accumulate beam from four SIS18 cycles into SIS100 via bunch-to-bucket transfer
- Dynamically schedule injection events, asynchronously triggered by UNILAC injector
- First tests during machine experiments in 2022

Outlook

- Conceptual work: Upgrade project to integrate UNILAC into the new Control System with its 50Hz operation and beam request-oriented execution
- Conceptual work: Discuss "Patterns" and their usage in general, then review the existing concepts considering the aforementioned new features

WEPV047

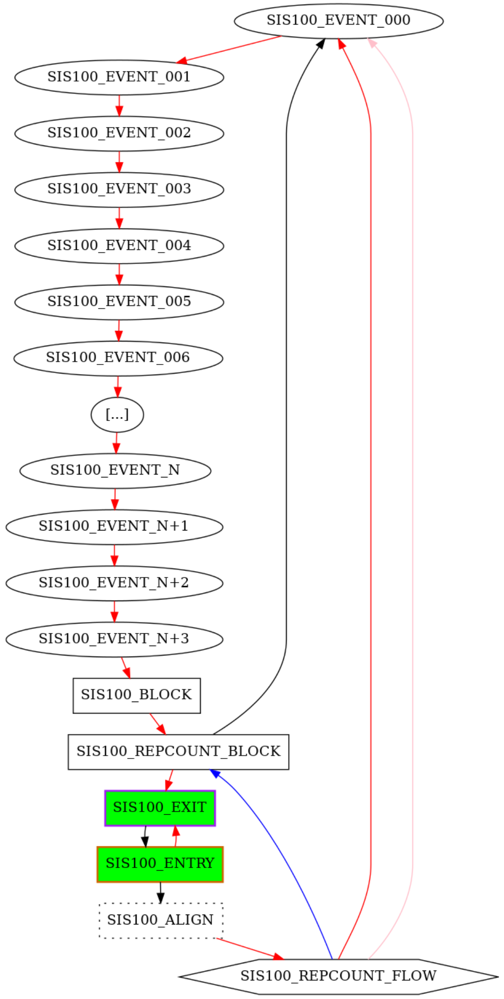
Runtime Control Through Beam Scheduling System

R. Mueller, J. Fitzek, H. Hüther, H. Liebermann, D. Ondreka, A. Schaller, A. Walter,
GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

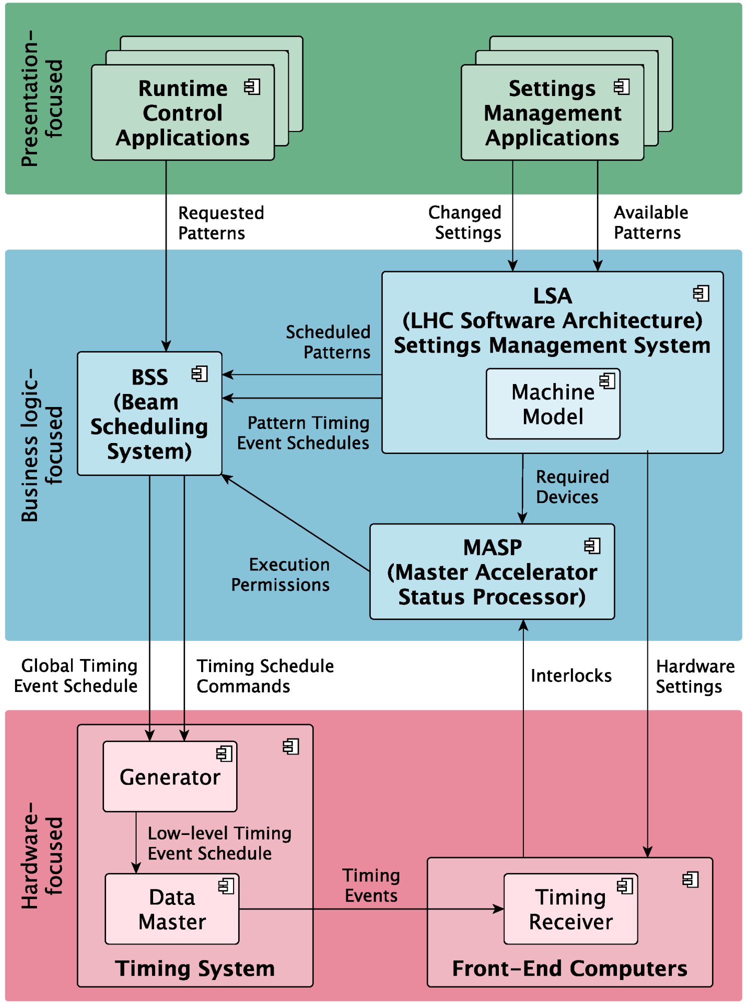
Beam Scheduling System (BSS) Support Implemented in LHC Software Architecture (LSA)

- Machine model (hierarchy) for Timing calculation
  → Chronological order of timing events
  → Schedule graph (DOT) generation
- BSS Signal definition
  → Enables conditional branching in the graph
  → Execution conditions for Patterns
- Pattern repetition count
  → If executed, execute it N times
- Coupling Patterns
  → Synchronize at a specific point, e.g. for beam transfer
- Pattern Groups
  → Which Patterns run alternately and which concurrently
  → Pattern structure provided to BSS

✓ Enables runtime control through BSS's signals and the timing event graph without the need of further interaction with LSA



Schematic schedule graph.



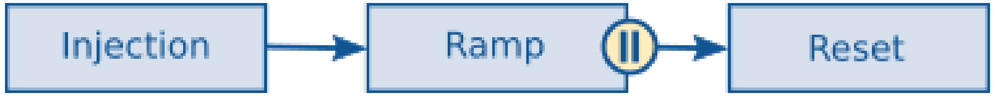
Control System interaction diagram.

Storage Ring Mode Features

R. Mueller, J. Fitzek, H. Hüther, H. Liebermann, D. Ondreka, A. Schaller, A. Walter,
GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

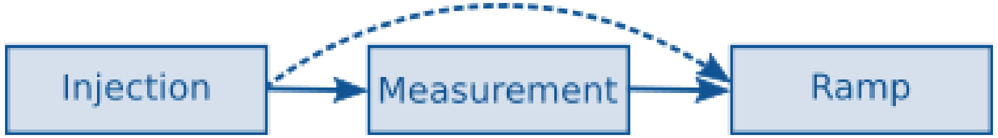
Breakpoint

- Pre-defined points where to pause
- The operator can pause and resume interactively
- Use case: perform measurements, until sufficient data has been collected



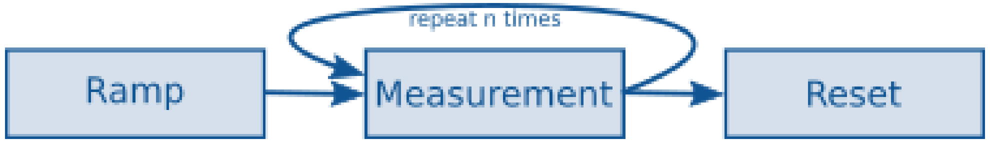
Skipping

- Pre-defined skippable blocks / optional parts
- The operator can decide to skip or not
- Use case: quickly reach the end of a Chain execution in case of unexpected beam loss



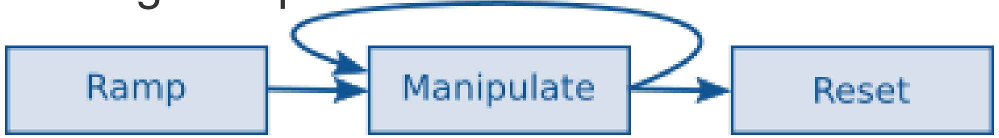
Repetition

- Pre-defined repeatable blocks with a specified number of repetitions
- The operator can define the amount, and can abort currently executed repetitions
- Use case: take a certain number of measurements



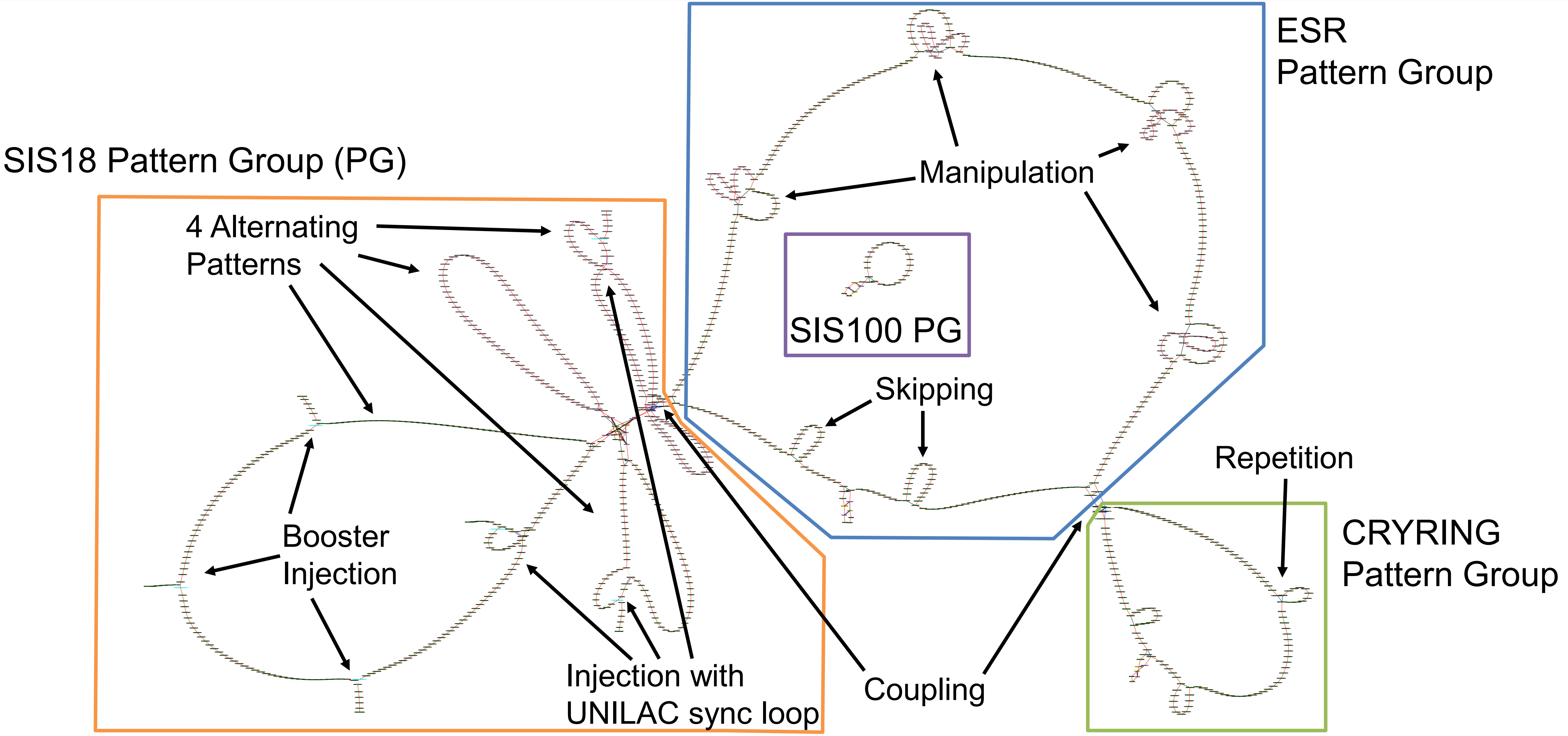
Manipulation

- Pre-defined points where to pause plus the ability to modify the settings
- The operator decides to enter and leave the paused state
- Use case: interactively find good settings by performing multiple small trims on stored beams



Global Timing Graph (DOT) With Annotations

R. Mueller, J. Fitzek, H. Hüther, H. Liebermann, D. Ondreka, A. Schaller, A. Walter,
GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany



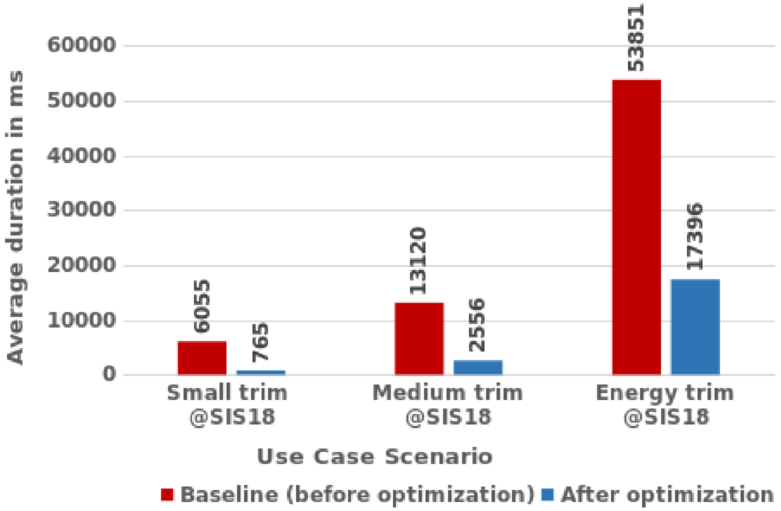
WEPV047

Performance Optimization and Outlook

R. Mueller, J. Fitzek, H. Hüther, H. Liebermann, D. Ondreka, A. Schaller, A. Walter,
GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Germany

Performance Optimization

- Real-world operating scenarios were defined
- Measuring was introduced through the whole Control System stack
- Optimizations implemented by domain experts and developers across departments
- Measurements before and after optimization showed a speedup between 7.91 for the “Small trim” and 3.1 for the “Energy Trim” scenario



Current Development – Booster Mode

- Accumulate beam from four SIS18 cycles into SIS100 via bunch-to-bucket transfer
- Dynamically schedule injection events, asynchronously triggered by UNILAC injector
- First tests during machine experiments in 2022

Outlook

- Conceptual work: Upgrade project to integrate UNILAC into the new Control System with its 50Hz operation and beam request-oriented execution
- Conceptual work: Discuss “Patterns” and their usage in general, then review the existing concepts considering the aforementioned new features