Assembly of Multi-Sample Probe to Measure Critical Current (I$_c$) of Superconducting Material

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Overview:

- Why Build?
- Materials used
- Probe Assembly
- Heat Transfer Analysis
- Data Acquisition
- Results
- Conclusion
- Acknowledgements
- Questions?

Why Build?

- Can hold 8 Superconducting strands at a time.
  - ✓ Opposed to previous models which held 1 or 2.

- Faster Turnover rate of Test Samples.

- Saves precious time.

- Reduces Cryogen Consumption.
  - ✓ $6.00 per Liter
  - ✓ 50-80 Liters per Sample

- Four fold decrease in Helium consumption.

- Receive better statistics on sample behavior.
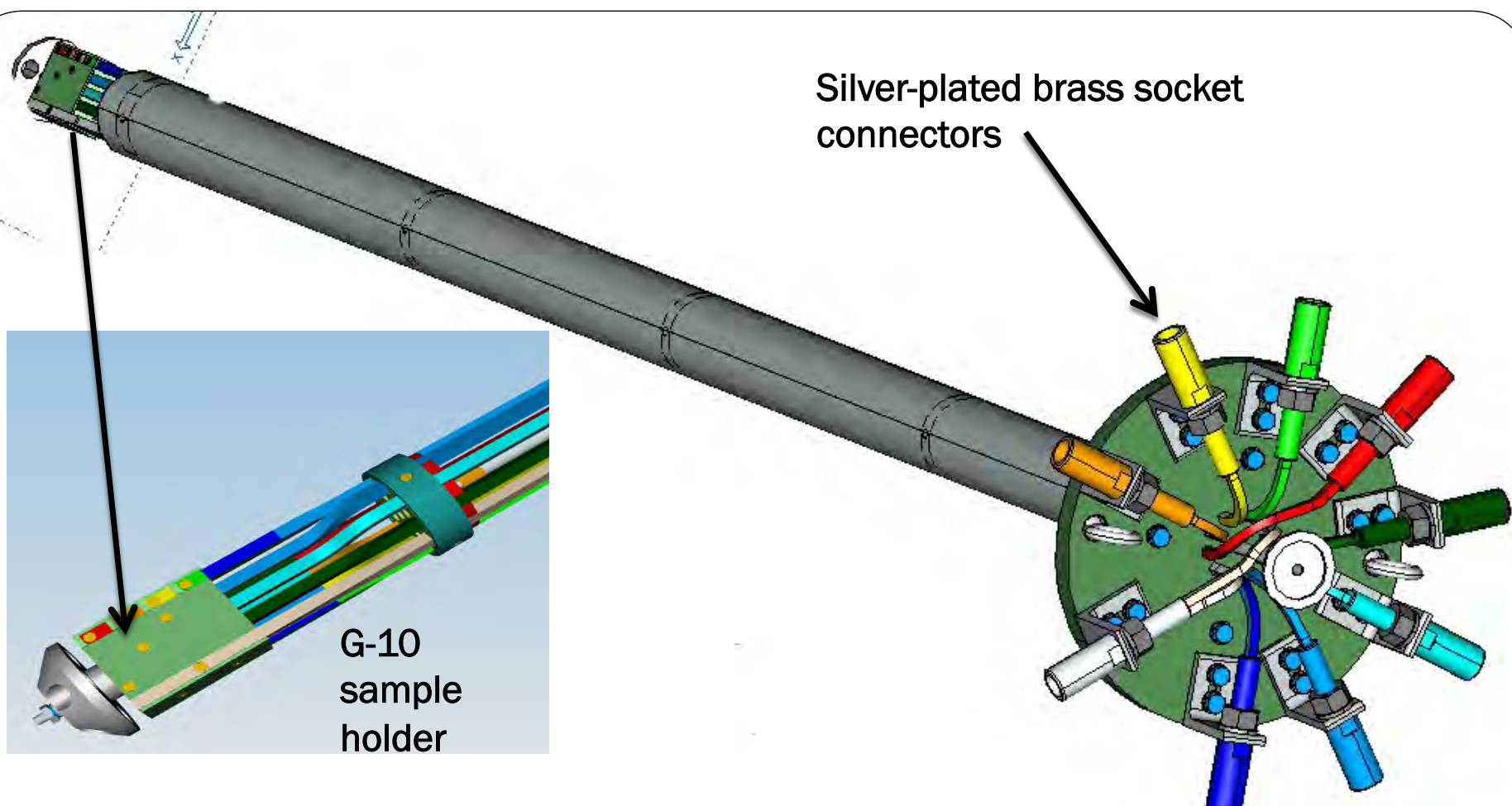
Materials used:

- G-10 Fiberglass-Laminate

Insulation plate

Sample-holder

Support rings

Copper leads

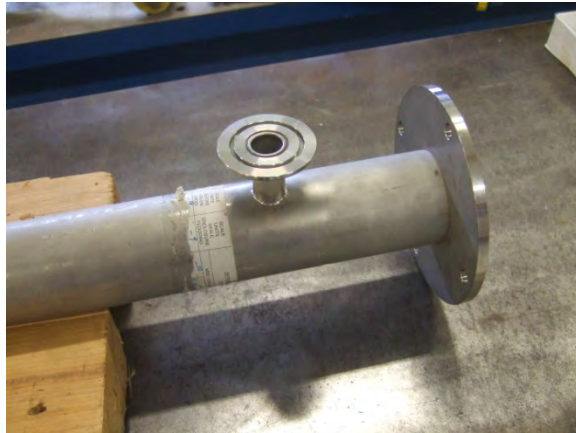Silver-plated brass socket connectors

G-10 sample holder

- G-10: impervious to moisture, good insulator and is easy to carve/grind.
- Silver is the best electrical conductor of all metals.
  - ✓ Used when high doses of current are required
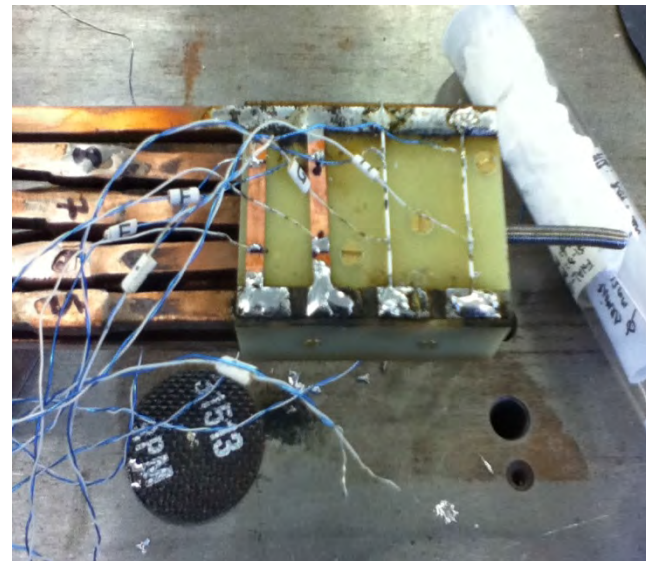- Brass is best for preventing sparks.

Materials used:

- **Stainless steel tube:** protects the instrumentation wire which runs trough probe.
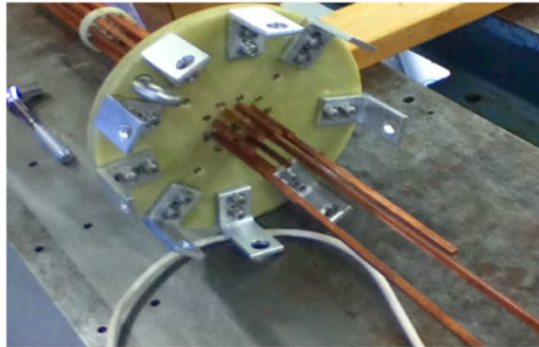
- **Stainless steel casing:** Protects probe.

- **Instrumentation wire:**
  - ✓ Copper alloy.
  - ✓ 12 pairs of insulated wire through center of probe.
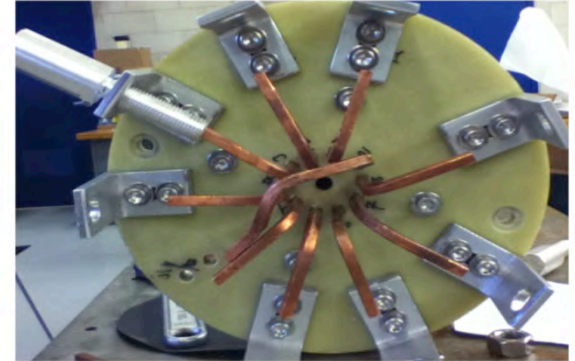 - ✓ Serves as voltage tap (**Bottom end**).

Before

After

TOP

BOTTOM

Probe Assembly:

✓Copper to copper Brazing
✓Hard and Soft Soldering
✓Copper Bending

Probe Assembly:

Why Brazing?

- Lower joining temperature than welding.

- Best used in tight situations [less access to surfaces].

- Results in non-ferromagnetic joint (best for high-magnetic-field apparatus).

How?

- Brazing metal **Sil-Fos** (15): (**5%**)phosphorus, (**80%**)copper and (**15%**)silver .

- Applied around joint; heated; fills gap by capillary action.
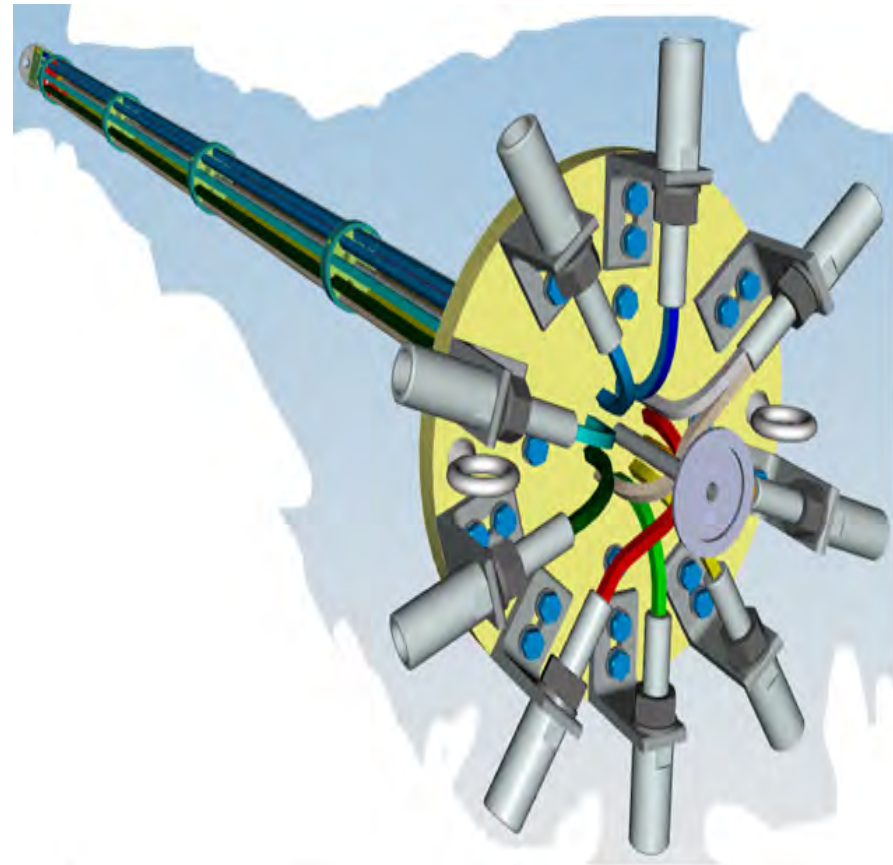
- Fitted with very low tolerance [sleeve].

Heat Transfer Analysis:

- To reduce Joule Heating.

- Soldering of superconducting YBCO.

$$\frac{d}{dx}\left[\kappa(T)\frac{dT}{dx}\right] - \frac{\dot{m}c_p(T)}{A}\frac{dT}{dx} + \frac{\rho(T)I^2}{A^2} = 0$$
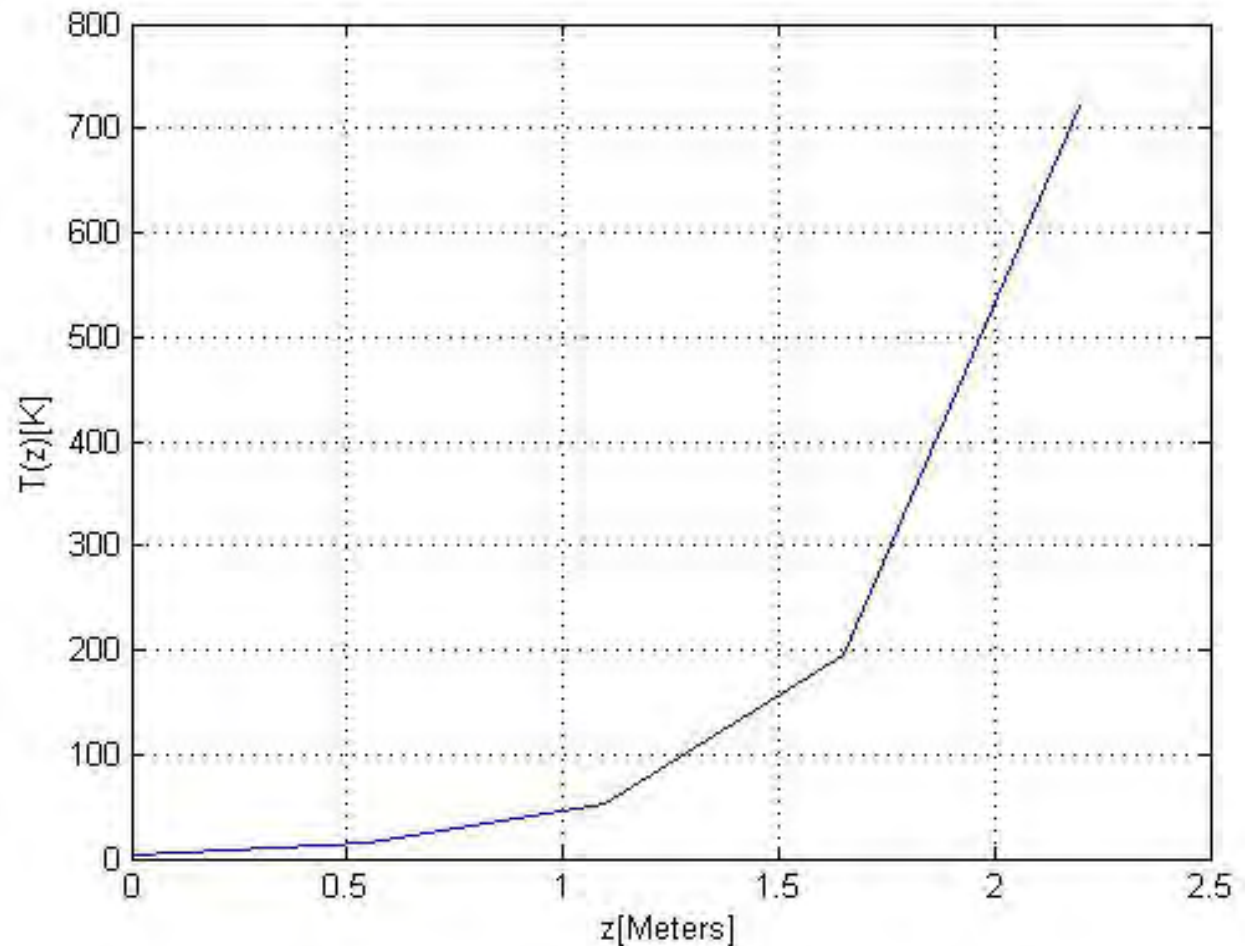
[Vapor-Cooled Copper Current Lead]

Temperature Profile: Standing Heat Input (I=0)

• Measurement of temperature increase along copper leads .
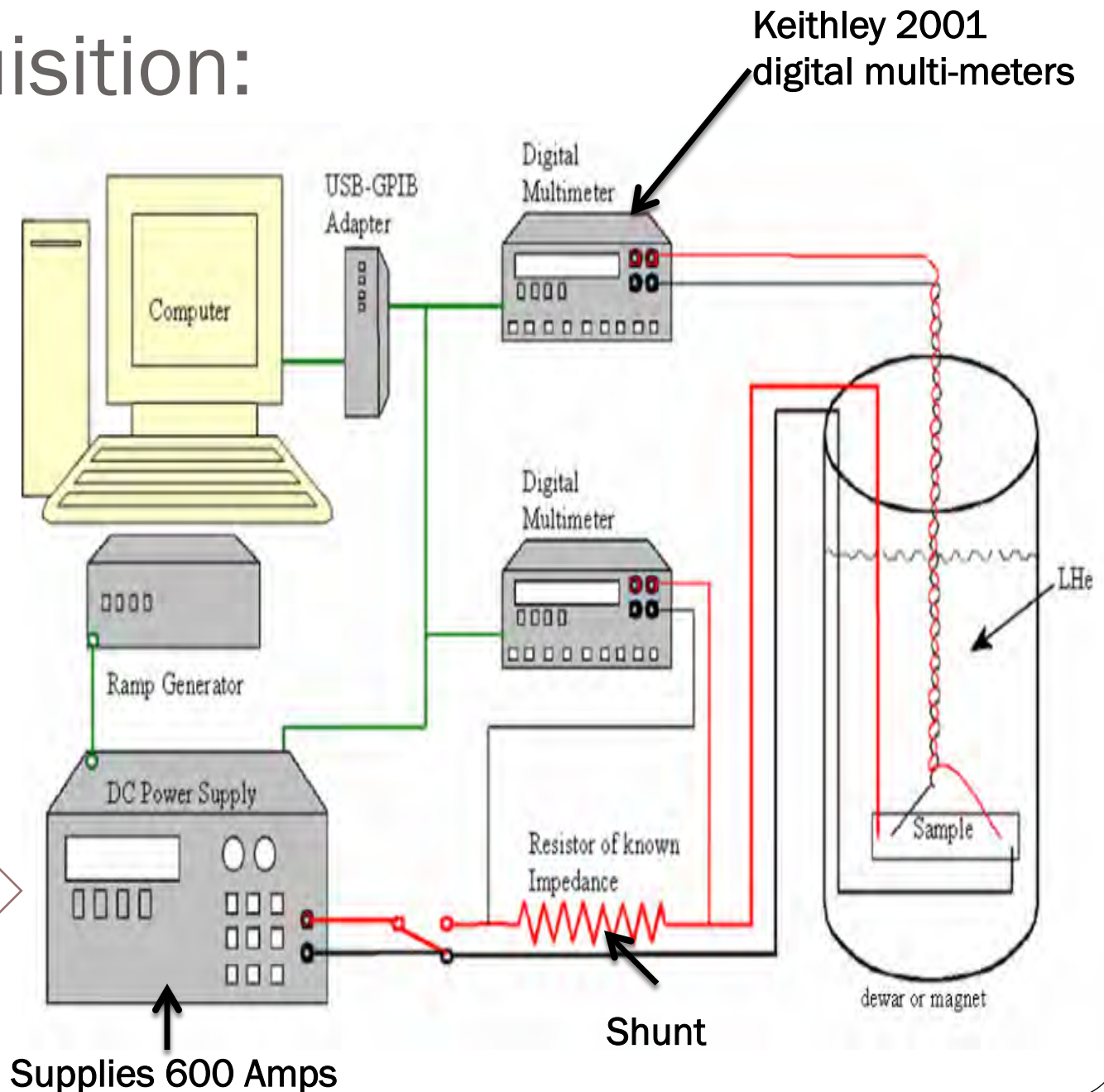
• Determine where YBCO should be soldered.

YBCO strip

Graph of Temperature vs. distance

Data Acquisition:
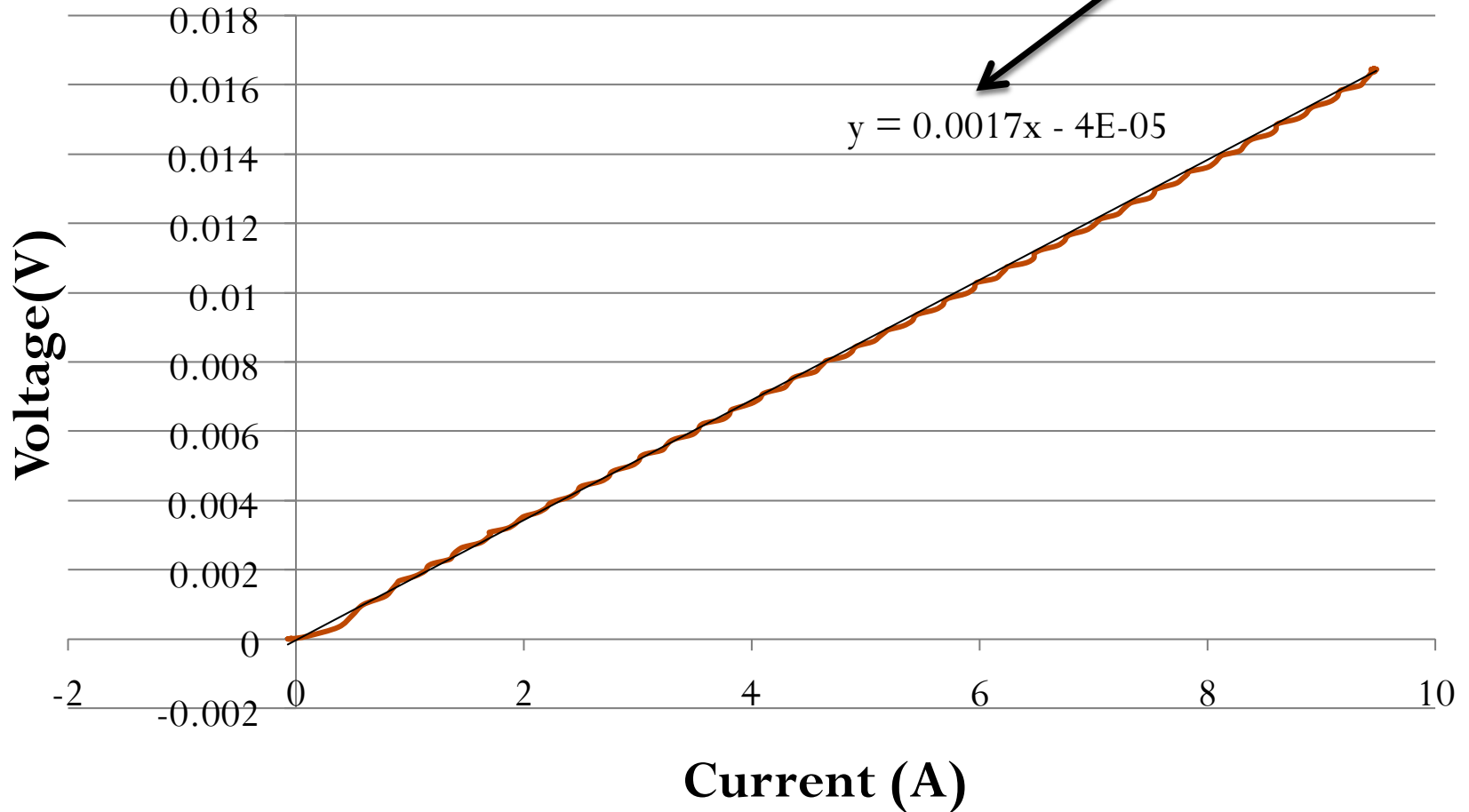
- Labview software
- Graphic user interface
- Enables user to control instruments, store, interpret and analyze data.

Keithley 2001 digital multi-meters

Computer

USB-GPIB Adapter

Digital Multimeter

Digital Multimeter

Ramp Generator

DC Power Supply

Resistor of known Impedance

LHe

Sample

dewar or magnet

Hewlett Packard 6681A DC power supply

Supplies 600 Amps

Shunt

Results: (Room temperature tests)

Voltage vs. Current

Ω

$y = 0.0017x - 4E\text{-}05$

Results: Liquid Nitrogen (77K) tests

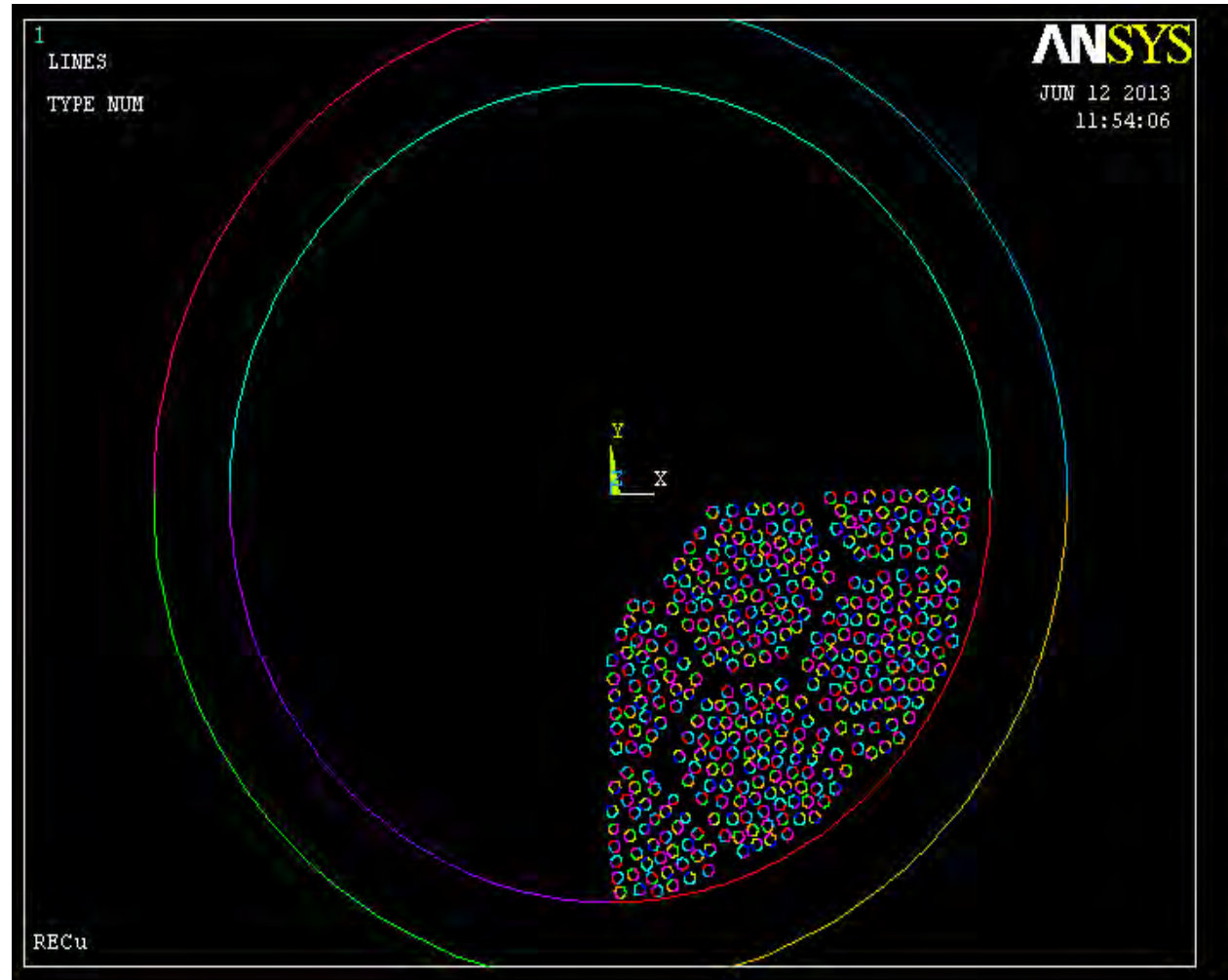| Sample#	Superconducting Material	I_C	Ω Value
1	YBCO	107	30
2	YBCO	103.3	28
3	YBCO	109.7	30
4	YBCO	107	29
5	YBCO	57*	17
6	YBCO	104	25
7	Bi2212	0.14	3
8	Bi2212	0.7	3

Conclusion:

- Multi-sample probe assembly was a success.
- Commissioned room temperature and liquid nitrogen tests.

Future Work:
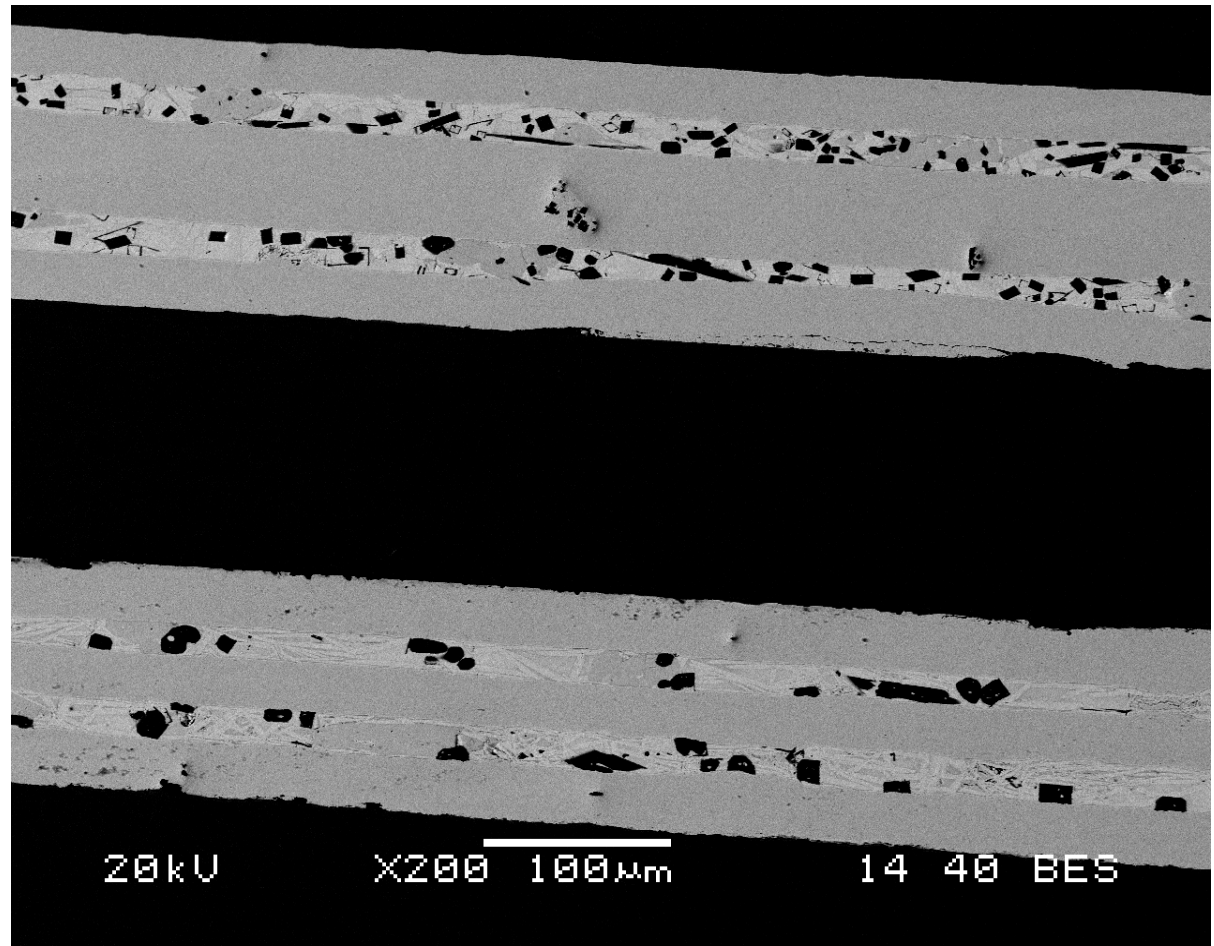
- 4.2K tests in high-magnetic-field.

Other Projects: (ANSYS)

- 2 dimensional model of a copper wire with Bi2212 powder within the filaments.

- APDL code.

- ANSYS.

- Fiji software.

Study of BSCCO conductor.

• Investigation of 521, 522, 523, 524 conductors.

• Photoshop (merge pictures from SEM).

• Liquid, AEC and CF phases.

What did I learn?

- Never grow to attached to the design or project.
- Stay critical and strive for perfection.
- Yes! even if it means going back to drawing board.

- Always think 3 steps ahead.
- Be the biggest optimist but remember things do go wrong sometimes.
- How to be more productive in a lab.

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Questions?