September 2019

X-ray Science Division Strategic Plan

The X-ray Science Division (XSD) at the Advanced Photon Source (APS) develops cutting-edge instrumentation and techniques to enable and perform world-class research using X-rays. This strategic plan lays out objectives to address the challenges XSD faces to achieve this mission, and provides a framework for how the Division will support our staff, beamlines, and users.

Guiding Principles

To enable great science, XSD requires both state-of-the-art facilities and highly-skilled staff. The continued evolution of our beamline portfolio; the hiring, development, and retention of talented scientists, engineers and technical professionals; and the expansion of the depth and breadth of our user community are essential in keeping the APS at the forefront of scientific research.

Vision

To fulfill our mission, XSD will:

- Develop world-class X-ray capabilities that address problems relevant to current and future scientific needs.
- Attract premier researchers teams from a wide range of scientific disciplines by providing top-of-the-line beamlines and outstanding user support.
- Maintain a safe, vibrant, challenging, diverse and inclusive work environment that fosters excellence and innovation, such that the APS continues to be the top choice for scientists, engineers, and technical staff pursuing careers at synchrotron light sources.

Strategy

To achieve the XSD vision, we must concentrate on the following components:

- *Invest in our people*: The XSD staff is key in providing the scientific vision for the future as well as the technical and scientific leadership for the facility. We must attract, retain and invest in our staff, the scientists, engineers and technical support personnel who will become the next generation of leaders and innovators at the APS. We must provide clear career advancement paths, R&D resources, and opportunities for professional growth.
- *Invest in beamlines*: As the APS upgrade nears, the APS beamline portfolio must shift to take advantage of the new and unique source characteristics that will become available. XSD will continue to operate and develop the most innovative, relevant, and effective beamlines.
- *Invest in R&D*: Continued advancement of methods development and technical support is critical to maintain the APS as a world-leading research facility. The development of wavefront preserving optics, engineering of high stability beamline components, robust nano-positioning instrumentation, advanced beamline controls, *in-situ* / *operando* sample environments, and new detectors are needed to make full use of current and future capabilities. Further, the rapid

advances in detector technologies are producing ever larger data sets that require new paradigms for data transfer, storage, reduction, and interpretation, not only for effective use of the capabilities of the APS today but even more so after the upgrade. All of these are critical science-enabling technologies that permit and promote discovery.

- *Invest in our users*: The success of the APS is ultimately measured by the impact of the science produced by our users. We therefore must prioritize and allocate resources to ensure the highest level of user support. Further, we need to expand outreach efforts in order to attract known and new scientific communities, with particular emphasis on areas that will benefit greatly from the APS upgrade.

Priorities

XSD will focus it's resources on four key priority areas:

1. **Brightness and coherence driven beamlines and techniques**

The APS source after the upgrade will provide world-leading beam coherence and high brightness. These beam characteristics greatly enhance experiments in the areas of imaging, microscopy, ptychography, coherent diffraction, and XPCS. The upgraded APS will make possible completely new experiments not feasible today. To work towards the upgraded APS, we will give the highest priority to beamline improvements, beamline staffing and beamline technical support that enhance these areas, and work today to establish methods and techniques that can take full advantage of the upgraded APS source in the future.

2. **High-energy beamlines and techniques**

The APS is unique amongst the present U.S. light sources in providing highly brilliant X-ray beams at high energies (>20 keV). XSD staff have exploited this feature to provide a number of world-leading capabilities in Materials Science, Chemistry, Extreme Conditions, etc. After the upgrade, the APS will have significantly enhanced flux densities at high energies, as well as greatly increased degrees of coherence. Utilizing these unique features will require the development of high-energy techniques and instrumentation (e.g., optics, focusing, detectors...).

3. **Timing and high-speed imaging capabilities**

The current APS bunch pattern, with a routine operating mode employing a large inter-bunch separation, is unique among third-generation synchrotron sources. This has led to the development of a number of novel ultra-fast x-ray imaging, scattering, and spectroscopy capabilities at the APS. The upgrade will support a 48-bunch pattern with a similar large inter-bunch separation. To retain the existing and unique strengths in high-speed measurements at the APS, we will continue to invest in this area, particularly where coupled to new approaches that leverage brightness, coherence and/or high energies.

4. **Beamline operations and development**

The APS serves a large number of users across highly diverse fields, who benefit greatly from excellent beamline capabilities and outstanding staff expertise. We will

continue to optimize and invest in valuable, sought-after programs and facilities, including but not limited to high-throughput approaches, core capabilities, etc.

Implementation

The APS X-ray Science Division develops novel X-ray instrumentation and techniques, and is responsible for the operation of APS-supported beamlines. XSD will need to maintain the productivity of these beamlines while simultaneously transitioning to a portfolio of beamlines and instruments that will more fully exploit the unique characteristics of the upgraded APS. Accomplishing this transition will require directing investments towards beamlines and technologies aligned with APS-U. Where possible we will seek to leverage these efforts through collaborations with Collaborative Access Teams, Argonne Divisions, and other light sources both within and beyond the DOE complex. Choices will have to be made to close and/or restructure particular research programs as part of the evolution of the facility. The newly available resources can then be redirected to enhance programs aligned with anticipated future user demand resulting from the scientific opportunities provided by the APS upgrade.

Goals and Action Plan for FY2020

- *Maintain active and productive user programs on XSD operated beamlines, and develop innovative instrumentation that further advances the beamline capabilities.*
- *Develop the full final designs for the APS-U feature beamlines. Finalize plans for APS-U funded enhancements to the other XSD beamlines. These APS-U enhancements will be coordinated with other operations-funded beamline improvements.*
- *Work with APS-U personnel on finalizing construction of the APS-U IDEA beamline. Implement a long-range R&D plan for optics and instrument testing, and deploy the RAVEN ptychographic laminography instrument on this beamline.*
- *Work with APS-U staff on the construction and commissioning of the 25-ID Advanced Spectroscopy beamline. After commissioning, transfer spectroscopy programs from 20-ID, and start consolidation of time-resolved spectroscopy programs from 11-ID-D and 7-ID onto 25-ID.*
- *Complete on-going major beamline upgrades:*
    - *Cant 2-ID to enable fully independent operation of the D and E stations in order to enhance nano-scale scanning-probe capabilities essential for APS-U*
    - *Implement High-Throughpout High Energy Diffraction Microscopy (HT-HEDM) at the newly extend 6-ID-D beamline.*
- *Continue use of the Modular Deposition System (MDS) for fabrication of novel multilayer optics.*
- *Implement scientific computing strategies that leverage on-demand high-performance computing resources at the APS and Argonne in the context of APS*

and APS-U, and through partnerships with other BES light sources and ASCR facilities.

- *Continue to refine strategy for beamline optics, detectors, instrumentation, controls, and computing, keeping it aligned with current and future APS priorities, while developing approaches for beamline and instrument design that incorporates all aspects of X-ray technologies.*
- *Address on-going obsolescence issues at the beamlines through a coordinated multi-year plan to replace key components.*
- *Contribute to R&D for future x-ray light sources by supporting work to advance XFEL oscillators and high-repetition high-brightness electron sources.*
- *APS management, XSD management, XSD group leaders and senior scientific and technical staff will together continue to develop a long-term vision for the XSD beamline portfolio with input from the APS user community, consistent with the roadmap for the APS-U beamlines.*