Update on Facilities and Activities at BNL

Ramesh Gupta

3rd Annual INFUSE Workshop

December 16, 2020
A Unique US Facility to Support Fusion and HEP R&D (with several upgrades – some demonstrated, some underway)

- A unique, one-of-a-kind facility in the world for testing HTS cables, joints and insert coils in a dipole field of up to 10 T
- A large opening which allows testing of long high current HTS cables with large bend radii & HTS coils in dipole field
- Common coil design has two bores that are energized by the same coil - allows a direct comparison of two variants
- BNL is investing ~2 M$ to support many upgrades for FES
- High ramp rates: ~1 T/s to ~4 T/s needed for fusion tests
- Cable/coil testing with high currents: ~20 kA with power supply and ~50 kA with superconducting transformer
- High temperature test environment: 20K (4K-40K possible)
- In-field rotation of cable/coil to study angular dependence
- Requests from users and feedback from reviewers played an important role in prioritizing these upgrades. Thanks.
BNL Common Coil Dipole with a Large Opening for a Variety of Tests

Two CFS samples in two aperture for direct comparison

Empty space

Insert cable

Cable with large bend radius

Long cable or insert coil with multi-turns in dipole field

Field in two apertures (and in two ends)

Other configurations for testing long cables

Upgrade for 20 K, 20 KA, 10 T Testing for Fusion

- 20 K Insert ready for installation in the magnet
- 20 K Insert exploded view (work in progress)
- With 20 K Insert installed in the magnet
- Insert lead connection
- Top-hat, 10kA & 20 kA leads
- User supplied insert with leads (Recent Award to GA)

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Upgrade on Facilities and Activities at BNL
3rd INFUSE Workshop
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Facility incorporates the latest instrumentation and is a test bed for the new technology (CFS INFUSE Test)

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First successful cryogenic demonstration of the method on a fusion cable

"Standalone" acoustic setup for detection and localization

Fusion cable instrumented with acoustic hardware. It was installed in a sealed “cassette” that was mounted in the BNL common coil structure

Temperature Control on HTS Cable ~4K to ~50 K (user provided setup, integrated with BNL cryo)

M. Marchevsky
LBNL

Cryogenic test was conducted at BNL on Feb 24-25, 2021

11.7 K -> 13 K
### CFS ARPA-E Test (data provided by CFS)

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<th>Field, T</th>
<th>dB/dt, T/s</th>
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<tr>
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### Graphs

- **Controlled Linear ramps**
  - Ramp up to 7.6 T
  - Down from 7.6 T

- **Controlled quenches (shut-offs)**
  - 3.8 T/sec

**Demonstration of High Ramp Rates for Fusion:** up to ~3.8 T/s

More BNL tests planned to evaluate higher ramp rates and at higher fields.
Upgrades for Independent, Versatile and Lower Cost Operation

➢ Earlier, the test had to be run with a big cryo-plant; **now upgraded to run with smaller system – significant cost-reduction**

➢ Earlier, the test had to be run from a common control system/room; **now upgraded to run independently, in parallel – significant freedom in panning new tests**

➢ Earlier, a single power supply was used for energizing magnet and insert; **now two power supplies – more options for testing**
Upgrade to Allow In-field Rotation of HTS Cables or Coils

**Block diagram:**
- Shaft blocks for in situ sample rotation
- 2-layer coil
- Wind & heat treat mandrel
- Retaining brackets
- Current leads

**Top View:**
2212/Ag/Superalloy strip coil

**Material:**
- **8.5 mm x 0.55 mm wire**

**SMS INFUSE Program**
(slide-deck available on request)

**Test conditions**
- Temperature (4.2 K and higher temperatures)
- Field to 9 T
- Field Orientation (by rotating coil)
  (Analysis at PPPL for CS and other fusion coil types is also ongoing)

**Material form, later focus**
- Transposed HTS tape cables in test coils

**First coil reacted and Ic tested**
1) Wire made, inspected
2) Coiling procedure established
3) First 2-layer coil wound, melt textured 12/14/21
4) Minor design deviations to be avoided in next coils
5) Ic tested, ~ 4 kA at 4.2K, self field

**Ultimate Aim:** Low cost HTS with > 10 kA at 20 T in R&W CS coils of > 40 cm φ
INFUSE Brings Benefits of Experience at National Labs to Industry

Joints for High-Temperature Superconducting Tapes

Old fashion research with hand drawings and hands-on R&D

Work in Progress:
- Demountable joints
- Material in splice joint between the two HTS tapes (amount and type used)
- Material between the layers within the HTS tapes (final tapes to come from Univ of Houston)

[technical outcome to be presented by the industry]

Brookhaven Lab Physicist William Sampson Receives IEEE Award for Applied Superconductivity Research

August 12, 2010

William (Bill) Sampson, PI

Magnet Division Ramesh Gupta Upgrade on Facilities and Activities at BNL 3rd INFUSE Workshop Dec 16, 2021
SUMMARY AND DISCUSSION

➢ A US facility based on the BNL common coil dipole with large opening offers unique R&D opportunities for developing HTS magnet technologies for fusion.

➢ Ongoing upgrades (with internal funding) makes this facility more responsive and economical for fusion R&D. They can be further expanded/accelerated.

➢ As a home to 3.6 km superconducting Relativistic Heavy Ion Collider (RHIC), and as a site of the future multi-billion-dollar Electron Ion Collider (EIC), BNL continues to have a significant experience in working with the industry.

➢ As a multi-disciplinary lab, BNL can help in many research areas. Recently an “Access Brookhaven” event was held with focus on the fusion technology.

https://www.bnl.gov/accessbrookhaven/events/
Superconducting Transformer (initial work just started)

Infrastructure-Test stand upgrade

Proposed upgrade for Fusion cable test stand
1. Extension of 44" to existing cryostat to accommodate new 50kA current source. This will include new high pressure He vessel and LN shield.
2. 50kA superconducting current source with precision current readback and quench protection.
3. A mini cryostat which can be inserted in the central slot of 10T common coil magnet. This cryostat will house the sample cable at 20k helium gas.