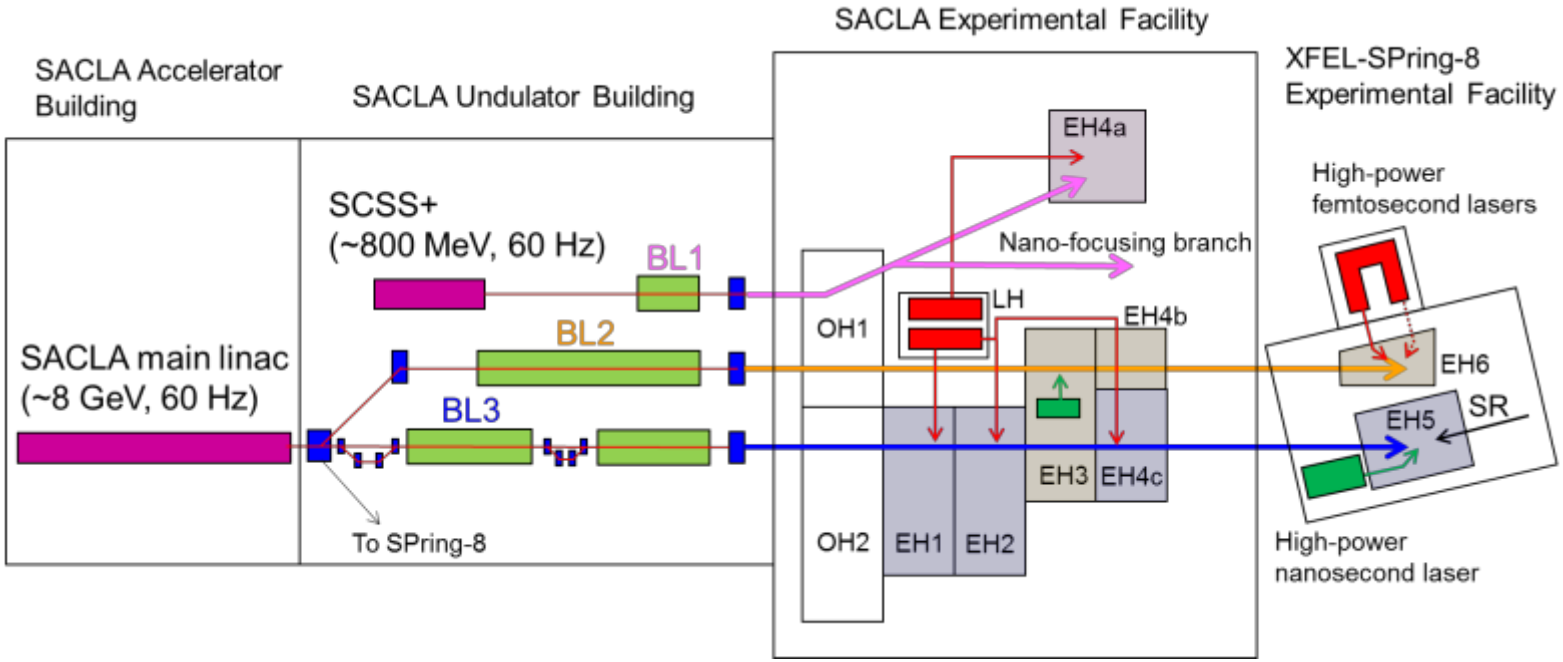
Updates on Beamlines

Kensuke Tono (SACLA)

Contents

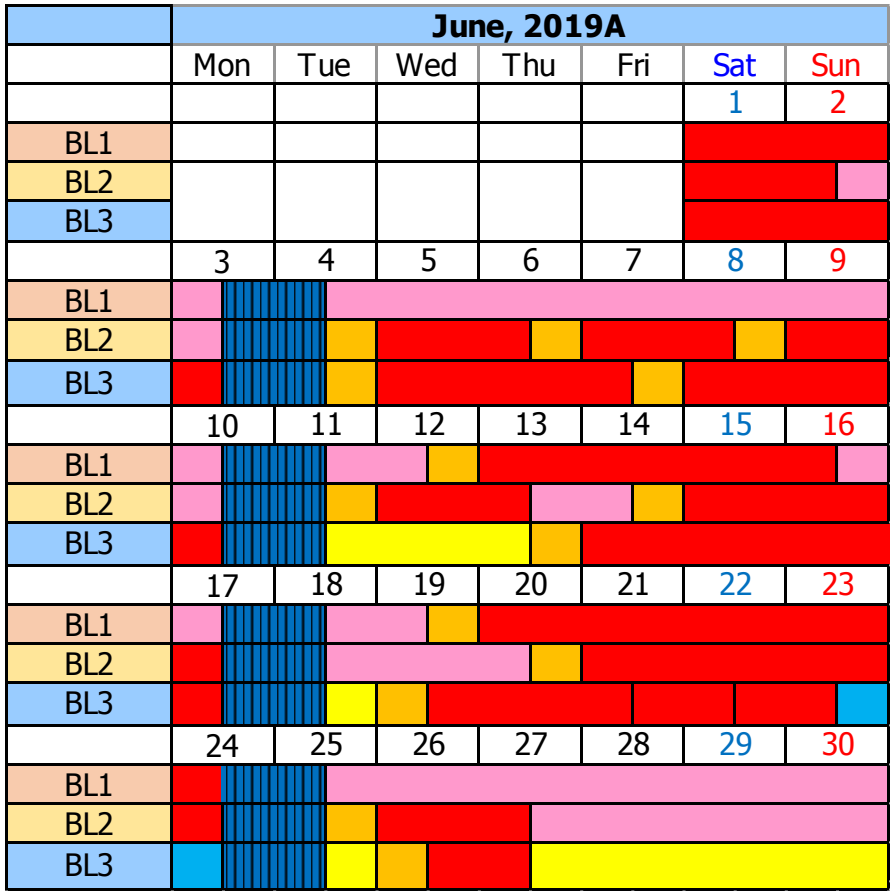
1. Operation in ‘phase 2’
2. Research highlights
3. New capabilities
4. Summary



Operation ‘Phase 2’ for two years

- Parallel operation of 3 BLs from 2017B

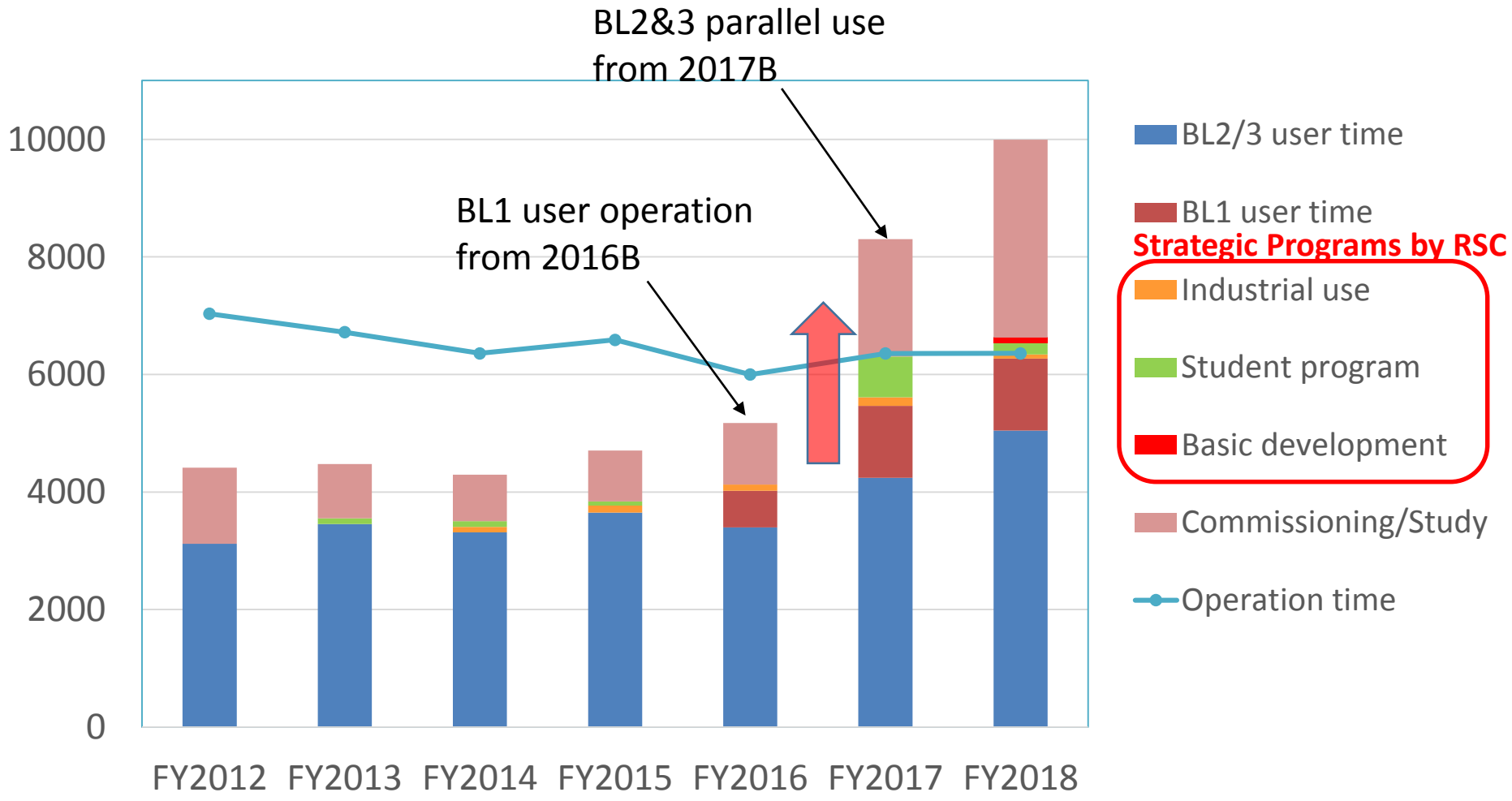
Operation schedule (June 2019)



⇒**Poster No.1, Inagaki-san**

- Machine tuning
- User time
- Preparation for user time
- Commissioning
- Study (Graduate Student, Basic Development, In-house)
- Industry-Academy Partnership Program

Beamtime


BL2&3 parallel use
from 2017B
BL1 user operation
from 2016B
10000
8000
6000
4000
2000
0
FY2012
FY2013
FY2014
FY2015
FY2016
FY2017
FY2018
BL2/3 user time
BL1 user time
Strategic Programs by RSC
Industrial use
Student program
Basic development
Commissioning/Study
Operation time

Expanding opportunities in ‘Phase 2’

- More user beamtime with 3 BLs
  - ⇒ 6,270 h user time in FY2018.
  - ⇒ Feasibility-check beamtime @BL2 (from 2017B)
  - ⇒ Beamtime allocation on a 12 h-a-day basis @BL2

- Opportunities for promotion programs
  - ⇒ SACLA Basic Development Program
  - ⇒ SACLA Research Support Program for Graduate Students
  - ⇒ SACLA Industry-Academy Partnership Program

- High-power lasers
  - ⇒ High power fs laser (500 TW): Open to users from 2018A.
  - ⇒ High power ns laser (ILE, Osaka U.)

Three beamlines

⇒Poster No.2, Inubushi-san

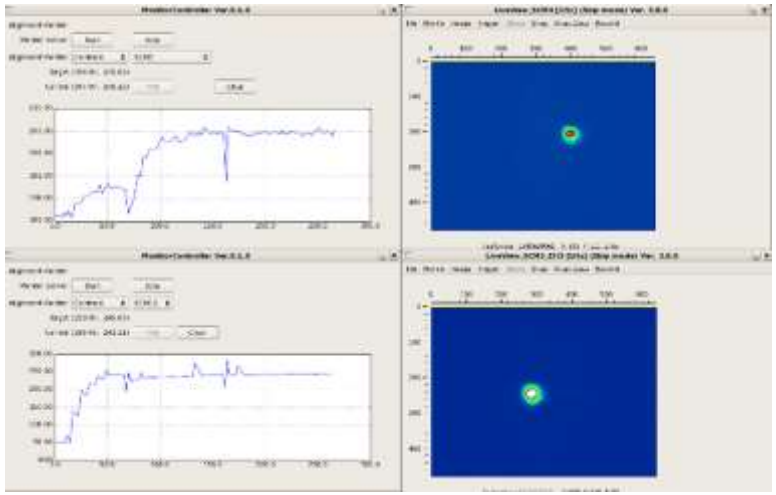
	Type of experiment	Major instruments	Remarks
BL1 (40-150 eV, higher-order harmonics)	Ion/electron spectroscopy SX spectroscopy Ellipsometry Imaging	fs optical laser KB (~5 μm) Timing tool Nano focusing optics Opto-spintronics platform	Users are encouraged to use their own end-stations
BL2 (4-15 keV)	Fixed-target PX SFX CDI/SAXS P&P with high power laser	ns optical lasers KB (~1 μm) DAPHNIS (SFX) MAXIC-S/II (CDI) High power fs laser	Feasibility-check beamtime
BL3 (4-20 keV)	XRD WAXS Spectroscopy SFX, CDI (fs resolution) XPCS Laser-shock compression	fs optical laser SDO Timing tool CRL, KB (~1 μm) 300 exa (~0.1 μm) High-power ns laser (Osaka U.)	Double-pulse XFEL (~300 fs delay@10 keV) Self-seeding Polarization control

The facility assigns BL2 or BL3 to HX-FEL users according to the type of experiment.

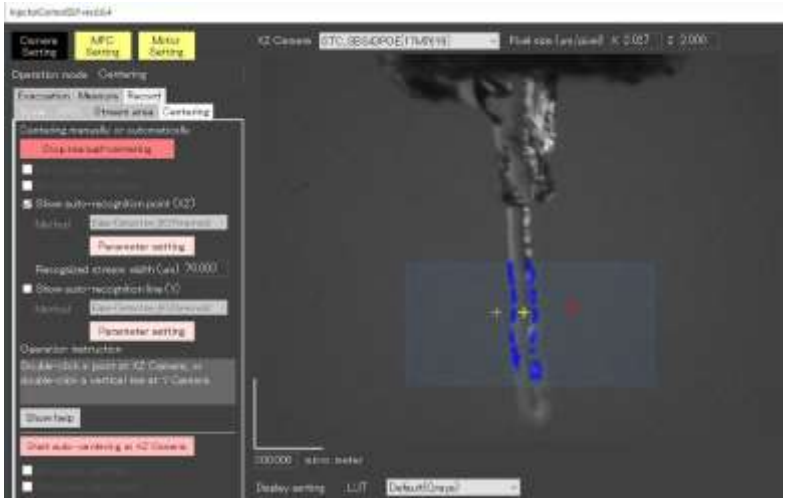
For more efficient operation

- Auto-positioning of XFEL beam/sample.

Auto tuning of BL optics



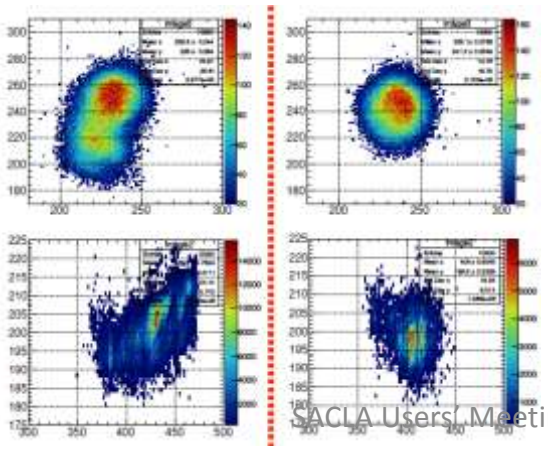
Sample injector (under development)



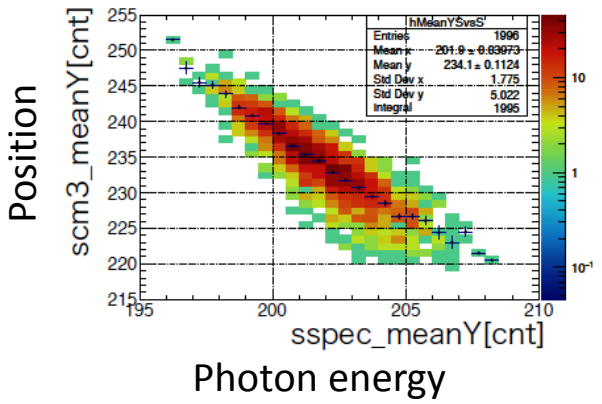
- Quick multiple-parameter optimization of XFEL (Intensity, bandwidth, beam size, etc.)

Beam profile

Spectrum



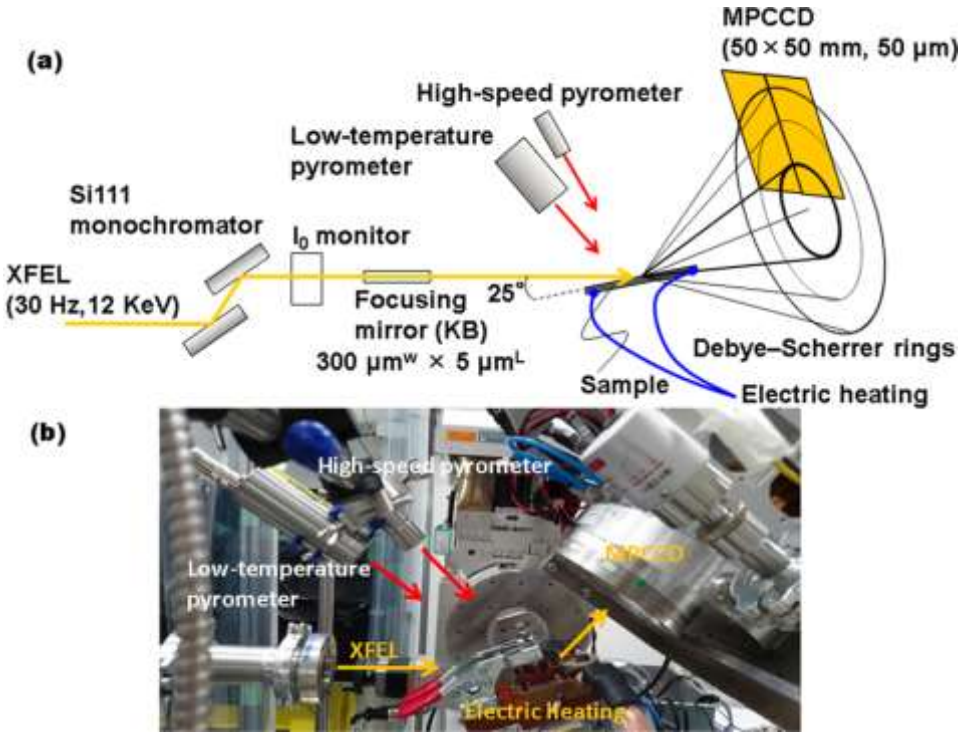
Photon-energy and position correlation

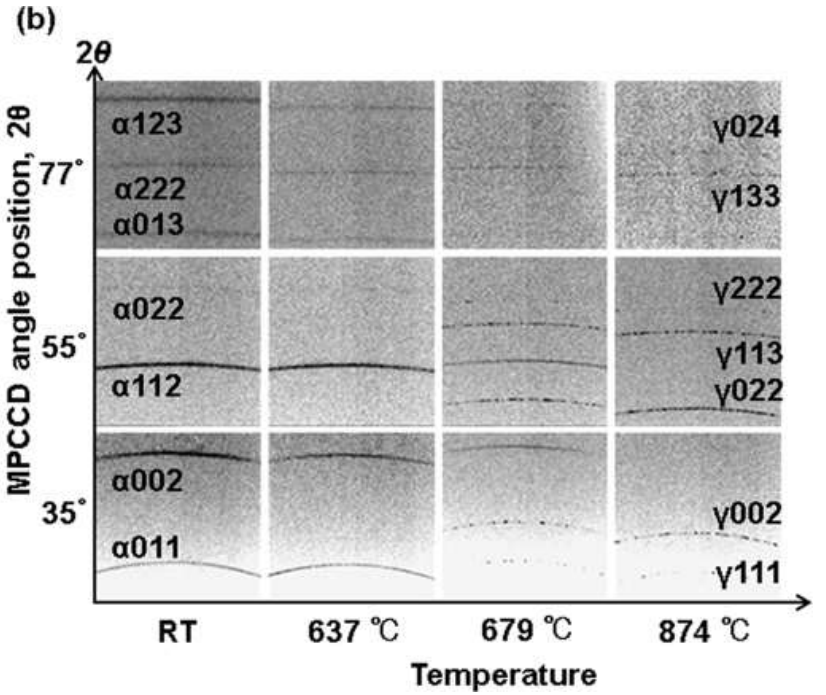


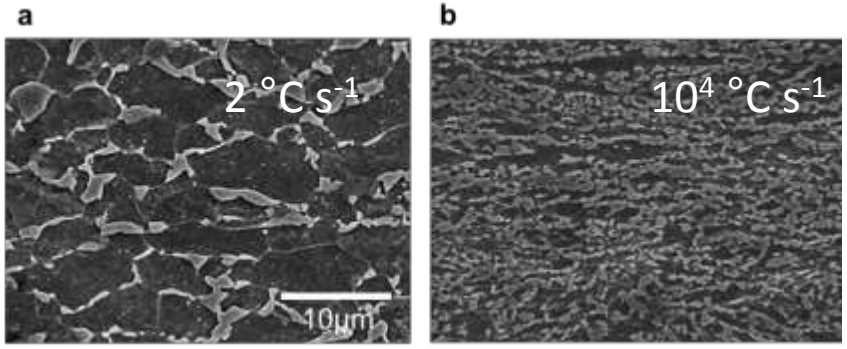
Contents

Time-resolved XRD of steel under ultrafast heating process

Yonemura（Nippon Steel Co.) et al.,
Scientific Reports 9, 11241 (2019).





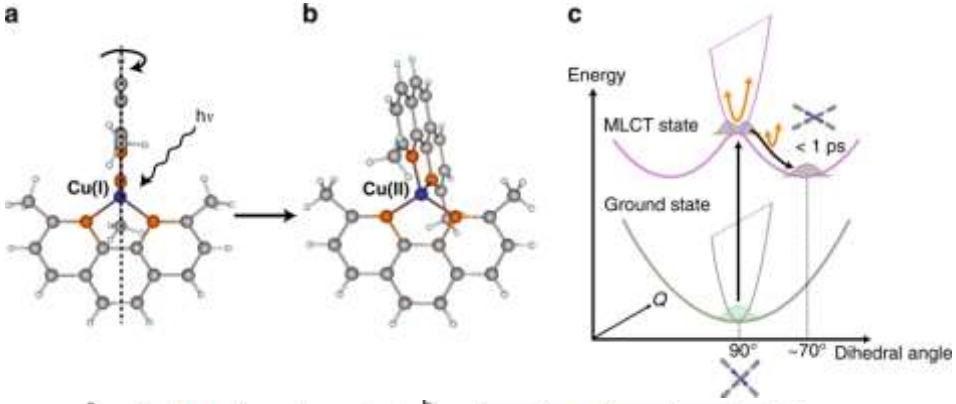


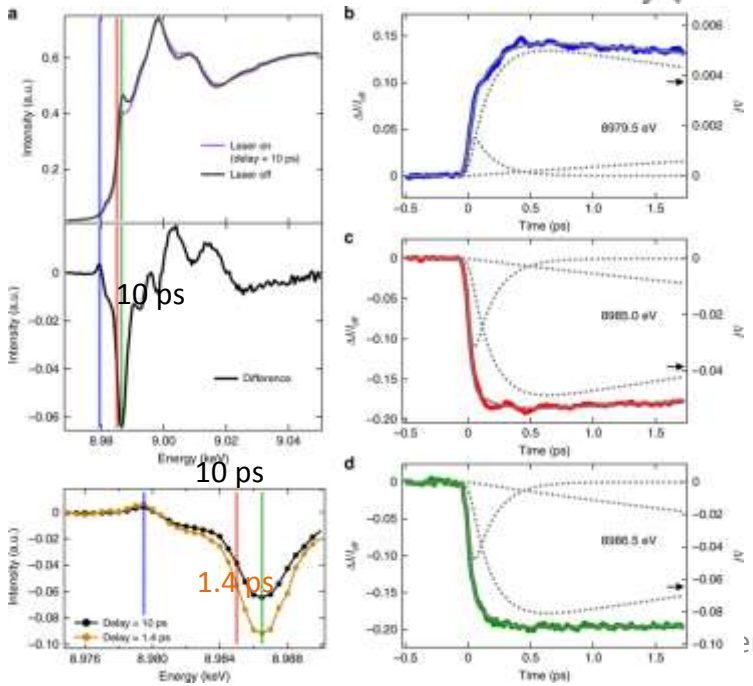
Ultrafast electrical heating at ~10^4 ℃/s

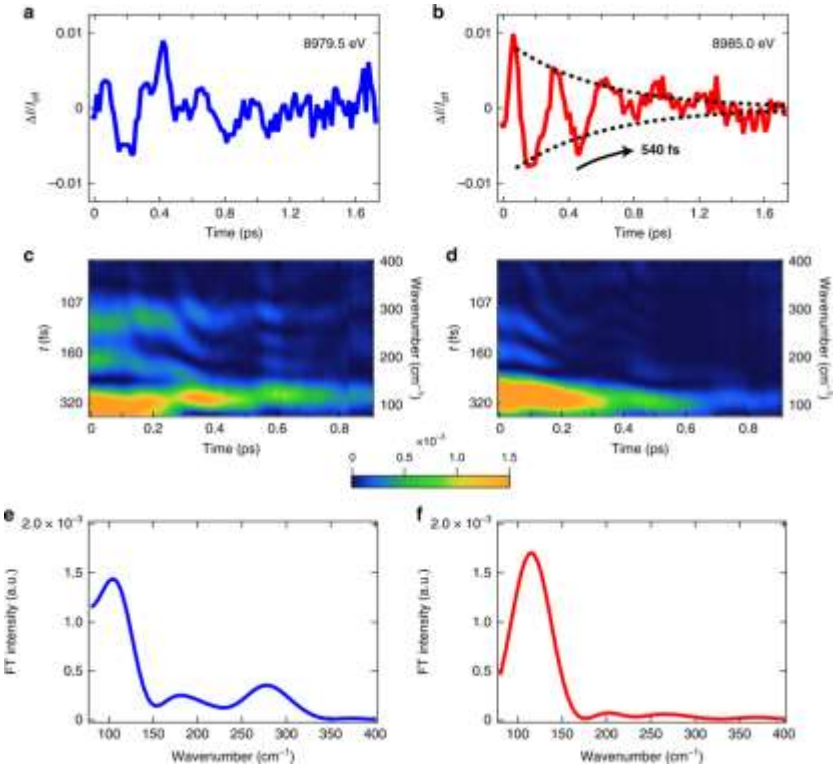
Tracking a nuclear wavepacket using ultrafast X-ray spectroscopy

Photoexcited Cu(I)-phenanthroline

Katayama et al.,
*Nat. Commun.***10**, 3606 (2019).







Probing ultrafast electronic decay processes in molecules

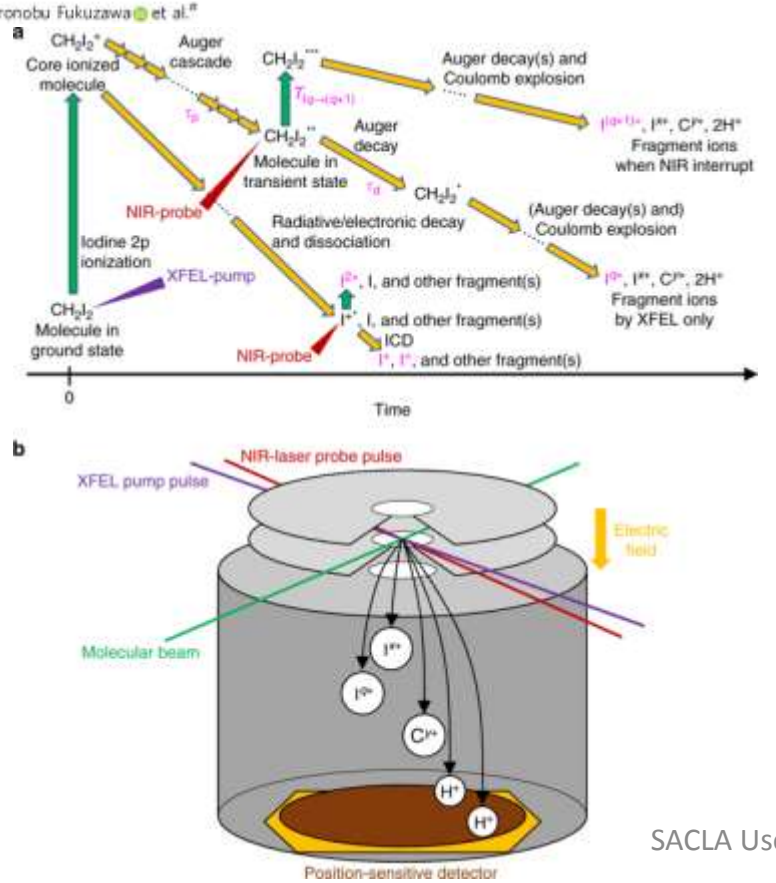
nature COMMUNICATIONS

ARTICLE

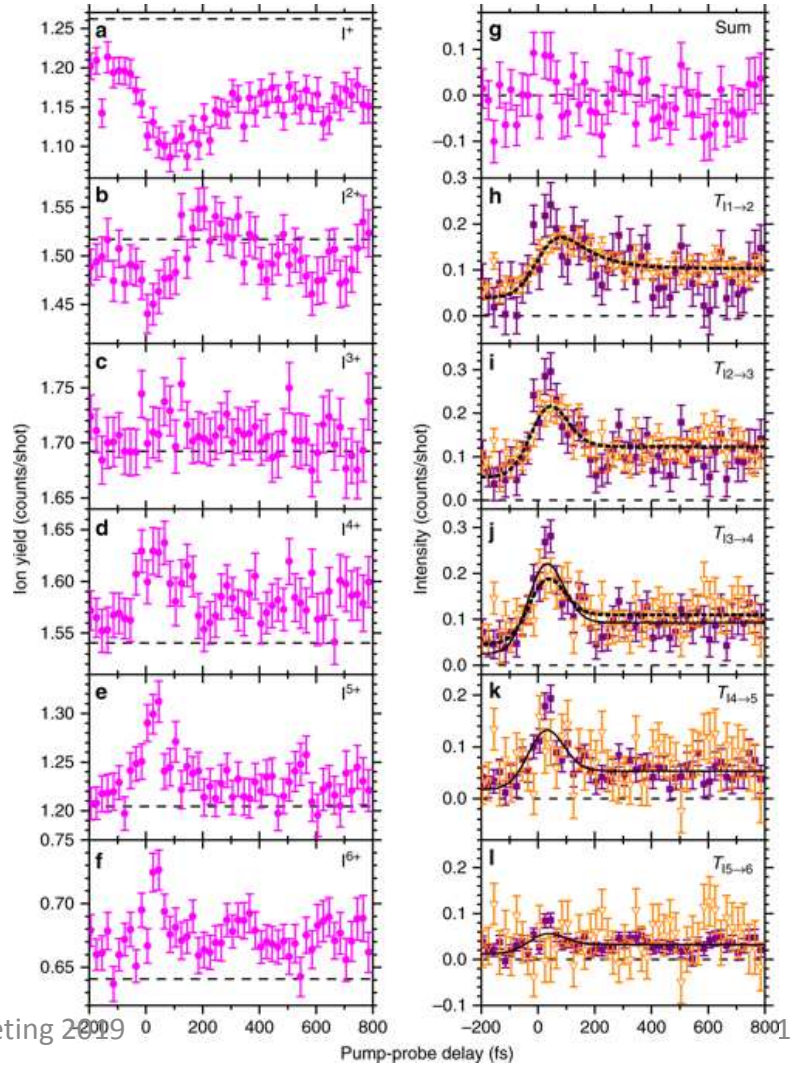
https://doi.org/10.1038/s41467-019-10060-z OPEN

Real-time observation of X-ray-induced intramolecular and interatomic electronic decay in CH_2I_2

Hironobu Fukuzawa et al.



Fukuzawa, Ueda et al.,
*Nat. Commun.***10**, 2186 (2019)



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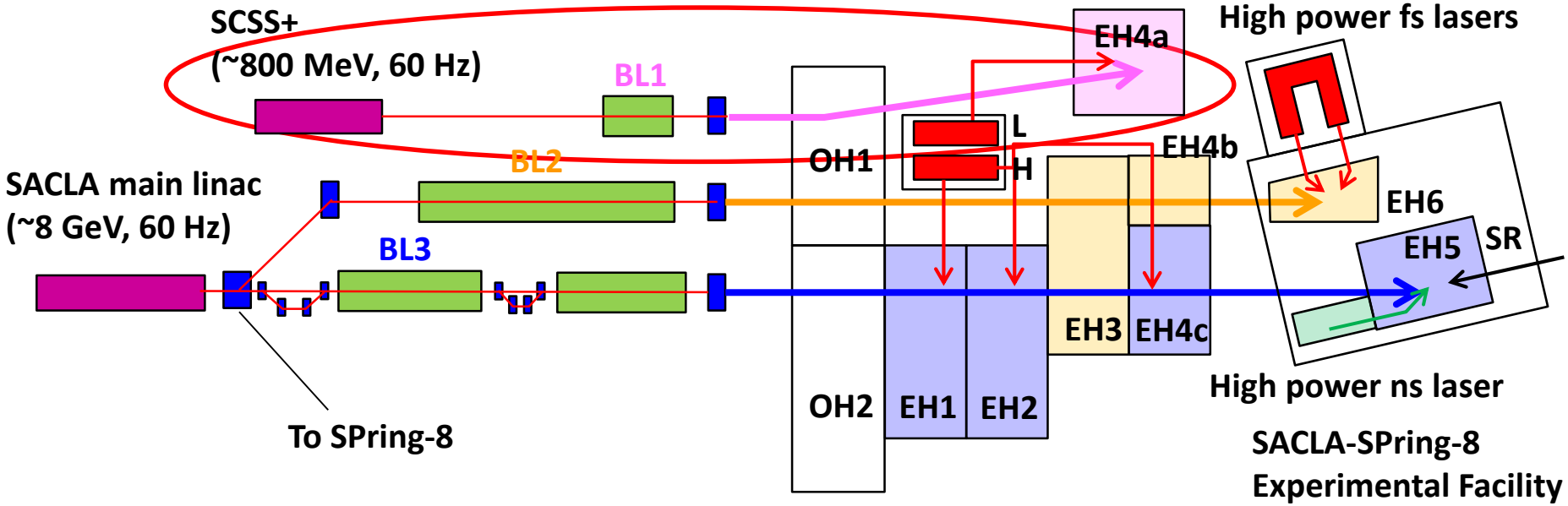
BL1

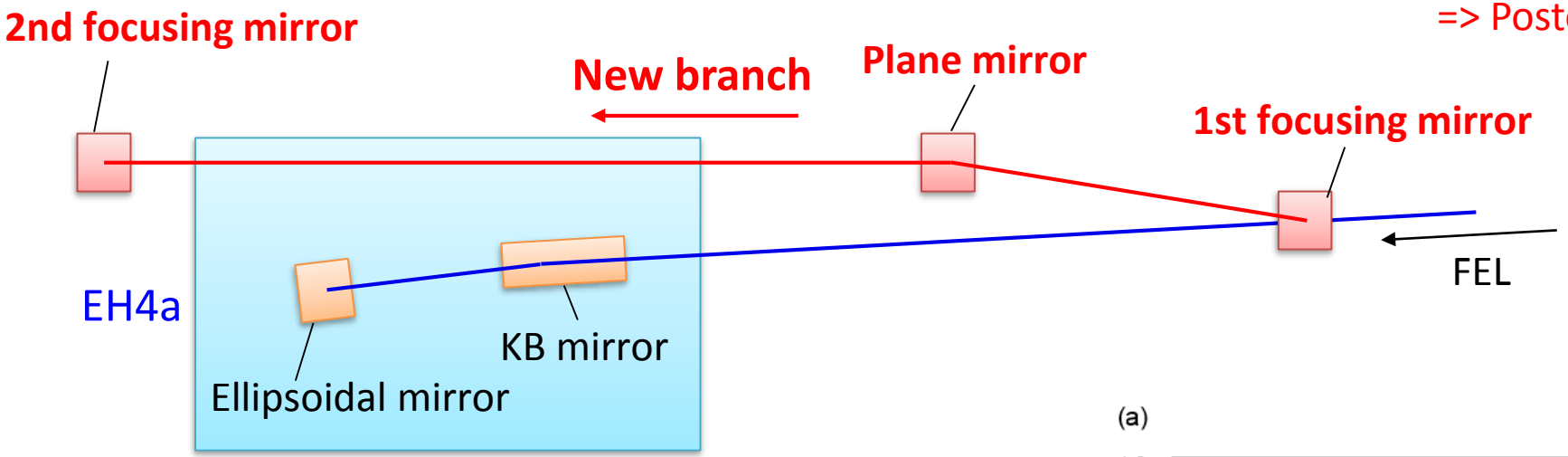
- Nano focusing optics
- Experimental platform for opto-spintronics researches.

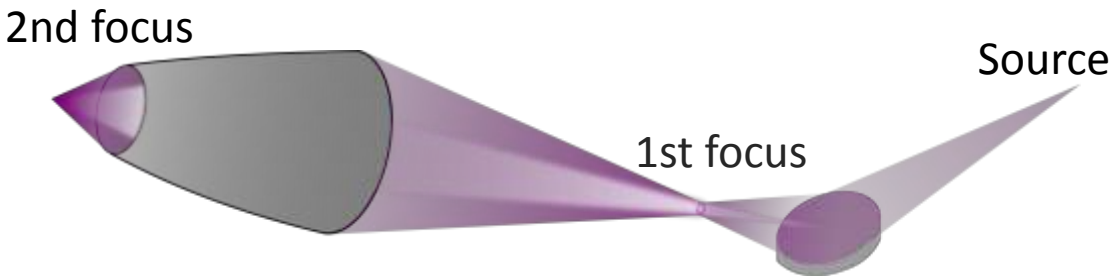


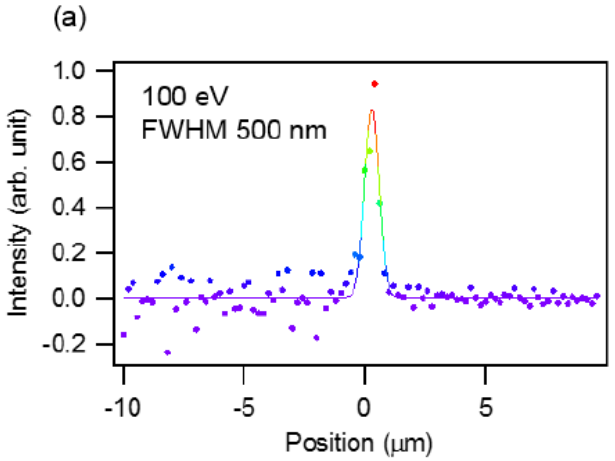
SX nano focusing system

Collaboration with U. Tokyo
Motoyama-san, Mimiura-sensei => Talk
Egawa-san, Yamaguchi-san, Yokomae-san
=> Posters

Nano focusing branch of BL1

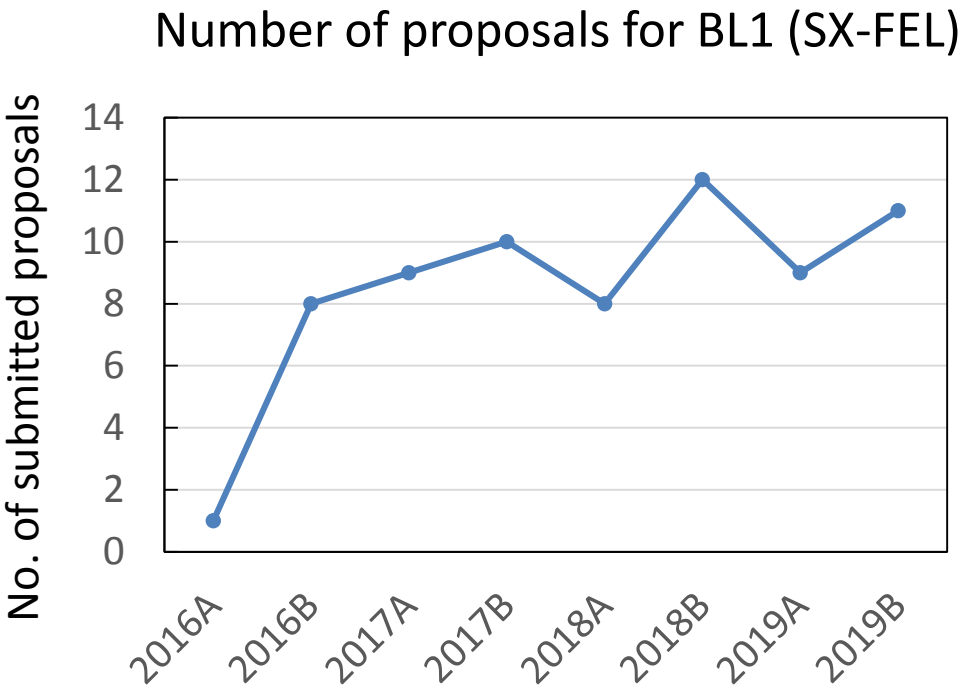


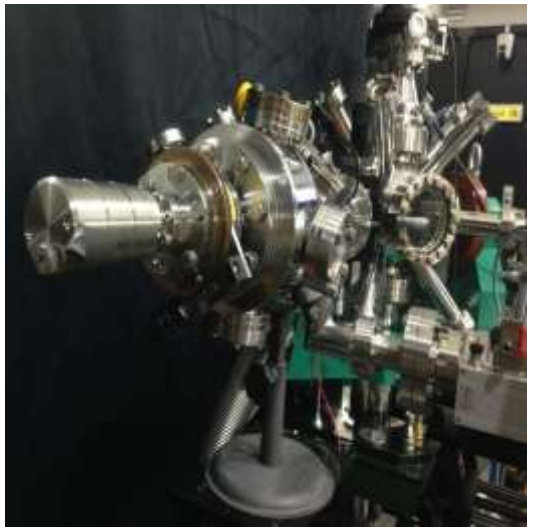




Motoyama et al., Proc. SPIE (2017); J. Synchrotron Rad. (2019).
Mimura et al., Rev. Sci. Instrum. (2018).
Egawa et al., Proc. SPIE (2019).

Experimental platform for materials science at BL1

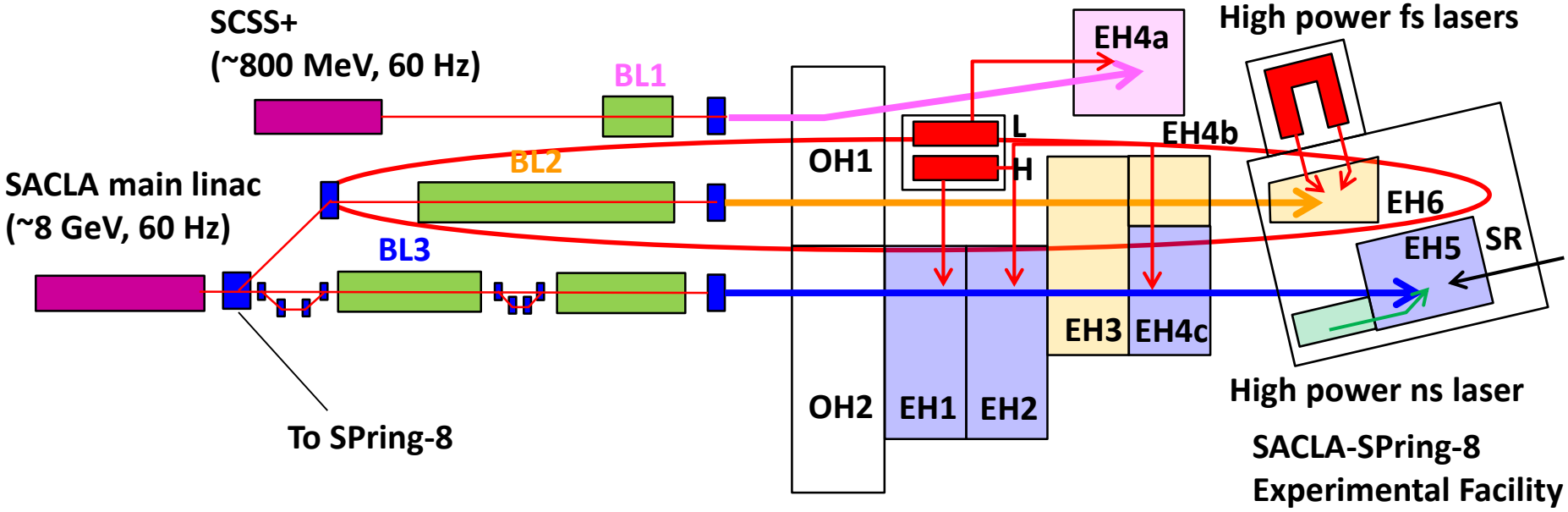




- Number of proposals tends to increase at BL1.
  => Common-use system will be useful.
- Experimental system for opto-spintronics researches is under development => Dr. Hirata and Prof. Matsuda (U. Tokyo), Talk in the next session

BL2

- MAXIC-S
- Large area detector (Rayonix MX-300HS)

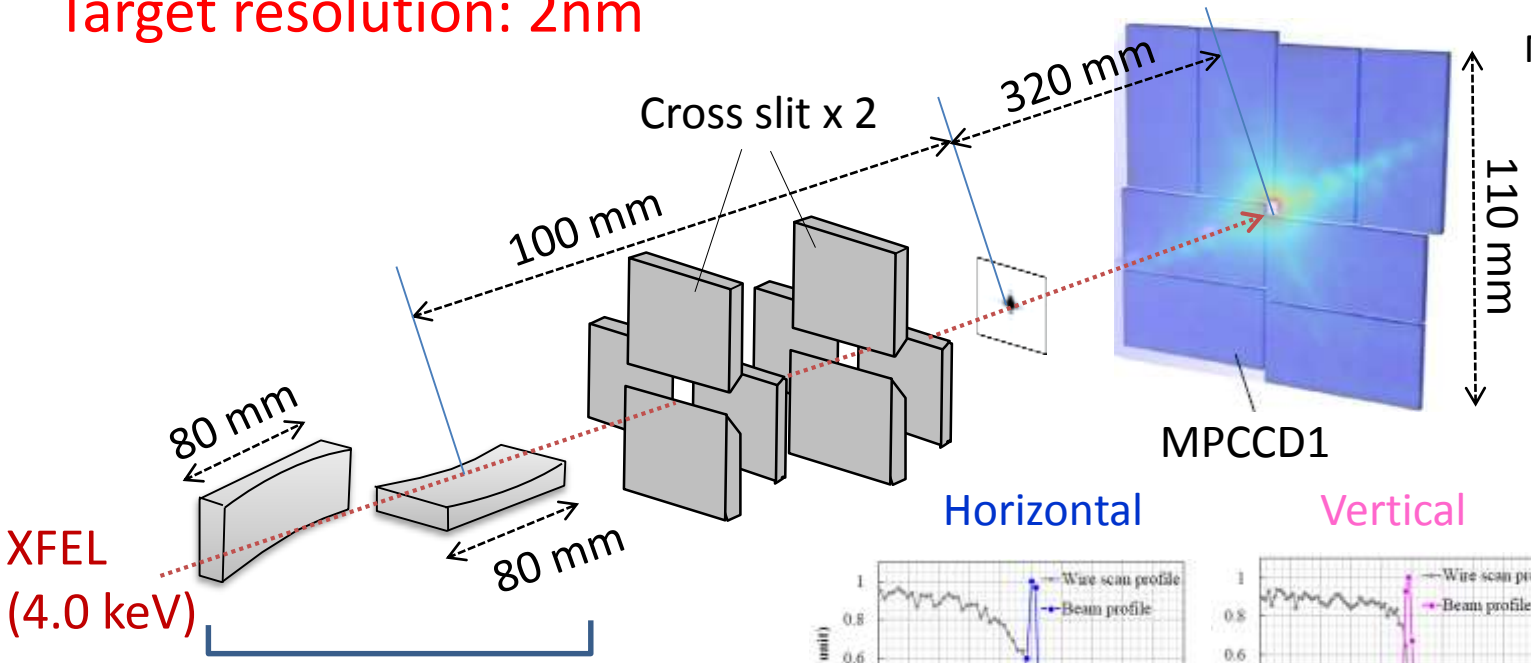


MAXIC-S for nano-beam CDI

BL2

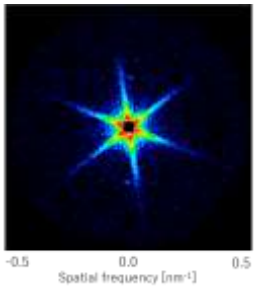
Collaboration with Hokkaido U.
Suzuki-san, Nishino-sensei (Talk)

Target resolution: 2nm

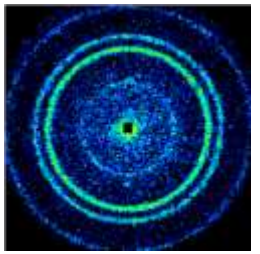


Multilayer mirrors
R ~55% (double reflection)
Glancing angle: 25 mrad (1.4°)

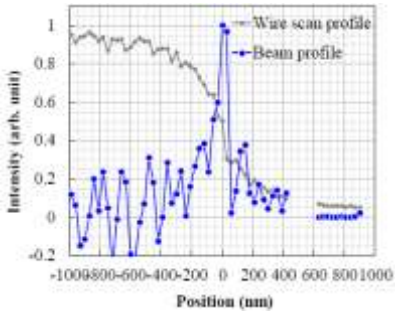
Metal nano triangle



Protein 2D crystal

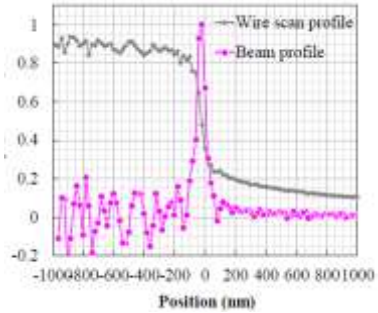


Horizontal



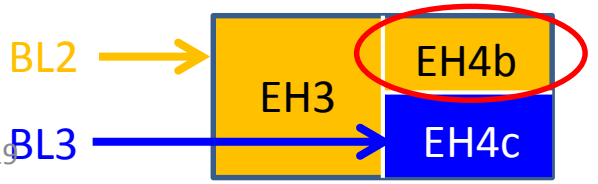
~110 nm (FWHM)

Vertical



<100 nm

Installed into EH4b for more efficient operation (this summer).

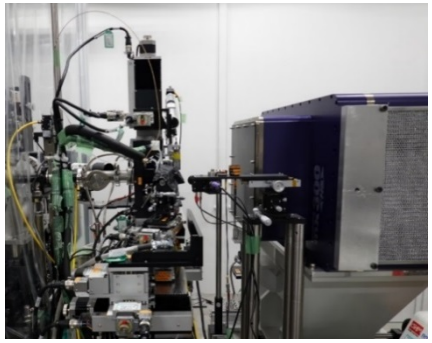


Large area detector for PX, WAXS

BL2
BL3

MX300-HS (Rayonix, L.L.C.) is now operated on the SACLA DAQ system.

Description	8 sensor MPCCD (Phase Ib)	MX300-HS*	
		2x2 binned	4x4 binned
Active area [mm^2]	110 x 110	300 x 300	
Max. frame rate [Hz]	60	10	33
Image format	2048 x 2048 50 um	3840 x 3840 78 um	1920 x 1920 156 um
Nominal Q.E. @12keV	0.2	0.8	0.8



DAPHNIS with MX300-HS

* https://www.rayonix.com/product/mx300-hs/

PX

For samples having large lattice constants. (longer camera distance).

WAXS

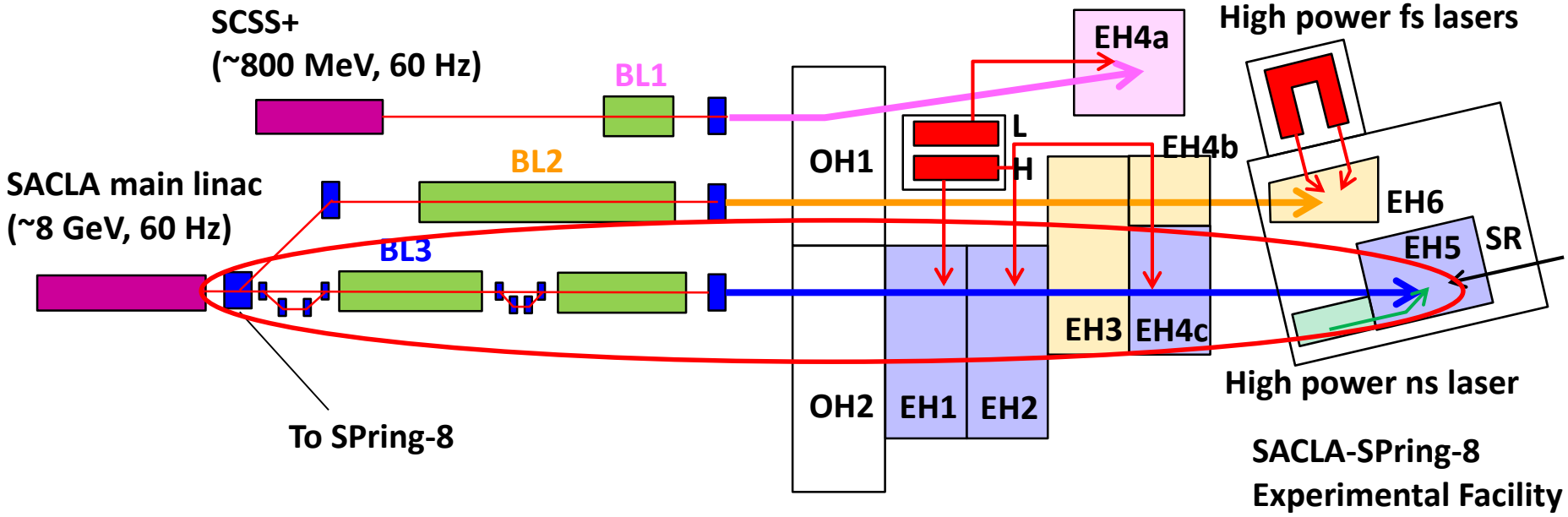
For wider angular range.

CITIUS detector will be technically available for SACLA.

- Small system (0.3M-pixel single sensor) from 2021.
- Deployment plan of larger area detectors will be determined after hearing user needs.

BL3

- Reflection self seeding
- Split-and-delay optics (SDO)
- Preparation for new sub-10 nm focusing system



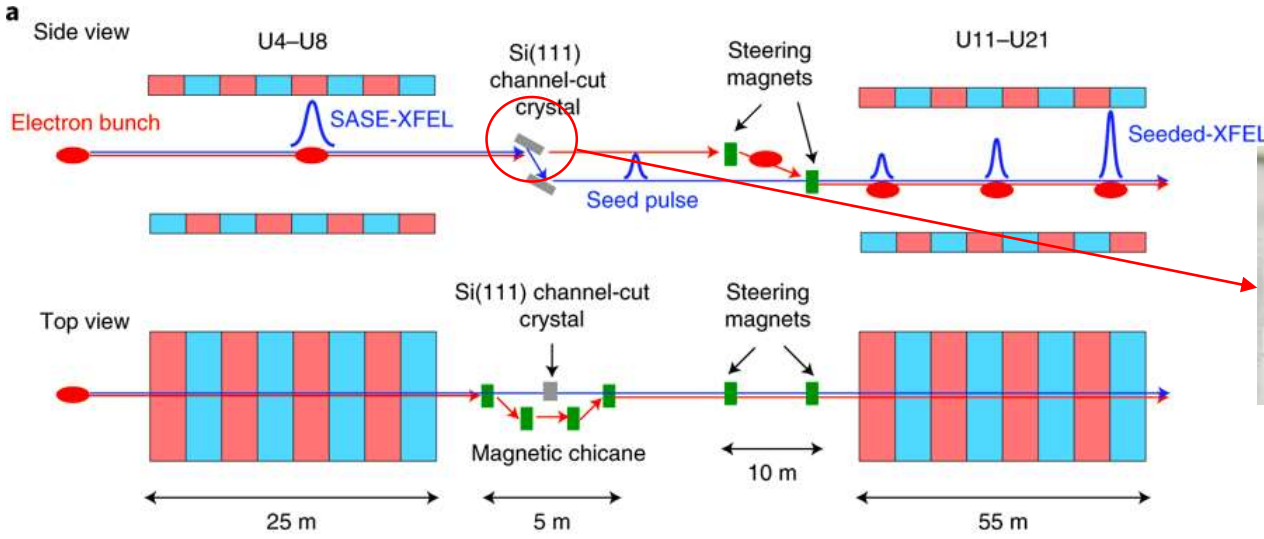
Reflection self-seeding

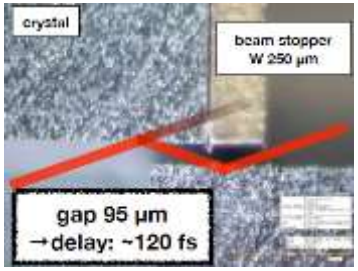
BL3

User operation from 2019A

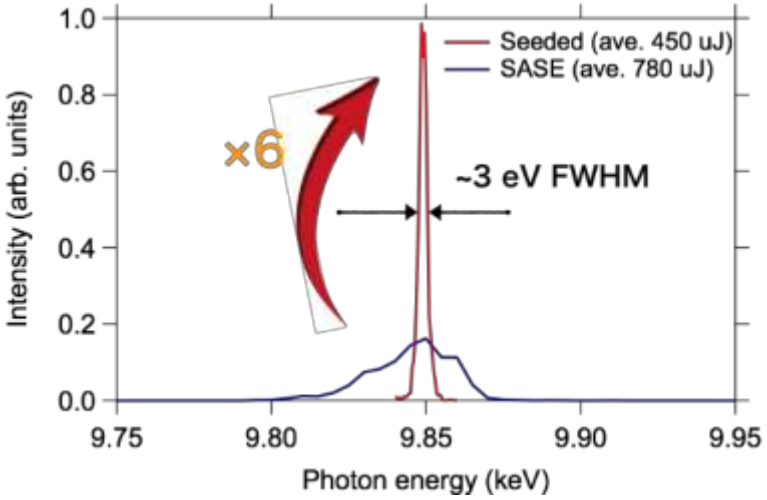
⇒ Poster No.3, Inoue-san

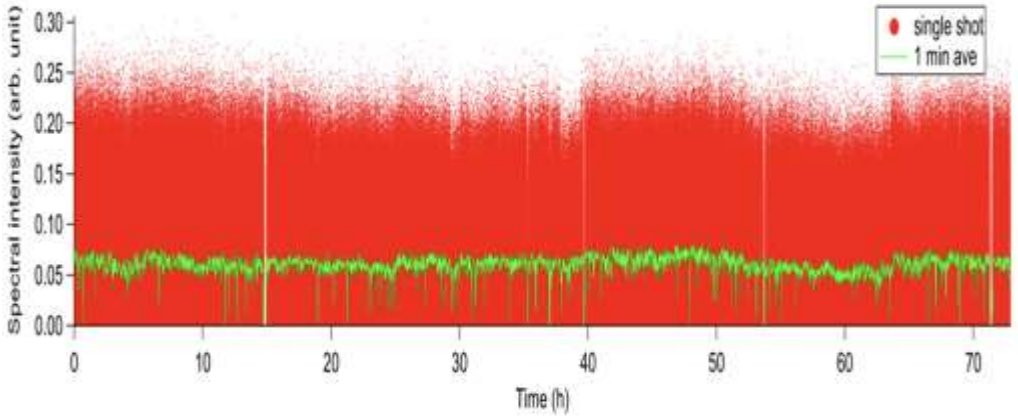
Inoue, Osaka et al,
Nat. Photon. (2019)





Micro channel-cut crystal with a 95-μm gap





3-day trend of pulse energy after Si(111) DCM

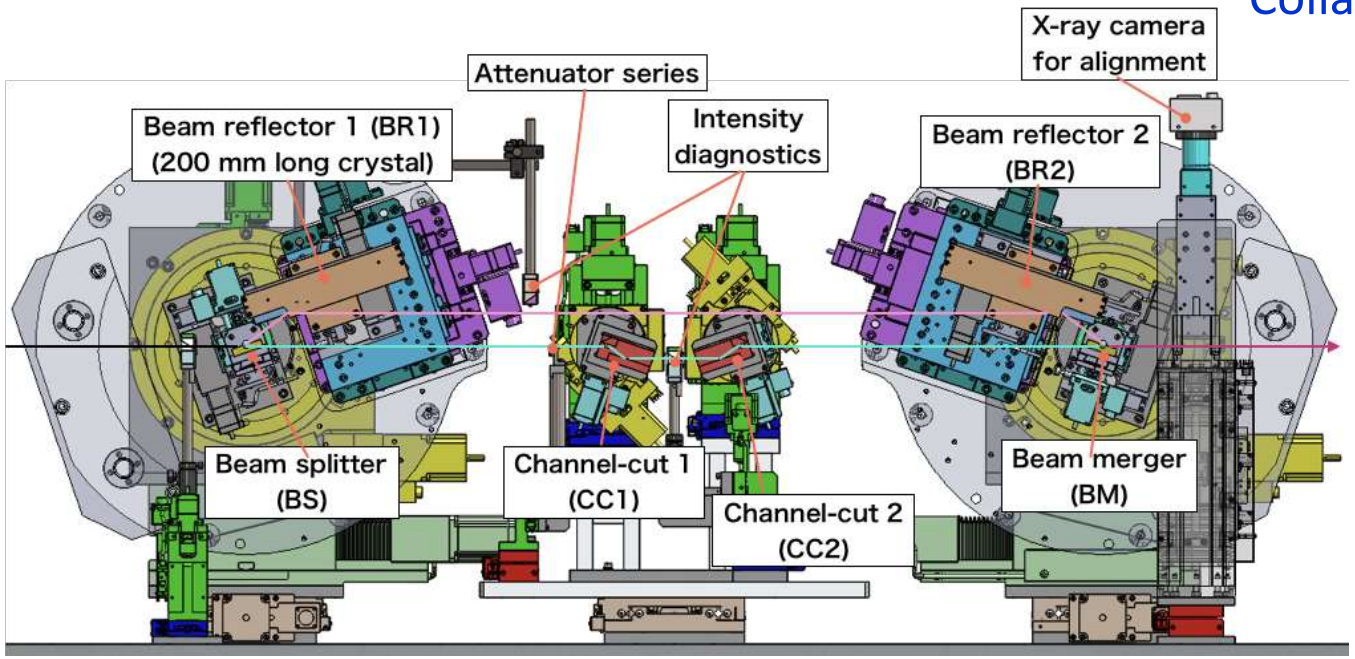
- Seeded XFEL has been used in >10 users' experiments
- R&D is on going for achieving higher stability.

Hard X-ray split-and-delay optics (SDO) BL3

Open for user experiments from 2018B.

⇒ **Poster No.4, Osaka-san**

Collaboration with Osaka U.



Photon energy range

5 – 15 keV

Time delay range

0 – >100 ps

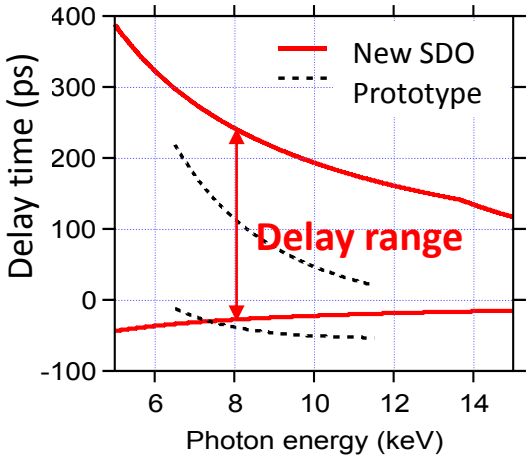
<1 fs delay step

Pulse energy of each pulse @10 keV

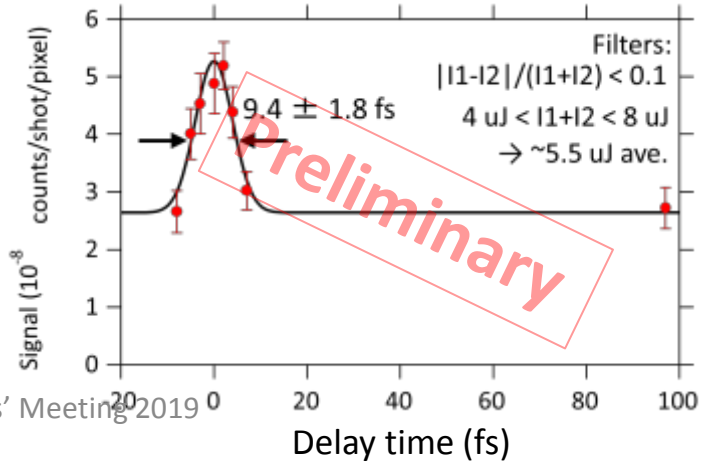
~0.3 μJ (SASE)

~1 μJ (self-seed)

Photon energy vs. range of delay time

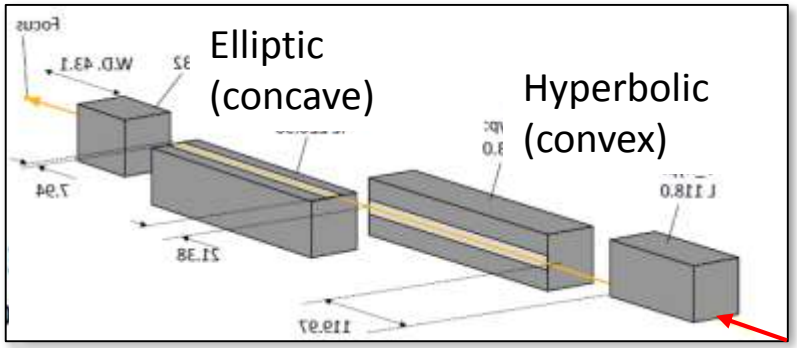


Autocorrelation measurement (preliminary)



For new sub-10 nm focusing system

Advanced KB system
Pair of hyperbolic & elliptic mirrors
('Wolter-III')



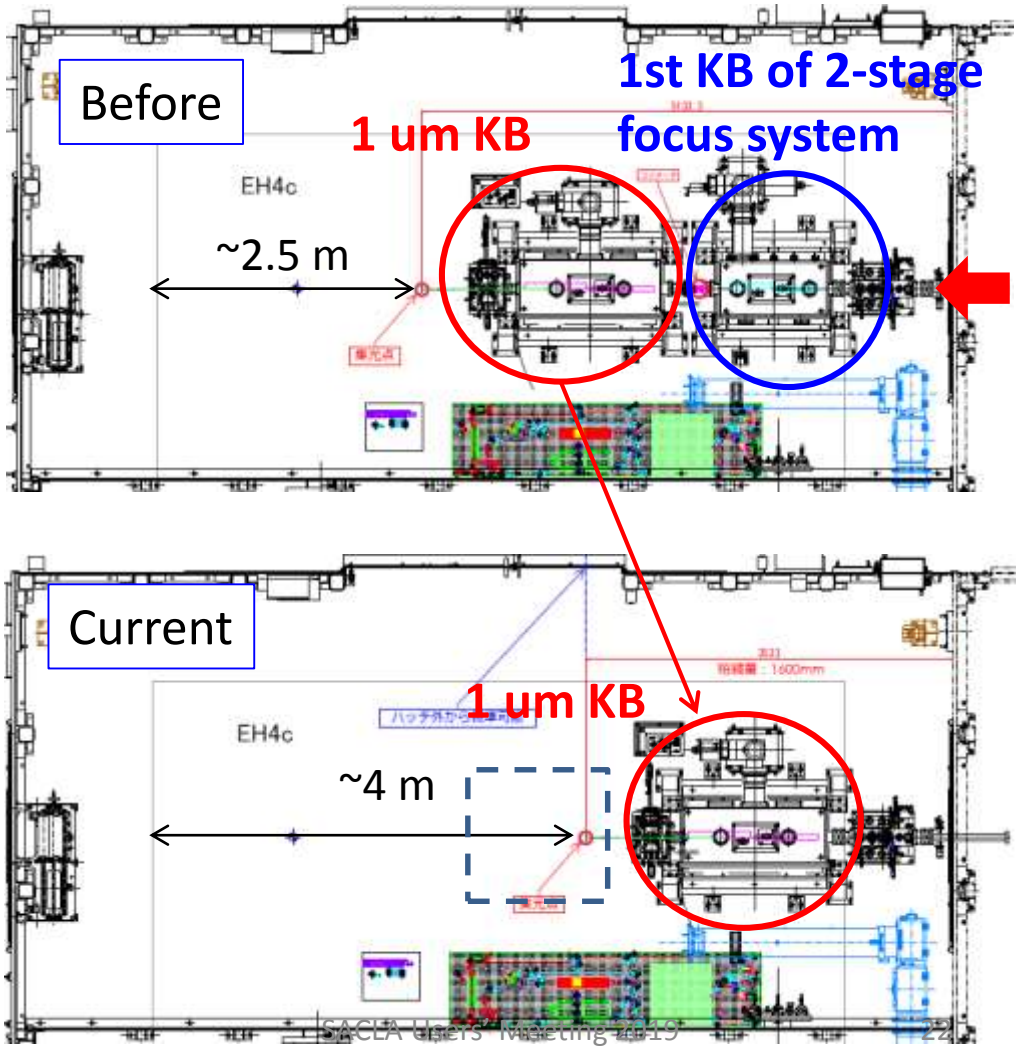
Collaboration with Osaka U.

⇒ **Poster No.5, Yamada-san**

⇒ **Breakout session 1**

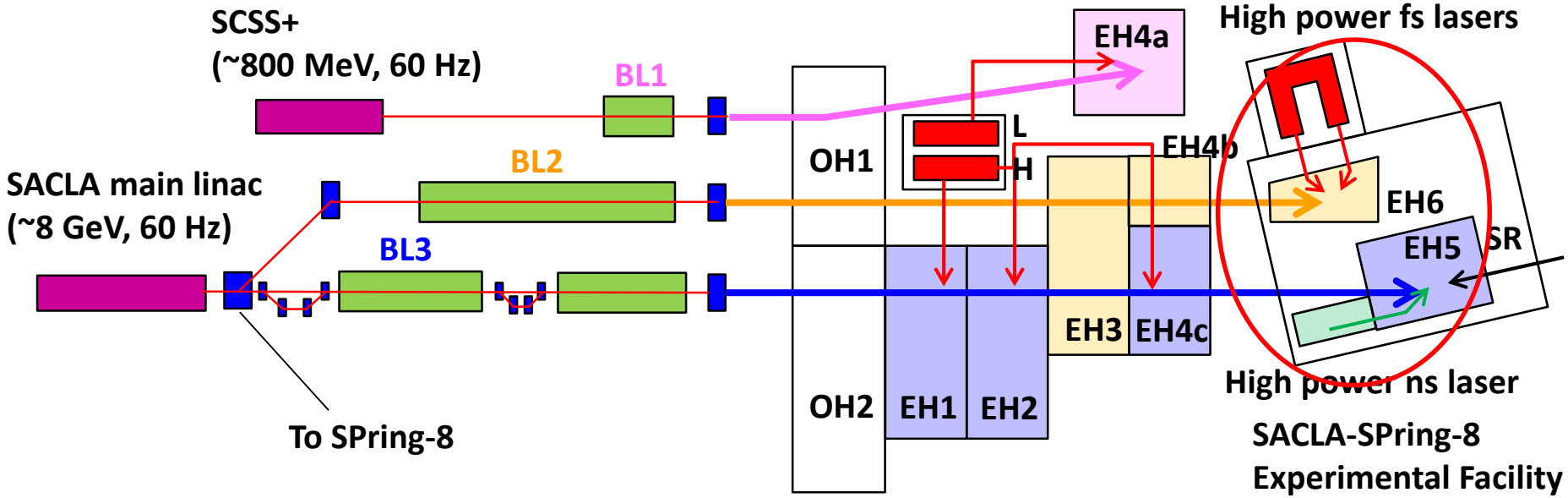
Commissioning has started at SPring-8.

Layout change in BL3 EH4c



High power lasers

- Femtosecond laser (BL2 EH6, 500 TW)
- Nanosecond laser (BL3 EH5, 100 J)



Current capabilities of experimental platform with high power fs laser at EH6

BL2

⇒ Poster No.8, Yabuuchi-san

6 user experiments have been carried out.

Focusing Capability of XFEL

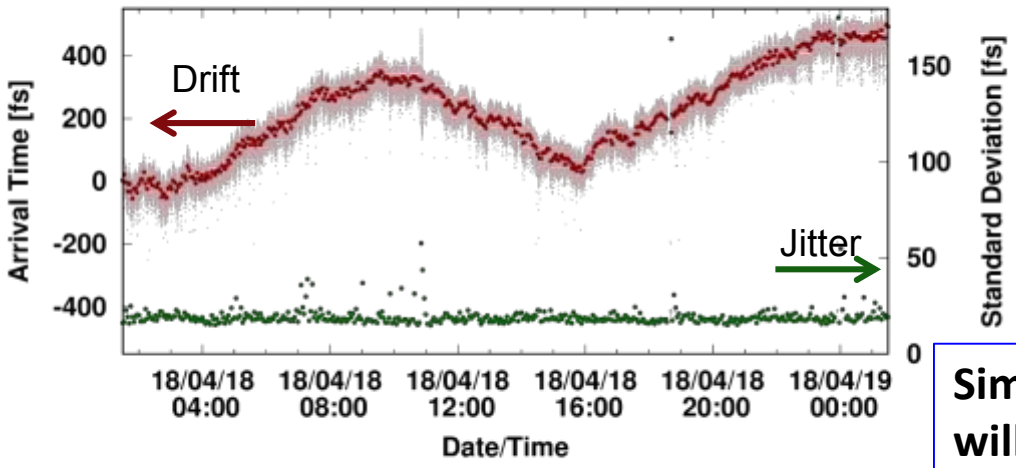
- Focused with sets of CRLs
- Minimum spot: a few um (FWHM) on sample

Typical Specs of High Power Laser

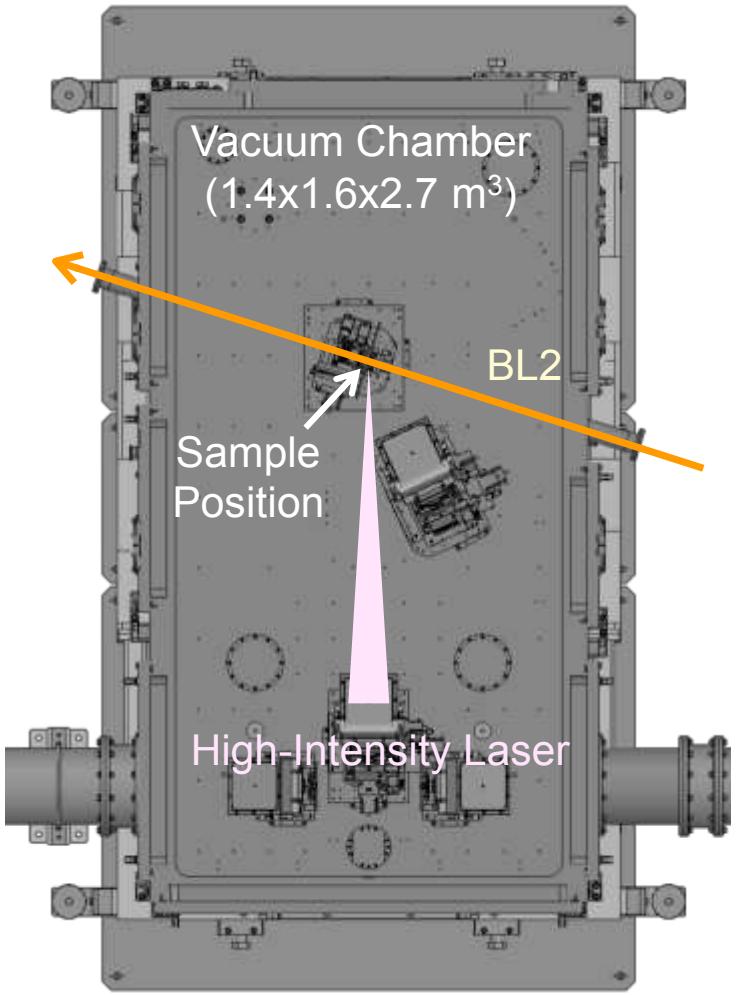
- One beam with f/10 off-axis parabolic mirror
- Maximum power: ~200 TW (~8 J/40 fs) on sample
- Minimum spot: ~20 μm (FWHM)
- Peak intensity: ~10^{19} W/cm^2

Temporal overlaps of XFEL and laser

- Jitter in short term (~5 m): **~20 fs (rms)**
- Drift in long term (~24 h): 0.7 – 1.0 ps



(24 h)



Similar synchronization system with BOM-PD will be applied to the fs synchronized lasers.

⇒ Poster No.6, Owada-san

Experimental platform for combinative use of XFEL and high power ns laser

BL3

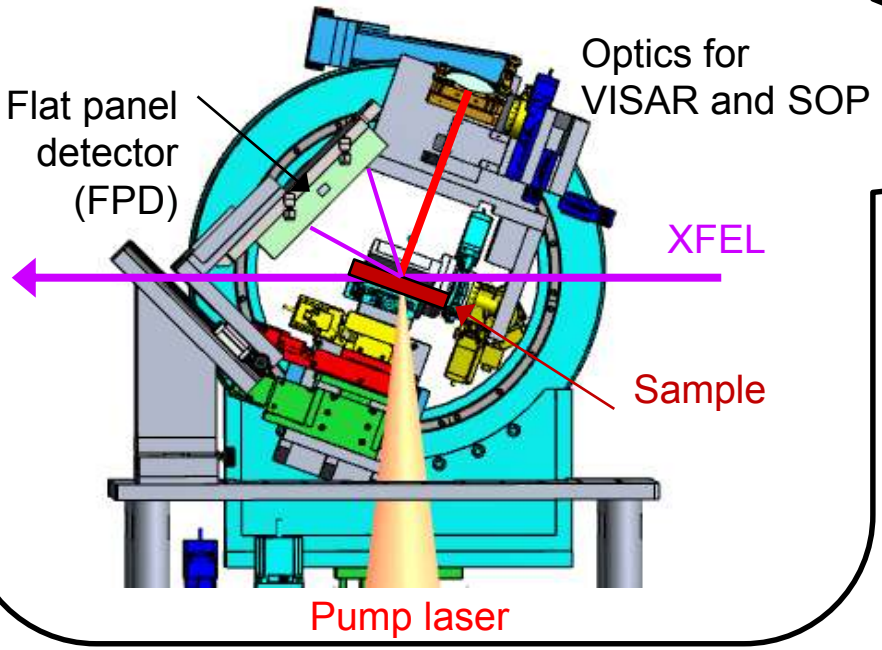
⇒ Poster No.7, Miyanishi-san

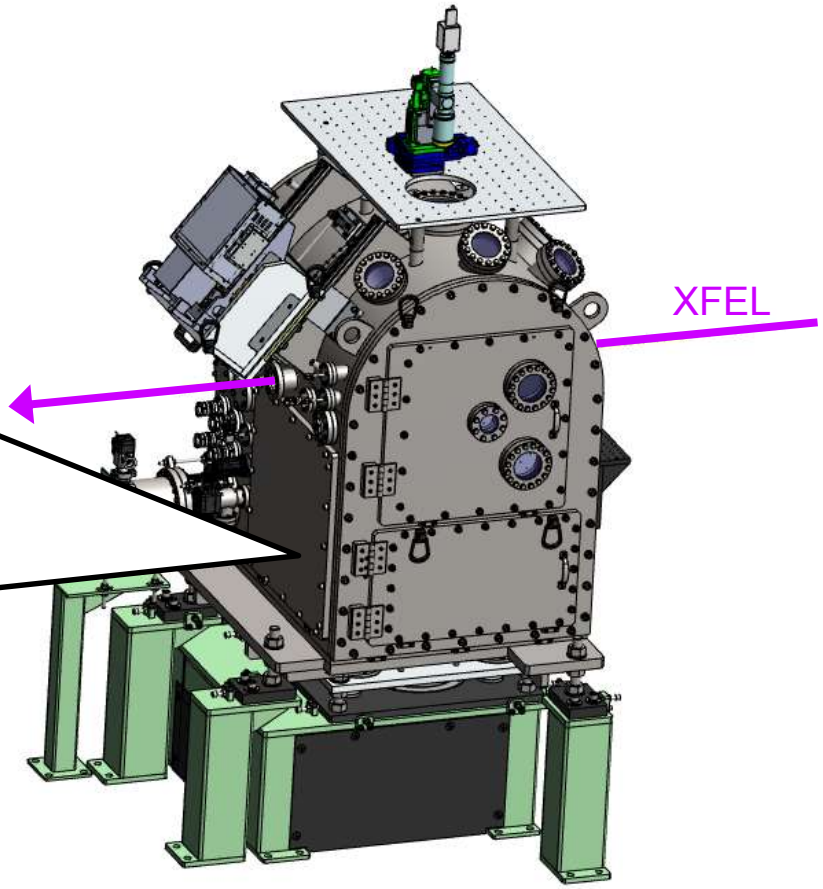
User operation from 2018B

100-J ns laser (ILE, Osaka U.)

- Pulse energy: ~100 J (max.)
- Wavelength: 532 nm
- Pulse duration: 3~10 ns (pulse shaping)
- Repetition rate: 0.1 Hz

Reflection geometry for X-ray diffraction measurement





Summary

- Operation Phase 2 with 3 BLs is getting mature thorough two-year experiences, but we still have many things to develop.
  - Beam injection to SP-8.
  - More advanced instruments & more efficient operation.
  - Effective user support, etc…
- Opportunities have increased.
  - Over 6200 h user time (FY2018).
  - Strategic research programs.
- New capabilities at BLs.
  - BL1: Opto-spintronics experimental platform, Nano focusing system
  - BL2: MAXIC-S
  - BL3: Reflection self seeding, SDO
  - High power lasers (500 TW fs laser, 100 J ns laser)
- Input from the users is welcome, important for directing the facility's R&D activities (optics, detectors, lasers, etc…).
- For successful beamtime, we should start discussion on experimental plans as early as possible.

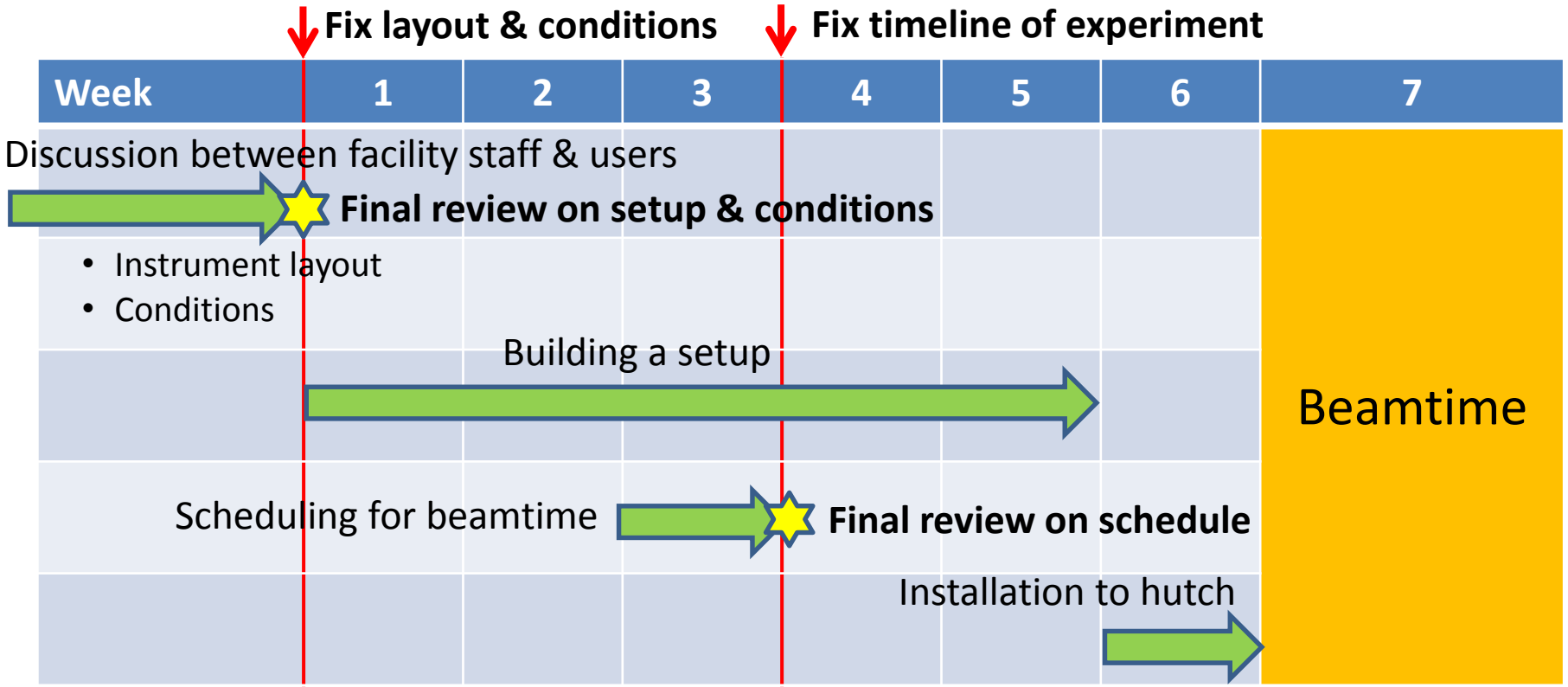
After obtaining approval of your proposal

- Contact beamline scientists:

  sacla-bl.jasri@spring8.or.jp
- Start discussion as early as possible:
  - Provide *Practical* (not only conceptual) information for setting up your experiment.
  - Final plan should be fixed at least *6 weeks* prior to your beamtime.
- Make enough preparation:
  - Especially for experiments that need *non-standard* setup/bring-in apparatus.
  - If necessary, apply for feasibility-check beamtime (for SFX users).
- Do experiment:
  - Users are encouraged to operate instruments *by themselves.*
  - User-friendly platforms and program interface (ExpCotrol APIs) are available (see Posters)

Typical schedule for preparation by the facility staff

Well-planned preparation is a key to successful experiment.



- Final experimental plan: *~6 weeks* prior to the beamtime.
- Final timeline: *~3 weeks* prior.

Thank you for your attention!