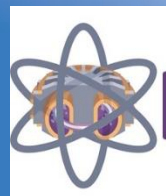
High Temperature Testing of HTS Cables and Coils in 10 T Dipole Field

Ramesh Gupta

BROOKHAVEN NATIONAL LABORATORY
a passion for discovery



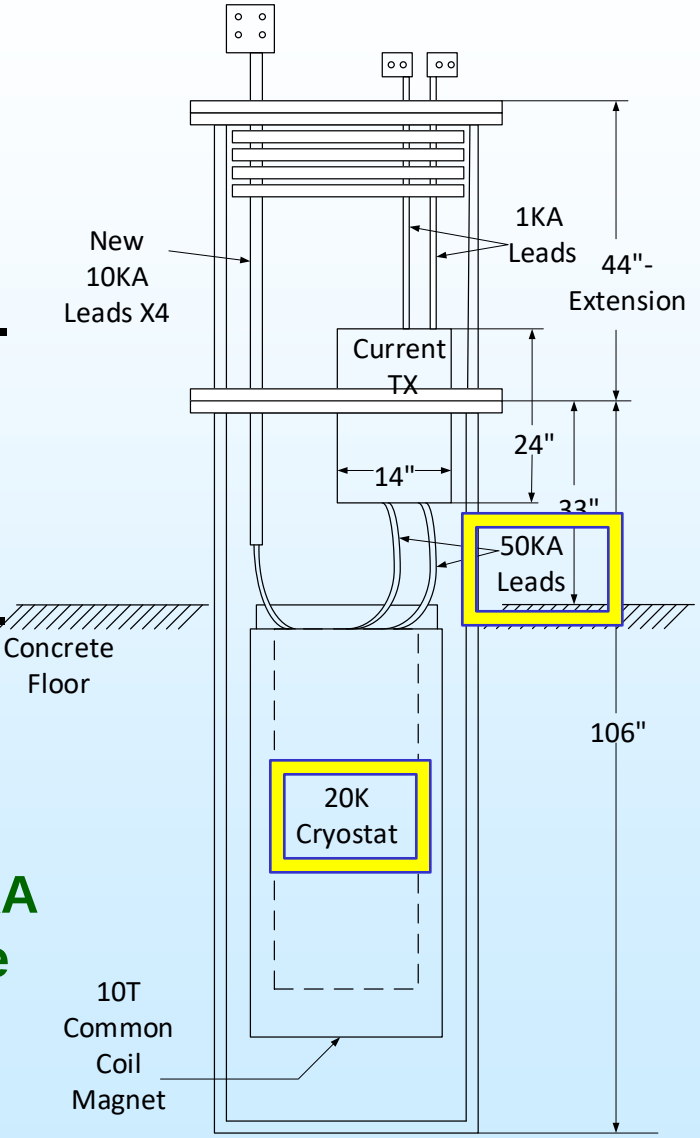
INFUSE Innovation Network for Fusion Energy

Office of Science U.S. DEPARTMENT OF ENERGY

2nd Annual INFUSE Workshop December 2, 2020

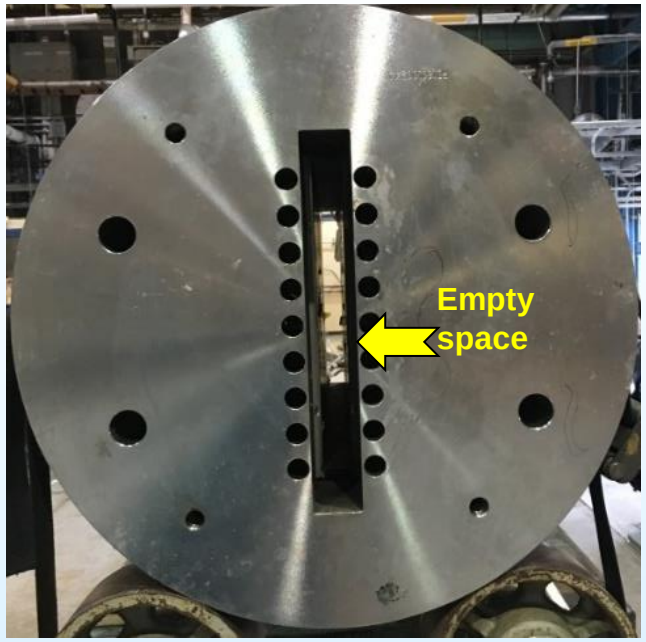
A Unique US Facility for Fusion and HEP Magnet R&D (with significant upgrades and more potential in near future)

- BNL has commissioned a unique facility that allows a variety of testing of HTS cables in a background dipole field of up to 10 T under different simulated scenarios.
- The facility also allows cable joint tests and a low cost, rapid-turn-around test of HTS coils in background field.
- This one-of-a kind facility is based on a Nb_3Sn dual aperture dipole with a large opening (next slide).
- BNL is investing significant funds (~1.5 M$) in various upgrades to turn a unique magnet into a unique facility.
- More capabilities can be added in a short period (1-3 years) with modest external support or collaboration.
- Near term potential: a US facility providing a 0-10 T dipole field on up to ~40 m long cables carrying 1-50$^+$ kA current with 15-50 cm bend dia, 4-40 K test temperature
- Other BNL capabilities in support of fusion and HEP programs will also be summarized.



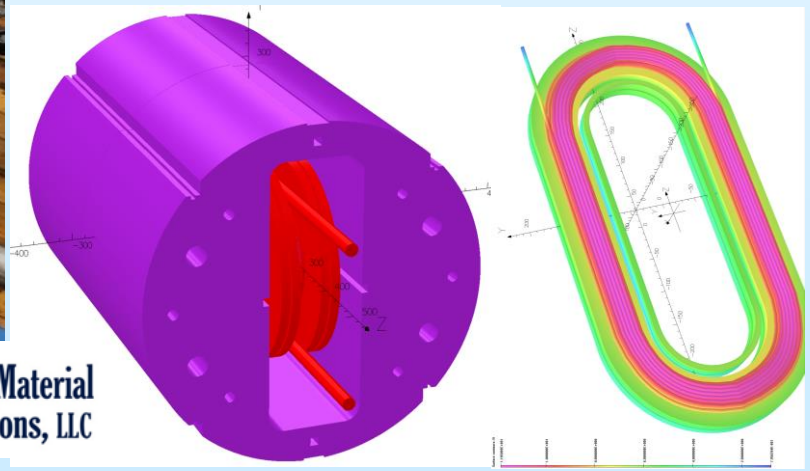
Nb_3Sn Common Coil Dipole for Cable and Coil Testing

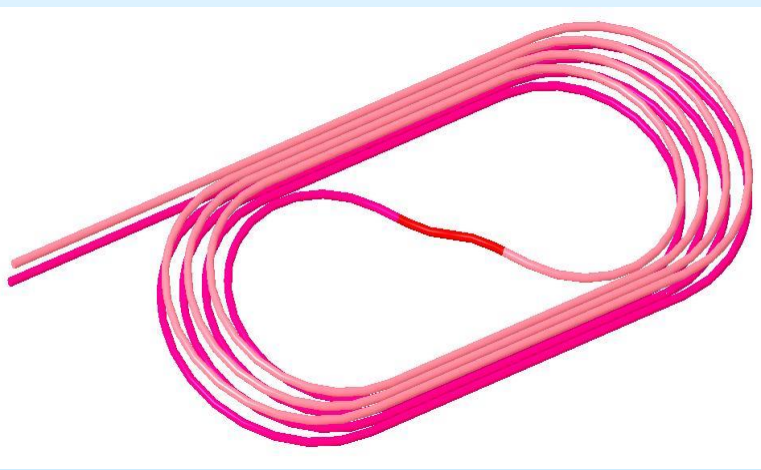
https://www.bnl.gov/magnets/staff/gupta/commoncoil/dcc017-for-insert-cable-coil-testing.pdf

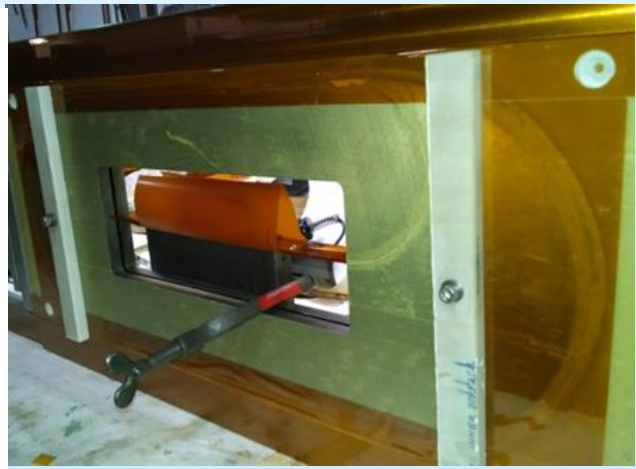


- A Nb_3Sn dipole providing a background field up to 10.2 T
- Large open space: 30 mm wide and 335 mm high
- Cable with large bend radius can be easily accommodated
- Longer length cable can be looped in the high field region
- Already used or being used in two INFUSE proposals, two FES arpa-e tests, two SBIR/STTR proposals, HEP high field magnet R&D – all with a variety of high current HTS cables
- Wider and more frequent use of this unique facility likely

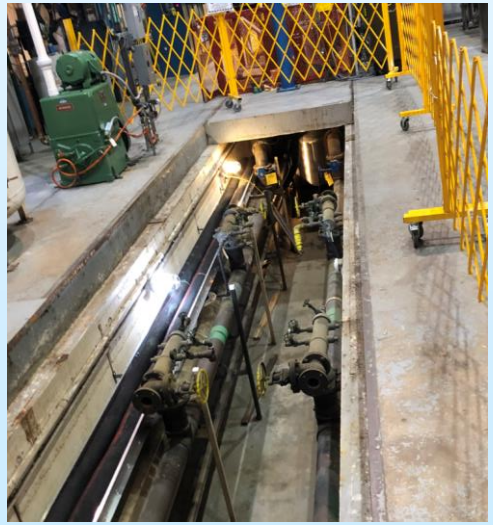
Solid Material Solutions, LLC







Upgrades - Completed, Planned and Possible



A unique facility for utilizing 10 T magnet with a large rectangular opening

Before Upgrade

- Sharing power supply, cryogenics, control system
- I_{max} = 3 kA, 10 kA in series with magnet, T_{max} = 4 K

Current Upgrades (internally funded)

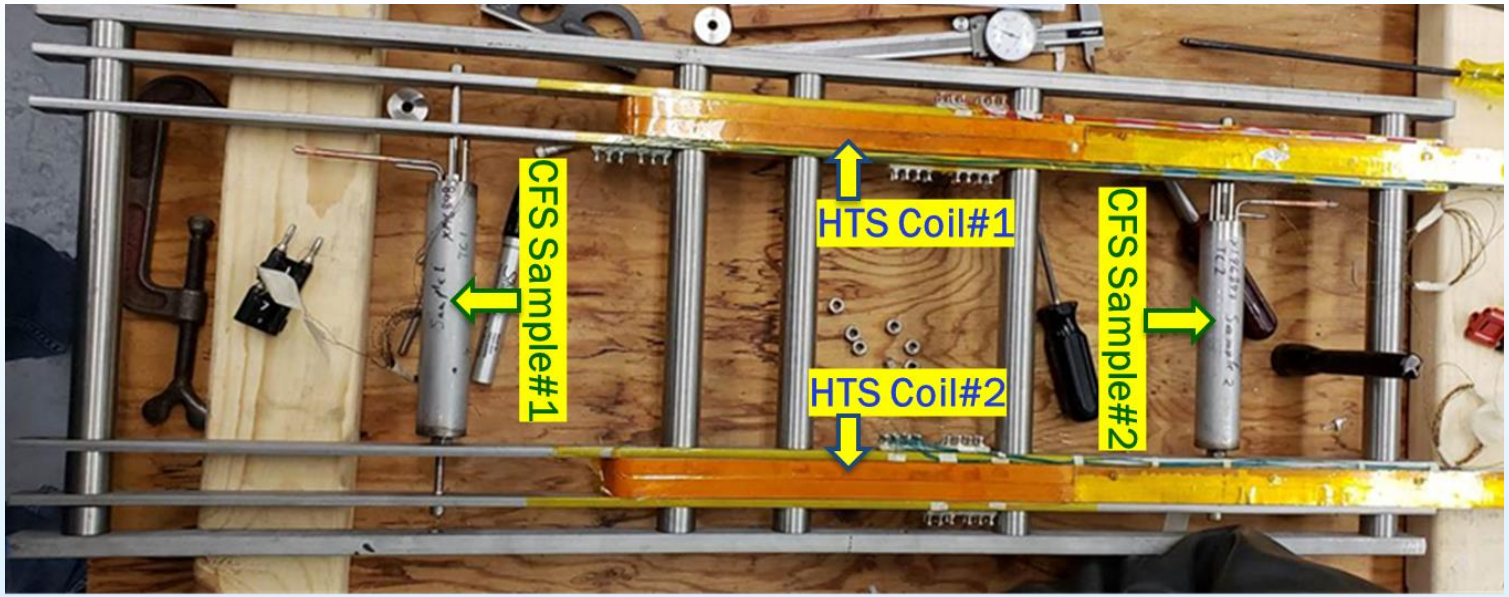
- Independent P.S., some cryogenics, control system
- Some flexibility in I_{max} and T_{max} (work with users)

Future Upgrades (low cost, not yet funded)

- Fully independent operation of the facility
- Cable current: 0-35 kA (configuring existing power supplies), 0-50^{+} kA with SC transformer
- Cable test temperature: 4-40 K with cryo-insert

INFUSE Test for Commonwealth Fusion System

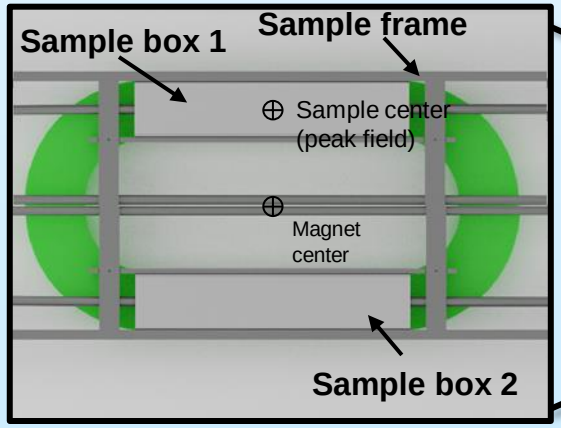
CFS 1st INFUSE test (could do 4 tests in one run)

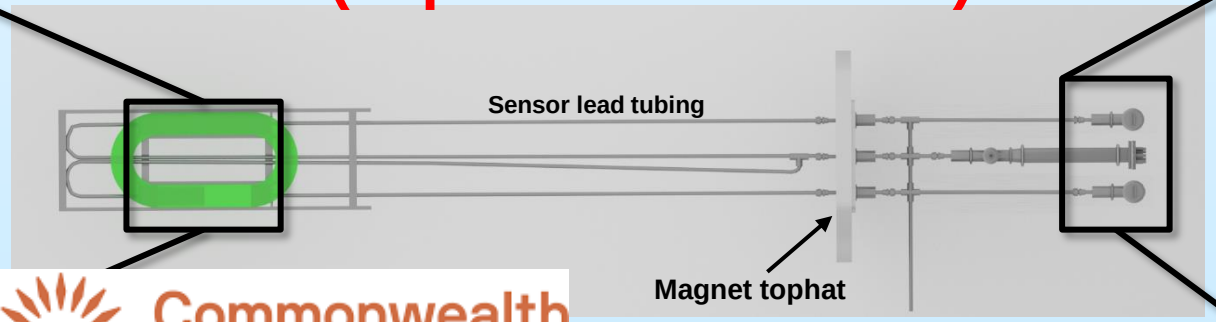


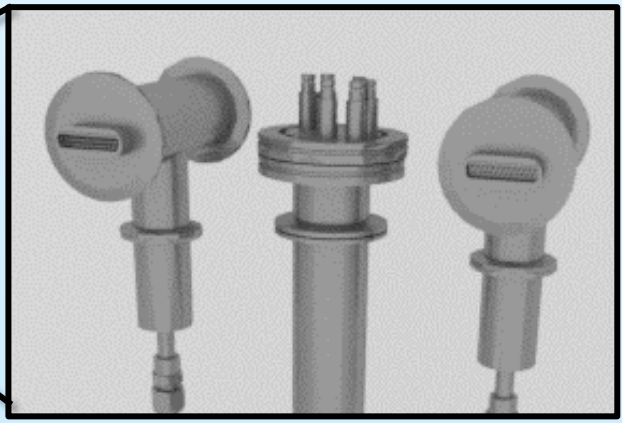
- 1st preliminary test in Jan 2020 (courtesy BNL funds that combined it with a HEP test for 12.3 T record hybrid dipole field)
- 2nd INFUSE test scheduled next week (delayed due to COVID)

(presentation by C. Sanabria, CFS)

Final Test (expected next week)



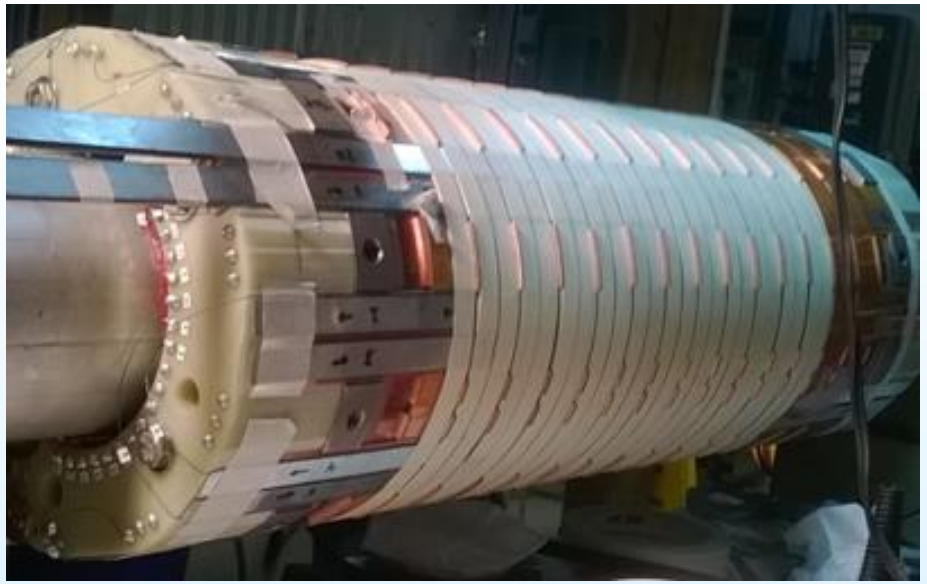




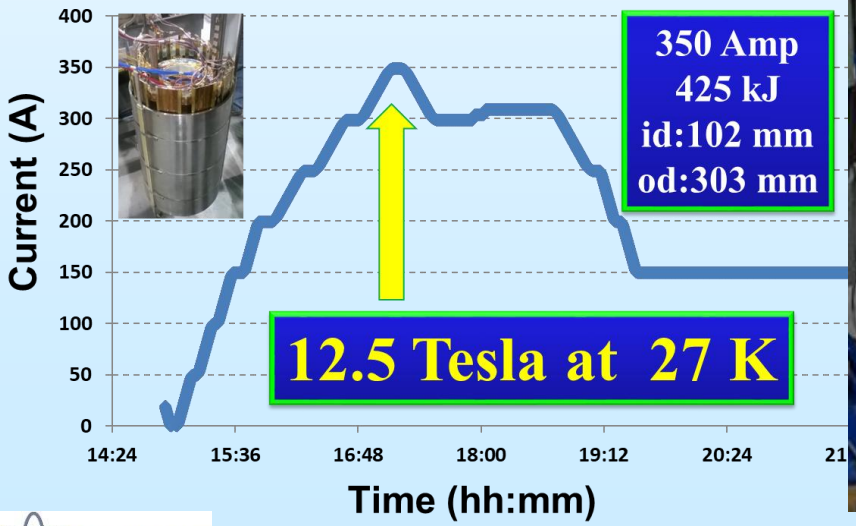
Commonwealth Fusion Systems

Other BNL Capabilities with HTS Technologies

- High temperature, high field HTS coils/magnets
- Advanced Quench Protection for HTS magnets
- Radiation damage studies of HTS samples
- HTS Splices (Renaissance INFUSE Proposal)



RENAISSANCE FUSION



Summary

- BNL is looking forward to supporting more fusion R&D (already participating in several INFUSE, arpa-e and SBIR programs)
- BNL offers a unique 10 T HTS cable and coil test facility based on a dual aperture dipole magnet with a large rectangular opening
- BNL management is investing ~1.5M$ in FES business development
- BNL, with little external support, can become even more flexible, high temperature, high current collaborative facility (not planned as a formal user facility yet) in a short period of time (~a few years)
- BNL can offer a variety of support thanks to its vast expertise with HTS magnet technology and general magnet engineering