

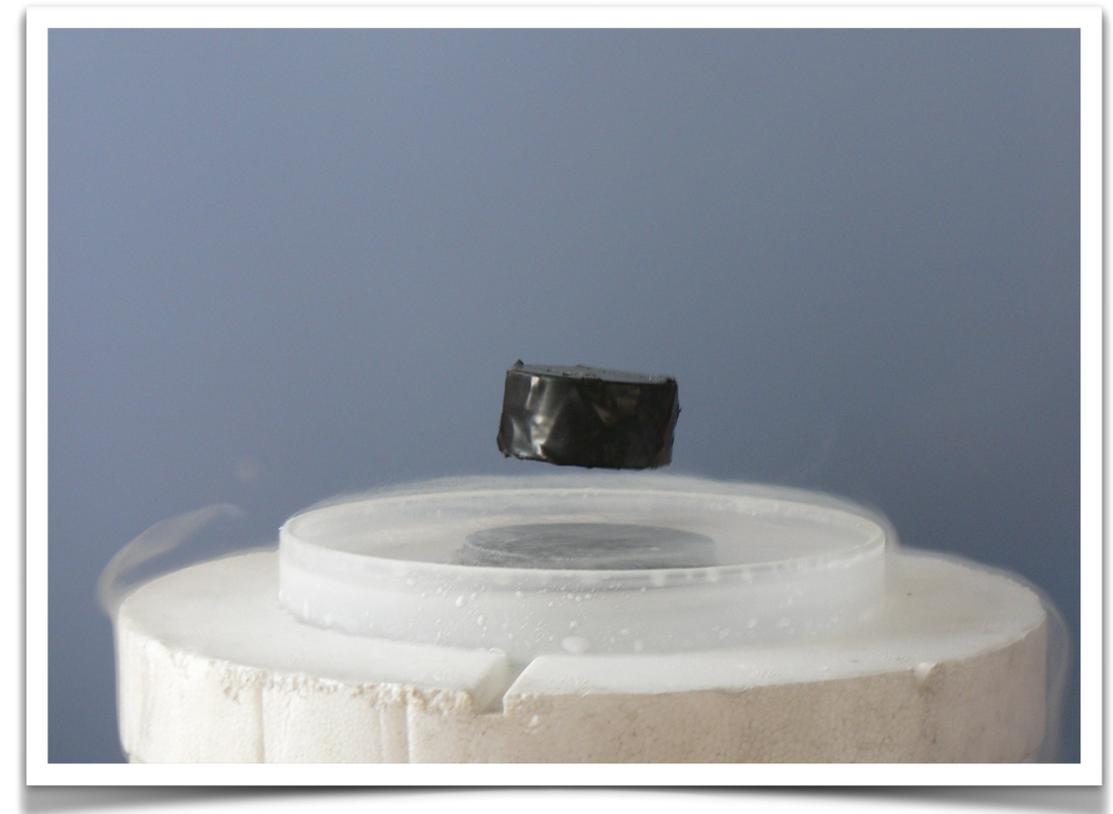
Superconductivity Lab: Week 1

AP 4018

Columbia University (Spring 2021)

Objective

- Cool high temperature superconductor and observe magnetic susceptibility as a function of temperature
- (Background) Meissner effect: weak magnetic fields are expelled from superconductors and appear as diamagnetic.



High Temperature Superconductors

- Eight Nobel Prizes awarded to discoveries involving superconductivity.
[<http://past.ieeecsc.org/pages/nobel-laureates-superconductivity>]
- Superconductivity at liquid nitrogen temperature discovered in 1987.
[<https://doi.org/10.1103/PhysRevLett.58.908>]
- High temperature superconductors (HTS) have become commercial and capable of producing the strongest magnetic fields.
[<https://doi.org/10.1088/1361-6668/ab06a2>]

This Lab: Repeat the Famous Experiments Reported by M.K. Wu and co-authors, *PRL*, 2 March 1987

VOLUME 58, NUMBER 9

PHYSICAL REVIEW LETTERS

2 MARCH 1987

Superconductivity at 93 K in a New Mixed-Phase Y-Ba-Cu-O Compound System at Ambient Pressure

M. K. Wu, J. R. Ashburn, and C. J. Torng

Department of Physics, University of Alabama, Huntsville, Alabama 35899

and

P. H. Hor, R. L. Meng, L. Gao, Z. J. Huang, Y. Q. Wang, and C. W. Chu^(a)

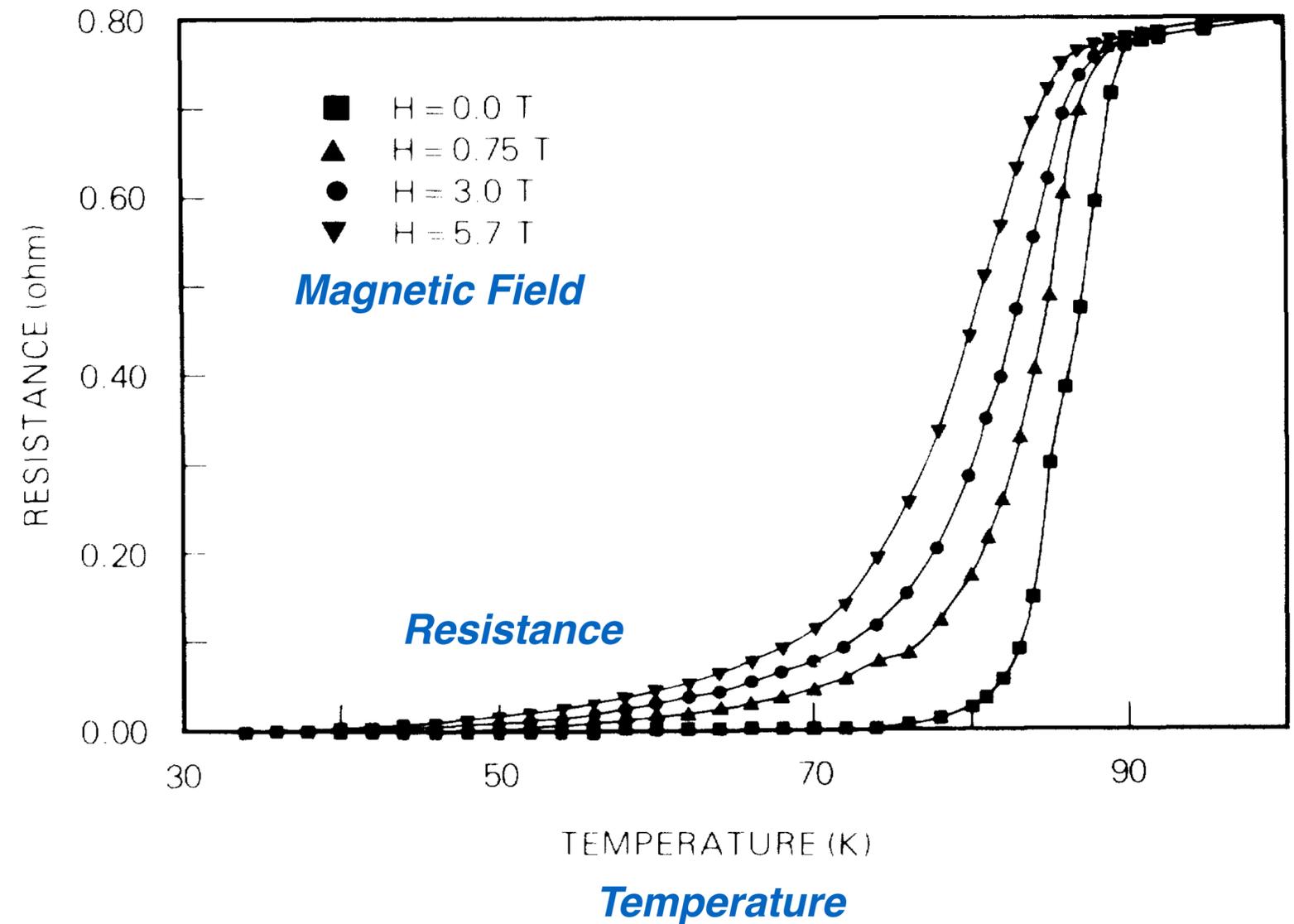
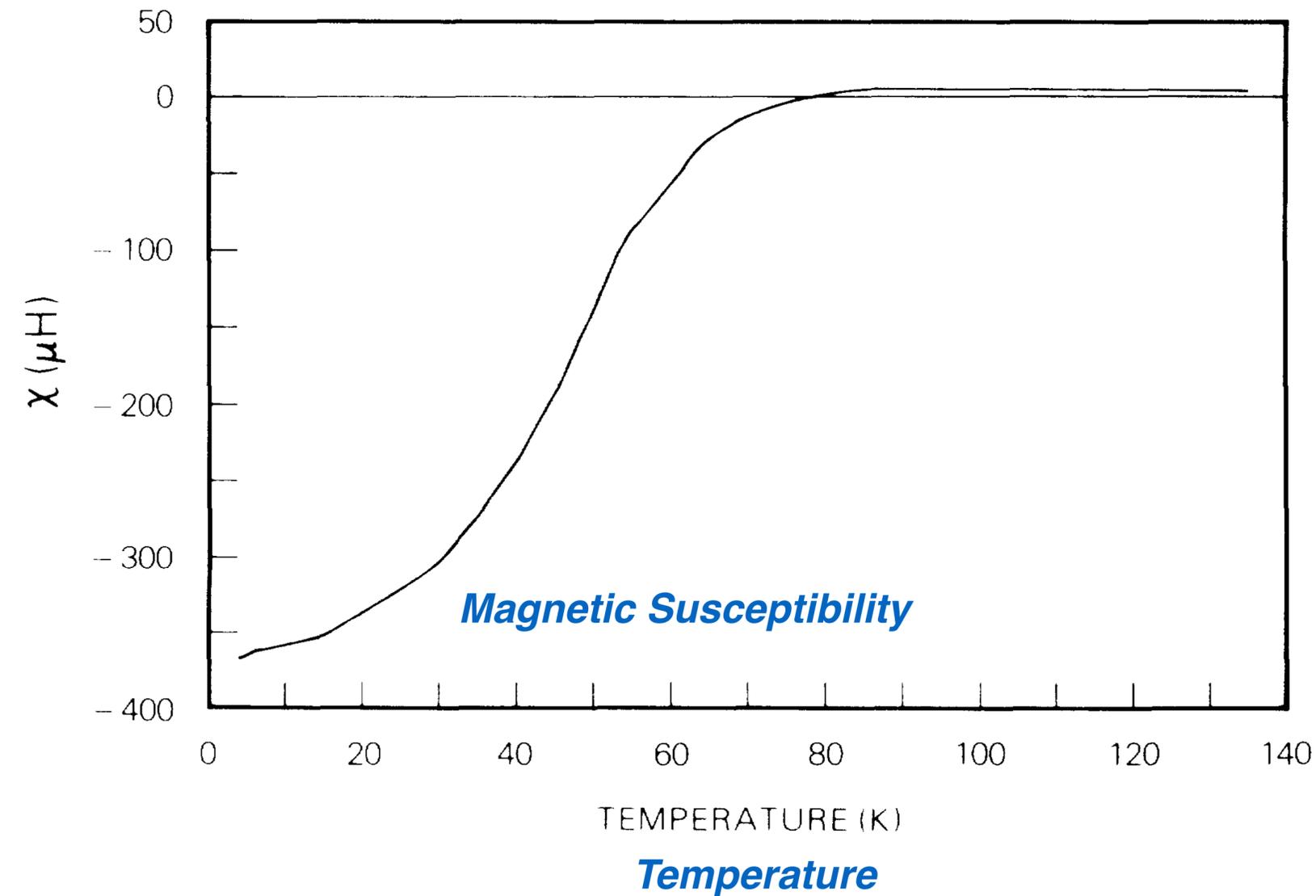
Department of Physics and Space Vacuum Epitaxy Center, University of Houston, Houston, Texas 77004

(Received 6 February 1987; Revised manuscript received 18 February 1987)

A stable and reproducible superconductivity transition between 80 and 93 K has been unambiguously observed both resistively and magnetically in a new Y-Ba-Cu-O compound system at ambient pressure. An estimated upper critical field $H_{c2}(0)$ between 80 and 180 T was obtained.

Three Observations:

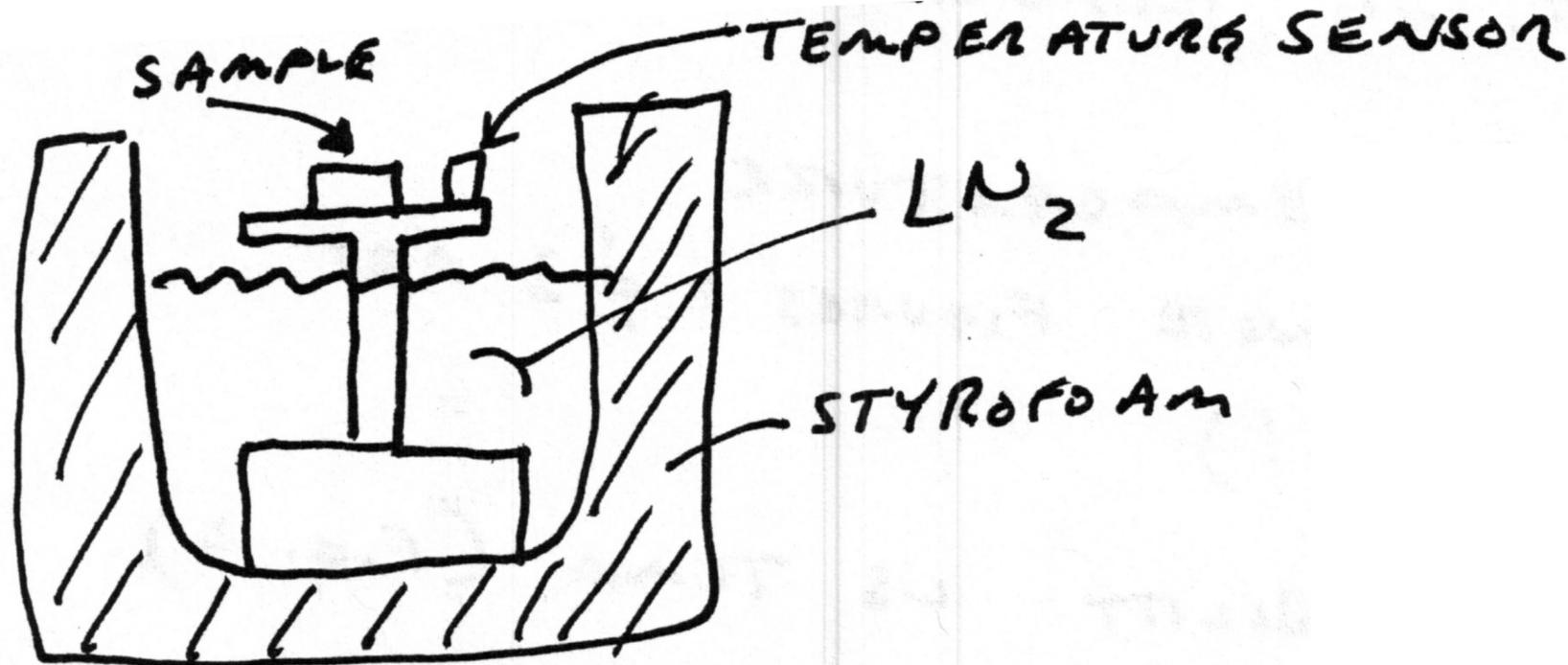
(1) Magnetic Susceptibility, (2) Temperature & Resistivity, and (3) Magnetic Field & Resistivity



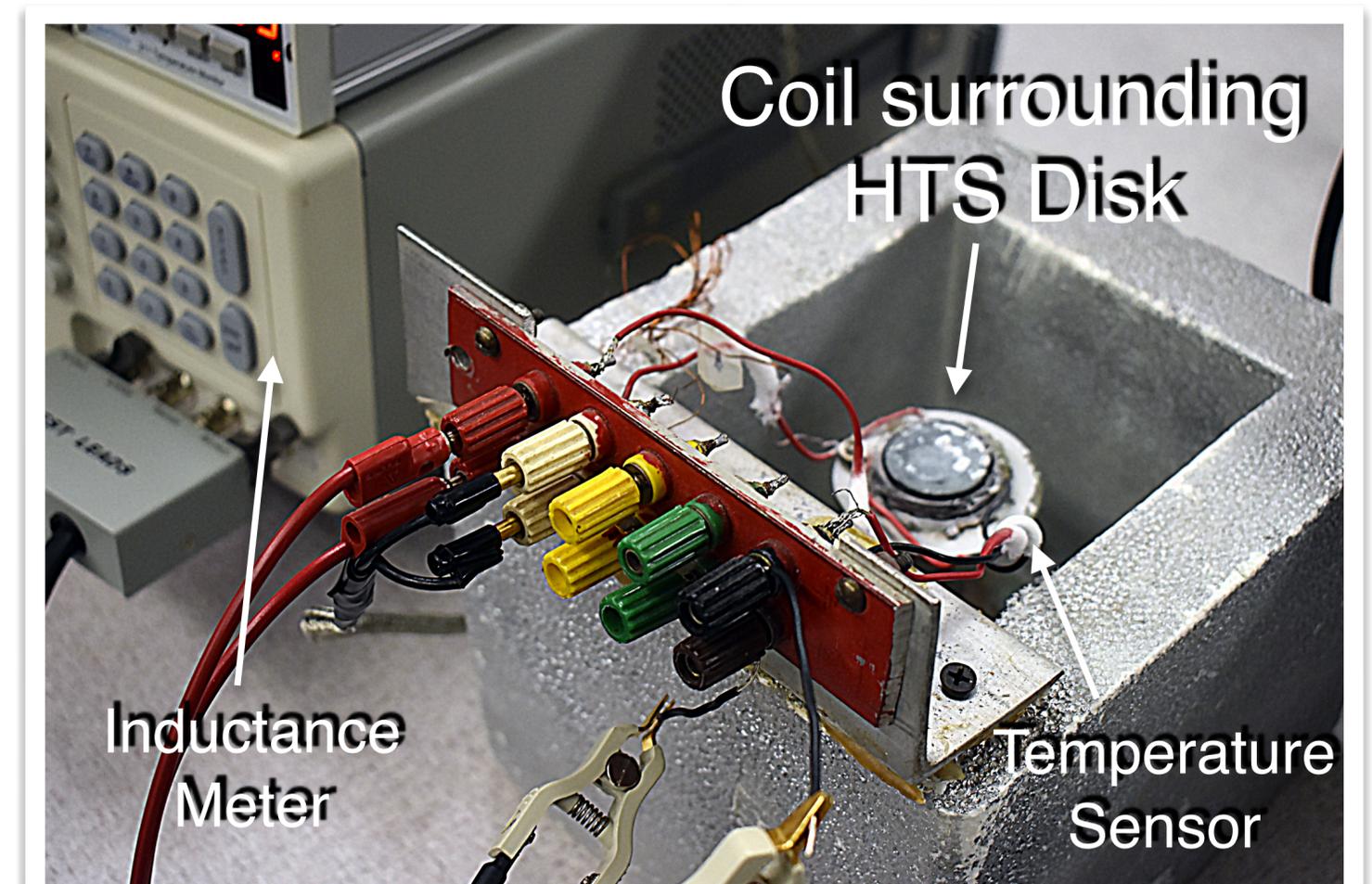
Overview

- *Week 1:* “Meissner Effect” is observed by levitation of a permanent magnet and measurement of inductance vs. temperature
- *Week 2:* Four-point measurement of resistance vs temperature with/without applied magnetic field

Styrofoam Dewar



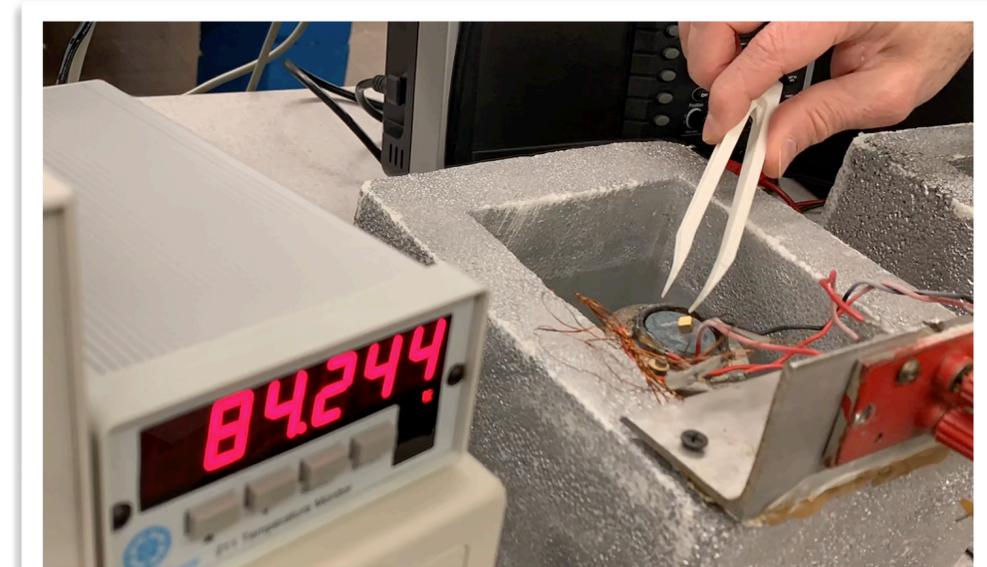
Recipe: To make YBCO disk, combine yttrium-oxide/copper-oxide/barium carbonate, then heat, cool, grind, heat, cool, press into disk, and heat once again.



Several types of HTS
This sample is $\text{YBa}_2\text{Cu}_3\text{O}_7$

What is Contained in Data Files?

- Observation of levitating magnet:
HTS-Time-Lapse-Meissner.mov



- Measurement of inductance vs. temperature:
HTS-Time-Lapse-Inductance.mov



Summary: Week 1

- Meissner effect: weak magnetic fields are expelled from superconductors and appear as diamagnetic.
- Measure: temperature when Meissner effect vanishes indicating a loss of superconductivity and a return to normal resistance.