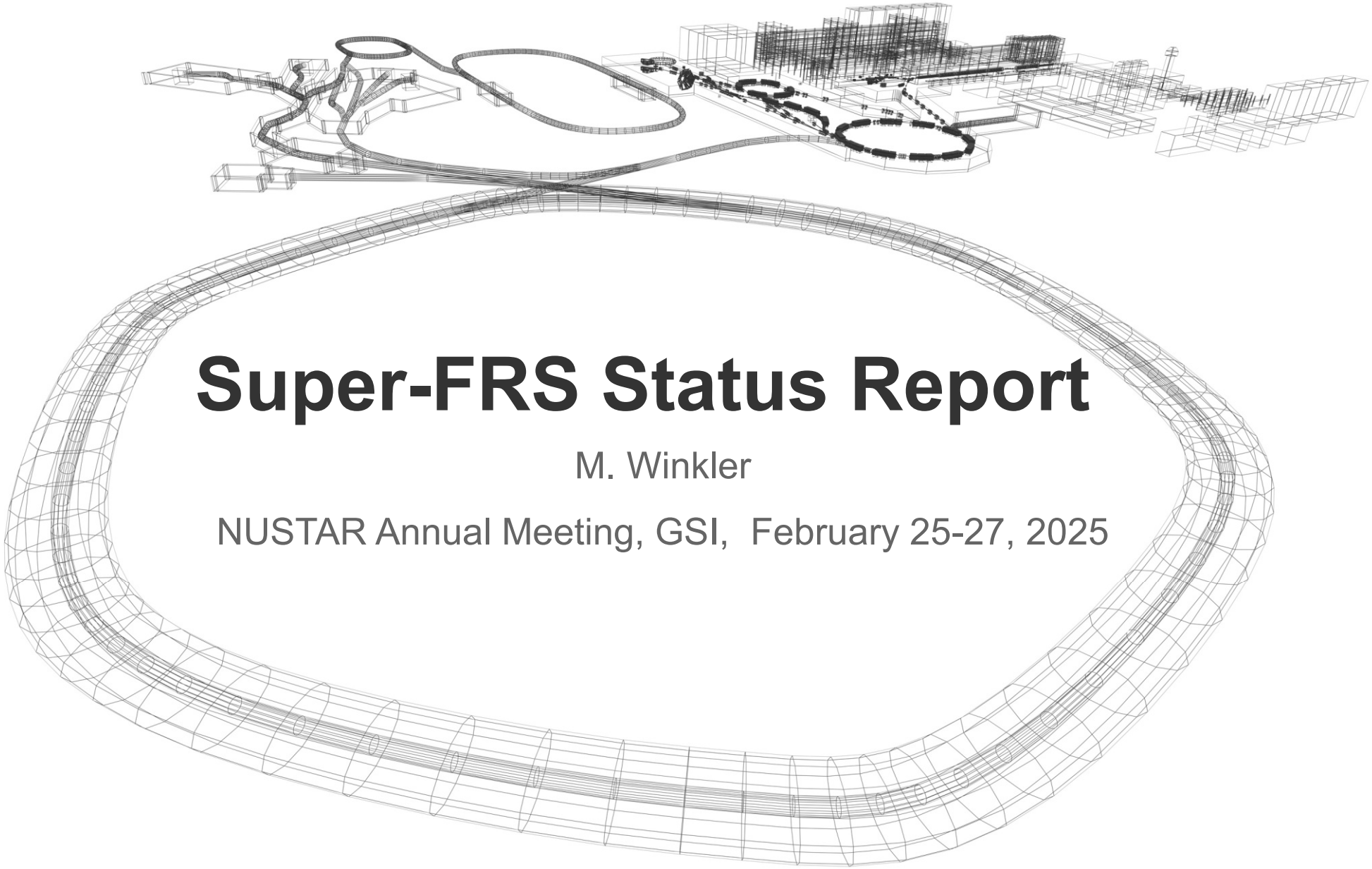


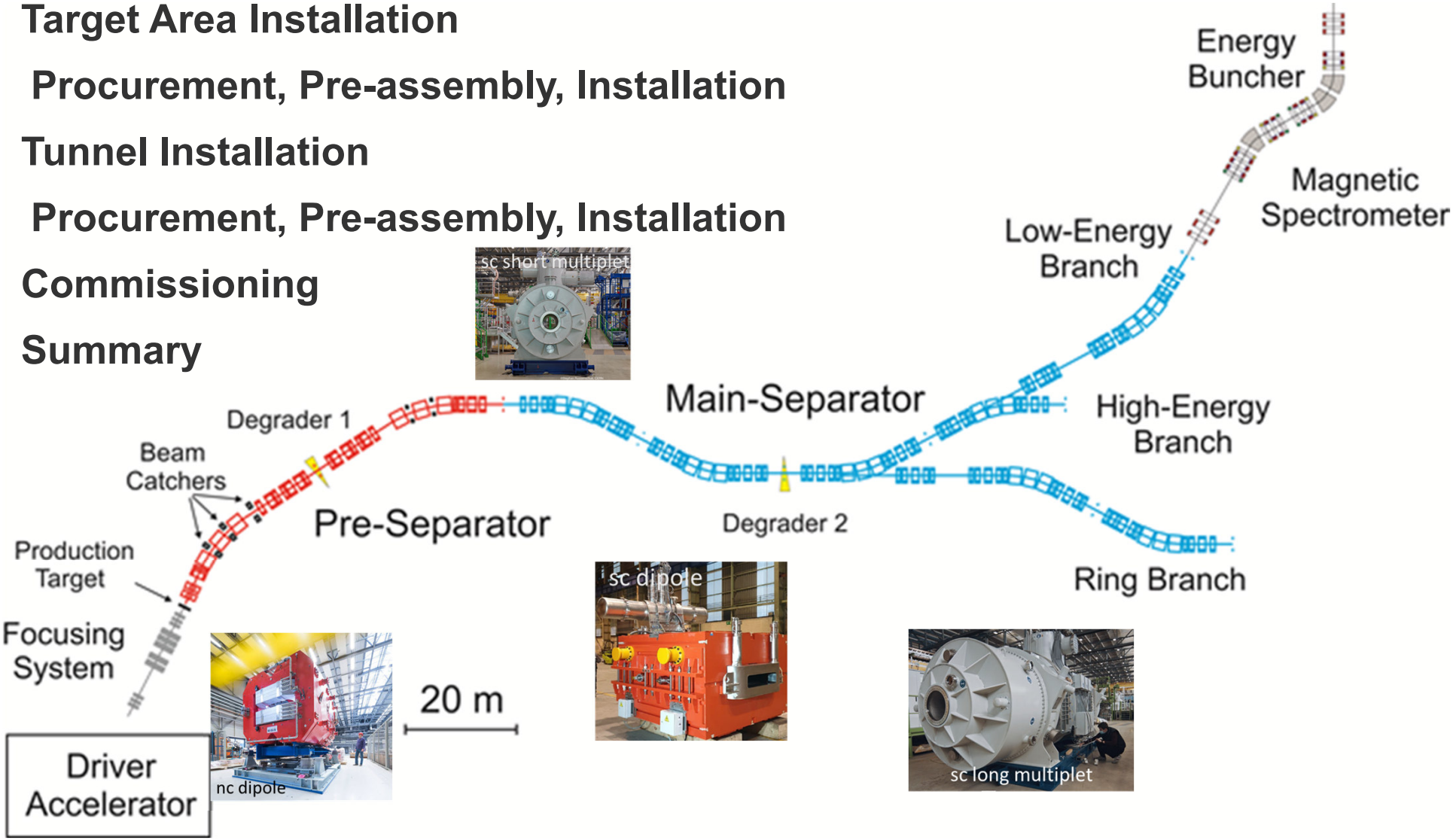
Super-FRS Status Report

M. Winkler

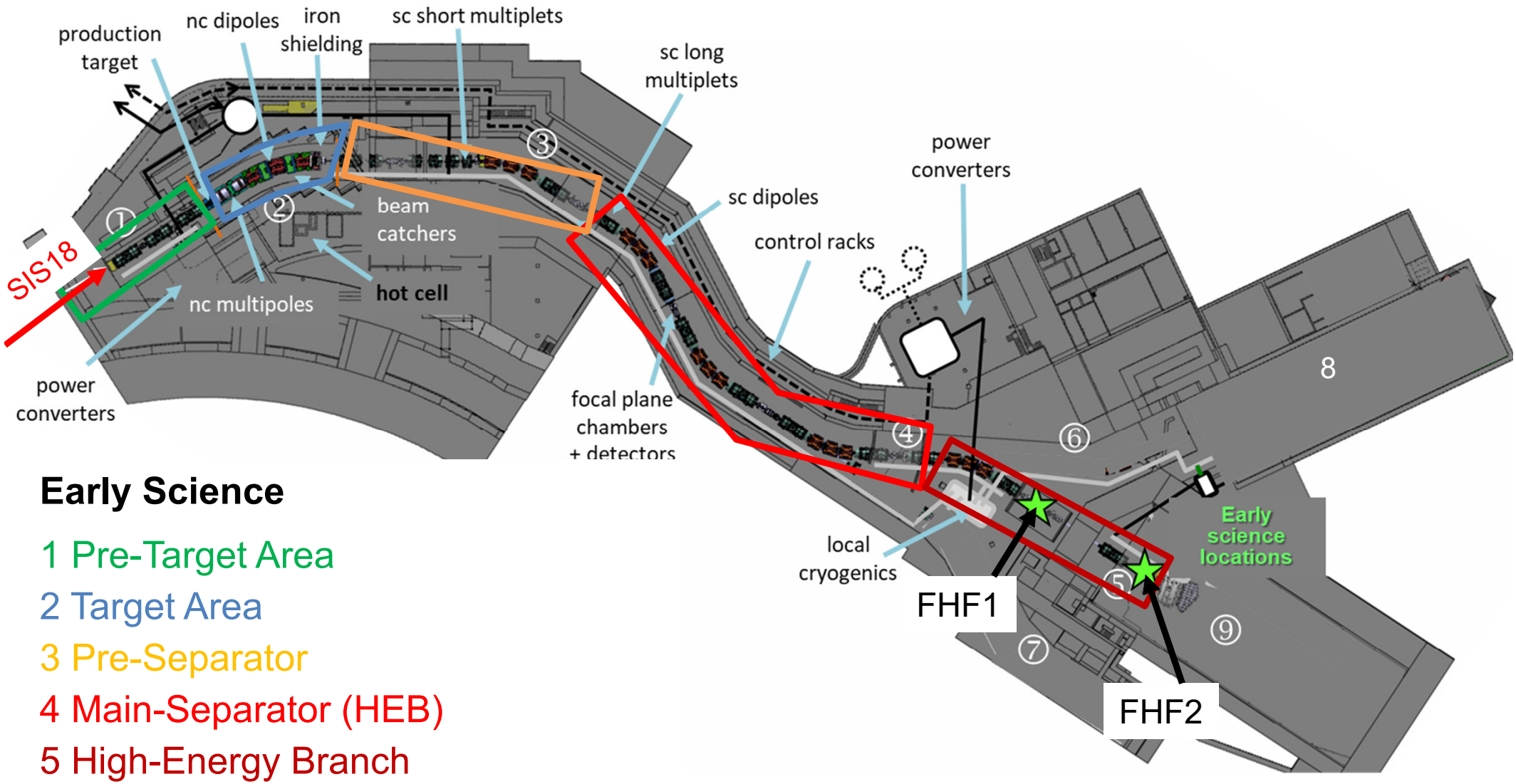
NUSTAR Annual Meeting, GSI, February 25-27, 2025

Outline

1) Early Science Scope & Installation Schedule
2) Target Area Installation
   Procurement, Pre-assembly, Installation
4) Tunnel Installation
   Procurement, Pre-assembly, Installation
4) Commissioning
5) Summary



ES Scope



Early Science

1 Pre-Target Area

2 Target Area

3 Pre-Separator

4 Main-Separator (HEB)

5 High-Energy Branch

9 High Energy Cave (NUSTAR)

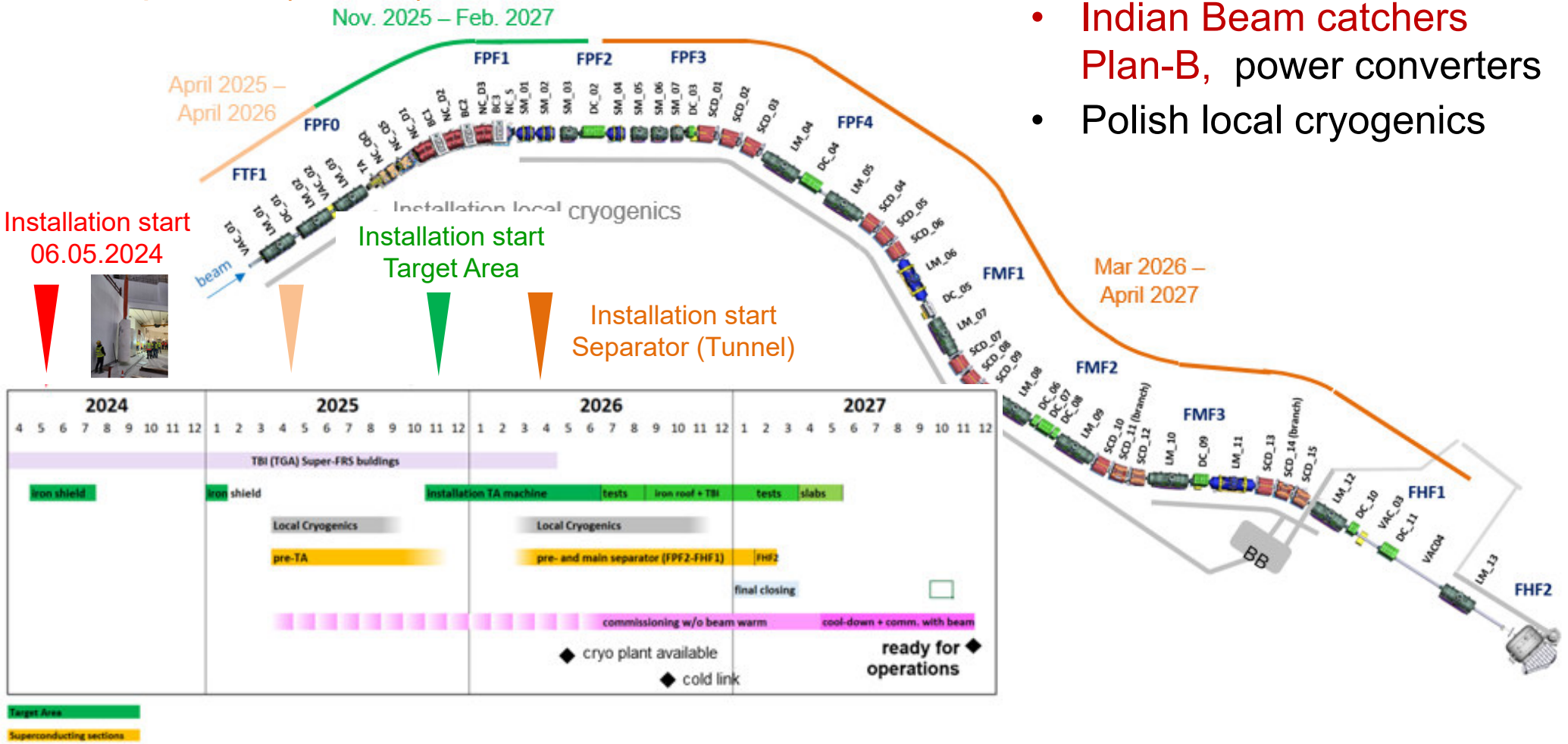
Overall Installation Schedule

3 installation areas:

1. Pre-Target Area
2. Target Area
3. Separator (Tunnel)

Challenging in-kind packages:

- Former Russian in-kind **needed replacement !**
- Indian Beam catchers Plan-B, power converters
- Polish local cryogenics

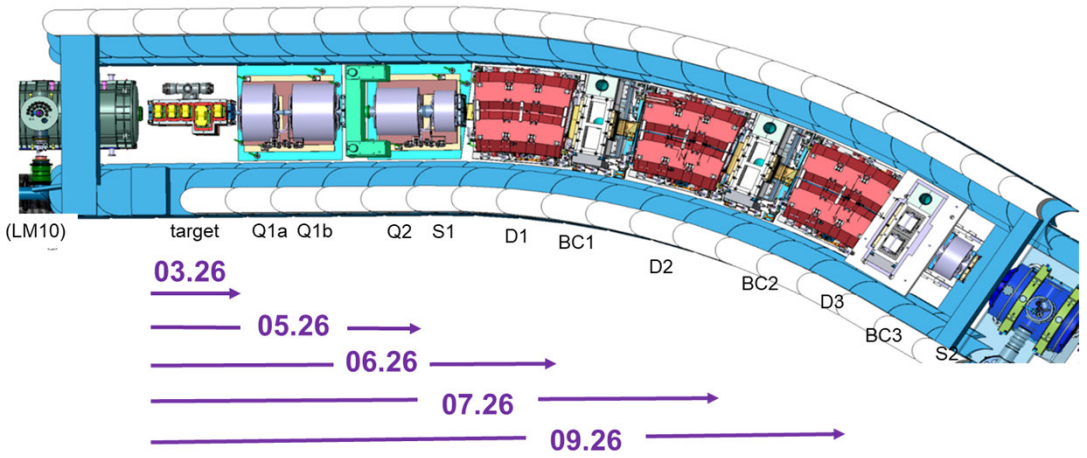


Target Area Installation

Sequence and Schedule

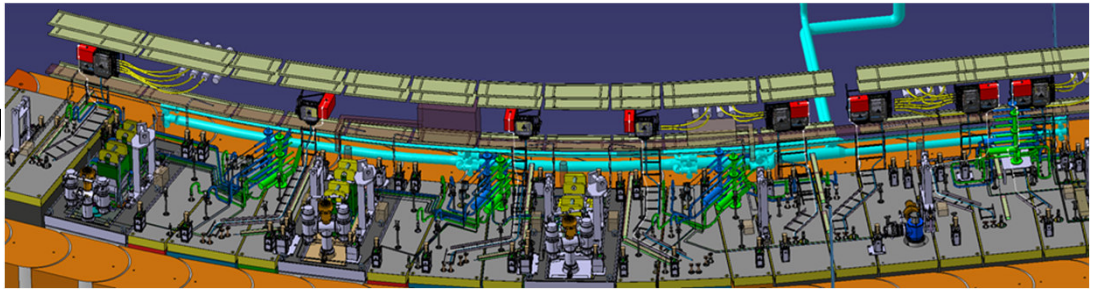
1) Installation of TA components

- installation ‘along the beamline’
- ➢ installation of target chamber running
- including section-wise vacuum commissioning



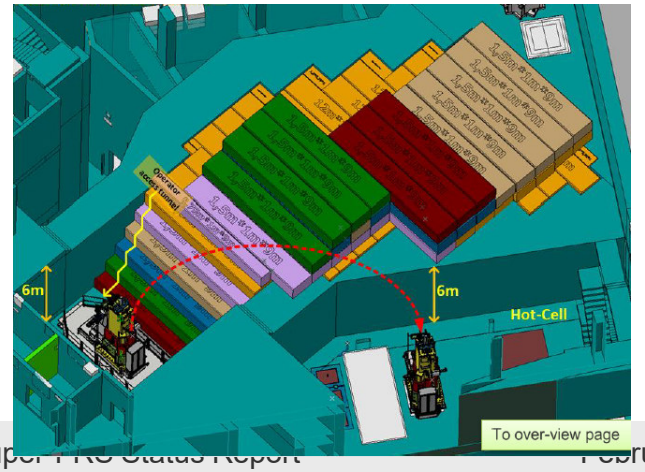
2) Closing beam tunnel with 1m thick iron roof

- step by step, each time after installing a component (will serve as ‘floor’)
- installation of building services on iron roof, starts ≈Q3/2026



3) Closing TA with concrete slabs

- installation of chamber plugs Q4/2026
- typical slab: 1m x 1.5m x 12m, ≈40ton
- TA closing starts ≈Q1/2027

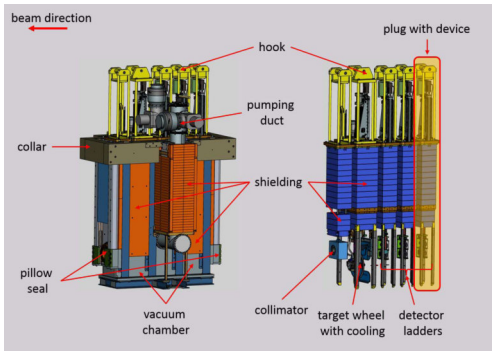


Target Area

Pre-assembly target chamber

P. Schwarz
K. Knie
V. Schöll et al.

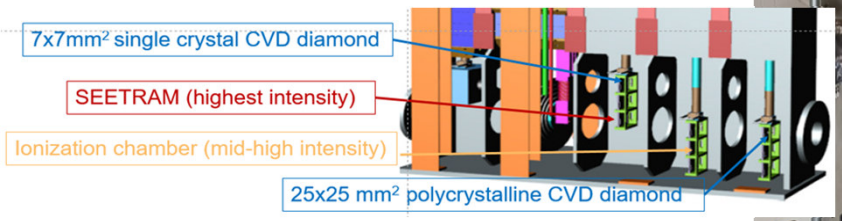
- Delivery from provider Fantini 07/2025
  - Chamber plus additional shielding
  - Vacuum duct
  - 1 x Target x Plug
  - 3 x Detector Plugs
  - 1 x Collimator Plug
  - 2 x Pillow Seal Plugs

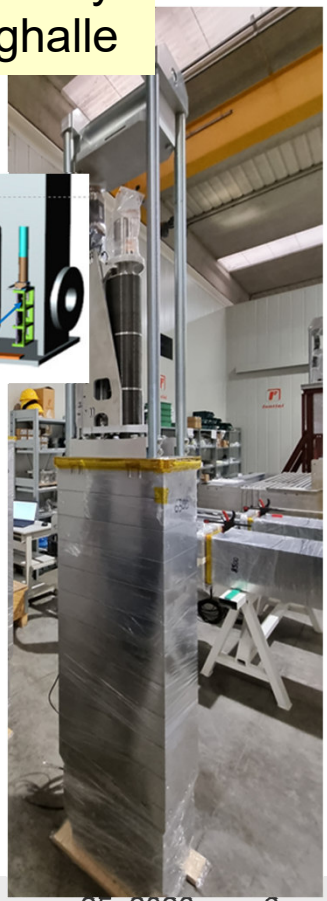


Pre-assembly in Testinghalle

- Pre-assembly / SAT @ Testinghalle
  vacuum, plug, detectors, interfaces, …
- Transportation to target building 12/2025

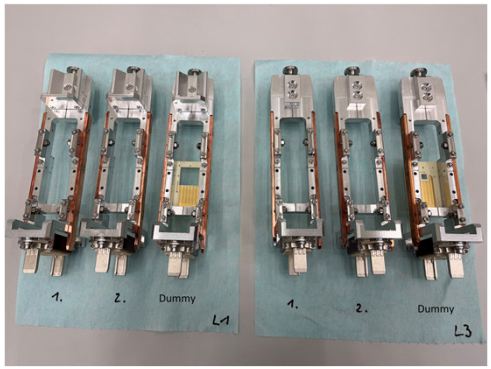
➢ installation ongoing

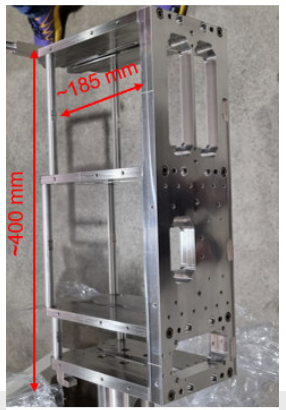




Detector-Ladder & Sub-frames

Transport to target building

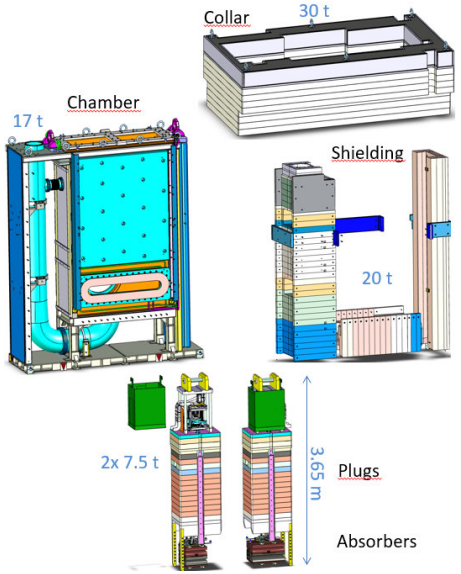


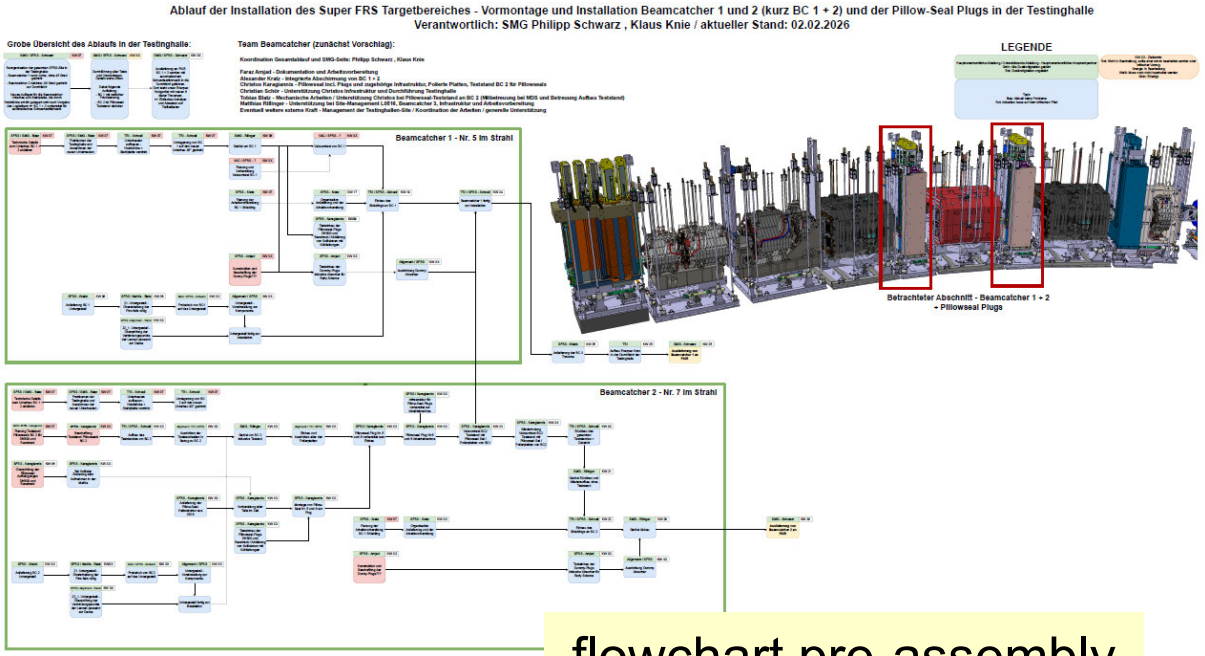


Target Area

Pre-Assembly of Beam Catcher

- BC1, BC2 (Plan-B FAIR), provider NTG (De), delivered 12/2025
- production of additional shielding running, FAT 02/2026
  - ➢ Pre-assembly running in ‘Testinghalle’
- BC3 (Indian in-kind), FAT 02/2026, ready to be delivere
- Collars and Plugs (Indian in-kind) to be delivered Q2/2026





flowchart pre-assembly beam catcher

Target Area

NC magnets & chamber

H. Leibrock,
S. Purushothaman
P. Rottländer et al.

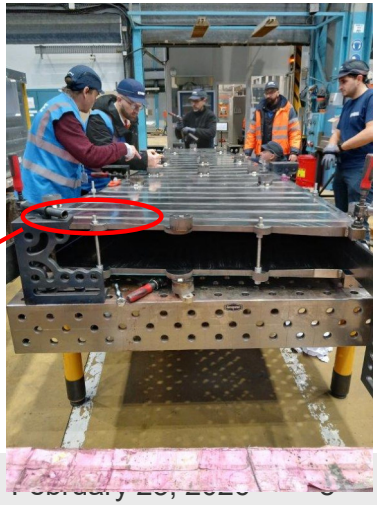
Features

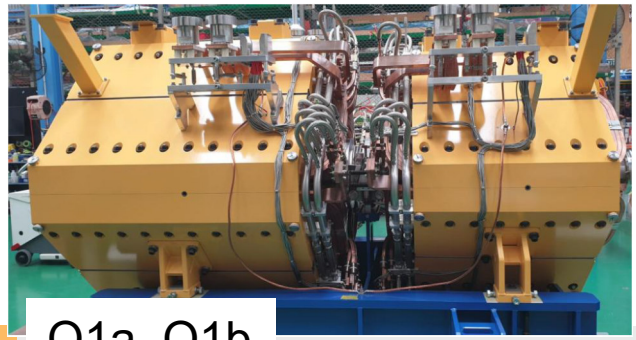
- radiation resistant MIC cable, remote connectivity
- dipole chamber includes cooling channels / EB welding

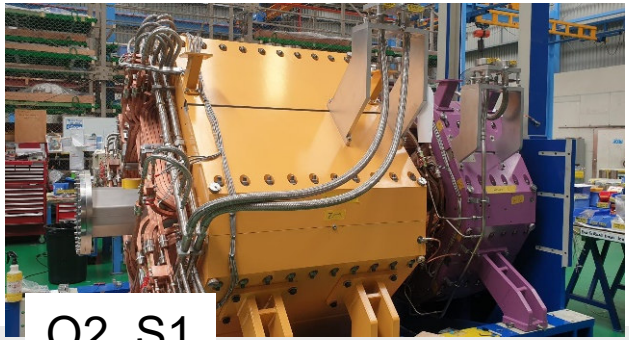
Status / Schedule (former Ru in-kind / FAIR re-procurement)

✓ 3 nc dipole magnets
  ✓ D1 ('BINP' dipole) in Testinghalle → load for SAT of PC
  ✓ D2, D3 (SigmaPhi, Fr) delivered, stored/pre-assembly in LEB
- 3 dipole Ti chambers under production (CNIM, FR)
  - FAT scheduled for 04/2026, 06/20,07/2026
- 3 quads and 2 sextupoles (Buckley Systems, NZ)
  ✓ 1st unit (Q2/S1) in delivery. expected at FAIR 03/2026
  - 2nd unit (Q1a/Q1b), FAT done, dispatch next week
  - S2 (to be combined with BC3) , FAT preparation

Ti chamber







TA Maintenance

Shielding Flask & Hot Cell

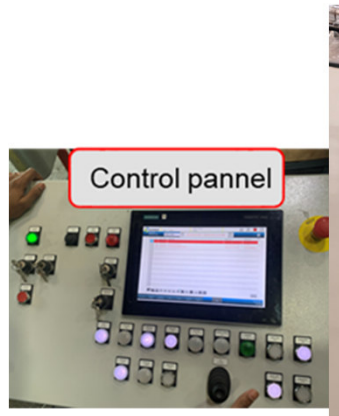
F. Amjad
C. Karagiannis
A. Gulavani
H. Weick et al.

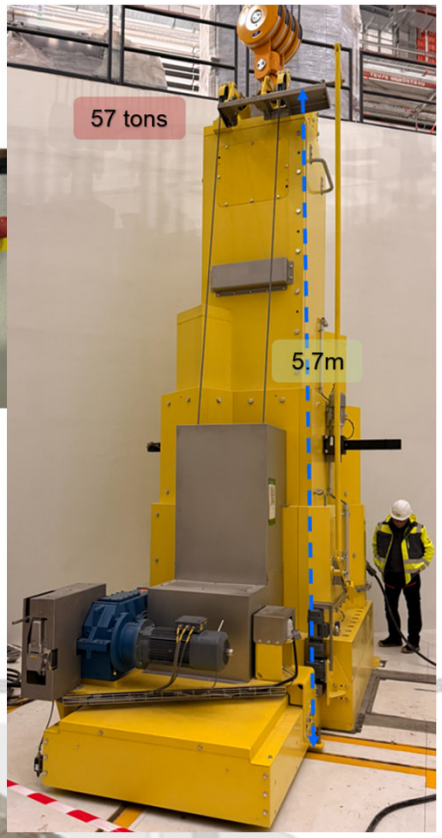
Plug-transport TA → HC via Shielding Flask

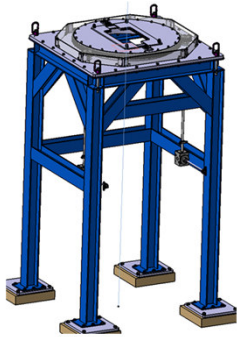
- combined Finland in-kind / FAIR
- Designed to have safety redundancy
- Remotely operated using control panel
- manufactured by BNET, FAT 09/2024
- functional test ongoing (on availability of plugs)

HC (equipment) **for ES**

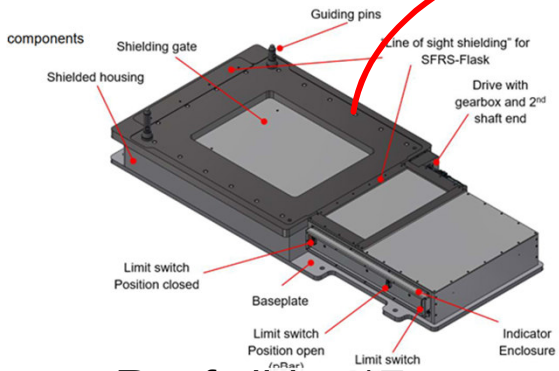
- Shell construction ready (by FSB)
- Roof slider (flask interface) in procurement
- Floor/Wall liner in procurement
- Procurement lead-glass window in preparation
- Master-Slave manipulators in house
- Turntable table in-house development



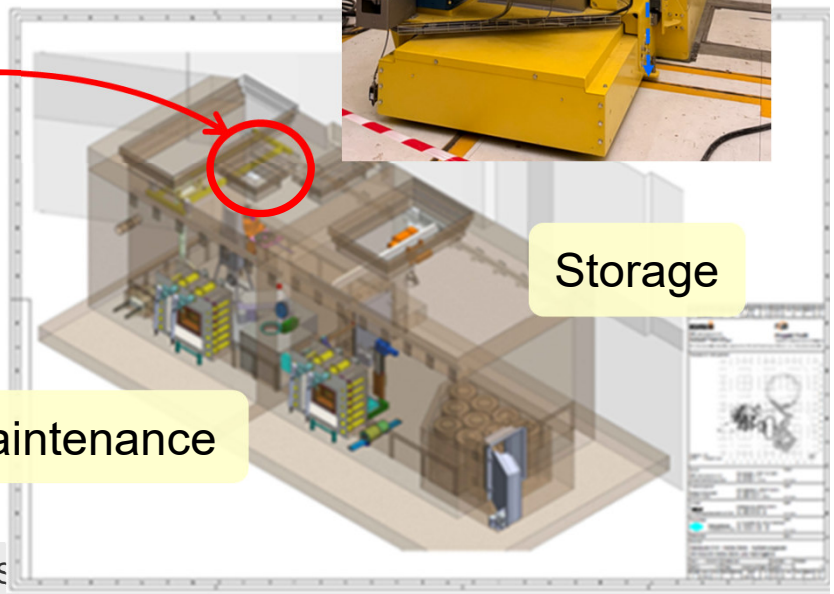




Turntable design
(3m x 1.6m x 1.5m)



Roof slider 17 tons
(4.3m x 2.5m x 0.45 m)



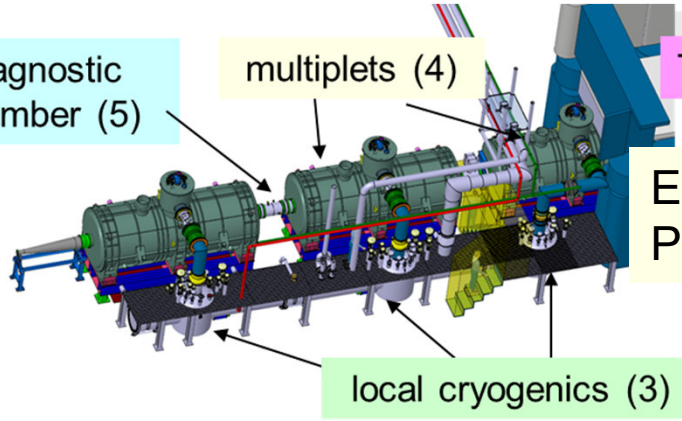
Tunnel Installation
(General installation sequence)

Two tunnel installation areas

1. Pre-target area
2. Separator tunnel, subdivided into sections
   - Pre-Separator section: P1, P2
   - Main-Separator section : M1, M2, M3
   - HEB section: H
   - NUSTAR section: G

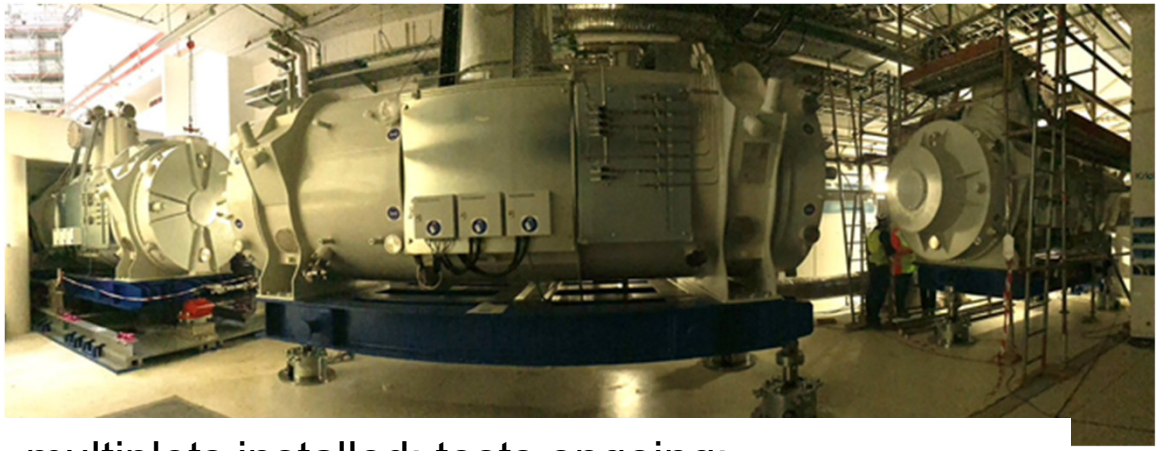
Installation sequence follows

1. Technical Building Infrastructure
   - cable trays 80%, power cables
2. Blue line
3. Local Cryogenics / cryo-branches
   - ✓ Branch Box and ACPS done
4. sc magnets
5. Diagnostic chambers
6. Remaining vacuum components
7. Beam instrumentation



Example: Pre-target area

start LC 04/2025

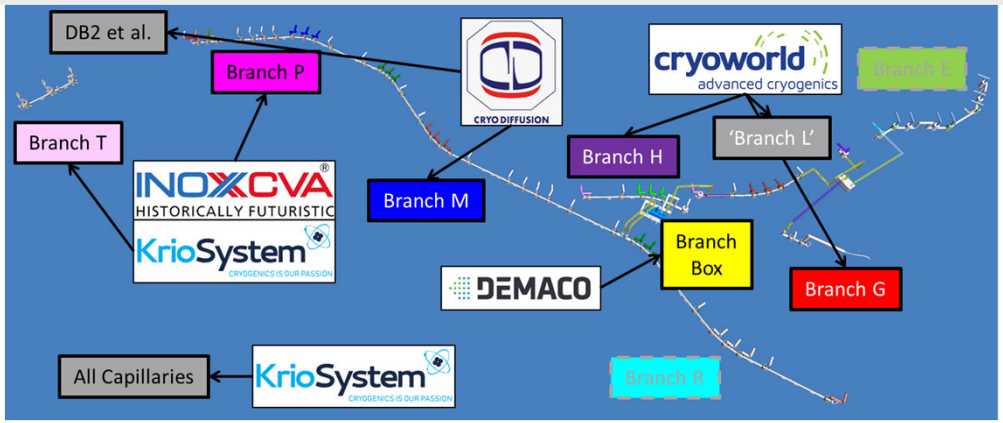


multiplets installed; tests ongoing;
installation IPM chamber to start; status 02/2026

Local Cryogenics
(Polish in-kind / WUST and FAIR)

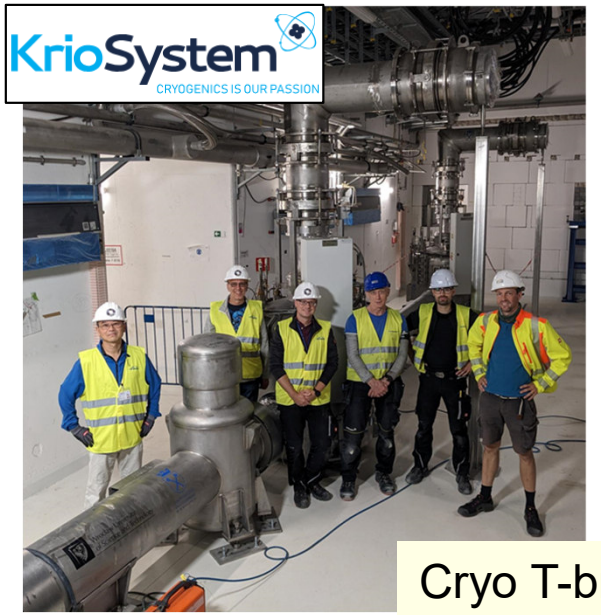
F. Wamers, Y. Xiang,
D. Schad, F. Dziuba,
J. List et al.

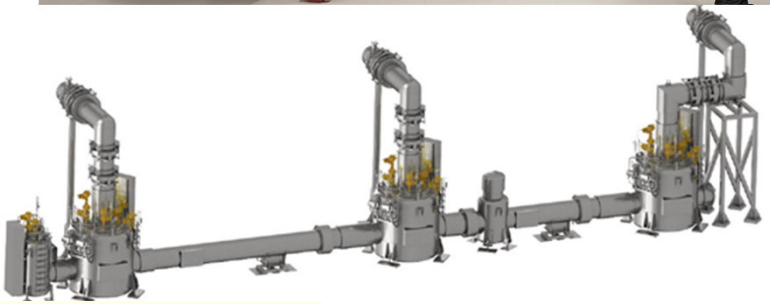
- Several providers for various cryo-branches
- FoS testing at STF prior installation
  - ✓ FoS testing T-branch done 2025
  - ➢ FoS testing P-branch ongoing
- Tunnel installation
  - ✓ T-branch done 2025 (pre-target area)
  - ✓ Branch Box and ACPS installed
  - P-/M-/H-/G-branch start Q2/2025 (tunnel)



Branch Box installation (03/2025)

FoS @ STF





Cryo T-branch (07/2025)

SC Multiplets

E.J. Cho,
H. Müller
V. Velonas et al.

Scope (ES):

- Main 7 short multiplets, 13 long multiplets
- up to 9 individual magnets in LM

characteristics:

- iron dominated, cold iron, warm pipe
- individual powering, I_{max} <300A

Provider:

- ASG, Genova, Italy

Production Status:

- Complete production of the last ES multiplet
  - FAT test and review ongoing.
- non-ES multiplet production ongoing

ASG SUPERCONDUCTORS

Notification Chart Super FRS Multiplet GSI — Update: 20/02/2026

Notification of production phases for the next 2 months

Activity completed
Activity ongoing

Quality Control Plan		QCP 9026797		QCP 9025681 /QCP 9025954 (TS rework)				
Starting item		item 2.1	item 3.4	item 1.2	item 2.8	item 2.17	item 2.47	ITEM 2.68
Mean minimum completion time [weeks]		4	8	2	1	3	0,5	3
Phase		MAGNETS ALIGNMENT	L-He assembly / welding	TS Central section assy	Lhe vessel dome Assy	TS circuit assy completion	Allignement of BP and welding	FAT
FLF2YMQ11	LM13							
FHF1YMQ21	LM15							
FHF2YMQ11	LM29							
FLF1YMQ11	LM19							
FRF3YMQ21	LM14							WK 10-26
FLF2YMQ21	LM17							WK 16-26
FRF2YMQ21	LM27				WK 08-26	WK 12-26	WK15-26	
FRF2YMQ11	LM24			WK 09-26	WK 12-26	WK 15-26		
FRF1YMQ11	LM26			WK 10-26	WK 13-26			
FSP2YMQ01	LM28		WK 10-26					
FRF3YMQ11	LM12	WK 05-26						
FLF3YMQ11	LM30							
FREXYMQ01	LM31							

ES Multiplets

Pre-assembly:

- ongoing in LEB cave
- team from IFJ-PAN, Pl

SC Dipoles

H. Müller,
E.J. Cho et al.

Scope (ES):

- D2: 3 x 11°
- D3: 10 x 9.75°
- branched dipole, 2 x 9.75°

Decision Q2/2025 (risk mitigation):

- use of standard dipoles for ES installation
- exchange with branched dipoles at a later stage

Main characteristics:

- iron dominated, warm iron. large aperture

Provider:

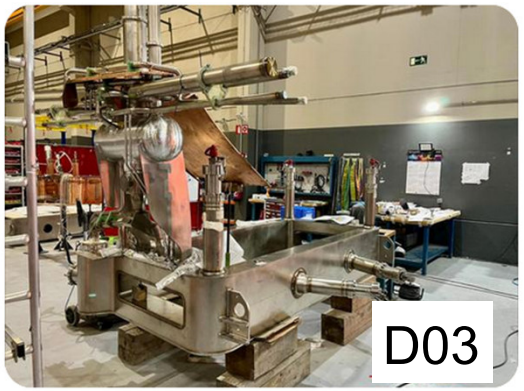
- Elytt, Bilbao, Spain

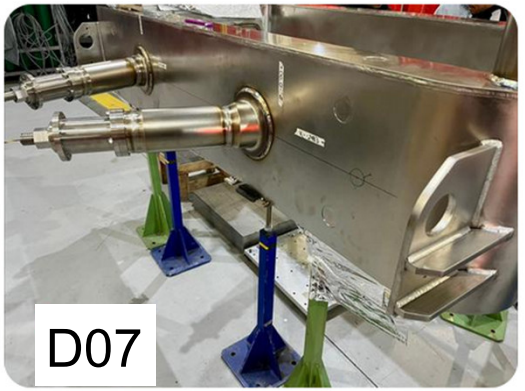
Production Status (after many mitigation actions) **:**

✓ D05, D04 SAT@CERN **completed**, D02 under testing.

(✓) D06, D01 repaired, to be re-tested after D02.

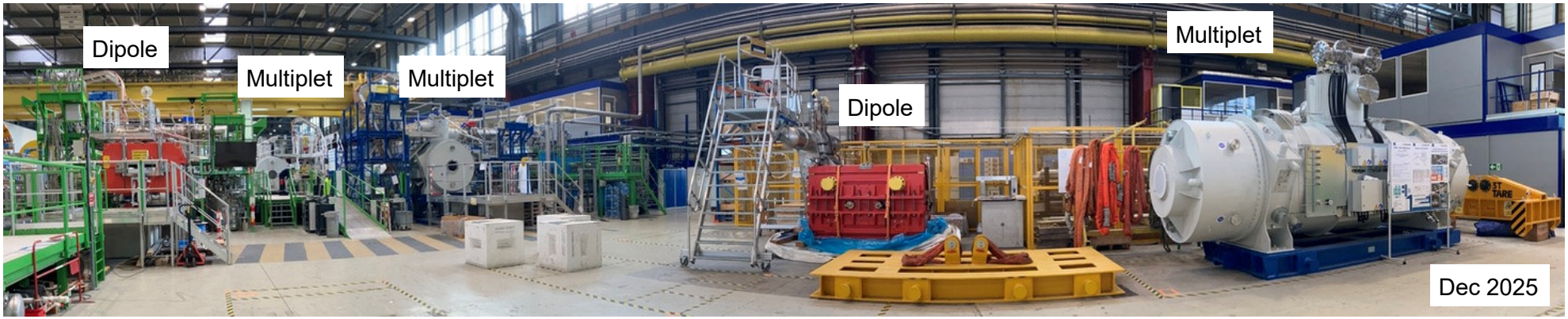
- D03 delivery to CERN in April/May
- manufacturing schedule for remaining D3 diples
  - ➢ 4 production benches operational
  - ➢ FAIR put a lot of support for the production
  - ➢ FAT last D3 dipole scheduled for 01/2027



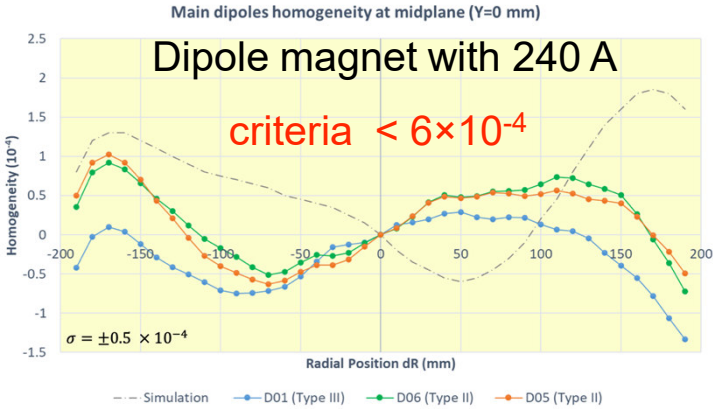


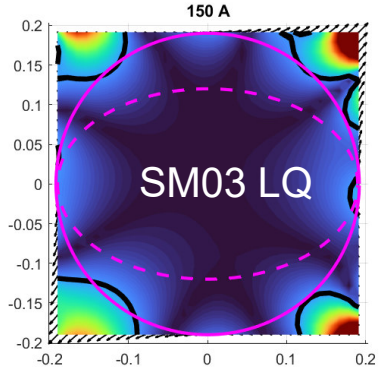
Testing at CERN

K. Suguta
H. Bajas et al.



Very successful testing @ CERN





- Magnetic measurements
  - Ion optical requirements achieved !
- 3 test benches: facility improvement
  - simultaneous powering of magnets at multiple benches
  - cryogenic facility maintenance completed during winter shutdown
  - resource is being increased
- **Many dipole magnets and rest of the multiplets will be tested untill Q1/2027**

Power Converter& QuD

A. Wiest,
W. Freisleben
T. Mohite et al.

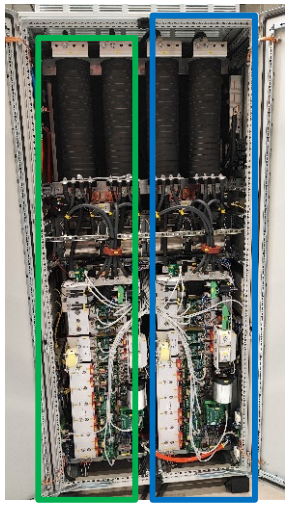
Features

- 2 PC units in one rack, bipolar, I_{Max}≈300A
- nc-magnets: 2 or3 racks combinable
- sc-magnets: QuD & dump resistor integrated

Status / Schedule

- ✓ 8 PC for nc magnets (FAIR)
  - ✓ all PC delivered 11/2025 and stored
- ✓ 58 PC (ES) for sc main magnets (FAIR)
  - ✓ 1st batch delivered 12/2025 and stored
  - ✓ 2nd batch delivered 02/2026, SAT running
- 56 PC for corrector magnets (India in-kind; ECIL)
  - ✓ FAT of FoS done 11/2025, series production running
  - delivery batch 1: 08/2026, batch 2: 11/2025

unit #1 unit #2

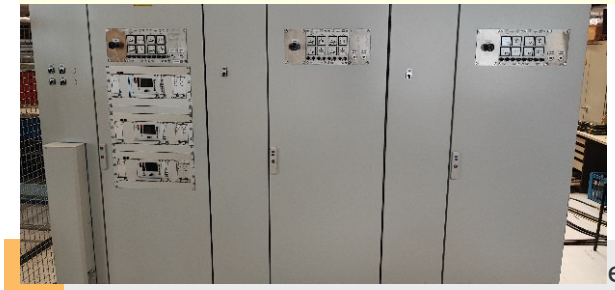


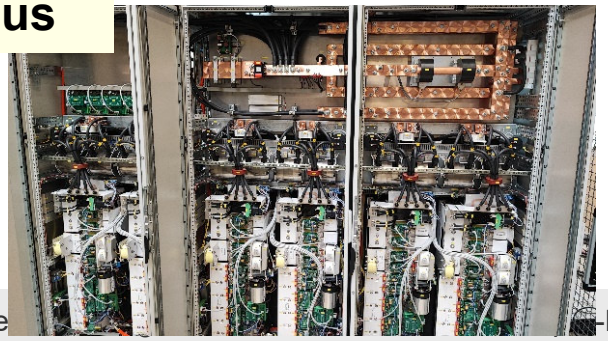
D2/Q4 PC (2 units)

Fr3 (2 units)

storage @ Weiterstadt

combination of 3 PC racks for nc magnet with power-bus





E40.L0516A

E30.L0321A

S. Purushotaman
N. Kurichiyanil et al.

Diagnostic Chambers

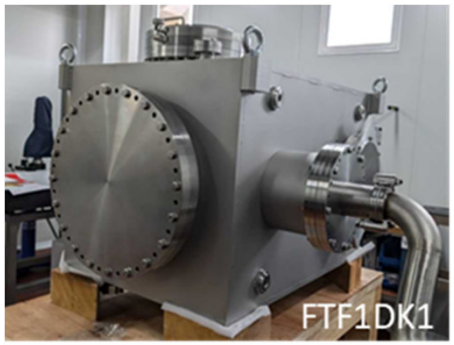
- ES scope: 12 chambers + 2 reference chambers
- procurement includes support frames (taking into account escape routes)
- ‘easy’ chamber exchange implemented

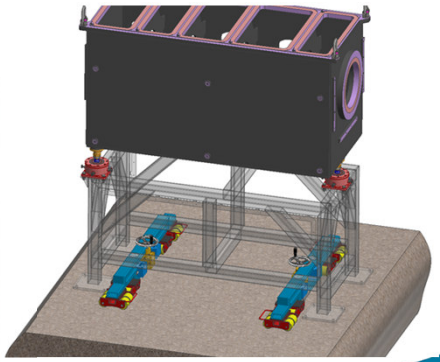
✓ 1 IPM chamber delivered by TVP (Sp)

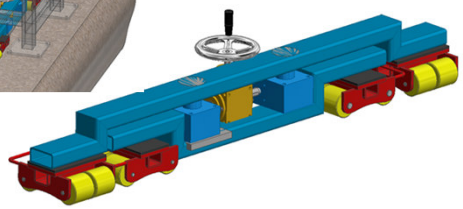
✓ 2 FoS chambers delivered by Pfeiffer (De)

✓ 9 series chambers + 2 reference chambers

- contracted to Streicher, Cz
- production in 3 batches
- all chambers produced, FAT of 1st batch done







No.	Batch	Focal plane chamber	Status
1	FOS	FTF1DK1	at GSI
2		FPF4DK1	at GSI
3		FMF1DK1	at GSI
4	Batch 1	FPF2DK1	FAT accepted
5		FPF3DK1	FAT accepted
6		RefDK1	FAT accepted, ready to ship
7		RefDK2	FAT accepted, ready to ship
8	Batch 2	FMF2DK1	Ready for FAT
9		FMF2DK2	Ready for FAT
10		FMF2DK3	Ready for FAT
11		FMF3DK1	Ready for FAT
12	Batch 3	FHF1DK1(a)	Ready for FAT
13		FHF1DK1(b)	Ready for FAT
14		FHF1DK2	Ready for FAT

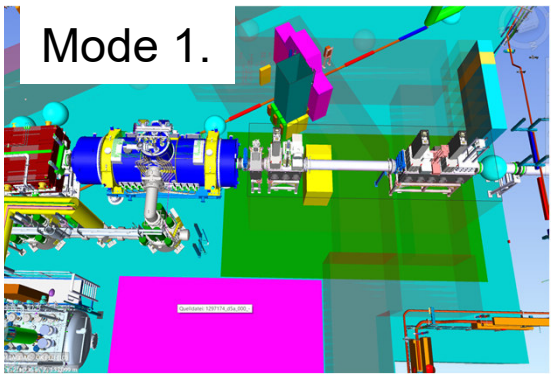
Diagnostic Chambers
(Configuration at FHF1)

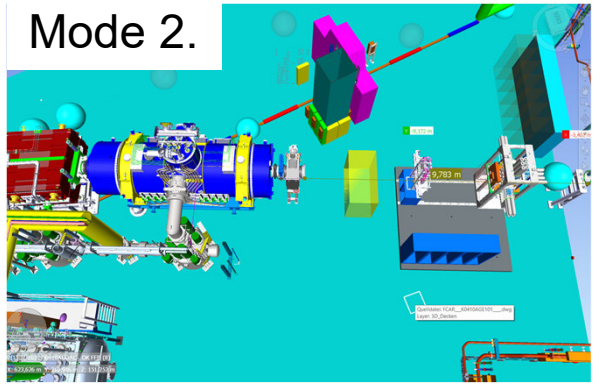
S. Purushotaman
N. Kurichiyanil
A. Bergmann et al.

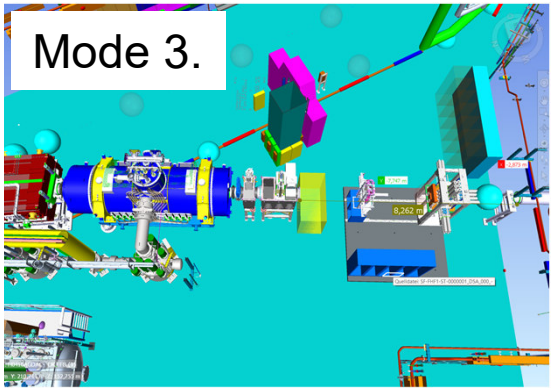
Operation modes @FHF1 :

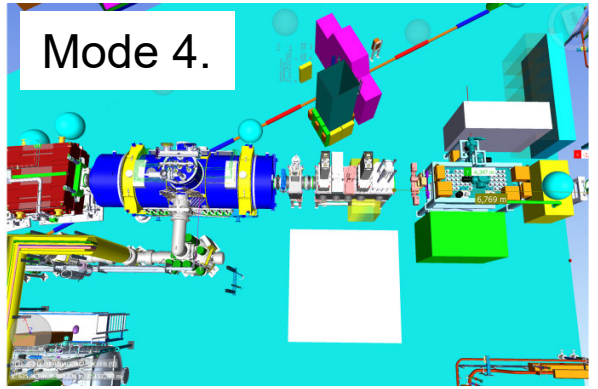
1. Standard set-up, beam to HEC:
   DK1a, DK1b, DK2 installed, full BI
2. Maximum space for exp. setup:
   only DK1a (beam stopper), no BI
3. Intermediate set-up 1:
   DK1a and DK1b installed, some BI
4. Intermediate set-up 2:
   DK1a and moved DK2 installed, some BI (including MUSIC)

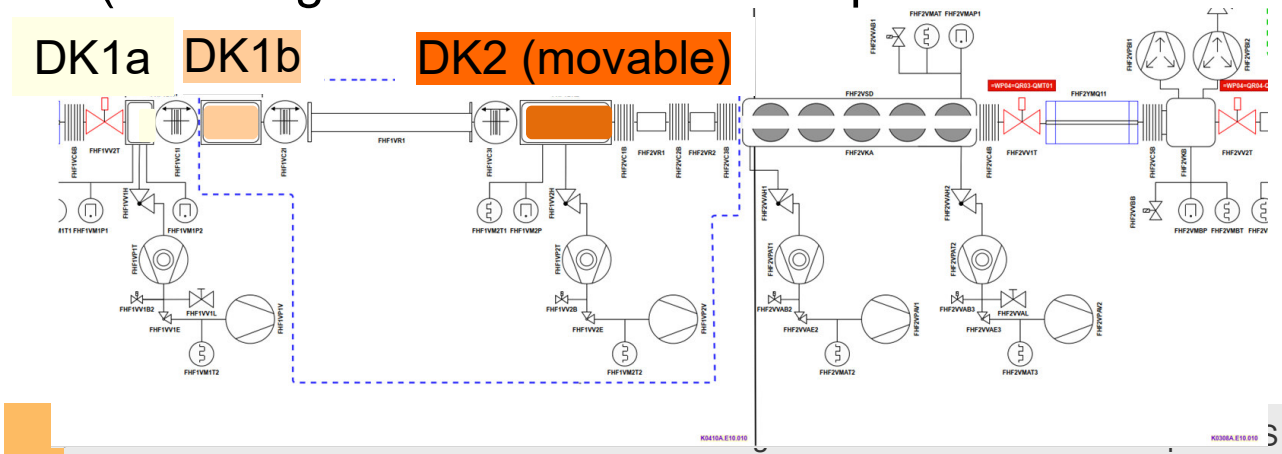
✓ vacuum concept at FHF1 adapted (including switchable beam dump









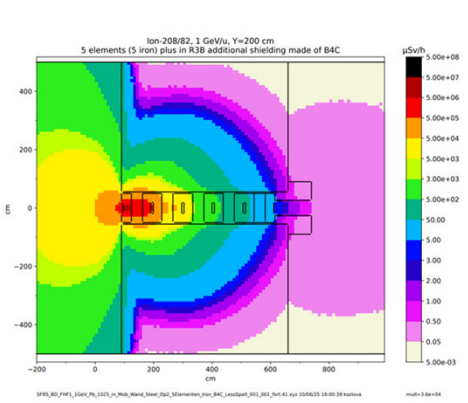


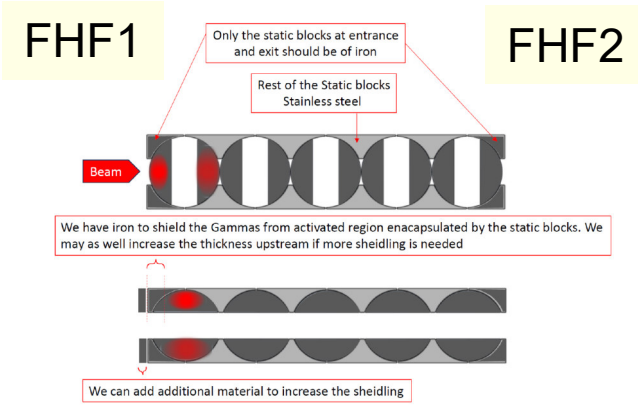
Mode No.	Aivalable space for experiment
1	-
2	≈9,5m
3	≈8,0m
4	≈6,5m

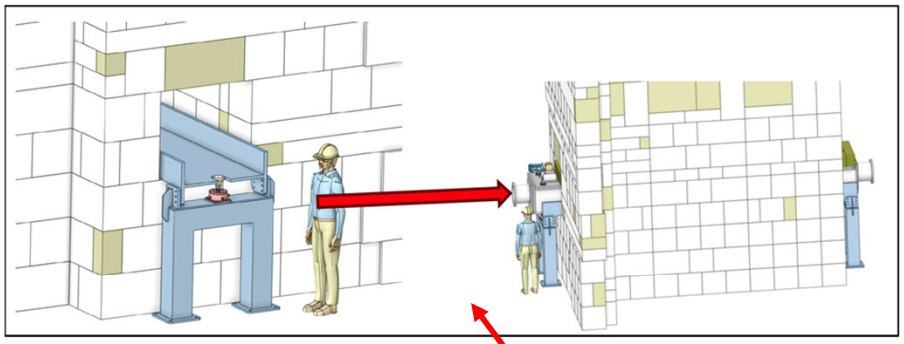
Switchable Beam Dump

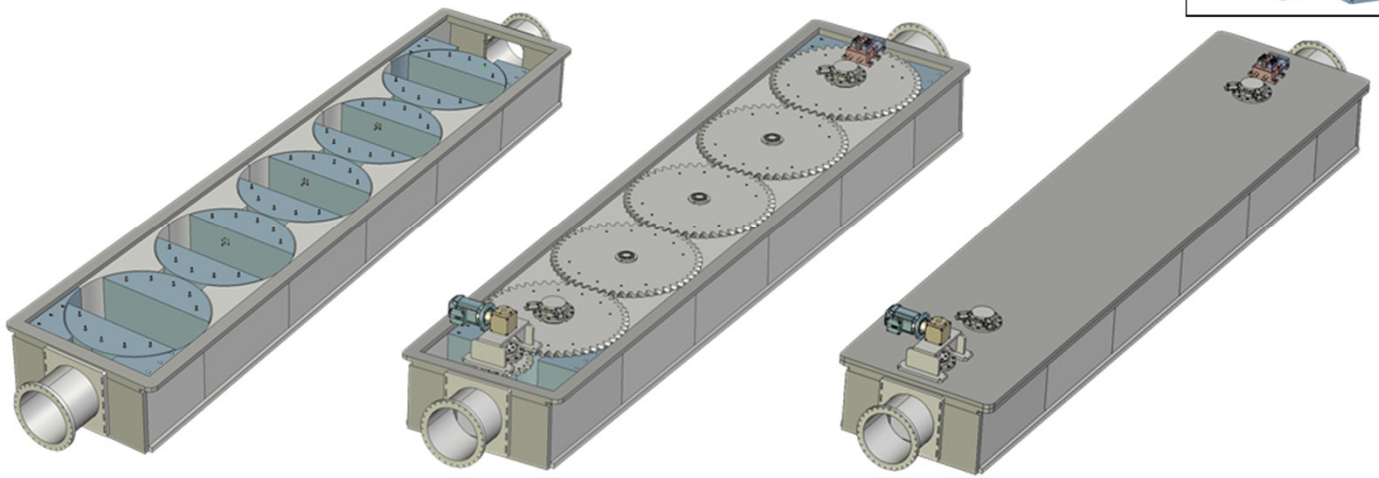
S. Purushotaman
N. Kurichiyanil
E. Kozlova

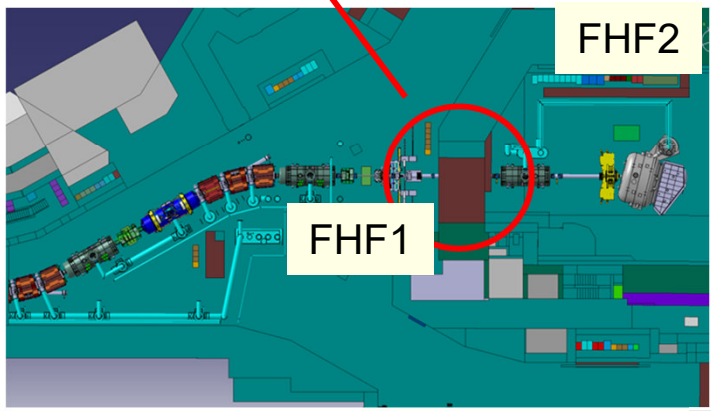
- serves as radiation safety device
- idea: use rotatable carbon steel blocks
- allow parallel operation
  - ➢ dump-in: run FHF1/ set-up FHF2
  - ➢ dump-out: run FHF2
- 3D concept developed (CDR)
- Mechanical and control system Engineering design (build-to-print), scheduled March 15, 2026
- budget approved, ready to tender









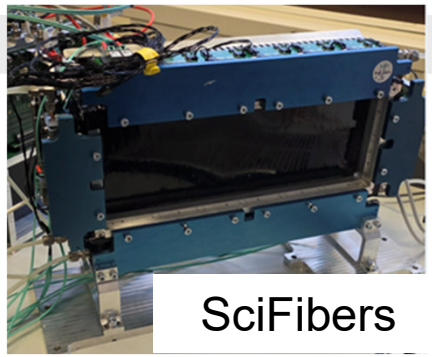


Beam Instrumentation
(mainly PID detectors for ES)

M. Schwickert, J. Galvis,
C. Caesar, C. Nociforo,
M. Czogalik, B. Voss,
D. Urner, S. Udrea, et al.

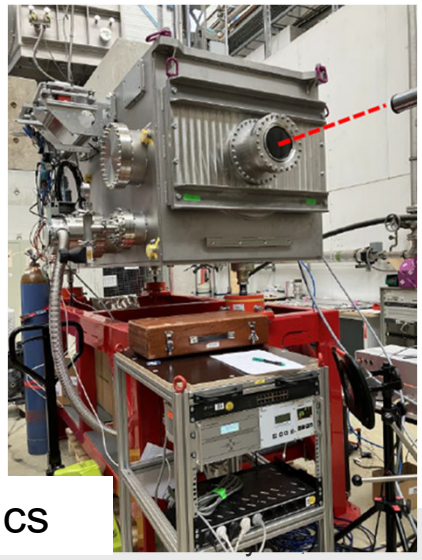
- Drive / position detectors (HIP)
  - ✓ FoS units at GSI and tested
  - ✓ design modification implemented
  - ➢ tender series running
- SciFiber (tracking, FAIR **plan B ES**)
  - ✓ FoS produced; in-beam test GSI 02/2025
  - ➢ production of series running (DetLab)
- Plastic Scint. (ToF, FAIR **plan B ES**)
  - ✓ FoS produced (in-house); non-segmented EJ-230, in-beam test 2025
  - ➢ series production (5 drives) awarded to Prevac (Pl); FAT expected 04/2026
- MUSIC (ΔE, GSI & Uni Jyvaskyla)
  - ✓ FoS (FMF1) in-beam test GSI 2025
  - ➢ design adaption for FHF1 ongoing
- … and much more activities …
  - ➢ Slits, beam stopper, PDC, GEM-TPC, SEM Grids, IPM, TA detectors

FoS Drive



SciFibers

FoS MUSIC



FoS Plastics

S. Pietri, et al.

Super-FRS Commissioning

- Benchmark: Pre-Target area
  - detailed Commissioning Planning for each technical system established
  - each plan divided in **two phases**
  - dependencies and activities (resource loaded) defined
- **Commissioning start** for pre-target area planned for **Q4/2026**

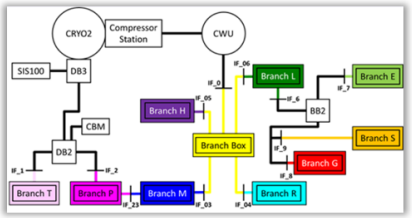
Phase 1 (ca. 34 days)

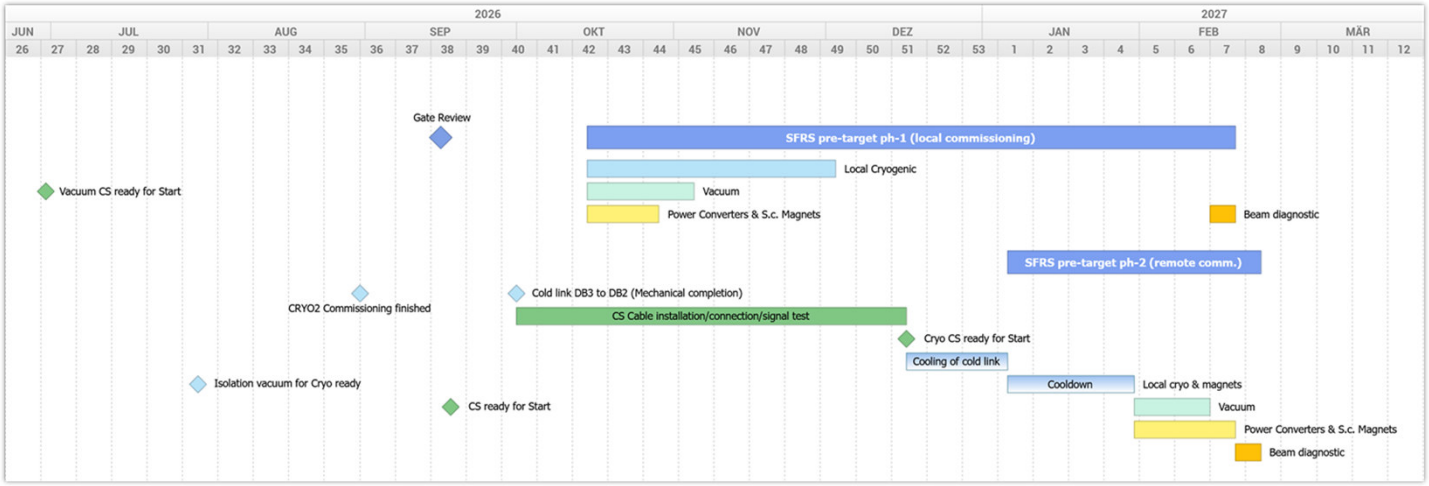
Dependencies
- media supply (TGA) available in the building (N2, compressed air)
- Insolation vacuum mechanical completion
- DB2 is commissioned

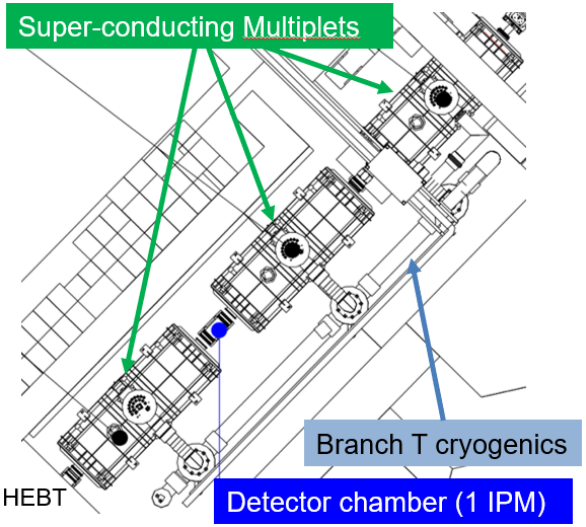
Activities, time and manpower
- valve position check: **1 day 1 CRY**
- instrument cable check cryo racks: **4 days. 1 CRY, 1 IND**
- instrument cable check ins. vac. rack : **4 days 1 VAC, 1 IND**
- pumping insolation vacuum : **7 days 1 VAC, 1 IND** (not full time)
- flushing N2 : **7 days 1 CRY** (**1 IND** in support)
- pumping and purge : **4 days 1 CRY** (**1 IND** in support)
- purifying GHe: **7 days 1 CRY**

Phase 2 (ca. 4 weeks)

Activities, time and manpower
- test cryogenics branch first without load (closing the feed-box valves) then with load
- cool down of all 4 TL lines, test EB bypass-valves, test heaters and establish regulation scheme: **2 weeks** (**2 CRY**)
- cool down of magnets with load: **2 weeks**







Summary

- Target Area installation started
  - ➢ all major TA procurements in-house or delivery to be started soon
  - ➢ pre-installation of target chamber done
  - ➢ pre-installation of beam catcher started
- Pre-Target Area installation to considerable part done
- Tunnel / Separator installation will start Q2 / 2026 and run until Q1 / 2027
  - ➢ 4 provider for various local cryo branches; installation P-branch in preparation
  - ➢ FAT of last ES sc multiplet done
  - ➢ non-conformities of sc dipoles mitigated; successful SAT of first dipoles done;
  - ➢ production of all vacuum component running; diagnostic chambers produced
- Commissioning benchmark for ‘Pre-target area’ established

Thank you for you attention !