

CERN-GSI Collaboration Super FRS magnets for FAIR

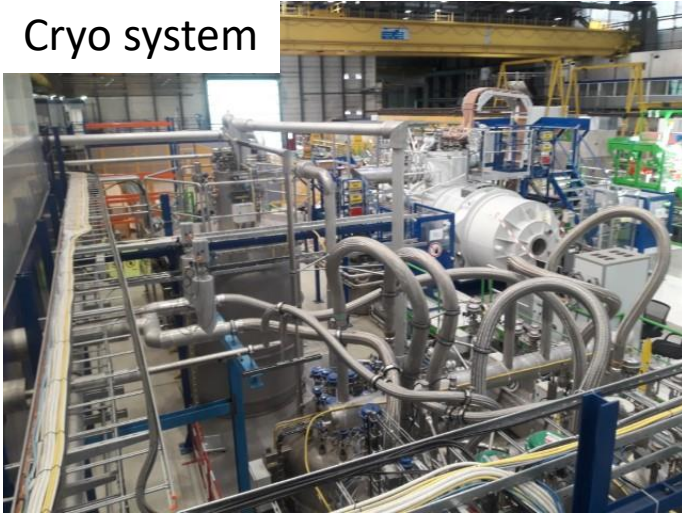
B180 Test facility and CERN activities

25 November 2021

G. Riddone on behalf of the CERN-GSI team, TE-RAS

CERN facility in B180

Cryo system



Racks for quench protection system



3x Test Benches



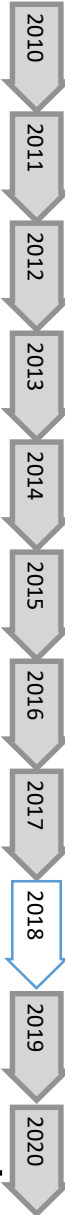
Content

- *Collaboration agreement: where we stand*
- *Organisation and CERN involvement*
- Magnet assembly deliveries
- **CERN activities**
- **Status of the main systems**
- From FoS to Series: preparation and planning
- Conclusions

History, testing at CERN and coll. agreement



Project leader
CERN: Luigi Serio
GSI: Pierre Schnizer



2010 CERN-GSI Agreement K1727
General agreement on collaboration in accelerator science and technologies

2012 Addendum No.2
Cryogenic testing of SuperFRS Magnets at CERN

2014 Addendum No.4
Procurement of pre-cooler, QPS, Survey tools

2015 Amendment to K1727
Extension of scope

2016 Addendum No.5
Floor, control room



2017 CERN: Lisette Van Den Boogaard
GSI: Kei Sugita

2018 Addendum No.12 [KR3912]
Operation of the cryogenic test facility at CERN for the test of the Super-FRS magnets for FAIR



2019 CERN: Stephan Russenschuck
GSI: Kei Sugita

2019 Books closed for project



2020 CERN: Germana Riddone

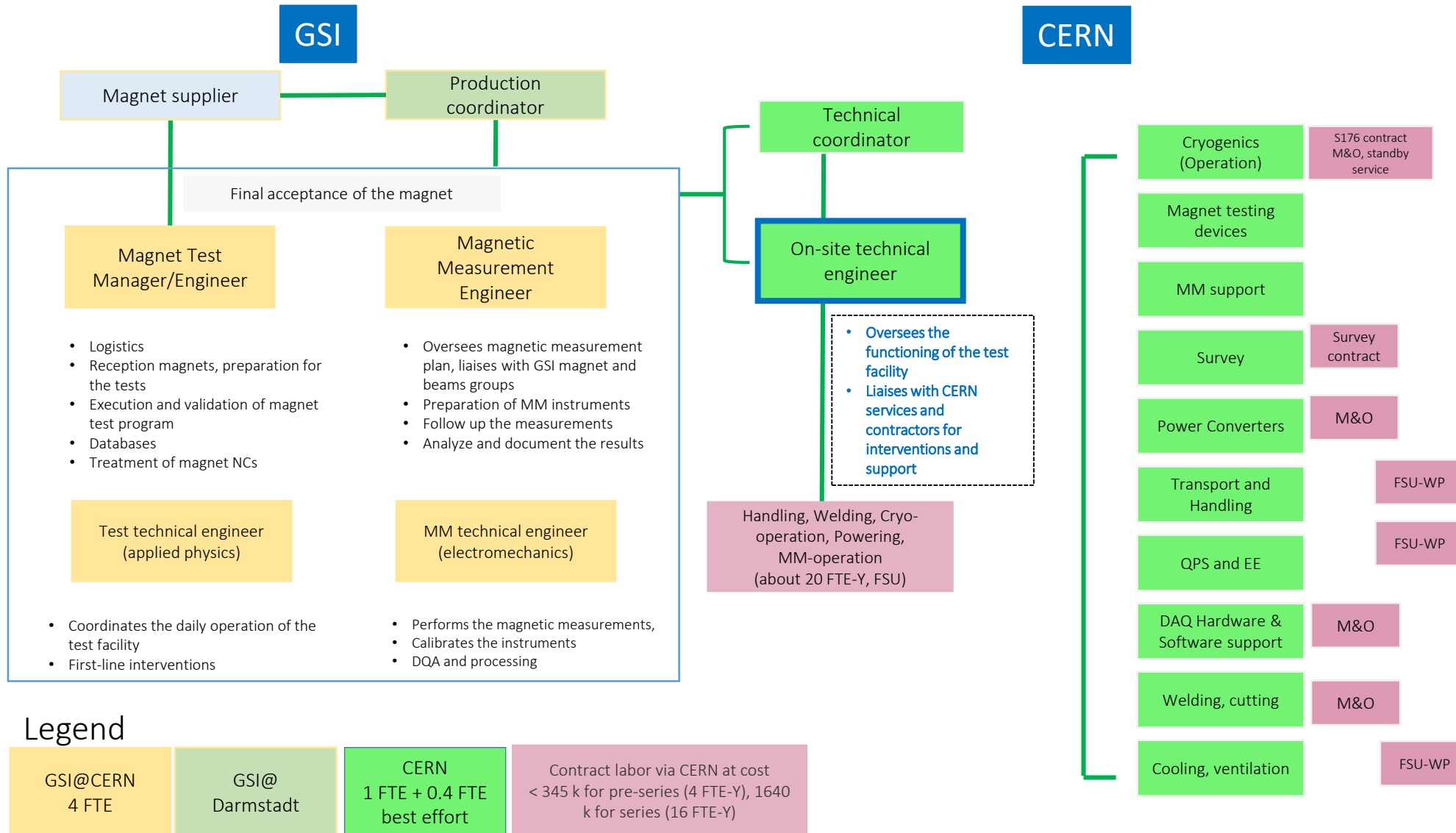
2020 Operation in times of Sars-Cov-2

GSI-CERN collaboration agreement

KR3912/TE, Addendum No. 12 to the 2010 agreement K1727/DG

- GSI is leading the activity, and contributes to it with:
 - 4 FTE: operation team (2 eng. and 2 technical eng.)
- CERN is contributing with:
 - 1.4 FTE of expertise, support and coordination with internal services and CERN contractors (operation and maintenance, special activities such as handling and survey);
 - **1 FTE: on-site technical engineer officially from Jan 1st 2022**
- Industrial support from other groups which is charged to GSI on **cost-recovery basis**: the total cost estimated at 5.4 MCHF for the two phases now until Q1/2026 (originally until Q1/2024).
 - **GSI has requested to make payments in advance.**
The result is that there is now a disconnect between Revenue and Expenses, substantial funds still available: **1.946 MCHF.**

Organisation



Work flow – Magnet assembly main steps

- GSI
- CERN
- Common

- Reception to bldg. 180
- Reception documents' check
- Handling
- Unpacking/unwrapping
- Visual inspection
- Electrical tests at warm
- Installation on feet
- Opening transfer lines
- Transport to test bench

- Removal of feet
- Purging
- Electrical tests at warm
- Packing (ext.)
- Handling
- Check out

Preparation
area IN

Test benches

Preparation
area OUT

- Alignment
- Transport rods removal
- Mounting safety valve
- Jumper alignment and connection
- Leak tests
- Electrical tests at warm
- Cold mass survey
- Control software settings
- Insulation vacuum pumping
- Gas analysis and Cooldown
- Current leads cooldown
- Cold mass survey
- Electrical test at cold
- Commissioning/Powering
- Magnetic measurements
- Magnetic axis fiducialization
- Warmup
- Cold mass survey
- Jumper Disconnection
- Insulation vacuum breakage
- Transport to preparation area

Activities and CERN resources

(7 groups, 4 departments)

Magnet

- | | Resources |
|------------------------------------|--------------------------|
| 1) Transport | EN-HE + Magnet supplier |
| 2) Unwrapping | TE-MSC + FSU |
| 3) Foot installation and alignment | TE-MSC + FSU + GSI@CERN |
| 4) Installation of safety valve | TE-MSC + FSU |
| 5) Jumper alignment | EN-MME |
| 6) Jumper connection | EN-MME |
| 7) Insulation vacuum | TE-VSC + CERN Contractor |
| 8) Cold mass survey | GSI survey + BE-GM |
| 9) Removal transport rods | TE-MSC + FSU + GSI@CERN |
| 10) Leak tests | TE-VSC, Contractor |
| 11) Purging | TE-CRG |
| 12) Electrical tests | TE-MSC + GSI@CERN |
| 13) Magnetic measurements | GSI@CERN + TE-MSC |

Facility

- | | Resources |
|---|--------------------------|
| 1) Removal platforms | EN-HE + FSU |
| 2) Platform adjustments | EN-HE |
| 3) Install brackets (for survey) | EN-SMM |
| 4) Piping for current leads | TE-CRG + CERN Contractor |
| 5) Cabling instrumentation panel and electrical cabinet | GSI@CERN |
| 6) Safety inspection | HSE-OHS |
| 7) QDS cable integrity | TE-MPE |
| 8) Commissioning facility | TE-MPE + TE-MSC |
| 9) Commissioning electrical cabinet and instrumentation panel | SY-EPC + GSI + GSI@CERN |

Main milestones

KR3912

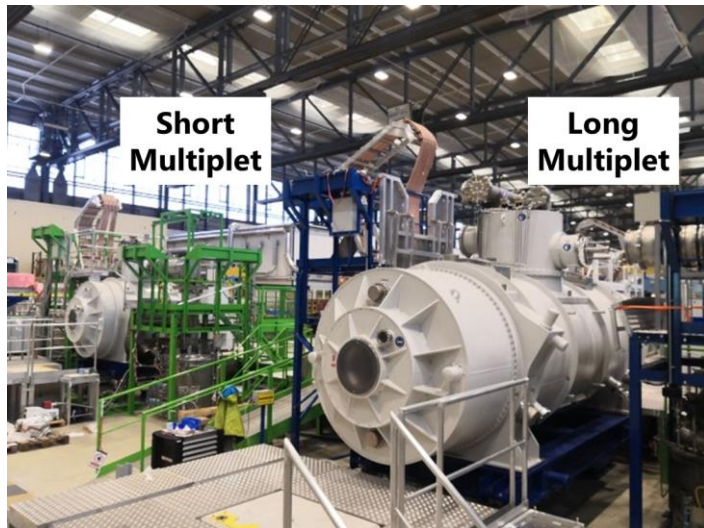
- Collaboration agreement signed in Jan 2018

FoS SM
ASG

- Delivery at CERN in Feb 2019

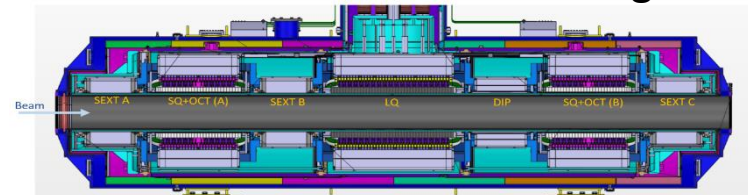


Feb 2021



FoS LM
ASG

- Delivery at CERN in Nov 2020



FoS dipole
Elytt

- Delivery at CERN in Feb 2021



CERN Test facility – cryogenic system

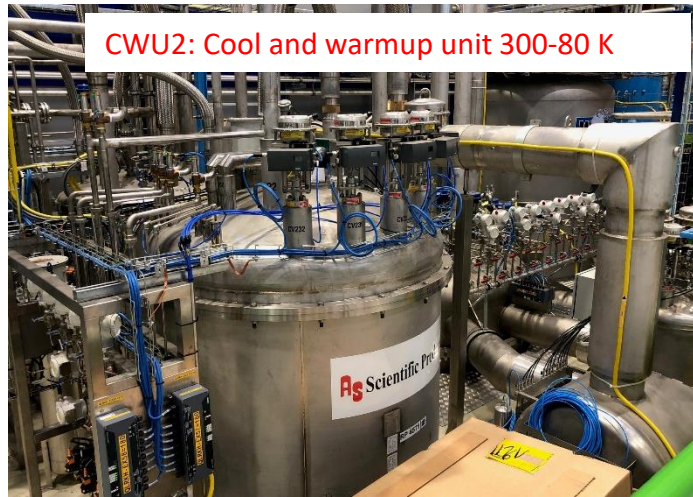
The test facility must be compatible with all 35 types of magnets:
 11 types of dipoles, 24 types of multiplets



DVB: distribution valvebox

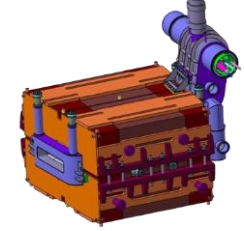


CVB: connection valvebox



CWU2: Cool and warmup unit 300-80 K

Standard dipole



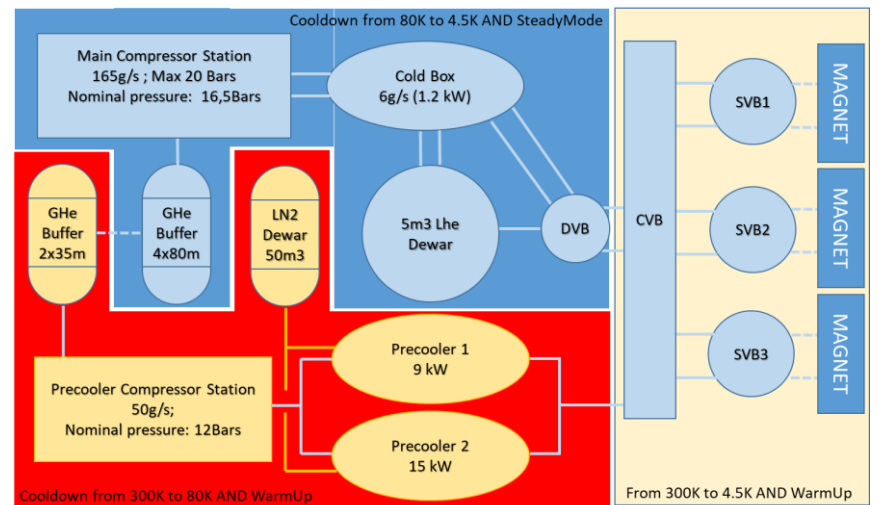
Long multiplet



Short multiplet



3 test benches
 3 main cryogenic sub-systems



Cryogenic system (recently done or to be done)

Precoolers (CWU)

- Regeneration sequence issue:
 - new regeneration group (Busch) ordered and received during W33 (installation in W38/39)
- Precooler 2 (CWU2)
 - Commissioning foreseen with next magnet cooldown or warmup
 - Replacement of mass flowmeter in Jan 2022



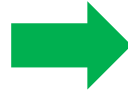
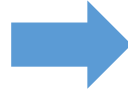
Cryoplant 4.5K

- Problem with sand in the Cold Box cooling water from EN/CV: Turbines trips (x2),
 - New inlet filters procured (installation in W38/39)
- Remarks:
 - EN/CV filtering 1000 μm
 - Additional new filters: 100 μm

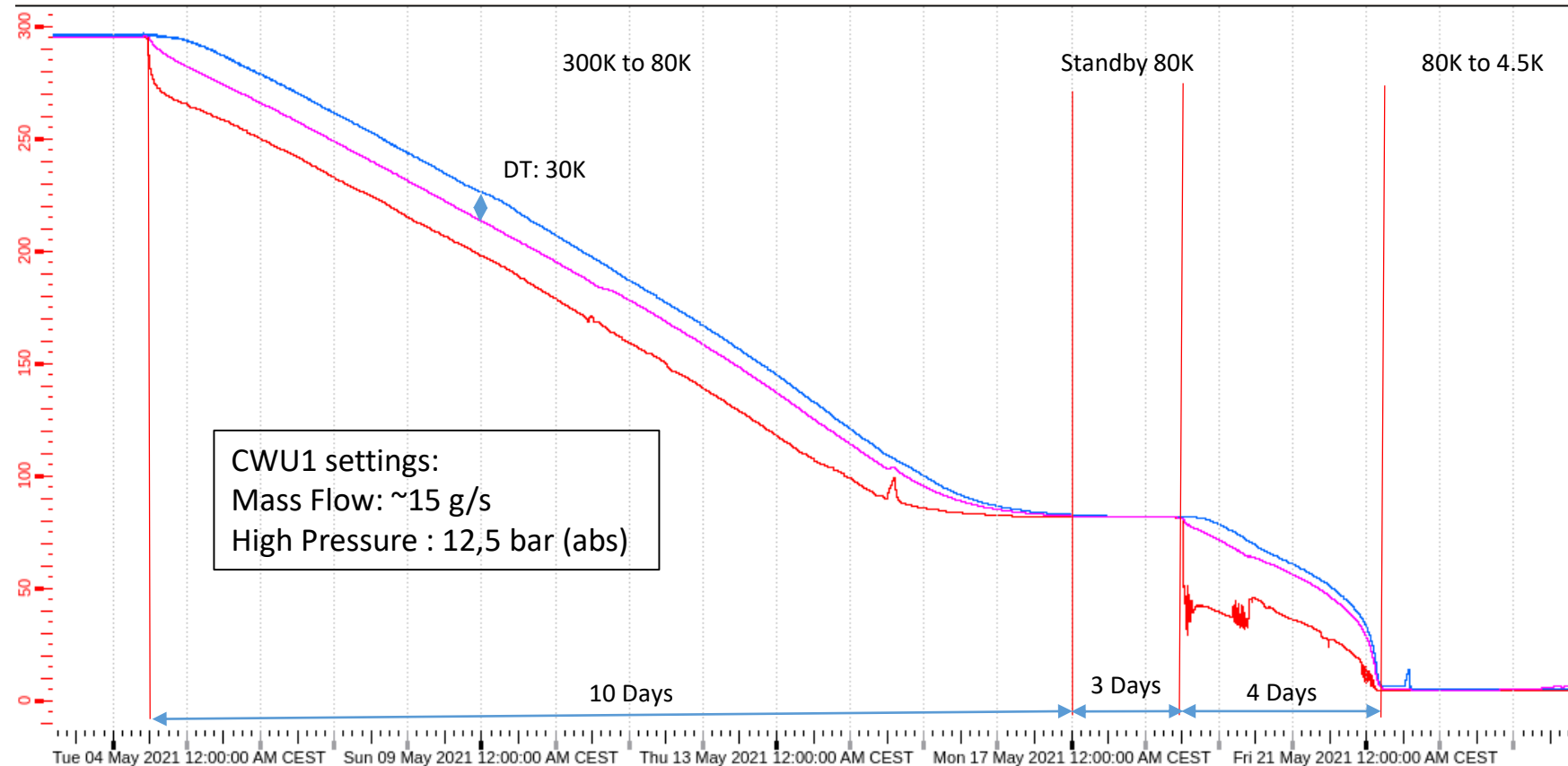


Cryogenic system (current status)

- 3 test benches, 3 main cryogenic sub-systems
 - Test Bench 1 (**blue**): Magnetic tests successfully completed (FoS LM) → WU started (issues on thermal shield circuit to be fully understood)
 - Test Bench 2 (**green**): Leak-tightness test before cooldown (FoS Dipole) showed important leak on thermal shield → back to Elytt for repair
 - Test Bench 3 (**white**): In Standby (no magnet connected)



LM first cooldown (17 days)



Tue 23 Nov 2021 04:14:49 PM CET .593

✓ TTMagMinx	135.4
✓ TTMagMax	159.7
✓ TTMagAvg	143.0

Start of cooldown: 04/05/2021 11 am
Stand by mode 80 K: from 14/05/21 to 18/05/21
End of cooldown: from 18/05/21 to 21/05/21
Cooldown rate: 0.75 K/h

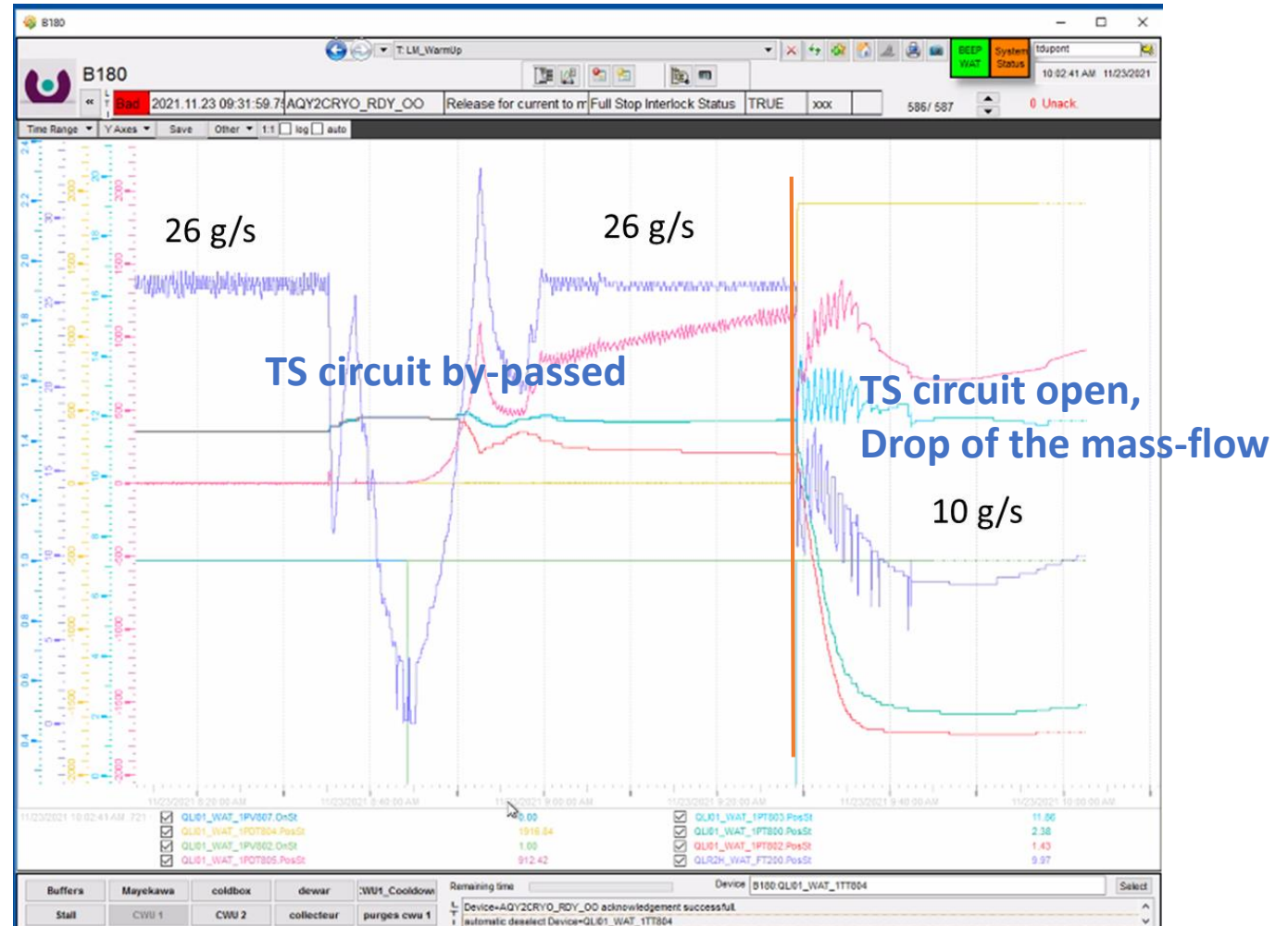
$\Delta T \sim 30$ K over cold mass (< 40 K required during phase 1)

LM warmup

Several tests are being performed to understand the issue on thermal shield circuit, namely the behaviour of the filter.

Goal: warm up completed on 6 Dec 2021

Issue already observed in previous WU, but we manage to overcome with WU parameter adjustment



Quench protection and energy extraction system

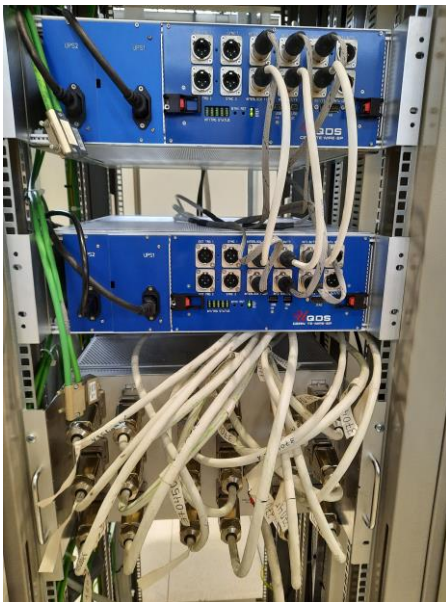
WP Quench Protection System

Mandate: Provide the Quench Detection System + controls layer for the Test Benches.

TB 1 blue: fully populate and fully commissioned

TB 2 green: 2 x UQDS operational (to be commissioned)

TB 3 white: 2 x UQDS operational (to be commissioned)



Controls Layer for the TB

SW is all updated, running the last version of RDA 3, NX CALS, DQAMX and PM (Post Mortem)

CALS (old database) has been decommissioned.

9 Power converters, 3 with energy extraction



WP Energy Extraction System

Mandate: Provide the Energy Extraction System + controls layer for the Test Benches.

Fully commissioned.

Load switches



Interlock PLC, HV and DMM racks

Interlock PLC

- ✓ Equipment commissioned in stand-alone 2 years ago
- ✓ Bench 1 running
- Bench 2: waiting for cold tests
- Bench 3 still to be commissioned
- Yearly maintenance organized

Software

- ## High Voltage racks
- 2 racks delivered, commissioned and already used for tests
- Software upgraded: bugs removal
 - New rack to be constructed: all material received, except NI (PXI equipment ordered by GSI) and rack

For electrical tests

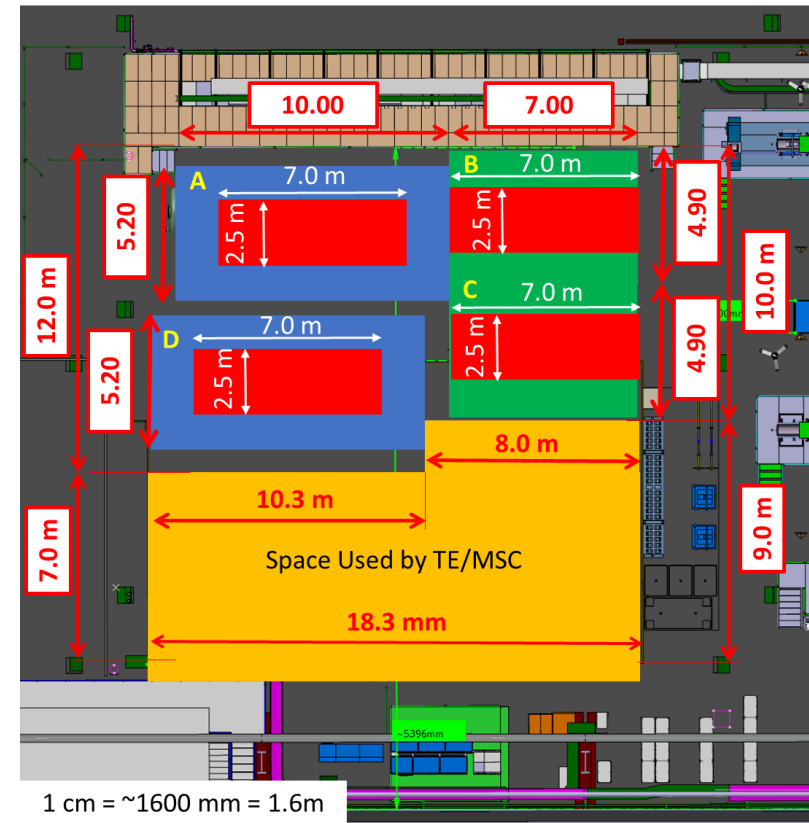
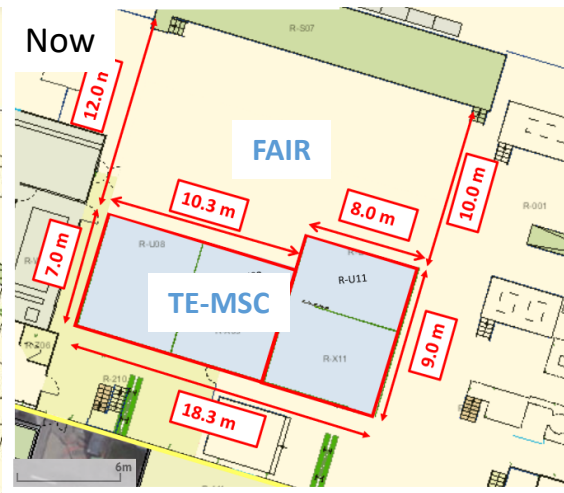
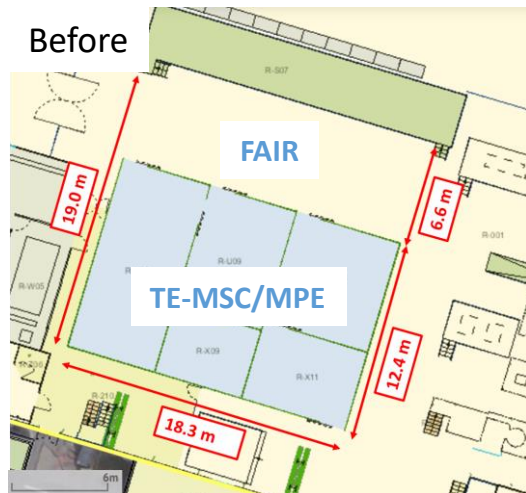
DMM – precision measurements

- ✓ 2 racks stable and validated from hardware and software point of view
- ✓ Last software version upgraded this summer
- Operational safety procedure to be written

Space management: preparation for series

Magnet preparation area

- Handling sequence analysed and confirmed that additional space was needed
- Relocation of TE/MPE equipment from B180 to B272 done by mid of July
- De-installation and Installation of the fence for the *new* area allocated to TE-MS (see photo)



Legend

- Red: Long Multiplet
- Blue: preparation place (use of stairs)
- Green: handling place (no use of stairs)

Handling Sequence:

- Zone A: Arrival, Unloading, unpacking, Electrical tests
- Zone B: Concrete blocks positioning for mounting feet before moving to TB
- Zone C: Concrete blocks positioning for dismantling feet before shipment
- Zone D: Electrical tests, packing, departure

Remark

- The zones A and D are needed for parallel activities on
 - 1 multiplet just arrived (electrical tests) and 1 multiplet ready to leave
 - Or 1 multiplet ready to be installed on the feet and 1 ready to leave

Before

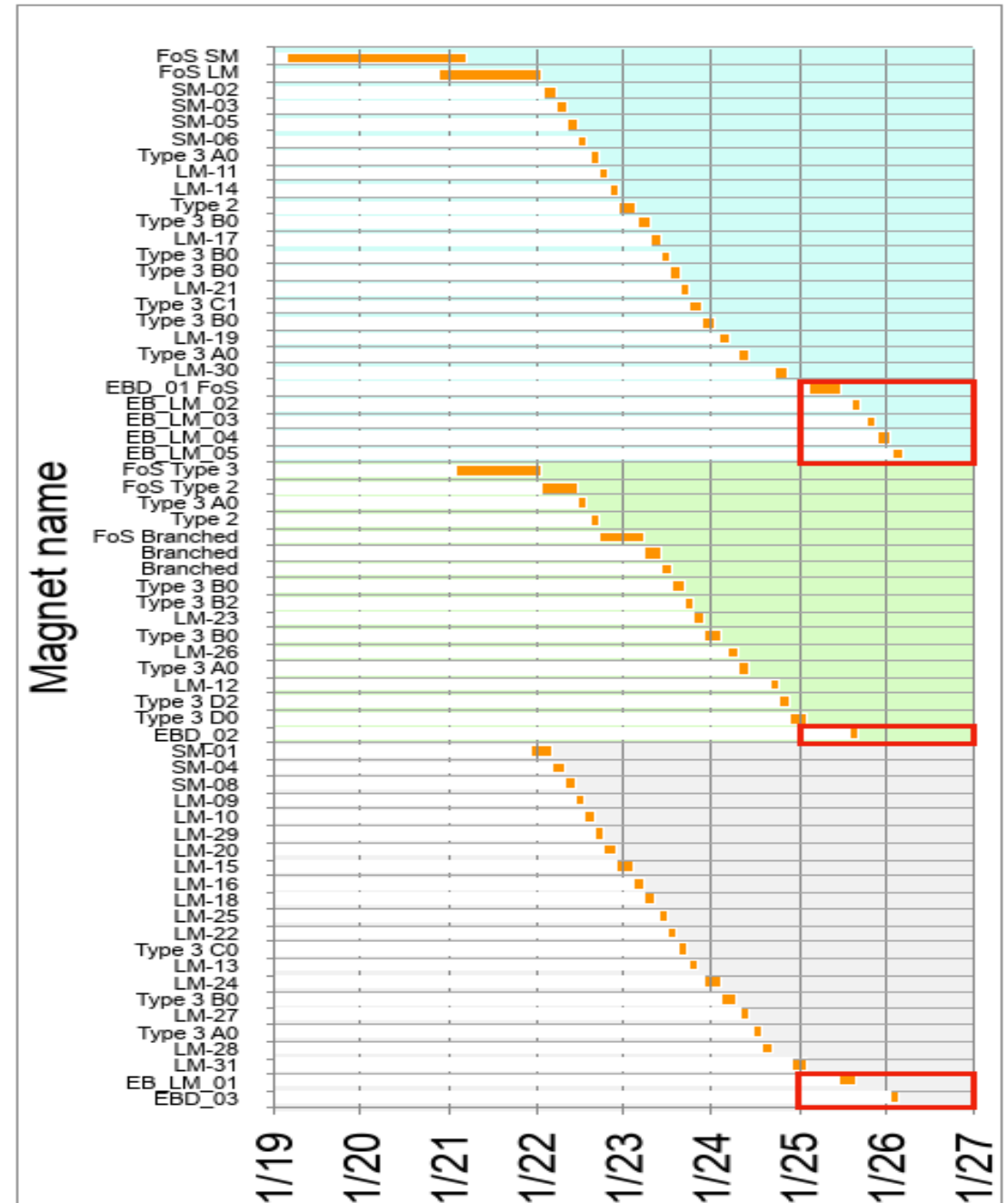


Now



Overall Planning

- Continuous operation
 - the validation tests are performed on one bench, while the second bench is cooling down and the third one is warming up;
 - the test sequence lasts about six weeks for each magnet.
- Pre-series is scheduled to end Q1/2022
- Last series magnets tested in Q1/2026, including new request to test also the EB magnets (8 additional assembly)
- Next magnet assemblies at CERN:
 - short multiplet SM08 in Dec 2021 (ASG)
 - D2 in Jan 2022 (Elytt)



Conclusions

- CERN-GSI agreement on SC magnets testing signed in Jan 2018 - very fruitful collaboration, see also recent [article in bulletin](#)
- CERN-GSI organization fully in place, including all interfaces (new post for CERN on-site technical engineer) – great collaboration with several CERN groups
- CERN test facility operational
- Pre-series magnets delivered from Feb 2019 to Feb 2020
- Series magnets' testing will start in Q1/2022
- New amendment to be prepared: extension of duration and scope