DEVELOPMENT OF A TE011 CAVITY FOR THIN-FILMS STUDY

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Bulk niobium cavities have almost reached their maximum performances. Maximum accelerating gradient field is above 35-40 MV/m for a multi-cells cavity at 1.8 Kelvin and it is reasonable to achieve 25-30 MV/m with high reliability. The question of increasing the accelerating gradient in a significant way is running regarding the huge amount of units required for new projects (16000 units for ILC). A promising solution is to use thin films of new materials deposited on copper or niobium. In order to investigate the behaviour of these materials for the accelerating cavities, we have developed a dedicated setup based on thermometric method and a TE011 cavity. We present here the design study of the setup and the expected sensitivity of the method for the surface measurement of materials under RF fields.

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Cavity design

Objectives

-Build a cavity working at two frequencies for the BCS characterization

-Test flat samples by keeping simple shape for coating

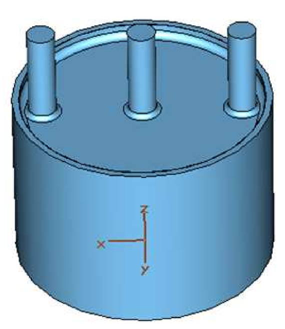
-Characterize macroscopic RF properties of thin-films

- Validate coating process for accelerating cavities

-Design for thermometric method increasing sensitivity and resolution compared to classical RF method

-Design based on TE011 cavity setup (CEA/IPN 1996)

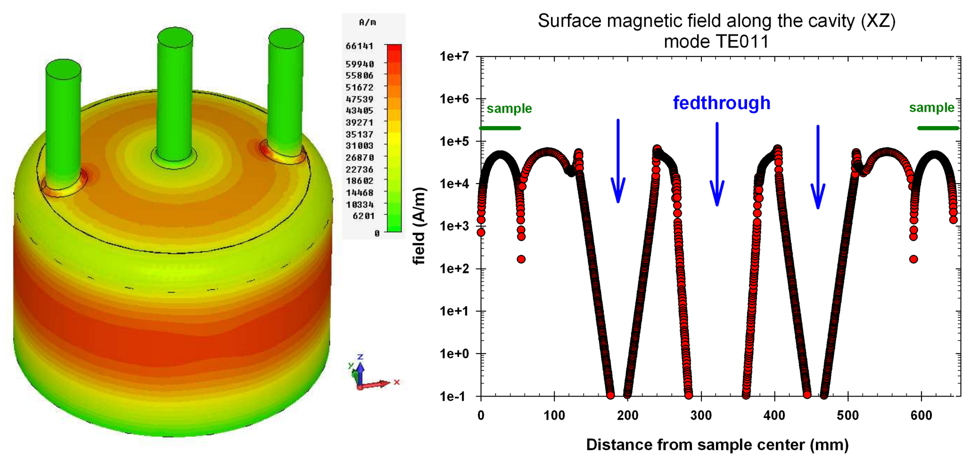
Comparison with the previous design



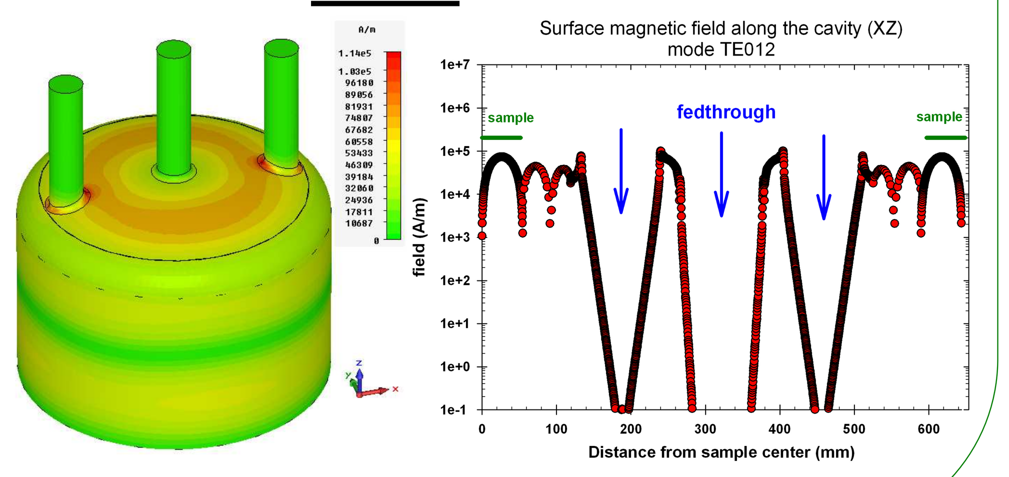
	1996 design	2008 design
Field ratio (TE011)	1.43	1.35
F_{TE011} (GHz)	4.02	3.85
F_{TM111} (GHz)	3.99	3.90
F_{TE012} (GHz)	5.62	5.12
F_{TM112} (GHz)	5.58	5.20
G_{TE011} (Ω)	722	773
G_{TE012} (Ω)	853	939

Surface magnetic fields

TE011

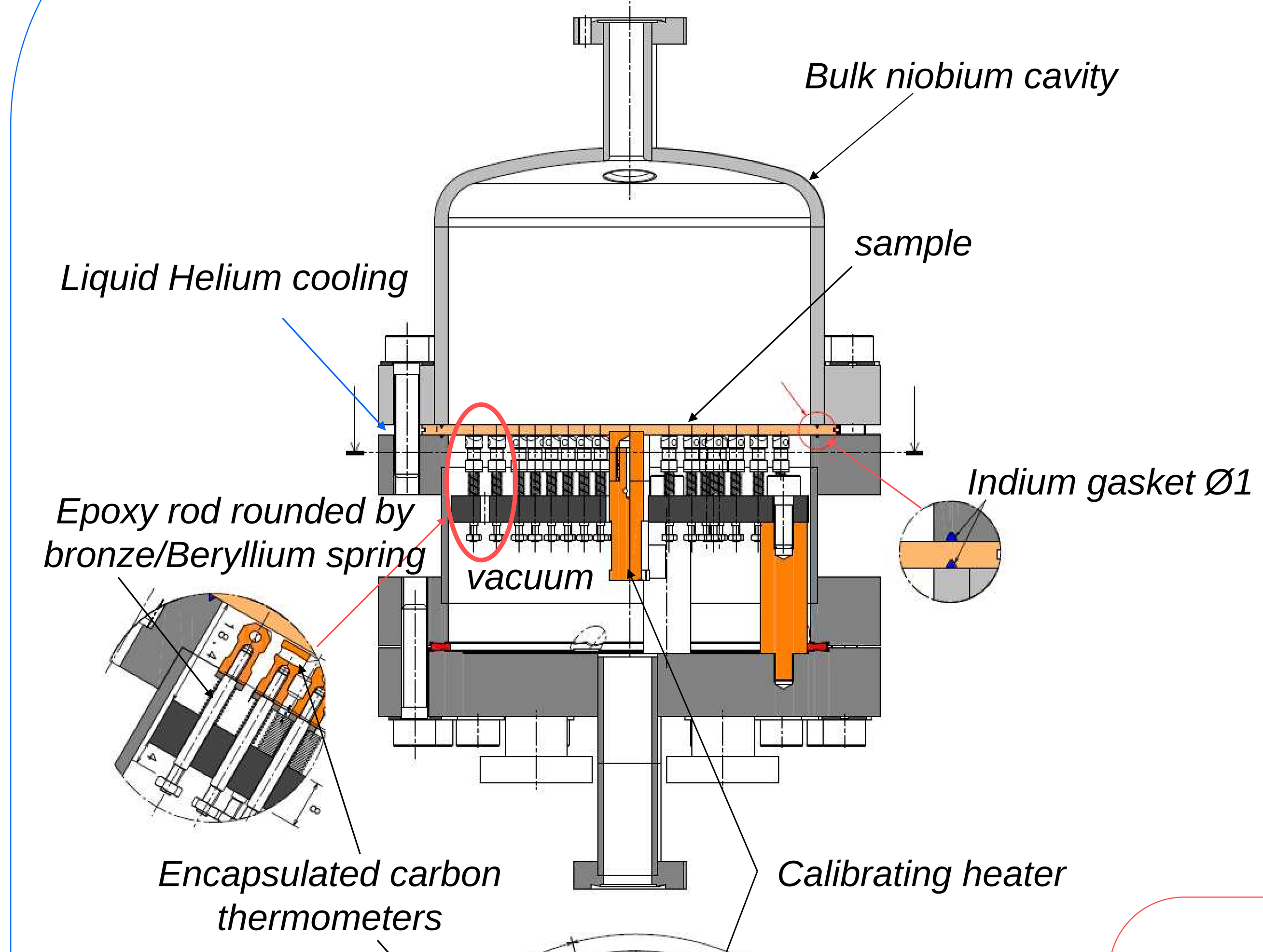


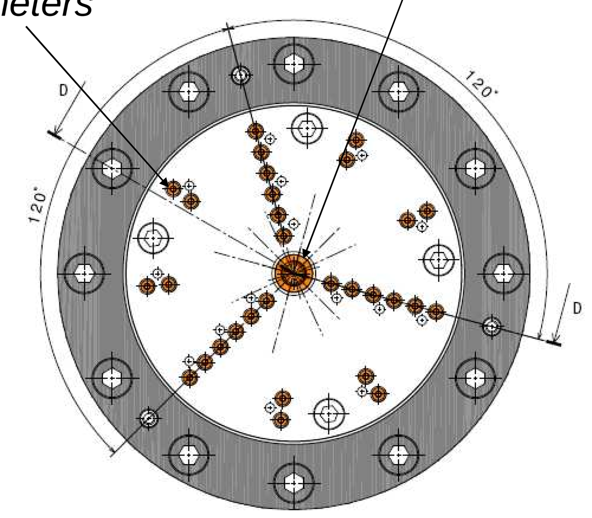
TE012



For high quality samples (R_S<R_S^{Nb}), the higher magnetic field is limited by the cavity body and niobium limitation.

Instrumentation





Back side of the sample

Description

- 28 encapsulated carbon thermometers mounted in stainless steel chamber. Fixation with epoxy rod rounded by bronze/beryllium spring to guarantee thermal contact on the back side of the sample.
- mapping of the surface resistance : 3 arms of 6 sensors for radial mapping at 120 degrees and 2 paired sensors between each one to access precisely to the RF power dissipated.
- Possibility to localize defects (depending on their size and localization)
- Liquid helium cooling all around the disc. Exchange surface increased by a 1 mm gorge.
- Arms support cooled down by 4 copper rods.

Method

- Calibration of dissipated power with resistive heater
- Measurement of residual resistance @1.8K :
  $P_s = \frac{1}{2}\iint_S R_s(H_s,T)H_s^2(S)dS$ with $R_s=R_{res}(H(s))$
- Measurement of $R_{BCS}(T)$ assuming R_{res}
- Repeat each step for both modes

Expected performances and status

Sensitivity and limitation

With a detectable heating of 0.1 mK, the expected sensitivity should correspond to the following tables

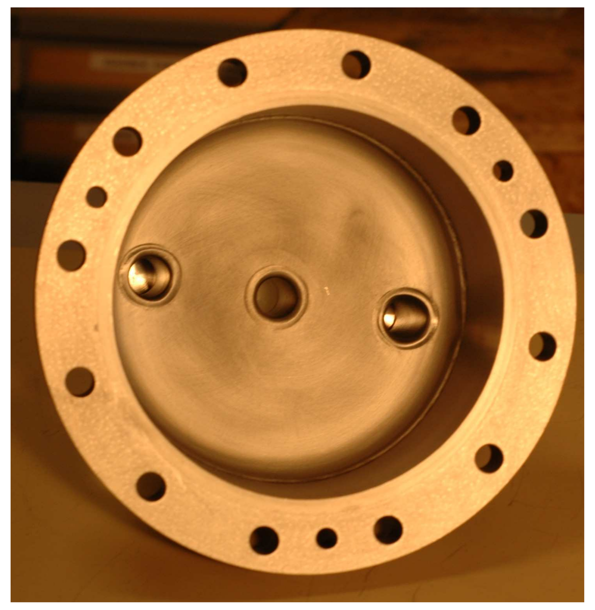
B_s(mT)	Sensitivity (nΩ) @1.8K
5	75
20	45
40	1

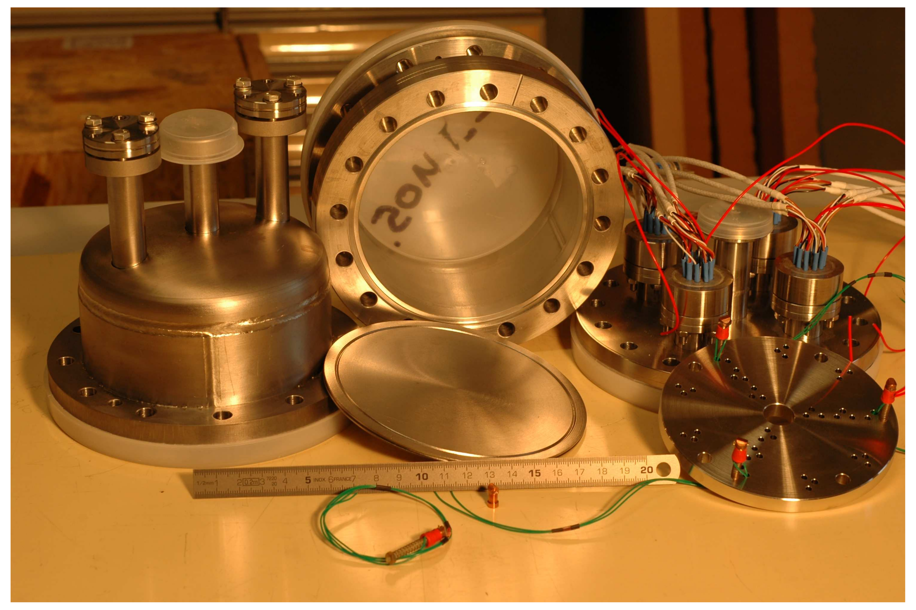
B_s(mT)	Sensitivity (nΩ) @4.2K
5	45
10	10
15	5

Limitation for maximum field reachable :
-For high quality thin films and @T=1.8K the limitation should be the quench of the niobium cavity.
-In other cases, it is depending of RF power dissipated on the sample, the critical field dependence with temperature and the cooling of the sample

Status

- All materials and components have been received.
- Setup must be assembled
- Cavity commissioning must be done with a niobium sample





Perspectives

- Characterize all sample which can be coated on a 110mm disc
- Investigate epitaxial coating method with new materials for accelerating cavities (MgB_2, Nb_3Sn…).
- Build and test a single cell cavity with characterized materials and techniques
- Investigate multilayer theory to increase roughly the existing accelerating gradient

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