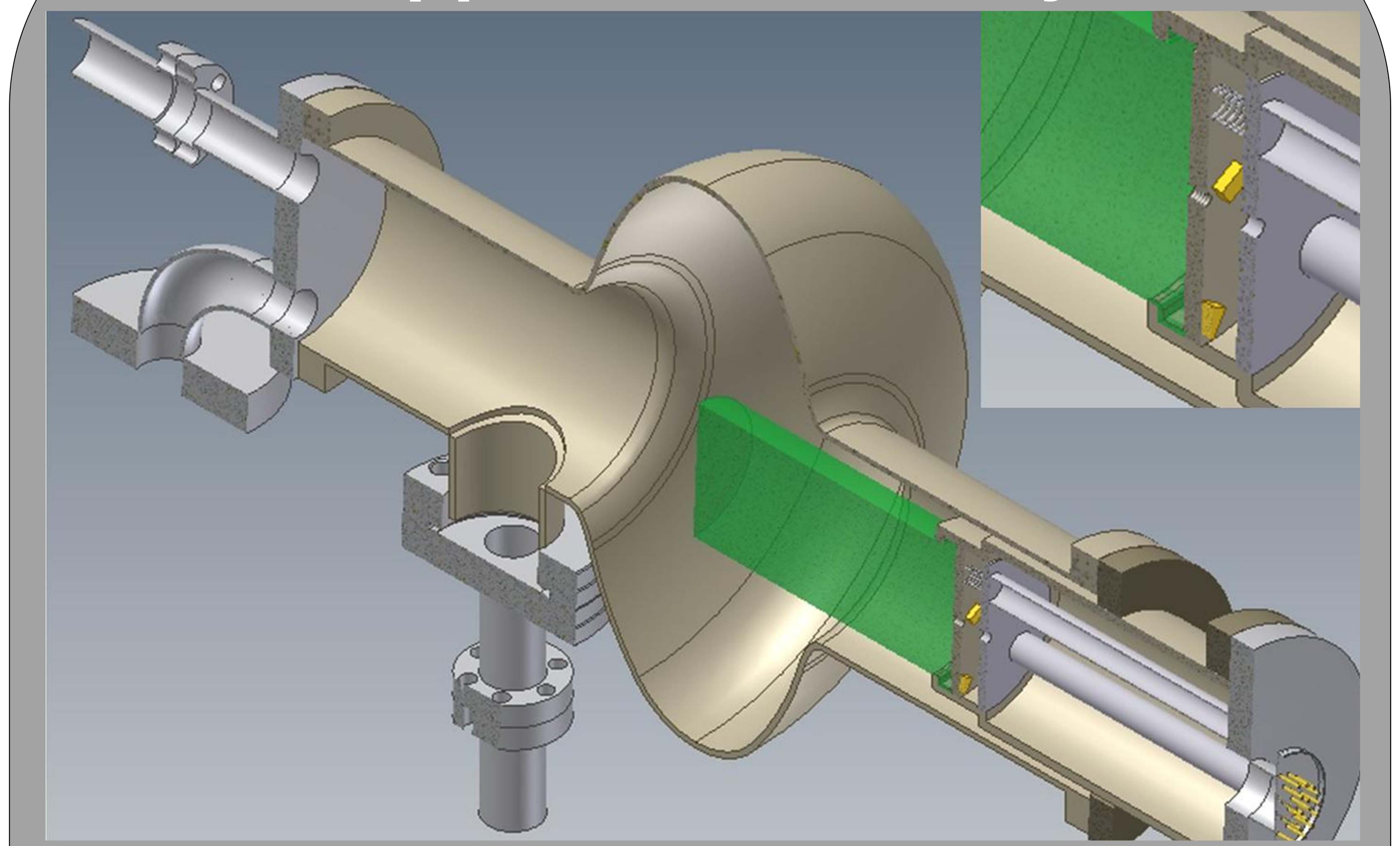
A Measurement of the Loss tangent and heat Capacity of a large single crystal and the impact on the design of wafer sample cavity

Nathaniel J. Pogue[1], Peter M. McIntyre[1], Akhdiyor I. Sattarov[1] and Charlie Reece[2]

[1]Department of Physics and Astronomy- Texas A&M University [2]Thomas Jefferson National Accelerator Facility

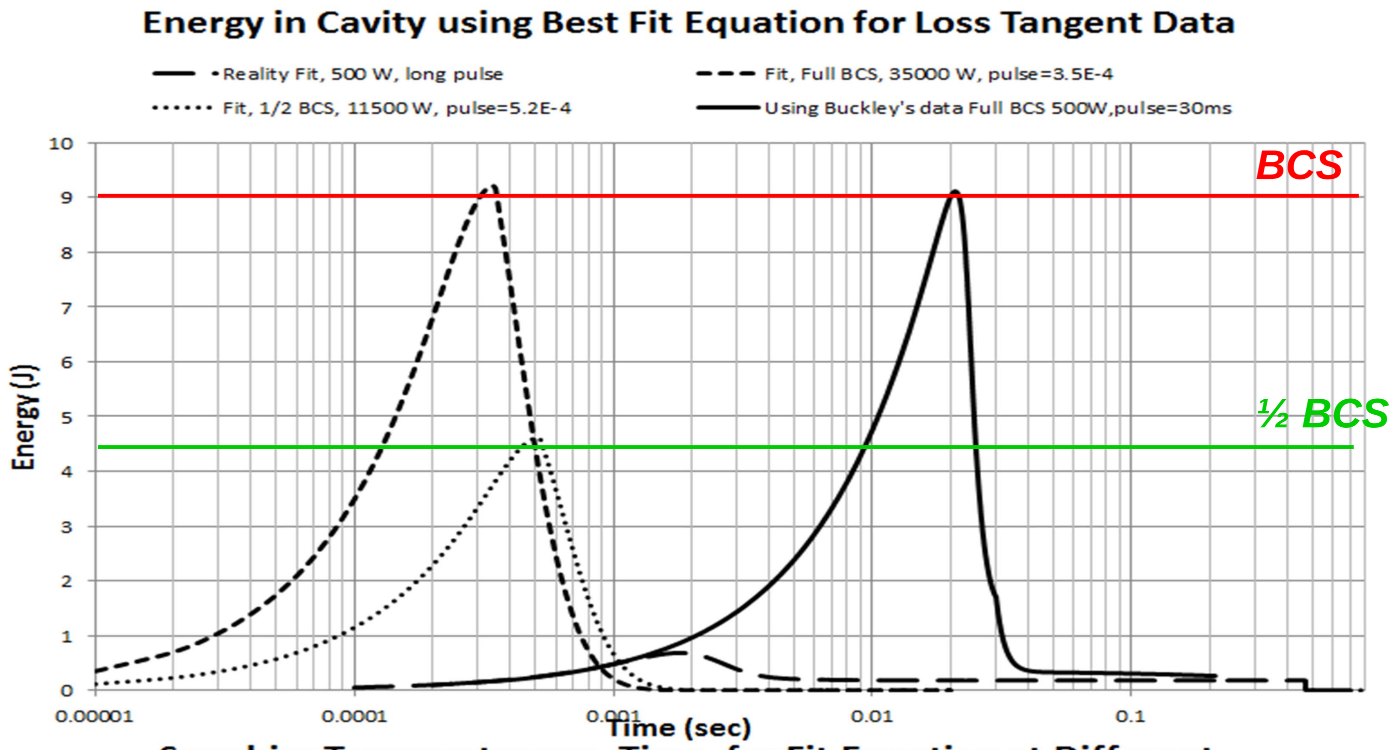
Sapphire Test Cavity

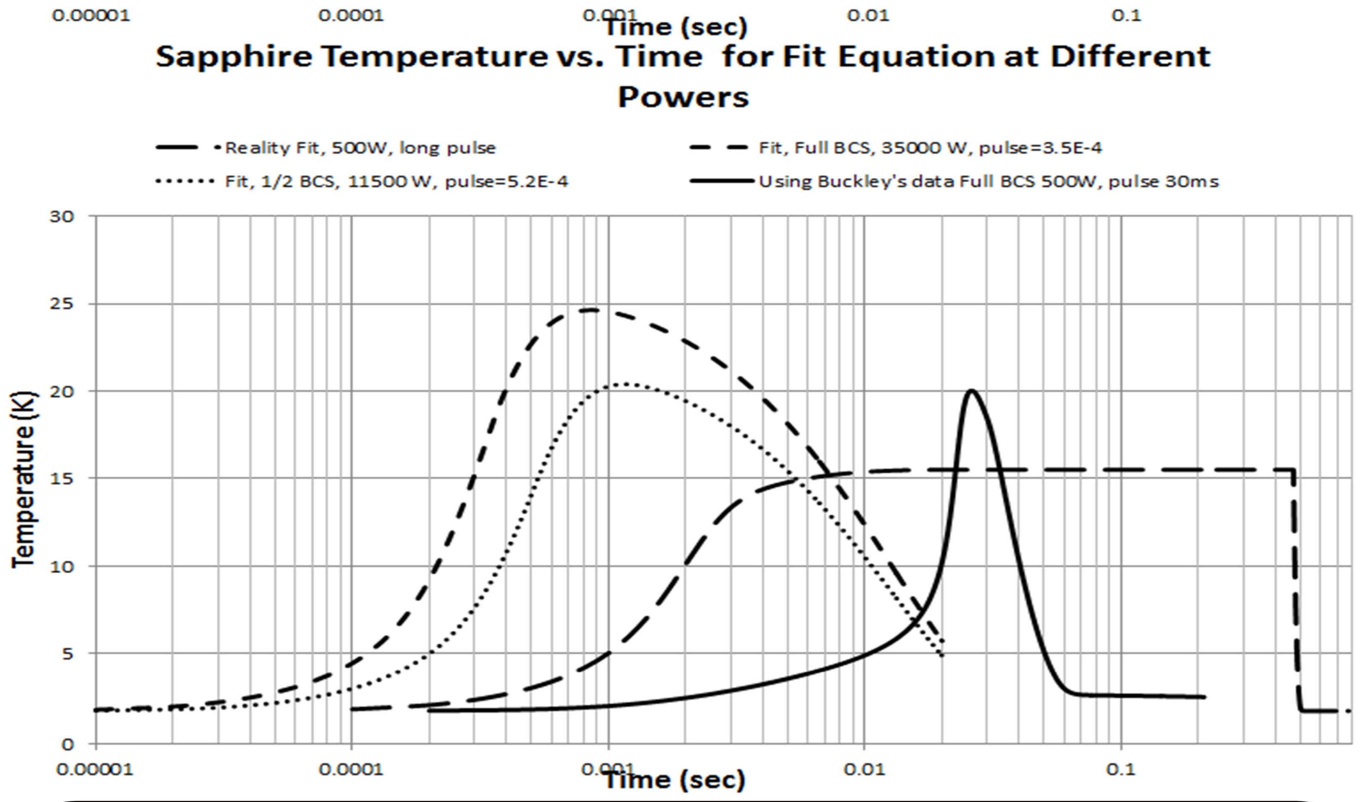


★Drawing of the Sapphire Test Cavity. The sapphire's (green) end face is parallel with the equator. The side and end ports were the locations of the probe and input couplers. The end flange also included the vacuum line. The sapphire is held in place by a Nb holder with an indium seal that acts as a thermal bridge between the sapphire, backing plate with resistors attached, and the holder which is the pathway to the Helium bath. The backing plate is spring loaded ensure consistent contact with the seal.

★The inset image is showing the two resistors used to measure the interior temp, the backing plate, and the spring loaded fixture.

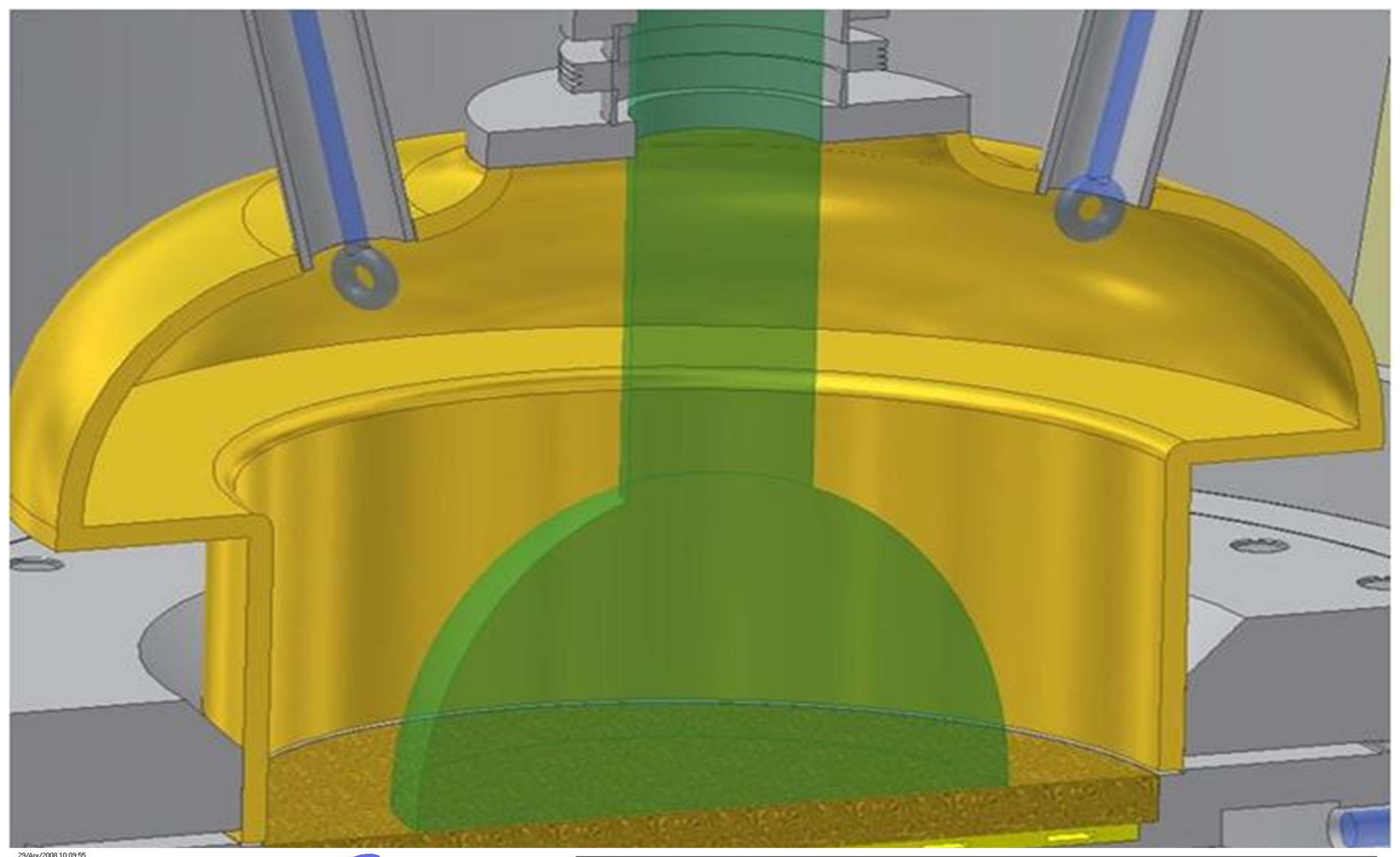
The data's significance for the WTC

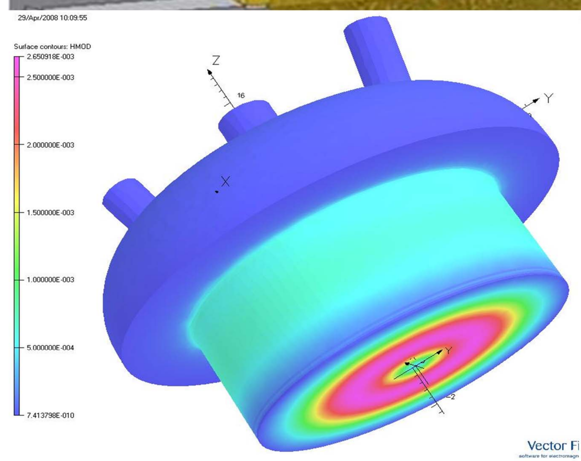


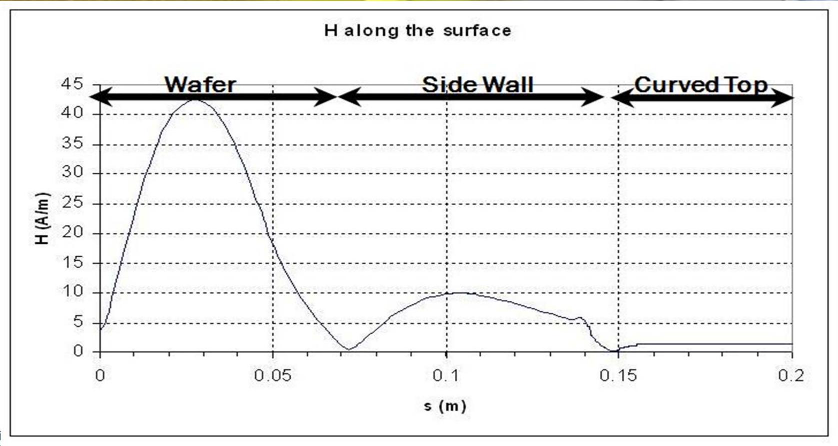


★ Top: This figure illustrates the ramifications of the STC tests. Long dashed line shows that at the maximum power that can be provided (500 W), the cavity cannot reach above 21 mT using the data acquired from the STC. However if the same results were to be achieved as those measured by calorimetry, then the cavity would respond as designed with 500W of power, as the solid line shows.
★ Bottom: The temperature of the sapphire as time goes by in the different scenarios. Note that the to reach the BCS limit in the calorimertry measured case the temperature is below 10 K during the measurement.

Wafer Test Cavity Design

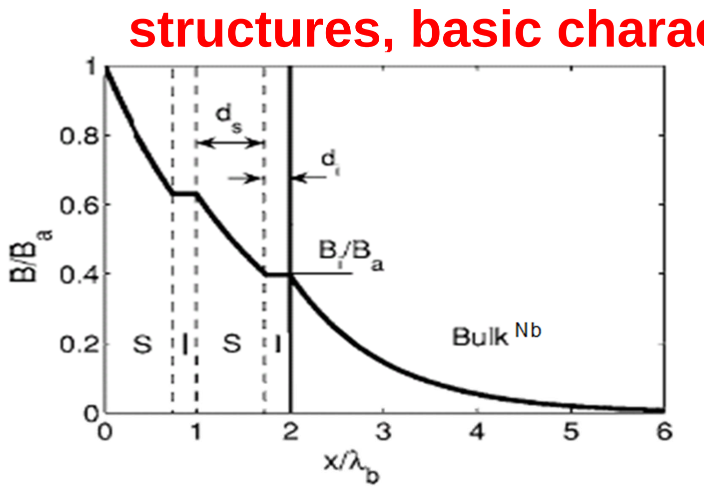


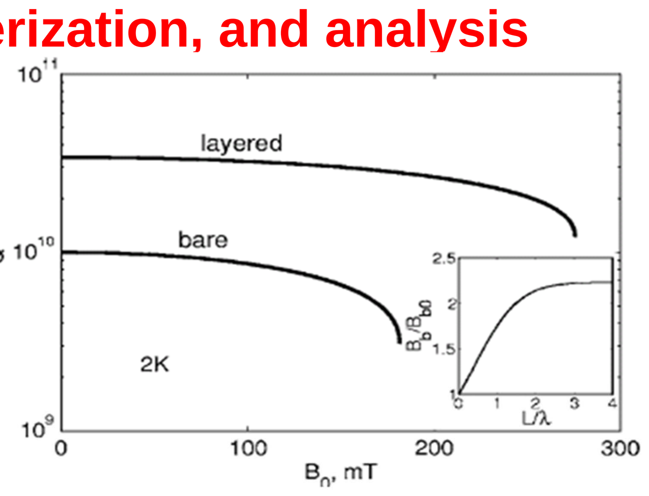




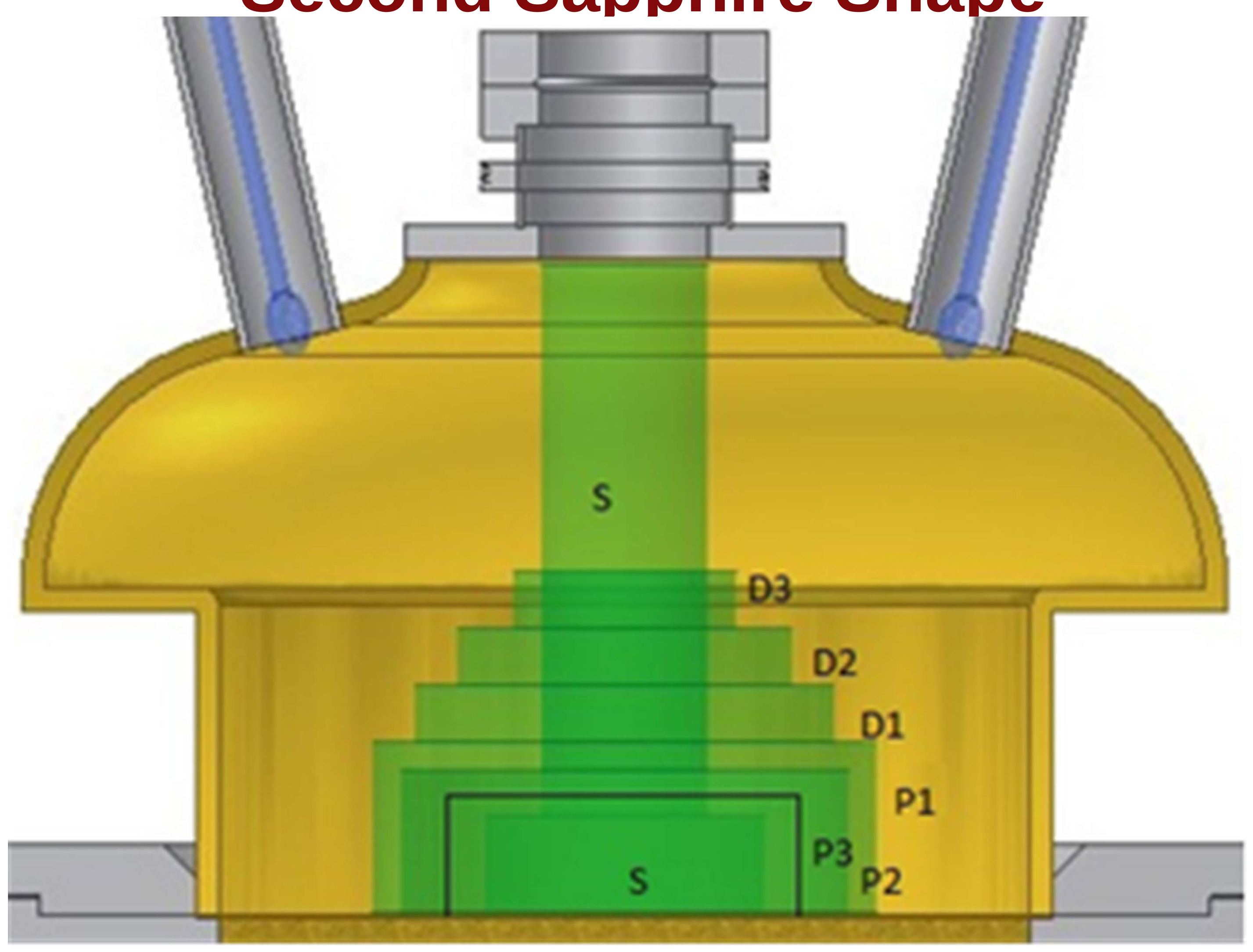
★ Top: The top half of the cavity. The mushroom is a half TESLA cell that's connected to a cylinder. The sapphire (green) is held by a bellows with an indium pinch seal at the top of the cavity. It allows adjustment of the sapphire above the sample. There are two ports located at the top: one probe and one input coupler. The two loops can be adjusted to get the optimal coupling. If necessary, dummy ports can be inserted to symmetrize the system.
★ Bottom: On the left a false color image of the magnetic field on the wall's and sample's surface. The magnitude of the field measured from the center to the sample to the top of the cavity along an azimuthal line for the specific case of the ellipsoidal sapphire.

Motivation for this work is to test advanced hetero-structures, basic characterization, and analysis





Second Sapphire Shape

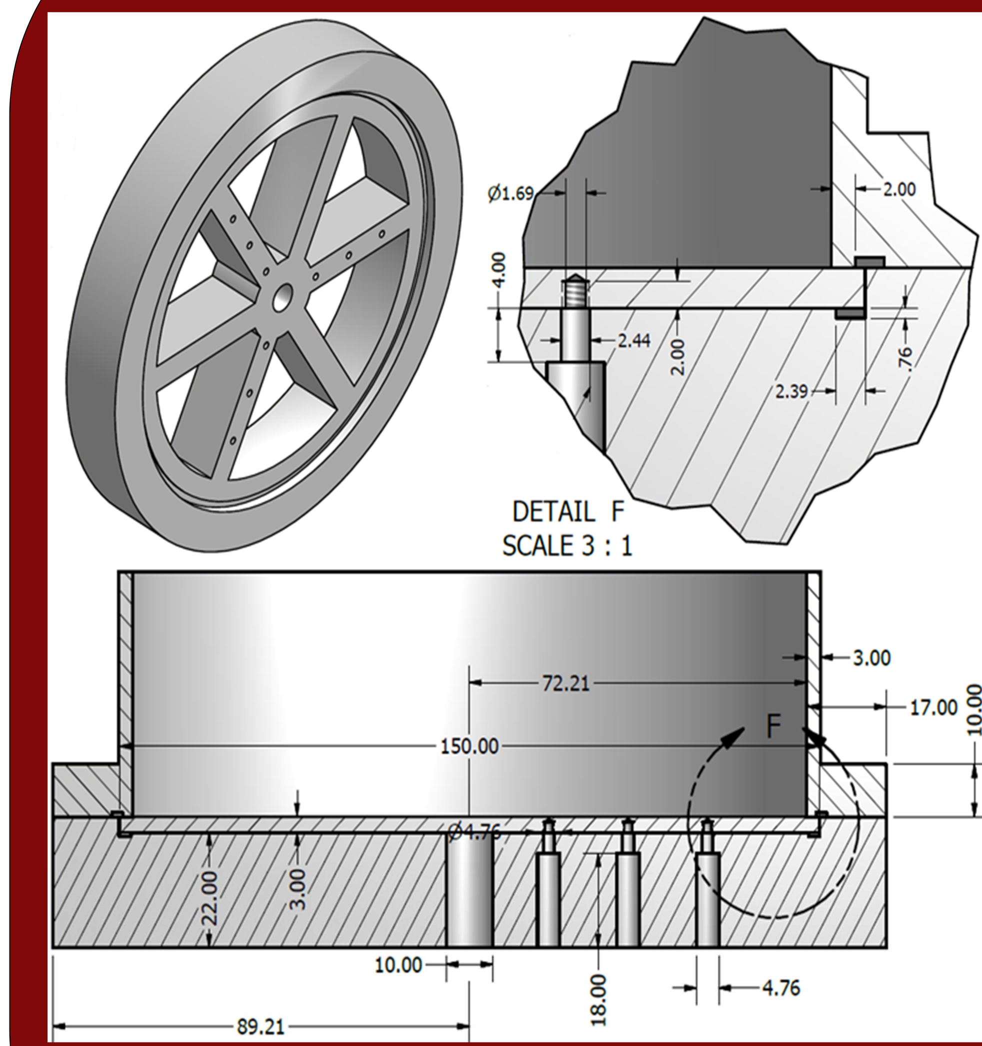


Field Ratio for Washer Design

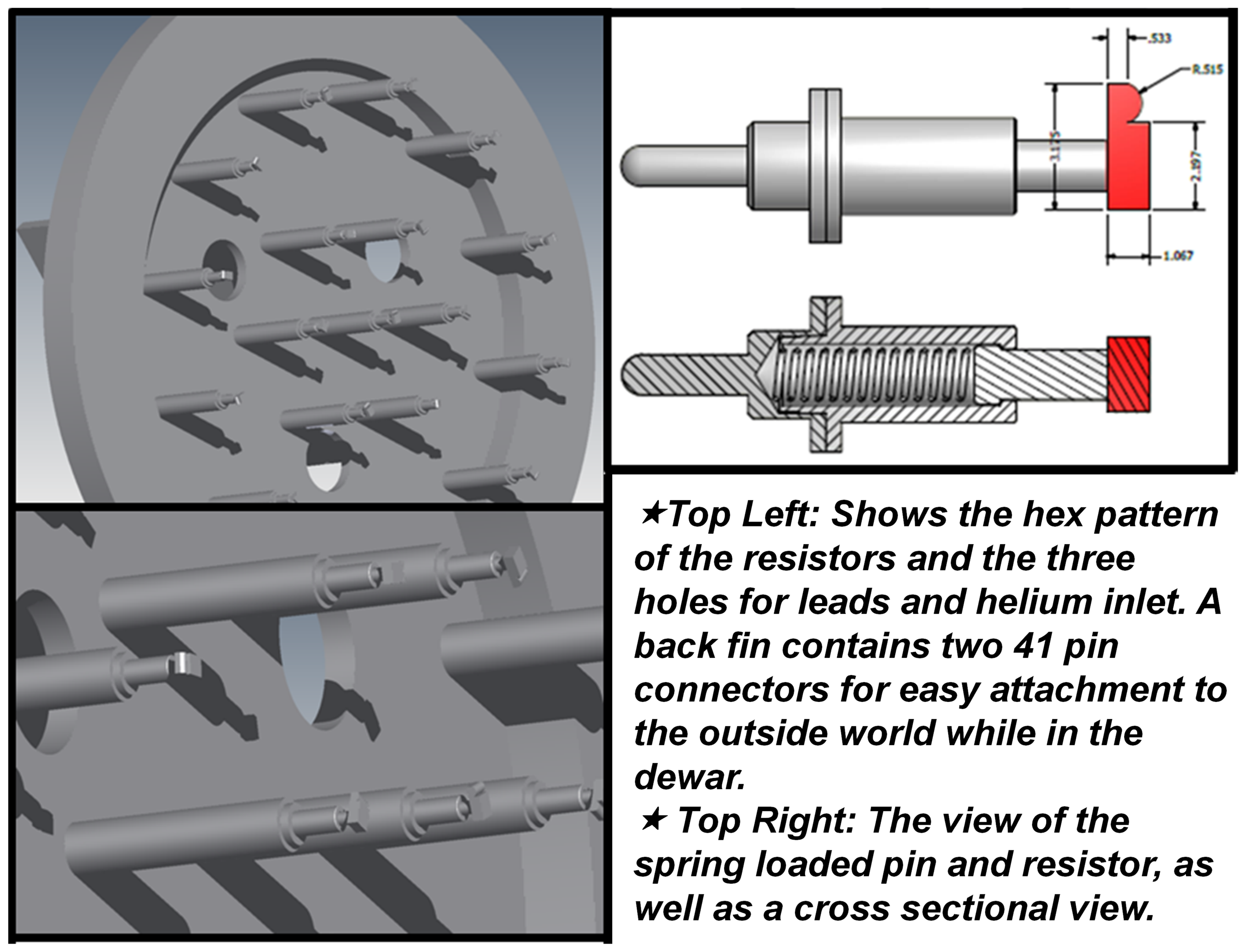
Cavity with the different amounts of sapphire	freq (GHz)	sample to wall ratio
No sapphire	2.78228	-
S only	-	-
Full sapphire	1.32	3.56
remove D3	1.3332	3.63
remove D3, D2	1.3727	4.13
remove D3, D2, D1	1.487	4.91046
Just S, P2, P3	1.682	7.265
Just S, P3	1.936	8.455
Just S and P3 are the maximum ratio		obtainable

★ The cylindrical pyramid that can be made into one or several pieces. The table above shows the frequency and sample to wall ratio if only certain pieces of sapphire are placed in the cavity.

6 Spoke Wafer Mount



★ Top Left: shows the design of the mount with 6 inch thick spokes with a hole in the center and 9 counter-bored holes for #2 socket head screws. It also shows the recess for placement of the wafer.
★ Bottom: Gives a cross section of the mount and wafer with dimensions.
★ Top Right: An enlarged view of the two indium joints providing the helium seal and the counter-bored holes. It also shows the tapped holes in the wafer. Each 3mm thick wafer must have the 9 holes drilled and tapped.



★Top Left: Shows the hex pattern of the resistors and the three holes for leads and helium inlet. A back fin contains two 41 pin connectors for easy attachment to the outside world while in the dewar.
★ Top Right: The view of the spring loaded pin and resistor, as well as a cross sectional view.

★Lower Left: Shows the close up view of spring loaded pins inserted into the extending cylinders and anchors them into position.

Accelerator Laboratory - Department of Physics - Texas A&M University 3380 University Dr. East, Magnet Lab, College Station TX 77845
Contact: Nathaniel Pogue – Cell: (979) 574 – 5672, Office: (979) 845 – 6015, npogue@physics.tamu.edu