Performance and operation status of hard x-ray split-delay optics at BL3 of SACLA

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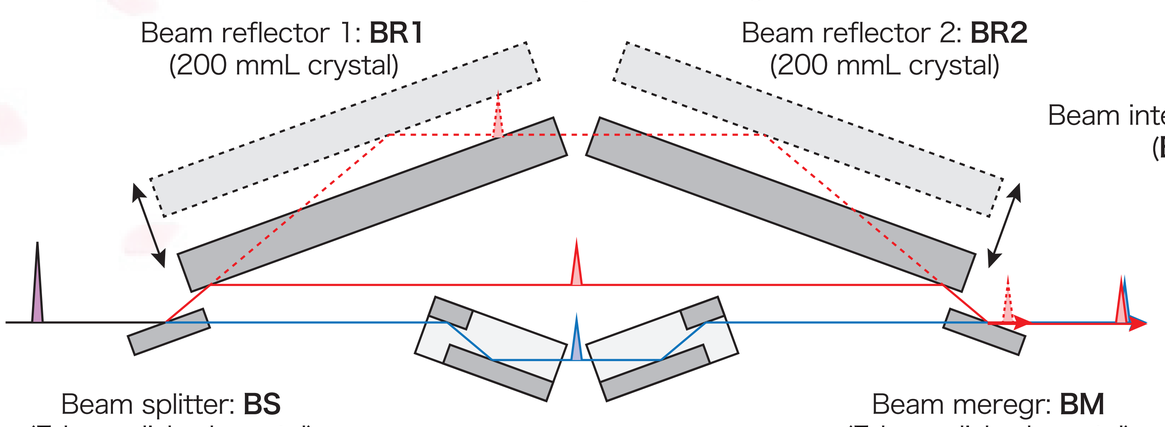
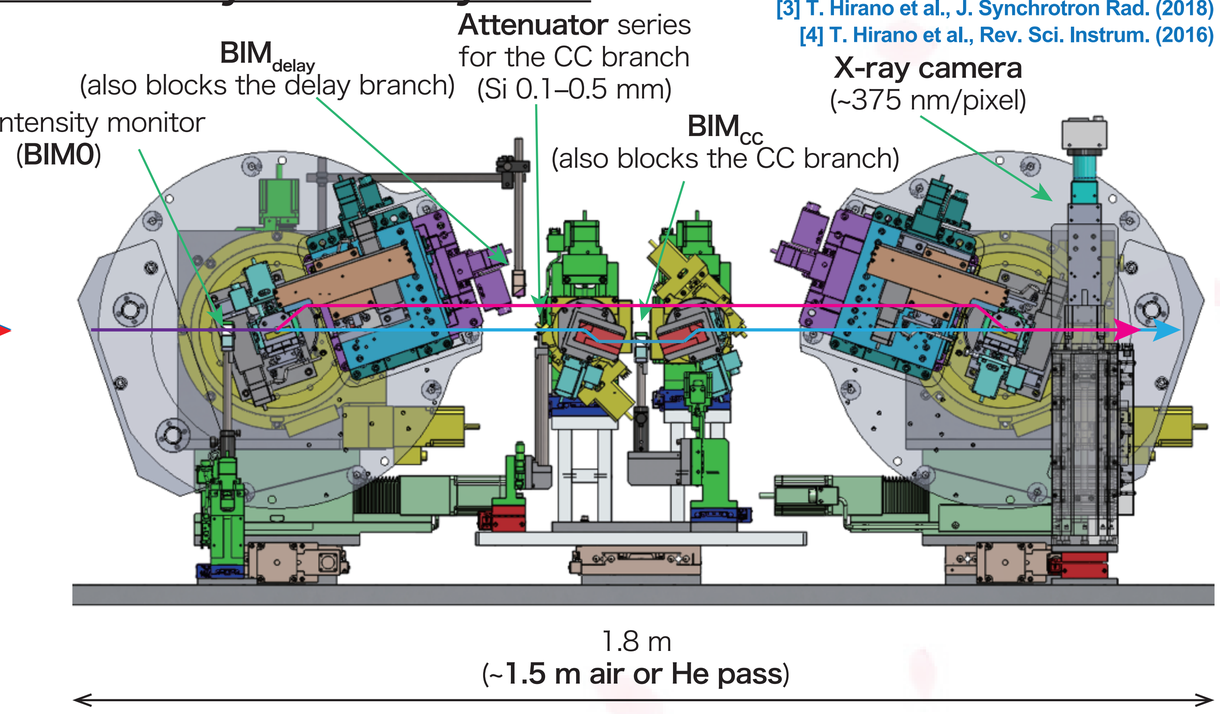
A hard X-ray split-and-delay optical (SDO) system has been developed, in collaboration with Osaka U., and installed in the optics hutch at BL3 of SACLA as a standard optical system, which allows ones to use double XFEL pulses temporally separated from each other in combination with other useful optics, diagnostic tools, and experimental platforms. The SDO system covers a photon energy range of 5–15 keV and a range of the time separation from 0 to >100 ps with a time step of <1 fs. Averaged pulse energies of each split pulse, with a relative bandwidth $\Delta E/E \sim 5.6 \times 10^{-5}$, will be 0.3 μJ at 10 keV under the normal SASE mode of operation. The self-seeding mode of operation should exceed the pulse energy by a factor of >5. In this Poster we present the detailed optical layout, performance (pulse energies of sub pulses and pointing stability at focus), and operation status over the past 1 year.

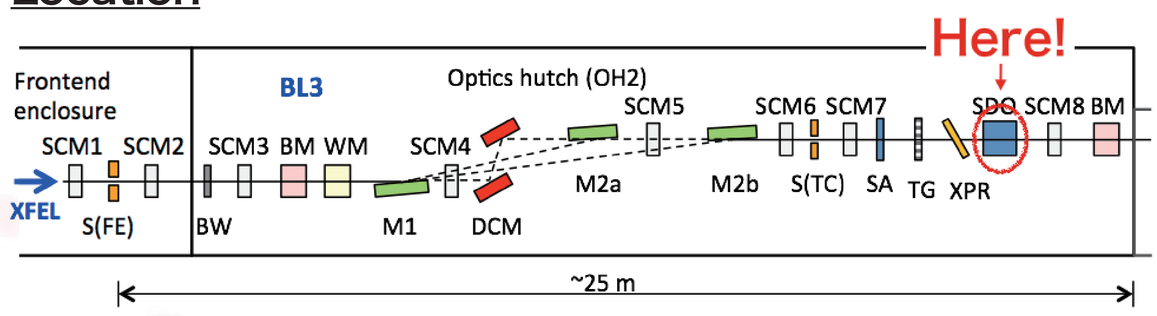
Optical layout & mechanical assembly of SDO system[1]–[3]

[1] T. Osaka et al., Opt. Express (2016)
[2] T. Osaka et al., IUCrJ (2017)
[3] T. Hirano et al., J. Synchrotron Rad. (2018)
[4] T. Hirano et al., Rev. Sci. Instrum. (2016)





Location



High-resolution single-shot spectrometer: EH1
Focusing optics (CRL for 2–100 μm : EH2, KB for 1 μm : EH4c, KB for 100 nm : EH5)

Specifications

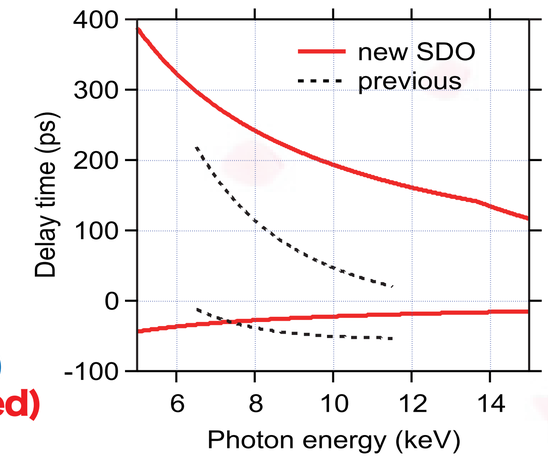
Photon energy range : **5 – 15 keV**

Time delay range : **0 – >100 ps**

Time delay step : **<1 fs**

Averaged pulse energies @10 keV :
~0.4 μJ (SASE)
~4 μJ (self-seed)

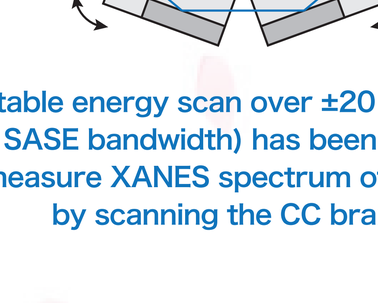
Two-color mode is also possible only under SASE mode.



Delay range vs photon energy

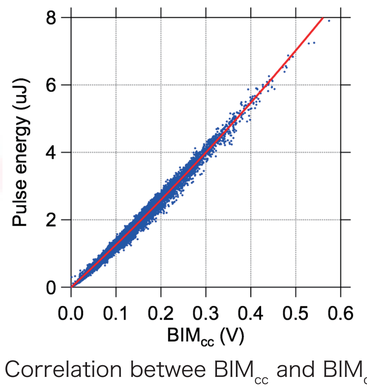
Performance & Operation Status

Intensity diagnostics & shot-to-shot fluctuation

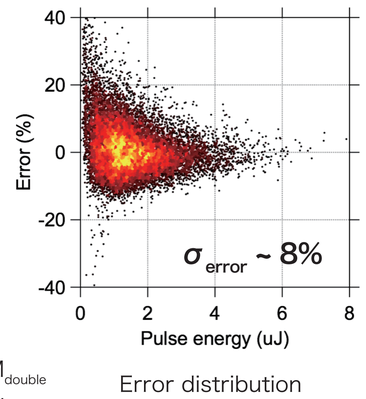


Shot-to-shot pulse energies of the two sub pulses can be measured independently.

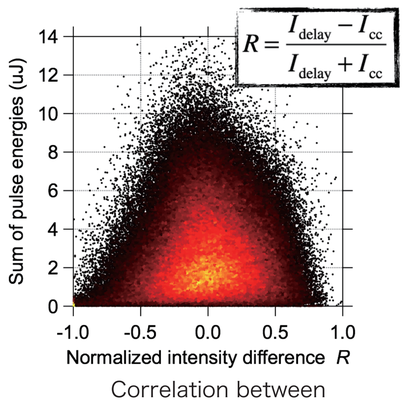
The rms error for pulse energy diagnostics has been evaluated to be <10%.



Correlation betwee BIM$_{cc}$ and BIM$_{double}$ while blocking the delay branch

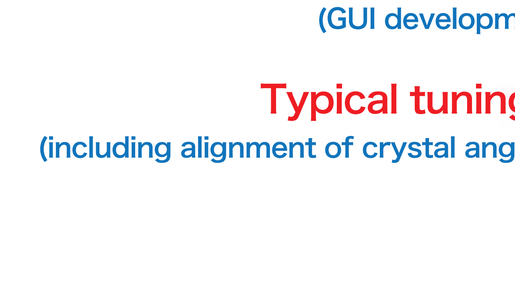


Error distribution

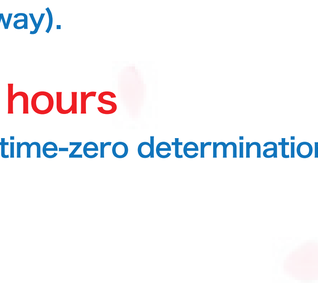


Correlation between I_{delay} and I_{cc}

Pointing stability on focus w/ 1-μm KB @EH4c



Long-term stability



Short-term pointing jitter

Pointing shift during delay scans

High pointing stability on focus has been observed for both long and short term.

Pointing shift during delay scans is still issue but the reproducibility is high enough.

Energy scan capability

Stable energy scan over ±20 eV range (within SASE bandwidth) has been demonstrated to measure XANES spectrum of Cu K edge by scanning the CC branch.

Operation status

So far, 5 users' experiments have been performed with the SDO system at SACLA. Users can easily control time delay, intensity ratio between the two sub branches, and realign the crystal optics through a Python-based command-line tool (GUI development is under way).

Typical tuning time: ~5 hours
(including alignment of crystal angle/position & time-zero determination)