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Cornell Laboratory for
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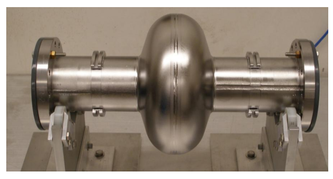
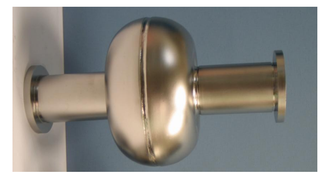


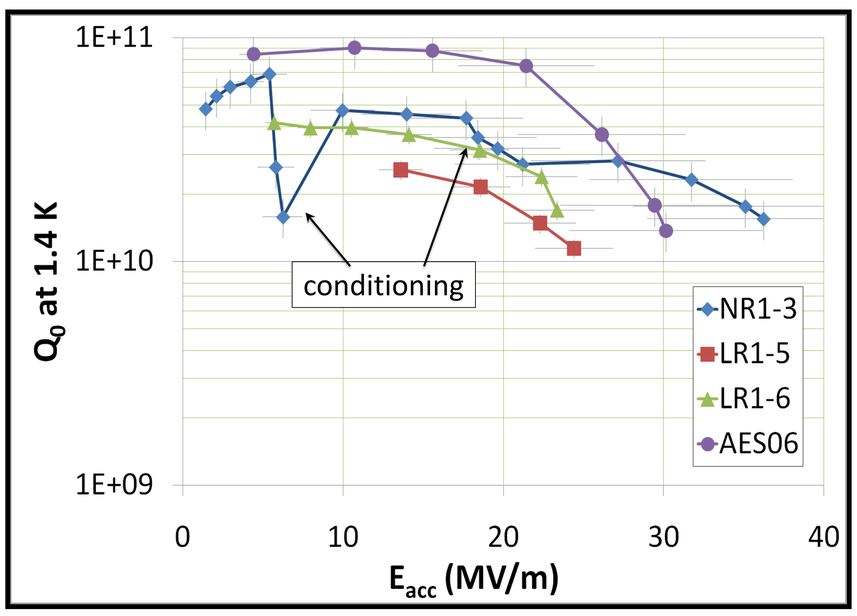
Quench Studies in Large and Fine Grain Nb Cavities

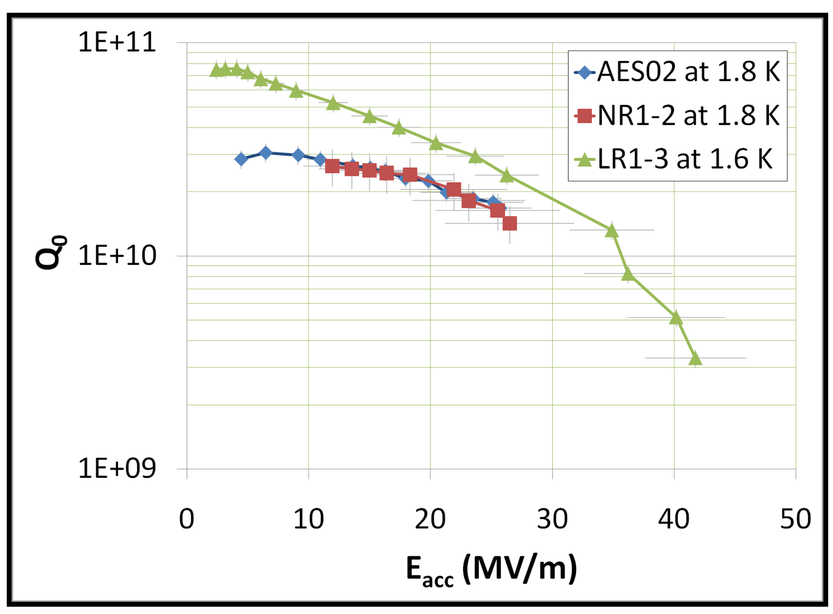
Sam Posen, Nicholas Ruben Alexander Valles, and Matthias Liepe



Abstract: Quenches without radiation are sometimes observed at fields between 25 and 40 MV/m in niobium SRF cavities. The cause for this limitation is not well understood. This work presents results from an investigation into quenches in seven 1.3 GHz single-cell cavities performing above 25 MV/m. Studies were carried out on both fine grain and large grain cavities in ILC and Cornell Reentrant shape geometries. The quenches were located by triangulation using Cornell oscillating superleak transducers and then cavities were optically inspected to determine the surface conditions of the cavity at the quench location. Optical inspection images are presented as well as 3D recreations of quench spots generated using a surface mold and a confocal microscope.

cavity name	AES02	AES06	NR1-2	NR1-3	LR1-3	LR1-5	LR1-6
shape	ILC	ILC	ILC	ILC	reentrant	reentrant	reentrant
grain	fine	fine	fine	fine	fine	large	large
last main chemistry	~300 um VEP	~300 um VEP	~200 um VEP	~300 um VEP	VEP (C. barrel polish prior)	BCP	BCP
800 C bake	2h	2h	2h	2h	2h	n/a	n/a
final chemistry	micro-VEP	micro-VEP	micro-VEP	micro-VEP	micro-VEP	n/a	n/a
120 C bake	20 h	48h	48h	48h	48h	48h	48h
max acc. field	27 MV/m	30 MV/m	27 MV/m	36 MV/m	42 MV/m	24 MV/m	23 MV/m
limitation	quench, no radiation	quench, no radiation	quench, no radiation	quench, small radiation	quench, no radiation	quench, no radiation	quench, no radiation
OST results	quench at 1 location	quench at 2 locations	quench at 1 location	large quench region	Global quench	quench at 1 location	quench at 1 location
highest Q0 at low fields	$3x10^{10}$ at 1.8K	$9x10^{10}$ at 1.4K	$3x10^{10}$ at 1.8K	$7x10^{10}$ at 1.4K	$8x10^{10}$ at 1.6K	$3x10^{10}$ at 1.4K	$6x10^{10}$ at 1.4K
optical inspection result	No defects observed	No defects near quench locations, but pits and bumps at other locations	No defects near quench locations, but pits and bumps at other locations	No defects observed	Some discolored spots observed	Rough area near weld and grain boundaries. Mold taken.	Rough area near weld and grain boundaries.



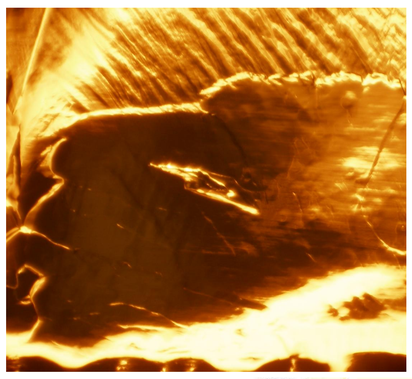


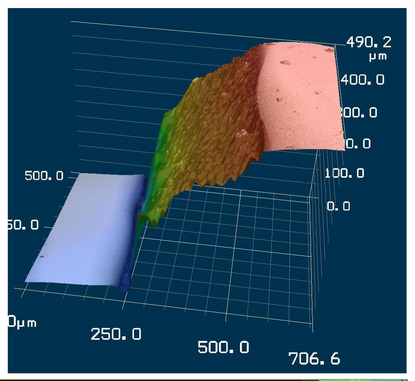
LR1-3

Typical image of surface

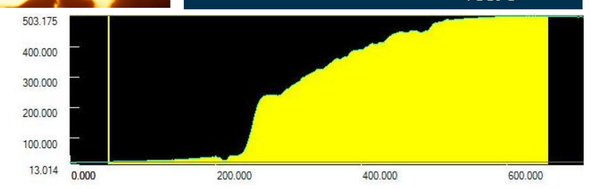
Discoloration that did not cause quench

LR1-5



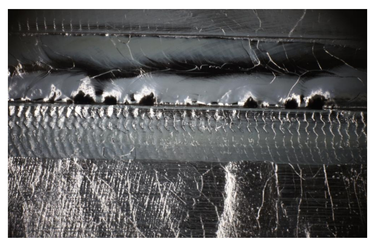


Quench location (above left)

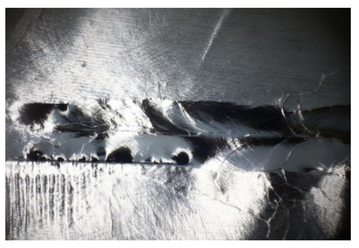


Confocal microscope rendering (above right) and profile (below) of 500 um high step in surface mold of quench spot

LR1-6



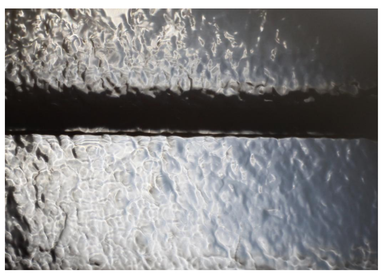
Quench location



Typical image near equator

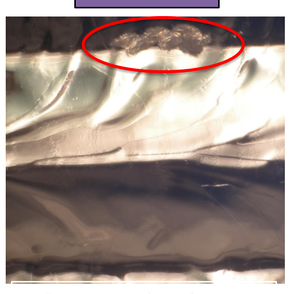
Cornell Reentrant cavities – manufactured by Cornell

AES02

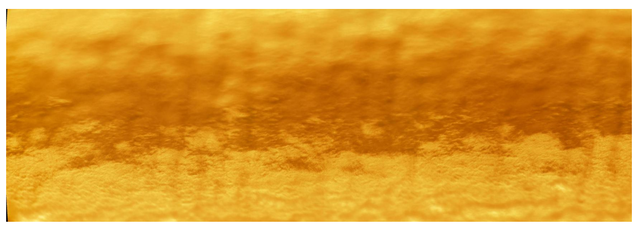


Quench location

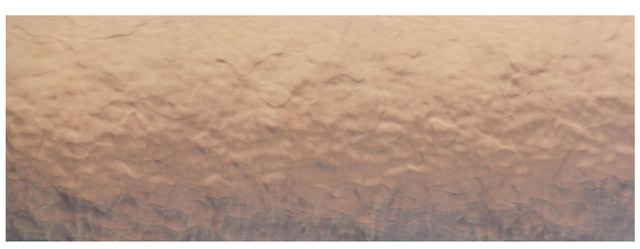
AES06



Scratch far from quench locations



Pit/bump far from quench locations, about halfway between iris and equator

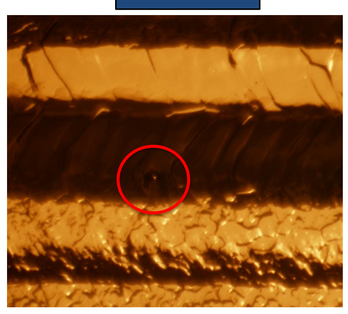


Quench locations

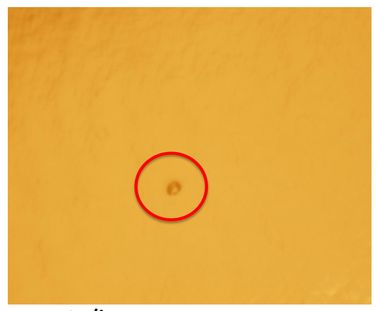
ILC single cells – manufactured by AES

NR1-2

Quench location



Pit/bump ~2 cm away from quench location



Pit/bump ~3 cm away from quench location

ILC single cells – manufactured by Niowave

NR1-3

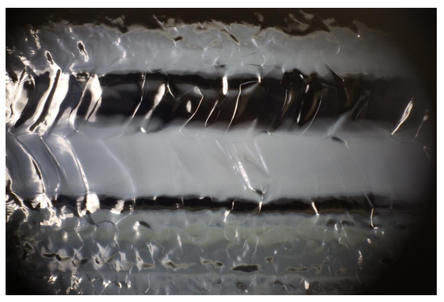


Image from quench region

Some conclusions can be made based on these tests.

- AES02, AES06, NR1-2, and NR1-3 show that **quenches without radiation at 25-40 MV/m can occur in locations with no topological defects**
- Whether or not these type of quenches occur **does not seem to depend on the manufacturer**
- VEP can reliably produce cavities with very good low-field Qs
- VEP can produce cavities with accelerating fields exceeding 40 MV/m

These tests do not point to any particular cause for quenches at 25-40 MV/m without radiation. To investigate further, a full-cavity single cell T-map is being commissioned that will fit both ILC and Cornell ERL shape cavities. Several cavities will be fabricated and tested with T-map. After testing, the cavities will be dissected, and surface studies will be performed on any hot spots.

LEPP, the Cornell University Laboratory for Elementary-Particle Physics, and CHESS resources have merged and a new lab, (CLASSE), has formed. CLASSE develops and operates facilities and provides infrastructure for the study of beams and accelerators, photon science, particle physics and the early universe, serving students, the public and scientists from Cornell and elsewhere. LEPP's primary source of support is the National Science Foundation.