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The 32 T Superconducting Magnet Achieves Full Field

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Introduction

The 32 T superconducting magnet is a science instrument intended to give researchers access to the realm of temperatures near absolute zero and high magnetic fields where quantum mechanics dominate. The magnet consists of a 15 T Low Temperature Superconductor (LTS) magnet combined with a pair of REBCO High Temperature Superconductor (HTS) insert coils generating 17 T. There are separate power supplies for the LTS and HTS components.

Experiments, results, and discussion

After years of technology development and verification using calculations, test coils and prototypes, the HTS coils were constructed, integrated with the LTS magnet and the supporting electronic systems built. Quench protection is provided by active quench heaters [1]. The test plan for the magnet included a spectrum of operation parameters at a number of magnetic field values below 32 T and a number of deliberately induced quenches up to 28 T. Comparing the resulting data with simulations gave the confidence that the magnet would perform safely as designed at the full 32 tesla magnetic field, both in normal operation and in foreseeable fault conditions. Observation of voltage signals from the coils allowed us to tune the quench detection system such that transient effects do not cause a false detection events while maintaining sufficient sensitivity to quickly detect real thermal runaway conditions. The magnet was then operated to 32 T and kept at 32 T for over 1 hour to conform that the entire system was stable. The magnet can be ramped between -32 T and + 32 T at 0.5 T/min which is relatively quick for a high field superconducting magnet. Uniformity of the magnetic field is illustrated in figure 2 and is significantly better than the 500 ppm specification. At 34 mm, the 4.2 K cold bore is slightly larger than the initial target of 32 mm. The field-current relation was mapped both with a hall-effect sensor and NMR spectroscopy on a copper sample (see Fig 1.). A slight hysteresis is observed and a peak field of 32.103 T was confirmed. Thus all specifications and expectations have been met or exceeded.

Completion of this magnet represents a breakthrough in magnet technology, capitalizing on the performance of high temperature superconductors at low temperatures and high magnetic field. Previous LTS superconducting magnets used for science are limited to 24 tesla, and progress in peak magnetic field on average has been around 0.2 T/year for decades; an 8 tesla increase in such a short period is unprecedented.
A variable-temperature insert is available and a dilution refrigerator is on order to allow science in a low-noise environment at a range of temperatures down to the milliKelvin range in a stable high magnetic field up to 32 T.

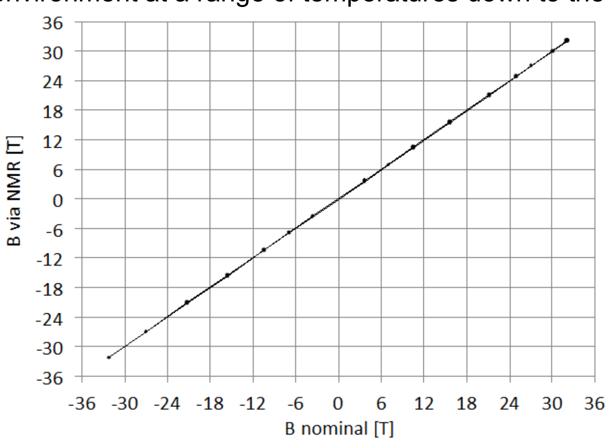

Fig. 1. Field measured with NMR vs. nominal magnetic field.

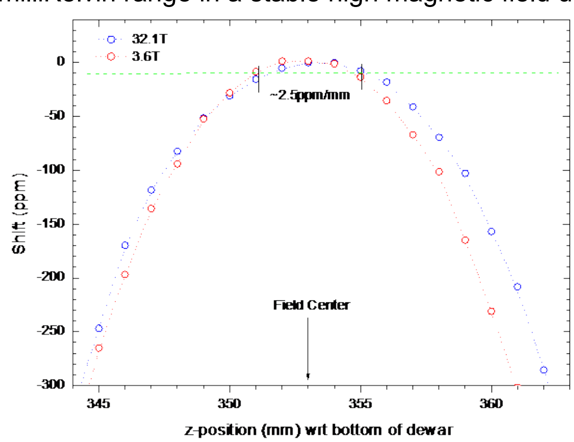

Fig. 2. Homogeneity of the magnetic field near field center.

Acknowledgements

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References

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[2] Weijers, H.W., et al., IEEE Transactions on Applied Superconductivity, **24**-3 4301805 (2015)