Coherent Hard X-ray Beamline (CHX)

Scientific scope

The Coherent Hard X-ray (CHX) beamline at NSLS-II will be dedicated to studies of nanometer-scale dynamics in materials using x-ray photon correlation spectroscopy (XPCS), as well as to other experimental methods enabled by bright, coherent, x-ray beams. XPCS is based on measuring time correlation functions of the speckle fluctuations that occur when a coherent x-ray beam is scattered from a disordered sample. It can be used to measure equilibrium dynamics via the "usual" single-speckle intensity-intensity autocorrelation functions $g^{(2)}(q, t)$ When combined with 2D area detectors and a multispeckle detection technique, it can also be used to measure non-stationary, non-equilibrium dynamics via two-time correlation functions $g^{(2)}(q, t_1, t_2)$. Higher-order correlation functions $g^{(n)}(q, t)$ can be used to characterize heterogeneities in the dynamical properties.

The key quantity that enables XPCS experiments is the source brightness. This determines the flux of coherent x-ray photons and ultimately the signal-to-noise ratio (SNR) of the measured correlation functions. With the unprecedented brilliance of the NSLS-II storage ring exceeding, for a photon energy near E~8 keV, 10^{21} ph/s/mrad^2/mm^2/0.1 % bw (more than one order of magnitude higher than that of the Advanced Photon Source), the CHX beamline will allow studies of dynamics on time scales that can be ~10^2=100 times faster and on shorter length scales than was ever possible before (figure 1).

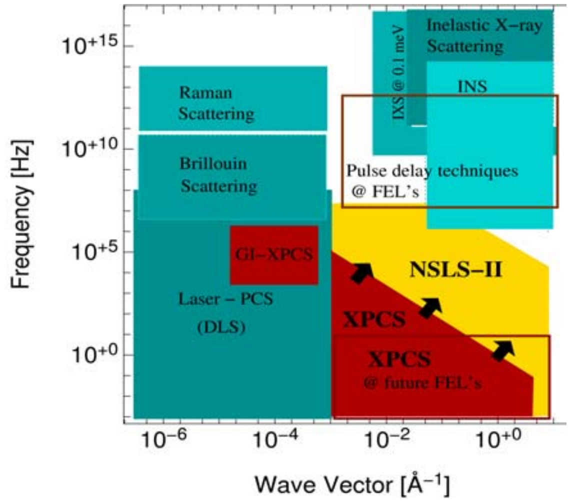

Figure 1 Phase-space currently accessible by XPCS at 3rd-generation light sources and projected region to be covered at NSLS-II. Smaller-length scales and/or faster time scales will become accessible at the CHX beamline, reducing, or even closing, the gap left open by techniques such as neutron spin echo and free electron laser pulse delay on the fast time scale side and today's XPCS experiments.

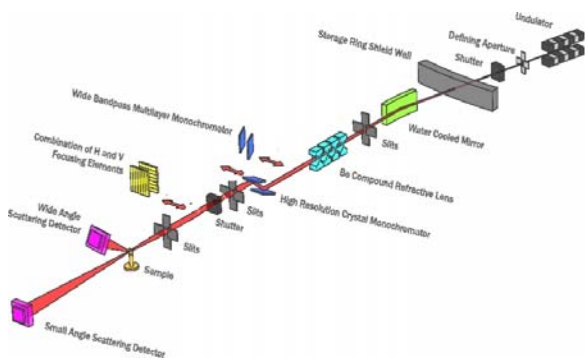

Figure 2 Schematic representation showing the optic layout of the CHX beamline.

Beamline description

The design of the CHX instrument is simple and robust (figure 2) and puts an emphasis on three key elements:

- coherence (brilliance) preservation by carefully designing and engineering key optical elements, reducing the number of windows, mirrors, etc. to an absolute minimum
- maximizing the useful signal by using the entire available coherent flux (via focusing optics)
- maximizing the mechanical stability of the instrument

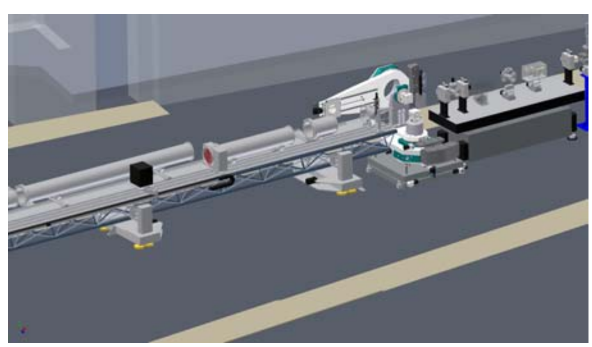

Figure 3 3D CAD model of the CHX endstation.

Endstation design

The experiments will be performed in a variety of scattering geometries such as small angle scattering (SAXS), wide angle scattering (WAXS) or grazing incidence small angle scattering (GI-SAXS) and the proposed instrument will

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provide the required flexibility to efficiently adapt to all these situations. A versatile five-circle diffractometer will allow hosting a large selection of sample environments for specific applications: cryo-furnace SAXS/WAXS chamber, various microfluidic environments, shear cell, Langmuir-Blodgett trough, etc.

Current status:	preliminary design
Construction:	starts January 2012
Commissioning:	begins June 2014
User operation:	begins June 2015

Beamline performance

Source	In-vacuum U20 Undulator
Energy range	6-15 keV (λ=2.07-0.83 Å)
Energy resolution	Si (111) DCM, $\Delta E/E \approx 10^{-4}$ (fwhm) DML, $\Delta E/E \approx 2\text{x}10^{-4}$ (fwhm) – pink beam
Coherent beam size (1σ) at sample (μm^2)	≈ 10 (v) x 10 (h) (for SAXS) ≈ 1 (v) x 3 (h) (for WAXS)
Coherent flux at sample @10keV ph/s (mono beam)	≈ 2 x 10^{11}

CHX team

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