Cryomodule Tests of Four Tesla-like Cavities in the STF Phase-1.0 for ILC

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Outline

- Introduction of the STF at KEK
- Cavity Package of the Tesla-like Cavity
- Cryomodule Assembly
- Performance of Couplers and Tuners
- Cavity Performance at High Fields
- Lorentz Force Detuning
- Dynamic RF Loss Measurement
- Summary and Future Plan

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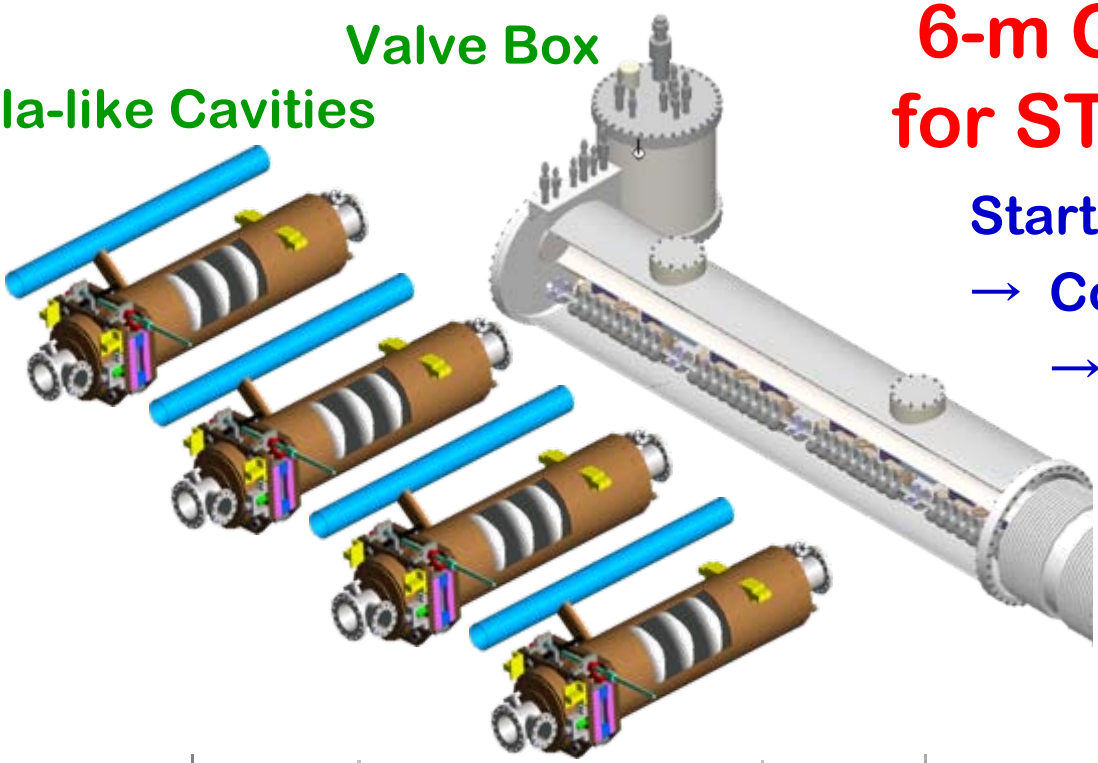
Superconducting rf Test Facility (STF)

Valve Box

Tesla-like Cavities

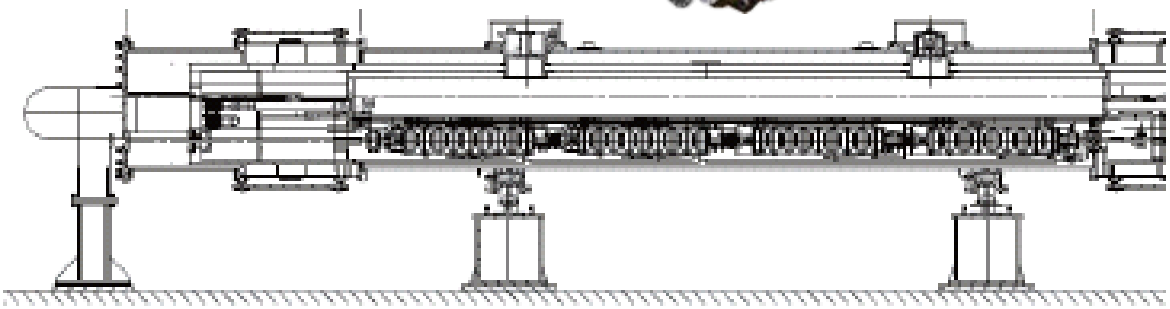


6-m Cryomodule for STF Phase-1.0

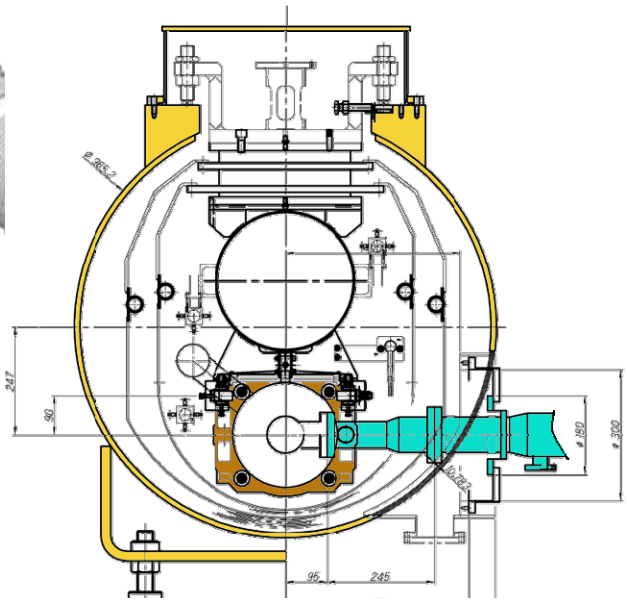
Started in April 2005'

→ Completed in Mar. 2008'

→ Cool-down in May 2008'



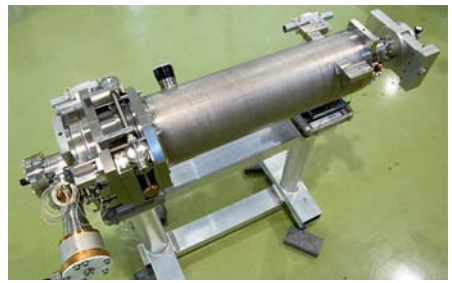
Four 9-cell cavities in the STF tunnel



Cryomodule Cross-section

Cavity Package of the Tesla-like Cavity

Input coupler and Doorknob

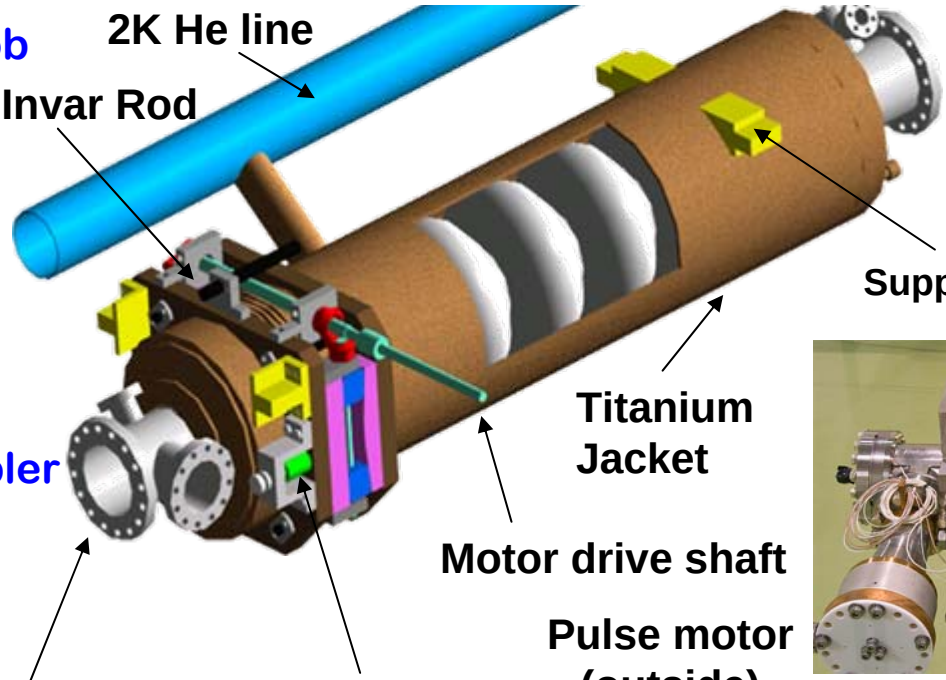


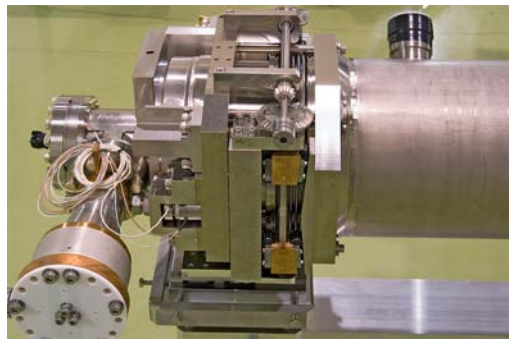
A niobium 9-cell cavity covered with Ti jacket

4 cavities
in vertical tests

Warm coupler & Cold coupler

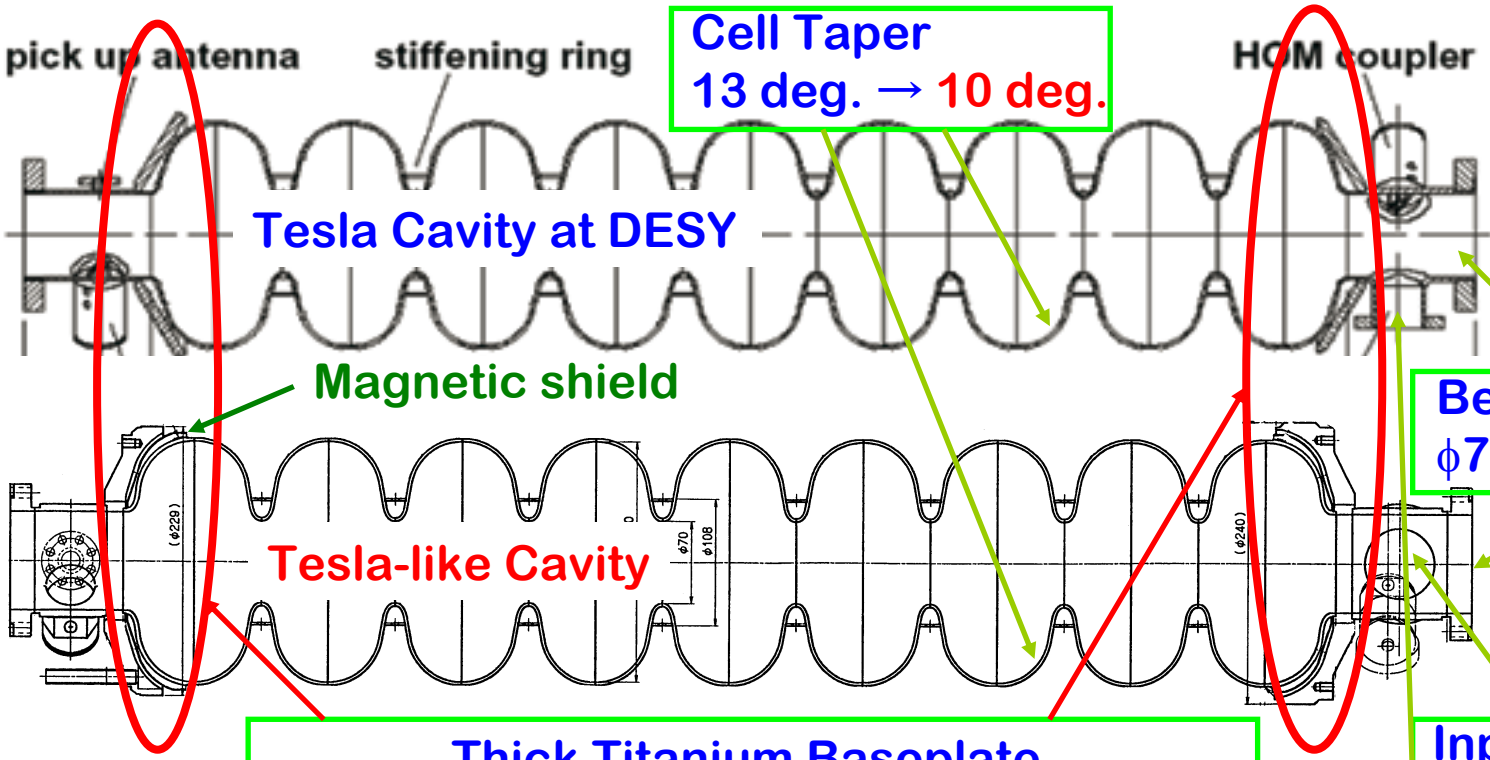
HOM couplers





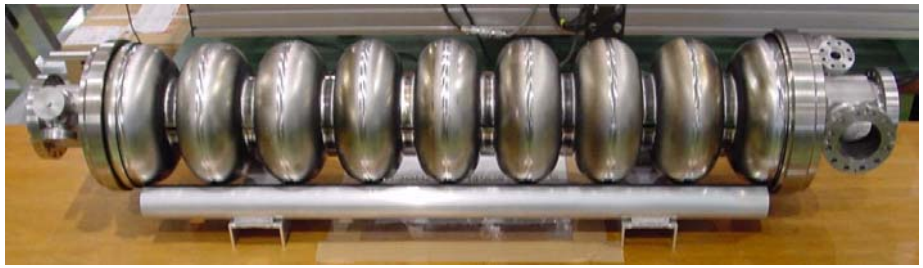
Slide-jack tuner
and Piezo tuner

Tesla-like Cavities ; Improved Stiffness

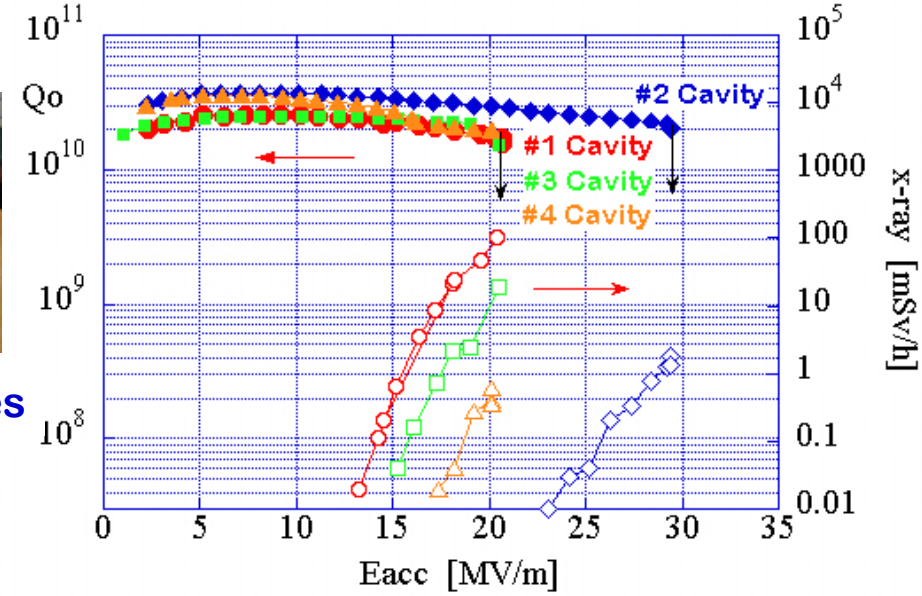


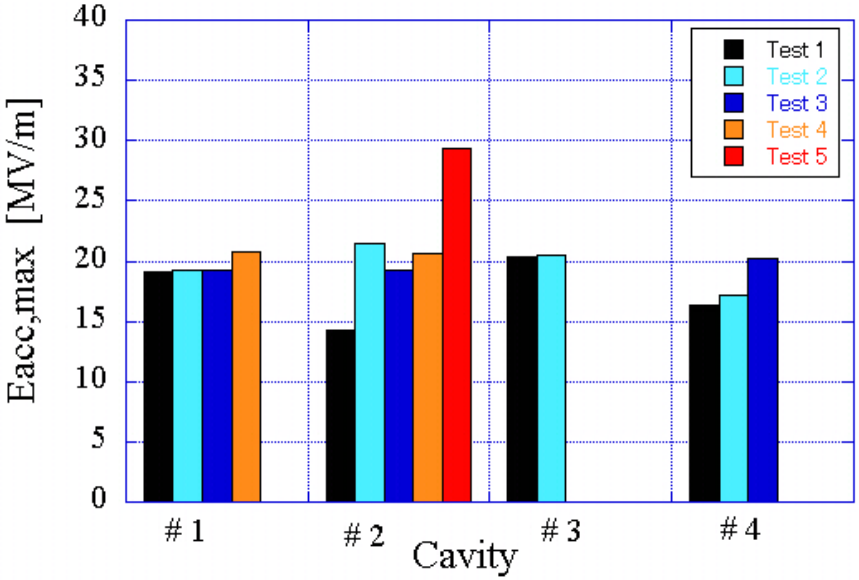
Stiffness of Cavity Sys. Lorentz Detuning at flat-top	Tesla-like Cavity 72 kN/mm Δf = - 150 Hz	Tesla Cavity 22 kN/mm Δf = - 500 Hz	Estimation at 31.5 MV/m

Vertical Test of #1, #2, #3, #4 Cavities



A Tesla-like 9-cell cavity with stiff Ti endplates





14 tests for 1year (Feb. 2006 ~Feb. 2007)

March, 2007'

Purpose of STF Cryomodule Test

- To check the performance as a total superconducting cavity system, and to find out the improvement points for the future project.
- To confirm a stable pulsed operation at higher fields, and to compare the achieved Eacc,max in the cryomodule tests with the results in the vertical tests.
- To demonstrate a compensation of Lorentz force detuning by a piezo tuner, and to establish the effectiveness of an improved stiffness in a cavity support structure.

Assembly of STF Cryomodule (1)

January, 2008'

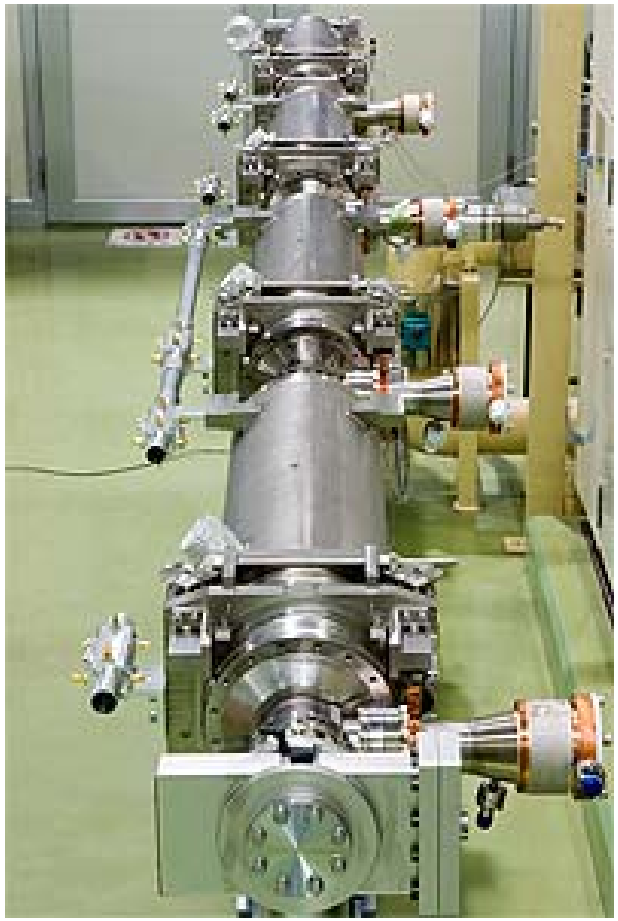
String assembly of 4 cavities
in a class-10 clean room

January, 2008'

Vacuum leak-check of string cavities
in a class-1000 clean room

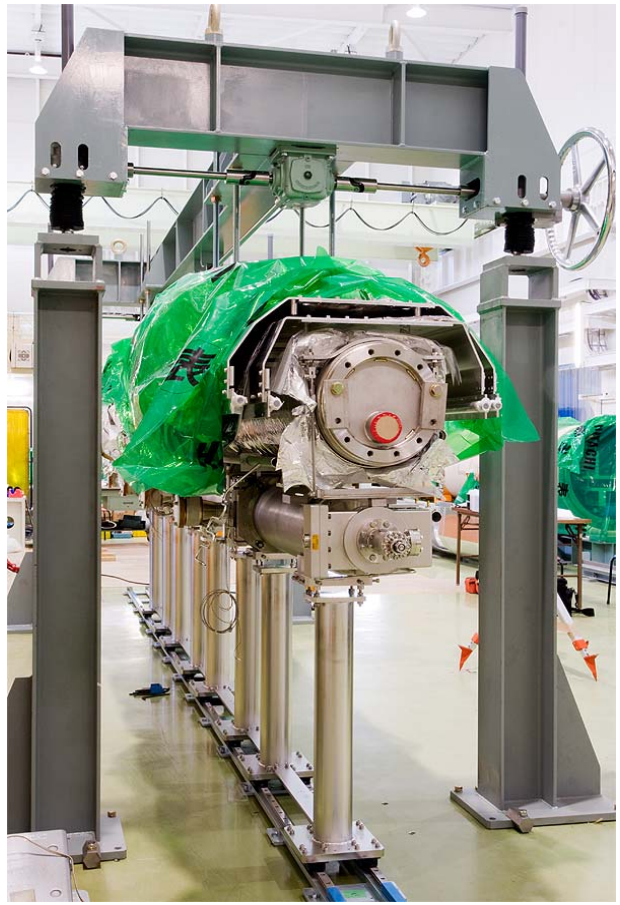
Assembly of STF Cryomodule (2)

February, 2008'



Tuner installation and alignment of four cavities at outside area of a clean room

February, 2008'



Hanging the string cavities on GRP at cryomodule assembly area

Assembly of STF Cryomodule (3)

March, 2008'

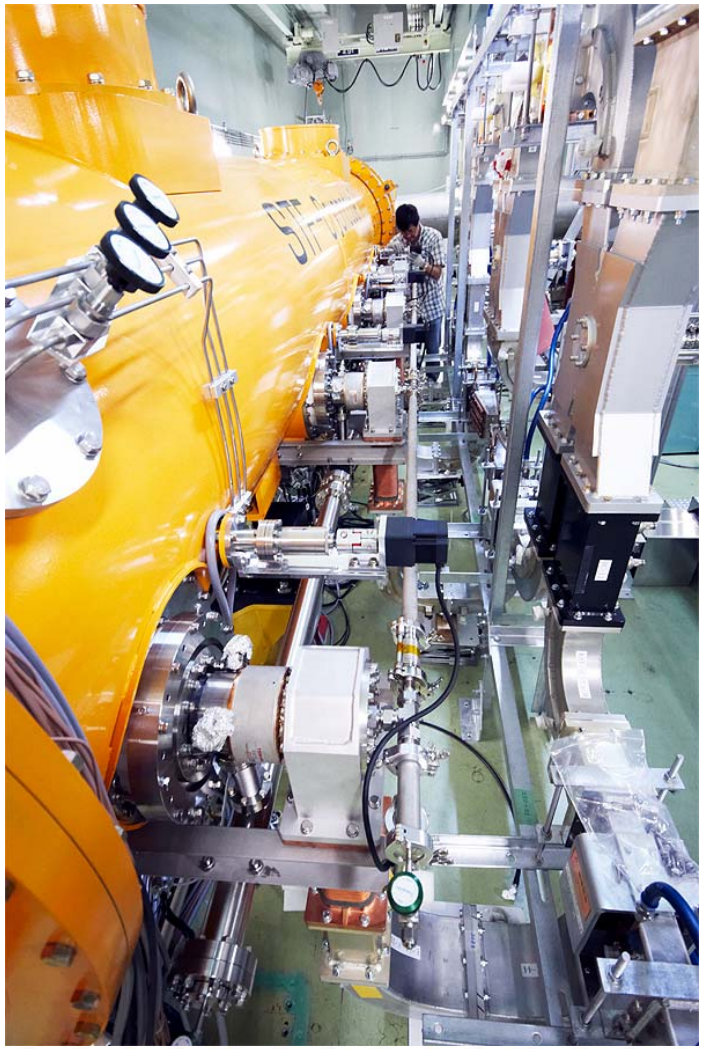
Insertion of an assembled cold mass into a vacuum vessel

March, 2008'

Completed STF cryomodule containing four Tesla-like cavities

Assembly of STF Cryomodule (4)

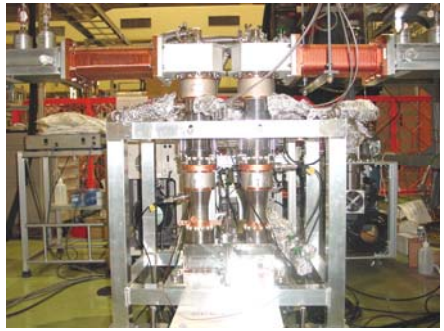
August, 2008'

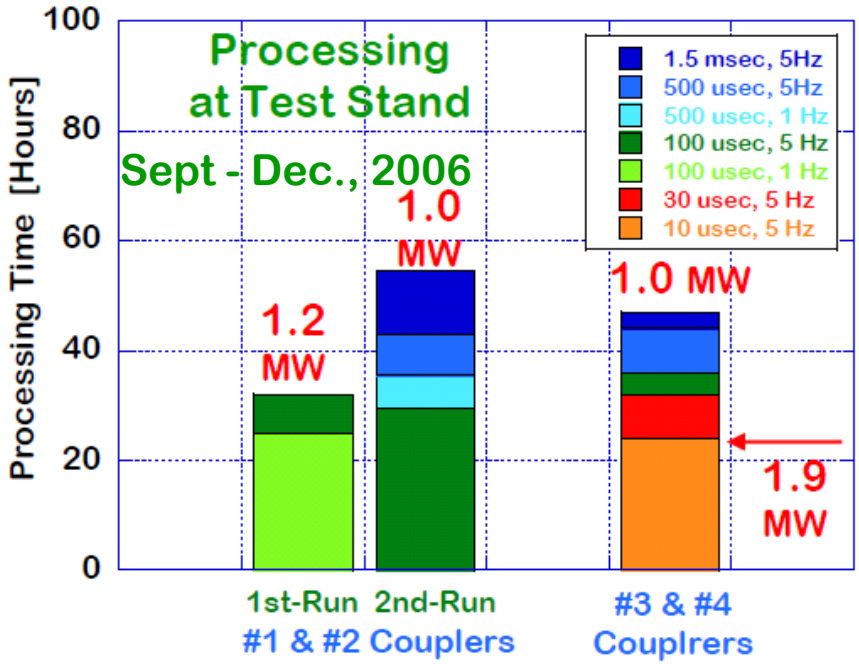


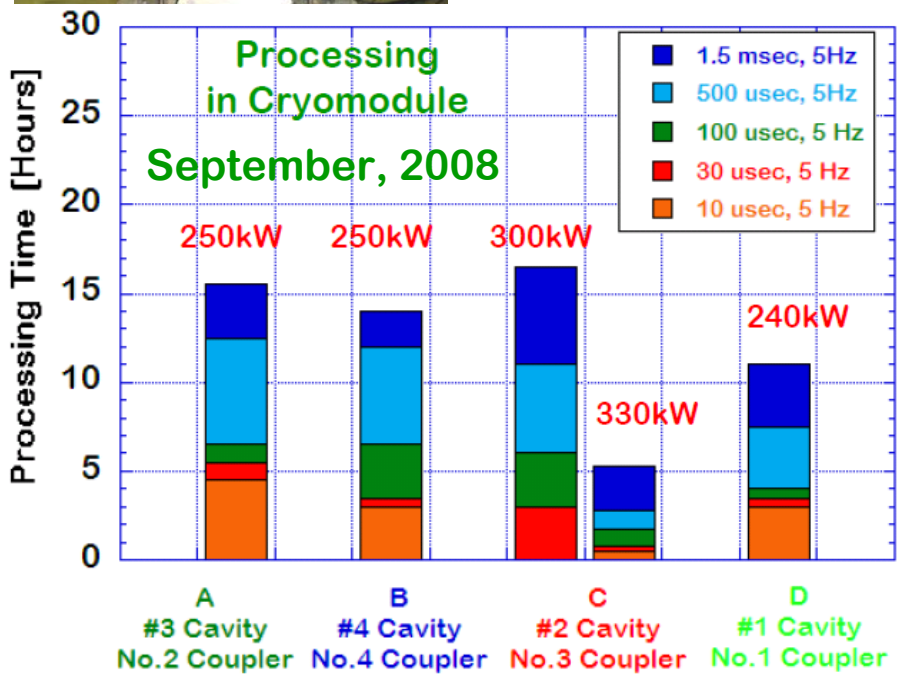
Installation of the cryomodule in the STF tunnel
Connection with high power rf distribution system

Processing of Input Couplers





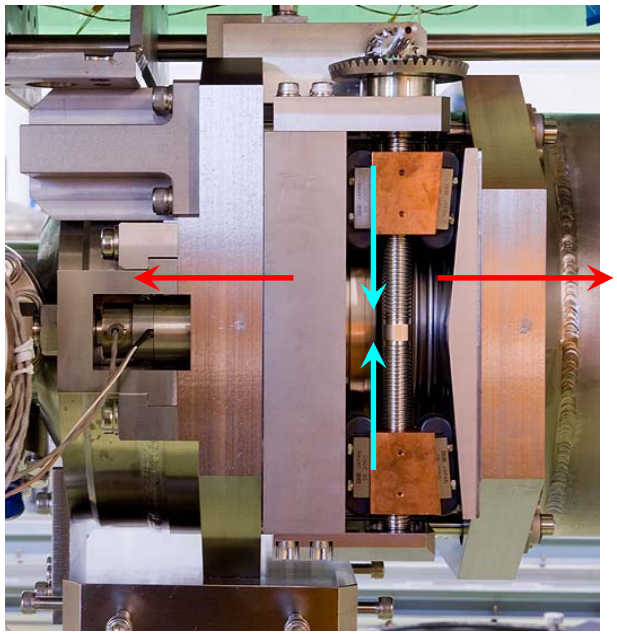



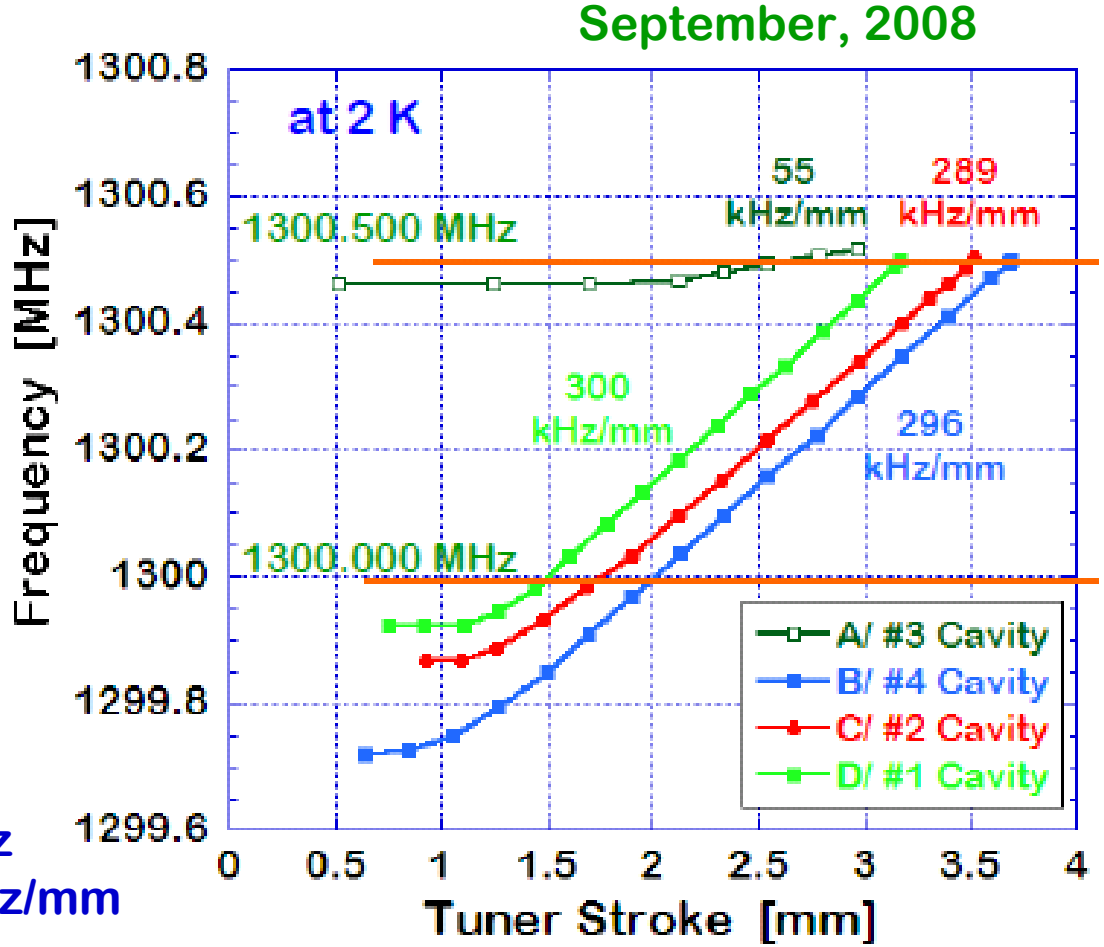


At the Test Stand
under matching condition

In the cryomodule
under total reflection condition

Performance of Slide-Jack Tuner

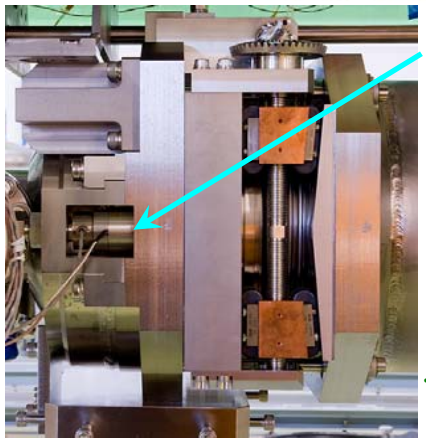




Dynamic Range = 600 ~800 kHz
Frequency Sensitivity = 300 kHz/mm

One cavity showed a strange performance due to mistake in the pre-tuning, so that an operating frequency changed to 1300.50 MHz to drive 4 cavities.

Performance of Piezo Tuner



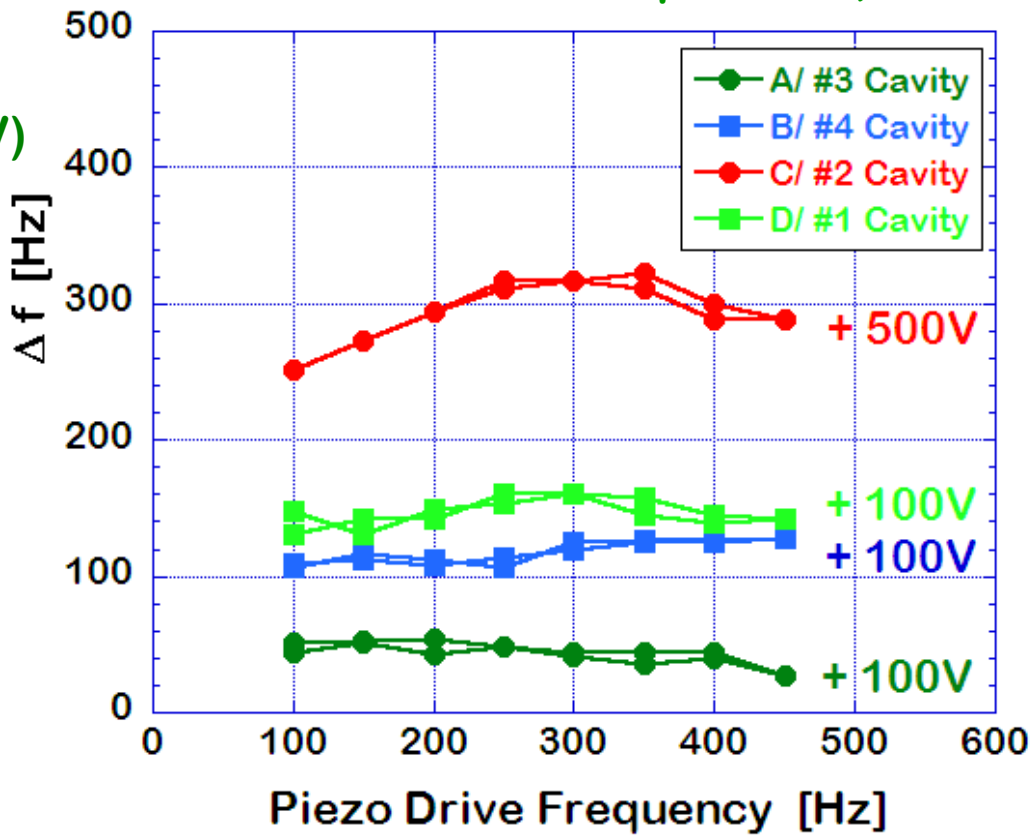
Piezo

1 - High voltage type (+1000V)

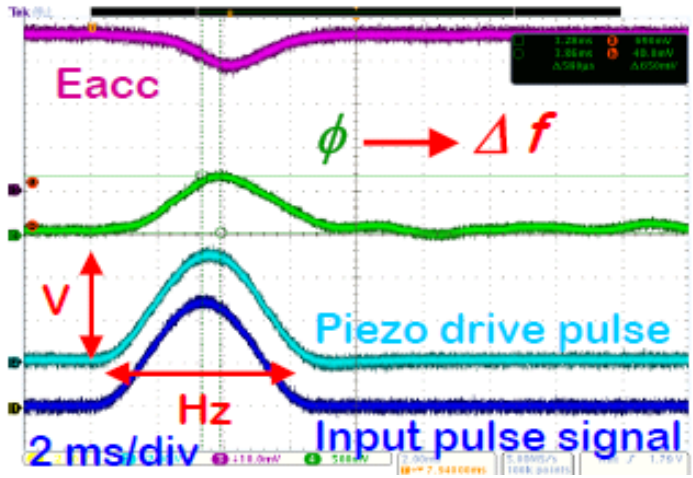
3 - Low voltage type (+150V)

for comparison.

September, 2008



Single pulse response signals driven by a piezo tuner



Frequency change in the low voltage type was considerably lower than the expectation.

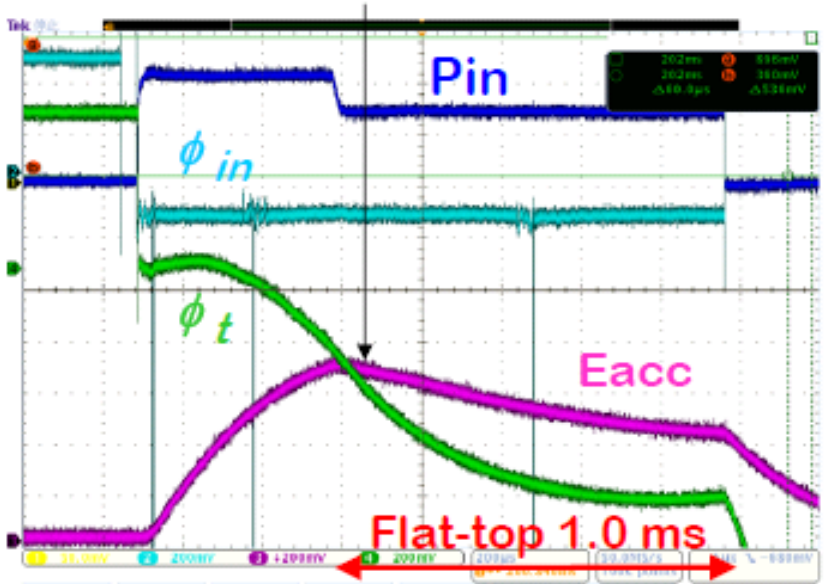
High Field Performance (1)

Stable Pulsed Operation at 32 MV/m in C/#2 Cavity

1.5 msec, 5 Hz operation

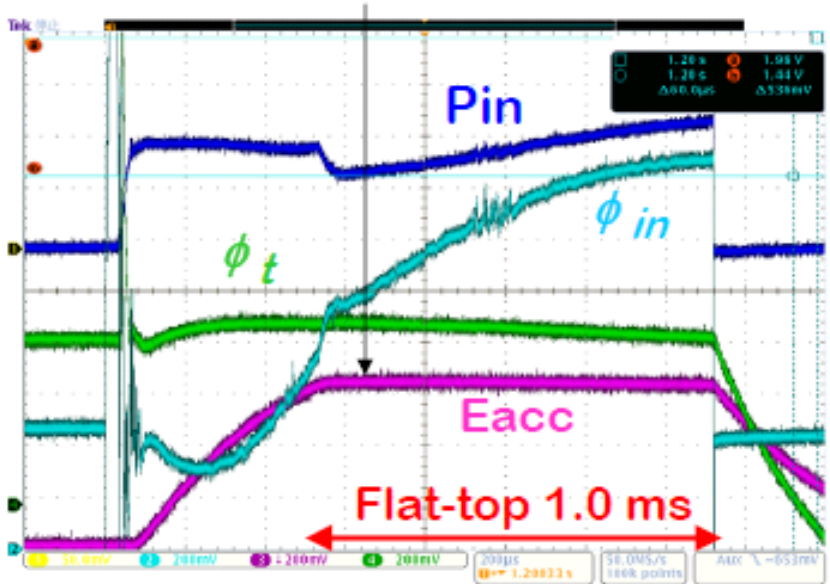
November, 2008'

RF Feedback / OFF
32.7 MV/m



no piezo drive
no pre-detuning

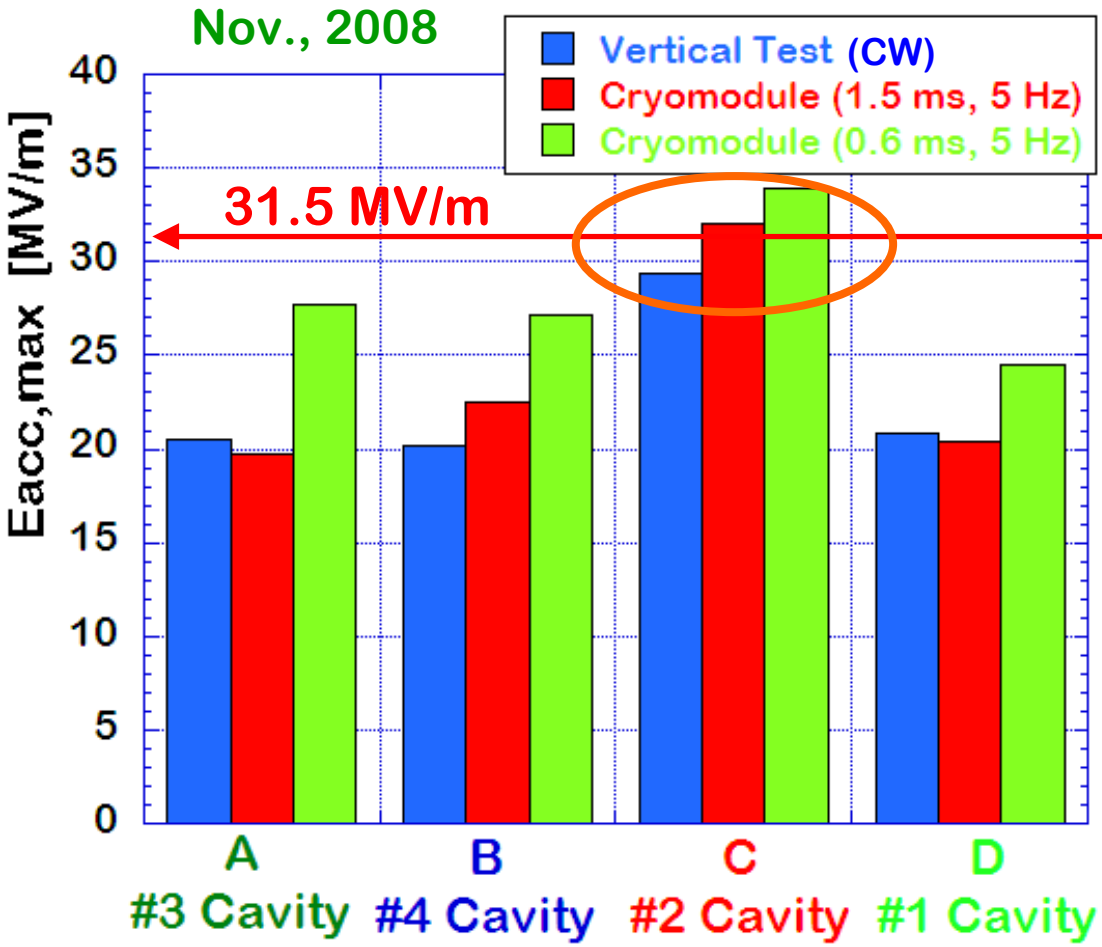
RF Feedback / ON
32.0 MV/m



no piezo drive
pre-detuning (Δf = +300 Hz)

High Field Performance (2)

Comparison of Eacc,max between V.T and C.T



RF Feedback / ON

Operational Gradient at 31.5 MV/m for ILC

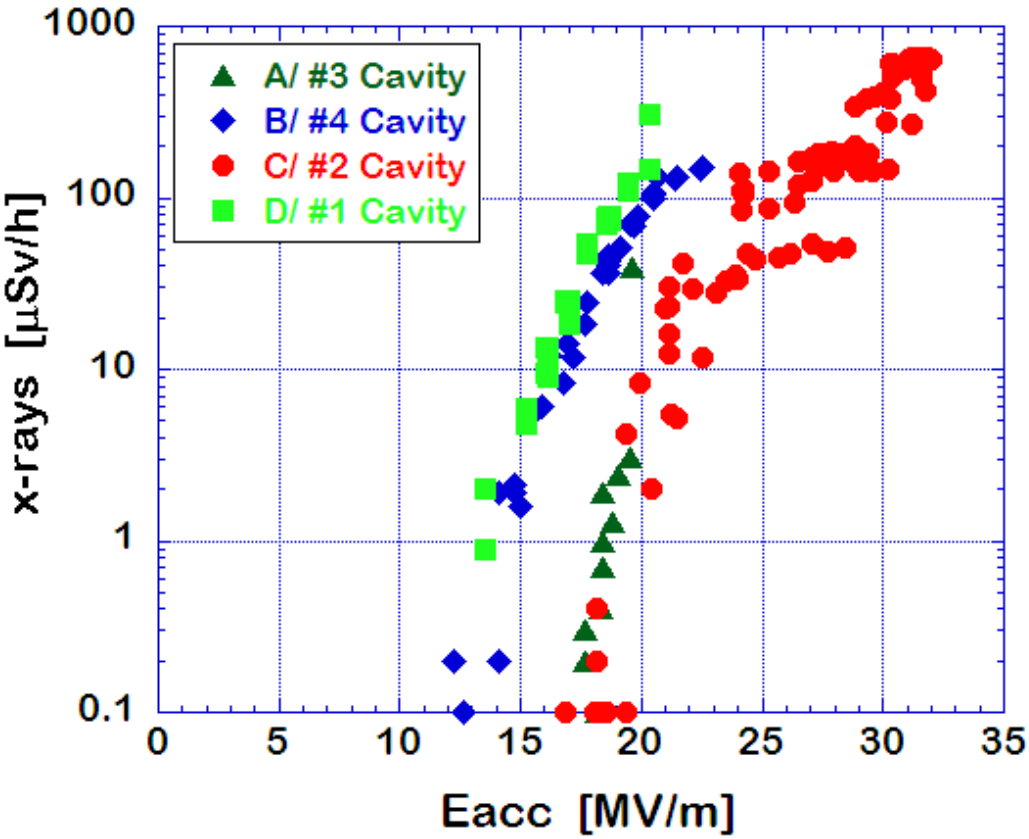
Ave. Eacc,max (V.T) = 22.7 MV/m

Ave. Eacc,max (Cryo. T) = 23.7 MV/m

No degradation was observed in the cryomodule tests.

High Field Performance (3)

X-rays Radiation Level vs. Eacc

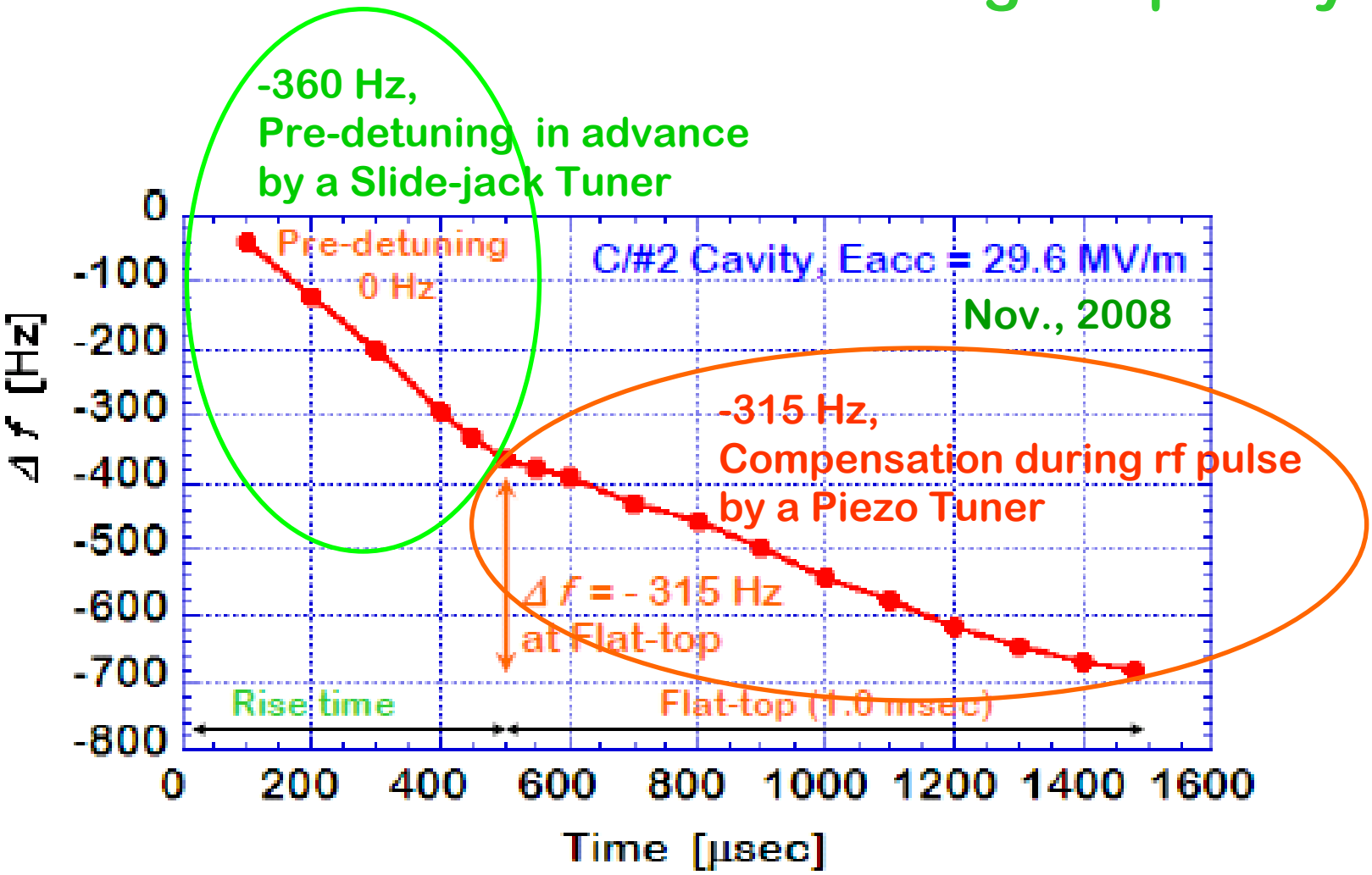


Nov., 2008

Heavy x-ray radiation due to field emission was observed with increase of Eacc.
We need more careful work in a clean room and in the tunnel
to avoid dusts contamination during the assembly.

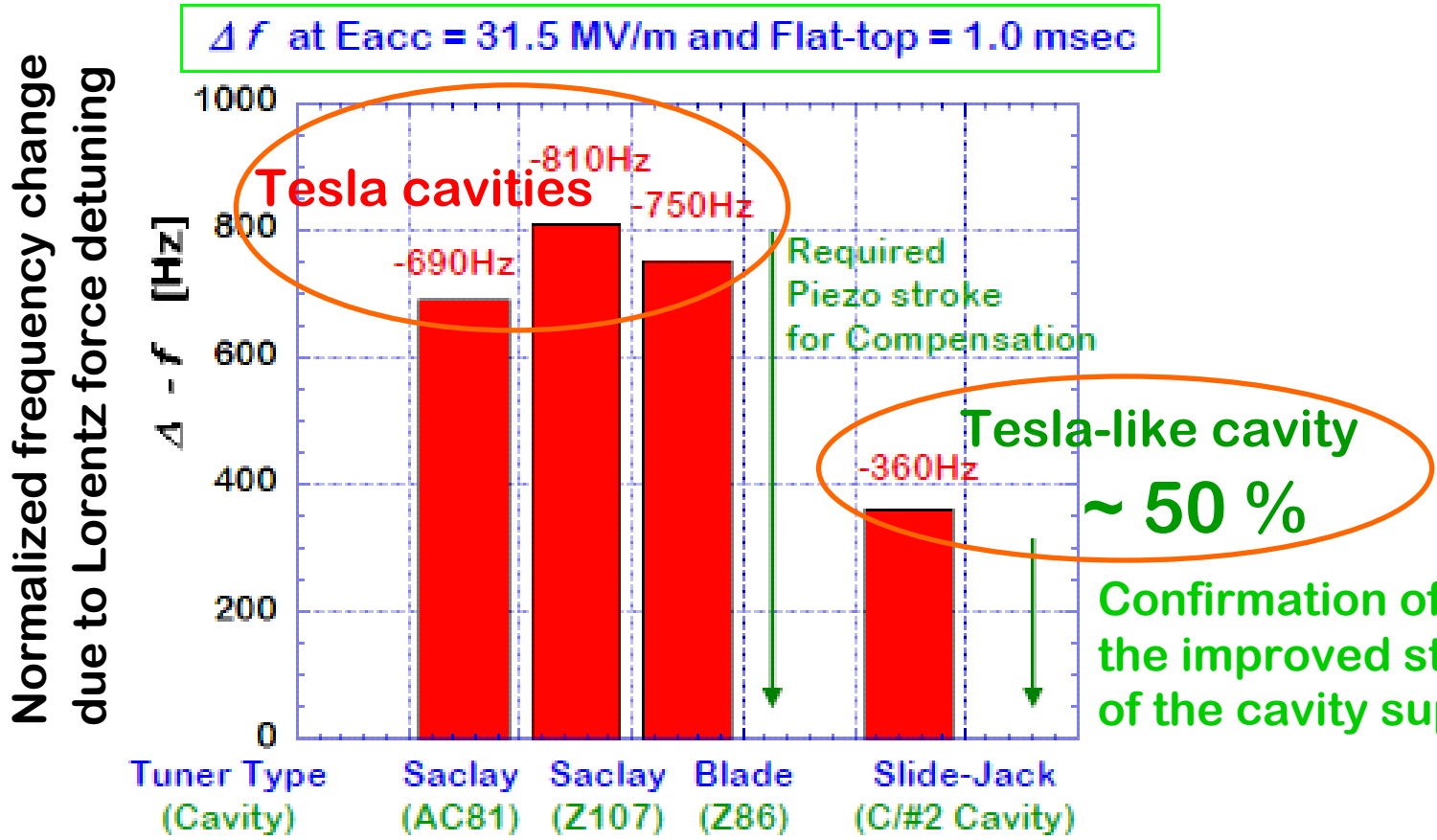
Lorentz Force Detuning (1)

Observation of Lorentz-detuning frequency



Lorentz Force Detuning (2)

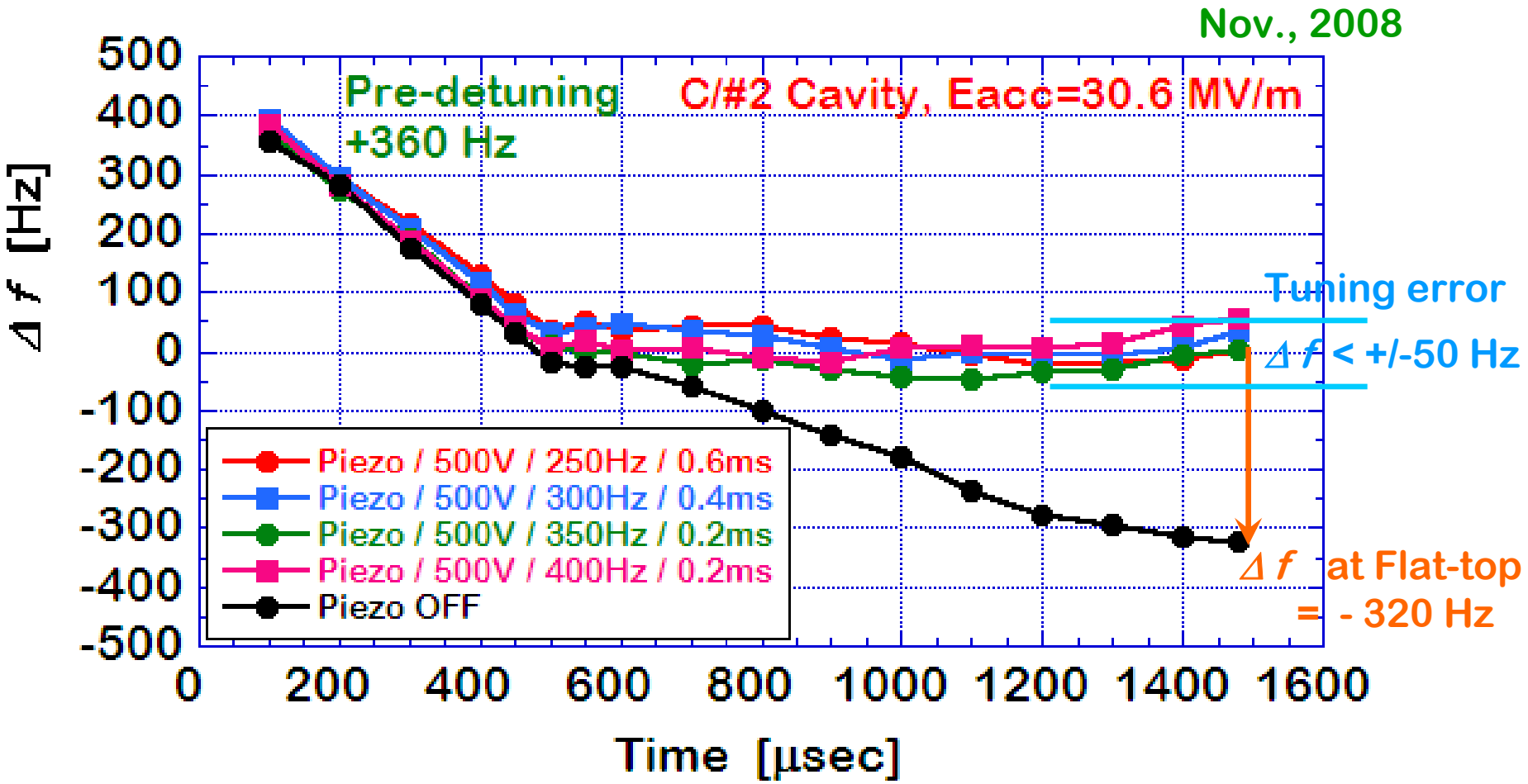
Comparison of Required Piezo Stroke



Required piezo stroke for compensation at 31.5 MV/m in Tesla-like cavity was reduced ~50 % of that in the Tesla cavities.

Lorentz Force Detuning (3)

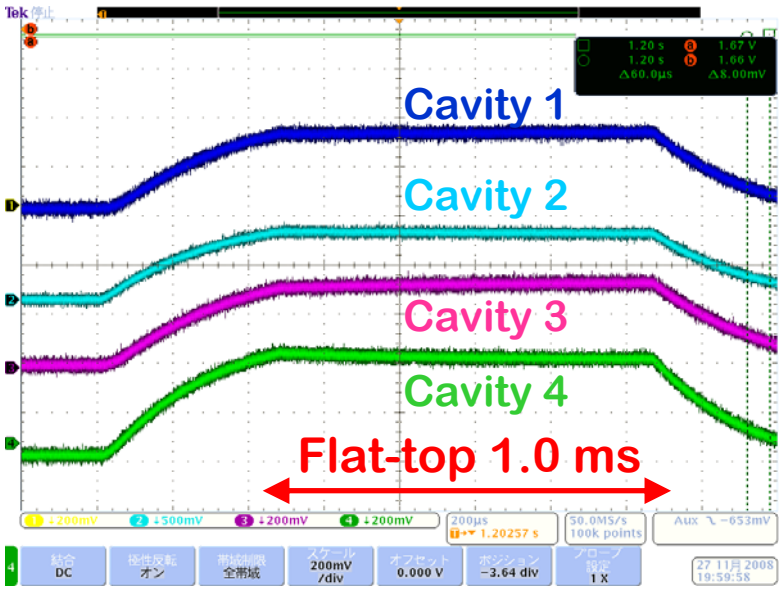
Compensation of Lorentz-detuning by Piezo Tuner



Dynamic Loss Measurement (1)

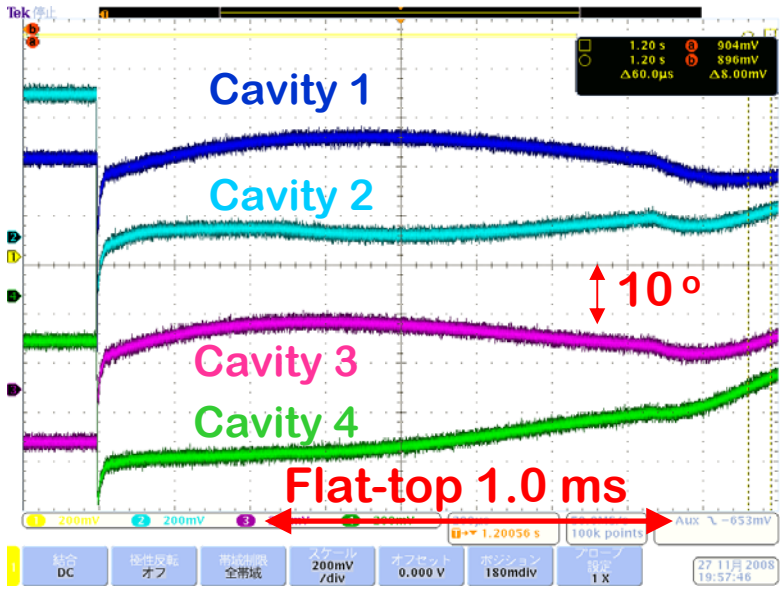
Four-cavity operation with vector-sum control

Accelerating Gradient (Eacc)



Cavity 1 ; Eacc = 17.6 MV/m
Cavity 2 ; Eacc = 18.0 MV/m
Cavity 3 ; Eacc = 17.9 MV/m
Cavity 4 ; Eacc = 15.2 MV/m

Cavity Phase (ϕ_t)

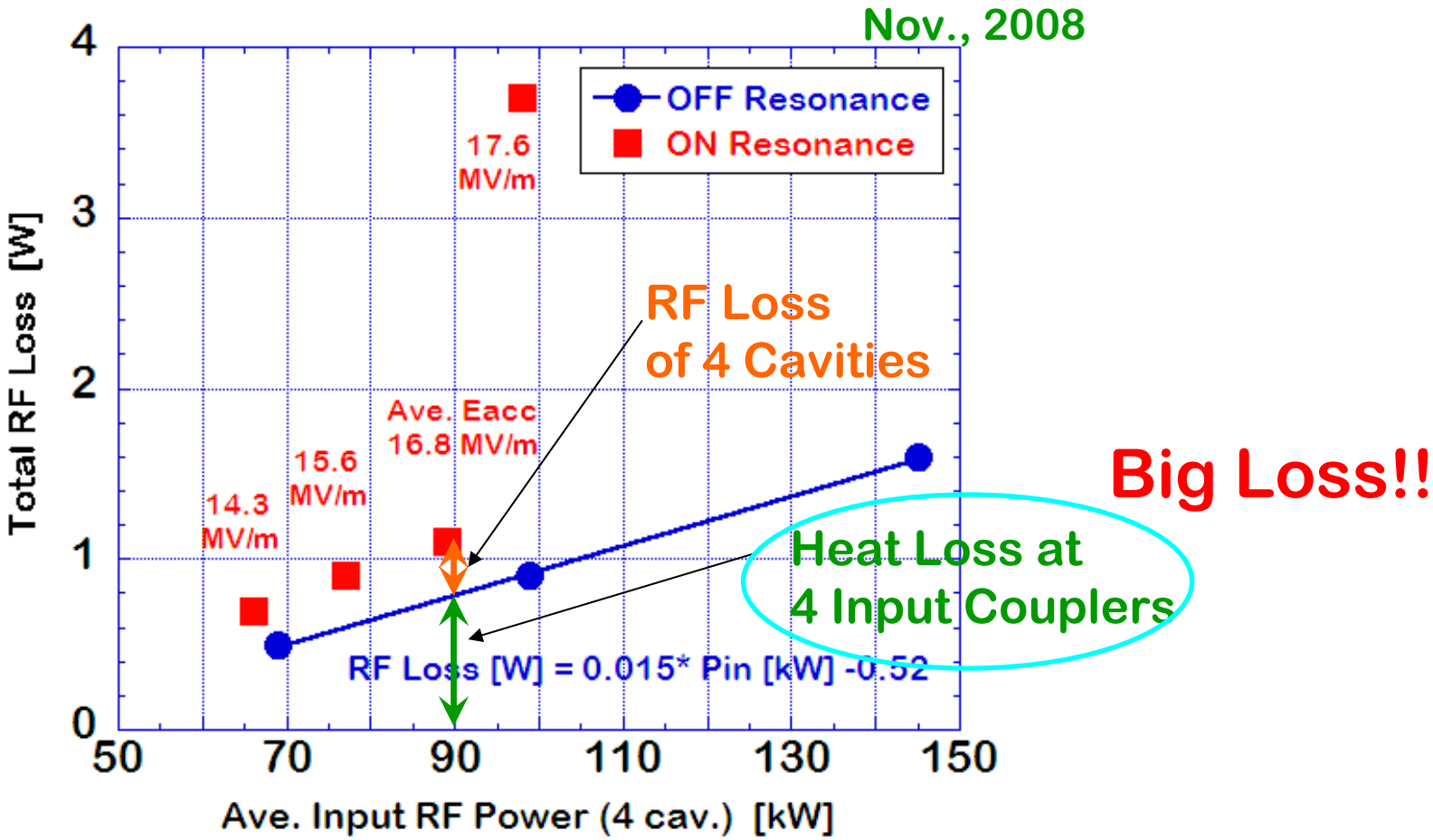


Nov., 2008

Total Acceleration Voltage
70 MV with ϕ_t < +/- 5o

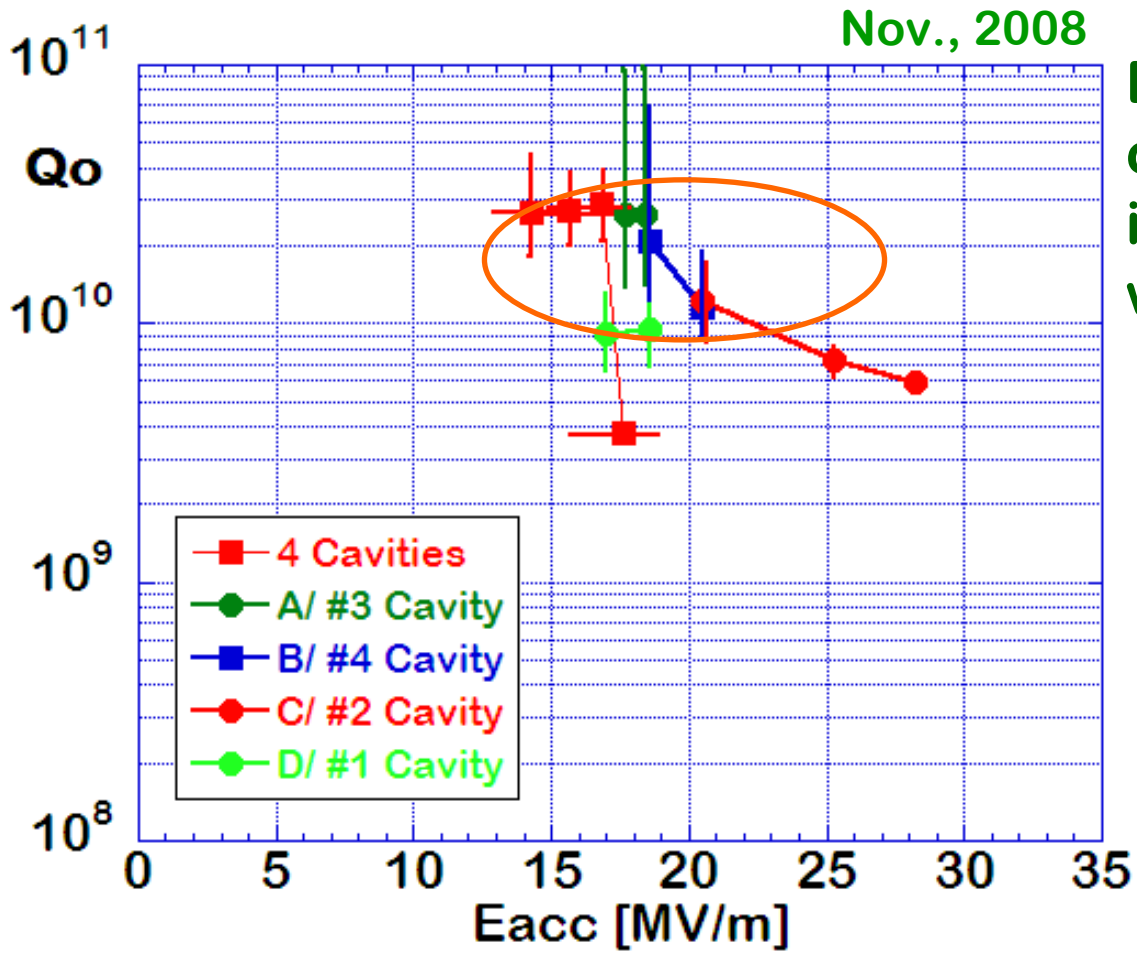
Dynamic Loss Measurement (2)

Dynamic RF Loss Meas. in on/off Resonance



Dynamic Loss Measurement (3)

Qo Values by Dynamic RF Loss Measurements



Effectiveness of the cavity magnetic shield inside the He jacket was confirmed !!

SUMMARY

Two notable progress were made in this cryomodue tests containing four Tesla-like cavities;

- A stable pulsed operation at **32 MV/m** was achieved in one of four cavities with no degradation from the vertical test results.
- Successful compensation of Lorentz force detuning at **31 MV/m** was demonstrated by pre-detuning and a piezo tuner.

Future Plan at KEK

- S-1 Global in 2010 ;

  International cryomodule containing 4 cavities from Asia, 2 cavities from USA, and 2 cavities from Europe will be operated at the average Eacc of 31.5 MV/m.

- STF phase-2 in 2013 ;

  First cryomodule containing 9 Tesla-like cavities will be operated with beam.

Thank you
for your attention.....