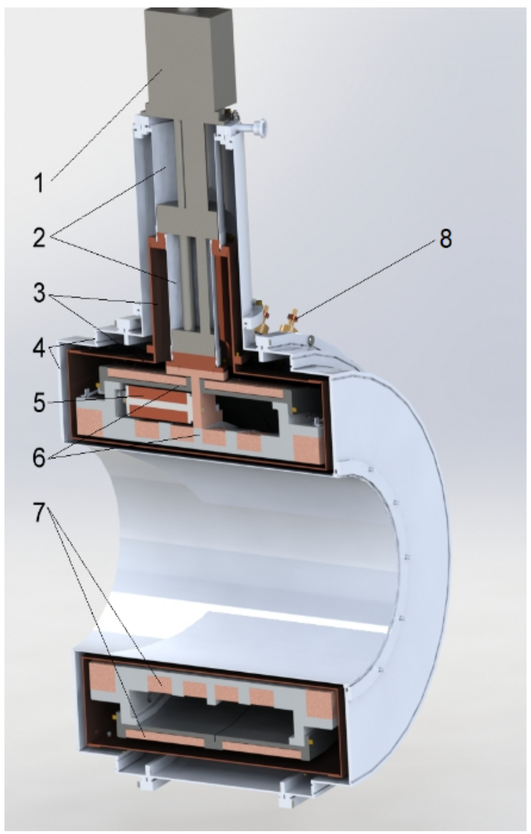
MT25 Performance test of 1.5 T cryogen free orthopedic MRI magnet

A. Bagdinov, E. Demikhov, E. Kostrov, V. Lysenko, N. Piskunov, A. Rybakov and Y. Tysyachnykh

P.N.Lebedev Physical Institute of the Russian Academy of Sciences
Lebedev Physical Institute
Russian Academy of Sciences
F I A N

A 1.5 T cryogen free superconducting magnet for a dedicated orthopedic MRI of human extremities was developed and tested. The magnet has a compact cryostat cooled by a pulse tube coldhead with cooling power of 1 W at 4.2 K. The warm bore of a cryostat is 325 mm in diameter, 600 mm in length. Cost effective NbTi wire was used for making superconducting coils. The magnet is actively shielded. 0.5 mT stray field located at 1.7 / 2.5 m from the magnet center in radial / axial directions correspondingly.

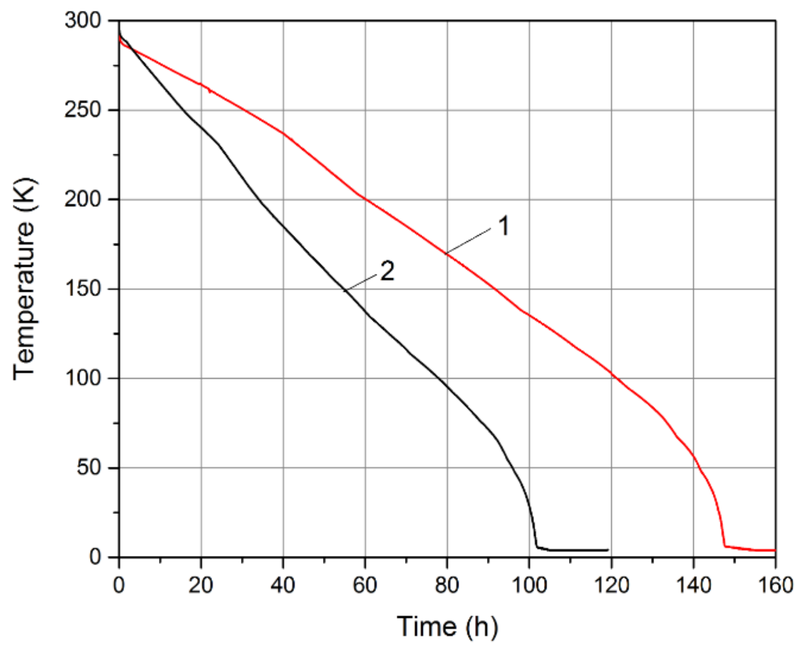
Magnet design and fabrication



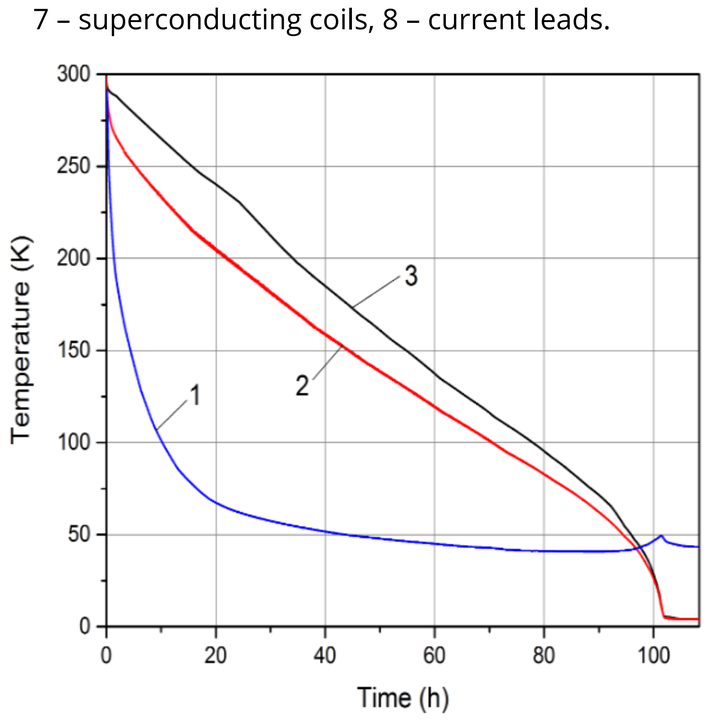
Magnet structure. 1 – coldhead, 2 – coldhead sleeve, 3 – radiation shield, 4 – outer case, 5 – persistent switch, 6 – aluminum mandrels, 7 – superconducting coils, 8 – current leads.

Cryogen free dedicated MRI magnet.

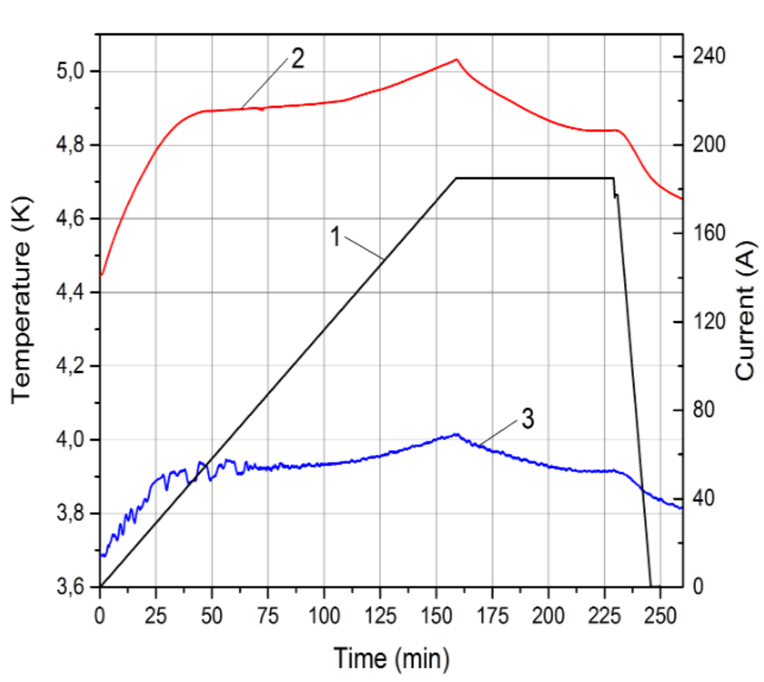
Experimental



Coil assembly temperature during the cool down. 1 - vacuumized coldhead sleeve, 2 - coldhead sleeve filled with helium.



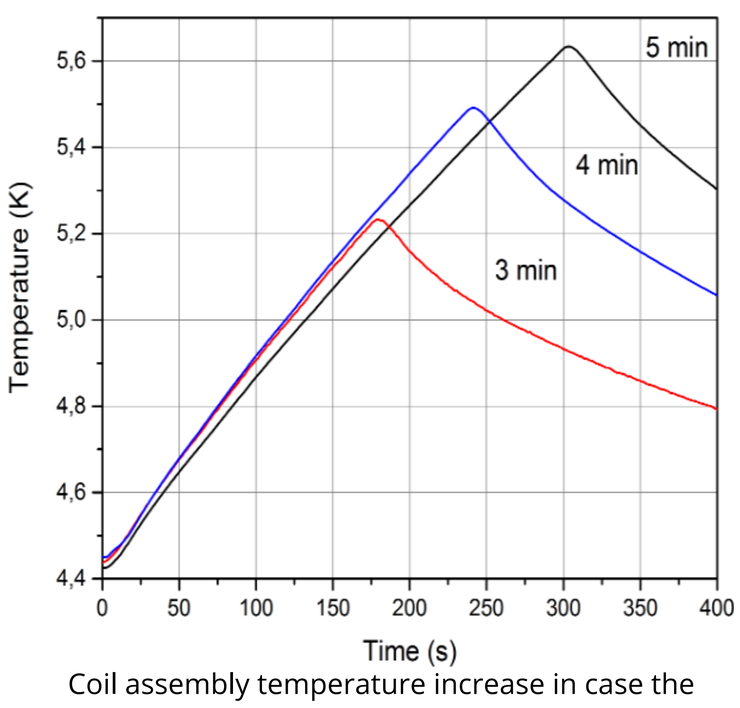
Temperature evolution during the cool down. 1 – first stage, 2 – second stage, 3 – coil assembly. The coldhead sleeve filled with the helium.



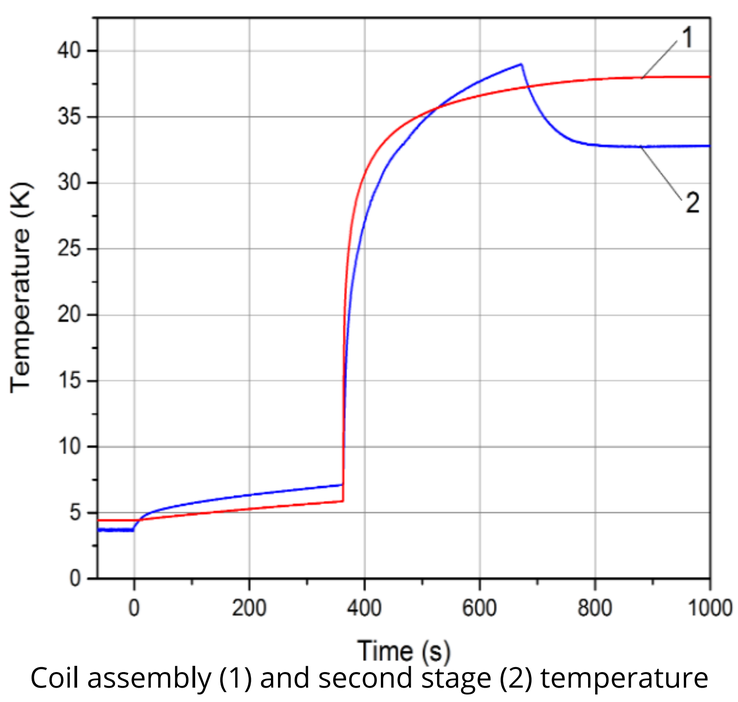
Power supply current and temperature evolution during the magnet ramping. 1 – current, 2 – coil assembly temperature, 3 – second stage temperature.

Magnet main parameters

Field strength	1.5 T
Operating current	186 A
0.5 mT stray field location:	
in radial direction	1.7 m
in axial direction	2.5 m
Peak field in winding	3.45 T
Inductance	10.4 H
Warm bore diameter	325 mm
Bore length	600 mm
Magnet weight	400 kg



Coil assembly temperature increase in case the coldhead is switched off for 3, 4, and 5 minutes.



Coil assembly (1) and second stage (2) temperature evolution. The coldhead was stopped for 11 minutes. Magnet quenched in 6 minutes after the coldhead was switched off.

Conclusion and outlook

A cryogen free 1.5 T superconducting magnet for dedicated MRI was developed and tested. Alternatively to the trend of developing HTS magnets, the cost-effective low temperature NbTi superconductor have been used.

The magnet operates in persistent mode with field stability of better than 0.01 ppm/hour. The field raw homogeneity is about 1000 ppm in 160 mm DSV that can be improved with shimming. The magnet has shown steady operation at 1.5 T even when the coldhead was switched off for more than four minutes.

A novel approach to decrease the cool down time of the magnet have been implemented. According to it, the coldhead was placed in the separate sleeve filled with the gaseous helium. It was shown experimentally that the convection of helium gas in the coldhead sleeve speeds up the cool down significantly, more than by 40% in our case. Cooling down the magnet from ambient to operating temperature takes about 100 hours.

*email: lysenko@lebedev.ru