

Overview of the Directorate for Mathematical and Physical Sciences

NSF Grants Conference

Hosted by George Washington University

Arlington, VA, October 6-7, 2014

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Program Director

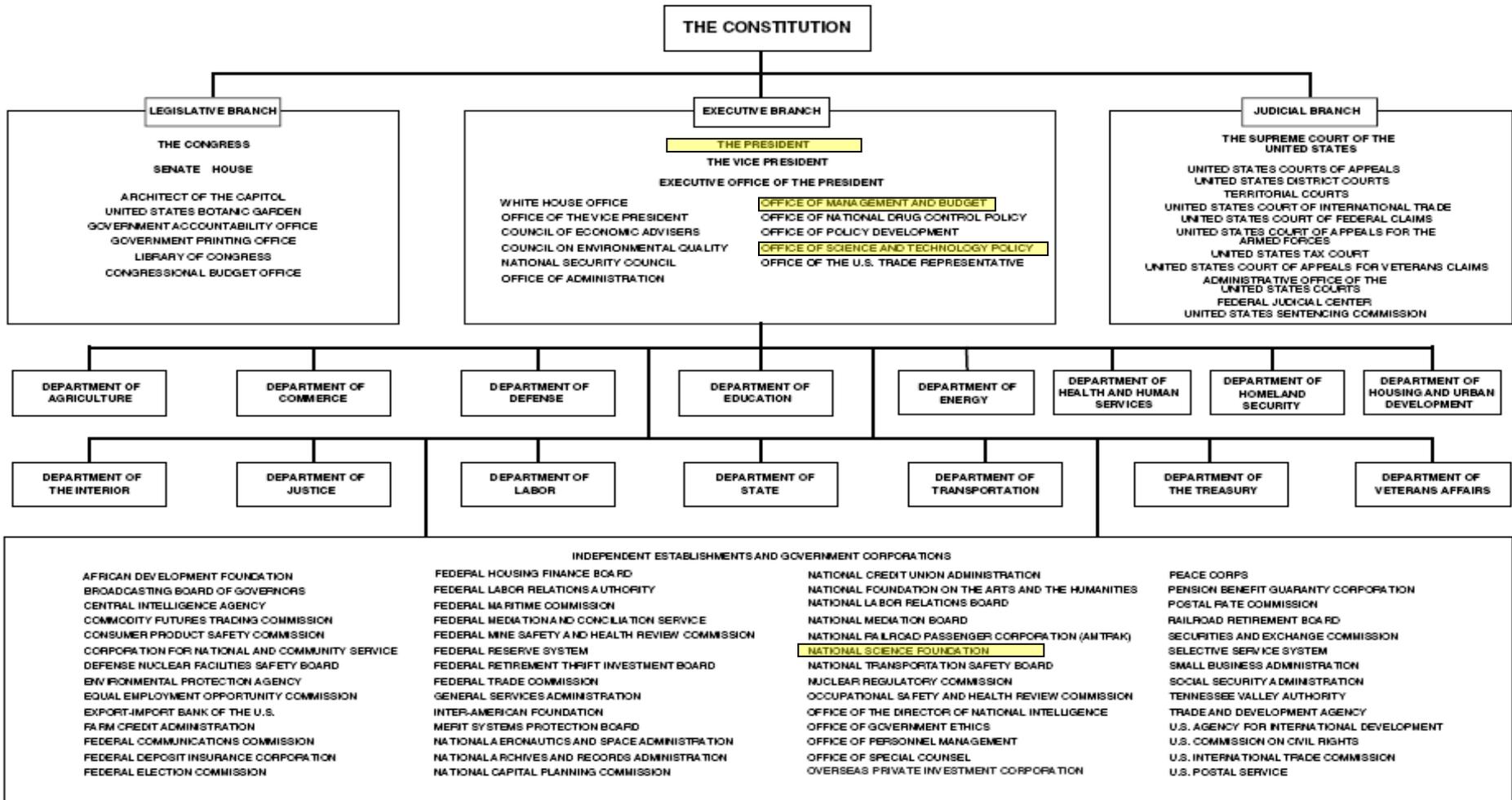
Division of Physics





US Government

THE GOVERNMENT OF THE UNITED STATES





NSF Vision and Goals

- **Vision**

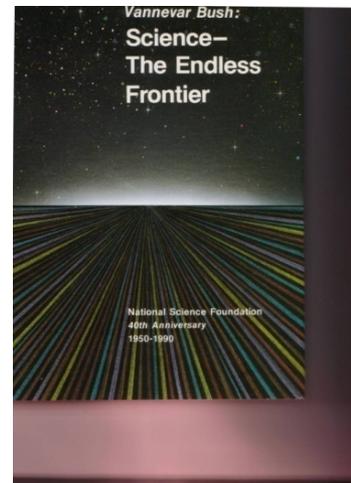
- » A Nation that creates and exploits new concepts in science and engineering and provides global leadership in research and education

- **Mission**

- » To promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense

- **Strategic Goals**

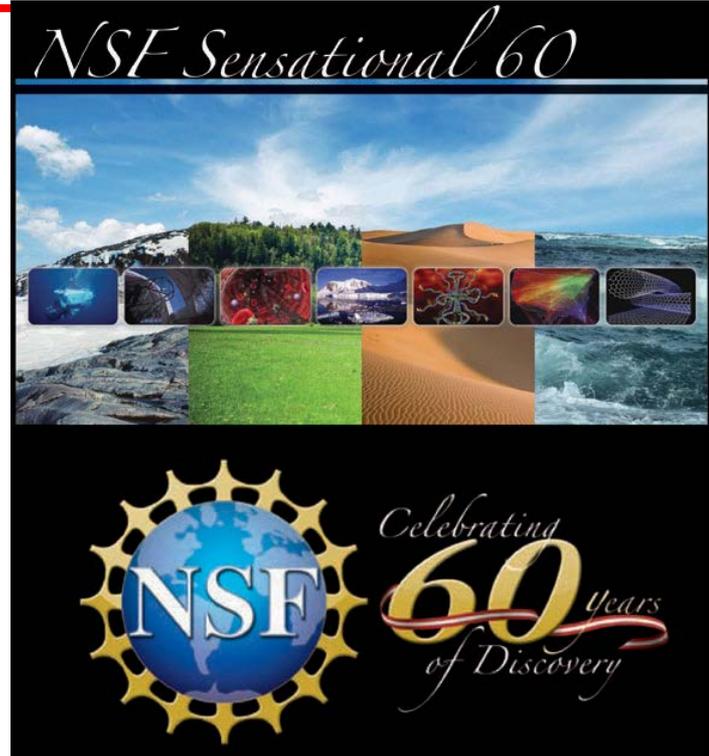
- » Transform the frontiers of science and engineering
- » Stimulate innovation and address societal needs through research & education
- » Excel as a Federal Science Agency



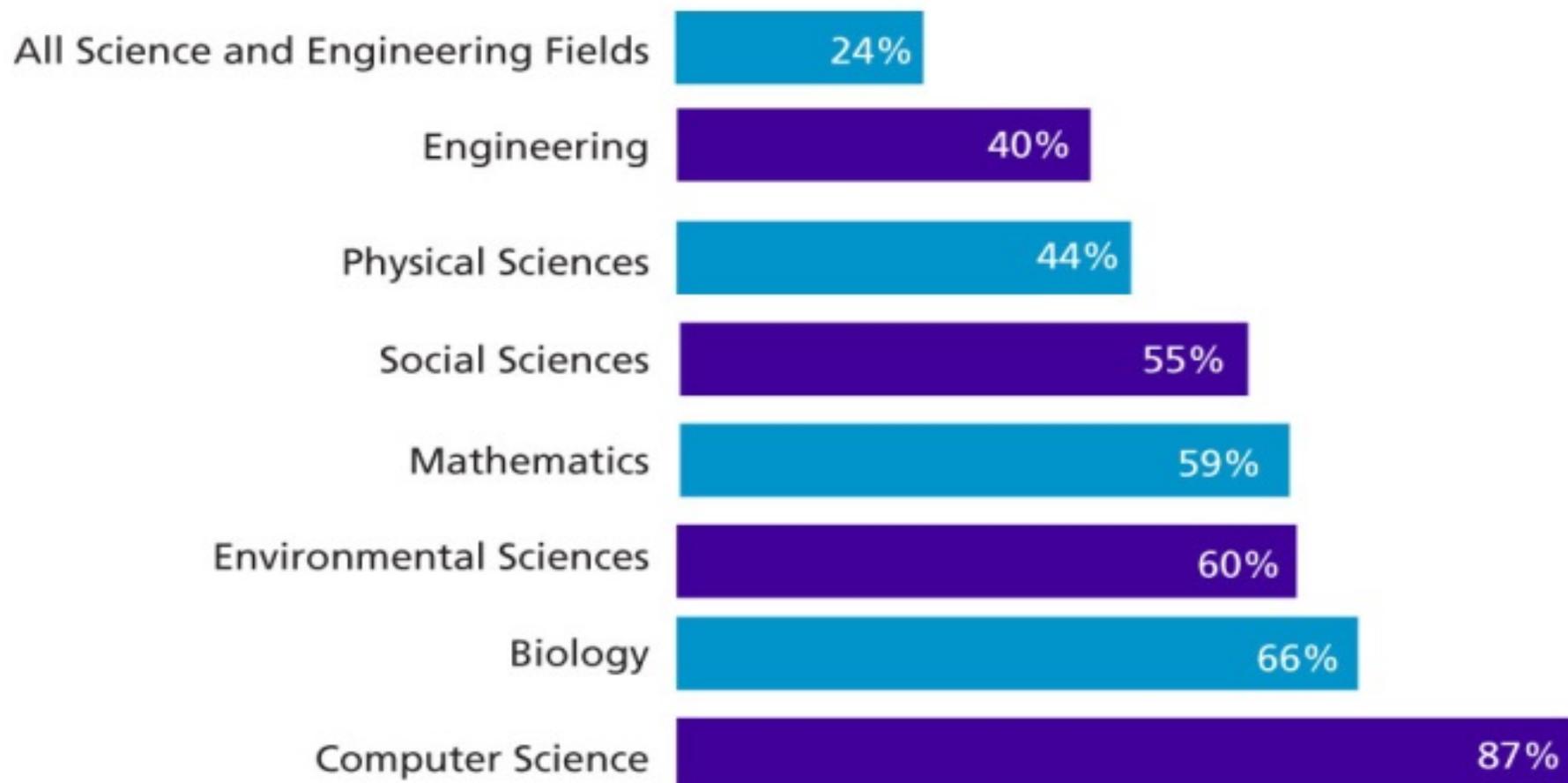


NSF in a Nutshell

- Independent agency to support basic research & education
- Grant mechanism in two forms:
 - » Unsolicited, curiosity driven
(the majority of the \$)
 - » Solicited, more focused
- All fields of science/engineering
- Merit review: Intellectual Merit & Broader Impacts
- Discipline-based structure, some cross-disciplinary
- Support large facilities



NSF Support of Academic Basic Research in Selected Fields (as a percentage of total federal support)

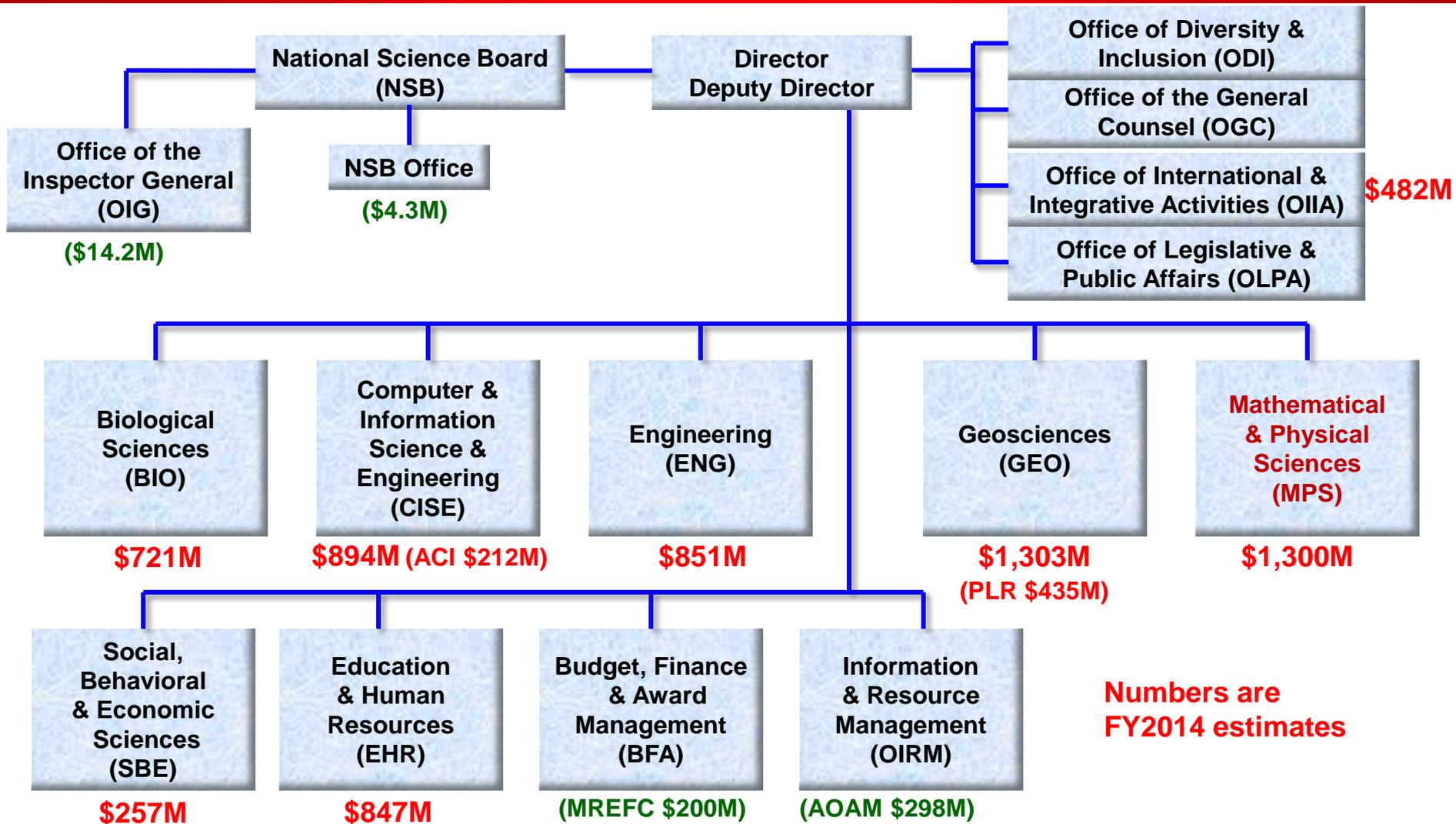


Note: Biology includes Biological Sciences and Environmental Biology; excludes National Institutes of Health.

Source: NSF/National Center for Science and Engineering Statistics, Survey of Federal Funds for Research & Development, FY 2011



NSF Organization Chart





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, to 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.**
- 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

- BRAIN: Brain Research through Advancing Innovative Neurotechnologies
- Optics and Photonics
- Midscale Infrastructures
- Physical sciences at the nanoscale
- 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
- CDS&E: Computational and data-enabled science and engineering



NSF-Wide & Other Directorate Programs

Of interest to
MPS proposers

Computational- and Data-Enabled Science and Engineering (CDS&E)

Nano-scale Science & Engineering

Software Infrastructure for Sustained Innovation

Science, Engineering & Education for Sustainability (SEES)

Enhancing Access to the Radio Spectrum (EARS)

RUI – self-identify as RUI, impact statement, extra considerations
ROA – part of RUI – research university submits proposal

CAREER (under “F”) – apply to Divisions

REU, RET (REV?)

BRAIN

Clean Energy Technologies

EPSCoR - Experimental Program to Stimulate Competitive Research

Graduate Research Fellowship (GRF)

Cyber-Enabled Materials Manufacturing and Smart Systems (CEMMSS)

NSF Research Traineeship (NRT, successor to IGERT)

Career-Life Balance – add-on

ADVANCE - to develop systemic approaches to increase the representation & advancement of women in academic STEM careers

Data Infrastructure Building Blocks (DIBBs)

Ethics Education in Science & Engineering (EERE)

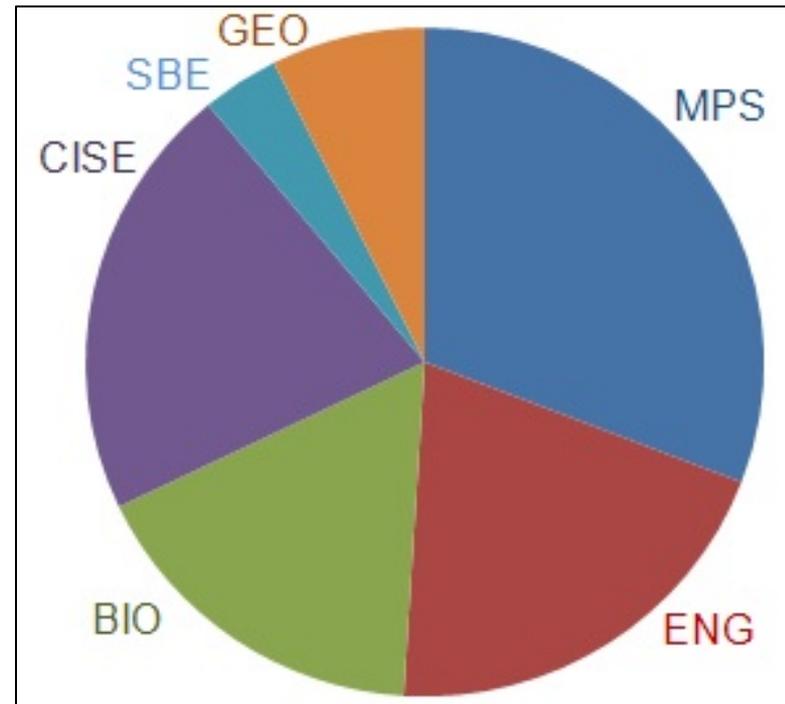
GOALI & I-Corps

Science Across Virtual Institutes (SAVI)



CAREER Program

- NSF's most prestigious awards for junior faculty (look under “F”).
- 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.



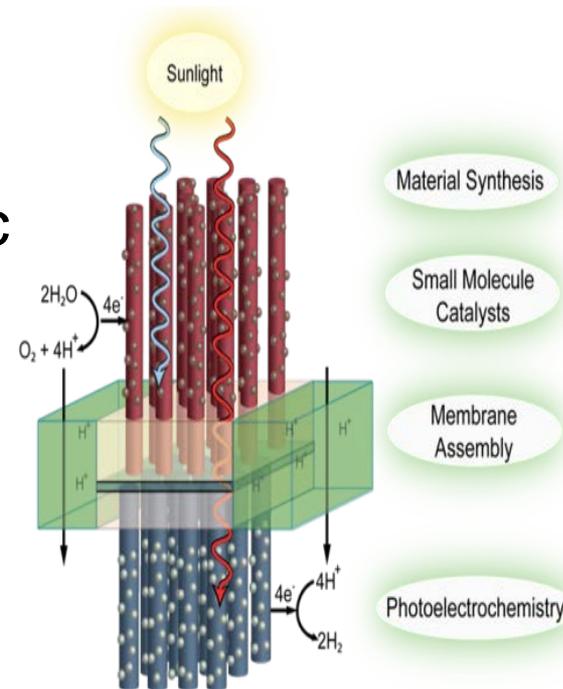
FY2014 est.



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

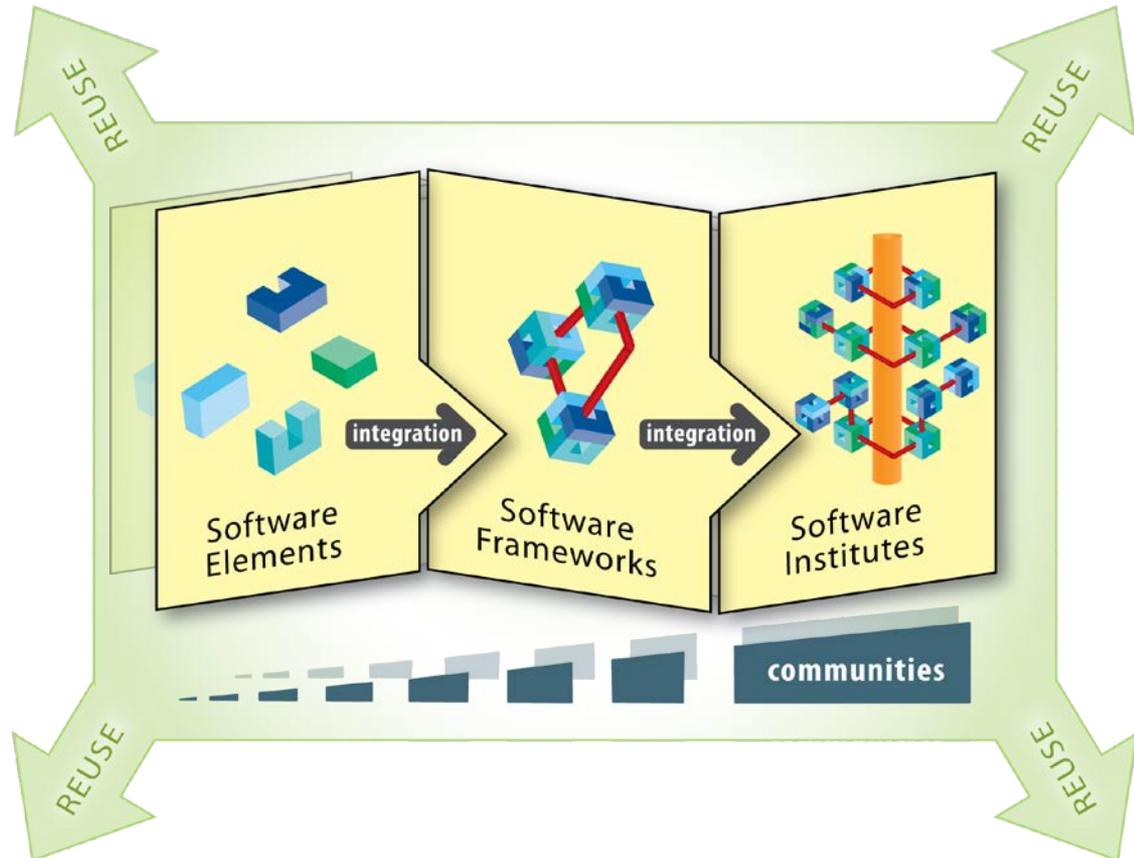


**MPS \$21.5M in
FY 2014**



Software Infrastructure for Sustained Innovation (SI²)

- SI² recognizes that software is the integral enabler of computation, experiment and theory, and a key part of the cyberinfrastructure that enables science and engineering research to achieve new discoveries.
- SI² encourages PIs to provide software that
 - Has a purpose (enables specific science and engineering research)
 - Has a user community that will be engaged in the project
 - May be used by a wider audience
 - Fits with other infrastructure, including other software





Data Infrastructure Building Blocks (DIBBs)

Building cyberinfrastructure to enable advances in science and engineering research, “blocks at a time”

- **Emphasizes cyberinfrastructure investments:**
 - **guided by science and engineering research priorities**
 - **built upon recognized community data collections**
- **Promotes ‘pilot’ activities in three categories**
 - **Small collaboration-focused projects, including prototypes (short duration)**
 - **Intermediate-scale pilots (typical duration)**
 - **At-scale early implementation pilots (possibly long duration)**
- **Collaborates with specific science and engineering research communities, to ensure continuing relevance**



Computational and Data-enabled Science and Engineering (CDS&E)

- MPS disciplines are both leading consumers and hard drivers of cyber-capability: their needs force, & their research creates, breakthroughs – in algorithms, in simulation & modeling methods, and in materials for emerging cyber-technology
- CDS&E is a cross-directorate program involving MPS, ENG, and CISE/ACI ***“to identify and capitalize on opportunities for major scientific and engineering breakthroughs through new computational and data analysis approaches”***

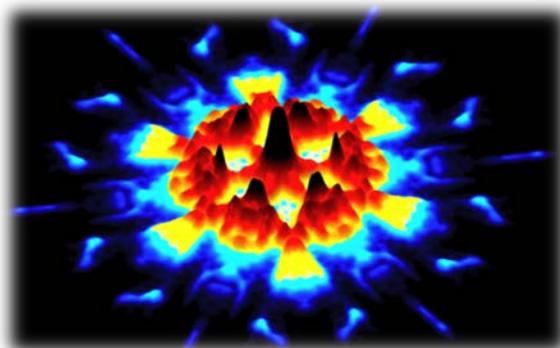


- Support for development, adaptation, or utilization of the capabilities offered by advancing both research and infrastructure in computation and data handling
- A “meta-program” – submit through pre-existing funding opportunities – see announcement PD12-8084



Cyber-Enabled Materials Manufacturing and Smart Systems (CEMMSS)

Topological Insulators

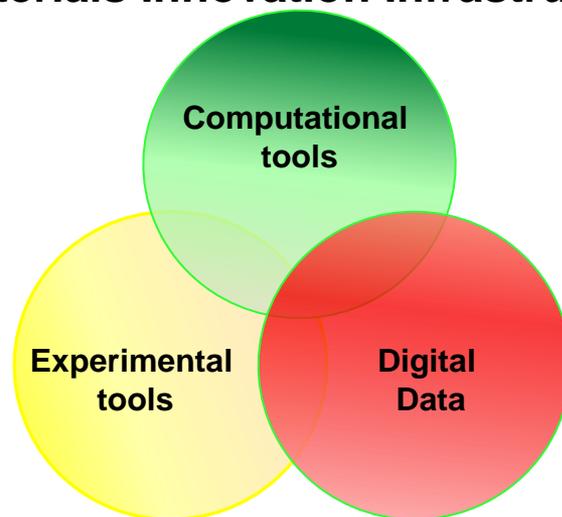


- Fundamental research for discovering, modeling, making, optimizing and manufacturing with new materials and material systems

- Partnership with ENG and CISE
- Advanced Manufacturing
- DMREF

\$50M MPS

Materials Innovation Infrastructure





Secure and Trustworthy Cyberspace (SaTC)

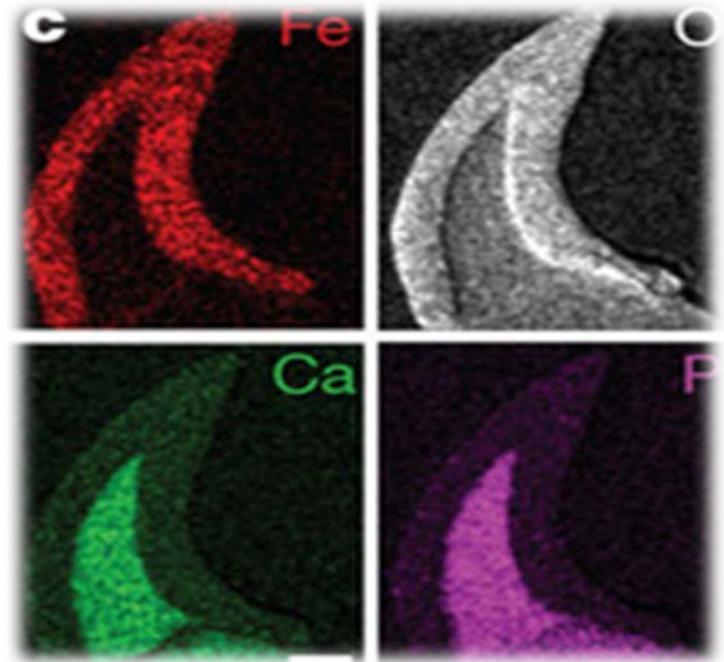
- Cross-foundation partnership to build a cyber-secure society **NSF: \$108M in FY13, \$125M in FY14**
- Produce high-quality digital systems and a well-trained cybersecurity workforce
- *Strategic Plan for the Federal Cybersecurity Research and Development Program*
- Comprehensive National Cybersecurity Initiative (CNCI)





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

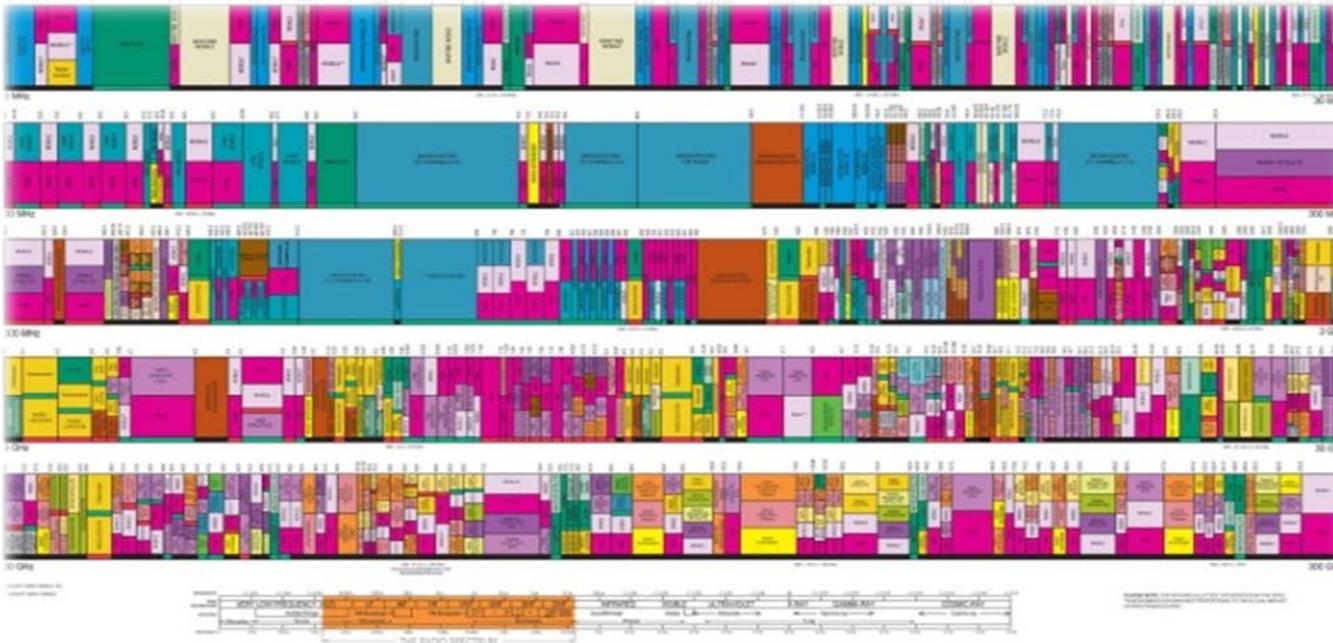
- Adaptive network models
- Biological design strategy for better composite materials
- Computational, Mathematical and Statistical modeling
- Cognitive Science
- Neuroscience



NSF \$30M,
MPS \$12M in
FY 2014



Enhancing Access to the Radio Spectrum (EARS)

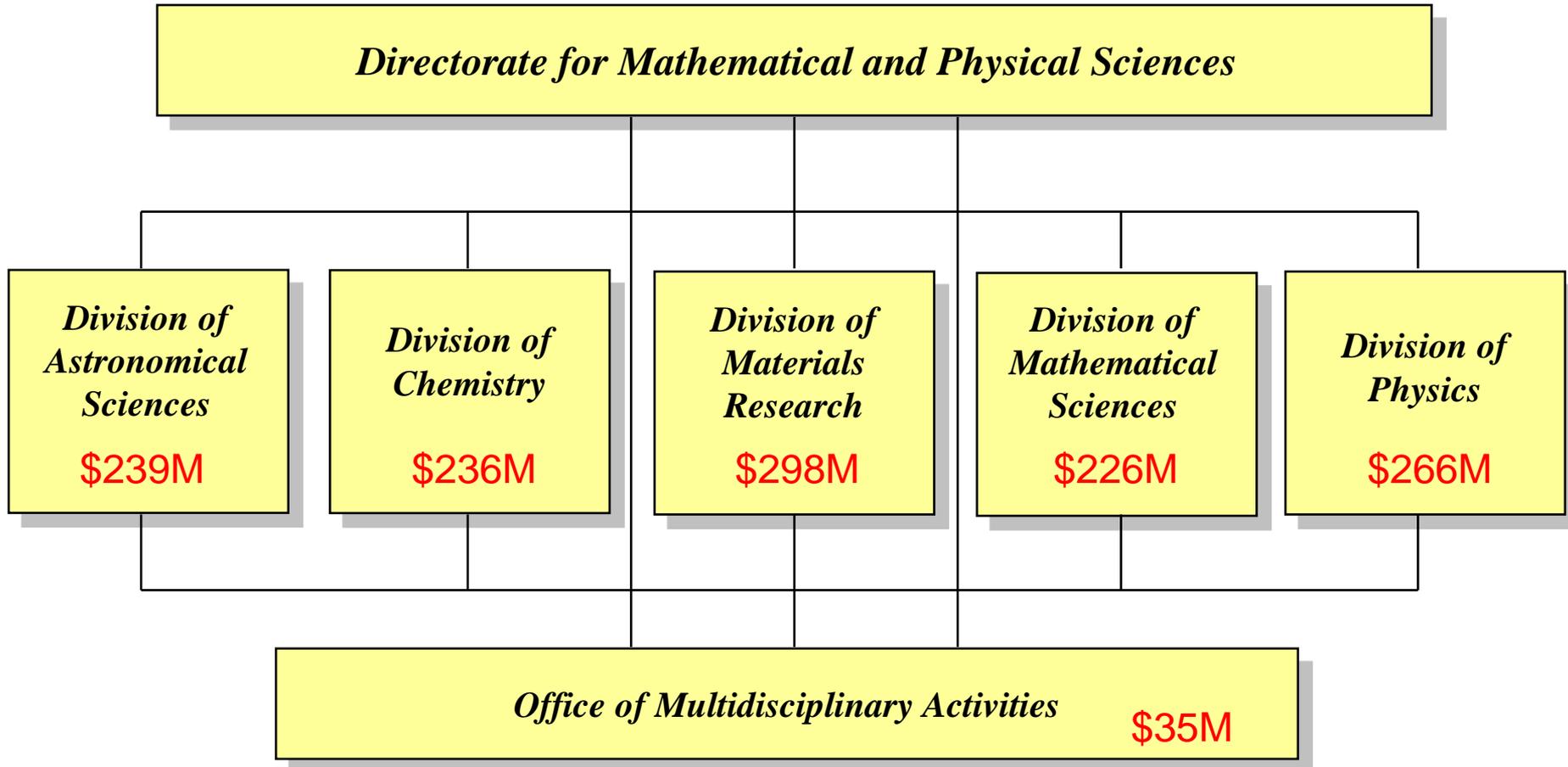


NSF \$24.5M,
MPS \$7.0M in
FY 2014

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



Directorate for Mathematical and Physical Sciences (MPS)

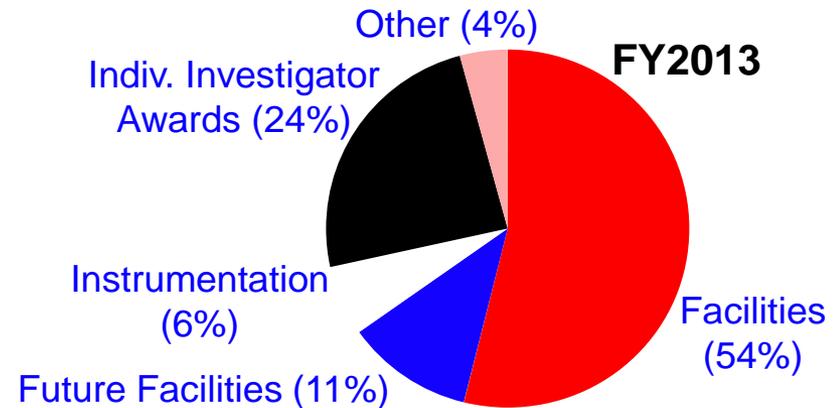


Numbers are estimates for FY 2014



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 – & international partnerships
 - » Strong tradition of private funding
 - » NSF assigned federal stewardship of ground-based astronomy
 - » **Includes open-access facilities & mission-free unrestricted grants**



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



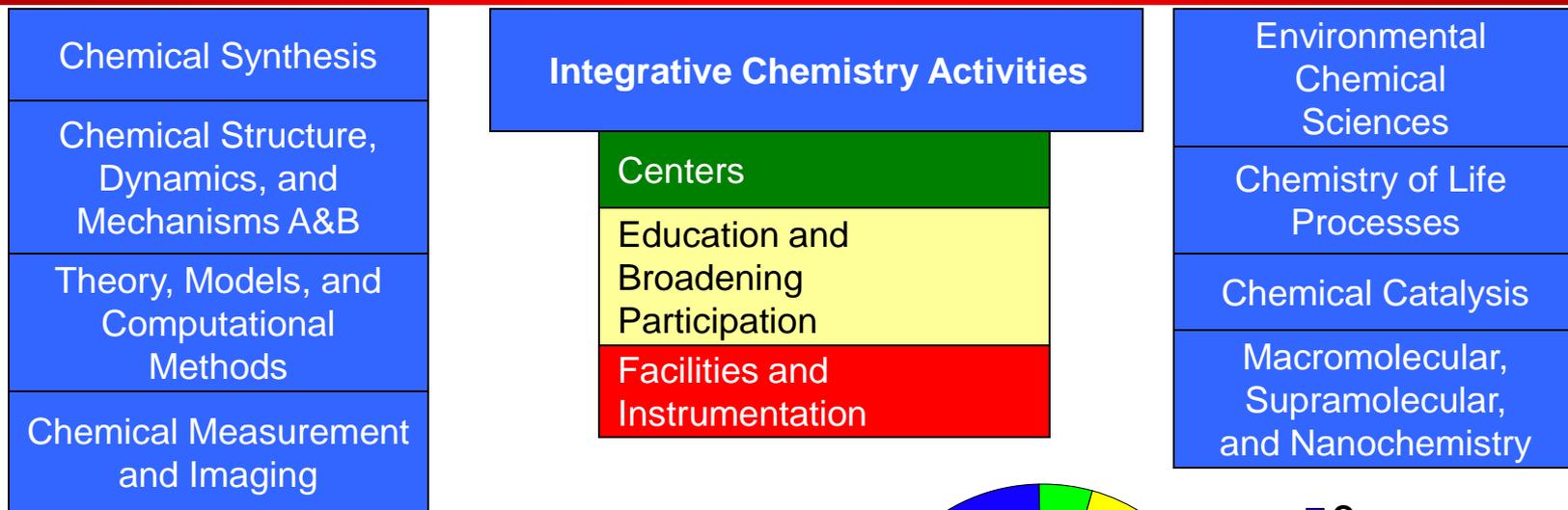
Astronomical Sciences (AST)

- Theoretical & Computational Astrophysics Networks (TCAN)
 - NSF/AST & NASA/Astrophysics, jointly reviewed, separately funded
 - To support coordinated efforts in fundamental theory & computational techniques to make groundbreaking advances in astrophysics;
 - Advance the training of the future workforce of theoretical and computational scientists.

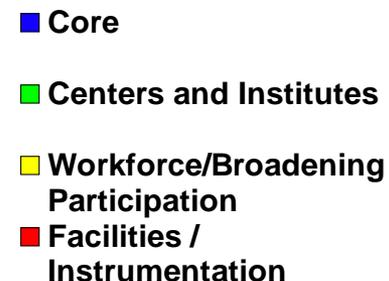
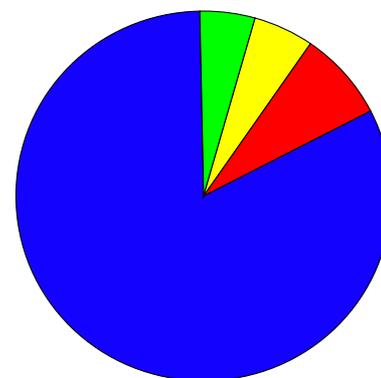
- Mid-Scale Innovations Program (MSIP)
 - Pre-proposals then full proposals, in four categories
 - ✓ Mid-Scale Science Projects
 - ✓ Mid-Scale Facilities
 - ✓ Development Investments
 - ✓ Open Access Capabilities (\$4 million minimum waived)



Chemistry (CHE)



- Major CAREER and REU support
- Collaborations with NIH and DOE
- Core Activities are IIA
- Critical areas of research:



Advanced Manufacturing; Computational and Data Enabled Science & Engineering, Sustainability; BioMAPS; DMREF

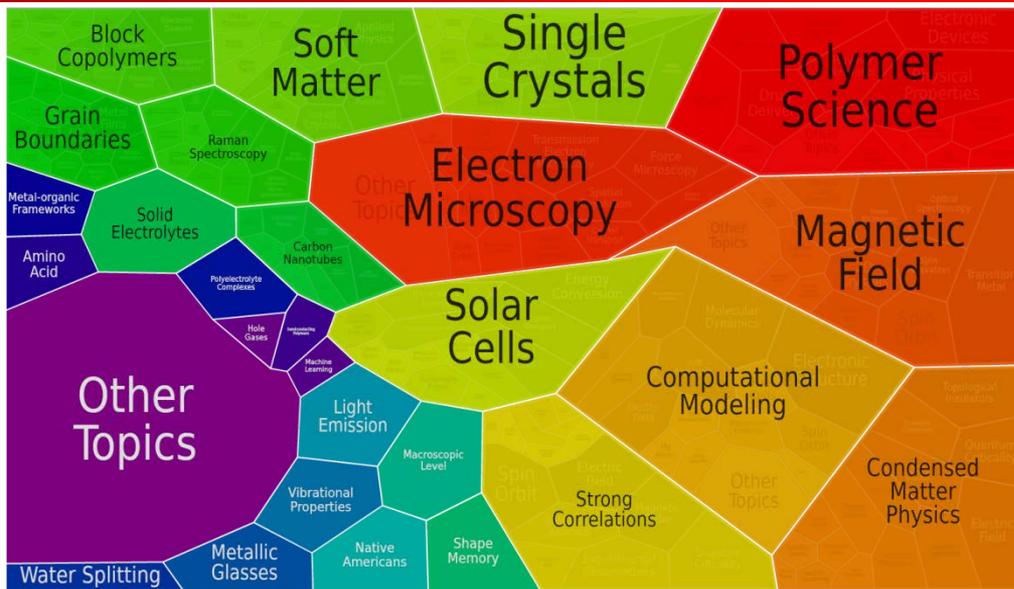


Chemistry (CHE)

- **Energy:** Which multiple electron processes will store and deliver more energy than gasoline? Which light driven reactions will make solar energy a major contributor to the renewable energy mix?
- **Element and molecule recycling:** Can metalloenzymes present in organisms be modeled to produce catalysts to recycle organic material in an energy efficient manner?
- **Designed emergent behavior:** Can we construct complex chemical assemblies like supramolecules and nanoparticles by design? Chemical synthesis from molecules to life?
- **Imaging the Ultrasmall:** Can we further develop Ultrafast Electron Diffraction, Probeless Laser-based Spectroscopy, Mass Spectrometry Imaging, Radiationless Magnetic Resonance, etc.
- **Centers for Chemical Innovation**
 - » Enhancing the US competitive edge by narrowing the innovation gap
 - » Agile, virtual centers of excellence promoting high risk/high gain transformative research, connections with industry, and the active and creative engagement of the public



Materials Research (DMR)

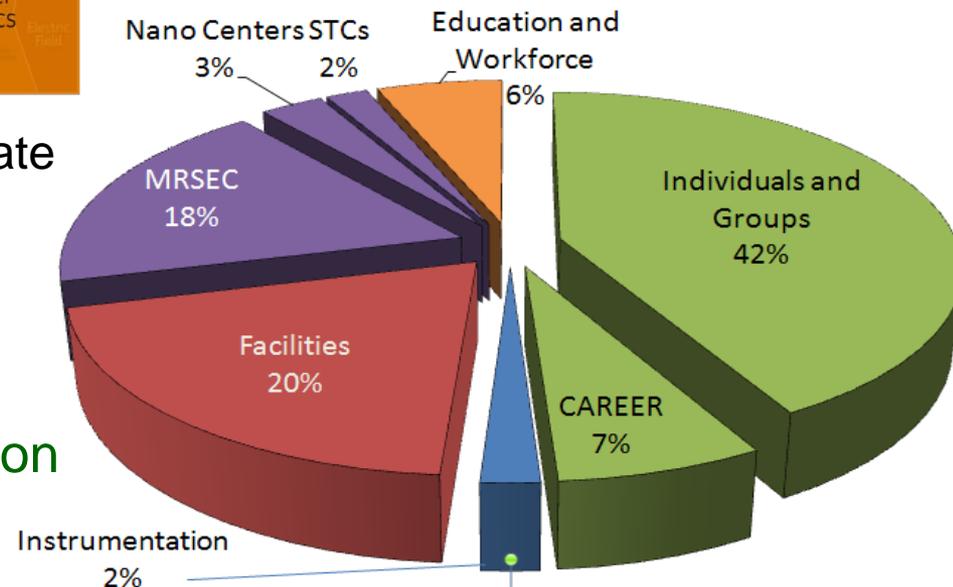


DMR Programs

- **Eight Major Areas:**
 - » 1) Ceramics, 2) Electronic and Photonic Materials, 3) Metals and Metallic Nanostructures
 - » 4) Condensed Matter Physics, 5) Condensed Matter & Materials Theory

» 6) Biomaterials, 7) Polymers, 8) Solid-State and Materials Chemistry

- **Materials Research Science and Engineering Centers (MRSEC)**
- **National Facilities and Instrumentation**



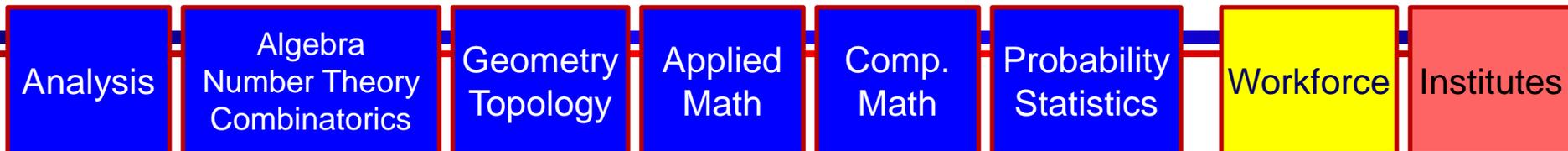


Materials Research (DMR)

- **Office of Special Programs**
 - » International collaboration
 - » Education and Broadening Participation
- **Materials Genome Initiative – a national initiative**
 - » Designing Materials to Revolutionize our Future (DMREF) – an opportunity to combine theory, data and experiment
- **Key interdisciplinary research areas**
 - » Sustainability
 - Sustainable Chemistry, Chemical Engineering and Materials Research (SUSCHEM)
 - » Nanoscience and Nanotechnology
 - » Advanced Manufacturing
 - » Interface of Bio & Physical Sciences
- **National Facilities available to you (each has a website)**
 - » National High Magnetic Field Laboratory (Florida State)
 - » Synchrotron CHESS at Cornell; ChemMatCARS at Argonne
 - » Neutron CHRNS at NIST Gaithersburg MD
 - » NNIN Nat’l NanoInfrastructure Network - 14 locations across US



Mathematical Sciences (DMS)



Covers the entire mathematical spectrum

Individual-investigator and group research grants

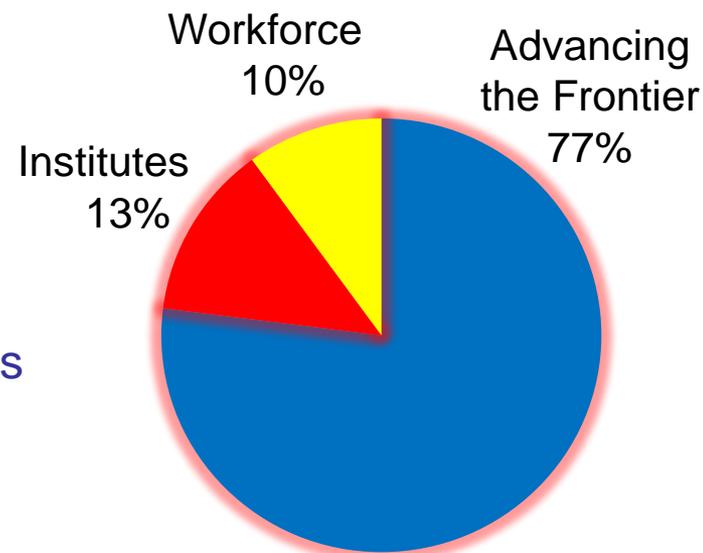
- » Disciplinary programs (unsolicited)
- » Special Research programs (solicited)

Institutes: National infrastructure for math. sciences

- » Visitors to long term programs, workshops

Workforce: Training the next generation of researchers

- » Postdoctoral fellowships
- » Graduate research training
- » Research experiences for undergraduates



In addition to supporting fundamental research in mathematical sciences, DMS plays an enabling role in 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

- Mathematical Sciences Innovation Incubator (MSII)
- Interface of the Biological and Mathematical Sciences (DMS/NIGMS)
- Algorithms for Threat Detection (ATD)
- Interaction in Basic and Applied Scientific Research in BIO, ENG & MPS (BIOMaPS)
- Secure & Trustworthy Cyberspace (SaTC)
- Software Infrastructure for Sustained Innovation (SISI)
- CIF21, SEES, INSPIRE, BRAIN



Mathematical Sciences (DMS)

New Activities

Mathematical Sciences Innovation Incubator

- Promotes involvement of mathematical scientists in multi-disciplinary research collaborations
- Emphasizes research of high national priority

New Graduate Research Training Program

- Enhancement to include research experiences complementary to the dissertation research theme.
- Doctoral students gain:
 - ✓ Enhanced understanding of research area in broader context;
 - ✓ Preparation to take mathematical inspiration from problems in other disciplines;
 - ✓ Better preparation for and knowledge of a wider range of career paths, including business, industry, and government.



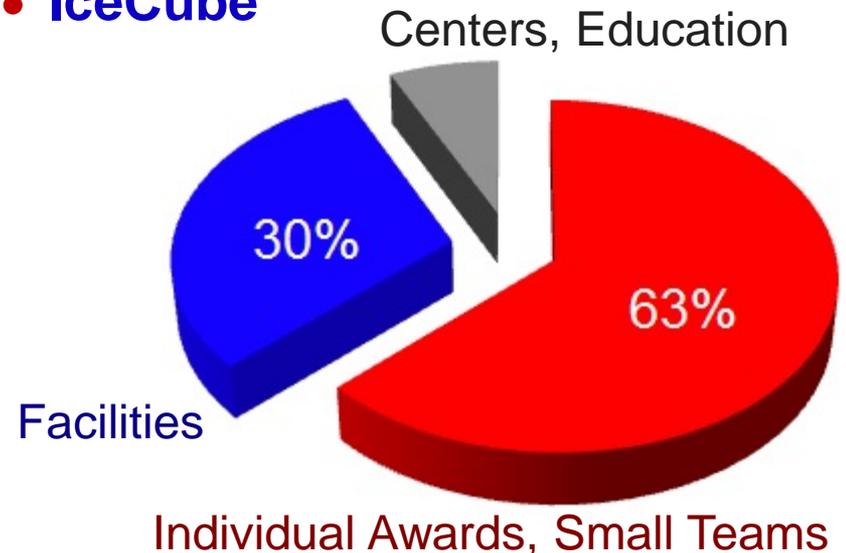
Physics (PHY)

Programs (Experiment & Theory)

- Accelerator Science
- Atomic, Molecular, & Optical Physics
- Computational Physics
- Elementary Particle Physics
- Education and Interdisciplinary Research
- Gravitational Physics
- Nuclear Physics
- Particle Astrophysics
- Physics of Living Systems
- Physics Frontiers Centers
- Quantum Information Science

Facilities:

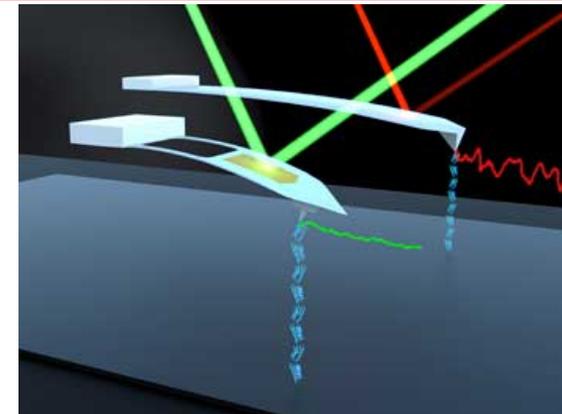
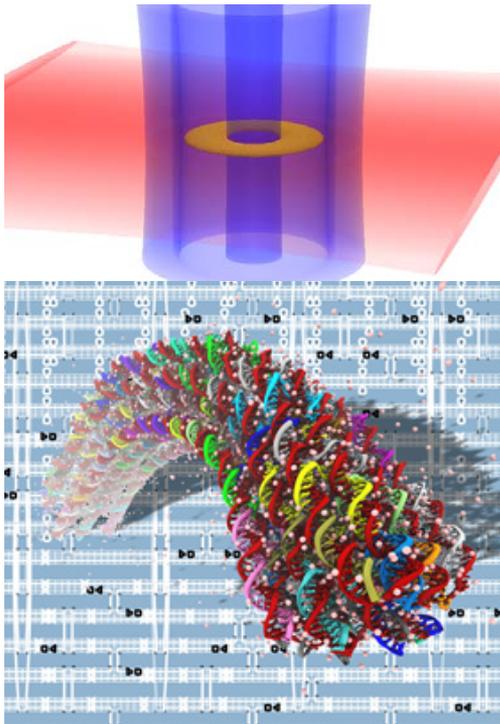
- Large Hadron Collider (LHC)
- Laser Interferometer Gravitational wave Observatory (LIGO)
- National Superconducting Cyclotron Laboratory (NSCL)
- IceCube





Physics (PHY)

PHY focuses on support for cutting- edge research at universities, and collaborates closely with DOE and international partners to support science and projects at large facilities

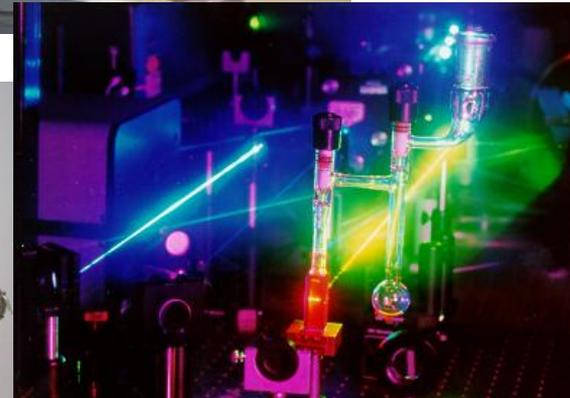
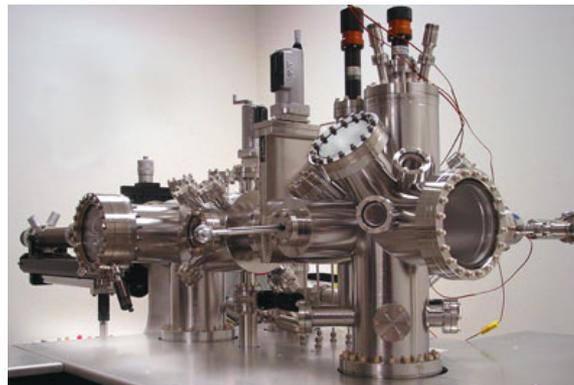


- Physics Frontiers Centers: intended to foster major advances at the intellectual frontiers of physics by providing combinations of talents, skills, disciplines, resources or specialized infrastructure not usually available to individual investigators or small groups.
- The program supports university-based centers and institutes where the collective efforts of a larger group of individuals can enable transformative advances in the most promising research areas.



Instrumentation

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





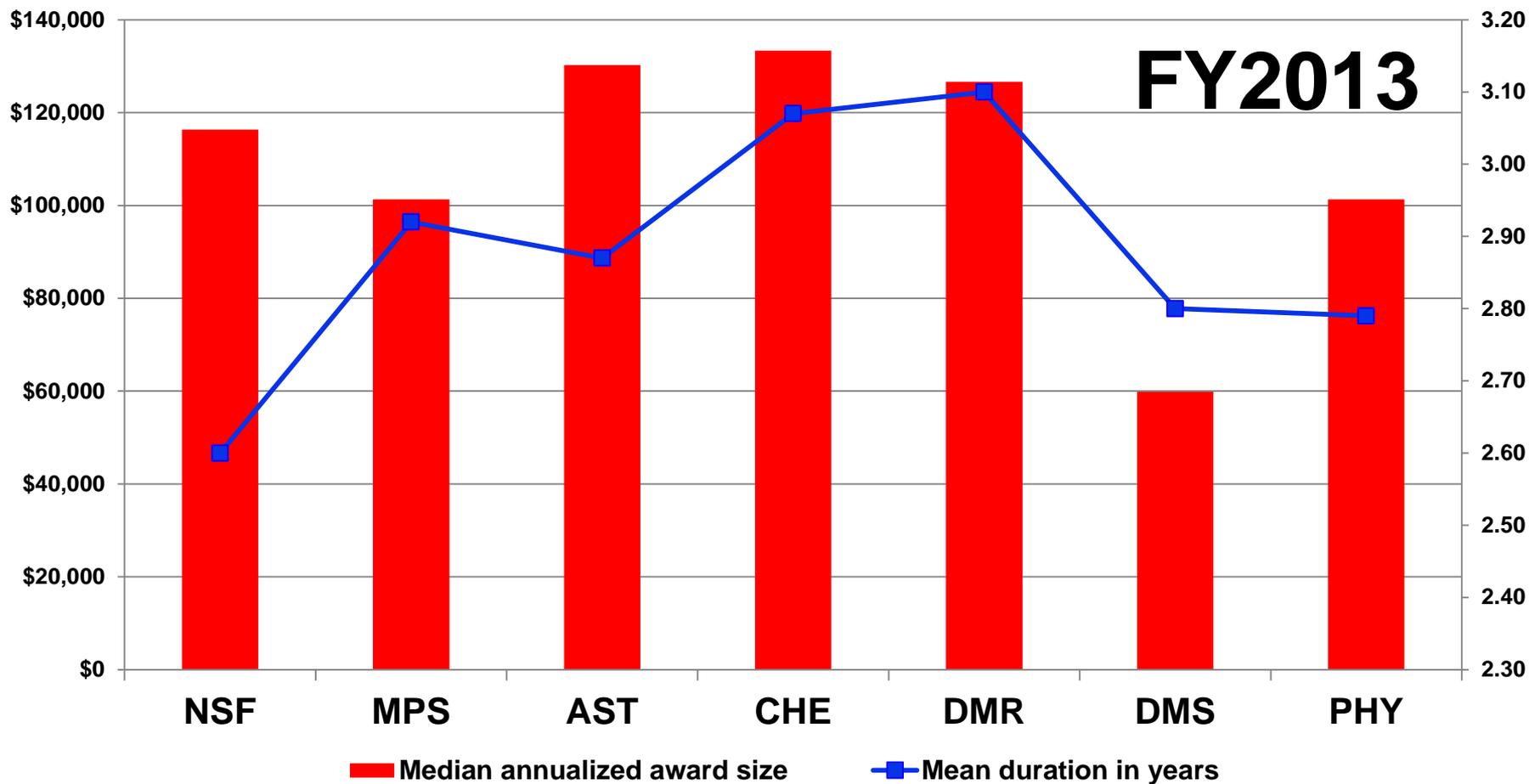
World Class Major Facilities

Keeping Researchers at the Frontier





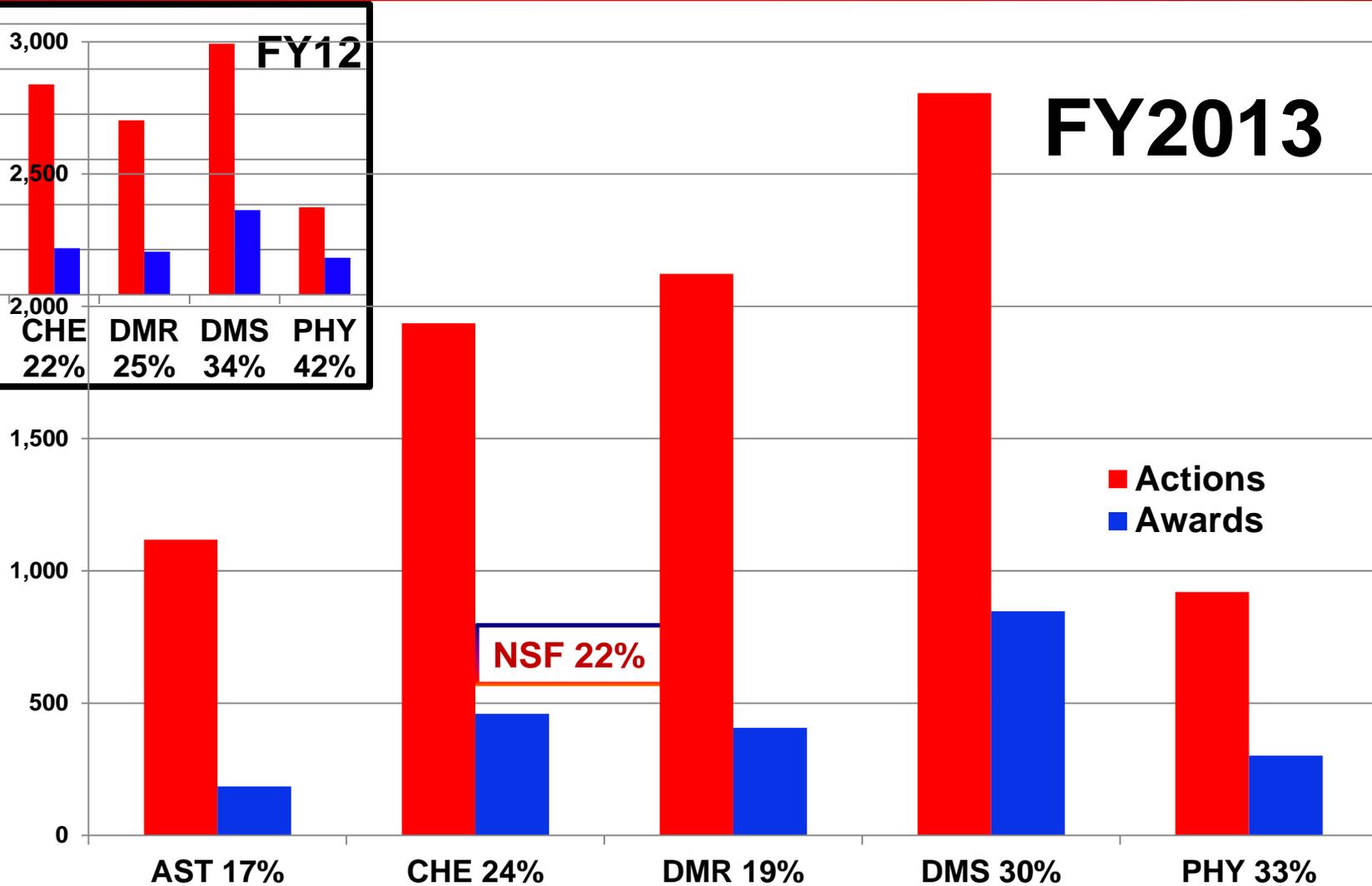
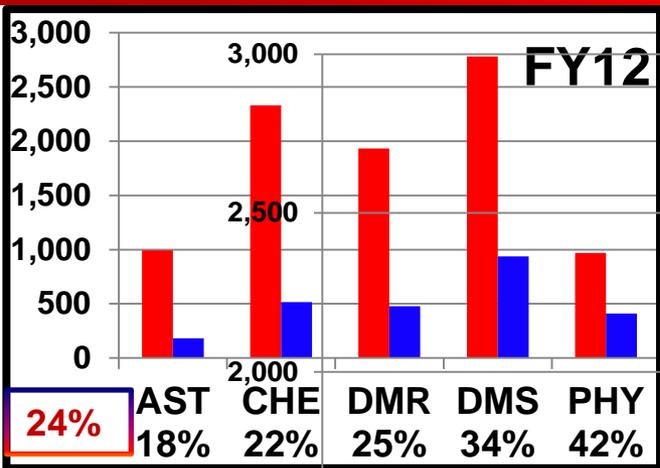
Median Annualized Award Size



Award duration from one to five years (longer allowed, but rare)



Funding Rates





Merit Review Criteria

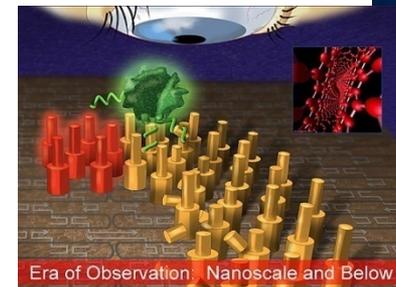
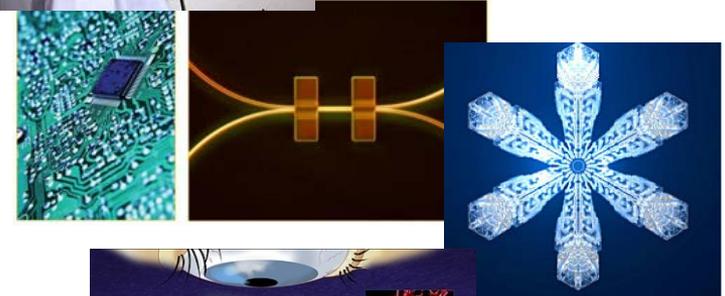
- Three Principles
 1. Highest quality: advance, even transform, the frontiers of knowledge.
 2. In aggregate, contribute more broadly to achieving societal goals.
 3. Based on appropriate metrics.
- Two Criteria (*unchanged*)
 1. Intellectual Merit
 2. Broader Impact
- Five Elements
 1. Potential to 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 Programs:
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/minute !!**
- Download your completed proposal back to you to check that what we got is really what you think 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



www.nsf.gov

The image shows a screenshot of the National Science Foundation (NSF) website homepage. The main header features the NSF logo and the tagline "National Science Foundation WHERE DISCOVERIES BEGIN". A navigation menu includes links for FUNDING, AWARDS, DISCOVERIES, NEWS, PUBLICATIONS, STATISTICS, ABOUT NSF, and FASTLANE. A large banner image shows a black hole with the text "Last Orbit Around a Black Hole" and a "FULL STORY" button. Below the banner, there are several news articles with images and titles, such as "VMI Researchers Unravel Life Cycle of Blue-crab Parasite" and "A Mammal Lays Its 3-D Eggs". A sidebar on the left contains a "SPECIAL" section with links like "New NSF Submitted" and "Nomination 2012". At the bottom, there is an "EVENT CALENDAR" section. A red circle highlights the "WORK LINKS" button in the top right corner. Another red circle highlights the "DISCOVERIES" menu item. A third red circle highlights the "FUNDING OPPORTUNITIES" sidebar widget, which includes a search bar and a "VIEW ALL FUNDING OPPORTUNITIES" button.



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 a specific MPS program, choose “Quick Links”, top right of <http://www.nsf.gov>, & click Mathematical & Physical Sciences

Contact NSF Program Directors for questions & suggestions



NSF Grants Conference

Ask Early, Ask Often

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