HOT TOPICS SESSION 1st part

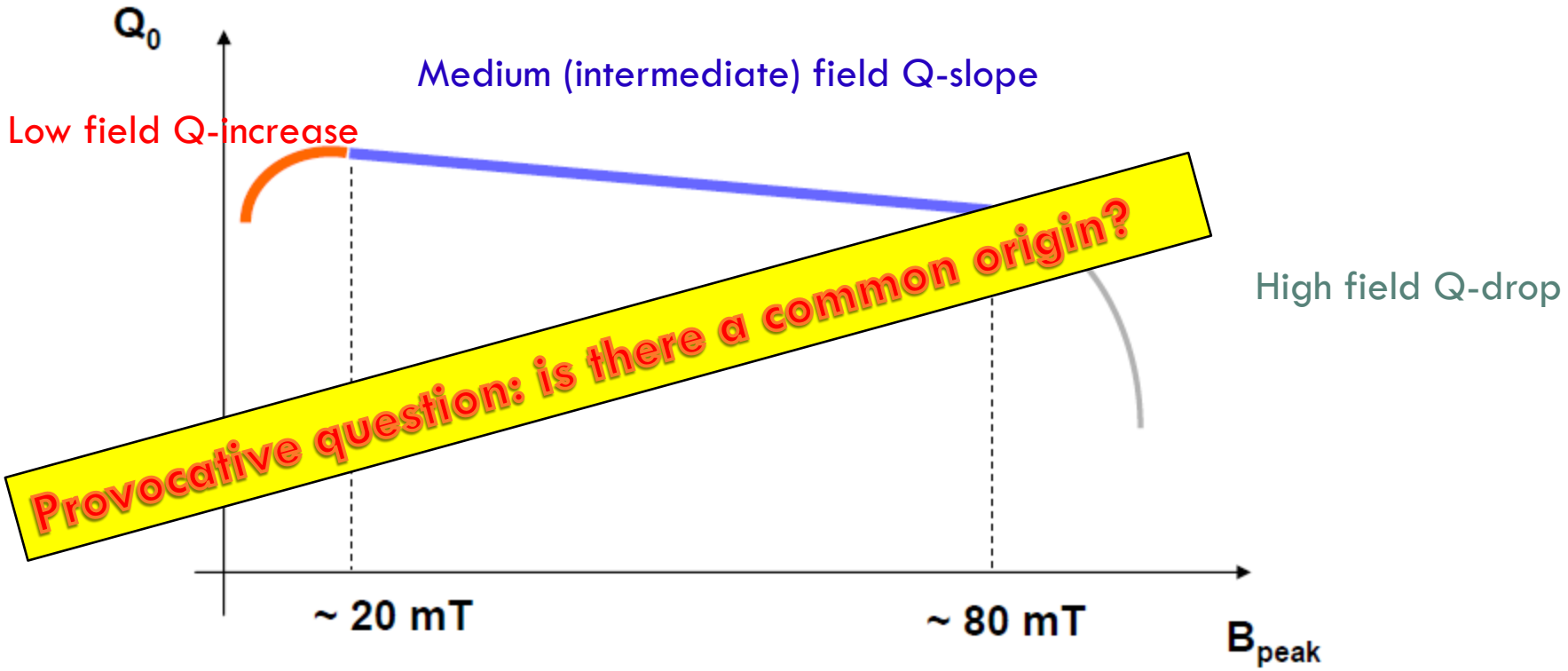
Medium field Q-slope and paths to high Q operation

1st part: Introduction

W. Weingarten / CERN

Disclaimer: no attempt made for a complete survey of original work

What are we talking about?



Incentive

Achieving larger gradients must be reciprocal to reducing the RF losses

Doubling the gradient => increasing Q by factor 4 and eliminating the medium and high field Q-slopes

Charge from International Program Committee

1. "In the final 15 minutes of the Mon., Tue., and Thur. sessions, just before lunch, the moderator will present **his view** of the current state of the particular topic. This 15 minute talk is intended to incite and provoke interest so a little bit of **controversy is welcomed**!
2. ...
3. The moderator will also have **pre-arranged a set of conference attendees** who, in the 6 pm sessions, will present his or her viewpoint on the topic. These should not be full talks. However, the person may show a couple slides espousing a point of view. ..."
4. ...

Experimental results on medium field Q-slope

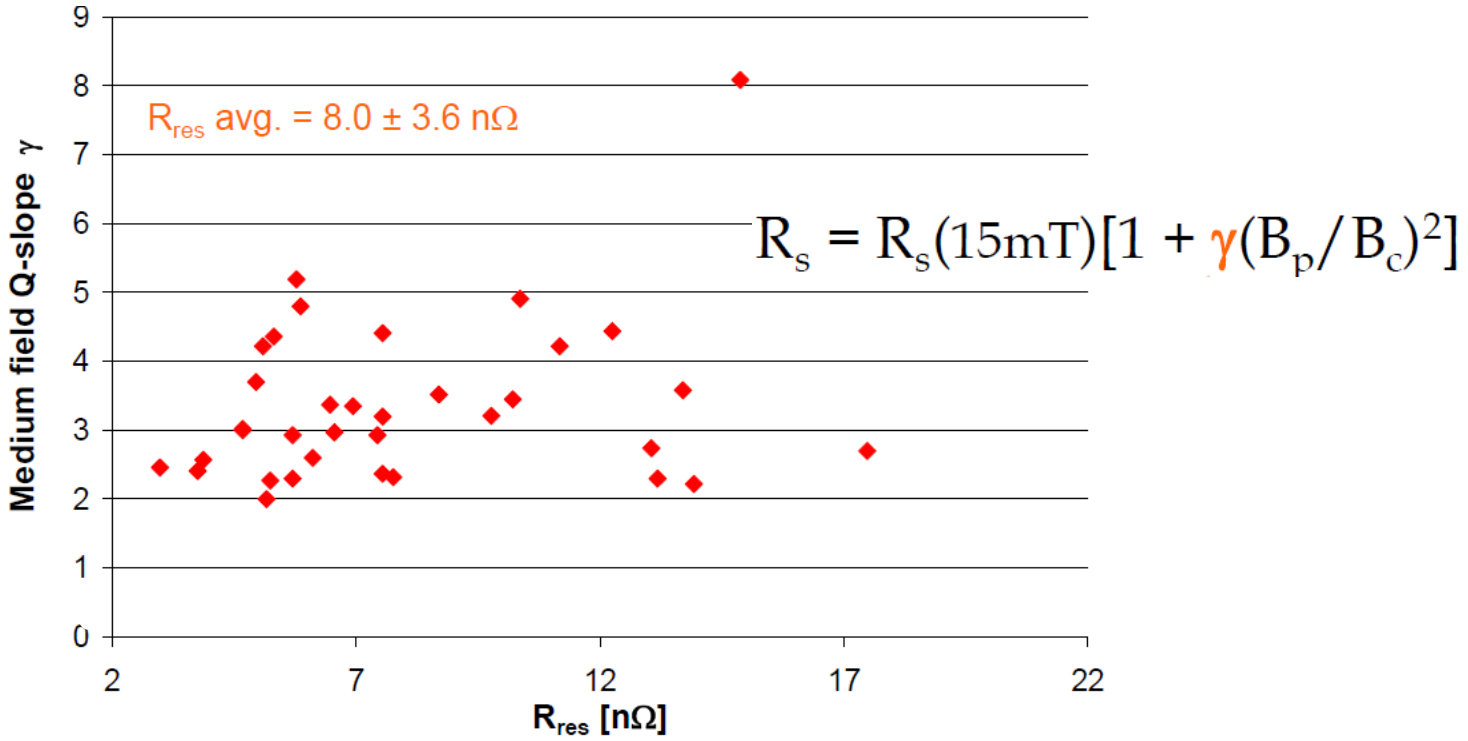
- no correlation with residual resistance (#1 *)
- R_s factorizes into temperature dependent and field dependent part (#2 and #3)
- temperature dependent with threshold behavior (#4)
- pretty independent of baking, if not decreasing, for whatever previous treatment (#5)
- quadratic dependence of $R_{s,fd}$ on B (#6)
- magnetic field effect (#7)
- insensitive to HF rinsing (#8)
- also visible for heat flow parallel to surface (no temperature gradient across Nb wall) (#9)
- closely linked to surface conditions (#10)

fd = (magnetic) field dependent

*the numbers refer to the piece of evidence as collected in subsequent slides

medium field Q-slope #1

no correlation with residual resistance

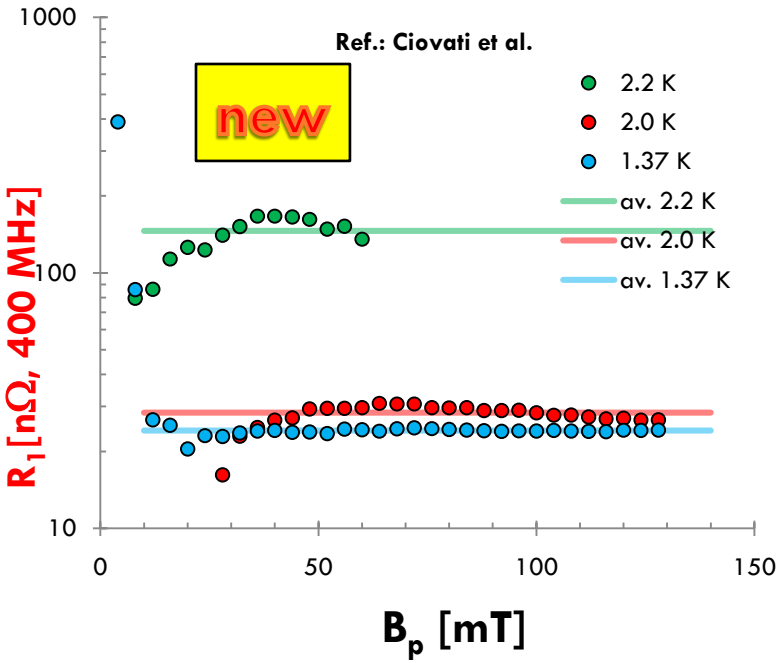


G. Ciovati, Pushing the limits of RF superconductivity, Workshop Argonne 2004

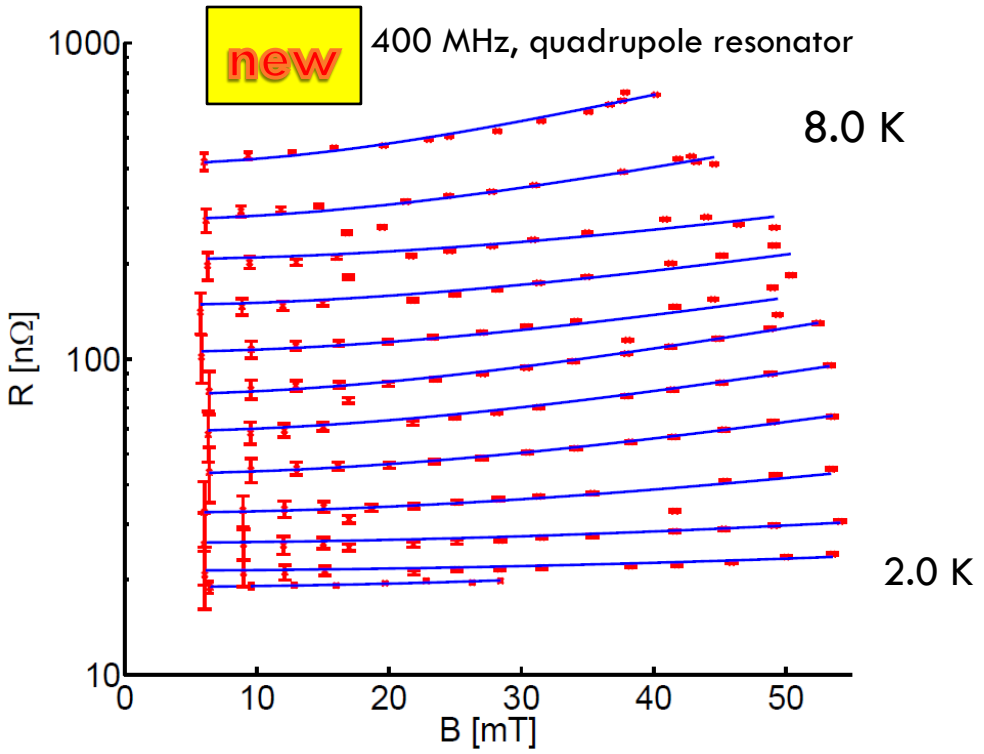
medium field Q-slope #2

factorization into temperature dependent and field dependent part

$$R_s\text{-slope} = [c + R_1(T, \omega)] \cdot R_2(B)$$



W. Weingarten, ATS/Note/2011/019 TECH CERN



T. Junginger, this conference
WEIOA04

medium field Q-slope #3 (Nb film on copper)

factorization into temperature dependent and field dependent part

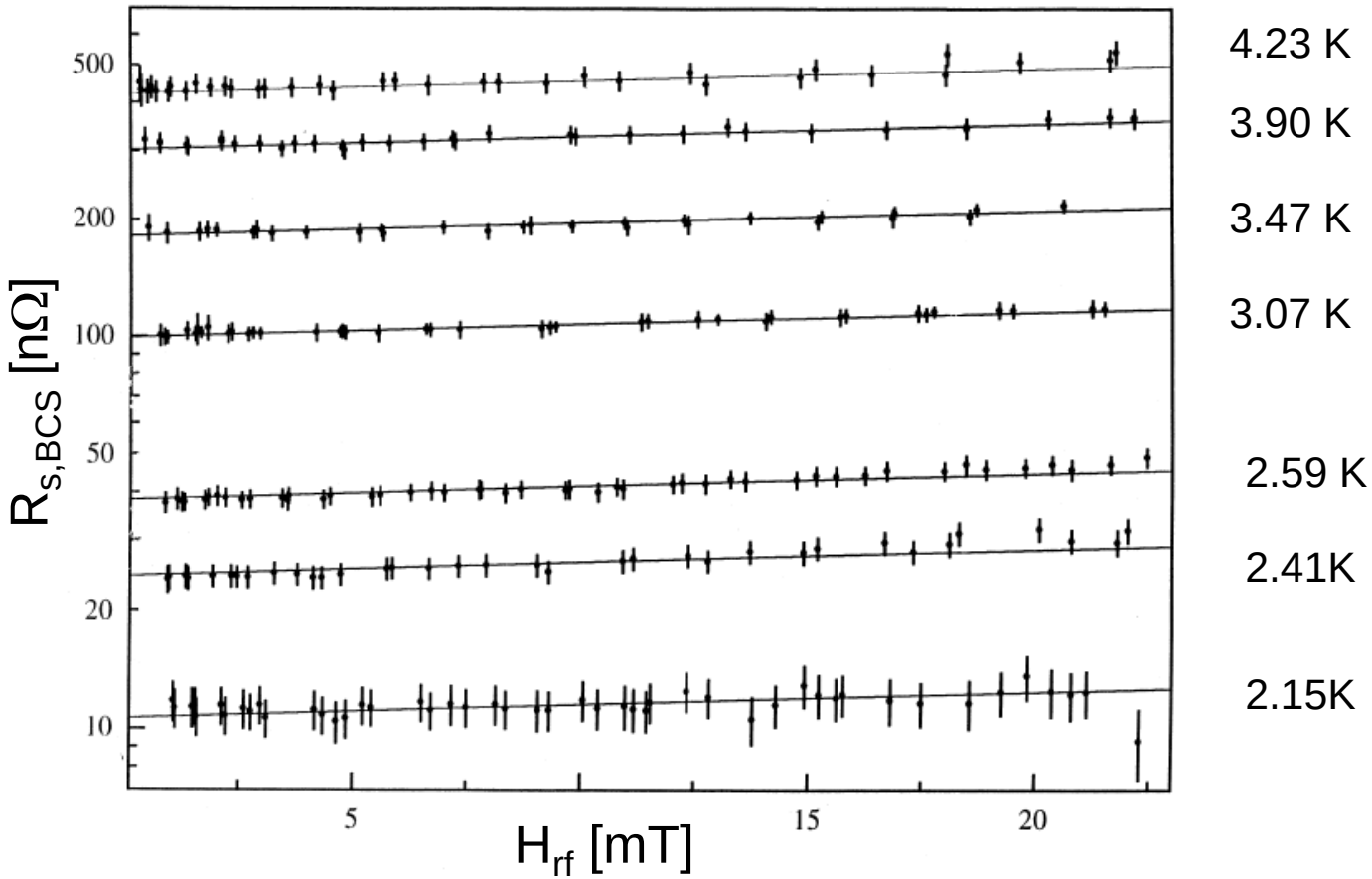
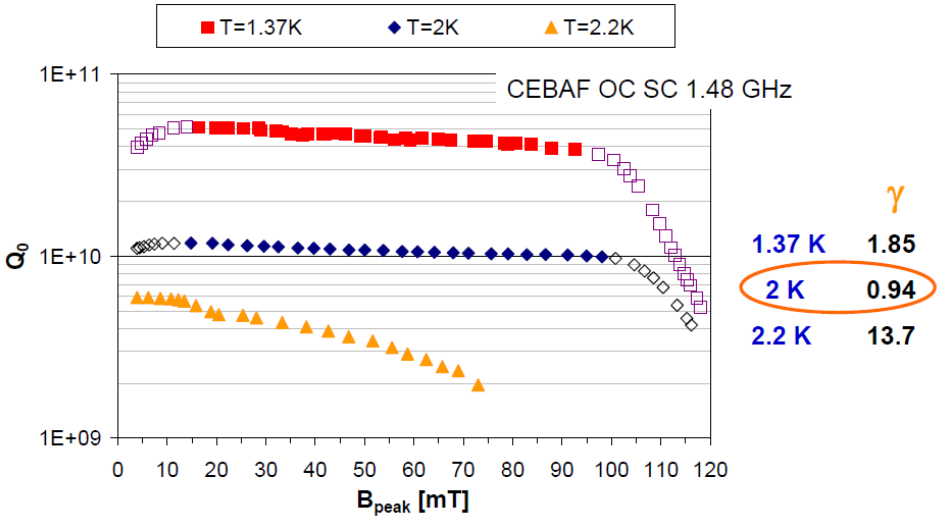


Fig. 8. Isothermal H_{rf} scans measured on a particular film. $R_{BCS}(T)$ is plotted as a function of H_{rf} for $T = 4.23$ K, 3.90 K, 3.47 K, 3.07 K, 2.59 K, 2.41 K and 2.15 K (from top to bottom). The lines represent the same H_{rf} dependence (up to a factor) for all values of T.

medium field Q-slope #4

temperature dependent with threshold behavior

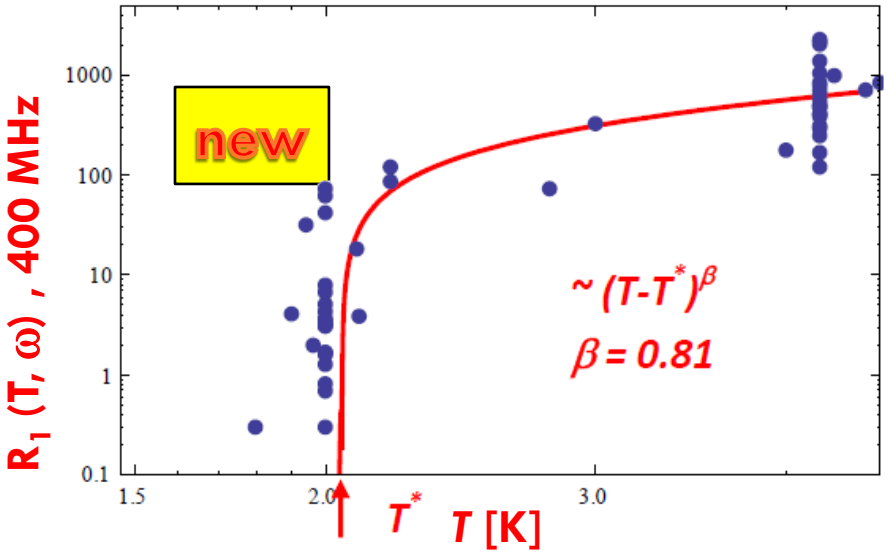
$$R_s = R_s(15\text{mT})[1 + \gamma(B_p/B_c)^2]$$



	γ
1.37 K	1.85
2 K	0.94
2.2 K	13.7

G. Ciovati, Review of frontier workshop, Argonne 2004

$$R_s\text{-slope} = [c + R_1(T, \omega)] \cdot R_2(B)$$



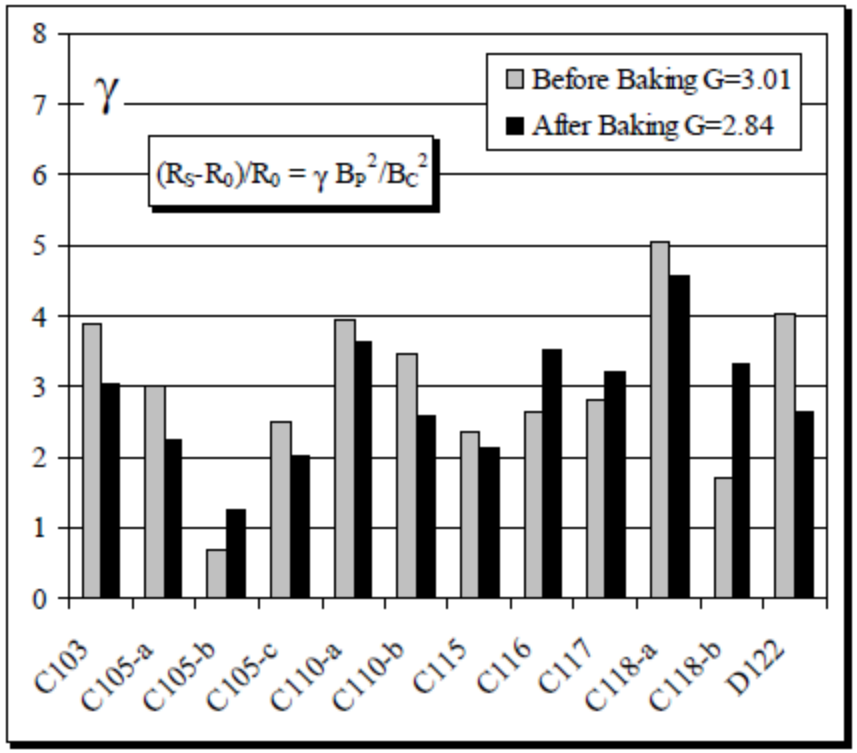
Steep increase of slope between 2 and 2.2 K

W. Weingarten, ATS/Note/2011/019 TECH CERN

medium field Q-slope #5

pretty independent of baking, if not decreasing, for whatever previous treatment

FIGURE 7. Gamma factor of the medium field Q-slope before and after UHV baking on BCP cavities, except for C103 and D122 (electropolishing) and for C110-b (air baking).



Low, Medium, High Field Q-Slopes Change with Surface Treatments

Bernard Visentin

Workshop "Pushing the limits …", Argonne 2004

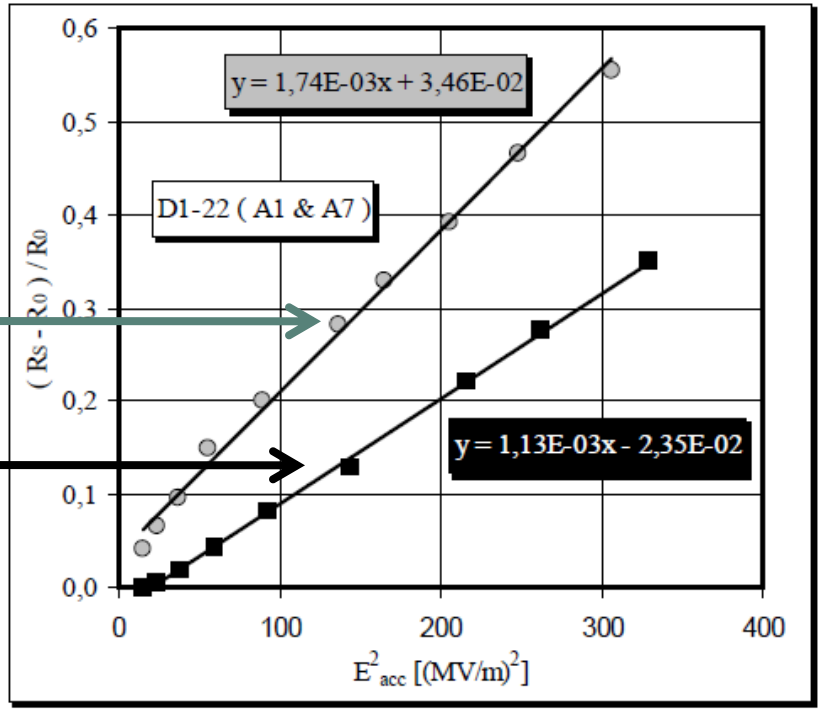
medium field Q-slope #6

quadratic dependence of $R_{s,fd}$ on B

fd = (magnetic) field dependent

before baking

after baking



Low, Medium, High Field Q-Slopes Change with Surface Treatments

Bernard Visentin

Workshop "Pushing the limits …", Argonne 2004

medium field Q-slope #7

magnetic field effect

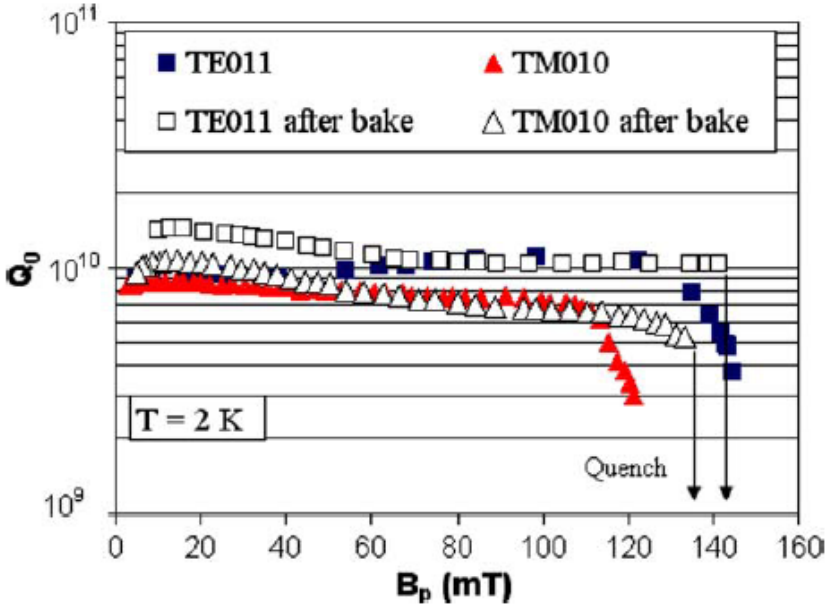
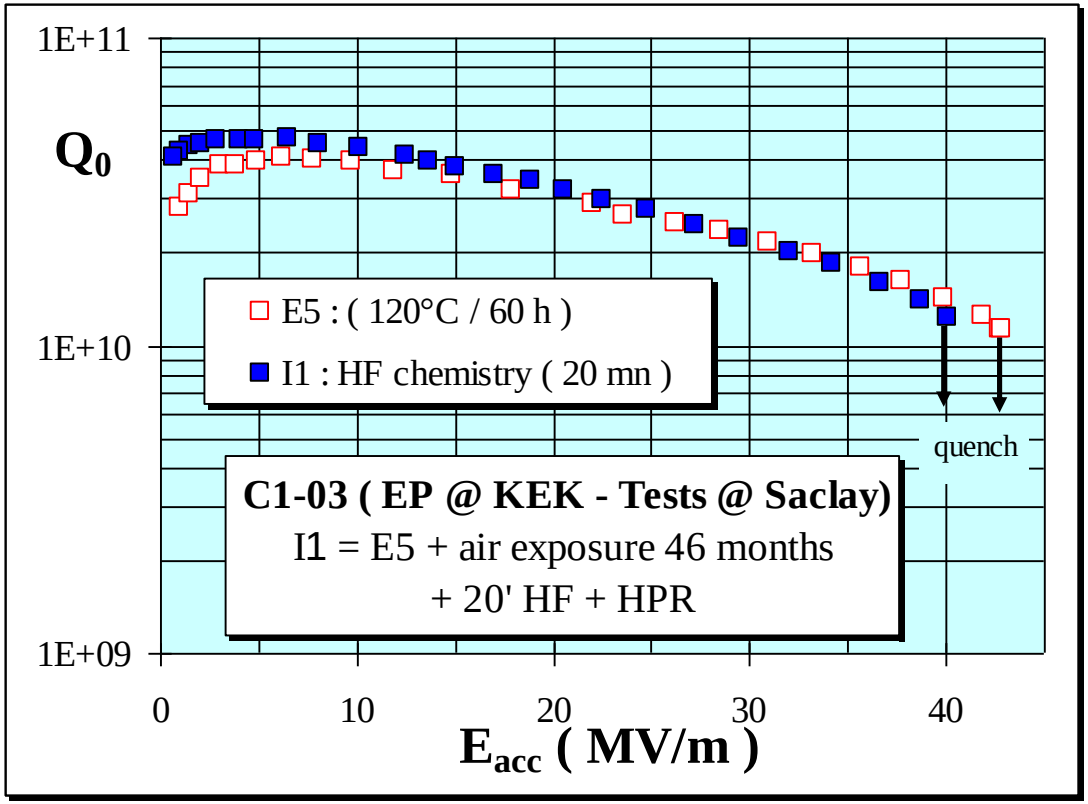


Fig. 8. Q_0 vs. B_p measured in the TM_{010} mode (1.47 GHz) and in the TE_{011} mode (2.82 GHz) of a post-purified single cell cavity before and after baking at 120 °C for 30 h [23].

G. Ciovati, Review of the frontier workshop and Q-slope results, Physica **C 441** (2006) 44.

medium field Q-slope #8

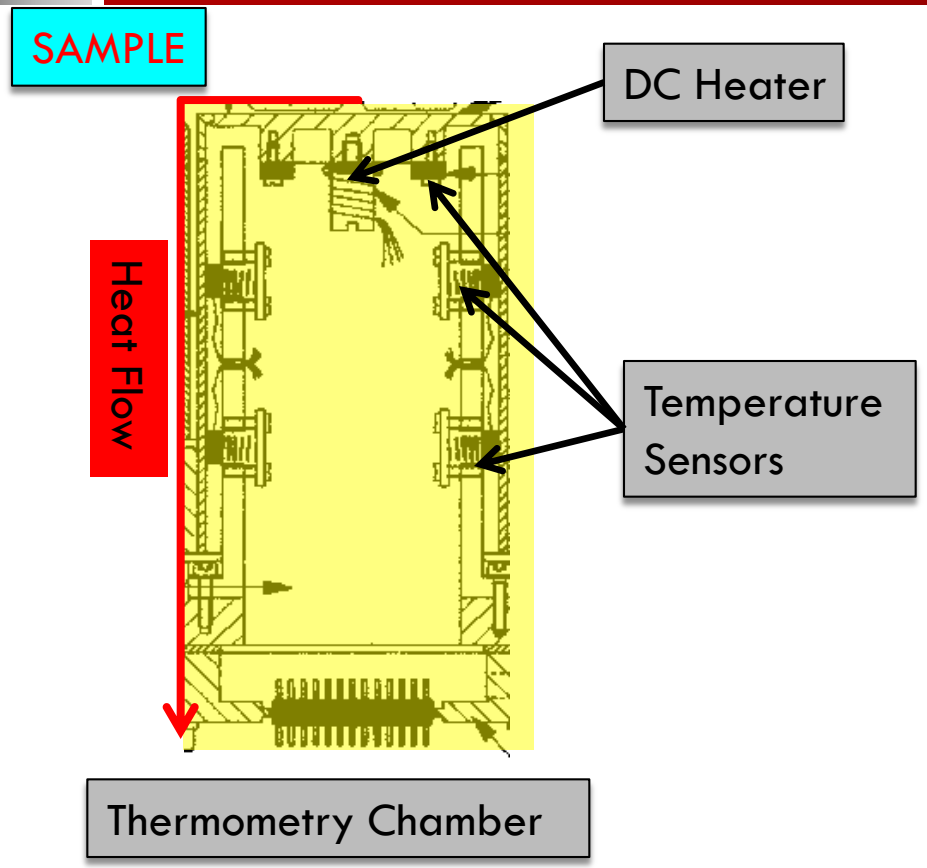
insensitive to HF rinsing



B. Visentin, International Workshop on Thin Films 2006, Legnaro (Italy), slide 17

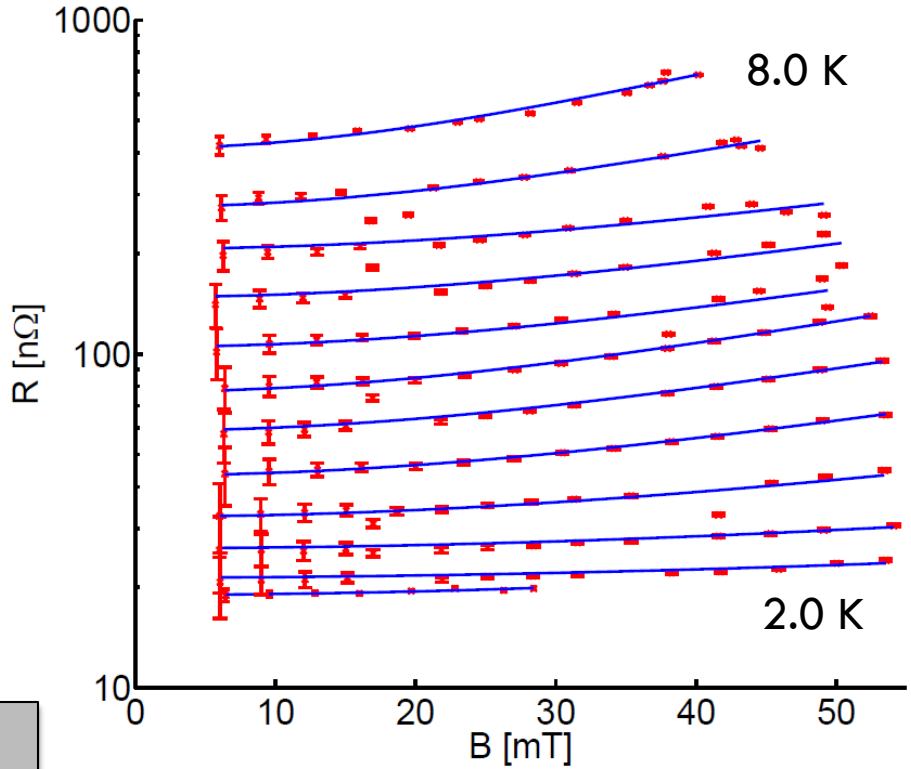
medium field Q-slope #9

also visible for heat flow parallel to surface (no temperature gradient across cavity wall)



RESULT

400 MHz, quadrupole resonator



T. Junginger, this conference
WEIOA04

- Measured Temperature=Temperature on sample surface
- Precise calorimetric measurement technique

medium field Q-slope #10

closely linked to surface conditions

Nb/Cu

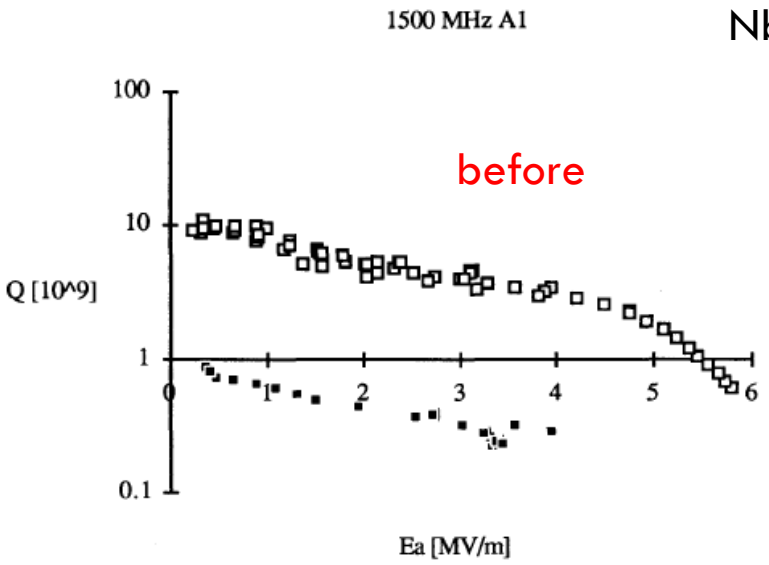


Fig. 2(a) Q value vs accelerating field for the fundamental mode at 4.2 K (lower) and 1.6 K (upper).

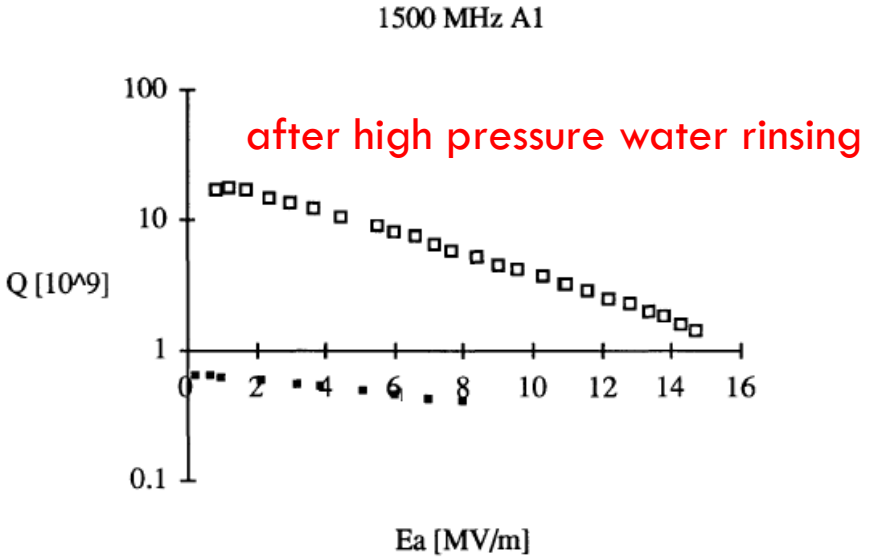


Fig. 2(b) Q value vs accelerating field for the fundamental mode at 1.6 K after high-pressure water rinsing at 4.2 K (lower) and 1.6 K (upper).

SUPERCONDUCTING NIOBIUM SPUTTER-COATED COPPER CAVITIES AT 1500 MHz

Ph. Bernard, D. Bloess, W. Hartung(*), C. Hauviller and W. Weingarten
CERN, Geneva, Switzerland

P. Bosland and J. Martignac
CEN Saclay, Gif-sur-Yvette, France

Proc. 5th Workshop RF Supercond. DESY Hamburg 1991

Current models for the Q-slope(s)

	which I personally find
Magnetic field enhancement at surface roughness features	**unplausible**
Interface tunnel exchange (localized electrons are injected from the oxide layer into the sc metal assisted by electric field)	**unplausible**
Thermal feedback via temperature dependent BCS contribution to surface resistance due to heat transport across cavity wall and interface to lHe	**unplausible**
Non-linear surface resistance from current dependent energy gap	**unplausible**
Magnetic flux entry at B_{c1} at favorable sites	**plausible**

More details in the discussion session at 6 pm

Thank you for your attention !

See you again at 6 p.m.