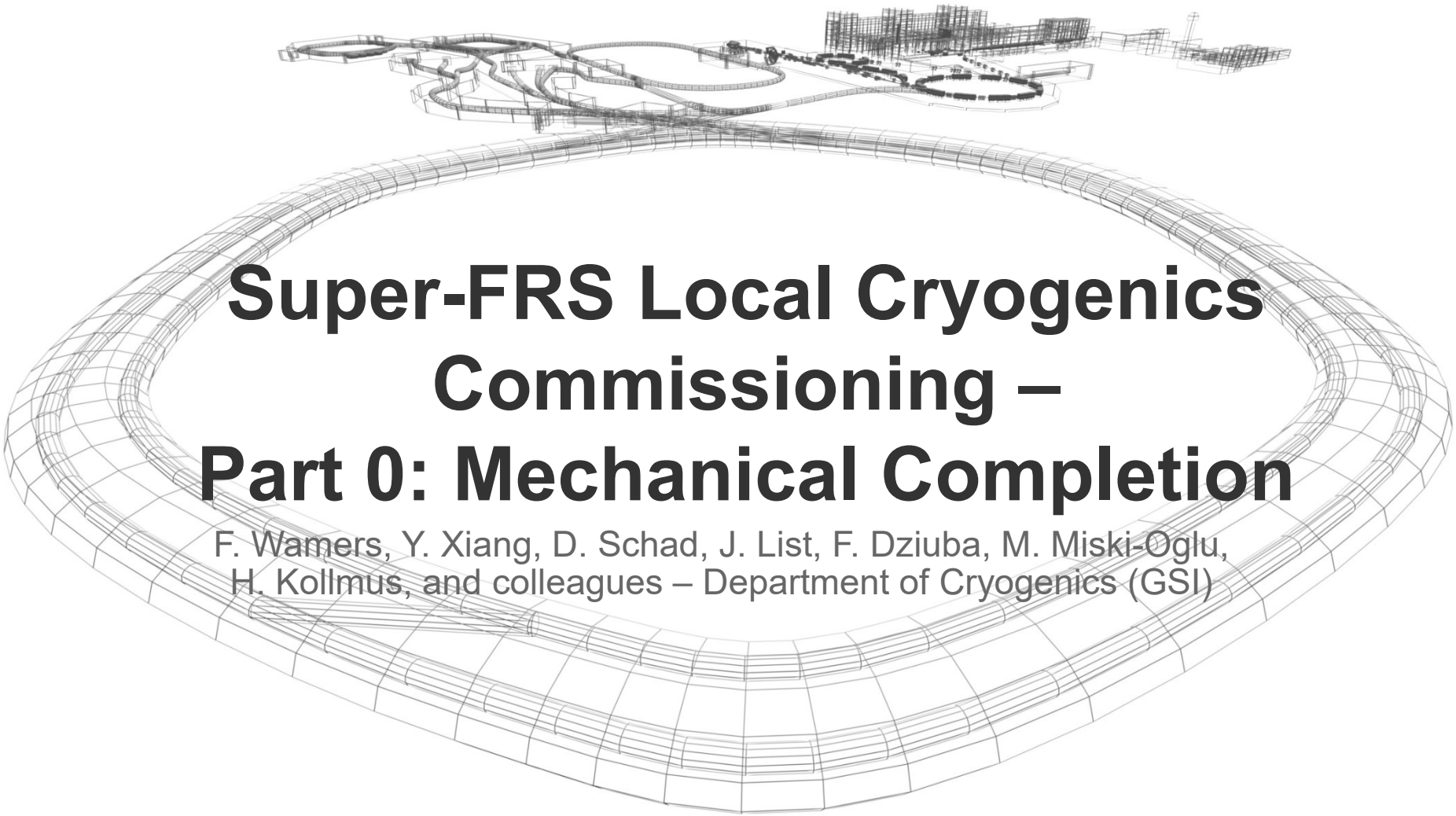


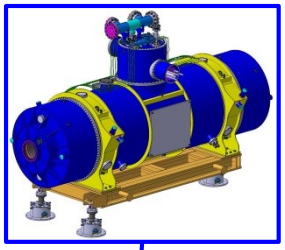
Super-FRS Local Cryogenics Commissioning – Part 0: Mechanical Completion

F. Wamers, Y. Xiang, D. Schad, J. List, F. Dziuba, M. Miski-Oglu, H. Kollmus, and colleagues – Department of Cryogenics (GSI)

INFO: The Super-FRS: Beam Line and Magnet Cryostats

2-Stage In-Flight Separator with 3 Branches to Experiments
* Large Acceptance (2.5 % Δp/p, 40 mrad φ); exotic beams
* Large Apertures for Beam Line
* Large magnetic rigidity (20 Tm)
→ **Superconducting Magnets**

24 Long Multiplets
* Cold Iron and Coils, LHe-Bath
* Cold Mass: ~ 45 tons
* LHe Volume: ~ 2000 liters
* Heat Load: 29 W / 220 W



Low-Energy Branch

High-Energy Branch

Super-FRS

Pre-Separator

Main-Separator

Secondary (exotic) Beams

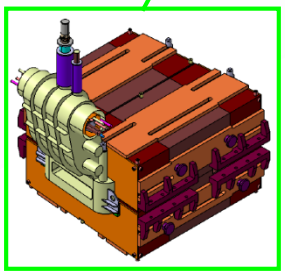
7 Short Multiplets
* Cold Iron and Coils, LHe-Bath
* Cold Mass: ~ 25 tons
* LHe Volume: ~ 1000 liters
* Heat Load: 13 W / 120 W

Ring Branch

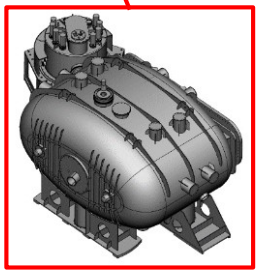
Production Target
→ Fragmentation

Focusing System

24 Dipoles
* Warm Iron, Cold Coils
* Cold Mass: ~ 1.1 tons
* LHe Volume: ~ 50 liters
* Heat Load: 12 W / 100 W



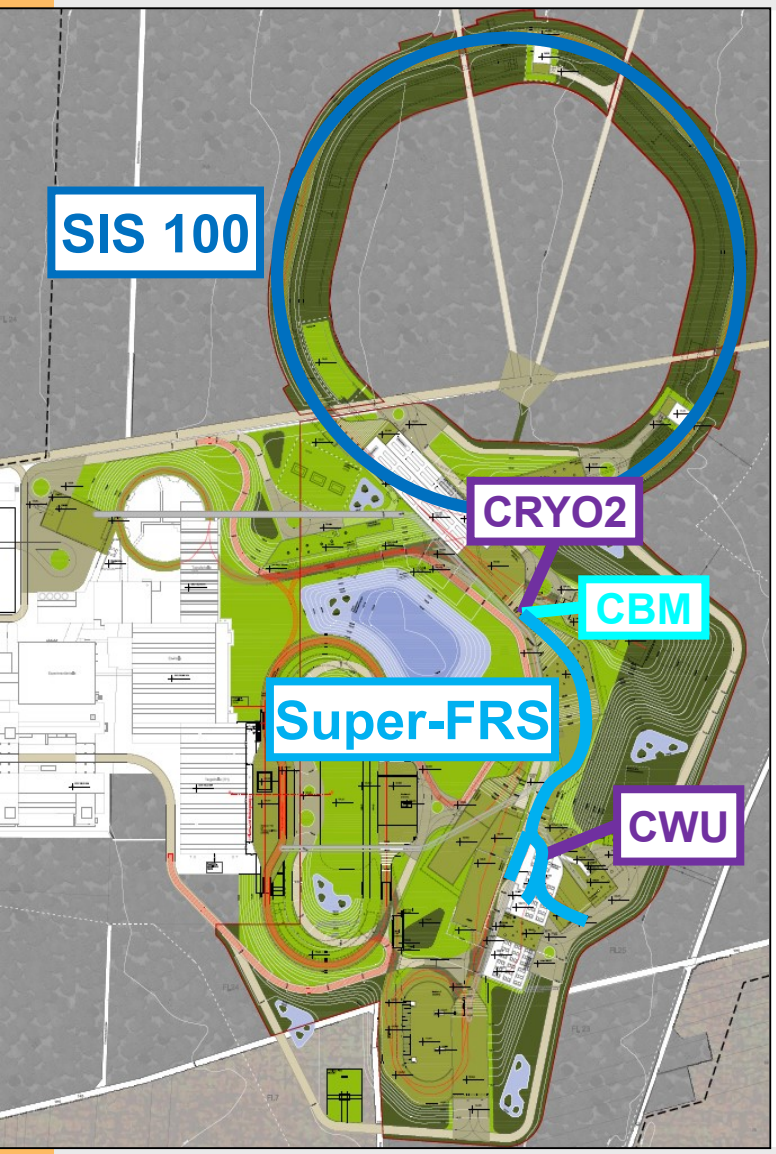
"GLAD" Experiment Dipole
* No Iron, Cold Coils
* Cold Mass: ~ 23 tons
* LHe Volume: ~ 230 liters
* Heat Load: 50 W / 300 W



Driver Accelerator (SIS 18 / SIS 100)
- Primary (stable) Ion Beams (p – U)
- ~ 1 GeV / u

~ 250 m

INFO: The Super-FRS: Part of the FAIR Cryogenic System



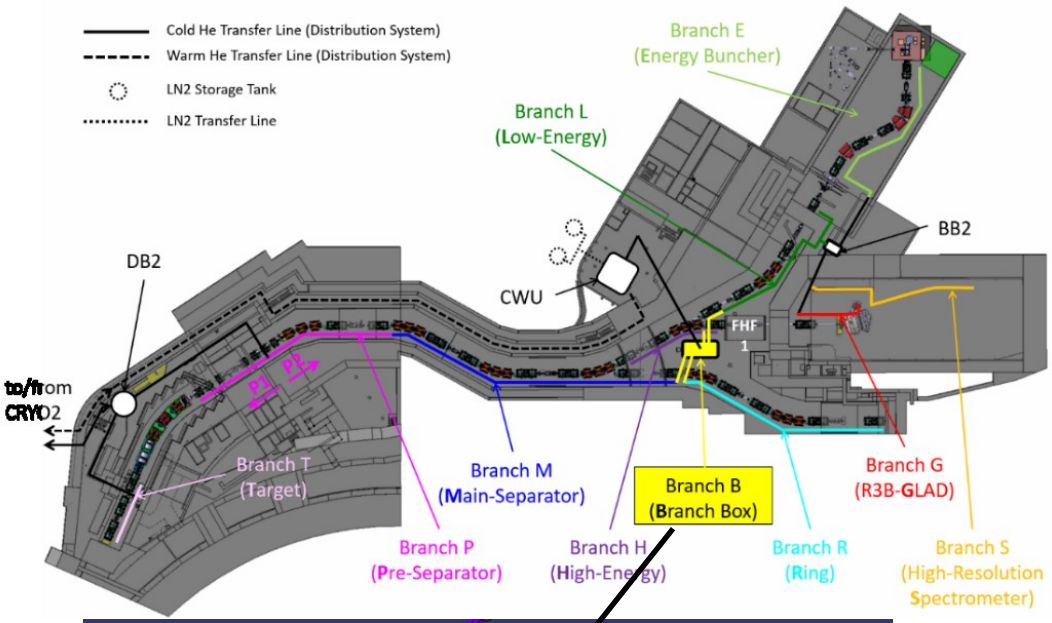
The **Super-FRS** Cryogenic System:

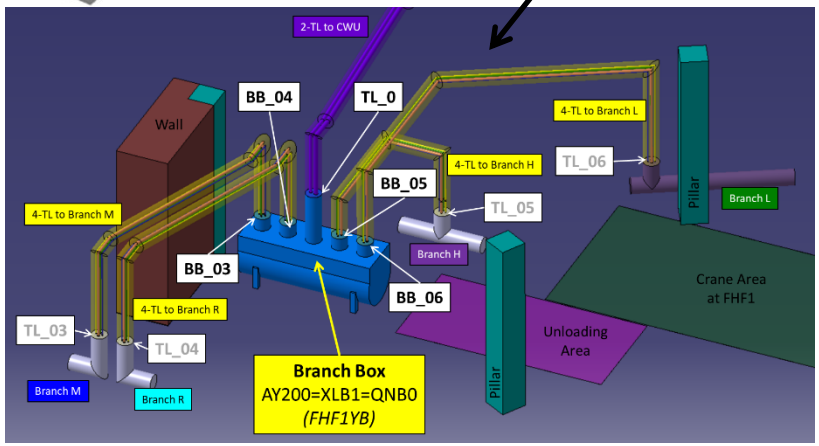
- 63 magnet cryostats (dipoles, multiplets, GLAD)
- ~ 410 m total beam-line length
- ~ 1500 tons total cold mass
- ~ 60000 liters total LHe volume
- ~ 2.1 kW static @ 4-5 K
- ~ 19 kW static @ 50-80 K
- ~ 9 g/s liquefaction needed (current leads)
- ~ 30 days total cool-down + filling time estimated (based on 100 kW (300-80 K) **CWU**, 7 kW (80-5 K) **CRYO2**, 50 g/s liquefaction)

Major Challenges for the **Super-FRS**:

- Large cold mass, large LHe inventory, PS = 20 bar
- Broad ranges of magnet types, in terms of LHe demand (factor 40) and cooling load (factor 10)
- Little beam symmetry – many bendings, many components
- Operation / cooldown in parallel with **SIS100** and **CBM** via shared use of **CRYO2** and exclusive use of **CWU**

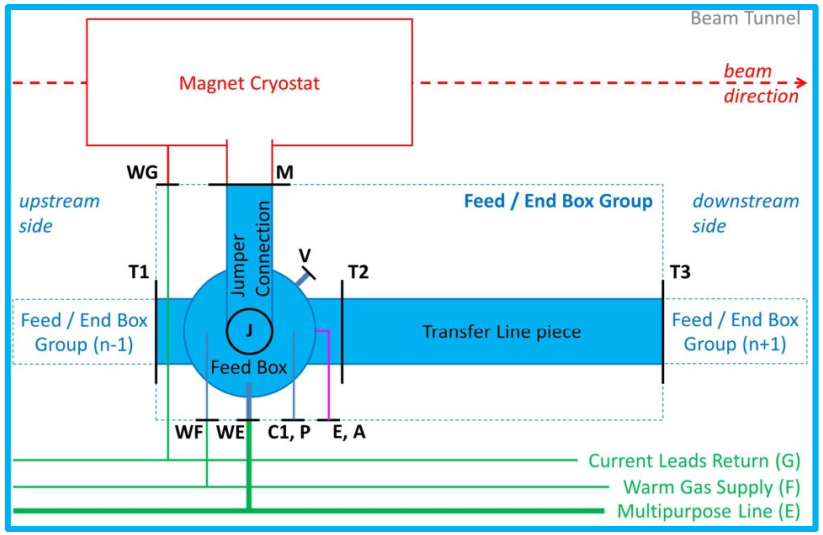
INFO: The Super-FRS Cryogenics System: Concept and Structure





Branch Box & its environment

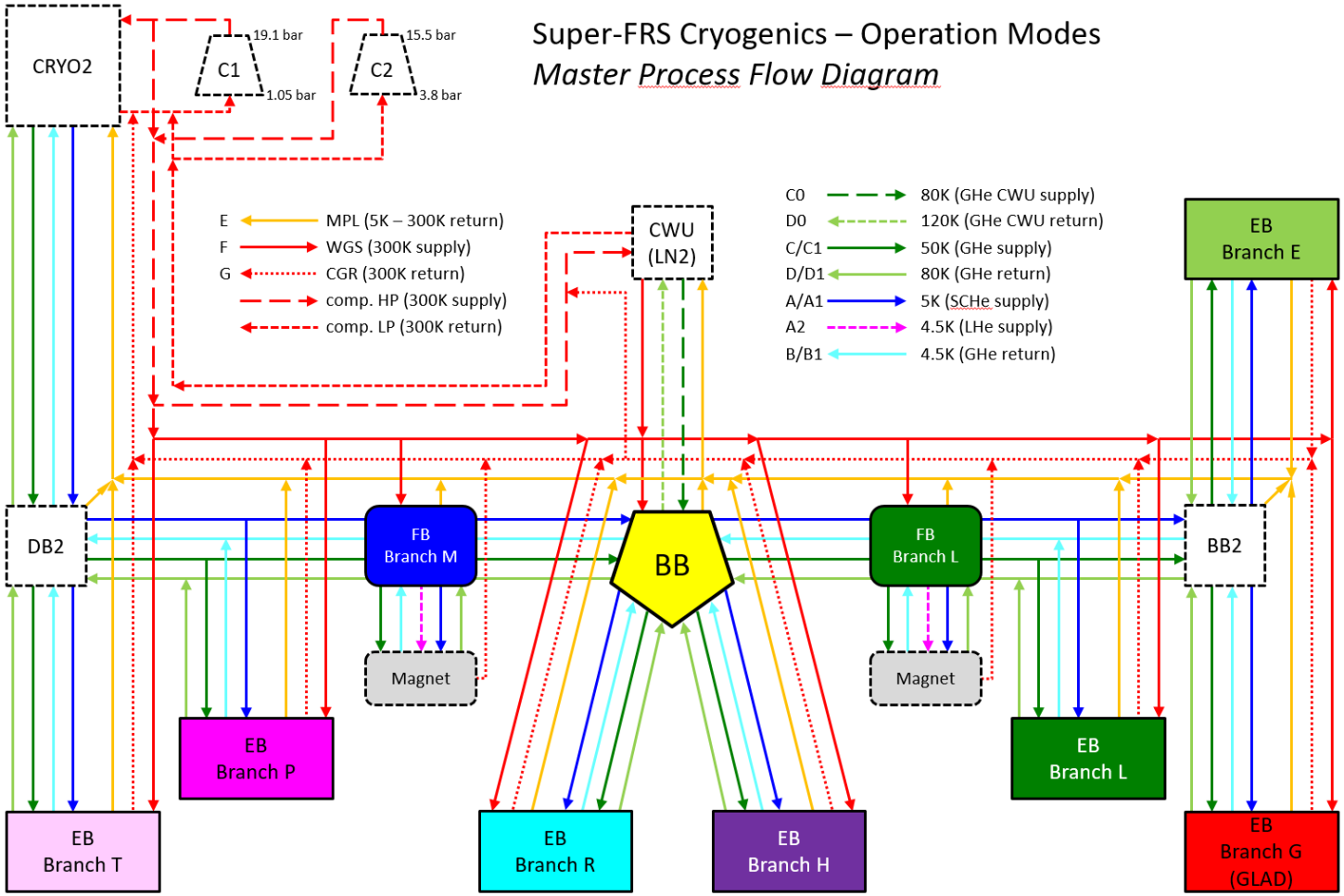
Feed Box group:
= Feed Box (or End Box)
+ Transfer Line (4 headers)
+ Jumper (5 headers, to magnet)



- Distribution Box 2 (DB2, link to CRYO2, link to CBM)
- **Branch Box** (BB, central distribution, link to CWU)
- Branch Box 2 (BB2, secondary distribution)

- **8 Branches of Feed Box groups** (Feed Boxes, End Boxes, Transfer Lines, Jumpers), in parallel to the beam line and the magnet cryostats
- **3 Auxiliary Cryogenic Piping lines** (per Branch)

INFO: The Super-FRS Cryogenics System: Operational Flow Scheme



DB2: CRYO2 operation of CBM (not shown), independent of Super-FRS cooldown, operation, and/or warmup

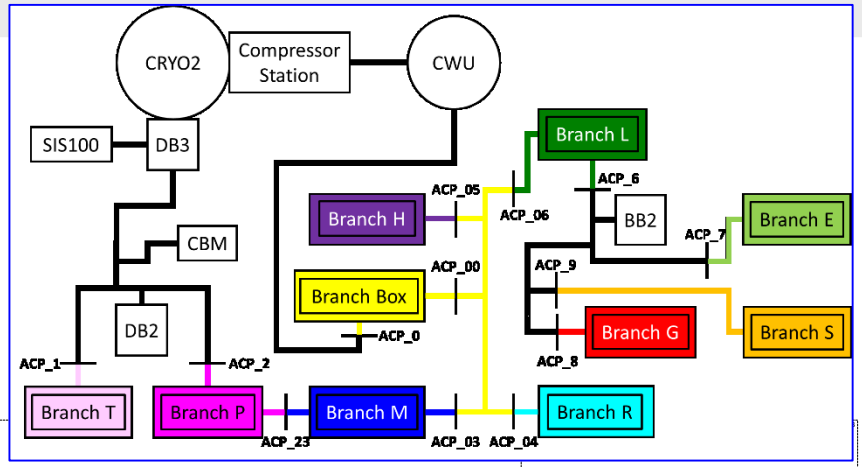
BB: parallel & independent operation (CRYO2) or cooldown/warmup (CWU) of Branches R, H, and L, to provide large flexibility for beam operation of the threes Super-FRS beam branches

BB2: parallel operation of Branches G and E, depending on beam operation for HE- and/or LE-experiments of NUSTAR

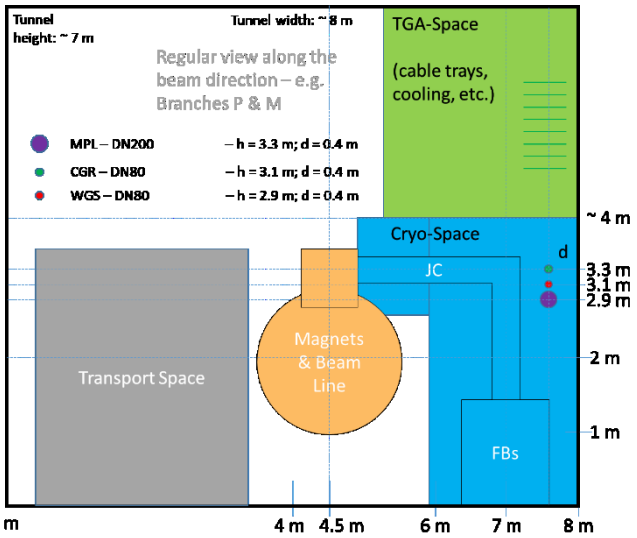
Super-FRS Local Cryogenics
Mechanical Completion – M102

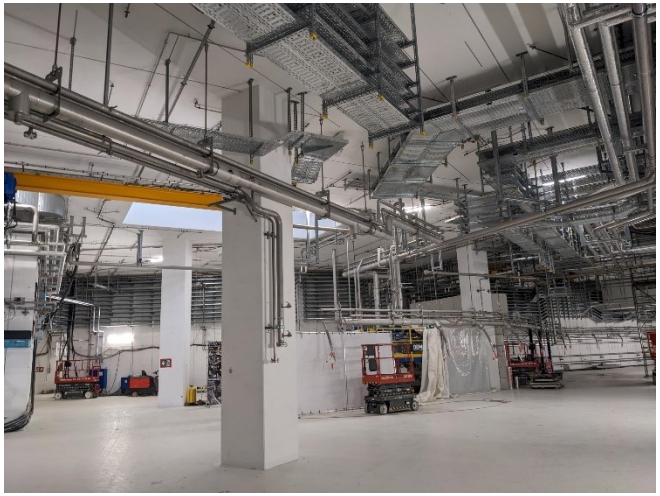
- ACPS — supplier: Demaco
- Branch Box — supplier: Demaco
- Branches of Feed Box Groups
  - Branch T — supplier: INOX/Kriosystem
  - Branch P — supplier: INOX/Kriosystem
  - Branch M — supplier: Cryodiffusion
  - Branch H — supplier: Cryoworld
  - Branch G — supplier: Cryoworld
- Capillaries for Branches‘ pressure measurement
  - Branch T — supplier: Kriosystem
  - Branches P, M, H, L, G — tender (Q3 2025) → need ~300k Euro
- Connection Works not yet contracted
  - ACPS to FBs (P, M, ++) — ~6k Euro / FB → 210k Euro
  - Magnets to FB (CL return) — ? IFJ PAN ?

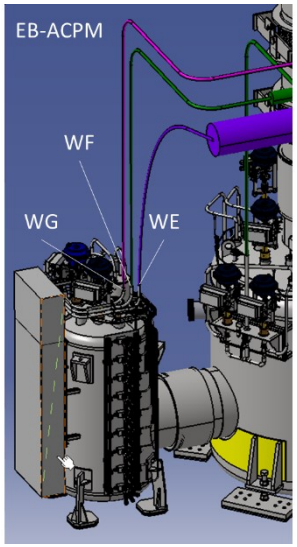
Super-FRS Cryogenics System: Mechanical Completion – M102 – ACPS

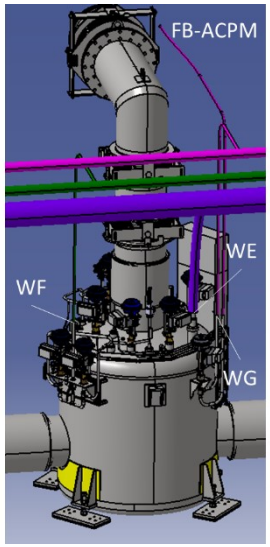


Super-FRS Cryogenics System: Mechanical Completion – M102 – ACPS





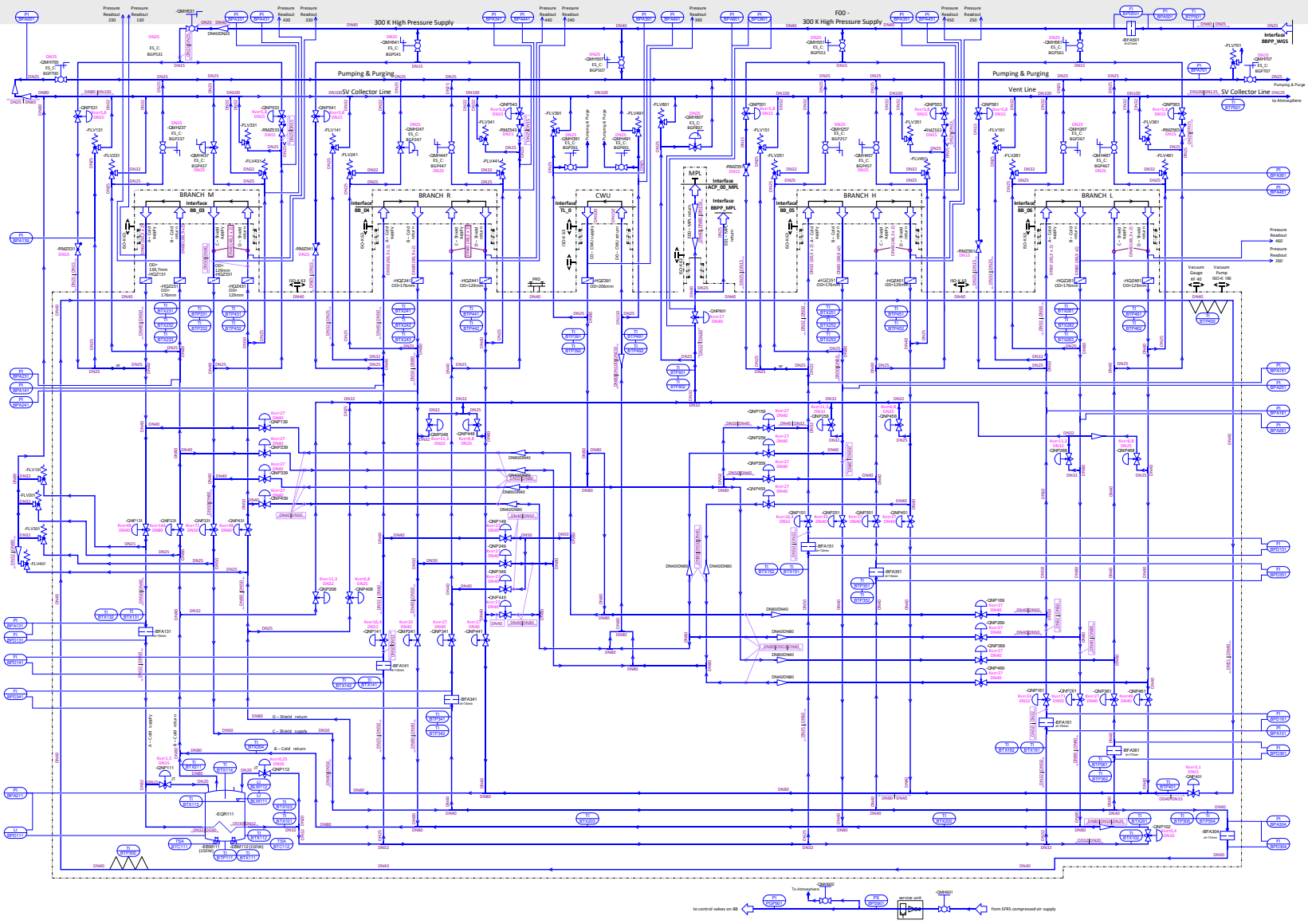




Super-FRS Cryogenics System: Mechanical Completion – M102 – ACPS

1. Installation of TBI (trays, piping, media) — done (?)
2. Installation ACPS — done
3. Connection ACPS – Branch Box — done
4. Connection ACPS – Distribution System
   - Branch T (DB2 System – Cryodiff.) — Feb 2026
   - Branch P (DB2 System – Cryodiff.) — Feb 2026
   - Branch B (CWU) — July 2025
   - Branch L (BB2 / Branch L System) — Jan 2026
   - Branch G (BB2 / Branch L System — Jan 2026
5. Connection ACPS – Branches (Feed / End Boxes)
   - see Branches
6. EDMS Documentation — (partly done – 2026)

Super-FRS Cryogenics System: Mechanical Completion – M102 – Branch Box

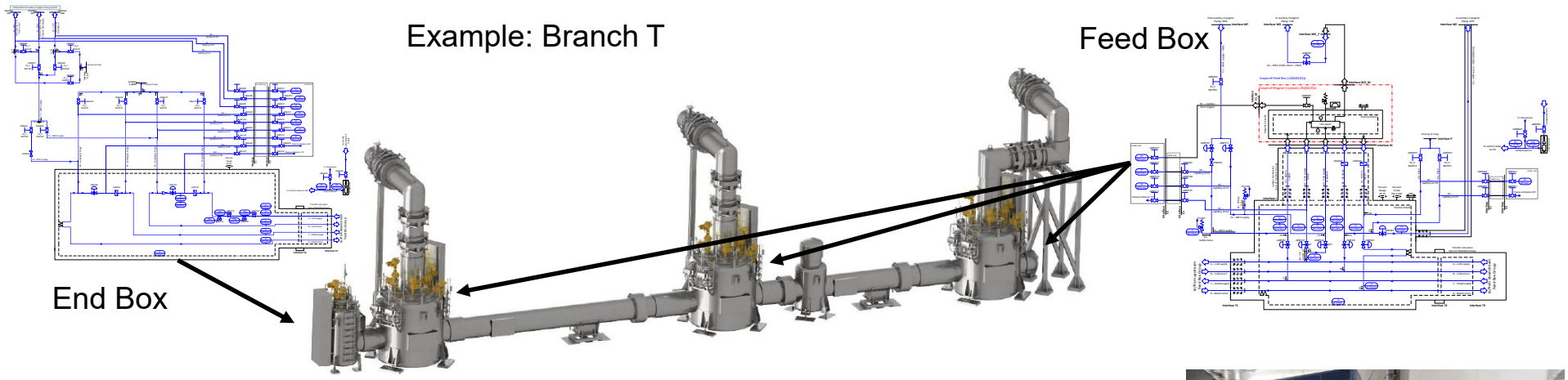


Super-FRS Cryogenics System: Mechanical Completion – M102 – Branch Box

Super-FRS Cryogenics System: Mechanical Completion – M102 – Branch Box

1.	Installation TBI (trays, piping)	done (?)
2.	Cable Pulling (placing into trays)	? 2026 ?
3.	Installation ACPS	done
4.	Installation Branch Box	done
	▪ Installation protection: cover	done
	▪ Instalaltion protection: impact blocks	June 2025
5.	Connection Branch Box – ACPS	done
6.	Connection Branch Box – Branches	
	▪ Distribution System (CWU-TL)	July 2025
	▪ Branch M (Cryodiffusion)	Sept 2026
	▪ Branch H (Cryoworld)	Oct 2026
	▪ Branch L (Cryoworld)	Jan 2026
7.	Installation Local Cabel Trays	? 2026 ?
8.	Connection Media	
	▪ Vacuum Pump Station	? 2025 ?
	▪ Compressed Air	? 2026 ?
	▪ Cables	? 2026 ?
	▪ Earthing	? 2026 ?
9.	EDMS Documentation	(partly done – 2026)

Super-FRS Cryogenics System: Mechanical Completion – M102 – FB Groups



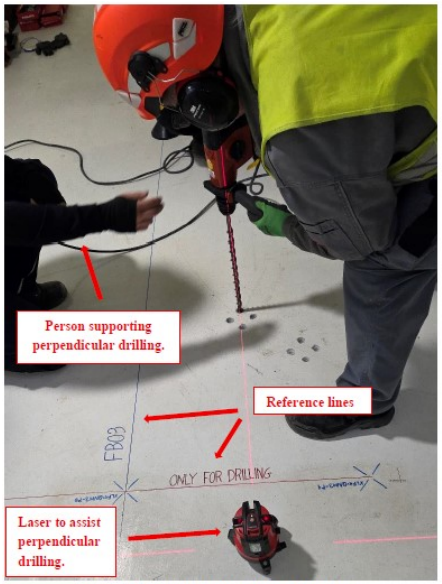


Fig. 2. The timing of the final drilling of the holes.

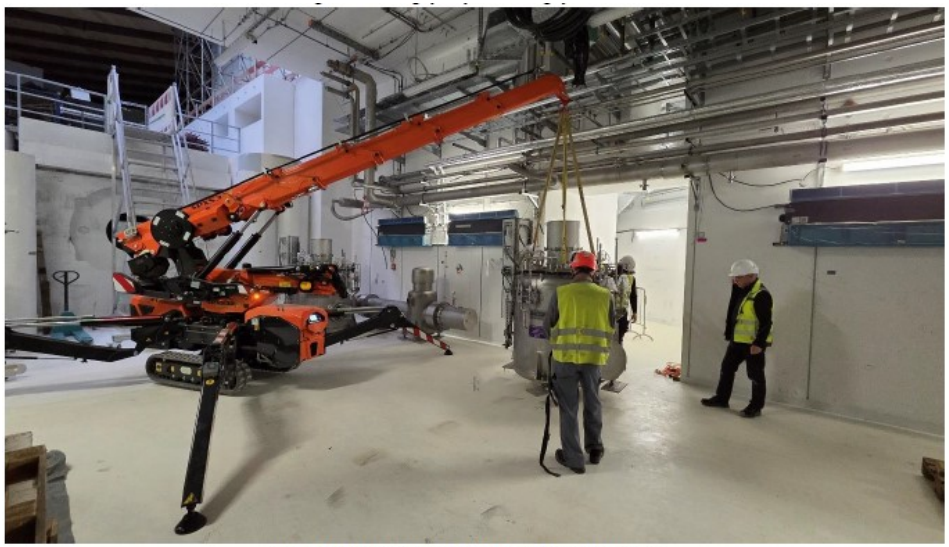


Fig. 3. Moment positioning of FB02 using a mobile crane.

Fig. 22. FB02 after positioning.

Super-FRS Cryogenics System: Mechanical Completion – M102 – FB Groups

1. Installation TGA (trays, piping, media)
2. Cable Laying (into trays)
3. Capillary Laying (into trays)
4. Installation ACPS
5. FoS-Testing (per supplier)
6. Installation Branch/Section (FBs+EBs)
7. Installation PT Racks
8. Connection Capillaries (FBs+EBs & Racks)
9. Connection ACPS FBs/EBs
10. Connection Jumpers-Magnets
11. (Connection ACPS to external (DS))
12. (Connection Branches to external (DS))
13. Installation Local Trays
14. Connection Magnet CGR and capillary
15. Connection Media
    - Vacuum Pumping Stations (Cryo Insulation Vacuum)
    - Earthing
    - Cables to Branches (FBs, EBs, Magnets)
    - Compressed Air
16. EDMS Documentation

Super-FRS Cryogenics System: Mechanical Completion – M102 – FB Groups

	T	P1	P2	M1	M2	M3	H	G
1 – TGA installation	? done	? 2025	? 2025	? done	? done	? done	? done	? done
2 – Cable laying	? Q3 2025	? Q1 2026	? Q1 2026	? Q1 2026	? Q1 2026	? Q1 2026	? Q1 2026	? Q1 2026
3 – Capillary laying	2025	Q1 2026	Q1 2026	Q1 2026	Q1 2026	Q1 2026	Q1 2026	Q1 2026
4 – ACPS installation	done	done	done	done	done	done	done	done
5 – FoS-testing (per supplier)	done	! Q1 2026	----------	? Q2 2026	----------	----------	----------	? Q2 2026
6 – Branch (FBs…) installation	Q3 2025	Q2 2026	Q2 2026	? Q3 2026	Q3 2026	Q3 2026	Q3 2026	? Q3 2026
7 – PT-Rack installation	? Q4 2025	? Q2 2026	? Q2 2026	? Q3 2026	? Q3 2026	? Q3 2026	? Q3 2026	? Q3 2026
8 – Capillary connect. (FBs / Racks)	Q3/Q4 2025	Q2/Q2 2026	Q2/Q2 2026	Q3/Q3 2026	Q3/Q3 2026	Q3/Q3 2026	Q3/Q3 2026	Q3/Q3 2026
9 – ACPS connections (FBs…)	Q3 2025	Q2 2026	Q2 2026	Q3 2026	Q3 2026	Q3 2026	Q3 2026	Q3 2026
10 – Jumper-Magnet connections	Q3 2025	Q2 2026	Q2 2026	Q3 2026	Q3 2026	Q3 2026	Q3 2026	Q3 2026
11 – ACPS connection ext.	Q1 2026	Q1 2026	----------	----------	----------	----------	----------	Q1 2026
12 – Branch connection ext.	Q1 2026	Q2 2026	P2 - M1: Q3 2026		----------	BB: Q3 2026	BB: Q3 2026	L: Q3 2026
13 – Local Tray installation	? Q4 2025	? Q3 2026	? Q3 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026
14 – Magnet CGR+cap. connect.	? Q4 2025	? Q3 2026	? Q3 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026
15. a) – Ins. Vacuum installation	Q3 2025	? Q3 2026	? Q3 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026
15. a) – Earthing	? Q4 2025	? Q3 2026	? Q3 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026
15. a) – Cable connections	? Q4 2025	? Q3 2026	? Q3 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026
15. a) – Compr. air connections	? Q4 2025	? Q3 2026	? Q3 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026	? Q4 2026
16 – EDMS documentation	Q1 2026	Q1 2027	Q1 2027	Q1 2027	Q1 2027	Q1 2027	Q1 2027	Q1 2027

Questions

- CRY: When and how will CWU commissioning be done ?
  - Can/should we use CWU already at an early stage, parallel to Branch T cooldown via CRYO2, in order to pre-commission (flushing / purging / pre-cool) the Branch Box in a closed loop?
- CRY: Details of FoS-Testing Branches P1, G, M1 ?
- SFRS: When will the Blue Line for Branches P, M, … be done?
- SFRS: Are ‚field cables' really not „routed" (cable cards)?
- SFRS: Are ‚field cables' only installed and connected after local-tray installation ?
  - installing them after Local-Cryo / Magnet installation could be too difficult or risky.
  - need discussion and clarification of work-flow (SCM, CRY, SFRS, SMG, FSB)
- SFRS: Will cables of Branch L be installed/pulled at all?
  - might impact necessity/possibility of Branch L capillary installation
- CRY/SFRS: Can capillaries be connected without prior local trays ?
  - if not, after local-tray installation
- SCM/IND/CRY: Let's do SCM loop checks (A103) in parallel to CRY?

Outlook

- A103 → M103: Local Hardware Commissioning
  - „Loop Checks“ – making sure all instrument channels (also SCM?) are wired and active for manual operation via IND
- A104 → M104: Remote Commissioning
  - Cooldown, cold operation and instrument tests, warmup of local cryo Branches (without Magnet cryostats cooling)
    - Commissioning of Transferlines, End Boxes and Branch Box
- A105 → M105: Integration
  - Cooldown, cold operation and instrument tests, of local cryo Branches (including Magnet cryostats cooling)
    - Commissioning of Feed Boxes and Magnet cryostats
- A11 → M11: Dry Run
  - Magnet powering → additional Cryo+Magnet tests