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**Performance comparison of the single-cell large grain
niobium cavities treated by EP and CP**

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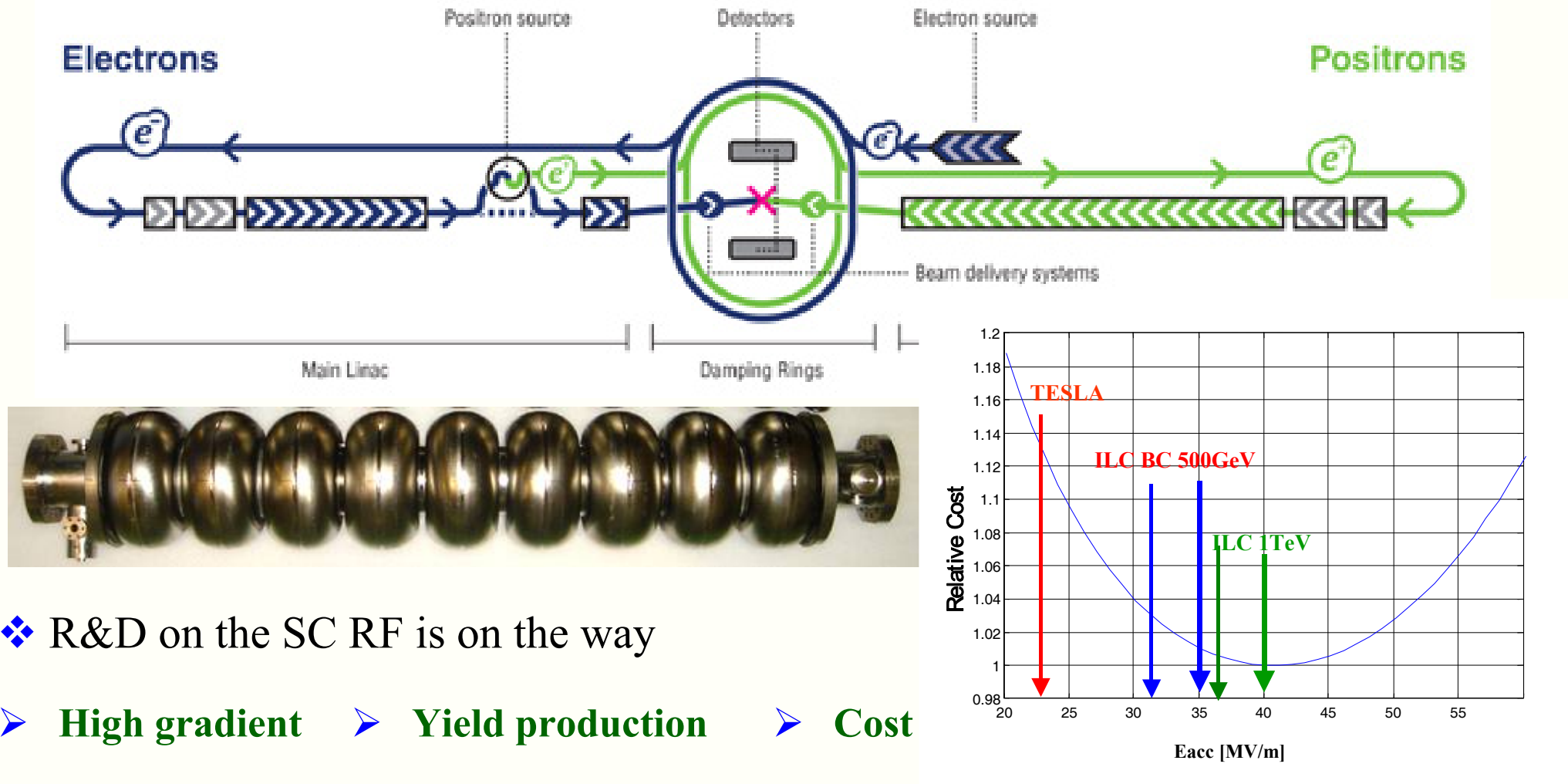
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Outline

- ❖ Why do we need the large grain niobium material for ILC?
- ❖ EP effect on the large grain cavities (Collaboration IHEP/KEK)
- ❖ CP effect on large grain cavity (Collaboration IHEP/KEK)
- ❖ Removal thickness of EP and CP for high gradients
- ❖ Performance of large and fine grain cavity chemically polished
- ❖ Surface resistance comparison



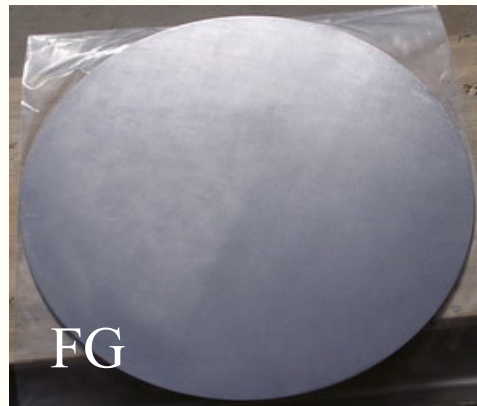
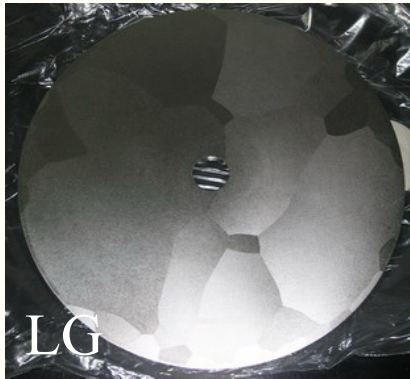
Why do we need the large grain niobium material?



- ❖ R&D on the SC RF is on the way
- **High gradient** ➤ **Yield production** ➤ **Cost**
- ❖ New cavity shape and large grain material are proposed

Large grain niobium material is a promising prospect for the ILC cavity performance and cost reduction. It becomes a hot topics.

EP effect on the large grain cavities (Collaboration IHEP/KEK)

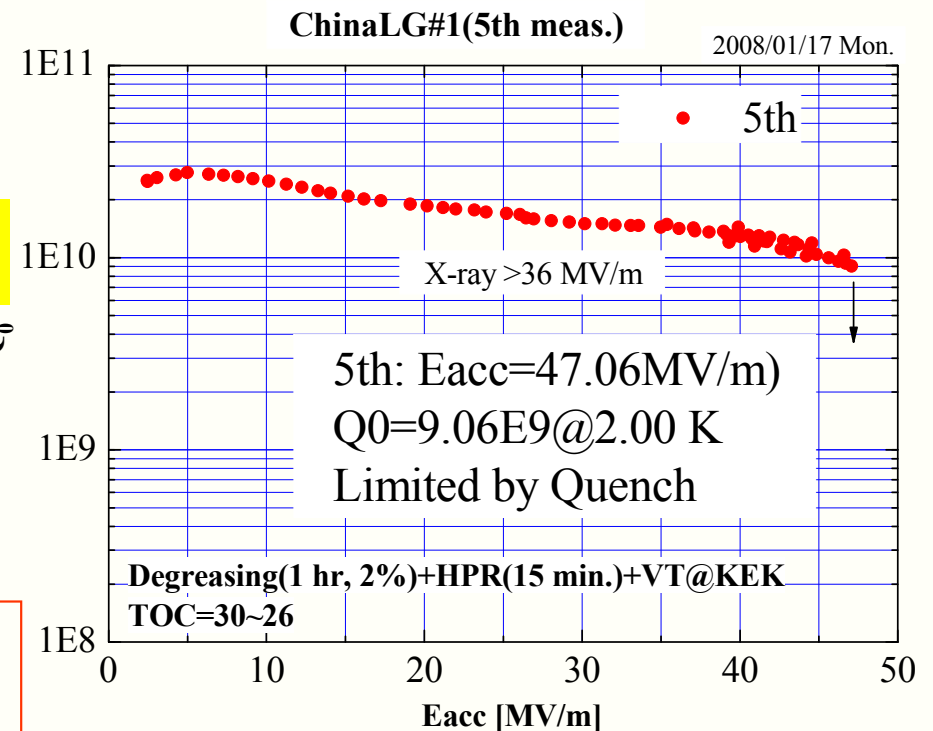


- ❖ In LG sheets the grain boundary is shorter.
- ❖ LG sheets from Ningxia by IHEP. Cavities were fabricated, treated and tested at KEK.

EBW+CBP+CP+Anealing+EP+Baking

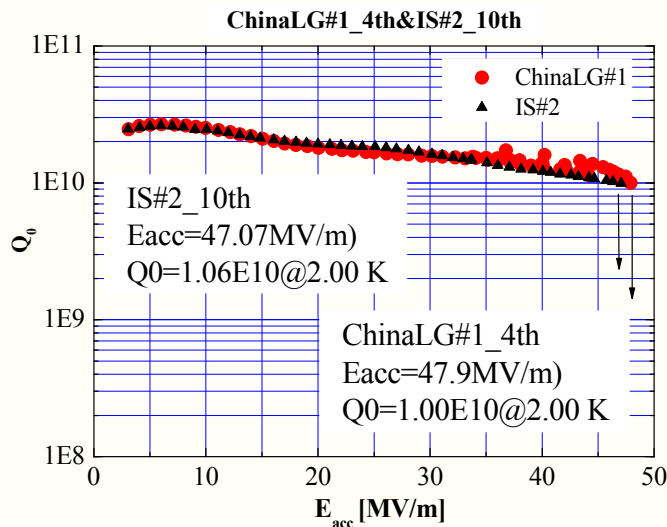
- ❖ LG high gradient potentials of ILC ACD σ performance (40 MV/m) was demonstrated in our first fabrication.

Large grain niobium is comparable with fine grain in the high gradient application

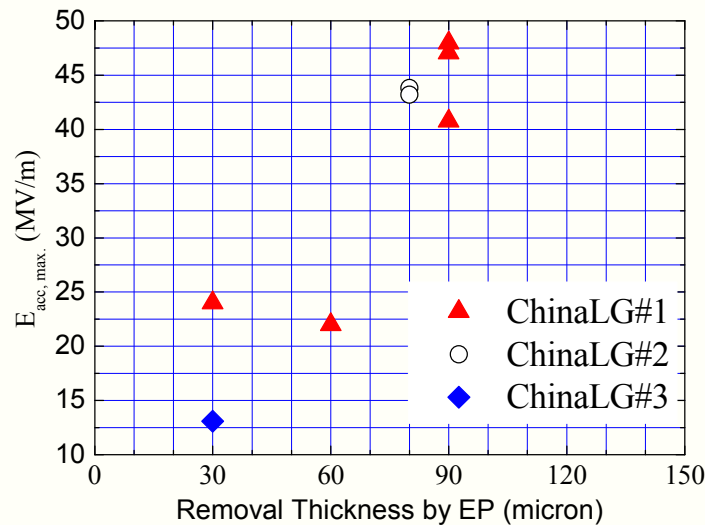


High gradient of ~50 MV/m was achieved

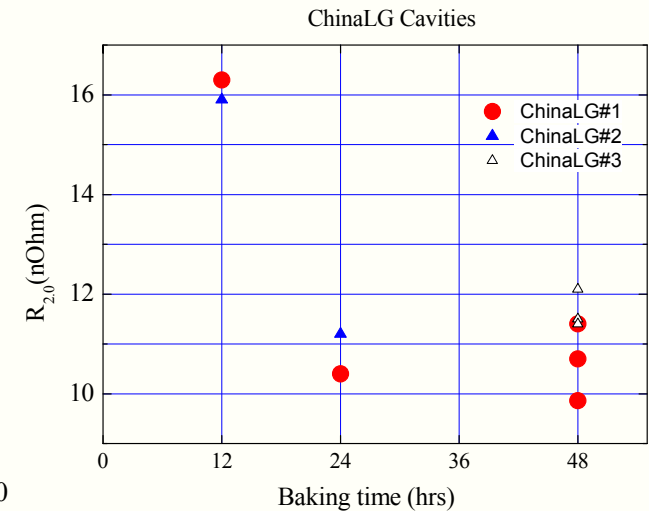
EP effect on the large grain cavity



EP on LG and FG



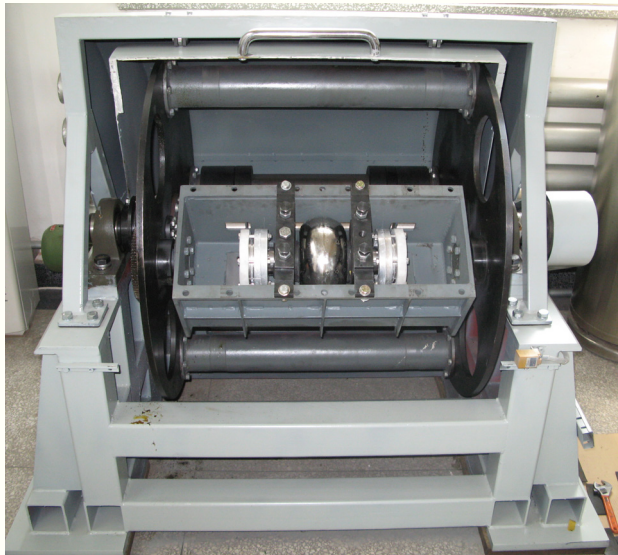
EP thickness vs Eacc,max



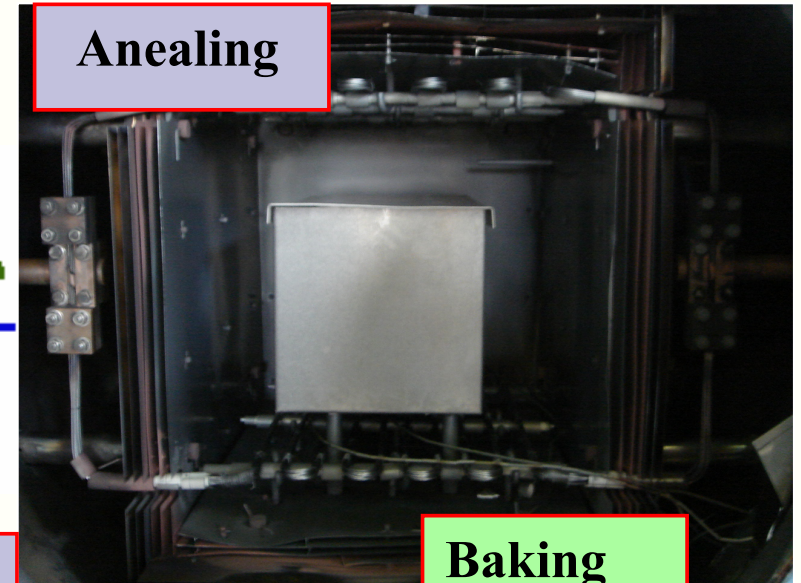
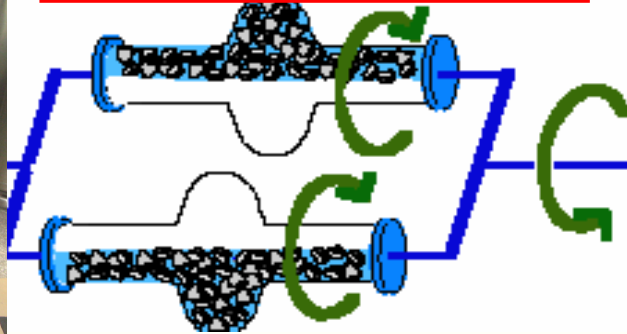
Baking time at 120 C vs Rs

- ❖ The non-uniform mechanical properties of LG brought some complex to the fabrication. But the manufacture was completed successfully.
- ❖ The performance of LG and FG was similar at both low and high fields.
- ❖ EP(>80 micron) is still needed for the high gradient (>40 MV/m)
- ❖ To minimize the surface resistance, LG should be baked for 48 hours. It is also similar with the FG.

Surface treatments introduction



CBP: Centrifugal barrel polishing



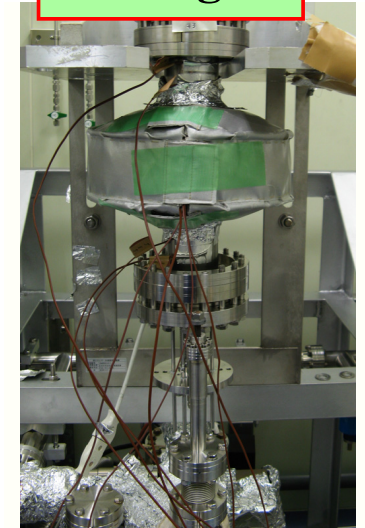
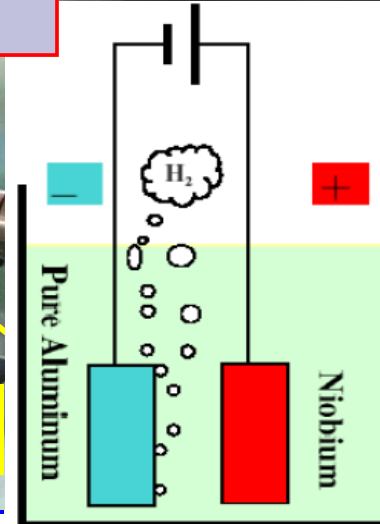
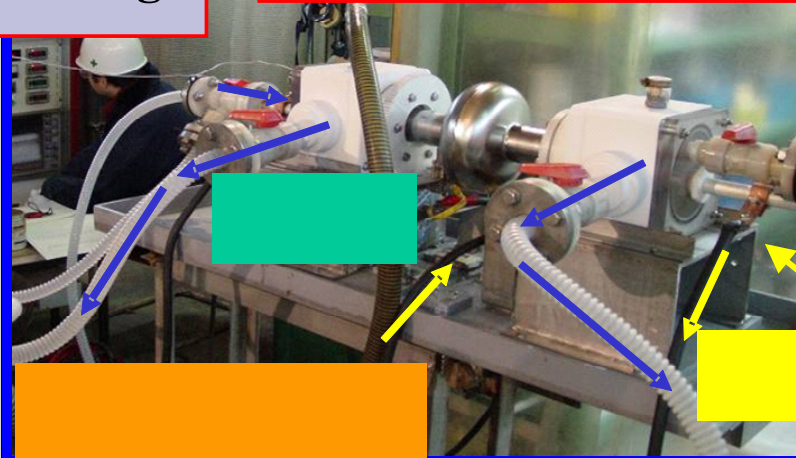
Annealing

Baking

CP: chemical polishing

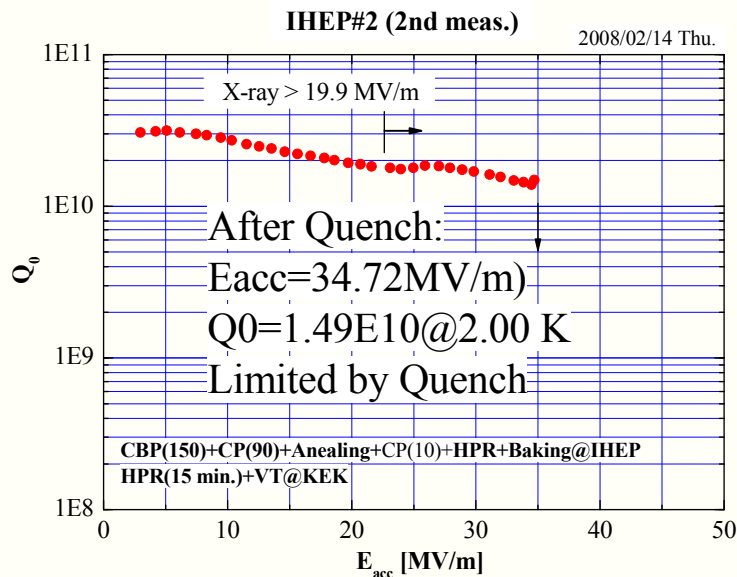


EP: Electro polishing

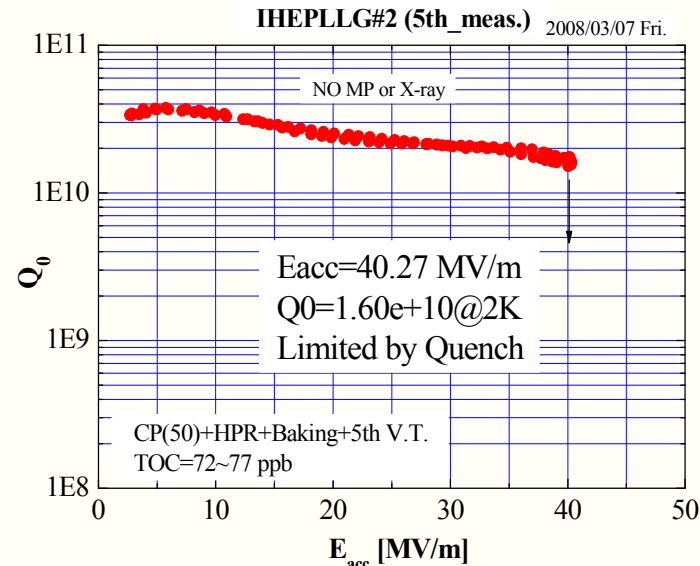


Standard surface preparation has been established to achieve ~ 50 MV/m high gradients based on EP. Large grain niobium has the potential to eliminate the complex EP.

CP effect on large grain cavity (Collaboration IHEP/KEK)



First test at KEK



After additional CP

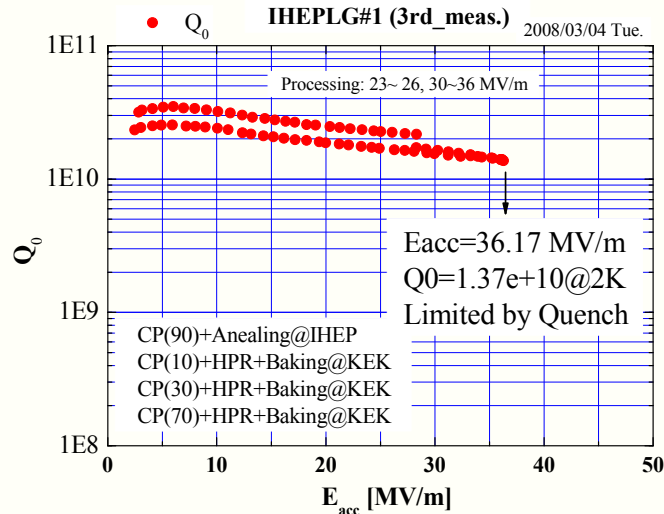
EBW+CBP+CP+Annealing+CP+Baking



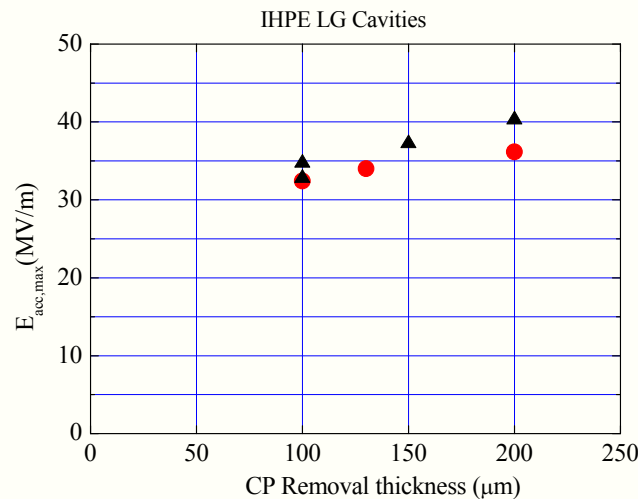
- ❖ The two large grain cavities were fabricated, CBP, chemically polished and annealed at IHEP and one cavity achieved 34.72 MV/m in the first test at KEK.
- ❖ Additional CP and VT was done at KEK. It achieved 40 MV/m.

ILC ACD performance (single cell) could be achieved by LG+CP

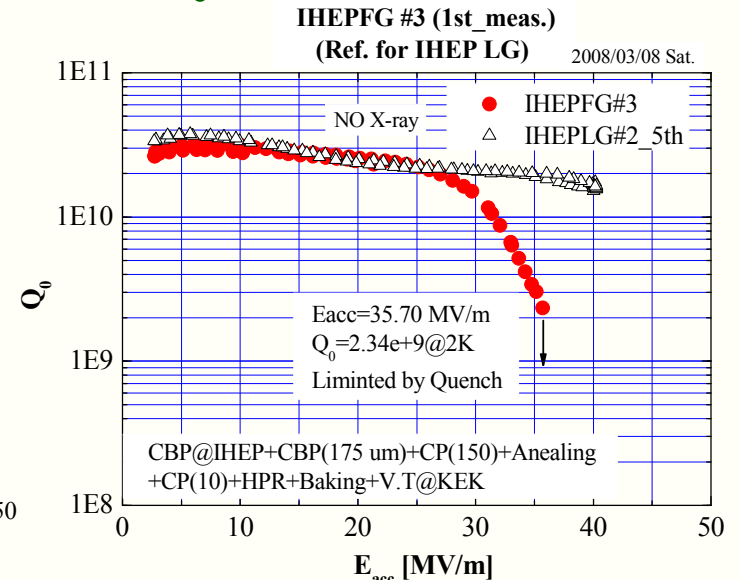
Some details of CP on LG study



Another cavity



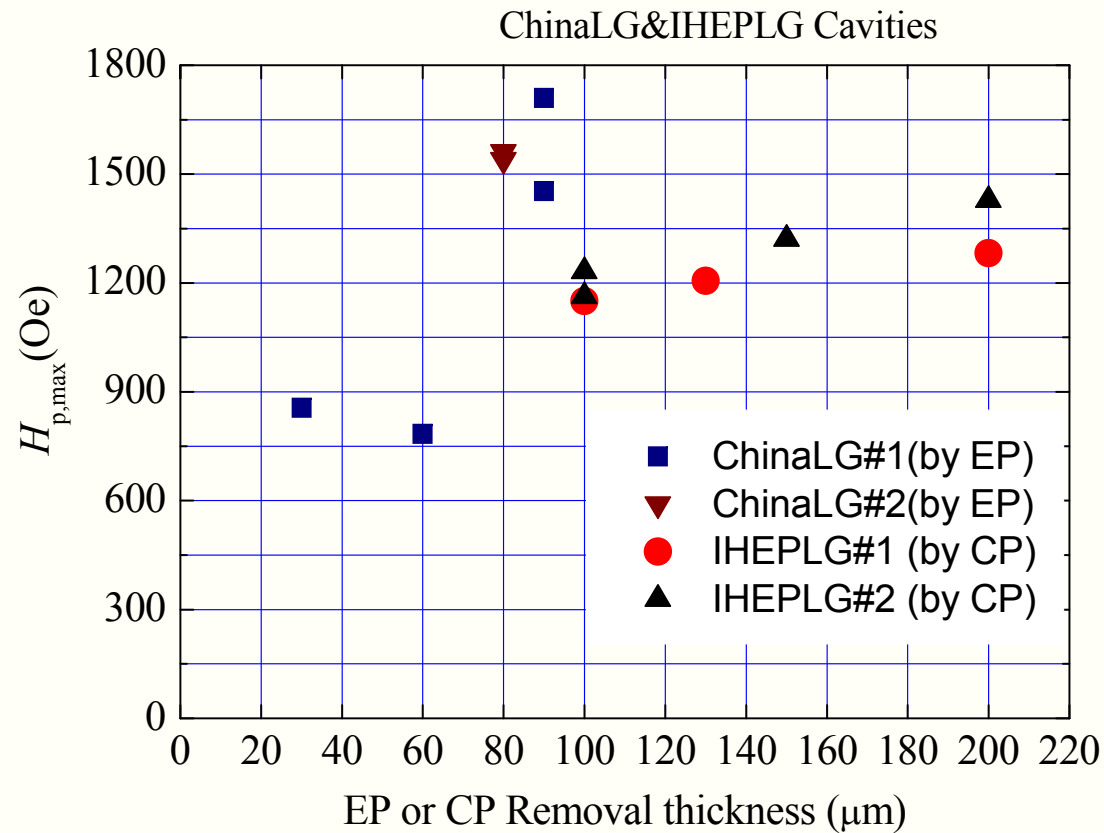
CP thickness vs $E_{acc,max}$



CP+FG ~ Q -slope in high field

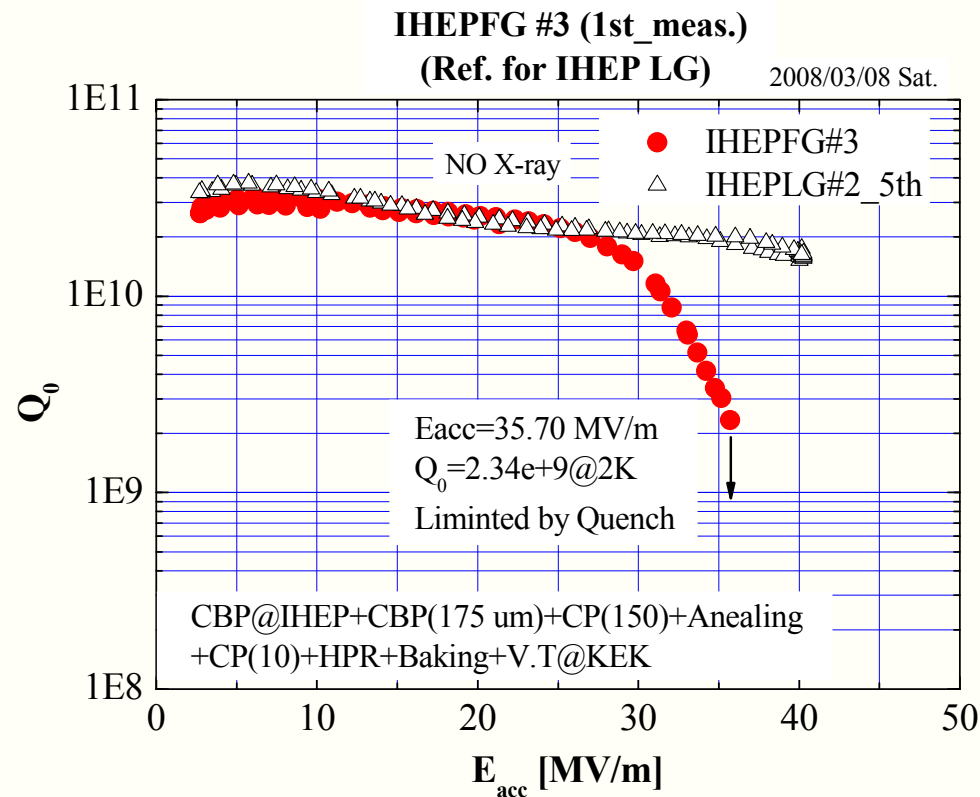
- ❖ Another IHEP LG cavity also achieved good performance of 36.17MV/m
- ❖ IHEP was qualified for the high gradient SC RF cavity. R&D on the 9-cell LG cavity has started at IHEP.
- ❖ 200 micron CP is needed for the cavity high gradient performance.
- ❖ The fine grain cavity polished chemically has a strong Q -slope in high fields.
- ❖ EP could be eliminated in the high gradient (40 MV/m) surface treatments of LG (single cell).

Removal thickness of EP and CP for high gradients



- ❖ To achieve high gradients (> 40 MV/m), the large grain cavities should be polished more than 80 micron by EP or 200 micron by CP.
- ❖ CP has a slow effect compared with EP on the large grain.

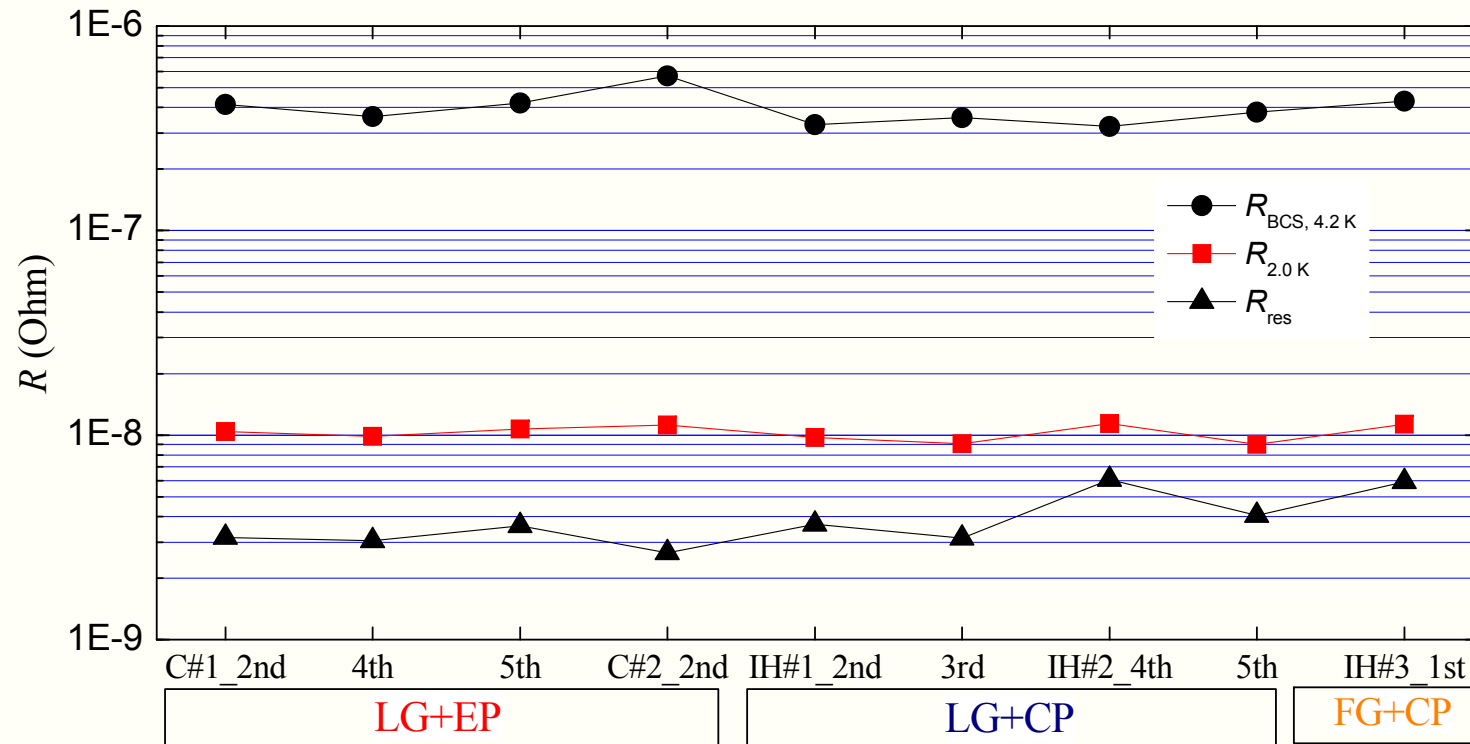
Performance of large and fine grain cavity chemically polished



- ❖ IHEPFG#3 is a fine grain cavity and treated by CP.
- ❖ There is an apparent Q-slope in the excitation curve without field emission.

The sensible difference of the quality factor at high gradient was attributed to the shorter grain boundary in the LG niobium.

Surface resistance comparison



There is almost no difference in the surface resistance of the various niobium and polishing methods.

Comparison of LG and FG treated by EP and CP

❖ The shorter grain boundary in the LG greatly benefits cavity performance.

➤ High gradient was demonstrated

EP on LG → ~50 MV/m High gradient

➤ ILC ACD available by CP

CP on LG → ILC ACD performance

➤ KEK new slicing techniques has been developed to reduce the cost. (Kenji Saito, KEK)

Items		LG	FG
High gradient (~40 MV/m)	EP	Yes	Yes
	CP	Yes	No
Cost		Lower	High
Defect		Lower	High
Fabrication by ST		Yes	Yes
Baking		No different	
Surface resistance		No different	
Mechanics for tuning		No different	

LG niobium would be a good solution to the ILC huge quantity and high quality requirements on the RF superconducting cavity.

Thanks for your attention