A Macromolecular Femtosecond Crystallography MFX station at LCLS and integrated structural biology approaches using x-ray and electron beams

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Synchrotron radiation has transformed biology over the past few decades by providing brilliant beams of X-ray light for probing the structures of molecules. Now X-ray free electron lasers (XFELs) promise to usher in another new era, allowing scientists to tackle important questions previously out of reach. With beams 10 billion times brighter and pulses 1,000 times shorter than those available at synchrotron light sources, XFELs can provide structural information from crystallized samples by enabling diffraction data collection before samples are damaged or destroyed by XFEL pulses. The project aims (1) to develop a new instrument for diffraction, scattering, and imaging at the world’s first operational XFEL, SLAC’s Linac Coherent Light Source (LCLS) with a 2-year time frame, and (2) to optimize the macromolecular femtosecond crystallography (MFX) instrument for biological research.

As part of an integrated biology platform being developed at SLAC, MFX will open new frontiers in biology, medicine, bioenergy, and environmental science, enabling researchers to investigate complex biological phenomena.

The MFX station was initiated as a multipartner project in spring 2014 and the beamline and experimental hutch have been commissioned early 2016. MFX began real experiments with the start of the user program on July 1, 2016. Various sample delivery and data acquisition systems are currently being implemented, which will enable femtosecond serial crystallography, scattering and spectroscopy and promise to reveal the structures and dynamics of complex biomolecules or assemblies. An in-air goniometer system combined with a sample exchange robot, developed by Structural Molecular Biology Group of SSRL, can be used for streamlined automated in-air data collection. This setup on the MFX enables more efficient screening to assess whether a given biological system would benefit from LCLS. The availability of a dedicated station for these types of experiments combined with multiplexing of XFEL beams provides an optimized infrastructure for the most effective and efficient use of LCLS beam time. Initial experiences from the first set of experiments in July/August will be reported briefly.

The substantial expansion of the overall capacity and efficiency of LCLS x-ray facilities will form a core of the integrated imaging approaches including the well established synchrotron x-ray methods at SSRL, and cryoelectron microscopy suite and ultra fast electron diffraction (UED) and microscopy (UEM) which are currently being developed at SLAC.

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