Recent results on high gradients at Cornell, including best cell shapes, reentrant multi-cell cavities, and VEP optimization

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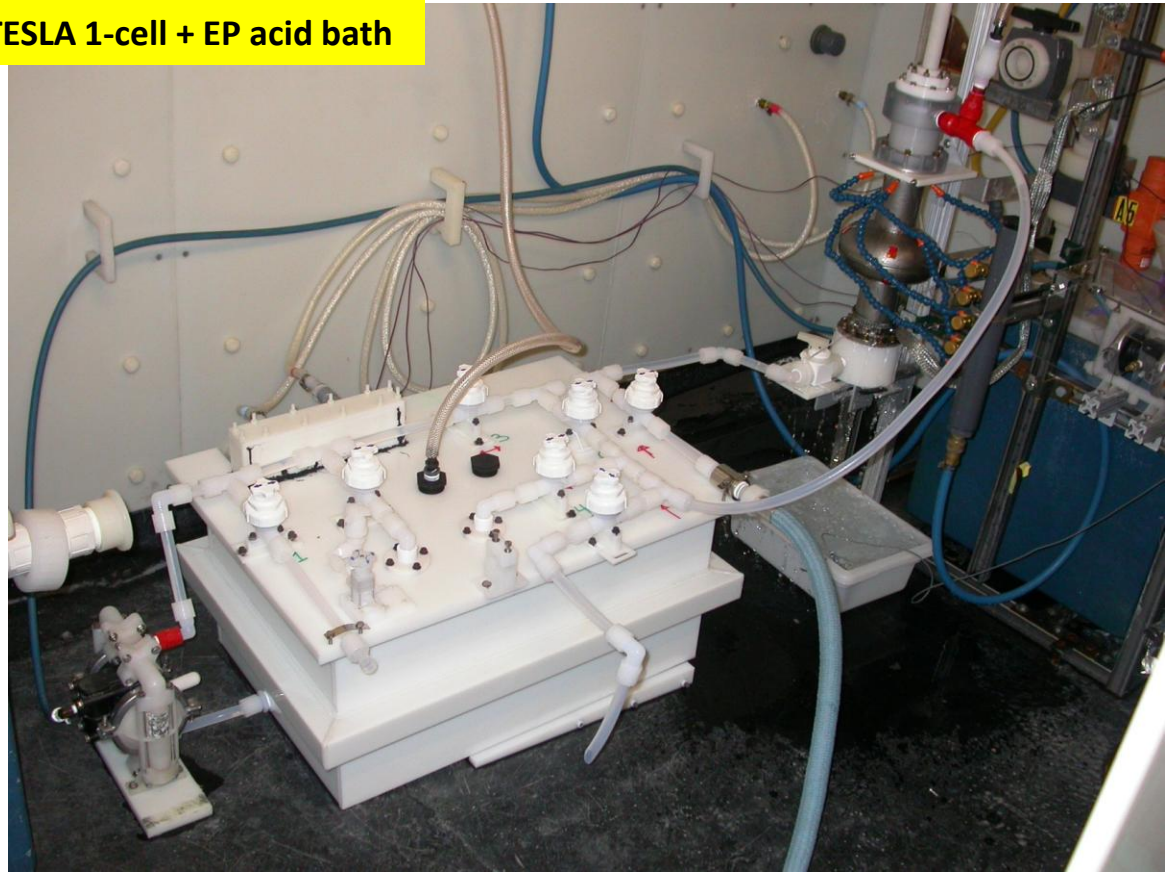
Cornell university

Vertical Electro-Polishing at Cornell

TESLA 1-cell + EP acid bath

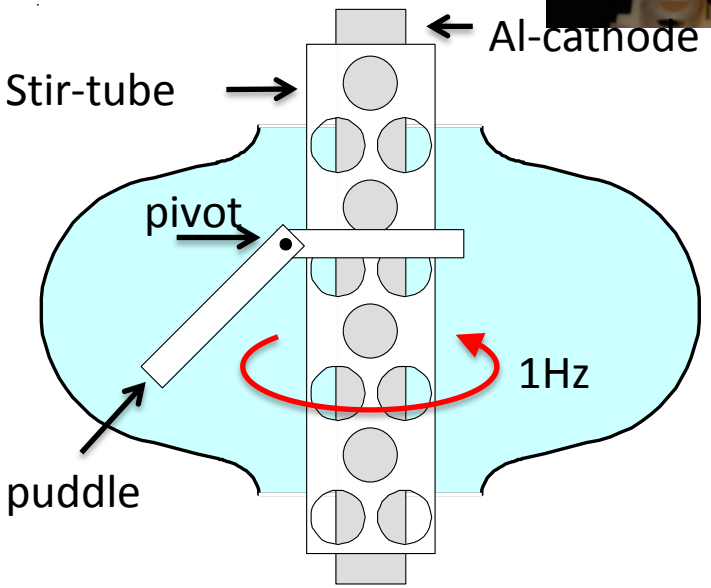


New acid bath is available for
(1) All single and multi cell cavities.
(2) Easy electrolyte mixing.
(3) EP acid circulation during process.

TESLA 9-cell

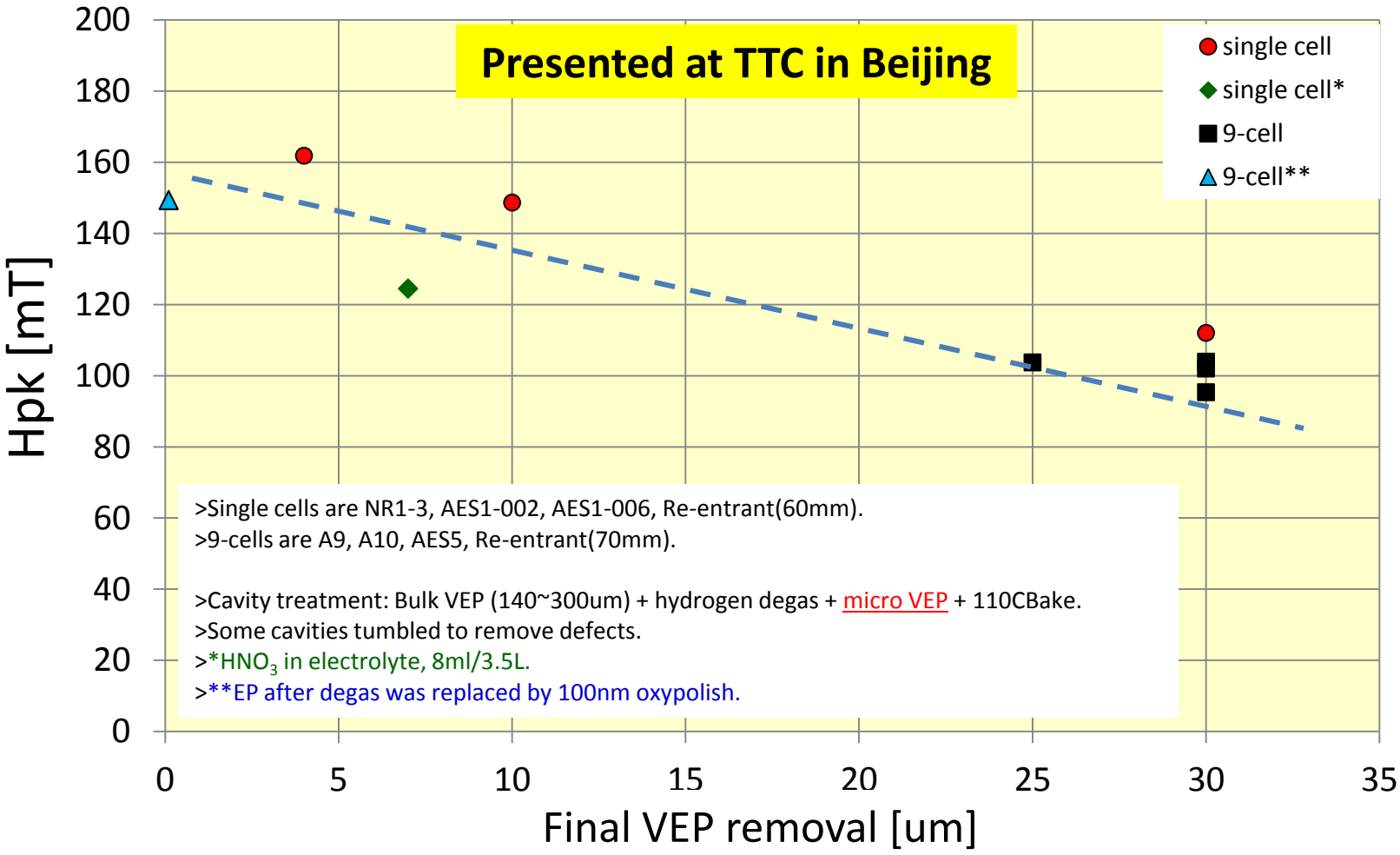
VEP parameters at Cornell

Parameters	
Cathode	aluminum >99.5%
Stir-tube	PVDF
Paddles	PVDF
Seals	FEP encapsulated O-ring
End group	PTFE, HDPE
Electrolyte	24 liters/9-cell
Electrolyte composition	10:1 (H_2SO_4: HF)
Maximum use	9g/L dissolved Nb
Current	150 Amperes
Voltage	14 Volts
Temperature	15 to 19 C
Stir-tube transparency	>50%
Stir frequency	1 Hz
EP removal rate (ave.)	~0.3um/min.

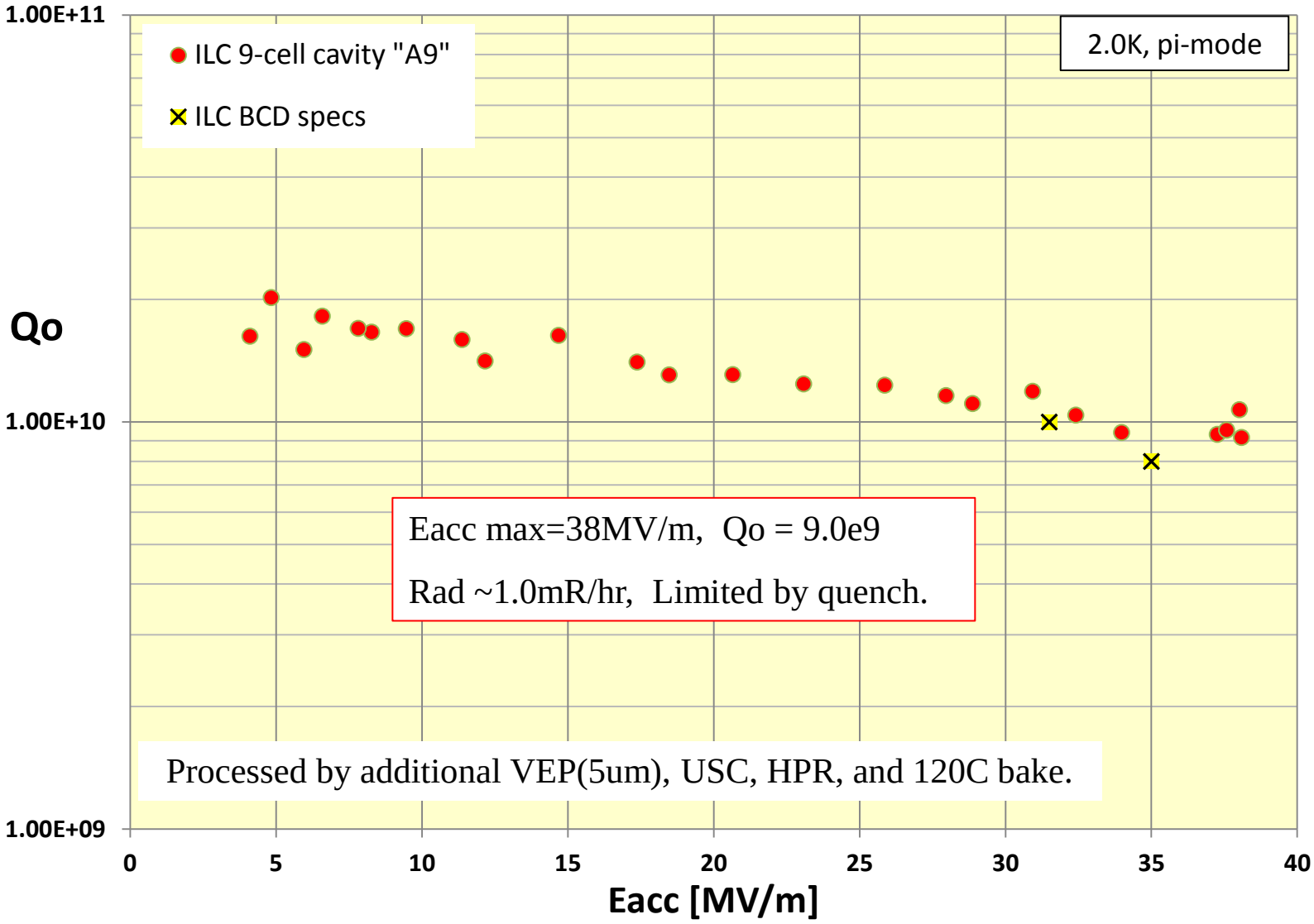


Analysis on VEP removal

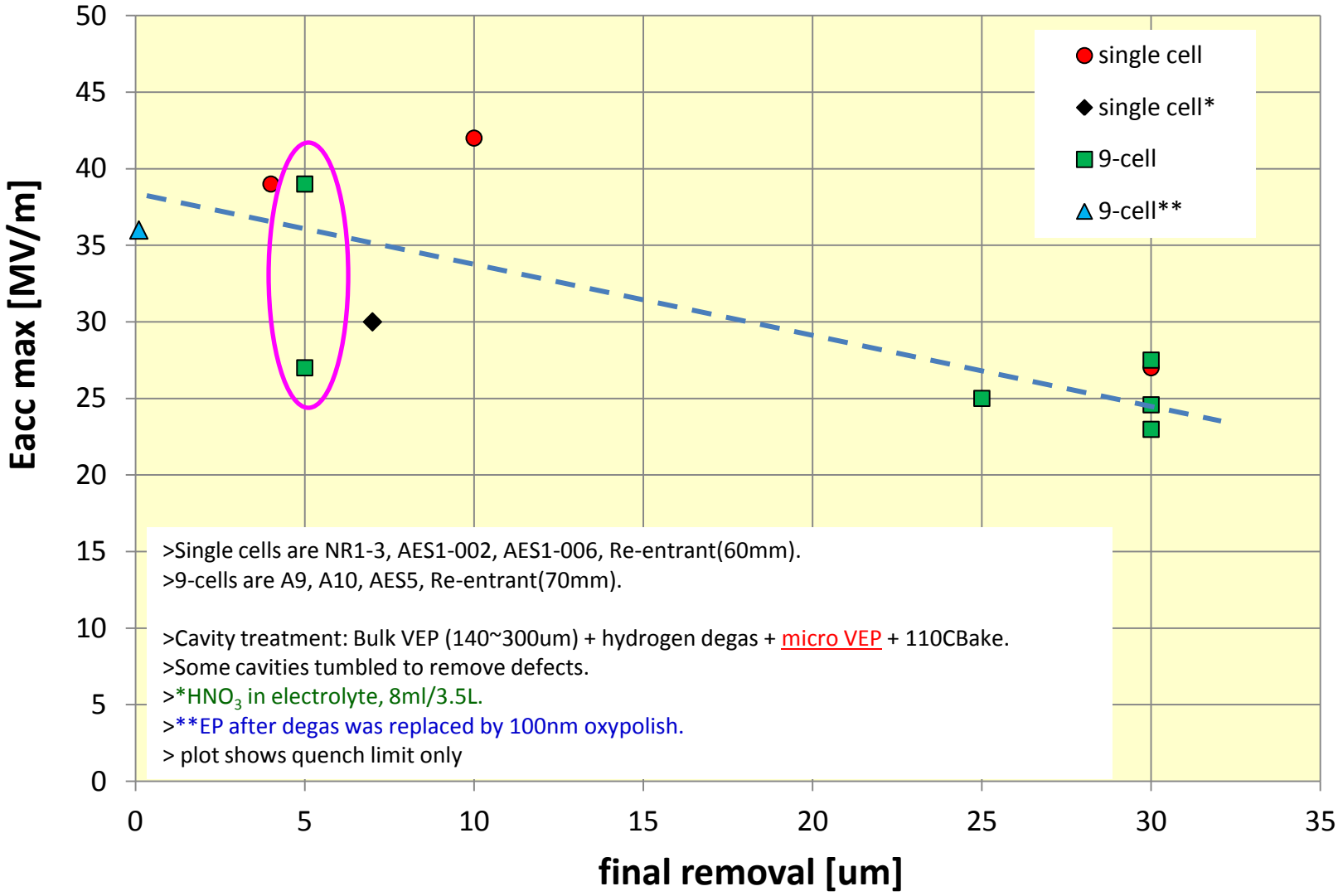
Analysis on the previous VEP results at Cornell, the final VEP removal of less than 10um seems promising for high gradient ~40MV/m.



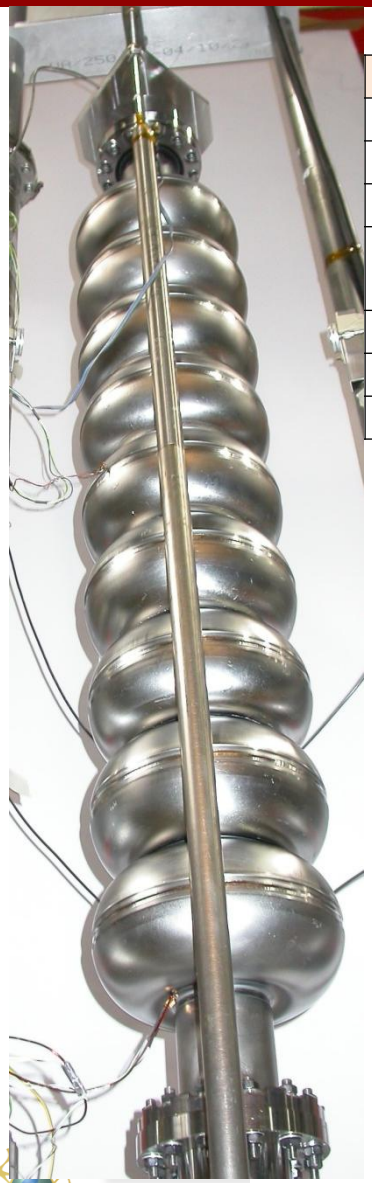
Cornell VEP + TESLA 9-cell achieved ~ 40MV/m



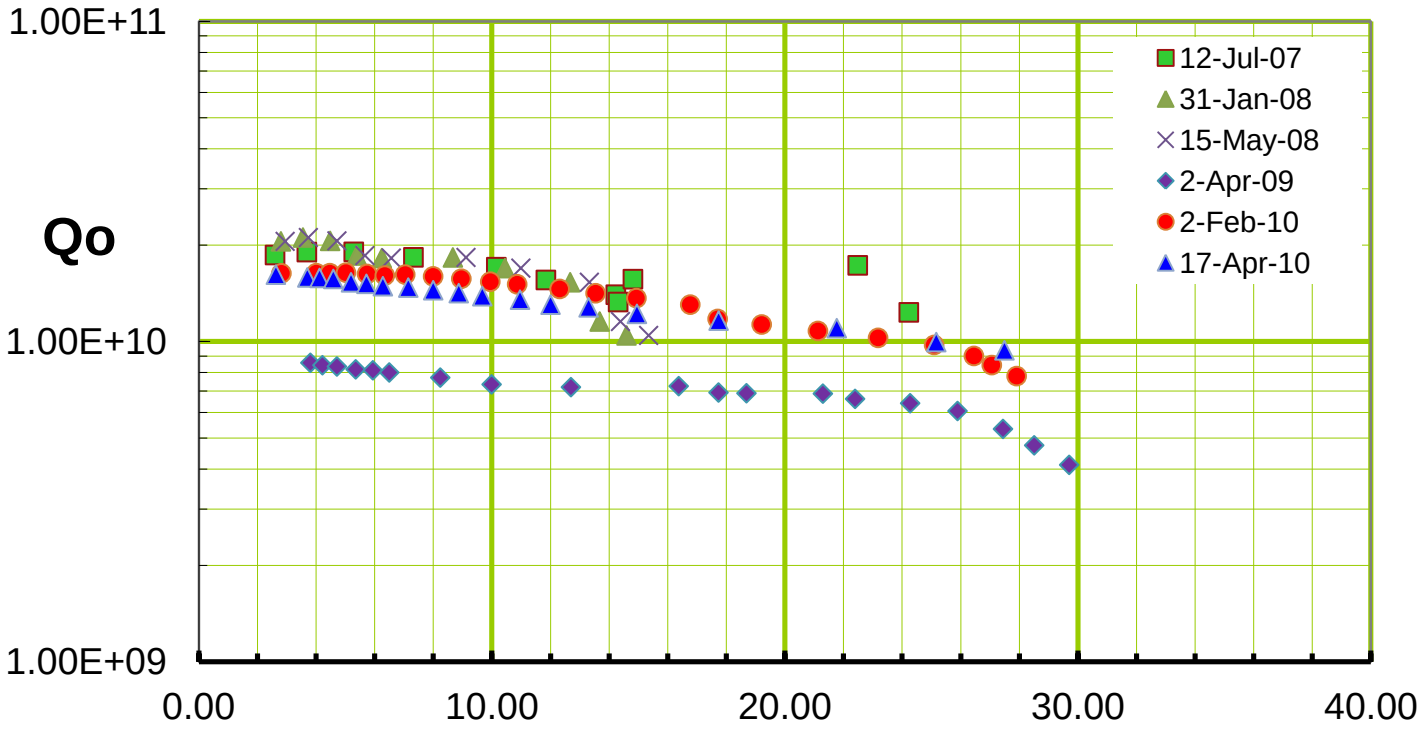
Analysis on VEP removal (2)



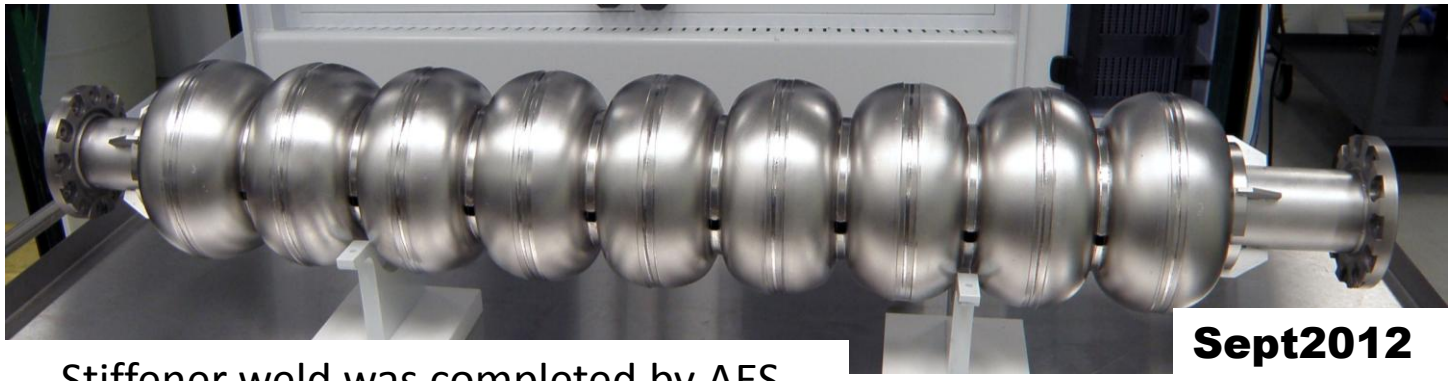
Re-entrant 9-cell history



cavity	date	Eacc max [MV/m]	Qo at Eacc max	process
LR9-1	12-Jul-07	24.23	1.23E+10	VEP200um, 600C bake(Jlab), VEP20um, 115C bake
LR9-1	31-Jan-08	14.59	1.05E+10	VEP20um, 115C bake
LR9-1	15-May-08	15.35	1.05E+10	VEP20um, 115C bake
LR9-1	2-Apr-09	29.70	4.12E+09	Tumbling80um, VEP200um, 600C bake(Jlab), VEP20um, 115C bake, Q-disease
LR9-1	2-Feb-10	27.49	9.39E+09	600C bake(Jlab), VEP, 115C bake
LR9-1	6-Apr-10	-	-	Re-HPR, 115C bake, RF cable/probe failure
LR9-1	17-Apr-10	27.91	7.80E+09	retune 4%, re-HPR only

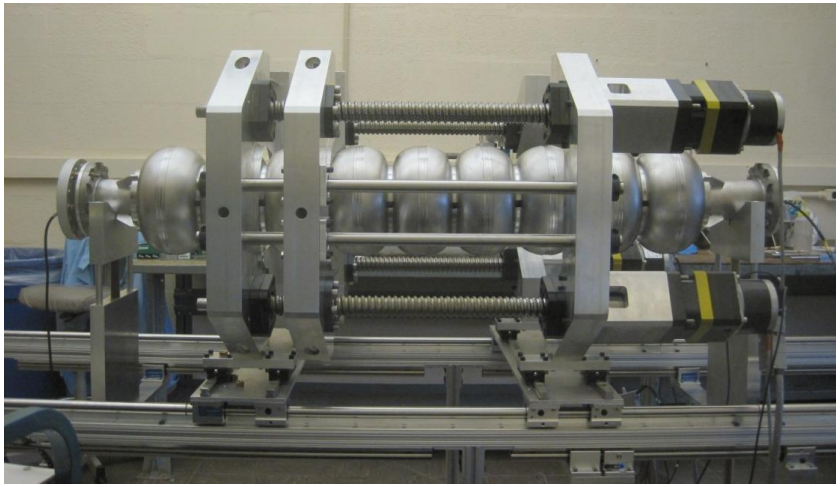


Re-entrant 9-cell status & plan



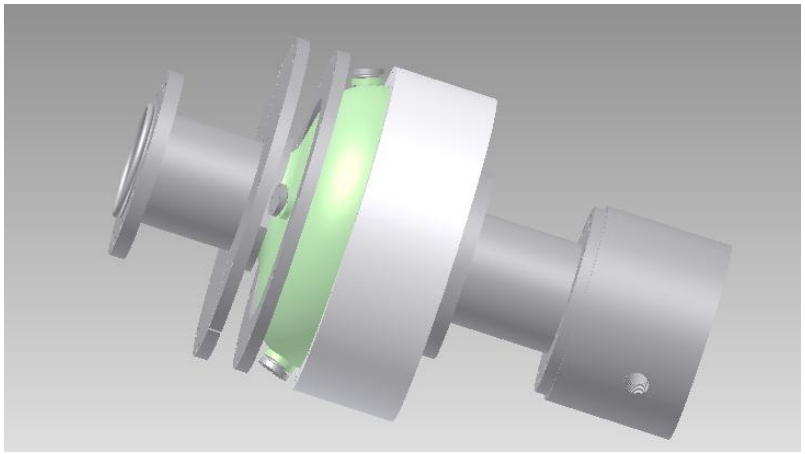
Sept2012

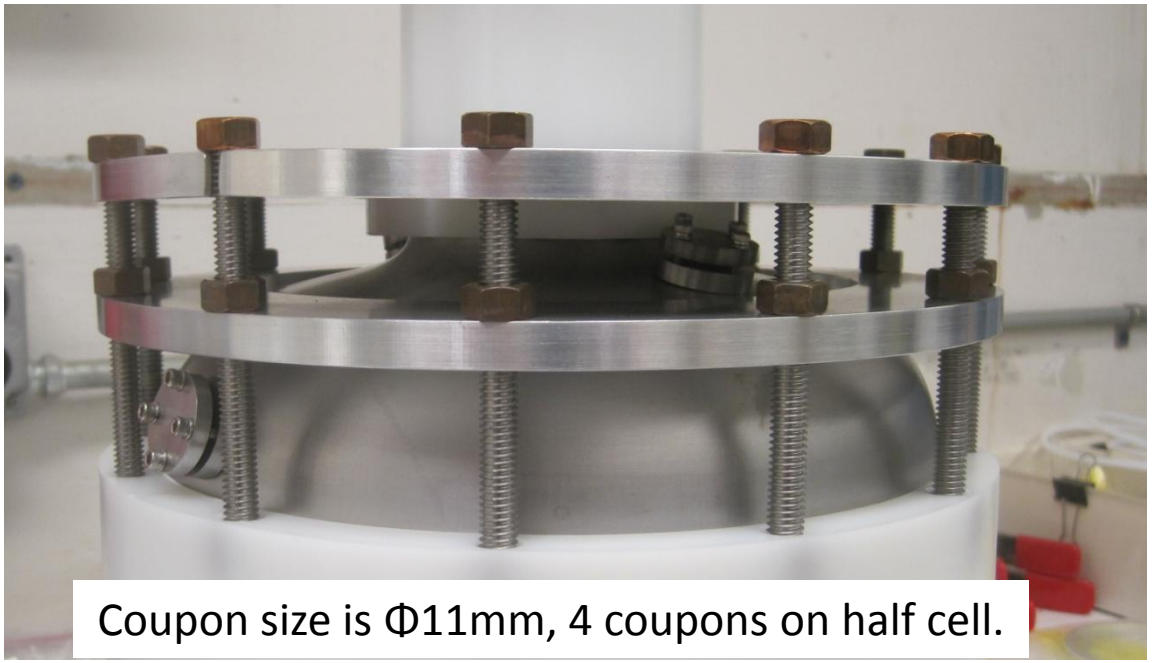
Stiffener weld was completed by AES.



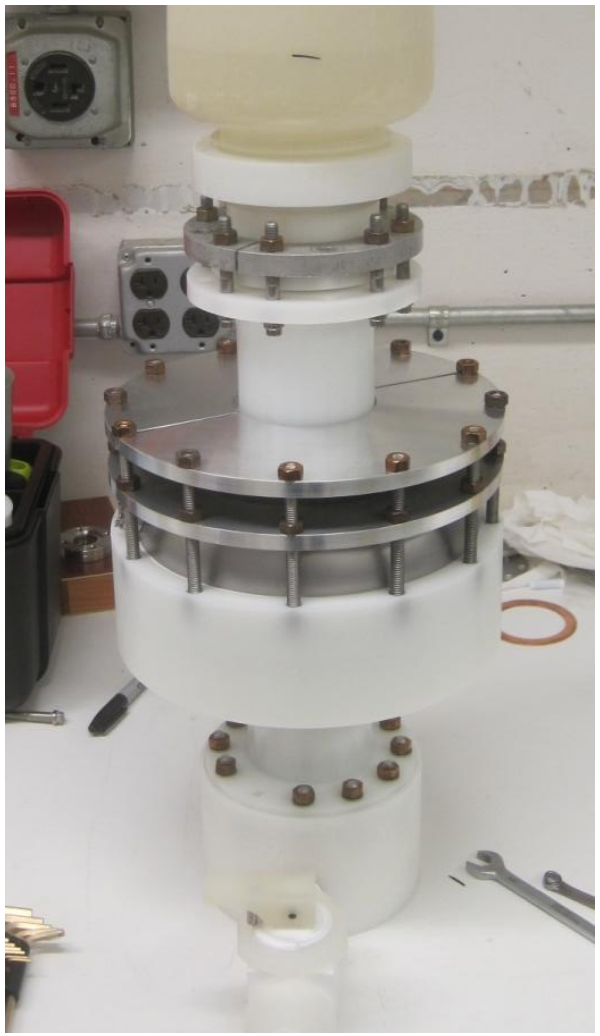
Field flatness tuning, VEP were done.
RF test next week.

Fundamental R&D on VEP w/ half cell coupon cavity





Coupon size is Φ11mm, 4 coupons on half cell.



Plan for coupon cavity R&D

Demountable half cell coupon cavity is ready, half cell w/ coupon could be oriented both of top and bottom side.

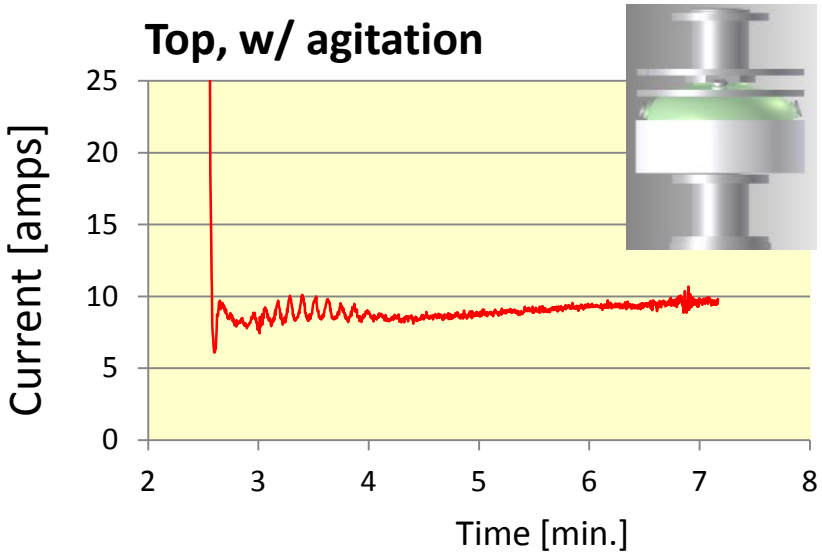
Short term plans

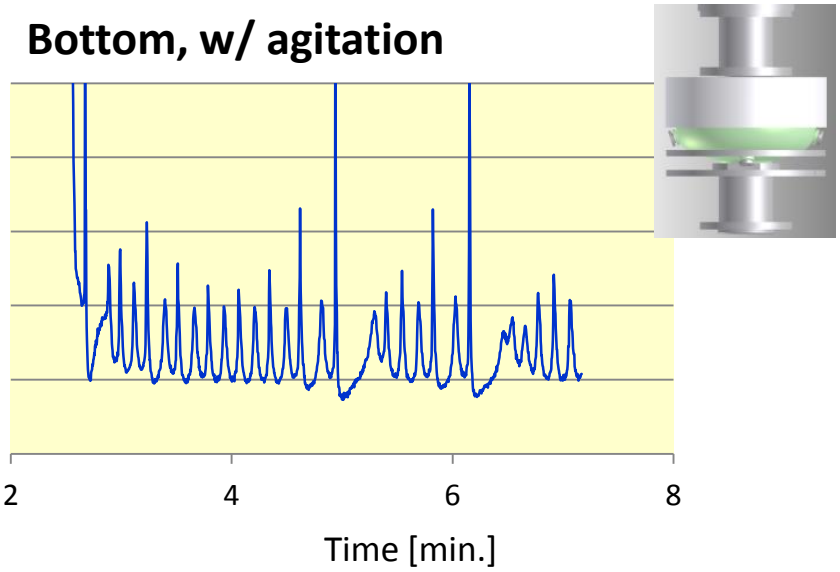
(1) Data taking of I-V curve, current & temperature profiles.
(2) Comparison of half cell orientation of top and bottom.
(3) Coupon analysis; removal, roughness, contaminants.
(4) Parameter (V, I, temp, stirring, etc.,) optimization for smooth & contaminants free RF surface.
(5) full-cell coupon cavity is under fabrication.

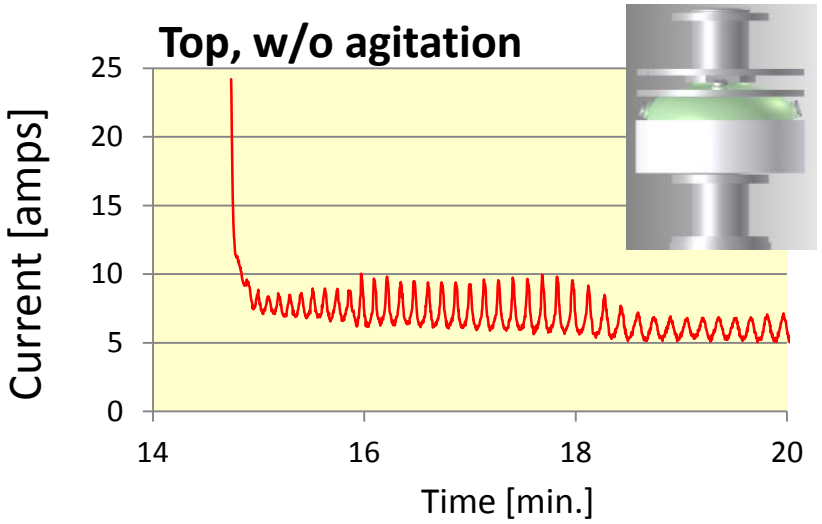
Long term goals

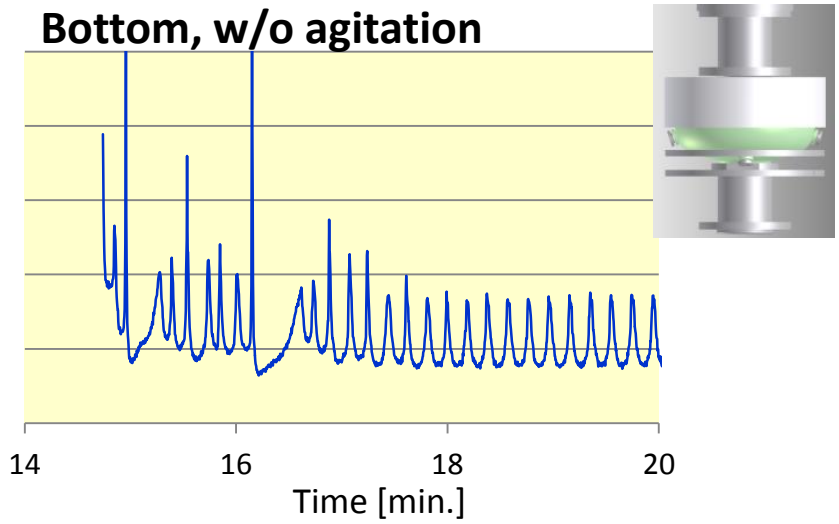
- Understanding & control of VEP.
- Feedback to single-, multi-cell process.
- Demonstrate high yield of cavity performance w/ VEP.

Results of half cell VEP Comparison of top & bottom

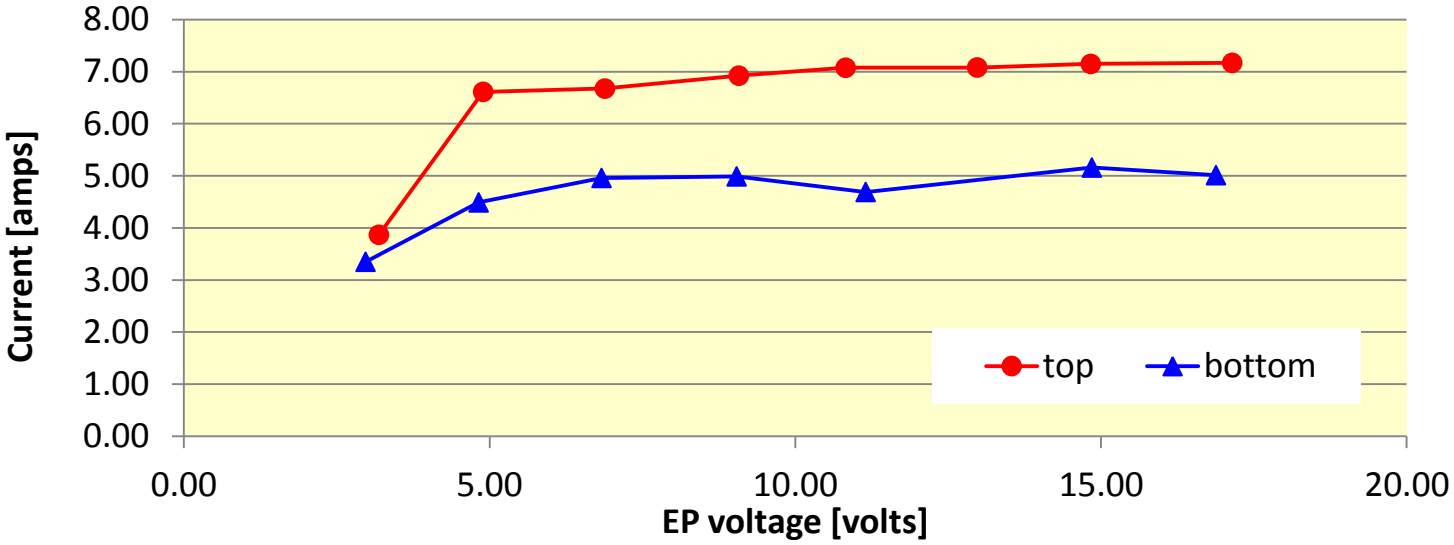


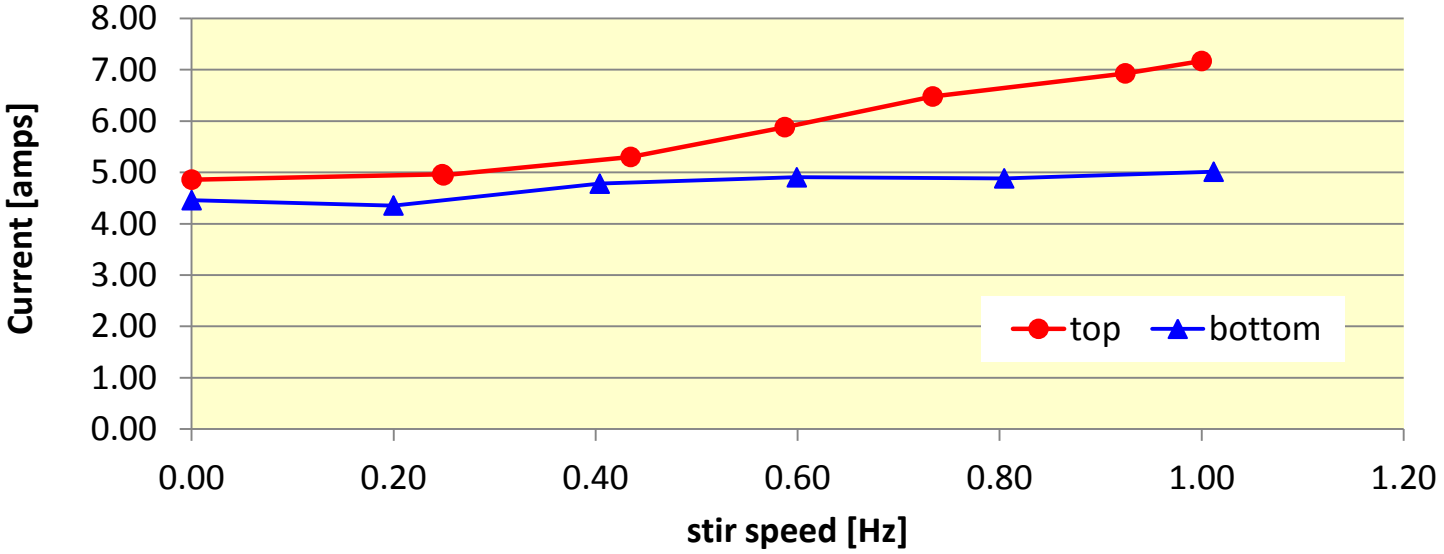




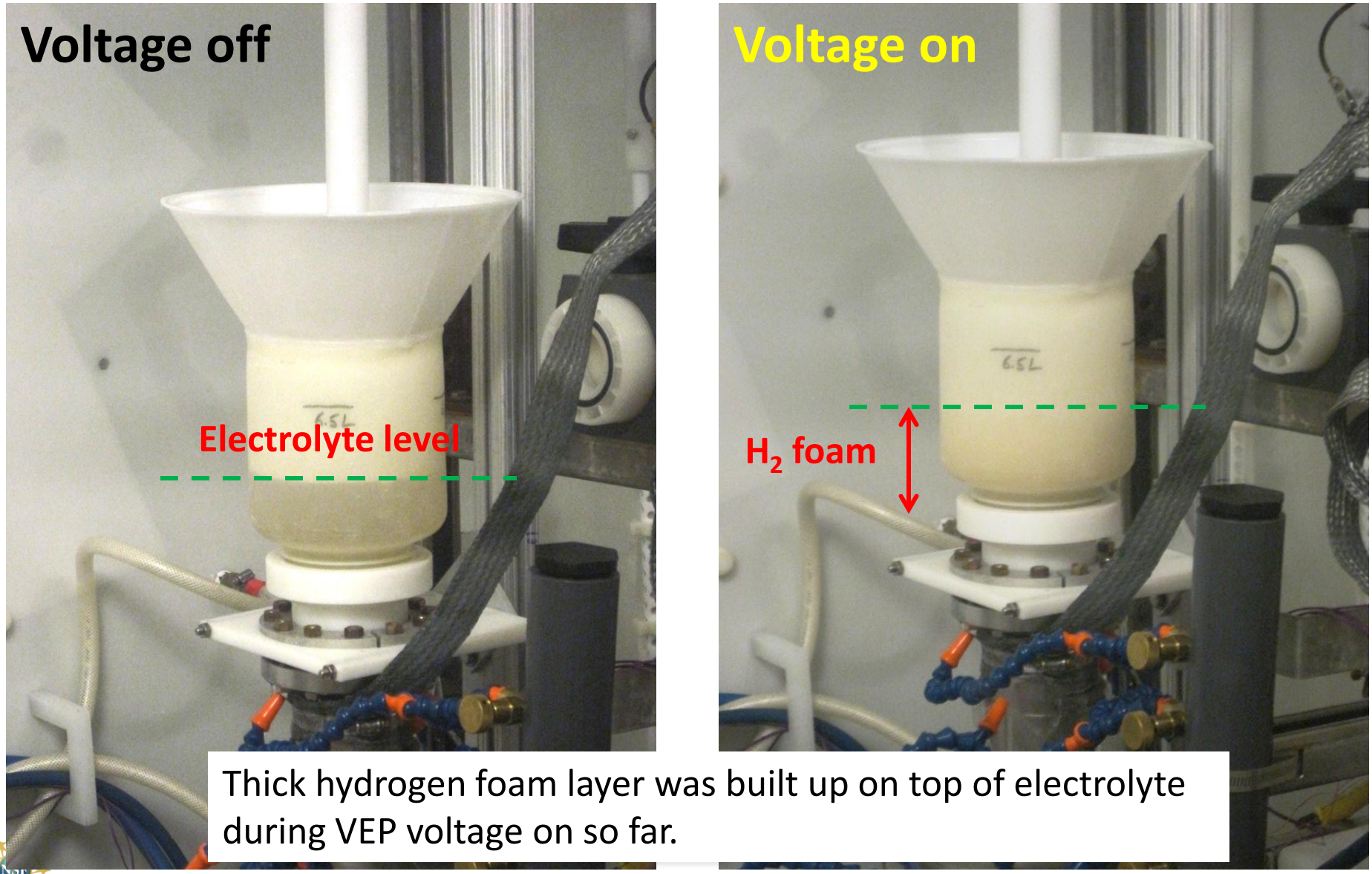


I-V curve, stir speed dependence



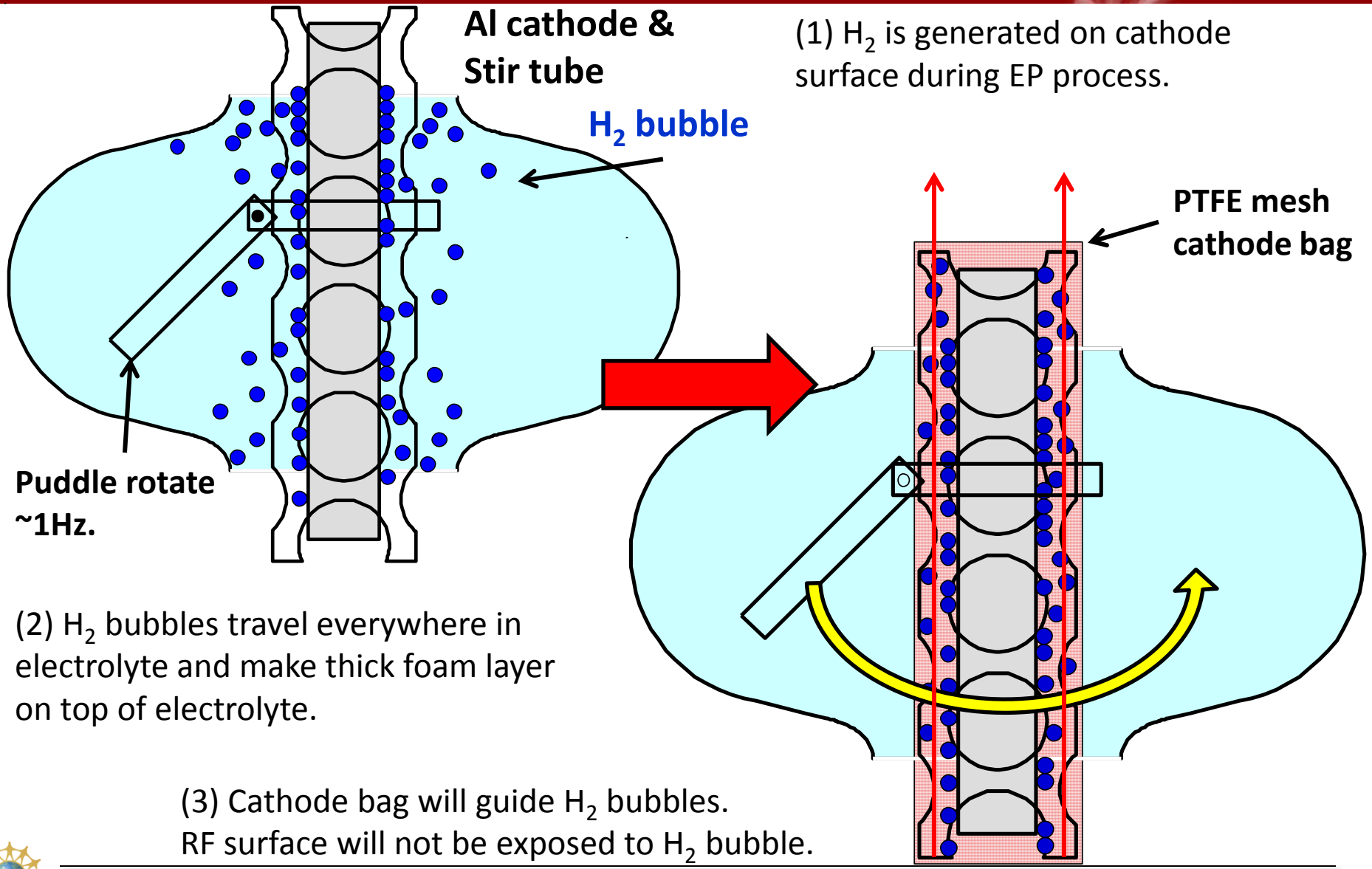


Reduction of hydrogen foam build up



Thick hydrogen foam layer was built up on top of electrolyte during VEP voltage on so far.

Image of H_2 bubble in electrolyte

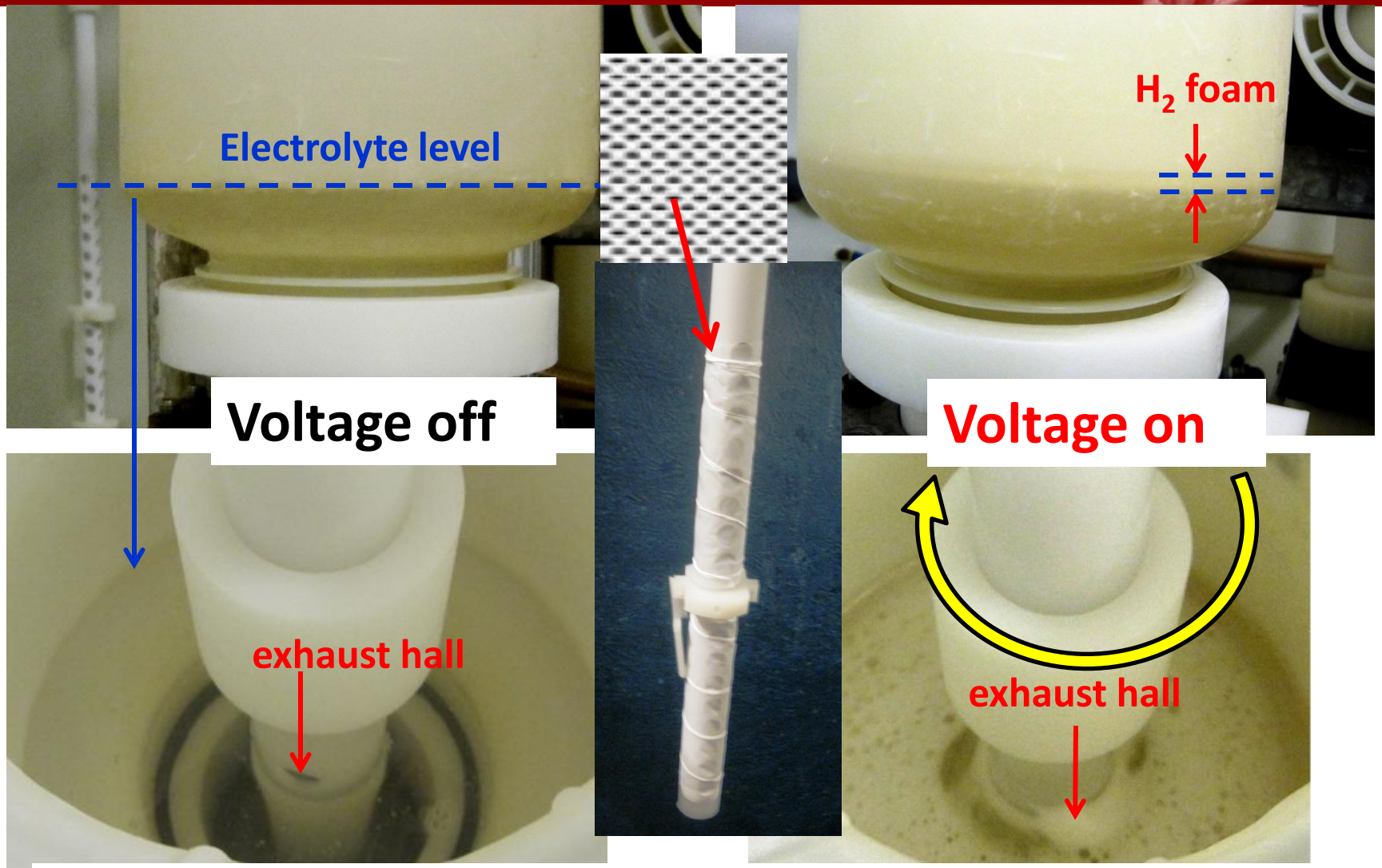


(1) H_2 is generated on cathode surface during EP process.

(2) H_2 bubbles travel everywhere in electrolyte and make thick foam layer on top of electrolyte.

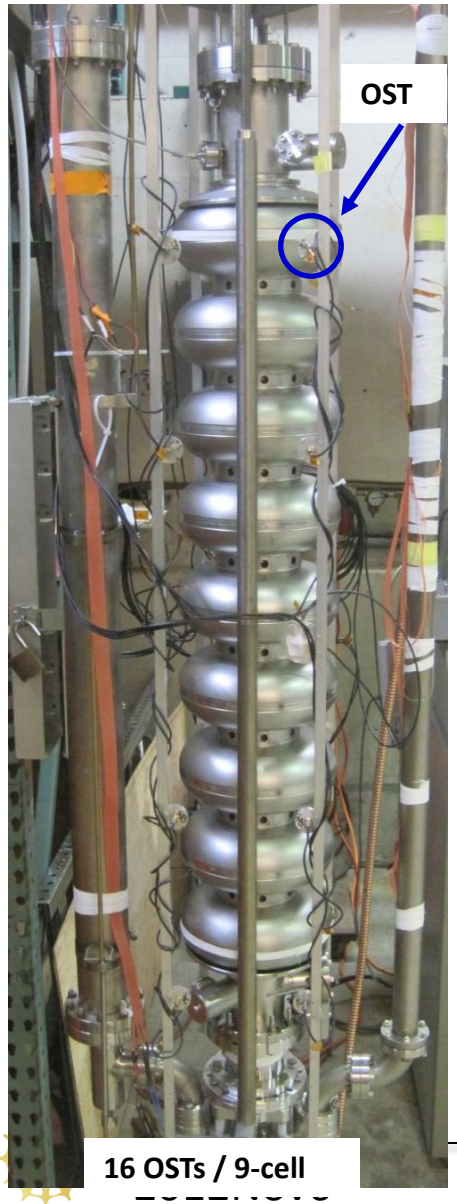
(3) Cathode bag will guide H_2 bubbles.
RF surface will not be exposed to H_2 bubble.

1st trial of VEP w/ PTFE mesh on cathode



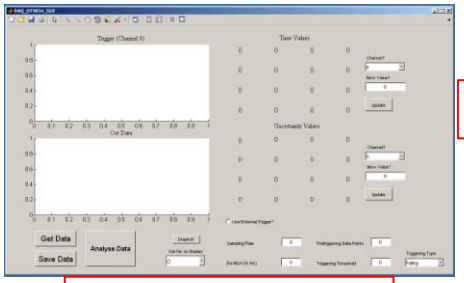
Cathode bag successfully guided hydrogen and reduced hydrogen foam layer.

Quench study –Cornell OSTs



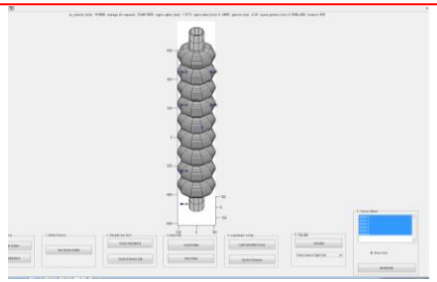
16 OSTs / 9-cell

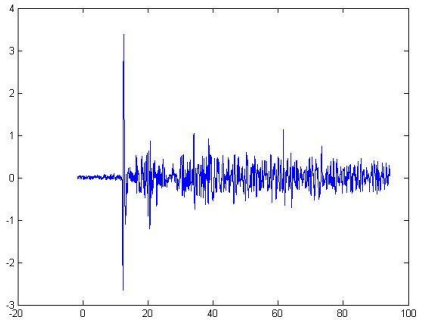
New OSTs signal analysis program

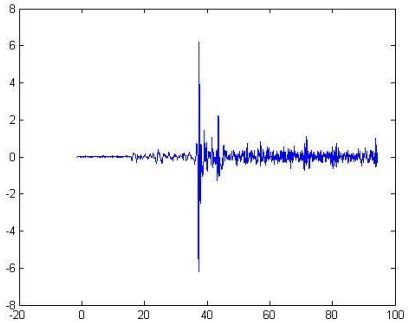


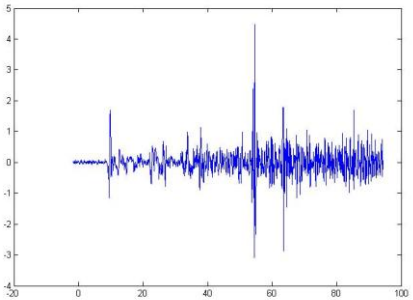
1. Data Acquisition

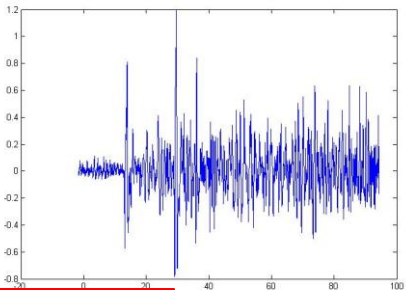
2. Quench location calculation





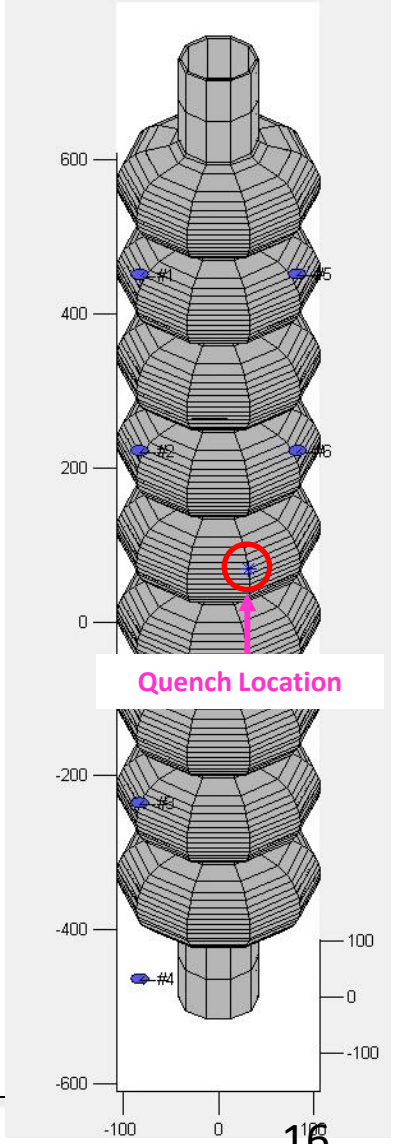






Examples of OSTs signal

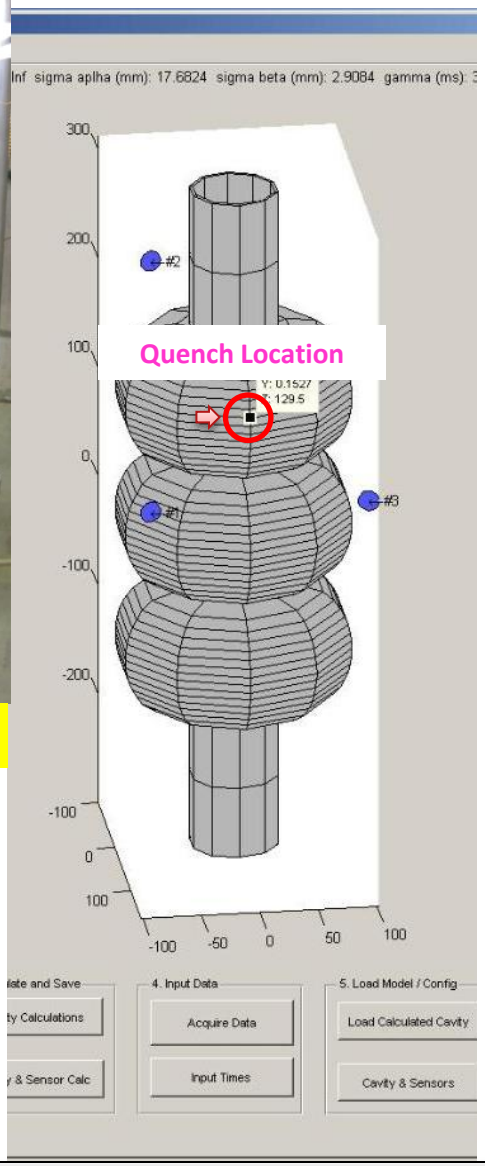
Program output



Quench study –Cornell OSTs (2)

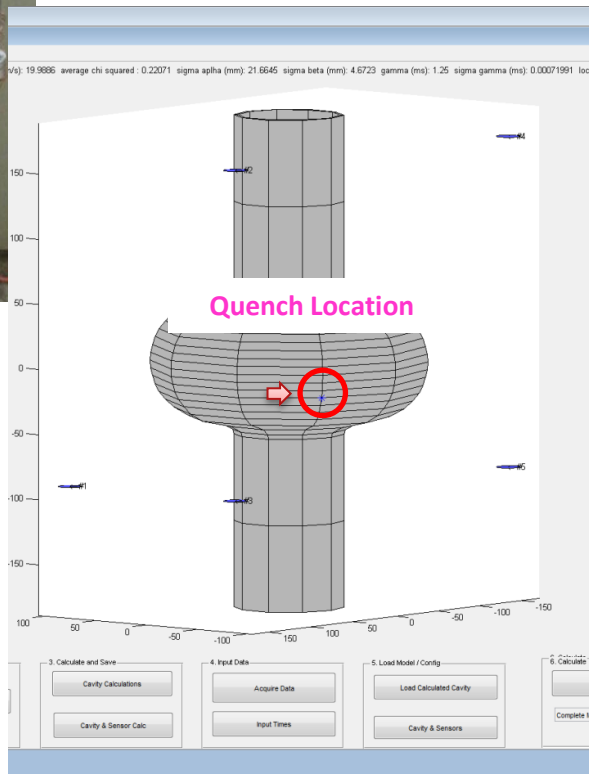
12 OSTs / 3-cell

Re-entrant 3-cell



8 OSTs / 1-cell

TESLA shape single



Quench study -Cornell multi-cell T-map

Multi-cell T-map boards are available for both of Cornell's ERL 7-cell and ILC TESLA 9-cell.

7-cells boards are in use.
11 [sensors/board]
x 24 [boards/cell]
x 7 [cell]
=1,848 [sensors]

End cell boards for 9-cell are under preparation.

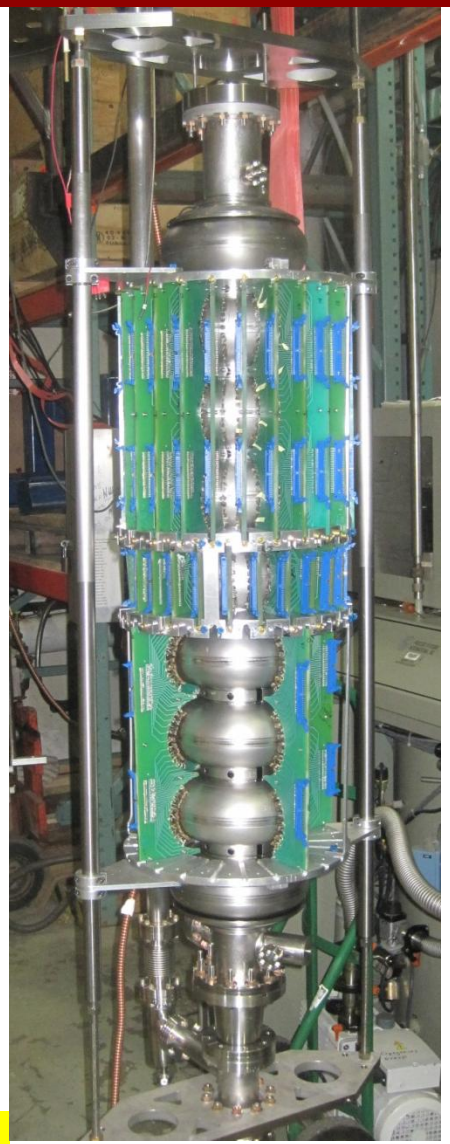
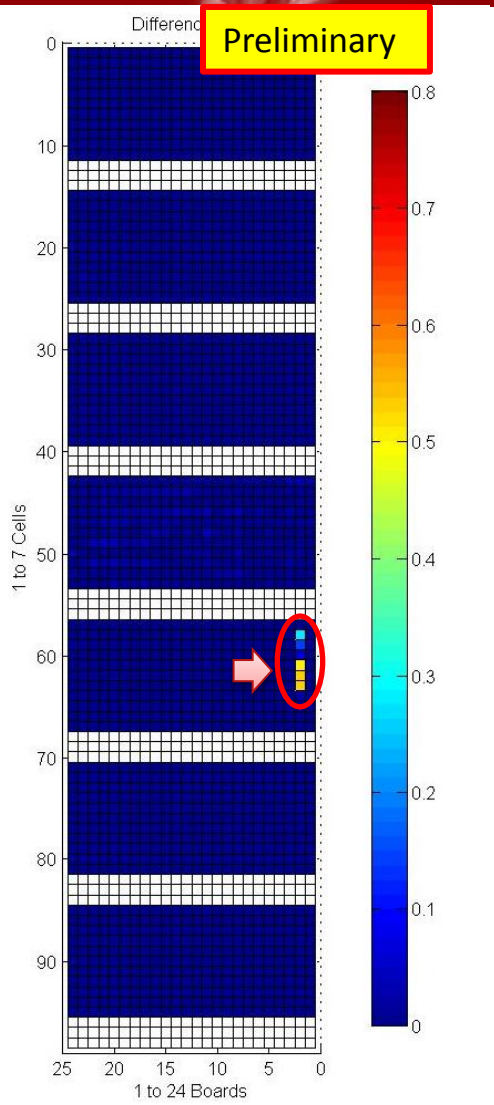


Photo: 9-cell w/ T-map boards.



1st results of hot spot taken by multi-cell T-map system w/ 9-cell.

Summary

Cornell's VEP achieved ILC's BCD specs w/ TESLA 9-cell.

1) Minimizing final VEP removal seems to be key to success.
2) Fundamental study w/ coupon cavity just starts.
   → systematic study is on going.
   → feedback to single- and multi-cell VEP.

High gradient R&D w/ RE shape is on going.

1) Stiffener weld on 9-cell Re-entrant was completed by AES,
   cavity is ready to test.
2) High priorities are
   → Establish of high yield w/ single cell (TESLA/RE) + VEP.
   → Demonstration of high gradient (>40MV/m) w/ 9-cell RE + VEP.

Cornell's OSTs and multi-cell T-map systems are well established. These techniques are available for many SRF cavity applications.