Beam Injection Control

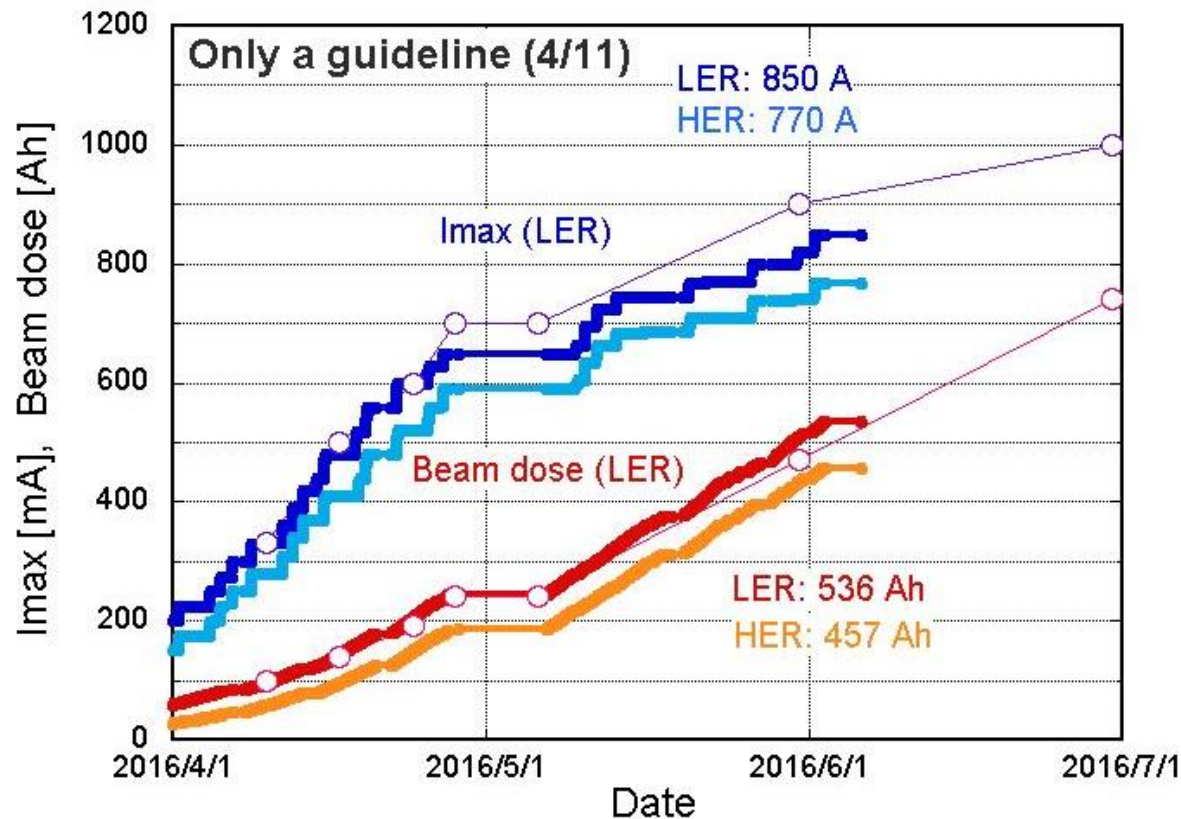## Hiroshi Kaji

Overview

Beam Injection Control consists of:
    Beam Gate & Injection Rate Control
    Bucket Selection & Injection Timing Control

It manages beam injection into two main rings during last 4 months.

One of the most successful systems in the phase-1 operation.

Beam Gate & Injection Rate Control

The Beam Gate and Injection Rate are controlled from same panel.

**Injection Rate Setting
Parameters are
transferred to LINAC
via Channel Access.**

Beam Gate Control
Enable/disable e⁻ gun

**Gate signals are
transferred to LINAC via
dedicated optical network.**

**Current Limit Setting
Injection is stopped
(Beam Gate is closed)
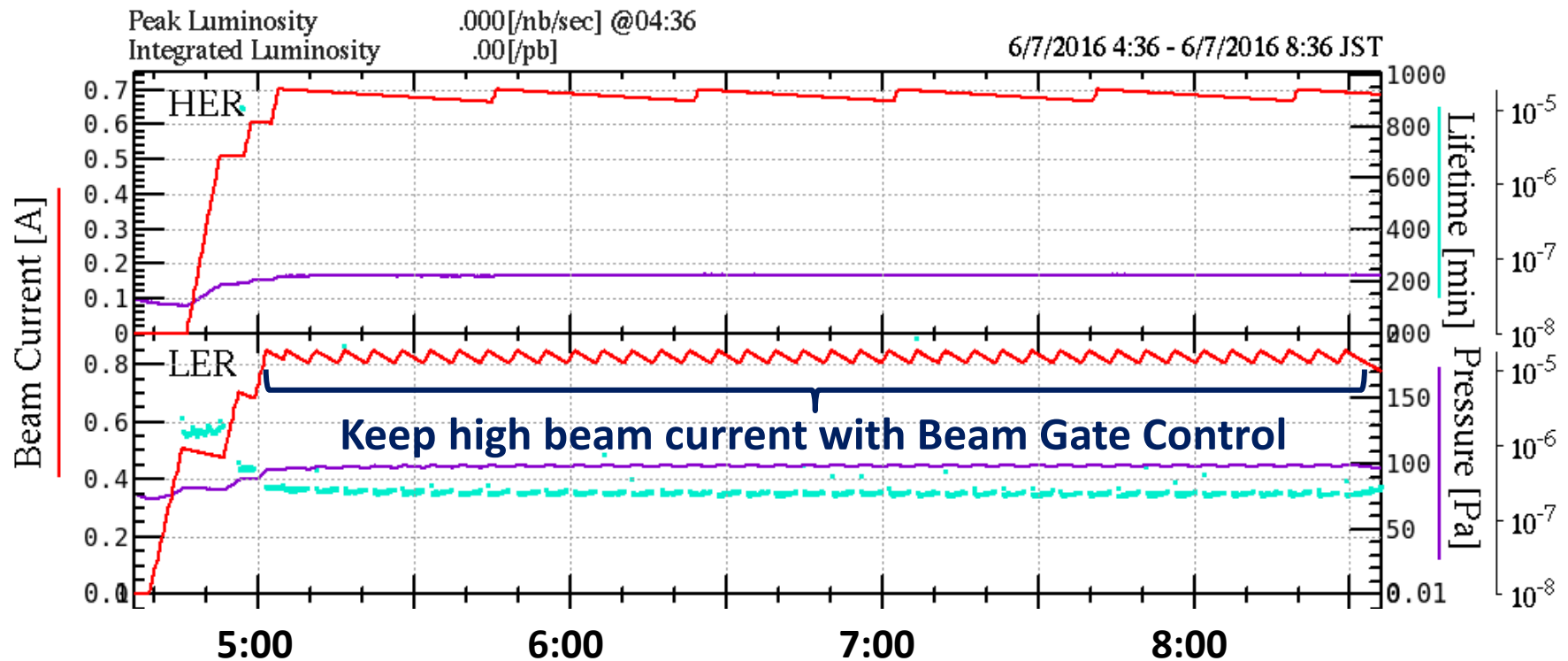when the beam current
exceed these limits.**

Mostly from KEKB

Automatic Gate Control for Vacuum Scrubbing

Well established beam gate control system realized the "nearly" top-up operation.

焼き出し君

Beam Currents are kept within 5% from requested values.
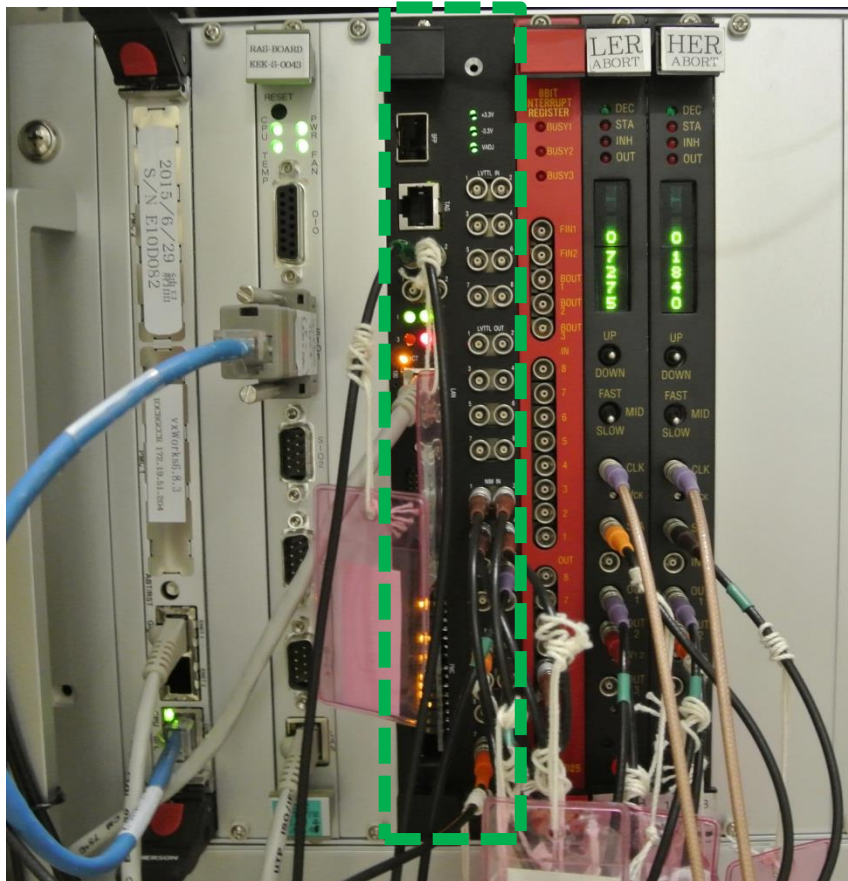

Keep high beam current with Beam Gate Control
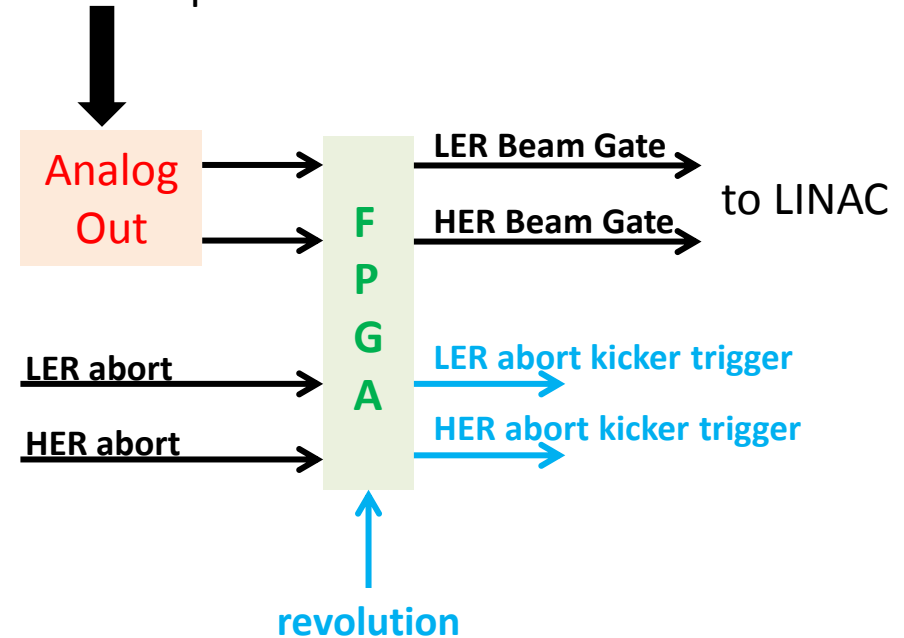
Beam Gate Hardware

VME type EPICS IOC (which manages also the beam abort signal)

Two kinds of Beam Gate control are implemented with FPGA based circuit.
- Open/Close from operation panel (via Channel Access)
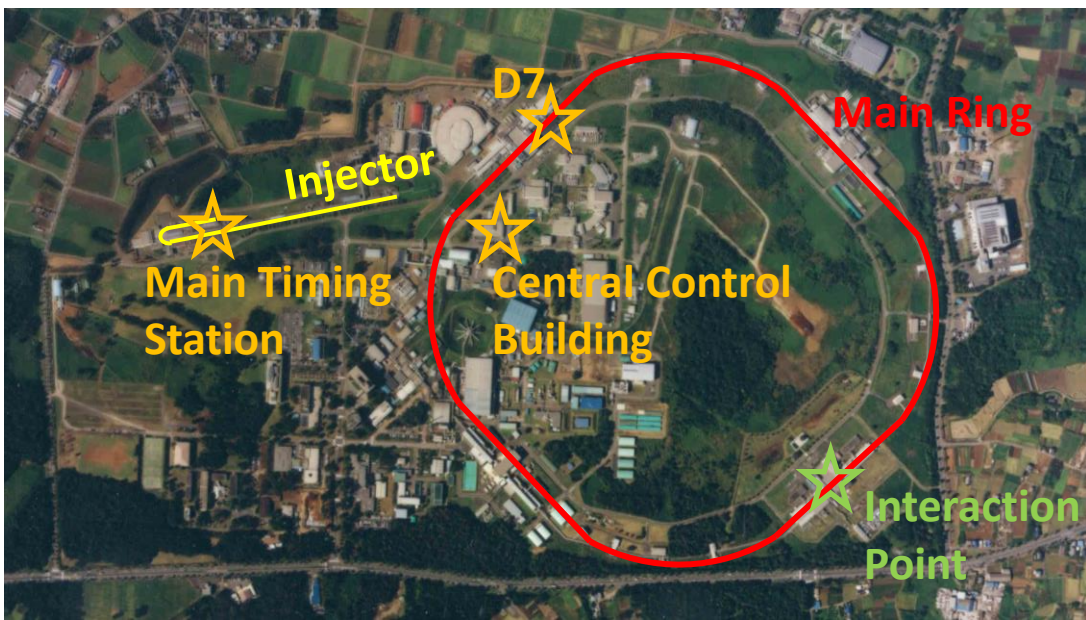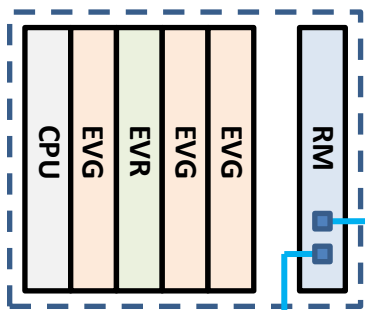**- Fast Close hard-wired with the abort signal**

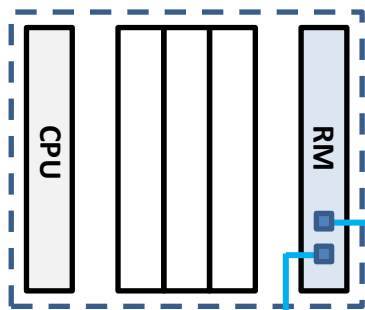# Bucket Selection

Reflective Memory VMIVME-5565

IOC Main Timing Station
Adjust injection timing for selecting RF-bucket
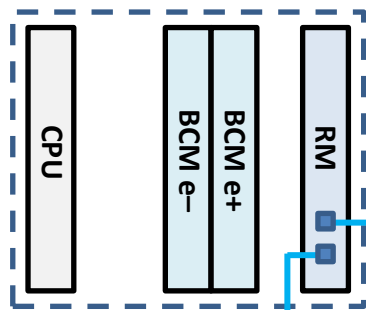
IOC Central Control
Indicate injection RF-bucket

IOC D7
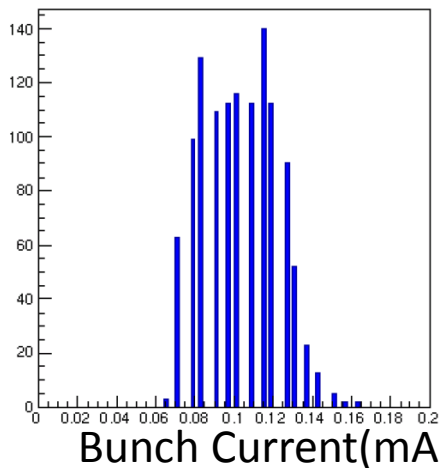Measure charge of individual bunches

Optical Cable

Bunch Current Equalizing

Turn BCE "ON" with following bunch current

13 minutes after ...

Mean: 0.103 mA
RMS: 0.019 mA

Mean: 0.103 mA
RMS: 0.0087 mA
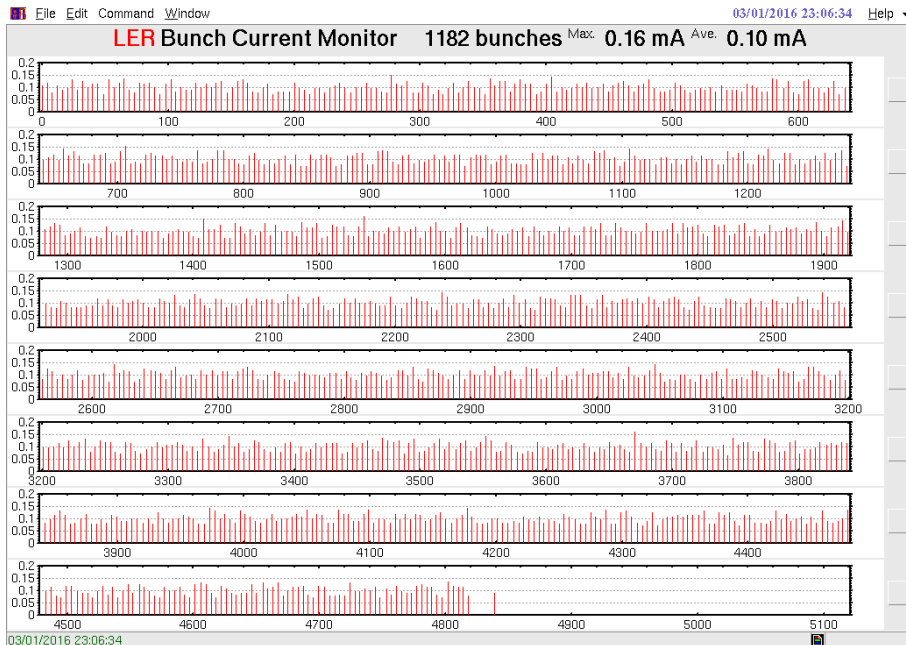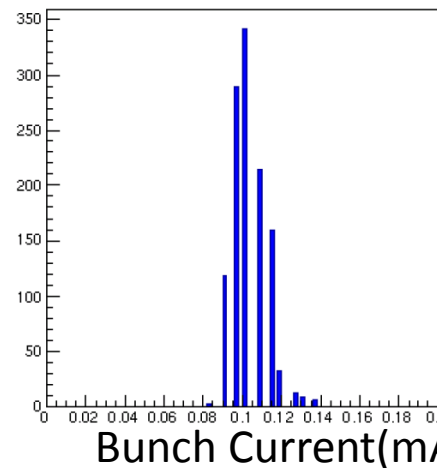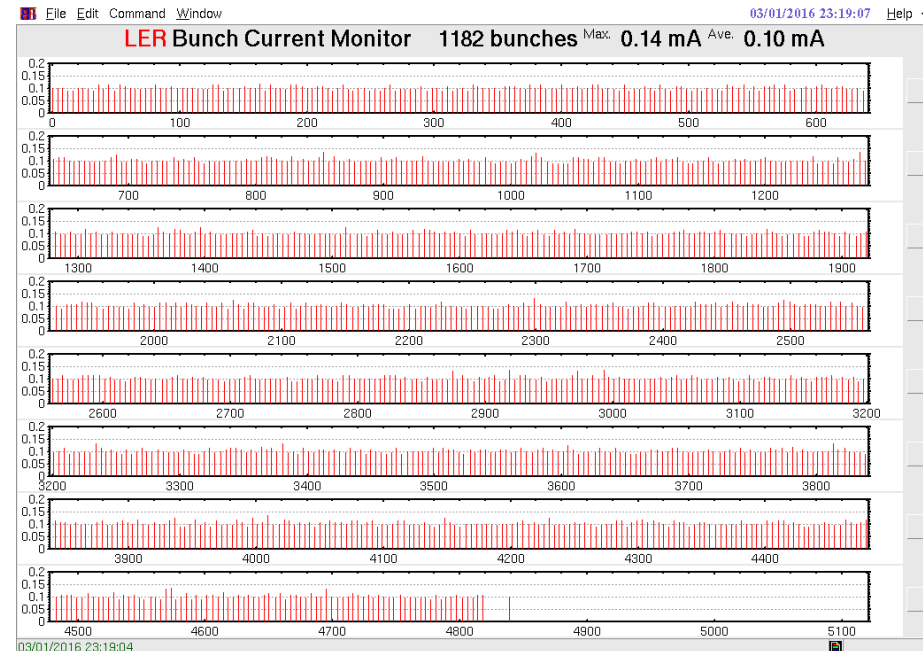
Event Timing System

MR Sub-timing Station is configured at Central Control Building.

The new Event Generator (EVG) is installed to enhance the capability of timing system.
It delivers 15 kinds of timing-triggers.
(BPMs at BT, kicker/septum magnets, other ring components …)

MR Sub-timing Station

MR Sub-timing Station is a **state-of-the-art** timing system.

We installed the **EVG** developed by Shanghai Institute of Applied Physics (SINAP).
Our Event Timing System is the mixture of MRF and SINAP modules.

The drift and jitter of upstream Event is cancelled by resynchronizing with Main Ring RF clock.
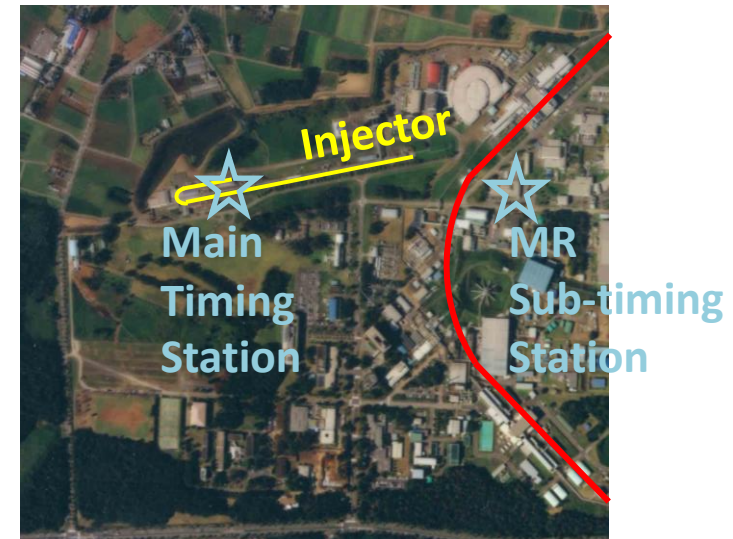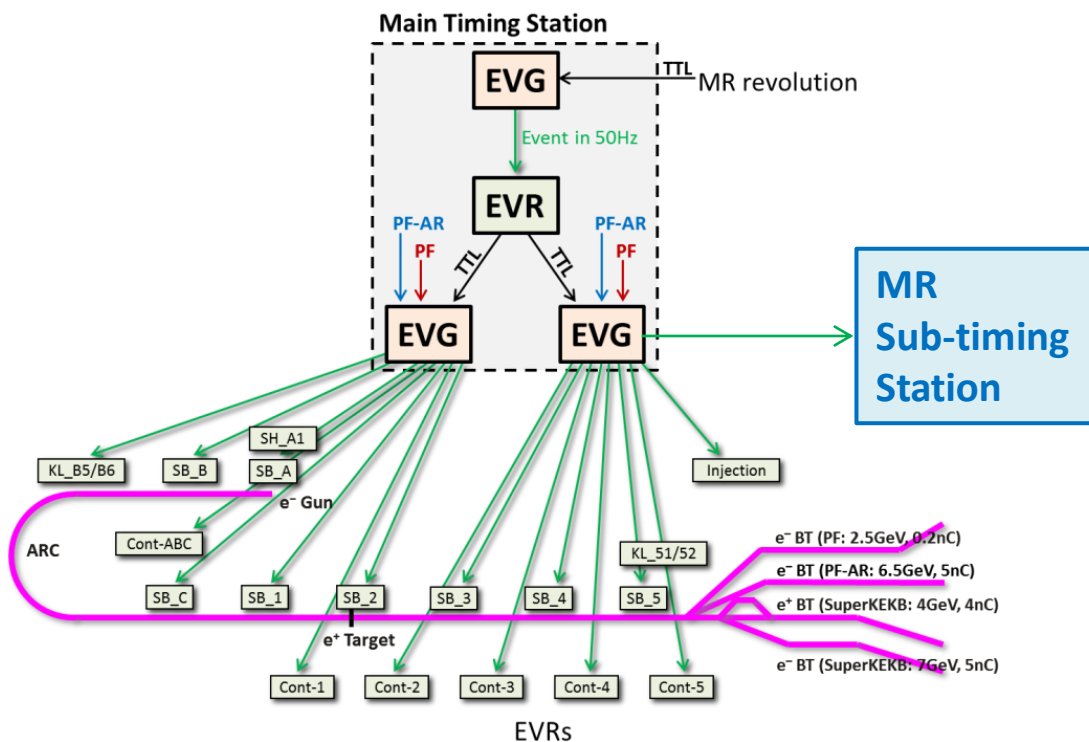
The 15 kinds of timing-triggers are generated from only one Event-Code.

Injector Linac

RF: **2856MHz**
1/55

VME-EVG-230 (MRF)
Event clock: 114.24MHz

Other EVRs at LINAC

distance ~1km

MR Sub-timing Station

RF: **508.89MHz**
1/7

EVG (SINAP)
Event clock: 72.70MHz

EVR (SINAP)
72.70MHz

septum/kicker magnets, ...
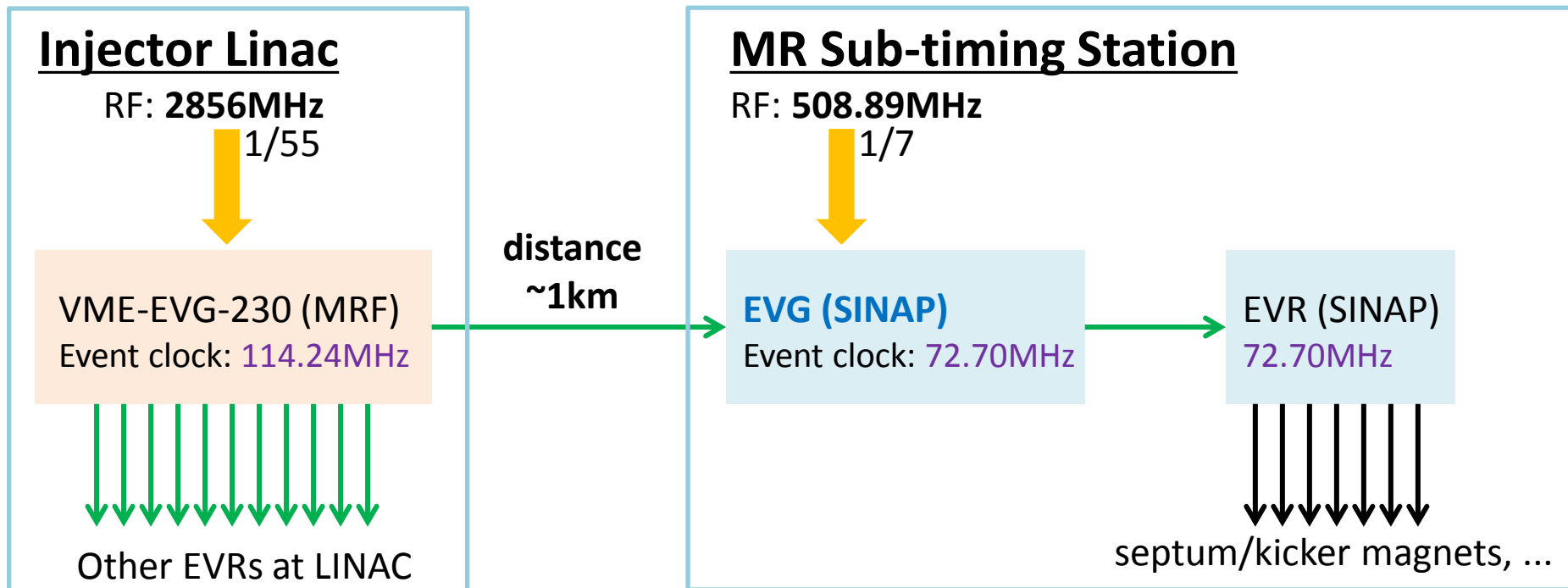
Picture of Sub-timing Station

Event fanout and trigger monitoring system

EVG **EVRs**

Main part (EVG and EVRs)

RF synchronization

KEKB

510MHz

$\sim$ → 1/51 → $\sim$ **508.89MHz**

Phase-shifter

RF phase is switched between e$^+$ and e$^-$.
(This is controlled by the KEKB side.)

LINAC

1/51

$\sim$ **571.2MHz**

division/multiplication

10.385MHz   114.24MHz   571.2MHz   2856MHz
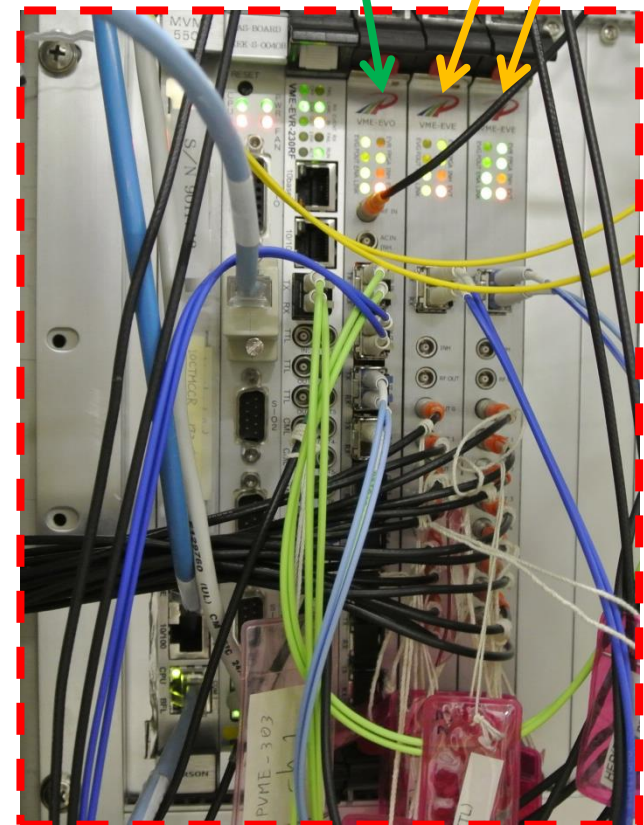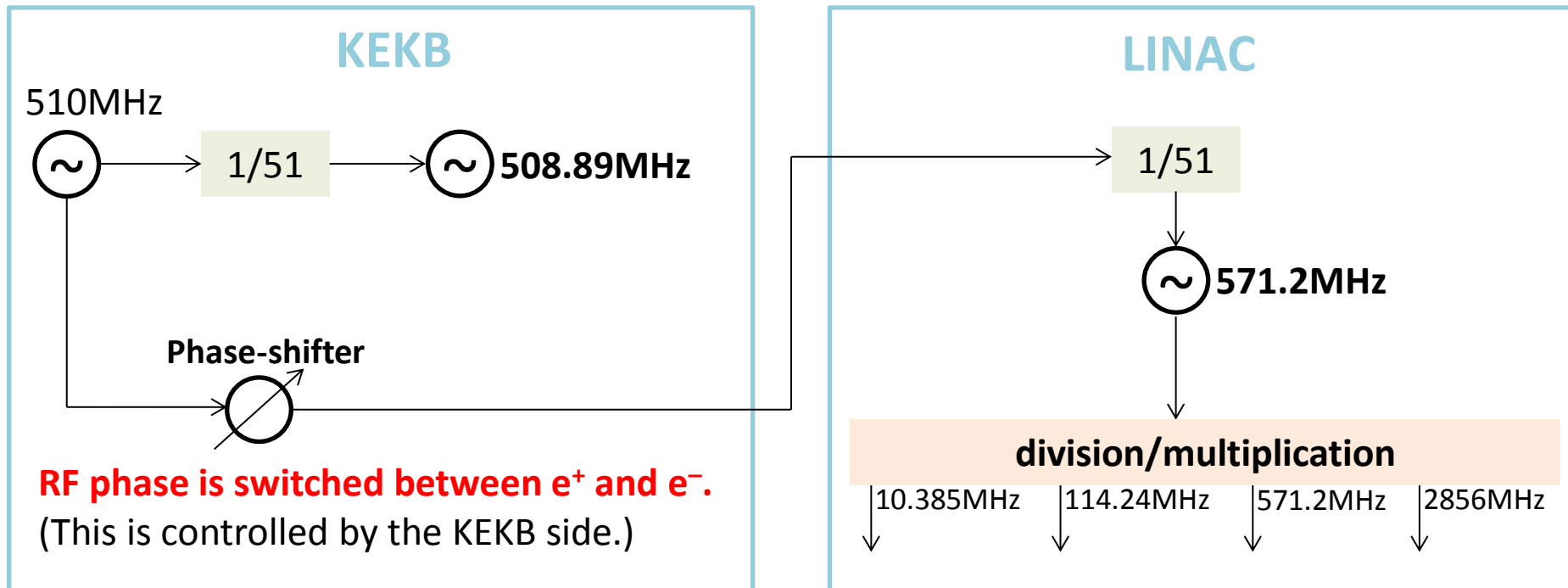
The RF phase switching (jumping) is not acceptable for some LINAC components.
 - We cannot operate RF gun for e$^+$/e$^-$ beam simultaneously.
 - Event Timing System becomes unstable.

We will remove the phase-shifter at KEKB in run-2.

New Configuration in run-1

We will test new configuration in the end of run-1.
 - do not switch RF phase at the KEKB side
 - Four local phase-shifters at LINAC
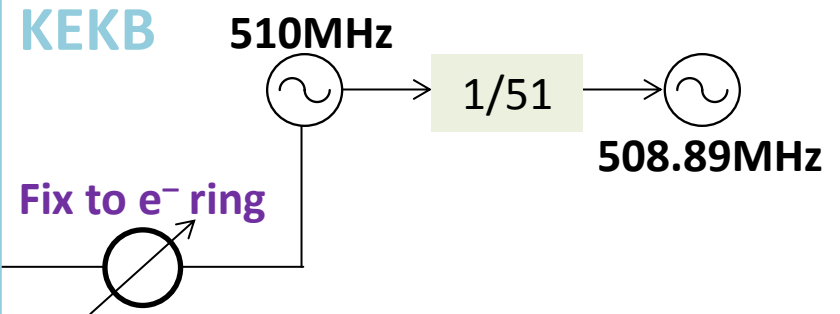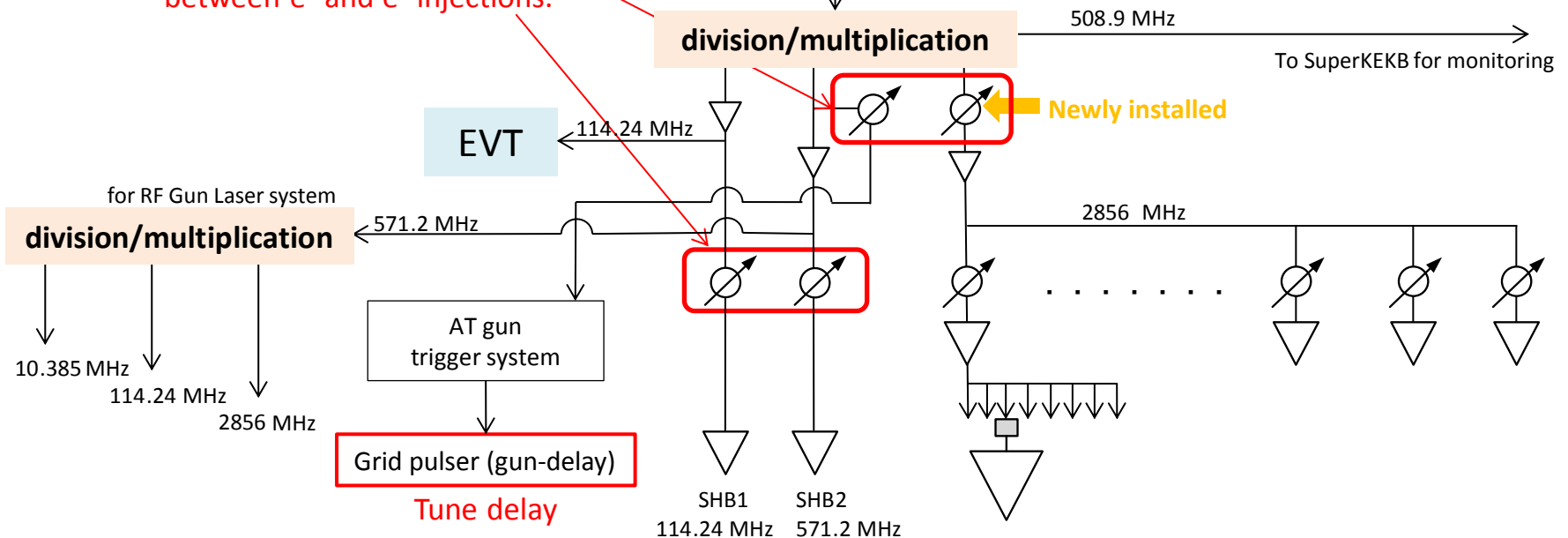   are switched between e⁻ and e⁺ injections.

KEKB

510MHz

1/51

508.89MHz

Fix to e⁻ ring

LINAC

1/51 → **571.2MHz**

Phase-shifters are switched between e⁻ and e⁺ injections.

division/multiplication

508.9 MHz
To SuperKEKB for monitoring

Newly installed

114.24 MHz

EVT

for RF Gun Laser system

division/multiplication

571.2 MHz

2856 MHz

10.385 MHz

114.24 MHz

2856 MHz

AT gun
trigger system

Grid pulser (gun-delay)

Tune delay

SHB1
114.24 MHz

SHB2
571.2 MHz

Summary

Injection Control System plays an important role for SuperKEKB.
This is one of the most successful system in the run-1 operation.
It delivered a large amount of beam into two main rings.

Injection processes by LINAC are control from main ring side with arbitrary injection rates.
Beam Gate Control system delivers fast and robust signals to LINAC for enabling and disabling electron gun.
It realizes the "nearly" top-up filling and helps the operation for vacuum scrubbing.

Bucket Selection manages the RF-bucket to be injected next beam-pulse and realizes the requested fill pattern.
The "Bunch Current Equalizing" mode is working properly.

MR Sub-timing Station is configured at Central Control Building.
Newly installed EVG enhanced the capability of timing system.
One local set of EVG and EVRs provides 15 kinds of timing-triggers by the only one Event-Code from LINAC.