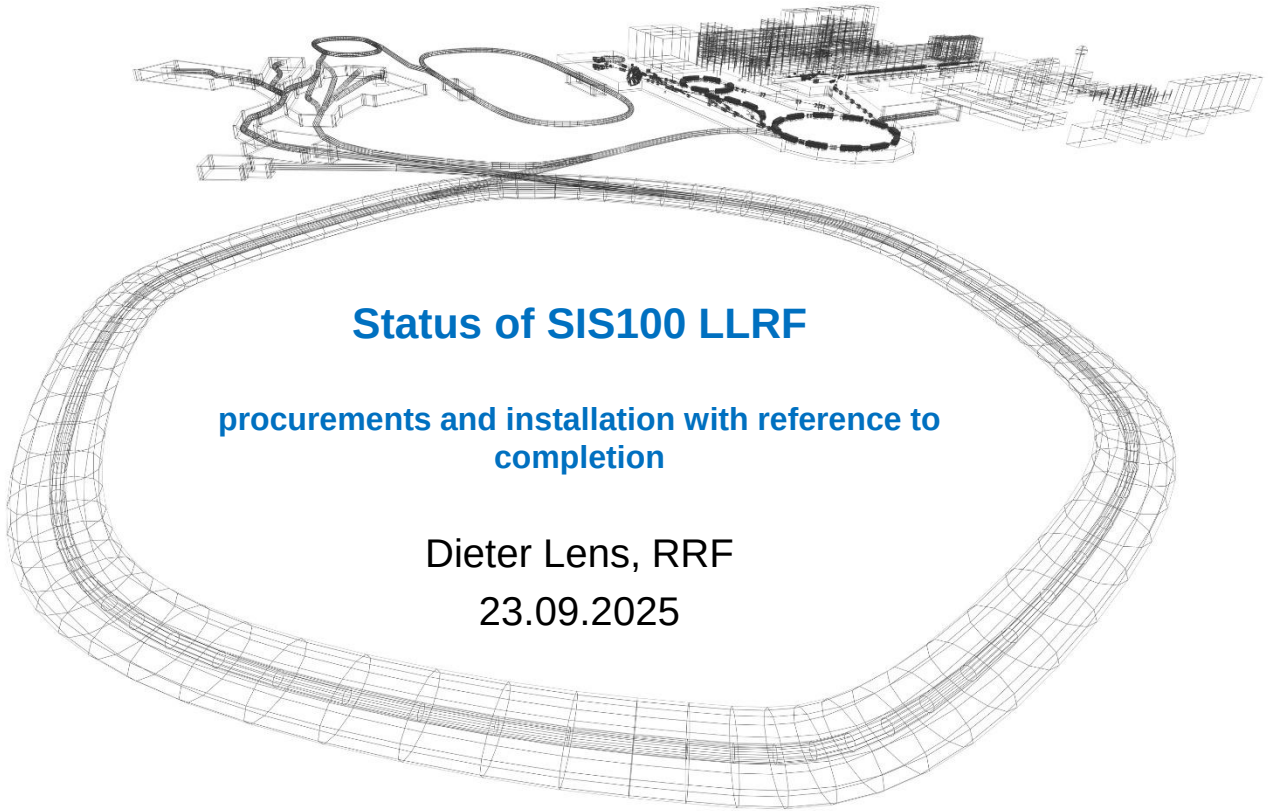
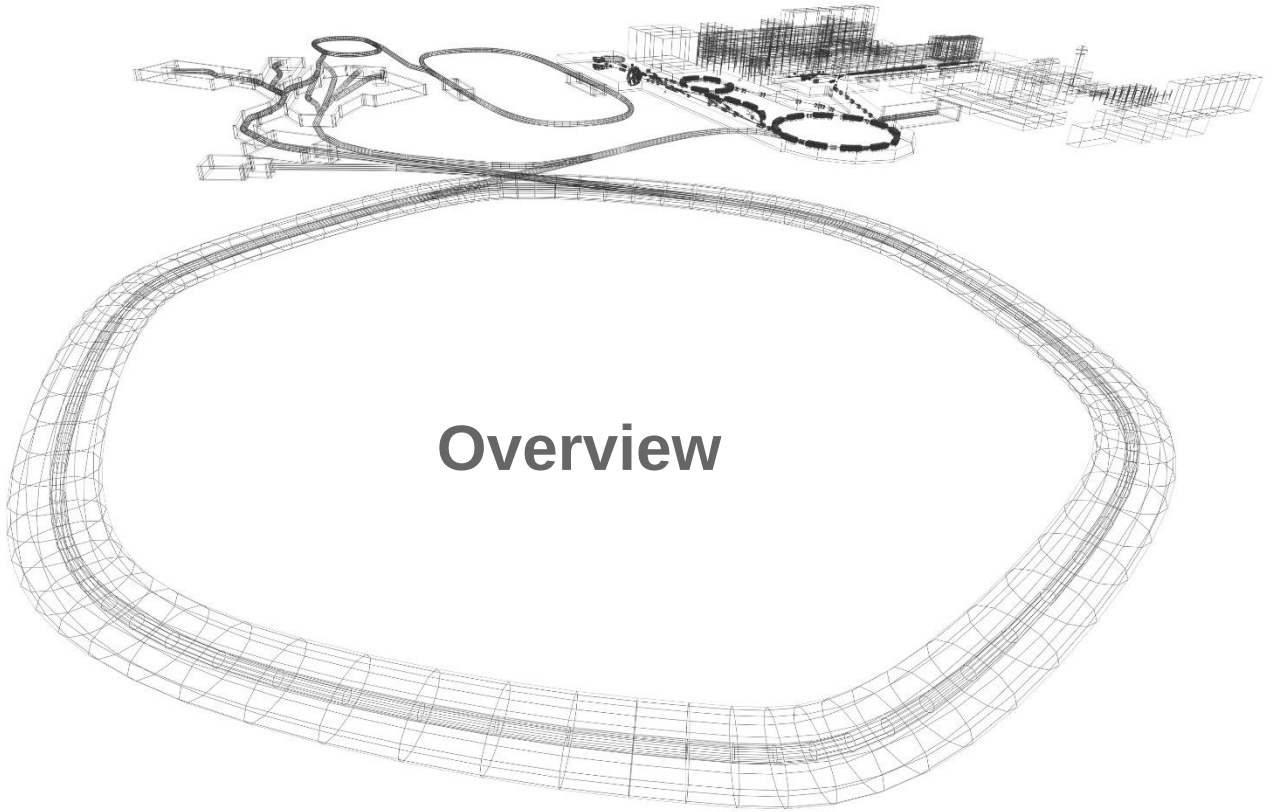


Status of SIS100 LLRF

procurements and installation with reference to completion

Dieter Lens, RRF

23.09.2025



Overview

General Setup of RF System (example: SIS100 ACC)

Cavity & Amplifier

C&A, PSU:
see talk by U. Laier

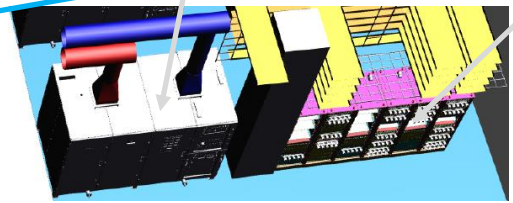
PSU

LLRF

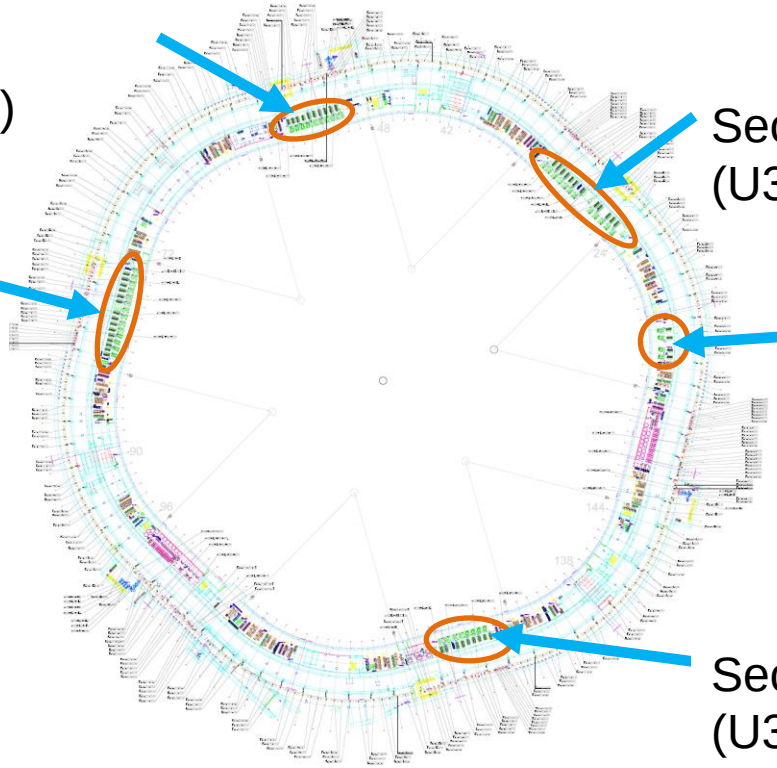
accelerator tunnel

niche (BEA racks)

supply area



SIS100 RF Supply Areas



Status of LLRF Racks (ACC & BC)

Number of racks	Sector 4, room 356	Sector 3, room 336	Sector 2, room 260	Sector 1, room 244	Sector 6, room 154	Sum
Common LLRF	10	10	8	4	6	
ACC LLRF	24	8	24	0	0	
BC LLRF	12	0	0	12	12	
Total	**46**	**18**	**32**	**16**	**18**	**130**
Pre-assembled	**46**	**18**	**32**	**16**	**18**	**130 (100%)**
Placed	**46**	**18**	**0**	**0**	**0**	**64 (49%)**
Mechanical completion	**0**	**0**	**0**	**0**	**0**	**0**

Remaining work until mechanical completion described in EDMS 2578715

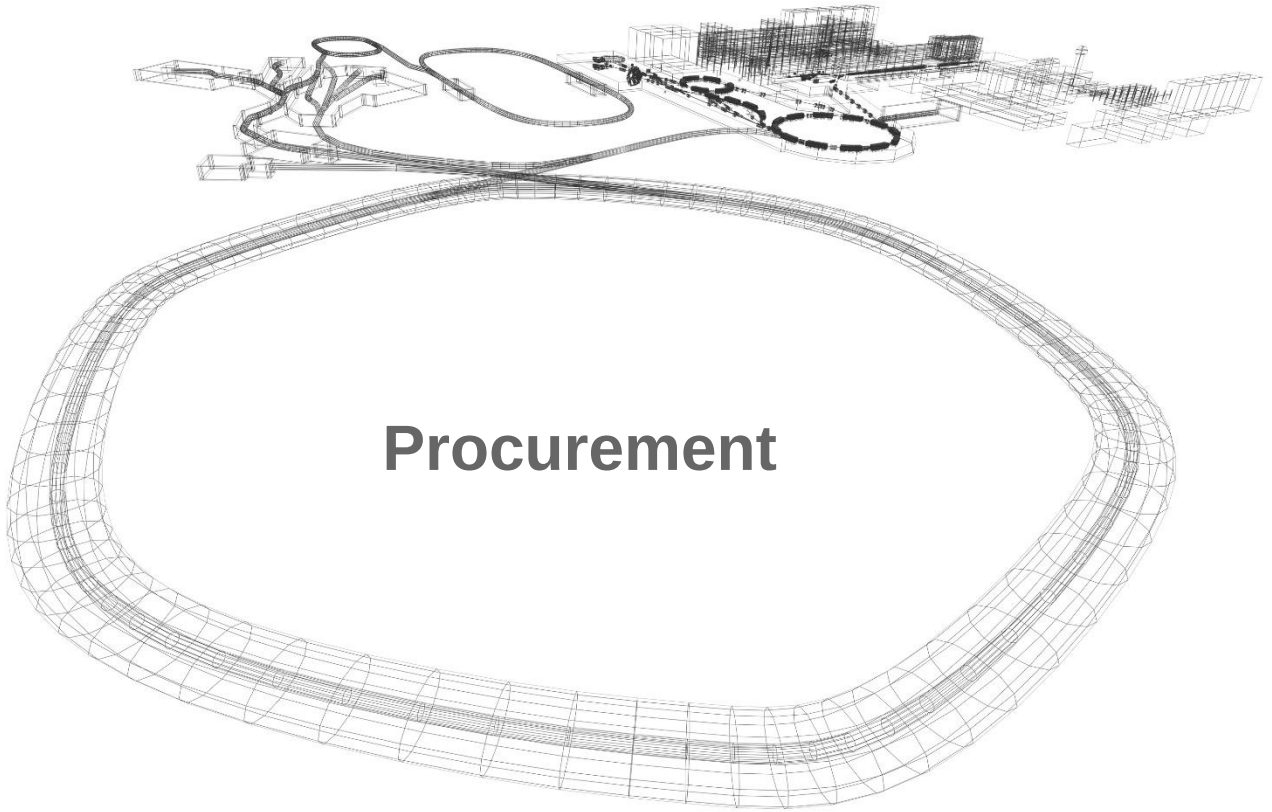
Pre-Assembly (completed)

- Pre-assembly (Betriebshof) completed
- Smaller number of modules will be installed on-site

Examples of pre-assembled material:

- ≈ 7000 internal cables (coaxial, optical, control, …)
- > 250 crates
- ≈ 70 driver amplifier modules
- > 500 LLRF modules

Start of LLRF installation

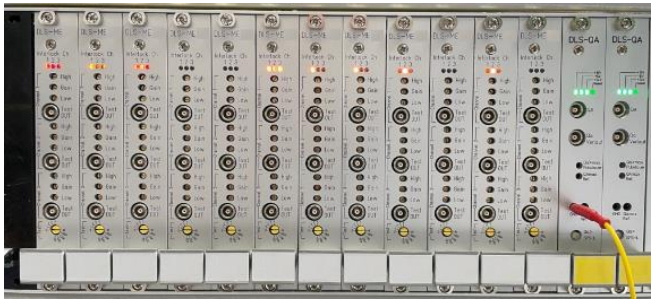


Procurement

Procurement is mostly completed, ongoing activities:

- FOT:
  - 100% of series quantity available
  - FOT crates have been pre-assembled in BEA niche racks

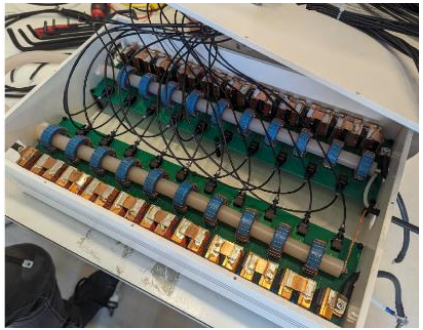
- DLS crate: 90% of series quantity available



- Optical Transmission System:
  - development needed, in preparation

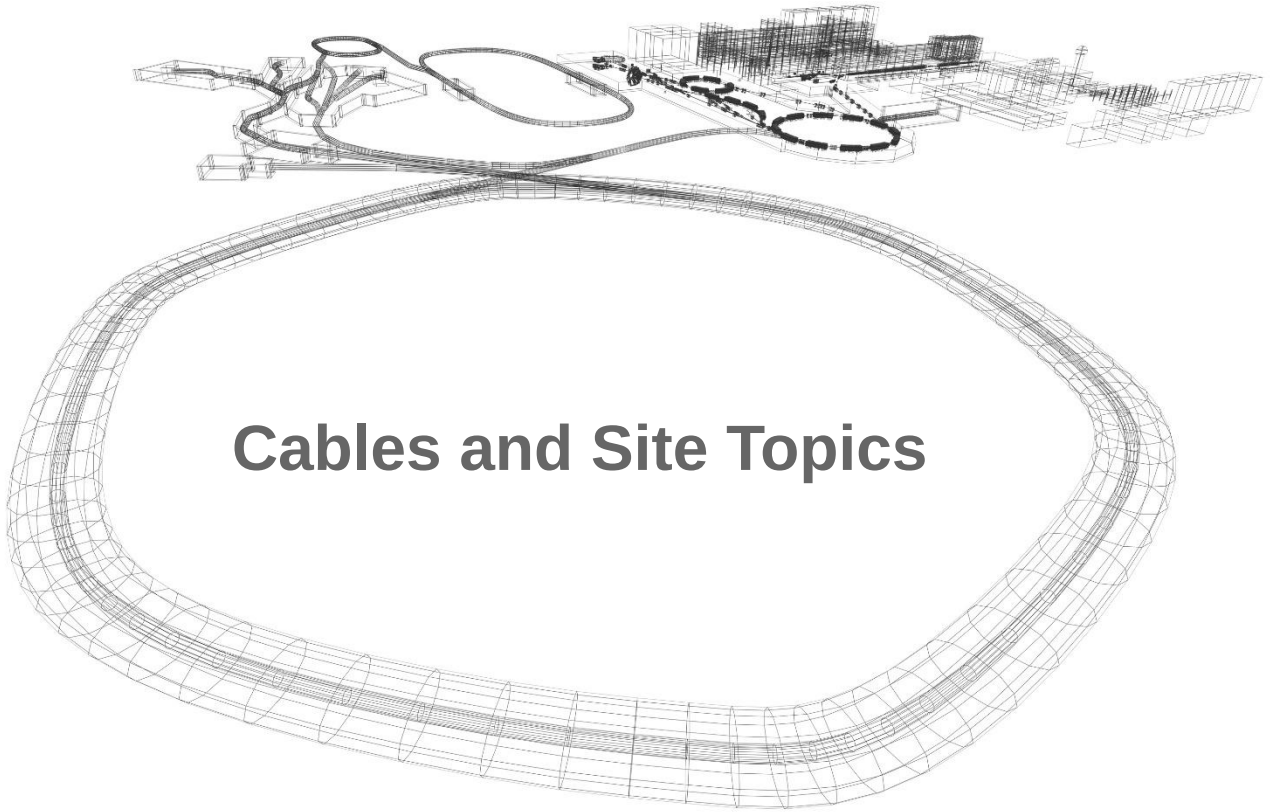
(ViaLite/PPM)

- Fast SiC gap switches: Call for tenders for the development is ongoing



prototype, TU Darmstadt, Prof. Griepentrog & Pikatron GmbH

photo: B. Zipfel



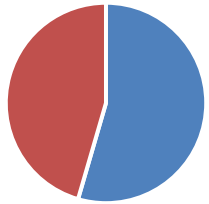
Cables and Site Topics

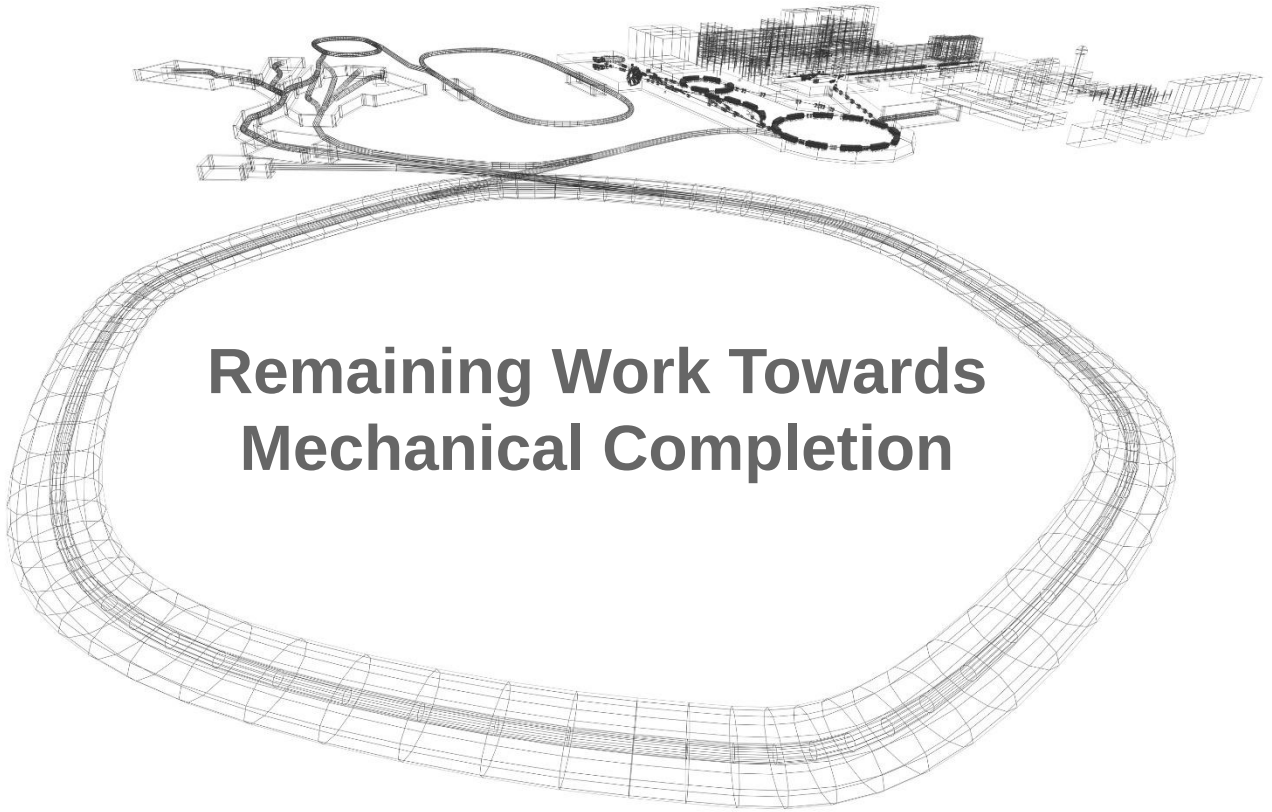
Cables and power

- CEE power outlets installed in S4 (fixed on cable ladders for overlength)
- Keep-alive: driver amplifier racks have to be powered once a year (cf. list of O. Ciosk)
- Routing checks and connector type clarifications ongoing in coordination with EPS
- Routing issues have decreased, but still some remaining topics (being clarified in the established process with EPS, SEAR, …)
- Length-sensitive cables:
  - length 100 (120) m: routing OK
  - length 500 m: routing OK
  - ButiS 1000 m: routing ongoing
  - length 33 m: routing finished, final check by RRF

- Laid cables (CDB, Sep. 15th, 2025) of RRF in SIS100 (no connectors yet!):

1972 of 3618 ≈ 55 %





Remaining Work Towards Mechanical Completion

Installation Steps for LLRF *

#	Work	Who	Status / Remarks
1	Verification of installation pre-requisites	RRF	
2	Transportation and positioning	EKL & ELC	49% completed
3	Installation and testing of earth connections	EPS	
4	Connection of racks to electrical power (CEE)	RRF	CEE adapter cables for S4 available
5	Cabling within supply areas, installation of missing modules	RRF, ELC, AÜG	Preparation for S4 & S3 currently finalized
6	Electrical testing of delay-sensitive cables	RRF	Test measurement planned

Time consuming: Support by ELC and AÜG planned

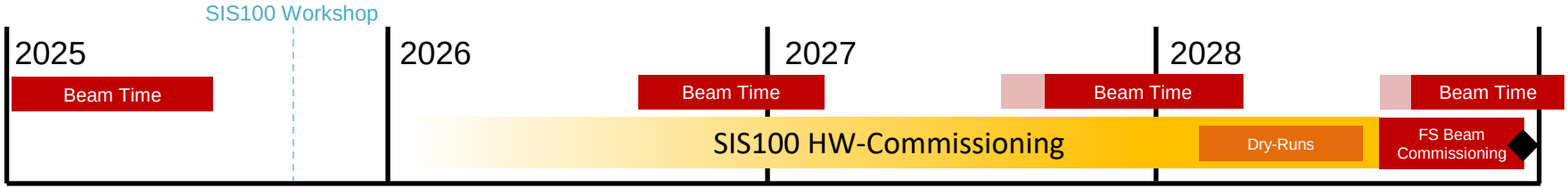
* see also: 1) P. Spiller: Ausstehende Arbeiten bis zur Vervollständigung des Aufbaus der Geraden Sektor 4
2) https://edms.cern.ch/document/2578715

Estimation of Time and Effort

- remaining work on LLRF per RF station ca. 5 days full-time with following assumptions:
  - cables between PSU and LLRF (ca. 250), purchased by RRF, will be laid by ELC (agreed & clarified)
  - 2 technicians of AÜG in parallel to RRF team (BANF for S4 available, clarification of time slot not yet done)

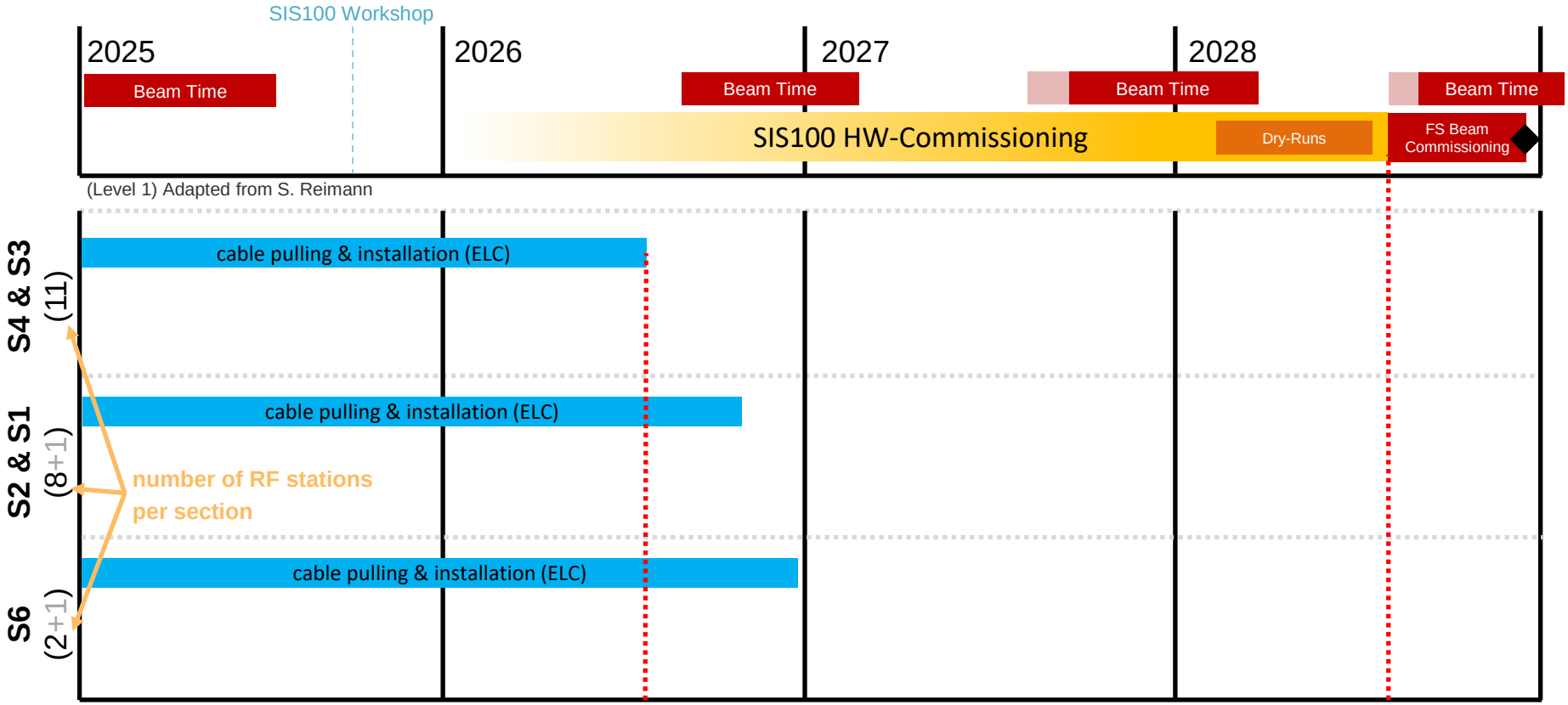
- time slots have to be coordinated with and integrated into LCM planning
- cable pulling not yet finished, time slots have to be synchronized with ELC time slots
- some tasks can only be done after connector assembly is finished, e.g. final checks and delay measurements
- additional time for coordination etc. needed

Time schedule – Level 1 vs. Work Package



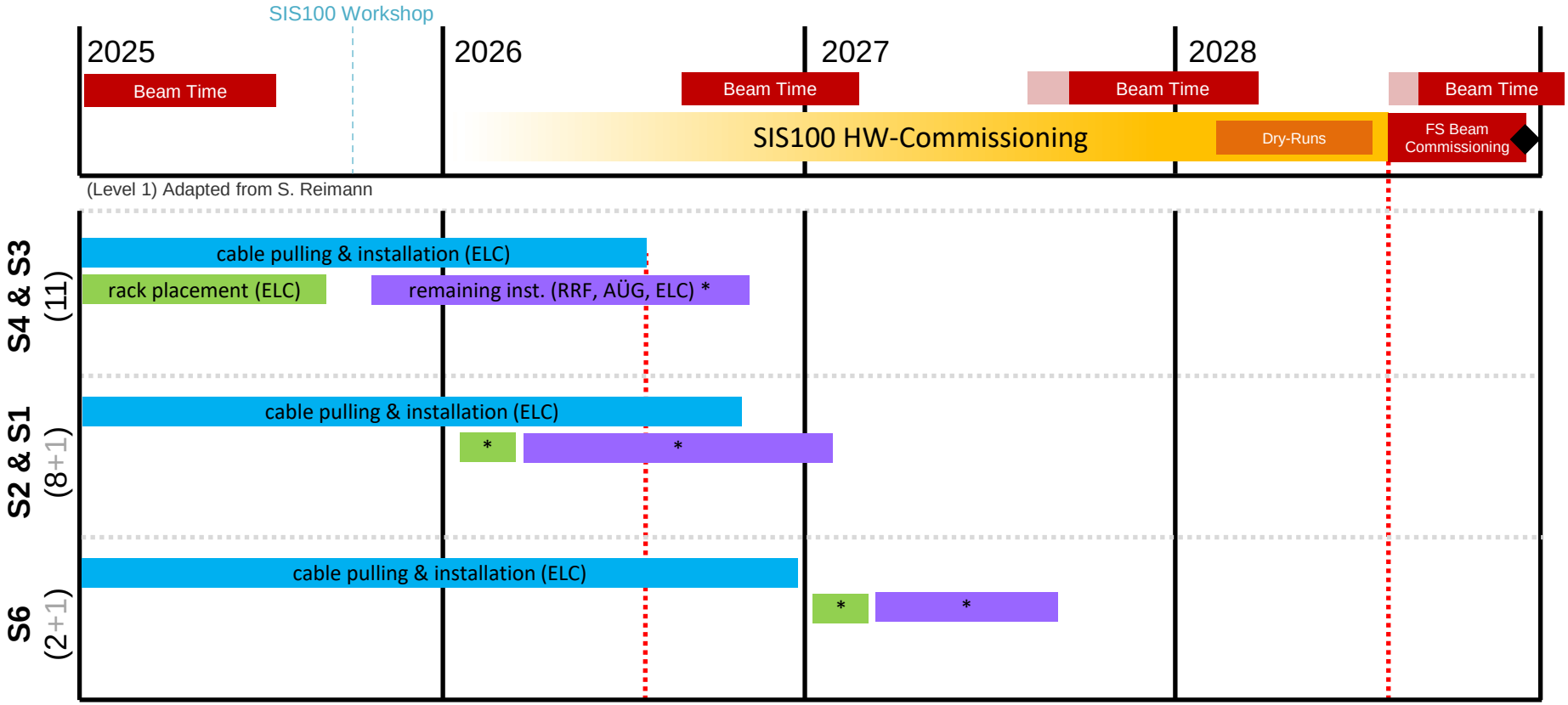
(Level 1) Adapted from S. Reimann

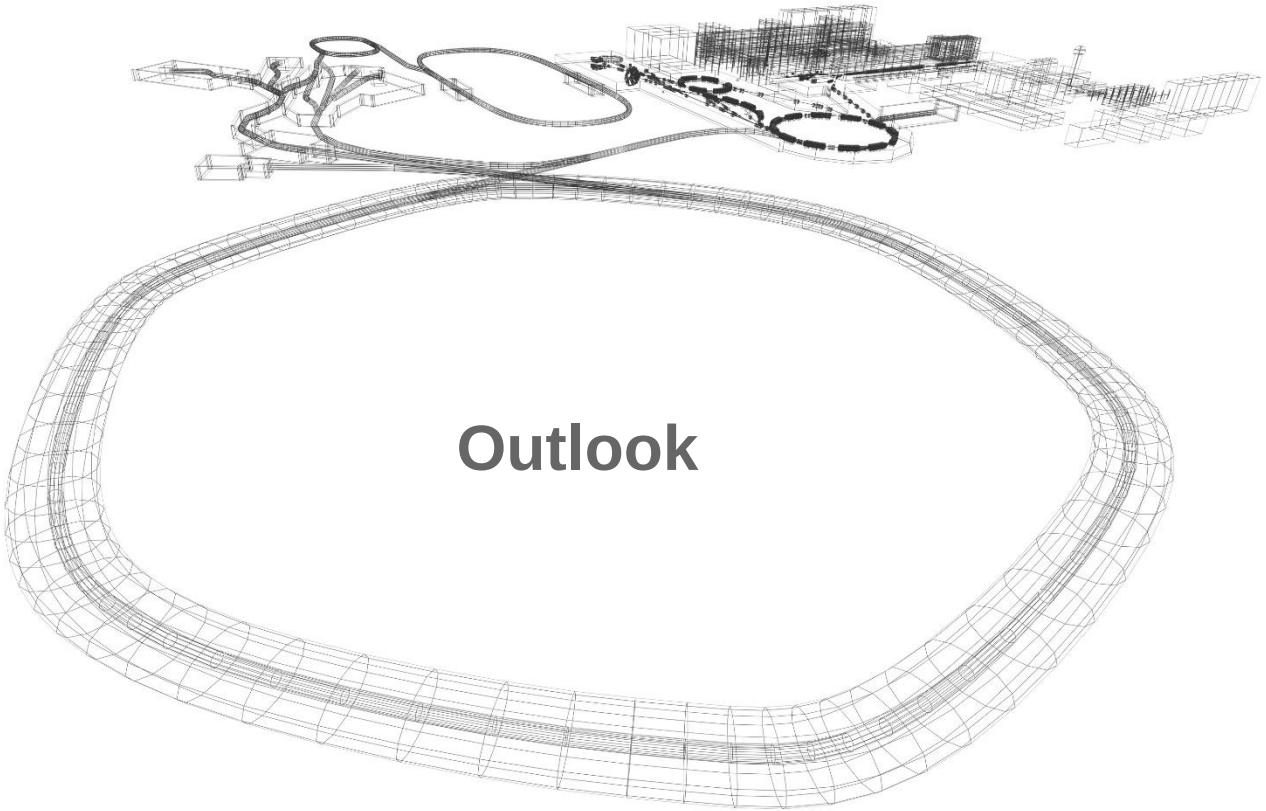
Time schedule – Level 1 vs. Work Package



Time schedule – Level 1 vs. Work Package

(* = estimation of WP, not yet in LCM)





Outlook

Preparation and assumptions for commissioning

1) Stand-alone commissioning of LLRF (Cavity & PSU: see talk by U. Laier):

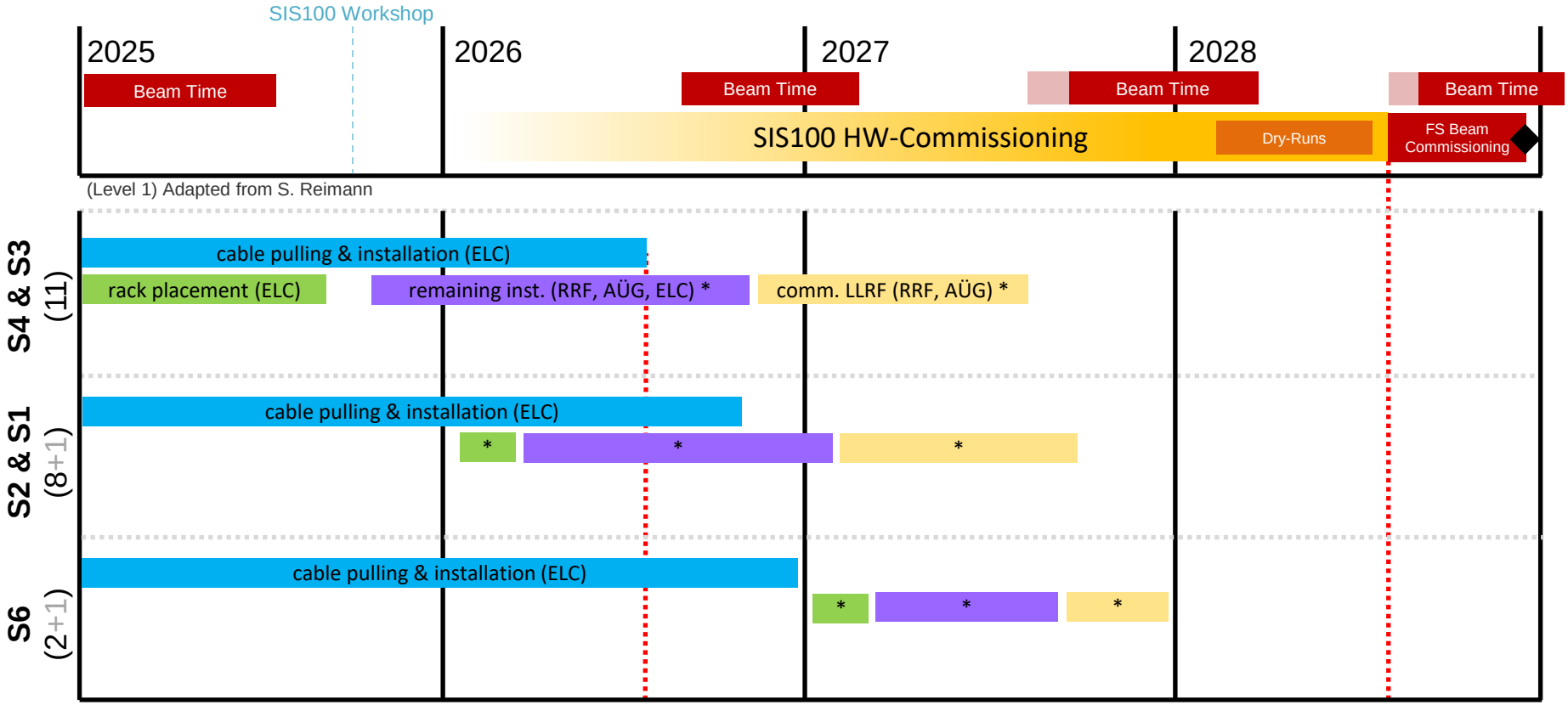
- module tests & firmware upgrades
- testing of complete signal paths with low voltages
- testing of gap voltage measurement & delays

2) RF commissioning of Cavity, PSU & LLRF:

- gradual increase of power (first with feedforward operation)
- status and interlocks for cavity, power & driver amplifier
- delay adjustment & measurement of feedforward curve for resonance frequency control
- optimization of all feedback parameters, spark detection, calibration (amplitude & phase)
- control system: FESA software, network, White Rabbit, …
- reference signals, BuTiS clocks, synchronization, Switch Matrix configuration, …
- …

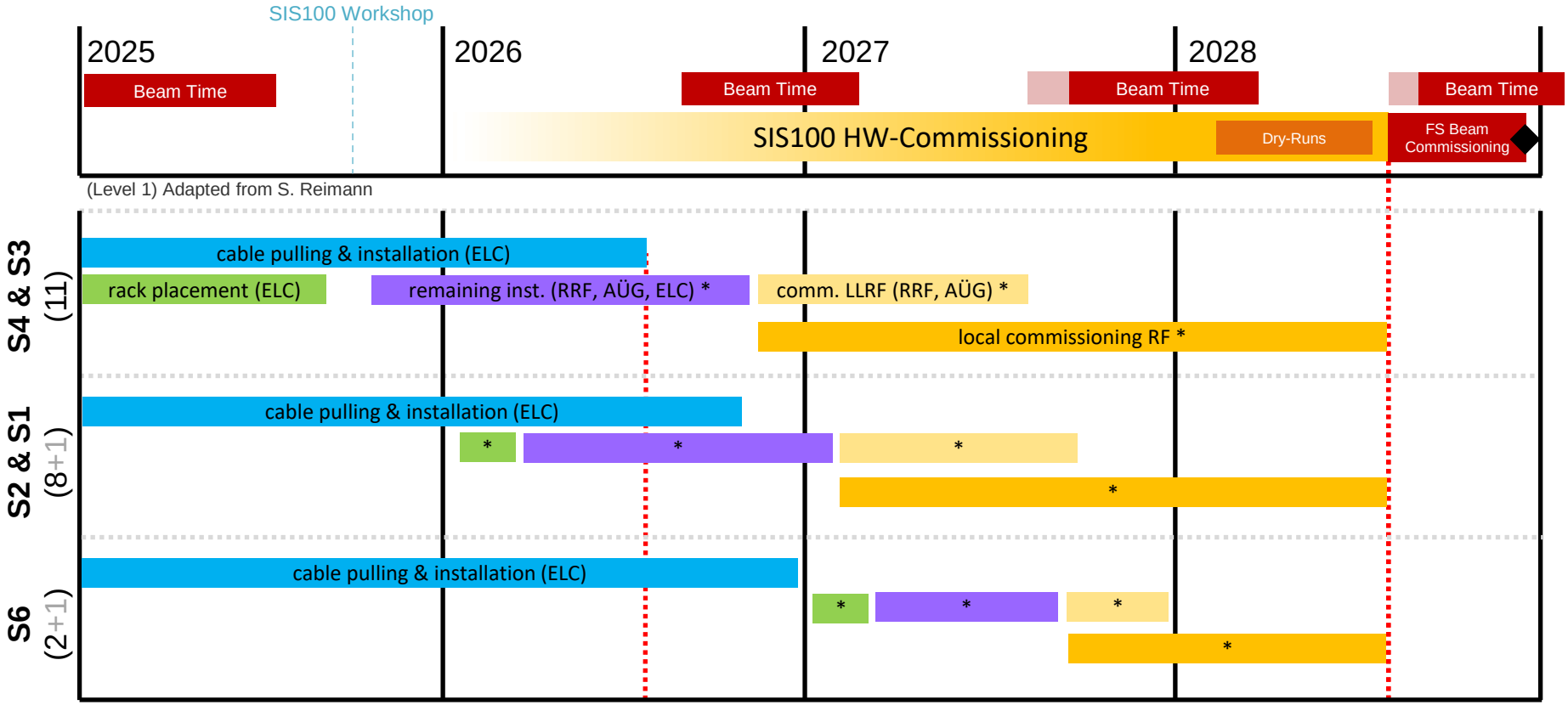
Time schedule – Level 1 vs. Work Package

(* = estimation of WP, not yet in LCM)



Time schedule – Level 1 vs. Work Package

(* = estimation of WP, not yet in LCM)



Consequences

- local LLRF commissioning (& PSU, cf. talk U. Laier) needs to start in Q4/2026:
  - power and media (cooling water, air etc.) must be operational in all supply areas
- RF commissioning (Cavity, PSU, LLRF) needs to start in Q4/2026:
  - vacuum systems need to be operational in order to allow high-voltage RF operation
  - dedicated time slots for RF operation of the cavities needed, ideally alternating between sectors (e.g. 2 weeks in S4 → 2 weeks in S3, etc.)
  - … (list is certainly not complete)
- support by AÜG for local commissioning planned (for simpler and repeating tasks)

In case of delays (cables, power, media, etc.) the following scenarios could be discussed:

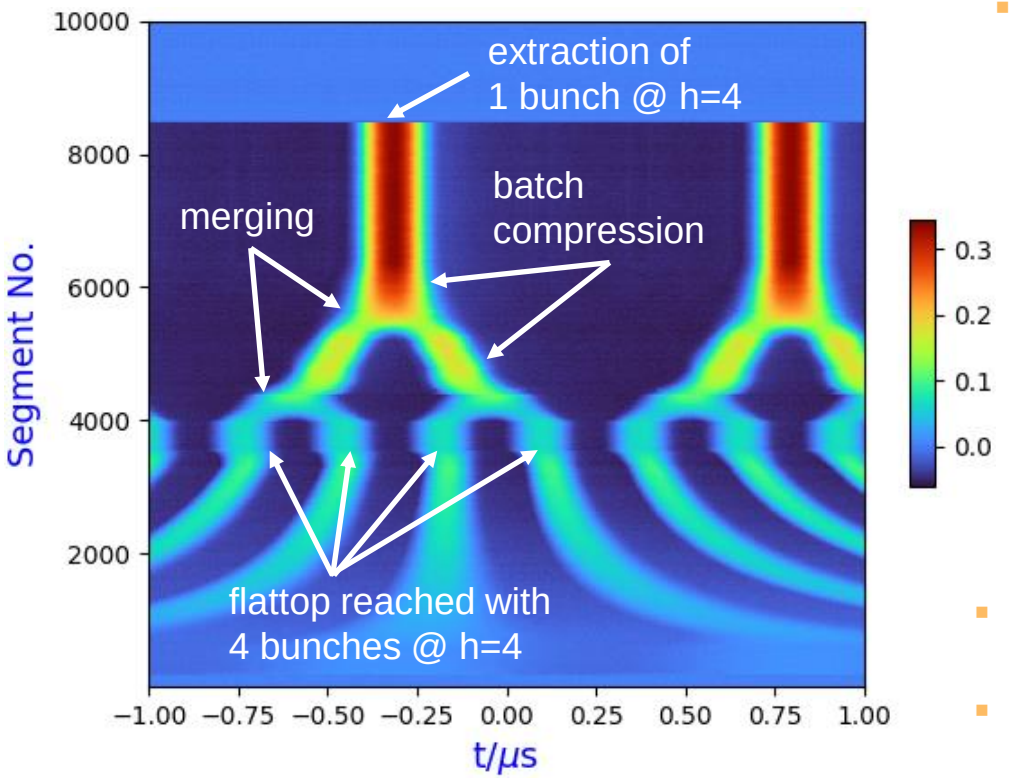
- focussing on SIS100 ACC first (saves up to 50% of commissioning time)
- focussing on finalization of certain sectors first

Preparation for SIS100 operation: validation of LLRF concepts during GSI beam time

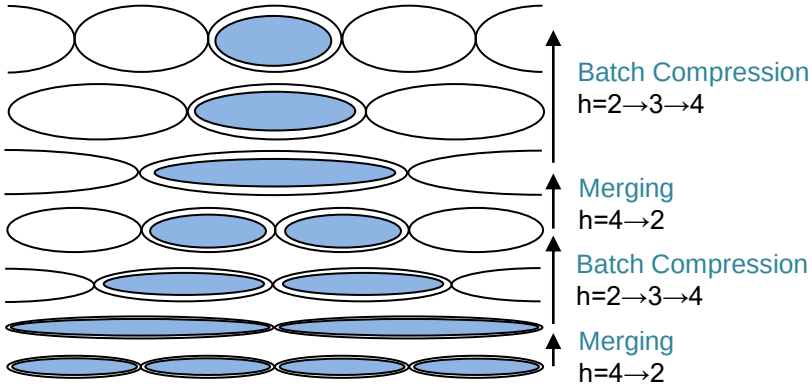
Some examples, important for SIS100 operation:

- first time realization of batch compression
- first beam transfer by new Bunch-2-Bucket transfer system using phase shifting
- first bunch compression with direct synchronization on gap voltage
- …

SIS18 Batch Compression (K. Groß, RRF)



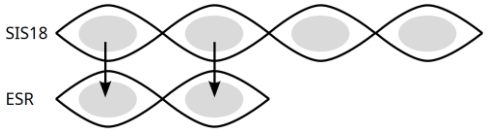
- in SIS100, batch compression schemes will be used; test in SIS18 with dedicated pattern (by K. Groß, H. Liebermann):



- **first time ever realization of batch compression at GSI !**
- partly manual ramps, not yet available in standard operation

Bunch-2-Bucket Transfer With Phase Shift Method

Here: Phase Shift in SIS18 (4 ms, #037)

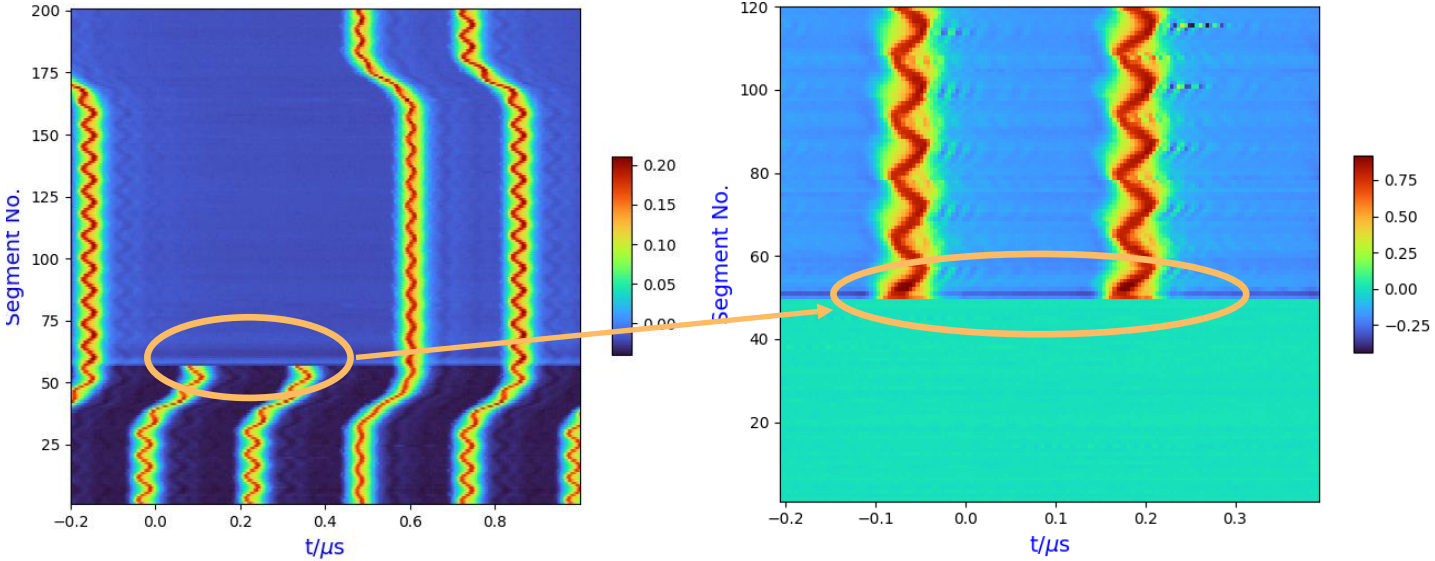


SIS18 (FCT)

$T_{rev} \approx 1\ \mu s$; $T_{sync} \approx 1.2$ ms

ESR (FCT)

$T_{rev} \approx 0.5\ \mu s$; $T_{sync} \approx 1.6$ ms



- B2B system implementation by D. Beck
- successful beam transfer using a phase shift at either SIS18 or at ESR
- **first time realization of phase shift method at GSI !**

1 segment = 100μs

D. Beck (ACO), D. Lens (RRF)

wiki.gsi.de/TOS/BunchBucket

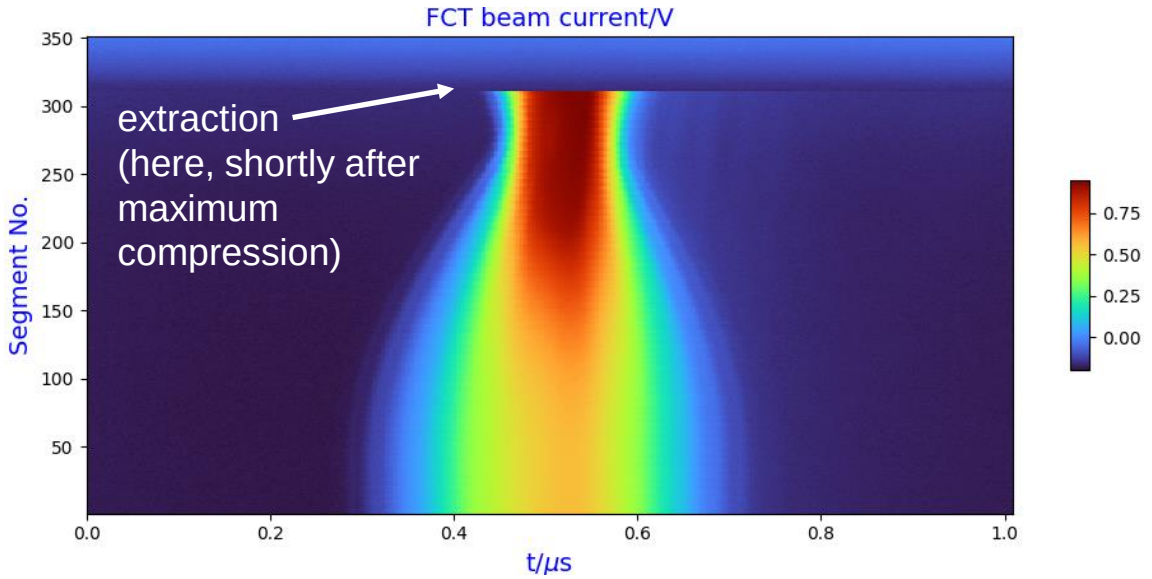
SIS18 Bunch Compression (D. Lens, RRF)

Upgrade of Low-Level RF of SIS18 Bunch Compressor:

- programmable logic control was integrated into the Central Control System (e.g. on/off/reset from HKR now possible)
- enhanced cavity phase synchronization topology, now using gap voltage directly

Result:

- phase synchronization worked with beam → also important for SIS100 Bunch Compression



compression of one SIS18 bunch (400 MeV/u, U^{73+})

Summary

- LLRF installation has started, next step is completion of remaining work for racks in S4 and S3
- time schedule towards SIS100 beam operation is tight

→ installation of (complete) RF systems in Sector 4 should be completed as soon as possible

- conditions for RF operation starting in Q4/2026 should be discussed
- development of LLRF for LF, BB, KO is ongoing