Operation status of self-seeded XFEL

RIKEN SPring-8 Center, XFEL Research & Development Division

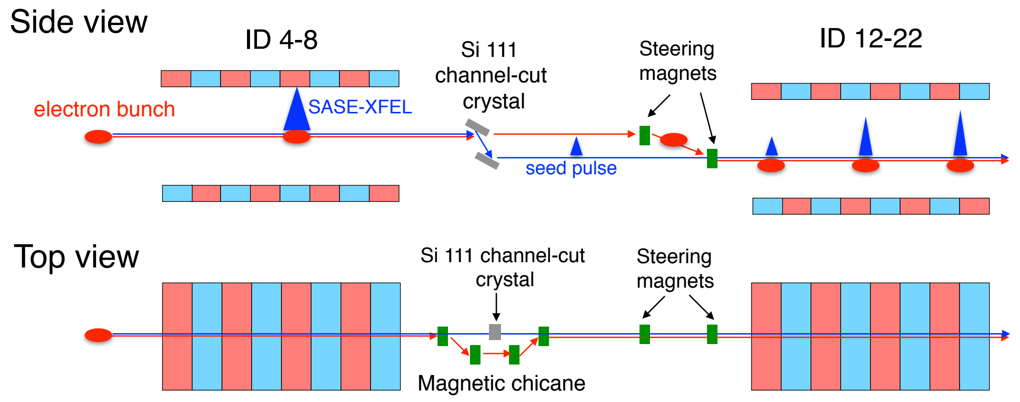
Japan Synchrotron Radiation Research Institute, XFEL Utilization Division

Contact: Ichiro Inoue (e-mail: inoue@spring8.or.jp)

Brief summary

XFELs are widely operated based on the SASE scheme, where spontaneous radiation originating from density modulations in the electron beam is amplified along periodic magnetic field in undulators. Although the SASE scheme is effective to produce intense X-ray beams, the stochastic starting-up processes cause poor temporal coherence and a broad spectrum. Here, we present an efficient seeding scheme for producing narrowband XFEL beams; the SASE-XFEL beam in the first-half undulators is monochromatized via Bragg reflection of a silicon channel-cut crystal, and the monochromatic seed is amplified in the remaining undulators. We applied this scheme to SACLA, and produced nearly Fourier-transform-limited XFEL pulses, corresponding to an increase of spectral brightness by a factor of six or more with respect to the SASE-XFEL. This achievement will not only enhance the throughput of the present XFEL experiments but also open new opportunities of X-ray sciences.

Concept of reflection self-seeding



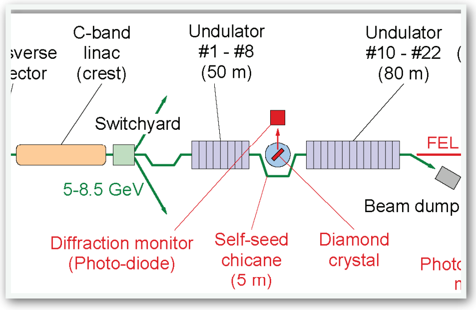
I. Inoue *et al., Nat. Photon.* 13, 319 (2019).

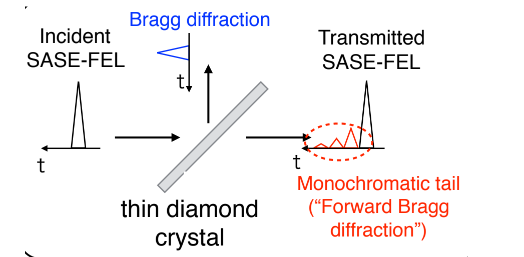
☑ **Purely mono-XFEL beam is delivered to downstream IDs**

☑ **High extraction efficiency of mono-beam from SASE-FEL**

(Seed power) / (Input SASE power) = ~3×10^{-2} *for reflection seeding (Si 111 channel cut)*; ~5×10^{-3} or less *for transmission seeding (C400, 100 μm)*

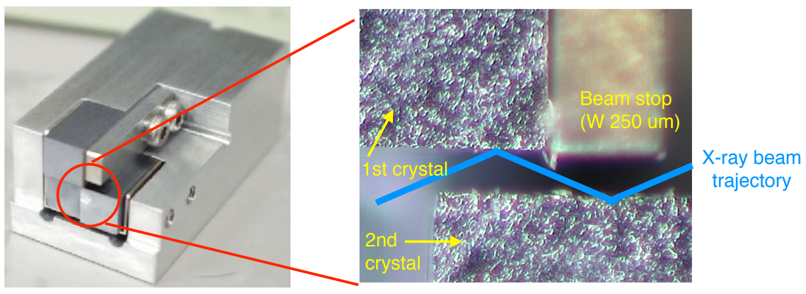
cf. transmission self-seeding using thin diamond





LCLS: J. Amann *et al., Nat. Photon.* (2012).
SACLA: T. Inagaki *et al., Proc. FEL 2014.*

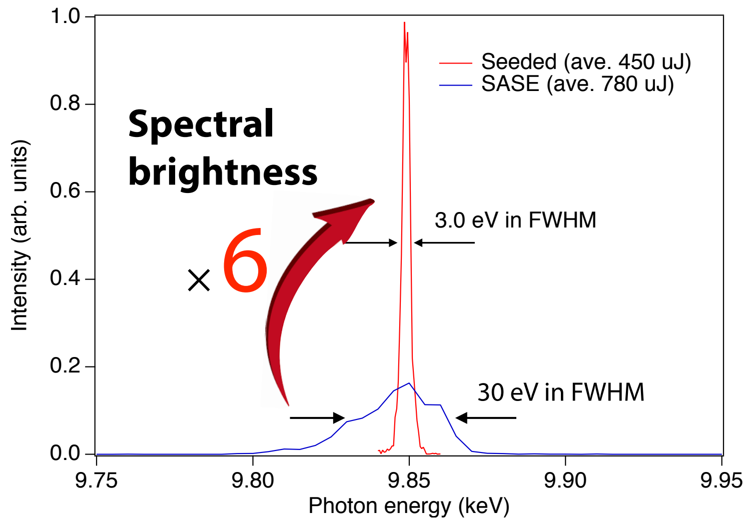
Channel-cut crystal with a gap of 90 μm



T. Osaka *et al., J. Synchrotron Rad. (in press)*

Properties of seeded-XFEL

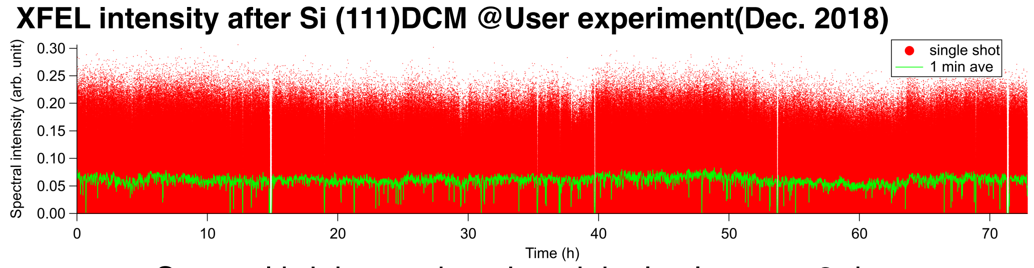
Average spectra of seeded- and SASE-XFEL



I. Inoue *et al., Nat. Photon.* 13, 319 (2019).

Long term stability

XFEL intensity after Si (111)DCM @User experiment(Dec. 2018)



Spectral brightness kept its original value over 3 days
(=typical beam time for single user)

Tuning time

•**Just realizing seeded-XFEL (typical gain compared with normal SASE mode: ~3): ~4 hours**

•**Optimizing seeding conditions: additional 4 hours are required**

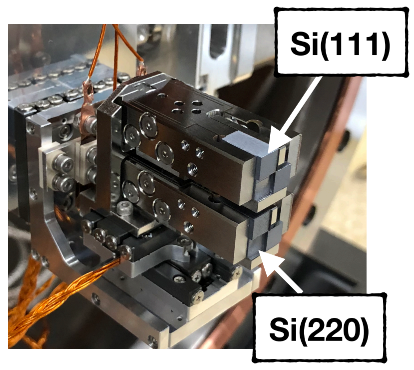
Photon energy range

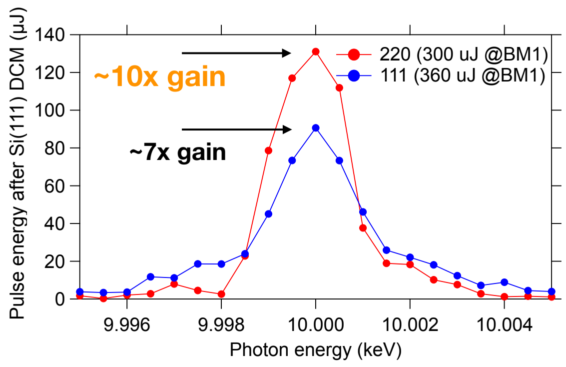
•**We confirmed that this seeding scheme works for 8 keV-12 keV.**

•**If you require seeded-XFEL with photon energies less than 8 keV or higher than 12 keV, please contact beamline staffs.**

Expanding capabilities of seeded-XFEL

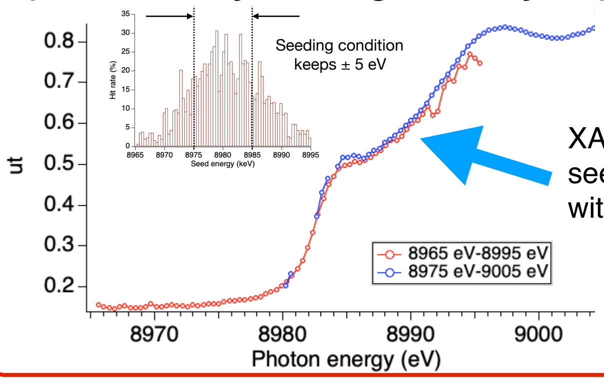
☑ **Boosting spectral brightness by narrowing seed bandwidth**





T. Osaka *et al., in preparation*

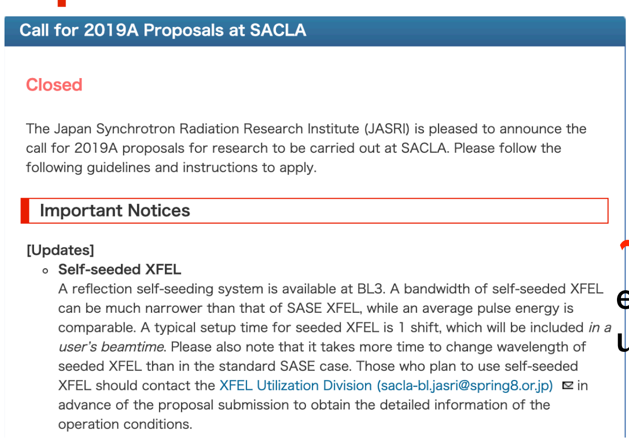
☑ **On-the-fly photon energy scan (continuously rotating seed crystal)**



XANES (Cu 10 μm) measured by seeded-XFEL beam without monochromatization

I. Inoue *et al., in preparation*

Self-seeding is now promoted to usual operation mode


Call for 2019A Proposals at SACLA

Closed

The Japan Synchrotron Radiation Research Institute (JASRI) is pleased to announce the call for 2019A proposals for research to be carried out at SACLA. Please follow the following guidelines and instructions to apply.

Important Notices

[Updates]

- Self-seeded XFEL
  A reflection self-seeding system is available at BL3. A bandwidth of self-seeded XFEL can be much narrower than that of SASE XFEL, while an average pulse energy is comparable. A typical setup time for seeded XFEL is 1 shift, which will be included *in a user's beamtime.* Please also note that it takes more time to change wavelength of seeded XFEL than in the standard SASE case. Those who plan to use self-seeded XFEL should contact the XFEL Utilization Division (sacla-bl.jasri@spring8.or.jp) in advance of the proposal submission to obtain the detailed information of the operation conditions.

~20% of all scheduled experiments at Run2019A utilized seeded-XFEL beam