SFRS magnet testing: progress

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Outline

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Testing Magnets

1. Cryomagnetic module integrity (machine safety)
   - Electric insulation quality
   - Leak tightness
   - Cool down behaviour
   - Sensors connection, voltage taps
2. Specification compliant (machine operation)
   - e.g. operation current with sufficient margin;
   - e.g. field length; iron quality, magnet end chamfering
3. Fine tuning of the machine
   - e.g. analysis of particle curvature
   - e.g. imaging properties

Testing Sc. Magnets for FAIR

- sc. accelerator projects $\rightarrow$ testing series @ LAB (e.g. Tevatron, SSC, RHIC, Nuclotron, LHC)
- assigned to different labs $\rightarrow$ "collaboration nature" of FAIR

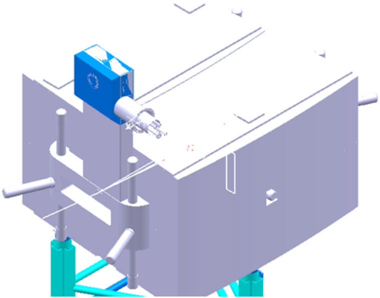
GSI	• SIS100 dipoles • SIS100 quadrupole doublet modules (integrity tests) • SIS100 string test • retests for all FAIR accelerator magnets (operation period)
JINR	• build up of test facility for NICA magnets • $\rightarrow$ collaboration on testing SIS100 quadrupole units
CERN	• **testing all SuperFRS magnets**

Outline

Testing SuperFRS Magnets

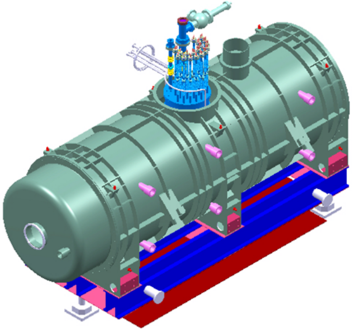
- Collaboration between GSI $\leftrightarrow$ CERN
- Established february 2013
- prepared and formed within the collaboration

SuperFRS Magnets



SuperFRS Dipole

superferric, cold coil, warm iron, 1.6 T, 2 t cold mass, 60 t total



SuperFRS Multiplett

superferric, cold coil, cold iron, quadrupole triplet, correctors up to 9 magnets, 65 t, 4.5 m high

Testing SuperFRS: CERN WP Leaders

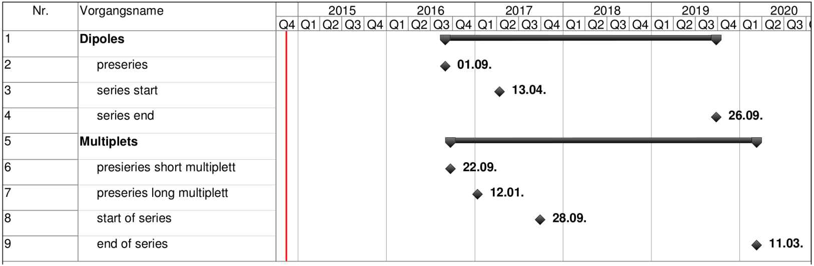
Package	Group	
Technical Coordinator	TE/CRG	Luigi Serio
Test Facility	TE/MSC	Marta Bajko
Magnetic measurements	TE/MSC	Stephan Russenschuck
Survey	EN/MEF	Dominique Missiaen
Cryogenics	TE/CRG	Antonio Perrin
Power converters	TE/EPC	Hugues Thiesen
Quench protection	TE/MPE	Reiner Denz
Energy extraction	TE/EE	Knud Dahlerup-Petersen
Platforms & Structure	EN/MEF	Mats Wilhelmsson
Electrical power	EN/EL	Rene Necca
Cooling and ventilation	EN/CV	Michele Battistin
Handling & transport	EN/HE	Ingo Ruehl
ICE	EN/ICE	Phillipe Gayet
Integration	EN/MEF	Yvon Muttoni

Boundary conditions

- Collaboration agreement: GSI $\leftrightarrow$ CERN
- CERN preparing for test
  - refurbishing compressors, utilities
  - procurement of power converters
  - planning of measurement program
- active interaction
  - cryo-infrastructure refurbishment
  - layout of facility
  - number of benches
  - test equipment preparation

Outline

Magnets Delivery



Module	pcs.	start	end	month	average
dipole	21	03/2017	09/2019	26	$\approx$1
multipletts	31	09/2017	03/2020	31	$\approx$1

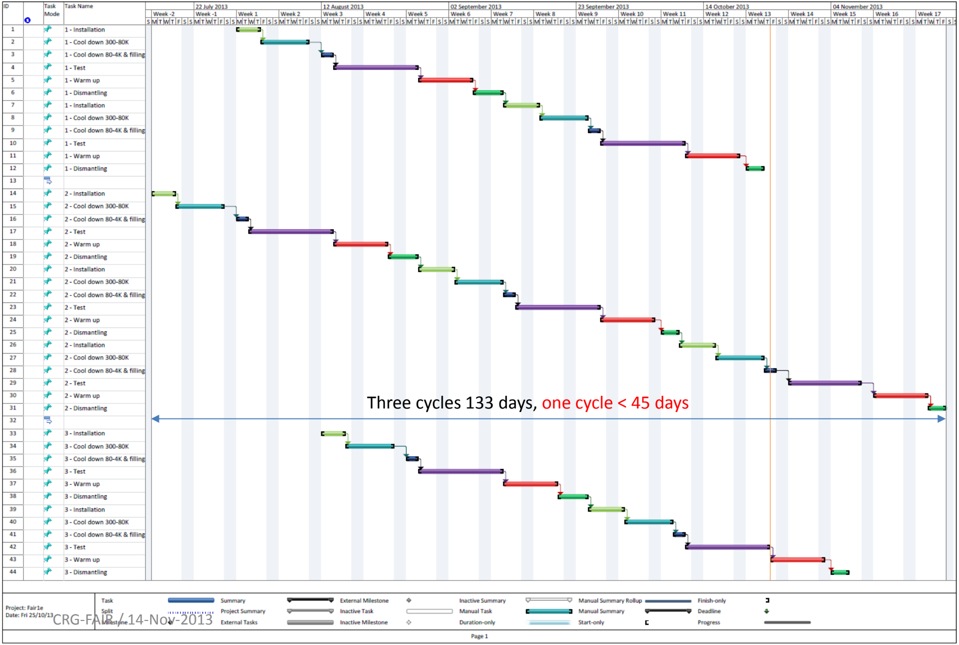
Testing: Matching Delivery I/II

- 2 modules per month
- estimation of testing time
- based on today's knowledge
  - cool-down, warm-up
  - equipment reliability
  - available equipment
  - basis of further evaluations
- based on long multipletts (most complex module)
- CERN's evaluation on following slides (courtesy of V. Benda, J. Bremer, O. Pirotte)

Updated assumption

- Testing speed
  - The same as magnet production — 2magnet /month
  - For 53 magnet to be tested — 2.4 year in total
  - Working weeks per year — 46
  - Number of magnets — 53
- Cooling speed
  - Cooling speed from 300 K - 80 K — 1 K/h
  - Cooling speed from 80 K – 5 K — no limitation
  - Warming speed from 5 K – 80 K — no limitation
  - Warming speed from 80 K – 300 K — 1 K/h
  - Maximum dT on a magnet — 50 K
  - Weight of magnets tested in parallel — 45 t
- Phases
  - Magnet installation — 4 days (working), *update from 3 days*
  - Cool down from 300 K - 80 K — 8 days
  - Cool down from 80 K - 5 K & filling — 2 days
  - Testing — 10 days (working)
  - Warm up from 5 K to 300 K — 9 days
  - Dismantling — 3 days (working)
- Operation
  - Number of shifts for magnetic measurement: — 1
  - Automatic modes: — Cool down, filling, warm up
  - Manual modes: — Installation, test, dismantling
  - Work during weekends: — No; only automatic modes
  - Magnetic test only on one bench — Only one set of power supplies

Updated base line



Testing: Matching Delivery II/II

- 2 modules / month
- cycle 45 days $\rightarrow$ 3 test benches
- check on:
  - space in building 180
  - available cold box / precooler
  - number of power converters
  - required measurement systems

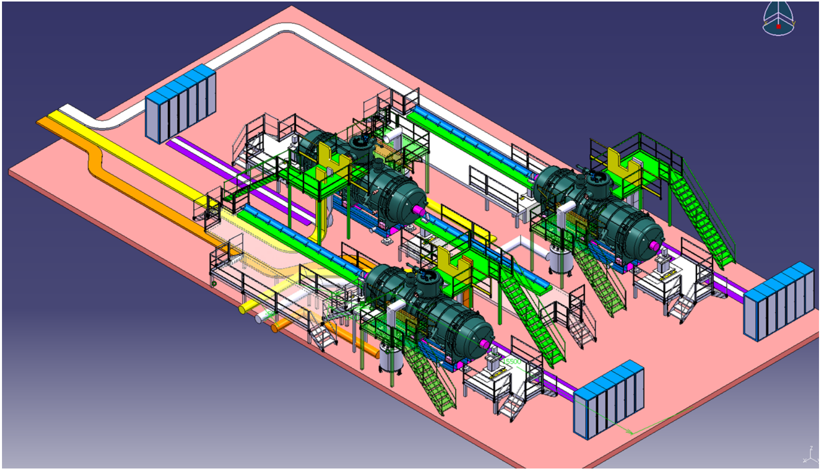
3 Benches: Impact on equipment

- planning:
  - 1 cool down
  - 1 testing @ cold
  - 1 at warm up
- infrastructure
  - cold box: sufficient for 1 cool down / 1 being tested
  - new precooler required (warm up with gas)
  - power converters: 1 set (9 power converters)
  - magnetic measurement equipment: 1 set
  - matching electrical power / cooling water

Space 180: Boundary conditions

- Space required for
  - measurement benches:
    - the magnet module (multiplet, dipole)
    - measurement device area (e.g. long shaft for rotating coil probe)
    - fixed installations (feed boxes, power converters, cabling and pipeing)
    - service area (e.g. scaffolds)
  - storage / loading / unloading (only place at CERN)
- one of three users in building 180

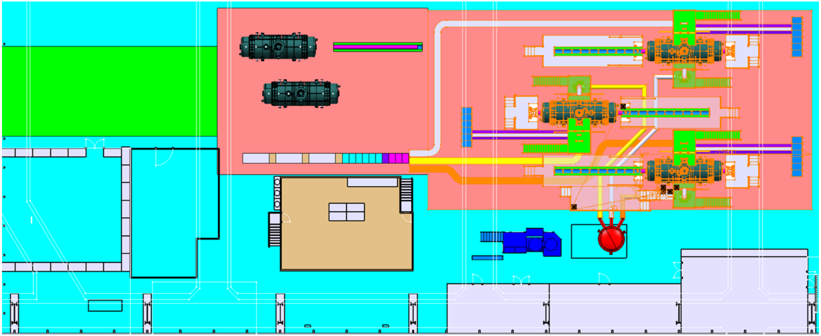
SuperFRS: Layout of Benches



Courtesy of CERN

Location of the multiplets, scaffolds, power converters, supply infrastructure, electronics cabinet

SuperFRS: Layout of Benches



Courtesy of CERN

multiplets on the bench, storage space (for 1), intermediate storage (for 1)

3 benches built up

- 3 operation modes $\leftrightarrow$ 3 benches
- current planning: per month, 2 modules tested, 2 modules produced $\leftarrow$ adjustment of dipole production made
- margin (retests, planning inaccuracy, shut down period)
  - cool down speed 1K/h $\rightarrow$ from magnets $\rightarrow$ cooling power allows 2 K/h
  - testing time $\rightarrow$ defined by MM $\rightarrow$ estimation based on multiplet with 9 magnets
  - no cross links $\rightarrow$ longer real world measurement time $\rightarrow$ linear scale in project time
  - limited mitigation: increase of shifts (currently 1 shift)

Outline

Interface definition

- CERN $\rightarrow$ realisation phase
  - procurement of cyrogenic infrastructure $\rightarrow$ magnet interface $\rightarrow$ forces during pressure test (nominal pressure 20 bar) $\rightarrow$ self contained system
  - safety documentation $\rightarrow$ agreement on standard, testing procedures
  - magnetic field measurements
  - electrical systems / power converter / quench detection / magnet protection
  - signal interface lists
- GSI clarifying same topics
  - (reviewing) design of the machine
  - test station $\leftarrow$ follows machine
  - test station $\rightarrow$ definition $\rightarrow$ drives machine

Interface specification: Example MM I/II

main dipoles				
	main field component	$5 \cdot 10^{-4}$		
	field quality $\Delta B/B$	$5 \cdot 10^{-5}$		
	horiz. spatial resolution	30	mm	
main quadrupoles				
	main field component	$5 \cdot 10^{-4}$		
	other harmonics	$5 \cdot 10^{-5}$		
	axis	0.2	mm	
	angle	0.5	mrad	
other magnets				
	main field component	$1 \cdot 10^{-3}$		
	other harmonics	$2 \cdot 10^{-4}$		(up to order 10)
	axis	0.2	mm	except steerer
	angle	0.5	mrad	

Interface specification: Example MM II/II

measurement systems:

- series
  - dipoles $\rightarrow$ flux meters
  - multiplets $\rightarrow$ rotating coil probes
- pre-series
  - dipoles $\rightarrow$ flux meters
  - multiplets $\rightarrow$ rotating coil probes

Outline

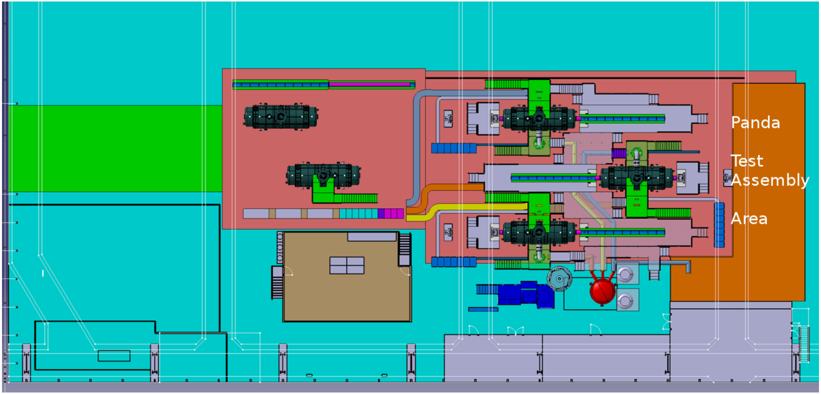
Further test facility use: Energy buncher

- magnet lists above: without energy buncher
- but $\rightarrow$ technical planning $\rightarrow$ feasibility checks made
- technical limitations investigated
- multiplets
  - different design $\rightarrow$ “series multiplets”
  - $\rightarrow$ technically testable at CERN
- dipoles
  - design currently revised
  - mass $\rightarrow$ significantly reduced $\rightarrow$ within test facility handling capabilities
  - not fully designed $\rightarrow$ current technical planning $\rightarrow$ taken in consideration as far as possible

Further test facility use: Panda I/II

- Panda detector magnet $\rightarrow$ CERN/PH $\rightarrow$ assembly and test (of cryostated coil) $\rightarrow$ same building
- check of impact on testing SuperFRS
- adjacent area $\rightarrow$ no conflict
- Panda magnet (cryostated coil) test $\rightarrow$ "only" functionality (no MM) $\rightarrow$ 1-2 month $\rightarrow$ 2 benches for SuperFRS magnet testing

Further test facility use: Panda III/II



Assembly and test area, adjacent to SuperFRS test area; cryosupply shared for 2 month, (check on stray field effects [electronics in cabinets, MM])

Outline

Conclusion

Testing SuperFRS@CERN

- currently
  - infrastructure refurbishment running
  - 3 test benches
  - interface documents under approval
  - procurement of required installations/systems
- next steps
  - measurement program $\rightarrow$ in detail planning
  - testing procedures