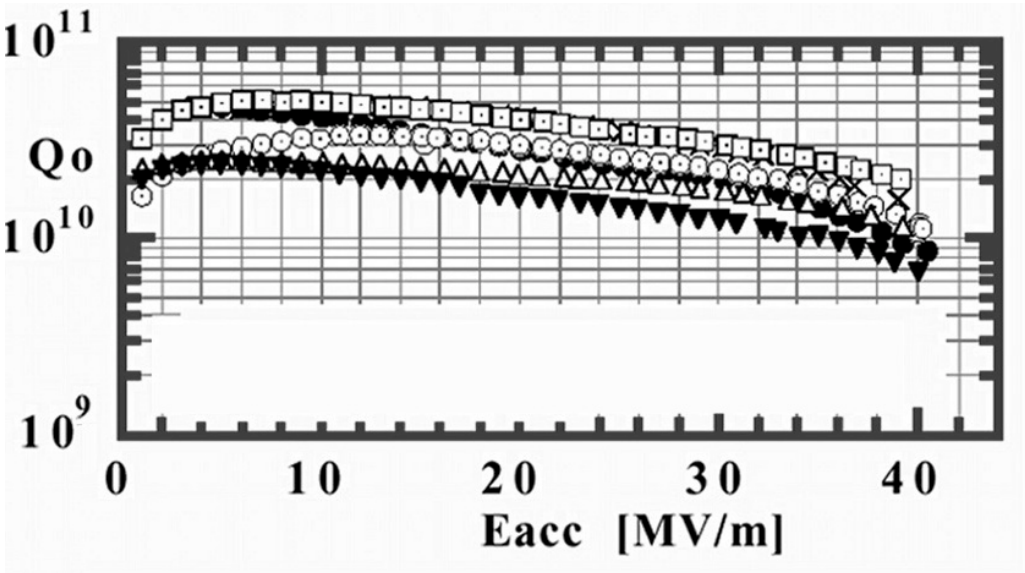
Discussion of Possible Superconducting RF Materials R&D at FNAL and ASC/UW

Objective:

- To participate in the world-wide effort to push performance and reduce cost of superconducting cavities in view of a linear collider.

Issues in Superconducting RF for Linear Colliders



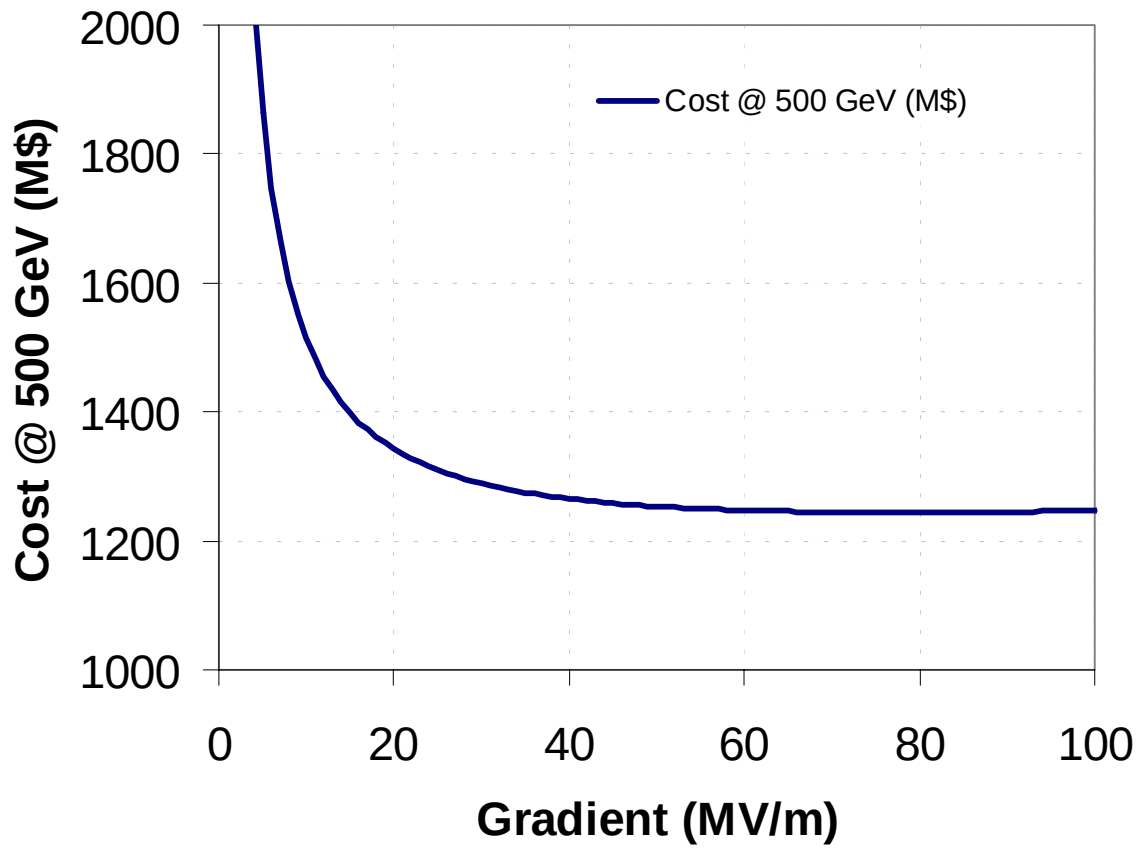
Bulk – Niobium cavities have made tremendous progress over the last 10 years – making TESLA a competitive option for a superconducting linear collider. The accelerating gradient for TESLA is specified to be 23.4 MV/m at $Q=10^{10}$.

Cost is the most important issue in superconducting RF for a linear collider! The current cost per m of cavity, according to a recent study by Garbincius/Edwards, is:

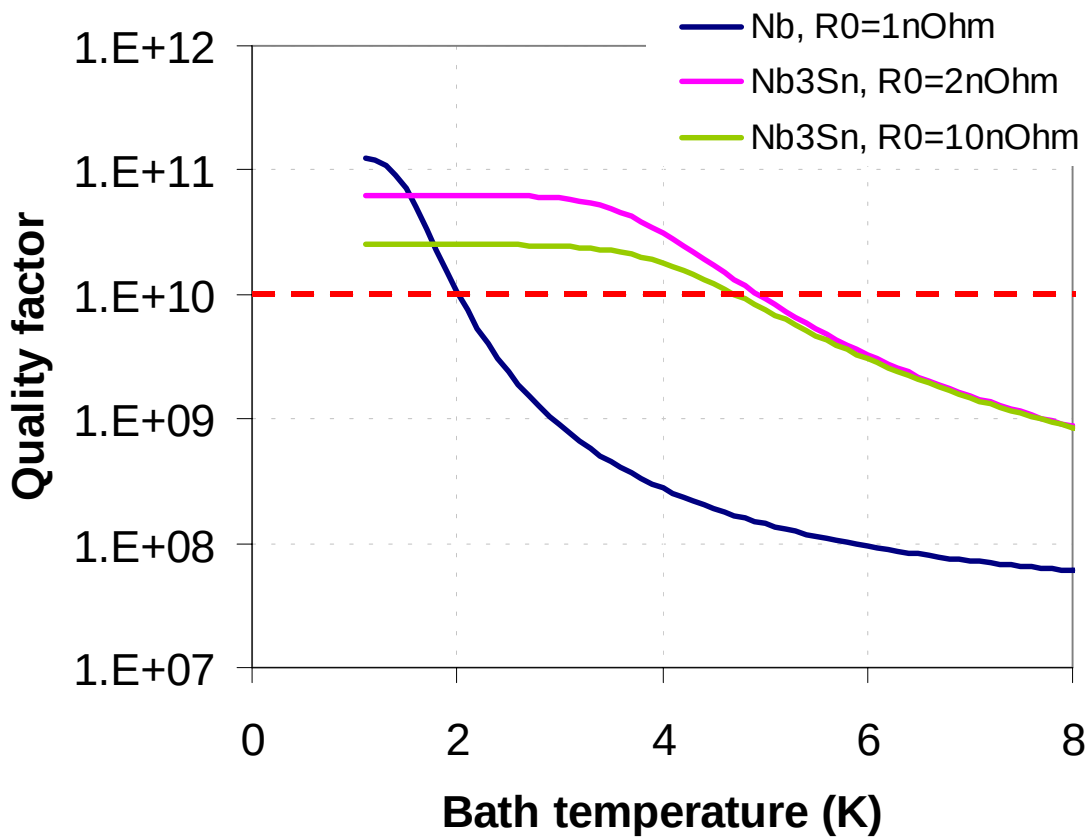
component	sub-component	Cost/m (k$)	comment
Naked cavity		*50*	
	material	*16.5*	RRR=300 grade at 400 $/kg
	e-beam welding	*16.5*	strong reduction expected in mass production
	Machining cups	*12*	cost of deep drawing is negligible
	HOM damper	*5*	
Input Coupler		*30*	each cavity is powered by its own coupler
Tuner		*5*	
Magn. Shield		*5*	
Cryo Vessel		*5*	
Miscellaneous		*5*	i.e. assembly man-power, cryostat welding
Sum		**100**	

A factor 2 cost-decrease is projected for TESLA, that is 21000 x 50 k$ > 1 billion $.

According to our analysis higher gradient is not necessarily beneficial for a linear collider. It is very likely that the cost of cavities increases with gradient. In an optimistic scenario the cost rises linearly. Even in this case the cost for the cavities in a 500 GeV LC (and the cryo-power operations cost over ten years) does not drop at higher gradients.



Therefore, the priority for superconducting RF research should be reducing manufacturing and operations cost. As shown before, the cost drivers are the input couplers, the cavity assembly (welding) and the material. Operations cost can be reduced by decreasing the surface resistance (increasing Q).



We therefore believe that the most useful research is to be conducted in the field of

1) cavity manufacturing ("seam-less" techniques such as hydro-forming,...)

2) materials – e.g. replacing bulk Nb with Nb on Cu

3) surface resistance – e.g. understanding the surface chemistry that leads to low surface resistance, exploring materials which produce lower surface resistance,..etc

4) Higher gradients in view of a second stage in the same tunnel – e.g. pushing Nb to the absolute limit, exploring other materials such as Nb3Sn and NbN;

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A. Gurevich

The UW EOI addresses the following issues:

a) RF theory

b) Surface physics and chemistry

c) Metallurgical – mechanical problems

d) Materials science, treatments

e) Film technology

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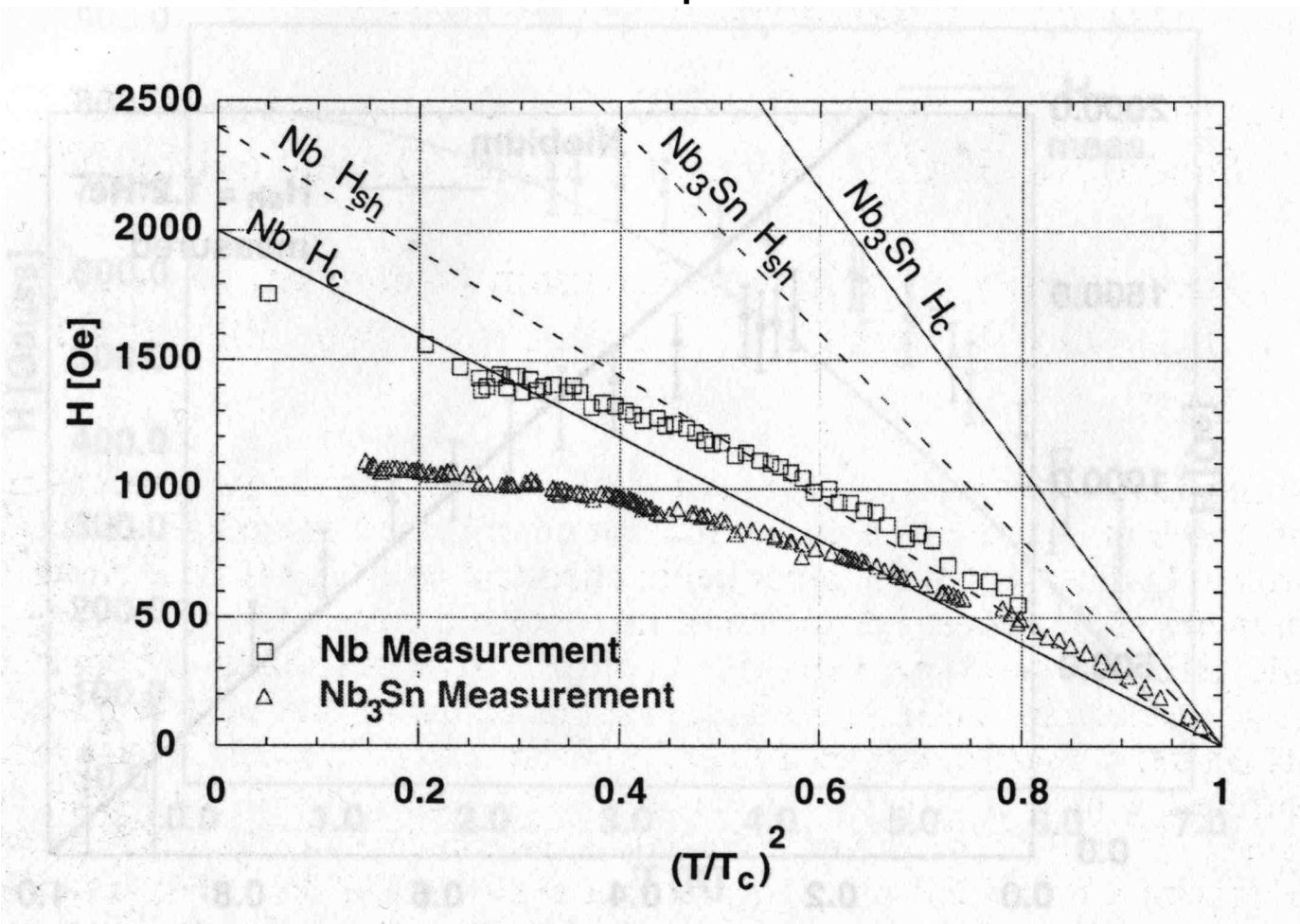
RF Theory: Using time-dependent GL theory the physics of RF critical fields ("superheating field") and the RF surface resistance will be explored.



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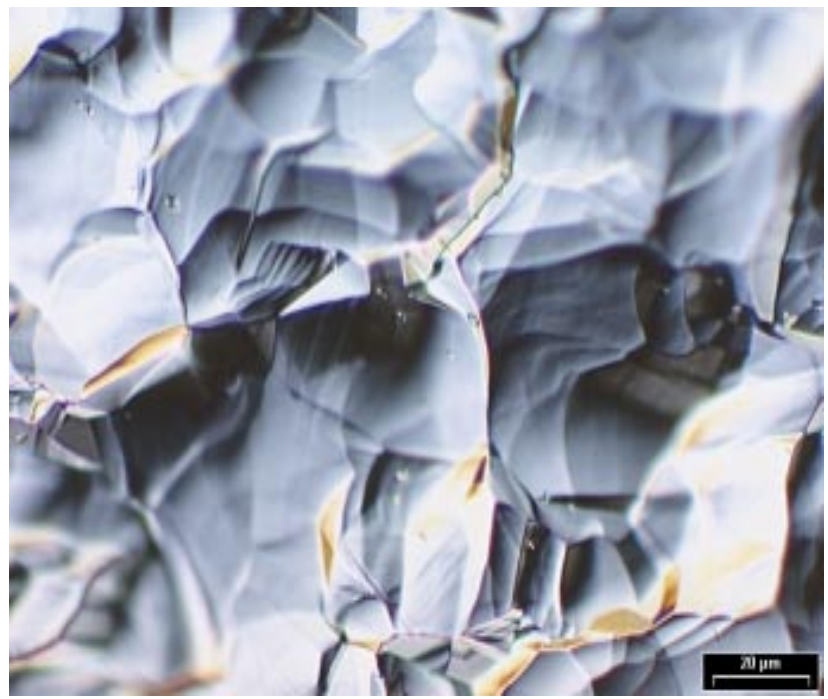
Surface Physics and Chemistry: The UW has extensive expertise and infrastructure in sc surface analysis. A systematic study of the issues related to the presence of O, H and other elements at or near the surface as well as the role of sub-oxides and the role of grain boundaries could be investigated.

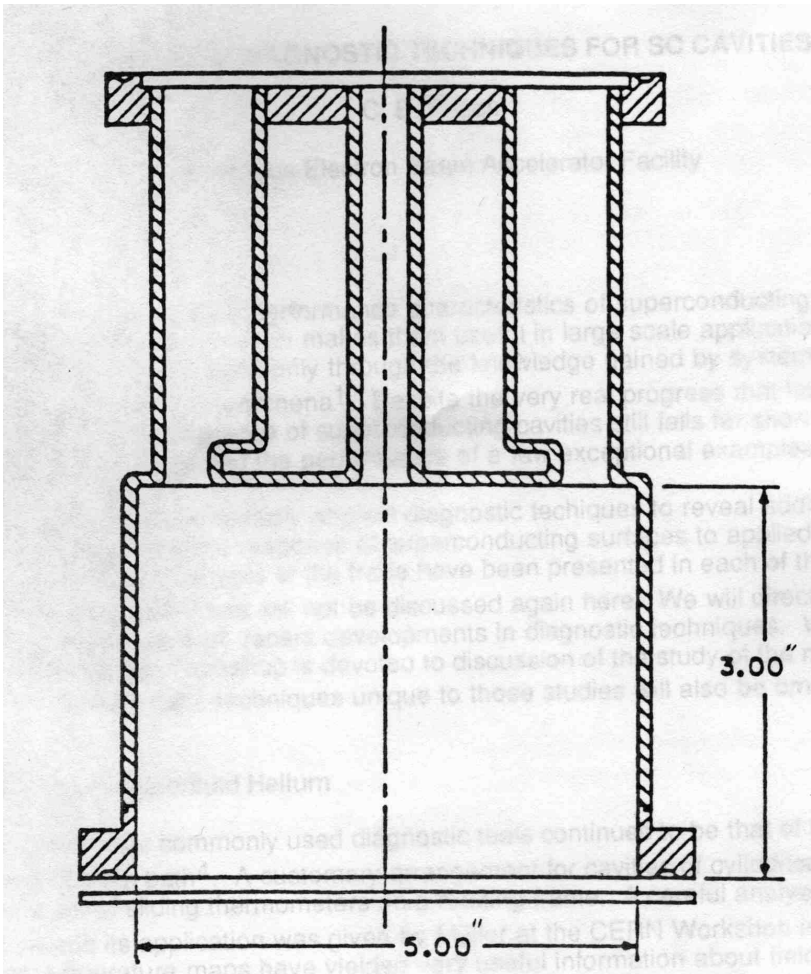
The effect of electro-polishing as well as the effect of other ingredients of successful cavity manufacturing recipes should be analyzed. UW's expertise in thin films is another asset in this context.

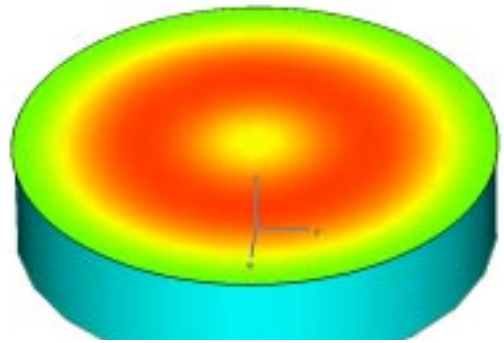


Small Sample Test Facility

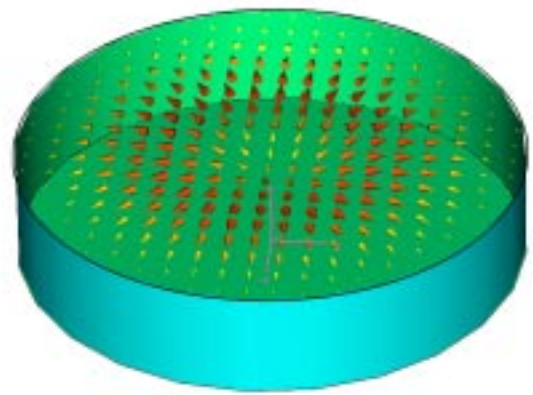
According to some preliminary discussions, Fermilab is attempting to design an experimental facility that allows measurements of the surface quench fields and/or surface resistance of small samples at high power. The small sample approach is ideally suited for systematic surface condition studies. The rich history of similar experimental approaches has been explored and no satisfactory solution was found. Among the solutions pursued in the past are: regular cavities with samples placed inside, TE011 cavities with removable end-plates, quadrupole cavities, tri-axial cavities, quarter wave resonators,….

Experimental Facilities – example cylindrical TE011 cavity



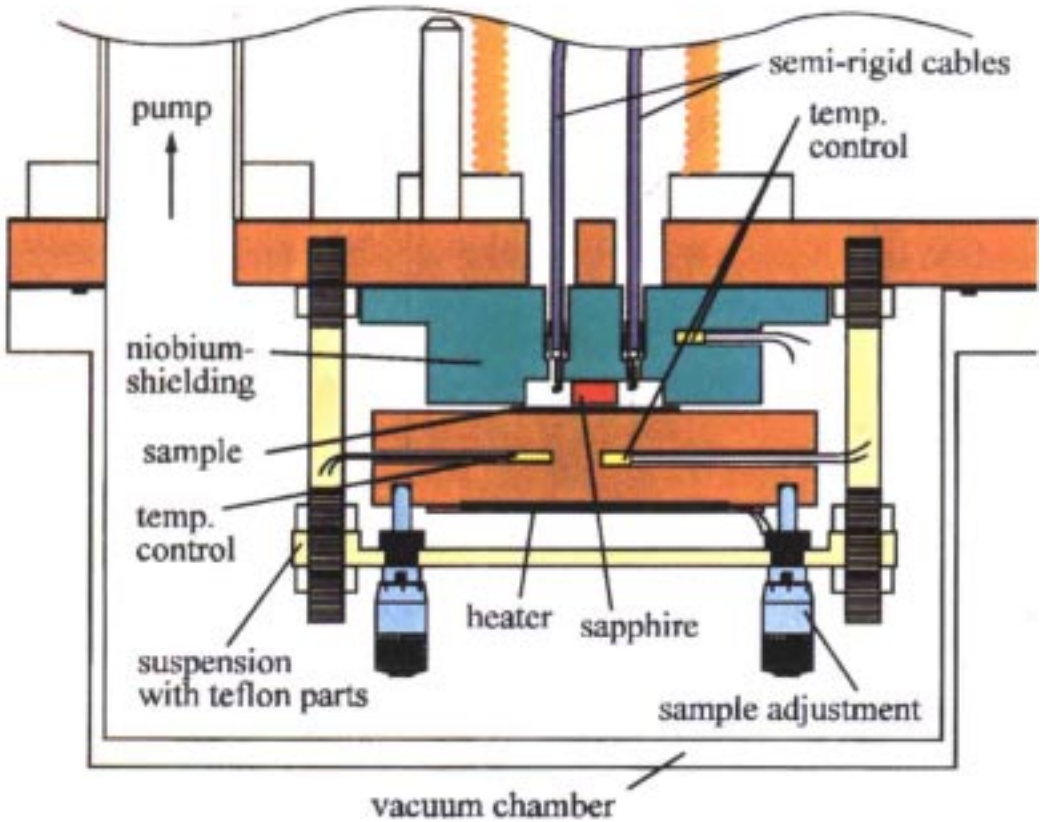


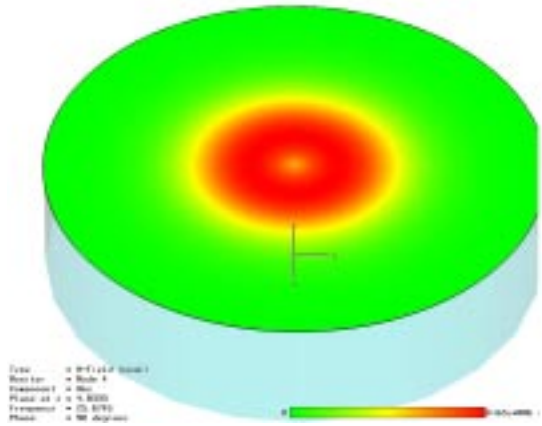
$H_{azimuthal}$



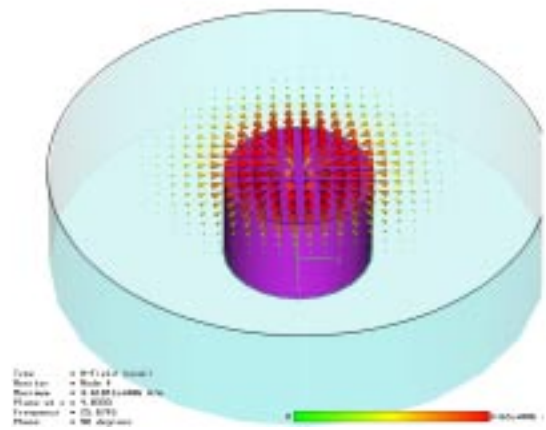
H

Alternate solution: Low Power Testing





H_{radial}



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Show result of Rs measurement!