



# Science Retreat

## SuperFRS installation, testing and operation

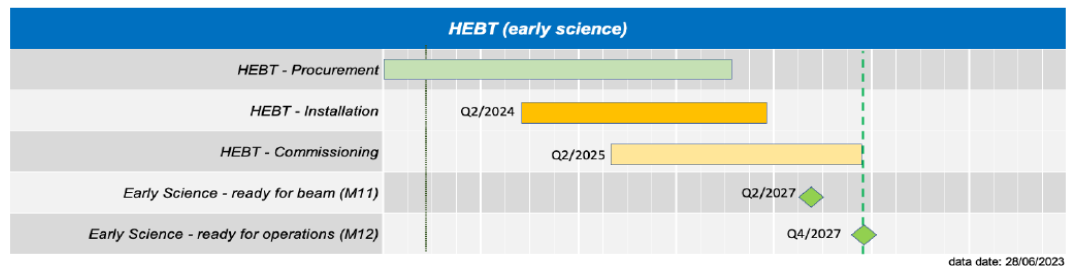
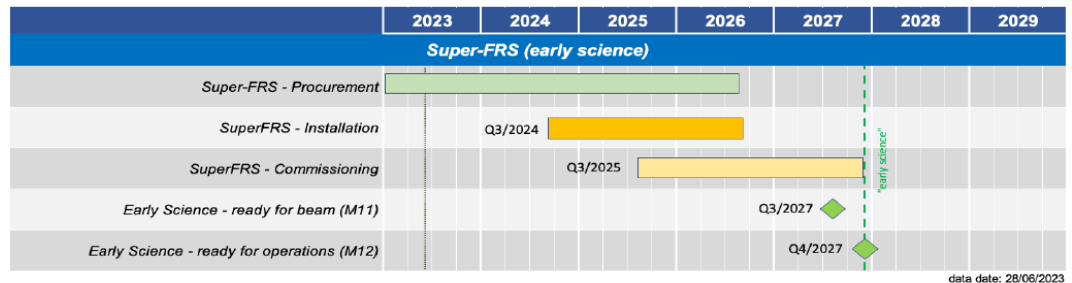
**H. Simon**

# Results of Rebaselining



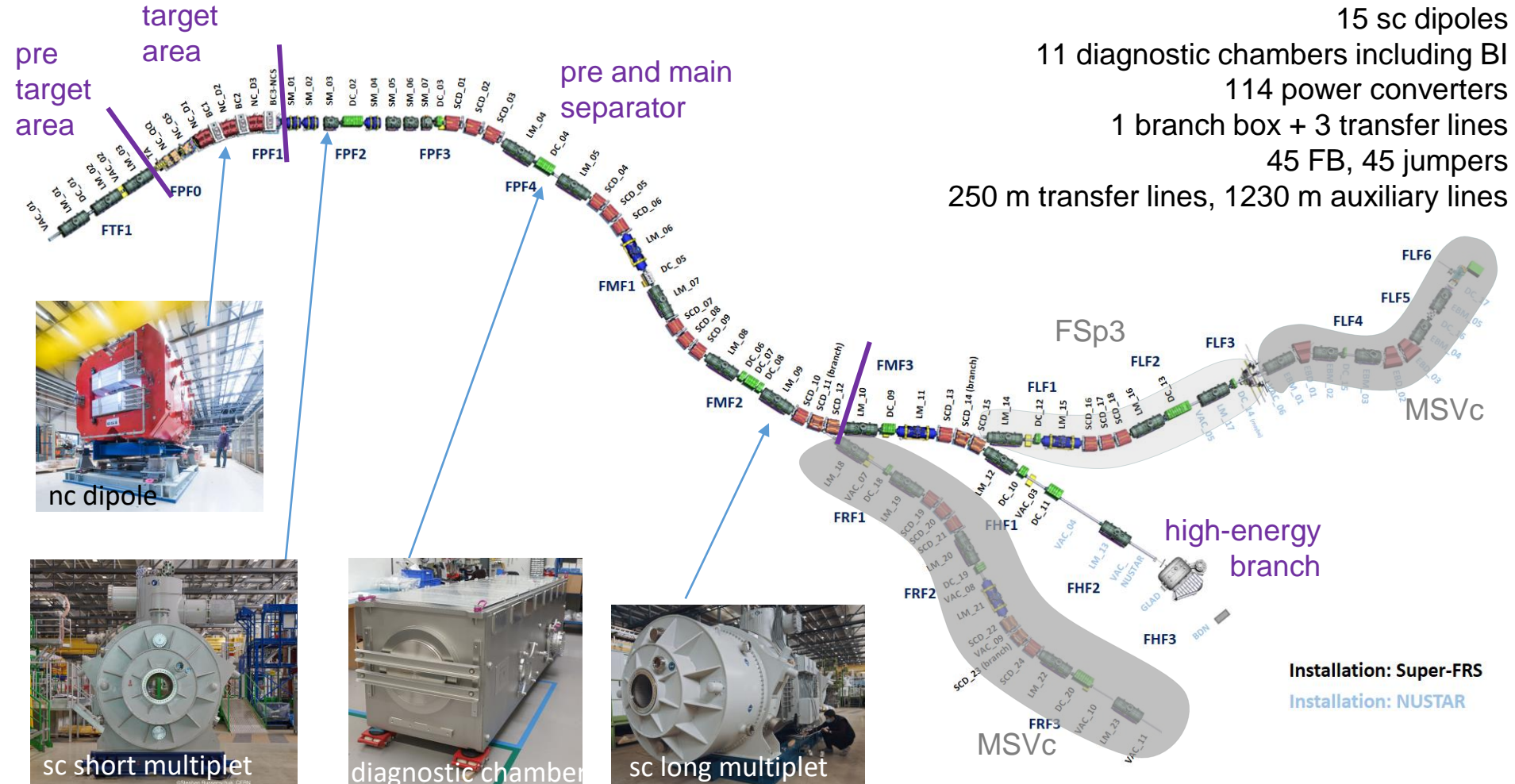
- Procurements
- Re procurements (RU replacements, Delayed In-Kind contributions)
- Testing (SAT)
- Preassembly Already ongoing for delivered components
- Installation Mechanical Completion 08/2026
- Component commissioning → Dry runs
- Beam tests in the course 2027

Activities are interleaved  
Project interdependencies  
(especially with building  
construction are covered)



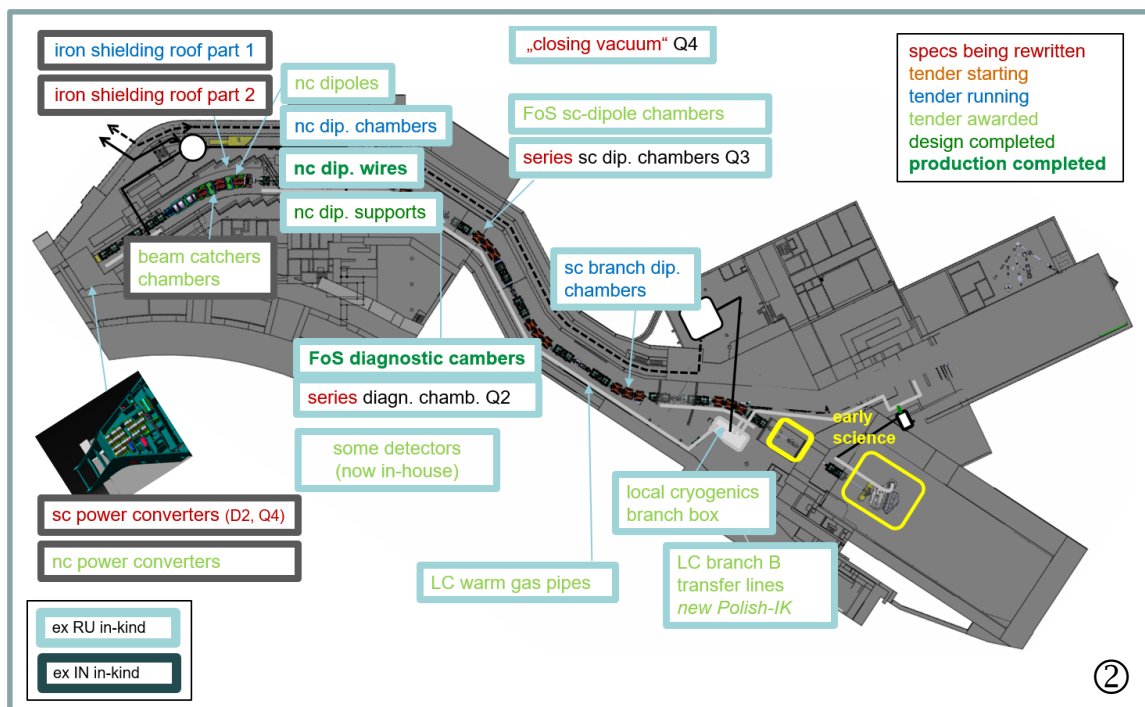
# Scope for early science and installation blocks

- 3 nc dipoles, 1 target chamber, 3 beam catchers, 5 nc multipoles
- 13 sc long multipoles, 7 sc short multipoles
- 15 sc dipoles
- 11 diagnostic chambers including BI
- 114 power converters
- 1 branch box + 3 transfer lines
- 45 FB, 45 jumpers
- 250 m transfer lines, 1230 m auxiliary lines



## Super-FRS

- **sc multipliers** for ES (22): 6 on campus (5 pre-assembled ①), 6 approved SAT, 16 approved FAT
- **Local cryogenics** branch T (WUST, PL): subcontracted to INOX India Ltd. (30/06/2023)
- Further progress on **re-procurements** of ex-RU and (ex)-IN components ②, in particular:
  - **nc dipoles** ③: contract signed (Sigma Phi, FR) (01/09/23); kick-off on 28/09/23
  - **power converters** for nc magnets (ex IN): contract signed (Jäger Elektronik, DE) (20/07/2023)
  - **Iron roof shielding** in target area (withdrawn IN): for 1<sup>st</sup> batch tender finished supplier chosen



# Status tenders of ex-RU components



component	tender status	re-writing specs for tender	contract award
NC-dipole wires	delivered (nVent Thermal)	done	done
NC dipoles	awarded (SigmaPhi)	done	done
NC-dipoles alignment supports	awarded (Fantini)	done	done
NC-dipole chambers	awarding phase	done	10/23
FoS vacuum chambers SC standard-dipoles	in production (Omega Physics)	done	done
Series vacuum chambers SC standard-dipoles	budget foreseen in CB9	done	Q1-24
Vacuum chambers SC branched-dipoles	running	done	Q1-24
FoS (spares) Diagnostic chambers	delivered (Pfeiffer), SAT done	done	done
Series Diagnostic chambers	budget foreseen in CB9	Q4-23	Q1-24
pumping chambers	budget foreseen in CB9	Q4-23	Q2-24
supports for pumping chambers	budget foreseen in CB9	Q4-23	Q2-24
Branch Box	awarded (DEMACO)	done	done
Branch B transfer lines	in-kind PL (WUST, 06/2023)	-	in progress
Warm Piping System	running	done	Q4-23
MPL 1-channel lines	running	done	Q4-23
ToF detectors (replacement)	in-house production (budget in CB9)	-	-
IPM (ex BPM)	In-house assembly; main part ordered	done	-

# Status of Indian in-kind components

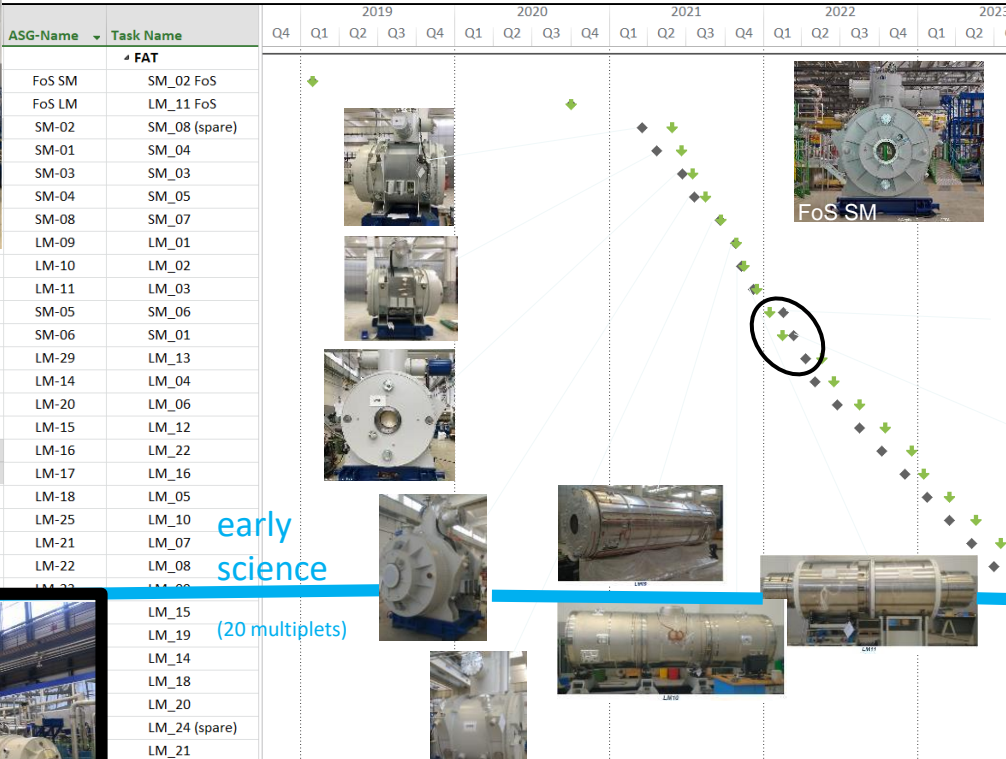


component	tender status	re-writing specs for tender	contract award
Beam catcher chambers (plan B)	awarded (NTG)	done	done
Power Converters for nc magnets	withdrawn, awarded (signature phase)	done	Jul-23
Power Converters for sc magnets (D2 and Q4)	announced to be partially withdrawn, expected reduction of sharehold share, budget foreseen in CB9	Aug-23	Q1-24
Power Converters for sc magnets (C3)	confirmed by India, but budget foreseen in CB9 in case of delays with possible reduction of sharehold share	Sep-23	Q1-24
Iron roof	announced to be withdrawn 07/2023, expected reduction of sharehold share, budget foreseen in CB9. Critical pieces: tender already running Next critical pieces to be tendered	done done	Q2-23 unclear
Beam catchers (all)	IN provider awarded the tender to sub-contractor, but IK contract still missing (Vacuum chambers in procurement)	-	(IK) Jun-23

# Status: Example for major component: sc multiplets - Procurement → Testing → Preassembly

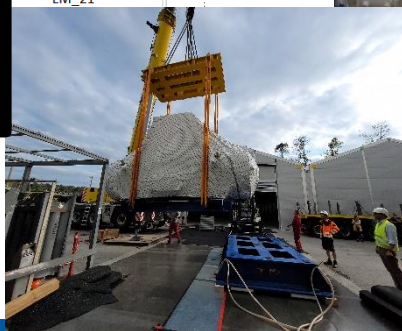


FTF1YMQ09	LM-10	LM_02
FTF1YMQ04	LM-11	LM_03
FPF3YMQ13	SM-05	SM_06
FPF2YMQ11	SM-06	SM_01
FHF2YMQ11	LM-29	LM_13
FPF4YMQ11	LM-14	LM_04
FMF1YMQ21	LM-20	LM_06
FHF1YMQ21	LM-15	LM_12
FRF3YMQ21	LM-16	LM_22
FLF2YMQ21	LM-17	LM_16
FMF1YMQ11	LM-18	LM_05
FMF3YMQ21	LM-25	LM_10
FMF2YMQ11	LM-21	LM_07
FMF2YMQ21	LM-22	LM_08
FMF2YMQ11	LM-23	LM_09



early science

(20 multiplets)



First-of-Series Magnets  
readily prepared for  
tunnel installation



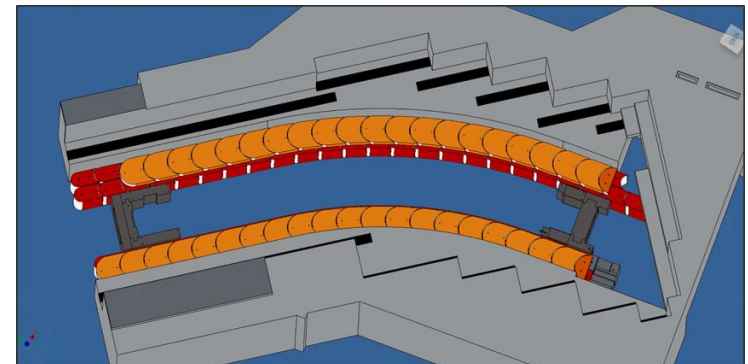
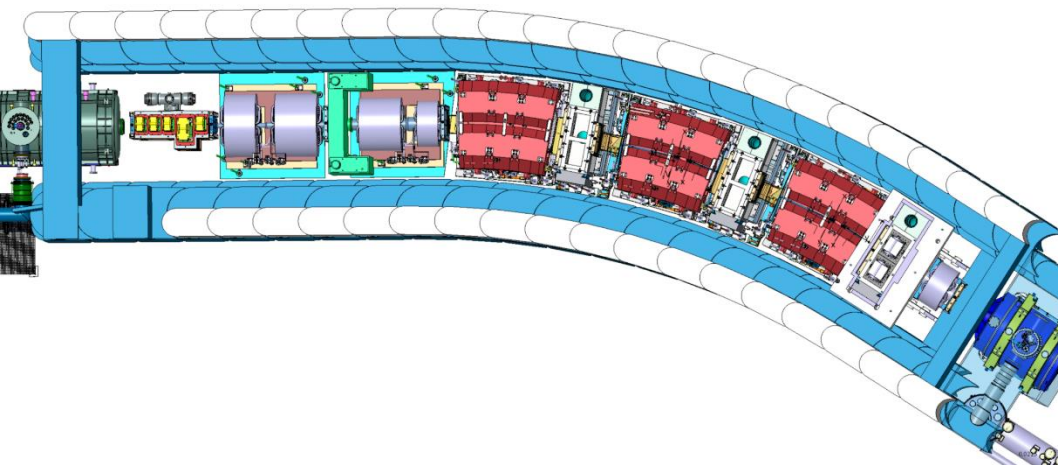
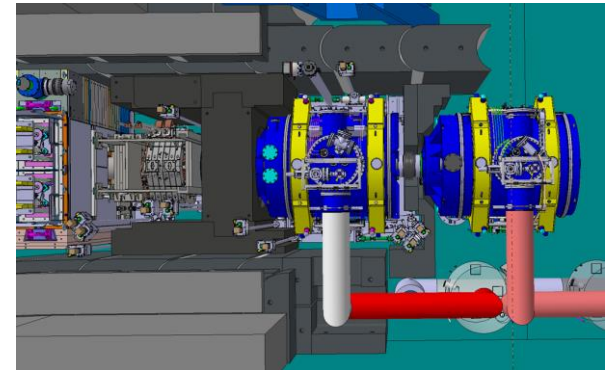
# Critical Path analysis

## critical path:

- **nc dipoles** (ex RU)  
mitigation: new FAIR tender published; proposed deliveries January and March 2025
- **iron roof** (Indian IK to be returned); installation: Sep 2025 (before TGA in target area)  
mitigation: FAIR tender prepared
- **iron at entrance and exit** (installation: June 2024)  
mitigation: FAIR tender

## mitigated:

- beam catcher chamber (plan B, awarded)
- ncDipole cable (delivered) + stands (awarded)
- ncDipole Ti chamber (procurement dep.)
- nc magnet PCs (returned IK, tender running)





# Critical components in tunnel

## critical path:

- **sc magnet testing (SAT) at CERN** extended testing phase  
mitigation: adaptation of installation sequence and test program
- **sc dipoles** manufacturing rate  
mitigation ongoing via double production shift (**expediting at manufacturer**)
- **SE/FIN detectors** (tracking detectors with drives / MUSIC): production schedule and technical difficulties  
mitigation: production of main series (MUSIC:2) via own resources, Sci-Fibre (**Plan-B:14**)
- **local cryogenics components:** (**expediting at university**)
  - Harmonized proposal to WUST with dedicated scope (COM, SIS100, Super-FRS)
  - Own tender of time critical components with many building interfaces
- **sc magnet PCs (Q, D)** (**expediting at manufacturer**)
  - Q,D supplies potentially outside Indian finances – return and own tender requested
  - India announced in July council to revisit package again – partial return announced, own tender to be started
  - Corrector (S,St,O) supplies arrive late 2025

## mitigated:

- local cryogenics components:
  - Branch Box (ex RU): FAIR tender awarded to DEMACO
  - auxiliary lines (ex RU): FAIR tender
- diagnostic chamber prototypes (2/11) delivered
- standard dipole chambers CDR (2/13)
- BPM (ex RU) replaced by IPM (in house BEA)

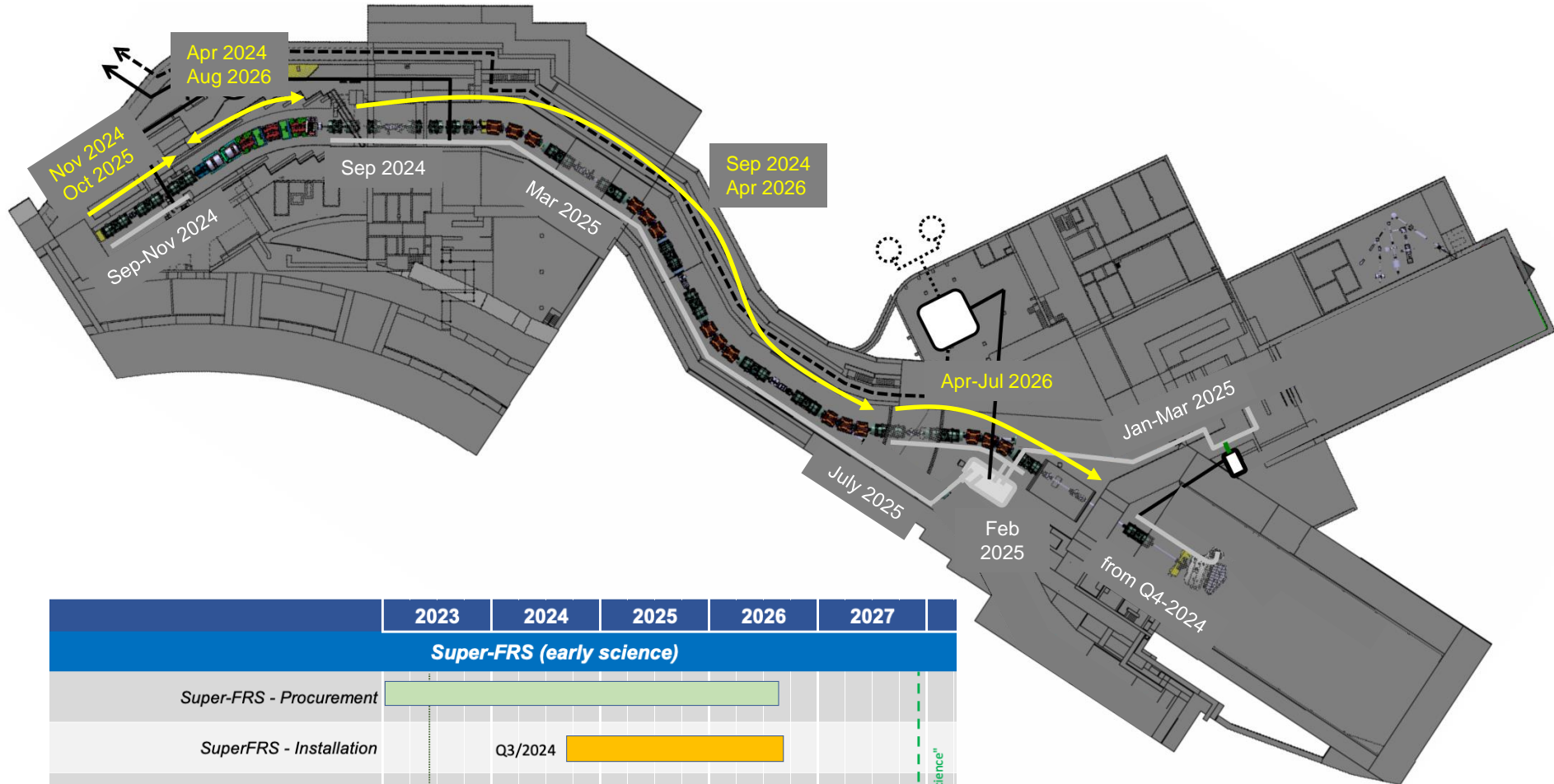
# Schedule Beam Instrumentation

exRu, exSE, plan-B FI

BI component (2.4.6)	Specs (M3)	Contract (M4)	FDR (M7)	FAT (M9)	SAT (M10)	Comment
GEM-TPCs (Fi) (Plan-B Sci Fib., 14pcs)	Done	Done (1st part, 5pcs)	Dec 2023	Jul 2025	Jan 2026	Technologically challenging
SEM grids (FI→ EEL)	Done	Done	Oct 2023	Jan 2025	May 2025	FoS successfully tested
Drives (SEM/GEM) (FI)	Done	Done	Dec 2023	Aug 2025	Sep 2025	Straight forward item
MUSICs (FI→DEL→ EEL)	Done	Done	Jan 2024	Feb 2025	Jun 2025	FoS under test
Plastics (replace ex-RU)	Done	Done (in house)	Dec 2023	Jan 2025	Nov 2025	ToF replacement
Media boards	Done	Done (in house)	Together with the FDR of BI items	Together with the FAT of BI items	Together with the SAT of the BI items	FoS successfully tested
IPM (ex-RU, via BEA)	Done	Closing for main component	Jun 2024	Sep 2024	Dec 2024	T Branch installation
PDCs	Done	Done (in house)	Done	Sep 2024	Feb 2025	FoS successfully tested concept
Beam stoppers	Done	Done	Done	Oct 2023	Ready by 2023	under production
Diamonds (ex-RU)	Done	Done (in house)	Feb 2024	Jan 2025	Mar 2025	FoS successfully tested
Slits	Done	Done	Done	Done	Ready by 2023	SAT running
Control drive (hardware, SE→BEA)	Done	Done	Not needed	Not needed	Together with the SAT of BI items	Straight forward items
ACC DAQ (BEA)	Done	Done	Not needed	Not needed	Together with the SAT of BI items	Straight forward items

Additional work load covered with redirected personnel

# Installation schedule mechanical completion (M102): Aug 2026



	2023	2024	2025	2026	2027
<b>Super-FRS (early science)</b>					
Super-FRS - Procurement	[Green bar]				
SuperFRS - Installation		Q3/2024	[Yellow bar]		
SuperFRS - Commissioning			Q3/2025	[Yellow bar]	
Early Science - ready for beam (M11)				Q3/2027	◆
Early Science - ready for operations (M12)				Q4/2027	◆

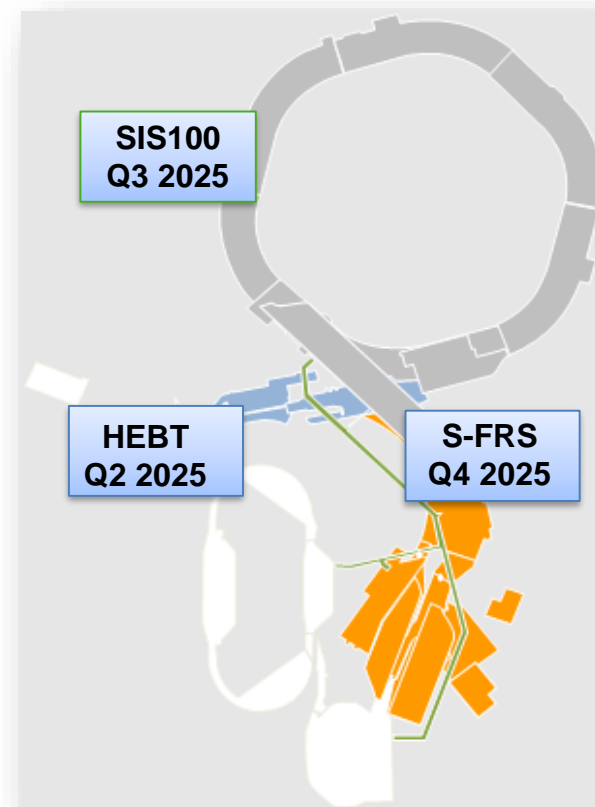
"early science"

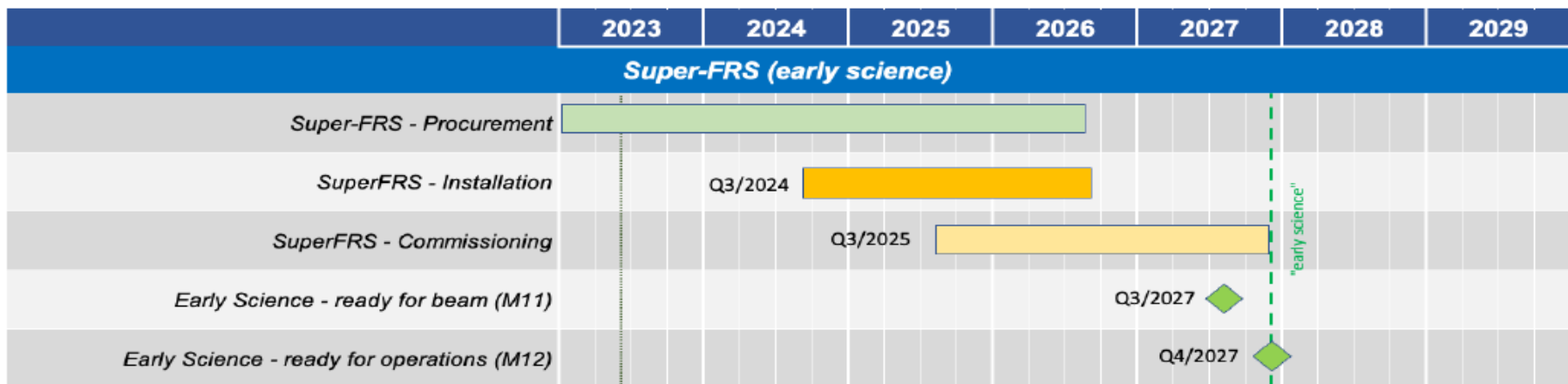
# Commissioning phases for ACC

Inst.	#	commissioning stage	accelerators & transfer lines	detectors
Commissioning without Beam	1 <small>(M??)</small>	local HW-commissioning	<ul style="list-style-type: none"> <li>local system tests in tunnel and supply areas</li> <li>Special cable connections by system experts</li> <li><b>Control system not needed</b> (only in limited aspects)</li> </ul>	<ul style="list-style-type: none"> <li>single detector tests</li> <li>tests of individual components</li> <li>install. service &amp; controls</li> </ul>
	2 <small>(M??)</small>	remote & system commissioning	<ul style="list-style-type: none"> <li><b>single system test</b> (vertical system integration test)</li> <li><b>remote testing</b> from MCR (sequences, checklists)</li> <li><b>control system integration of the system and timing is needed</b></li> </ul>	<ul style="list-style-type: none"> <li>system tests (with HV, gas, ...)</li> <li>pre-test of DAQ system</li> <li>local control</li> </ul>
	3 <small>(M11)</small>	integration	<ul style="list-style-type: none"> <li>(3.1) multi system tests &amp; (3.2) full Dry-Runs</li> <li>control system and accelerator models for pilot beam scenarios fully available</li> </ul>	<ul style="list-style-type: none"> <li>full detector test and DAQ using cosmics</li> </ul>
Beam Commissioning	4 <small>(M12)</small>	pilot beam commissioning	<ul style="list-style-type: none"> <li>commissioning with pilot beam</li> </ul>	<ul style="list-style-type: none"> <li>commissioning with pilot beam</li> </ul>
		beam commission & operation	<ul style="list-style-type: none"> <li>operation with PCP-beam respectively status quo beam</li> <li>development towards nominal intensities</li> <li>commissioning of advanced systems</li> </ul>	

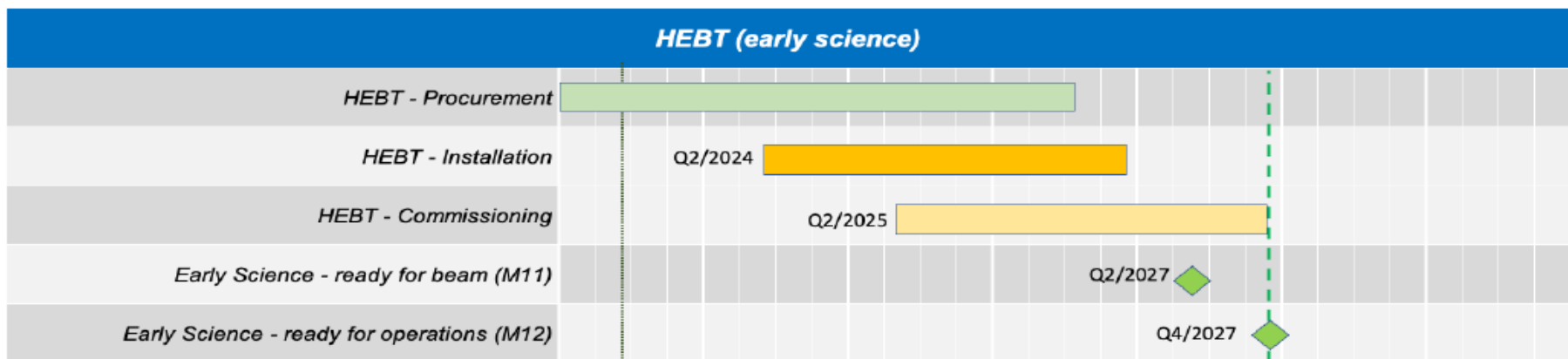
handover to operations

## Start of ACC Commissioning





data date: 28/06/2023



data date: 28/06/2023

For the first **NUSTAR** experiment right after commissioning the first focal plane of the Super-FRS (FHF1) is blocked with the last PID chamber. Verification (e.g. by Isomer tagging) could help to verify the ID in the high mass region.

# Potential experimental places at the Super-FRS

Idea: install and operate magnets to FLF2/3 instead of storage

- Not covered: vacuum items, special installation, infrastructure extra cost, feed boxes (local cryogenics reduced scope), instrumentation (could be initially in air), power converters
- Modified shielding wall position for FLF2/3 science location
- Freezing scenario shall be presented to scrutiny group following up council decision in July

RB will end at the branched dipole magnet, further beam-line will not be installed, magnets to be stored.

**Possible science location prior to FS++  
HI/DESPEC/SEC (J. Gerl, H. Albers)**

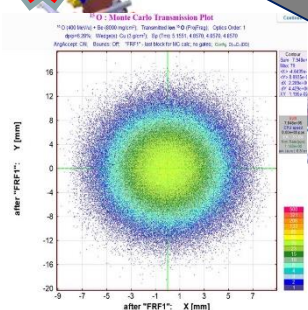
13,600k€  
CB8@2005

Energy buncher  
spectrometer in Low-  
Energy-Cave

TGA ~  
10,000k€  
max 10e7 pps

max 10e8 pps

**Possible science location for  
BIOMAT  
Prior to FS++  
(D. Severin/C Trautmann)**  
U (Au), <sup>16</sup>O fragment, <sup>12</sup>C fragment beam  
180-600 AMeV  
**5e9 pps**, few mm beam spot.  
(Impact Analysis started,  
2 (h) x 2 (w) x 4 (l) m<sup>3</sup> measurement area)  
“modified beam dump”

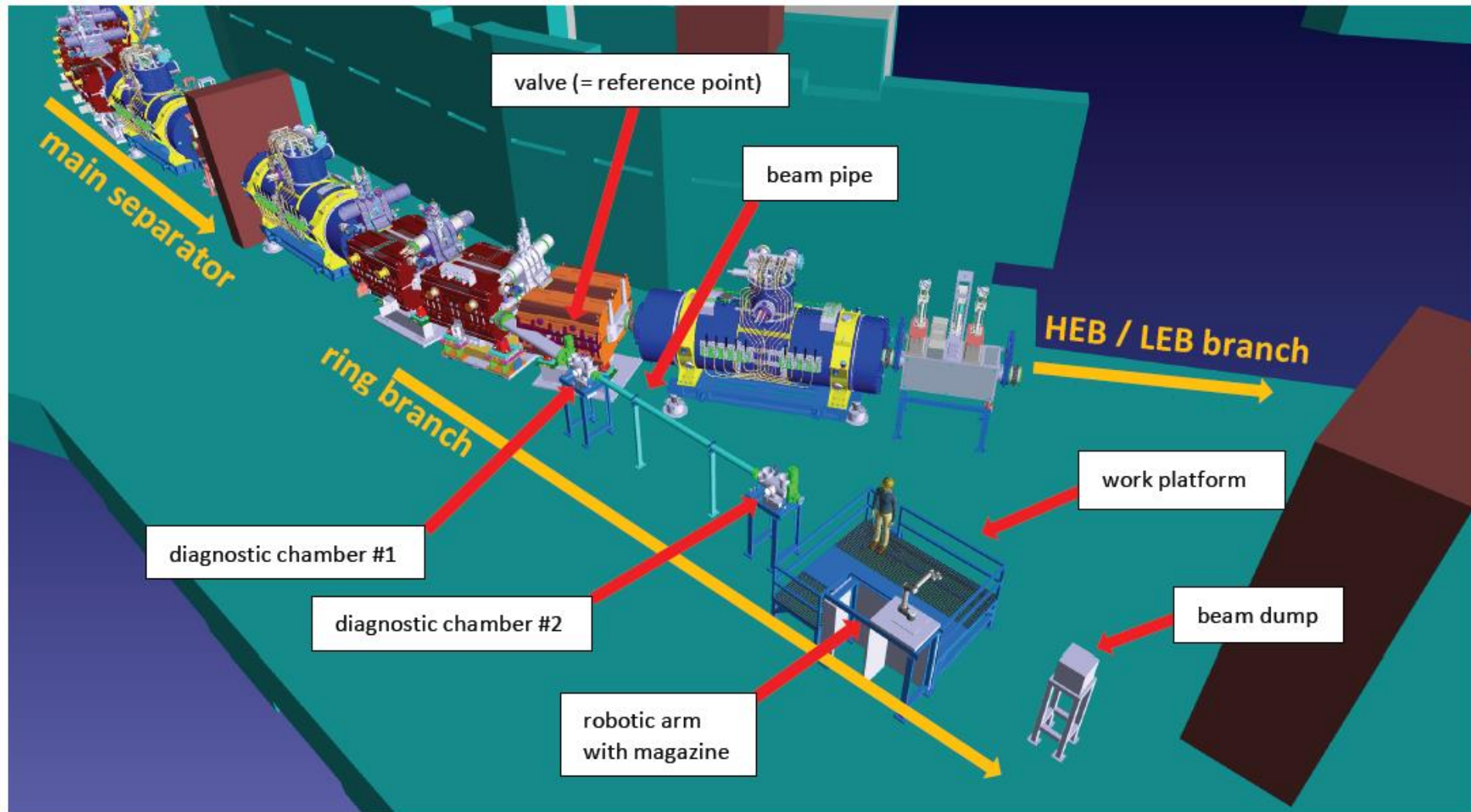


**early science locations**

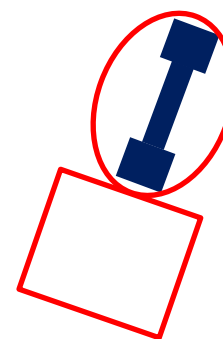
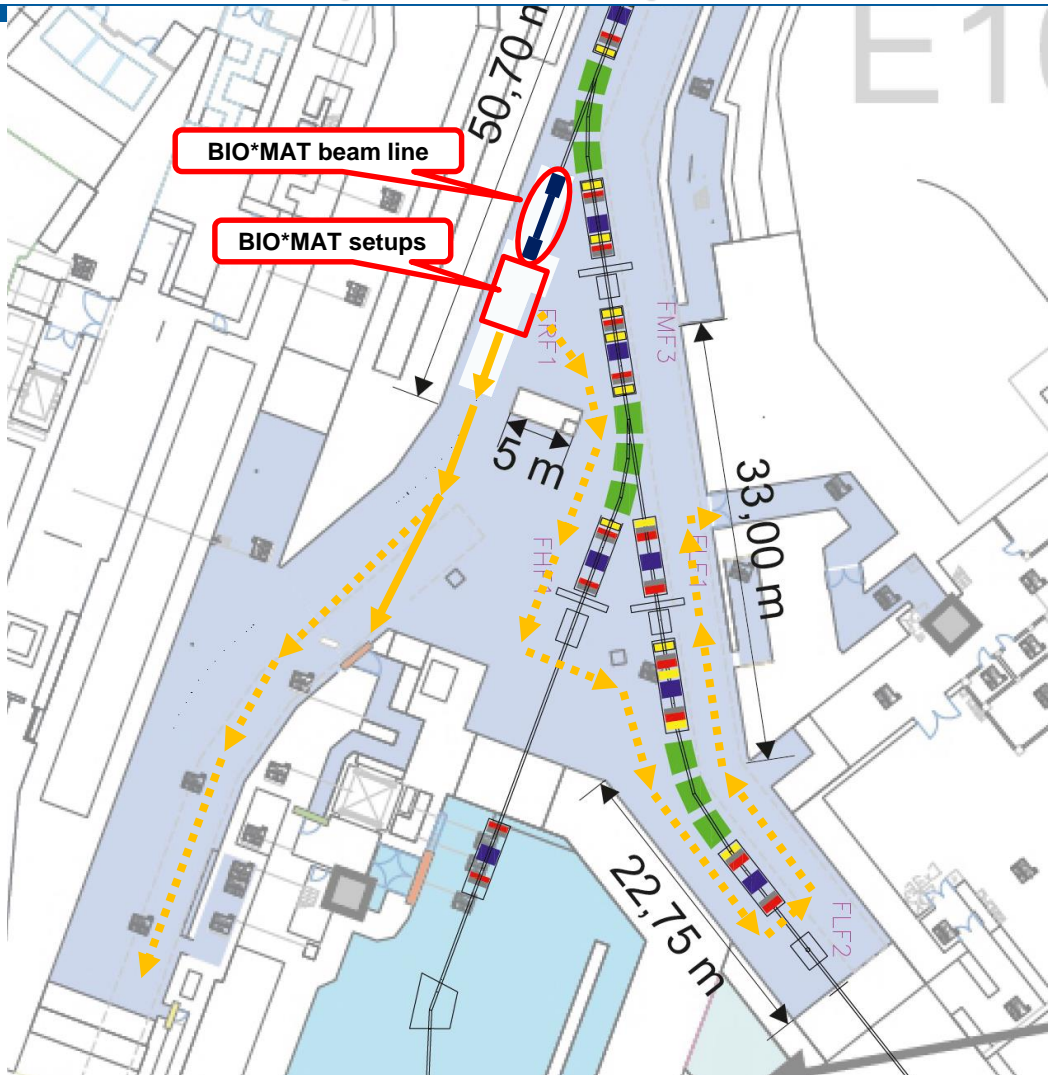
**Ring tunnel serves as storage are  
(avoid activation of materials)**

- ★ = committed and partially in production
- ✗ = not in scope and budget

# Potential experimental places at the Super-FRS (2028- ?)



# Potential experimental places at the Super-FRS (2028- ?)



- Beam line:
- L x W = 6 x 1,5 m<sup>2</sup>
  - permanently installed
  - DK1 + beam pipe + DK2

- Target area:
- L x W = 5 x 4 m<sup>2</sup>
  - constantly changing exp. setups
  - incl. work platform

- preferable walking/escape route
- - - other walking/escape routes



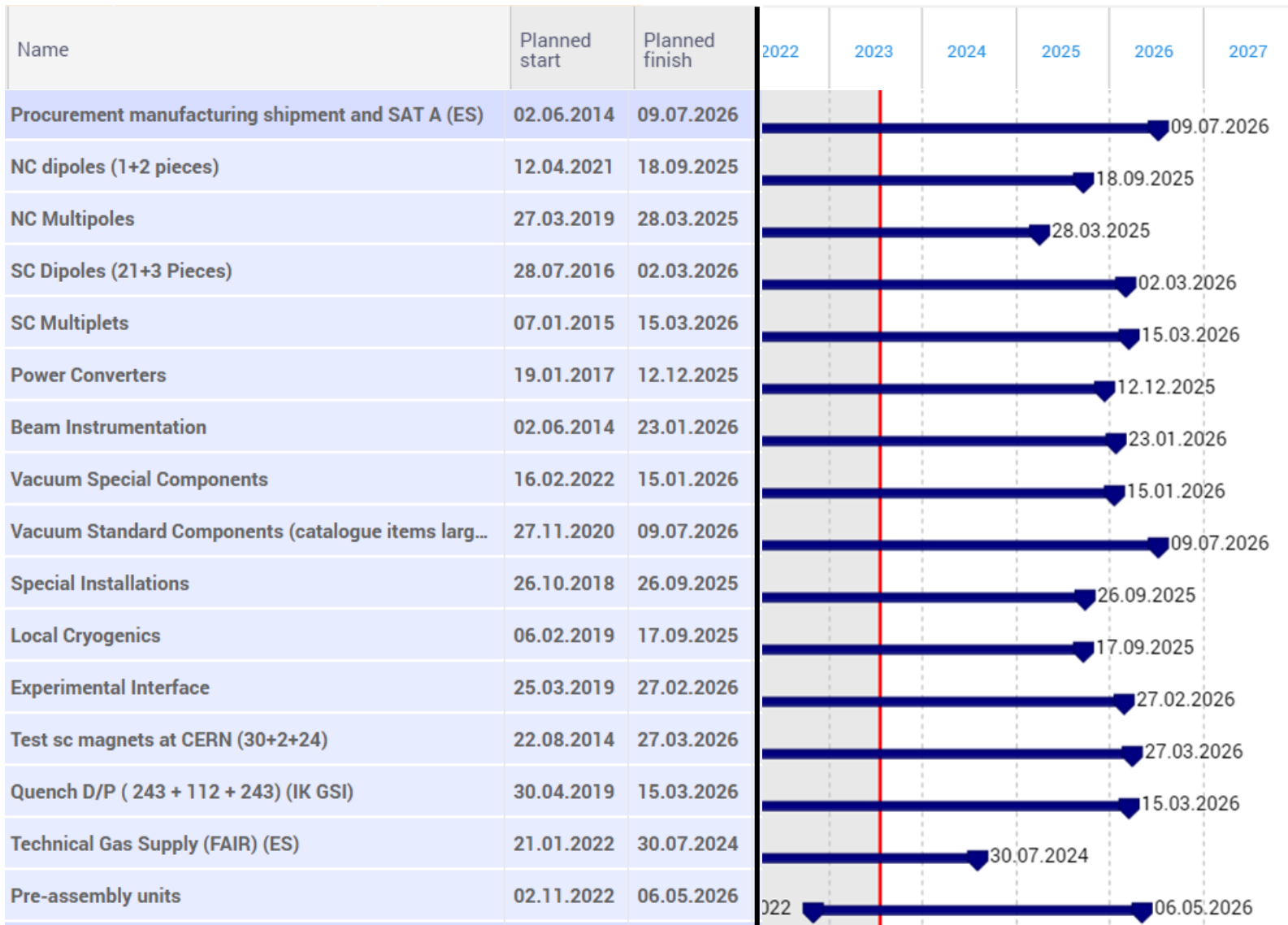
- Very busy period in view of all actions related to returned in-kind and exRU contributions.
- Pre-installation (preparation for tunnel installation Q2-3/2024) started.
- (Pre-)Installation process overlaps with procurement phase.
- Scenario for Commissioning with and without beam developed.
- AI supported controls, pilot study NUSTAR.DA
- Initial configuration allows for program at FHF1 and FHF2, possible opportunities are studied.
- BIOMAT setup at missing ring branch
- Low energy branch with additional funding (FS++) – realization depends on timely budget decision (procurement restart auxiliaries)
- Ring Branch (MSV) similar

*Thank you*





# Super-FRS availability of components for ES/FS



# Installation: LCM workshops ongoing

## Working Steps – Aufbau Target Bereich

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	
Vermessung der Beamlinie und der Einbaupunkte	Einbau der seitlichen unteren Stahlabschirmung	Einbau der seitlichen oberen Stahlabschirmung	<del>Gießen des Festbetons</del>	Einbau der seitlichen Beton Abschnürung	Einbau der seitlichen Beton Auflage	Einbau der Kabelkanälen und Medien z.B. Wasserrohr	Einbau der Kabelanschlussschüskasten und Verlegung der Magnetkabel	Einbau der Kabelkanälen und Medien z.B. Wasserrohr	VM Maschine Einbau der Maschine	Einbau der Stahldecke	Einbau der Betonplatten auf dem Stahldach	Verkabelung und in Betrieb nehmen der Maschine	Einbau der Abschirmwände	Einbringen der Beton-Brammen				

Blueline und Zentrierungseinbau (1 mm Präzision)  
Für Einbau der Stahlabschirmung, DMU-Daten (IOL) reichen

In Folie 6 als Meilenstein „TA für Einbau der Maschine bereit“

Auswärtsvergabe - Umfang abklären: Schritte 2&3 sollen vom Rohbau Süd gemacht werden. Anschließend Verguss des Betons (Schritt 4)  
→ Angebot von Züblin wurde abgelehnt, Installation der seitlichen Abschirmsteine wird nach Installation der Kranes stattfinden. Neues Konzept benötigt, externe Vergabe

Shielding Flask and platform SAT Aa and SAT Ba

CRYO

Installation parallel Check transport...

Details siehe Folien 6 und 7

Folie 7, Schritte 20. und 21.

Auf Basis der Präsentation „Target Bereich Aufbau-ReihenfolgeV1“ von A. Kratz erstellt

### Legend

<b>Party responsible for installation</b>	MC	Mechanical completeness
<span style="display: inline-block; width: 15px; height: 10px; background-color: #90EE90; border: 1px solid black;"></span> GSI/ BINP, technical group	NG	Netzgerät
<span style="display: inline-block; width: 15px; height: 10px; background-color: #FFD700; border: 1px solid black;"></span> External company	IL	Interlock
<span style="display: inline-block; width: 15px; height: 10px; background-color: #FFFFFF; border: 1px solid black;"></span> Responsibility to be clarified	VAC	Vakuum
<span style="display: inline-block; width: 15px; height: 10px; background-color: #ADD8E6; border: 1px solid black;"></span> In Kind Partner	KW	Kühlwasser

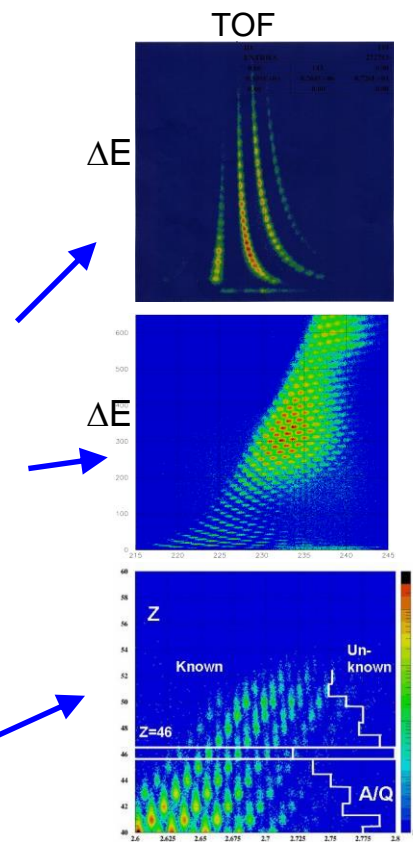
- Work instruction released
- Work instruction in progress
- No work instruction available
- Operating Manual from manufacturer
- Similar work instruction available

Open points  
Remarks

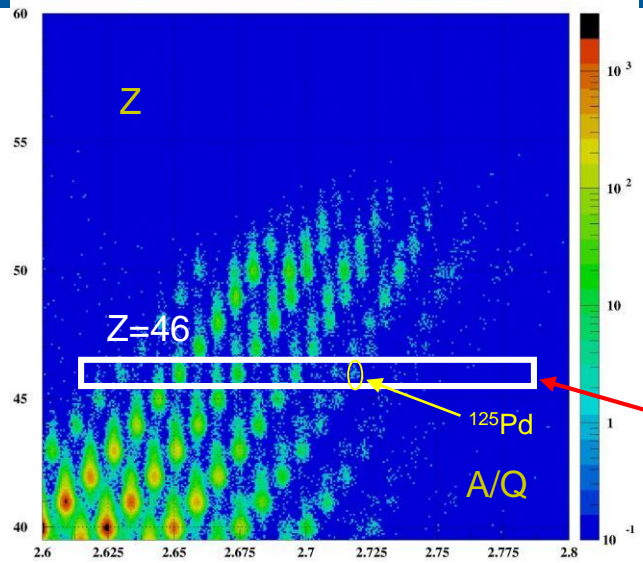
# Example: Commissioning RIBF and first experiments

## History of RIBF commissioning

- Dec. 28<sup>th</sup>, 2006  
 First Beam  $^{27}\text{Al}^{10+}$  345 MeV/u at RIBF-SRC  
 Break at the facility !
- March, 2007  
 12<sup>th</sup>  $^{86}\text{Kr}^{31+}$  beam at 345 MeV/u several pA.  
 13<sup>th</sup> First production of RI beams with  $^{86}\text{Kr}$  beam
- 23<sup>rd</sup> First successful acceleration of  $^{238}\text{U}^{86+}$  beam at 345 MeV/u and 0.002 pA
- 27<sup>th</sup> First production of RI beams with  $^{238}\text{U}$  beam
- May-June, 2007 (without ZDS) ( $\sim 1 \times 10^8$  pps)  
 with  $^{238}\text{U}$  beam at 345 MeV/u and 0.02 pA max
- May 16<sup>th</sup>-23<sup>th</sup> BigRIPS commissioning experiment  
 May 24<sup>th</sup> – June 3<sup>rd</sup> Search for new isotopes  
 End of June(a few days) detector testing
- Nov. 2007 acceleration test with  $^{86}\text{Kr}$  beams, 30 pA

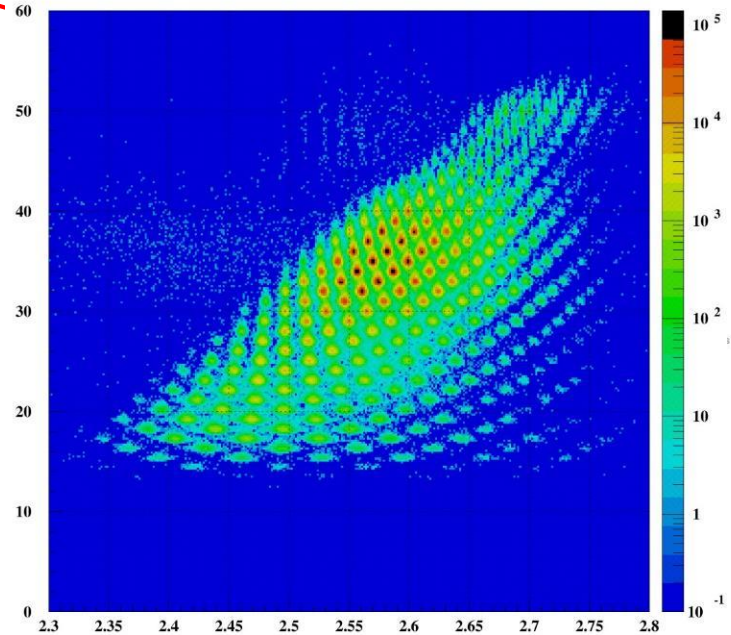
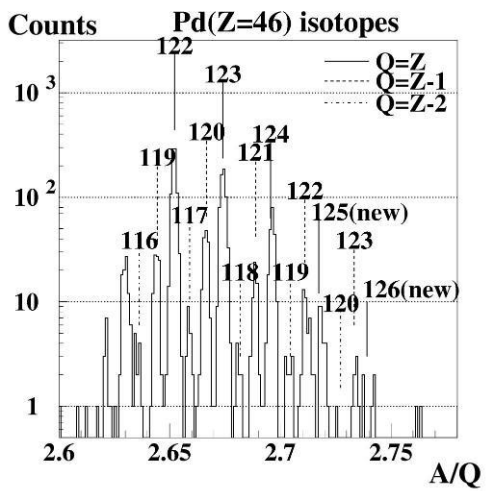


# Example: Commissioning RIBF and first experiments



## Searching for new isotopes May 2007

J. Phys. Soc. Jpn. 79, 073201 (2010) [5 Pages]  
 LETTERS  
 OPEN SELECT  
 Identification of 45 New Neutron-Rich Isotopes Produced by In-Flight Fission of a  $^{238}\text{U}$  Beam at 345 MeV/nucleon



## H. Crawford et al. FRIB (2022)

### FRIB'S FIRST EXPERIMENT CONCLUDES SUCCESSFULLY

14 June 2022  
 The first experiment at FRIB—which studied the beta-decay of calcium-48 fragments that are so unstable that they only exist for mere

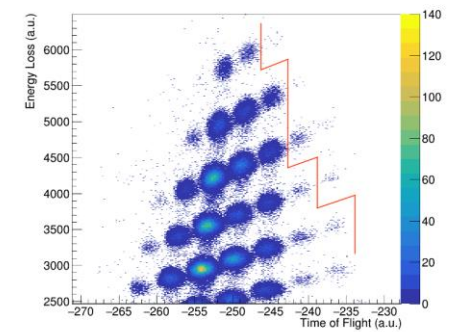


Figure 1: Particle ID of nuclei produced in the first FRIB experiment. Nuclei to the left of the red line have published half-lives, while the nuclei to the right are new and have never been cataloged before

First beam in the facility Dec. 28<sup>th</sup>, 2006