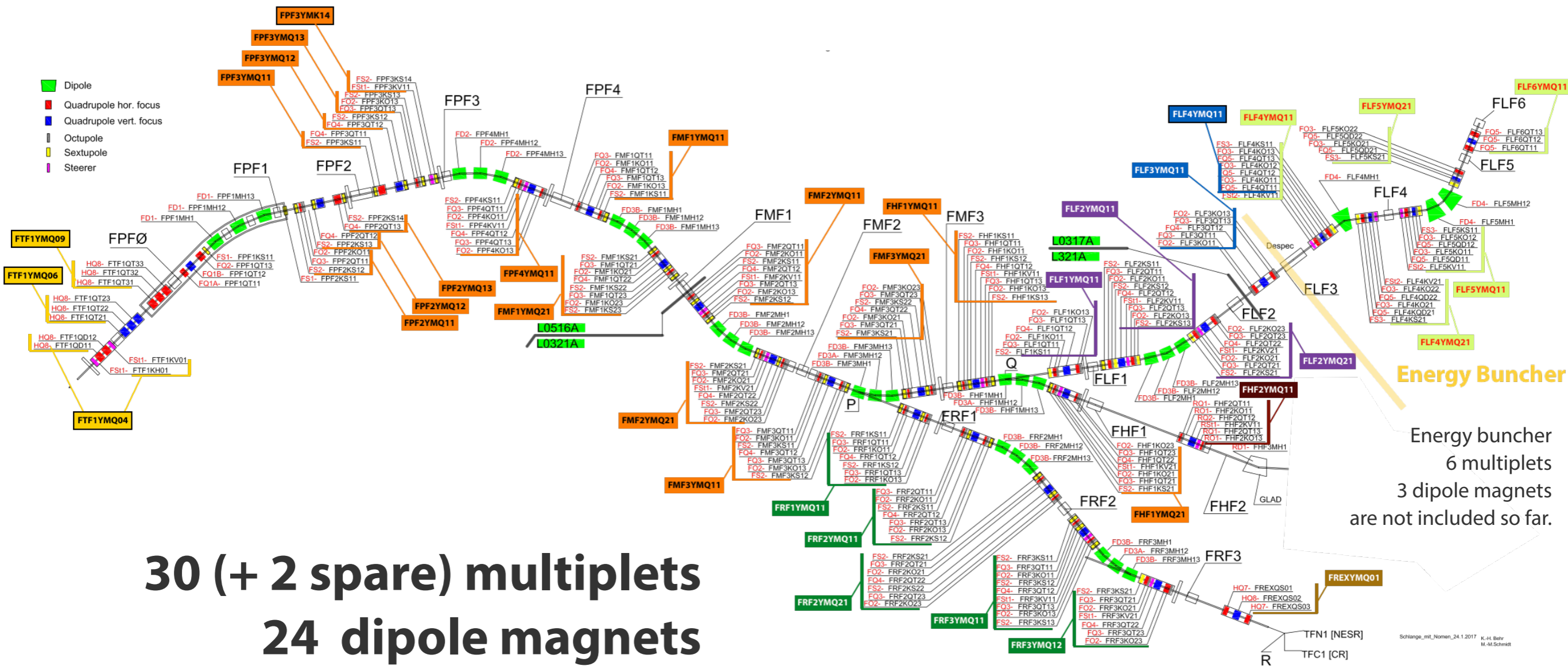




# Super-FRS magnet testing at CERN overview and test plan

Work package leader: **Kei Sugita**  
Superconducting Magnet Technology,  
SCM, SIS100/18, GSI

# Super-FRS superconducting magnets

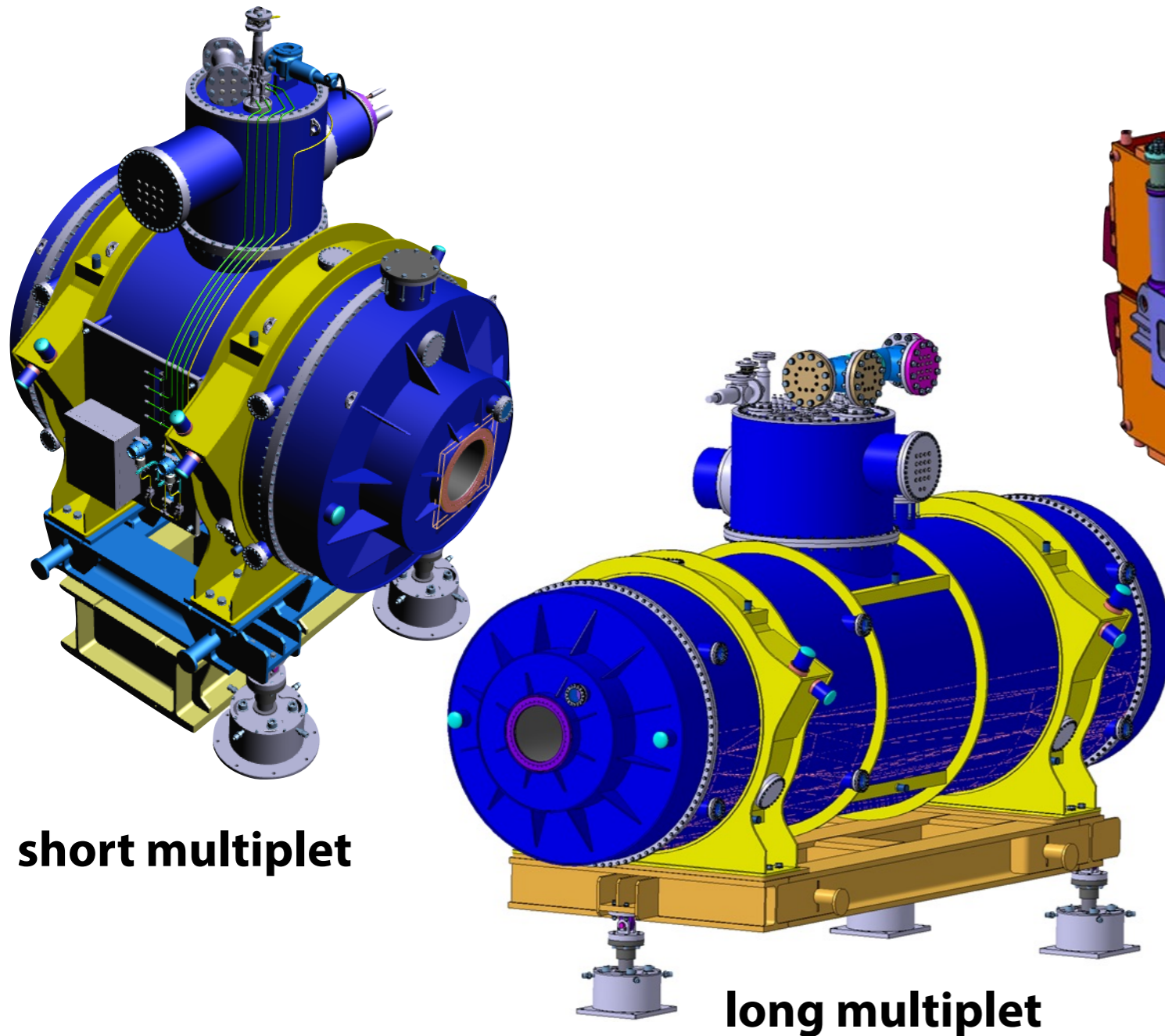


**30 (+ 2 spare) multipliets**  
**24 dipole magnets**  
**(56 magnets in total)**

**will be tested at CERN**

# Magnets

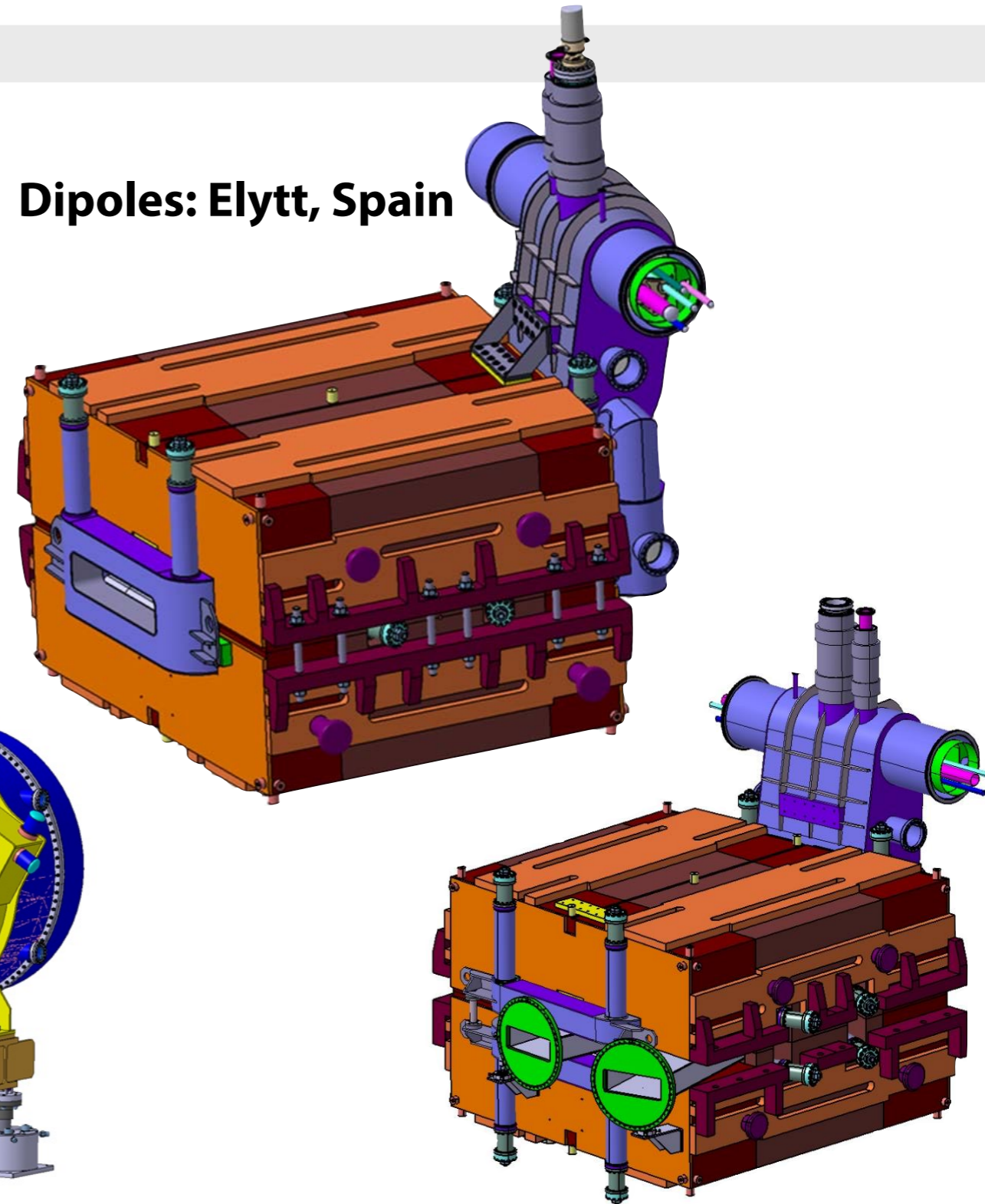
**Multiplets: ASG, Italy**



**short multiplet**

**long multiplet**

**Dipoles: Elytt, Spain**



**branch magnet**

# FAIR work packages

WP: **Super-FRS Multiplet**  
 PSP: **2.4.2.2.3**  
 WPL: **Hans Müller**  
 as **German in-kind, GSI**

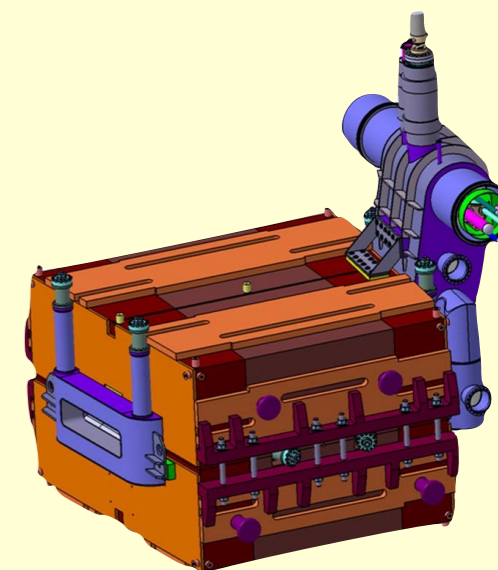
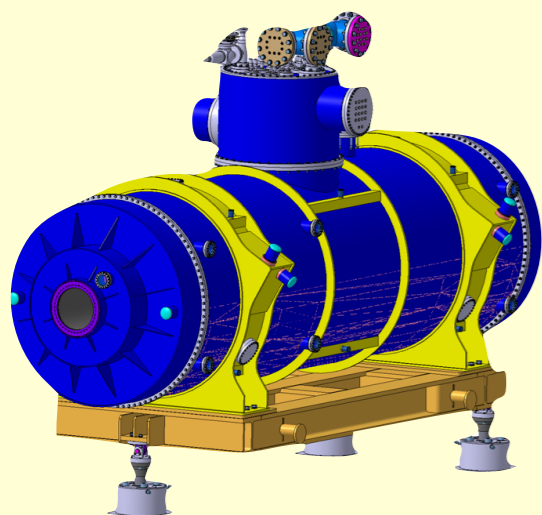
WP: **Super-FRS Dipole**  
 PSP: **2.4.2.1.2**  
 WPL: **Hans Müller**  
 as **FAIR tendering**  
 Remark: **Collaboration with CEA/Saclay for technical follow-up of the production.**

## Factory Acceptance Test (FAT)

## Factory Acceptance Test (FAT)

FAT approval Transport to CERN

FAT approval Transport to CERN



WP: **Super-FRS Magnet Testing**  
 PSP: **2.14.13.22**  
 WPL: **Kei Sugita**  
 as **German in-kind, GSI**  
 Remark: **Collaboration contract with CERN Testing, Testing at CERN Building 180**

## Site Acceptance Test (SAT) Warm and cold tests

SAT approval

SAT approval

Transport to FAIR/GSI

Transport to FAIR/GSI

FAIR/GSI

FAIR/GSI

# GSI organisation

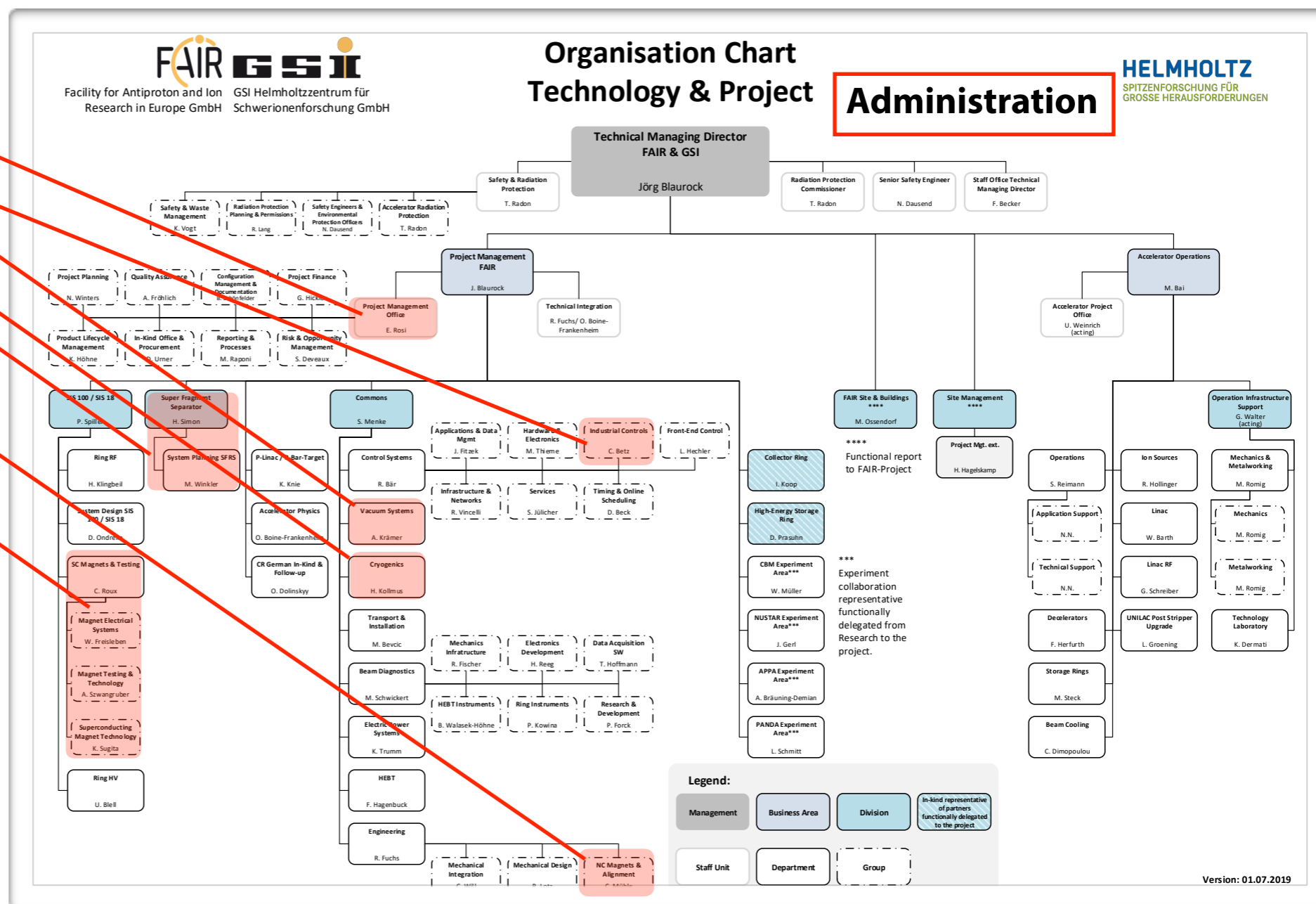
**FAIR Project leader: Jörg Blaurock**

**Sub-project leader Super-FRS: Haik Simon**

WP: Super-FRS Magnet Testing  
 PSP: 2.14.13.22  
 WPL: Kei Sugita  
 as German in-kind, GSI  
 Remark: Collaboration contract with CERN Testing, Testing at CERN Building 180

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**Site Acceptance Test (SAT)**  
**Warm and cold tests**

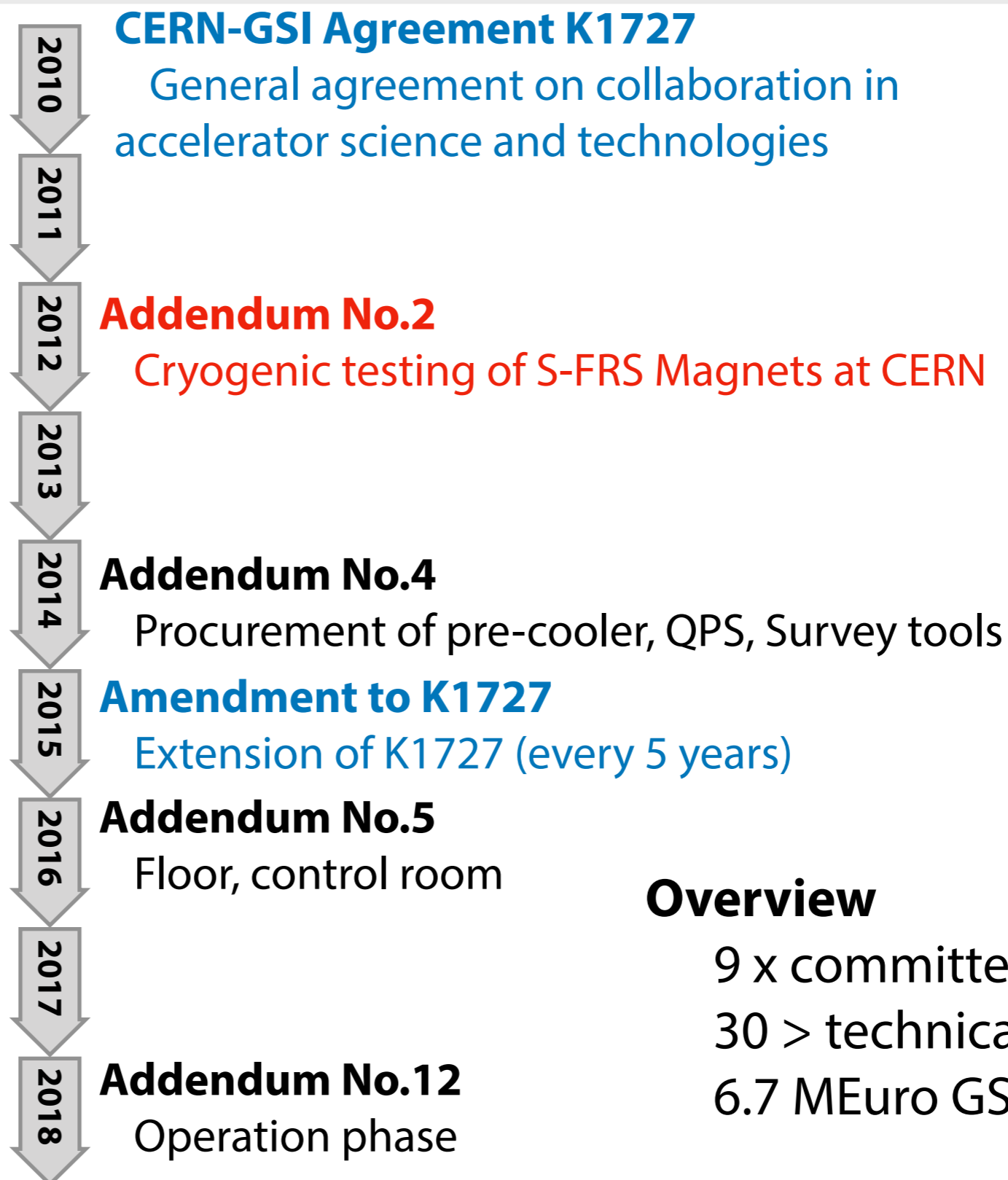


# Testing @ CERN, History

## Project leader

CERN: Luigi Serio

GSI: Pierre Schnizer



-----  
CERN: Lisette Van Den Boogaard

GSI: Kei Sugita

## Overview

9 x committee meetings

30 > technical meetings

6.7 MEuro GSI to CERN

# Scope of GSI and CERN

In general

**CERN** prepares and maintains **the facility** as available.

Exception: *jumper lines, sensor signal cabinets, instrumentation panels, vacuum pumps*

**GSI** executes **the testing**.

Exception: *Alignment and fiducialization (CERN survey team)*

Details are defined in the **addendum No.12** (Jan. 2018) for test facility operation phase

## CERN

- guarantees the functionality of the facility
- contributes 1 + 0.4 FTEs
- supports GSI activities incl. training.
- offers standard offices and tools
- covers energy cost
- offers CERN IT network

## GSI

- executes the testing
- deploys 4 FTEs
- pays operation costs (cost-recovery-basis )

### 3.1 CERN's Contribution

In general, CERN contribute to guarantee the functionality of the test facility so that the testing is performed. However, the costs, except specified below, shall be invoiced to GSI cost-recovery basis.

3.1.1 CERN shall contribute to the Activity in accordance with the test program outlined in Annex 2 and further agreed between the Parties on that basis.

3.1.2 For the entire duration of the Activity CERN will participate in the Operation Team with:

- A Test Engineer (1 FTE), who will oversee the functioning of the test facility and liaise with CERN services and contractors for interventions and support.

3.1.3 CERN will support the Activity with best-effort service from its equipment groups (cryogenics, survey, power converters, energy extraction, quench protection, data acquisition and controls; estimated total of 0.4 FTE).

3.1.4 CERN will ensure the following services, which are subject to payment by GSI on a cost-recovery basis (set out in Article 6.1, and Annex 3):

- Assistance with the installation and removal of magnets, such as the provision of crane and rigging services, geometrical survey and alignment, welding and cutting;
- Operation and maintenance of the cryogenic facility;
- Operation and maintenance of the technical infrastructure; and
- On-call interventions during non-working hours for cryogenics, cooling water and electrical power distribution.

3.1.5 CERN shall provide training of GSI staff on operation of the facility and in the domain of safety. CERN shall provide documentation of the infrastructure and instruction manuals.

3.1.6 CERN shall agree that computers and peripherals belonging to GSI, which are needed to carry out the test program, may be connected to the CERN computer network, provided they are compatible with it and meet CERN's computer security standards, including those set out in the document "Operational Circular 5 – Use of CERN computing facilities" and subsidiary rules.

3.1.7 CERN will pay from its operation budget the energy costs of running the test facility and its infrastructure.

3.1.8 CERN will provide, free of charge and within the limits and constraints imposed by the available resources, the following standard services and facilities for the duration of this Agreement:

- Office space, equipped with standard furniture and infrastructure facilities, including network connections, telephones and electricity;
- Local infrastructure for the supply of electricity, raw cooling water, compressed air; and
- Access to its safety services for advice, inspection and verification, and first aid and other emergency help.

Annex 3 treats specifically expenses not covered within this section.

### 3.2 GSI's Contribution

In general, GSI contribute to the testing itself, except specific operation such as survey and fiducialization by CERN experts, which the Parties have agreed. Decisions on the magnets such as acceptance, in case of non-conformity, are GSI's responsibility.

3.2.1 For the entire duration of the Activity, GSI shall contribute adequate qualified experts to the Operation Team. More specifically the roles of:

- A Test Manager (1 FTE), who will be responsible for:
  - Logistics of the magnets;
  - Reception of the magnets and their preparation for the tests;
  - Coordination and execution of the test program;
  - Validation of each tests;
  - Issue the test documents including SAT report
  - Communication with the manufacturers, transport companies and GSI.

In addition:

- A Test Technician (1 FTE), who will take part in and coordinate the daily operation of the test facility and make first-line interventions;
- A Magnetic Measurement Engineer (1 FTE), who will
  - Oversee the process of magnetic measurements and preparation of instruments; and
  - Follow up the measurements, and analyze and document the results.
- A Magnetic Measurement Technician (1 FTE), who will perform the measurements, calibrate the instruments and provide a first interpretation of the results

are anticipated to be covered. These personnel resources shall be continuously available at CERN during the testing. All necessary personnel in order to perform the testing, besides 1.4 FTE from CERN, shall be deployed by GSI. GSI is entitled to change the number and responsibilities of its personnel from the afore mentioned under the premise that the listed tasks are fully covered by GSI.

3.2.2 GSI shall send additional experts for following activity.

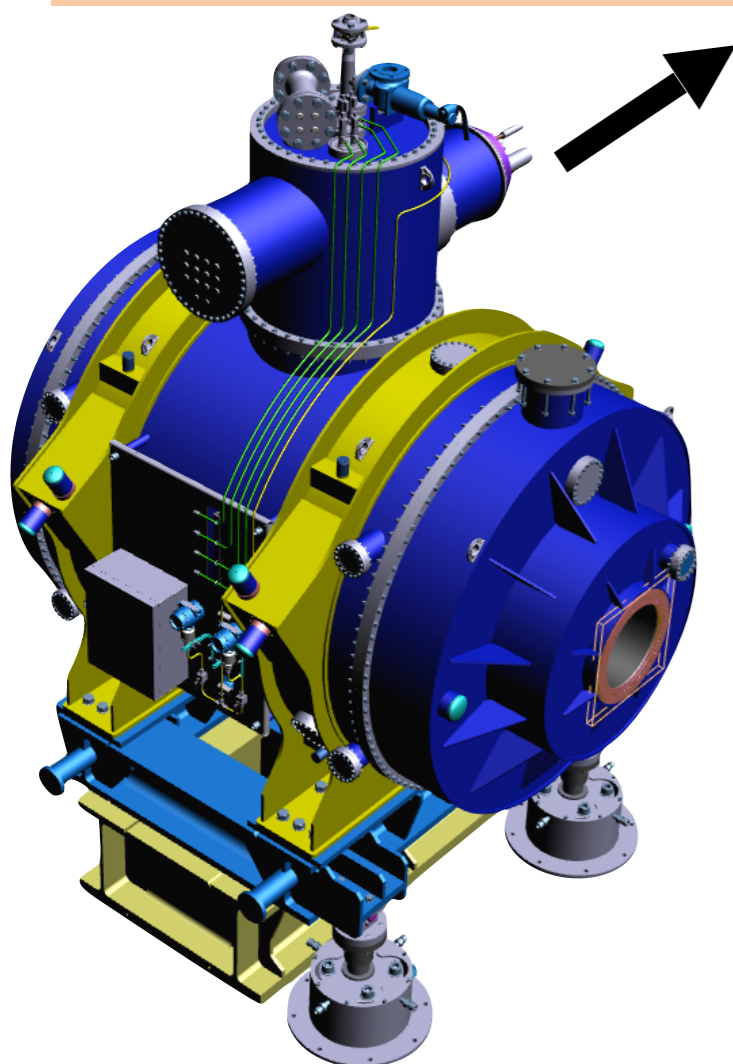
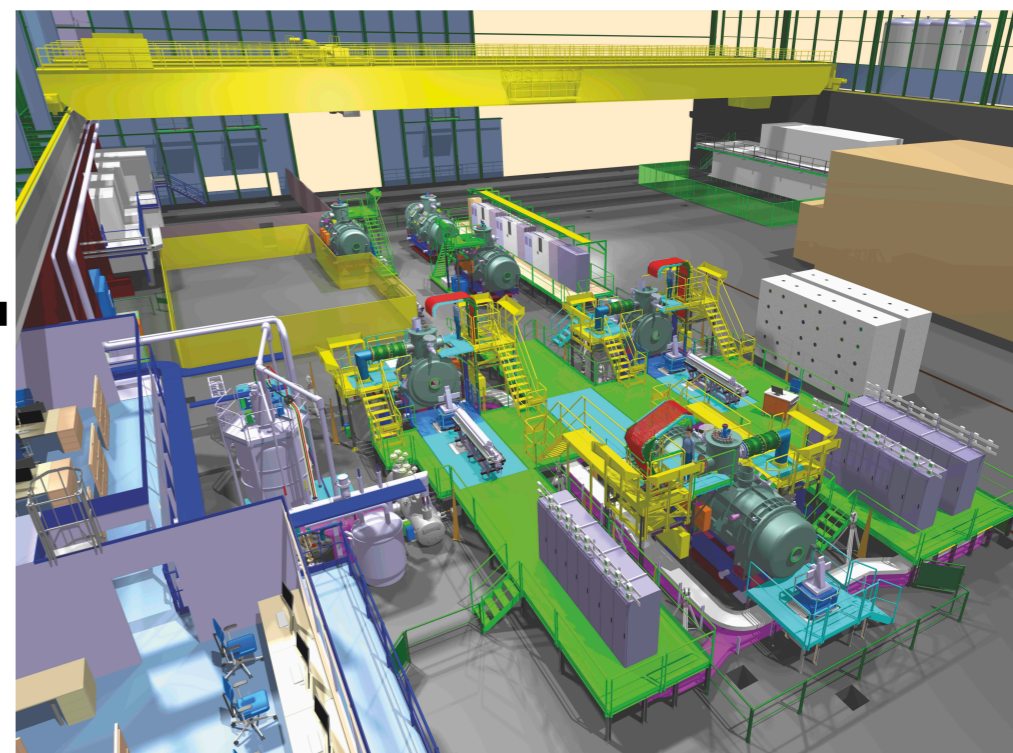
- Survey of the cold mass movement during the testing of the Pre-series Multiplet magnets.

3.2.3 GSI shall be responsible for the delivery to and removal from the test facility of the Super-FRS Magnets, in compliance with applicable export laws and restrictions. The associated cost shall be borne by GSI.

# Test facility interfaces

Due to big delay of the magnet procurements, interface to the CERN facility could not be defined and delivered to CERN in accordance with CERN preparation schedule.

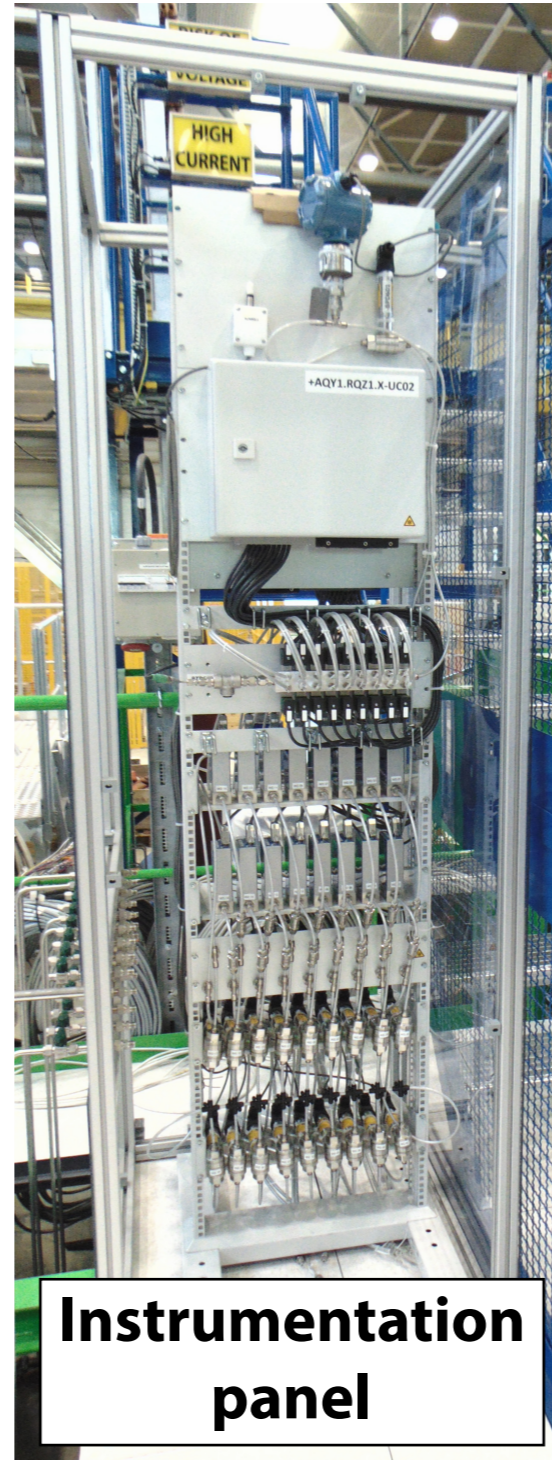
GSI takes care "intermediate" parts, namely



Interface	GSI	Facility	CERN
Electric	Current lead warm terminal		Cable from power converter
Mechanic	Magnet feet		Spacer on the floor
Cooling	<b>Cryogenic jumper line</b>		Satellite valve box
(Helium return)	<b>Instrumentation panel</b>		Helium return line
Vacuum	Cryostat vacuum pump port		Vacuum pump
Alignment	Fiducial targets on cryostat		Fiducialization
Instrumentation	<b>Cabinet for sensor signals</b>		Control sytem
Magnetic	Magnet		Magnetic measurement systems



# Cabinet, instrumentation panel, jumperline



Interfaces are always difficult, but these three components have to work deeply together with CERN system. This created big complexity and time consuming repair work etc.

# Testing team from GSI

## GSI colleagues @ CERN

test manager: **Antonella Chiuchiolo** (Nov. 2018 -)

magnetic measurement physicist: **Giancarlo Golluccio** (May 2018 -)

magnetic measurement technician: **Pawel Kosek** (Dec. 2018 -)

test technician: **Florian Greiner** (Feb. 2019 -)



GSI internal kick-off meeting  
in 11. Dec. 2018

common understanding  
status, issues, grey zone...

Topic	GSI	
Project leader	<b>Kei Sugita</b>	SIS100/SIS18, SC Magnets & Testing
Multiplets/dipole magnets	<b>Hans Mueller, Melanie Cho</b>	SIS100/SIS18, SC Magnets & Testing
Safety	<b>Hans Mueller, Melanie Cho</b>	SIS100/SIS18, SC Magnets & Testing
Transport (Crane)	<b>Hans Mueller, Melanie Cho</b>	SIS100/SIS18, SC Magnets & Testing
Test facility	<b>Kei SUGITA</b>	SIS100/SIS18, SC Magnets & Testing
Modeling	Alexander Bergmann	Commons, Engineering, Mechanical Integraton
Electrical test	Piotr Szwangruber, Walter Freisleben	SIS100/SIS18, SC Magnets & Testing
Survey	<b>Vasileios Velonas, Ina Pschorn</b>	Commons, Engineering, NC Magnets & Alignments
Controll system	Christine Betz, Christian Mueller	Commons, Control systems
Vacuum	<b>Jörg Kurdal</b>	Commons, Vacuum systems
Cryogenics	Felix Wamers	Commons, Cryogenics
Power converter	Alexander Wiest	Commons, Electric Power Systems
Quench protection	Piotr Szwangruber, Walter Freisleben	SIS100/SIS18, SC Magnets & Testing
Project management	M. Valentina Ricciardi	Super-FRS
Beam optics	John Winfield	Super-FRS
Risk and opportunity assessment	Stephanie Deveaux	Project Management Office

**bold:** CERN Cooperation Associate (COAS)

## Test plan and schedule

- test plan
  - sequence of the test activities and time line
  - MS Project file controlled by Antonella
    - the MS Project file is not implemented to FAIR Project file yet
  - implemented into Carpenter so that we can monitor from GSI
  - this is the first testing
    - improvement, re-arrangements are often happened

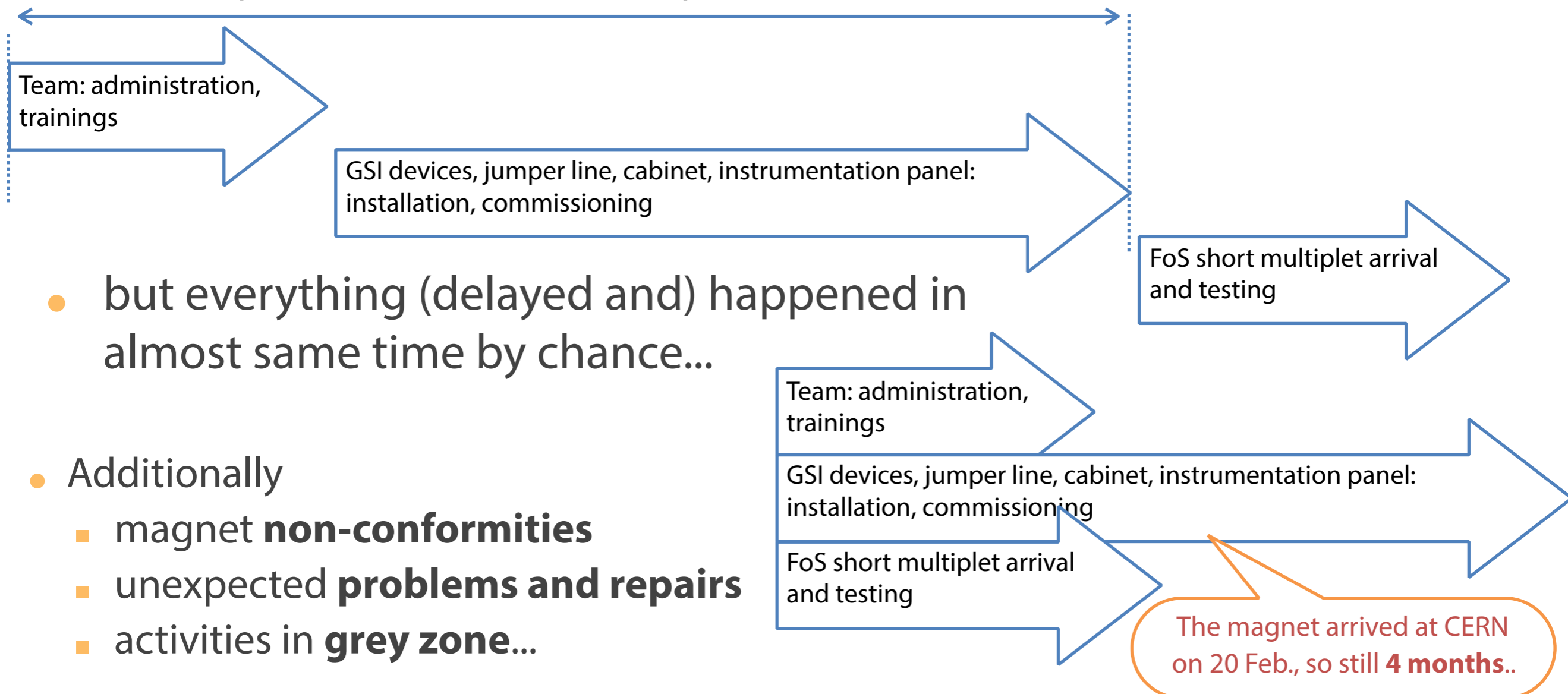
# Test plan and schedule

Approval cold down	0 days	Thu 04.07.19	Thu 04.07.19
Cooling down	10 days	Fri 05.07.19	Thu 18.07.19
Cold mass Survey	1 day	Fri 19.07.19	Fri 19.07.19
Installation power cable platform	0,5 days	Mon 22.07.19	Mon 22.07.19
Interlock <b>commissioning</b> at cold	5 days	Mon 22.07.19	Fri 26.07.19
HV test	1 day	Mon 29.07.19	Mon 29.07.19
Connection current leads	1 day	Tue 02.07.19	Wed 03.07.19
QPS <b>commissioning</b> at cold	5 days	Mon 22.07.19	Fri 26.07.19
Power converters <b>commissioning</b>	5 days	Mon 22.07.19	Fri 26.07.19
<b>Commissioning</b> data storage	5 days	Mon 22.07.19	Fri 26.07.19
<b>Cold powering tests</b>	<b>2,5 mons</b>	Mon 29.07.19	Fri 04.10.19
Cryogenic tests	5 days	Mon 07.10.19	Fri 11.10.19
RRR DAQ <b>commissioning</b>	1 day	Mon 07.10.19	Mon 07.10.19
Warmup	10 days	Mon 07.10.19	Fri 18.10.19
Cold mass survey	1 day	Mon 21.10.19	Mon 21.10.19
2nd cooldown	10 days	Mon 21.10.19	Fri 01.11.19
<b>Cold powering tests</b>	<b>1 mon</b>	Mon 04.11.19	Fri 29.11.19
2nd warmup	10 days	Mon 02.12.19	Fri 13.12.19
Preparation to disconnection	1 day	Mon 16.12.19	Mon 16.12.19
Preparation and transport to test area	1 day	Tue 17.12.19	Tue 17.12.19
Feet dismounting	1 day	Wed 18.12.19	Wed 18.12.19
Safety valve dismounting	0,5 days	Thu 19.12.19	Thu 19.12.19
HV and electrical tests	2 days	Thu 19.12.19	Mon 23.12.19
fill nitrogen before leaving	0,5 days	Mon 23.12.19	Mon 23.12.19
magnet preparation for packing and shipped back	2 days	Tue 24.12.19	Wed 25.12.19

# Test plan and schedule

- remark: **delay?**

- initially, it was planned that first, GSI team deployment, second, GSI devices delivery and commissioning, and third, magnet arrival (estimated ~4 months)



- but everything (delayed and) happened in almost same time by chance...

- Additionally

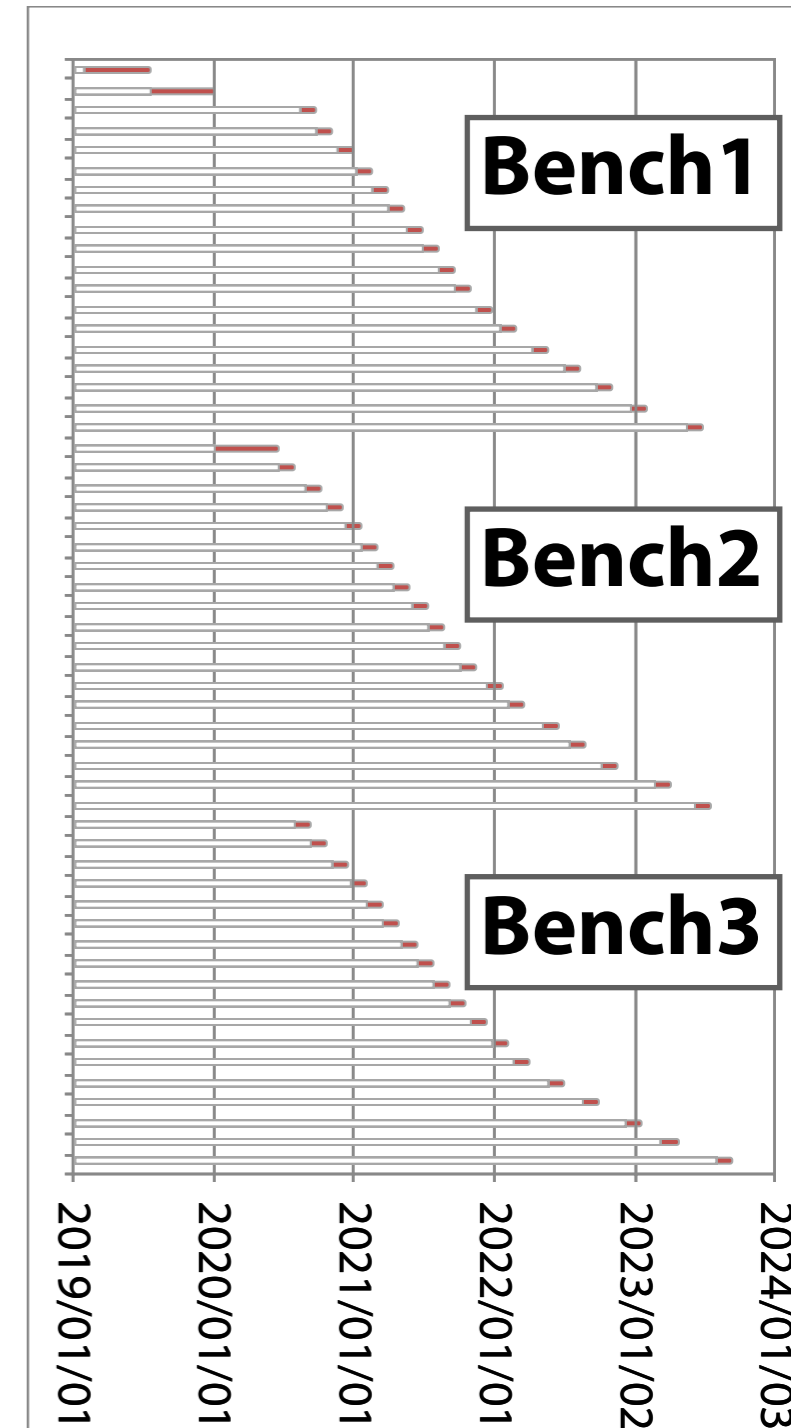
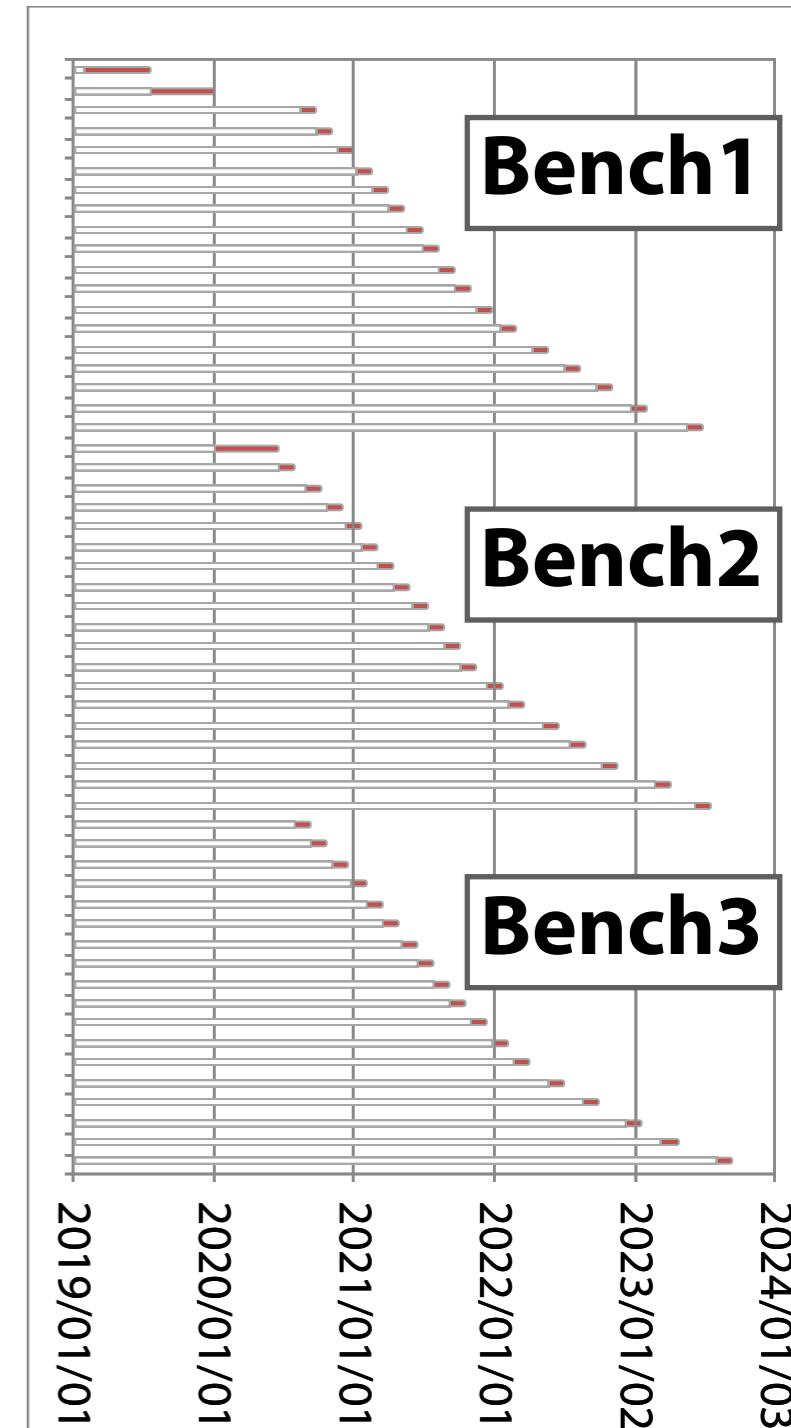
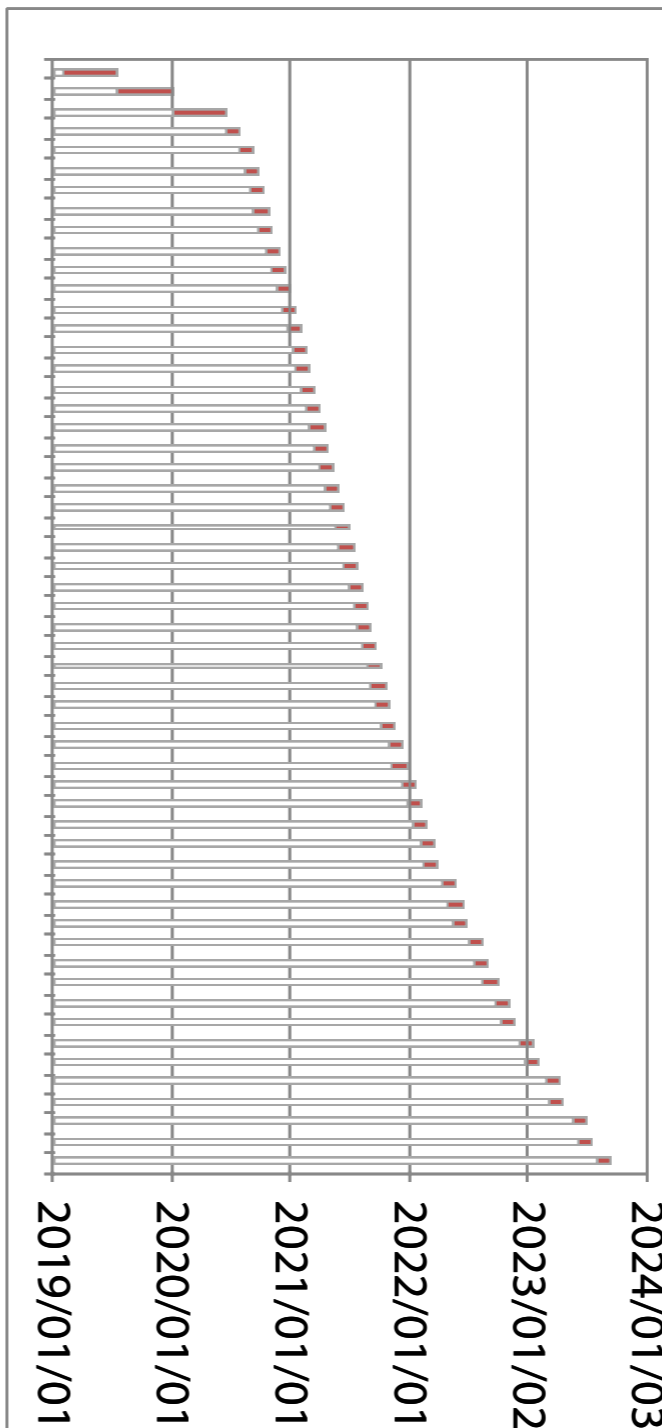
- magnet **non-conformities**
- unexpected **problems and repairs**
- activities in **grey zone...**

## Test plan and schedule

- global schedule
  - whole project until end of the last magnet testing (– 2023)
  - 2 magnet suppliers deliver production/delivery plan
  - combine these plans, sorting by magnet arrival date
  - integrate constraints, cryo facility shutdown, test bench, etc.
  - GSI will update it soon (ongoing).

# (previous one, preliminary)

	Magnet name	FAT	Earliest arrival at CERN 1 week after FAT	Ready for installation	due to	Redy for cool down	due to	Magnet waiting time at prep. area	Magnet waiting time at bench	Total magnet waiting time	SAT start	Test duration weekday	SAT end	Ready for next test at the bench
Pre-series	SM_1	1/28/19	2/4/19	2/4/19	magnet	2/4/19	magnet	0:0	0:0	0:0	2/4/19	24:0	7/22/19	7/22/19
Pre-series	LM_1	5/15/19	5/22/19	7/22/19	bench	7/22/19	bench	8:5	0:0	8:5	7/22/19	24:0	1/6/20	1/6/20
Pre-series	D3_1	8/7/19	8/14/19	1/6/20	bench	1/6/20	bench	20:5	0:0	20:5	1/6/20	24:0	6/22/20	6/22/20
first D2	D2_1	4/5/20	4/12/20	6/22/20	bench	6/22/20	bench	10:1	0:0	10:1	6/22/20	6:0	8/3/20	8/3/20
	SM_2	6/20/20	6/27/20	8/3/20	bench	8/3/20	bench	5:2	0:0	5:2	8/3/20	6:0	9/14/20	9/14/20
	LM_2	8/11/20	8/18/20	8/18/20	magnet	8/18/20	magnet	0:0	0:0	0:0	8/18/20	6:0	9/29/20	9/29/20
	SM_3	8/15/20	8/22/20	8/22/20	magnet	9/1/20	cryo	0:0	1:3	1:3	9/1/20	6:0	10/13/20	10/13/20
	D3_2	9/1/20	9/8/20	9/14/20	bench	9/15/20	cryo	0:6	0:1	1:0	9/15/20	6:0	10/27/20	10/27/20
	D3_3	9/20/20	9/27/20	9/29/20	bench	9/29/20	bench	0:2	0:0	0:2	9/29/20	6:0	11/10/20	11/10/20
	SM_4	10/16/20	10/23/20	10/23/20	magnet	10/23/20	magnet	0:0	0:0	0:0	10/23/20	6:0	12/4/20	12/4/20
	D3_4	10/31/20	11/7/20	11/7/20	magnet	11/7/20	magnet	0:0	0:0	0:0	11/7/20	6:0	12/19/20	12/19/20
	D3_5	11/15/20	11/22/20	11/22/20	magnet	11/22/20	magnet	0:0	0:0	0:0	11/22/20	6:0	1/3/21	1/3/21
	D3_6	12/5/20	12/12/20	12/12/20	magnet	12/12/20	magnet	0:0	0:0	0:0	12/12/20	6:0	1/23/21	1/23/21
	LM_3	12/7/20	12/14/20	12/19/20	bench	12/26/20	cryo	0:5	1:5	1:5	12/26/20	6:0	2/6/21	2/6/21
	D3_7	12/23/20	12/30/20	1/3/21	bench	1/9/21	cryo	0:4	0:6	1:3	1/9/21	6:0	2/20/21	2/20/21
	SM_5	12/26/20	1/2/21	1/23/21	bench	1/23/21	bench	3:0	0:0	3:0	1/23/21	6:0	3/6/21	3/6/21
	D3_8	1/11/21	1/18/21	2/6/21	bench	2/6/21	bench	2:5	0:0	2:5	2/6/21	6:0	3/20/21	3/20/21
	LM_4	1/17/21	1/24/21	2/20/21	bench	2/20/21	bench	3:6	0:0	3:6	2/20/21	6:0	4/3/21	4/3/21
	D3_9	1/30/21	2/6/21	3/6/21	bench	3/6/21	bench	4:0	0:0	4:0	3/6/21	6:0	4/17/21	4/17/21
first branch	D3Y_1	2/15/21	2/22/21	3/20/21	bench	3/20/21	bench	3:5	0:0	3:5	3/20/21	6:0	5/1/21	5/1/21
	SM_6	3/5/21	3/12/21	4/3/21	bench	4/3/21	bench	3:1	0:0	3:1	4/3/21	6:0	5/15/21	5/15/21
	LM_5	3/27/21	4/3/21	4/17/21	bench	4/17/21	bench	2:0	0:0	2:0	4/17/21	6:0	5/29/21	5/29/21
	SM_7	5/1/21	5/8/21	5/8/21	magnet	5/8/21	magnet	0:0	0:0	0:0	5/8/21	6:0	6/19/21	6/19/21
	D3_10	5/4/21	5/11/21	5/15/21	bench	5/22/21	cryo	0:4	1:0	1:4	5/22/21	6:0	7/3/21	7/3/21
	D3_11	5/15/21	5/22/21	5/29/21	bench	6/5/21	cryo	1:0	1:0	2:0	6/5/21	6:0	7/17/21	7/17/21
	LM_6	6/7/21	6/14/21	6/19/21	bench	6/19/21	bench	0:5	0:0	0:5	6/19/21	6:0	7/31/21	7/31/21
	D3_12	6/15/21	6/22/21	7/3/21	bench	7/3/21	bench	1:4	0:0	1:4	7/3/21	6:0	8/14/21	8/14/21
	SM_8	6/28/21	7/5/21	7/17/21	bench	7/17/21	bench	1:5	0:0	1:5	7/17/21	6:0	8/28/21	8/28/21
	D3_13	6/30/21	7/7/21	7/31/21	bench	7/31/21	bench	3:3	0:0	3:3	7/31/21	6:0	9/11/21	9/11/21
	D3_14	7/21/21	7/28/21	8/14/21	bench	8/14/21	bench	2:3	0:0	2:3	8/14/21	6:0	9/25/21	9/25/21
	LM_7	7/30/21	8/6/21	8/28/21	bench	8/28/21	bench	3:1	0:0	3:1	8/28/21	6:0	10/9/21	10/9/21
	D3_15	8/11/21	8/18/21	9/11/21	bench	9/11/21	bench	3:3	0:0	3:3	9/11/21	6:0	10/23/21	10/23/21
	D3_16	9/2/21	9/9/21	9/25/21	bench	9/25/21	bench	2:2	0:0	2:2	9/25/21	6:0	11/6/21	11/6/21
	D3_17	9/23/21	9/30/21	10/9/21	bench	10/9/21	bench	1:2	0:0	1:2	10/9/21	6:0	11/20/21	11/20/21
	LM_8	10/26/21	11/2/21	11/2/21	magnet	11/2/21	magnet	0:0	0:0	0:0	11/2/21	6:0	12/14/21	12/14/21
	D3_18	11/3/21	11/10/21	11/10/21	magnet	11/16/21	cryo	0:6	0:6	1:5	11/16/21	6:0	12/28/21	12/28/21
	D2_2	12/7/21	12/14/21	12/14/21	magnet	12/14/21	magnet	0:0	0:0	0:0	12/14/21	6:0	1/25/22	1/25/22
	LM_9	12/25/21	1/1/22	1/1/22	magnet	1/1/22	magnet	0:0	0:0	0:0	1/1/22	6:0	2/12/22	2/12/22
	D2_3	1/11/22	1/18/22	1/18/22	magnet	1/18/22	magnet	0:0	0:0	0:0	1/18/22	6:0	3/1/22	3/1/22
	LM_10	1/31/22	2/7/22	2/7/22	magnet	2/7/22	magnet	0:0	0:0	0:0	2/7/22	6:0	3/21/22	3/21/22
	LM_11	2/7/22	2/14/22	2/14/22	magnet	2/21/22	cryo	1:0	1:0	2:0	2/21/22	6:0	4/4/22	4/4/22
	LM_12	4/7/22	4/14/22	4/14/22	magnet	4/14/22	magnet	0:0	0:0	0:0	4/14/22	6:0	5/26/22	5/26/22
	LM_13	5/1/22	5/8/22	5/8/22	magnet	5/8/22	magnet	0:0	0:0	0:0	5/8/22	6:0	6/19/22	6/19/22
second branch	D3Y_2	5/9/22	5/16/22	5/16/22	magnet	5/22/22	cryo	0:6	0:6	1:5	5/22/22	6:0	7/3/22	7/3/22
	LM_14	6/30/22	7/7/22	7/7/22	magnet	7/7/22	magnet	0:0	0:0	0:0	7/7/22	6:0	8/18/22	8/18/22
	LM_15	7/13/22	7/20/22	7/20/22	magnet	7/21/22	cryo	0:1	0:1	0:2	7/21/22	6:0	9/1/22	9/1/22
third branch	D3Y_3	8/15/22	8/22/22	8/22/22	magnet	8/22/22	magnet	0:0	0:0	0:0	8/22/22	6:0	10/3/22	10/3/22
	LM_16	9/20/22	9/27/22	9/27/22	magnet	9/27/22	magnet	0:0	0:0	0:0	9/27/22	6:0	11/8/22	11/8/22
	LM_17	10/5/22	10/12/22	10/12/22	magnet	10/12/22	magnet	0:0	0:0	0:0	10/12/22	6:0	11/23/22	11/23/22
	LM_18	12/5/22	12/12/22	12/12/22	magnet	12/12/22	magnet	0:0	0:0	0:0	12/12/22	6:0	1/23/23	1/23/23
	LM_19	12/17/22	12/24/22	12/24/22	magnet	12/26/22	cryo	0:2	0:2	0:4	12/26/22	6:0	2/6/23	2/6/23
	LM_20	2/22/23	3/1/23	3/1/23	magnet	3/1/23	magnet	0:0	0:0	0:0	3/1/23	6:0	4/12/23	4/12/23
	LM_21	3/2/23	3/9/23	3/9/23	magnet	3/15/23	cryo	0:6	0:6	1:5	3/15/23	6:0	4/26/23	4/26/23
	LM_22	5/14/23	5/21/23	5/21/23	magnet	5/21/23	magnet	0:0	0:0	0:0	5/21/23	6:0	7/2/23	7/2/23
	LM_23	6/5/23	6/12/23	6/12/23	magnet	6/12/23	magnet	0:0	0:0	0:0	6/12/23	6:0	7/24/23	7/24/23
	LM_24	7/30/23	8/6/23	8/6/23	magnet	8/6/23	magnet	0:0	0:0	0:0	8/6/23	6:0	9/17/23	9/17/23



## Summary

- overview of the project was presented.
- we will test 56 magnets in total by end of 2023.
- major milestones "deployment of GSI personnel", "delivery of GSI devices", "arrival of the magnet" were completed, but happened almost same time.
- we faced unexpected issues.
- nevertheless, by big efforts of GSI team, CERN and GSI colleagues, testing are progressing well. (optimisation of activities are essential and effective!)
- so far, no critical issue/show-stopper is detected.
- "communication" is a key for successful project
  - GSI, CERN, GSI team, magnet manufacturers
  - communication "between" and "within" above parties