Instructions of MPCCD detector specification and data format

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RIKEN

Document change log

Issue	Date	Change	Modified pages	Notes
1	6/29/2012	New document		
2	12/7/2012	Added document change log.	2	
3	12/7/2012	Modified specification of full well capacity. 2.0 Me- -> 3.5 Me-	3	
4	4/18/2013	Added information of SWD octal	5, 9	
5	6/19/2013	Modified note of full well capacity. 1200 -> 2100	3	

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List of Tables and Figures

1 Introduction

This document describes the system performance and the mechanical features of MultiPort Charged Coupled Device (MPCCD) detector and the data structure in the HDF5 file provided by the SACLA DAQ system.

2 MPCCD detector

2.1 System specifications

	Specifications	Note
Features	Front illuminated, Full frame transfer CCD	8 port readout
CCD format	512 x 1024, 50 x 50 μm	
Imaging area	25.6 x 51.2 mm	
Frame rate	30 Hz	
Full well capacity (Peek signal)	3.5 Me- (typical)	= ~ 2100 photons @ 6 keV
System noise	300 e- (typical)	= ~ 0.18 photons @ 6 keV
System gain	18 e-/ADU (typical)	
Dark current	600 ke-/sec/pixel @ 20 °C	
Deepest cooling temperature	-30 °C	thermoelectric cooling with water circulation
Non-linearity	1 % (typical)	
Operating environment	< 10^{-1} Pa	non-condense atmosphere

Tab. 1 Detector specifications

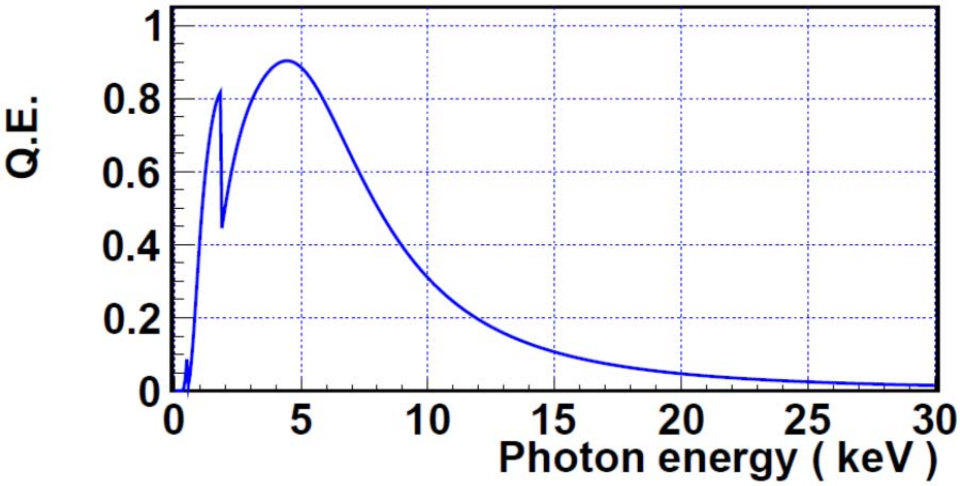

Fig. 1 Quantum efficiency

2.2 Detector line-up

	Single sensor detector	Dual sensor detector	Octal sensor detector	SWD octal detector
Features	1 CCD	2 CCDs array	8 CCDs array with an aperture in the center of the array	8 CCDs array with an aperture in the center of the array
Image format	512 x 1024 25.6 x 51.2 mm	1024 x 1024 ~ 51.2 x 51.2 mm	2048 x 2048 ~110 x ~ 110 mm 0~9 mm square hole (controllable)	2048 x 2048 ~110 x ~ 110 mm 3 mm square hole (fixed)
Weight (kg)	~11	~20	~80	~80
Dimensions (mm^2)	294 (H) × 410 (V) × 281 (D)	294 (H) × 429 (V) × 268 (D)	584 (H) × 800 (V) × 440 (D)	584 (H) × 800 (V) × 440 (D)
Flange structure	Be window with a thickness of 230 μm attached to the ICF114 flange for atmospheric usage (default).	Be window with a thickness of 280 μm attached to the ICF152 flange for atmospheric usage (default).	VG 350 (bolt holes are oriented on the principal center line)	VG 350 (bolt holes are oriented on the principal center line)
Operating environment	Atmosphere with a Be window or HV under non-condense atmosphere	Atmosphere with a Be window or HV under non-condense atmosphere	HV under non-condense atmosphere	Either Atmosphere or vacuum
Note			Frequently used for CDI	Frequently used for crystallography

Tab. 2 Detector line-up

2.3 Mechanical features

2.3.1 Sensor position in detector

The front views of MPCCD detectors drawn below show that the sensor arrays are placed in the center of flange for every detector. The deepest distances from the flange front to the sensor surface are 25.1 mm, 23.9 mm, and 54 mm, respectively for single, dual and octal sensor detector. The sensor array maps labeled with every distance from flange fronts are also described below. The sensor array of the SWD octal sensor detector is sticking out of the detector flange in the vacuum direction to cover wide angle signals.

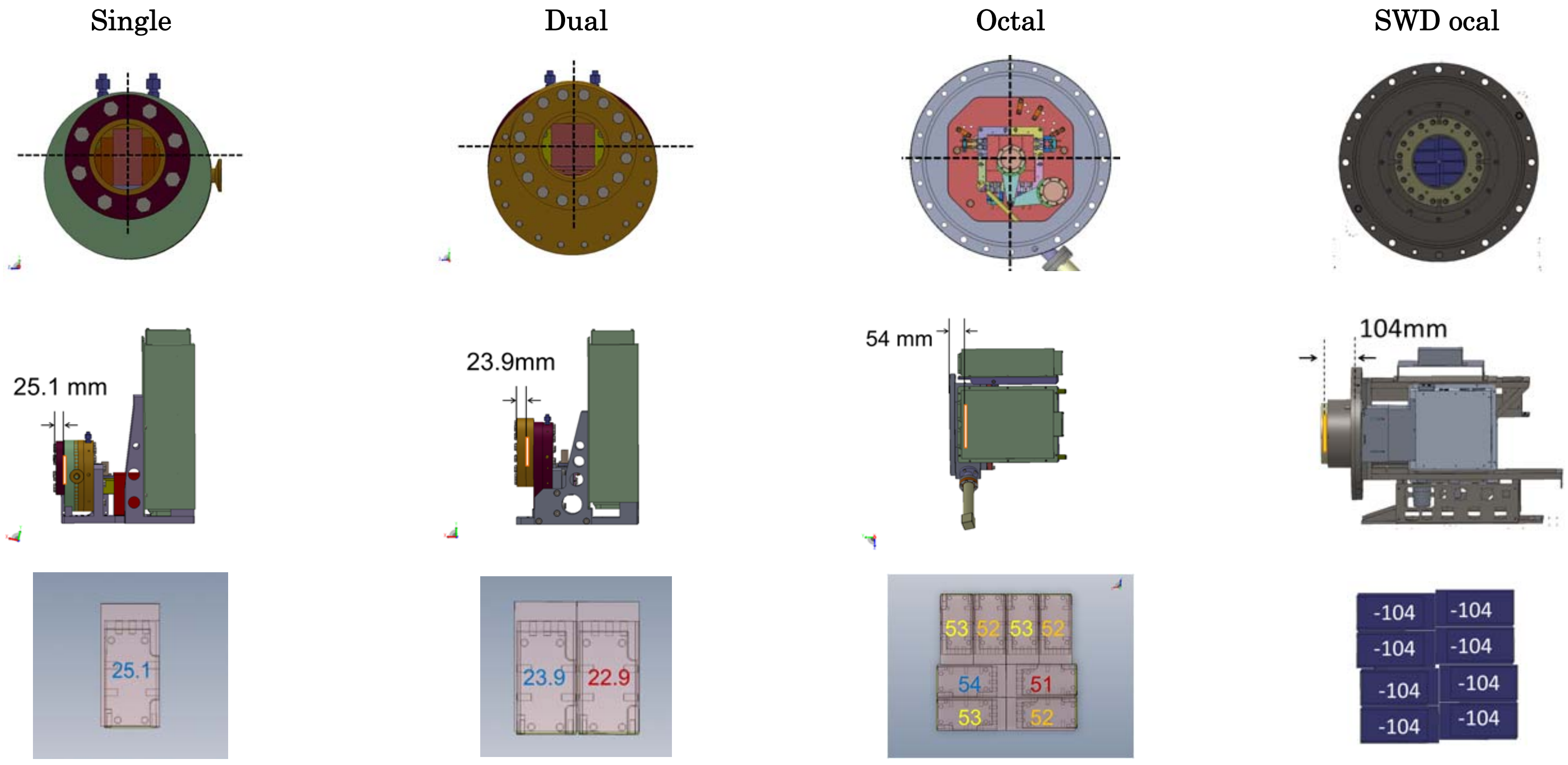

Fig. 2 Sensor position in detectors

2.3.2 Dead area distribution

The MPCCD sensor has dead areas as described in Fig. 4. Except for the SWD octal detector, the dead areas of arrayed sensors are minimized by overhanging them as illustrated in Fig. 5.

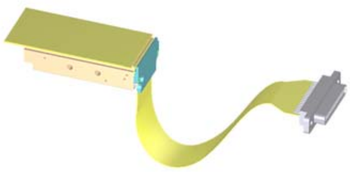

Fig. 3 Sensor package

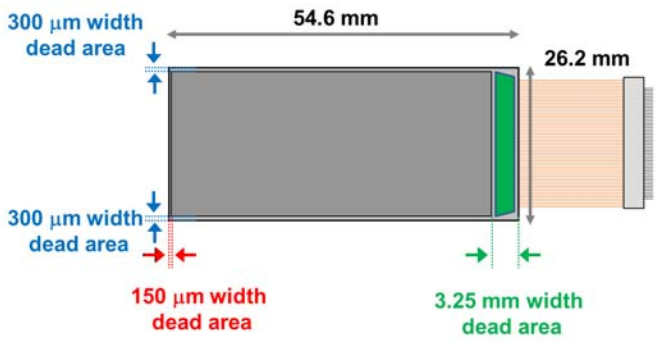

Fig. 4 Dead area distribution on the MPCCD sensor

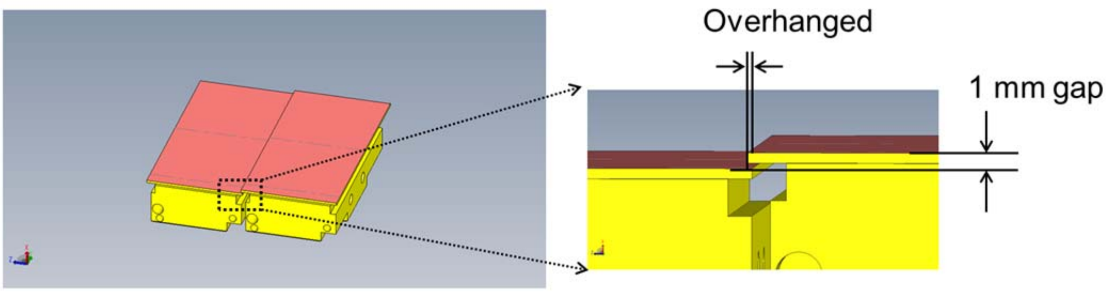

Fig. 5 Schematic of sensor overhang

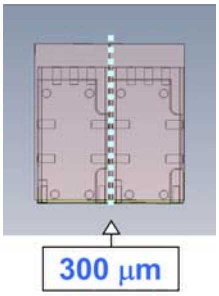

Fig. 6 Dead area in dual sensor detector

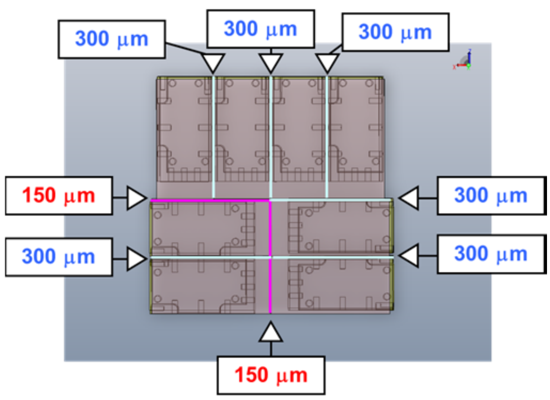

Fig. 7 Dead areas in octal sensor detector

3 File format

The data of the MPCCD sensors, saved in the high-speed storage system with RAW data format, are translated to HDF5 files, named as "SACLA run data format", upon user request. HDF5 file format is a completely portable file format with no limit on the number or size of data objects in the collection. HDF5 library runs on a range of computational platforms, from laptops to massively parallel systems, and implements a high-level API with C, C++, Fortran 90 and Java interfaces.HDF5 is supported by many commercial and non-commercial software platforms, including MATLAB, IDL and IGOR.

HDF5 files are organized in a hierarchical structure, with two primary structures: groups and datasets. HDF5 group is a grouping structure containing instances of zero or more groups or datasets. HDF5 dataset is a multidimensional array of data elements. Frequently-used datasets in SACLA run data format are listed in Tab. 3.

Sample file of the SACLA run data format in HDF5 file
http://xfel.riken.jp/users/mpccd_detector/28930.h5

HDFVIEW (viewer of HDF5 file)
http://www.hdfgroup.org/hdf-java-html/hdfview/

Softwares handling HDF5 file
http://www.hdfgroup.org/tools5app.html

HDF5 Dataset Name	Description
/file_info/run_number_list	List of Run-Numbers in the HDF5 file (integer array)
/run_[Run-Number]/event_info/tag_number	List of Tag-Numbers in the Run (integer array)
/run_[Run-Number]/event info/bm_1_signal_in_coulomb	List of detected electronic charges at beam monitor 1 in the Run [Coulomb] (float array)
/run_[Run-Number]/event info/bm_2_signal_in_coulomb	List of detected electronic charges at beam monitor 2

	in the Run [Coulomb] (float array)
/run_[Run-Number]/detector_2d_*[Sensor Specification]/detector_info/absolute_gain	System gain of the sensor [e-/ADU] (float array)
/run_[Run-Number]/detector_2d_*[Sensor Specification]/detector_info/tag_[Tag-Number]/detector_data	Counts in CCD pixels [ADU] (float array)

Tab. 3 Variable table

(*) e.g., Sensor number for single sensor, "octal" for octal sensor detector, and so on.

4 Data calculation procedure

The signal in a pixel at a unit of digital value is calibrated at the number of photons, using the formula described below.

$$N_{ph} = (S_{ADU} * G_{sys}) / (E_{ph} / \varepsilon)$$

N_{ph}: the number of detected photons [photon]
S_{ADU}: CCD count [ADU]
G_{sys}: system gain [e-/ADU]
E_{ph}: photon energy [eV]
ε: energy to create an electron-hole pair in silicon = 3.65 [eV/e-]

<< Example >>
S_{ADU} = 150 [ADU]
G_{sys} = 18 [e-/ADU]
E_{ph} = 10 [keV]

N_{ph} = (150 *18) / (10*1000 / 3.65) = ~ 1 [photon]

(*) The image data of an arrayed sensor detector is provided after calibrated relatively on the basis of the absolute gain of 1st sensor (expressed in HDF5 file as `/run_[Run-Number]/detector_2d_1/detector_info/absolute_gain`). Therefore, we can treat the data of a sensor array as the one of a single sensor.