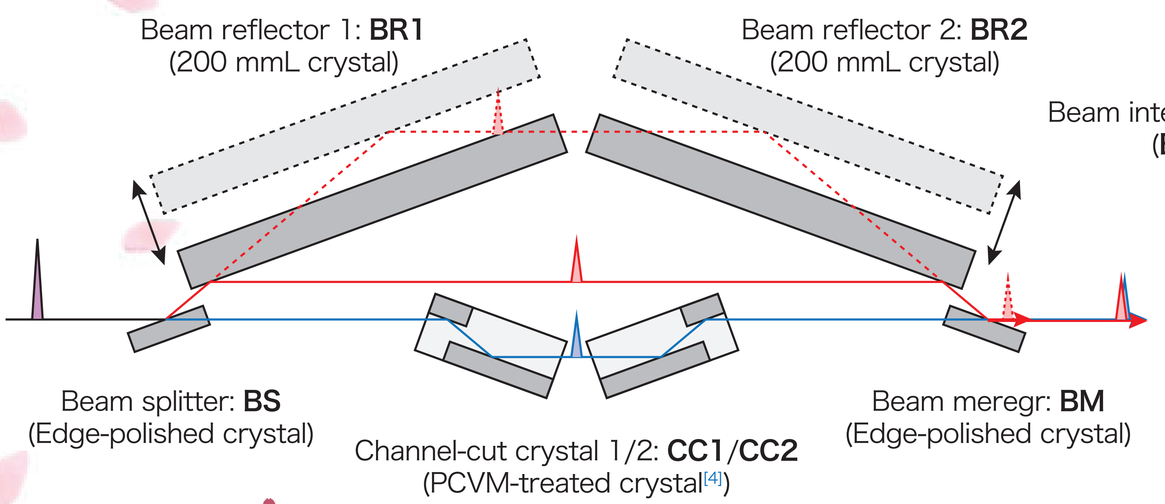
Hard X-ray split-and-delay optical system at BL3 of SACLA

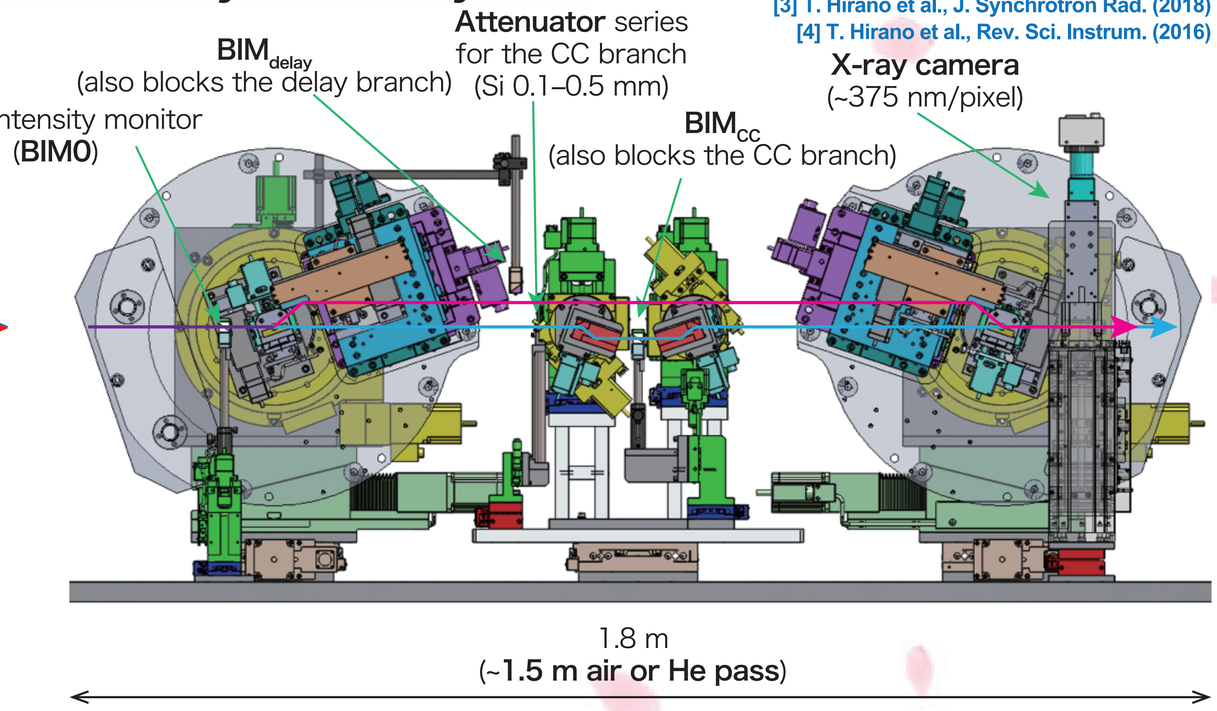
Taito Osaka,[1,*] Yuichi Inubushi,[1,2] Ichiro Inoue,[1] Kensuke Tono,[1,2]
Takashi Hirano,[3] Yuki Morioka,[3] Shotaro Matsumura,[3] Yasuhisa Sano,[3] Kazuto Yamauchi[3] and Makina Yabashi[1,2]

[1]RIKEN SPring-8 Center, [2]JASRI, [3]Osaka University
*E-mail: osaka@spring8.or.jp

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, at least, 2–3. In this Poster we present the detailed optical layout, capabilities for diagnostics, and pointing stability of the split beams focused by a KB focusing system for 1 μm focusing.

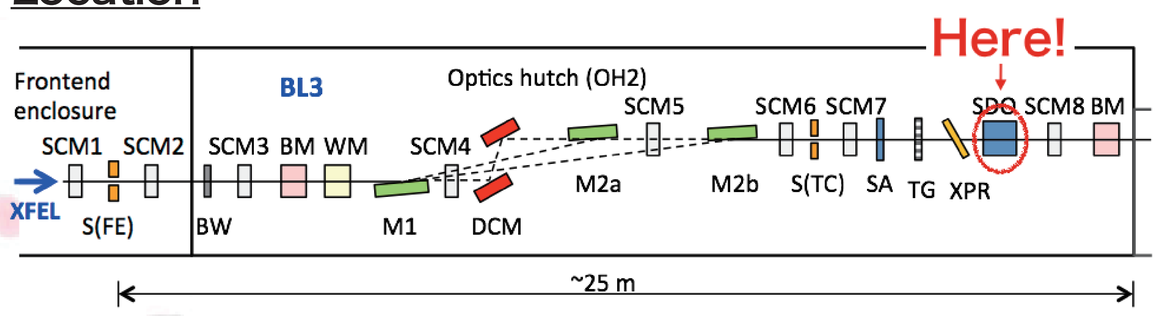
Optical layout & mechanical assembly of SDO system[1]–[3]





[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)

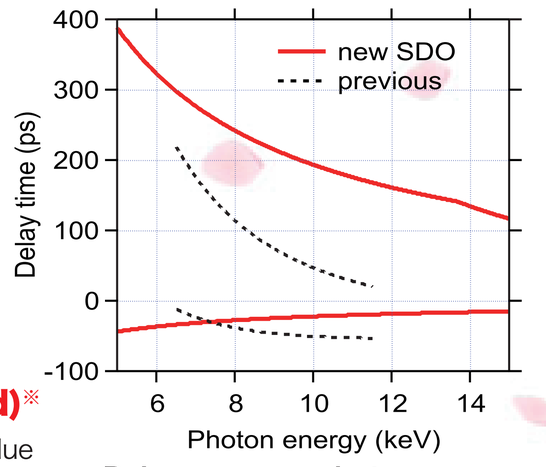
Specifications

Photon energy range : **5 – 15 keV**

Time delay range : **0 – >100 ps**

Time delay step : **<1 fs**

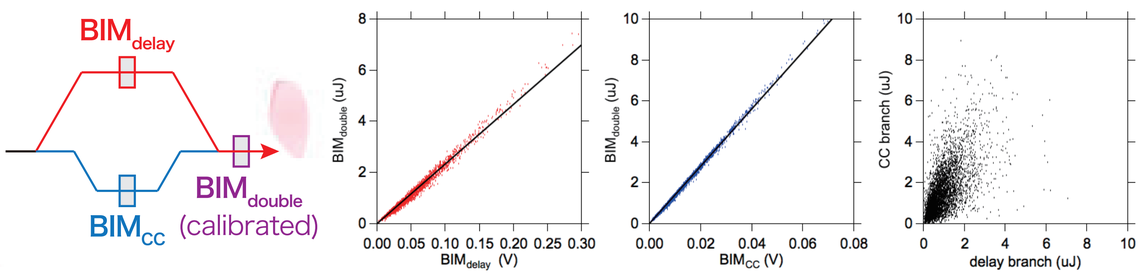
Averaged pulse energies @10 keV :
~0.3 μJ (SASE)
~1 μJ (self-seed)※
※measured value



Delay range vs photon energy

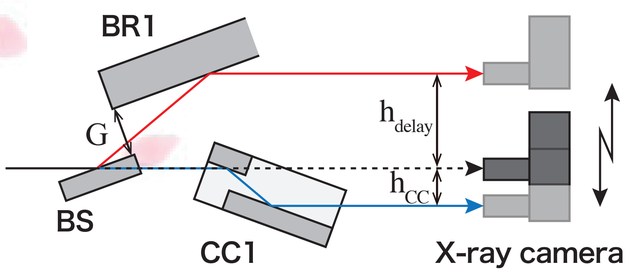
Diagnostics

Shot-to-shot pulse energies



Each pulse energy can be measured with an rms error of <10%.

Linearity b/w delay & trans.

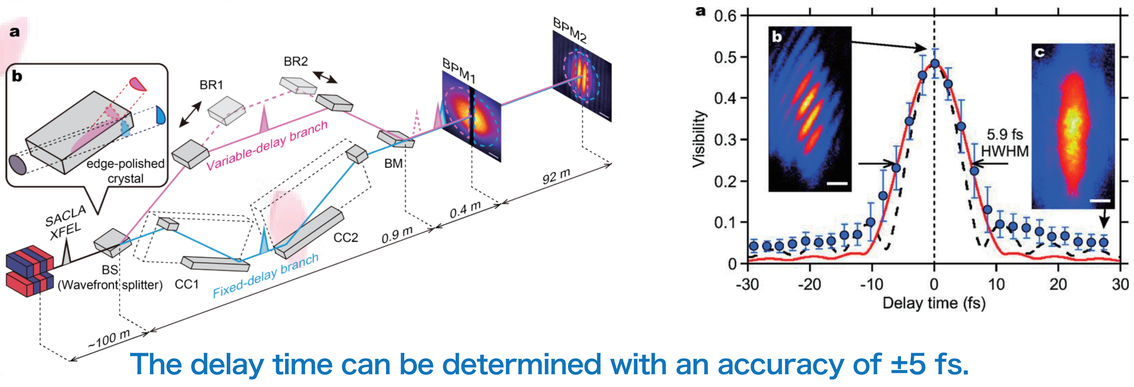


$$h_{\mathrm{delay}} = 2G\cos\theta_{\mathrm{B}}$$

$$\Delta h = h_{\mathrm{delay}} - h_{\mathrm{CC}}$$

$$\Delta t = \frac{\Delta h \tan\theta_{\mathrm{B}}}{c}$$

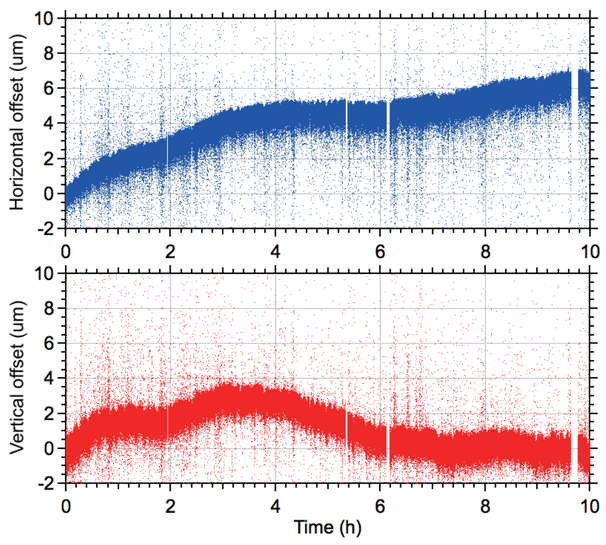
Exact time zero

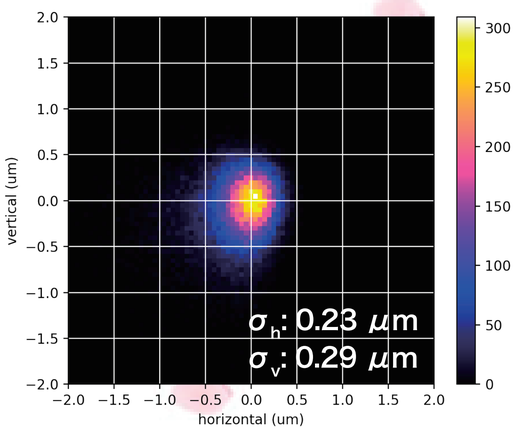


The delay time can be determined with an accuracy of ±5 fs.

Stability in spatial overlap of focused split beams

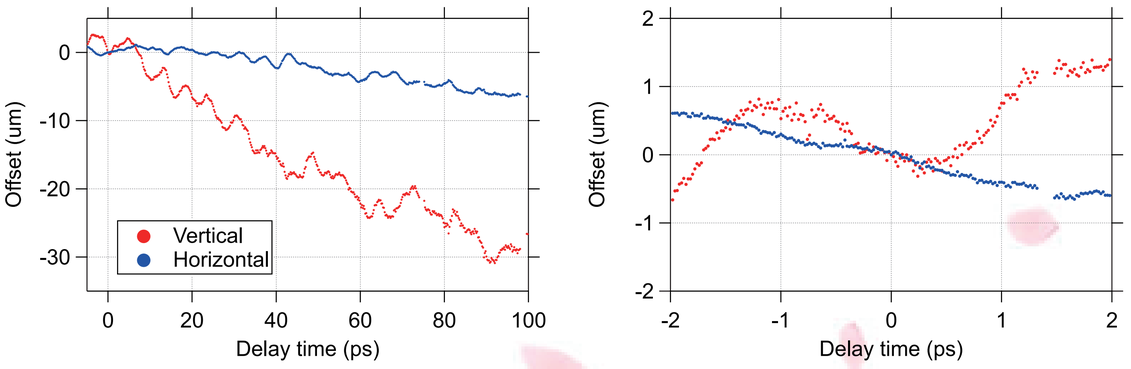
Short-term jitter & long-term drift





2D histogram of pointing offset
(50,000 events, ~30 min)

Pointing shift during delay scans



Long-term drift (probably associated with the temperature instability) must be suppressed for various kinds of experiments with focused split beams.