Overview of the Directorate for Mathematical and Physical Sciences

NSF Regional Grants Conference

Hosted by Howard University

Arlington, VA, March 11-12, 2013

Nigel Sharp, nsharp@nsf.gov

Program Director

Division of Astronomical Sciences

NSF Grants Conference

- CEMMSS
- CIF21
- E^2
- INSPIRE
- I-Corps
- SaTC
- SEES

- Transform the Frontiers
- Innovate for Society
- Perform as a Model Organization

US Government

THE GOVERNMENT OF THE UNITED STATES

THE CONSTITUTION

LEGISLATIVE BRANCH

THE CONGRESS

SENATE HOUSE

ARCHITECT OF THE CAPITOL
UNITED STATES BOTANIC GARDEN
GOVERNMENT ACCOUNTABILITY OFFICE
GOVERNMENT PRINTING OFFICE
LIBRARY OF CONGRESS
CONGRESSIONAL BUDGET OFFICE

EXECUTIVE BRANCH

THE PRESIDENT

THE VICE PRESIDENT

EXECUTIVE OFFICE OF THE PRESIDENT

WHITE HOUSE OFFICE
OFFICE OF THE VICE PRESIDENT
COUNCIL OF ECONOMIC ADVISERS
COUNCIL ON ENVIRONMENTAL QUALITY
NATIONAL SECURITY COUNCIL
OFFICE OF ADMINISTRATION
OFFICE OF MANAGEMENT AND BUDGET
OFFICE OF NATIONAL DRUG CONTROL POLICY
OFFICE OF POLICY DEVELOPMENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
OFFICE OF THE U.S. TRADE REPRESENTATIVE

JUDICIAL BRANCH

THE SUPREME COURT OF THE UNITED STATES

UNITED STATES COURTS OF APPEALS
UNITED STATES DISTRICT COURTS
TERRITORIAL COURTS
UNITED STATES COURT OF INTERNATIONAL TRADE
UNITED STATES COURT OF FEDERAL CLAIMS
UNITED STATES COURT OF APPEALS FOR THE ARMED FORCES
UNITED STATES TAX COURT
UNITED STATES COURT OF APPEALS FOR VETERANS CLAIMS
ADMINISTRATIVE OFFICE OF THE UNITED STATES COURTS
FEDERAL JUDICIAL CENTER
UNITED STATES SENTENCING COMMISSION

EXECUTIVE BRANCH — DEPARTMENTS

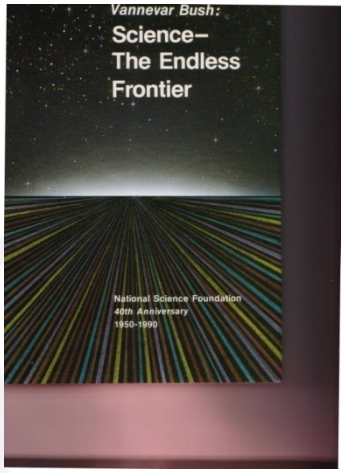
DEPARTMENT OF AGRICULTURE
DEPARTMENT OF COMMERCE
DEPARTMENT OF DEFENSE
DEPARTMENT OF EDUCATION
DEPARTMENT OF ENERGY
DEPARTMENT OF HEALTH AND HUMAN SERVICES
DEPARTMENT OF HOMELAND SECURITY
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
DEPARTMENT OF THE INTERIOR
DEPARTMENT OF JUSTICE
DEPARTMENT OF LABOR
DEPARTMENT OF STATE
DEPARTMENT OF TRANSPORTATION
DEPARTMENT OF THE TREASURY
DEPARTMENT OF VETERANS AFFAIRS

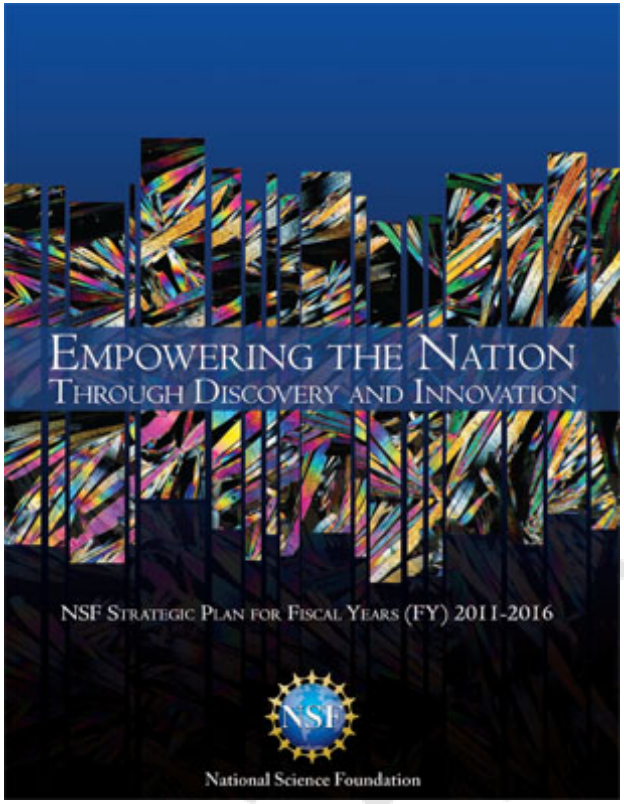
INDEPENDENT ESTABLISHMENTS AND GOVERNMENT CORPORATIONS

AFRICAN DEVELOPMENT FOUNDATION
BROADCASTING BOARD OF GOVERNORS
CENTRAL INTELLIGENCE AGENCY
COMMODITY FUTURES TRADING COMMISSION
CONSUMER PRODUCT SAFETY COMMISSION
CORPORATION FOR NATIONAL AND COMMUNITY SERVICE
DEFENSE NUCLEAR FACILITIES SAFETY BOARD
ENVIRONMENTAL PROTECTION AGENCY
EQUAL EMPLOYMENT OPPORTUNITY COMMISSION
EXPORT-IMPORT BANK OF THE U.S.
FARM CREDIT ADMINISTRATION
FEDERAL COMMUNICATIONS COMMISSION
FEDERAL DEPOSIT INSURANCE CORPORATION
FEDERAL ELECTION COMMISSION
FEDERAL HOUSING FINANCE BOARD
FEDERAL LABOR RELATIONS AUTHORITY
FEDERAL MARITIME COMMISSION
FEDERAL MEDIATION AND CONCILIATION SERVICE
FEDERAL MINE SAFETY AND HEALTH REVIEW COMMISSION
FEDERAL RESERVE SYSTEM
FEDERAL RETIREMENT THRIFT INVESTMENT BOARD
FEDERAL TRADE COMMISSION
GENERAL SERVICES ADMINISTRATION
INTER-AMERICAN FOUNDATION
MERIT SYSTEMS PROTECTION BOARD
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
NATIONAL ARCHIVES AND RECORDS ADMINISTRATION
NATIONAL CAPITAL PLANNING COMMISSION
NATIONAL CREDIT UNION ADMINISTRATION
NATIONAL FOUNDATION ON THE ARTS AND THE HUMANITIES
NATIONAL LABOR RELATIONS BOARD
NATIONAL MEDIATION BOARD
NATIONAL RAILROAD PASSENGER CORPORATION (AMTRAK)
NATIONAL SCIENCE FOUNDATION
NATIONAL TRANSPORTATION SAFETY BOARD
NUCLEAR REGULATORY COMMISSION
OCCUPATIONAL SAFETY AND HEALTH REVIEW COMMISSION
OFFICE OF THE DIRECTOR OF NATIONAL INTELLIGENCE
OFFICE OF GOVERNMENT ETHICS
OFFICE OF PERSONNEL MANAGEMENT
OFFICE OF SPECIAL COUNSEL
OVERSEAS PRIVATE INVESTMENT CORPORATION
PEACE CORPS
PENSION BENEFIT GUARANTY CORPORATION
POSTAL RATE COMMISSION
RAILROAD RETIREMENT BOARD
SECURITIES AND EXCHANGE COMMISSION
SELECTIVE SERVICE SYSTEM
SMALL BUSINESS ADMINISTRATION
SOCIAL SECURITY ADMINISTRATION
TENNESSEE VALLEY AUTHORITY
TRADE AND DEVELOPMENT AGENCY
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
U.S. COMMISSION ON CIVIL RIGHTS
U.S. INTERNATIONAL TRADE COMMISSION
U.S. POSTAL SERVICE

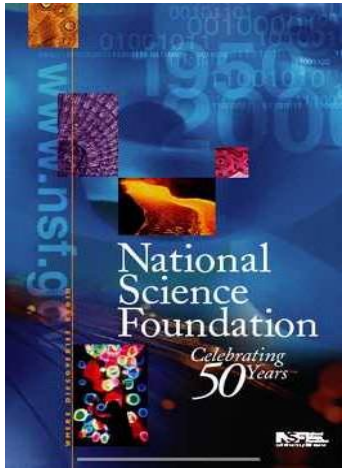
NSF Vision and Goals

- Vision
  - » NSF envisions a nation that capitalizes on new concepts in science and engineering and provides global leadership in advancing research and education
- Mission
  - » To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense
- Goals
  - » Discovery
  - » Learning
  - » Research Infrastructure
  - » Stewardship





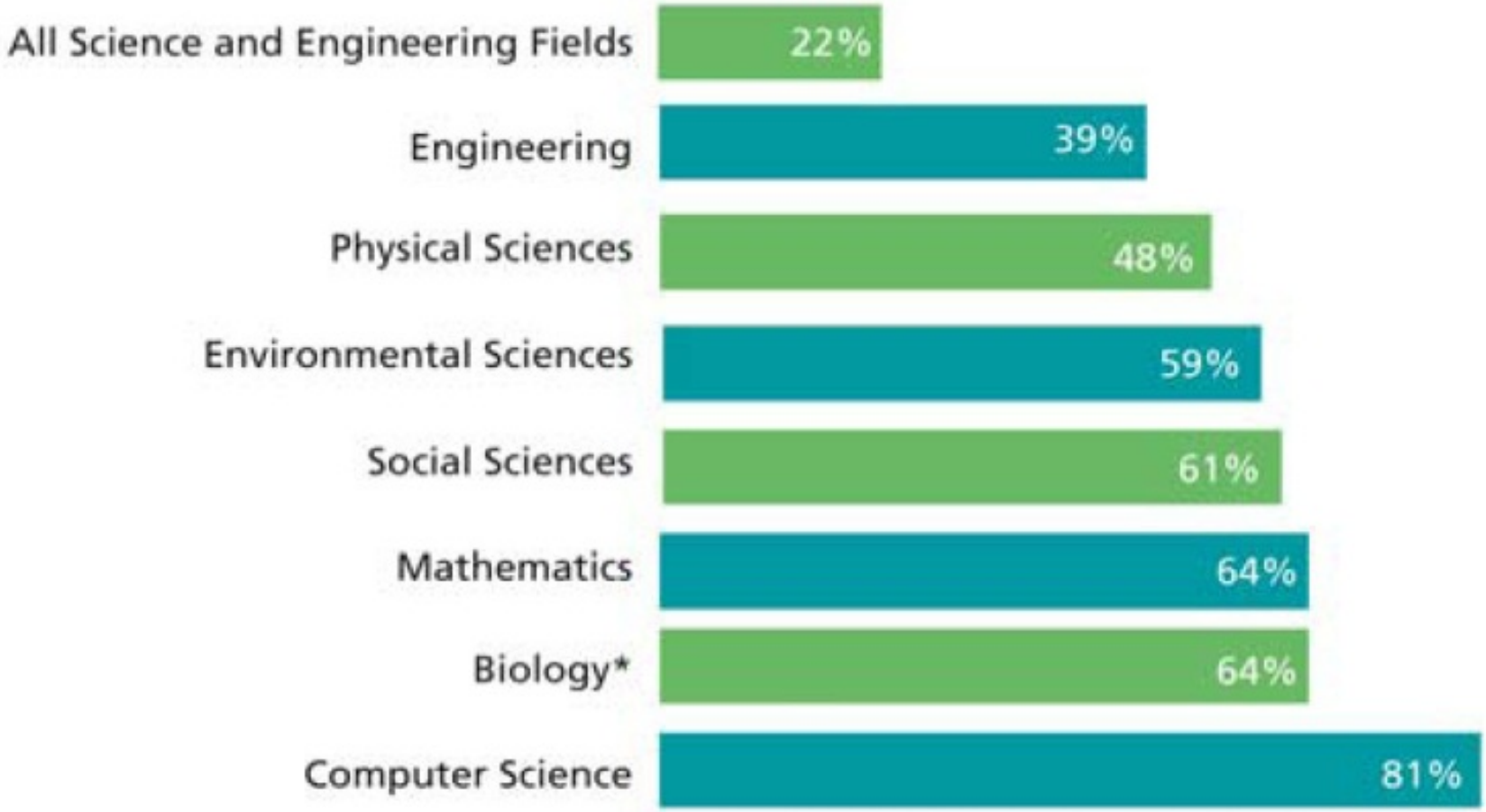
NSF in a Nutshell



- Independent agency
- Support basic research and education
- Use grant mechanism in two forms:
  - » Unsolicited, curiosity driven (majority of $)
  - » Solicited, more focused
- Merit review: Intellectual Merit & Broader Impacts
- Support all fields of science/engineering
- Discipline-based structure
- Cross-disciplinary mechanisms
- Support large facilities

NSF Support of Academic Basic Research in Selected Fields

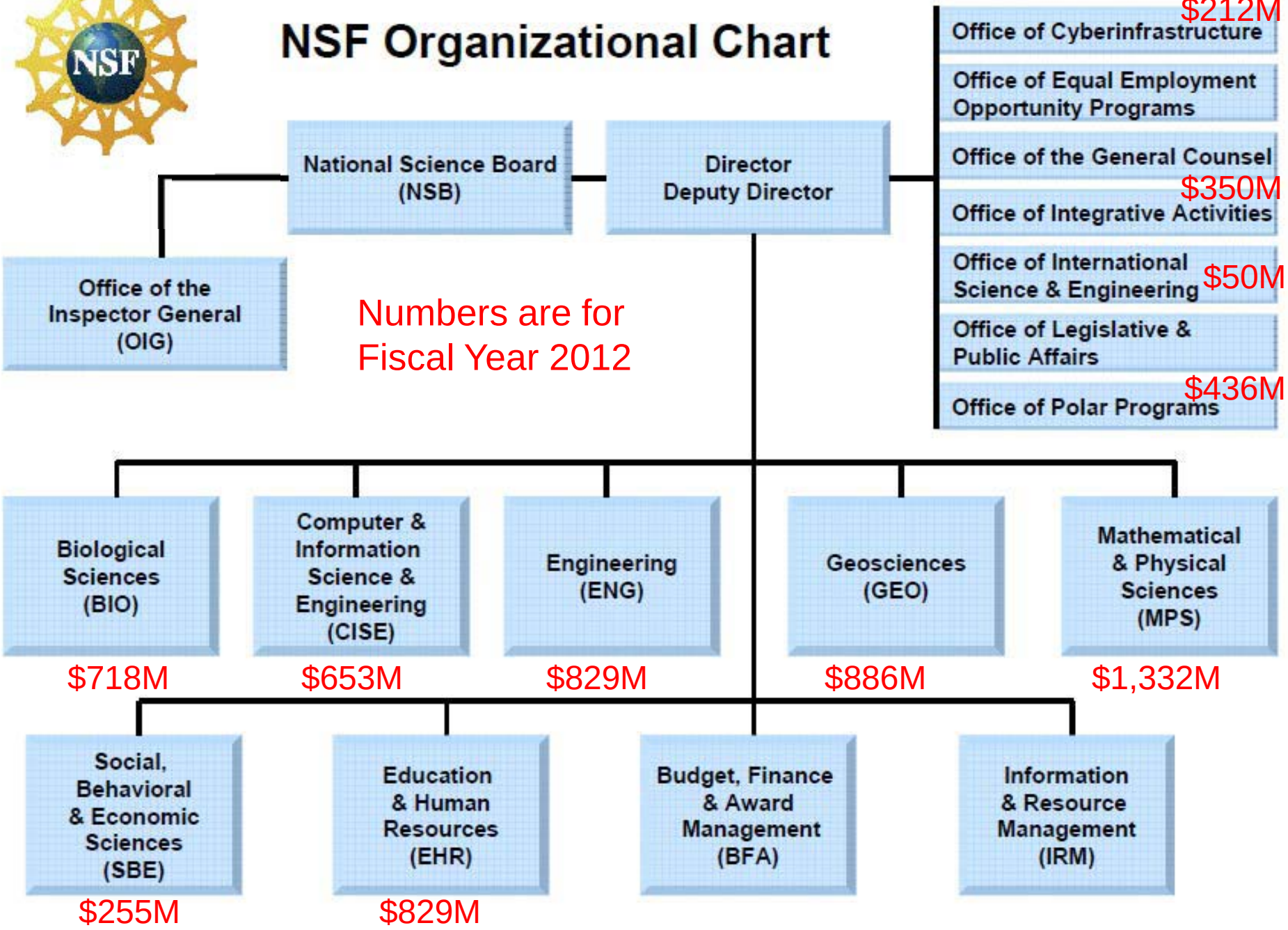
(as a percentage of total federal support)



Note: Data shown is for FY 2008, the most recent available at this time.
*Includes Biological Sciences and Environmental Biology; excludes NIH.

Source: NSF/National Center for Science and Engineering Statistics, Survey of Federal Funds for Research & Development.

NSF Organizational Chart



Numbers are for Fiscal Year 2012

NSF-Wide Scientific Investments

Directorates

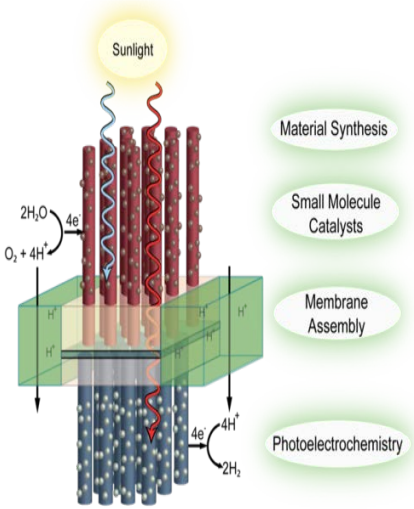
- Biological Sciences
- Computer & Information S&E
- Engineering
- Geosciences (now w/OPP)
- Math and Physical Sciences
- Social, Behavioral, & Econ Sci.
- Education & Human Resources
- OIIA (OIA+OISE) OCI (in CISE)

- CyberInfrastructure Framework for the 21st Century (CIF21)
- Nano-scale Science & Engineering
- Advanced Manufacturing
- Science and Engineering Beyond Moore's Law
- Networking & Information Technology R&D
- Science Engineering & Education for Sustainability (SEES)
- Enhancing Access to the Radio Spectrum (EARS)
- Broadening Participation

Science, Engineering, and Education for Sustainability (SEES)

To advance science, engineering, and education to inform the societal actions needed for environmental and economic sustainability and sustainable human well-being

- » Resilience to natural and technological disasters
- » Coastal and Arctic systems
- » Sustainable Chemistry, Engineering and Materials
- » Improvements in IT energy efficiency



MPS: $27.2M in FY 2013

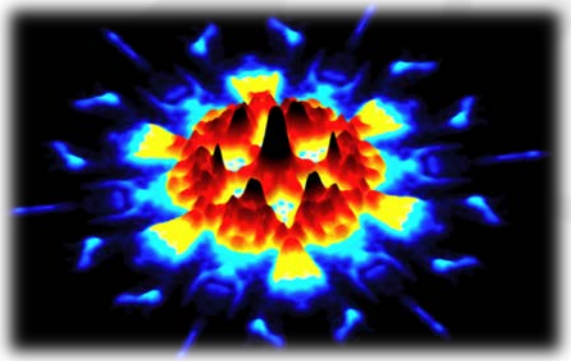
Cyber Infrastructure Framework for 21st Century Science and Engineering (CIF21)

- Cyberinfrastructure to transform research, innovation, and education
- Major components
  - » Computational and Data-enabled Science
  - » Core Technologies, Tools, Algorithms
  - » Big Data Projects
  - » Workforce Development
  - » Partnerships: internal/external

MPS: $19.5M in FY 2013

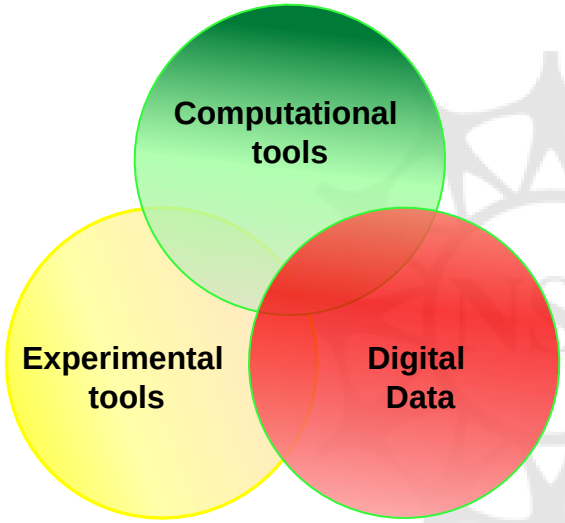
Cyber-Enabled Materials Manufacturing and Smart Systems (CEMMSS) $50M/MPS

Topological Insulators



- Partnership with ENG and CISE
- Advanced Manufacturing
- DMREF

Materials Innovation Infrastructure



- Fundamental research for discovering, modeling, making, optimizing and manufacturing with new materials and material systems

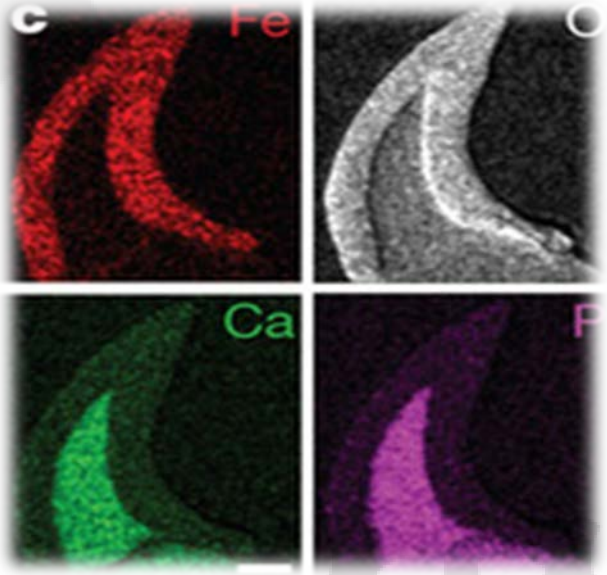
Secure and Trustworthy Cyberspace (SaTC)

MPS: $2.0M in FY 2013

- Cross-foundation partnership to build a cybersecure society
- Produce high-quality digital systems and a well-trained cybersecurity workforce
- *Strategic Plan for the Federal Cybersecurity Research and Development Program*
- Comprehensive National Cybersecurity Initiative (CNCI)

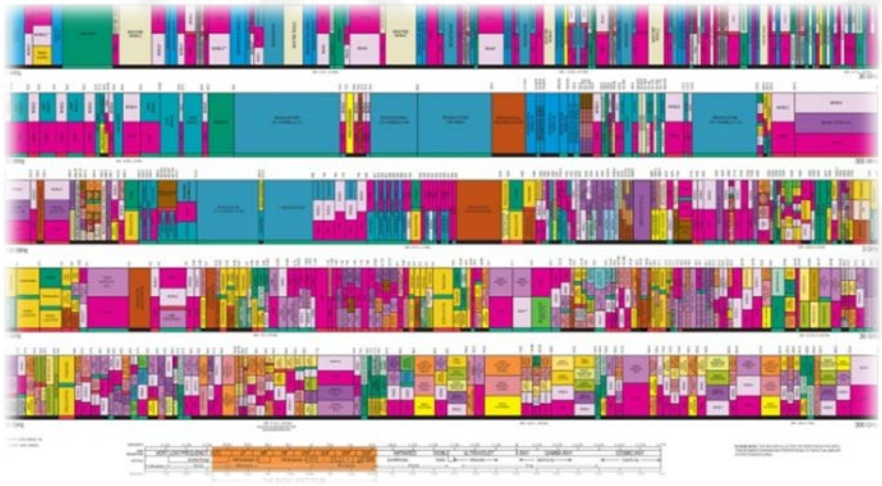
Research at the Interface of Biological, Mathematical, & Physical Sciences (BioMaPS)

- Adaptive network models
- Biological design strategy for better composite materials
- Computational, Mathematical and Statistical modeling



MPS: $11.6M in FY 2013

Enhancing Access to the Radio Spectrum (EARS)



MPS: $12.0M in FY 2013

- **Partnership among MPS, ENG, CISE, and SBE**
- **Cross-cutting research on efficient use of radio spectrum**
- **Technology, economics, social science, and public policy**
- **Responsive to national broadband plan**

Supporting Multidisciplinary Research Across NSF

- INSPIRE
  - Track 1/2 (1 was CREATIV)
  - High-risk/high-reward research across disciplines
- I-Corps
  - Business friendly
  - NSF's first I-Corps award: solar irradiation to dissolve oil contaminants in water
- Science Across Virtual Institutes (SAVI)
  - Virtual Institute for Mathematical and Statistical Sciences (VI-MSS) connects Institutes based in the U.S. and India

NSF-Wide Programs

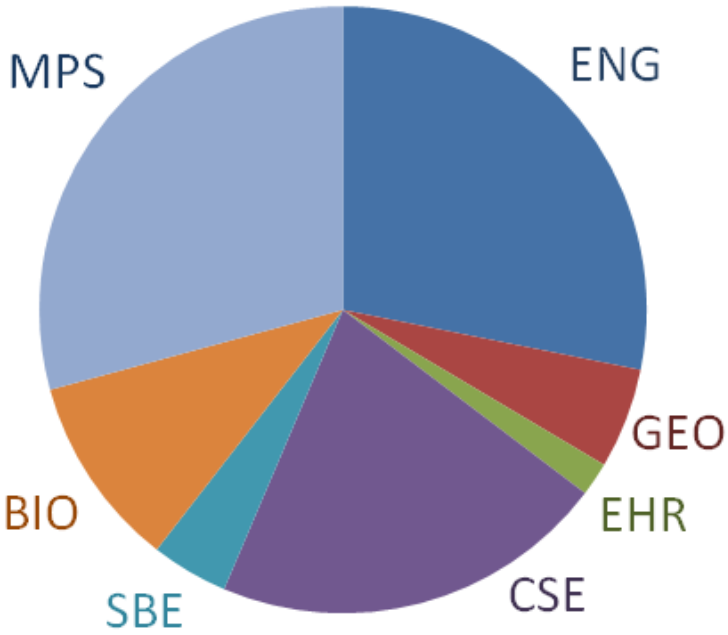
Directorates

- Biological Sciences
- Computer & Information S&E
- Engineering
- Geosciences (+ OPP)
- Math and Physical Sciences
- Social, Behavioral, & Econ Sci.
- Education & Human Resources
- Office of Int'n'l & Integ.Activities

- CAREER
- ADVANCE
- RCN
- GRFP & IGERT
- REU, RET
- GOALI & I-Corps
- RUI, ROA
- EESE
- EPSCoR

CAREER Program

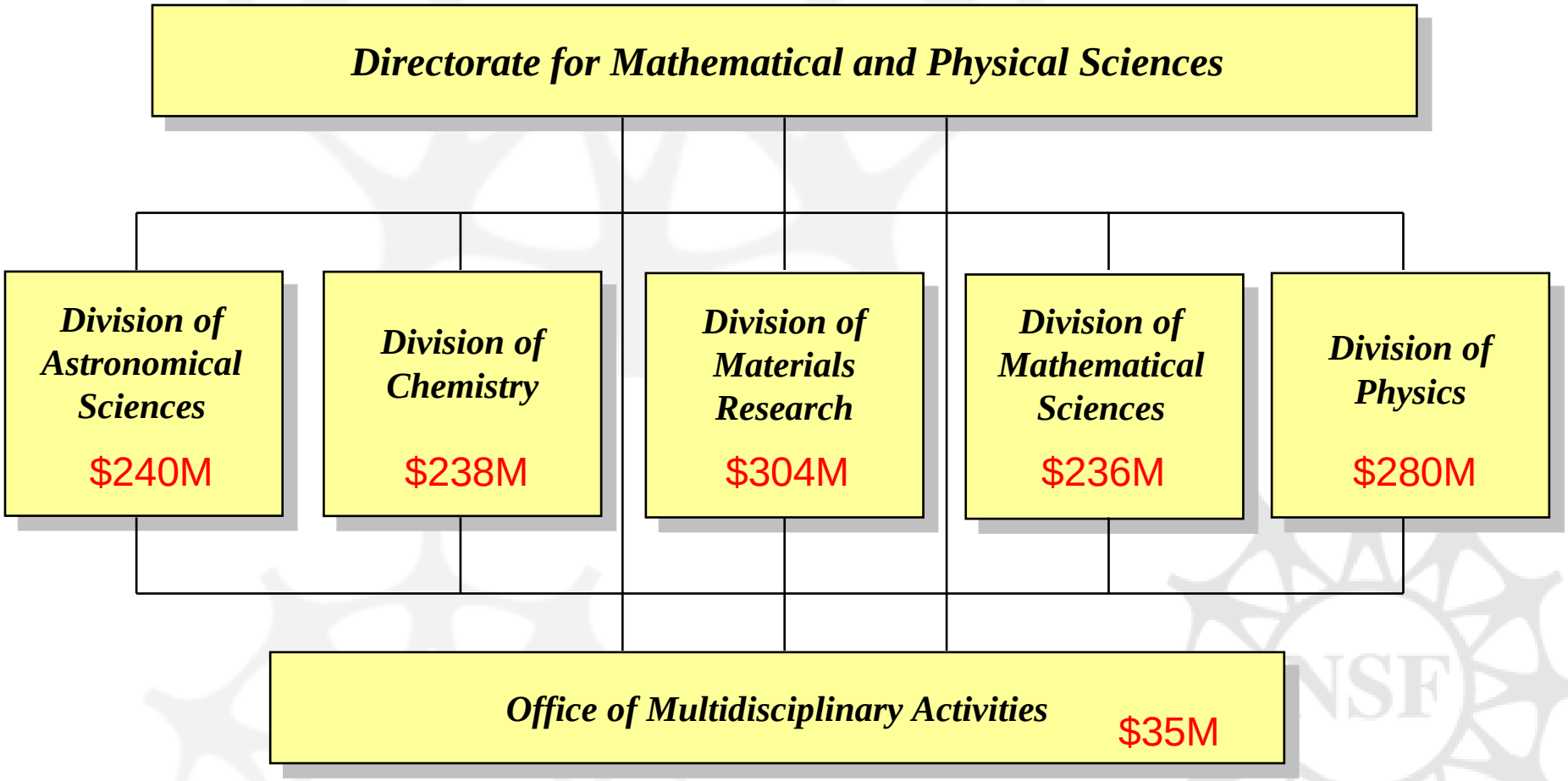
- NSF's most prestigious awards for junior faculty.
- Awardees are selected based on their plan of outstanding research, excellent education, and the integration of research and education within the context of the mission of their organizations, building a firm foundation for a lifetime of leadership.
- Increased participation of those traditionally under-represented in science and engineering is encouraged.



Directorate for Mathematical and Physical Sciences (MPS)

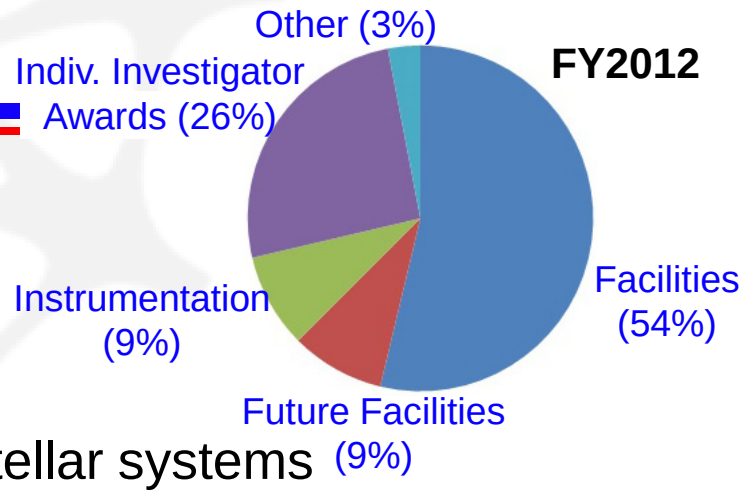
- To make discoveries about the Universe and the laws that govern it;
- To create new knowledge, materials, and instruments which promote progress across science and engineering;
- To prepare the next generation of scientists through research, and to share the excitement of exploring the unknown with the nation.

Directorate for Mathematical and Physical Sciences (MPS)



Numbers are for Fiscal Year 2012

Astronomical Sciences (AST)



- From the Big Bang to DNA
  - » Origin and evolution of the Universe
  - » Origin and evolution of galaxies
  - » Origin and evolution of planetary and stellar systems
- National astronomy portfolio
  - » Three agencies – NSF, NASA, and DoE – and international partnerships
  - » Strong tradition of private funding
  - » NSF assigned federal stewardship of ground-based astronomy
  - » **Includes open-access facilities and mission-free unrestricted grants**

AST has a strong program in Education and Special Programs (including a major investment in post-docs)

Astronomical Sciences (AST)
2011 Physics Nobel Prize

- Discovery of accelerating universe/Dark Energy by two groups
  - » Winners: Brian Schmidt, Adam Riess, Saul Perlmutter
- AST Individual Investigator awards
  - » Over a dozen awards to Robert Kirshner at Michigan, then Harvard for studies of supernovae in 1980s and 1990s
    - » Schmidt and Riess were graduate students at Harvard in 1990s when key work was done
  - » Grants to other co-authors also supported the work
- National facilities
  - » Key supernova identifications for both groups from Cerro Tololo Interamerican Observatory (part of National Optical Astron. Obs.)
    - » Confirming/supporting observations at Kitt Peak, Gemini
  - » NSF Center for Astroparticle Physics at UC Berkeley provided some of the support for Perlmutter's group

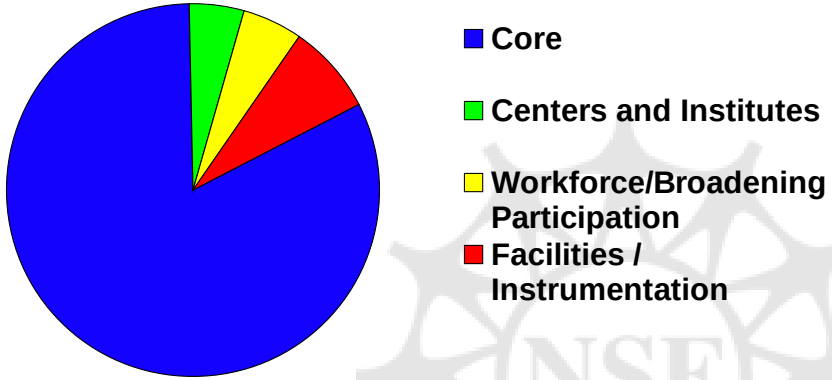
Chemistry (CHE)

- Chemical Synthesis
- Chemical Structure, Dynamics, and Mechanisms
- Theory, Models, and Computational Methods
- Chemical Measurement and Imaging

Integrative Chemistry Activities

- Centers
- Education and Broadening Participation
- Facilities and Instrumentation

- Environmental Chemical Sciences
- Chemistry of Life Processes
- Chemical Catalysis
- Macromolecular, Supramolecular, and Nanochemistry



- **Major CAREER and REU support**
- **Centers program growing**
- **Collaborations with NIH and DOE**
- **Critical areas of research:**

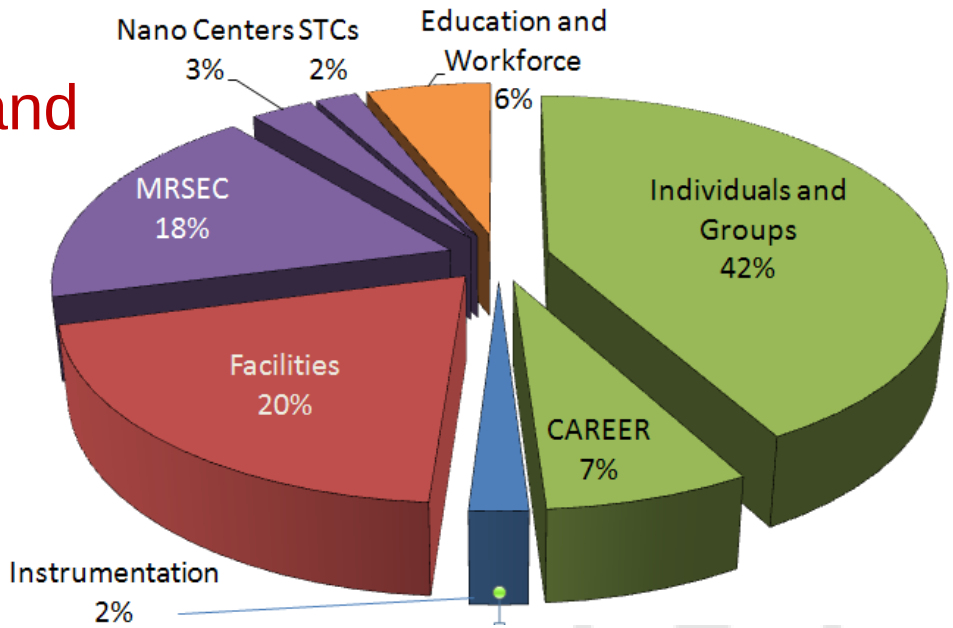
Sustainability; CyberInfrastructure; Energy, Element and Molecule Recycling; Designed Emergent Behavior; Imaging the Ultrasmall

Materials Research (DMR)

DMR Programs

- Eight Major Areas:
  - » Ceramics, Electronic and Photonic Materials, Metals and Metallic Nanostructures
  - » Condensed Matter Physics, Condensed Matter & Materials Theory
  - » Biomaterials, Polymers, Solid-State and Materials Chemistry
- Materials Research Science and Engineering Centers
- National Facilities and Instrumentation
- Office of Special Programs
  - » International collaboration
  - » Education

DMR supports a wide breadth of science – fundamental research to the development of technological applications.



Materials Research (DMR)

- Key disciplinary research areas
  - » Unsolicited programs continue to cover the eight major areas of materials research
  - » Designing Materials to Revolutionize our Future (DMREF) – an opportunity to combine theory, data and experiment
- Key interdisciplinary research areas
  - » Interface of Bio and Physical Sciences
  - » Sustainability
    - – Sustainable Chemistry, Chemical Engineering and Materials Research (SUSCHEM)
  - » Nanoscience and Nanotechnology
  - » Advanced Manufacturing

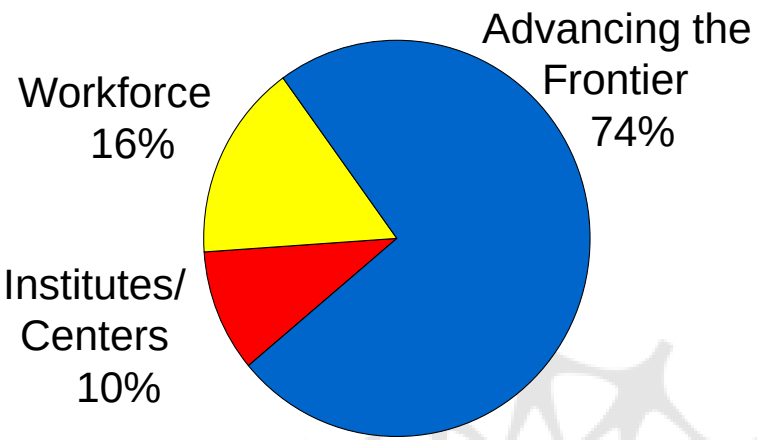
Mathematical Sciences (DMS)

Analysis	Algebra Number Theory Combinatorics	Geometry Topology	Applied Math	Comp. Math	Probability Statistics	Workforce	Institutes

"Core business:" single investigator and group proposals through targeted solicitations
Covers the entire mathematical spectrum

Institutes: 5 NSF-initiated, support for 3 others
- » Visitors to long term programs, workshops

Workforce: responding to a major challenge.
- » EMSW21 training grants
- » Postdoctoral fellowships
- » Research for Undergraduates



In addition to the fundamental research in mathematical sciences, DMS plays an enabling role of all other sciences; DMS has been successful in partnering with other NSF Divisions and Directorates and with other government agencies.

Mathematical Sciences (DMS)

Priorities

Disciplinary

- Algebra and Number Theory
- Analysis
- Applied Mathematics
- Combinatorics
- Computational Mathematics
- Foundations
- Geometric Analysis
- Mathematical Biology
- Probability
- Statistics
- Topology

Interdisciplinary

- Interface of the Biological and Mathematical Sciences (DMS/NIGMS)
- Algorithms for Threat Detection (ATD)
- Emerging Frontiers in Research & Innovation(EFRI)
- Interaction in Basic and Applied Scientific Research in BIO, ENG & MPS (BIOMaPS)
- Software Infrastructure for Sustained Innovation (SISI)
- CIF21, SEES, INSPIRE, SAVI

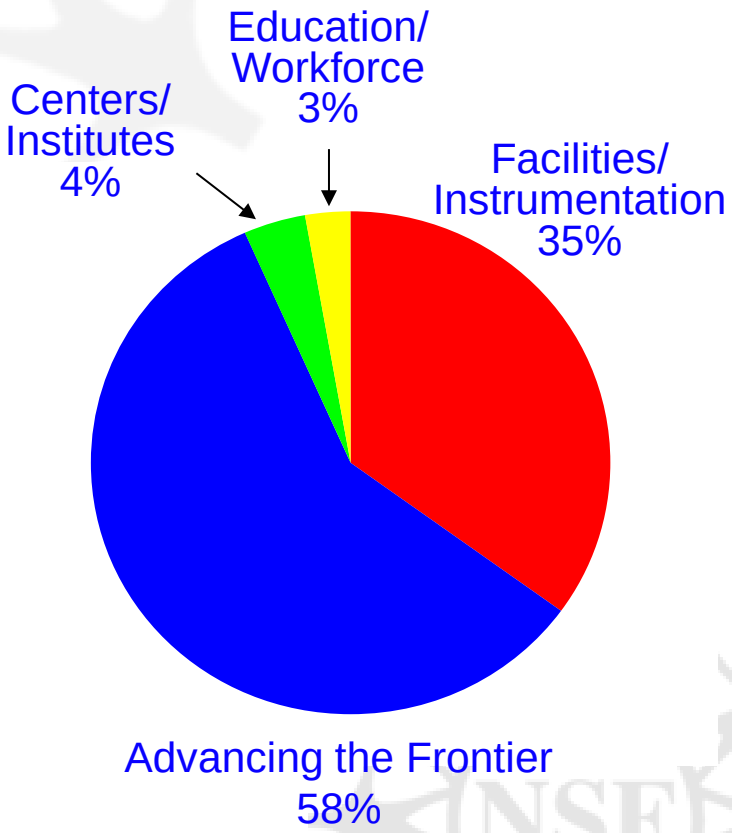
Physics (PHY)

Facilities:

LHC, LIGO, IceCube, NSCL, …

Programs:

- Atomic, Molecular, Optical, and Plasma Physics
- Biological Physics
- Elementary Particle Physics
- Gravitational Physics
- Nuclear Physics
- Particle and Nuclear Astrophysics
- Physics at the Information Frontier
- Physics Frontiers Centers
- Theoretical Physics
- Education and Interdisciplinary Programs



PHY collaborates closely with DOE and international partners to support science at large facilities. NSF's physics portfolio is more diverse than those at any other federal agency.

MPS in a (different) Nutshell

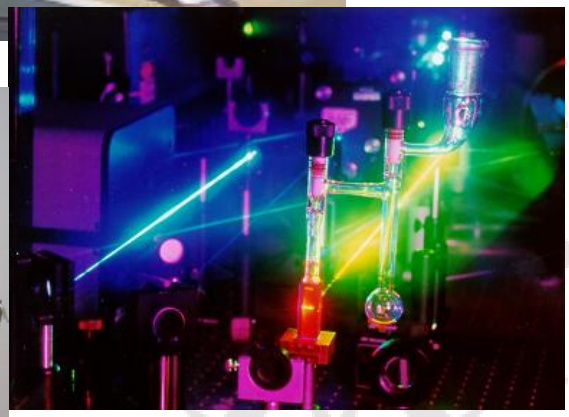
- Largest directorate
  - ~23% of R&RA, ~18% of proposals, FY13 request $1345m
- About half of NSF's large facilities
- Responsible for the three "core" university disciplines – Physics, Chemistry, Mathematics – and Astronomy and Materials Research
- ~40% of university federal funding in the physical sciences
  - More than 80% in mathematics
  - Federal steward for ground-based astronomy
- Science scope - extension on every scale
  - Femtoseconds and attoseconds to petaseconds and exaseconds
  - From the Planck size to the Cosmic size
  - From nanoKelvin to GigaKelvin
  - From fundamental research to marketable technologies
  - Every mental horizon from n-dimensions to infinity and beyond …

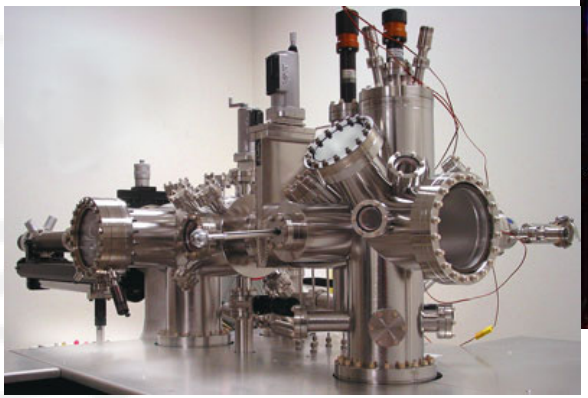
MPS Scientific Opportunities

- Physical sciences at the nanoscale
- Science beyond “Moore’s Law”
- Physics of the Universe
- Complex systems (multi-scale, emergent phenomena)
- Fundamental mathematical and statistical science
- Sustainability (energy, environment, climate)
- Interface between the physical and life sciences
- Computational and data-enabled science and engineering (CDS&E)

Instrumentation

- Both acquisition and development
- Major Research Instrumentation (MRI)
- Divisional instrumentation programs
- Research grants

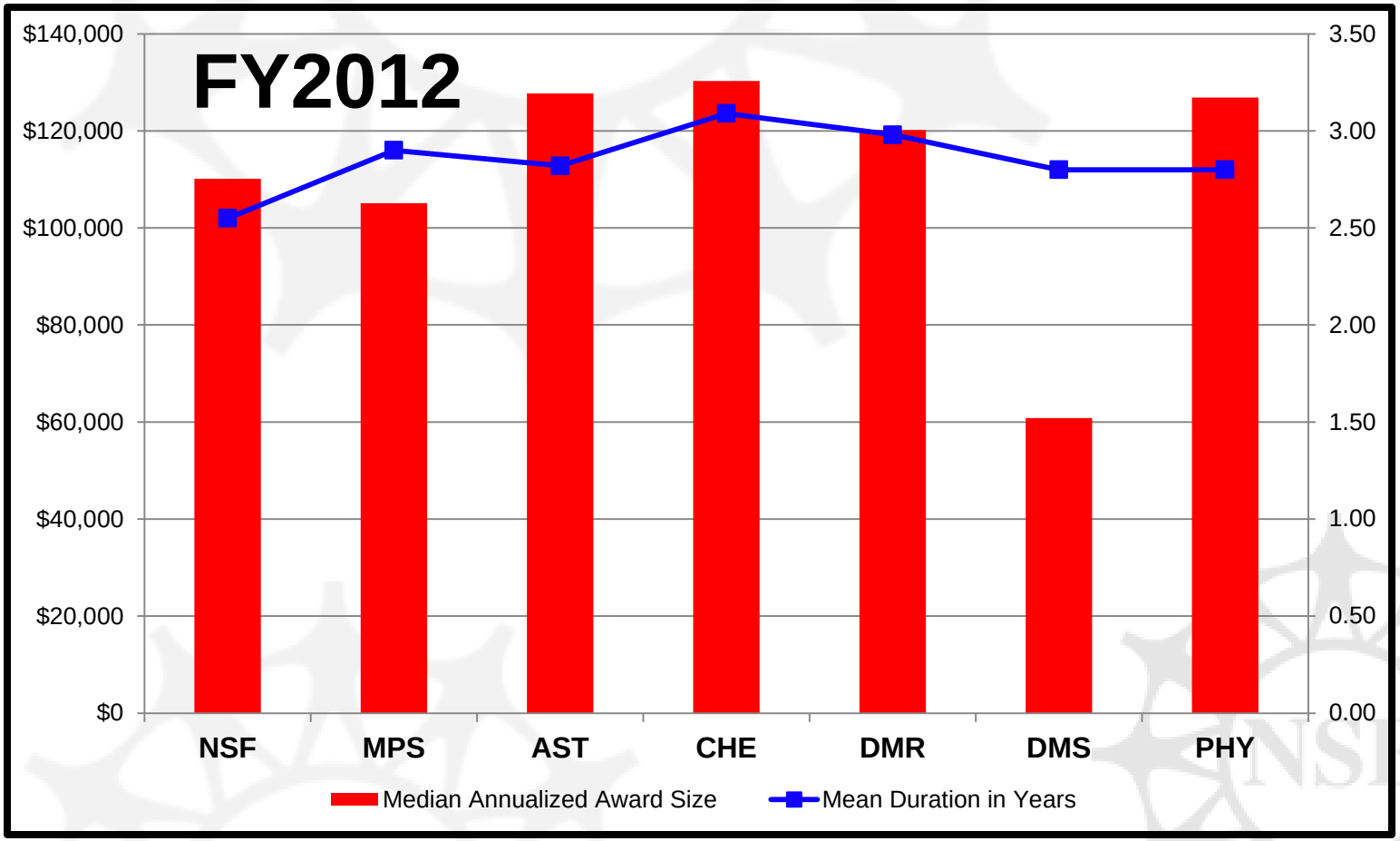




World Class Major Facilities

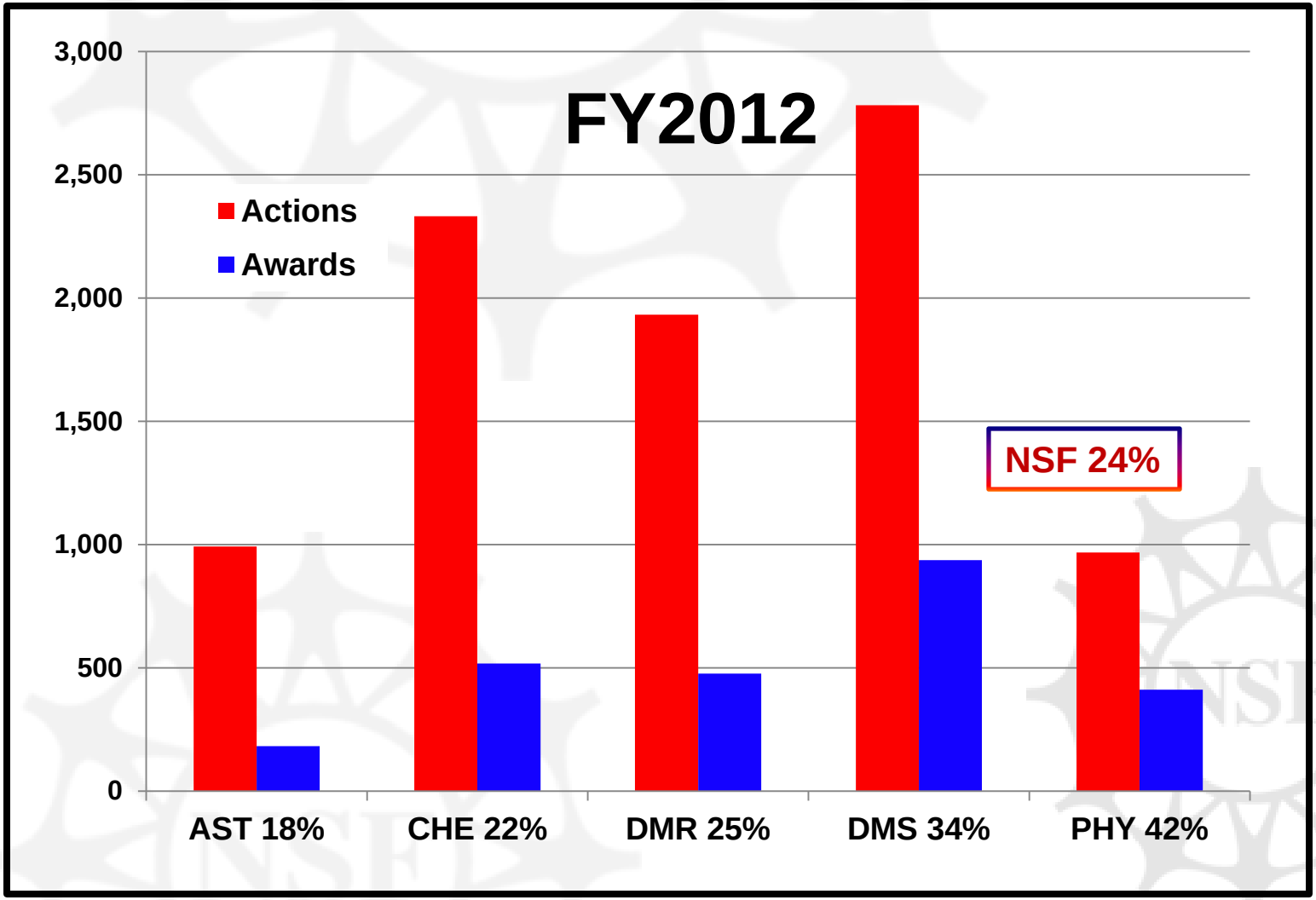
Keeping Researchers at the Frontier

Median Annualized Award Size



Award duration ranges from one to five years (even, though rarely, more), with a mean around three years

Funding Rates

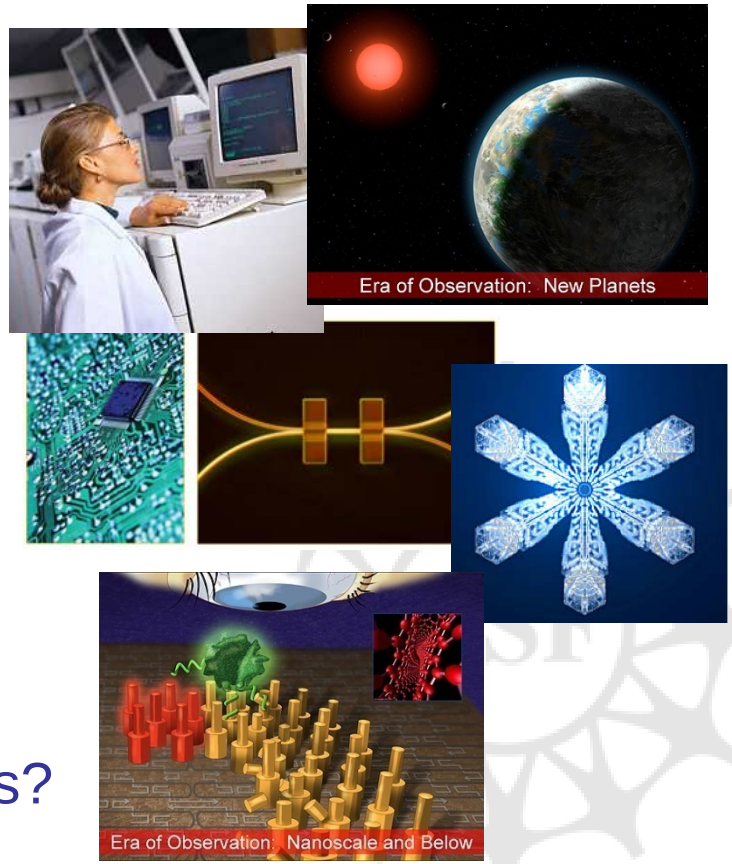


Merit Review Criteria: Recent Changes

- Three Principles
  1. Highest quality: advance, even transform, the frontiers of knowledge.
  2. In aggregate, contribute more broadly to achieving societal goals.
  3. Based on appropriate metrics.
- Two Criteria *(unchanged)*
  1. Intellectual Merit
  2. Broader Impact
- Five Elements
  1. Potential to advance knowledge & benefit society
  2. Creative, original, or potentially transformative concepts?
  3. Well-reasoned, well-organized, sound rationale, & assessed?
  4. Qualified (individual, team, institution)?
  5. Adequate resources?

Merit Review Criteria: Intellectual Merit

- How important is the proposed activity to advancing knowledge and understanding within its own field or across different fields?
- How well qualified is the proposer (individual or team) to conduct the project?
- To what extent does the proposed activity suggest and explore creative, original, or potentially transformative concepts?
- How well conceived and organized is the proposed activity?
- Is there sufficient access to resources?



Merit Review Criteria:
Broader Impacts

- How well does the activity advance discovery and understanding while **promoting teaching, training, and learning**?
- How well does the proposed activity broaden the participation of **underrepresented groups**?
- To what extent will it enhance the **infrastructure** for research and education, such as facilities, instrumentation, networks, and partnerships?
- Will the **results be disseminated** broadly to enhance scientific and technological understanding?
- What may be the benefits of the proposed activity to **society**?

NSF Proposal Preparation

- **ASK EARLY, ASK OFTEN**
- Read the paperwork (descriptions, solicitations etc.) with care; ask a Program Director for clarifications
- Contact the Program Director(s) to discuss your project: email with 1-2 page description and questions, call, visit
- Be familiar with programs and funded projects
  - Guide to Program:
    http://www.nsf.gov/funding/browse_all_funding.jsp
  - Award information, including abstracts:
    http://www.nsf.gov/awardsearch
- Know the audience for your proposal review - it **really** is a **competition!**

NSF Proposal Submission

- Know and follow the ***current*** Grant Proposal Guide (GPG) - it changes! (data management, postdoc mentoring, bio.sketch contents … *ad infinitum*)
- ***Explicitly*** address Intellectual Merit and Broader Impacts in both the Project Summary and Project Description
- Match and justify the budget to the scope of the proposed work - ask for what you need
- Submit proposals **before the last day/hour !!**
- Download your completed proposal back to you to check it's what you sent

What Makes a Strong Proposal?

- New and original ideas (what?)
- Sound, succinct, detailed focused plan (how?)
- Preliminary data and/or feasibility calculations
- Relevant experience (why me/us?)
- Important & timely within field (why now?)
- Clarity concerning future direction (so what?)
- Well-articulated broader impacts

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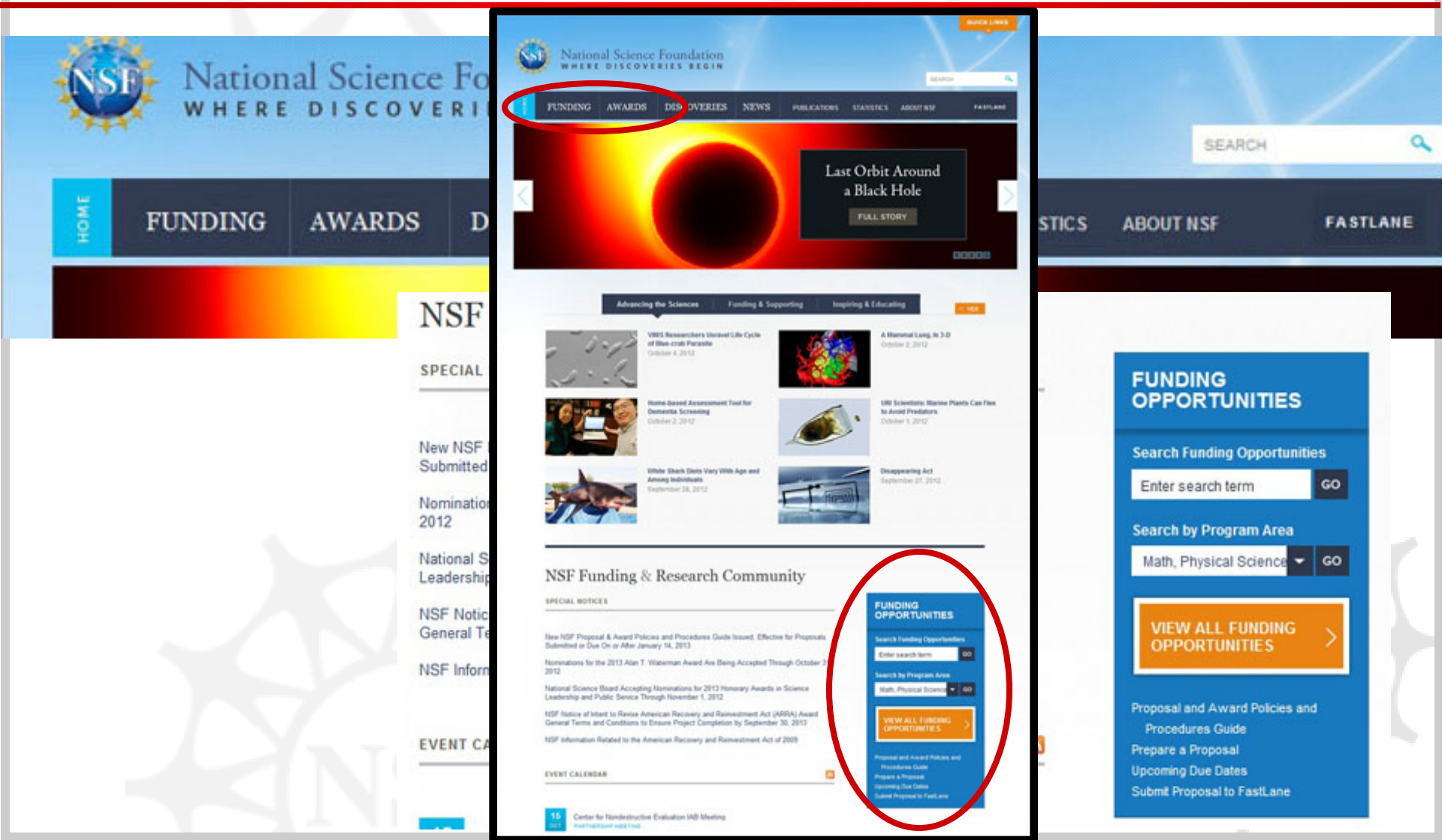
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Get Involved

- Volunteer to be a reviewer and panelist
- Participate in NSF-funded events, workshops, meetings
- Proposals: send your best ideas to NSF
- Get to know your Program Directors
- Keep us informed of your accomplishments
- Work to support collaborative, interdisciplinary research
- Call our attention to things that need improvement
- Suggest strategies to go from basic research to production
- Serve as a program officer (“rotator”) or division director

For information on a particular MPS division and program:

http://www.nsf.gov/home/mps

Contact NSF Program Directors for questions & suggestions

Some Useful Web Sites

- NSF: www.nsf.gov
- MPS: http://www.nsf.gov/home/mps
- Guide to Program: http://www.nsf.gov/funding/browse_all_funding.jsp
- Award information: http://www.nsf.gov/awardsearch
- FastLane: https://www.fastlane.nsf.gov
- Broader impacts: http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf
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Nigel Sharp
703-292-4905
nsharp@nsf.gov