

High Energy X-ray Science at the APS in 2013

The Advanced Photon Source offers unique capabilities in the Western Hemisphere for science using high-energy x-rays (defined loosely as photons between 50 keV and 120 keV). The 7 GeV operating energy of the storage ring is very well suited for the production of high-energy x-rays, and it is unlikely that any current or planned storage ring in the U.S. will approach the current high-energy x-ray performance of the APS. Worldwide, however, other facilities (e.g., the ESRF, PETRA-III) are pursuing upgrade paths that expand their capabilities and threaten the APS position as a leading world-class high-energy x-ray source. Fortunately, nearly every aspect of the APS high-energy x-ray operations benefits substantially from relatively straightforward upgrades possible in the five-year time frame. Upgrades in any of the areas will give marked increases in experimental performance for a wide range of scientific applications. Upgrades in all of the possible areas would give an increase in capabilities that is nothing short of spectacular.

Currently, three beamlines are essentially dedicated to high-energy x-ray usage: 1-ID, 11-ID-B, and 11-ID-C. The 6-ID beamline has a side station that is used part of the time for high-energy operations (sometimes parasitically with the low-energy branch and sometimes in a dedicated mode). A few other beamlines (e.g., 5-BM and 13-BM), occasionally operate in the high energy range, but it is not a major part of their operations.

A common factor for high-energy x-ray beamlines is that they are all limited in some way lack of optimization for high-energy x-ray operations. The 1-ID beamline was dedicated to high-energy x-ray usage in 2005, but supports three techniques that mutually limit each other. The 11-ID beamlines share 11-ID with a low-energy beamline, and are compromised in performance by this and their mutual interference with each other. Overall, the dedicated high-energy beamlines are heavily oversubscribed. The only way to address this serious problem without cutting healthy scientific programs is to expand the number of high-energy x-ray beamlines at the APS. The medium-term proposals by APS staff propose a new ID beamline, a new dedicated high-energy bending magnet beamline, and several steps to make current beamlines more independent towards this purpose. With expanded beamline availability, several instruments could be fully optimized, and high-energy x-ray capability would be significantly increased.

The move towards more specialized undulators has already started with the installation of 2.3-mm period devices at 1-ID and 11-ID in the last year. Further use of specialized devices will significantly increase the brilliance of the beamlines, in particular if ID vacuum chambers are modified to allow the closure to at least 9.5 mm. Tremendous gains in flux/brilliance are possible with superconducting undulator technology that is currently in development. Improvement in optics and use of customized beta-functions (w/o this horizontal size limit will be order of 5-10 μm) can provide focusing in two dimensions to the submicron level.

The use of large area detectors has revolutionized high-energy x-ray experiments at the APS in the last seven years. The GE amorphous-Si detector is in heavy demand with at least twice as many experiment requesting it as can be accommodated. A similar Perkin Elmer detector is being purchased and this will be of significant help in this respect. However, these detectors are based on technology that is aging, and by 2013 we expect considerable advances, most likely in detector speed and pixel resolution. Improvements in data handling, reduction and analysis are key to fully utilizing detector advances.

Finally, an important factor for high-energy experiments is the penetration possible through furnaces, cryostats, and other sample environmental chambers. Development of such ancillary equipment will continue on all high-energy beamlines. Optimizing and expanding high-energy beamlines will make more of these unique *in situ* experiments possible, including experiments using multiple probes (e.g., diffraction and SAXS, or diffraction and imaging).