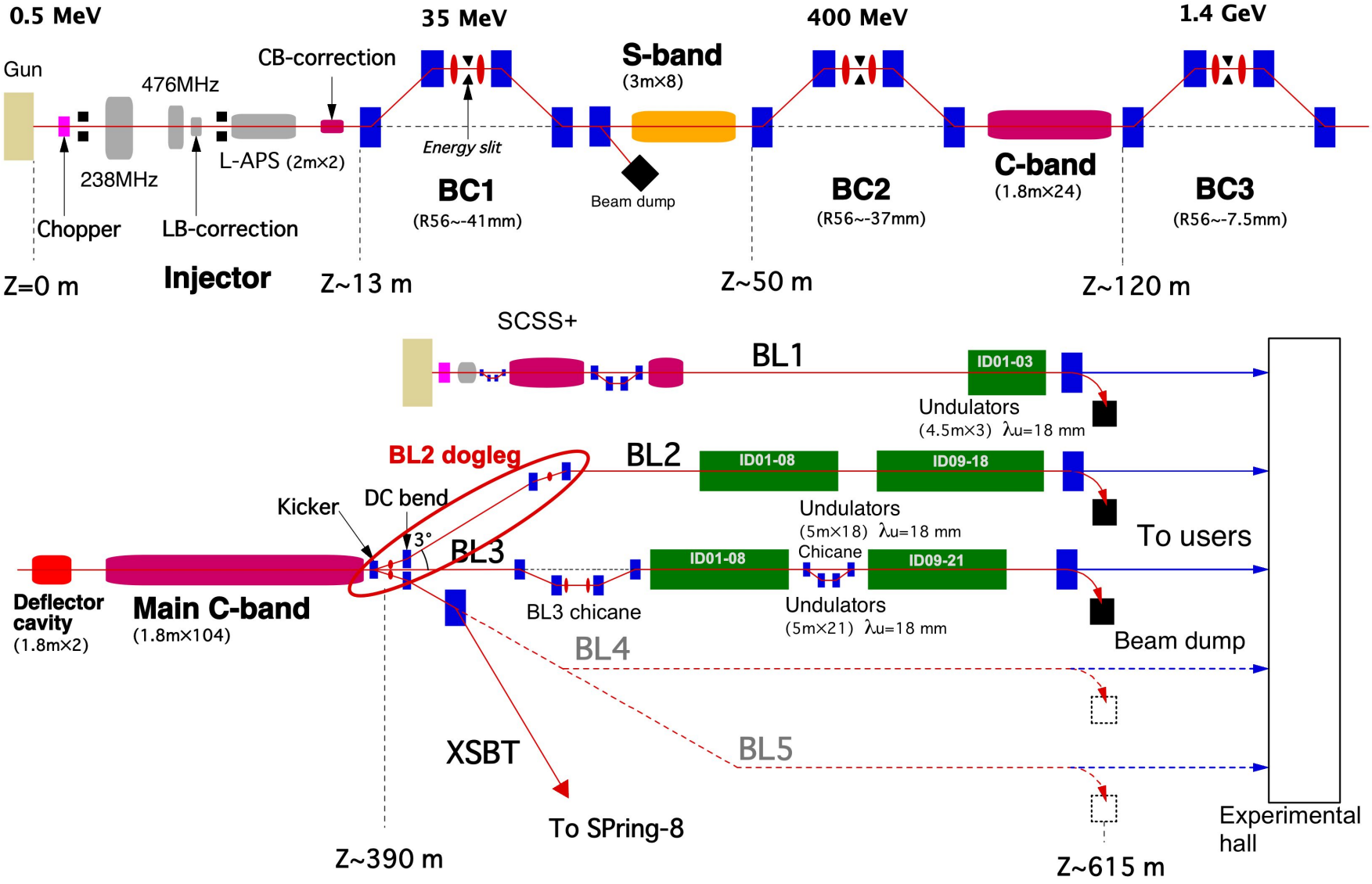
Suppression of the CSR effects at a dogleg beam transport using DBA lattice

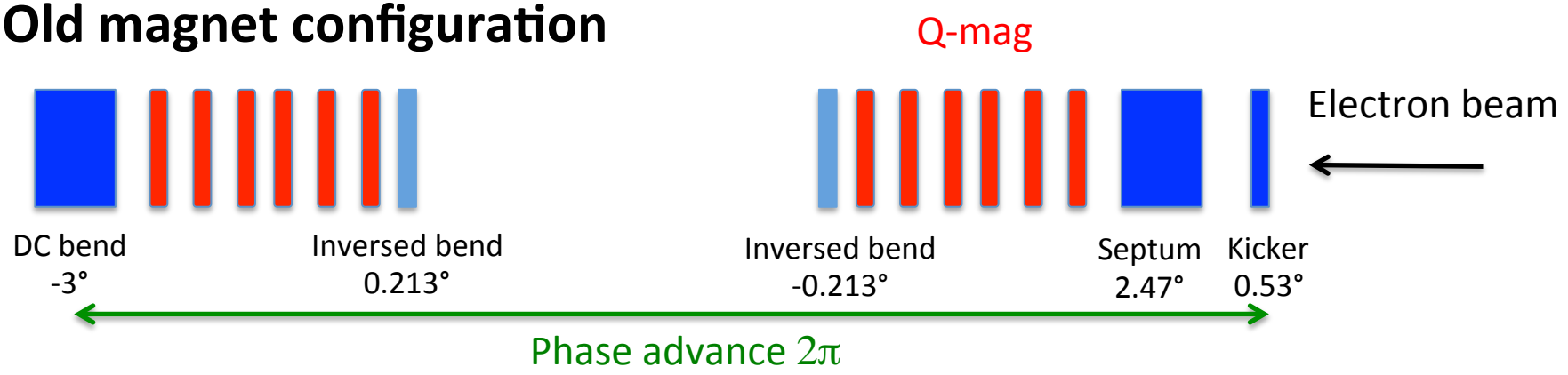
Toru HARA[1], Takahiro INAGAKI[1], Chikara KONDO[2],
Kazuaki TOGAWA[1], Kenji FUKAMI[2], Shingo NAKAZAWA[3],
Taichi HASEGAWA[3], Osamu MORIMOTO[3], Masamichi YOSHIOKA[3],
Hirokazu MAESAKA[1], Yuji OTAKE[1], Hitoshi TANAKA[1]
[1]RIKEN SPring-8 Center, [2]JASRI, [3]SPring-8 Service Co., Ltd.

SACLA accelerator



Replacement of the beam optics

- **Old magnet configuration**

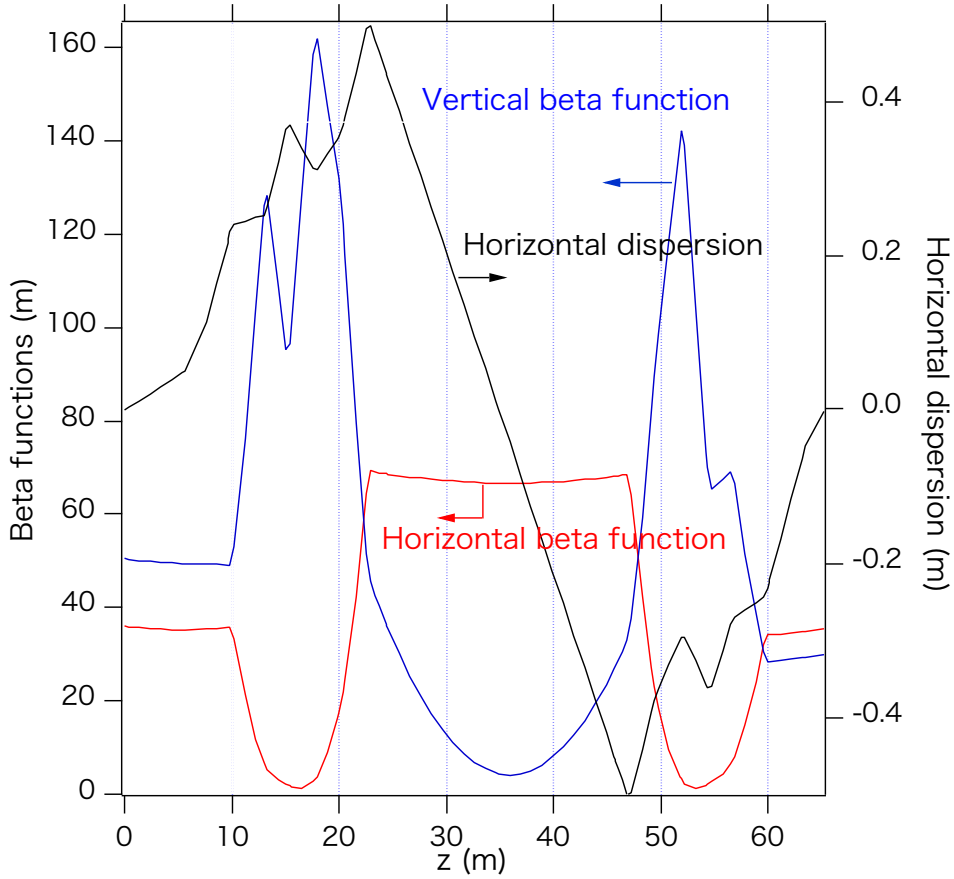


January 2017

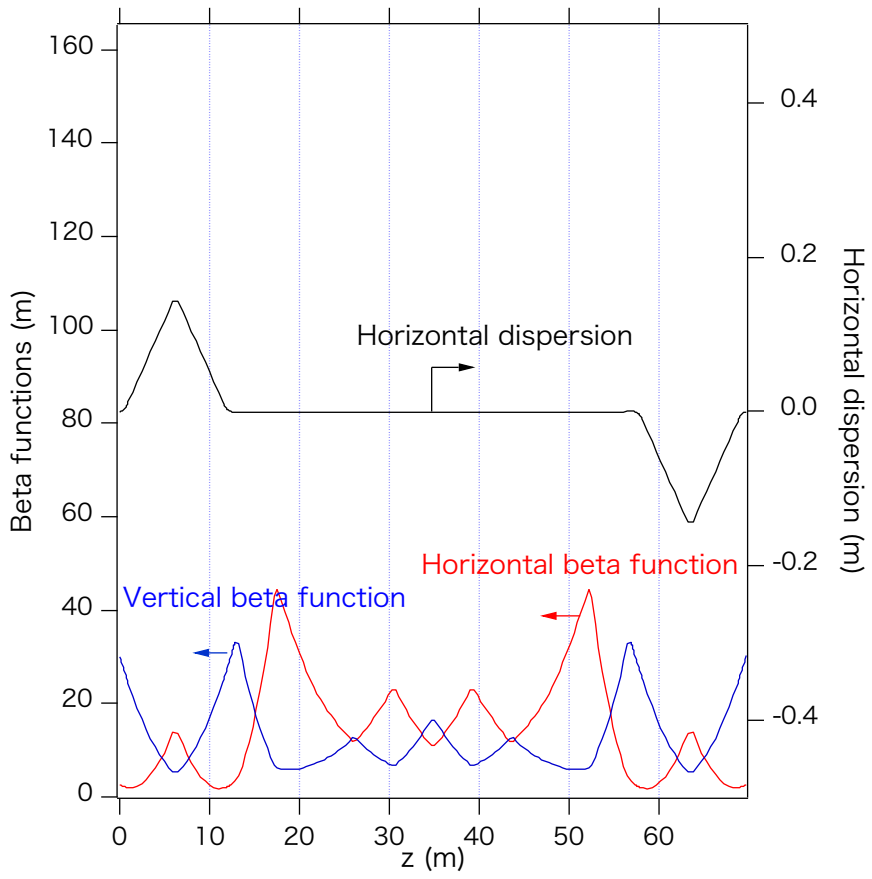
- **New magnet configuration（two DBA）**

To make R_{56} zero and maintain the same longitudinal bunch profile, the electron beam passes off-center at Q-mags of DBA.

Beam optics functions



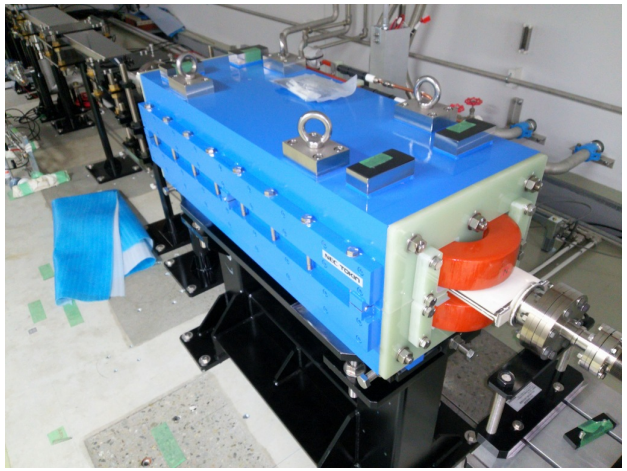
Old optics functions



New optics functions

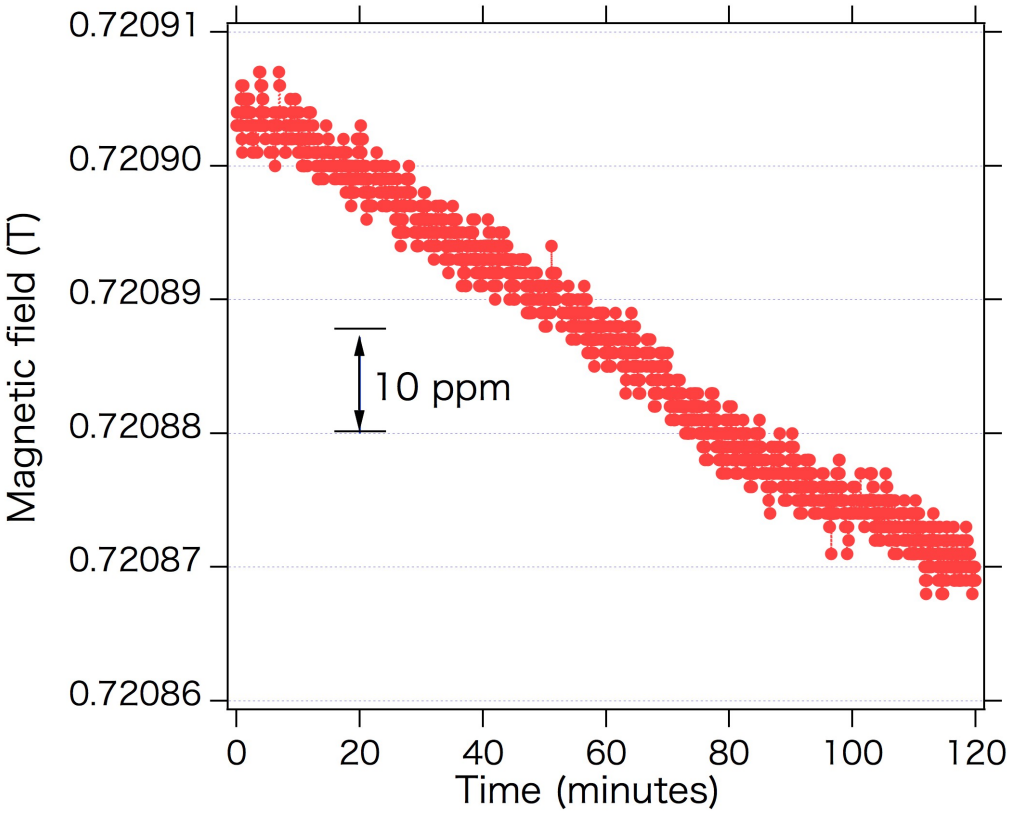
Small horizontal beta at bending magnets in new beam optics.

Pulsed power supply of the kicker magnet



Kicker magnet
(Yoke length 0.95 m, B_{max}=0.9 T)

Power supply（60 Hz, 1 kV-299 A）

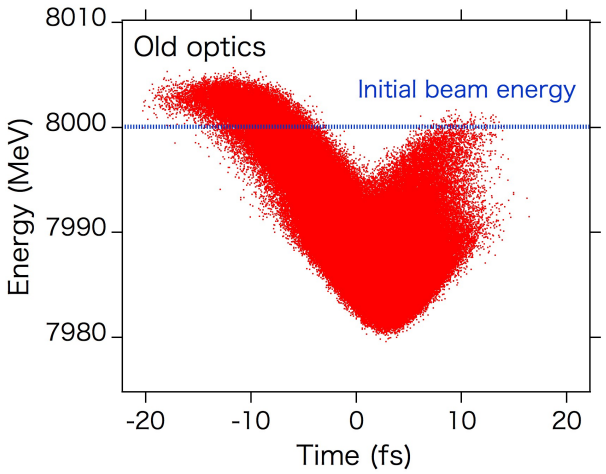


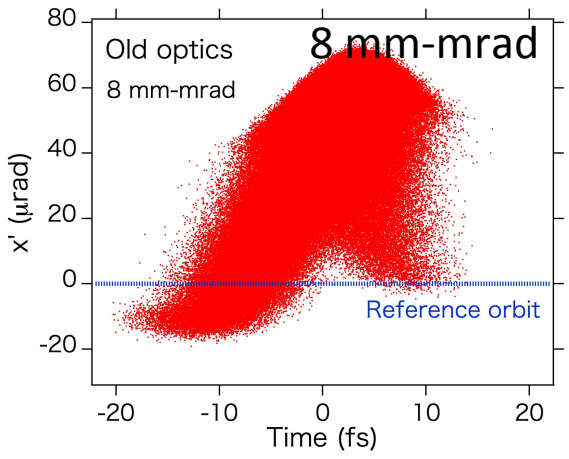
Stability of the kicker magnetic fields

SiC MOSFETs are used as switching elements.

Suppression of the CSR effects (simulation)

Old beam optics



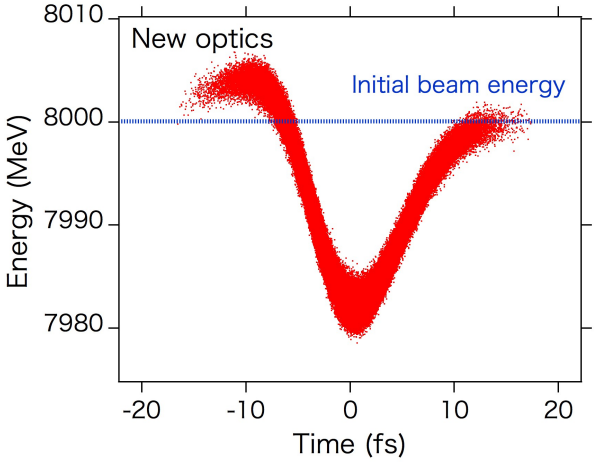


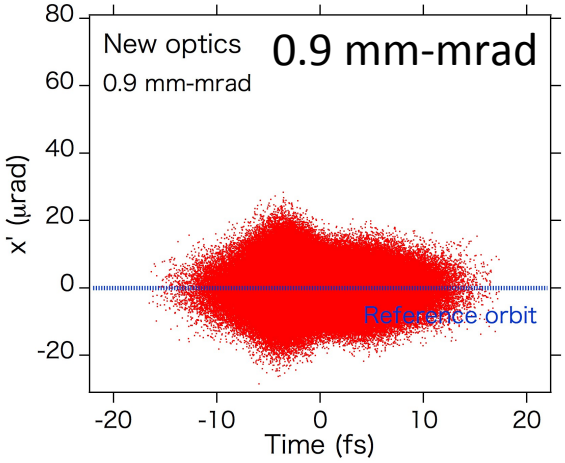
Energy deviation after BL2 dogleg

Initial bunch conditions
Gaussian, 8 GeV,
10 fs (FWHM), 10 kA
0.8 mm-mrad.

t-x' phase space after BL2 dogleg

New beam optics

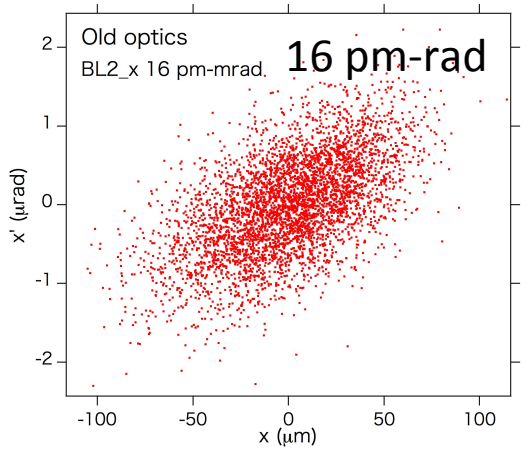


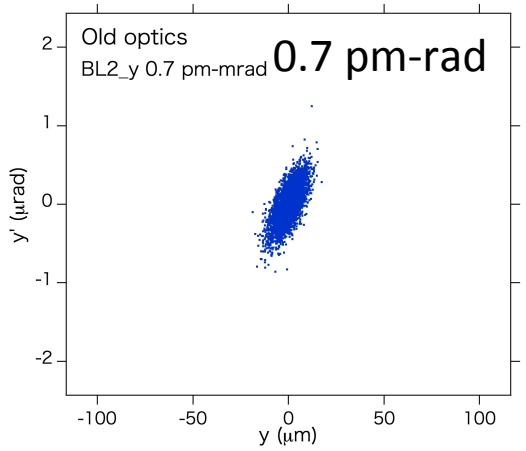


Projected emittance growth is about 10 % for the new beam optics.

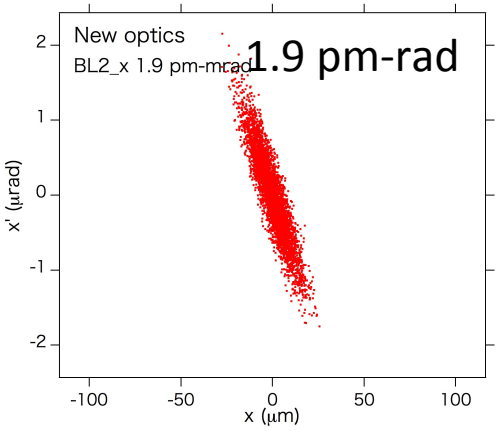
Suppression of the CSR effects (measured)

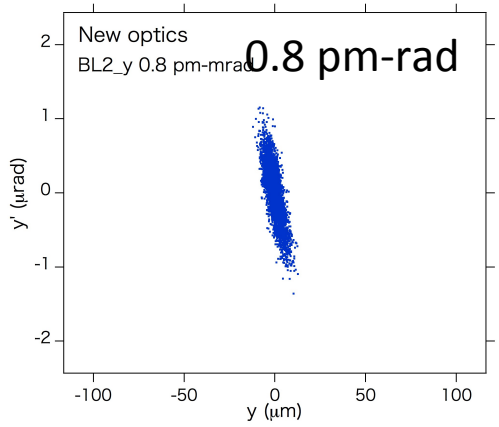
Old beam optics





New beam optics





Horizontal orbit stability after BL2 dogleg

Beam energy 7.9 GeV, peak current ~10 kA, bunch repetition 30 Hz, electron bunches are alternately sent to BL2 and BL3.

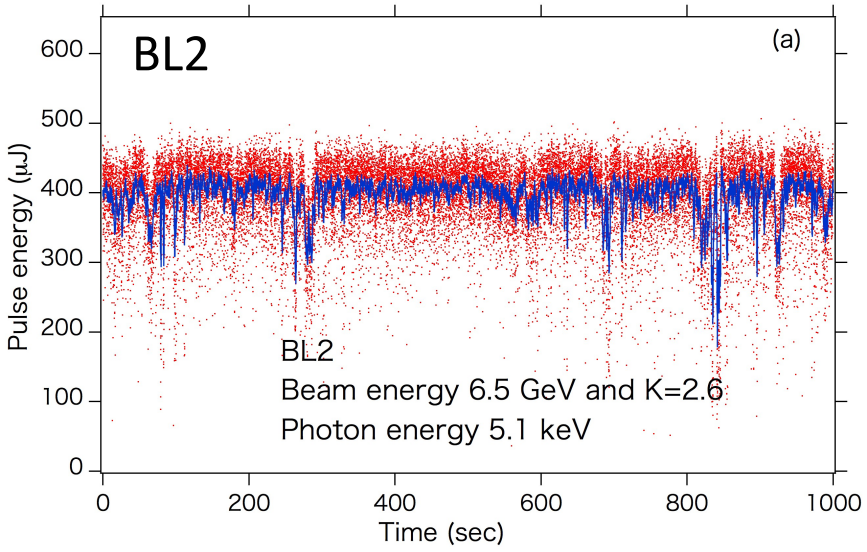
Vertical orbit stability

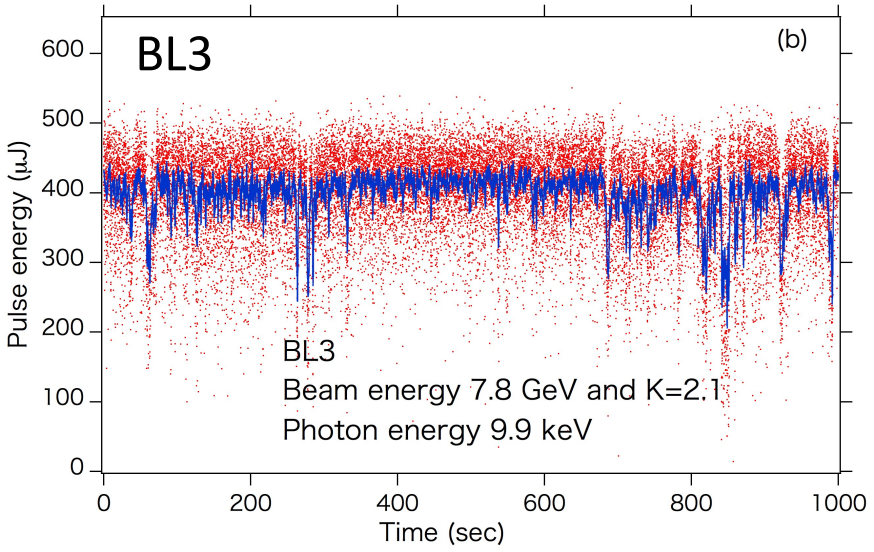
Orbit stability of BL3 is 0.8 pm-rad in horizontal and 0.5 pm-rad in vertical.

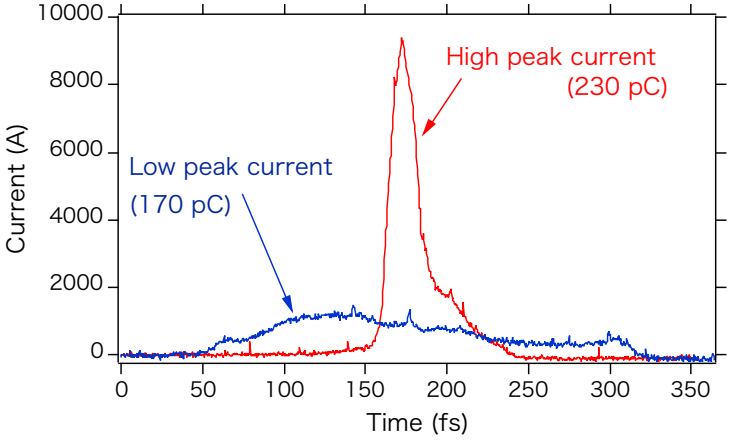
Horizontal orbit stability is improved by an order.
10 kA bunches are stably transported to BL2 through the dogleg.

Multi-beamline operation

60 Hz electron bunches are alternately deflected to BL2 (6.5 GeV) and BL3 (7.8 GeV).



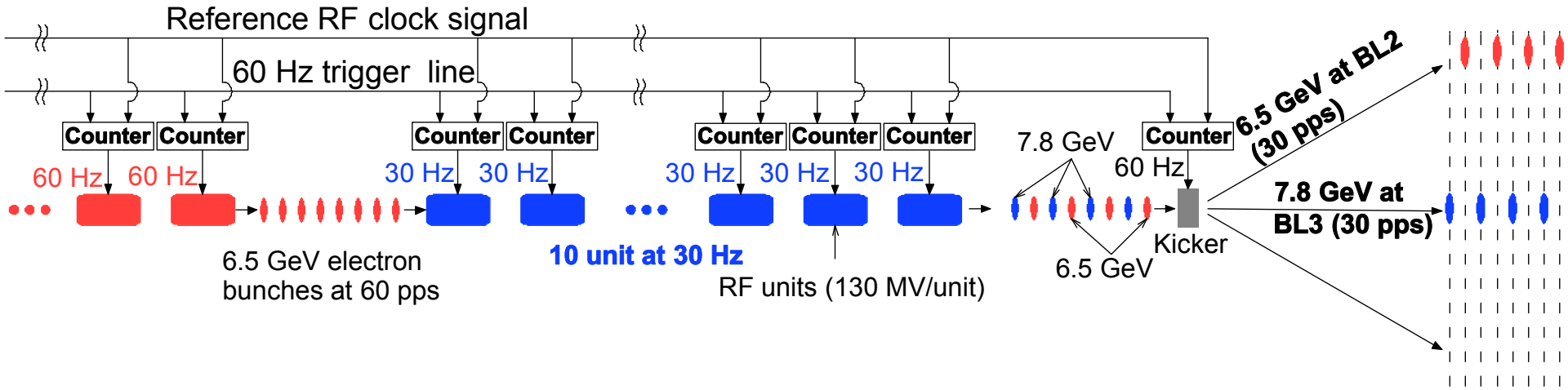




- The peak current is increased from 3 kA to 10 kA, consequently the laser pulse energy is also increased by a factor of 2~3.
- The laser wavelength of each beamline can be independently adjusted over a wide spectral range through the beam energy and undulator K-value.

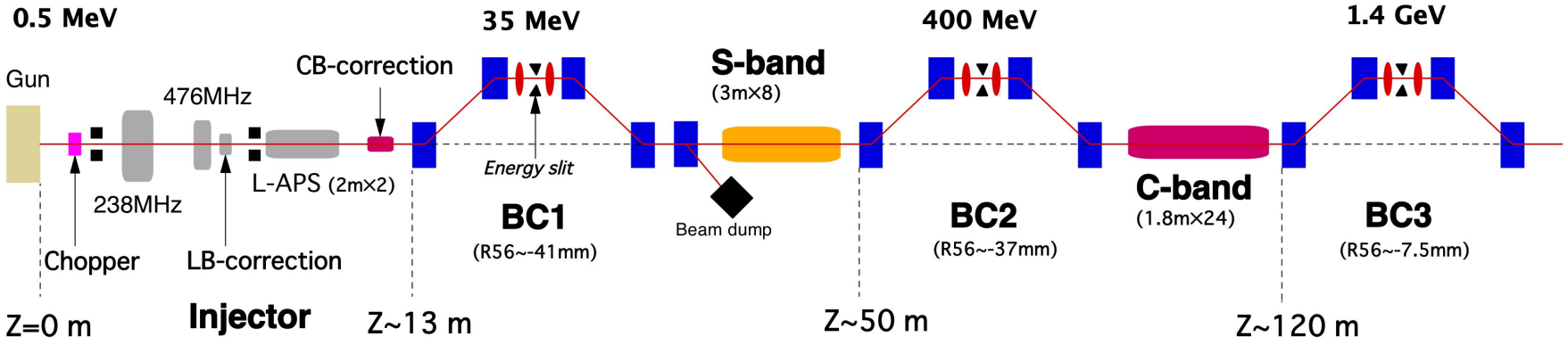
Multi-energy acceleration of linac

For wide spectral tunability of XFEL multi-beamline operation.

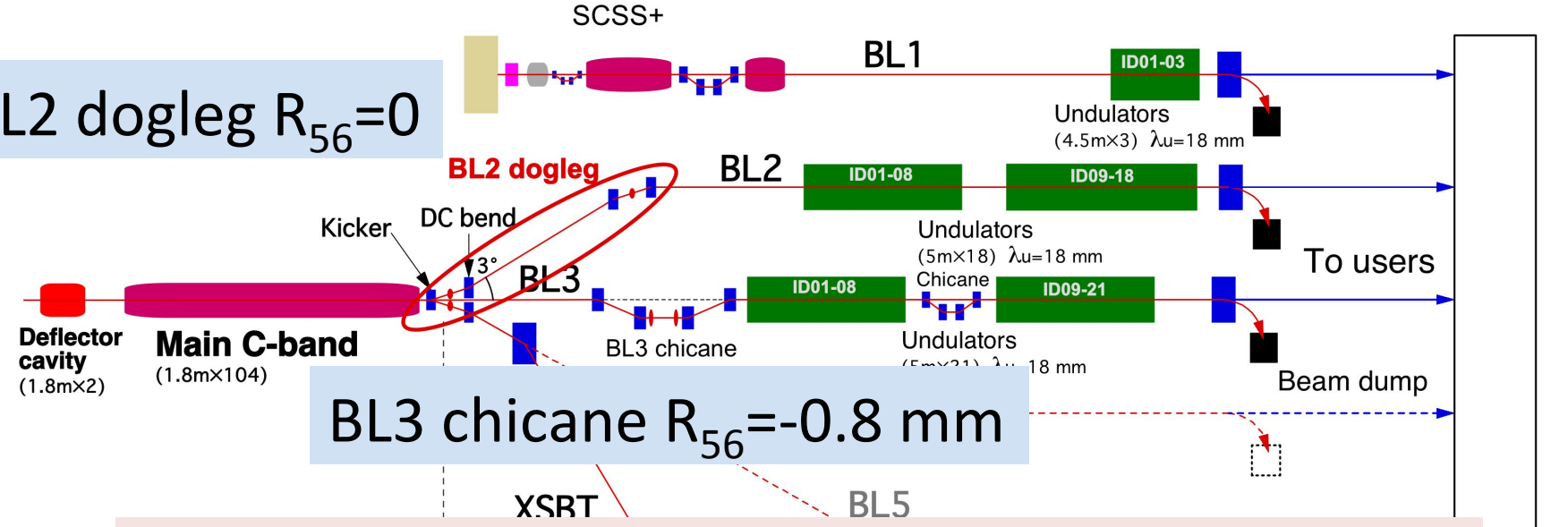


- Twenty C-band accelerating structures downstream of BC3 are operated at 30 Hz.
- One half of the 60 Hz electron bunches are accelerated to 6.5 GeV and other half to 7.8 GeV.
- The kicker magnet deflect low energy bunches to BL2 and high energy bunches to BL3.

SACLA accelerator



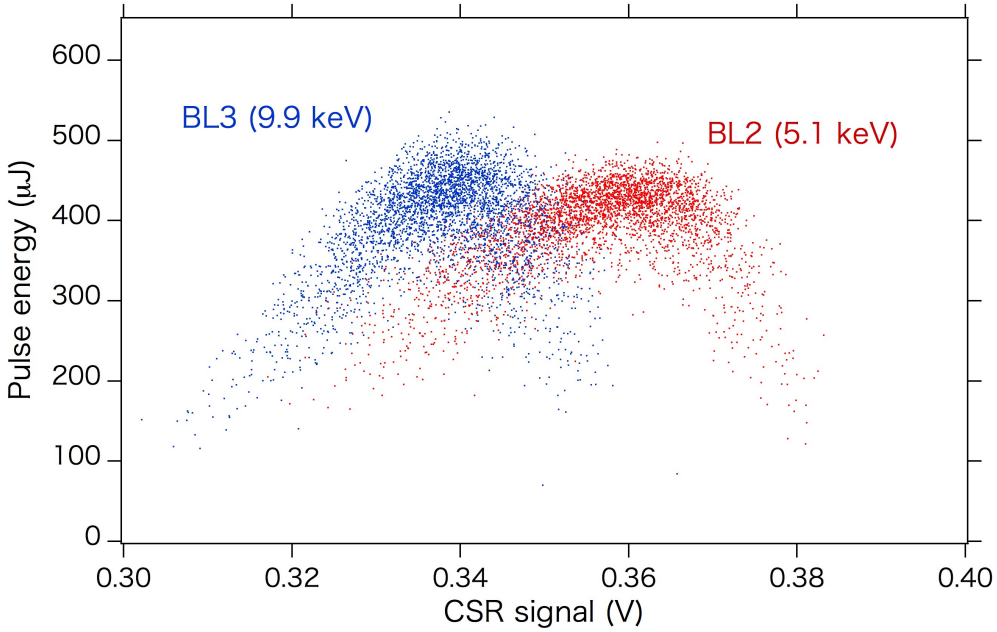
BL2 dogleg R_{56}=0



BL3 chicane R_{56}=-0.8 mm

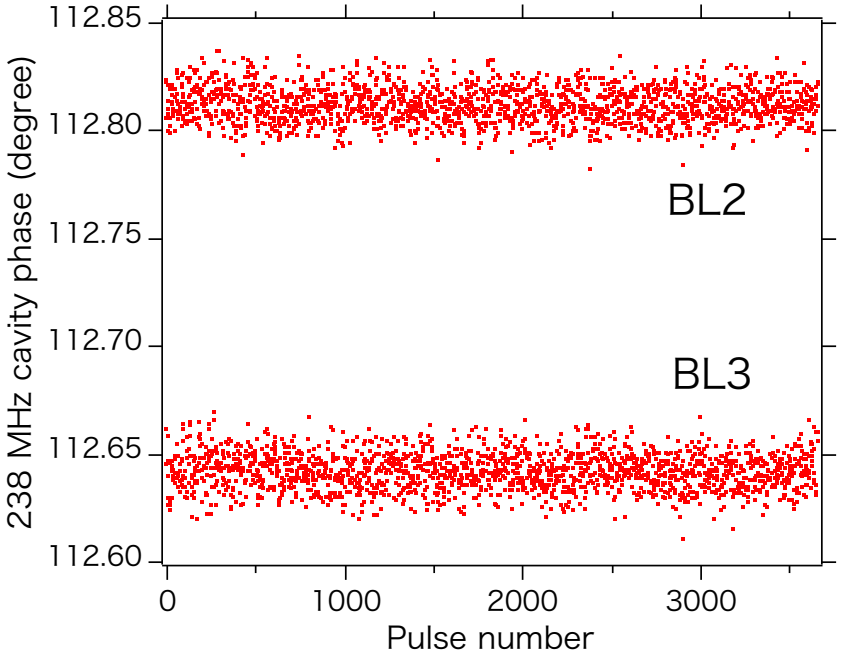
Optimum condition of the bunch compression is slightly different between the two beamlines.

Bunch to bunch RF phase control



Laser pulse energy as a function of BC3 CSR monitor output.

Beam energy	BL2 6.5 GeV
	BL3 7.8 GeV
Undulator K-value	BL2 2.6
	BL3 2.1
Electron beam repetition	60 Hz
BL2 laser repetition	30 Hz
BL3 laser repetition	30 Hz



RF phase of 238 MHz cavity in injector

Summary

- The new beam optics of the BL2 dogleg based on two DBA structures successfully suppresses the transverse CSR effects.

- The laser pulse energy of BL2 increases from 150-200 μJ to 400-500 μJ due to the higher peak current.

- In the multi-beamline operation, the beam energy and the bunch compression parameters are controlled from bunch to bunch and independently optimized for the two beamlines. Thus the laser pulse energies can be maximized for the two beamlines and wide spectral tunability of XFEL is maintained.

- Parallel operation of three beamlines including a soft x-ray FEL beamline (BL1) will be open to users from October 2017, which expands the opportunity of user experiments.