Horizontal Tests for Crab Cavities

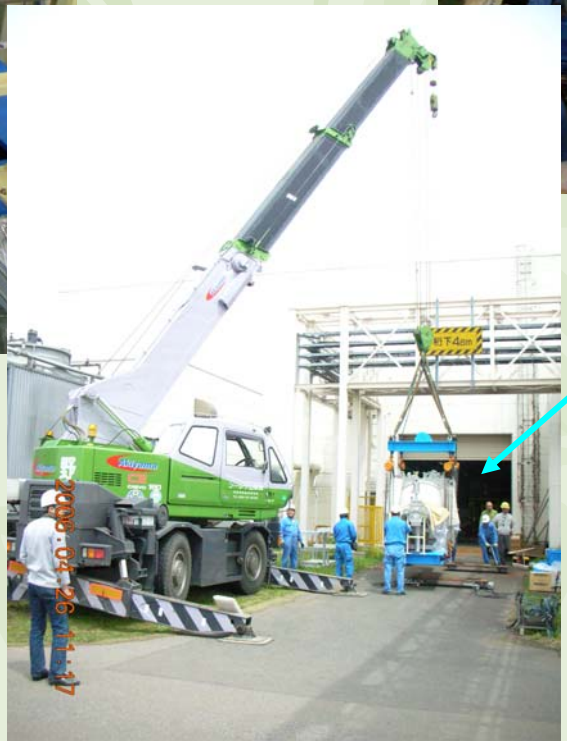
Contents

- Brief History
- First Horizontal Test for HER Crab Cavity
- Reforming the various components
- Final Horizontal Tests for Both Crab Cavities
- Summary

03/19/2007 Y. Yamamoto

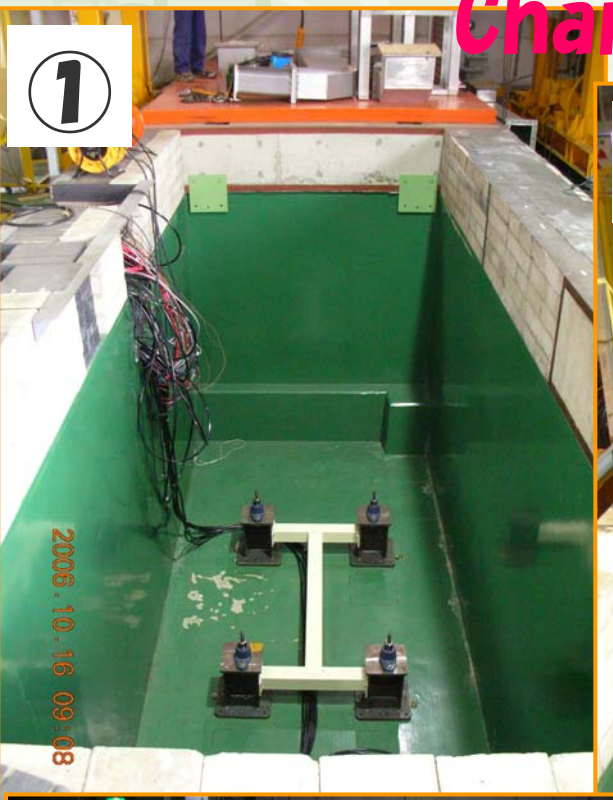
We finally succeeded in the first assembly of HER Crab Cavity on Apr/21/2006!

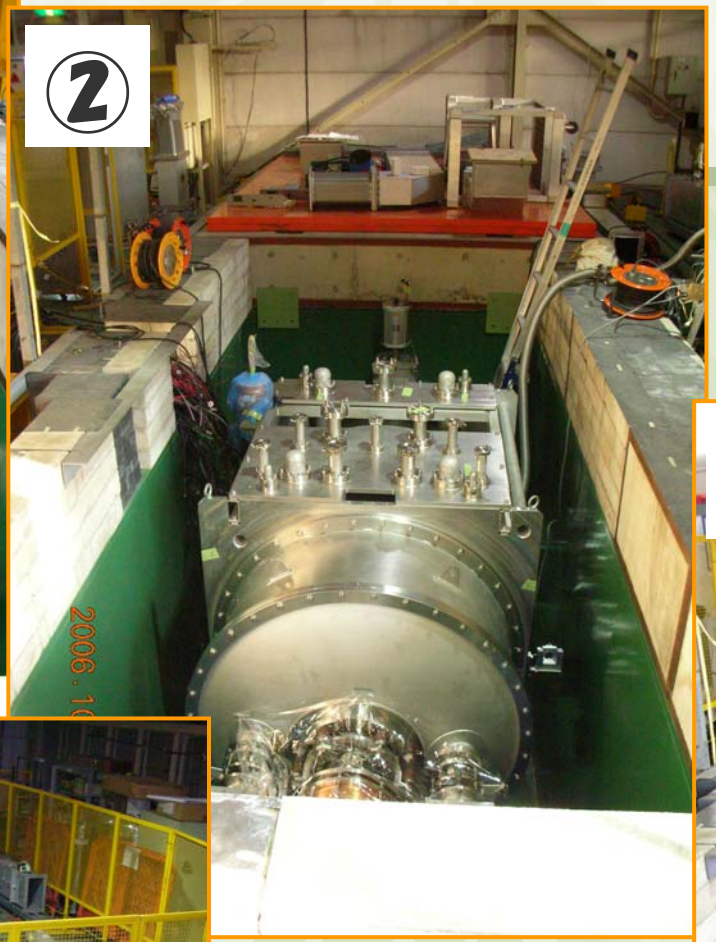
It was moved for the horizontal test on 26/Apr.



experimental site at D10 area

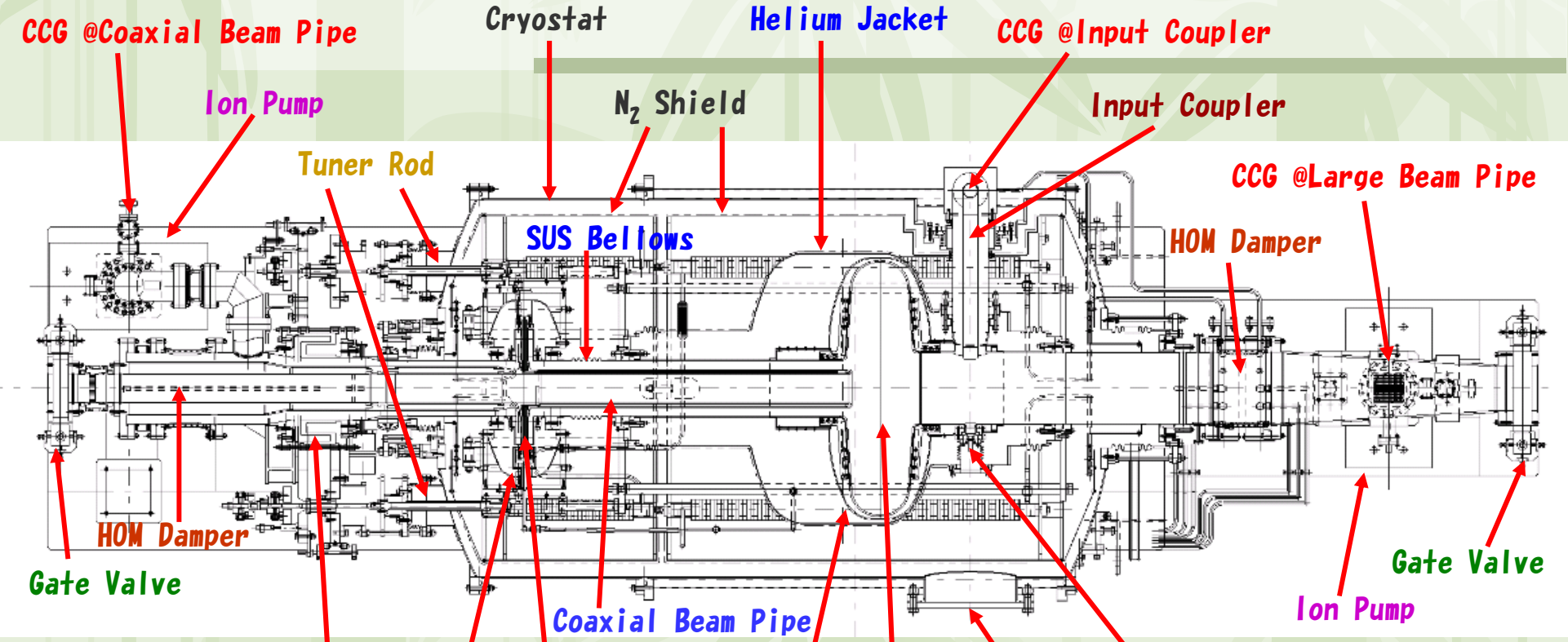
Change of Horizontal Test Area





The pit was very narrow for the Crab Cavity!

Various Components in Crab Cavity



Top View

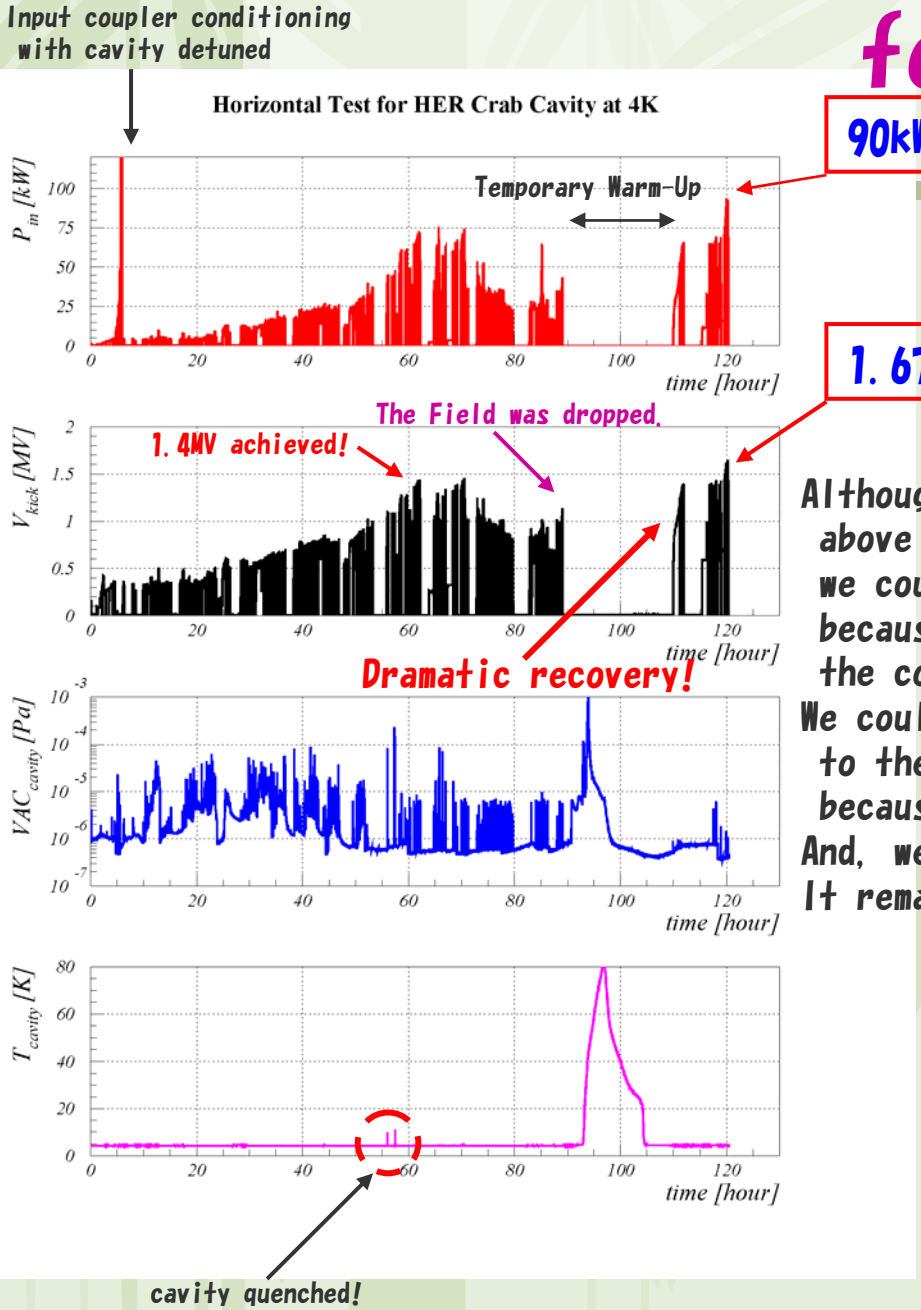
The History of the Horizontal Tests for Both Crab Cavities

	Exp. #	Period
HER	#1	Jun/2006
HER	#2	Nov/2006
LER	#1	Dec/2006

Reform!

During the first horizontal test, it found that the cavity had a problem which the tuner performance was not good.
Therefore, we needed to reform the mechanical structure of the coaxial beam pipe.
(It must be smoothly driven by the tuner.)

Result of the First Horizontal Test for HER Crab Cavity①

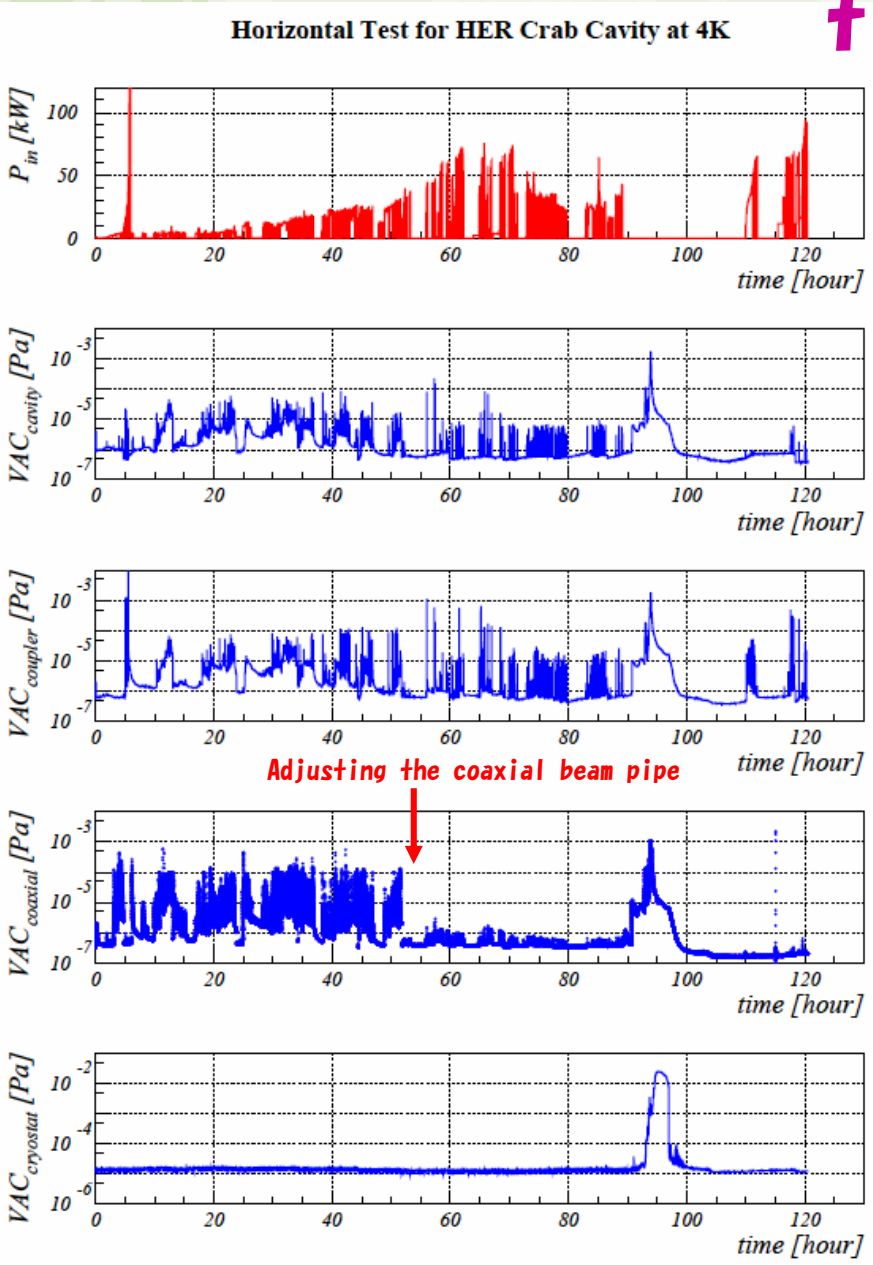


Although we achieved the cavity voltage of **1.67MV** above the operation one of 1.4MV, we could not go to the installation to the tunnel, because the tuner performance was not good and the coaxial beam pipe was not driven smoothly.

We could not set the cavity frequency to the operation one of 508.8875MHz, because the stroke of the bellows was short.

And, we could not set the coaxial beam pipe to the center. It remained **off-center** during the first horizontal test.

Result of the First Horizontal Test for HER Crab Cavity②



The vacuum pressure of the coaxial beam pipe became higher during the conditioning, as it remained largely off-center at first.
And then, when we set it as center as possible, the vacuum pressure became lower.

Reform①

Bellows

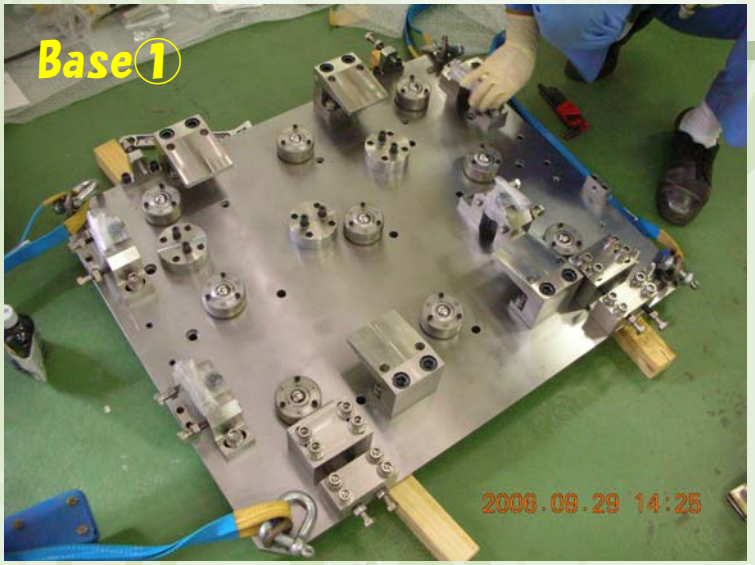
Material : Cu ⇒ SUS316L
Thickness : 0.4mm ⇒ 0.2mm
Stroke : ±3mm ⇒ ±10mm

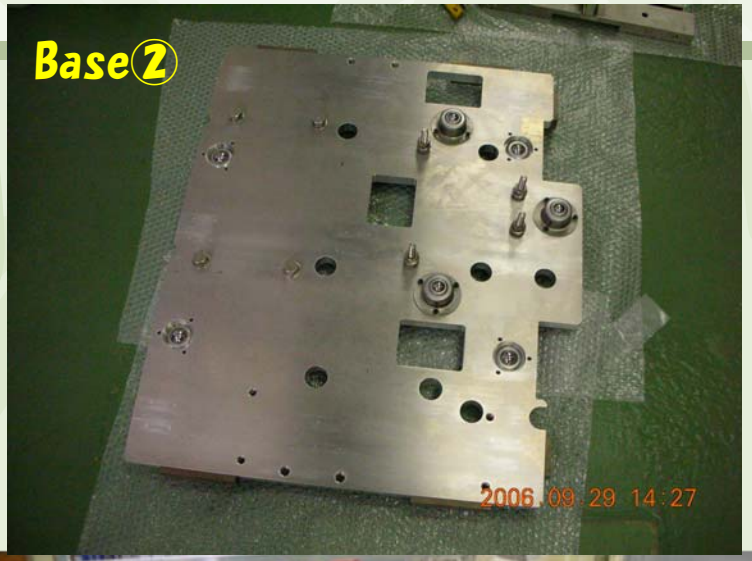
**The stroke was short,
as the copper bellows was rigid.**

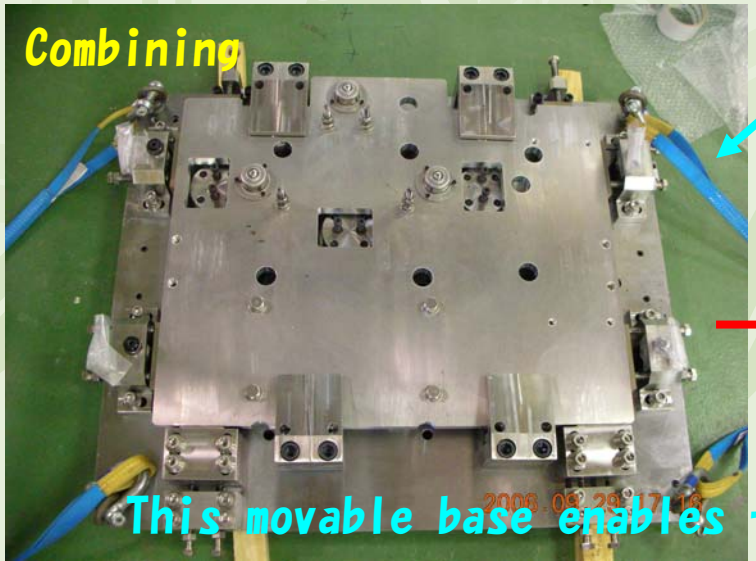
After shaping...

Movable Base

Reform②







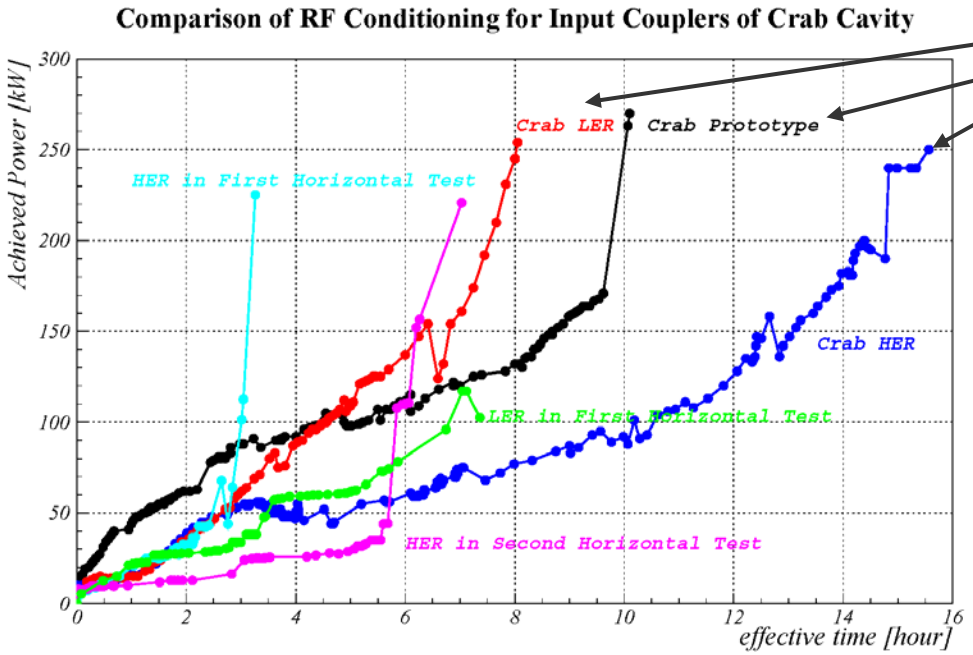
This movable base enables the coaxial beam pipe to drive smoothly.

Room Temperature

- Baking

  (HOM Damper, Ion Pump, Cavity, Coaxial Beam Pipe)
- Tuner Drive Test (Motor & Piezo)
- Input Coupler Conditioning

Input Coupler Conditioning



High-Power RF test using Input Coupler only

The achieved power was above 200kW for HER, but we stopped at 100kW for LER. Because we had no time!

During Cool-Down & Warm-Up

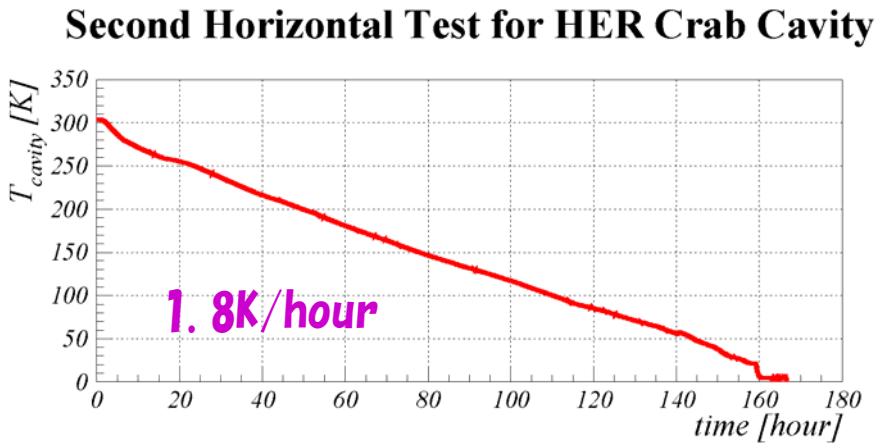
- Monitoring Frequency and Q_L
- Monitoring Shrinkage of the Cavity
- Cool-Down Rate Adjustment

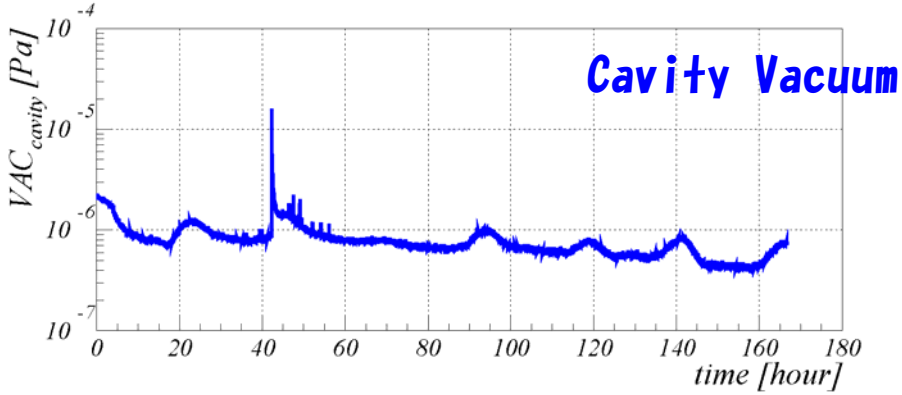
(for slow cooling)

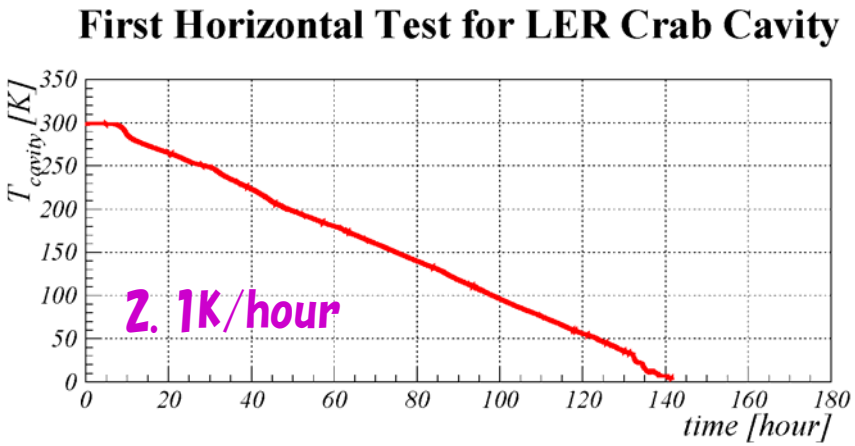
We were afraid of the vacuum leakage from the cavity!
Therefore, we decided the cool-down rate of 2K/hour.

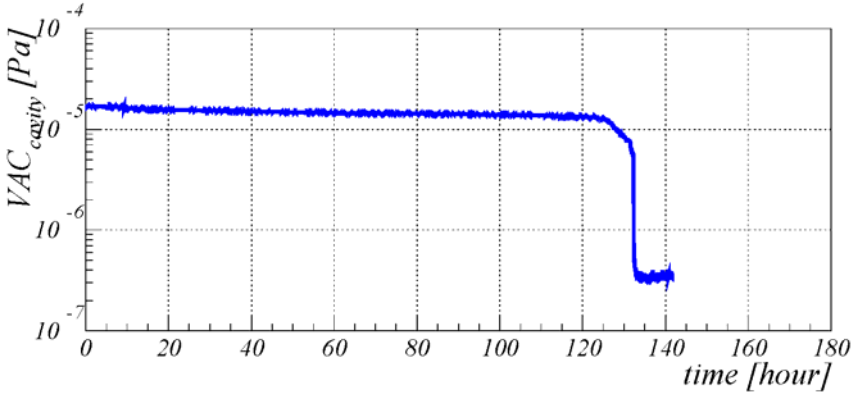
Time Profile of Cool-Down

HER Cavity Temperature LER



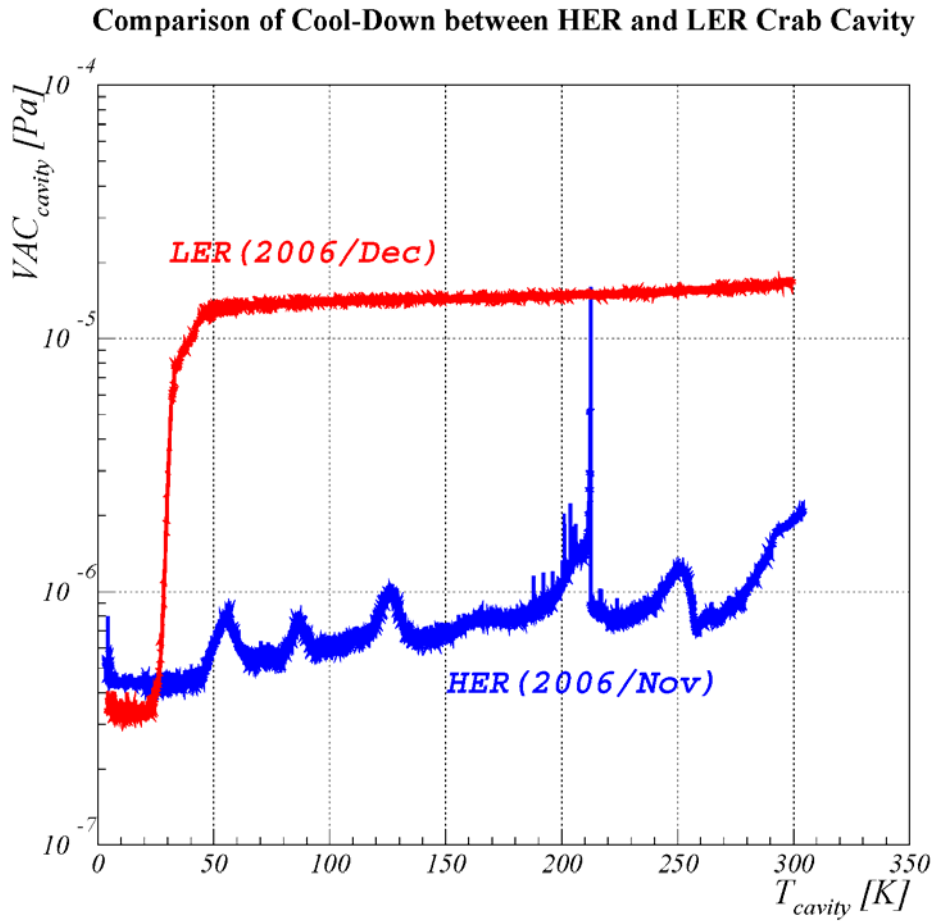






Although HER Cavity vacuum became good, LER became higher.
As we were afraid of the vacuum leakage, we did the leak check many times.
After the cavity temperature reached 50K, the vacuum pressure was lower.

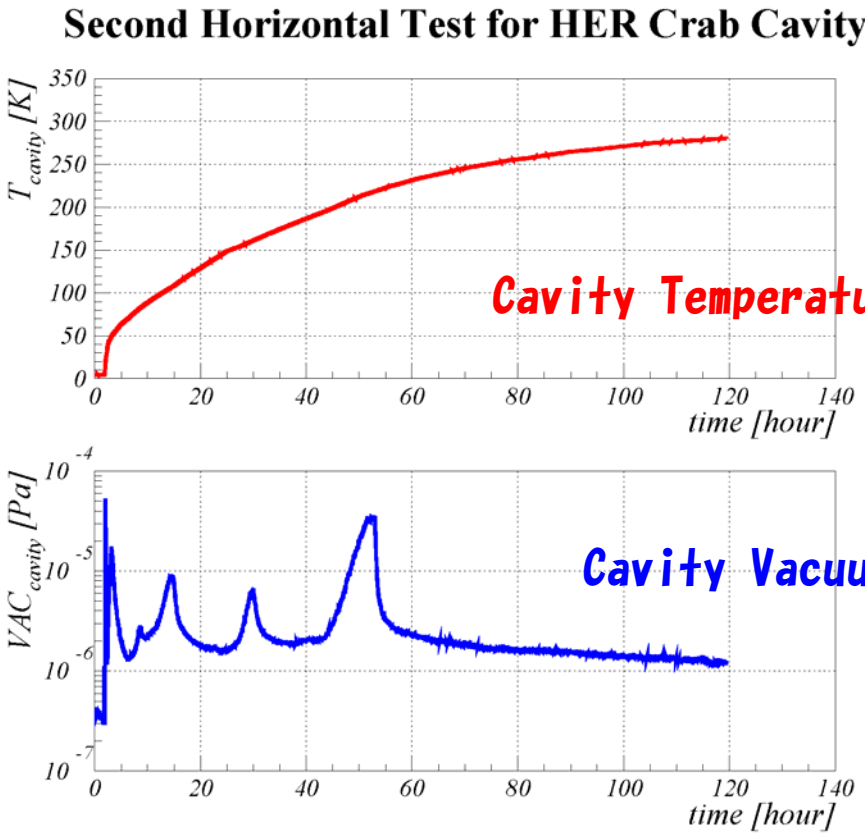
Correlation between Vacuum and Temperature during Cool-Down



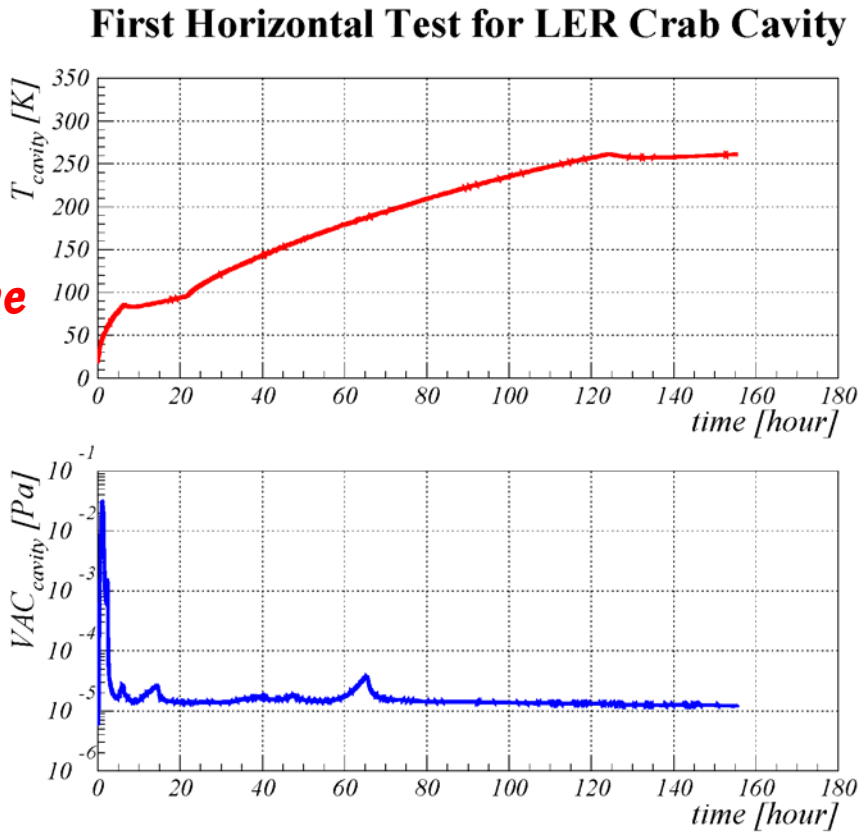
Although the behavior of the vacuum pressure was much different between both cavities during cool-down, the pressure level around 4K was almost same.

Time Profile of Warm-Up

HER

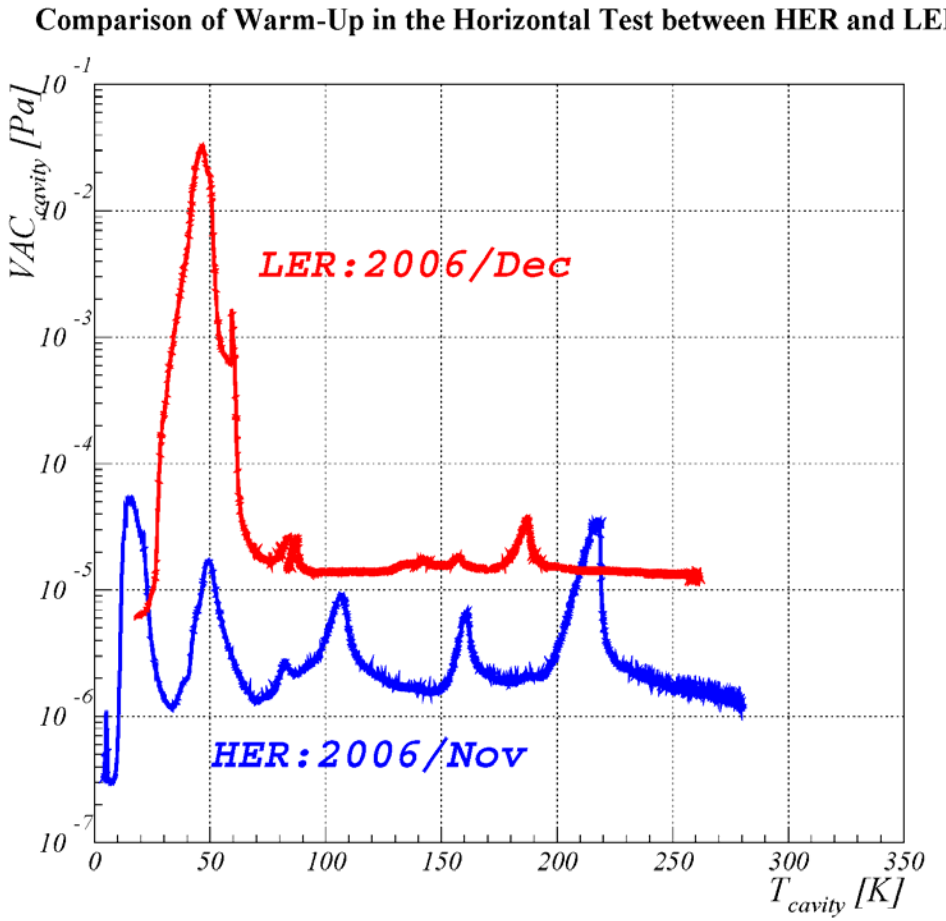


LER



The vacuum pressure for LER Crab Cavity became higher during warm-up.
After the cavity temperature reached the room temperature,
the pressure level was almost same as before cool-down.

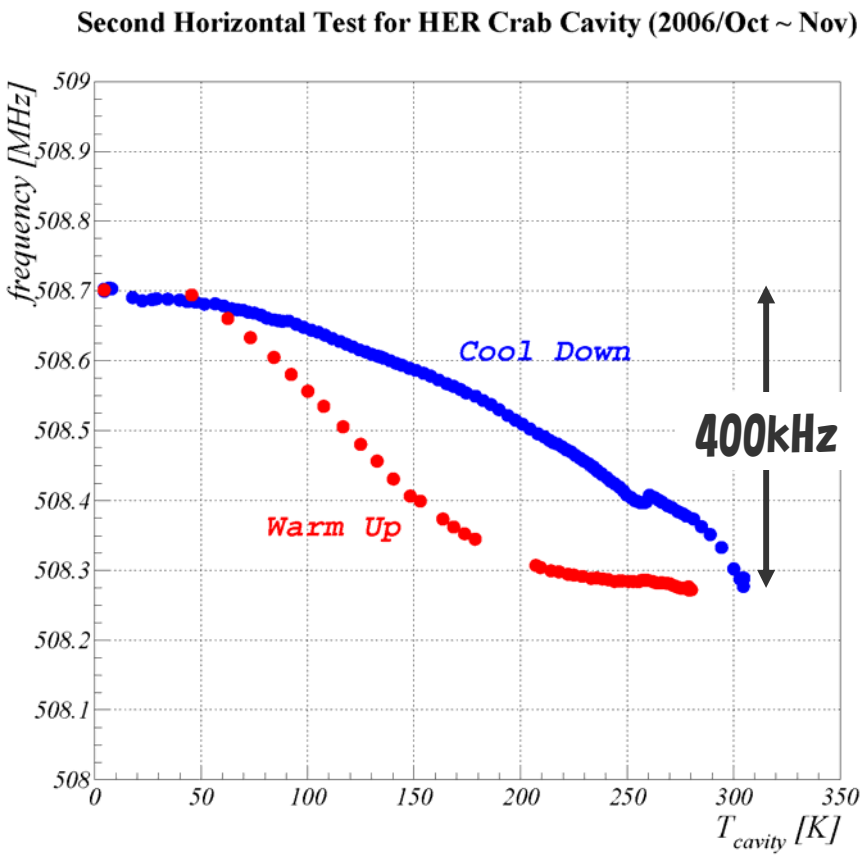
Correlation between Vacuum and Temperature during Warm-Up



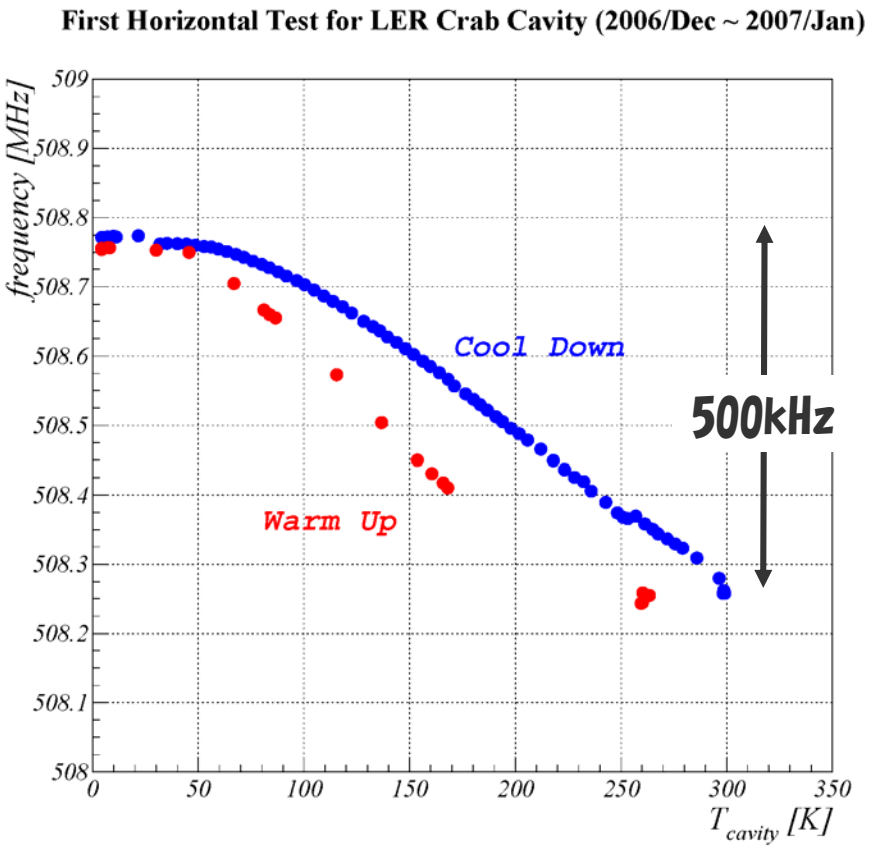
The vacuum pressure was different by 3 orders between both cavities around 50K!
The pressure level of the coaxial beam pipe for LER was always higher at 4K.
We think that this part was the outgas source.

Frequency Trend during Cool-Down & Warm-Up

HER



LER



We think that the difference of the change of the frequency between both cavities is due to the mechanical property of the cavity.

The change of the frequency was 600kHz in the case of the cavity only without the coaxial beam pipe.

After the cool-down, we set the frequency to 508.8875MHz by another way.

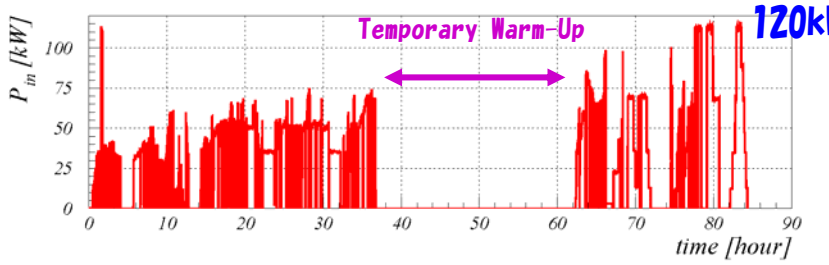
4K

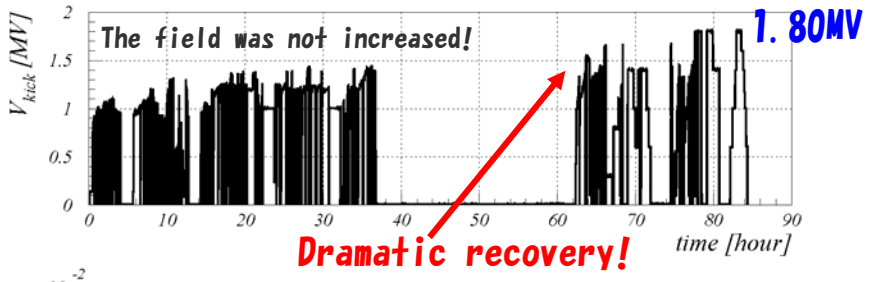
- Adjustment of the Cavity Frequency
- Adjustment of the Coaxial Beam Pipe
- Tuner Drive Test (Motor & Piezo)
- Cavity/Coupler/Coaxial Beam Pipe Conditioning
- Q_L Measurement (using high-power)
- Tuner Phase Check
- Tuner Feedback Check
- Eigen Oscillation Check
- Q_0 Measurement
- Static Loss Measurement
- HOM Measurement (using low-power)
- Checking the Radiation Level

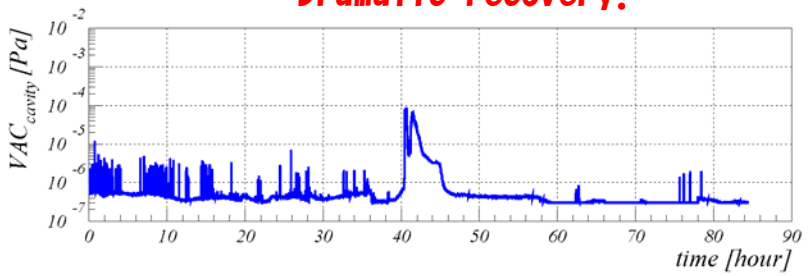
During the High-Power Conditioning

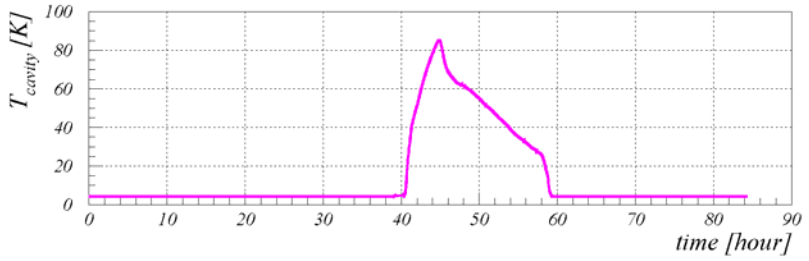
HER

Second Horizontal Test for HER Crab Cavity at 4K



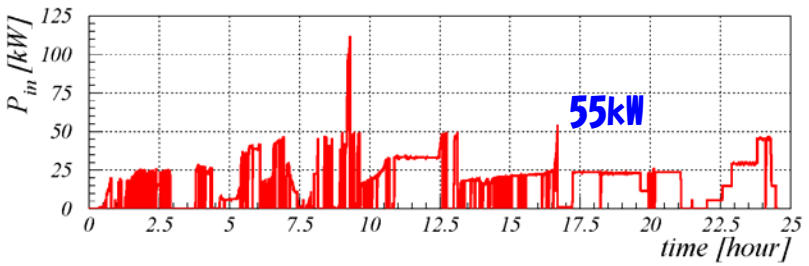


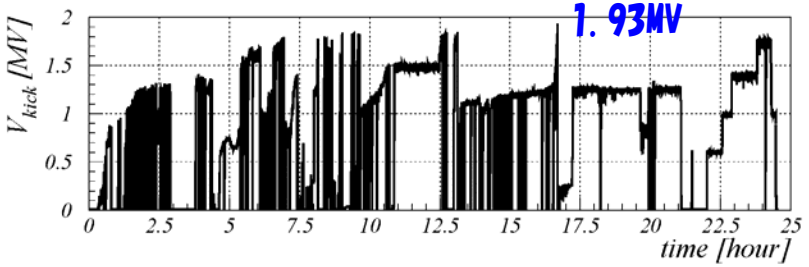


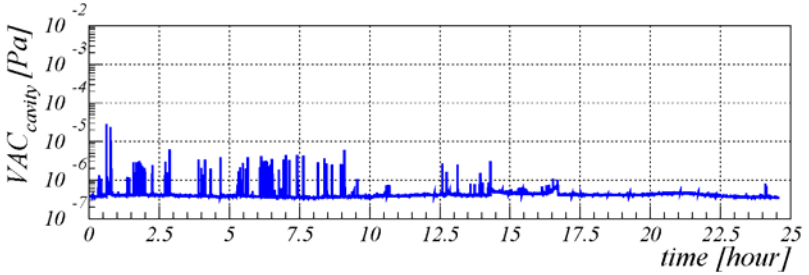


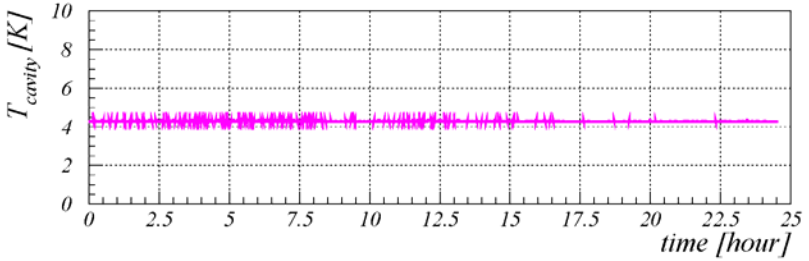
LER

Fisrt Horizontal Test for LER Crab Cavity at 4K





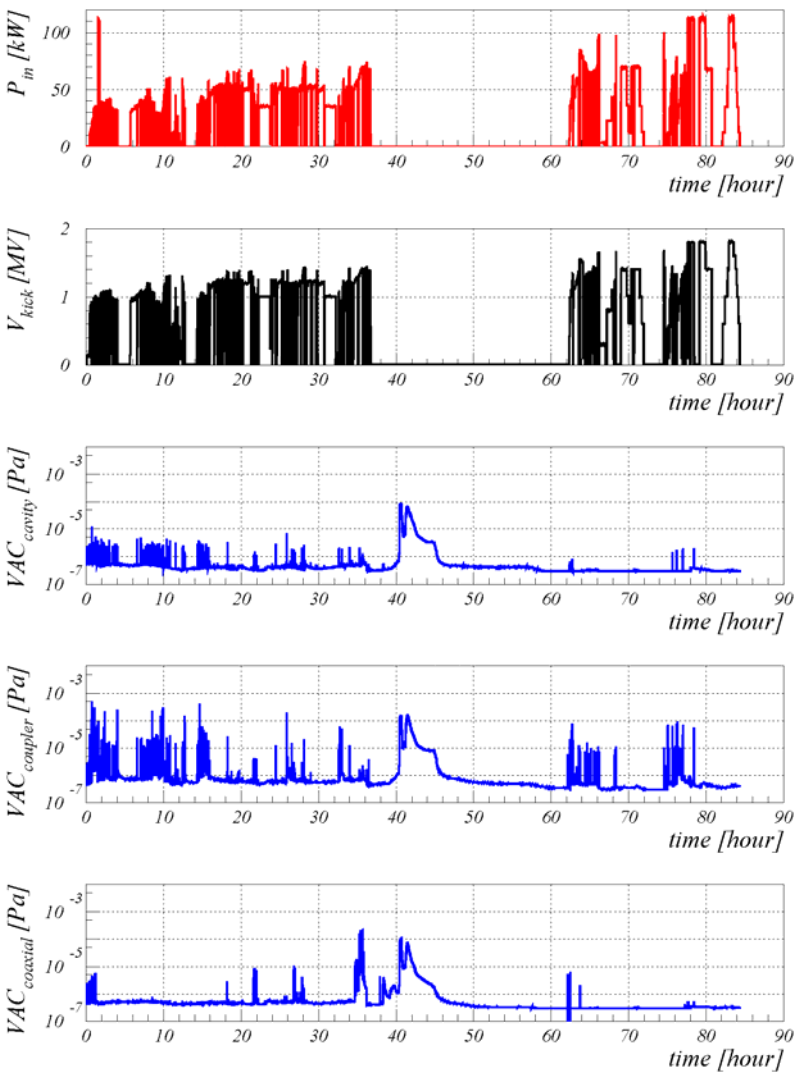




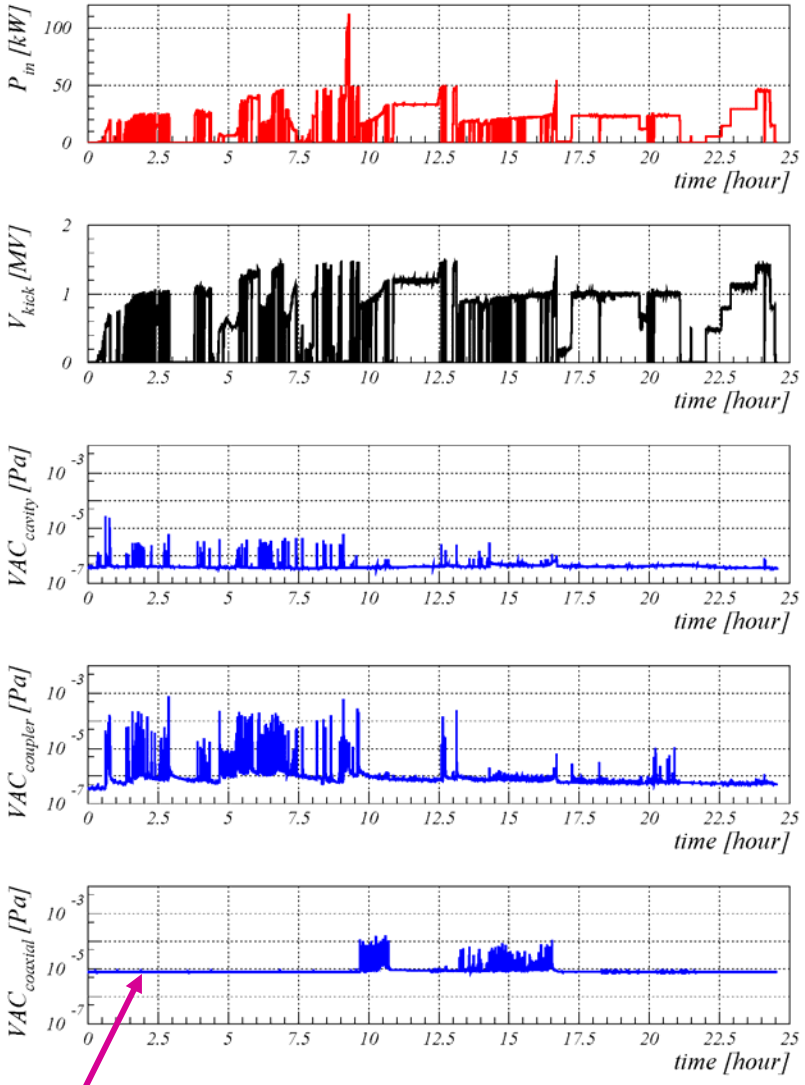
We decided the temporary warm-up of the HER Crab cavity again, as the field was not increased.

Vacuum Pressure during the Conditioning

HER



LER



The pressure level of the coaxial beam pipe for LER was always higher at 4K.

Q_L Measurement

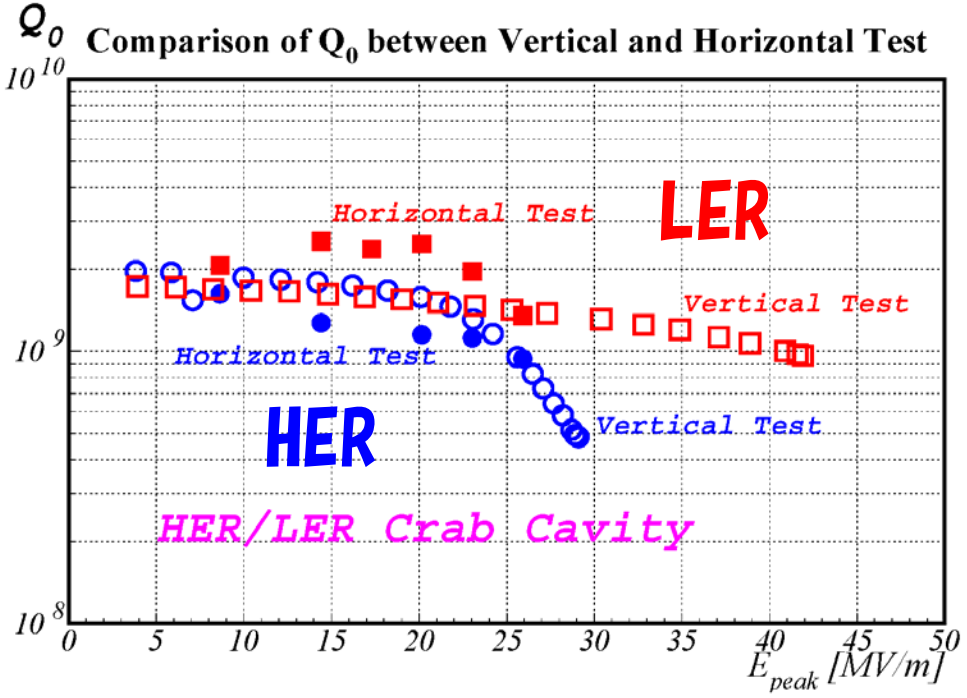
We usually adopt the result of the decay time method using the transmitted power, because the readout value of the power meter was fluctuated in the band width method.

			HER		LER
Condition	P_{in}[kW]	Method	Q_L (Jun/2006)	Q_L (Nov/2006)	Q_L (Dec/2006)
High power	20	Decay time	1.66×10^5	1.34×10^5	2.07×10^5
High power	10	Band width	1.59×10^5	1.64×10^5	1.86×10^5
Simulation		HFSS (ver. 9.2)	1.6×10^5		

The difference between two measurements for HER Crab Cavity was above 20%.
We think that this is the systematic error of the alignment in the assembly.
Because the same cavity and the same input coupler were used in these tests.
These measured values are within ±20% compared to the result of the simulation.

Q_0 Measurement

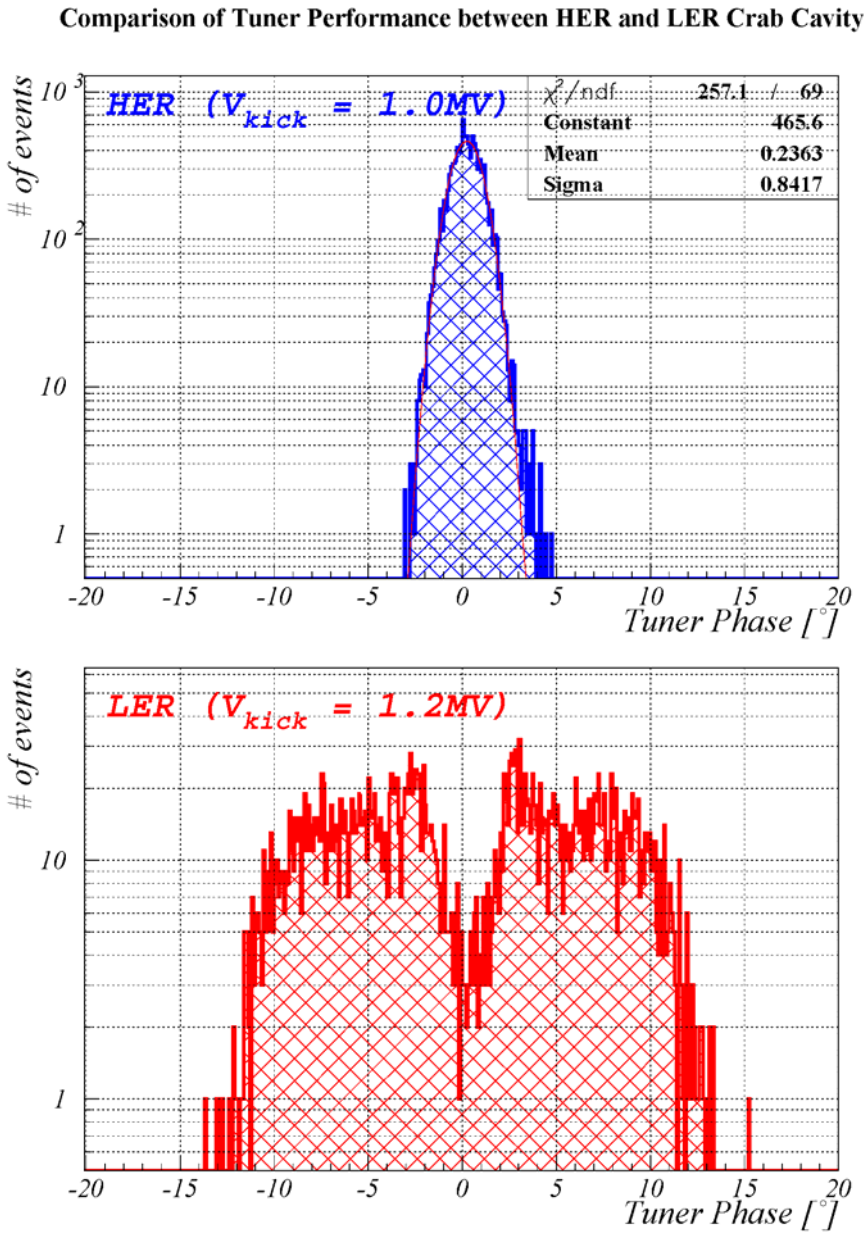
We used the heater compensation method for Q_0 measurement in the horizontal test.
This method requires the fine tuning of the helium level.



In the stage of the vertical test, LER Crab Cavity was much better than HER.
LER Crab Cavity was also better in the horizontal test.
And then we could **easily** achieve the cavity voltage of 1.93MV.
The cavity performance was comparable to the vertical test.

The static loss of HER and LER Crab Cavity were 32.3W and 25.7W, respectively.

Comparison of Tuner Phase between Both Cavities



Although HER Tuner performance had no problem,
LER Tuner performance was not good.
The behavior was unstable and it had the hysteresis.
We were afraid that this behavior prevent the cavity from operating stably.
And then, we tested the tuner drive of LER Crab so many times by the various ways.
But unfortunately, we didn't understand the reason.

On 28/Dec, we gave up it and finished the test.

After the beam commissioning,
it found that this behavior was not serious.
Now the both cavities are very stable beyond our expectations.
We are very lucky!

The expansion of the tail was twice HER.

Summary

- The both cavities achieved above the operation voltage of 1.4MV.
  (HER : 1.80MV, LER : 1.93MV)
- The temporary warm-up was effective to recover the cavity voltage for HER Crab Cavity.
- The vacuum pressure of the coaxial beam pipe of LER Crab Cavity became higher at 4K.
- The measured Q_L values were consistent within ±20% compared to the simulation.
- The cavity performance (Q_0) in the horizontal test was comparable to the vertical test.
- The static loss of the both cavities was around 30W.
- We didn't understand the difference of the tuner performance between the both cavities.
- The refrigerator system had no problem in these measurements.