HFCC-A Proposal Summary

- PI: Mike Sumption
- The Ohio State University
- Research areas:
  - Focused on materials issues in steering and focusing magnets for circular collider option for Higgs factory
  - Further detail: Insulation/Potting and Mechanical/Electrical/Thermal aspects of magnet winding and conductor components

- Budget Request: 200 k$/yr
- Background of the primary participants
  - Professor OSU, Materials Science Department
  - Research on materials for particle accelerators more than 30 years (NbTi, Nb_3Al, Nb_3Sn, Bi:2212, ReBCO, cables, magnets, experiment and modelling)
- [Higgs Factory project contact]

Proposed Research Scope

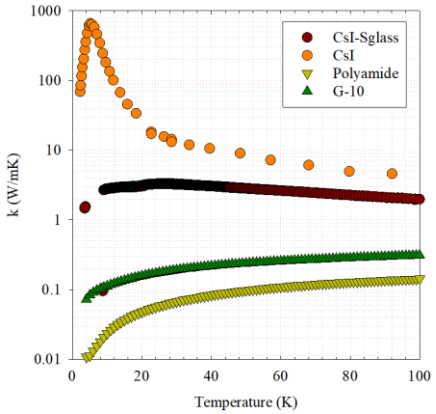
Objectives

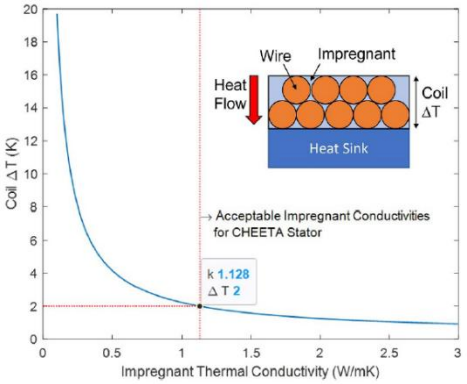
- Objective 1.1: Investigate High thermal conductivity insulations and potting materials for magnet windings
- Objective 1.2: Investigate (Thermal/Mechanical measurements) potting materials which are tough at cryogenic temperatures, but can be used in existing magnet fabrication processes
- Objective 1.3: Model/Measure tradeoffs in thermal transport through magnet windings vs mechanical toughness and sufficient stiffness
- Objective 1.4: Model/Measure small coils (< 1.5 m) via conduction cooling to measure magnet thermal properties and influence of cycling

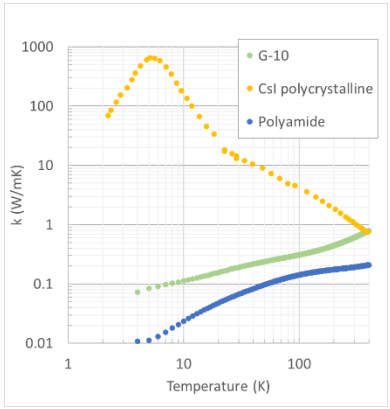
- **Impact**
  - OSU MSE has substantial materials expertise and mechanical testing expertise which could complement the larger scale efforts at labs, as well as significant expertise in thermal and electrical modelling and measurement for conductors and windings
- **Relevance and/or benefit to US HEP program:**
  - Would inform US lab partner work on magnets, develop new materials options
  - Could be integrated into larger program led by lab partners for offshore contributions
- **Synergies with existing R&D programs**
  - Would Integrate well with efforts and FNAL, LBNL and BNL, and has synergy with existing USMDP and GARD program.

Objective 1.1: Investigate High thermal conductivity insulations and potting materials for magnet windings

- It might be possible to use Metal-halide salts for impregnation of superconducting windings
- Much higher κ than polymers (factor of 100 to 1000
- Shrinkage and Mechanical strength must be studied
- Other aspects affecting practical use must be studied
- Other materials may be possible too



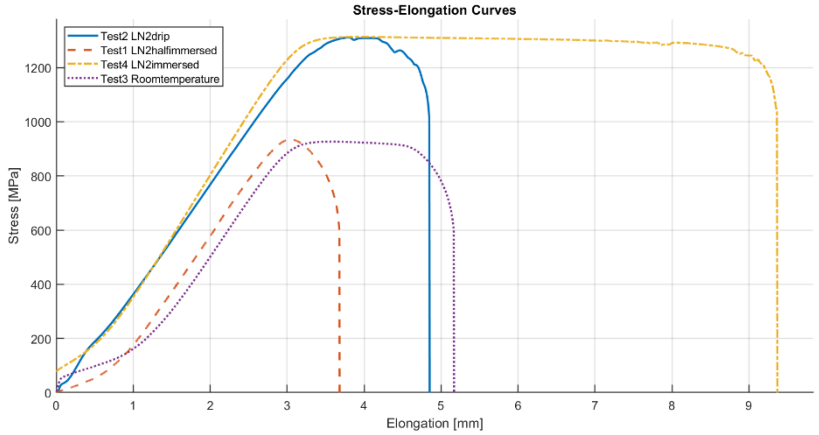




- Plan to involve C. Kovacs (Scintillating Solutions and originator) to suggest and develop best materials
- Our role fab, measurement, test, electron microscopy and chemical studies

Objective 1.2: Investigate (Thermal/Mechanical measurements) potting materials which are tough at cryogenic temperatures, but can be used in existing magnet fabrication processes

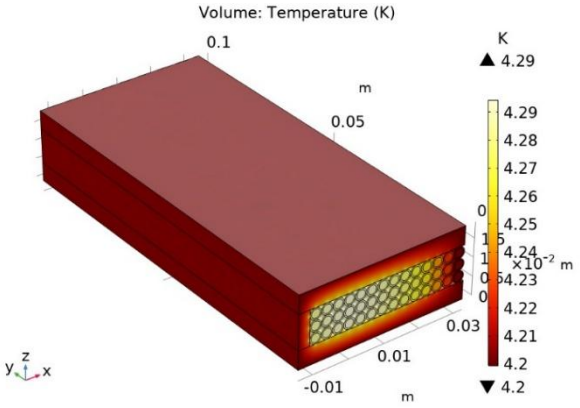
- Epoxy cracking does happen at cryogenic temperatures
- Some epoxies have greater toughness, and avoidance of neat epoxy is a well known technique
- More recently, an “old” solution, viz wax, has become of interest
- However, other options would be welcome
- Composites may be of strong interest here, but must be usable in existing or anticipated magnet processes

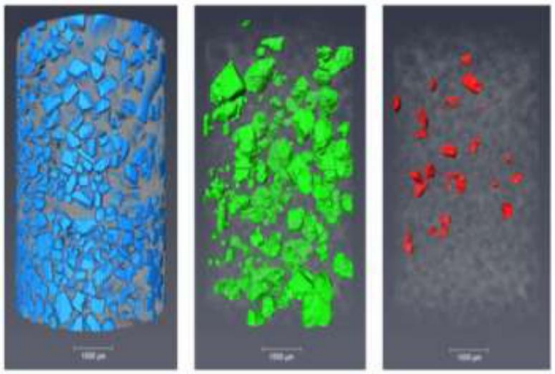


- Telene? (co-polymer)
- “room temperature” ionic liquids, e.g., (organic salts)
  - Wick in well, can be better thermal conductivity
  - (for example …)

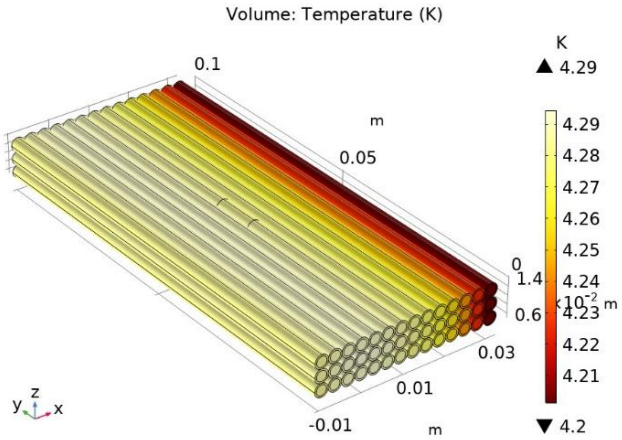
Objective 1.3: Model/Measure tradeoffs in thermal transport through magnet windings vs mechanical toughness and sufficient stiffness

- For best options for potting, can model and measure thermal conductivity
- Measure toughness at cryo temps for composites (as opposed to materials alone)





OSU Helissan (Micro-CT)



Objective 1.4: Model/Measure small coils (< 1.5 m) via conduction cooling to measure magnet thermal properties and influence of cycling

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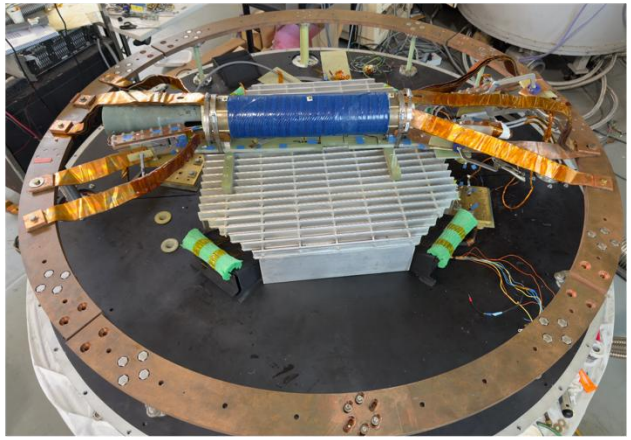

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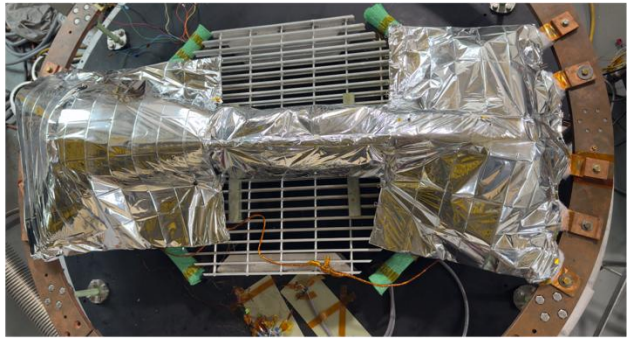
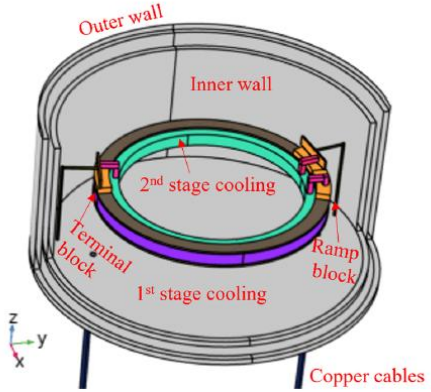
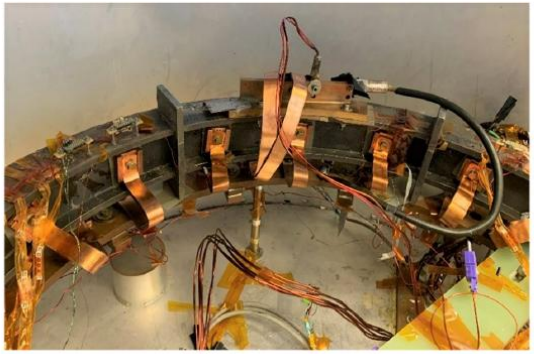






High cycle, cryogenic temperature electrical fatigue

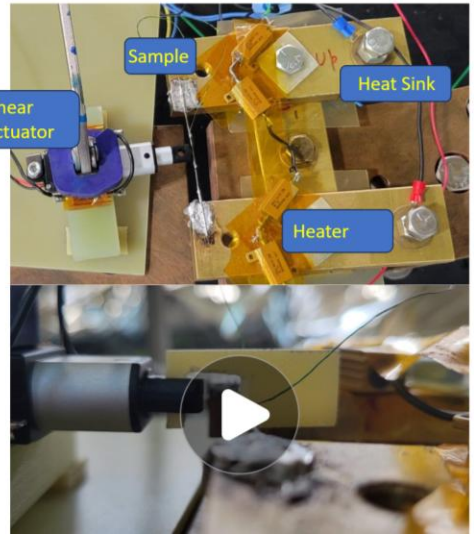
10 K bi-directional 3-point bend test <100 cycles

- RRR decreased from **684 to 273**

Observed room temperature **recovery**

- RR recovered to **474** after cycling to 280 K for same sample

Recovery study is on-going as well as high cycle fatigue (>10,000 cycles)



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