

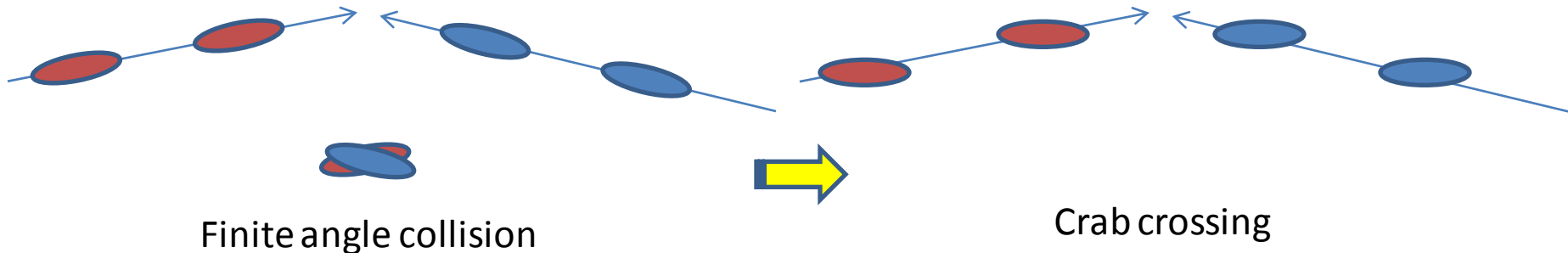
Commissioning of crab cavity system

Presented by NAKANISHI Kota (KEK)

Factories08@BINP 2008/4/15

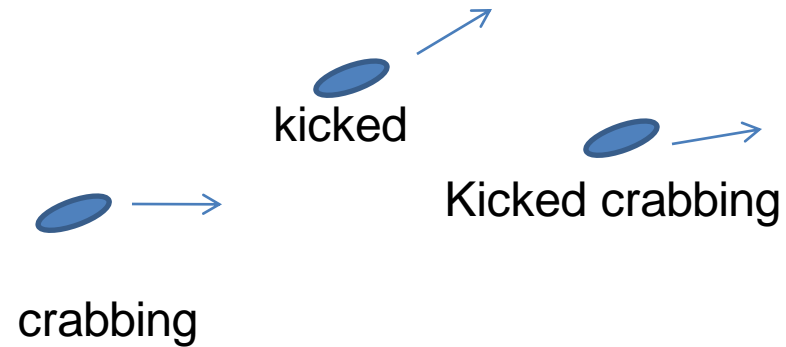
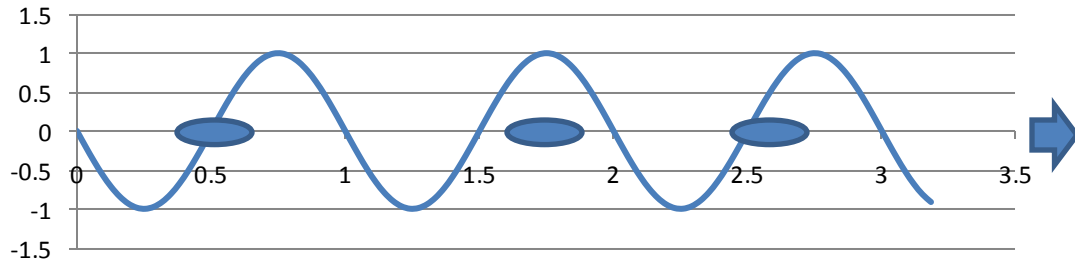
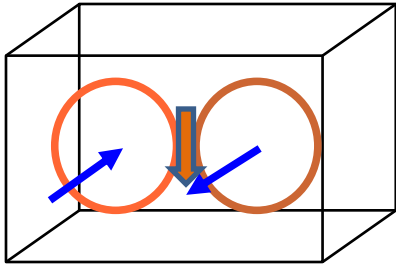
Crab crossing

- The highest luminosity in the world was achieved at KEKB even using finite angle collision scheme.
(17.1/nb/s)
- To avoid the instability at high beam current operation, the crab crossing scheme was proposed.
- Dr. Ohmi showed the luminosity will be doubled by crab crossing scheme by the computer simulation.



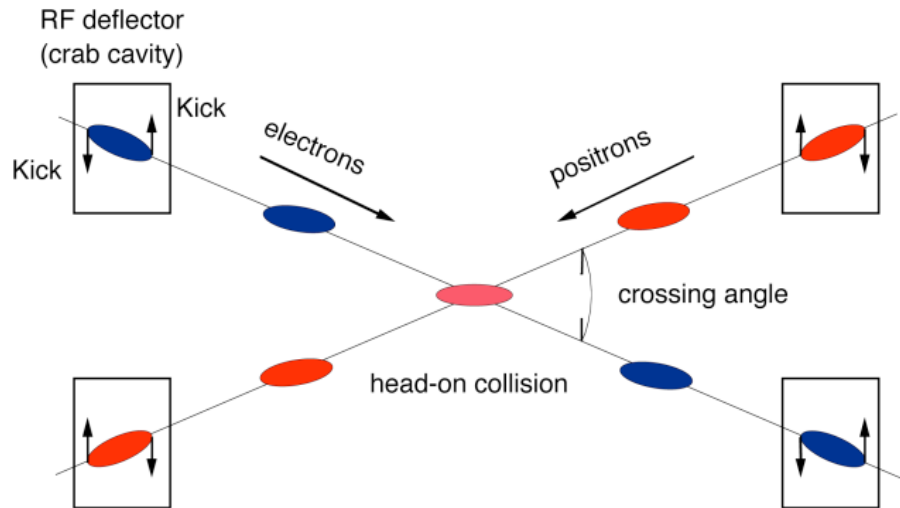
Crabbing

Crabbing mode

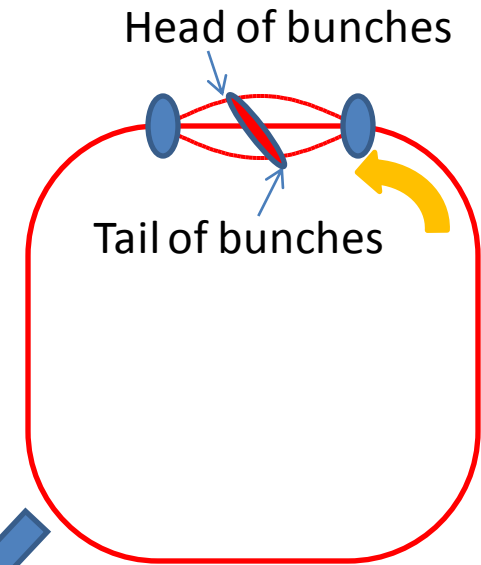


- Time varying magnetic field is applied to bunches.
- The phase and voltage should be controlled.

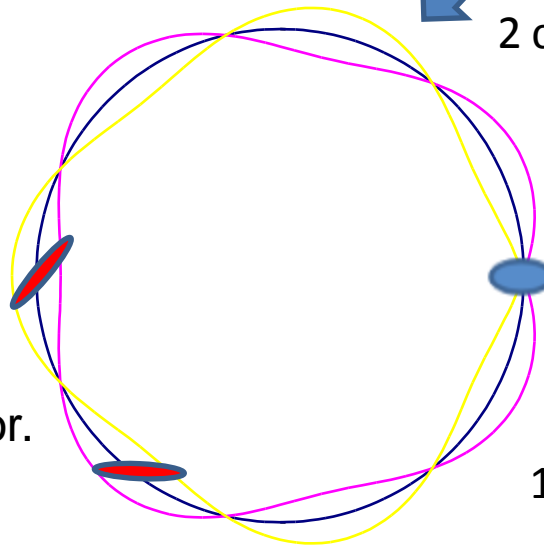
How many crab cavities are required?



Original scheme (4 cavities)



2 cavities for each rings

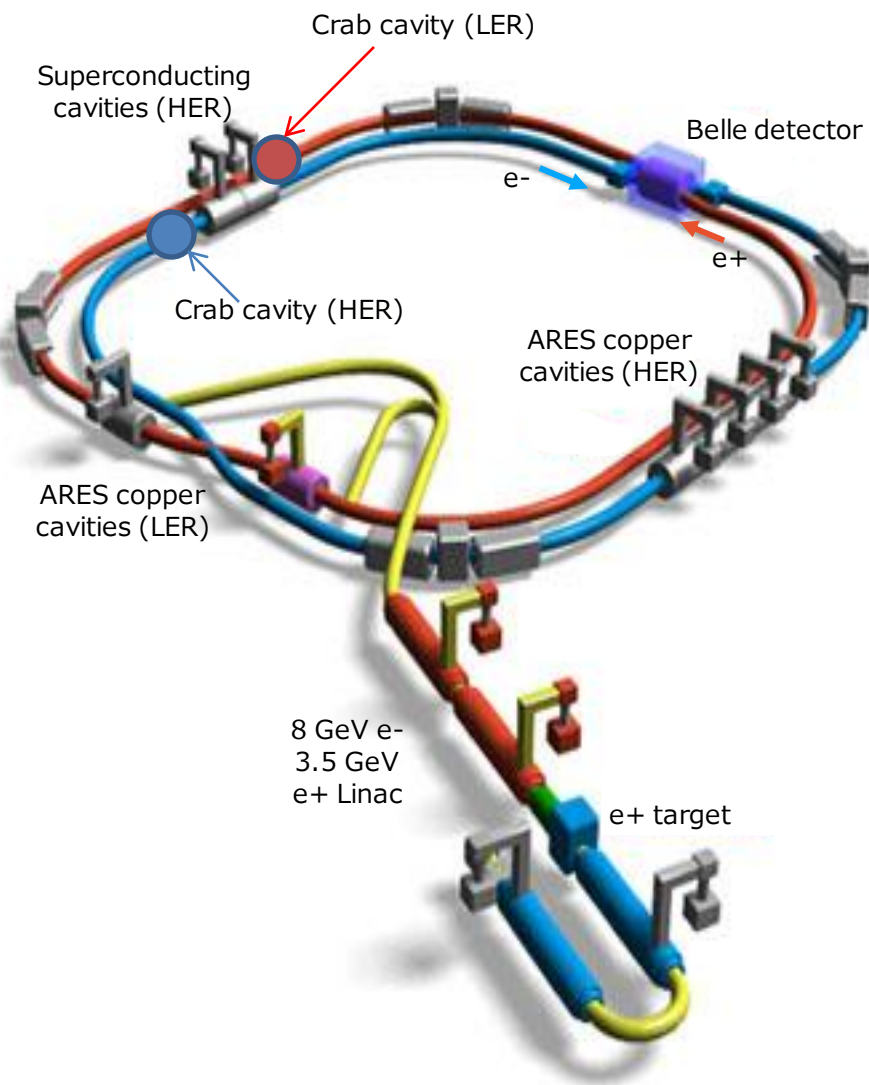


1 cavity for each rings

To adopt this scheme is very effective to reduce the cost.

- (1) The number of cavities can be reduce.
- (2) The installation site can be chosen freely. They was installed near by He refrigerator.

Install to KEKB



Crab cavities were installed near by superconducting acceleration cavities.



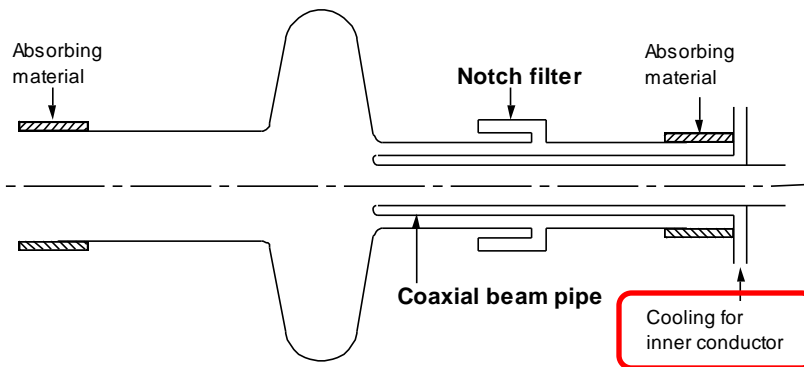
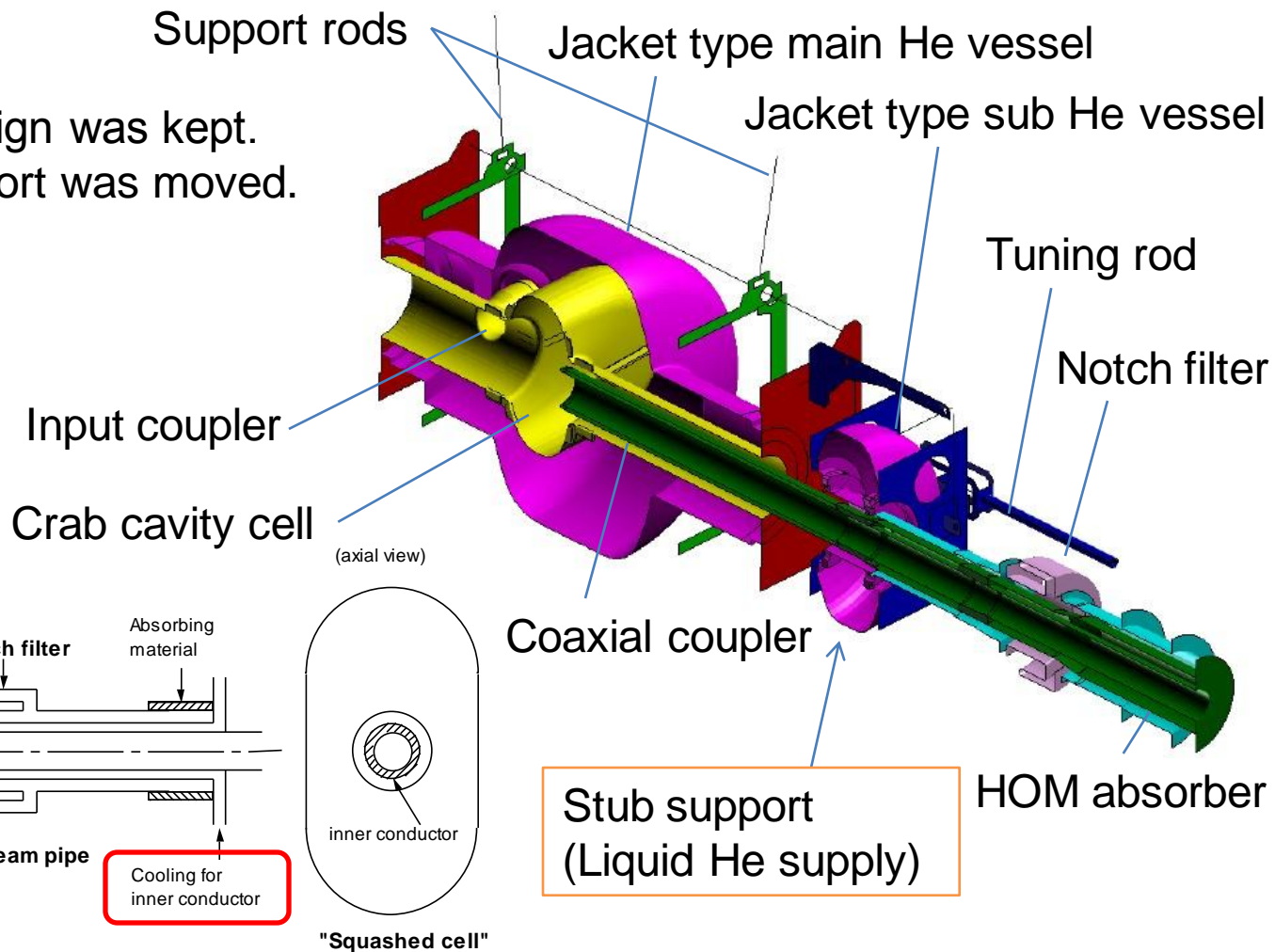
LER



HER

Baseline design of crab cavity

Basically Dr.Akai's design was kept.
Just liquid He supply port was moved.



Squashed Crab cavity for B-factories

Why coaxial coupler is needed?

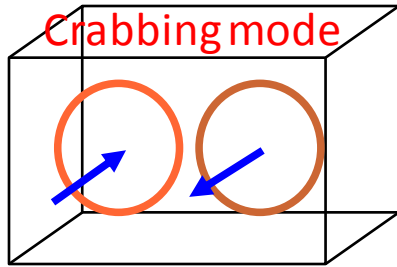
Superconducting acceleration cavities use lowest mode in KEKB.

But crabbing mode is not lowest mode.

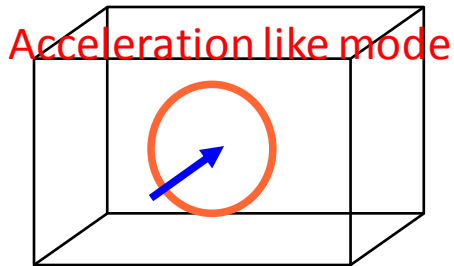
Cut off frequency of large beam pipe is about 750MHz.

To dump the parasitic modes below 750 MHz, coaxial coupler is needed.

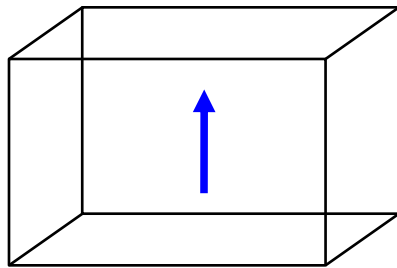
Dipole mode cut off frequency of small beam pipe (coaxial coupler) is about 610MHz.



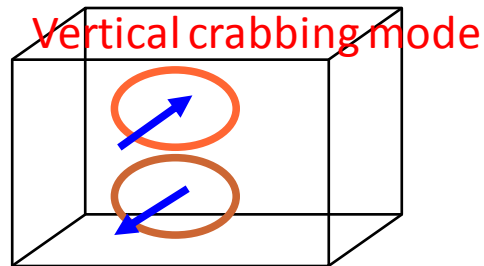
509MHz



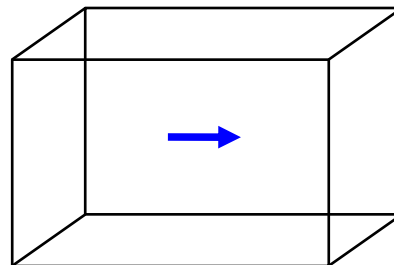
~415MHz



~630MHz



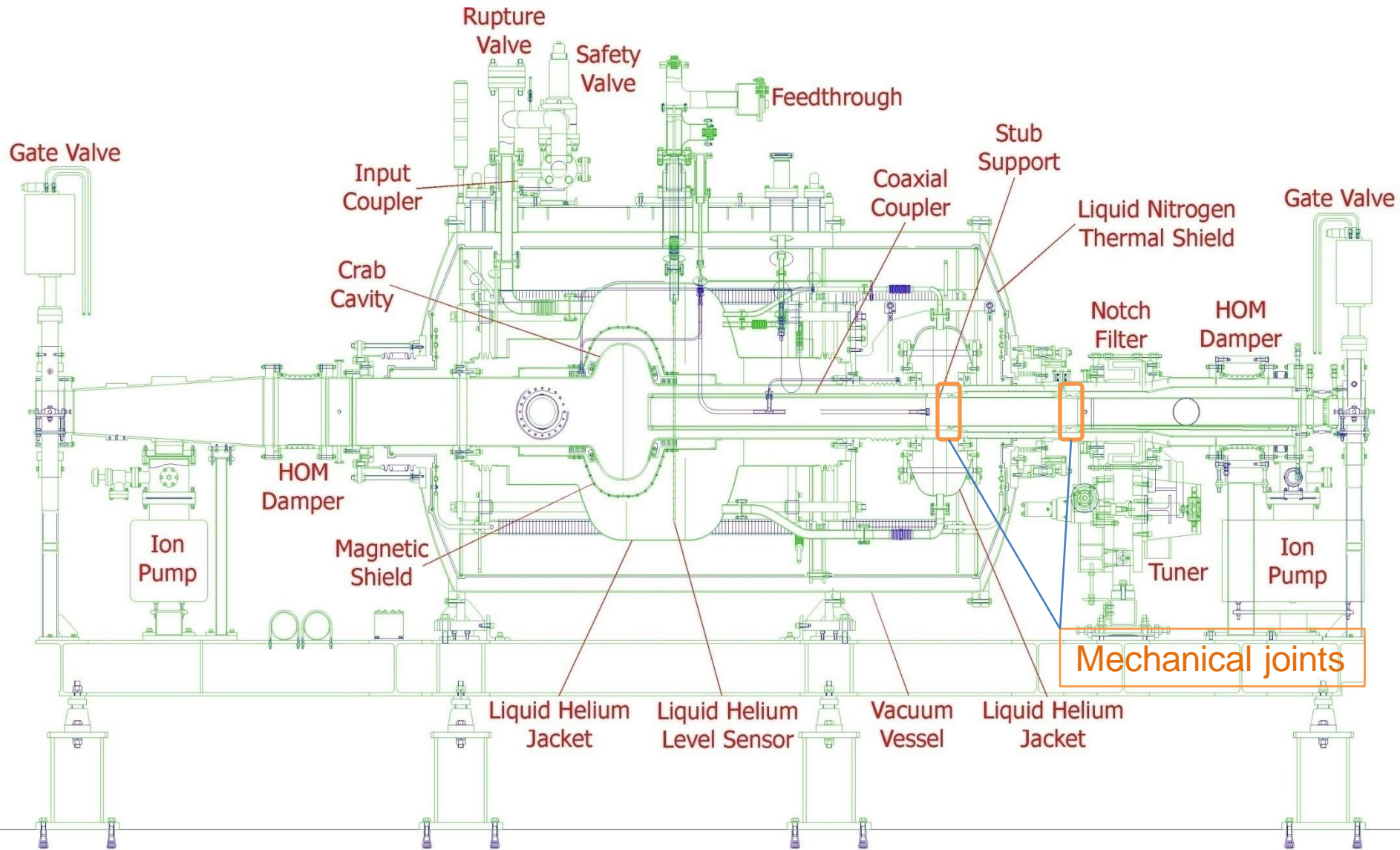
~680MHz



~650MHz

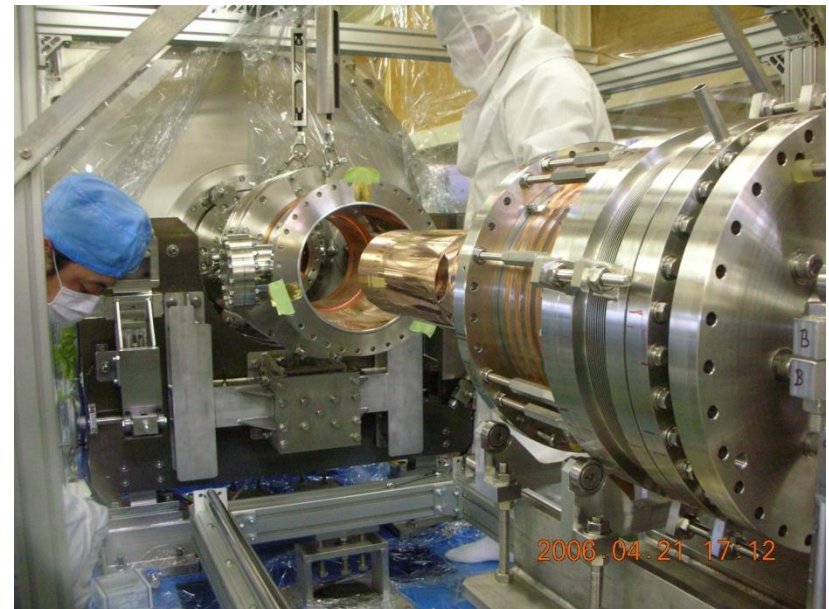
These mode should be
dumped by coaxial coupler.

Schematic Drawing of Cryostat

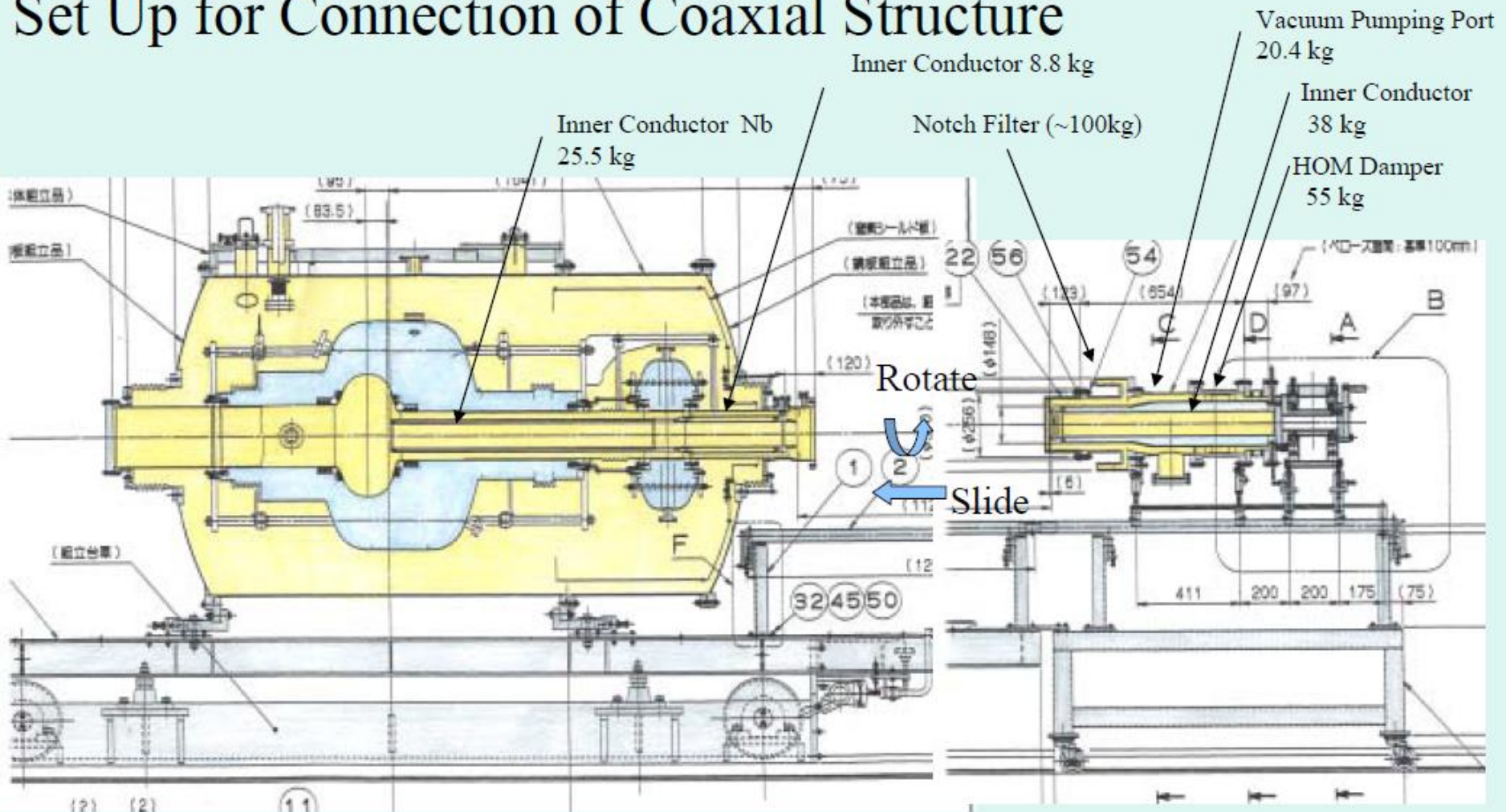


Assembling the coaxial coupler

- Assembling the coaxial coupler was very difficult. We spent about 2 months to connect the mechanical joints.
- To connect them, an accurate installation tool should be made.



Set Up for Connection of Coaxial Structure



Could not connect !

The Coaxial Structure is Heavy.

Need Precise Alignment

Position of Axis
Direction Axis



Insertion Tool

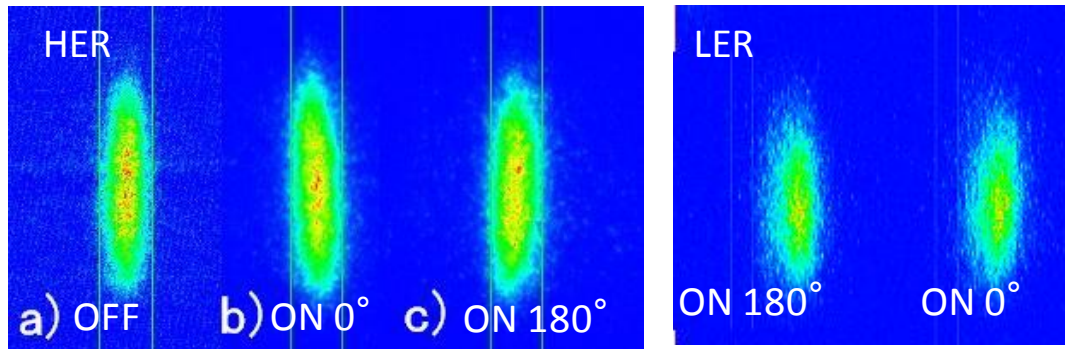
Not Strong Support Structure
No Precise Adjustment Knob



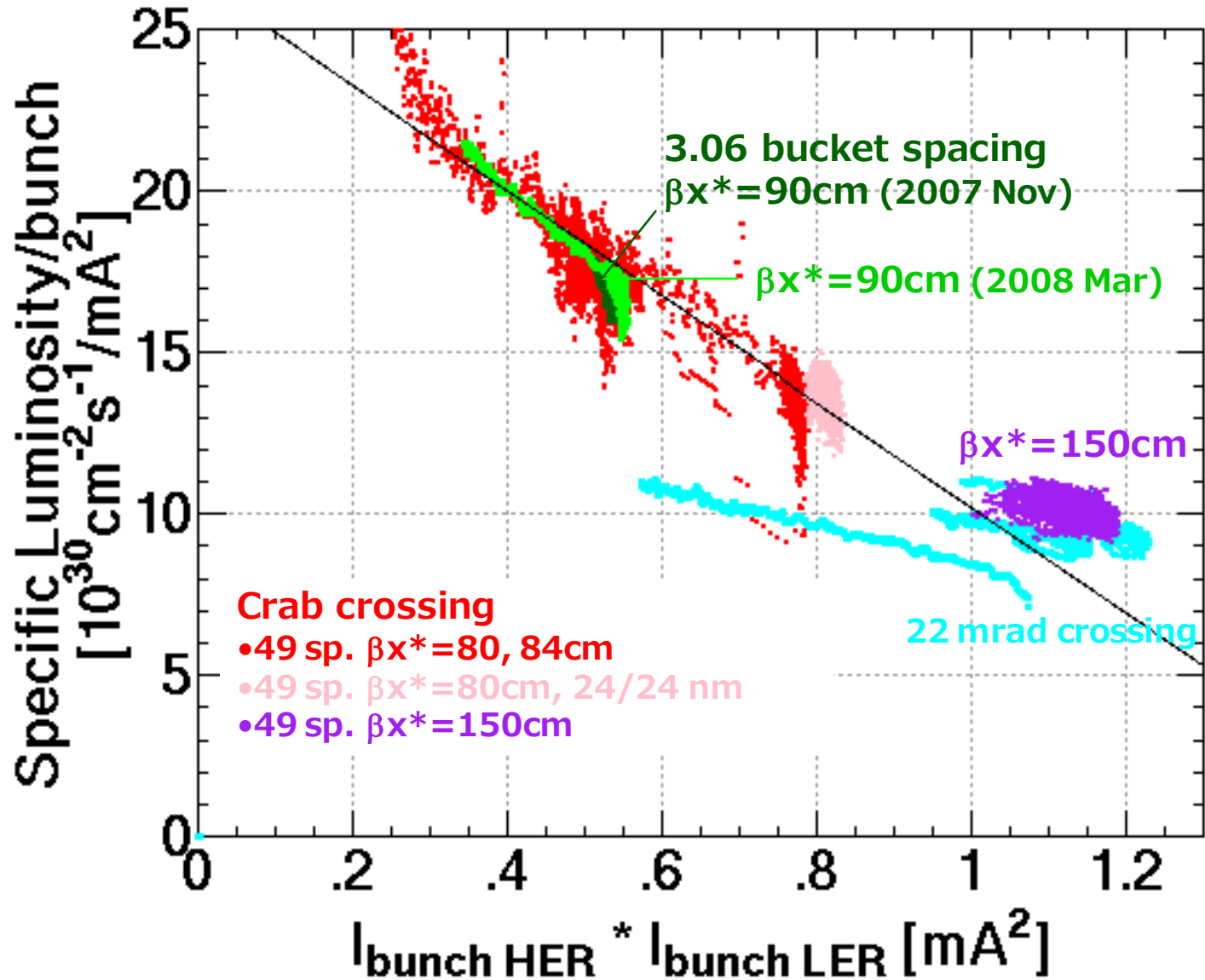
Need Modification

Bunches has tilted

- The crab motion was observed directly using a streak camera.



Specific Luminosity



Tuner

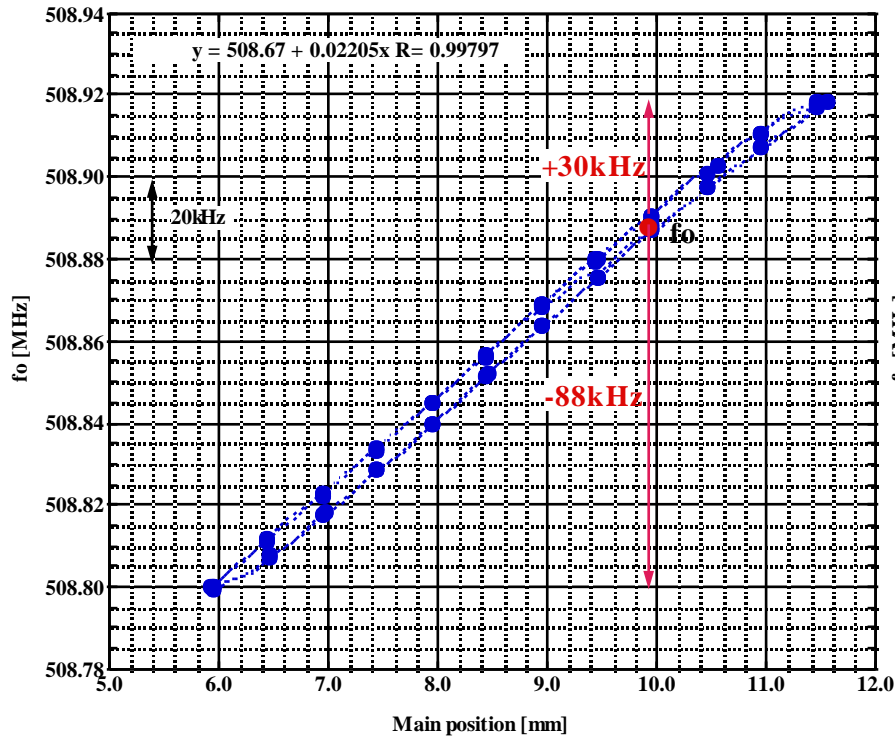
Main tuner(Motor)

Feb 2007

HER

Main tuner (motor)

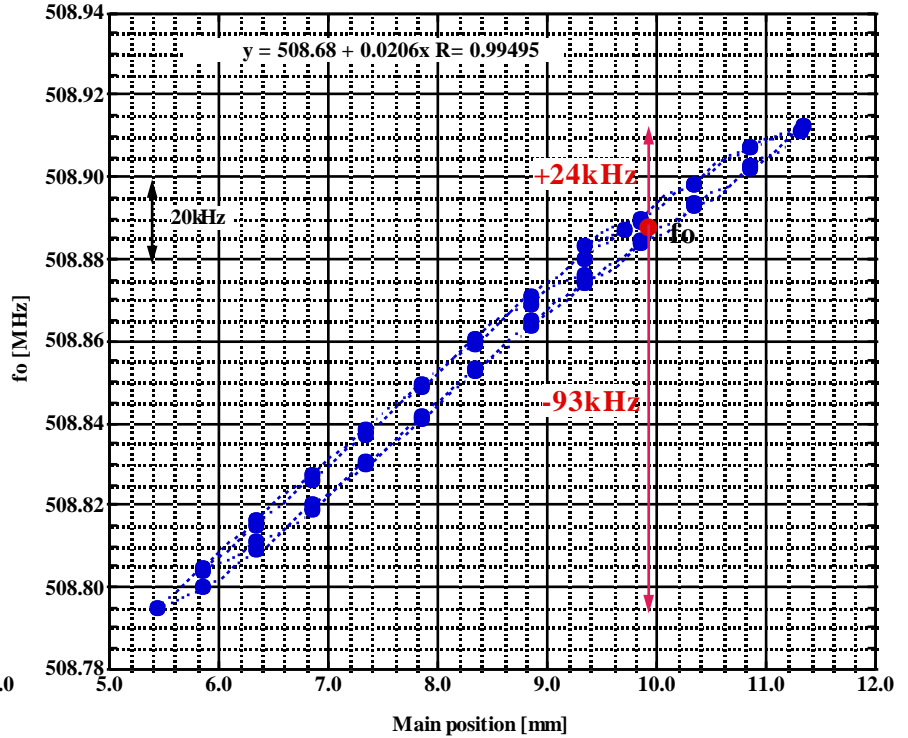
070206



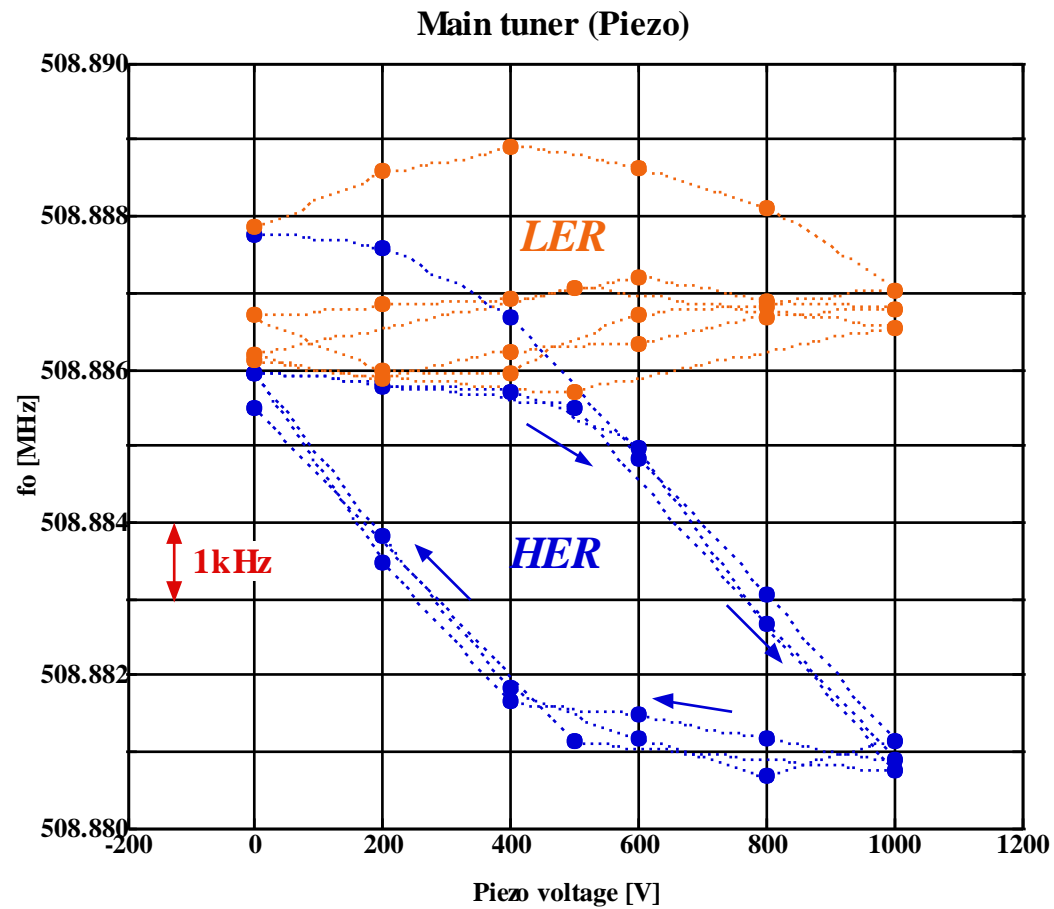
LER

Main tuner (motor)

070208



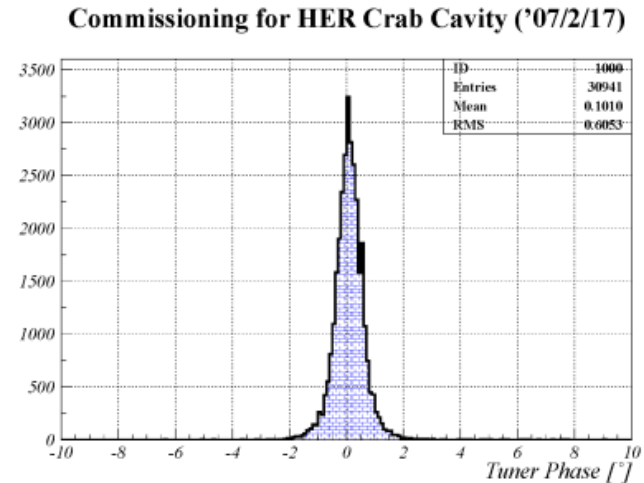
Main tuner (Piezo)



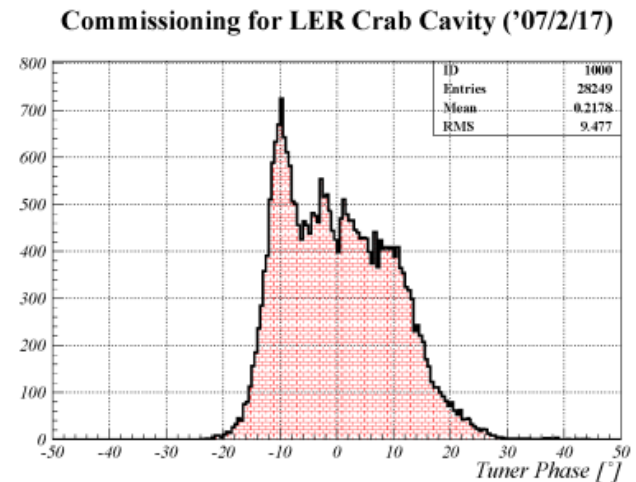
Distribution of tuner phase

- The tuner phase for LER is unstable due to the bad fine tuner response.

RMS=0.6°



RMS=9.5°

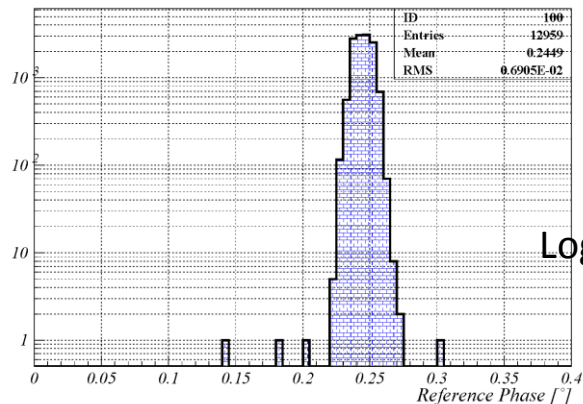
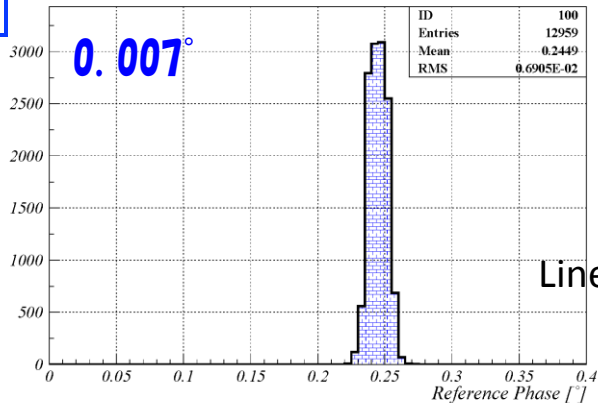


Phase stability (histogram of phase detector signal)

The tuner phase instability was suppressed by low level RF control system.

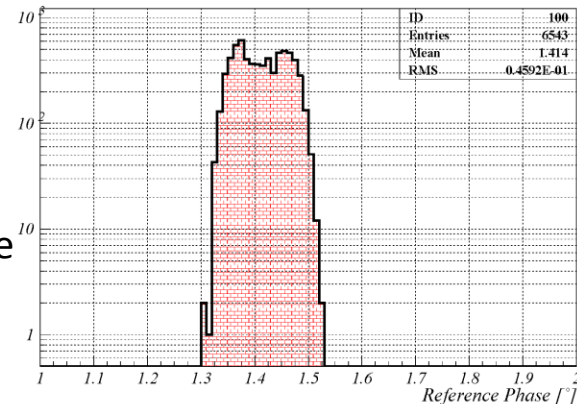
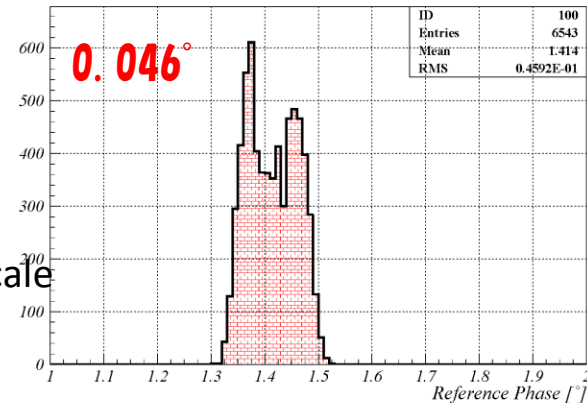
HER

Commissioning for HER Crab Cavity ('07/2/20)



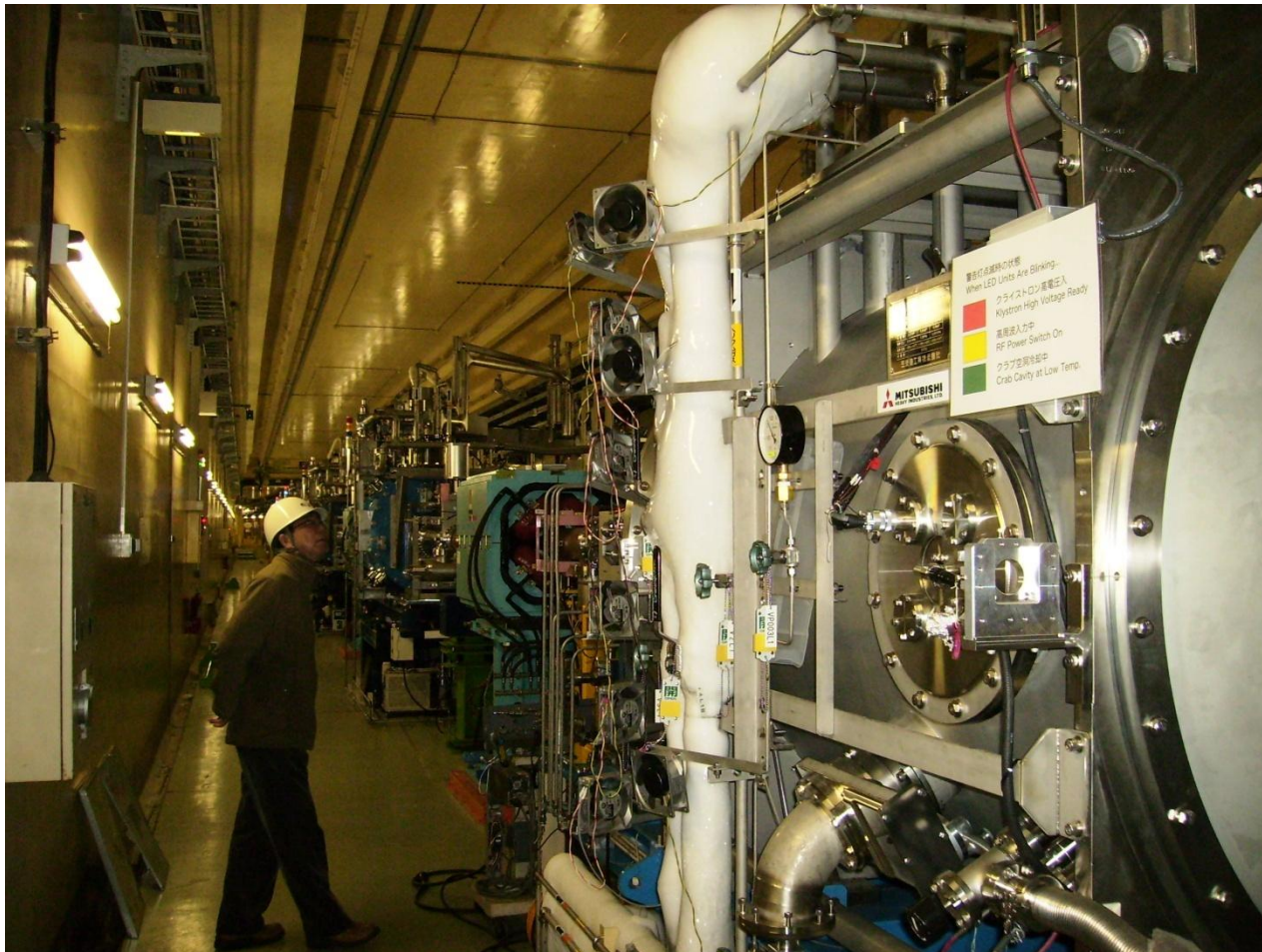
Commissioning for LER Crab Cavity ('07/2/20)

LER



Distribution of cavity phase (cavity feedback loops on)

Ice balls



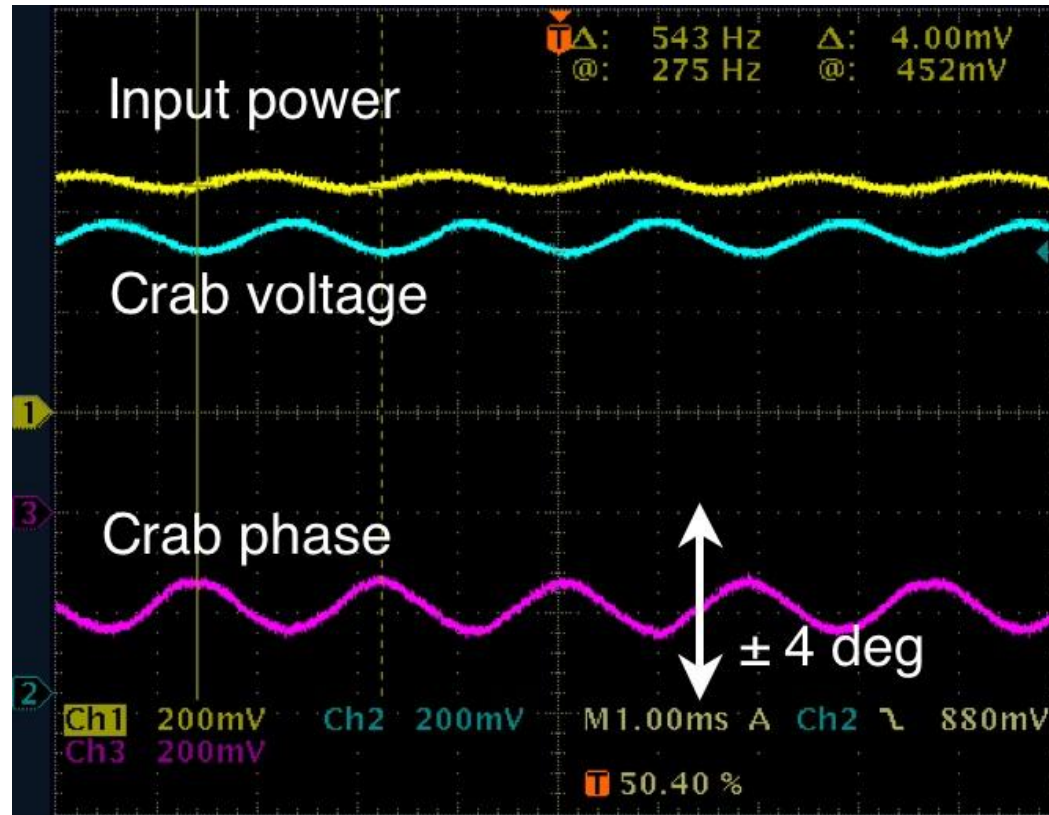
Ice balls

- (1) Boiled He gas return to refrigerator through isolation pipe. To cool down the coaxial coupler, Liquid He was taken from He vessel. That gas return to suction of compressor through the normal (not isolated) pipe, because the amount of He flow was expected very small.
- (2) Some coaxial coupler quench was observed. Temperature of gas outlet rose at that time. After that gas flow was increased.
- (3) Ice ball grew.

LER kick voltage limit

- (1) Big quench was occurred on March 17, 2007.
- (2) The reachable kick voltage of LER crab cavity decrease from 1.36MV to 0.98MV.
- (3) To cure this trouble, aging was done. But the reachable kick voltage was not changed.
- (4) Crab cavities were warmed up to 80K. After that, the reachable kick voltage was increased to 1.1MV.
- (5) The reachable kick voltage was gradually increased to 1.14MV by steady aging effort.

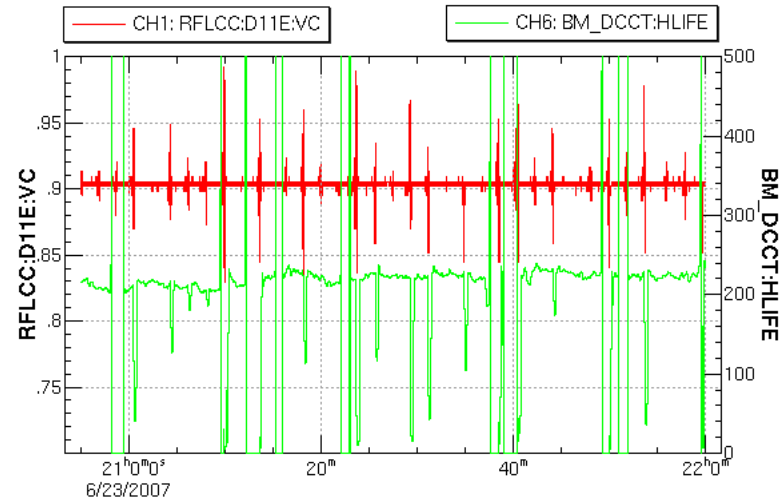
Instability in high current operation



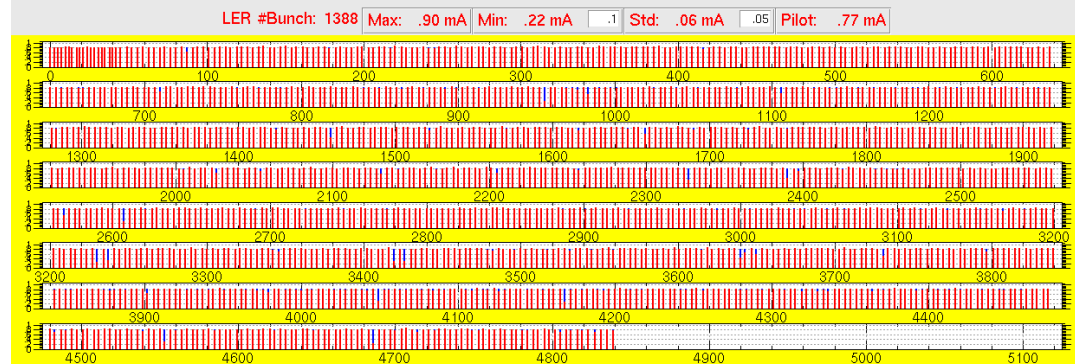
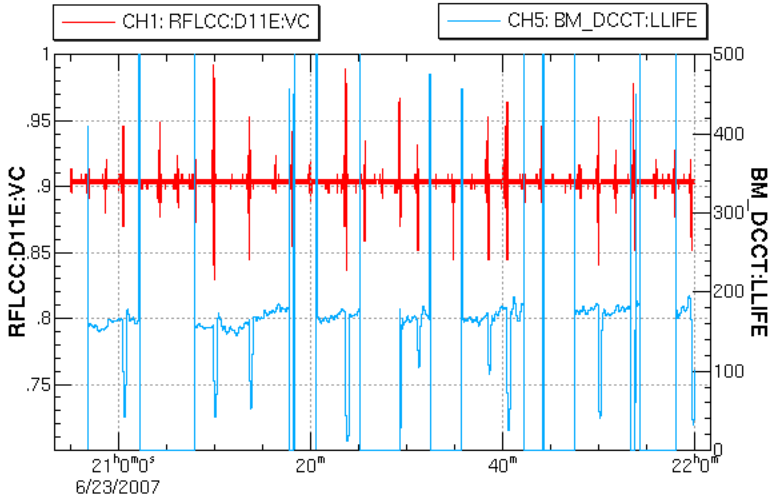
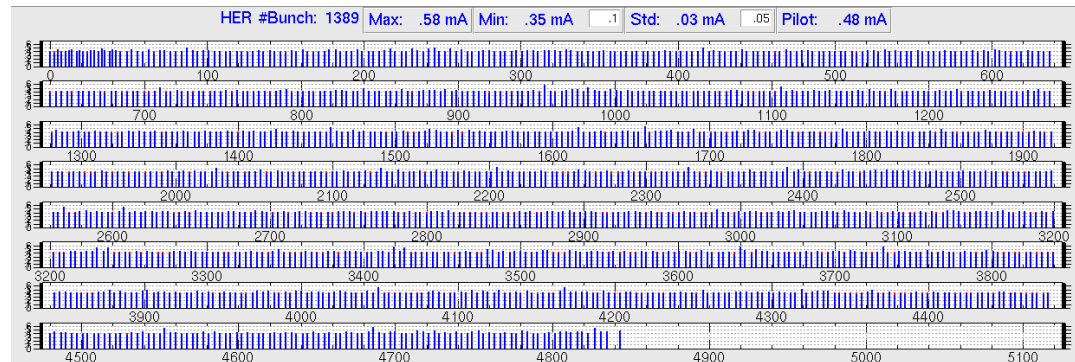
In the high-current crab-crossing operation, we encountered a large-amplitude oscillation of beams and the crabbing field caused by the beam loading on crab cavities together with the beam-beam force at the IP. We found that the oscillation can be avoided by shifting the crabbing phase, shifting the tuning offset angle, and adjusting the loop gain appropriately.

Comments

- 両リングの寿命が急落することがあり、
LER 電圧変動と同期している。

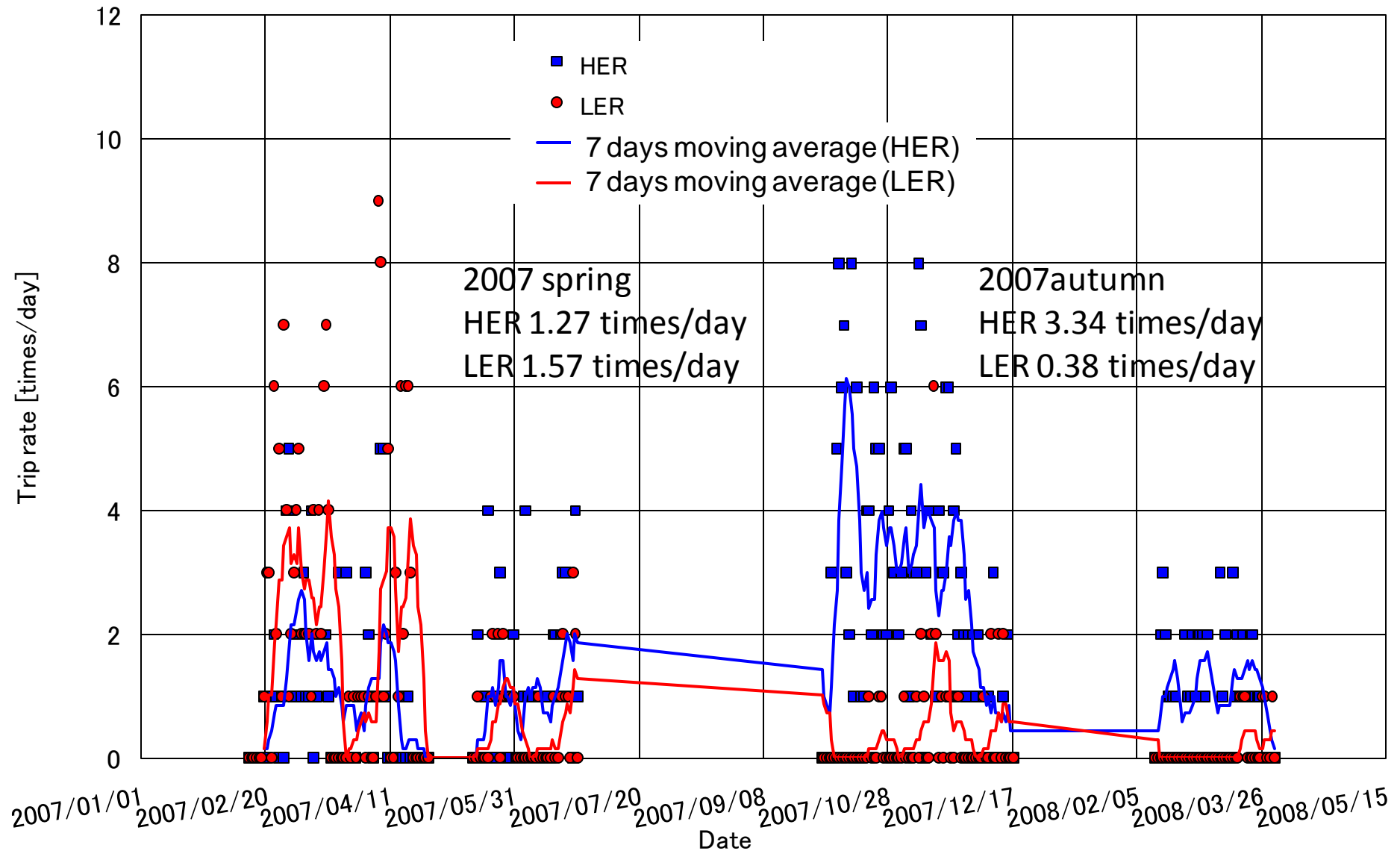


Some times, beam life was suddenly dropt.
LER Vcrab was also unstable at that time.



From KCG shift report (Jun 23, 2007)

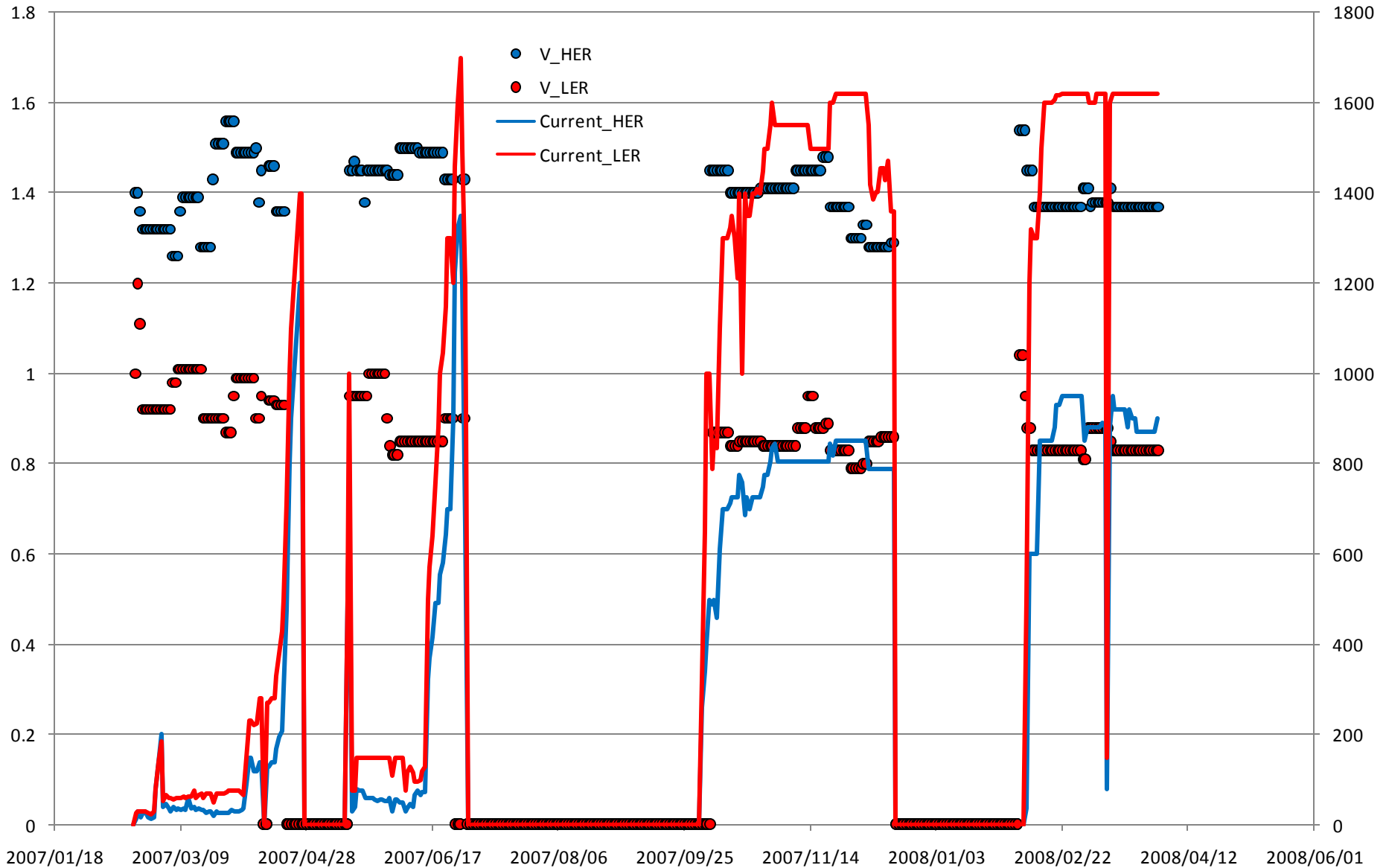
Trip rate



Beam current

Kick voltage [MV]

Beam current [mA]

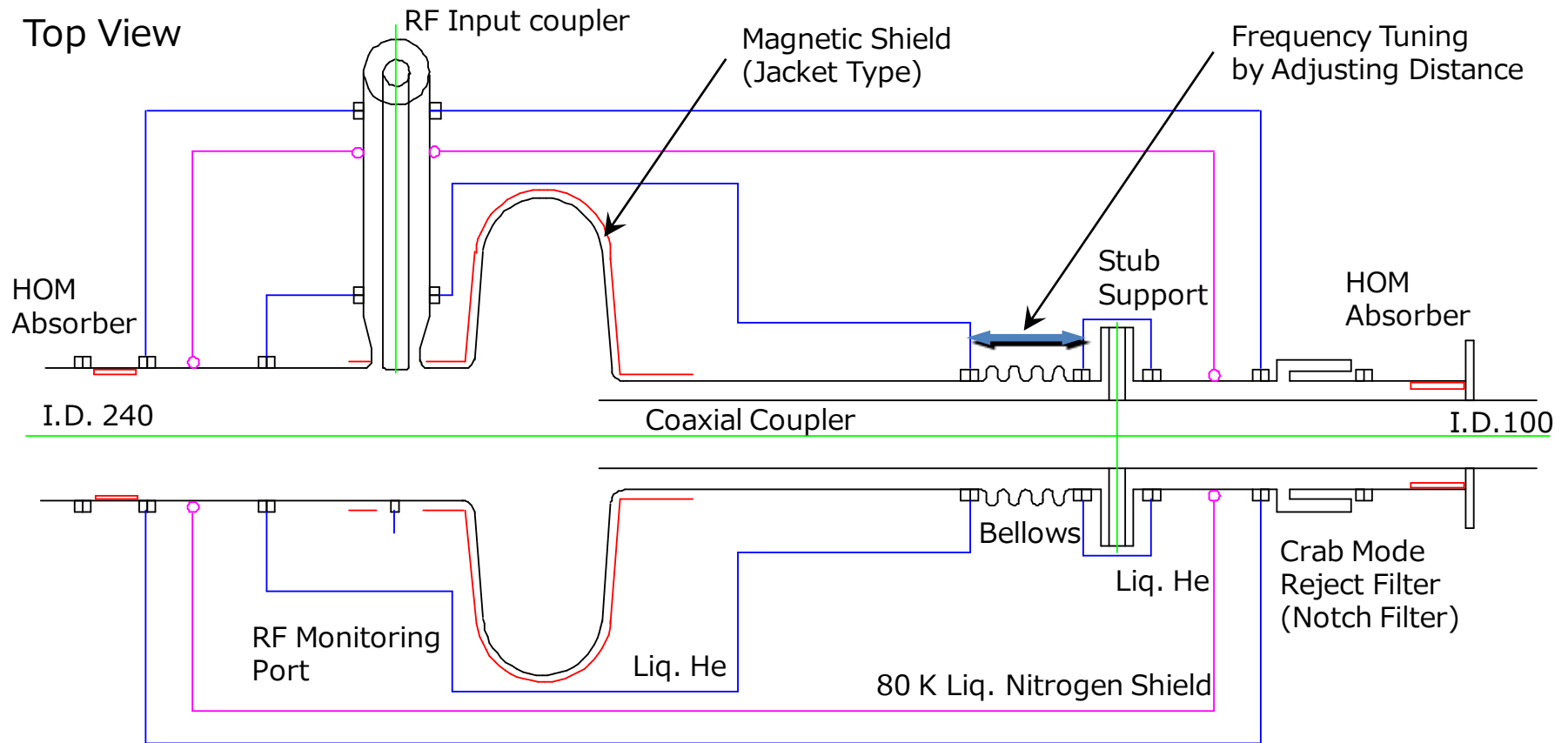


summary

- Two crab cavities were installed to KEKB.
- Crab cavity made kick voltage more than 1.8MV at KEKB.
- Bunches had been tilted.
- The luminosity was increased at low bunch current operation with crab cavity.
- The peak luminosity reach to 15.1/nb/sec with crab cavities. (17.1/nb/sec without crab cavity.)
- The tuner for LER crab cavity has big back rash. It is compensated by low level RF control system.
- At high current operation, RF instability was observed. It is suppressed by adjusting crabbing phase, tuning offset and feedback loop gain.

Cryostat Conceptual Design

Top View



Fabrication Procedure of Crab Cavity

Crab Cavity Cell

Beam Pipe & Flange

MHI
Kobe

KEK
Tsukuba

Nomura
Plating
Kanuma

Kinzoku
Giken
Mito

Nb Sheet Tokyo Denkai
5 mm t RRR = 180

Nb Sheet

Half Cell Hydro-forming

Roll

Mechanical Polishing & Trimming

Electron Beam Welding

Grinding of Welding Part Cell Equator

Barrel Polishing ~ 100 μm

Electro-Polishing EP 1
~ 100 μm

High Pressure Water Rinsing 80 bar. 60 min

Annealing 700 °C x 3 hr

Electro-Polishing EP 2
~ 5 μm

High Pressure Water Rinsing

Assembling for Cold Test

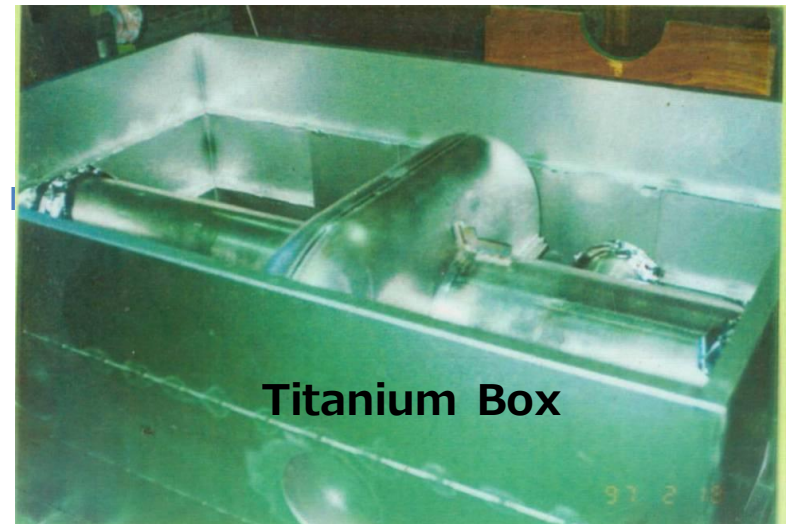
Cold Test in Vertical Cryo.

Electro Polishing & Annealing



Electro Polishing at Nomura Plating Ltd.

EP 1 $\sim 100 \mu\text{m}$
EP 2 $\sim 5 \mu\text{m}$



**Annealing at 700°C for 3 hours
at Kinzoku Giken Ltd.**

Forming and Barrel Polishing



Forming of 4 Half-Cells for Crab Cavity for LER and HER

Feb. 14, 2005 at Mitsubishi Heavy Industries, LTD. Kobe



Barrel Polishing

Polishing Time 312 Hr

Nov. 11, 2005 at KEK

High Pressure Rinsing and Assembling for RF Cold Test



Set Flanges of Beam Pipes and Ports
in Class 100 Clean

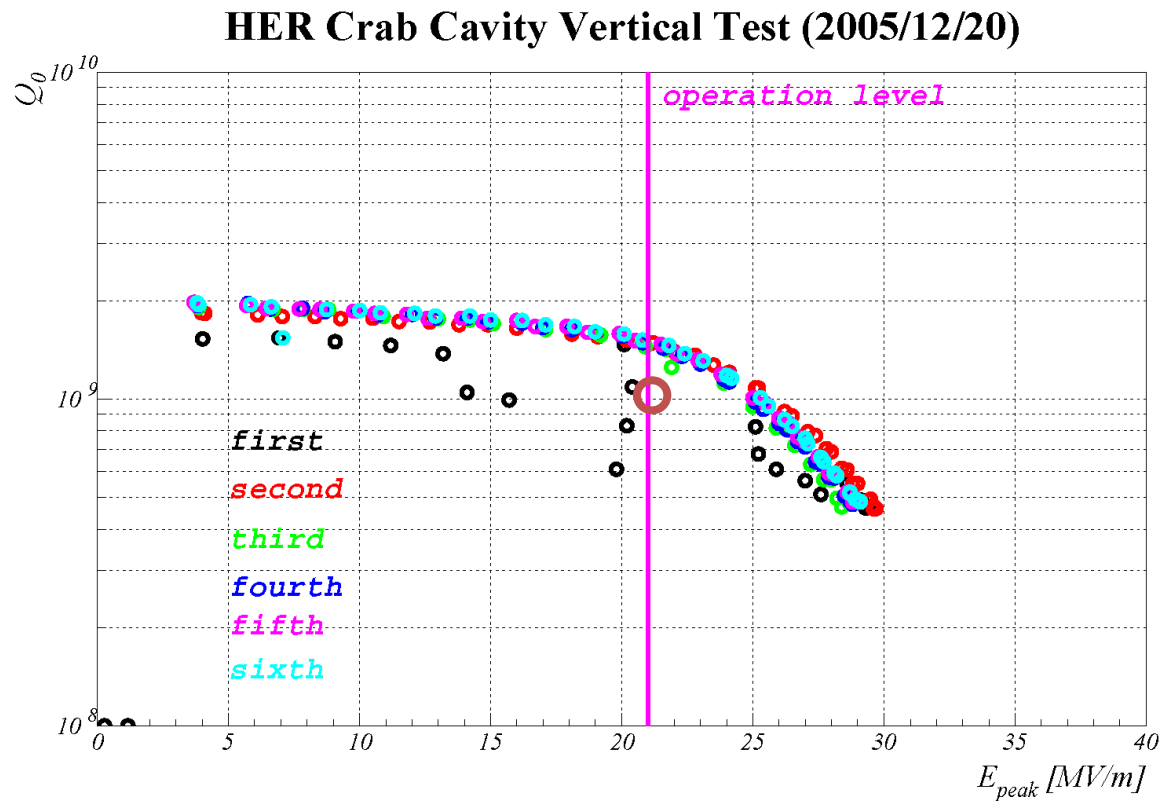
High pressure rinsing



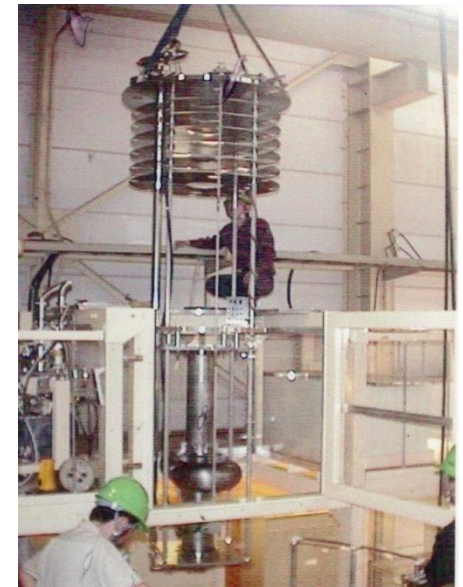
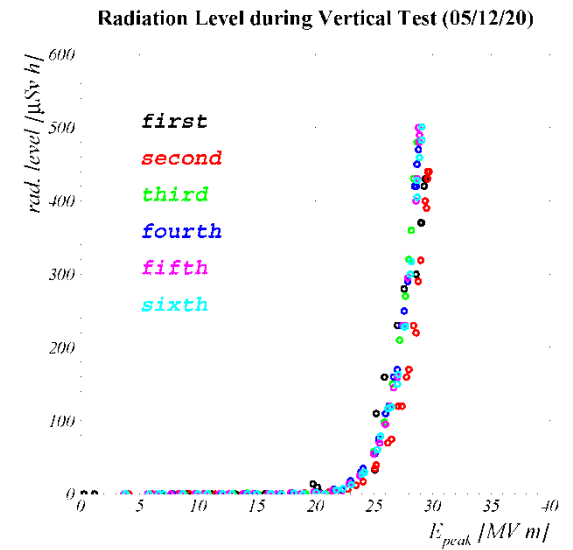
High Pressure Water Rinsing
by 80 bar Ultra-Pure water

Rotation & Up-Down Motion

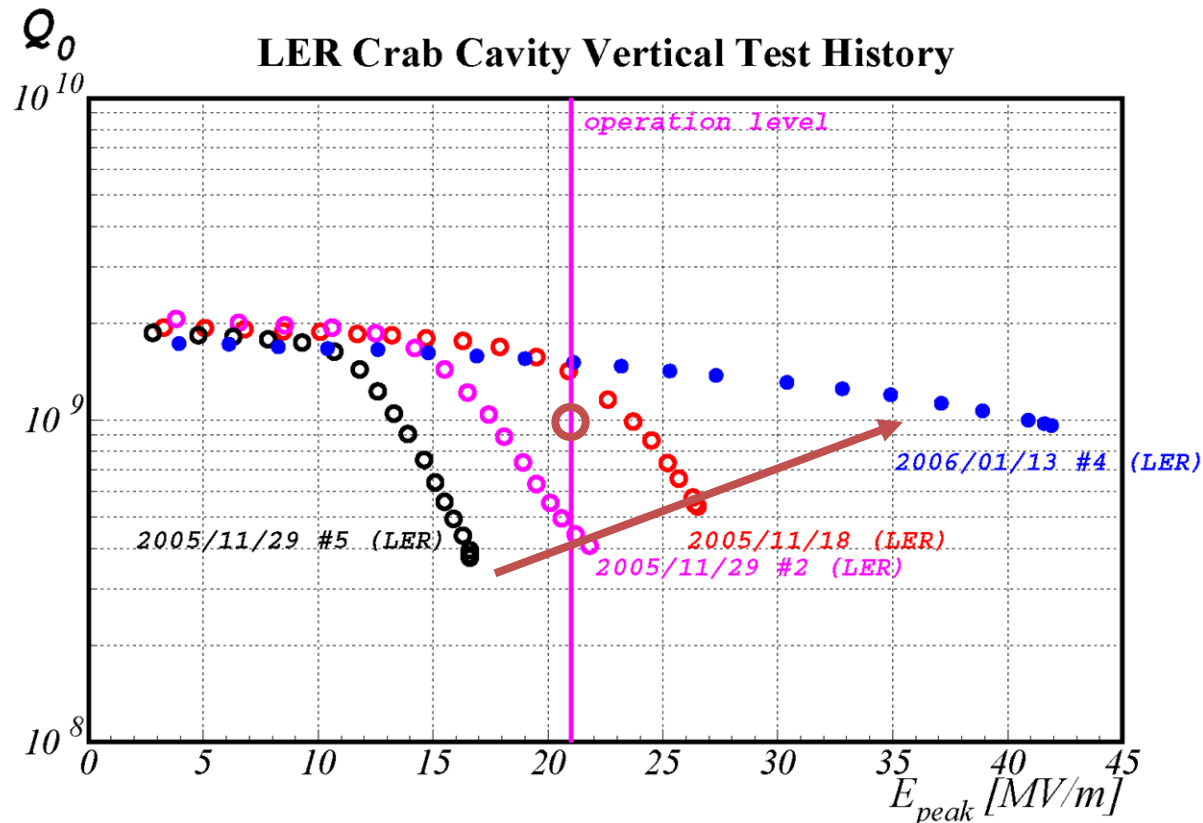
Test Result Crab Cavity for HER



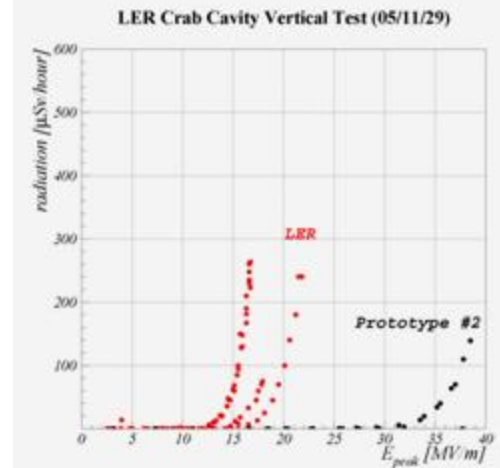
21MV/m (E_{peak}) = 1.4MV (Kick voltage)



Test Result Crab Cavity for LER



X-Ray



Nov. 18 1st Test

H.P.R.

Nov. 29 2nd Test

Re-processing

Field Emission

EP2

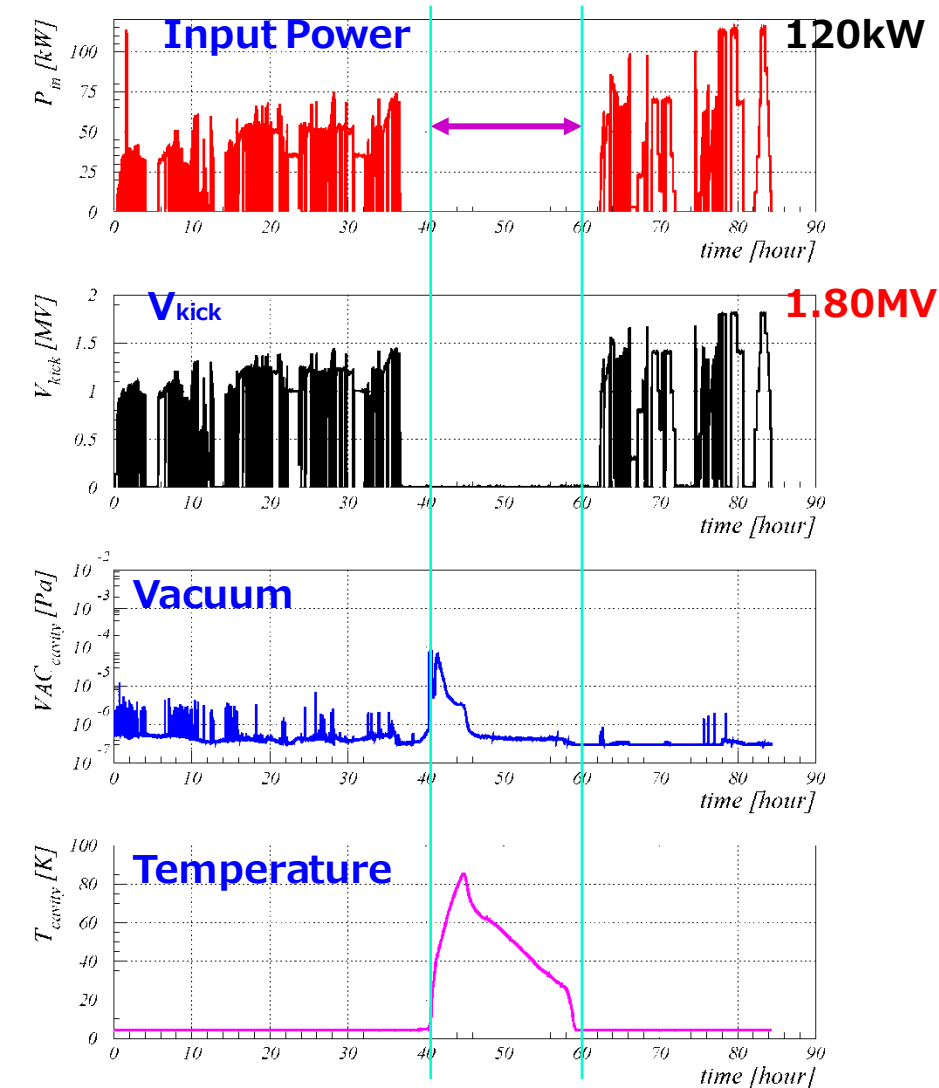
Jan. 13 Test

Recovered !

High Power Test for Crab Cavity HER & LER

Crab Cavity HER

Second Horizontal Test for HER Crab Cavity at 4K



Crab Cavity LER

Fisrt Horizontal Test for LER Crab Cavity at 4K

