

# Tuner performance at cERL

2015/12/3

TTC meeting WG4

Kensei Umemori (KEK)

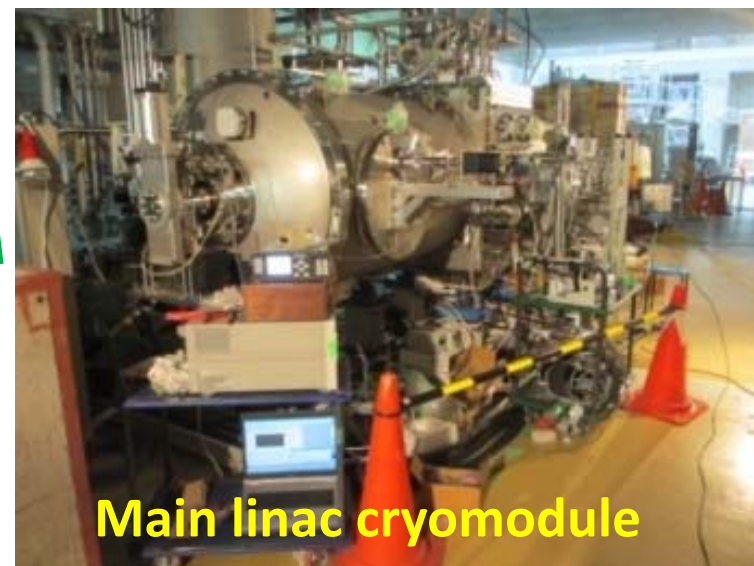
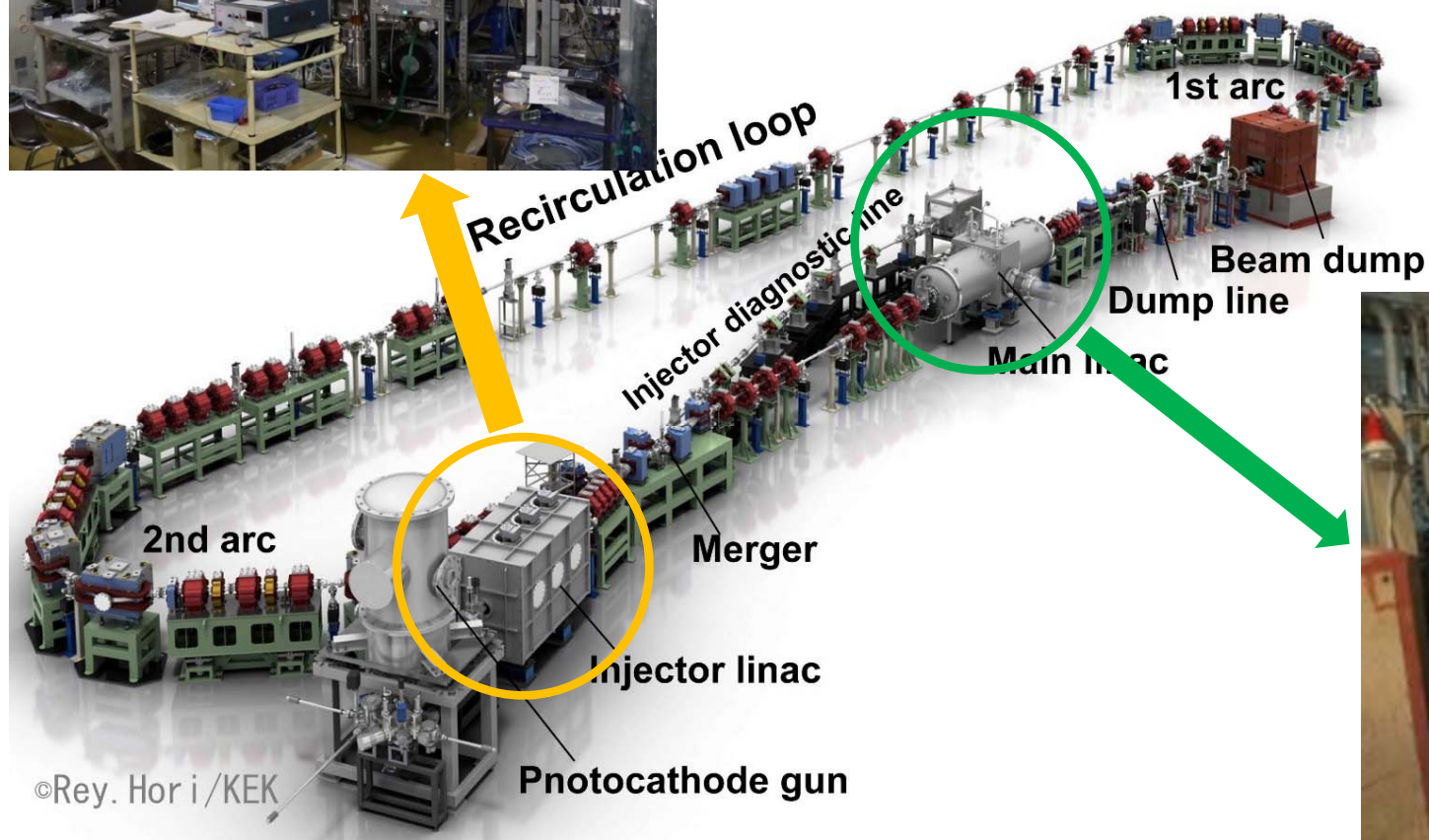
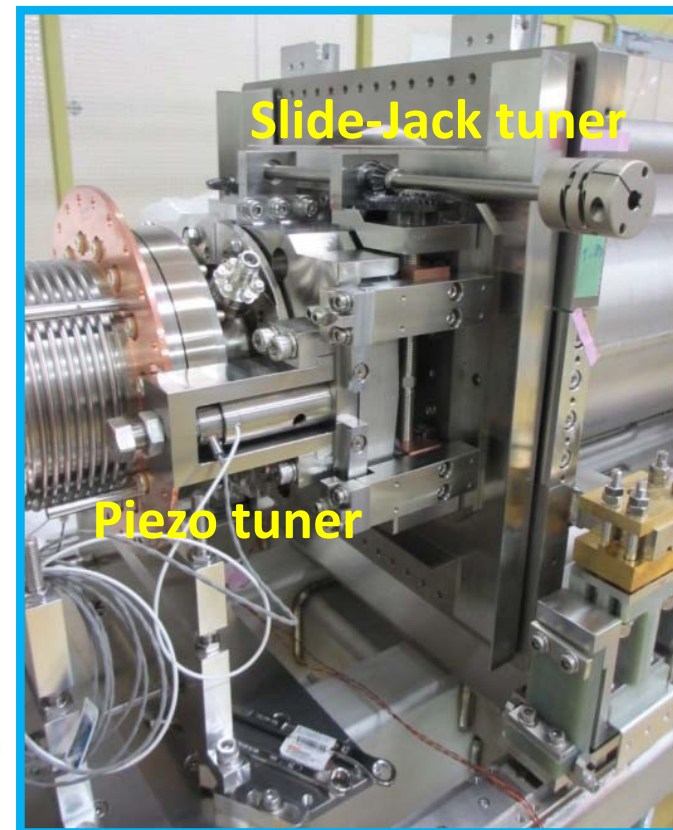
# Contents

- cERL (injector and main linac cryomodule)
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# cERL

Beam Energy: 20 MeV  
Max. Beam Current:  
80  $\mu\text{A}$  ( $\rightarrow 10\text{mA}$ )  
RF Frequency: 1.3 GHz

in operation since 2013



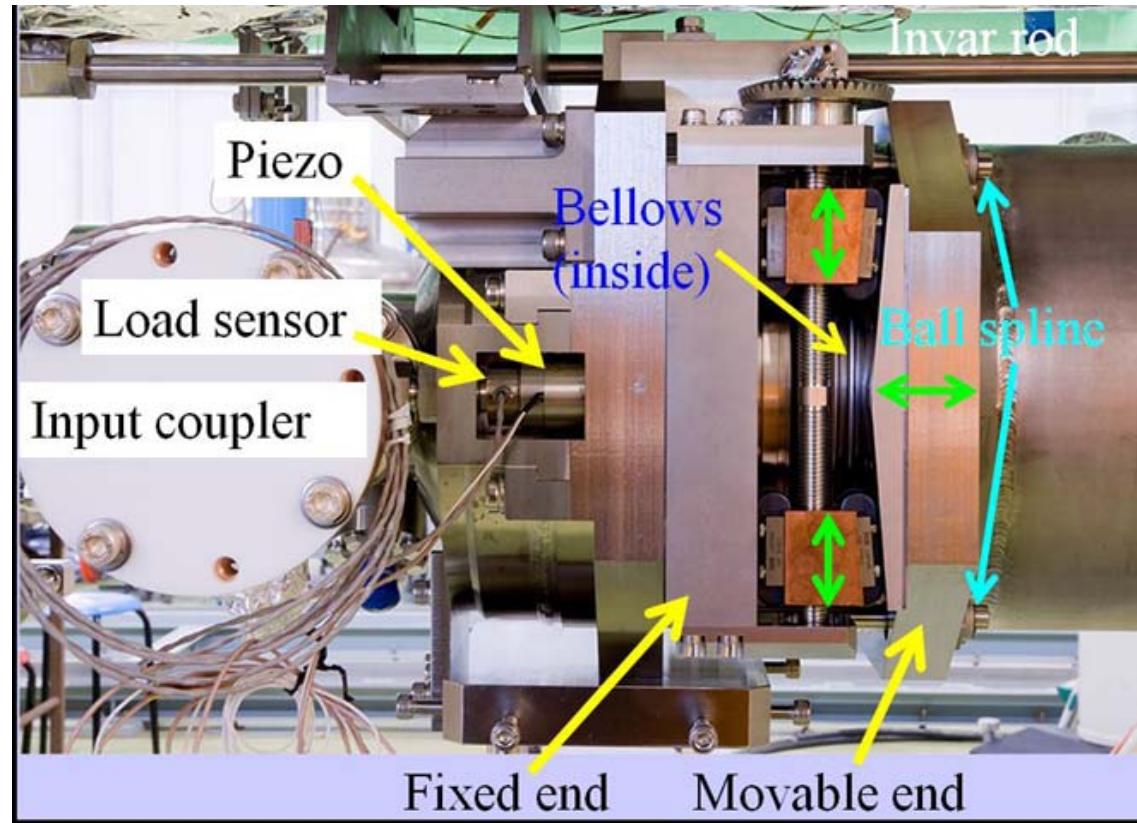
# Tuner specification

- Coarse tuning

- Slide-Jack tuner
  - 3mm stroke for  $\sim 900\text{kHz}$  change
  - Max. Torque  $\sim 1\text{ton}$
  - Controlled by motor through shaft

- Fine tuning

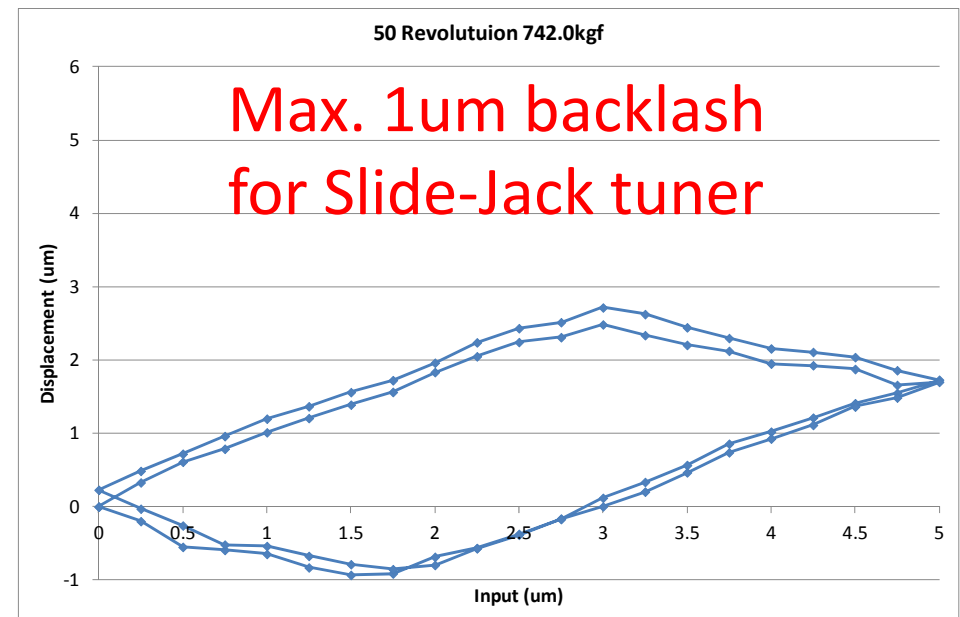
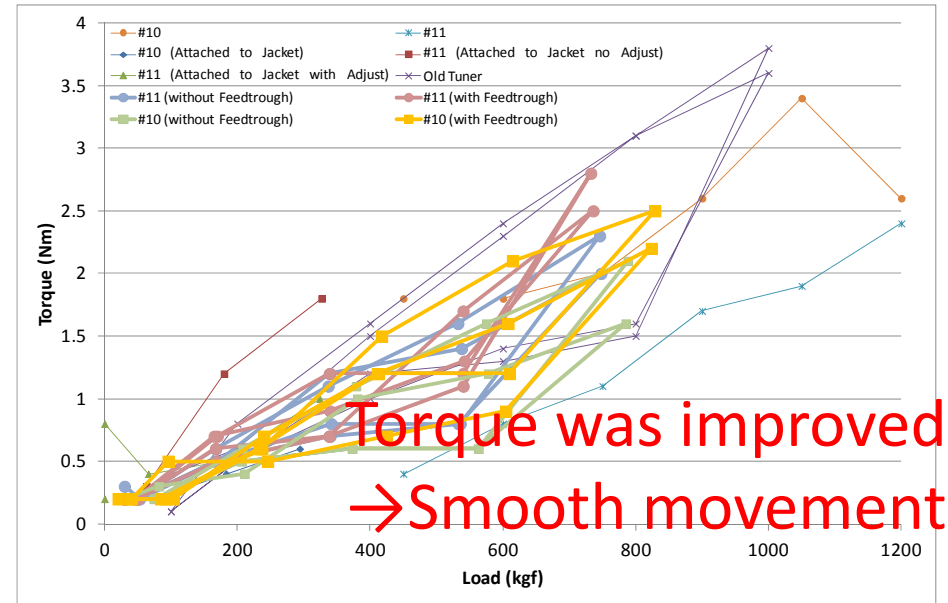
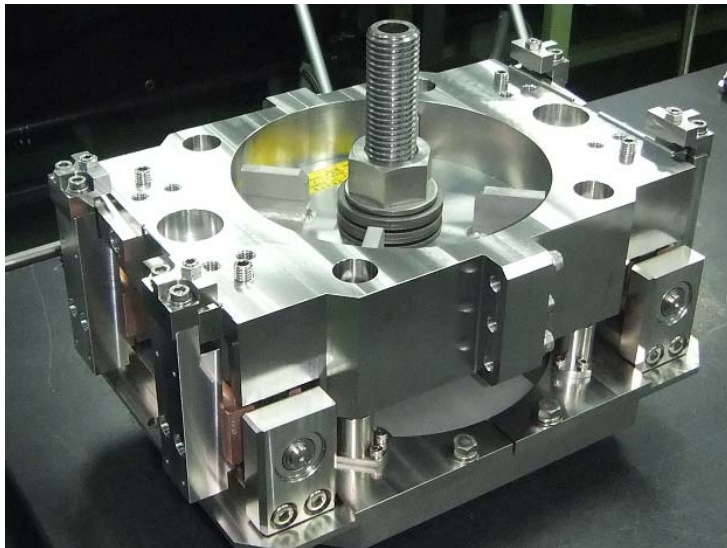
- Piezo tuner
  - Stroke  $> 4\mu\text{m}$  at low temp.  
( $80\mu\text{m}$  at room temp)
  - Controlled by voltage (Max.  $1\text{kV}$ )



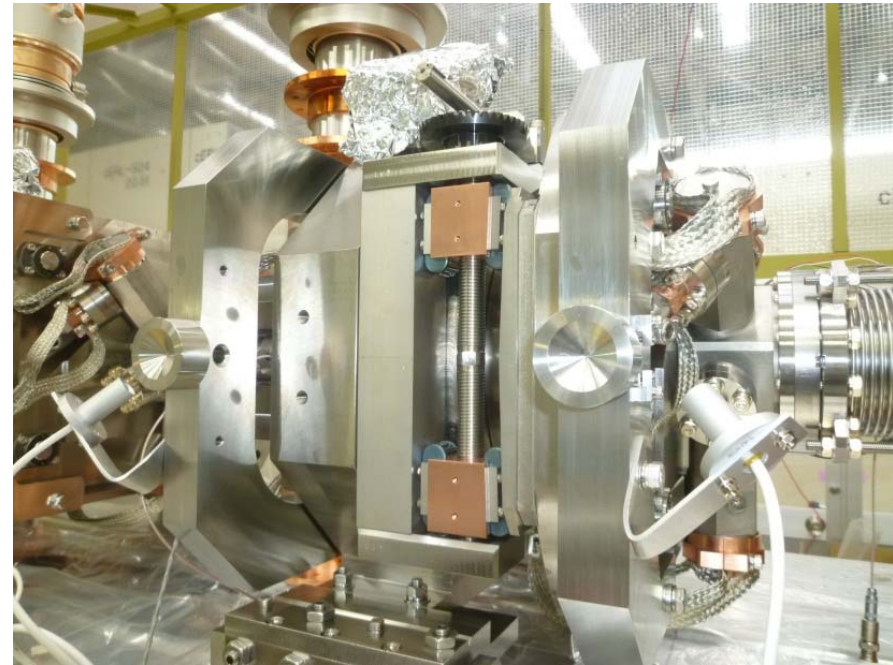
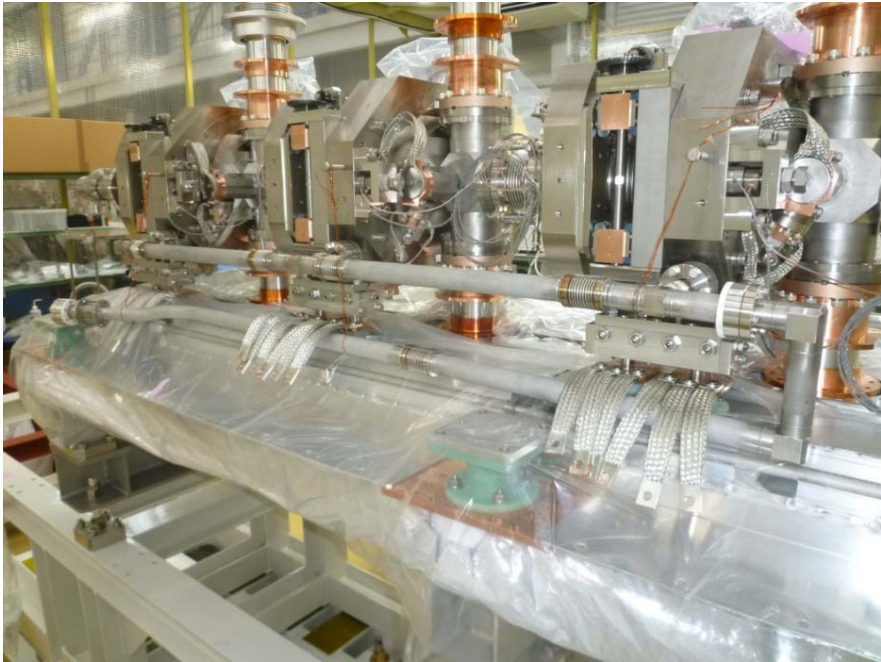
Picture from STF tuner

# Off-line study & Improvements

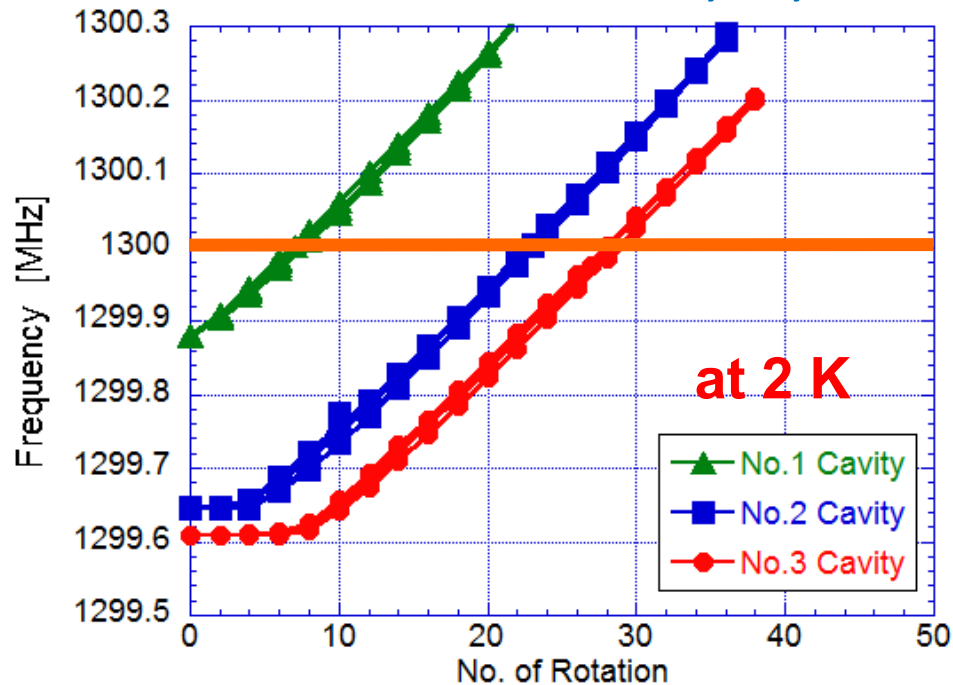
- Sometimes too much torque was needed at old version of tuner. Worst case stacked.  $\Rightarrow$  Alignment between gear and shaft is important
- Basic research of off-line tuner performance.
- Some improvements were applied.
  - Pre-alignment on thicker baseplate
  - use thicker shaft ( $\Phi 8\text{mm} \Rightarrow \Phi 10\text{mm}$ )
- Use two piezo tuners for one cavity.



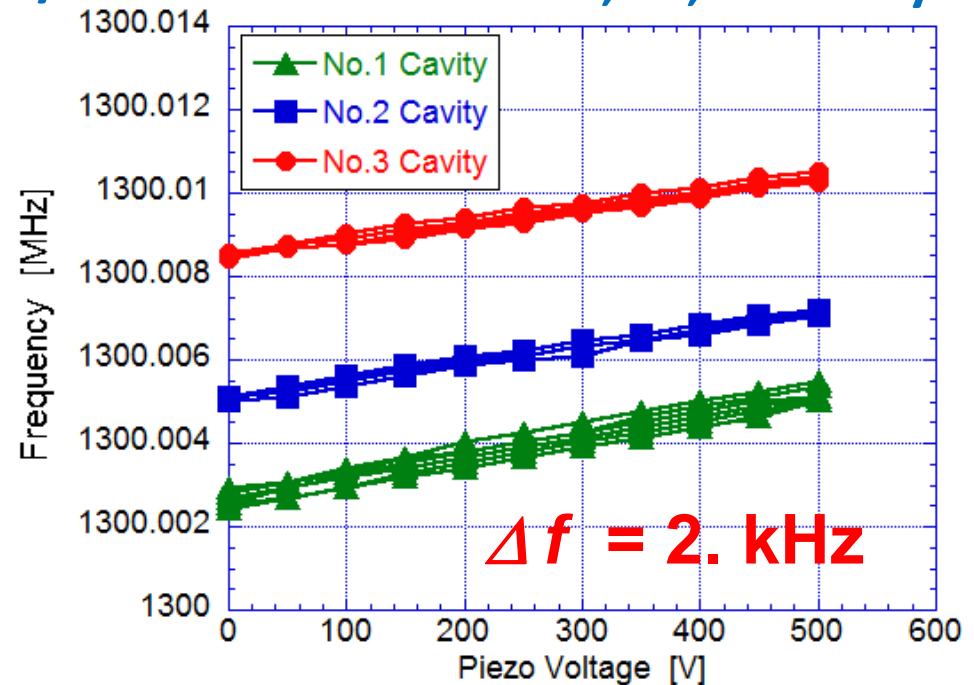
# tuner in CW operation cERL injector 2-cell cavity (E. Kako, KEK)



Slide-Jack Tuner Stroke of #1, #2, #3 Cavity

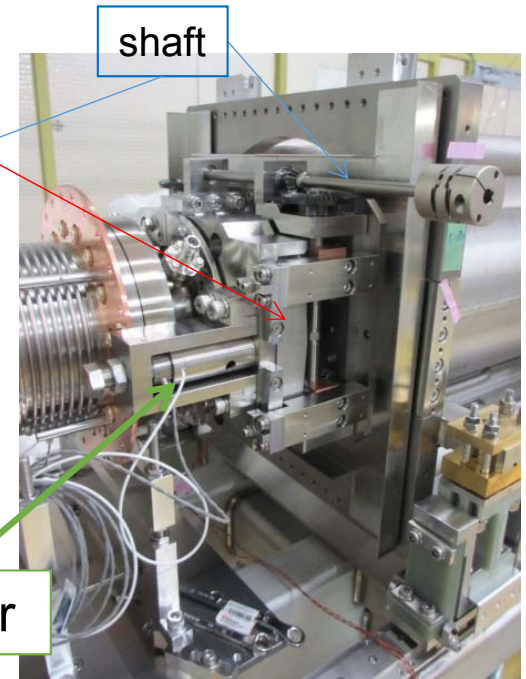
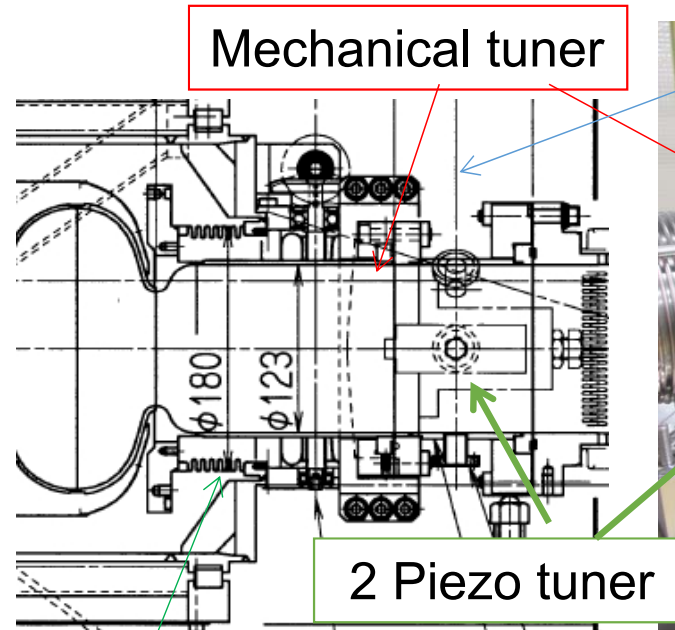


Piezo Stroke of #1, #2, #3 Cavity

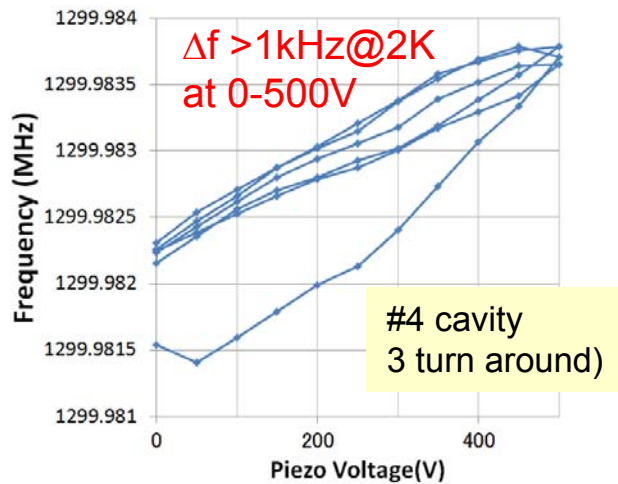


# tuner in CW operation

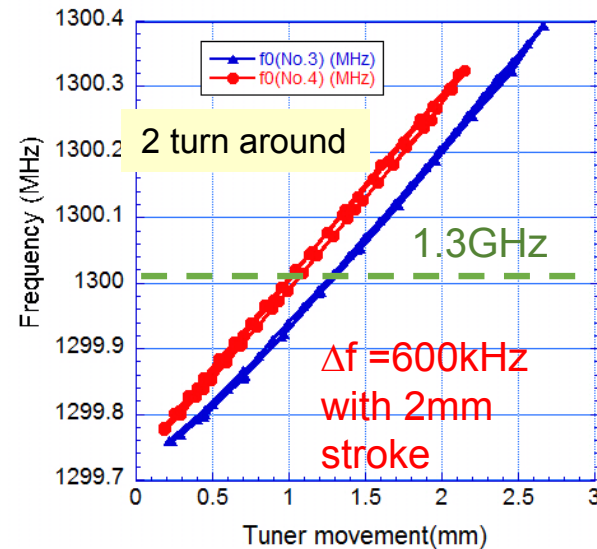
## cERL main linac



Piezo performance @ 2K



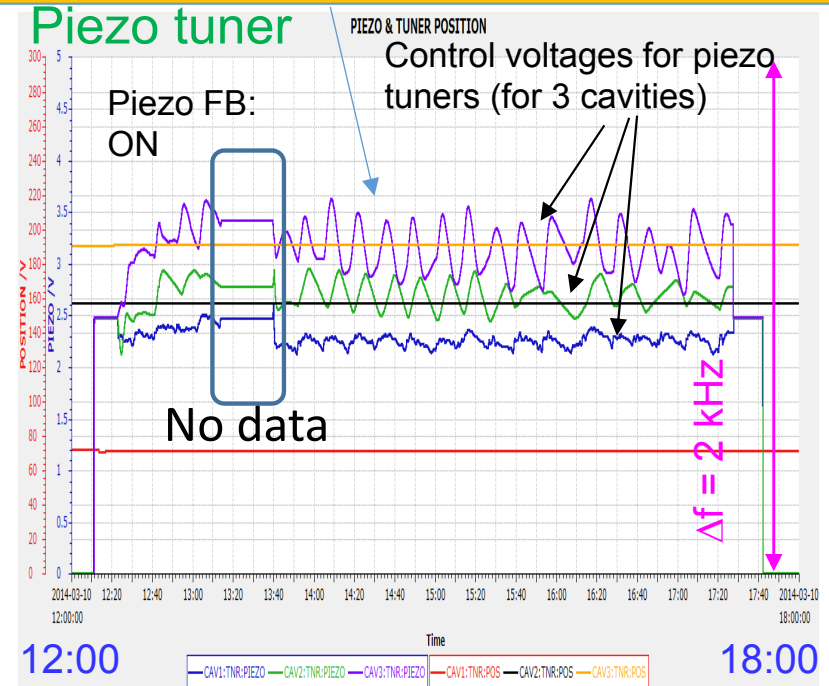
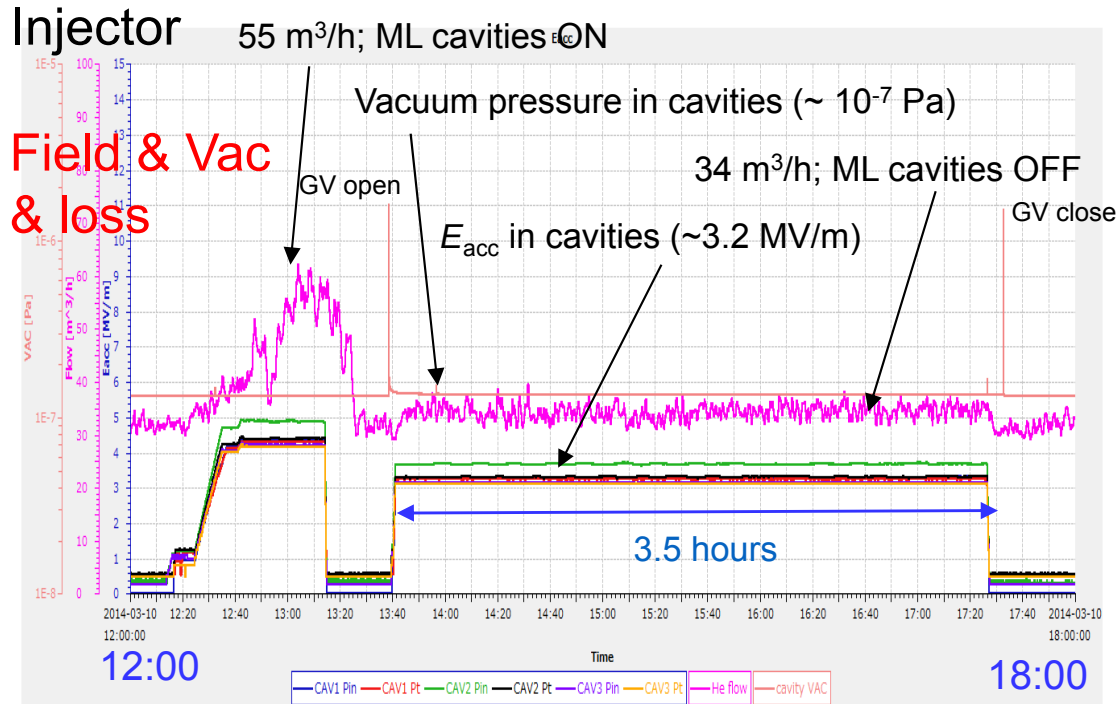
Coarse mechanical tuner stroke @ 2K



Course and fine piezo tuners also worked smoothly and had enough stroke under 2K cooling.

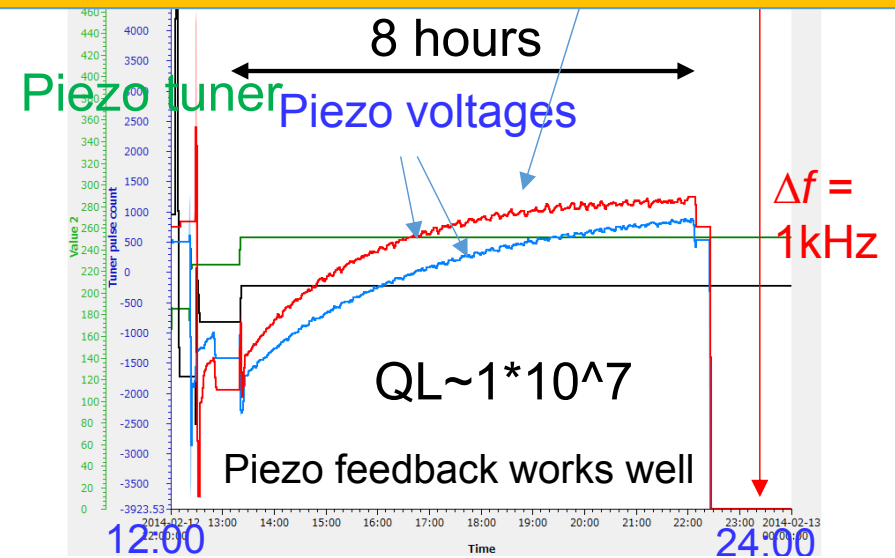
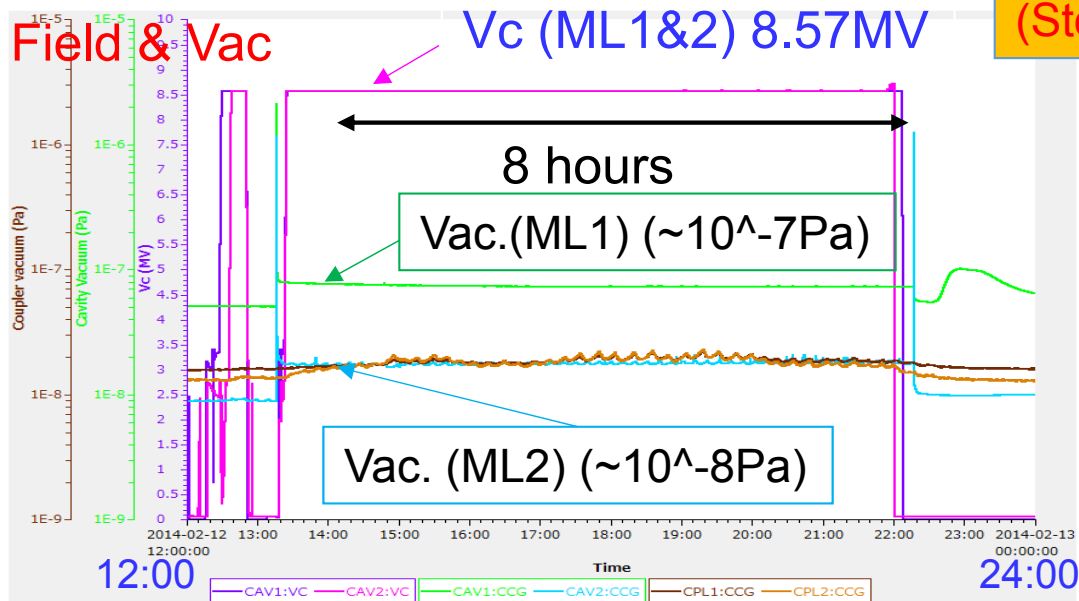
# Typical one day operation of cERL tuners

Synchronized with 80K line temperature

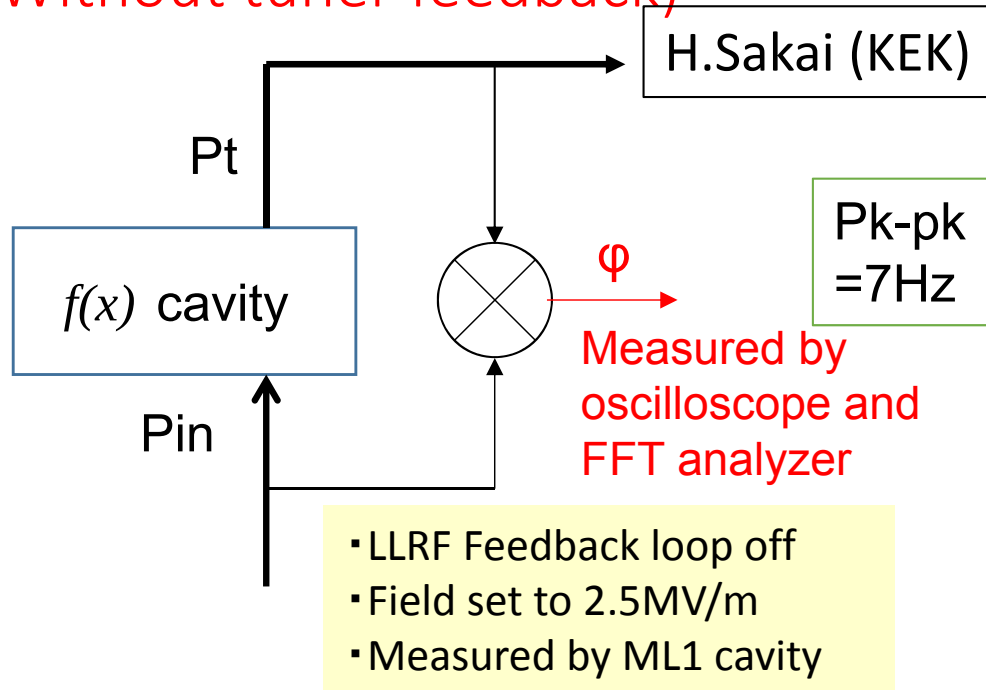


## Main linac

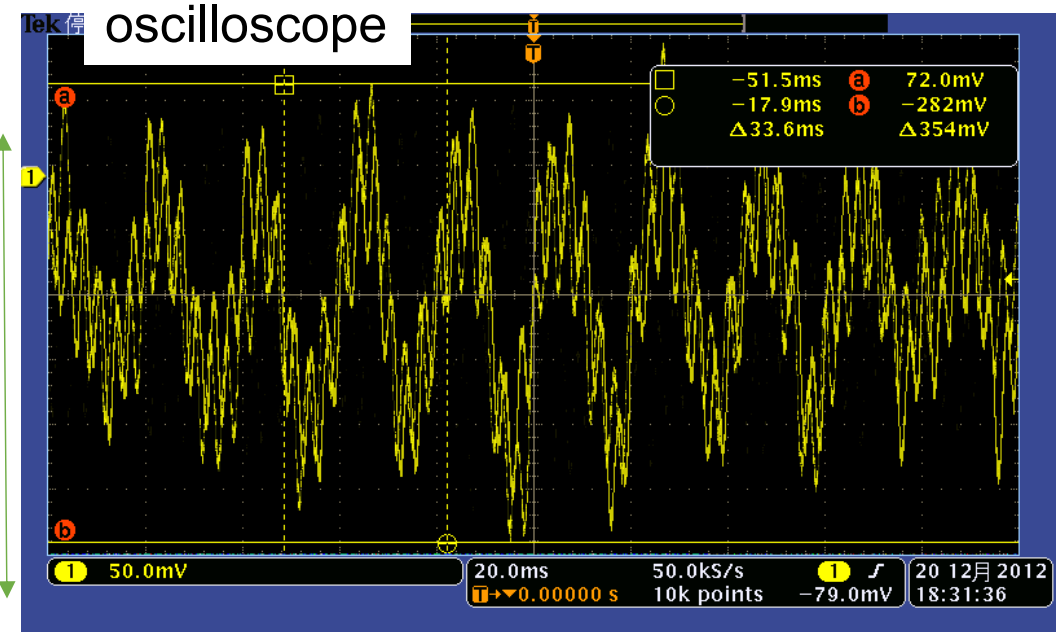
Drift due to temperature change of tuner system  
(Stop 2K operation during night time)



## 2K microphonics measurements (Without tuner feedback)



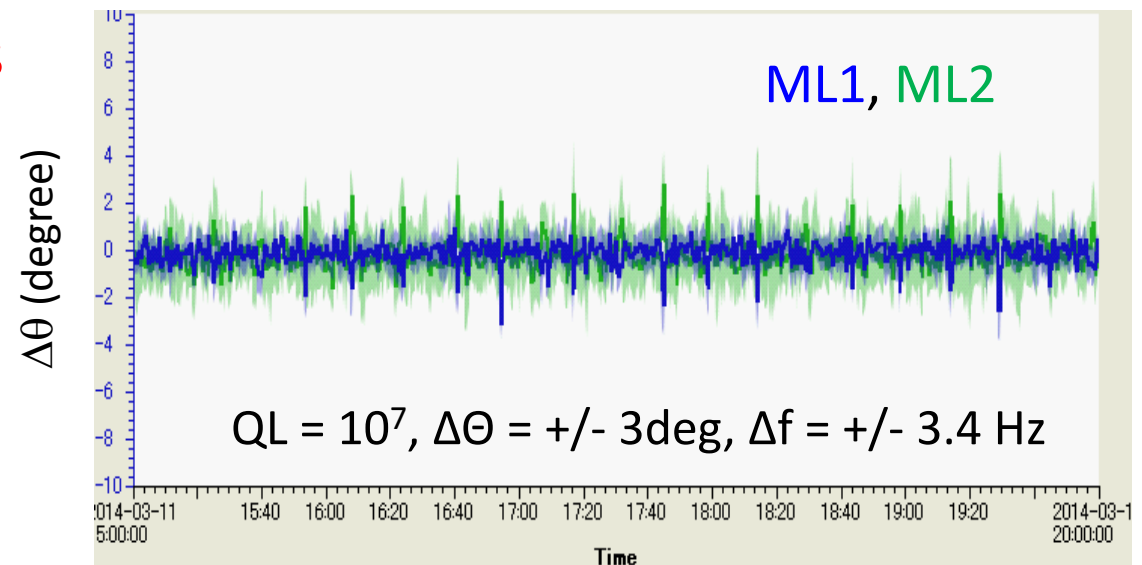
• Example of ML1 cavity,  $QL = 1.15 \times 10^7$



- $P_{k-pk} = 7\text{Hz}$
- Main peak was observed at **49.5Hz** (not 50Hz of electrical noise) by FFT

## 2K microphonics measurements (With tuner feedback)

T.Miura (KEK)

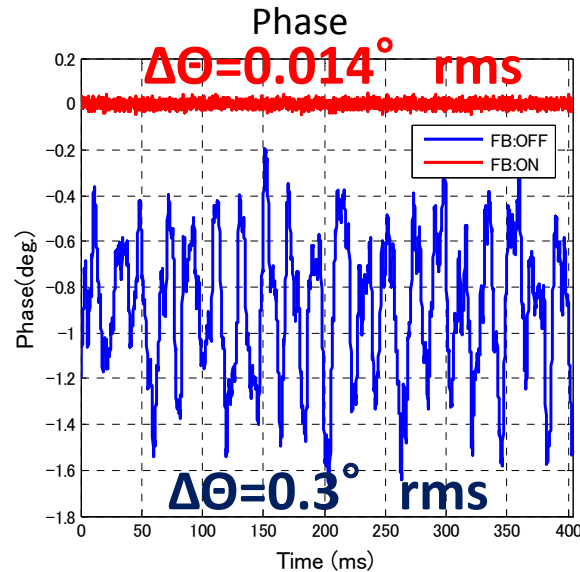
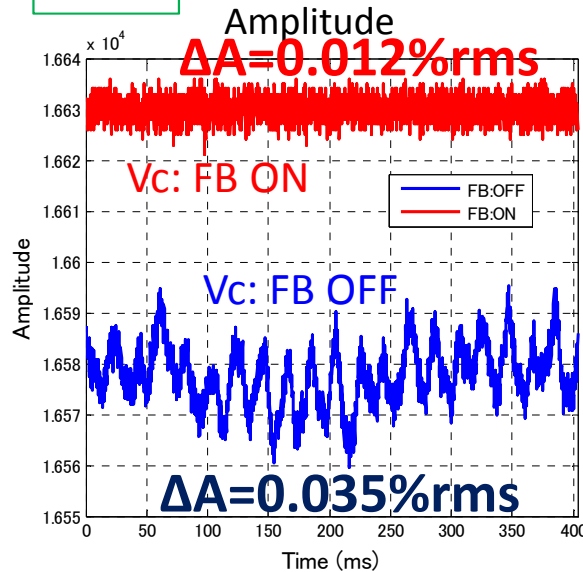


# Performance of RF Feedback Control

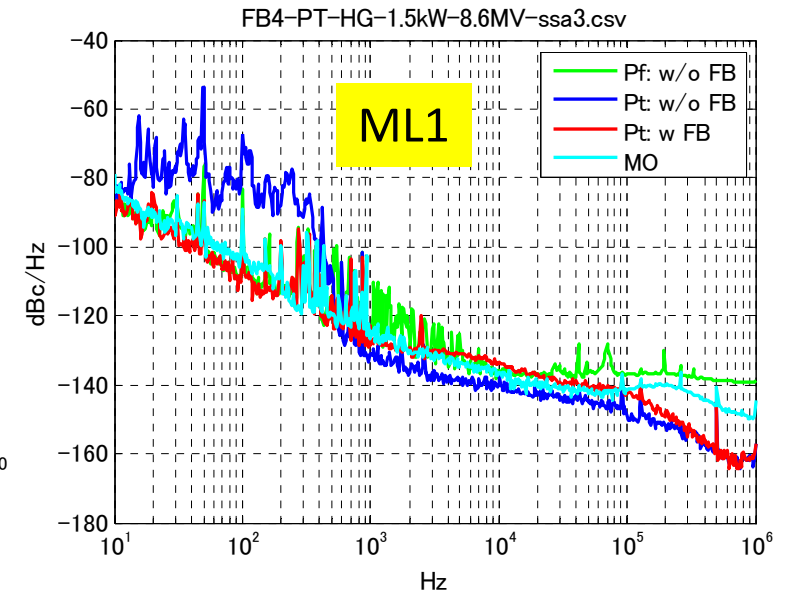
T.Miura (KEK)

ML1

Waveforms of cavity pick-up

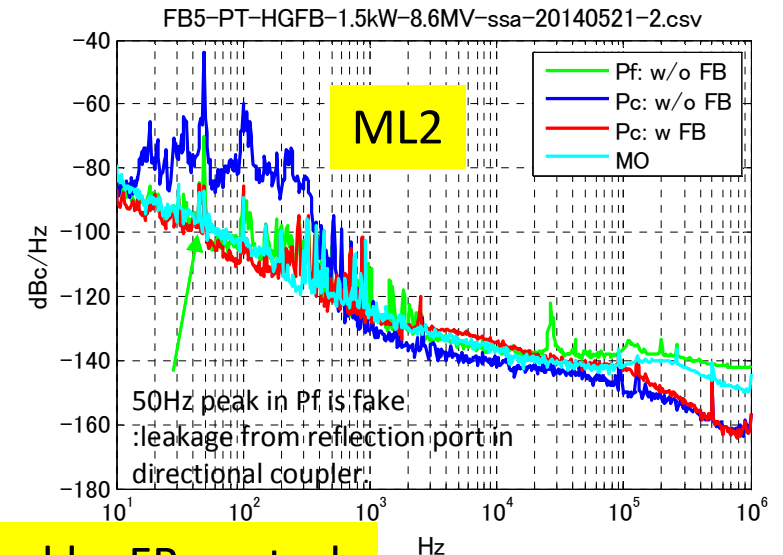
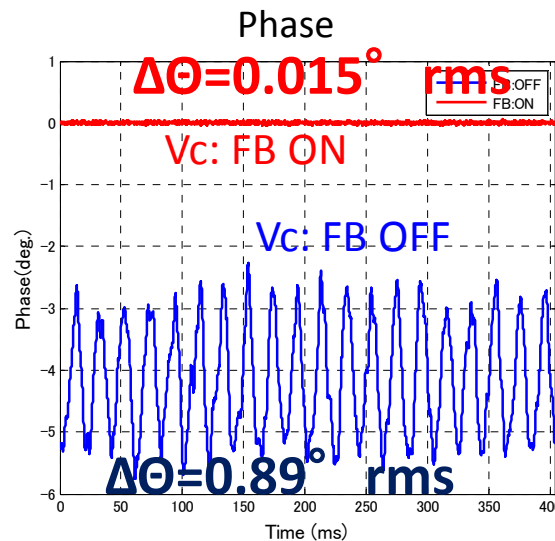
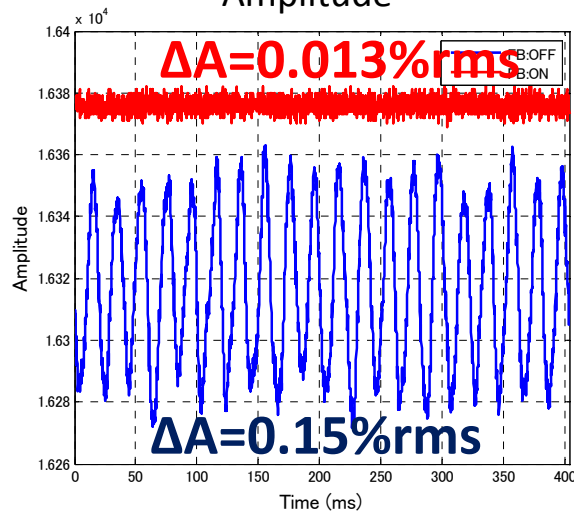


*Phase noise measurement using signal source analyzer*



ML2

Amplitude



Fluctuations by microphonics have been well suppressed by FB control.

## Summary

- cERL injector cryomodule and main linac cryomodule adopt Slide-Jack tuner and piezo tuner.
- Alignment of Slide-Jack tuner was improved and smooth movement was realized.
- Both tuners work well. No failure during 3-years cERL operation.
- Amount of microphonics is less than 10 Hz.
- Applying tuner feedback loop and RF digital feedback loop, phase stability of 0.01degree is achieved.