Performance of Large Grain and Single Crystal Niobium Cavities

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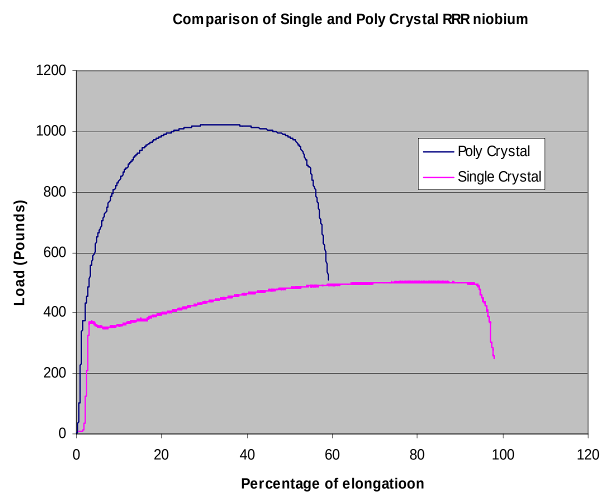
Jlab/CBMM Technology(1)

- Development started with the need for understanding mechanical properties of niobium from different manufacturers (G. Myneni)
- Ingot material supplied by CBMM with large grains (T. Carneiro)
- Mechanical properties –especially elongation – excellent, permitting forming of cavity cells
- Investigate influence of grain boundaries on “Q-drop”

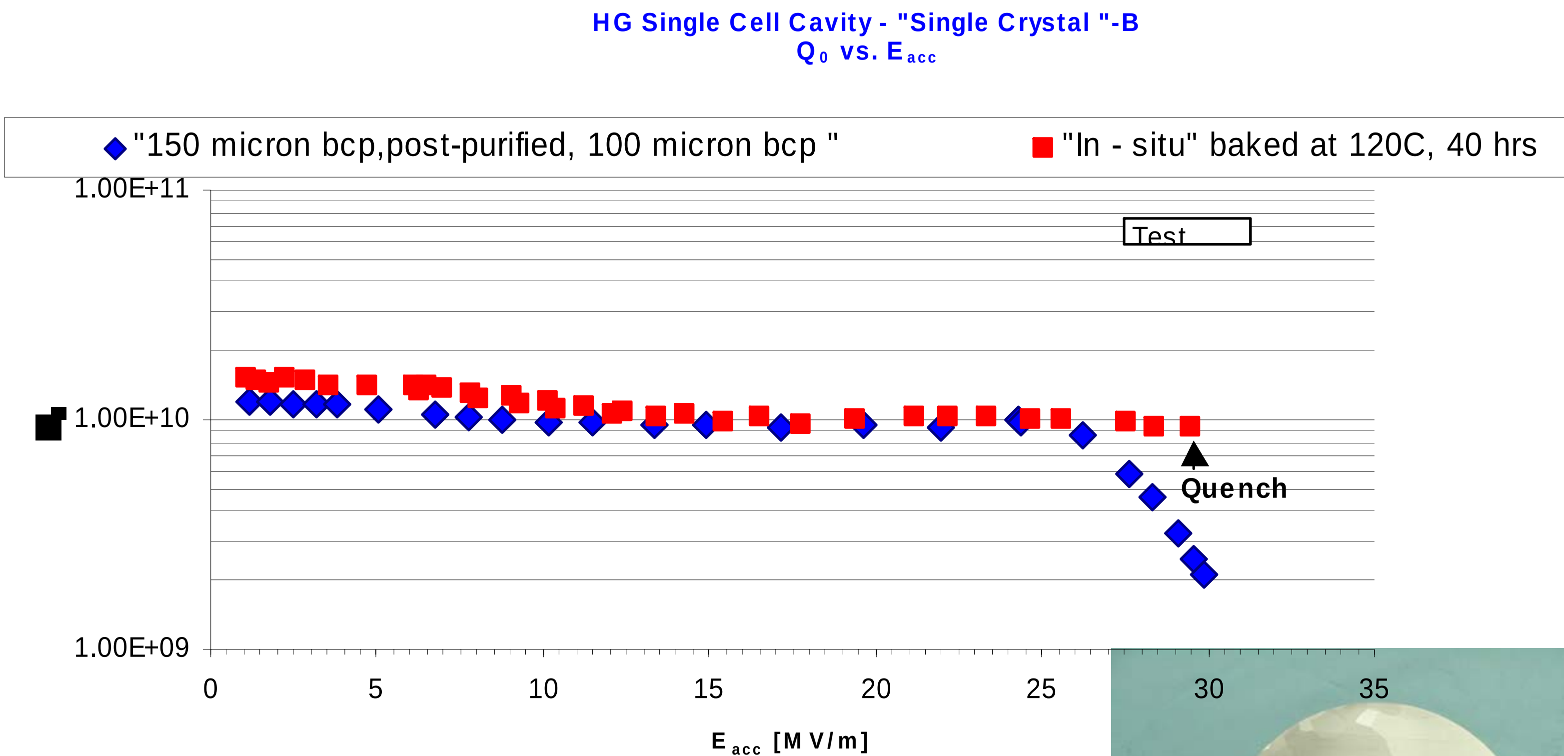


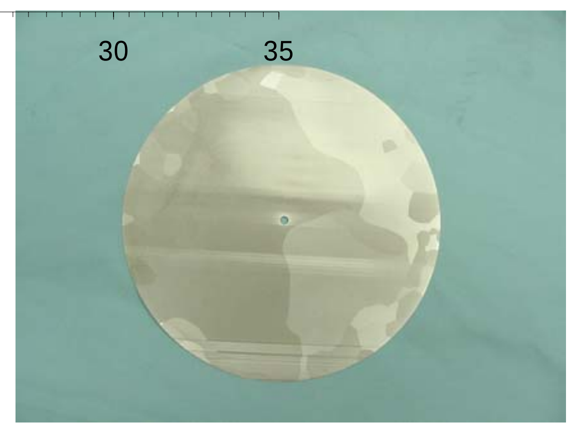
Jlab/CBMM Technology(2)

- Since the first ILC workshop we have fabricated and tested 5 single cell cavities (1300 MHz – 1500 MHz) from sliced material (wire EDM and saw cut) from 3 different ingots ("A","B","C"),3 different shapes, CBMM
- We have fabricated and tested 2 single crystal cavities from ingot "A" at 2.3 GHz, CBMM
- We have fabricated two 2.3 GHz cavities with material from a second vendor (WC) with somewhat smaller grains (not yet tested)
- We have fabricated a single cell cavity from large grain niobium from China-Ningxia (not yet tested)
- We have fabricated a 7-cell HG –Jlab-Upgrade cavity, which has been tested with problems so far (leaks, FE)
- We are in the process of fabricating an ILC_LL 7-cell cavity and intend to present results at the Snowmass meeting

Jlab/CBMM Technology(3)

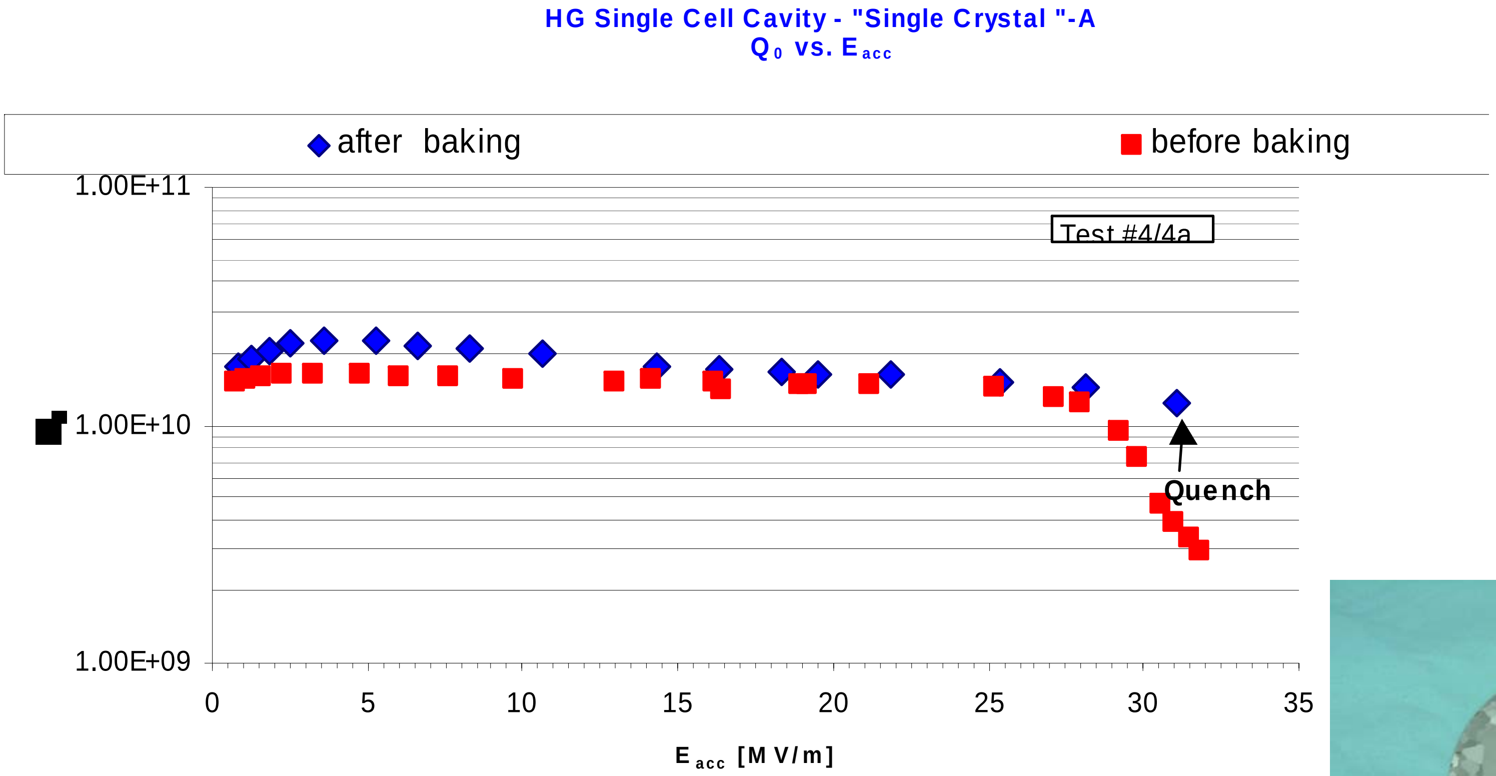
Ingot "B"

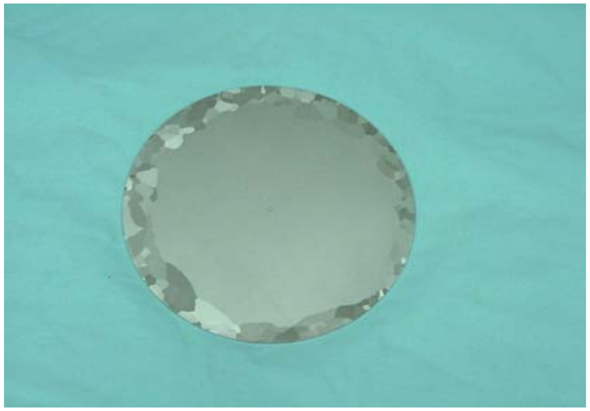




Jlab/CBMM Technology(4)

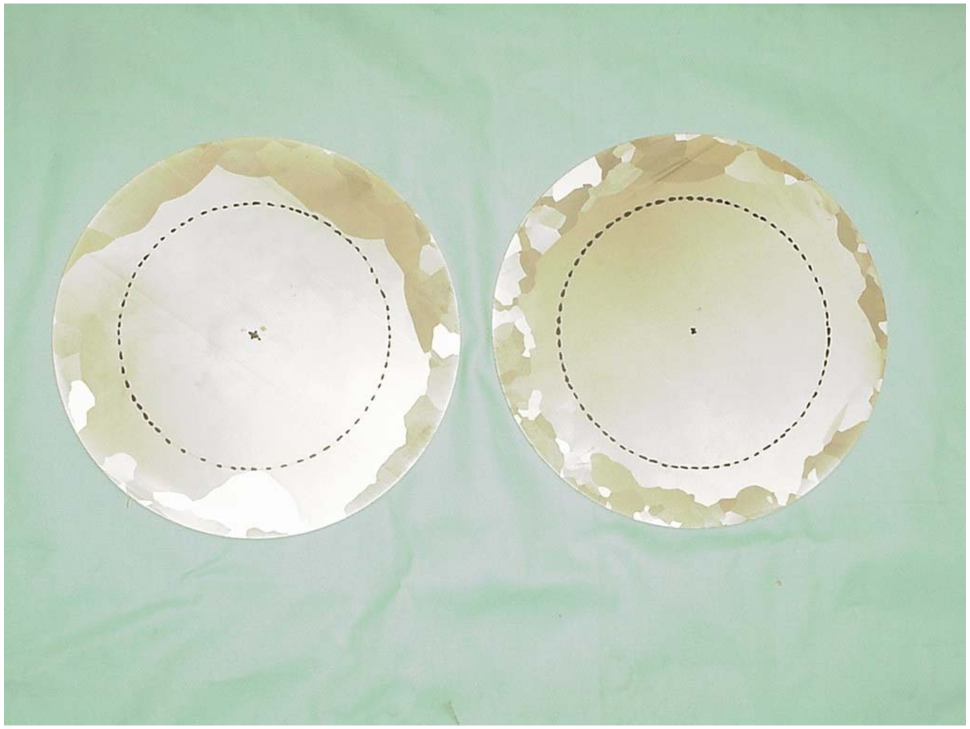
Ingot "A"





Jlab/CBMM Technology(5)

Discs from Ingot



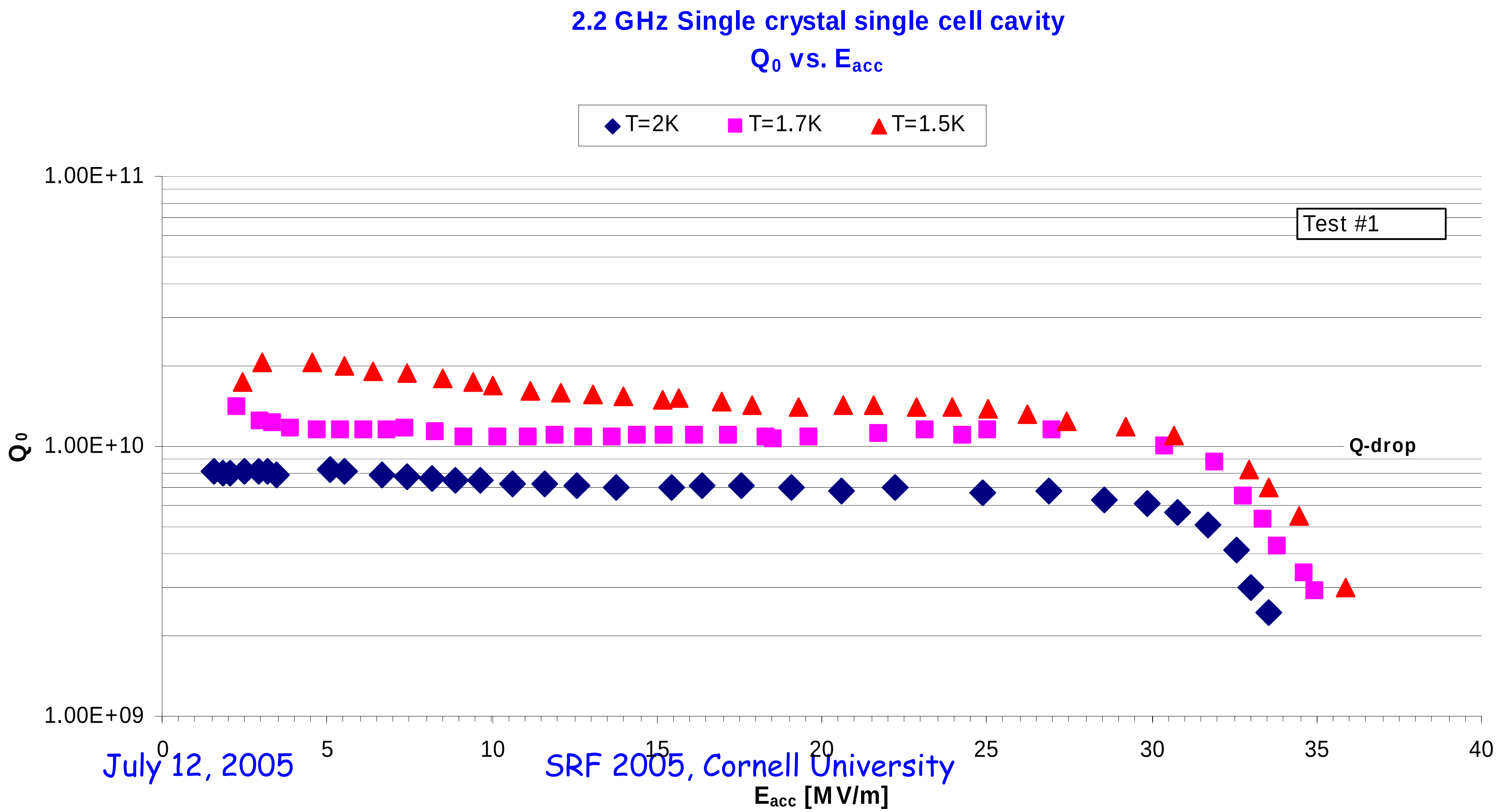
Cavity

E_{peak}/E_{acc} = 1.674

H_{peak}/E_{acc} = 4.286 mT/MV/m

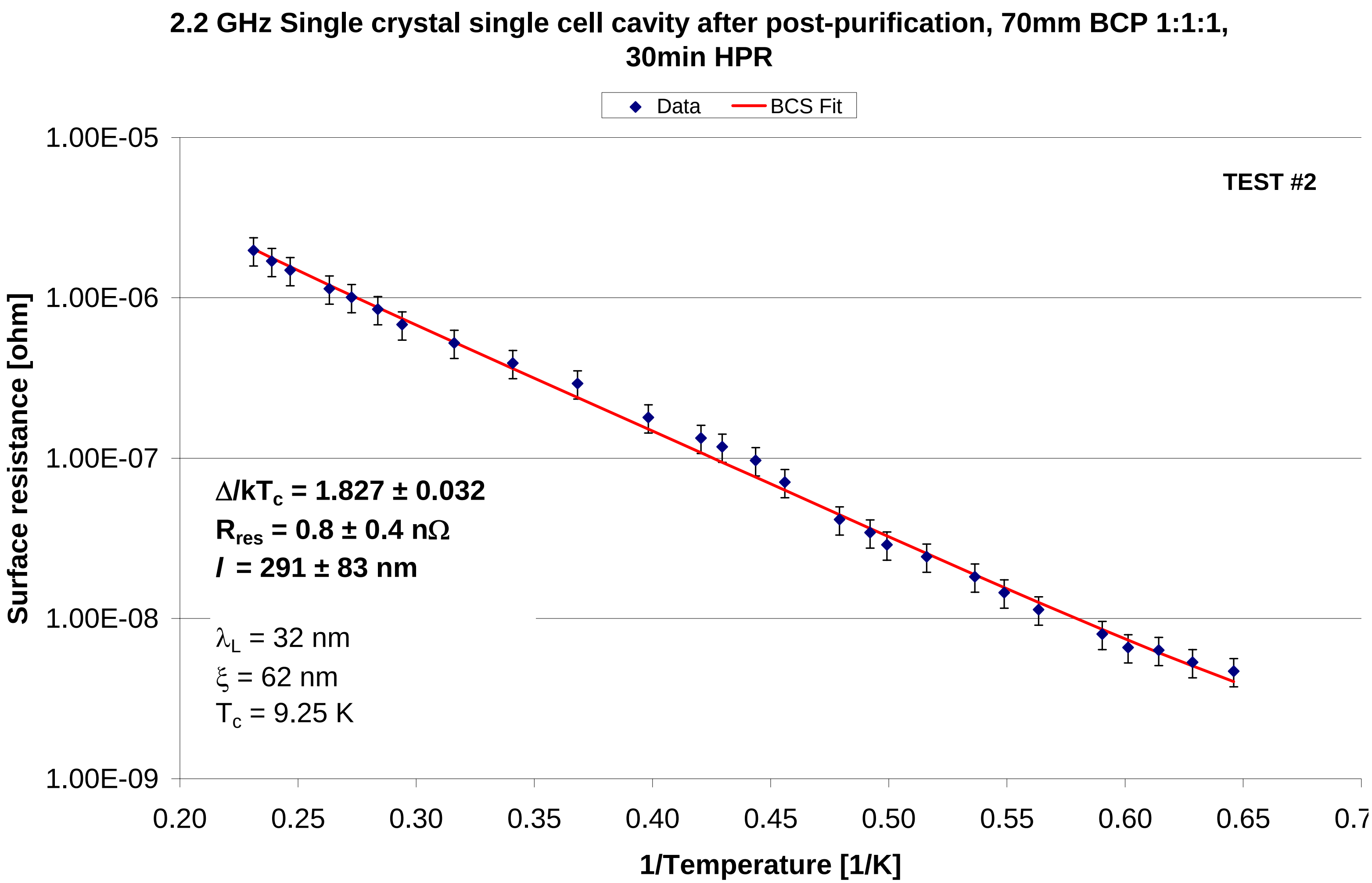
Single Crystal Niobium Cavity (1)

Test #1a: Treatment 100 μm BCP, 800C hydrogen degassing, 100 μm BCP, high pressure rinsing for 30 min



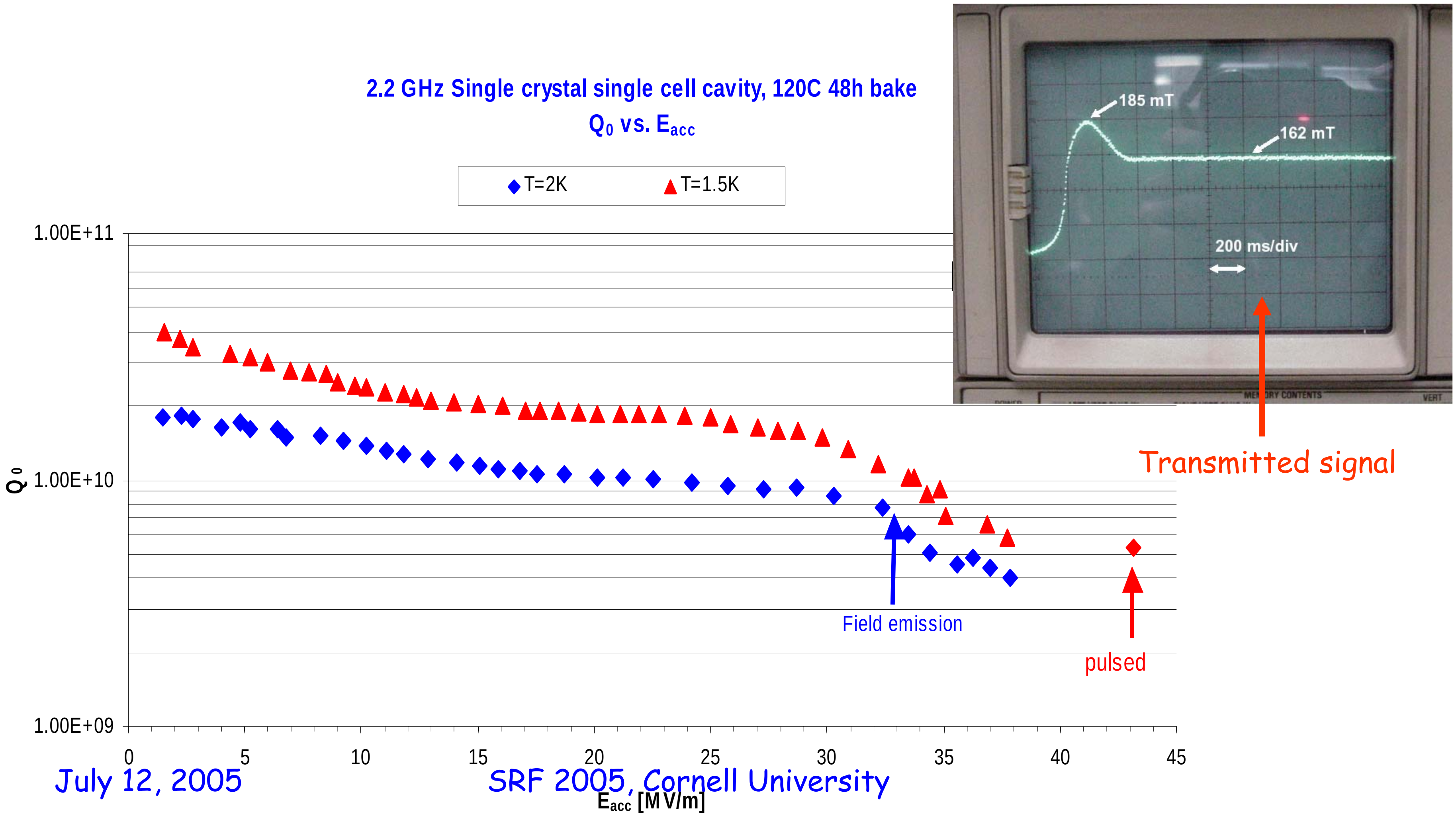
Single Crystal Niobium Cavity (2)

Test #2: T-dependence (before baking)



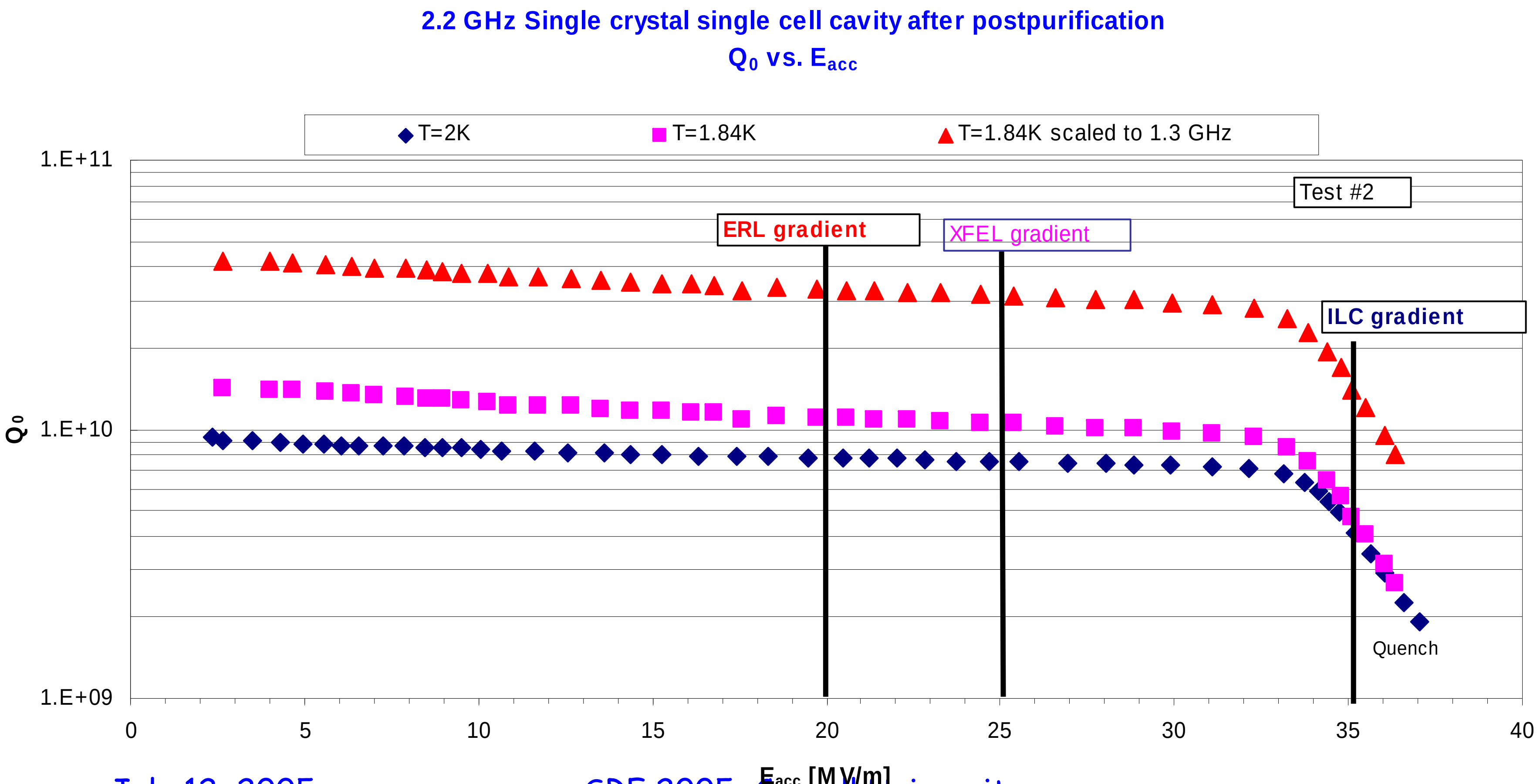
Single Crystal Niobium Cavity (3)

Test #1b: Treatment 100 μm BCP, 800C hydrogen degassing, 100 μm BCP, high pressure rinsing, "in situ" baked at 120C for 48 hrs



Single Crystal Niobium Cavity (4)

Test #2: post-purification heat treatment at 1250 C for 10 hrs, 100 μm BCP ,high pressure rinsing



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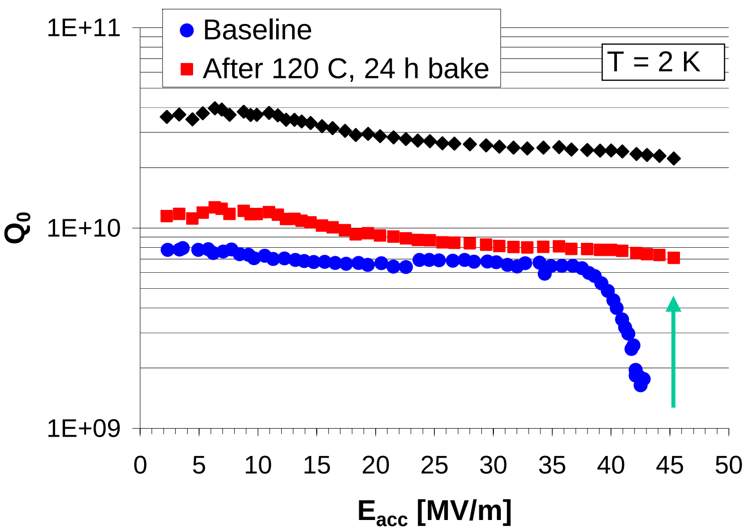
Nb Discs



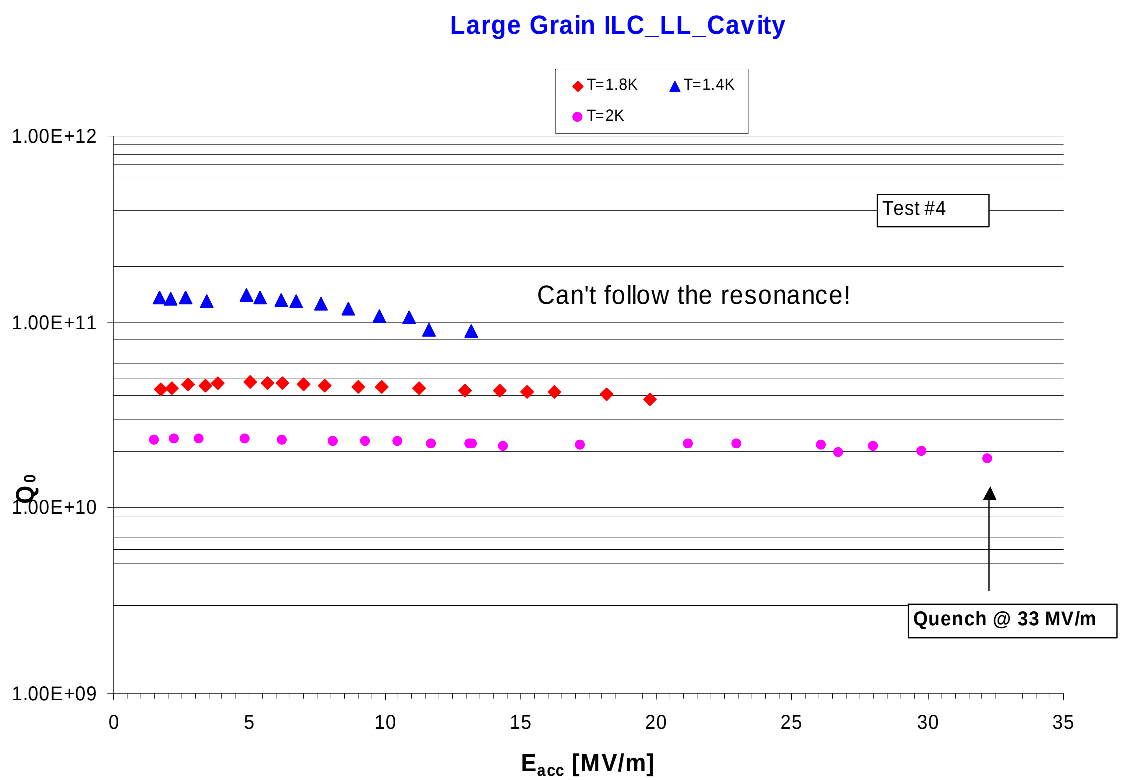
LL cavity 2.3GHz

E_{peak}/E_{acc} = 2.072

H_{peak}/E_{acc} = 3.56 mT/MV/m

Jlab/CBMM Technology(7)

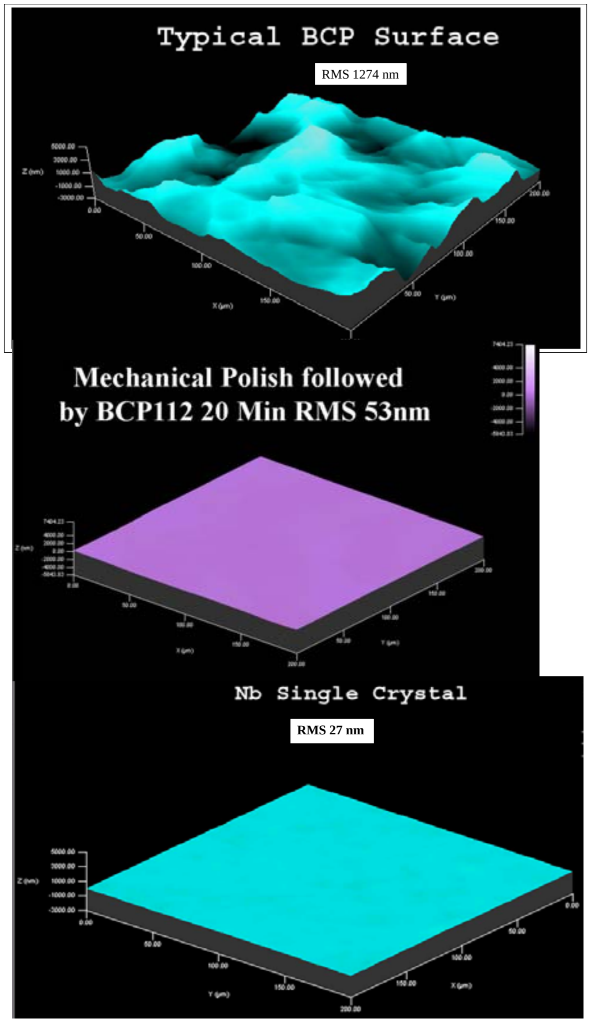
ILC_LL Cavities: no Q-drop w/o baking



1500 ppm Ta

Surface Roughness (1)

BCP provides very smooth surfaces as measured by A.Wu, Jlab

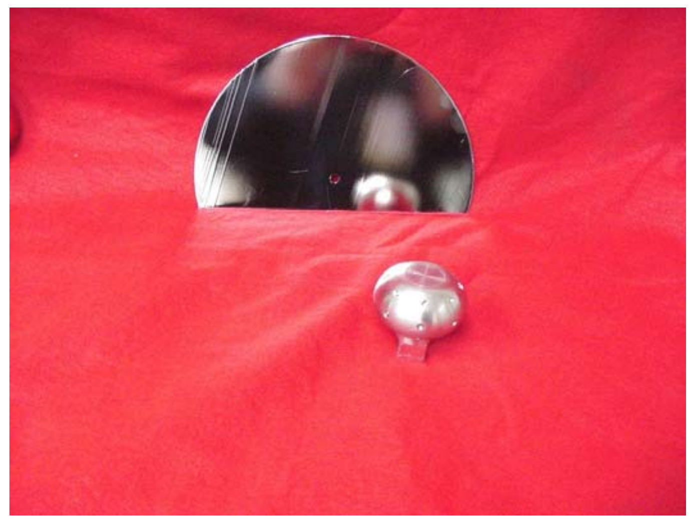


RMS: 1274 nm fine grain bcp

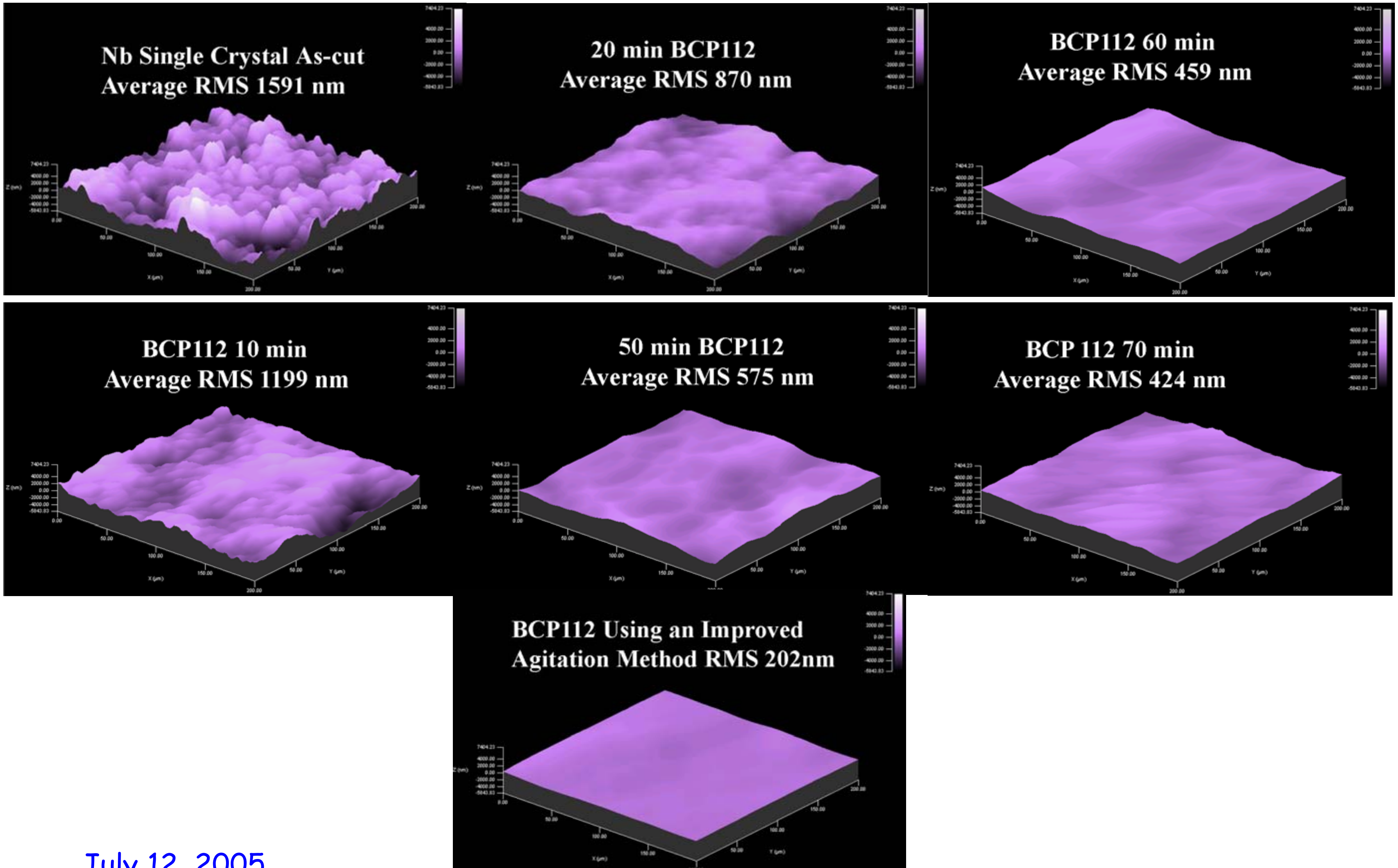
53 nm after ~ 35 micron, single Crys

27 nm after ~ 80 micron,single Crys

251 nm fine grain ep



Surface Roughness (2)(A. Wu)



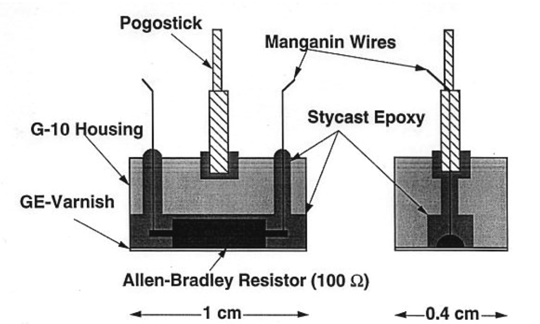
Jlab/CBMM Technology(8)

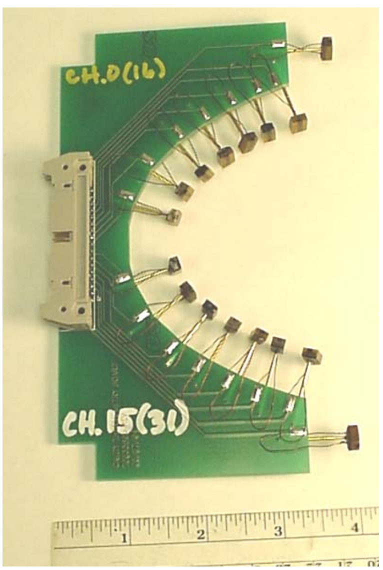
With a single cell cavity of the OC shape and fabricated from ingot "A" material we are investigating the "improvements" in cavity performance as a function of material removal employing T-mapping with the goal to:

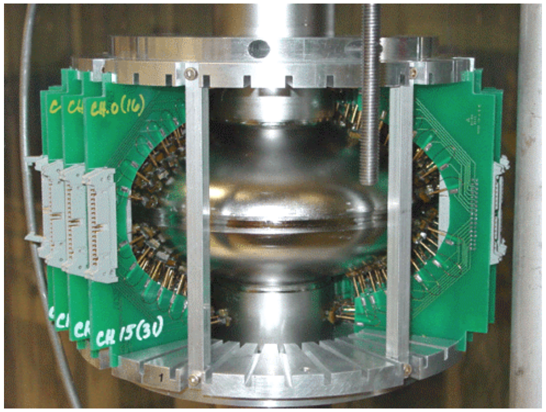
- understand the loss mechanisms in the cavity, especially in the region of the "Q-drop"
- "streamline" the surface treatment by BCP with respect to the amount of material removal, which might result in cost savings

T-Mapping (1)

T-mapping system: ~600 Allen-Bradley C-resistors



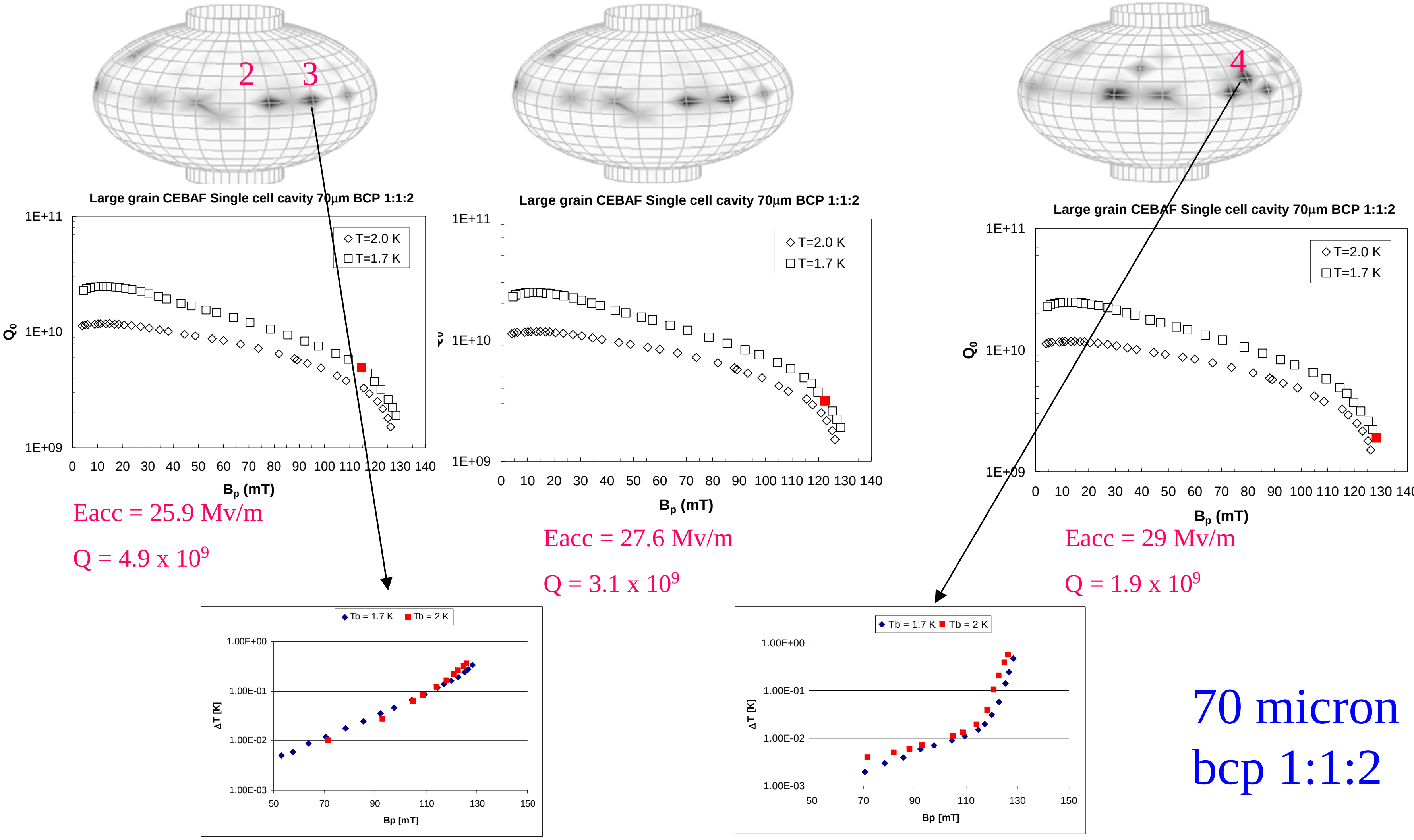




a)

b
)

T-Mapping (2)



Eacc = 25.9 Mv/m

Q = 4.9 x 10^9

Eacc = 27.6 Mv/m

Q = 3.1 x 10^9

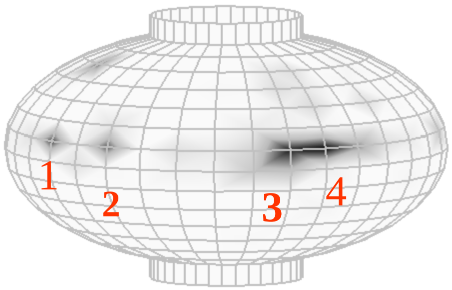
Eacc = 29 Mv/m

Q = 1.9 x 10^9

70 micron
bcp 1:1:2

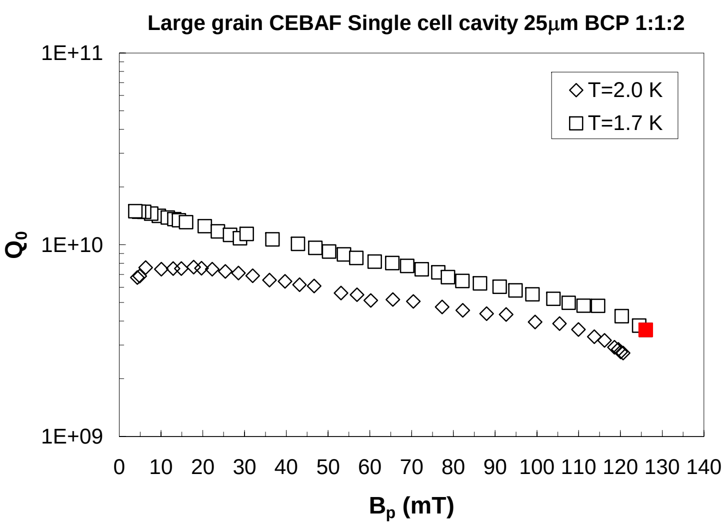
T - Mapping(3)

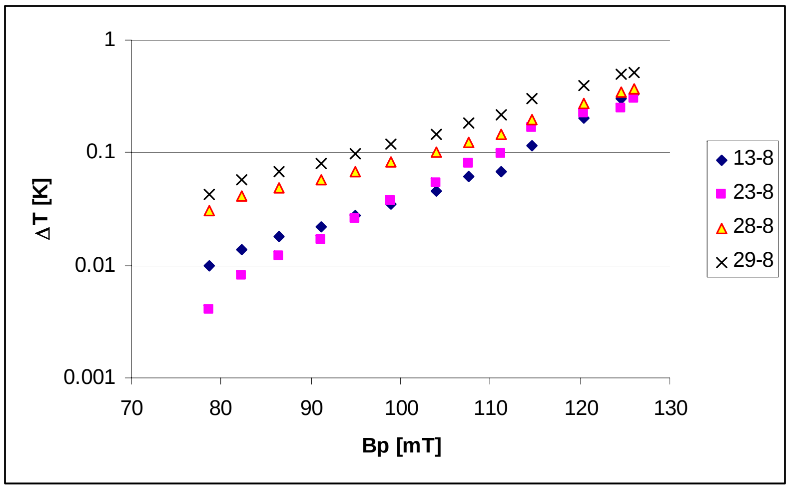
Add. 25 micron bcp 1:1:2



E_{acc} = 28.5 MV/m

Q = 3.6 x 10^9





Jlab/CBMM Technology(9)

What are the potential advantages of large grain/single crystal niobium?

- Reduced costs
- Comparable performance
- Very smooth surfaces with BCP, no EP necessary
- Possibly elimination of "in situ" baking because of "Q-drop" onset at higher gradients
- Possibly very low residual resistances (high Q's), favoring lower operation temperature(B.Petersen)
- Higher thermal stability because of "Phonon-Peak"
- Good or better mechanical performance than fine grain material (e.g.predictable spring back..)
- Less material QA (eddy current/squid scanning)

Cavities awaiting testing

Wah Chang

2.2 GHz, HG shape

China

1.5 GHz, OC shape

CBMM

1.3 GHz ILC LL shape

Acknowledgement

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