1.3 GHz 9-cell cavity T-mapping and surface inspection results at LANL

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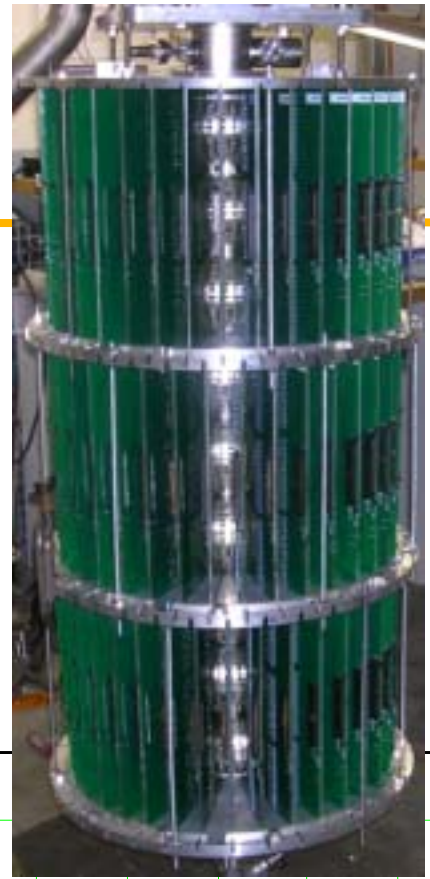
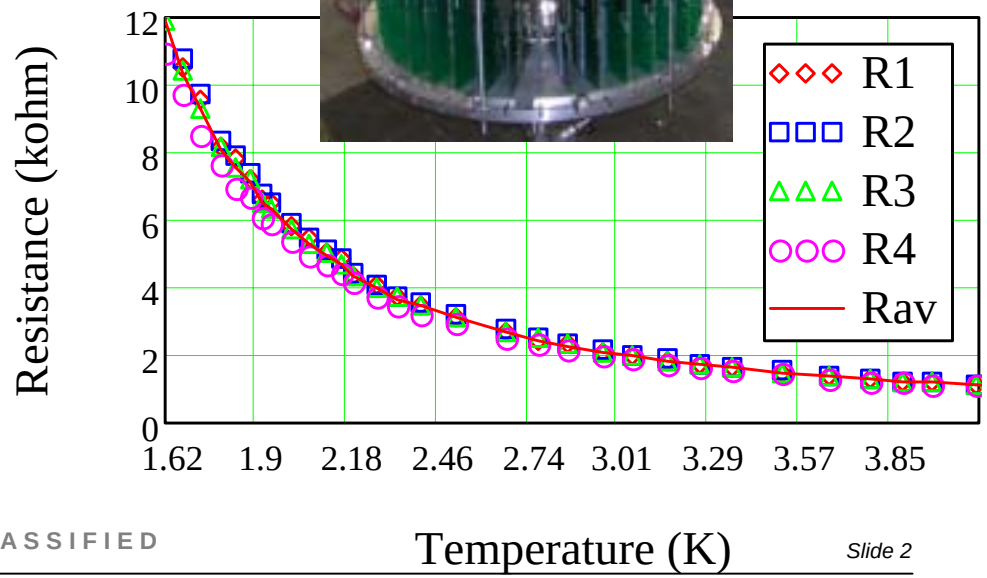
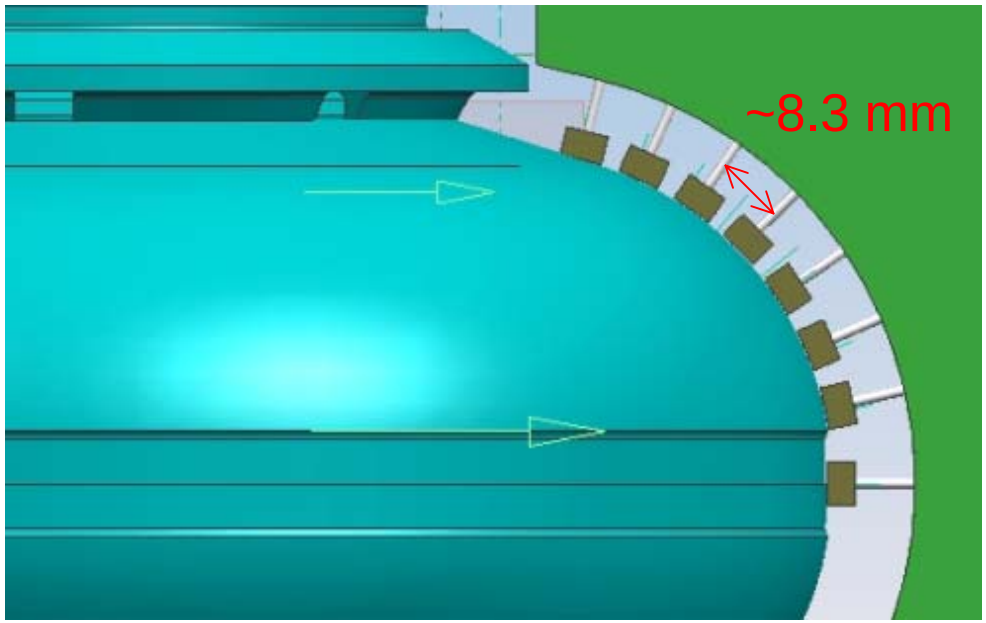
9-cell temperature mapping system

- **Sensors**
  - A total of 4608 Allen-Bradley 100-ohm resistors
- **System**
  - One board covers 3 cells
  - Every 10 degrees, 108 boards.
  - Cavity was divided into 9 sectors azimuthally (every 40°) and signal was multiplexed
  - 768 manganin wires in custom-made feedthrough





Sensor positions

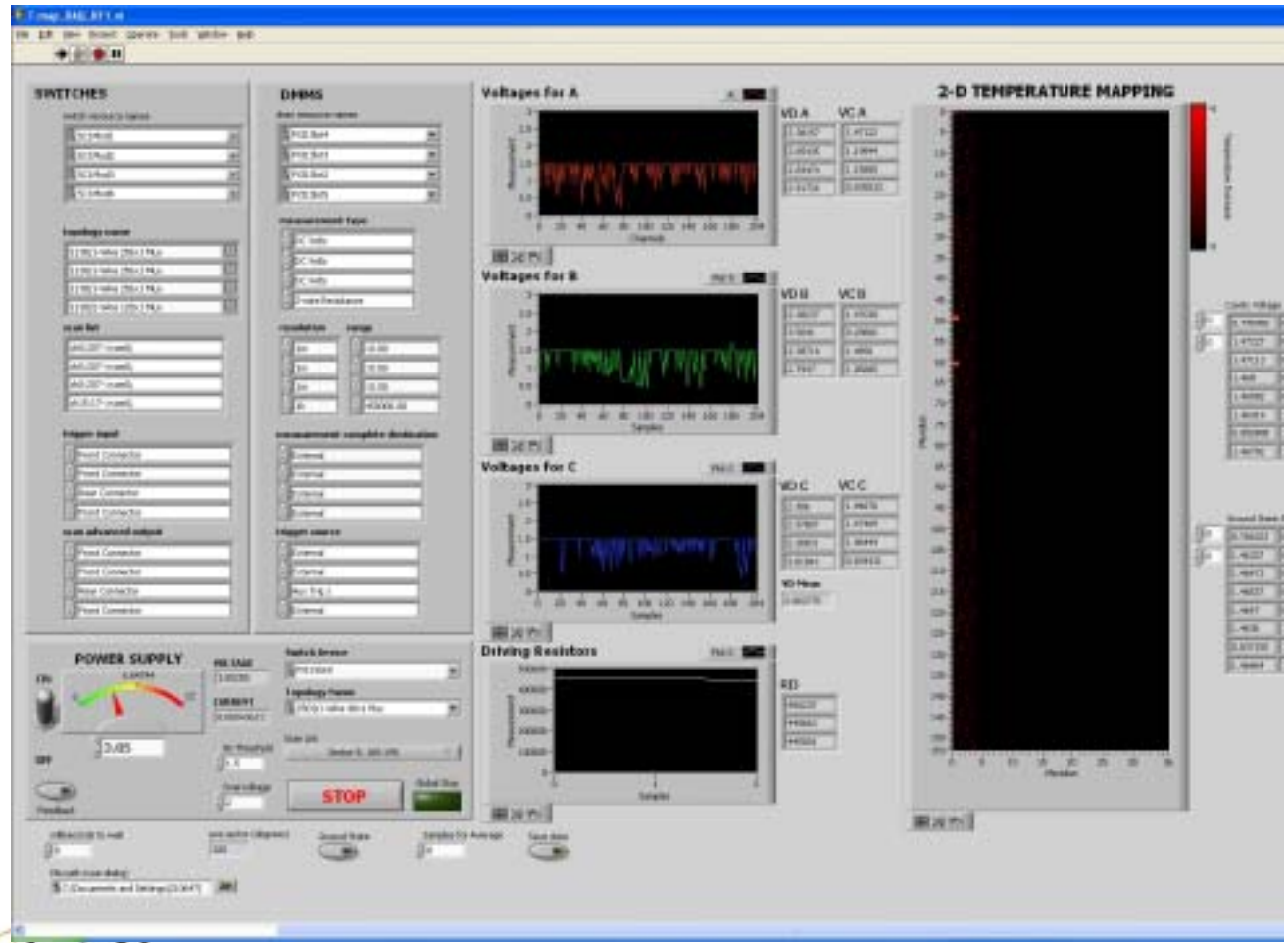


- One board covers 3 cells and a total of 108 boards cover all the cells at 10° interval.
- 15 sensors per cell per meridian except for cell 1 (12) and cell 9 (11). A total of 4608 sensors.

A cavity (AES-03) loaned from FNAL has been used to commission the system

- **The first 2 tests were carried out in June 2008. The second test was done without breaking vacuum, but with thermal cycle. We did not have time to disassemble and re-apply grease to the sensors.**
- **Tests summary**
  - Some heating spots were observed.
  - Only sector-by-sector 2D maps were obtained.
  - Four sectors out of 9 were not tested due to some disconnection problem.
  - A noise problem prevented full mapping.

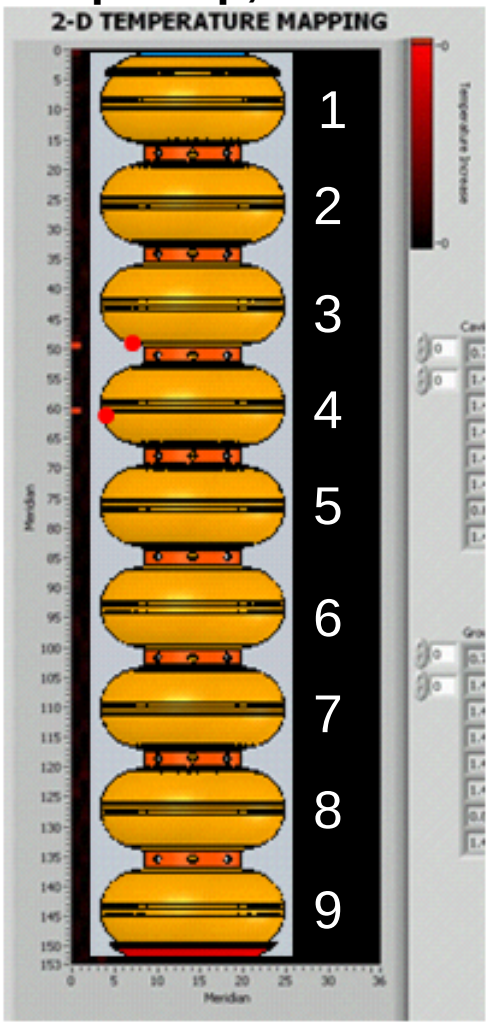
Screen shot of the T-mapping program



- sensors at every 10 degrees azimuthally
- Divided into 9 sectors, i.e., 40 degrees each to reduce the number of cables coming out of the cryostat
- Diodes insensitive to temperature change used to multiplex the power

Summary of first 2 tests in June 2008
Q-E curve was not taken due to a computer problem

RF pickup, HOM 0°



Sensor numbers from top to bottom with the position of equator
Cell 1: 1-17 equator 9
Cell 2: 18-34 equator 26
Cell 3: 35-51 equator 43
Cell 4: 52-68 equator 60
Cell 5: 69-85 equator 77
Cell 6: 86-102 equator 94
Cell 7: 103-119 equator 111
Cell 8: 120-136 equator 128
Cell 9: 137-153 equator 145

- Previous FNAL measurement was limited at ~20 MV/m with quench.

- 1st test at quench

61@120° cell 4 near eq.
75@150° cell 5 near eq.
50+61@160° cell 3 near iris+cell 4 near eq. (X-ray was detected as well)
23@200° cell 2 in the middle

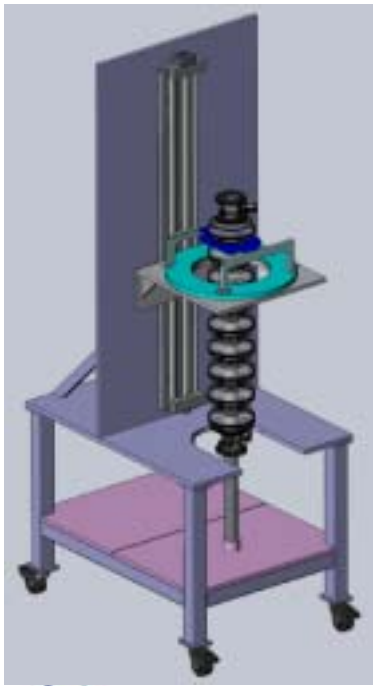
- 2nd test after warming up to room temperature (we did not re-apply grease!)

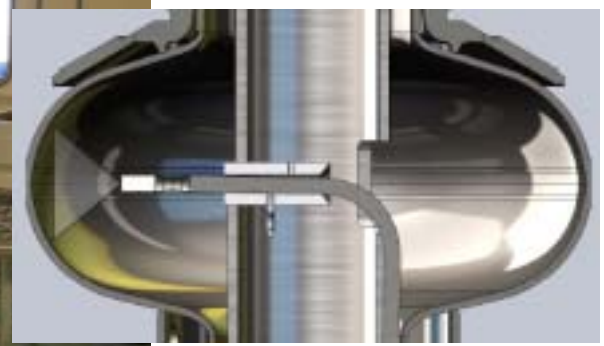
112@220° cell 7 near eq.
79@230° cell 5 near eq.
112@260° cell 7 near eq.
No X-ray was detected.

E D

Cavity inner surface optical inspection system

- A videoscope with 1/10 inch CCD (250,000 pixels) inside the tip was used.
- 80° field of view and 7-40 mm working distance.
- Although there is tip articulation function of +/- 120°, it has not been used.
- Although there is a function of measuring distance and depth, it has not been used.





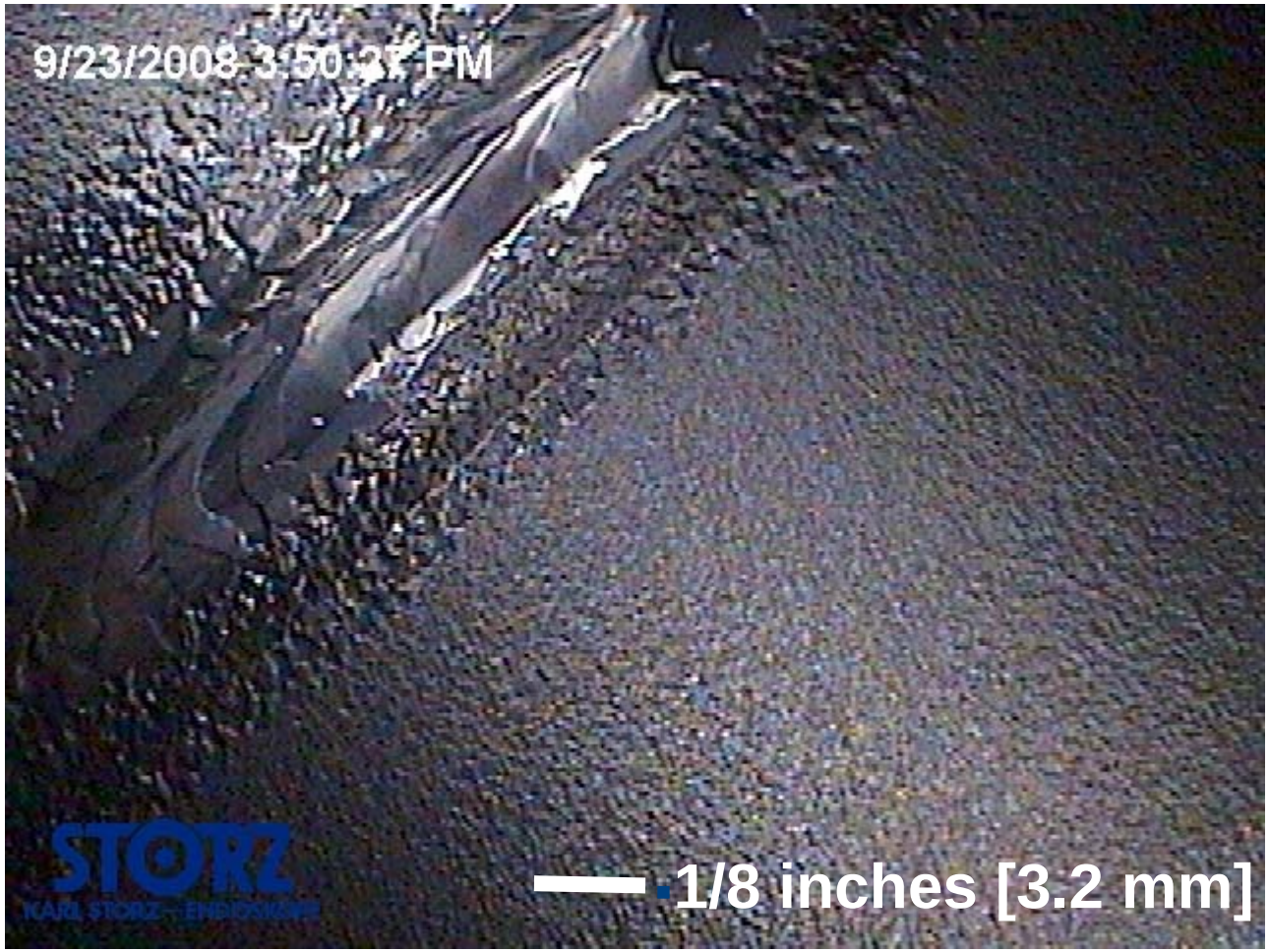
AES-03 cavity inspection results
Cell 2, 230°, 3 sensors up from equator

Marked as 200° on the cavity

Cell 3, 160° near iris to cell 4

- **This spot was not checked possibly due to the fact that the location was not marked on the cavity surface??**

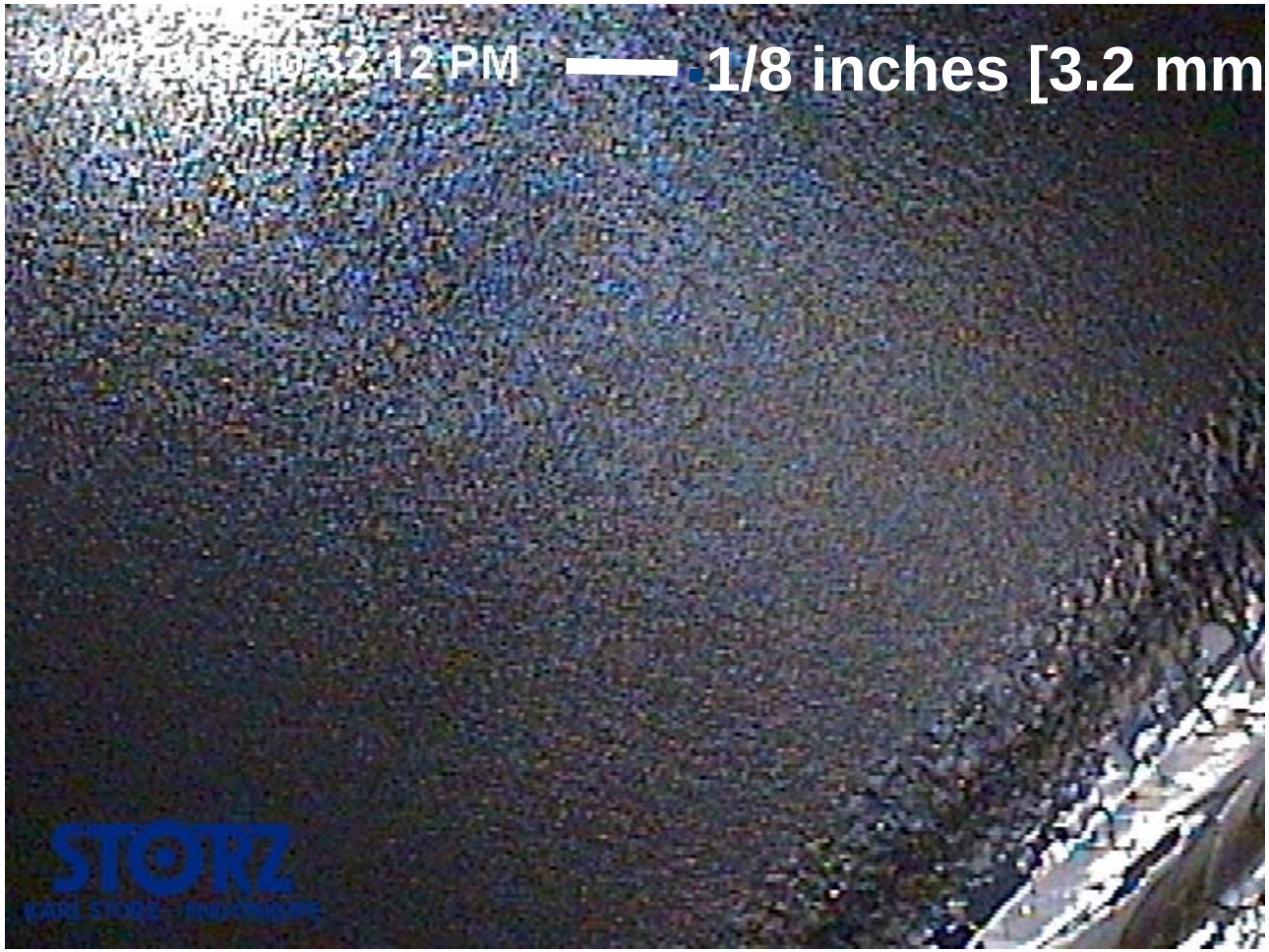
Cell 4, 160°, 1 sensor down from equator
X-ray was detected in the first test



Cell 4, 120°, 1 sensor down from equator

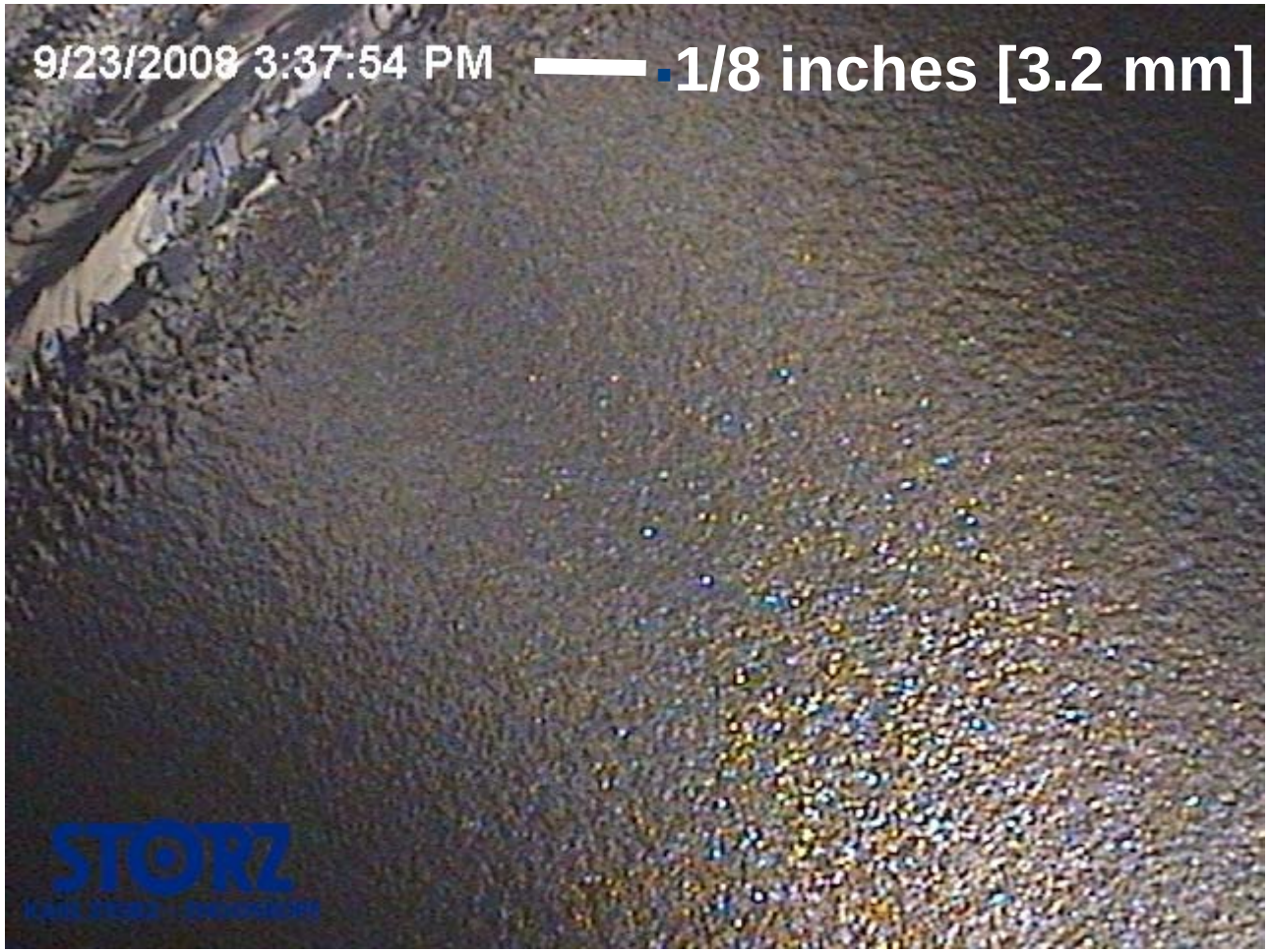
- **This spot was not checked possibly due to the fact that the location was not marked on the cavity surface??**

Cell 5, 150°, 2 sensors up from equator

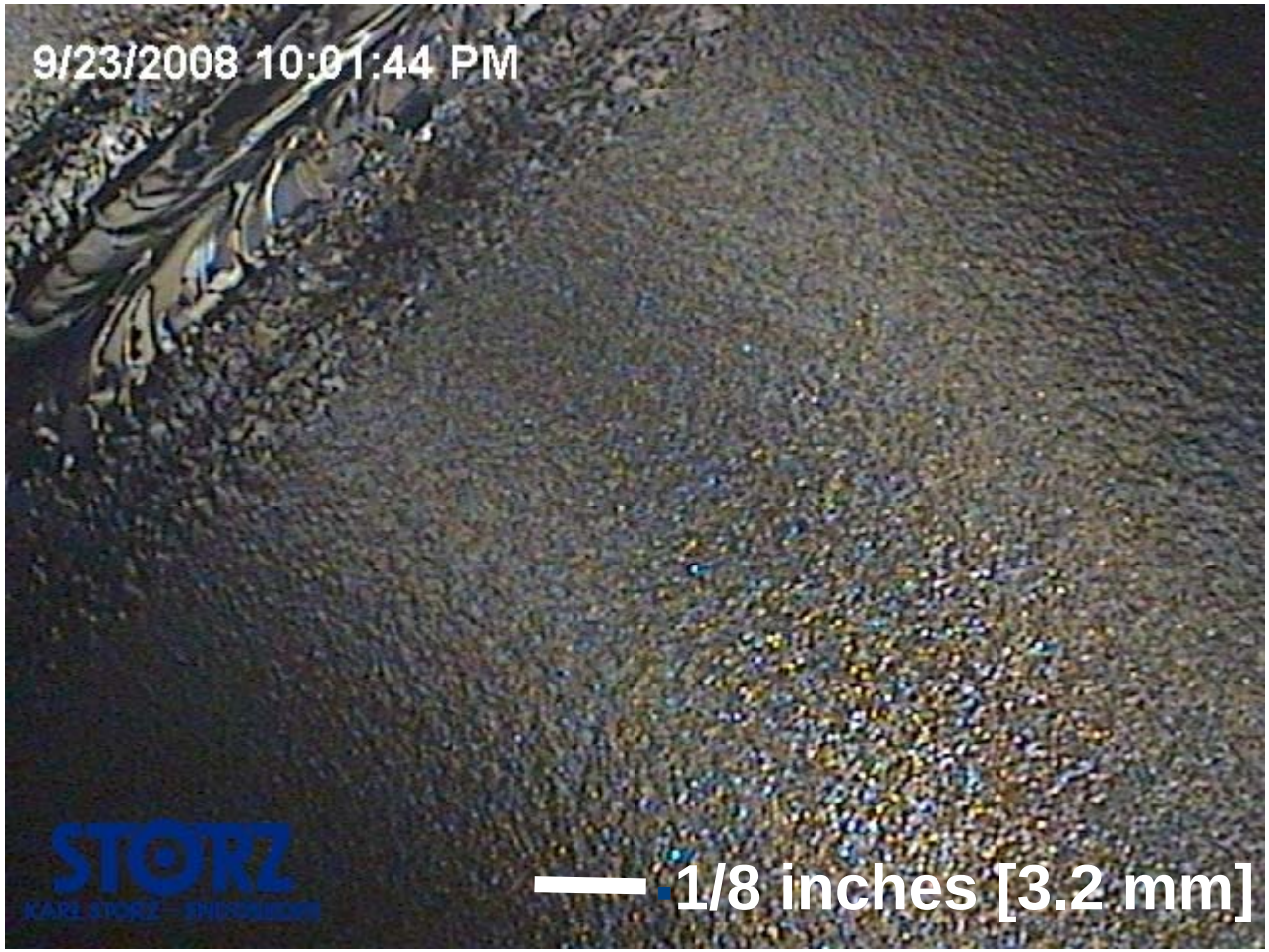


Cell 5, 150°, at the equator, marked on the cavity

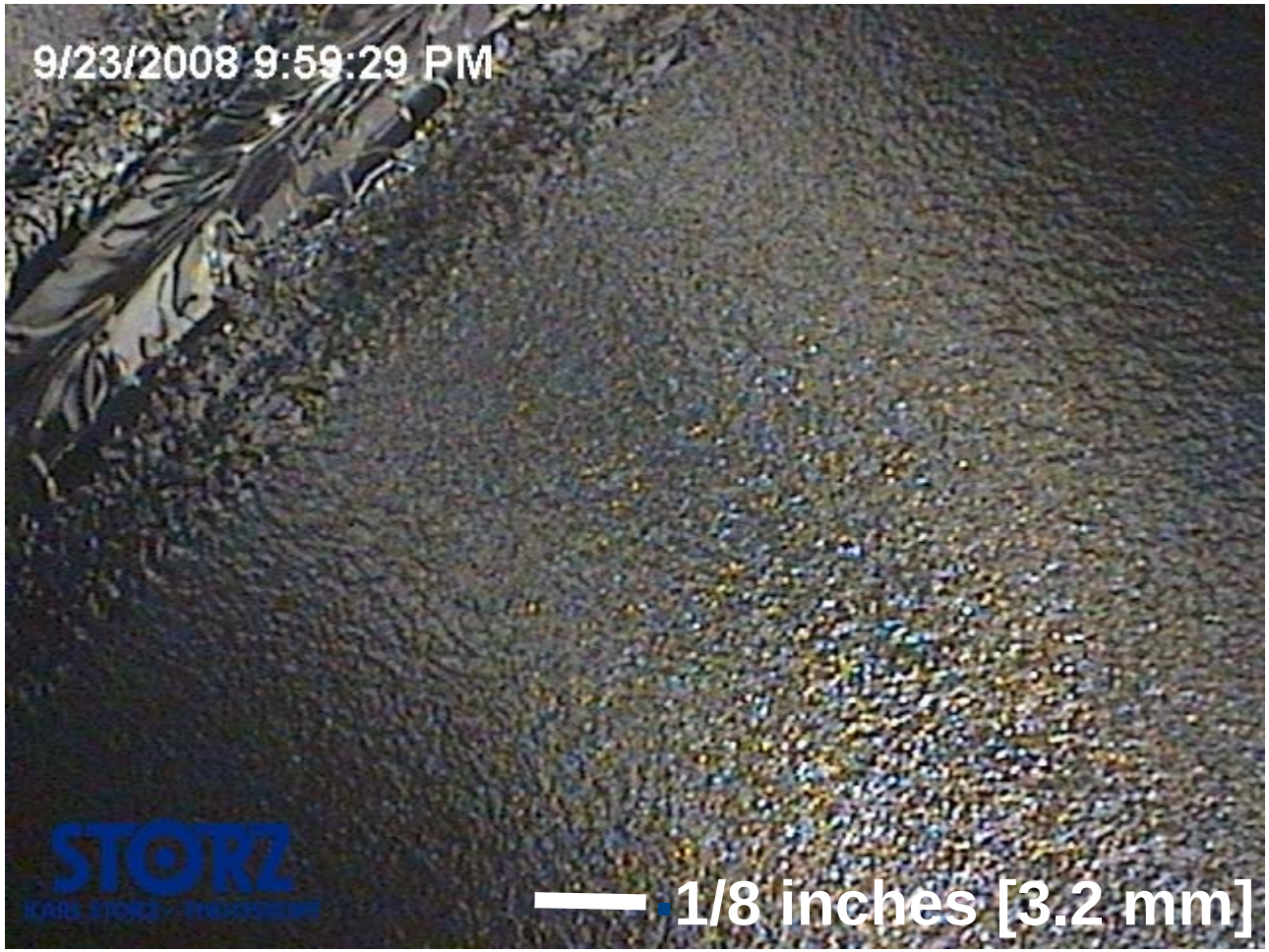
Cell 5, 230°, 2 sensor down from equator



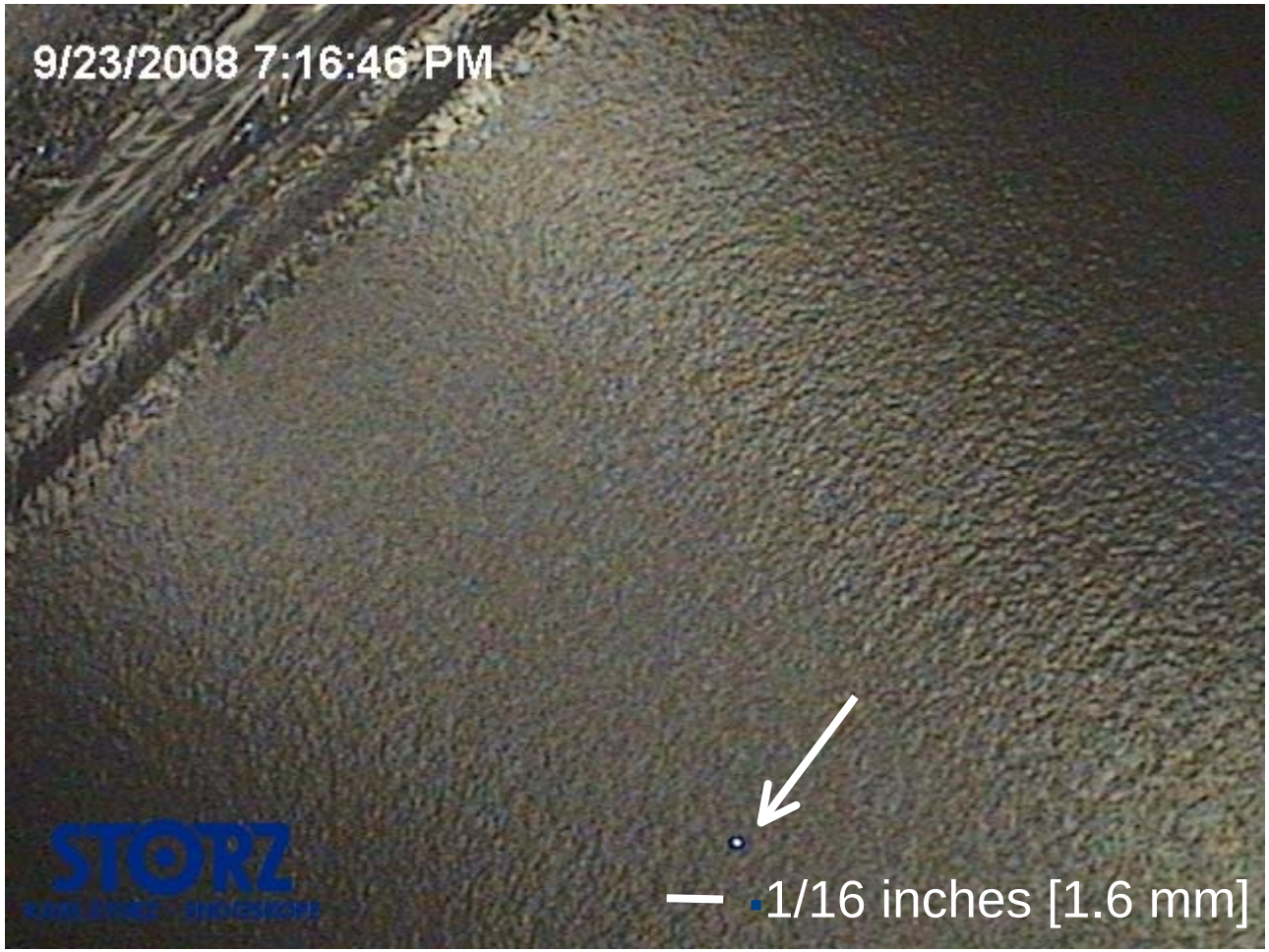
Cell 7, 220°, 1 sensor down from equator



Cell 7, 260°, 1 sensor down from equator

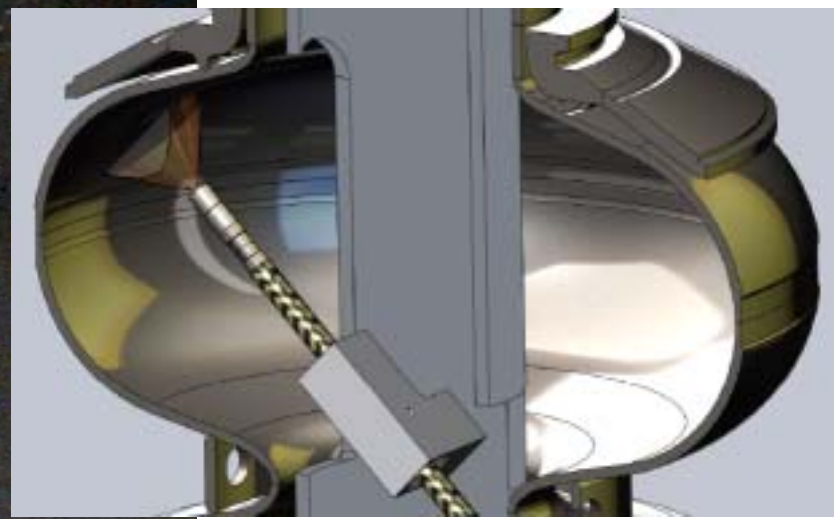


Other imperfections found
Cell 9, 160°, below equator



Cell 7 iris to cell 6, approx. 70°. This might have been caused by a screw head of the inspection system.

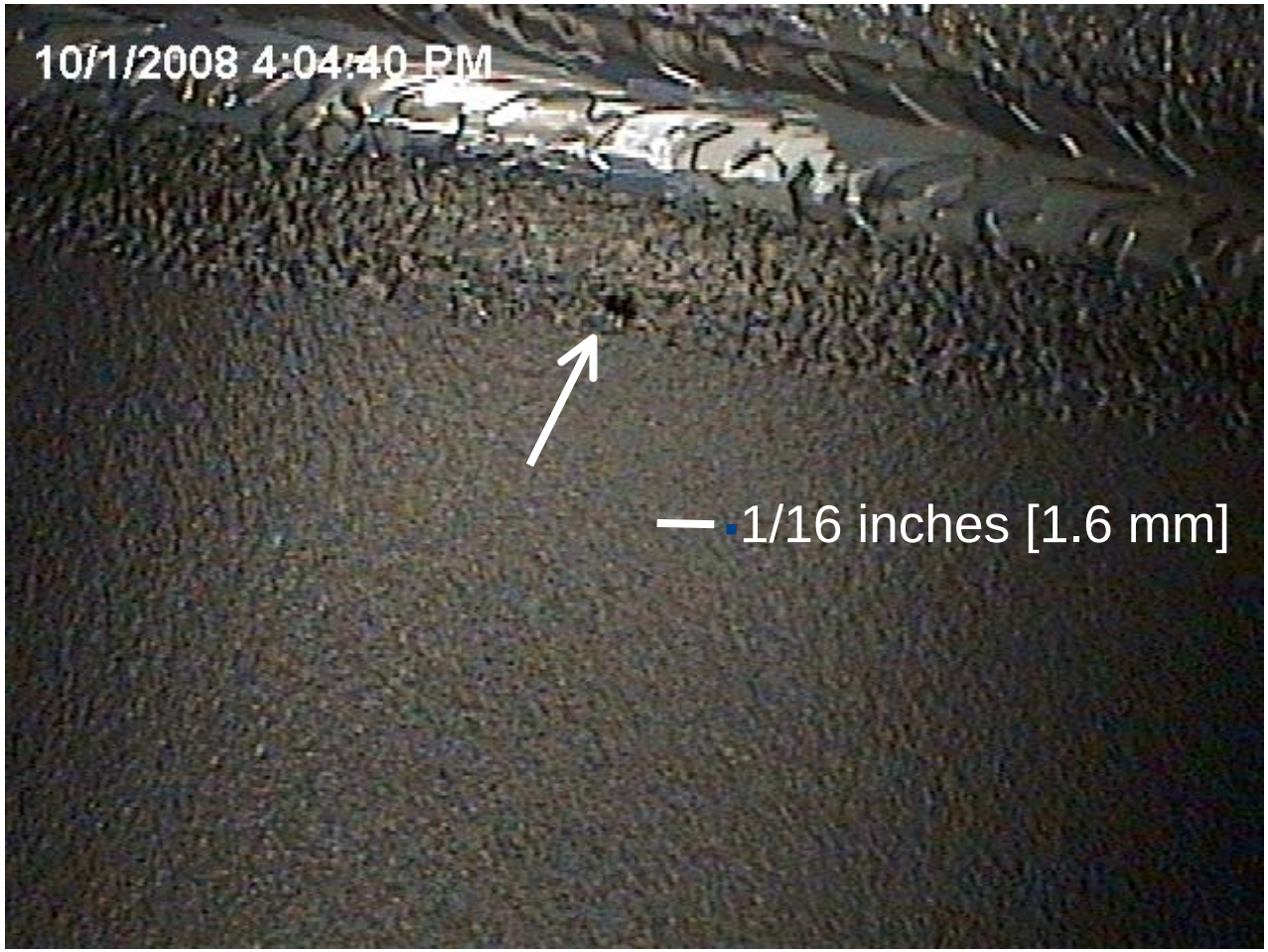
Cell 5, 150° ~45° up, 2 scratches are found



Cell 1, marked X4

Cell 9, marked X, ~45° up

Cell 6, marked X1



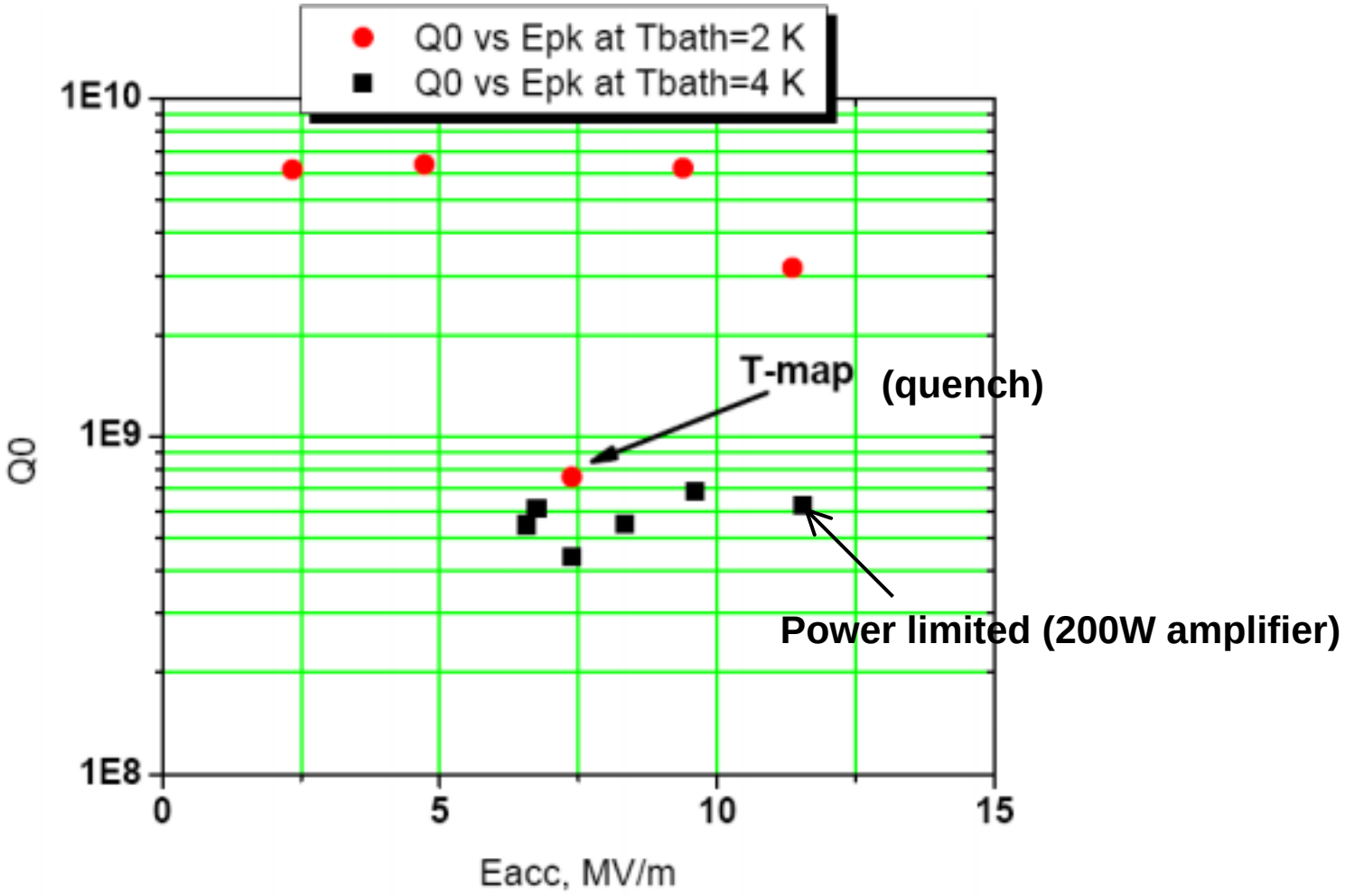
Cavity preparation for the third test at LANL in October 2008

- The cavity was slowly vented with filtered air in the clean room.
- Surface inspection was carried out with top (HOM side) flange on. This is the same position as during cold tests.
- High-pressure (700-1000 psi) ultra-pure water rinsing was done for 2 hours. The top flange was removed for HPR nozzle to go through it. The cavity was dried over night with top and bottom flanges open in class 100 clean room.
- The cavity was sealed with blank beam pipe flanges and a vacuum valve in the class 100 clean room.
- Pumped down, leak test (no leak), then, baked at ~120° C for 48 hours. The cavity vacuum after baking at room temperature was ?? Torr. We skipped baking of vacuum line. We usually get 2-3E-9 Torr if we do it.

Third cavity test at LANL in October 2008

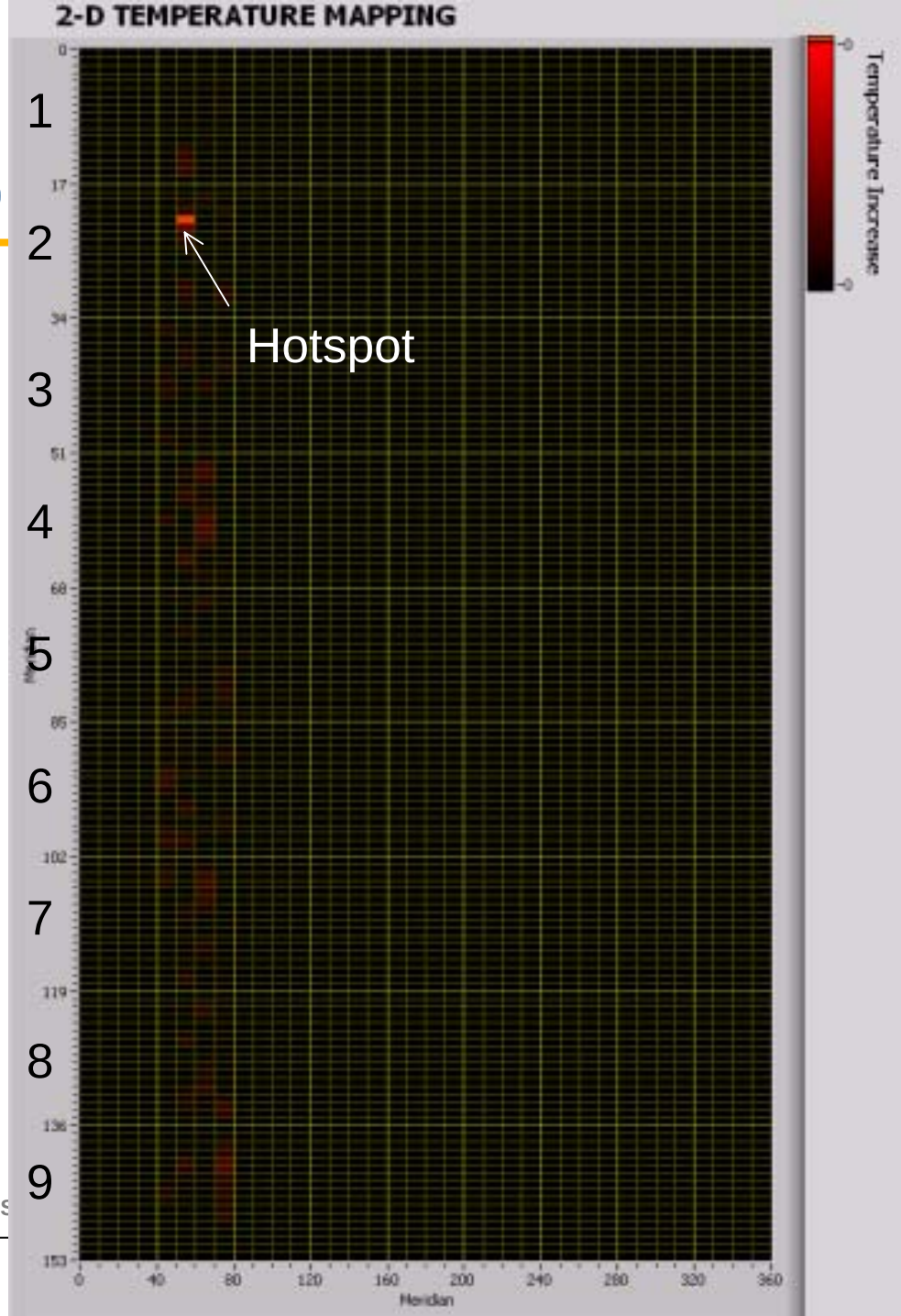
- **4K data was taken, but unfortunately, when we pumped down the LHe, part of the top cell was exposed above the liquid, which made it impossible to carry out a correct measurement at ~2K. We did not have enough helium to refill the cryostat.**
- **T-mapping**
  - **Taken sector by sector**
  - **After taking reference data without RF power in the cavity, the T-map is taken continuously with an interval of ~230 ms.**
  - **Only 3 sectors (0° - 110°) worked**

4K data and data at ~2K with part of top cell above liquid (E_{acc} might be wrong)



We observed one hot spot. (only 0°-110° were monitored.)

- Cell 2 top half at 50° showed heating
- Only sector 2 (40°-70°) data are shown on the right map.
- Unfortunately, the T-map for 120°-350° range where we found most of the heating in the June 2008 tests did not work possibly due to disconnects at the connectors in the cryostat.



T-map system future improvements

- **Hardware interface will be increasingly robust. 83 ft. cables currently are prone to failure. Connections are strained on both ends leading to increased risk of broken pins, etc.**
- **Reduction of noise**
  - **Future revisions of the T-mapping system will incorporate better shielding especially from 60 Hz crosstalk.**
  - **Other noise-filtration methods will be incorporated by means of signal processing on the program end, hardware filtering, or a combination of the two.**
- **Acquisition method currently focuses on one sector at a time. Future revisions may incorporate simultaneous scans to reduce acquisition time.**

Backup slides

Checks and repairs on T-map system after the first 2 tests

- **Sensors and wiring**
  - Physical inspection of sensors found 21 broken sensors out of 4608 sensors. They were all repaired.
  - Electrical tests were conducted and found 4 diodes on the T-map boards were reverse-biased. They were fixed.
  - No disconnects were found in the 108 60-pin ribbon cables connecting the signal from T-map boards to an interface board located in the cryostat.
  - 8 out of 12 83.3-ft. cables having a 62-pin connector each had problems and they were all fixed.
  - 5 out of 1536 pins for hermetic manganin wire feedthrough on the cryostat lid had been damaged and repaired.

T-map system improvements and issues

- **Improvements**
  - **2D T-map display has been improved to show accurate azimuthal angel on the horizontal axis and eliminated the signals from non-existent sensors.**
- **Remaining issues that need to be solved**
  - **The manganin wire connectors are sometimes loose without a means to secure it.**
  - **Strain on the cables attached to the connectors at the ends of long (83 ft.) cables connecting the cryostat and the control room.**
  - **The signal shows 60 Hz noise. Electrical shielding needs to be done.**
  - **Noise when switching power from one sector to another. We had to do the mapping sector by sector without fast switching.**

false signals due to 60 Hz noise
This can be seen at high resolution T-mapping.