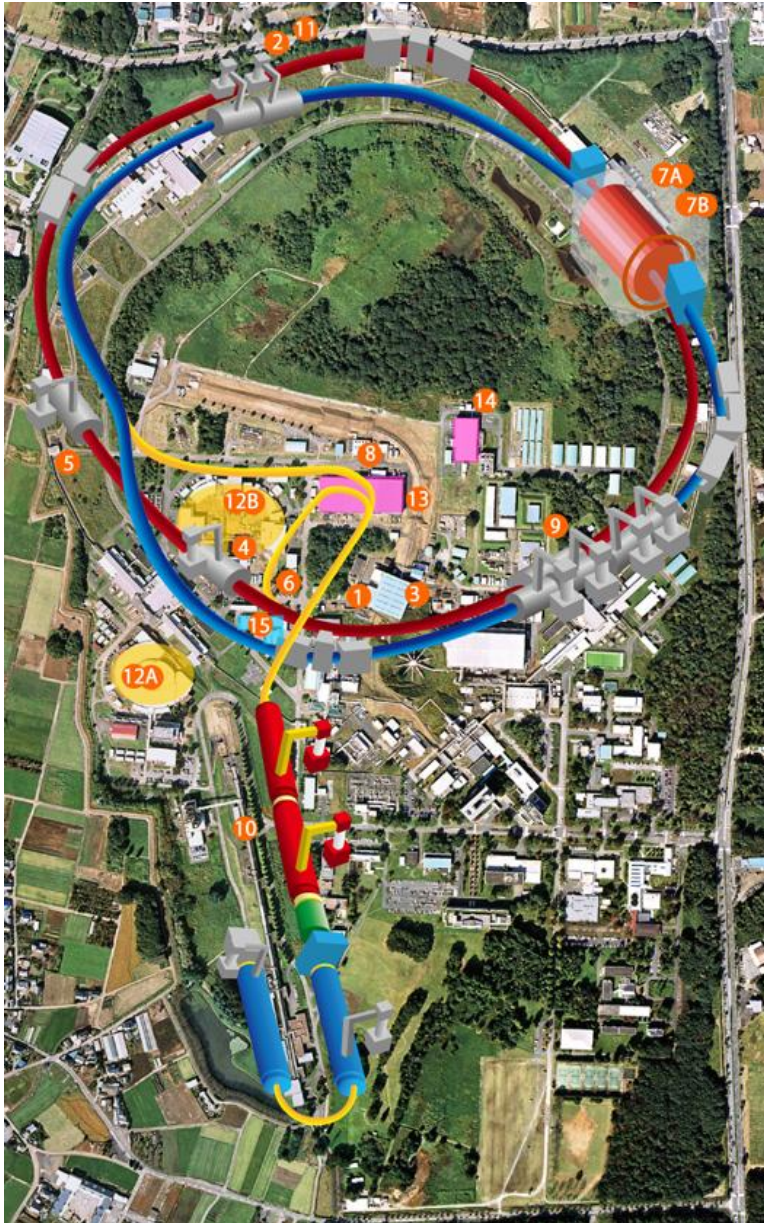


New Event Timing System for Damping Ring at SuperKEKB

Hiroshi Kaji (KEK)

on behalf of the SuperKEKB control group

SuperKEKB and KEK



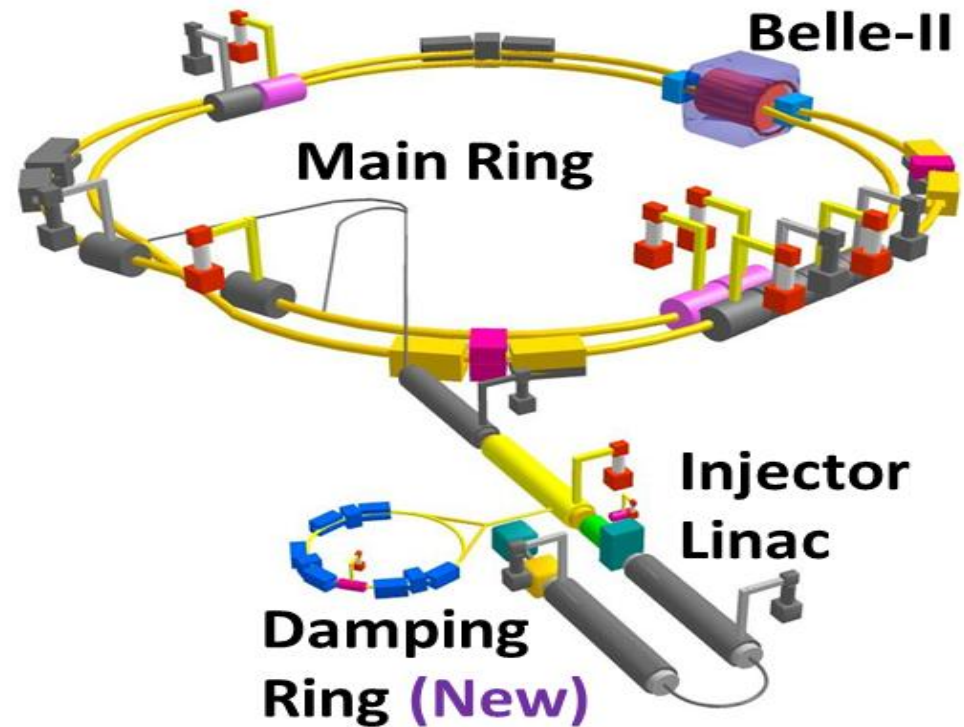
SuperKEKB

Accelerators, the electron-positron collider

One of the most important projects at KEK

Operation will start in the early 2016

Target luminosity is $8 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1}$. ← **world record**

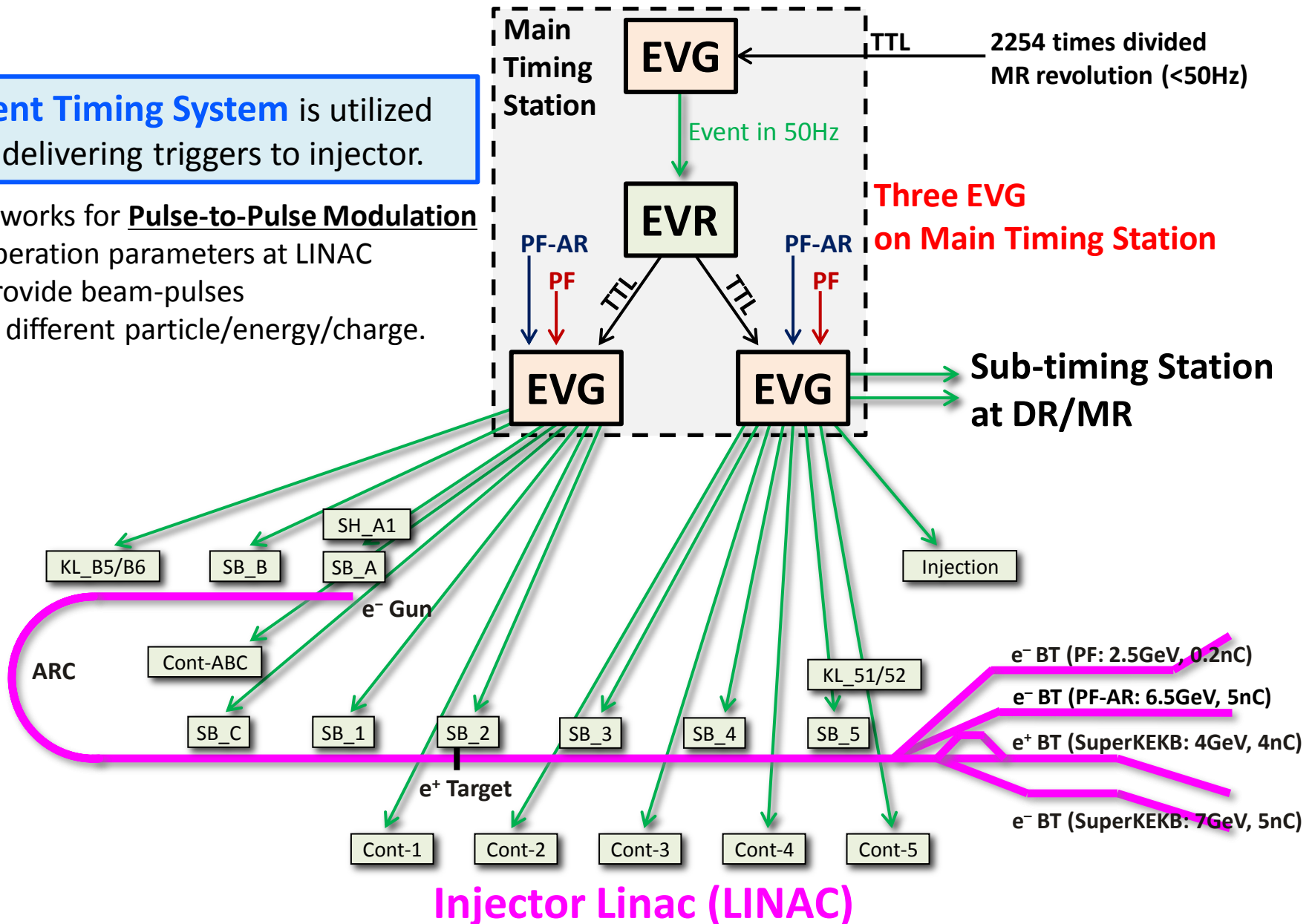


Today, we focus on the timing system for newly constructed Damping Ring.

Timing System for SuperKEKB Project

Event Timing System is utilized for delivering triggers to injector.

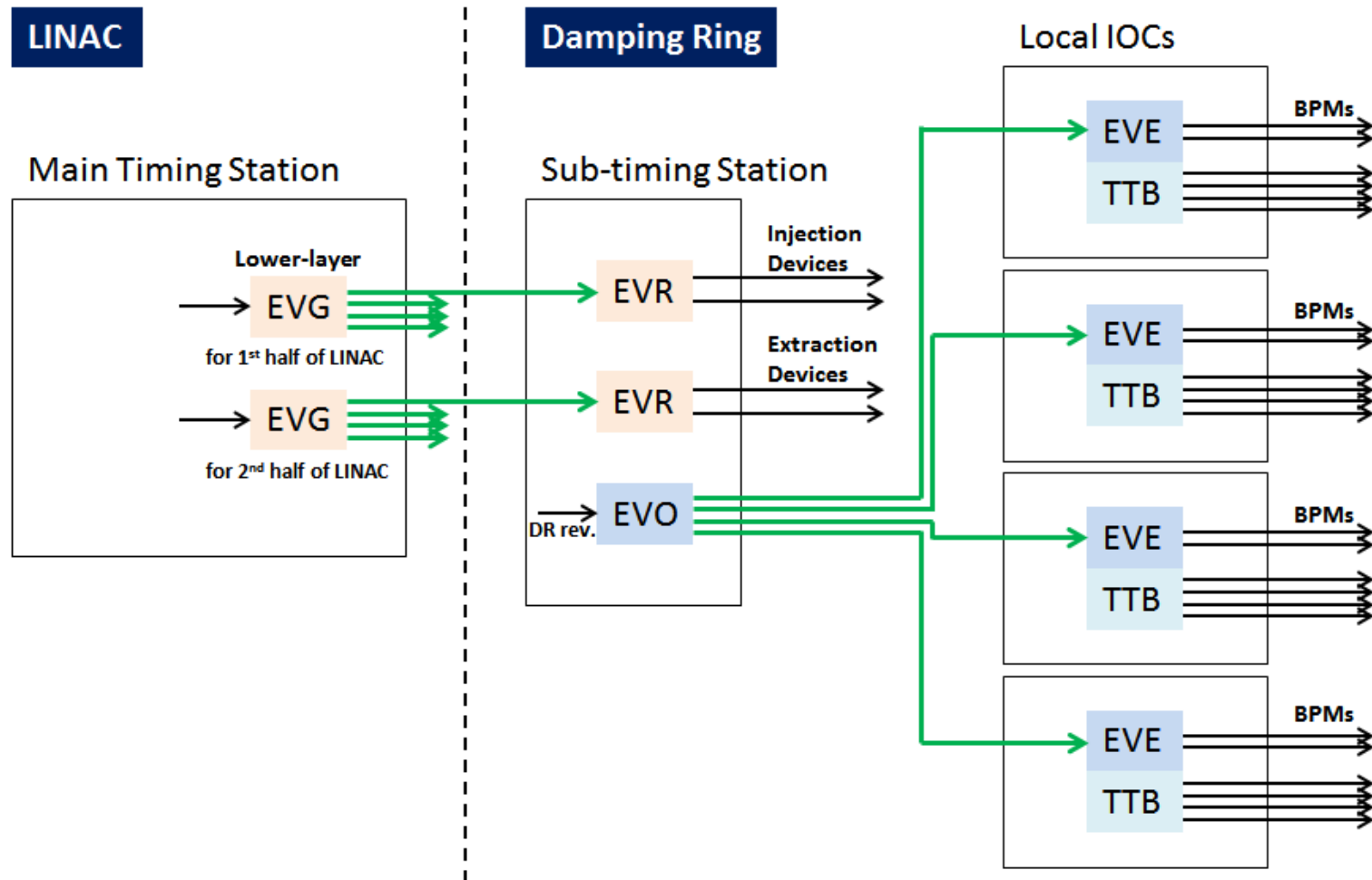
also works for **Pulse-to-Pulse Modulation** of operation parameters at LINAC to provide beam-pulses with different particle/energy/charge.



Sub-timing Station at Damping Ring

Damping Ring (DR) needs two kinds of triggers:

- Injection/extraction Triggers \Rightarrow Events from Main Timing Station
- Triggers for beam monitors \Rightarrow **New Modules** triggered by DR revolution



VME-EVO

Originally developed for proton therapy machine at SINAP.
We customized it for SuperKEKB.

VME-EVO works as EVG, EVR, or fanout modules — *It depends on the setting.*

Based on

FPGA Xilinx vertex-6

Input:

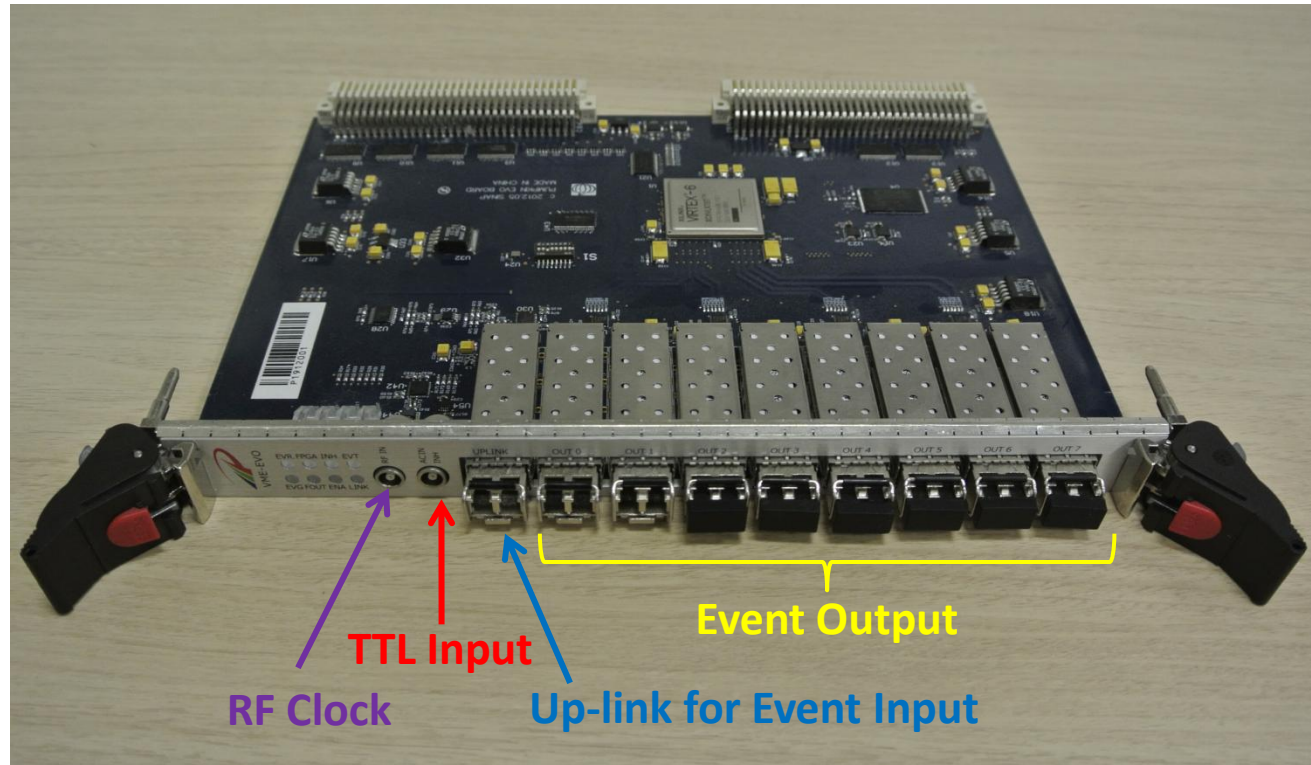
TTL or Up-link Event

Output:

8 Ports for Event output

Event clock:

60-135 MHz



We do not need fanout module.

VME-EVO(EVG) can choose different Event clock from that of up-link module.
even though it operates with the triggers from up-link.

It can be connected with VME-EVG-230 (up-link) and VME-EVR-230RF (8outputs).

VME-EVE and VME-TTB

They work as EVR and its expansion modules.

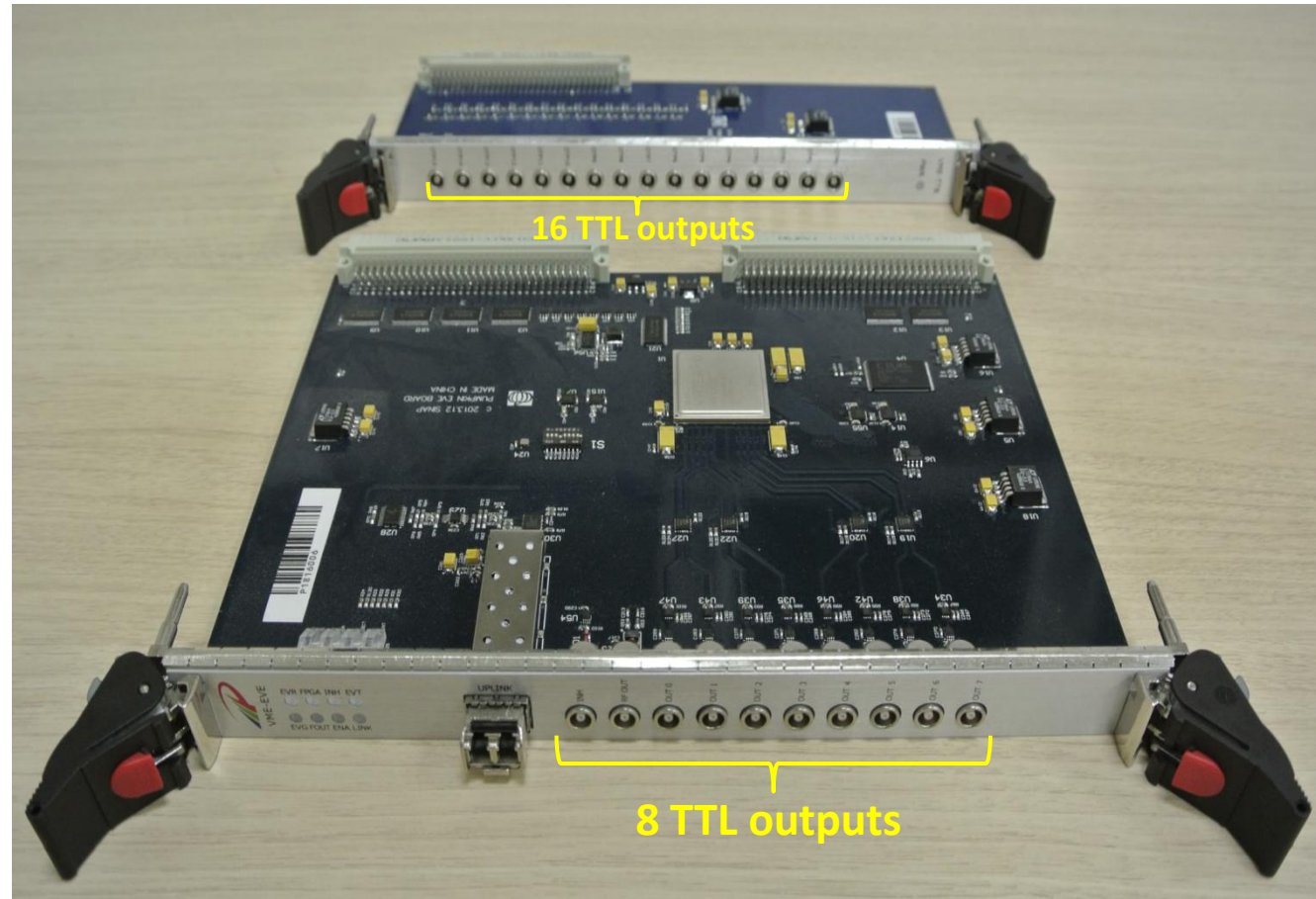
We customized also them for SuperKEKB.

VME-EVE:

- 8 TTL outputs
- Two kinds of delays
 1. Event clock delay
 2. 20 time fine delay (based on GTX)

VME-TTB:

- Expansion board for VME-EVE
- 16 TTL outputs
- Two kinds of delays
 1. Event clock delay
 2. 20 time fine delay (based on GTX)



Totally 24 outputs, they can be enable/disable and delayed independently.

Note, we are developing also module with NIM outputs.

Its up-link can be connected with VME-EVG-230.

Trigger Requirements for 84 BPMs at DR

There are 84 BPMs at DR.

⇒ We prepare 4 IOCs of “VME-EVE and VME-TTB” and individual IOCs manage triggers for 21 BPMs.

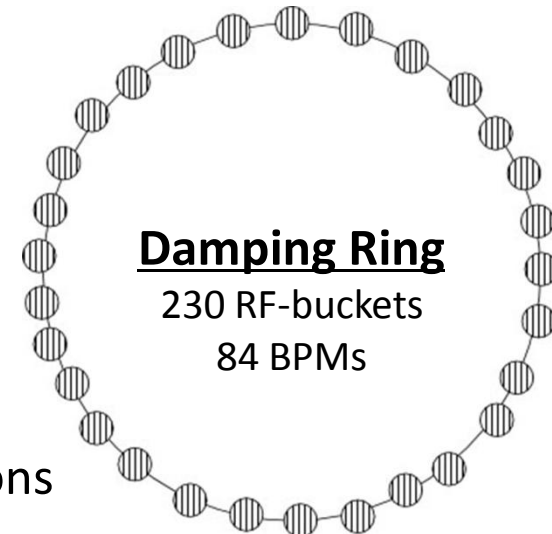
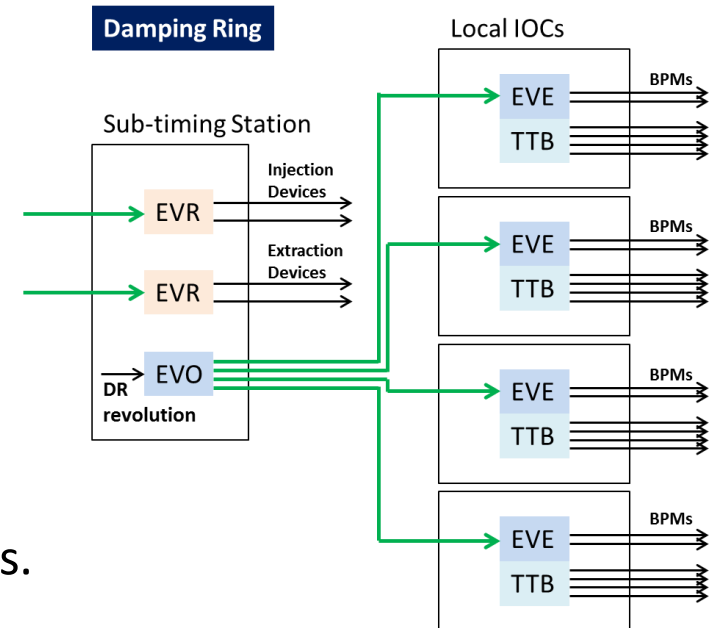
Triggers should be coincided with the storage bunches.

⇒ Put RF clock of 508.89MHz for RF cavity into RF-IN

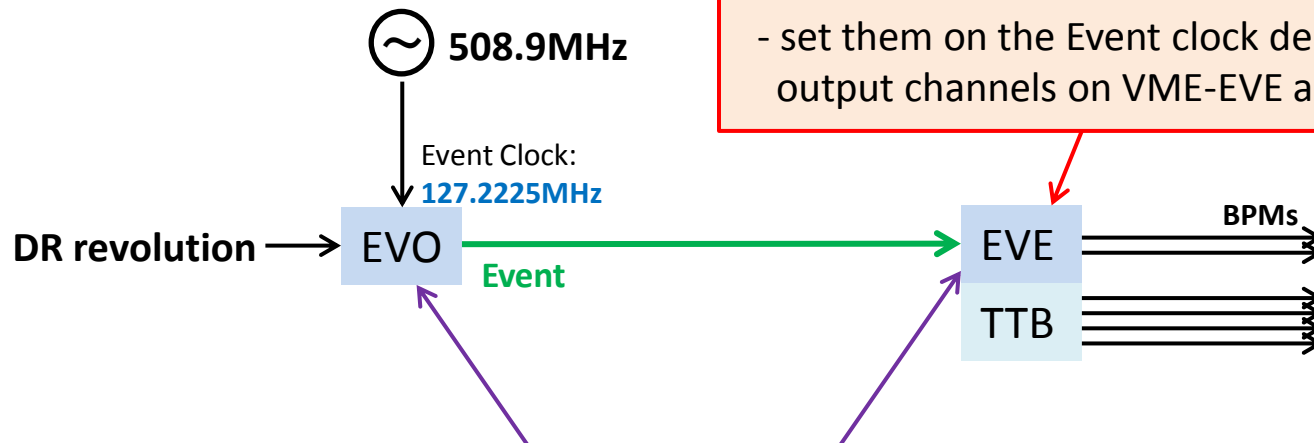
⇒ Put DR revolution into AC-IN

Delay values for triggers are determined from two kinds of timing adjustments.

- Adjustment for compensating the difference in BPM positions
- Adjustment to the timing to storage bunches



Delay Setting for BPM Triggers



Timing Adjustment for BPM Positions

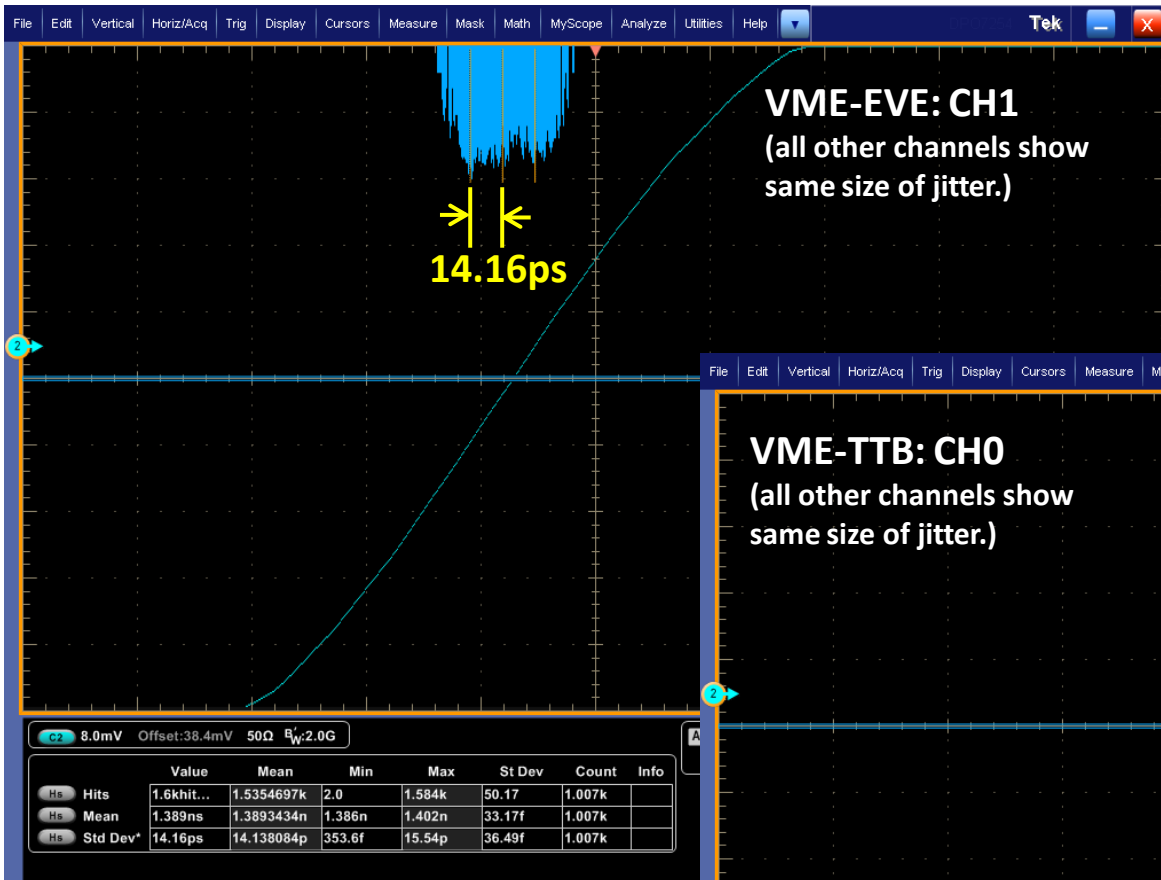
- different for the individual BPMs
- set them on the Event clock delay of individual output channels on VME-EVE and VME-TTB

Adjustment to fit the timing to storage bunches

- common for all BPMs
- scheduled on the sequence RAM of VME-EVO, however 4 times precise setting is mandatory
- use find delay functions of VME-EVE outputs to satisfy required precision

Module	Type	Precision	
VME-EVO	Scheduled on sequence RAM	127.2225 MHz, 7.8ns step	For beam-pulse timing, changed in 50Hz
VME-EVE (or VME-TTB)	Event clock delay	127.2225 MHz, 7.8ns step	For BPM position, static
VME-EVE (or VME-TTB)	Fine delay based on the GTX technology	2544 MHz (127.2225 x20)	For beam-pulse timing, changed in 50Hz

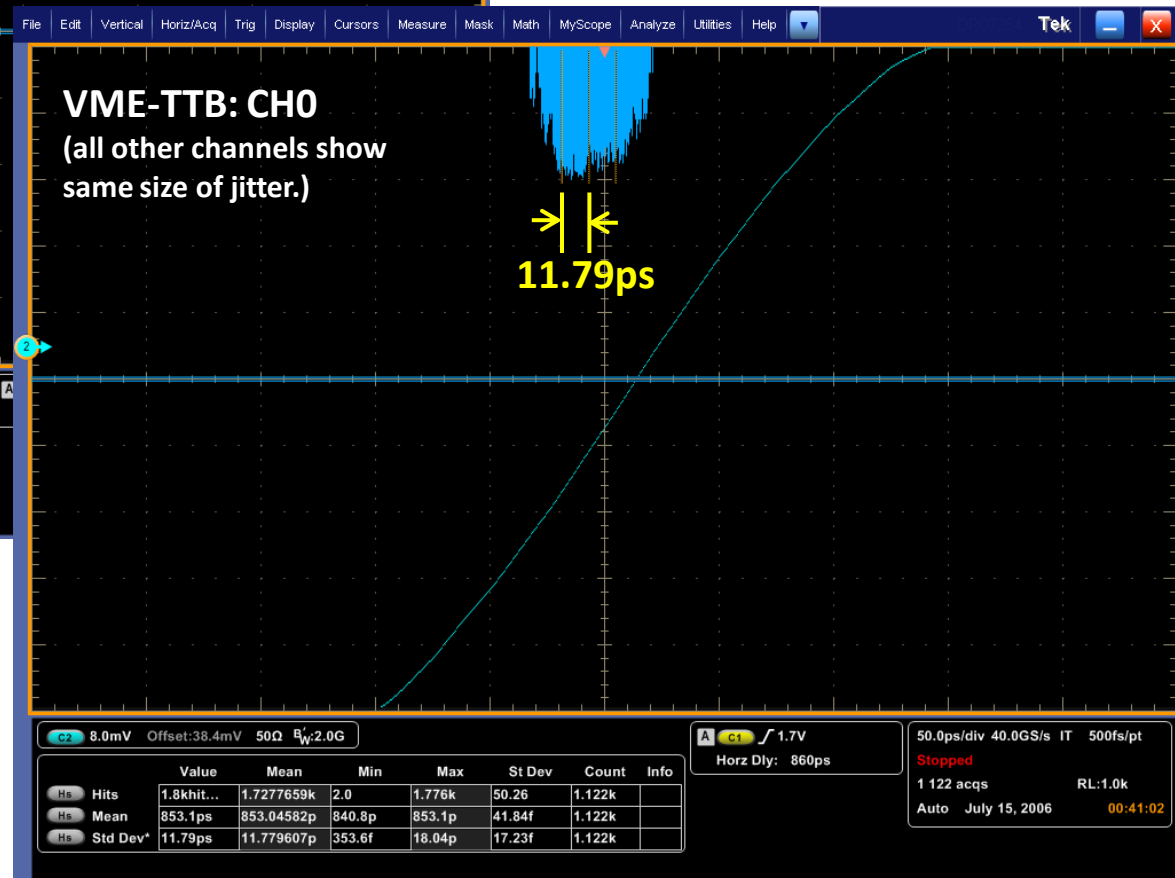
Timing Accuracy of New Modules



Tektronix DPO7254

Trigger resolution: 100fs

Sampling step: 500fs



Note, same study performed at SINAP shows jitters of ~6ps and ~8ps for VME-EVE and VME-TTB, respectively.

Summary

We utilize the Event Timing System for operating our injector.

- not only for delivery of triggers but frequent switching of parameters.

We develop Sub-timing Station at DR with three Event modules.

- injection/extraction timing for septum magnets
synchronized with injector
- triggers for beam monitors which are synchronized with DR revolution

New Event modules are developed (work done by SINAP and KEK).

- The triggers for 84 BPMs can be managed with only 5 Event modules.
- Complicated timing adjustment can be realized with VME-EVO and VME-EVE
- They are compatible with MRF modules.

Timing accuracy of triggers from VME-EVE and VME-TTB are determined to be $\sim 15\text{ps}$ and $\sim 12\text{ps}$, respectively.

⇒ They are well satisfies requirements form our BPMs

