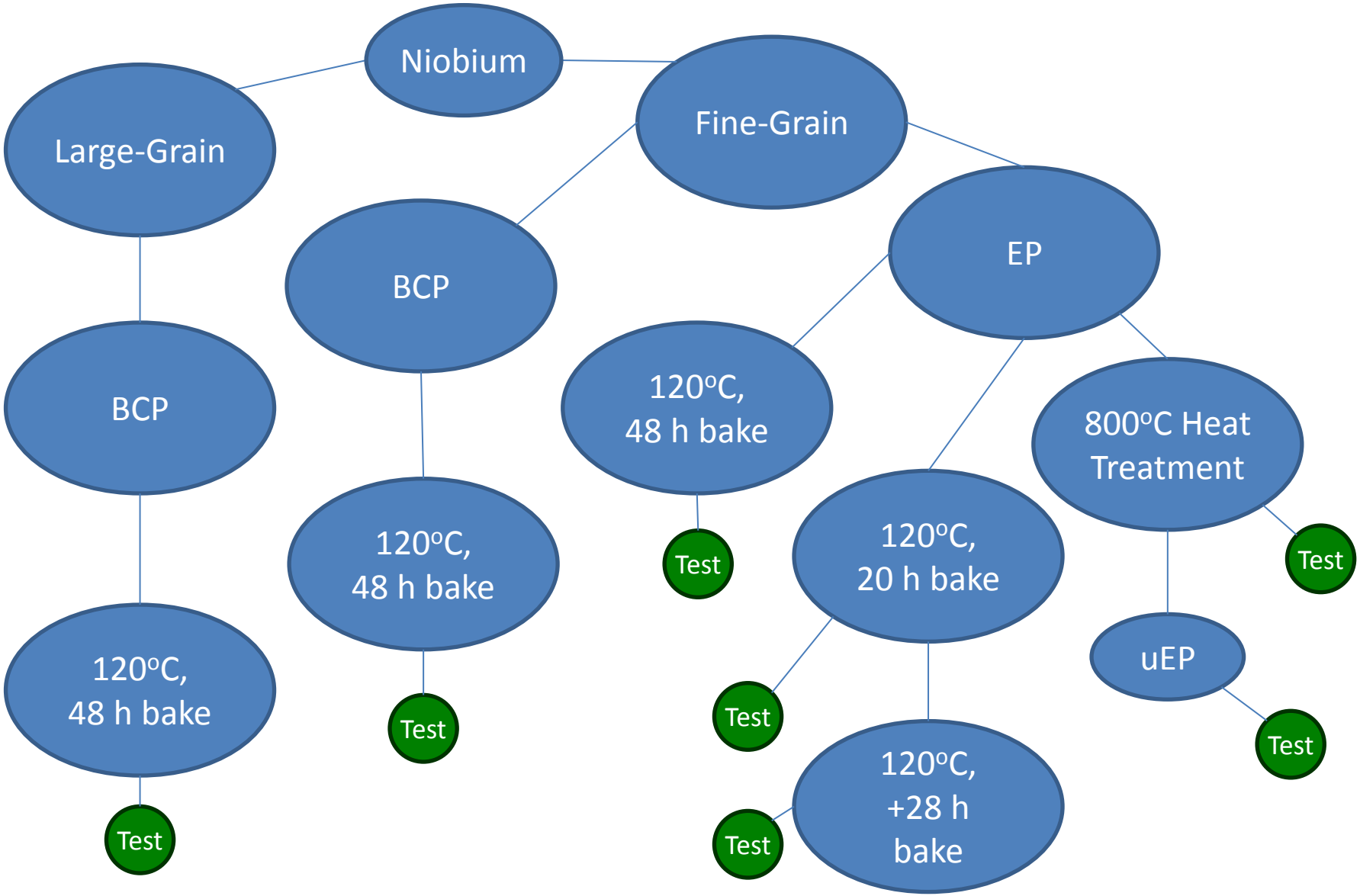
High Q Cavities at Cornell University

N. Valles, D. Gonnella, M. Liepe, S. Posen
Cornell University

Motivation

- Most important figure of merit for CW machines is Q_0
- We investigate the impact of preparation on cavity residual resistance
- We apply these techniques to the first Cornell ERL 7-cell cavity and show record results for a cryomodule test
  - $Q_0 = 6 \times 10^{10}$ at 1.6 K

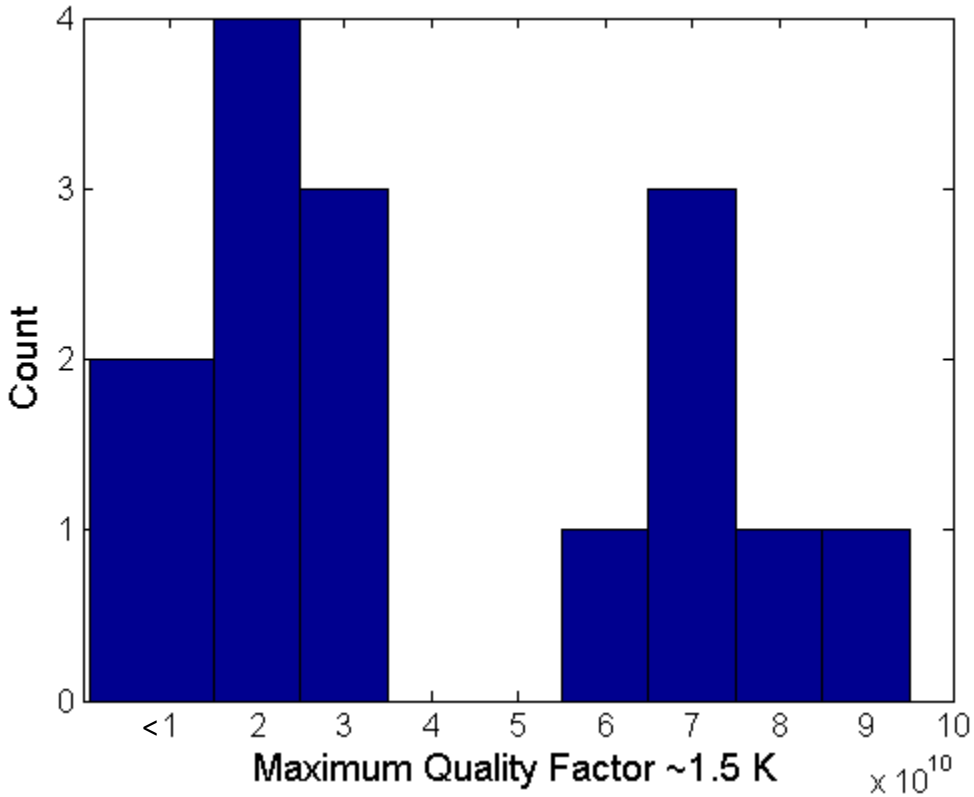
Single Cell Preparation Methods



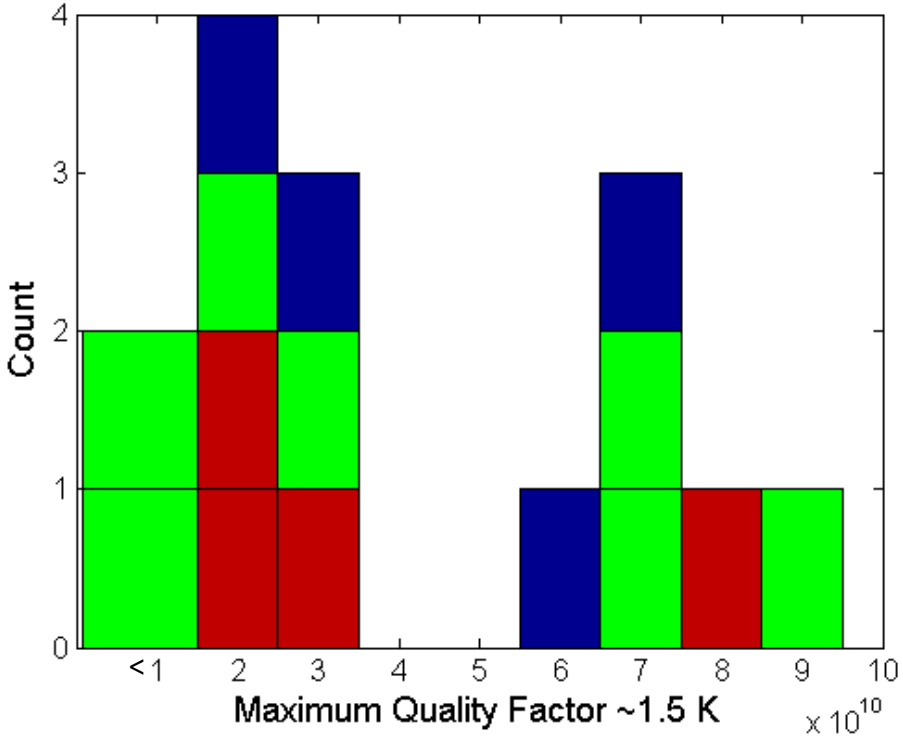
Summary of Cavity Tests

	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
Manufacturer	AES	AES	Niowave	Niowave	Cornell	Cornell	Cornell
Main Chem.	300 um VEP	300 um VEP	200 um VEP	300 um VEP	VEP after CBP	BCP	BCP
800 C bake [h]	2	2	2	2	2	--	--
120 C bake [h]	20	48	48	48	--	48	48
Bpk [mT]	120	130	120	150	150	90	86
Highest Q_0	$5x10^{10}$	$9x10^{10}$	$3x10^{10}$	$7x10^{10}$	$8x10^{10}$	$3x10^{10}$	$6x10^{10}$
Temp [K]	1.8	1.4	1.8	1.4	1.6	1.4	1.4
Quench	1 location	2 locations	1 location	Large region	Global	1 location	1 location
Optical Inspection	No visible defects	No defects near quench	No defects near quench	No visible defects	Discolored spots	Rough area near weld	Rough area near weld

‘Low Temperature’ Maximum Q’s



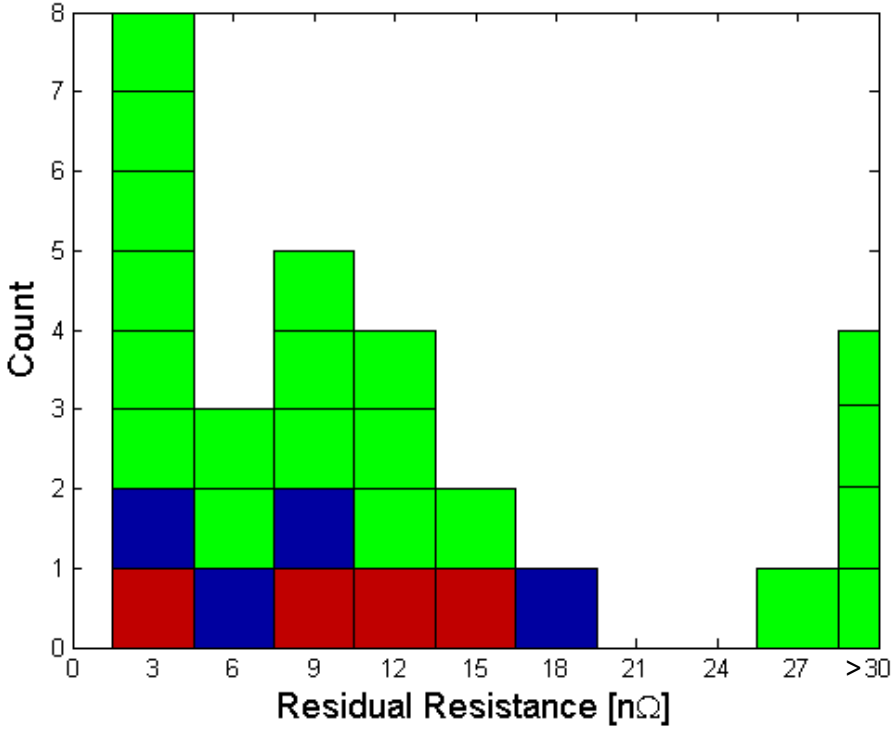
‘Low Temperature’ Maximum Q’s



Break down of treatment and maximum Q

- **800°C Bake**
- **Electropolish**
- **Buffer Chemical Polish**

Residual Resistance

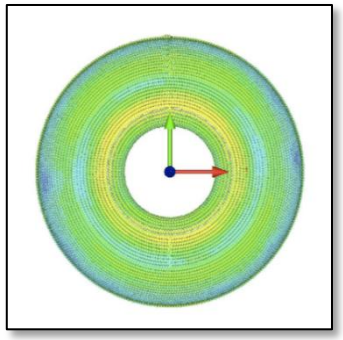


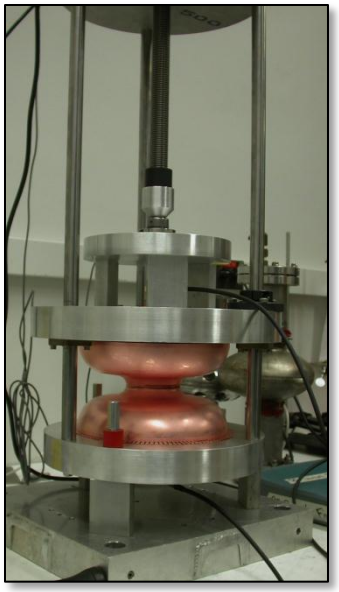
Break down of treatment and residual resistance

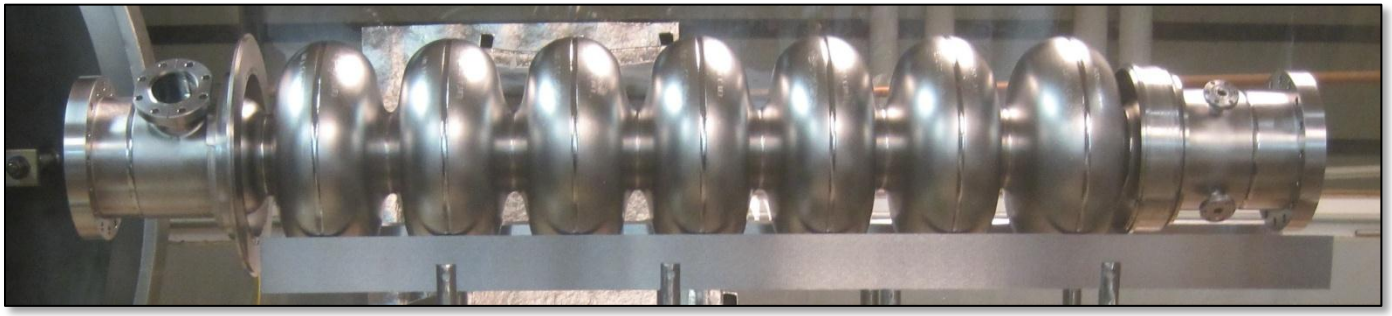
- **800°C Bake**
- **Electropolish**
- **Buffer Chemical Polish**

CERL 7-Cell Preparation

- Bulk BCP
- After fabrication, heat treated cavity at 650°C for 12 hr
- Final BCP
- High pressure rinse
- 120°C bake for 48 hr

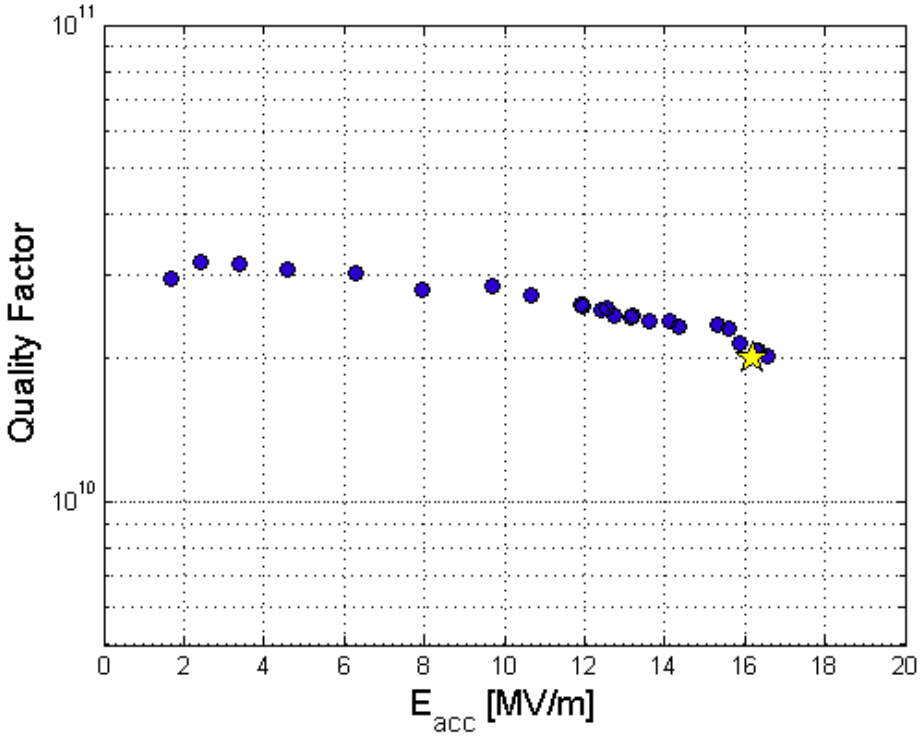






Cryomodule Test Results (1.8 K)

- Initial max(Q_o) = 3.18 x 10^{10}



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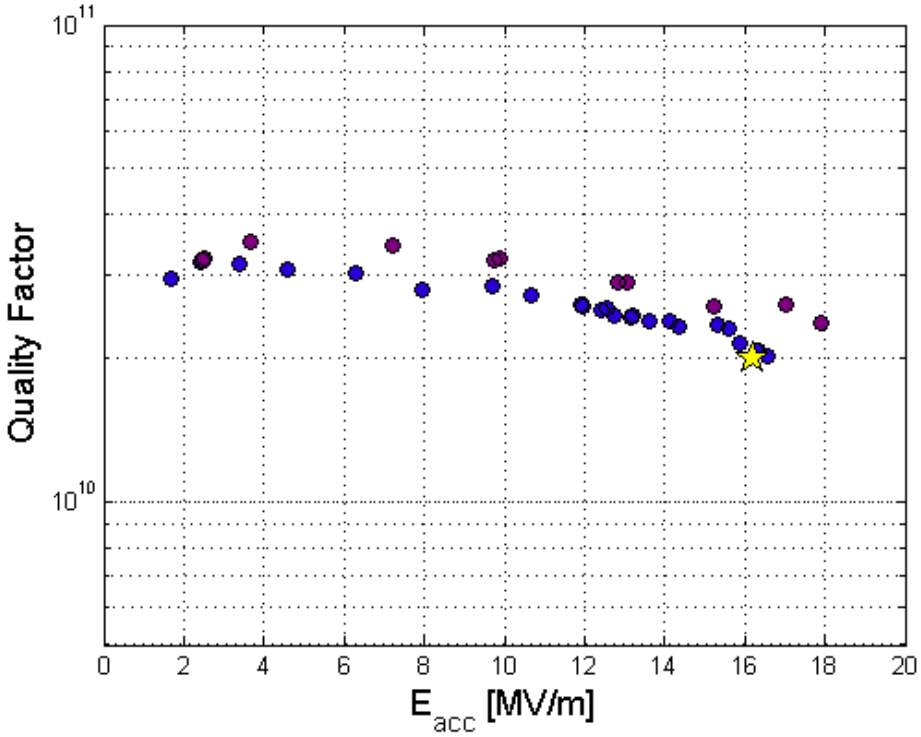

- Initial max(Q_o) = 3.18 x 10^{10}
- Warmed > 10 K
  - max(Q_o) = 3.52 x 10^{10}
  - max(Q_o) increased 11%

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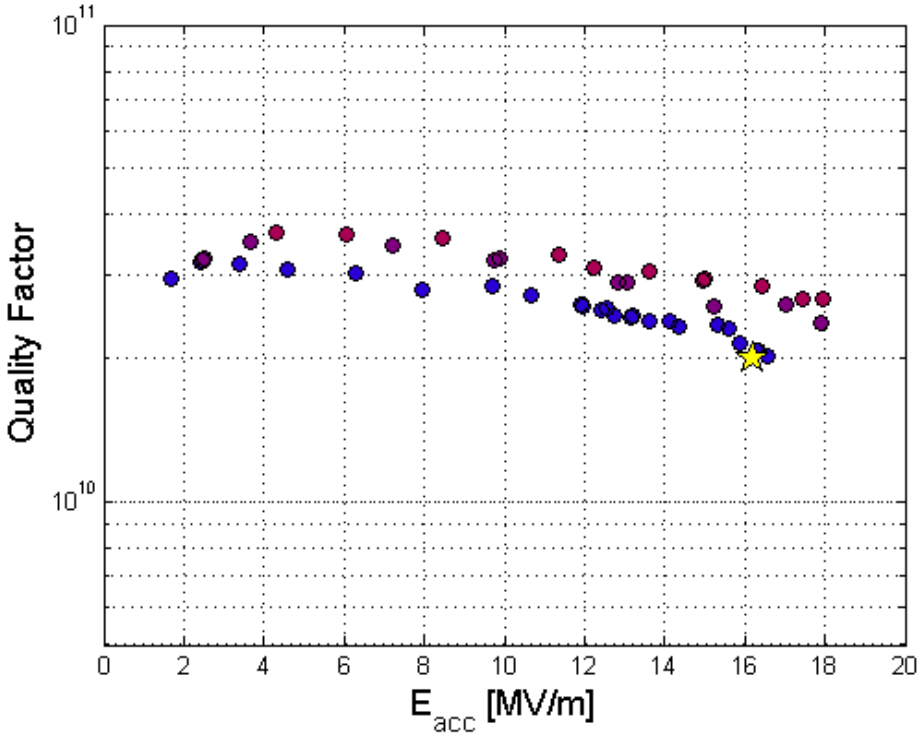

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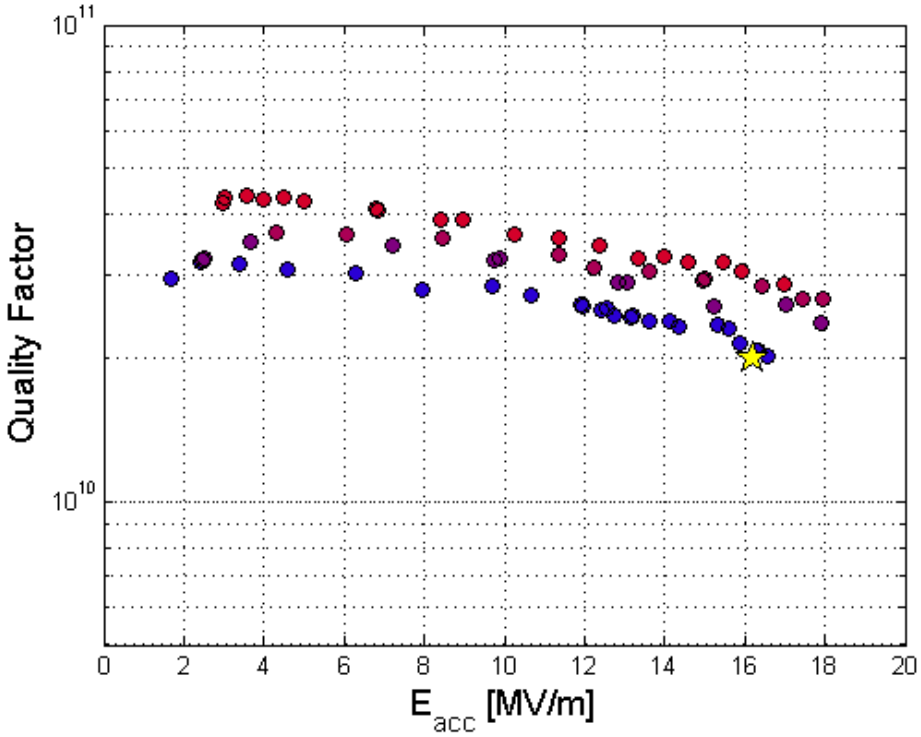
- Warmed > 10 K
  - max(Q_o) = 3.52 x 10^{10}
  - max(Q_o) increased 11%
- Warmed > 10 K
  - max(Q_o) = 3.67 x 10^{10}
  - max(Q_o) increased 4%

Cryomodule Test Results (1.8 K)



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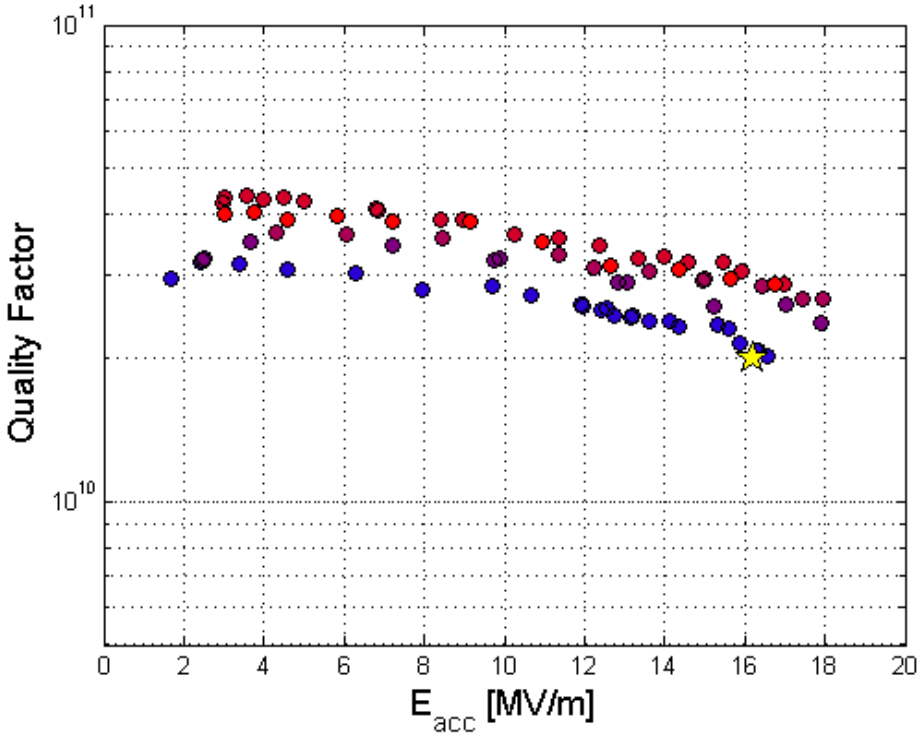
  - max(Q_o) = 3.52 x 10^{10}
  - max(Q_o) increased 11%
- Warmed > 10 K
  - max(Q_o) = 3.67 x 10^{10}
  - max(Q_o) increased 4%
- Warmed > 100 K
  - max(Q_o) = 4.37 x 10^{10}
  - max(Q_o) increased 19%

Cryomodule Test Results (1.8 K)



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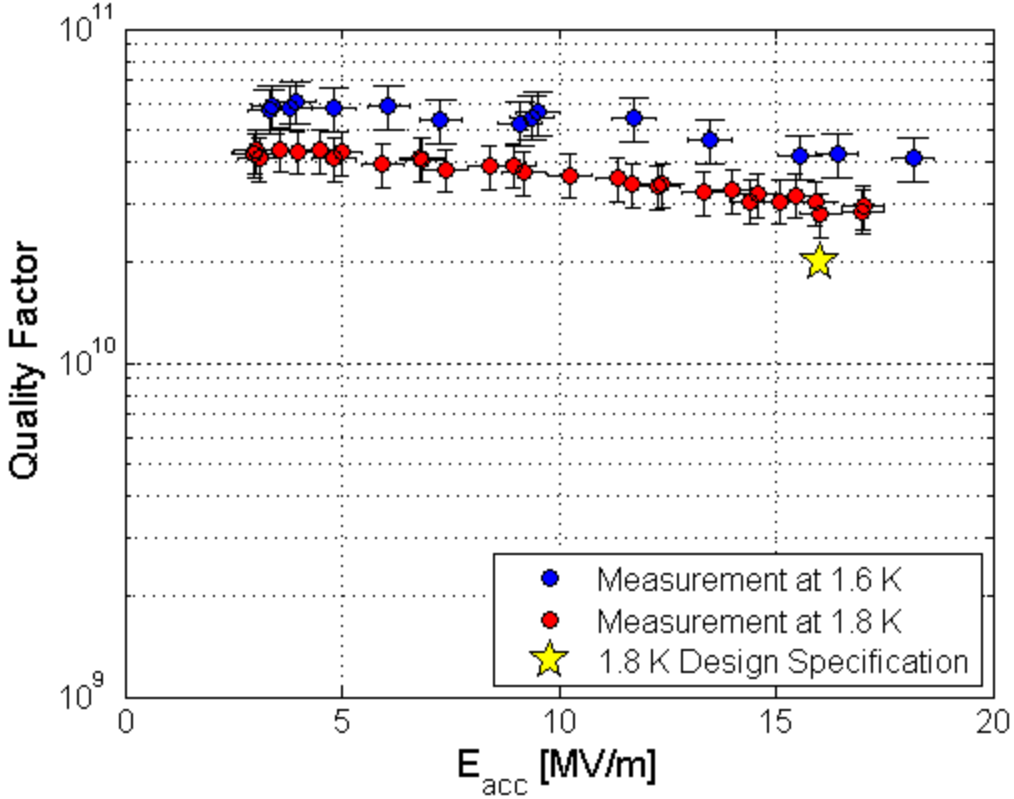
  - max(Q_o) = 3.52 x 10^{10}
  - max(Q_o) increased 11%
- Warmed > 10 K
  - max(Q_o) = 3.67 x 10^{10}
  - max(Q_o) increased 4%
- Warmed > 100 K
  - max(Q_o) = 4.37 x 10^{10}
  - max(Q_o) increased 19%
- Warmed > 100 K, fast cool down
  - max(Q_o) = 4.06 x 10^{10}
  - max(Q_o) **decreased** 7%

Comparison 1.6, 1.8 K Q vs E



Maximum $Q_o = 6 \times 10^{10}$ at 1.6 K

($R_{res} \sim 4.5$ nΩ)

Conclusions

- High quality factor cavities can be produced through several different methods
  - Final surface chemistry (EP, BCP) after heat treatment not necessarily required for high Q's
    (At least for fine grain)
  - High Q's can be obtained without 120°C bake
- More tests are needed for good statistics
- Thermal cycling can help to boost Q-factors
  - Above 10 K needed to release trapped flux (?)
  - Above 100 K needed to remove adsorbed gas (?)
- ERL cavity reached $Q_0 = 6 \times 10^{10}$ in cryomodule