

JOINT INSTITUTE
FOR NUCLEAR RESEARCH

Superconducting magnets for NICA project

Nikiforov D.
on behalf of the team





Outline

- Creation of the test facility
- SC magnets
- Cryogenic test of SC magnets
- Conclusions

Stages of development a high-technology line for assembling and testing of SC magnet of NICA and FAIR projects





Test facility



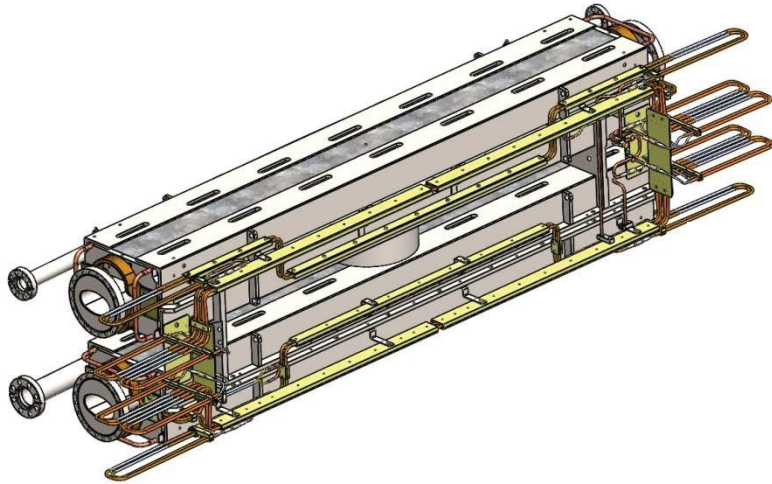
- 1 – Section of manufacture SC cable
- 2 – Section of manufacture SC coils
- 3 – Section of assembling SC magnets
- 4 – Section of “warm” magnetic tests
- 5 – Section of vacuum tests
- 6 – Section of assembling SC magnets in cryostates
- 7 – Section of cryogenic tests
- 8 – Section of power supply

SC magnets

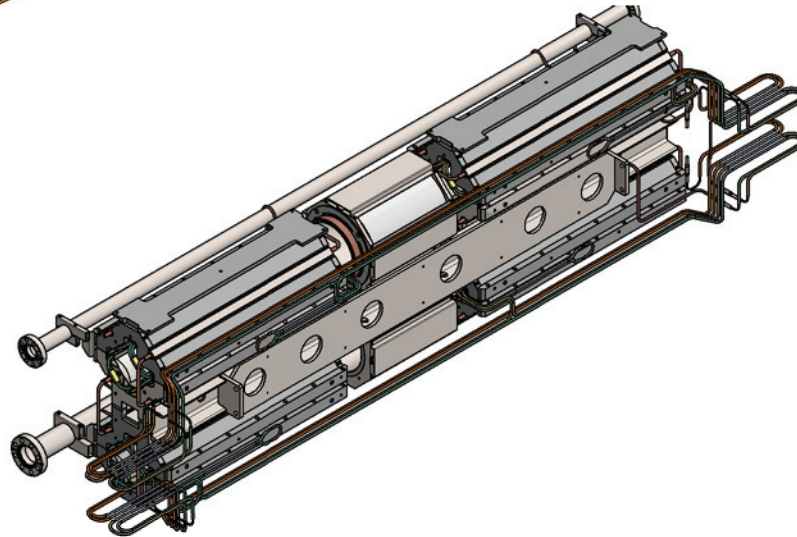
Booster synchrotron	Dipole magnet	40
	Quadrupole magnet	56
	Dipole correction magnet	24
	Multipole correction magnet	8
	Total:	128
Collider	Dipole magnet	86
	Quadrupole lens (arch)	50 (6)
	Quadrupole lens (doublet)	30 (0)
	Dipole magnet BV	10 (0)
	Quadrupole final focus lens (LFF)	15 (0)
	Correction magnet	132 (81)
	Total:	323 (173)
Synchrotron SIS100	Quadrupole magnet	166 (27)
	Sextupole magnet	42 (19)
	Steerer	83 (20)
	Multipole correction magnet	12
	Total:	303 (66)
	Total:	754 (367)

-magnets were produced
 -magnets are produced
 -magnets are in the design phase

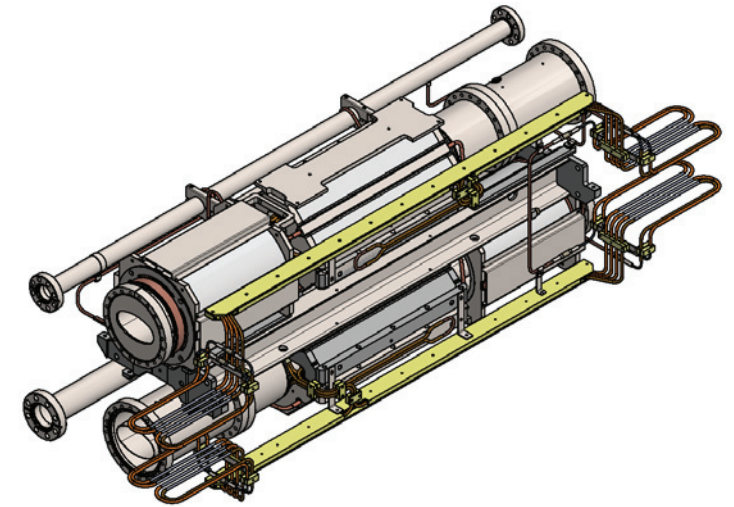
Three types of SC twin regular magnets of NICA collider



Dipole magnets

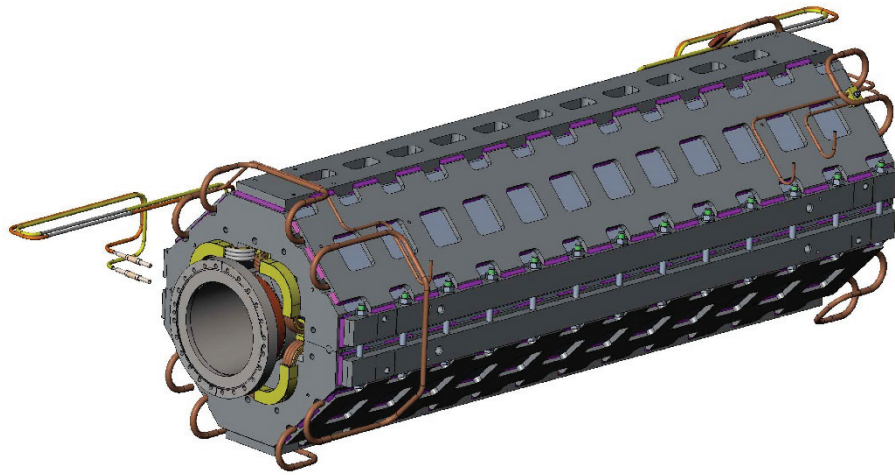


Quadrupole magnets (doublet)
with multipole correctors

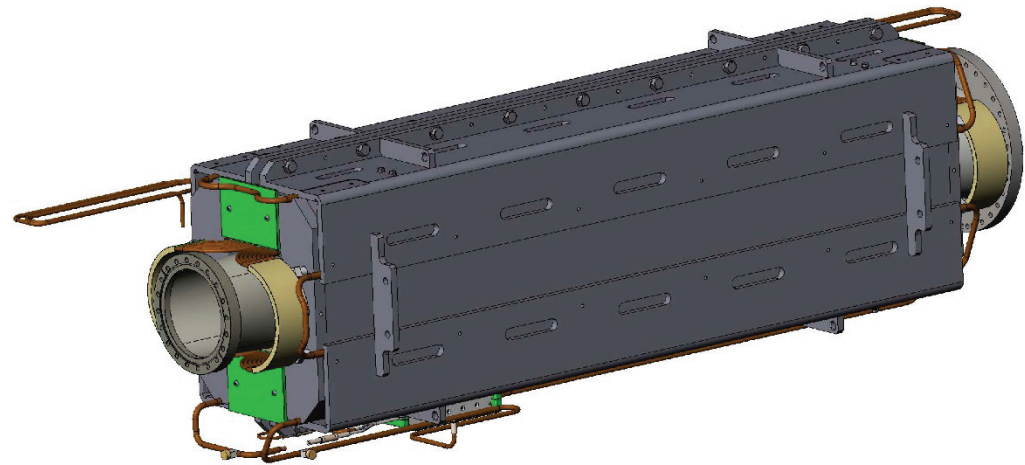


Quadrupole magnets (arch)
with multipole correctors

Two types of SC non regular magnets of NICA collider



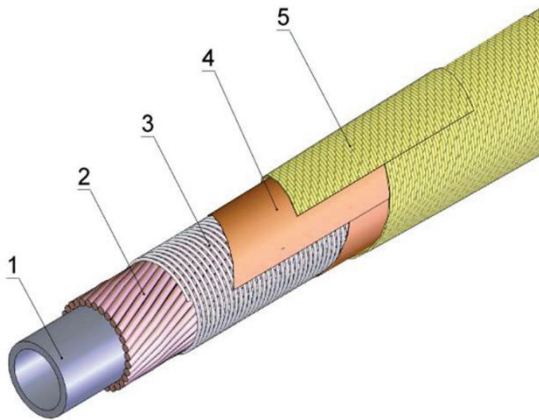
Quadrupole magnets LFF



Dipole magnet BV



Section of manufacture SC cable



SC cable: 1 – CuNi tube 4x0,5 mm, 2 – SC strand (NbTi), 3 – NiCr wire, 4 – carbon tape, 5 – fiberglass tape.

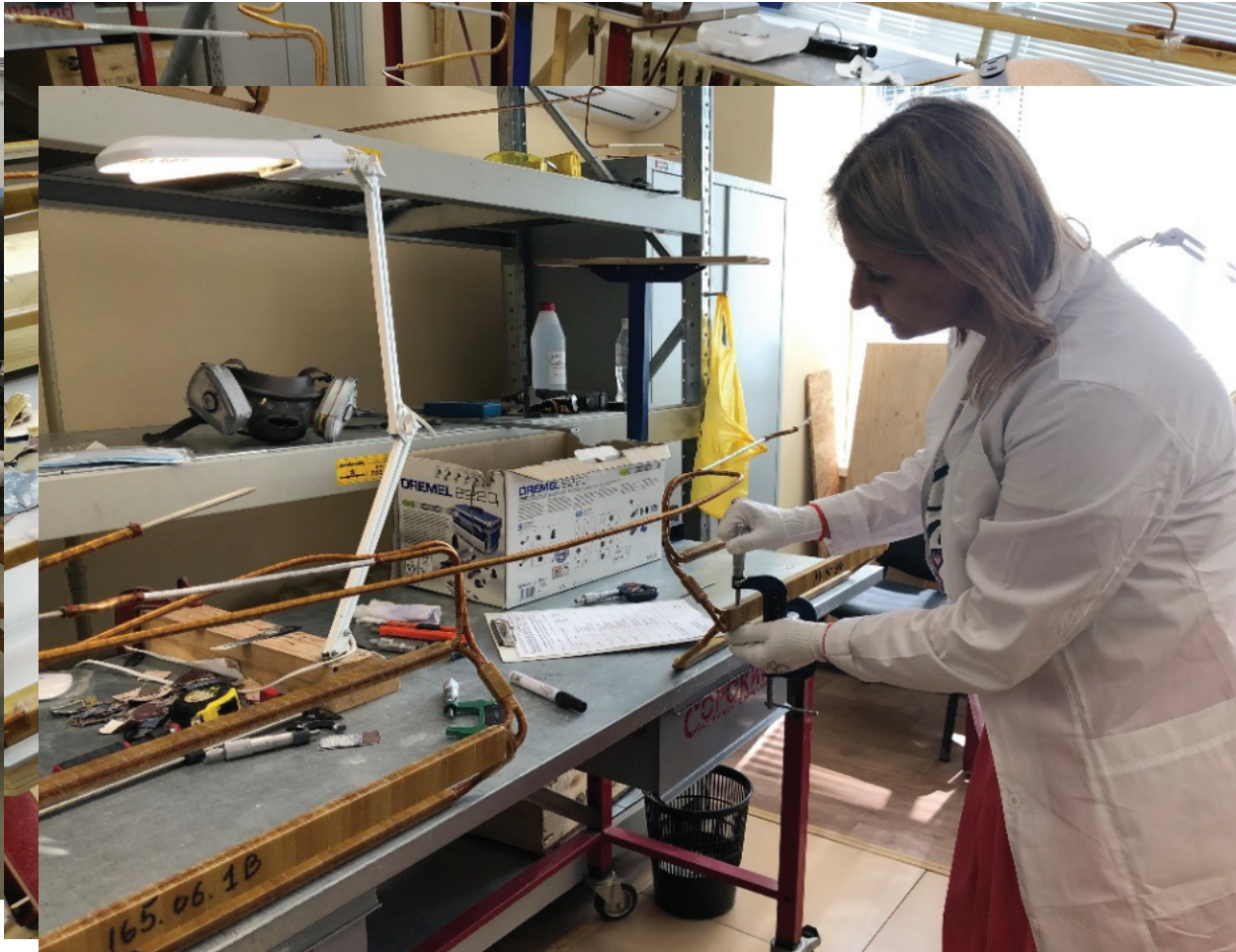
Produced SC cable – 25 km.



Machine for production SC cable



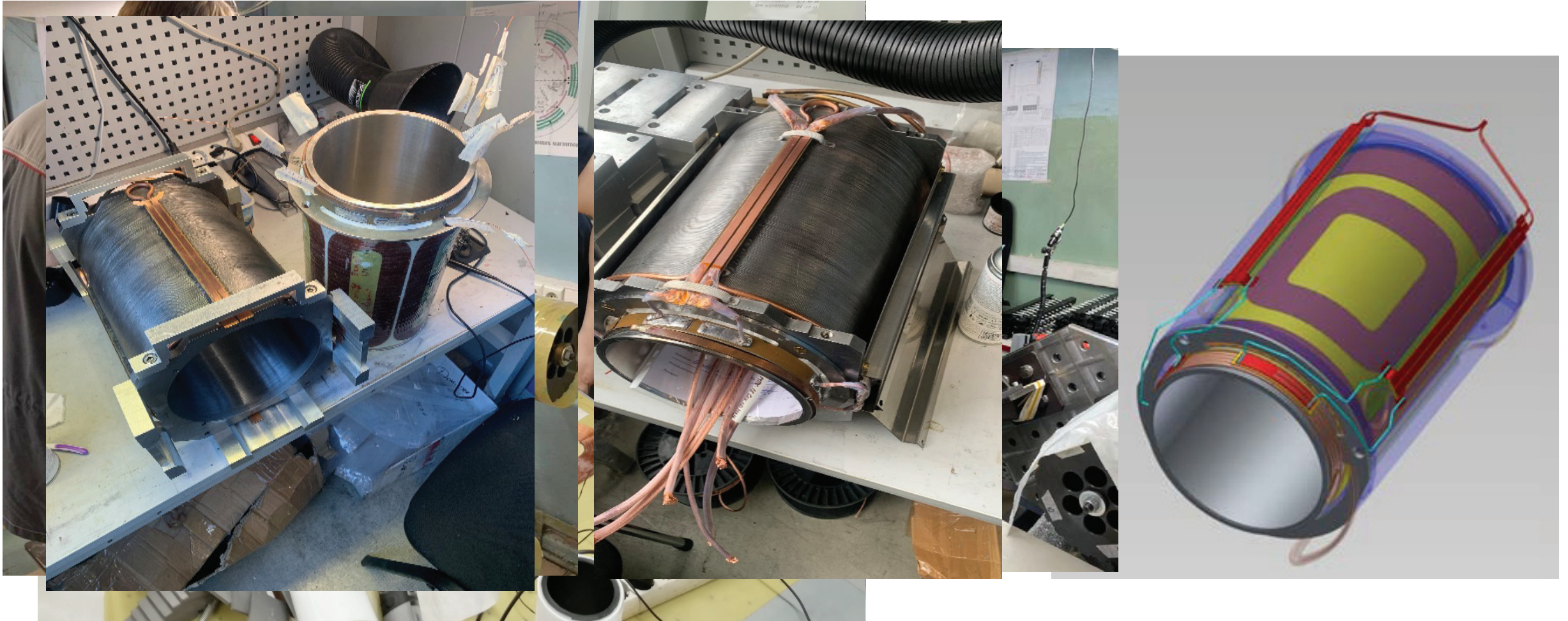
Section of manufacture SC coils



Produced SC coils – 422.



SC correction magnets

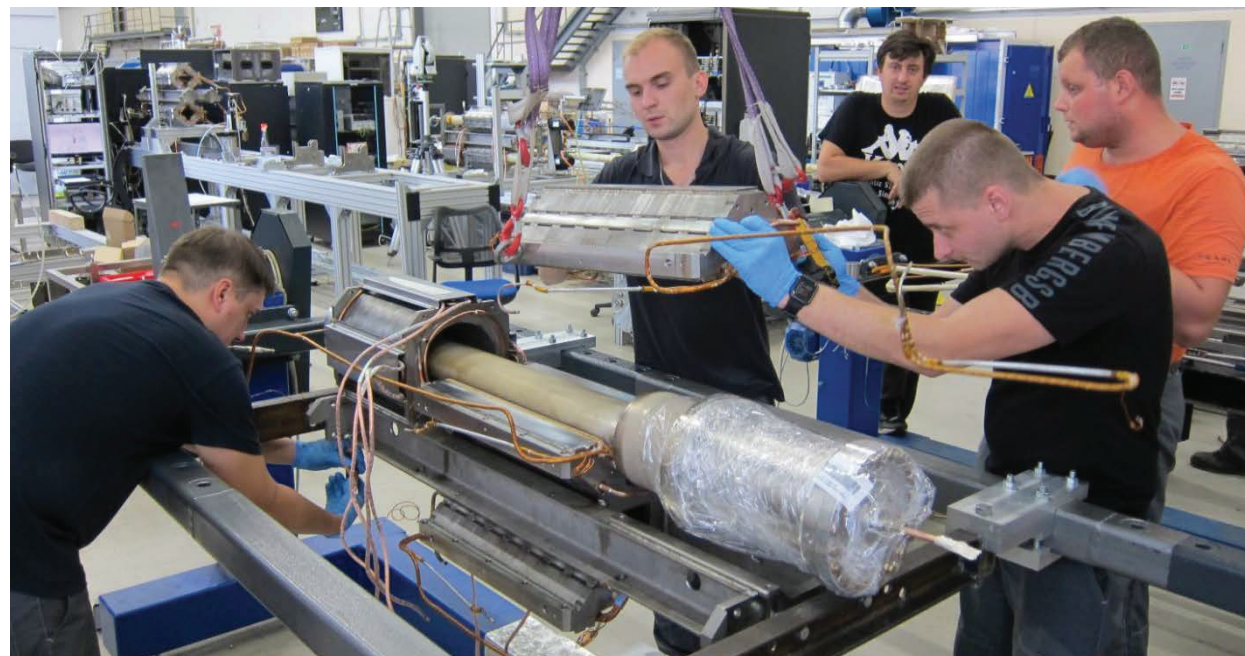
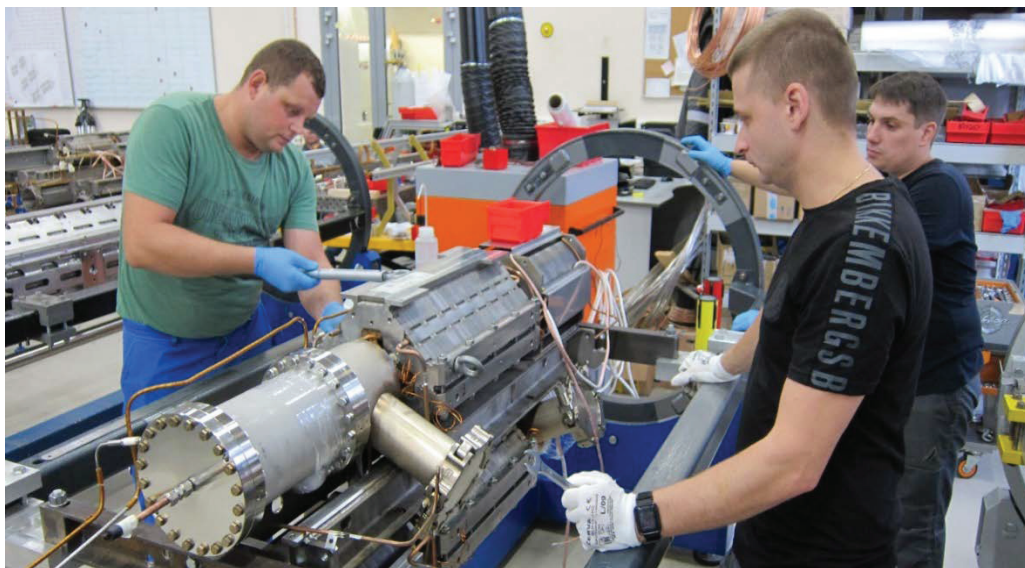


Produced – 81 (88 %) SC correction magnets for quadrupole magnets (arch)

Produced – 0 (0 %) SC correction magnets for quadrupole magnets (doublet)



Section of assembling SC magnets





Sections of tests

1. Warm magnetic measurement (E. Fisher, A. Shemshuk, T. Parfilo)



Quadrupole magnets (arch)

Quadrupole magnets SIS10





Cryogenic system of test section

Cryogenic test bench consists:

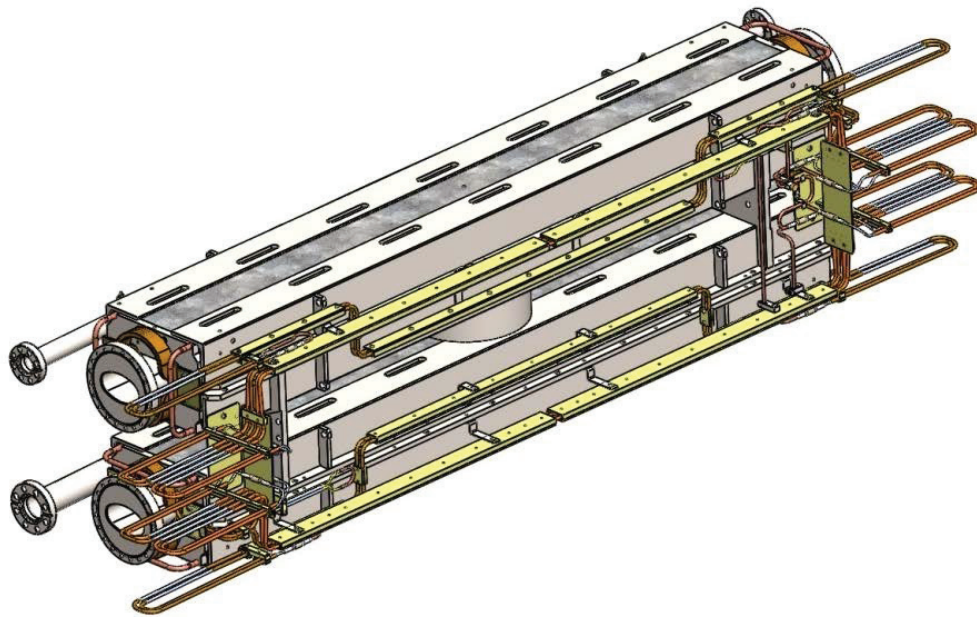
- Three helium satellite refrigerators,
- Six test stand,
- Twelve HTSC current leads,
- Maximum productivity 12 SC magnets per month.





SC dipole magnet for collider

The number of SC magnets successfully passed the test - 86.
The total number of cryogenic tests - 113.

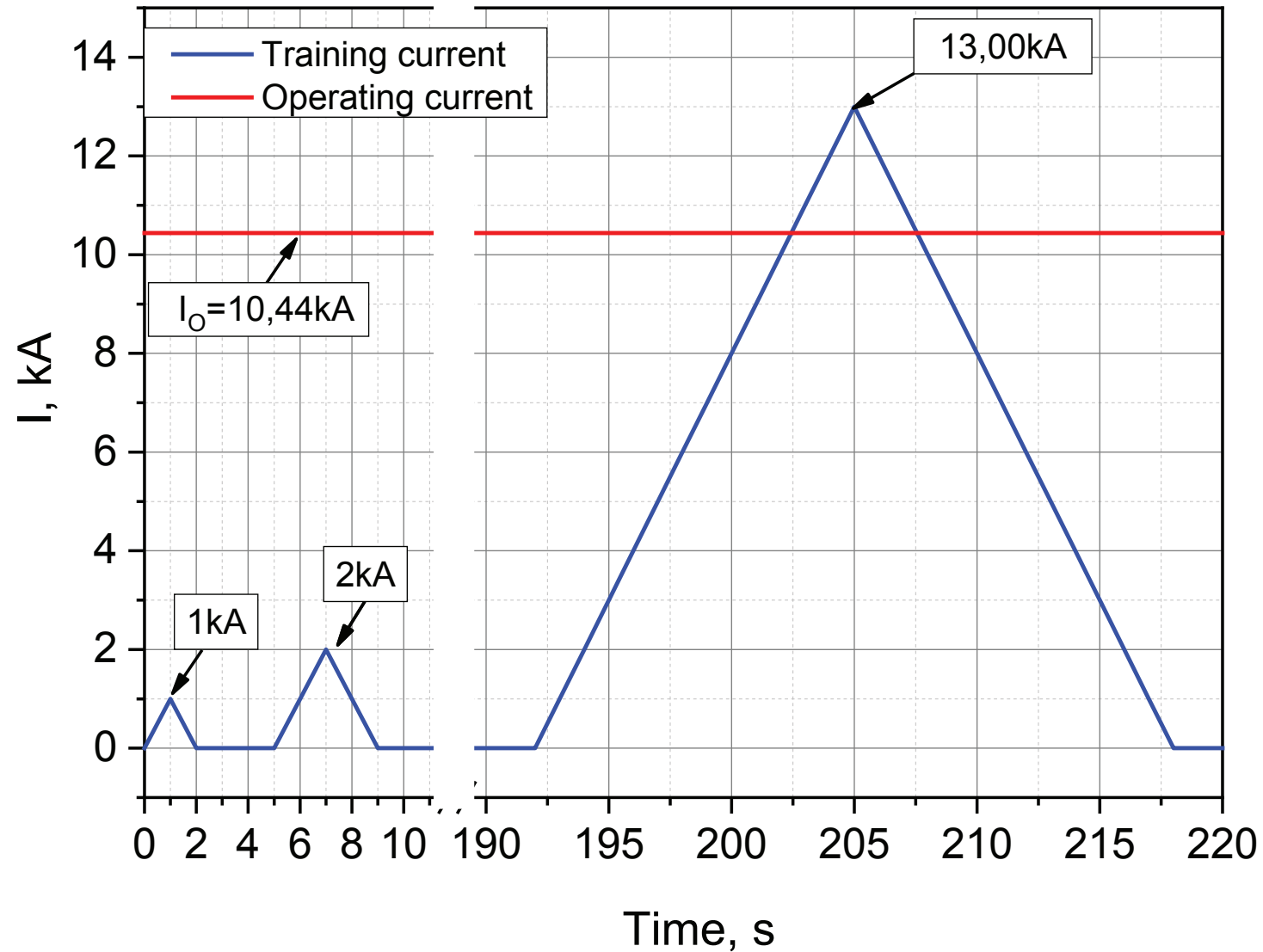


Parameter	Dipole magnets
Cooling channel diameter, mm	3
Number of SC strands (diameter 0,90 mm)	16
Superconductor	Nb – Ti
Length of SC cable, m	120
Operation current (1.8T, 4.65K), kA	10.44
Critical current (2.5T, 4.7K), kA	19.2
Effective magnetic length, m	1.924
Overall weight, kg	1800
Number of SC magnets for collider.	81
Cooling time, h	65



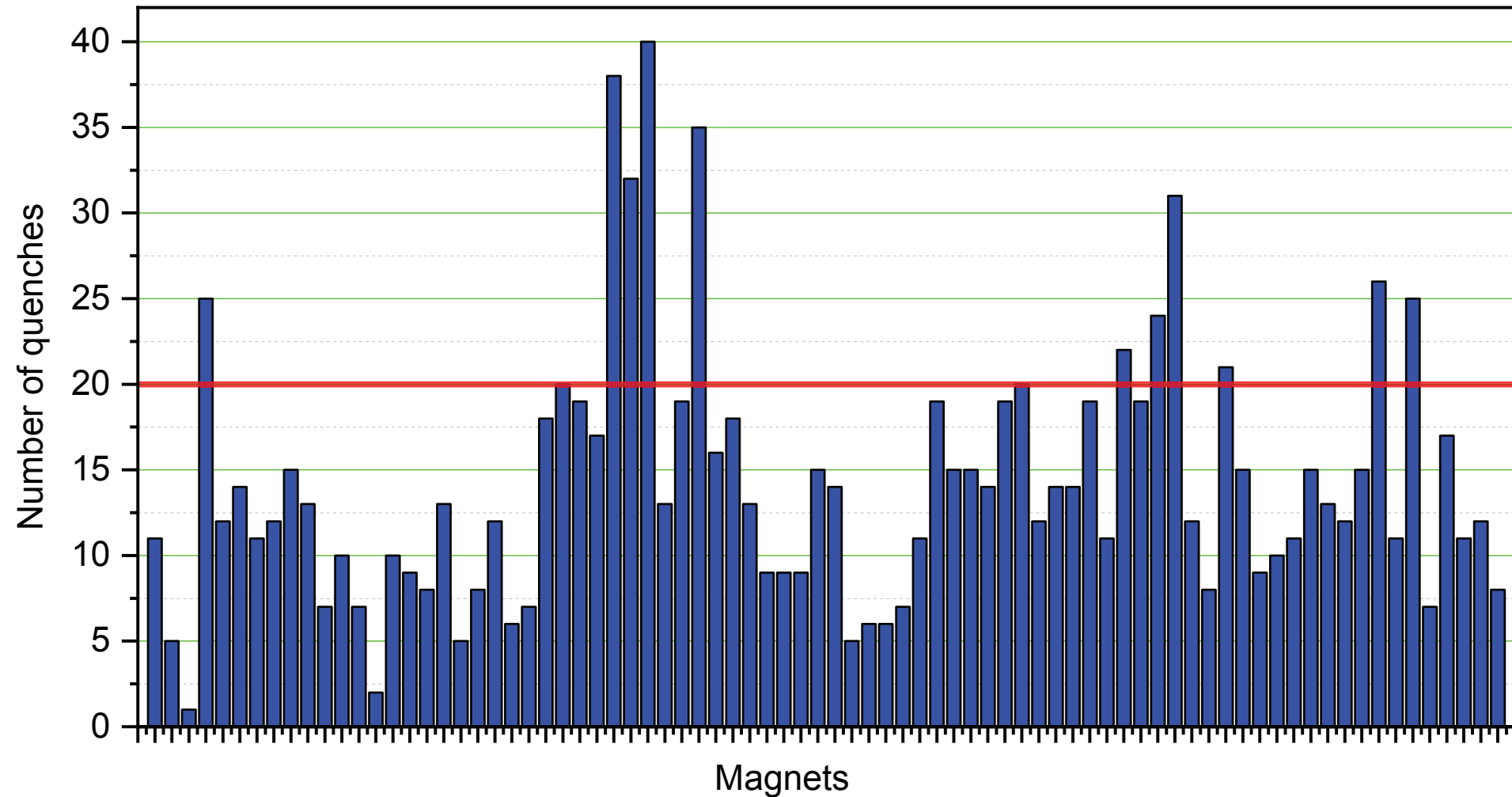
SC magnets of collider

Cycle for training the SC of the collider coils



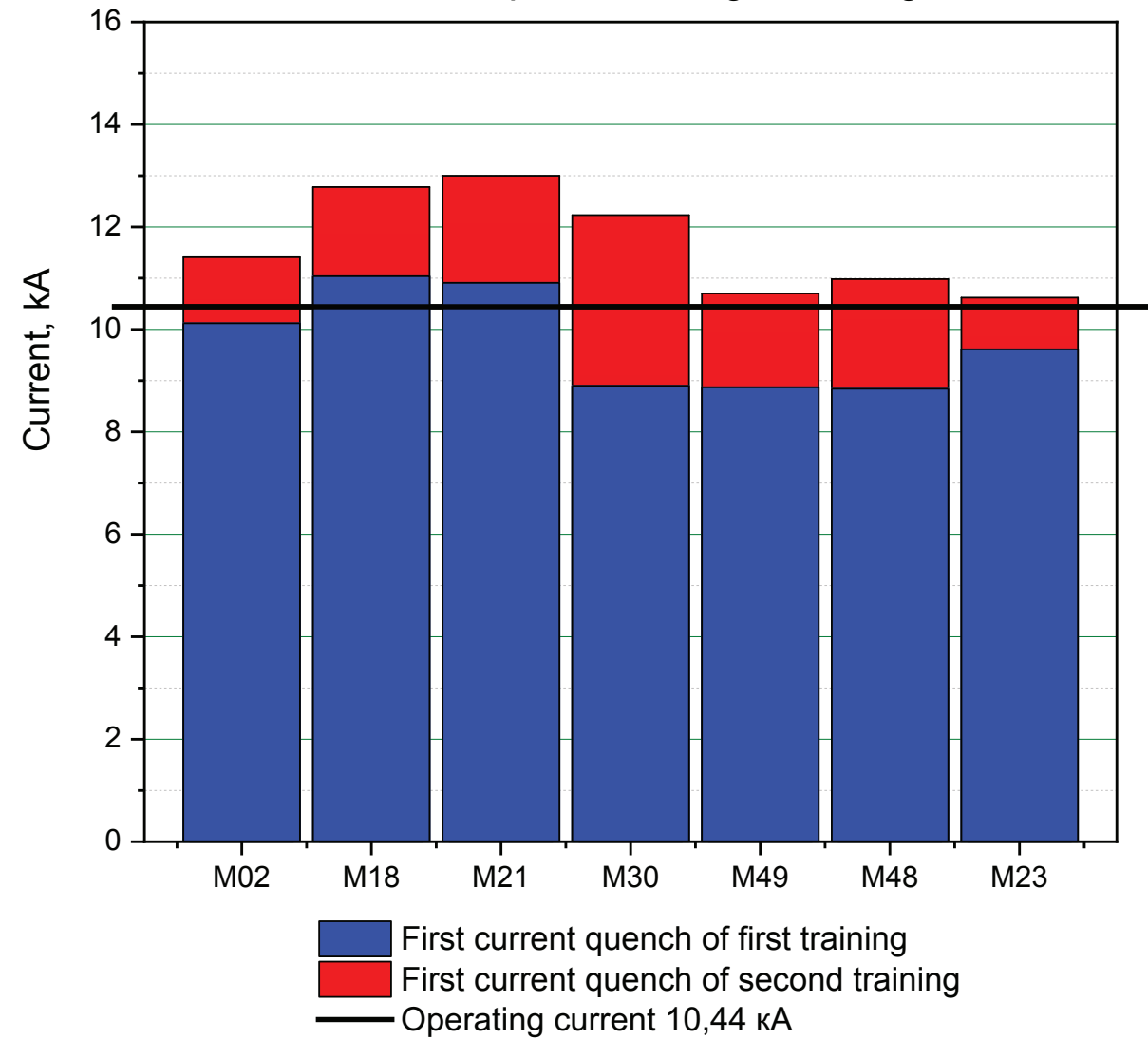


Training of dipole magnet



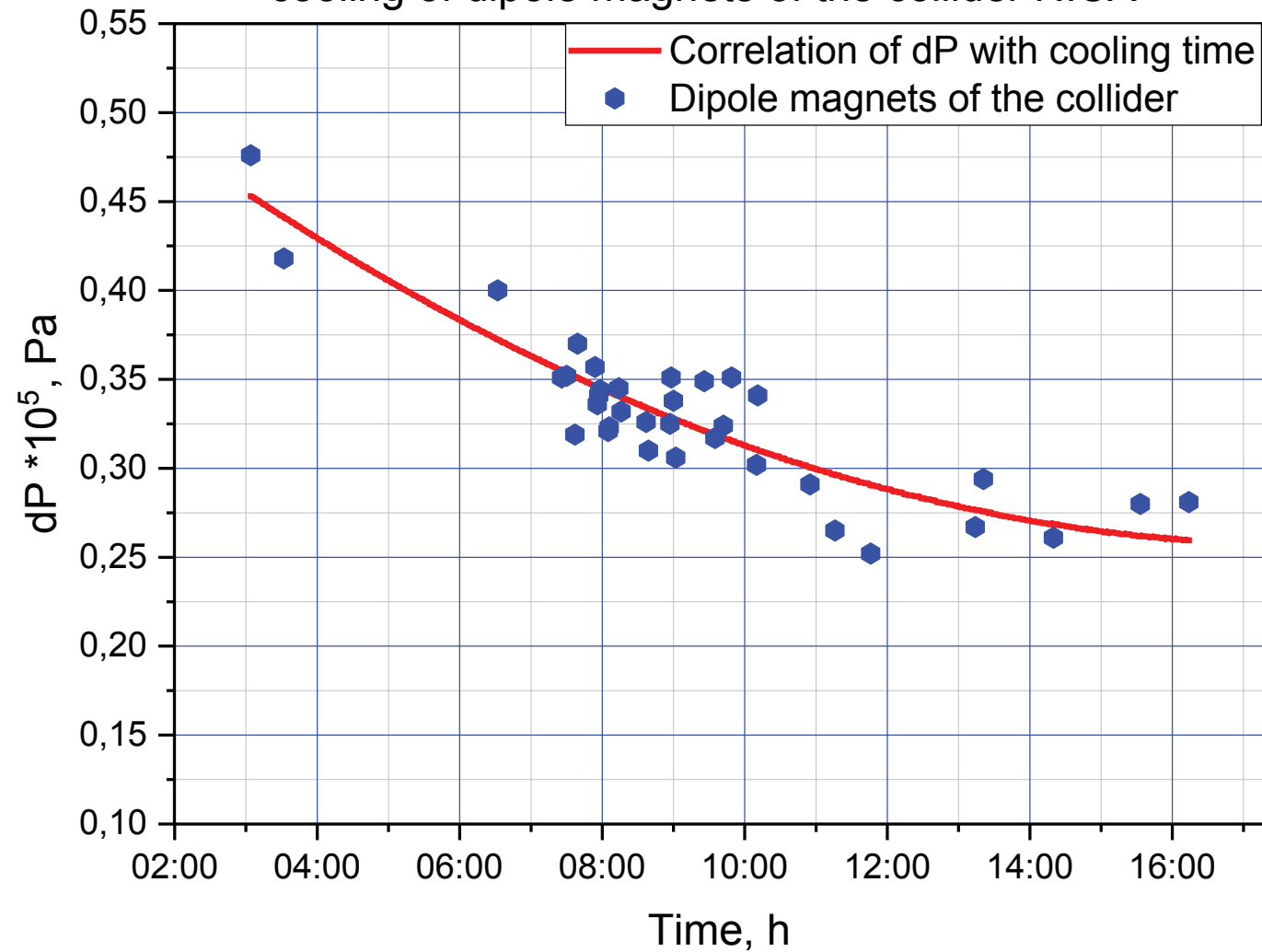


First current quench during retraining





Correlation of dP and time of helium
cooling of dipole magnets of the collider NICA

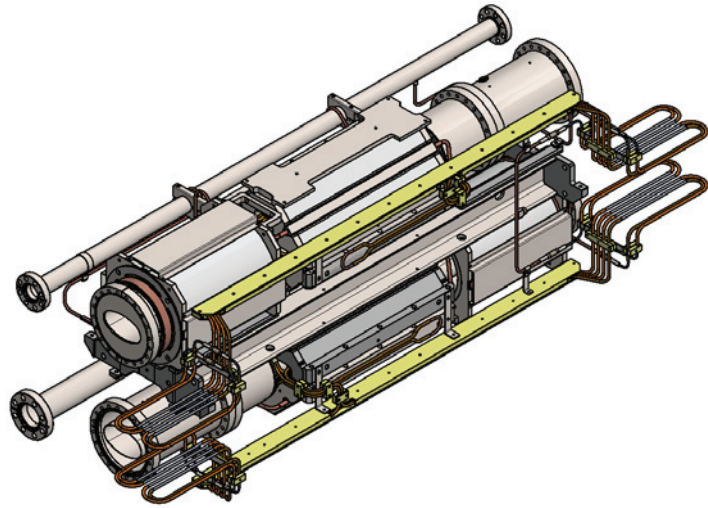


I=const=10.44 kA
Q=1.73 W



SC Quadrupole magnets (arch) for collider

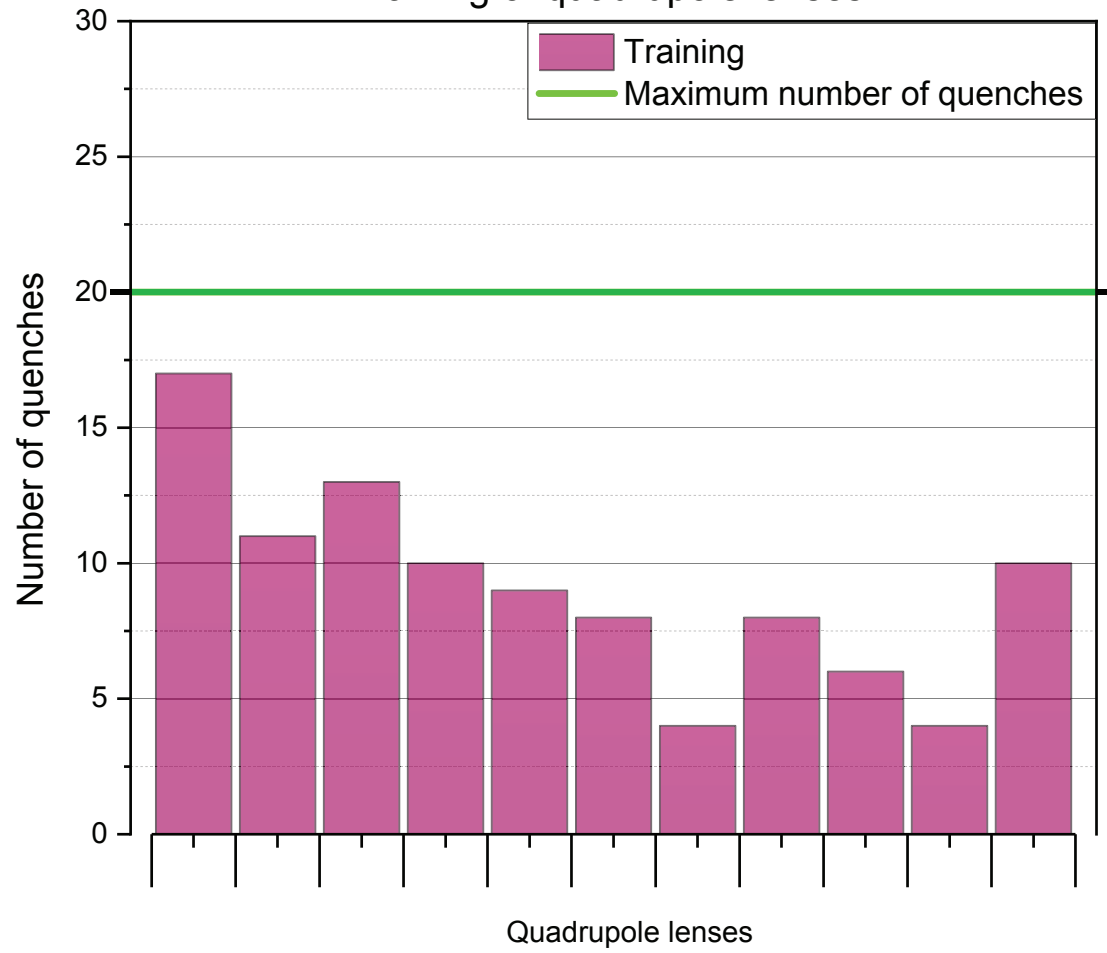
The number of SC magnets successfully passed the test - 17.
The total number of cryogenic tests - 29.



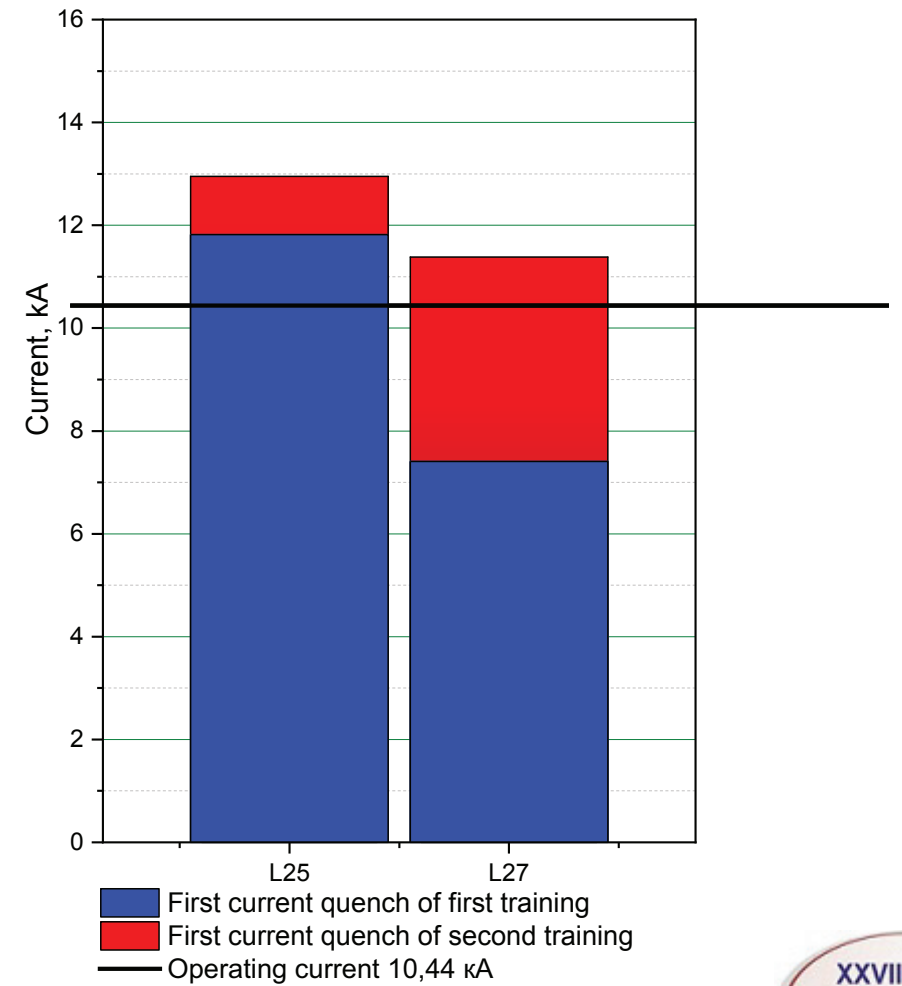
Parameter	Dipole magnets
Cooling channel diameter, mm	3
Number of SC strands (diameter 0,90 mm)	16
Superconductor	Nb – Ti
Length of SC cable, m	46
Operation current (1.8T, 4.65K), kA	10.44
Critical current (2.5T, 4.7K), kA	19.2
Effective magnetic length, m	0.476
Overall weight, kg	520
Number of SC magnets for collider.	46
Cooling time, h	45



Training of quadrupole lenses

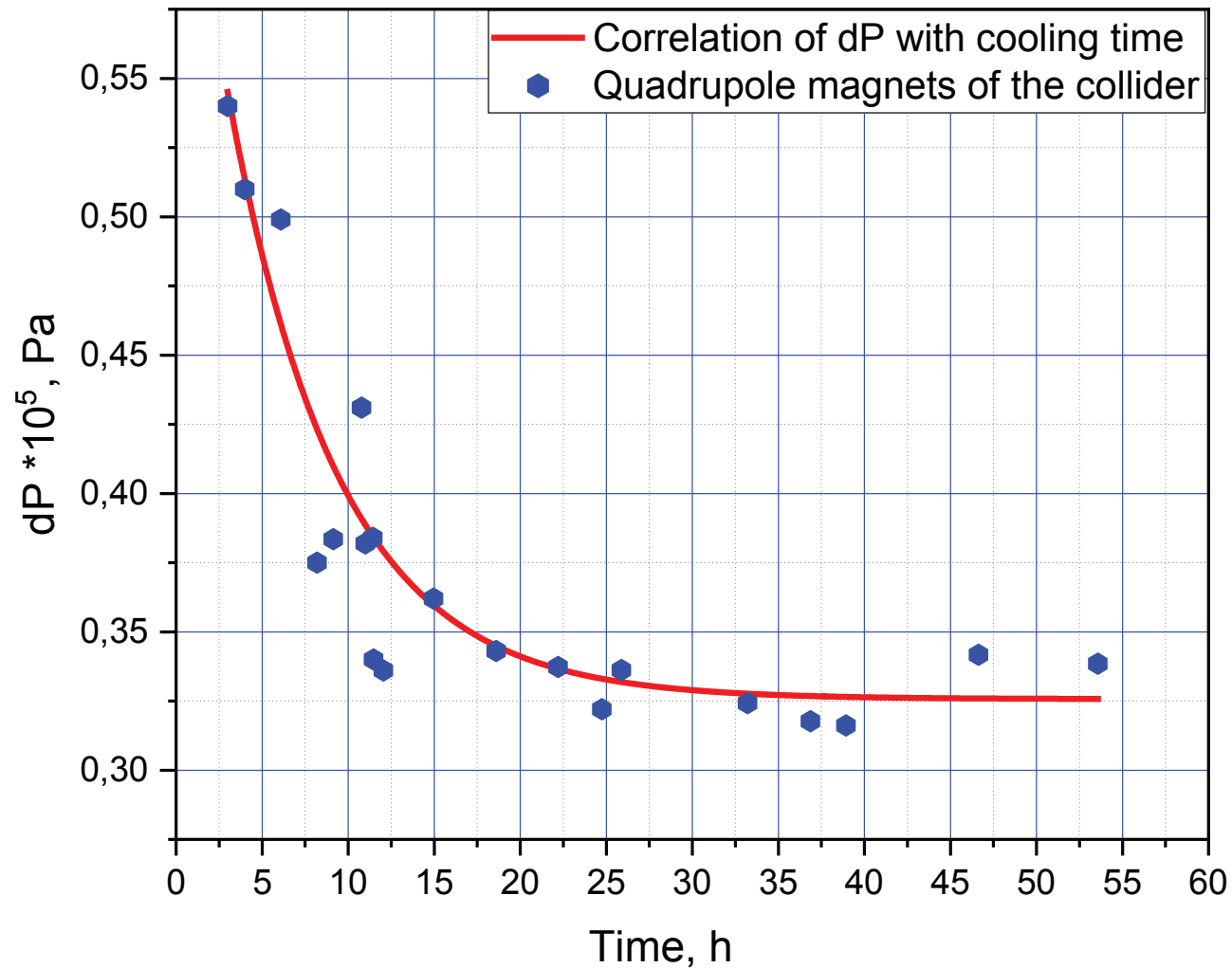


First current quench during retraining of quadrupole magnets





Correlation of dP with time of helium
cooling of quadrupole magnets of the collider NICA



$I = \text{const} = 10.44 \text{ kA}$
 $Q = 1.09 \text{ W}$



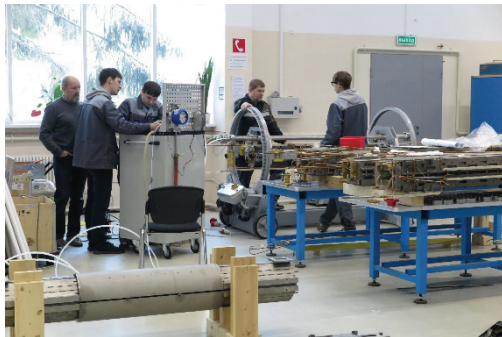
Conclusions

		total	prod. %			total	prod. %			total	prod. %
Dipole magnet	Coil	81	100	Dipole magnet (BV)	Coil	8	0	Correction magnet	Coil	132	90
	Yoke	81	100		Yoke	8	50		Yoke	132	100
	Thermal shield	81	100		Thermal shield	0	0		Cooling cylinder	132	61
	Cryostat	81	100		Cryostat	0	0		Magnet	132	61
	Cryogenic test	113	100		Cryogenic test	0	0		Cryogenic test	95	31
	Module	81	100		Module	8	0		Module	70	6
Quadrupole magnet (arch)	Coil	46	100	Quadrupole magnet (doublet)	Coil	24	100	Quadrupole magnet (LFF)	Coil	12	0
	Yoke	46	100		Yoke	24	93		Yoke	12	8
	Thermal shield	46	100		Thermal shield	24	0		Thermal shield	12	0
	Cryostat	46	100		Cryostat	24	100		Cryostat	12	0
	Cryogenic test	60	50		Cryogenic test	35	0		Cryogenic test	15	0
	Module	46	13		Module	24	0		Module	12	0



Conclusions

- All (86) of the dipole magnets for the NICA collider were successfully passed cryogenic test and installed in the cryostat.
- 17 Quadrupole magnets (arch) were successfully passed cryogenic test and 4 of them installed in the cryostat.
- In 2021, the number of cryogenic tests SC magnets doubled (from 72 to 150).
- All (46) quadrupole magnets (arch) will be ready for ring mounting in early 2022
- All magnets of the NICA complex will be ready by mid-2022



Thank you for attention!

