New Time-Resolved Detector for Small-Angle X-ray Scattering Studies

J. P. Hessler[a], P. M. De Lurgio[b], G. Jennings[c], A. S. Kreps[b], S. Seifert[c], J. Weizeorick[b]

[a]Chemistry Division, [b]High Energy Physics Division, [c]Experimental Facilities Division, Argonne National Laboratory, Argonne, Ill. 60439 USA

Many new small-angle x-ray scattering (SAXS) studies of nano-sized systems will be possible by improving the time resolution to sub-μs and beyond. We have designed and are constructing a new time-resolved detector for SAXS that will have a resolution of ~300 ns. Finer time resolution will be possible in a pump-probe mode.

The detector is made from a 500 μm (thick) x 15 cm diameter disk of high-resistivity silicon. At 12 keV 92% of the x-rays will be absorbed in the silicon. Annular rings, which serve as the anodes, are etched into the back of the disk. The minimum radial width of the inner rings is designed to be comparable to the size of the incident x-ray beam, ~ 250 μm, while the outer rings maintain a $\Delta R/R \sim 0.02$, which is comparable to the energy resolution of the incident beam. This produces a detector with only 128 rings or channels. Sixteen additional channels are available for auxiliary information, such as the incident and transmitted x-ray intensity. The current from each channel is amplified by dual operational amplifier stages followed by an eight-pole optimized low-pass filter and five amplifiers. The signal from each channel is then digitized by a 20 MHz analog-to-digital converter (a time interval of 50 ns). Up to 60 averaged intervals, which form the 12-bit data word for a single frame, are stored every 3.68 μs (the period of the APS) in a DRAM. Up to 1048576 frames (3.85 s of continuous data) may be stored in the DRAM. Any combination of the 60 time intervals may be selected, via software, to provide the optimum signal-to-noise and time resolution.

The second phase of commissioning, with a monochromatic beam, was completed on Dec 13, 2004 at 12 ID-C. The evolution of the reaction $Na_2CO_3 + CaCl_2 \rightarrow CaCO_3 + 2NaCl$ to precipitate $CaCO_3$ was monitored in aqueous solution with a time resolution of 3.68 μs. A total of 815217 scattering profiles (frames) were obtained in a single experiment of 3 seconds duration. The third phase of commissioning, with a "pink" beam, will take place at 8 ID during run 2005-1. The first experiments are planned for run 2005-2.

This work and use of the Advanced Photons Source have been supported by the U.S. Department of Energy, Office of Science, Basic Energy Sciences, under contract No. W-31-109-ENG-38.