

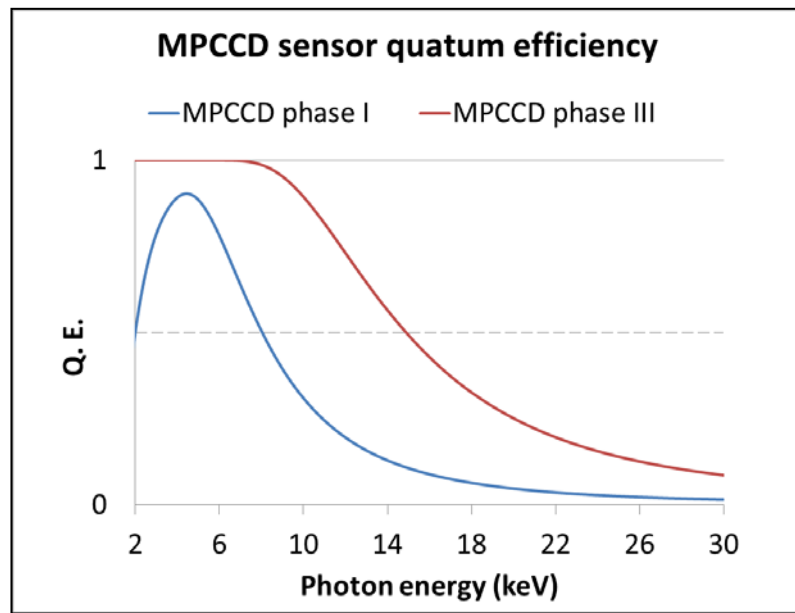
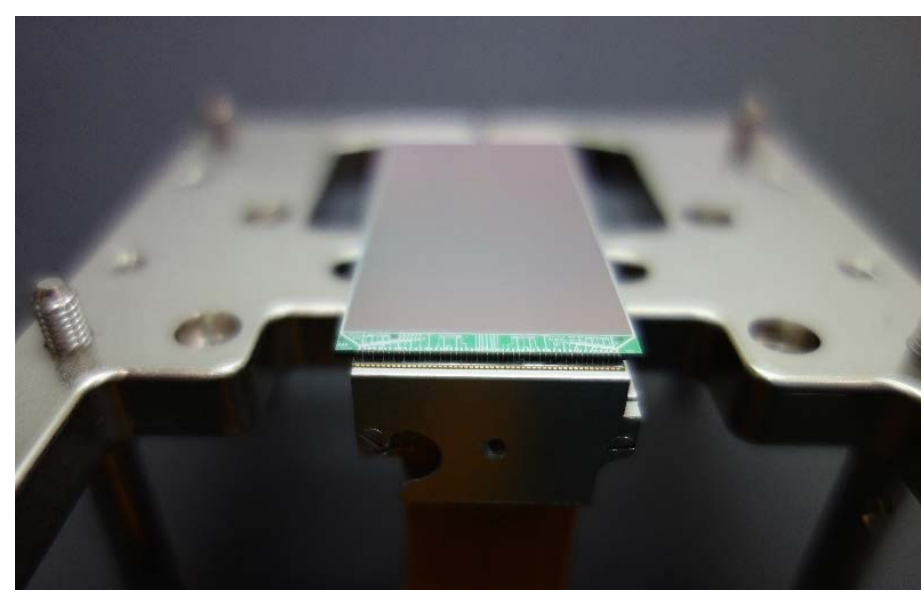
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Abstract

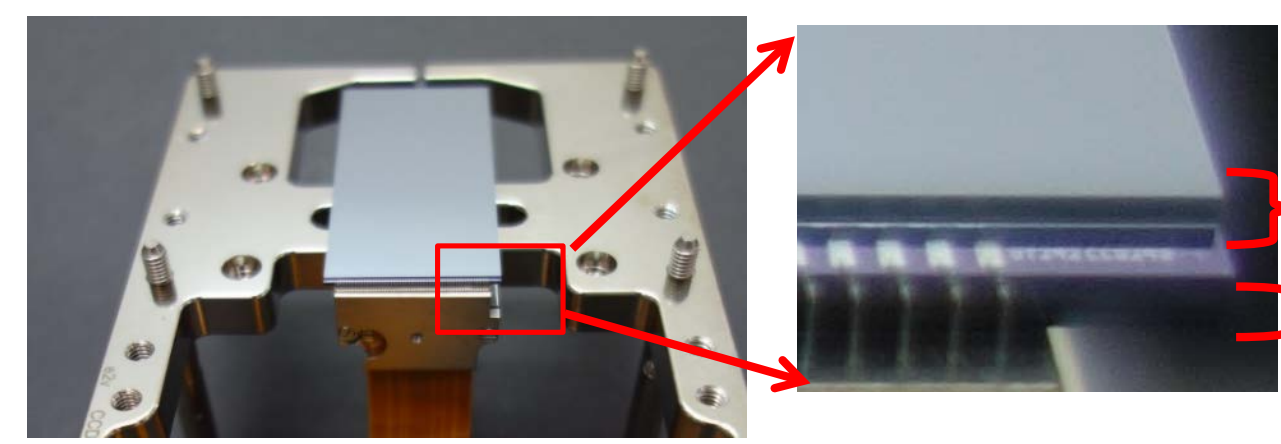
We present our six-year operation from 2011 to 2017 of the multi-port charge-coupled device (MPCCD) detector family at the X-ray Free-Electron Laser (XFEL) facility SACLA. We summarize the current performance with three types of sensors with 50 [1] and 300 micrometer thick MPCCDs, in combination with the first generation camera system [1] and upgraded compact camera system. Also, we show the deployed MPCCD variants and its integration details.

Sensor variants



Phase I Standard device

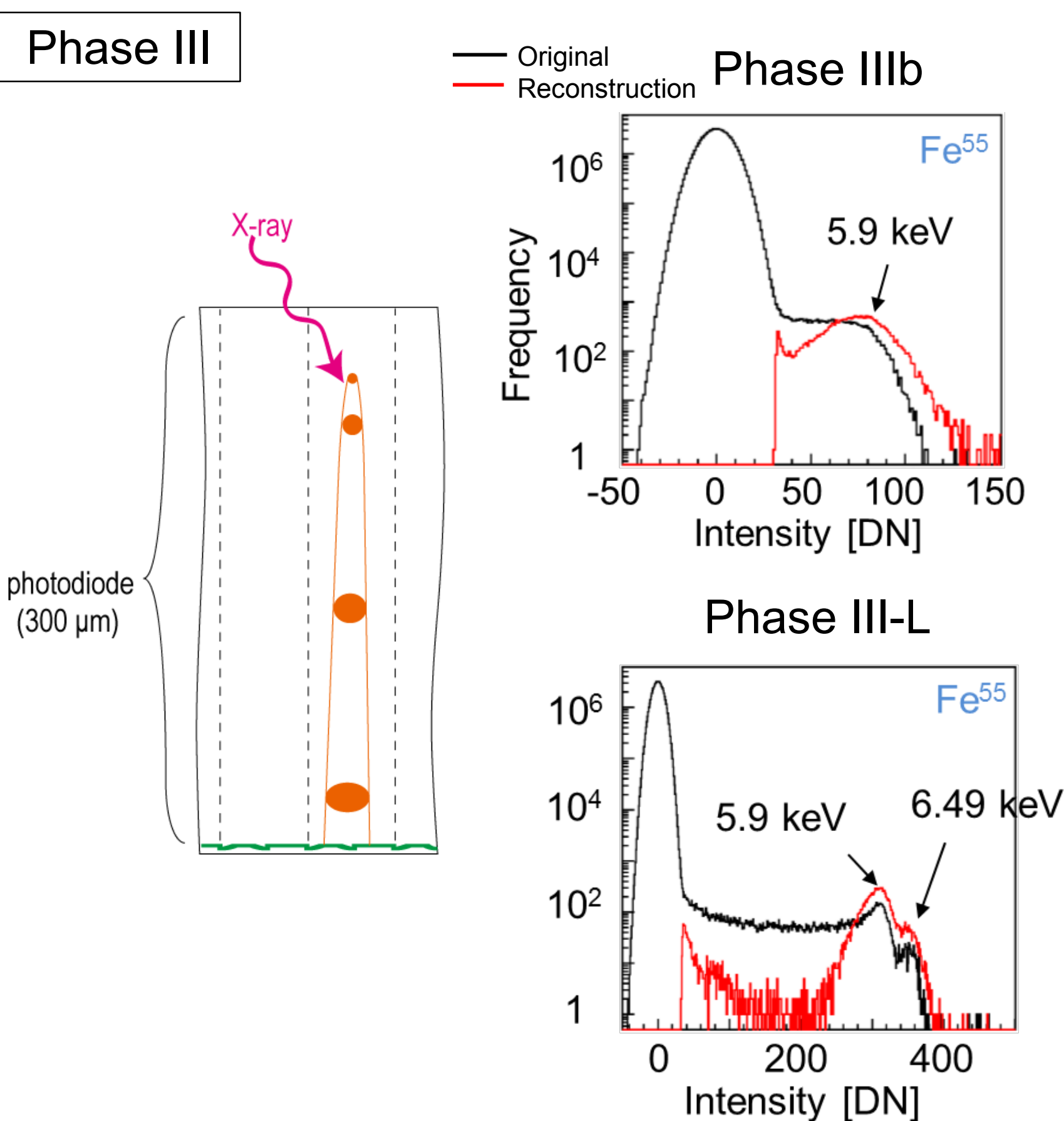
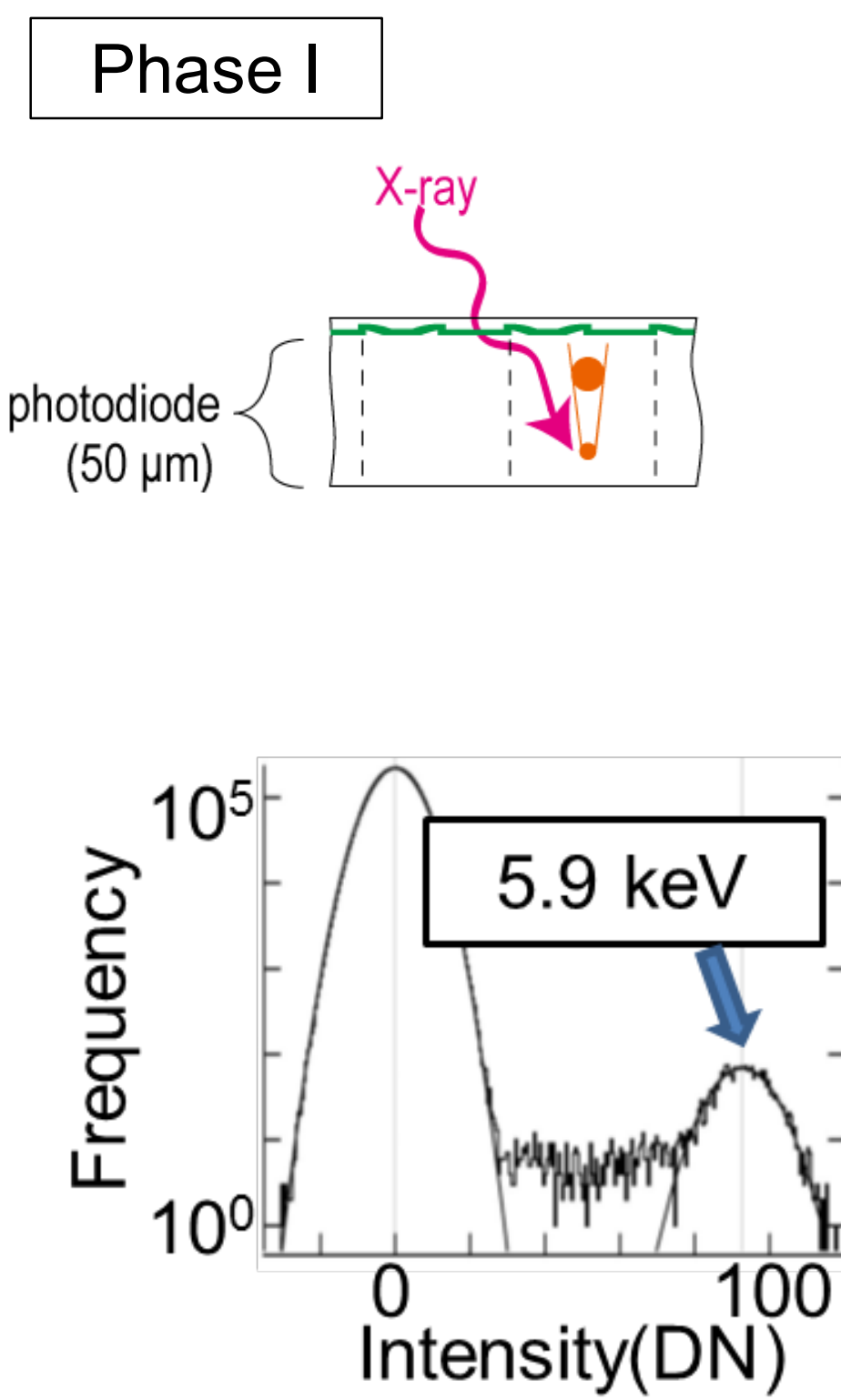
- Epitaxial silicon
- Front illumination



Phase III Thicker device

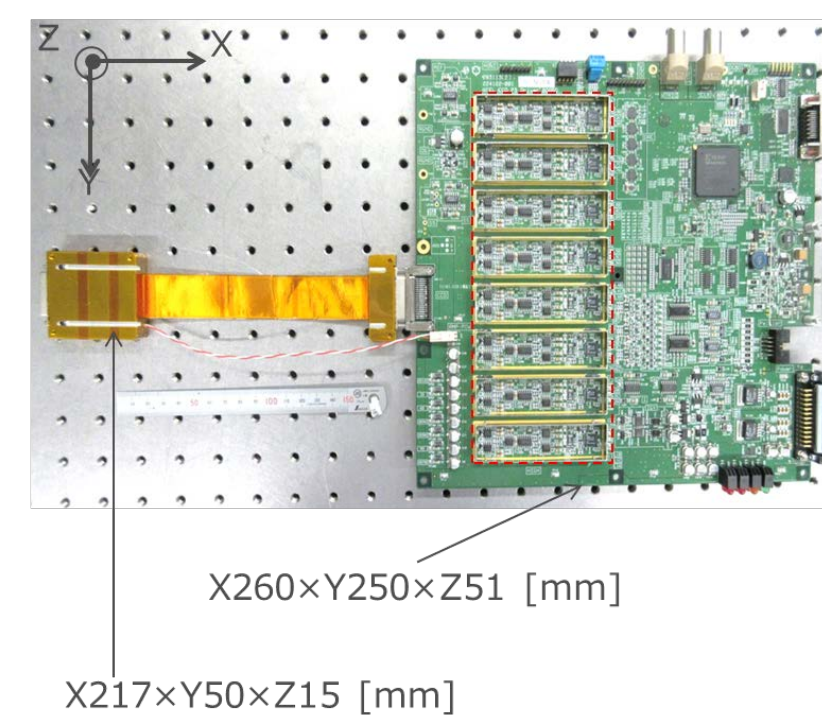
- Bulk silicon
- Back illumination
- High gain type (Phase III-L) is also developed.

	Phase Ib	Phase IIIb	Phase III-L
Feature	Workhorse at SACLA for most of the experiments	Compromise on PSF	Rare event detection Compromise on PSF
Image format	1024 x 512 pixels, 50 μm pixel front illuminated	1024 x 512 pixels, 50 μm pixel back illuminated	1024 x 512 pixels, 50 μm pixel back illuminated
Sensitive layer thickness	50 μm	300 μm	300 μm
ENC	110 ~ 180 e- r.m.s.	130 ~ 180 e- r.m.s.	32 ~ 47 e- r.m.s.



Compact Camera System

First generation camera system



- **Issues in the Accuracy**
 - ✓ Cross-talk, Undershoot (serial)
 - ✓ Cross-talk, Undershoot (parallel)
- **60 fps operation**
 - ✓ Significant accuracy degradation
- **New needs**
 - ✓ In-vacuum operation
 - ✓ > 4 M pixel detector with 4-side butted sensor array

➔ Compact camera system

Compact camera system

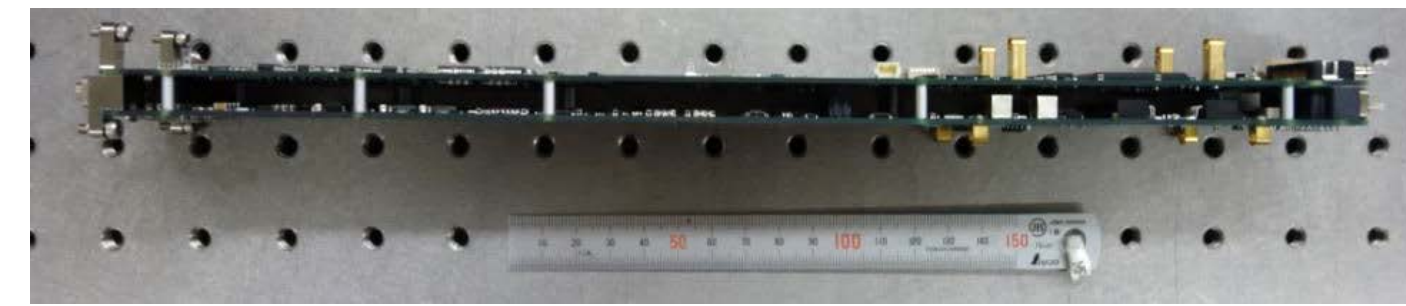
Video Chain Board (VCB)



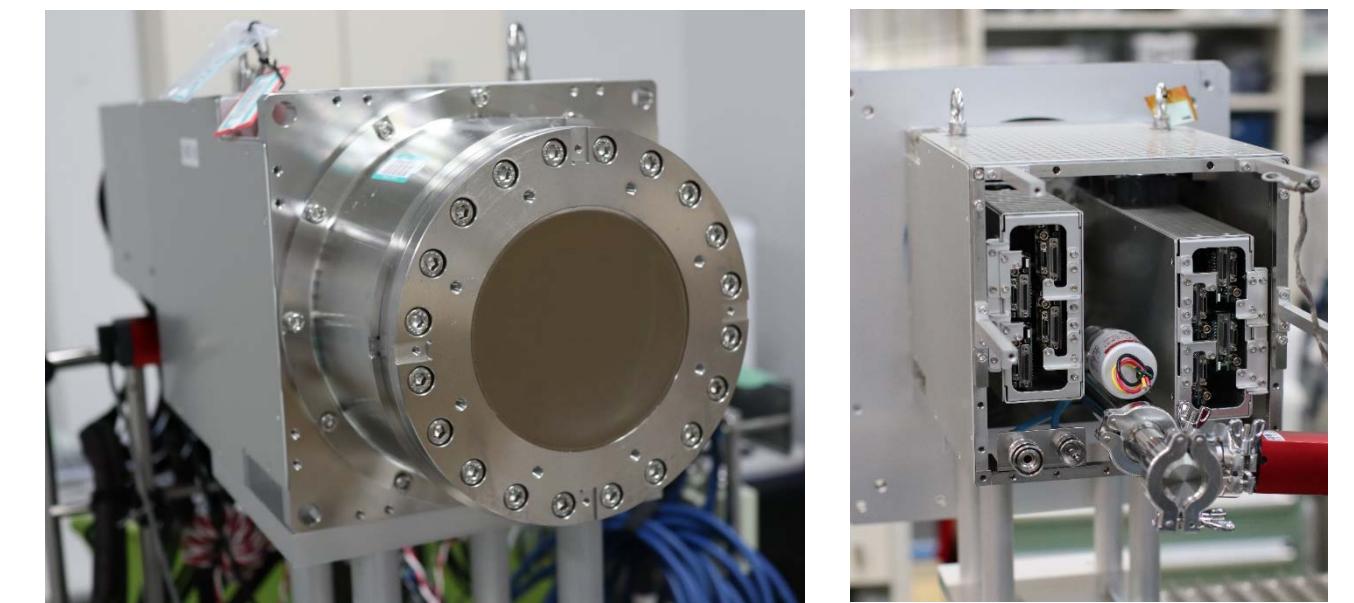
Driver Board (DB)



Proximity Readout Board (PRB)

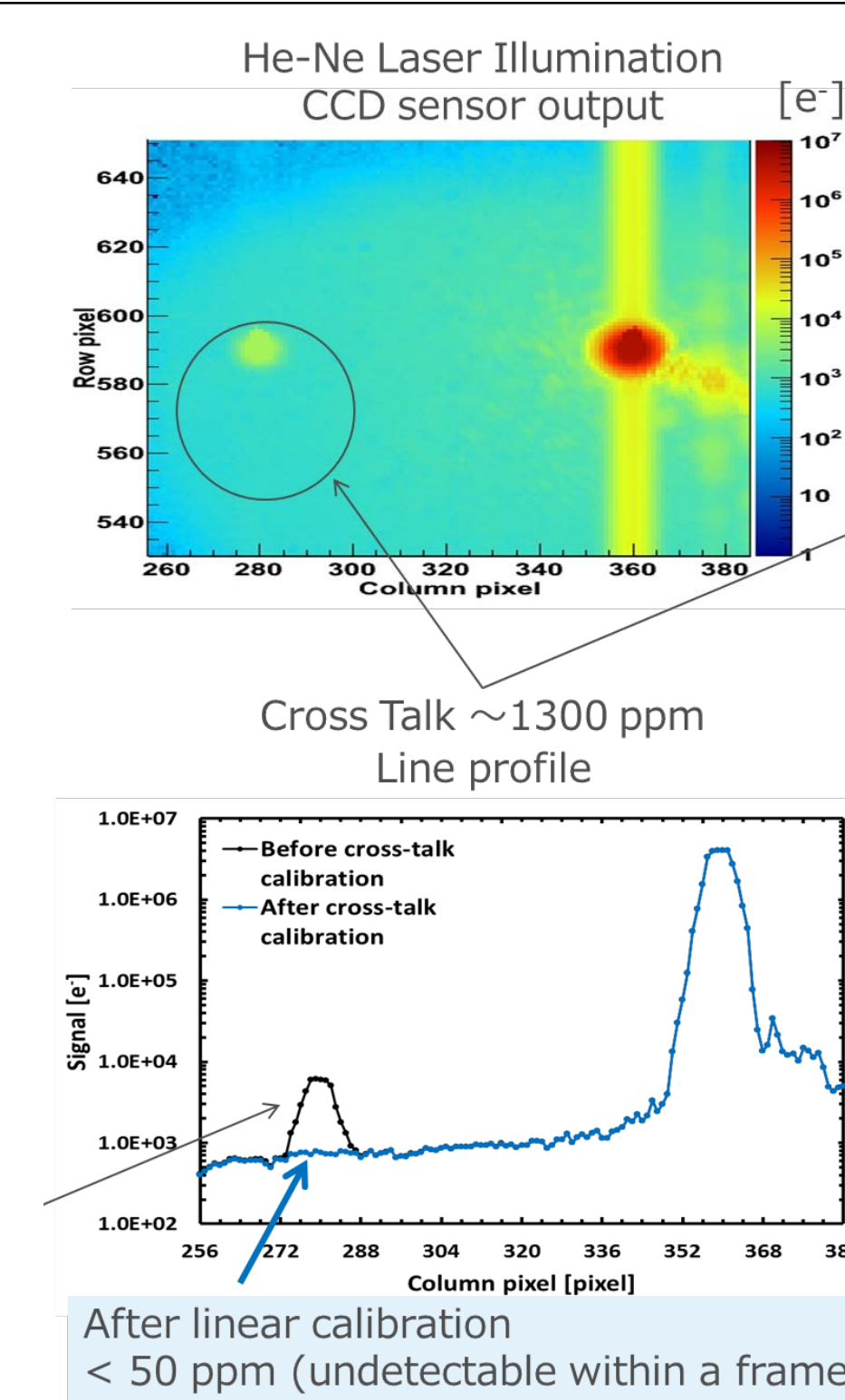


Example

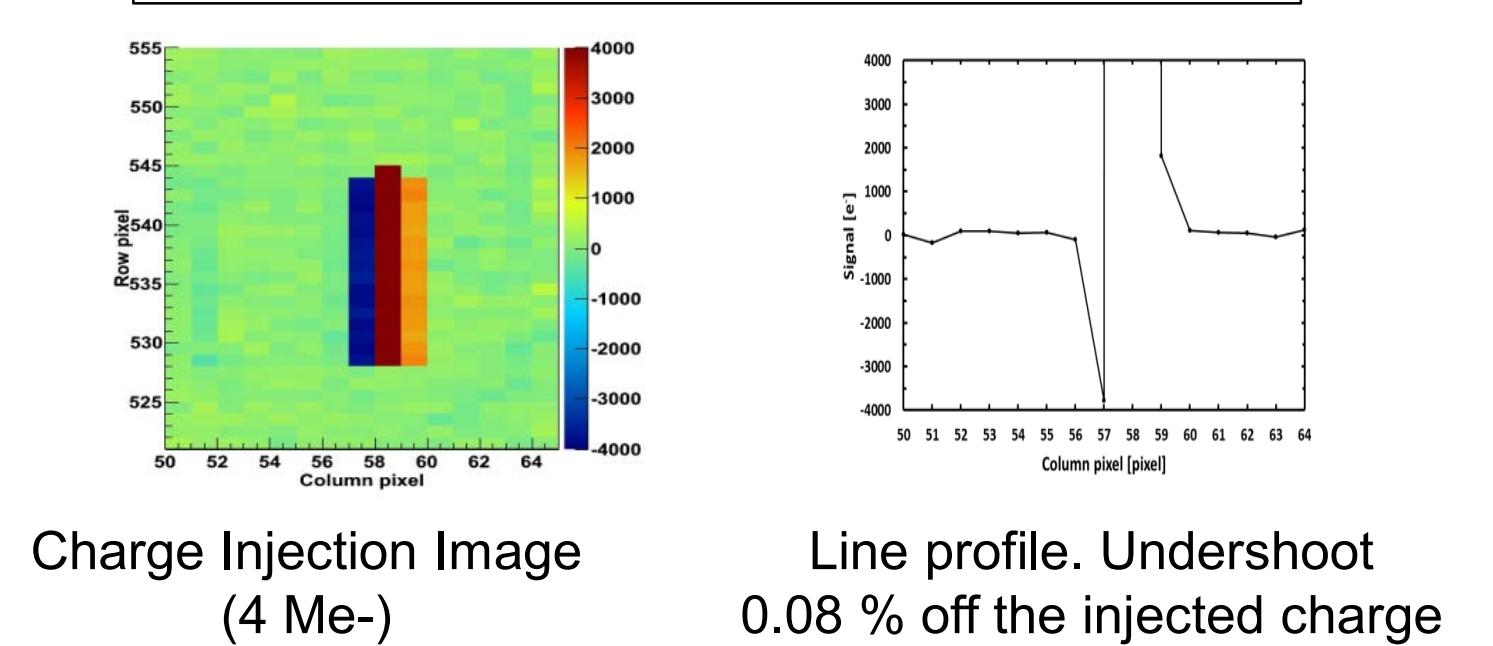


Weight, Power Dissipation, and Footprint reduced significantly. Power Dissipation is 29 W for a CCD, which contribute to the X-ray optics stability

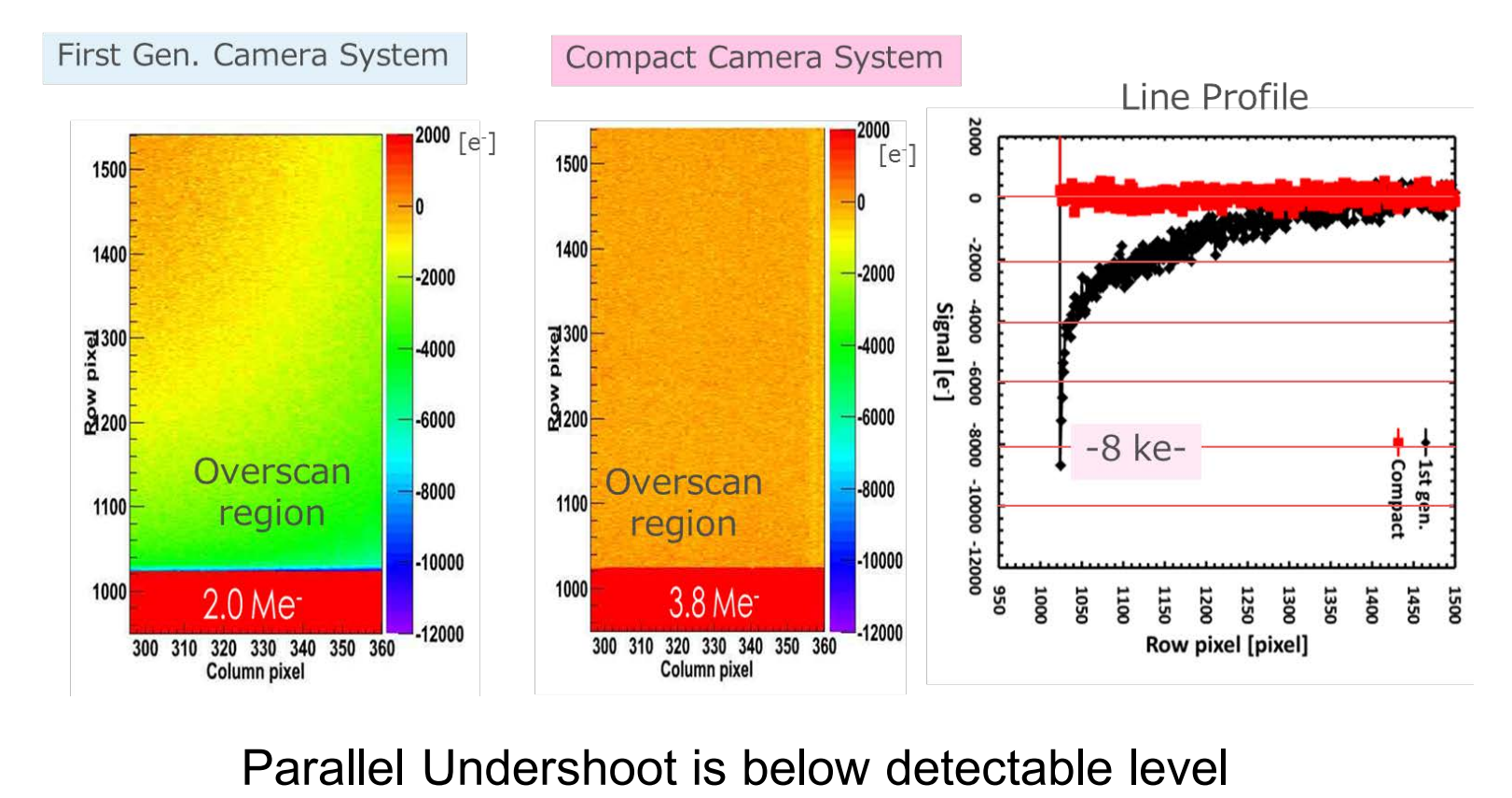
Cross-talk



Serial undershoot

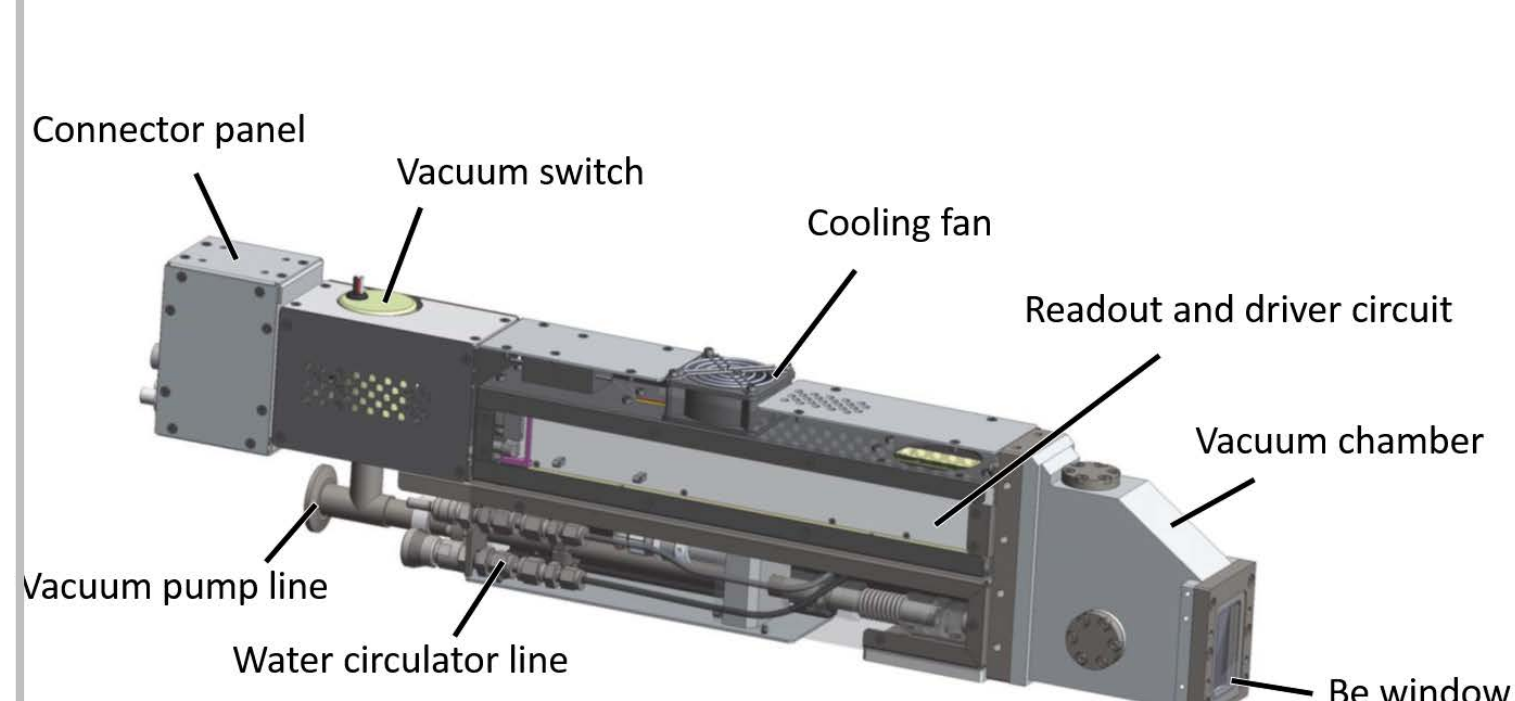


Parallel undershoot



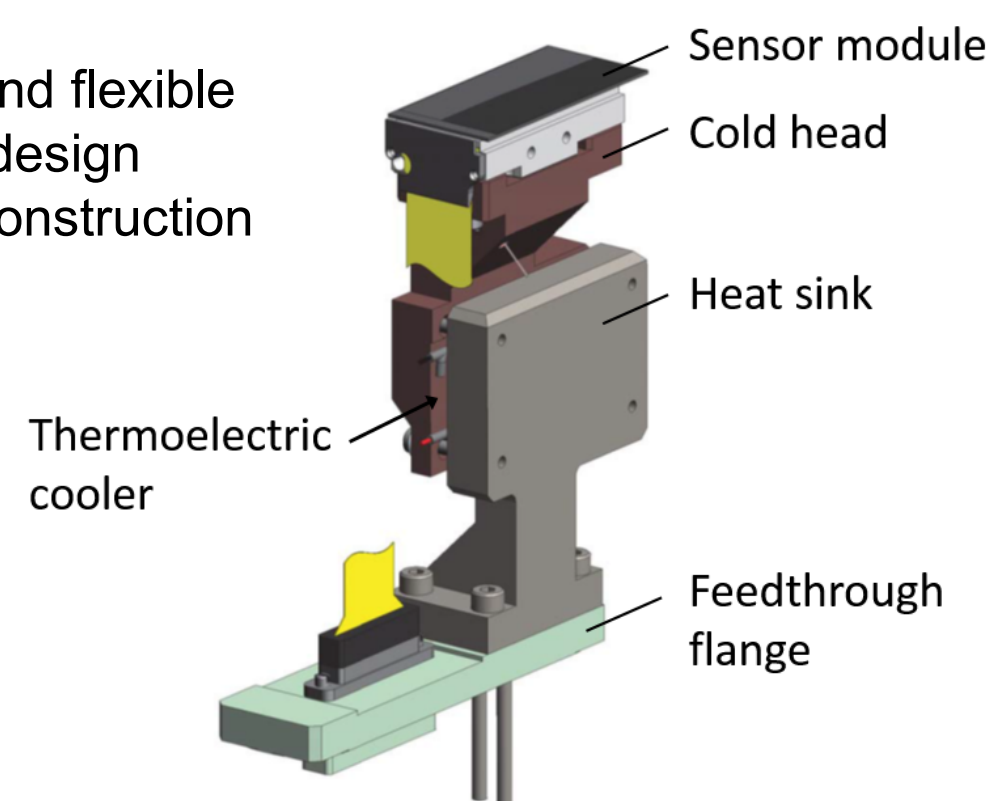
MPCCD variants and its integration

Single sensor detector

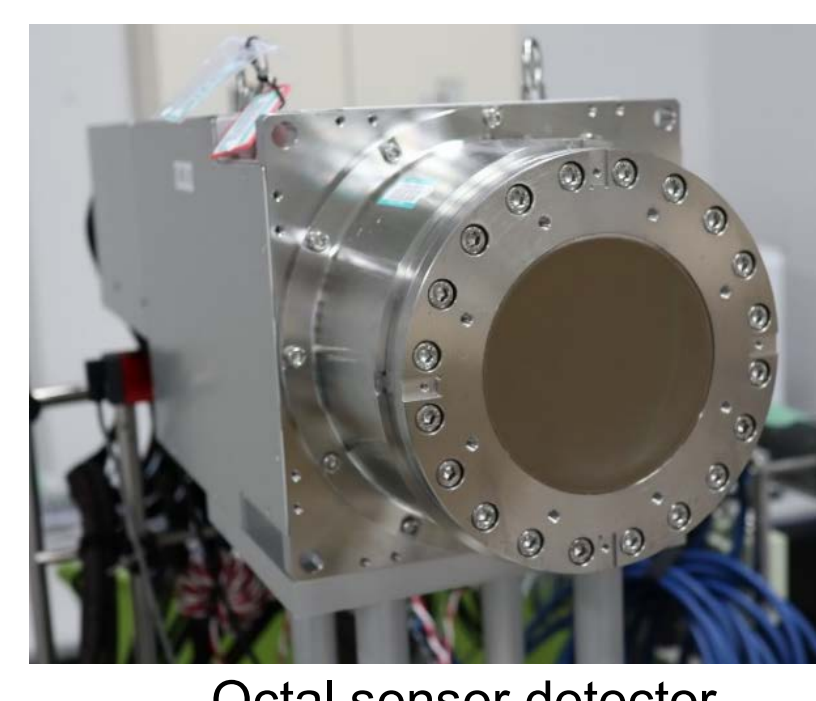


Camera module

- Fast and flexible array design
- Fast construction



Octal sensor detector



Octal sensor detector for crystallography experiments

Detector family

- 0.5 Mpixel Detector (17 systems in operation)
- 1 Mpixel Detector (8 systems in operation)
- 4 Mpixel Detector (7 systems in operation)

Total 15 variants
 Operation 29 systems with 44.5 Mpixels.
 Number is still increasing.

Summary

- MPCCD operated for 6 years with successful scientific outcome at SACLA. Modular design enabled developments of 14 mechanical variants in short lead time.
- New detector circuit enabled 60 Hz operation and enhanced the data accuracy.
- Integrated interlock to the several workhorse instruments were made detector with high availability.
- Only two detectors were damaged so far in 6 years.

References

- [1] T. Kameshima et al., Review of Scientific Instruments 85, 033110 (2014).
- [2] References in the review, T. Hatsui and H. Graafsma IUCrJ, Vol. 2, p. 371 (2015).
- [3] Publications can be found at <http://xfel.riken.jp/eng/research/indexxne.html>