

SYnergy of Soft and Tender X-rays for Earth Research (SYSTER)

Research conducted by the Earth and Environmental Science (EES) community involves basic and applied research activities to understand Earth processes, including those affecting human and ecosystem health. The EES community makes use of synchrotron soft, tender, and hard X-ray instruments across all available spatial resolutions (nanometer to bulk) for imaging, spectroscopy, scattering, and more. Among these, X-ray techniques in the soft and tender regimes are critical capabilities. Soft-X-ray methods enable the chemical characterization of light elements, particularly carbon and nitrogen, that are central to life on Earth and participate in key element cycles in the lithosphere, hydrosphere, and atmosphere. Tender-X-ray methods enable the analysis of elements having abiotic and biotic roles in Earth surface systems (e.g. sulfur, aluminum, silicon). The U.S. EES community does not have adequate access to synchrotron methods in these energy ranges.

This facility proposal, “*SYnergy of Soft and Tender X-rays for Earth Research*” or SYSTER, will focus on soft and tender X-ray spectromicroscopy for EES applications at the Advanced Light Source (ALS). The SYSTER program will increase the amount of soft and tender X-ray spectromicroscopy instrument time available to the EES community in the near term, enable ESS support for advanced spectromicroscopy following the ALS upgrade, and create a community of practice that can train EES researchers new to synchrotron approaches and drive innovations in data collection and analysis. SYSTER will work to develop both high spatial resolution and high throughput spectroscopy to ensure that leading-edge nano-scale observations are put into an environmentally relevant context.

The ALS is the premier soft X-ray source in the U.S. and uniquely poised to host the SYSTER program. In addition to a strong portfolio of X-ray spectromicroscopy and ptychography instruments, the ALS provides complementary hard X-ray microprobe spectroscopy, diffraction, and tomography, as well as infrared imaging and spectroscopy. With the planned ALS upgrade for coherent soft X-rays, the ALS has a strong future in imaging, spectroscopy, and ptychography. With SYSTER, the EES community can be an integrated part of that future.

Through an Approved Program, the SYSTER program will support two early career Researchers at the ALS. We will invest in the development of an EES focused spectromicroscopy program with three main goals involving four specific endstations, two bend magnet (BM) and two insertion device (ID) lines:

- 1. Immediate Access to Soft X-ray Nanoscale Imaging and Spectroscopy (200-2000 eV):** Endstations 5.3.2.2 (BM) and 11.0.2.2 (ID);
- 2. Development of Soft to Tender X-ray Nanoscale Imaging and Spectroscopy (200-2600 eV):** Endstations 5.3.2.1 (BM) and 7.0.1.2 “Nanosurveyor 1”(ID);
- 3. Increased Capacity and Training:** The programmatic goals will increase the total amount of scanning transmission X-ray microscopy (STXM) beamtime available and increase EES access to STXM instrumentation. Synchronized use of BM and ID STXMs allows for a more comprehensive study (more samples investigated) with high resolution analysis on samples known to be representative. To make the most of the STXM instruments, many in the EES community will need application specific training. We will create and host three workshops. Each workshop will address the needs of new and experienced users by disseminating the latest best practices regarding: (a) integrated study design for EES researchers, (b) sample collection, preparation, and analysis, and (c) data curation, analysis, and reporting.