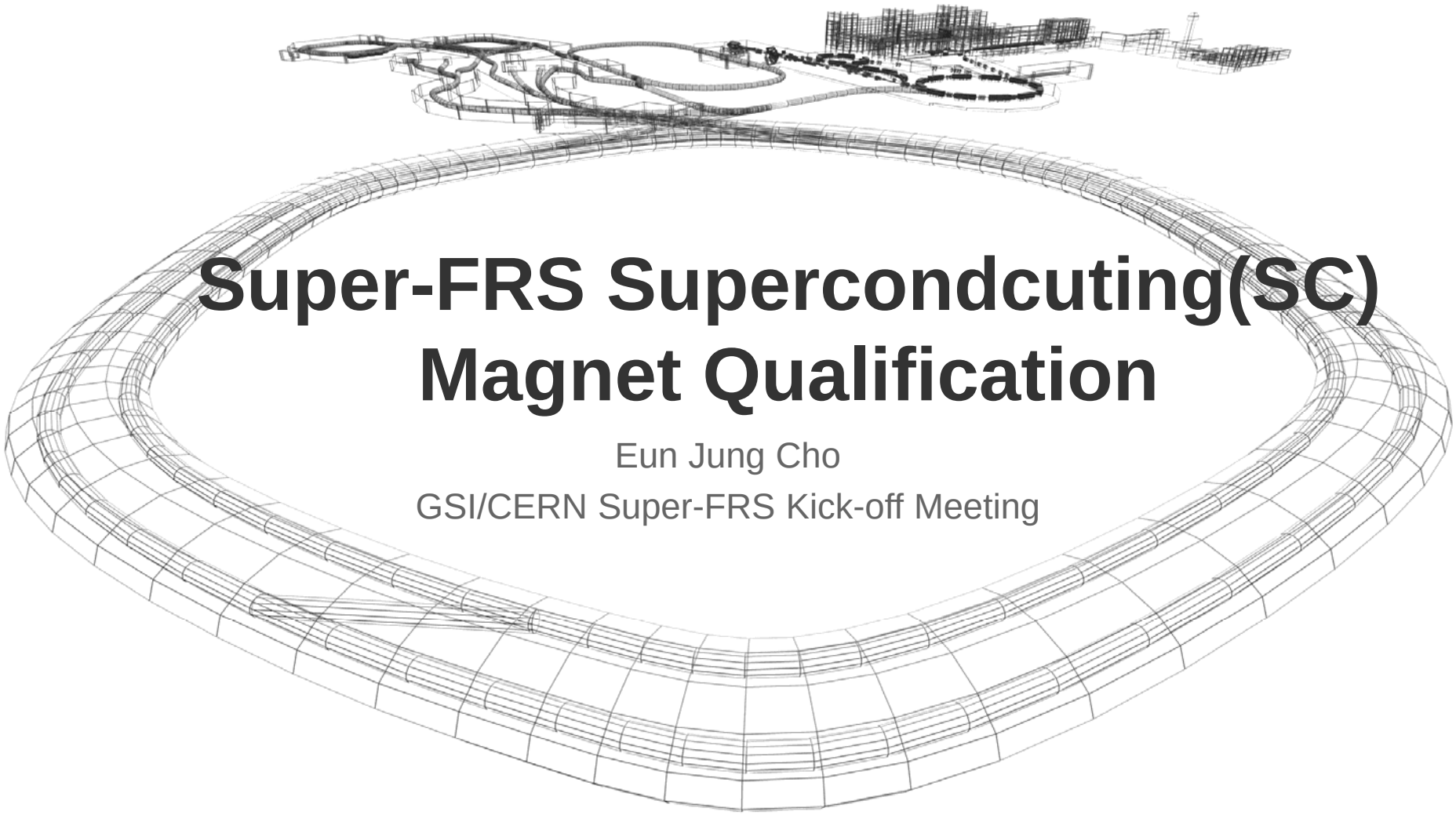


Super-FRS Supercondcuting(SC) Magnet Qualification

Eun Jung Cho

GSI/CERN Super-FRS Kick-off Meeting

Super-FRS SC Magnet Qualification

- Qualification Process
- FAT (Factory Acceptance Test)
- SAT A (Site Acceptance Test A)
- SAT Acceptance Criteria
- Pre-qualification for FoS (First of Series) Magnet
- Summary

Qualification Process

FAT

- Multiplets @ASG, La Spezia
- Dipoles @Elytt Energy, Bilbao

SAT A

Cold test
@ Test facility, B180, CERN

SAT B

Comissioning with beam
@GSI, Darmstadt

FoS SM FAT (Jan, 2019 @ ASG)

Test Programs

- Electrical test (low/high voltage test, sensor alive/continuity/polarity test).
- Pressure test (thermal shield pipe, He-vessel, cryostat).
- Leak test (safety valve, cryostat, beam pipe).
- No magnetic field measurement at warm.

FAT Protocol

FAIR GSI	Kind of Document: **Test Protocol**	Document Number: F-PP-SCM-0067	Date: 31.01.2019
		Template Number: Q-FO-QA-0002	Page 1 of 2

..... ☐ CDR M6 ☐ FDR M7 ☐ PS M8 ☐ FAT M9 ☒ SAT Aa ☐ Ab M10 ☐ Ba M11 ☐ Bb M12 ☐

Part / module / component:	Super-FRS short pre-series multiplet FPF2YMQ12	Manufacturer:	ASG
PSP Code:	2.4.2.2.3 (leading) 2.4.2.3.2 2.4.7.1.6 2.4.7.2.1.5	3D model number:	20102REV.0_ShortMultiplet_02082018.stp https://edms.cern.ch/document/2037190/1
CID:	02-000226-05-3	(Assembly) Drawing number:	600RM20102_revC https://edms.cern.ch/document/2037192/1
Review or test at (date):	25.01.2019	Model or drawing of (date):	12.10.2018

Remarks (specify exactly what shall be taken into account or what shall be modified and where):

Work to do after FAT:
Cleaning and re-painting where necessary
Adaptation of cryogenic process pipes (Attchment of weding rings and fixation rings)

Overall result: Accepted: ☒ Conditionally accepted: ☐ Rejected: ☐

For conditional acceptance or rejection: Date of next meeting:

Required signatures:

Function (e.g. work package leader):	Name:	Date and signature:
MPL	Haik Simon	21.1.2019
WPL	Hans Müller	1.2.2019
QA	Detlef Grünberg	01.02.2019

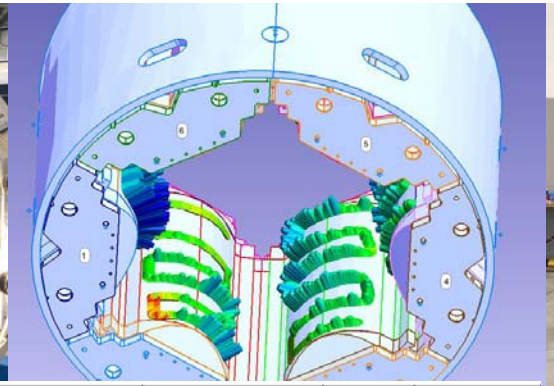
- **Approved by**
  - GSI QA.
  - Super-FRS SC magnet work package leader
  - Subproject leader.
- **FAT document dossier**

  (https://edms.cern.ch/document/1999049/19

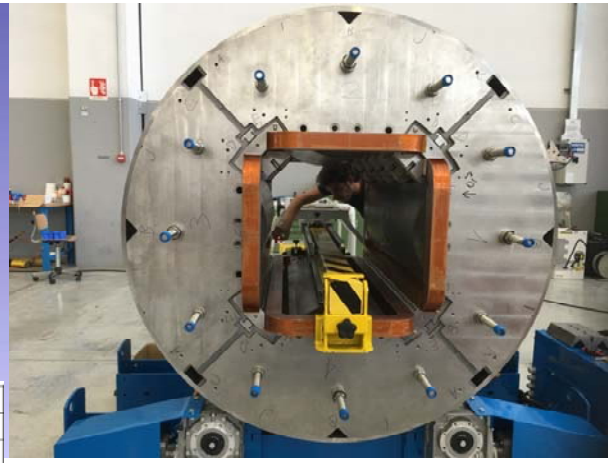
SAT A (Site Acceptance Test A)

Goal

- Design verification (mechanical/cryogenic and magnetic design).
- Quality conformity check.
- Reproducibility of magnet performance check.
- Providing inputs for the machine operation (cryo-genic facility and beam optics).



ENTITY	NOMINAL / TOL	MEASURED [mm]	TEST	OUT OF TOL
POLAR DIAMETER	476.3 ± 0.2 mm	476.14	OK	-
POLAR PROFILE (672RM19175 Rev.B)	⌓ 0.15	0.147	OK	-



SAT A at B.180

During the SAT, the magnets are under the responsibility of the SC magnet WPL (Hans Mueller).

SAT Aa
- on the lorry
- the preparation area

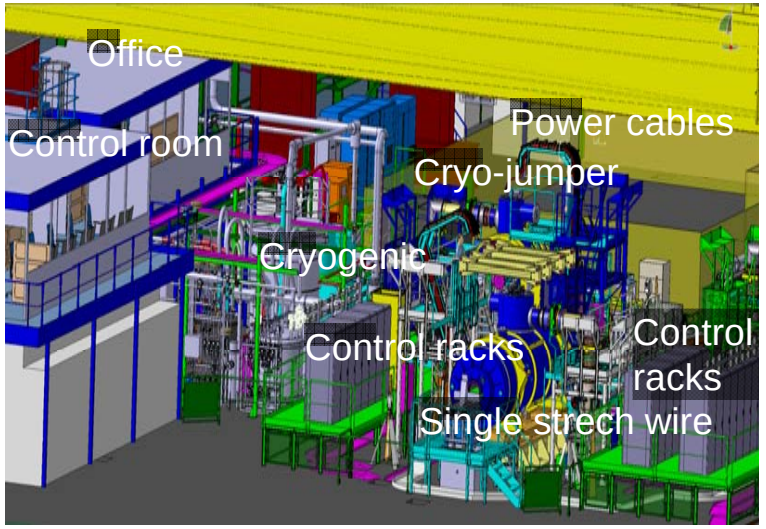
SAT Ab
- at the test bench (warm/cold/after warm-up)
- preparation area

Approval of SAT A
- GSI QA
- SC magnet WPL
- Subproject Leader

Packing /Transport to GSI

ASG

- GSI testing team @ CERN.
- Support from the CERN colleagues.
- On-site support from GSI Darmstadt and ASG are available



Courtesy by Antoine Kosmicki, CERN

Test Programs and Acceptance Criteria

- The complete test plan is availble.
- The aceeptance ctriteria is shared with ASG.
- **Common agreement on the following points;**
  - **Heat load, leak rate.**
  - **Magnet and sensor insulation performance.**
  - **Maximum current, the maximum allowed number of quenches**
  - **Field quality.**
- Still open to discuss on the following points;
  - Magnet axis alignement
  - Cold mass movement during transportation

SAT Aa

Test at warm before installation at the test bench.

Area	ID	Description	Relevant Document	Aceeptance criteria	Unit	Tolerance	Aceeptance relavent
On the lorry	In0.0	Accelerometer	F-CS-MT-03e				Yes
		manometers on the vessels	F-CS-MT-03e				Yes
		Visual Inspection	F-CS-MT-03e				Yes
		Document Dosierer	F-CS-MT-03e				Yes
	In1.0	shock sensor check	F-CS-MT-03e				Yes
Preparation		manometers on the vessels	F-CS-MT-03e				Yes
Area		Visual Inspection	F-CS-MT-03e				Yes
	C.0.1.	Continuity test of Voltage taps					Yes
	S.0.1.	Sensor alive test	F-CS-MT-03e				Yes
	HV.0.1.	High Voltage Test: Coil to ground	F-DS-MT-11e	> 1	Gohm		Yes
	HV.0.2.	High Voltage Test : Magnet to magnet	F-TG-MT-01e	< 1	µA		NA

SAT Aa

The check list and guide line are also available .

		on the lorry	preparation area
Accelerometer	#1		
	#2		
	#3		
Visual Inspection	Sign of Damage		
	General cleanliness		
	Cryo-process line		
	(length, cleanness)		
	CID Number		
	etc.		
Documentations	Shipping Documents		
	CE Mark		
	3rd party approval		
	Acceleration report		
	FAT reports		
	Manuals		
	etc..		

SAT Ab Test Program

Test at the test bench

1. At warm before cool down
   - Leak test
   - Instrumentation test
   - Polarity and continuity test
   - Cold mass survery
2. At cold
   - Cold mass survey
   - Heat load
   - HV test
   - Magnetic field measurement
   - 110% excitation
   - Ramp-up cycle
3. Warm-up
   - RRR (only FoS)
4. At warm
   - HV/LV test
   - Instrumentation test
   - Polarity and continuity test
   - Cold mass survery

Acceptance Criteria

Description	Relevant Document	Acceptance criteria	Unit	Aceeptance relavent	Comment
Sextupole excitation curve measurement upto 1.1 x Inom		quench less than three times		NA	Pre-series magnets are exempt from the requirement
Long Quadrupole + Sextupole excitation curve measurement upto 1.1 x Inom		quench less than three times		NA	Pre-series magnets are exempt from the requirement
Long Quadrupole ramp-up cycle Test (0 to Inom x 3 times)		-		YES	No Quench
Sextupole ramp-up cycle Test (0 to Inom x 3 times)		-		Yes	No Quench
Long Quadrupole + Sextupole ramp-up cycle Test (0 to Inom x 3 times)		-		Yes	No Quench
Cold mass survey w window after 110%excitation		-		No	
Long Quadrupole magnetic field measurement	F-CS-MT-03e, F-DS-MT-25e, 700RM18040	± 10 unit< 0.8 gmax, ± 60 unit > 0.8 gmax gmax = 11.5 T/m @R= 190 mm	x 10^{-4}	Yes	Field quality requirement is all
Sextupole magnetic field measurement		± 50 unit, gmax=40 T/m^2 @R= 190 mm	x 10^{-4}	Yes	
Maximum allowed total error between position of magnetic axis and mechanical axis	F-CS-MT-03e, 700RM20116		mm	Yes	Under discussion between GSI and ASG
Pitch	F-CS-MT-03e,		mrad	Yes	
Yaw	700RM20116			Yes	
Roll	F-CS-MT-03e	±1.15	mrad	Yes	

Magnet Field Measurement

Name of Multiplet	**FPF2YMQ12**
Quadrupol type IV	**FPF2QT12**

	sextupole	long quadrupole
irom length (m)	0.5	1.2
name of magnet	FPF2KS13	FPF2QT12

Raius of the reference circle for the measurement r=170 mm

Current level	Integral Field Gradient, G_L	Homogeniety	Magnet Axis					Harmonics (unit : 10 -4), normal													
(A)	(T/m x m)		Δx (mm)	Δy (mm)	pitch (mrad)	yaw (mrad)	roll (mrad)	b2	b3	b4	b5	b6	b7	b8	b9	b10	b11	b12	b13	b14	b15
17																					
30																					
50																					
75																					
100																					
115																					
130																					
150																					
165																					
180																					
200																					
215																					
230																					
250																					
275																					
300																					
Name of the Reference Data file																					

Only for FoS
Not SAT relevant

FoS : 15 current levels
Series : 5 current levels

- Requirement for the FQ at 190 mm but the measurement will be done 170 mm ?
- Data of the harmonics at 170 mm were provided to Giancarlo for comparison with the measurement result.

Pre-qualification of FoS SM

Background

- ASG would like to have confidence in the magnetic designs and proceed procurement of materials for the series short multiplets in order to avoid high risk.
- ASG claims that other risks are negligible and can be mitigated by manufacturing technology.
  - delivery of the series SM 1/2/3: March, May and June

Goal

- Magnetic design verification until M/August, 2019 for key design parameters of the single magnets.
  - The pre-qualification program is agreed between GSI and ASG to validate single magnet design within 2 - 3 weeks (best scenario).
  - Comprehensive SAT program will be continued after the pre-qualification program.

Pre-qualification Program

- Excitation up to 110 % (LQ and Sextupole)
- Magnetic Field Measurement (Single Magnet)
  - Long Quadrupole : 50, 150, 300 A
  - Sextupole : 50, 150, 291 A
- After the comissioning of the QDS at the cold, this measurement program will be started.

Outlook

- Acceptance criteria for the FoS LM and the FoS dipole will be prepared soon based on the experience from the FoS SM.
  - **Delivery of FoS LM : Jan. 2020**
  - **Delivery of FoS Dipole: April. 2020**

- In order to avoid any delay in SAT A approval of the FoS SM (Nov. 2019), the following ponts are important;
  - Sharing SAT data with ASG and GSI internally in a timely manner and discussing about the results. Do not wait until the last minute.
  - Finalizing two open points with ASG as soon as possible.

Acknowledgement

A. Bergmann, B. Christine, M. Chesi, A. Chiuchiolo, W. Freisleben, G. Golluccio, F. Greiner, P. Kosek, F. Wamers, J. Kurdal, I, Pschorn, M. V. Ricciardi, C. Mueller, M. Schmidt, K. Sugita, P. Szwangruber, V. Velonas, Y. Xiang.

L. Stewart, A. Kosmicki, G. Rolando, A. Henriques, T Barbe, J. P. Espinos, J. G Perez; M. Arnaud, S. Pelletier, P. Bestmann, C. Vendeuvre, G. Ferlin, A. Perin, G. Favre, M. Charrondiere, D. Calcoen, D. Reiner, D. Missiaen, L. Bottura, H. Thiesen, E. B. Vinuela, O. C. Ditsch, R. Speroni, B. F. Adiego, H. Reymond, J. Steckert, S. Russenschuck, L. Serio L. Van Den Boogaard.