

**DIRECTORATE FOR MATHEMATICAL  
AND PHYSICAL SCIENCES (MPS)**

**\$1,219,430,000  
-\$129,350,000 / -9.6%**

**MPS Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
Astronomical Sciences (AST)	\$246.63	-	\$221.15	-\$25.48	-10.3%
Chemistry (CHE)	246.52	-	221.05	-25.47	-10.3%
Materials Research (DMR)	309.88	-	282.87	-27.01	-8.7%
Mathematical Sciences (DMS)	233.95	-	209.78	-24.17	-10.3%
Physics (PHY)	276.91	-	253.30	-23.61	-8.5%
Office of Multidisciplinary Activities (OMA)	34.89	-	31.28	-3.61	-10.3%
<b>Total</b>	<b>\$1,348.78</b>	<b>-</b>	<b>\$1,219.43</b>	<b>-\$129.35</b>	<b>-9.6%</b>

**About MPS**

MPS serves the Nation by supporting fundamental discoveries at the forefront of science. These discoveries form a tapestry of knowledge and innovation that transforms the future. Research in the disciplines supported by MPS has led to advances that are used for a wide variety of applications; examples include laser technology, navigation using the Global Positioning System, materials fundamental to integrated circuits, and algorithms used for advanced cybersecurity. The FY 2018 Budget Request for MPS supports a collection of vigorous disciplinary and multidisciplinary research programs that foster discovery and cultivate the technical workforce. The awards funded by MPS provide the foundation of basic research in astronomical sciences (AST), chemistry (CHE), materials research (DMR), mathematical sciences (DMS), and physics (PHY) that explore the frontiers of science.

The programs in MPS span the range from individual investigator awards to large, multi-user facilities. The science spans an enormous range as well: from the smallest objects and shortest times ever studied to distances and times that are the size and age of the universe. Individual investigators and small teams receive the majority of awards, but centers, institutes, and multi-user facilities are all integral to MPS-funded research. MPS continues to participate in NSF-wide investments and multi-directorate activities, particularly ones that connect to the fundamental research at the heart of its mission. These multi-directorate activities include growing MPS foundational research for several of the Big Ideas that are discussed elsewhere in this document.

Programs in the MPS divisions respond to special intellectual opportunities and reflect careful choices in order to provide the greatest return on the research investment. Identifying these opportunities involves the community through the MPS Advisory Committee and through groups chartered to identify prospects for revolutionary science in particular areas. National Academies input is critical for prioritization; two recent examples are *New Worlds, New Horizons: A Midterm Assessment* (delivered in August 2016) and *Frontiers of Materials Research: A Decadal Survey* (scheduled for completion in FY 2018).

Facilities that enable unique science that would be impossible without the special resources of a shared, multi-user environment are integral to our mission. Some of these facilities are observatories for photons, neutrinos, or gravitational waves. Others provide unique resources such as the largest controlled magnetic fields in the world or beams of rare isotopes. Stewardship of the MPS facilities portfolio and the balance among the different awards programs are critical issues that also engender extensive community

consultation. MPS continues assessing the future of different facilities and fostering collaborations for those facilities.

MPS participates in building the foundation for several of the Big Ideas described previously, in cooperation with many other directorates. In particular, FY 2018 investments will advance the work of two of the Big Ideas.

- DMR and PHY support investments that are important for defining and developing the direction of the Quantum Leap Big Idea. For example, the DMR funding request includes renewal of the Center for Integrated Quantum Materials, while PHY emphasizes investments in Quantum Information Science.
- Both AST and PHY are building the foundation for the Windows on the Universe Big Idea by continuing to invest in large facilities and research awards that make use of information carried by electromagnetic waves, particles, and gravitational waves.

More discussion of these investments and foundation-building for other Big Ideas may be found in the division narratives below as well as in the Facilities chapter.

MPS provides about 49 percent of the federal funding for basic research at academic institutions in the mathematical and physical sciences.

### Major Investments

#### MPS Major Investments

(Dollars in Millions)

Area of Investment	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
CAREER	\$77.97	-	\$71.49	-\$6.48	-8.3%
CEMMSS	63.83	-	43.00	-20.83	-32.6%
NSF I-Corps™	1.60	-	1.70	0.10	6.2%
NSF INCLUDES	2.14	-	2.60	0.46	21.5%
NRT <sup>1</sup>	4.47	-	1.00	-3.47	-77.6%
Risk and Resilience	2.31	-	0.50	-1.81	-78.4%
SaTC	1.64	-	1.00	-0.64	-39.0%
SEES	53.47	-	10.42	-43.05	-80.5%
Understanding the Brain	24.13	-	16.56	-7.57	-31.4%
<i>BRAIN Initiative</i>	<i>24.13</i>	<i>-</i>	<i>16.56</i>	<i>-7.57</i>	<i>-31.4%</i>

Major investments may have funding overlap and thus should not be summed.

All funding decreases/increases represent changes over the FY 2016 Actual.

- Faculty Early Career Development (CAREER) (-\$6.48 million to a total of \$71.49 million): This will support about 535 awardees. This program remains an MPS priority, ensuring that top early-career scientists in all the MPS disciplines are funded at a healthy level. The CAREER program is an important element in the growth and development of junior scientists.
- Cyber-Enabled Materials Manufacturing and Smart Systems (CEMMSS) (-\$20.83 million to a total of \$43.0 million): MPS participates in CEMMSS primarily through the Advanced Manufacturing and Materials Genome Initiatives. The Designing Materials to Revolutionize and Engineer our Future (DMREF) program, which contributes to these activities, will not hold a competition in FY 2018.

Rather, DMREF, with its partners in ENG and CISE, will invest in community building activities focused on leveraging the data generated by existing awards to accelerate the discovery and deployment of materials with a specific function or property.

- NSF Innovation Corps (I-Corps™) (+\$100,000 to a total of \$1.70 million): Investments are directed to an assessment of the commercial viability of the scientific discoveries in MPS disciplines.
- Inclusion across the Nation of Communities of Learners of Underrepresented Discoverers in Engineering and Science (NSF INCLUDES) (+\$460,000 to a total of \$2.60 million): MPS will increase its investment in this program, an NSF-wide broadening participation activity.
- NSF Research Traineeships (NRT) (-\$3.47 million to a total of \$1.0 million): Funding continues to support the development and implementation of new models for STEM graduate education.
- Risk and Resilience (-\$1.81 million to a total of \$500,000): This research improves predictive and risk-assessment capabilities and increases resilience to impacts of extreme events on critical infrastructure.
- Secure and Trustworthy Cyberspace (SaTC) (-\$640,000 to a total of \$1.0 million): Funding reflects continued national need for fundamental cybersecurity research that investigates questions surrounding secure information networks against hostile intrusion and ensuring individual privacy in anonymized data sets.
- Science, Engineering, and Education for Sustainability (SEES) (-\$43.05 million to a total of \$10.42 million): This investment concluded in FY 2017. Remaining funds will focus on Sustainable Chemistry, Engineering, and Materials (SusChEM) research, supporting commitments made for prior year awards.
- Understanding the Brain (UtB) including the BRAIN Initiative (-\$7.57 million to a total of \$16.56 million): MPS will continue to invest in the scientific understanding of the full complexity of the brain.

### MPS Funding for Centers Programs and Facilities

#### MPS Funding for Centers Programs

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total, Centers Programs</b>	<b>\$88.43</b>	<b>-</b>	<b>\$91.60</b>	<b>\$3.17</b>	<b>3.6%</b>
Centers for Analysis & Synthesis (DMS)	0.20	-	-	-0.20	-100.0%
Centers for Chemical Innovation (CHE)	28.10	-	21.60	-6.50	-23.1%
Materials Centers (DMR)	55.54	-	55.00	-0.54	-1.0%
Nanoscale Science & Engineering Centers (CHE, DMR)	0.50	-	-	-0.50	-100.0%
STC: Center for Integrated Quantum Materials (DMR)	4.09	-	5.00	0.91	22.2%
STC: STC for Real-Time Functional Imaging (DMR)	-	-	5.00	5.00	N/A
STC: Center for Bright Beams (PHY)	-	-	5.00	5.00	N/A

For detailed information on individual centers programs, see the NSF-Wide Investments chapter.

**MPS Funding for Facilities**

(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over	
				FY 2016 Actual Amount	Percent
<b>Total, Facilities</b>	<b>\$289.42</b>	-	<b>\$291.08</b>	<b>\$1.66</b>	<b>0.6%</b>
Atacama Millimeter Array (ALMA)	\$37.65		\$43.48	5.83	15.5%
Arecibo Observatory	4.80	-	3.90	-0.90	-18.8%
Cornell High Energy Synchrotron Source (CHESS)	10.03	-	8.00	-2.03	-20.2%
Daniel K. Inouye Solar Telescope (DKIST)	13.50		16.00	2.50	18.5%
Gemini Observatory	19.88	-	21.03	1.15	5.8%
IceCube Neutrino Observatory (IceCube)	3.48	-	3.50	0.02	0.6%
Large Hadron Collider (LHC) <sup>1</sup>	20.00	-	22.30	2.30	11.5%
Laser Interferometer Gravitational Wave Observatory (LIGO)	39.43	-	39.43	-	-
National High-Magnetic Field Laboratory (NHMFL)	35.34	-	34.77	-0.57	-1.6%
National Nanotechnology Coordinated Infrastructure (NNCI)	2.88	-	2.50	-0.38	-13.2%
National Optical Astronomy Observatories (NOAO)	21.99	-	20.67	-1.32	-6.0%
National Radio Astronomy Observatories (NRAO) <sup>2</sup>	43.84	-	32.86	-10.98	-25.0%
National Solar Observatory (NSO) <sup>3</sup>	9.50	-	5.00	-4.50	-47.4%
National Superconducting Cyclotron Laboratory (NSCL)	24.00	-	23.00	-1.00	-4.2%
Other MPS Facilities (Total)	3.10	-	14.64	11.54	372.3%
Center for High Resolution Neutron Scattering (CHRNS)	2.77	-	2.79	0.02	0.7%
Other Astronomical Facilities (LBO, GBO) <sup>2</sup>	-	-	11.85	11.85	N/A
OMA co-funding of special activities in facilities	0.33	-	-	-0.33	-100.0%

<sup>1</sup> Includes \$6.30 million in FY 2018 for High-Luminosity LHC Upgrade planning.

<sup>2</sup> The decrease in NRAO is chiefly due to the separation of the Green Bank Observatory and the Very Long Baseline Array from NRAO and ALMA. That funding is now shown under the "Other Astronomical Facilities" line in this table.

<sup>3</sup> Totals do not include \$11.50 million in FY 2016 and \$14.0 million in FY 2018 for operations and maintenance support for the DKIST facility construction project. That funding is captured as part of the total presented on the DKIST line above.

For detailed information on individual facilities, see the Facilities and the Major Research Equipment and Facilities Construction chapters.

**Funding Profile**

MPS supports investment in core research, education, and research infrastructure.

In FY 2018, the number of research grant proposals is expected to increase by over 500 as compared to FY 2016. This expected increase reflects a general upward trend in numbers of research proposals received in recent years. Of this total, MPS expects to award about 1,800 research grants. Average annual award size and duration are not expected to materially fluctuate in FY 2018.

In FY 2018, MPS will invest \$91.60 million for centers, accounting for 7.5 percent of the MPS budget. This increase is due to the initiation of two new Science and Technology Centers. Several centers, including Centers for Analysis and Synthesis and the Nanoscale Science and Engineering Centers, have sunset as planned. MPS will continue to support the Materials Centers and the Centers for Chemical Innovation.

Operations and maintenance funding for MPS-supported user facilities is 23.9 percent of MPS's FY 2018 Request. Funding is maintained for most facilities in order to keep operational capacity current. Information about specific funding decreases may be found in the division narratives that follow.

### MPS Funding Profile

	FY 2016 Actual Estimate	FY 2017 (TBD)	FY 2018 Estimate
<b>Statistics for Competitive Awards:</b>			
Number of Proposals	9,203	-	9,900
Number of New Awards	2,436	-	2,300
Funding Rate	26%	-	23%
<b>Statistics for Research Grants:</b>			
Number of Research Grant Proposals	7,979	-	8,500
Number of Research Grants	1,930	-	1,800
Funding Rate	24%	-	21%
Median Annualized Award Size	\$122,100	-	\$120,000
Average Annualized Award Size	\$142,500	-	\$140,000
Average Award Duration, in years	3.2	-	3.2

### Program Monitoring and Evaluation

#### External Program Evaluations and Studies:

- The Astronomy and Astrophysics Advisory Committee (AAAC) completed its annual report<sup>1</sup> on interagency activities by the Department of Energy (DOE), the National Aeronautics and Space Administration (NASA), and NSF in March 2017. The next annual report is expected in March 2018.
- AST, together with the NASA Astrophysics Division and the High Energy Physics Branch of the DOE Office of Science, commissioned a study (“Review of Progress Toward the Decadal Survey Vision in New Worlds, New Horizons in Astronomy and Astrophysics”), of the mid-term status of agency responses to the 2010 decadal survey in astronomy and astrophysics, through the NRC Space Studies Board. The resulting NRC mid-term review committee report was published in August 2016.<sup>2</sup>
- In FY 2017, the MPS/CHE/Centers for Chemical Innovation (CCI) program will initiate an evaluation of the CCI program. Results are expected to inform CHE regarding program effectiveness and to establish best practices. Final study results expected in late FY 2018 or early FY 2019.
- DMR co-sponsored with the DOE Office of Basic Energy Sciences (BES) a NAS Decadal Survey entitled *Frontiers of Materials Research*. This important study will identify future needs and important emerging research areas of materials research in the context of U.S. and international efforts.<sup>3</sup> A report is anticipated in June 2018 which will inform DMR of future directions.

#### Workshops and Reports:

- In October 2016, CHE-sponsored a workshop titled “Measuring the Brain: From the Synapse to Thought”. The goal was to bring together chemical and neuroscience communities to better understand the intersection of their needs and opportunities. The discussion focused on identifying challenges in brain research for the next decade and how chemical probes, sensors, and measurements could address challenges in understanding brain functioning. A report is expected in late FY 2017.
- CHE sponsored two workshops on opportunities for mid-scale investment. The "Workshop for Mid-Scale Instrumentation in the Chemical Sciences" was held in September 2016 and identified research areas where scientific progress in chemistry is limited or inhibited by a lack of access to mid-scale instrumentation. The “Workshop on Mid-Scale Instrument Development in the Chemical Sciences”

<sup>1</sup> [www.nsf.gov/mps/ast/aaac.jsp](http://www.nsf.gov/mps/ast/aaac.jsp)

<sup>2</sup> [http://sites.nationalacademies.org/SSB/CurrentProjects/SSB\\_161177](http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_161177)

<sup>3</sup> <http://sites.nationalacademies.org/DEPS/materials-decadal/index.htm>

was held in November 2016 and focused on the development of new instrument development capabilities. Reports from both workshops are expected by summer 2017.

- The CHE workshop “Quantum Information and Computation for Chemistry” was held in November 2016, with representatives attending from the chemical community, the NAS, multiple federal agencies, and industries involved in quantum sciences (e.g., Google, Microsoft, and Intel). The workshop summarized recent progress at the interface of quantum information science and chemistry and explored promising research opportunities for chemists in quantum sensing, communication, computers, and computing. A report is expected in late FY 2017.
- The workshop “Framing the Role of Big Data and Modern Data Science in Chemistry” was held in April 2017 and focused on big data research and the use of modern data science in chemistry. The workshop addressed the needs of the chemical research and data science communities to fully develop sharing, searching, and repurposing, for data mining, machine learning, and data analytics.
- DMR sponsored several workshops in FY 2016 and FY 2017 focused on advancing the use of data-driven research in the DMREF program<sup>4</sup>, grand challenges in soft condensed matter physics<sup>5,6</sup>, emerging trends in topological phases of matter research<sup>7</sup>, challenges for young condensed matter physics investigators<sup>8</sup>, and new mid-scale tools to advance biomaterials<sup>9</sup> and quantum materials<sup>10</sup>.
- DMR supported two major topical program reviews in FY 2016; a decadal survey for polymer science<sup>11</sup> and a four-year review of emerging fundamental science trends in ceramics<sup>12</sup>.
- DMR plans to sponsor several workshops throughout FY 2017 and FY 2018 which will focus on condensed matter science, quantum materials<sup>13</sup>, mid-scale instrumentation, solid state materials chemistry, electronic and photonic materials, and the application of data-driven science and machine learning to accelerated materials discovery.
- DMS, BIO/IOS, and BIO/MCB sponsored a workshop on *Deciphering Genome to Phenome Relationships: Interdisciplinary Research at the Interface of the Biological and Mathematical Sciences*<sup>14</sup> in October 2015. The findings of the workshop recommended the development of a joint initiative to support research centers on the Mathematics of Complex Biological Systems.
- In April 2016, DMS and CISE/CCF sponsored the workshop “Theoretical Foundations of Data Science (TFoDS): Algorithmic, Mathematical, and Statistical”<sup>15</sup>. Findings led to a FY 2017 joint program for the development of small collaborative institutes on Transdisciplinary Research in Principles of Data Science (TRIPODS) by DMS and CISE/CCF.
- In collaboration with the National Institutes of Health (NIH), DMS supported a Data Science Innovation Lab workshop focused on Interdisciplinary Approaches to Biomedical Data Science in June 2016. The activity brought together researchers in quantitative and biomedical sciences with a goal of developing new research teams to work on problems in biomedical data science. A program solicitation *Joint NSF/NIH Initiative on Quantitative Approaches to Biomedical Big Data (QuBBD)* was issued to encourage proposals for inter- and multi-disciplinary collaborations that focus on innovative and transformative approaches to address challenges in this topic area.
- DMS made an award “GROW: Strengthening the Mathematical Workforce” to support two related conferences aimed at addressing gender imbalances within the mathematical sciences. The first of the

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<sup>4</sup> [www.ornl.gov/mgi2016/](http://www.ornl.gov/mgi2016/)

<sup>5</sup> <https://mrsec.uchicago.edu/events/grand-challenges-soft-matter-experiment>

<sup>6</sup> <https://journals.aps.org/rmp/abstract/10.1103/RevModPhys.89.025002>

<sup>7</sup> <http://scholar.princeton.edu/nsfcmp>

<sup>8</sup> <http://reg.conferences.dce.ufl.edu/Physics/1202>

<sup>9</sup> [www.biomatworkshop.org/home.html](http://www.biomatworkshop.org/home.html)

<sup>10</sup> <http://sites.krieger.jhu.edu/miqm/>

<sup>11</sup> <https://sites.google.com/a/umn.edu/nsf-polymer-workshop/>

<sup>12</sup> <http://faber.caltech.edu/nsf/>

<sup>13</sup> <https://sites.google.com/harvard.edu/nsfquantumrev>

<sup>14</sup> [www.nsf.gov/mps/dms/documents/Deciphering\\_Genome-to-Phenome\\_Relationships.pdf](http://www.nsf.gov/mps/dms/documents/Deciphering_Genome-to-Phenome_Relationships.pdf)

<sup>15</sup> [www.cs.rpi.edu/TFoDS/](http://www.cs.rpi.edu/TFoDS/)

conferences was held in October 2016 and the second will be held in October 2017. In view of this, DMS and EHR will be encouraging proposals that would improve and support student transition to and subsequent success in doctoral programs in the mathematical sciences.

Committees of Visitors (COV):

- In FY 2016, COVs reviewed CHE and DMS. The MPS Advisory Committee subsequently accepted both reports.
- In FY 2018, a COV will review PHY.
- In FY 2019, COVs will review AST and DMR.

The Performance chapter provides details regarding the periodic reviews of programs and portfolios of programs by external COVs and directorate Advisory Committees. See this chapter for additional information.

**Number of People Involved in MPS Activities**

	FY 2016 Actual Estimate	FY 2017 (TBD)	FY 2018 Estimate
Senior Researchers	8,600	-	8,000
Other Professionals	3,200	-	2,900
Postdoctoral Associates	1,900	-	1,700
Graduate Students	8,200	-	8,000
Undergraduate Students	5,200	-	4,000
K-12 Teachers	-	-	-
K-12 Students	-	-	-
<b>Total Number of People</b>	<b>27,100</b>	<b>-</b>	<b>24,600</b>

**DIVISION OF ASTRONOMICAL SCIENCES (AST)**

**\$221,152,000**  
**-\$25,480,000 / -10.3%**

**AST Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total</b>	<b>\$246.63</b>	-	<b>\$221.15</b>	<b>-\$25.48</b>	<b>-10.3%</b>
<b>Research</b>	<b>60.72</b>	-	<b>51.76</b>	<b>-8.96</b>	<b>-14.8%</b>
CAREER	4.63	-	4.17	-0.46	-9.9%
<b>Education</b>	<b>5.90</b>	-	<b>5.40</b>	<b>-0.50</b>	<b>-8.5%</b>
<b>Infrastructure</b>	<b>180.01</b>	-	<b>163.99</b>	<b>-16.02</b>	<b>-8.9%</b>
Arecibo Observatory	4.80	-	3.90	-0.90	-18.8%
Atacama Large Millimeter Array (ALMA)	37.65	-	43.48	5.83	15.5%
Daniel K. Inouye Solar Telescope (DKIST)	13.50	-	16.00	2.50	18.5%
Gemini Observatory	19.88	-	21.03	1.15	5.8%
National Optical Astronomy Observatory (NOAO)	21.99	-	20.67	-1.32	-6.0%
National Radio Astronomy Observatory (NRAO) <sup>1</sup>	41.73	-	32.86	-8.87	-21.3%
National Solar Observatory (NSO) <sup>2</sup>	9.50	-	5.00	-4.50	-47.4%
Other Astronomical Facilities	-	-	11.85	11.85	N/A
Mid-Scale Innovations Program (MSIP)	21.25	-	6.00	-15.25	-71.8%
Research Resources	9.71	-	3.20	-6.51	-67.0%

<sup>1</sup> The decrease in NRAO is chiefly due to the separation of the Green Bank Observatory and the Very Long Baseline Array from NRAO and ALMO, starting in FY 2017. That funding is now shown under the "Other Astronomical Facilities" line in this table.

<sup>2</sup> Totals do not include \$11.50 million in FY 2016 and \$14.0 million in FY 2018 for operations and maintenance support for the DKIST facility construction project. That funding is captured as part of the total presented on the DKIST line above.

AST is the federal steward for ground-based astronomy in the United States, funding research with awards to individual investigators and small research groups, and supporting operations of large telescope facilities via cooperative agreements. These telescope facilities provide world-leading, one-of-a-kind observational capabilities on a competitive basis to thousands of astronomers each year. These facilities also enable scientific advances by making archived data products available to researchers. AST also supports the development of advanced technologies and instrumentation and manages the electromagnetic spectrum for scientific use by the entire NSF community.

AST supports research to understand the origins and characteristics of planets, stars, and galaxies, as well as the structure that has evolved in the universe since its origin more than 13 billion years ago. The results of this research will lead to a better understanding of the cosmos, of the possibility of life existing on planets circling other stars, and of the nature of the mysterious dark matter and dark energy that comprise more than 95 percent of the mass-energy of the universe.

In general, about 28 percent of the AST portfolio is available for new research. About 61 percent of AST's budget supports the forefront instrumentation and facilities needed for progress at the frontiers of observational astronomy, while almost 20 percent supports the research of individual investigators. Through the MREFC appropriation, AST also oversees the construction of LSST and DKIST.

**FY 2018 Summary**

All funding decreases/increases represent change over the FY 2016 Actual.

**Research**

- CAREER (-\$460,000 to a total of \$4.17 million): This level continues AST's commitment to early-career investigators and will support about 35 awards.
- Disciplinary and interdisciplinary research programs (-\$8.68 million to a total of \$44.03 million): Support for fundamental research is a major focus. This level will continue support for the Astronomy and Astrophysics Research Grants and Solar and Planetary Grants programs but at a lower level.

**Education**

- Partnerships in Astronomy and Astrophysics Research and Education (PAARE) (-\$500,000 to a total of \$1.0 million): Reduced proposal demand in FY 2016 has resulted in a shift in the funding balance between PAARE and other workforce development and early-career programs.

**Infrastructure**

- ALMA (+\$5.83 million to a total of \$43.48 million): As ALMA approaches steady state operations, funding includes an increase of the annual contribution to the ALMA Development Fund and long-term maintenance budget as agreed to by the international partners.
- Arecibo Observatory (-\$900,000 to a total of \$3.90 million): The FY 2016 Actual includes \$700,000 in forward funding. The \$200,000 balance of the reduction is consistent with the proposed divestment amount appearing in the FY 2017 Arecibo management solicitation.
- DKIST (+\$2.50 million to a total of \$16.0 million): This supports the continued ramp-up of DKIST operations within NSO to \$14.0 million, plus the DKIST cultural mitigation award held steady at \$2.0 million. See the Major Research Equipment and Facilities Construction chapter for more detail.
- Gemini Observatory (+\$1.15 million to a total of \$21.03 million): This supports a slight increase in operations and the instrument development fund as agreed to by the international Gemini Board.
- NOAO (-\$1.32 million to a total of \$20.67 million): This supports operations of NOAO's optical telescope and data science programs.
- NRAO (-\$8.87 million to a total of \$32.86 million): This decrease is due to the removal of the Green Bank Observatory and the Very Long Baseline Array (VLBA) from the NRAO base budget in FY 2017. Funding for GBO and VLBA is captured in the Other Astronomical Facilities line.
- NSO (-\$4.50 million to a total of \$5.0 million): Of the total change, most (-\$2.50 million to zero) is due to the end of a one-time activity in FY 2016 to make NSO Space Weather infrastructure more robust, and the rest (-\$2.0 million, to a total of \$5.0 million) is a decrease in NSO base support with the divestment of facilities on Sacramento Peak and Kitt Peak and with emphasis shifting to DKIST operations.
- Other Astronomical Facilities (+\$11.85 million to a total of \$11.85 million): This funds operational support for GBO and VLBA (now operated by the Long Baseline Observatory), which were moved from the NRAO base budget as noted in the NRAO bullet above.
- Mid-Scale Innovations Program (MSIP) (-\$15.25 million to a total of \$6.0 million): Of the total change, -\$13.25 million results from re-balancing MSIP with core individual investigator programs, but with lower priority given to MSIP while maintaining a minimal level for the program. The \$2.0 million balance of the reduction is due to a technical adjustment to recategorize funding for the Dark Energy Survey Data Management within Research Resources below.
- Research Resources (-\$6.51 million to a total of \$3.20 million): This includes a reduction of \$250,000 after the final increment of a five-year planning award for the Giant Segmented Mirror Telescope that is scheduled to end in FY 2017. Funding for other activities on this line are the Advanced Technologies and Instrumentation (ATI) program, which is minimally maintained and to be offered in alternating years, and the Dark Energy Survey Data Management, which remains constant at \$2.0 million.

**DIVISION OF CHEMISTRY (CHE)**

**\$221,050,000**  
**-\$25,470,000 / -10.3%**

**CHE Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over	
				FY 2016 Actual Amount	Percent
<b>Total</b>	<b>\$246.52</b>	<b>-</b>	<b>\$221.05</b>	<b>-\$25.47</b>	<b>-10.3%</b>
<b>Research</b>	<b>232.49</b>	<b>-</b>	<b>213.95</b>	<b>-18.54</b>	<b>-8.0%</b>
CAREER	26.66	-	23.99	-2.67	-10.0%
Centers Funding (total)	28.35	-	21.60	-6.75	-23.8%
Centers for Chemical Innovation	28.10	-	21.60	-6.50	-23.1%
Nanoscale Science & Engineering Centers	0.25	-	-	-0.25	-100.0%
<b>Education</b>	<b>6.47</b>	<b>-</b>	<b>2.40</b>	<b>-4.07</b>	<b>-62.9%</b>
<b>Infrastructure</b>	<b>7.56</b>	<b>-</b>	<b>4.70</b>	<b>-2.86</b>	<b>-37.8%</b>
National High Magnetic Field Laboratory (NHMFL)	1.92	-	1.73	-0.19	-9.9%
National Nanotechnology Coordinated Infrastructure (NNCI)	0.30	-	-	-0.30	-100.0%
Research Resources	5.34	-	2.97	-2.37	-44.4%

CHE supports a large and vibrant research community engaged in fundamental discovery, invention, and innovation in the chemical sciences. CHE enables research in the theoretical, computational, and experimental design, synthesis, and characterization of new molecules, surfaces, and nanostructures often leading to commercial products which benefit society. The division provides new tools for chemical discovery, including those in data discovery science where increasing volumes and varieties of data are harnessed to advance discovery and innovation. CHE solves gaps in our knowledge of the fundamental rules of life in terms of determining structure-function relationships in biological systems. CHE researchers contribute to the production of next generation technologies for sensing, computing, modeling, and communicating at the quantum level by observing, manipulating, and controlling the behavior of particles and energy in nanometer dimensions. The division is also involved in the development of new tools to examine and solve complex chemical problems including the synergistic combination of multiple types of measurements (including remote access and cyber-enabled tools) and the development of de novo instruments. CHE supports curiosity-driven research that leads to increased understanding of molecules and their chemical transformations, that are often manifest in the chemical, agricultural, and pharmaceutical industries. The division also supports the development of new instrumentation to study and detect molecules important for sensing, monitoring, understanding, and improving the sustainability of chemical reactions at both the lab bench and commercial scales.

In general, 61 percent of the CHE portfolio is available for new research grants and 39 percent is available for continuing grants.

**FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

**Research**

- CAREER grants (-\$2.67 million to a total of \$23.99 million) are funded at a rate equal to general unsolicited research grants. This is consistent with the CHE objectives of encouraging broadening participation and education while focusing on the frontiers of the field. This will fund about 90 awards.
- Disciplinary and Interdisciplinary Research (-\$9.04 million to a total of \$163.79 million): Support for

fundamental research is the core mission of CHE. Funding changes include:

- Research at the Interface of the Biological, Mathematical and Physical Sciences (BioMaPS) (-\$5.70 million to a total of \$1.90 million) was widely embraced by the CHE community and will be mainstreamed into core programs. CHE will only support remaining continuing grant increments (CGIs) in FY 2018. CHE continues to support efforts at the chemistry-biology interface in activities such as the Brain Research through Advancing Innovative Neurotechnologies (BRAIN) Initiative (level at a total of \$5.76 million) as well as an examination of the rules of life, which focus on structure-function relationships related to biological systems.
- Some programs are scheduled to sunset as activity moves from special investments to core research programs. Continuing grant increments at FY 2018 Request for SEES include Sustainable Chemistry, Engineering and Materials (SusChEM, -\$31.28 million to a total of \$10.42 million).
- Designing Materials to Revolutionize and Engineer our Future (DMREF) program (-\$3.0 million to zero) will not issue a solicitation in FY 2018. Instead, CHE will focus on engaging the community in data-driven discovery science which seeks to emphasize the effective sharing, mining, and repurposing of rapidly-growing chemical datasets and to apply state-of-the-art data analytics tools to expand chemical understanding.
- The Centers for Chemical Innovation (CCI) program (-\$6.50 million to a total of \$21.60 million) makes two levels of awards: Phase I for center development, and Phase II for full centers. Phase I awards are considered part of CHE's D&IR investments. In FY 2018, CHE will support six Phase II Centers (two have sunset since FY 2016) at a reduced level relative to the standard center award. The CCI program continues the exploration of major, long-term research challenges, producing transformative research that leads to innovation and attracts broad scientific and public interest.
- Nanoscale Science and Engineering Centers (-\$250,000 to zero): This program will sunset as planned in FY 2017.

### **Education**

- CHE contributes to a number of education and diversity activities: Research Experiences for Undergraduates (REU) support totals \$2.35 million (-\$3.28 million); success rates for REU Sites is projected to be similar to proposals submitted to core research programs. Support is level at \$50,000 in total for Research Experiences for Teachers (RET) and Career Life Balance (CLB) and level at \$330,000 for Alliances for Graduate Education and the Professoriate (AGEP).

### **Infrastructure**

- NHMFL, specifically the Ion Cyclotron Resonance (ICR) facility (-\$190,000 to a total of \$1.73 million): The decrease is consistent with the decrease in chemistry-focused research at the facility.
- NNCI (-\$300,000 to zero): Nanochemistry investments are well supported within our core programs as demonstrated by the National Nanotechnology Initiative (NNI, level at \$47.94 million).
- Research Resources (-\$2.37 million to a total of \$2.97 million): Support includes the Chemistry and Materials Consortium for Advanced Radiation Sources (ChemMatCRS) at Argonne National Laboratory (level at \$970,000) and adds support for highly meritorious Materials Research Instrumentation (MRI) proposals (-\$2.37 million to a total of \$2.0 million).

**DIVISION OF MATERIALS RESEARCH (DMR)**

**\$282,870,000**  
**-\$27,010,000 / -8.7%**

**DMR Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over	
				FY 2016 Actual Amount	Percent
<b>Total</b>	<b>\$309.88</b>	<b>-</b>	<b>\$282.87</b>	<b>-\$27.01</b>	<b>-8.7%</b>
<b>Research</b>	<b>238.28</b>	<b>-</b>	<b>227.12</b>	<b>-11.16</b>	<b>-4.7%</b>
CAREER	24.06	-	24.03	-0.03	-0.1%
Centers Funding (total)	59.88	-	65.00	5.12	8.6%
Materials Research Science & Engineering Centers	55.54	-	55.00	-0.54	-1.0%
Nanoscale Science & Engineering Centers	0.25	-	-	-0.25	-100.0%
STC: Center for Integrated Quantum Materials	4.09	-	5.00	0.91	22.2%
STC: Science and Technology Center on Real-Time Functional Imaging	-	-	5.00	5.00	N/A
<b>Education</b>	<b>5.79</b>	<b>-</b>	<b>2.00</b>	<b>-3.79</b>	<b>-65.4%</b>
<b>Infrastructure</b>	<b>65.82</b>	<b>-</b>	<b>53.75</b>	<b>-12.07</b>	<b>-18.3%</b>
Cornell High Energy Synchrotron Source (CHESS)	10.03	-	8.00	-2.03	-20.3%
National High Magnetic Field Laboratory (NHMFL)	33.42	-	33.04	-0.38	-1.1%
Nat'l NanotechnologyCoordinated Infrastructure (NNCI)	2.58	-	2.50	-0.08	-3.1%
Mid-scale Research Infrastructure	15.28	-	6.09	-9.19	-60.1%
Research Resources <sup>1</sup>	1.73	-	1.33	-0.40	-23.2%
Center for High Resolution Neutron Scattering (CHRNS)	2.77	-	2.79	0.02	0.7%

<sup>1</sup> Includes investments in materials instrumentation. Higher funding in FY 2016 is attributed to one additional instrumentation award.

DMR invests in the discovery of new materials and the explanation of materials phenomena. Materials are ubiquitous and pervasive, serving as the critical building block to modern technology and innovation. DMR accomplishes its goal by support of basic experimental and theoretical research through a range of programs focused on condensed matter physics, solid-state and materials chemistry, and the science of materials that are ceramic, metallic, polymeric, nano-structured, biological, electronic, photonic, and multifunctional.

The discovery and deployment of new materials have shaped our understanding of our world and enabled significant advances in electronics, communications, transportation, and health-related fields. The health of this enterprise is dependent on investments across scales; from single investigators to teams and centers; to singularly focused discipline research versus that requiring interdisciplinarity; and small instruments to large-scale facilities.

In general, 34 percent of the DMR portfolio is available for new research grants and 66 percent is available for continuing grants.

**FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

**Research**

- CAREER (\$24.03 million, no change): DMR places a high priority on developing the pipeline of new faculty in materials research who will help form the future community. This supports about 180 awards.
- Disciplinary and Interdisciplinary Research (-\$16.53 million to a total of \$133.10 million): Support for fundamental research is the core mission of DMR. Funding changes include:

- CEMMSS (-\$10.88 million to a total of \$14.67 million): DMR participates in CEMMSS through the Advanced Manufacturing and Materials Genome Initiatives. Programs that contribute to these initiatives are DMREF, MIP (see Research Infrastructure below), the Scalable Nanomanufacturing solicitation, and Materials Research Science and Engineering Centers, and core program investments. There will not be a DMREF (-\$8.97 million for a total of \$5.0 million) competition in FY 2018. DMR, along with program partners in ENG, CISE, and other MPS divisions, will invest in community building activities focused on leveraging the data generated by these awards to accelerate the discovery and deployment of materials with a specific function or property through synergistic integration of theory/computation, experiments, and systematic use of materials data.
- Materials Research Science and Engineering Centers (MRSECs) (-\$540,000 to a total of \$55.0 million): MRSECs advance materials research through collaborations of groups of principal investigators and provide students with a rich interdisciplinary education, while addressing fundamental research problems at the forefront of the field. The long-standing, flagship program will complete its triennial competition in FY 2017. In FY 2018, about 20 new and continuing awards are expected.
- Science and Technology Centers (+\$5.91 million to a total \$10.0 million): Funding reflects the prospective renewal of the Center for Integrated Quantum Materials, which explores the fundamental science of quantum materials and quantum devices, and ramp up support for the new STC on Real-Time Functional Imaging, initiated in FY 2016 to integrate different imaging modalities using electron, X-ray, optical, and nano-probe microscopies to tackle major scientific challenges with broader impacts to manufacturing quality control, medical diagnostics, and airport security.
- Nanoscale Science and Engineering Centers (-\$250,000 to zero): This program will sunset as planned in FY 2017.

### **Education**

- Research Experiences for Undergraduates (REU) Sites (-\$3.12 million to a total of \$2.0 million): DMR remains committed to supporting the next generation of scientists and engineers. This reduced level will allow for the renewal of the most productive REU sites. Further, DMR infrastructure programs, such as centers (MRSEC and PREM) and facilities (NHMFL, CHRNS, CHESS, and MIP), provide significant REU opportunities for undergraduates across the U.S.

### **Infrastructure**

- CHESS (-\$2.03 million to a total of \$8.0 million): CHESS, as a high-energy X-ray national user facility, serves researchers in fields of biology, engineering, and materials. The FY Budget 2018 Request is consistent with plans to transition the facility from NSF stewardship to a partnership model, which will begin ahead of schedule in FY 2018.
- NHMFL (-\$380,000 to a total of \$33.04 million): The world leading NHMFL is the only U.S. facility that provides extremely high magnetic fields, enabling transformative research in disciplines ranging from biology and chemistry to materials and condensed matter physics. NHMFL remains a high divisional priority.
- Mid-scale Research Infrastructure program (MIP) (-\$9.19 million to a total of \$6.09 million): DMR awarded the first class of MIPs in FY 2016. MIPs embrace the goals set forth by the Materials Genome Initiative, including a focus on data-driven accelerated research, and the inaugural class is focused on the discovery of new 2D materials for advanced electronics. The planned FY 2018 competition is postponed until the next focus topic is identified; the FY 2018 Request funds the operations costs only for the class of 2016 MIPs.
- Research Resources (-\$400,000 to a total of \$1.33 million): This supports liquid helium and liquid helium recovery systems, the Chemistry and Materials Consortium for Advanced Radiation Sources (ChemMatCARS), and instrumentation for materials research. One additional instrumentation award was made in FY 2016, which is not anticipated in FY 2018.

**DIVISION OF MATHEMATICAL SCIENCES (DMS)**

**\$209,780,000**  
**-\$24,170,000 / -10.3%**

**DMS Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total</b>	<b>\$233.95</b>	-	<b>\$209.78</b>	<b>-\$24.17</b>	<b>-10.3%</b>
<b>Research</b>	<b>222.09</b>	-	<b>199.28</b>	<b>-22.81</b>	<b>-10.3%</b>
CAREER	14.07	-	12.00	-2.07	-14.7%
Centers Funding (total)	0.20	-	-	-	-
Centers for Analysis & Synthesis	0.20	-	-	-0.20	-100.0%
<b>Education</b>	<b>11.86</b>	-	<b>10.50</b>	<b>-1.36</b>	<b>-11.5%</b>

The influence of mathematical sciences on daily life is fundamental and pervasive. For example, every secure commercial transaction on the internet is an application of research in number theory and algebraic geometry, and similarly many of the modern smart materials used in advanced manufacturing are the result of mathematical analysis and simulation. Modern communication, transportation, medicine, manufacturing, security, and finance all depend on developments in the mathematical sciences. DMS investments catalyze research at the frontiers of fundamental, applied, and computational mathematics and statistics and enable discovery and innovation in other fields of science and engineering linked to key national priorities. In turn, advances in science and engineering inspire development of ever more sophisticated mathematical and statistical methodologies, theories, and tools. DMS investments underpin these developments as well as the training of future researchers in the mathematical sciences.

In addition to supporting a vibrant research community through core research programs in mathematics and statistics, DMS supports a range of other investments that advance research, increase the impact of the mathematical sciences, respond to national needs, and expand the U.S. talent base engaged in mathematical and statistical research. These include mathematical sciences research institutes, multi-agency programs such as joint activities in biosciences with the National Institutes of Health, joint activities in threat detection/data science with the National Geospatial-Intelligence Agency, a program for the development of small collaborative institutes on Transdisciplinary Research in Principles of Data Science with CISE/CCF as well as an initiative to support research centers on the Mathematics of Complex Biological Systems with BIO.

In general, 47 percent of the DMS portfolio is available for new research grants and 53 percent is available for continuing grants.

**FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

**Research**

- CAREER (-\$2.07 million to a total of \$12.0 million): Support for early-career researchers is a division priority. This level supports about 170 awards.
- Centers for Analysis and Synthesis (-\$200,000 to zero): DMS contribution to the National Institute for Mathematical and Biological Synthesis (NIMBioS) ends as planned in FY 2017.
- Disciplinary and Interdisciplinary Research (-\$20.80 million to a total of \$182.39 million): Support for fundamental research is the core mission of DMS. Funding changes include:

- Critical Techniques, Technologies and Methodologies for Advancing Foundations and Applications of Big Data Sciences and Engineering (BIGDATA) (-\$2.0 million to zero): DMS will realign its investment amid new DMS activities in data science.
- Research at the Interface of the Biological, Mathematical and Physical Sciences, and Engineering (BioMaPS) (-\$3.26 million to zero): DMS will realign its investment into new DMS activities in life sciences.
- DMREF (-\$1.50 million to zero): DMS will continue to support fundamental discoveries in materials science and Advanced Manufacturing by investing in new capabilities for mathematical modeling, computational simulation, numerical algorithms, and data analysis and management through disciplinary programs.
- Mathematical Sciences Innovation Incubator (MSII) (-\$2.0 million to zero): DMS will put this new program on hold.
- Mathematical Sciences Research Institutes (-\$3.10 million to a total of \$25.80 million): Six DMS-supported institutes will continue to catalyze frontier research through an array of scientific programs. DMS will maintain the level of support for the development of small collaborative institutes on Transdisciplinary Research in Principles of Data Science. DMS will start supporting research centers on the Mathematics of Complex Biological Systems jointly with the Directorate for Biological Sciences.
- Optics and Photonics (-\$1.50 million to zero): Fundamental research in optics and photonics will be supported by DMS disciplinary programs.
- Secure and Trustworthy Cyberspace (SaTC) (-\$1.0 million to a total of \$1.0 million): Funding reflects continued national need for fundamental cybersecurity research, which investigates questions surrounding securing information networks against hostile intrusion and ensuring individual privacy in anonymized data sets.
- Understanding the Brain (UtB) (-\$1.54 million to a total of \$3.0 million): DMS will support investments into scientific understanding of the full complexity of the brain cross-disciplinary investments.
- Workforce Program in the Mathematical Sciences (-\$4.0 million to a total of \$18.0 million): DMS will put on hold the relatively new Enriched Doctoral Training in the Mathematical Sciences program.

### **Education**

- Research Experiences for Undergraduates (REU) (-\$1.36 million to \$4.50 million): DMS maintains a commitment to REU Sites and REU Supplements activities.
- Mathematical Sciences Postdoctoral Research Fellowships (MSPRF) (level at \$6.0 million). Investments continue in a number of education and diversity activities through the program.

**DIVISION OF PHYSICS (PHY)**

**\$253,300,000**  
**-\$23,610,000/ -8.5%**

**PHY Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over	
				FY 2016 Actual Amount	Percent
<b>Total</b>	<b>\$276.91</b>	-	<b>\$253.30</b>	<b>-\$23.61</b>	<b>-8.5%</b>
<b>Research</b>	<b>174.12</b>	-	<b>152.09</b>	<b>-22.03</b>	<b>-12.7%</b>
CAREER	8.12	-	7.30	-0.82	-10.1%
STC: Center for Bright Beams (CBB)	-	-	5.00	5.00	N/A
<b>Education</b>	<b>5.40</b>	-	<b>4.80</b>	<b>-0.60</b>	<b>-11.1%</b>
<b>Infrastructure</b>	<b>97.39</b>	-	<b>96.41</b>	<b>-0.98</b>	<b>-1.0%</b>
IceCube	3.48	-	3.50	0.02	0.6%
Large Hadron Collider (LHC)	20.00	-	16.00	-4.00	-20.0%
Laser Interferometer Gravitational Wave Observatory (LIGO)	39.43	-	39.43	-	-
Nat'l Superconducting Cyclotron Lab. (NSCL)	24.00	-	23.00	-1.00	-4.2%
Midscale Research Infrastructure	10.48	-	8.18	-2.30	-21.9%
Pre-construction planning:	-	-	6.30	6.30	N/A
High-Luminosity LHC Upgrade Planning	-	-	6.30	6.30	N/A

PHY supports fundamental research addressing frontier areas of physics that lead to the understanding of the make-up of the universe, from the formation of stars and galaxies to the principles of life processes on Earth. This research covers a range of physics subfields: atomic, molecular, optical and plasma physics, elementary particle physics, gravitational physics, nuclear physics, particle and nuclear astrophysics, physics of living systems, physics at the information frontier, and theoretical physics. PHY is the primary supporter of all research in the United States in gravitational physics and the leading supporter of fundamental research in atomic, molecular, and optical physics in the United States. PHY is a major partner with DOE in support of elementary particle physics, nuclear physics, and plasma physics. PHY also has the only U.S. program designed for the support of physics research in living systems.

Research in physics is invariably accompanied by the development of new analytical, computational, and technological approaches, many of which then go on to have major impact in other scientific and engineering fields. These include, for example: advances in ways to move, analyze, and store large data sets that are directly related to the data revolution; advances in understanding of quantum mechanics that underpin the development of a spectrum of quantum technologies that influence communication, computation, and sensing; and the search for theoretical concepts that could provide guidance to understanding how and why cancer develops.

In general, about 20 percent of the PHY portfolio is available for new research grants. The remaining 80 percent is used primarily to fund continuing grants made in previous years (47 percent) and to support operations and maintenance for four facilities that are a key part of the division portfolio (32 percent).

## **FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

### **Research**

- CAREER (-\$820,000 to a total of \$7.30 million): This level preserves the percentage of CAREER awards as a fraction of the overall D&IR budget and will support roughly 60 awards.
- Disciplinary and Interdisciplinary Research (-\$25.56 million to a total of \$135.53 million): Funding will retain emphasis on investments in Quantum Information Science and computational needs for addressing large data sets and in NSF-wide investments such as:
  - UtB (-\$1.75 million to a total of \$4.0 million): This provides continued support for physics-based research that enables scientific understanding of the full complexity of the brain, in action and in context.
- Science and Technology Center: Center for Bright Beams (+\$5.0 million to a total of \$5.0 million): Funding will ramp up as planned for this Class of 2016 cohort.

### **Education**

- REU (-\$570,000 million to \$4.70 million): This level preserves the percentage of funding for the REU program as a fraction of the overall D&IR budget.

### **Infrastructure**

- IceCube (+\$20,000 to a total of \$3.50 million): This reflects the funding profile developed under the new cooperative agreement initiated in FY 2016.
- LHC (-\$4.0 million to a total of \$16.0 million): This supports operations of the ATLAS and CMS detectors at LHC. The decrease is due to the redirection of funds to planning for the High-Luminosity LHC Upgrade as described below.
- LIGO (level at \$39.43 million): This supports operations of LIGO and commissioning of its upgraded interferometer following completion of the Advanced LIGO construction project in FY 2014.
- NSCL (-\$1.0 million to a total of \$23.0 million): This supports operations of NSCL at Michigan State University. This will result in fewer operating hours, but is consistent with prior funding levels..
- Mid-scale Research Infrastructure (-\$2.30 million to a total of \$8.18 million): Funding will support the continuation of projects started in previous years. The decrease is due to the redirection of funds to planning for the High-Luminosity LHC Upgrade as described below.
- High-Luminosity LHC Upgrade Planning (+\$6.30 million to a total of \$6.30 million): This added funding will allow development and planning that could possibly lead to a major construction upgrade of the ATLAS and CMS detectors at LHC beginning in FY 2020.

**OFFICE OF MULTIDISCIPLINARY ACTIVITIES (OMA)**

**\$31,280,000**  
**-\$3,610,000 / -10.3%**

**OMA Funding**  
(Dollars in Millions)

	FY 2016 Actual	FY 2017 (TBD)	FY 2018 Request	Change Over FY 2016 Actual	
				Amount	Percent
<b>Total</b>	<b>\$34.89</b>	<b>-</b>	<b>\$31.28</b>	<b>-\$3.61</b>	<b>-10.3%</b>
<b>Research</b>	<b>21.24</b>	<b>-</b>	<b>20.18</b>	<b>-1.06</b>	<b>-5.0%</b>
CAREER	0.42	-	-	-0.42	-100.0%
<b>Education</b>	<b>7.02</b>	<b>-</b>	<b>4.10</b>	<b>-2.92</b>	<b>-41.6%</b>
<b>Infrastructure</b>	<b>6.63</b>	<b>-</b>	<b>7.00</b>	<b>0.37</b>	<b>5.6%</b>

OMA enables and facilitates MPS support of novel, challenging, or complex projects of varying scale, in both research and education, which are not readily accommodated by traditional organizational structures and procedures. This is done primarily in partnership with MPS disciplinary divisions and is especially directed at activities undertaken by multi-investigator, multidisciplinary teams, as well as cross-NSF and interagency activities.

In FY 2018, OMA will focus on multidisciplinary research, chiefly through grant co-funding with MPS Divisions, that advance the basic foundations of mathematical and physical sciences. An important scientific focus for OMA investment in FY 2018 will be the area of quantum information science, where NSF participation in the form of sponsored projects could provide the impetus to advance both science and technology in a disruptive manner. This investment is expected to involve several divisions within MPS as well as within ENG and CISE. This investment also has the potential for significant societal benefit, as it offers approaches that move past the limitations of silicon technology. OMA also will provide leadership and support for I-Corps™, INCLUDES, and NSF Research Traineeships (NRT) activities within MPS. Beginning in FY 2016 and continuing through at least FY 2018, OMA purposefully invests, in partnership with the disciplinary programs that comprise the MPS Directorate, in grants to PIs at HBCUs to build capacity. Finally, in FY 2018, OMA will continue to invest generously in supplements that are designed to engage students from historically underrepresented racial and ethnic groups through graduate research supplements to projects at institutions that have active or legacy awards for the Alliances for Graduate Education and the Professoriate (AGEP-GRS) and Graduate Research Supplements to Veterans (GRSV).

In general, 39 percent of the OMA portfolio is available for new, multidisciplinary research grants within MPS, and 61 percent is available to support research and education activities that are of interest to MPS but that are led by NSF directorates other than MPS.

**FY 2018 Summary**

All funding decreases/increases represent changes over the FY 2016 Actual.

**Research**

- **Disciplinary and Interdisciplinary Research (+800,000 to a total of \$17.90 million):** Funding will focus on multidisciplinary research that addresses key MPS and NSF-wide investments such as Quantum Information Science, the Materials Genome Initiative through NSF’s CEMMSS program, Clean Energy, and UtB.

- I-Corps™ (+100,000 to total of \$1.70 million): Investments are directed to an assessment of the commercial viability of the scientific discoveries in MPS disciplines through the individual investigator award program.

**Education**

- In FY 2018, OMA will continue to invest on behalf of the entire MPS Directorate in the NRT program (-\$3.47 million to \$1.0 million).
- Career Life Balance (-\$200,000 to \$200,000): The decrease in the OMA investment is counterbalanced by a contribution from the sponsoring program or division, resulting in 1:1 funding with OMA.

**Infrastructure**

- Portfolio analysis (+\$370,000 to a total up to \$7.0 million): OMA will support responsible decision-making regarding implementation of portfolio analysis recommendations. This investment will support studies of possible environmental issues, stewardship transition costs, or partnership program start-up costs.

