Cornell University
Laboratory for Elementary-Particle Physics

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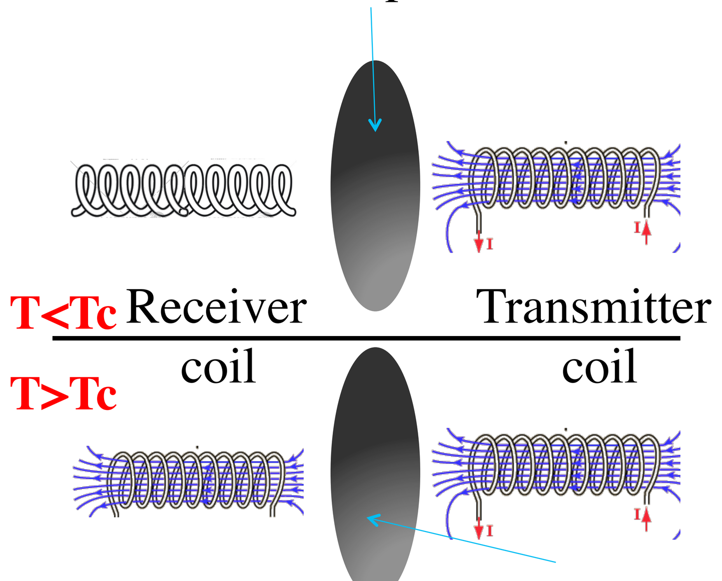
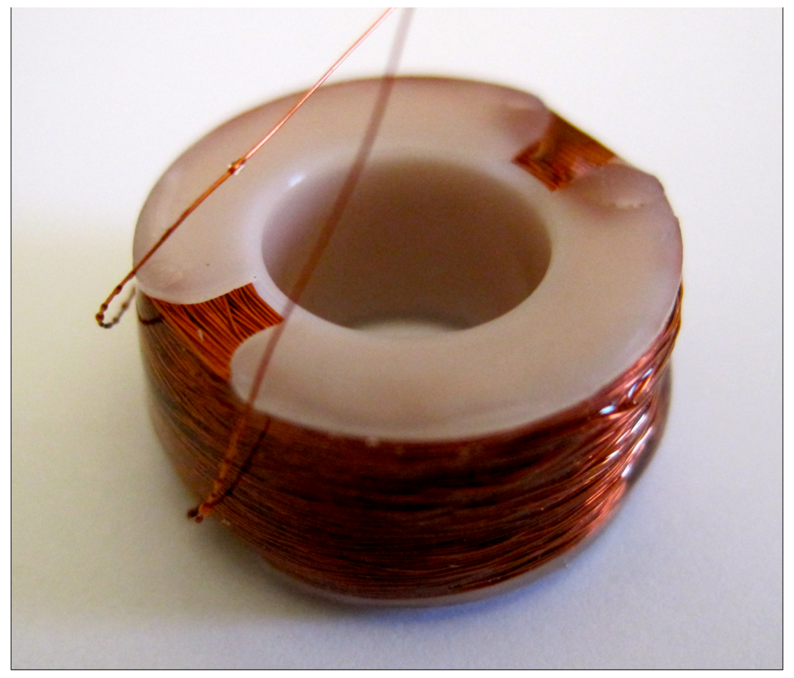
Summer Research for Community College Students – 2011

Critical Temperature Measurement Setup

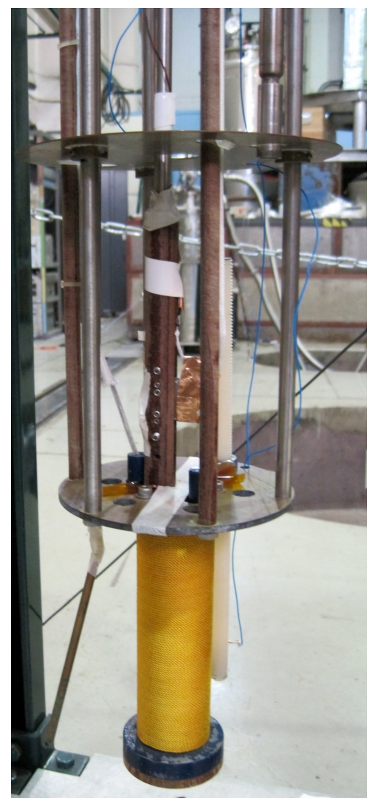


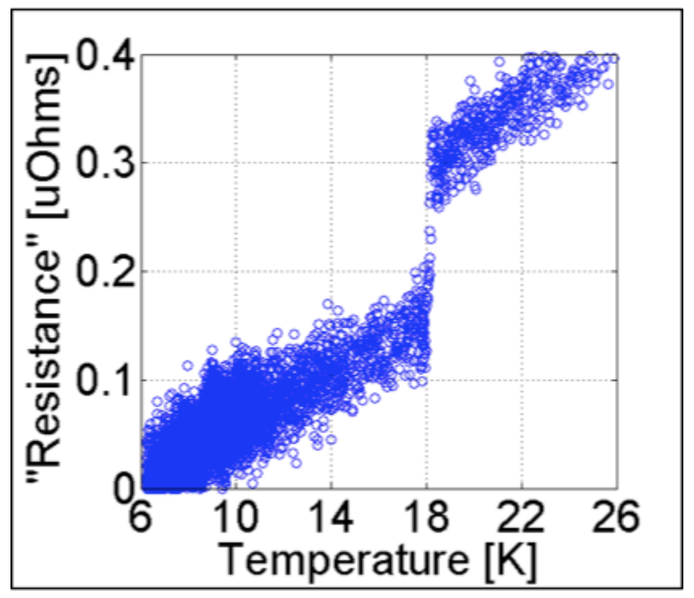
For every superconducting material, there is a critical temperature and a critical magnetic field that the material must be maintained below in order for it to maintain the superconducting state. This creates limitations to what can be done with RF cavities. Having a higher magnetic field means that the accelerating field will be greater, while it is obviously easier to maintain temperatures that are closer, if only slightly, to room temperature. Currently, RF cavities are made of niobium, but it is known that another superconductor, Nb_3Sn, is more ideal due to its higher critical temperature and critical magnetic field. The device used to make this material already exists, but it is also capable of making other Nb-Sn compounds, which are useless for RF cavities, and are difficult to distinguish from Nb_3Sn. Fortunately, these compounds can be identified by their characteristic critical temperatures.

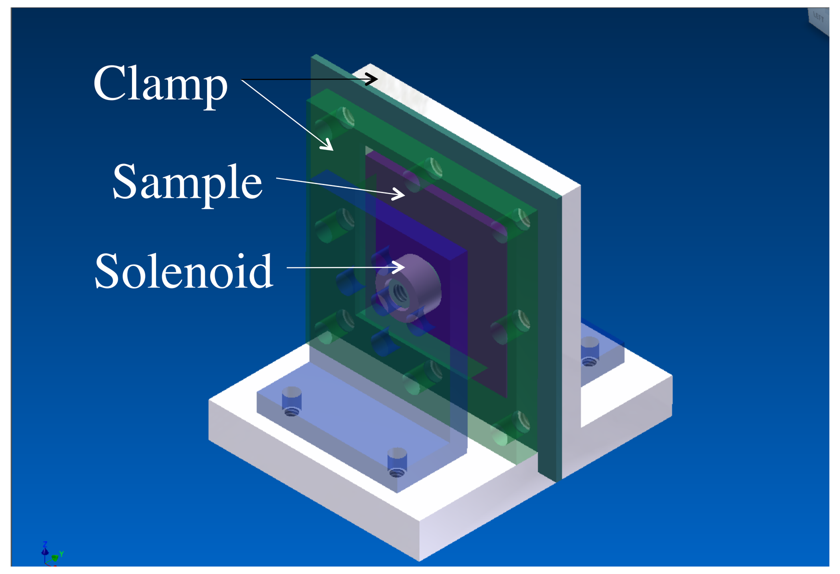


Solenoid

While the sample is in the normal conducting state, magnetic flux will be able to penetrate it, so the magnetic field through the receiving solenoid will be comparable in magnitude to the field through the current-carrying transmitting solenoid , assuming the solenoids to be close together. Once the solenoid becomes superconducting, the sample will expel all magnetic flux, causing the magnetic field in the receiving solenoid to drop significantly. By keeping track of the temperature and the voltage in the solenoids (which is proportional to the magnetic field), the critical temperature of the sample can be found.





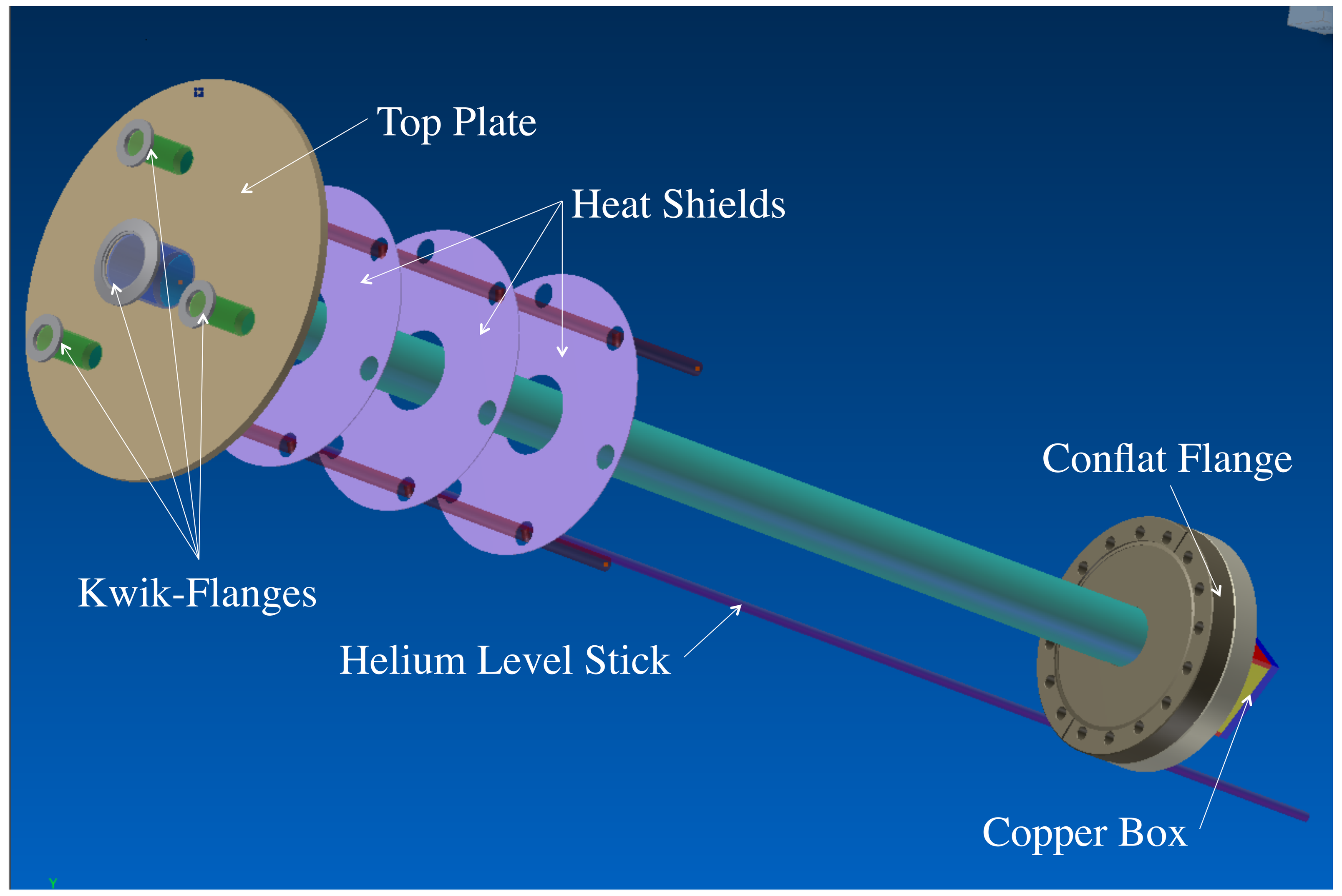


Experimental Setup

The setup consists of two solenoids (represented by pink placeholder parts), attached to a stand to keep them in place around a superconducting sample, held in place by a clamp to maintain good thermal conductivity. The setup uses magnetic shielding to reduce the amount of magnetic flux that will bypass the sample while its superconducting.

The Old System

There already is a setup in existence that is designed for the same purposes as this one. It works by keeping track of the resistance of the sample, which should jump when it reaches the critical temperature. It somewhat works, but it is greatly affected by noise and inductive reactance, which has caused it to produce imprecise graphs. Some of the old system's flaws have been mitigated, but the new system, shown in the model, is expected to work much better.

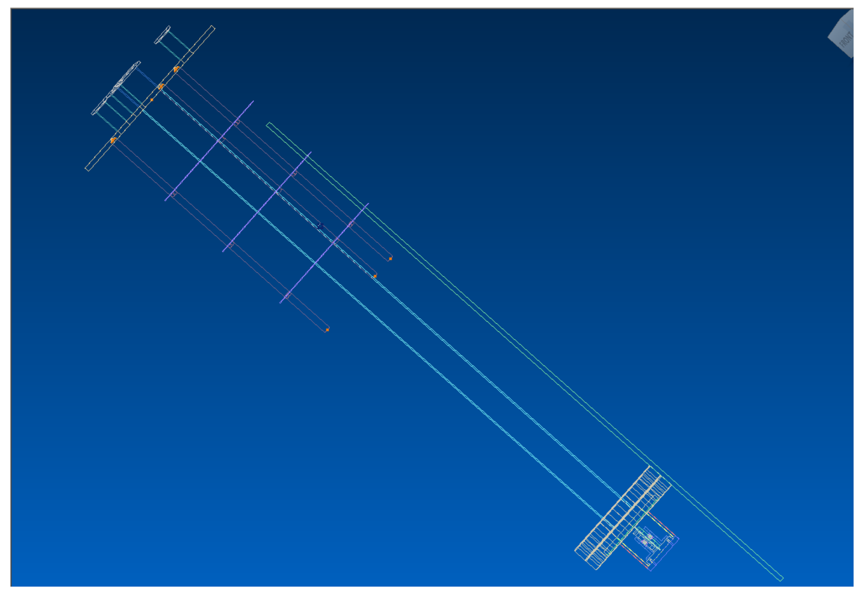


Completed Model of the Critical Temperature Measurement Setup

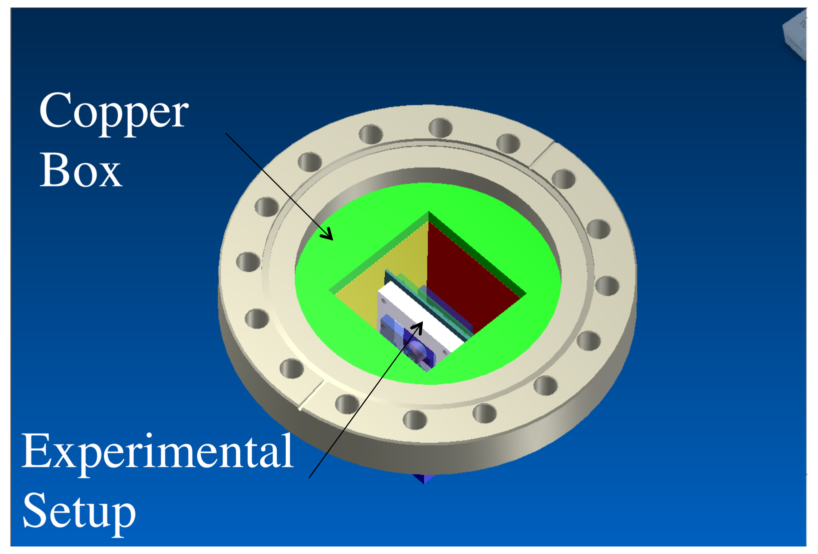
The parts visible in this picture function to weaken heat transfer from the outside environment, allow for the recovery of the helium, and measure the helium level. the parts that need to be observed in the experiment are inside the copper box. Not included in the model are a cross that will be used to maintain vacuum conditions above the center kwik-flange, the parts that make the flanges work, the Dewar itself, any wires or meters that will be used, bolts, and the resistors that will be used to heat and cool the sample.

The Next Steps

Many of the parts shown in the model still need to be made, ordered, and/or welded together. Once the parts are available (some parts, such as the helium level stick and the solenoids, already are), the setup will need to be assembled as it is in the model, and attached to a lock-in amplifier and a temperature probe before it can be tested.



Wireframe image of Main Assembly



Copper Box

The copper box allows for relatively even heating of the sample.. It will be welded onto a circular copper plate that is designed to fit into a 6" conflat flange . This box contains the experimental setup..

LEPP, the Cornell University Laboratory for Elementary-Particle Physics, has joined with CHESS to become the Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE). LEPP's primary source of support is the National Science Foundation.
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