

# S0 status for the single-cell tests

**GDE meeting at Beijing**

**5<sup>th</sup> February 2007**

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**and KEK SRF group**

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- Summary

# Single-cell cavity test activity at KEK

Deep drawing

trim

EBW

Mech. grind

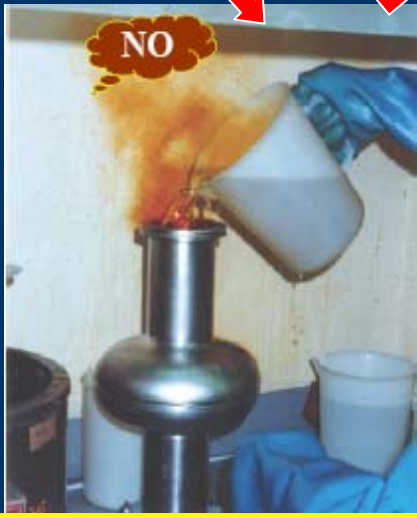
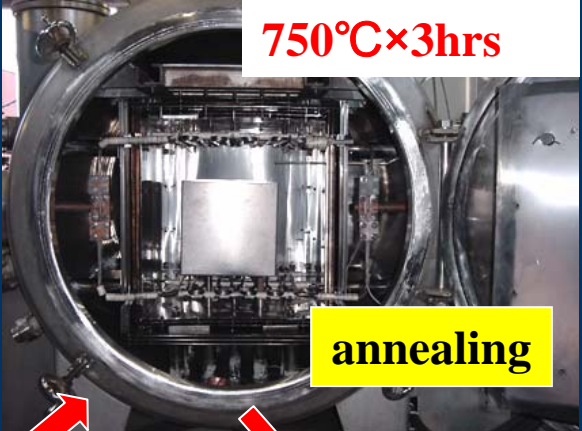
light CP

annealing

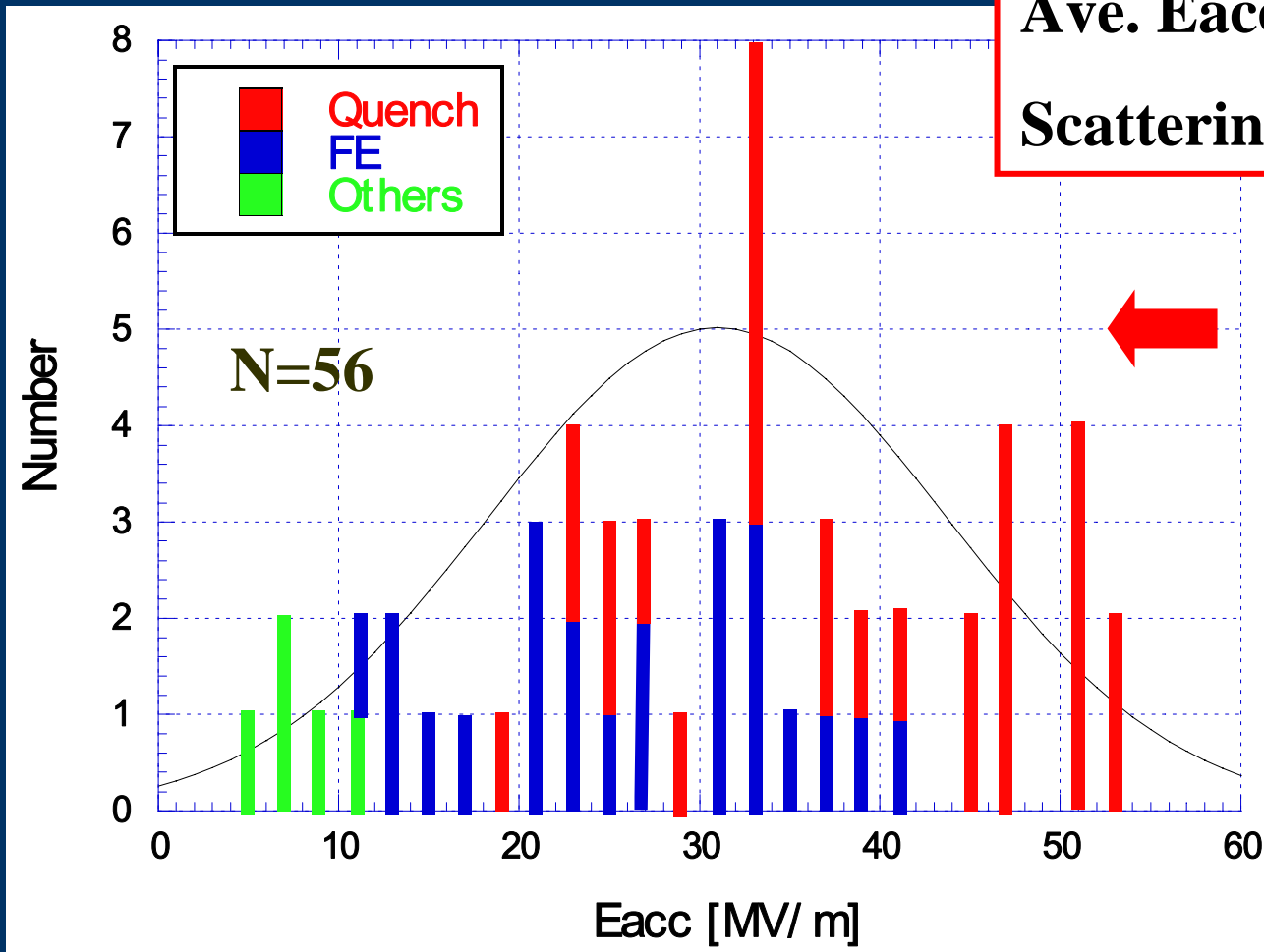
EP+HPR

Baking + evacuation

VT



# Scattering of cavity performance at KEK in 2005



**Ave. Eacc=31.0±12.7MV/m**

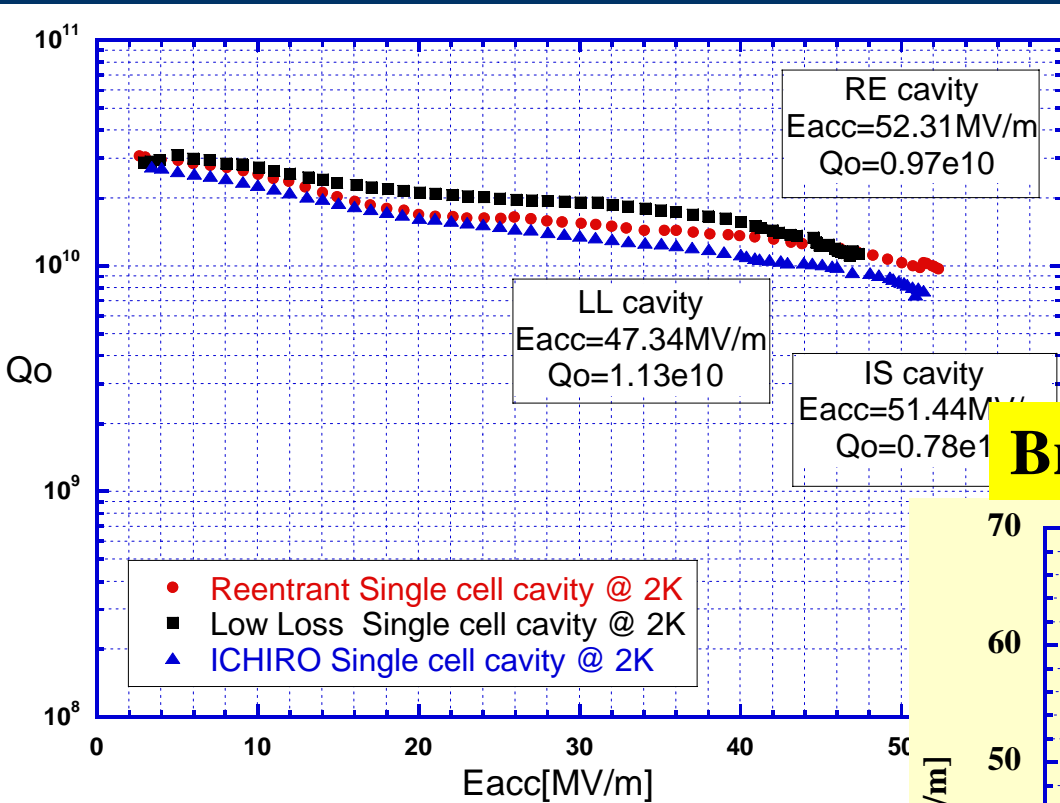
**Scattering 41%**

**LL, RE cavity VT**

**Nov. 2004 – Nov. 2005**

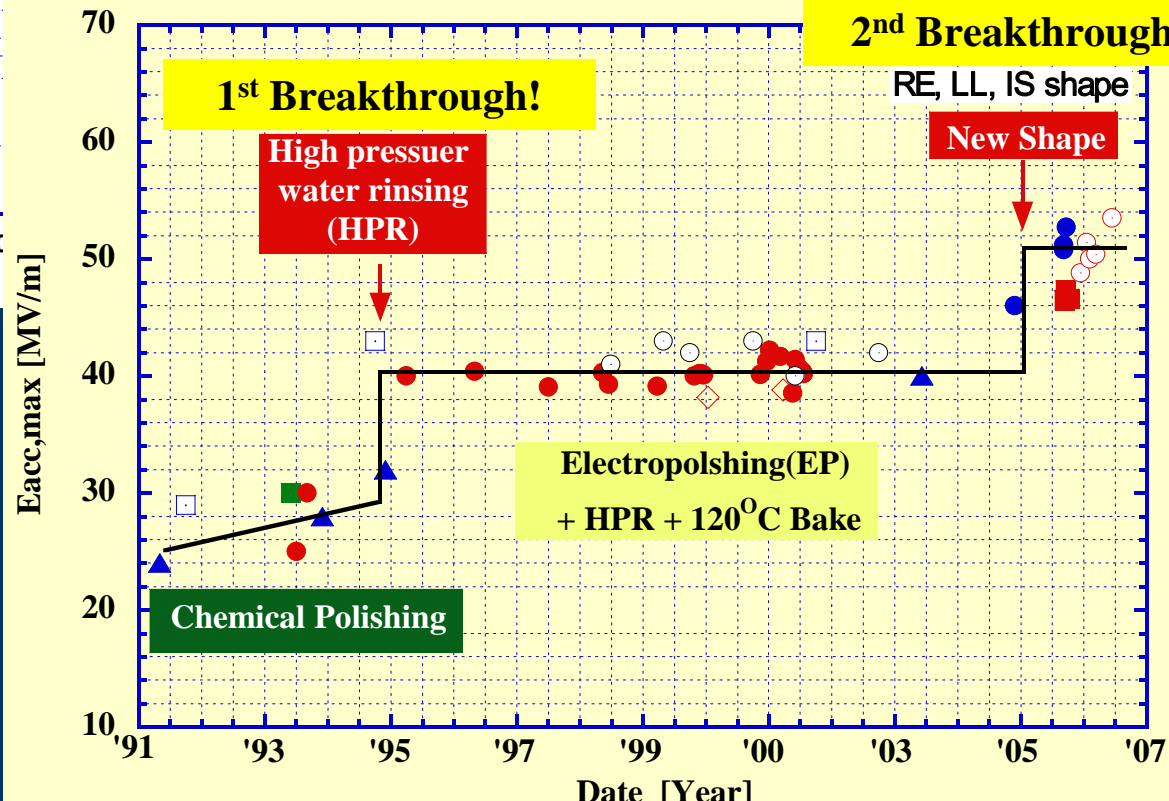
**Scattering was caused by bad HPR environment, easy mistakes of cavity assembly, RF processing method and so on.**

# Proof of principle for 50MV/m



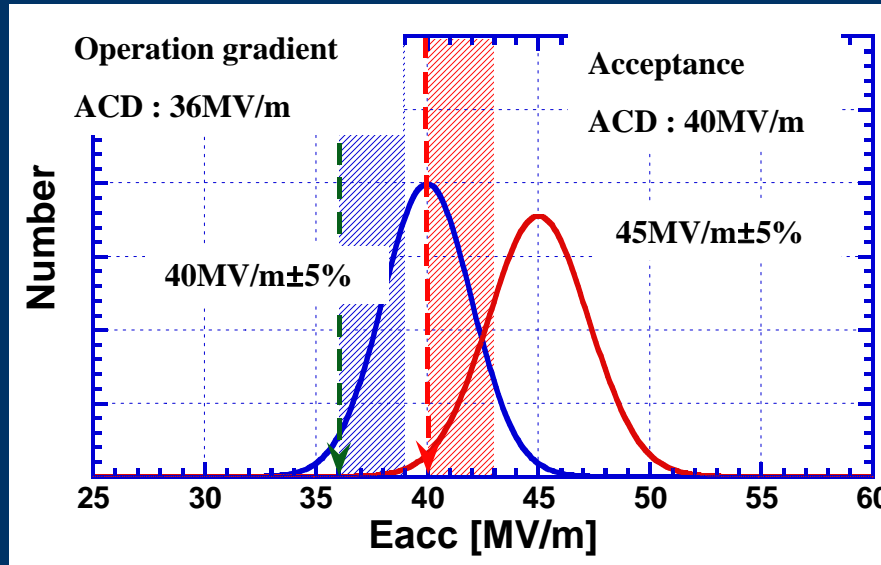
## Break-through by new-shapes

**RE, LL and ICHIRO Single-cell (IS) achieved 45MV/m**



# Importance of high-gradient

We need more margin in the operation

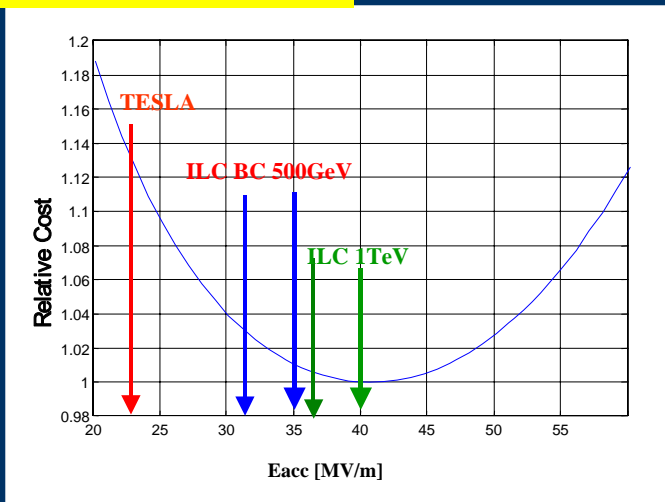
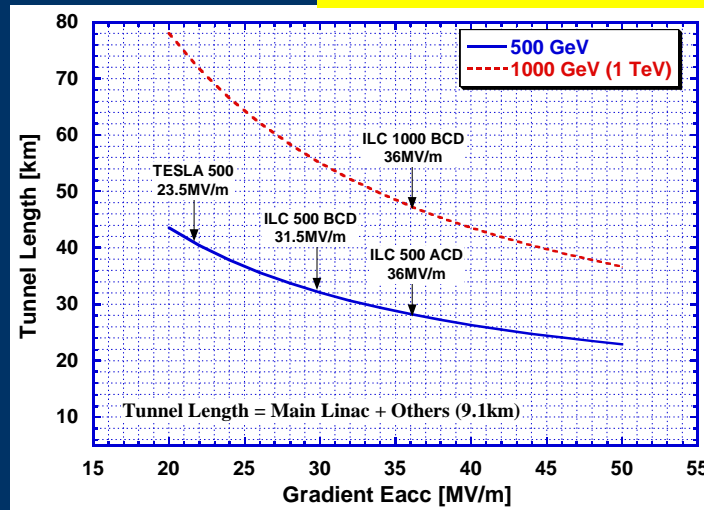


ACD acceptance:

Eacc >40MV/m

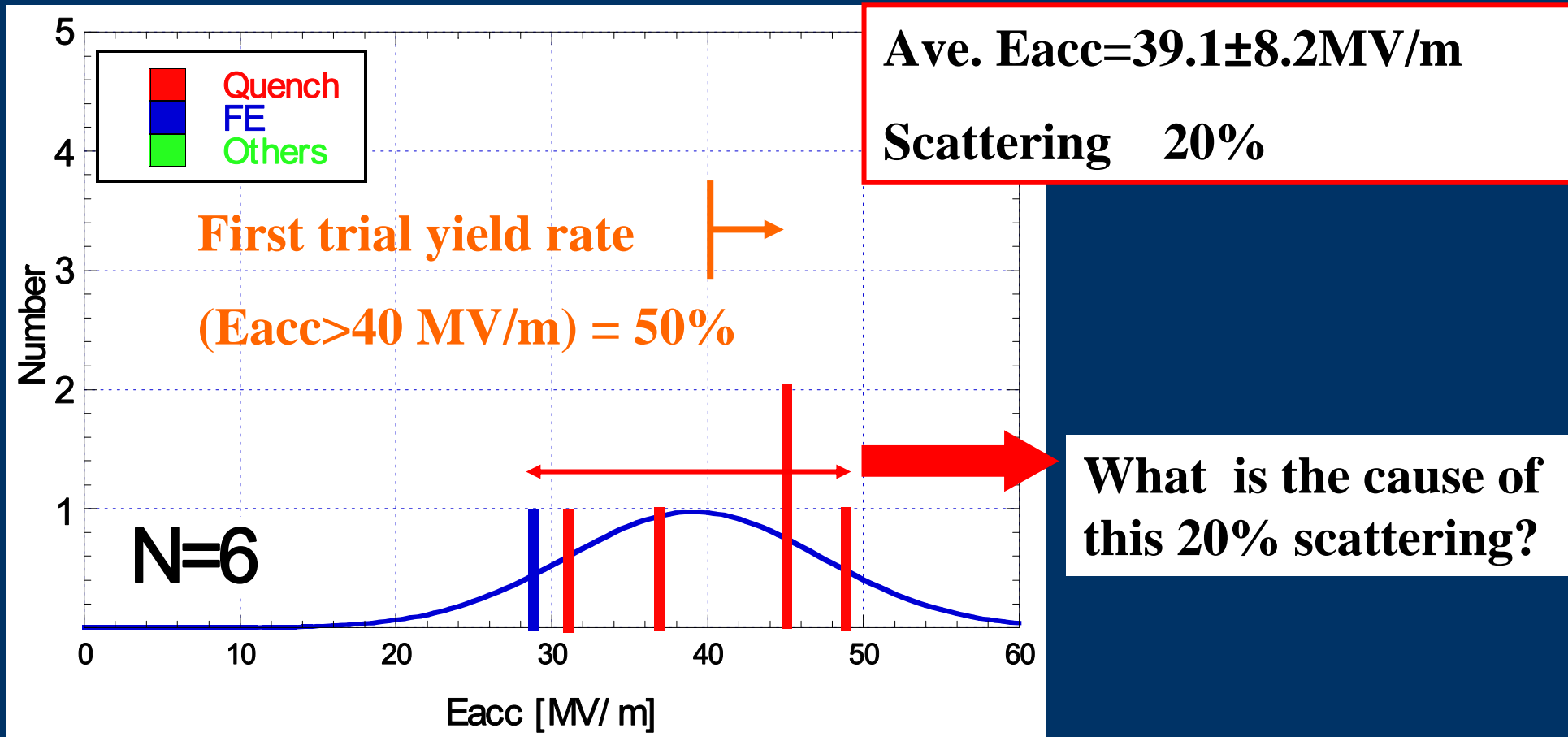
Qo 0.8e10@40MV/m

## Tunnel length and Costing



# Results after improvements in 2005 (1<sup>st</sup> series test)

Mechanical grind +light CP+Anneal+EP(80 $\mu$ m)+HPR+Baking



Training of operators and new HPR method reduced the scattering.

# What is the cause of 20% scattering?

Re-HPR or HF rinse  
can improve  
performance?

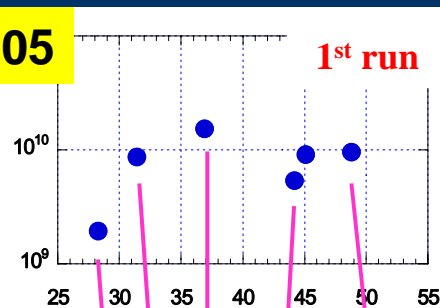


We need  
more removal.  
Try EP(3  $\mu\text{m}$ ,  
fresh EP acid)

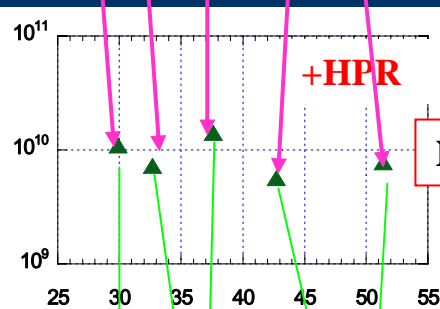
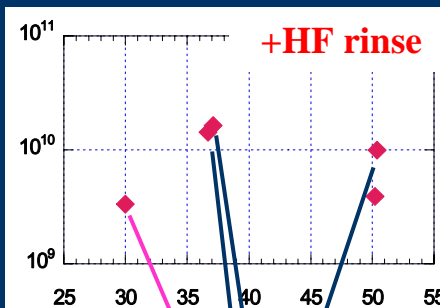


EP (3 $\mu\text{m}$ ,  
fresh EP acid)  
Improved  
performance

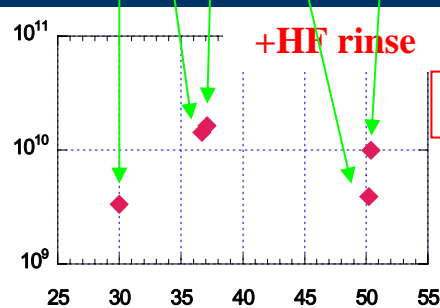
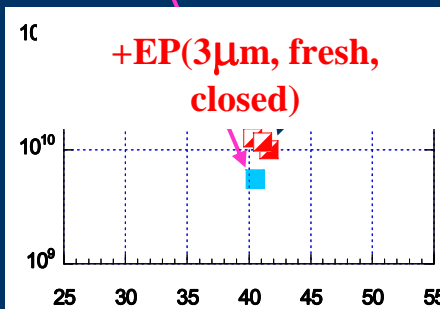
2005



Q  
Eacc  
max



No-removal



~0.1 $\mu\text{m}$

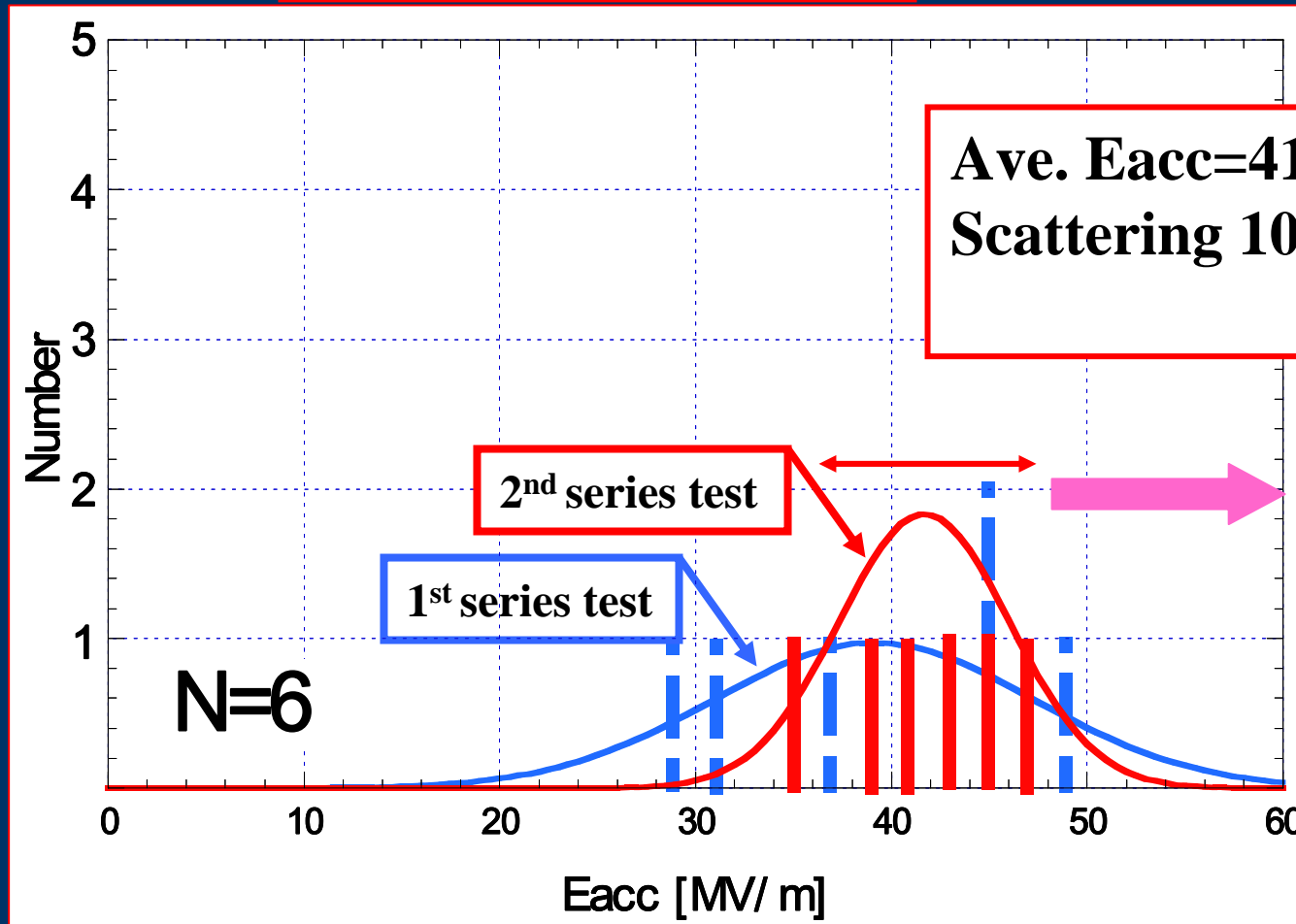


Reset the surface of  
six IS cavities by  
mechanical grinding.  
Try new recipe EP(80 $\mu\text{m}$ )  
+ EP(3 $\mu\text{m}$ , fresh EP acid)  
↓  
IS 2<sup>nd</sup> series test



# Results of 2<sup>nd</sup> series test in 2006

KEK new recipe : CBP+CP+Anneal+EP(80 $\mu$ m, tank)  
+ EP(3 $\mu$ m, fresh EP acid) + HF + HPR + Baking



EP(3 $\mu$ m, fresh EP acid) reduced the scattering.

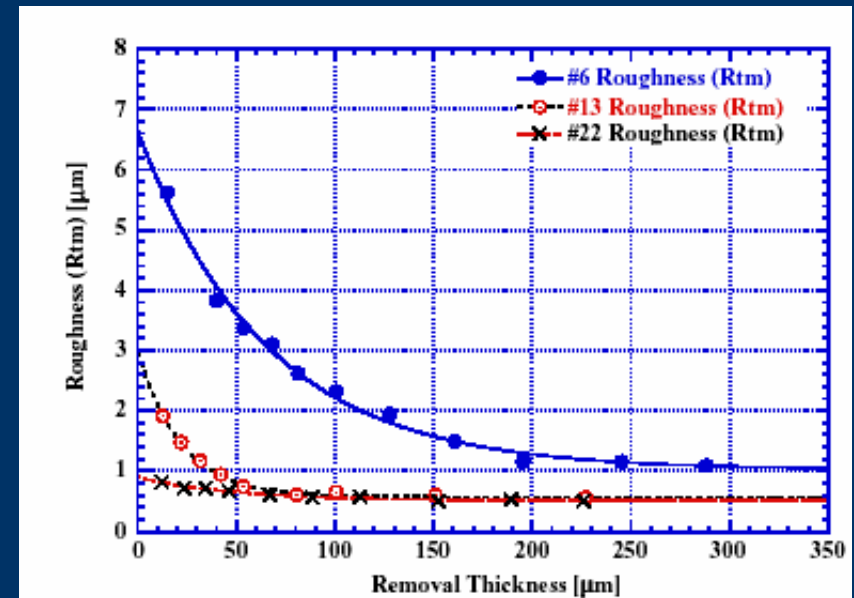
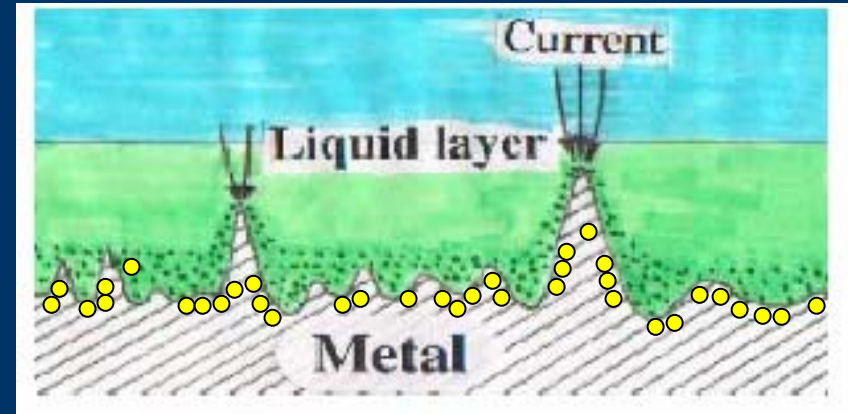
# More consideration about scattering

EP(3  $\mu\text{m}$ , fresh EP acid) removes the contamination of surface during EP (80  $\mu\text{m}$ ).

Additionally, we doubted thick EP removal (80  $\mu\text{m}$ ) makes oxidation layer during EP process.

If mechanical grinding makes the surface roughness  $< 5 \mu\text{m}$ , less EP removal is OK.

We explored the possibility of less EP removal (20  $\mu\text{m}$ ) with tank EP acid.

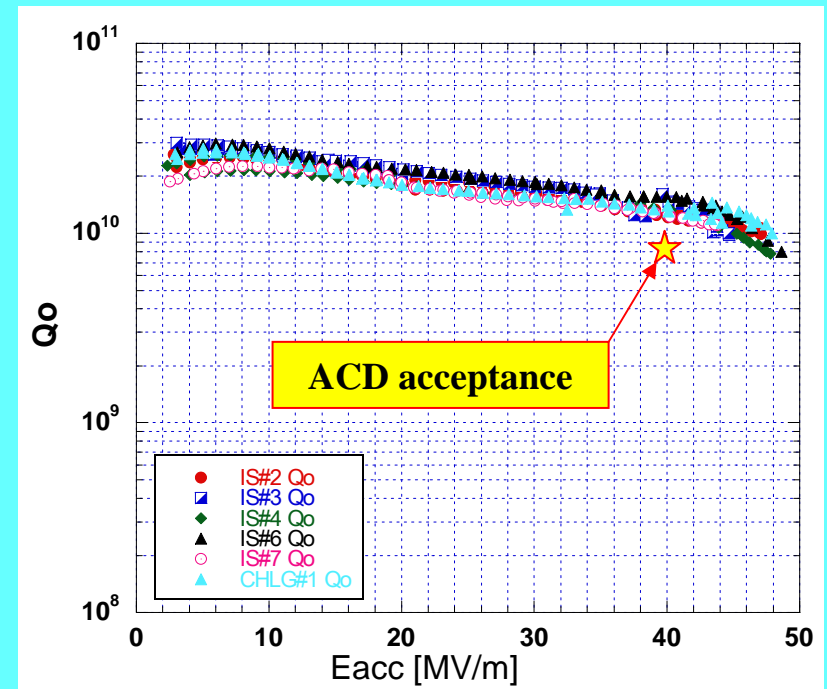
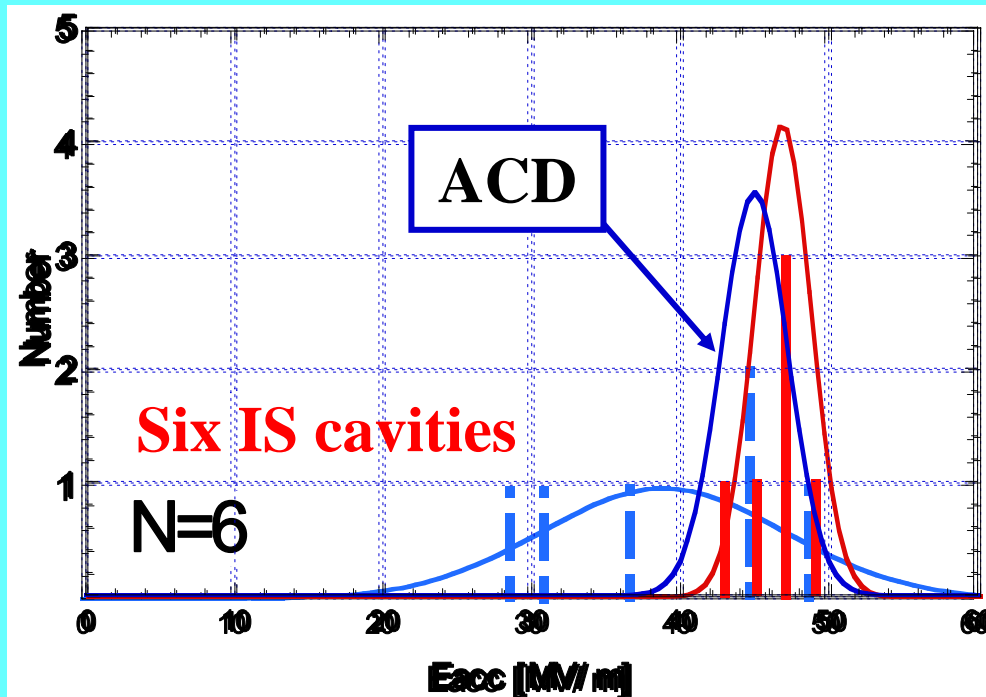


# EP(80 $\mu\text{m}$ ) + EP(20 $\mu\text{m}$ ) + EP(3 $\mu\text{m}$ , fresh EP acid)

EP(80  $\mu\text{m}$ , tank) + EP(20  $\mu\text{m}$ , tank) + EP(3 $\mu\text{m}$ , fresh EP acid) + HF + HPR + Baking

Ave. Eacc =  $46.7 \pm 1.9 \text{ MV/m}$

Scattering 5%



First trial yield rate (Eacc > 40 MV/m) = 100%

# Cleaning Process Score for the S0 study (KEK example)

	Expected yield rate	Disadvantage	Comment	Simplicity & Safety	Cost increase	Normalized Score	Priority
EP(20) + HPR+Bake	0.7		ILC BCD	1.0	1.0	1.0	Ref
EP(20)+H <sub>2</sub> O <sub>2</sub> +HPR+Bake	0.9	Cost increase	TRISTAN Recipe	1.1	1.1	1.17	1
EP(20)+Degreasing+HPR+Bake	0.9	Cost increase	29MV/m with TESLA 9-cell cavity @ Jlab	1.1	1.1	1.17	1
EP(20)+Alcohol +HPR+Bake	0.85	Cost increase Cure against burst	Stopped @ KEK Desy trying	1.15	1.15	1.06	2
EP(20)+HF rinsing+HPR+Bake	0.8	Cost increase Hazardous	Not so big potential but low FE @ KEK	1.1	1.15	0.99	3
EP(20)+Boling W +HPR+Bake	0.8	Cost increase complex	Hydrogen doping	1.1	1.15	0.99	3
EP(20)+EP(3 with fresh)+HPR+Bake	1.0	Cost increase	45MV/m with LL shape @ KEK	1.1	1.2	1.19	1
EP(20)+Oxipolishing +HPR+Bake	0.9	Additional process	Stopped @ KEK	1.5	1.3	0.99	3

Normalized Score : (Expected yield rate /Cost increase ) / Reference score (0.7 / 1.0)

# Plan for S0 single-cell cavity study at KEK

cavity		IS#2	IS#3	IS#4	IS#5	IS#6	IS#7	IS#8
EP(80+3) +HF	Eacc	43.88	42.0	46.1	44.7	48.60	39.30	49.2
	Qo	9.47e9	9.72e9	9.47e9	1.08e10	8.00e9	1.03e10	4.33e9
EP(20) +HPR		42.68						
		3.74e9						
EP(20)+H <sub>2</sub> O <sub>2</sub> +HPR								
EP(20)+Degreasing +HPR								
EP(20)+EP(3) +HPR								

Already we started S0 single-cell study.

Plan is to fill this table within next 4 months.

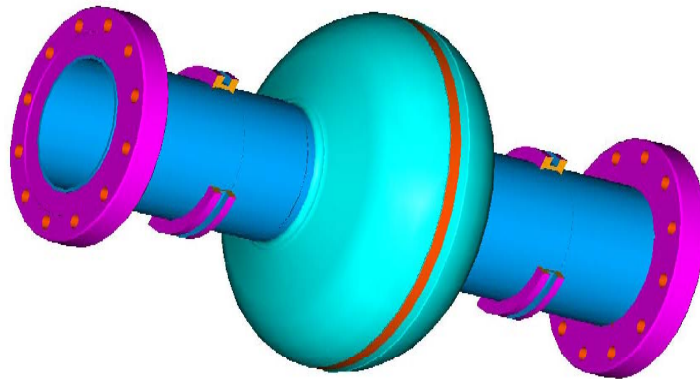
# Single-cell cavity tests @ DESY

Specification of cavity fabrication for XFEL project is important.

Qualification of modified fabrication parameters is urgent work

## Status and Results

- DESY standard single-cell cavity:



- 16 cavities at DESY completed:
  - machining, etching, EB welding + mechanical/optical checks inhouse
  - deep drawing of cups and electropolishing (EP) of cavities in industry
- 6 cavities at Accel Co. completed (large grain + mono crystal):
  - final mechanical/optical checks at DESY; EP at Henkel Co.; BCP at Accel

# Single-cell cavity tests @ DESY

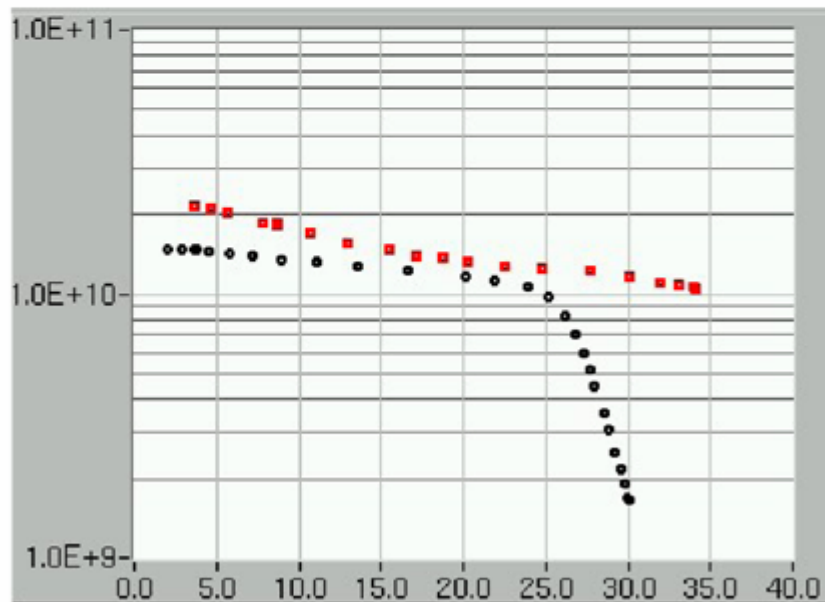
## Status + Results: Qualification of DESY production

- First step: Qualification of DESY in-house production:
  - 3 single-cells of well-known Nb quality (Heraeus 1999)
  - deepdrawing of cups at Zanon Co.
  - All electropolishing at Henkel Co.
  - Assembly, HPR and tests at hall NO
- all cavities exceed 30 MV/m at high Q-value
- Example for cavity data presentation

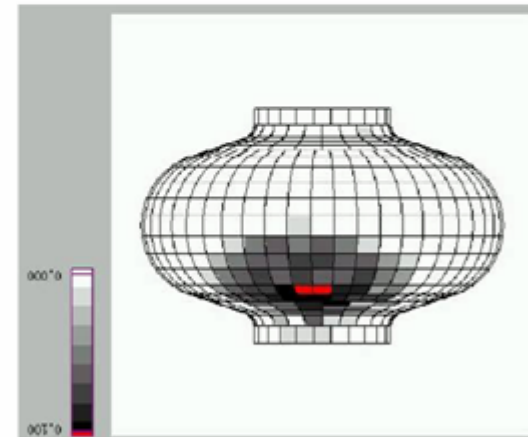
# Single-cell cavity tests @ DESY

## 1DE1: First DESY-Cavity successful

- First Cavity of DESY inhouse fabrication
- 150 $\mu\text{m}$  EP@Henkel, 800C, 130 $\mu\text{m}$  EP@Henkel, HPR, 127C bake, HPR  
(i) 130 $\mu\text{m}$  EP due to grinding; ii) add. HPR after bake necessary due to field emission)  
 $E_{\text{acc}} = 34 \text{ MV/m @ } Q_0 = 1 \cdot 10^{10}$ ; no FE; limited by BD; few MP



Q(E)-curves before and after bake at  $T = 2\text{K}$



Quench location far off the equator



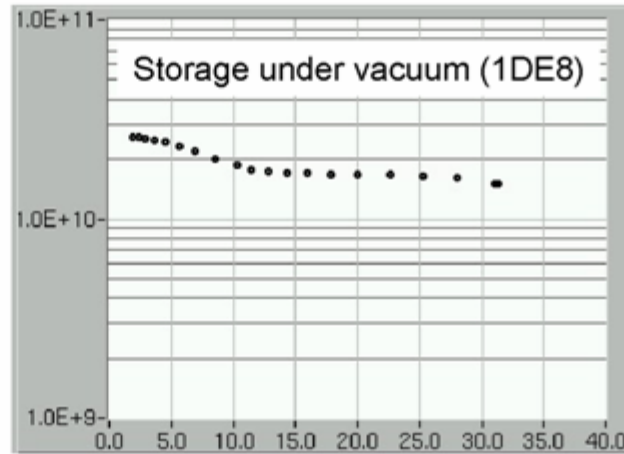
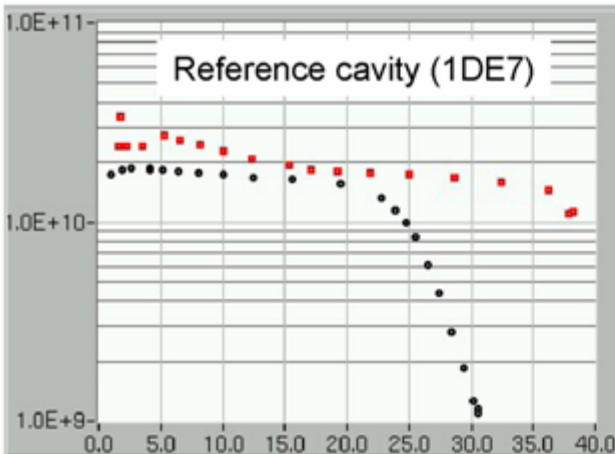
# Single-cell cavity tests @ DESY

## Status and Results: Welding preparation

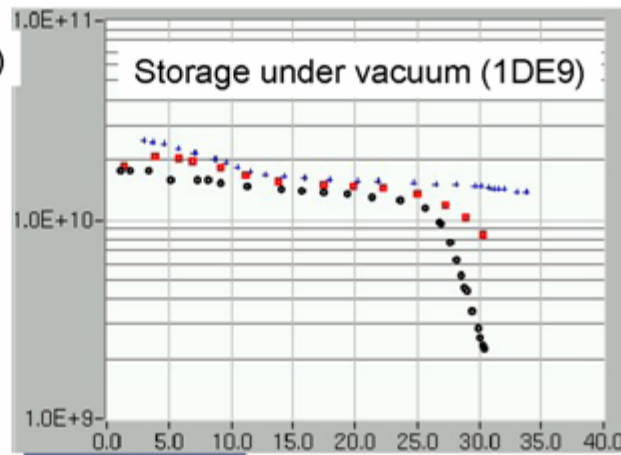
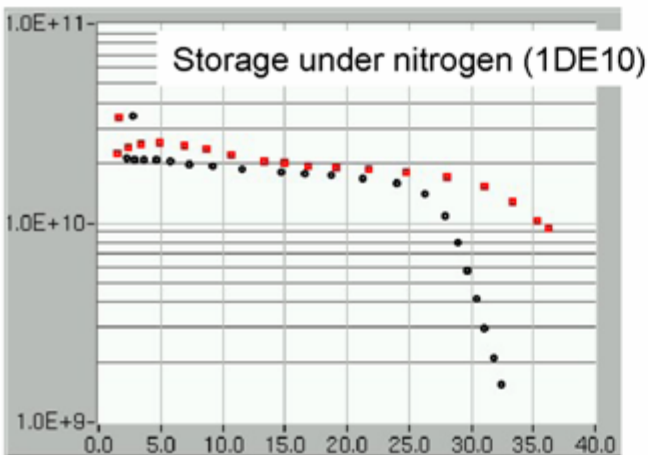
- Modification of present spec for welding preparation during cavity fabrication:
  - 1x reference cavity: max 8h between final etching of weld area and EB welding; (tested)
  - 2x cavities with **168h storage under vacuum** of components after final etch of weld area; (2x tested)
  - 2x cavities with **168h storage under nitrogen atmosphere** of components after final etch of weld area; (1x tested; 1x ready for test)
- **Good cavity performance with gradients between 31MV/m and 38 MV/m!!**
- **Modified welding preparation is accepted !!**

# Single-cell cavity tests @ DESY

## Status and Results: Welding preparation II



Q(E)-curves at 2K  
before and after  
bake at app. 130C



Detlef Reschke



28.07.2006

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These studies are for XFEL project. How to join S0 study is still under discussion.

# New EP facility @ CEA (Saclay)



## Material

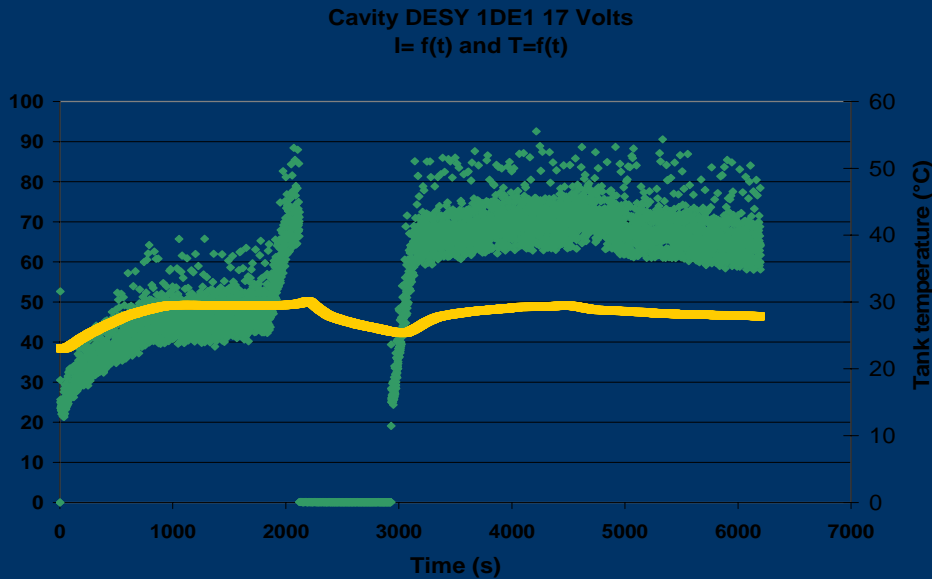
- PFA piping
- PVCC Tank + internal cooling PVDF pipe
- Nitrogen Flow in cavity and tank
- Data monitoring: I, T, V
- Some pneumatic valves

**First operation with acid: 10-17-2006**

**First cavity (1DE1) polished for test: 10-24-2006**

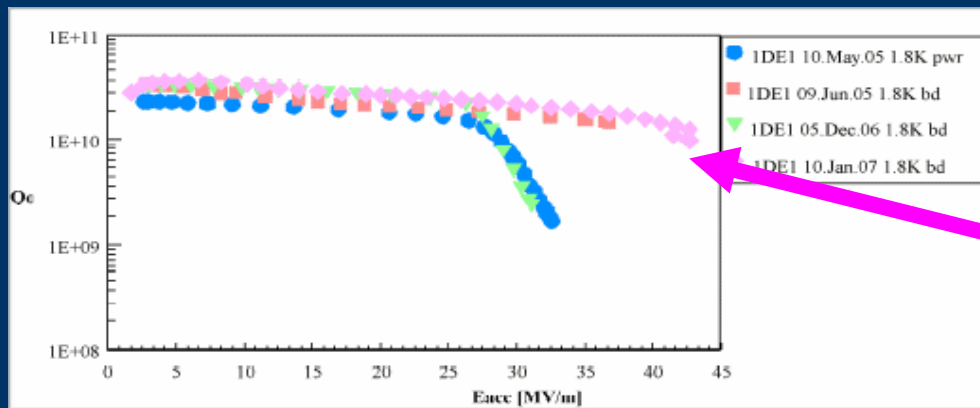
- Processing @ constant voltage: 17 Volts
- 1 Vol HF (40%) - 9 Vol H<sub>2</sub>SO<sub>4</sub> (95%) Mixture (Fresh bath)
- Ethanol rinsing

# FIRST RF RESULTS AFTER TREATMENT: 1DE1 CAVITY @ CEA



**42 μm removed**

- Acid flow 7L/min
- Cavity rotation: ~1 tr/min
- Acid temperature: 25-30°C
- Nitrogen flow: 3-10 L/min (tank)  
2L/min (cavity)
- Voltage: ~17 Volts
- Maximum intensity: ~ 80 A
- Strong sulfur odor after treatment



## Baking and RF Test @ DESY

31 MV/m (Quench?) before baking

**42.73 MV/m @1.8K after baking**

**+7MV/m / last treatment**

Q<sub>o</sub> Vs E<sub>acc</sub> for last treatments

**CEA is ready to join S0 program in collaboration with DESY**

# Large Grain/Single Crystal study @ Jlab

CBMM



Ingot "D", 800 ppm Ta



Ingot "A", 800 ppm Ta



Ingot "B", 800 ppm Ta

Ninxia



Wah Chang



Heraeus



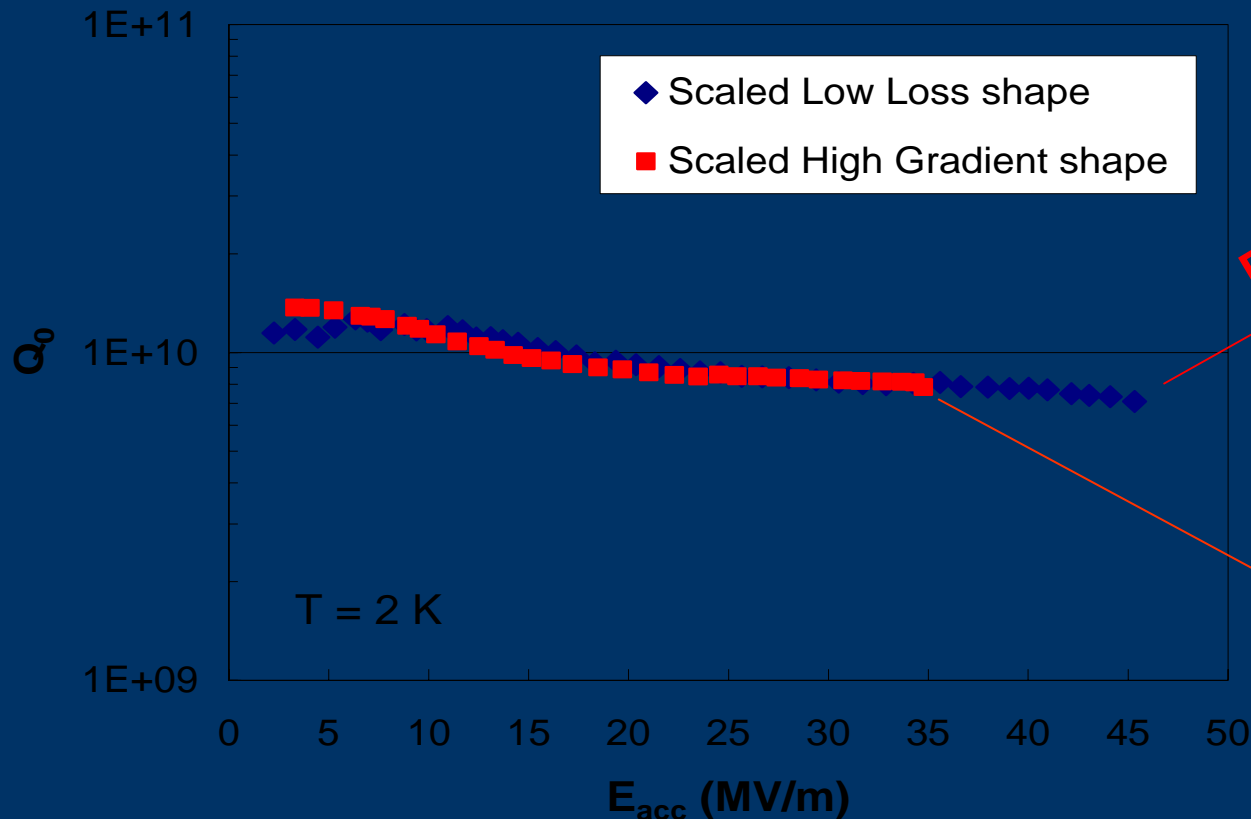
Ingot "C", 1500 ppm Ta



**Main activity is focused on LG/SC study.**

# LL and HG single-crystal cavities @ Jlab

## 2.3 GHz single-cells, treated by BCP

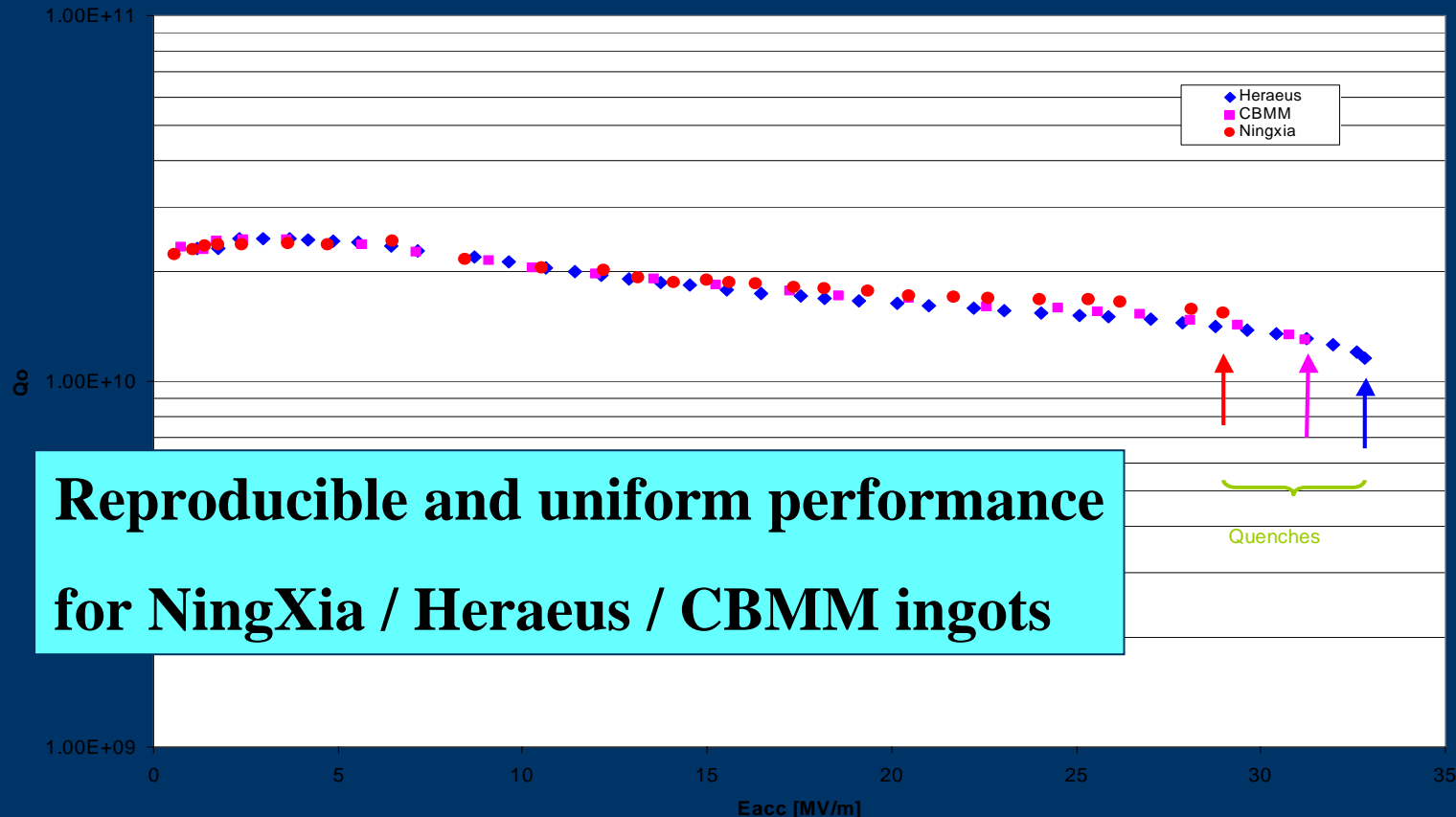


*P. Kneisel et al., Proc. of PAC'05, Knoxville, TN, 2005, p. 399*

**Scaled LL successfully reached 45 MV/m**

# Summary of LG/SC before post-purification

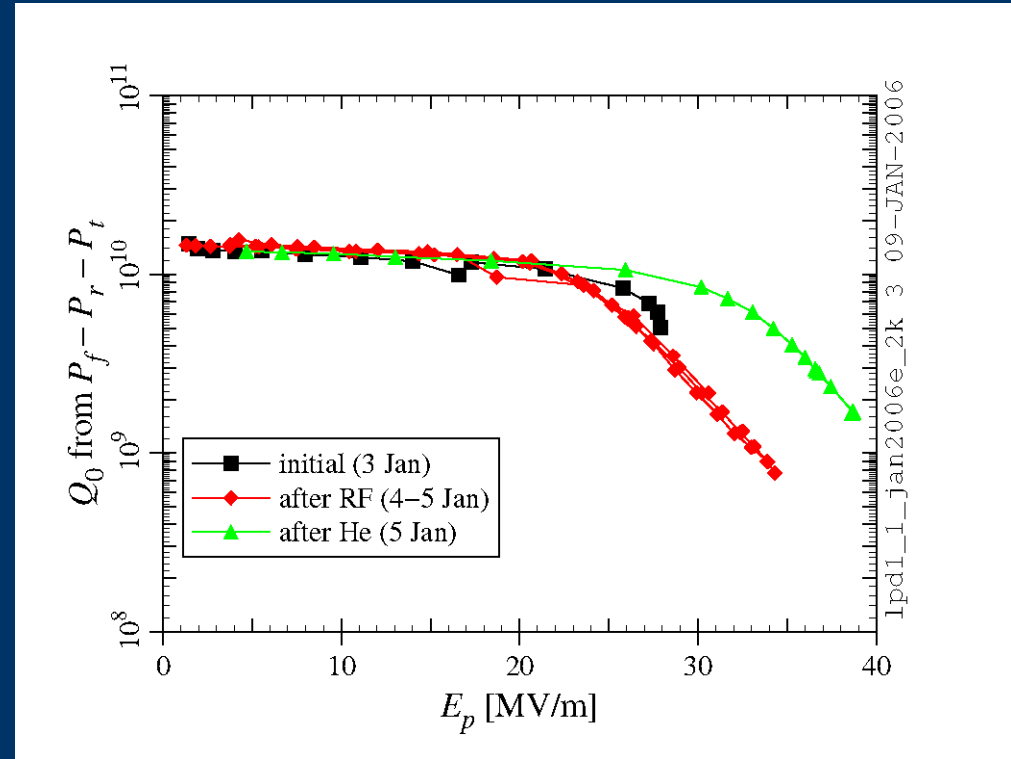
Large Grain ,TESLA Cavity Shape, before post-purification  
T = 2K



Details of LG/SC studies will be presented in parallel session

Jlab just started discussion about S0 single-cell study.

# Michigan State University (MSU)



1.3 GHz  $\beta=0.81$  for FNAL Proton Driver.

Half-Reentrant cavity for high-gradient study.

MSU is interested in S0 program.



# Single-cell study @ IHEP



Deep drawing



Trimming



After the fabrication



Beam pipe EBW



Half cell EBW



After the EBW

**Close collaboration with KEK**

# Single-cell study @ IHEP



Chemical Polishing (CP) of 1.3GHz/ $\beta=0.45$  SCC

**IHEP is ready to join S0 study**

# Summary

- **KEK : EP(80 um) + EP(20 um) + EP(3um, fresh EP acid) produced small scattering of 5 % (N=6). The result of Avr. Eacc=46.7 @ high Q is already beyond ACD acceptance.**
- **KEK proposed an example of S0 program with 8 final rinsing methods. KEK picked up 4 items and plan is to test 4 items with six cavities within 4 months.**
- **DESY : Urgent work is fabrication specification for XFEL project. From single-cell tests, new fabrication specifications were established. 8-hour rule, nitrogen atmosphere storage between final edge of welding area and welding.**
- **CEA : CEA and DESY collaboration is in good shape. DESY cavity processed at CEA (EP 42 um) reached 43 MV/m in VT at DESY. DESY/CEA are ready to join S0 program.**
- **JLab : Scaled ILC LL reached 45 MV/m. Main focus of single-cell cavity studies is on large-grain and single-crystal material. Just start discussions how to contribute S0 study.**
- **Michigan State University and IHEP is ready for S0 program.**