Replica-method and local grinding repair

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LCWS 2010 in Beijing.

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1. Method of cavity repair for geometrical defect

All labs have a inspection and T-mapping (or second sound) system to find a defect inside cavity.

After find the defect, the labs are challenging a repair in various ways for the 9-cell SC cavities .

The methods are under testing on the bench test, single cell and 9-cell cavities. (in progress)

2. Summary of the cavity repair for single and 9-cell SC cavities

Labs	Method	Instances	Results
DESY	Local Grinding (KEK)	AC71	26MV/m (???) -> 30 MV/m
FNAL	Local Grinding (KEK)	AES-03	20 MV/m (Bump, scratch) -> 34 MV/m
Cornell	Tumble	9-Cell Reentrant Cavity	15 MV/m (Pit) -> 30 MV/m
JLAB	Local e-beam re-melting	1-cell cavity C1-1	19 MV/m -> 27 MV/m
	Local Grinding (KEK)	JLAB LG#1	30 MV/m (Pit) -> will be tested until summer.
KEK	Local Grinding	MHI-08	16 MV/m (Pit) -> 27 MV/m
	EP	AES-01	15 MV/m (Bump) -> 22 MV/m

Note, All cavities were made the optical inspection after vertical test with T-mapping or second sound method. After find the defect by optical inspection, we were tried the repair for the quench location.

This is very important things to remove the geometrical defect after checked the location and size of the defect. (to obtain better yield and the reference of the quality.)

The electro-polishing is also have a effect to remove the defect (however, it has a geometry dependence).

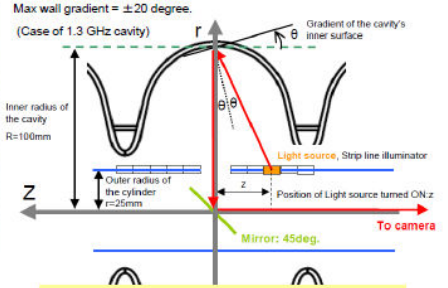
2. Introduction of the tools for 9-cell cavity repair. (example)

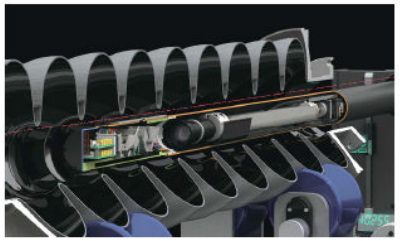
- Inspection system and T-mapping (second sound) system
  (The labs already tried for SC cavity.)

- Grinding and Melting machine to remove the defect.
  (The labs already tried for SC cavity.)

- Replica-method
  (The labs already tried for SC cavity.)

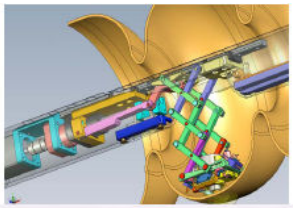
These are the technology which has already been used to understand the surface condition and repair of the SC cavities. The combination and development of these method are very important for the repair to achieve better yield of SC cavity for ILC.

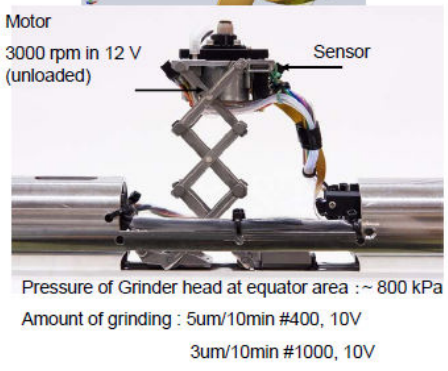


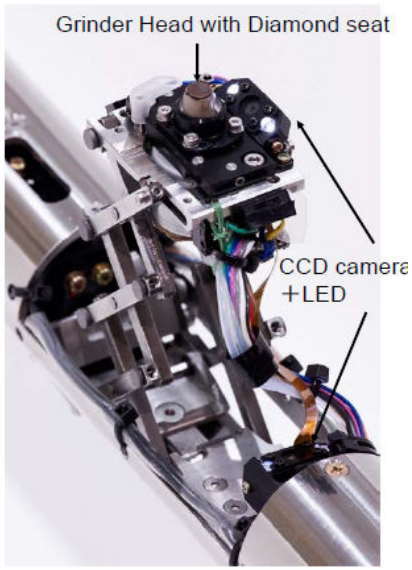


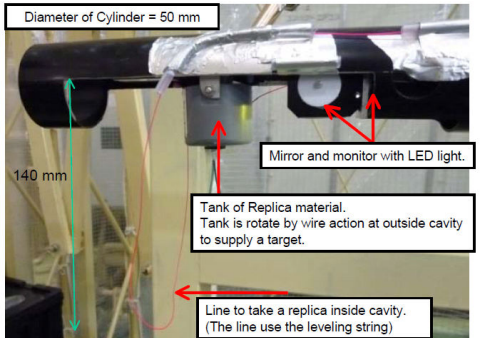
Characteristic of Kyoto camera system

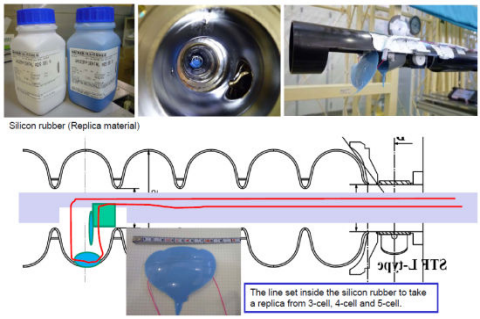
* The high resolution image can be taken. (10μm/pixel)
* The wall gradients of inner surface can be measured to use the Strip line illuminator (LED+LGP). (Judgment of Pit or Bump is possible)
* The heights or depths can be estimated by measured wall gradients for some well-conditioned defects.

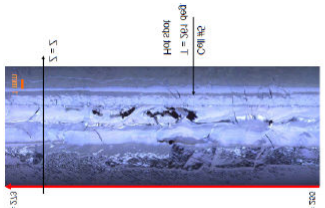


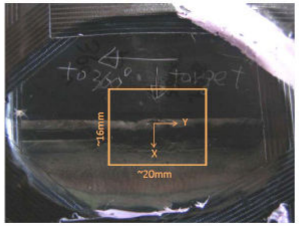


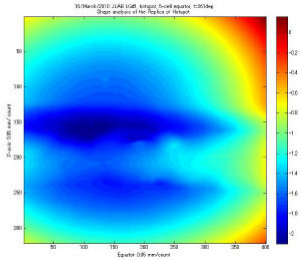






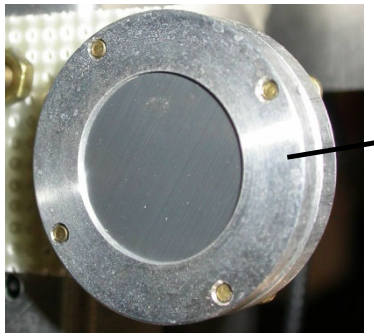




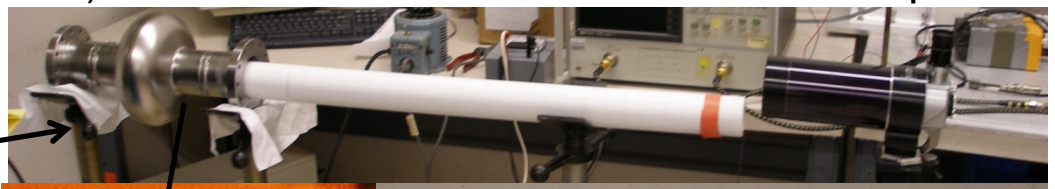


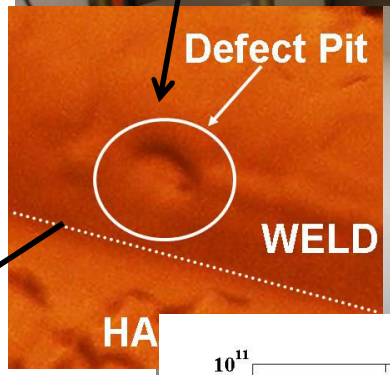
3. 9-cell re-entrant cavity
Defect location, characterization, and repair @ Cornell

1) Defect location with OSTs

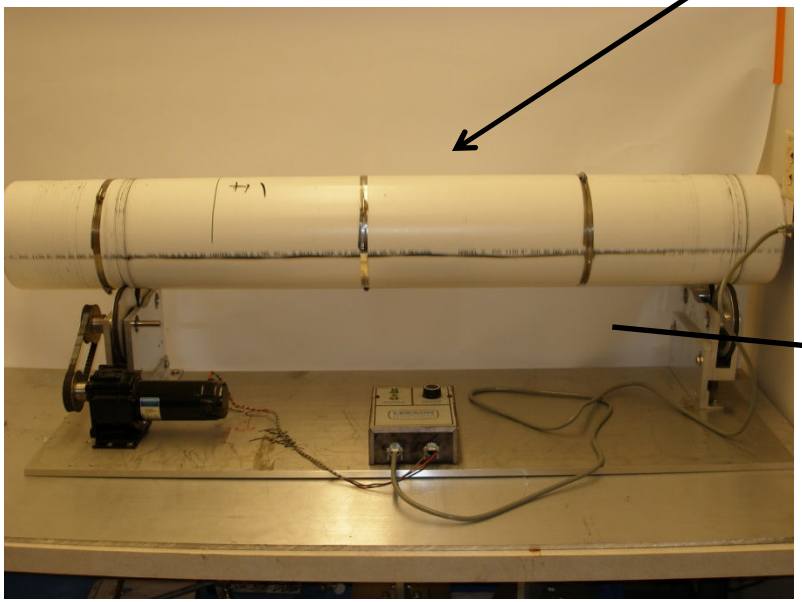


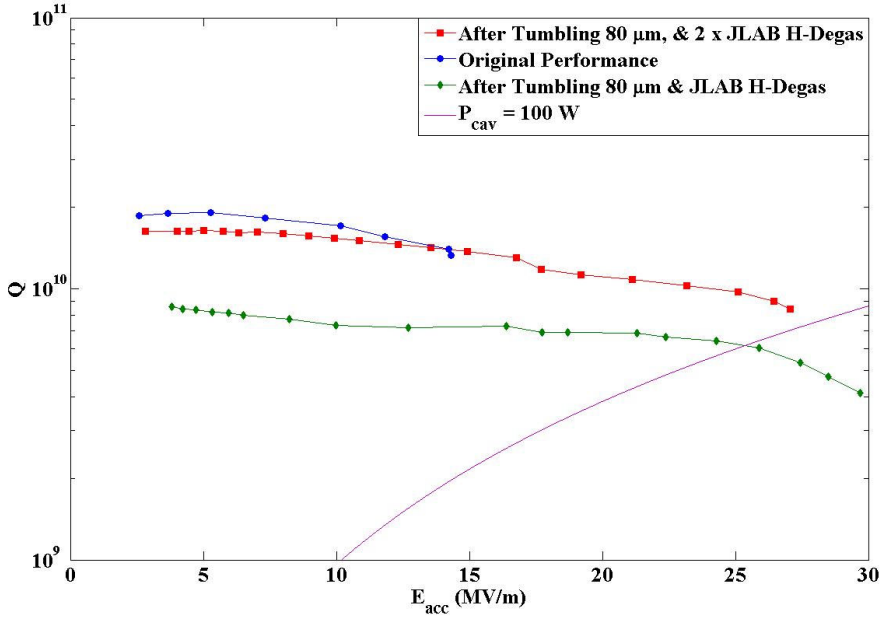
2) Defect characterization with microscope





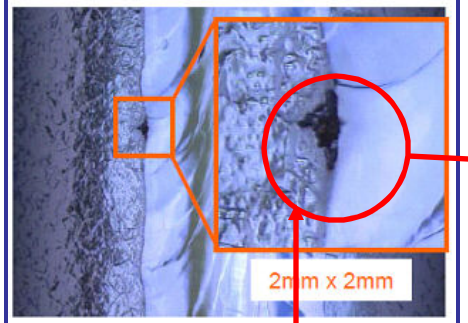
3) Defect repair via tumbling





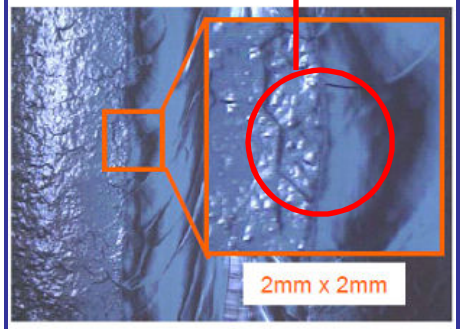
4. MHI-08 : The location of target for Grinding

2-cell equator, t=172 deg. Pit



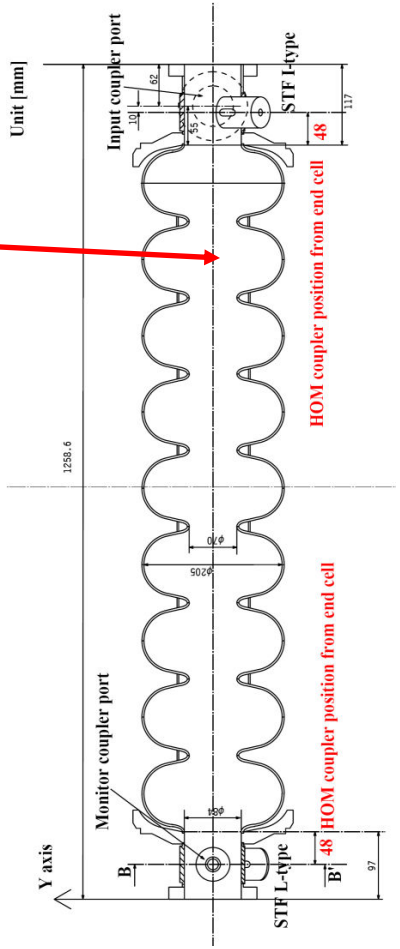
After V.T.

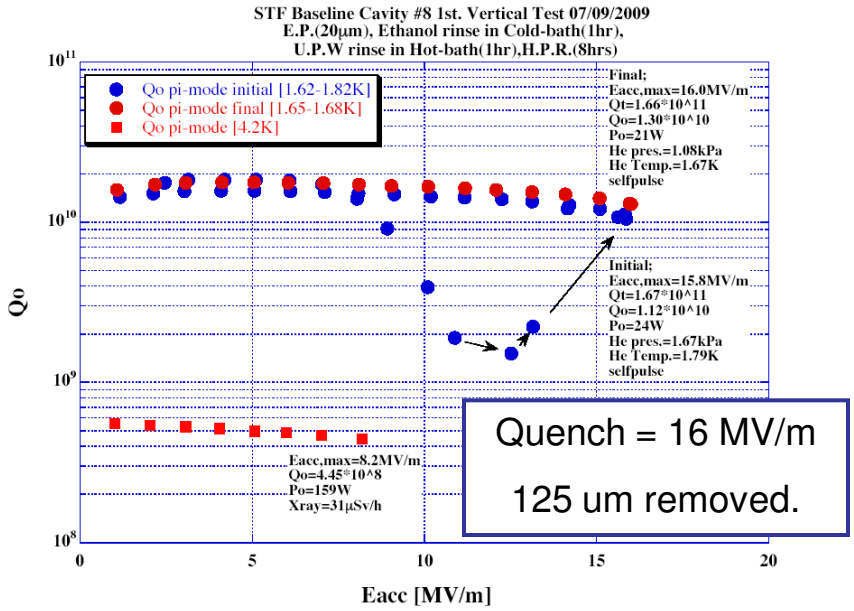
(Removed material = 125 μm)



Before V.T.

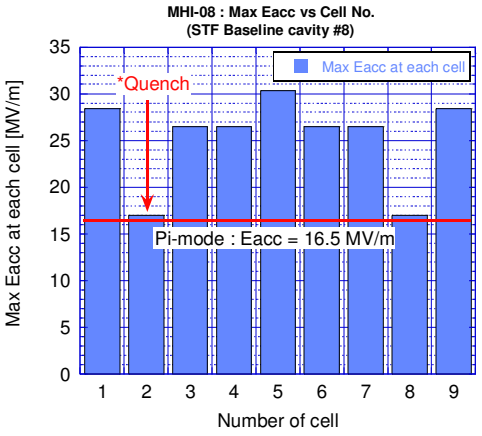
(Removed material = 105 μm)

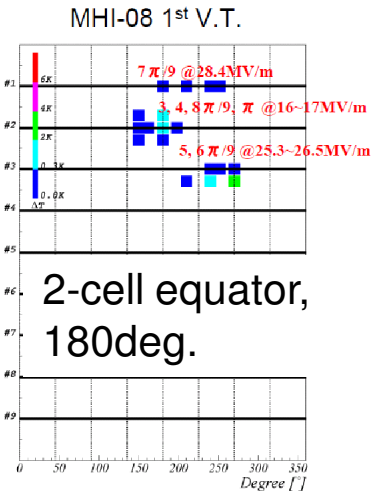




Quench = 16 MV/m

125 um removed.

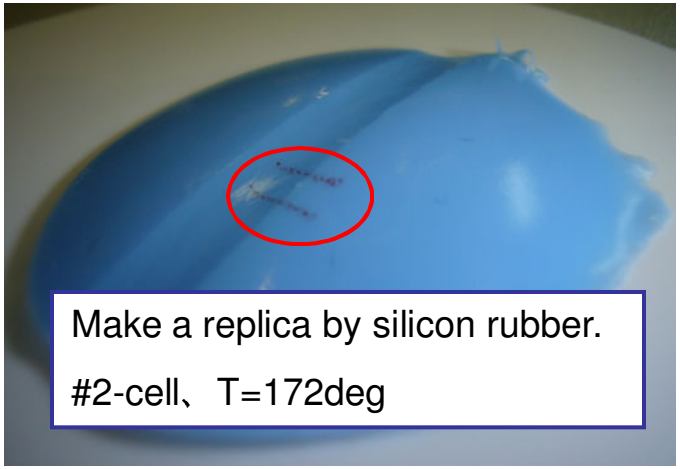




2-cell equator, 180deg.

The cavity was quench at 16 MV/m on the 2-cell equator. The defect was made after EP-2 process.

4. MHI-08 : Make a replica and shape analysis for Hot Spot



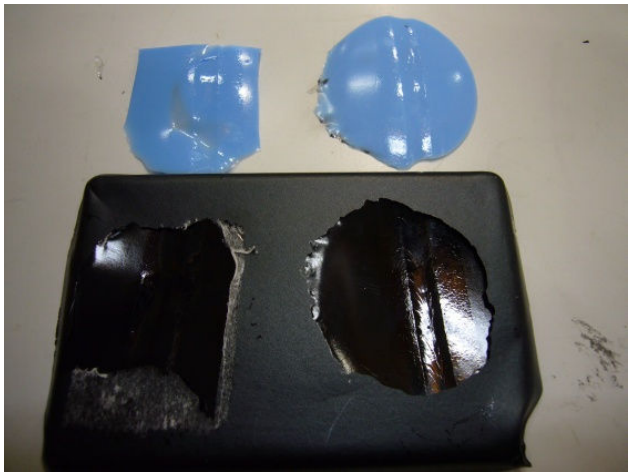
Make a replica by silicon rubber.

#2-cell、T=172deg

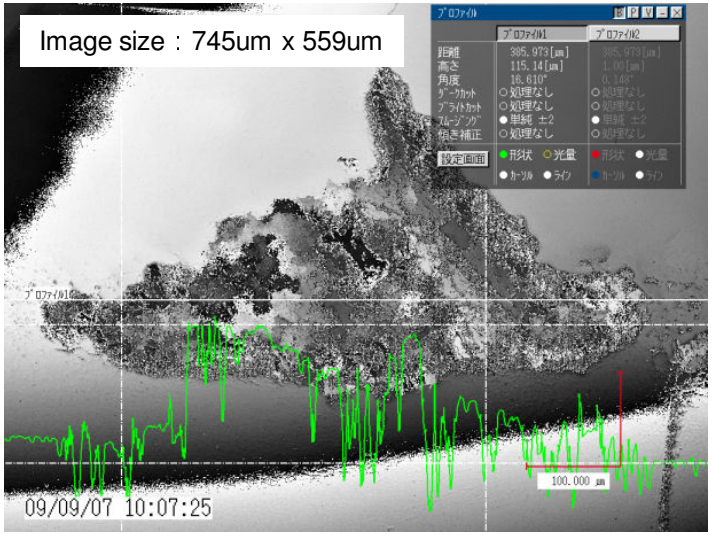
Copy to stycast.

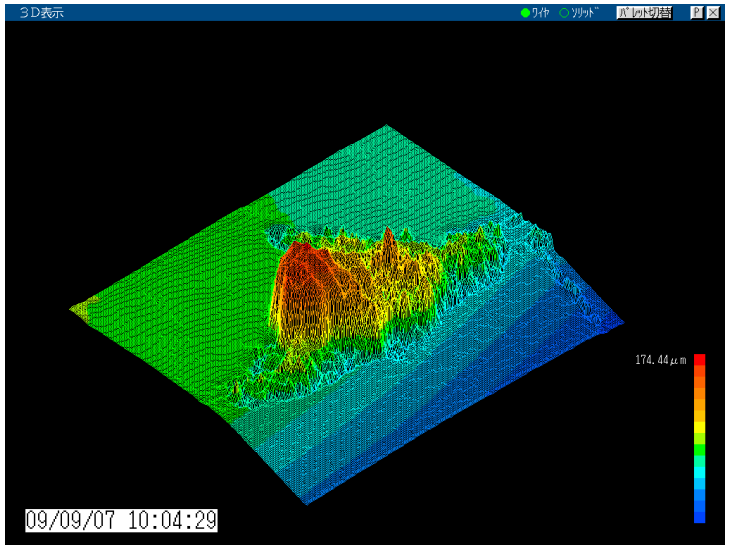
Shape analysis by Laser microscope.

Test of the grinding for the target.



Result of shape analysis by Laser microscope. : Pit type deep defect, depth = 115 um.





4. MHI-08 : Grinding of the defect : 2-cell equator t = 172deg

In this case, the defect type was pit at the boundary between EBW seam and HAZ.

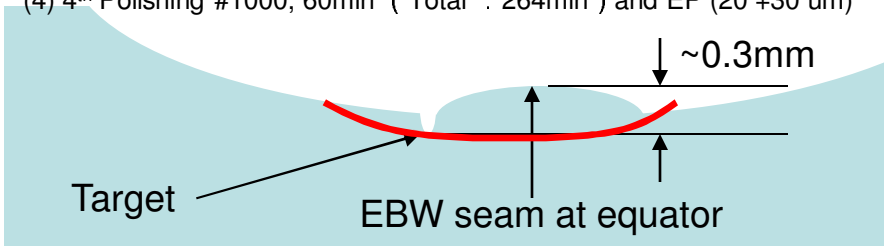
History of the Grinding, (0) before Grinding.

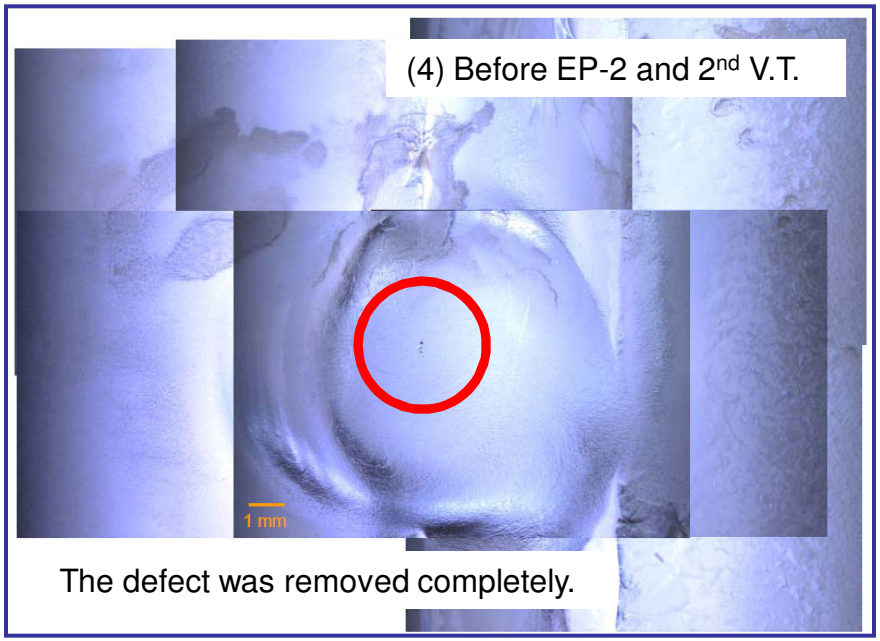
(1) 1st Grinding #400, 58 min

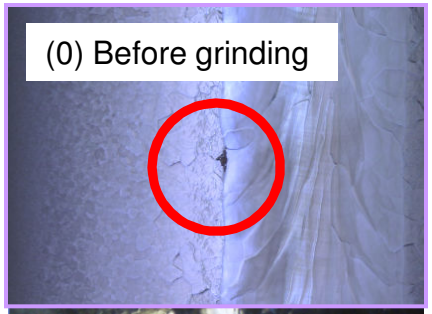
(2) 2nd Grinding #400, 76min (Total 134min)

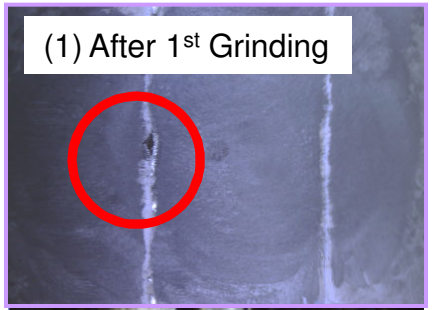
(3) 3rd Grinding #400, 70min (Total 204min)

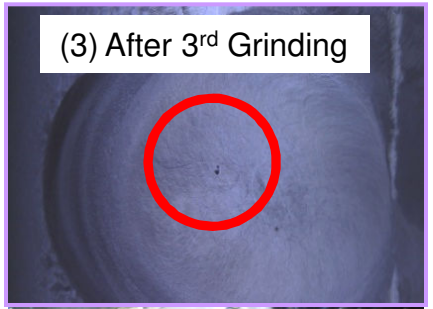
(4) 4th Polishing #1000, 60min (Total : 264min) and EP (20 +30 um)

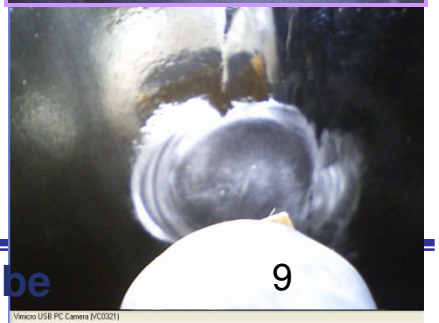












4. MHI-08 : 2nd V.T. result

Progress work after 1st V.T. (June 2009):

* Inspection after 1st V.T.
* Make a replica and shape analysis
* Local Grinding (One equator)
* Cleaning by water and wiping before EP process

* EP 20um, 50mA/cm2 (Air) at KEK-STF
  1st water rinsing (Air) 90 min, HPR 2 hour

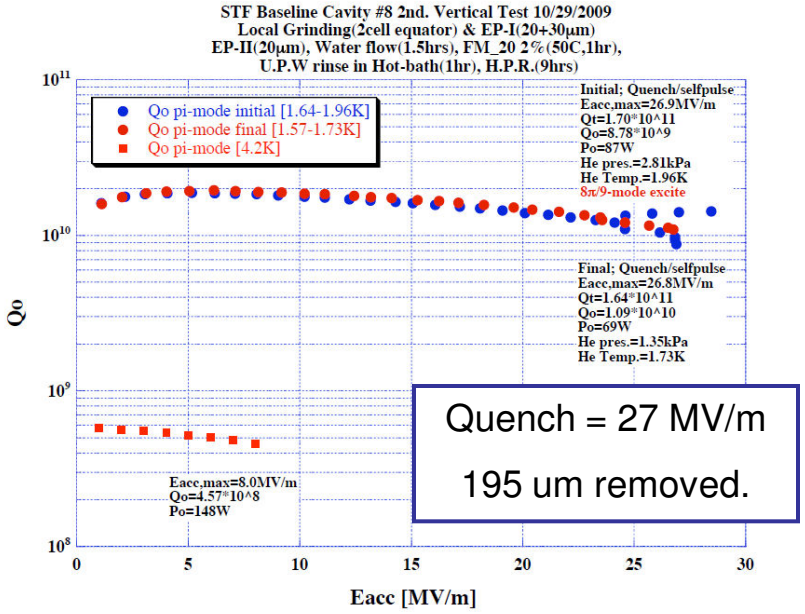
* Inspection after EP 20um
* Local Grinding to obtain narrow edge around circle.

* EP 30um, 50mA/cm2 (Air) at KEK-STF
  1st water rinsing (Air) 90 min, HPR 2 hour

* Inspection after EP 30um, check the grinding location
  Field flatness measurement = keep the flatness.

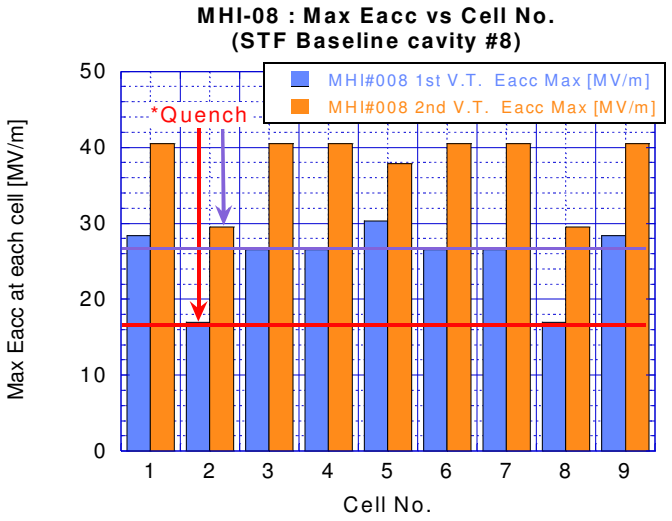
* EP 20um, 50mA/cm2 (Air) at KEK-STF
  1st water rinsing (Air) 90 min
  FM-20 (2%) 50 C 1hour
  Hot bath 50 C 1hour
  HPR 9 hour, baking 100 C 48 hour

* 2nd Vertical test at KEK-STF. The gradient was raised to 27 MV/m. The quench was occurred at other location.



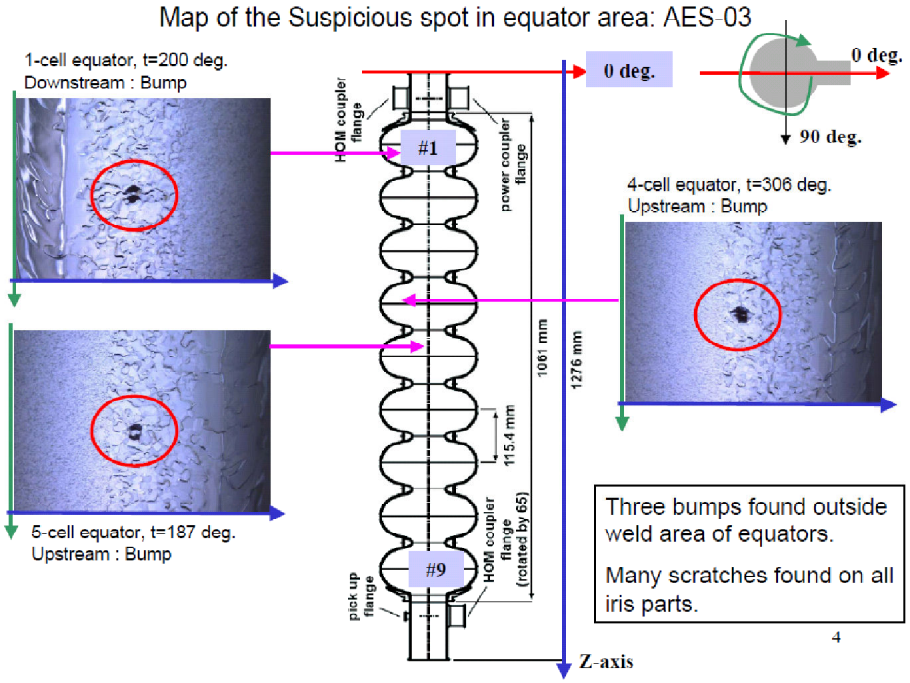
Quench = 27 MV/m

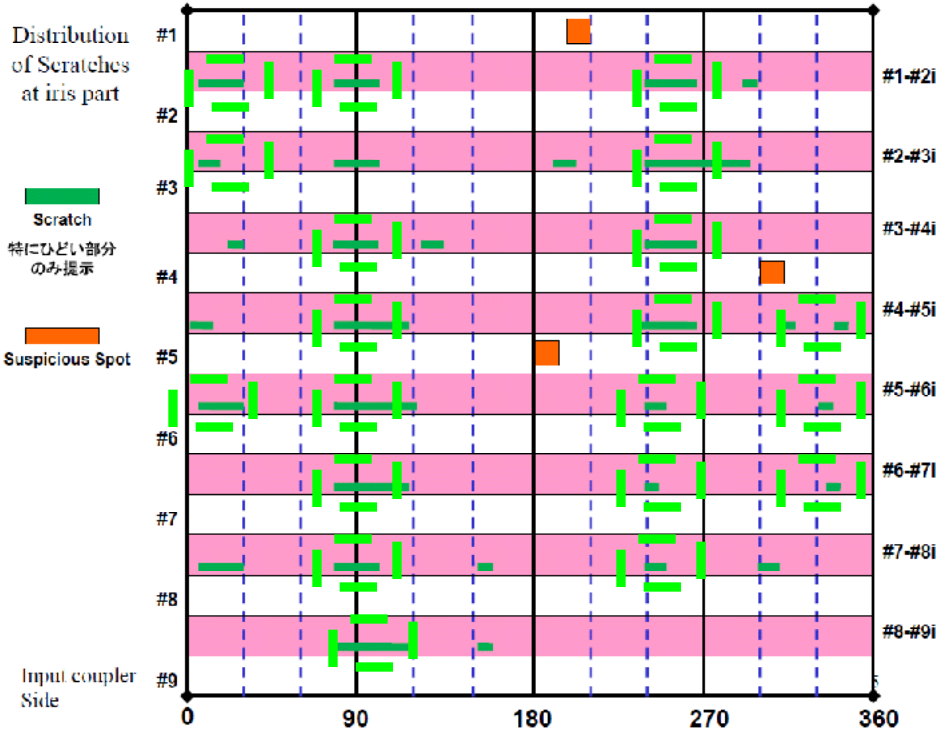
195 um removed.



5. AES-03 : The location of target for Grinding

superconducting rf test facility





Equator: three places (1-cell t=200, 4-cell t=306, 5-cell t=187)

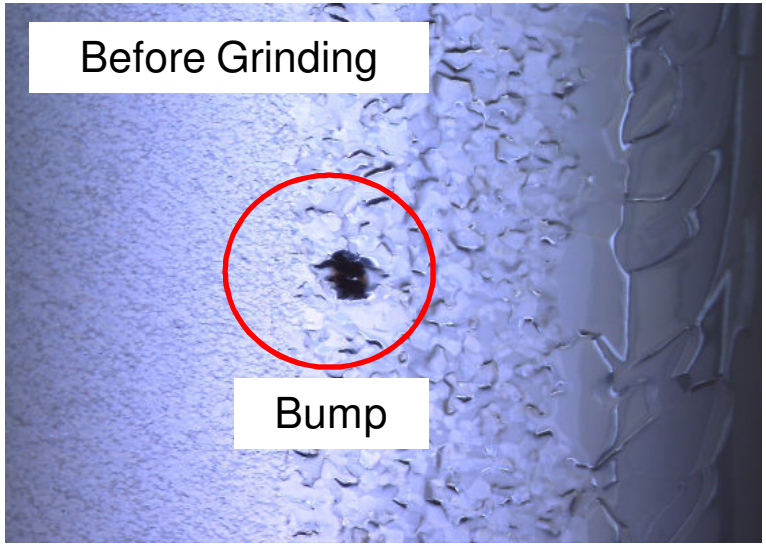
Iris: 20 places (see the map of the iris part.)

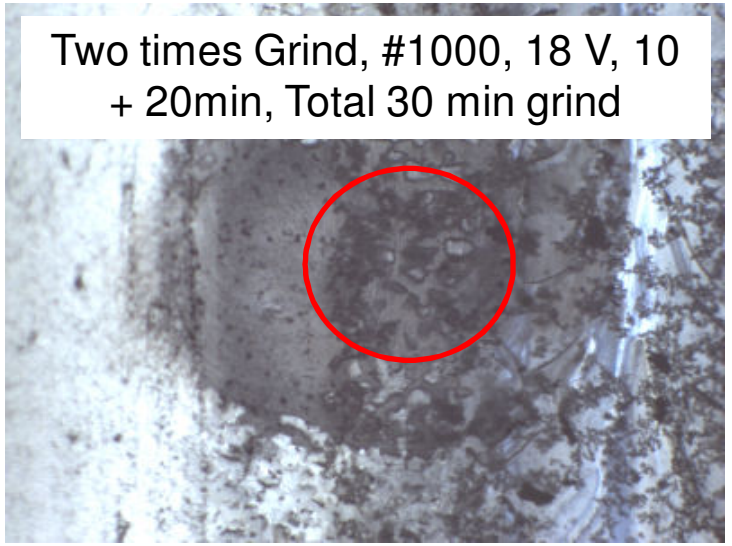
The Quench location was “4-cell equator, near t=306 degree” at 20 MV/m measured by FNAL and JLAB.

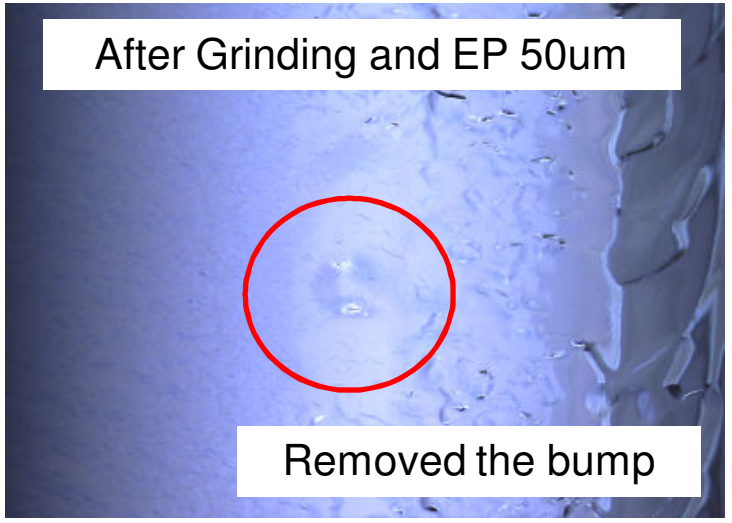
The cavity was tested by JLAB, FNAL and LANL in America labs before send to KEK-STF.

The history of AES-03 is summaries by Camille Ginsburg (FNAL).
http://tdserver1.fnal.gov/project/ILC/S0/web/Cavity_Listing.asp

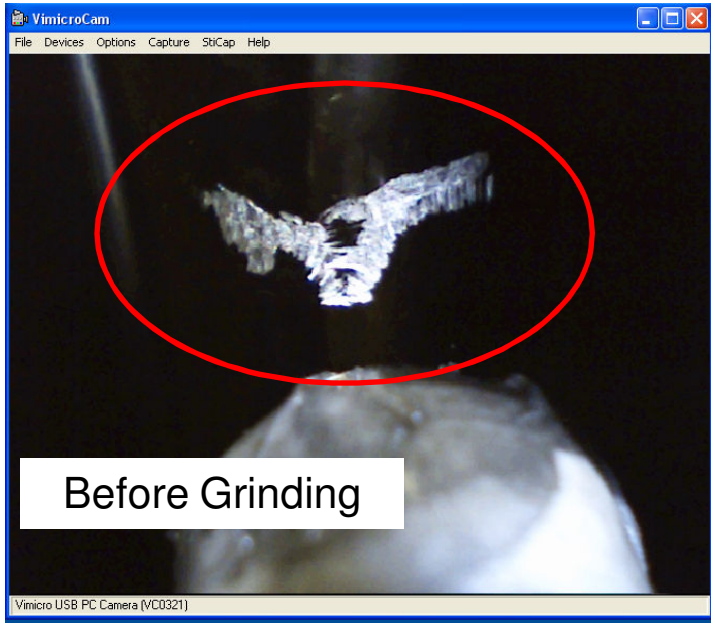
5. AES-03 : Quench location, 4-cell equator, t=306 degree

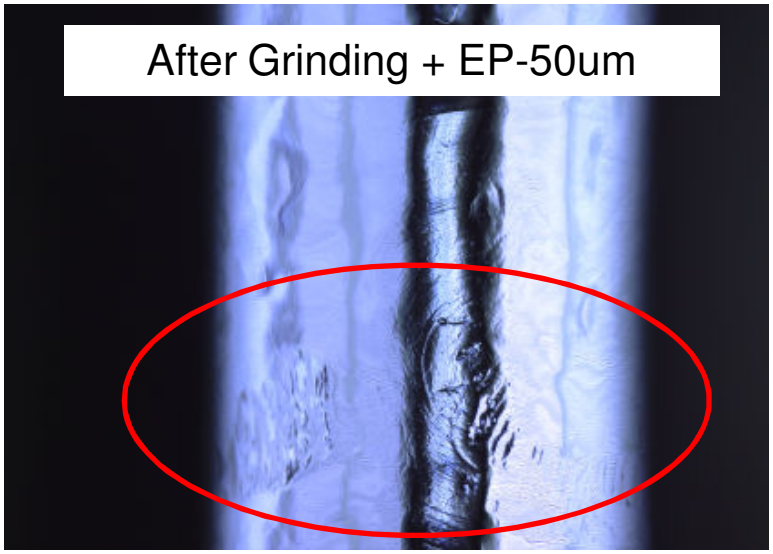






5. AES-03 : Example: Scratch #1-#2iris t=106deg.





5. AES-03: V.T. results, improvement by grinding

Progress work after send to KEK (Sep 2009):

* Inspection (Shape analysis of defects)
* Local Grinding (20 Irises and three Equators)
* Cleaning by water before EP process

* EP 50um, 50mA/cm2 (Air) at KEK-STF
  - 1st water rinsing (Air) 90 min
  - FM-20 (2 %) 50 degC 1hour
  - HPR 4.5 hour
  - Pumping to Vacuum, N2 purge
* Inspection after EP 50um

* HPR and pumping to Vacuum and Back to FNAL (Dec 2009)

Progress work in FNAL

* 2 times V.T. at FNAL (Jan 2010)

*HPR rinsing at FNAL before 1st V.T.

* HPR at ANL and Baking 120 C, 48 hour before 2nd V.T.

The gradient was very improvement. The gradient was raised to 30 MV/m in first test, to 34 MV/m in second test at FNAL. The limitation of cavity performance was field emission. The location of local grinding were no quench at high field.

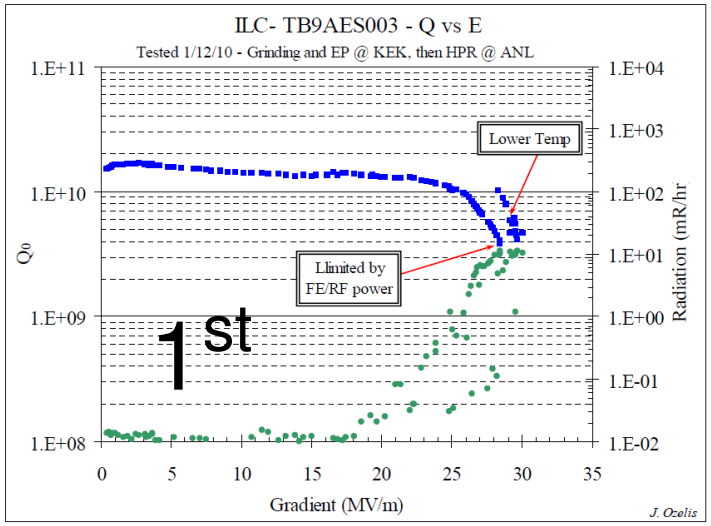


Figure 1.) Q_0 vs E run at 2.05K. The highest gradients reached were after some degree of CW processing of the field emitter coupled with a decrease in the He bath temperature (to 1.97K)

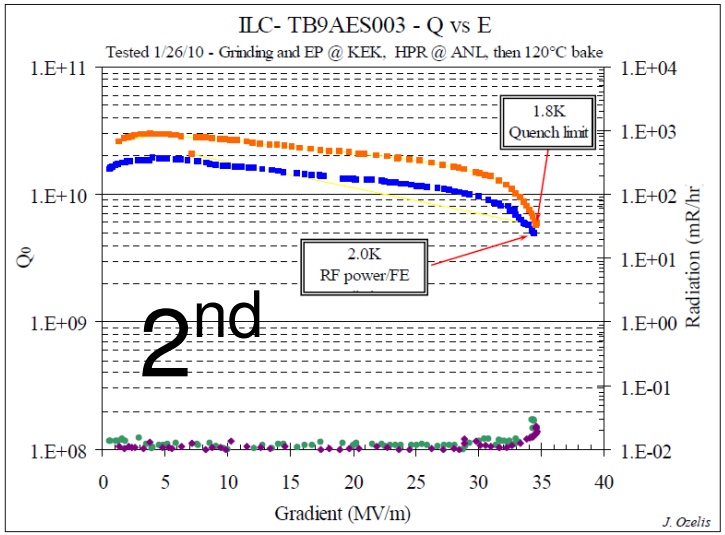
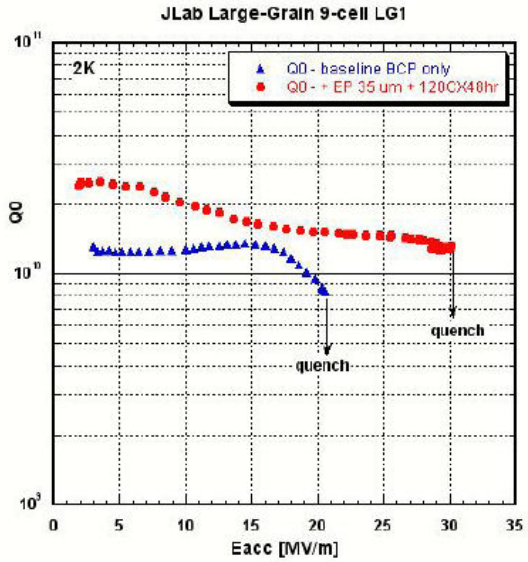


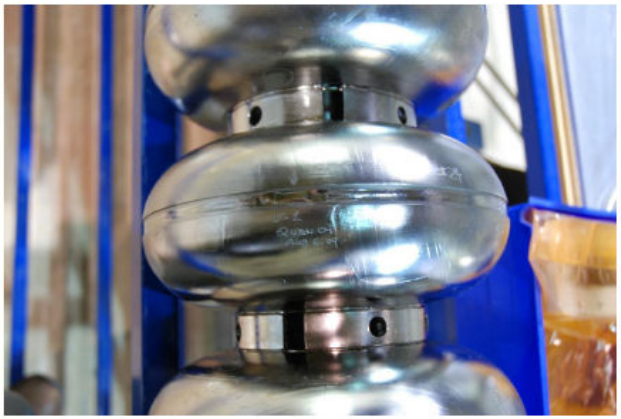
Figure 1.) Q_0 vs E runs at 2.00K and 1.80K.

6. JLAB LG-01 : History of the cavity.

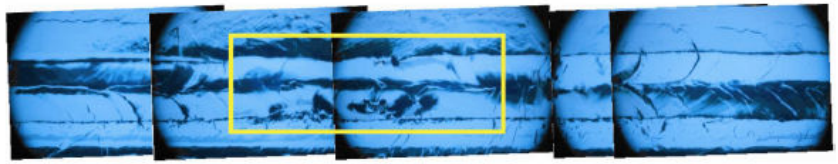
JLAB LG#1 9-cell cavity on its way to KEK for local grinding

30 MV/m quench limited cavity, one defect in one cell. Other cells 33-35 MV/m





Limiting defect is weld repair – geometric flaw!

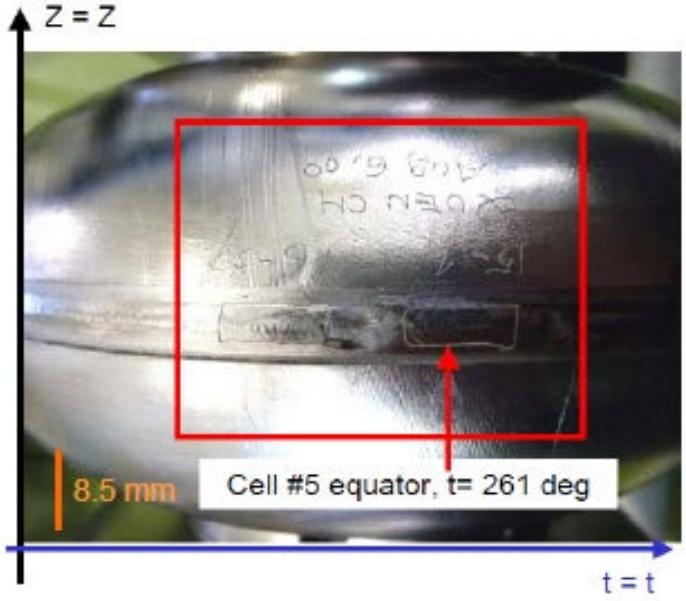


Surface Analysis and Cavity Exchanges

Rongli Geng

JLab-KEK-FNAL meeting

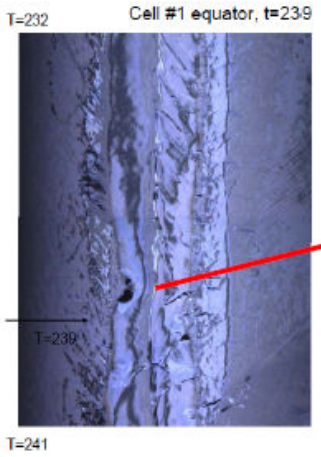
November 5, 2009

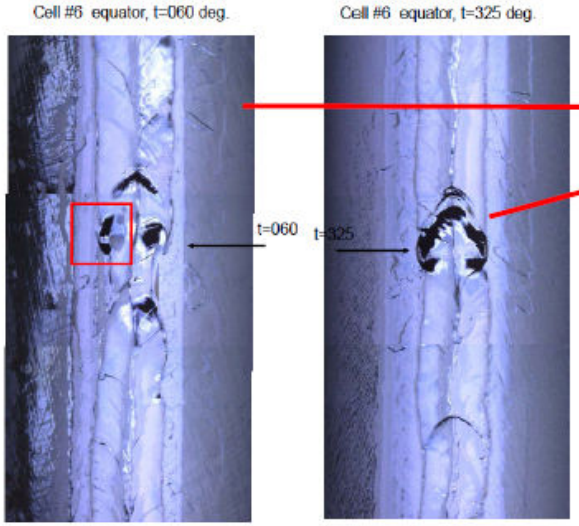


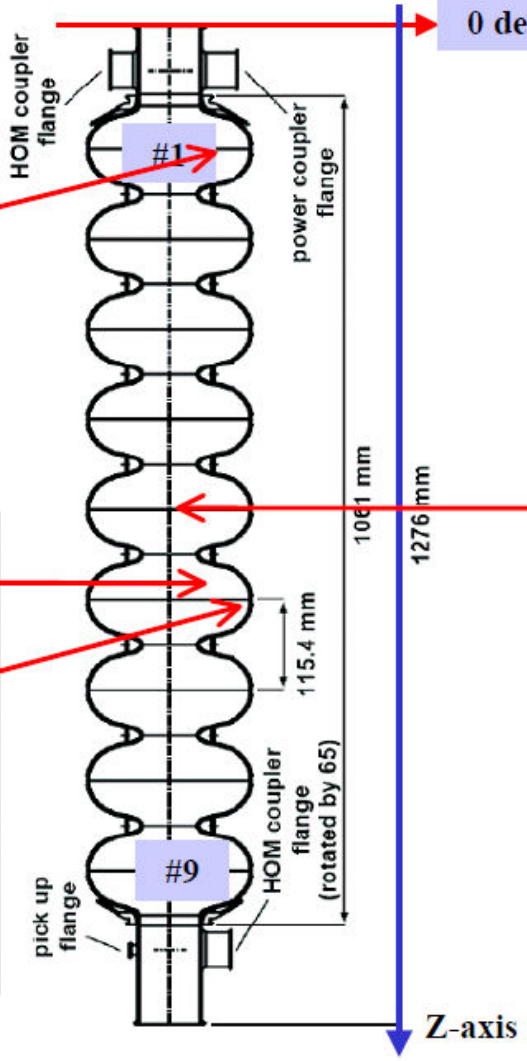
After the baseline test with quench limit at ~ 20 MV/m, the cavity was light EP treated - and the quench limit was raised to 30 MV/m. T-mapping found the quench location at the equator EBW of the cell#5. This cavity was then sent to KEK for local grinding.

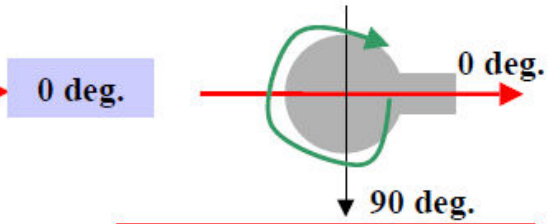
6. JLAB LG-01 : The location of target for Grinding

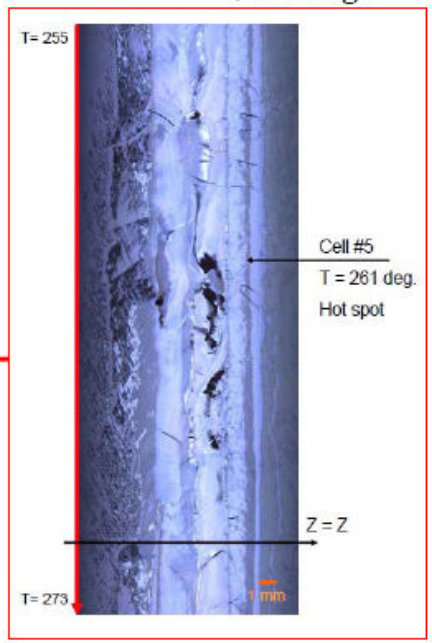
Map of the suspicious spot in equator area: JLAB LG#1







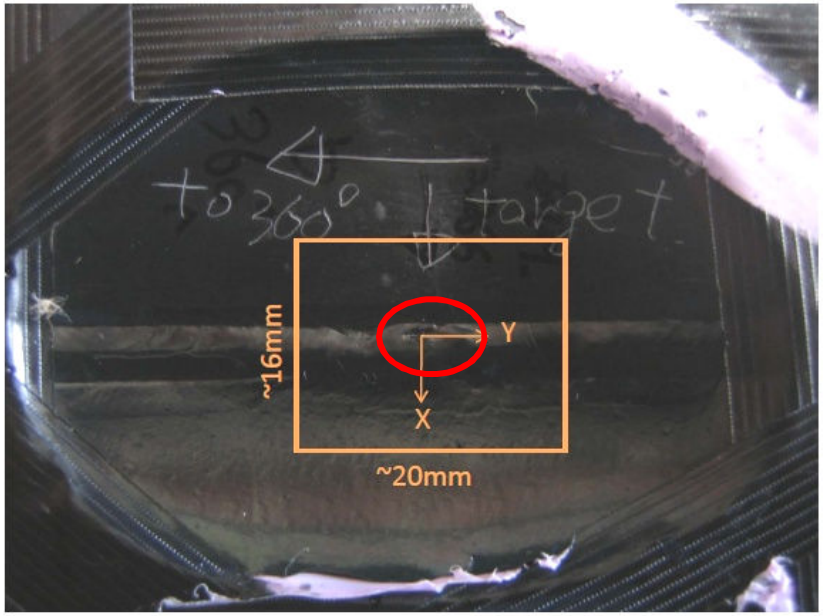


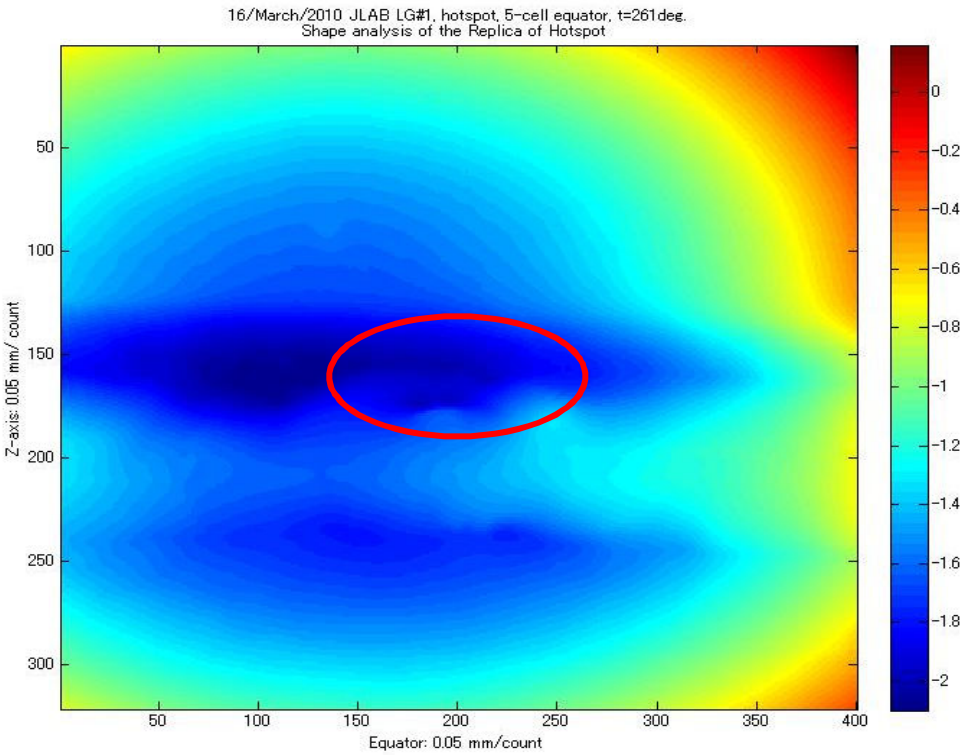


Hot spot at 30 MV/m

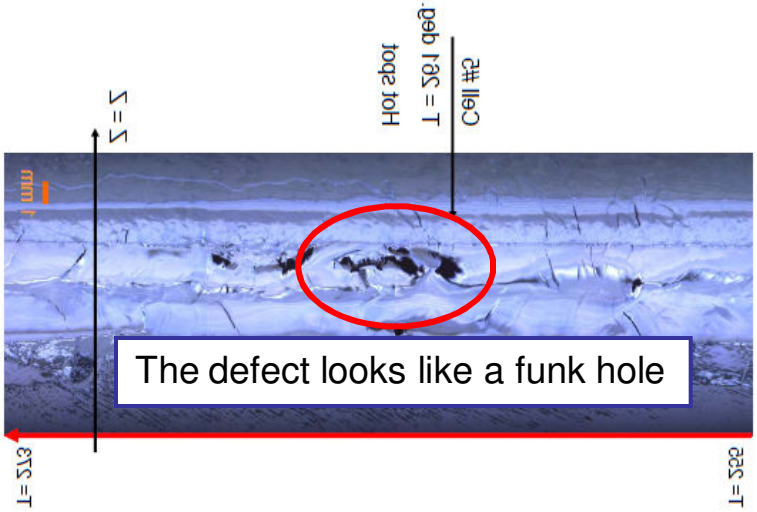
The welding seam was flaw in hot spot and other locations. Take a replica at 5-cell using by special tool. The Local Grinding made at 5-cell defect.

6. JLAB LG-01 : Shape analysis of the replica at 5-cell





Measured by FORMTRACER CS-5000 (Mitutoyo)

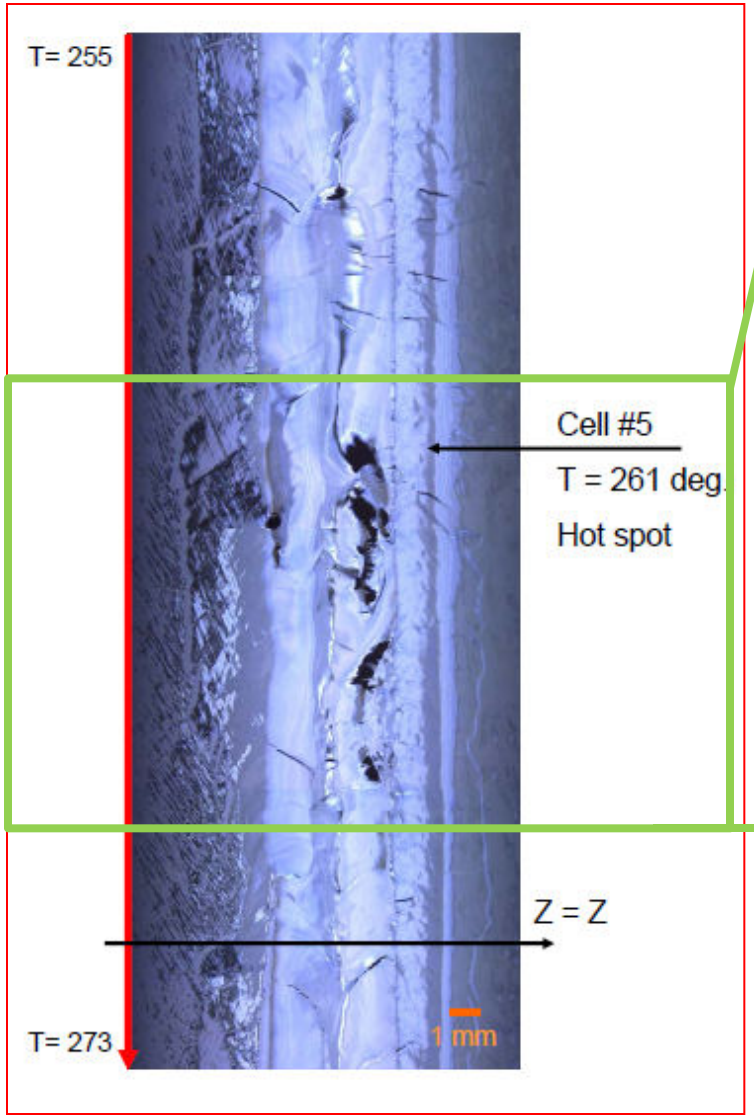


The Shape analysis is very easy by the replica before and after repair.

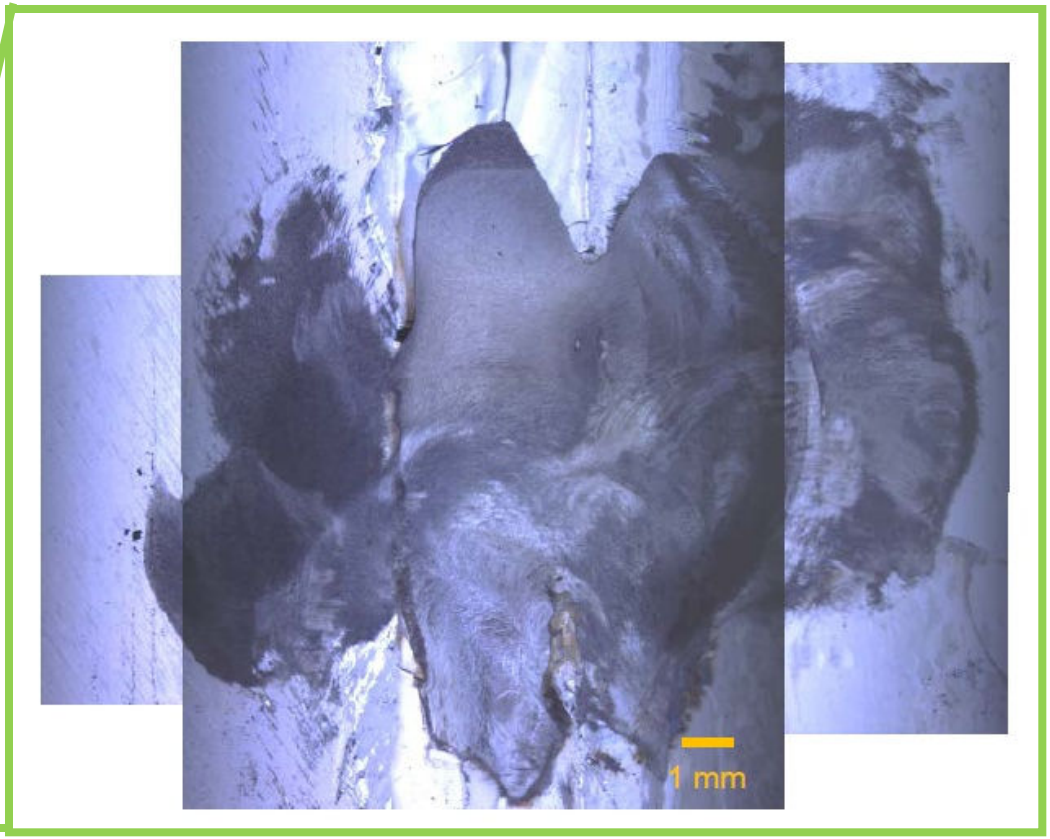
Depth = ~ 300 um.

6. JLAB LG-01 : After Local Grinding of 5-cell equator t= 261 deg.

Before Grinding : 5-cell t=261 deg.



After Mechanical Grinding (Total time, 8 hour): 5-cell t=261 deg.



Next step:
*Try to sponge wipe to cleaning the dust, that is occur by Mechanical grinding.
*EP 50um and rinsing. (until May 2010 in KEK-STF)
The vertical test will be tested in JLAB.

Thank you for your attention

Appreciation to the people who gave me materials.

Rong-Li Geng, Camille Ginsburg, Sebastian Aderhold, Zachary Conway.

Appreciation to the Labs to rent the cavity for the study of the cavity repair.

DESY, FNAL and JLAB