Suggestions of H.G limitations from single cell study @ KEK

KEK

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Presented by Y.Morozumi

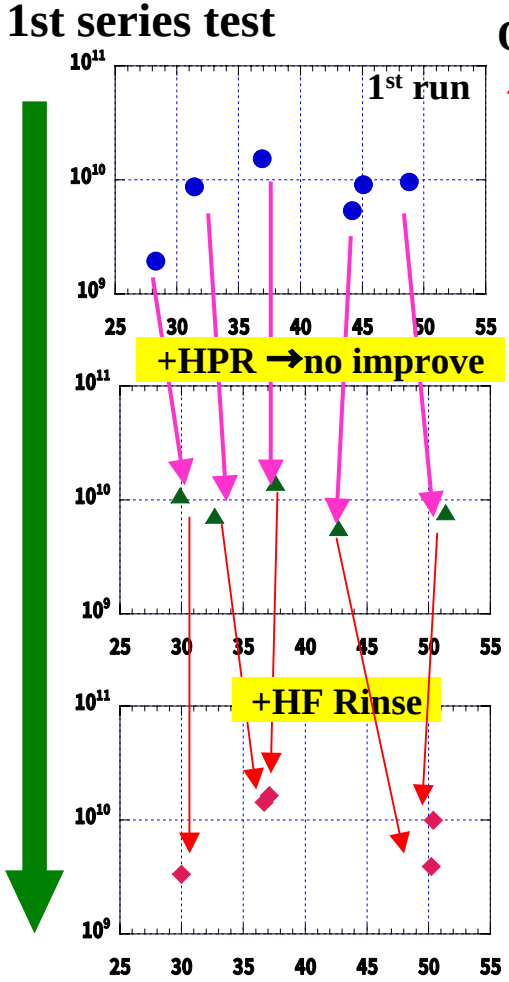
Several trials to eliminate defects

Easy mistake
In HPR or assembly ?
↓
Additional HPR only

Contaminations
in EP process?
↓
Rinse, Light polishing

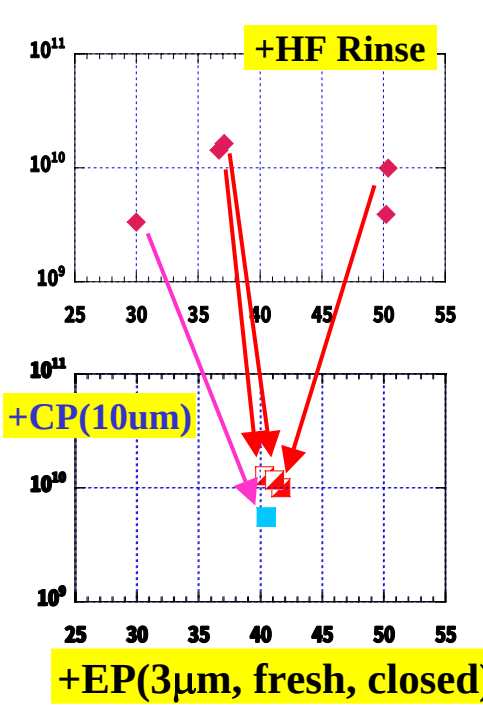
Additional 3μm EP
with fresh acid
is effective.

1st series test



Q

Eacc max



Conclusion:

The source of failure (50%) is coming from thin surface < ~20 μm.

Need a material removal to eliminate these hard quenches.

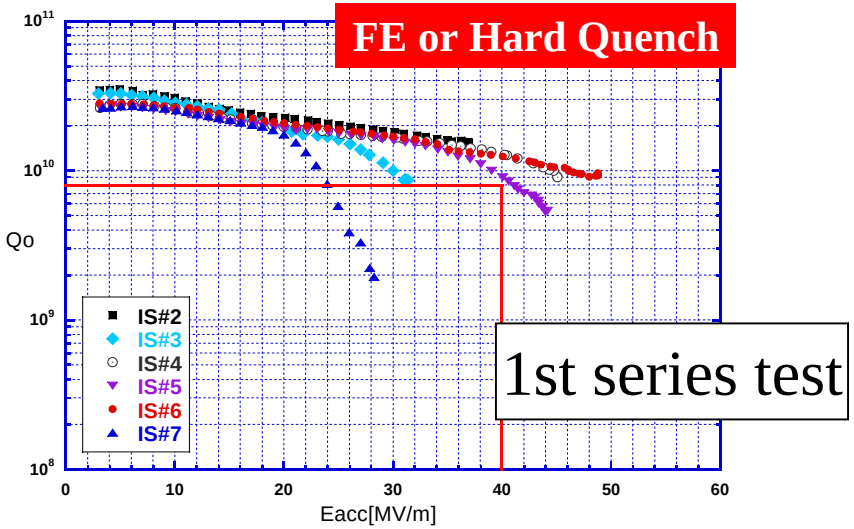
Reset cavity surface by CBP, try new recipe include 3μm EP after a heavy EP of 80μm.

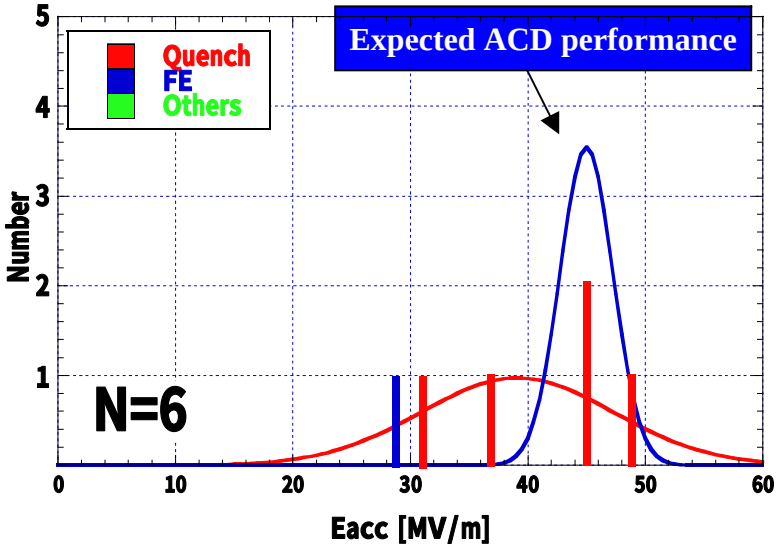
IS 2nd series test

Current recipe study by single cell @ KEK

CBP(100μm)+BCP(10μm)+AN(750^{O}C, 3hr)+EP(80μm)+HPR+Bake:

Ave. Eacc=39.1±8.2MV/m, Scattering:20%, Acceptability@40MV/m(ACD):50%

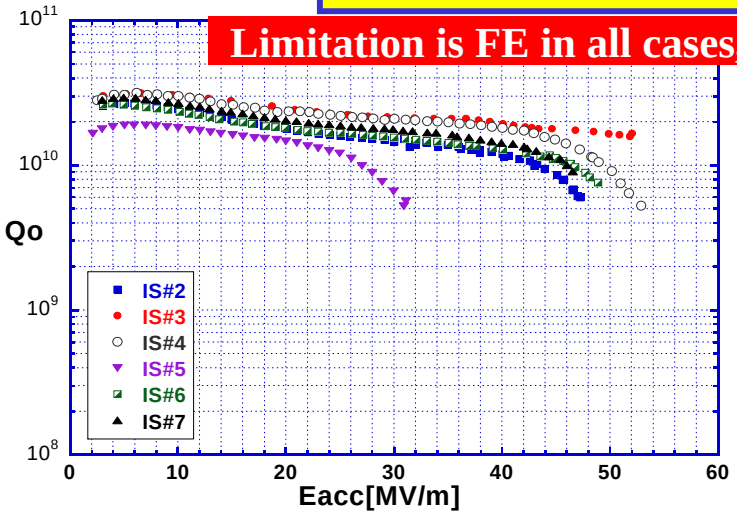


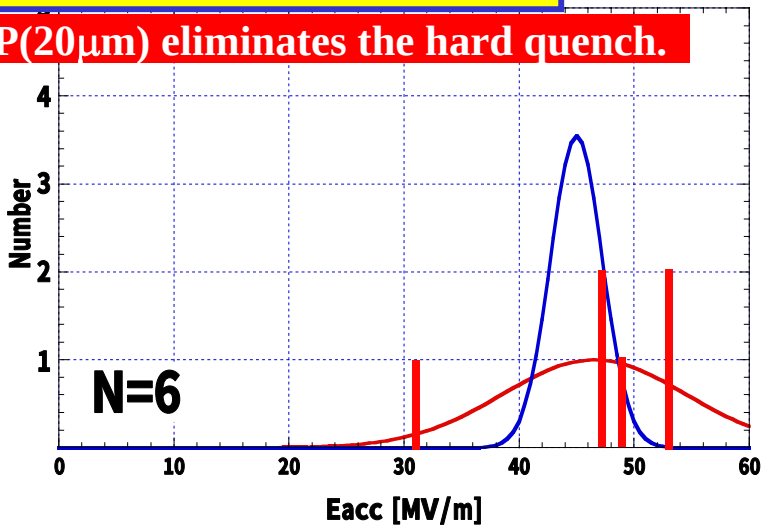


+EP(20μm)+HPR + Bake

Ave. Eacc=46.5±8.0MV/m, Scattering:17%, Acceptability@40MV/m(ACD):83%

Limitation is FE in all cases, the +EP(20μm) eliminates the hard quench.

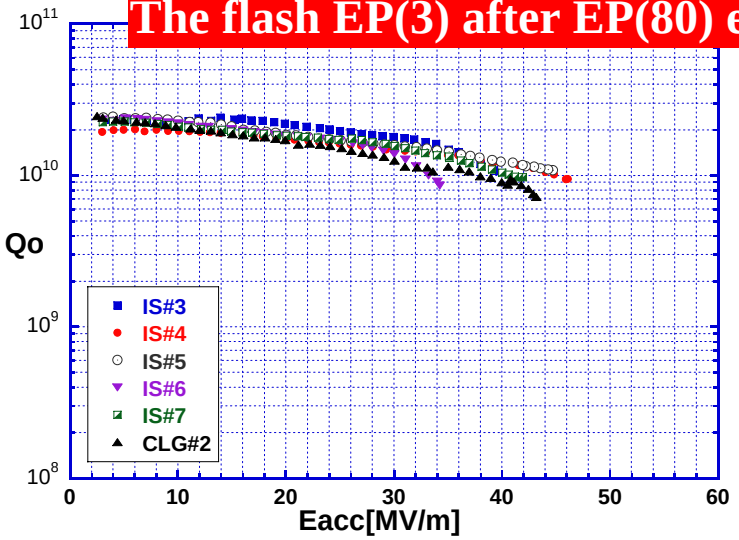


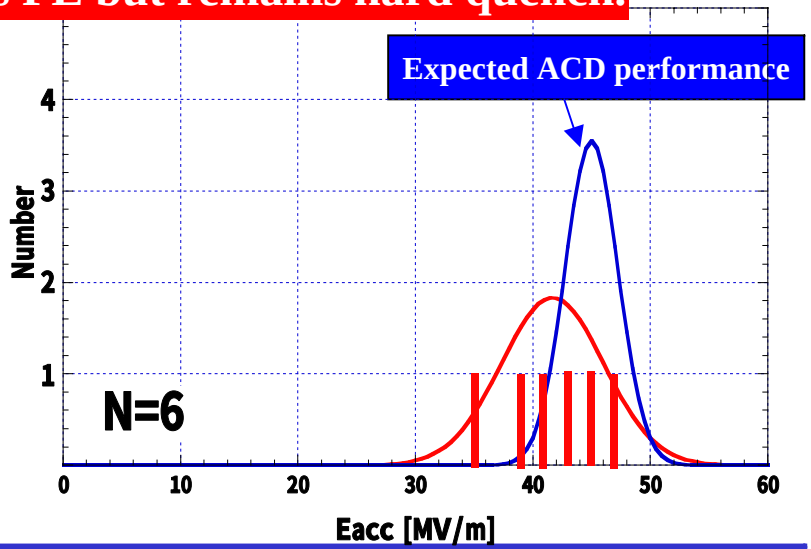


Flash EP effect on single cell @ KEK

CBP(100μm)+BCP(10μm)+AN(750^{O}C, 3hr)+EP(80μm)+EP(3μm, fresh acid) + HPR+Bake:
Ave. Eacc=41.7±4.4MV/m, Scattering:10%, Acceptability@40MV/m(ACD):67%

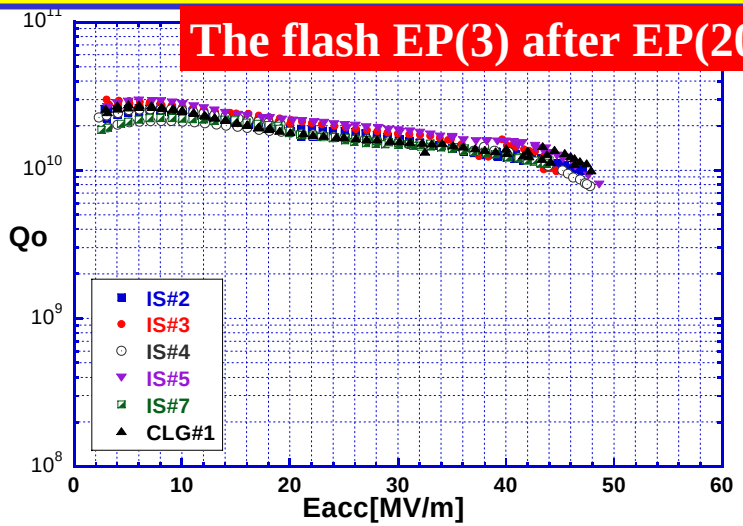
The flash EP(3) after EP(80) eliminates FE but remains hard quench.

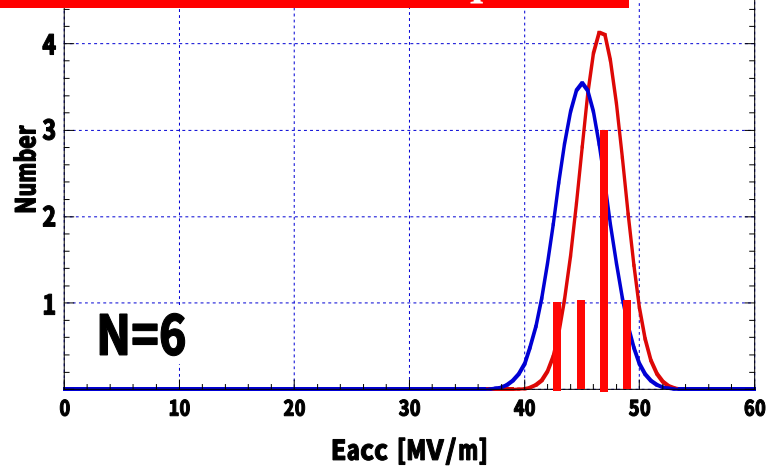




+EP(20μm)+ EP(3μm, fresh acid) + HPR + Bake: Ave. Eacc=46.7±81.9MV/m, Scattering:4%, Acceptability@40MV/m(ACD):100%

The flash EP(3) after EP(20) eliminates both FE and hard quench.



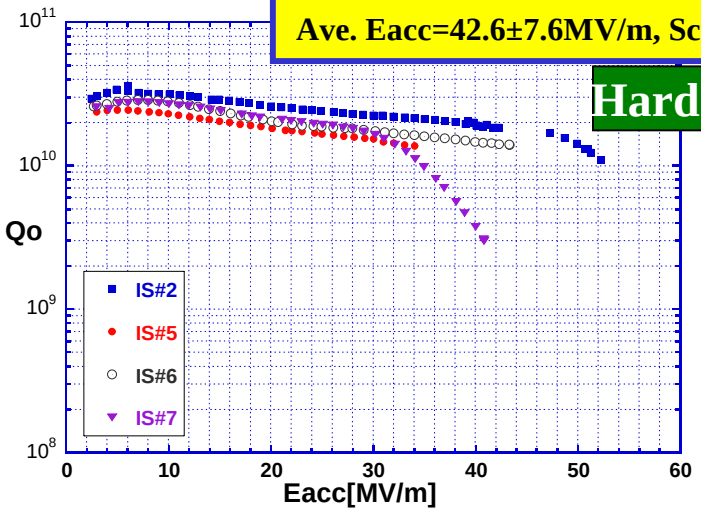


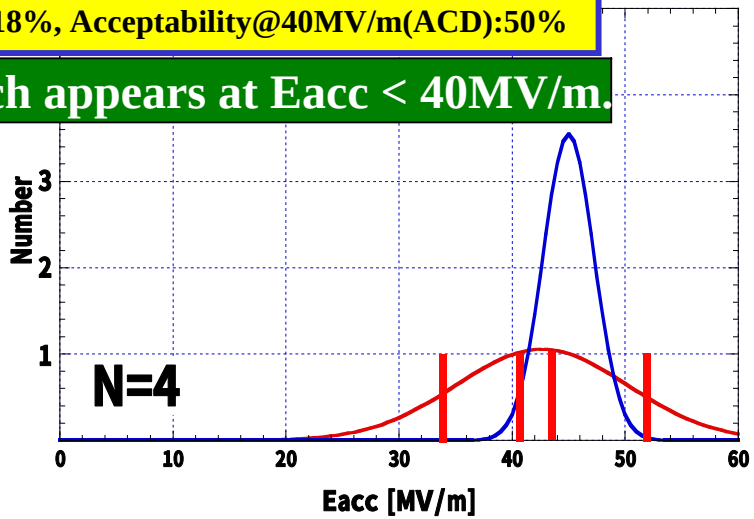
Degreasing/H_2O_2 rinsing effect on single cell @ KEK

+EP(20μm)+H_2O_2 rinsing+HPR+Bake

Ave. Eacc=42.6±7.6MV/m, Scattering:18%, Acceptability@40MV/m(ACD):50%

Hard quench appears at Eacc < 40MV/m.

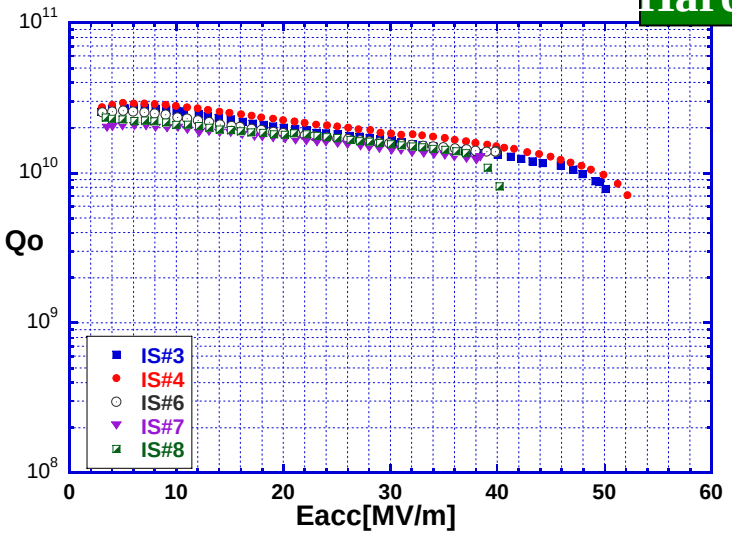


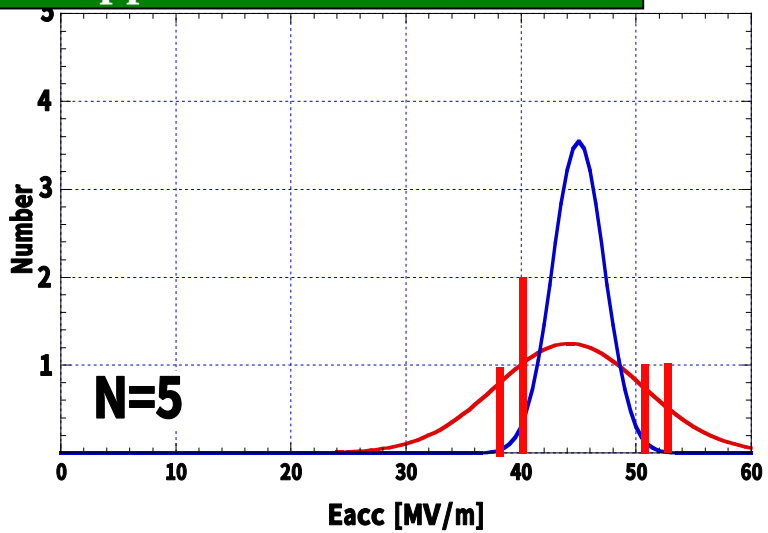


+EP(20μm)+Degreasing(0.2%)+HPR+Bake

Ave. Eacc=44.2±6.4MV/m, Scattering:14.5%, Acceptability@40MV/m(ACD):60%

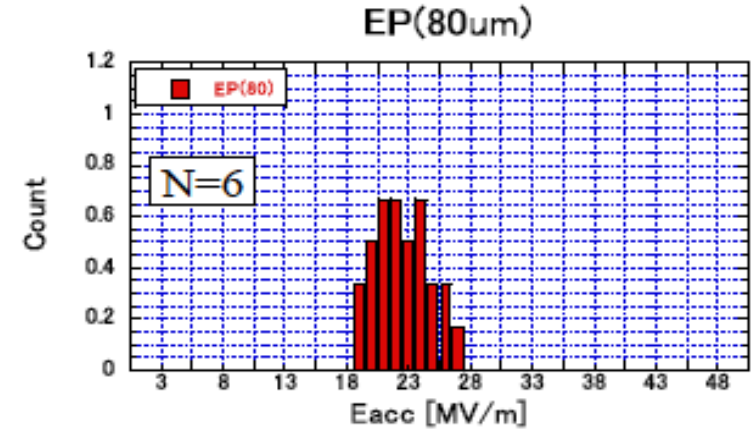
Hard quench appears at Eacc < 40MV/m.

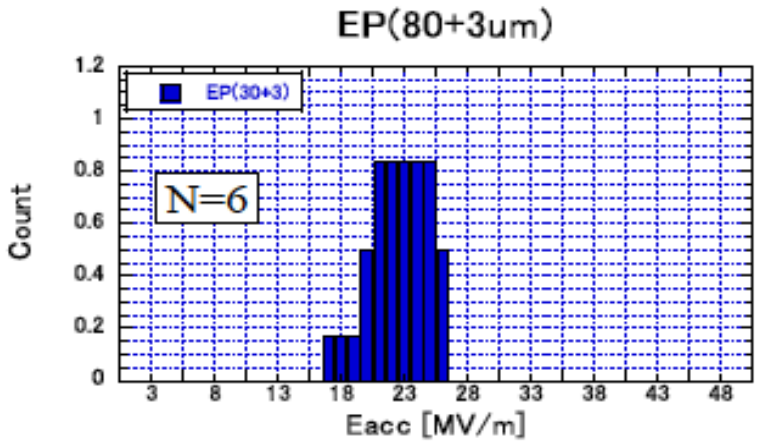


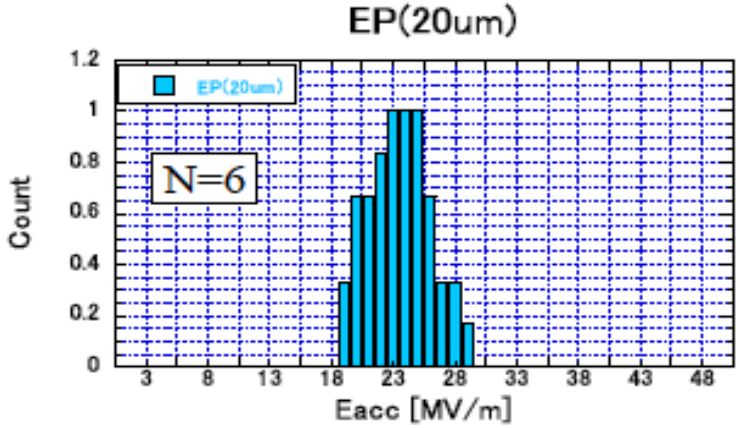


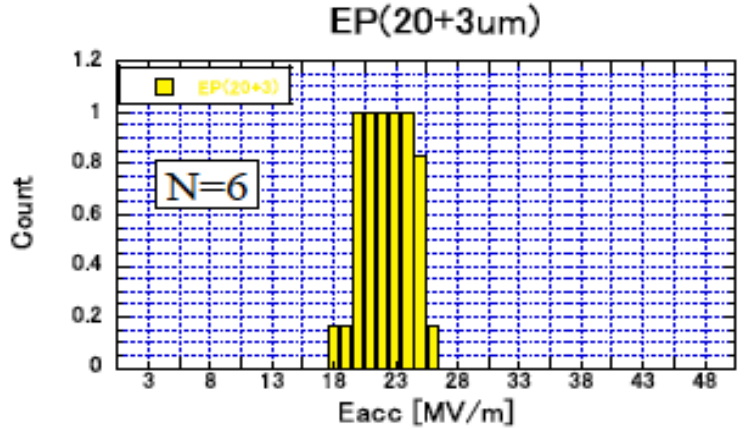
Multipacting

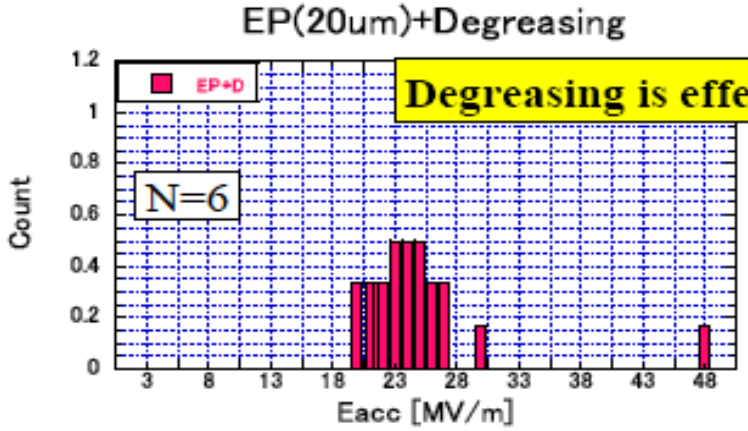
Probability of X-ray appearance



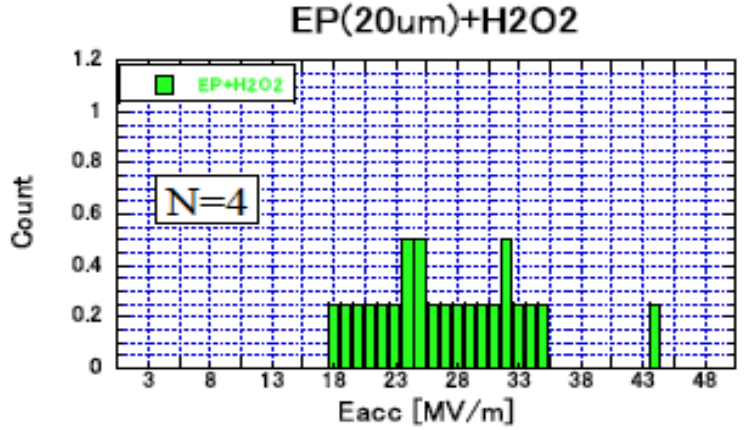








Degreasing is effective !



Basic Studies to Identify EP Residues That May Cause Field Emission

Cornell

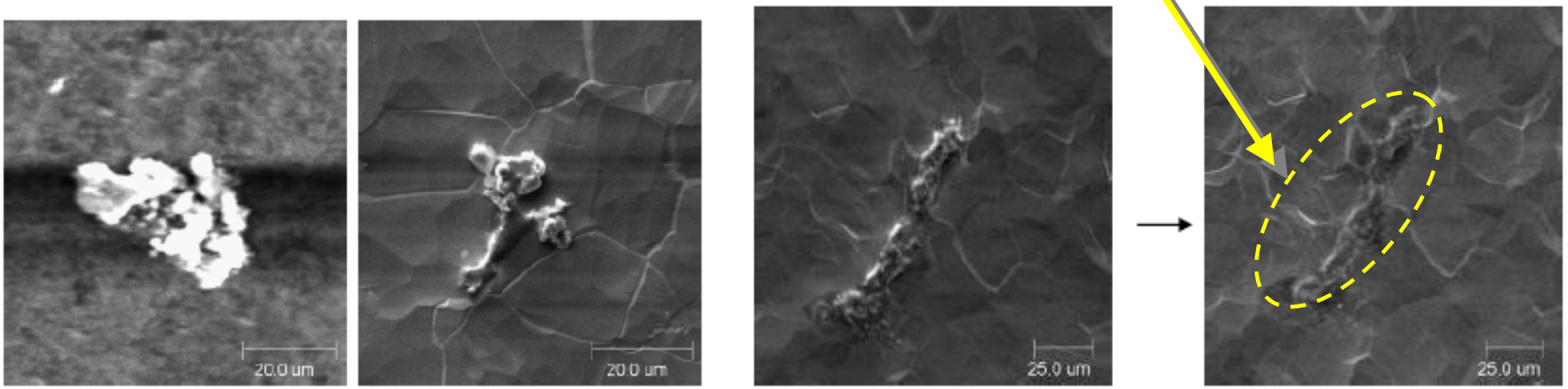
- Two main types of particles captured during EP,
  - S and niobium-oxide
  - Traces of Al also found with Auger, as expected due to Al cathode
- S particles dissolve in ethanol rinse but leave an imprint
- Oxide particles dissolve in HF rinse
  - But did not dissolve in EP !

Nb sulfide !?

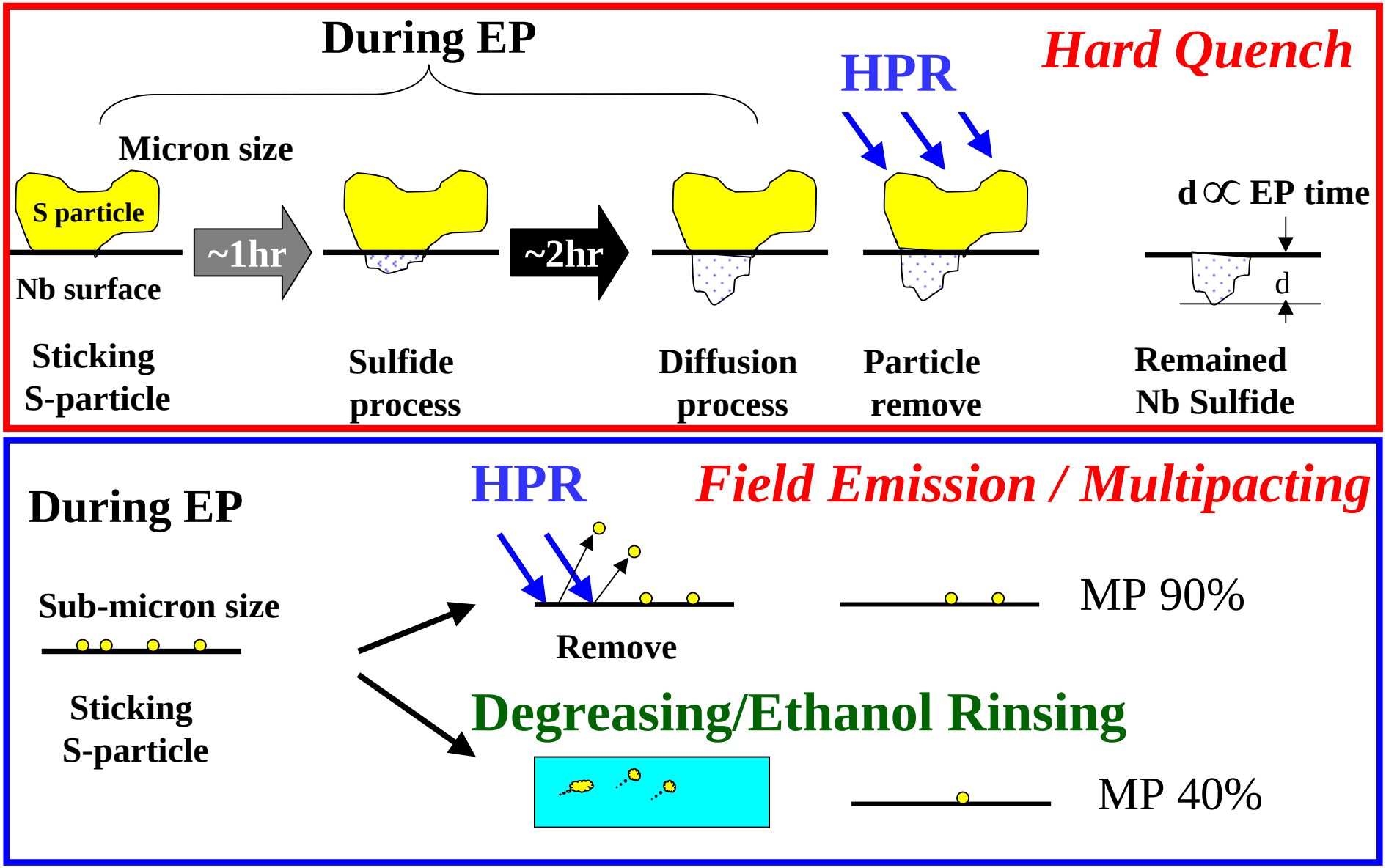
Oxide Particle

Typical S particles Deposited on Nb Surface During EP

S-Particle After Ethanol Rinse



A picture on the limitation by Sulfur contamination



Nb-sulfide could happen hard quench. The flash EP would remove the defects.
Small S-particle contamination could happen field emission or multipacting.

1st Summary on S-contamination

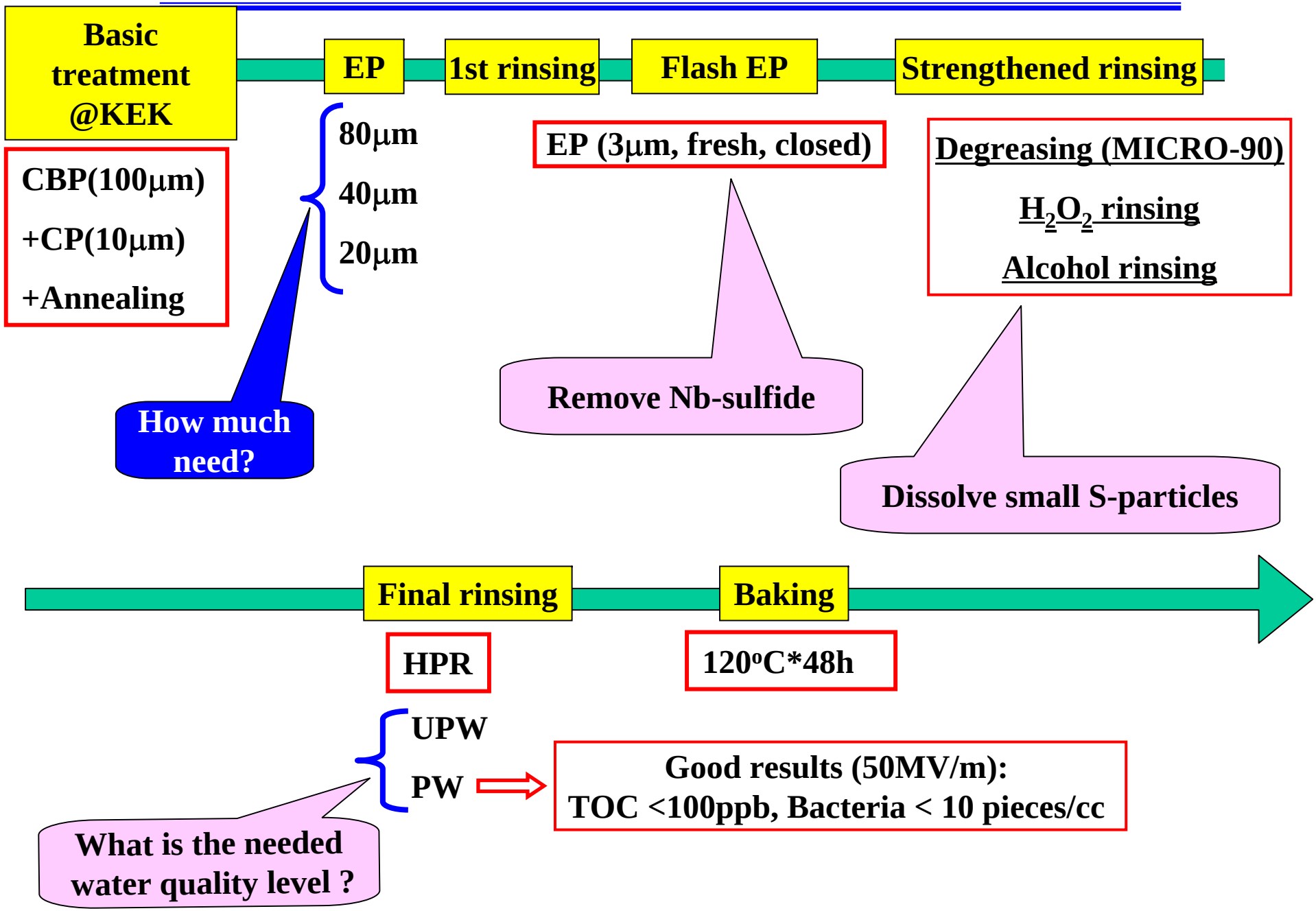
- S-contamination brings two kinds of defects:

1) Field Emission seeds by small S-particle sticking

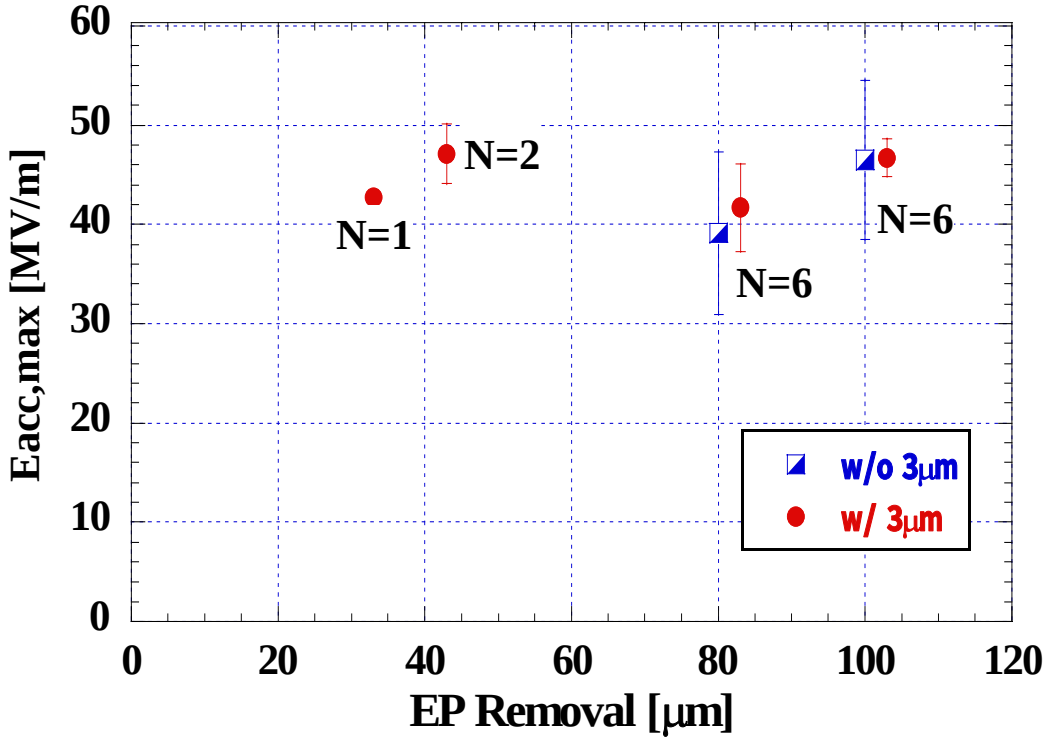
2) Hard quench defects by Nb-sulfide remained on the RF surface

- Light EP(20-30μm) can remove the Nb-sulfide, and eliminates hard quench.
- Flash EP can eliminate both defect after the light EP
- Degreasing or H_2O_2 rinsing can not eliminate hard quench.

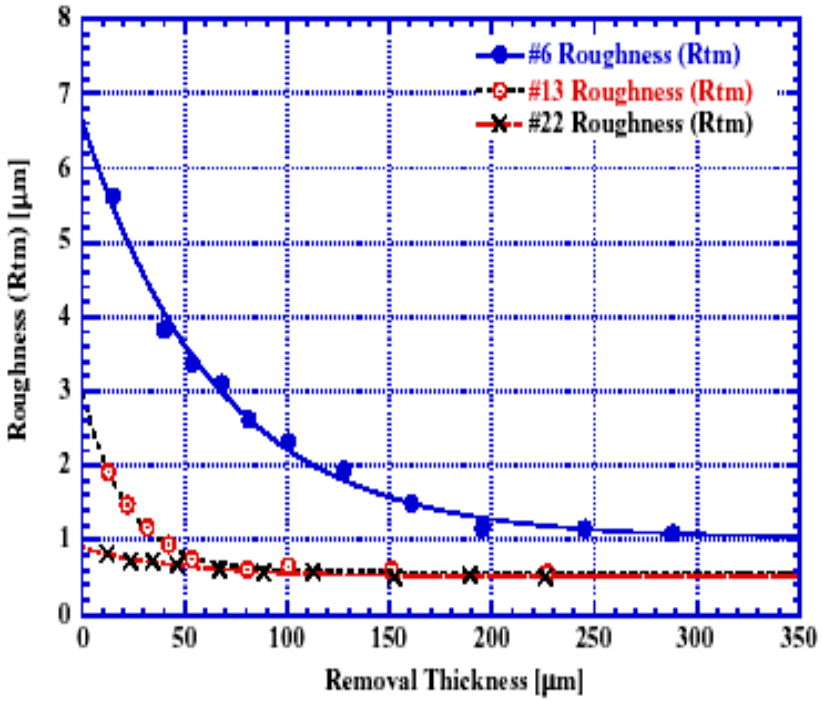
Further Single cell study for the next step



EP Material removal effect and Surface roughness after CBP(100μm, Rz~2μm) on Ichiro center single cell cavity



Correlation between
EP material removal after CBP100μm and Eacc,max



Relationship between
EP material removal and Surface roughness

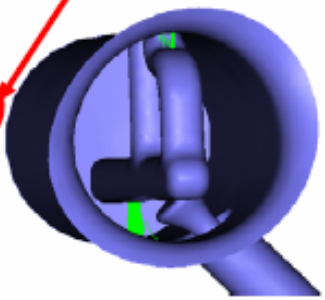
2nd Summary

Surface roughness ~1μm, which relates to field enhancement, is enough for 40MV/m on Ichiro center single cell cavities.
EP material removal could be reduced to 30-40 μm, if CBP is applied before the EP.

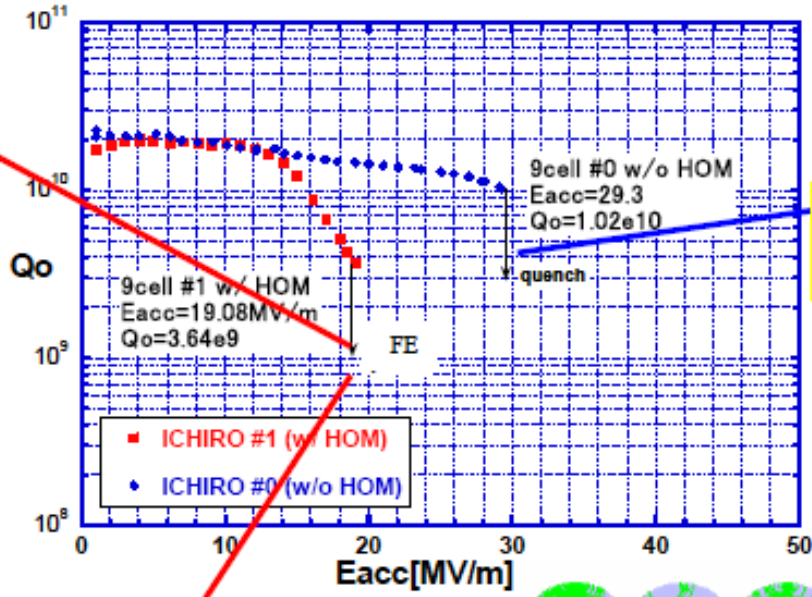
Problems in Ichiro 9-cell cavity

(Superstructure Version)

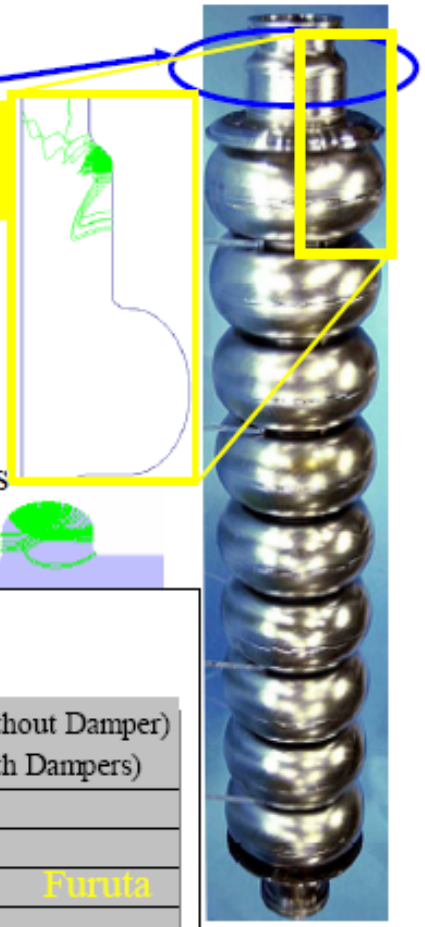
9-Cell-#1
Equipped



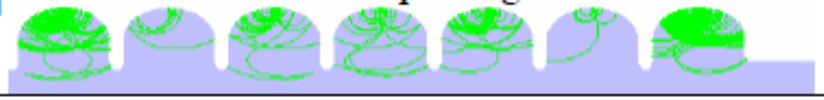
Multipacting
in Dampers

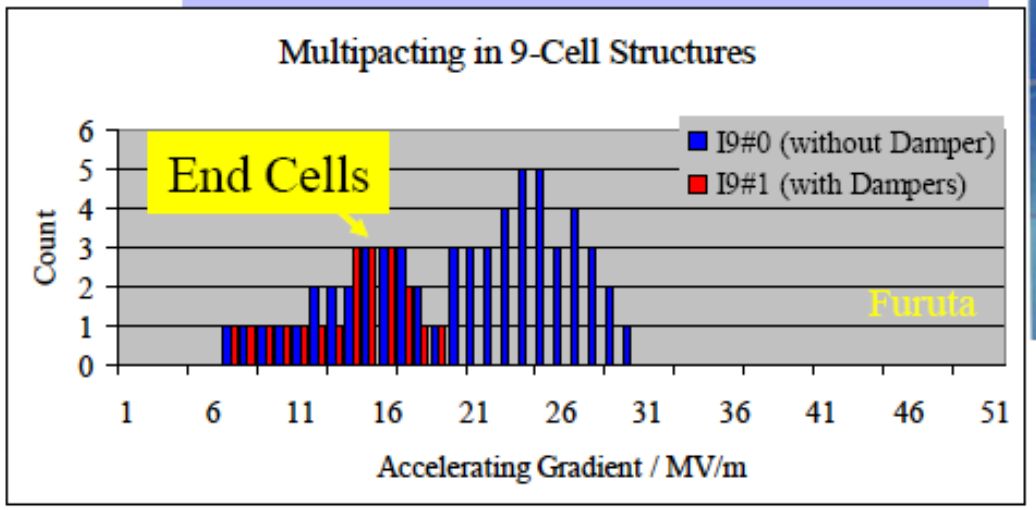


Multipacting at
Tapered Beam Port



Multipacting in Cells





9-Cell-#0
Plain

Probably main problem is in END groups !

END group study

We have to understand why the result so different between single and multi-cell .

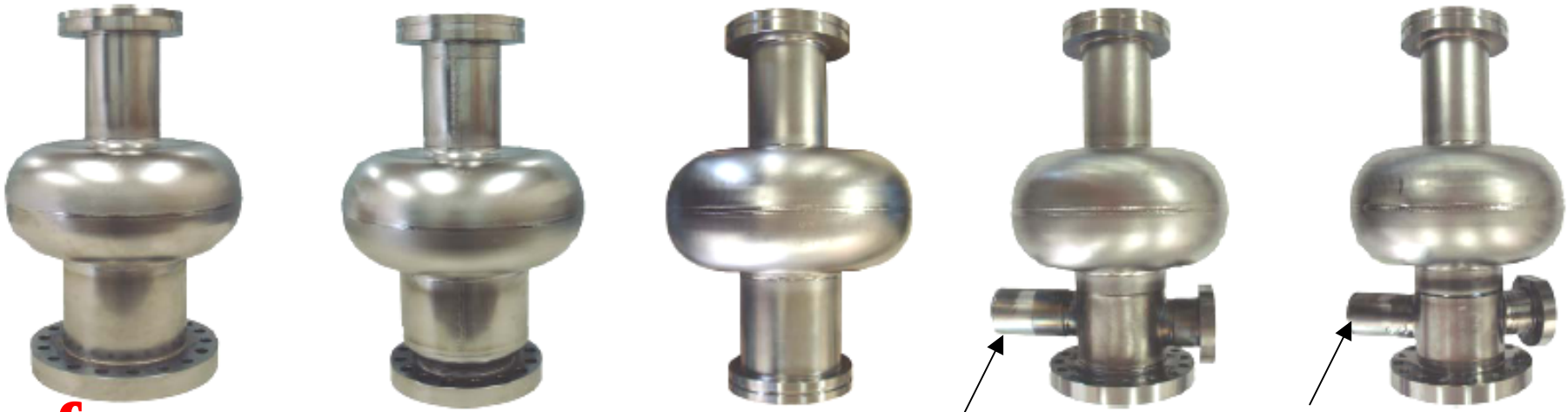
$$\text{9-Cell} = \text{  } + \sum_{i}^{7} \textit{Center Cell} + \text{  } = 50\text{MV/m ?!}$$

ISE#1 ISE#2

Ichiro Cavity END Cell

ISE#3 ISE#4 ISE#5

Redesigned END Cell



Just HOM cylinder

HOM

So far:

30MV/m **41MV/m**

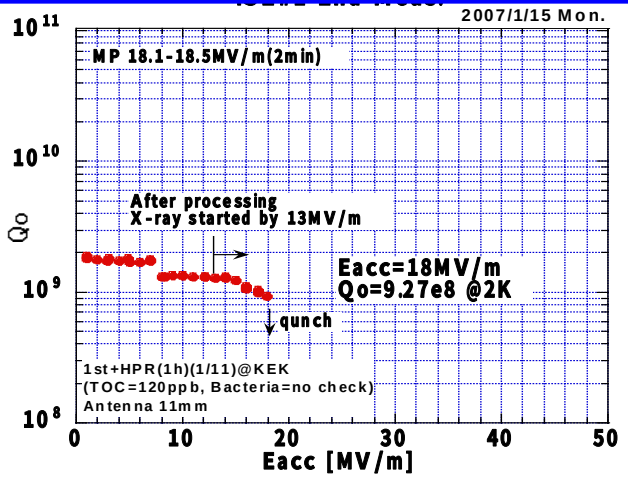
Theoretical limitation : ~ 40MV/m

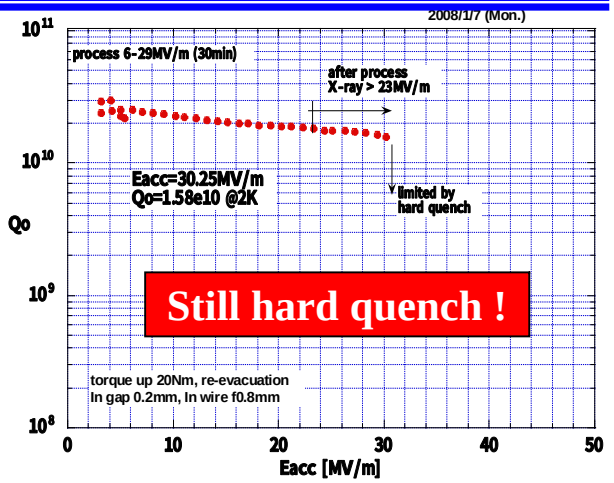
50MV/m **51MV/m** **40MV/m**

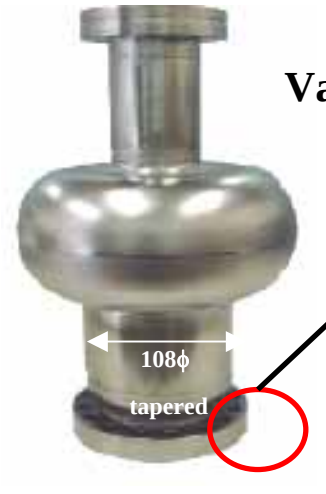
Theoretical limitation ~ 45MV/m

END cell H.G limitation study on the old Ichiro cavity and the cure

ISE#1

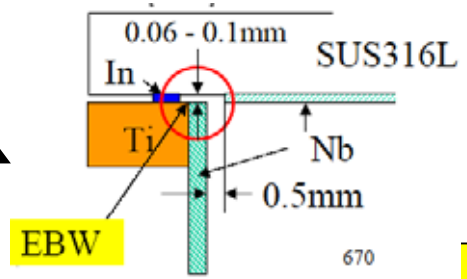




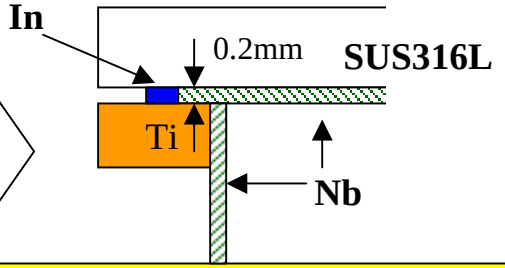


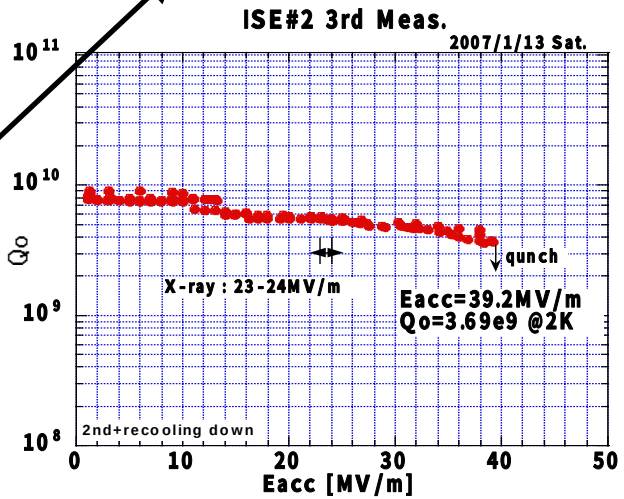
ISE#2

Vac. sealing



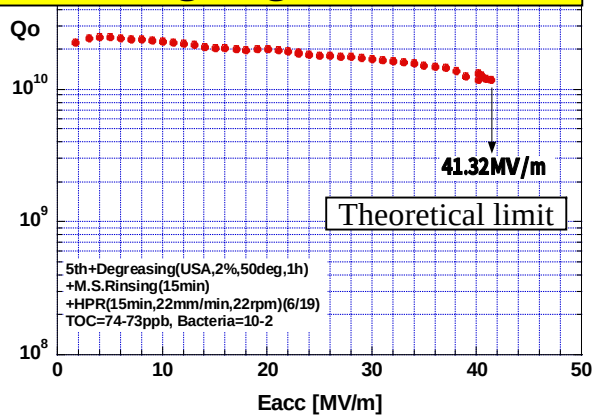
modified





3rd Summary

Sealing gap brings Q-switch or hard quench , if it exposed to strong magnetic field.

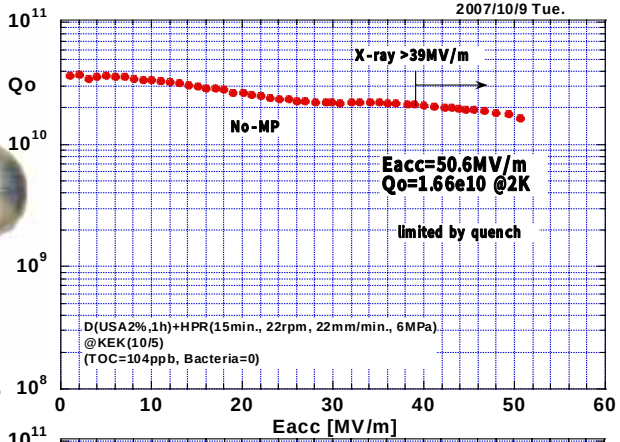


New end cell study

4th Summary
Complicated END group happens FE, if rinsing is poor.
Ethanol rinsing looks effective to remove the FE.

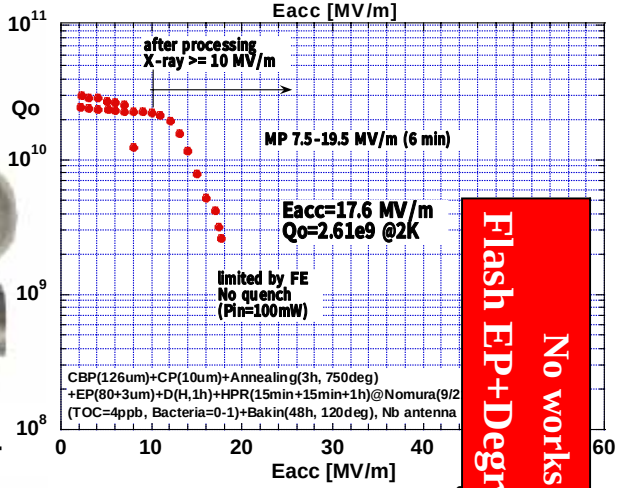
New Ichiro End cell

ISE#3



Just HOM cylinder

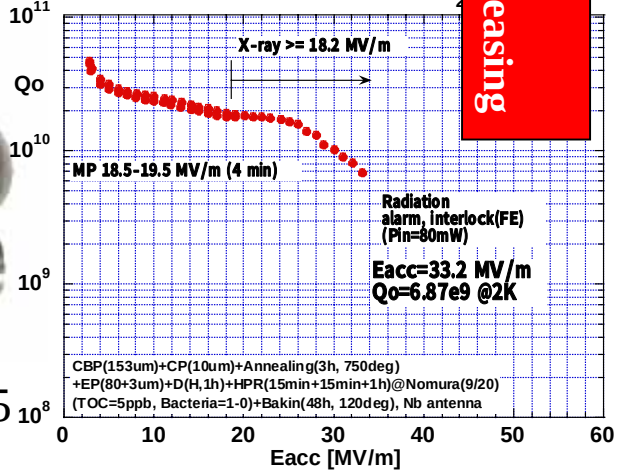
ISE#4



No works
Flash EP+Degreasing

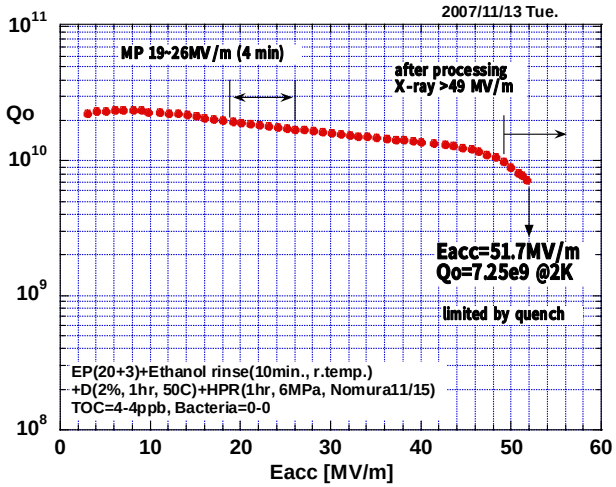
Full HOM

ISE#5

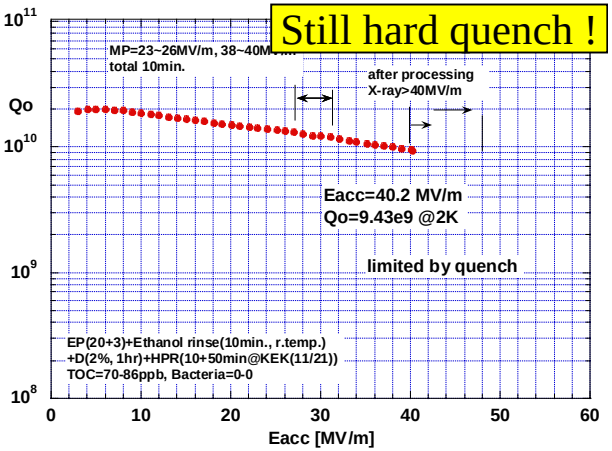


Sulfur contamination might remain on the complicated beam pipe.

+ Ethanol Rinsing

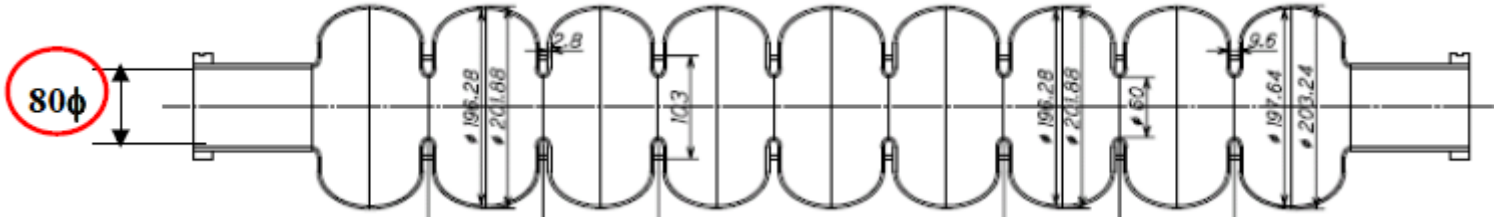


Still hard quench !



Accept test result (preliminary) @ JLAB on the Ichiro#5

9-Cell =  + $\sum_{i}^{7}$ *Center Cell* +  = 50MV/m ?!



We expect to improve the gradient by the Tight Loop Tests @ JLAB