Pulse-by-pulse control of linear accelerator at SACLA

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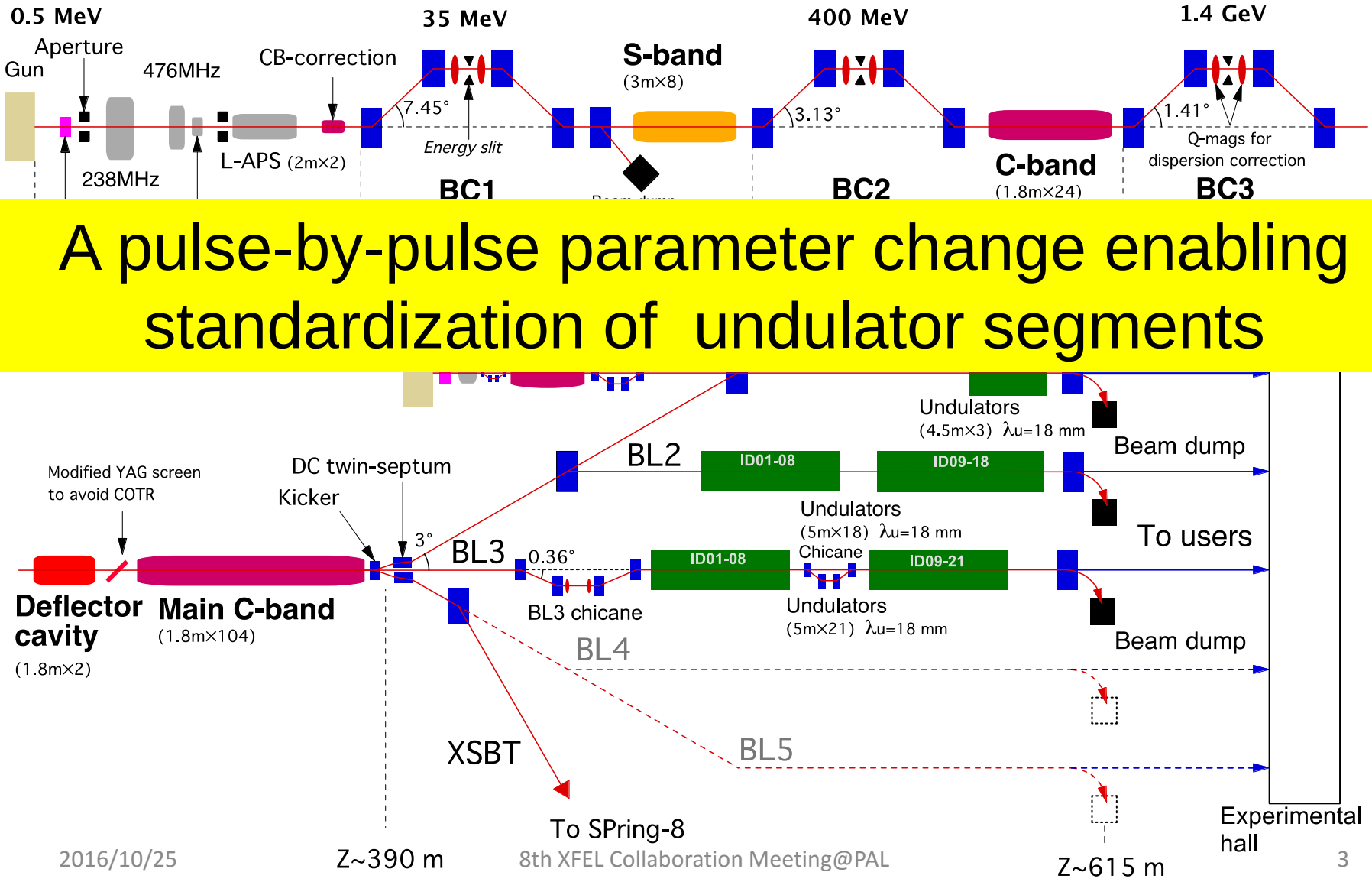
Outline

1. Why pulse-by-pulse control required?
2. R&D overview and time schedule
3. Present status
4. Summary

5 XFEL BLs potentially Installable



Ring-based SR source in the campus

A pulse-by-pulse parameter change enabling use of the SACLA linac as a high performance injector to SPring-8-II

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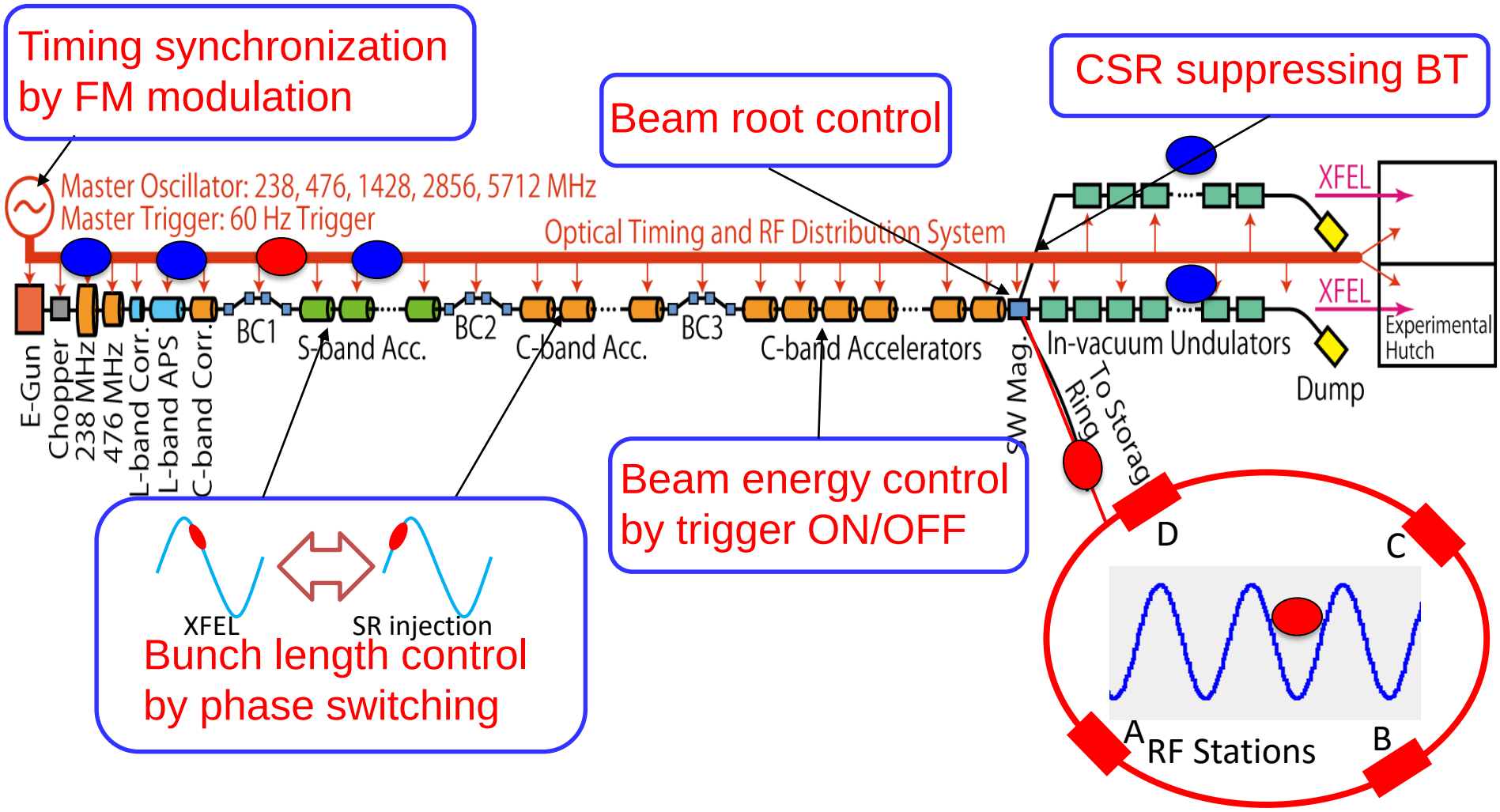
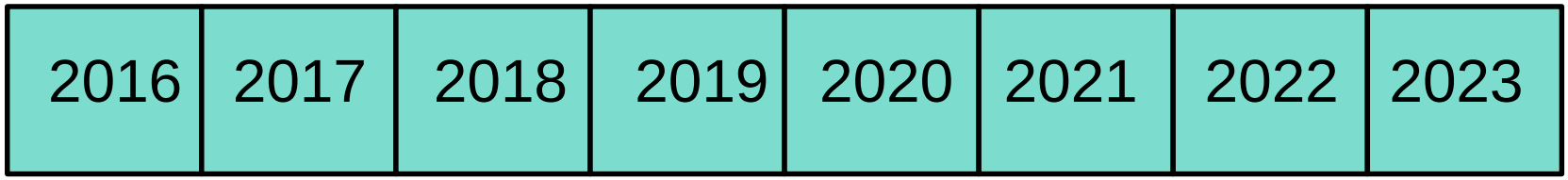
R&D Outline



Five major R&D subjects under progress

SPring-8 Storage Ring

Fiscal Year



CSR suppressing beam transport installed

BL2/BL3 pulse-by-pulse XFEL operations with full performance started

Beam injection test from SACLA linac to current SPring-8 started

Via on-demand beam injection test, existing injector replaced by SACLA linac

Black-out Period of Current SPring-8

Operation with SPring-8-II restarted

1. Why pulse-by-pulse control required?
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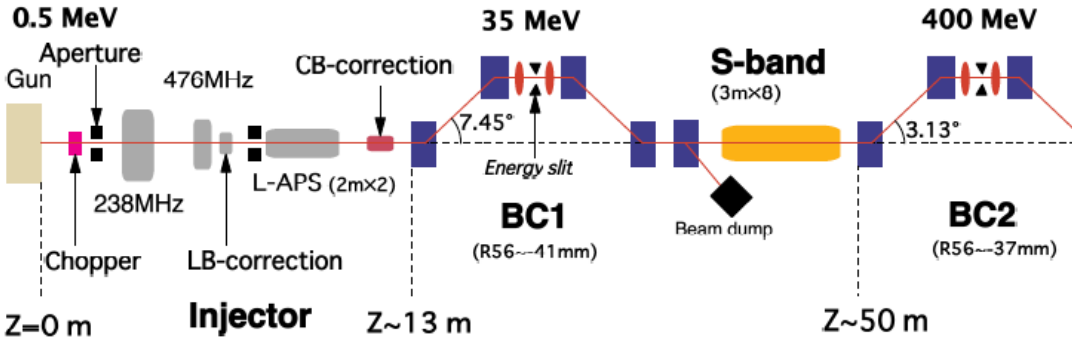
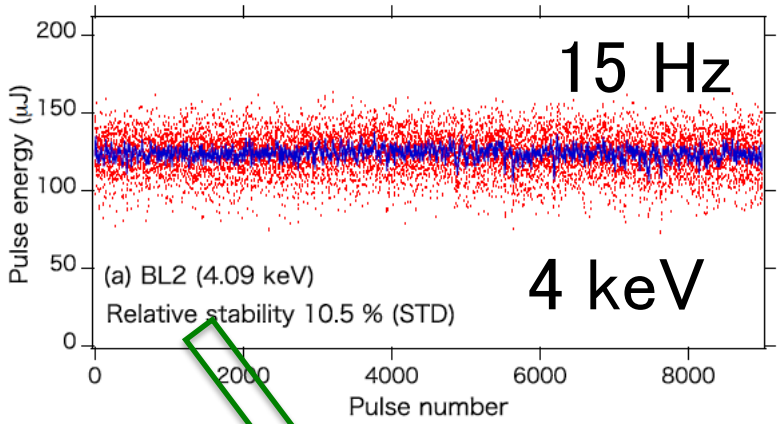
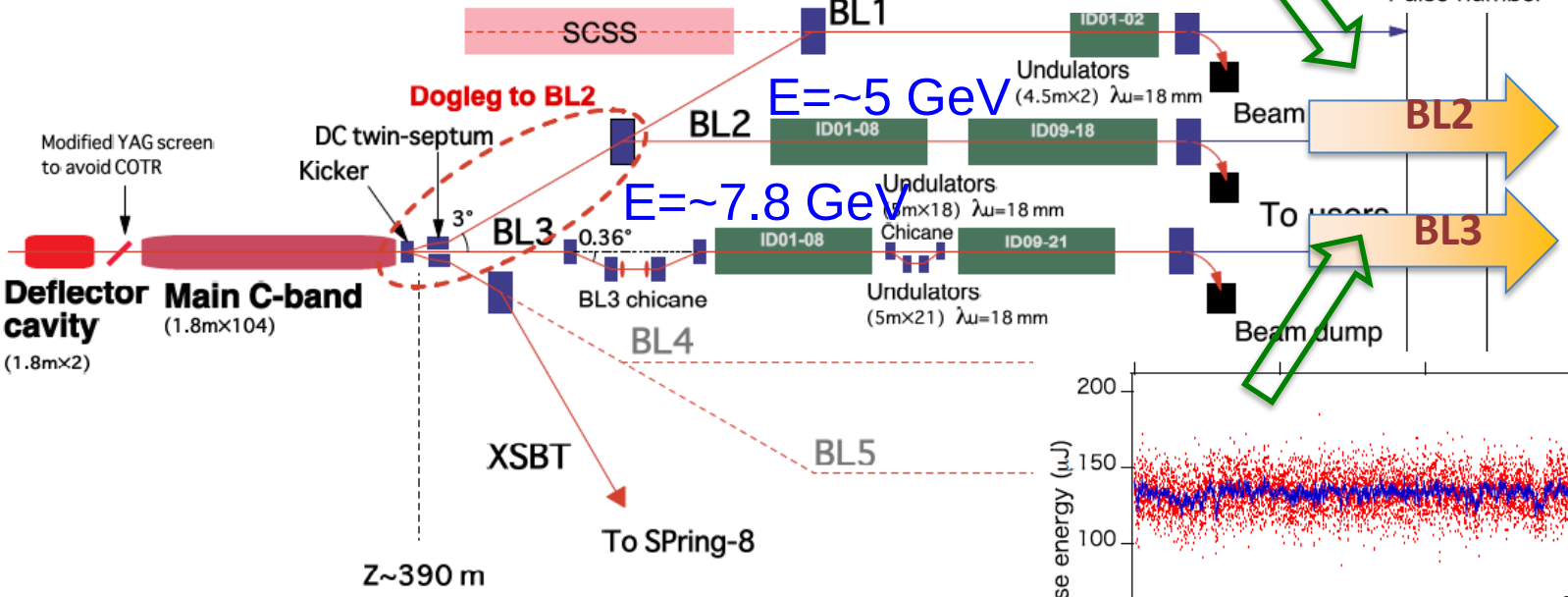
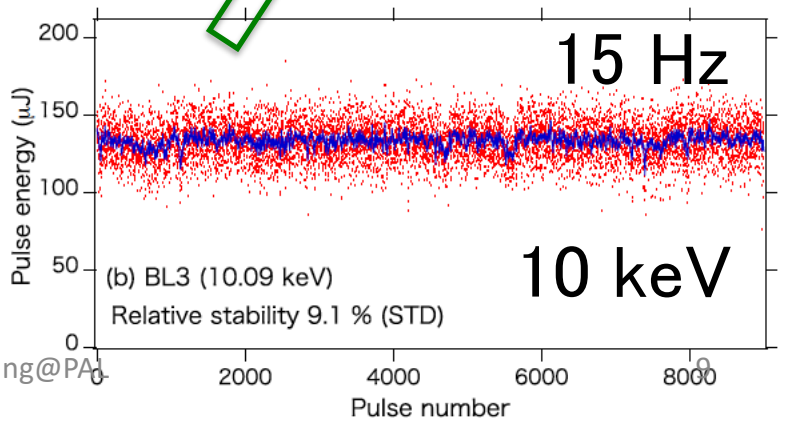
3.1 Towards full performance multi-XFEL BLs pulse-by-pulse operations



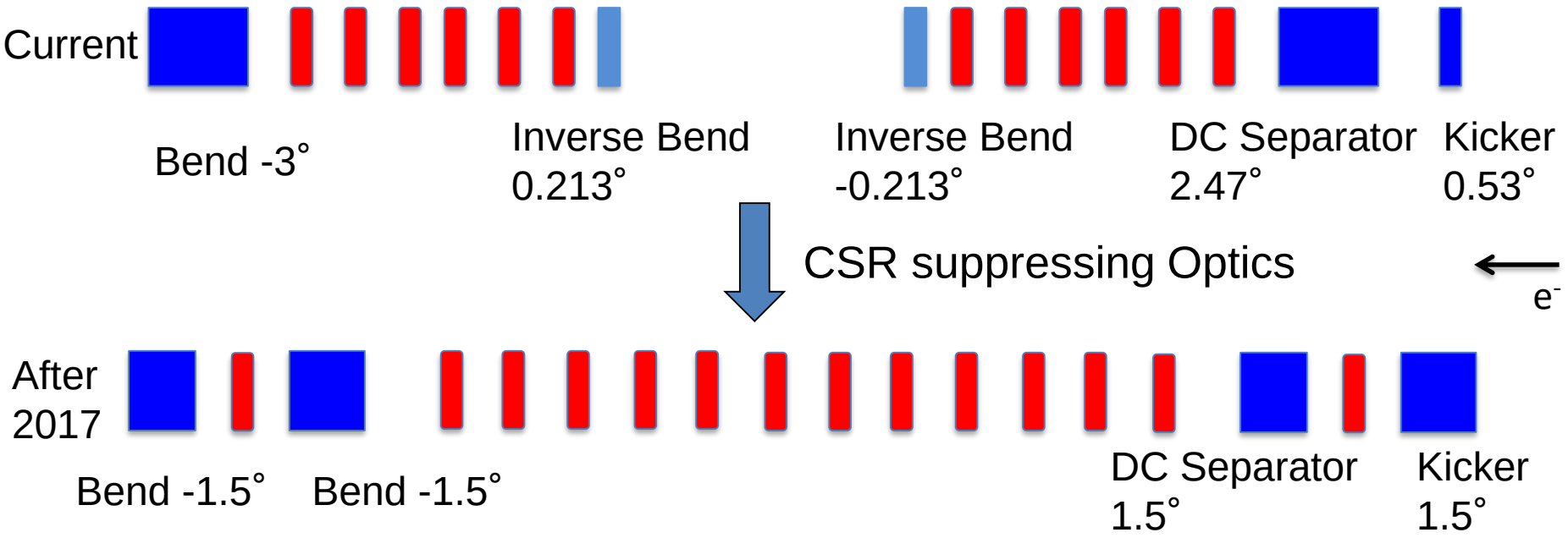


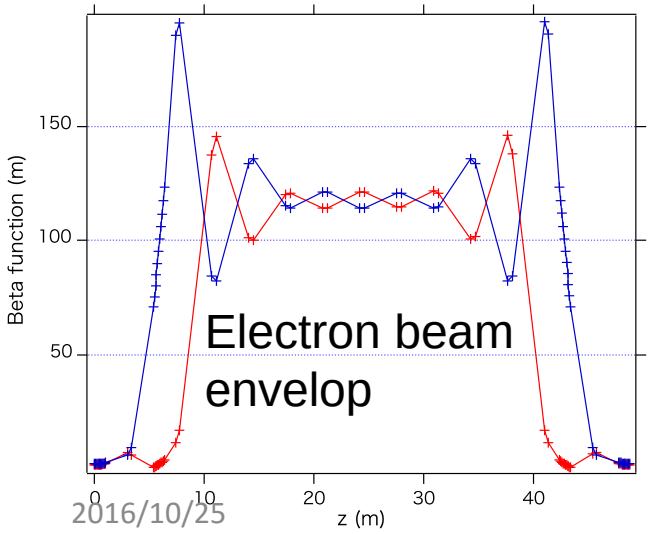


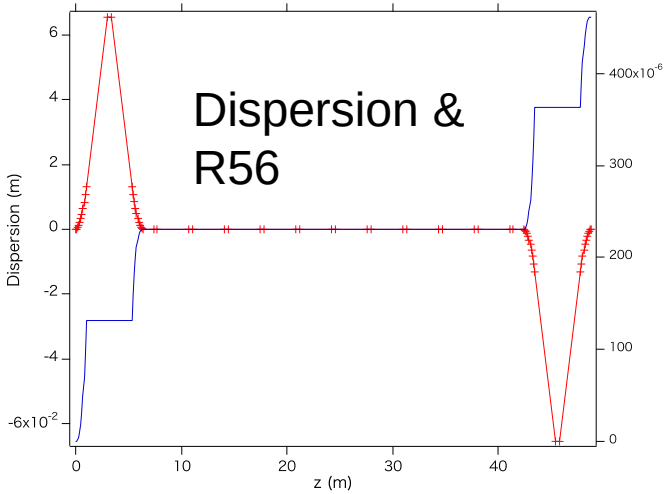


Physical Review Accelerators and Beams 19, 020703 (2016)

3.1 CSR suppressing beam transport





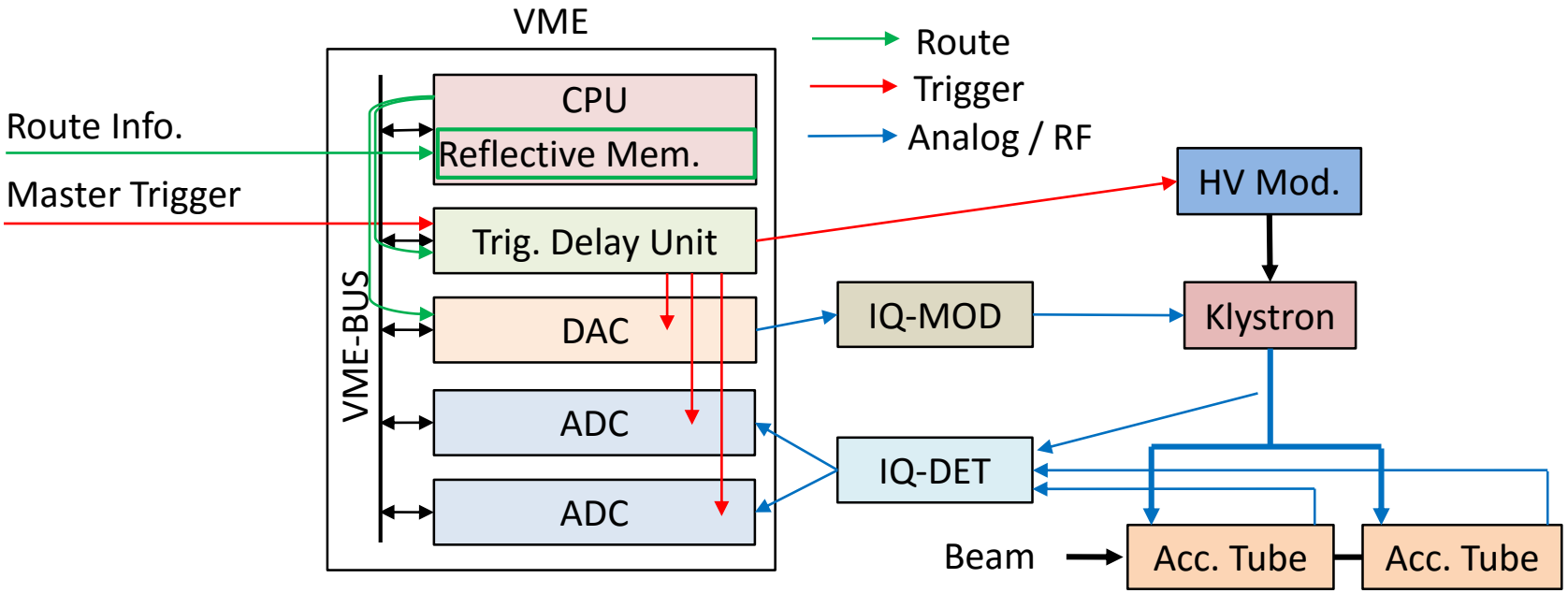


Issues

- One order higher power AC PS
- Wider envelop matching section
- Field shielding for BL3 MAG.

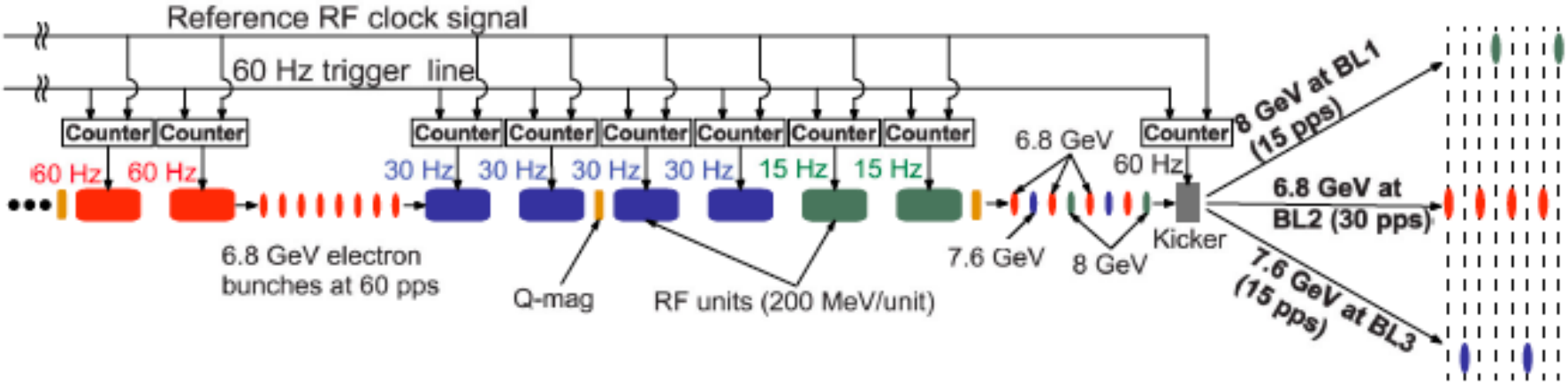
3.2 Pulse-by-pulse accel. param. control

Ethernet based “event information” delivery system



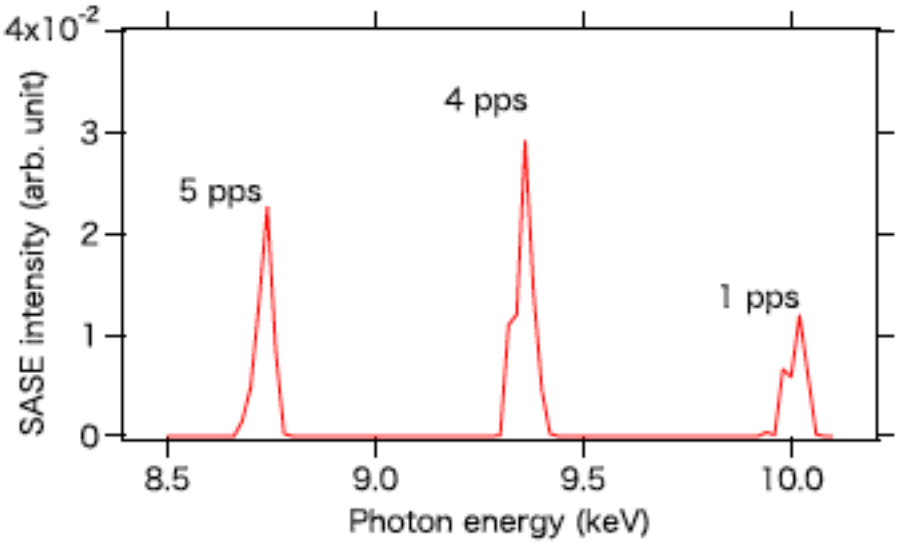
1. Bunch length control by changing the setting phase through DAC
2. Beam energy control by trigger ON/OFF for HV Mod. through TDU
3. Beam root control based on a virtual machine concept

3.2.1 Beam energy pulse-by-pulse control



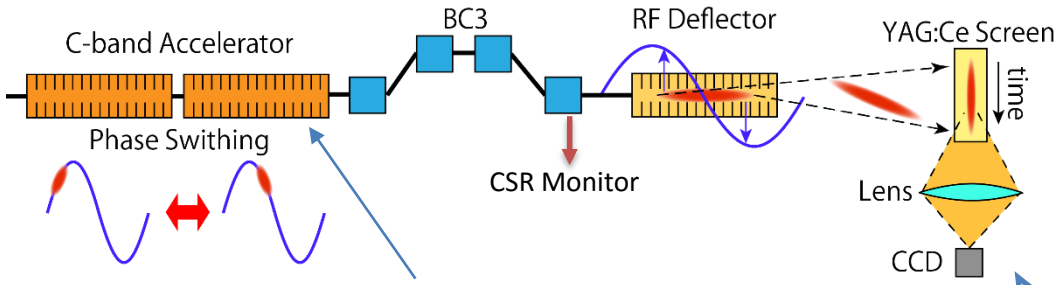
At first, by simple trigger ON/OFF switching for each acceleration unit after BC3, beam energy is changed with a resolution of about 200 MeV

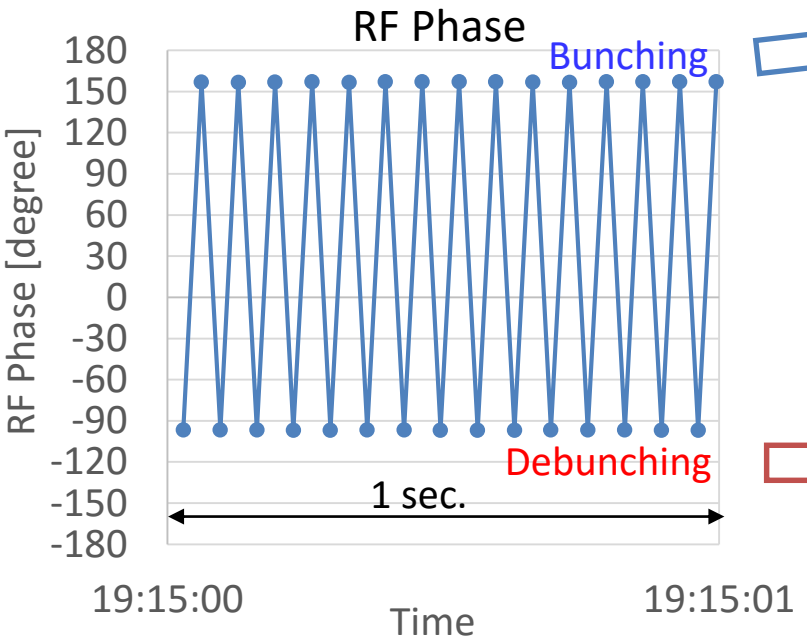
Proof-of-principle experiments were done and this scheme has already released to SACLA routine operations



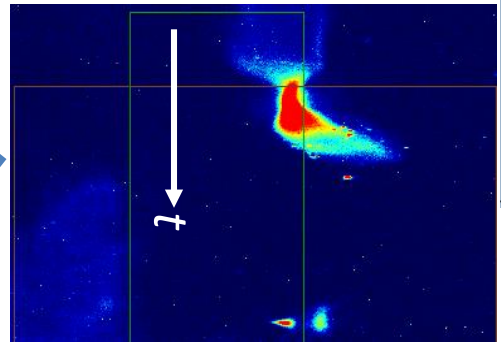
Physical Review Accelerators and Beams 16, 080701 (2013).

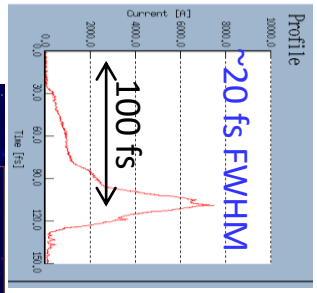
3.2.2 Bunch length pulse-by-pulse control

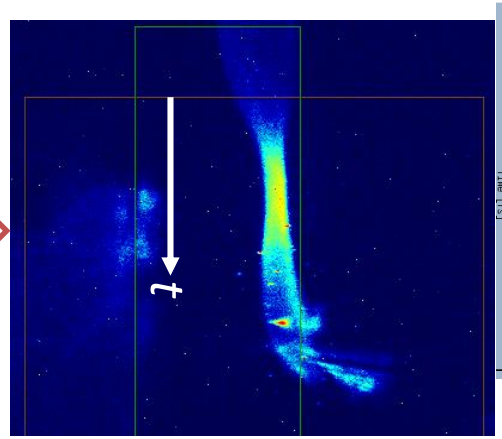


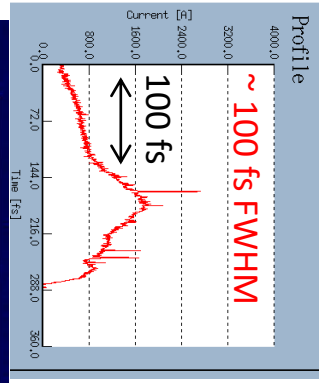


Bunch length measurement by RF deflector









3.2.3 Beam root pulse-by-pulse control(1)

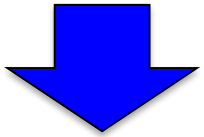
Boundary Condition

1. RF parameters and root switching magnets only changed in a pulse-by-pulse manner
2. Even spaced beam pulses delivered to each XFEL BL

   →Easy data collection
3. Avoiding Interruption of XPP experiments using low repetition rate synchronous lasers by on-demand injections
4. In the first stage, on-demand parameter change is "Top-up injection only"
5. Experimental conditions using XFELs known beforehand
6. Frequency of on-demand injection less than 1 pps

3.2.3 Beam root pulse-by-pulse control(2)

The above boundary condition



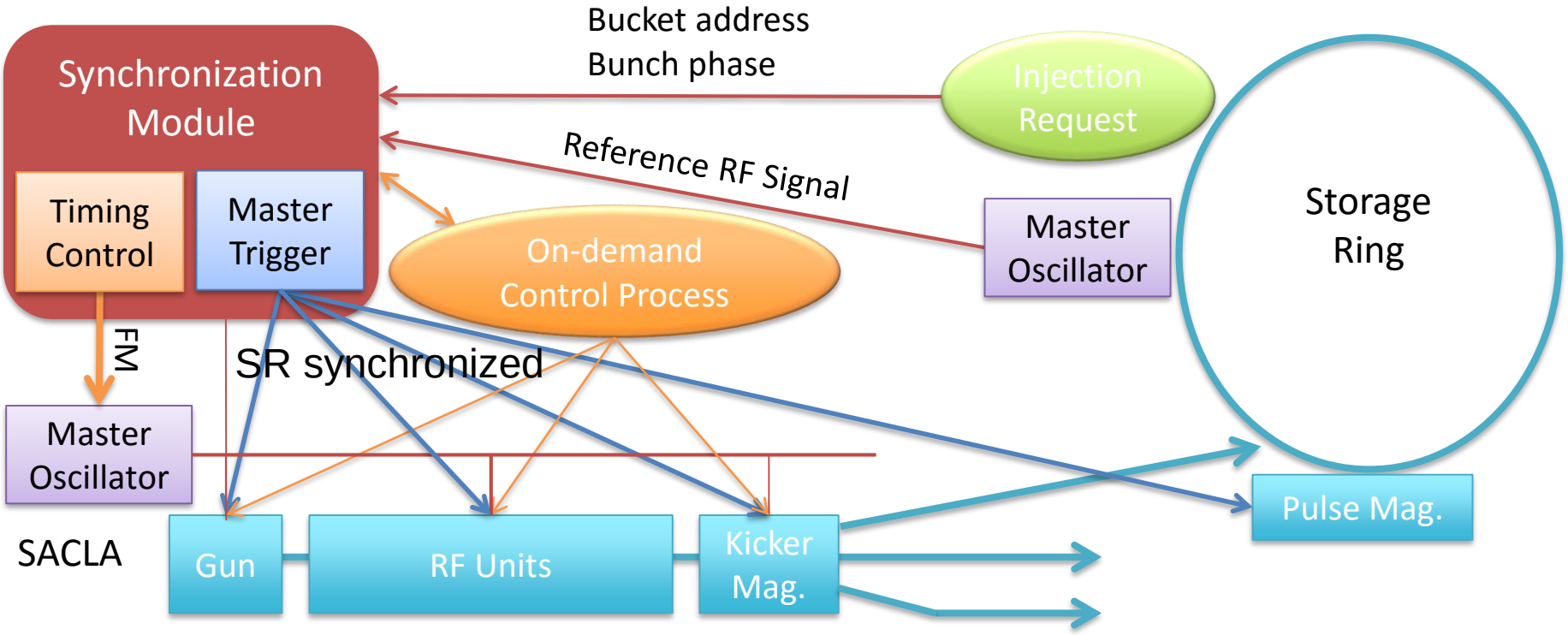
- Not so many root patterns
- Updating root information every 1 sec

Field strengths of switching magnets are changed according to the root information

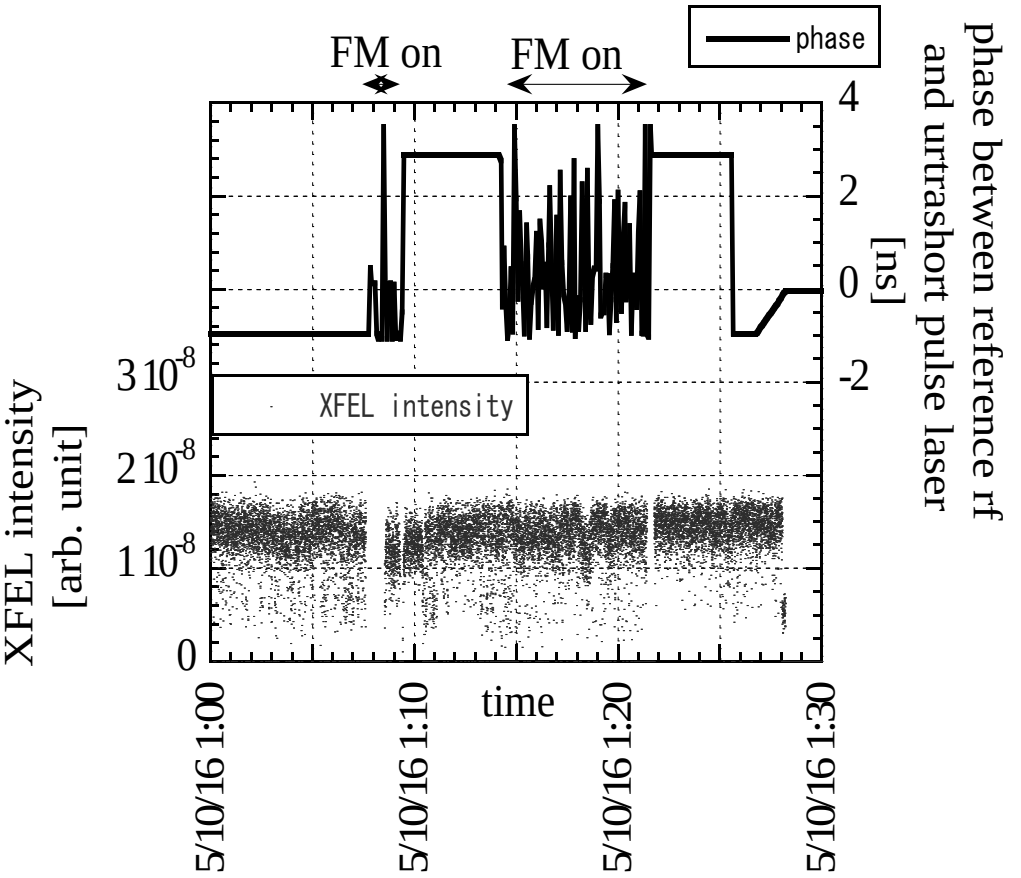
Pattern	1	2	3	4	5	6	7	8	9	10	...	60
BL3 60Hz	BL3	BL3	BL3	BL3	BL3	BL3	BL3	BL3	BL3	BL3		BL3
BL2 60Hz	BL2	BL2	BL2	BL2	BL2	BL2	BL2	BL2	BL2	BL2		BL2
BL2 15Hz, BL3 30Hz	BL2	BL3	---	BL3	BL2	BL3	---	BL3	BL2	BL3		BL3
BL3 60Hz, SR 1-shot	BL3	BL3	BL3	BL3	BL3	BL3	SR	BL3	BL3	BL3		BL3
BL2 60Hz, SR 1-shot	BL2	BL2	BL2	BL2	BL2	BL2	SR	BL2	BL2	BL2		BL2
BL2 15Hz, BL3 30Hz, SR 1-shot	BL2	BL3	---	BL3	BL2	BL3	SR	BL3	BL2	BL3		BL3

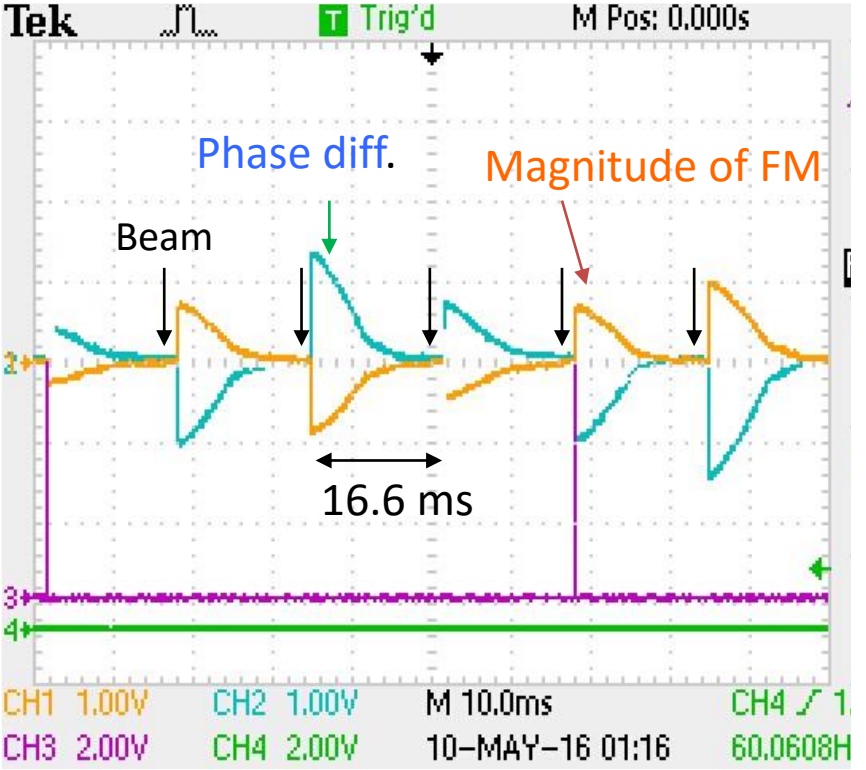
3.3 Timing synchronization(1)

Synchronizing SACLA beam extraction timing to specified RF bucket of the Storage Ring



3.5 Timing synchronization(2)





Prototype of the synchronization system tested at SACLA.

- Timing jitter of 1.2 ps rms obtained, which satisfies target value
- Small influence to the XFEL performance

Summary

1. So far no showstopper found and all R&D activities have well progressed.

2. Full-performance pulse-by-pulse XFEL operations with two BLs, BL2 and BL3 will be started in next spring.

3. Test beam injections from SACLA to the current storage ring will be performed in FT2018, prior to shutdown of the current SPring-8 accelerator complex.

Thank you for your attention!