SACLA Beamline Updates

Kensuke Tono (SACLA)

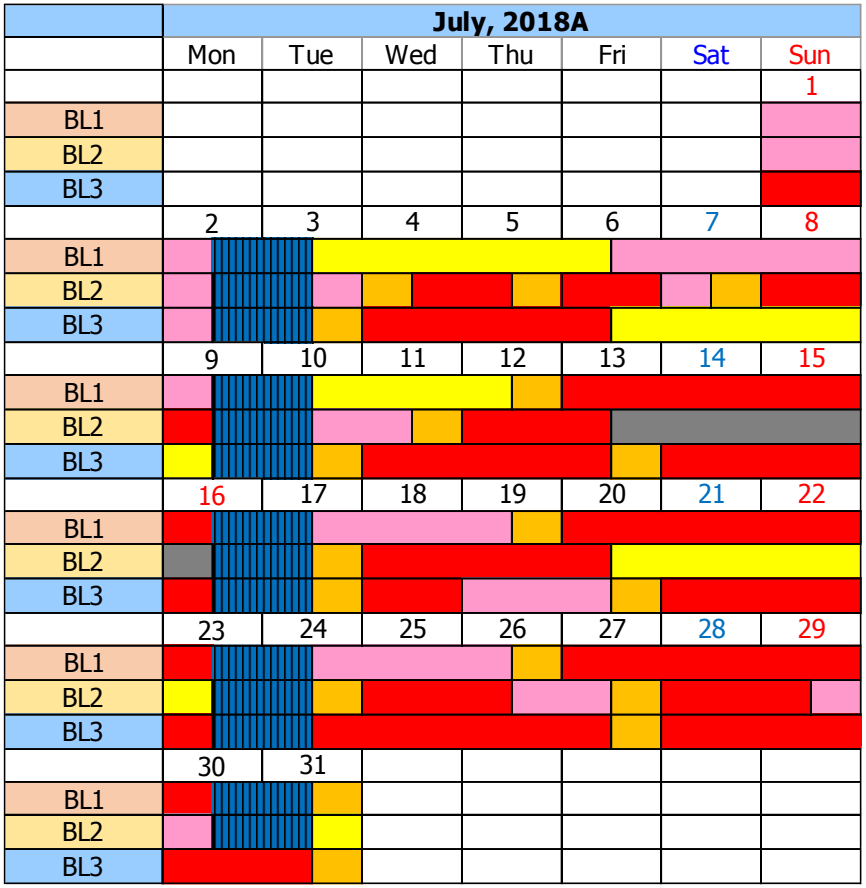
Contents

1. Operation in ‘phase 2’
2. Research highlights
3. New capabilities
4. Proposal review and preparation for experiments
5. Summary & outlook

Operation ‘Phase 2’

- 3-BL parallel operation from 2017B

Operation schedule: July 2018



Machine tuning

User time

Preparation for user time

For promotion program/facility

Commissioning new Instruments

Not operated

⇒**Poster No.1, Inagaki-san**

Operation ‘Phase 2’

- More user beamtime
  - ⇒ Over 6,000 h in a year.
  - ⇒ Feasibility-check beamtime @BL2 (from 2017B)
  - ⇒ Trial for beamtime allocation on a 12 h-a-day basis @BL2 (from 2018B)

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

- New photon source: 500-TW optical lasers
  - ⇒ Open to users from 2018A

Beamlines

	Type of experiment	Major instruments	Remarks
BL1 (40-150 eV)	Ion/electron spectroscopy SX spectroscopy Ellipsometry Imaging	fs laser KB (~5 μm) Timing tool	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	KB (~1 μm) DAPHNIS (SFX) MAXIC-S/II (CDI) 500 TW laser	Feasibility-check beamtime
BL3 (4-15 keV)	XRD WAXS Spectroscopy SFX, CDI (fs resolution) XPCS X-ray pump X-ray probe	fs laser Timing tool CRL, KB (~1 μm) 300 exa (~0.1 μm) SDO Platform for utilizing high-power ns laser	Double-pulse XFEL (~300 fs delay @ 10 keV) Self-seeding (trial use) X-ray polarization control

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

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Element selective SHG of $GaFeO_3$

BL1

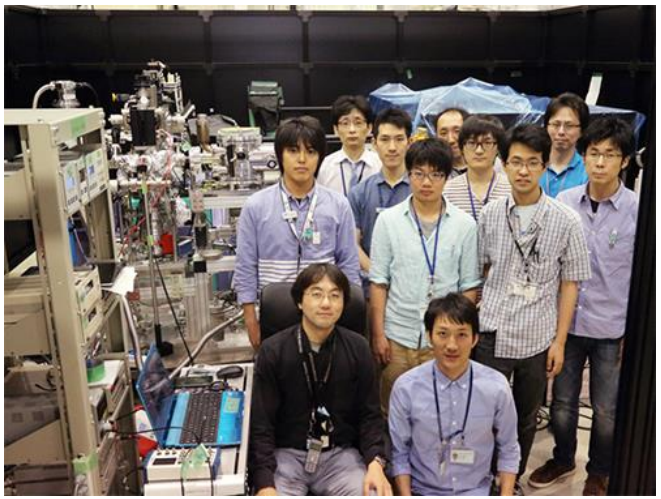
PHYSICAL REVIEW LETTERS **120,** 223902 (2018)

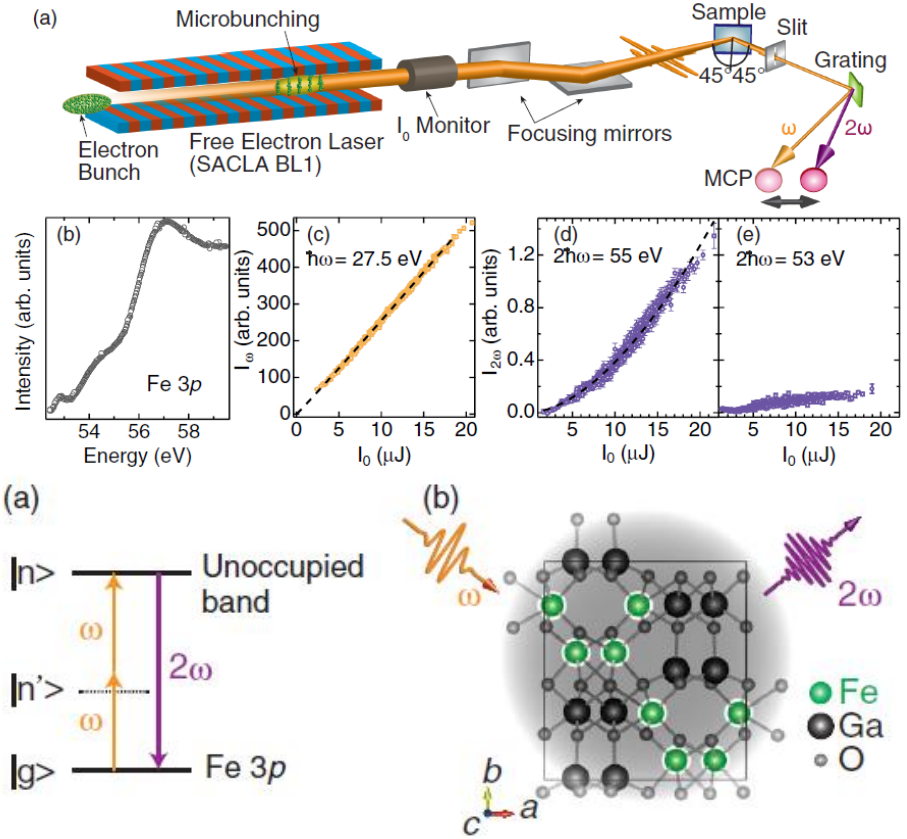
Element Selectivity in Second-Harmonic Generation of $GaFeO_3$ by a Soft-X-Ray Free-Electron Laser

Sh. Yamamoto,[1,†] T. Omi,[2] H. Akai,[1] Y. Kubota,[1] Y. Takahashi,[3] Y. Suzuki,[3] Y. Hirata,[1] K. Yamamoto,[1] R. Yukawa,[4] K. Horiba,[4] H. Yumoto,[5] T. Koyama,[5] H. Ohashi,[5] S. Owada,[6] K. Tono,[5] M. Yabashi,[6] E. Shigemasa,[7,8] S. Yamamoto,[1] M. Kotsugi,[3] H. Wadati,[1] H. Kumigashira,[4] T. Arima,[2,9] S. Shin,[1] and I. Matsuda[1,*]

First user group of BL1

PI: I. Matsuda (U. Tokyo)





Ultrafast probing of nanoplasma formation in Xe clusters

BL2/BL3

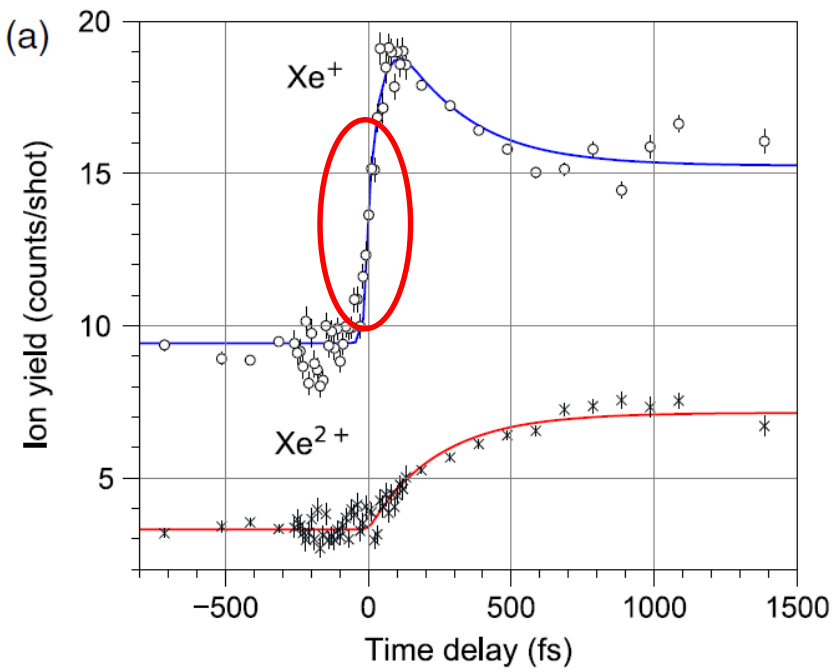
PHYSICAL REVIEW X **8,** 031034 (2018)

Featured in Physics

Following the Birth of a Nanoplasma Produced by an Ultrashort Hard-X-Ray Laser in Xenon Clusters

Yoshiaki Kumagai,[1] Hironobu Fukuzawa,[1,2] Koji Motomura,[1] Denys Iablonskyi,[1] Kiyonobu Nagaya,[2,3] Shin-ichi Wada,[2,4] Yuta Ito,[1] Tsukasa Takanashi,[1] Yuta Sakakibara,[1] Daehyun You,[1] Toshiyuki Nishiyama,[3] Kazuki Asa,[3] Yuhiro Sato,[3] Takayuki Umemoto,[4] Kango Kariyazono,[4] Edwin Kukk,[5] Kuno Kooser,[5,6] Christophe Nicolas,[7] Catalin Miron,[7,8,9] Theodor Asavei,[8] Liviu Neagu,[8] Markus S. Schöffler,[10] Gregor Kastirke,[10] Xiao-jing Liu,[11] Shigeki Owada,[2] Tetsuo Katayama,[12] Tadashi Togashi,[12] Kensuke Tono,[12] Makina Yabashi,[2] Nikolay V. Golubev,[13] Kirill Gokhberg,[13] Lorenz S. Cederbaum,[13] Alexander I. Kuleff,[13] and Kiyoshi Ueda[1,2,*]

Ultrafast population of excited states of Xe fragments on a timescale of 10 fs.



Featured in *Nature*

https://www.nature.com/articles/d41586-018-05912-5

X-ray two-photon absorption spectroscopy BL2/BL3

PHYSICAL REVIEW LETTERS **121,** 083901 (2018)

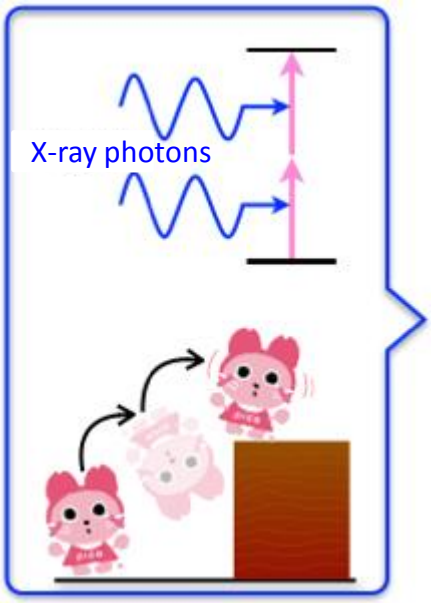
Editors' Suggestion

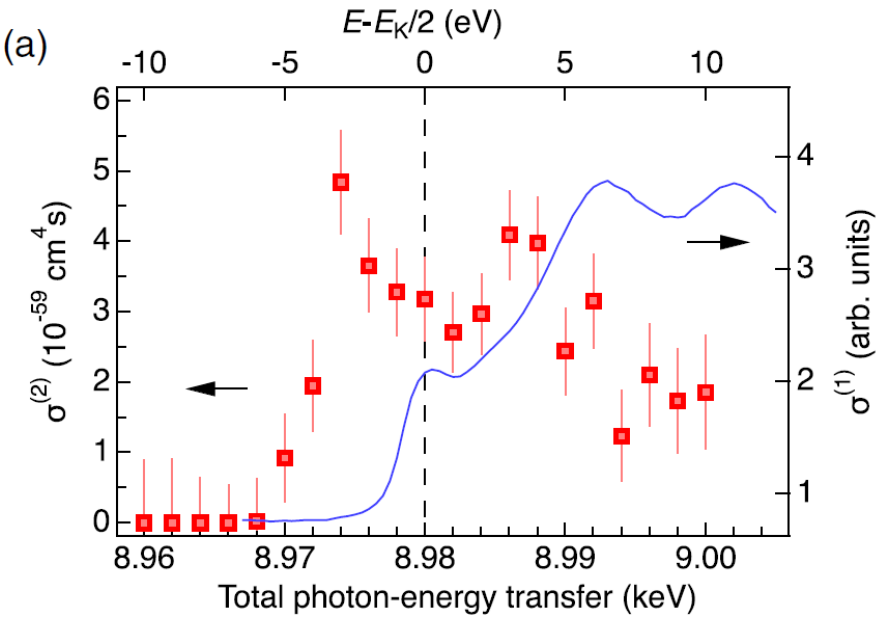
Nonlinear Spectroscopy with X-Ray Two-Photon Absorption in Metallic Copper

Kenji Tamasaku,[1,*] Eiji Shigemasa,[2] Yuichi Inubushi,[3] Ichiro Inoue,[1] Taito Osaka,[1] Tetsuo Katayama,[3] Makina Yabashi,[1,3] Akihiro Koide,[2,4] Toshihiko Yokoyama,[2] and Tetsuya Ishikawa[1]

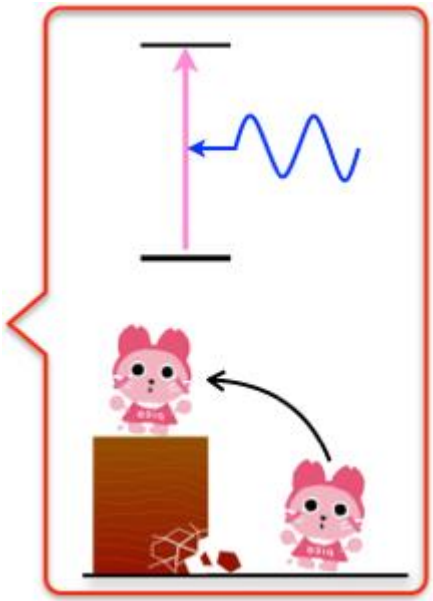
Two-photon XAS: Accessible to 3*d* band

Two-photon absorption





One-photon absorption



http://www.spring8.or.jp/ja/news_publications/press_release/2018/180822/

Structure of drug target GPCR BL2/BL3

Structure

Volume 26, Issue 1, 2 January 2018, Pages 7-19.e5

Cell PRESS

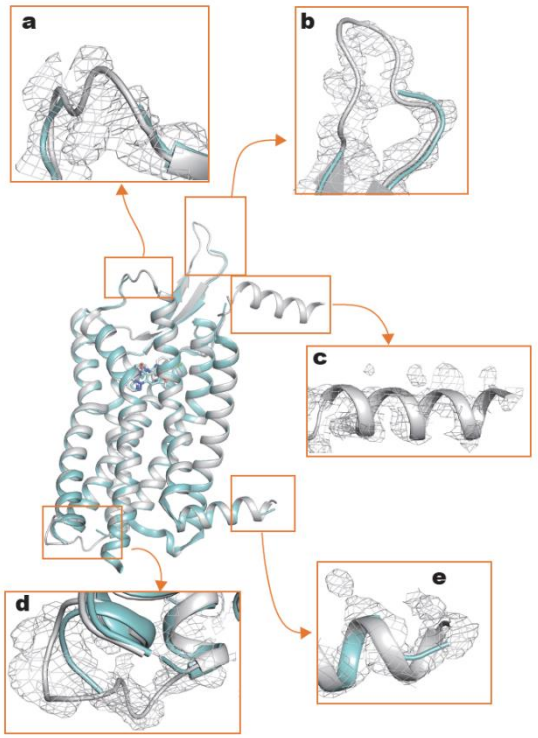
Article

Crystal Structures of Human Orexin 2 Receptor Bound to the Subtype-Selective Antagonist EMPA

Ryoji Suno [1], Kanako Terakado Kimura [1], Takanori Nakane [2], Keitaro Yamashita [3], Junmei Wang [4], Takaaki Fujiwara [1], Yasuaki Yamanaka [1], Dohyun Im [1], Shoichiro Horita [1], Hirokazu Tsujimoto [1], Maki S. Tawaramoto [1], Takatsugu Hirokawa [5, 6], Eriko Nango [3], Kensuke Tono [3, 7], Takashi Kameshima [3, 7], Takaki Hatsui [3], Yasumasa Joti [3, 7], Makina Yabashi [3, 7], Keiko Shimamoto [8], Masaki Yamamoto [3], Daniel M. Rosenbaum [9], So Iwata [1, 3, 10] ✉, Tatsuro Shimamura [1] ✉, Takuya Kobayashi [1, 11, 12] ✉

First report of structural determination of a human GPCR by SFX using SACLA.

2.30 Å resolution



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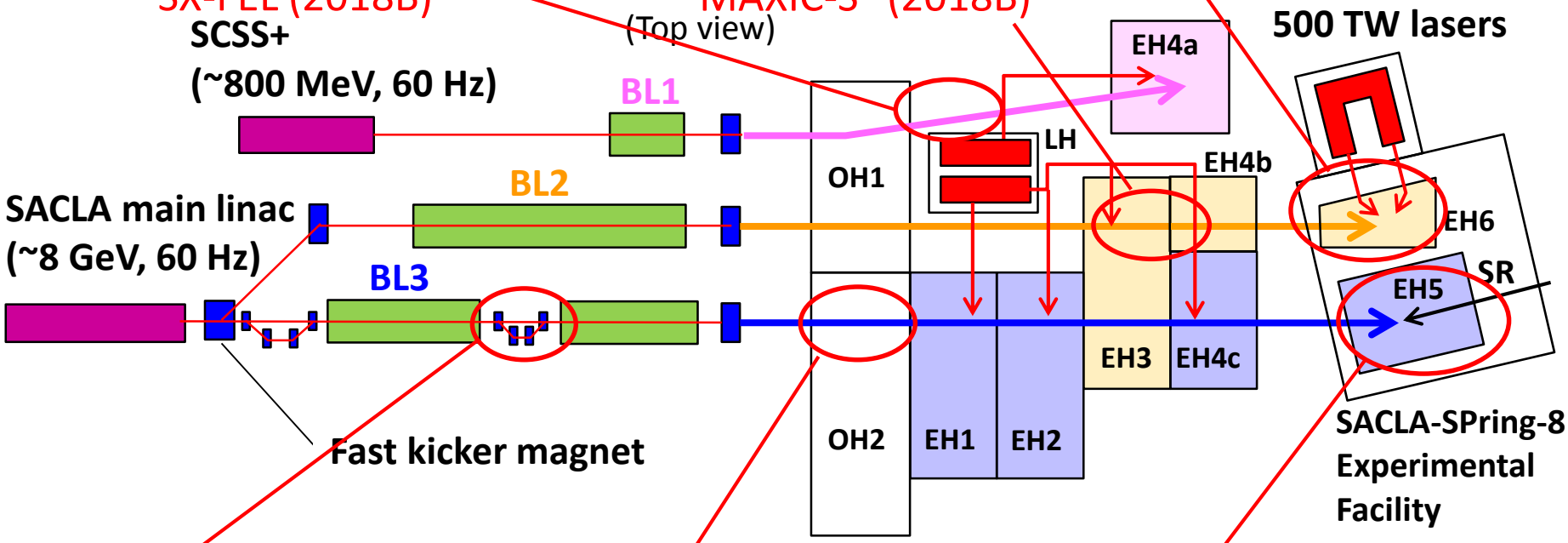
New capabilities

Detailed information is provided by posters.

- Timing monitor for SX-FEL (2018B)
- Nano-beam CDI "MAXIC-S" (2018B)
- HEDS station (2018A)



- Reflection-type self-seeding system (trial use in 2018B)
- Split-and-delay optics (2018B)
- New nm-focus system "300exa" (2018A)
- New end-station for high power ns laser (2018B)

- BL1: Soft X-ray FEL (40 - 150 eV)
- BL2: Hard X-ray FEL (4 - 15 keV)
- BL3: Hard X-ray FEL (4 - 15 keV)

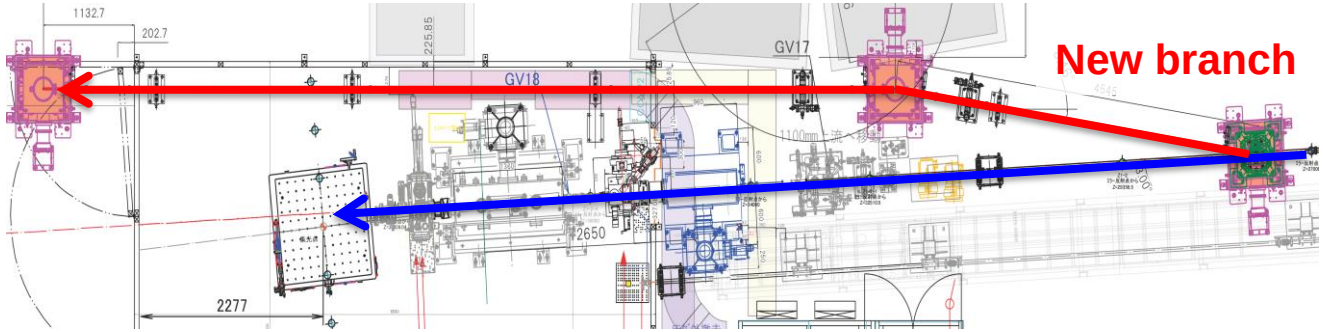
New optics in BL1

BL1

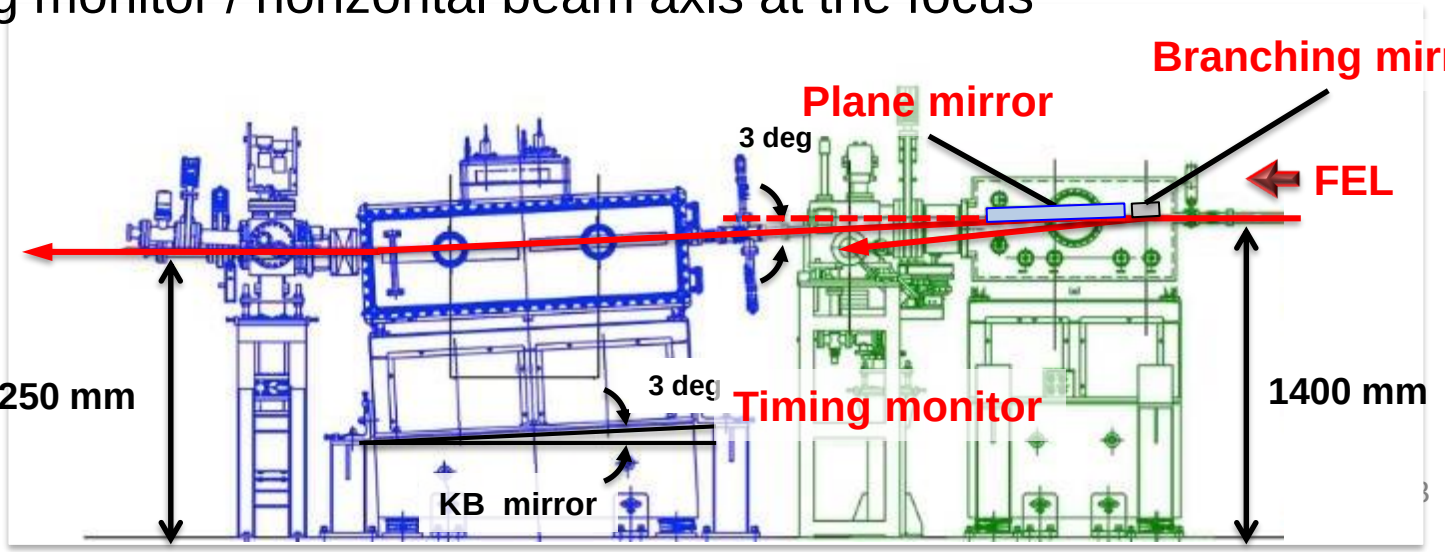
⇒**Poster No.3, Owada-san**

- Optics R&D branch
  => R&D for SX nano-focusing

Collaboration with U. Tokyo



- Branching mirror & plane mirror (1.5 deg. glancing angle)
  => Timing monitor / horizontal beam axis at the focus



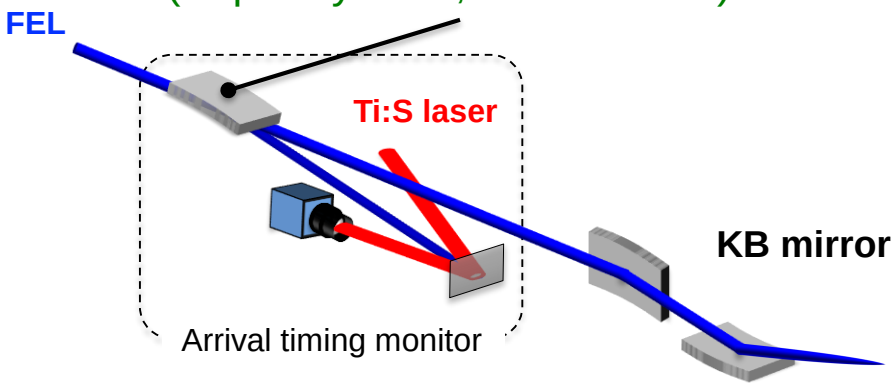
Arrival timing monitor for SX-FEL

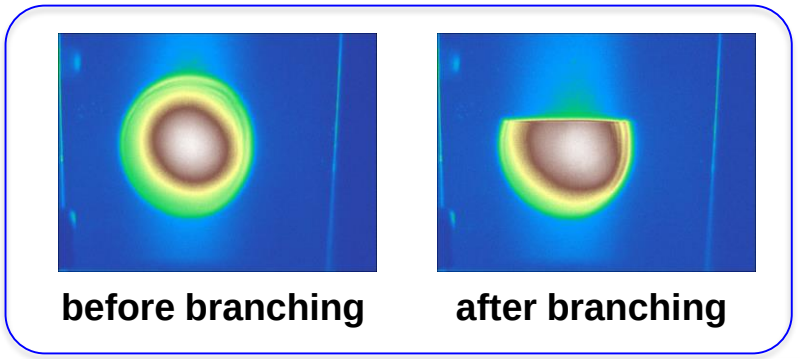
BL1

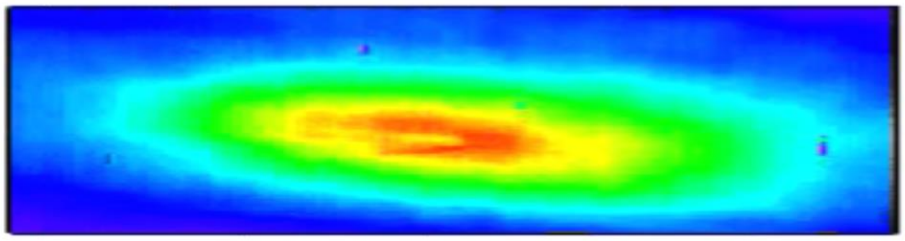
For soft X-ray FEL

- Small penetration depth (~30 nm) => Measure reflectivity change
- Beam branching => Wavefront-splitting

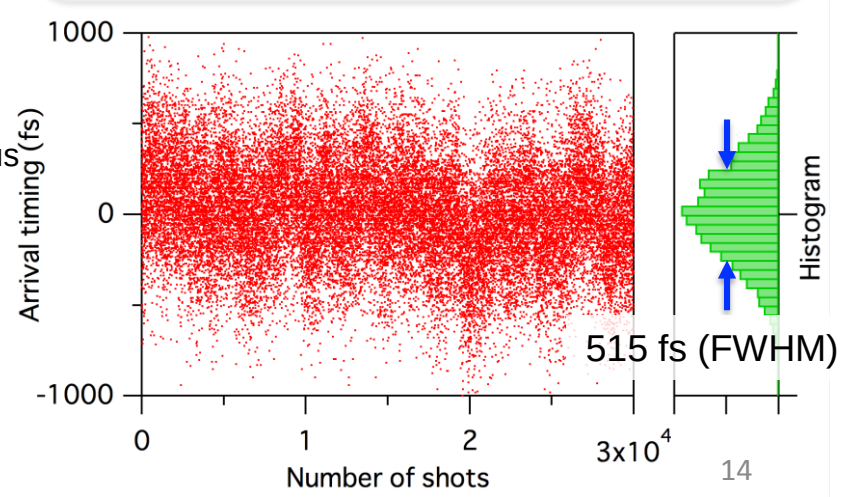
Beam branching & line-focusing mirror
(elliptic cylinder, f = 1300 mm)





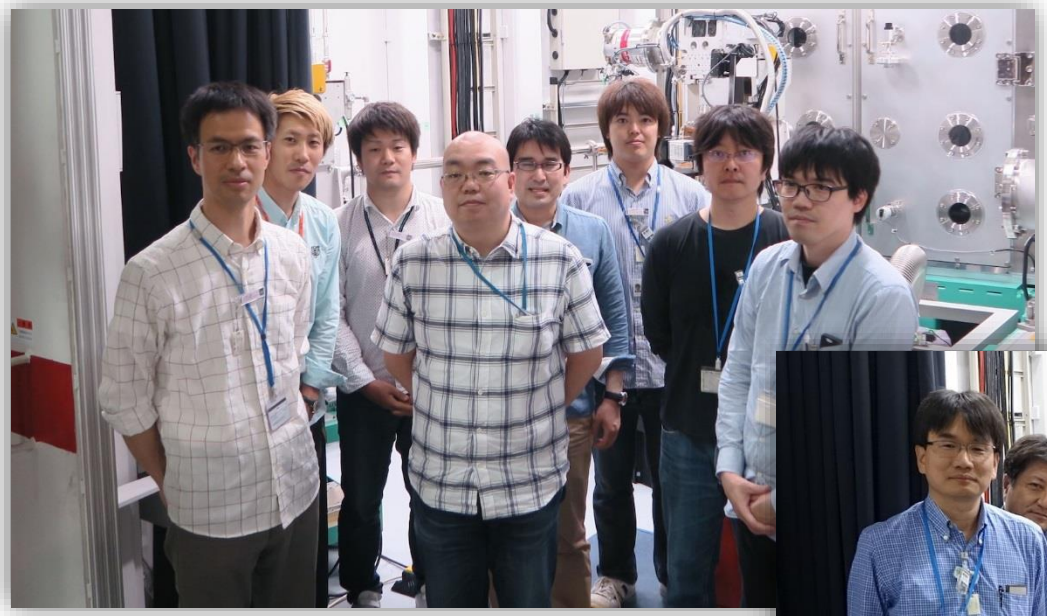


CCD image of reflected beam

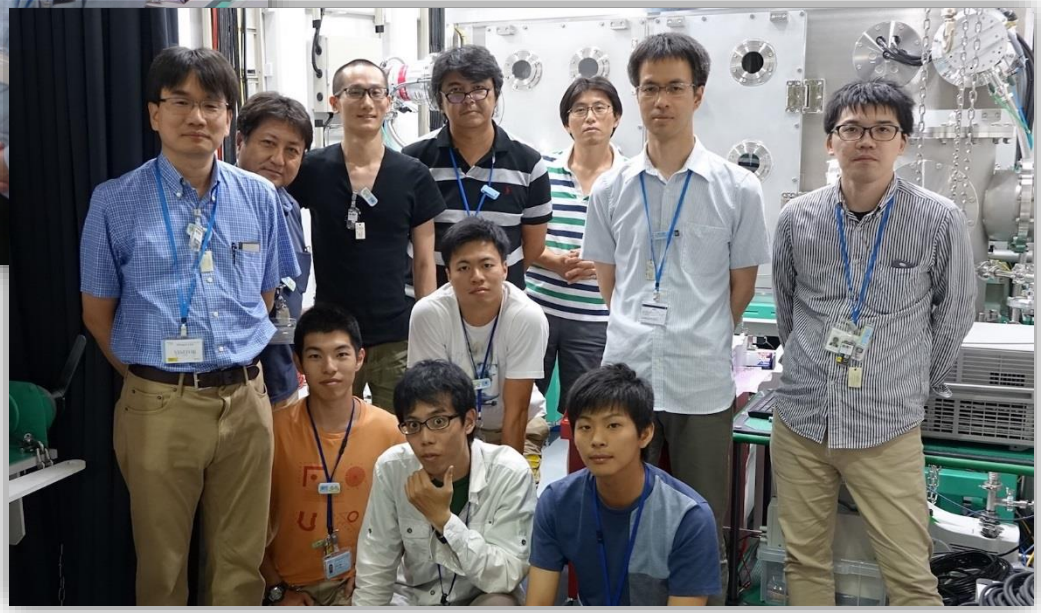


Early users' experiments have been carried out at EH6 with high intensity laser system

BL2



PI: Y. Inubushi (JASRI)



PI: K. Shigemori (Osaka U.)

Current capabilities of experimental platform with high intensity laser system at EH6

BL2

⇒**Poster No.8, Yabuuchi-san**

Focusing Capability of XFEL (BL2)

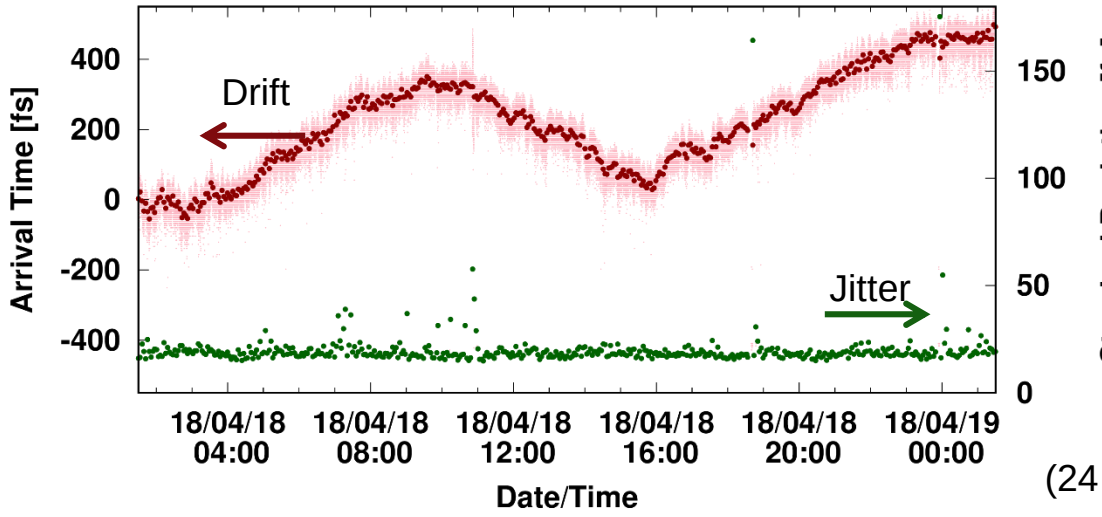
- Focused with sets of CRLs
- Minimum spot: a few um (FWHM) on sample

Typical Specs of High Power Laser

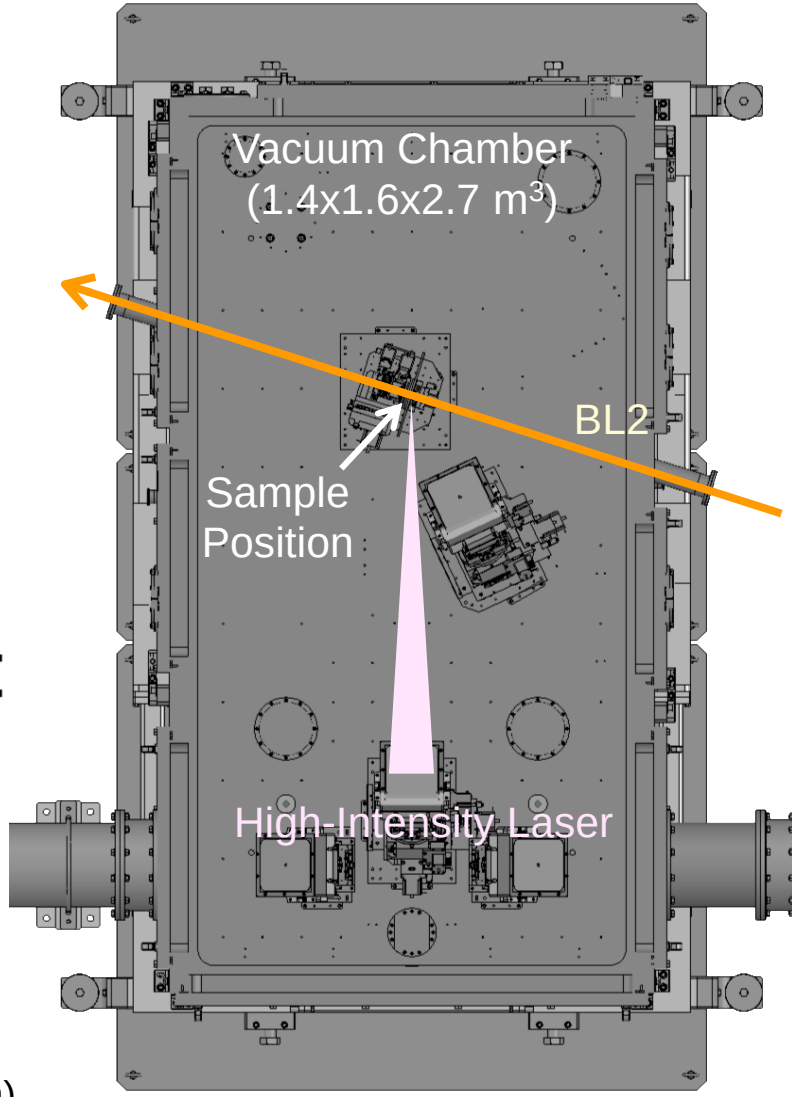
- One beam with f/10 off-axis parabolic mirror
- Maximum power: ~200 TW (~8 J/40 fs) on sample
- Minimum spot: ~20 μm (FWHM)
- Peak intensity: ~10^{19} W/cm^2

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)



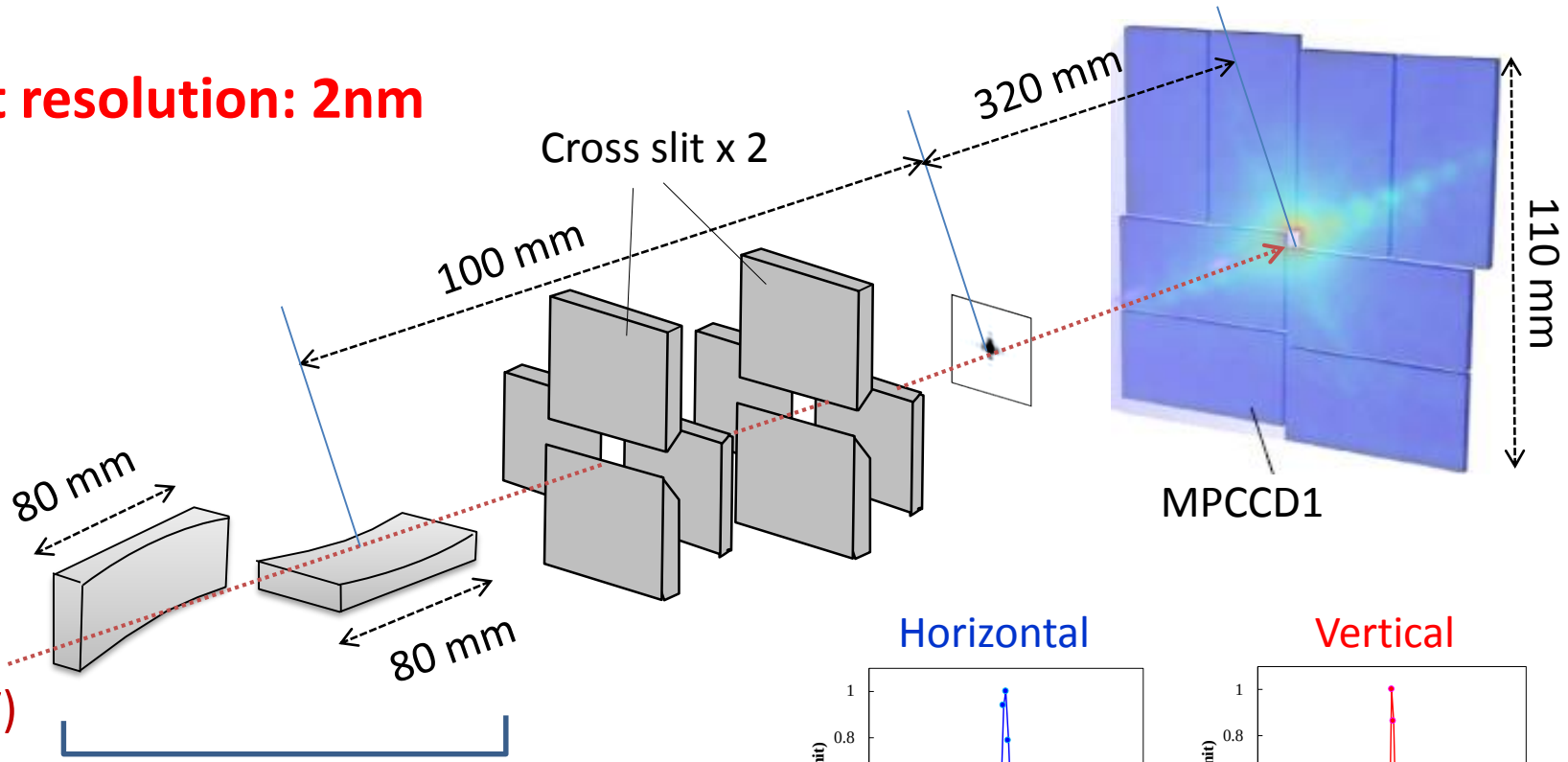
MAXIC-S for nano-beam CDI

BL2

Collaboration with Hokkaido U.

⇒Poster No.12, Suzuki-san

Target resolution: 2nm

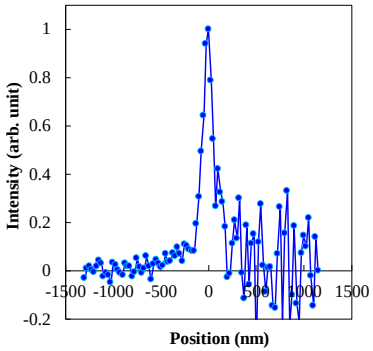


Multilayer mirrors

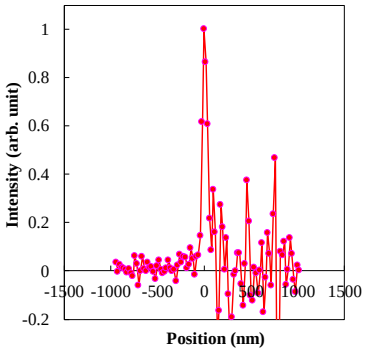
R ~55% (double reflection)

Glancing angle: 25 mrad (1.4º)

Horizontal



Vertical

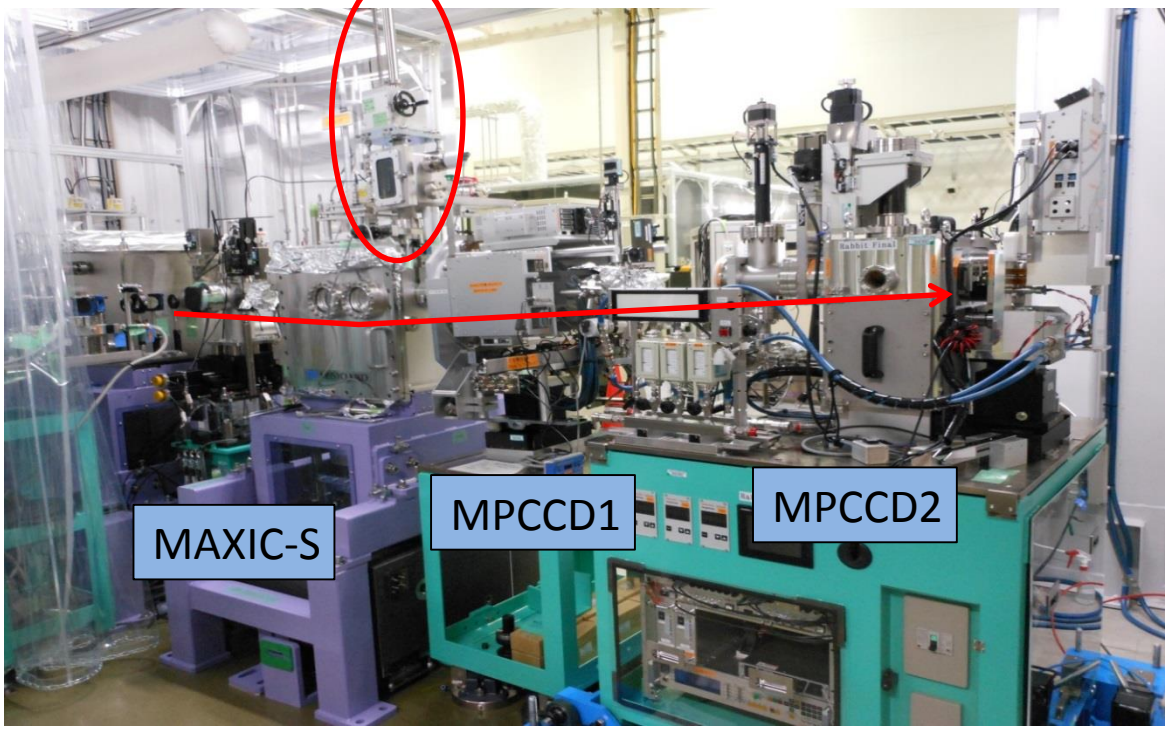


128 nm (H) x 70 nm (V) (FWHM)

MAXIC-S: Pilot experiment

BL2-EH3

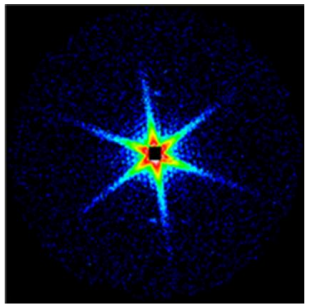
Load-lock chamber & sample transfer rod



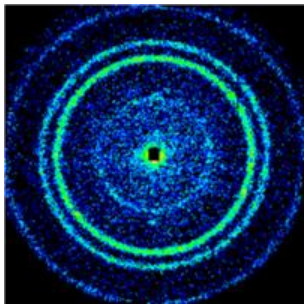
- Fixed target.
- Load lock device for quick sample exchange.
- Compatible with the micro-liquid enclosure array (MLEA).
- Fast sample scanning.

First diffraction patterns

Metal nano triangle

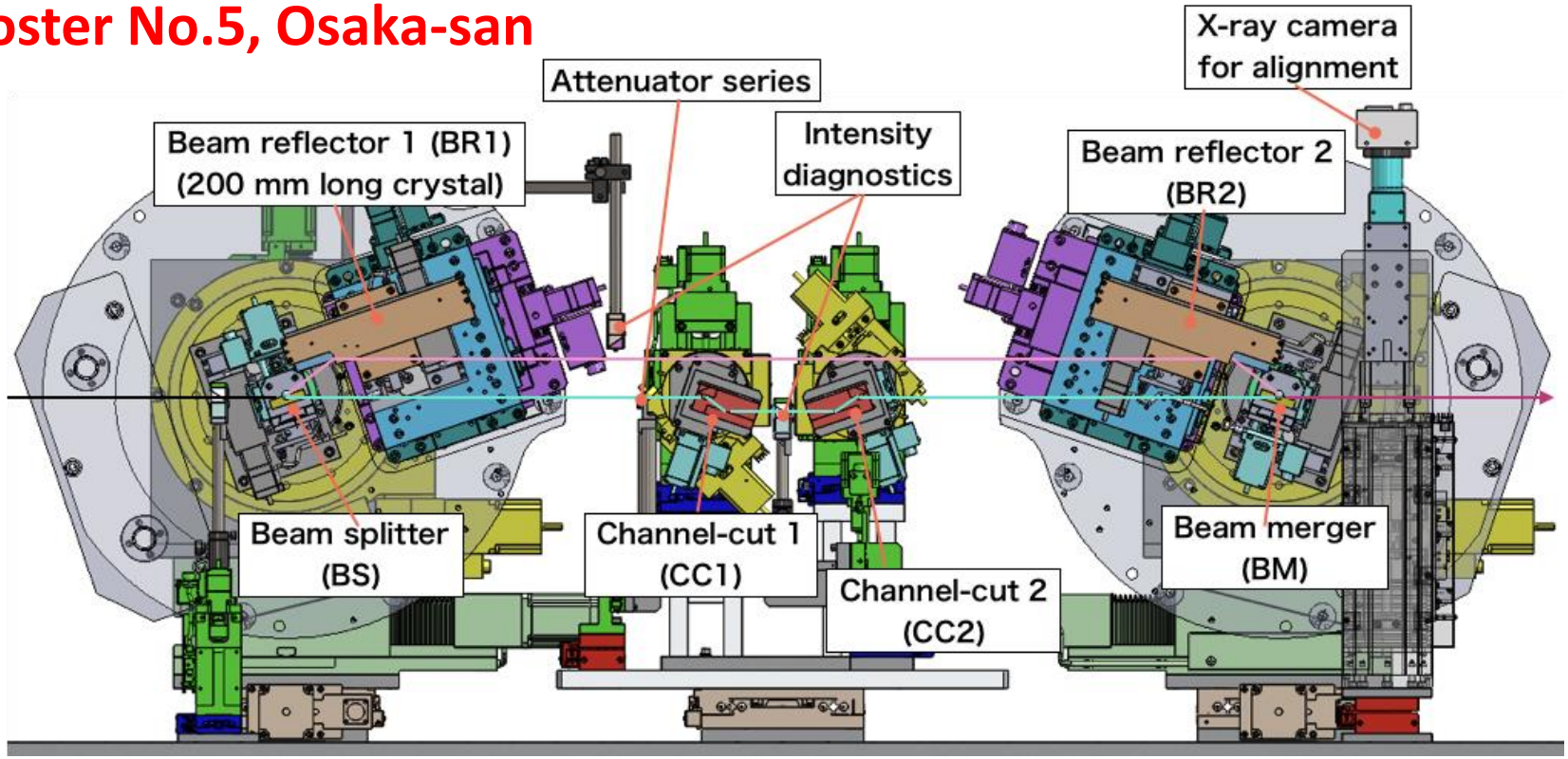


Protein 2D crystal



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

⇒Poster No.5, Osaka-san



Photon energy range

5 – 15 keV

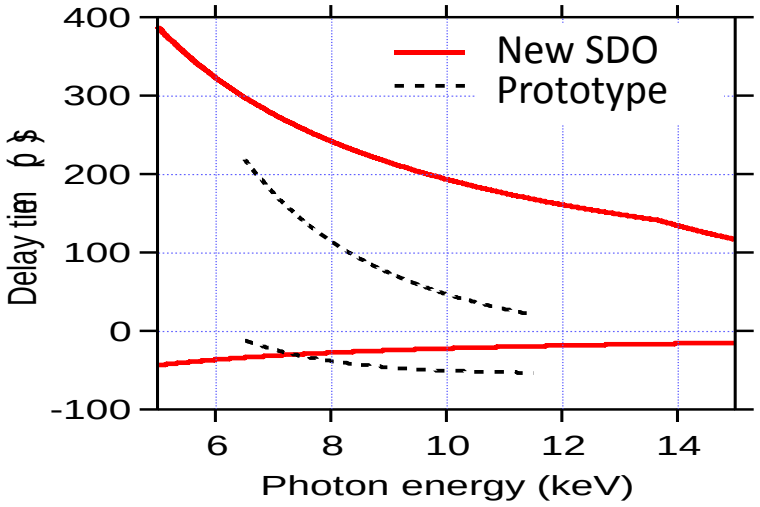
Time delay range

0 – >100 ps w/ <1 fs delay step

Pulse energy of each split pulse @10 keV

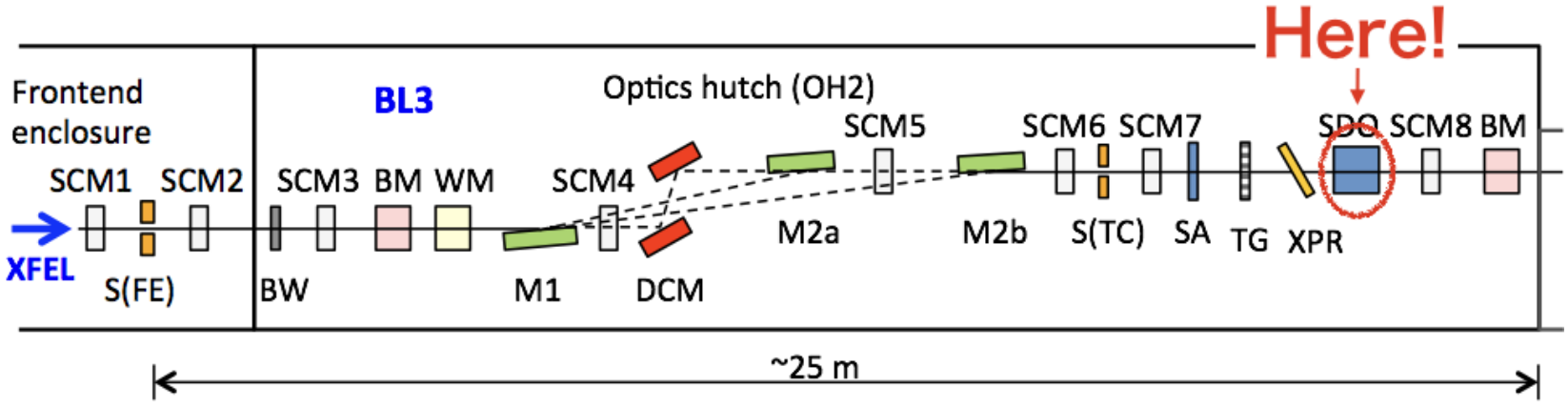
~0.3 μJ (SASE mode)

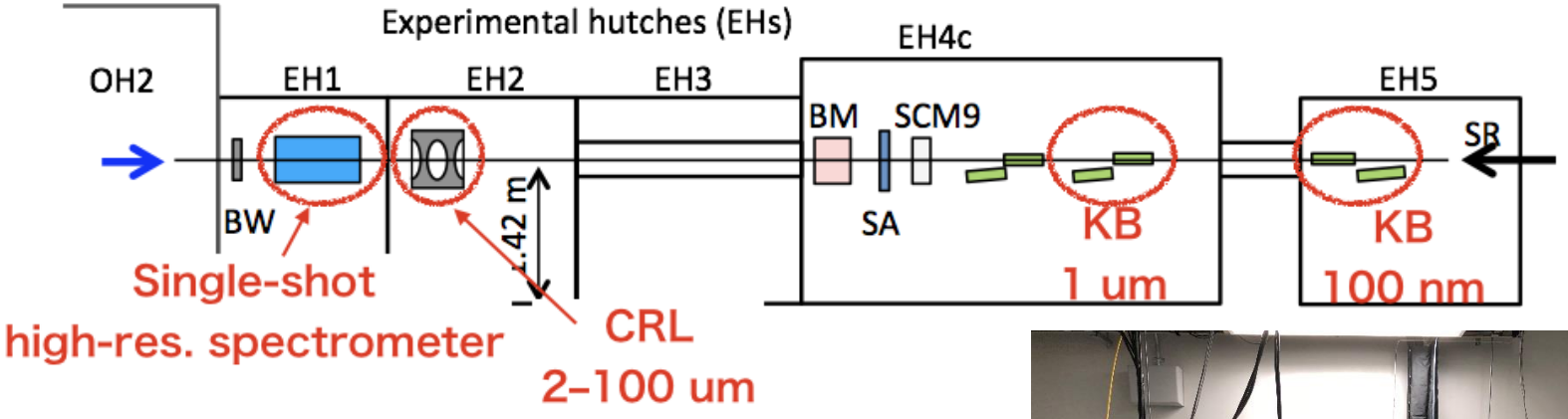
~1 μJ (self-seeding mode)



SDO: Installed in the optics hutch

BL3



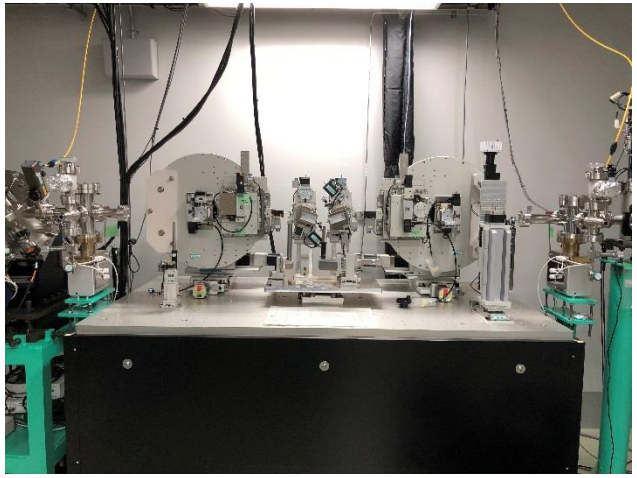


Test of new mechanics: Finished

Installation in the optics hutch: Finished

Commissioning: Oct. 2~

SDO will be used for users' experiments from 2018B.

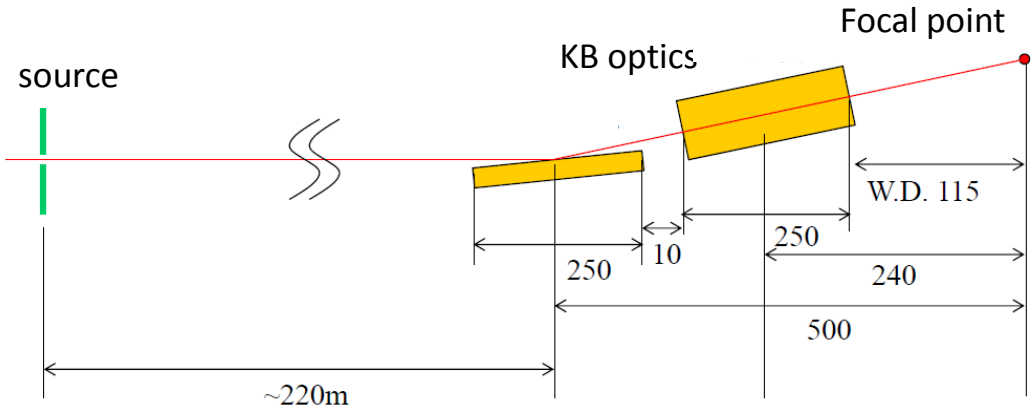


Experimental platform using 100-nm focusing optics

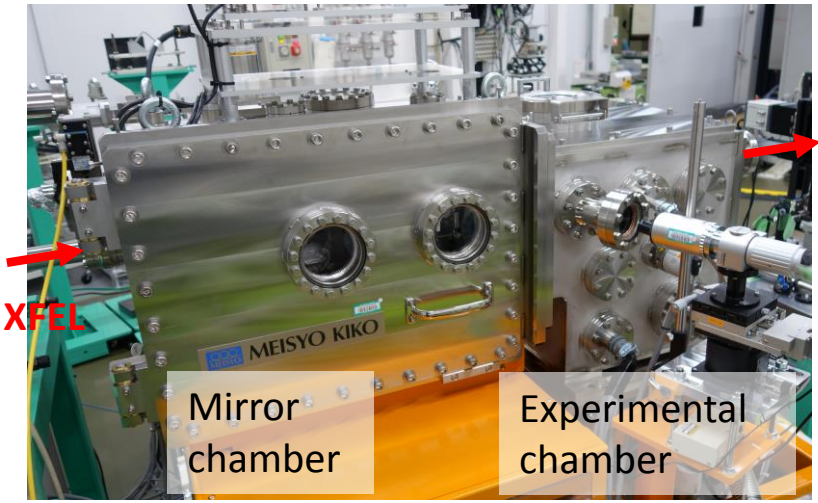
BL3

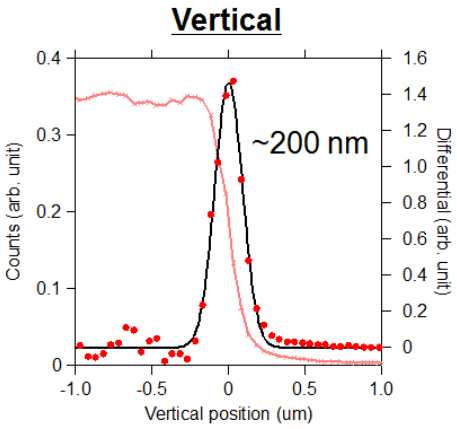
⇒Poster No.6, Inubushi-san

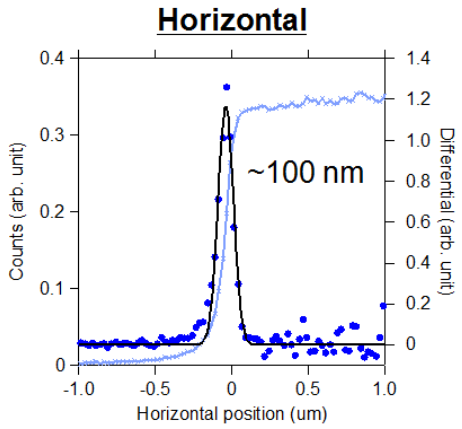
New 100-nm focusing system (single-stage) based on the current XFEL beam properties (installed in summer 2017).



（Mirror acceptance： 1000 x 950 μm² ）







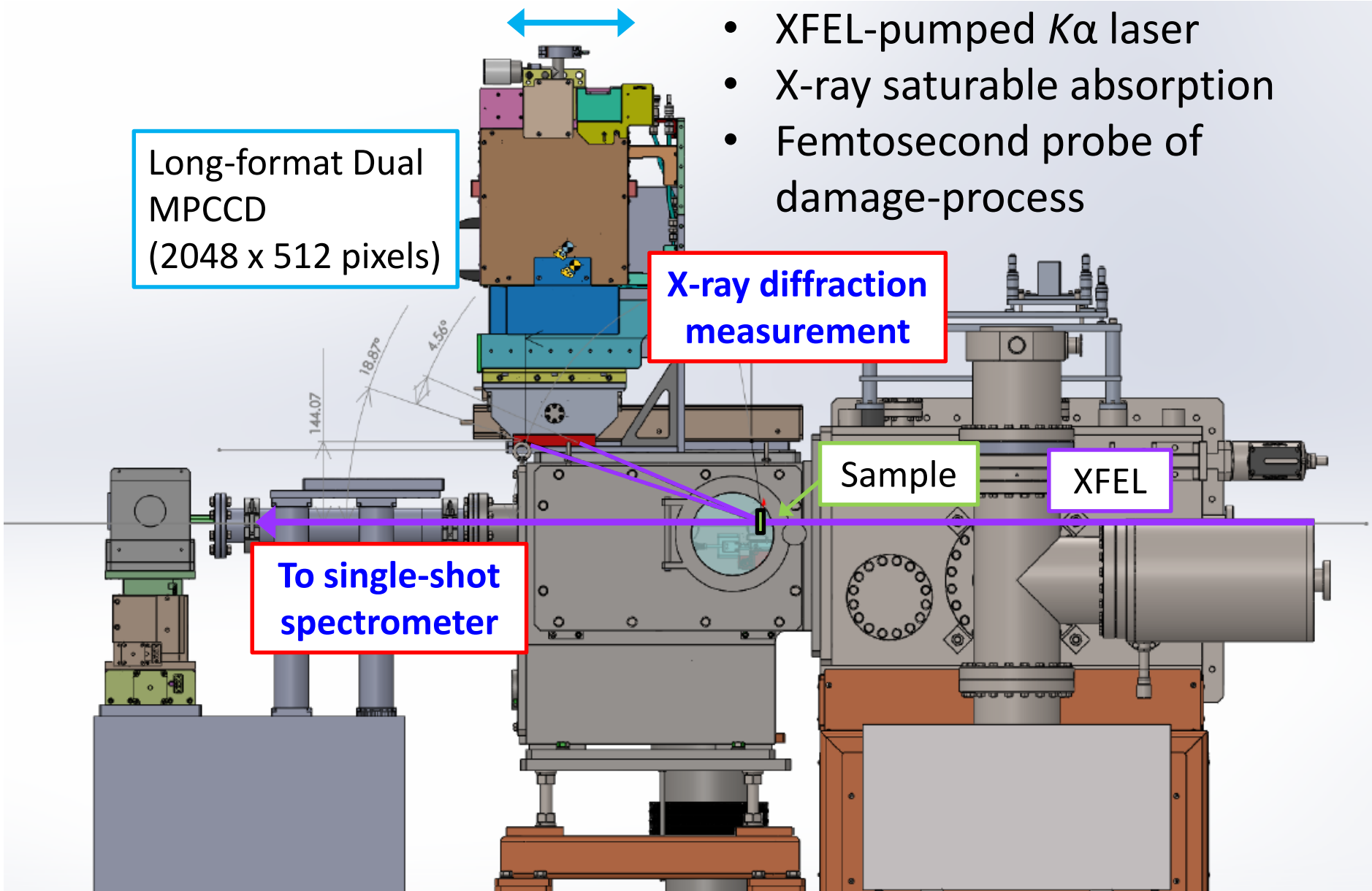
Pulse energy after KB optics： ~150 μJ
= 600 μJ x 0.25
(throughput to focal point)
Focal spot: 200 x 100 nm²
Pulse duration: 8 fs
⇒ **~ 10^{20} W/cm²**

Experimental platform using 100-nm focusing optics

BL3

Applications:

- XFEL-pumped *K*α laser
- X-ray saturable absorption
- Femtosecond probe of damage-process



Experimental platform for combinative use of XFEL and high pulse-energy laser

BL3

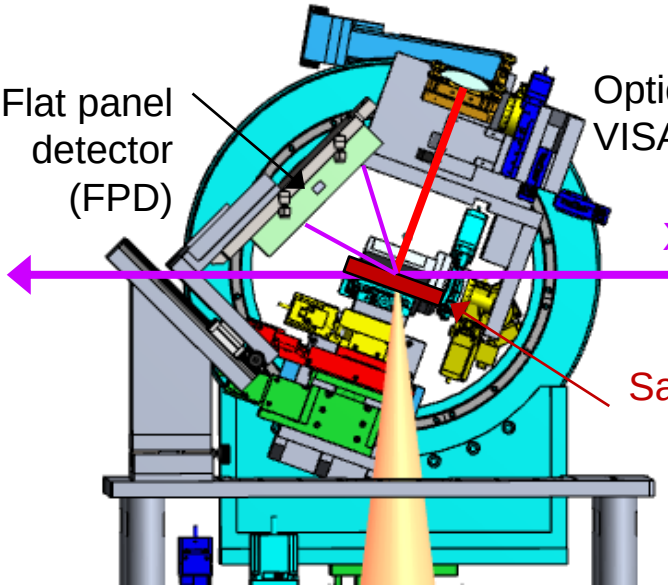
Summer 2017: Conceptual design
Autumn 2017: First design
December 2017: Design review
February 2018: Final design
September 2018: Installation
Early 2019 - : Open to users

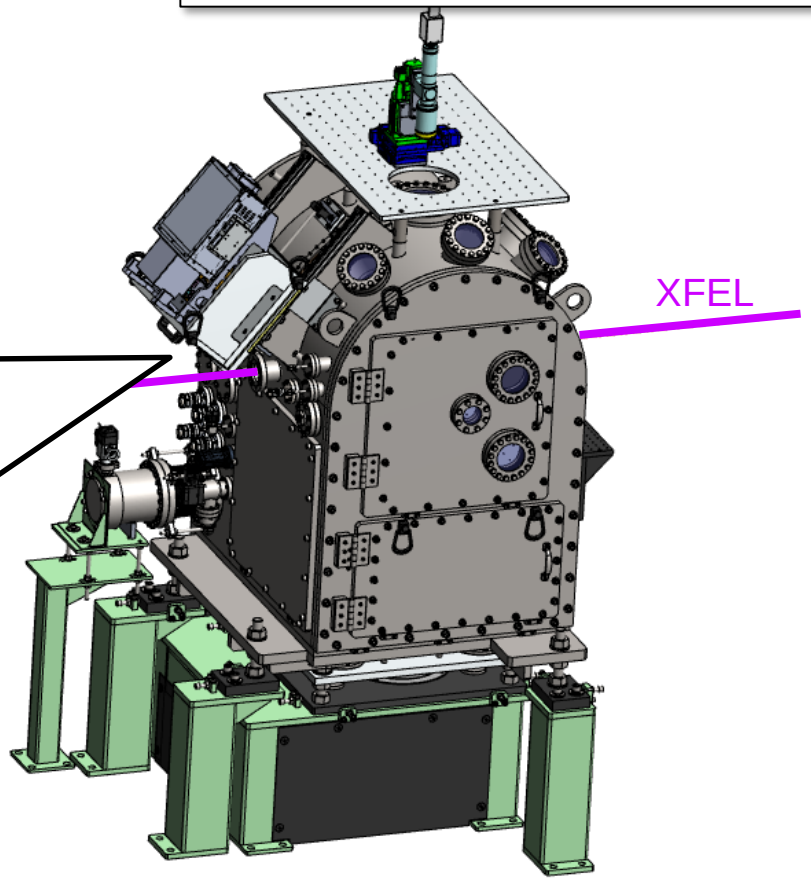
⇒Poster No.7, Inubushi-san

Laser parameters

- 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





These new system will be available from 2018B (early 2019).

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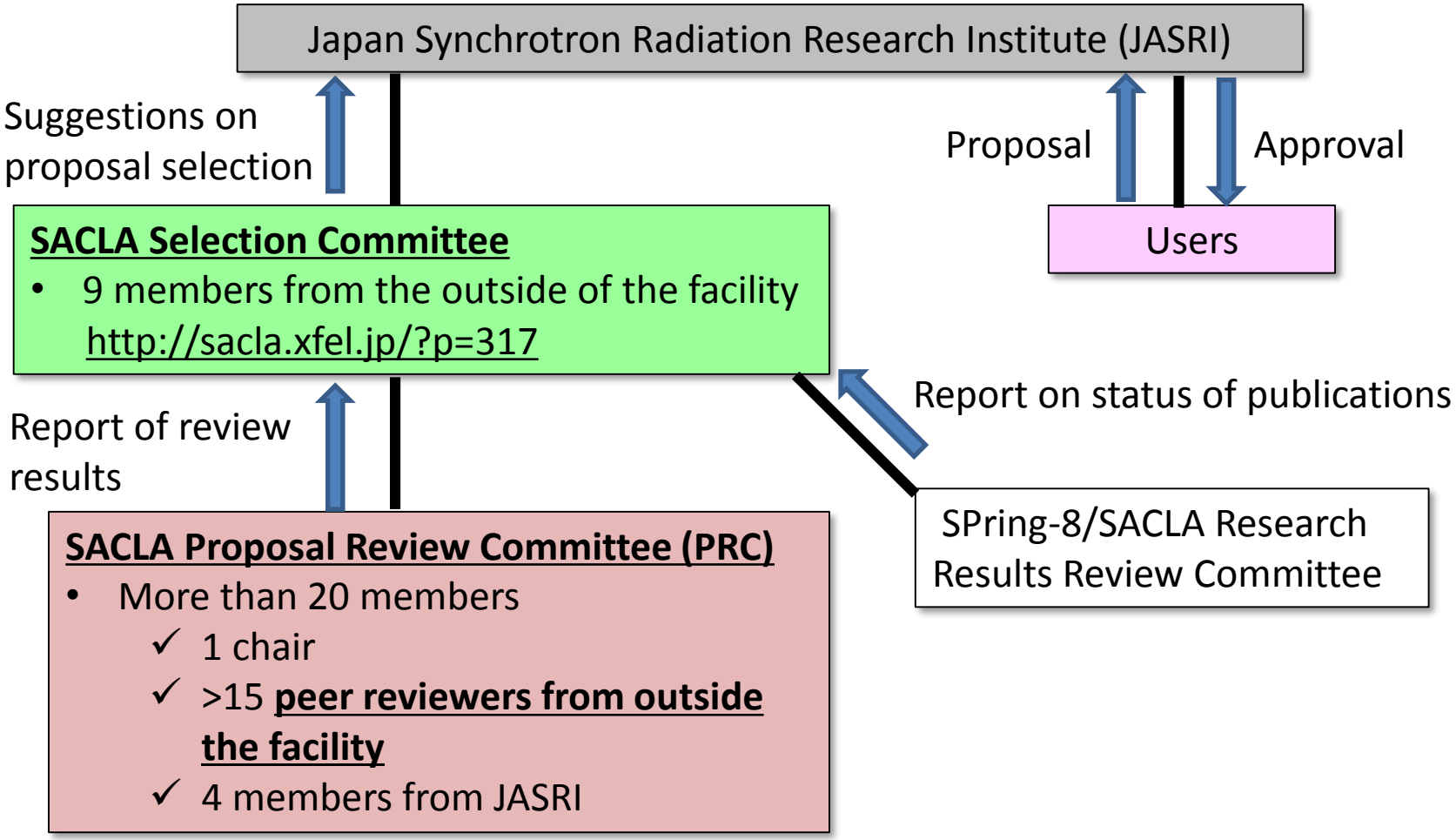
Prof. Amemiya's slide in the last meeting

Proposal review system



- Information on proposal application (JASRI): **http://sacla.xfel.jp/?lang=en**
- SACLA portal HP (technical information, publications, etc.): **http://xfel.riken.jp/**

General information

- Two calls in a year.
  - May (Deadline in June) for Term B (Sept.-Feb.)
  - Oct. (Deadline in Nov.) for Term A (March-July)
- Two categories
  - General proposal (non-proprietary proposal)
    - The project leaders need to publish their research results.
  - Proprietary proposal
    - Beamtime fee: 1,098,000 JPY/2 hours
      (1,647,000 JPY/2 hours for *Time-Designated Proposal*)

Contact:

About application procedures:

sacla.jasri@spring8.or.jp (SACLA Users Office)

Technical queries:

sacla-bl.jasri@spring8.or.jp (SACLA beamline staff)

Review process

- Peer review by external PRC members
  - Each proposal is rated by 5 reviewers.
  - Scientific/technological importance is evaluated.
  - The reviewers rate proposals independently and submit comments for the discussion of PRC.
  - Each proposal is ranked based on the average score of the reviewers.
- Technical feasibility and safety are evaluated by JASRI members of PRC.
- SACLA PRC members discuss the priority of proposals based on the reviewers' results.
  - Acceptable proposals are selected according to the the available beam time of each beamline.

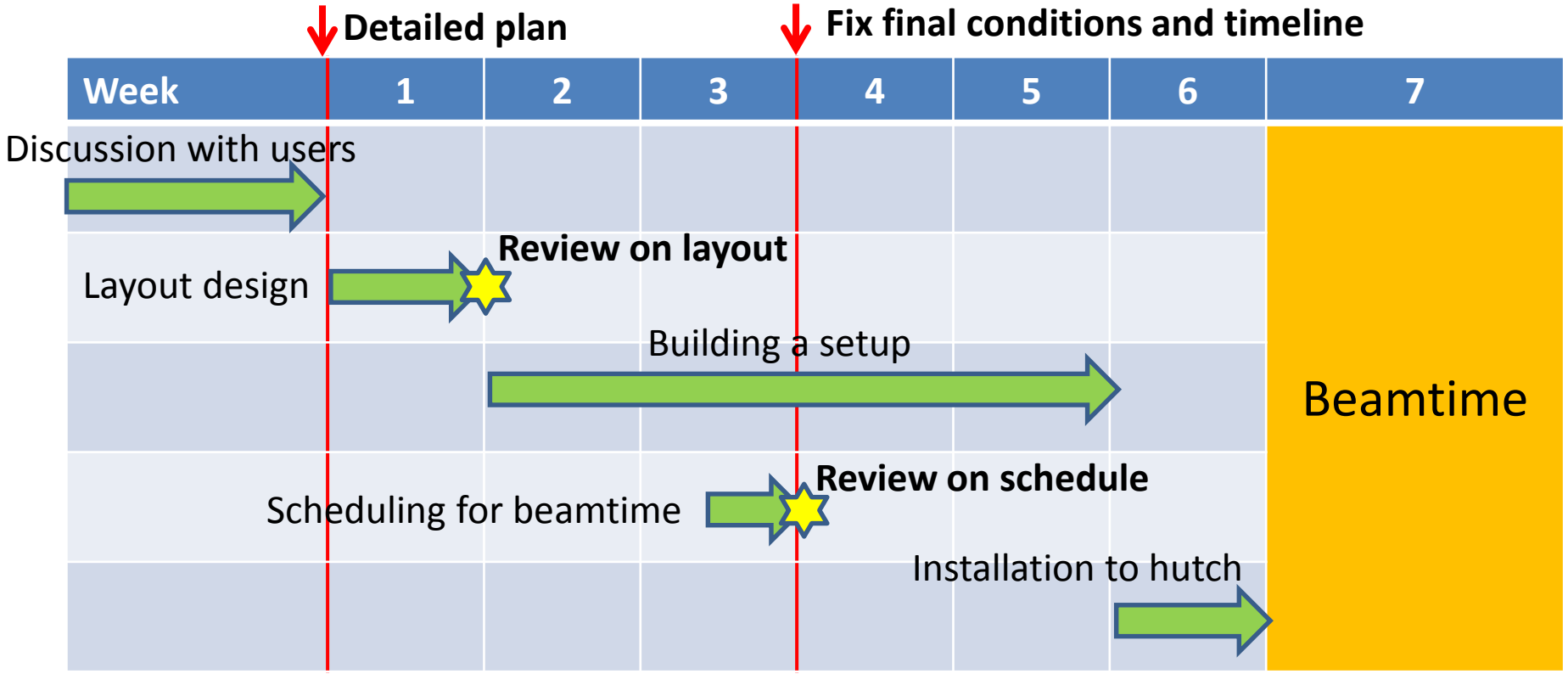
After obtaining approval of your proposal

- Contact beamline scientists:

  sacla-bl.jasri@spring8.or.jp
- Provide information as early as possible:
  - *Practical* (not only conceptual) information for setting up your experiment.
  - Final plan should be provided 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 (ExpCotrolAPI) are available (see Posters)

Typical schedule for preparation by the facility staff

Well-planned preparation is a key to successful experiment.



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

Summary & outlook

- SACLA entered a new operation phase with 3 BLs operated in parallel.
- Over 6000 h user time is expected in this year.
- New capabilities.

  BL1: Timing tool

  BL2: HEDS station , MAXIC-S

  BL3: SDO, self seeding, nanometer focusing system,
  Endstation for high pulse-energy laser.
- For successful beamtime, information should be provided as early as possible (at least 6 weeks prior to your experiment).
- On-demand beam delivery to SP-8: Start testing from this year.