Performance of RF System for cERL Injector in KEK

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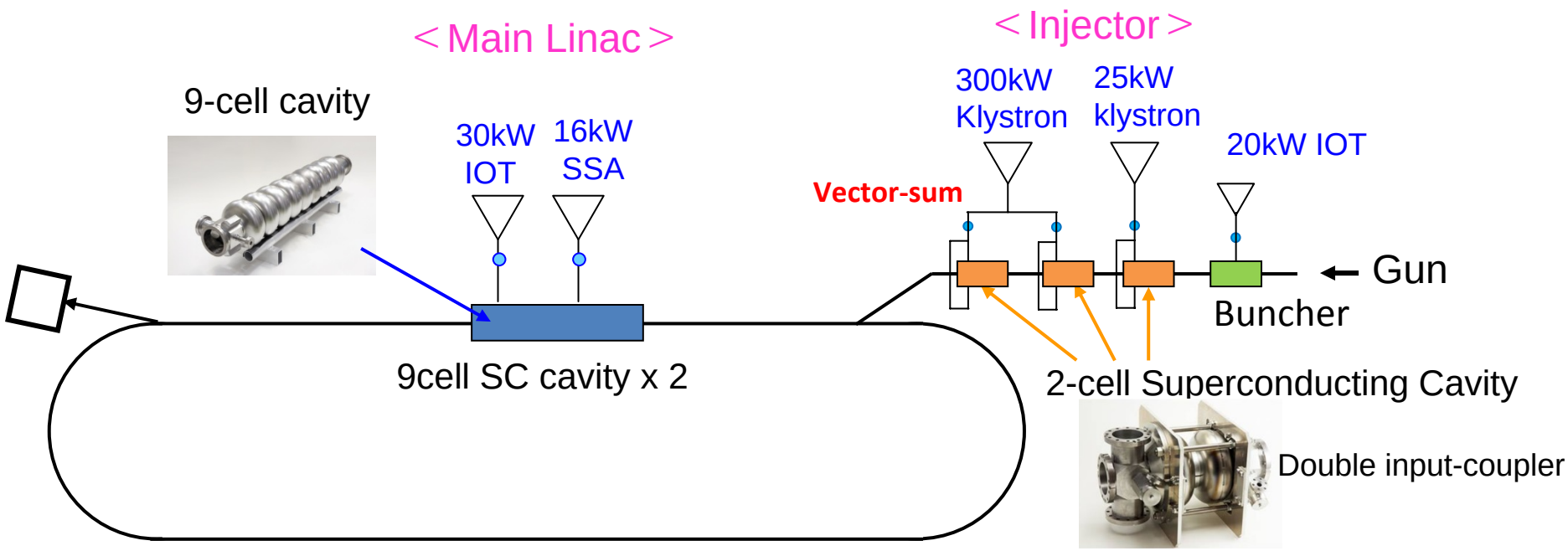
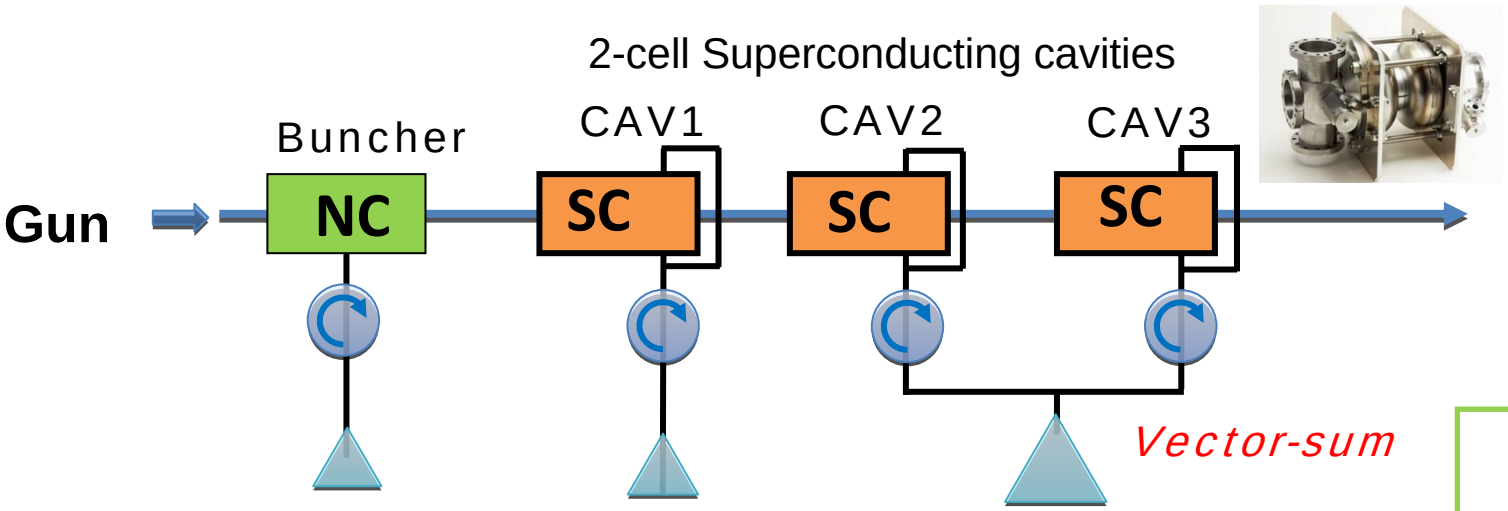
Introduction

- Compact ERL (**cERL**) is under construction as a test facility for 3-GeV ERL future plan.
- Construction of the injector was finished until 2013 April.
  First beam commissioning at the injector was performed for 2 months from this April to June.
- Main linac is under construction now.
  Construction of the whole cERL will complete until middle of November 2013.
  Beam commissioning will start this Decenver.



RF Power Sources for Injector



Double input-couplers

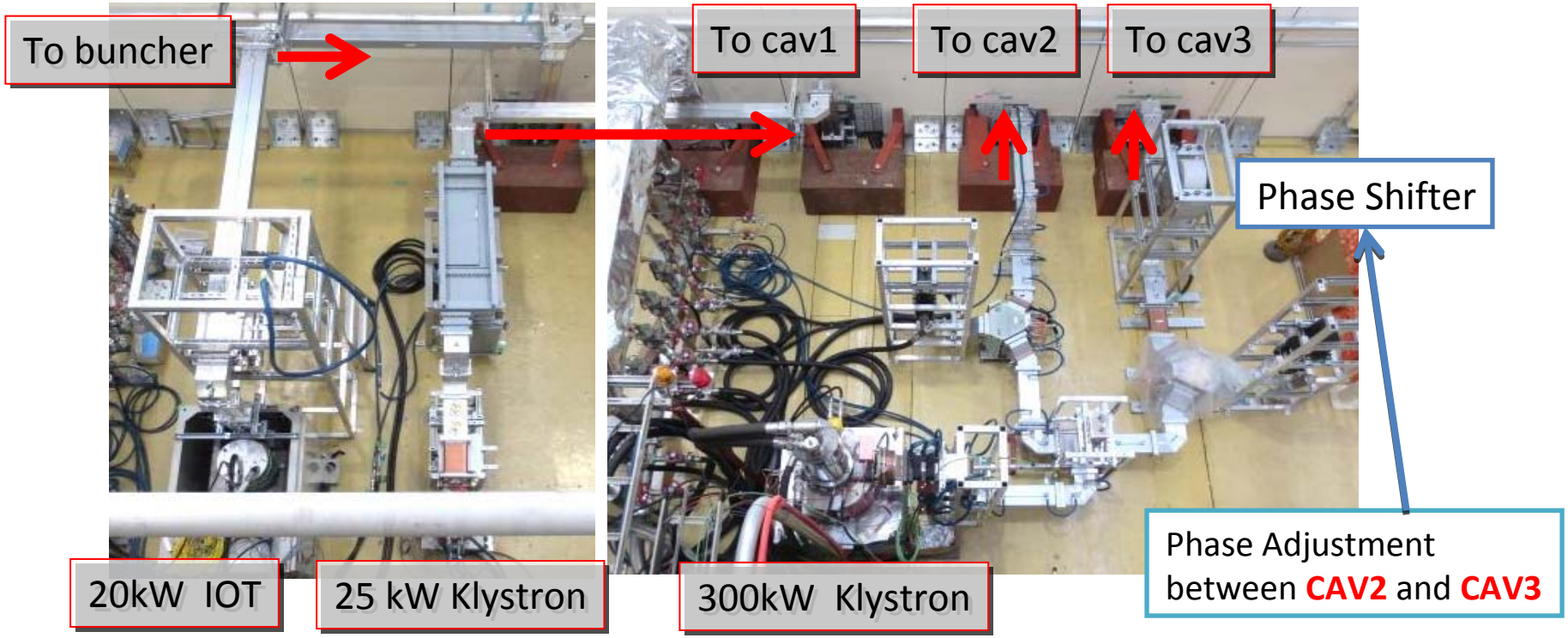
Loaded Q
CAV1: 1.2×10^6
CAV2: 5.8×10^5
CAV3: 4.8×10^5

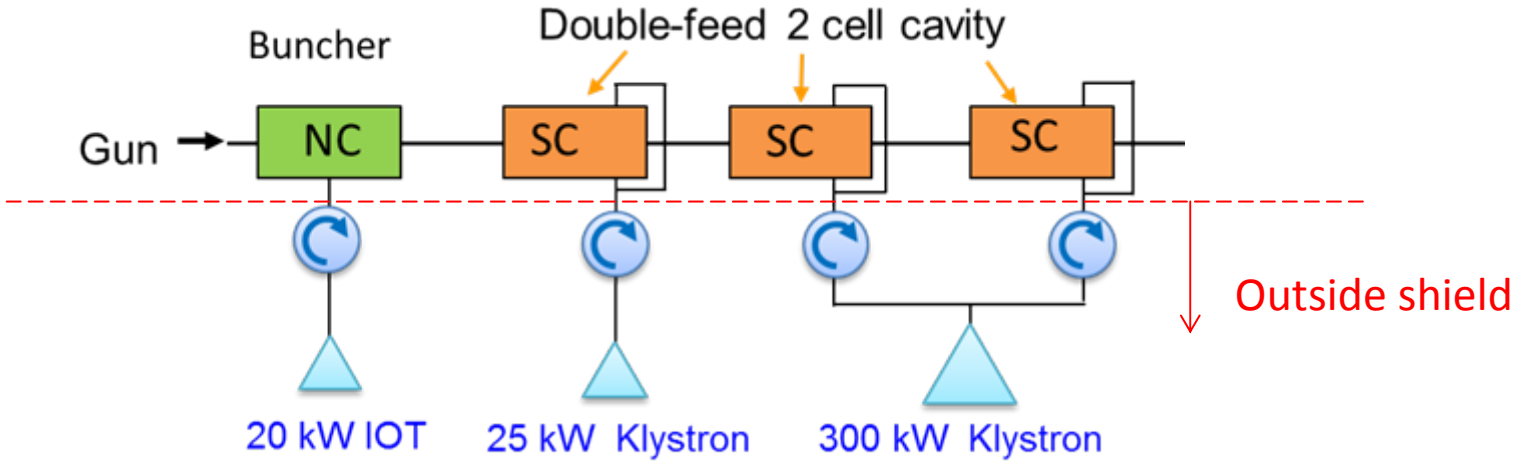
20-kW IOT **25-kW Klystron** **300-kW Klystron**

RF freq=1.3 GHz

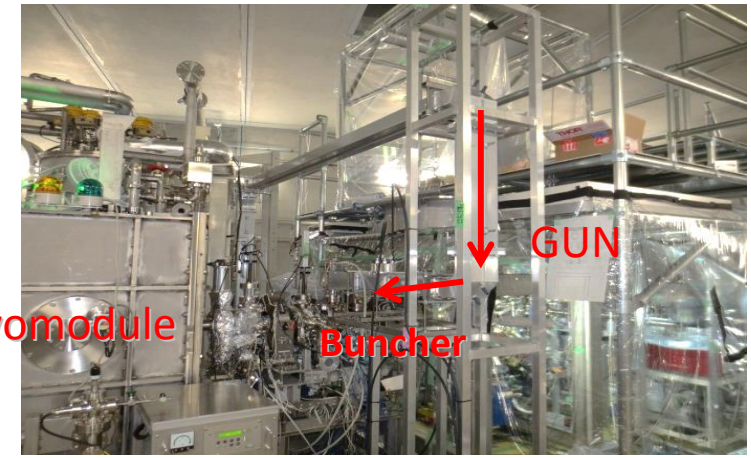
Requirements of RF stabilities: 0.1%rms,0.1deg.rms for cERL
0.01%rms,0.01deg.rms for 3GeV-ERL

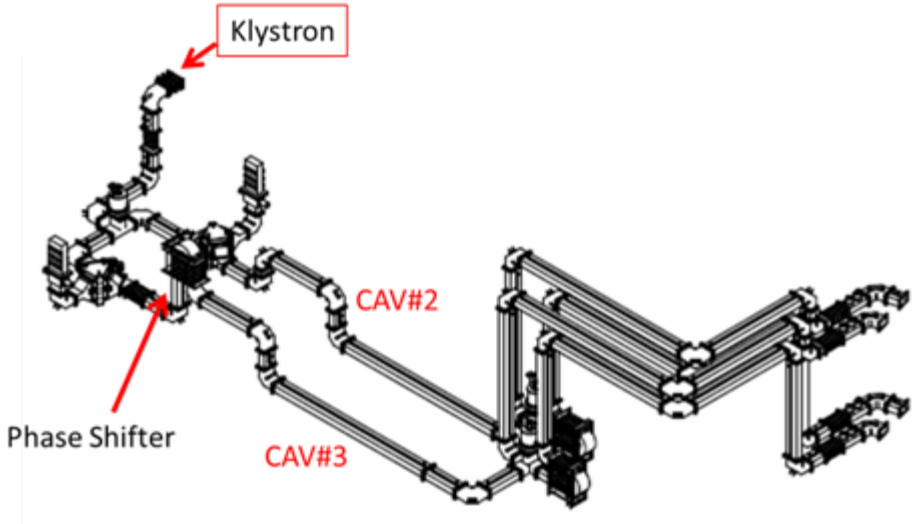
RF Power Distribution System (outside shield)

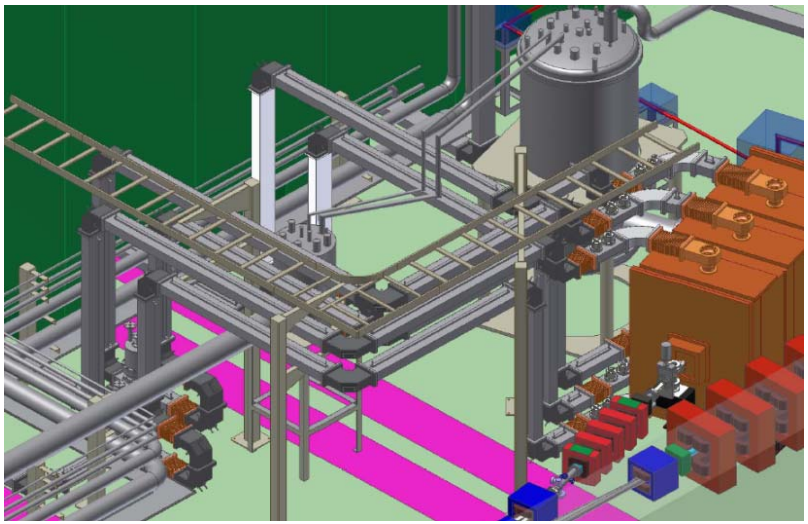




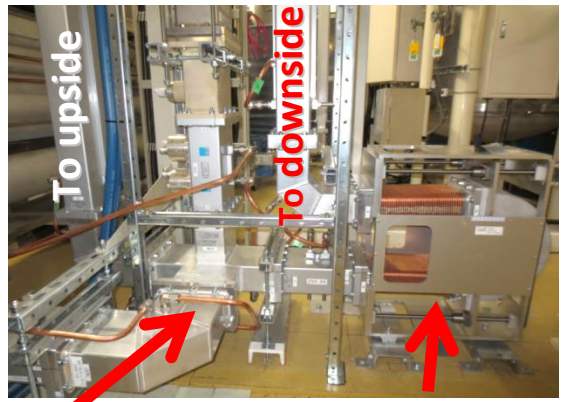
RF power distribution system (inside shield)







Space is narrow and very complicated.

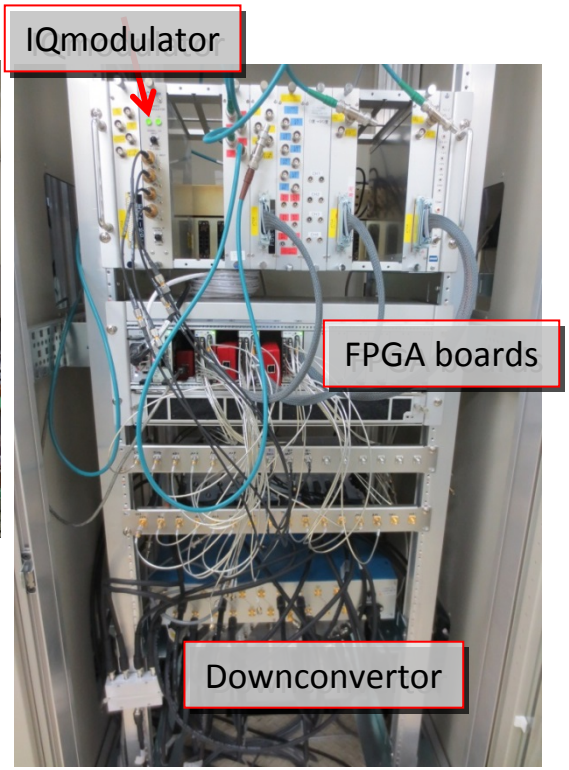


Magic-T

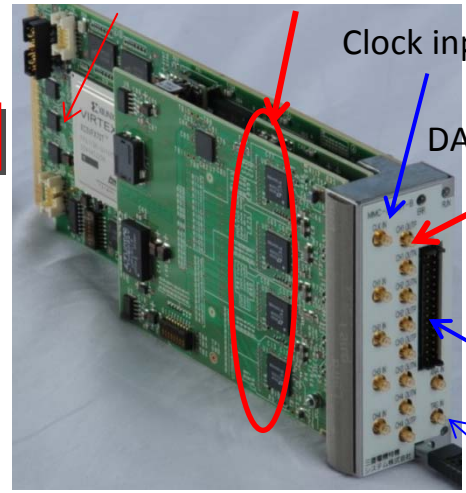
Phase shifter (±33.5°)

: match RF phase between **top** and **bottom** input-couplers

Digital Low Level RF System



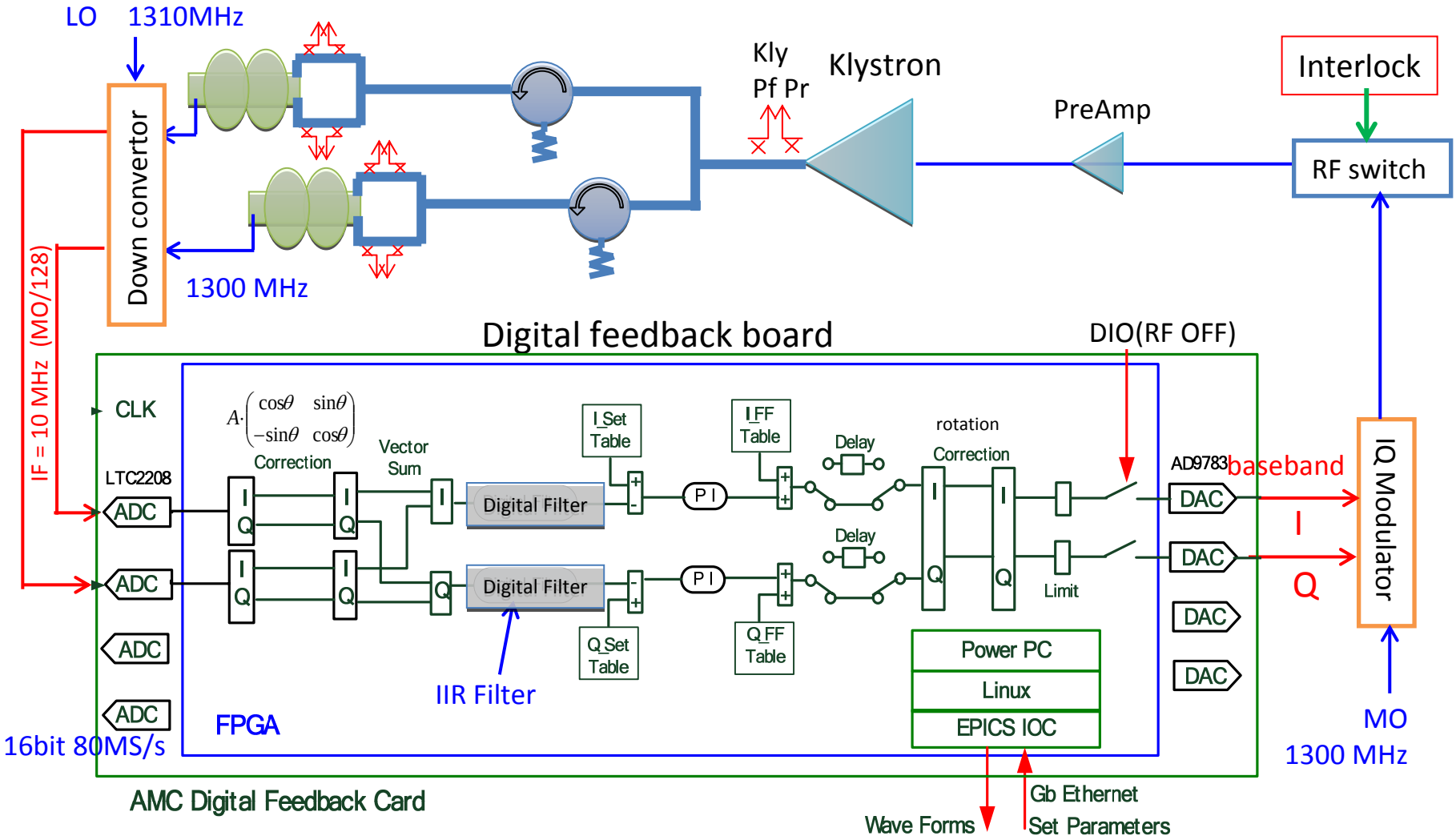
μTCA Digital Board



AMC(Advanced Mezzanine Card)

	BUN	CAV1	CAV2	CAV3
Feedback board	FB0	FB1	FB2 (Vector-sum)	
Tuner board	TN0	TN1	TN2	TN3

Schematic Diagram of Digital FB System



Tuner Control

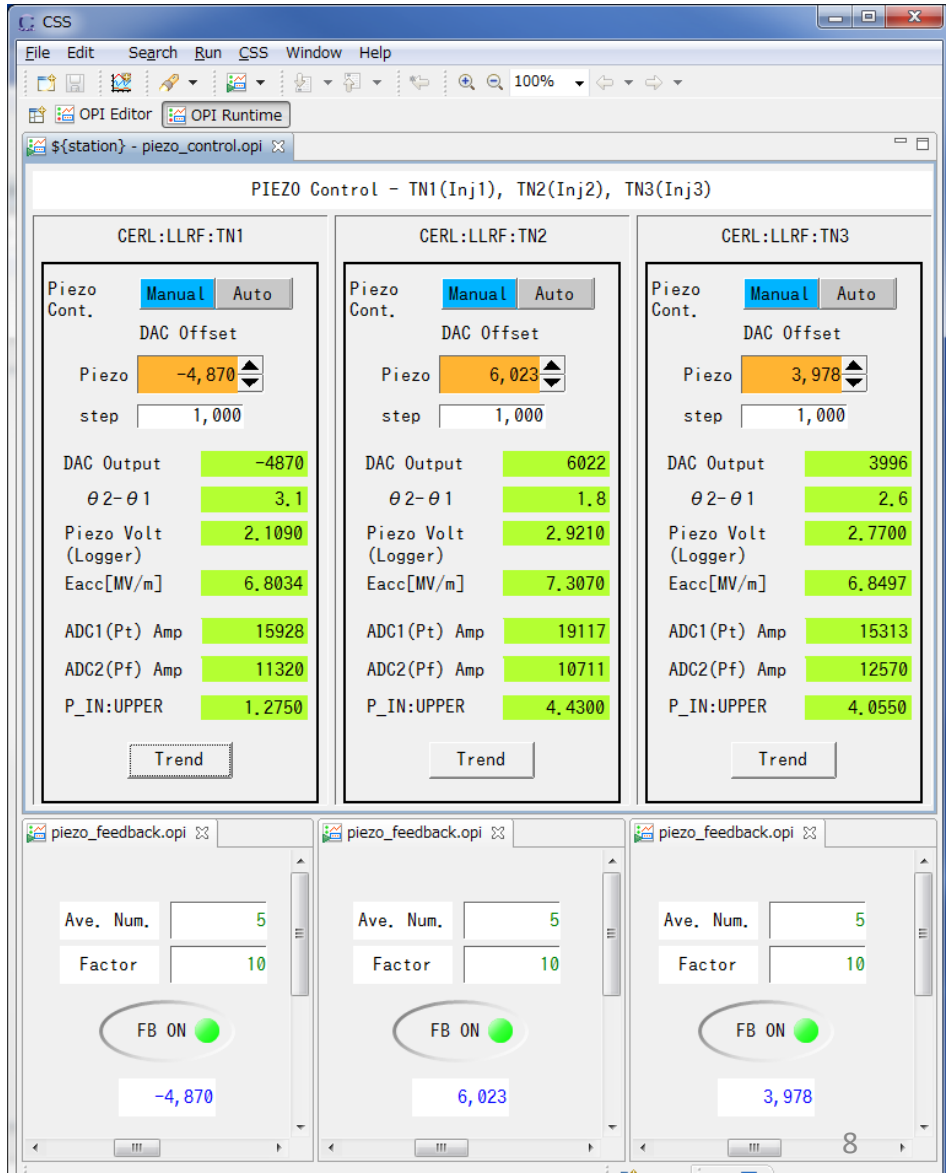
μTCA digital board was used for tuner control.

DAC ⇨ Piezo tuner

Digital I/O → CW → Stepping motor
Digital I/O → CCW → Stepping motor

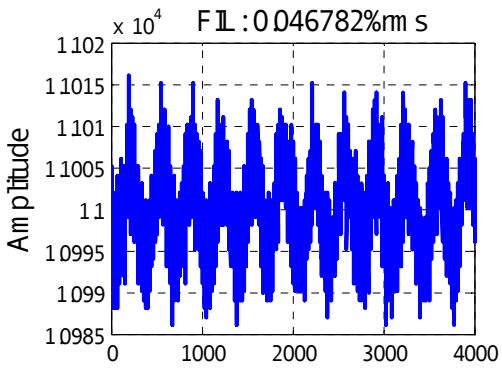
Mechanical tuner

Slow piezo-tuner feedback was performed through EPICS in this commissioning.

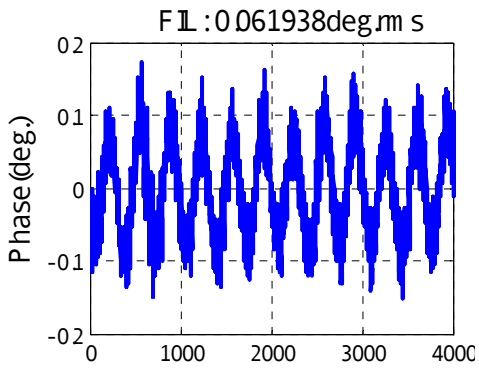


Stabilities of Cavity Fields

FB0 (Buncher)



Amp 0.05% rms

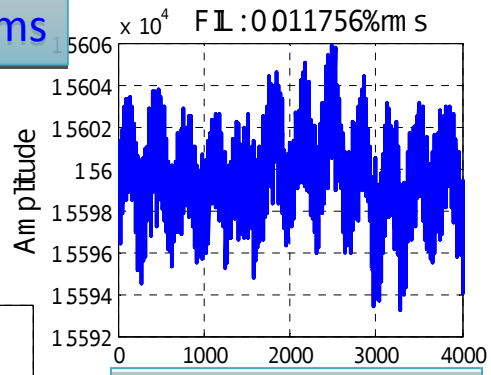


Phase 0.06 deg. rms

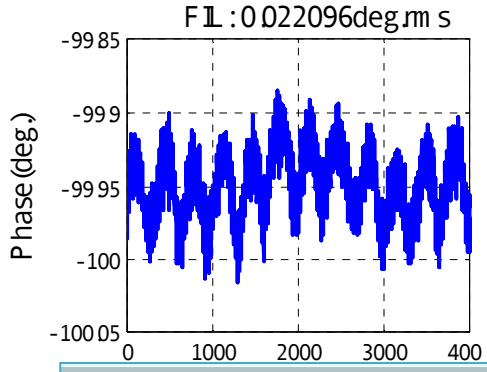
100kS/s

300Hz ripple
from power supply

FB2 (Vector-sum)

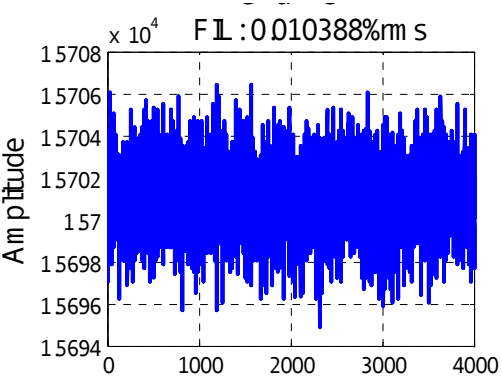


Amp: 0.01% rms

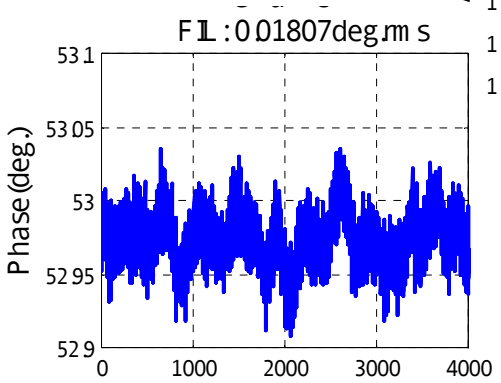


Phase 0.022 deg.rms

FB1 (CAV1)



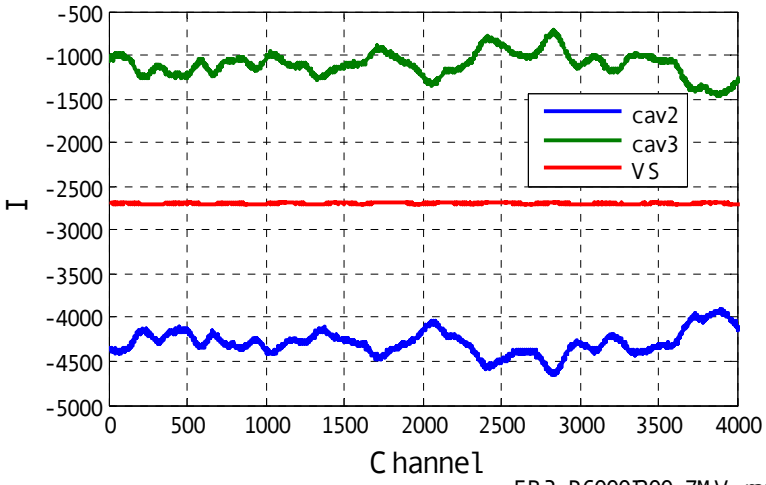
Amp: 0.01% rms ,

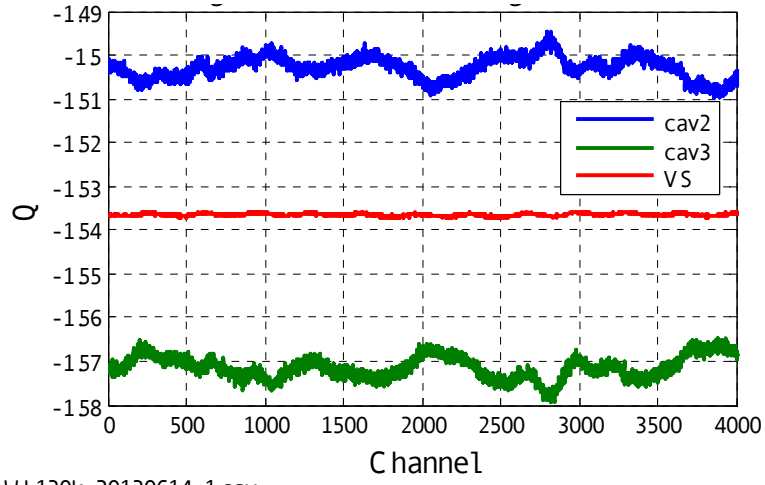


Phase 0.02 deg. rms

RF stabilities satisfy the required stabilities of 0.1%rms, 0.1deg.rms

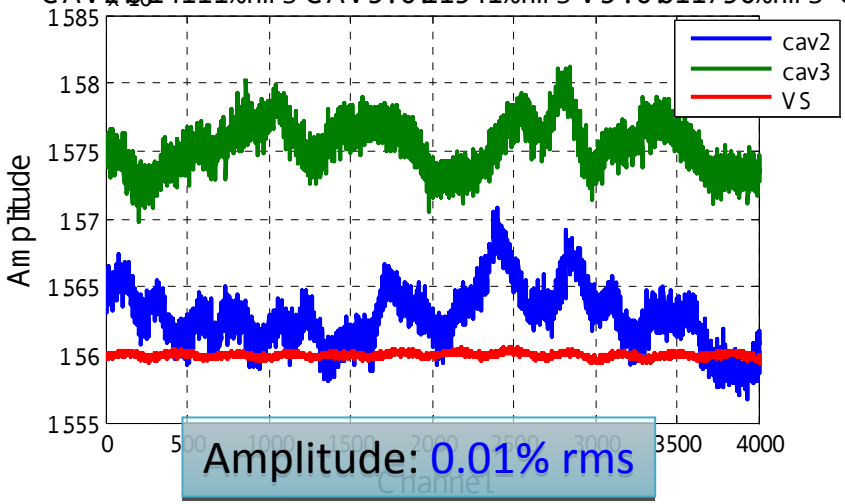
Waveforms of FB2 (vector-sum)



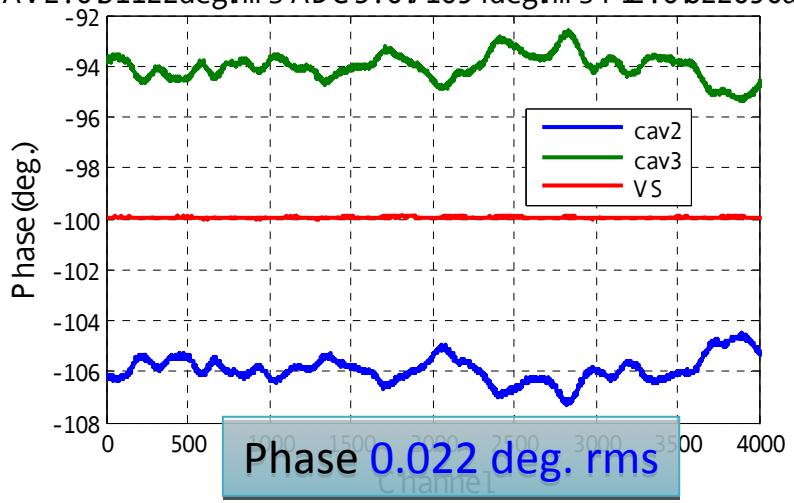


FB2-P60001200-7MV-rate799-WL130k-20130614-1.csv

CAV2:0.14111%rms CAV3:0.11541%rms VS:0.011756%rms CAV2:0.51122deg.rms ADC3:0.71094deg.rms FIL:0.022096deg.rms



Amplitude: 0.01% rms

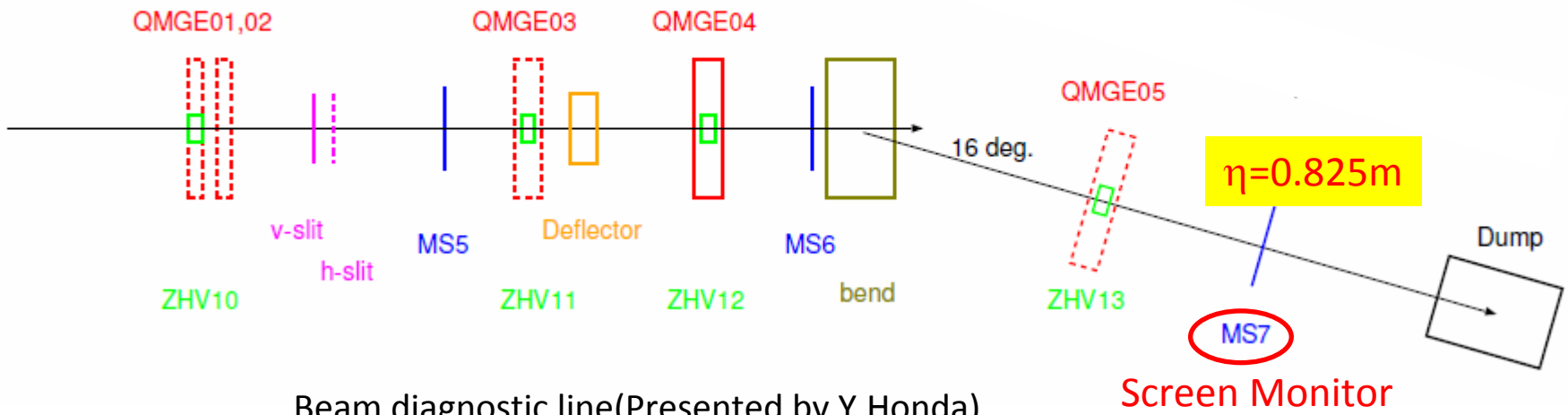


Phase 0.022 deg. rms

Measurement of Beam Momentum Jitter

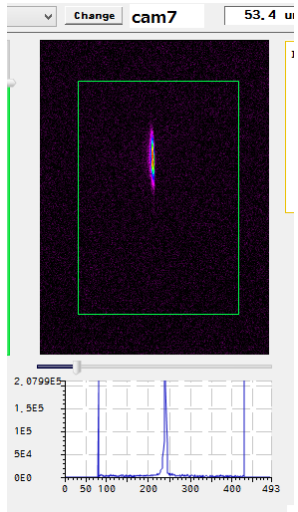
Beam : 5nA (5Hz, 0.77pC/Bunch, 1ps rms, Macro pulse=1μs) Small current & short length

Buncher was not used. (turned off)



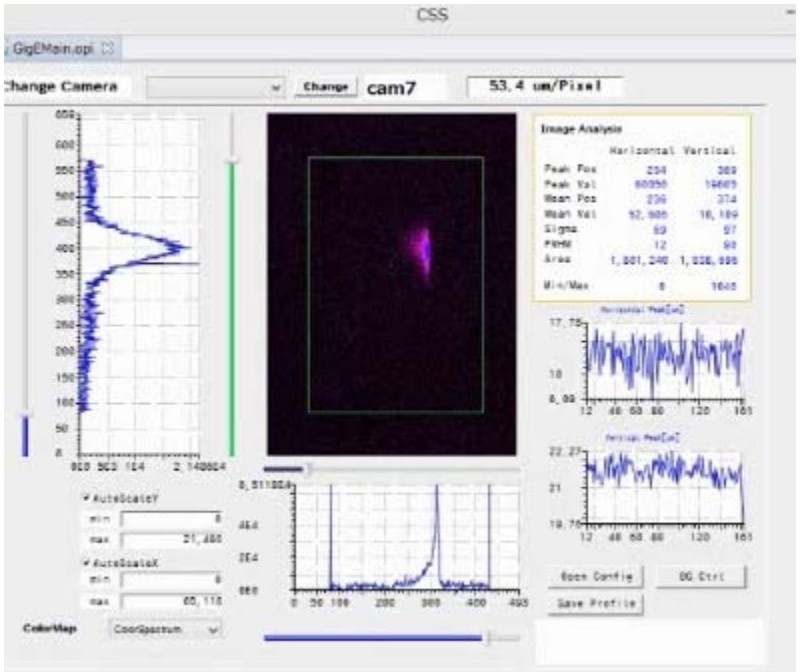
Beam diagnostic line(Presented by Y.Honda)

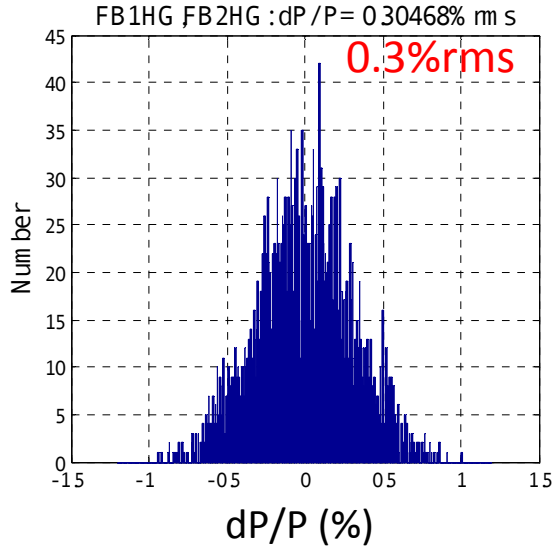
Dispersion @ screen monitor = 0.82m
Resolution = 53.4 μm/pixel
(ΔP/P=6.5e-5)



Momentum was determined by the peak point of the projection of the screen.

Momentum Jitter before Phase Optimization





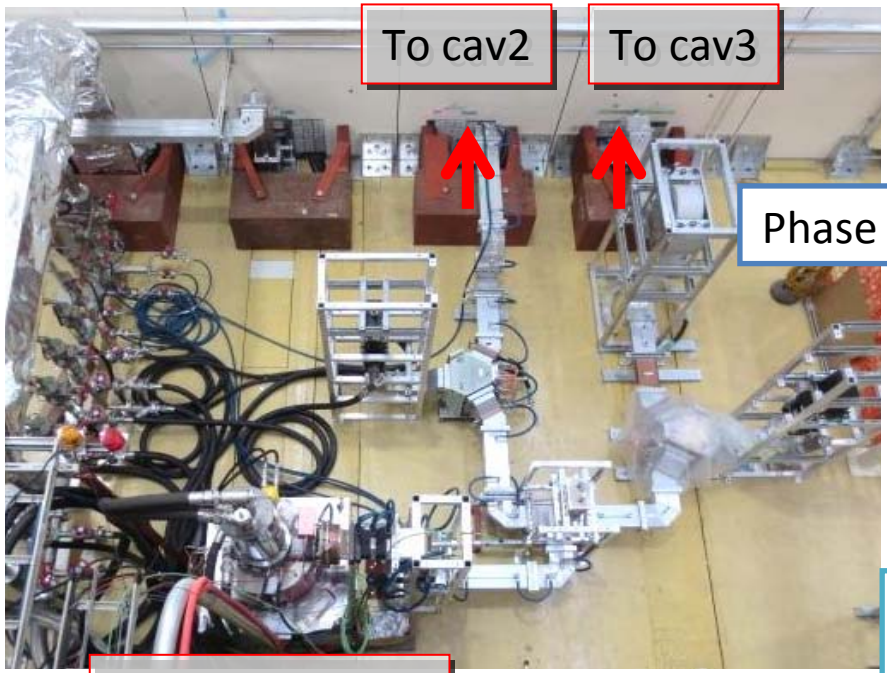
RF feedback was working, but

Beam momentum Jitter was very large, 0.3% rms

It caused by phase error between CAV2 and CAV3

Phase Optimization for Vector-sum

"Phase shifter in CAV3 line " and "feedback phase" were optimized while observing screen monitor.
(CAV2-CAV3 transit time is depends on the energy)



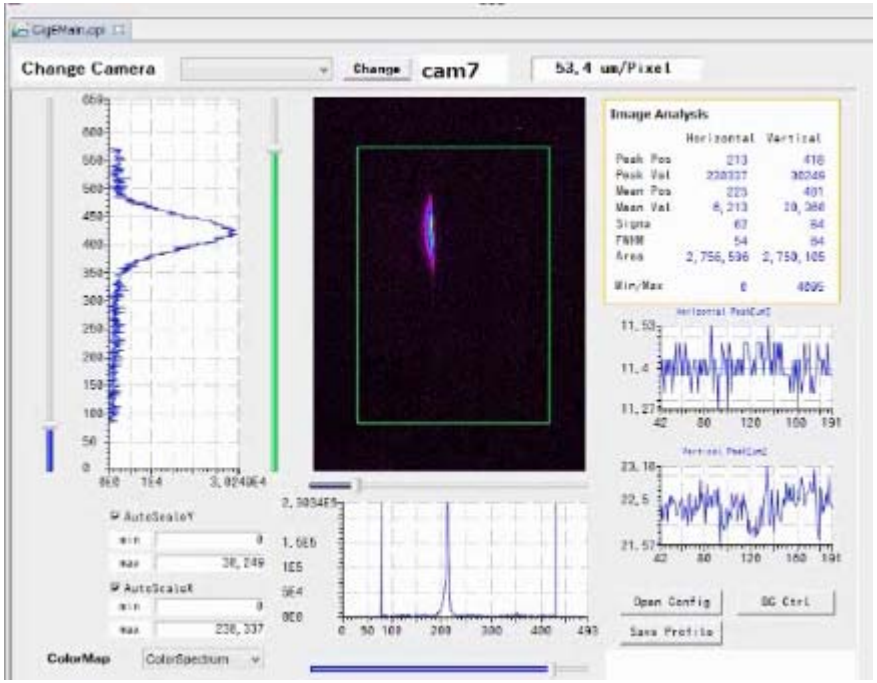
Phase shifter was changed to the direction to beam energy high. (-> crest phase)

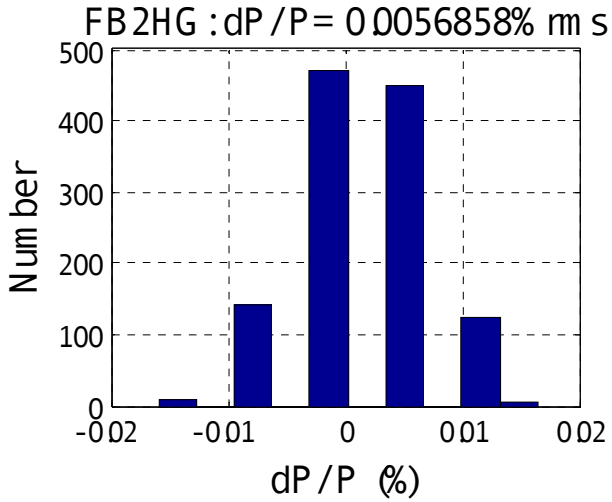
Phase-shifter was changed 34mm shorter than before . (38deg)

Phase Adjustment between **CAV2** and **CAV3**

Momentum Jitter After Phase Optimization

Momentum jitter was improved.





Momentum Jitter= 0.006% rms

Good stability of beam momentum was achieved.

Summary

- Construction of RF system for cERL-injector was finished.
- Commissioning had been performed for 2-months.
- RF fields in every cavities satisfied the required stability, 0.1%rms,0.1deg.rms.
- Good stability of beam momentum was achieved.

Future Plan

In middle of November 2013, operation of the whole cERL will start.

- RF system for two 9-cell cavities of the main linac (ML) should be completed until then.

- In the case of 9-cell, we should pay attention to TM_{010} passband except for π mode.
  To remove $8/9\pi$ mode without long latency -> IIR digital filter will be modified

- Loaded Q of ML-cavities is high, 2×10^7, therefore tuner control is very important.
  The tuner feedback using FPGA will apply.

Thank you for your attention.