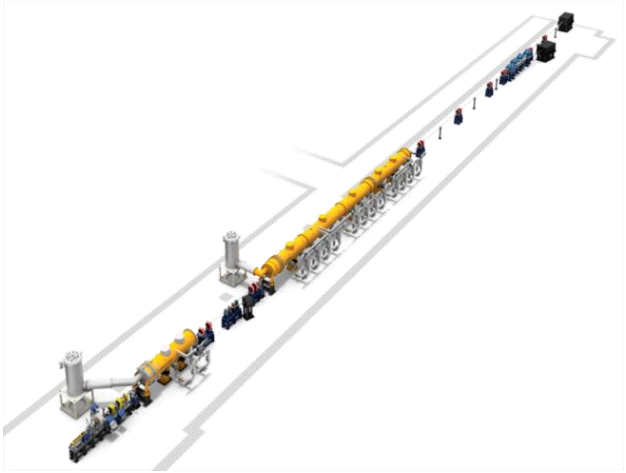
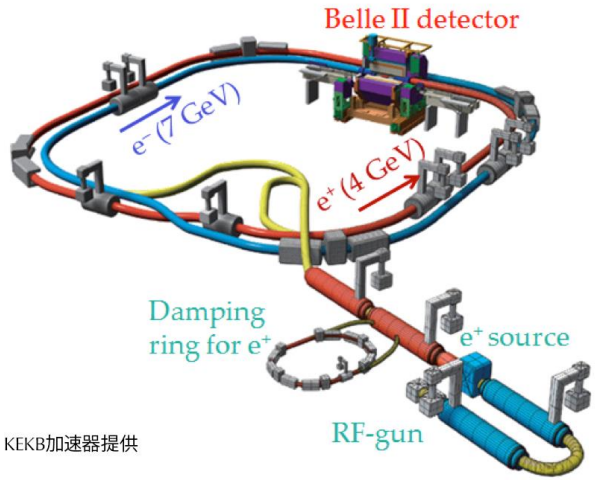
KEK Lab Talk

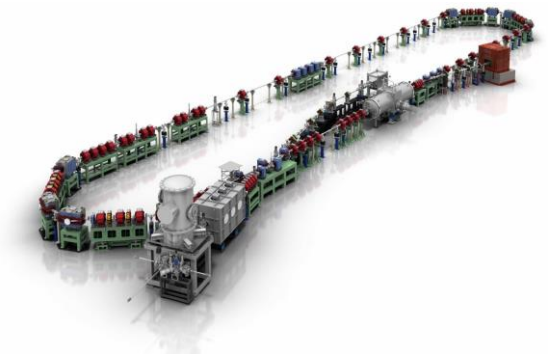


STF-2



KEKB加速器提供

SuperKEKB
- Injector linac
- SuperKEKB ring



cERL

T. MATSUMOTO

(KEK)

Recent progress of LLRF control system for KEK's accelerators:

- SuperKEKB Ring & Linac Damping Ring
  - LLRF control system using MTCA boards
  - ⇒ **LLRF control system are working well with no serious problem**

  T. Kobayashi, IPAC14, IPAC18
- Injector Linac
  - Reconfiguration of RF Distribution System
  - LLRF control and monitor system using FPGA board
  - ⇒ **Simultaneous top up injection to four rings (HER, LER, PF and PF-AR)**
  - Phase Drift Compensation System between Linac MO and Ring MO
- cERL
  - LLRF control system using MTCA boards
  - ⇒ **Investigation of microphonics in ML SC cavities**

  F. Qiu, ERL19
- STF-2
  - LLRF control system using MTCA boards
  - ⇒ **Average 33.1 MV/m beam operation under vector-sum feedback control**

  Y. Yamamoto, SRF19

- FPGA (Virtex 5 FX),
- 4 x 16-bit ADCs
- 4 x 16-bit DACs
- Digital I/O

- 2 x SFP
- 1 x RJ-45
- Digital I/O

2 FPGAs (Zynq-7000, Spartan 6)
14 x 16-bit ADCs
2 x 16-bit DACs

Mitsubishi Electric TOKKI System Co., Ltd.

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T. Matsumoto, IPAC18
T. Miura, IPAC18
H. Katagiri, IPAC18

N. Liu, PRAB 22, 072002 (2019)

- cERL
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- STF-2
  - LLRF control system using MTCA boards
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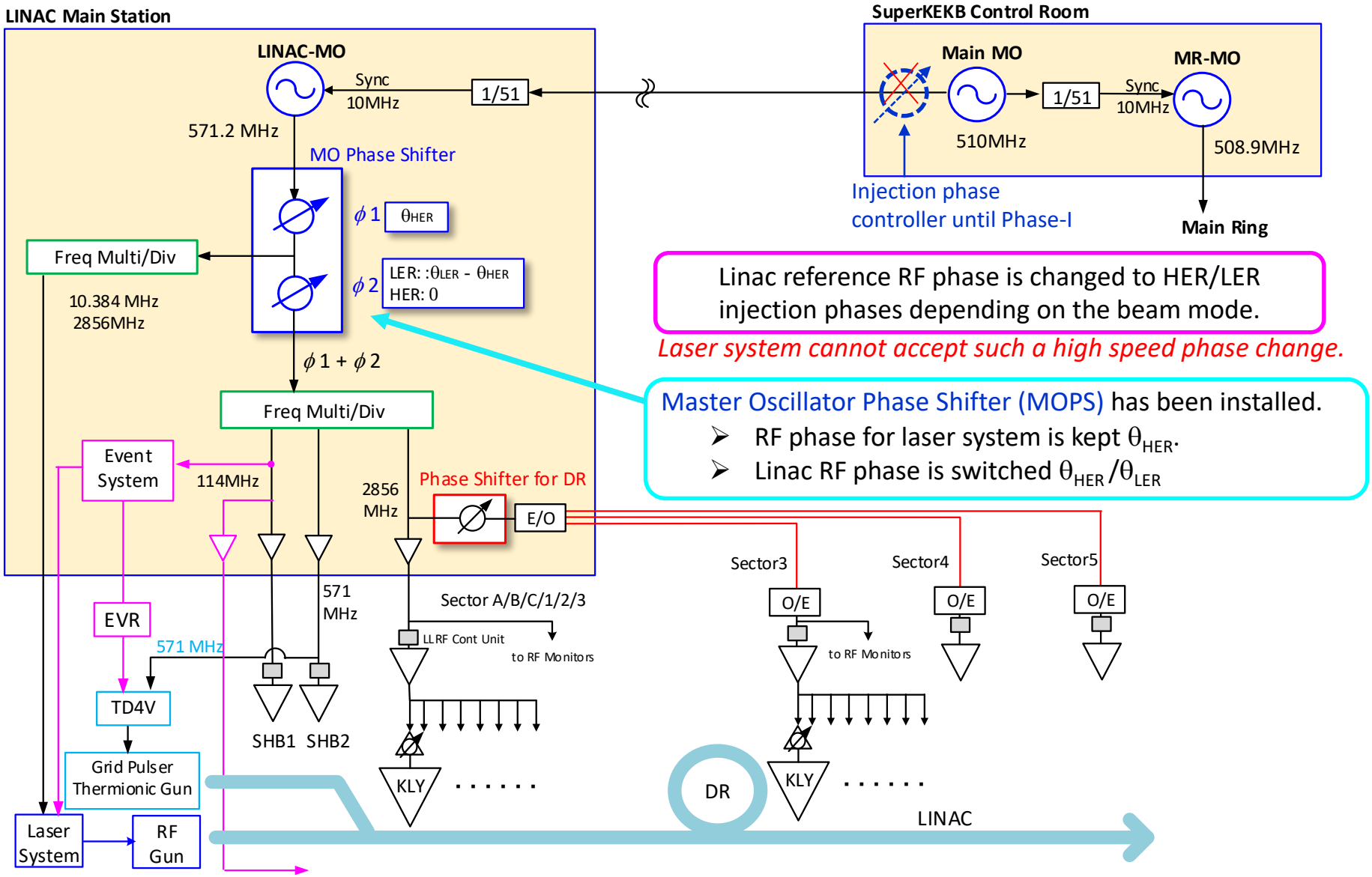
The digital control units in the Injector Linac are based on Xilinx ML605 and its daughter board.

Reconfiguration of RF Distribution System for SuperKEKB:



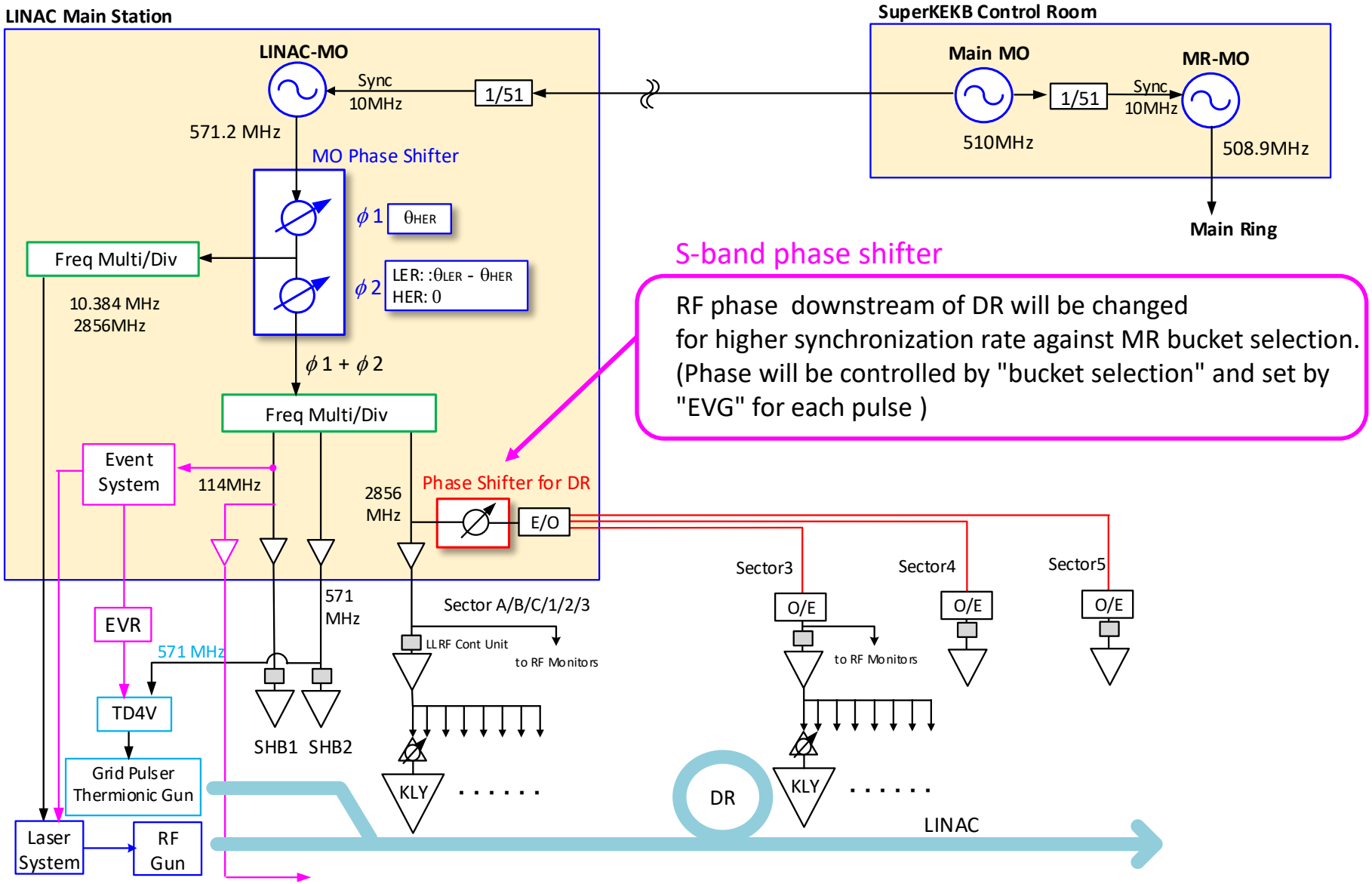
Linac reference RF phase is changed to HER/LER injection phases depending on the beam mode.

Laser system cannot accept such a high speed phase change.

Master Oscillator Phase Shifter (MOPS) has been installed.

- RF phase for laser system is kept θ_{HER}.
- Linac RF phase is switched θ_{HER} /θ_{LER}

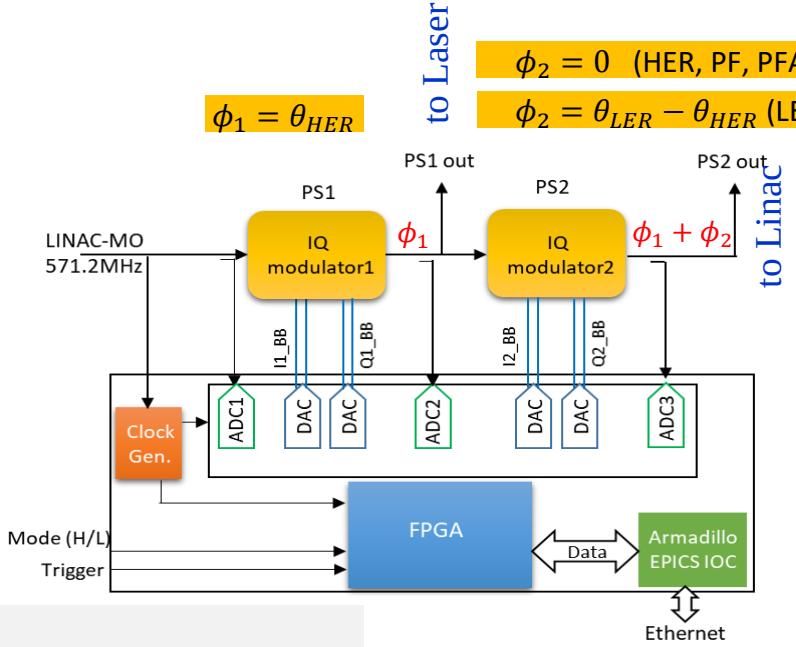
Reconfiguration of RF Distribution System for SuperKEKB:

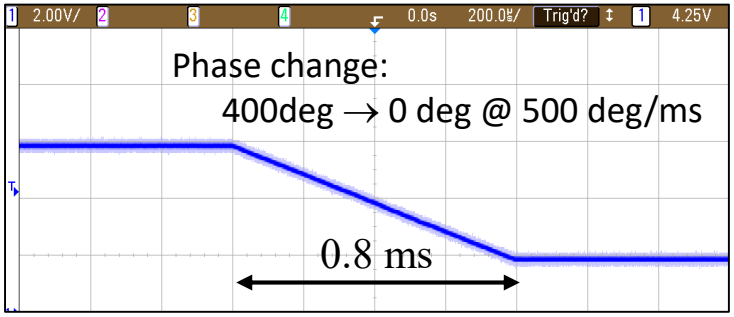


MO/S-band Phase Shifter :

571.2 MHz / 2856 MHz Phase Shifter

Specification of MO Phase Shifter	
Phase Range	-450.00 deg ~ + 450.00 deg
Resolution	0.01 deg
Speed	1 deg/ms ~ 1000 deg/ms
Linearity	< 0.1 deg
Mode	High: LER / Low: HER





The digital control units in the KEKB Linac are based on Xilinx ML605 and its daughter board.

In the operation of SuperKEKB, phase change speed :

PS1 = 1 deg/ms
PS2 = 100 deg/ms

Master Oscillator System in the KEKB Linac

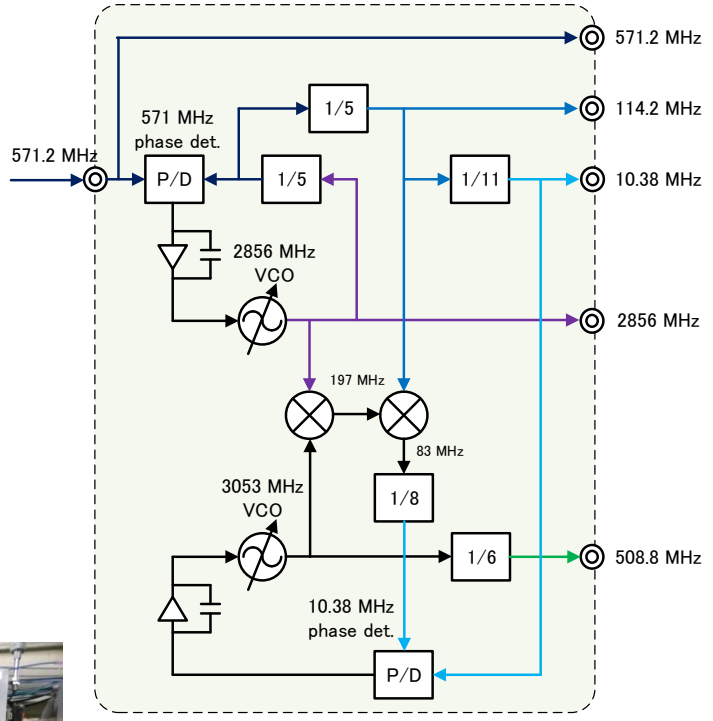
Freq Mult/Div (#0)
MO Phase Shifter

Freq Mult/Div (#1)
Amplifiers

S-band Phase shifter
(for sect.3- sect.5)

Linac Master Oscillator
571.2 MHz

Reference Signal Generator
(Frequency Multiplier/Divider)



Thermostatic chamber : 28 ± 0.05 °C

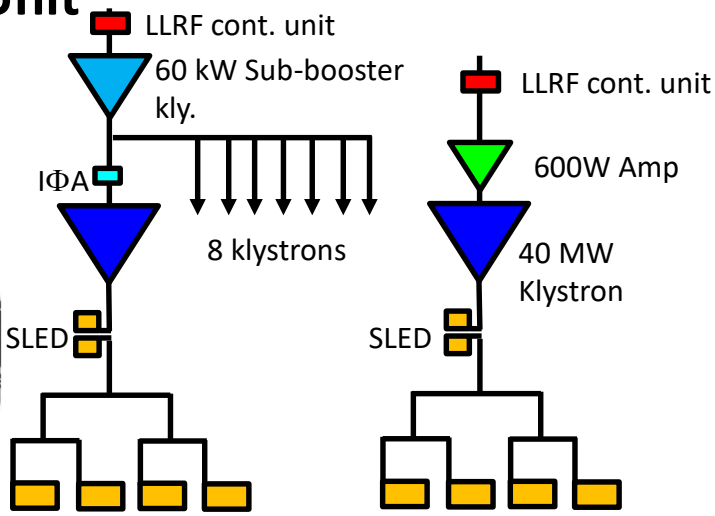
Peltier devices
(no mechanical vibration)

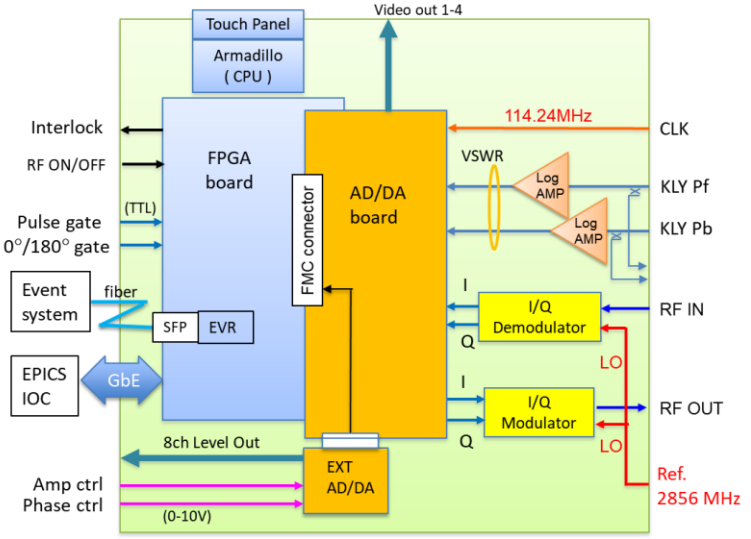
LLRF Control Unit and RF monitor:

LLRF Control Unit

Front

Rear

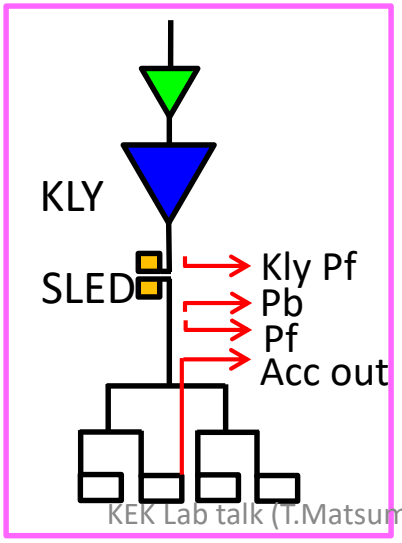


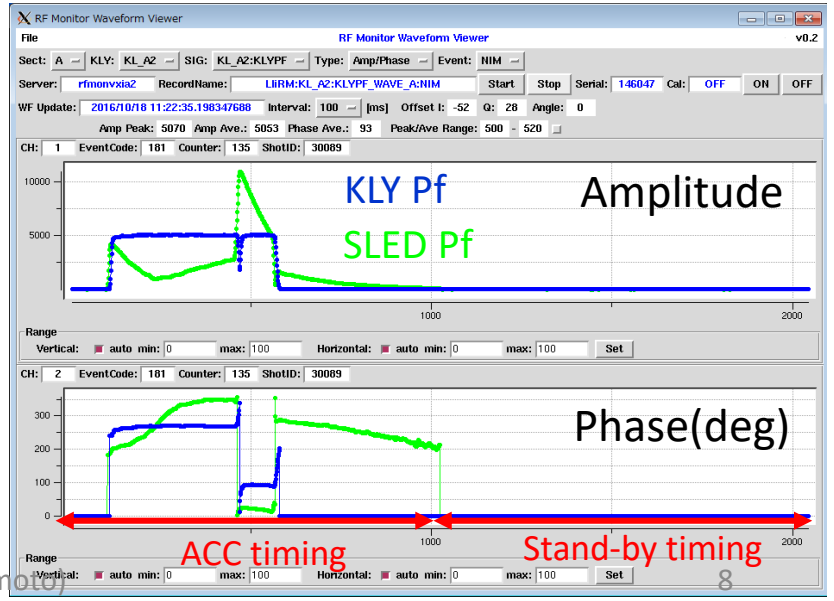


"EVR" is built-in to identify the Event code & Shot ID.

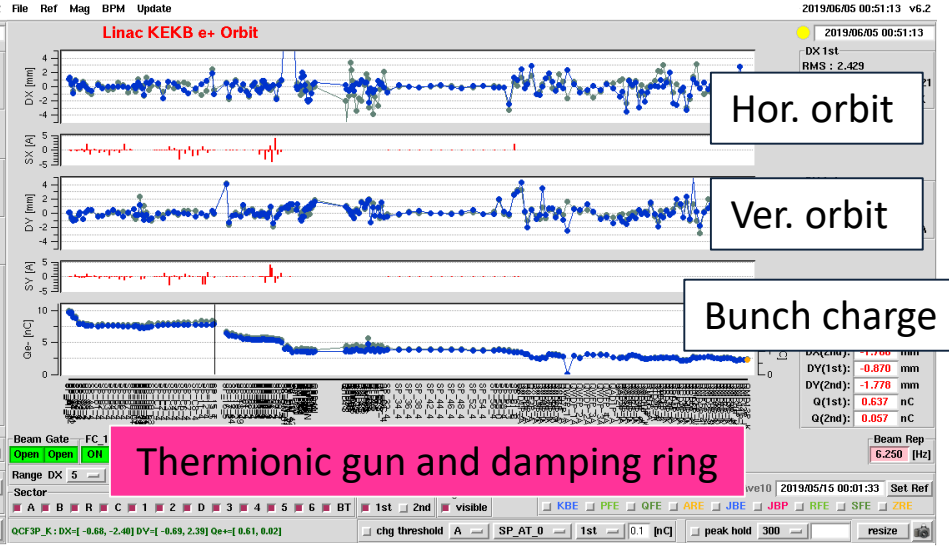
RF Monitor

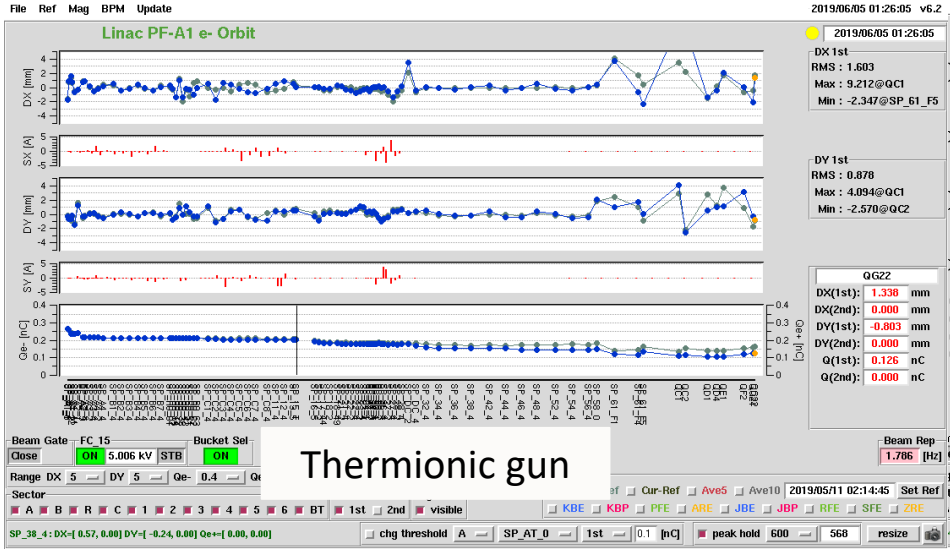
RF monitor rack
(30 racks are installed)

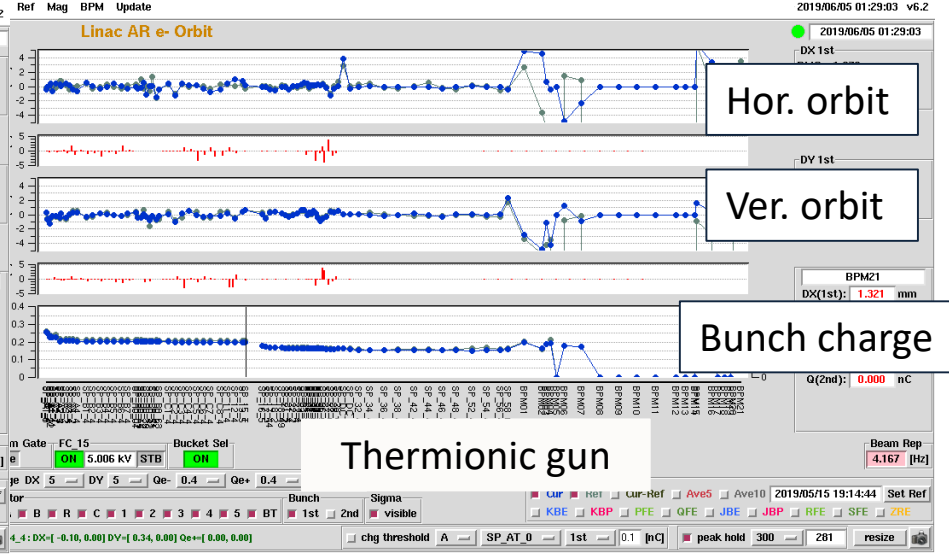




Simultaneous beam operation with thermionic e- gun and rf e- gun







Beam Induced RF monitor (Application of RF monitor)

Motivation

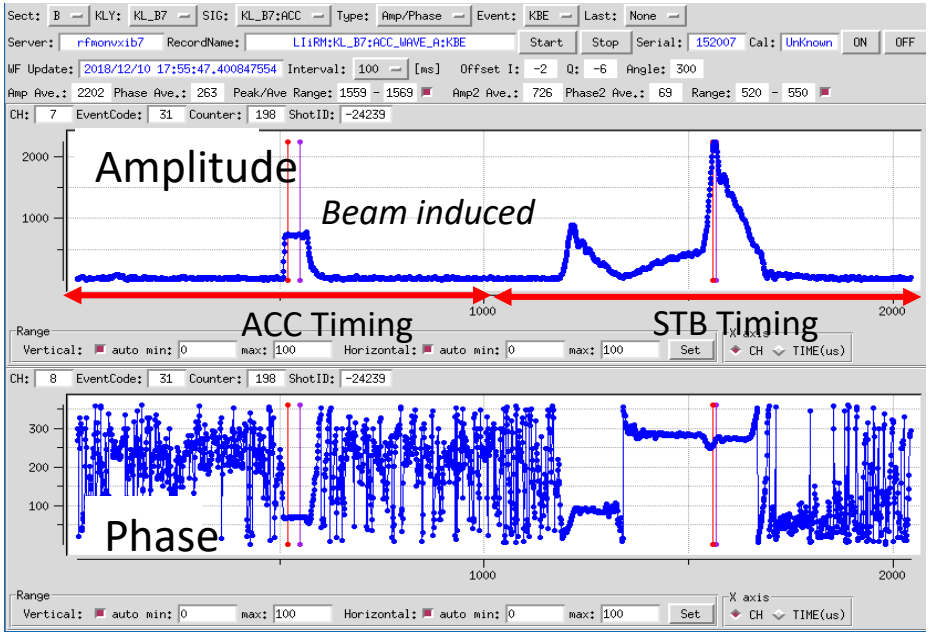
Monitored RF phase is affected temperature drift of cable and monitor system.
By comparing the phase of driving RF and beam induced RF in the accelerating structure, we can expect to get the beam phase against RF without system drift error.

Amplitude estimation

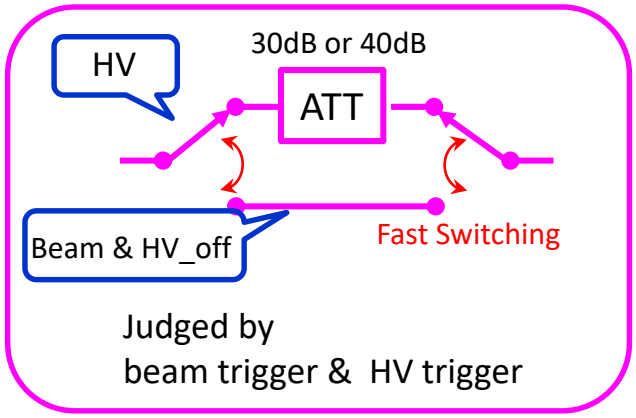
ACC Grad : 20 MV/m

-40.9 dB
small

Beam Induced:
180 kV/m @ 2nC, 3.3ps

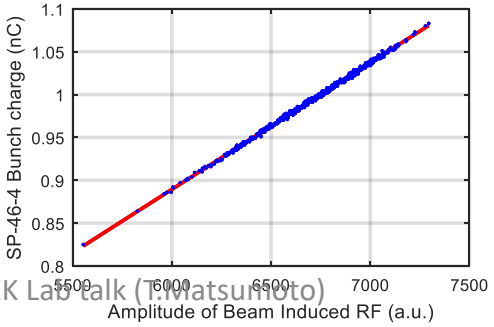


Fast ATT switching module



Installed Unit : A2, B7, C1, 12, 22, 38, 45, 53, 57

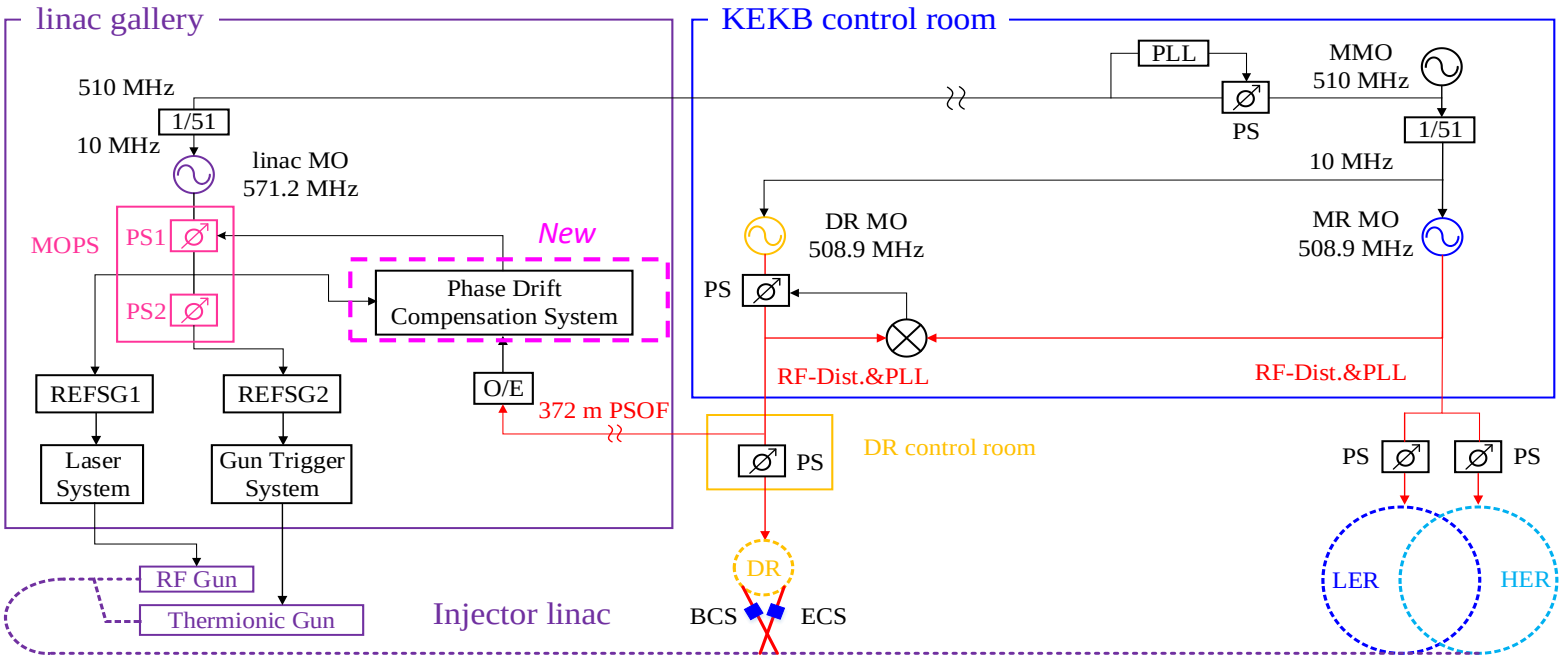
2018/12/10



Amplitude of Beam Induced RF vs. Bunch charge

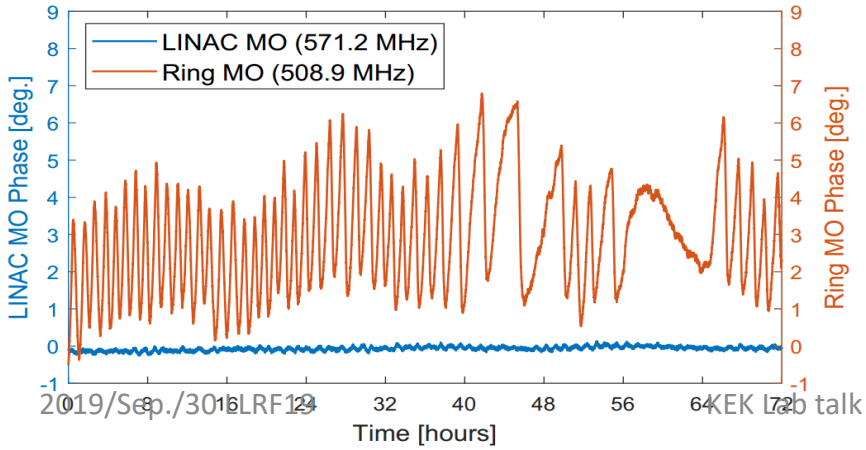
Amplitude of beam induced RF is proportional to bunch charge.
(plotted at the same shot ID)

Block Diagram of MO Synchronization System



MR MO and DR MO phases have been locked by PLL.

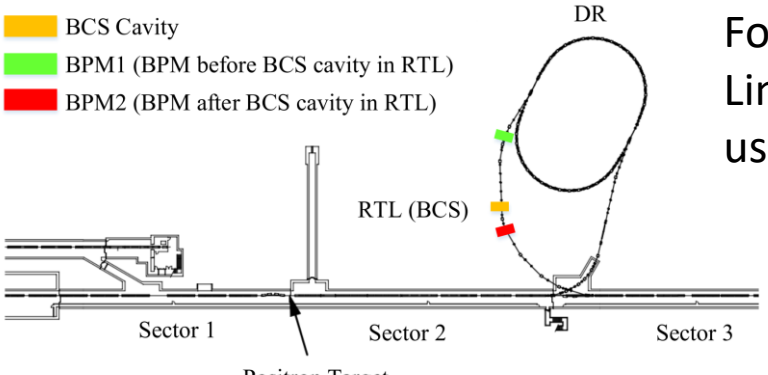
⇔ Linac MO phase had not been locked to Ring MO phase.



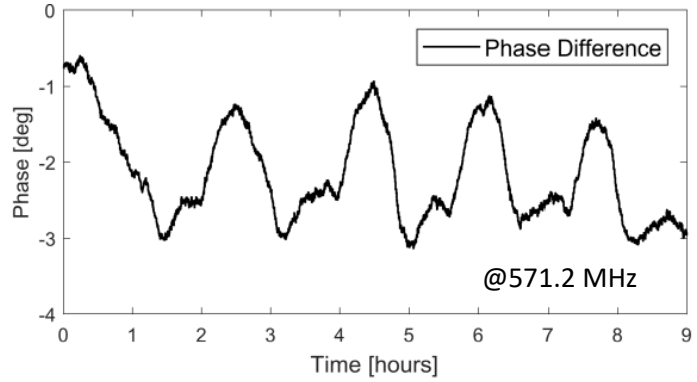
Linac MO & Ring MO phases are monitored with the clock based on Linac MO.

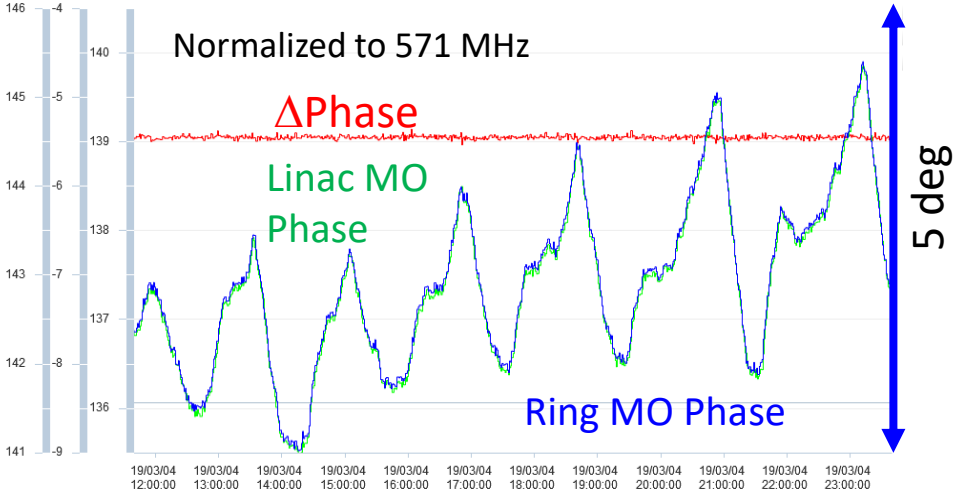
This phase drift has strong correlation with temperature of the Ring MO room.
(by T. Kobayashi)

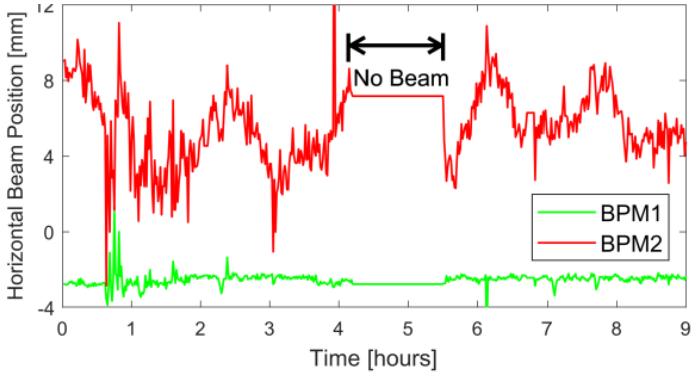
Phase Drift Compensation between Linac MO and Ring MO



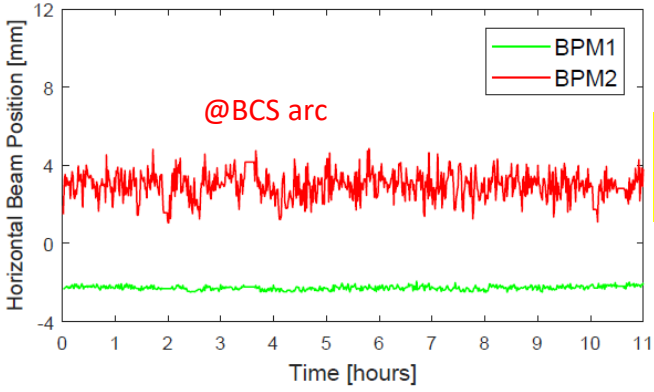
For the drift compensation between Linac MO & Ring MO, Linac MO phase is changed to follow Ring MO phase by using MO Phase shifter.







FB ON



Slow drift was disappeared

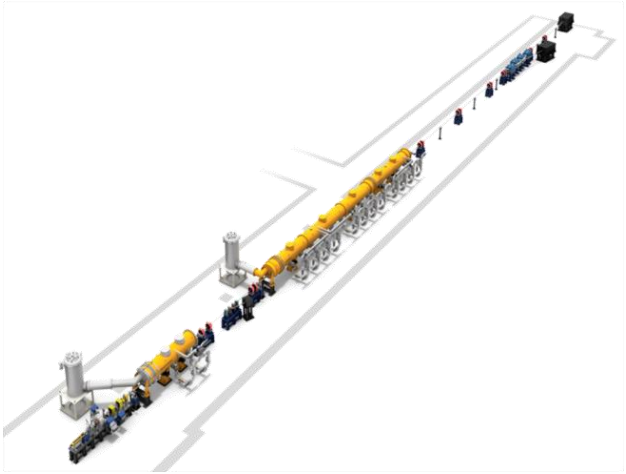
Summary

- In the KEK, the LLRF control systems of each accelerator work well. This contributes to steady beam operation for each accelerator.

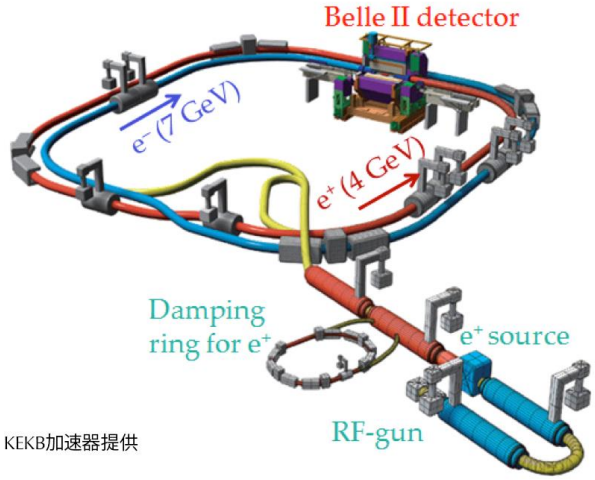
- The RF distribution system of Injector linac was reconfigured for SuperKEKB project. The MO phase shifter and the S-band phase shifter, and the phase drift compensation system between Linac MO and Ring MO were installed.

- The LLRF control unit and the RF monitor have been developed to achieve the simultaneous beam injection of four independent rings.

- Thank you for your attention!

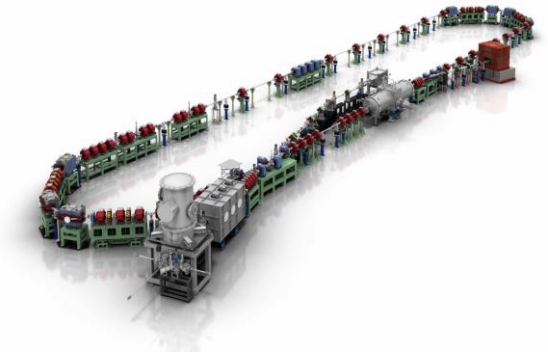


STF-2



KEKB加速器提供

SuperKEKB
- LINAC
- SuperKEKB ring



cERL