HTS Coils Project
The Applied Superconductivity Center

FAMU-FSU
College of Engineering

ASC NATIONAL MAGLAB

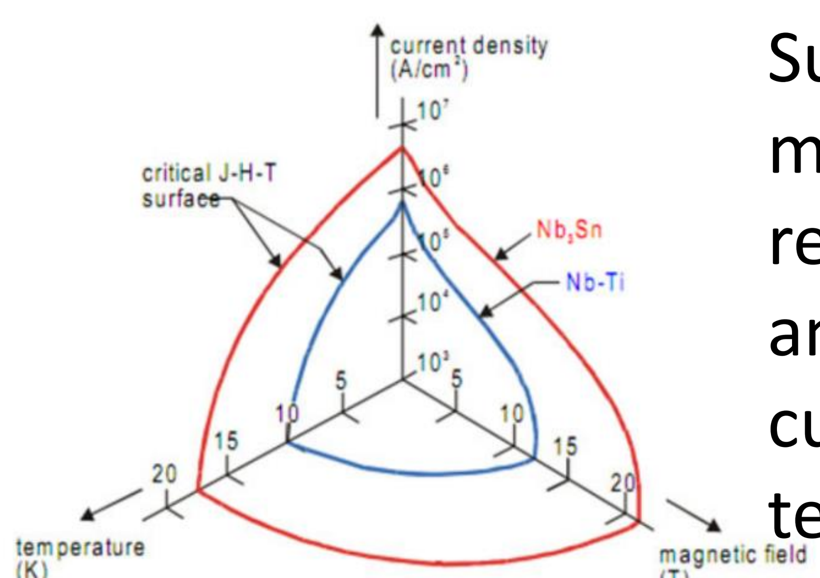
Objective

The objective of this project is to design and fabricate a current lead for the Applied Superconductivity Center (ASC) that delivers 1kA of current and dissipates less than 4 watts

Mission

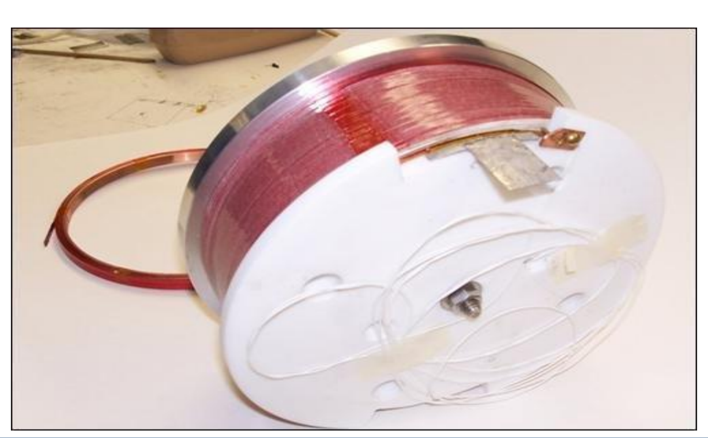
- Overarching purpose of the MagLab is to use high field magnets to push the boundaries of several scientific fields
- The ASC which is attached to the MagLab uses superconductivity to aid this objective

Superconductivity and Test Coils



Superconductivity means zero electrical resistance in a material and depends on a current density(J), temperature(T) and magnetic field(H)

More advanced materials called high-temperature superconductors (HTS) are created with higher critical J-H-T and are subject to testing



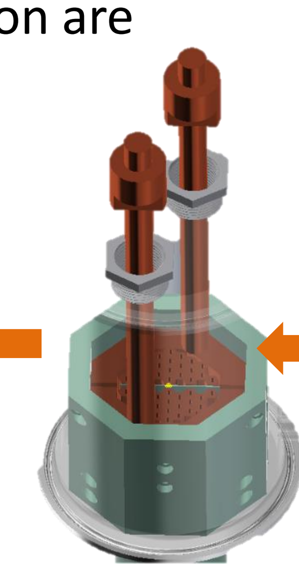
Hexagonal Tube Design and Operation

Testing Operation

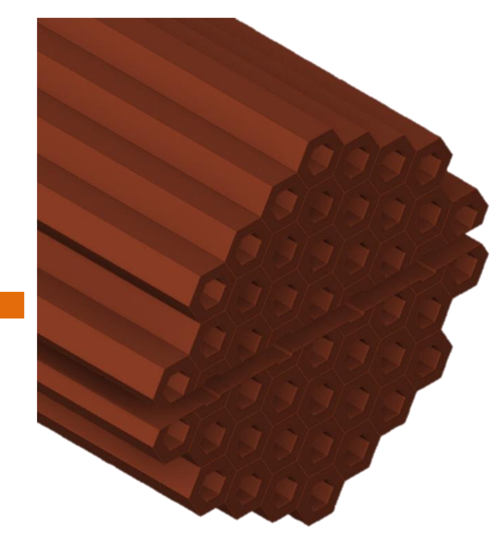
Test coil is attached to the base of Current lead → Lead assembly is inserted into vacuum sealed chamber → Cryostat is cooled to 4.2K with liquid helium before experiment begins

Design and Assembly

Helium flow and instrumentation are attached here



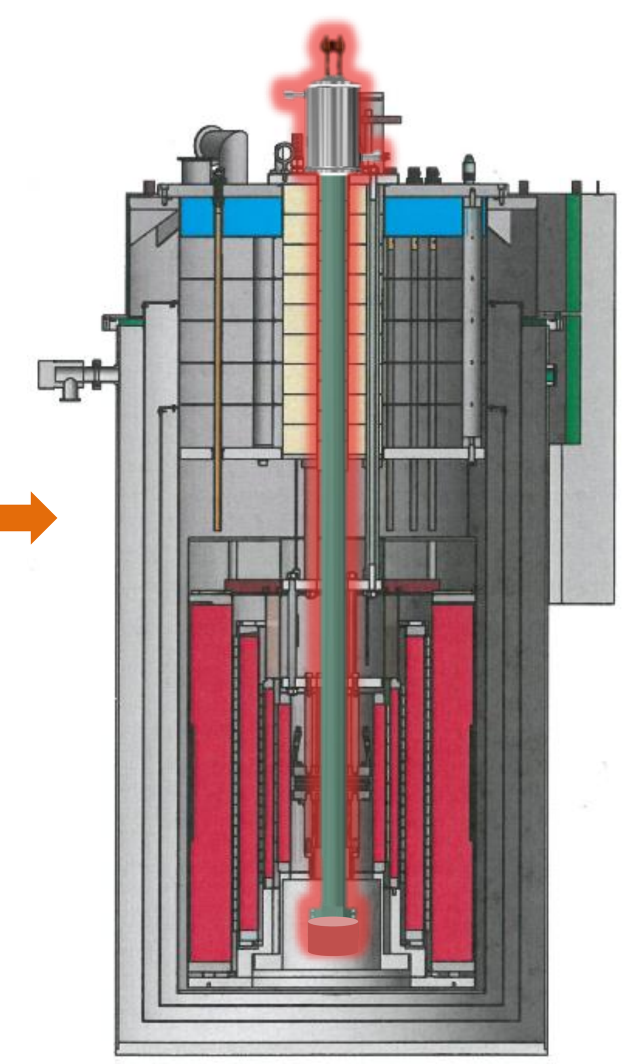
Nipple



Hexagonal Tubes

Copper 122 was used for its excellent electrical stability

Current lead with G10 Insulation (green) and test coil (red)



Vacuum Sealed chamber with magnet, test coil and current leads

Hexagonal Tubes

- Hexagonal hollow tubes allow for vapor cooling within the vacuum sealed chamber
- Hexagons are the most efficient way to pack a large amount of objects in a minimum space
- at cryogenic temperatures
- Copper tubing "drawn" and "hexed" using hydraulic drawing bench and appropriate hex dyes

Assembly

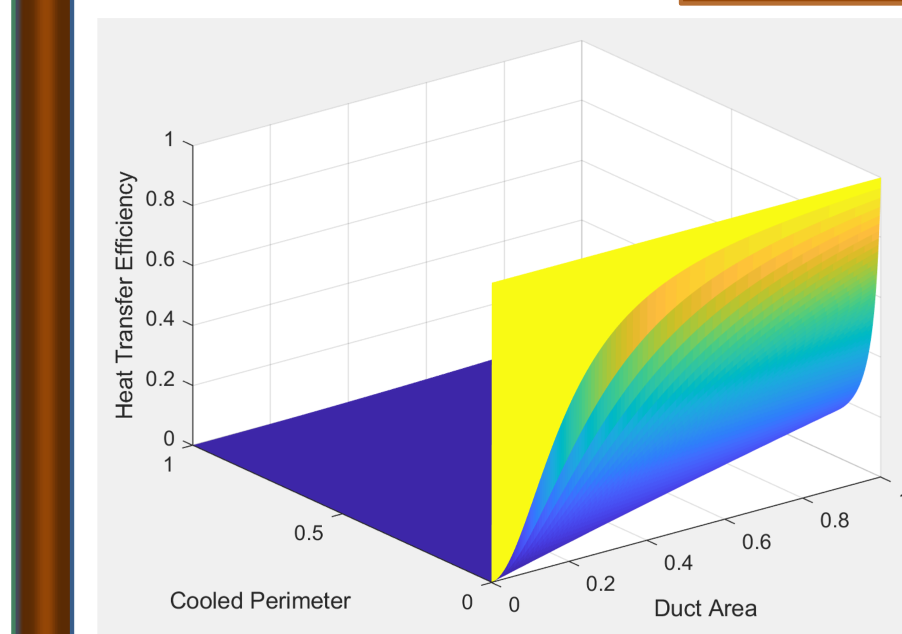
- Tubes are soldered and stacked together
- The tube are placed into a G10 sleeve
- Voltage signals are soldered into the copper to measure any potential difference in leads
- The current lead, attached to a small electromagnet, is inserted into a larger electromagnet

Theoretical Framework

This project was heavily rooted in material science, for electrical and thermal aspects, and thermal fluids for heat transfer science

$$\frac{Ix}{A} = 3.5 \times 10^6 \qquad f \cong \left(1 + \frac{2w_o u}{PhX_2}\right)^{-1} \qquad \frac{dP}{dx} = \frac{32\eta\dot{m}}{\gamma A D^2}$$

Shape Factor | Heat transfer efficiency | Pressure drop



During the design process it was discovered that cooled perimeter and duct area were key to optimization

Results and Conclusions

Current	1,195 A
Heat Leak	2.4895 W
Helium Consumption	3.43 L/hr.
Pressure Drop	30.90 Pa

- Hexagonal Tubes were also good for electrical contact among other things d
- Using optimized theoretical work provided very good real world approximations

References

- WILSON, M. N. (1983) *Superconducting Magnets* ch. 11, Oxford Press
- ROHSENOW, W. M. and CHOI, H. Y. (1961) *Heat mass and momentum transfer,* Patience Hall, New Jersey
- LANGE, F. (1960) *Cryogenics, Sept., p.171*