Probing Nanoscale Complexity

What do coherent soft x-rays from an FEL offer?

- Excellent contrast to exotic material phases and biological systems with few nm spatial resolution in 3D (10 nm demonstrated)
- Field of view of a few microns: full cell imaging, robust statistical ensemble of nanoscale domain structures, etc. (demonstrated)
- Probe real and q-space on equal footing: robust statistical averages from coherent scattering complemented by detailed microstructural information from diffractive imaging (in progress)
- Access thermally-driven fluctuations simultaneously with nanoscale spatial sensitivity using correlation spectroscopy (initial experiments)
- Single-shot nanoscale imaging with or without pump-probe cycling (demonstrated)
- Probe ultrafast thermal fluctuations using probe-probe techniques (to be demonstrated)

Issues and Difficulties

- Huge advances can already be enabled at third generation sources by improved detectors; limited dynamic range and readout time of CCD's; need for pixelated detectors with on-chip processing

- Optimal time structure for correlation spectroscopy is CW; single shot imaging, probe-probe, and many other experiments need ultrafast capability

- Pulse-to-pulse stability is a key issue in several experiments; need to develop robust techniques to normalize variations

- Radiation damage is a serious issue already in soft and some hard materials at third generation sources; efficient use of photons will help