Dedicated Bending Magnet for Geomaterials Characterization

Prepared by Matthew Newville, Antonio Lanzirotti

Existing Facility __ Existing Facility with major enhancements ___ New Facility _x_

Abstract

We propose to develop the existing but currently unused bending magnet beamline at APS sector 14 with an end-station to provide core X-ray techniques for the characterization of a wide variety of geological materials. This beamline will produce monochromatic X-rays with a size range from 10x10 μm to 2x15 mm for bulk and meso-scale (10x10 μm to 100x100 μm) X-ray absorption spectroscopy (XAS), X-ray fluorescence (XRF) imaging, X-ray diffraction (XRD), and X-ray computed tomography (CT), with optional future developments including high-energy resolution fluorescence detection (HERFD) XAS. As with other micro- and meso-scale beamlines, these methods are compatible with each other and can be used on for "multi-modal" analysis of some samples. We propose X-ray optics to give an energy range from 2.1 to 42 keV (P K-edge through Ba K-edge and L-edges of heavier elements) with Si(111) and Si(311) crystals, and also allow pink-beam up to 42 keV for some high-speed CT measurements. Some dedicated end-station equipment will be needed, but some surplus equipment and detectors from APS sector 13 can be moved to this station or shared with APS 13-ID-E and other existing end-stations.

This beamline is expected to serve the low-temperature geochemistry community studying planetary materials, environmental, and soil sciences, but will provide methods for the broad geoscience community. The instrumentation at this beamline will be complementary to the state-of-the art APS beamlines serving geoscientists, including the X-ray microprobe at APS 13-ID-E, surface and interface scattering program at APS 13-ID-C, high-pressure programs at APS 13-ID-D, nuclear resonant and inelastic scattering programs at APS 3-ID, and other APS beamlines. In particular, this beamline will complement and be a sibling beamline to APS beamline 13-ID-E and recover some of the lost capabilities at US synchrotron facilities for core competencies and characterization methods such as bulk XAS that have negatively impacted the geochemistry community. This beamline will have a strong and dedicated program for education and outreach by providing easy-to-use access to basic synchrotron methods for training students and scientists new to synchrotron methods. We will set aside about three weeks of beam time per year at this beamline explicitly for educational programs including short courses, webinars, and providing a virtual classroom for teaching synchrotron methods.

With an initial investment in capital equipment to outfit the X-ray optics for this beamline, a new facility can be brought online that supports these core synchrotron methods used by the entire geoscience community. The proximity with the experienced GSECARS staff already serving these communities means that the current staffing level of the GSECARS microprobe and microtomography program as outlined in the GSECARS overview (4 full-time staff), will be able to run this beamline by having a continuous post-doc for planetary science and/or low-temperature geochemistry at the combined beamlines of 14-BM, 13-BM, and 13-ID.