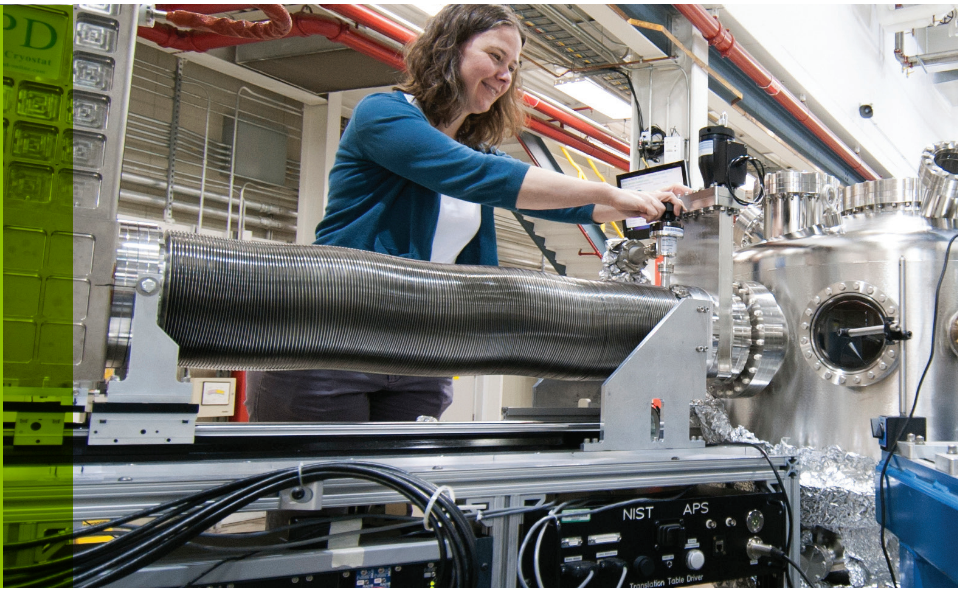
Argonne NATIONAL LABORATORY

INTERMEDIATE ENERGY X-RAY (IEX) BEAMLINE AT THE ADVANCED PHOTON SOURCE



Jessica McChesney, APS beamline scientist, connecting the transition edge sensor (TES) detector to the resonant soft X-ray scattering (RSXS) endstation.

Types of samples you can bring to the beam

- Bulk single crystal
- Thin films

Types of Sample Environments

- Ultra-high vacuum (UHV)
- Cryogenics

Applications

- Materials Science
- Condensed Matter Physics
- Molecular Chemistry

Researchers working to create next-generation electronic systems and to understand the fundamental properties of magnetism and electronics have a new cutting-edge tool in their arsenal to help them tackle grand challenges such as quantum computing. The Advanced Photon Source (APS), a U.S. Department of Energy (DOE) Office of Science User Facility located at Argonne National Laboratory, recently unveiled a new capability: the Intermediate Energy X-ray (IEX) beamline at sector 29.

Using relatively low-energy X-rays, the IEX beamline at the APS will help illuminate electronic ordering and emergent phenomena in ordered materials so scientists can better understand the origins of distinct electronic properties. Another important feature for users is a greater ability to adjust X-ray parameters to meet experimental needs.

BENEFITS

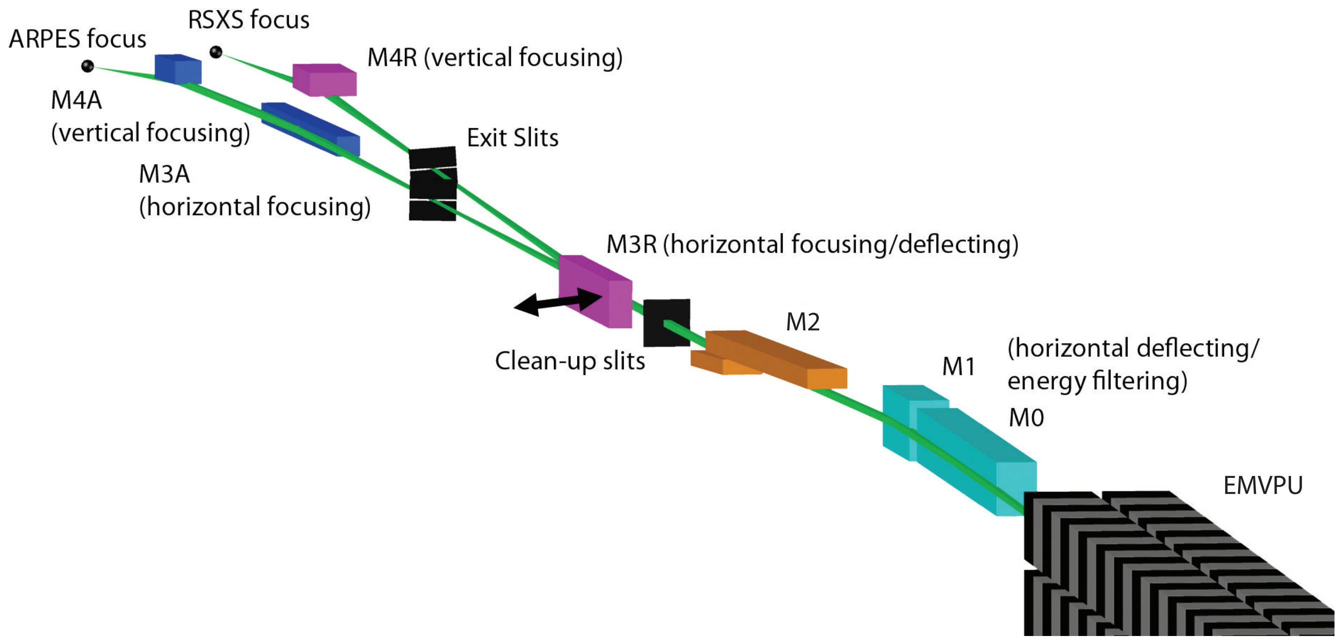
The Intermediate Energy X-ray (IEX) beamline at sector 29 uses relatively low-energy X-rays and a cadre of specialized components to help illuminate electronic ordering and emergent phenomena in ordered materials.

One important aspect of the IEX beamline is its ability to attack a specific scientific question from varied perspectives on a single beamline. Offering two unique but complementary endstations, users can choose between angle-resolved photoemission spectroscopy (ARPES) and resonant soft X-ray scattering (RSXS) for the exploration of challenges ranging from transition temperatures in superconducting materials to the dynamics of electronically structured interfaces.

Following are key features of the two end stations:

- ARPES measures the energy and angle of emitted electrons and can determine their properties before they leave the material.
- RSXS is a photon-in-photon-out technique that uses resonance, the tuning of the X-ray beam to a specific electronic excitation, to scatter off of an ordered electronic state to determine electron density.

The beamline's electromagnetic variable polarizing undulator (EMVPU) was built to meet the specific requirements of the IEX endstations, and currently has no equal in the world. Operating in a range of 250 to 2,500 electron volts (eV), this state-of-the-art insertion device (ID) allows the source to run in quasi-periodic mode, suppressing higher harmonics in the beamline for a much higher signal-to-noise ratio. The EMVPU is expertly



A schematic drawing of the IEX beamline optics, showing the source, an EMVPU; M0 and M1 and planar horizontal deflecting mirrors; the VLS-PGM which consists of M2, an internally cooled plane mirror and three gratings; M3R, a movable cylindrical mirror that horizontally focuses the source onto the RSXS sample position; M4R, a cylindrical mirror that vertically focuses the exit slit onto the RSXS sample position; and M3A (M4A), an elliptical cylinder that focuses the source (exit slit) horizontally (vertically) at the ARPES sample position. Image courtesy of J. L. McChesney, et al., *Nuclear Instruments and Methods in Physics Research, A. 746, 98 (2014).*

coupled with highly adaptive X-ray optics, which precisely adjust X-ray parameters, such as focus, energy resolution, and coherence fraction.

Another of the highly unique applications on this beamline is the RSXS endstation's two-dimensional energy-resolving detector, considered among the most sensitive energy-resolving detectors in the world. Based on transition-edge sensor (TES) technology pioneered by the National Institute of Standards and Technology (NIST), it could prove to be 1,000 times more sensitive to heterogeneity than any previous technology.

EXAMPLES OF RESEARCH OPPORTUNITIES

- Map the origins of the electronic structures of materials
- Understand how/why a material has specific electronic properties so scientists can design and manufacture materials with higher energy efficiencies and new functionalities.

EXAMPLES OF BUSINESS PROBLEMS OR SCIENTIFIC CHALLENGES THIS ADDRESSES

- Manipulate electron spin in the development of battery and logic components for spintronic devices.
- Identify transition temperatures in high-temperature superconducting materials to develop faster and cheaper means of transporting energy.
- Determine whether heterogeneity is relevant for optimizing superconductivity.
- Create artificial structures on a surface which exhibit emergent magnetic monopoles that are not supposed to exist in nature, but can be made to exist in a 2D object. Testing can be performed to explore whether nonexistent magnetic monopoles can be created artificially in the laboratory and applied to simple circuits.
- Study complex oxide materials like ferroelectrics.
- Measure bit configuration and study patterned magnetic arrays for better magnetic recording media.
- Develop new electronically structured interfaces for solar panel development.
- Perform extremely targeted technology development research, such as the use of self-assembled polymers to template features for fabricating integrated circuits.

CONTACT

Jessica McChesney
Physicist
X-ray Science Division
Phone: 630-252-7107
E-mail: jmcchesn@aps.anl.gov
www.aps.anl.gov/Sectors/Sector29/