

Detector upgrade drives new scientific capabilities at the Bio-SANS Instrument

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The Bio-SANS instrument is ideally suited for studies of biomacromolecules including proteins, DNA/RNA, lipid membranes and other hierarchical complexes. A wide-angle detector bank was installed on Bio-SANS in 2016. The combination of the main detector and new wing detector has extended the q range to $\sim 1 \text{ \AA}^{-1}$, which is unprecedented for reactor-based SANS and expands capabilities beyond the small-angle regime. Length scales spanning $\sim 0.7 - 300 \text{ nm}$ ($0.002 - 0.9 \text{ \AA}^{-1}$) or $\sim 3 - 600 \text{ nm}$ ($0.001 - 0.2 \text{ \AA}^{-1}$) can now be obtained in a single measurement. This detector expansion nearly doubles the active detector area and increases the Bio-SANS dynamic scattering vector range 15-fold to a new dynamic range greater than 200. In addition, data collection times are decreased by up to a factor of ~ 2 . New science opportunities include, *in situ* kinetic processes using time-resolved SANS, and studies of hierarchical and complex biological systems with simultaneous access to multiple length scales. The added detector bank builds on ORNL in-house technology that has been demonstrated to be successful on Bio-SANS since 2012 when its main detector was replaced. The main Bio-SANS detector has count rate capabilities ($>10^6 \text{ Hz}$) that enable utilization of the full potential of the high neutron flux from the cold source. Several sample environment capabilities are available for studies of biological systems using neutrons. These include a pressure cell to monitor chemical reactions *in situ* such as biomass pretreatment studies, a multi-position sample holder with rotational (tumbling) capability especially useful for studying suspensions, a humidity-controlled chamber critical for membrane studies and a flow cell for systems that partition to multiple phases (e.g. microemulsions) with additional capability of flowing one or two phases during measurement. Furthermore, grazing-incidence SANS in conjunction with a humidity chamber is available for studies of biomembranes and substrate-supported biosensors. Remote data reduction for the Bio-SANS user community is now available from a centralized analysis cluster at the SNS. The BDL features a bioreactor system that supports working volumes from 700 ml to 7.5L in addition to a parallel bioreactor system (4 x 250mL). Both systems allow high-density cell growth with precise control and monitoring of dissolved oxygen, pH, agitation, and feeding rates. Other new laboratory capabilities include a Rigaku single-crystal diffractometer, a Rigaku Bio-SAXS small-angle x-ray scattering instrument, liquid handling robots for preparing crystallization screens, and a suite of incubators for temperature-controlled protein crystallization.