Cavity Gradient R&D

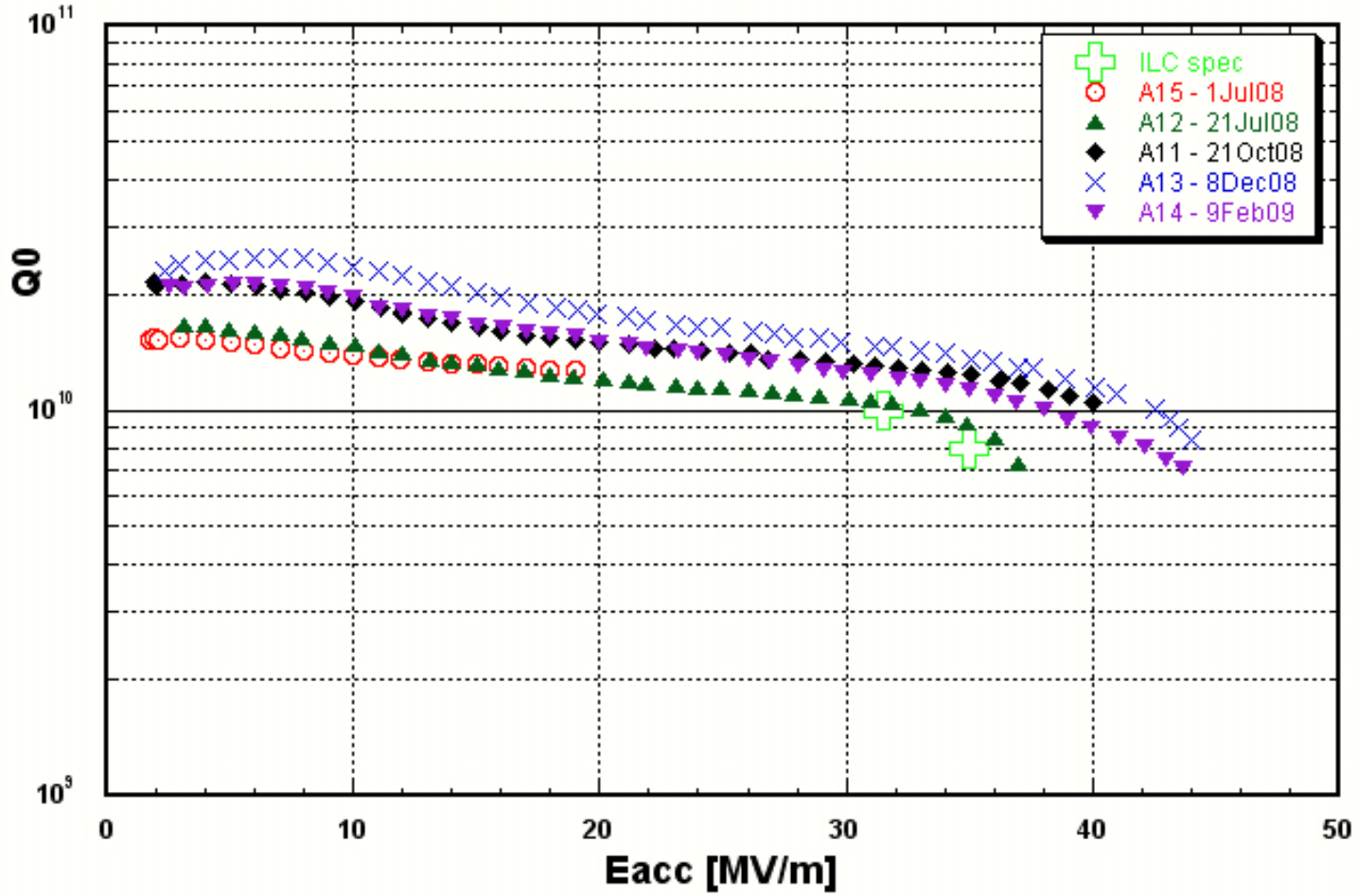
Contents

- R&D Current Status
  - **What has been obtained**
  - **What has been standard**
- R&D Plan in TDP
  - **R&D subjects and what will be expected**
  - **Time-line**
  - **Resource**
  - **Global cooperation**
- Reference Information (to be attached)
- NOT:
  - **How to establish the optimum field gradient for ILC**
    - Decision process
    - Time scale
  - **Next talk by A. Yamamoto**

R&D Current Status:

- Americas
  - **Successful preparations at JLab**
    - Most recent production
  - **Startup of the facility at FNAL**
  - **Second sound**
  - **T-map at LANL**
  - **New vendor Qualification**
- Asia
  - **STF**
    - Pulsed tests
    - Vertical Tests online
    - EP online
  - **Vendor qualification**
  - **Optical inspection system development**
    - Guided repair as an option to recover faulty cavities
- Europe
  - **Preparation for mass production**
  - **Development optical inspection**
  - **HiGrade**

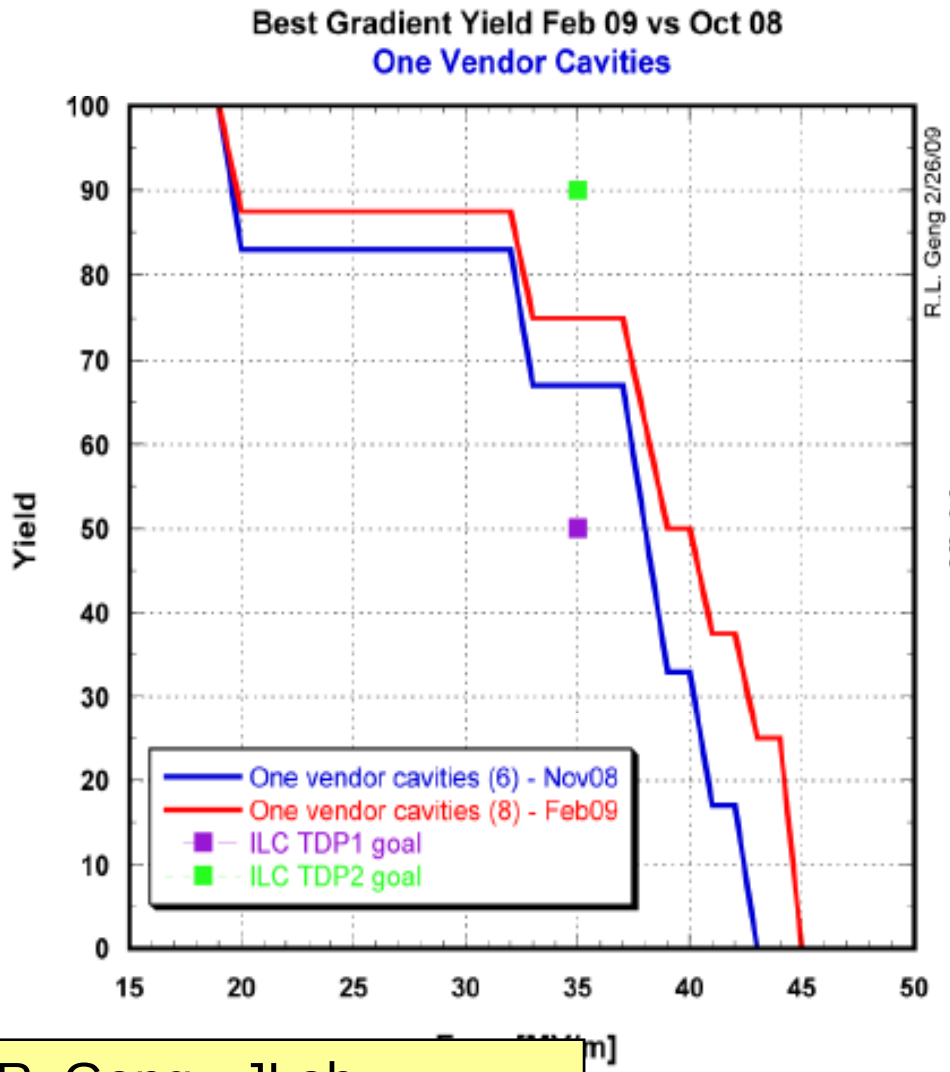
America R&D: Nine-cells new series

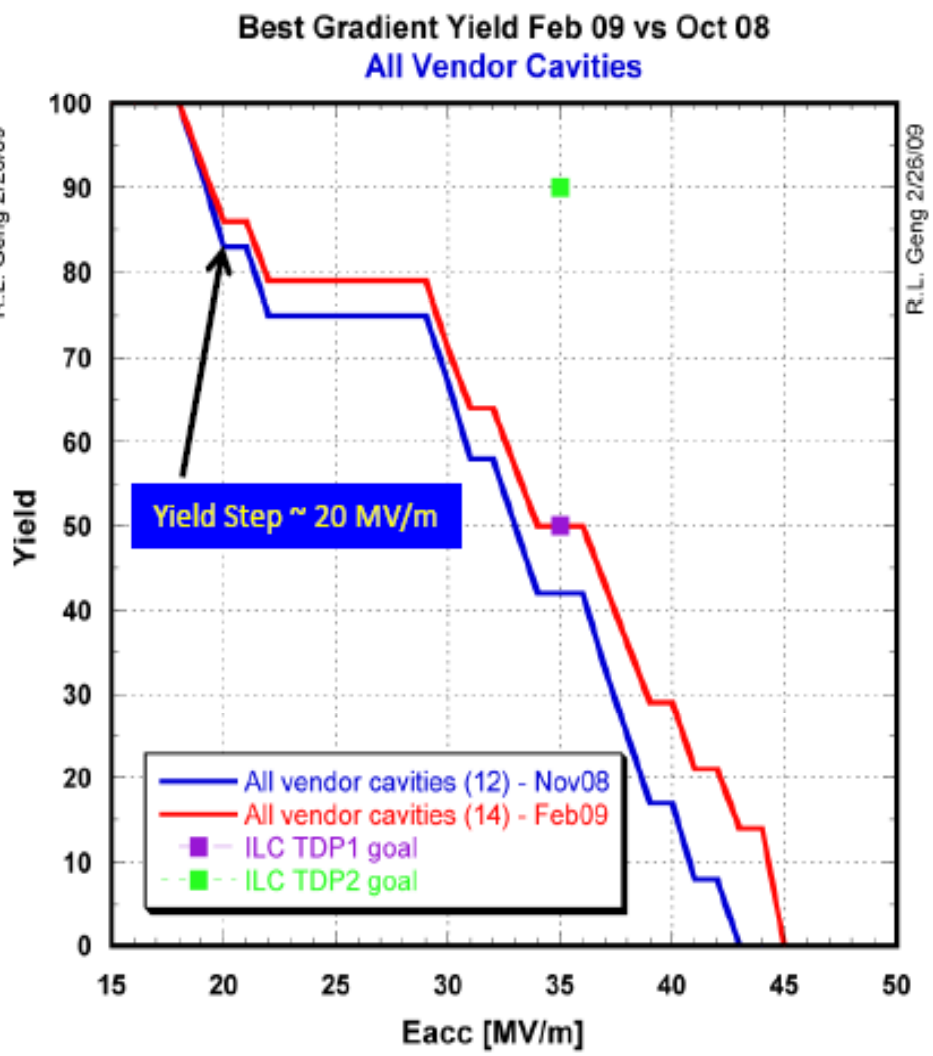


- Five 9-cell cavities: built by ACCEL, and processed/tested at Jlab.
- All of them processed with one bulk EP followed by one light EP and by ultrasonic pure-water cleaning with detergent (2%).

Yield Curve – as of Feb 09

14 9-cell Cavities Processed & Tested at JLab

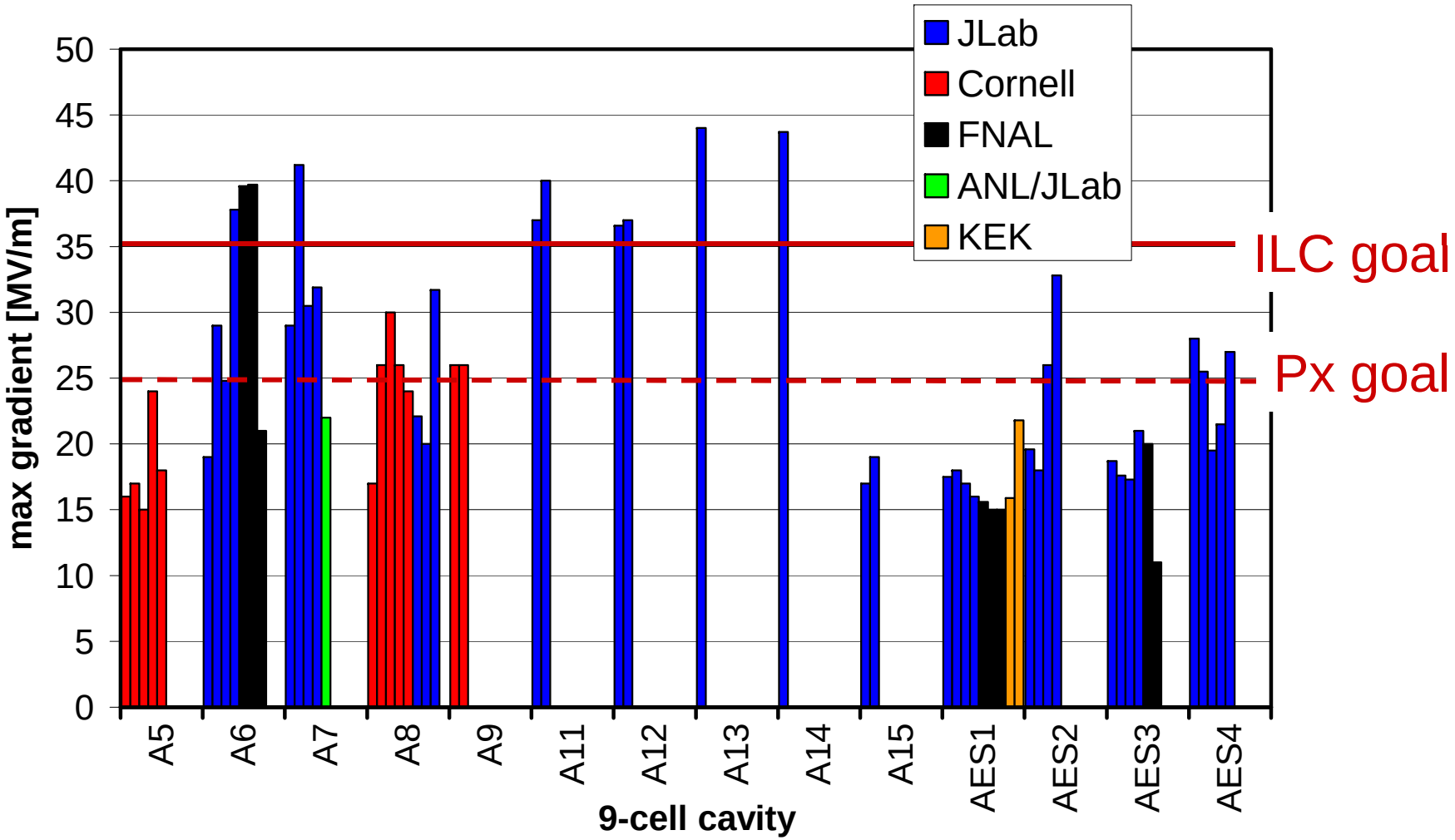




R. Geng - JLab

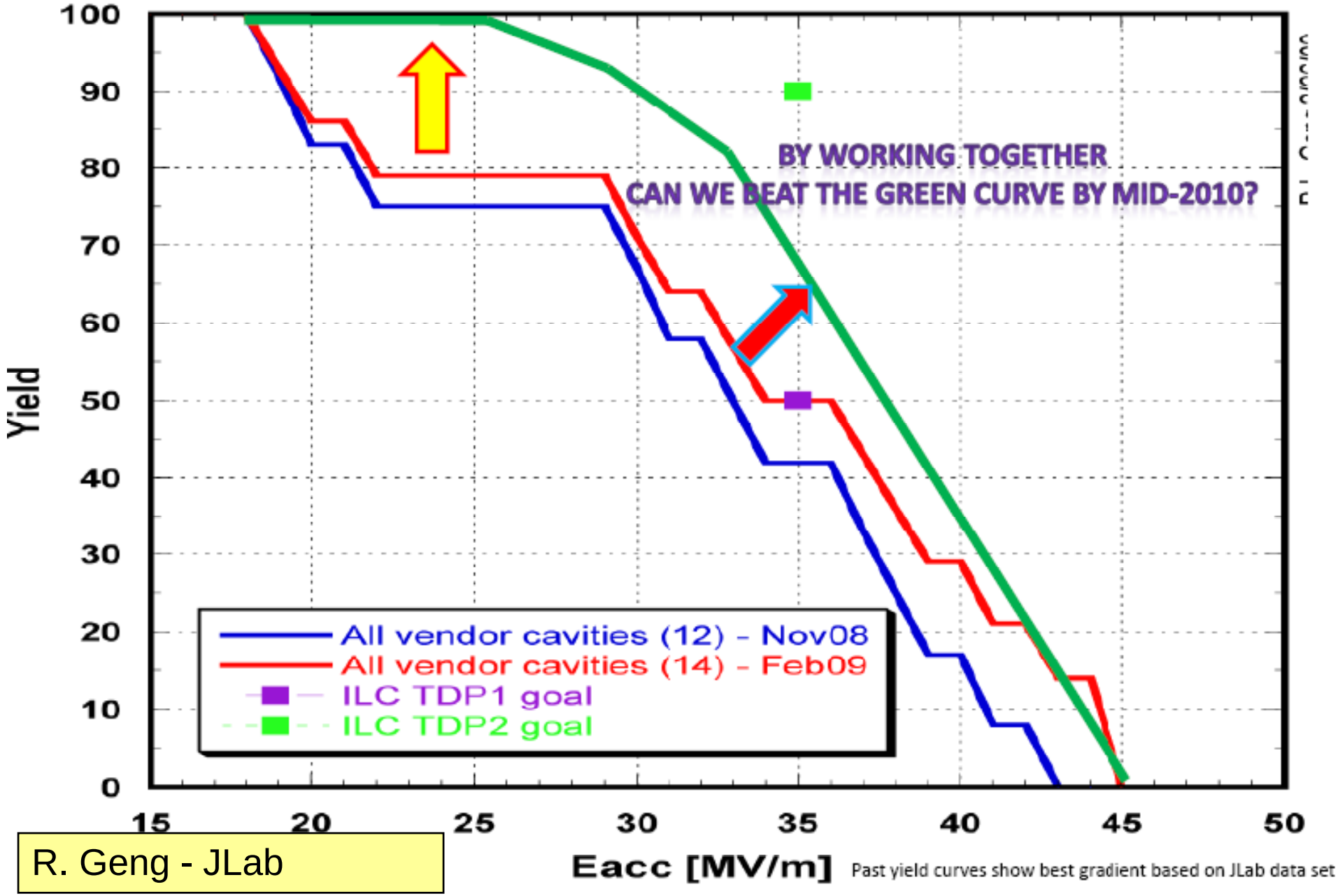
Americas 9-cell Vertical Tests

Of 14 cavities, 6 cavities meet ILC VT spec & 10 meet Project X VT spec
NB: These are the tests which individual Labs choose to publish…



C. Ginsburg

Two Big Pushes Ahead…



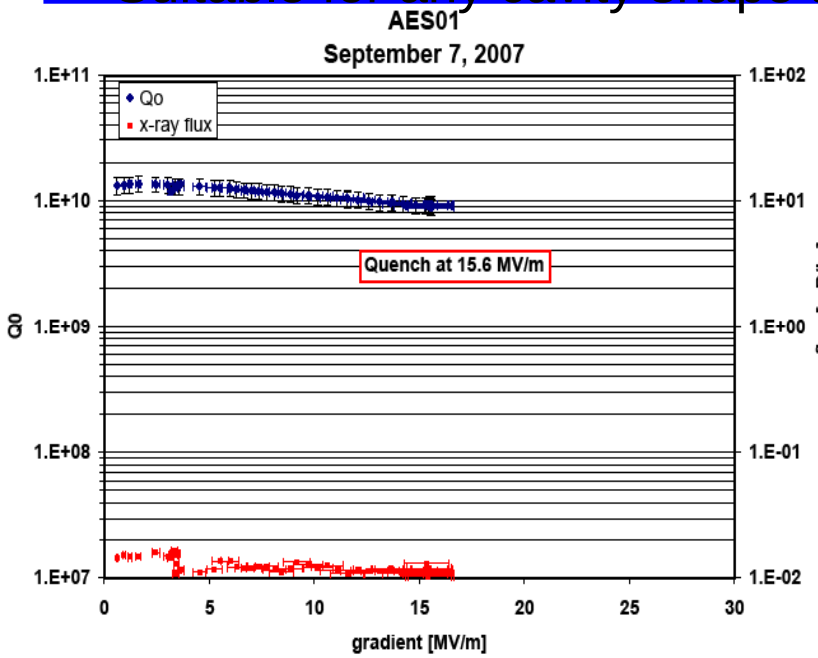
Past yield curves show best gradient based on JLab data set

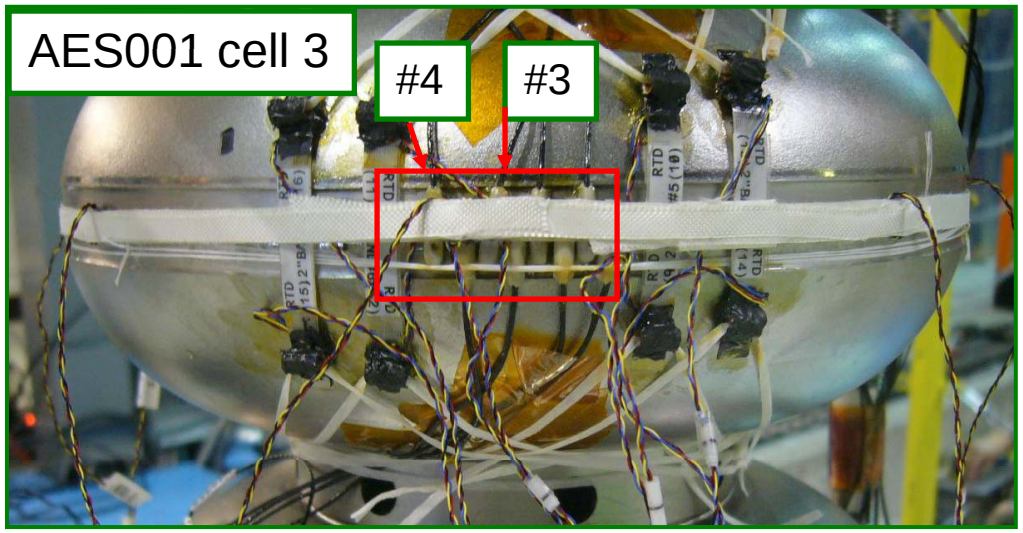
R. Geng - JLab

Quench Location with Fast Thermometry

FNAL

- Example of cavity which quenched at 16 MV/m without field emission
  - Temp rise ~0.1 K over ~2 sec in sensors #3 & #4 before quench seen on all sensors
- Cernox RTD sensors (precise calibration, expensive) with fast readout (10 kHz)
- Flexible placement of sensors, attached to cavity surface with grease and band; slow installation
- Suitable for any cavity shape and highly portable





America R&D: FNAL Infrastructure

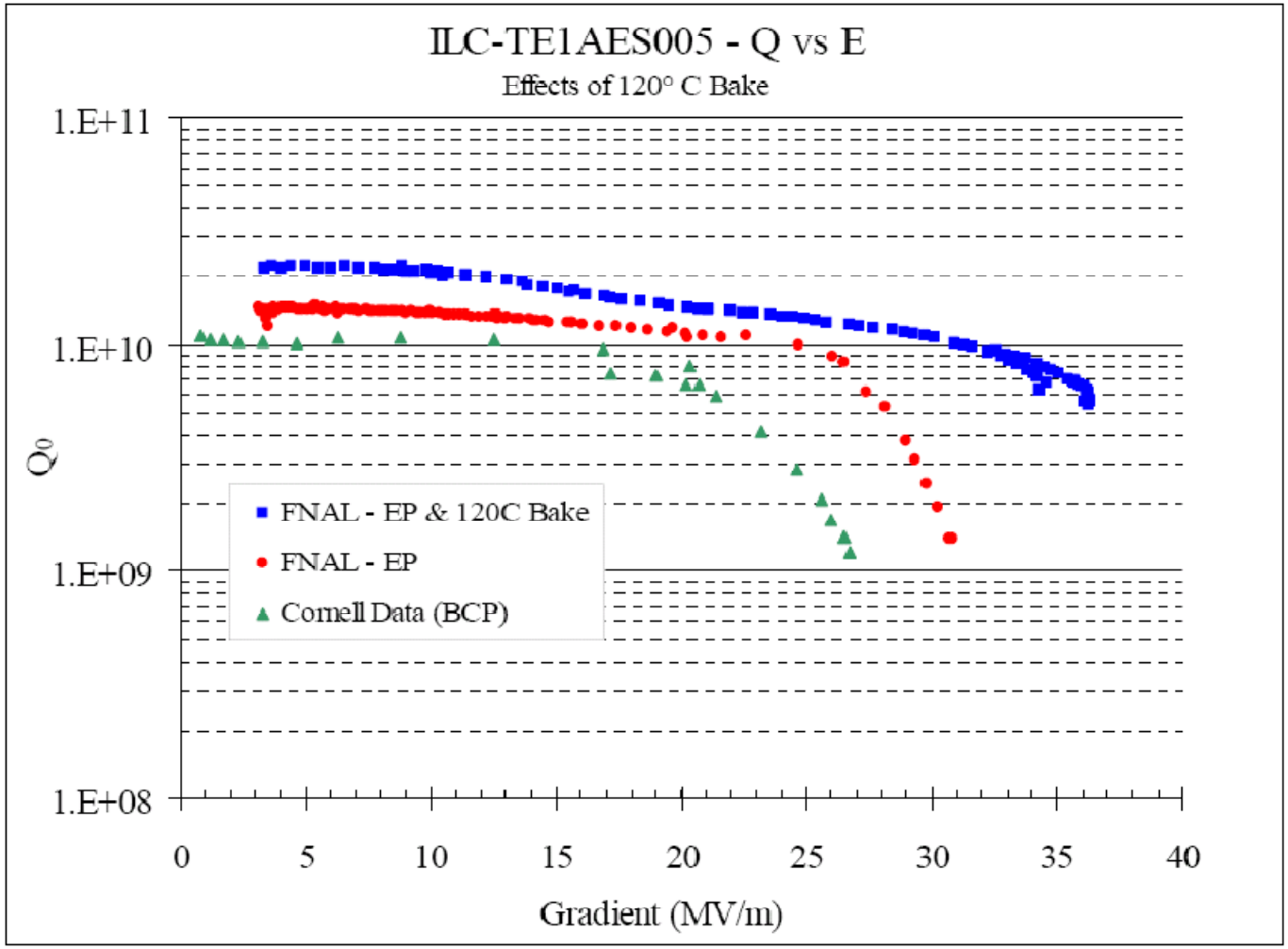


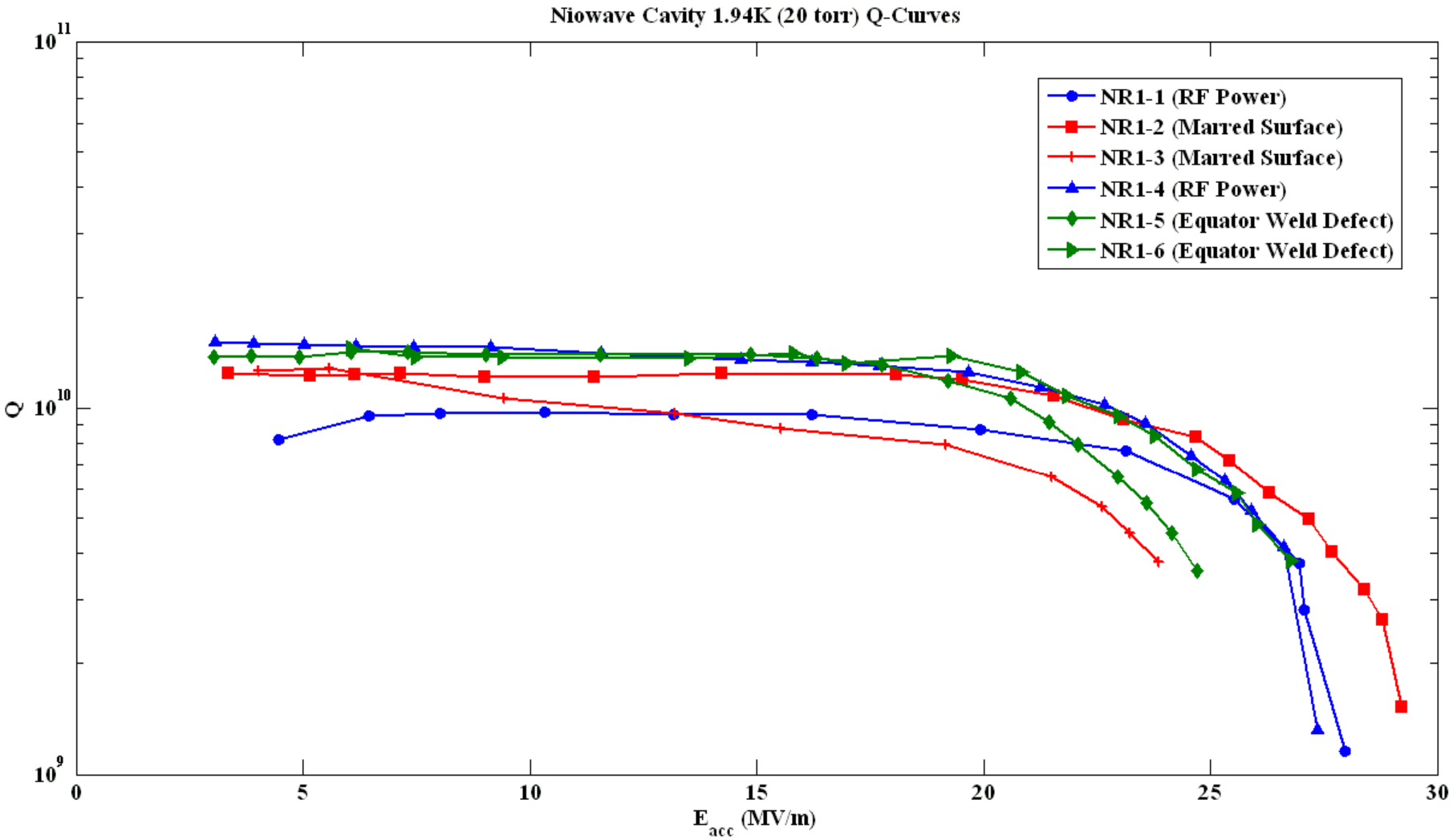
Figure 2.) Q_0 vs E run at 2K. Data from the previous Fermilab and Cornell tests are shown for comparison.

G. Wu, J. Ozelis FNAL

Niowave Single-Cell BCP Cavity Performance

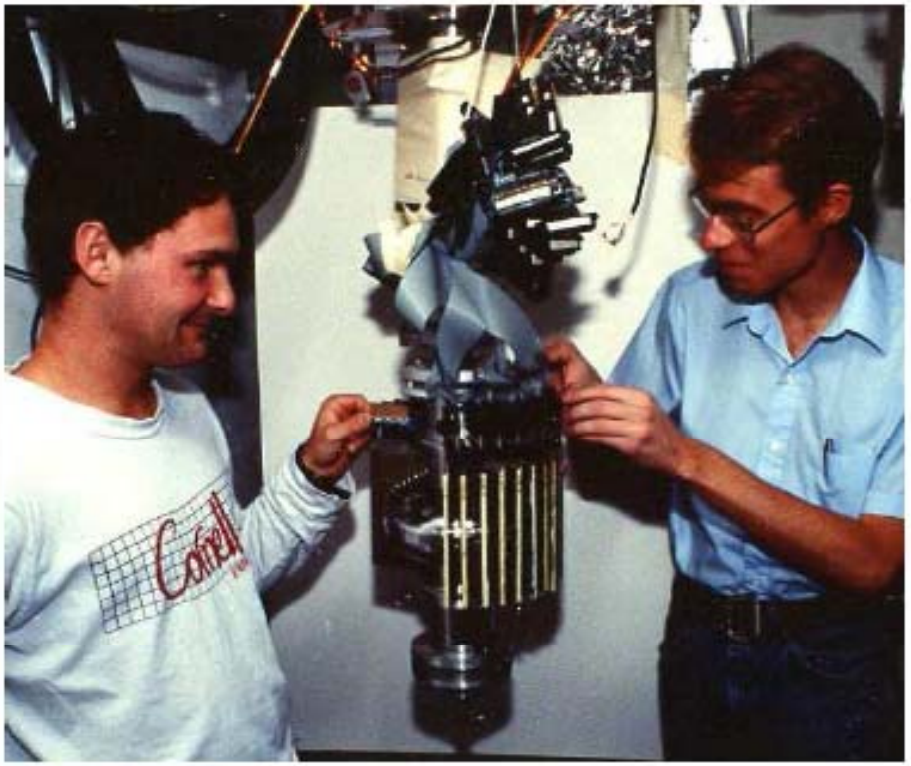
Niowave Cavity	BCP (1:1:2) Etch	Q_0 (1.94 K)	Peak E_{acc}	Q at Peak E_{acc}	Field Limit
NR1-1	85 μm	8.2 e 9	27.9 MV/m	1.2 e 9	RF Power
NR1-2	113 μm	1.2 e 10	29.2 MV/m	1.5 e 9	Marred Surface
NR1-3	60 μm	1.3 e 10	23.8 MV/m	3.8 e 9	Marred Surface
NR1-4	254 μm	1.5 e 10	27.4 MV/m	1.3 e 9	RF Power
NR1-5	184 μm	1.4 e 10	24.7 MV/m	3.6 e 9	Equator Weld Defect
NR1-6	205 μm	1.5 e 10	26.8 MV/m	3.8 e 9	Equator Weld Defect

Niowave Single-Cell BCP Cavity Performance

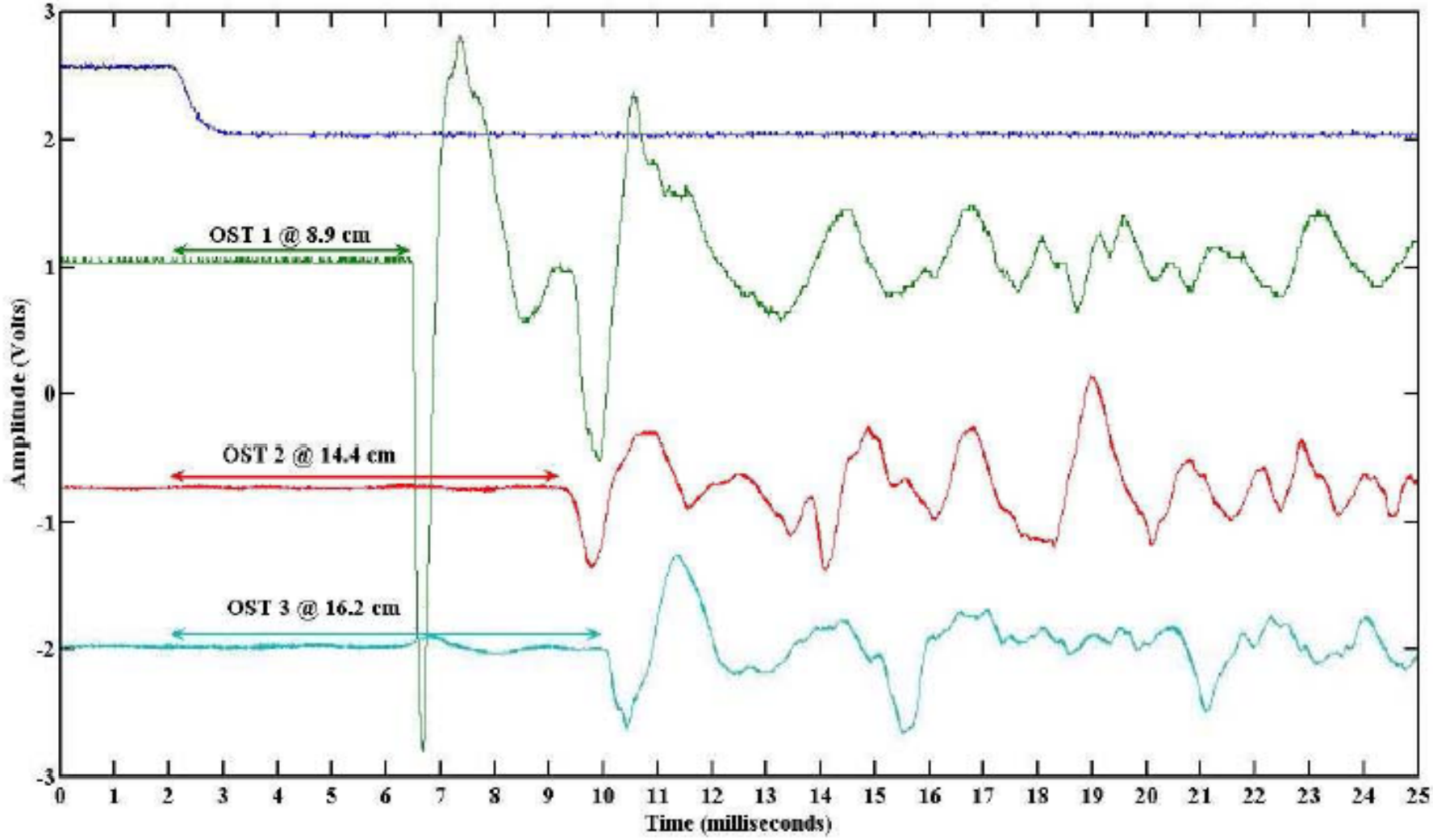


Z. Conway - Cornell

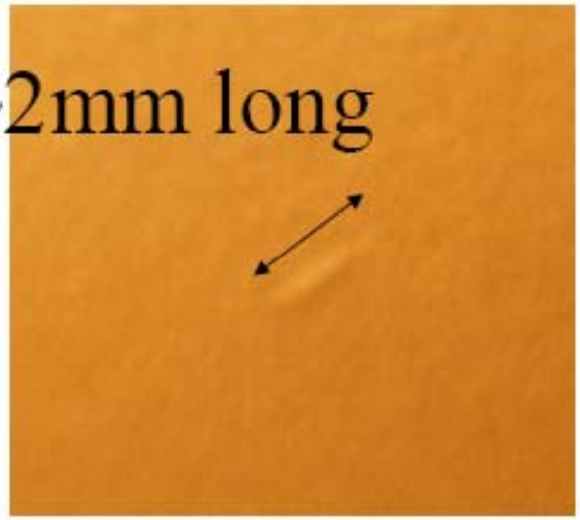
Cavity Defects



Defect Location



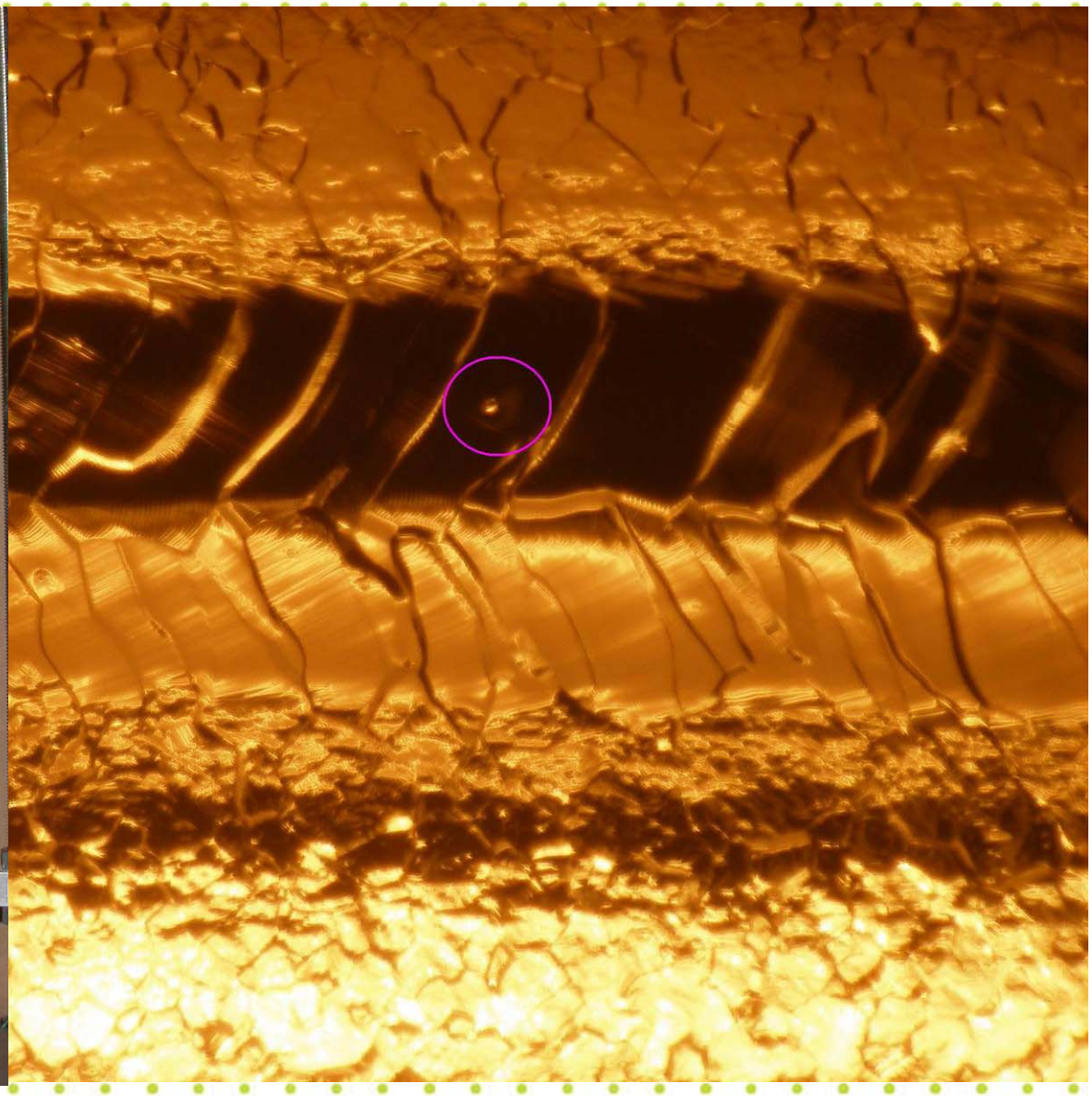
Surface Defects



Right-hand picture courtesy of Charles Reece (JLAB)

and Genfa Wu (FNAL)

Niowave Single Cell NR-5



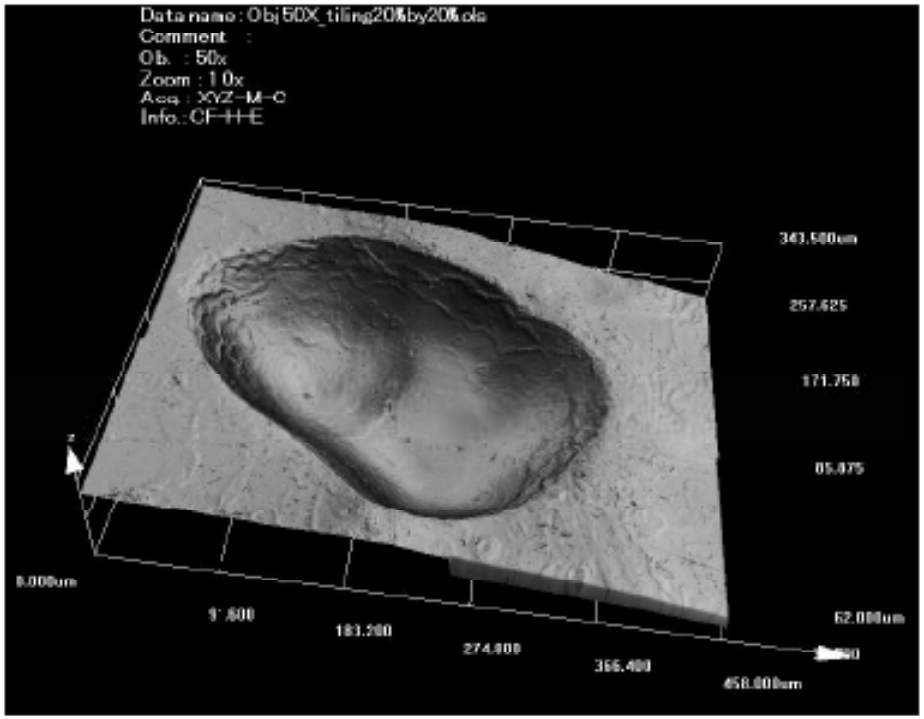
Z. Conway - Cornell

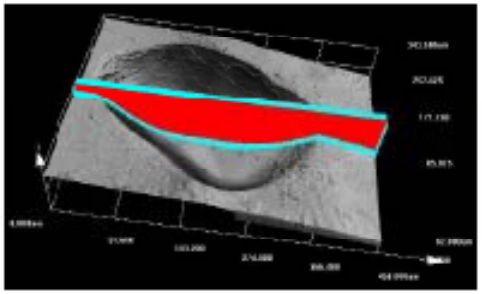
Pit 1

ASC/NHMFL/FSU
Imaged using Olympus Laser Scanning Confocal 3D Microscopy (LSCM-LEXT)

Obj 50X – 2 by 2 tiling image

Courtesy Zu-Hawn Sung and Peter Lee, FSU



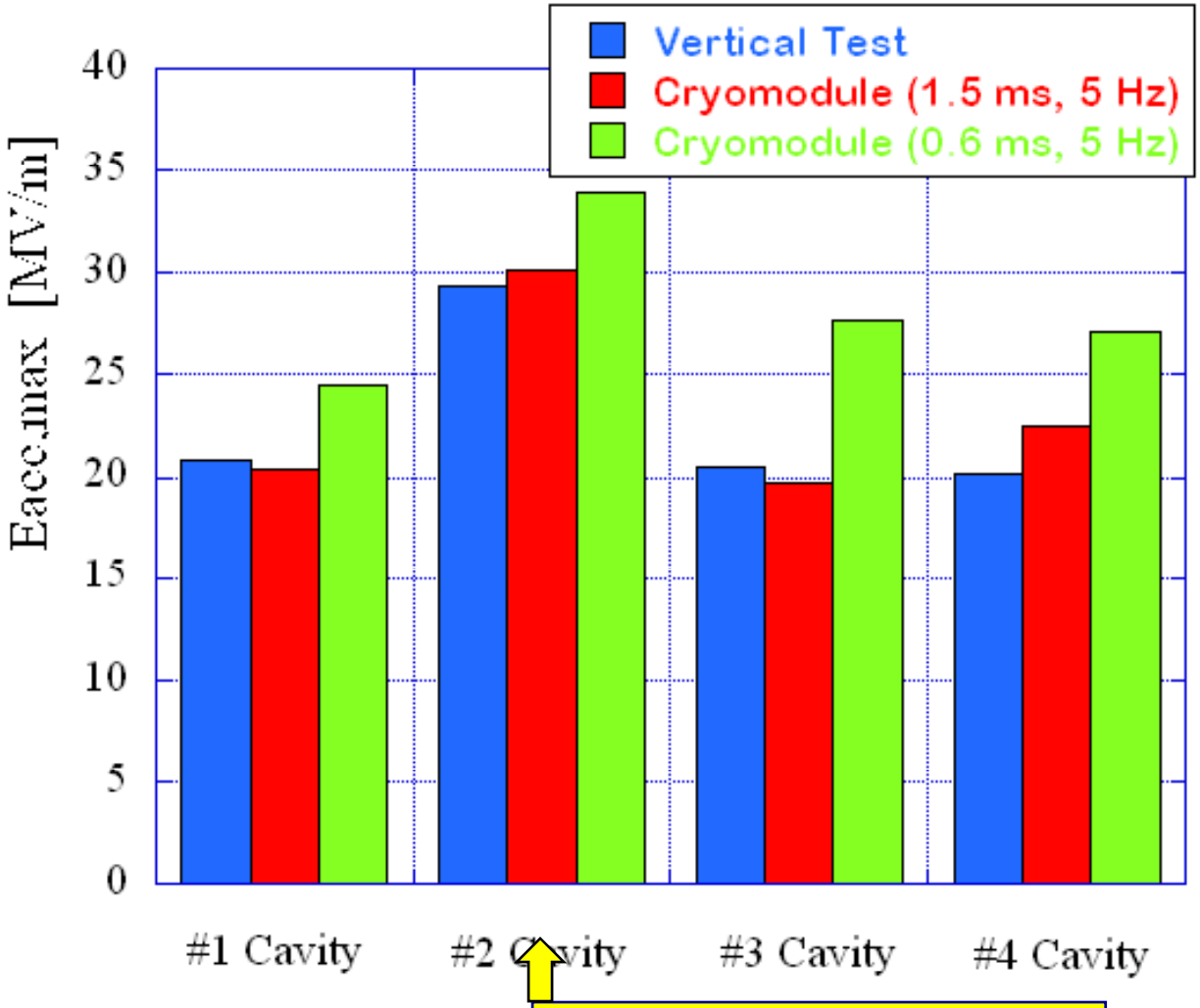


Profile is across the red line on the left 3D surface image

Asia R&D

- First pulsed measurements at high gradients
  - **STF operation**
  - **Demonstrated upto 32 MV/m with standard puls length**
- Kyoto Camera Upgrade
  - **Improve resolution**
- Manufacturer Training

KEK: 9-cell Cavity in VT/Cryomodule



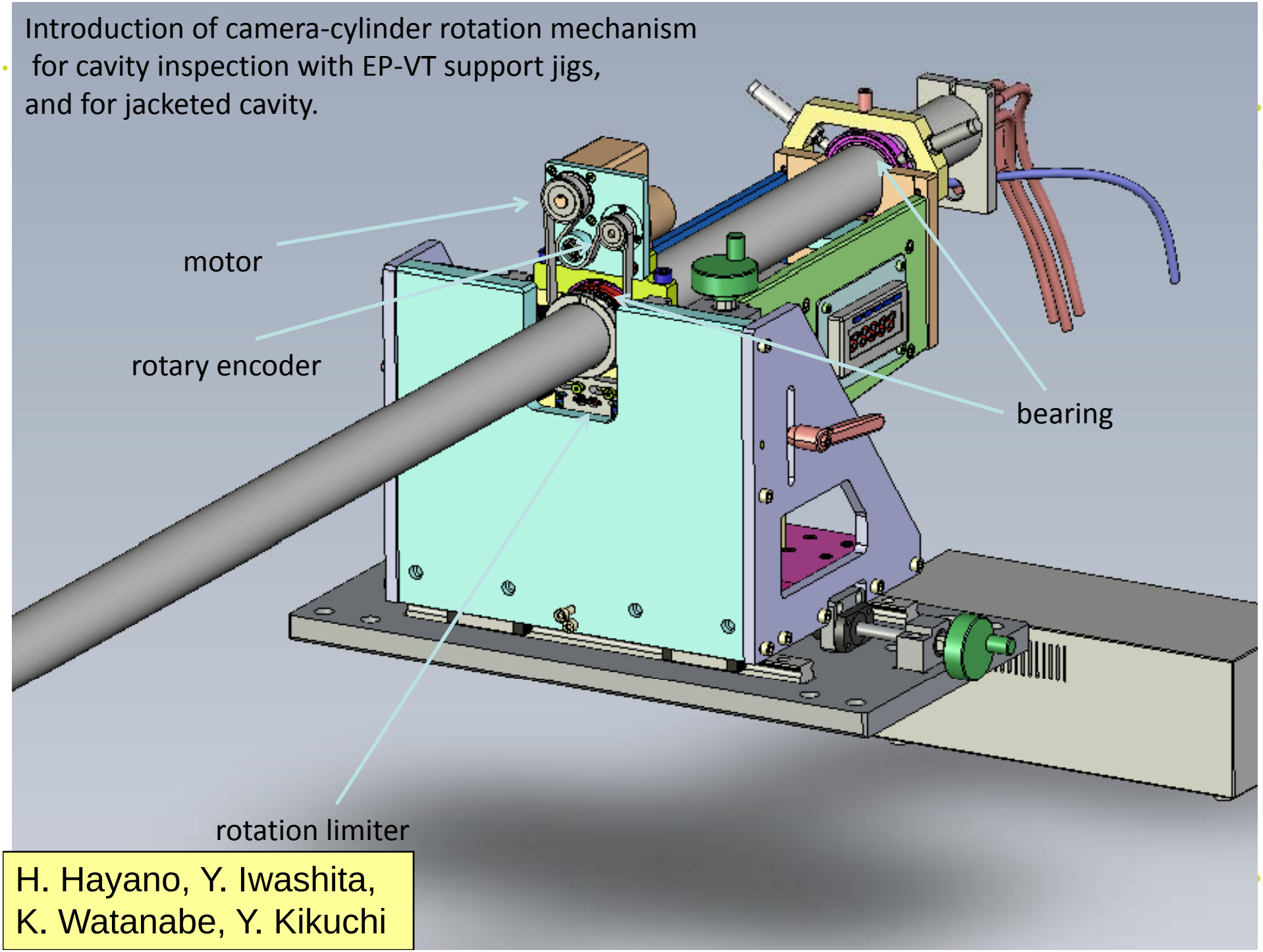
high power test, one by one

high power test, with 4 cavities

Finally reached 32 MV/m

S. Noguchi, E. Kako, H. Hayano

Introduction of camera-cylinder rotation mechanism
for cavity inspection with EP-VT support jigs,
and for jacketed cavity.



H. Hayano, Y. Iwashita,
K. Watanabe, Y. Kikuchi

Kyoto Camera Upgrade

(1)CCD camera upgrade

from 5µm CCD pixel to 2.2µm CCD pixel camera.

(2) Lens upgrade

more magnification with more larger aperture.

(3) illumination upgrade

EL panel has limited life with more high voltage
(for more brightness).
-> LED + light guide with scattered surface (twice more light).

~7µm/pixel → targeting 3.5 µm/pixel

H. Hayano, Y. Iwashita,
K. Watanabe, Y. Kikuchi

Kyoto Camera Upgrade: Image Capture Automation

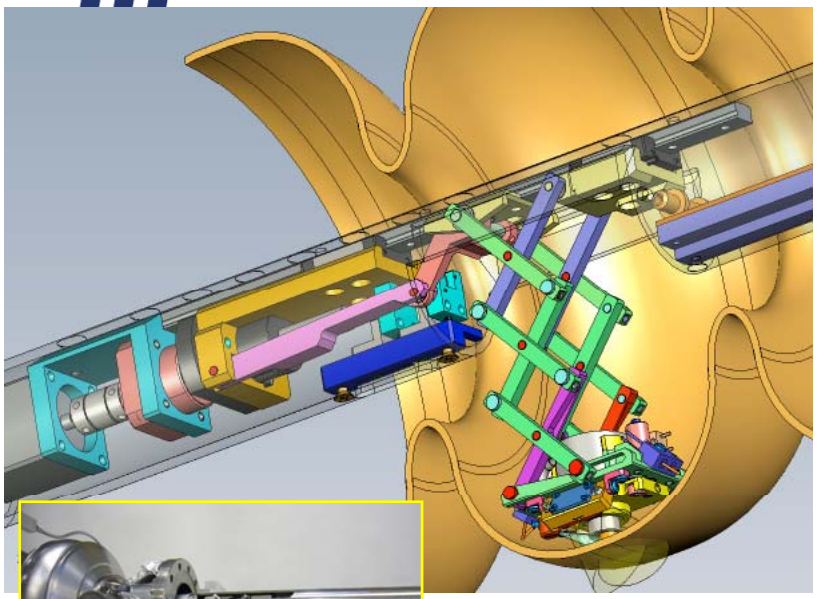
(1)control of cavity position
being done by VB application.

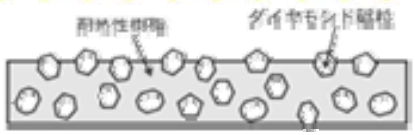
(2) Image capture and automated file-save
already done by VB application.
(speed is enough fast, but must wait for vibration damping)
(automated focus is the next concern)

(3) defect pattern matching
the software already fabricated in 2007 was tested
using recent high quality pictures.
-> no good results, so far.
(match to every bright traces, not suspected defects only)

H. Hayano, Y. Iwashita,
K. Watanabe, Y. Kikuchi

Grinding Effort at KEK



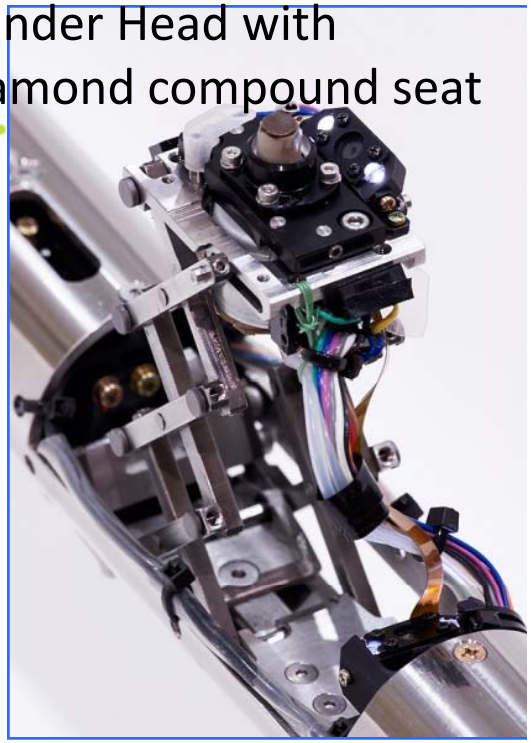


Diamond compound seat

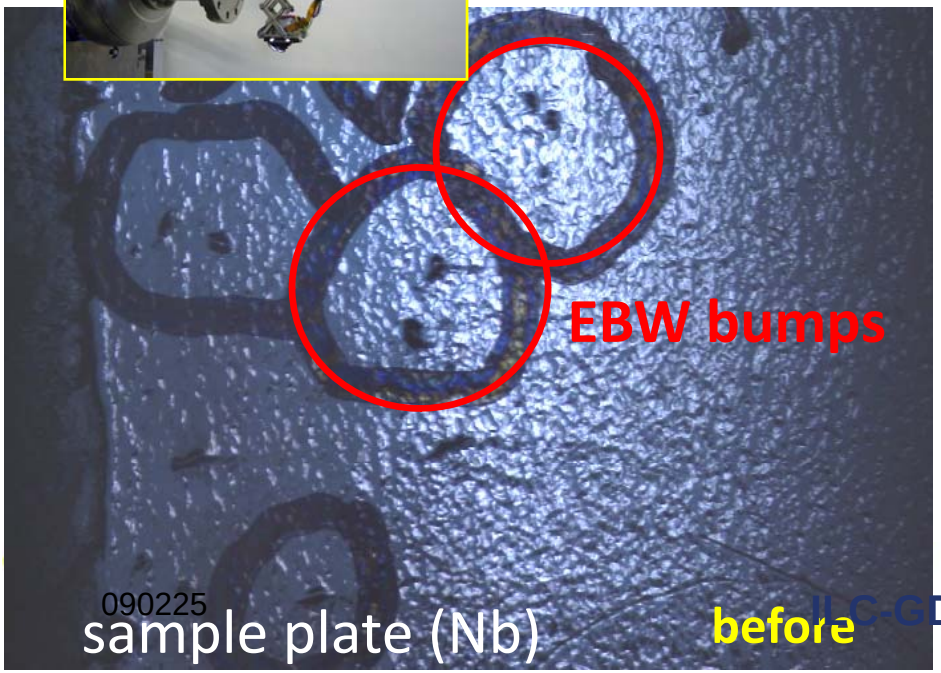
#400 (size = 40 ~ 60 um)

as for 1st test

Grinder Head with
Diamond compound seat

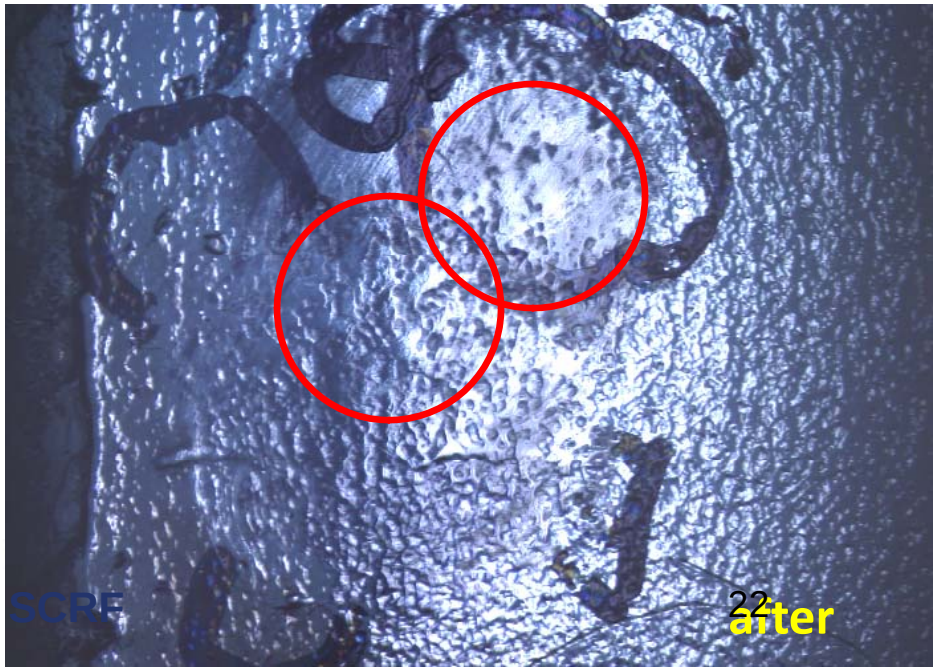


Grinding machine was delivered in last week.



sample plate (Nb)

before

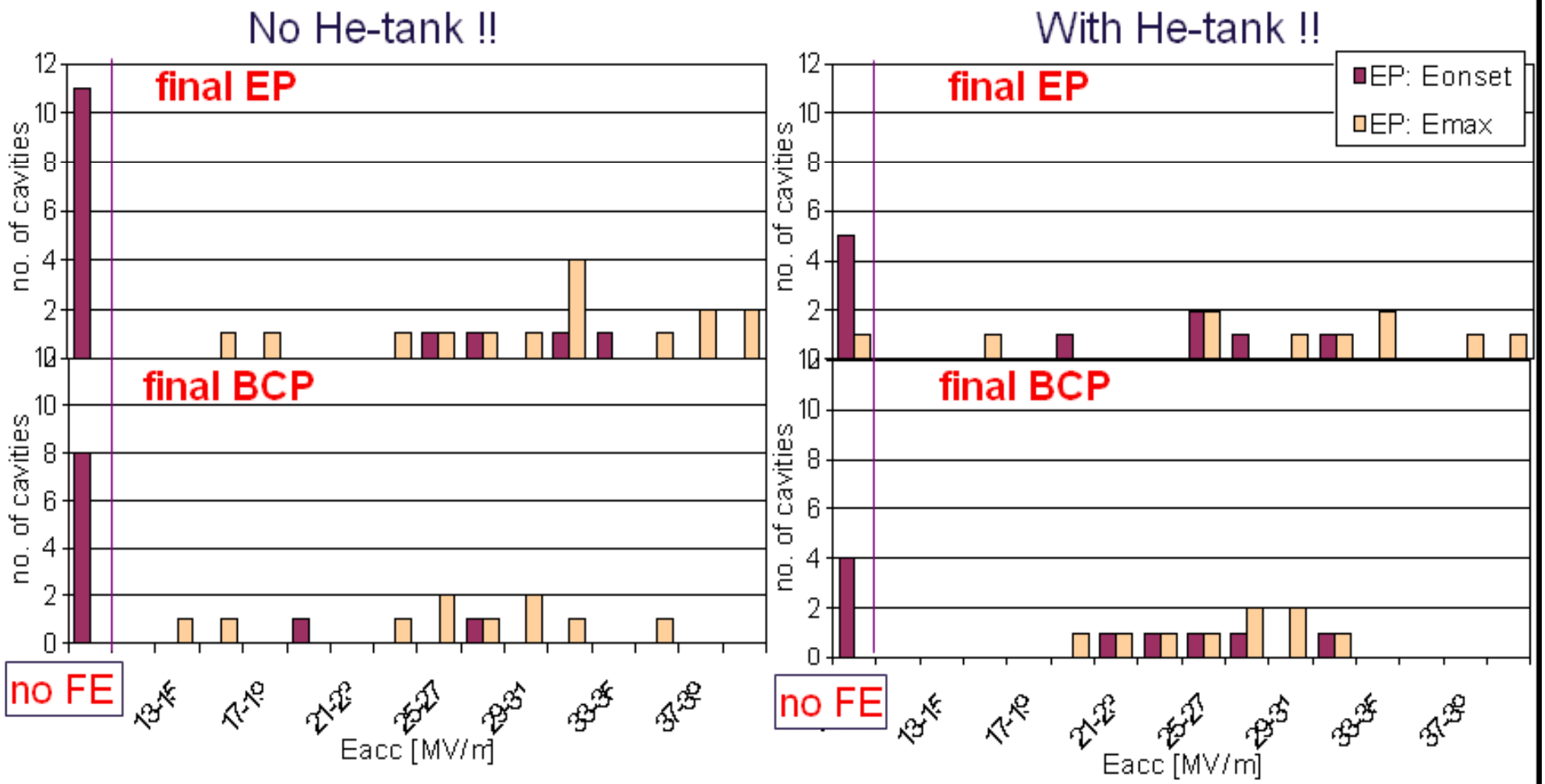


after

EU Status: Cavity Summary

- **Processes streamlined for mass production**
  - processes yield similar results as before
  - tank welding at an early state poses no problem
- **Electropolishing is still superior**
  - Data is problematic as it mixes different vendors
- **Scatter is large**
  - Can be traced to mechanical fabrication
  - Defects have been identified
    - Need to improve QC at companies

Final preparation: Analysis of final test



=> as expected: some improvement with respect to field emission

=> "final EP" gives higher E_{max} than "final BCP"

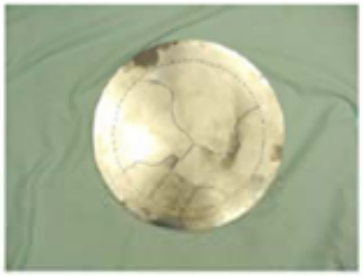
D. Reschke, to be published SRF 2009

Alternative Developments for ILC

- Cost reduction is a strong driving force for ILC
  - ~16000 cavities
- New Material
  - Large-grain niobium Material
  - Less fabrication steps than standard material
- New Shapes
  - ‘Low-loss‘ and ‘Re-entrant‘
  - Could reduce power dissipation at cryogenic temperatures

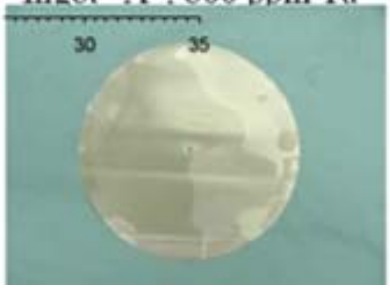
Large Grain Material (JLab)

CBMM



Ingot "D",800 ppm Ta

Ingot "A", 800 ppm Ta

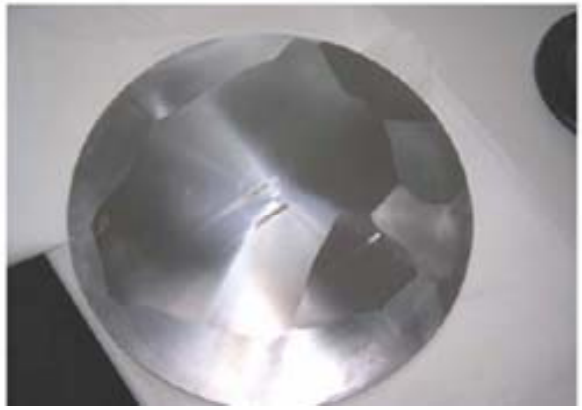


Ninxia

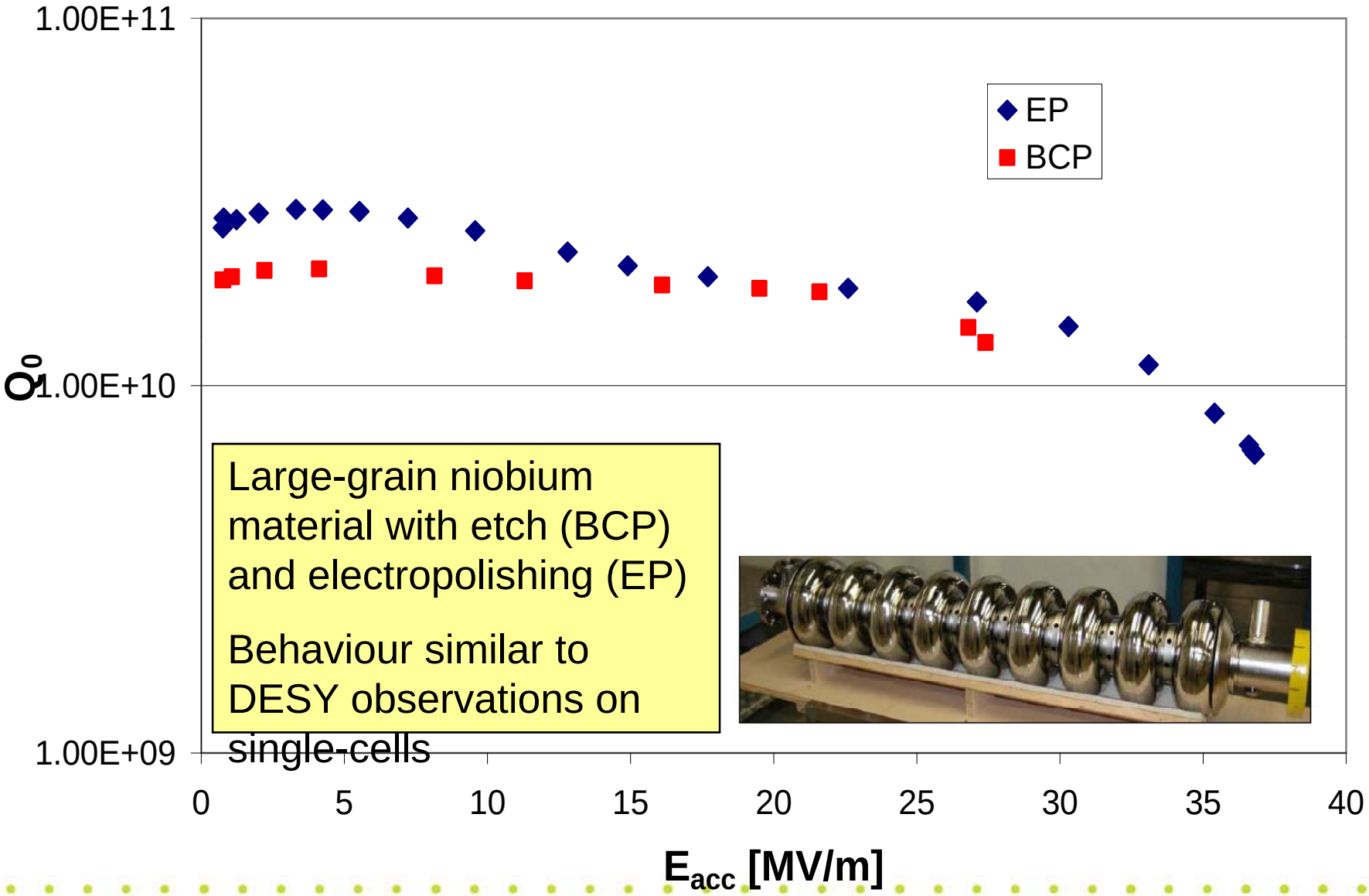
Ingot "C", 1500 ppm Ta

Wah Chang

Heraeus



XFEL: Large Grain Multi-cell with EP

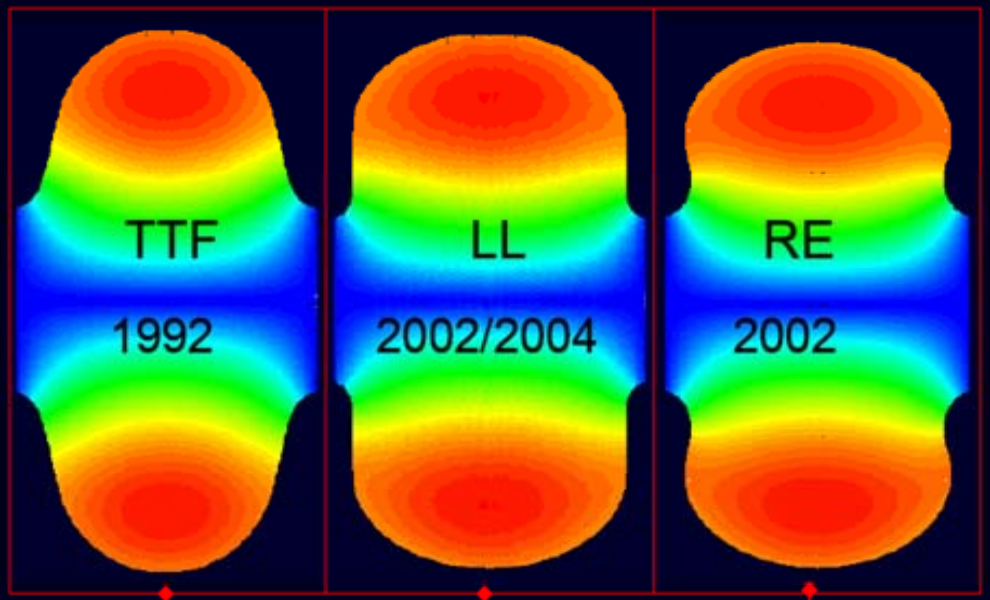


Large-grain niobium material with etch (BCP) and electropolishing (EP)

Behaviour similar to DESY observations on single-cells

Alternative Cavity Shapes

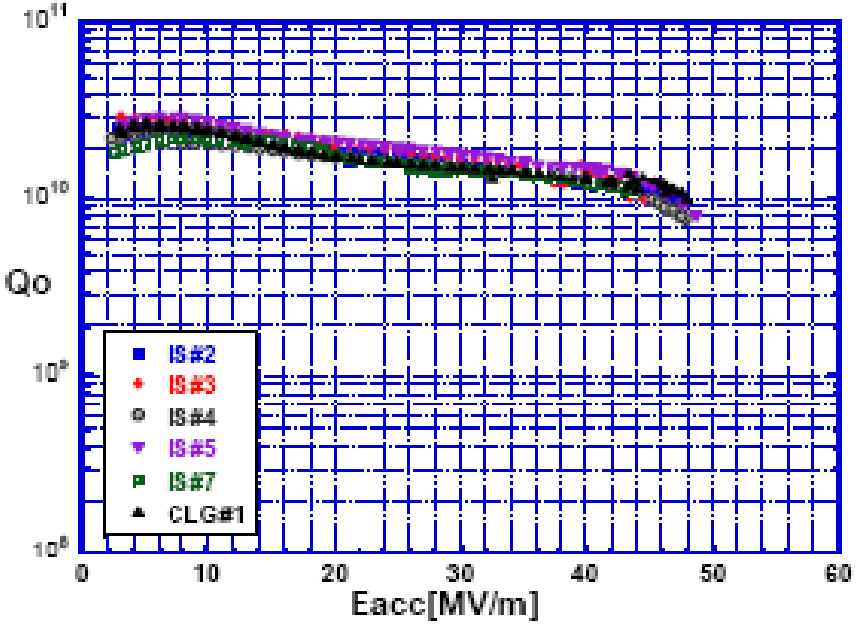
Example: 1.3 GHz inner cells for TESLA and ILC

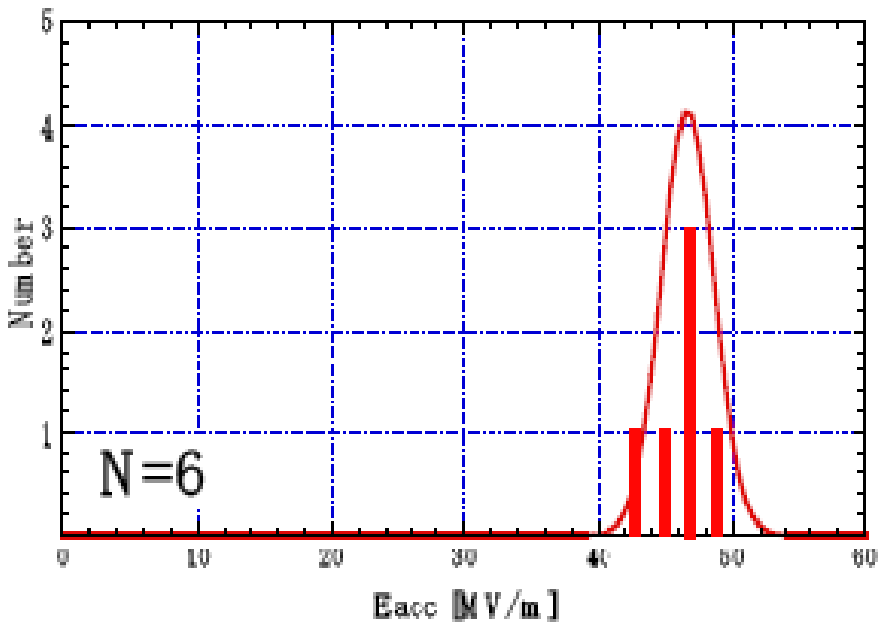


r_{irisb}	[mm]	35	30	33	
k_{cc}	[%]	1.9	1.52	1.8	field flatness
E_{peak}/E_{acc}	-	1.98	2.36	2.21	max gradient (E limit)
B_{peak}/E_{acc}	[mT/(MV/m)]	4.15	3.61	3.76	max gradient (B limit)
R/Q	[Ω]	113.8	133.7	126.8	stored energy
G	[Ω]	271	284	277	dissipation
R/Q*G	[Ω*Ω]	30840	37970	35123	dissipation (Cryo limit)

(D) +EP(20μm)+EP(3μm, fresh, closed) +HF*
+HPR+Baking (120C*48hrs)

K. Saito et al.





Ave. Eacc=46.7+1.9MV/m

Scattering:4%, Acceptability@40MV/m(ACD):100%

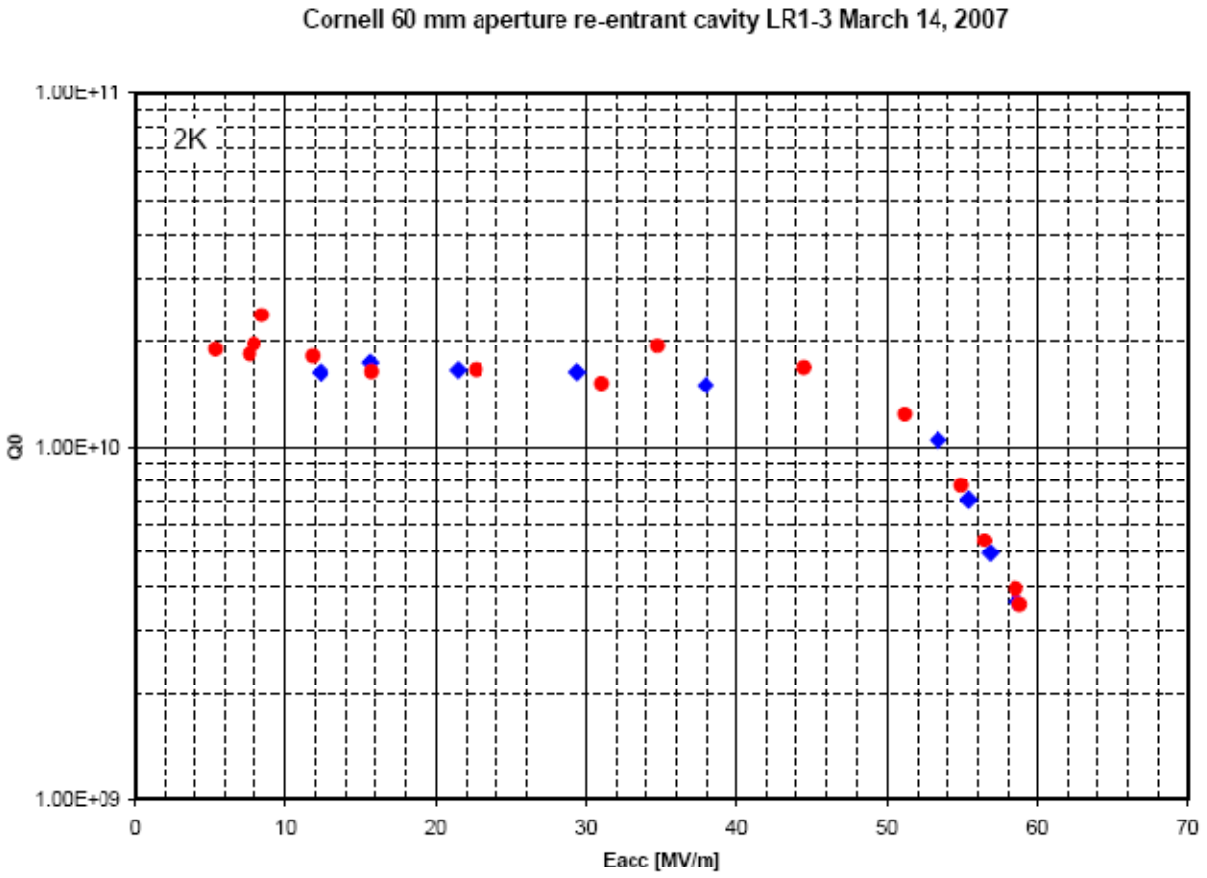
		IS#2	IS#3	IS#4	IS#6	IS#7	CLG#1
+EP(20+3) +HF*	Eacc	47.07	44.67*	47.82	48.60*	43.93*	47.90*
	Qo	1.06e10	0.98e10	0.78e10	0.80e10	1.17e10	1.0e10

60mm-Aperture Re-Entrant Cavity
Best Eacc = 59 MV/m

Cornell-KEK Collaboration

H. Padamsee et al.
WEPMS009

RE-LR1-3



Next steps

- EU
  - **Preparation of the call for tender for XFEL cavities**
    - Focus at DESY will be
      - resolution of mass production problems
      - improvements to QC process
  - **HiGrade**
    - Serves as a tool to implement the ILC process
- US
  - **Project X**
  - **Vendor development**
  - **Coupon studies**
- KEK
  - **S1-Global**
  - **Inspection methods**
  - **Local repair**

R&D Plan in TDP

- R&D subjects and what will be expected
  - **Improve the yield of the preparation process**
    - Vertical test yield not yet sufficient
      - Subsets of certain vendors do pass
    - Module integration (cavity assembly) will be investigated
  - **Improve weld quality**
    - PMs have visited the various cavity manufacturers
    - Training for manufacturers is important
  - **Alternatives not to be forgotten**
    - Large-grain
    - Low-loss shape
- Time-line
  - **Beginning 2010**
    - Revise choice of the gradient
- Resources
  - **Ongoing cavity fabrication in the three regions**
    - ~60 tests targeted at ILC in TDP1
    - parallel startup of XFEL with 800 cavities on order

Thanks!

- Several people provided data
- ….