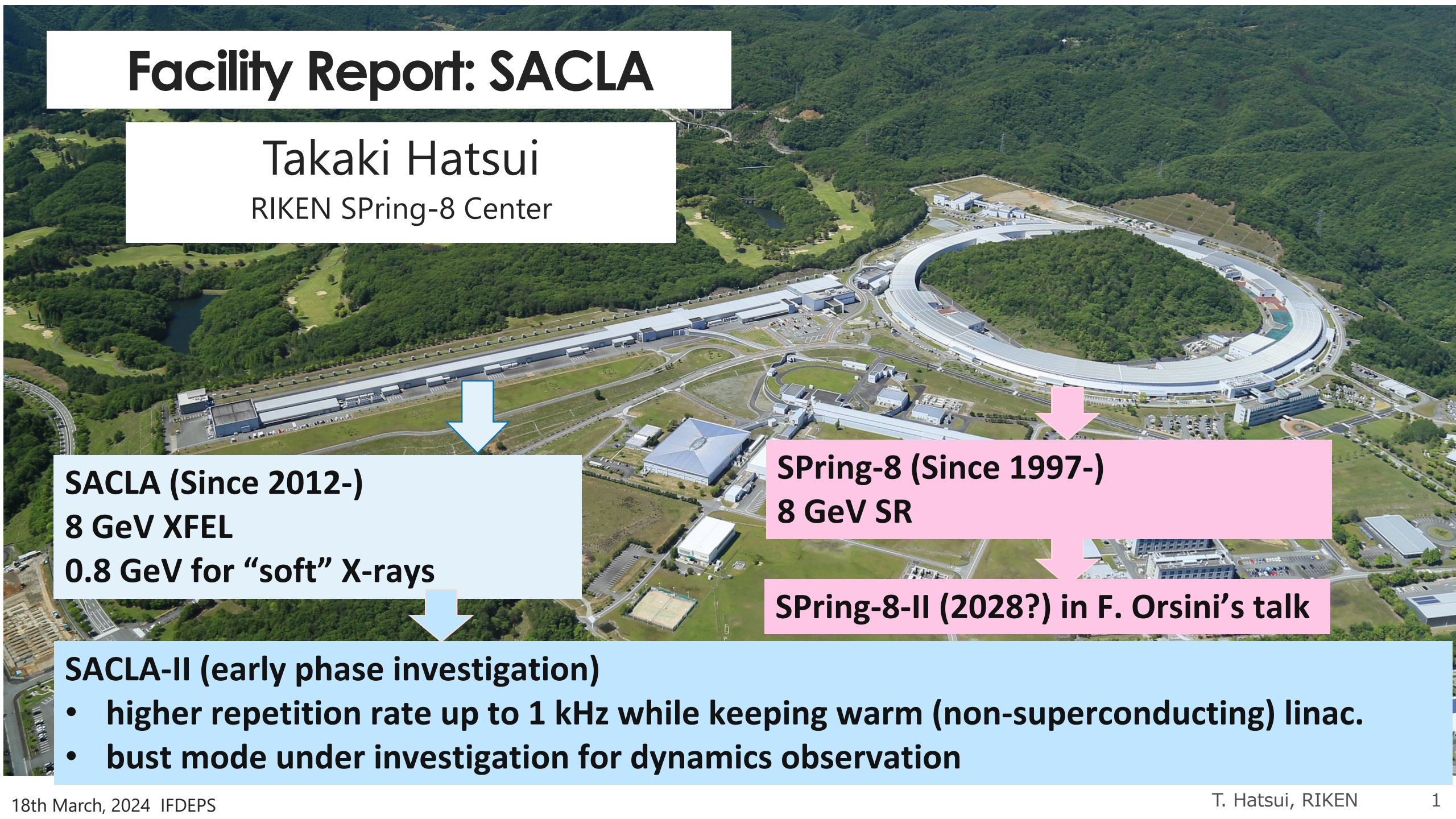


Facility Report: SACLA

Takaki Hatsui

RIKEN SPring-8 Center



SACLA (Since 2012-)
8 GeV XFEL
0.8 GeV for “soft” X-rays

SPring-8 (Since 1997-)
8 GeV SR

SPring-8-II (2028?) in F. Orsini’s talk

SACLA-II (early phase investigation)

- higher repetition rate up to 1 kHz while keeping warm (non-superconducting) linac.
- burst mode under investigation for dynamics observation

Supercomputer Fugaku

- Operated by RIKEN
 - Closely working on the data processing pipeline for SACLA/SPring-8
- Fugaku
 - Peak Theoretical Performance
 - Double Precision 488 Pflops
 - #1in Top500 for Jun. 2020-Jun. 2022
 - Now #4



Multi-Port CCD (MPCCD) Detector Family deployed since 2011

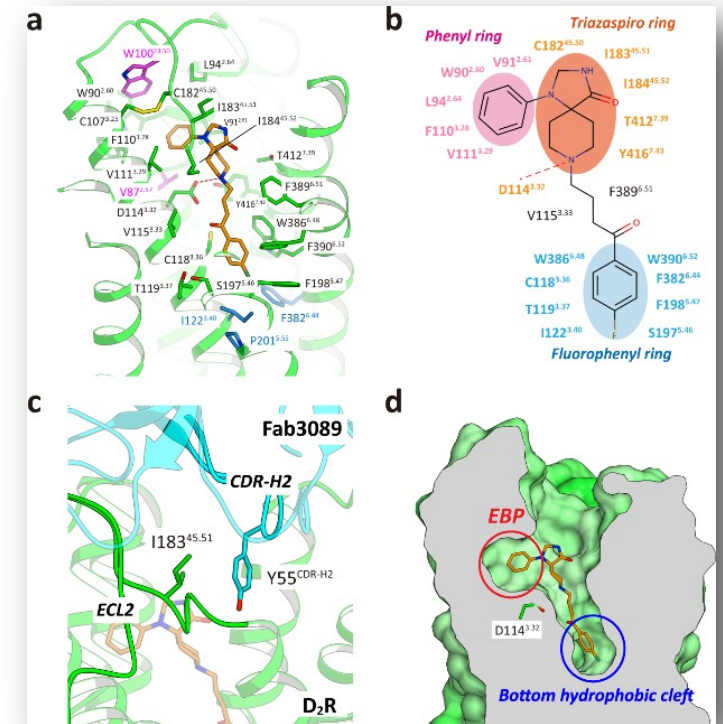
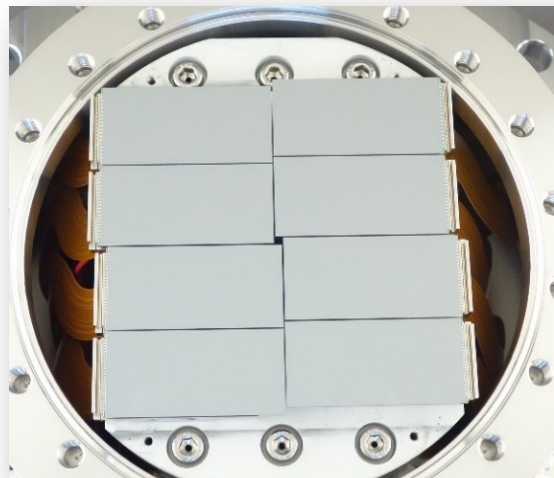
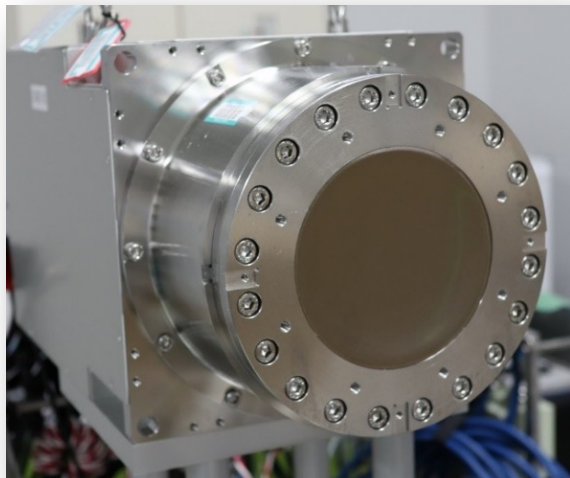
Kameshima et al., Rev. Sci. Instrum. 85, 033110 (2014).

Features

- 50 μm square pixel with max. 4 Mpixels /60 Hz
- 20 bit Effective Dynamic Range
- Dead area between sensor tiles can be 150 or 300 μm

Deployment Status

- Total 14 variants
- 38 systems operational (in total 59 Mpixels)
- More than 60 % experiments uses MPCCD detectors as primary data collection apparatus.



SFX Experiments

Structure of the dopamine D2 receptor in complex with the antipsychotic drug spiperone. D. Im, S. Iwata, T. Shimamura, et al., Nat. Commun. 11, 6442 (2020).

Now

with Rayonix MX300-HS at 10 Hz.
Hongjie Li et.al., Nature 2024

Experimentally verified Performance

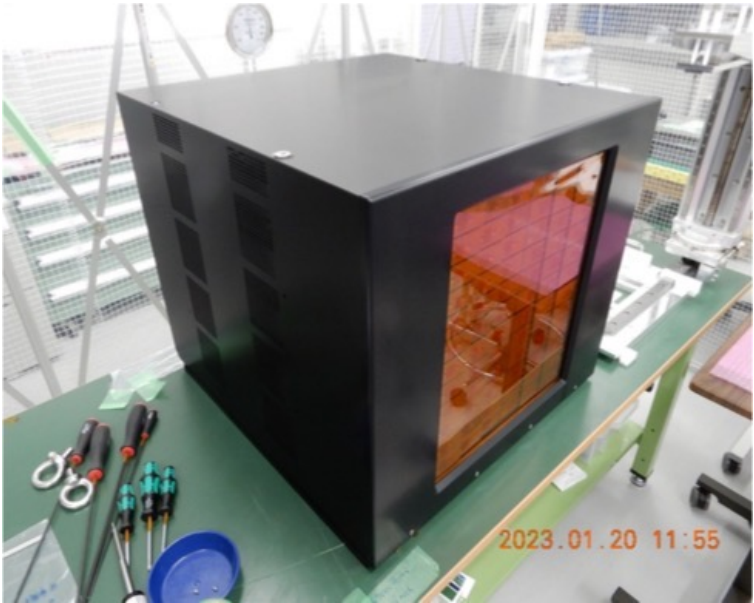
Parameters		Value	
Sensor	Thickness	650 μm	
	Pixel Size	72.6 μm	
	Pixel Number	0.28 Mpixel/sensor	
	Noise	0.018 phs.@8 keV (40 e-)	
		XFEL variants	SR variants
	Peak Signal	> 17,000 phs. @ 6 keV	> 1,800 phs. @ 12 keV
	Frame Rate	5 kHz	17.4 kHz

30 Mcps/pixel @12 keV
1 Gcps/pixel @10 keV in an extended mode

Overview: Takaki Hatsui today
Data-processing: Haruki Nishino tomorrow.

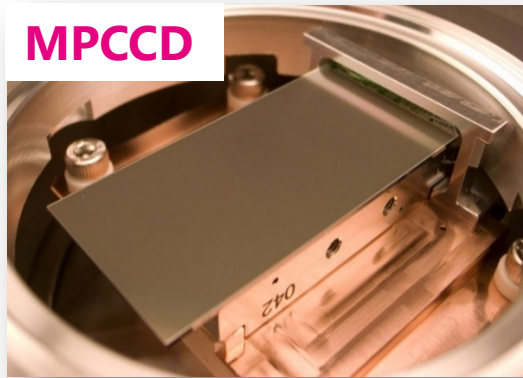
System Development

Largest System	Pixel Number	20.2 Mpixel
	Image Area	325 x 363 mm



to be installed to SACLA June 2024

mxdCMOS: SOI based X-ray energy dispersive detector



2009-2011

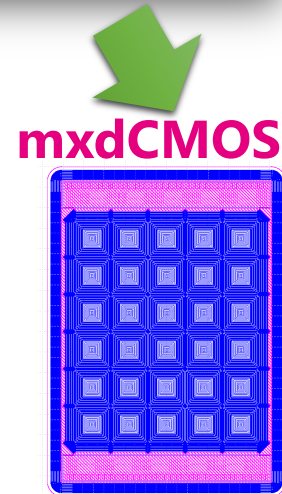


2009-2014



2013-2020

2019-2020
Rad. Hard SOI-Transistors
developed. (I. Kurachi et.al.,)



Target spec. for phase 1

- 1 Mcps with 140 eV FWHM @ 6 keV
- 1.8 mm square element
- 64 elements/chip
- 64 Mcps/14.4 mm x 14.4 mm

Current Status

Proto-type chip (30 elements)
under testing

sxCMOS: soft x-ray imaging detector

QST, U.of Tokyo, Tohoku U., U. Hyogo, and AIST.

Hiroya Shike, **R. Kuroda**, R. Kobayashi, M. Murata, Y. Fujihara, M. Suzuki, S. Harada, T. Shibaguchi, N. Kuriyama, T. Hatsui, **J. Miyawaki**, T. Harada, Y. Yamasaki, T. Watanabe, Y. Harada, and **S. Sugawa**. IEEE Trans. Elec. Dev. 2021 Vol. 68(8) p.2056.

- Funded by SACLAL Basic Development Program
- Full chip manufactured with 1k x 1k pixels

See Jun Miyawaki's talk

Pixel Size	22.4 μm square
Full Well Capacity	21.9 Me-, 160,000 photons @ 500 eV
System Noise	8.1 e-rms @ room temp for 1 ms exposure (S/H cap. Limit is 2.3 e-rms)
Process	Back-illuminated CMOS Image Sensor Process with trench cap.
Shutter	Global Shutter
Frame Rate	450 fps (1k x 1k full chip to be operated at 1000 fps)
Fill Factor	100 %
Radiation Hardness	45 μm thick silicon 3 x 10 ¹⁶ photons/mm ² @ 1 keV did not show any damage

Summary

CITIUS: an integrating-pixel fast-framing detector

Overview: Takaki Hatsui today
Data-processing: Haruki Nishino tomorrow.

- detector family with max. 20.2Mpixels.
 - 5 kHz for XFELs/ 17.4 kHz for SR; 1 Gcps/pixel detection
- Custom Data-processing pipeline under development.

mxdCMOS: an energy dispersive silicon detector with 64 elements in a chip.

- 30-element prototype under testing.

sxCMOS: an high dynamic range soft x-ray image sensor (with QST, U. Tokyo and Tohoku U.)

- 8.1 e-rms noise, 21.9 MeV peak signal for 22.4 μm square pixel demonstrated for a prototype chip.
- Full chip will run at 1000 fps

See with QST, Miyawaki's talk