**FLOODS – Flux-Optimized Order/Disorder SANS**

FLOODS is a time-of-flight SANS optimized for highest neutron flux onto small samples with a focus on relatively short length scales and disordered structures as well as time-resolved measurements. High flux is obtained with high neutron beam divergence at relaxed minimum Q and Q-resolution. In low-resolution mode, FLOODS will provide >$10^9$ neutrons/second across a 10 $mm^2$ sample which is ≈1000x higher flux than the current CG-3 Bio-SANS at HFIR. In high resolution mode, FLOODS will have a minimum Q and Q-resolution similar to EQ-SANS but with an order of magnitude higher count rate.

Science Drivers

In general, FLOODS will enable studies of any low contrast and/or weakly scattering samples. The increased neutron flux also improves the time-resolution for kinetics measurements. A particular area of benefit is intrinsically disordered proteins (IDPs). This protein class is shifting the structure-function paradigm in biology as it becomes clear that IDPs, or intrinsically disordered protein regions (IDRs), are highly prevalent in the human proteome (50% of all human proteins are either wholly disordered or contain disordered regions) and essential for function in many biological processes. Many proteins possess IDRs that exhibit heterogeneous, dynamic conformations that are influenced by their environment (e.g., pH, ionic strength, extent of molecular crowding, cellular localization, etc.) and interactions with multiple cofactors, substrates, and regulatory partners. Neutrons can greatly contribute to advancing this challenging area of research because of their unique ability in probing the heterogeneous conformations of disordered systems, in particular disordered regions of proteins. FLOODS will have sufficient beam power and neutron flux required to extract a very low intensity signal from small volume biological samples and will address topics such as:

- Establish relationships between disorder and function in IDPs and proteins with IDRs - A particular challenge with IDPs is that many become unstable with increasing concentration, leading to undesired precipitation. Furthermore, concentrations can be studied that more closely approach *in vivo* conditions.
- Rational drug design - Many critical-functioning and disease-relevant proteins are difficult to prepare in sufficient quantities for a conventional SANS measurement. For example, numerous drug targets are membrane-associated proteins that typically have low expression yields.

The high flux of FLOODS will also enable time-resolved studies including:

- Monitoring amyloid protein aggregation kinetics – it is a challenge to identify and characterize the earliest formed, transient species that are believed to be the most toxic.
- Observing the kinetics of phase transitions that drive phenomena in polymer science including phase separation, gelation, and self-assembly.

Science Requirements

The study of small volume, low-concentration samples and time-resolved kinetics requires an instrument with the highest neutron flux and the following characteristics:

1. A relaxed Q-resolution, $\Delta Q/Q$ ~20 – 50 % with a minimum Q of at least 0.1 $Å^{-1}$.
2. The ability to operate in a more conventional SANS mode with a dynamic range of at least 0.01 $Å^{-1} \leq Q \leq 0.5$ $Å^{-1}$.
3. A neutron beam with flexible optics able to focus on samples from 0.1 $mm^2$ to 10 $mm^2$.
4. Sample environments optimized for time-resolved experiments including stopped-flow and continuous-flow devices to support controlled in-beam mixing. The small beam focus will enable use of microfluidic devices.

Technical Description

With its focus on illuminating small samples with the highest neutron flux, FLOODS will optimally view the 3 x 3 $cm^2$ face of the high brightness coupled moderator at STS. With a total flight path of moderator to detector of 20 m, FLOODS will have a dynamic range in wavelength of 19.8 Å at the 10 Hz repetition rate of STS. FLOODS will include a multi-channel bender (and possibly a T0 chopper as well) in order to reduce instrument backgrounds as far as possible supporting the study of very small samples. The optics system will be adjustable, able to focus the neutron beam onto a sample as small as 0.1 $mm^2$. In high flux mode, the relaxed beam divergence of 2 deg (FWHM) implies that a minimum scattering angle ($2\theta$) of ≈8 deg is required to maintain $\Delta Q/Q$ at 50% as the resolution is dominated by the beam divergence. $Q_{min}$ under these operating conditions will be <0.044 $Å^{-1}$ at the longest wavelength, 19.8 Å, accessed in first frame operation. Adjustable collimation can reduce the beam foot print on the detector and reduce $\Delta Q/Q$, allowing for a more conventional SANS set up.

With a focus on small coherent scattering cross sections in samples that typically have high incoherent background from hydrogen (an even deuterium), methods for suppression of incoherent scattering will be extremely valuable. Methods that should further be investigated for potential suitability include: (a) choppers that remove in background from inelastic scattering (i.e., thermalization of cold neutrons in hydrogen-rich samples), (b) dynamically polarized hydrogen, and (c) spin-polarization/analysis. All of these methods have specific limitations and drawbacks, and their suitability for FLOODS needs further R&D.

**Key parameters of HiRes-SWANS**

| Parameter | Description |
|---|---|
| Moderator | High-peak brightness moderator (3 x 3 $cm^2$ face) |
| Sample size | 0.1 $mm^2$ to 10 $mm^2$ |
| Moderator–sample distance | 17 to 18 m |
| Sample–detector distance | 2 to 3 m |
| Wavelength range | 0.5 Å ≤ $\lambda$ ≤ 20 Å |
| Resolution | variable $\Delta Q/Q$; 20 – 50% |
| Detector | 0.8 cm diameter linear position-sensitive detector, $^3He$ |