A New White/Pink-Beam Station 14-BM-D Serving the Broader Earth Science Community

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This proposal seeks to develop the 14-BM-D beamline at the APS to serve the broader geoscience community. 14-BM-D is a bending magnet beamline built in the late 1990's by the BioCARS group for macro-molecular crystallography but has not been used for many years. It is capable of white beam and pink beam operation, which is a scarce resource at the APS. The beamline enclosures and safety systems are already built, and thus converting this beamline to geoscience experiments is at least 10 times lower in cost than building an entirely new beamline. The items that are needed are the x-ray optics (x-ray transport, slits, and a focusing mirror), shielded x-ray transport, and the end-station experimental equipment.

We propose to dedicate the 14-BM-D station to two experimental techniques: (1) White and pink beam tomographic imaging at ambient pressure and at relatively low pressures and temperatures in tri-axial deformation and fluid flow cells, and (2) white and pink beam diffraction and imaging in a 1000-ton capacity large volume press.

Currently, four out of five stations at GSECARS, except for 13-ID-E (spectroscopy station), are shared by multiple techniques. Beam time has been highly competitive. For the past 5 years, the beam time allocated to the large-volume press (LVP) program was equivalent to about 65% of a single station per year. Of all the received shifts, 32.3 % and 54.7% were white or pink beam experiments in 13-BM-D and 13-ID-D, respectively. Similarly, the computed microtomography (CMT) program averages to about 30% of a single station's beam time per year. Thus, under the current highly competitive beam allocation constraint, LVP and CMT programs take up about 95% of the single station's beam time.

The new station will allow us to increase user beamtime for the above techniques and provide additional capabilities that are not currently available at the existing GSECARS beamlines. It will yield more beam time to the highly oversubscribed DAC program in 13-ID-D and the Surface/Interface program in 13-ID-C, to accommodate heavy user demands. In addition, 13-BM-D will become a primarily monochromatic station, making it possible to offer an x-ray absorption spectroscopy program. This is a highly sought-after capability by the geochemistry community, one of the areas targeted in the new NSF solicitation.

Both the LVP and CMT programs have the potential to significantly expand our technology portfolio to serve the rock mechanics community, which has been under-represented at synchrotrons. Therefore, we propose to develop additional white- and pink-beam techniques in 14-BM-D for the rock mechanics community. These include focused and defocused pink beam to a 1000-ton press, for mapping stresses in large rock samples during faulting, cryogenic deformation for studying rheology of various high-pressure phases of ice, torsional shear deformation of complex rocks with 3D imaging, and oscillating deformation at seismic frequencies to study rock anelasticity. For the CMT program, development of triaxial cells with pore fluid control and acoustic emission monitoring capabilities will greatly enhance synchrotron technique for in-situ studies on fluid-rock interactions. These new capabilities are a direct response to the rock deformation community's need to address pressing earth science issues as identified in the 2020 decadal report *Earth in Time* prepared by the National Academy of Sciences, Engineering, and Medicine.

To achieve these goals, some new equipment items are required, in addition to beamline optics. We estimate a total budget of $1.4 million for all beamline optics components, a 1000-ton press with its positioning and detection devices, and table and sample stages for the CMT. Essentially all the high-pressure modules currently being used at GSECARS can be shared with 14-BM-D, with no additional cost. We propose to manage this station under the general GSECARS programs. Yanbin Wang, Tony Yu, and Mark Rivers will contribute to the design, installation, and operation. To better serve the broader ESS user community, we request a full-time beamline scientist position to provide full support for this beamline.