Experimental platform using high-intensity laser with XFEL at SACLA

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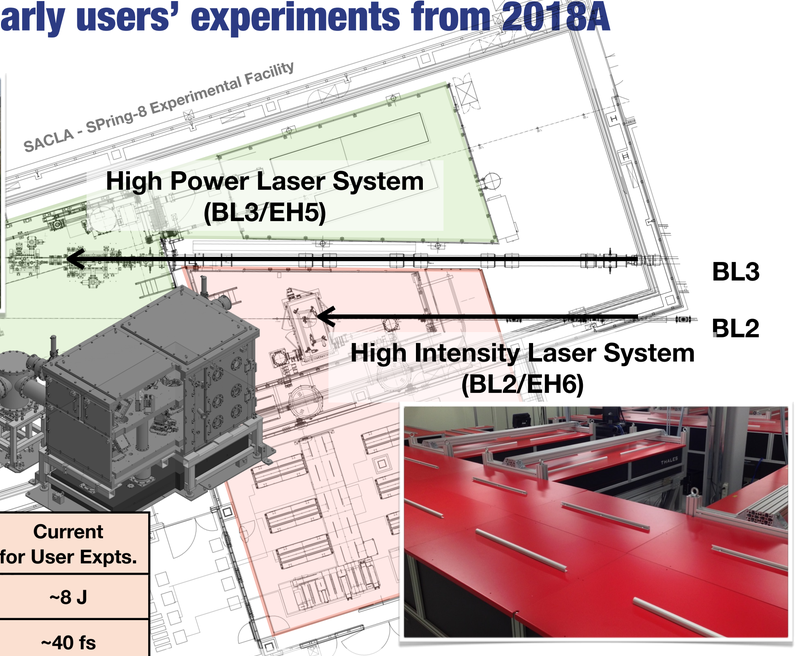
Summary

- **X-ray free electron lasers (XFELs) provide new capabilities for high energy density science (HEDS) using high intensity lasers (HILs) as a probe or a pump because of its brilliance, transverse coherency, and ultrashort pulse duration.**
- **The experimental platform for combinative use of XFEL and HIL are now open for user experiments at SACLA. Two user experiments have been carried out in 2018A with the maximum laser power of ~200 TW.**
- **The relative jitter of arrival timing between XFEL and HIL is ~20 fs with a synchronization system using 5.7 GHz RF signal from SACLA.**

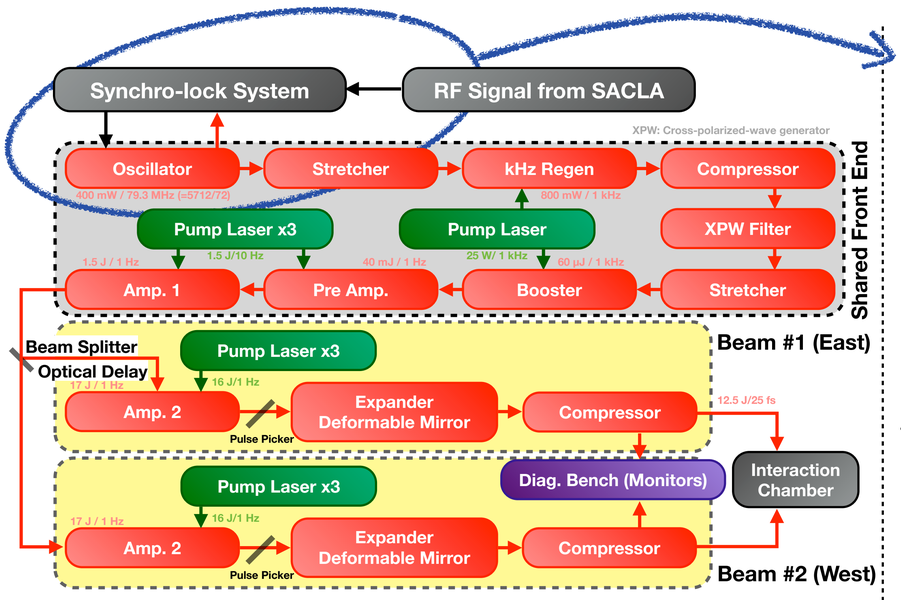
Experimental platform with high-intensity laser is open for early users' experiments from 2018A

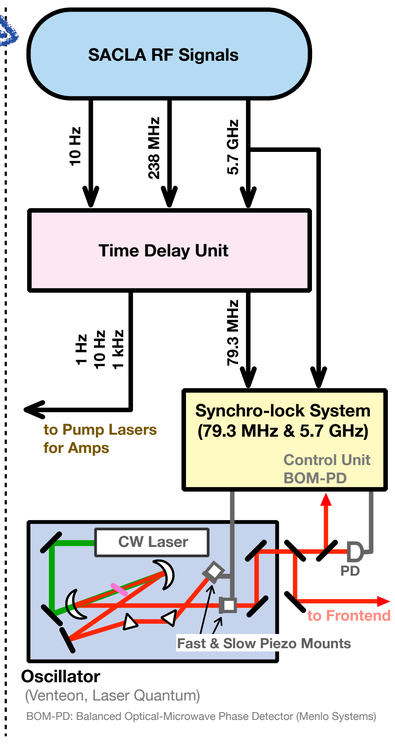


High-intensity laser at EH6	Design	Current for User Expts.
Laser Energy	12.5 J	~8 J
Pulse Duration	25 fs	~40 fs
Peak Power	500 TW	200 TW
Number of Beams	2	1
Repetition Rate	1 Hz	1 shot/~3 min

- Two users' experiments have been carried out in 2018A.
- Over 900 shots have been taken with the high intensity laser in the two experiments.

Single front-end synchronized with RF signals from SACLA is shared for two 500 TW beams

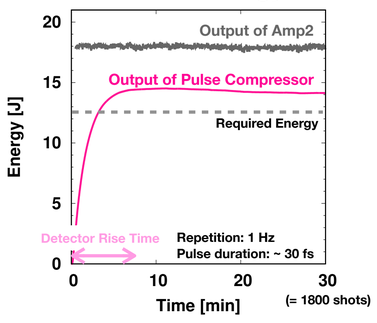




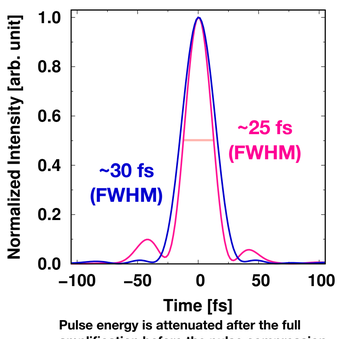
- 5.7 GHz (or 79.3 MHz) RF signal from SACLA is used in synchro-lock system of the oscillator in the shared front-end.
- Zero-timing-jitter can be achieved between two optical laser pulses because of the front-end sharing.

Pulse energy and duration have met requirements to achieve power of 500 TW with 10^{-10} contrast

Pulse Energy

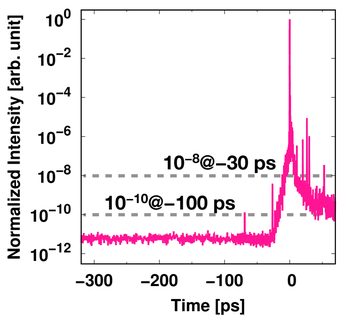


Pulse Duration



Pulse energy is attenuated after the full amplification before the pulse compression

Pulse Contrast

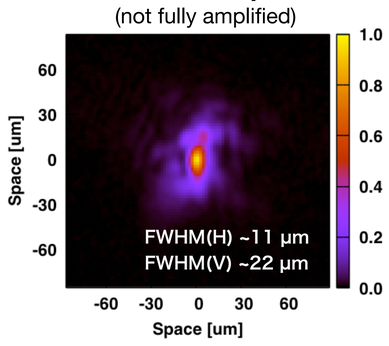


*The measurements above were performed in single beam mode (ie. non-shared front-end)

Target shots at high intensities have been carried out during commissioning of experimental platform

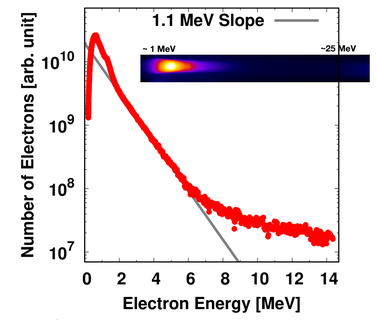
Laser Condition: ~7 J on target, ~50 fs, ~10x20 µm², ~1x10¹⁹ W/cm²
Sample: Cu (20 µm), Laser Inc. Angle: 45°, Detector: IP (2 shots accumulated)

Focused Spot
(not fully amplified)



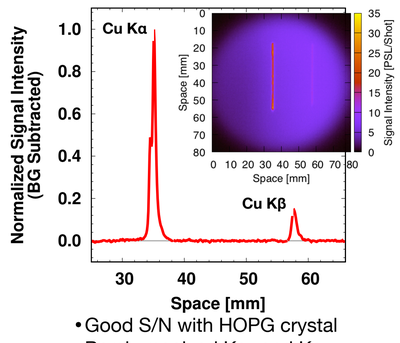
[Updates] Focus optimization is now performed with fully amplified beam.

Vacuum Electrons



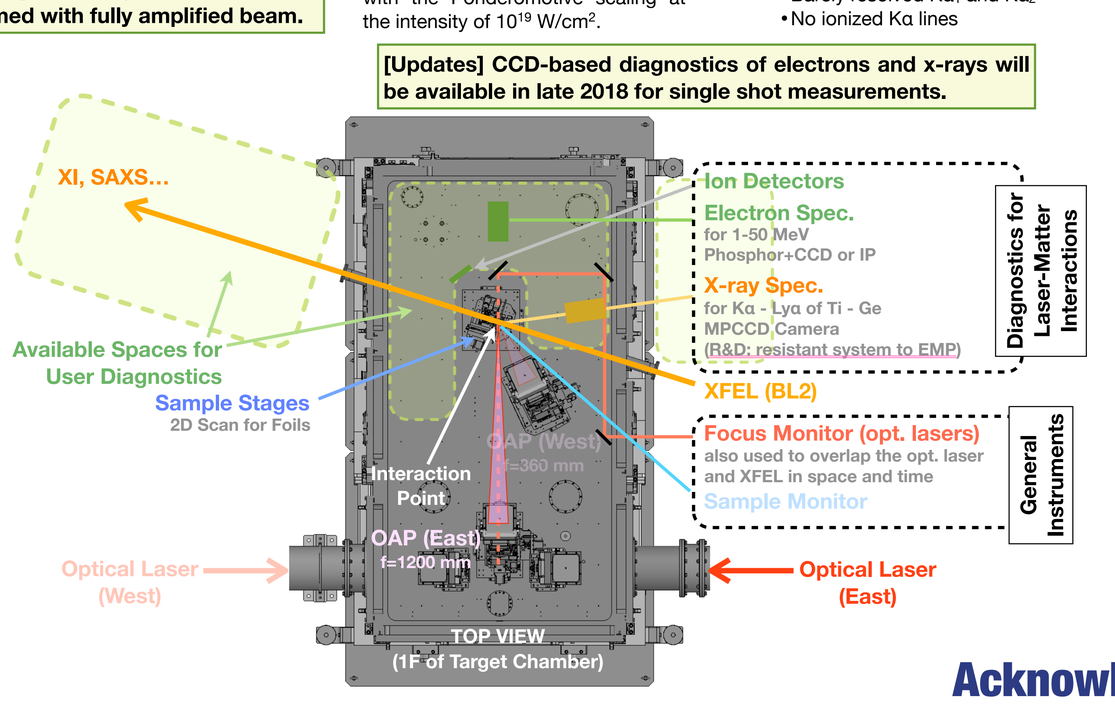
Slope temp. of ~1 MeV is consistent with the Ponderomotive scaling at the intensity of 10^{19} W/cm².

Laser-induced X-rays

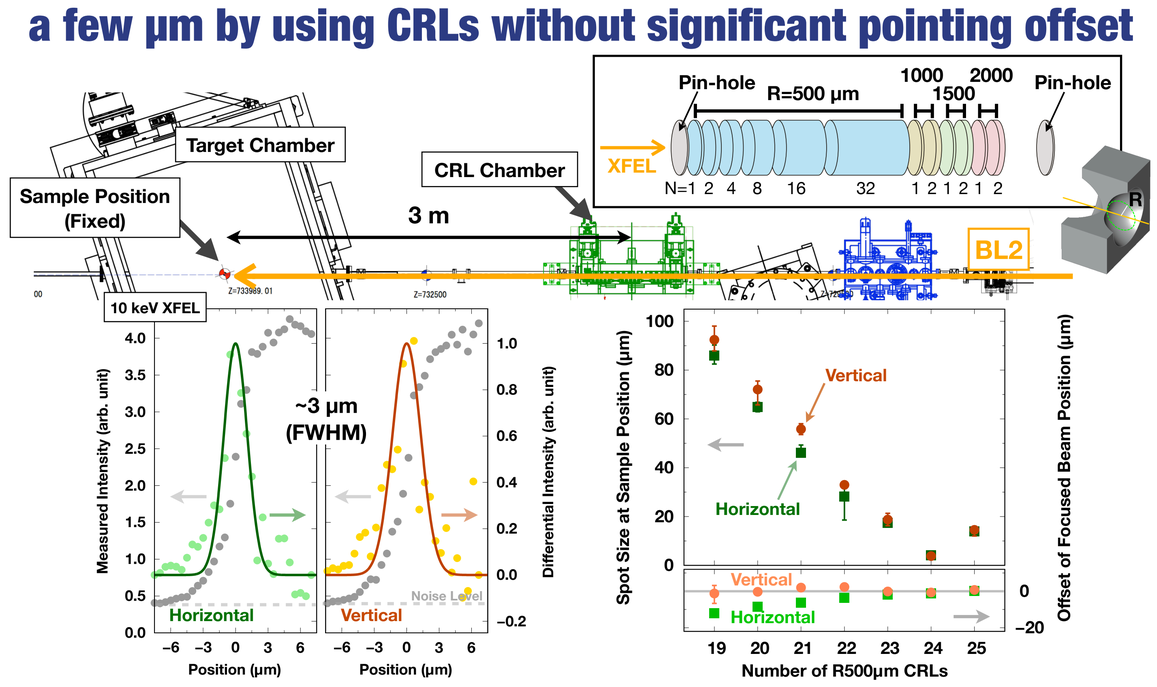


- Good S/N with HOPG crystal
- Barely resolved Kα₁ and Kα₂
- No ionized Kα lines

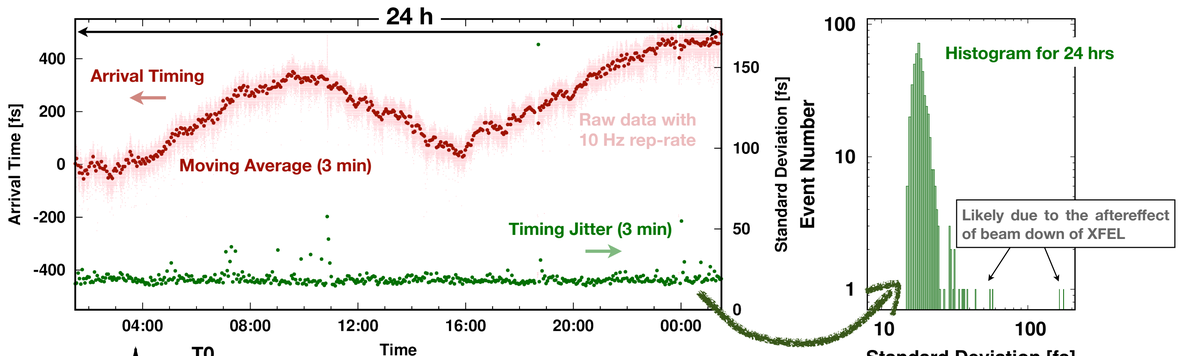
[Updates] CCD-based diagnostics of electrons and x-rays will be available in late 2018 for single shot measurements.

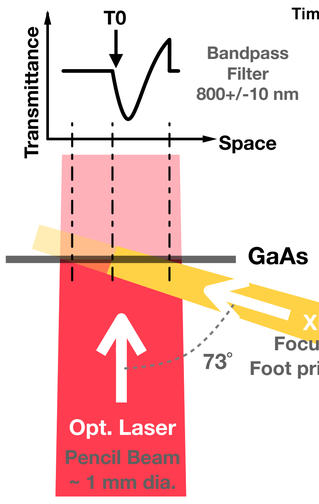


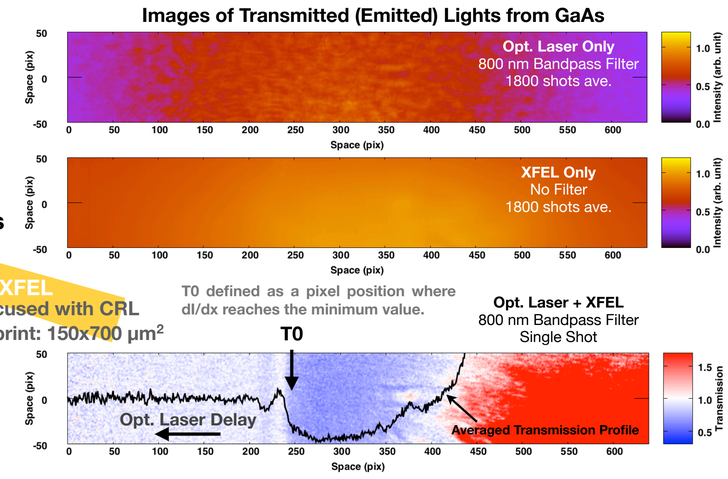
XFEL beam size at sample position can be varied down to a few µm by using CRLs without significant pointing offset



Relative timing jitter of XFEL and laser has been suppressed down to ~20 fs (less than the laser pulse duration)
Next challenges are on timing drift







Acknowledgements

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