

Super-FRS Magnet Testing, Status and outlook

Haik Simon
CERN, April 26th, 2024

Current collaboration contracts



On 14/04/2010, GSI and CERN signed the Agreement K1727/DG establishing an operational framework for collaboration in accelerator sciences and technologies, and other scientific domains of mutual interest:

- collaborative effort
- free information exchange except sensitive contract relevant issues
- e.g. NC negotiations with suppliers

Following Addendums to Agreement K1727/DG

TITLE/SCOPE	Machine	Status	Addendum	Date
Cryogenic testing of the superconducting magnets for the Super-FRS	Super-FRS	active	#2	2012
			#4	2014
			#5	2016
			#12, KR3912	2018
			Amendment to #12	2023

31/10/2023
31/12/2026

Amendment to Addendum #12



AGREE TO AMEND THE ADDENDUM AS FOLLOWS:

1. The duration of the Activity set out in the Addendum shall be modified to allow the Activity to continue on the same terms until 31 December 2026.
2. The estimated cost for GSI's payment remains unchanged. The breakdown over the years will reflect the real cost.
3. All other provisions of the Addendum and its Amendment No. 1 remain unchanged in so far as they are neither modified nor countermanded by the terms of this Amendment No. 2.
4. This Amendment No. 2 shall form an integral part of the Addendum and shall be subject to its provisions.

GSI Helmholtzzentrum für Schwerionenforschung GmbH

Date: 27.9.2023

Jörg Blaurock

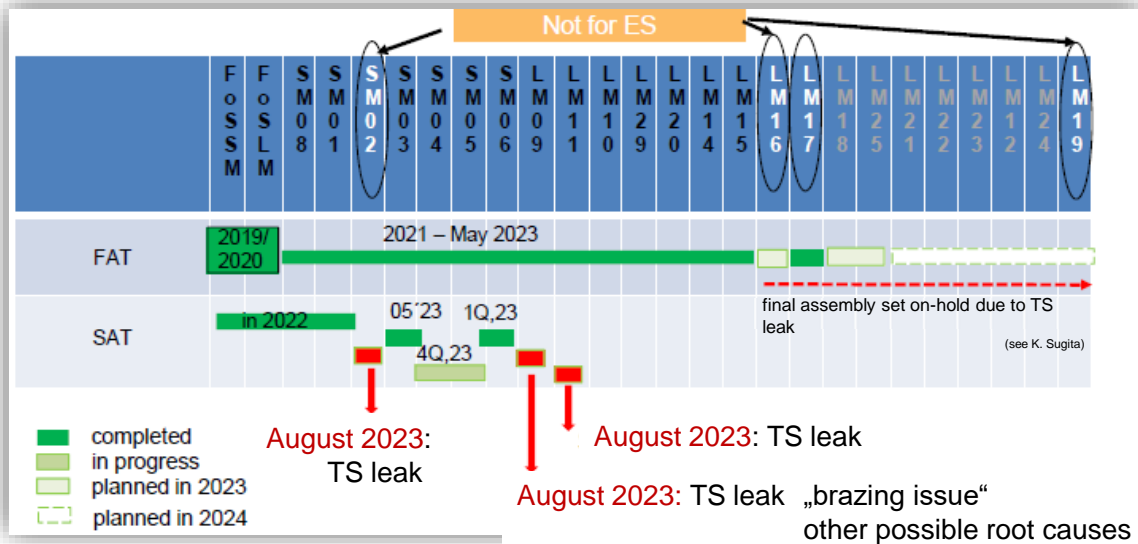
European Organization for Nuclear Research (CERN)

Date: 21.08.2023

José Miguel Jimenez
Head of Technology Department

Status:

Issue solving: Superconducting multiplets



other possible root causes excluded

FAIR/GSI triggered the establishment of a
task force GSI-CERN-ASG (20230912)

probable cause of leak envisaged (brazing joints)
 refurbishment of LMs ongoing with new turrett design

LM11 refurbished and right now ongoing cold test @Bat 180 (80K no leak ...)

Superconducting multiplets

Mitigation and repair schedule in continuous work with ASG (since 20231120)
Decision points Feb 2024, May 2024 following revised magnet SAT testing

revision strategy for

5 pcs **Early Science** magnet incl. spare requested

finished magnets

5 pcs **Early Science**

assembled magnets

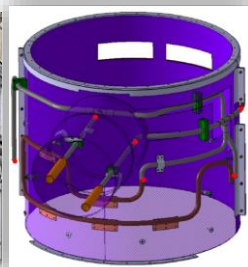
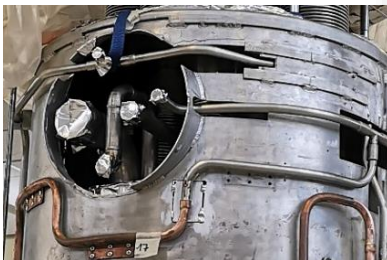
7 pcs **Early Science**, 1 pcs not Early Science

un-assembled

5 pcs **Early Science**: 9 pcs not Early Science



Similar activity with Elytt
➔ entering series testing if
current tests are successful



Forecast overall schedule ES



Assembly Unit	Magnet (at CERN) (at GSI) (back at Elytt) (back at ASG)	start in PA normally 2 weeks before bringing on bench	bring on bench	bring off bench	end of test in PA (end of SAT) (PLW)
SM_04	SM01			3.00	15/12/2022
SM_07	SM08			4.00	22/09/2022
SCD_01 FoS	1D2 (FoS) (being repaired)			30/11/2022	14/12/2022
SM_03	SM03			07/07/2023	21/07/2023
SM_06	SM05			31/01/2024	approx. pending
SM_05	SM04			15/02/2024	approx. pending
LM_01	LM11 (after repair)	03/04/2024	07/04/2024	21/07/2024	28/07/2024
SCD_06	3D3 (being repaired)	16/02/2024	unclear	07/09/2024	21/09/2024
LM_02	LM09	15/05/2024	01/06/2024	15/08/2024	22/08/2024
LM_03	LM10*	15/07/2024	01/08/2024	21/09/2024	28/09/2024
SCD_05	2D3	21/08/2024	07/09/2024	15/10/2024	22/10/2024
SM_01	SM06	07/07/2024	21/09/2024	31/10/2024	07/11/2024
SCD_04	1D3 (ex-FoS D3)	01/10/2024	15/10/2024	21/11/2024	28/11/2024
LM_05	LM18	15/10/2024	01/11/2024	21/12/2024	13/01/2024
SCD_02	2D2	07/11/2024	21/11/2024	10/01/2025	17/01/2025
SCD_03	3D2	21/12/2024	06/01/2025	12/02/2025	19/02/2025
LM_04	LM16	27/11/2024	11/12/2024	10/03/2025	17/03/2025
LM_06	LM20	27/12/2024	10/01/2025	28/03/2025	04/04/2025
SCD_07	4D3	05/02/2025	19/02/2025	29/03/2025	05/04/2025
SCD_08	5D3	01/03/2025	15/03/2025	06/05/2025	13/05/2025
SCD_09	6D3	31/03/2025	14/04/2025	21/05/2025	28/05/2025
LM_07	LM21	15/03/2025	29/03/2025	22/07/2025	29/07/2025
LM_08	LM22	09/07/2025	23/07/2025	03/10/2025	10/10/2025
SCD_11 (br)	1D-B (branch)	07/06/2025	21/06/2025	05/11/2025	12/11/2025
SCD_14 (br)	2D-C (branch)	24/09/2025	08/10/2025	03/12/2025	10/12/2025
LM_10	LM25	06/10/2025	20/10/2025	27/01/2026	03/02/2026
LM_09	LM23	25/10/2025	08/11/2025	23/02/2026	02/03/2026
LM_11	LM13	27/12/2025	10/01/2026	25/03/2026	01/04/2026
SCD_10	7D3	10/02/2026	24/02/2026	13/04/2026	20/04/2026
LM_12	LM15	27/01/2026	10/02/2026	12/05/2026	19/05/2026
SCD_12	8D3	13/03/2026	27/03/2026	13/05/2026	20/05/2026
SCD_13	9D3	01/04/2026	15/04/2026	23/05/2026	30/05/2026
SCD_15	10D3	01/05/2026	15/05/2026	21/07/2026	28/07/2026
LM_13	LM29	29/04/2026	13/05/2026	18/08/2026	25/08/2026

Tentative schedule, based currently expected constraints and durations

Series testing optimizations still missing.

same base:
schedule presented by K. Sugita



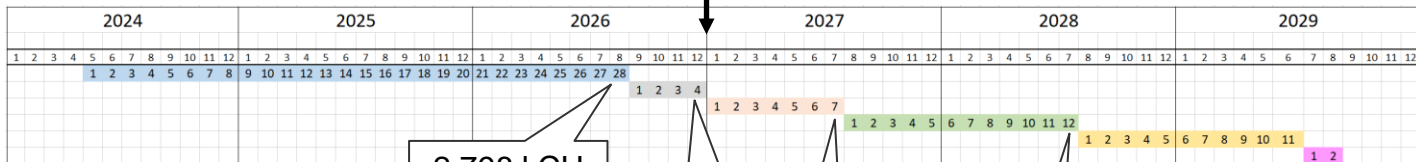
➔ Last magnet installation 10/2026 in tunnel.

Forecast:

Overall timeline and remaining costs



31/12/2026



2,798 kCHF

3,078 kCHF

3,688 kCHF

LM: $112 \times 4 = 448$
D: $56 \times 3 = 168$

4,908 kCHF

1 big FoS Dipole = 500
EBM: $112 \times 5 = 560$
EBD: $80 \times 2 = 160$

6,006 kCHF

LM: $112 \times 6 = 672$
D: $56 \times 6 = 336$
FoS LM: 90

- ES
- Re-cool down of 6 SM + 1D2 (**)
- LEB + SM08
- EB (assuming FoS testing only for dipoles)
- RB
- Re-cool down of FoS LM

(**) 5 weeks (25 working days) per SM, 4 weeks for 1D2, plus average 4 weeks for shut-down and holidays; divided over 3 benches

budget	spent	available
kCHF	kCHF	kCHF
5,500	2,281	3,219

	working days			
	LM	SM	D	DB
connection	10	10	7	7
PREC	9	4	4	4
CD+Fill	5	2	2	2
MM	variable	7	7	variable
EVAP	2	2	2	2
WU	9	4	4	4
disconnect	4	3	3	3

Current budget sufficient for ES coverage incl. re-testing SM

- Very successful collaboration.
- Task Force activities enabled major improvements mitigating quality problems in both magnet supplier chains!
- No apparent issues for current Early Science scope.
- Next steps: (beyond ES scope, decision pending)
 1. First Science++ scenario: LEB (mid 2027)
 2. First Science++ scenario: Energy buncher (mid 2028)
 3. MSVc (mid 2029)
if realization would just proceed.

Backup transparencies

Constrains and durations for series testing



DURATIONS (working days)

				LM	SM	D	DB
connection				10	10	7	7
PREC				9	4	4	4
CD+FILL				5	2	2	2
MM			variable		7	7	vari
EVAP				2	2	2	2
WU				9	4	4	4
disconnect				4	3	3	3

CONSTRAINS

No 3 x brown



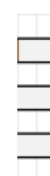
No 2 x green



No 2 x dark brown (LM – LM)



No 3 x grey



No 2 x blue



2 months shut-down, 7 wd public holidays
 Calendar for cooling and warming: 24/7
 Calendar for all other activities: 8/5

Money transferred to CERN



Test facility preparation phase

- 5.00 M€ ~ 6 MCHF (2012, addendum No.2)
- 1.86 MCHF ~ 1.548 M€ (2014, addendum No.4)
- 0.210 MCHF ~ 0.191 M€ (2016, addendum No.5)

in total about 8.07 MCHF (about 6.739 M€)

Testing phase

in total 5.5 MCHF (about 5.05M€) (2018-2024, addendum No. 12)

Invoice No.	Amount	Position	Date	Invoice received	Invoice payed
1	380,000 CHF	10	01/10/2018	yes	13/12/2018
2	380,000 CHF	20	01/03/2019	yes	22/10/2019
3	380,000 CHF	30	01/10/2019	yes	22/10/2019
4	520,000 CHF	40	02/03/2020	yes	18/12/2020
5	520,000 CHF	50	01/10/2020	yes	18/12/2020
6	520,000 CHF	60	01/03/2021	yes	05/05/2021
7	520,000 CHF	70	01/10/2021	yes	06/10/2021
8	520,000 CHF	80	01/03/2022	yes	24/03/2022
9	520,000 CHF	90	01/10/2022	yes	08/11/2022
10	520,000 CHF	100	01/03/2023	yes	29/03/2023
11	520,000 CHF	110	01/10/2023	yes	pending
12	200,000 CHF	120	01/03/2024	yes	pending
	5,500,000				