Review on EP advances worldwide

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Cornell university

Outline

- Introduction
- EP facilities in the world
- Recent achievement
  Horizontal EP / Vertical EP
- Summary

Introduction

Now EP is applied on many projects as high reliable surface preparation.

It allows us to focus on other issues of cavity production.

We could find many progress on EP'ed cavity production.

Recent achievement is established not only by EP, but also with all other efforts on cavity production steps.

Cavity production
- Fabrication
  - material
  - EBW
- Surface preparation
  - Bulk removal
    - BCP
    - EP
    - CBP
  - Degassing
  - Light removal
  - Baking
- Assembly
- Test

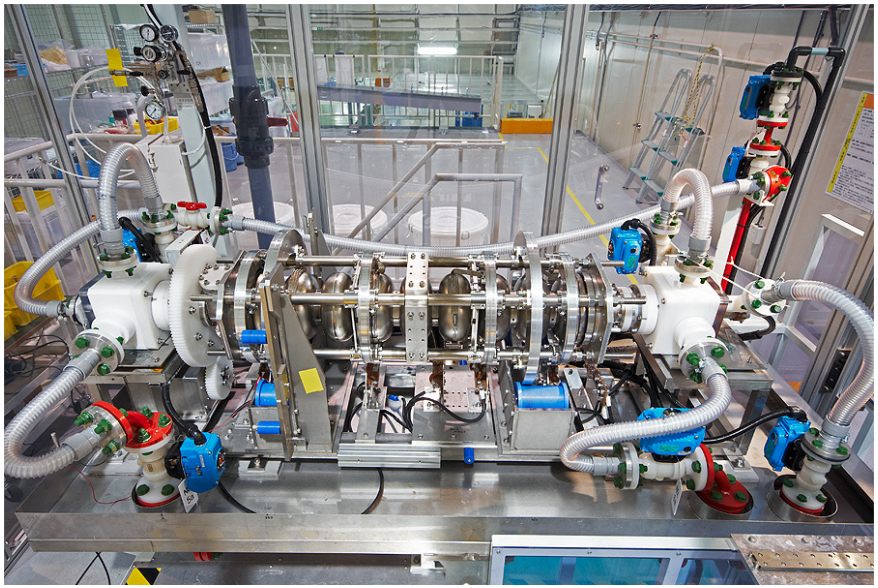
EP facilities

Horizontal or Vertical ?

Orientation	Facility
Horizontal EP	Asia: KEK STF Euro: DESY, ZANON, RI US: FNAL/ANL, Jlab
Vertical EP	Asia: KEK/Marui Euro: Saclay US: Cornell, Jlab

KEK, STF EP Facility

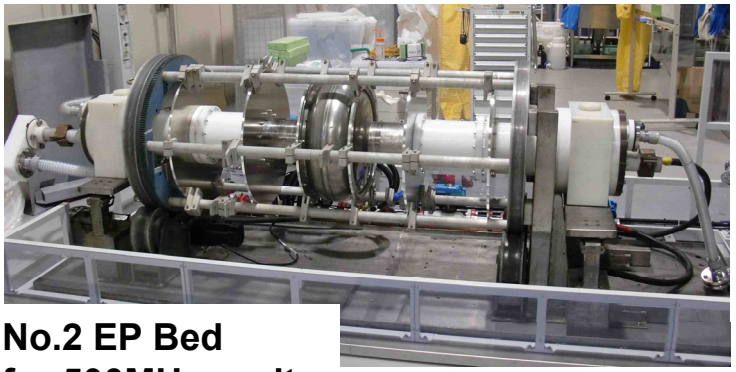
No.1 EP Bed



No.2 EP Bed modified to fit ILC cavity

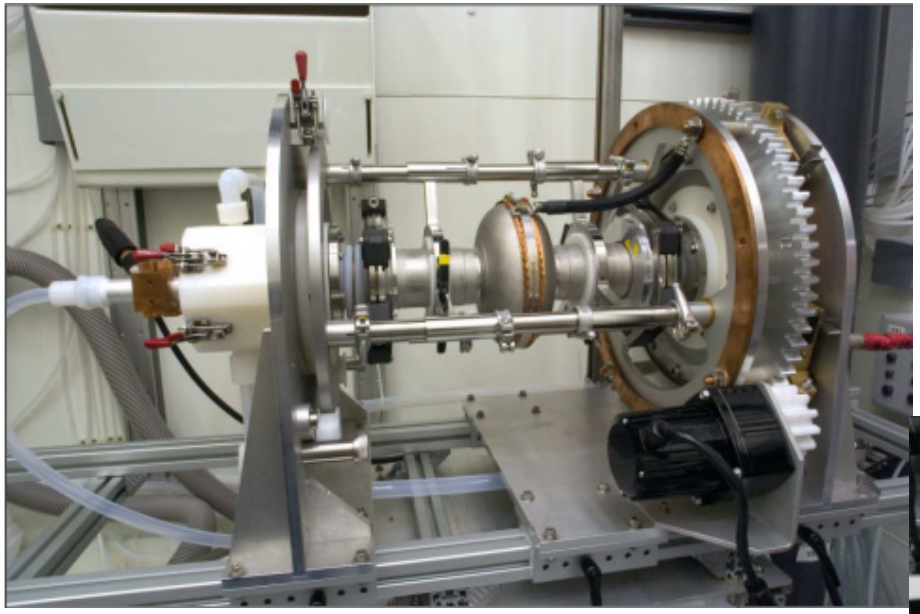
flow test using water

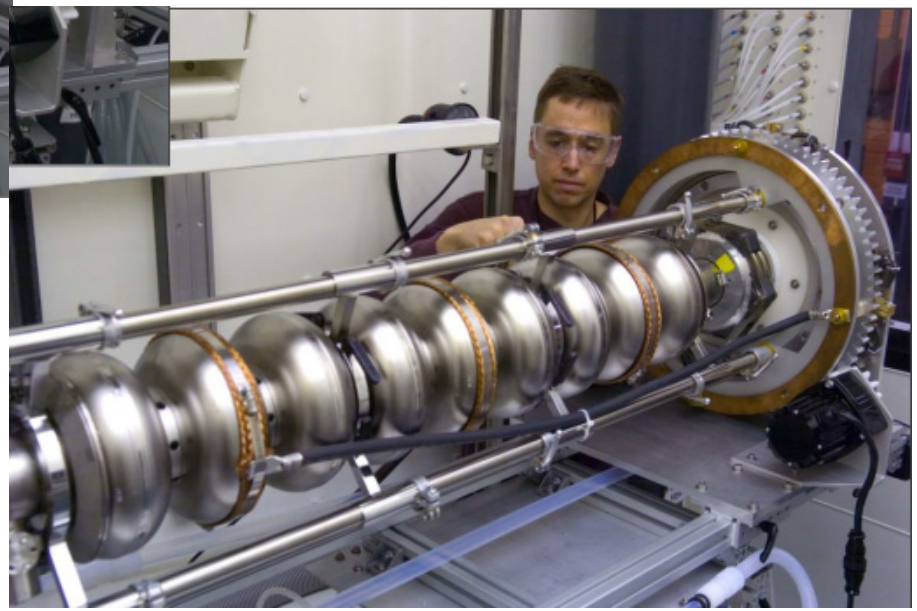
Presented by H. Hayano (KEK), cavity group meeting, 2012



No.2 EP Bed for 500MHz cavity

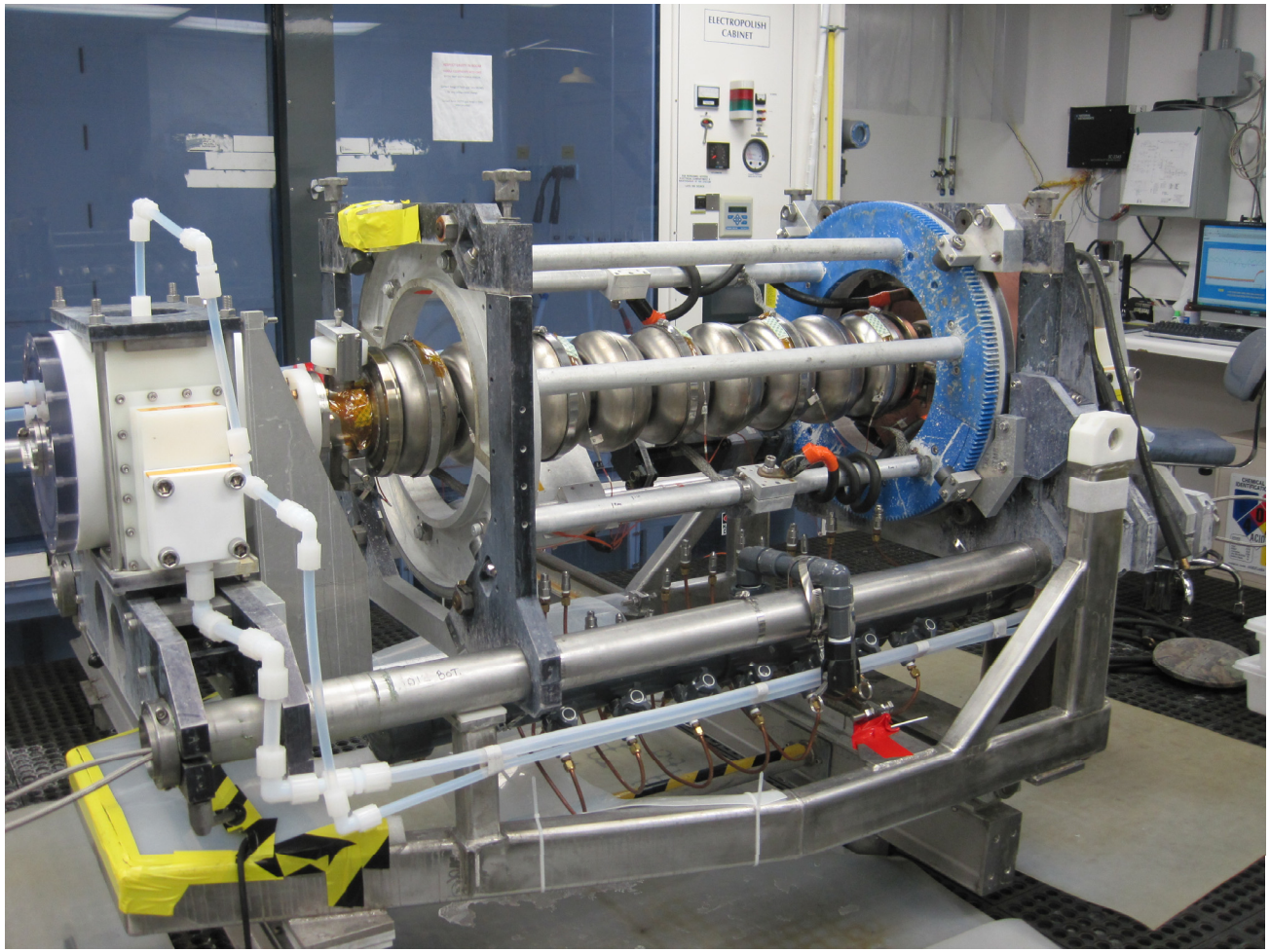
FNAL/ANL, Horizontal EP





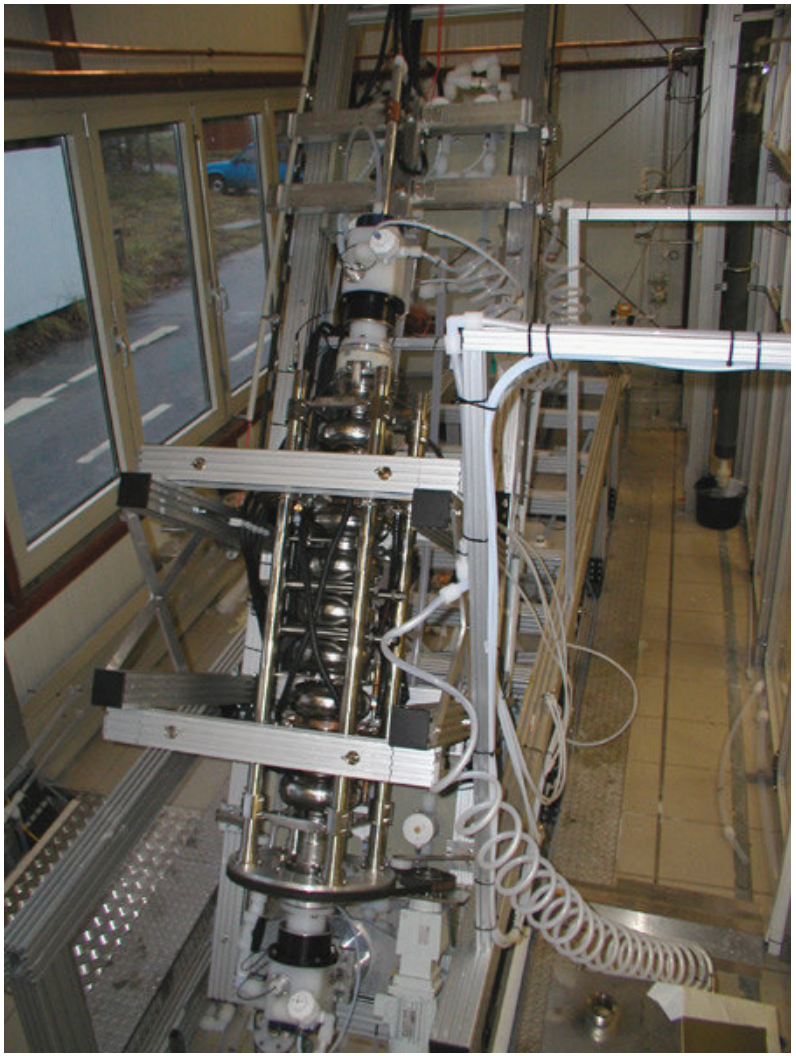
Presented by S. M. Gerbick (ANL) SRF2011, Chicago

Jlab, Horizontal EP

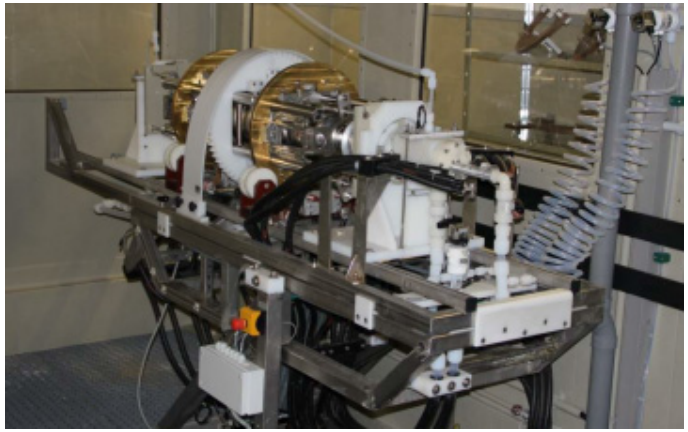


for XFEL, Horizontal EP

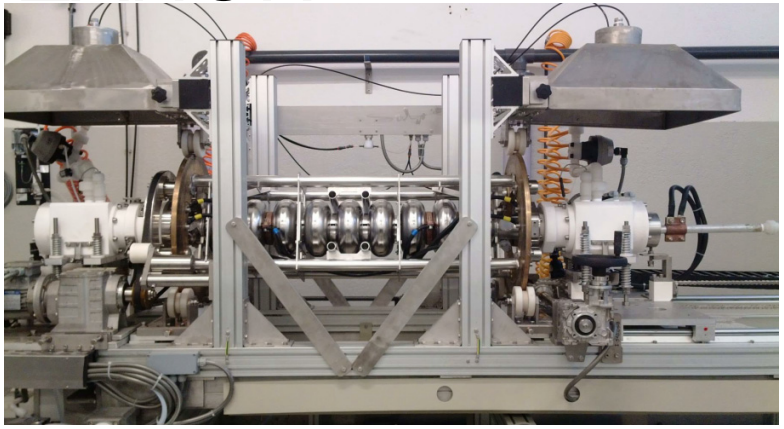
DESY



RI



ZANON

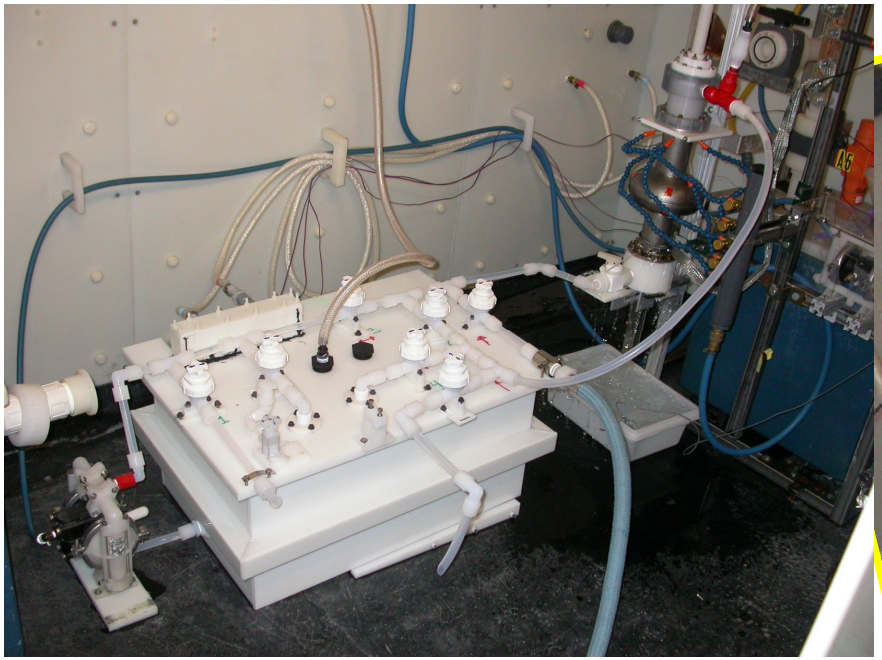


Presented by W. Singer, ECFA LC2013, DESY

Saclay, Vertical EP

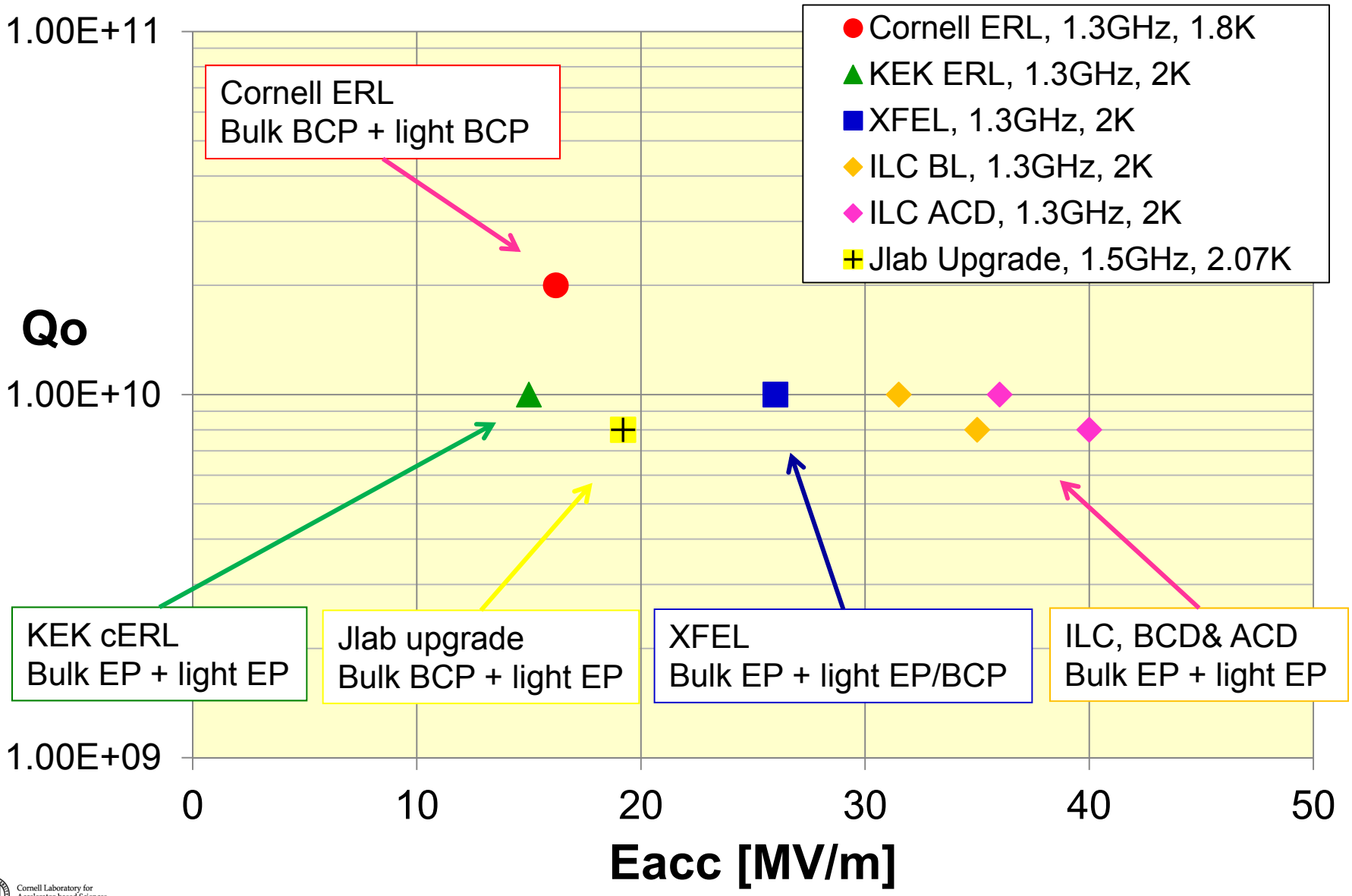
Presented by F. Eozénou, TTC meeting 2012,

Cornell, Vertical EP



Recent achievements w/ Horizontal EP

Required cavity specs

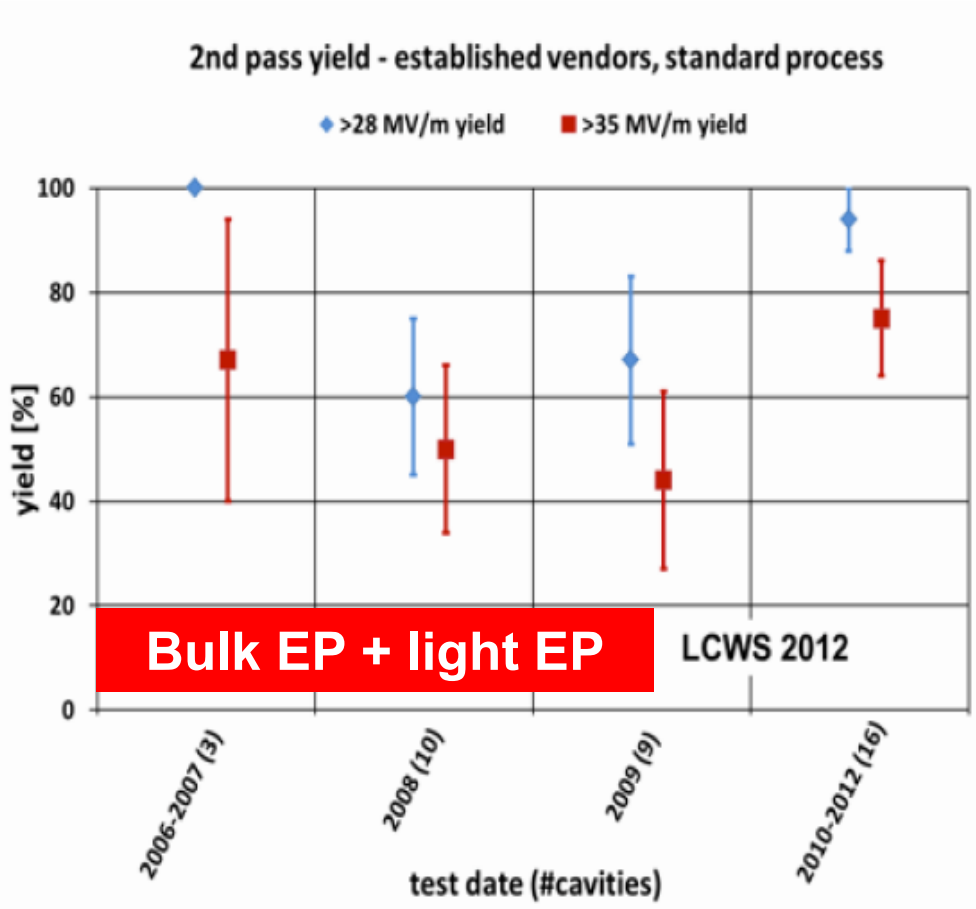


Surface preparations

Project	Bulk removal	Degassing/ Annealing	Light removal	120C Bake	*Rinse
ILC	EP	800C*2hrs	EP	120C*48hrs	USC HPR
XFEL			EP / BCP		
Jlab 12GeV	BCP	600C*10hrs	EP	120C*24hrs	
Cornell ERL		650C*4days	BCP	120C*48hrs	HF rinse

On going R&Ds	CBP, VEP	High temp. process	VEP	Ar bake (145C*3hrs)	HF rinse Ethanol rinse

Progress in SCRF Cavity Gradient



Production yield:
94 % at > 28 MV/m,

Average gradient:
37.1 MV/m

reached (2012)

A. Yamamoto, May 17, 2013 IPAC'13 Acc. Technology 75

Presented by A. Yamamoto, IPAC13

Jlab 12GeV, C100 SRF cavities

C100: string of **8 7-cell cavities**, **1497 MHz**, produced by **RI** (Research Instruments)

80 cavities + 8 pre-production tested and assembled at JLAB

18-step qualification process

EP derived from **ILC R&D**

Bulk BCP + light EP

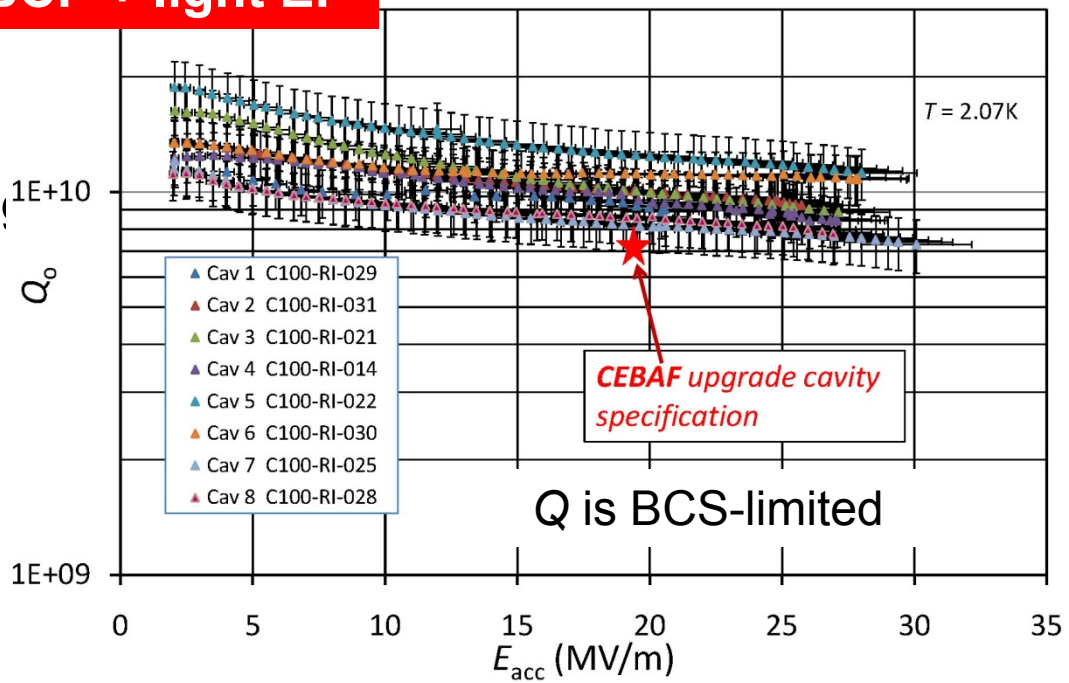
The cavity tests are performed at the Vertical Test Area (VTA)

Design gradient: **19.2 MV/m** avera

Average heat/cavity: **29 W**

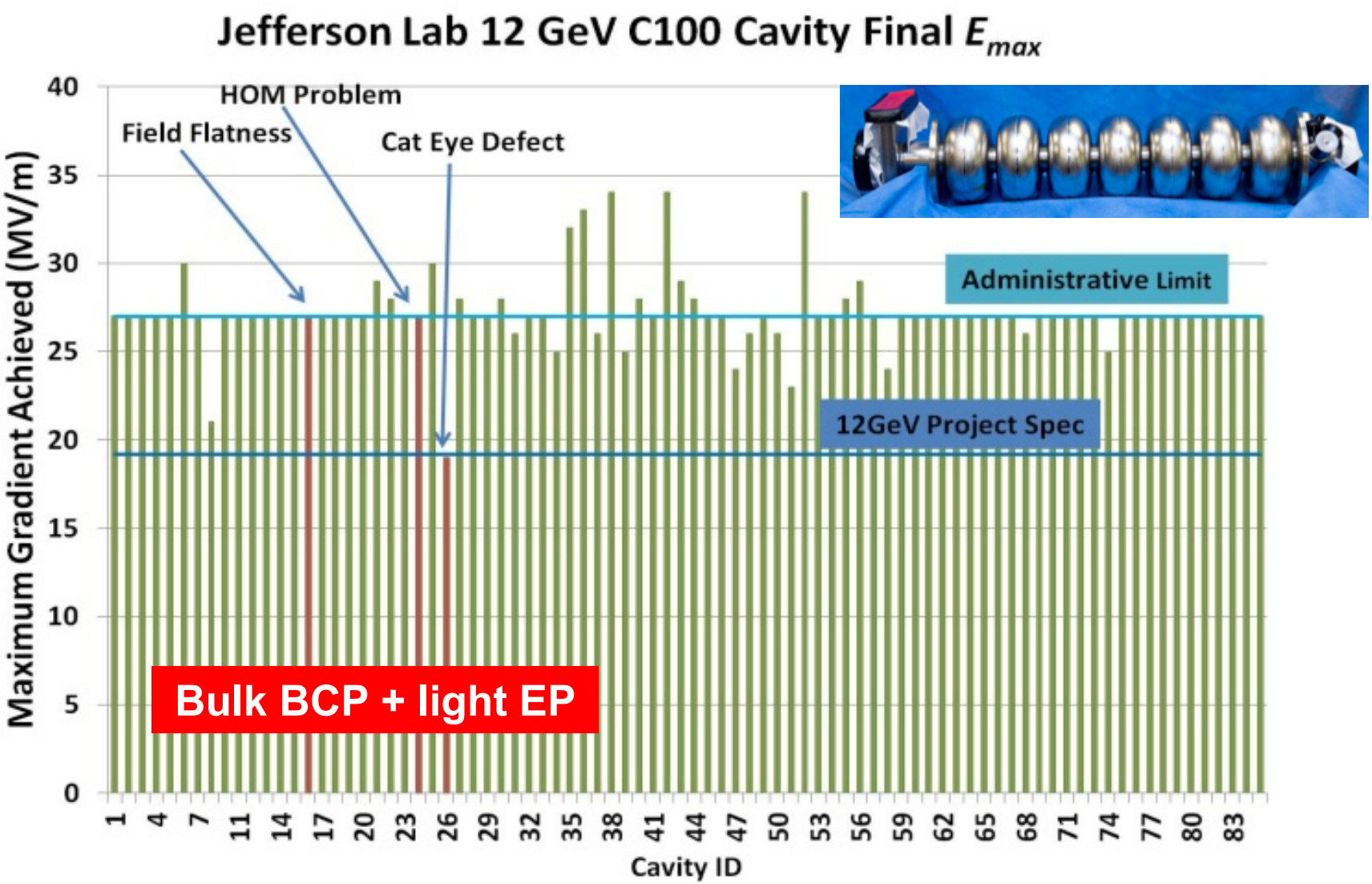
Operational limit: **25 MV/m**

(limited by the klystron RF power and possibly field emission)



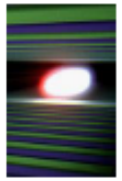
Presented by F. Pilat, TTC2012, Jlab

12GeV cavities: overall performance

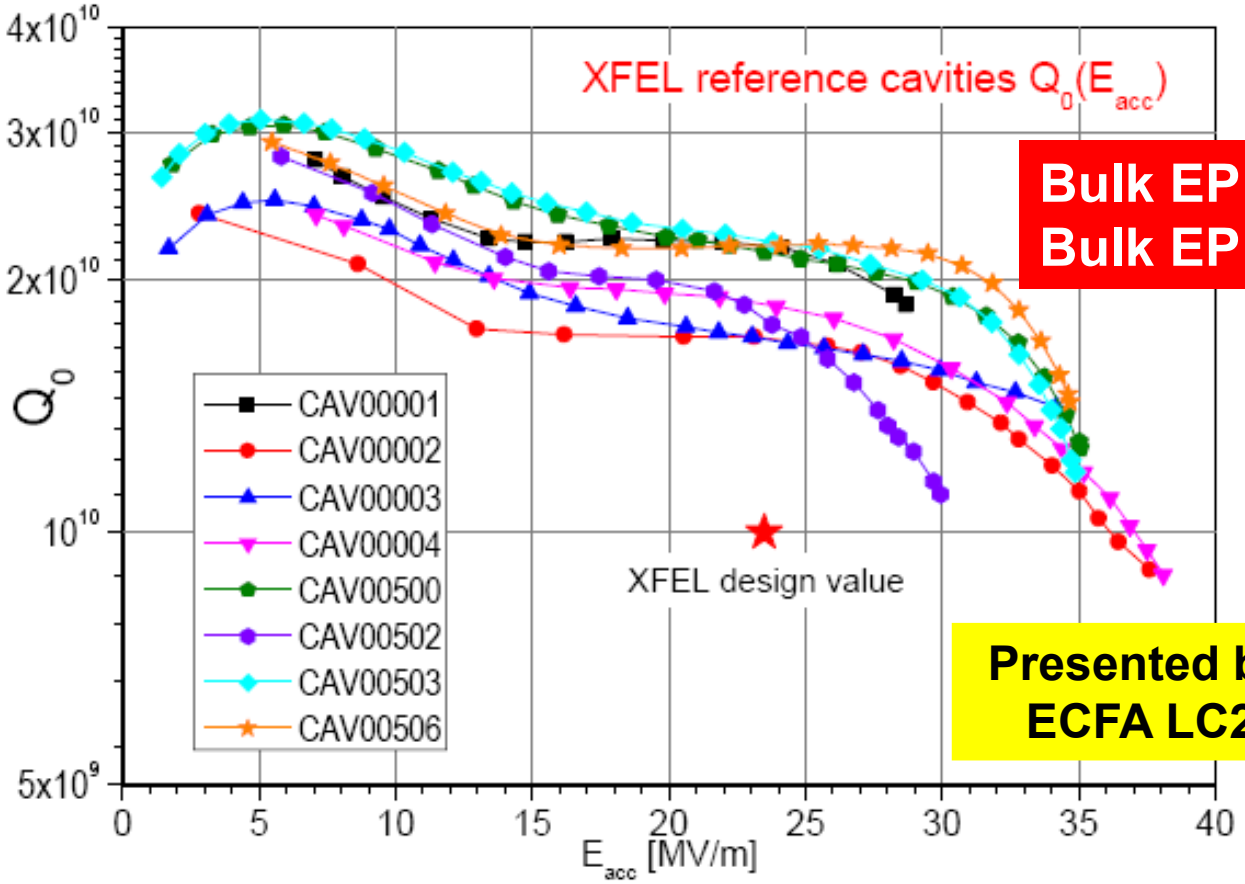


Presented by Fulvia Pilat, TTC2012, Jlab

Performance of RCVs after treatment at DESY



4 RCVs of RI and 4 RCVs of E. Zanon: acceptance test successful



Bulk EP + light EP: n=4
Bulk EP + light BCP: n=4

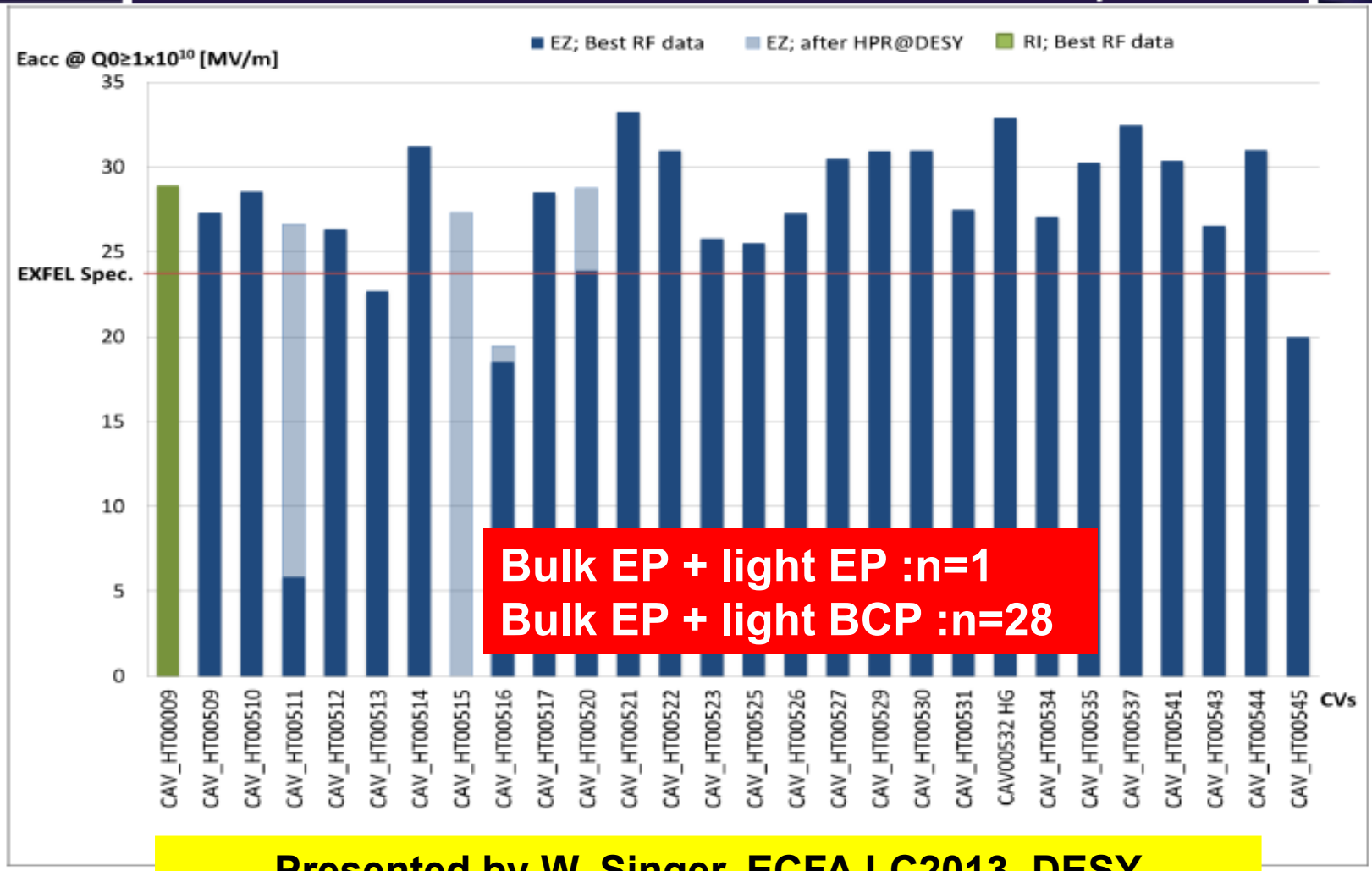
Presented by W. Singer, ECFA LC2013, DESY

Industrial Cavity Fabrication and Treatment. ECFA LC 13, AC4, May 28, 2013. Waldemar Singer

Status of Cavity Production

Performance (status 24.05.13): E_{acc} at Qo=1x10^{10} (or max Eacc for curves with Qo>1x10^{10})

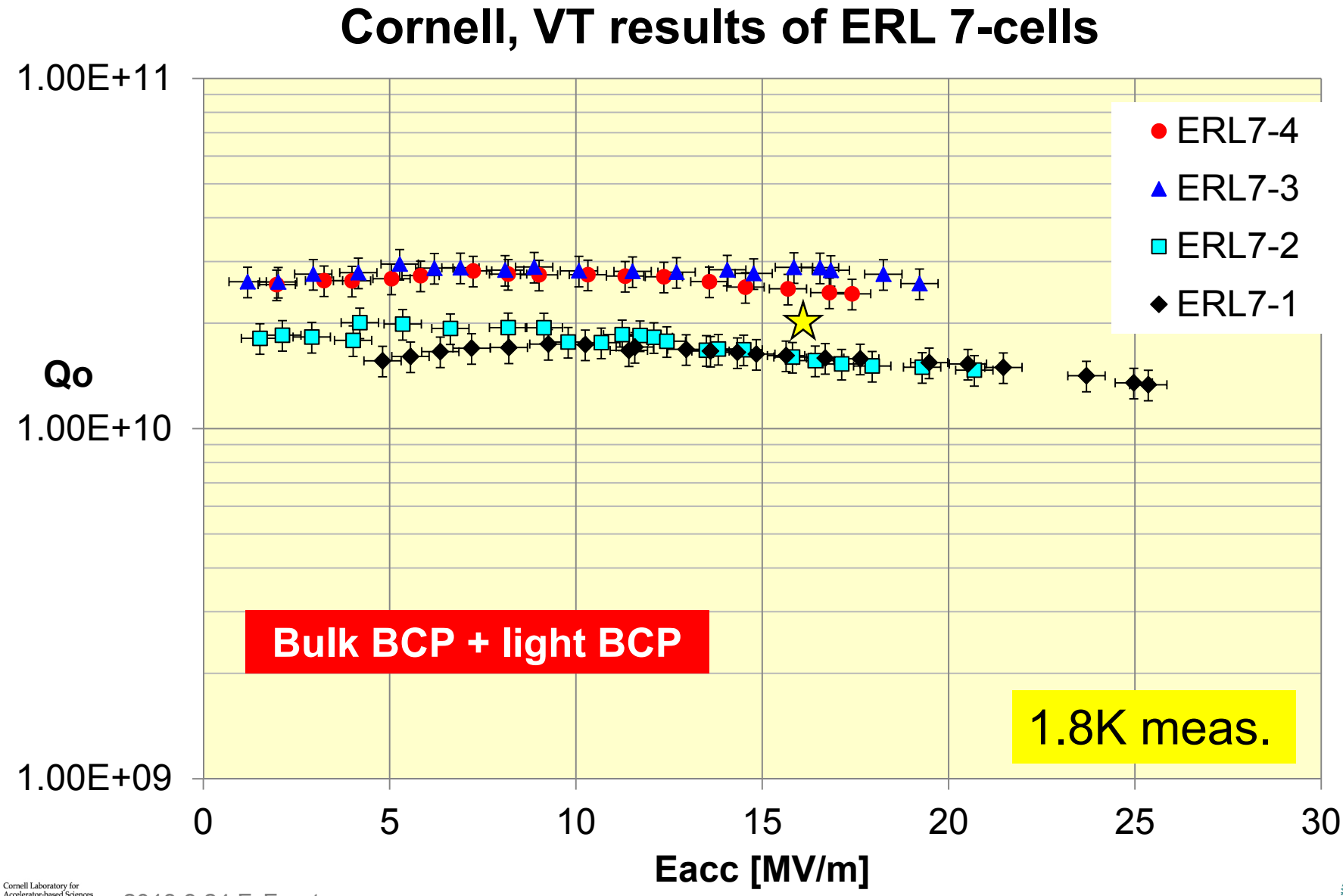
European XFEL



Bulk EP + light EP :n=1
Bulk EP + light BCP :n=28

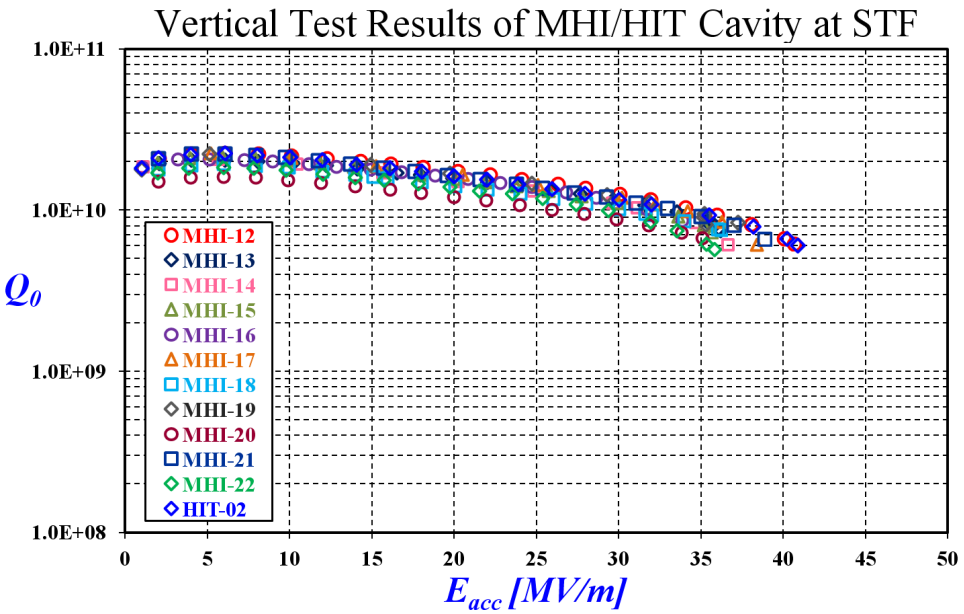
Presented by W. Singer, ECFA LC2013, DESY

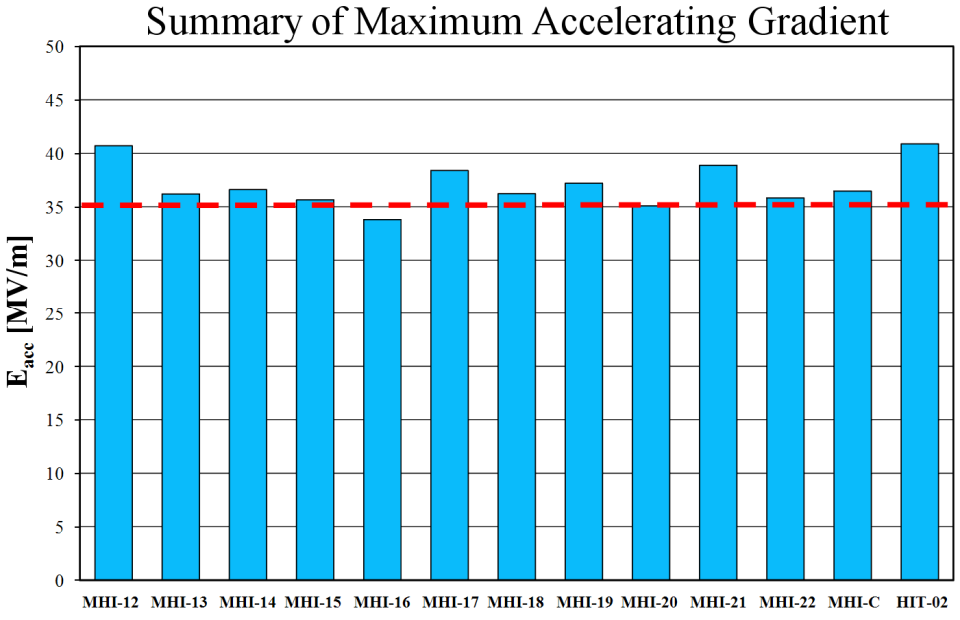
Cornell ERL 7-cell



KEK, ILC 9-cells

Recent Results of V.T.

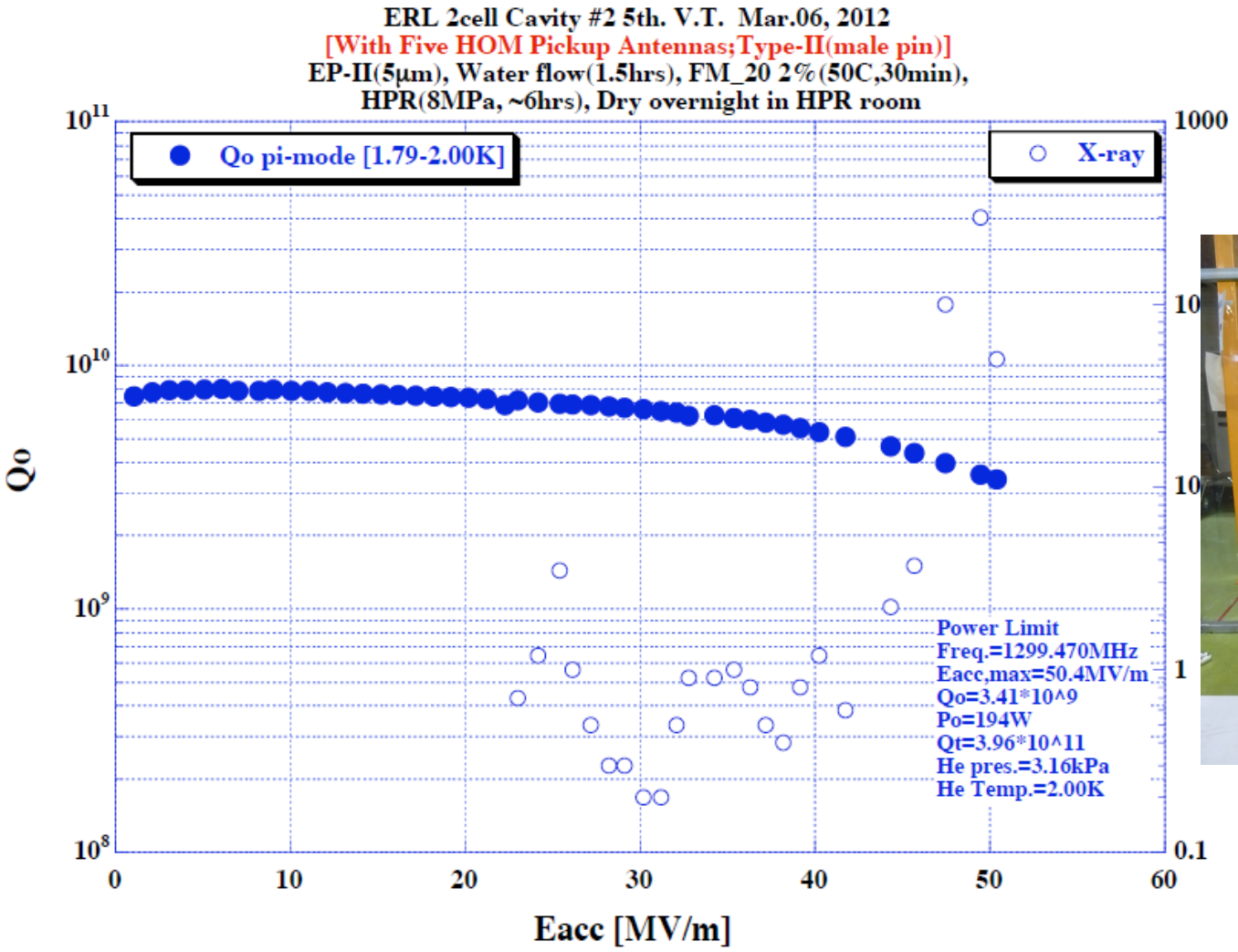


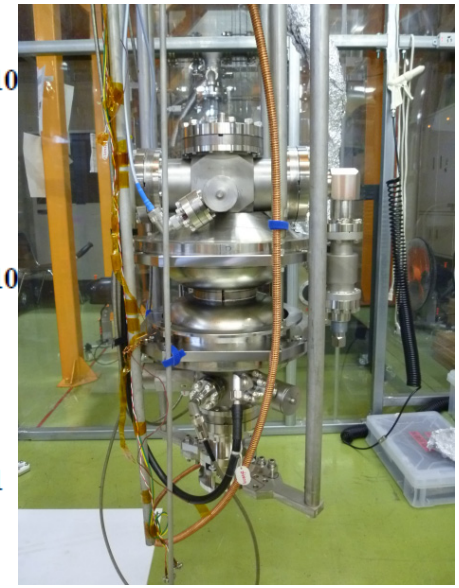


- Eight cavities for STF-2 reached above 35 MV/m.
- HIT-02 reached around 41 MV/m.
- MHI-C reached around 36 MV/m.

Presented by Kirk Yamamoto
LCC cavity Group Meeting 16/Apr/2013

KEK, cERL 2-cell





Presented by K. Watanabe (KEK) May/2012

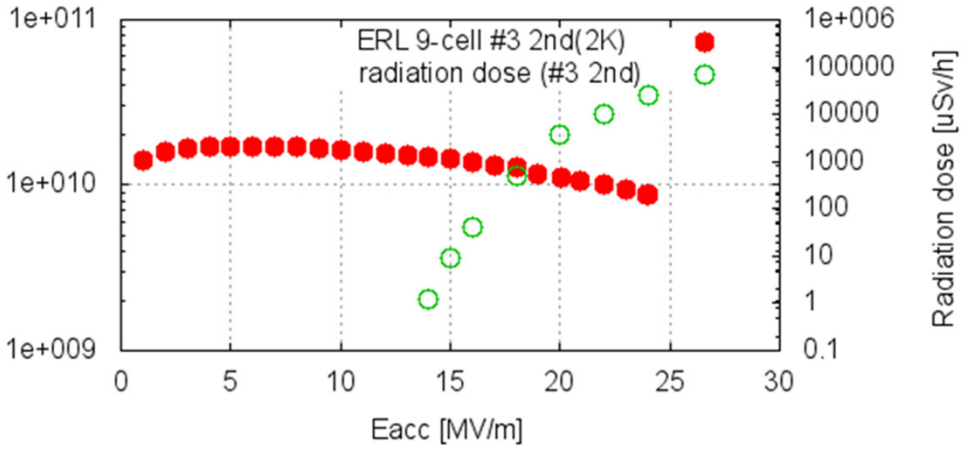
KEK, ERL 9-cells

Two 9-cell cavities were fabricated for cERL and vertical tests were performed two times for each cavity. (followings are results for 2nd tests)

by K. Umemori

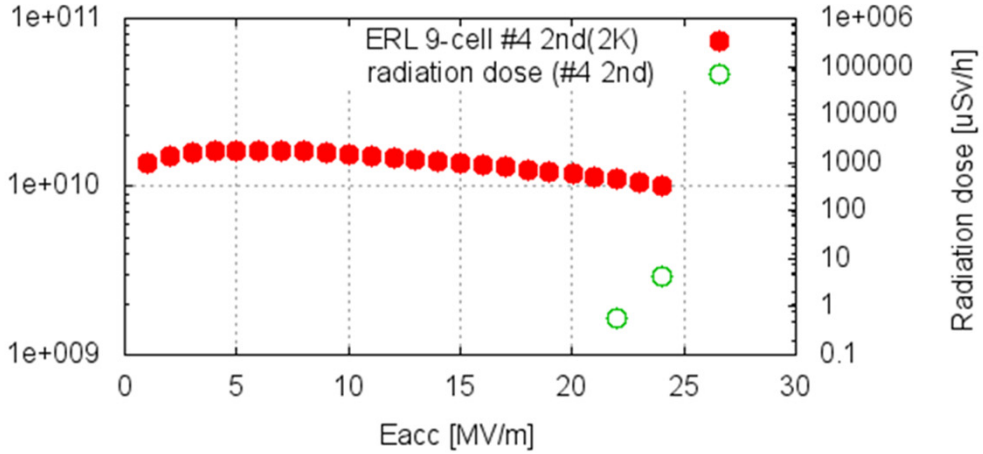
ERL 9-cell #3 cavity

- Field reached to 25 MV/m
- No limitation up to 25 MV/m
- Q > 1e10@15MV/m
- Satisfied cERL specification
- X-ray onset around 14 MV/m



ERL 9-cell #4 cavity

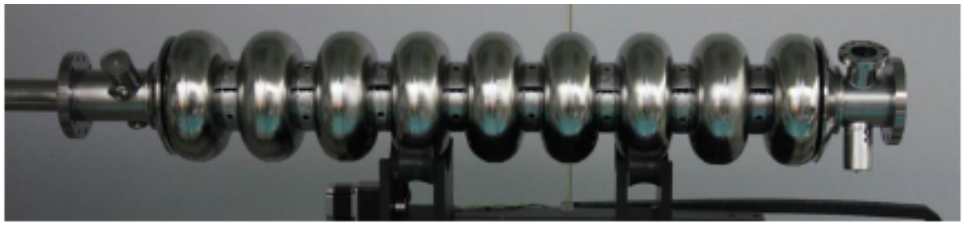
- Field reached to 25 MV/m
- No limitation up to 25 MV/m
- Q > 1e10@15MV/m
- Satisfied cERL specification
- X-ray onset around 22 MV/m



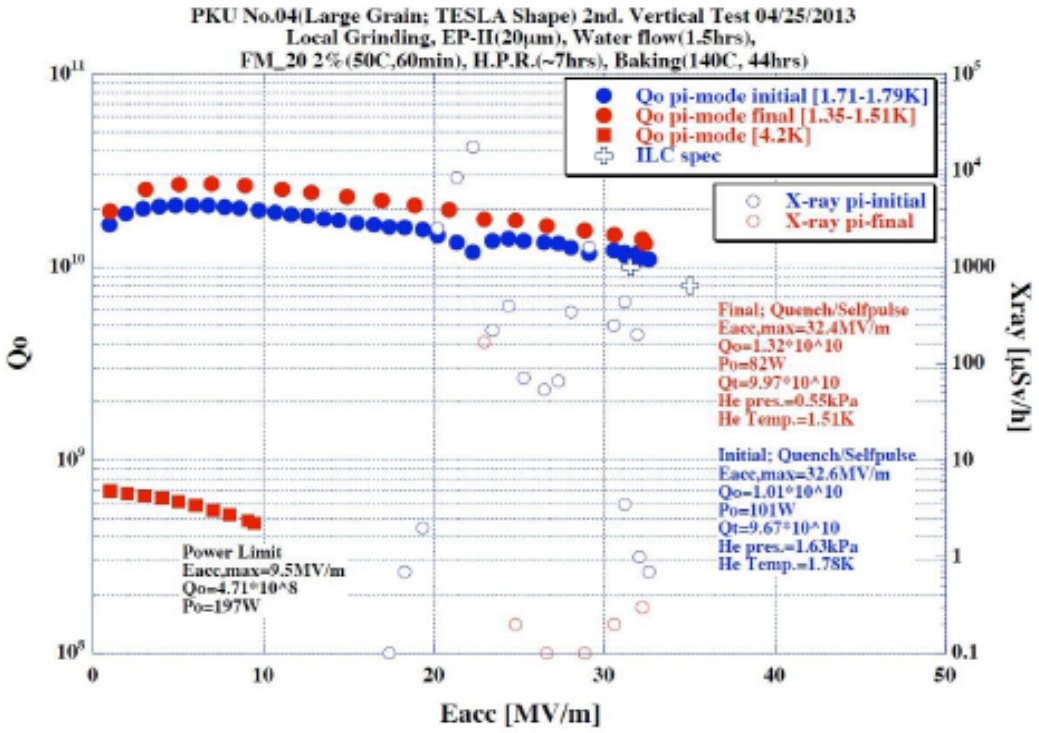
Presented by E. Kako (KEK), TTC meeting 2012, Jlab

PKU Large grain 9-cell cavities: PKU4

PKU/KEK collaboration



- Test01 at KEK
  - EP 120 μm, HT 750 °C 3 hr
  - EP 5μm, baking 140 °C 48 hr
  - Eacc 23.8 MV/m, Q_0=6.9E9@Emax
- Test02 at KEK, after local grinding



Latest test April 25, 2013
PKU4 achieved 33 MV/m
At Q0 1E10 at 1.8K

Further processing and testing including local grinding under way

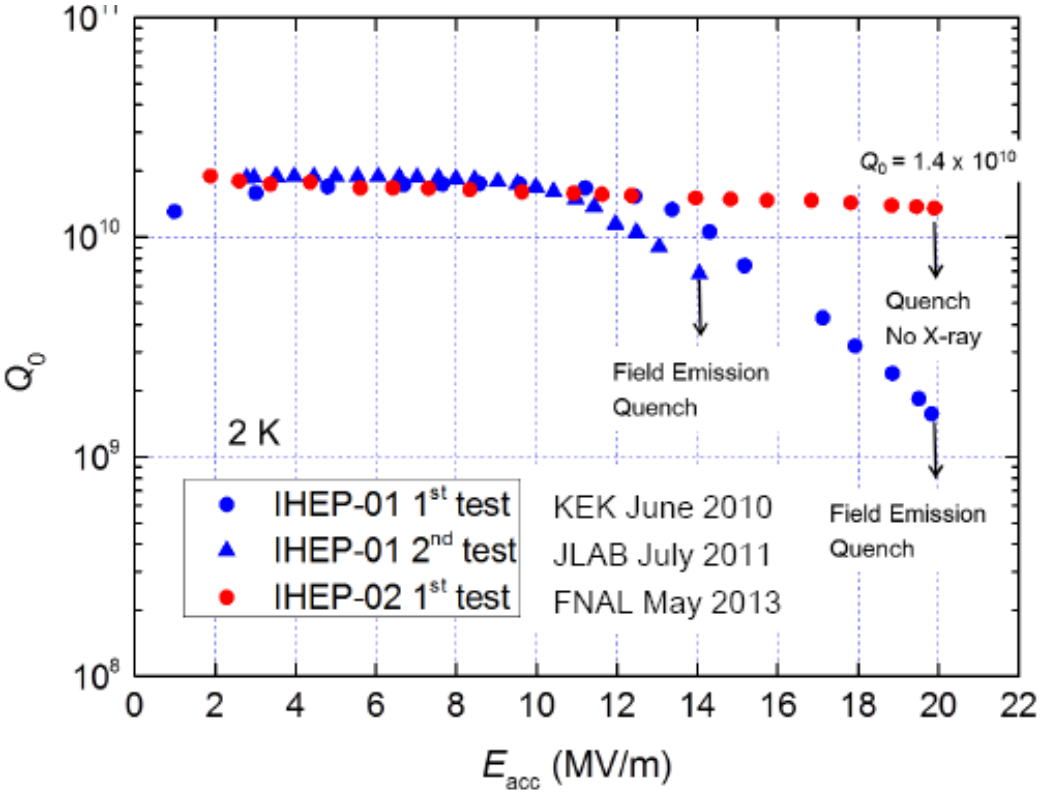
Courtesy Jiankui Hao, PKU

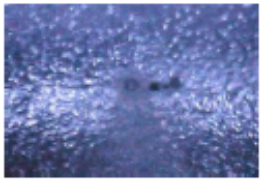
Presented by R. Geng, ECFA LC2013, DESY

9-cell Test Results and Limitation

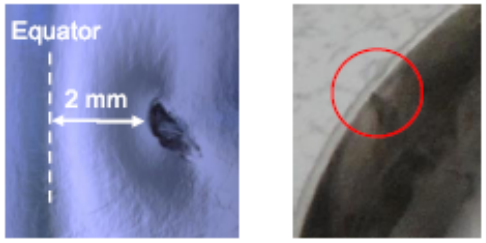
IHEP/KEK, Jlab, FNAL collaboration

Courtesy Jiyuan Zhai, IHEP





A pit on the iris and possible contamination may be the reason of strong field emission of IHEP-01.



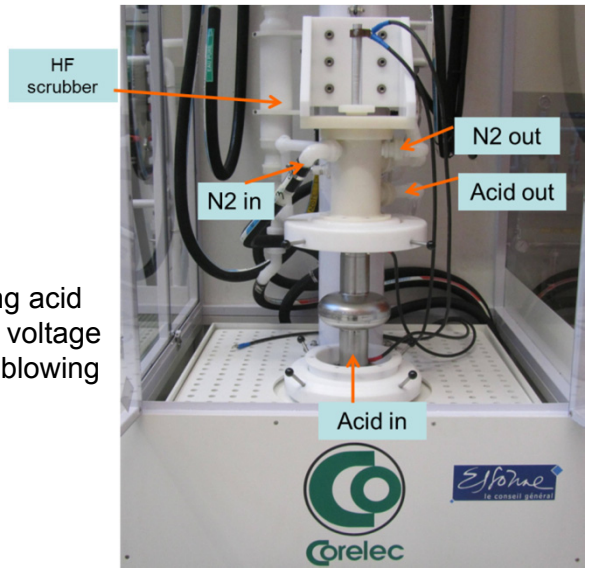
IHEP-02 quench defect (detected by second sound and thermometry). The quench location has sharp and deep grain boundary step made during half cell pressing.

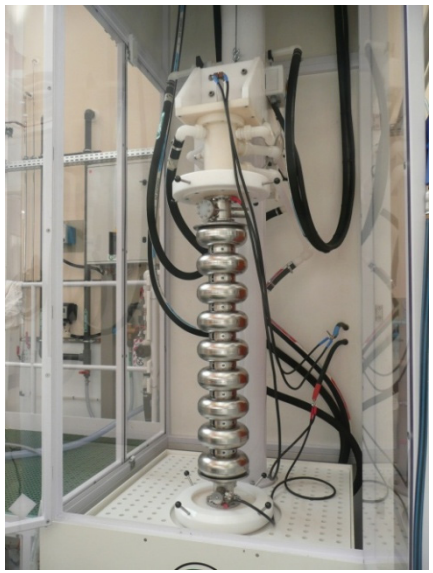
By passband mode test, 5 cells of IHEP-01 ≳ 30 MV/m, 7 cells of IHEP-02 ≳ 40 MV/m, both Pi modes quench at 20 MV/m in cell#9 300 deg equator.

Presented by R. Geng, ECFA LC2013, DESY

Recent achievements w/ Vertical EP

Saclay, VEP





Fermilab
TB9RI025 cavity
Prior to VEP

- Circulating acid
- Constant voltage
- Nitrogen blowing

- VEP of 1Cell and 9Cell cavities
- Focus on parameters: low voltage (~ 6V) – high acid flow (25L/min)
  - Improved degassing (H_2 , O_2)
  - Lower heating
- Four 1-Cell cavities and 1 nine-cell cavity prepared by VEP
- But delay in results: Field Emission problems (cleanroom's water)

Presented by F. Eozénou, 1st LCC/ILC cavity group meeting, 2013

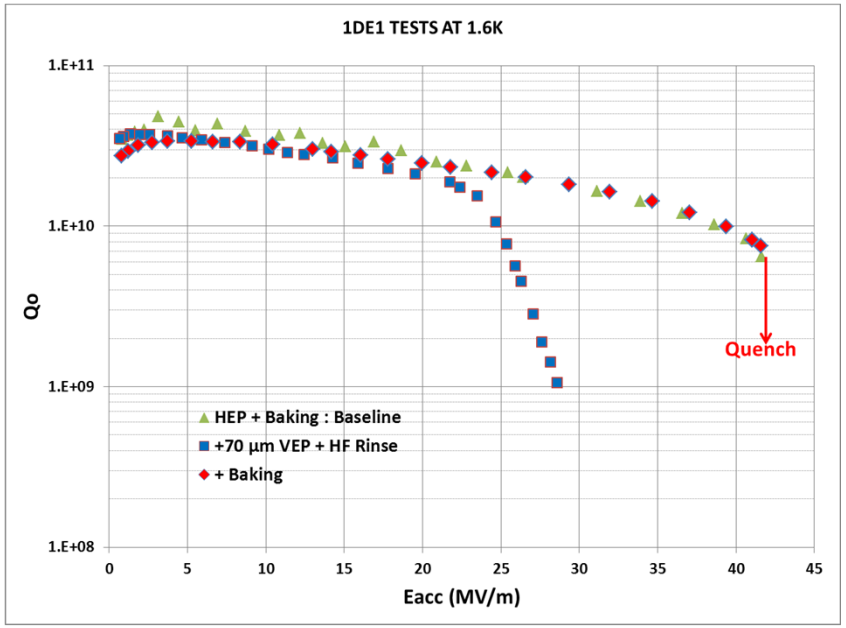
Saclay VEP, >41MV/m w/ 1-cell

1DE1: Horizontal EP + 70 μm VEP

- Parameters: 6V & >24L/min
- Bright and smooth surface

- Performance before/after baking similar to HEP
- High gradient maintained after VEP

1DE1 after HEP + 70 μm VEP



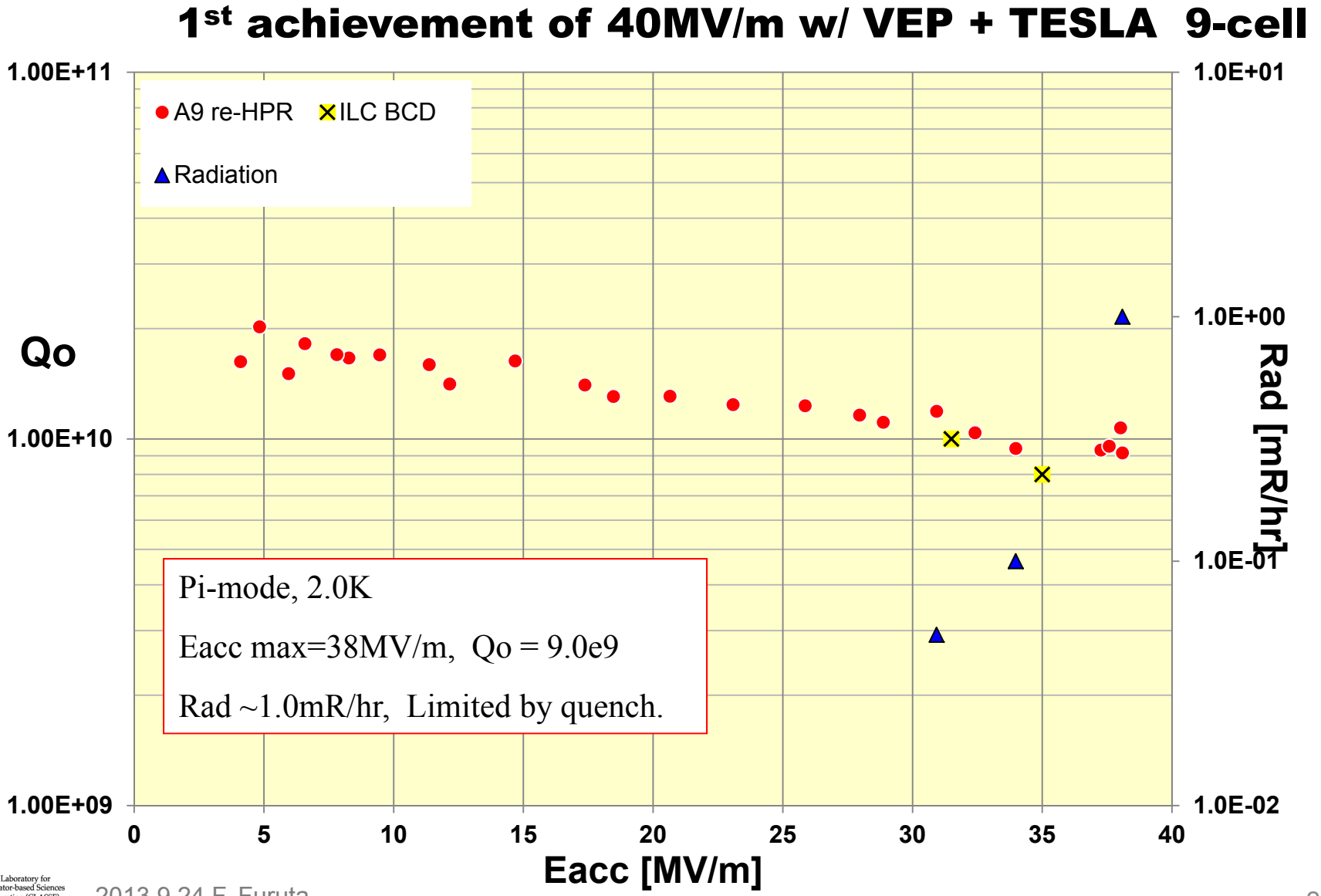
Aspects to improve:

-Low removal rate at 19° C: 0.2μm/min

- asymmetry: removal rate higher in the upper part of the cell (x 3)

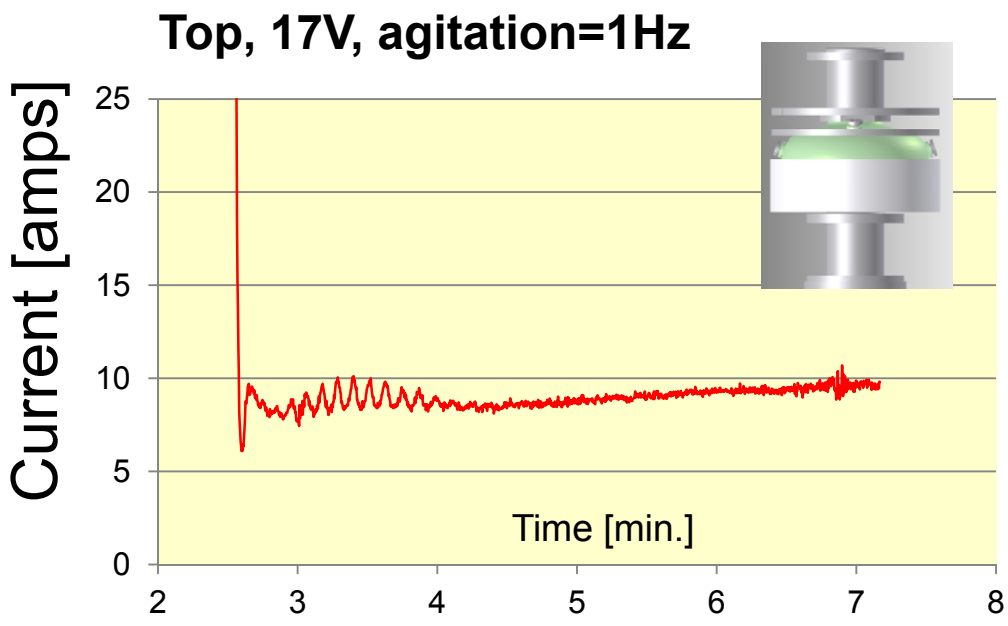
Presented by F. Eozénou, 1st LCC/ILC cavity group meeting, 2013

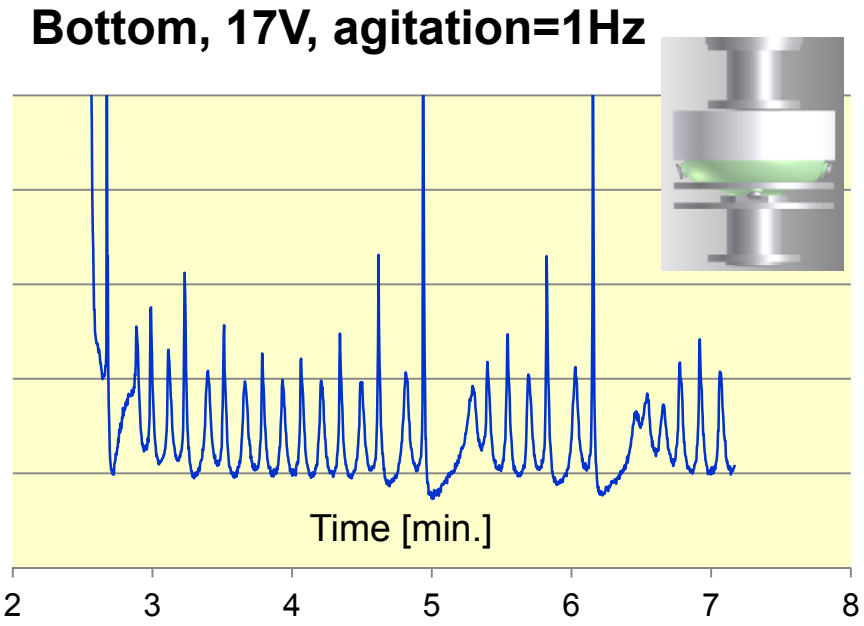
Cornell VEP, 40MV/m w/ ILC 9-cell

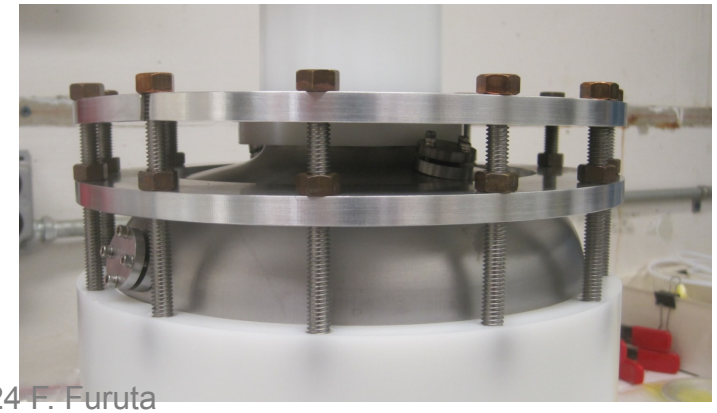


Cornell, half cell VEP

Results of half cell VEP, Comparison of top & bottom

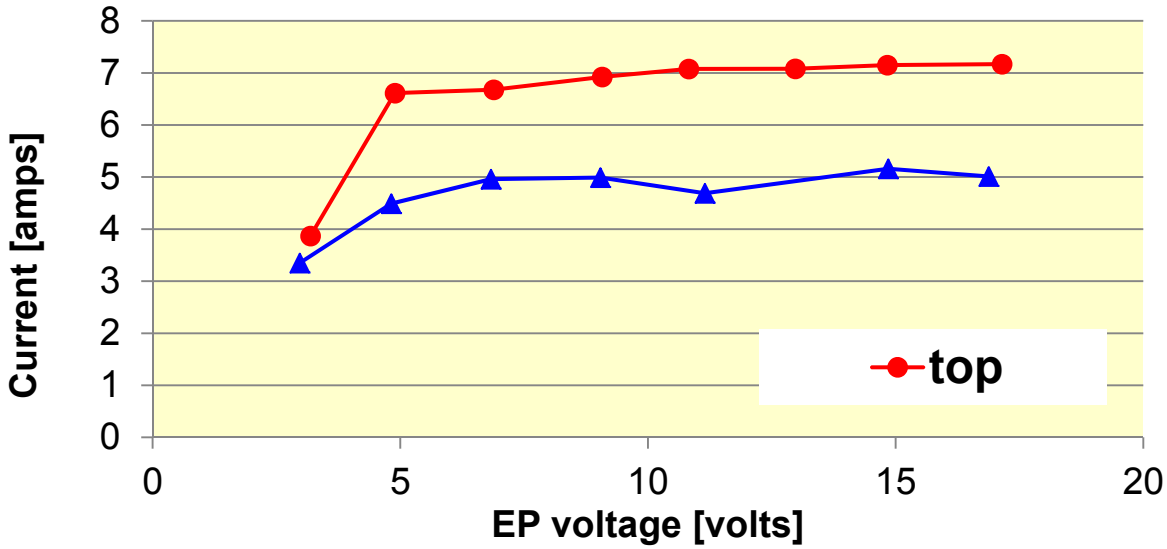


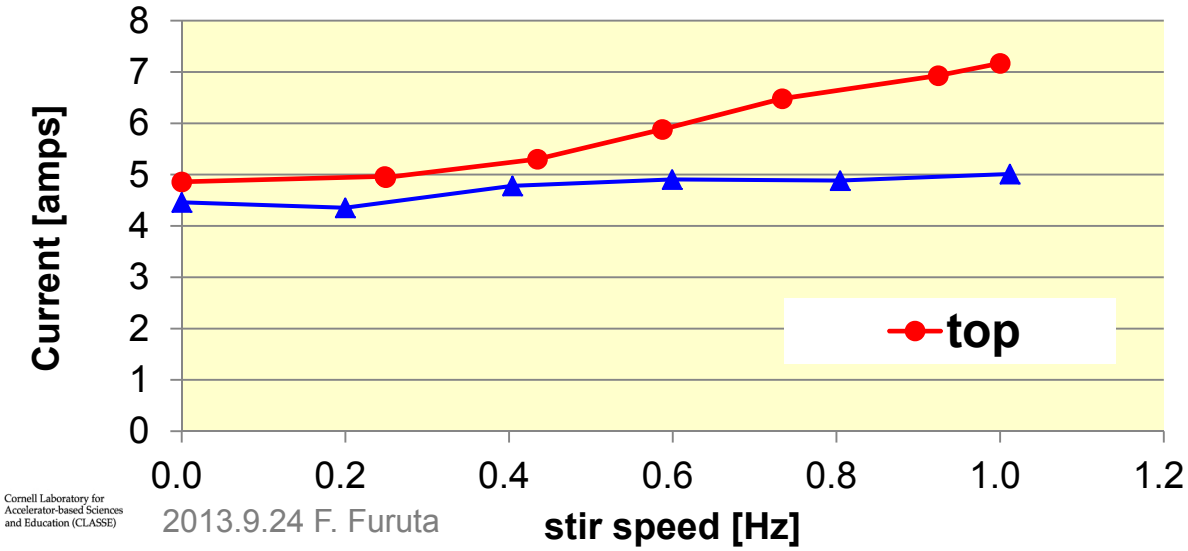


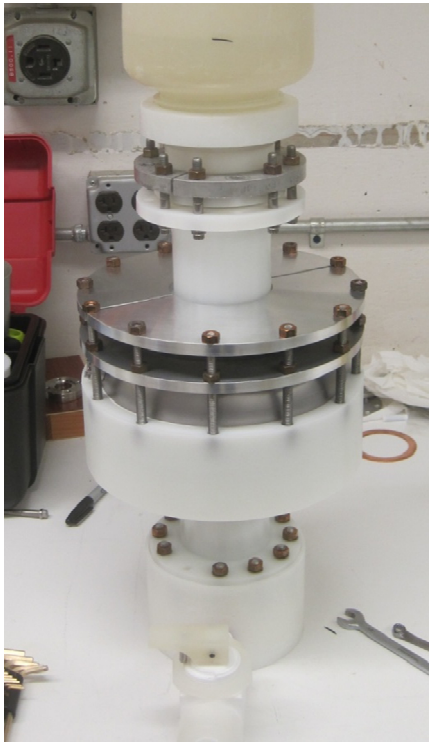


Cornell, half cell VEP

Half cell VEP, I-V curve, stir speed dependence







Summary

- EP based surface preparations have successfully achieved design specs with high yield in various project.

- This means the reliability of EP facility and cavity production procedures are also very high.

- Reliable EP facilities are also available for qualification of new cavity manufacturing. Collaboration on surface process and VT become more strong.

- Based on high reliability of EP, we could focus on other parts of surface processes to improve or cure cavity performance.

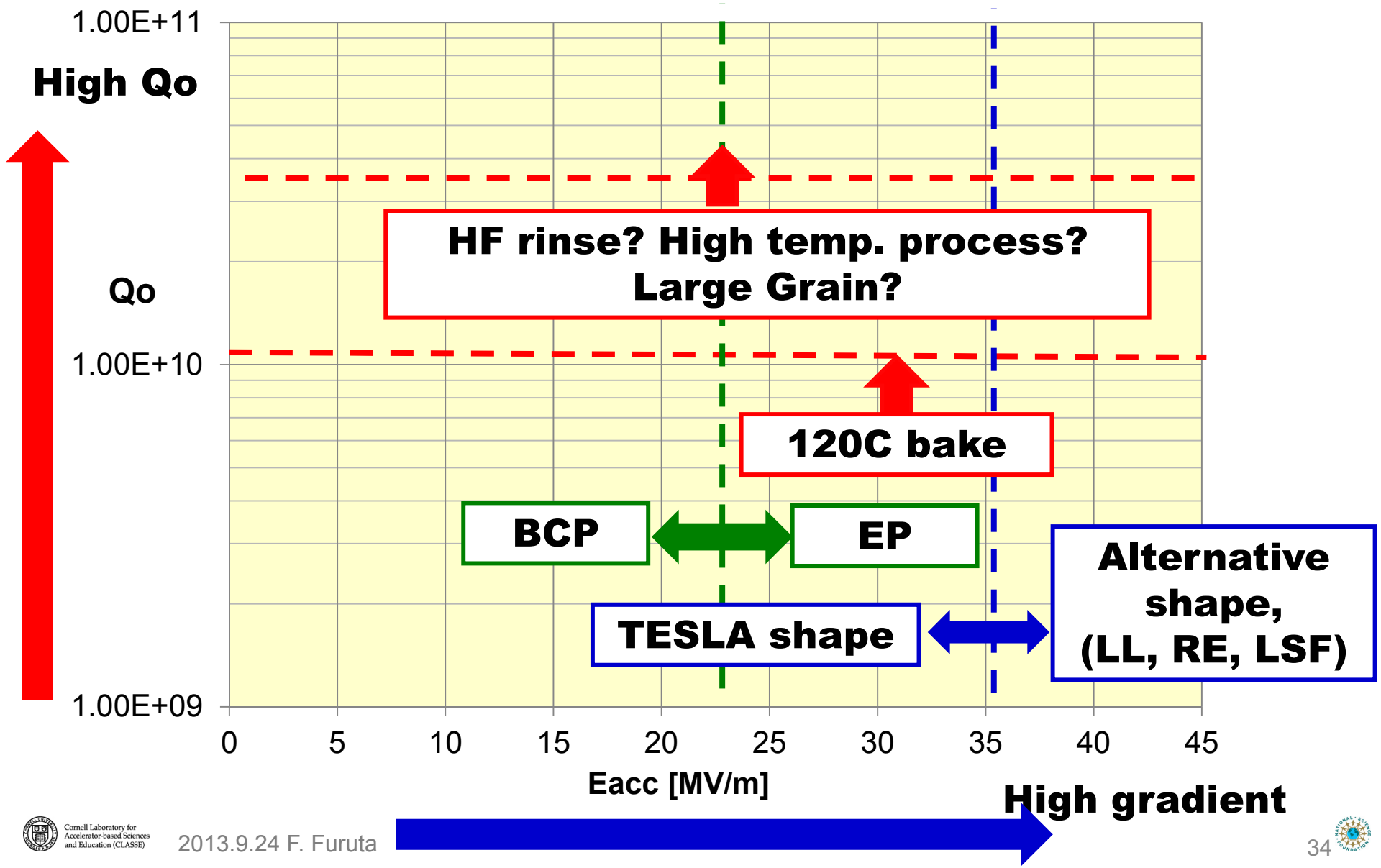
Summary

- VEP'ed cavities have successfully achieved high gradient with high Qo. Demonstration of VEP capability are done.

- R&Ds on VEP parameter optimization are on going. Next high priority is demonstration of high yield with VEP.

- Many VEP facilities are now available, more close communication, discussion, and collaborations are expected.

What is the best surface treatment?



Today's posters related to EP

- TUP046, F. Eozénou (Saclay) et al.
- TUP047, L.M.A. Ferreira (CERN) et al.
- TUP049, F. Furuta (Cornell) et al.
- TUP052, Y.I. Ida (MGH) et al.
- TUP053, A.A. Sulimov (DESY) et al.
- TUP054, E.J. Taylor (Faraday Technology, Inc.) et al.
- TUP055, Y. Yang (ANL) et al.
- TUP056, A. Matheisen (DESY) et al.