Draft Concept for Beam Commissioning

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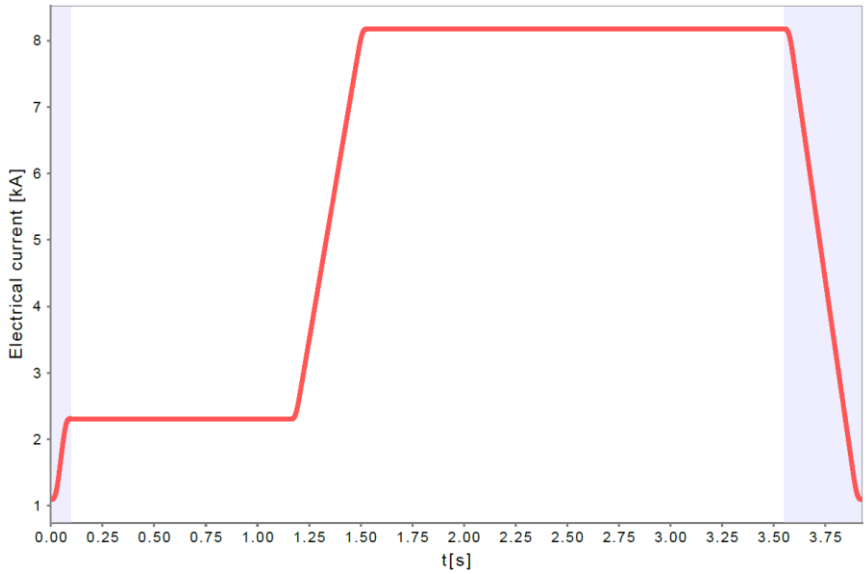
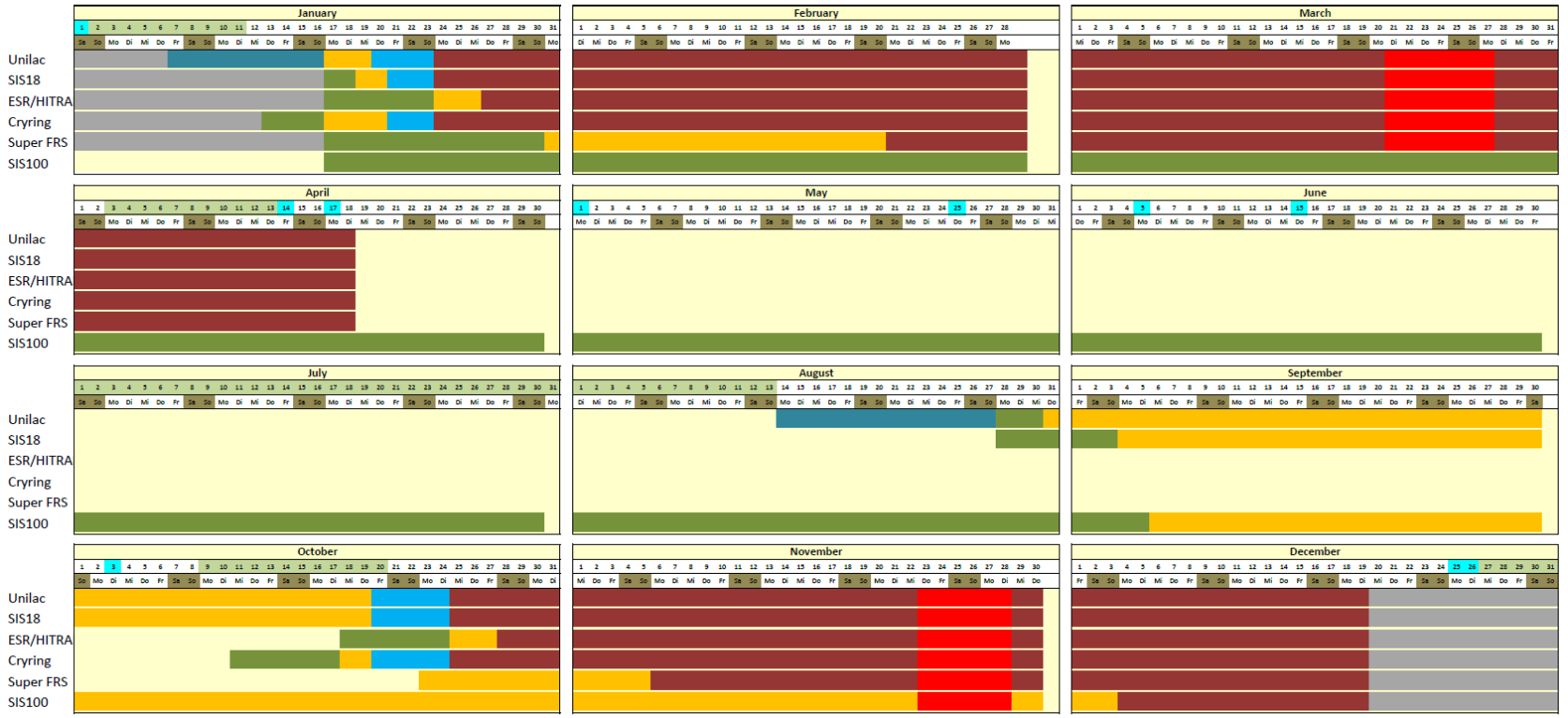
Goals

- Testing each individual component with beam
- Establishing proper functioning of SIS100
- Validating machine protection systems
- Preparation of first NUSTAR experiment in FS

Cycle for U^{28+},1.5GeV/u, 4 injections, 2s extraction



Annual Schedule 2028



user beam time
129 days (3096 h)

machine time
13 days

FAIR
HEBT & SIS100 beam commissioning

Early Science physics

(Source: S. Reimann, Beam Time Retreat 2025)

Conditions

- Pre-conditions
  - Machine cooled down
  - Hardware commissioning finished
  - Cryo system tuned for commissioning cycle in dry run
  - Operational and commissioning tools tested in dry run

- Expected boundary conditions
  - Six weeks of exclusive operation for SIS100 BC
  - Six weeks of shared operation with physics run at SIS18
  - Commissioning only during day shifts (F, S)
    - Limited personnel (machine experts)
    - Frequent interventions by technical groups expected
  - Semi-automated test-procedures maybe run over night

Organization:
Commissioning Team

- BC manager (+ deputy)
  - Organizes and coordinates commissioning program
  - Authorizes major program changes in response to issues
- BC leader (machine experts, weekly turn, overlap with SIS18 on-call)
  - Responsibility for execution of commissioning
  - Coordination of commissioning activities
  - Reporting in daily commissioning meeting
- BC shift crew (machine experts, operators)
  - Execution of commissioning
  - Experts for difficult tasks, operators for systematic checks

Strategy:
Commissioning Tracks

- Fast track (‘pioneers’)
  - Try to get beam through machine as fast as possible
  - Ignore non-functional devices if not critical (but document the fact)

- Main track
  - Systematically check all devices, follow-up on non-functional ones
  - Document achieved intermediate results
  - Establish commissioning, set-up, and tuning procedures for operation

Commissioning Sequence (I)

- Beamline from SIS18 to SIS100
  - Main goal: beam spot on injection screen/grid with correct parameters
  - Steering, optics verification
- First turn in SIS100
  - Main goal: loss-free transport around circumference up to injection point
  - Beam steering using BPMs and first-turn grids
- Circulating beam at injection level
  - Main goal: prepare systematic measurements
  - Options for injection
    - Bunch-to-coasting and bunching in SIS100
    - Bunch-to-bucket
  - Beam deposition at injection energy on collimator using orbit bump
- Systematic measurements
  - Main goal: validate and establish proper functioning of correctors and BI
- Correction of closed orbit and tune
  - Main goal: establish correct optic and good orbit for further steps

Commissioning Sequence (II)

- Commissioning of fast/emergency extraction
  - Main goal: establish simple way to dispose of beam
  - Useful for systematic tests of everything except SX
- Commissioning of acceleration
  - Main goal: establish accelerated beam
  - Test of synchronicity of acceleration RF (among cavities and with magnets)

- Commissioning of slow extraction
  - Main goal: establish slow extraction with high efficiency
  - Expected to be most challenging step due to strong non-linearities
  - Quick shot based on design settings shall be tried
  - Systematic approach with simpler schemes will be prepared

Preparations

- Development of commissioning procedures
  - Description of steps to be executed in the commissioning sequence
  - Include input and exit conditions and define criteria for fulfillment
- Development of software tools for commissioning
  - Necessary due to large size of SIS100 for efficient commissioning

Tool	Purpose
First-Turn Steering	Steering based on single-pass BPM data
Closed Orbit Correction	Correction of closed orbit based on multi-pass BPM data
Tune Measurement	Measurement and correction of machine tune Measurement and correction of chromaticity Validation of sextupoles Validation of octupoles?
ORM Measurement	Validation of steerers and BPMs Validation of optics Validation of octupoles?

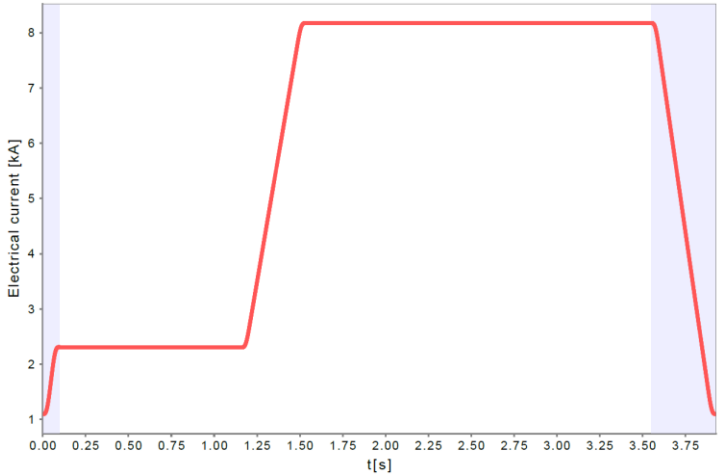
Commissioning Cycle

- Boundary conditions
  - Heat load must correspond to experiment cycle
  - Flat-top rigidity in experimental range
  - Reasonably short cycle time for commissioning

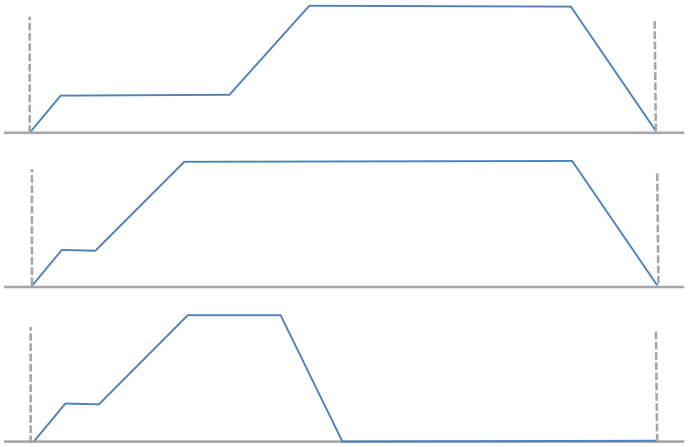
- Expectations for first NUSTAR experiment
  - U^{28+}, 1 – 1.5 GeV/u, $<10^{11}$/spill
  - ES intensity limit: $2 \cdot 10^{11}$, 2s extraction, 4s cycle

- Proposed cycle
  - Flat-top rigidity: 50 Tm
  - Duration: 4 – 5 s
  - Flexibility in defining flat-bottom/flat-top length
  - Low charge state ions to lower energy (Ar^{10+}: 3 GeV/u, Kr^{16+}: 2 GeV/u, U^{28+}: 1 GeV/u)
    - Minimization of activation (interventions!)
    - Better control of SX losses (collimation system!)

Cycle for U^{28+},1.5GeV/u, 4 injections, 2s extraction



Cycles with identical heat load



Summary

- Goals, preconditions, organization, and strategy sketched
- Coarse commissioning sequence presented
- Procedures and tools need to be developed

Thanks for your attention!