Cavity characterization

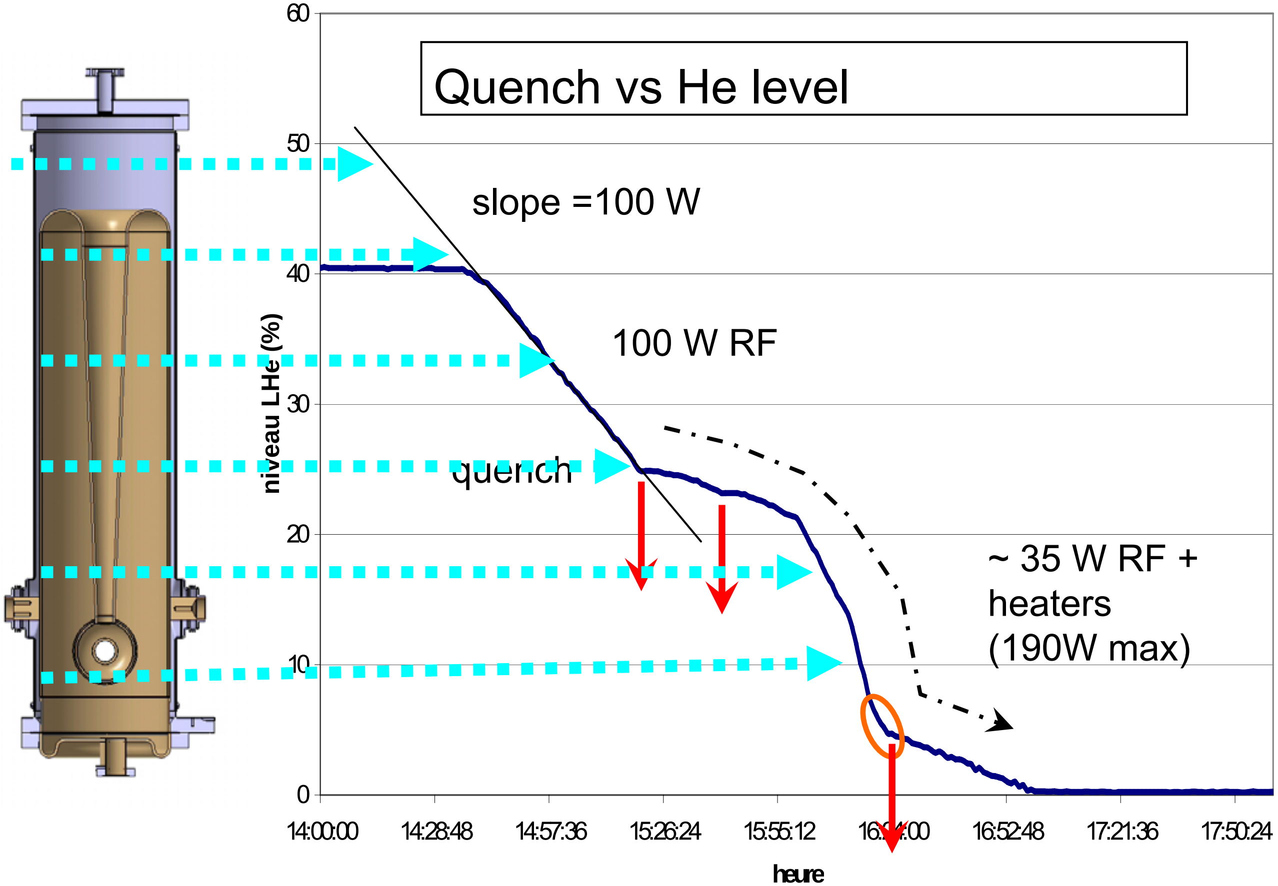
Outlines:

- Recent activities in France
  - Spiral 2 Defective cavity
    - RRR investigation
    - Chemical analysis (LIBS)
  - New sample testing TE011 cavity
  - X-Rays (Soleil)
  - Replica technique
- Other interesting topics

(personal opinion to start discussion !)

Spiral 2 Issue

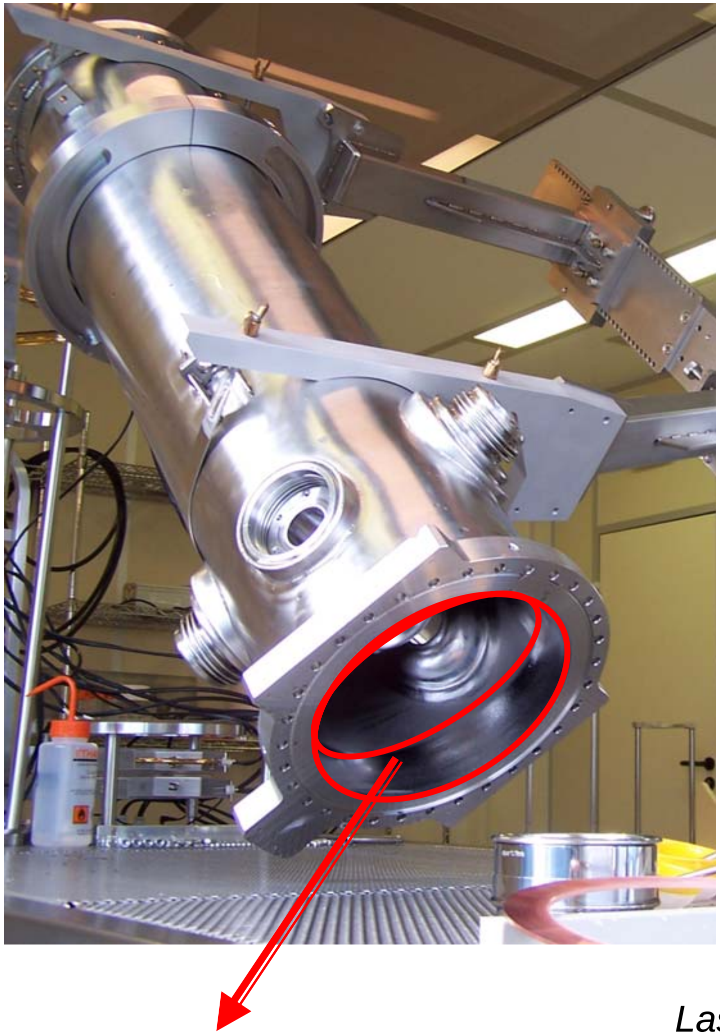
Very high losses on this cavity => ? Quench loccation ?



Very high losses come from the bottom of the cavity

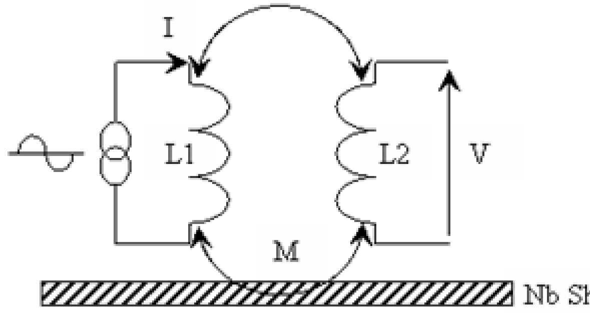
[Courtesy : P. Bosland, G. Devanz]

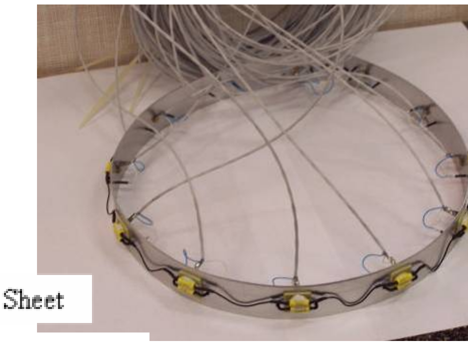
Spiral 2 Issue (2)



How characterizing a completed, large cavity ?!

- RRR/ magnetometry





Mutual inductance modification / sheet

- LIBS (chemical characterization in air)

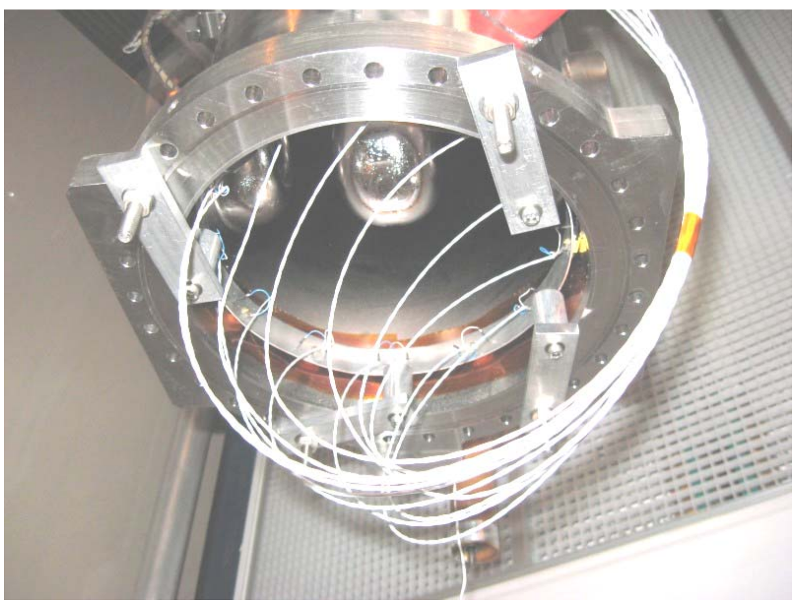
Laser Induced Breakdown Spectroscopy

Trouble during brazing ???

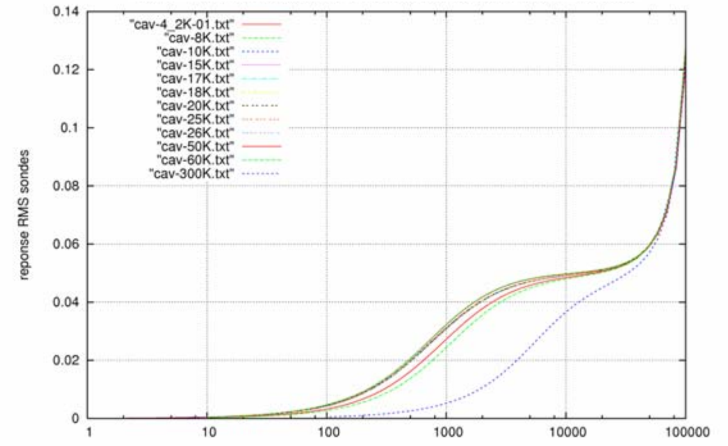
magnetometry

Local RRR measurement *

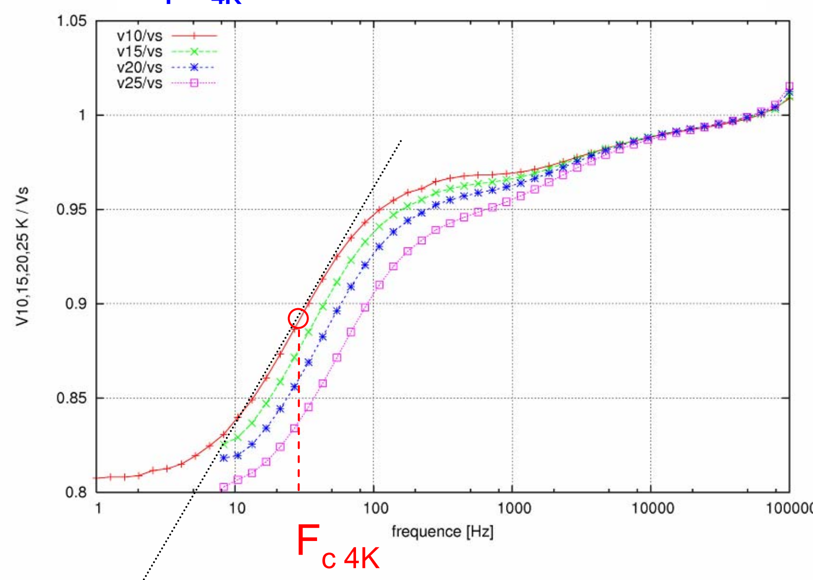
- 12 sets of 2 coils
- Non destructive
- Mutual inductance modification / sheet depends on frequency (penetration depth variation)
- Some influence of the support medium (Al) => must be improved (next exp : insulating material)



V_T for T=4.2K to 300 K.

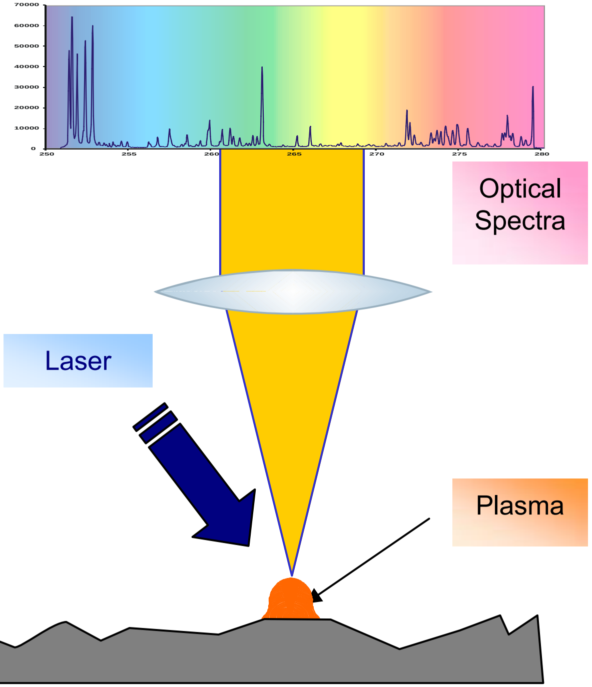


V_T/V_{4K} for T=10K, 15K, 20K et 25K.

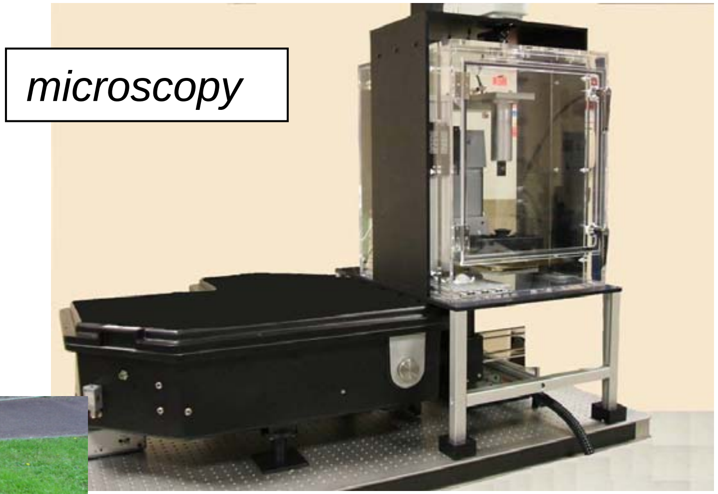


$$\frac{F_{c1}}{F_{c2}} = \frac{\sigma 2}{\sigma 1} = \frac{\rho 1}{\rho 2} = RRR$$

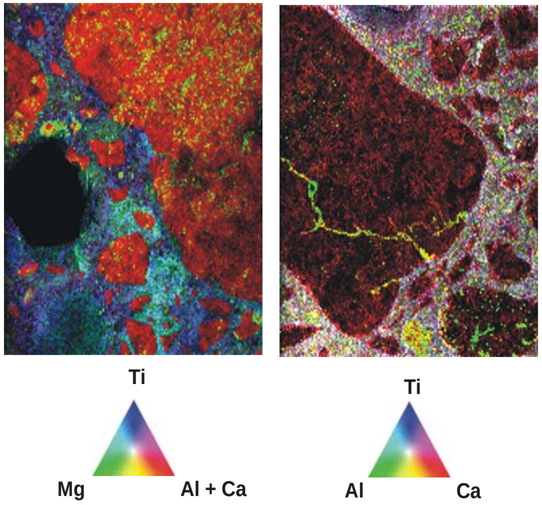
LIBS

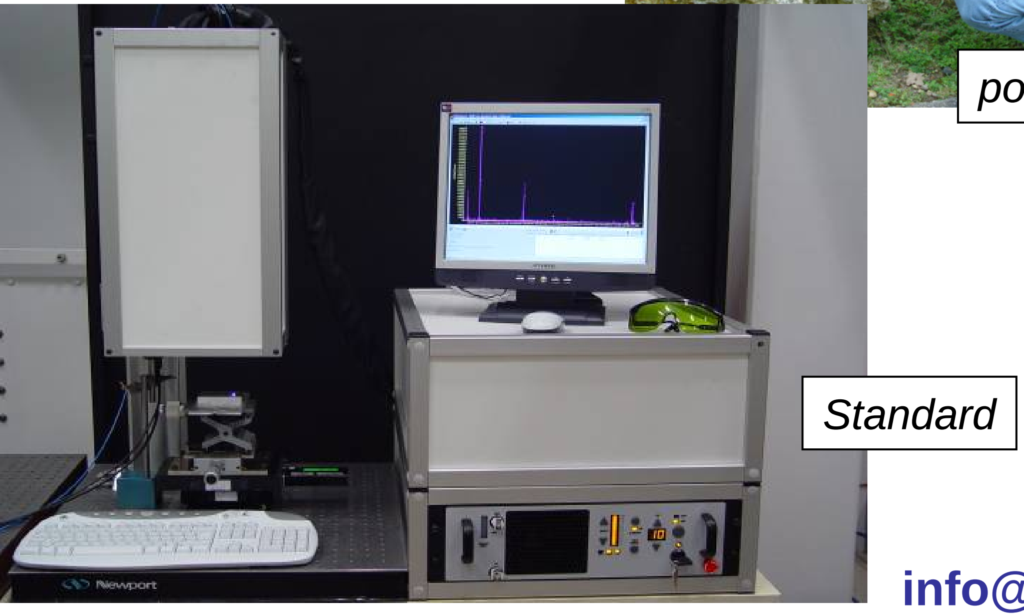


Photos CEA



Micro analyse de béton chargé au titane
(particules de 100 à 300 nm)





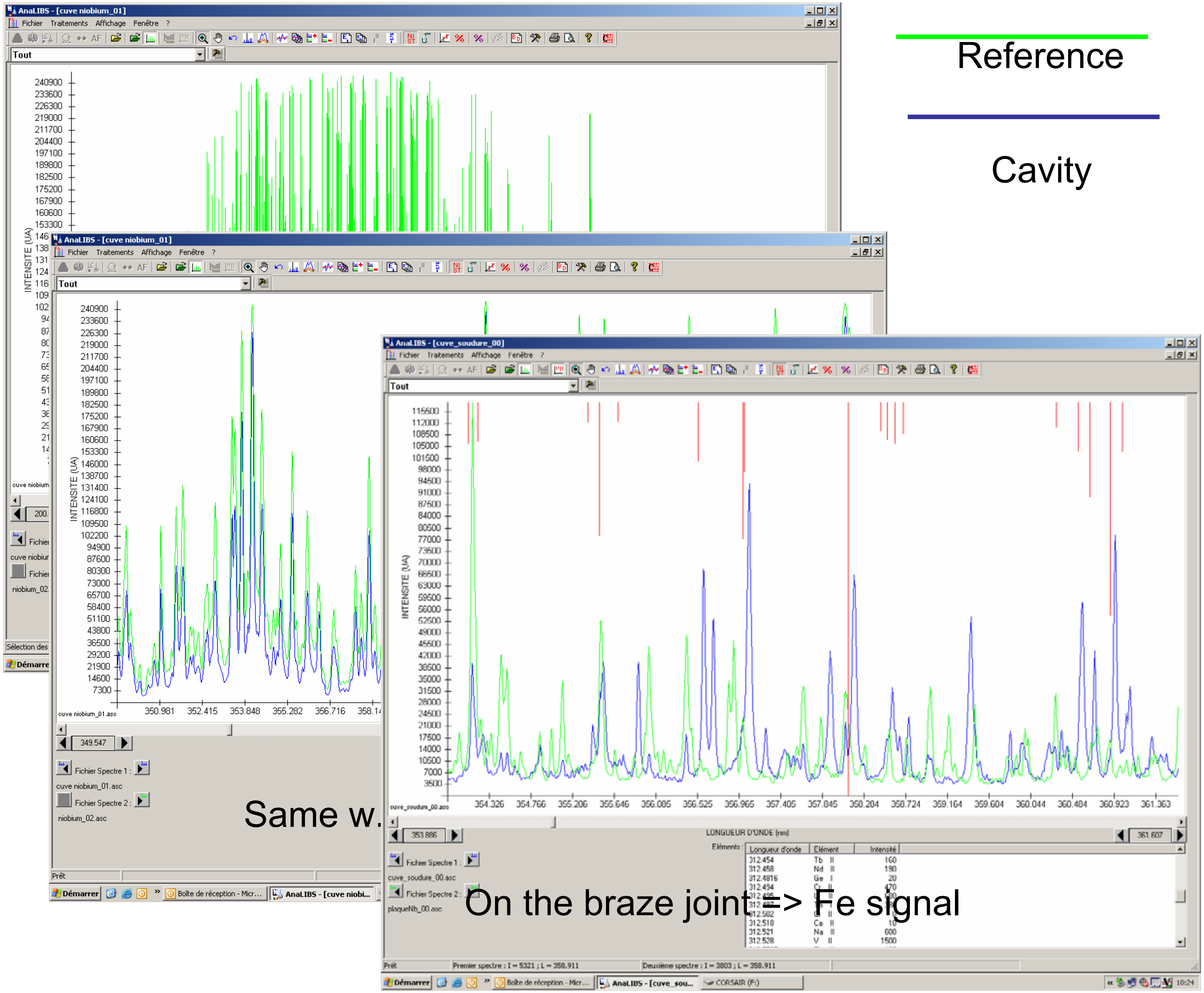
(Taille des images : 1,6 x 2 mm)

Résolution 10 µm

info@ivea-solution.com

Reference

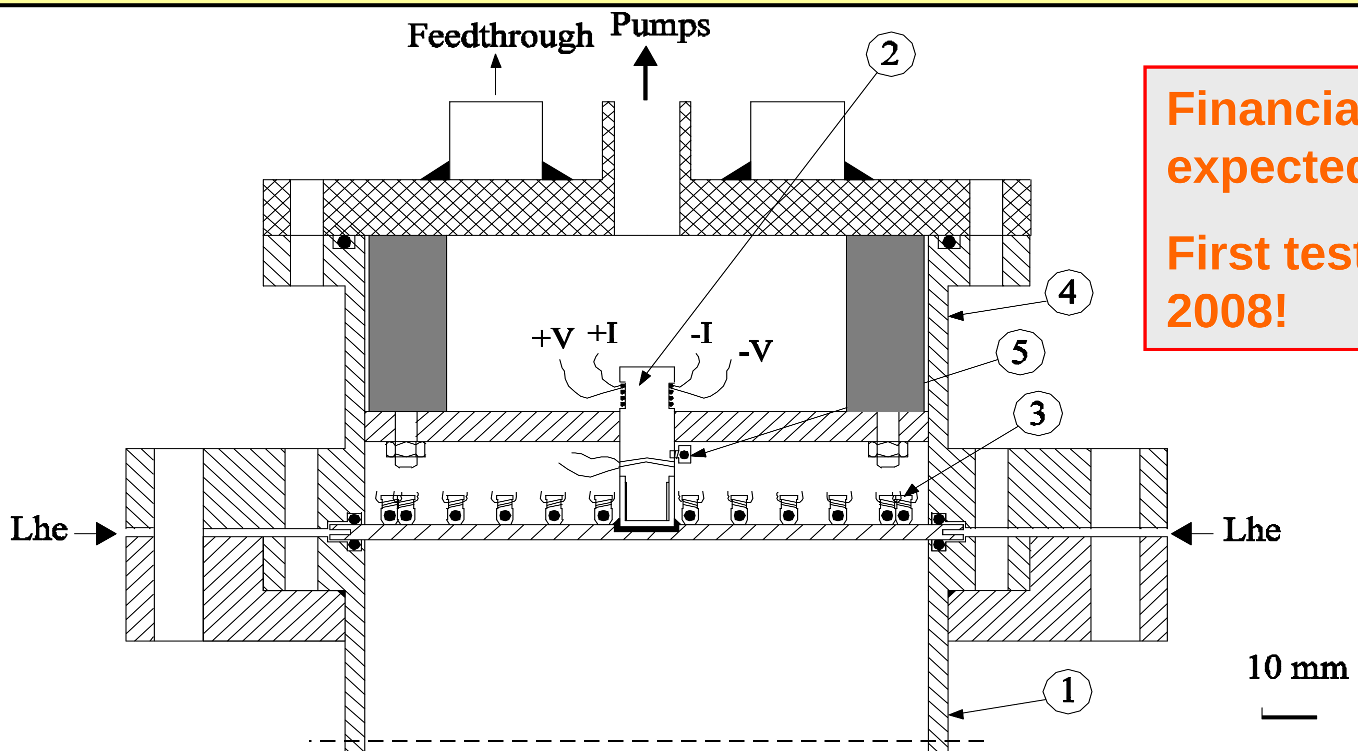
Cavity



Same w.

On the braze joint => Fe signal

New TE011 Type cavity
w. Thermometric system



Financial support expected in 2008!

First tests: end 2008!

① **Bulk Niobium cavity : TE011 mode f=4GHz TE012 mode f=5.6GHz**
② **Calibration heater**
③ **24 thermometers**
④ **Vacuum chamber**
⑤ **Heater thermometer (Heat leaks)**

New TE011 Type cavity

- **Lack of accuracy and sensitivity at 4.2 K for measurements performed by the end plate replacement method !**
- **Local, direct measurement of Rs w. thermometry**

  ➔ **Improve accuracy and sensitivity of Rs measurement,**

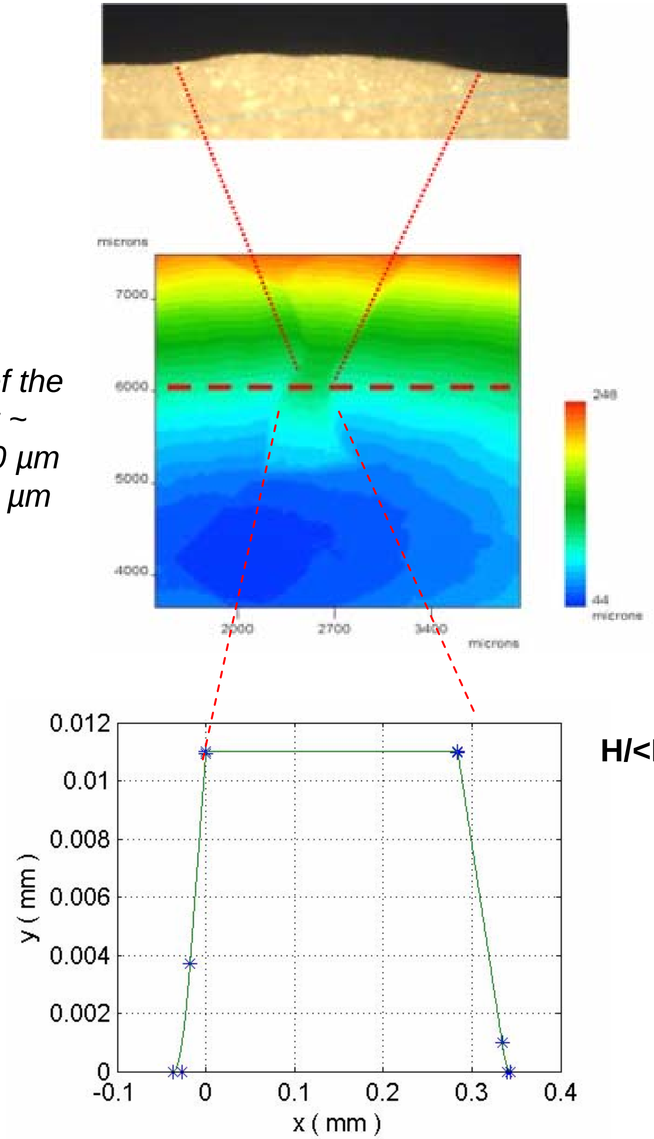
  ➔ **Measure exclusively the test-sample RF losses by excluding any extra RF losses :**

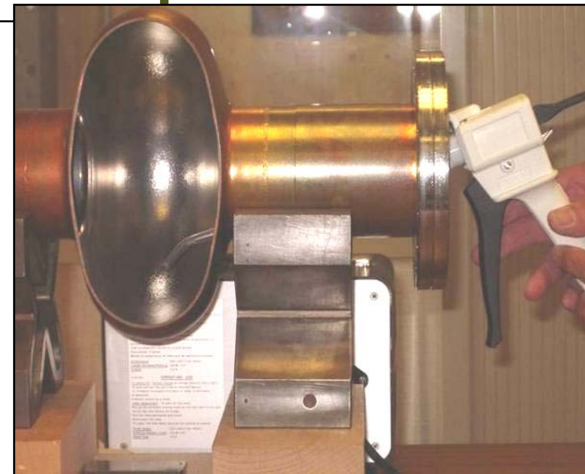
  ➢ **extra RF losses inherent to the 'classical' method (rest of the cavity, indium gasket, RF coupling loops)**

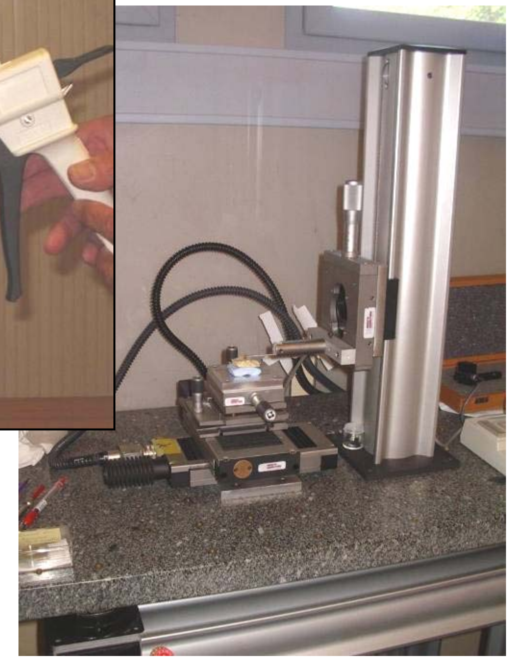
  ➢ **anomalous RF losses induced by Field Emitted electron impacting area other than the sample**

Replica @ the quench site…

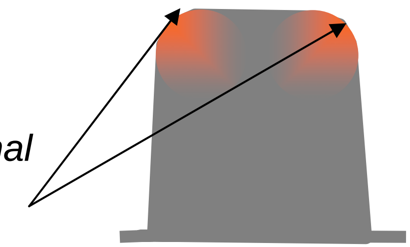
Size of the defect ~
→ 550 µm
x ↑ 15 µm

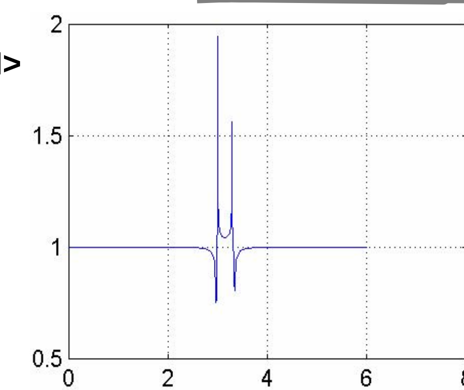


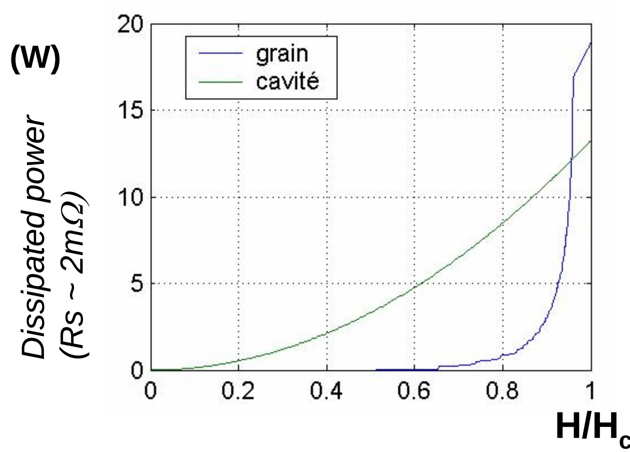




Normal cond.







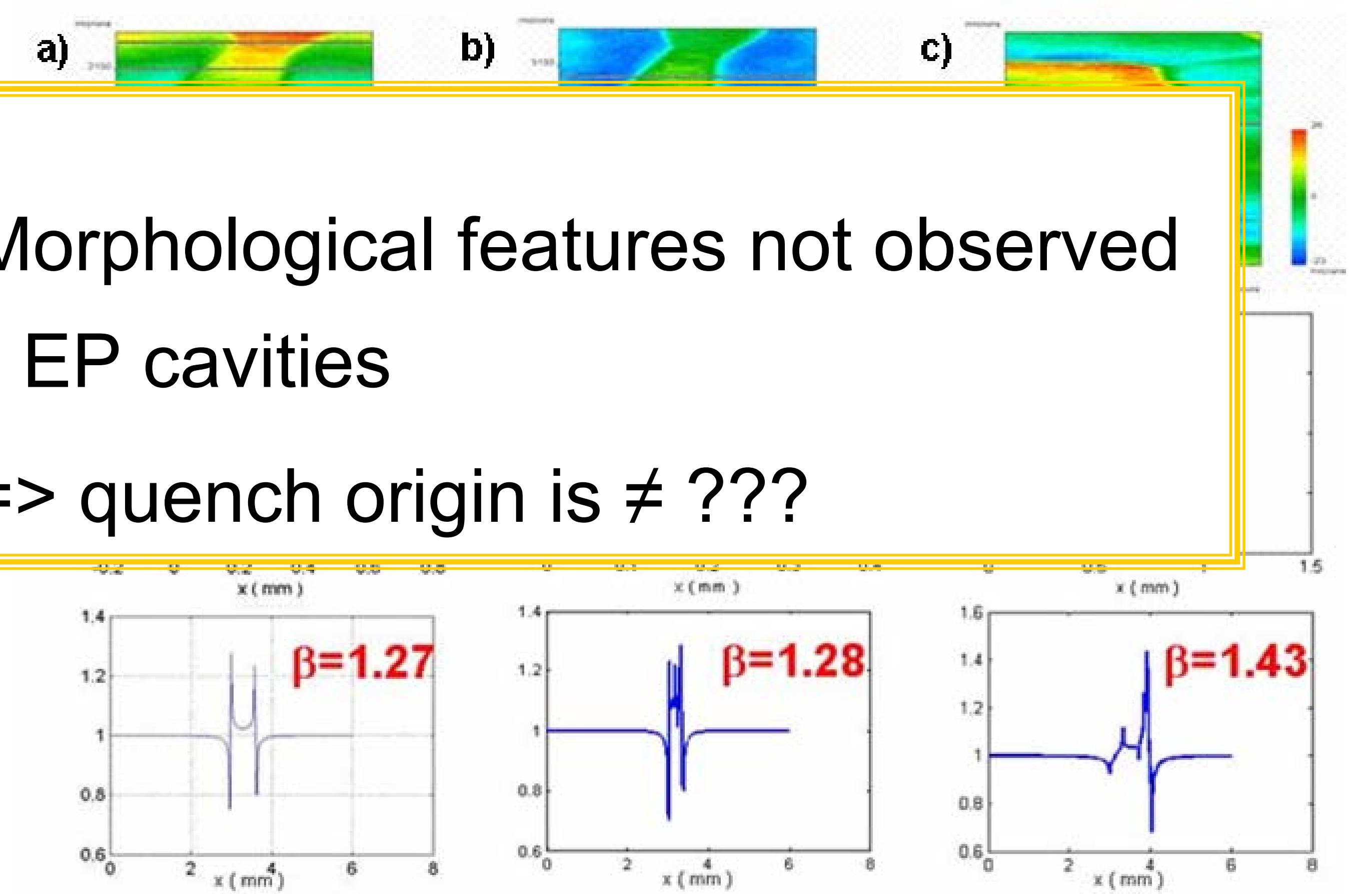
Replica @ the quench site

a) *first quench site,*
b) *same area after 20 µm (quench site @ a new location)*
c) *new quench location.*

Contour lin

Modeling
profile

β (field enhancement factor)



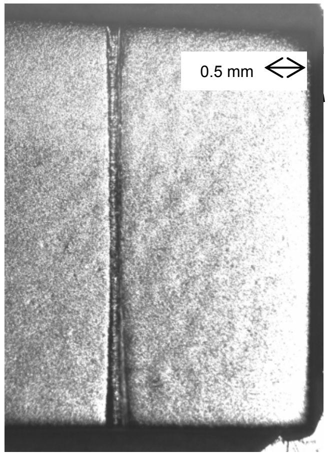
- Morphological features not observed on EP cavities
- => quench origin is ≠ ???

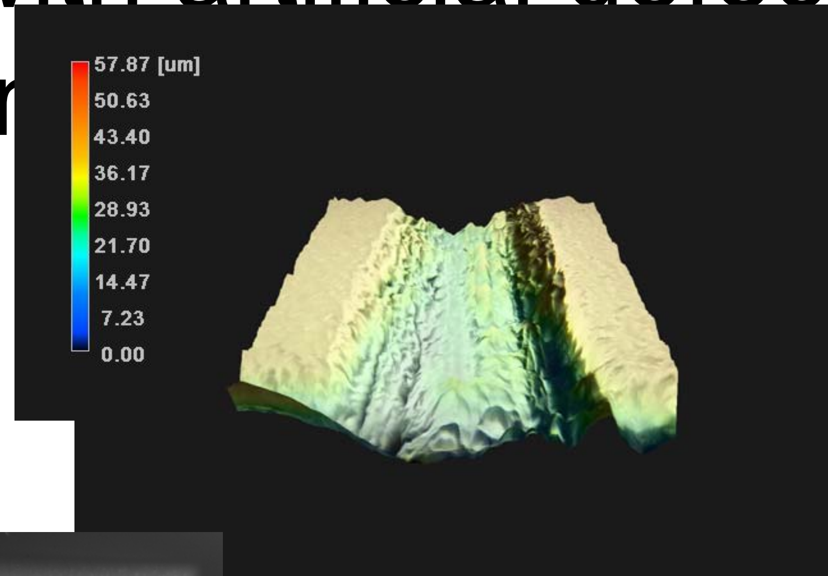
Local morphology is consistent for explaining the quench

2D model => need to go to 3D model

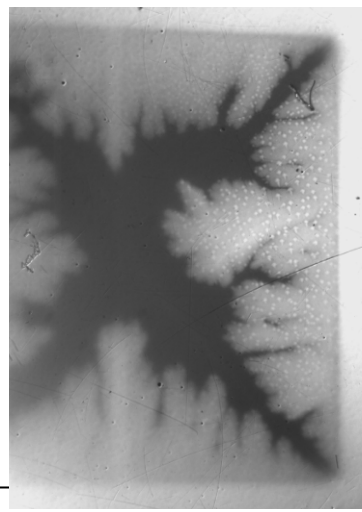
Single crystal with artificial defect

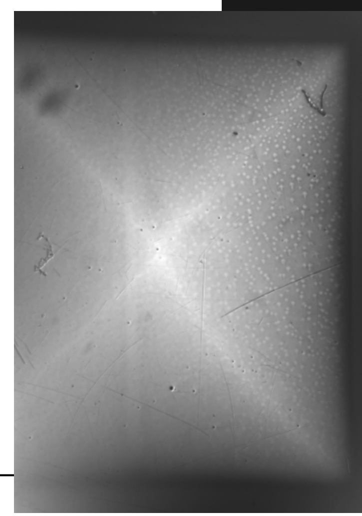
ch) or





#52 ZFC H=40 mT T=7K



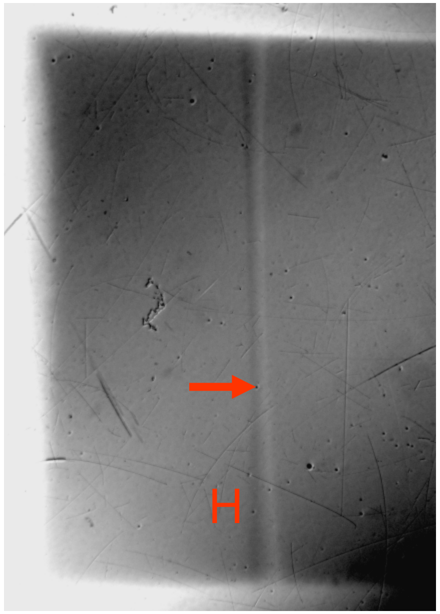


#62 Remn H=80 mT T=7K

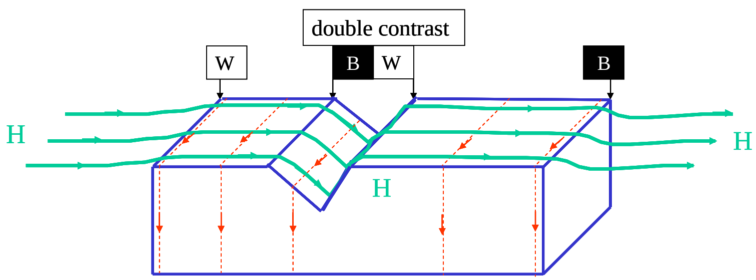
[A. Polyanskii et al, WU/FSU]

- H $\perp$ surface: notch has small impact on flux distribution even at higher T

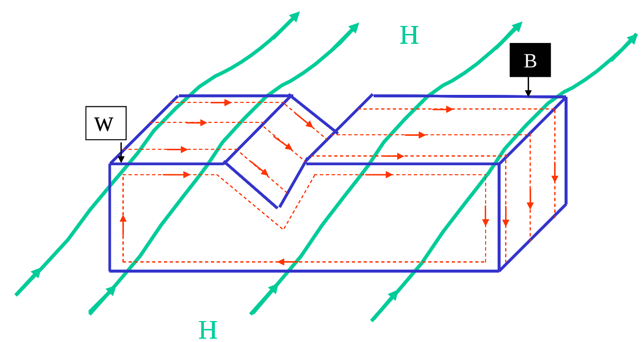
Single crystal with notch on the surface : H // surface



T=5.6K



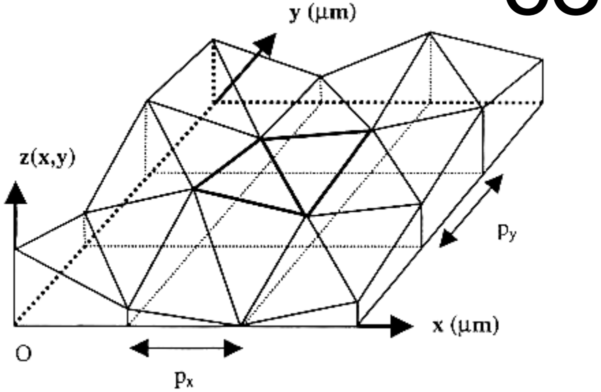
MO contrast is double at the groove, when in-plane field perpendicular to groove



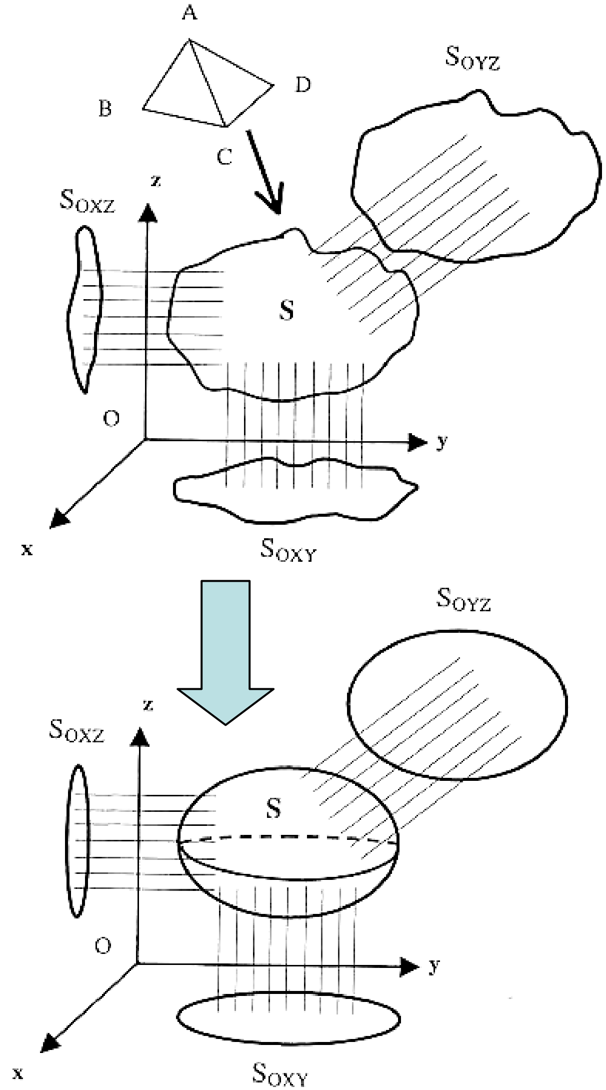
No MO contrast at the groove, when in-plane field parallel to groove

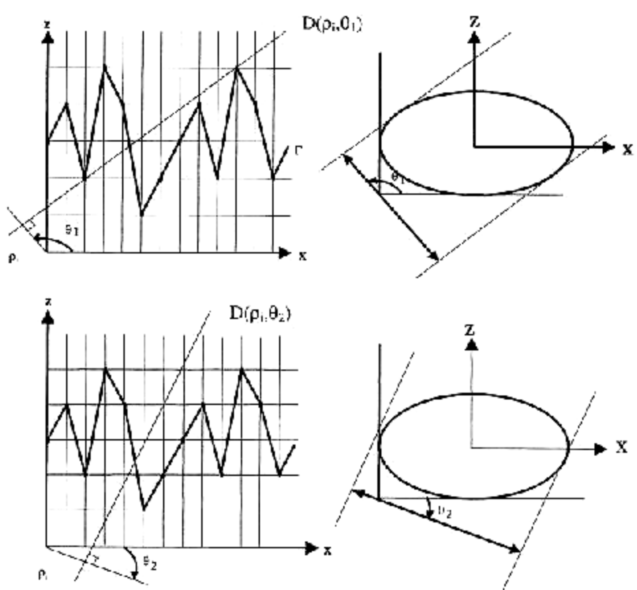
Morphological effect … Roughness

« conformal equivalent structure » concept



1. Decomposition of a sampled surface into elementary segments mode) or elementary micro-triangles (3D mode).



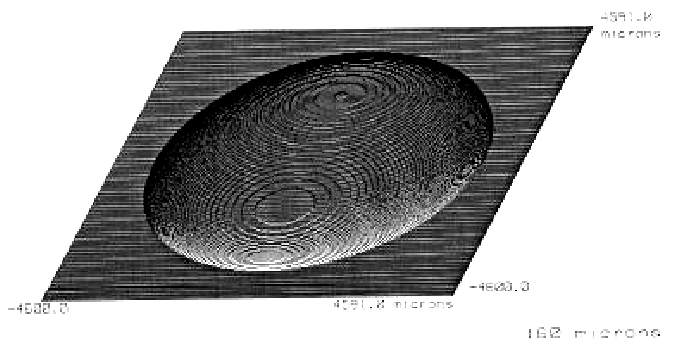


Works with 1! Defects or many.

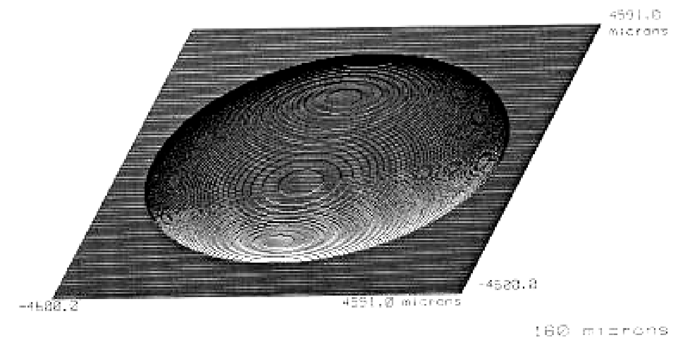
On Nb samples

a) Annealed ~ 1 grain b) not annealed ~ 15 grains

EP

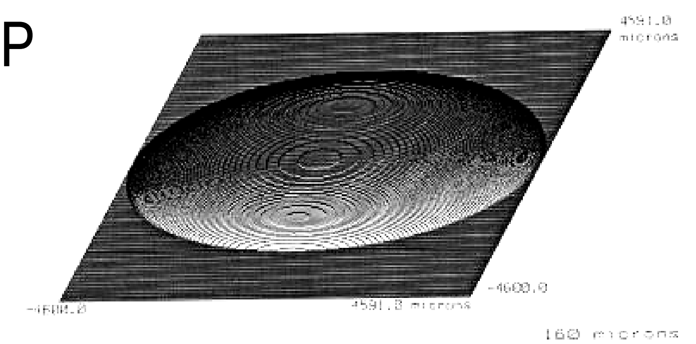


7R.A-EP recuit

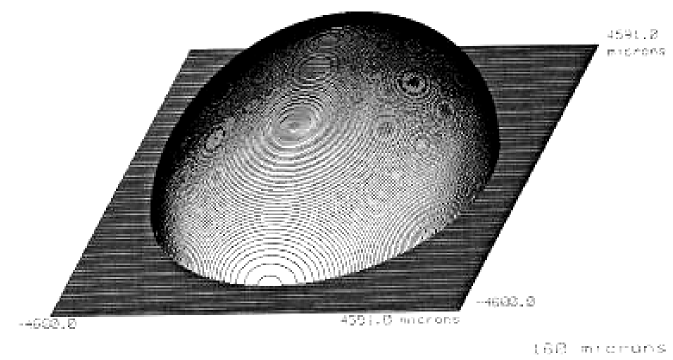


7B-EP non recuit

BCP



1R.A-FNP recuit

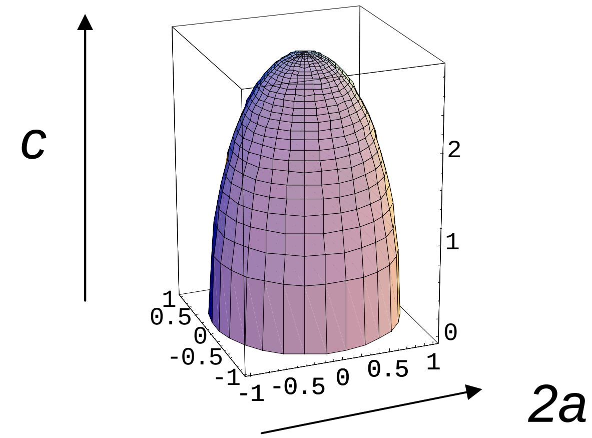


7F-FNP non recuit

a)Annealed material with grain ∅ ~ 1-2 mm
b) Small grain material with ∅ ~ 70 μm

Demagnetization factor

$$D_a = \frac{1}{1-m^2}\left\{1 - \frac{m}{\sqrt{1-m^2}}\arccos m\right\}$$



m=a/c

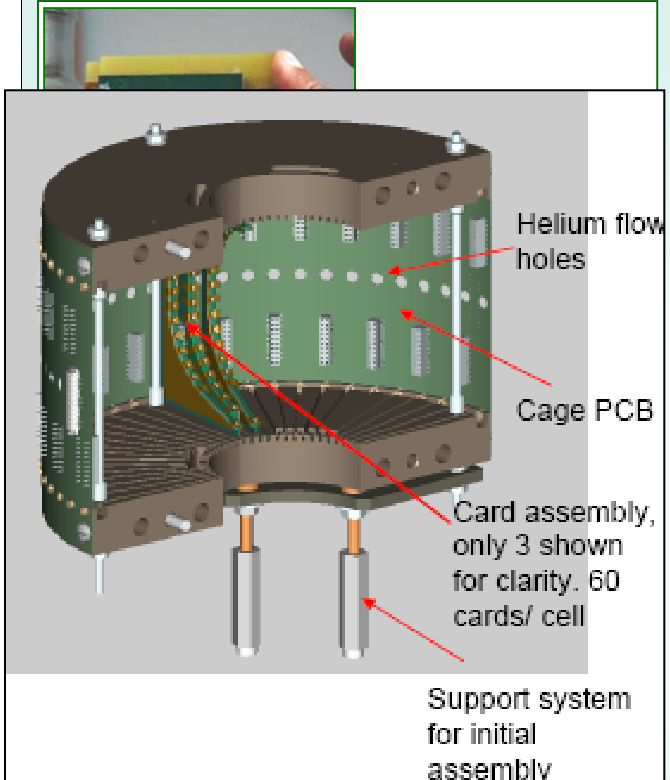
parameter	Small grain material a)	out of welding seam b)	Welding seam	Bulge 50µm high, 200µm Φ
Ra	1-2 µm	4-8 µm	40-80 µm	
C	~ 300	~ 90-100	~ 350	
C/A	~ 0,085	~ 0,024	~ 0,085	~ 0.5
β=1/(**D**)	**1,065**	**1,028**	**1,4 ***	**1.9 !!!!**
Φ grains	70 µm	1-2 mm	0,5-1 cm	

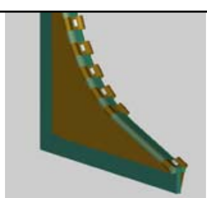
All the welded, BCP, cavities stand there ↑ in the heat affected zone (± 2 cm around welding seam)

**Same order of magnitude Jens calculation/individual grain /mean value in the welding seam*

[Courtesy : C. Ginzburg, A. Mukherjee, N. Dhanaraj]

New T-mapping System : diodes instead of resistor





Flex shown in compressed state as if contacting cavity

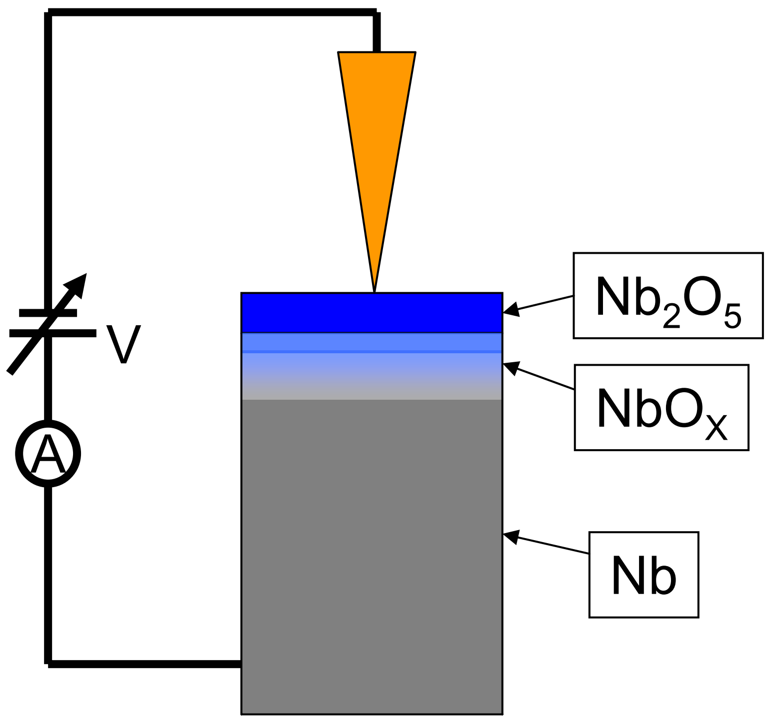
9-cell thermometry - hot spot detection

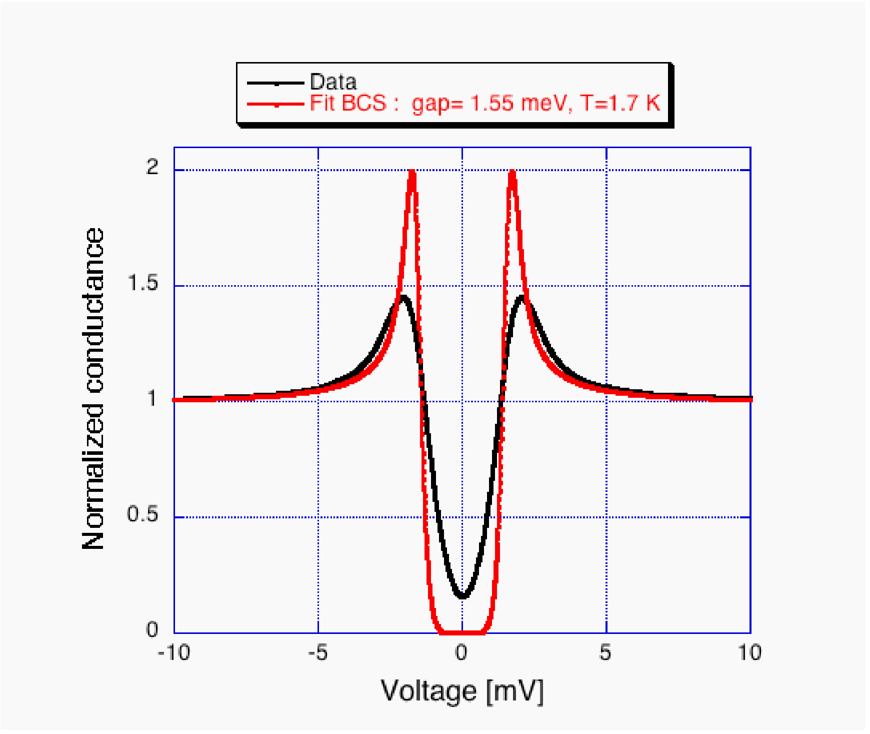
- System requirements
  - Measure temperature rise, not absolute temperature, in a comprehensive pattern around each of the 9 cells, all 9 cells tested in a single step
  - Fast installation; use for "every" 9 cell test
- Design
  - Diode sensors – 1mm x 1mm sense area, ~1cm spacing
    - Diodes allow multiplexing without active multiplexer
    - 1N4148 diode in a SOD523 package
  - 960 diodes per cell = 60 cards x 16 diodes/card
    - 8640 diodes for a 9-cell cavity
  - Cards: G10 boards, Kapton printed circuit, Kapton flex loop provides spring to hold diodes against surface
  - Cage: Cards installed once on two half-shells which bolt together
- Status: Single-cell prototype being built; test CY07

1rst tests http://home.fnal.gov/~aseet/ILC/Ilc080108.pdf

Point contact tunneling: non-ideal BCS density of states

[Courtesy : T. Proslier, J. Zasadzinski]



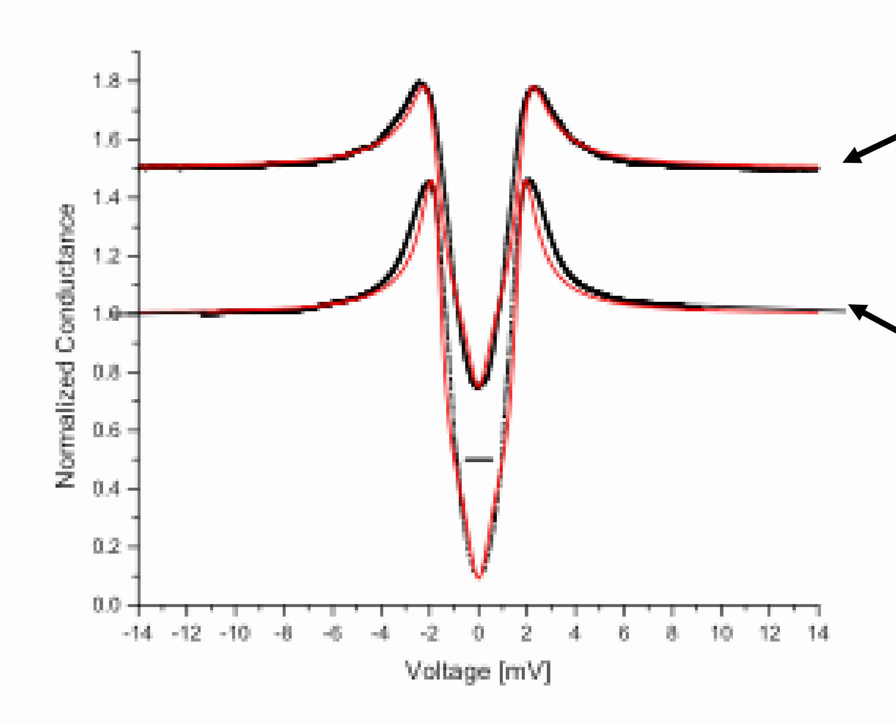


Measure I(V) and dI(V)/dV.
Tunnel regime: R >10 kOhms

Non ideal BCS behavior:
-States inside the gap
-Peaks at higher energy

Evidence for magnetic scattering
The baking effect

$Nb_2O_{5-\delta}$ and $NbO_{2-\delta}$ are magnetic



Red: Fits using Shiba theory

Baked Nb Crystal Shows reduced Magnetic scattering (Γ_{SF})

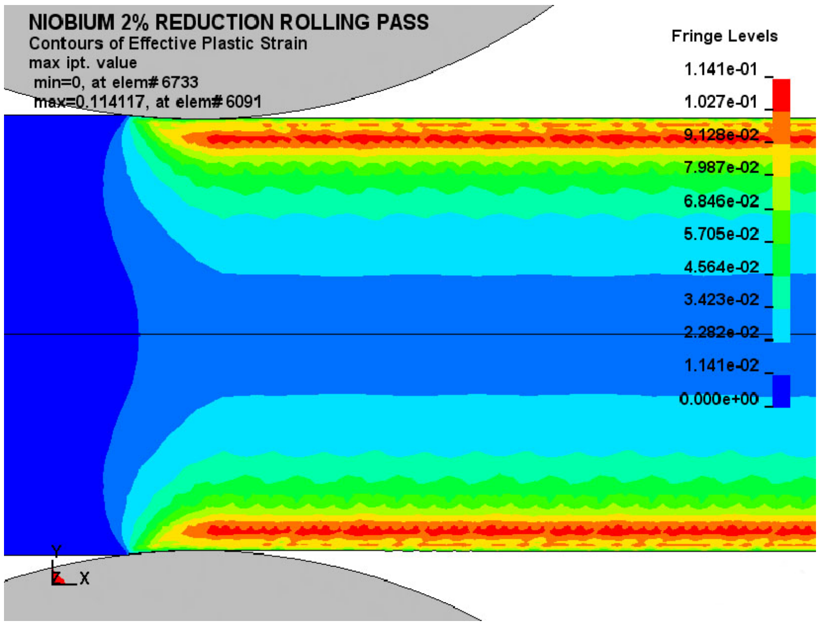
Fits parameters:

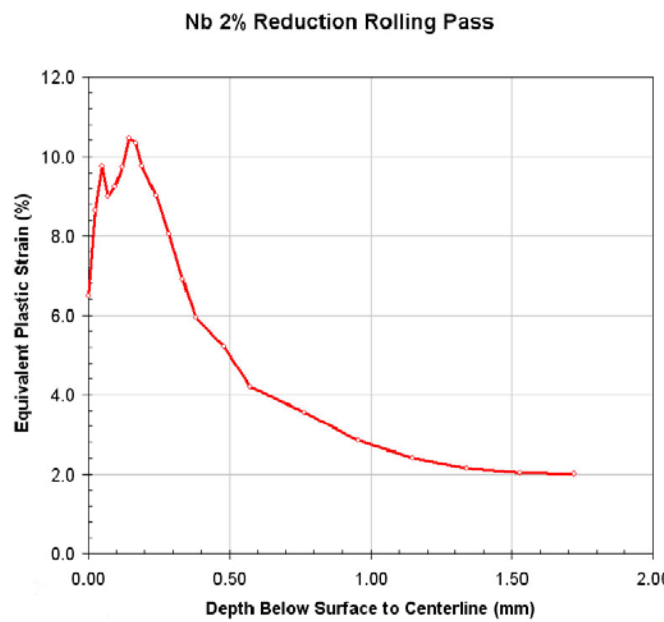
Unbaked (up): Δ=1.55 meV, Γ_{SF}=0.3 meV, ε=0.6 -> C=0.27%

Baked (down): Δ=1.55 meV, Γ_{SF}=0.17 meV, ε=0.6 -> C=0.14%

Damage…?

Finite Element, Computational Plasticity
Simulation of small-roll, small-reduction (2%) pass



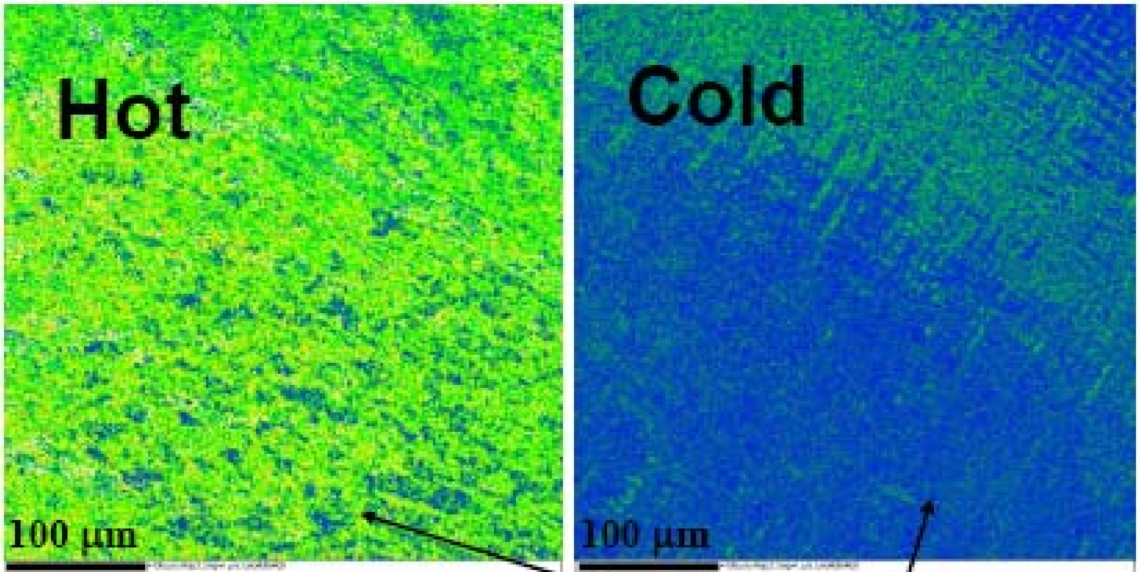


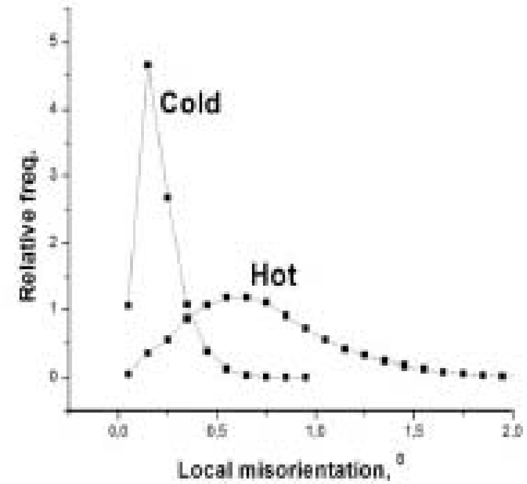
Finite element simulation (run under LS-Dyna) of 2% reduction of 3.5 mm sheet with 1 cm diameter rolls. Strain is concentrated in the near-surface region (red). Localized strain exceeds the average by a factor of 5.

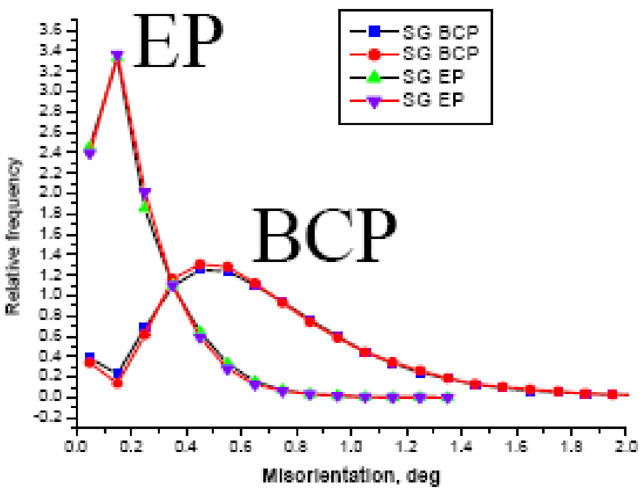
[R. Crooks, Black Laboratories]

http://tdserver1.fnal.gov/project/workshops/RF_Materials/talks/Talk5_Roy%20Crooks_Novel%20Surface%20Treatments.ppt

Damage







Significant difference!

[A. Romanenko,Cornell]

http://www.pku.edu.cn/academic/srf2007/download/conference/tuesday/Romanenko_Lecture_TU103.pdf

SRF material Workshop

First Edition

May 23 & 24, 2007

Fermilab, Wilson Hall

http://tdserver1.fnal.gov/project/workshops/RF_Materials/agenda.htm

next workshop at Michigan State University, in East Lansing, Michigan, USA

May 2008