Status of SACLA at SPring-8

Tetsuya Ishikawa

On behalf of the SACLA team

RIKEN Harima Institute
Sayo, Hyogo 679-5148, Japan
ishikawa@spring8.or.jp

26 January 2012 @ European XFEL Users' Meeting

SACLA

(SPring-8 Angstrom Compact free electron LAser)

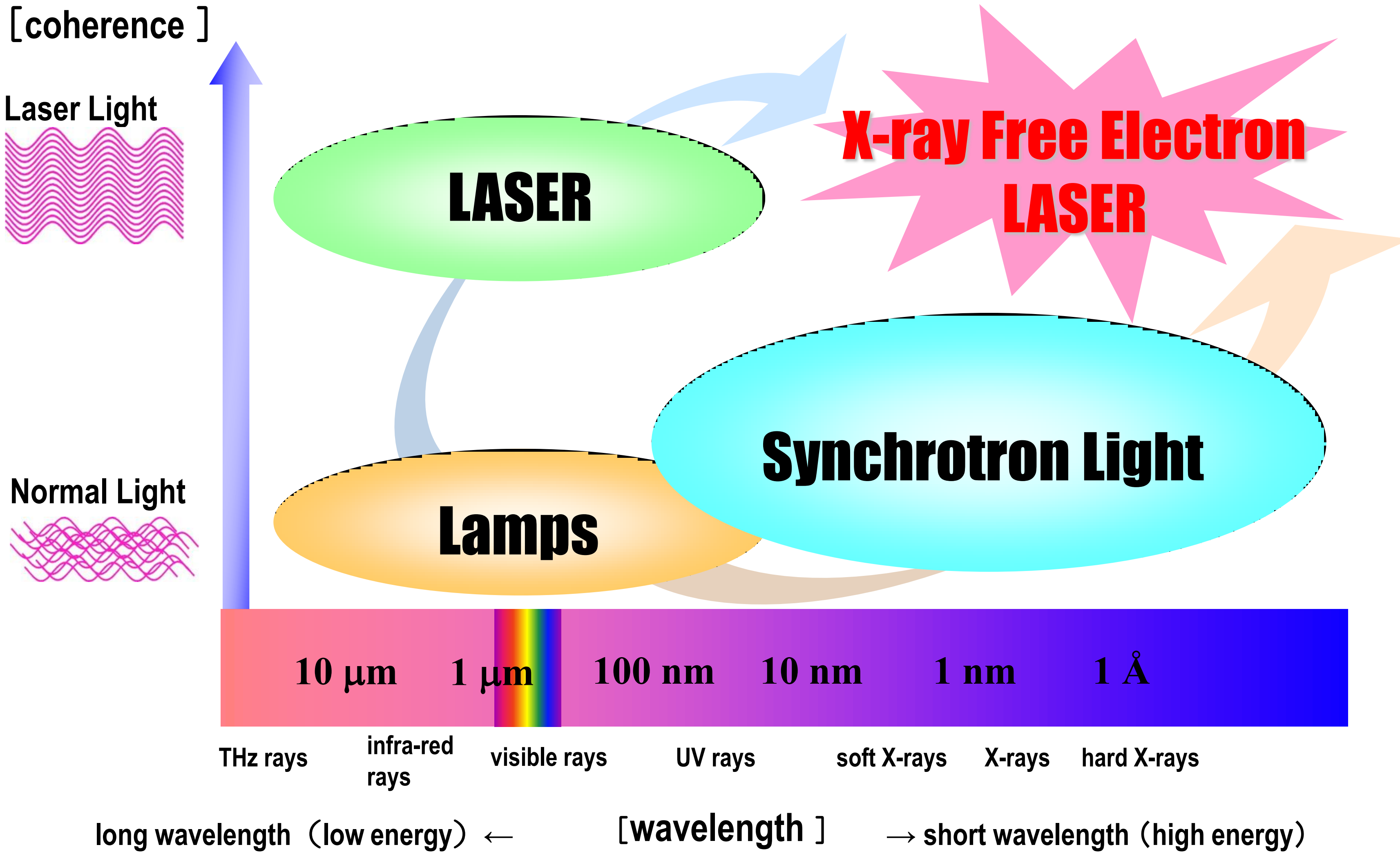
X-Ray Free Electron Laser with 8 GeV electron Liniac
With 700 m length with experimental building
Completed in March 2011
Open for public users both domestic and internationa


Cherry Blossoms = SAKURA
SACLA ?


SACLA' ITALIA
QUALITA' ITALIANA DAL 1939
SACLA' ITALIA
Arrabbiata
Pasta Sauce
STIR THROUGH
SACLA' ITALIA
QUALITA' ITALIANA DAL 1939
SACLA' ITALIA
Classic
pesto

“X-ray Free Electron Laser, XFEL”

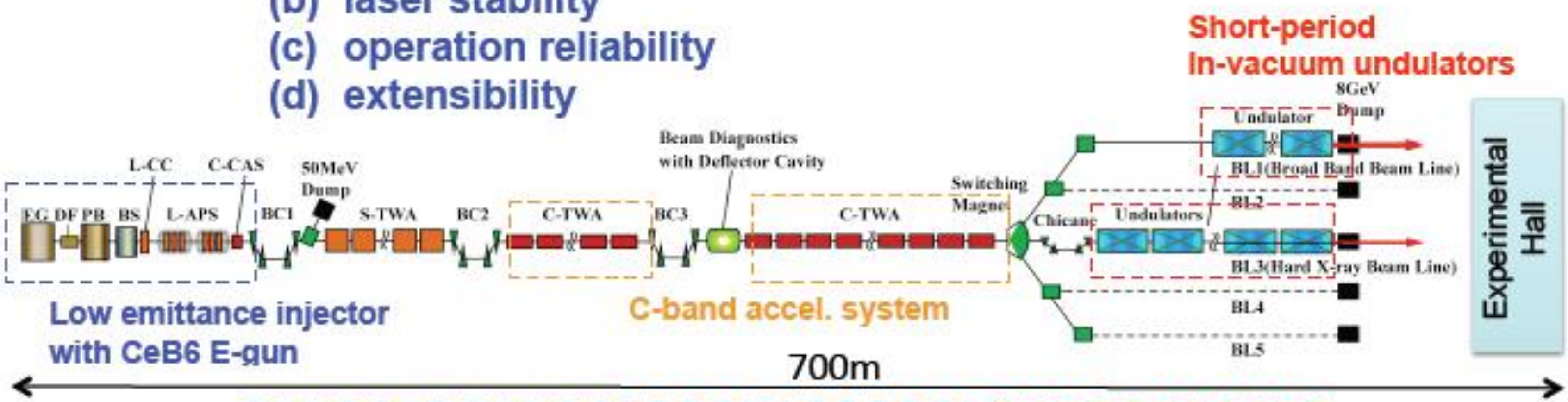
coherent light to explore nano-world



SACLA System

The world's first compact XFEL based on in-vacuum UNDs having the following features;

(a) small scale
(b) laser stability
(c) operation reliability
(d) extensibility



RIKEN SACLA

Japan’s XFEL:
SPring-8 Compact SASE Source (SCSS) Concept

Use of short-period undulator

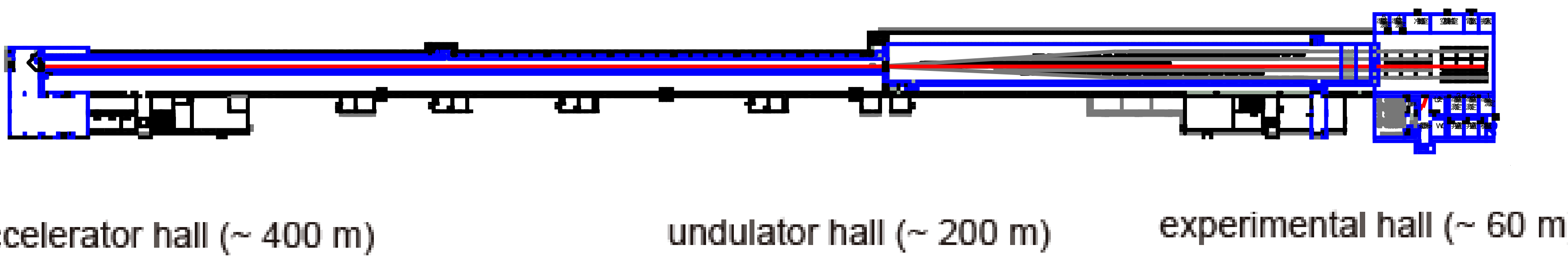
↓

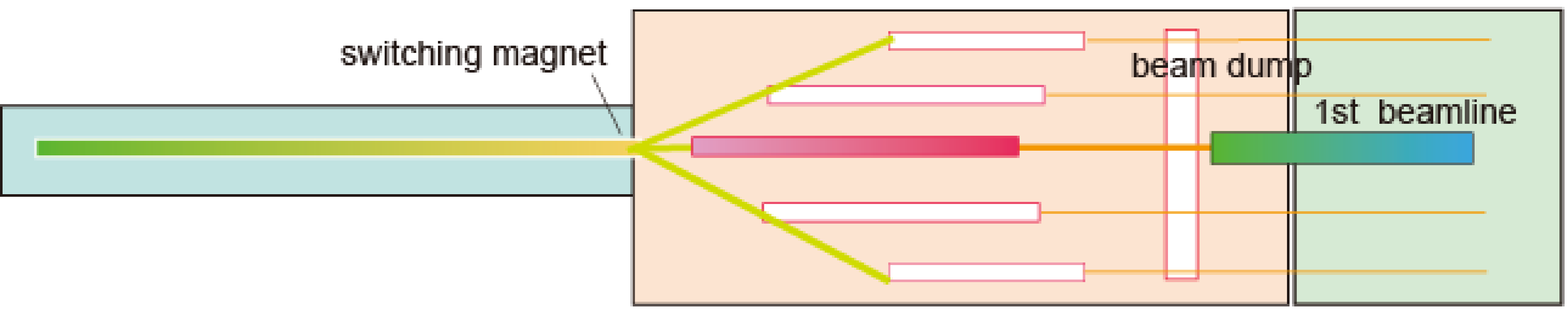
Suppression of acceleration energy

+ Use of high-gradient linac

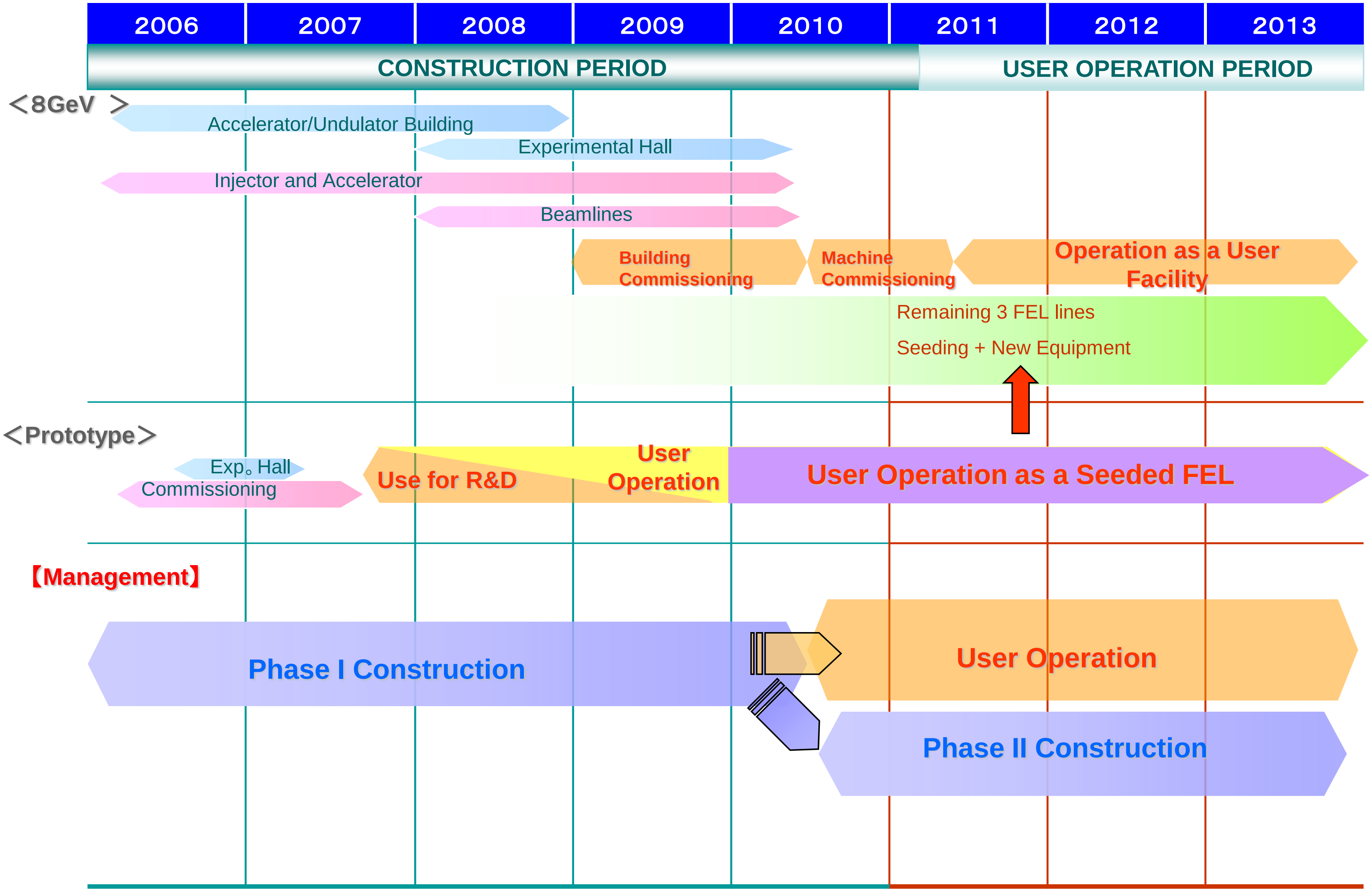
= Total length of 700 m

$$\lambda_{photon} = \frac{\lambda_{magnet}}{2\gamma^2}\left(1 + \frac{K^2}{2}\right)$$

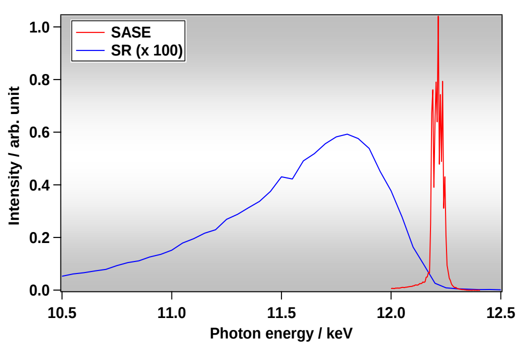


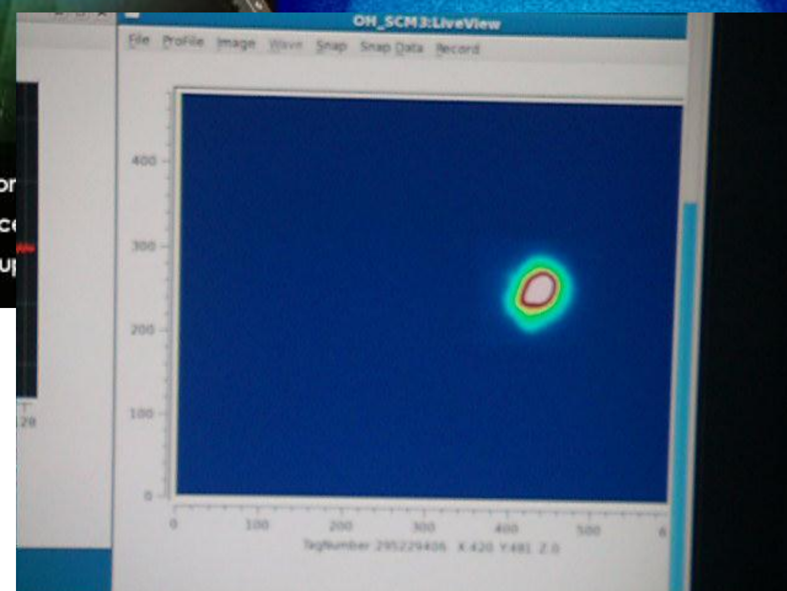


Road Map


2006
2007
2008
2009
2010
2011
2012
2013
CONSTRUCTION PERIOD
USER OPERATION PERIOD
＜8GeV ＞
Accelerator/Undulator Building
Experimental Hall
Injector and Accelerator
Beamlines
Building Commissioning
Machine Commissioning
Operation as a User Facility
Remaining 3 FEL lines
Seeding + New Equipment
＜Prototype＞
Exp。Hall
Commissioning
Use for R&D
User Operation
User Operation as a Seeded FEL
【Management】
Phase I Construction
User Operation
Phase II Construction

SACLA has delivered Laser Light





Achieved Performance (I) as of July 2011

Present Result Summary w/o Laser Heater

Quick beam commissioning (~3 months to the lasing) with a newly constructed machine

Maximum laser power

~4 GW

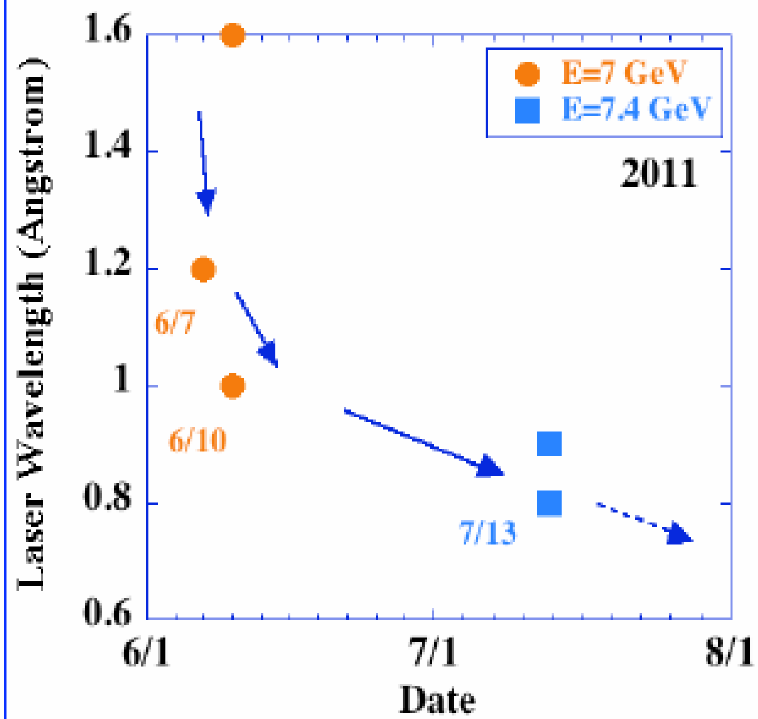
Lasing wavelength range

0.8 ~ 1.6 Å

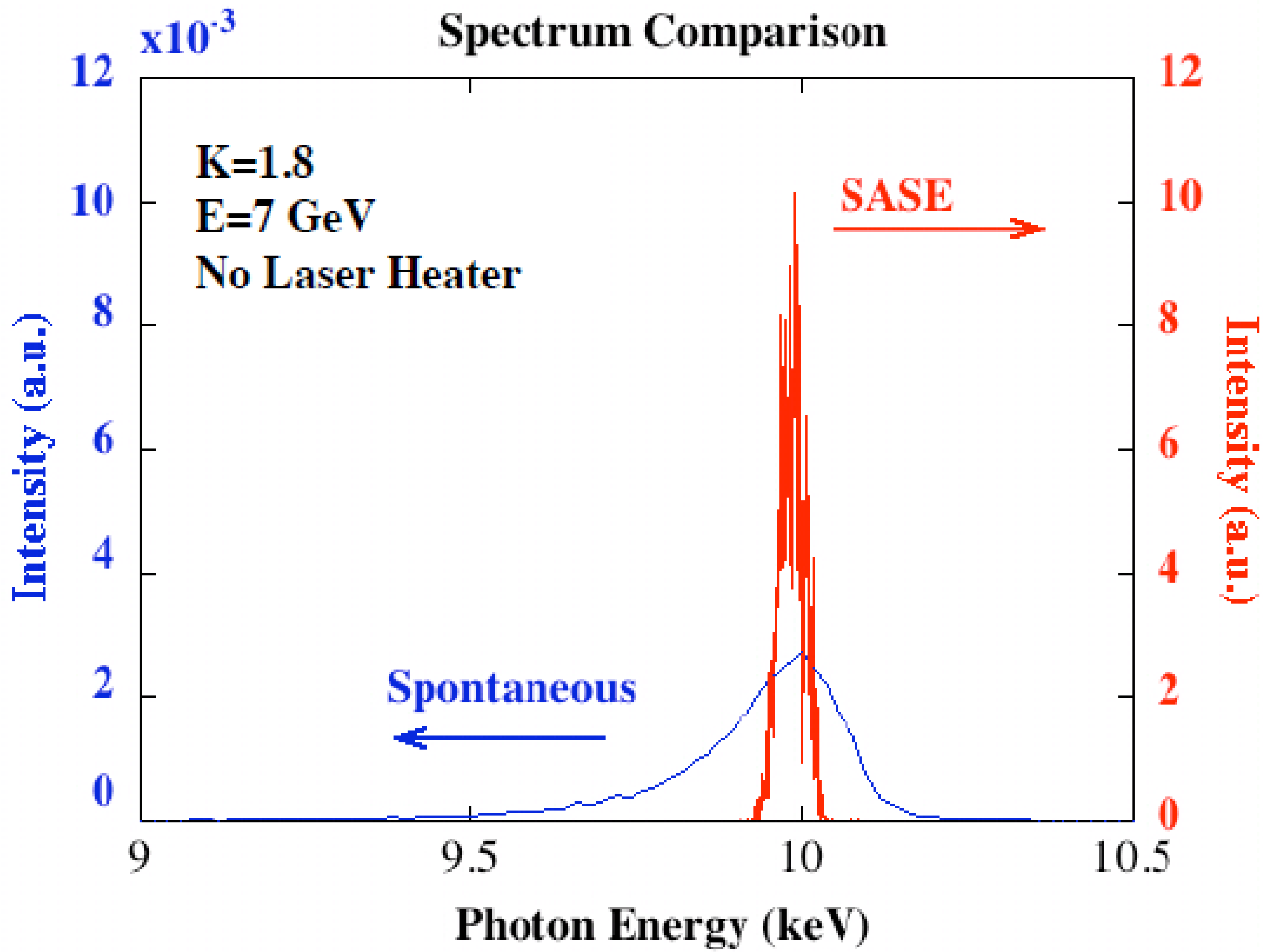
Laser being reproducible

- w/o beam FB keeping the peak current
- at 60~70% of peak intensity

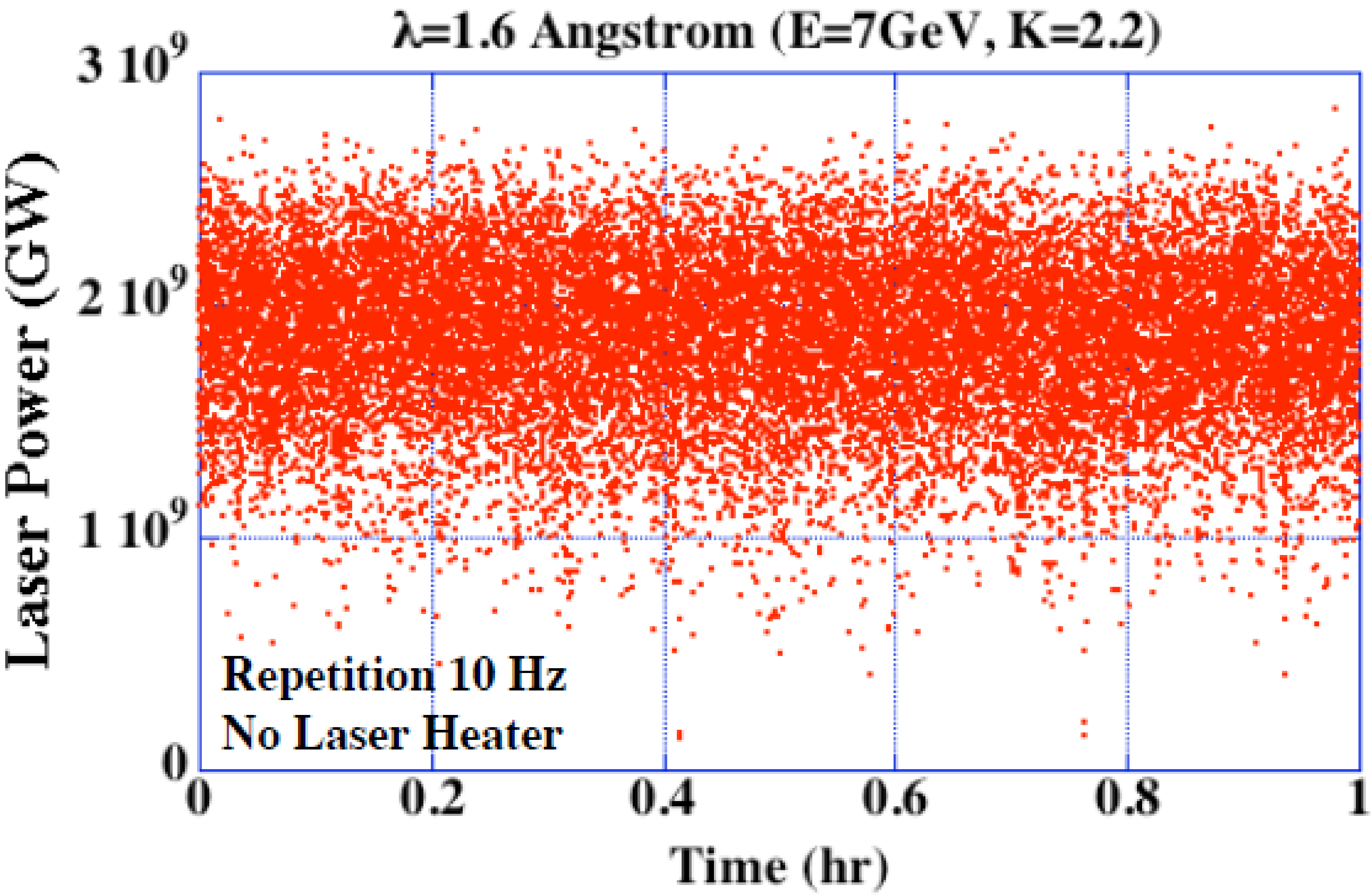
Shortening of Laser Wavelengths



Achieved Performance (III) as of July 2011

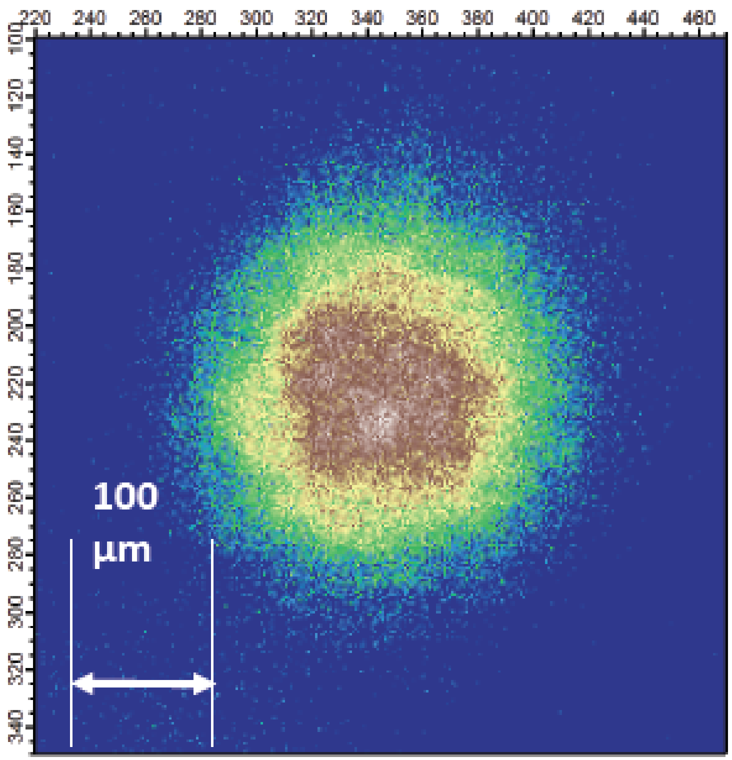


Achieved Performance (IV) as of July 2011

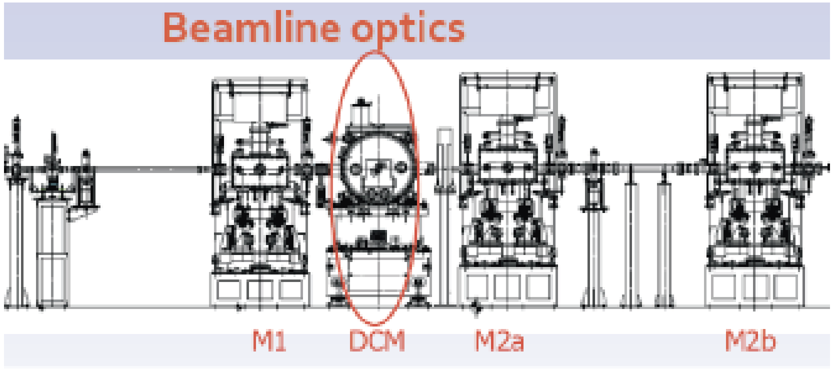


Achieved Performance (V) as of July 2011

Laser Spatial Profile after Monochromatization



Photon energy: 10 keV
110 m from the exit of ID18



Si(111) DCM covering photon energy range from 4 to 30 keV

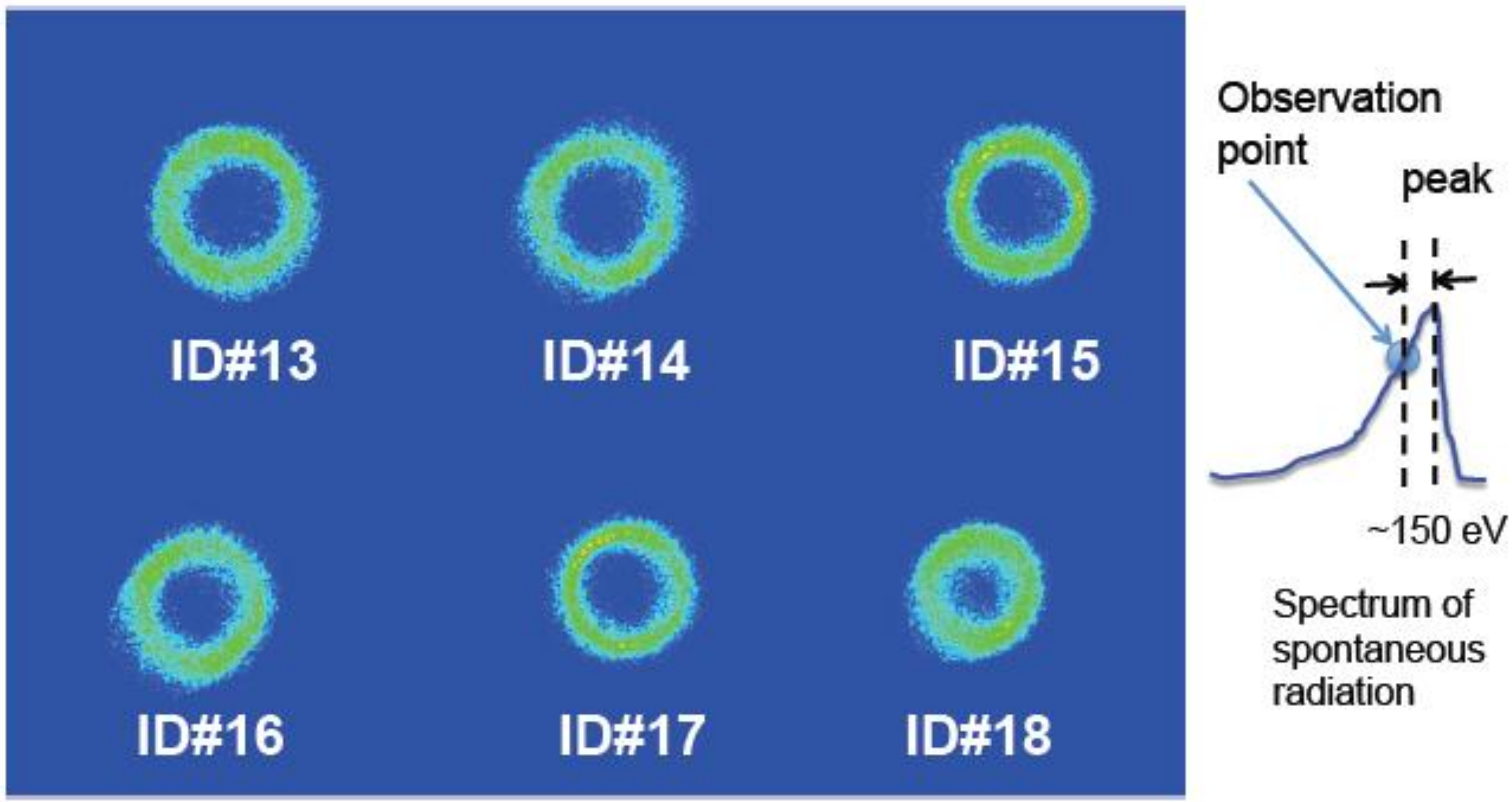
Undulator Performance

XFEL Undulator Main Parameters

Magnet Structure	Hybrid Type
Material	NdFeB
Length (m)	5
Period Length (mm)	18
Number of Periods	277
Number of Undulators	18
Minimum Gap (mm)	3.5
Maximum K	2.2
K@λ=0.12 nm, E=7 GeV	~1.8

Spatial Profile of the Undulator Beam after Monochromator (July)

After full-beam tuning at the end of July, each spatial distribution at the low energy tail became more clear



Beamline commissioning plan

June ~ July:

- Facility inspection
- Characterization of XFEL
    - Transverse properties
    - Energy spectra including spikes
    - Stability, fluctuations
- Core experimental systems
    - 1-um focusing system (-> Prof. Yamauchi)
    - Synchronization laser
    - MPCCD & DAQ

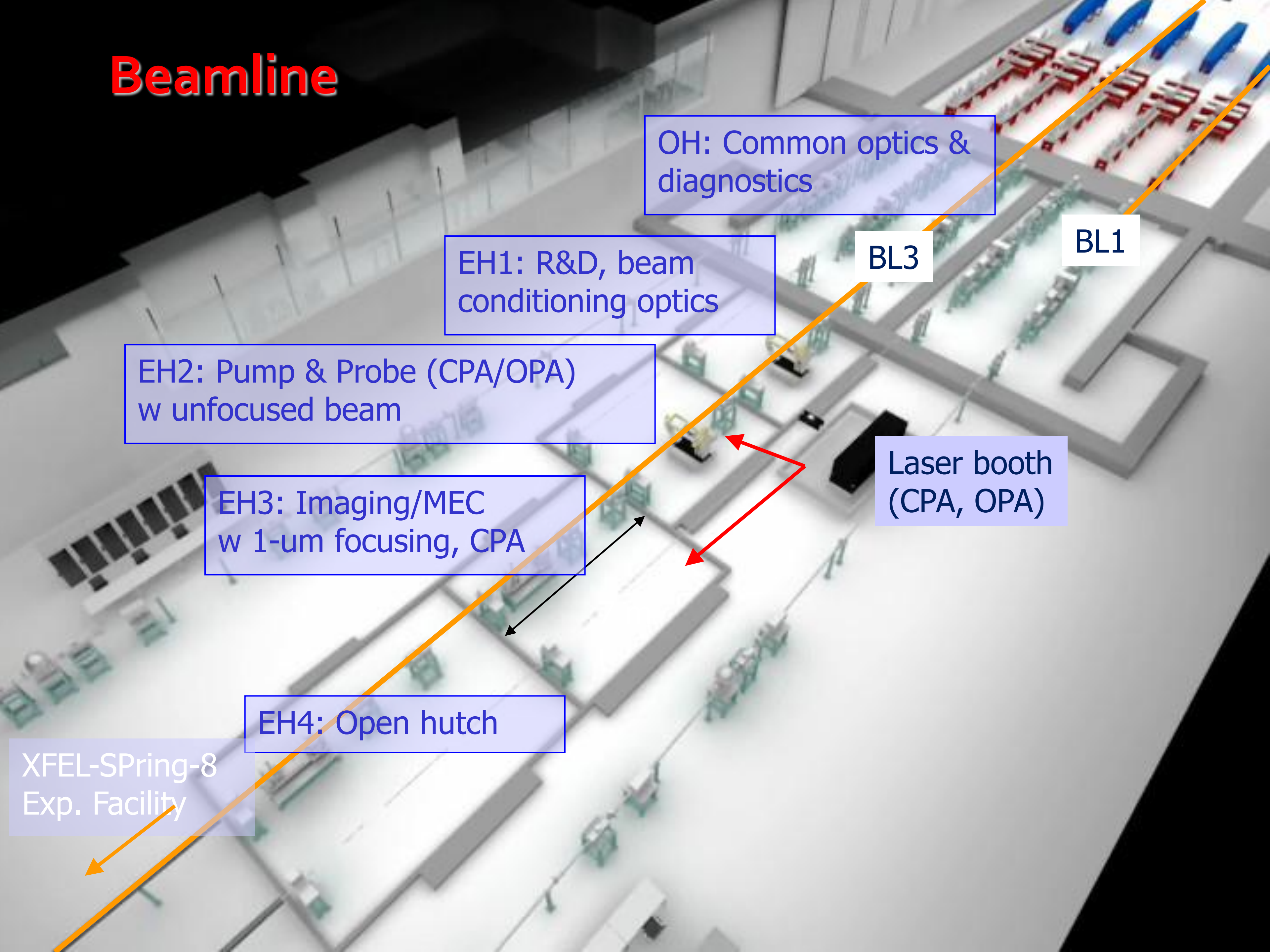
August: Shutdown

Sep ~ Feb:

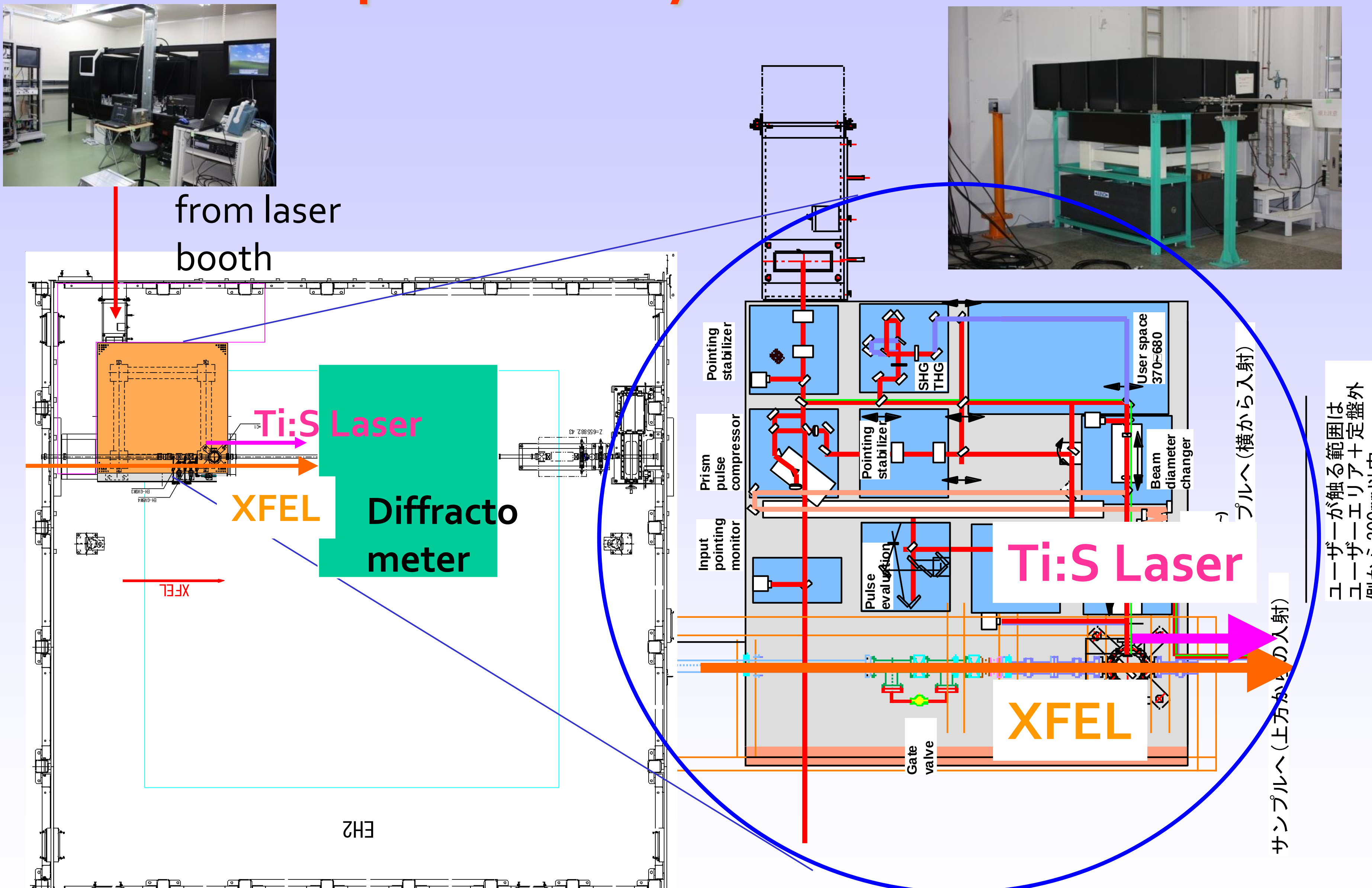
- Continue of characterization
    - Absolute intensity (SP8-AIST-DESY-PTB collaboration)
- Experimental systems
    - CDI chambers
    - Pump-probe systems: Laser to X-ray; X-ray to X-ray (autocorrelator)
    - Large-area MPCCD

March, 2012 ~ : User Operation

Beamline


OH: Common optics &
diagnostics
BL3
BL1
EH1: R&D, beam
conditioning optics
EH2: Pump & Probe (CPA/OPA)
w unfocused beam
Laser booth
(CPA, OPA)
EH3: Imaging/MEC
w 1-um focusing, CPA
EH4: Open hutch
XFEL-SPring-8
Exp. Facility

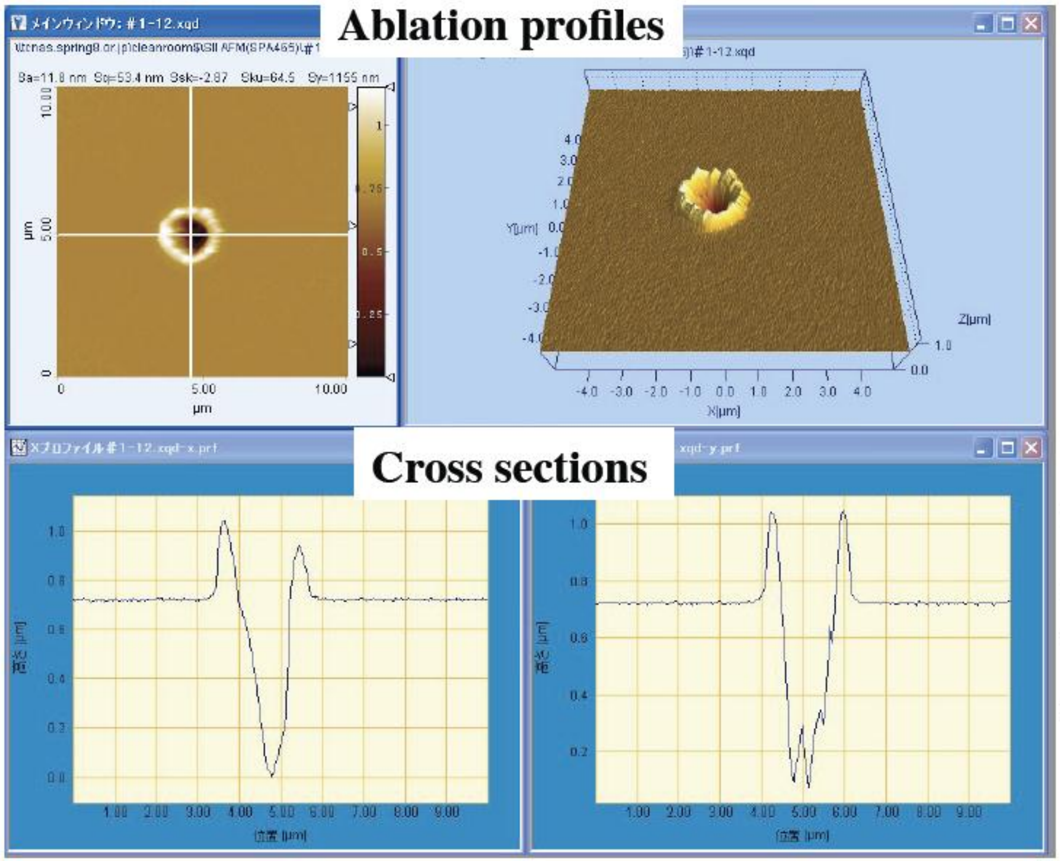
EH2: Pump & Probe system



- Collinear geometry
- Cross geometry is optionally available

EH3: 1-um K-B focusing by Osaka mirror

Focused down to 1.1 μm x 0.9 μm (FWHM)



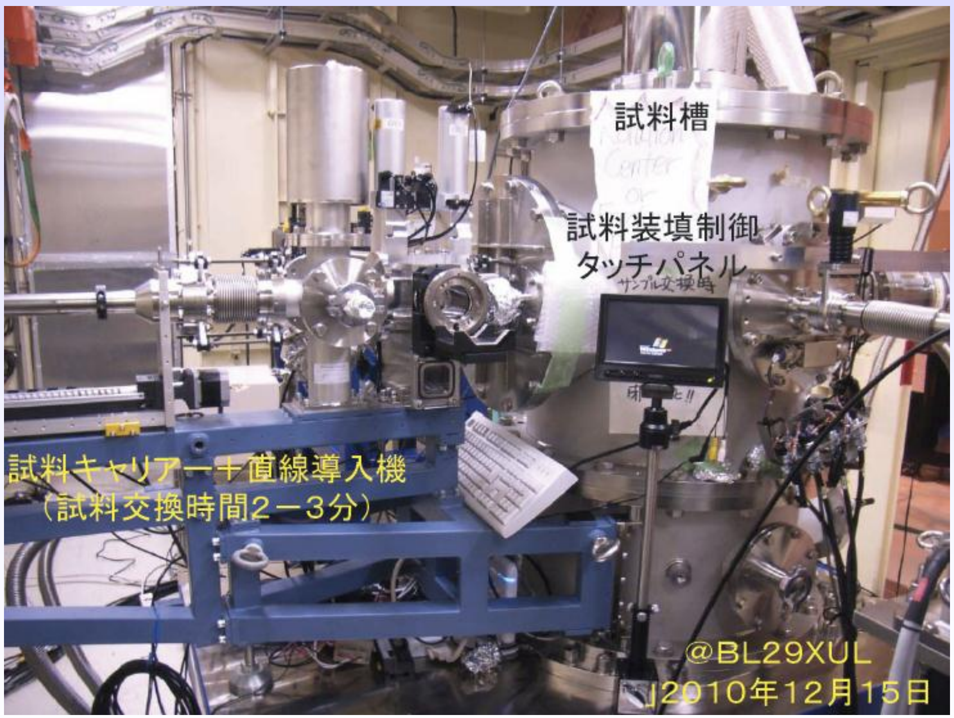
Ablation pattern by focused XFEL on gold-deposited film

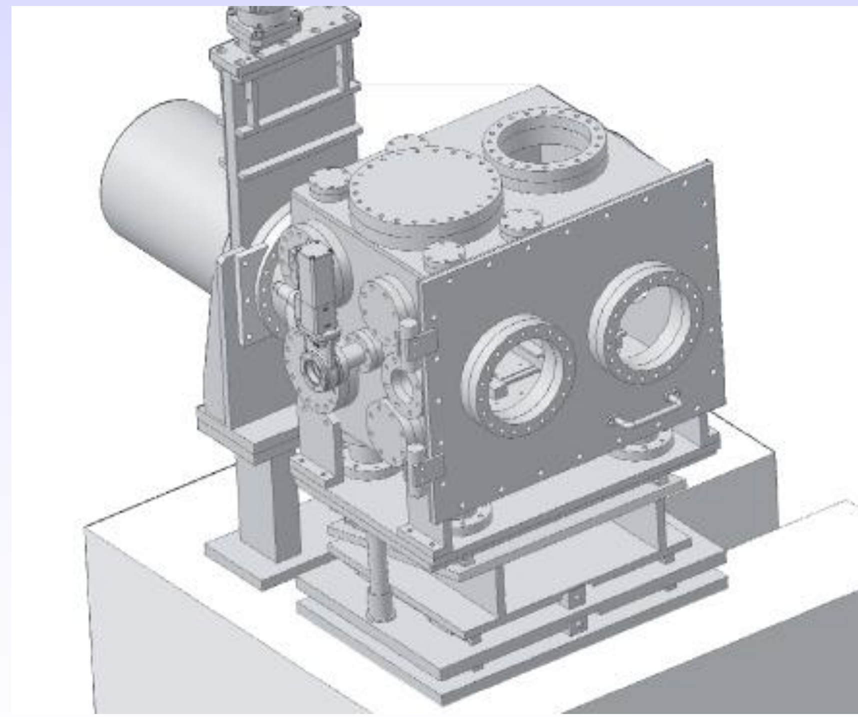
Collaboration with Osaka Univ. (Prof. Yamauchi) and Univ. Tokyo (Prof. Mimura)

Instruments for imaging

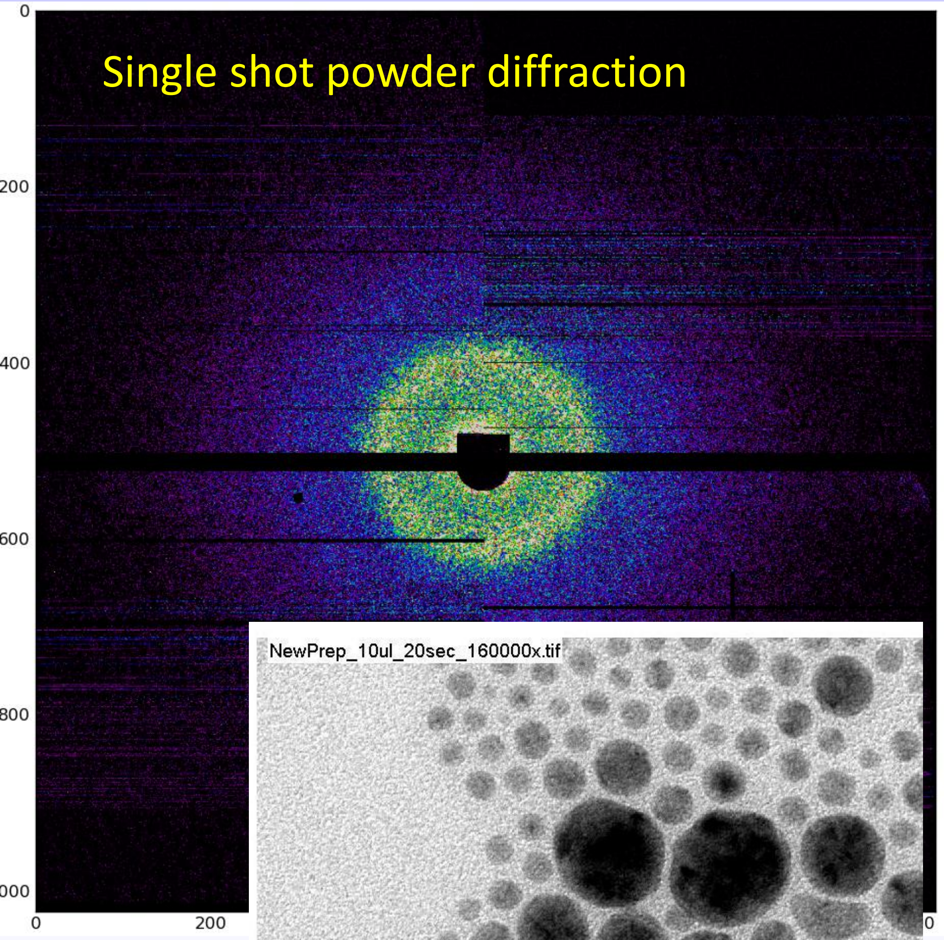
Cryo-imaging
(Prof. Nakasako, Dr. Yamamoto)

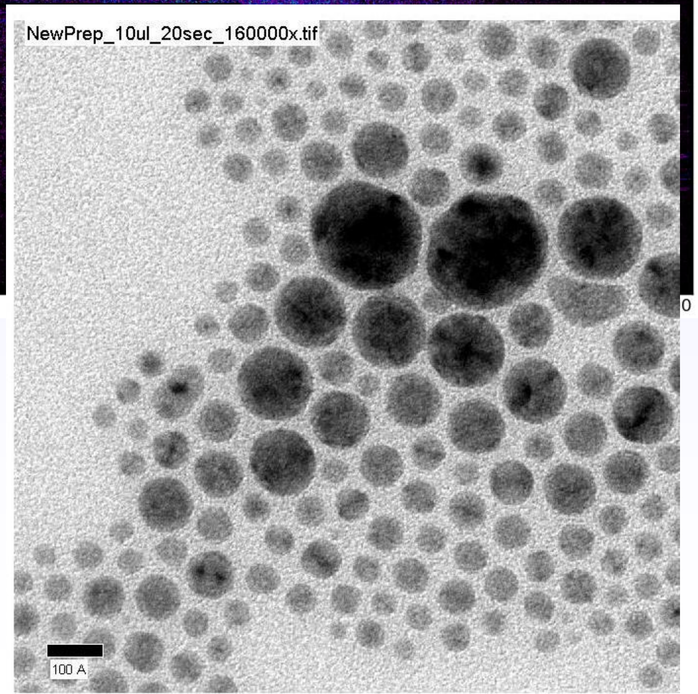
MAXIC (Dr. Song, Dr. Tono + Profs. Mafune, Nishino, Dr. Wada)

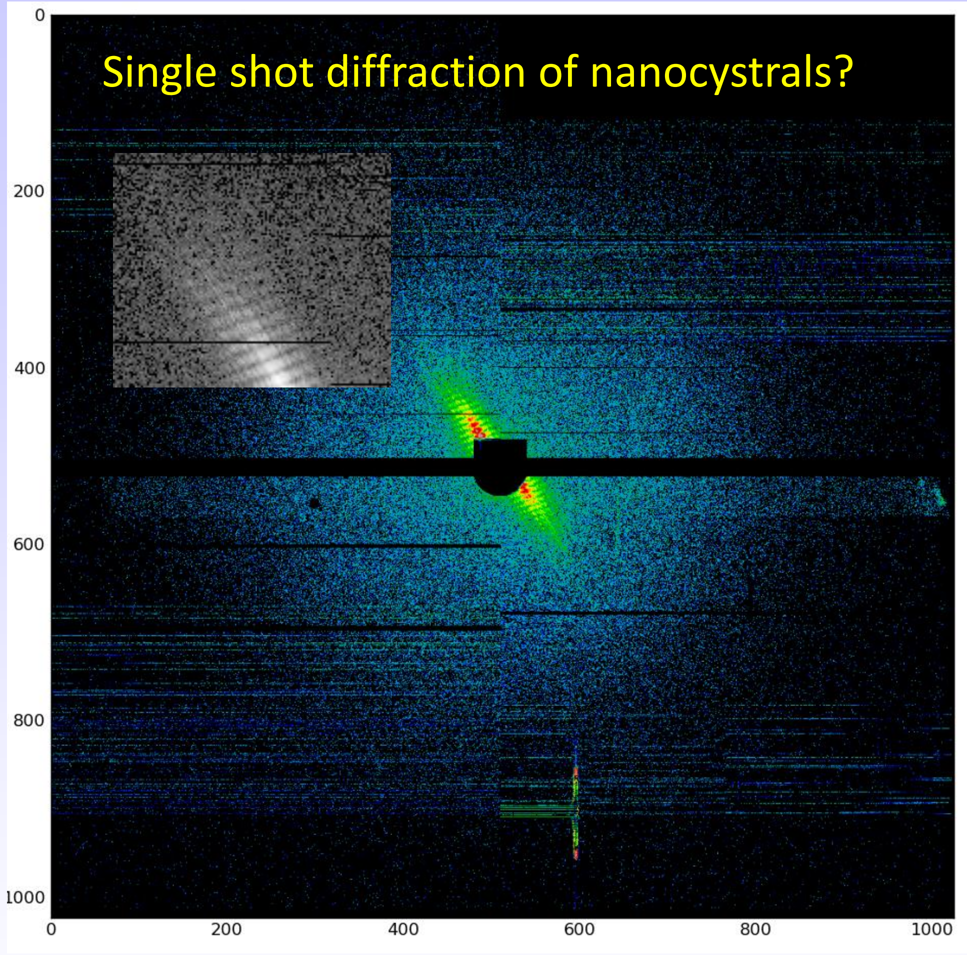




Single shot imaging of silver nano-particles

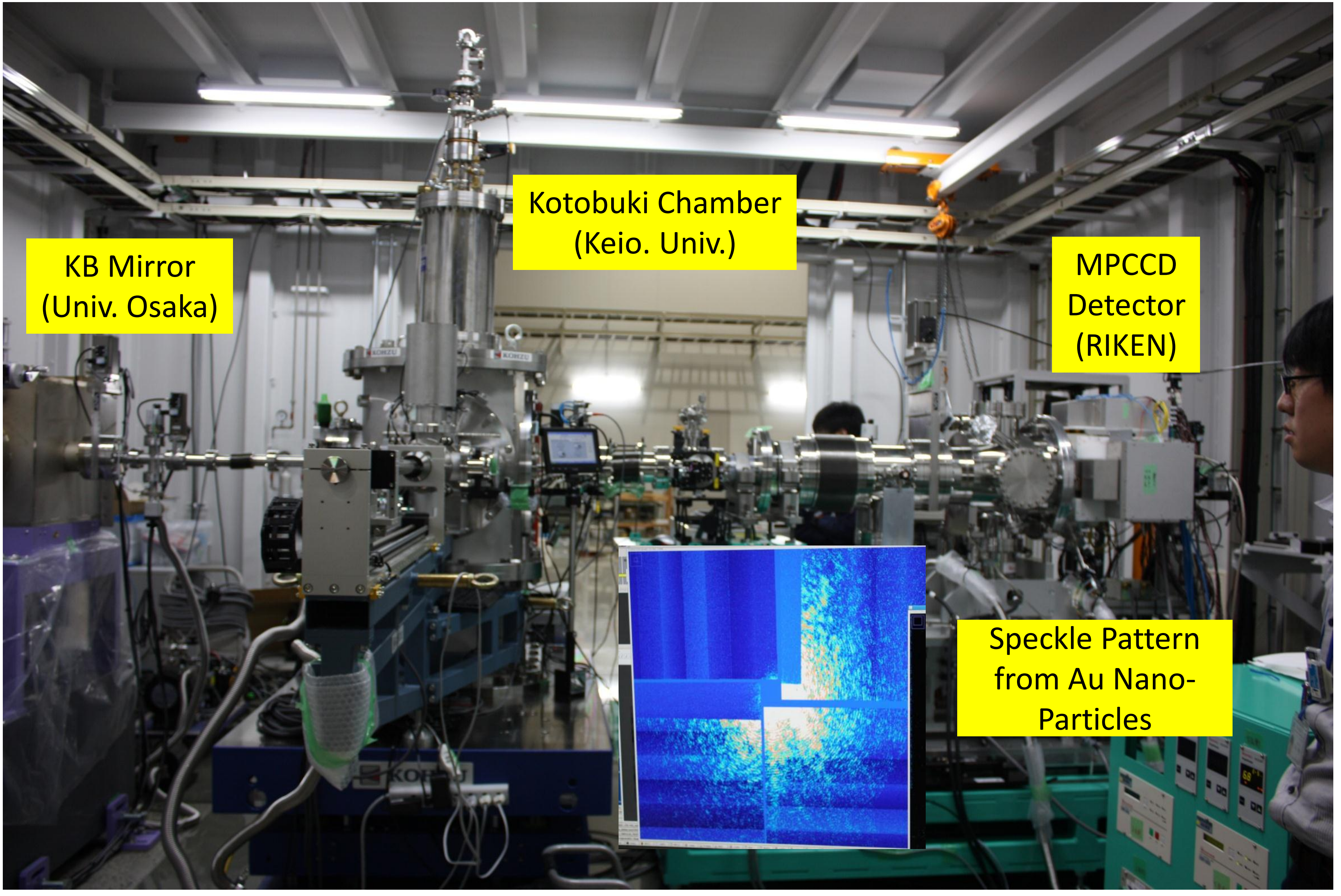




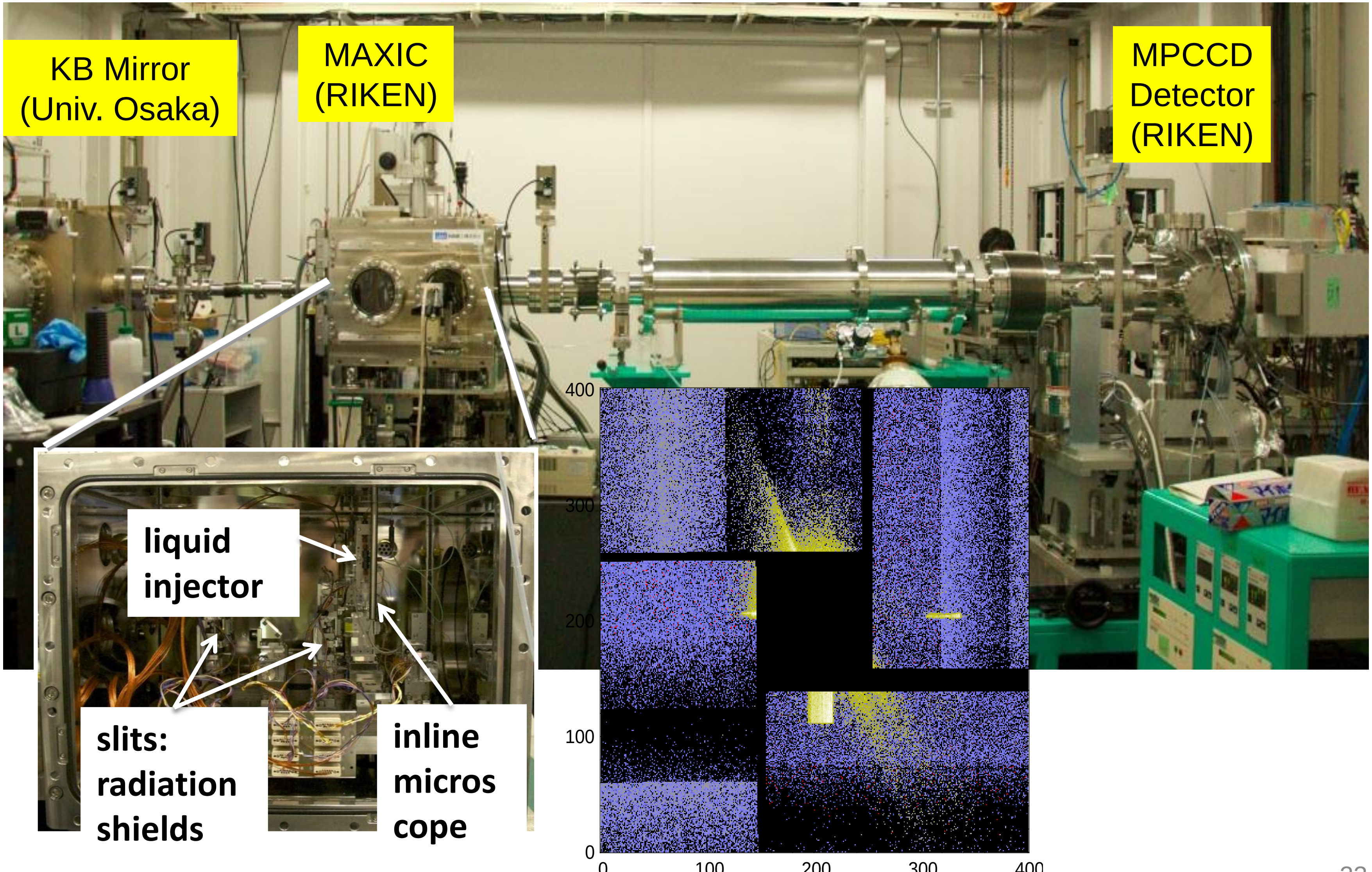


Ueda (Tohoku Univ.), Yao (Kyoto Univ.)
Ullrich (MPI)

Kotobuki-Chamber for Cryogenic Coherent Diffraction Imaging



MAXIC（Multiple Application X-ray Imaging Chamber）

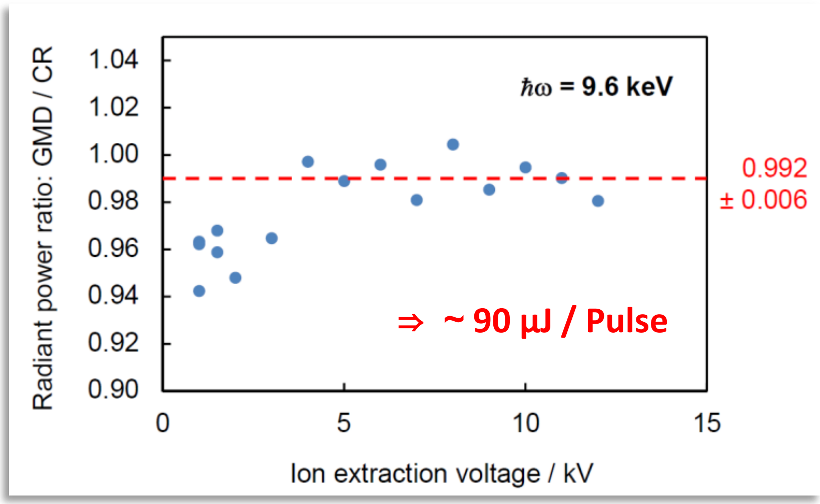


Absolute Intensity Measurement

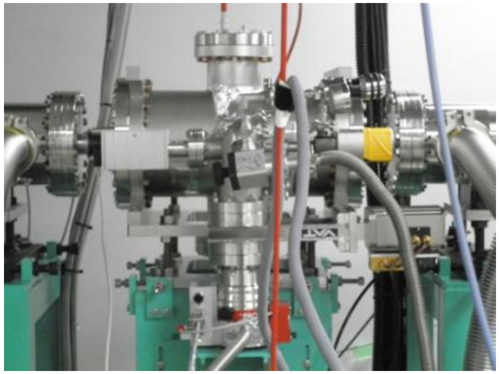
AIST-PTB/DESY-SACLA Collaboration

AIST	Calorimeter
PTB/DESY	Gas Monitor Detector
SACLA	Diamond Foil Scattering Monitor

Three Detectors were Inter-calibrated.



DEST/PTB GMD



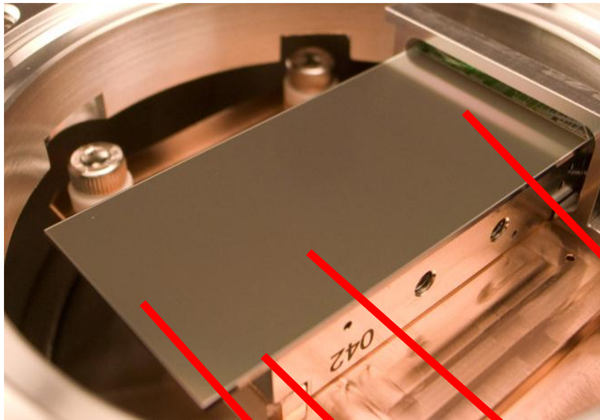
AIST Calorimeter

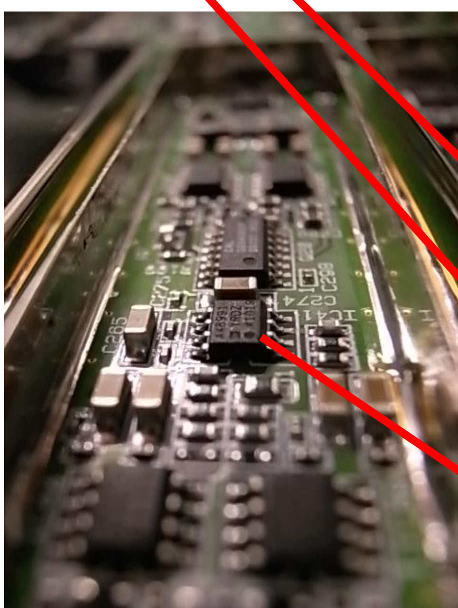
New Instruments are being prepared in collaboration with domestic researchers

25 proposals bundled into several categories

- Coherent Imaging
  - Cryo-imaging
  - MAXIC (multi-application)
  - Liquid/Aero injector
- Pump & Probe
  - Solid/liquid/gas
- AMO & Spectroscopy
  - Ion/Electron spectrometers
- Optics & Diagnostics
  - K-B Focusing
  - Autocorrelator
  - Phase retarder
  - Absolute intensity
- Laser upgrade

Multiport-CCD (MPCCD) Sensor

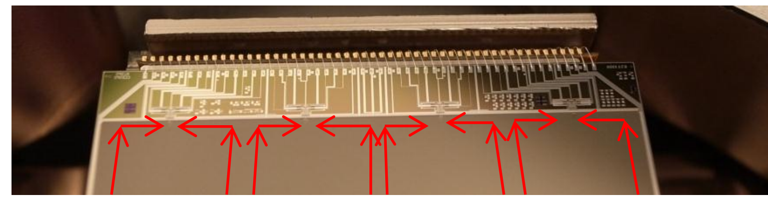




50 um pixel

512 x 1024 pixels/sensor

60 frame/sec achieved by 8 ports/sensor



Peak signal of 2700 photons @ 6 keV achieved by XFEL optimized pixel design

Dead area of 300 um by optimized drive line pattern

Device life > 30 Mrad demonstrated

Noise < 0.18 photon@ 6 keV is achieved by state-of-art CDS electronics.

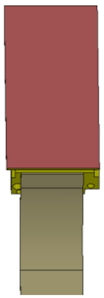
RIKEN SACLA

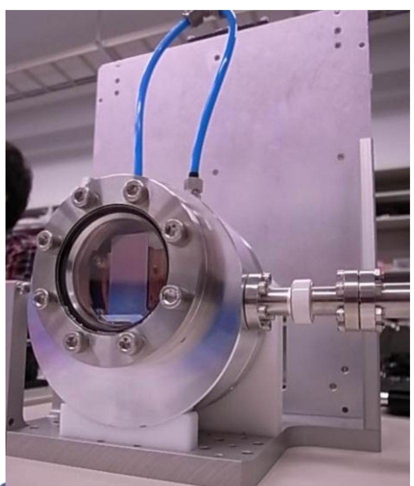
MPCCD Detector Systems

Single-sensor

1024 x 512 pixels

54.6 x 26.2 mm^2

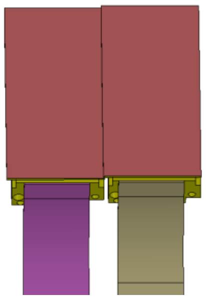




Dual sensor

1024 x 1024 pixels

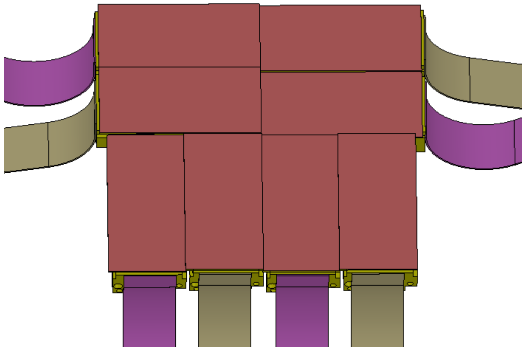
54.6 x 52.1 mm^2

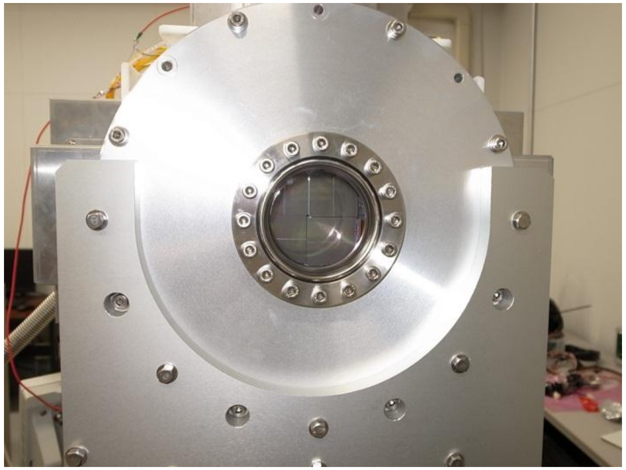


Octal-sensor

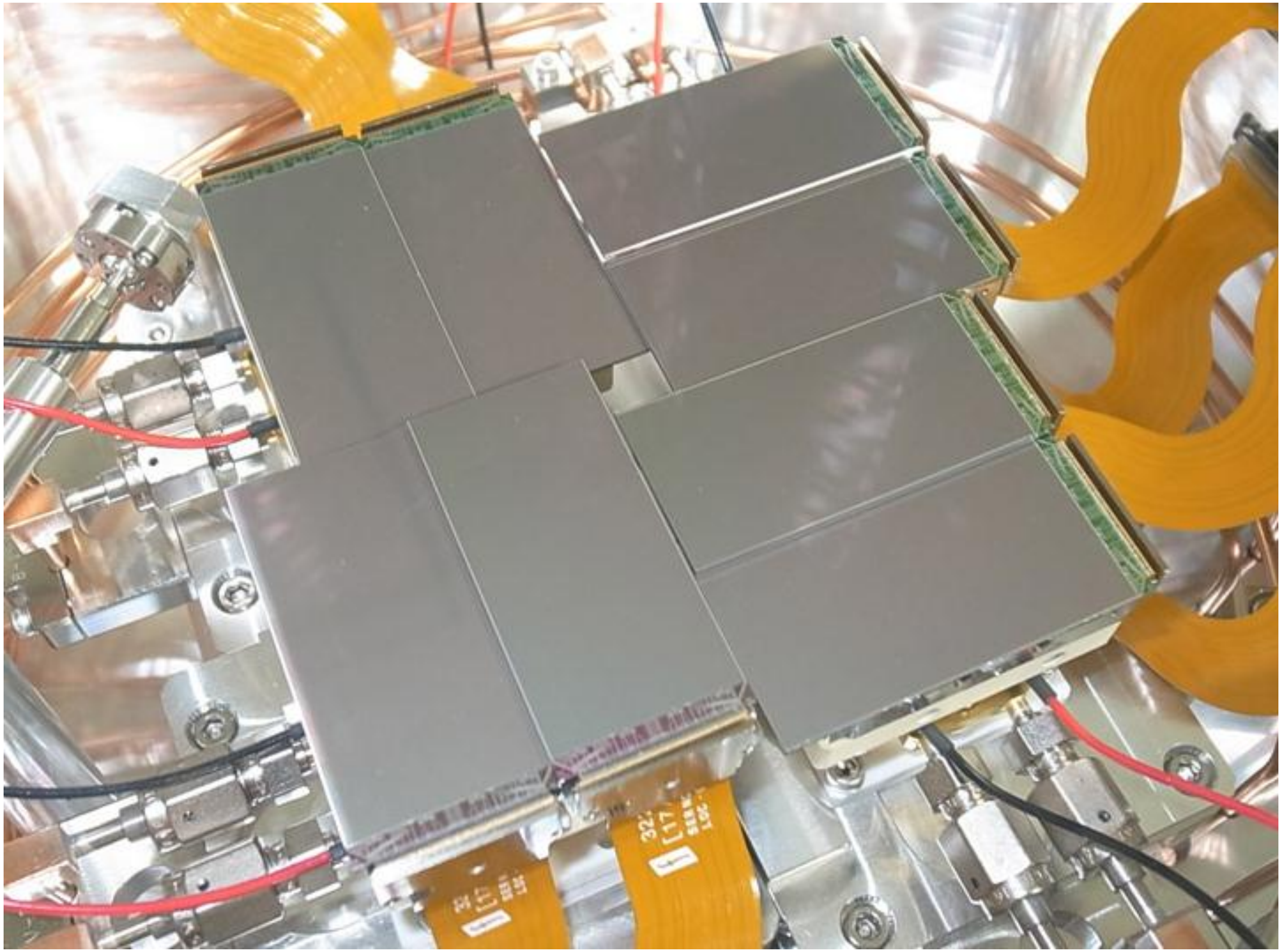
2048 x 2048 pixels

~ 110 x 110 mm^2





Adjustable Central Hole of Octal-Sensor Detector



Synergistic Use of Two RIKEN-Hosted Key Technologies of National Importance

SACLA: concluding remarks

- Japan started construction of compact XFEL in 2006 and completed in 2011. It was named SACLA, and delivering 0.6~2.3 A SASE light at the moment.
- Commissioning of end-station equipment started in September, followed by the scheduled opening to public users in March 2012.
- Call for proposals started in October.
- Synergic use with both SPring-8 and K-computer is considered.
- By using the low-emittance and ultra-short-pulse electron linac of SACLA as an injector, we are considering upgrade of SPring-8 to SPring-8-II, hopefully in 2019.