Performance of PAL-XFEL and its Future Plan

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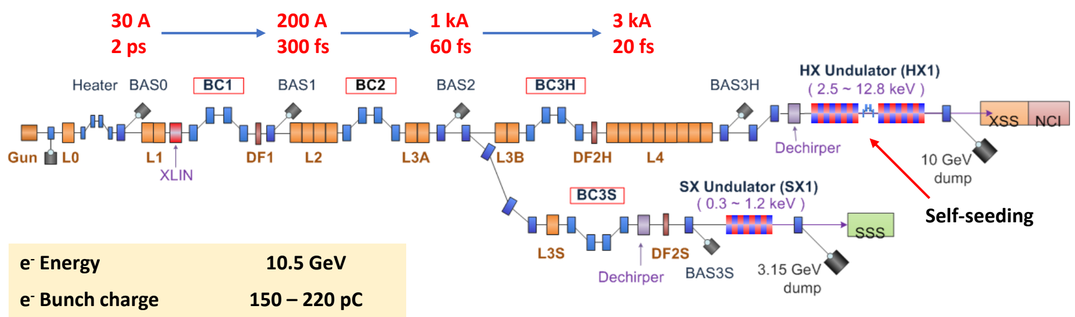
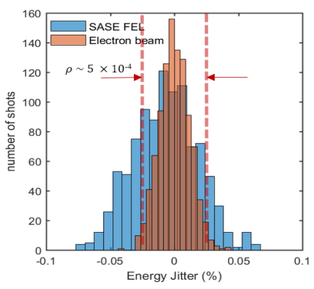
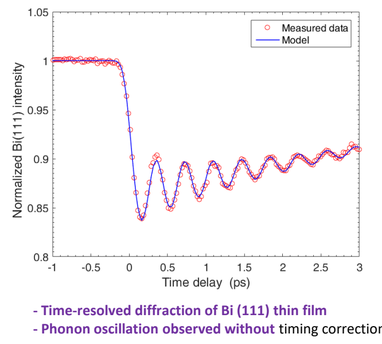
PAL-XFEL Layout



e⁻ Energy	10.5 GeV
e⁻ Bunch charge	150 – 220 pC
Slice emittance	< 0.4 μm
Repetition rate	60 Hz

Undulator Line	HX1	SX1
Photon energy [keV]	2 ~ 20	0.25
Beam Energy [GeV]	4 ~ 10.5	3.0
Wavelength Tuning	Energy & gap	Gap
Undulator Type	Out-vacuum / Variable gap Planar	
Undulator Period / Gap [mm]	26 / 8.3	35 / 9.0
No. of undulators	20	7



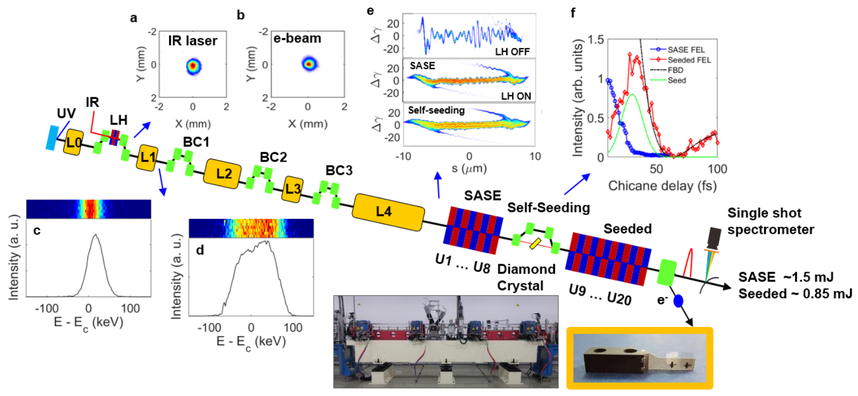


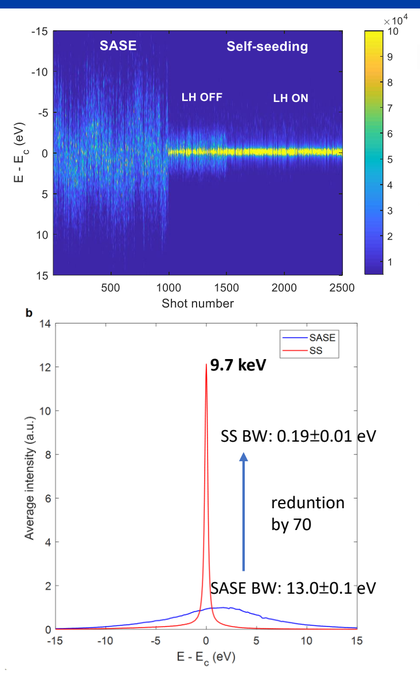
- Time-resolved diffraction of Bi (111) thin film
- Phonon oscillation observed without timing correction

❖ Electron energy jitter: 0.012% rms → 4 times smaller than Pierce parameter

❖ Timing jitter of 18 fs between X-ray pulses and optical pulses: Nature Photonics, 11, 708–713 (2017)

PAL-XFEL Hard X-ray Self-seeding

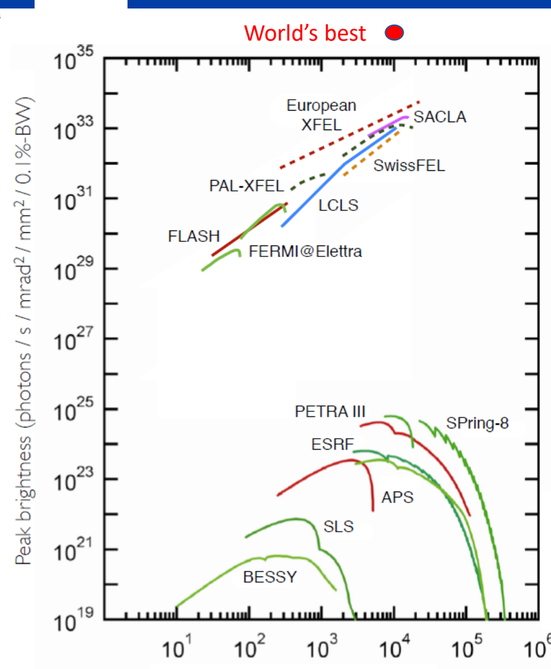


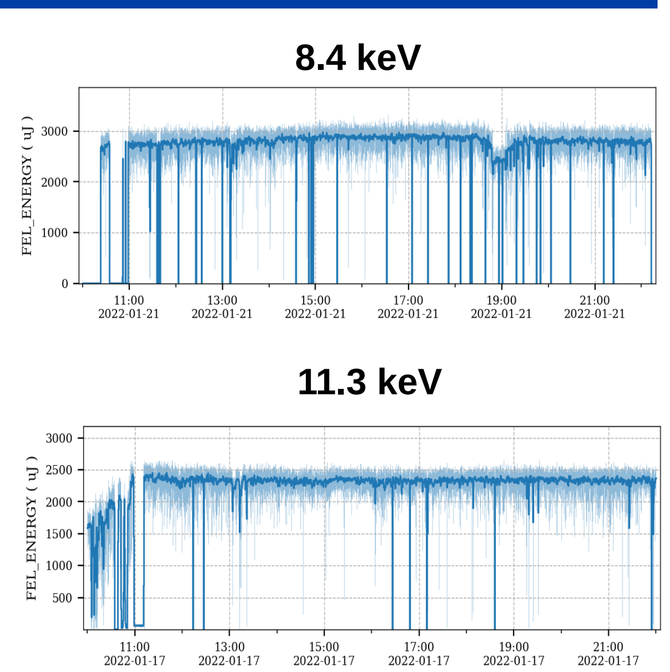


1. Sideband effects are substantially suppressed by a laser heater
2. Close to Fourier-transform limited:
   Time-bandwidth product: (BW) × (FEL duration) = (0.19 eV) × (20 fs) = 3.8 eV·fs
   ~ 2 × FTL
3. Spectral brightness of Self-seeding is 40 times the SASE
   Peak Brightness: **3.2×10^{35}** (photons/s/mm²/mrad²/0.1% BW)
   → the highest to date

Inhyuk Nam et al. High-brightness self-seeded X-ray free-electron laser covering the 3.5 keV to 14.6 keV range. ***Nature Photonics* 15**, 435-441 (2021)

Operation data during the user service

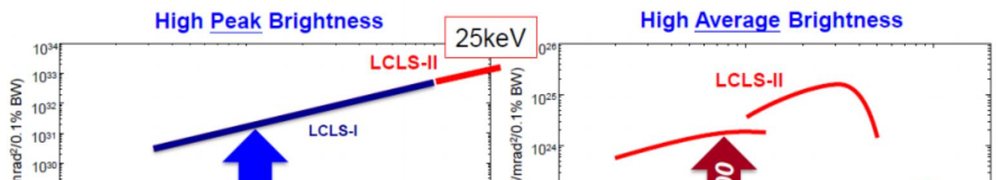




Super-conducting CW XFEL

◆ **CW XFEL (based on superconducting RF)**

- Two (LCLS-II, SHINE) are under construction
- 1 MHz rep rate
- Increase the average brightness to ~10^{25} level (peak brightness : ~10^{31})
  - ◆ **LCLS-II:** 4-GeV SCRF (Superconducting RF) Linac, ~2022
  - ◆ **LCLS-II-HE:** Add more cryomodules to LCLS-II to reach 8 GeV, ~2029
  - ◆ **SHINE (**Shanghai HIgh repetition rate XFEL aNd Extreme light facility): 8 GeV SCRF Linac, 1.5 BUSD, ~2025

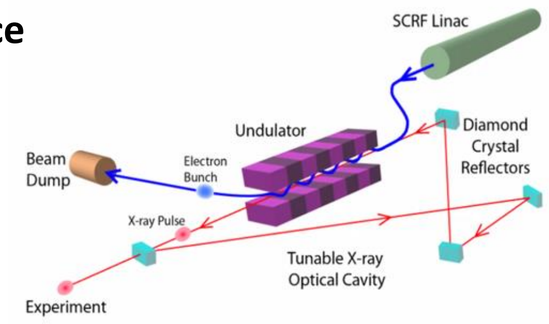


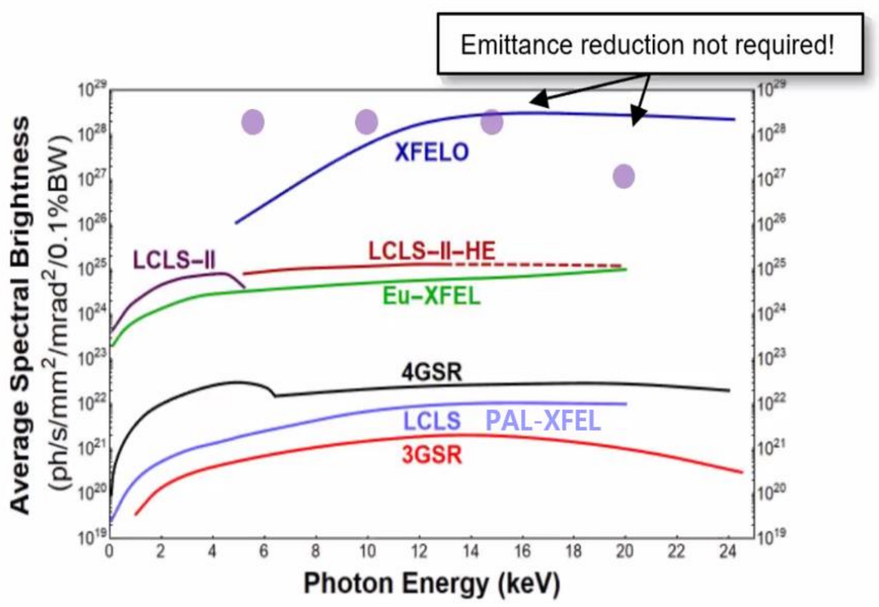
Brachmann, SLAC

XFEL-Oscillator

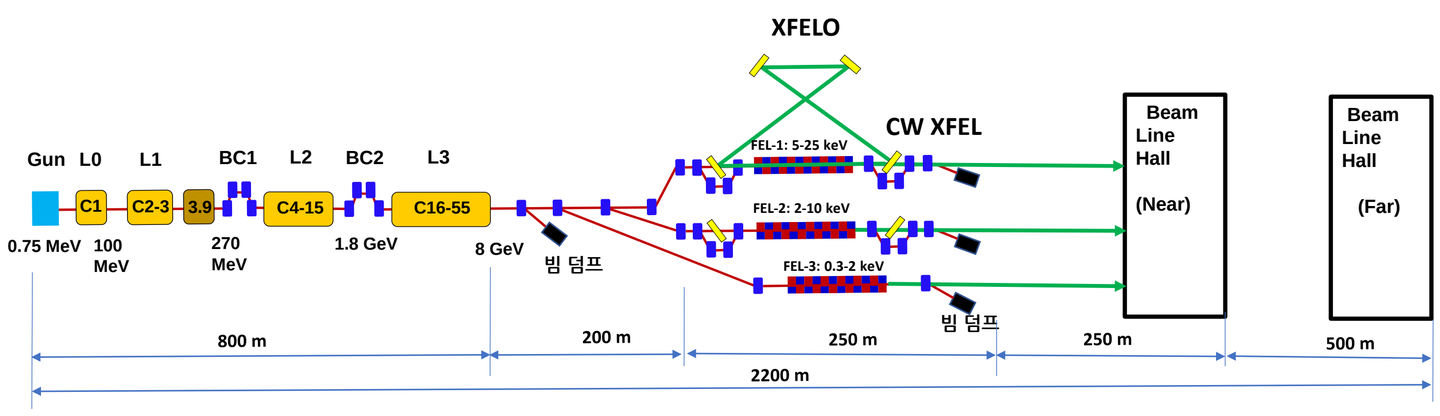
◆ **XFELO: fully coherent source**

- **cavity geometry**
- **1 MHz beam with superconducting linac**
- **BW (Δλ) ~ a few meV**
  - **the brightest source**





Thinking of a Future Plan



	SASE (CW XFEL)	XFELO
• Peak power	~10 GW	~ 10 MW
• Average power	~ 100 W (at ~ 1 MHz)	20 W (at ~ 1 MHz)
• Spectral bandwidth	~ 10 eV	~ 1 meV
• Pulse length	~ 1 – 100 fs	~ 1 ps
• Stability	Poor	Excellent
• Longitudinal coherence	Poor	Excellent
• Transverse mode	Defined by gain-guiding	Defined by the optical cavity