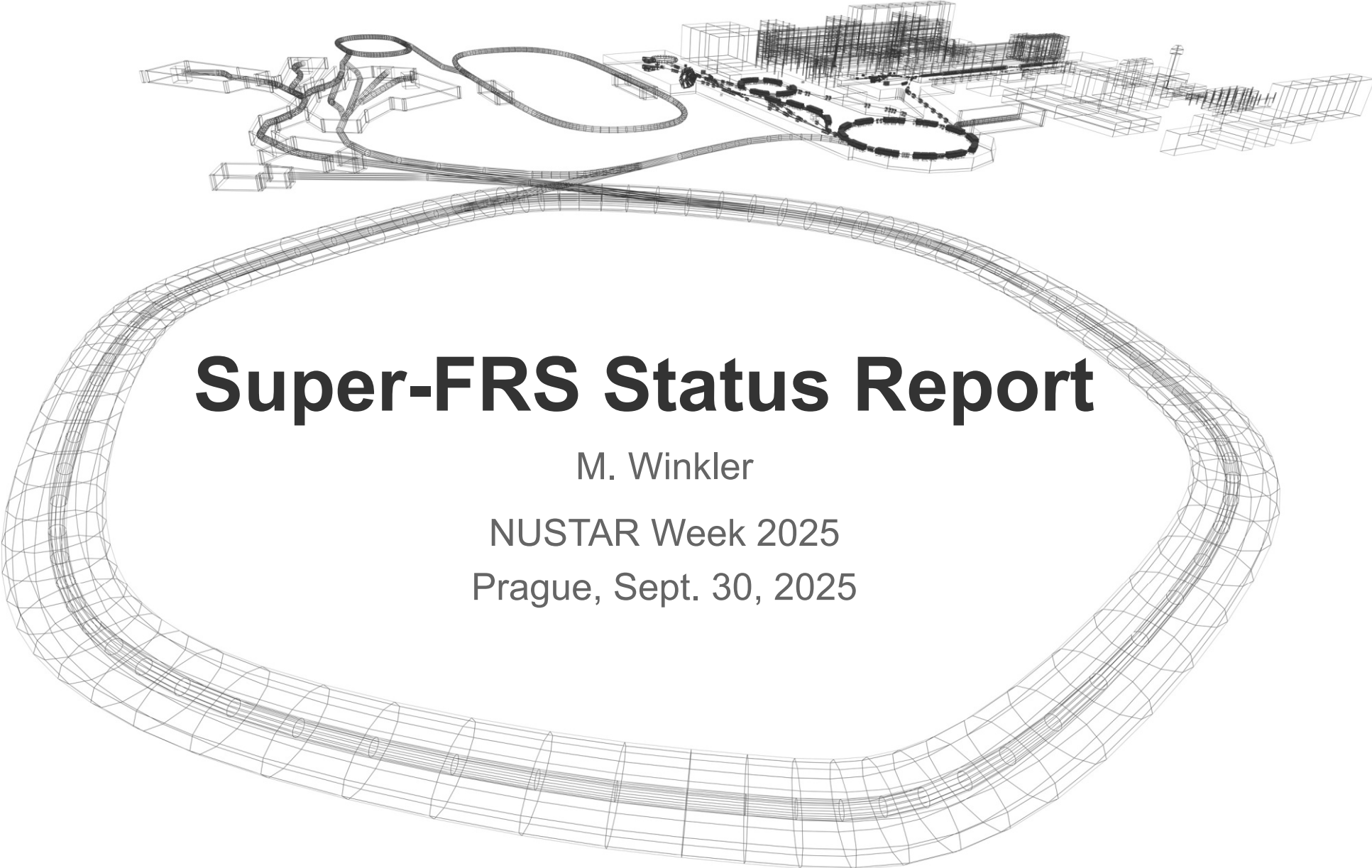


A detailed wireframe 3D model of the Super-FRS (Super-Fragment Separator) accelerator complex. The model shows a large, elongated, and curved structure, likely representing the main acceleration region, with various internal components and support structures visible. The structure is composed of many thin, interconnected lines forming a mesh-like appearance.

Super-FRS Status Report

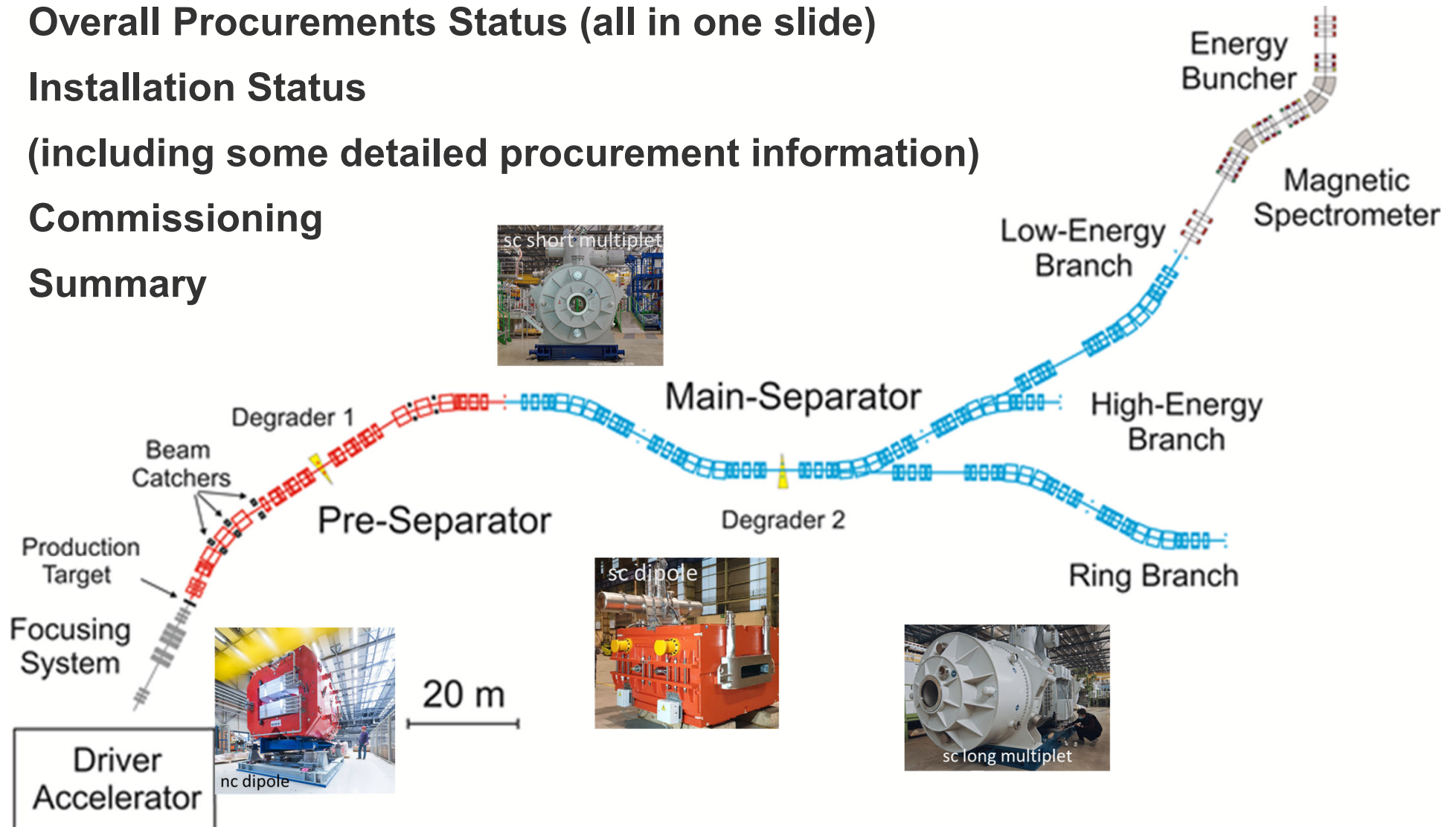
M. Winkler

NUSTAR Week 2025

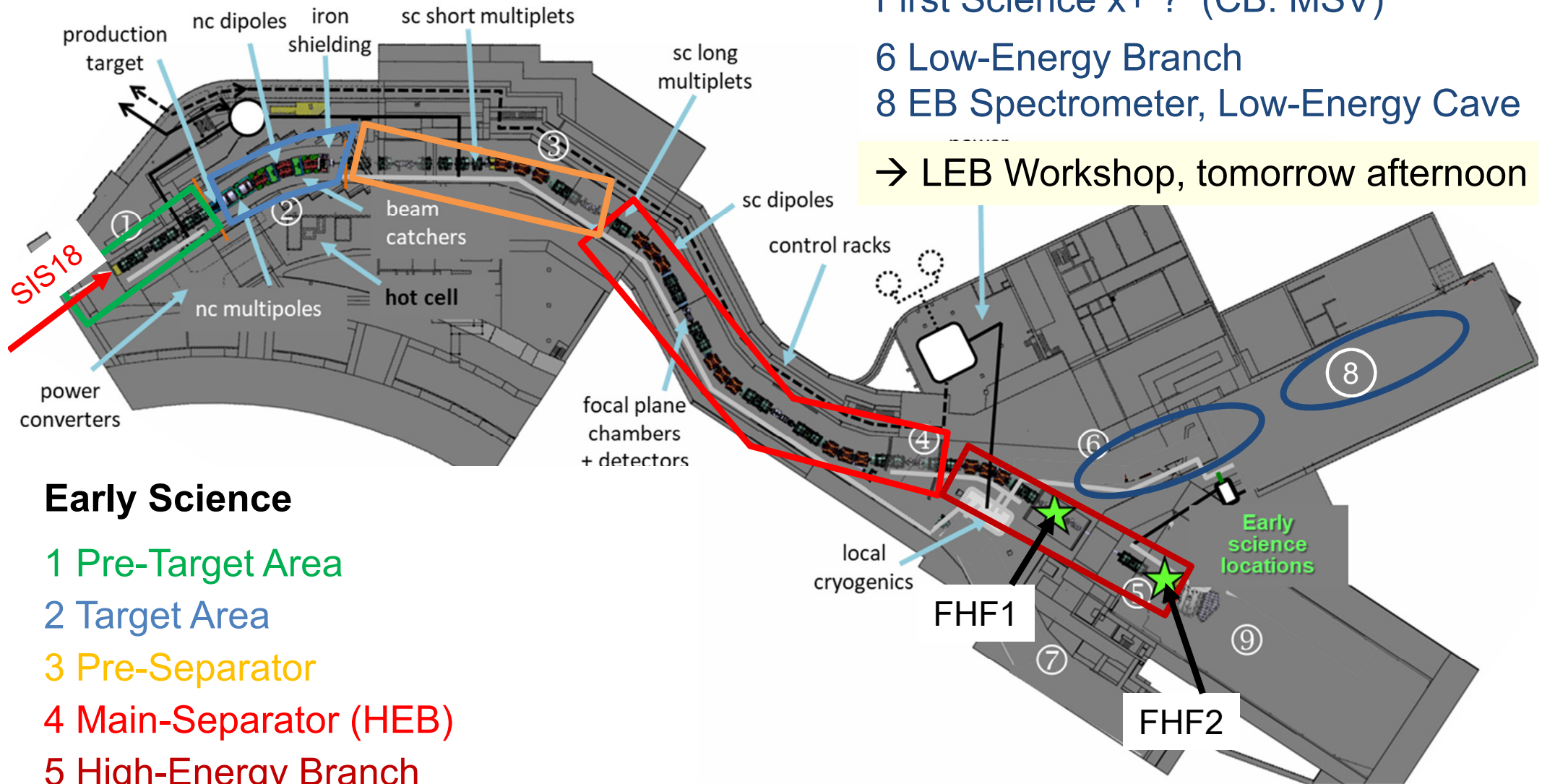
Prague, Sept. 30, 2025

Outline

- 1) **Early Science Scope**
 - 2) **Overall Procurements Status (all in one slide)**
 - 3) **Installation Status**
(including some detailed procurement information)
 - 4) **Commissioning**
 - 5) **Summary**
- 



ES Scope



Early Science

1 Pre-Target Area

2 Target Area

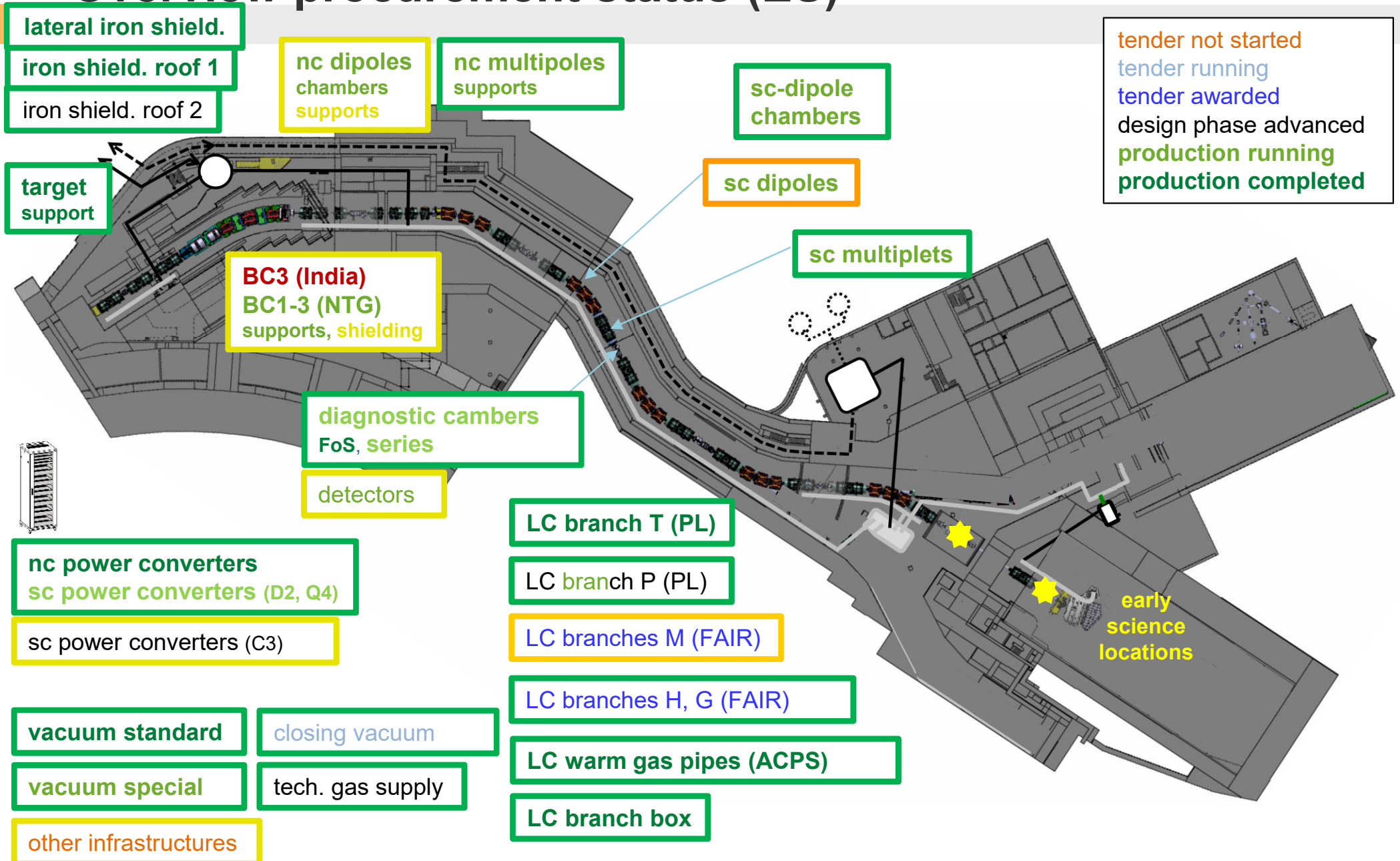
3 Pre-Separator

4 Main-Separator (HEB)

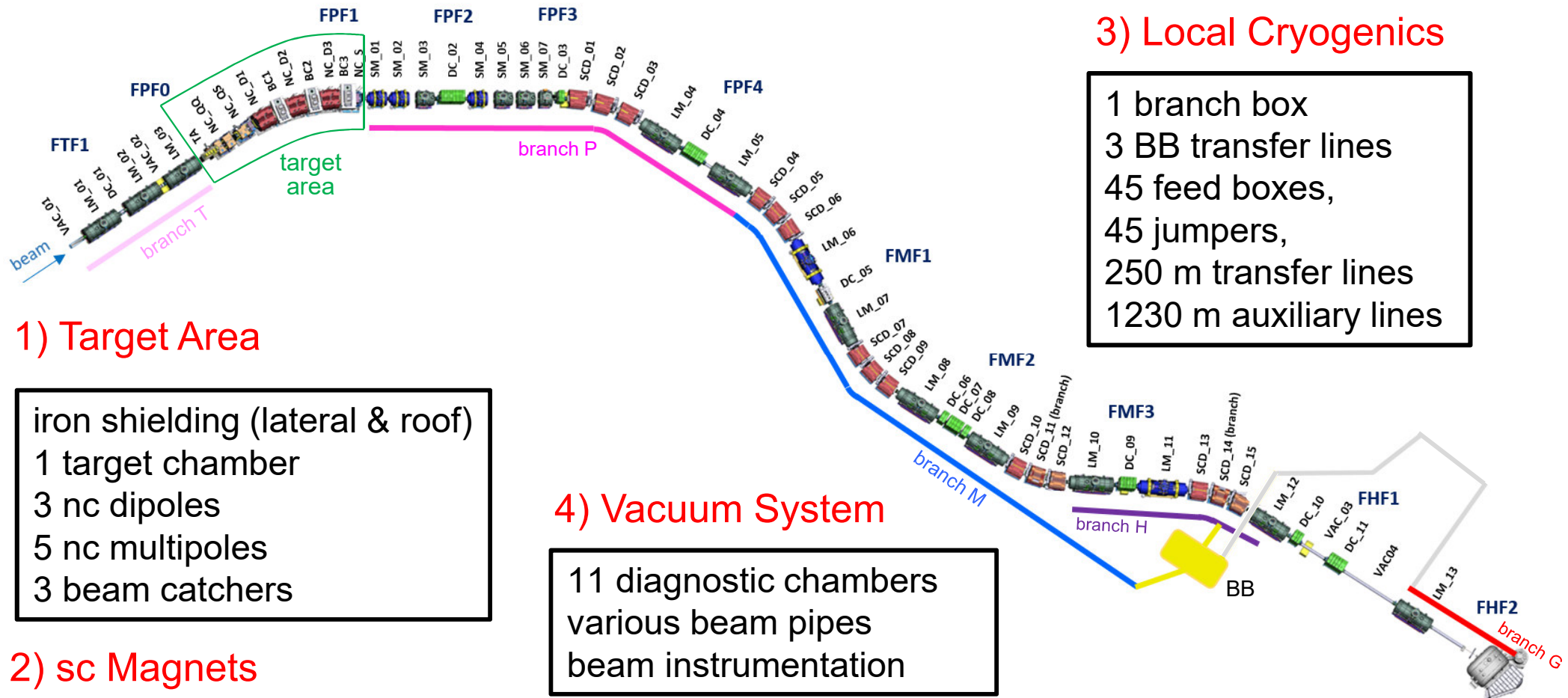
5 High-Energy Branch

9 High Energy Cave (NUSTAR)

Overview procurement status (ES)



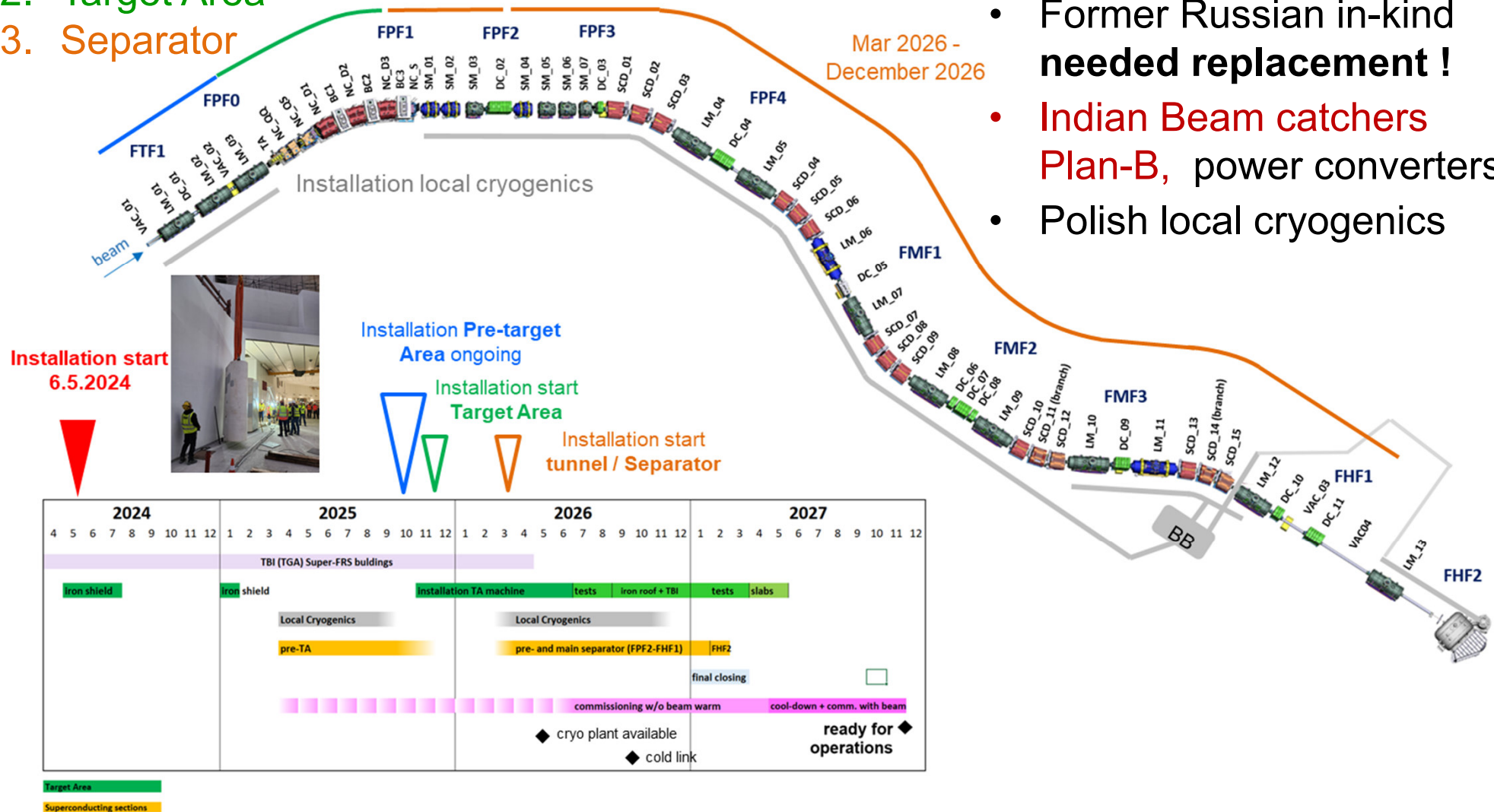
Assembly Units for ES



- ### 3. Separator

Challenging in-kind packages:

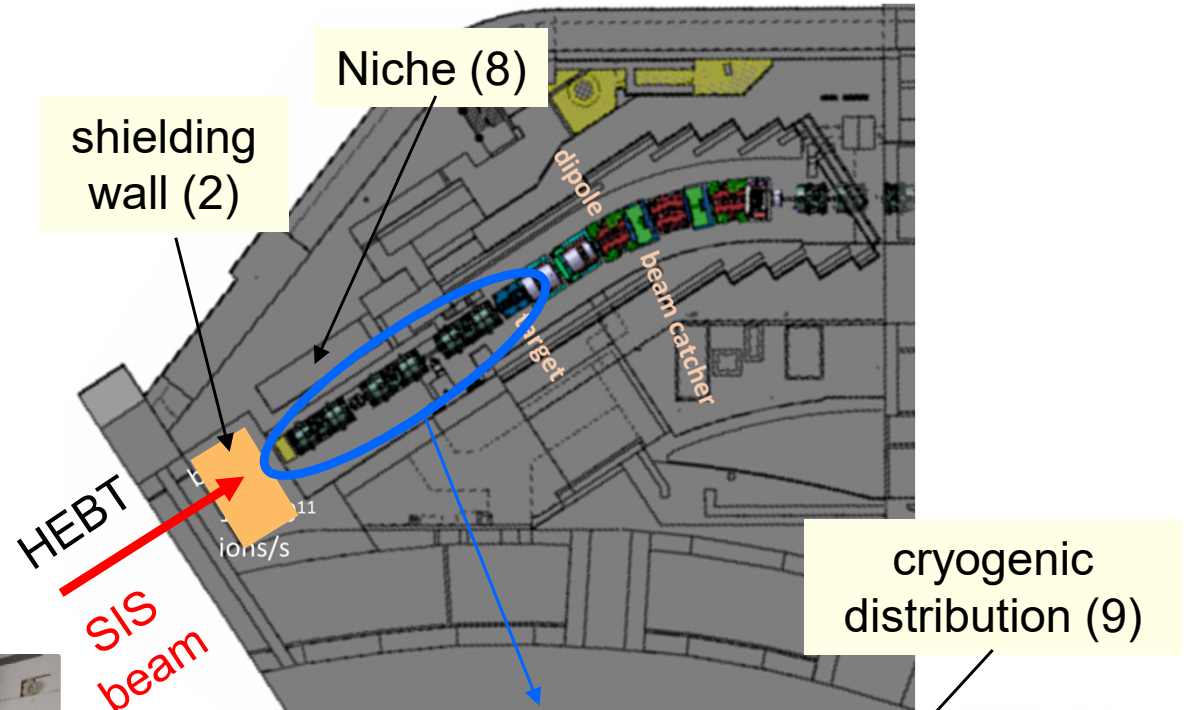
- Former Russian in-kind **needed replacement !**
- **Indian Beam catchers**
Plan-B, power converters
- Polish local cryogenics



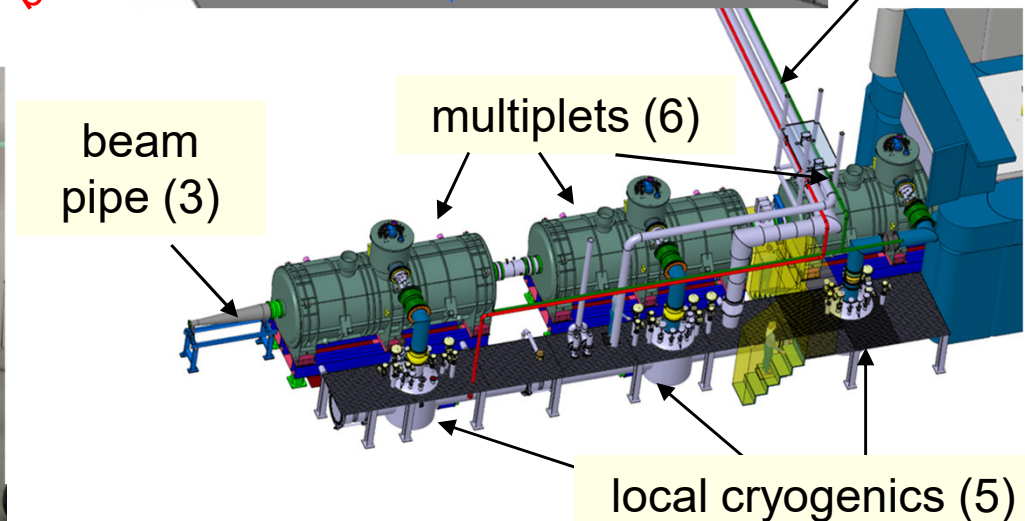
Installation

Pre-Target Area, Sequence

1. Blue line
2. Mobile shielding wall (HEBT – Super FRS)
3. Beam pipe connection to HEBT
4. TBI (in particular power cable)
5. Local Cryogenics
6. sc magnets (multiplets)
7. Remaining vacuum components
8. Niche / control racks
9. (Cryogenic distribution)



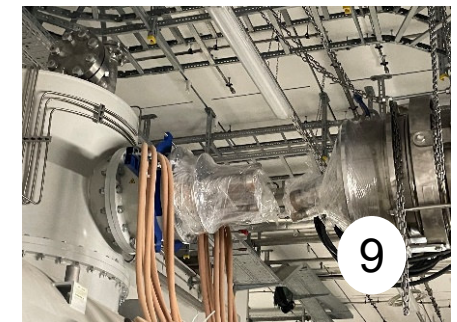
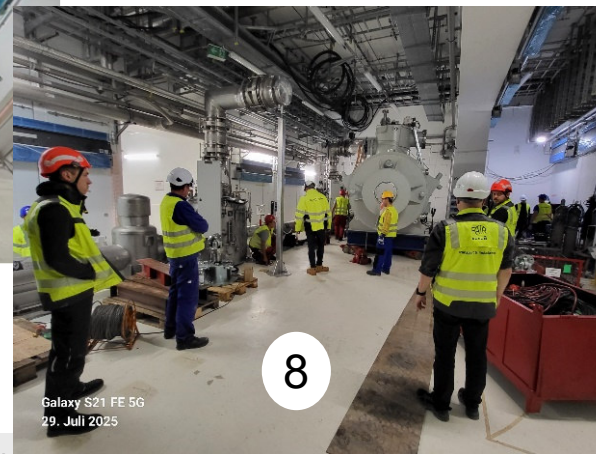
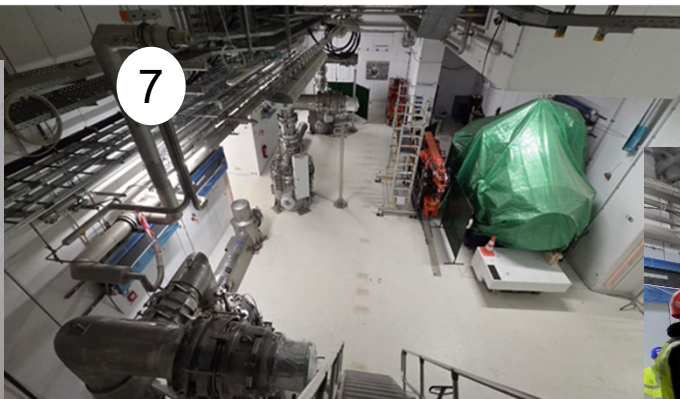
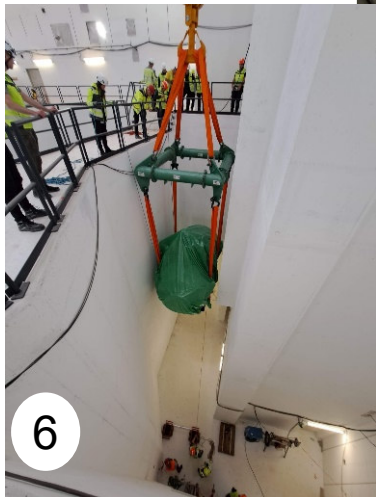
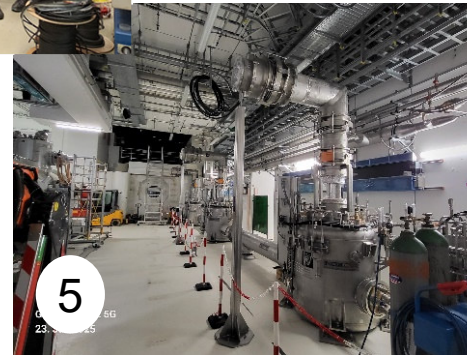
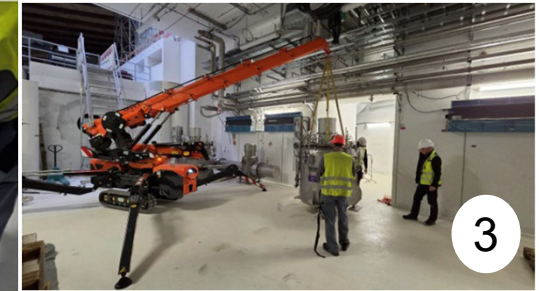
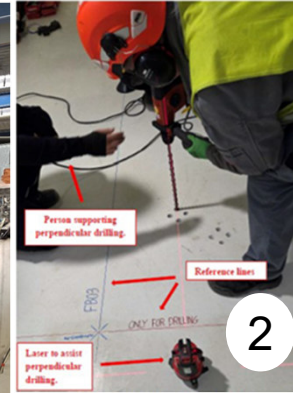
Beam pipe (3)
**1st component
on blue line !**



Installation

Pre-Target Area, step-by-step

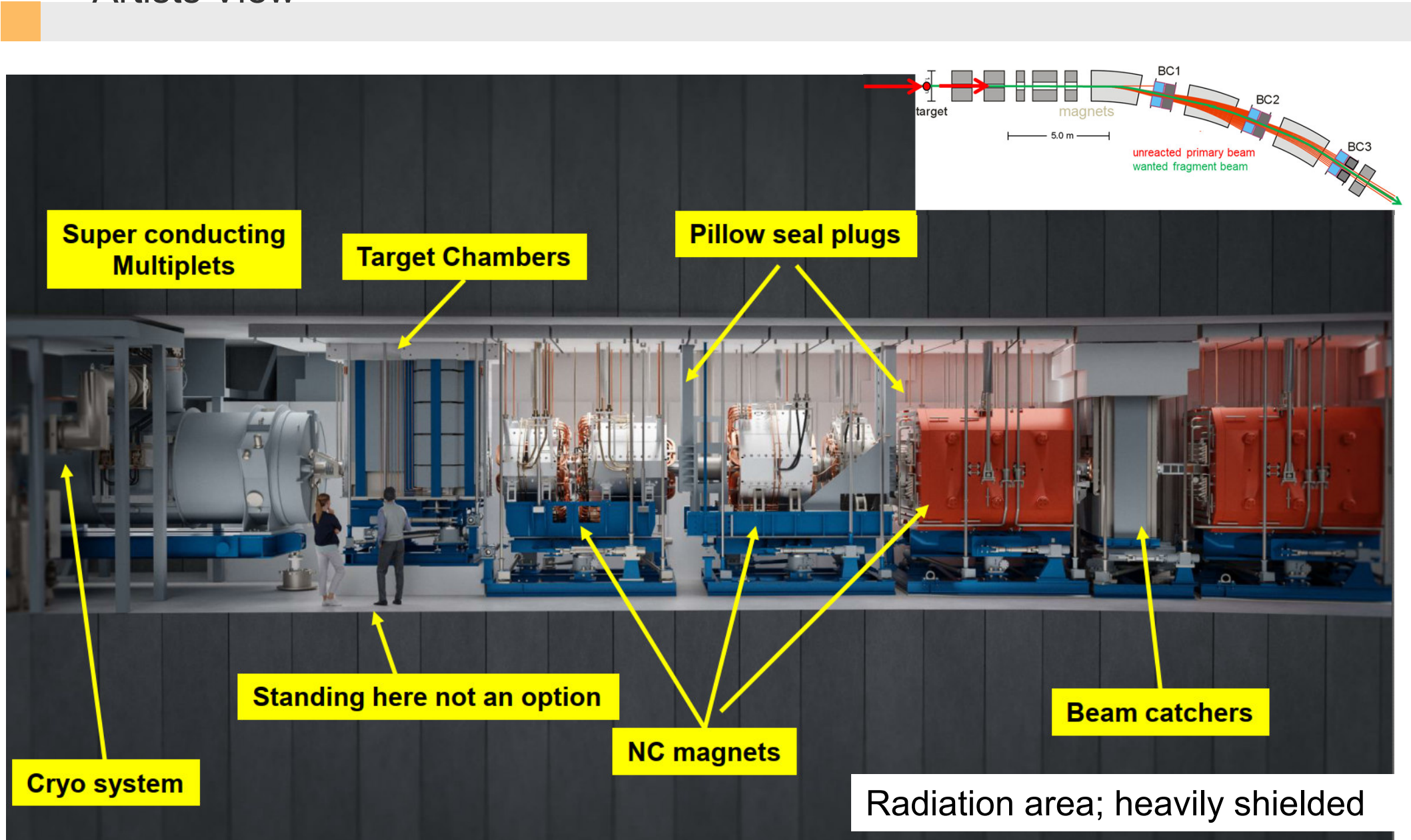
1. Cryo FoS Testing in STF
2. Prepare floor-anchoring (blue line)
3. Bring-in 1st feedbox
4. Connect feedbox via transfer line
5. Local cryo system completed
6. Bring-in 1st Multiplet
7. Multiplet in park-position
8. Place 1st Multiplet in final position
9. Close the cryo interface



9 fotos $\approx$ 9 month

Target Area

Artists View

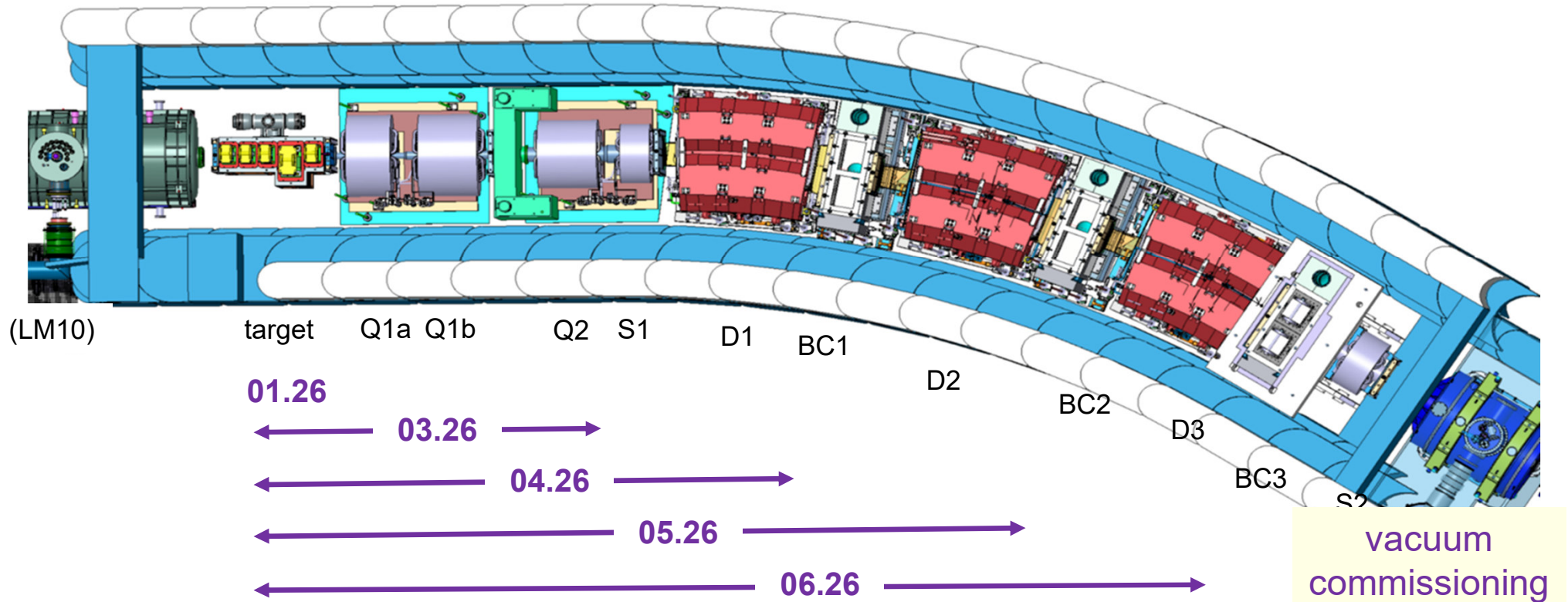


Target Area as of today



Target Area Installation

Sequence and Schedule



13.09.25

	Nov.			Dez.			Jan.			Feb.			März			Apr.			Mai			Juni			Juli			Aug.			Sep.			Okt.			Nov.			Dez.			Jan.			Feb.																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																					
	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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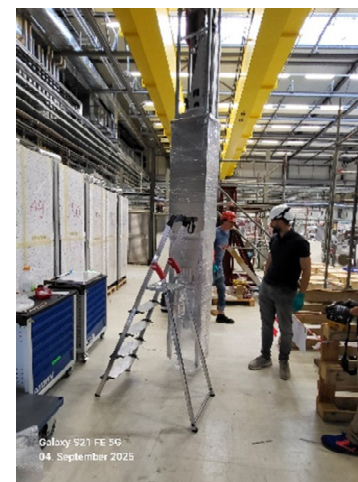
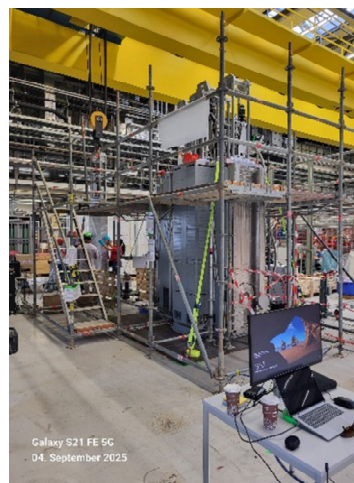
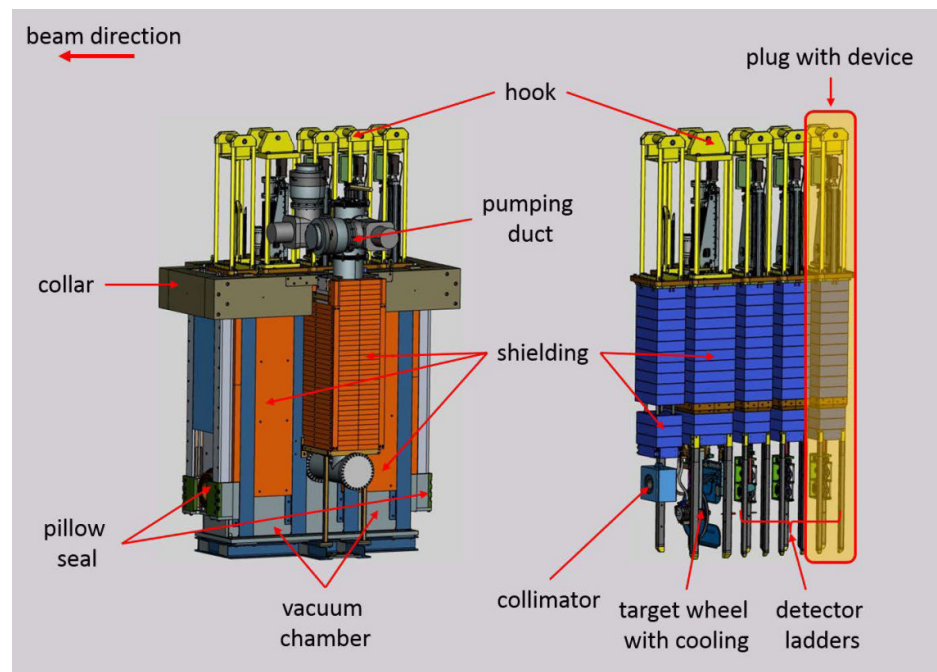
Target Area

Target chamber & Plugs

H. Weick
C. Karagiannis
R. Knöbel et al.



- Design KVI (NI)
- Manufacturing Fantini (It)
 - Chamber plus additional shielding
 - Vacuum duct
 - 1 x Target x Plug
 - 3 x Detector Plugs
 - 1 x Collimator Plug
 - 2 x Pillow Seal Plugs
- ✓ FAT/Delivery 07/2027
- Pre-assembly / SAT ongoing @GSI vacuum, plug, handling, interfaces
- mock-up optical TA monitoring
- installation scheduled for 11/2025



Target Area

NC magnets & auxiliary

H. Leibrock,
S. Purushothaman
A. Wiest et al.



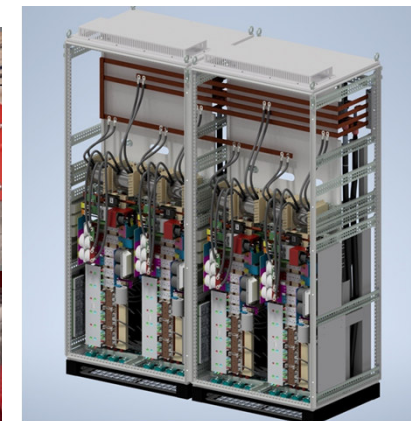
PC double cabinet

NC Dipoles (2 units, 90 ton, MIC cable):

- ✓ One unit on campus (Budker)
- ✓ Provider (Sigmaphi, Fr), 08/2023
- FAT: 08/2025 (D1), 10/2025 (D2)
 - ✓ FAIR providing FoS nc PC
- Delivery: Oct. 8, 2025 (D1), 11/2025

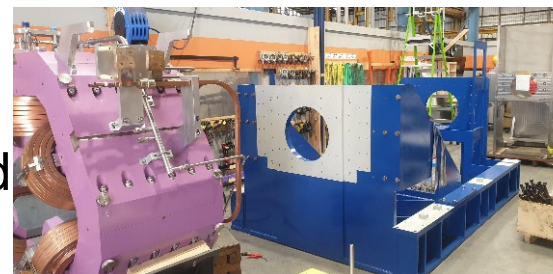


D1 @ SigmaPhi



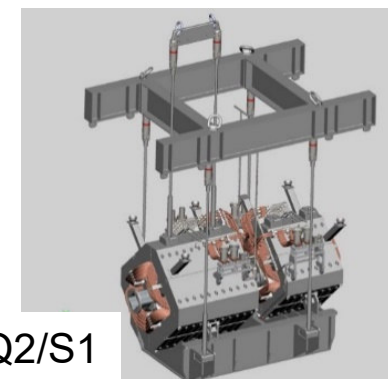
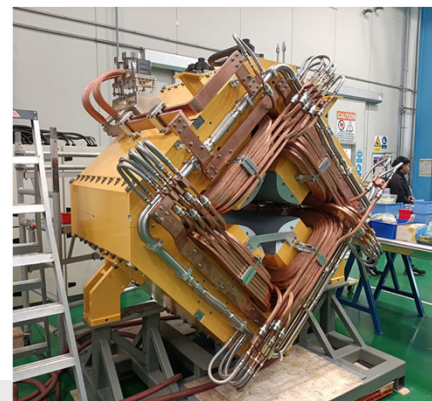
Vacuum Chambers (3 units, Ti based):

- ✓ Provider (CNIM, Fr), 12/2023
- ✓ Design includes cooling channels
 - EB welding required
- Production running, sub-contractor involved
- Delivery: between 01/2026 and 03/2026



NC multipoles (3 quads, 2 sext):

- ✓ Provider (Buckley Systems, NZ)
- Double magnet assemblies on common support frame, including vacuum pipe
- FAT: Batch 1 running, all FAT 12/2025
- Delivery: 02/2026, **no pre-assembly**



Q2/S1

Target Area

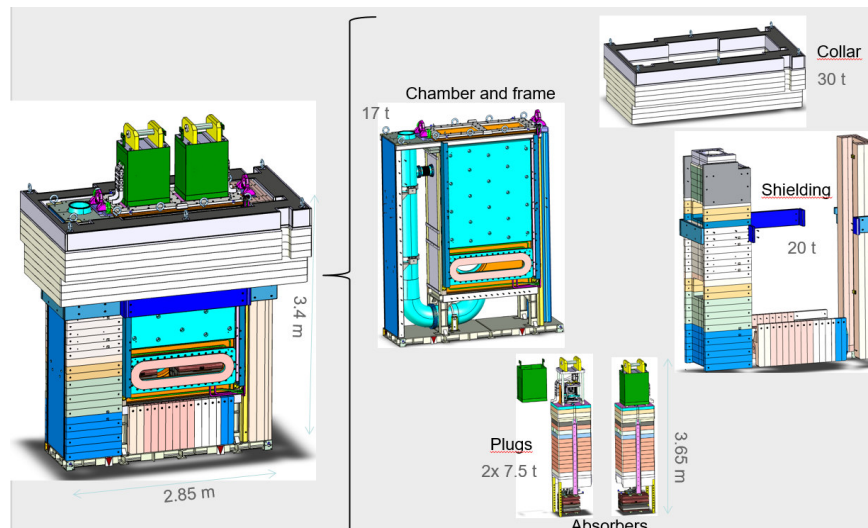
Beam Catcher & Plugs (BC1, 2, 3)

H. Weick
C. Karagiannis
et al.



In-kind India

- Design: CMRI, Dugapur (Ind)
- Man: Trident Ltd. Kanpur (Ind)
 - 3 x Chamber with frame
 - additional shielding
 - 6 x Plugs & beam absorber
- FAT BC3 not successful 08/2025
- Revision ongoing; some issues meanwhile solved



Trident



Plan-B FAIR (only empty chambers)

- ✓ Provider NTG (De)
- ✓ revised CMRI design
 - FDR BC3 running
- FAT BC1, BC2 scheduled for 11/2025
 - BC3 production discussed as mitigation action
- tender to procure additional shielding running



Separator Installation

Sequence and Schedule

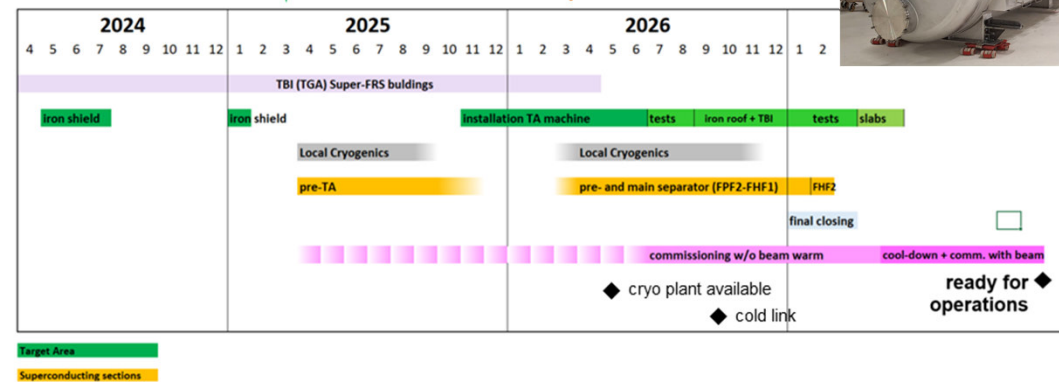
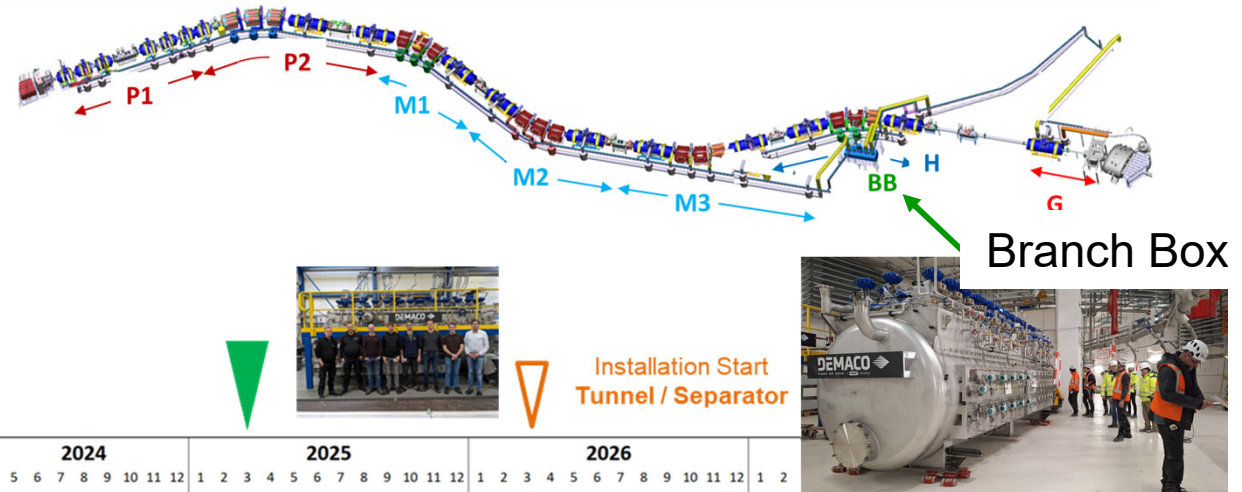


Installation is **subdivided in sections** following cryo branches:

- Pre-Separator: P1, P2
- Main-Separator: M1, M2, M3
- HEB: H
- (NUSTAR: G)

Installation sequence follows

1. Technical Building Infrastructure (in particular along 'cryo side')
 - cable trays 80% done
 - (power) cable installation
2. Local Cryogenics
 - installation of cryo-branches
 - ✓ Branch Box and ACPS done
3. sc magnets
4. Vacuum (diagnostic chambers) (installation of BI at the very end)



Procurement and installation of cryo-branches

branch P: PI in-kind, prod. tender signed (Inox, Kriosystem)

Agreed FAIR-PL installation: **March – September 2026**

branch M: FAIR contracts: March 2025 (Cryo Diffusion)

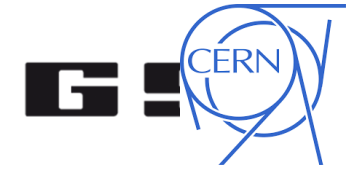
Provider date (D.D. Sep. 2025): **May – December 2026**

branch G, H: FAIR contracts: March 2025 (Crywold)

Provider date (D.D. Sep. 2025): **August – September 2026**

SC Multiplets

E.J. Cho,
H. Müller
V. Velonas et al.



Scope (ES):

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

Main characteristics:

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

Provider:

ASG, Genova, It

Production Status:

- **He leak in thermal shield detected during end 2023**
 - ✓ intense GSI-CERN-ASG Task Force established
 - ✓ root cause analysis / design change / repair
 - ✓ **1st successfully re-SAT 06/2024 (LM11)**
 - ✓ **meanwhile implemented to ALL multiplets**
- FAT of last ES multiplet scheduled for Q1/2026

Pre-assembly running at GSI

- pre-assembly area established in LEB cave
- pre-assembly team from IFJ-PAN, PI

Project Status ASG, 09/2025

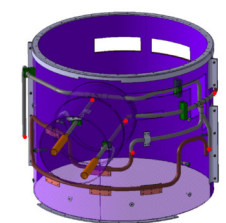


Legend									
Super FFG - SC Multiplets	not necessary								
Purchase Order	not started								
PIB	planned								
1) status depends on GSI	in process								
	ready								
Production									
Integration sequence	DMU Drawing no.	Control unit	Delivery date	Forecast FAT date	Location	status	sub	region	last test
1	PPF110001		20.03.2024						
2	PPF110002		01.08.2024						
3	PPF110003		21.08.2024						
4	PPF110004		01.07.2024						
5	PPF110005		01.08.2024						
6	PPF110006		21.08.2024						
7	PPF110007		01.08.2024						
8	PPF110008		01.08.2024						
9	PPF110009		21.08.2024						
10	PPF110010		21.08.2024						
11	PPF110011		21.08.2024						
12	PPF110012		01.08.2024						
13	PPF110013		01.08.2024						
14	PPF110014		21.08.2024						
15	PPF110015		01.08.2024						
16	PPF110016		01.08.2024						
17	PPF110017		21.08.2024						
18	PPF110018		21.08.2024						
19	PPF110019		01.08.2024						
20	PPF110020		01.08.2024						
21	PPF110021		21.08.2024						
22	PPF110022		21.08.2024						
23	PPF110023		01.08.2024						
24	PPF110024		21.08.2024						
25	PPF110025		21.08.2024						
26	PPF110026		01.08.2024						
27	PPF110027		01.08.2024						
28	PPF110028		21.08.2024						
29	PPF110029		21.08.2024						
30	PPF110030		21.08.2024						
31	PPF110031		01.08.2024						
32	PPF110032		21.08.2024						
33	PPF110033		21.08.2024						
34	PPF110034		01.08.2024						
35	PPF110035		21.08.2024						
36	PPF110036		21.08.2024						
37	PPF110037		01.08.2024						
38	PPF110038		21.08.2024						
39	PPF110039		21.08.2024						
40	PPF110040		01.08.2024						
41	PPF110041		21.08.2024						
42	PPF110042		21.08.2024						
43	PPF110043		01.08.2024						
44	PPF110044		21.08.2024						
45	PPF110045		21.08.2024						
46	PPF110046		01.08.2024						
47	PPF110047		21.08.2024						
48	PPF110048		21.08.2024						
49	PPF110049		01.08.2024						
50	PPF110050		21.08.2024						
51	PPF110051		21.08.2024						
52	PPF110052		01.08.2024						
53	PPF110053		21.08.2024						
54	PPF110054		21.08.2024						
55	PPF110055		01.08.2024						
56	PPF110056		21.08.2024						
57	PPF110057		21.08.2024						
58	PPF110058		01.08.2024						
59	PPF110059		21.08.2024						
60	PPF110060		21.08.2024						
61	PPF110061		01.08.2024						
62	PPF110062		21.08.2024						
63	PPF110063		21.08.2024						
64	PPF110064		01.08.2024						
65	PPF110065		21.08.2024						
66	PPF110066		21.08.2024						
67	PPF110067		01.08.2024						
68	PPF110068		21.08.2024						
69	PPF110069		21.08.2024						
70	PPF110070		01.08.2024						
71	PPF110071		21.08.2024						
72	PPF110072		21.08.2024						
73	PPF110073		01.08.2024						
74	PPF110074		21.08.2024						
75	PPF110075		21.08.2024						
76	PPF110076		01.08.2024						
77	PPF110077		21.08.2024						
78	PPF110078		21.08.2024						
79	PPF110079		01.08.2024						
80	PPF110080		21.08.2024						
81	PPF110081		21.08.2024						
82	PPF110082		01.08.2024						
83	PPF110083		21.08.2024						
84	PPF110084		21.08.2024						
85	PPF110085		01.08.2024						
86	PPF110086		21.08.2024						
87	PPF110087		21.08.2024						
88	PPF110088		01.08.2024						
89	PPF110089		21.08.2024						
90	PPF110090		21.08.2024						
91	PPF110091		01.08.2024						
92	PPF110092		21.08.2024						
93	PPF110093		21.08.2024						
94	PPF110094		01.08.2024						
95	PPF110095		21.08.2024						
96	PPF110096		21.08.2024						
97	PPF110097		01.08.2024						
98	PPF110098		21.08.2024						
99	PPF110099		21.08.2024						
100	PPF110100		01.08.2024						

FHF2 (in front of GLAD)

FAT 10.02.2026

ES multiplets

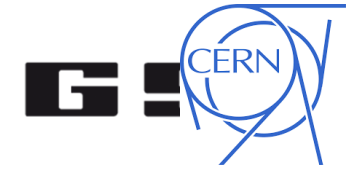


Pre-assembly @ LEB



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 (risk mitigation):

use of standard dipoles only for ES installation
exchange with branched dipoles afterwards

Main characteristics:

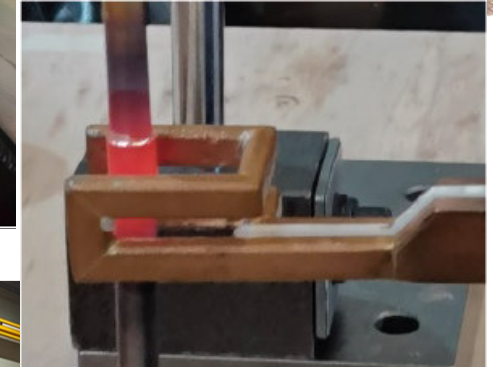
- iron dominated, warm iron. large aperture

Provider:

- Elytt, Bilbao, Sp

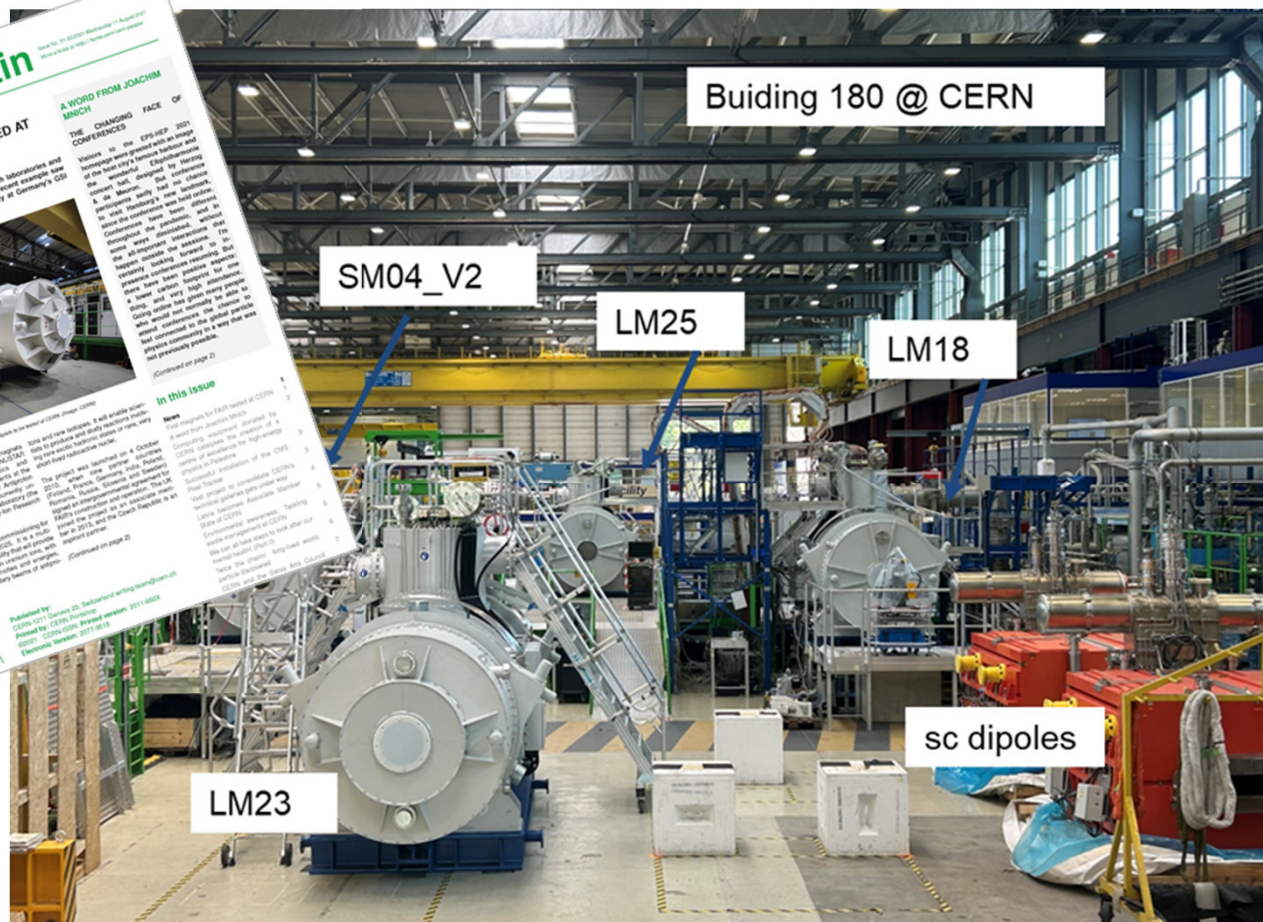
Production Status (issues during FoS SAT):

1. He leak in thermal shield detected
 - ✓ New brazing method + x-ray qualification
 2. Chamfer movement observed
 - ✓ New fixation method (tested mechanically)
- Series production running, capability increased
 - 4 production benches established
 - Transport of 1st repaired dipole in preparation
 - SAT expected prior end 2025



Testing at CERN

K. Suguta
H. Bajas et al.



Very successful tests
@ CERN
Ion optical performance
well achieved !

But:
magnet leaks at cold
observed ...

... and solved with GSI-
CERN task forces

Magnet type / group	Gradient tolerances, 1e-4 units		Tolerances, mm						Tolerances, mrad					
			Horizontal shift		Vertical shift		Longitudinal shift		Pitch		Jaw		Roll	
	Transm.	Res. pow.	Transm.	Res. pow.	Transm.	Res. pow.	Transm.	Res. pow.	Transm.	Res. pow.	Transm.	Res. pow.	Transm.	Res. pow.
SQ	>10	1, 2.5 if compensated	0.4	0.2	0.6	0.3	5	1	>2	>2	>2	>2	≥4	≥0.5
LQ	>10	1, 2.5 if compensated	>1	0.1	0.5	0.2	5	1	>2	>2	>2	>2	≥4	≥0.5
All Sext	>50	2.5	1.5	0.5	>>2	2	5	0.5	>2	>2	>2	>2	≥4	7
All dipoles	7	2.5 @FMF2, 1 @FHF1	>2	>2@FMF2, 1@FHF1	>10	>10	>10	>10	1.7453	0.87266	>20	>10	>2	>2

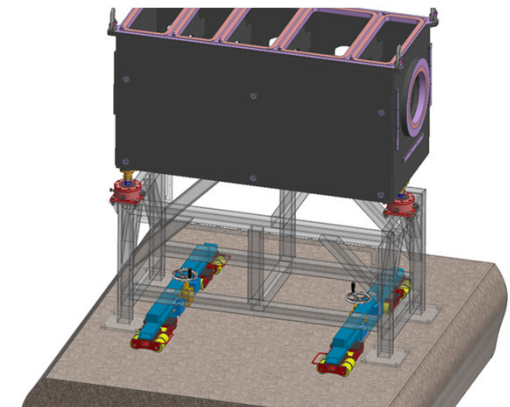
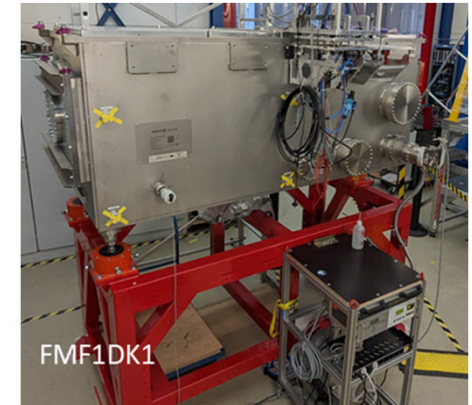
Vacuum Chambers (Diagnostic Chambers)

S. Purushotaman
N. Kurichiyanil et al.

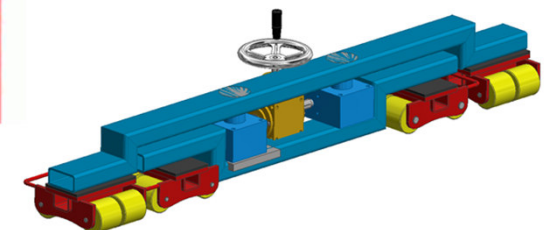
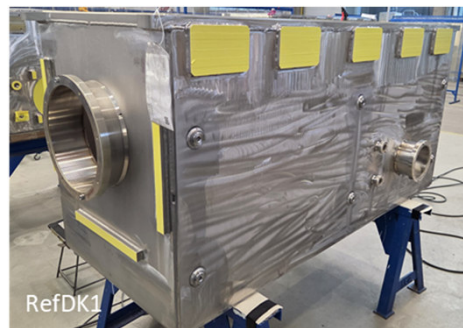


Early Science: 12 + 2 reference chambers

- 1 IPM chamber (pre-target area) produces by TVP, Sp
- 2 FoS chambers produced by Pfeiffer, DE
- 9 + 2 provider **Streicher, Pilsen Cz**
- concept to exchange diagnostic chambers established and going to be implemented by Streicher



No.	Focal plane chamber	Status
1	FTF1DK1	AT GSI
2	FPF4DK1	At GSI
3	FMF1DK1	at GSI
4	FPF2DK1	Ready for FAT
5	FPF3DK1	Ready for FAT
6	RefDK1	Ready for FAT
7	RefDK2	Ready for FAT
8	FMF2DK1	Under production
9	FMF2DK2	Under production
10	FMF2DK3	Under production
11	FMF3DK1	Under production
12	FHF1DK1(a)	FDR
13	FHF1DK1(b)	FDR
14	FHF1DK2	FDR



Vacuum Chambers

(other vacuum equipment)

S. Purushotaman
N. Kurichiyanil et al.

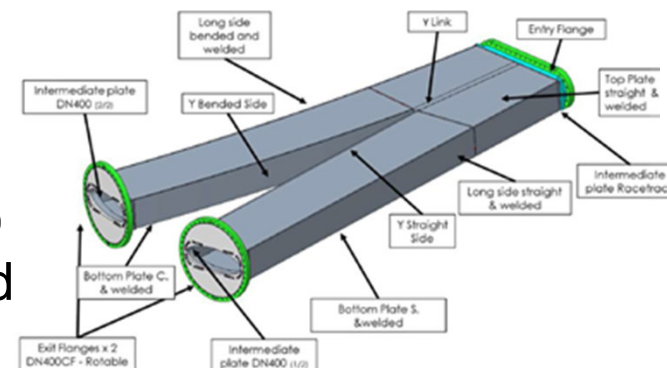
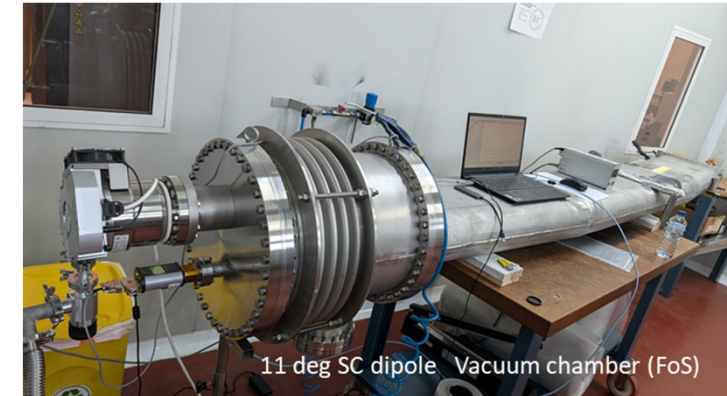


Vacuum chambers for sc dipoles

- ✓ 2 FoS chambers (9,75°, 11°); Provider: VTP, Sp
- Series chambers **awarded 09/2024**
 - Provider: Fantini (It)
 - ✓ design phase finalized
 - manufacturing of 1st chamber running
 - FAT 1st chamber scheduled still 2025
- Integration of chambers into dipoles during pre-assembly at GSI

Further vacuum components

- pumping chambers (SAES, It), design phase running
- Bellows (TEES, It), design phase running
- branching dipole chambers (CNIM, Fr) design phase done; production on hold
- beam pipes, tender to come



Super-FRS Commissioning

- ✓ (1st) Commissioning workshop in May 2025
 - focus local and remote commissioning
- ✓ agreement of beams needed for commissioning
 - Goal for 2025: detailed commissioning planning for Super-FRS before December
- Main topics open points under discussion
 - branch T, and pre-separator magnets: when cooling can happen
 - use of branch T and FTF1 as a commissioning play ground
 - need NUSTAR tracking detectors at FHF2 to commission last quadrupole



Summary

- All major procurements are awarded
- Installation of Pre-Target Area far advanced
- Installation of Target Area in preparation
 - target chamber installation will start still 2025
- Installation of Tunnel / Separator will start Q2 / 2026 and run until Q1 / 2027
 - altogether 4 provider for local cryo branches P, M, H, G
 - FAT of last ES sc multiplet in Q1 / 2026
 - Non-conformities of sc dipoles mitigated; SAT of 1st repaired dipole in Q4 / 2025; (series) production capabilities increased
- Commissioning planning established

Thank you for you attention !

