

Recent 9-Cell Cavity Test Results From FNAL

TB9RI024 and TB9RI026

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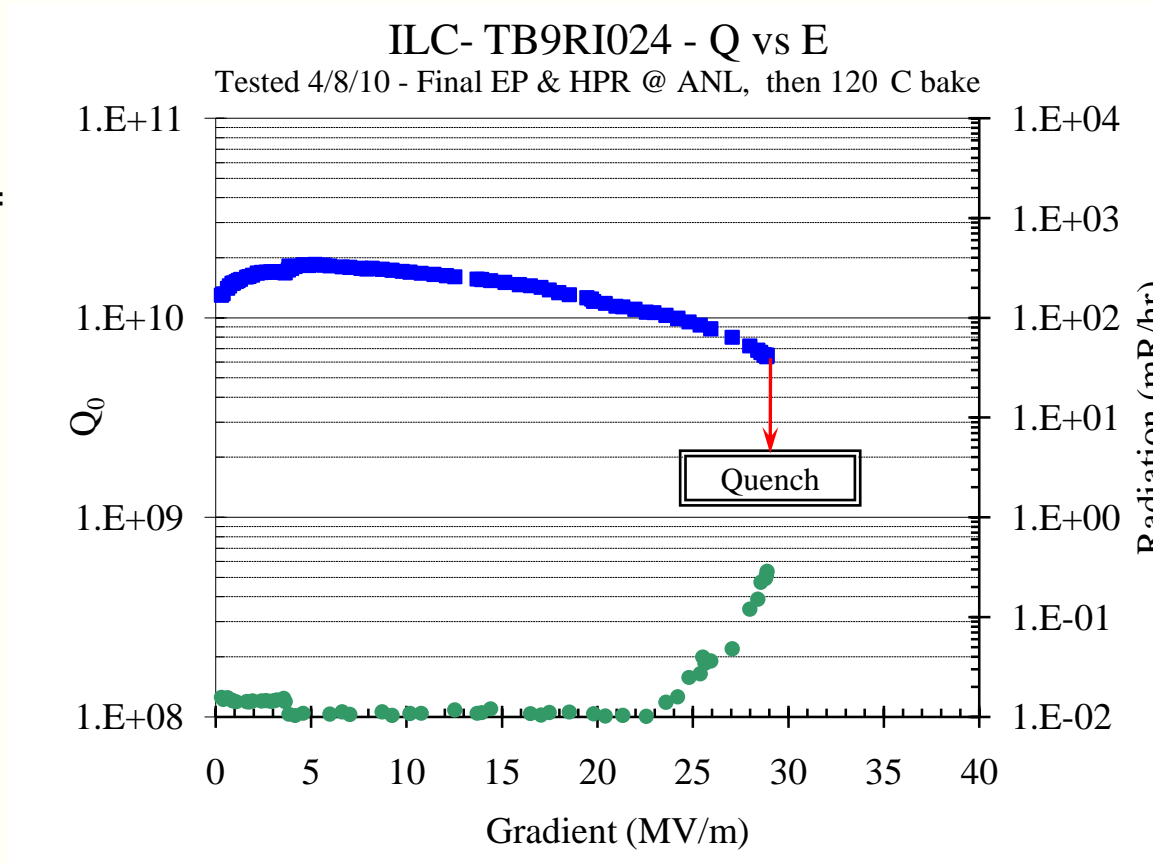
TB9RI024 – new cavity fabricated by RI, bulk EP performed at RI, remainder of processing at FNAL/ANL and JLab (800°C H de-gassing). First test w/OST's (second-sound sensors).

TB9RI026 – new cavity fabricated by RI, all processing at FNAL/ANL (bulk and final EP, HPR, etc.) except 800°C H de-gassing at JLab. Cavity sat in the Dewar at 4.5K for ~2 weeks due to cryoplant compressor failure/replacement.

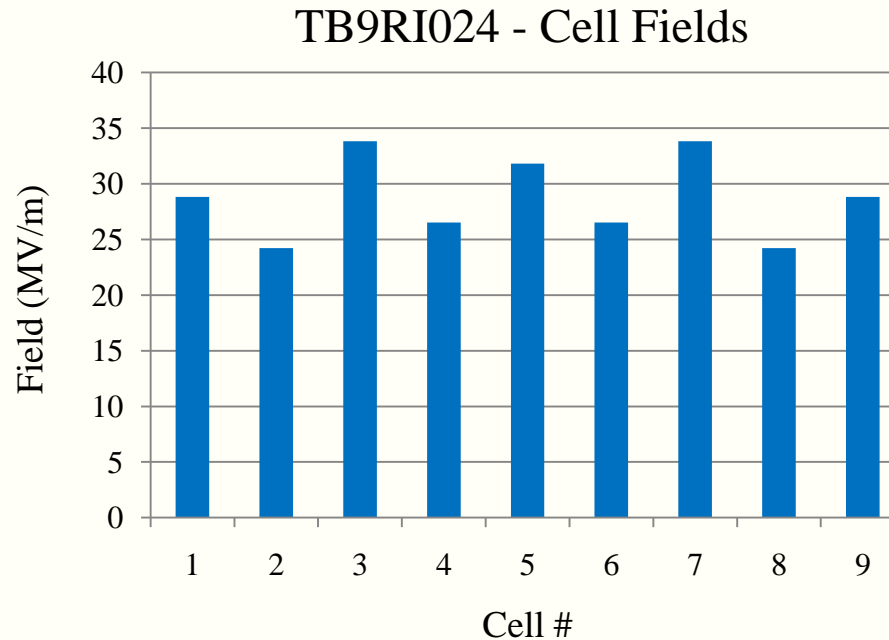
Note: all tests performed at 2K with cavity actively pumped, fixed input coupling (typically between 6×10^9 to 1×10^{10}). Cooldown is fast - 1 to 2 minutes between 140-100K. Full cable calibrations performed for each test – reproducibility of calibration 3-4%.

- Fabricated by RI
- Bulk (130 μ m) EP at RI
- Inspections (visual, CMM, RF, optical)
- H de-gassing (800°C, 2 hours) @ JLab
- Light EP (70 minutes), HPR, assy
- 120°C bakeout (63hrs)
- Vertical test

Low field $Q_0 = 1.75 \times 10^{10}$

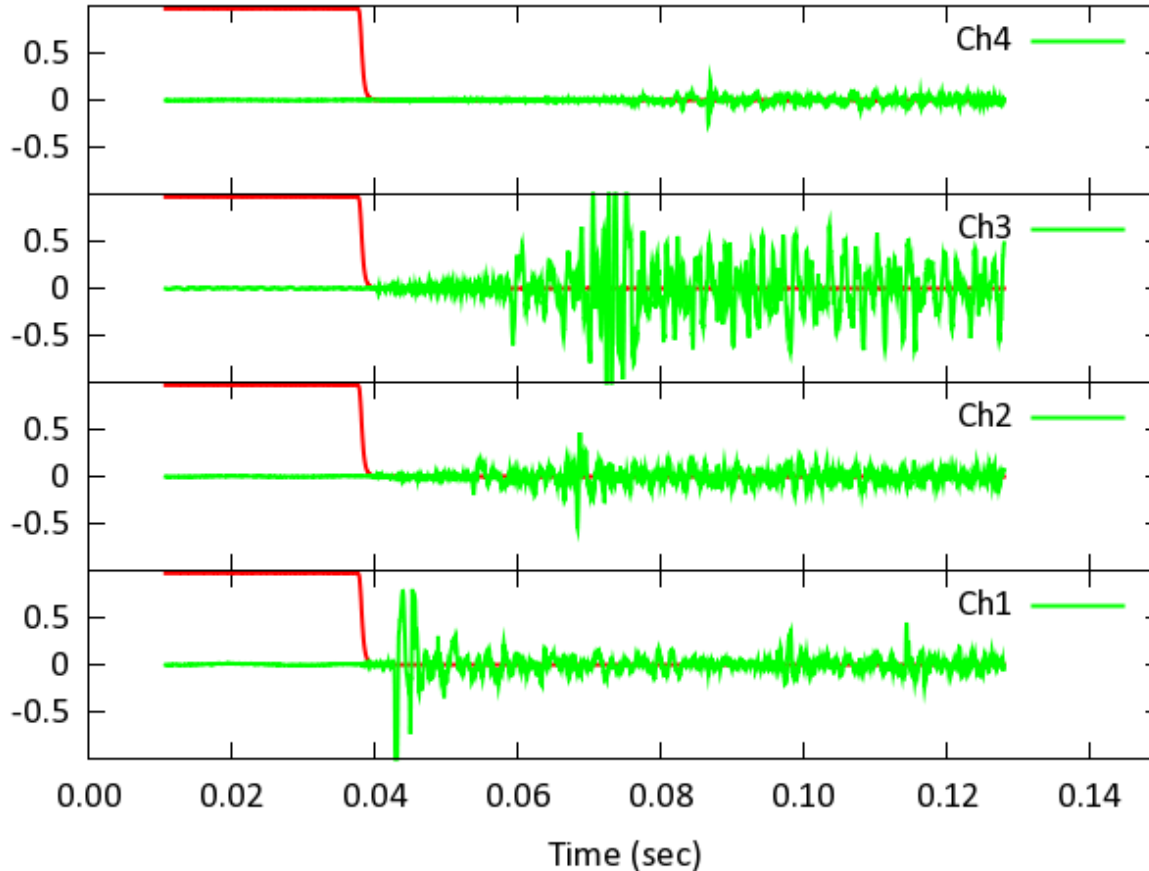


Quench at 28.8 MV/m, Q_0 at quench = 6.5×10^9
 FE onset at 23.6 MV/m, radiation levels moderate. Fairly strong Q-slope beginning at ~ 20MV/m, even without presence of FE.



Cells 2/8 lowest performing, quench at 24MV/m.

Four OSTs' (second sound) were mounted on the test stand insert, preliminary data suggest cell #2.



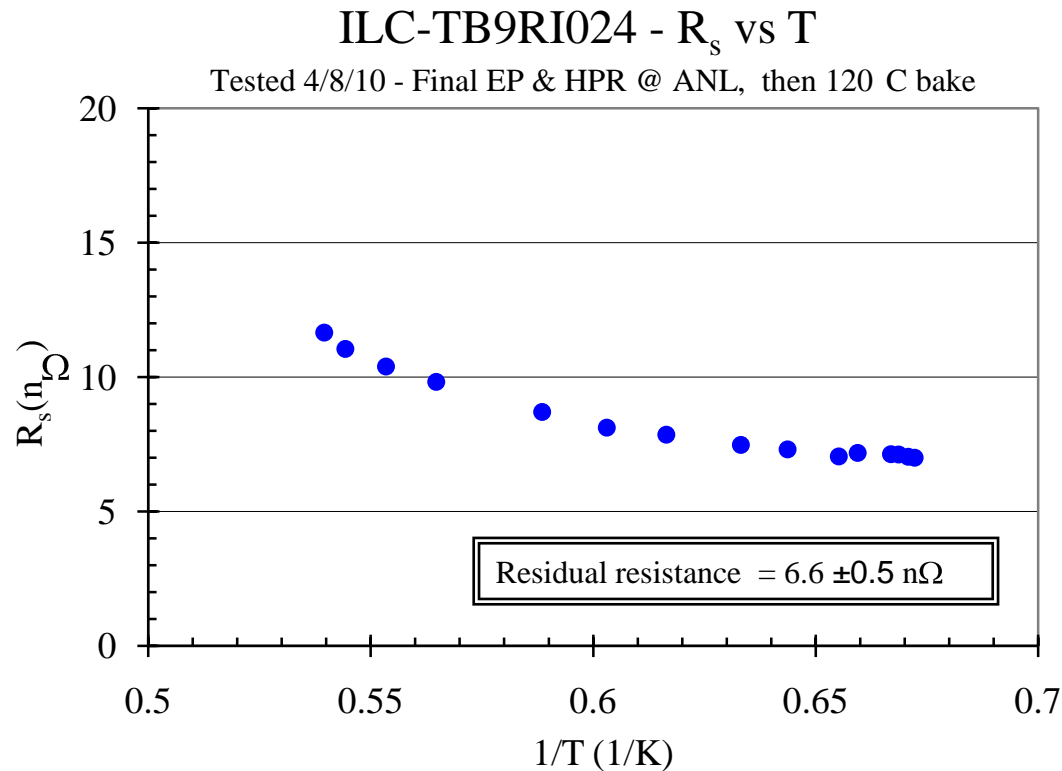
Signals during a quench in the $8\pi/9$ mode from 4 OST's mounted vertically along cavity cage. Channel 1 is at cell #1, channel 4 is at cell #9, channels 2 & 3 are roughly equidistantly placed between them.

Green traces are OST signals, red is the cavity transmitted power.

Data is taken at 1.85K, at 25.6kHz.

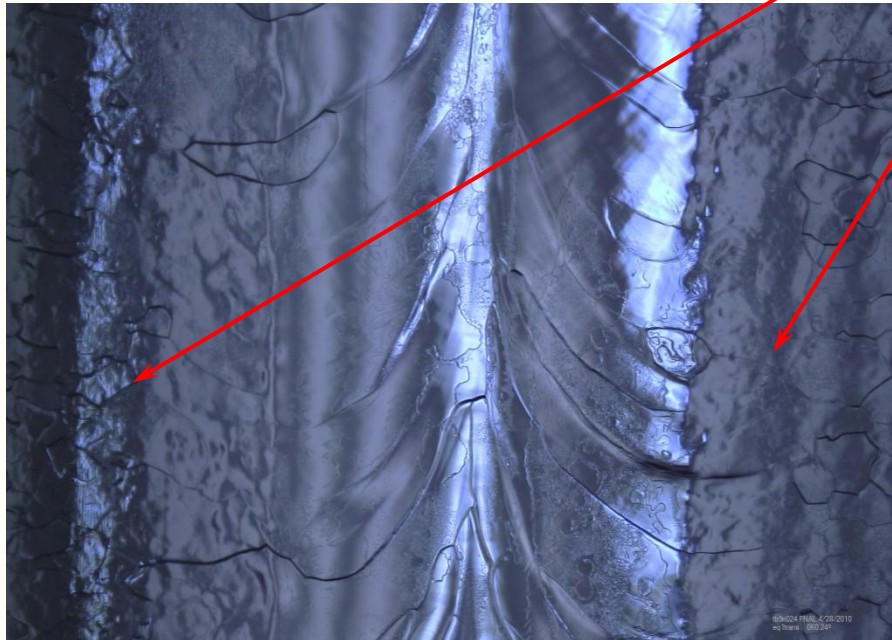
Shortest signal delay is on channel 1, indicating that in the $8\pi/9$ mode, cell #1 (rather than cell #9) is the quench source.

(D. Sergatskov)



Residual resistance = 6.6 nΩ – somewhat on the high side for EP 9-cell cavities, but a generally good value.

Optical inspection performed after vertical test - no obvious defect observed on cell #2. Overall surface appears “etched” (somewhat high residual surface resistance?).



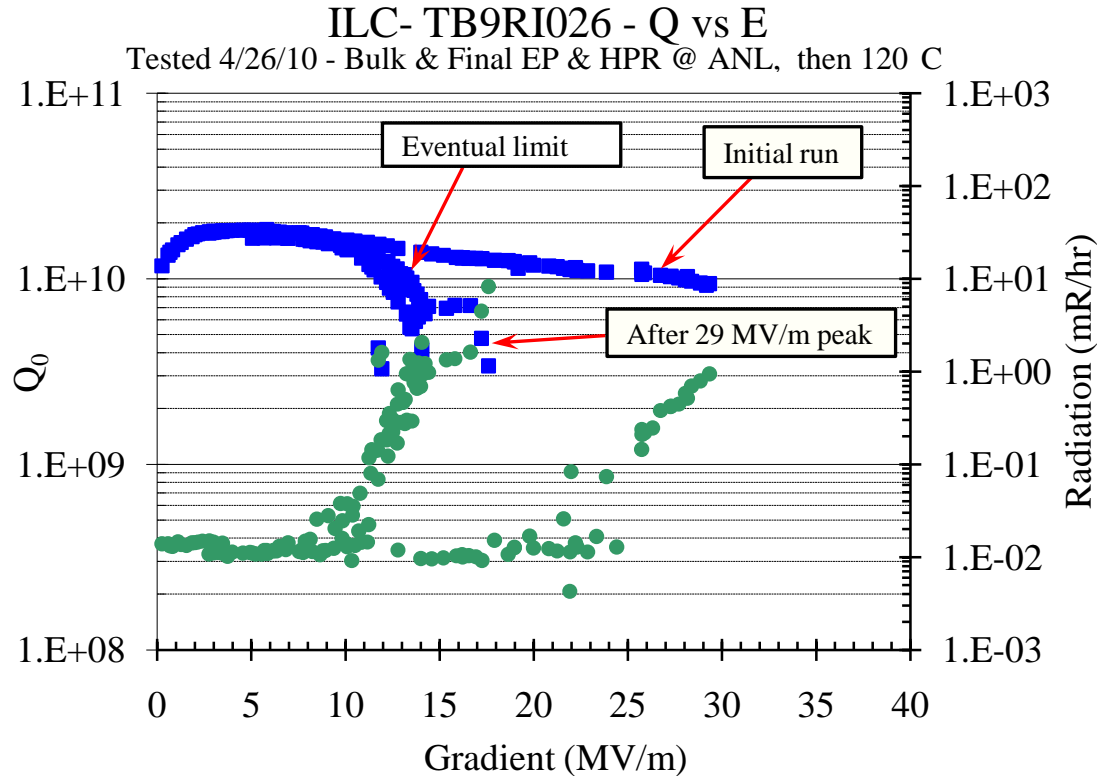
Next steps :

- Light EP (~ 20 μ m)
- HPR/assy
- 120°C bake
- Vertical test

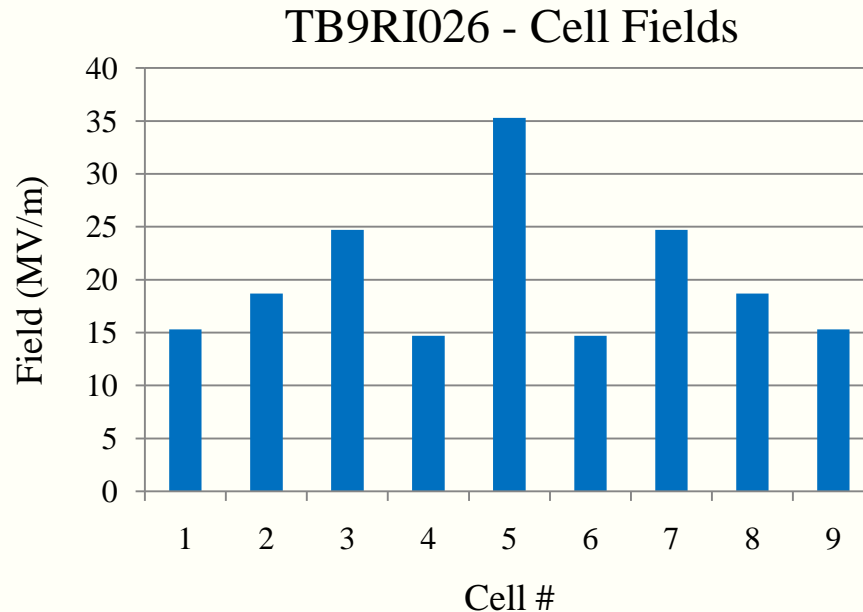
Photo courtesy D. Sergatskov

- Fabricated by RI
- Inspections (visual, CMM, RF, optical)
- Bulk EP (2x, 80 μ m + 70 μ m)
- US cleaning, HPR
- Optical inspection
- H de-gassing (800°C/2 hrs) @ JLab
- Tuning
- Light EP (26 μ m), HPR, Assy
- 120°C bake, 63 hrs
- Vertical test

Initial low-field
 $Q_0 = 1.8 \times 10^{10}$

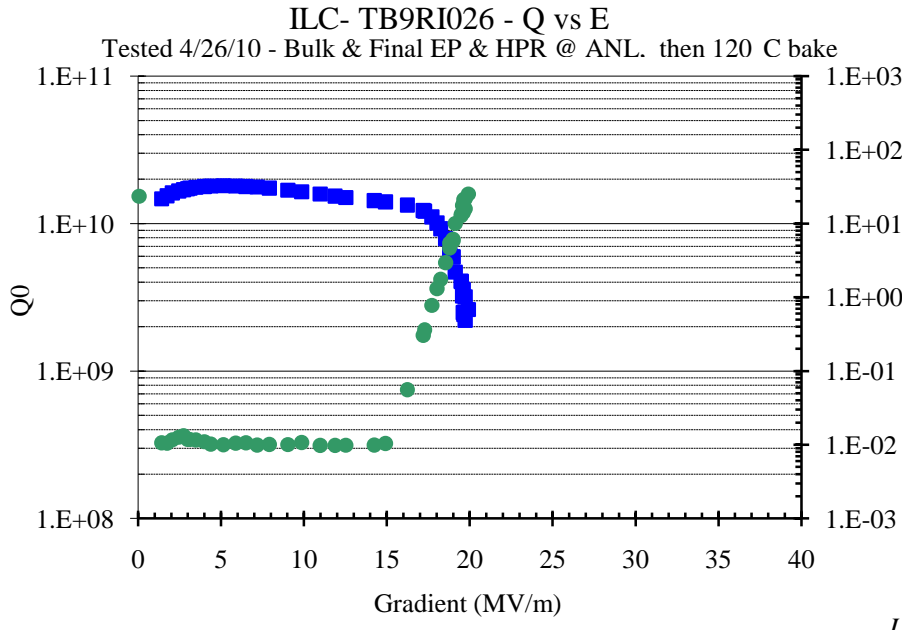


Initial FE onset at 25MV/m (after a few “bursts” at 20MV/m), increased with gradient until cavity reached 29MV/m. Quenched from FE at 29MV/m, then much reduced field (16-17MV/m, then down to 14MV/m) and higher FE. Cavity now limited by FE – FE increased sharply while testing.



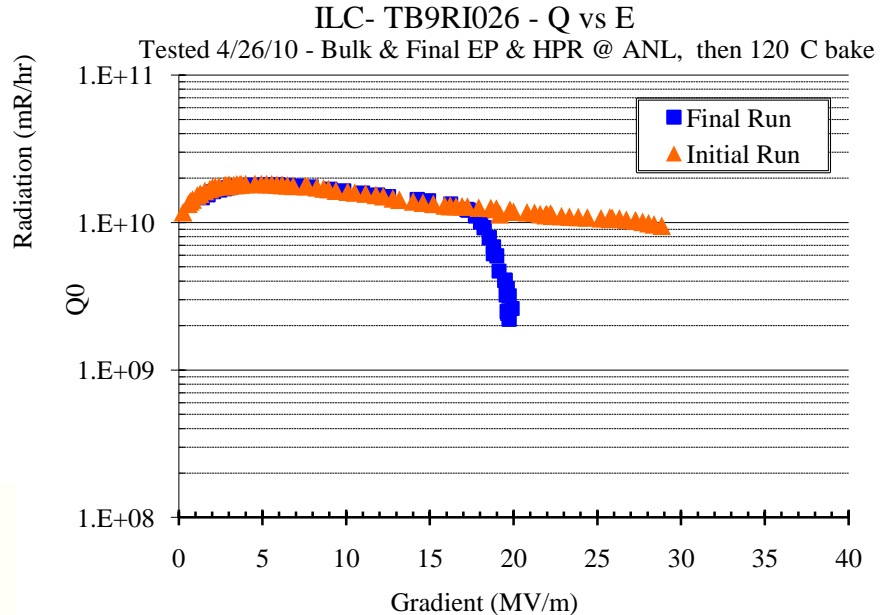
Mode measurements show FE in all modes, least in $\pi/9$ (cell 5 only), highest in $2\pi/9$ and $3\pi/9$ (cell pairs 3/7 and 2/8). Individual mode gradient limits are due to FE behavior, and not intrinsic (defect) limitations.

Some evidence of emitter processing was observed while performing mode measurements so π -mode checked again...



After mode measurements where FE processing was observed, cavity now reached 19.6MV/m in the π -mode (up from 14MV/m, but well below initial run to 29MV/m).

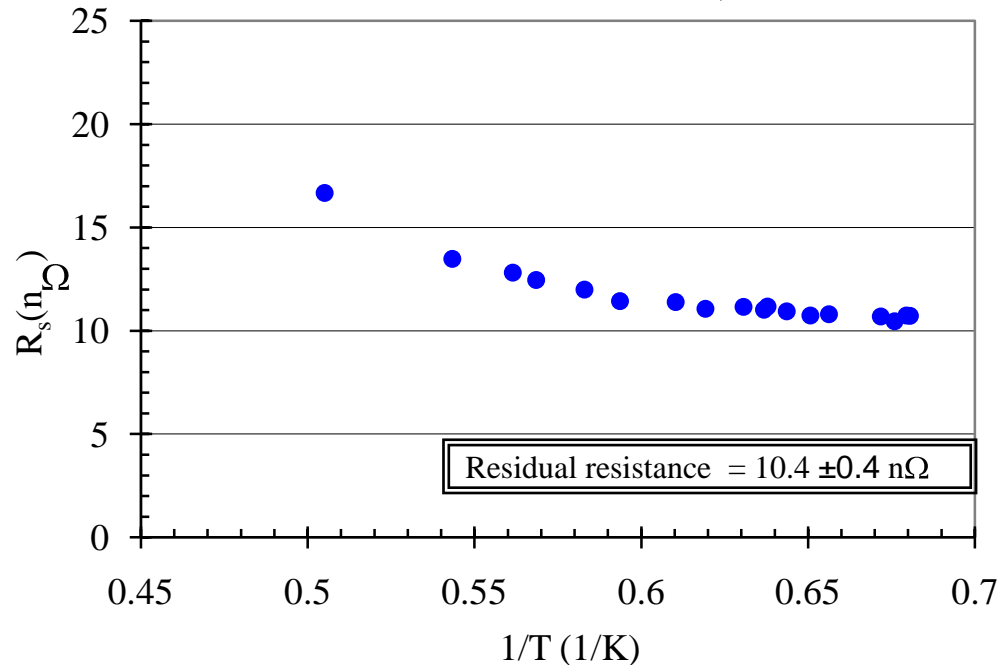
Limited by strong FE/Q-drop.



Comparison of initial (pre strong emitter turn-on) and final (post mode meas.) Q_0 vs E curves. Low-field Q_0 behavior is unchanged, but Q_0 drops sharply at 16MV/m due to strong FE (FE onset 15 MV/m).

ILC-TB9RI026 - R_s vs T

Tested 4/26/10 - Bulk & Final EP & HPR @ ANL, then 120 C bake



Residual surface resistance = 10.4n Ω – a rather high value compared to typical (good) EP'd 9-cell cavities (4.5 – 6.0 n Ω). Is the degradation due to the activation of a strong emitter, which subsequently globally affects the cavity surface? Q_0 vs T measurements are performed at low fields (3-4 MV/m) where FE is not active, so it does not affect the Q_0 vs T measurement.

Optical inspections (D. Sergatskov) revealed the evolution (growth) of a feature on the iris between cells 8 & 9 :



As received



After 1st EP



After 2nd EP
Diameter ~ 350-400 μm

Cavity is (severely) FE limited. Significant change in performance after reaching 29MV/m implies something drastic happened.

Mode measurements support (not very strongly) problem may be in ends.

Was the feature on the iris between cells 8 & 9 the source? Did it “turn on” after reaching some threshold, then “process” or evolve into a bad (worse) emitter? Optical inspection to follow vertical test.

The high surface resistivity and severe performance degradation suggest that additional HPR alone will not be sufficient to improve cavity performance significantly. Additional EP is warranted - but EP has been making the defect larger! Wait for optical inspection results.

Cavity TB9RI024 is quench limited to 29M/m, limiting cell identified as cell #2 using second-sound technique. No obvious feature observed in quenching cell (cell #2). Cavity was processed again (light EP) and is undergoing HPR & assy, in preparation for 120°C bakeout and vertical test.

Cavity TB9RI026 is field emission limited to 19.6 MV/m, after initially reaching 29 MV/m. The source of the FE *may* be in the ends. A feature on the iris between cells 8 & 9 was observed during the latest pre-vertical test optical inspection. Additional optical inspection will be performed next, followed probably by additional light EP (and perhaps optical inspection to document the evolution of this feature after additional EP), then 120°C bakeout and re-test (w/ thermometry and OST's).