Talk by K.Saito in the TESLA collaboration meeting on January 21-23 2004

Heveay Field Emission Problem in Electropolished Multi-Cell Cavities

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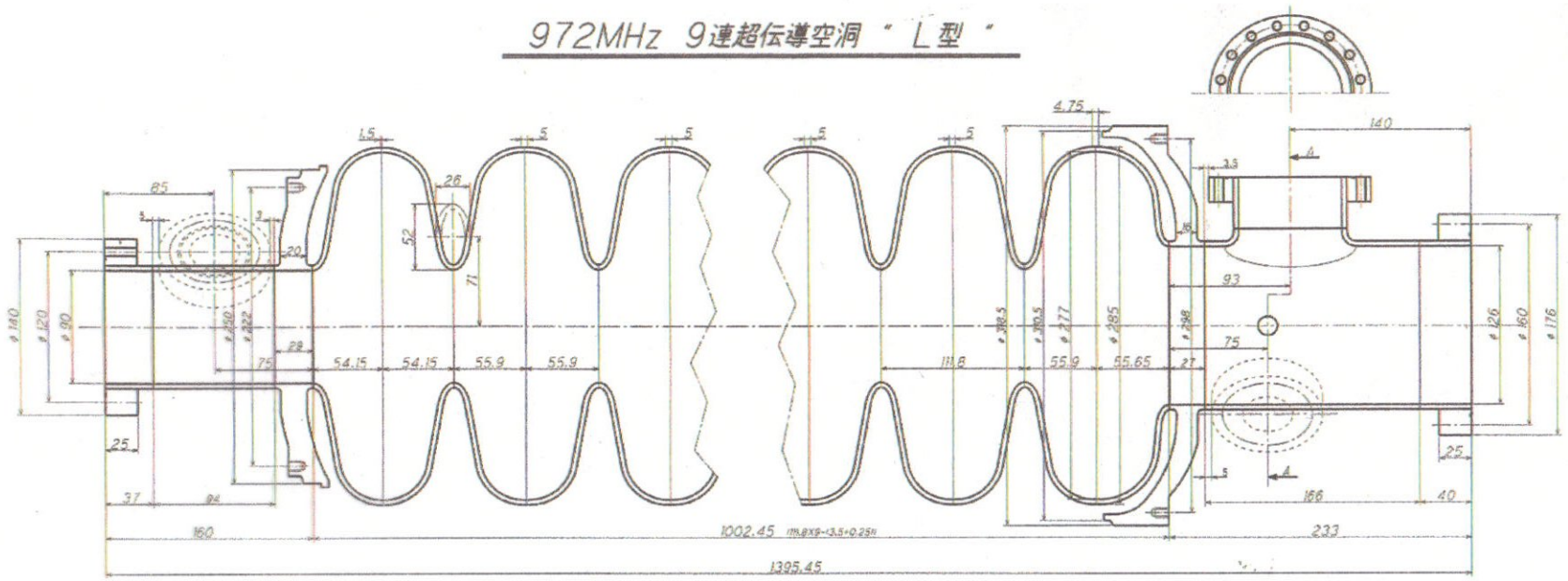
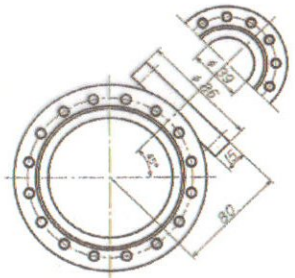
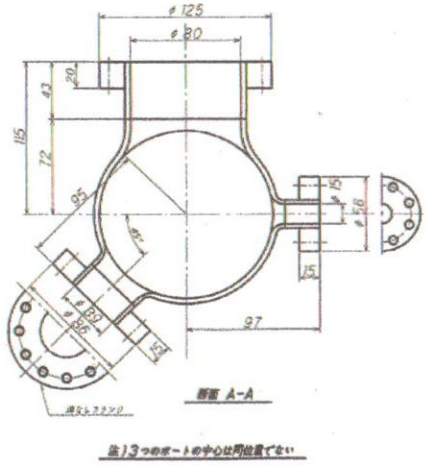
Outline

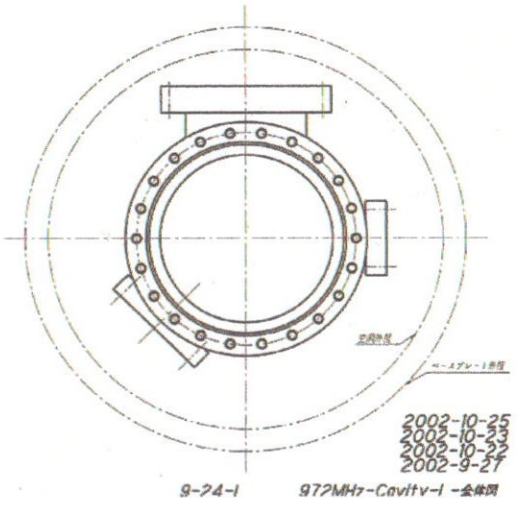
1. **Bad Performance with Recent 972MHz, β=0.725 9-cell Cavities**
2. **Field Emission and Multipacting Analysis**
3. **Pass-band Measurement**
4. **Discussion and Summary**

972MHz 9-cell Cavity (L-cavity) for KEK/JAERI Joint R&D









f=972MHz

β=0.725 (~400MeV)

Ep/Eacc=3.07

Hp/Eacc=55.4 Gauss[MV/m]

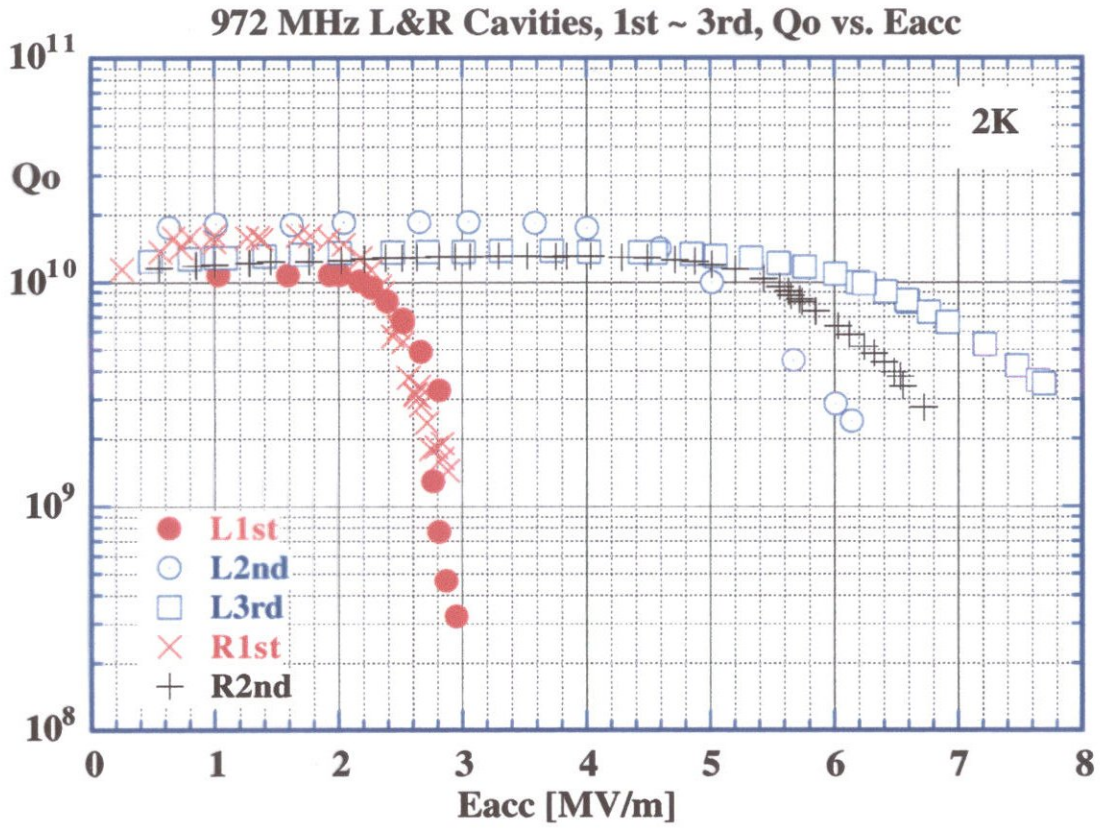
R/Q=47.8 Ω

G=208.0 Ω

Cell to cell coupling =2.8%

designed by E.Kako

1. Bad Performance of The Recent 972MHz 9-Cell Cavities



L1st, R1st : BP+EP(100)+ANL(750^{O}C)+ EP(50~30)+Hot rinsig +HPR(DI, 2hr)+UPW +Bake(120^{O}C,48hr)

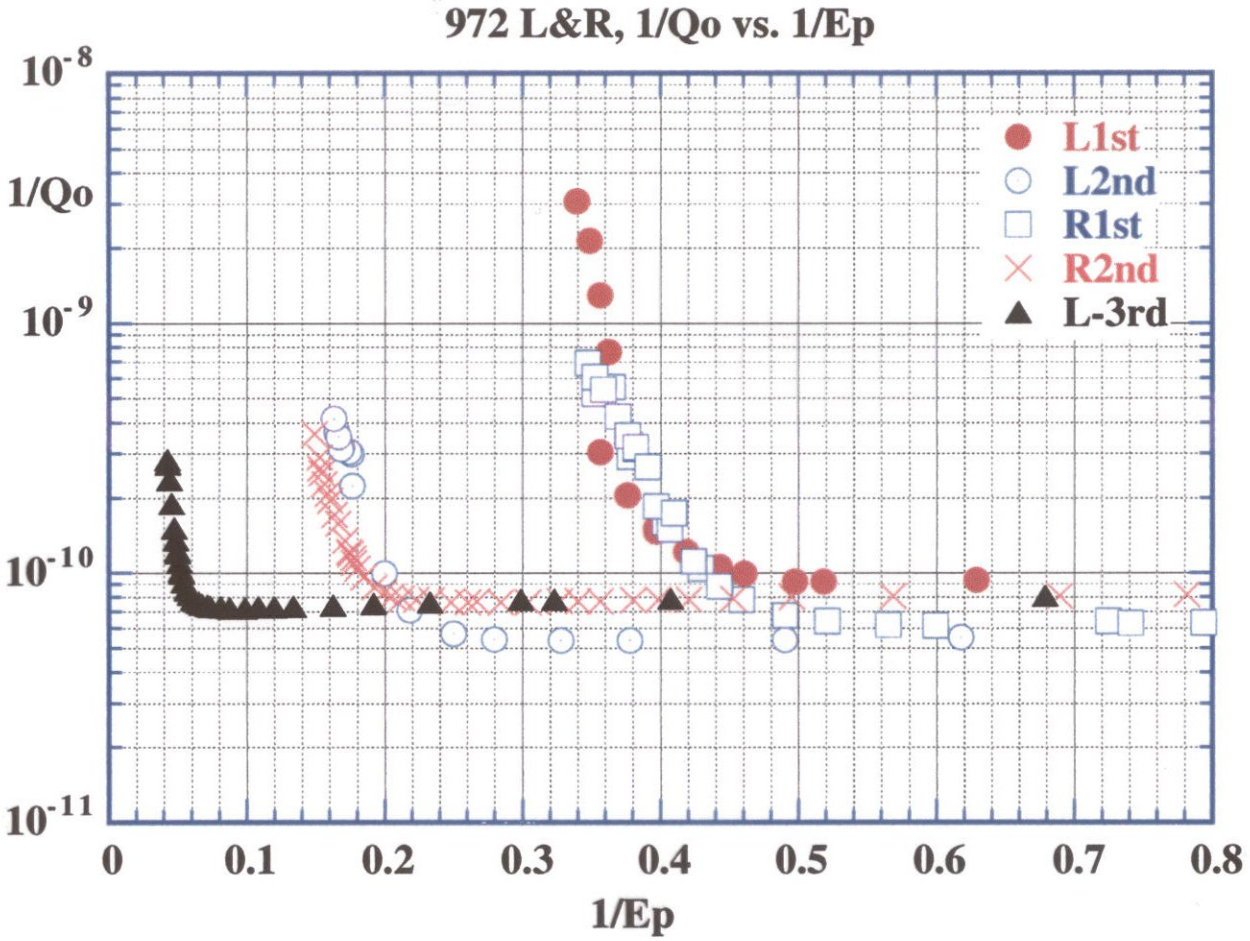
L2nd : EP(10)+H_2O_2 rinsing +Hot rinsing + UPW, "No HPR", + Bake(120^{O}C,48hr)

R2nd : EP(10)+ H_2O_2 rinsing +Hot rinsing + HPR(DI,4hr)+UPW, +Bake(120^{O}C,48hr)

L3rd : HPR(DI,4hr)+UPW, +Bake(120^{O}C,48hr)

KEK has confirmed the serious field emission problem in electropolished multi-cell cavities same as DESY or JLAB.

2. Field Emission Analysis



The same FE behavior in both cavities

Evaluation of Emission Size and β

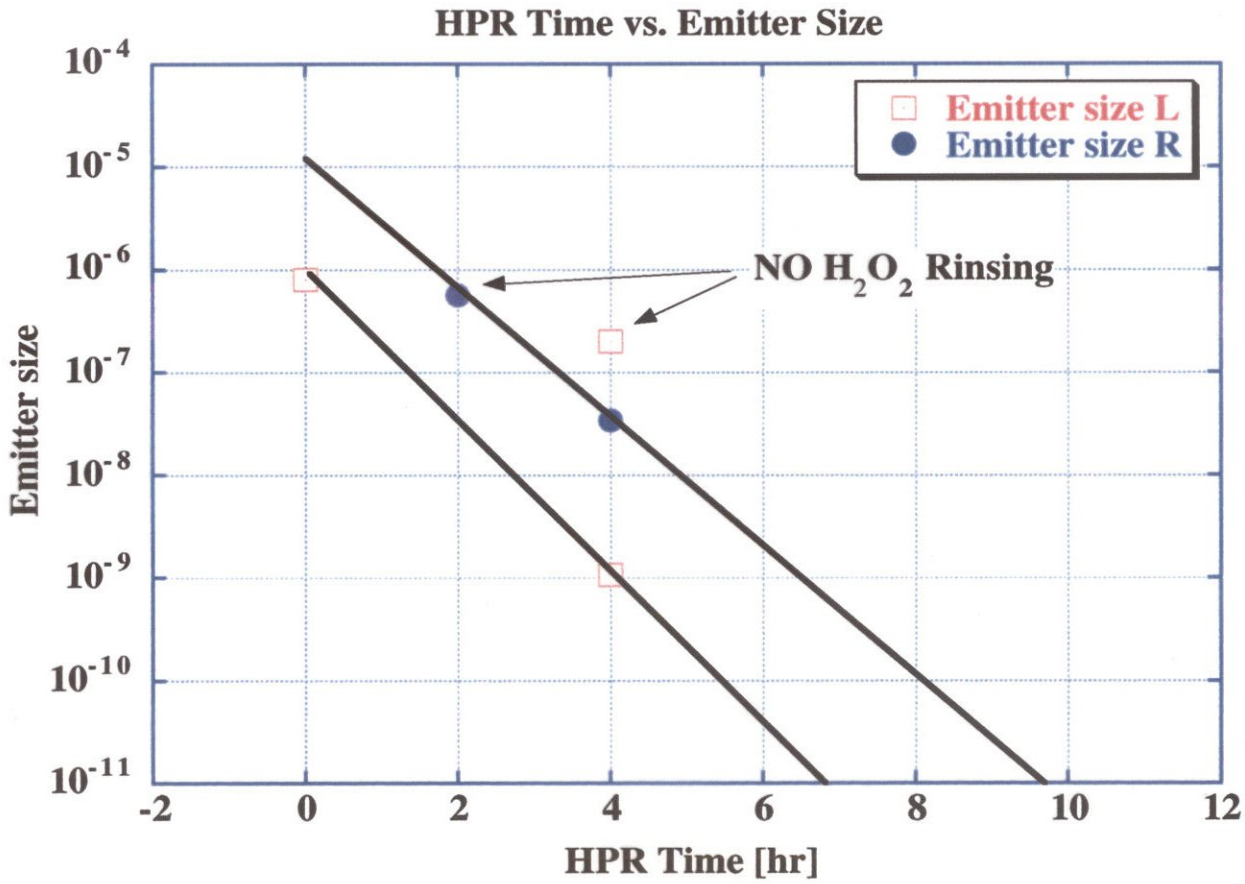
$$\Delta\left(\frac{1}{Q_o}\right)=\frac{1}{Q_o(E_p)}-\left(A+B\cdot {E_P}^2\right),\qquad \Delta\left(\frac{1}{Q_o}\right)=S\cdot {E_p}^{1.5}\cdot\exp\left(-\frac{5.46\cdot 10^4}{\beta\cdot E_p}\right),\qquad E_p=3.07\cdot E_{acc}\,[MV/m]$$

Cavity No. & Meas. No.	Emitter size S	Field enhancement Factor β	Preparation
972L-1st	2.02E-7	627	EP(50)+Hot rinsing+HPR(2hr)+UPW+Bake
972L-2nd	7.97E-7	389	EP(10)+H_2O_2 rinsing+Hot rinsing+ UPW+ Bake "No HPR"
972L-3rd	1.08E-9	360	HPR(4hr)+UPW+Bake
972R-1st	5.62E-7	619	EP(30)+Hot rinsing+HPR(2hr)+UPW+Bake
972L-3rd	3.41E-8	283	EP(10)+H_2O_2 rinsing+ Hot rinsing+"HPR(4hr)"+UPW+Bake

1) H_2O_2 rinsing reduces β about half.

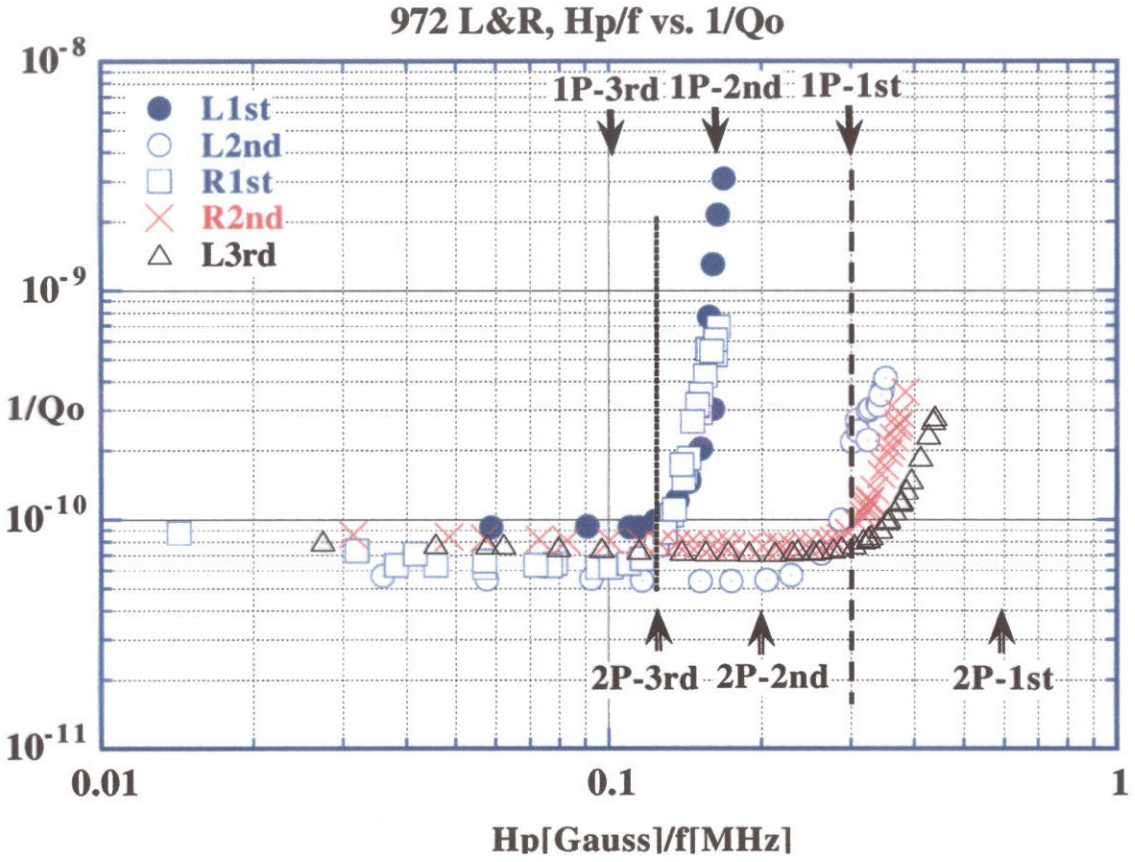
2) HPR decreases the emission size remarkably but has less effect on β.

How effective is the long hour HPR ?



The long term HPR for totally 7~10 hours is needed in order to decrease the emission size.

Multipacting Analysis



Onset field of Multipacting

$$\frac{H_p[Gauss]}{f[MHz]} = \frac{0.3}{n}, \quad n = 1, 2, \cdots \quad \text{for One Point MP}$$

$$\frac{H_p[Gauss]}{f[MHz]} = \frac{0.6}{2n-1}, \quad n = 1, 2, \cdots \quad \text{for Two Point MP}$$

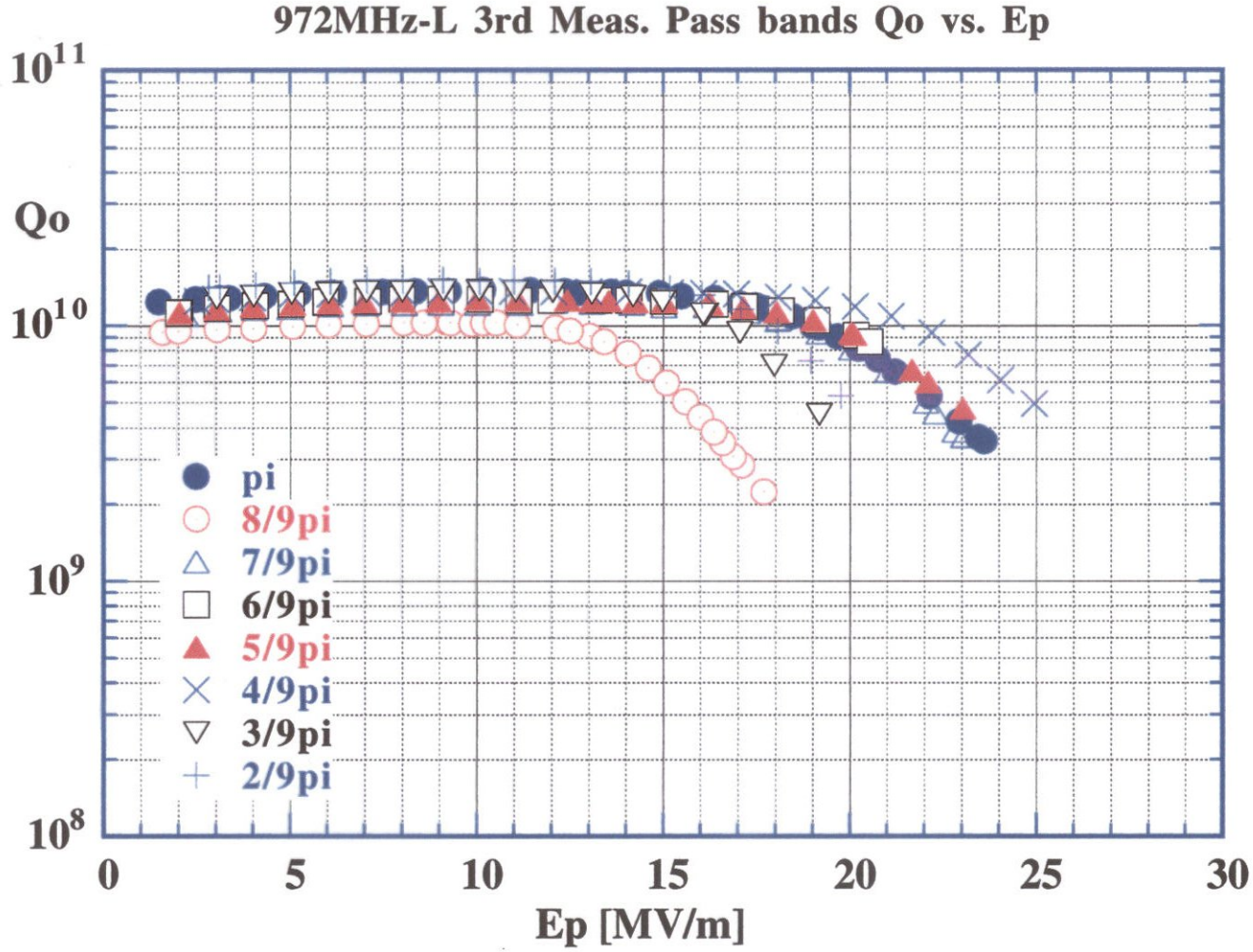
The field emission will be initiated by multipacting

The starting points of Qo-dropping well fit the onset field of multipacting :

2P-3rd, 2P-2nd or 1P-1st.

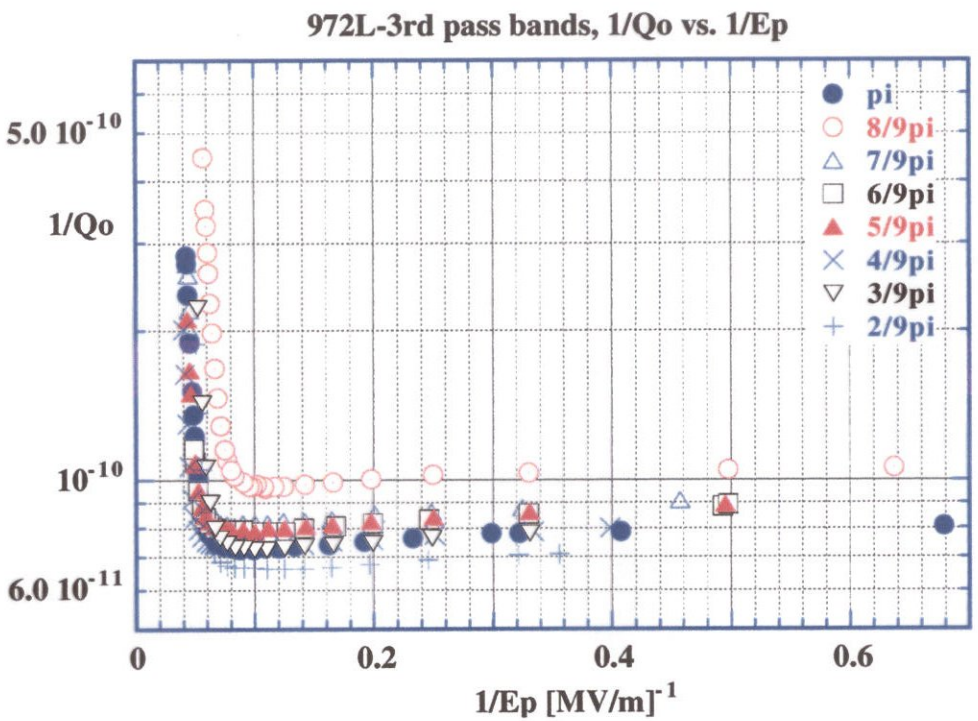
H_2O_2 rinsing pushes down multipacting from higher order to lower one.

3. Pass-band Measurement

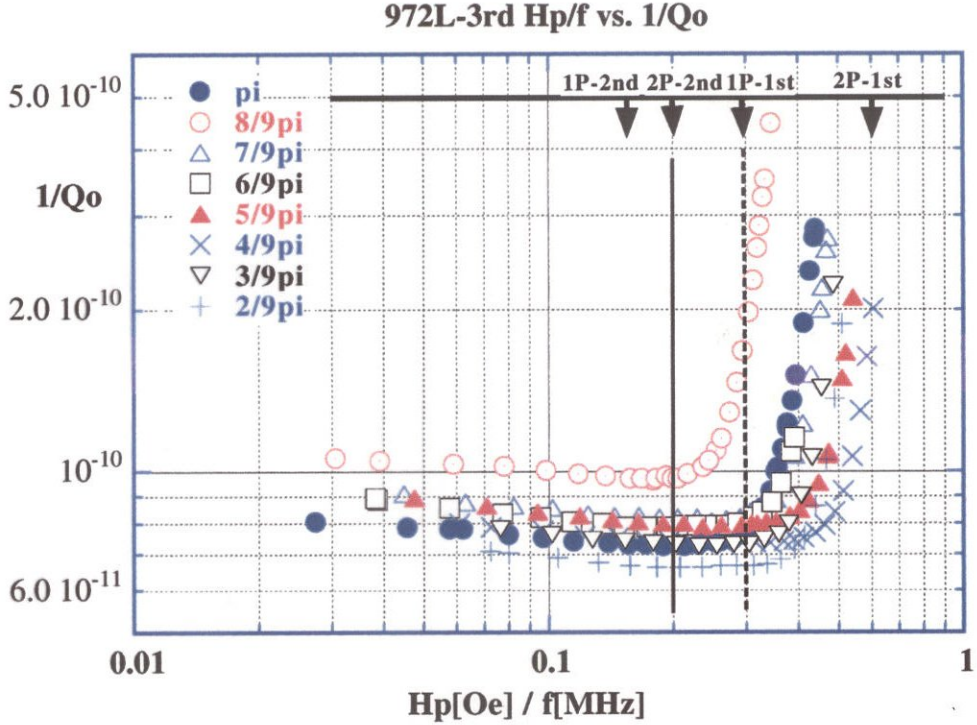


The 1/9 π mode is missing due to the weak coupling by our input coupler.

FE and MP Analysis with Pass-band Modes



FE Analysis

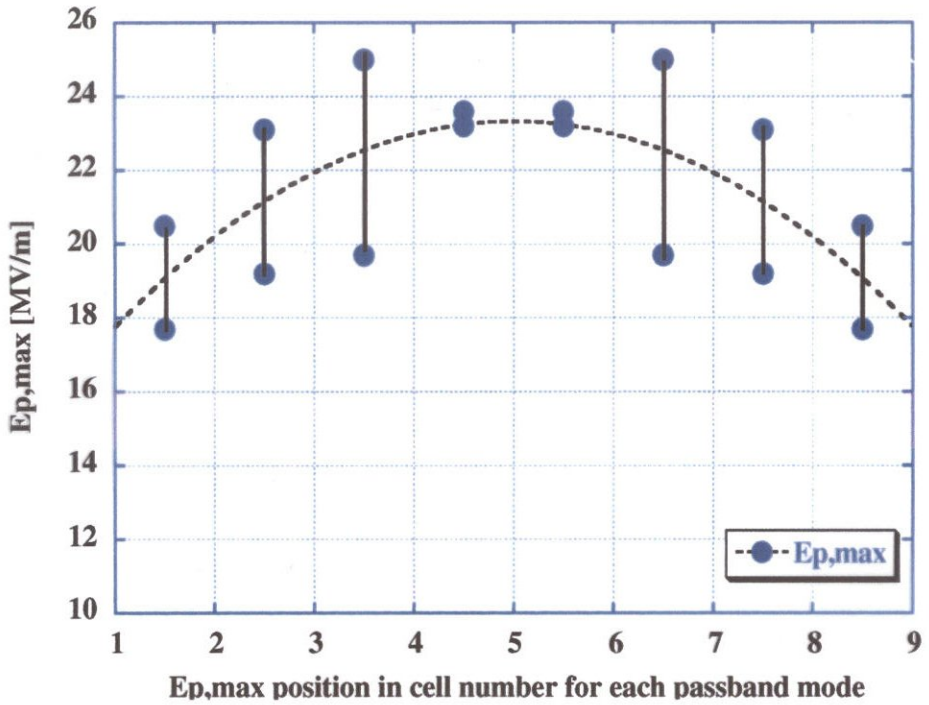


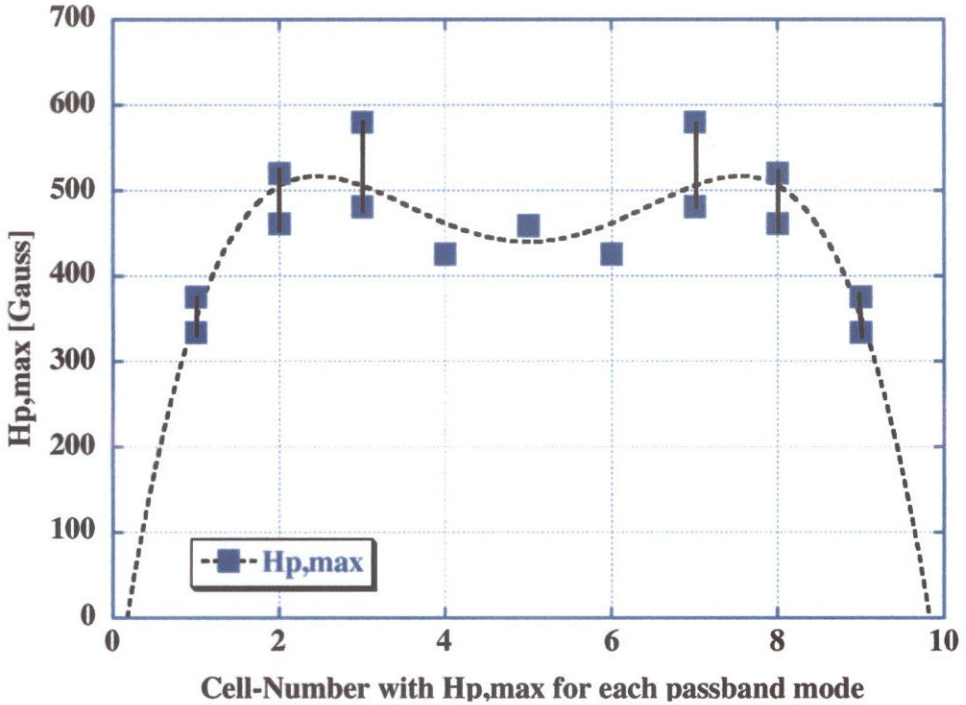
MP Analysis

Every mode looks like FE initiated by MP.

The 8/9π-mode behaves badly. ⇒ End cells might be problem.

Problem Cell





From FE Analysis

From MP Analysis

The problem might be in the both end-cells or one of them.

4. Discussion and Summary

1) KEK has confirmed the heavy FE with electropolished multi-cell cavities same as DESY or JLAB.
2) This FE problem would be initiated by multipacting.
3) The rinsing method in the TRISTAN SC cavities, which consists of H_2O_2 rinsing and long term water rinsing, is not helpful against this FE problem.
4) However the H_2O_2 rinsing (40 min) pushes down multipacting to the lower order. In an addition, this rinsing is effective to decrease the field enhancement factor β. The further long term H_2O_2 rinsing might be effective.
5) From the effect of the H_2O_2 rinsing, sulfur contamination in electropolishing is strongly suggested as the origin of the multipacting.
6) HPR reduces the emission size remarkably but is less effective to decrease β on this FE problem. The longer term HPR should be effective.
7) For the TESLA production, a more effective rinsing method has to be developed for time saving.