Reflection self-seeding at SACLA

Ichiro Inoue[1], Taito Osaka[1], Toru Hara[1], Takashi Tanaka[1], Takahiro Inagaki[1], Toru Fukui[1], Shunji Goto[1,2], Yuichi Inubushi[1,2], Hiroaki Kimura[2], Ryota Kinjo[1], Haruhiko Ohashi[2], Kazuaki Togawa[1], Kensuke Tono[1,2], Mitsuhiro Yamaga[1], Hitoshi Tanaka[1], Tetsuya Ishikawa[1], and Makina Yabashi[1,2]

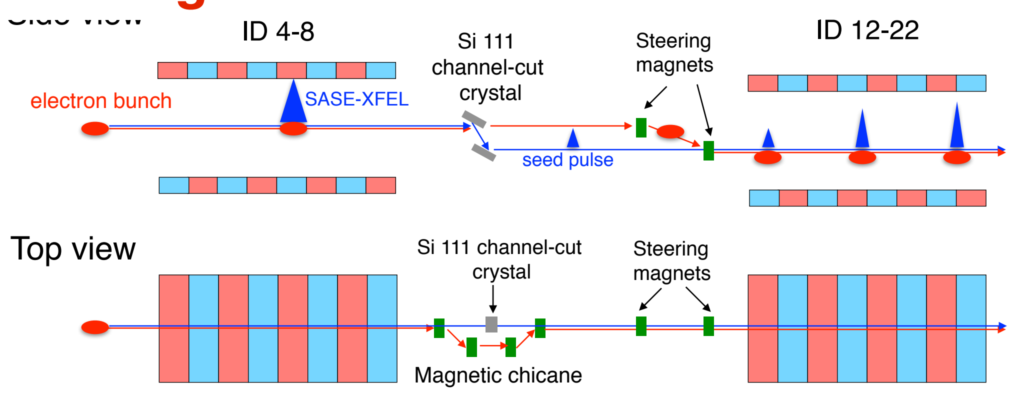
[1]RIKEN Spring-8 Center

[2]Japan Synchrotron Radiation Research Institute

Brief summary

ed 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 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



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

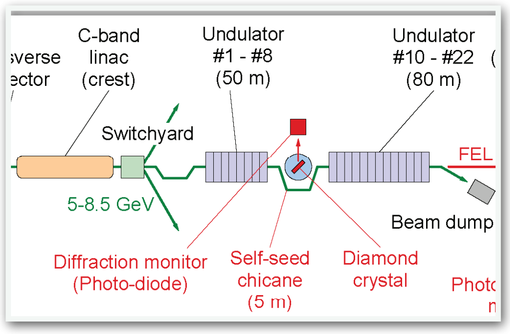
•No SASE contamination to the seed pulse

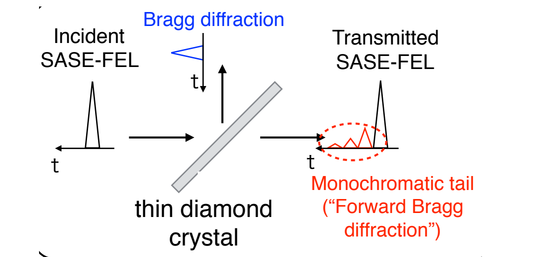
☑ **High extraction efficiency of mono-beam from SASE-FEL**

(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)*

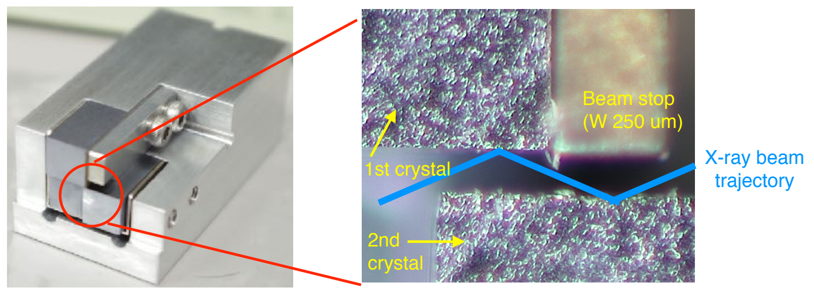
cf. transmission self-seeding using thin diamond





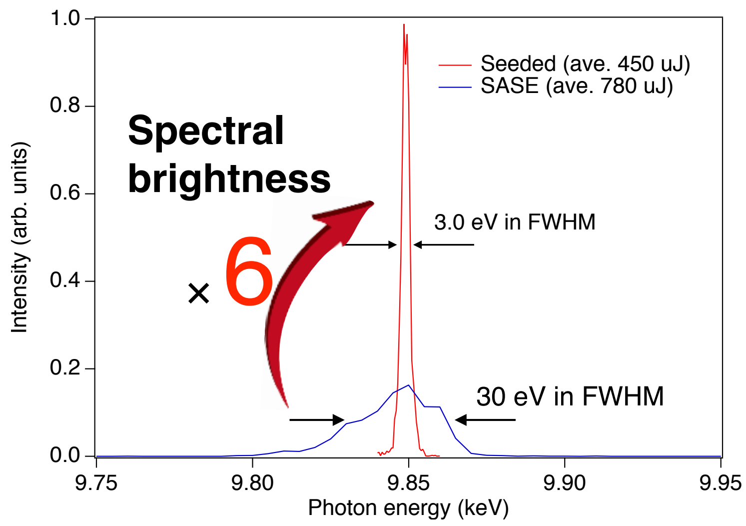
LCLS: J. Amann *et al*., Nature Photon. (2012).
SACLA: T. Inagaki *et al*., *Proc. FEL 2014*.

Channel-cut crystal with a gap of 90 μm

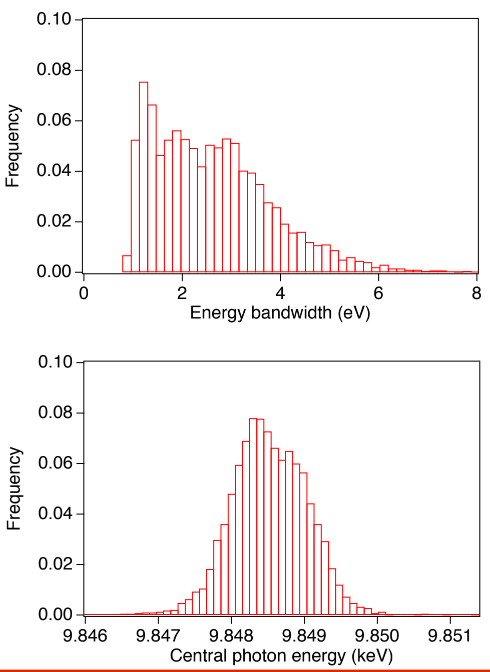


Properties of seeded-XFEL

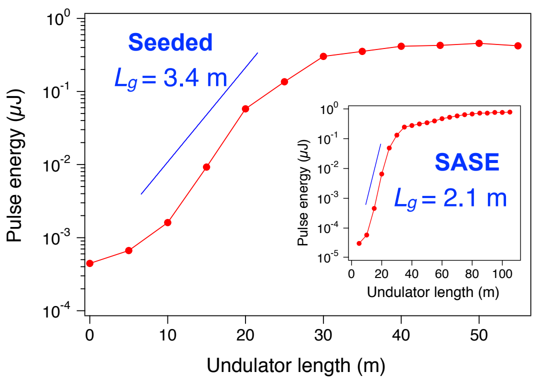
Average spectra of seeded- and SASE-XFEL



Statistics of beam properties



Gain curves of seeded- and SASE-XFEL



☑ Seeded-XFEL reaches saturation

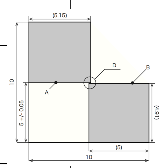
☑ Gain length of seeded-XFEL is comparable to that of SASE-XFEL, indicating that high quality e-beam was injected to the second-half undulators

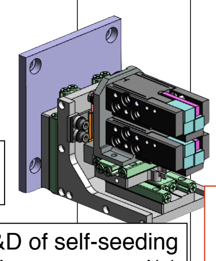
Roadmap towards user operation

2018: Jun. | Jul. | Aug. | Sep. | Oct. | Nov. | Dec. — 2019: Jan. | Feb. | Mar.

Summer shutdown (Aug.–Sep.)

- ☆ We confirmed the concept of reflection self-seeding works !!
- Designing & manufacturing crystal covering wide photon energy range (> 6 keV)
- Crystal evaluation at SPring-8
- Installation of new crystal(s)
- R&D of self-seeding using new crystal(s)
- Seeded-FEL beam is partially released to user experiments (10-keV seeded-FEL only)
- User service starts for seeded-FEL (>6 keV)





Let us know what kind of sciences do you want to perform with seeded-XFEL !!!