5 IMSS Instrument R&D Team

The IMSS Instrument R&D team has been trying to develop a new detector system for material physics and biology since early May 2010. The detector R&D projects in the Photon Factory made steady progress in FY2011 as follows.

A. Ultra-fast signal processing system for Si-APD array X-ray detectors

The project team successfully developed a prototype detector consisting of a 64-ch Si-APD linear array and its ultra-fast ASIC circuits. 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 guarantee a good time resolution of 100 ps. The front-end ASIC was newly designed to process a fast pulse of nanosecond width and a high count-rate of more than 10^8 s^{-1}, which were obtained from the Si-APD operating in linear mode. The spatial resolution of 100-μm order will be useful for position-selective time spectroscopy with a 100-ps time resolution. The nanosecond response of the array detector will increase the efficiency of data acquisition in time-resolved X-ray diffraction measurements by using a shorter pulse interval such as 2 ns in the multi-bunch mode operation of a 500-MHz synchrotron ring. The team obtained test results with a 64-channel digital circuit using Field Programmable Gate Arrays (FPGAs) with a network processor for Ethernet, and confirmed that each channel of the prototype system had a 10-ns time resolution and a high count-rate of > 10^7 s^{-1}. Figure 1 shows a time-course count distribution observed by the detector system. A mirror-focused X-ray beam of 8 keV hit the linear array and the maximum count-rate was larger than 10^7 s^{-1} per pixel. Four blocks of 126-ns X-ray pulse trains and 30-ns gaps were recorded for the multi-bunch mode operation of the PF ring by the 10-ns time resolution. A faster FPGA will be mounted in the next system and will show a 1-ns time resolution.

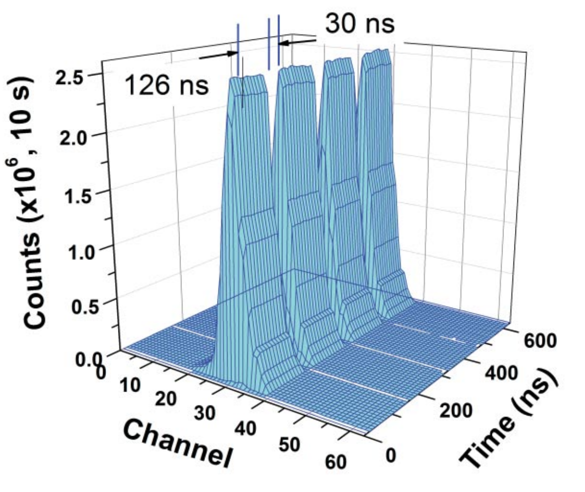

Figure 1
Time-course count distribution of 8-keV X-ray beam, measured by the 64-ch Si-APD linear array detector with a 10-ns time resolution.

B. Auger-electron detector system for depth-resolved X-ray magnetic circular dichroism (XMCD)

The XMCD group working at beamline BL-16 has been preparing a multi-anode micro-channel plate (MCP) detector system, which has an angle resolution and a fast digital data read-out of 30 channels, instead of the old system consisting of a CCD and a fluorescence screen. In the new operation of the 10-Hz polarization switching at BL-16, the MCP system is expected to improve the S/N ratio and the dynamic range of output counts in XMCD measurements. Continuous 1-kHz data acquisition from each channel was already successfully achieved in test operation of the 10-Hz polarization switching with the MCP system. Data acquisition at a high count-rate of > 10^7 s^{-1} is now being prepared by developing a fast counting system using a faster ASIC amplifier.

C. Improvement of position-sensitive detector system for small-angle scattering (SAX) experiments

The SAX group tried to improve data acquisition from a position-sensitive proportional counter (PSPC) installed at BL-10C by using an FPGA and a network processor. With the help of the IMSS Neutron Science Division, they developed the TDC-NET module, which converted the time difference between two outputs from the delay-line PSPC to the position of the incident X-ray. Further improvements are under consideration such as triggering a signal for controlling the conditions around a sample, coincidentally with data acquisition.

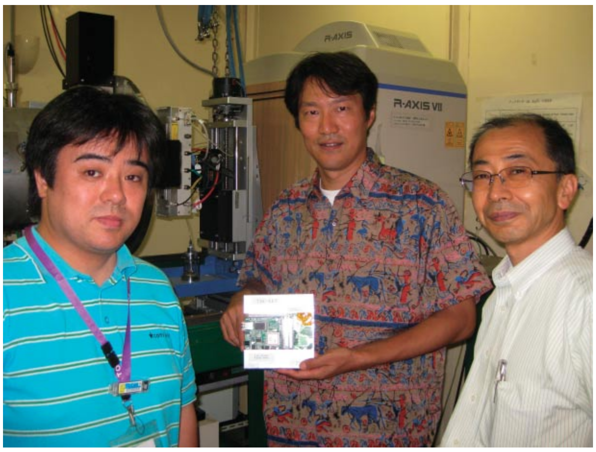

Figure 2
The SAX group with the newly developed data acquisition board.