Status of experimental platform with high-intensity optical laser at SACLA

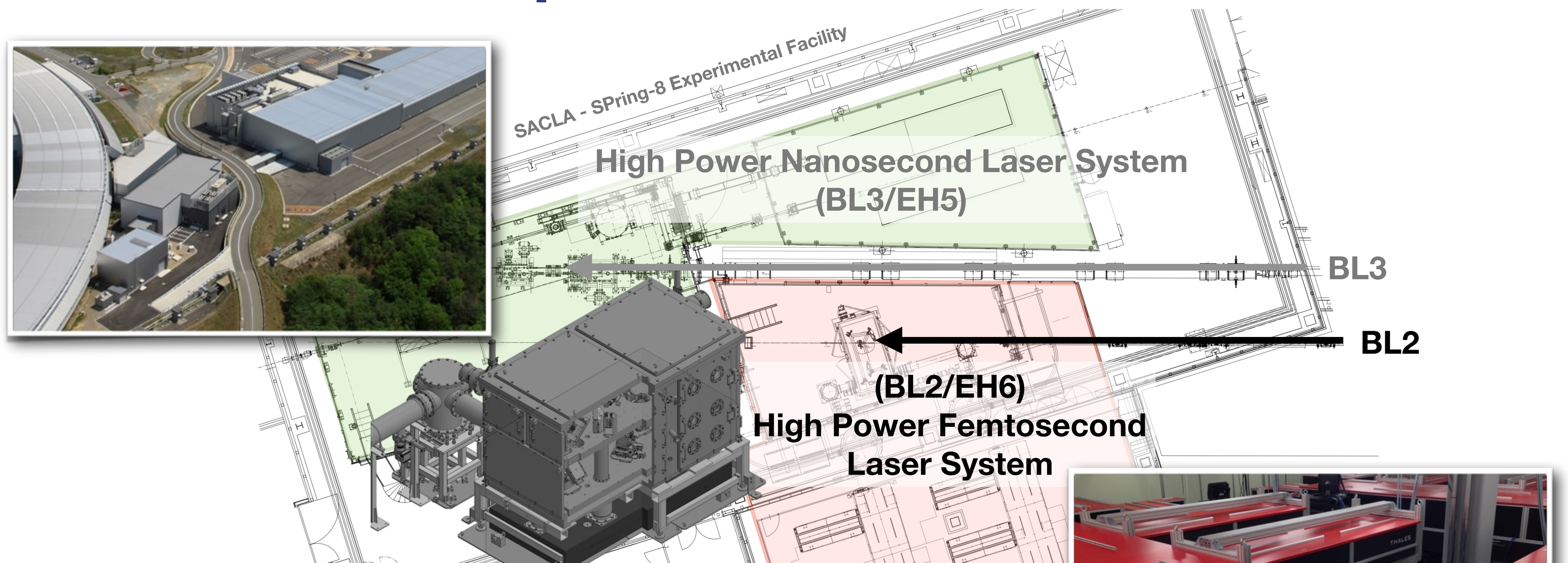
T. Yabuuchi, K. Sueda, Y. Inubushi, T. Togashi, K. Miyanishi, H. Tomizawa, M. Yabashi

SACLA

Summary

- The experimental hutch 6 (EH6) has been opened for user experiments since 2018A with a joint operation capability with a high-power, high-intensity optical laser mainly for high energy density science (HEDS).
- Single-shot diagnostics have been developed and installed to the experimental platform to monitor shot-to-shot fluctuations of the high-intensity laser-matter interactions.
- Further improvement of the platform is planned to improve stability and performance.

Experimental platform with high-power femtosecond laser has been opened for users since 2018A



High-power fs laser at EH6	Design	User Operation (Typical)
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

- Six (6) users' experiments have been carried out since 2018A.
- Achieved shot number per day varies from few 10's to ~100, which strongly depends on the sample alignment complexity.

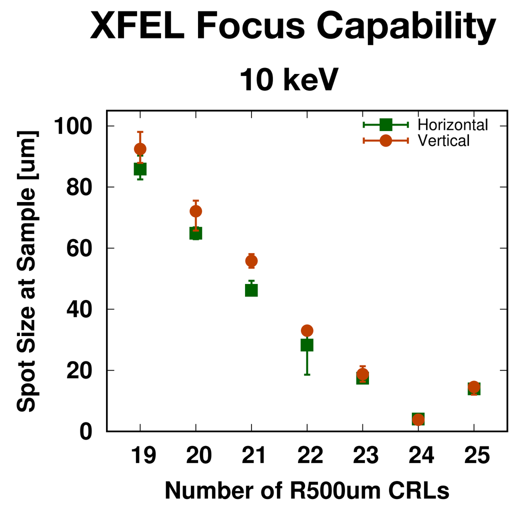
Over 100 shots have been taken per day with high-power laser in combination with XFEL for user experiments

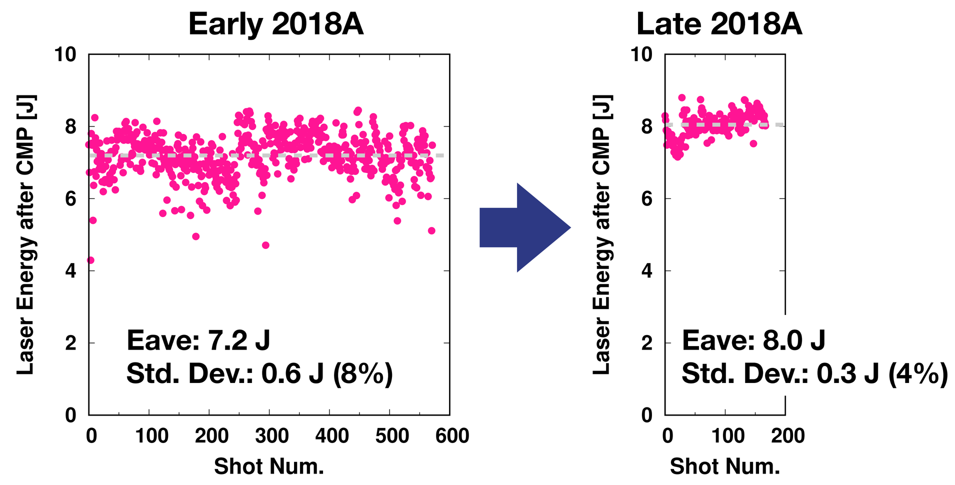
XFEL Application
3x X-ray Imaging
2x X-ray Scattering incl. SAXS
1x Others

High-intensity Laser Application
Pump with energies from sub-J to ~8 J

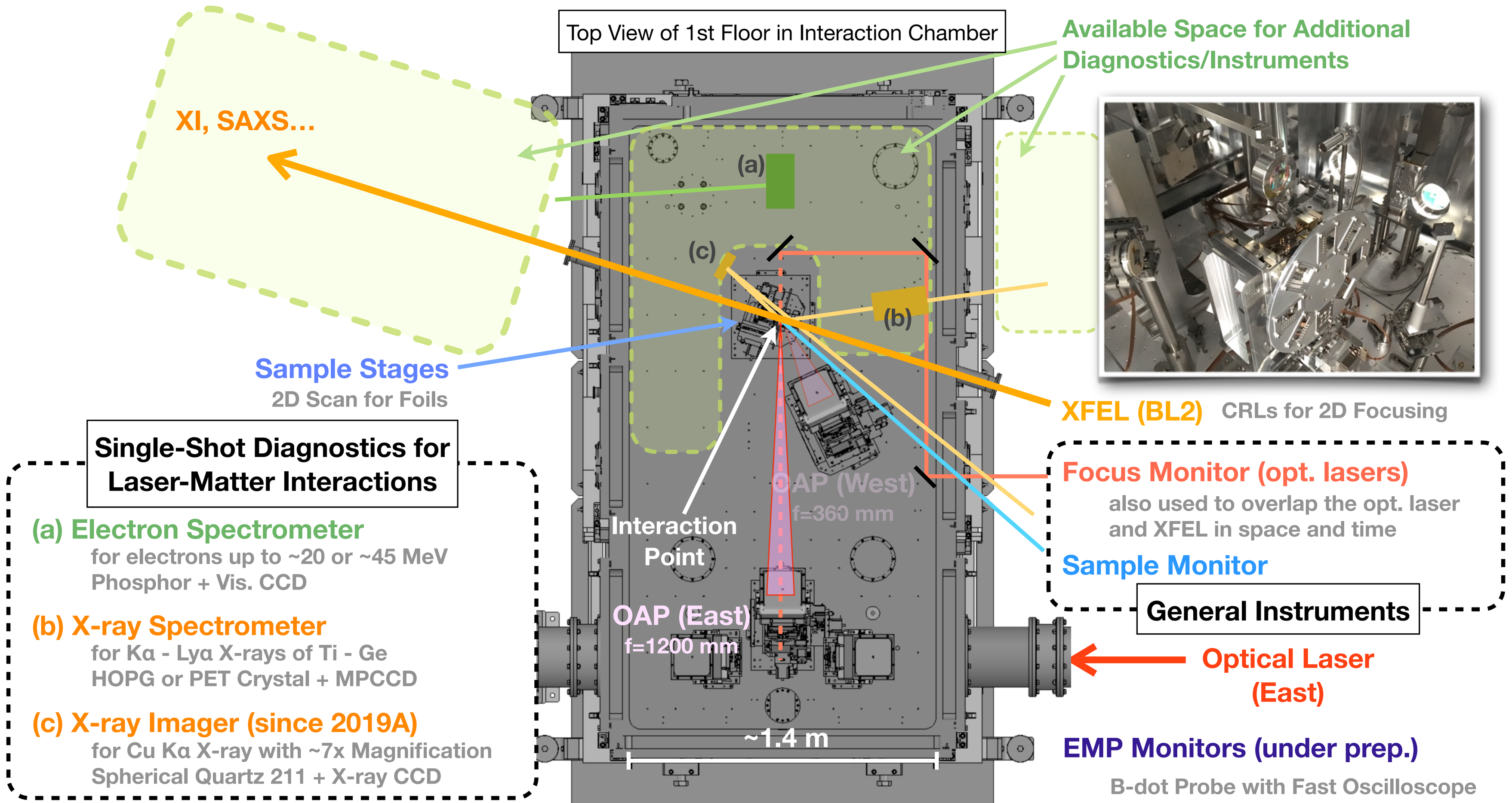
XFEL Focus
Best Focus at Sample
Focused in Upstream
Unfocused Beam

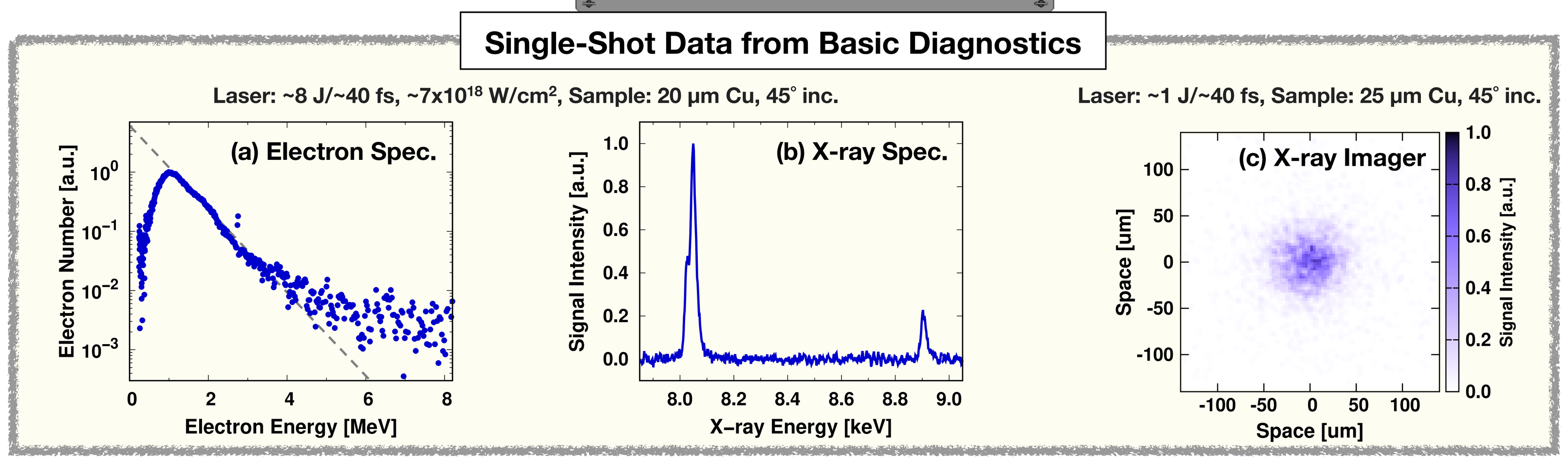
High-intensity Laser Focus
Best Focus (down to ~15 μm)
Defocus (over a few hundreds' μm)





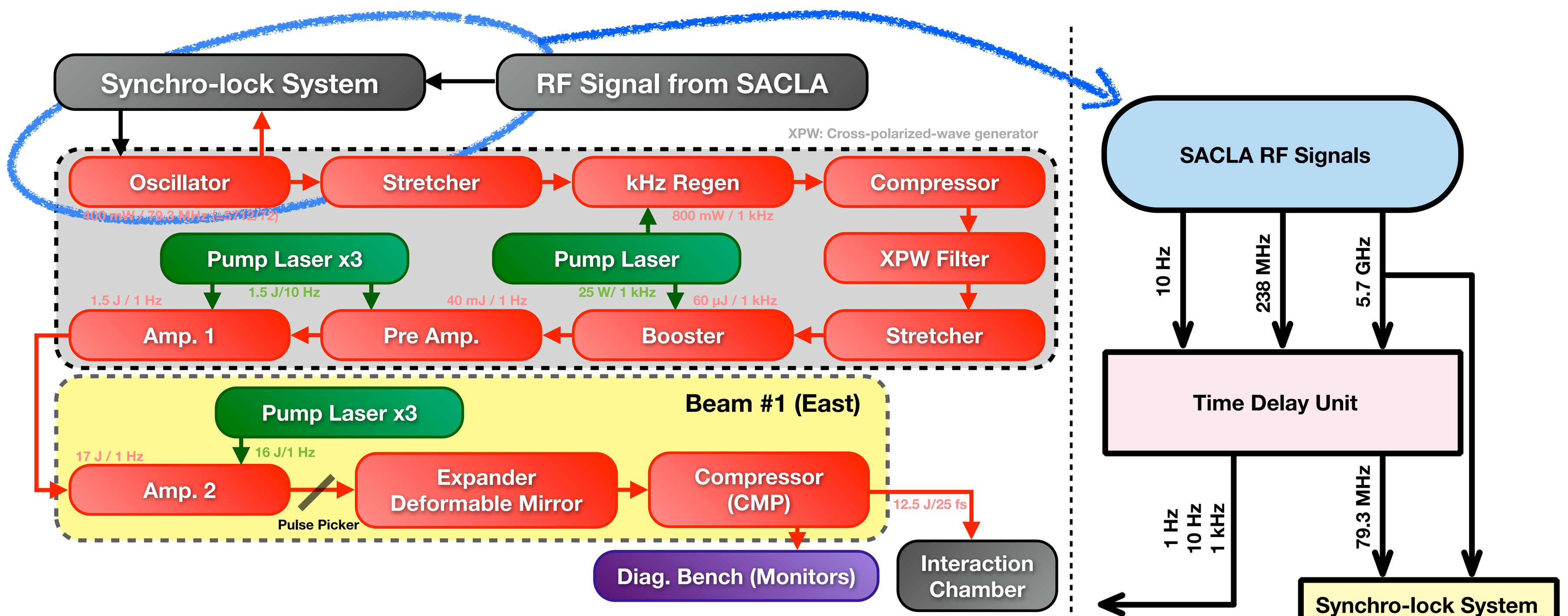
Experimental platform has been continuously upgraded to expand and improve its capabilities

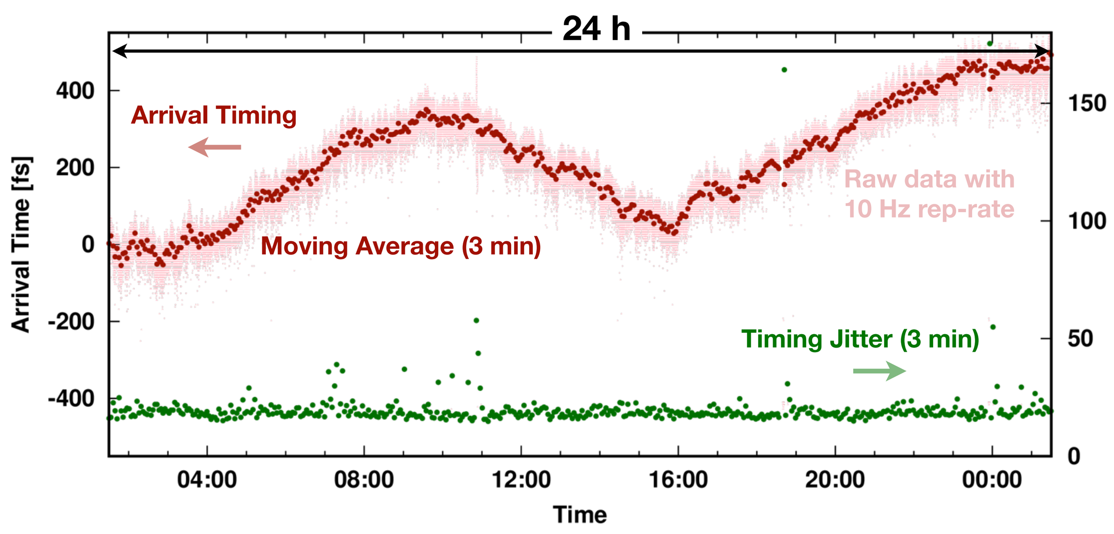




- Basic diagnostics are now all applicable for "single-shot" measurements.
- High-resolution x-ray imaging detector (Poster #9) can also be used in this platform.

Laser system is synchronized to SACLA XFEL with timing jitter of ~20 fs rms at sample position



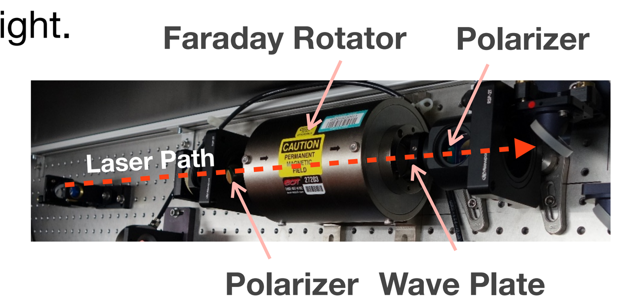


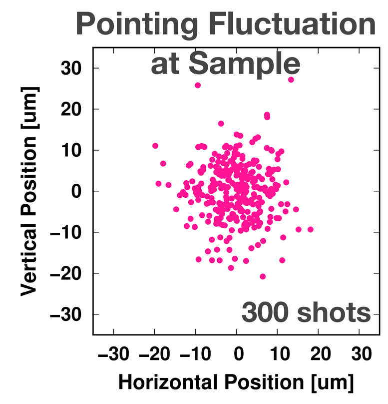
- The 5.7 GHz RF signal from SACLA is used for the time synchronization of the laser system.
- Timing jitter and drift relative to the XFEL have been measured at the sample position using the spatial-decoding technique with a GaAs wafer.
- Observed timing jitter is small (~20 fs in rms), but the drift (typically ~50-70 fs/h) causes significant uncertainties on the arrival timing on shots.

Further improvement is planned to solve issues found in past user experiments

Operation Reliability of High-Power Laser System

- Optics are damaged during user experiments in 2019A on the best-focused shots with over a few J, most likely due to back-reflected light.
- A Faraday isolator is under installation in the system and expected to be operational from 2019B.



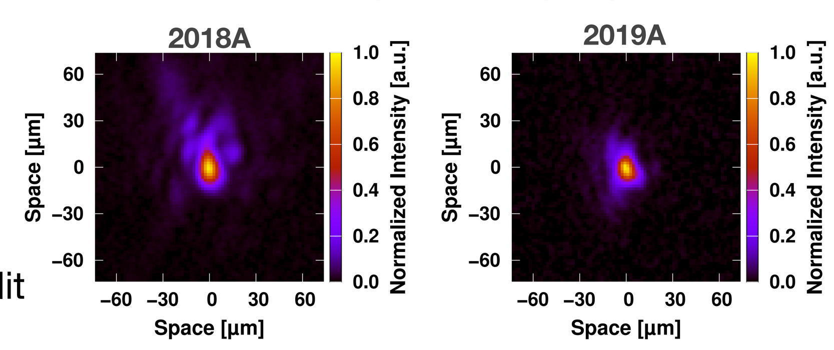


Focused Beam Profile and Pointing Stability

- Improvement of focused beam profile is ongoing since late 2018 with a wavefront correction using a deformable mirror.
- Pointing stability has to be improved, particularly in the case with a tightly focused beam.

Accuracy of Sample Replacement

- Accuracy of sample replacement sometimes becomes an issue, particularly for small samples.
- Some sample stages will be replaced with improved mechanical design/components before 2019B for more precise sample adjustment.



Compensation and Monitoring of Timing Drift

- Reducing the timing drift is one of the remaining tasks for precise pump-probe experiments. The first step is to identify the source causing the drift.
- Development of an arrival timing monitor on shots is another option to improve the pump-probe capability. Alternate to observe the timing with split pulses of optical and x-ray, we are currently trying to diagnose the timing between the reference RF signal and the optical pulses.