SACLA Users' Meeting 2023
March 2–3, 2023

Technical Updates:
Hard X-ray Beamlines (BL2/3)

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on behalf of SACLA

Technical Updates at BL2/BL3

Diagnostics / Acc. Tuning

- ***Middle-resolution inline spectrometer (BL2/BL3)***
  → Tailor-made XFEL generation w/ ML-based acc. optimizer

Advanced Operation

- ***Two-color XFELs with SASE + mono (BL3)***
  → Nonlinear spectroscopy / X pump & X probe w/ high sensitivity

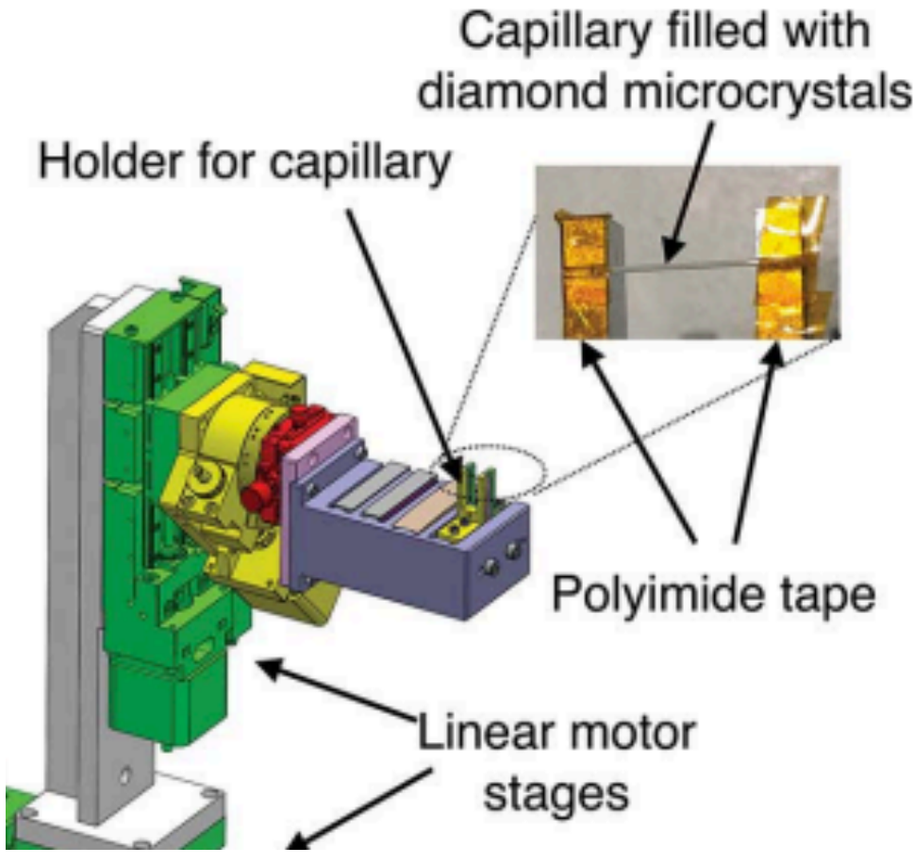
Beamline Instruments

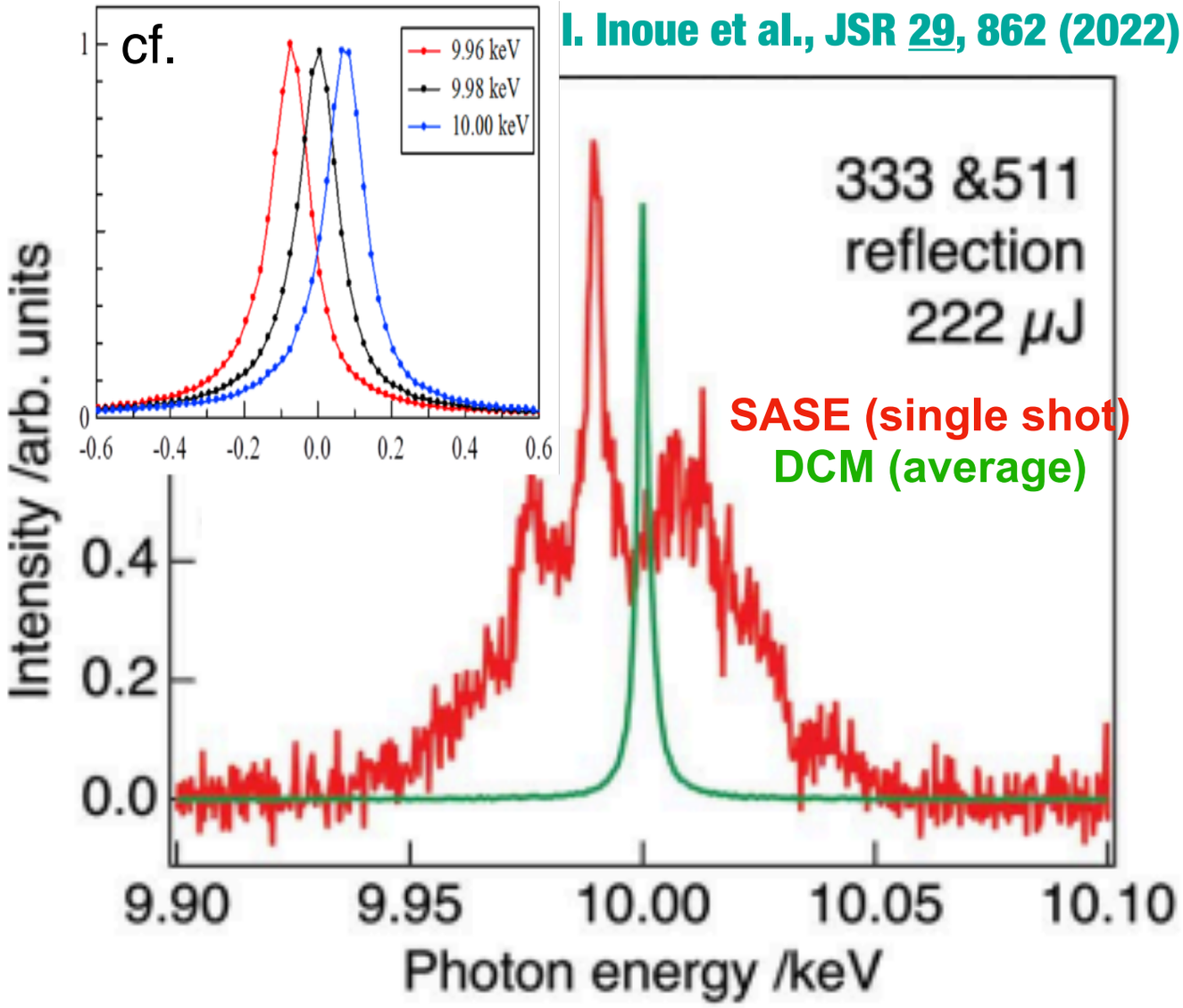
- ***Ru-coated beam transport mirrors (BL2/BL3)***
  → High-resolution crystallography w/ high-E XFEL

- ***Various options for channel-cut monochromator (BL2/BL3)***
  → Optimization of XFEL bandwidth for specific experiments

- ***Portable nano-focusing system (BL2/BL3)***
  → Flexible experiments w/ nano-focused XFEL

Middle-Resolution Inline Spectrometer (BL2/3)





Narrow Debye-Scherrer rings from **micro crystals** (diamond, silicon etc.) are detected.

- ☑ **Easy to use** (insert the capillary & adjust the detector angle)
- ☑ **Middle resolution (several eV)**; cf., 30–40 eV for nano-crystal I-spec
- ☐ **Destructive** (thick capillary used to make Debye-Scherrer rings uniform)

Installed in optics hutches at both BL2 & BL3 in 2022

Tailor-made XFEL Generation w/ ML-Based Acc. Optimizer

Advanced diagnostic systems have enabled ***tailor-made XFEL generation*** w/ **ML-based acc. optimizer**.

Parameters:

- ☑ Pulse energy
- ☑ Bandwidth (both narrow & broad)
- ☑ Spectral brightness
- ☑ Central photon energy
- ☑ Beam size/shape

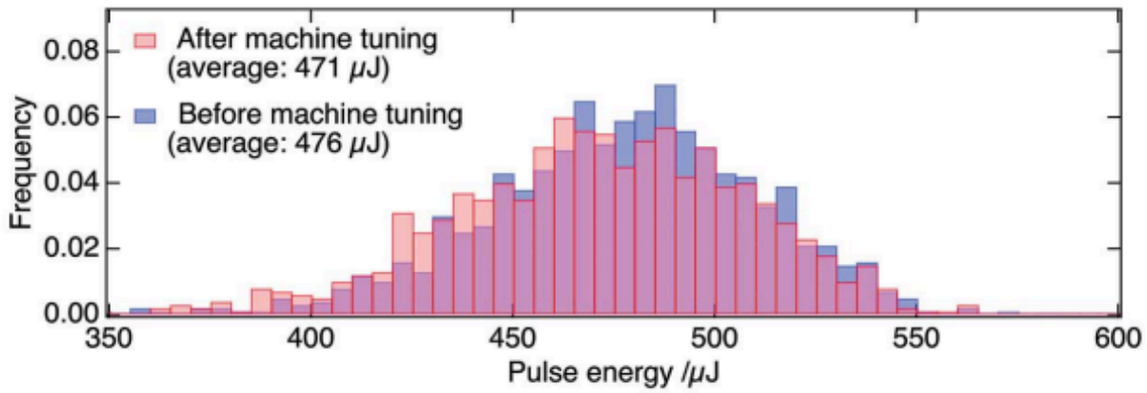
  and so on…

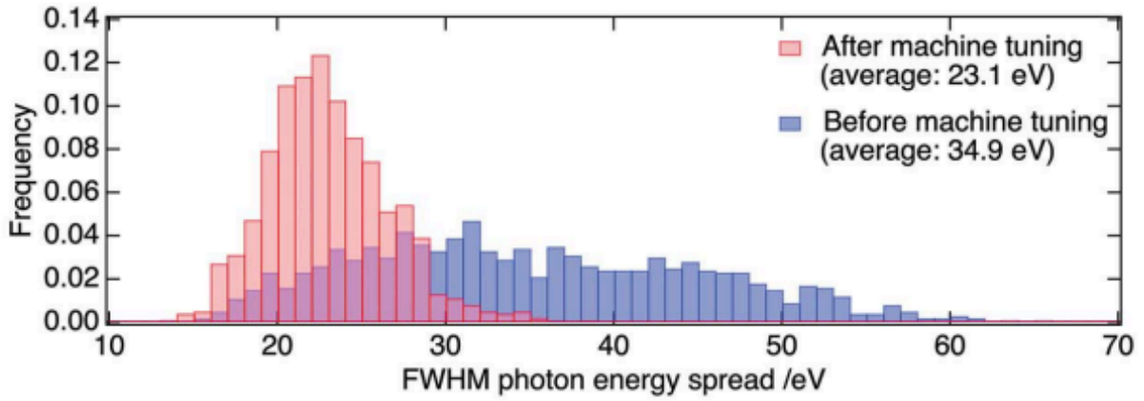
- ☑ Weighted score of several param.
- ☑ Manual examination (not tried)

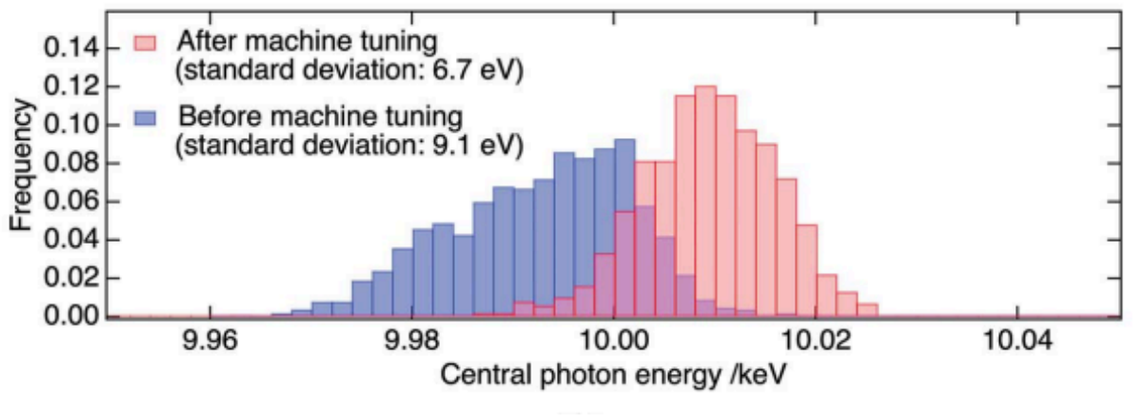
Example:

Maximizing ***spectral brightness*** while keeping ***pulse energy***

I. Inoue et al., JSR 29, 862 (2022)
E. Iwai et al., in preparation



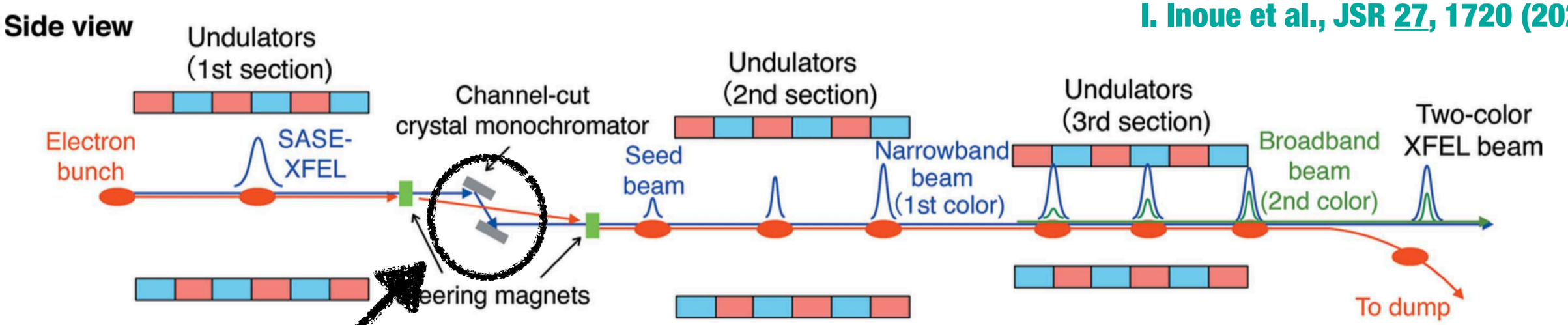


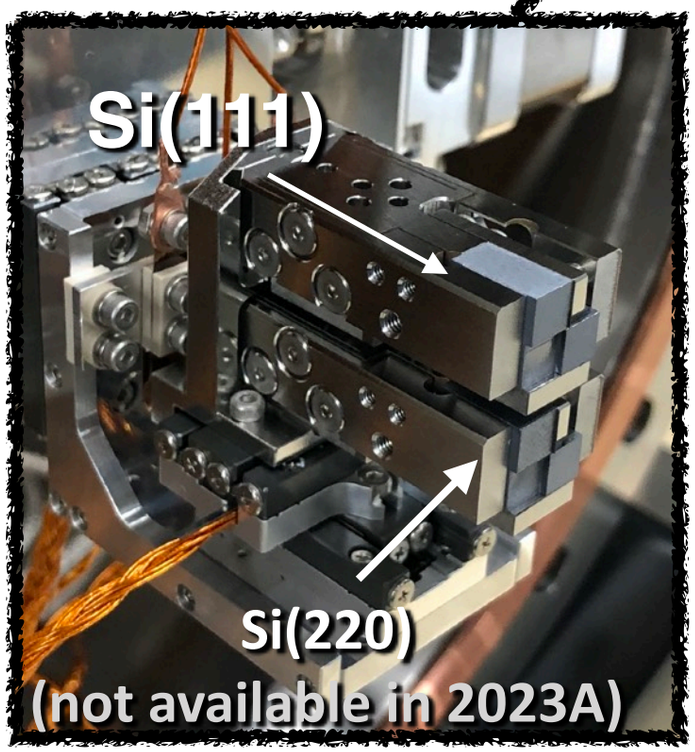


Please contact beamline scientists & let us know your specific requirement

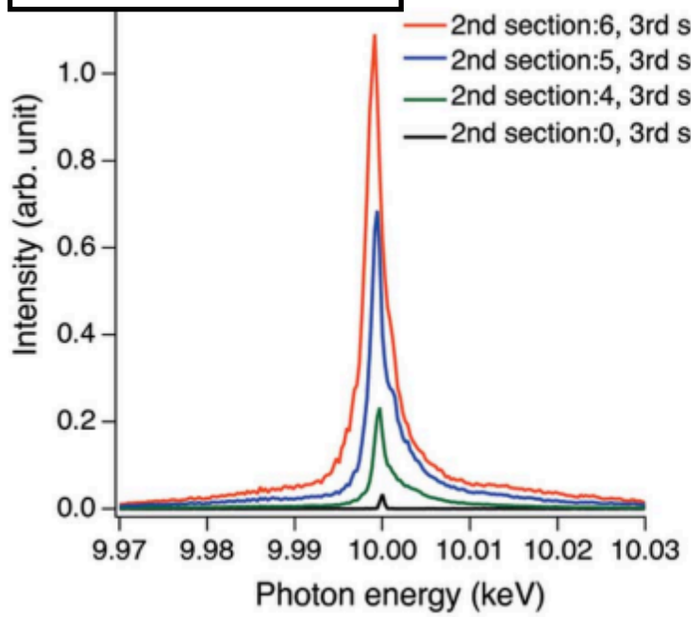
Two-color SASE & mono XFELs (BL3)

I. Inoue et al., JSR 27, 1720 (2020)

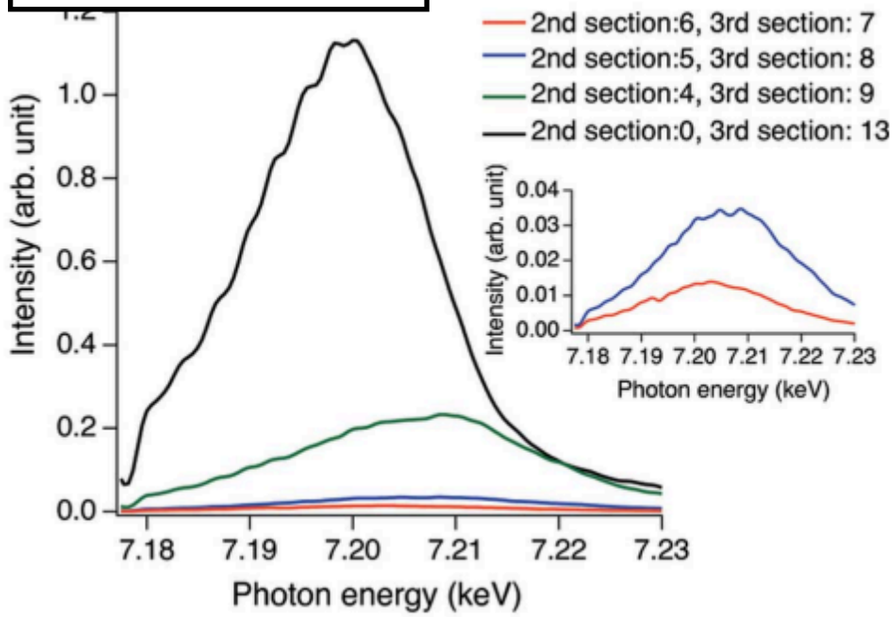




1st color (mono)



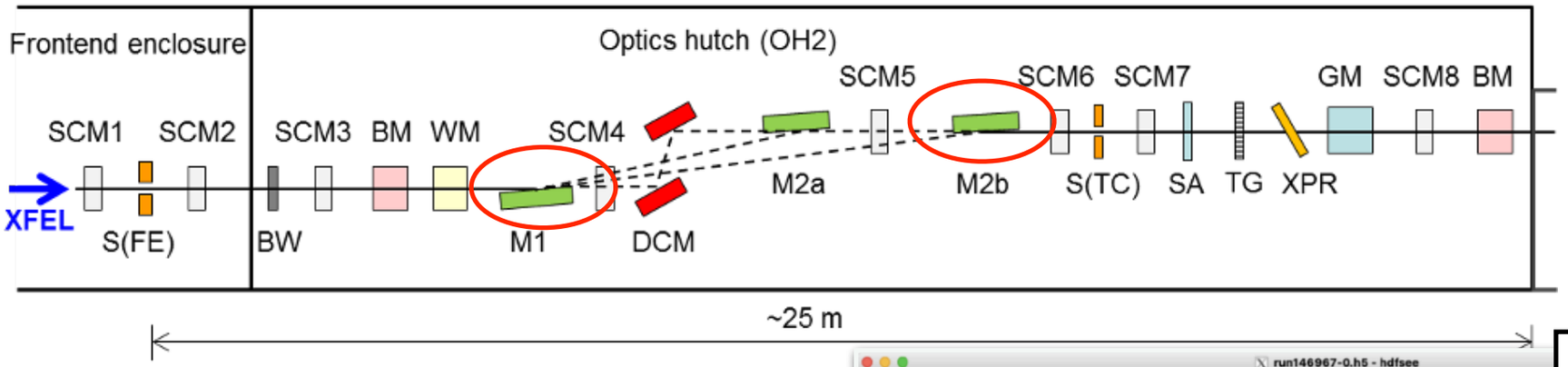
2nd color (SASE)



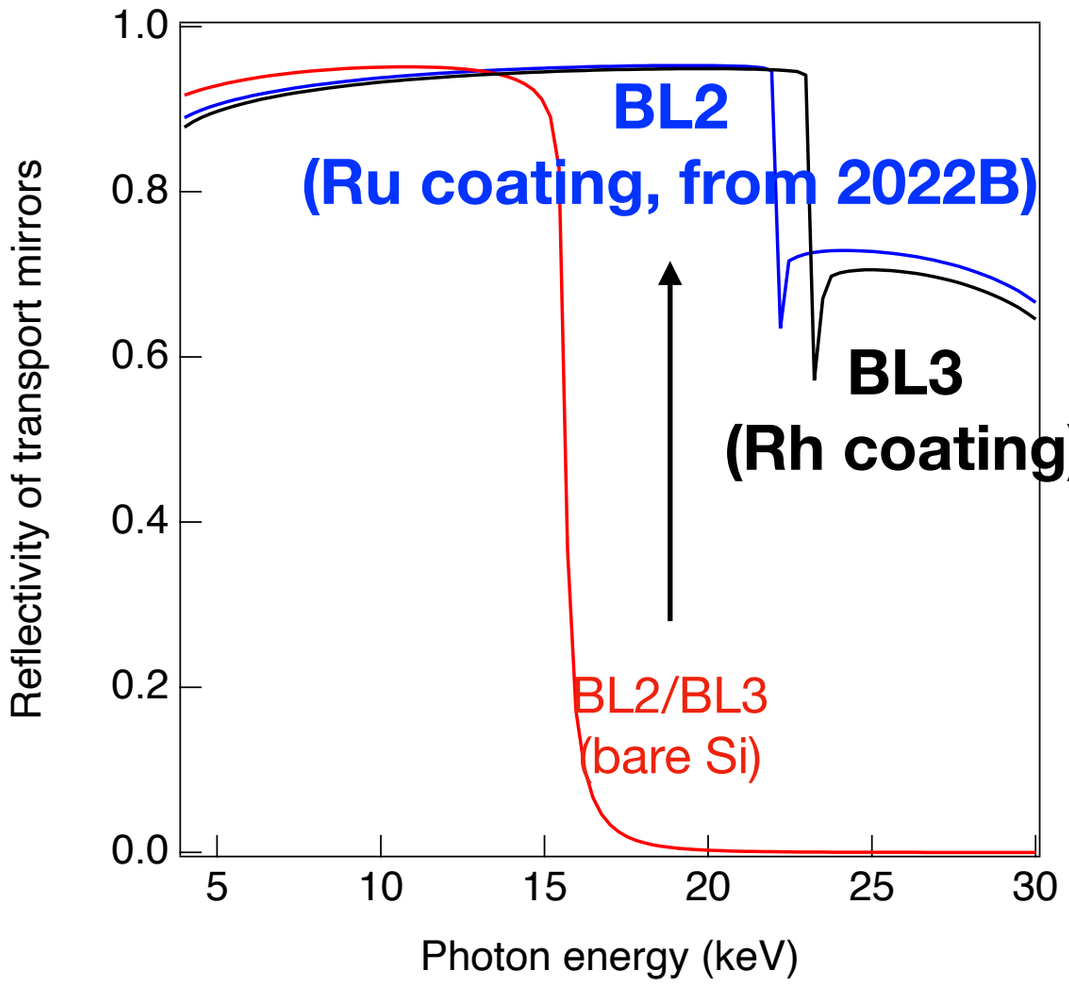
μCC mono enables unique operation mode that generates
two-color SASE (pump) & mono (probe) XFELs w/ energy- & delay-scan capabilities.

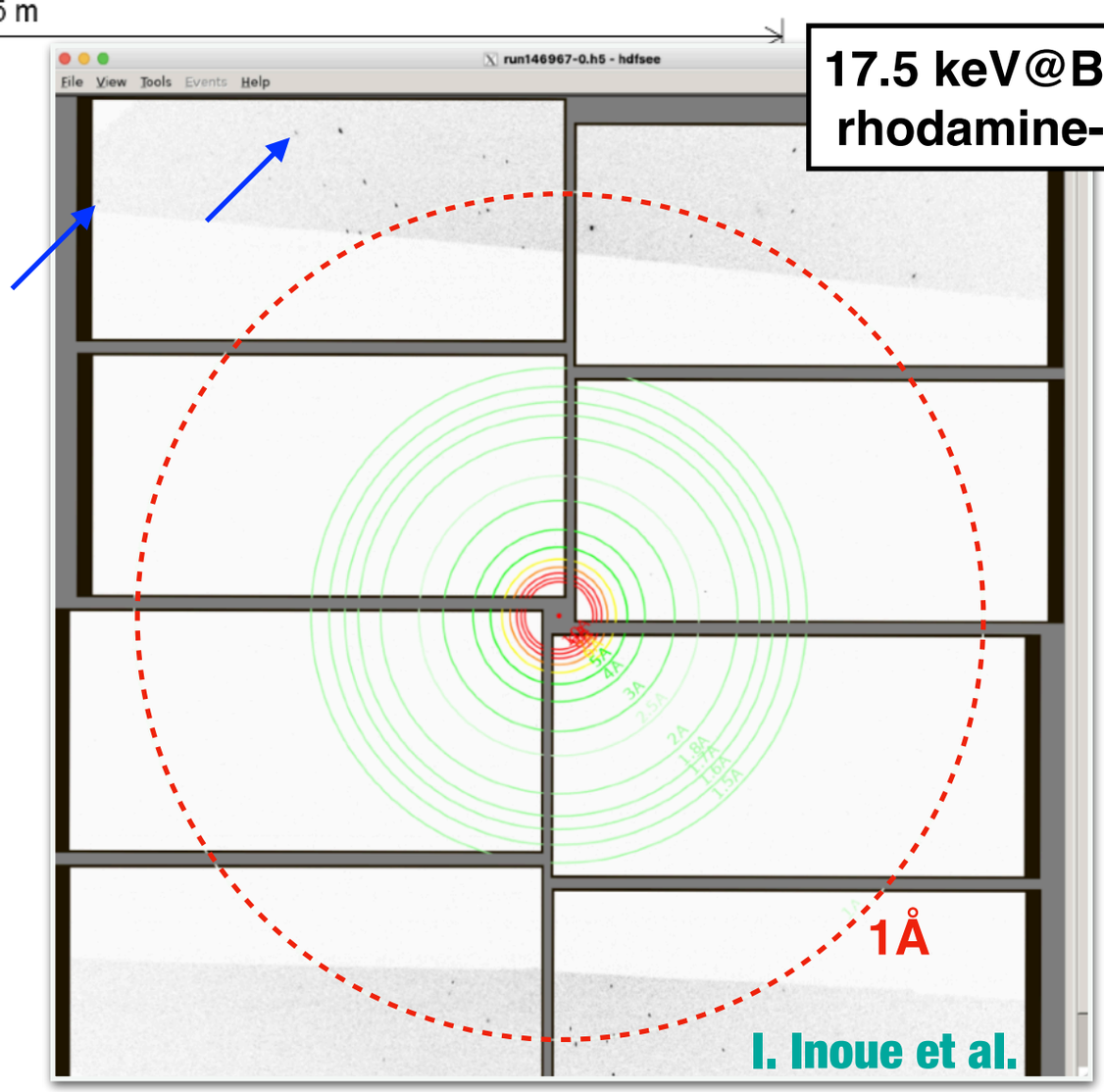
Nonlinear spectroscopy & sensitive probe of matter excited by SASE

Ru-Coated Beam Transport Mirrors (BL2)



T. Koyama et al.





High energy XFEL (***up to 22 keV***) became available at BL2 since 2022B.

Useful for high-resolution (<Å) crystallography

Channel-cut monochromators (BL2/BL3)

Si(111) double channel-cut monochromator (DCCM) has been routinely utilized for ultrafast optical & XFEL pump-probe experiments at BL3.

T. Katayama et al., JSR 26, 333 (2019).

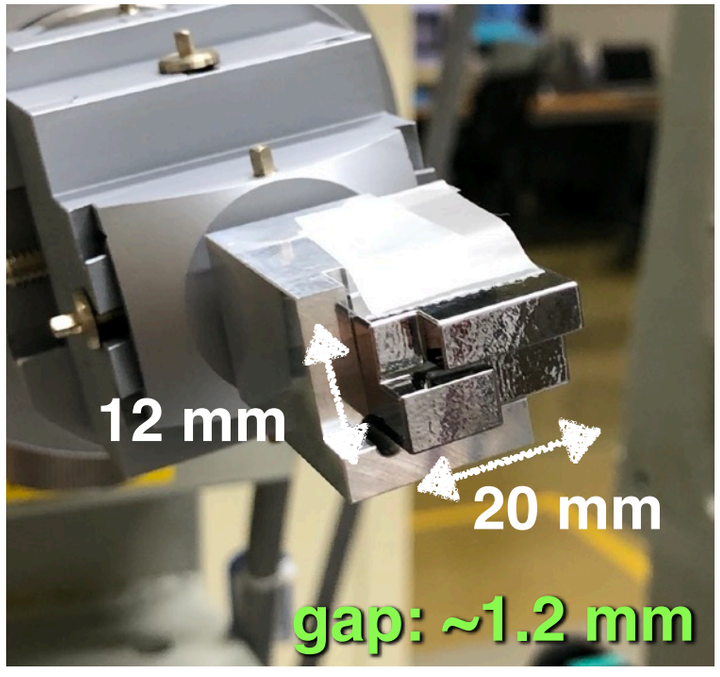
Various high-quality CCs will be available from 2023A → ***optimization of XFEL bandwidth*** for ***advanced spectroscopy (narrow b.w.)*** & ***diffraction experiments (moderate b.w.)***

List of currently available CCs

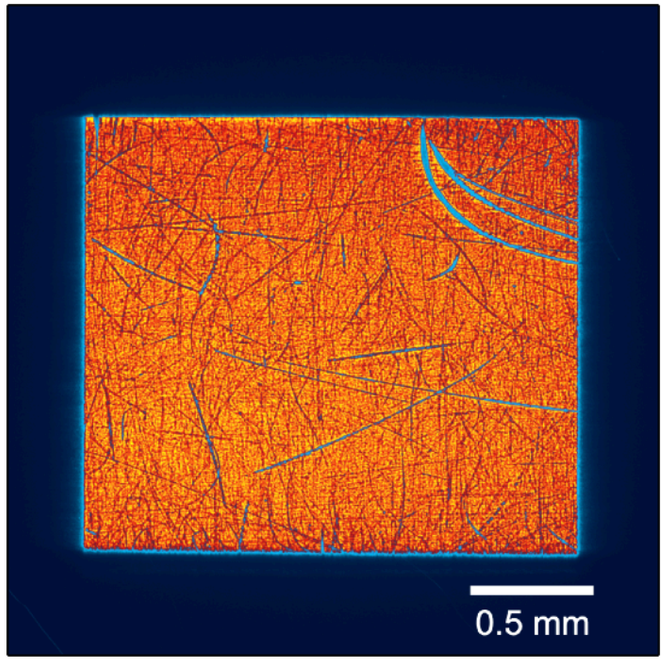
Crystal	Plane	θ_{B_min} (deg)	θ_{B_max} (deg)	gap (mm)	**Plasma polish**	# of sets	Comments
Si	(111)	5.4	38.6	8	done	1	default (111)
Si	(111)	20.0	63.4	20	done	1	(111) at low energy (333) or (444)
Si	(111)	10.8	58.0	10	in FY2022	1	(333) or (444)
Si	(110)	〃	〃	〃	partly done	1	(220) or (440)
Si	(100)	〃	〃	〃	in FY2022	1	(400)
Si	(311)	〃	〃	〃	done	1	(311)
Si	(331)	〃	〃	〃	in FY2022	1	(331)
Ge	(111)	4.6	25.6	1.2	under commissioning	1	(111) w/ ⊿E/E = 3.0x10^{-4} **CCM option** available **higher flux than Si(111)**

These CCs are available both at **BL2 (in air)** & **BL3 (in-vacuum dedicated chamber)**

Compact Ge(111) CCM

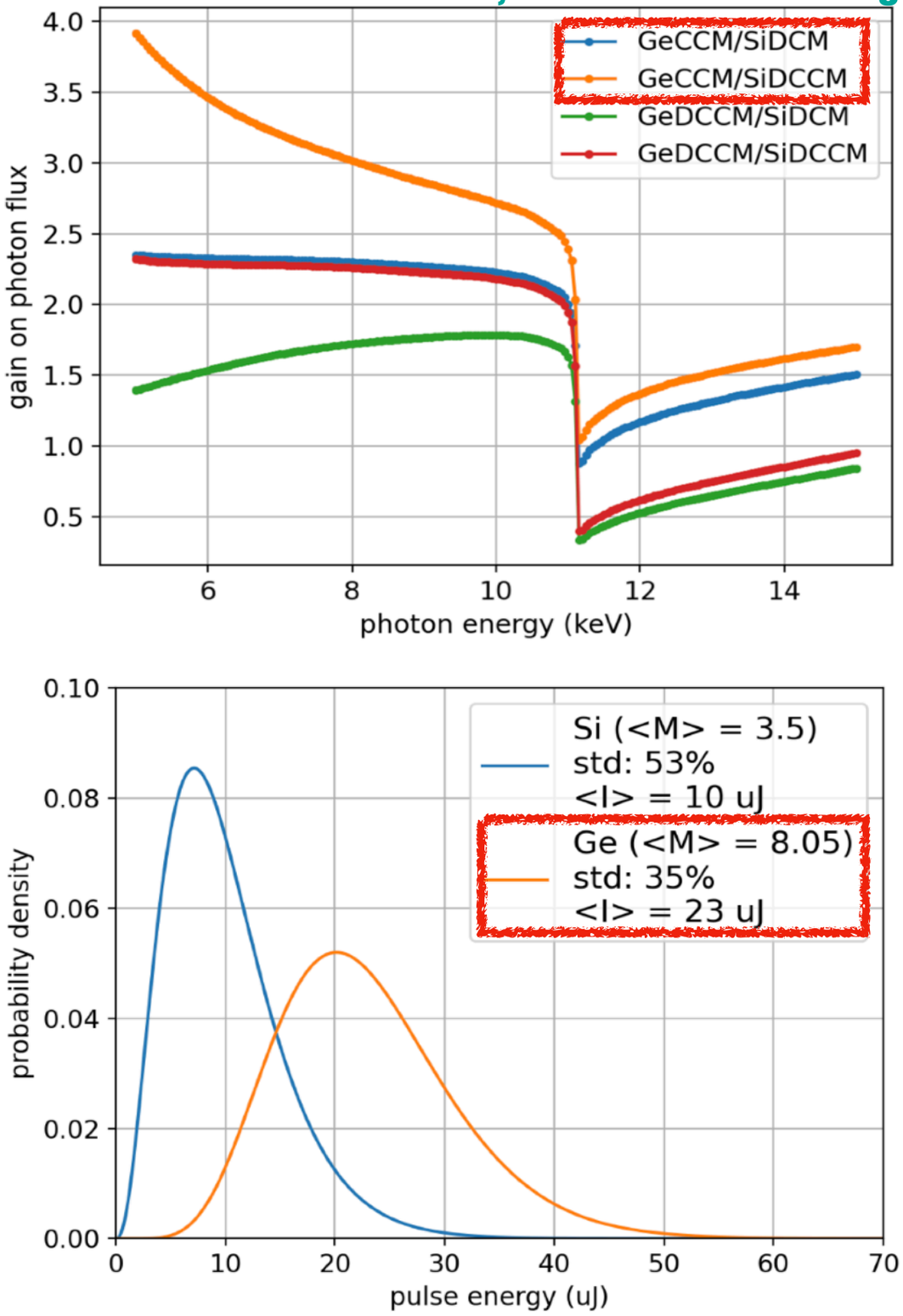


Picture of Ge(111) CCM



Four-bounce reflection profile

Y. Sano et al., under commissioning



- ☑ Broad bandwidth ($\Delta E/E \sim 3.0\times10^{-4}$)
- ☑ **CCM operation** available (w/ beam offset)
  → ***higher throughput & less fluctuation than Si(111) DCM/DCCM***

- ☐ K edge at 11.1 keV
- ☐ In-vacuum only (available only at BL3)
- ☐ Scratched surface → speckles & decreased *R*
  (Plasma polishing is under commissioning in collaboration w/ Prof. Sano, Osaka U.)

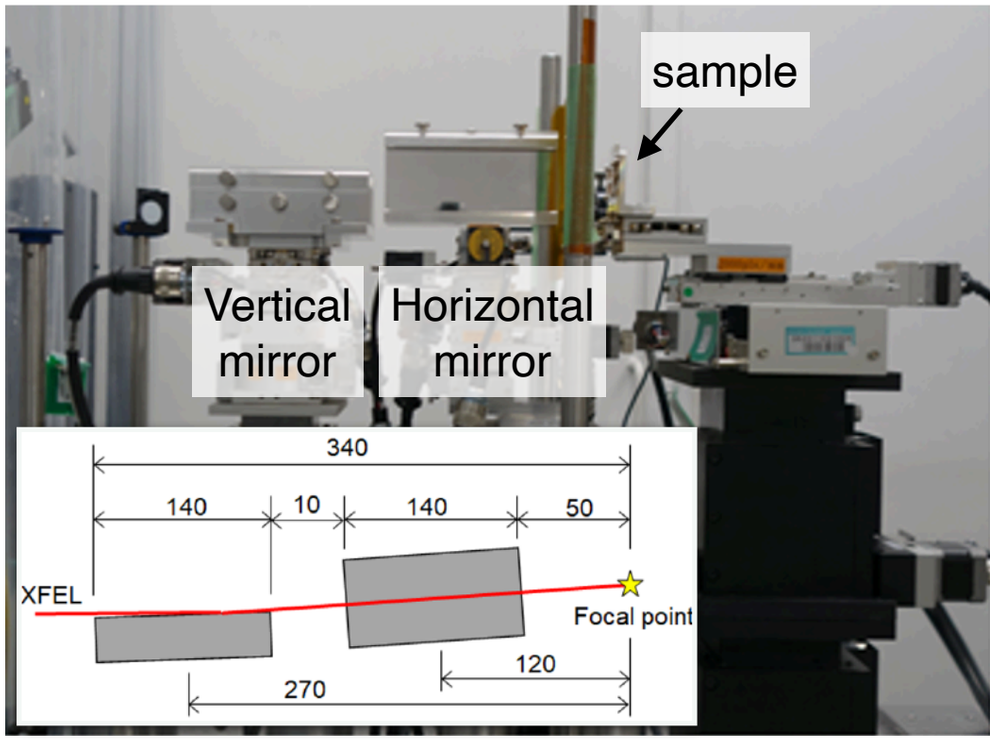
Portable Nano-Focusing System (BL2/BL3)

Y. Inubushi et al., in preparation

Portable nano-focusing mirror + auto-tuning system is under commissioning.

Flexible experiments with nano-focused XFEL

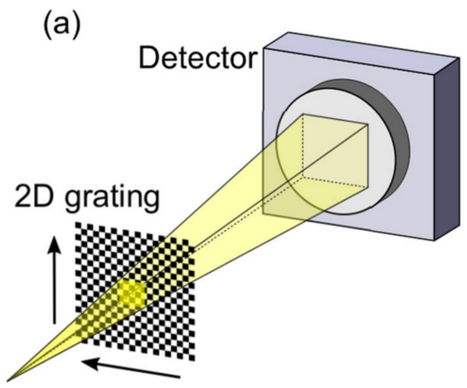
(w/ fs optical laser, large detector, bring-in instruments, etc.)

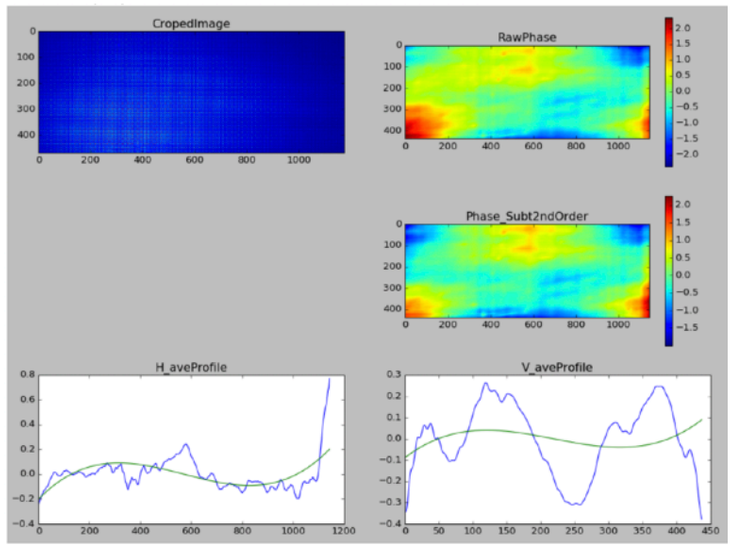


- ☑ Easy assembly
- ☑ Easy alignment (2 hours initial, ~10 min retuning)
- ☑ Reliable performance
  (***auto-tuning based on wavefront sensing***)

→Talk by J. Yamada (Osaka U) from 3:15pm, today

- ☑ Flexible design of mirrors (AKB etc.)
- ☑ Easy implementation (w/o dedicated chamber)
- ☐ Operated in air or He





Current performance

360 nm (V) × 240 nm (H) FWHM

→ ~2×10^{19} W/cm^2

(in air @9 keV, up to ~11.5 keV)

Summary: Updated Capabilities in HX BLs

		BL2 (HX)	BL3 (HX)
Photon energy		4 ~ **22** keV	4 ~ 22 keV
Pulse duration		<10 fs	<10 fs
Pink beam	Bandwidth (ΔE/E)	~3x10^{-3}	~3x10^{-3}
	Pulse energy	~500 μJ @10 keV	**~700 μJ** (up to 900 μJ) @10 keV
Monochromatic beam (Si 111 DCM/DCCM)	Bandwidth (ΔE/E)	1.3x10^{-4}	1.3x10^{-4}
	Pulse energy	~10 μJ @10 keV	~10–50 μJ @10 keV
Monochromatic beam (DCCM option)	Bandwidth (ΔE/E)	**0.05–1.3×10^{-4}** @10 keV (in air)	**0.05–3.0x10^{-4}** @10 keV
	Pulse energy	depends on b.w.	depends on b.w.
Repetition rate		30 / 60 Hz	30 / 60 Hz
Advanced operation modes		Two color (SASE+SASE w/o delay)	Two color (SASE+SASE / **SASE+mono**) Self-seeding / SDO
Tailor-made XFEL generation		○	○
Portable nano-focusing system		to be available	to be available

Thank you for your kind attention !