New 9-Cell Cavity Results at JLab

in collaboration with FNAL and KEK

What happed in 08

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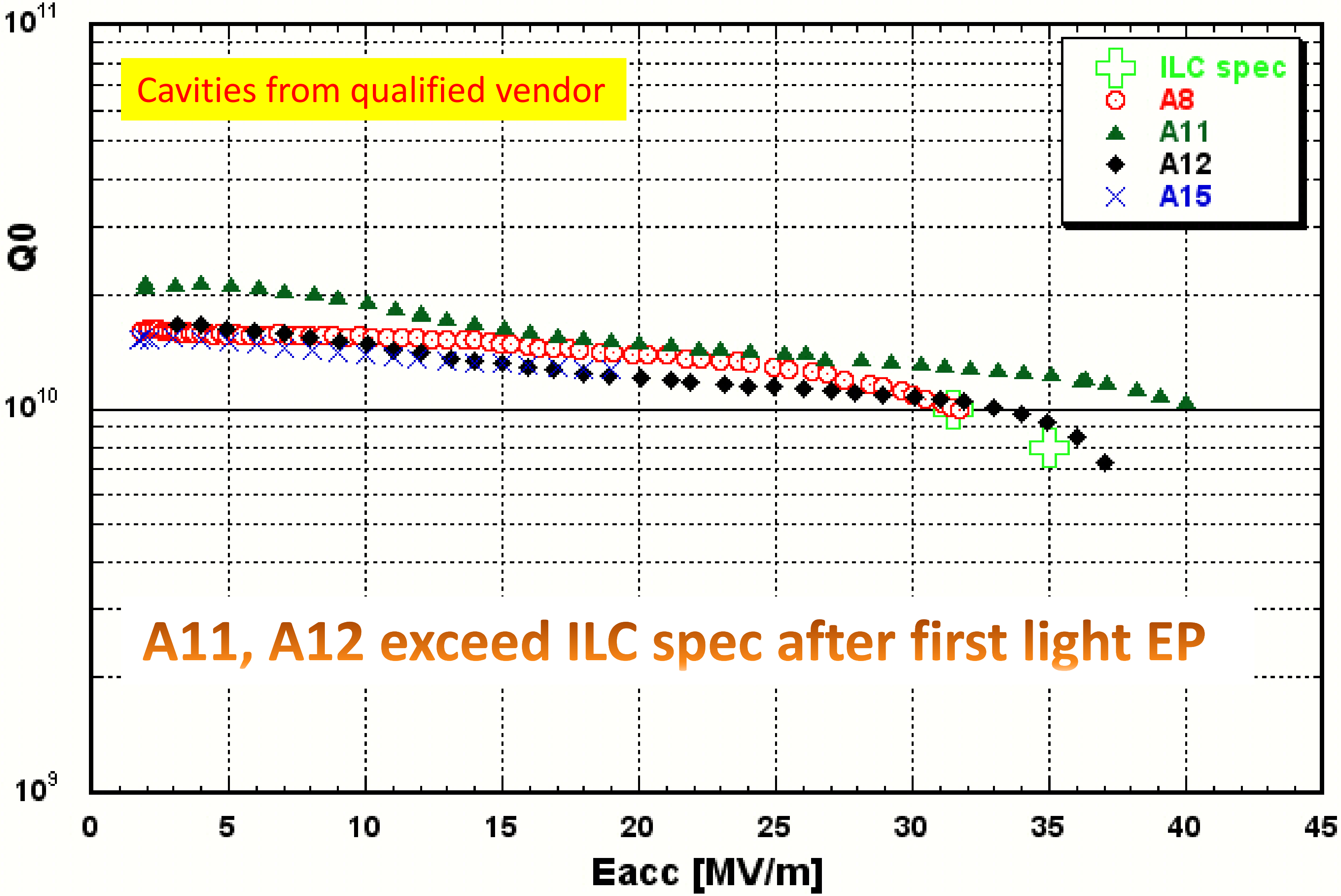
for JLab Team and Collaborators
Jefferson Lab

ILC08, November 16-20, 2008, UIC

New 9-cell Results FY08 – Best Gradient



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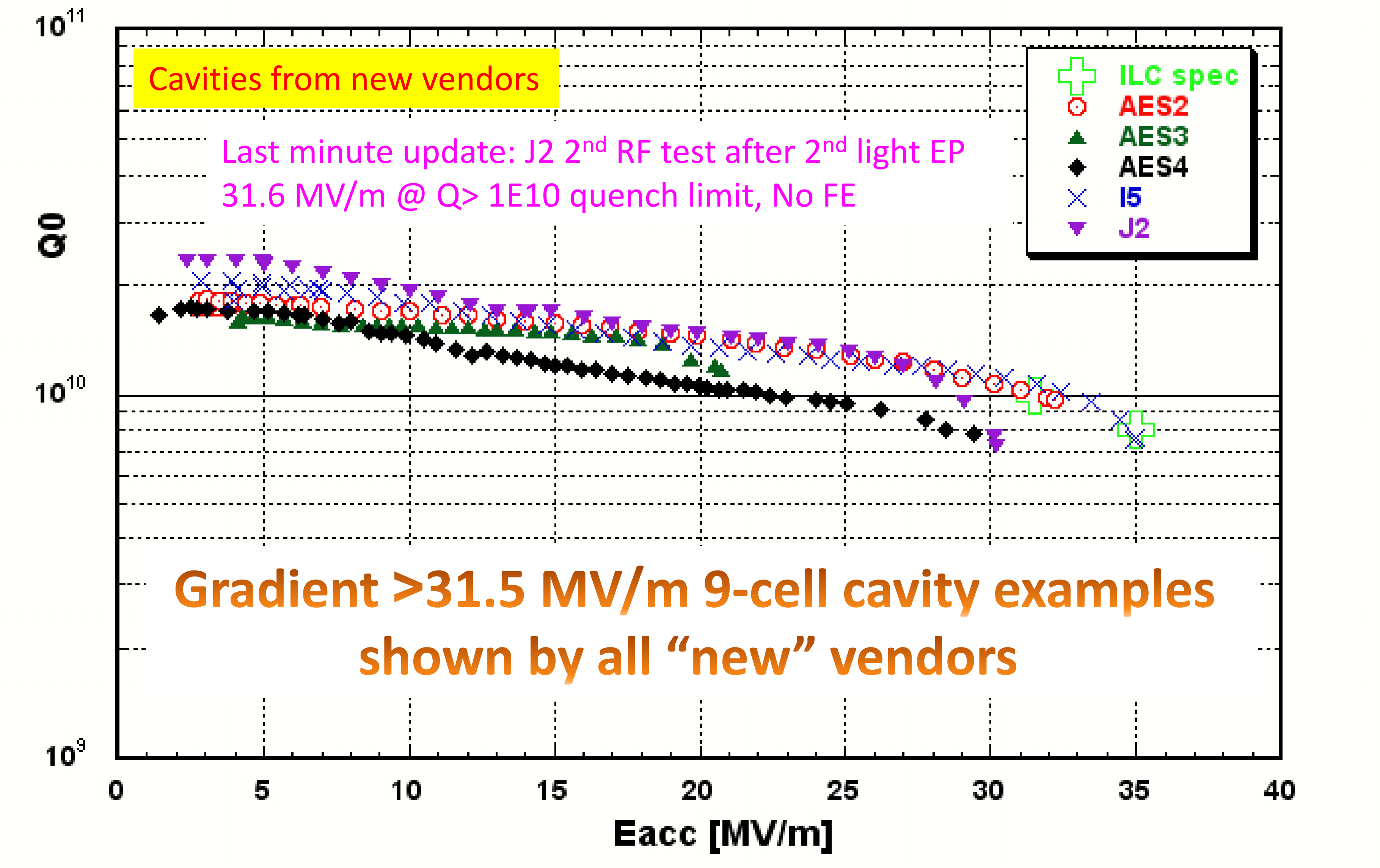


Overview of ILC S0 9-Cell Activities at JLab

- 13 cavities EP processed, 12 RF tested.
- 117 hour active EP time.
- 30 EP & 30 VT cycles done in FY07
- 17 EP & 27 VT cycles done in FY08 (more VT in 08 for understanding FE and quench).
- 8 cavities optical inspected.
- 4 cavities T-mapped w/ 2-of-9 thermometry system.
- FY09 plan: 30 EP cycles, 30+ VT cycles including T-mapping and optical inspection.

Result details published at SRF2007 & LINAC08:

1. R.L. Geng et al., “Latest Results of ILC High-Gradient R&D 9-cell Cavities at JLAB ”, SRF2007, Beijing, China, October 2007, WEP28.
2. R.L. Geng et al., “High-Gradient SRF R&D for ILC at Jefferson Lab”, LINAC08, Victoria, Canada, September 2008, THP042.

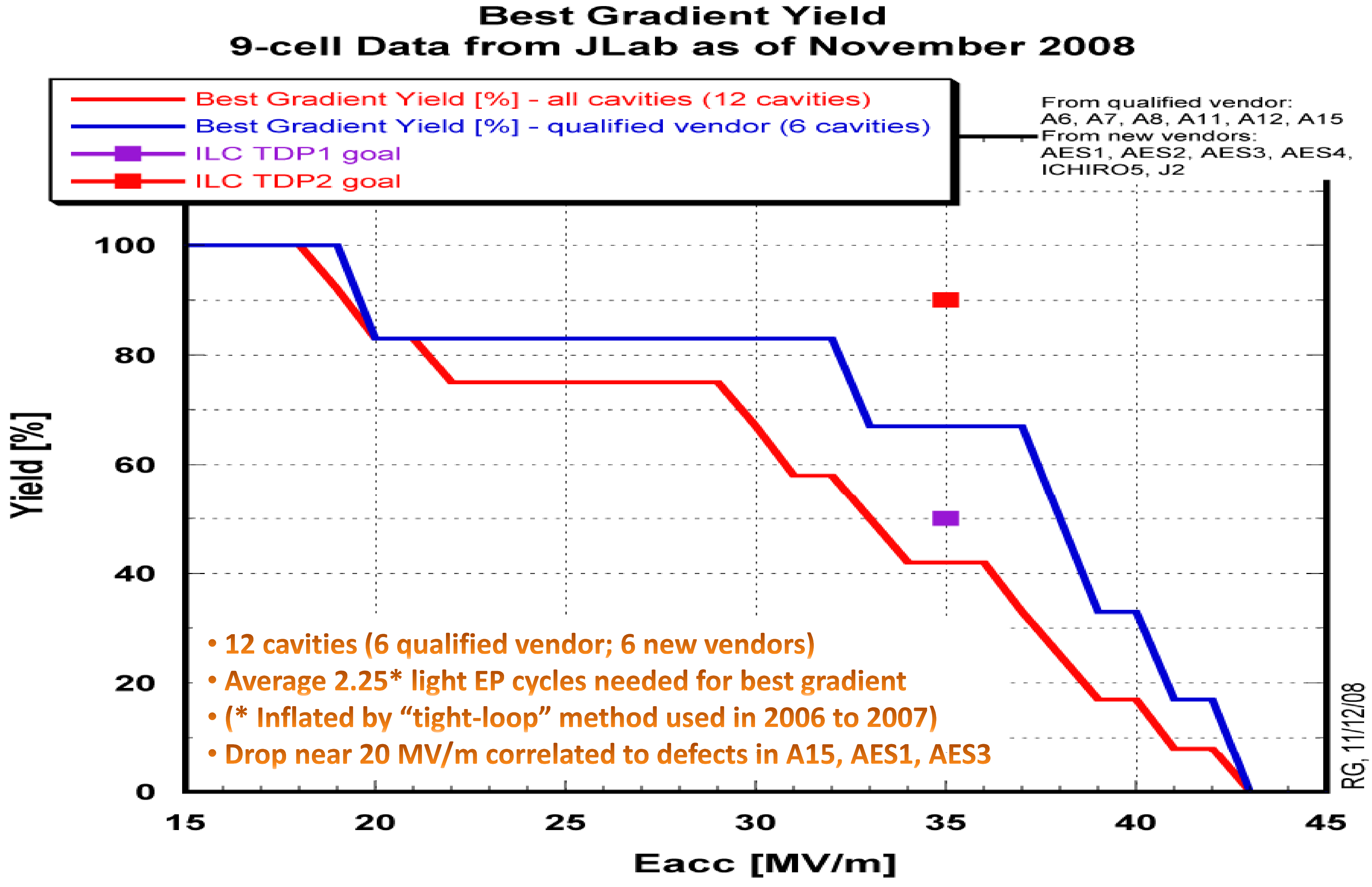
2008 vs. 2007 Progress Made
Reaching 35 MV/m after 1st Light EP
(cavities by qualified vendor only for consistency)

	Jan 07	Mar 07	Nov 07	Jul 08	Jul 08	Aug 08	
Cavity	A7	A6	A8	A12	A15	A11	Yield
Eacc ≥ 31.5 MV/m?	Y	Y	Y	Y	N	Y	**5/6 (83%)**
S0 cycles needed	2	4	3	1	-	1	
Eacc ≥ 35 MV/m?	Y	Y	N	Y	N	Y	**4/6 (67%)**
S0 cycles needed	2	4	-	1	-	1	

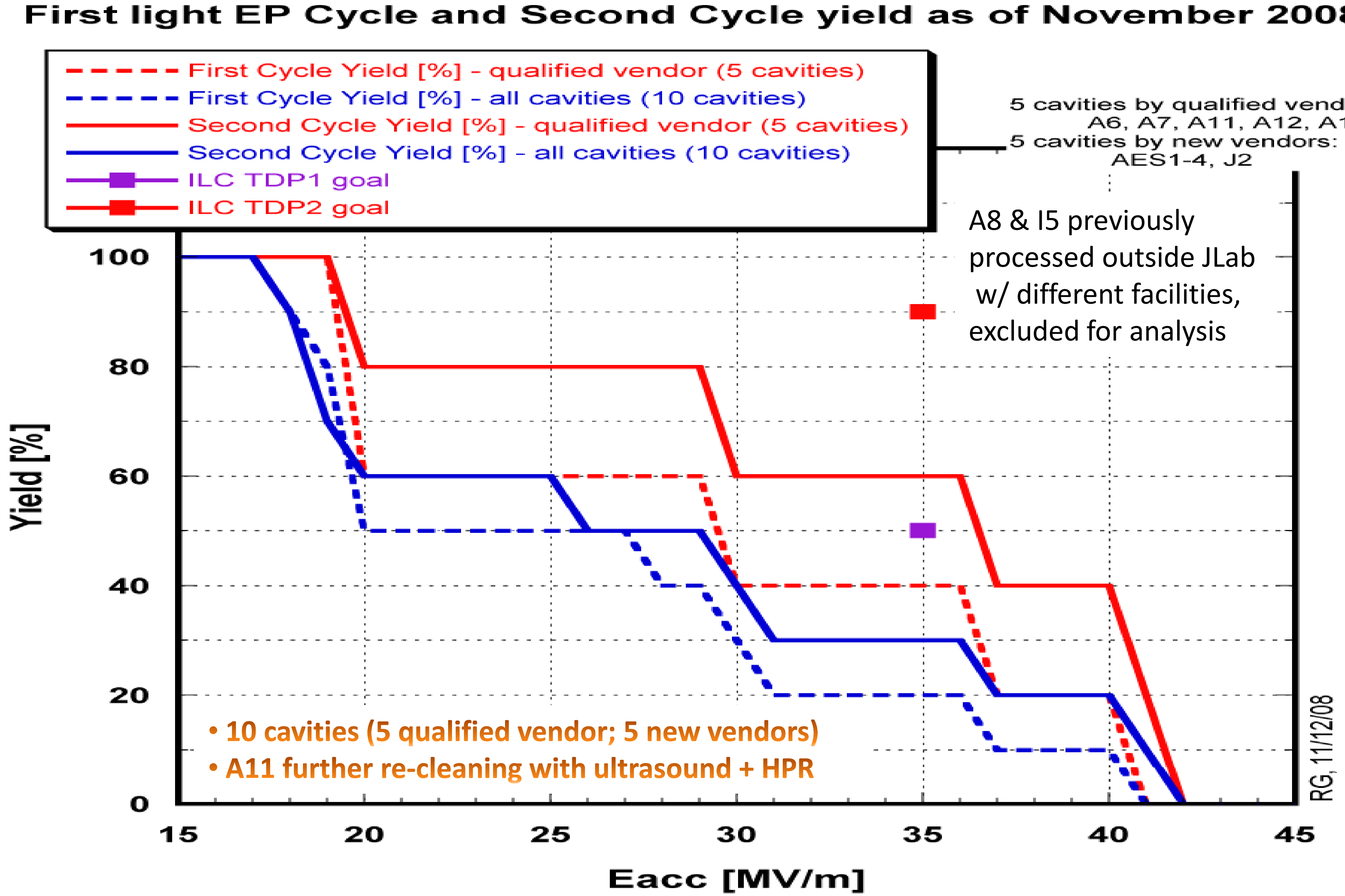
Relevant improvements made toward optimal processing with JLab facilities

- Initial acid mixing volume ratio 1:10 (HF(49%):H2SO4(98%))
- Nominal voltage 14-15 V
- Continuous current oscillation
- Minimum purging N2 gas
- HPR after bulk EP and before 600 C furnace heat treatment
- …

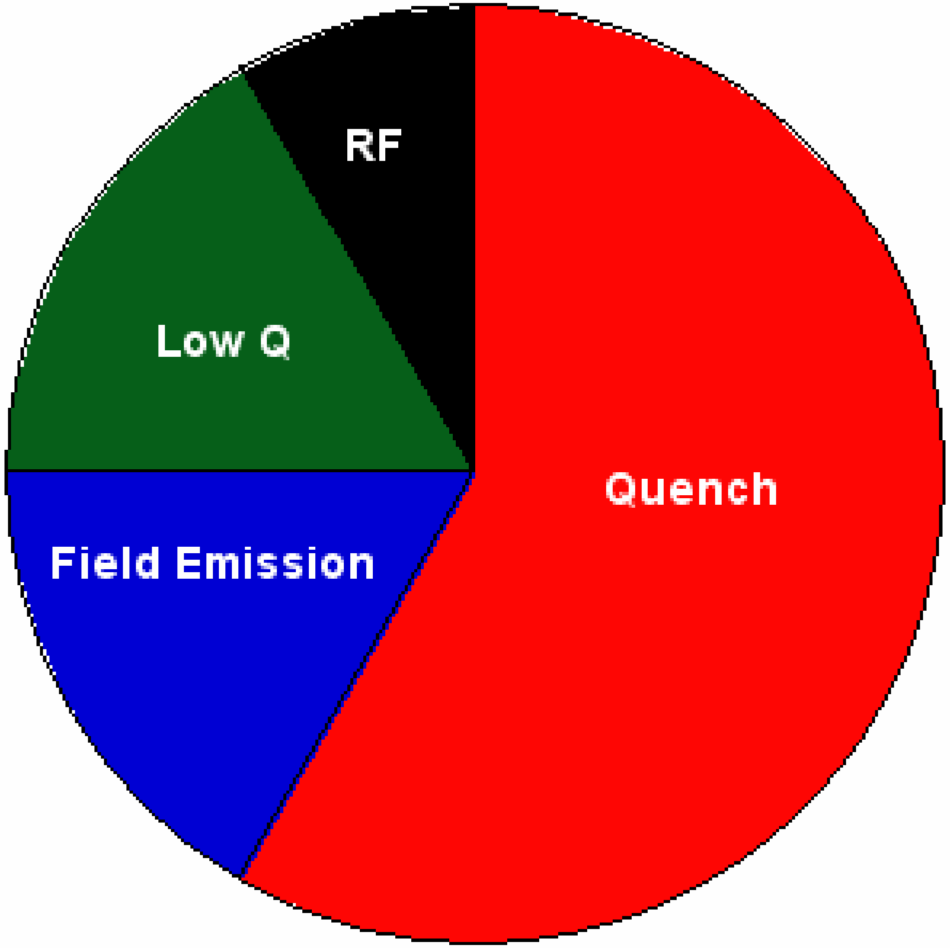
Yield Curve – Best Gradient



Yield Curve – 1st pass and 2nd pass



Best Gradient Limit Factors



- Pushing against quench is central; fighting remaining FE is still needed.
- Progress expected by real cavity studies as well as controlled sample surface analysis.
- This talk focuses on cavities; for surface studies see talk for example by Saeki of KEK (JLab and KEK has on-going collaborative efforts supported by US-Japan fund).
- Focused talk later on JLab studies of defects in real cavities as well as fundamental materials.

Understand Gradient Limitation when Quench is Hit in Real 9-cell Cavities

1. Pass-band measurements determine quenching cell pair.

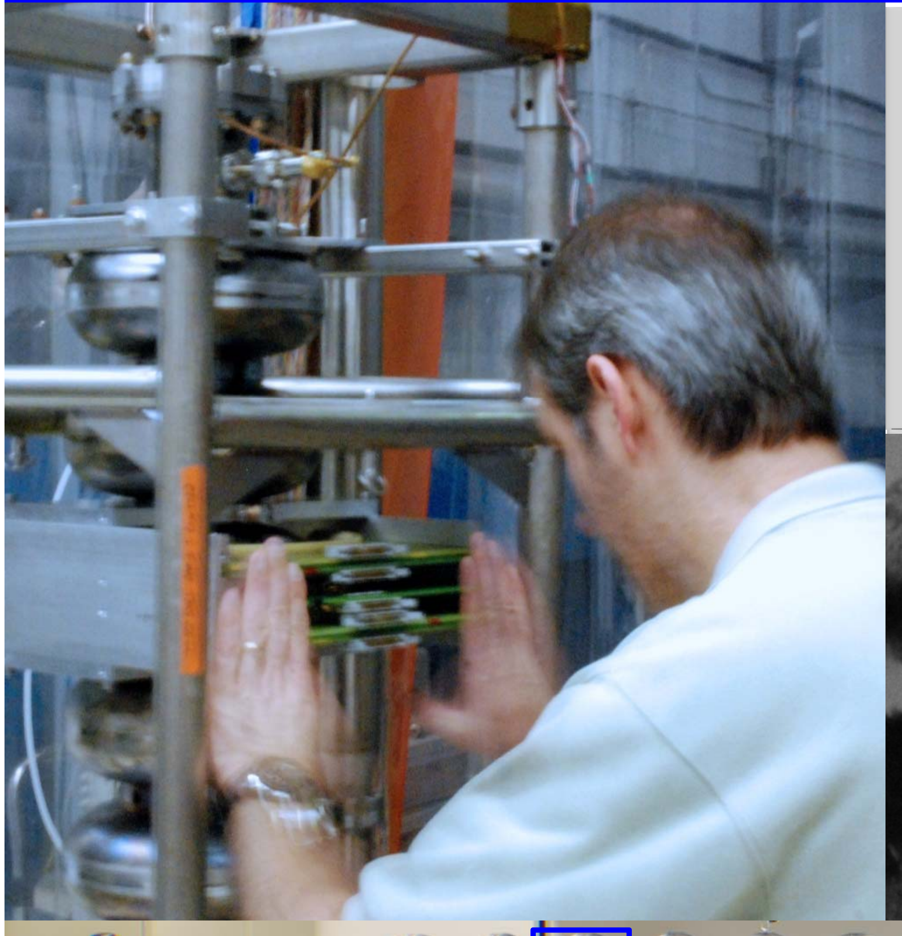
2. Second test with T-mapping near equator of 2 cells.

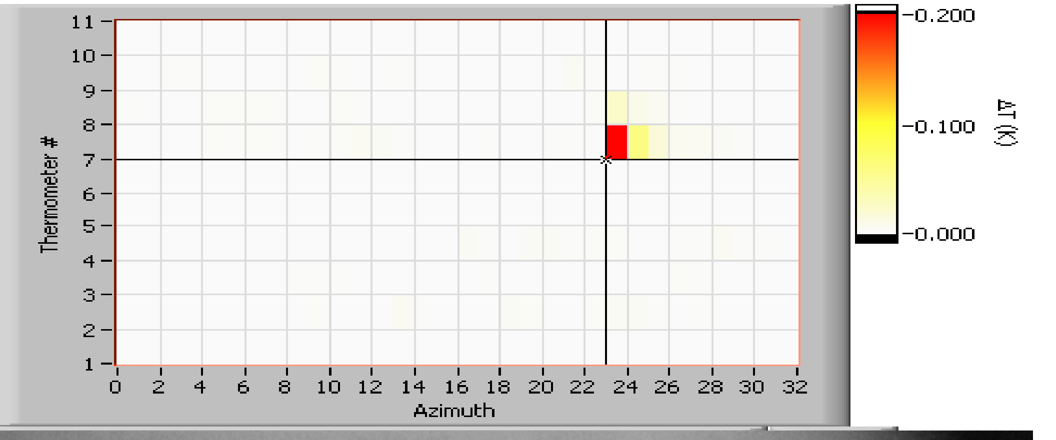
    - 2-cell T-mapping sufficient as our experience showed because actual quench often triggered by one dominant source.
    - We are interested in incorporating 2nd sound method developed by Cornell to compliment thermometry.

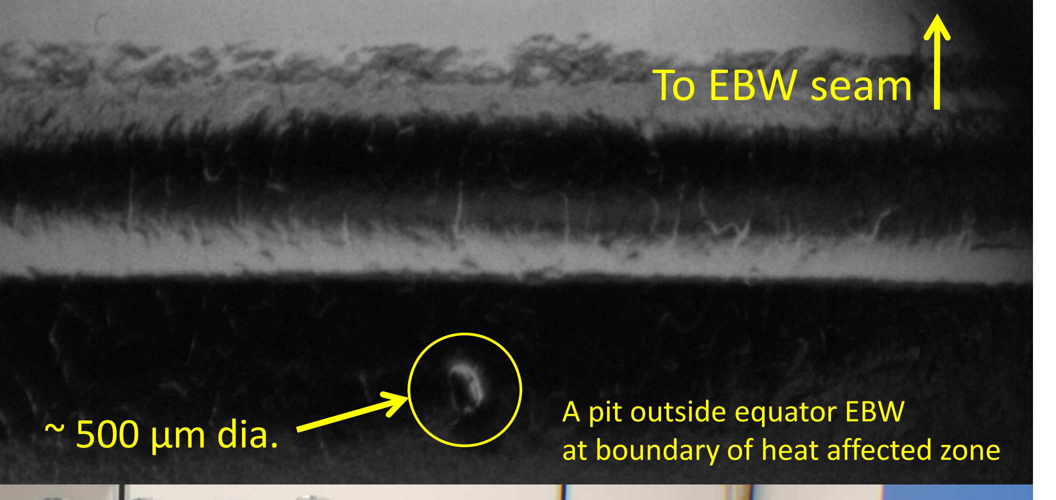
3. Visual inspection with long-distance microscope 9-cell cavity inspection apparatus.

4. A new paradigm is to begin: 2 sets of 1-cell thermometers to be mounted before 1st RF test based on optical inspection data.

A15 gradient limit at 19 MV/m: T-mapping found a hot spot correlated to quench
Long distance microscope identified a defect near hot spot

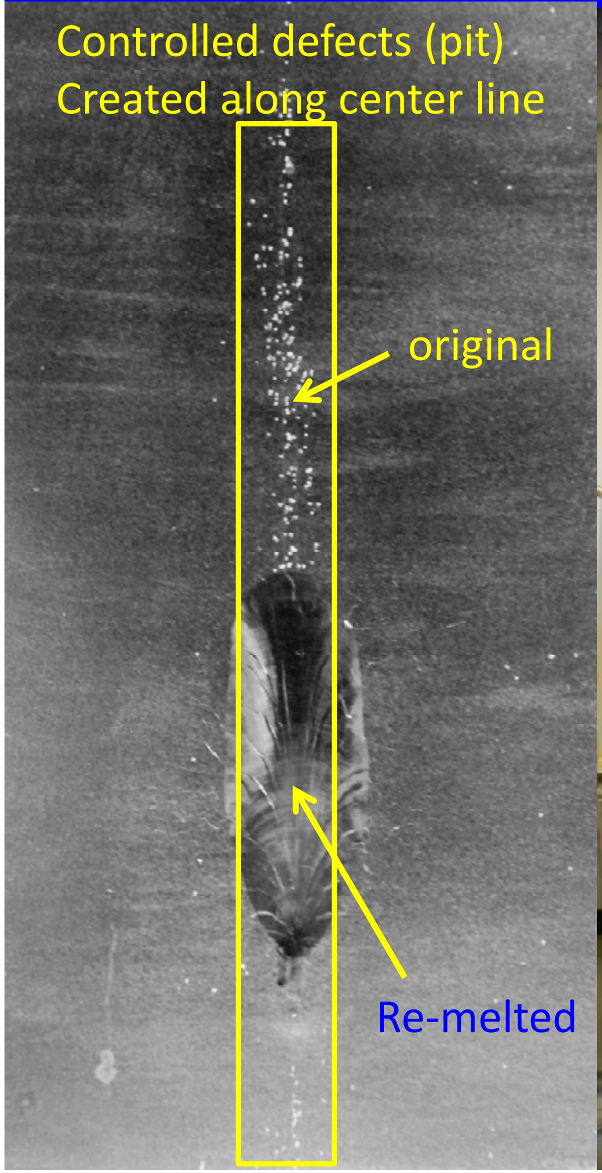






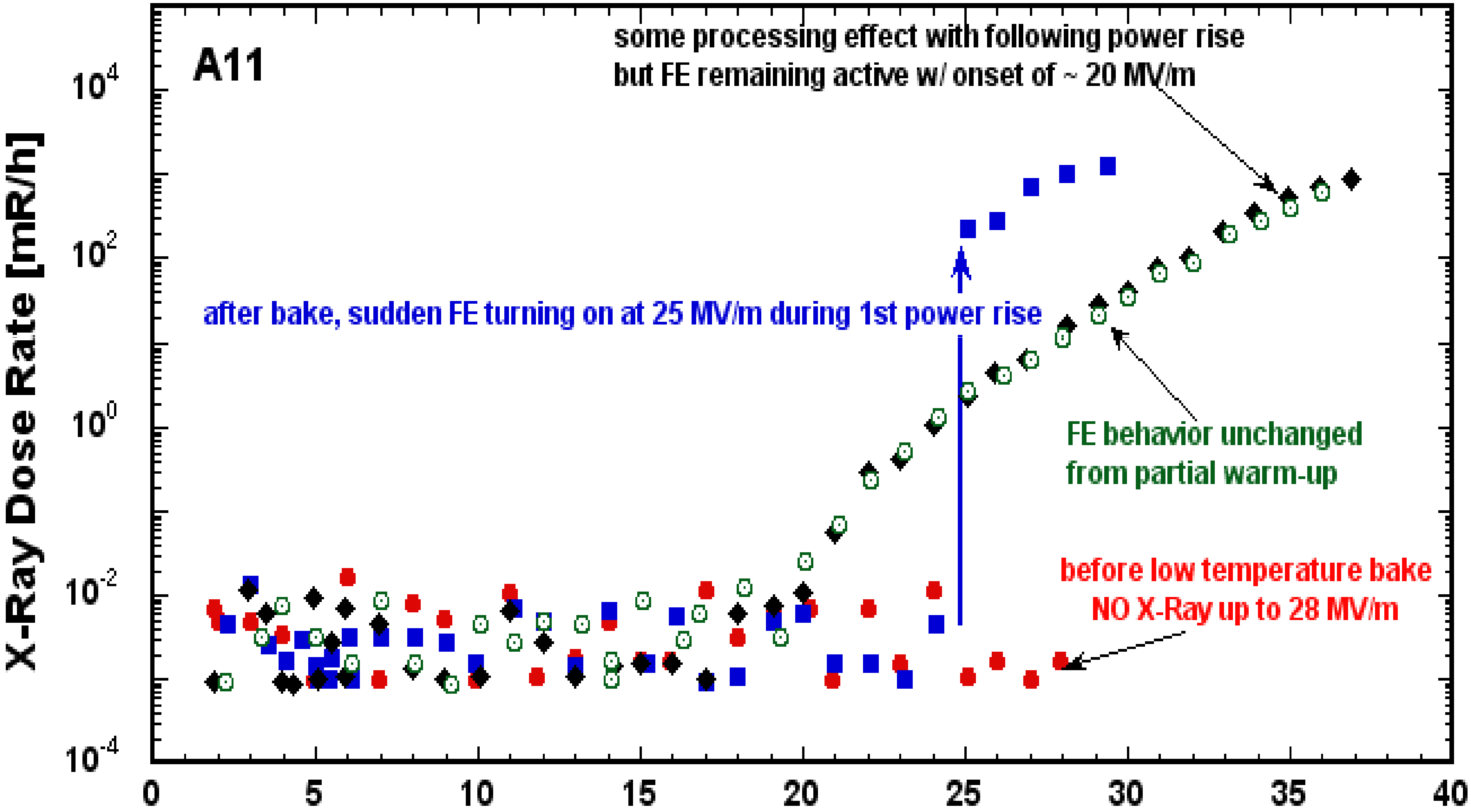
Only cell#3 responsible, all other cells 28-33 MV/m

JLab Proposes to Remove this Defect in A15 by E-Beam Local Re-melting then re-process and test



Understanding FE Behaviors w/ Real Cavities

Observation of Baking Induced Field Emission in EP'ed Cavity



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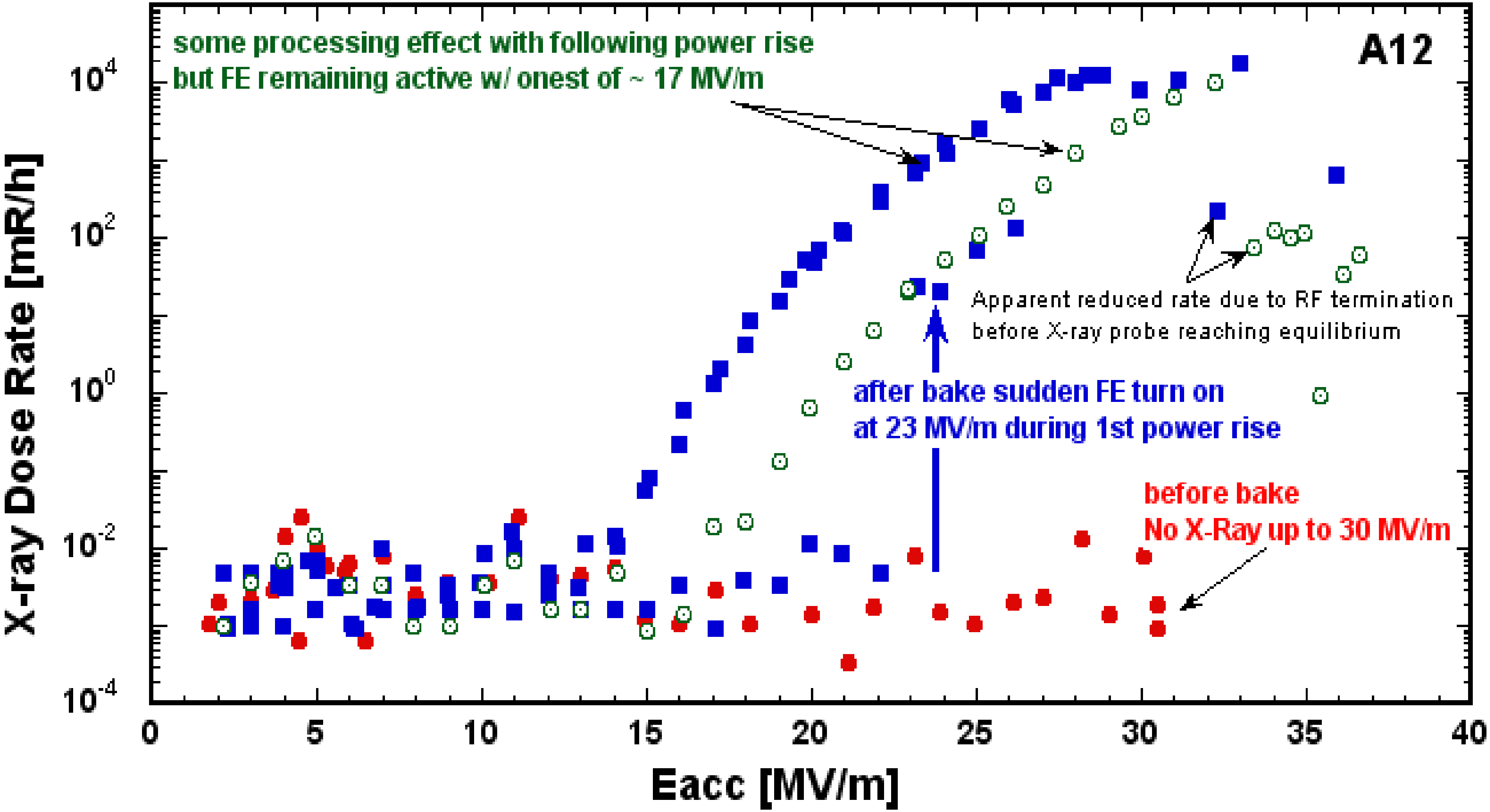
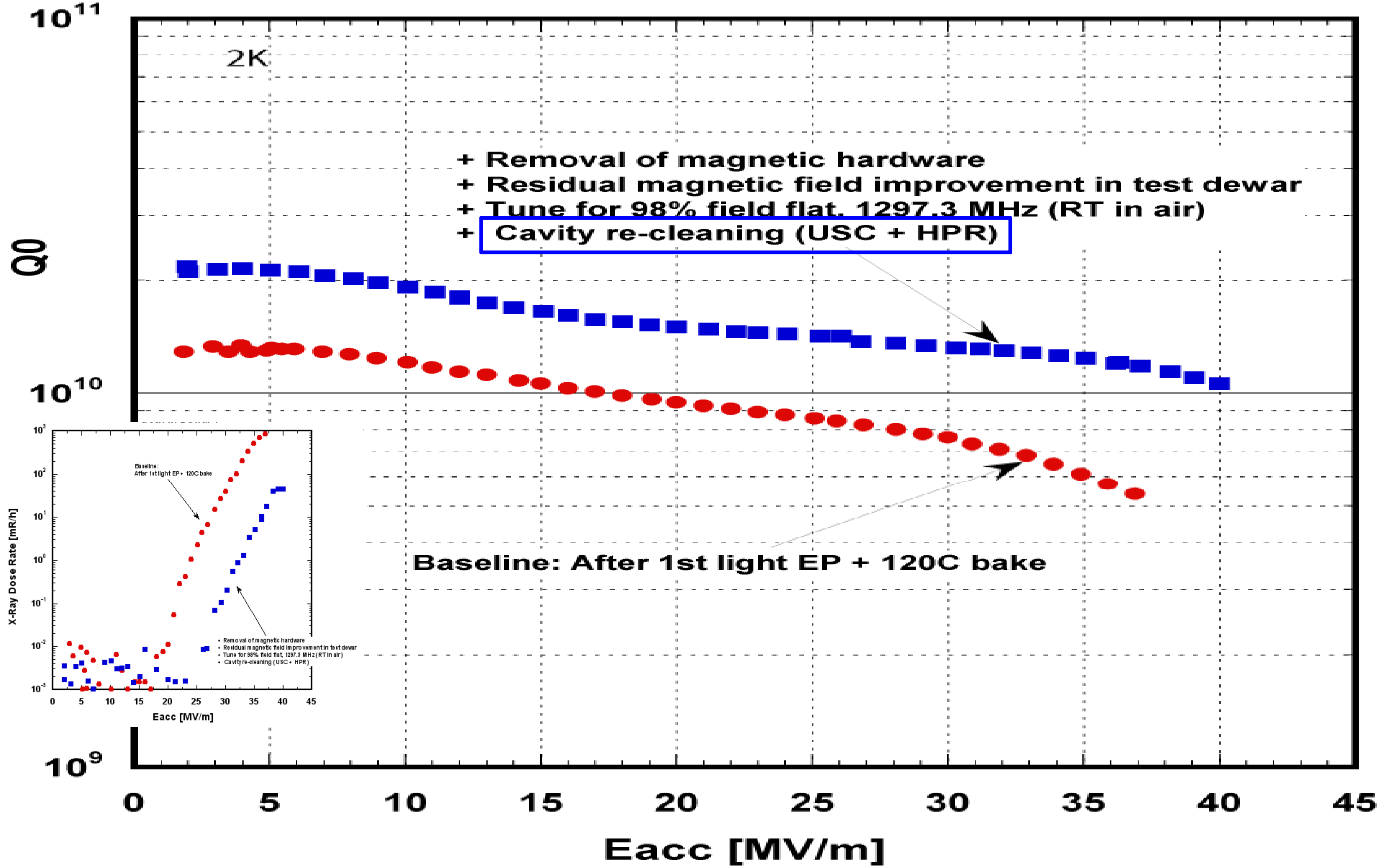


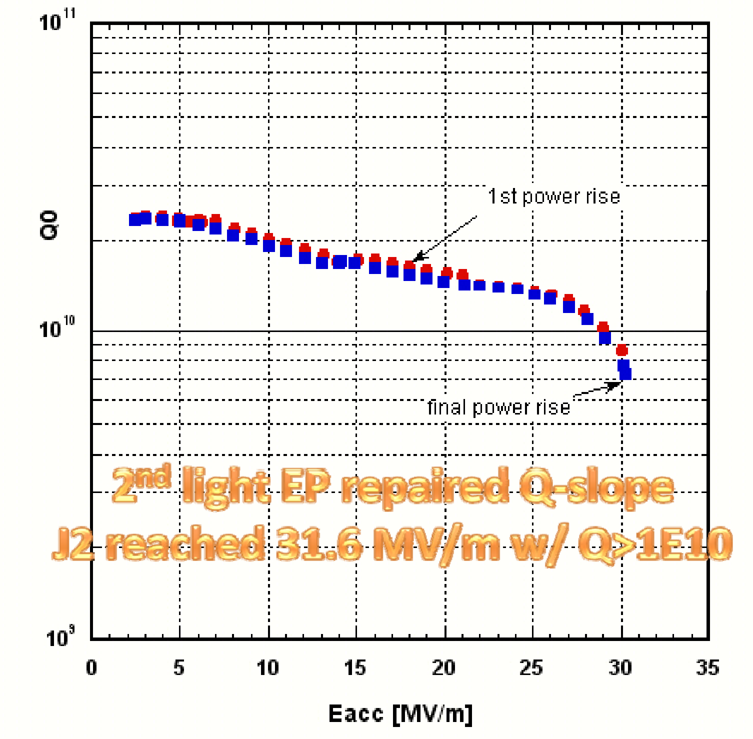
Reduce/Eliminate FE by Re-cleaning

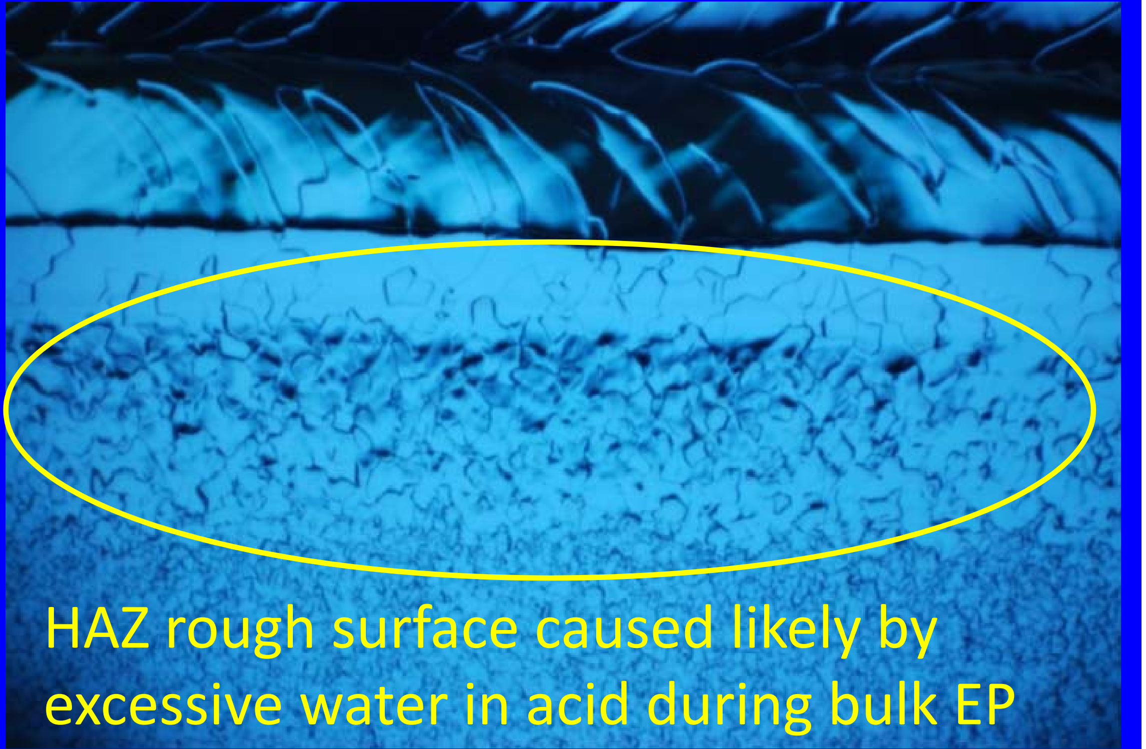
A11: the most recent (4th) example; earlier ICHIRO5, A6, A12



A Possible Example of Q-drop Correlated to Enhanced Surface Roughness

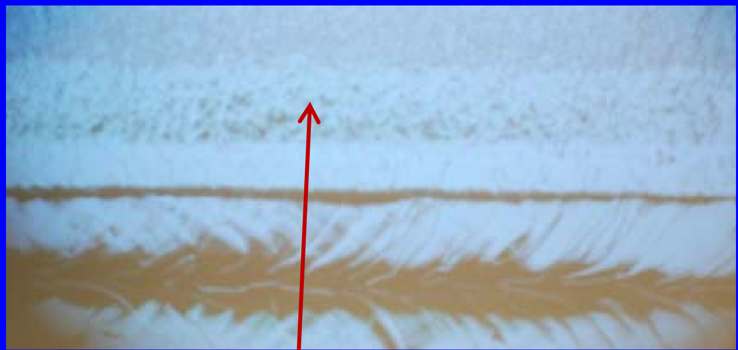
- J2 bulk EP less-perfect parameter (too high current) – suspected too much water in electrolyte. Stopped bulk EP earlier (120 μm removal) for roughness concern.
- 1st light EP 50 μm (heavier than usual) with optimal EP parameter for reducing roughness.
- First test strong Q-drop despite 120CX48hr bake.
- Post-test inspection: enhanced roughness in HAZ observed.
- "Water addition" now confirmed (occurred after one use of acid due to a bug in EP machine).





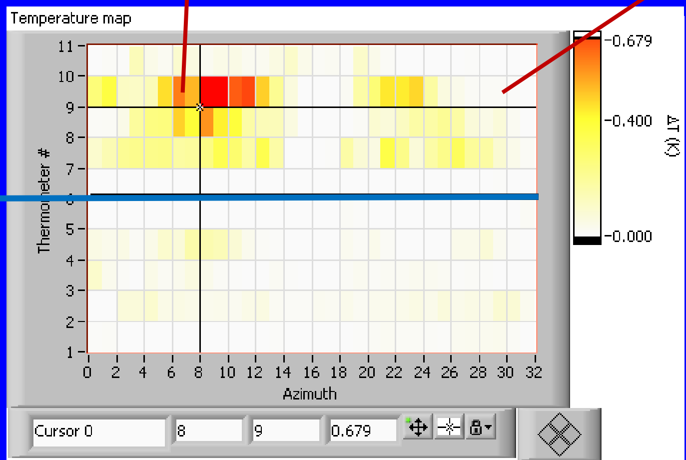
J2 Insights from Additional Test with T-mapping

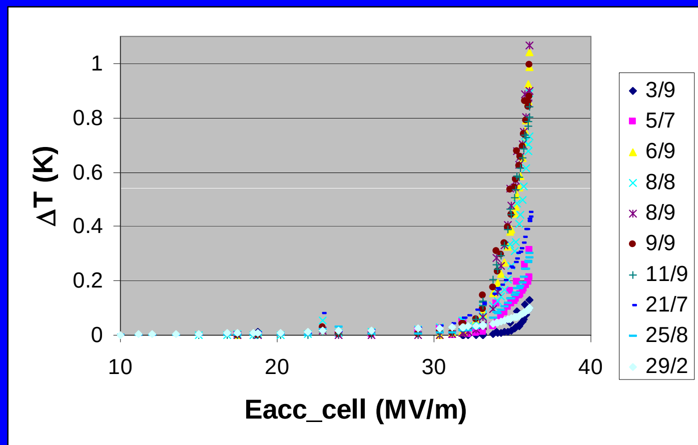
- T-map cell 1/9, 8π/9-mode, quench 36 MV/m. Hot spots in cell#1.
- Apparent enhanced roughness (shown in picture) in hot region as well as pits (not shown) close to hot spots.
- ΔT(Eacc)QE^n, n=2.5-3 for Eacc=10-30 MV/m in hot AND cold region; n=25-40 for Eacc>30MV/m.



Cell#1

Cell#9





Future Plans and Challenges

- Intensify use of inspection & T-mapping w/ significant EP/VT cycles.
  - Goal is to correlate quench with defect.
  - Inspection beginning with as-built cavity.
  - 1^{st} RF test w/ T-mapping cells determined by optical inspection.
- Feedback knowledge on defects to cavity manufacturers.
  - Direct communication between cavity builders and testers.
- Explore defect removal by E-beam local re-melting.
  - Proof of principle demonstrated with samples.
  - Single cell next and then 9-cell.
- Continue basic studies (EP, FE) with samples and real cavities.
  - Surface studies: contaminants; roughness; circular or linear defect.
  - Experimenting with real cavities.
- Develop Integrated Cavity Processing (ICP).
  - Goal is to improve processing reliability and throughput at much lower cost.
  - ICP necessary given growing demand for EP of cavities for HEP as well as NP and BES.
  - Initial work started with strong commitment supporting JLab core SRF goals.