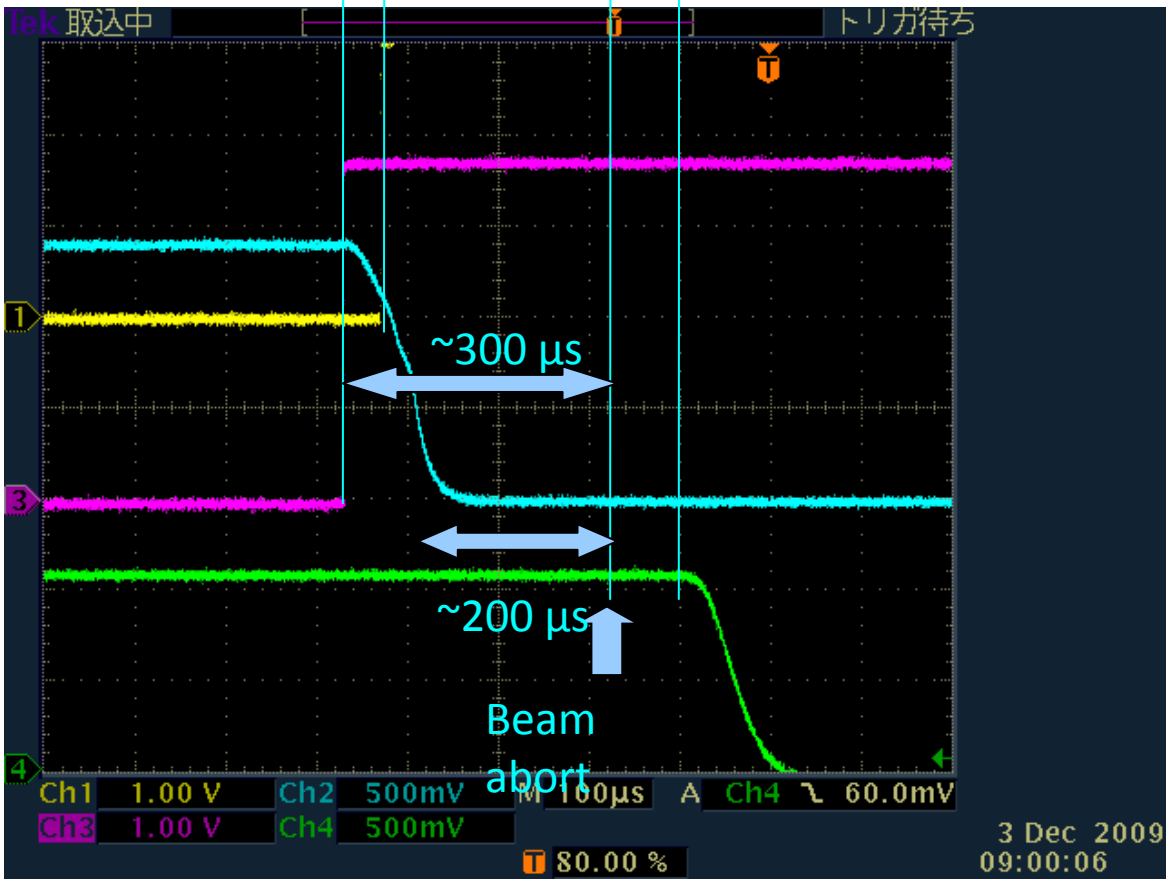
KEK-B crab trips & RF signals

K.Nakanishi
KEK
Dec. 16 , 2010
LHC-CC10

DCCT signal delay 80microsecond,
when that is caught at RF station



Cavity voltage

Abort request

RF switch

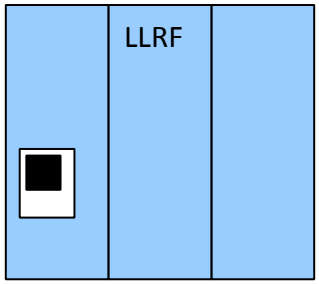
Beam current
(DCCT)

In KEKB, the beam was aborted 300us after the RF trips.
It corresponds to 30 turns of beam circulation.

Data taking

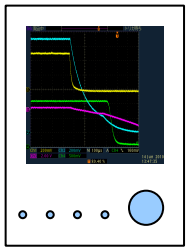
•Various data measured by RF abort monitor and BOR are introduced in this report.

•RF abort monitor

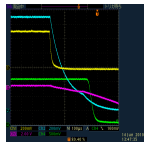


It is an oscilloscope attached to LLRF

It is triggered by beam decaying.

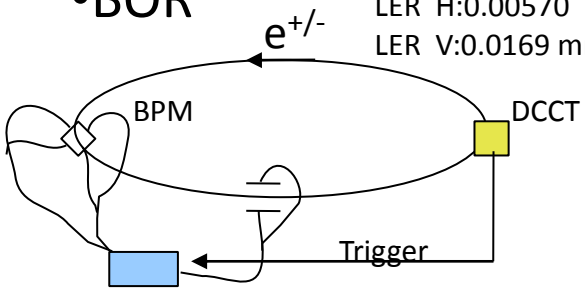


When a beam abort is required, the snapshot of an oscilloscope is saved.

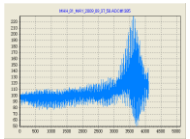


•BOR

HER H:0.0118
HER V:0.00655
LER H:0.00570
LER V:0.0169 mm mA/count



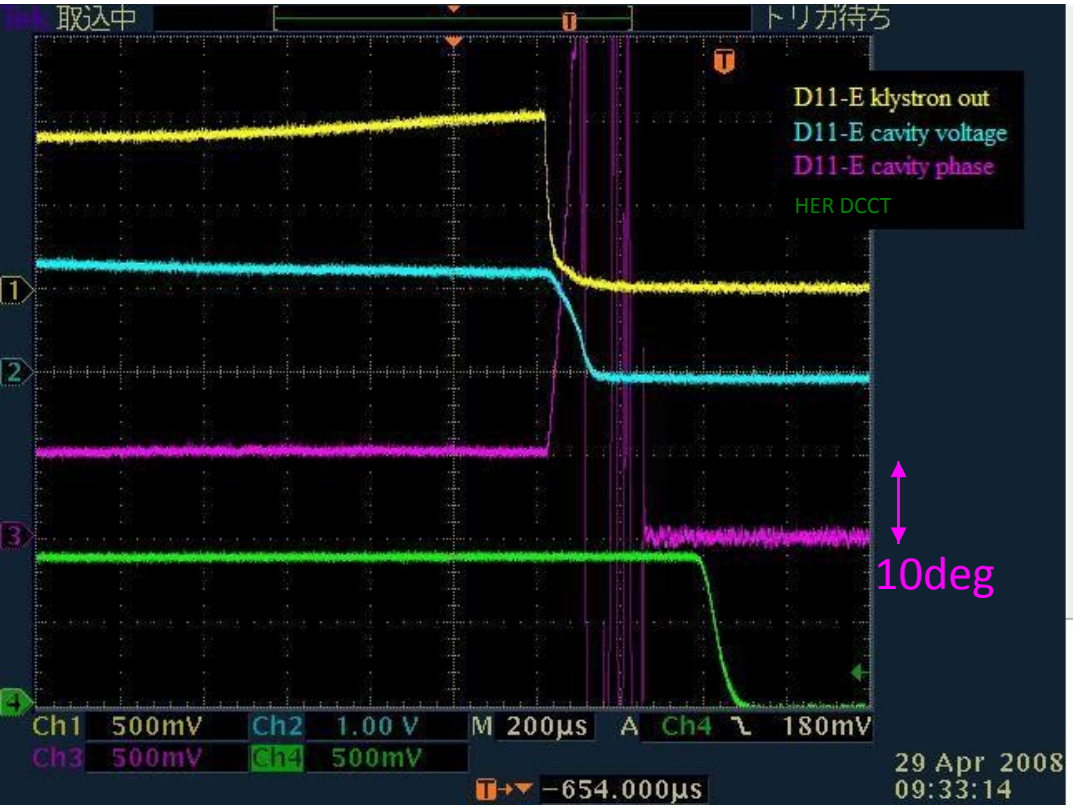
Bunch by bunch feedback system



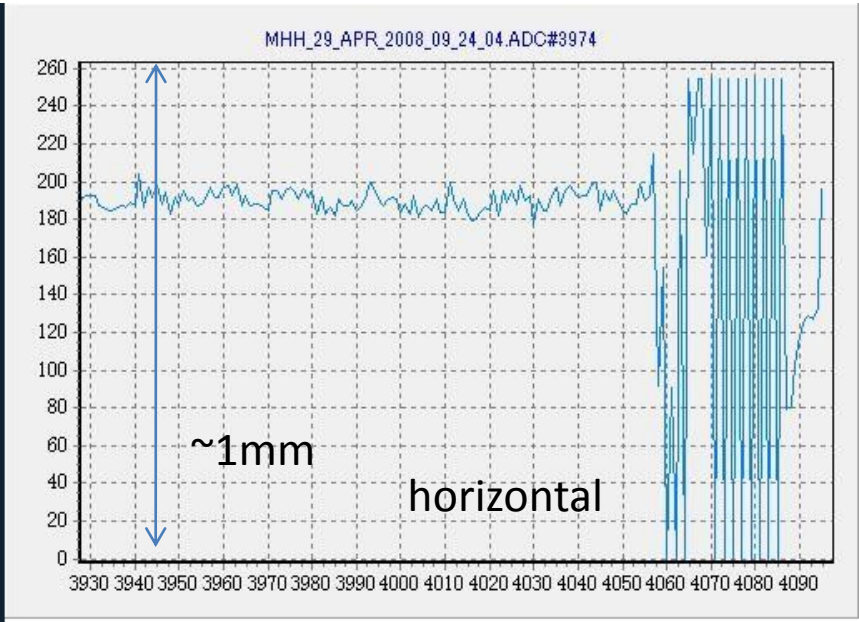
KEKB HER(High Energy Ring) and LER(Low Energy Ring) have a bunch-by-bunch feedback system respectively.
The beam positions in 4096 turns of every bunches are stored in ring buffer of them.
When a beam loss is observed by DCCT, the data is saved.

At first, I searched characteristic signals in data of RF abort monitor. And corresponding data was find in the BOR data.

Yellow :Klystron output power
Blue :Power form pick up antenna at the cavity.($\propto Vc^2$)
Purple :Cavity phase
Green :Beam current

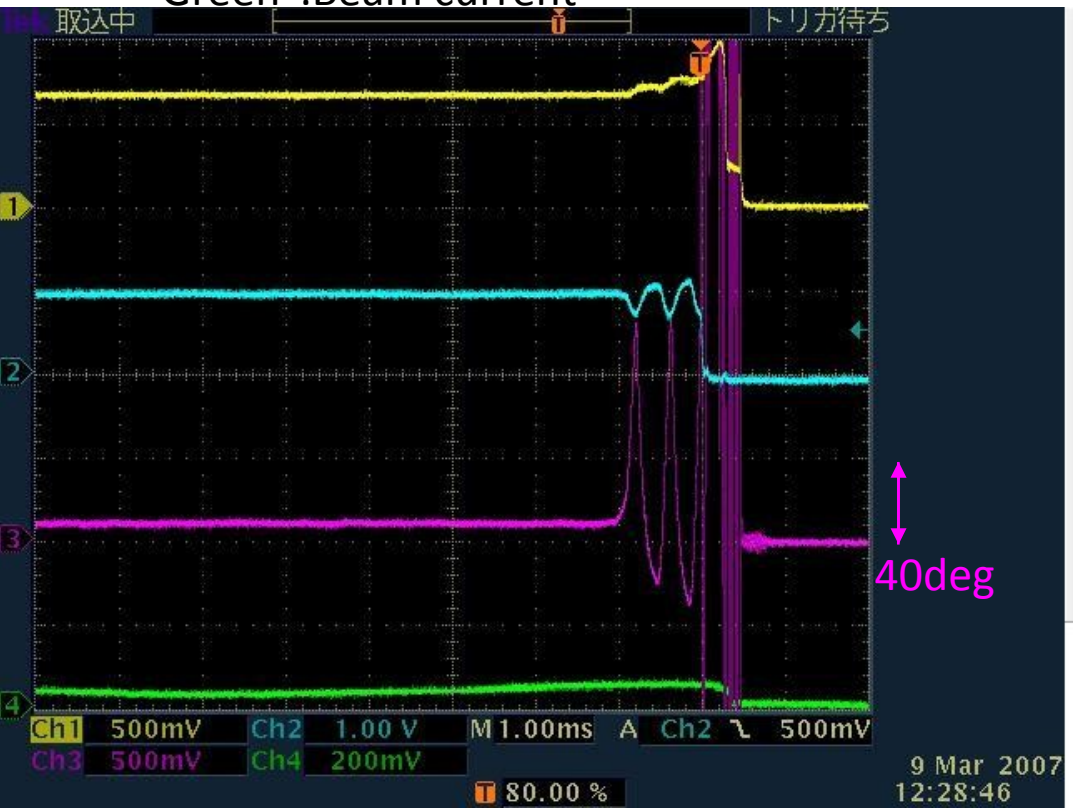


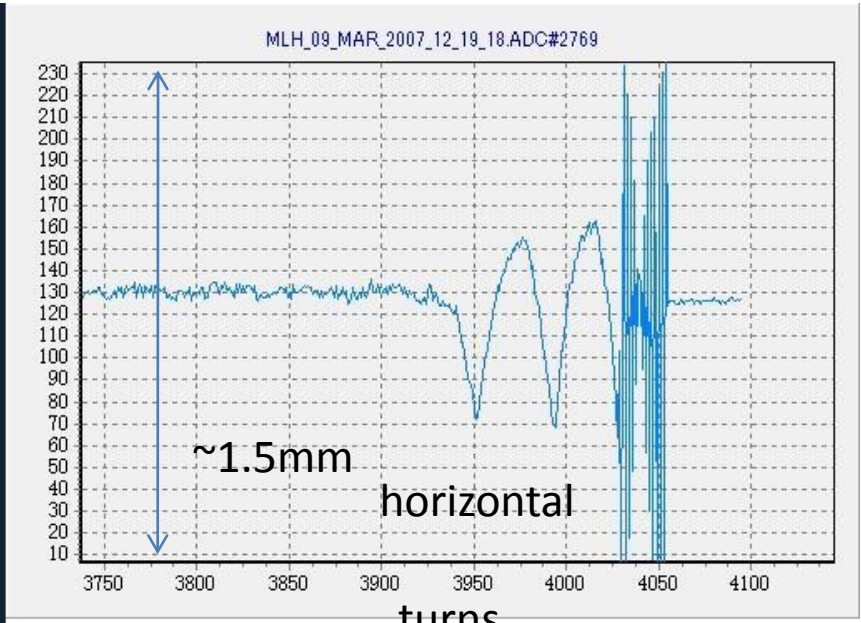
The beam was kicked when a quench was occurred.



The vertical axis shows a quantity related to a displacement and bunch current.

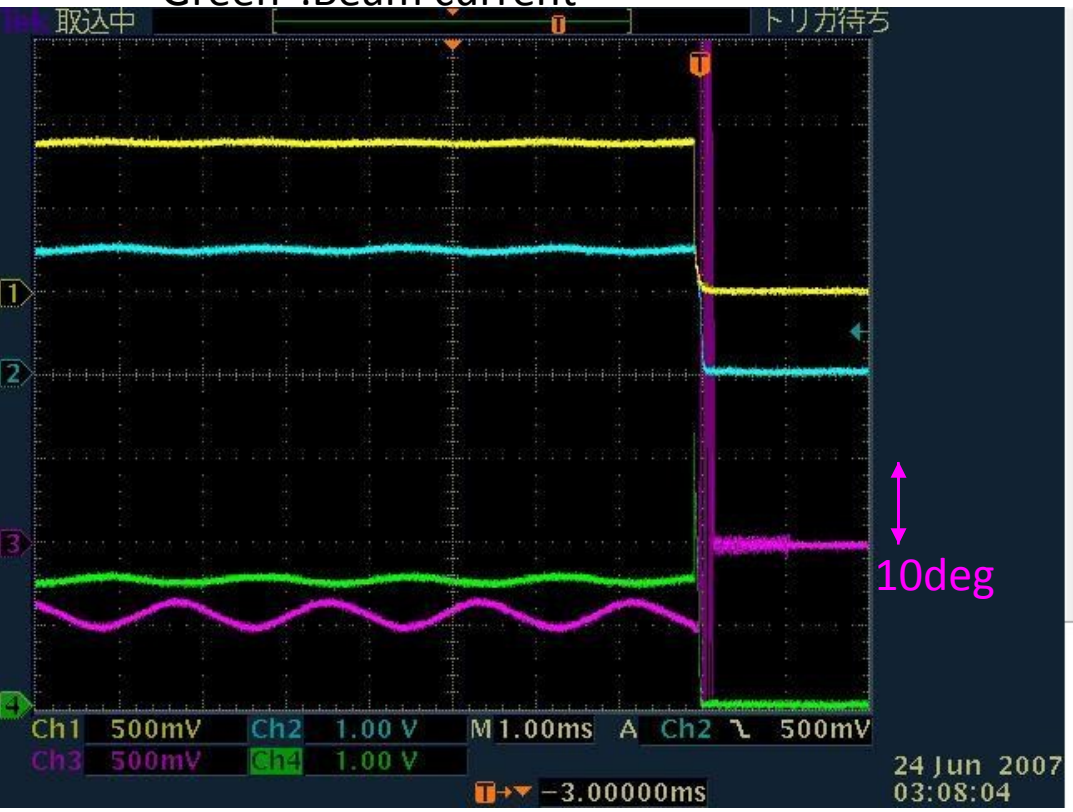
Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Purple :Cavity phase
Green :Beam current

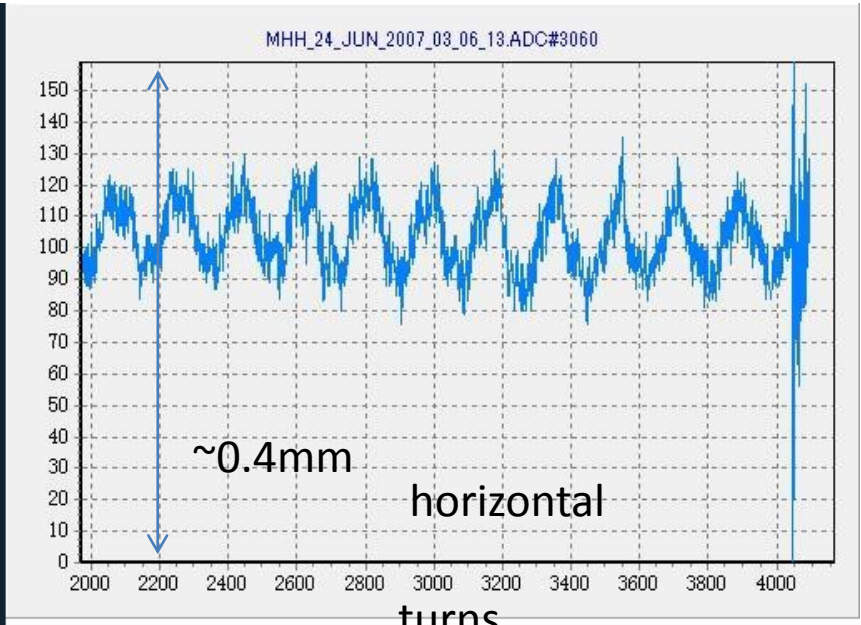




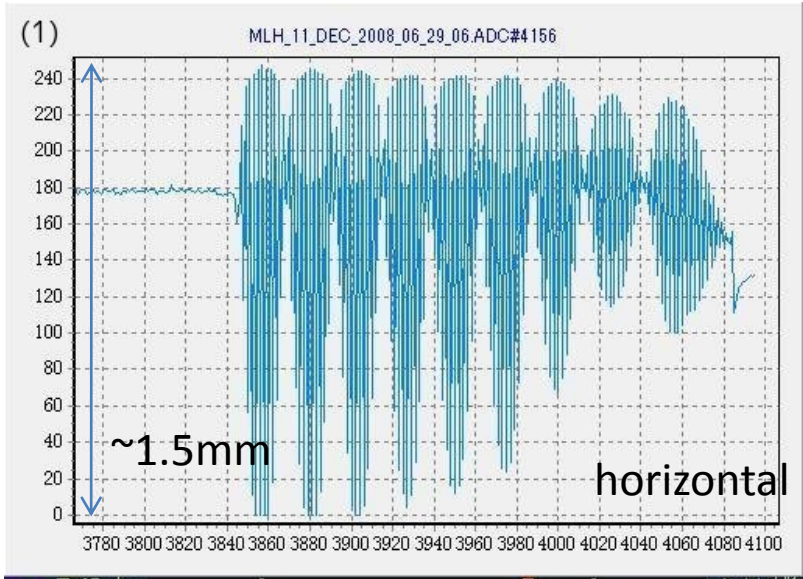
Some turbulence occurred in the cavity. Corresponding displacement was observed.
Finally, the cavity phase was lost, and the beam was kicked.
Because the betatron tune is very close to half integer, the beam observed with alternative displacement turn by turn.
Beating structure is observed, because the betatron tune is not half integer.

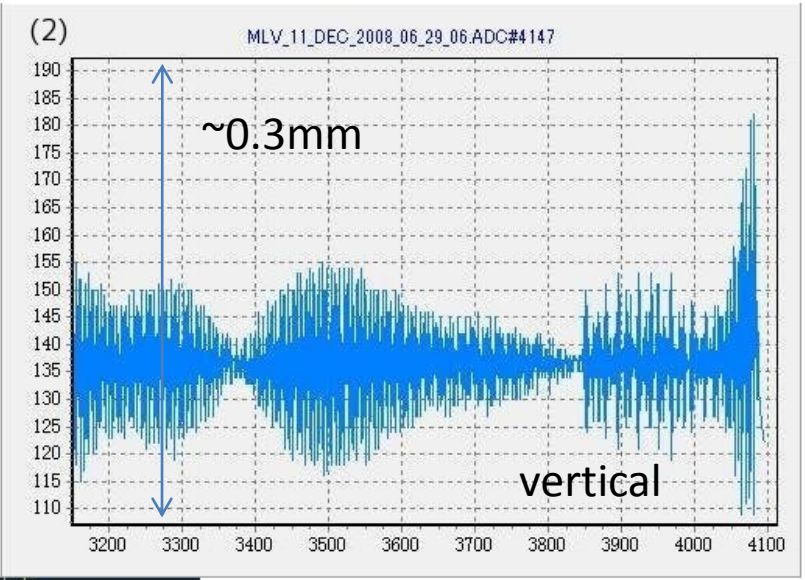
Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Purple :Cavity phase
Green :Beam current

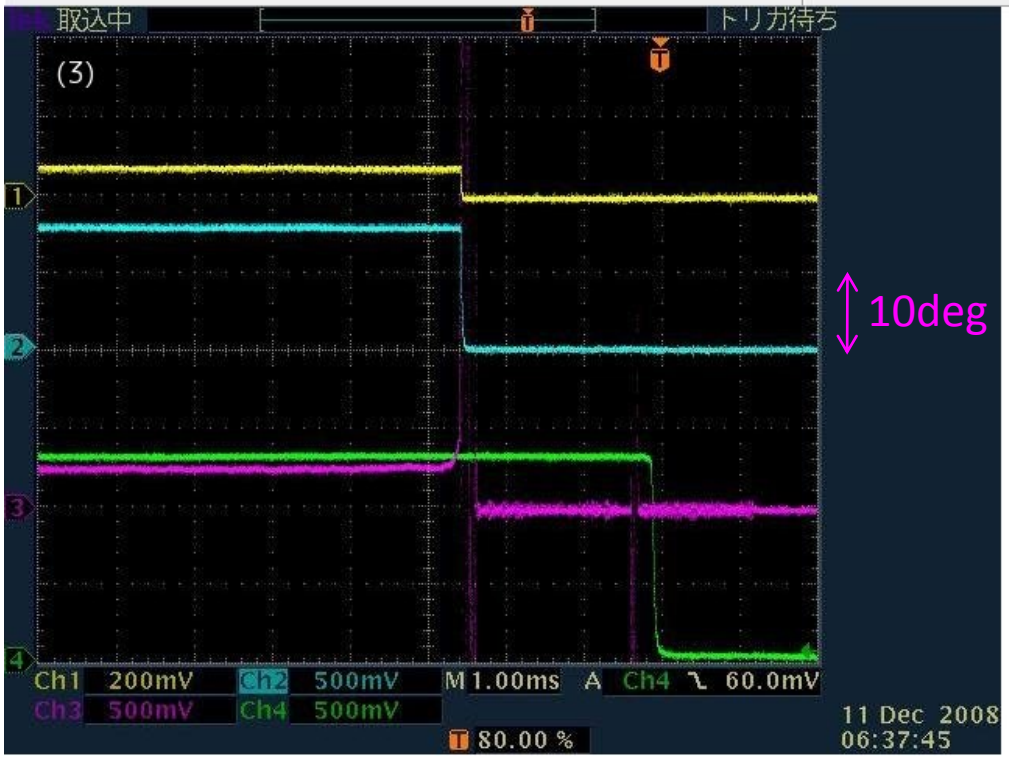




When LLRF feedback was oscillated at 540Hz, corresponding displacement was observed.







In this case, the beam was not aborted after turn off the RF.
After turned off the RF, a horizontal oscillation was started. And it seems decaying. Finally, the beam was aborted due to discharge caused by the beam induced field. The beam survived for 2msec after turned off the RF.

Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Purple :Cavity phase
Green :Beam current

Crab kickによるCOD

- Horizontal COD by crab kick

$$\Delta x = \frac{\sqrt{\beta_x^C \beta_x^M}\cos\left(\pi\nu_x - \left|\Delta\psi_x^C\right|\right)}{2\sin\pi\nu_x}\frac{V_C \sin(\omega_{RF} t)}{E}$$

- Arc部でのCOD (COD at arc section)

$$\Delta x \cong 5\,\mathrm{mm}$$

$$\beta_x^C = 50\,\mathrm{m}\,(\text{crab beta})$$

$$\beta_x^M = 25\,\mathrm{m}\,(\text{Arc peak})$$

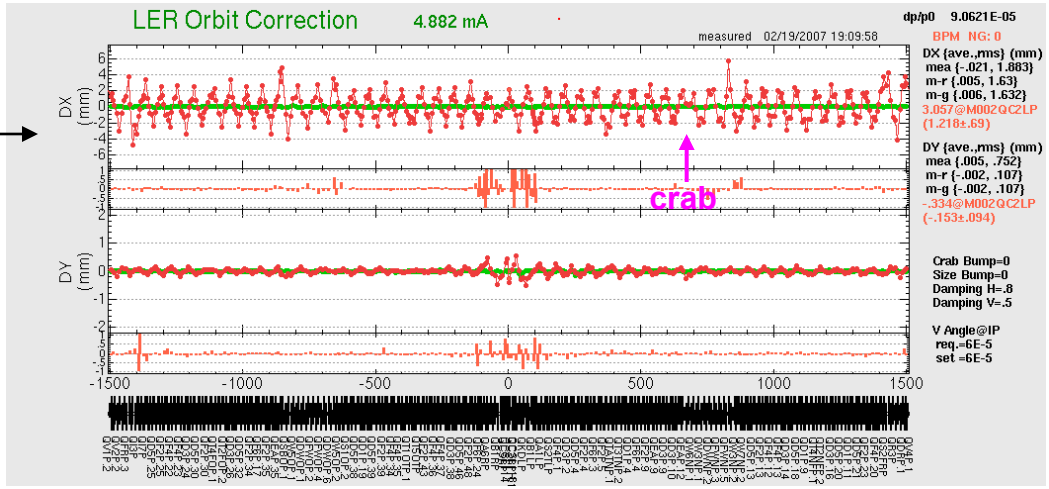
$$E = 3.5\,\mathrm{GeV}$$

$$Vc = 1\,\mathrm{MV}\,(\text{crab Vc})$$

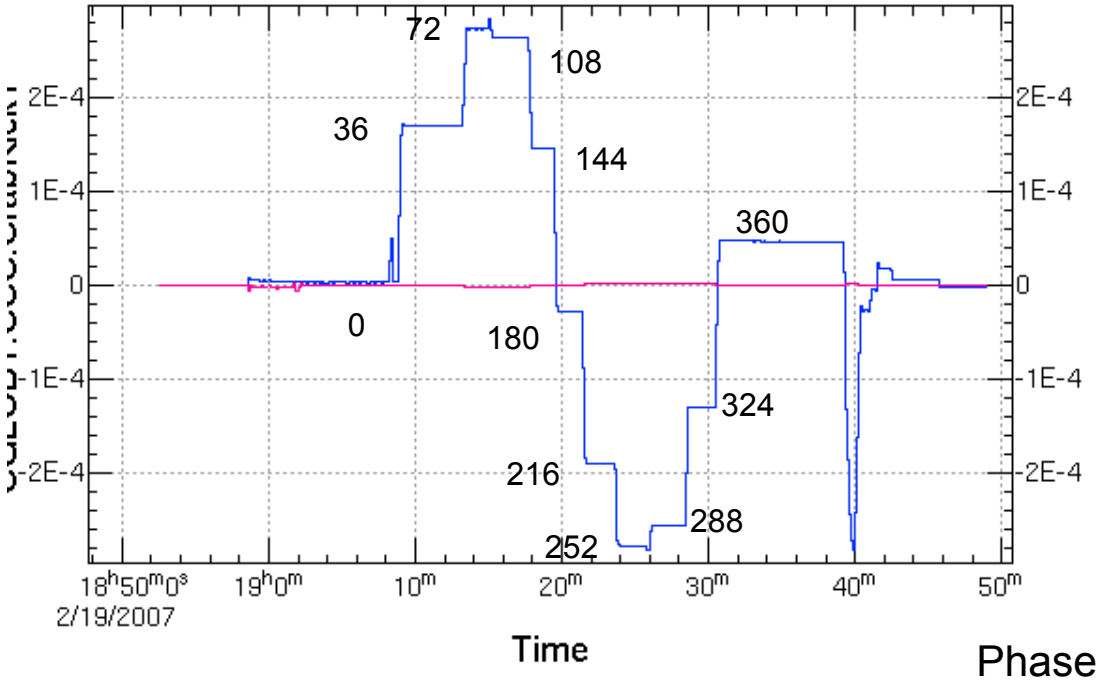
H. Koiso, A. Morita

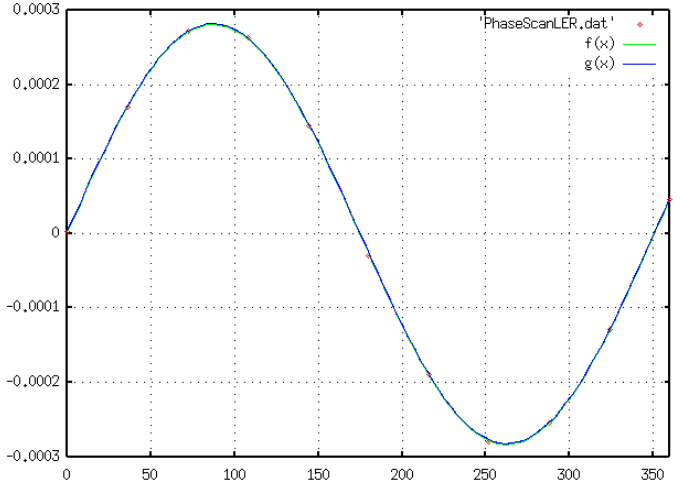
Crab Phase Scan (LER)

Horizontal orbit by crab kick



Horizontal kick by crab cavity (rad)
(Estimated from orbits around the ring)





Phase 0 : 174.8 deg.
Vcrab set:1.0MV, estimated: 0.987MV

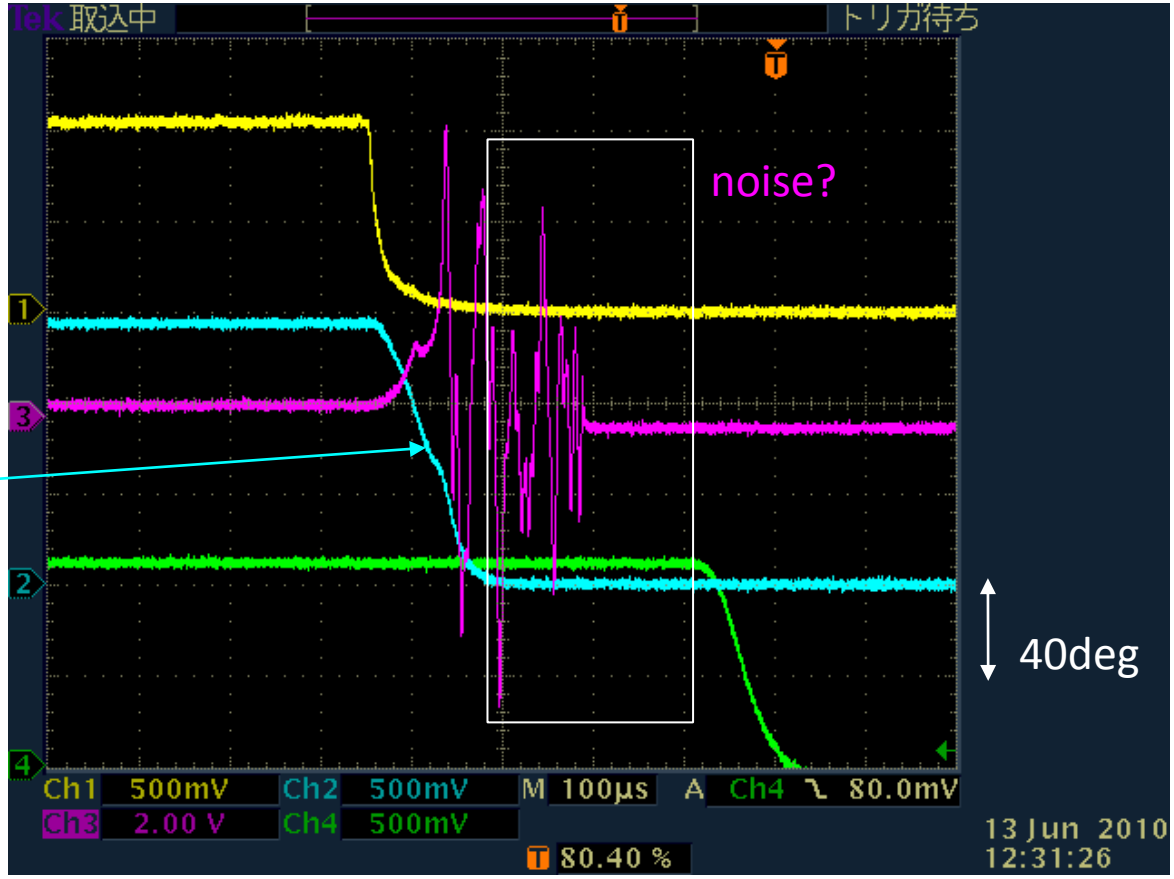
agree very well

Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Green :Beam current
Purple :Cavity phase

The HER beam was aborted by intentional abort request.

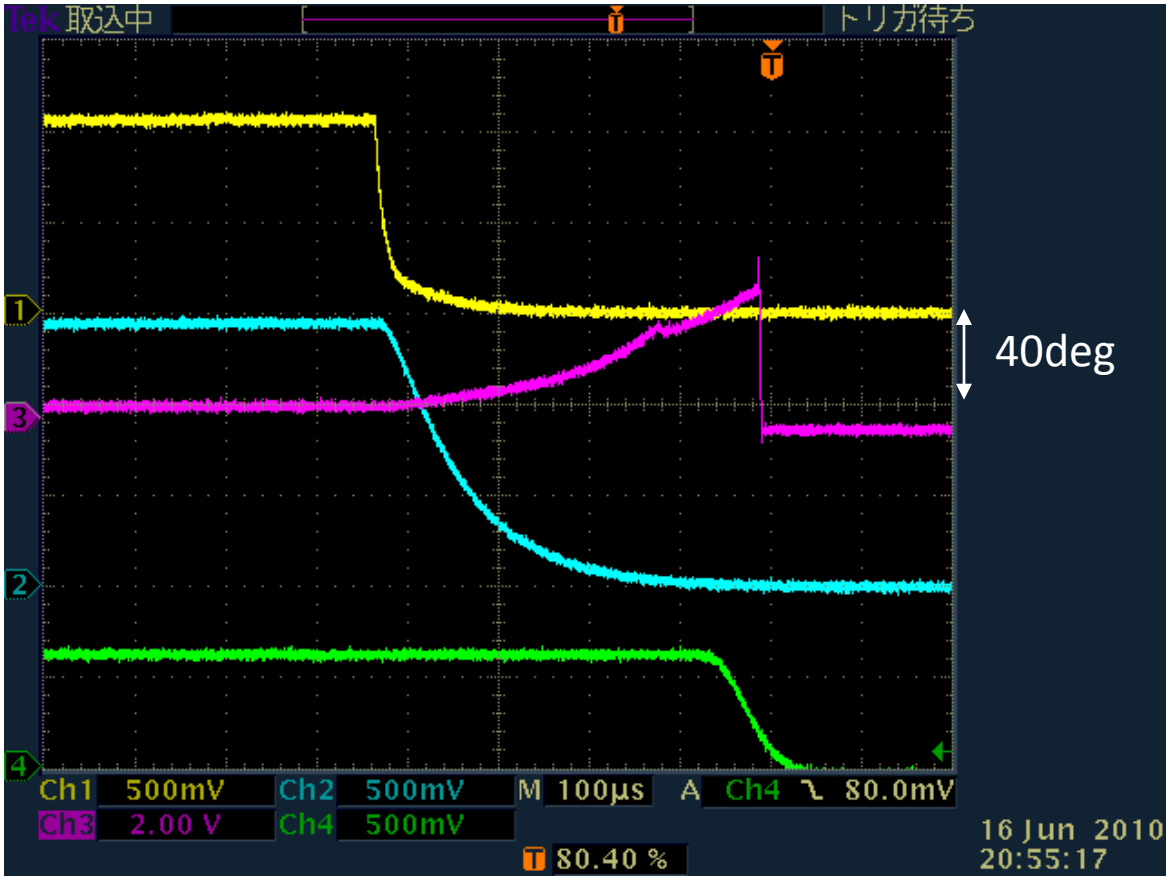
The arc sensor was lighten by a LED.

The expected decay time of stored energy was 42 µsec. (84 µsec for cavity voltage)



Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Green :Beam current
Purple :Cavity phase

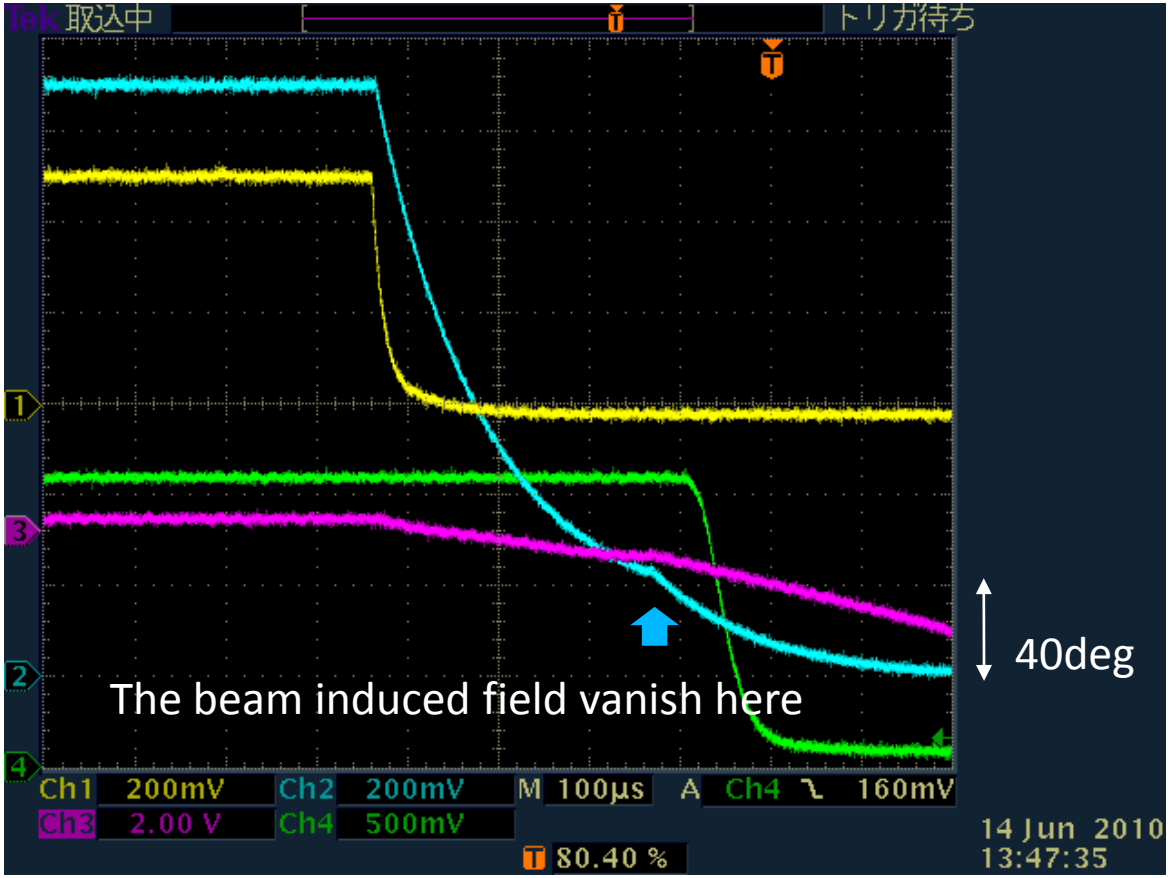
The HER beam was aborted.
Sometimes the cavity voltage decays cleanly.
What is different from previous page?



Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Purple :Cavity phase
Green :Beam current

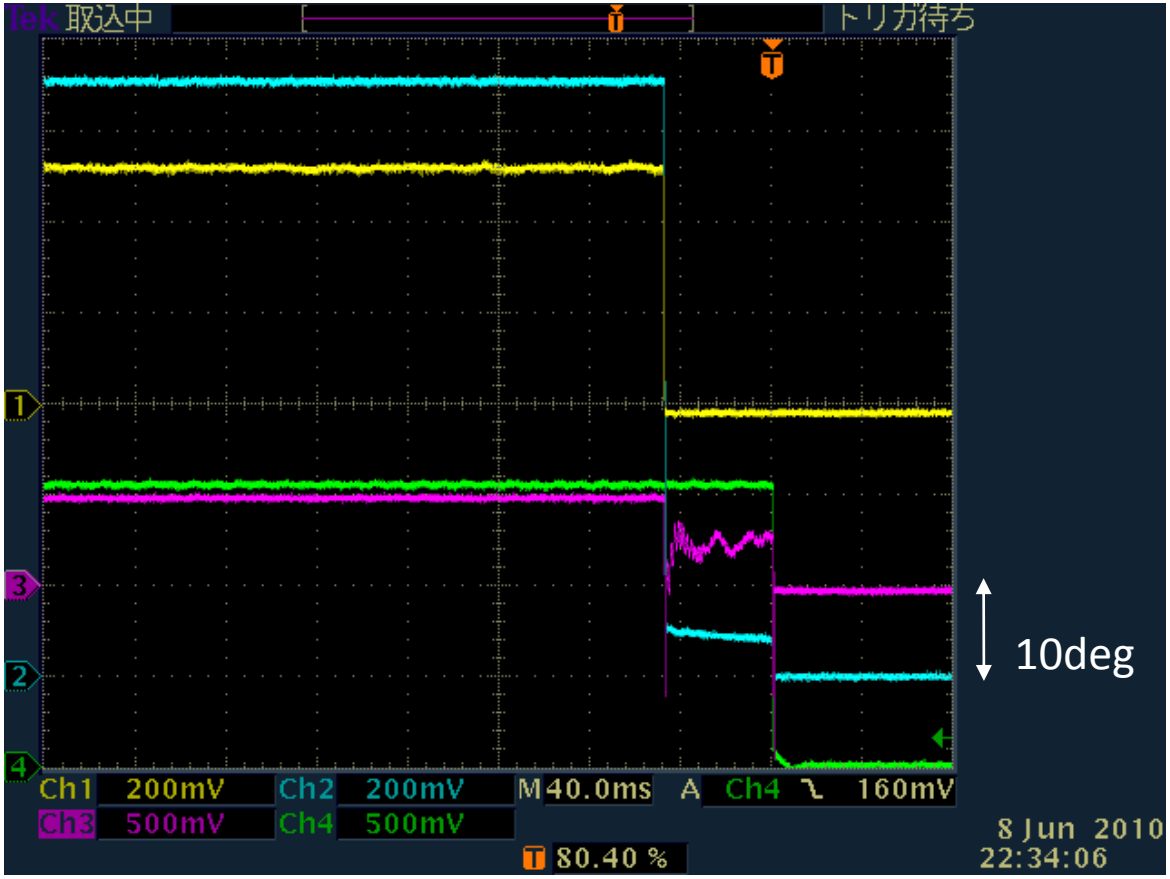
The LER beam was aborted by intentional abort request.

The expected decay time of stored energy was 65 µsec.
(130 µsec for cavity voltage)



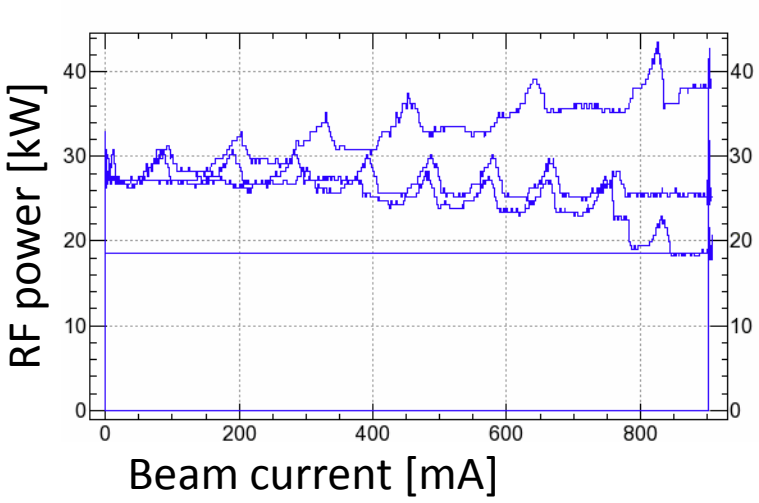
Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Purple :Cavity phase
Green :Beam current

The RF power for LER crab cavity was turned off.
The beam was aborted in 50 msec.
Anyway the beam could circulate, and it seems to stabilized by the beam induced field.

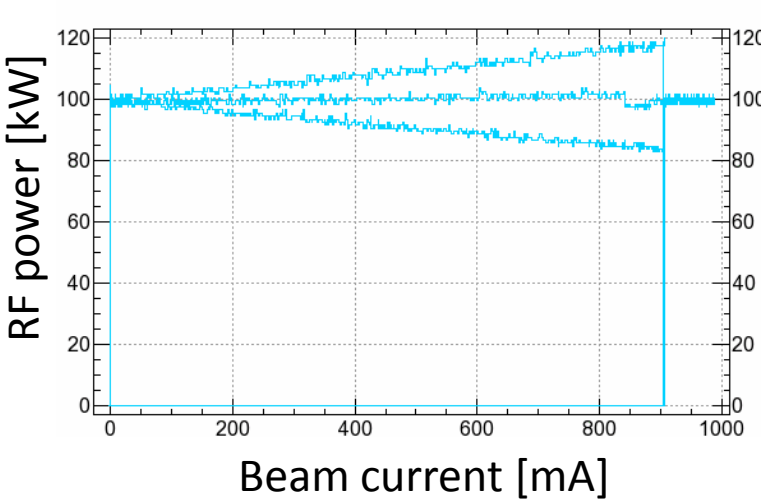


Beam loading depend on the beam position

LER

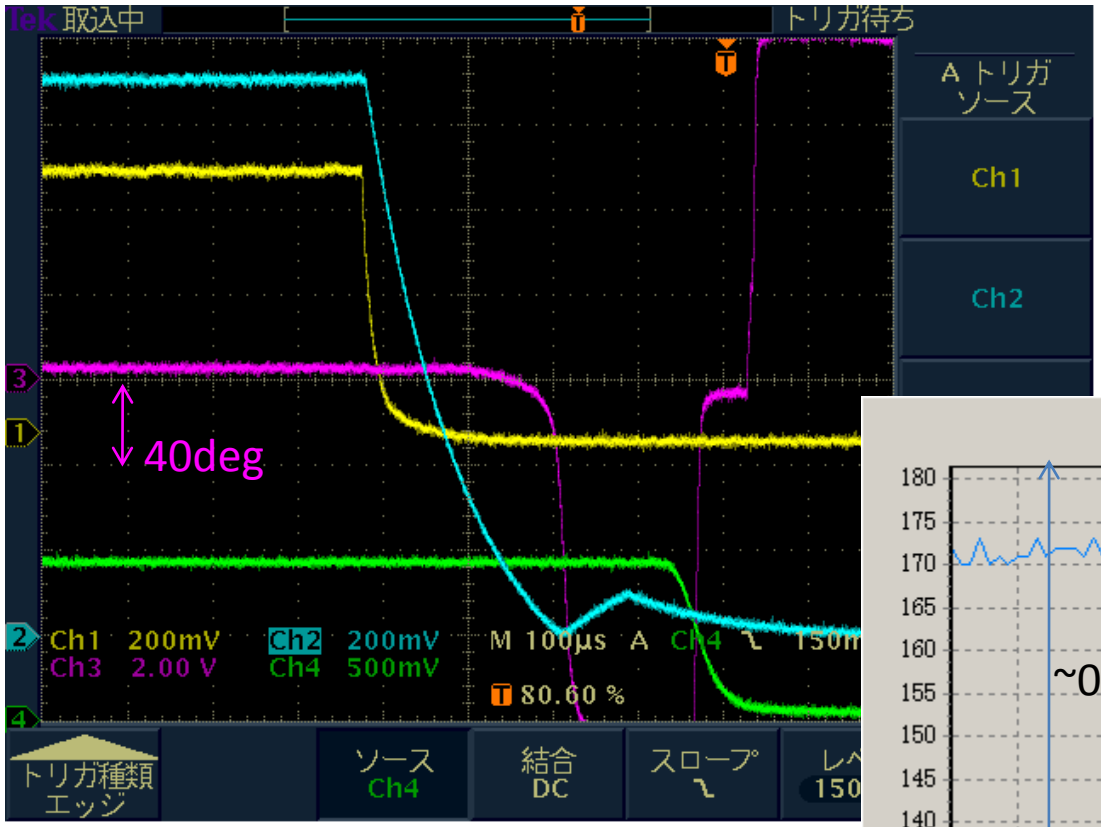


HER

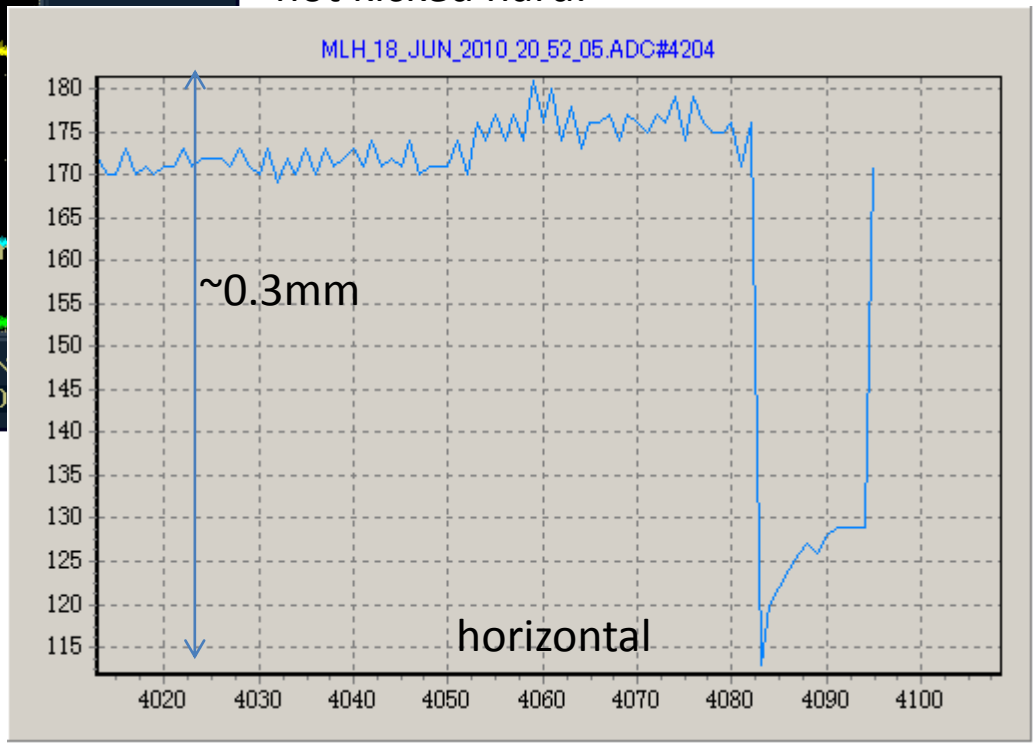


The beam position is adjusted to center.
The conditions that the beam is offset 2mm for both sides are prepared.

In LER negative beam loading case

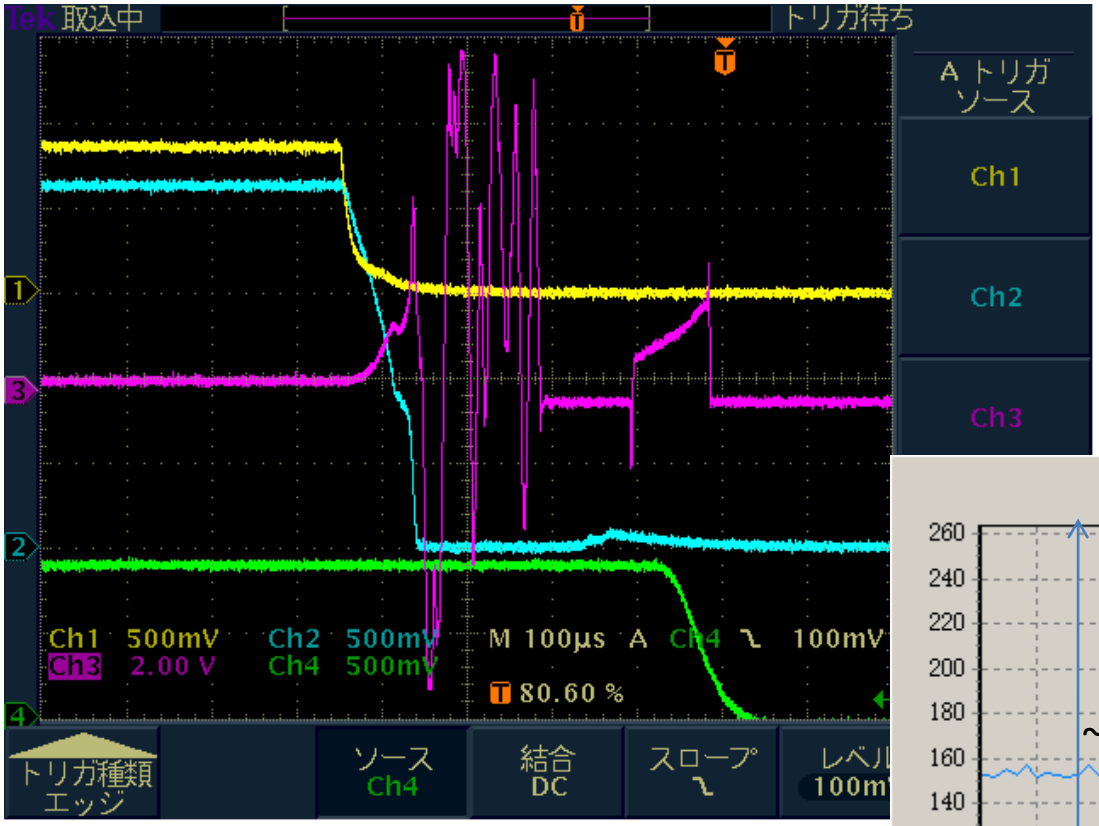


In LER negative beam loading case, opposite phase beam induced field was observed.
But the phase behavior was rather gentle.
Even in this condition, the beam was not kicked hard.

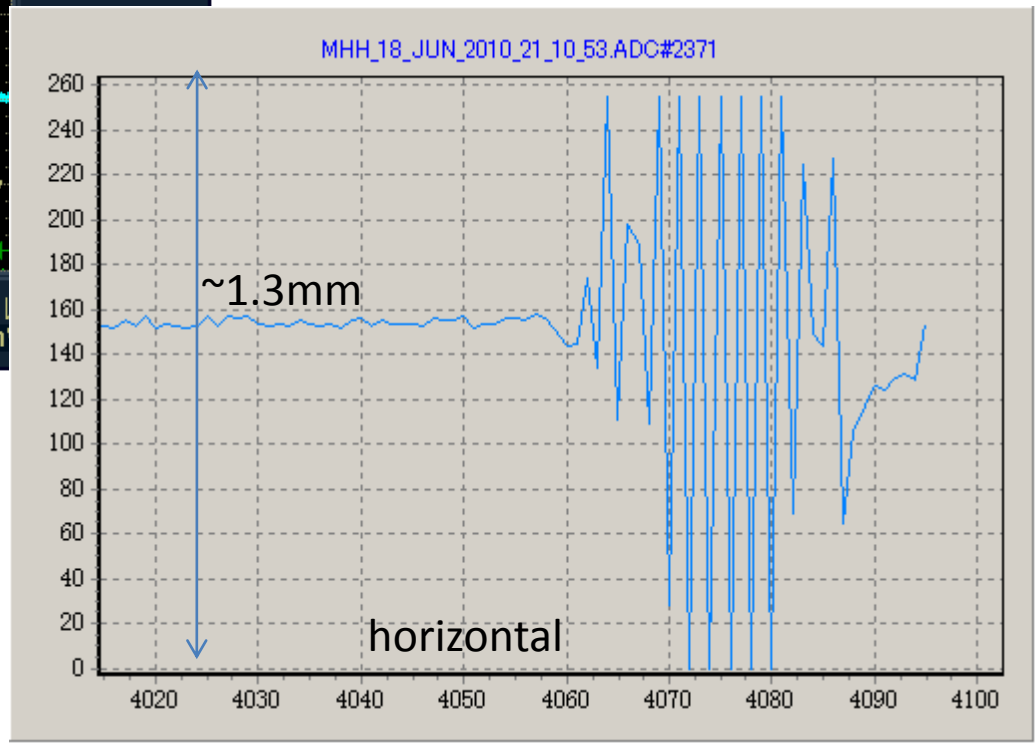


In case of on axis and positive beam loading, the beam was also not kicked.

In HER positive beam loading case



In this case, the positive beam loading don't help the phase stabilization.
In these experiments, other beam positions tests show same result.



summary

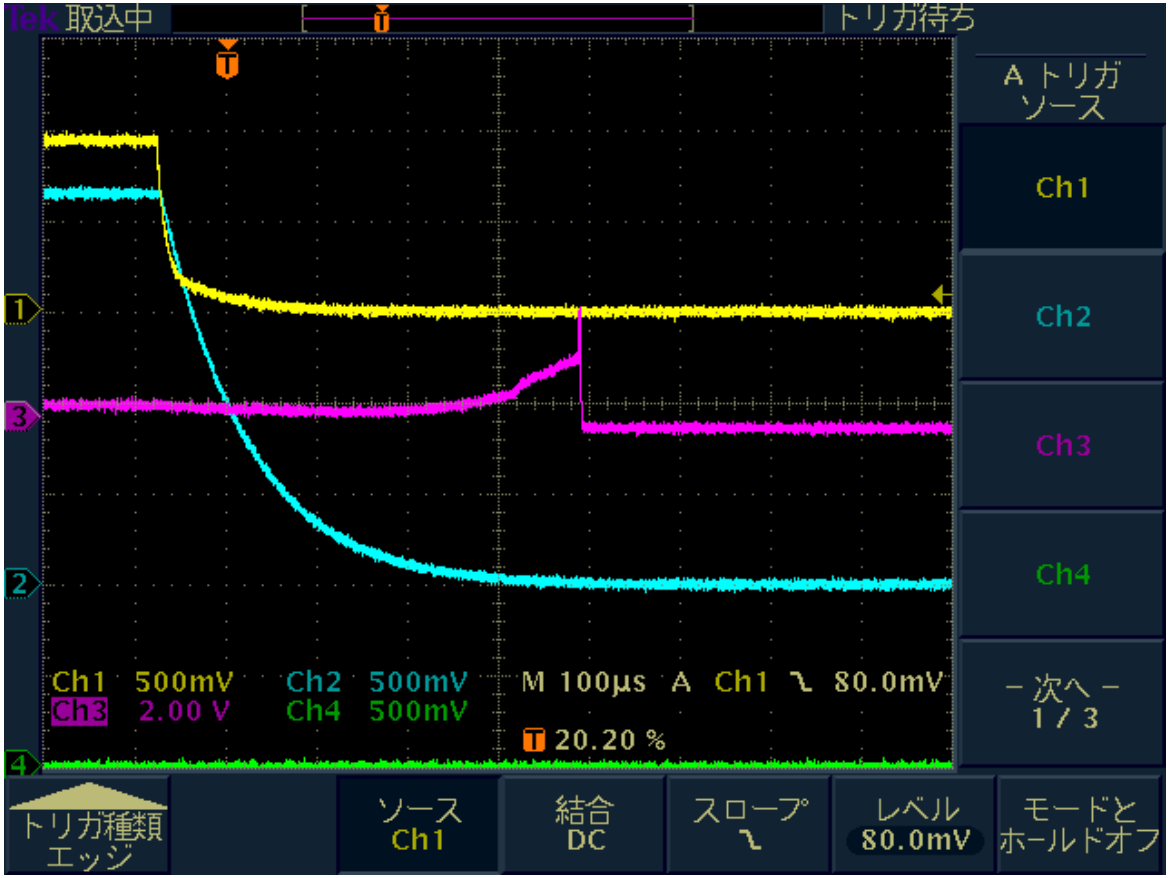
- The beam oscillation due to decaying crabbing field was observed.
- The beam oscillation was related to the turbulence of the crab cavity phase.
- In most case, the crab cavity phase turbulence is observed at the HER crab cavity.

Possible hypothesis

- Strong traveling wave RF field induce discharge at input coupler.

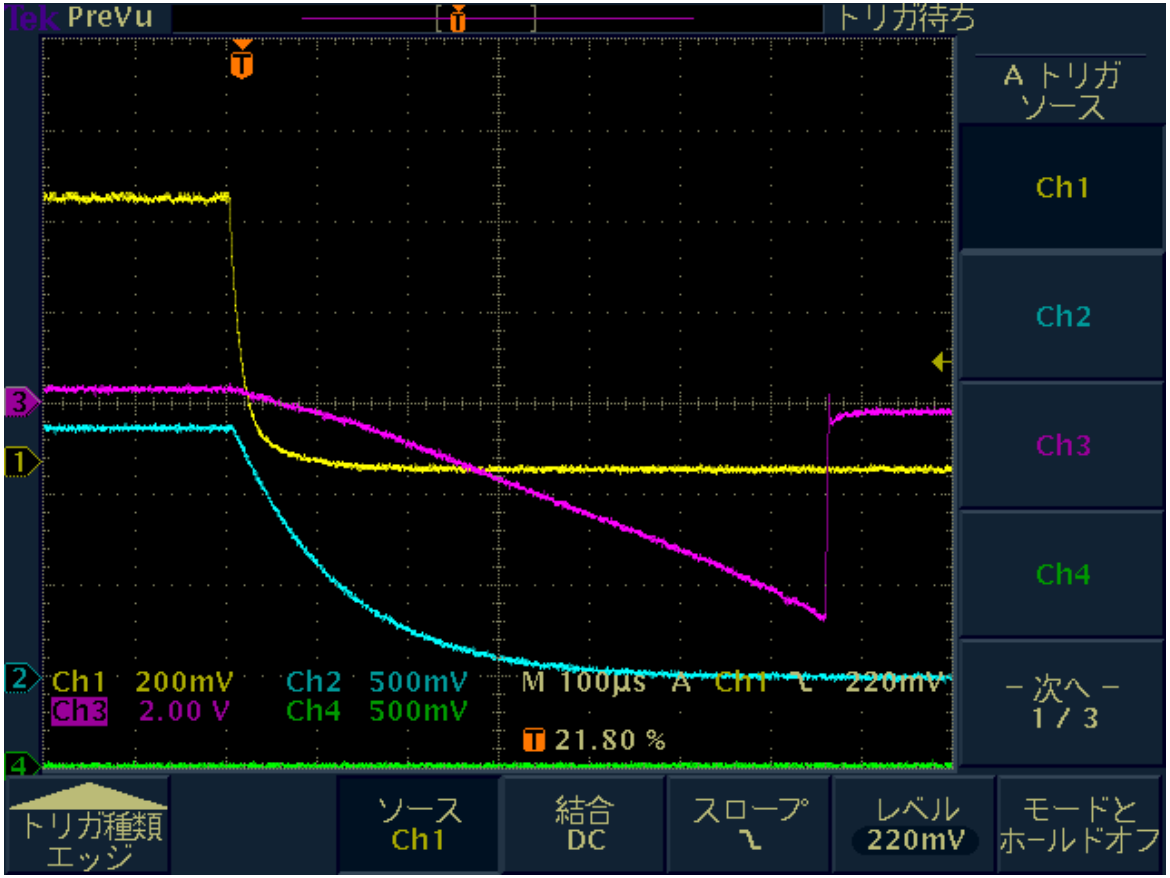
Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Purple :Cavity phase
Green :Beam current

The HER RF power is turned off without beam.

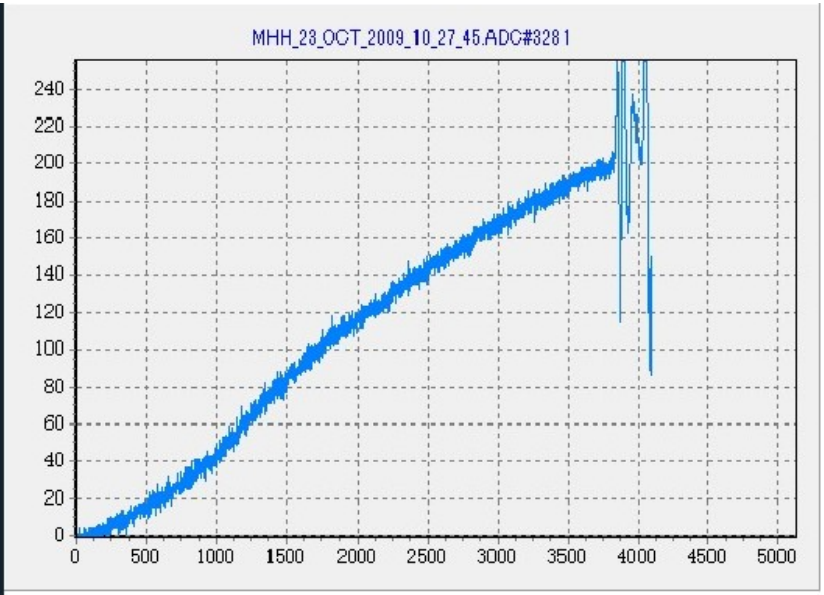


Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Purple :Cavity phase
Green :Beam current

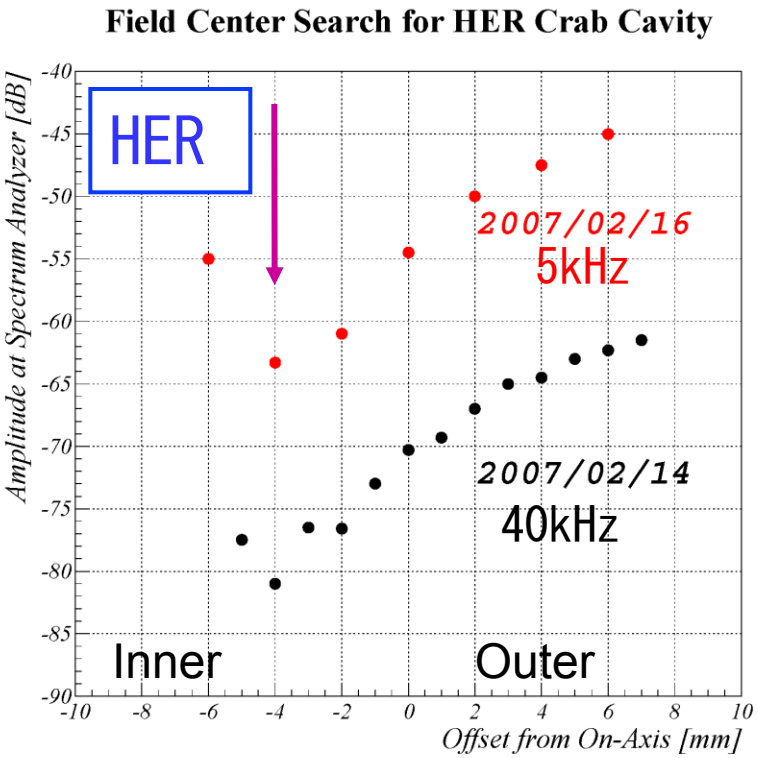
The LER RF power is turned off without beam.

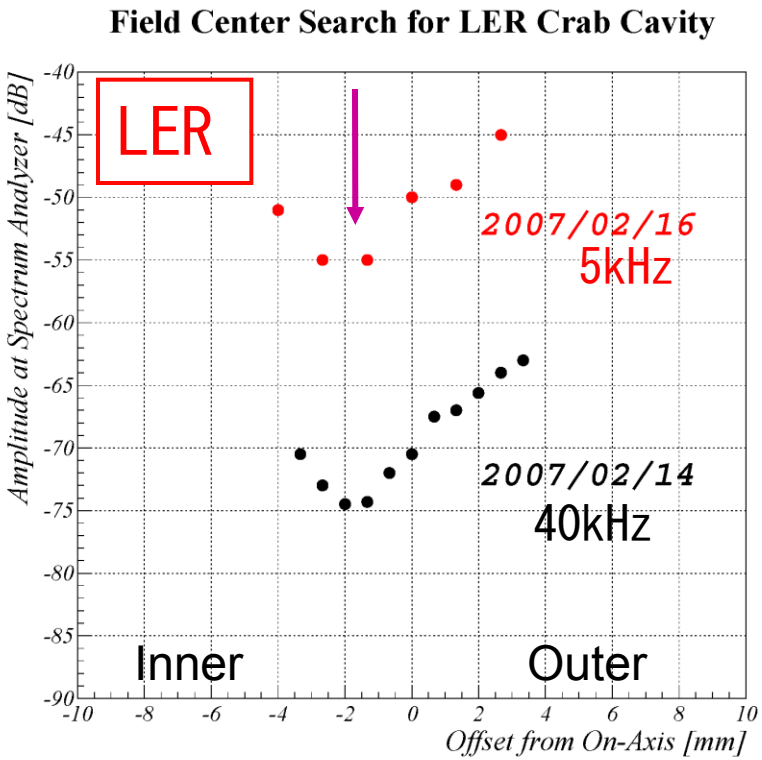


Yellow :Klystron output power
Blue :Pick up power($\propto Vc^2$)
Purple :Cavity phase
Green :Beam current



Searching Field Center in Crab Cavity





- Field center was searched by measuring the crabbing mode amplitude excited by a beam with the crab cavity detuned. Two measurements with different detuning frequencies agreed to each other.
- A local bump orbit was set to make the beam aligned on the field center.

Typical parameters

	LER	HER	unit
β x*	80	80	cm
β x monitor	21	39	m
β x cavity	73	162	m
νx	44.506	45.511	-
I bunch	1.0	0.75	mA
ϕ cavity	0.35	0.35	rad
V cavity	0.95	1.45	MV
τ crab	130	84	μsec