

# Single Cell R&D Results to Guide Improvements for 9-cells in Asia

**K.Saito and WG-5 Asia**

## **Guide Improvement for 9-cell Cavities :**

- 1) Light EP material removal can produce a smaller performance scatter.**
- 2) Final fresh EP(3 $\mu$ m) is effective to reduce the scatter.**
- 3) Need an alternate final rinsing to suppress multipacting, degreasing (John's method) is very much promising.**
- 4) After a heavy material removal,  
“ EP20 + (EP3) + Degreasing + HPR + Baking ” would be a best recipe so far.**
- 5) EP acid is “Okay” at least up to 9g/L of Nb dissolved.**

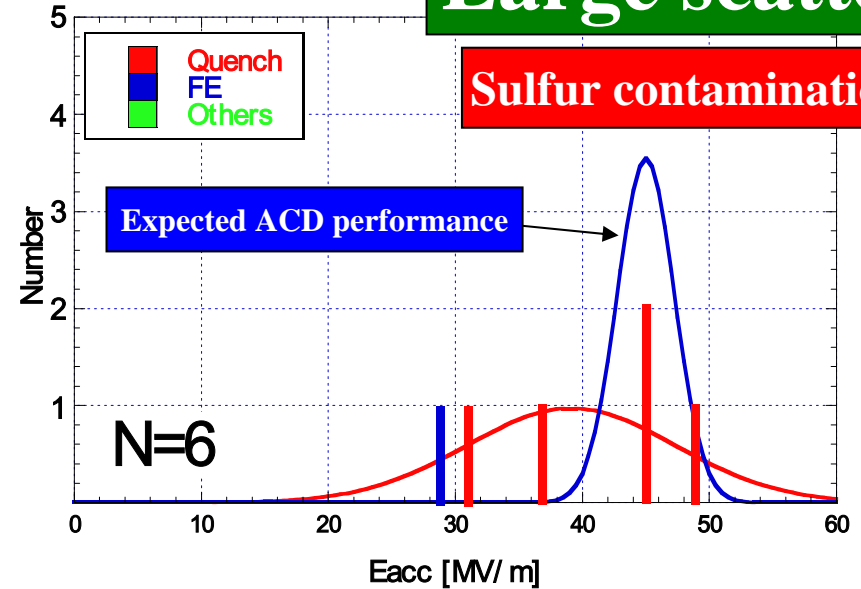
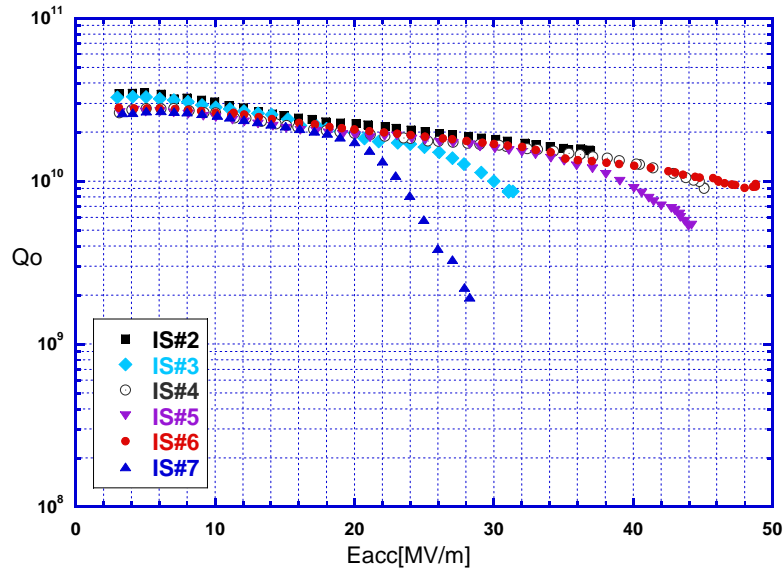
# S0 Single Cell Study @ KEK on 21 Apr 2007

|   | Eacc,max [MV/m] / Qo @ Eacc,max |         |        |         |         |         |        |         |        | Emax average [MV/m] | Scatt. [%] | MP     | Acceptability @ 40M V/m [%] |
|---|---------------------------------|---------|--------|---------|---------|---------|--------|---------|--------|---------------------|------------|--------|-----------------------------|
|   | IS#2                            | IS#3    | IS#4   | IS#5    | IS#6    | IS#7    | IS#8   | CLG#1   | CLG#2  |                     |            |        |                             |
| CBP+CP+AN+EP(80)+HPR+ Bake                      | 36.9                            | 31.4    | 45.1   | 44.2    | 48.8    | 28.3    |        |         |        | 39.1 ± 8.2          | 21         | Yes    | 50                          |
|   | 1.53E10                         | 8.66E9  | 9.07E9 | 5.38E9  | 9.64E9  | 1.94E9  |        |         |        |                     |            |        |                             |
| CBP+CP+AN+EP(80+3 fresh)+HPR+Bake               |                                 | 42.0    | 46.1   | 44.3    | 34.3    | 39.3    |        |         | 43.8   | 41.7 ± 4.4          | 11         | Yes    | 67                          |
|   |                                 | 9.72E9  | 9.47E9 | 1.08E10 | 8.56E9  | 1.03E10 |        |         | 3.46E9 |                     |            |        |                             |
| CBP+CP+AN+EP(40+3 fresh)+HPR+Bake               | 43.9                            |         |        |         |         |         | 49.2*  |         |        | 46.6 ± 3.7          | 8          | Yes    | 100                         |
|   | 9.47E9                          |         |        |         |         |         | 4.33E9 |         |        |                     |            |        |                             |
| +EP(20)+HPR+Bake                                | 47.2                            | 52.2    | 52.9   | 31.1    | 48.9    | 46.5    |        |         |        | 46.4 ± 8.0          | 17         | Yes    | 83                          |
|   | 5.98E9                          | 1.51E10 | 5.23E9 | 5.21E9  | 7.56E9  | 9.03E9  |        |         |        |                     |            |        |                             |
| +EP(20+3 fresh)+HPR+HF+Bake                     | 47.1                            | 44.7    | 47.8   |         | 48.6    | 43.9    |        | 47.9    |        | 46.7 ± 1.9          | 4          | Yes    | 100                         |
|   | 1.06E10                         | 9.80E9  | 7.80E9 |         | 8.00E9  | 1.17E10 |        | 1.00E10 |        |                     |            |        |                             |
| +EP(20)+H <sub>2</sub> O <sub>2</sub> +HPR+Bake | 52.3                            |         |        | 34.1    | 43.4    | 40.9    |        |         |        | 42.7 ± 6.0          | 18         | Light  | 50                          |
|   | 1.09E10                         |         |        | 1.37E10 | 1.39E10 | 3.01E9  |        |         |        |                     |            |        |                             |
| +EP(20)+Degreasing (US)+HPR+ Bake               | 50.1                            | 52.2    |        |         |         |         |        |         |        | 51.2 ± 1.5          | 2.9        | Lights | 100                         |
|   | 7.80E10                         | 7.08E9  |        |         |         |         |        |         |        |                     |            |        |                             |
| Others Megasonic                                |                                 |         |        |         |         |         |        |         |        |                     |            |        |                             |
|   |                                 |         |        |         |         |         |        |         |        |                     |            |        |                             |

IS: Ichiro center cell shape, Tokyo Denkai polycrystalline Nb material

CLG: NingXia Large grain, Ichiro center cell shape

# CBP(100 $\mu$ m)+CP(10 $\mu$ m)+Anneal(3hr@750 $^{\circ}$ C)+EP(80 $\mu$ m)+HPR+Baking

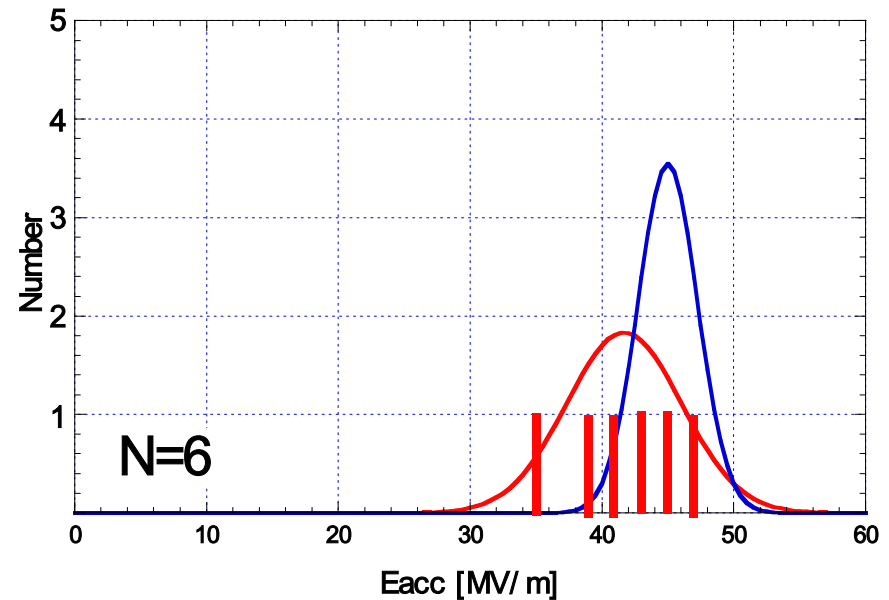
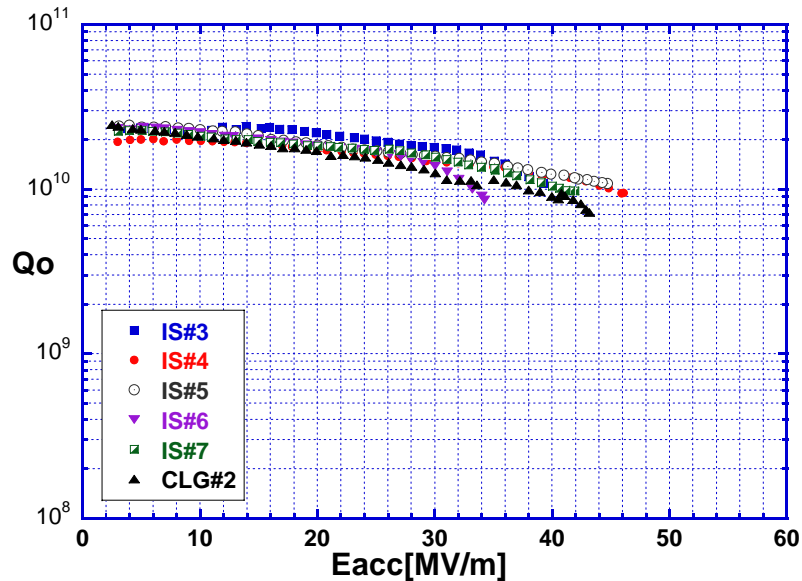


**Ave.  $E_{acc}=39.1\pm 8.2$  MV/m**

**Scattering: 20%, Acceptability @ 40 MV/m (ACD): 50%**

|        |      | IS#2    | IS#3   | IS#4   | IS#5   | IS#6   | IS#7   |
|--------|------|---------|--------|--------|--------|--------|--------|
| EP(80) | Eacc | 36.90   | 31.40  | 45.10  | 44.20  | 48.80  | 28.30  |
|        | Qo   | 1.53e10 | 8.66e9 | 9.07e9 | 5.38e9 | 9.64e9 | 1.94e9 |

CBP(100 $\mu$ m)+CP(10 $\mu$ m)+Anneal(3hr @ 750 $^{\circ}$ C)+EP(80 $\mu$ m)+  
**EP(3 $\mu$ m, fresh acid)**+HF+HPR+Baking

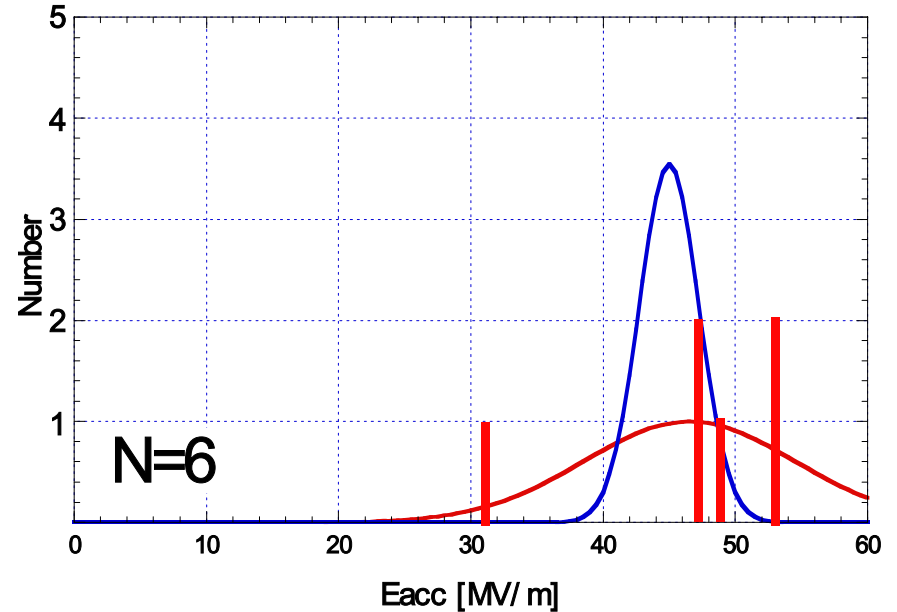
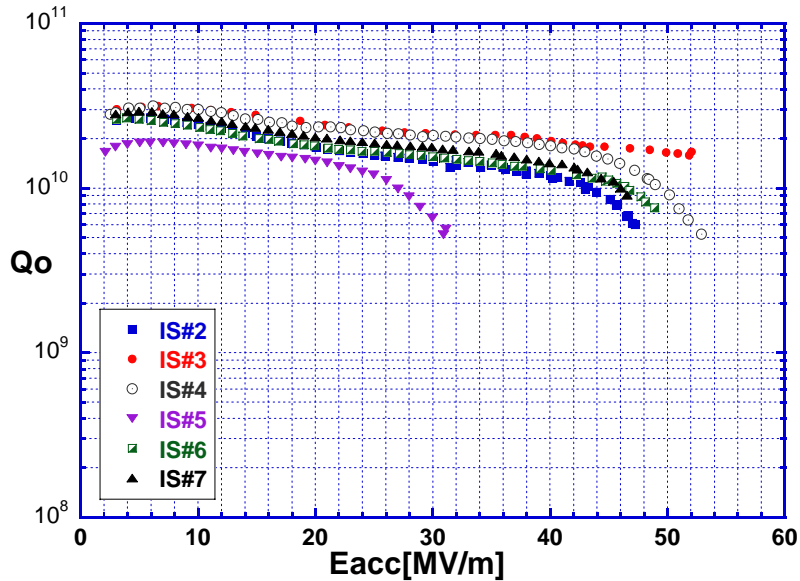


**EP(3 $\mu$ m) with fresh acid is effective to reduce the scatter.  
 HF rinsing is not so effective. See later**

**Ave. Eacc=41.7 $\pm$ 4.4MV/m,  
 Scattering:10%, Acceptability@40MV/m(ACD):67%**

|                 |      | IS#3   | IS#4   | IS#5    | IS#6   | IS#7    | CLG#2  |
|-----------------|------|--------|--------|---------|--------|---------|--------|
| EP(80+3)<br>+HF | Eacc | 42.00  | 46.10  | 44.70   | 34.25  | 39.30   | 43.80  |
|                 | Qo   | 9.72e9 | 9.47e9 | 1.08e10 | 8.56e9 | 1.03e10 | 3.46e9 |

# +EP(20 $\mu$ m)+HPR+Baking

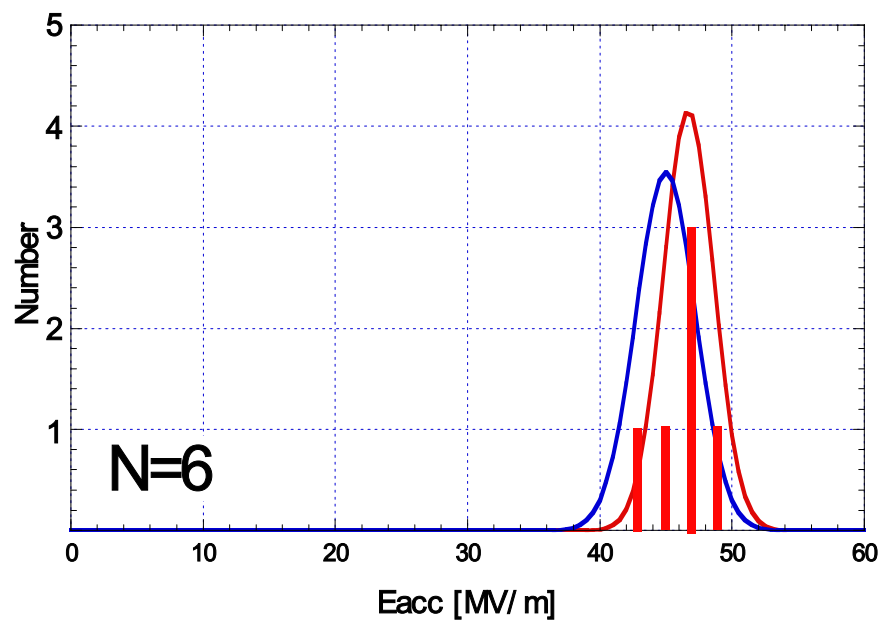
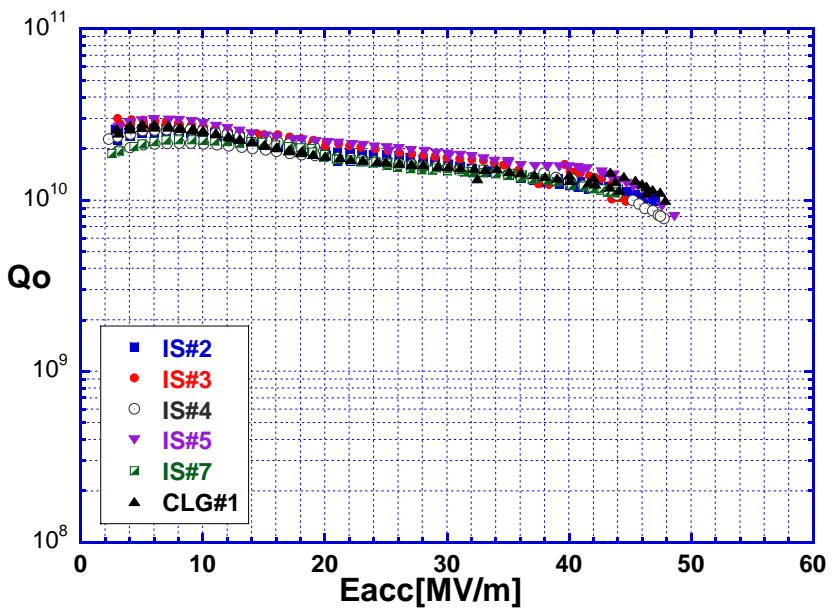


**Light EP is effective to increase Eacc average, but large scatter appears again.**

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

|         |      | IS#2   | IS#3    | IS#4   | IS#5   | IS#6   | IS#7   |
|---------|------|--------|---------|--------|--------|--------|--------|
| +EP(20) | Eacc | 47.24  | 52.44   | 52.91  | 31.10  | 48.92  | 46.53  |
|         | Qo   | 5.98e9 | 1.51e10 | 5.23e9 | 5.21e9 | 7.56e9 | 9.03e9 |

**+EP(20μm)+EP(3μm, fresh, closed) +(HF\*or No HF)+HPR+Baking**



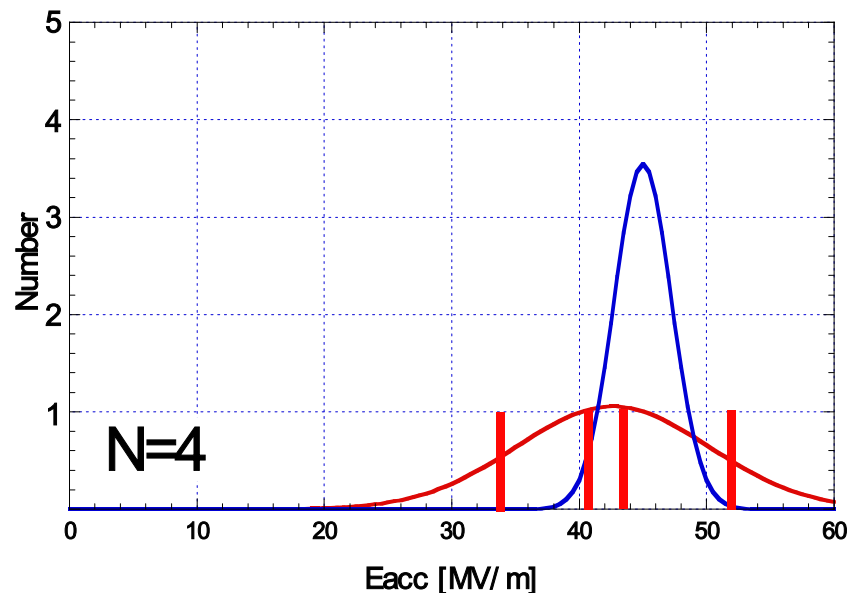
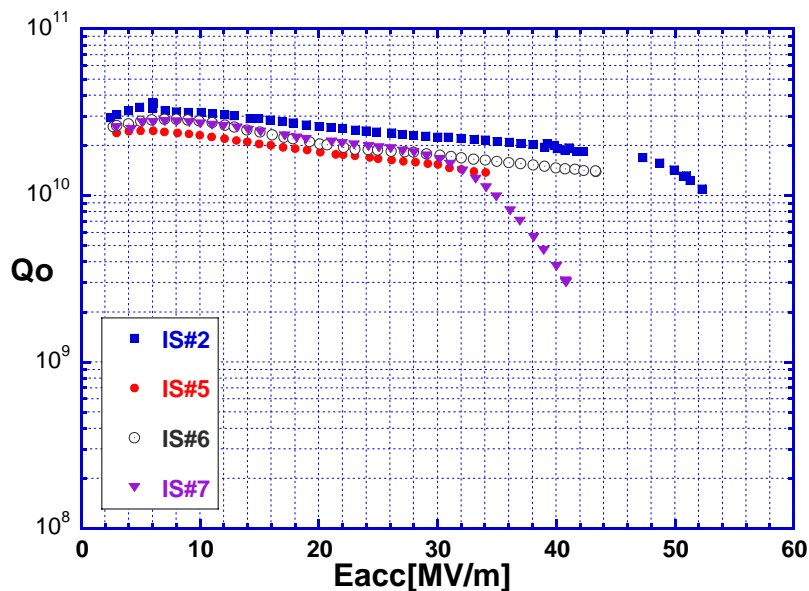
HF rinsing effective is small.

Light EP +EP(3) is effective for both high gradient and narrow scatter.

**Ave. Eacc=46.7±1.9MV/m**  
**Scattering:4%, Acceptability@40MV/m(ACD):100%**

|                   |      | IS#2    | IS#3    | IS#4    | IS#6    | IS#7    | CLG#1  |
|-------------------|------|---------|---------|---------|---------|---------|--------|
| +EP(20+3)<br>+HF* | Eacc | 47.07   | 44.67*  | 47.82   | 48.60*  | 43.93*  | 47.90* |
|                   | Qo   | 1.06e10 | 0.98e10 | 0.78e10 | 0.80e10 | 1.17e10 | 1.0e10 |

# +EP(20 $\mu$ m)+H<sub>2</sub>O<sub>2</sub> rinse+HPR+Baking

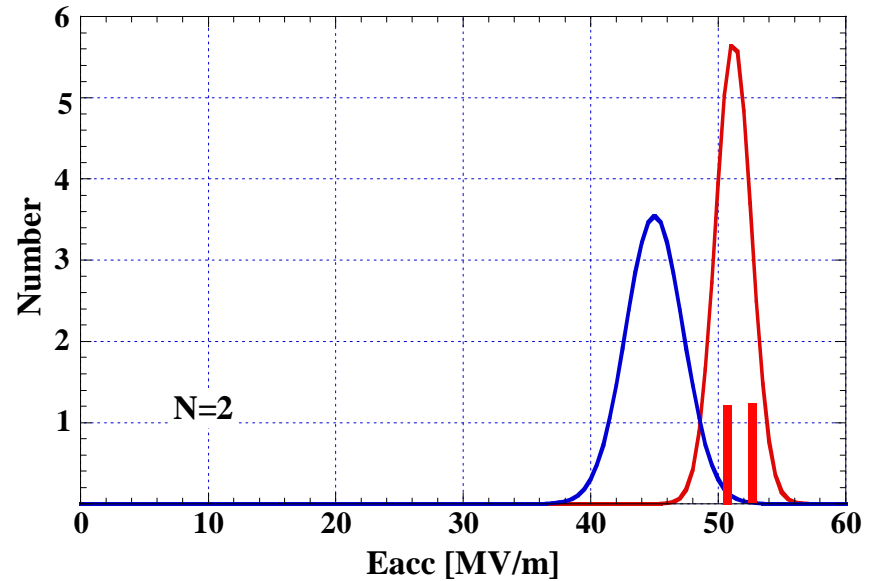
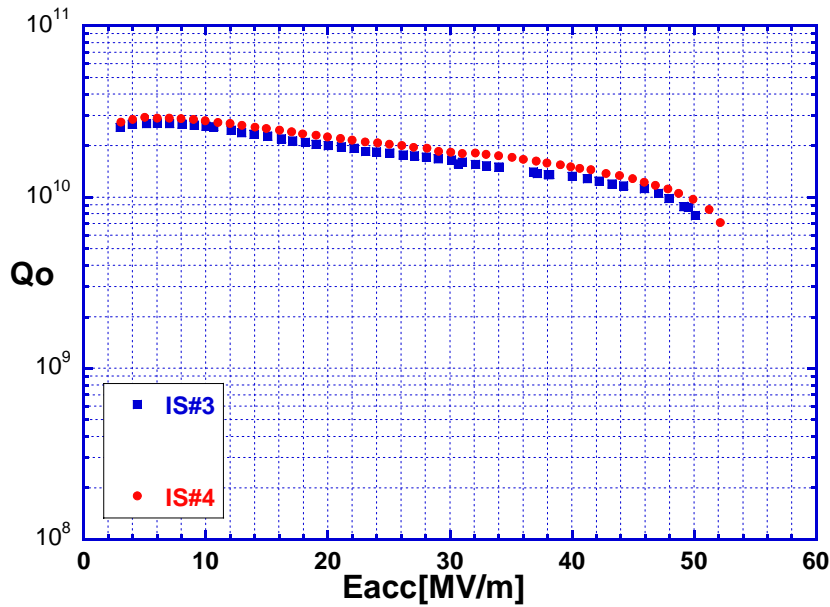


**Hard quench appears.**

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

|                                |      | IS#2    | IS#3 | IS#4 | IS#5    | IS#6    | IS#7   |
|--------------------------------|------|---------|------|------|---------|---------|--------|
| +EP(20)                        | Eacc | 52.3    |      |      | 34.1    | 43.4    | 40.9   |
| +H <sub>2</sub> O <sub>2</sub> | Qo   | 1.09e10 |      |      | 1.37e10 | 1.39e10 | 3.01e9 |

# +EP(20 $\mu$ m)+Degreasing+HPR+Baking



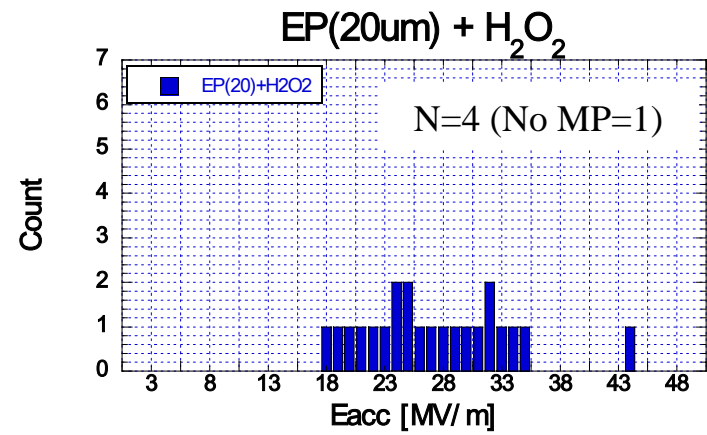
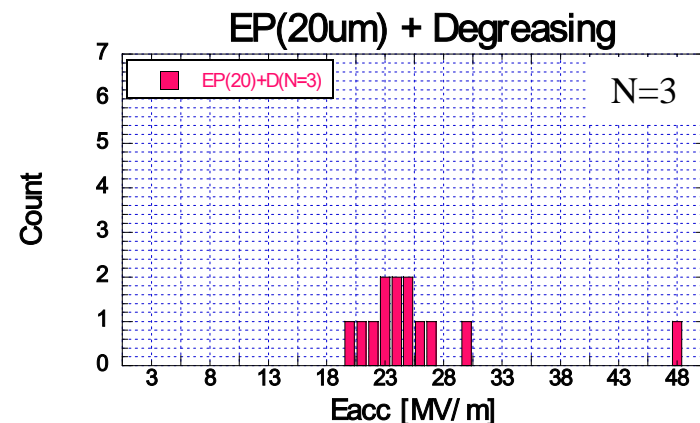
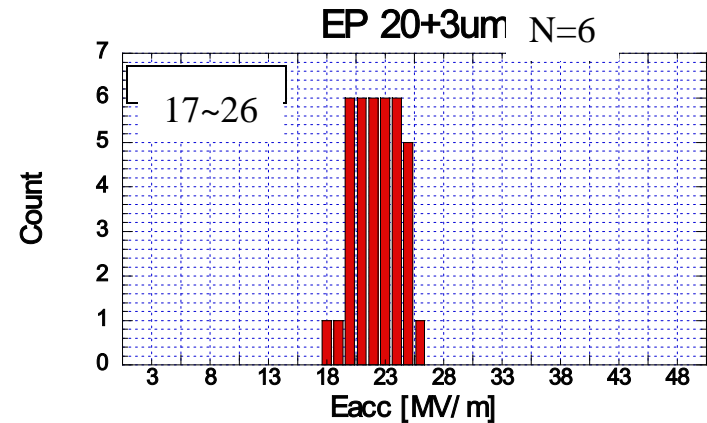
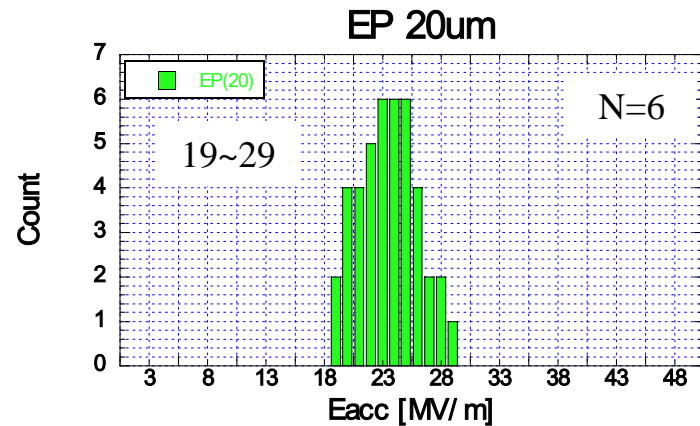
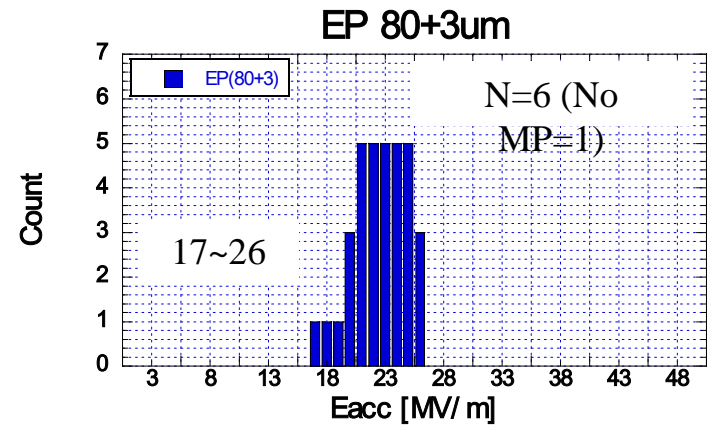
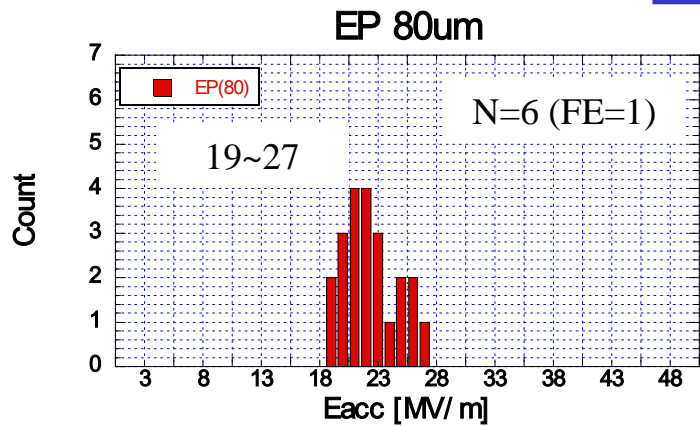
**Ave. Eacc=51.2 $\pm$ 1.4MV/m**

**Scattering:3%, Acceptability@40MV/m(ACD):100%**

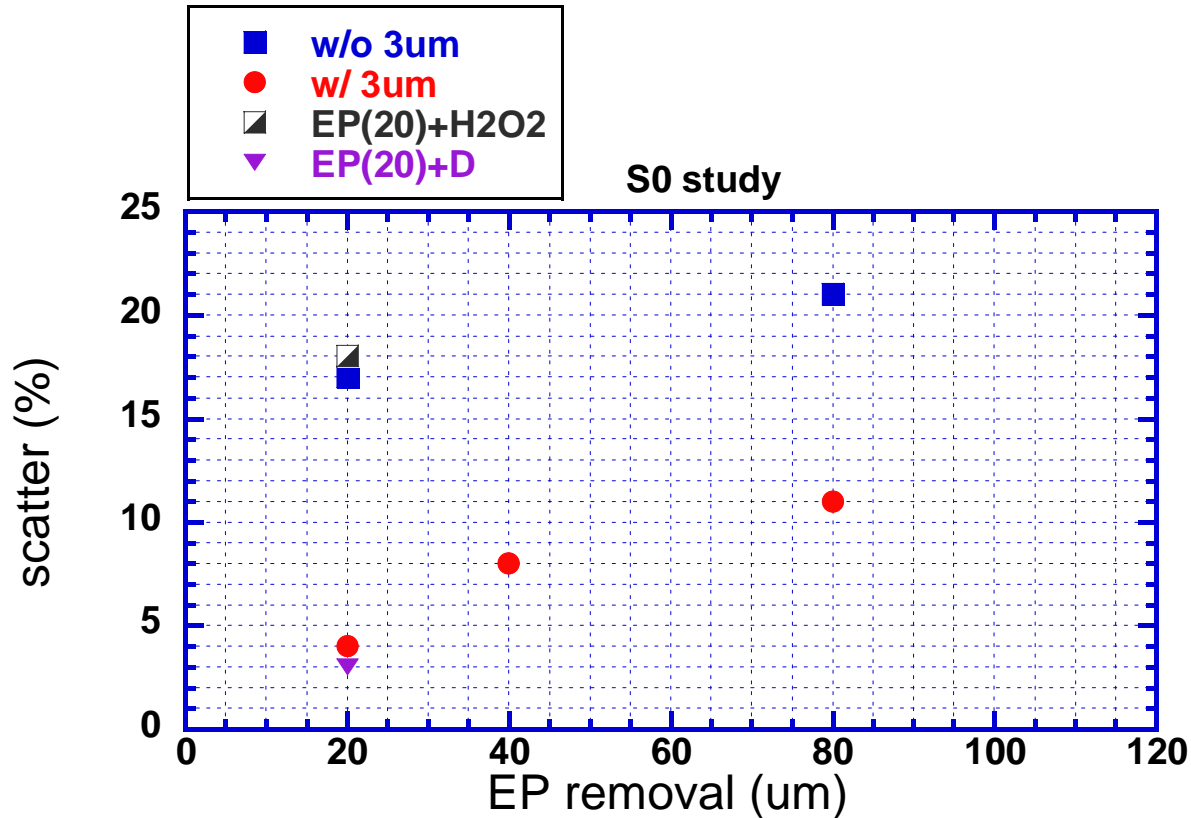
|             |      | IS#2 | IS#3   | IS#4   | IS#5 | IS#6 | IS#7 | IS#8 |
|-------------|------|------|--------|--------|------|------|------|------|
| +EP(20)     | Eacc |      | 50.13  | 52.16  |      |      |      |      |
| +Degreasing | Qo   |      | 7.80e9 | 7.08e9 |      |      |      |      |



# Multipacting

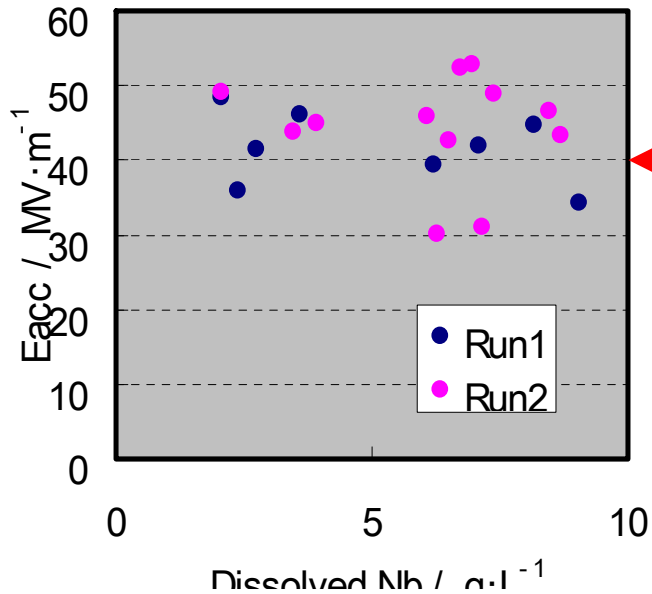


# $E_{acc \max}$ scattering vs EP material removal



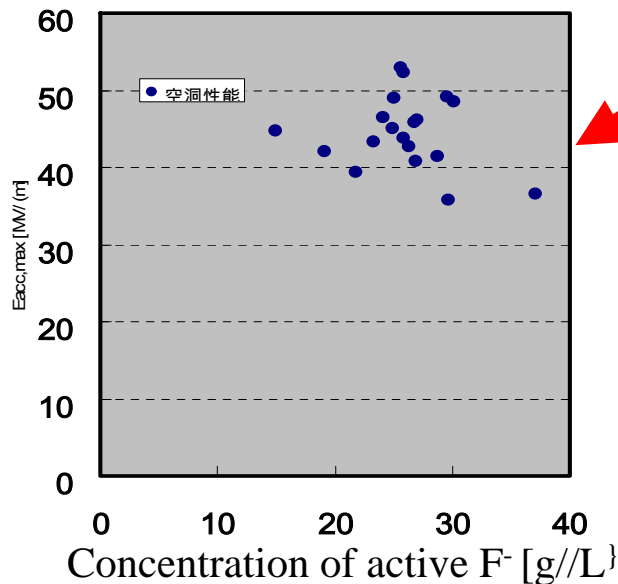
|            | EP(20)   | EP(20+3)  | EP(80)   | EP(80+3) | EP(20)+H <sub>2</sub> O <sub>2</sub> | EP(20)+D |
|------------|----------|-----------|----------|----------|--------------------------------------|----------|
| Eacc ave   | 46.5±8.0 | 46.7 ±1.9 | 39.1±8.2 | 41.7±4.4 | 42.6±7.6                             | 51.2±1.4 |
| Scatter(%) | 17       | 4         | 21       | 11       | 18                                   | 3        |
| N          | 6        | 6         | 6        | 6        | 4                                    | 2        |

# Relationship between active F<sup>-</sup> concentration and cavity performance



There is no correlation between dissolved Nb and cavity performance up to the dissolved Nb of 9 g/L. F

The dissolved Nb of 9 g/L is still OK.



In the EP process of Nomura plating Co. Ltd., this region of dissolved Nb corresponds to the Active HF concentration >15 g/L.

The region of dissolved Nb > 9 g/L and active HF < 15g/L should be explored in further experiment !

# Summary

## **Guide Improvement for 9-cell Cavities :**

- 1) Light EP material removal can produce a smaller performance scatter.**
- 2) Final fresh EP(3 $\mu$ m) is effective to reduce the scatter.**
- 3) Need an alternate final rinsing to suppress multipacting, degreasing (John's method) is very much promising.**
- 4) After a heavy material removal,  
“ EP20 + (EP3) + Degreasing + HPR + Baking ”  
would be a best recipe so far.**
- 5) EP acid is “Okay” at least up to 9g/L of Nb dissolved.**