

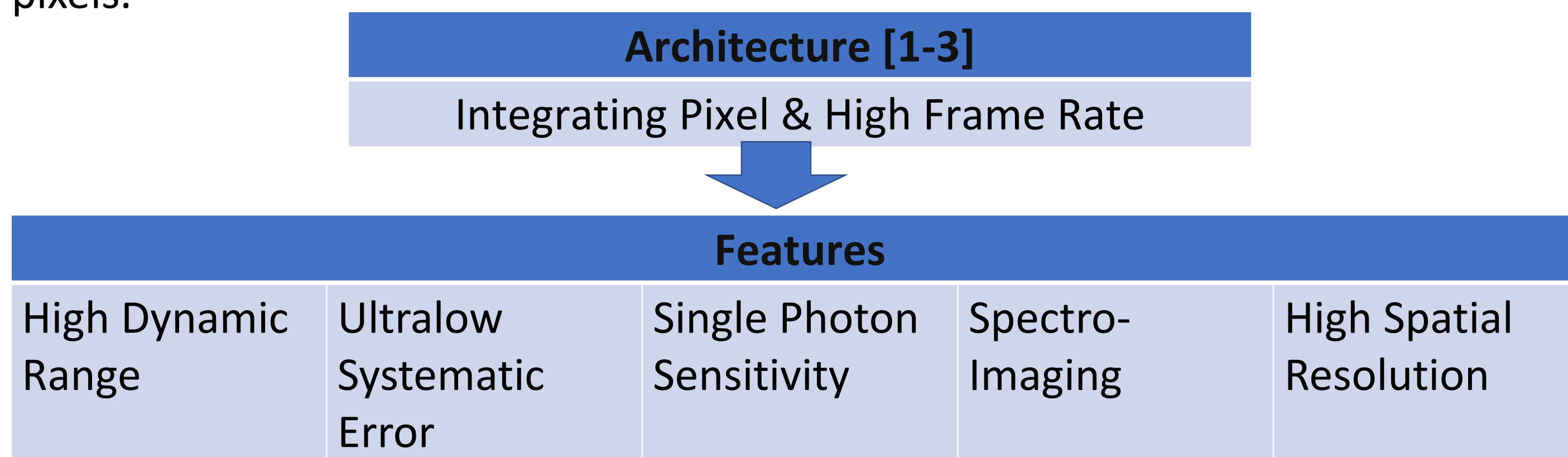
## Abstract

A new X-ray imaging detector, CITIUS-20.2M, has been developed for Serial Femtosecond Crystallography (SFX) at SACLA. CITIUS-20.2M has a seven times higher peak signal, seven times smaller noise, and five times more pixels than the currently used detector MPCCD (Phase III). The total number of pixels will be the world's largest as a direct detector for XFEL. Our objective is to improve the spatial resolution of SFX with higher-Q measurements. The detector will be deployed in FY2024. Status of the development and the preparation for the deployment are presented in this poster.

## CITIUS detector

A new charge-integrating X-ray imaging detector, CITIUS, has been developed for high photon fluxes onto samples with upgraded synchrotron radiation facilities. The integration of CITIUS detectors into synchrotron radiation experiments are in progress at SPring-8.

In parallel, we are also developing another larger version, CITIUS-20.2M, with high spatial resolution for Serial Femtosecond Crystallography (SFX) at SACLA. CITIUS-20.2M will have the world's largest number of pixels as a direct X-ray detector for XFEL. In comparison with the current detector MPCCD (Phase-III) in operation, CITIUS-20.2M has a seven times higher peak signal, seven times smaller noise, and five times more pixels.



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

## Specifications of CITIUS-20.2M and MPCCD (Phase-III) for SACLA

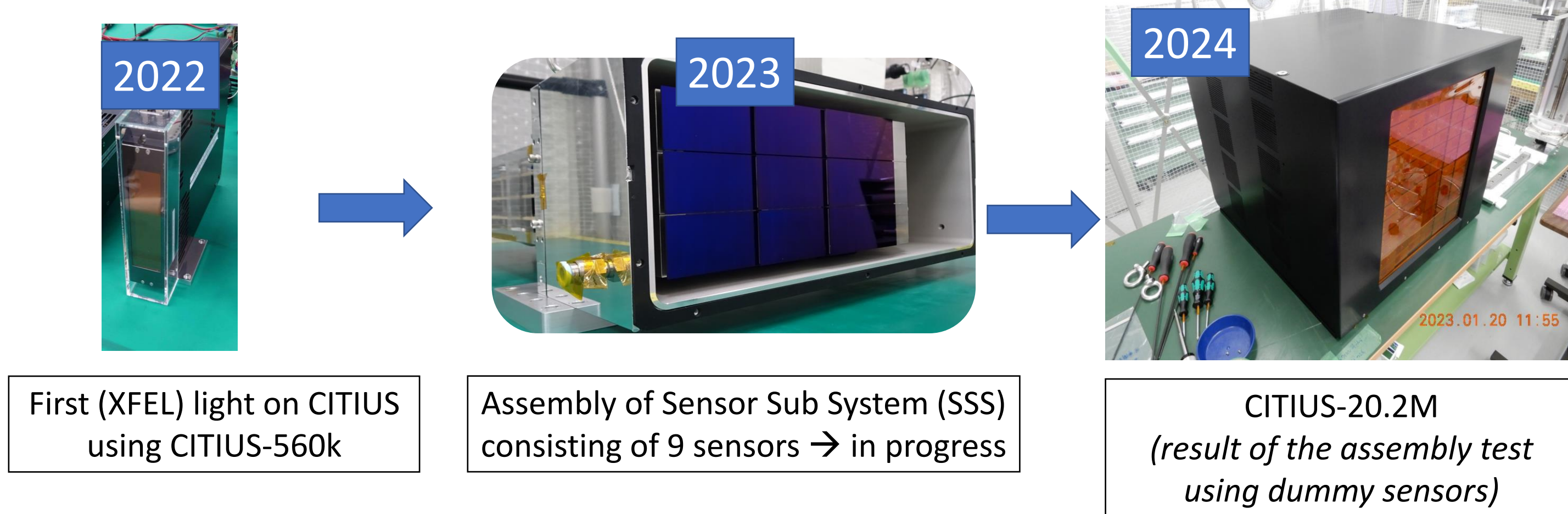
| Parameters    | Value                   |                   | unit                      |
|---------------|-------------------------|-------------------|---------------------------|
|               | CITIUS for XFEL (SACLA) | MPCCD (Phase III) |                           |
| <b>Sensor</b> | Silicon                 |                   | N/A                       |
| Thickness     | 650                     | 300               | μm                        |
| Pixel Size    | 72.6                    | 50                | μm                        |
| Pixel Number  | 0.28                    | 0.5               | Mpixels/Sensor module     |
| Peak Signal   | 17,000                  | 2,400             | phs/pixel@6 keV           |
| Typical noise | 25                      | 250               | e-rms                     |
| Frame Rate    | 60*                     | 60                | Hz                        |
| Data Rate     | 1.6**                   | 0.06              | GB/s @ digital out        |
| <b>System</b> | 325 × 363               |                   | 100 × 100 mm <sup>2</sup> |
| Pixel Number  | 20.2                    | 4                 | Mpixels                   |
| Data Rate     | 116*                    | 0.48              | GB/s @ digital out        |

\* The frame rate of CITIUS is 17.4 kHz (SR variant) and 5 kHz (XFEL variant).

\*\* The data rate of CITIUS is the total raw data rate from the sensor. Each frame data has 16 multi-AD sampled data.

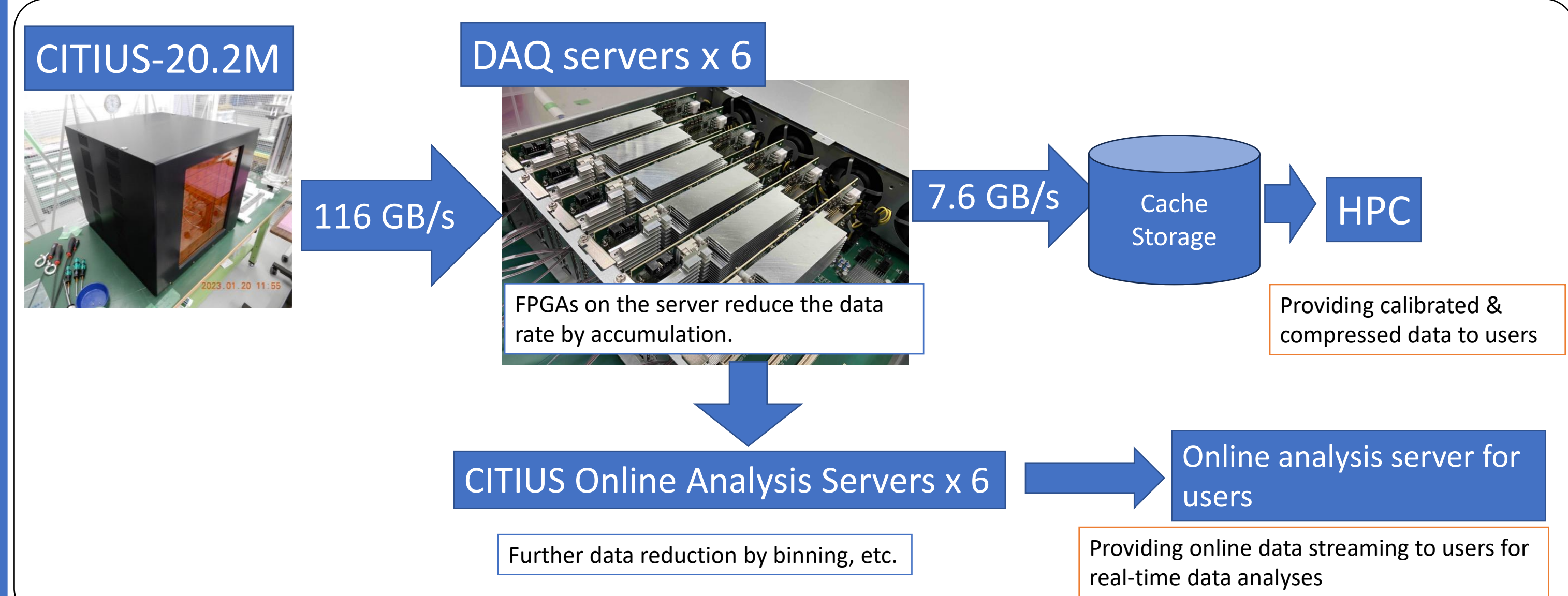
## Timeline for deployment

- FY2022: Feasibility study with CITIUS-560k
- FY2023: 20.2M camera assembly and the installation of data acquisition system
- FY2024: Installation of CITIUS-20.2M at SACLA on BL2 EH3



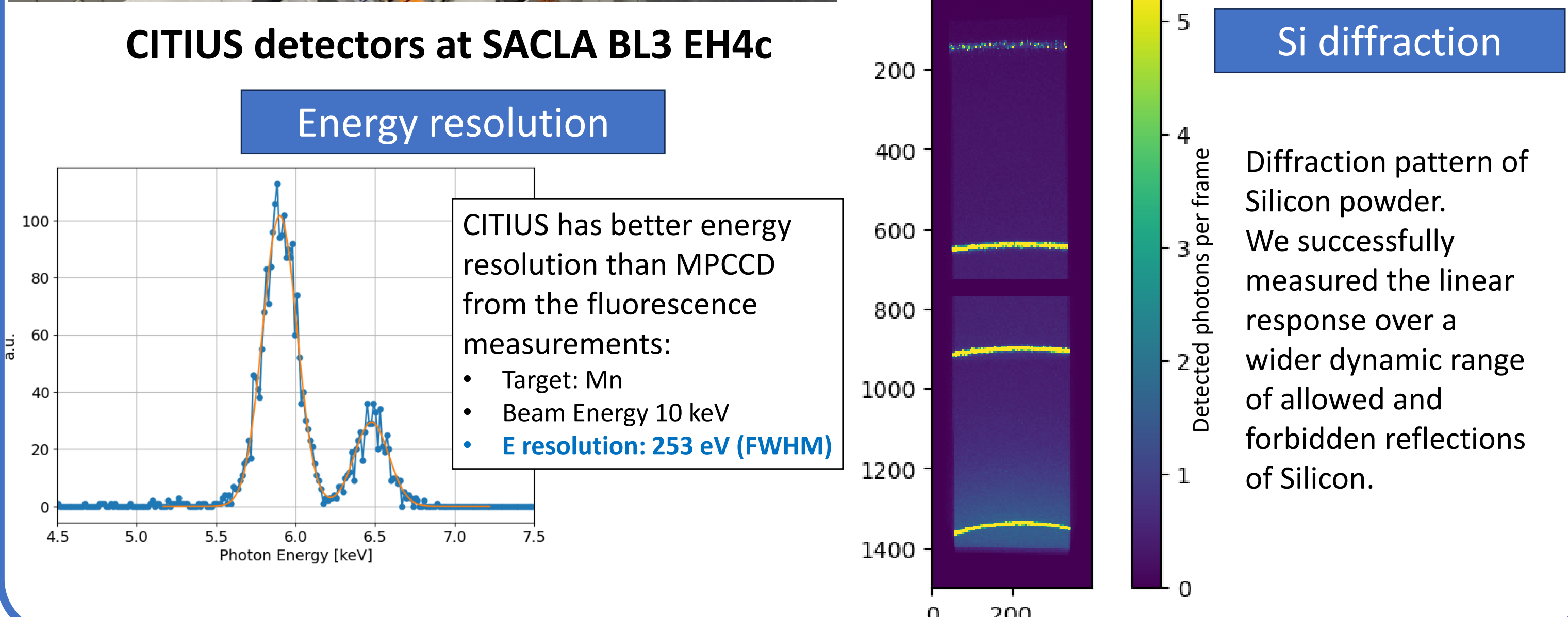
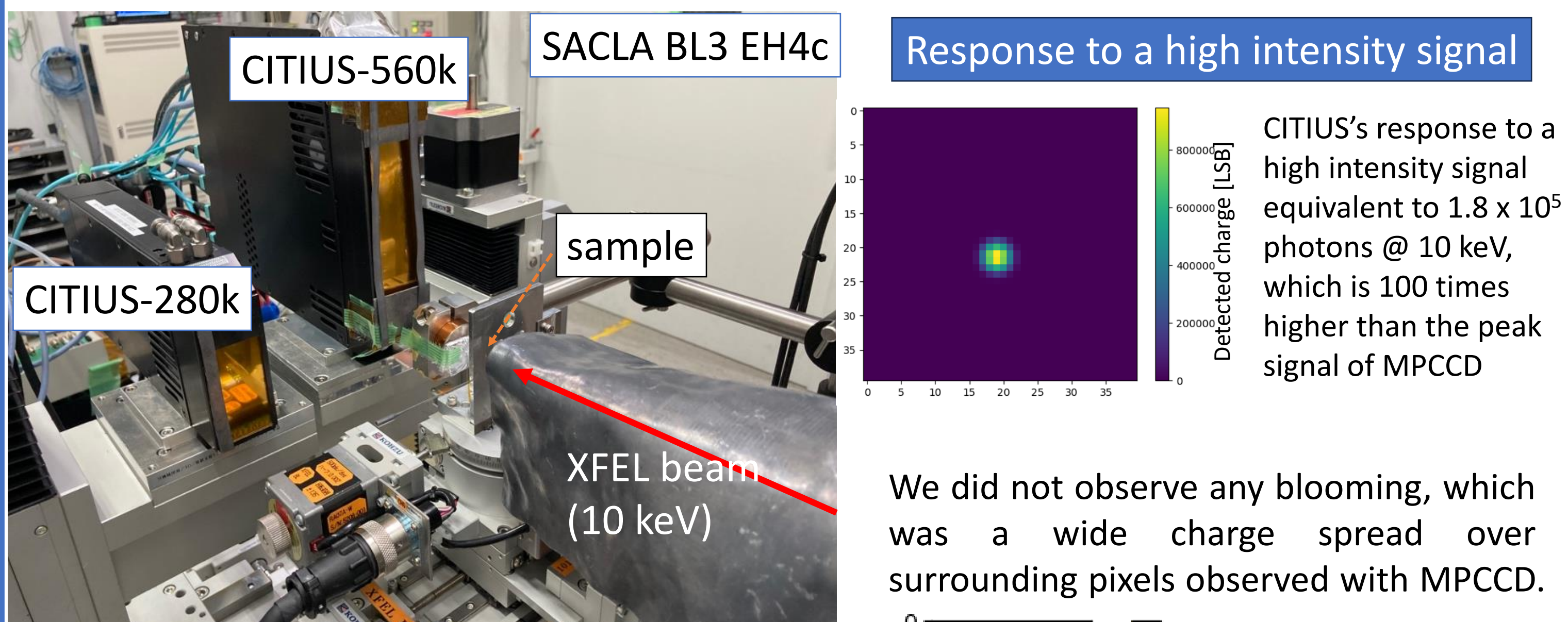
## Preparation of data acquisition system

CITIUS-20.2M generates orders of magnitude more data than the data rate of MPCCD. This amount requires dedicated computers for data acquisition and data processing. The new computing system will have an analysis environment similar to the one currently used for SFX experiments with MPCCD environments for SACLA users, by reducing the huge amounts of data

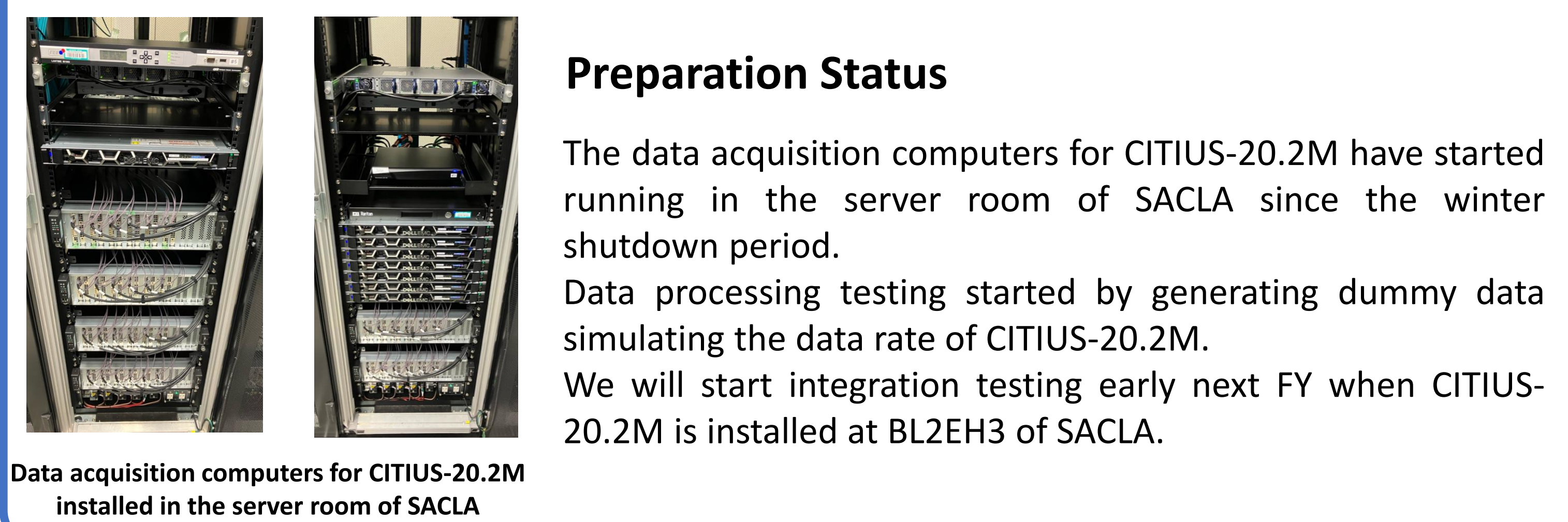


## Feasibility Study with CITIUS-560k

The first beamtime at SACLA, using CITIUS-560k, has been conducted in December 2022 and the response of CITIUS to XFEL beam conditions has been measured. The successful DAQ integration to RunControl of SACLA, the lower noise, higher dynamic range, and linearity have been confirmed.



## Outline of CITIUS-20.2M data flow



## Summary

- CITIUS-20.2M is the world's largest direct X-ray detector developed with high spatial resolution of SFX at SACLA.
- The sensor of CITIUS detectors has been confirmed to work as expected for XFEL. CITIUS-20.2M is now under assembly and the data acquisition computers are in preparation.
- CITIUS-20.2M will be installed in FY2024. After the verification of CITIUS-20.2M through test experiments, the detector will be provided for users' experiments.

## Acknowledgement

本開発の実施にあたり、以下の方々、協力会社（敬称略）からの協力・支援を頂きました。心より感謝申し上げます。  
理研・JASRIのチーム関係者（阿部 利徳、東末 敏明、工藤 統吾、亀島 敬、稲垣 康彦、藤原 邦弘、中川 敏治、親木 康高、木本 学、中町 将貴、株式会社キャンドックスシステムズ、グローリーメカトロニクス株式会社、グローリーシステムクリエイト株式会社、株式会社日本技術センター、明星電気株式会社、JEPICO Corporation）、松田 祐二（理研（現 株式会社ミスト））、寺西 信一、渡邊 健夫、木下 博雄（兵庫県立大学）、ソニーセミコンダクタソリューションズ株式会社、東京エレクトロニクス株式会社、番村 芳樹、玉作 賢治、矢橋 牧名、石川 哲也（理研）、関澤 央輝、安田 伸広、杉本 邦久、宇留賀 朋哉、および検出器利用支援WGの皆様（JASRI）、高橋幸生（東北大学）、SACLA BL研究員の皆様