HiRes-SWANS – High Resolution Small/Wide Angle Neutron Scattering

HiRes-SWANS is a single instrument that combines the features of a modest-resolution neutron diffractometer with a SANS instrument to probe length scales spanning from the interatomic out to tens of nanometers. The instrument takes advantage of the low STS repetition rate and being located as close to the moderator as possible to cover a broad Q-range. A flexible optics system will enable studies in a grazing incidence geometry. HiRes-SWANS is anticipated to have approximately 10x the time-averaged flux at sample as EQ-SANS.

Science Drivers

Bulk properties of soft matter derive from phenomena that impact a vast range of length and energy scales. Both bonded and non-bonded interactions produce local structure and function while also driving macromolecular behaviors such as self-assembly and long-range dynamics that ultimately give rise to bulk properties. While the large scale structures forming at 10's of nanometers that arise in soft materials are well-probed by small-angle neutron scattering, it is evident that a holistic picture of the structure requires simultaneously understanding interactions at the atomic-level. HiRes-SWANS will measure the evolution of structure and organization across a range of length scales critical to understanding, predicting and ultimately controlling the physical properties of wide classes of materials that are at the forefront of basic and applied research. The instrument will address topics including:

- Understanding the interplay of geometry (e.g. film thickness) and local interactions that drive supramolecular assembly.
- Elucidating the role of interfacial adhesion and chemistry that determine the mechanical strength and functionality of soft/hard composite materials.
- Structure and assembly of hierarchical, complex materials in solution.
- Characterizing process-dependent parameters in 3D-printed polymer composites, including density fluctuations and orientation derived mechanical properties.
- The mechanism of membrane fusion and local lipid reorganization.

Science Requirements

1. Broad dynamic range from 0.01 $Å^{-1} \leq Q \leq 6$ $Å^{-1}$; with high-Q resolution, $\Delta Q/Q \leq 0.01$.
2. Include grazing-incidence geometry/optics providing the ability to probe lateral organization as well as structures perpendicular to thin films.
3. Maximum beam size of 1 cm x 1 cm.
4. Open sample area, providing the ability to mount a wide variety of sample environments relevant to soft materials including vacuum ovens, humidity chambers, illumination systems, and simultaneous in situ spectroscopies.

Technical Description

HiRes-SWANS could be placed on the High-intensity coupled moderator; however, it could take advantage of the high peak brightness coupled moderator depending on design of the optics system. With a total flight path (moderator-detector) of approximately 20 m, the instrument will have a very broad wavelength band of approximately 20 Å at the STS 10 Hz pulse rate and be able to probe structures from sub-1 Å to 600 Å simultaneously. The instrument will include a multi-channel bender (with very high-index guide in order to transmit 0.5 Å neutrons), a focusing optics system, and flexible collimation. The optics design will also be capable of deflecting the beam downward to support grazing-incidence geometry. The low-angle SANS detector will be located 3–5 m from the sample, and the diffraction detectors at angles up to two-theta = 45° will be located approximately 1–1.5 m from the sample. The lowest-scattering angles will require relatively high spatial resolution and must be able to achieve high count rates.

Key parameters of HiRes-SWANS

Parameter	Description
Moderator	High-intensity coupled moderator/High-peak brightness moderator
Sample size	up to 1×1 cm^2
Moderator–sample distance	15–17 m
Sample–detector distance	1.5–5 m
Wavelength range	0.5 Å $\leq \lambda \leq$ 20 Å
Resolution	$\Delta Q/Q = 0.01$
Detector	0.8 cm diameter linear position-sensitive detector, ^{3}He Low-angle Anger camera (1.2 mm resolution)