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Investigation of 9-Cell Cavity Performance Problem by Facilities in KEK AR East 2nd Experimental Hall

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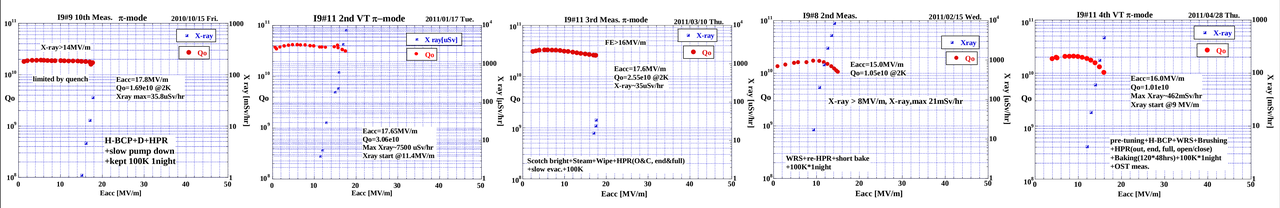
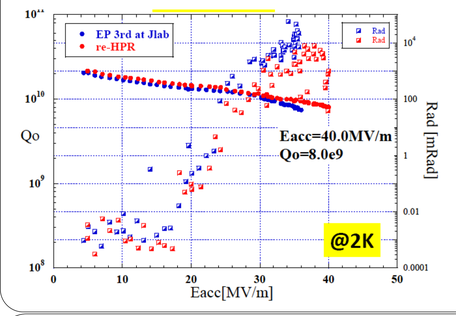
Abstract

So far our 9-cell cavity performance is suffering from field emission. We are investigating our facilities at the KEK AR East 2nd experimental hall. We examined two points of view post EP/BCP cleaning and particle contamination. Particle contamination problem has been found in our HPR system, cavity assembly and vacuum evacuation procedure. We have taken cures against these problems. We will report about these problems and the cured results on cavity performance in this paper.

Motivation of the Investigation



As seen in the top figures, since last October 2010, our Ichiro 9-cell cavities have very bad results. The measurement were in order. I9#2nd and 3rd were limited by hard quench due to less material removal(60μm). Comparison of these results suggests that our strengthen end group cleaning is effective to reduce field emission. However, other most cases were limited by field emission. The most concern is the onset of X-ray. X-ray starts from 10-15MV/m level. We have often seen the X-ray onset around 20MV/m due to multipacting (two point first order) in single cell cavities but 10-15MV/m X-ray onset is too low.



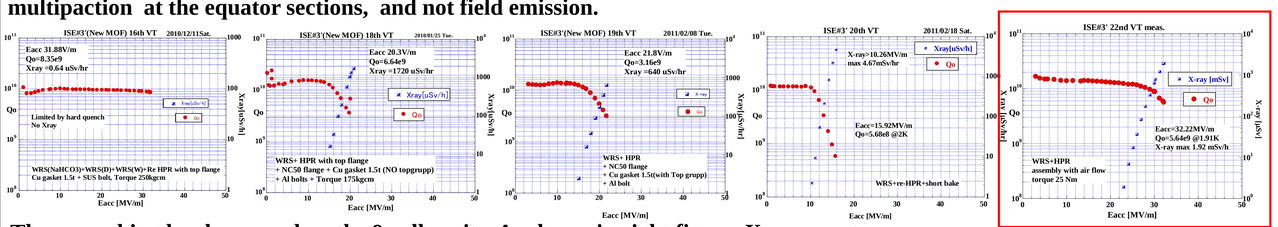
The left figure shows the ICHIRO#7's results which were tested in Jlab. All preparations including EP were done in Jlab. In this case, X-ray onset is around 15MV/m. ICHIRO#7 has a lower X-ray onset and much serious in amount compared with ILC TESLA shaped cavities treated and tested in Jlab. ICHIRO cavity shape has a few higher Ep/Eacc ratio: 2.3 with ICHIRO 9-cell and 2.0 with TESLA 9-cell. Is the difference of cell shape related to this result?

Our concern are in 1): why the X-ray onset is so low in our recent test,
2): why the amount of X-ray is so serious in our test.

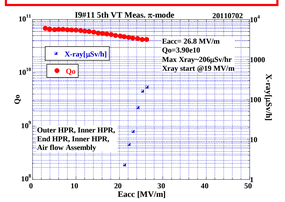
We have investigated our facility to look for the answer on above question from particle contamination point of view.

Results on Cavity Performance

Similar results as above 9-cell cavity ones were happened on the single cell cavity with MO sealing. Since last January every result was limited serious field emission of which X-ray onset is 10 to 15MV/m. When clean air flow assembly method and other cures on HPR were applied, the flow was clearly changed. X-ray onset was pushed up to 21MV/m, which relates the two points multipaction at the equator sections, and not field emission.



The same thing has happened on the 9-cell cavity. As shown in right figure, X-ray onset was pushed over than 20MV/and much reduced the amount of X-ray by theses cures.



Summary

We have investigated our facility specially from particle contamination point of view.We found that our traditional HPR, cavity assembly and evacuation processes have a high probability to introduce lots of particle contamination into cavity. Assembly and evacuation were very problematic.

We learn Jlab is doing right way on these problems: ultrasonic rinsing of bolts and nuts, air blowing before their uses and slow evacuation .We have innovated more reliable and worker independent assembly method by clean air flow, which might eliminate large cleanrooms for cavity assembly in near future.

Method

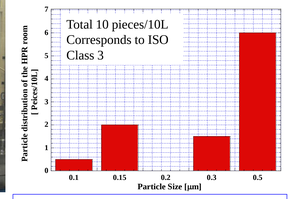
Generally saying, this kind of problem might be related to many things like cavity shape, fabrication, surface treatment, cleaning, cavity assembly, evacuation and cavity setup in vertical test. However, our facilities at AR East 2nd experimental hall in KEK have been qualified for single cell cavities. We suspect first whether there would be problems with 9-cell cavity in the traditional procedure established for single cell cavity.

Field emission is coupled easily with particle contamination issue. So we started from this issue. First we investigated all the processes after HPR up to cavity assembly using particle counter. If we find a problem, it will be cured. Finally the procedure included all cures are applied for a single cell and a 9-cell cavities and the effect isb confirmed.

Investigation of particle contamination in the procedure and the cures

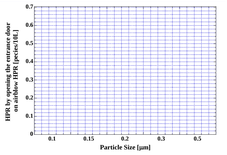
1) Environment of HPR Room

Environment is not so great.



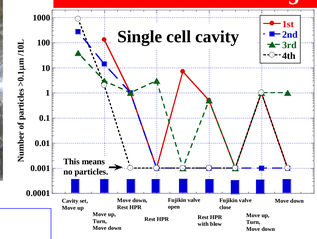
As the cure, clean air flow method was applied, which was so excellent!

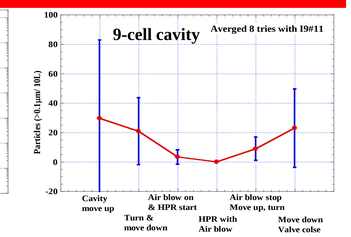
Even door is opened during HPR, no particle comes into cavity.



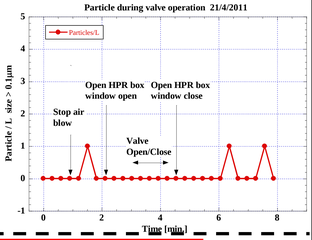
2) HPR Process

Lots of particles come into cavity before/after HPR from the environment on both single and 9-cell cavities.



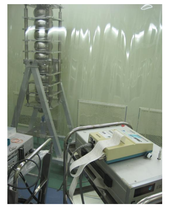


As the cure for protecting particle after HPR, a small window was put on the HPR box, by which we can access to close the cavity bottom valve at the end of HPR.



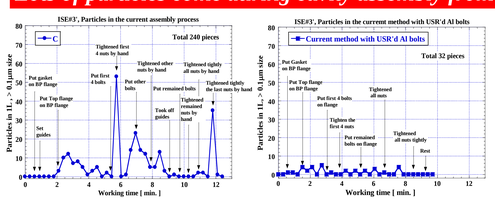
3) Class 10 Cavity Assembly Area

Excellent ! No particles



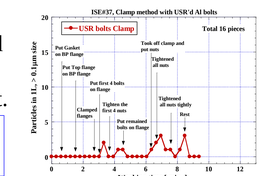
4) Assembly

Lots of particles come during cavity assembly from bolts and nuts.



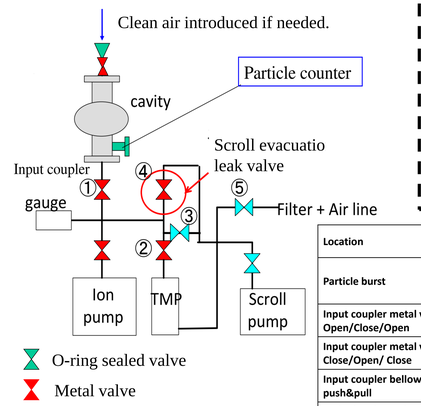
Ultrasonic cleaning of bolts and nuts helps to reduce particle contamination.We understand Jlab is doing right way.Clamp method also helpful for MO sealing. Aluminum alloy bolt produces more particles than SUS bolt. However, these cures are not always perfect.

As a more reliable cure, we applied clean air flow method, which reduces more particle contamination with less worker dependence.



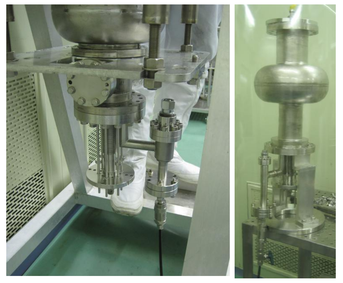
5) Vacuum Evacuation

Lots of particle appear at valve operation.



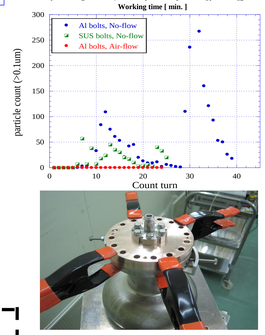
The particle counter breaths air in the cavity through the input coupler port to count particle. The particle larger than 0.1μm was measured.

Location	Averaged number of particles at Input port	Max	Min	
Particle burst	-	33706	80	Needle valve, Input coupler metal valve
Input coupler metal valve Open/Close/Open	15.4	22	1	Closed needle valve
Input coupler metal valve Close/Open/ Close	2.5	8	0	
Input coupler bellows push&pull	1.6	3	0	
Turbo head metal valve Close/Open/Close	7.2	17	1	
Scroll valve Close/Open/Close	13.2	33	0	
Slow evacuation valve Close/Open/Close	3.4	7	0	
Open needle valve	-	79	0	
Clean air through needle valve	14.2	29	3	



Air flow effect

Worker	Present method Al bolts	Present method SUS bolts	Air flow method Al bolts
A	698 (In)	73 (In)	0 (MO Cu)
B	575 (MO Cu)	333 (MO Cu)	7 (MO Cu)
C	2239 (MO Cu)	424 MO Cu)	1 (MO Cu)
D	123 (In)	27 (In)	7 (MO Cu)



Cavity Input coupler MV opened under a vacuum level of the evacuation line		Opened the scroll top valve suddenly at a cavity vacuum level
Vacuum level of the evacuation line	Particles > 0.1μm size/min.	Particles > 0.1μm size/min
710mBar	0	9
650mBar	0	11
600mBar	0	5
500mBar	0	2
6.1E-2 mBar	0	Average 6.8

Cure: First evacuate the line with cavity valve closed, then open the valve when the evacuation line pressure goes down an under-pressure.