Design and Development of the New SANS at LENS

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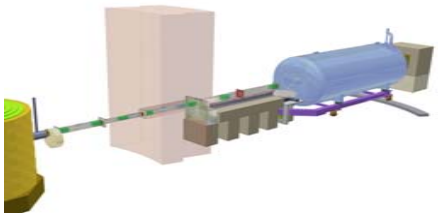
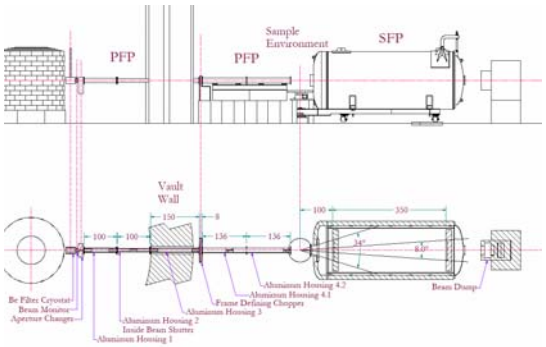
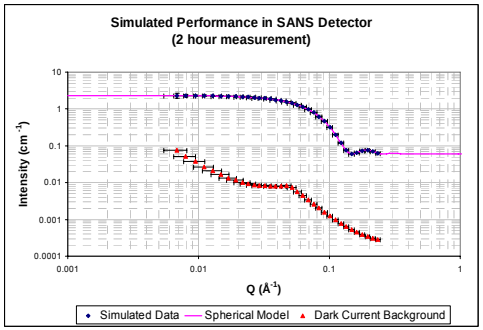
The new SANS instrument at LENS will be placed on one of the facility's four beam lines. It will utilize pinhole collimation and cover a Q-range of 0.006 - 0.5 Å^{-1} with an expected integrated flux of greater than 10^4 n/cm^2/sec at the sample position. The instrument is designed both for scientific studies and as a test bed for neutron optical devices.





Design Criteria / Instrument Parameters

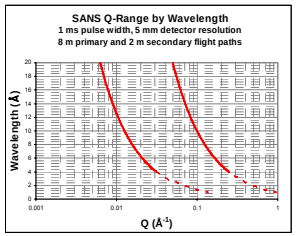
- Wavelength range: λ = 4 Å– 20 Å at 20 Hz
- Instrument will view up to a 10 cm diameter circle on the moderator
- Standard sample size: 1.5 cm diameter
- Primary flight path (PFP) length: 8 m
- Secondary flight path (SFP) length: 1 m - 4.5 m, variable
- Q-range: Q = 0.006 Å^{-1}– 0.5 Å^{-1}
- Q-resolution: 5% - 20%
- Integrated neutron flux on sample: Φ > 10^4 n/cm^2/s within wavelength range with proton accelerator power at 13 MeV and 20 kW
- Intrinsic background count rates < 10 cm^{-1} (low-Q) and < 0.1 cm^{-1} (high-Q)

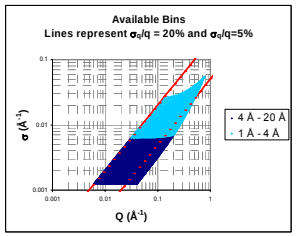


Simulated Performance in SANS detector:

The dark current in the SANS detector has been measured to be ~0.5 counts/s over the ~4 x 10^4 cm^2 of detector surface. The graph to the left illustrates where this dark current would be compared to the modeled scattering from a representative sample. A standard spherical model was used assuming spheres with a radius of 30 Å, 5% volume fraction, SLD contrast of 2 x 10^{-6} Å^{-2}, and a uniform incoherent background of 0.06 cm^{-1}. These parameters correspond to a class of dendrimers we have been studying.

Horizontal error bars were calculated based on the resolution of radial / time bins contributing to the signal. Vertical error bars represent anticipated statistical precision for each q-bin. The instrument was assumed to be operating at 13 MeV at 15 Hz with a 1 ms pulse width and a 20 mA peak current.





SANS Resolution:

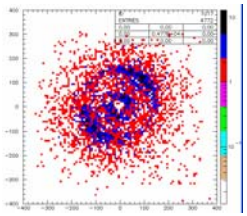
The graphs above show calculated resolutions on a 8 m primary path and 2 m secondary path configuration. The pulse width is 1 ms, and the pinholes are taken to be 10 cm in diameter at the moderator and 1.5 cm in diameter at the sample. The detector resolution is taken to be 5 mm, and the timing resolution is taken as 100 μs. Corners of the square detector have been ignored, resulting in a reduction in maximum Q.

Indiana University's Low Energy Neutron Source

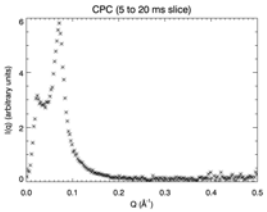
The Low Energy Neutron Source (LENS) will be the first university-based pulsed neutron source in the U.S. By utilizing low energy (p,n) reactions in a beryllium target coupled to a light water reflector and cold methane moderator, LENS is expected to produce time-averaged thermal neutron fluxes suitable for neutron scattering and development of instrumentation. The facility is seen as playing a role similar to that played by many of the national-scale research reactors in Europe. It has a three fold mission to perform research with neutrons, educate students in neutron science and develop new neutron instrumentation and technology.

Preliminary Diffraction Data:

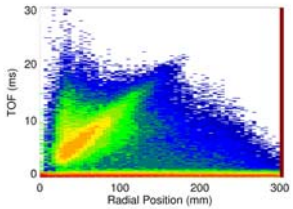
Several trial measurements have been taken on a temporary prototype instrument operating at about 0.5% of eventual maximum accelerator power. The measurements below are of Cetyl Pyridinium Chloride (CPC), a ~2% scatterer with an asymmetric scattering pattern. The measurement time on the prototype instrument was 11 hours. The data are compared with results on the same sample obtained at NIST.



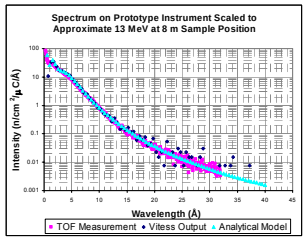
Counts on detector in 17 ms to 18 ms time bin (~11-12 Å). The image is of raw data with no background subtraction.



I(q) for CPC sample is plotted in arbitrary units. A D_2O background has been subtracted.



Histogram of counts on detector as a function of radial position and TOF. Color scaling is arbitrary and has been adjusted to enhance appearance of signal. The image is of raw data with no background subtraction.

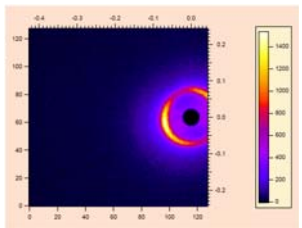


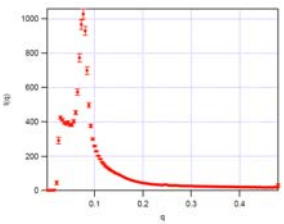
SANS Spectrum:

The graph on the left shows TOF measurements taken on the prototype instrument at low accelerator power using a low efficiency ^{3}He detector. The data have been scaled to the expected performance at 13 MeV. The vertical axis was calibrated by activating a gold foil at the detector position. An analytical model (with ~30 K tail) was fit to the TOF data and used as input for both VITESS simulations and analytical calculations of expected instrument performance

SANS Timeline

First Neutrons – December 2004
First Cold Neutrons – April 2005
First Scattering Signal – October 2005
Upgrade to ~3 kW from ~100 W with klystron installation – Fall 2006
Upgrade to 13 MeV from 7 MeV with accelerator upgrade – Summer 2007
Eventual Power target with 13 MeV is ~20 kW (50 mA with a 3% duty factor)





CPC Sample data taken at NIST:

The CPC sample and scattering data (left) taken on the NG3-SANS instrument at NIST has been provided by David Worcester (University of Missouri / NIST) and Boualem Hammouda (NIST).

The vertical scale on the I(q) curve is in arbitrary units.

Proposed / Ongoing Research Projects:

- Solidification in confined geometries
- Study of hydrogen storage materials
- Clay mineral suspensions / complex fluids
- Characterization of core-shell magnetic nanoparticles
- Micelle / Vesicle structure and transitions
- Characterizations of novel dendrimer structures
- Studies of virus structure in various media
- Characterization of polymer networks
- Intrinsically disordered proteins

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