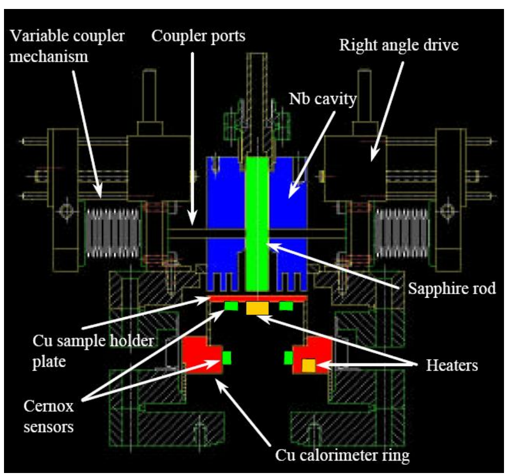
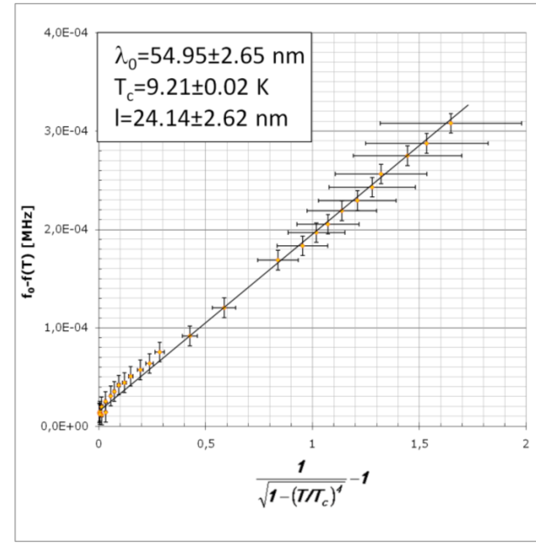
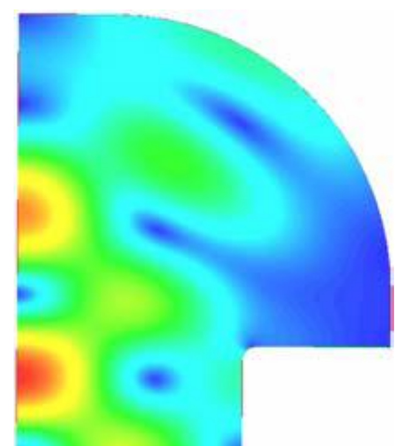
RF Characterization of Superconducting Samples







Tobias Junginger

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14th International Conference on RF Superconductivity, Berlin 20-25 Sept 09

RF Characterization of Superconducting Samples

" It is not yet clear what surface properties are the most important for achieving high Q–values and high peak RF fields. The answer to this question will be provided by a careful correlation between microwave cavity measurements and surface studies on small samples processed at the same time."

A. Septier – 1st Workshop on RF superconductivity

This talk:

- Focus on microwave cavity measurements
- Present TE cavities and 4 modified devices
- and 1st results on Quadrupole Resonator

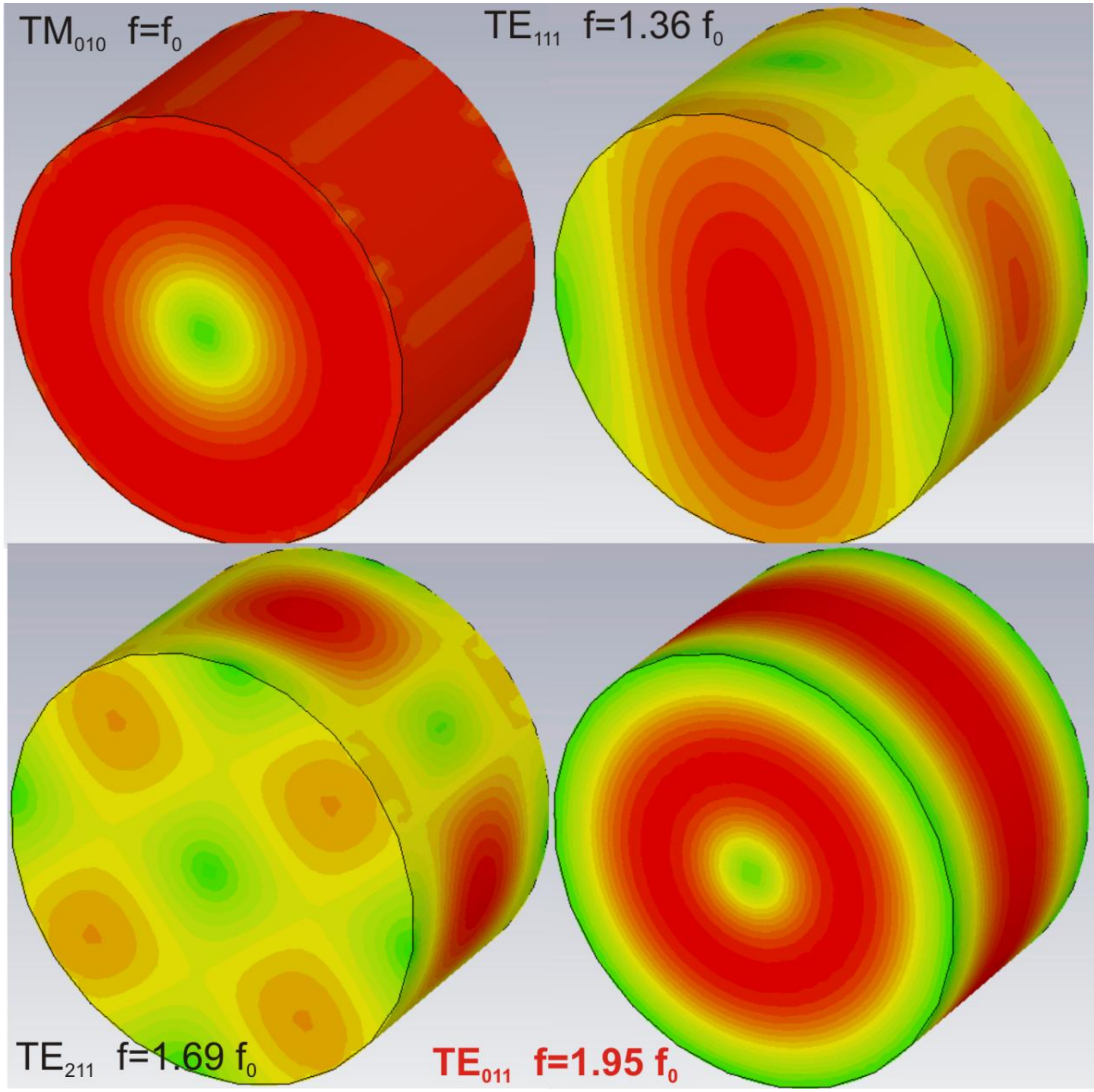
- R_S can be determined by measuring Q_0

$$Q_0 = G/R_S$$

  - R_S may vary strongly over the cavity surface

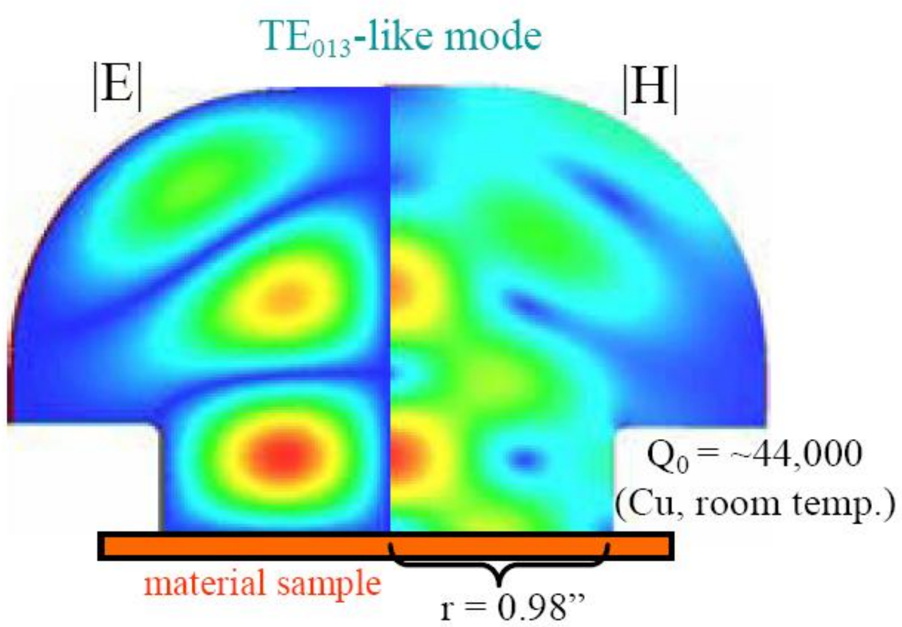
- More convenient: Investigation of small samples

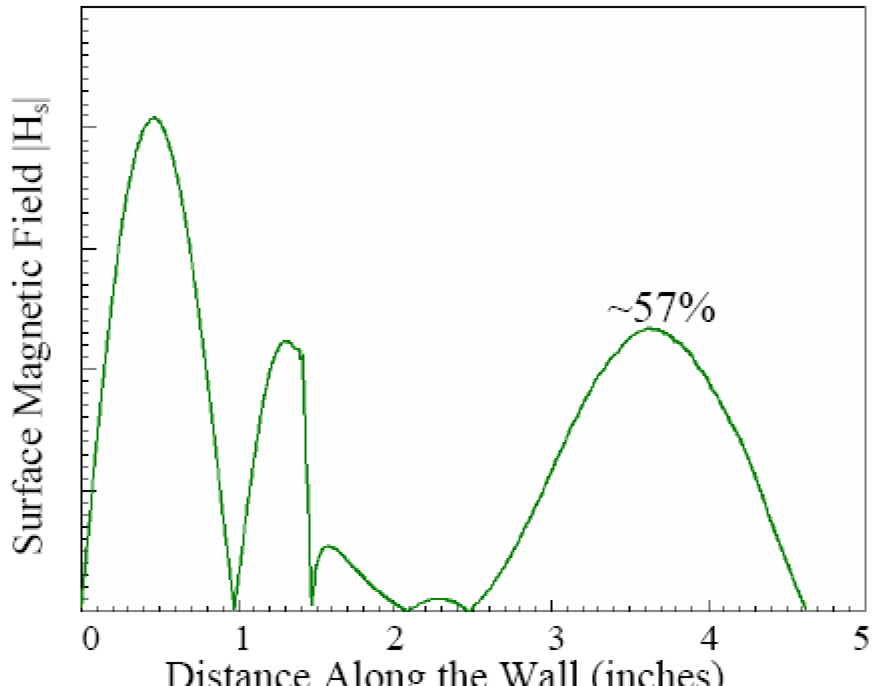
- One way TE cavity with demountable endplate
  - Large size concerning frequencies of interest for accelerator applications
  - Same field value on both endplates



A. Canabal et al.

- Mushroom form and TE_{013}-like mode yield higher fields on the sample than anywhere else the surface
- X-band frequency
- Small sample sizes (ø≈75 mm)





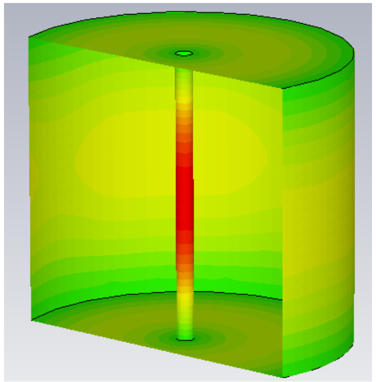
Coaxial Cavity at JLAB

G. Ciovati et al.

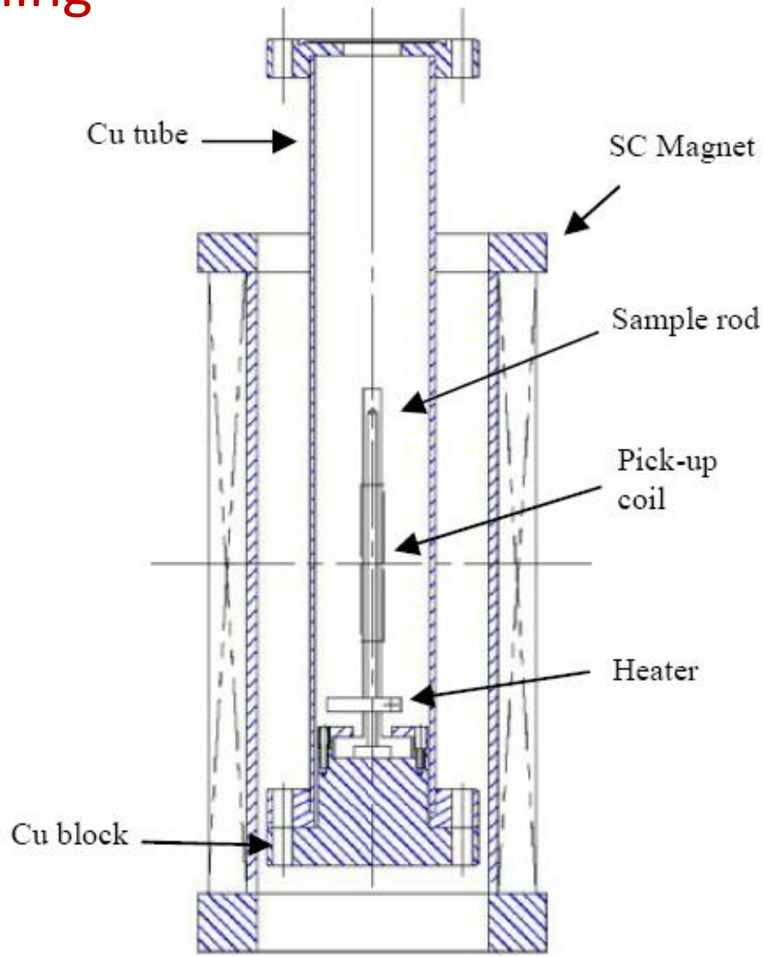
- Highest fields on cylindrical sample forming a coaxial structure with the cavity
- Samples can be attached to a system to measure further properties

Coaxial Cavity

Sample

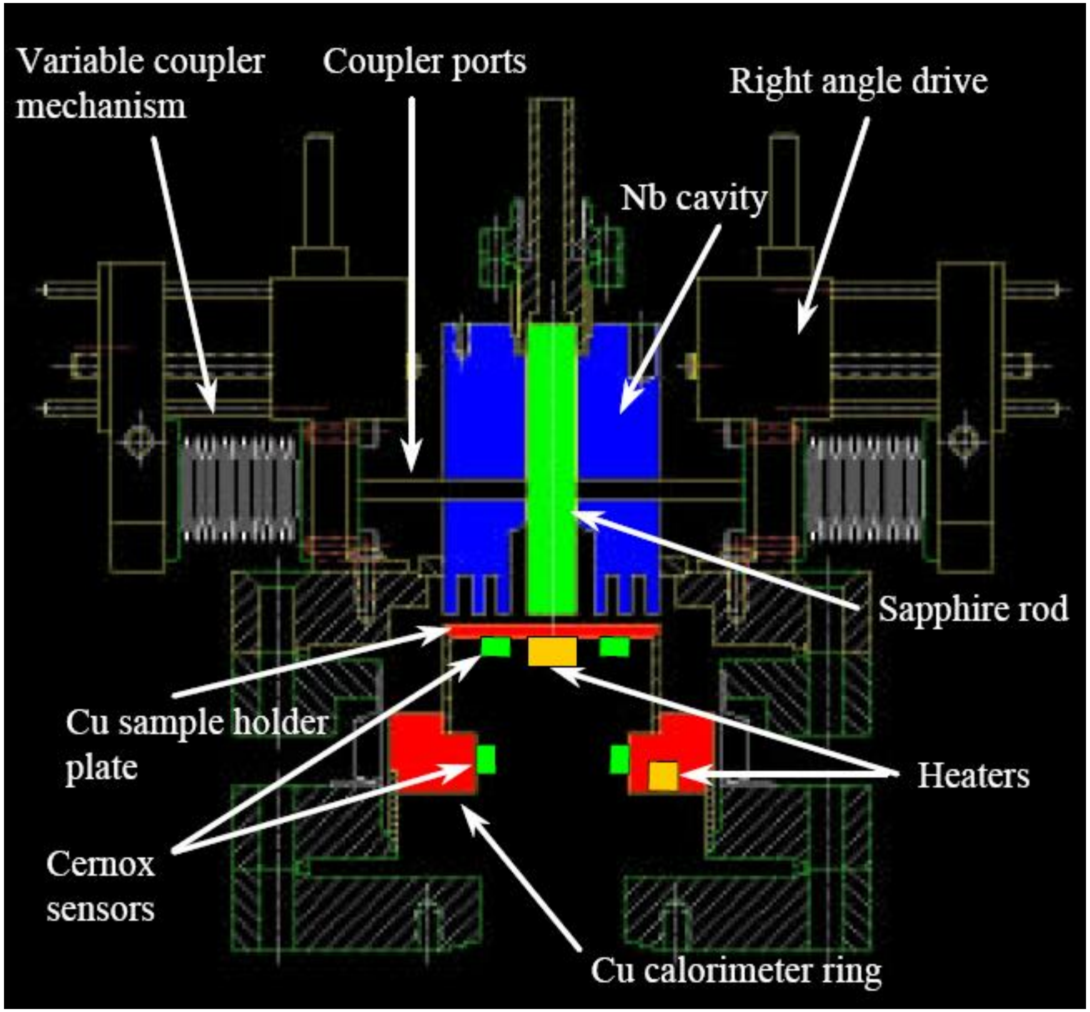


Field plot



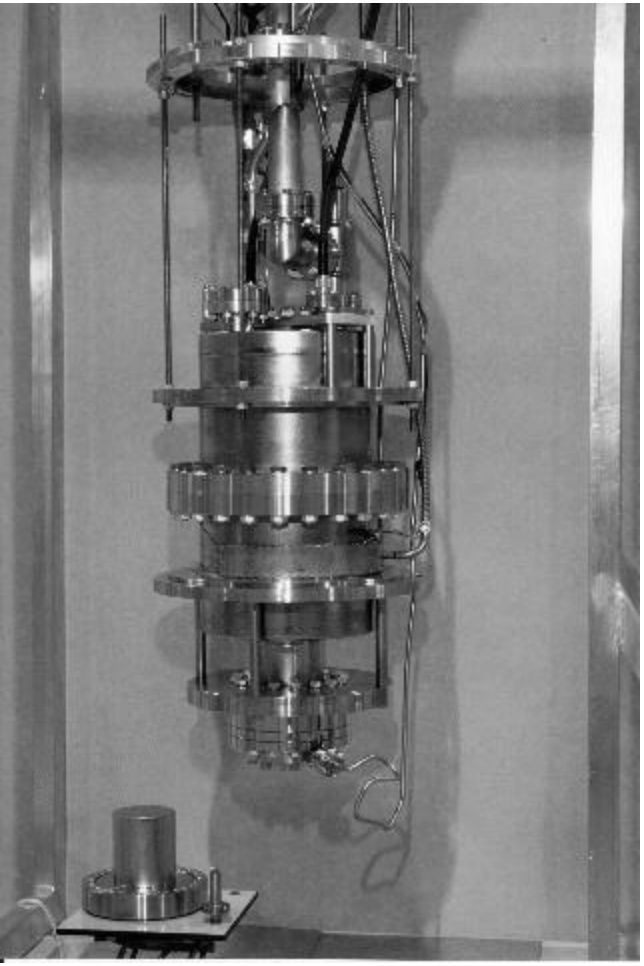
DC System

B. Xiao et al.

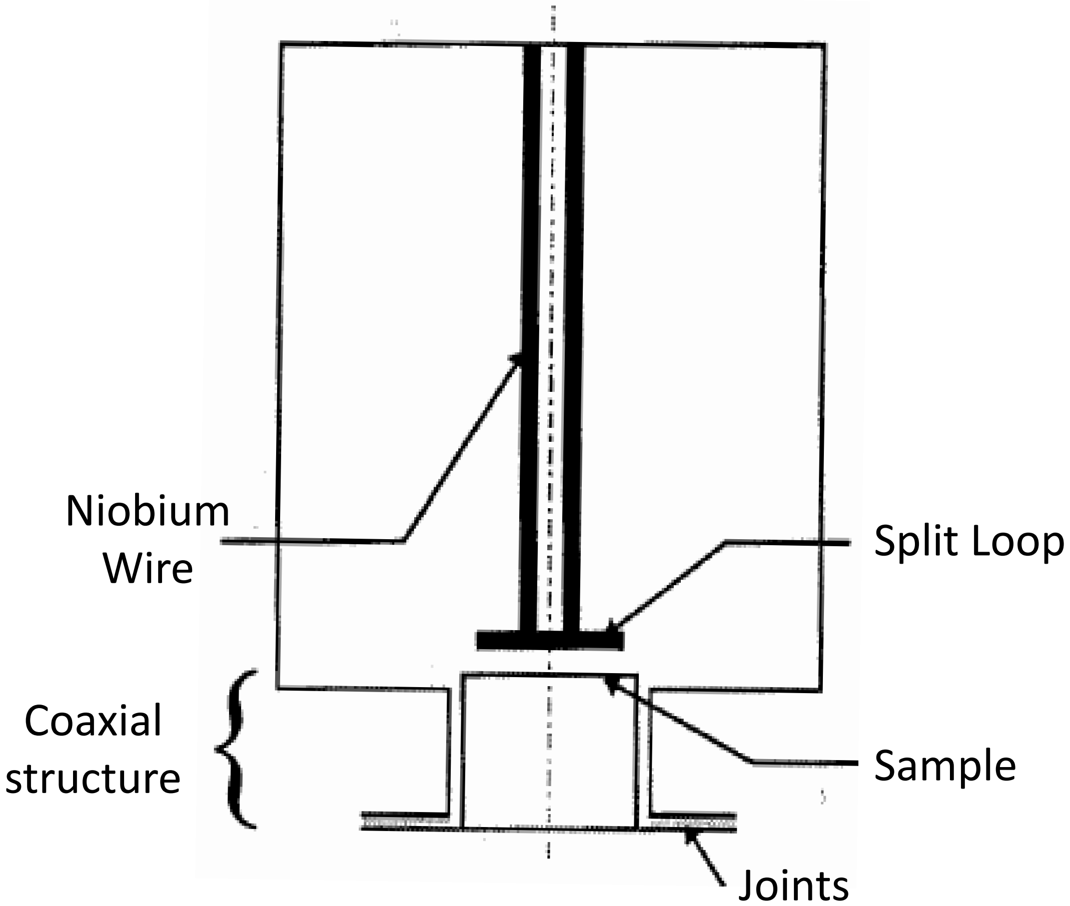


- Sapphire rod attached inside the cavity lowers resonance frequency
- Sample thermally decoupled from the cavity
- The calorimetric measurement technique is sensitive to the sample surface only while being insensitive to other cavity losses.

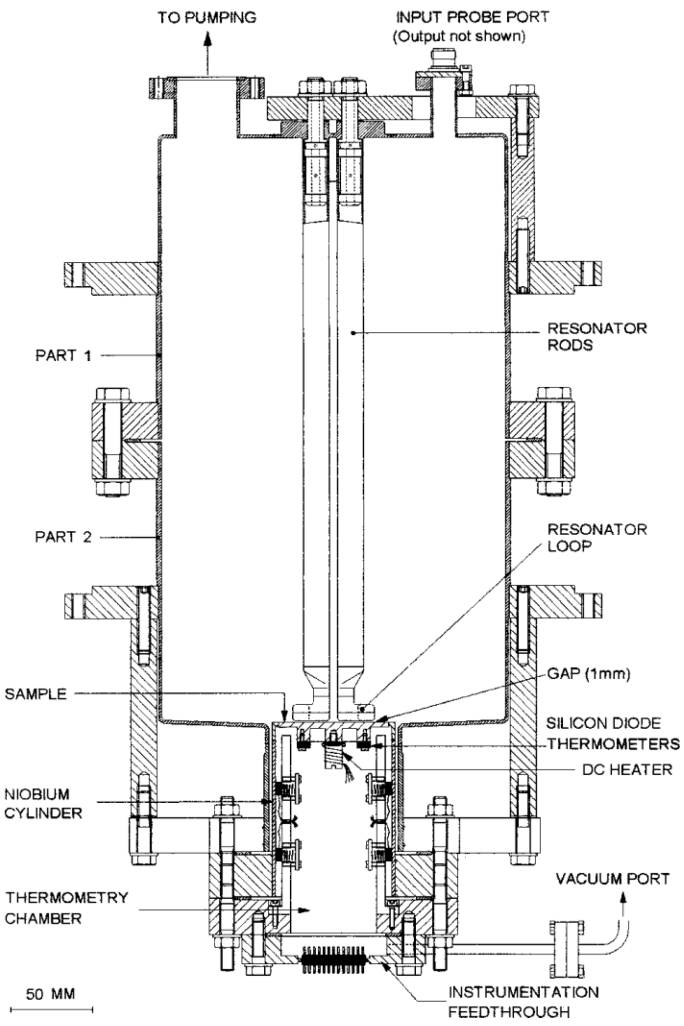
E. Mahner et al.



- Resonator excited in a TE_{21} like mode
- Samples attached in a coaxial structure
- Calorimetric measurements
- Resonant frequency 400 MHz (LHC)



E. Mahner et al.



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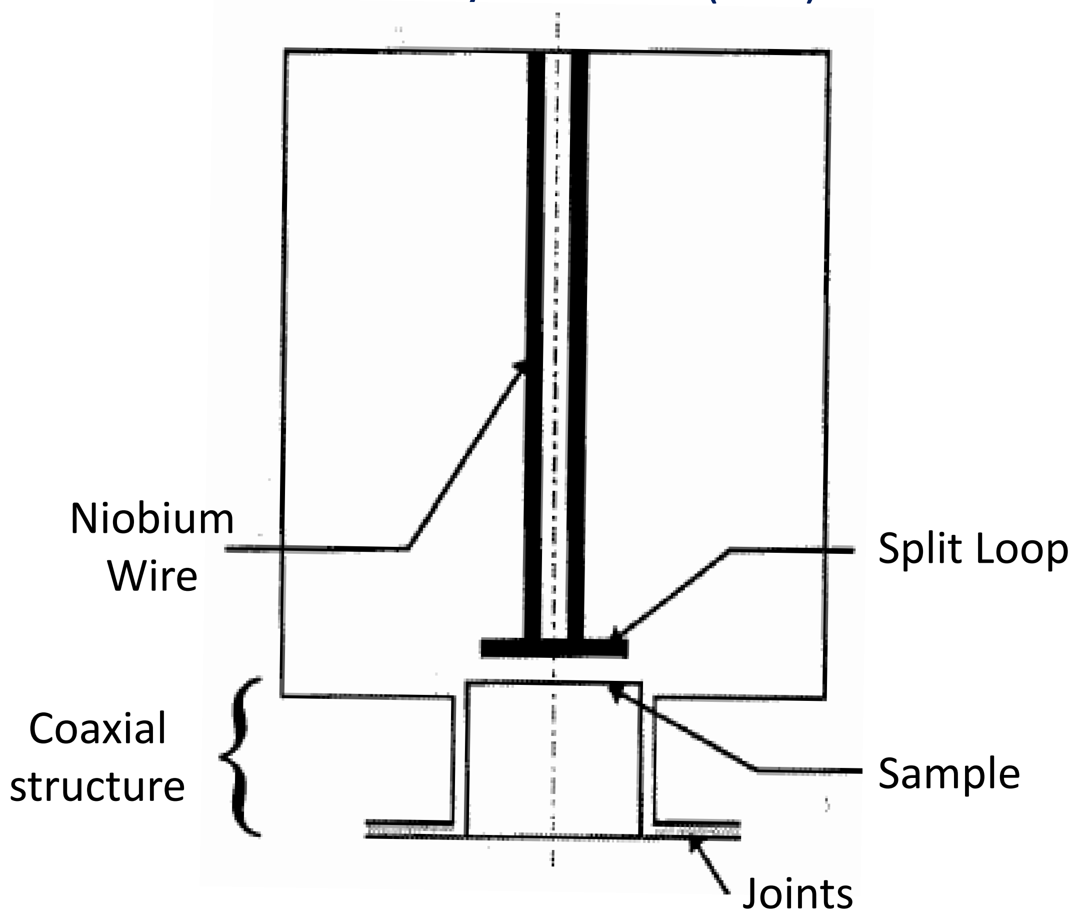
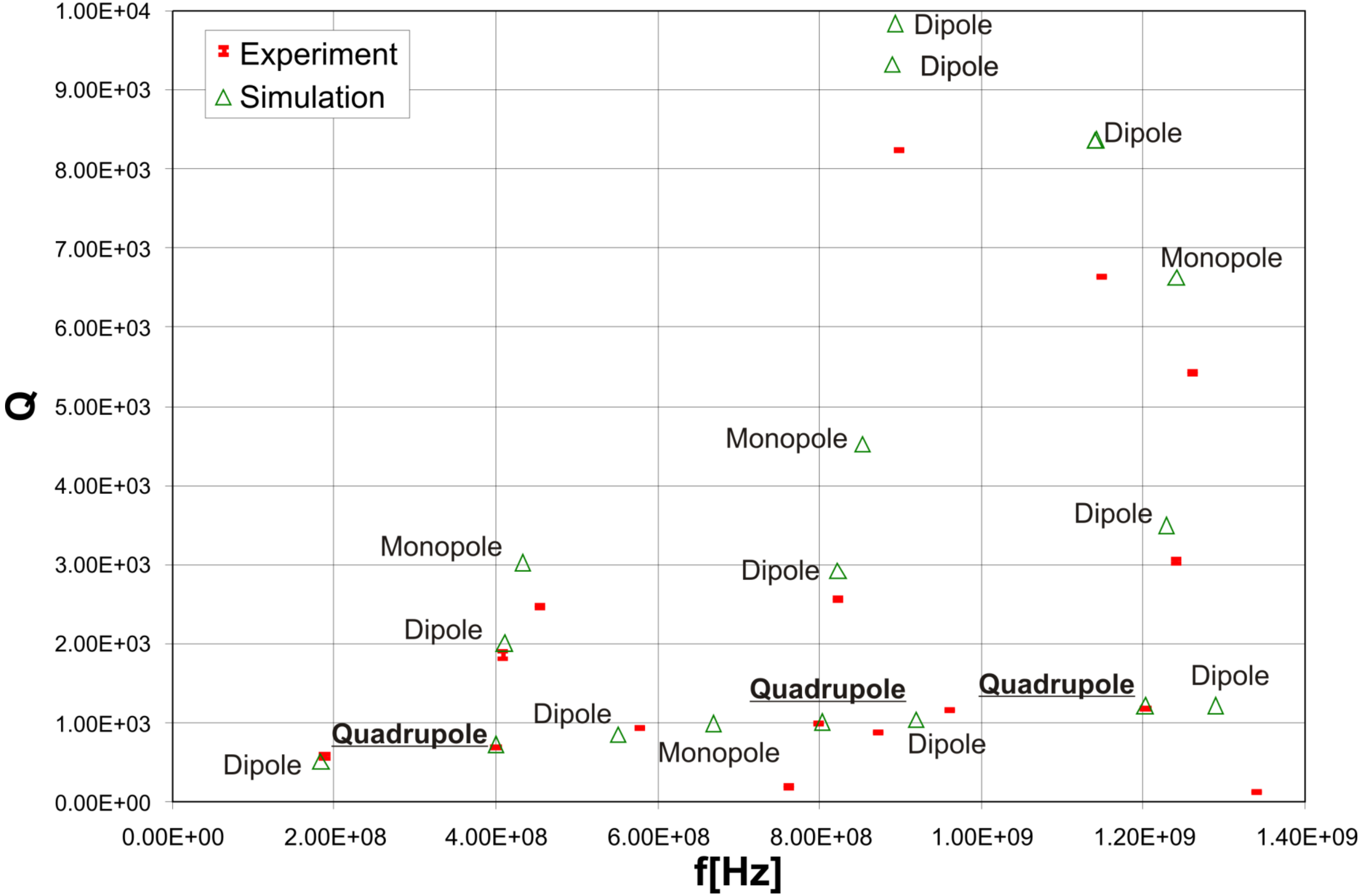
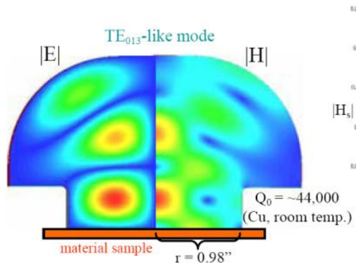


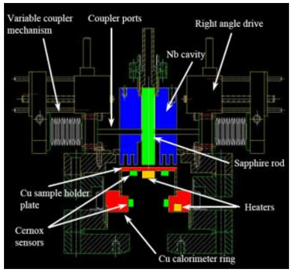
Collaboration with W. Weingarten

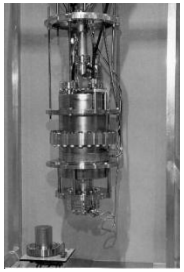
Q value of resonant modes at RT



Comparison of the Different Devices



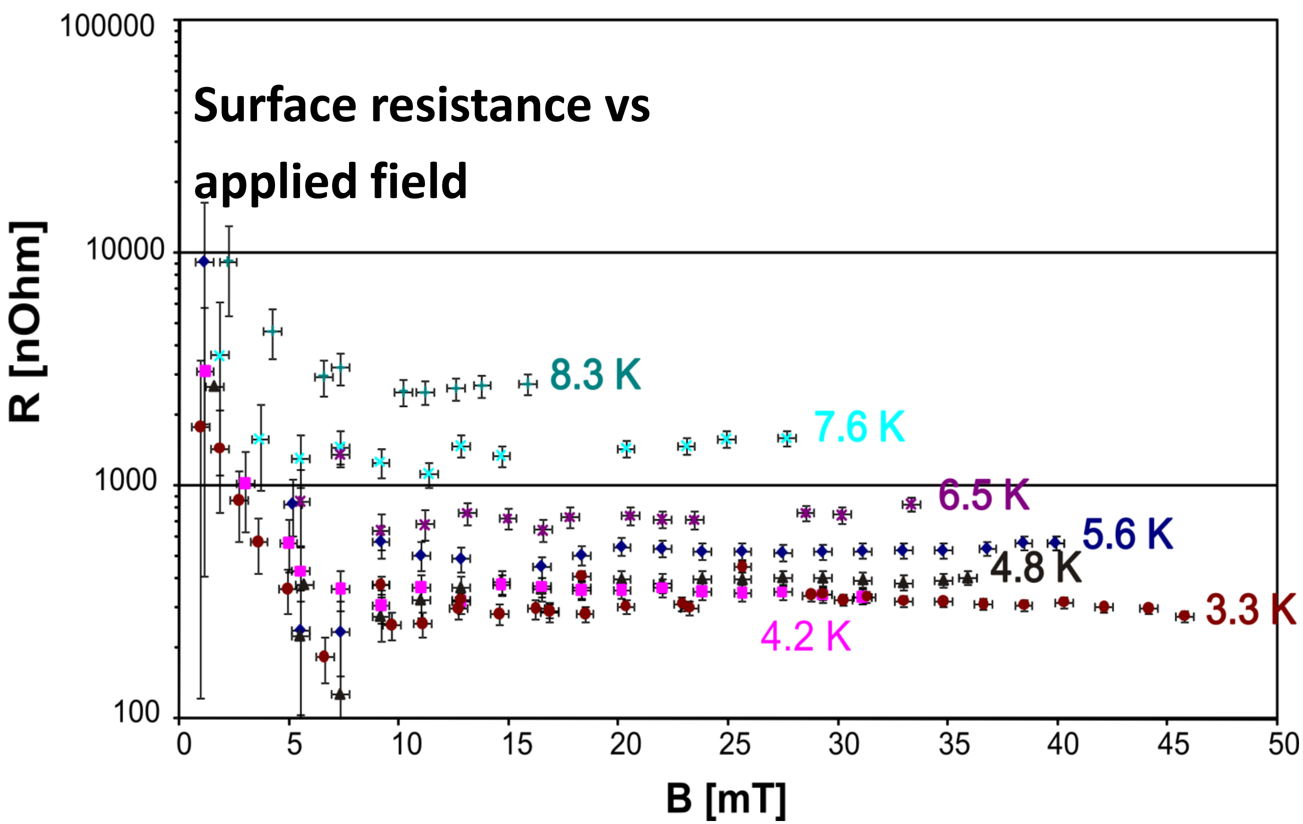




	Mushroom	Coaxial	Sapphire loaded	Quadrupole
$\frac{H_{max,sample}}{H_{max,cavity}}$	1.75	2.38	1	1.2
f [GHz]	11.43	3.544	7.5	0.4
R [mm]	41.3 / 25	57.4	25	105
Sample size A [cm^2]	44	22	19.6	44
Calorimetric system	No	No	Yes	Yes

Collaboration with W. Weingarten

- Reactor grade bulk niobium sample
- Chemically etched
- 400 MHz



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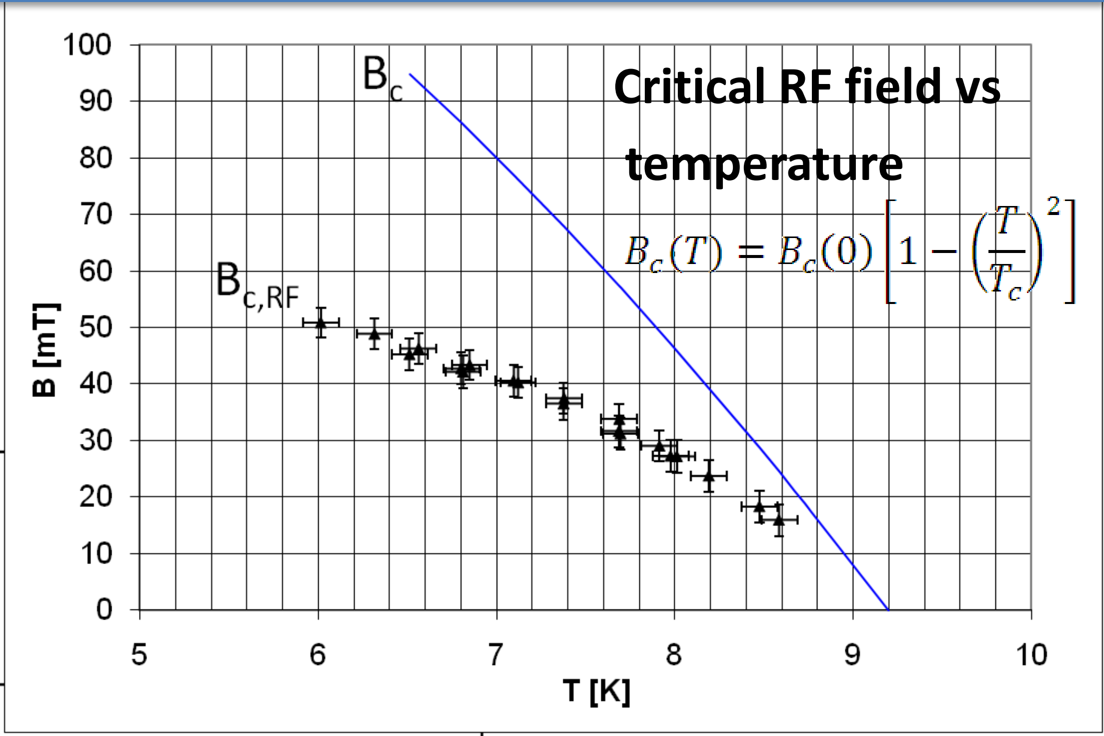
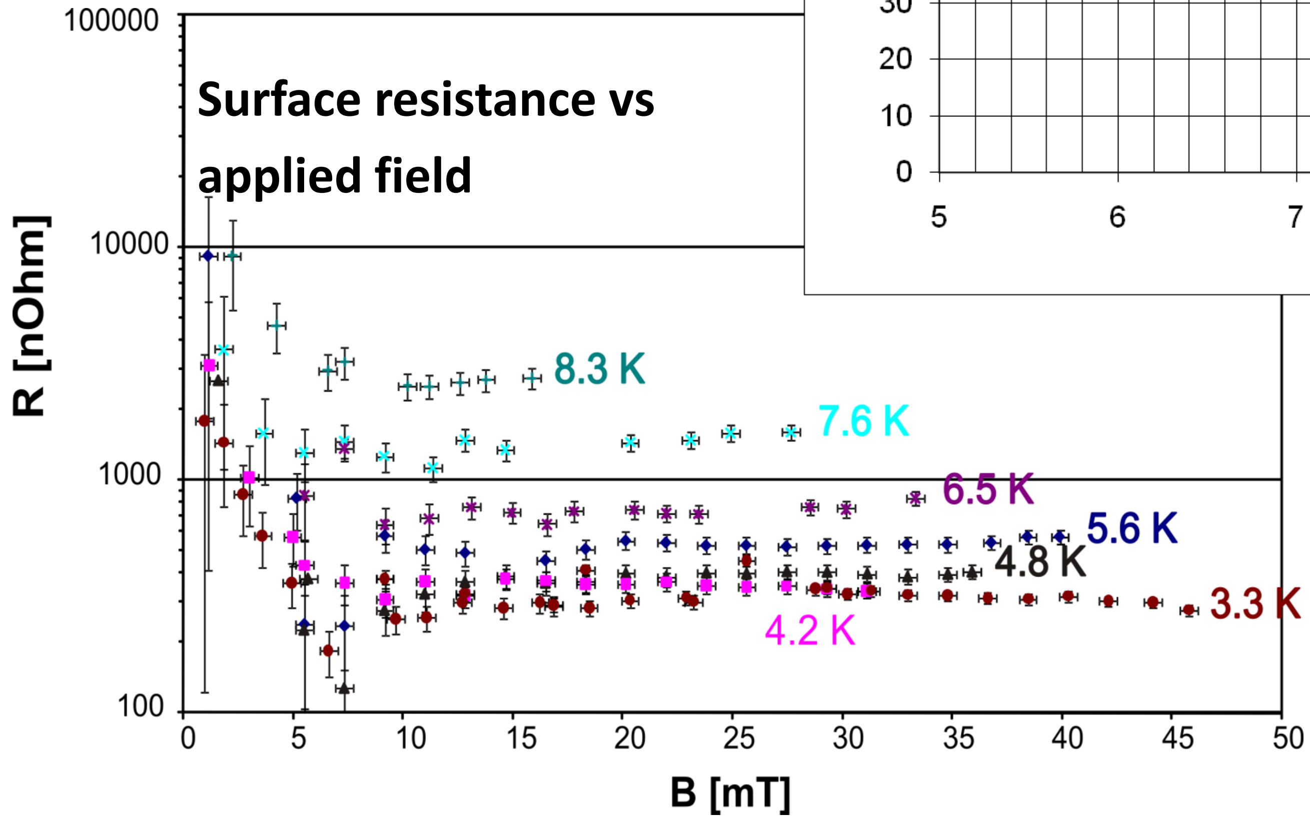
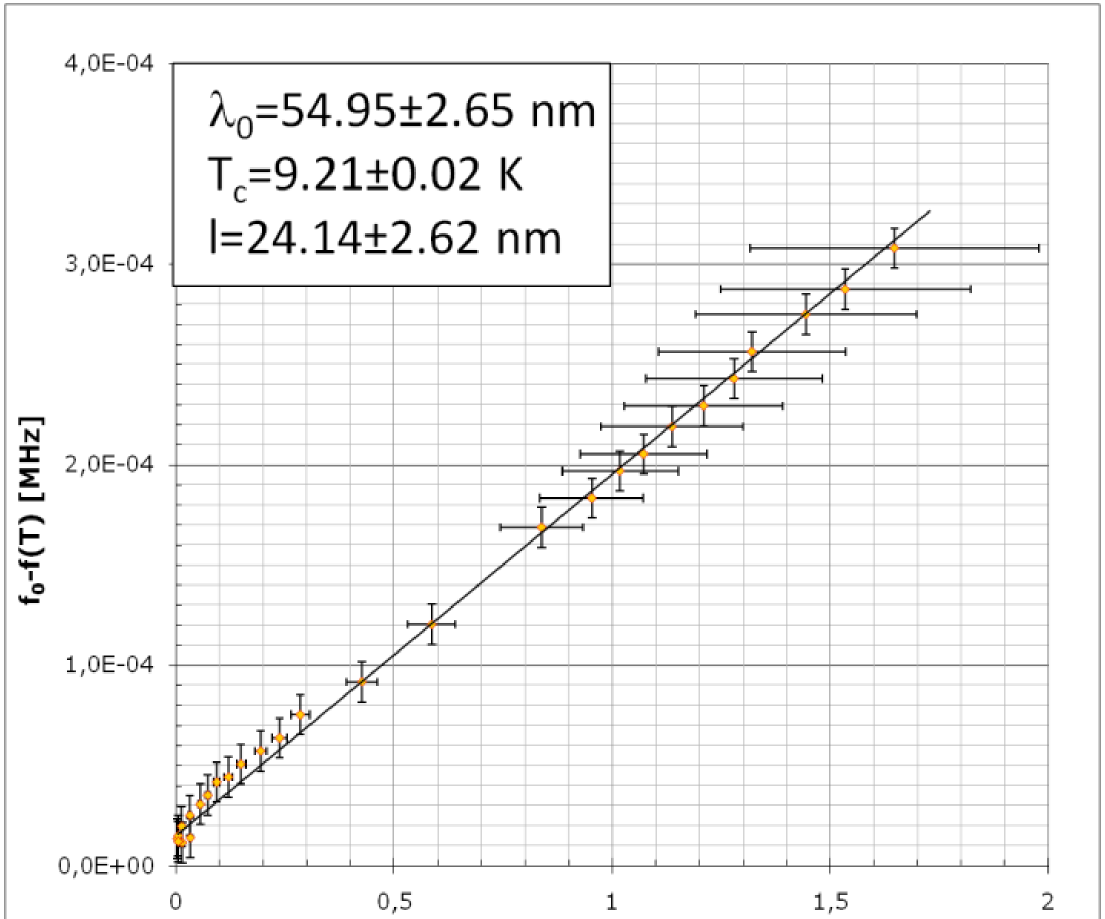




Collaboration with W. Weingarten
Special thanks to G. Ciovati

Penetration depth as a function of temperature



$$\frac{1}{\sqrt{1-(T/T_c)^4}}-1$$

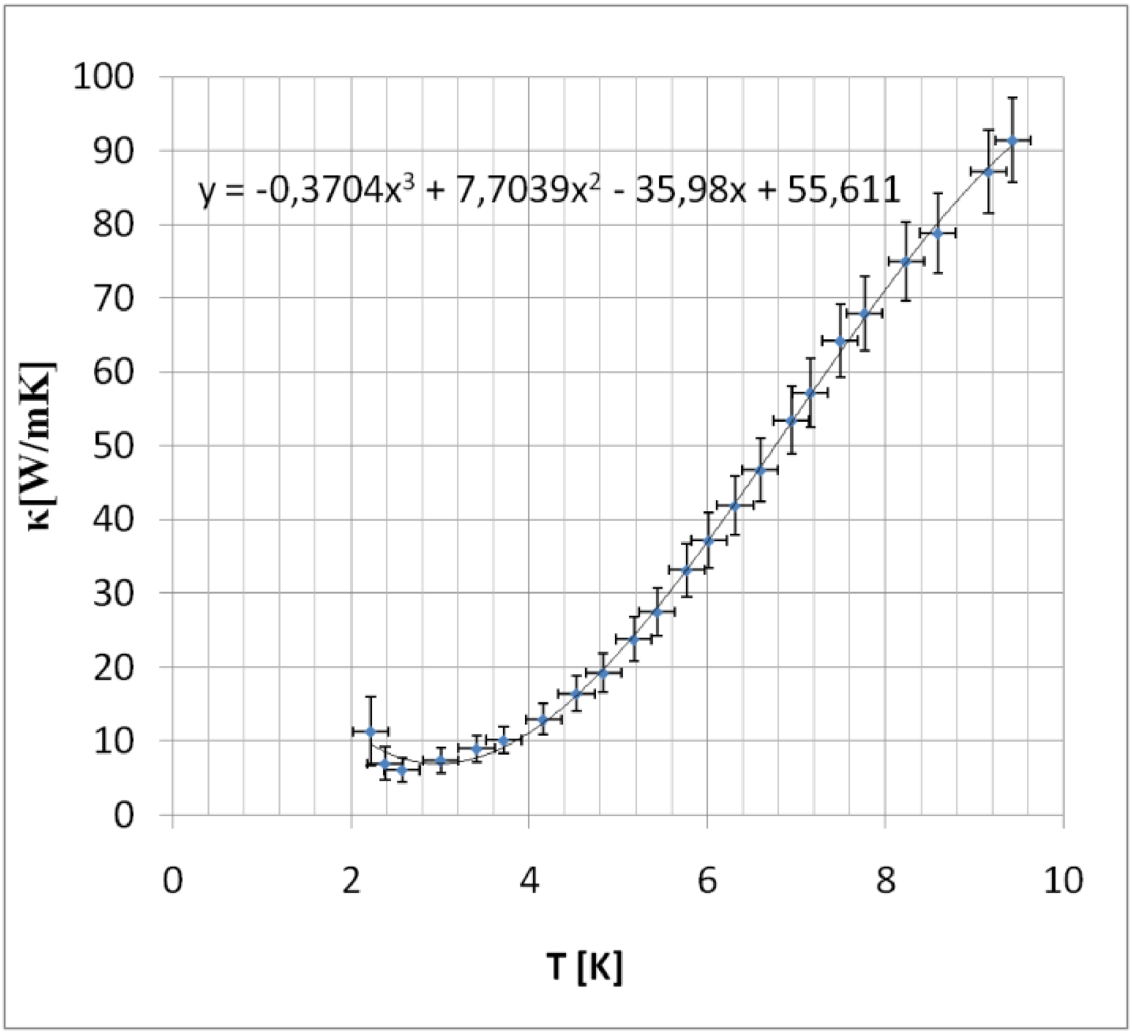
$$\Delta\lambda = -\frac{G}{\pi f^2 \mu_0}\Delta f$$

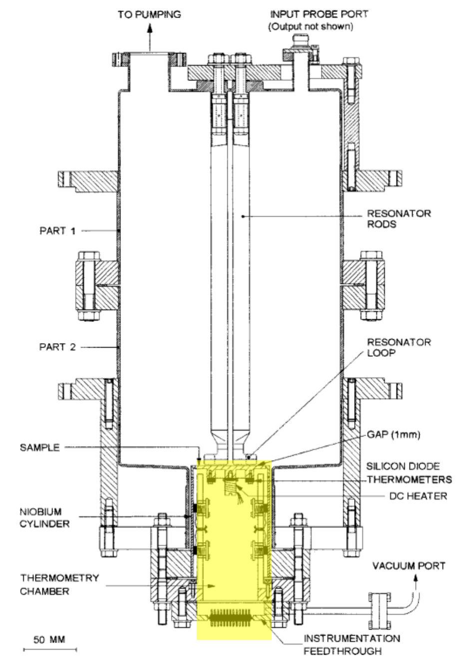
Fit using two fluid model

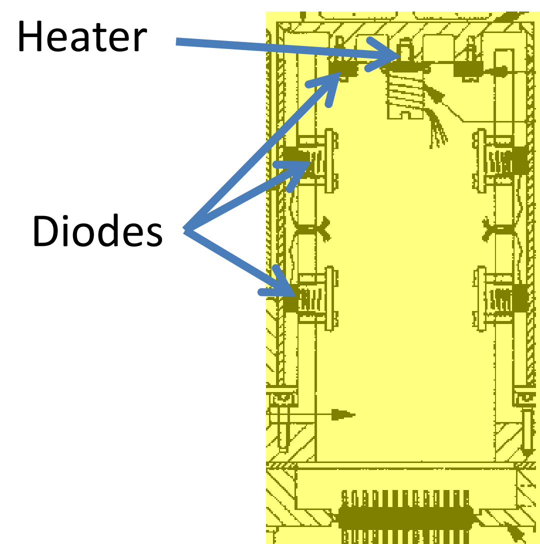
$$\Delta\lambda = \lambda_L \sqrt{1+\frac{\xi}{l}} \cdot \frac{1}{\sqrt{1-\left(\frac{T}{T_c}\right)^4}} - \lambda(T_0)$$

Collaboration with W. Weingarten

Thermal conductivity as a function of temperature

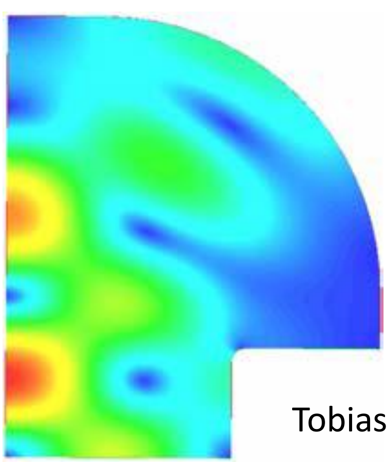






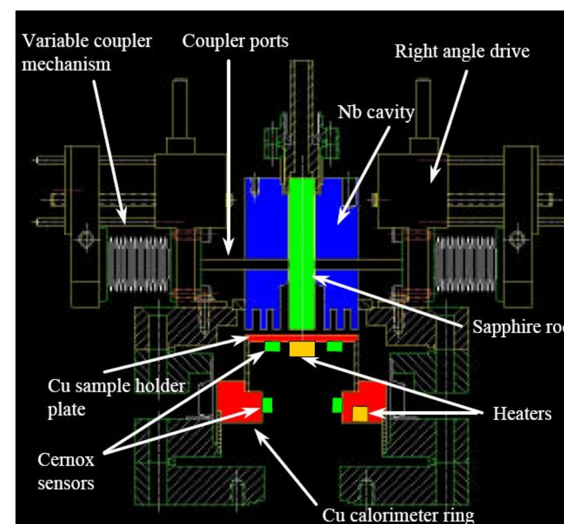
- A convenient way to examine RF properties of superconducting materials is the investigation of small samples
- Impractical large size and inconvenient field configuration of TE_{011} cavities with demountable endplate lead to the development of several new devices for RF characterization of superconducting samples
- Quadrupole resonator is refurbished and enables to measure
    - Surface resistance
    - Critical RF field
    - Penetration depth
    - Thermal conductivity
    - at 400, 800 and 1200 MHz

RF Characterization of Superconducting Samples



- A variety of systems have been developed during the past 20 years.
- Each has its unique capabilities.
- None has yet become a “workhorse” for systematic sample characterization.

C. Reece



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