

# Detector Development Programs

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T. Hatsui

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# Development programs of X-ray Imaging Detectors (SACLAL)

## (mainly for) Transmitted X-rays

- DIFRAS

## (mainly for) Diffracted/Scattered X-rays

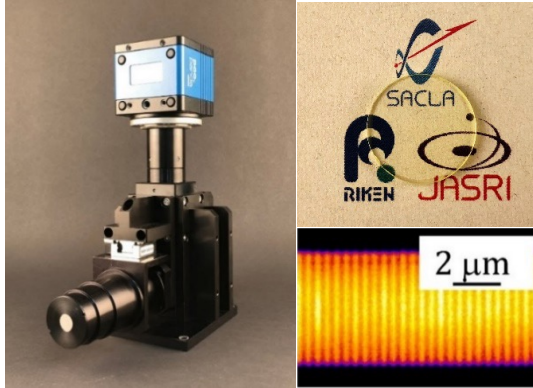
- sxCMOS ( < 1 keV)
  - 22.4  $\mu\text{m}$  pixel, under development
  - SPRING-8 Basic Development Program 2022
  - Talk by Dr. J. Miyawaki (QST), today
- CITIUS ( > 1.5 keV), *this talk*
  - 72.6  $\mu\text{m}$  pixel
  - an upgrade of MPCCDs

# High-spatial-resolution X-ray imaging detector DIFRAS

T. Kameshima et.al.,

## DIFRAS microscope

*T. Kameshima et al., Optics Letters 44, 1403 (2019)*

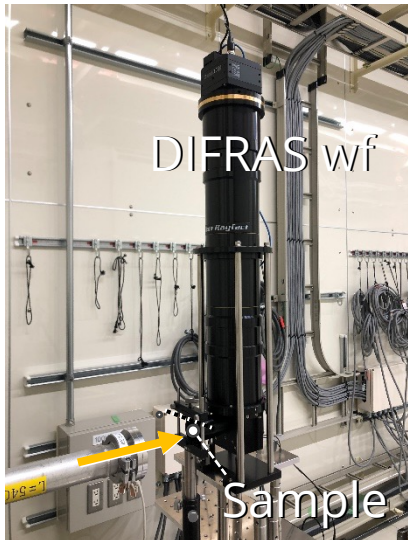


- Photodiffusion-free transparent scintillator
- Quasi-diffraction-limit resolution & damage-free operation

**200 nm line-and space resolution**  
**main use: beam monitors**

## DIFRAS widefield

*T. Kameshima and T. Hatsui, J. Phys.: Conf. Ser. 2380, 012094 (2022).*



- Implementation of 151 Megapixels image sensor
- 200 nm L&S resolution and 53 mm FOV provided by 5 lens variants

		Lens A1	Lens A2	Lens A3	Lens A4	Lens A5
Resolution (L&S)	[μm]	~0.2	0.45	0.6	1.0	4
Field of view	[mm <sup>2</sup> ]	2.6 x 1.9	7.6 x 5.7	10.3 x 7.7	15.2 x 11.4	53.3x 40.0
Status		under develop.	available	under develop.	available	available

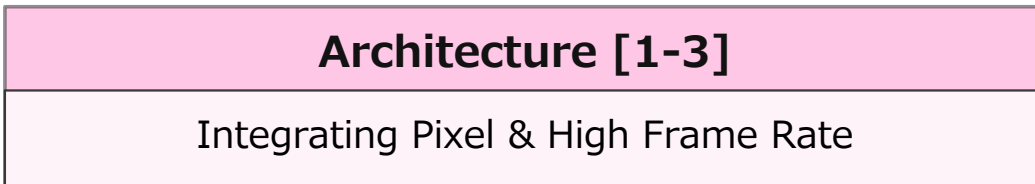
# X-ray Imaging Detectors (SACLA)

(mainly for) Transmitted X-rays

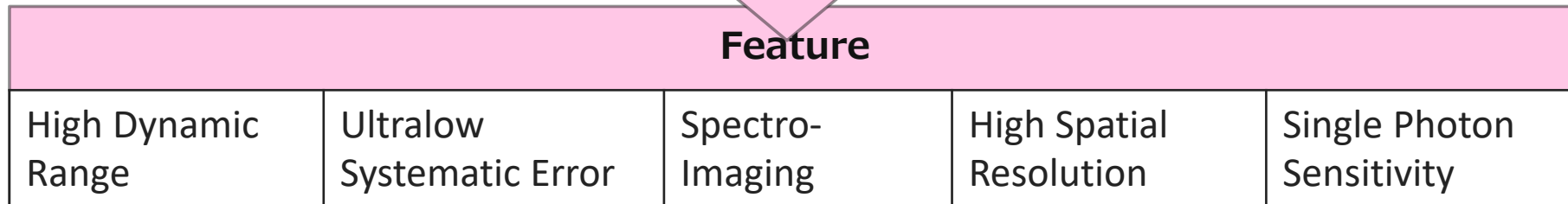
- DIFRAS

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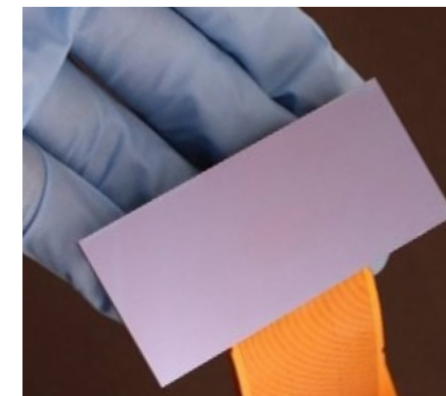


[1] SPring-8 II CDR (2014) with updated values.  
[2] T. Hatsui, presented at iWorld (June. 2014).  
[3] T. Hatsui, AOSFRR (Nov. 2015)



### Experimentally Verified Performance

Parameters		Value	
Sensor	Thickness	Si 650 $\mu\text{m}$	
	Pixel Size	72.6 $\mu\text{m}$	
	Pixel Number	0.28 Mpixel/sensor	
	Noise	0.027 phs.@8 keV (60 e <sup>-</sup> )	
		SR variant	XFEL variant
	Peak Signal	1,800 phs. @ 12 keV (6 Me <sup>-</sup> )	17,000 phs.@ 6 keV (28 Me <sup>-</sup> )
	Frame Rate	17.4 kfps	5 kHz
	Sat. Count Rate @12 keV	30 or 600 Mcps	-
	Pixel Readout Rate	4.87 Gpixels/s	1.4 Gpixels/s

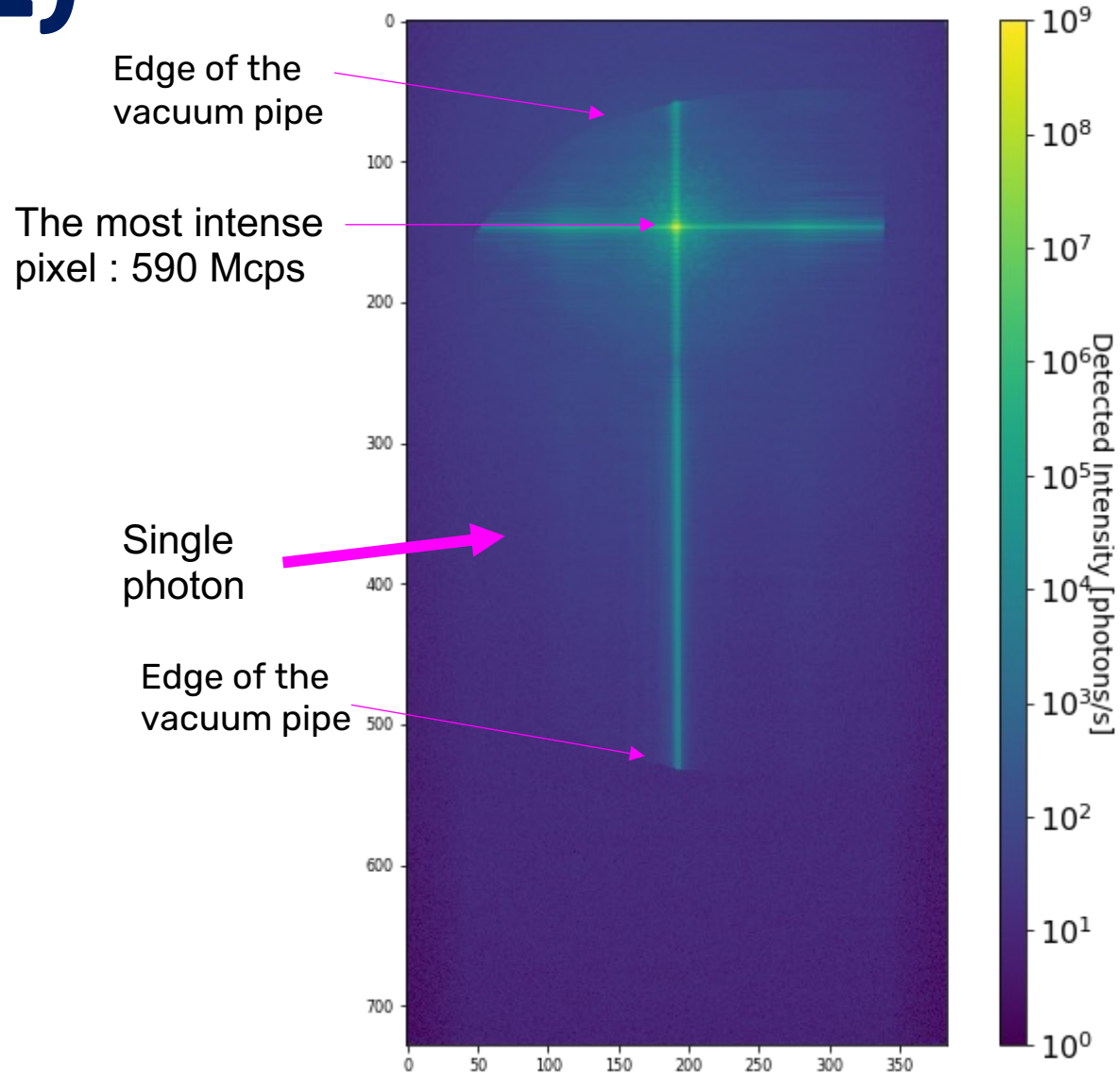


# Count Rate (1/2)

Photon Energy: 10keV

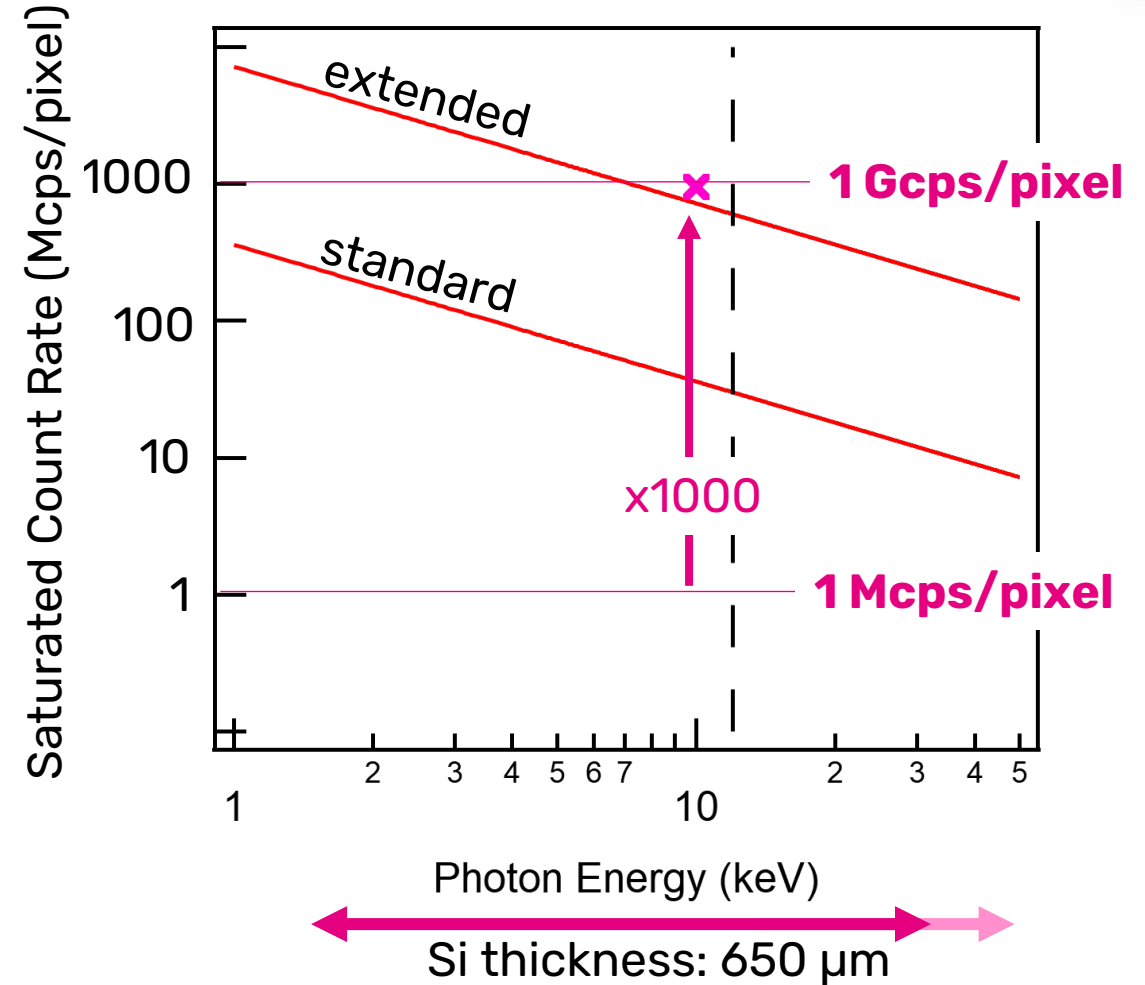
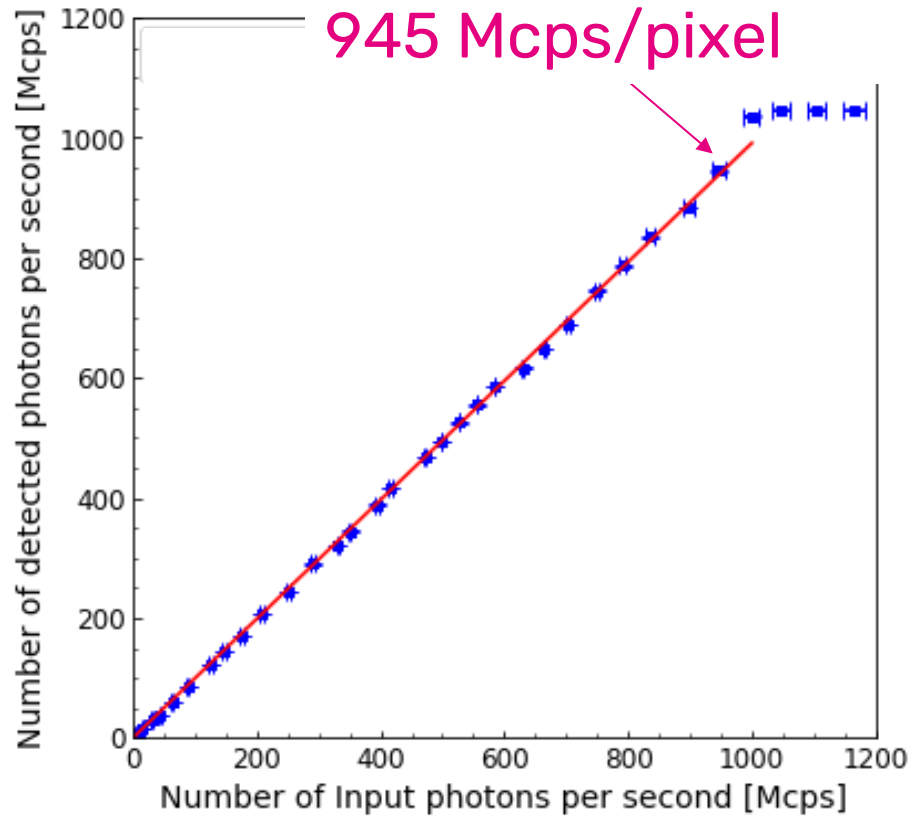
Slit to CITIUS: 15m

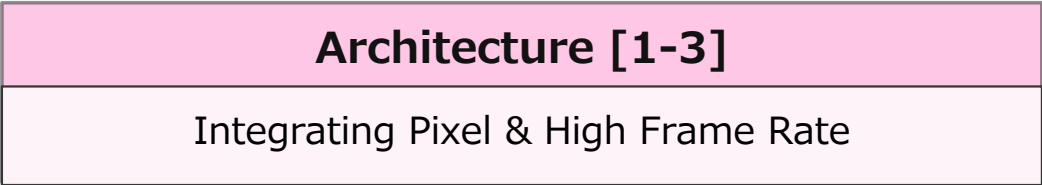
Slit Size:  $20 \times 20 \mu\text{m}$



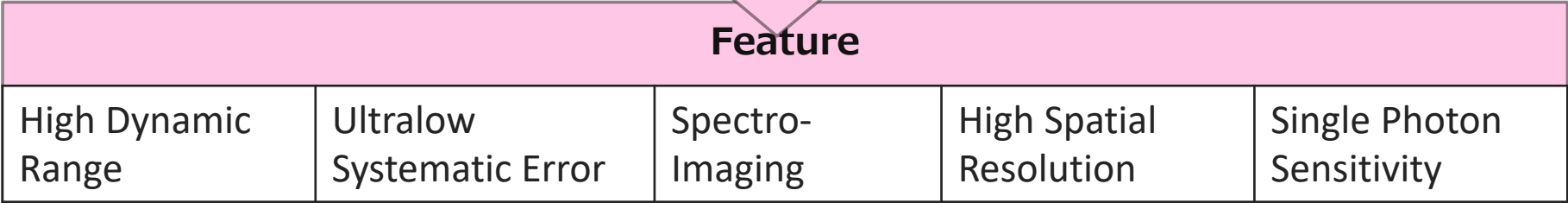
# Count Rate (2/2)

Photon Energy = 10 keV



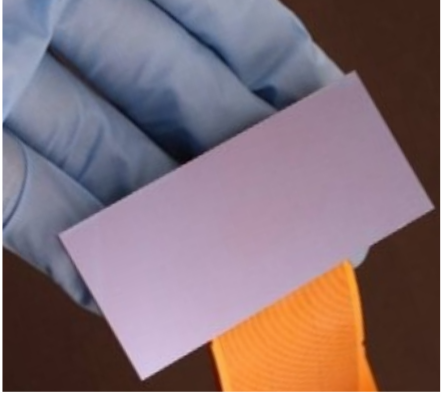


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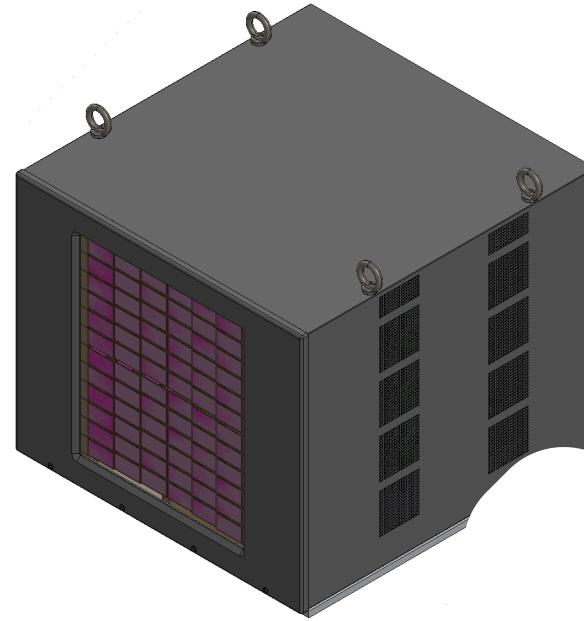
# 20.2M Large Area Detector

To be integrated to SACLA in 2023

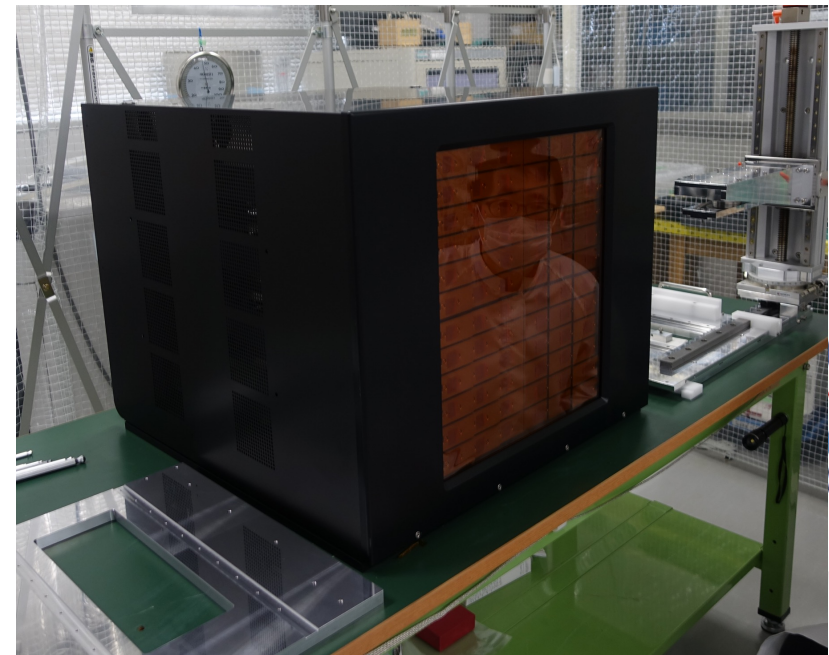
- 20.2 Mpixel @ 60 frames/s
  - 72 sensors
- User experiments
  - 2024 (planned)
  - semiconductor crisis still affects the availability of some parts

Development for SPring-8 MX beamline under discussion

- 20.2 Mpixel @ 17.4 kfps



T. Tosue et.al.,



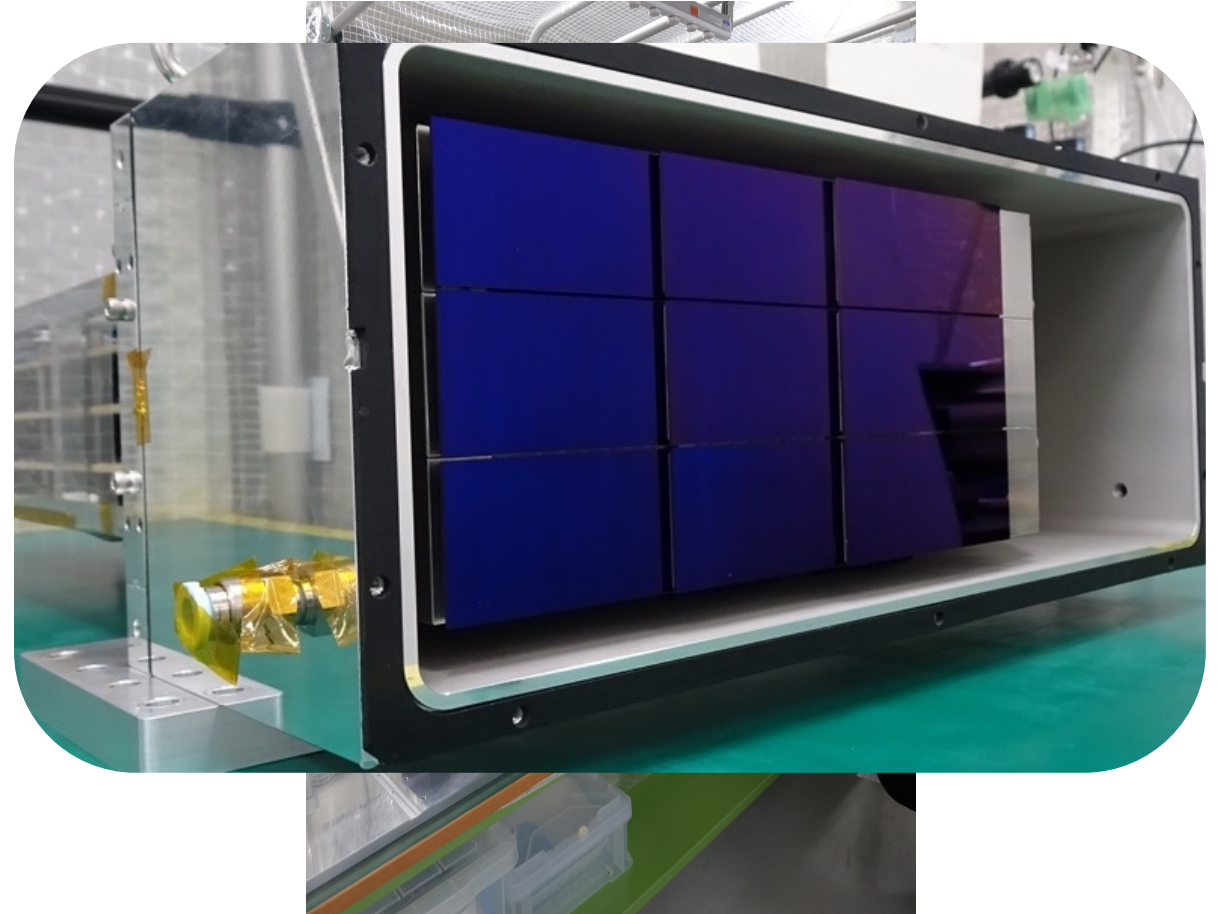
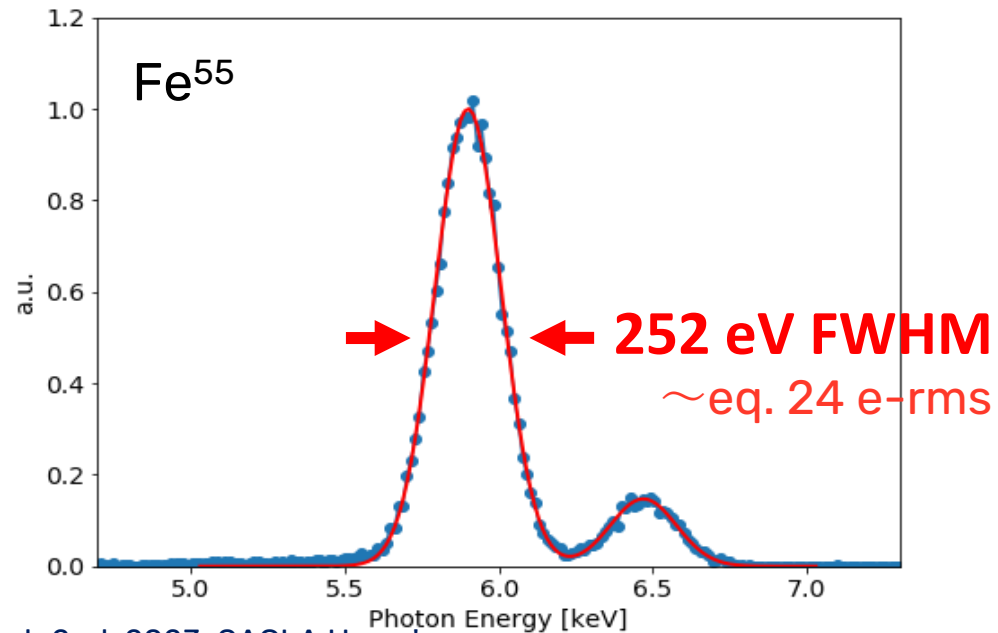
# 20.2 M: Sensor Sub System

Each Sensor Sub System can be tested and calibrated.

2.52 Mpixels

Spare Units in case of damage

Optimized for SACLA operation



# SACLA beamtime

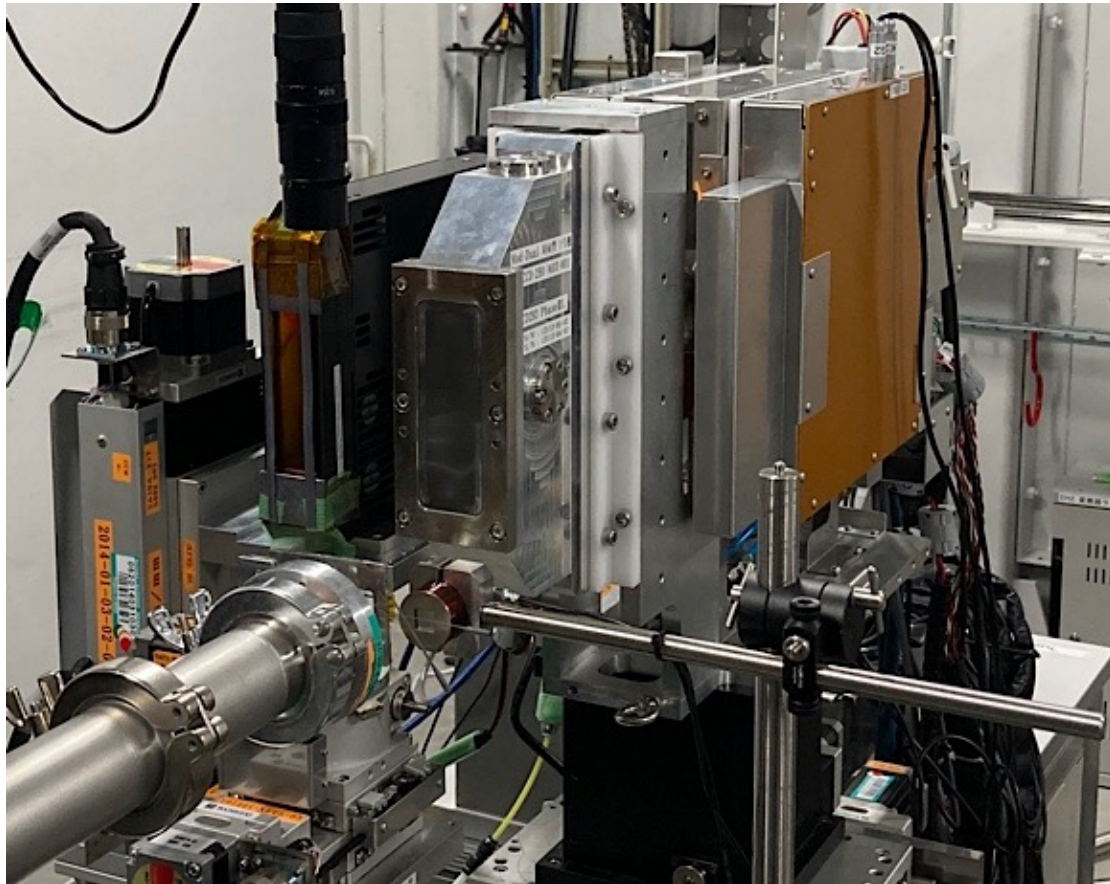
*Dec. 2022*

CITIUS-560k-linear

MPCCD-1M-linear

CITIUS-280k

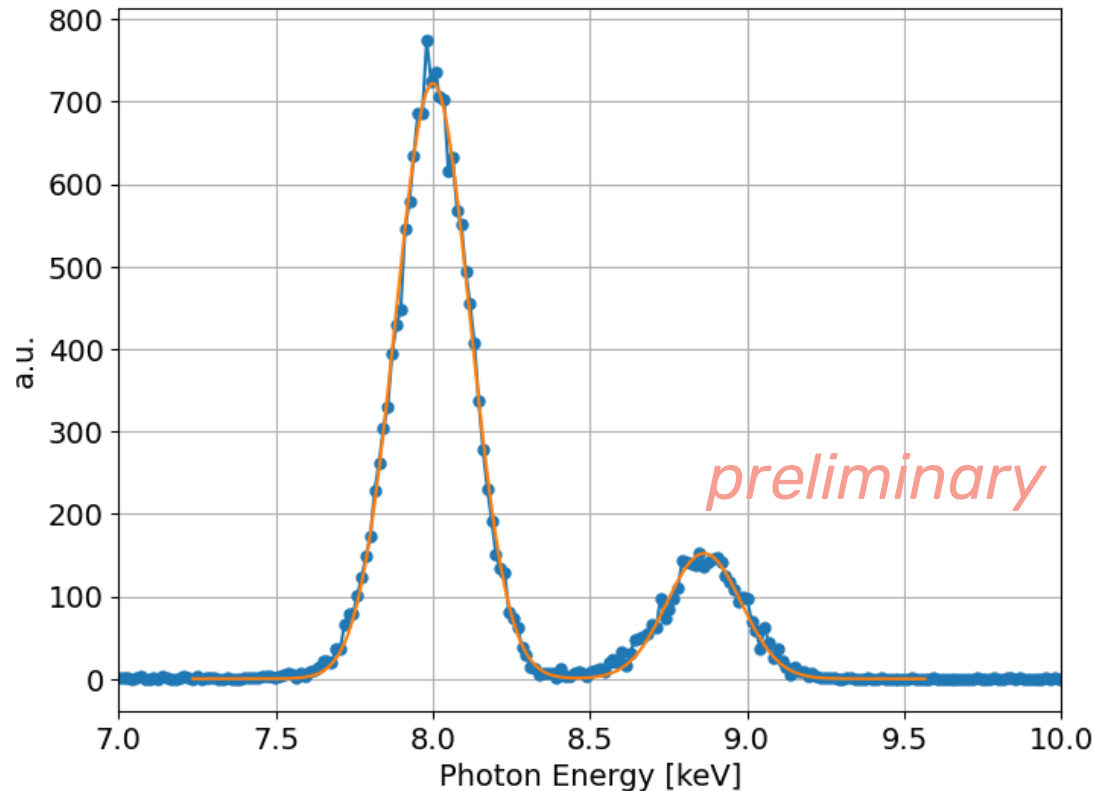
CITIUS-560k-linear



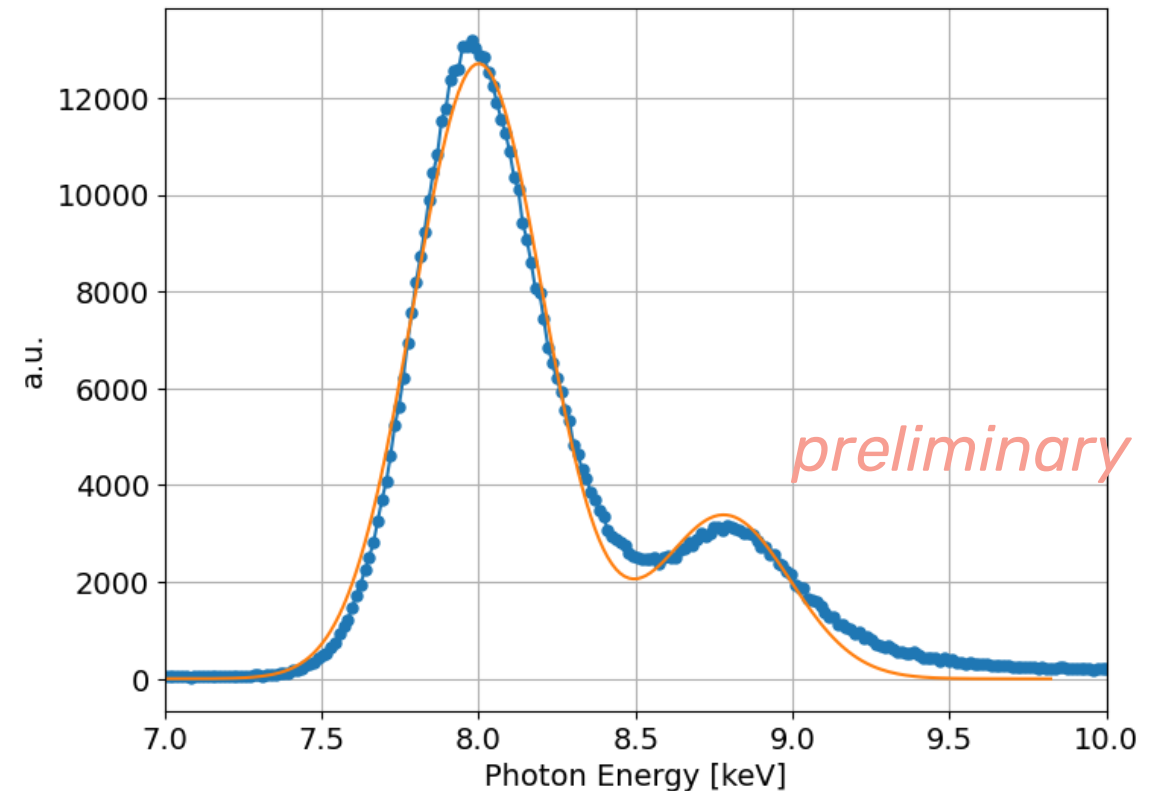
# Evaluations Results at SACLA (1/2)

*Weak Intensity Regime: Single Photon Detection and Spectro-imaging*  
Cu K emissions

single event analysis

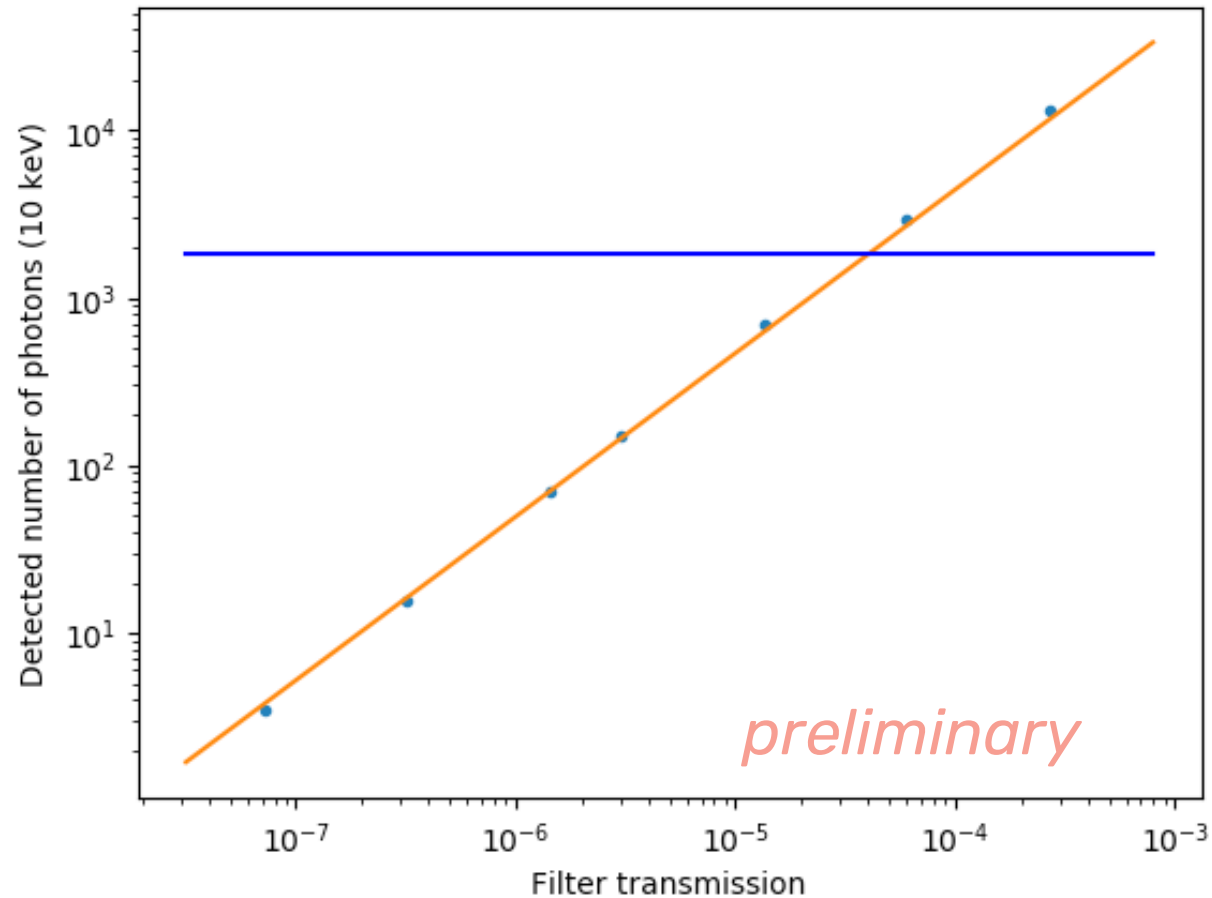


Droplet analysis



# Evaluations Results at SACLA (2/2)

## Linearity



←MPCCD Phase-Ib, III

# CITIUS Summary

CITIUS at SPring-8 and other synchrotron facilities are ramping up

- saturation count rate of about 1 Gcps/pixel
  - x100-x1000 compared to photon counting detectors
- spectro-imaging with  $< 1$  keV FWHM resolutions

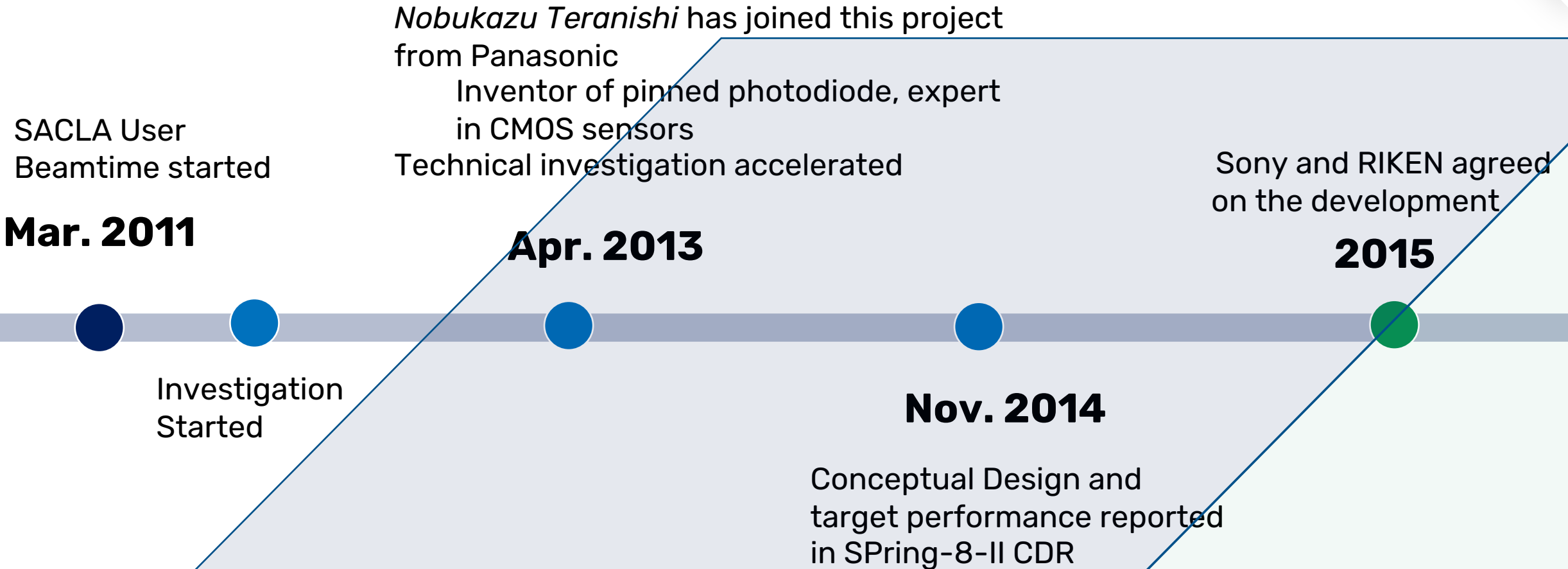
CITIUS for SACLA

- 20.2 Mpixel system under integration, planned to be deployed in 2024.
  - The semiconductor crisis still affects the availability of some parts
  - gives better noise, better peak signal than MPCCDs.
  - SFX integration (data analysis pipelines) needs to be implemented.
    - Contribution from the SFX user community to be discussed.
- in-house science experiments with 560k and 2.5M is planned in 2023.

If you are interested in the new detectors, please contact the beamline scientists.

# SPARE SLIDES

# Research to Development





# Integration

Project Schedule finalized  
First X-ray Image capture  
scheduled on June 2020

**Mar.  
2016**



**Sep.  
2020**

First Optical Image  
System evaluation  
started



First X-ray Image capture  
Delayed by 3.5 months

**Oct. 2<sup>nd</sup>,  
2020**



**Oct.  
2021**

First Science  
Experiment  
(XPCS)



First Science Experiment  
at Public Beamline

**Jul.  
2022**



**Jul.  
2022**

Feasibility  
Study at  
ESRF

**Dec.  
2022**

First experiment  
at SACLA  
First experiment  
(Ptychography)



Integration to

- SWAXS
- Single Crystal  
Structure Analysis

**2023**

**2023**

20.2 M detector  
to be integrated  
to SACLA

