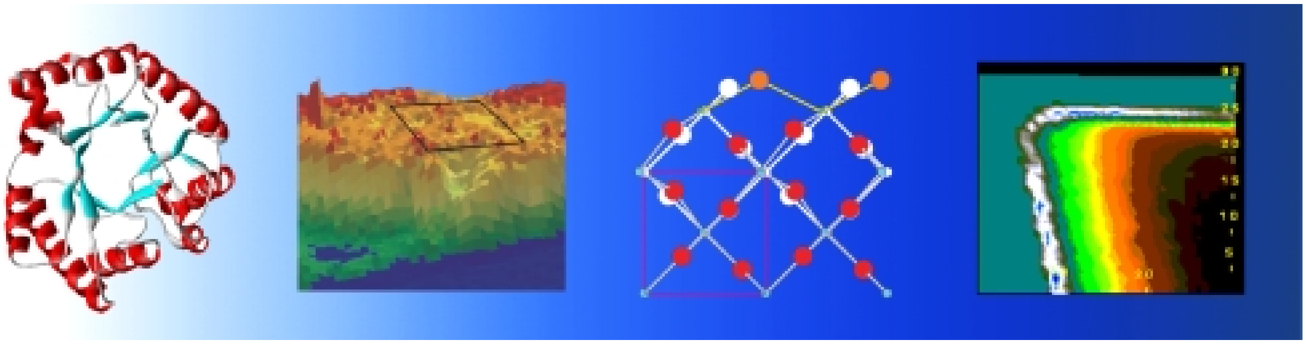
Workshop 6: Advanced Instrumentation

Dean Chapman, organizer

Thursday, October 11, 2001
1:30–5:00 pm



Great strides have been made in the development of high-performance instrumentation at the Advanced Photon Source and at other x-ray synchrotron radiation facilities. These innovations in devices, methods, and techniques for acquiring and analyzing experimental data have dramatically improved the quality and quantity of the data and have given us new and exciting insights into a wide variety of phenomena. This workshop will focus on several of these exciting and productive new developments.

1:30–2:00 pm	**Sagittal Focusing of High-energy X-rays** Zhong Zhong, *National Synchrotron Light Source*
2:00–2:30 pm	**Advanced X-ray Detector Development at NSLS** D. Peter Siddons, *National Synchrotron Light Source*
2:30–3:00 pm	**DetectorSync—What Is It and Where Is It Going?** Dennis M. Mills, *Advanced Photon Source, Argonne National Laboratory*
3:00-3:30 pm	**Refreshments**
3:30-4:00 pm	**Nanoscale Positioning with Large Dynamic Range: Recent Development Progress at the APS High Precision Instrumentation Group** Deming Shu, *Advanced Photon Source, Argonne National Laboratory*
4:00-4:30 pm	**New Methods for X-ray Absorption Fine Structure Spectroscopy** Grant Bunker, *Illinois Institute of Technology*
4:30-5:00 pm	**DuPont's Fiber Spinning Machine at DND-CAT: Capturing the Development of Fiber Structure at 5 Km/min** J. David Londono, *E.I. DuPont de Nemours and Co.*

Sagittal Focusing of High-energy X-rays*

Z. Zhong, *National Synchrotron Light Source, Brookhaven National Laboratory, Upton, NY 11973 USA*

The availability of high-energy x-rays with large horizontal divergence (of the order of 5 milliradians) at the bending magnet of the newer synchrotron radiation facilities such as the APS, and the wiggler beamlines at lower energy facilities such as NSLS, calls for effective and easy-to-implement focusing and monochromatizing optics. Traditional horizontal focusing methods, using mirrors or sagittal-focusing Bragg crystals, were limited at high x-rays energies, due to the large foot-print of the beam at these energies and the limited numerical aperture of mirrors. Curved multi-layer optics are promising if technical challenges can be met.

Sagittal focusing and monochromatization of high-energy synchrotron x-rays with asymmetric Laue crystals is proposed and demonstrated. At high x-ray energies, this is preferred because of the small extent of the beam's foot-print on such a crystal, and the ability to take advantage of the anticlastic-bending by using the inverse-Cauchois geometry in the meridional plane to improve energy resolution. Reflectivity curves of sagittally bent Laue crystals were measured, on planar crystal wafers, bent by a four-bar bender, at x-rays energies from 15 to 70 keV. A model for the diffraction properties of sagittally bent Laue crystals, which takes into account the anisotropy in the elastic property of the crystals, was developed. The widths of the rocking curves, calculated using the analytical model, were compared with measurements on crystals of three different orientations, (111), (100), and (511), over a total of five different zones. Results of depth-resolved rocking-curve measurements on selected zones are presented and discussed.

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Advanced X-ray Detector Development at NSLS*

D. Peter Siddons, *National Synchrotron Light Source, Brookhaven National Laboratory, Upton, NY 11973 USA*

The status of current synchrotron radiation detector development projects currently underway at BNL will be described. These include high-speed gas proportional counters, multi-element silicon spectroscopy systems and custom devices for special diffraction experiments.

*The work was supported by US DOE contract DE-AC02-76CH10886.

DetectorSync—What Is It and Where Is It Going?

Dennis M. Mills, *Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439 USA*

Steady progress in accelerator and insertion device performance at synchrotron radiation facilities worldwide has resulted in tremendous increases in x-ray flux and brilliance over the last decade. Needless to say to most researchers working at synchrotron radiation sources, detector progress has not kept pace with the above mentioned advances. In an effort to bring this critical issue to light, users and representatives from all the US synchrotron radiation facilities have recently formed an organization, DetectorSync, to promote a coordinated national initiative into the development of advanced detectors for synchrotron radiation science. This presentation will review what DetectorSync is about, what has happened to date, and where we are planning to go with this effort. But, perhaps most important is that the audience relay to the organizers of this effort what their needs are and suggestions as to how these needs can be most effectively met. Further information on DetectorSync can be found at:
http://www-esg.lbl.gov/esg/meetings/detectorsync/index.html

Nanoscale Positioning with Large Dynamic Range: Recent Development Progress at the APS High Precision Instrumentation Group*

Deming Shu, *Advanced Photon Source, Argonne National Laboratory, Argonne, IL 60439 USA*

Two major ultraprecision motion control techniques have been developed at the Advanced Photon Source (APS):
—A novel laser Doppler encoder system with multiple-reflection optics [1].
—A specially designed high-stiffness weak-link mechanism with stacked thin metal sheets having sub-angstrom driving sensitivity with excellent stability [2].

Recently, we have tested a linear actuator with 2 Å closed-loop control resolution and 50 millimeter travel range. Applications of this new technique to synchrotron radiation instrumentation are discussed in this presentation.

*This work was supported by the U.S. Department of Energy, Office of Science, under Contract No. W-31-109-Eng-38.

References

[1] D. Shu *et. al*., *SPIE Proc*. **3429** 284–292 (1998).
[2] D. Shu *et. al*., "Modular Overconstrained Weak-Link Mechanism for Ultraprecision Motion Control," to be published in the *Proceedings of 7th International Conference on Synchrotron Radiation Instrumentation, August 21-25, 2000, Berlin, Germany.*

New Methods for X-ray Absorption Fine Structure Spectroscopy

Grant Bunker, *Illinois Institute of Technology, Chicago, IL 60304 USA*

XAFS has long been a powerful technique for the study of noncrystalline materials such as amorphous solids, liquids, and metalloprotein solutions. However, several factors have limited the application of the method and kept it from achieving its full potential. In this presentation we describe our recent work which directly addresses several of these basic limitations through improvements in instrumentation and data analysis.

DuPont's Fiber Spinning Machine at DND-CAT: Capturing The Development of Fiber Structure at 5 Km/min

J.D. Londono, N. Agarwal, D.J. Brill, H. Chang, D. Clemens, R.V. Davidson, D. Dixon, P. Geoghegan, W.E. Guise, D.T. Keane, R.A. Leach, J. Potter, J.P. Quintana, and J. Stanley, *E.I. DuPont de Nemours and Co., Wilmington, DE 19880 USA and DND-CAT, Northwestern University, Evanston, IL 60208 USA*

A fiber melt spinning apparatus was installed at the Advanced Photon Source (DND-CAT). A one-inch diameter single screw extruder and associated extrusion equipment, weighing ca. 3000 lbs, sits on a pallet that can be raised 10 feet vertically. The vertical displacement of the spin head allows for study of structure development as a function of distance from the spinnerette. This unit is capable of processing melt-spun fibers from 0.5 to 10 lbs/hr at speeds up to 6000 mpm, which covers the speed range of most commercial spinning processes. It is well known that fiber properties depend on spin speeds, attenuation ratios, and polymer viscosity. Wide-angle x-ray scattering data were collected during the first set of experiments at a range of spin speeds from 500 to 4500 mpm. Nylon 66 "live" fibers did not exhibit well-developed, oriented crystalline structures during spinning at speeds below 2000 m/min. The crystalline structures formed at spin speeds greater than 2000 m/min are similar to those formed at elevated temperatures. The amount of crystallinity in "dead" yarns just after quenching is dependent on the spin speed.