August 30, 2021

XSD/Detectors Group Strategy and FY2022 Goals

Strategy

The mission of the XSD Detectors (DET) Group is to deliver cutting-edge detectors to APS beamlines. Our mission is accomplished in two ways. First, we introduce new, cutting-edge commercial detectors to the APS community via the Detector Pool. We accelerate and facilitate early access to new detectors that come on the market. We also provide detector advisory services in a variety of ways (e.g., market research, design reviews, etc.) to assist beamlines with detector purchases and best detector practices. XSD/DET includes staff who work as users in the Argonne's CNM cleanroom and are available to consult on microfabrication projects for other groups in XSD. A recent example includes X-ray lens arrays fabricated by silicon deep reactive ion etching (DRIE). This project is in collaboration with the Structural Science and Magnetic Materials groups.

Second, we develop new, cutting-edge detectors which are unlikely to be commercially available. The group is engaged in a number of detector R&D projects to meet the future needs of the APS. These projects were chosen to align with the major scientific thrusts of the APS, take advantage of the source, leverage strategic partnerships with external detector groups and leverage unique Argonne facilities. We focus our detector R&D efforts in three areas: pixel array detectors, high-energy sensors, and high-resolution emission detection. For pixel array detectors, this includes the VIPIC detector for ultra-fast XPCS with BNL and FNAL, the MM-PAD detector with Cornell and a new initiative on detector ASICs with on-chip edge capabilities (e.g., compression). For high-energy sensors, we are collaborating on a new project on high-Z sensors for pixel detectors with BNL, Cornell, SLAC and ANL/MSD; the ANL component consists with developing perovskite sensors. For emission detection, we are collaborating with NIST on transition edge sensors for high energy-resolution emission detection applications. At the APS, we are focused on developing application-specific TES sensors for hard X-ray applications. In particular, we are modelling, designing, fabricating and testing TES sensors optimized for XRF, XES, XAFS and Compton scattering experiments. Finally, we are exploring AI/ML methods to accelerate data processing for TES and pixel array detectors.

Detector Pool Goals – FY2022

- Upgrade as many computers to RHEL 8 as possible and verify DPbin EPICS functionality
- Deploy software configuration management using Ansible for Detector Pool machines
- Deploy the KA Imaging's amorphous selenium (a-Se) BrillianSe X-ray camera
- Support cavity-based XFEL (CBXFEL) project with diagnostics detectors
- Support APS-U beamlines with detector advisory services and creation of bid packages

Detector R&D Goals – FY2022

- Superconducting Detectors
  - Continue to increase number of working pixels in the TES array at 1-BM
  - Continue to perform experiments at 1-BM (e.g., Compton imaging, high-energy X-ray emission spectroscopy)
  - Continue to improve individual TES pixel performance to maximize count rate throughput for hard (5-20 keV) and very hard (> 20 keV) X-ray energies
- Germanium Strip Detector (GSD)
  - Improve X-ray shielding of the first GSD-192 system for Compton imaging applications
  - Build the second high-energy GSD-192 system with a radiation shield and getter to improve performance
- MM-PAD v2.1
  - Deploy the first complete (2x3 = 256 X 384 pixel) detector systems with Si and CdTe sensors
- Detector ASIC with on-chip compression
  - Continue design of a full-scale detector ASIC to maximize continuous frame rate
- VIPIC
  - Assist with VIPIC pilot run chip testing at BNL.
- High-Z collaboration
  - Improve CsPbBr growth process to minimize defects
  - Support with X-ray beamline testing of 64x64 CsPbBr sensors on MM-PAD ASIC
  - Investigate metallization options for perovskites sensors with 100-micron pitch for SLAC ePix ASIC.
- AI/ML – "Actionable Information from Sensor to Data Center (AISDC)"
  - Support the DOE/BES/SUF funded project with ANL/SLAC project to accelerate crystallographic (e.g., HEDM) data processing using edge AI/ML.
    - https://www.anl.gov/psc/edgebased-machinelearningenabled-materials-exploration-pipeline
    - https://github.com/AISDC
  - Continue to explore AI/ML methods for spectroscopic detectors (e.g., silicon and TES detectors)
- Microfabrication support
  - Continue to improve performance of silicon micromachined lenses for high-energy focusing