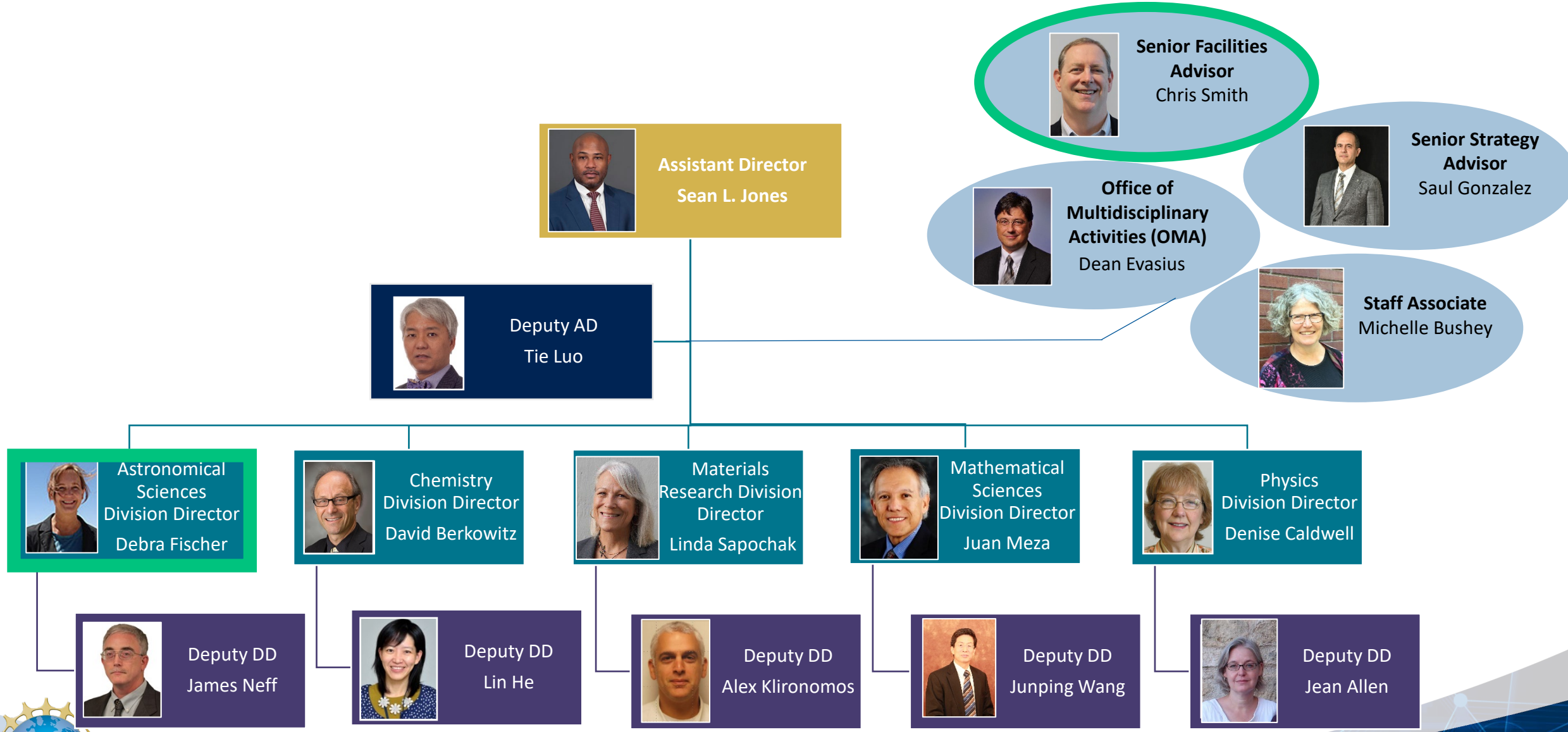
MPS Update

NSAC Meeting: November 16, 2021

Sean L. Jones, Assistant Director

MPS Senior Staff



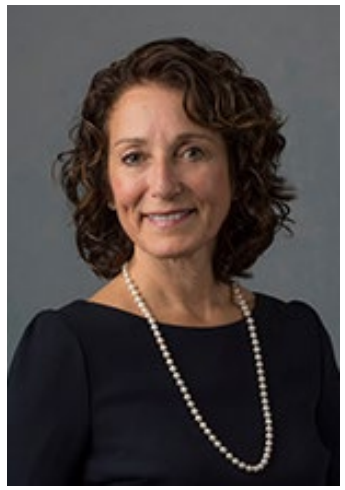
NSF Changes in Leadership

CORF
Linnea Avallone

COO
Karen Marrongelle

OISE Head
Kendra Sharp

EHR AD
(Acting)
Sylvia Butterfield

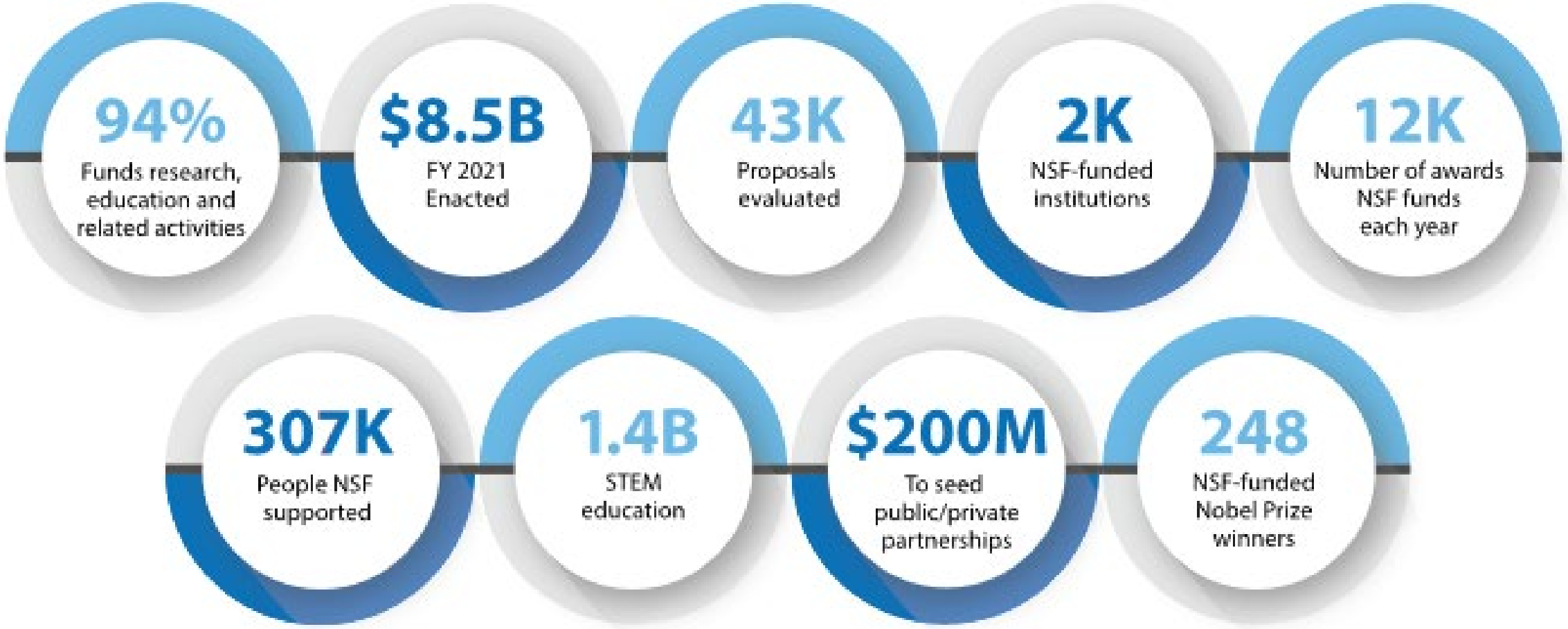


ENG AD
Susan S. Margulies

OIA OH
Alicia Knoedler

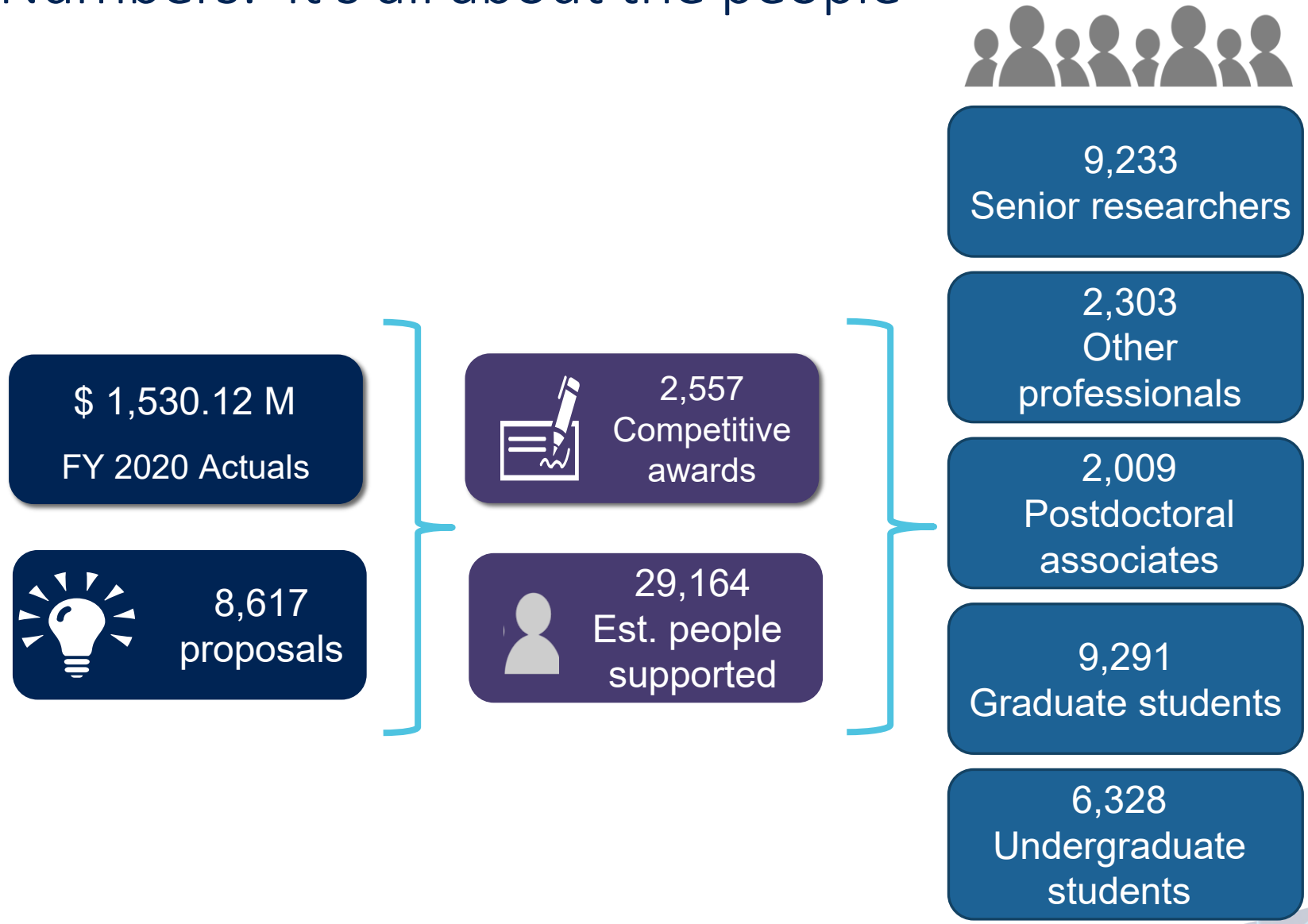
GEO AD
Alexandra Isern

NSF by the numbers



(numbers represent FY 2020 Actual data except where indicated).

MPS by the Numbers: It's all about the people



Facilities Updates: Construction

- DKIST on schedule for transition to operations in late November 2021
  - All four instruments have completed site acceptance tests, and two have completed Science Verification (SV) and other two have collected on-sky SV data
- Rubin Observatory ~91% complete, re-baseline underway
  - Expect COVID delay of ~22 months
  - Project teams back on site, making excellent progress (now ~90% complete)
- HL-LHC: Progress (~20% complete),
  - but COVID impacts being felt

The Top-End Assembly for the Telescope Mount Assembly (TMA) was lifted by crane into observatory dome an installed on the TMA on March 2, 2021. The task was completed successf and was a highly celebrated milestone for Rubin Observatory. *Credit: Ru Observatory/AURA/NSF.*

Facilities Updates: Operations

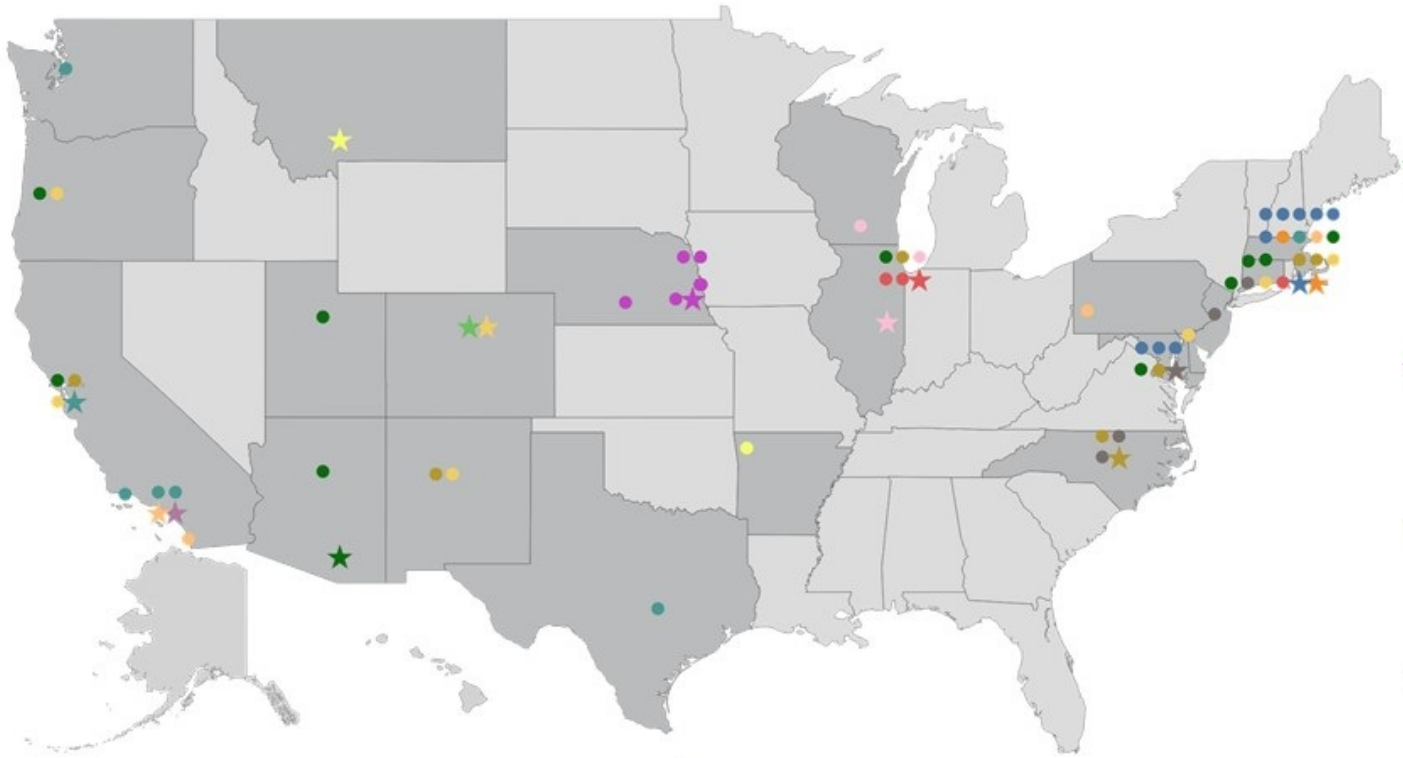
- All Facilities operational, under COVID protocols
  - Vaccination mandates may have staffing impacts
- Arecibo cleanup: projected to be complete by end of 2021
  - Focus shifting to future; workshop explored ideas for instrumentation as well as STEM roles
- LIGO Livingston: only minor damage from Hurricane Ida
  - Work continues at both sites to improve detector sensitivity for O4, to start some time after Aug 2022
- Ongoing efforts on Satellite Constellations
  - SATCON 2 workshop & international Dark & Quiet Skies conference raising awareness, exploring mitigations

Quantum Awards FY21

- Quantum Challenge Institutes, 2 awards this year, $50 Million total
  - **NSF Quantum Leap Challenge Institute for Quantum Sensing in Biophysics and Bioengineering**
  - **NSF Quantum Leap Challenge Institute for Robust Quantum Simulation**

- Quantum TAQS, 10 awards, $24,962,455 total
  - Quantum Interconnect Challenges for Transformational Advances in Quantum Systems
  - Interdisciplinary teams to conduct transformative research that develops and applies quantum science, quantum computing, and quantum engineering in the specific area of quantum interconnects

Quantum Institutes



Center for Integrated Quantum Materials (Award -1231319)
Harvard University
Bunker Hill Community College
Gallaudet University
The Learning Center for the Deaf
Massachusetts Institute of Technology
Prince Georges Community College
Museum of Science
Wellesley College
Howard University
Mount Holyoke College

The Institute for Quantum Information and Matter: Advancing the Entanglement Frontier (Award -1733907)
California Institute of Technology

JILA PFC: Measurement, Manipulation, and Meaning at the Quantum Frontier (Award -1734006)
University of Colorado at Boulder

Center for Ultracold Atoms (Award -1734011)
Massachusetts Institute of Technology
Harvard University

PFCQC: STAQ: Software-Tailored Architecture for Quantum co-design (Award -1818914)
Duke University
Massachusetts Institute of Technology
North Carolina State University
University of Maryland, College Park
Tufts University
University of Chicago
University of New Mexico
University of California-Berkeley

Enabling Quantum Leap: Q-AMASE-i: Quantum Foundry at UCSB (Award -1906325)
University of California-Santa Barbara
Boston University
University of California-San Diego
University of Pittsburgh

Enabling Quantum Leap: Q-AMASE-i: MonArk Quantum Foundry: Rapidly Incubating Translational Advances in QISE with a 2D-Quantum Materials Pipeline (2D-QMaP) (Award -1906383)
Montana State University
University of Arkansas

NSF Engineering Research Center for Quantum Networks (CQN) (Award -1941583)
University of Arizona
Brigham Young University
University of Massachusetts Amherst
Howard University
Massachusetts Institute of Technology
Northern Arizona University
Stanford University
University of Chicago
Harvard University
University of Oregon Eugene
Yale University

RII Track-1: Emergent Quantum Materials and Technologies (EQUATE) (Award -2044049)
University of Nebraska
Creighton University
Nebraska Indian Community College
University of Nebraska at Omaha
Little Priest Tribal College
University of Nebraska at Kearney
University of Nebraska-Lincoln

QLCI-CI: NSF Quantum Leap Challenge Institute for Enhanced Sensing and Distribution Using Correlated Quantum States (Award -2016244)
University of Colorado at Boulder
Harvard University
Massachusetts Institute of Technology
Stanford University
University of Delaware
University of New Mexico
University of Oregon Eugene

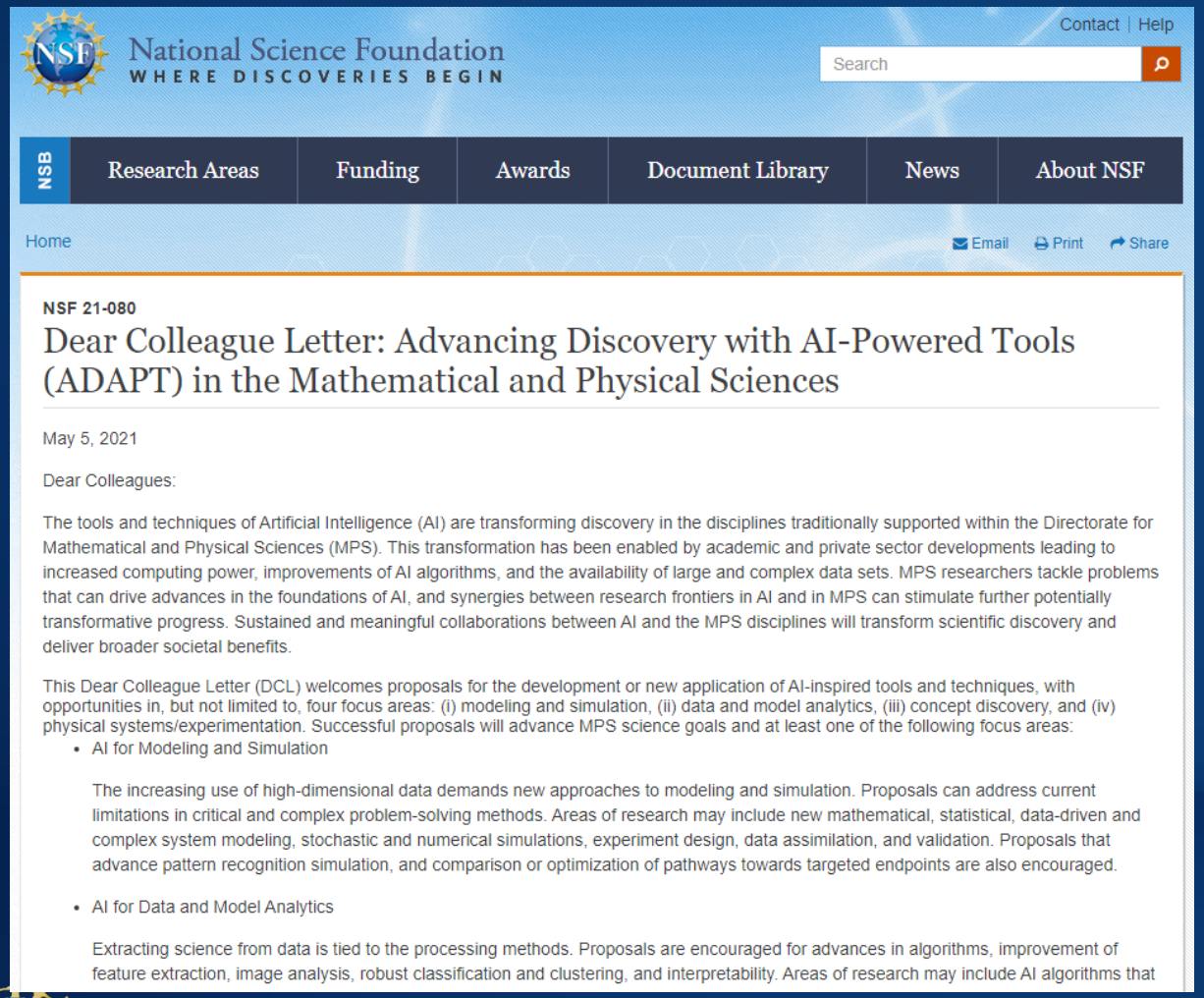
QLCI-CI: NSF Quantum Leap Challenge Institute for Hybrid Quantum Architectures and Networks (Award -2016136)
University of Illinois at Urbana-Champaign
University of Chicago
University of Wisconsin-Madison

QLCI-CI: NSF Quantum Leap Challenge Institute for Present and Future Quantum Computing (Award -2016245)
University of California-Berkeley
California Institute of Technology
Massachusetts Institute of Technology
University of California-Los Angeles
University of California-Santa Barbara
University of Texas at Austin
University of Washington

QLCI-CI: NSF Quantum Leap Challenge Institute for Quantum Sensing in Biophysics and Bioengineering (Award -2121044)
University of Chicago
Chicago State University
Harvard University
University of Illinois at Chicago

QLCI-CI: NSF Quantum Leap Challenge Institute for Robust Quantum Simulation (Award -2120757)
University of Maryland, College Park
Duke University
North Carolina State University
Princeton University
Yale University

DCL: Advancing Discovery with AI-Powered Tools (ADAPT)



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NSF 21-080

Dear Colleague Letter: Advancing Discovery with AI-Powered Tools (ADAPT) in the Mathematical and Physical Sciences

May 5, 2021

Dear Colleagues:

The tools and techniques of Artificial Intelligence (AI) are transforming discovery in the disciplines traditionally supported within the Directorate for Mathematical and Physical Sciences (MPS). This transformation has been enabled by academic and private sector developments leading to increased computing power, improvements of AI algorithms, and the availability of large and complex data sets. MPS researchers tackle problems that can drive advances in the foundations of AI, and synergies between research frontiers in AI and in MPS can stimulate further potentially transformative progress. Sustained and meaningful collaborations between AI and the MPS disciplines will transform scientific discovery and deliver broader societal benefits.

This Dear Colleague Letter (DCL) welcomes proposals for the development or new application of AI-inspired tools and techniques, with opportunities in, but not limited to, four focus areas: (i) modeling and simulation, (ii) data and model analytics, (iii) concept discovery, and (iv) physical systems/experimentation. Successful proposals will advance MPS science goals and at least one of the following focus areas:

- AI for Modeling and Simulation

  The increasing use of high-dimensional data demands new approaches to modeling and simulation. Proposals can address current limitations in critical and complex problem-solving methods. Areas of research may include new mathematical, statistical, data-driven and complex system modeling, stochastic and numerical simulations, experiment design, data assimilation, and validation. Proposals that advance pattern recognition simulation, and comparison or optimization of pathways towards targeted endpoints are also encouraged.

- AI for Data and Model Analytics

  Extracting science from data is tied to the processing methods. Proposals are encouraged for advances in algorithms, improvement of feature extraction, image analysis, robust classification and clustering, and interpretability. Areas of research may include AI algorithms that

https://www.nsf.gov/pubs/2021/nsf21080/nsf21080.jsp

DCL published on May 5; Very late in the FY, so focused on EAGERs, RAISEs, and supplements to existing awards.

DCL Prioritizes:

- Collaboration among MPS domains
- Collaboration between MPS and AI researchers
- Broadening participation
- Academic/industry collaborations

Outcome (so far):

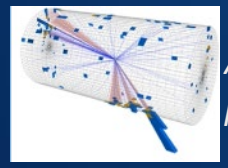
- Funded 5 EAGERs and 3 supplements: $1.74 M total

Needs for AI-enabled Discovery Science at MPS

Modeling and simulation

Mathematical and statistical modeling

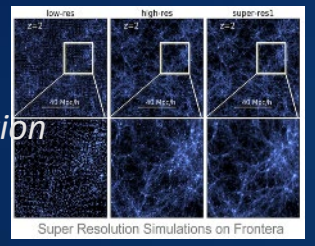
emulation



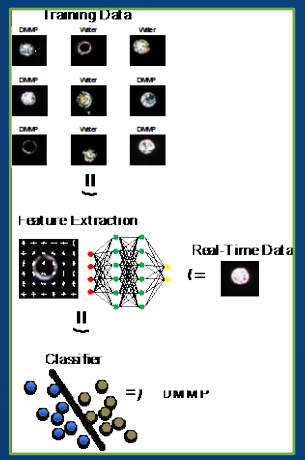
Acceleration of multi-physics simulations

Understanding structure-function relationships for better performance

ML-based modeling of galaxy formation

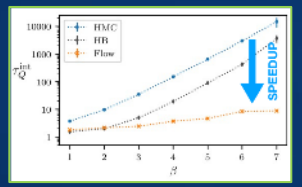


Data and Model Analytics



ML-driven development of liquid crystal sensors

Key feature extraction for optimization, imaging, and expansion of chemical space



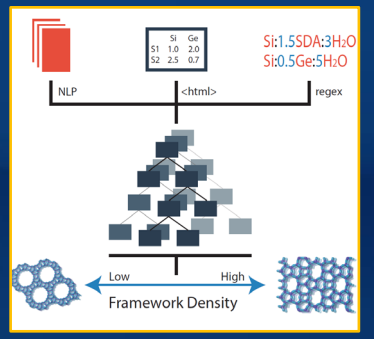
AI that respects physical laws, symmetries

Concept Discovery

Interpretable ML

Matching feature extraction with physical properties to discover new concepts and models

Small data analysis



Natural Language Processing acceleration of zeolite synthesis

Physical Systems and Experiments

Remote facilities Operations / control

AI-driven synthesis of small molecules

Experimental design with high dimensional, heterogeneous, cross-cutting data

Real-time analysis

Embedded, edge systems

NSF COVID-19 Response

What next ?

Most Strongly Affected Groups

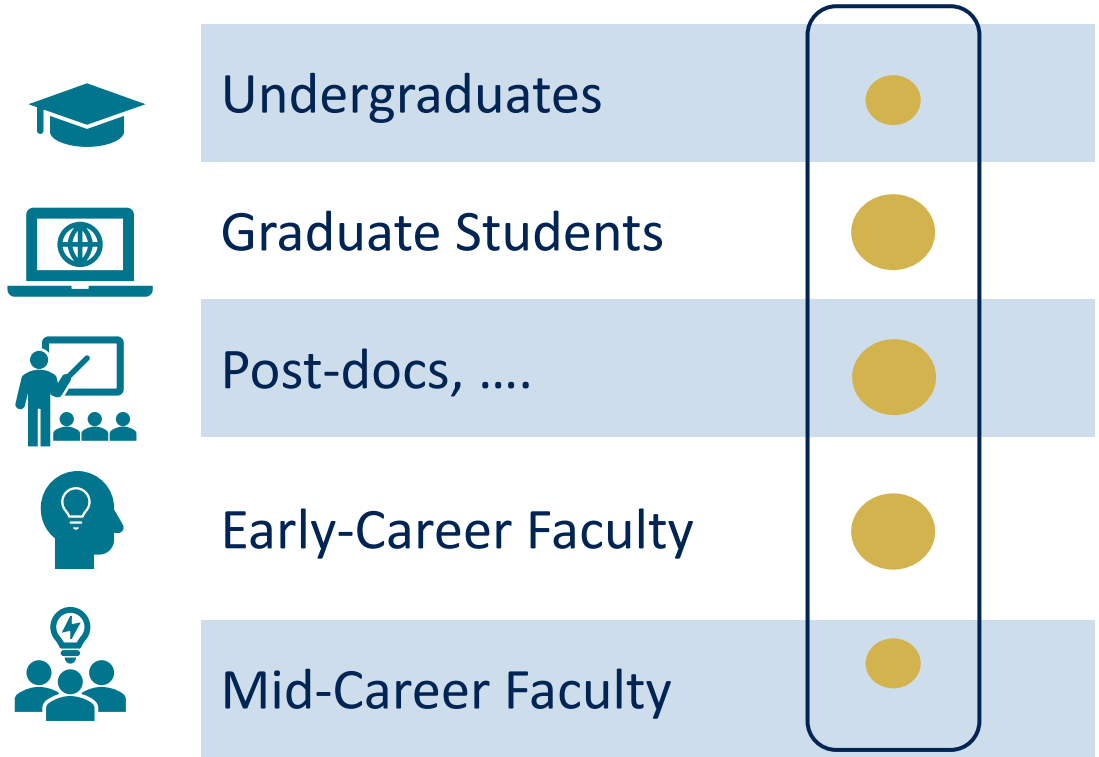
- MSIs, Less Affluent Institutions
- Women Researchers
- Underrepresented Groups
- Early-career Faculty
- Post-docs, Trainees, Fellows

Vulnerable Transition Points

- Undergraduate Students
- Graduate Students
- Post-docs, Trainees, Fellows
- Early-career Faculty
- Mid-career Faculty

NSF COVID-19 Response

Priority of Responses



MPS Ascend Postdoctoral Fellows FY21

12 to 36 Months, $100,000 per year

- A monthly stipend of $5,833 (up to $70,000 annually)

- An annual allowance of $30,000 for:
  a) expenses directly related to the conduct of the research and/or
  b) support of fringe benefits, dependent care, and moving expenses.

33 MPS Ascend Awards made

Preparing for the next cohort
NSF 22-503 MPS-ASCEND, DEADLINE JAN. 6, 2022
Anticipating 40-50 awards

Launching Early-Career Academic Pathways in the Mathematical and Physical Sciences (LEAPS-MPS) FY21

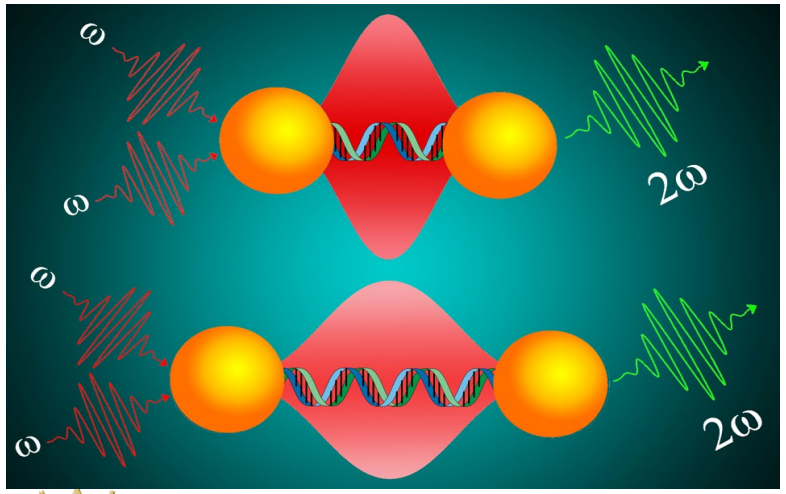
- A discussion of how activities will facilitate development of a subsequent research proposal.
- A specific plan on broadening participation activities will increase (1) the participation of scientists from underrepresented groups and (2) the numbers of such individuals that serve as role models for the scientific workforce of the future.
- LEAPS Impact Statement (3 pages): (1) impact on institutional research environment, (2) impact on career of PI and department's ability to prepare students to enter STEM careers, including provisions for increasing broader participation.
- 45 Awards made

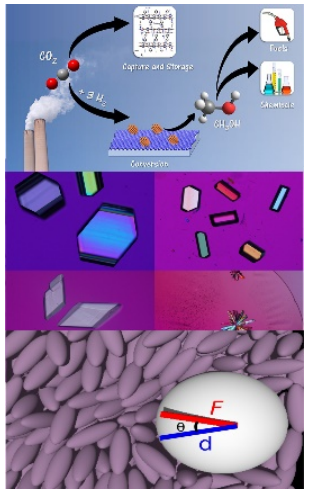
NSF 22-503 LEAPS-MPS, DEADLINE JAN. 7, 2022

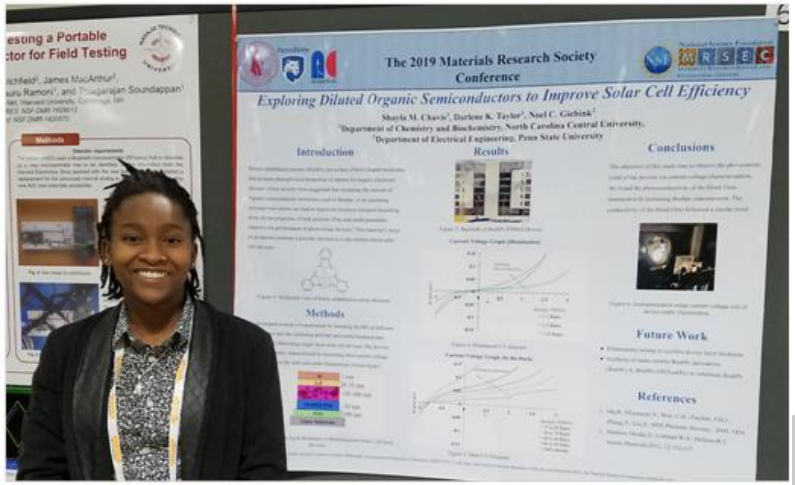
ANTICIPATING 20-40 AWARDS

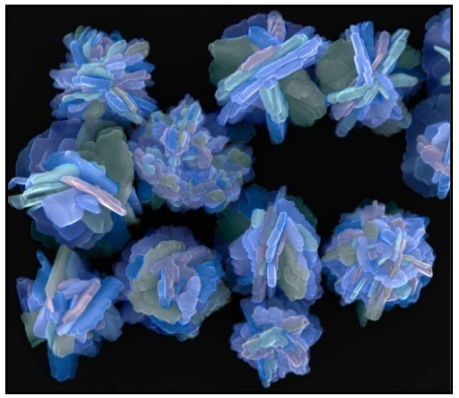
Partnership Model for Broadening Participation

- MSI in partnership with an MPS-supported research center, facility, platform or network
- Partnership for collaborative research and education providing value to both partners
- Building a national cohort of researchers from underrepresented and underserved groups in STEM fields





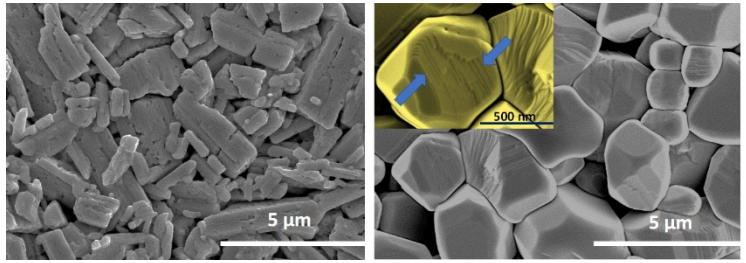




Partnerships for Research and Education in Materials (PREM)

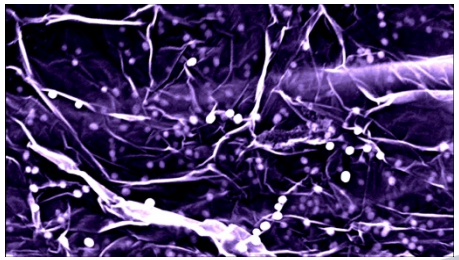
Minority-Serving Colleges & Universities

- Hispanic Serving/High Hispanic Enrollment Institutions (HSI/HHE)
- Historically Black Colleges and Universities (HBCUs)
- Minority Serving Institutions (MSI)
- Alaska Native Serving Institutions (ANSI)
- Native American-serving non-Tribal Institutions and Tribal Colleges and Universities (TCU)
- Native Hawaiian Serving Institutions (NHSI)



DMR-Supported Centers & Facilities

- Materials Research Science and Engineering Centers (MRSECs)
- DMR supported Science and Technology Centers (STCs)
- DMR supported Materials Innovation Platforms (MIP)
- National High Magnetic Field Laboratory (NHMFL)
- Cornell High Energy Synchrotron Source (CHESS)
- Center for High Resolution Neutron Scattering (CHRNS)



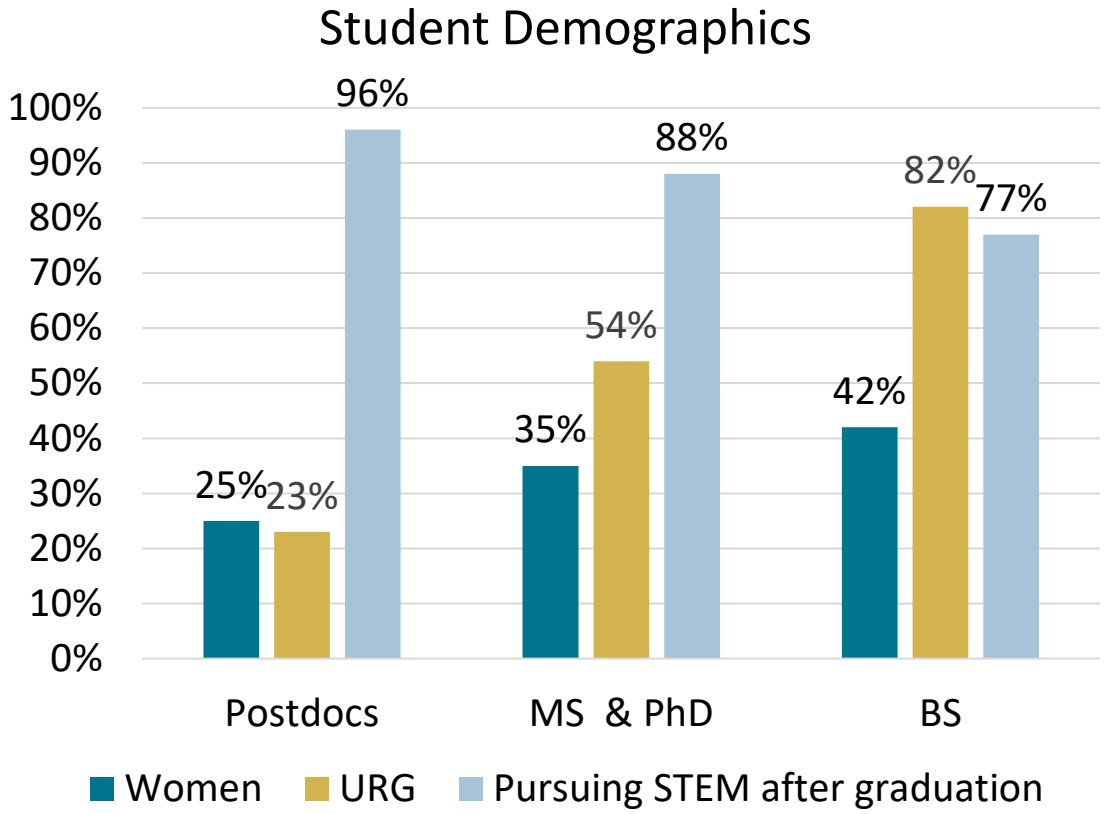
NSF

PREM
PARTNERSHIPS FOR RESEARCH AND EDUCATION IN MATERIALS

PREM in Numbers & Charts

- **Since inception (2004) 7 competitions have been held (1 every 3 years)**

Number of Awards: 46 Full + 12 Seed
Postdocs trained: 133
PhD and MS degrees awarded: 540
BS degrees awarded: 1105
Number of publications: 2405
Number of presentations: 5407



Partnerships for Research and Education in MPS

- **Enable, build, and grow *partnerships*** between minority-serving institutions and division-supported Centers, Facilities and Institutes…
- **Increase recruitment, retention and degree attainment** by members of those groups most underrepresented in Mathematical and Physical Sciences research
- **Support excellent research and education endeavors** that strengthen such partnerships

PREP: Partnerships for Research and Education in Physics

- **Solicitation:** 21-610
- **Partners:** 11 Physics Frontiers Centers
- **Funding structure:** $300,000/yr for 3 years
- **Anticipated awards:** 3-6 awards

PREC: Partnerships for Research and Education in Chemistry

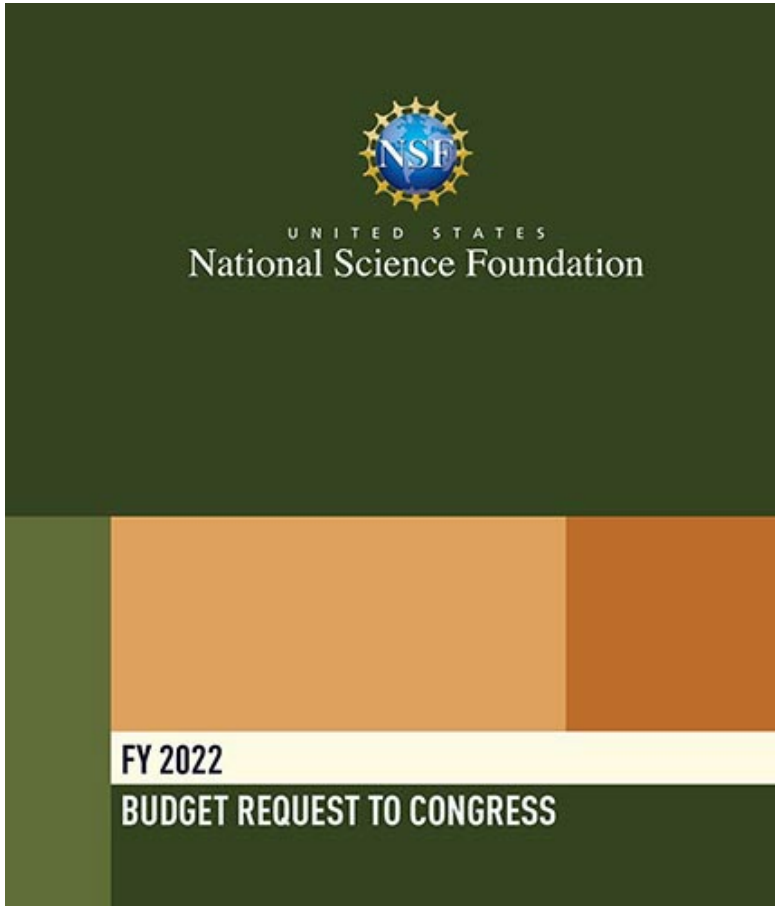
- **Solicitation:** 21-620
- **Partners:** 8 Centers for Chemical Innovation, Facilities, and Institutes
- **Funding structure:** *Track 1:* $300,000/yr for 3 years; *Track 2:* $600,000/yr for 3 years
- **Anticipated awards:** 2-4 awards

FY 2022 Budget

- Currently under CR through Dec. 3

- NSF Budget Request: $10.17 billion
  - $1.68 billion over FY2021 Enacted

- MPS budget request of $1.69 billion
  - $0.11 billion over FY2021 Enacted



Biden Administration

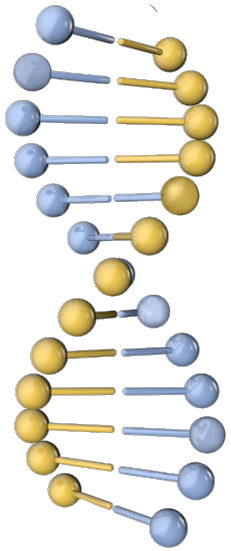
Clean Energy

Climate Change

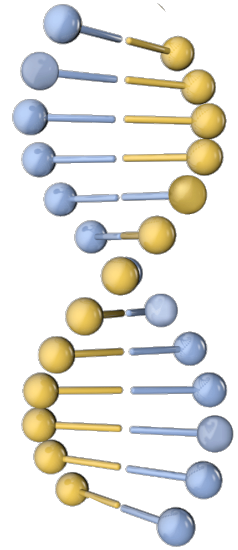
Racial Equity

Emerging Industries

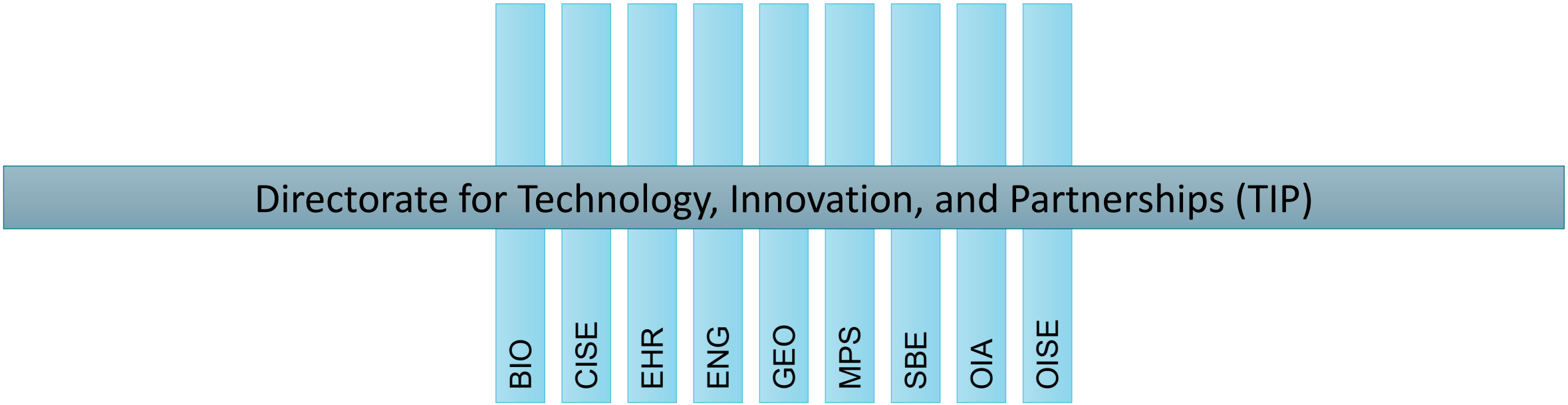
A New NSF Directorate?



Technology Innovation and Partnership



A new “horizontal” to enhance use-inspired and translational research



Realigned investments: $364.87M

New investments: $500M

Technology Translation: $329.87M

- PFI
- SBIR/STTR
- Innovative Pathways

Technology & Innovation Ecosystem: $485M

- Convergence Accelerator
- I-Corps
- Regional Innovation
- Industries of Tomorrow co-investment
- Entrepreneurial Fellows

Partnerships as a Foundation: $50M

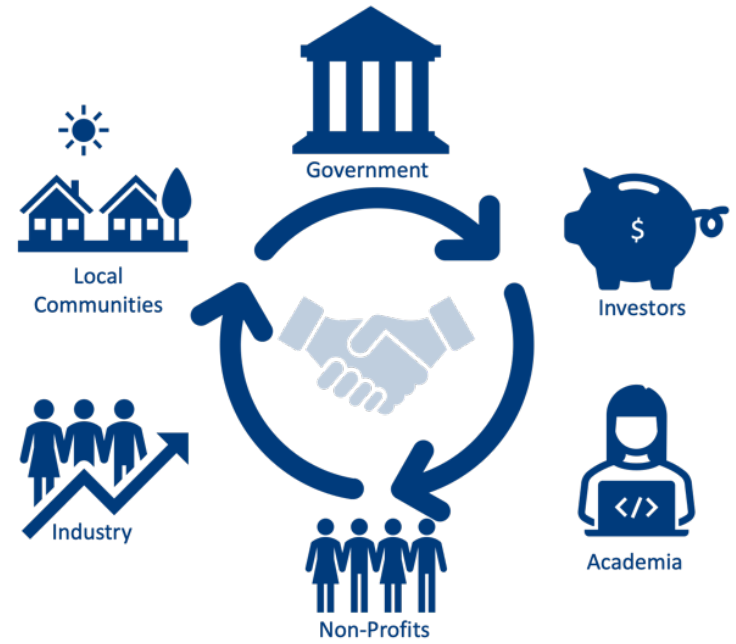
- Accelerate Partnerships

BIO | CISE | EHR | ENG | GEO | MPS | SBE | OIA | OISE

Regional Innovation Accelerators

- Cultivate innovation ecosystems at the scale of individual communities and/or regions throughout the U.S.
- Address major scientific and technological goals while ensuring broad societal benefits
- Balance technical and geographic innovation; incentivize partnerships; serve as hubs for NSF's broader portfolio

foundational science drivers



societal impacts, economic growth, new jobs

- Iterative co-design / co-creation
- Earlier engagement of broadest set of stakeholders to motivate / shape research
- Intentional co-funding (e.g., cost-share) and access to range of resources

Thank You!

Path to INCLUDES - IGEN:
Fisk Vanderbilt Bridge Program

Keivan Stassun; Vanderbilt University

CAREER: Order-of-Magnitude Problems in Star Formation and Minority Representation Vanderbilt University (Award AST – 0349075) **2003**

*Goal 3: **Train a cadre of minority undergraduate and Masters-level students for PhD study in astronomy and astrophysics**: 4. Prepare graduate students for their future roles integrating research and education. **This ambitious plan will be made possible by working in partnership with nearby Fisk University, an Historically Black University."*** (Abstract)

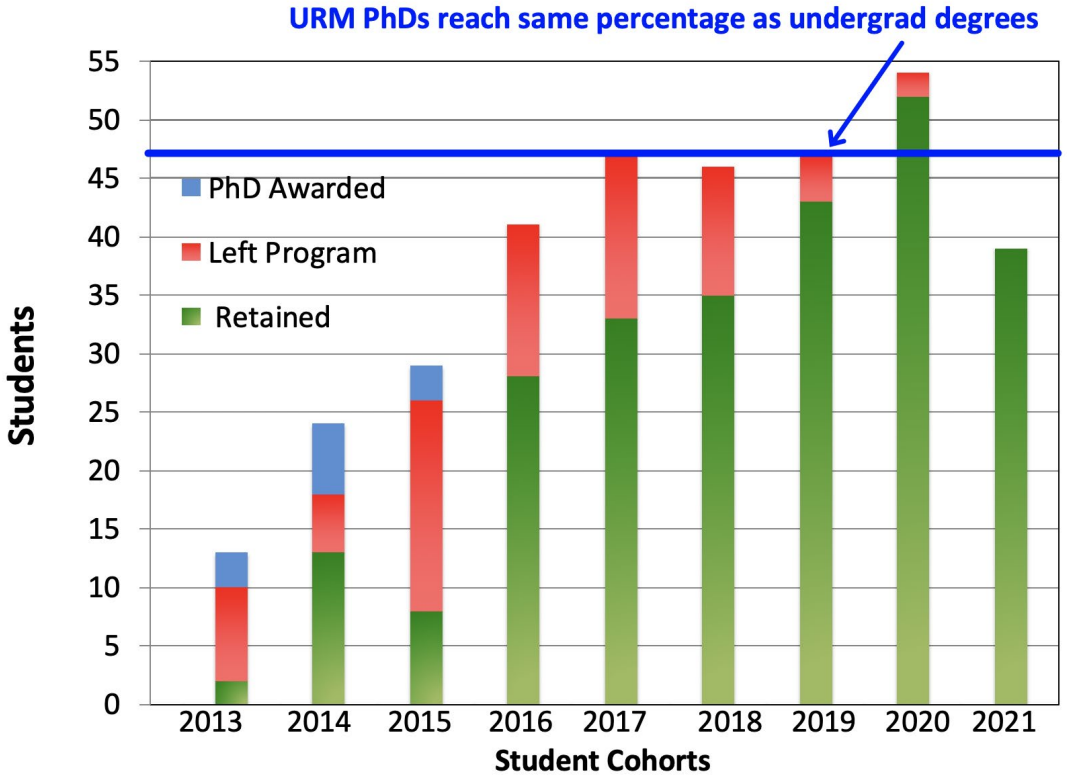
Now:
Vanderbilt: ~3-5 PhDs a year
Fisk: #1 producer of African Americans with Master's degrees

PATH to IGEN: *APS Bridge Program*

American Physical Society: (2011)

- Bridge program to support underrepresented minority (URM) students, including Black, Latinx, and Indigenous students.
- Partnership and Membership Institutions
- Strong emphasis on department mentoring
- Partnership between PHY and EHR (HRD)

Total number of physics students placed (all cohorts): 340
Overall retention rate: 78%
Total number of PhD graduates (to date): 12



Inclusive Graduate Education Network (IGEN)

Professional Societies: The **American Physical Society**, the **American Chemical Society**, the **American Geophysical Union**, the **American Astronomical Society**, and the **Materials Research Society**

Other Major Players: CIMER, Rochester Institute of Technology, University of Southern California, WestEd

Bridge Program	Year 1	Year 2	Year 3	Total
APS (Since the inception of IGEN)	• 47 APS Bridge Students	• 53 APS Bridge Students	• 37 APS Bridge Students	• 137 APS Bridge Students
ACS	• 10 ACS Bridge Students	• 21 ACS Bridge Students	• 25 ACS Bridge Students	• 56 ACS Bridge Students
AGU	• 0 AGU Bridge Students	• 7 AGU Bridge Students	• 20 AGU Bridge Students	• 27 AGU Bridge Students
Total	• 57 IGEN Bridge Students	• 81 IGEN Bridge Students	• 83 IGEN Bridge Students	• 221 IGEN Bridge Students

Main Goals:

- catalyzing graduate enrollment through new application and holistic review processes
- supporting programs to create more inclusive graduate education environments
- improving the mentoring of students.

IGEN Bridge programs have supported 221 students (95% retention)

Meeting this moment with an intentional focus