"Improved RRCAT cavities Processing & 2K test result"

Manish & Avinash

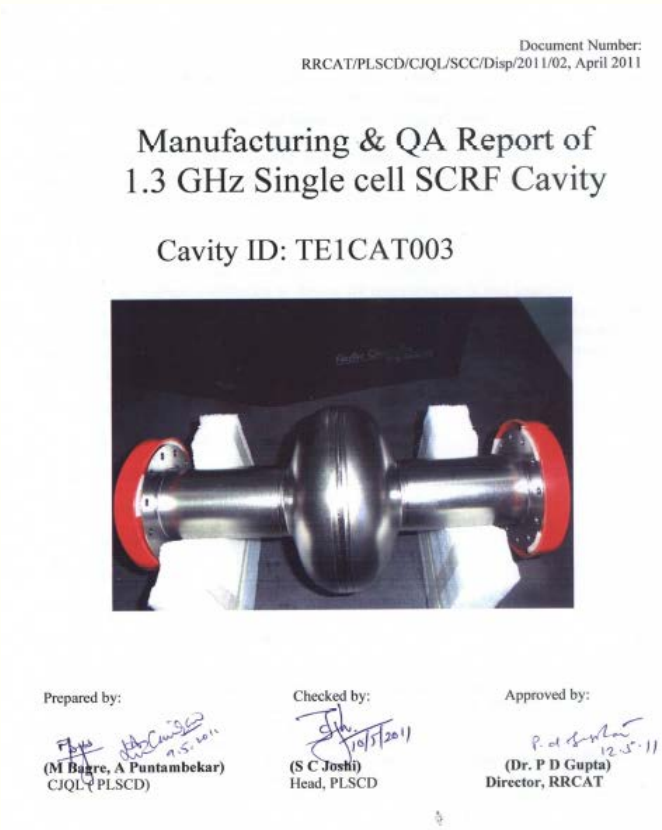
On Behalf of Collaborators

IIFC Meeting
110811

Improved Single cell cavities

- RRCAT made two more single cell 1.3 GHz (2nd prototype) during 2011.
- TE1CAT003 arrived FNAL (May-11) & TE1CAT004 (August-11)

Detail technical report available in IIFC website.



Document Number:
RRCAT/PLSCD/CJQL/SCC/Disp/2011/02, April 2011

Manufacturing & QA Report of
1.3 GHz Single cell SCRF Cavity

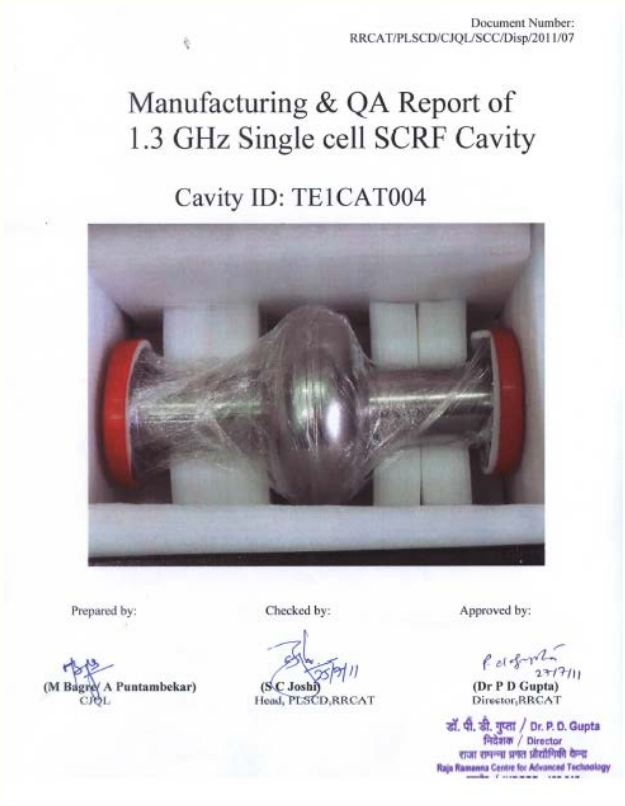
Cavity ID: TE1CAT003

Prepared by: (M Bagre, A Puntambekar) CJQL, PLSCD)

Checked by: (S C Joshi) Head, PLSCD

Approved by: (Dr. P D Gupta) Director, RRCAT

TE1CAT003



Document Number:
RRCAT/PLSCD/CJQL/SCC/Disp/2011/07

Manufacturing & QA Report of
1.3 GHz Single cell SCRF Cavity

Cavity ID: TE1CAT004

Prepared by: (M Bagre, A Puntambekar) CJQL

Checked by: (S C Joshi) Head, PLSCD,RRCAT

Approved by: (Dr P D Gupta) Director,RRCAT

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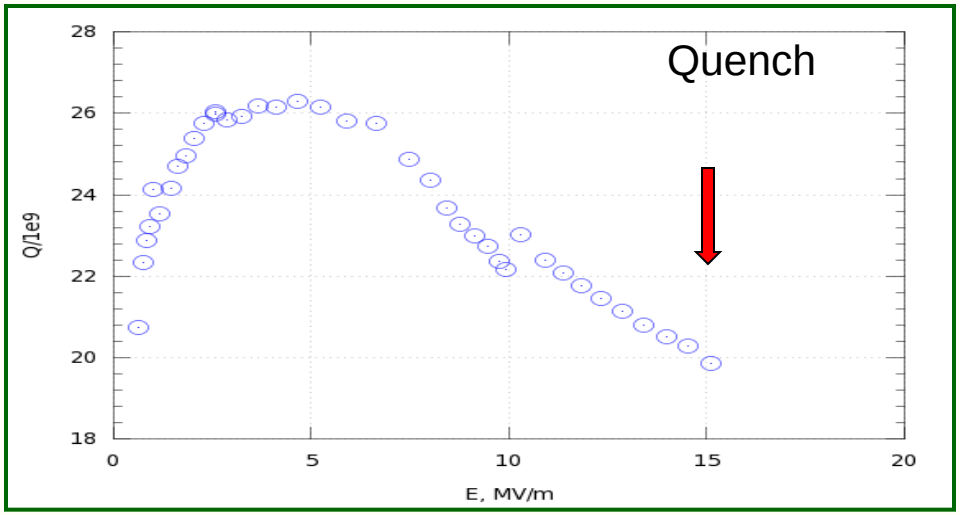
Raja Ramanna Centre for Advanced Technology

TE1CAT004

TE1CAT003

- **Cavity initially tested after received the std ILC recipe-consisiting of bulk EP,800c furnace treatment, light EP,HPR,assembly & 120 bake.**

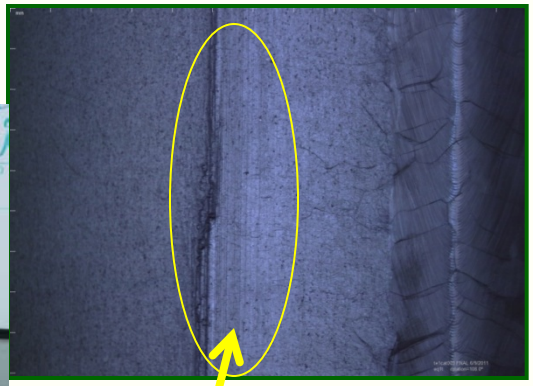


Bump was cause of quench

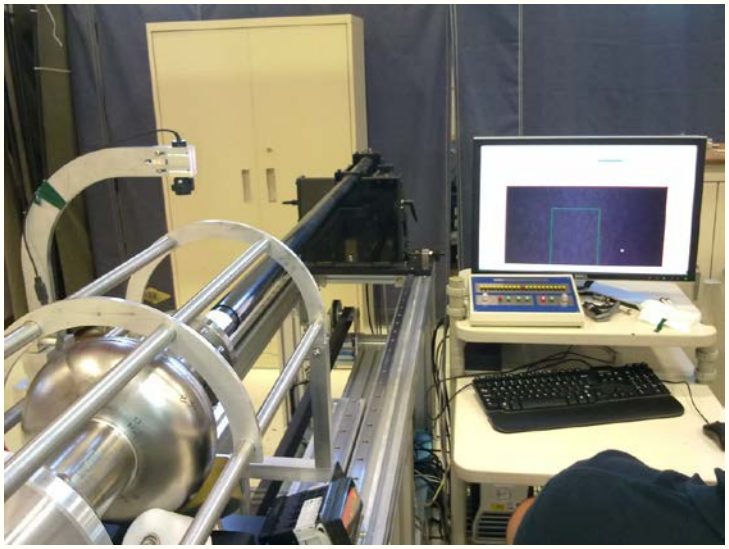
Details Presented by Avinash on IIFC CCM meeting on August 23,2011

Processing & Optical Inspection

- **It was decided to remove machining marks & features after scraped bump by Centrifugal barrel polishing with optical inspection between rounds.**

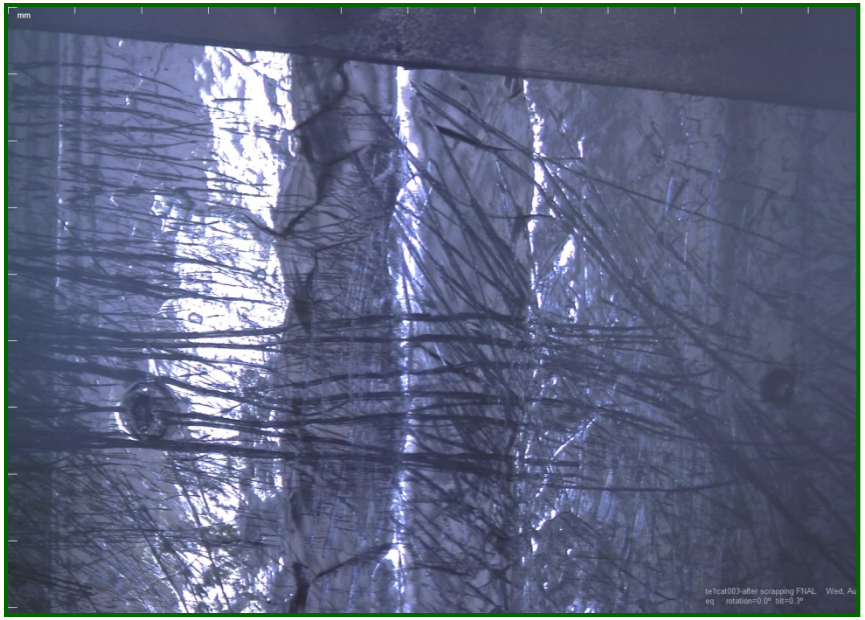


Machining marks

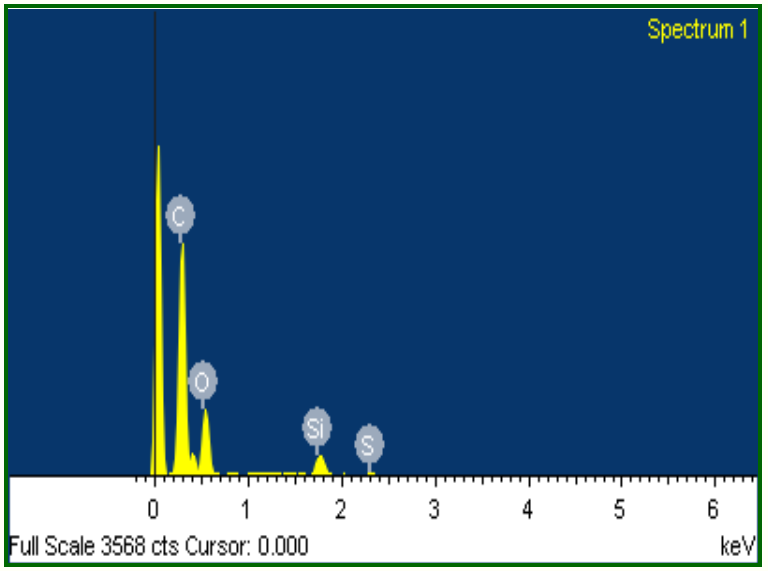


TE1CAT003_Quench cause investigation

Scrapping the bump



EDX plot of debris removed



Element	Weight%	Atomic%
C K	63.58	71.28
O K	31.20	26.26
Si K	4.52	2.17
S K	0.71	0.30
Totals	100.00	

By: Donna & Charlie

Centrifugal Barrel Polishing

CBP is an alternative processing technique (Tumbling) that polishes the inside of superconducting RF cavities by rotating the cavities at high speed while filled with an abrasive media

Source :C Cooper

Media used

Step 1
Cutting, Time as needed

+ Soap & Ultrapure Water

Removal Rate – 11 um / hr

Step 2
Intermediate Polishing, 12 hours

+ Soap & Ultrapure Water

Removal Rate – 3 um / hr

Step 3
Intermediate Polishing, 15 hours

Water + 400 Mesh Alumina

Step 4
Intermediate Polishing, 20 hours

Water + 800 Mesh Alumina

Step 5
Final Polishing, 40 hours

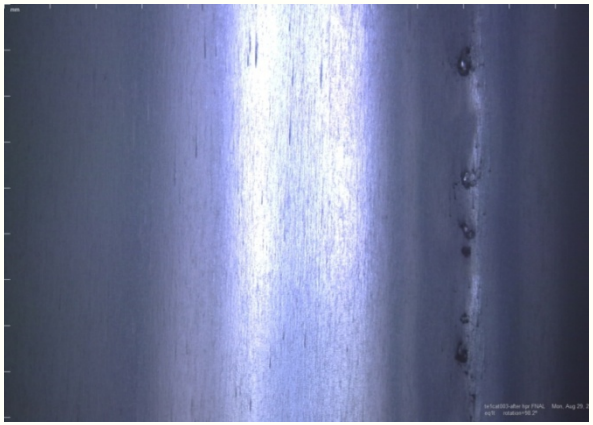
Colloidal Silica

Removal rate of final 3 steps is hard to measure, but not nearly as much as 1st 2 steps

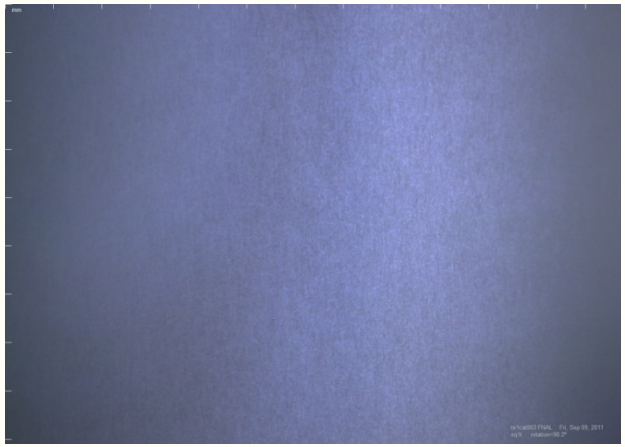
Source :C Cooper

Optical inspection images
0f TE1CAT003

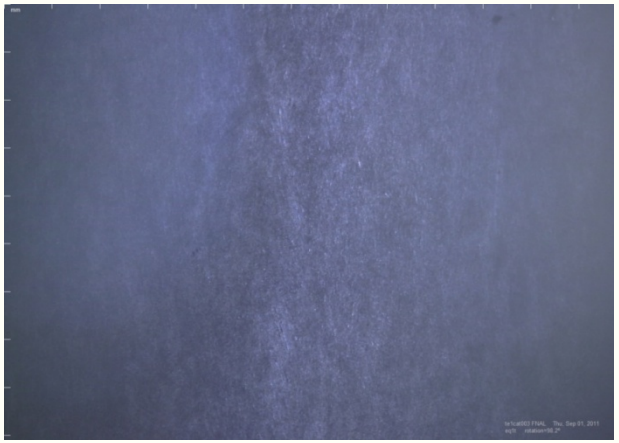
eq1t_98.2 after cbp 2011/08/29



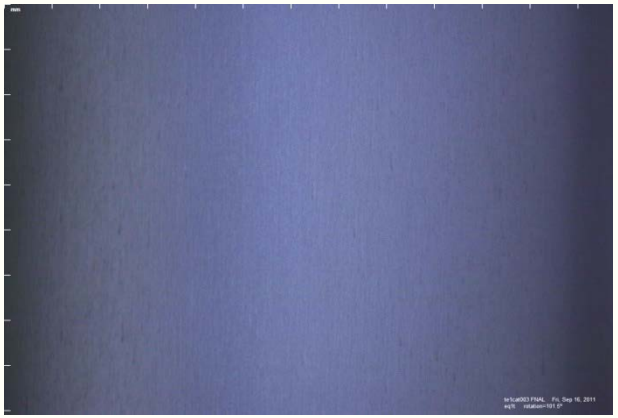
te1cat003_eq1t_98.2
2011-09-09



- te1cat003_eq1t_98.2 2011-09-01

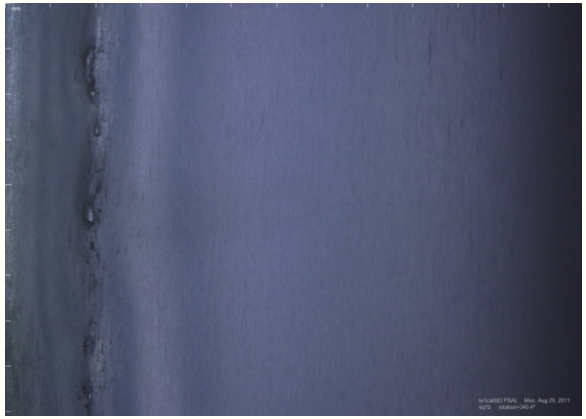


te1cat003_eq1t_101.5 2011-09-16



Optical inspection images of TE1CAT003

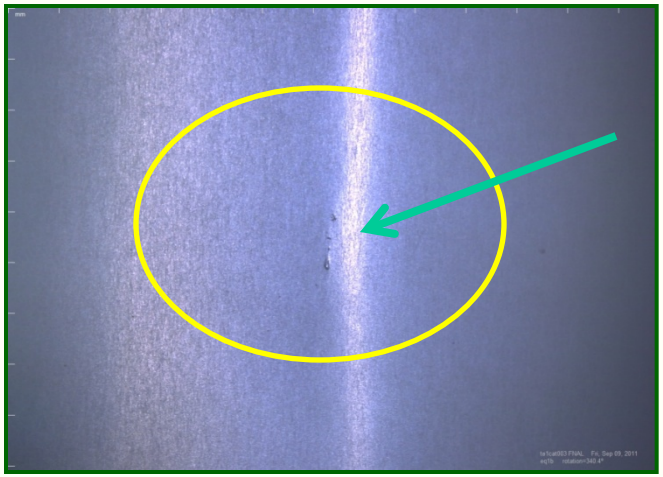
te1cat003_eq1b_340.4 2011-08-29



- **te1cat003_eq1b_340.4 2011-09-01**

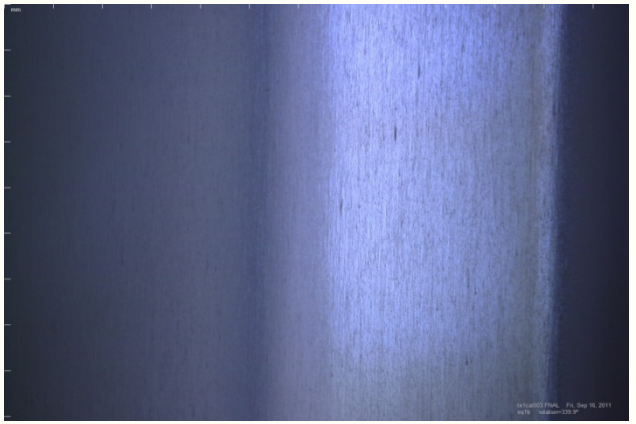
te1cat003_eq1t_339.9

2011-09-09



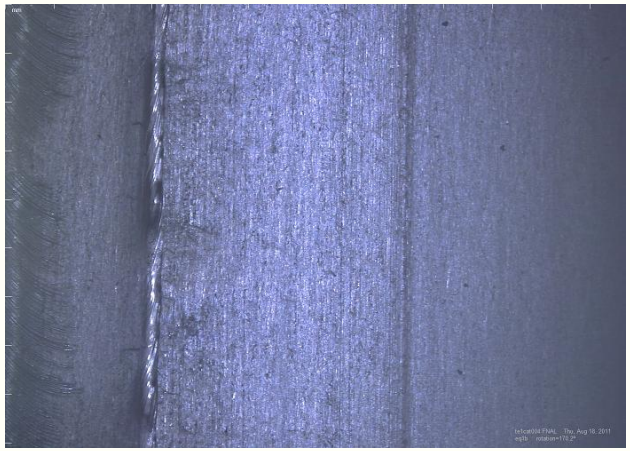
Suspect features.
Rest all is clean

- **te1cat003_eq1b_339.9 2011-09-16**

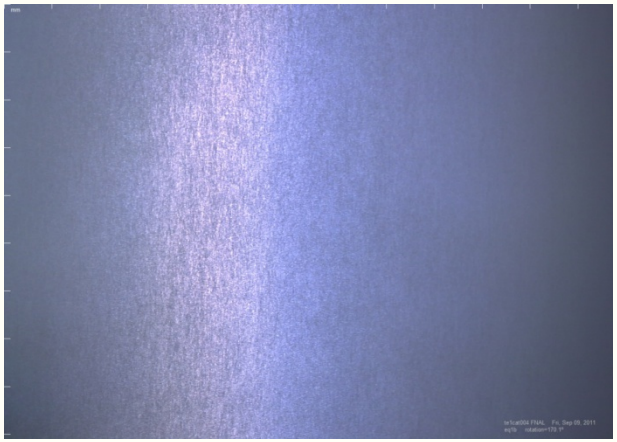


Optical inspection images
0f TE1CAT004

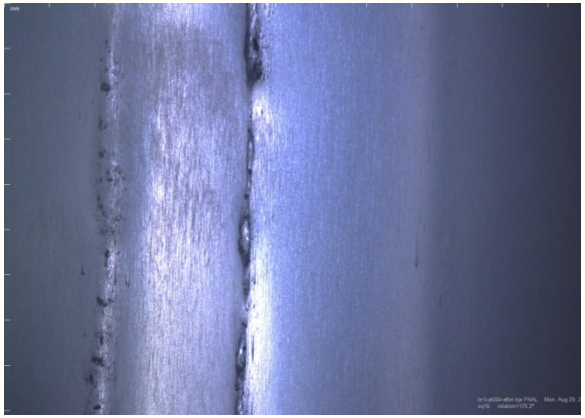
te1cat004- before CBP_eq1b_170.2 2011-08-18



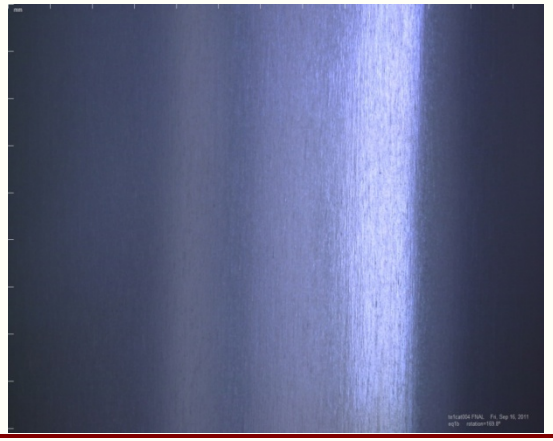
te1cat004_eq1b_170.1 2011-09-09



- te1cat004-after CBP _eq1b_170.2 2011-08-29

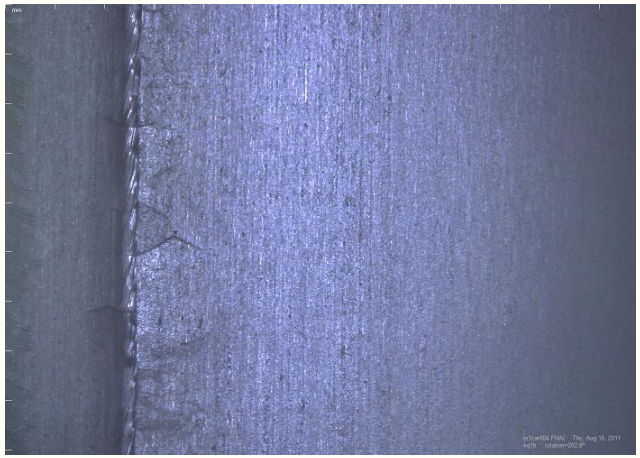


te1cat004_eq1b_169.8 2011-09-16

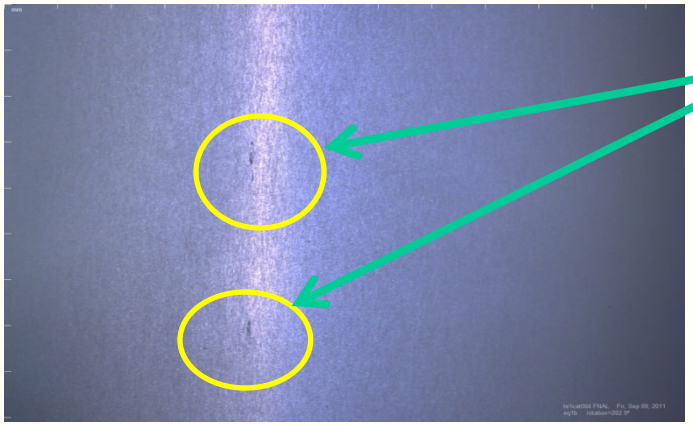


Optical inspection images of TE1CAT004

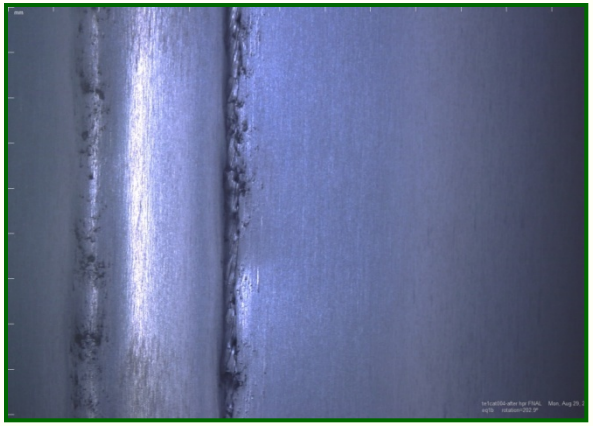
- te1cat004-before CBP_eq1b_202.8_**2011_08-18**



te1cat004_eq1b_202.5 2011-09-09

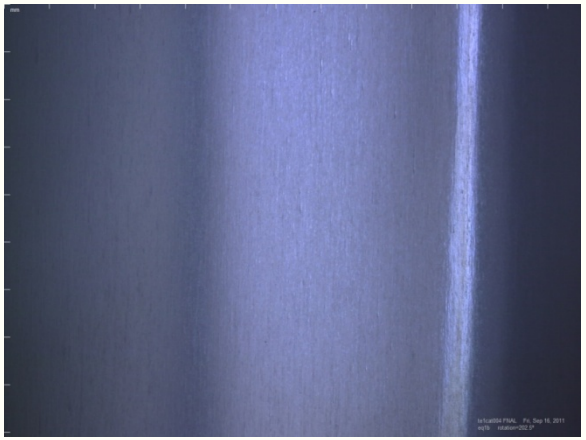


- **te1cat004-after CBP** _eq1b_202.9 **2011-08-29**



te1cat004_eq1b_202.5 2011-09-16

The only concern area, apparently looks very negligible, all other suspected area looks cleaned up



CBP data of TE1CAT003

date	CBP step	Wt before CBP	Wt after CBP	Tumbling time
2011-08-25	Step1	5288.5g	5245.8g	7 hrs
2011-08-25	step2	5245.8g	5221.2g	12 hrs
2011-08-27	step4	5221.2g	5218.3g	40hrs
2011-08-30	Step4	5218.3g	----	6 hrs
2011-08-30	step2	-------	-------	12 hrs
2011-08-31	Step4 (then OI)	--------	------	40hrs
2011-09-02	step2	------	-------	12 hrs
2011-09-07	step4	5129.8g	-------	40hrs
2011-09-12	step2	-------	--------	12 hrs
2011-09-14	Step4(then OI)	---------	------	40 hrs
2011-09-16	Step5 then HPR		------	87 hrs,30 min

CBP data of TE1CAT004

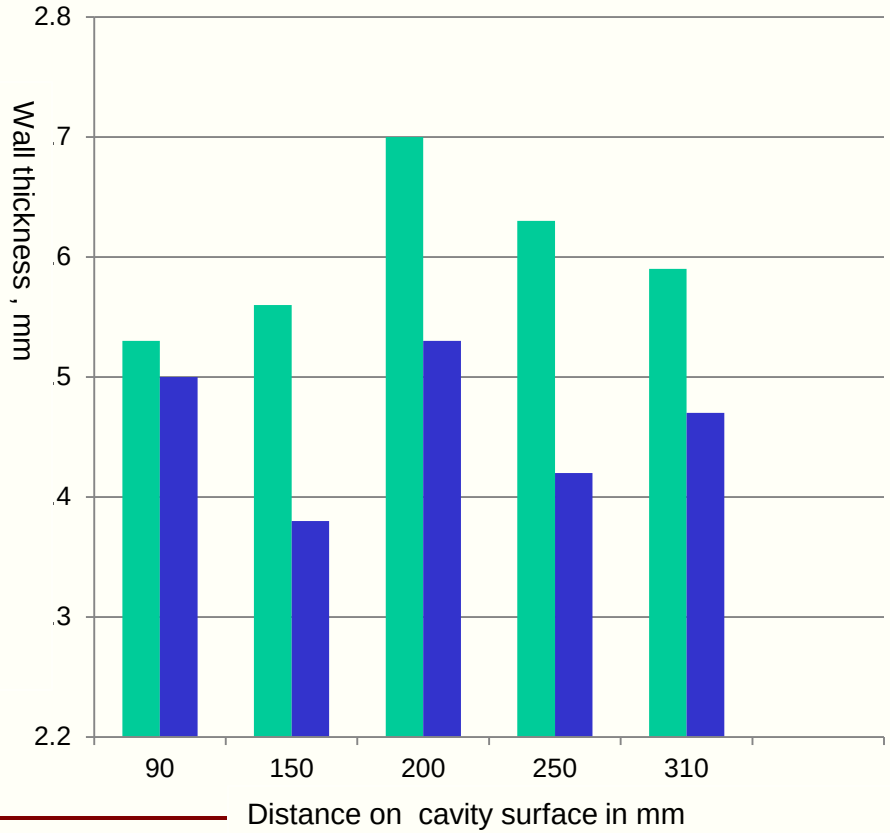
date	CBP step	Wt before CBP	Wt after CBP	Tumbling time
2011-08-25	Step1	5526.1g	5484.6g	7 hrs
2011-08-26	step2	5484.6g	5460.0g	12 hrs
2011-08-27	step4	5460.0g	5458.8g	40hrs
2011-08-30	Step1	5458.8g	----	6 hrs
2011-08-30	step2	-------	-------	12 hrs
2011-08-31	Step4 (then OI)	--------	------	40hrs
2011-09-02	step2	------	-------	12 hrs
2011-09-07	step4		-------	40hrs
2011-09-12	step2	-------	--------	12 hrs
2011-09-14	Step4(then OI)	---------	------	40 hrs
2011-09-16	Step5 then HPR		------	87 hrs,30 min

Material removed by processing

TE1CAT003

position	distance in mm	before processing	after processing	Material removed
Beam pipe	90	2.53	2.5	0.03
near Iris	150	2.56	2.38	0.18
near Equator	200	2.7	2.53	0.17
near Iris	250	2.63	2.42	0.21
Beam pipe	310	2.59	2.47	0.12

Average **0.142**

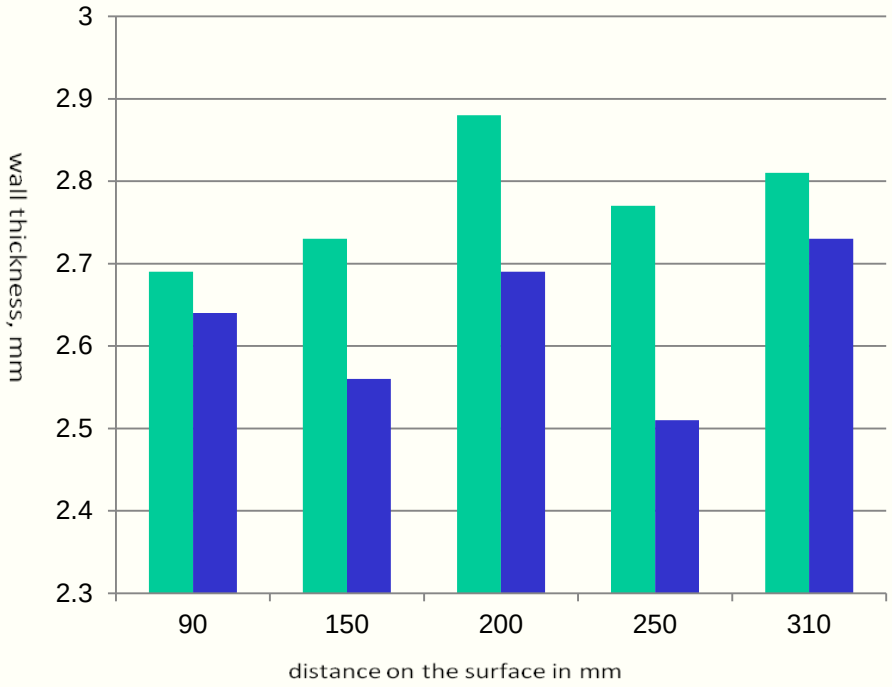


Material removed by processing

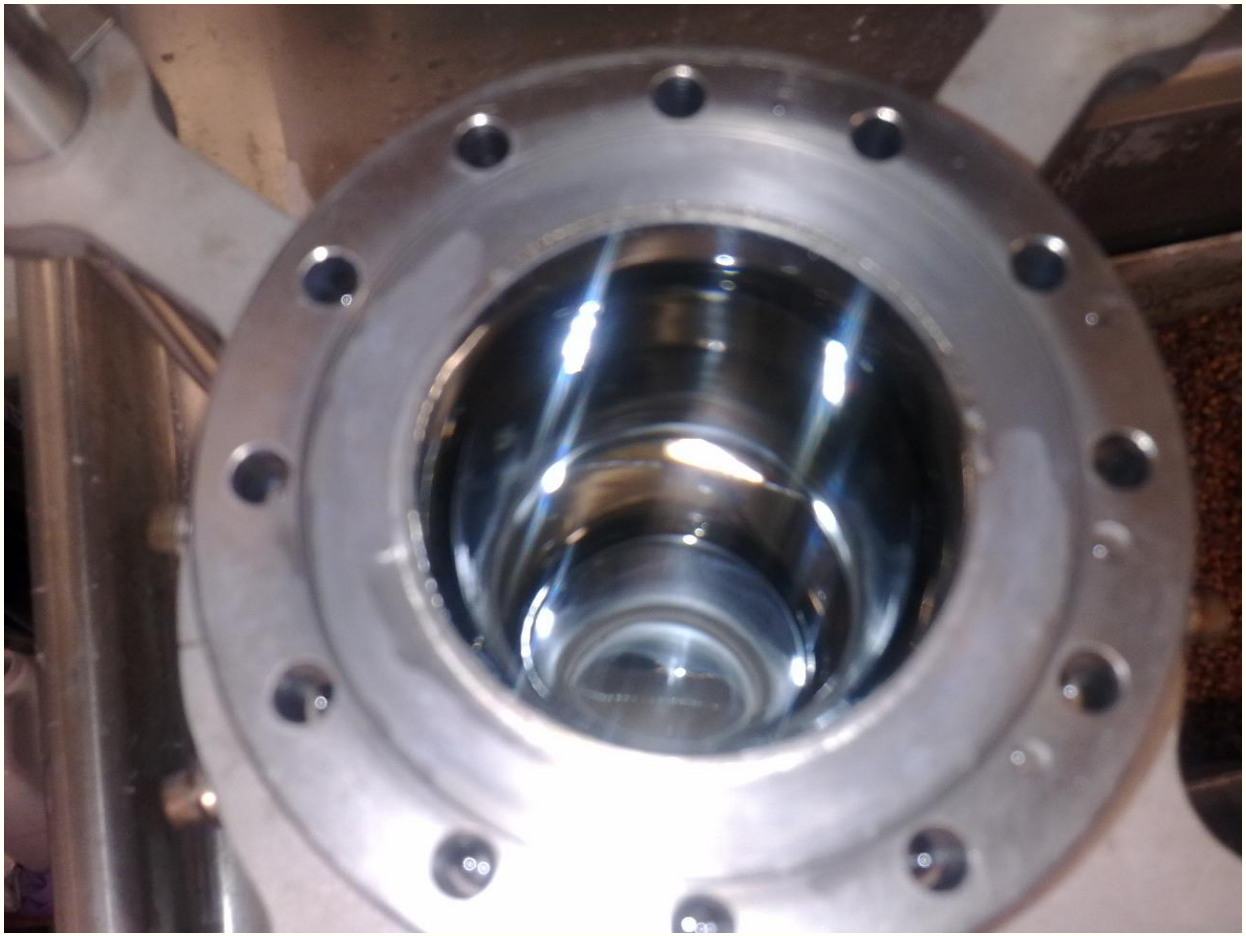
TE1CAT004

position	distance in mm	before processing	after processing	Material Removed
Beam pipe	90	2.69	2.64	0.05
near Iris	150	2.73	2.56	0.17
near Equator	200	2.88	2.69	0.19
near Iris	250	2.77	2.51	0.26
Beam pipe	310	2.81	2.73	0.08

Average **0.15**

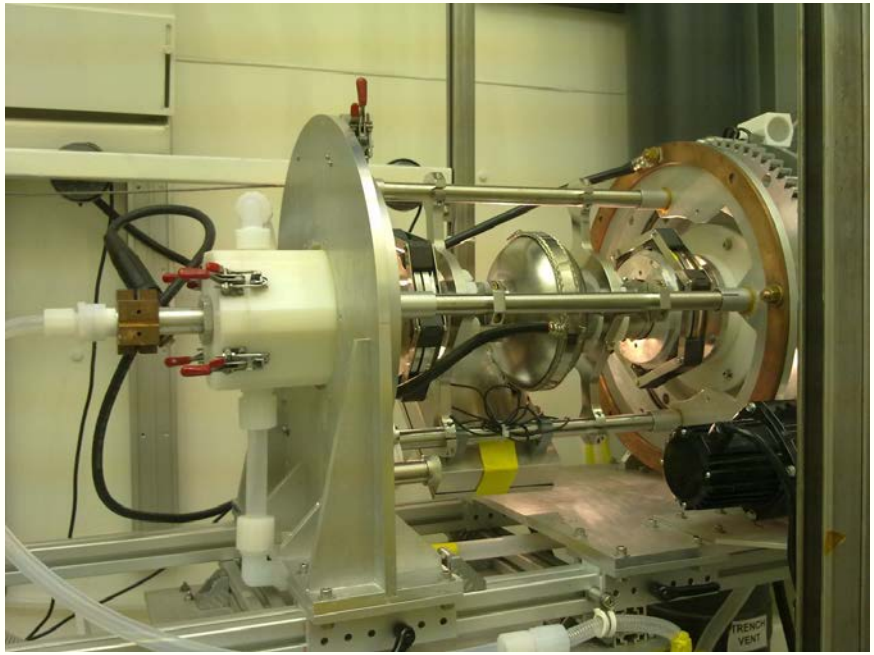


Mirror finish due to CBP before EP



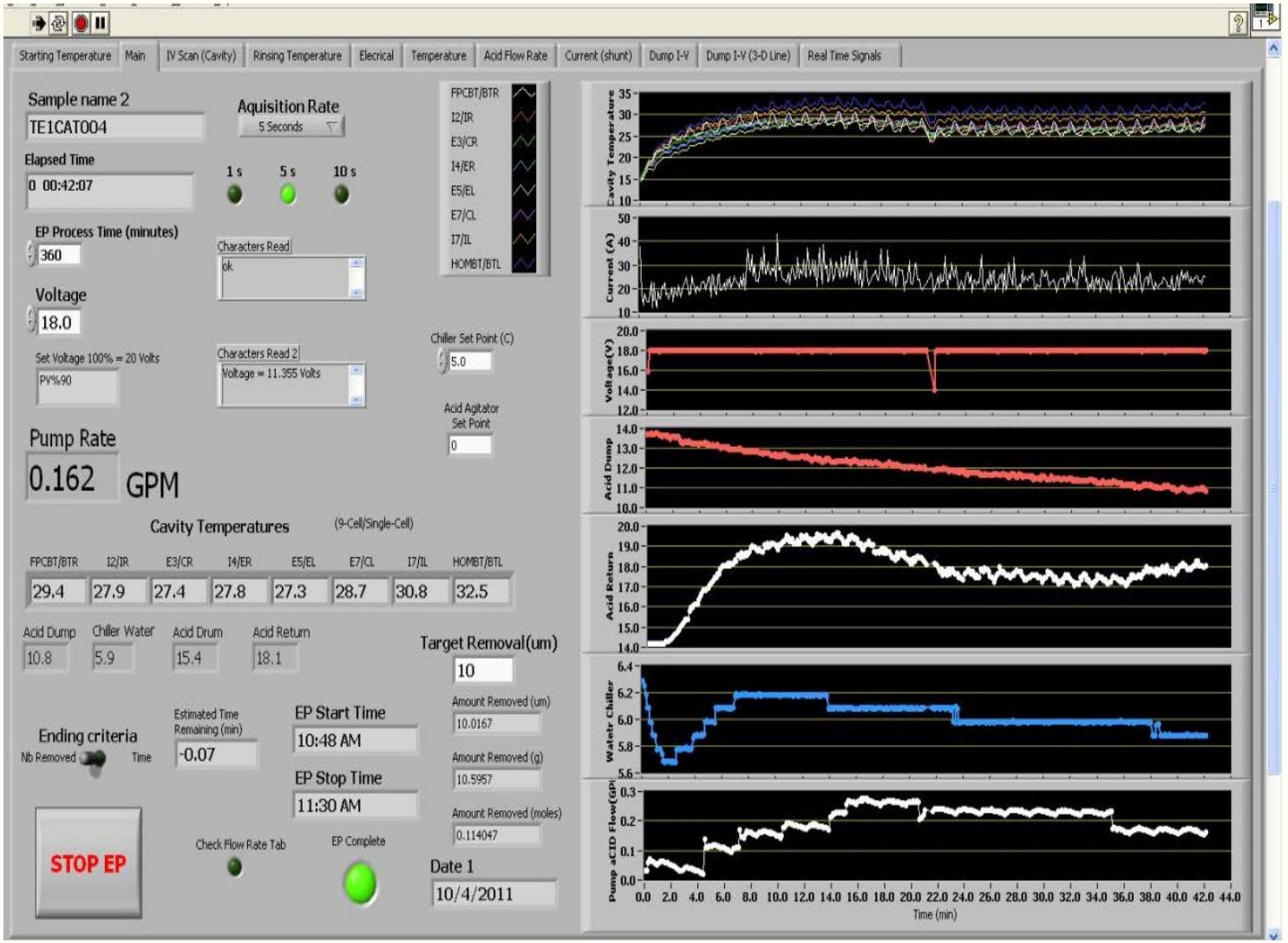
EP at ANL

- **Planned material removed during EP was 20 micron**
- **Average current 27 A, voltage 18V,cavity temperature 27 °C.**



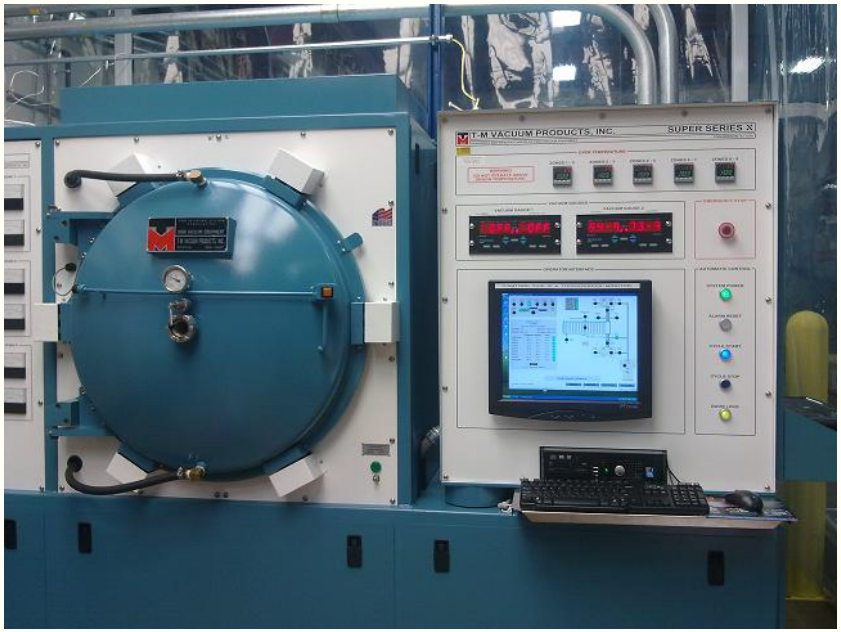
removed { @0.3 µm/min} for a duration of 1hr,6min

Typical EP process Monitoring



Time	Acid Dump (°C)	Chiller (°C)	Acid Drum (°C)	Acid Return (°C)	Nitrogen Flow (cfm)	Current (A)	Voltage (V)	Chiller Setpoint (°C)	Acid Flow (gpm)

800°C heat treatment for 3hrs



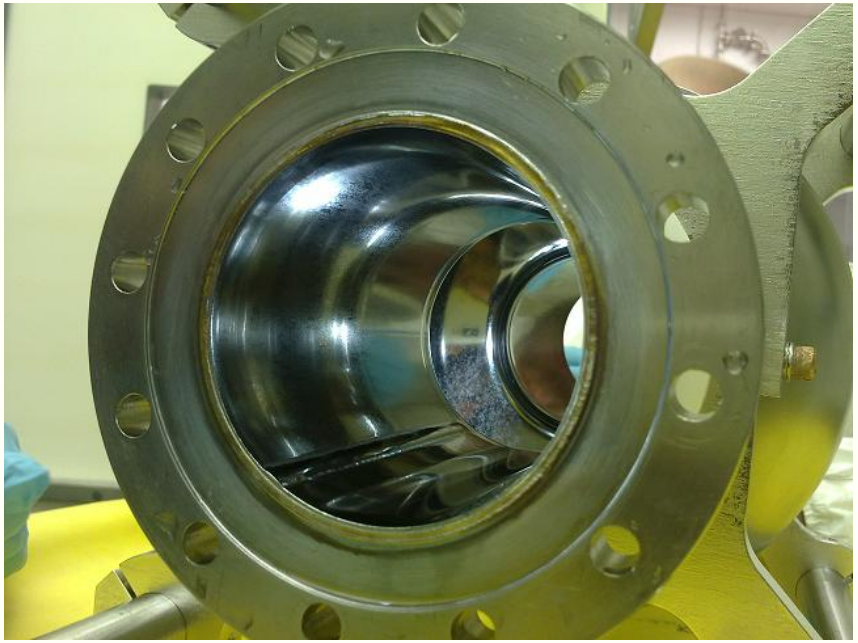
Vacuum furnace in IB4 (Max temp 1000°C)

Cavity moving inside the vacuum furnace

EP at ANL

- Planned material removed during EP was 10 micron.

Draining of acid & rinsing after EP

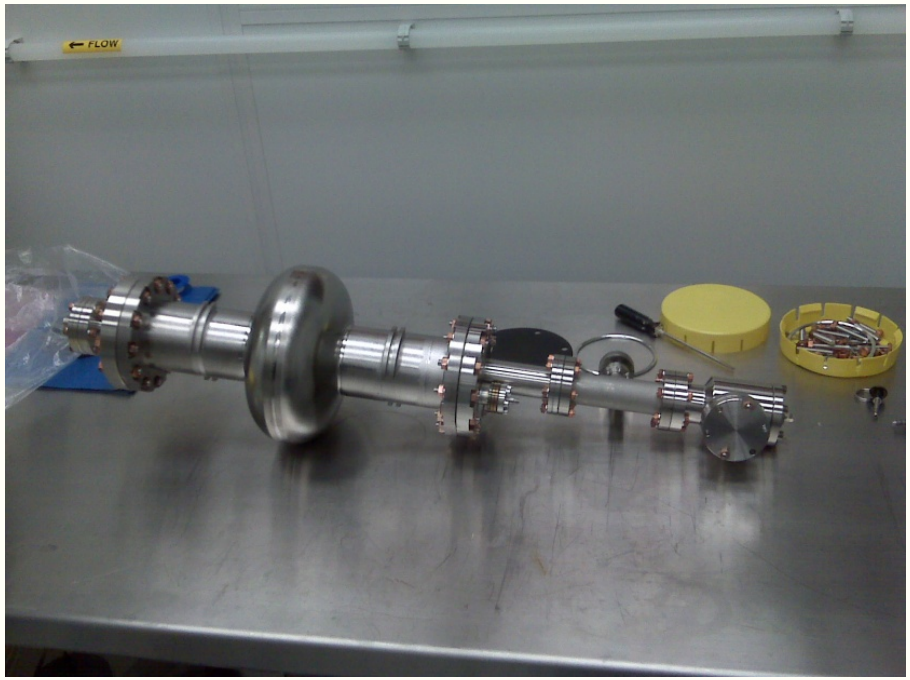


Inside surface after EP

HPR & Assembly at ANL

After EP, ultrasonic cleaning for 60 min before HPR

HPR station



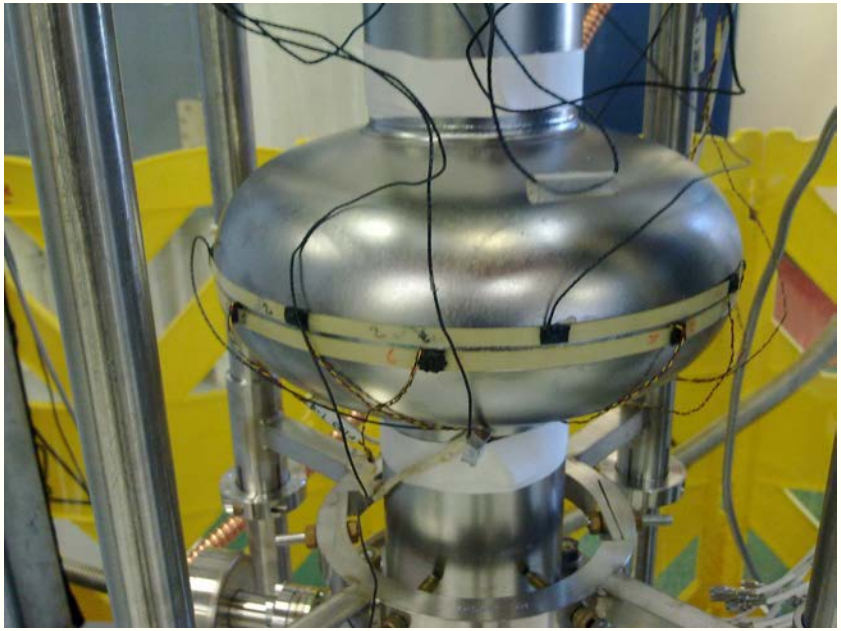
Assembly under vacuum 7.2 E-7

120°C bake out at IB1 (48hrs)

Assembly of cavity with VTS insert

Heating Jackets around the cavity with temp monitor for 120 °C bake,

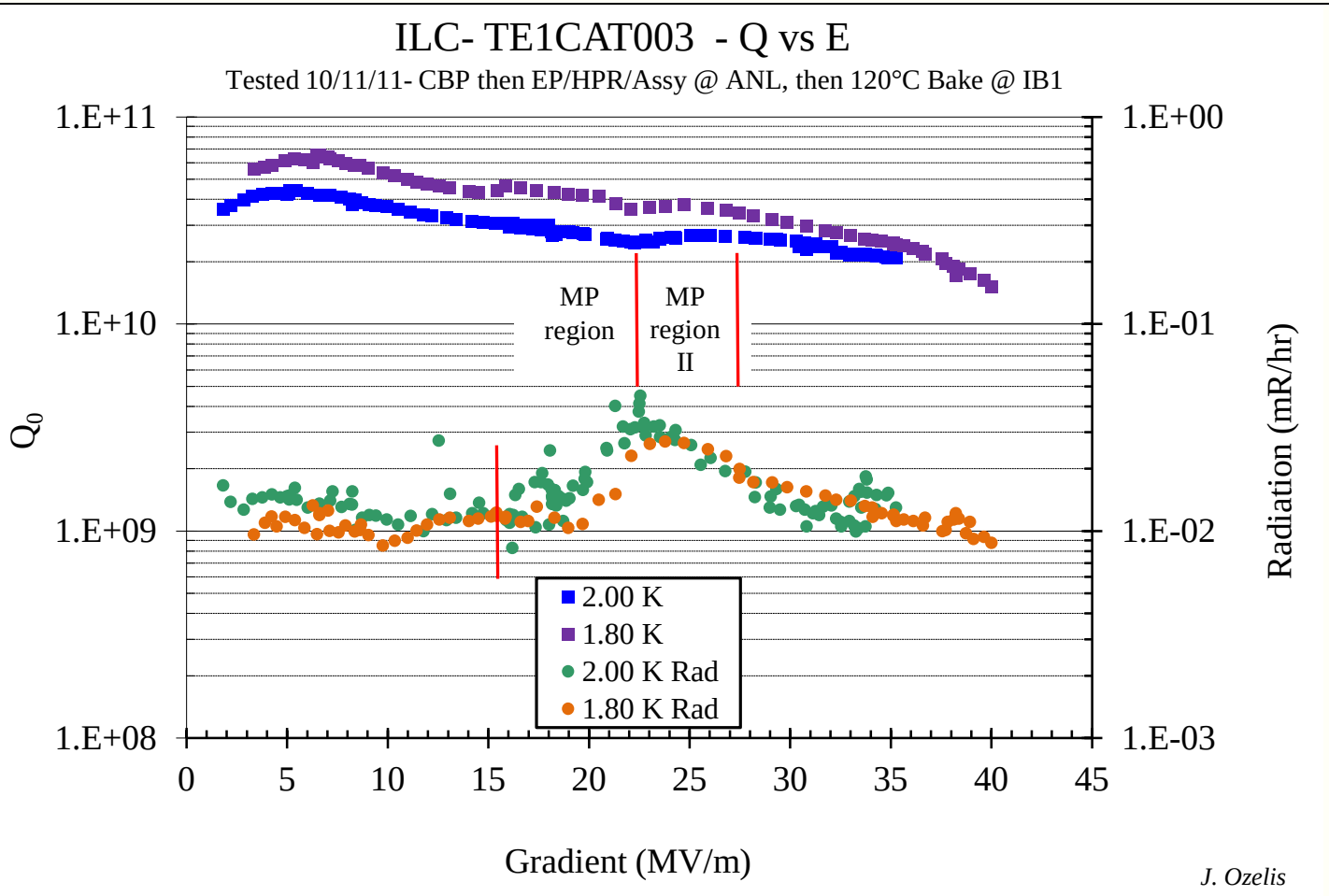
VTS test preparation



Fast thermometry around equator to detect Quench

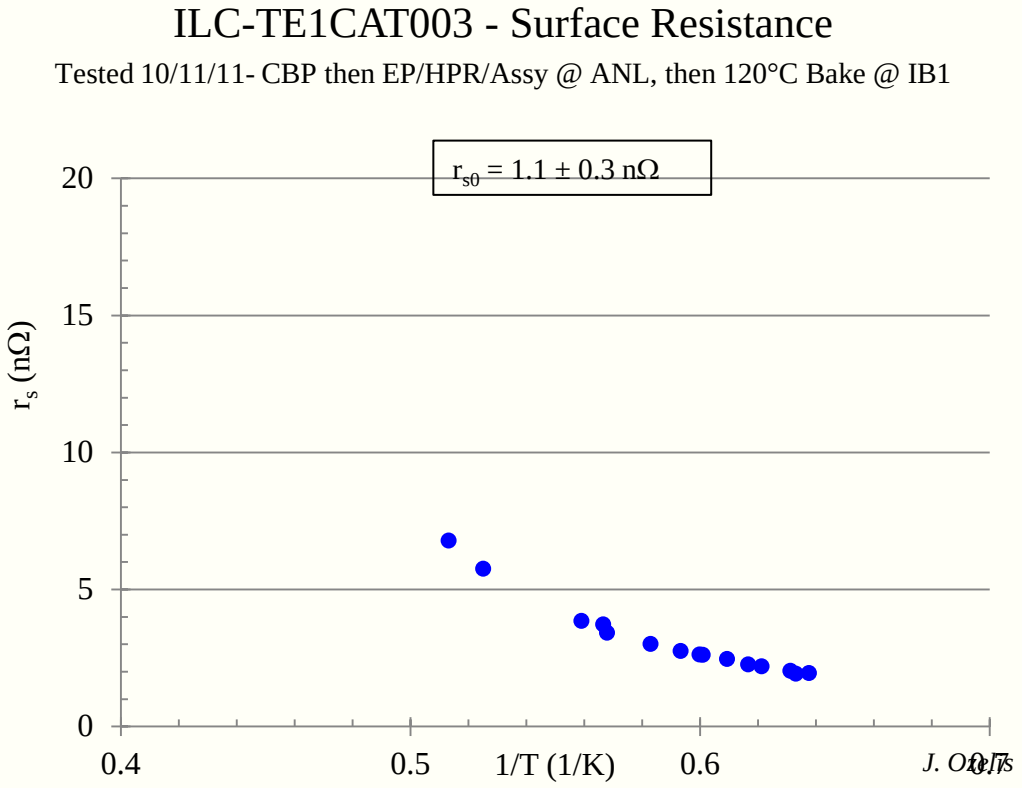
Cavity insert mounted inside the VTS cryostat

2K VTS result of TE1CAT003



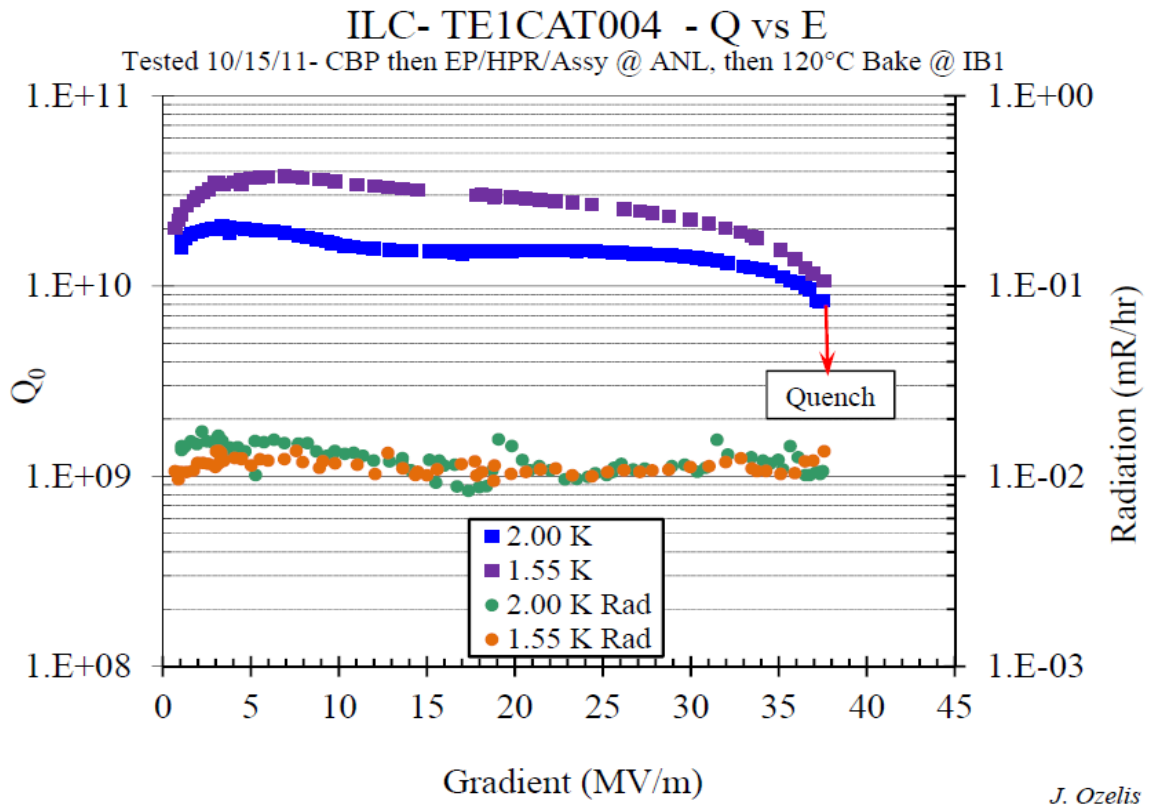
Achieved accelerating gradient 35 MV/m, with a Q 2.1 x E10.
Accelerating gradient is limited by global thermal instability

2K VTS result of TE1CAT003



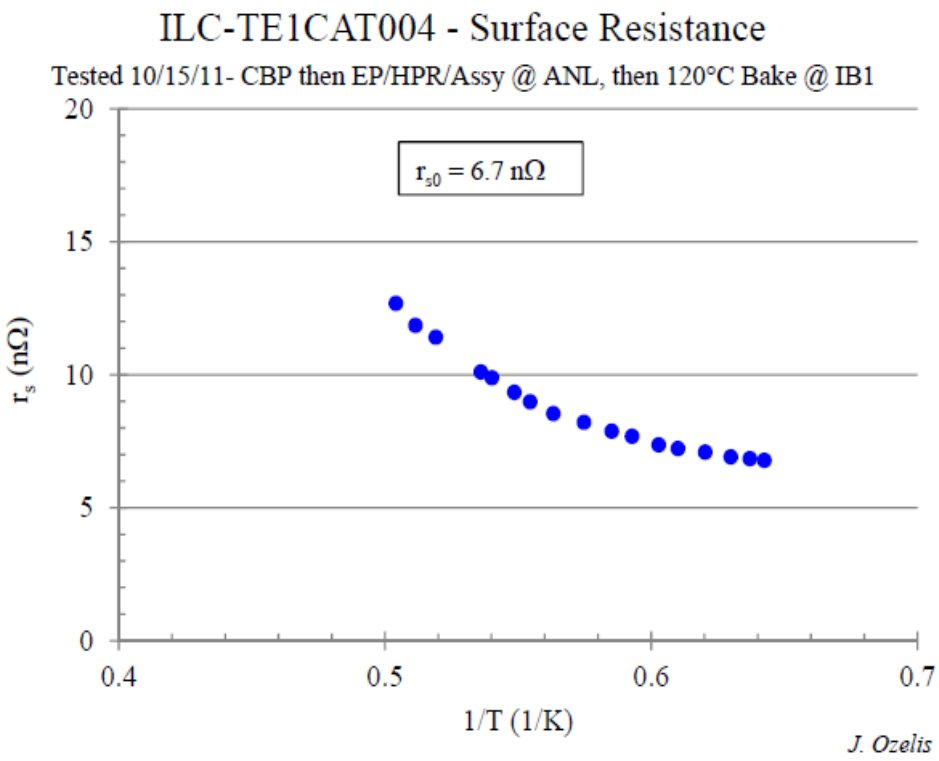
The residual surface resistance of 1.1 ± 0.3 nΩ – among the lowest e measured at Fermilab. Surface resistance in general is very low for this cavity (as evidenced by high Q0 values throughout).

2K VTS result of TE1CAT004



Achieved accelerating gradient **37.5 MV/m**, with a Q **8.4 x E9** at **2K .**No Multipacting & field emission were observed at ant time during testing.
Accelerating gradient is limited by quench.

2K VTS result of TE1CAT004



The residual surface resistance was measured 6.7 nΩ .

Acknowledgement

Optical Inspection
George Steuer
Centrifugal Barrel Polishing Process
Charlie Cooper,Dave Burk,George Steuer
Cavity EP Processing & clean room Assembly
Allan Rowe,Tom Reid & Ryan Murphy (ANL) ,Brent Stone
Cavity baking & transport
Allan Rowe, Damon Bice, Mayling Wong & all transport crew
Cold Test & preparation
Joe Ozelis,Dmitri A. Sergatskov ,Morgan Carter
Frequancy measurment:
Timergali Khabiboulline
I would also like to acknowledge Camille Ginsburg, Mark Champion & all team members.

Thanks

For excellent support & teamwork from all the colleagues at FNAL & ANL