5 IMSS Instrument R&D Team

The IMSS Instrument R&D team has been developing new detector systems for material science and biology since May 2010. Here we introduce two R&D projects ongoing in the Photon Factory and their results obtained in FY2012.

5-1 Ultra-Fast Signal Processing System for a Si-APD Array X-ray Detector

The project team developed a prototype detector consisting of a 64-ch Si-APD linear array and its ultra-fast application-specific IC (ASIC) circuits, in FY2011. The linear array had 64 pixels of 100 μm × 200 μm with a pitch of 150 μm. The array device had a thickness of 10 μm to obtain a good time resolution of 100 ps. The front-end ASIC was newly designed to process fast pulses of nanosecond width and a high count-rate obtained from the Si-APD operating in the linear mode. In test measurements carried out at BL-14A, the prototype system revealed a 10-ns time resolution and a high count-rate of > 10^7 s^{-1} per pixel. Then, in FY2012, the team successfully measured the count distribution by 1-ns sampling with a new system using improved front-end ASICs and field programmable gate arrays (FPGAs). Figure 1 shows a result of the count distribution obtained from the No. 15 channel of the system in the hybrid-mode operation of the Photon Factory ring. The hybrid mode consists of single-bunch and multi-bunch electrons revolving in the accelerator ring. A fine X-ray beam of 8 keV hit the No. 15 pixel of the APD linear array. A time resolution of 1.4 ns (FWHM) was measured from the peak width of the No. 15 channel, fitted in the single-bunch part. To investigate laser-induced structural changes in some organic molecules, it is useful to record their X-ray diffraction patterns using a detector with a time resolution of less than 2 ns. Moreover, the 1-ns sampling will greatly decrease the measuring time in time-resolved experiments by using X-rays of 2-ns interval in the multi-bunch part.

5-2 Auger-Electron Detector System for Depth-Resolved X-ray Magnetic Circular Dichroism (XMCD)

The group working for beamline BL-16 has been preparing a multi-anode MCP detector system, which has an angle-resolution and a fast digital data read-out of 30 channels, instead of the system consisting of a CCD and a fluorescence screen. In the 10-Hz polarization switching of the insertion devices installed in BL-16, the new MCP system improved the S/N ratio and the dynamic range of output counts in XMCD measurements. In FY2012, a fast counting system using fast pulse-amplifier ASICs was tested for data acquisition at higher count rates of more than 10^7 s^{-1} per channel. The system is now undergoing improvements to the threshold-level setting in signal inputs and to the cross-talk of counting between ASIC channels.

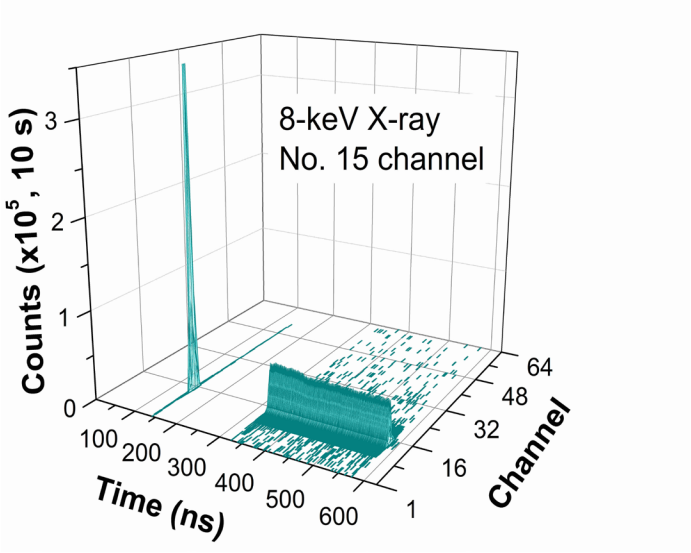

Figure 1: Continuous time distribution of 8-keV X-ray counts measured in the hybrid-mode operation of the Photon Factory ring.