Status of the APS Time-resolved capabilities in 2013, Eric Dufresne XSD July 29, 2008

The APS is the best machine in the world to perform time-resolved science that uses the bunch structure of its ring. Its 24 bunch and hybrid mode are ideal, since one can isolate x-rays from a single bunch with gated detectors such as Avalanche Photodiodes (APD), Silicon Drifts Detectors and Pixel Array Detectors (PAD). This is ideal from laser-pump/x-ray probe experiments, where the laser can be synchronized to the source and delayed with respect to the x-rays.

In 5 years, the APS will be commissioning its new Superconducting RF crab cavity sector. This new capability will deliver a short one ps duration x-ray pulse having a 6.5 MHz repetition rate and about 1-2 x 10^{11} ph/s. This source will be tunable from the soft to the hard x-ray range and provide some polarization selection. The source will complement the LCLS, as it will provide a significant flux of tunable high-energy x-rays and bridge the time resolution gap between the XFEL (100 fs) and the synchrotrons (100 ps). Since it operates in all the modes of operations of the APS, this new source shall foster the growth of the Ultrafast X-ray community.

With its excellent coherence and brightness, experimenters will push the frontier of nanoscience with the studies of novel materials with 10-20 nm x-ray nanoprobes and 100 ps time resolution. Some of these studies will have demonstrated a few picosecond time resolution with an x-ray sensitive streak camera. Experimenters in the field of atomic physics, material science and chemistry have developed high-repetition rate lasers that best use the source, with some experiments pushing the repetition rate as high as 6.5 MHz. The repetition rate will be limited by the sample damage or heating from the laser source. New high-power Ti:Sapphire laser will have been installed on several beamlines and some groups are using novel fiber lasers, or THz pulsed lasers in their experiments. Fs-laser pulse shaping has been demonstrated in coherent-control experiments.

Ultrafast imaging in full-field mode is now routinely observing irreversible processes with sub-microsecond resolution using the latest CMOS high-speed camera and long specialized undulators. In its 324 bunch mode, with suitable detectors, it could even push the study of irreversible processes to tens of nanoseconds. New communities will gather around these new tools to elucidate non-equilibrium phenomena. Note that in periodic processes, 32ID has already demonstrated imaging with the large hybrid single bunch of the APS achieving a resolution of 100 ps using a white beam, in conjunction with a high-speed chopper.

PADs are routinely used in time-resolved diffraction and spectroscopy having increased the efficiency of experiments by several orders of magnitude. Every time-resolved beamline is equipped with a PAD. The first semiconductor-based ultrafast area detectors are being tested around 2013. They will use arrays of fast diodes to resolve time-dependent phenomena within the bunch structure with a few picosecond time resolution. These fast diodes will start to compete with x-ray streak cameras which have achieved sub-picosecond resolution with x-rays.

With its new upgrade, beamline 8ID will be routinely studying dynamic correlation function with up to a microsecond resolution, and could push down the time resolution to 100 ns in some demonstration experiments with area detector. With a combination of new specialized undulators and long straight sections, the time-resolved community will benefit from flux increases by up to factors of 4-10 which will allow experimenters to push the frontier of time-resolved science.