



Control System Readiness

From development to installation and commissioning

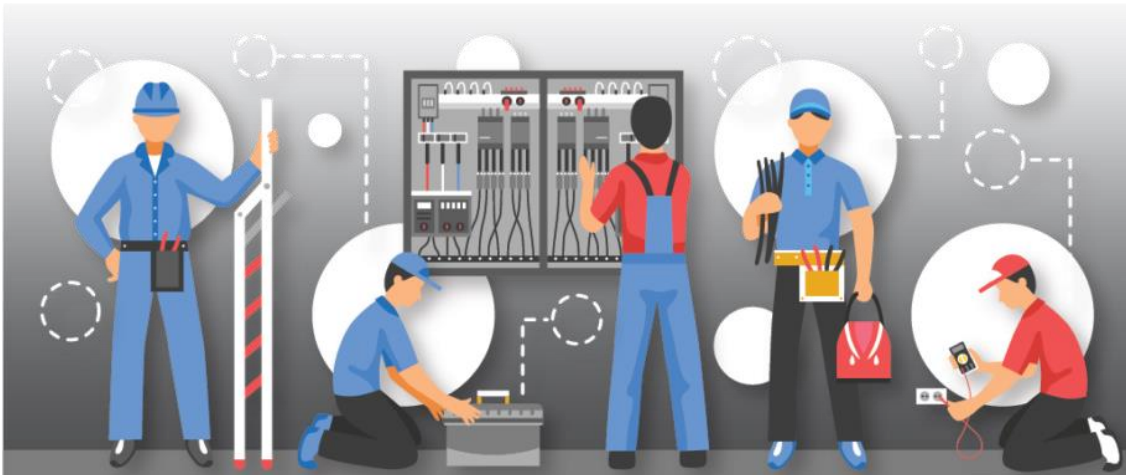
Ralph Bär, Accelerator Controls

SFRS Commissioning Workshop

26.05.2025

Presentation Outline

- **Update** to presentation of 1st Commissioning Workshop (08.11.2024) with focus on SFRS
- **Control System Hardware**
 - Status and Outlook of Hardware
 - Commissioning Planning: Schedule and concepts
- **Status Software Development**
 - Readiness of important functions for commissioning without beam



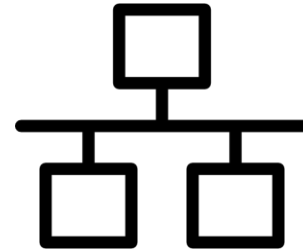
Commissioning Phases

Definitions by subproject Commissioning:



inst.	#	commissioning phase	accelerators & transfer lines	detectors	
Commissioning without Beam	1 D1 M103	local HW-commissioning	<ul style="list-style-type: none"> local system tests in tunnel and supply areas Control system not needed (only in limited aspects) 	<ul style="list-style-type: none"> single detector tests tests of individual components install. service & controls 	D1
	2 D2 M104	remote & system commissioning	<ul style="list-style-type: none"> single system test (vertical system integration test) remote testing from MCR (sequences, checklists) TBI, control system integration of the system and timing is needed 	<ul style="list-style-type: none"> system tests (with HV, gas, ...) pre-test of DAQ system local control 	D2
	3 D3 M105 M11	integration	<ul style="list-style-type: none"> (3.1) multi system tests & (3.2) full Dry-Runs control system and accelerator models for pilot beam scenarios fully available 	<ul style="list-style-type: none"> full detector test and DAQ using cosmics 	D3
Beam Commissioning	4 E M12	pilot beam commissioning	<ul style="list-style-type: none"> pilot beam commissioning (completion parameters) operation permit 	<ul style="list-style-type: none"> commissioning with pilot beam 	D4
		beam commission & early science	<ul style="list-style-type: none"> operation with PCP-beam respectively status quo beam commissioning of advanced systems and complex operation modes / intensity ramp-up 	handover to operations	OP

color-codes aligned with responsibility matrices



- Controls provides **networks** across FAIR buildings:
 - Accelerator (ACC) network → communication within control system
 - Timing (White Rabbit) network → time and events
 - Industrial (ProfiNet) network → network for Vacuum, Cryo, PAS, Interlocks, ...
- Availability of networks is **pre-requisite** for commissioning phase 2
 - → Install and commission as early as reasonably possible
- **All components already delivered** and waiting for installation ✓
 - ACC network switches → **ready for installation**
 - All White Rabbit switches → **ready for installation**
 - All ProfiNet switches → **ready for installation**
- **Central Installations** → done ✓
 - Installations in BG.2.009 (and Green Cube) completed
 - Core ACC switches already installed and already in operation
 - WR Timing → already in operation for several years
 - Industrial Ethernet → ProfiNet Core installed and in operation (GSI ring), FAIR rings prepared

D2

Essential pre-condition for network commissioning:

- Installation of network racks and cabling → responsibility of FSB
- Uplinks** – FOC connections to BG.2.009 (“Datenanbindung FAIR zur GSI”)
- Uplink northern buildings: established*
- Uplink southern buildings (SFRS): unknown, already several times requested to FSB

Status Overview

Stage	Machine	Building	Building old	Uplink date	Remark
ES	HEBT	G0704A	G004A	31.05.25	Transfer supply building
ES	HEBT	H0719A	G17.1	31.05.25	Main supply building
ES	HEBT	H0705A	G04	none	Transfer building (no active network comp.)
ES	Cryo	K0720A	G17A	31.05.25	Cryo compressor building
ES	SFRS	K0410A	T103	none	no active network components
ES	SFRS	L0312A	G006a	???	SFRS supply building
ES	SFRS	G0314A	G17.2	???	SFRS/NUSTAR
ES	SFRS	L0516A	G018	???	SFRS target
ES	SFRS	K0308A	G06	???	SFRS/NUSTAR HEB
FS	SIS100	K0923A	T110	31.05.25	SIS100 supply (6 main, 6 substations)

■ Installation



- starts as soon as building & cabling conditions are met → building milestones required
- installation of pre-configured equipment & patching, short powering test
- **Installation duration:** 1 week/rack estimated
(including documentation in cable/asset management system FNT Command)

■ Commissioning works

D1

D2

D3

- As soon as **uplink** is established and **building conditions** allow
→ uplink milestones for south buildings not known
- Powering equipment, communication tests → **stay in operation**, maintained by INN
- **Commissioning duration:** ½ day/rack estimated

OP

Installation and Commissioning Front-End Controls



Equipment control installation scope

- SCU FE-controllers for power converters
- MBox stepping motor controllers
- Interlock Collectors
- Fast Beam Abort (FBAS) Systems*



Special SFRS devices:

- QuD DAQ systems
- Phytron stepping motor controllers
- NMR probes



NB: network-connected equipment
usually does not need local installation

Installation and Commissioning

Front-End Controls (1)



■ Installation works (**Power Converters**)

- SCU standard controllers for 2025/2026 available (100 units) ✓
- SCUv4.1 to be produced in 2025 (100-150 units)
- SCUv5 under development, production in 2026 for FS/ES/FS+ (600 units)
- installation works: install SCU in power converter, cable connection ACC, WR, Interlocks, FBAS-FOC
- to be done by: ACO field support team (electronic technicians), teamed with EPS
- **Installation duration:** ½ day / power converter estimated



■ Commissioning works (**Power Converters**)

- remotely by FEC & APP/LSA teams (supported by field support team, local works)
- pre-conditions: PC released for remote operation, all data available (calibrations, interlock lists, field calibrations in DB, testing sequences available, ...)
- phase 2: Deployment of FESA class software, configuration, signal checks
- phase 3.1: LSA integration, beam pattern execution
- Use Sequencer Service for automation (sequences available)
- **Commissioning duration:** ½ day / power converter estimated

D2

D3

■ Preparations

- ACO Field Support Team: electronic technicians to be established & trained

Installation and Commissioning

Front-End Controls (2)



■ Installation works (**Stepping Motor Controllers**)



- all MBOX stepping motor controllers available (13 units for SFRS, abt. 100 axes)
- installation works: install MBox system, cable connection ACC, Interlocks, PDC
- to be done by: ACO field support team (electronic technicians), teamed with BEA
- **Installation duration:** ½ day/unit

■ Commissioning works (**Stepping Motor Controllers**)

- FEC & APP teams (field support by ACO/HEL field team)
- pre-conditions: Stepping motor already configured by BEA in local mode, all data available (calibrations, testing sequences available, ...)
- phase D2: Deployment of FESA class software, configuration, signal checks
- phase D3: LSA integration, beam pattern execution
- use Sequencer Service for automation (sequences available)
- **Commissioning duration:** ½ day / axis

D2

D3

■ Preparations / pre-conditions

- Hire of motion control expert in ACO/FEC needed (re-occupation of position)

Installation & Commissioning

Vacuum Controls (HEBT & SFRS)



- Controls of BL Vacuum → IND contributes to Vacuum Installation & Commissioning

Hardware Status

- Beamline Vacuum (SLO in-kind)
- Bake-out Control System (FAIR)
- Cryo Insulation Vacuum (GSI in-kind)



Stage	Machine	Type	Beamline Vacuum			Bakeout System			Cryo Insulation Vacuum			Remark
			need	deliv	plan	need	deliv	plan	need	deliv	plan	
ES	HEBT	PLC	5	5	0	2	2	0	-	-	-	
ES		SSR	-	-	-	7	7	0	-	-	-	
ES		TB	-	-	-	21	21	0	-	-	-	
ES		all	5	5	0	30	30	0	-	-	-	
ES	SFRS	PLC	4	4	0(+3)	-	-	-	25	0	25*	*delivery in 2025
ES		SSR	-	-	-	-	-	-	-	-	-	
ES		TB	-	-	-	-	-	-	-	-	-	
ES		all	4	4	0(+3)	-	-	-	25	0	25	
FS	SIS100	PLC	22	22	0	18	18	0	17	0	17*	*delivery in 2025
FS		SSR	-	-	-	84	84	0	-	-	-	
FS		TB	-	-	-	252	252	0	-	-	-	
FS		all	22	22	0	354	354	0	17	0	17	

*** 3 cabinets:**
needed for low energy branch (LEB) and Ring branch

Status:

"need" = required for stage/machine
 "deliv" = already delivered
 "install" = already installed
 "plan" = planned but not yet produced/delivered

PLC = PLC control cabinets

SSR = solid state relais cabinet

TB = terminal box

Installation & Commissioning

Vacuum Controls (SFRS)



Installation

- Since Q1/2025: all vacuum control cabinets for SFRS are **ready for installation** (M10)

D1

Commissioning (vacuum sector-wise)

- Pre-condition: vacuum sector is fully installed and closed
- 1. Signal testing → by IND & VAC
- 2. System testing → by VAC & IND
- After successful **signal testing** and **system testing**: system is commissioned (base operation)

D3

Schedule

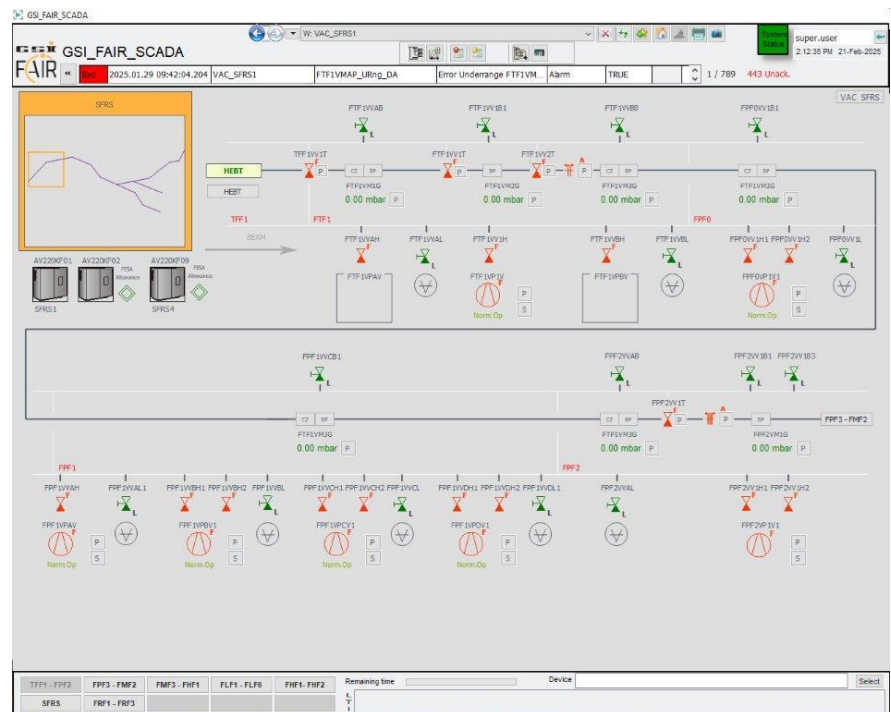
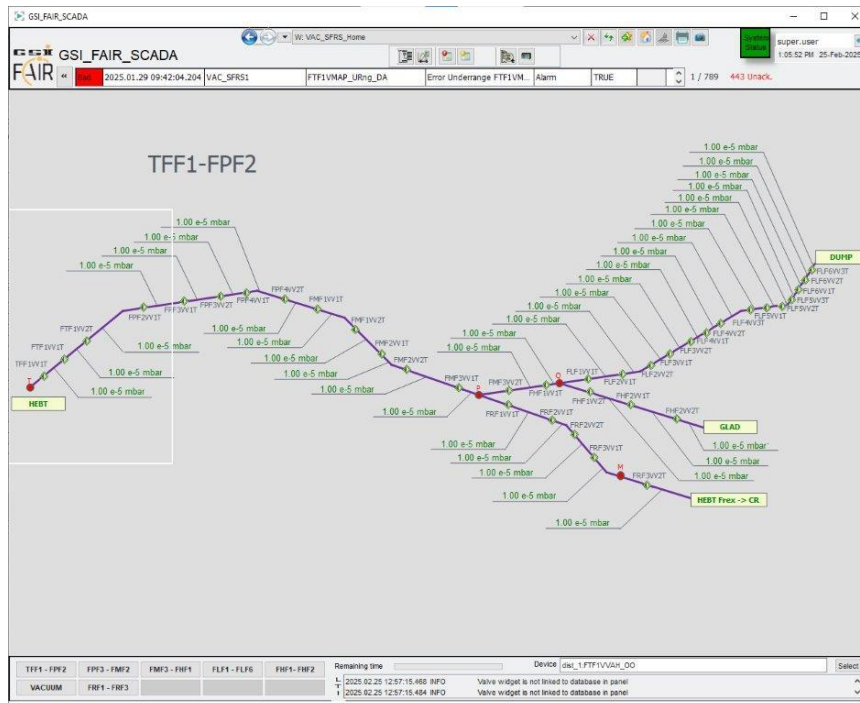
- Schedule aligned to vacuum system planning

271			2.14.10.6		ES: Vacuum Control System System Ready for Beam Operation	18.04.2026	03.06.2026
272			2.14.10.6.43	S007.M11	Vacuum controls ready for beam operation for HEBT		17.04.2026
273			2.14.10.6.44	S007.M11	Vacuum controls ready for beam operation for SFRS		03.06.2026

Installation & Commissioning Vacuum Controls (SFRS)



- Development of PLC & SCADA software parallel to cabinets, already available



Installation and Commissioning

Cryogenic Controls (incl. INV)



- Controls of Cryogenic System → IND contributes to Cryo Installation & Commissioning
 - Cryo2 plant integration (data exchange PLC cabinet)
 - SFRS cryo control (including DB2) cabinets
 - GLAD magnet control cabinets
 - Insulation vacuum control
 - SIS100 cryo cabinets (including DB4)

- **Hardware status** – still under development / production
 - SIS100 cabinets almost delivered (M10), except sector cabinets
 - Insulation vacuum control cabinets: delivery of first 50% in Q3/2025
 - Production of cabinets according to sorting order of tunnel installation (“back to front”)

- **Critical path:** Design of DB2 and XLF8 can be started after instrumentation lists are defined
 - DB2: instrumentation list expected in Q4/2025
 - XLF8: instrumentation list expected in Q3/2025



Installation and Commissioning Cryogenic Controls



Hardware Status

Stage	Machine	Type	Cryogenic Control System				Remark
			need	deliv	install	plan	
ES	SFRS	XLF1	1	1		-	
		XLF2	2	2		-	
		XLF3	3	3		-	
		XLF5	2	0		2	FAT for both cabinets already done
		XLF8	1	0		1	Instrumentation List missing, under development
		BB1	1	0		1	budget request under preparation to start production
		DB2	1	0		1	Instrumentation List missing (expected Q4/2025)
		all	11	6		5	
FS	SIS100	EB	6	6	2	0	
		FB	3	3		0	
		DB4	1	1		0	
		Sec	6	0		6	
		all	16	10		6	

Status: May 2025

"need" = required for stage/machine

"deliv" = already delivered

"install" = already installed

"plan" = planned but not yet produced/delivered

XLF1 = pre-target branch cabinet (T-branch)

XLF2 = pre-separator cabinet (P-branch)

XLF3 = main separator cabinet (M-branch)

XLF5 = high energy branch, towards NUSTAR (H-branch)

XLF8 = high energy branch, in NUSTAR cave (G-branch)

BB1 = branch box 1

DB2 = distribution box 2 (SFRS)

EB = end box

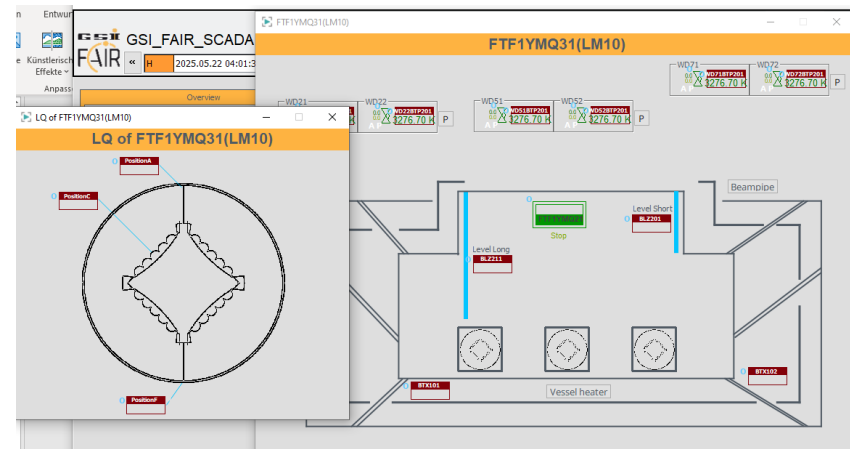
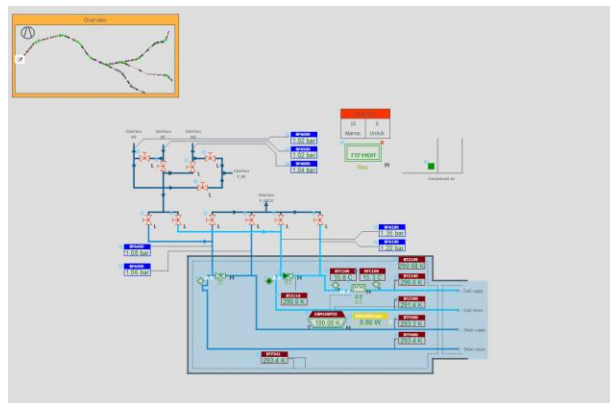
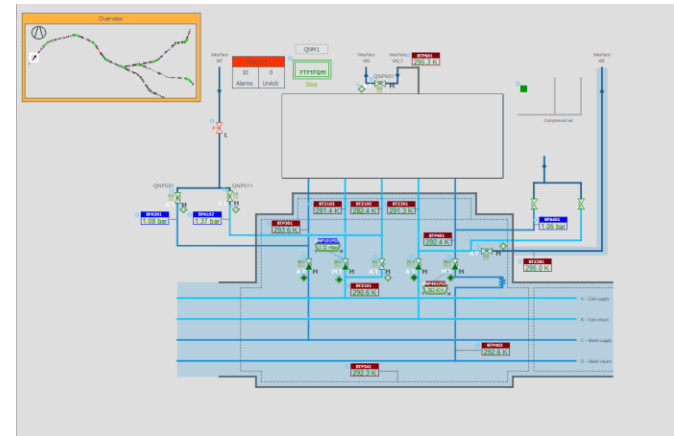
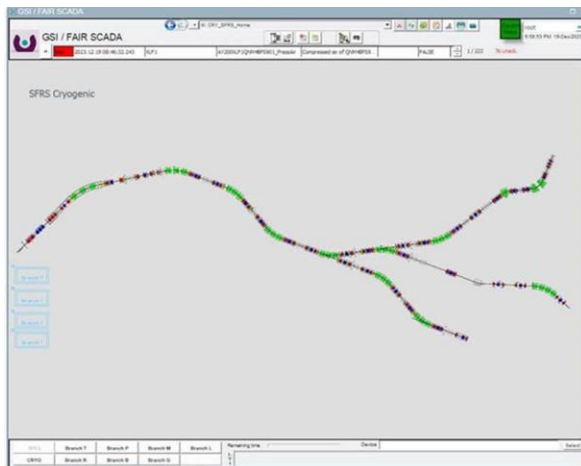
FB = feed box

DB4 = distribution box 4 (SIS100)

Sec = sector cabinet

Installation and Commissioning Cryogenic Controls (incl. INV)

- PLC software and SCADA software is already developed in parallel to cabinets and available already, already available)



Installation and Commissioning

Cryogenic Controls (incl. INV)



Installation

- Not presented here

D1

Commissioning

D2

- by joint commissioning teams
- to be executed branch-wise
- Signal testing → by CRY / SCM / VAC together with IND
 - Time estimates: abt. 10 min/sensor expected, 1h per valve, ...
- Commissioning sequence:
 - beamline vacuum → IND with VAC
 - insulation vacuum → IND with VAC
 - feedbox, endbox, distribution box, branch box & magnets → IND with CRY & SCM in manual mode
 - Implementation and testing of automatic mode (after learning about cool-down procedures)

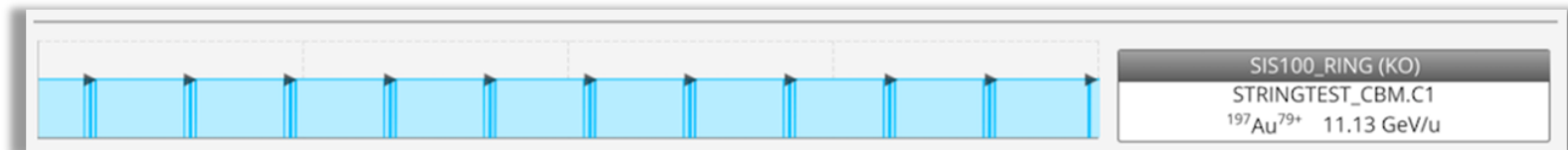
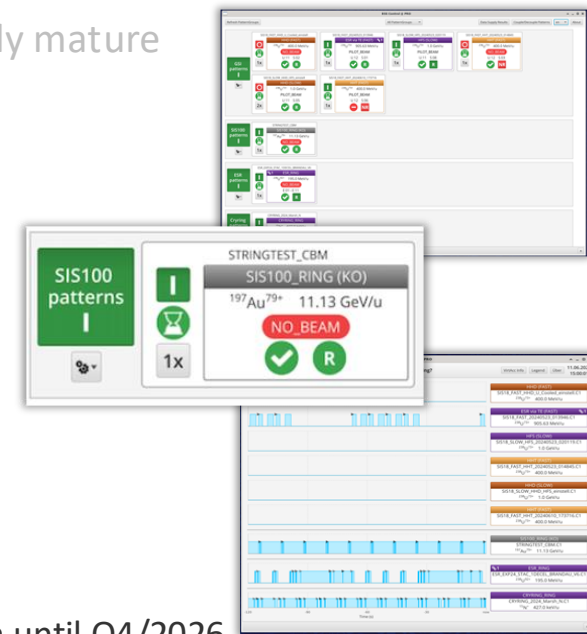
Preparations

- On-call service** for IND team during cooldown/cold operation (expected from mid-2026, cooldown of transfer line to DB2)



Status Control System

- FAIR CS operated since 2018, first production run 2019, 6th physics beam time with new CS in 2025
- Stable operation on SIS18, ESR, CRYRING and GSI-HEBT, sufficiently mature
- Increasing stability, functionality, useability
- CS architecture has shown to be stable adequate for ES
- SIS100 already operated virtually and for String Test
- UNILAC upgraded to FAIR control system until 2026
- Basic functions and applications are already available
- Some key items still to be done for ES:
 - SFRS ACC-EXP data exchange gateway → until Q4/2025
 - Post Mortem functionality → still to be designed and scheduled
 - FBAS machine protection → CDR approved 12/2024, implementation until Q4/2026
 - Improve Archiving System and integrate Industrial SCADA



Development FESA Software



- GSI Facility is operated already with **FESA** for several years
- Equipment control (FESA) software for HEBT / **SFRS**

Early Science Need (FAIR HEBT and SFRS)	Status	Completion date	Implementation
Power Supply Class (include: DAQ, Post Mortem)	already in operation, further features under development	Q2/2026	ACO
Motion (MBox stepping motors; include: ref-multiplexing)	already in operation, further features under development	Q1/2026	ACO
Motion (Phytron-controlled)	under development	Q2/2025	CSL/ACO
Fast Foil Stripper Integration (HEBT)	stripper specified, tender not yet awarded	Q3/2026	tbd
Vacuum sector valves and pressures via SILECS	completed	done	ACO
NMR Probe Integration	spec delayed, to be started in 08/2025	Q1/2026	CSL/ACO
FBAS Collectors and Logic (logic matrices/WR interface)	to be started in 07/2025	Q3/2026	ACO
QuD Data Concentrator	prototype completed, further features to be developed	Q3/2024	CSL/ACO

Thank You!
Questions?



Installation and Commissioning Cryogenic Controls (incl. INV)



- **Present Schedule**
 - aligned to overall cryogenic system planning

✓		175	☒	➔	2.14.10.7		ES: Cryo Controls for Early Science	25.04.2022	15.04.2027
>		176	☒	➔	2.14.10.7.44		ES: SFRS Cryo Controls Cabinets Hardware for Early Science	13.07.2022	12.11.2026
>		203	☒	➡	2.14.10.7.44		ES: SFRS Cryo Controls Software Development and Tests	25.04.2022	22.08.2025
>		209	☒	➔	2.14.10.7.44		ES: SFRS Cryo Control Readiness for Commissioning (CS Commissioning)	14.08.2026	12.11.2026
✓		213	☒	➔	2.14.10.7.44		ES: SFRS Cryo Controls Commissioning and Cooldown	14.08.2026	15.04.2027
>		214	☒	➔	2.14.10.7.44		Commissioning SW + Cooldown (Distribution systems SFRS) B:T	14.08.2026	22.10.2026
		215	☒	➔	2.14.10.7.44	S007.M11	Controls Cryo distrib. syst. + local cryo ready for cold operation (Branch T)		22.10.2026
>		216	☒	➔	2.14.10.7.44		Commissioning SW + Cooldown (Distribution systems SFRS) B:P+M	13.11.2026	11.03.2027
		217	☒	➔	2.14.10.7.44	S007.M11	Controls Cryo distrib. syst. + local cryo ready for cold operation (Branch P+...		11.03.2027
>		218	☒	➔	2.14.10.7.44		Commissioning SW + Cooldown (Distribution systems SFRS) B:H+G	15.01.2027	15.04.2027
		219	☒	➔	2.14.10.7.44	S007.M11	Controls Cryo distrib. syst. + local cryo ready for cold operation (Branch H+G)		15.04.2027