Update on the Development of Alternative Shape Cavities

- 9-cell re-entrant shape at Cornell
- 9-cell low-loss shape at IHEP
- 9-cell low-surface-field shape at JLab

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Introduction

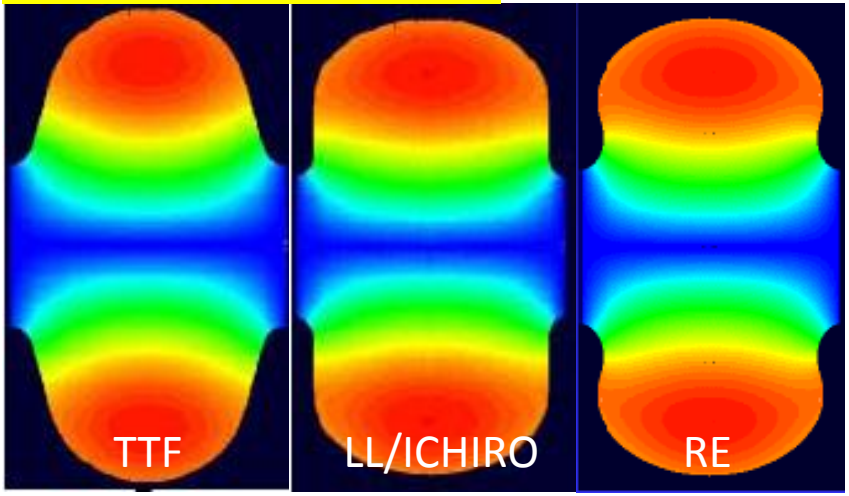
Alternative shape cavities

New Cavity Shape with low Hp/Eacc

$$E_{acc} = \frac{H_{CR}^{RF}}{H_{pk} / E_{acc}}$$

TTF: TESLA shape
Reentrant (RE): Cornell Univ.
Low Loss(LL): Jlab/DESY
LL/ICHIRO: KEK
Low Surface field(LSF): SLAC/Jlab

from J.Sekutowicz lecture Note



shape	TTF	LL/ICHIRO	RE	LSF
Iris Diameter [mm]	70	60	60	60
Ep/Eacc	1.98	2.36	2.28	1.98
Hp/Eacc [Oe/MV/m]	41.5	36.1	35.4	37.1
G*R/Q [Ω²]	30840	37970	41208	36995
Eacc max[MV/m]	42.0	48.5	49.4	47.2

ILC Baseline/Alternative cavity shapes

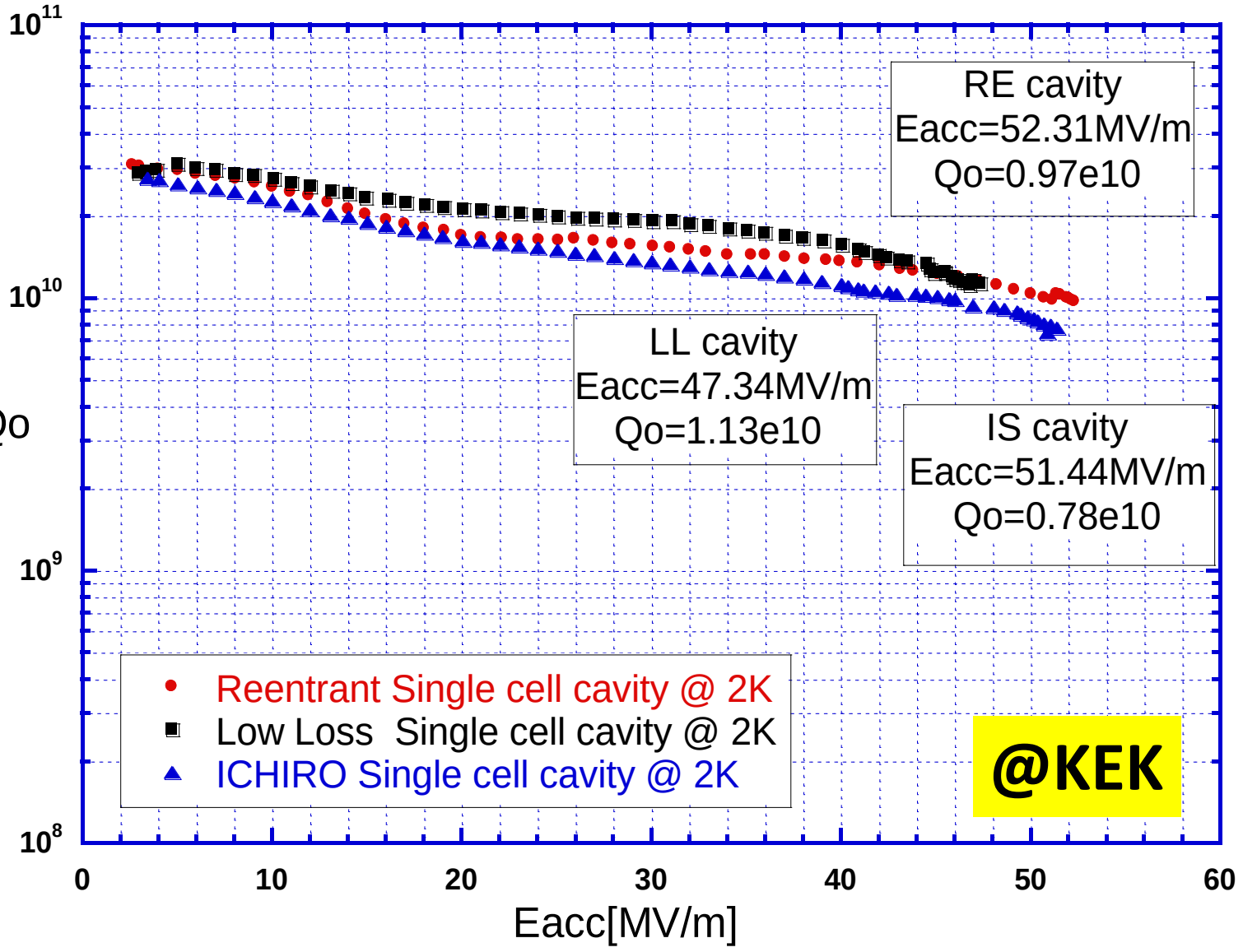
ILC main linac cavity		BCD: Baseline	ACD: Alternative
Cavity Shape		TESLA	Low loss Reentrant
Acceptance Performance	Eacc[MV/m]	35	40
	Qo	0.80E10	0.80E10
Operation Performance	Eacc [MV/m]	31.5	36
	Qo	1.0E10	1.0E10

Proof of high gradient w/ single cells (1)

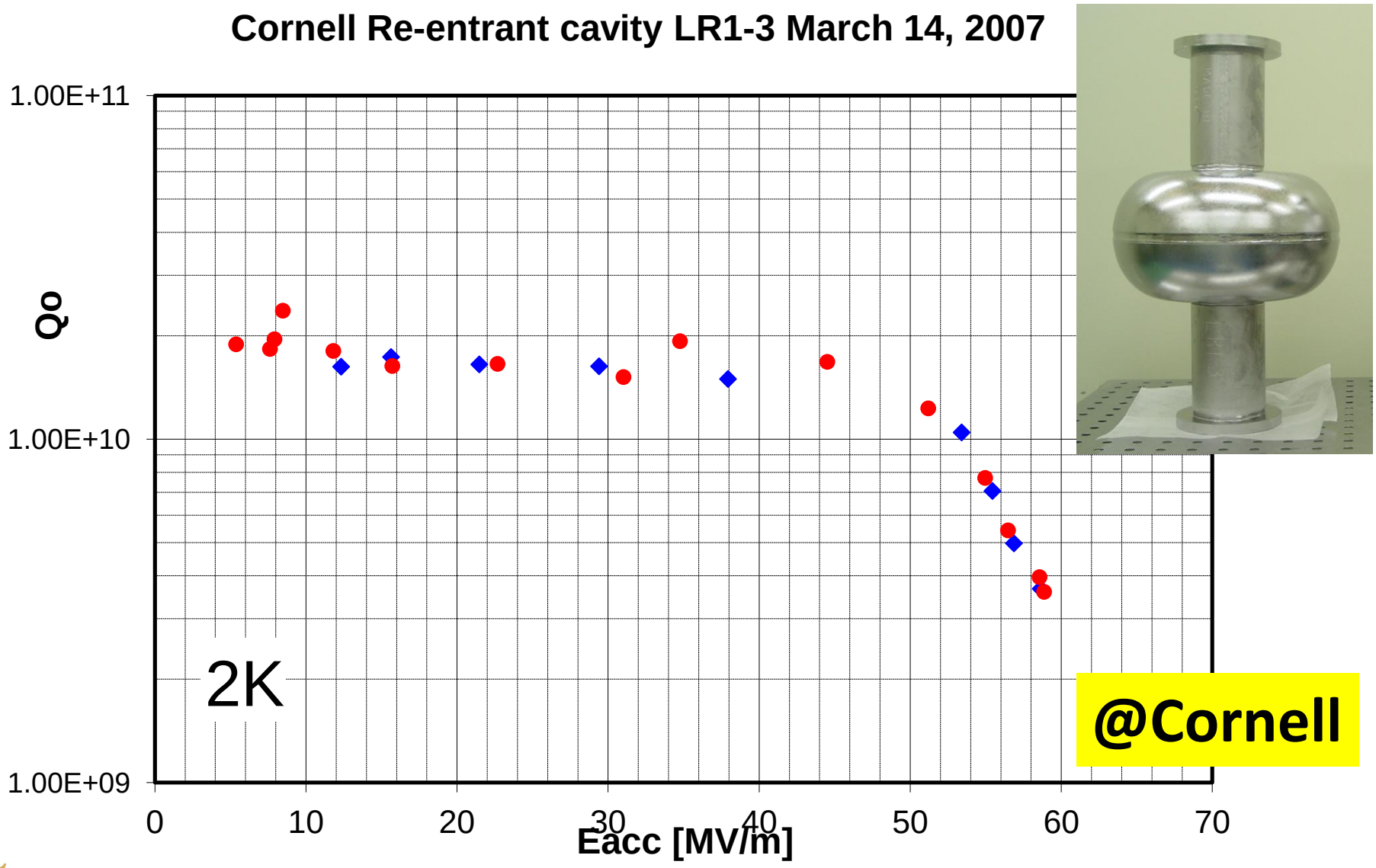
Reentrant

Low Loss

Ichiro Single



Proof of high gradient w/ single cells (2)



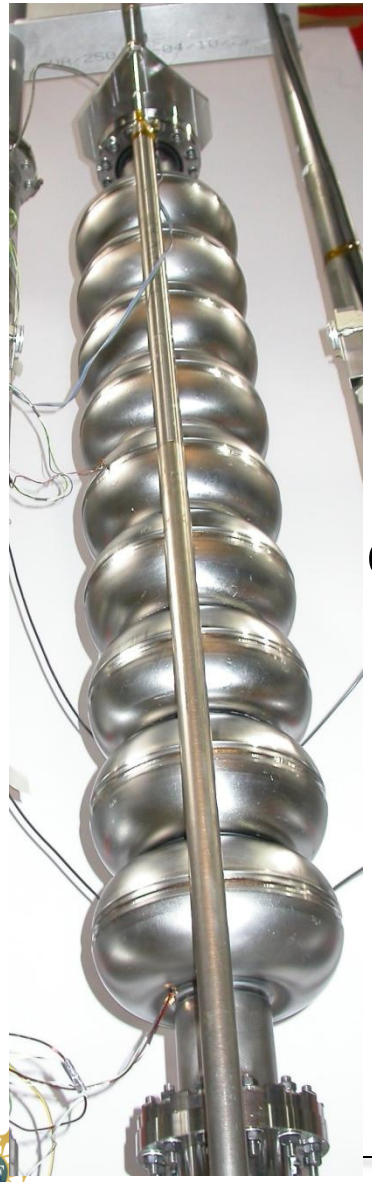
Proof of alternative shapes are done

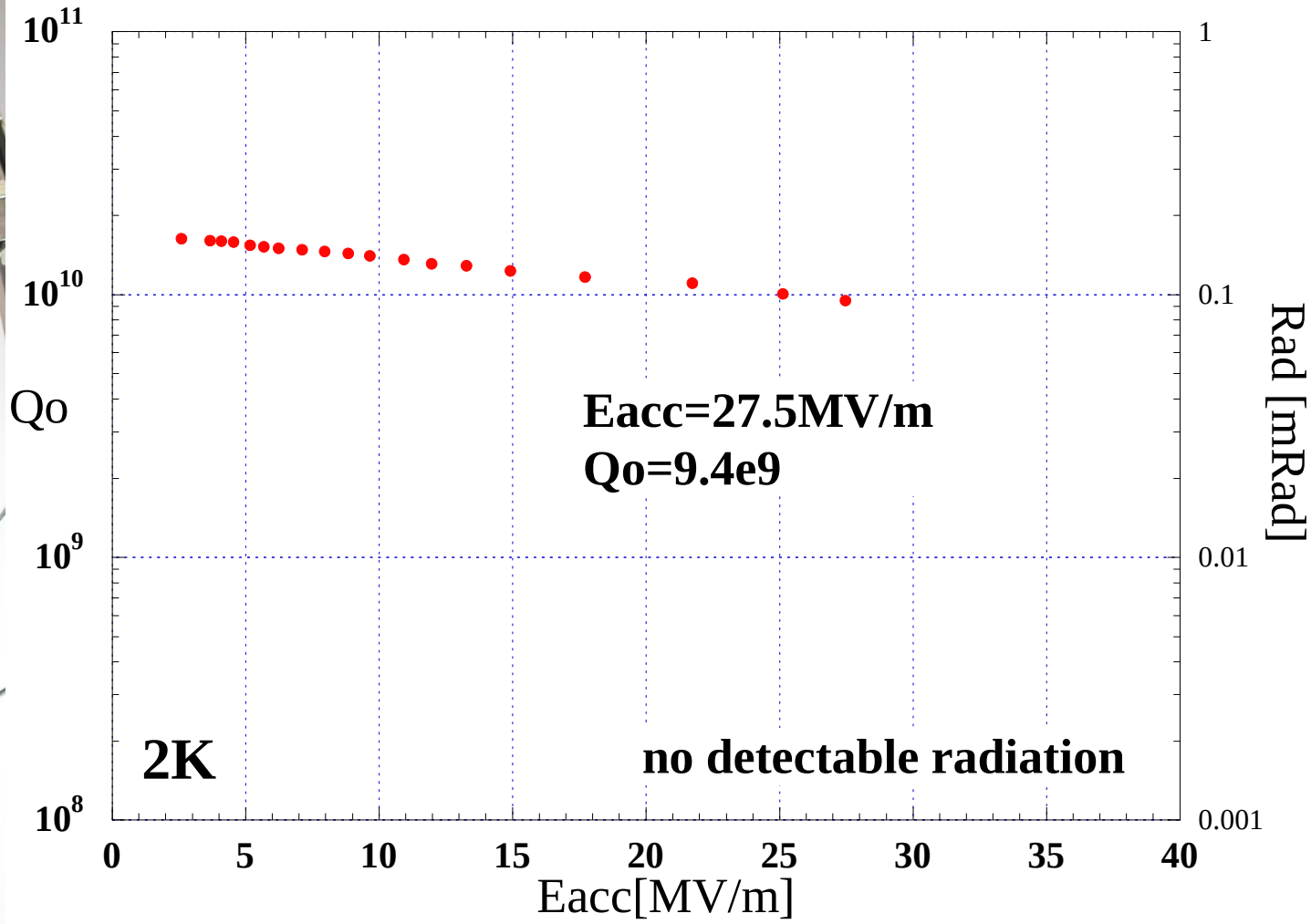
Alternative shape cavities, (LL, ICHIRO, RE,) have successfully demonstrated high gradient of 50MV/m with single cells.

- KEK had successfully demonstrated >50MV/m with new shape cavities of Low loss, ICHIRO, and Reentrant.
- Cornell had achieved 59MV/m with Reentrant.
- Processes for those singles were based on CBP and horizontal EP.
- Reentrant cavities were also processed with high temp. anneal at Cornell before CBP.

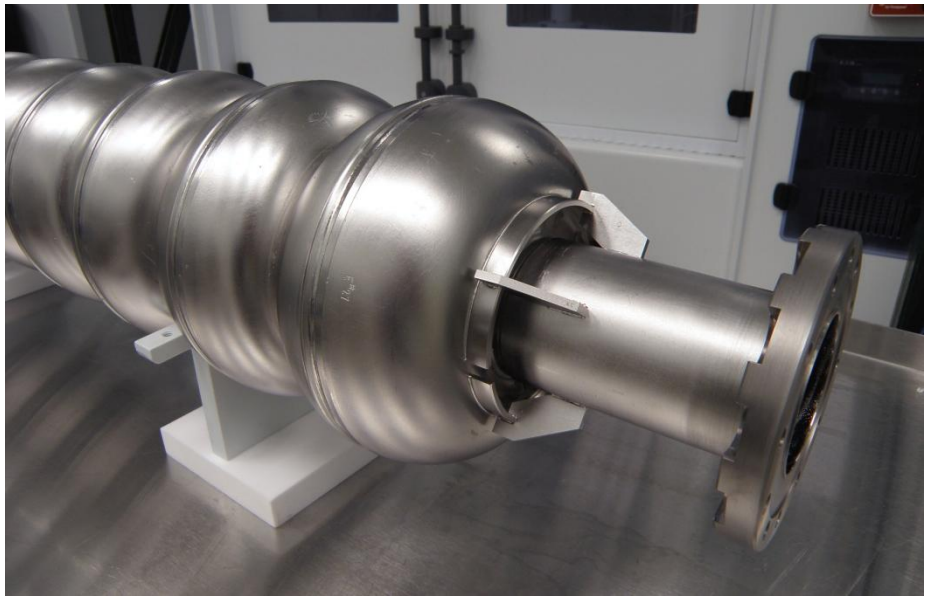
Status of alternative shape 9-cells

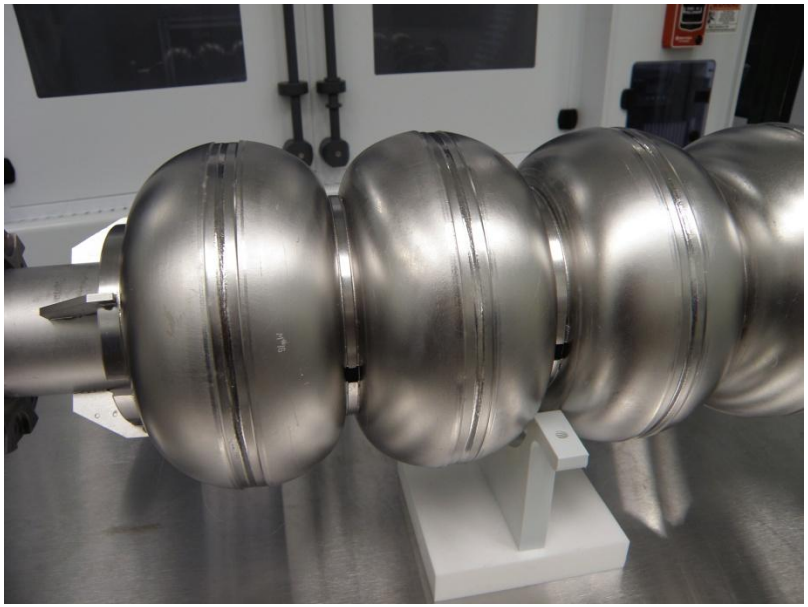
Re-entrant 9-cell (no HOM) at Cornell





Stiffener weld on RE 9-cell by AES





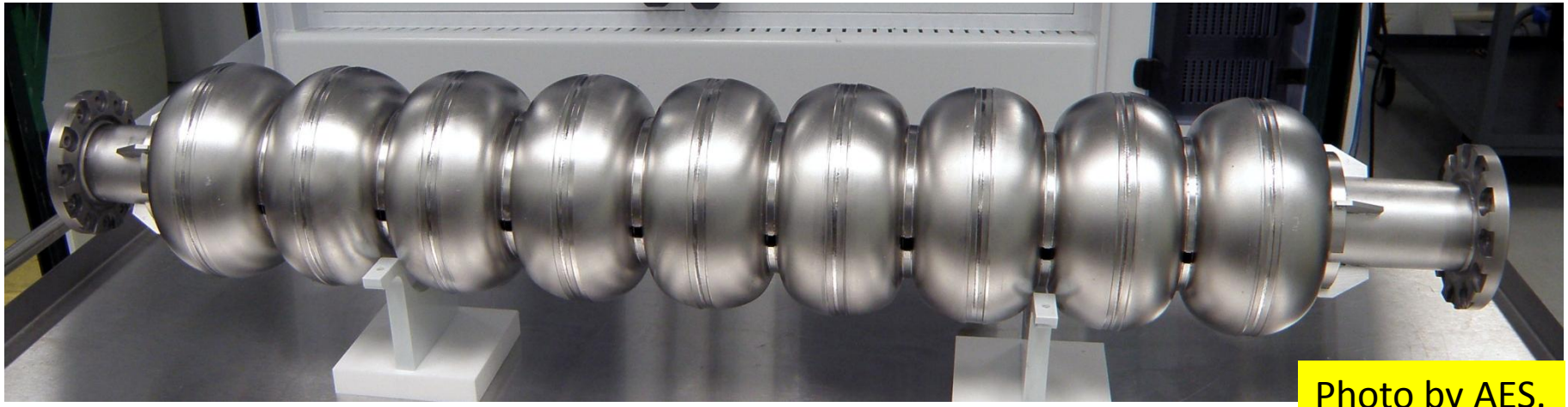
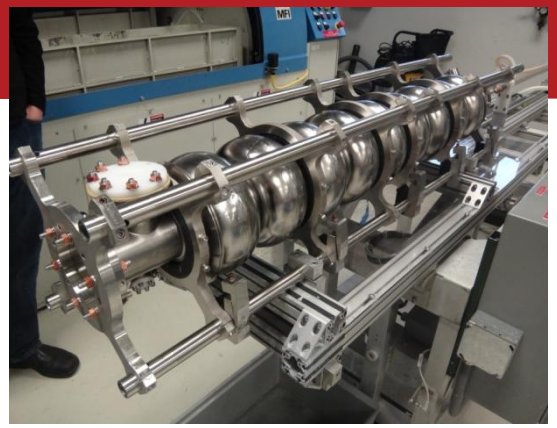
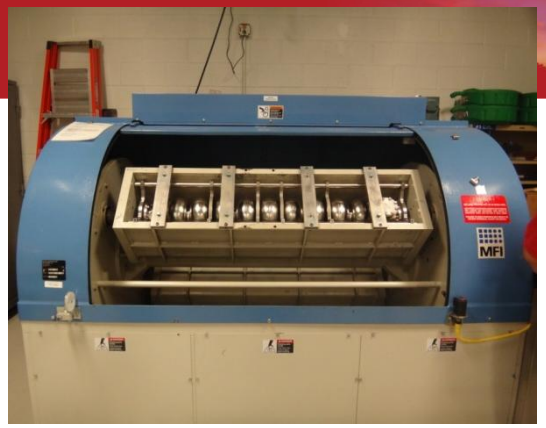
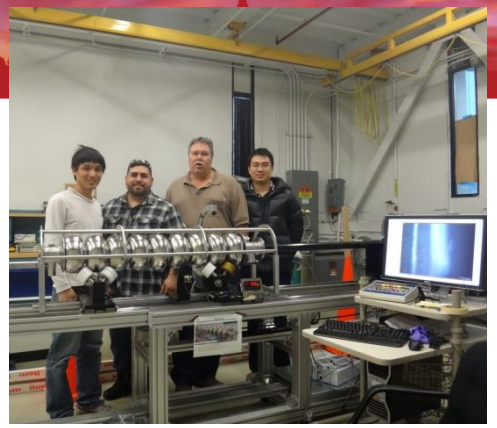


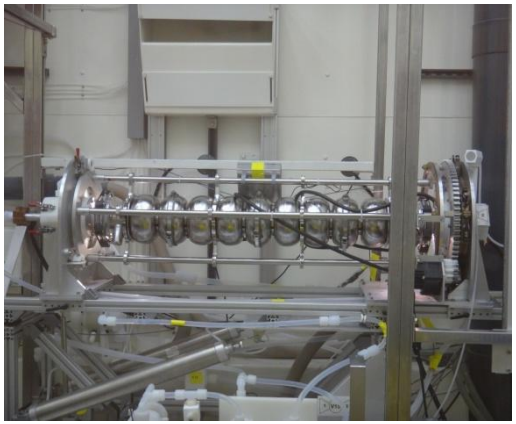
Photo by AES.

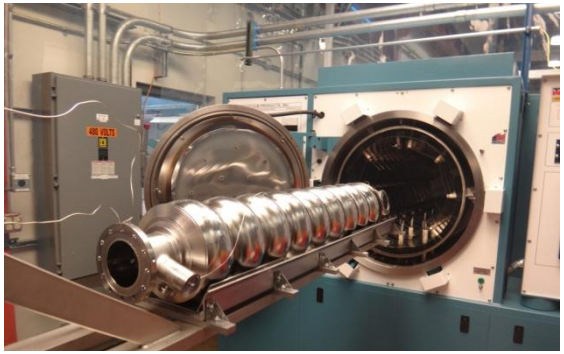
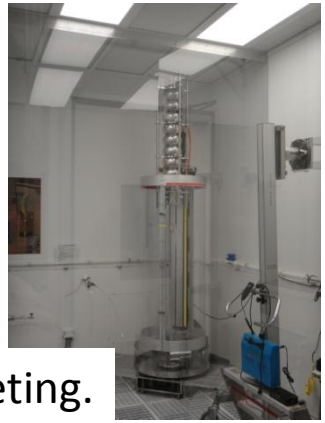
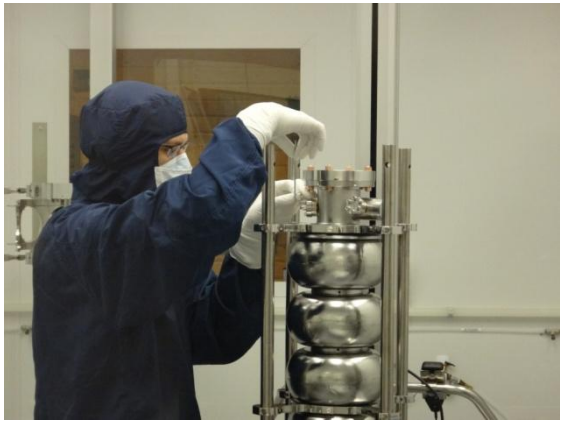
IHEP-02, LG LL 9-cell w/ HOM, IHEP/FNAL

- IHEP-02 is a low-loss shape large grain 9-cell cavity with full end groups for ILC R&D
- FNAL and IHEP are collaborating to process and test the cavity using FNAL facilities and expertise. Two IHEP staff members (Jiyuan Zhai and Tongxian Zhao) are participating in the work.
- The cavity will be dressed and installed in the *IHEP ILC Test Cryomodule* (containing only one cavity) late this year. The input coupler (two couplers test in KEK last month, reached ILC spec.: 1MW, 1.5ms, 5Hz), tuner and cryomodule are all ready to assemble.

*Presented at 1st LCC Cavity Group Meeting.

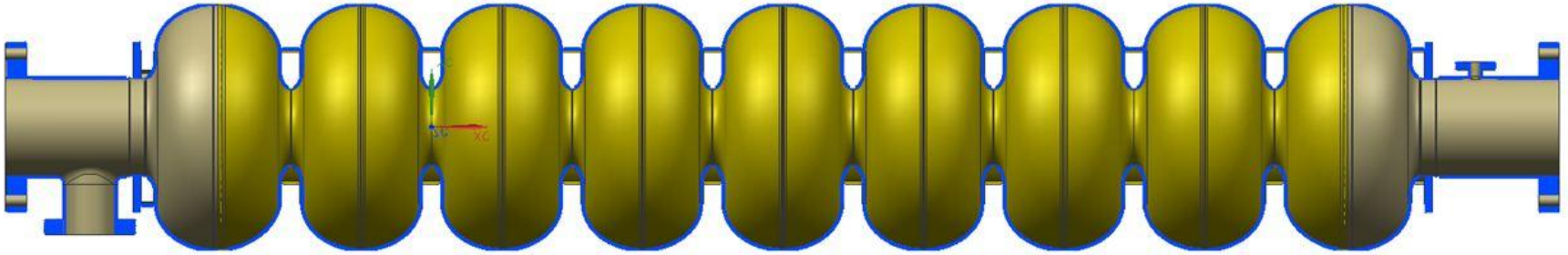


*Presented at 1st LCC Cavity Group Meeting.

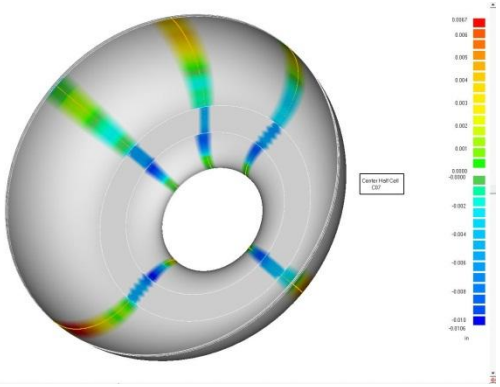
LSF-Shape Cavity Development at JLAB

*slide from Jlab.

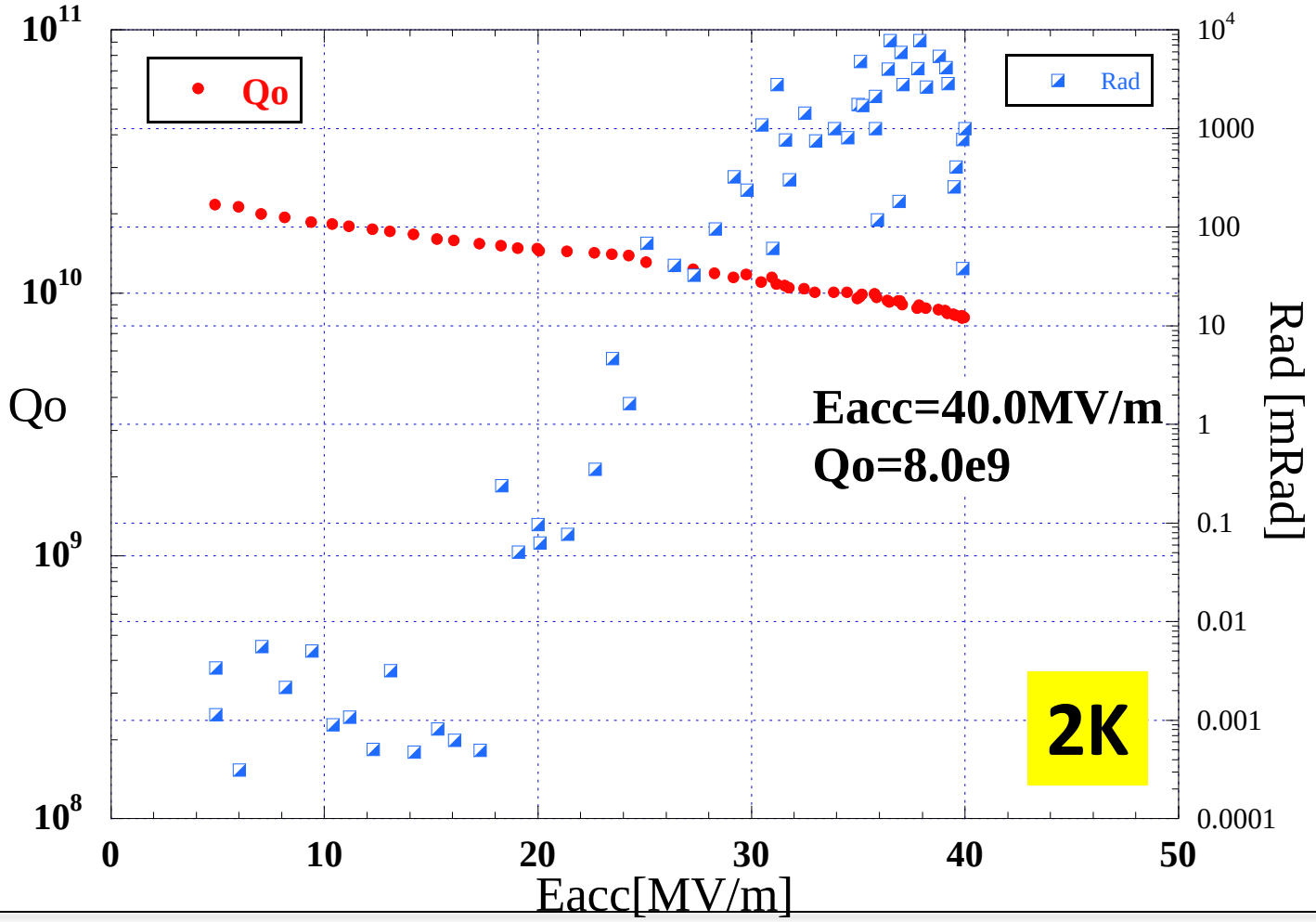


	Unit	TESLA	LL	RE	LSF
Aperture	mm	70	60	60	60
E_{pk}/E_{acc}	-	1.98	2.36	2.28	1.98
H_{pk}/E_{acc}	mT/(MV/m)	4.15	3.61	3.54	3.71
k	%	1.90	1.52	1.57	1.27
G*R/Q	Ω^2	30840	37970	41208	36995

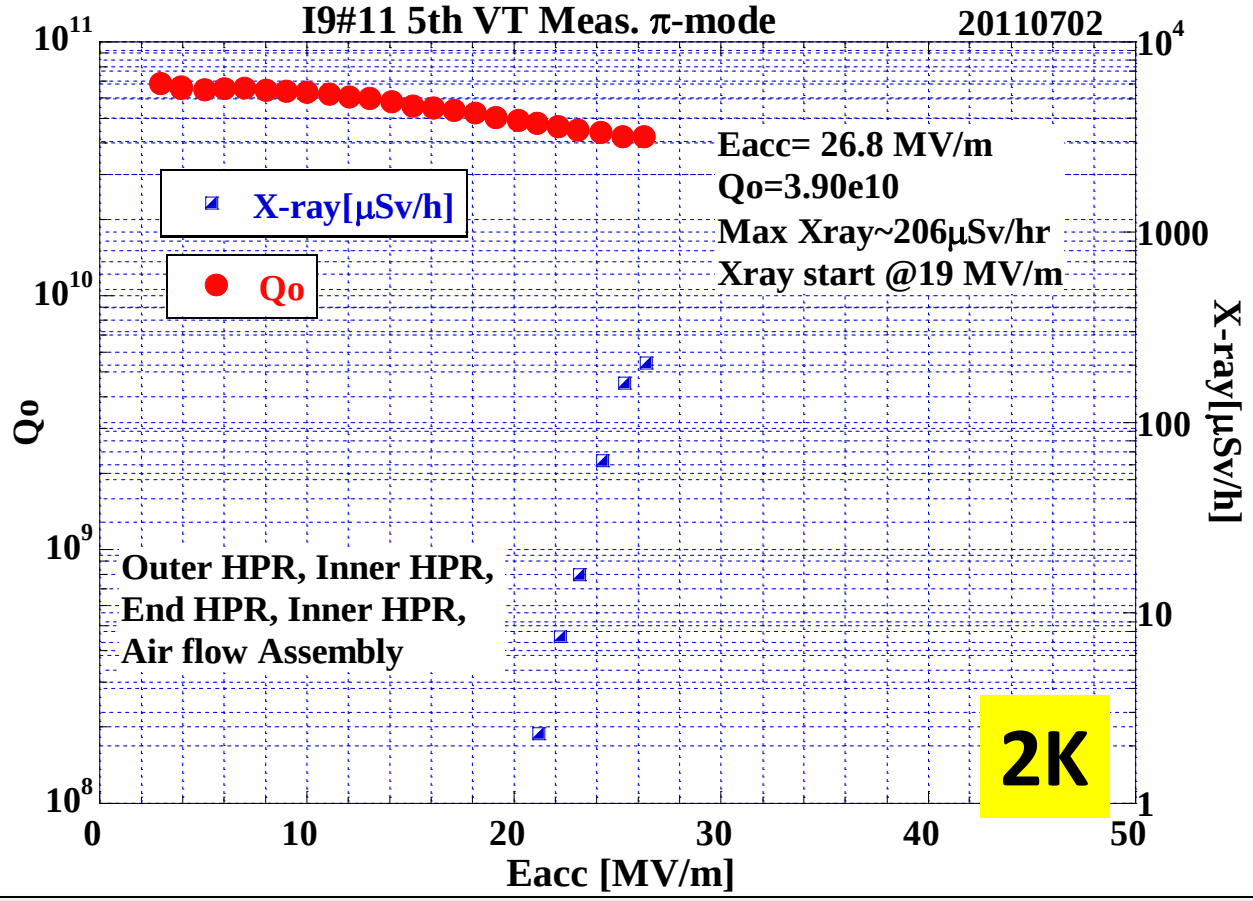
- LSF shape (SLAC design) reduces Hpk/Eacc without sacrificing Epk/Eacc
- A new 9-cell prototype LSF shape cavity is being developed at Jlab
- All half cells are completed for weld prep machining
- Adopted new approach for half cell and dumb bell fabrication
  - For high repeatability
  - For low cost (goal is to eliminate labor intensive dumb bell tuning)
- Half cell CMM inspection and RF inspection completed with good results



ICHIRO 9-cell #7 (w/ HOM) at KEK/Jlab



LG ICHIRO 9-cell #11(w/ HOM) at KEK



Status of alternative shape 9-cells

Cornell, IHEP/FNAL, Jlab, KEK have been worked on alternative shape 9-cells.

- Reentrant 9-cell achieved 27~30MV/m with vertical EP.
- ICHIRO 9-cell achieved 40MV/m with Qo of 8e9 in collaboration with Jlab and KEK.
- Large grain LL and ICHIRO 9-cells are processed and tested. 20~27MV/m are achieved so far.
- LSF 9-cell is under fabrication at Jlab.

What are the issues of alternative 9-cells?

- Available number of alternative shape 9-cells are very small.

-1 RE 9-cell at Cornel (FG).
-2 LL 9-cell at IHEP (LG).
-1 LSF 9-cell under fabrication at Jlab.
-4 ICHIRO 9-cell, but no activities right now (2 FG+2 LG).

- Fabrication error like defects in EBW seam could be issue. These defects are expected to be fixed with CBP, local grinding, laser re-melting, etc..

What are the issues of alternative 9-cells?

- R&Ds on alternative shape 9-cells include another challenges.

-Reentrant + Vertical EP.

-LG Nb + LL, ICHIRO.

-ICHIRO + MO seal.

- For the demonstration of 50MV/m with alternative shape 9-cells, it is better to use the most reliable processes right now.

R&D plans of Cornell SRF group

- Alternative shapes for high gradient cavities.
  *we are involved in Re-entrant shapes, ICHIRO single.
- Vertical EP for high gradient.
  * TESLA 9-cell + VEP achieved 38MV/m w/ Qo of 8.0e9, VEP R&Ds on RE 9-cell is on going.
- OST quench detection and multi-cell T-map system
  *we have been applied both techniques on cavity tests.
- New SRF materials and high Qo cavity
  *we are already producing Nb3Sn.
- Nb/Cu Cavities
  *already investigating spun cavities from explosion bonded copper on niobium. 500MHz cavities are under fabrication at RI.
- New production techneques
  *spinning and/or hydroforming.
- Field emission detection
  *we have started a simulation effort for field emission, dark current, and radiation background.
- Cut-cavity analysis of single cells.

Summary

- Many R&Ds on alternative shape 9-cells are on going at many laboratories now, Cornell, IHEP/FNAL, Jlab.

- Demonstration of 50MV/m with alternative shape 9-cells is top priority. Need more alternative shape 9-cells to investigate reproducibility and yield test.

- Yield of baseline cavities are getting higher and higher. Feedbacks from them should be applied on alternative 9-cells.

- R&Ds on alternative shape 9-cells sometimes includes new challenges, so we need to be careful about the performance limitation. It comes from alternative shape or not?