# TILC09 / SCRF Session

# Update on S0 Work in the Americas Region

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**With slides provided by:**

- **Zack Conway, Cornell**
- **Rongli Geng, Jefferson Lab**
- **Camille Ginsburg, Fermilab**

**18 April 2009**

# Outline

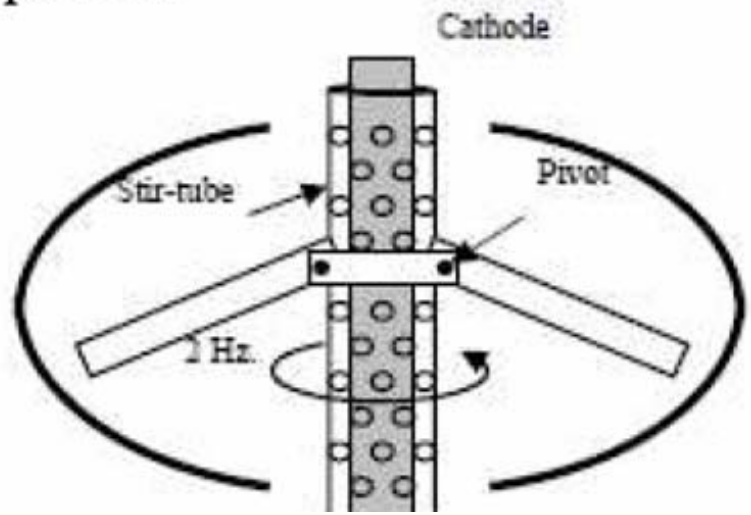
- Progress at Cornell
- Progress at Jefferson Lab
- Progress at Fermilab & Argonne
- Cavity Inventory and Plans

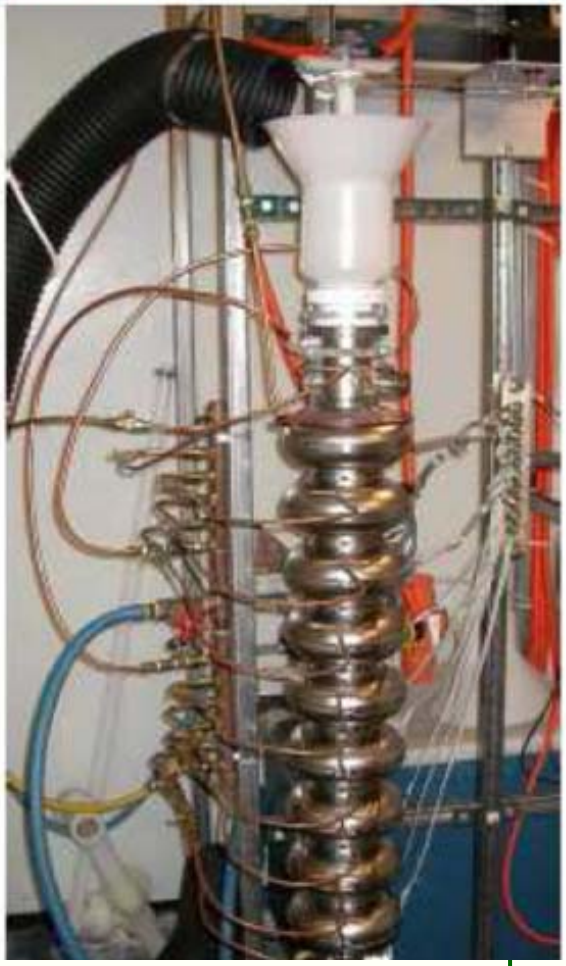
# ILC-ART FY2009 Technical Progress

*CLASSE SRF Group*
Cornell University
Laboratory for Elementary-Particle Physics

# Vertical Electropolish Proven Effective

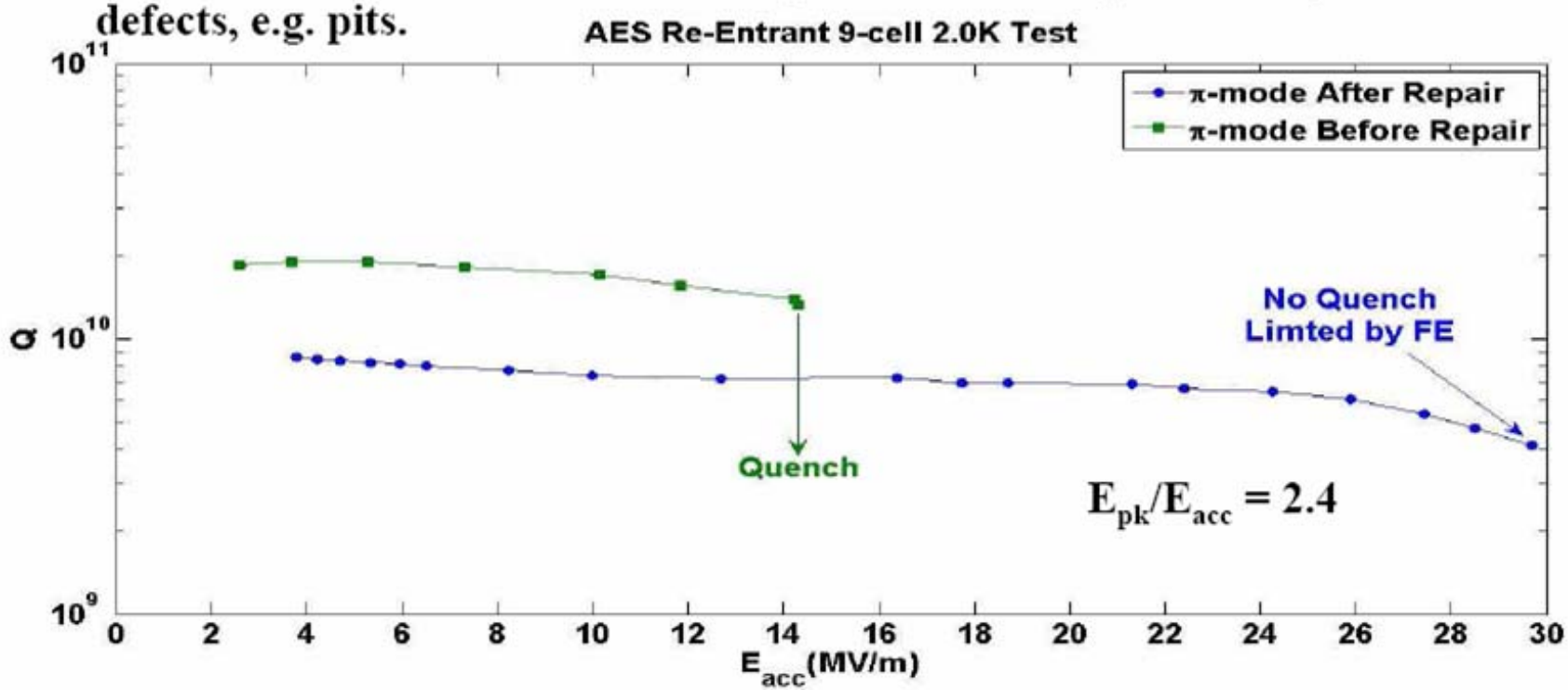
- We have demonstrated gradients >35 MV/m in individual cells of two 9-cell cavities processed with vertical EP. (Accel 9 and AES re-entrant)
- In each test the π-mode was limited by quench.



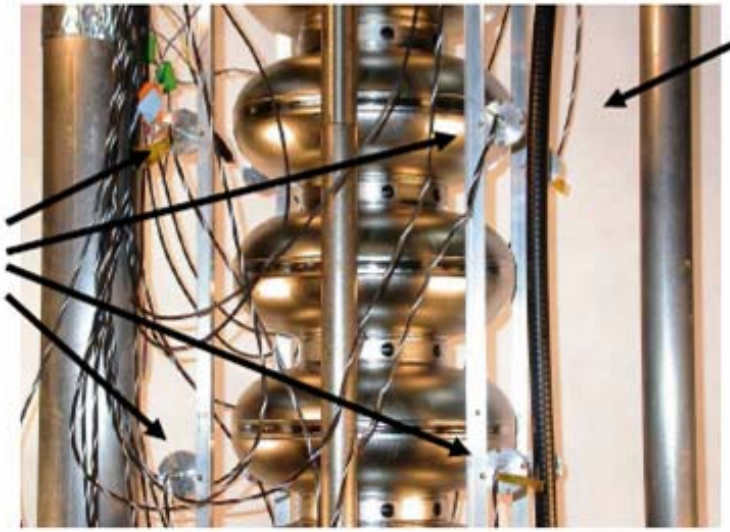
# AES Fabricated 9-Cell Cavity Weld Pits Repaired

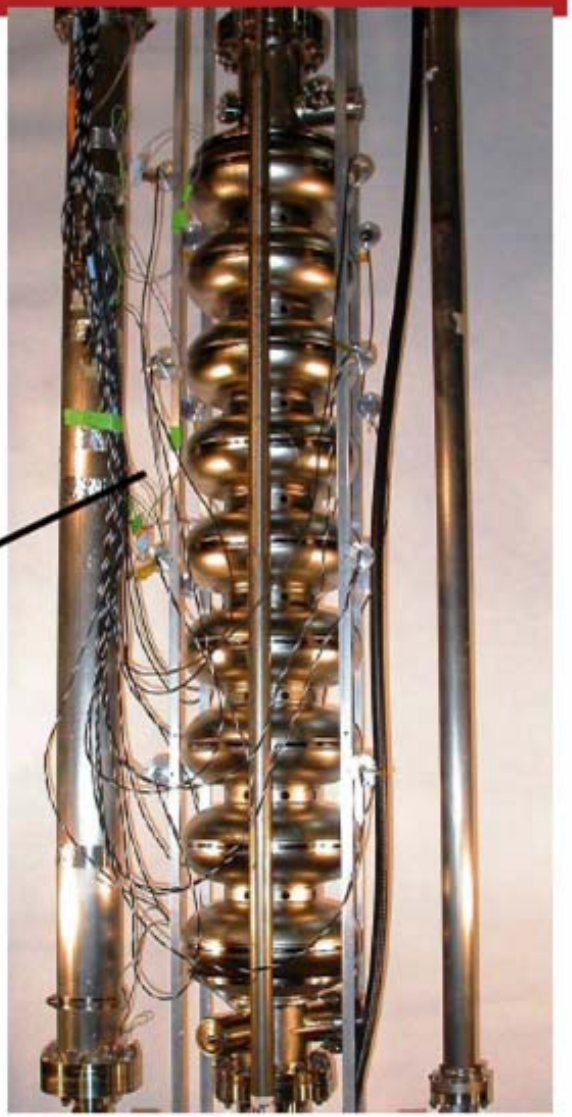
- **We have successfully repaired an AES 9-cell cavity with tumbling and VEP.**
- **This cavity originally quenched at $E_{acc}$ = 15 MV/m at a weld pit in the first cell, after tumbling and reprocessing $E_{acc}$ > 30MV/m.** (100 um tumbling, 200+25 um EP)
- **When excited in the 5π/9-mode a peak fields of 89 MV/m and 1400 Oe were reached in the center cell. This corresponds to $E_{acc}$ > 37 MV/m.**
- **This test demonstrates that tumbling is an effective option to repair weld defects, e.g. pits.**



# 2nd Sound Quench Detection

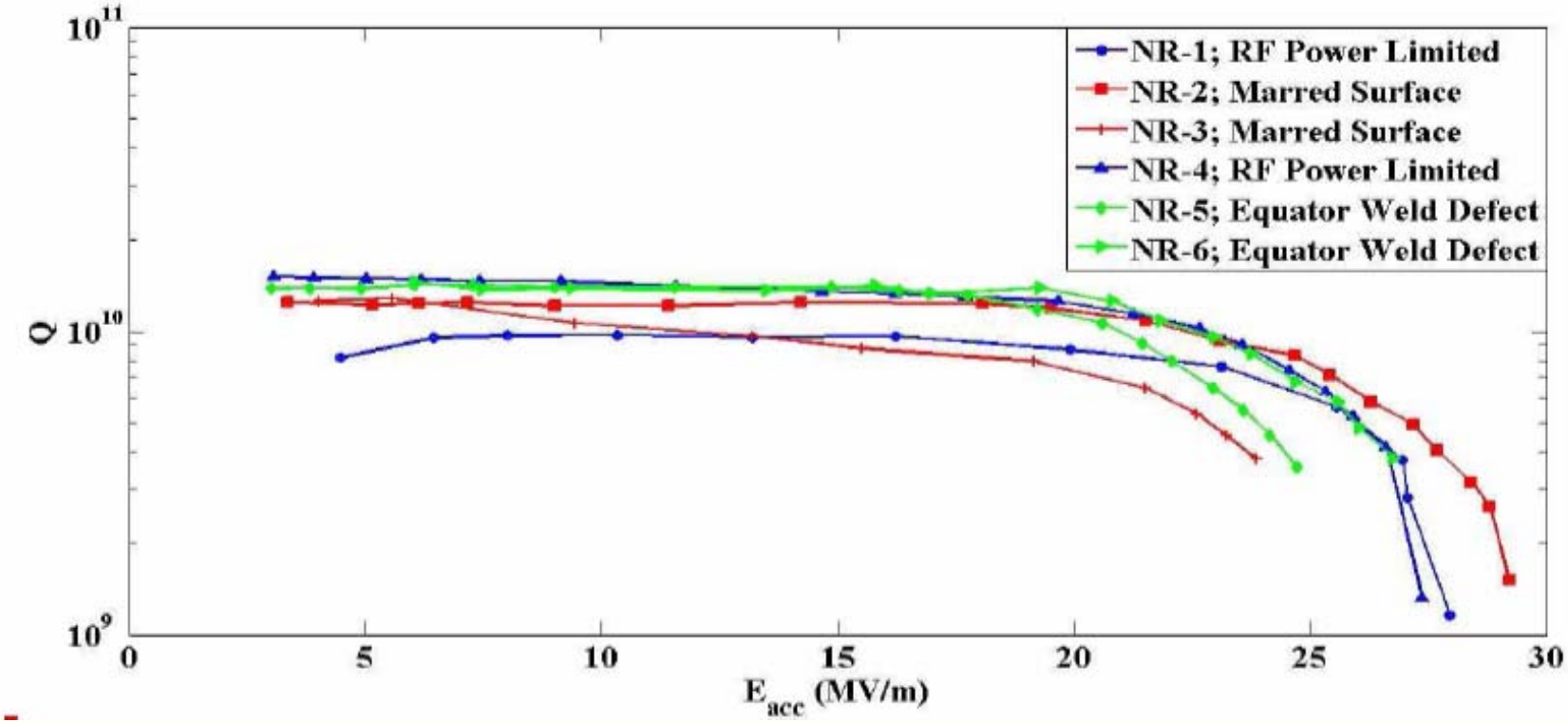
- We have demonstrated that 2nd sound detection can locate multiple quench locations in a single 9-cell cavity cold test
- By exciting different $TM_{010}$ pass-band modes of a 9-cell cavity different cells can be driven to quench.
- This technique is simple, low cost, and quick to implement.



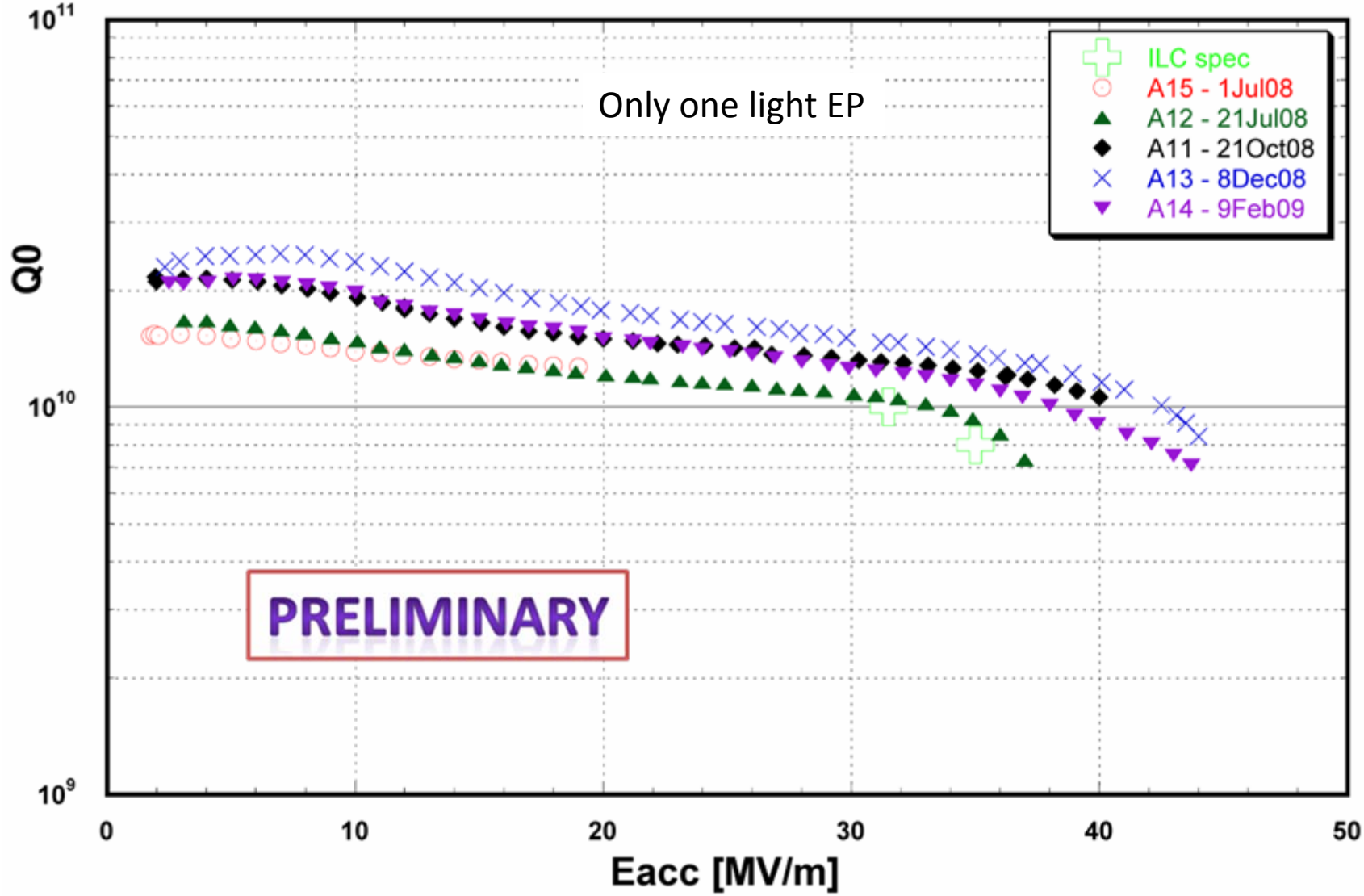
# Pre-Qualified Niowave/Roark Cavities

- Quick pre-qualification of 6 Niowave/Roark 1-cell cavities in 13 cold tests.
  - BCP (~150 µm), Ultrasonic Degreasing, HPR, and Clean Assembly.
- 2 cavities did not quench and showed the expected Q-slope limit due to BCP. (NR-1, NR-4)
- 2 cavities quenched due to "surface bump" from a defect on the manufacturing die. (NR-2, NR-3)
- 2 cavities quenched due to pits on equator weld. (NR-5, NR-6)
- All quench locations were located by 2nd sound detection and inspected with a Questar long distance microscope.

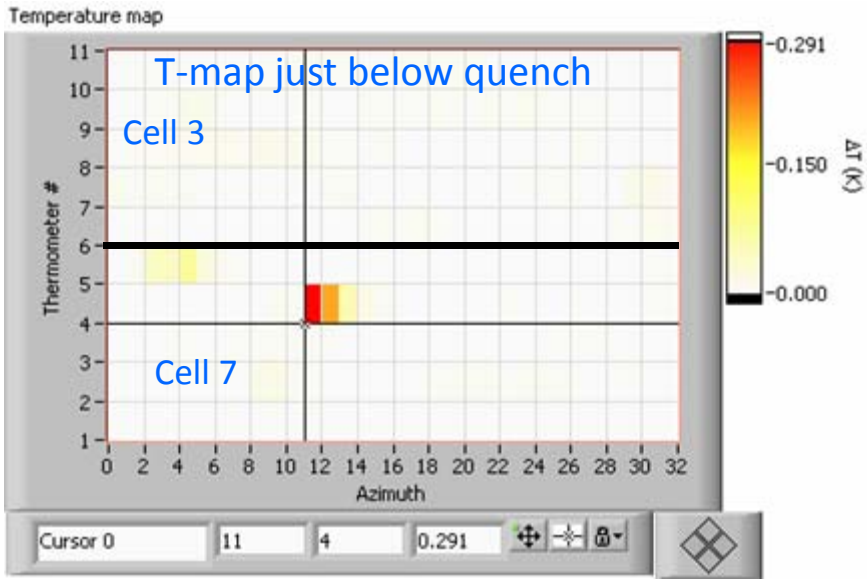


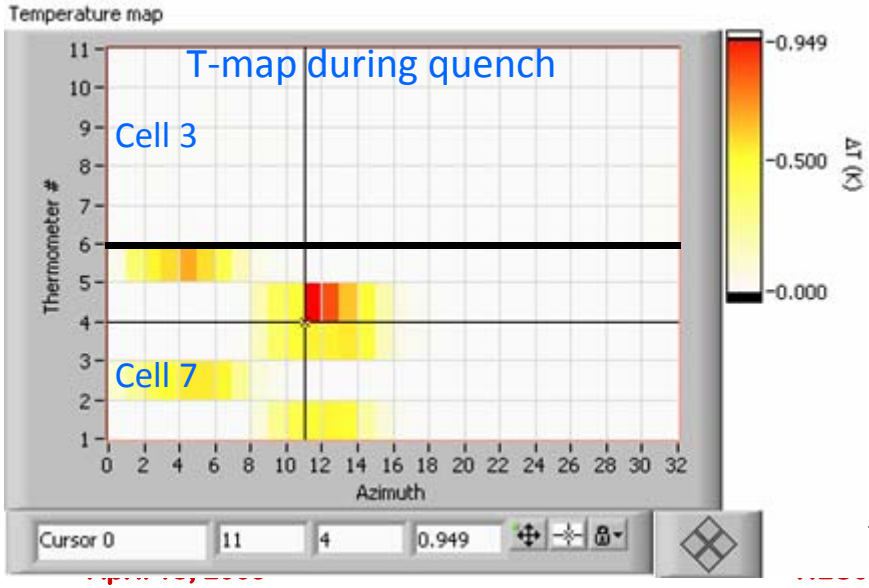
# Progress at Jefferson Lab

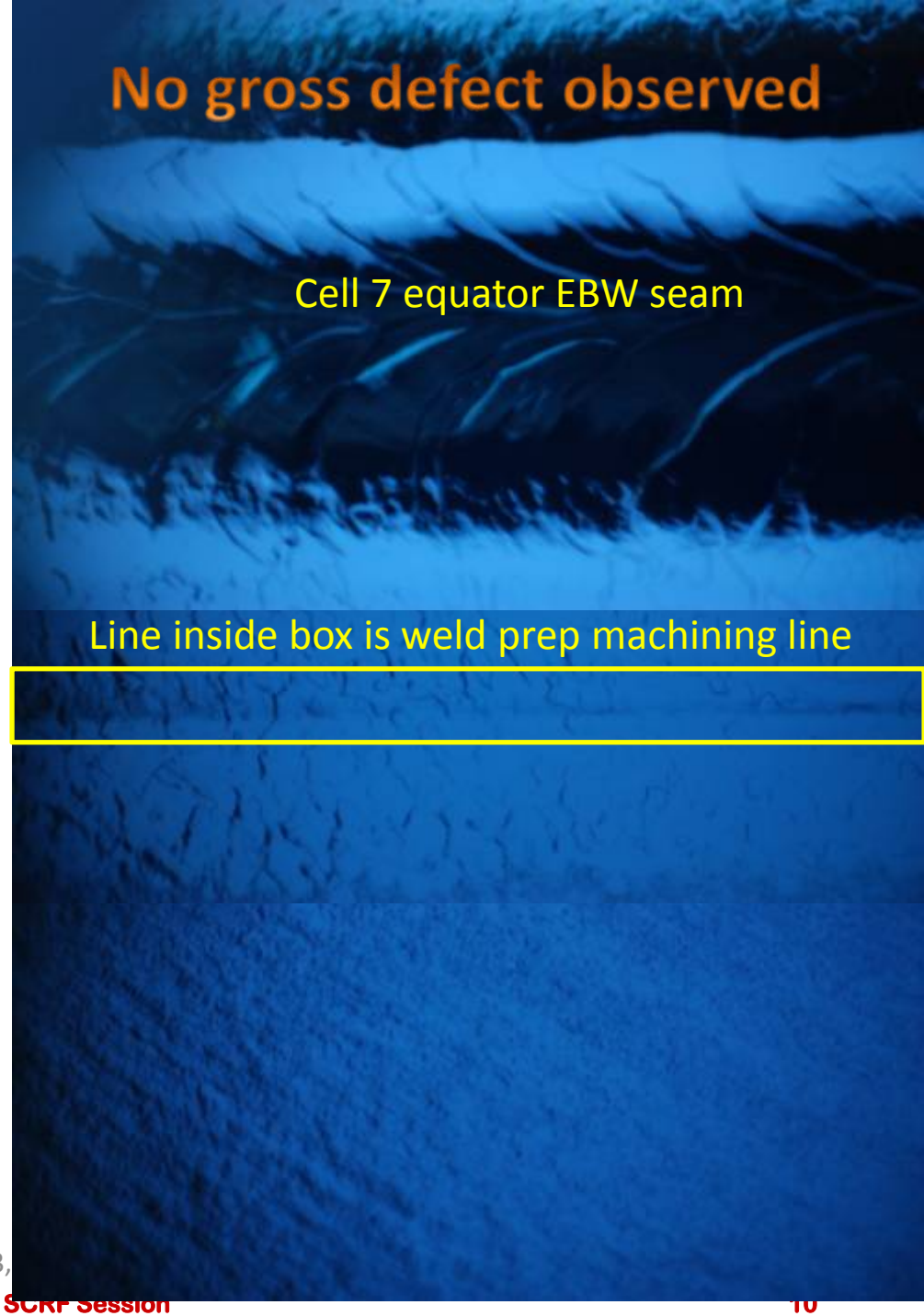
One vendor cavity in past 6 months EP processed and RF tested at JLab



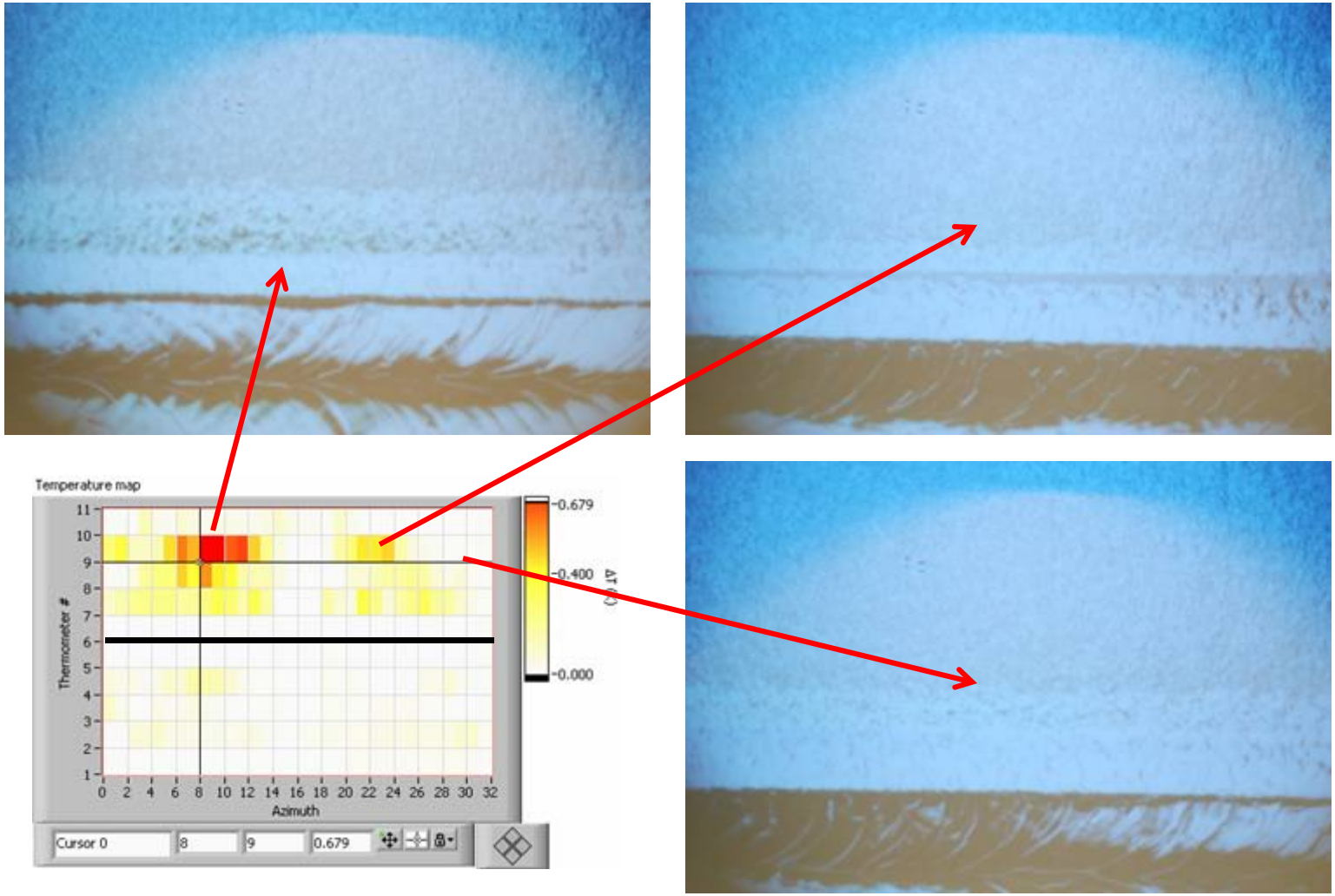
# Observing RF surface at hot spots correlated to 30 MV/m quench
# 9-cell cavity A12 T-mapping in Cell#7



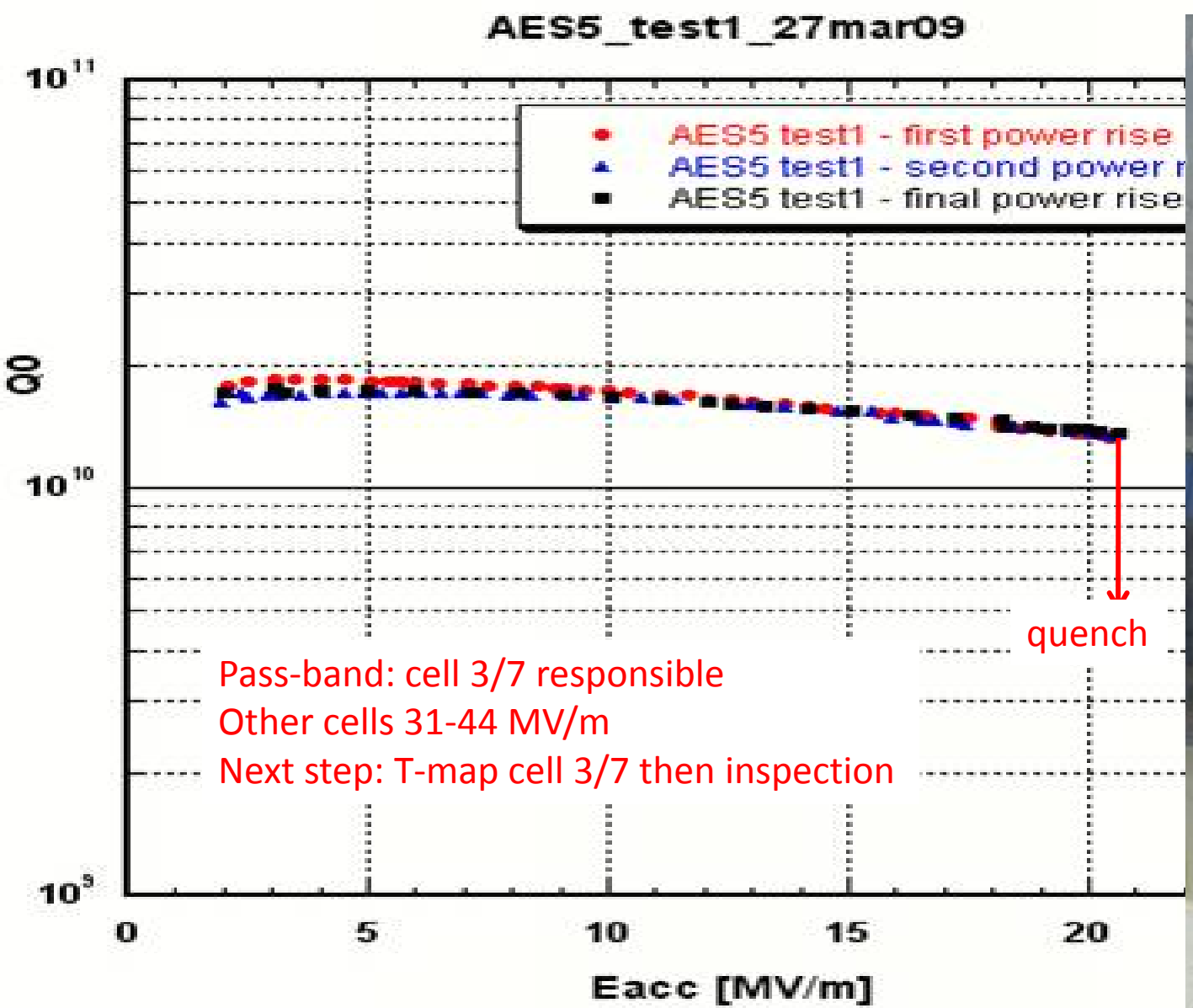



Correlating off-normal EP process with hot region and RF surface apparent roughness
9-cell cavity J2, 30 MV/m strong Q-drop
T-mapping and Inspection cell#1 from input coupler port, Equator weld & “hot” HAZ

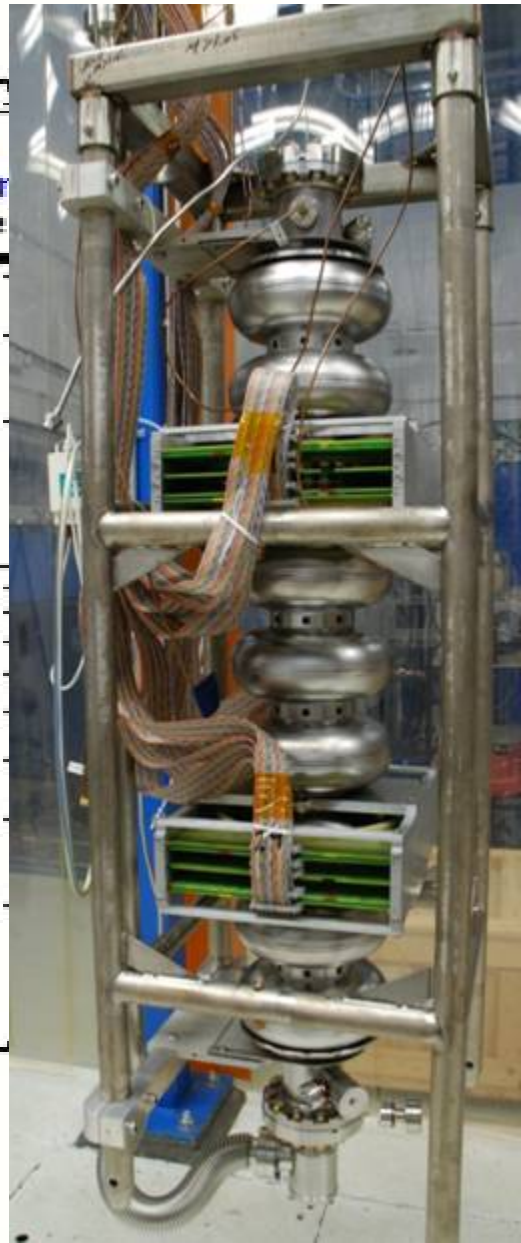


New AES 9-cell cavity: AES5 first test after first light EP




Pass-band: cell 3/7 responsible
Other cells 31-44 MV/m
Next step: T-map cell 3/7 then inspection

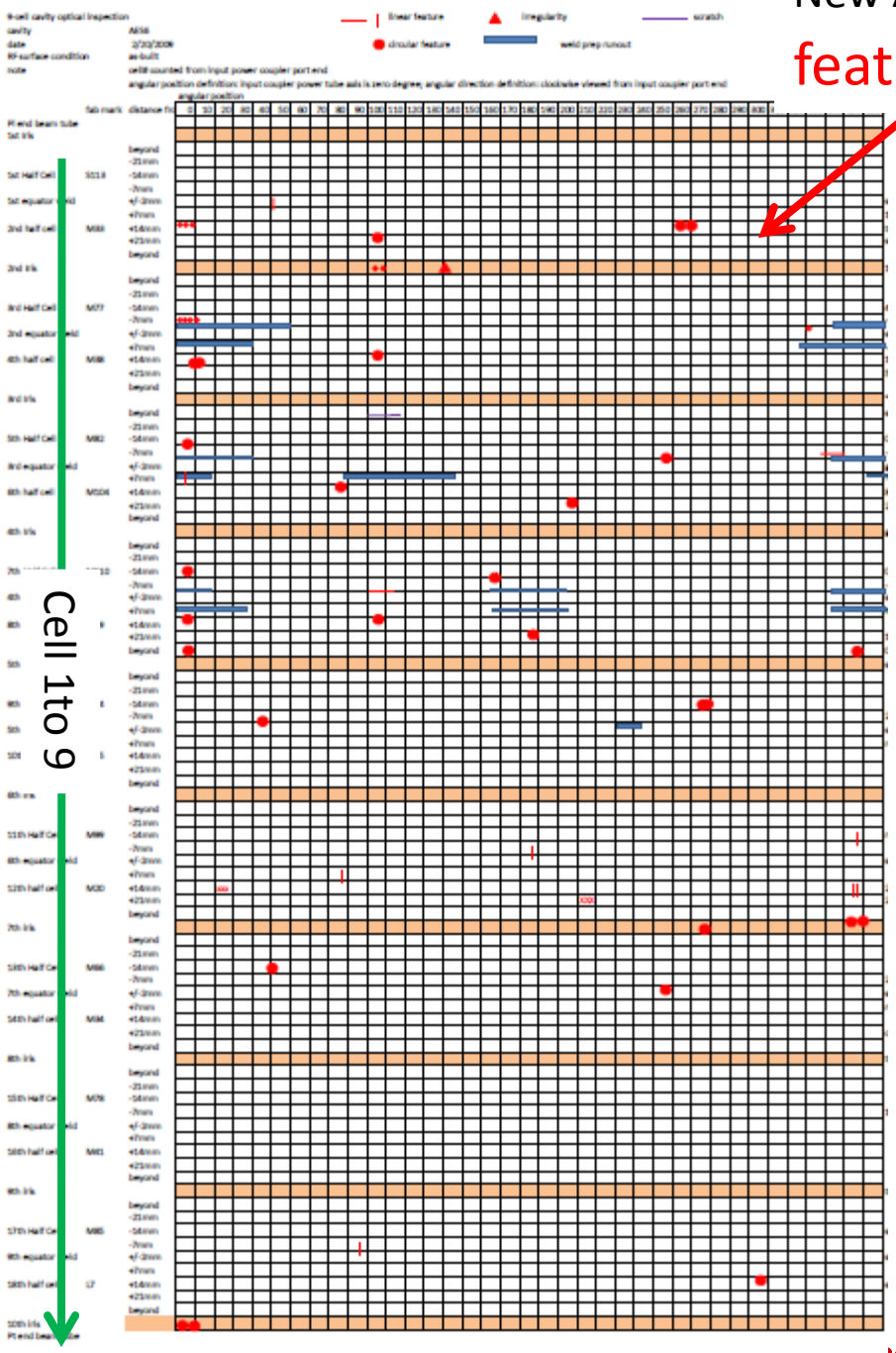
AES5 T-mapping



# AES5 Defect Photo
## Cell 3, ~700 um diameter, 8 mm from weld seam

# New AES 9-cell cavity AES6 as-received inspection

## feature/defect mapping & categorizing

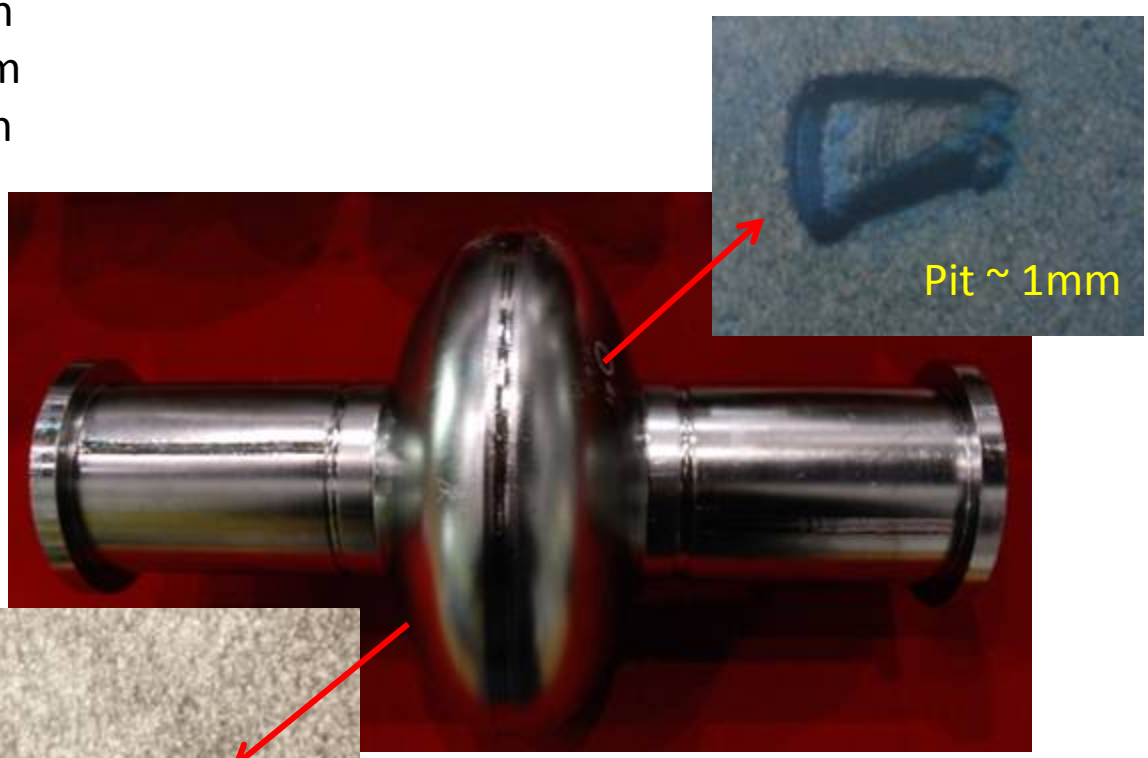



Examples of observable defects

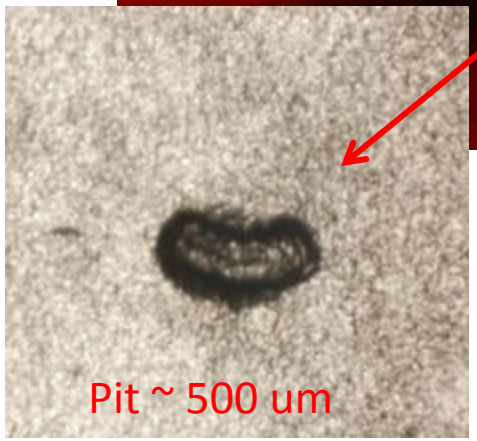


# 1-cell defect study cavity

1. Optical inspection for locations of defects (two shown)
2. BCP 40 um
3. Inspection
4. BCP 40 um
5. inspection

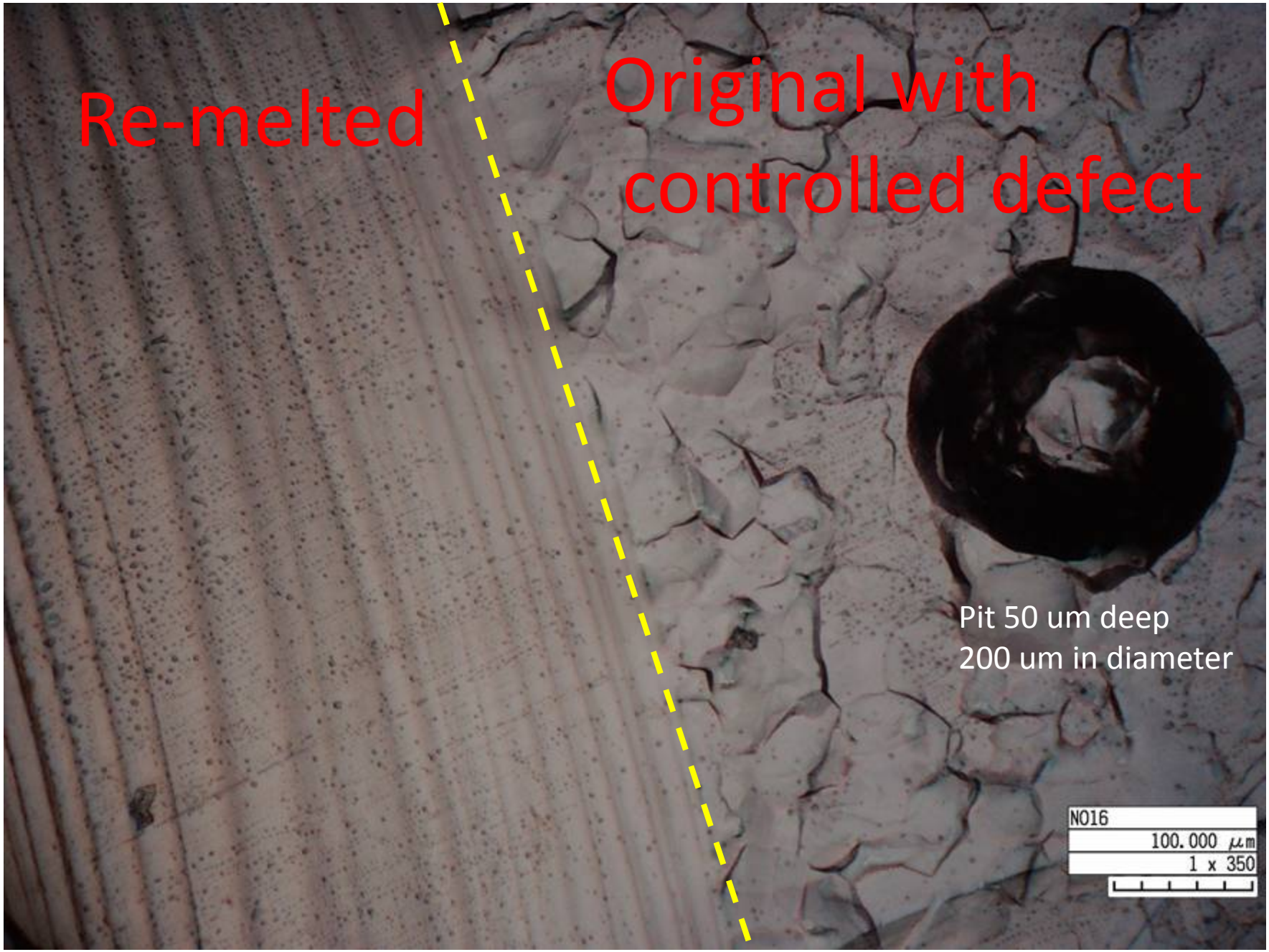




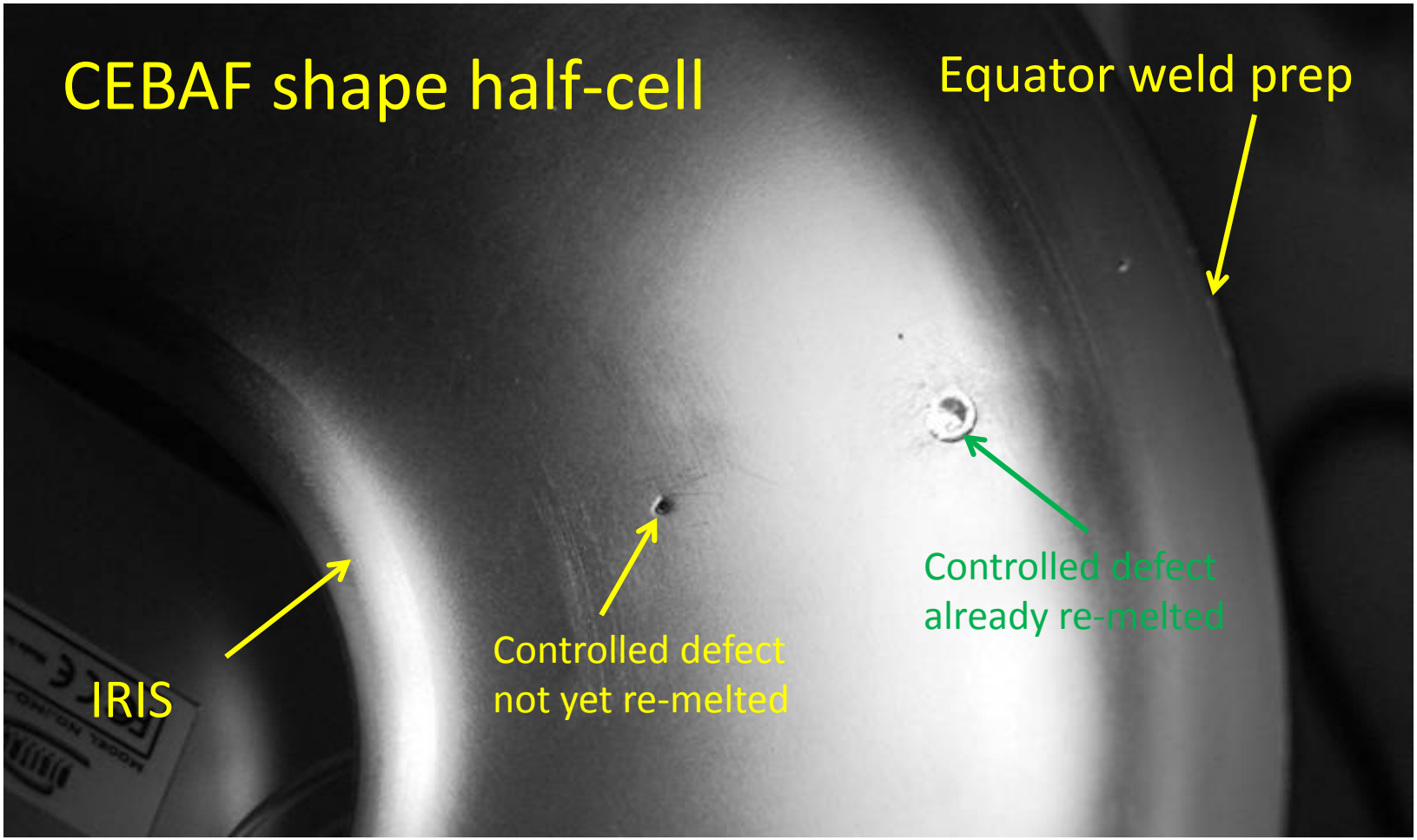




Next step

1. RF test with T-mapping at JLab
2. Remove responsible defect(s) by grinding at KEK
3. RF test with T-mapping again at JLab


Re-melted
Original with controlled defect
Pit 50 um deep
200 um in diameter
N016
100.000 μm
1 x 350

A half-cell re-melting experiment




A 1-cell cavity is being made for re-melting studies


# First step toward ICP

1. VEP1 150 minutes
2. Rotate Cavity
3. VEP2 150 minutes
4. 600 degree x 10 hour furnace degas
5. VEP3 75 minutes
6. Rotate cavity
7. VEP4 75 minutes

Cavity is now in preparation for RF test

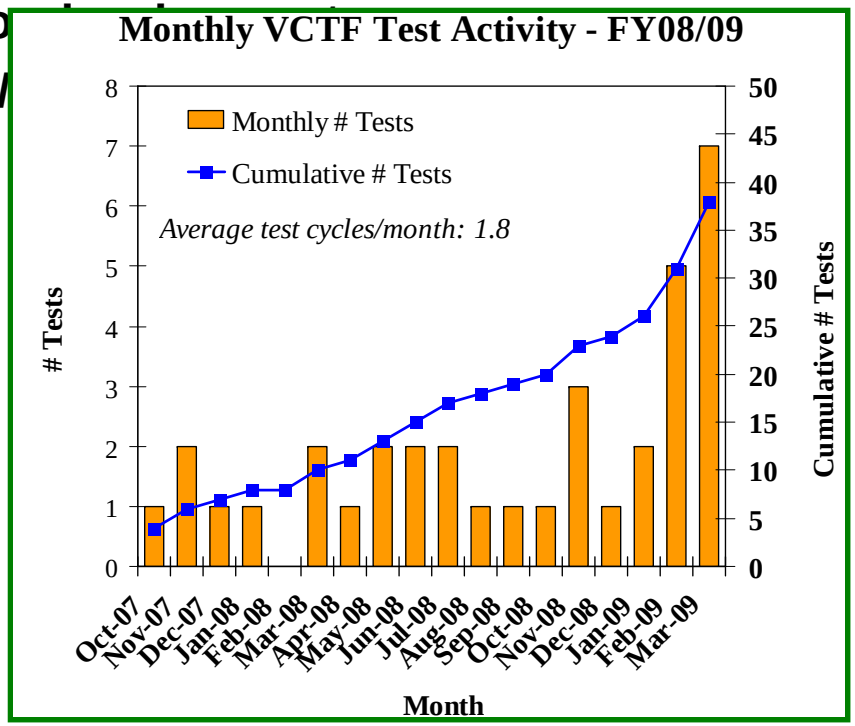
# Progress at Fermilab and Argonne

# Vertical Cavity Test Facility

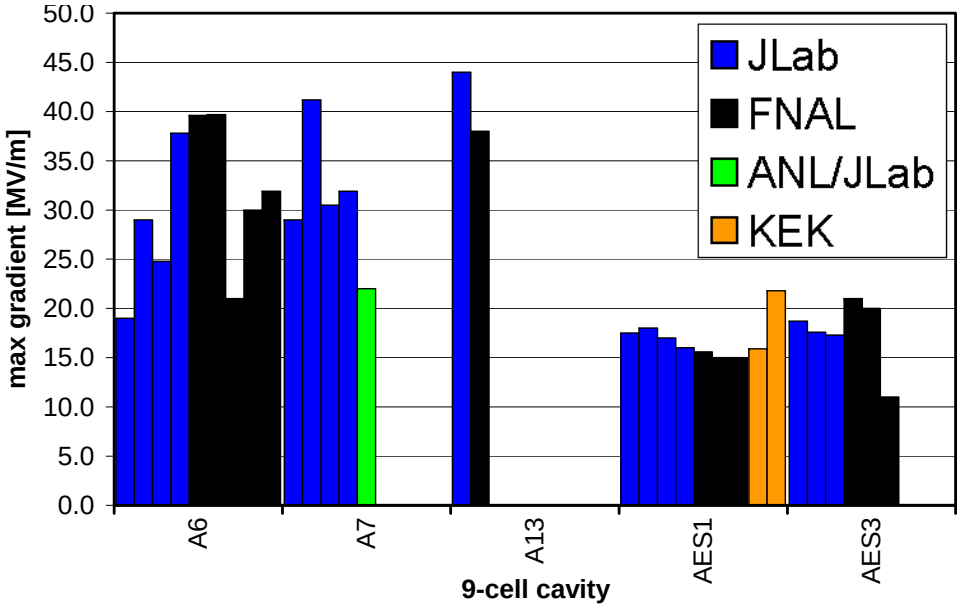
- **35 cavity tests in FY08/FY09, where "test" = cryogenic thermal cycle**
  - **9-cell & single-cell 1.3 GHz elliptical cavities and 325 MHz HINS single-spoke resonators**
  - **instrumentation development, variable coupler, thermometry, cavity**

Accel 6 w/ variable coupler

TE1ACC001 w/ thermometry
TE1ACC002



# FNAL/ANL 9-cell activity

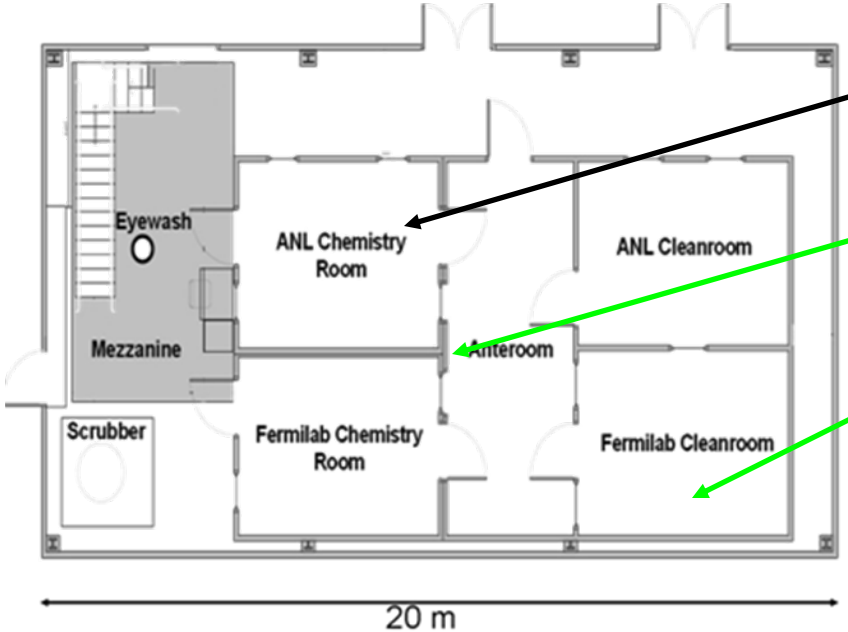



- ACCEL6 (A6): After 4 JLab cycles, used for variable coupler development. Currently limited by field emission (probably intrinsic to cavity now, not facility problem). Candidate for light EP.
- ACCEL7 (A7): After 4 JLab cycles, used for ANL EP commissioning and tested at JLab. Parameters and process were not adequately controlled, possibly causing performance degradation.
- TB9ACC013 (A13): Test after receipt from JLab under vacuum without any modification.
- AES001 (AES1): Quench location with fast thermometry, optical inspection development, KEK facility commissioning. First FNAL dressed cavity.
- AES003 (AES3): Quench location with fast thermometry, variable coupler (also FE limited), LANL facility and instrumentation development
- TB9ACC017 (A17): (new, not shown) first 9-cell full EP/process/assembly/test cycle

# ANL/FNAL Cavity Processing Facility

Facility being commissioned (already complete for single-cell cavities)

Provides complete processing of 1.3 GHz cavities: electropolishing, ultrasonic cleaning, high-pressure rinse, assembly, and vacuum leak test




Electro-polishing

Ultrasonic rinse

NEW!

High-pressure ultrapure water rinse

- First EP run with 9 cell cavity ACCEL 7 in 2007-2008
- 6 single-cell EP processes in 2009 complete with excellent performance >30 MV/m (7 total)
- Plan 1st attempt on 9-cell with full facility in April 2009

# ANL/FNAL CPF Updates

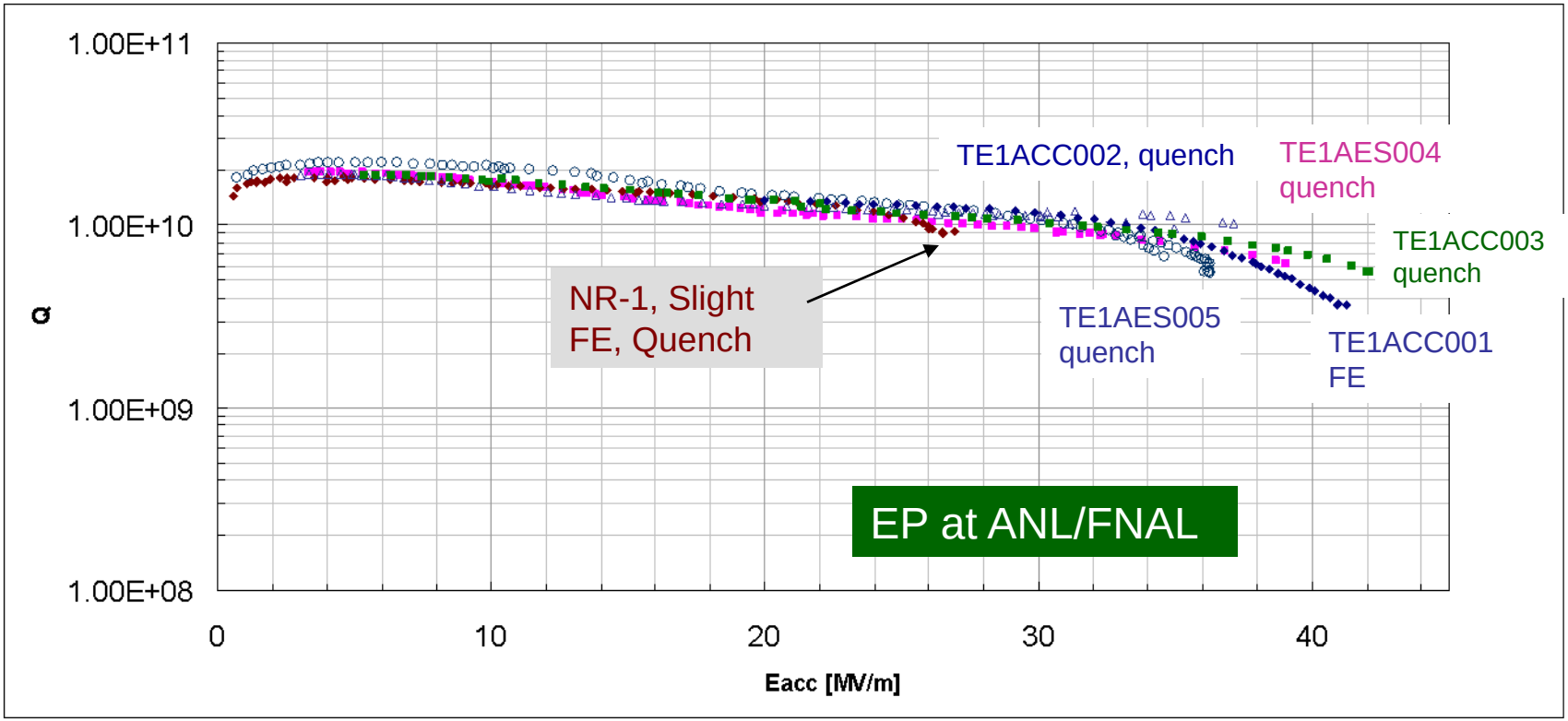
Ultrasonic rinse with gantry crane

High-pressure rinse system with cart

Cavity assembly rail, shown in vertical & horizontal orientation

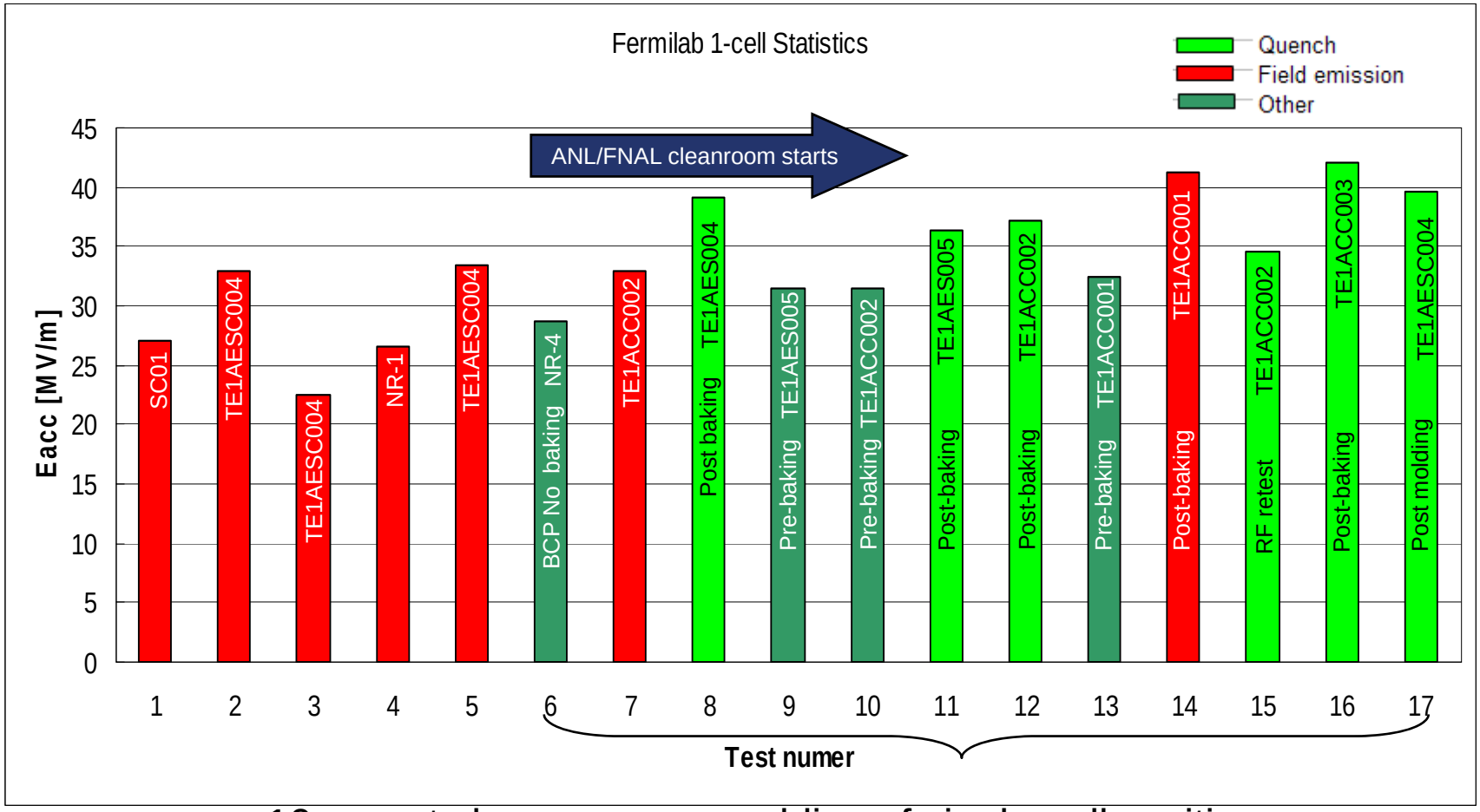
Cavity vacuum system

# EP single cell cavity performance




| | BCP | EP | Ethanol | Eacc [MV/m] | Notes |
|---|---|---|---|---|---|
| **NR-1** | **150** | **93** | | **26.5** | Oxidation by acid residual |
| **TE1AES004** | **107** | **65** | | **39.2** | Equator large pit present |
| **TE1AES005** | **104** | **100** | **Yes** | **36.3** | Oxidation by HPR water |
| **TE1ACC002** | | **112** | **Yes on second** | **37.1** | |
| **TE1ACC001** | | **99** | | **41.3** | FE appeared after 120°C baking |
| **TE1ACC003** | | **119** | | **42.1** | Pit present |
| **TE1ACC004** | | | | | |

# Fermilab/Argonne cavity experience




10 recent cleanroom assemblies of single-cell cavities show no field emission at ANL/FNAL joint facility

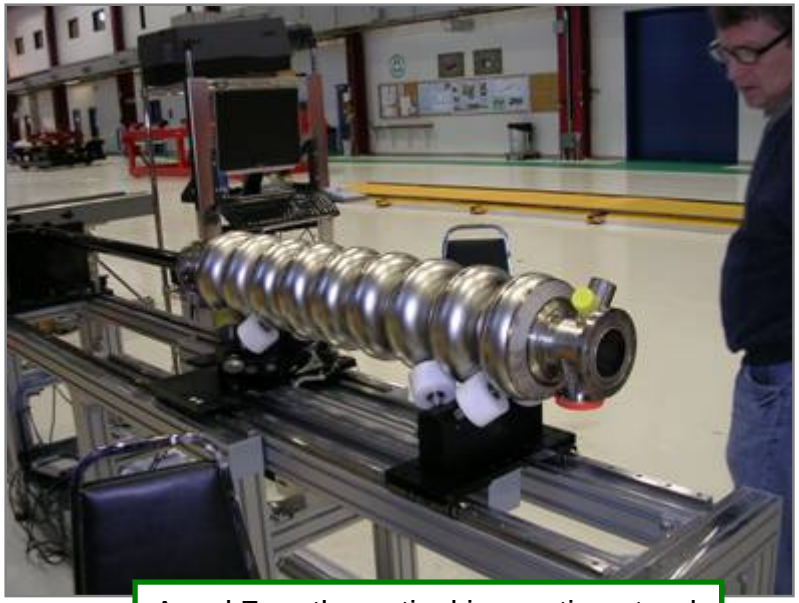
Test 7 TE1ACC002 handled with new pumping station

Test 14 FE appeared only after 120 C baking

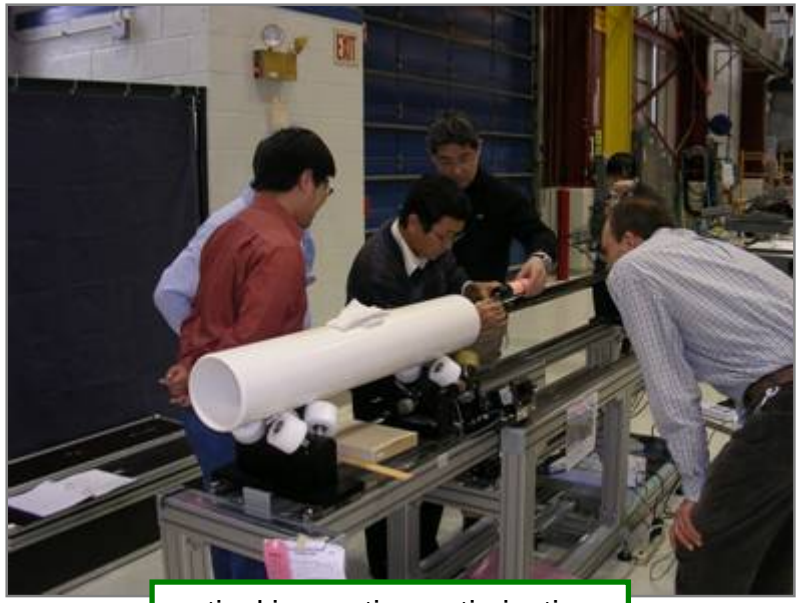
We are satisfied with the complete process/test cycle for single-cell cavities

# FNAL (KEK/Kyoto) Optical Inspection

- KEK/Kyoto inspection system delivered, installed, commissioned early in 2009
- Expert assistance to optimize system March 2009



Accel 7 on the optical inspection stand

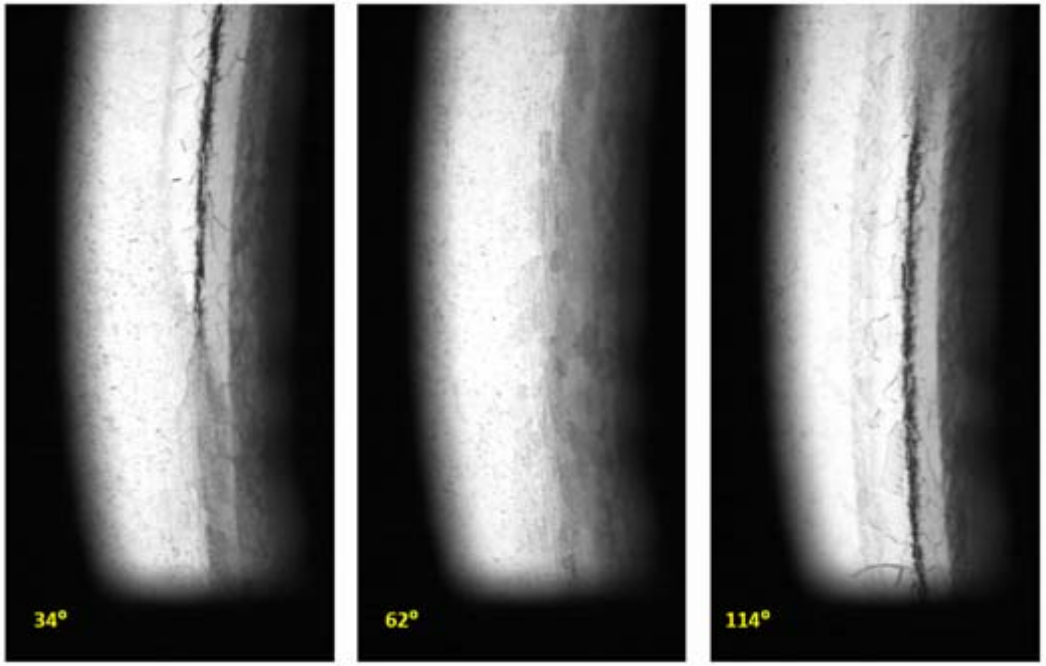


optical inspection optimization

# FNAL (KEK/Kyoto) Optical Inspection

9-cell cavities

- 9-cell TB9ACC010 was fully inspected as received from vendor before sending to Cornell for vertical EP commissioning



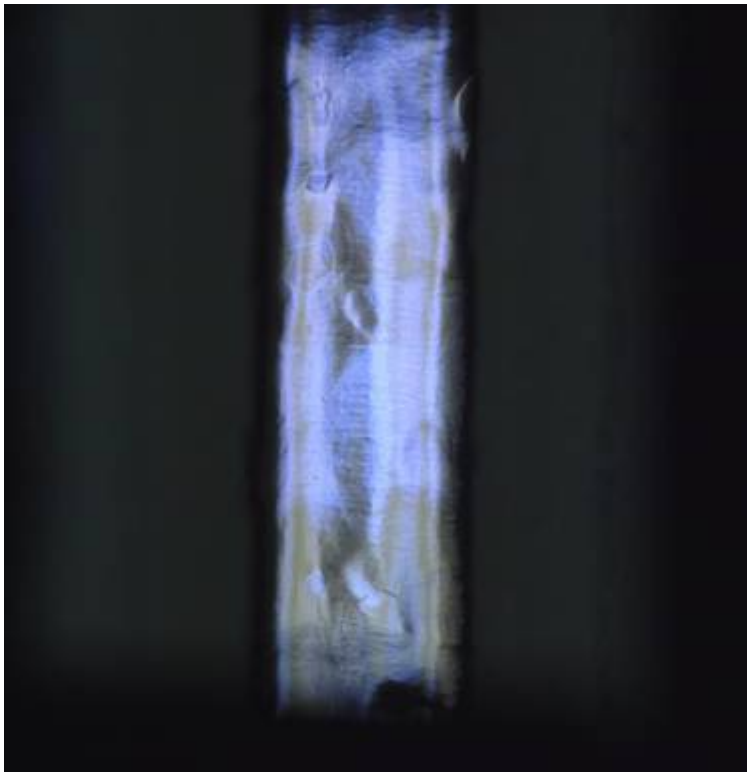

- No defects discovered.
- Iris anomaly (smoothness) between cells 8 and 9 noted.
  - Accel informed us of grinding in this region during fabrication.

# FNAL (KEK/Kyoto) Optical Inspection

9-cell cavities

- 9-cell ACCEL6 limited by field emission after repeated HPR

Iris between cell 1-2



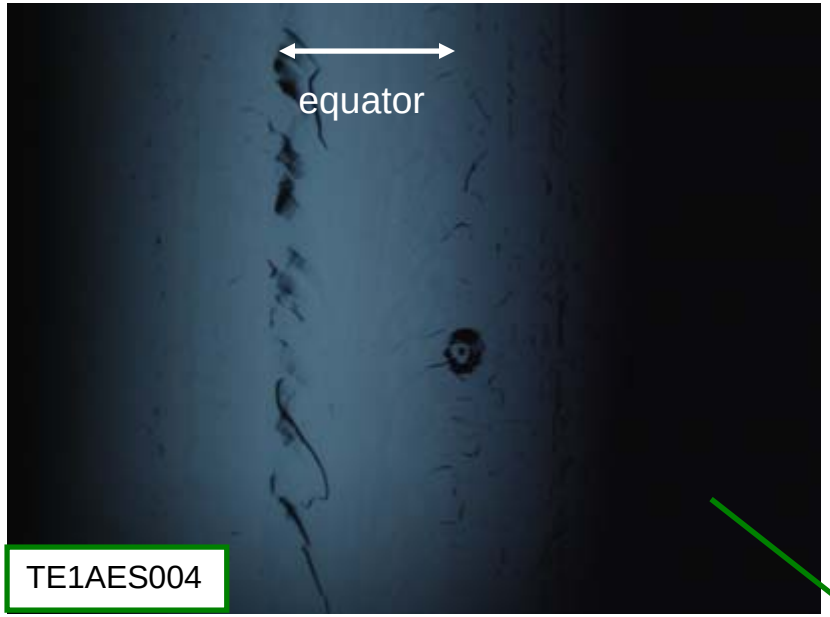
Iris between cell 7-8

Irises near input coupler end seem rougher with many tiny sharp-looking bumps
Irises seem smoother at other end

# FNAL (KEK/Kyoto) Optical Inspection

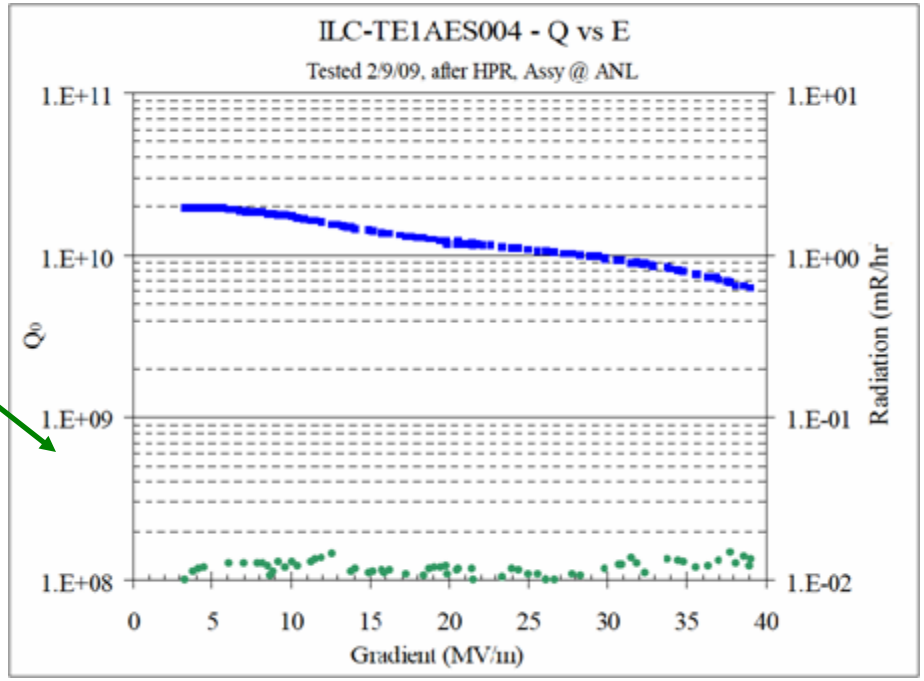
1-cell cavities

- TE1AES004 has huge pit at edge of weld seam, size ~1mm
- Nevertheless, 39 MV/m




TE1AES004

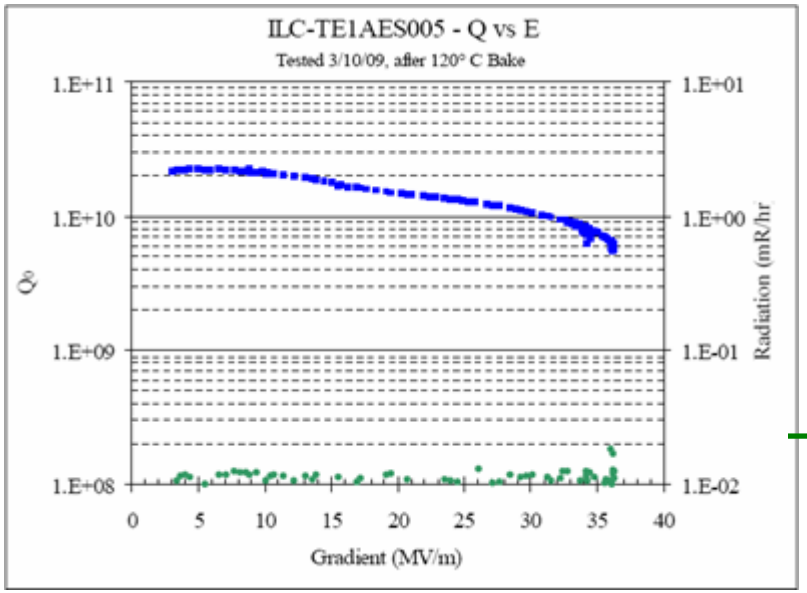
HPR and reassembly only



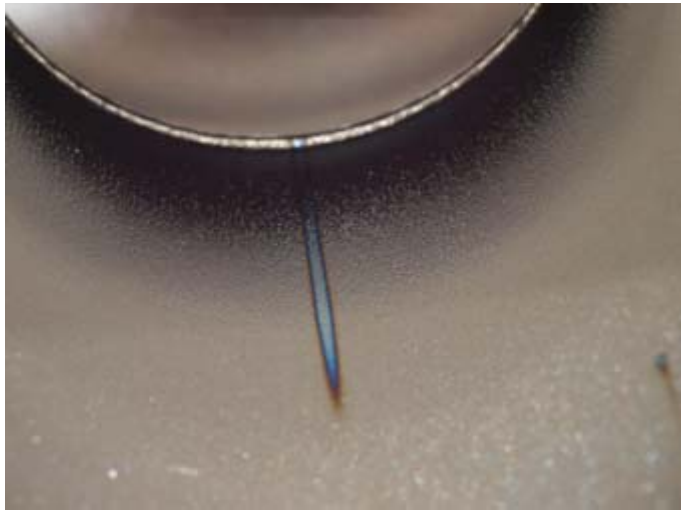
# FNAL (KEK/Kyoto) Optical Inspection

1-cell cavities

TE1AES005: Good performance limited by quench. Found oxidized stripe in beam tube (caused by rotation failure during high-pressure rinsing)



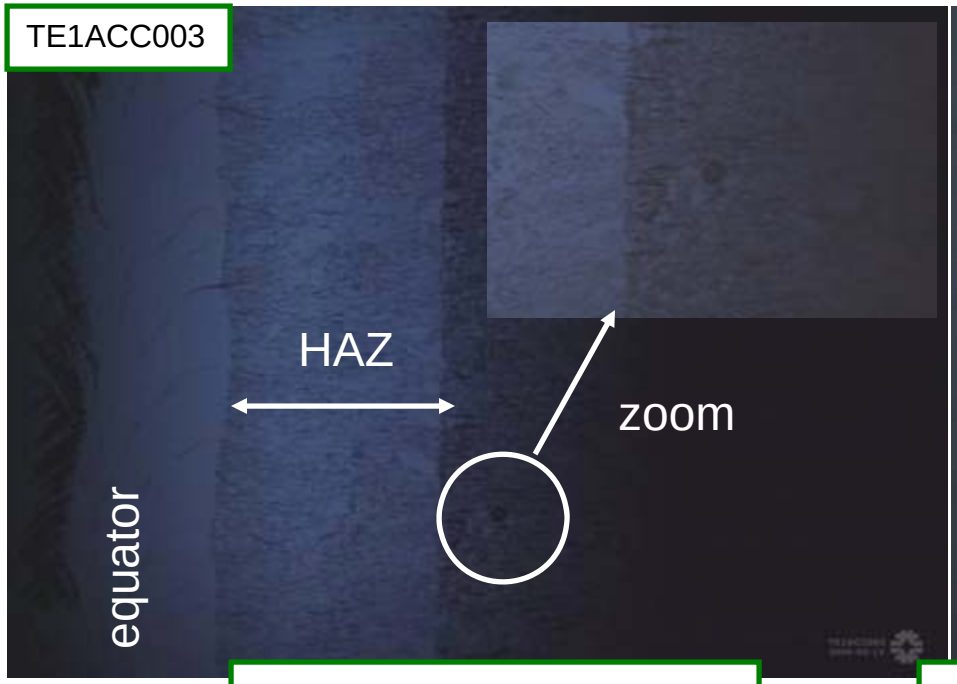

TE1AES005



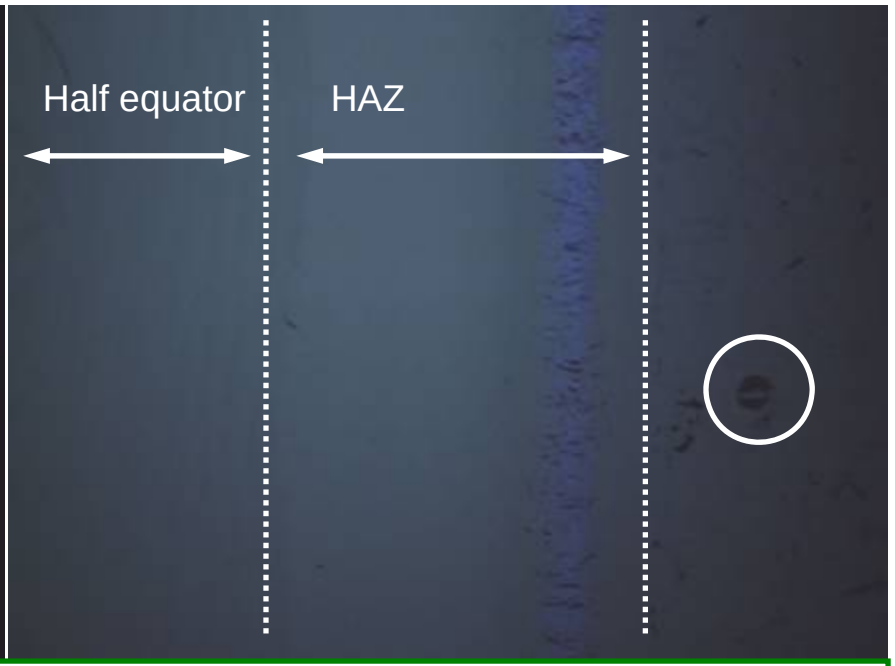
Inspection after test without any cavity processing

# FNAL (KEK/Kyoto) Optical Inspection

1-cell cavities




1st inspection




2nd insp. after 119 micron EP

- TE1ACC003 has a large pit outside the heat-affected zone, which was still there after 119 micron EP
- After 2nd inspection, then only HPR/assembly/120C bake, achieved 42MV/m limited by quench (location verified by T-map)

# Cavity Inventory

| Tesla-shape nine-cell cavities | | |
|---|---|---|
| **Description** | **No. Cavities** | **Status** |
| AES 1-4 | 4 | tested |
| AES 5-10 | 6 | received; testing in progress |
| AES 11-16 | 6 | due Oct 2009 |
| Accel 6-9 | 4 | tested |
| Accel 10-17 | 8 | received Mar 2008; testing in progress |
| Accel 18-29 | 12 | due May 2009 |
| Jlab fine-grain 1-2 | 2 | fabrication complete; testing in progress |
| Niowave-Roark 1-6 | 6 | due Oct 2009 |
| Stimulus Procurement | xx | still in the planning stages; assume first cavities ~April 2010 |
| | | |
| **Total** | **48** | |
| Already Received | 24 | |
| | | |
| **Tesla-shape single-cell cavities** | | |
| **Description** | **No. Cavities** | **Status** |
| AES 1-6 | 6 | tested at Cornell; further testing in progress |
| Accel 1-6 | 6 | received Dec 2008; testing in progress |
| Niowave-Roark 1-6 | 6 | received Jun 2008; testing in progress |
| PAVAC | 4 | requisition in progress |
| | | |
| **Total** | **22** | |
| Already Received | 18 | |

# Summary

- Much progress in the Americas region
- Vertical EP shown to enable >35 MV/m in individual cells of nine-cell cavities
  - Further testing planned
- Good tumbling result at Cornell (15 → 30 MV/m)
- Optical inspection has been very useful in locating quench-inducing defects
- Thermometry & second-sound enables quench location
- Cavity processing facility at Argonne commissioned with single-cell cavities
  - Nine-cell cavity commissioning has begun
- Excellent series of process/test on Accel cavities
- 12 new nine-cell cavities due in May; 12 more in Autumn
- FY2010 planning underway
  - ART review Apr 29-30 at SLAC