X-RAY SCIENCE DIVISION FY2018 PRIORITIES

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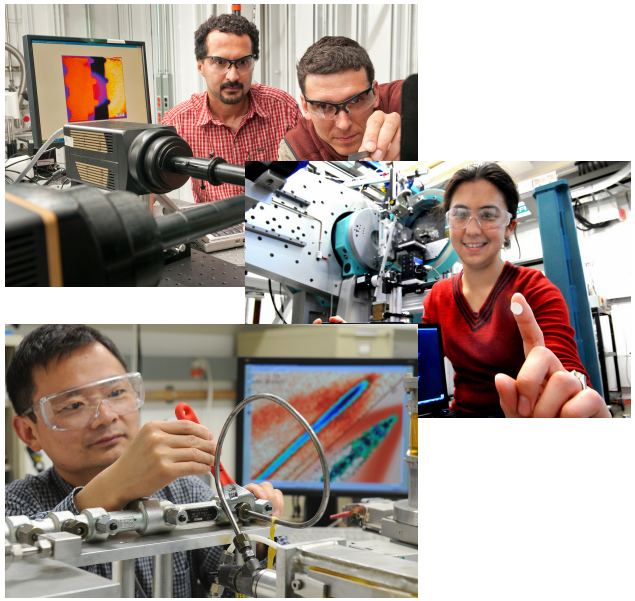
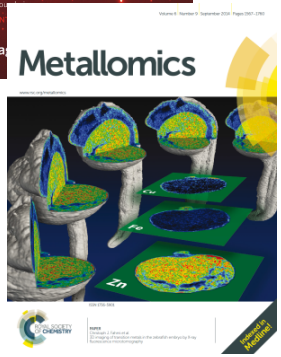
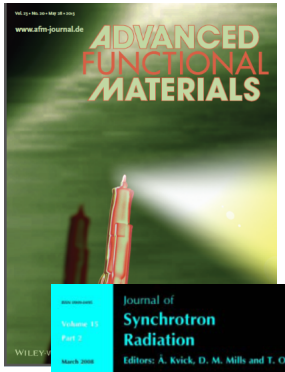
APS All-Hands Meeting
October 18, 2017

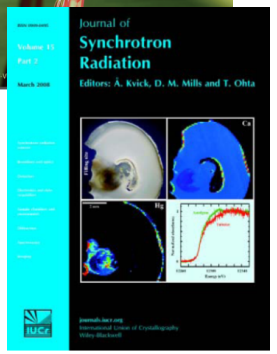
X-RAY SCIENCE DIVISION - MISSION

Enable and conduct world-class research using x-rays by developing cutting-edge x-ray instrumentation and techniques.









Operate 36(+2) of 67 beamlines; partner in 3 additional beamlines

APS CY16: **1889** (1035) **publications** ~18% high impact; > 5500 users

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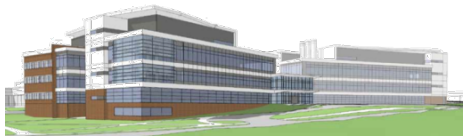
X-RAY SCIENCE DIVISION STRATEGY

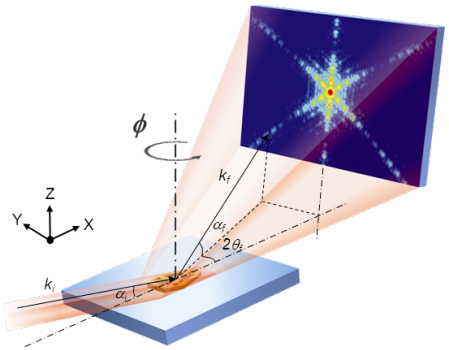
Leverage unique characteristics of APS.

- High brilliance
  - APS-U 3000 pm-rad to ~42 pm-rad
- High energy storage ring (> 20 keV x-rays)
  - Deep penetration enables measurements deep inside samples, high-pressure, *in-situ* environments, …..
- Unique timing structure
  - Large intra-bunch separation (24 (48) vs. many bunches)
- Large range of end-stations/capabilities
  - Multiple techniques; High-throughput
- Co-location with a programmatic research lab
  - Opportunities for collaborations to develop more complex set-ups/environments; staff engagement in large scale scientific thrusts



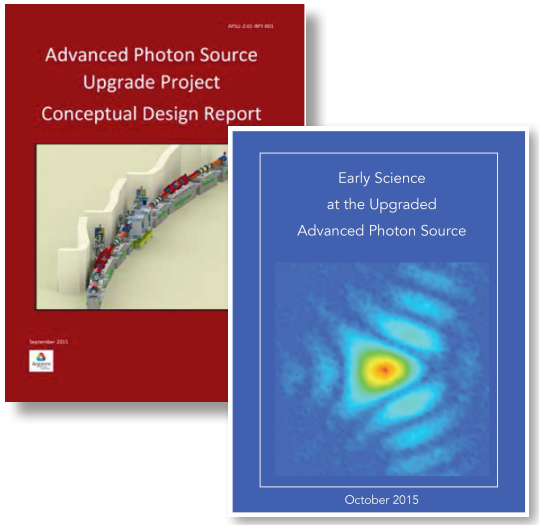
X-RAY SCIENCE DIVISION STRATEGY

- Near term (pre-upgrade)
  - Enhance and expand core capabilities related to APS-U (Nanofocusing, Coherence, Imaging, High-Energy, …)
  - Prototype optics, detectors, instruments, and data strategies relevant to APS-U
  - Develop effective lab (& external) partnerships to improve APS capabilities & strengthen ANL programmatic research.
    (*in-situ* / *in-operando* environments, ….)
  - Improved automation & capabilities for core techniques
    - High-throughput XRD, PDF, SAXS, …
  - Mission Readiness & Obsolesce
    - APS >20 yrs. Old ➔ replace aging infrastructure:
      - Cryo-pumps; mirrors; vacuum systems, motion controls, detectors, ...



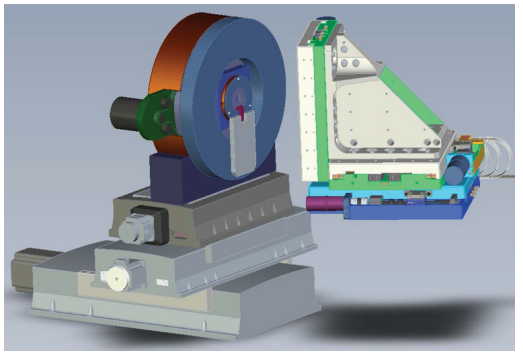
XSD BEAMLINE STRATEGY

- Long-term (APS – Upgrade)
  - APS-U beamlines
    - Design and develop “feature” beamlines within APS-U core scope
    - Implement APS-U “enhancements” & make strategic investments under operations to remainder of beamline suite.
  - X-ray technologies for APS-U
    - Consider beamline, sample environments, scanning systems, detectors, data pipe-lines & analysis as a complete integrated system



FY18 BEAMLINE PROJECTS

- High brilliance
  - APS-U R&D beamline. Test optics and concepts for next-generation beamlines
  - PRISMA, 3D imaging of integrated circuits using ptchography
- High energy x-rays
  - High-throughput HEDM experimental end-station leveraged by funded NSF proposal (Carnegie-Mellon)
- Timing
  - Instrument for studies of mesoscale dynamics using multiple pump-probe excitations/detection methods. (ECA - H. Wen)
- New capabilities/ Lab partnerships
  - Helical SCU commissioning and testing
  - Additive manufacturing opportunities (32-ID, 1-ID, 34-ID, ...)
  - Complete X-TIP beamline construction (APS/NST)



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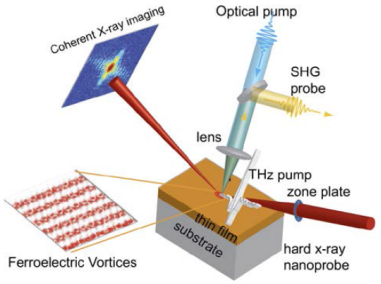
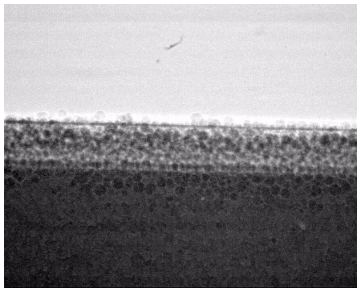
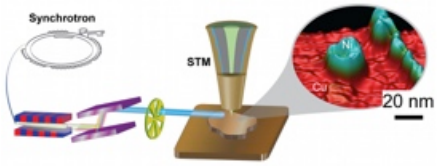




High-speed imaging of AM



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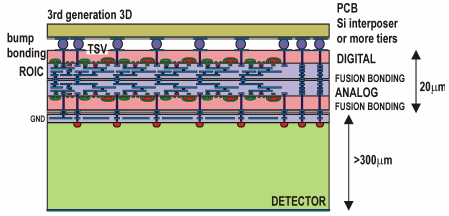
XSD FY2018 PLANS – DETECTORS

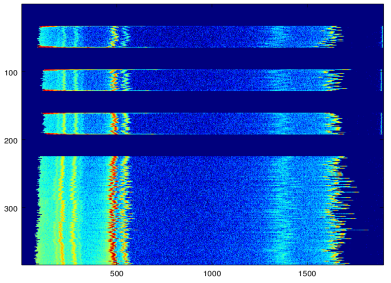
APS Detector Pool

- **Expand Selection of Integrating Pixel Array Detectors**
  - **Jungfrau detector** for high-photon-rate applications (>2k fps; 64 GB/s)

Detector R&D (focus on areas where no COTs solutions)

- **Transition Edge Sensors (TESs)** (APS/NIST/SLAC)
  - High energy resolution (1-5 eV) spectroscopy. Beamline detectors by FY2020
- **VIPIC** (Vertically Integrated Photon Imaging Chip) (BNL/FNAL/APS)
  - Ultra-Fast XPCS. Complete 1-Mpixel detectors for APS, NSLS-II
- **Germanium Strip** (BNL/APS)
  - 1-D energy resolving detector for high-energy applications (EDD, XRD). Complete 2-3 detectors for APS, NSLS-II
- **High-Energy, High Dynamic Range Area Detectors** (Cornell/APS)
  - DOE Proposal to deliver two 100K-pixel detectors to APS beamlines by FY2021





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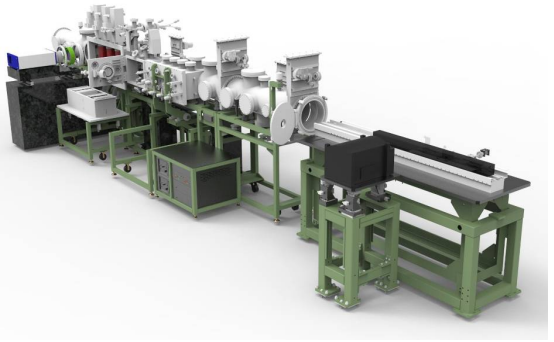
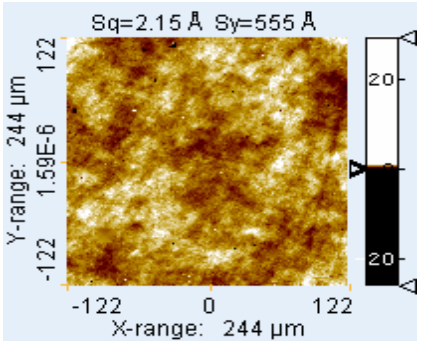
XSD FY2018 PLANS – OPTICS

Low-emittance sources require optics with dramatically smaller figure errors and tailored profiles. Novel ways to fabricate, measure, and simulate these optics are required.

- **Modular deposition system**
  - Develop velocity profiling for laterally graded multilayers and *in situ* metrology for mirrors
- **Wavefront-preserving mirrors**
  - Develop non-invasive wave-front sensing (with SLAC, ALS, NSLS-II)
- **Mirror-based zoom optics for variable focal spot size**
  - Develop optical profiler for adaptive mirrors (LDRD)
- **APS-U: Zone Plate R&D**
  - Demonstrate 16 nm focus, stacked zone plates instrument
- **Focusing Optics for 40-100-keV X-rays to <1 μm**
  - Sawtooth and kinoform refractive lenses, S. Shastri (XSD) (with NSLS-II)





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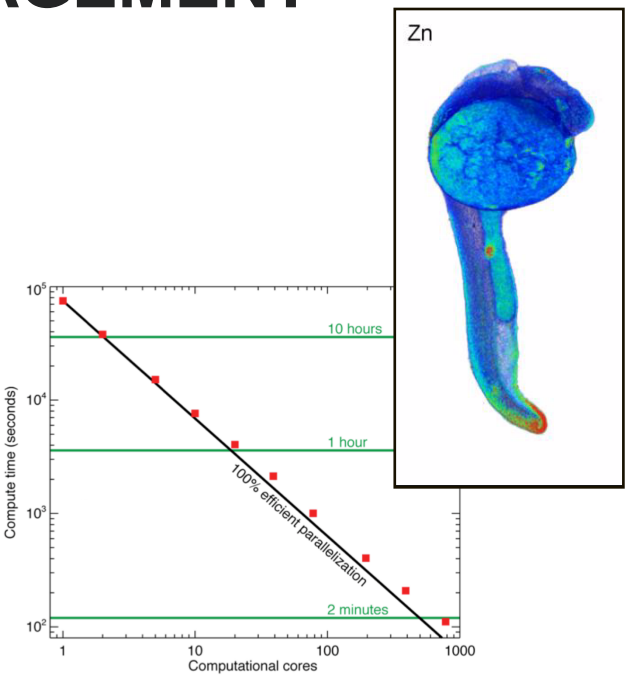
INTELLIGENT DAQ, ANALYSIS & MANAGEMENT

Strategic Priorities

- Experiment control software that enables **adaptive feedback**
  - eg, Bluesky (NSLS-II), project MONA
- **High-performance computing (HPC)** for fast analysis
  - Work with ALCF, NERSC, and Argonne LCRC for on-demand utilization of leadership facilities
- **Novel Algorithms** that enable multimodal, multiscale experiments, and minimize dose, etc
- Facility-wide **data management and distribution** services



GOAL:

Smart system that couple acquisition, analysis, and feedback for adaptive experiment control, acquiring only the data needed to answer the scientific question

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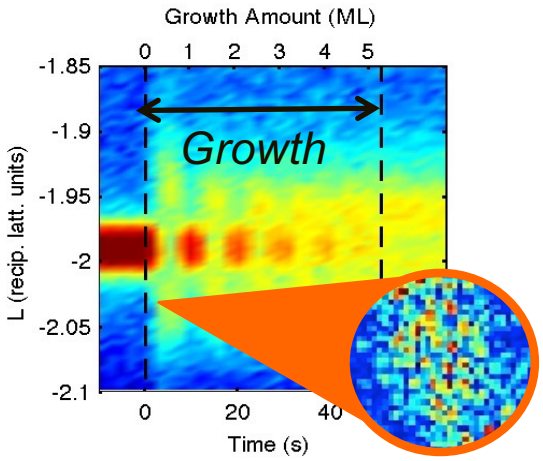
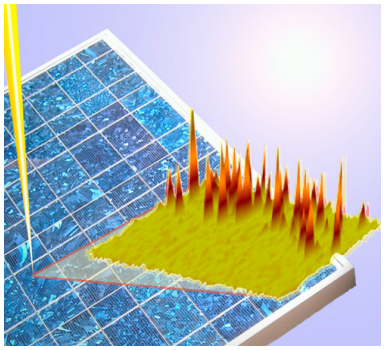
X-RAY SCIENCE DIVISION FY18 GOALS

- Maintain active and productive user programs on all XSD operated beamlines
- Develop innovative instrumentation that further advances beamline capabilities particularly for high-energy, coherence, nano-focusing, ….
- Complete current beamline development plans
  - APS-U R&D beamline (28-ID); PRISMA
  - High throughput HEDM
  - X-TIP (4-ID)
- Meet FY18 milestone deliverables for DOE funded optics and detector projects (VIPIC, wave-front preserving mirrors, …)
- Work with APS-U to complete designs of “feature” beamlines and implementation of “enhancements” to broader beamline suite.
- Continue to attract, develop, and retain a diverse set of talented scientific and technical staff.





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