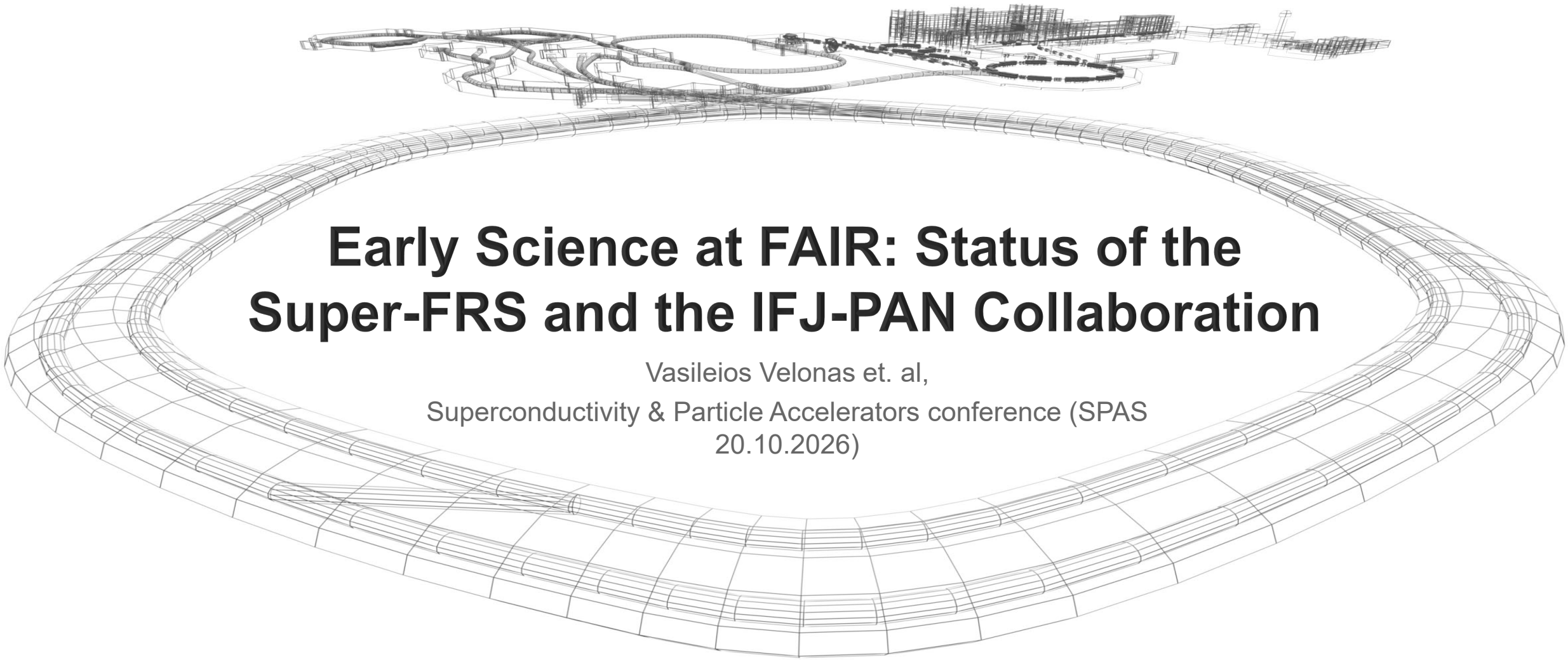


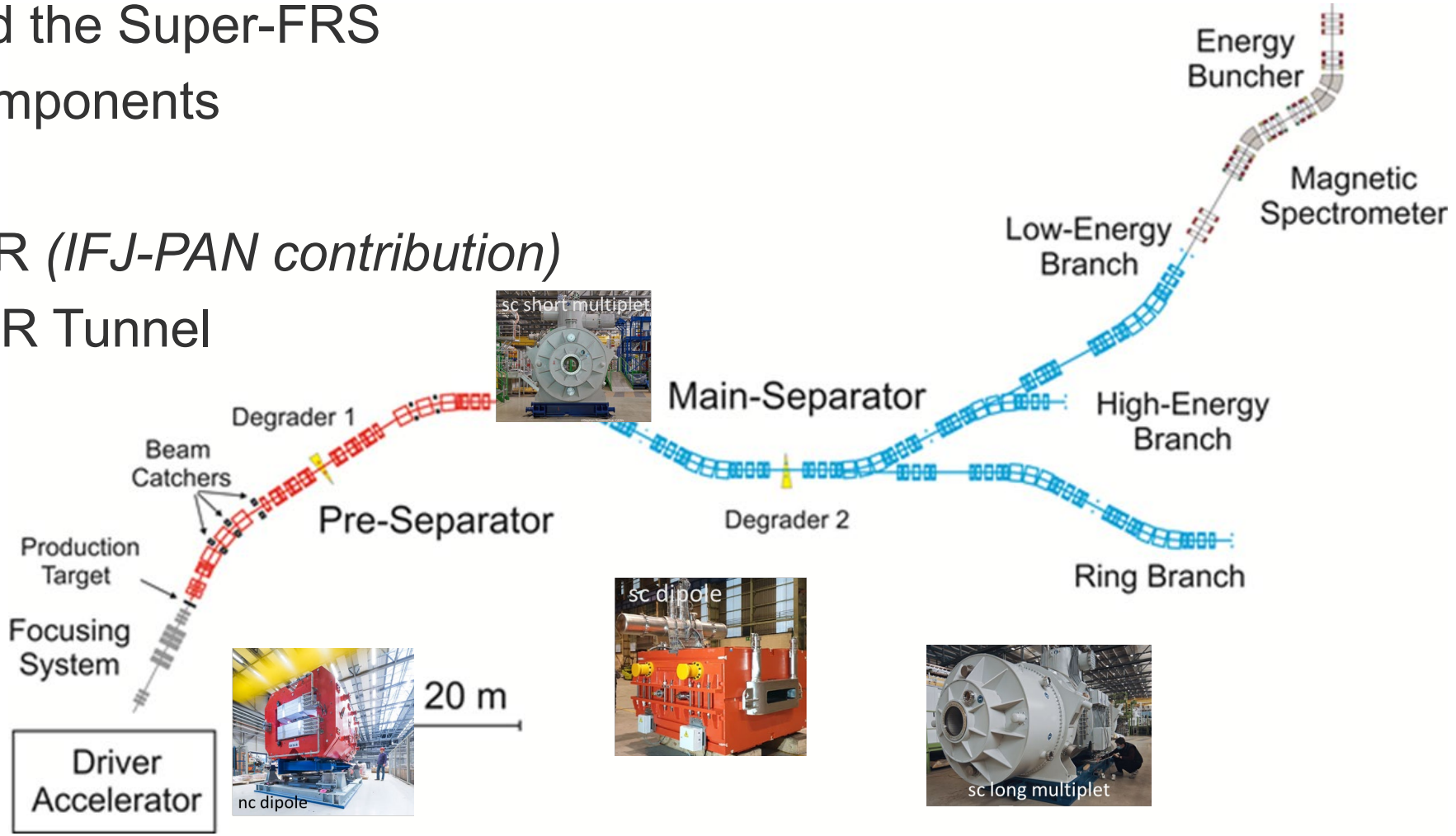
Early Science at FAIR: Status of the Super-FRS and the IFJ-PAN Collaboration

Vasileios Velonas et. al,

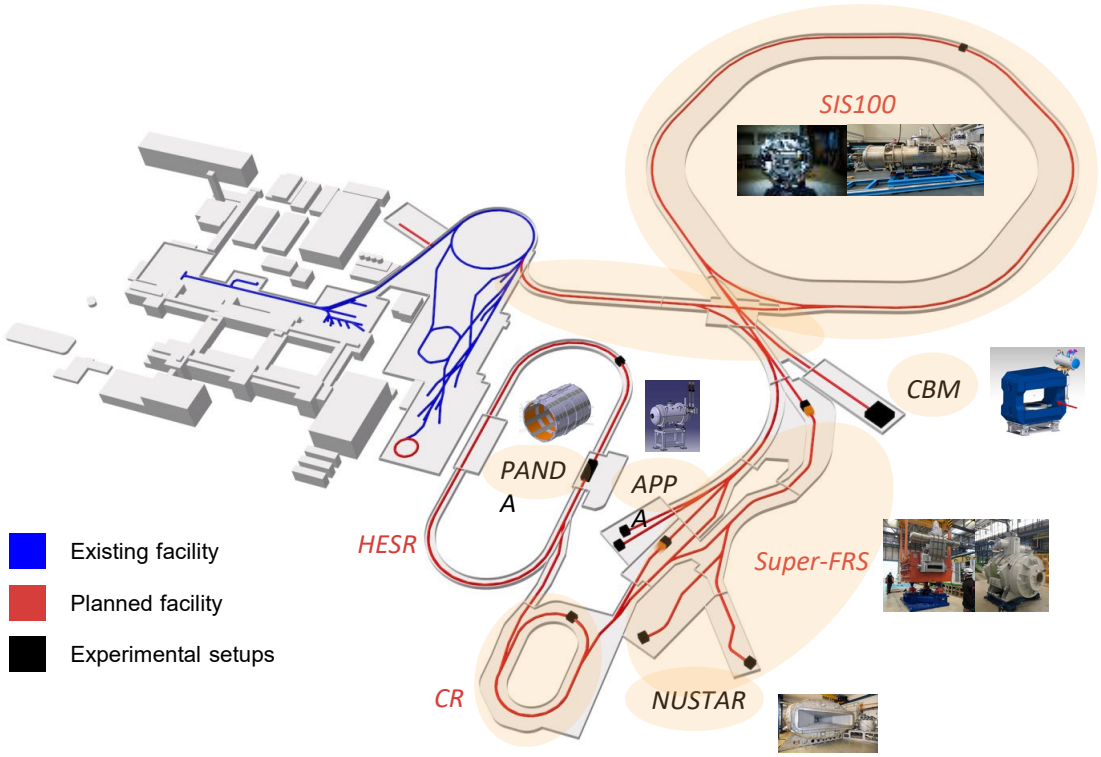
Superconductivity & Particle Accelerators conference (SPAS 20.10.2026)

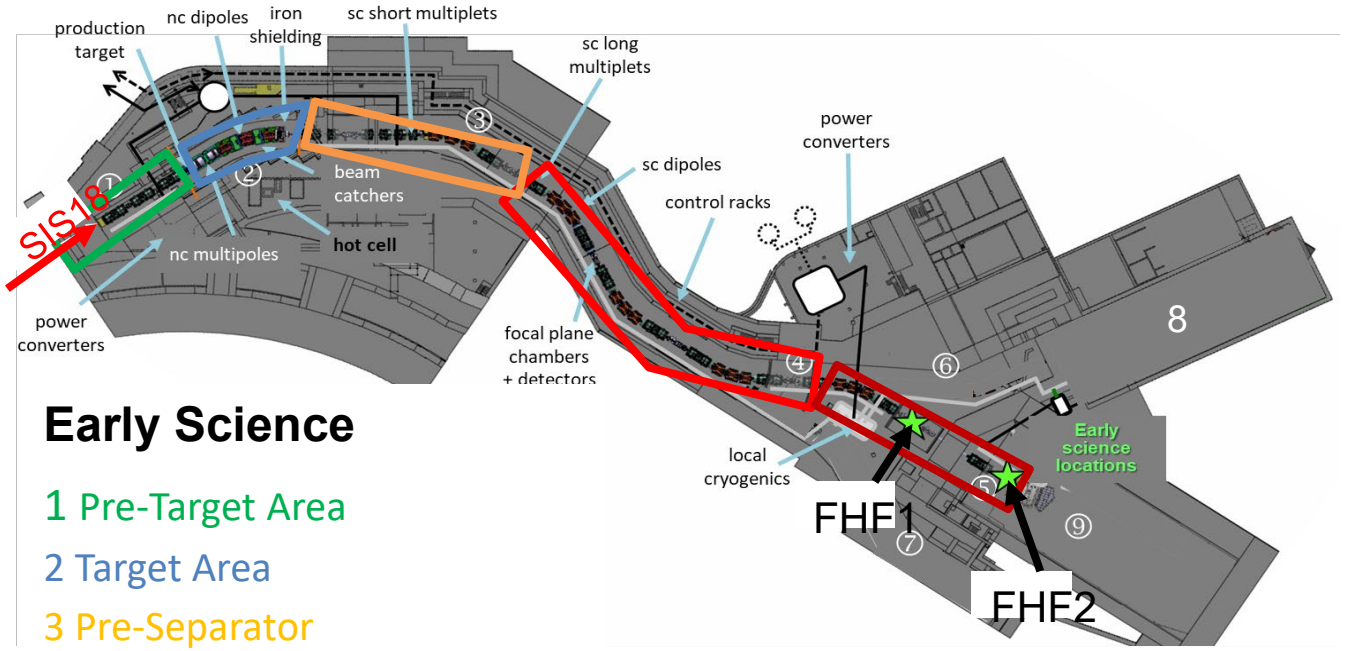
Outline

- The FAIR Facility and the Super-FRS
- Superconducting Components
- Testing at CERN
- Pre-Assembly at FAIR *(IFJ-PAN contribution)*
- Installation in the FAIR Tunnel
- Installation Schedule
- Summary



The FAIR Facility and the Super-FRS





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)

Superconducting Components

ASG, Genua, Italy

Production Multiplets

CERN/GSI, Geneva, Swizerland

Cold test Super-FRS Magnete

CEA, Saclay, Frankreich

Dipoldesign + Technical Follow up

Elytt Energy, Bilbao, Spanien

Dipole Production

GSI

Pre-Assembly and Installation



Superconducting Components

E.J. Cho,
H. Müller

The Super-FSR Multiplets (32 components, 20 for ES)



8 Short Multiplets (ca. 30t each)
Length: ca. 3m
Width: ca. 2.7m
Height: ca. 4.3m

24 Long Multiplet (ca. 60t each)
Length: ca. 7m
Width: ca. 2.7m
Height: ca. 4.3m



	Steering Dipole	Quadrupole III	Quadrupole IV	Sextupole	Octupole	Unit
Magnet type	Cos- theta	Superferric	Superferric	Superferric	Cos- theta	
n	1	2	2	3	4	
Integrated gradient, G at I_{nom}	> 0.1	> 8.0	> 11.5	20	80	T/m^{n-1}
Length of iron	500	800	1200	500	-	mm
Pole tip radius	250	250	250	238	-	mm
Outer radius of yoke	420	701	701	420	-	mm
Good field region radius	190	190	190	190	190	mm
Nominal current, I_{nom}	***293***	***275***	***268***	***291***	***160***	A
Inductance	0.62	30	42	1.04	0.1	H
Stored energy at I_{nom}	2.6	664	952	37	1.3	kJ
Number of layers	1	26	26	22	2	
Number of turn/layers	5 blocks	48	48	11	18	
Peak field in the conductor at I_{nom}	1.0	4.2	4.2	1.9	0.2	T
Magnet weight	1.6	8	12	2.5	0.125	tons
Number of magnets	14	42	32	39	40	



Typical long multiplets :
Cool down phase 1: 300 K-80 K, 7 days at a He mass flow of 30 g/s
Cool down phase 2: cold mass 80 K - 4.2 K, 4 days
Warm up (evaporation till ~300 K): 4.5 K - 300 K: 8 days

Short Multiplets:
Cool down phase 1: 300 K-80 K, 3 days
Cool down phase 2: cold mass 80 K - 4.2 K, 1.5 days
Warm up (evaporation till ~300 K): 4.5 K - 300 K: 7 days

Superconducting Components

H. Müller,
E.J. Cho,

The Super-FRS Dipoles (24 components, 15 for ES)









24 Dipoles (ca. 60t each)
Length: ca. 3.30m
Width: ca. 2.70
Height: ca. 4.5m

Scope (ES):

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

Main characteristics:

- iron dominated, warm iron. large aperture

Cold operation: Cold mass cooled by liquid helium (thermosiphon) thermal shield around 60-70 K

Cool down phase 1: 300 K-80 K, 2 days
Stabilization at 80 K: 2 days

Cool down phase 2: cold mass 80 K - 4.2 K, 8 hours Warm up:
4.5 K - 300 K: 2 days

Electrical parameters:
Nominal current: 240 A
Nominal ramp rate: 2 A/s

Testing at CERN

K. Suguta
H. Bajas et al.





rotating coils

induced voltage due to flux change + Fourier analysis

field strength/quality, harmonics

stretched wire

flux through surface traced by moved wire

field strength / quality, harmonics, magnetic axis

further (for dipole)

translating fluxmeter

Hall sensor on 3D mapper

collaboration with CERN

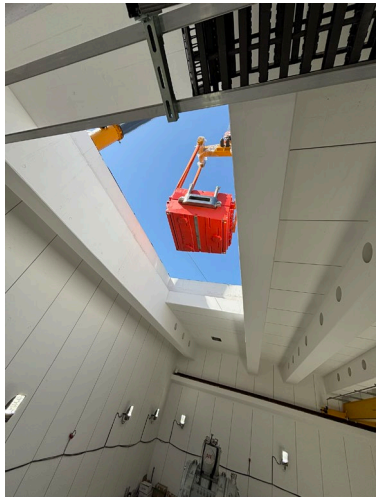
- Very successful collaboration with CERN !
- Series magnet-testing running routinely
- Personal is being increased (in total 6 GSI colleagues at CERN)
- Knowledge transfer from the testing to FAIR commissioning
- GSI-CERN Workshop and Collaboration Board Meeting in April 2026

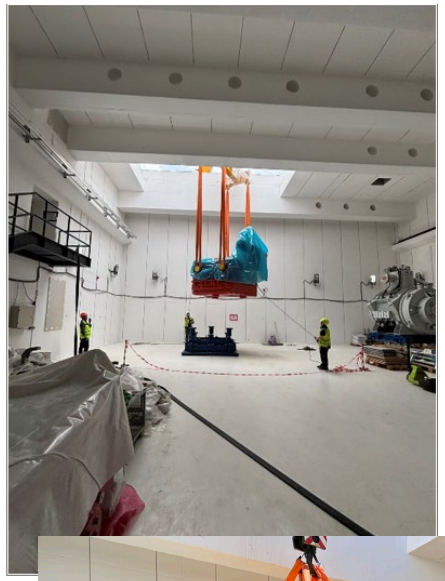
Pre-Assembly at FAIR

V. Schöll,
K. Baldus et al.

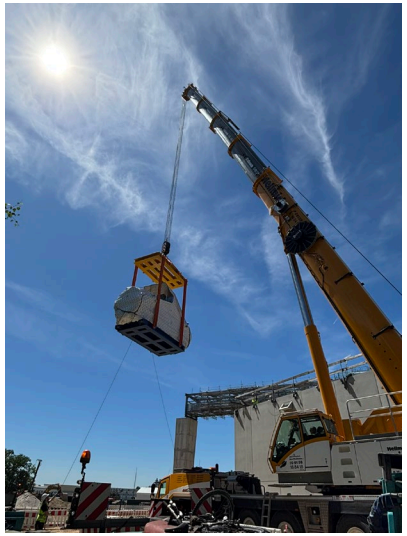
Delivery day from CERN to FAIR construction site











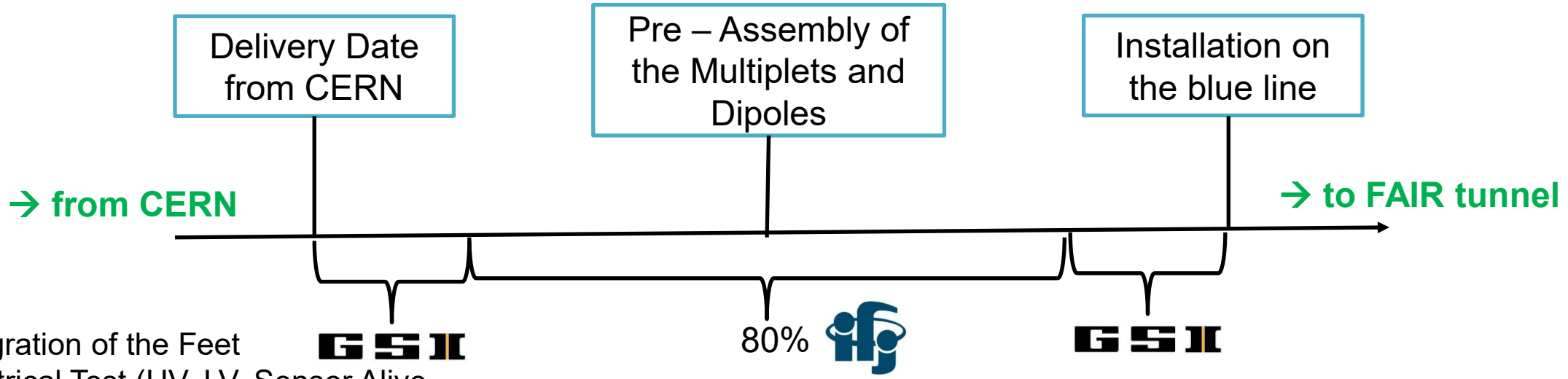






Pre-Assembly at FAIR (IFJ-PAN contribution)

T. Krochmal, B. Liszka, M. Sienkiewicz,
R. Bluemel, S. Lindner et. al.



- Integration of the Feet
- Electrical Test (HV, LV, Sensor Alive, Continuity)
- Geometrical Tests





Pre-Assembly at FAIR (IFJ-PAN contribution)

T. Krochmal, B. Liszka,
M. Sienkiewicz et. al.

- Preparing for the pre-assembly
- Visual Inspection of the components
- Installation of the strain relieve system and power boxes
- Installation of the power cable
- Beam pipe cleaning and vacuum tests



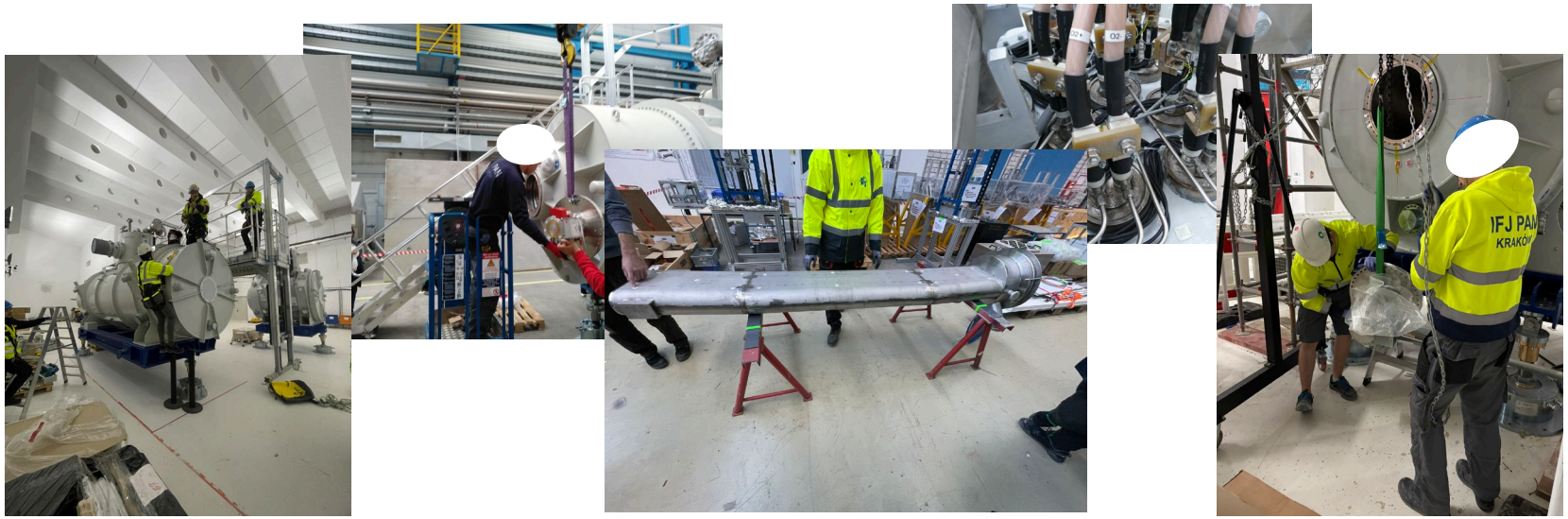






Pre-Assembly at FAIR (IFJ-PAN contribution)

T. Krochmal, B. Liszka,
M. Sienkiewicz et. al.





- Proportional valve system Installation and Leak Tests
- Integration of the dipole chamber
- Deliver of the Documentation
- Spontaneously tasks regarding multiplets and dipoles in both, pre-assembly and tunnel!

Vacuum test of the empty FPC	13 FPC chambers
Assembly of components and vacuum test of FPC	
Pre-assembly and installation	21 patch panels

Installation in the FAIR Tunnel

K. Knie, M. M. Schmidt, V. Scholl, et al.

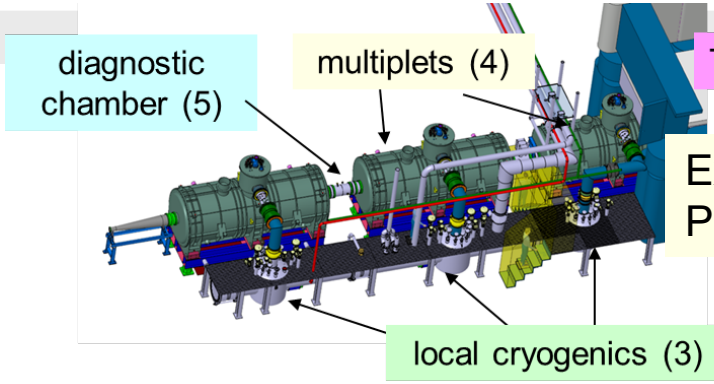
Tunnel Installation (General installation sequence)

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: IPM inst.



Example: Pre-target area



start LC 04/2025



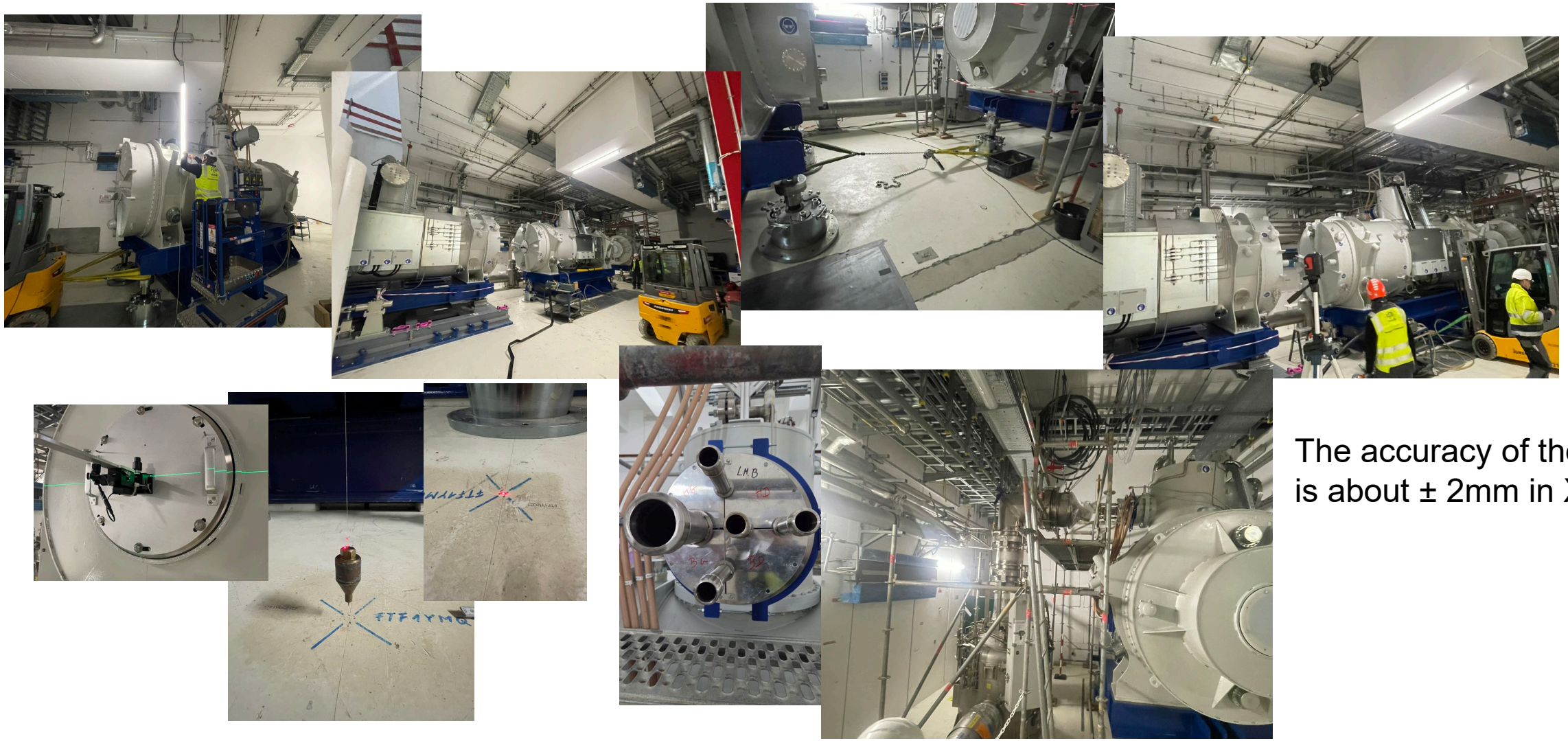


multiplets installed; tests ongoing; vacuum closed

Installation in the FAIR Tunnel

V. Schöll,
K. Baldus et al.

Pre-Target Area Installation



The accuracy of the position is about ± 2mm in XYZ

Installation in the FAIR Tunnel

F. Wamers, Y. Xiang, D. Schad, F. Dziuba, J. List, M. Miski-Oglu, et al.

Local Cryogenics

Branch P tunnel installation, part P1 – status 09 / 2026



Installation P1 (6FBs, 1EB)
- Local Cryo: close to complete

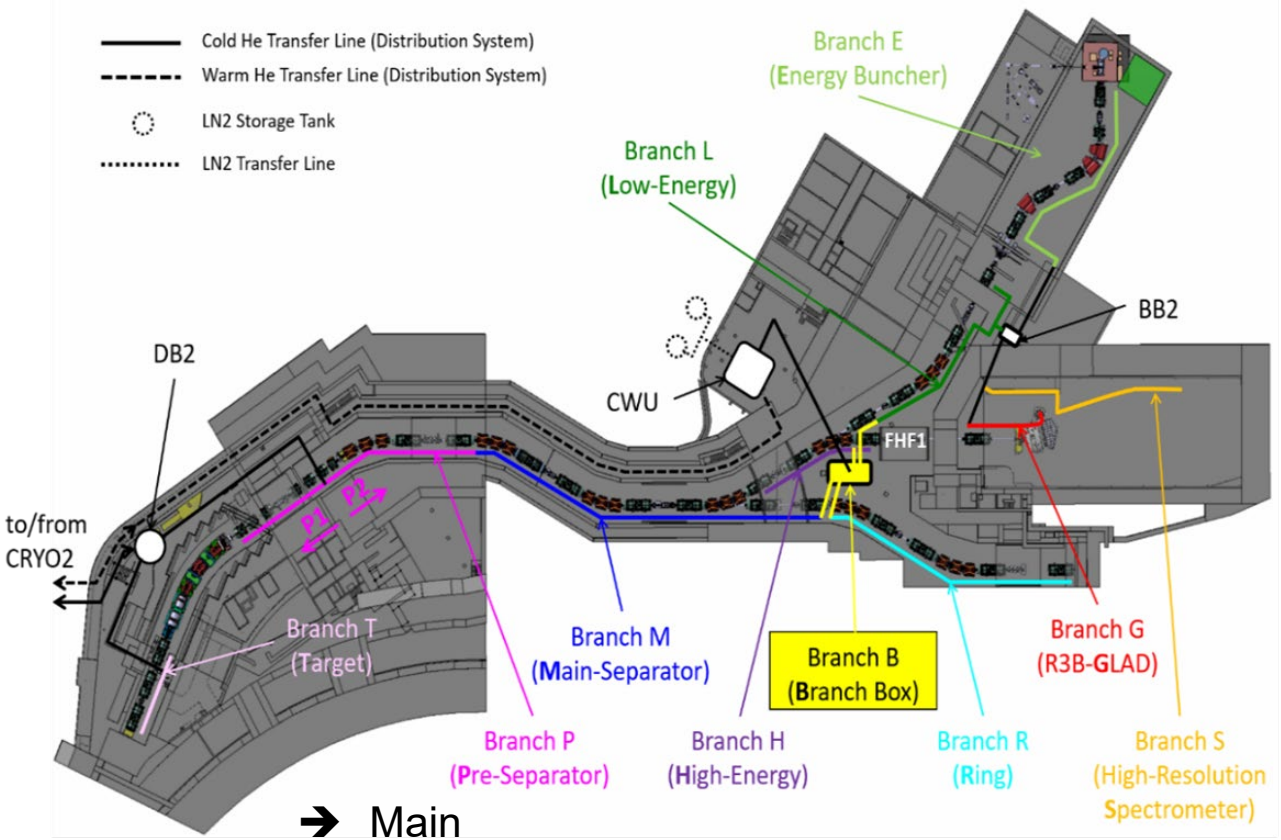
Installation P2 (6FBs)
- Local Cryo: started

Conceptual System Design: WUST

Wrocław University of Science and Technology

Provider (Cryo-Branches):
- Branch T+P: WUST (INOX+Kriosystem)
- Branch M: Cryodiffusion
- Branch H: Cryoworld
- Branch L: Cryoworld (replacement)
- Branch G: Cryoworld

Provider (Auxiliaries):
- Branch Box: Demaco
- ACPS: Demaco



➔ Main cool Down (P,M,G,H) Q1/2028

➔ First test of Branch-T Q2/2027

Installation in the FAIR Tunnel

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

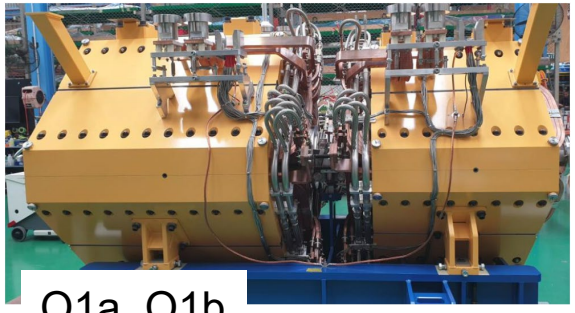
Target Area NC magnets & chamber

Features

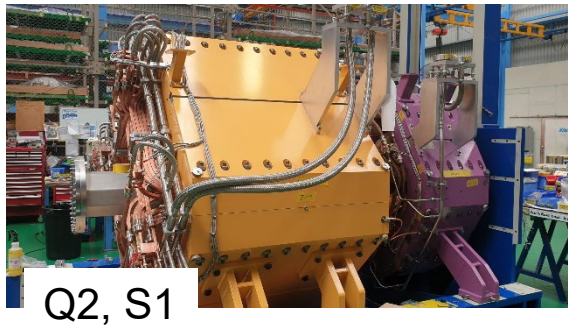
- radiation resistant MIC cable, remote connectivity
- dipole chamber includes cooling channels / EB welding

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, pre-ass. @ LEB
- 3 dipole Ti chambers under production (CNIM, FR)
  - FAT #1 passed delivery on Monday, FAT #2/3 ongoing
- 3 quads and 2 sextupoles (Buckley Systems, NZ) on site, pre-ass. in target hall



Q1a, Q1b



Q2, S1

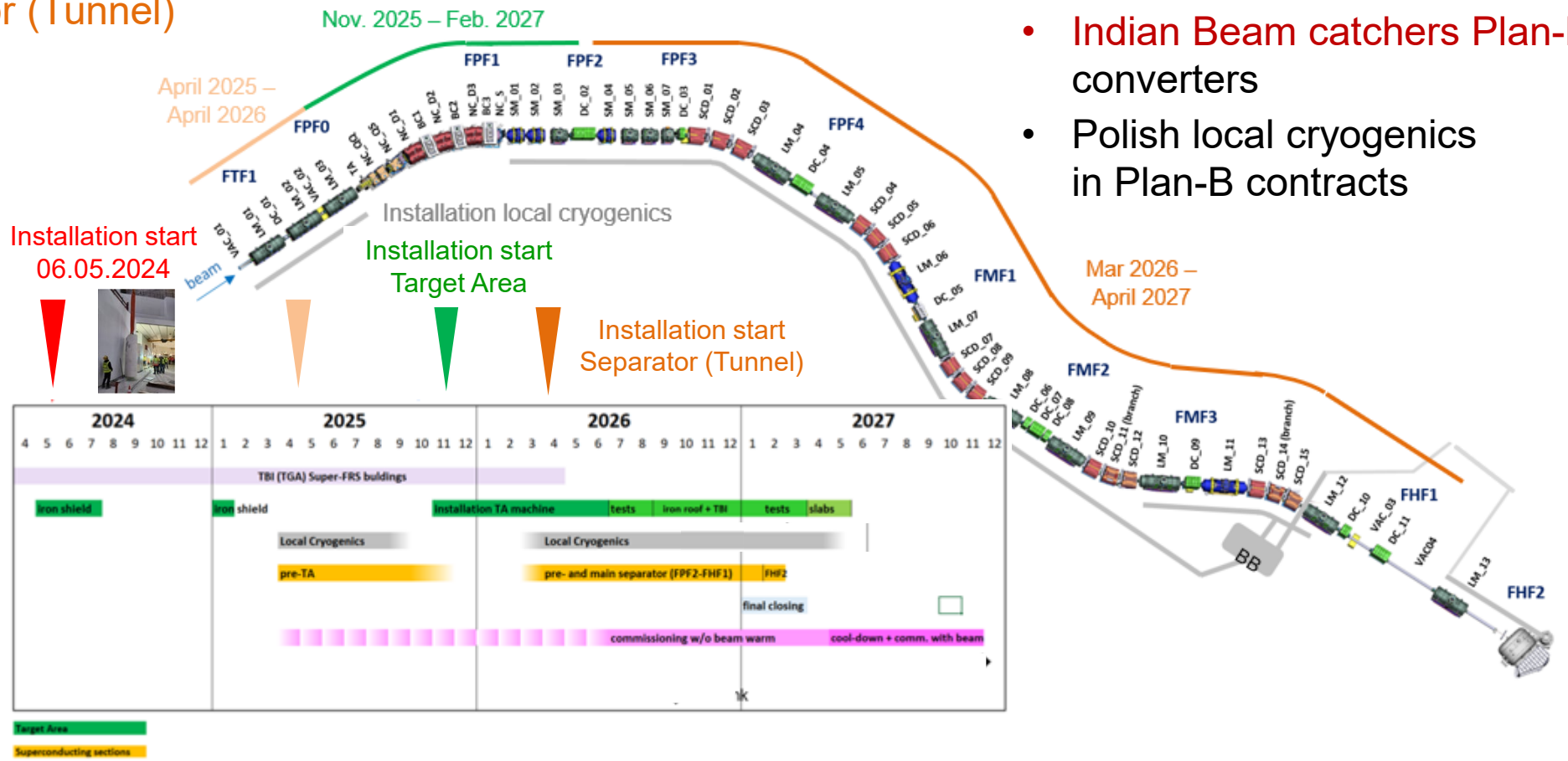


Target Area

Installation Schedule

3 installation areas:

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



Challenging in-kind packages:

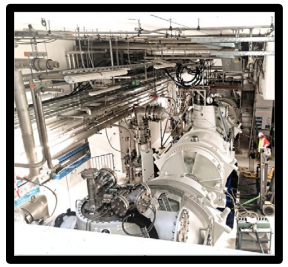
- Former Russian in-kind **needed replacement !**
- Indian Beam catchers Plan-B, power converters
- Polish local cryogenics in Plan-B contracts

Summary

- **Delivery of the Magnets at FAIR and Completion of the Pre-Assembly by IFJ-PAN**
  - 7 Short Multiplets + 1 FOS (First of Series) → All are ready for installation.
  - 10 Long Multiplets + 1 FOS → 10 are ready for installation; LM21 is ongoing → 3 remain for ES.
  - 4 Dipoles → Pre-assembly is ongoing → 11 remain for ES.



- **Pre-Target Installation**
  - All multiplets are on the blue line. The remaining interfaces will be completed by the beginning of next year.
  - First cooldown is planned for Q2/2027.

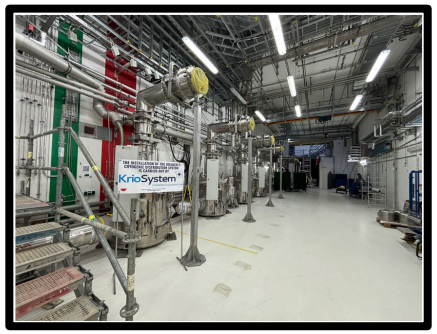


- **Target Area Installation**
  - All major TA procurements are in-house.
  - Target chamber installed and vacuum commissioning completed.
  - Pre-assembly of the units is running (along the beamline):



Summary

- **<u>Tunnel / Separator installation ongoing.</u>**
  - P1 branch installed; installation of the P2 branch has started.
  - FAT of the last ES superconducting multiplet completed.
  - Four superconducting dipoles delivered to FAIR; series production still ongoing.
  - Installation of three multiplets at the P1 branch will start in November 2026.



Dziękuję bardzo!

Thank you very much!

