MPS Mid-Scale Programs

Briefing for MPS Advisory Committee

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Overview

- MPS Divisions and their communities have made extensive use of the NSF-wide MRI program

- MPS currently has the most Large Facilities of any Directorate, relying on the MREFC for construction of some of the largest scientific facilities in operations today (e.g., ALMA, ATLAS & CMS at CERN/LHC, LSST)

- The MPS communities were early voices in recognizing the critical gap between MRI and MREFC

AST: Mid-Scale Innovations Program (MSIP)

- Following recommendation in the 2010 A&A Decadal Survey
- Four Subcategories:
  - limited term, self-contained science projects;
  - longer term mid-scale facilities;
  - development investments for future mid-scale and large-scale projects; and
  - community open access capabilities.
- MSIP Program funding has varied with funding conditions; grants range from ~$1M to ~$10M

AST MSIP Examples

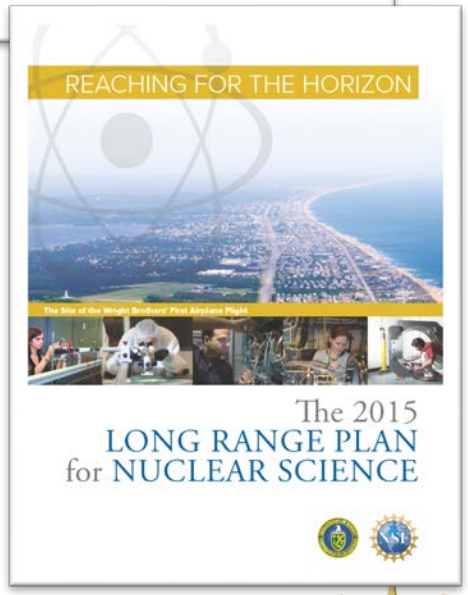
- FY17 solicitation (17-592) funded at ~$50M. Example MSIP projects:
  - MMT Adaptive Optics System
  - BICEP upgrade to Stage 3
  - HERA Project for low-frequency Cosmology
  - Facility IFU Spectrograph for Magellan
  - Dedicated FRB localization
  - Keck All-Sky Adaptive Optics
  - Long Wavelength Array
  - GBT Metrology (won kudos from WVa Congressional staff…)
  - ALPACA L-Band Phased Array for Arecibo

HERA

CLASS

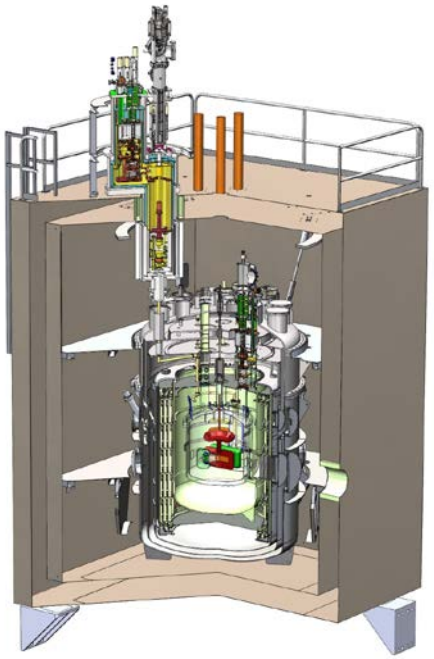
PHY: Mid-Scale Instrumentation

- Reports: Need to enable experimental physics programs to carry out cutting-edge science with instrumentation that they would not be able to afford without a significant reduction in research
- PHY Midscale is not a separate program: no separate call for proposals. Midscale proposals come through the Division solicitation to individual programs and are competitively reviewed
- Funds design and construction or acquisition of instrumentation
  - Typical size of award ~ $4M < TPC < ~ $15M over multiple years; Invested about $60M in the last 5 years
  - Pre-award R&D and post-award O&M costs must be covered by the sponsoring program



PHY Mid-Scale Projects

- Selection of projects is based on
  - Demonstration of exceptional science opportunity in the context of community priorities
  - Availability of funding / opportunity costs to research program (inc. O&M impacts)
- PHY currently has 8 Midscale projects in four programs
  - Particle Astro (ATLAS, CMS, LHCb, CDMS)
  - Elementary Particle Physics (IceCube Gen2)
  - Nuclear Physics (nEDM, MUSE)
  - Gravitational Physics (LIGO)



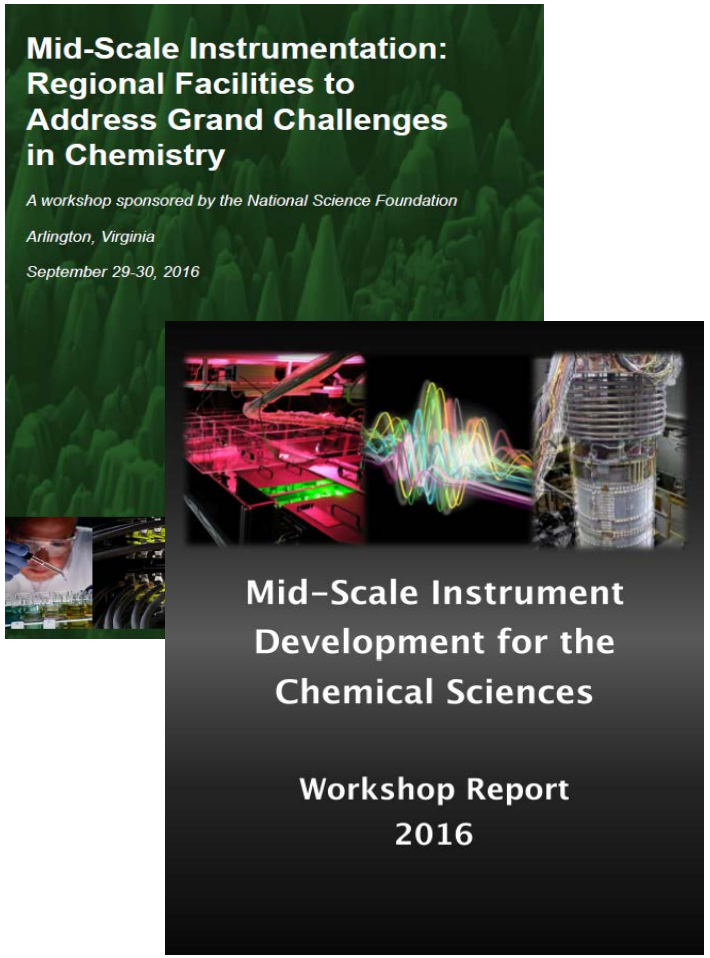
nEDM @ ORNL
Nuclear Physics: Neutron electric dipole moment

LHCb@CERN
Partical Physics: Upstream Tracker upgrade
(credit: CERN)

CHE: Mid-Scale Instrumentation

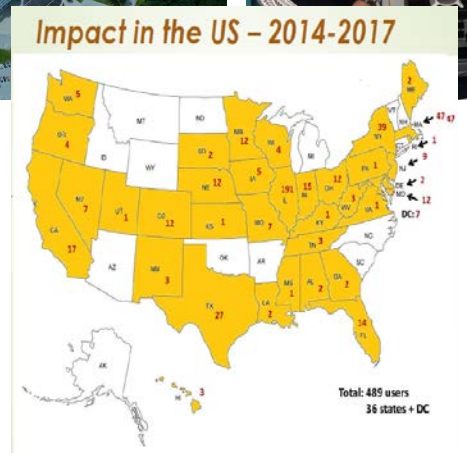
- Single biggest need for experimental chemistry communities
- Research challenges and opportunities have been identified in two 2016 CHE Mid-Scale Workshops.
- CHE provides $5 Million annually to supplement over 112 MRI research proposals.

- **<u>MRI is insufficient</u>** to fund next generation of integrated instruments with specialized, complementary capabilities (real-time, in situ).



CHE Midscale Facilities

- **ChemMatCARS @ APS**
  - A sub-facility at the Advanced Photon Source (APS) of the Argonne National Laboratory
  - Basic infrastructure supported by DOE; NSF supports one of 36 research facilities.
  - Continued funding of $12 M for FY 2019-FY 2024 operations and maintenance, average $2.4M annually. Co-funded by CHE and DMR; managed by CHE.
- Ion Cyclotron Resonance Facility @ NHFML
  - A sub-facility at NSF/DMR's National High Field Magnetic Laboratory (NHFML)
  - Funding ~$1.7M annually, plus occasional facility development funding at $1-3M level



DMR Diverse Mid-Scale Portfolio

- **Instrumentation for Materials Research- Major Instrumentation Projects (IMR-MIP)**
  - Ranging from $4M to $20M for 3 types of awards: R&D, Conceptual Engineering design, & Construction of individual instruments
  - Solicitations in 2004, 2009, 2018
- **Enabling Quantum Leap: Convergent Accelerated Discovery Foundries for Quantum Materials Science, Engineering and Information (Q-AMASE-i)**
  - 2019: Quantum Foundry w/ MPS (DMR+DMS), ENG, & CISE support
- **Materials Innovation Platform (MIP)**
  - A hybrid **center-facility** opportunity using Materials Genome Initiative approach and with an emphasis on knowledge sharing
  - $15M to $25M over 5 years with single 5-year renewal option
  - First call 2015, 2 awards for multi-faceted multi-user facilities

PARADIM
AN NSF MATERIALS INNOVATION PLATFORM

www.paradim.org

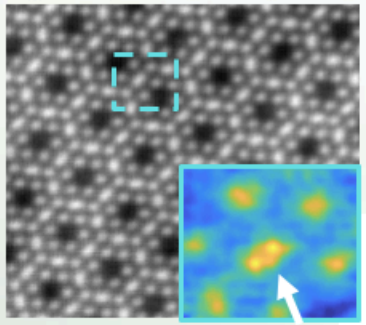
Focus: interfacial quantum materials – combining oxides & 2D materials. To empower practitioners to accelerate the discovery of atomically engineered inorganic materials that revolutionize electronics

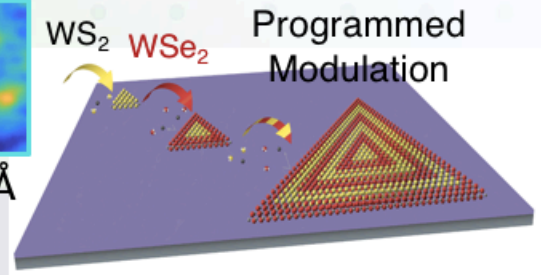
Major User Facilities (at Cornell University unless otherwise noted):

- Thin-film growth: MBE (62 elements) with ARPES & CVD, stand-alone CVD
- Transmission Electron Microscopy: record resolution w. an EMPAD detector
- Bulk crystal growth: world's first 300-atm floating-zone furnace (FZF), titled laser-diode FZF, and other FZFs **(at Johns Hopkins University)**
- Theory and Simulation: electronic properties **(at Clark Atlanta University)**

Major Activities:

- Accept user proposals year round – no user fee
- Summer schools (all recorded & available online)
- PARADIM Data Collective
- REU





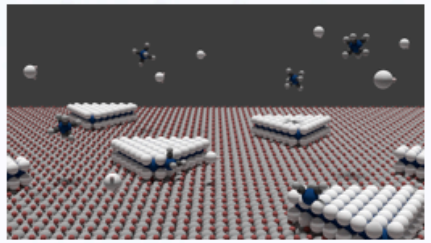
DMR DIVISION OF MATERIALS RESEARCH
DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES

2D Crystal Consortium
NSF Materials Innovation Platform

PennState

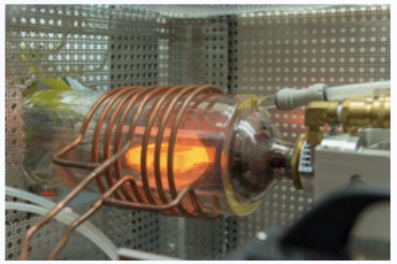
www.mip.psu.edu

Focus: 2-dimensional chalcogenide materials for future electronics



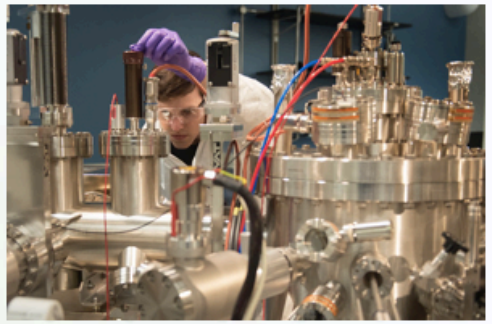
Major User Facilities (all at Penn State University):

- Thin-film growth: CVD, MBE with ARPES, STM & SEM in HIVE
- Bulk crystal growth: Vertical Bridgman & chemical vapor transport
- Theory and simulation: growth kinetics, characterization, etc.



Major Activities:

- Accept user proposals year round – no user fee
- Sample request option – Many delivered
- Annual *Graphene and Beyond* workshops
- Webinars (all recorded and available online)
- Data: Lifetime Sample Tracking (LiST) and STEPFORWARD



DMR DIVISION OF MATERIALS RESEARCH
DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES

Summary: MPS Mid-Scale Research Infrastructure

- Unquestionable **demand** for mid-scale investments has been a common theme for over a decade

- **Diversity** in science leads to diversity in approaches to, and management of, the mid-scale challenge

- **Big Ideas Mid-scale initiatives critical** for NSF visibility and agency-wide support (especially at the large end!), but are **complementary** to MPS Divisions' diverse set of midscale initiatives which will **continue** to provide critical opportunities at the domain-specific level