DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES (MPS) **1,690,740,000 +$110,26,000 / 7.0%**

MPS Funding
(Dollars in Millions)

	FY 2020 Actual[1]	FY 2020 CARES Act Actual	FY 2021 Estimate[1]	FY 2022 Request	Change over FY 2021 Estimate Amount	Percent
Astronomical Sciences (AST)	$279.10	-	$277.05	$294.05	$17.00	6.1%
Chemistry (CHE)	260.37	-	259.71	284.14	24.43	9.4%
Materials Research (DMR)	330.15	-	329.78	349.92	20.14	6.1%
Mathematical Sciences (DMS)	244.09	-	243.54	259.47	15.93	6.5%
Physics (PHY)	304.39	-	303.90	316.59	12.69	4.2%
Office of Multidisciplinary Activities (OMA)	112.01	6.00	166.50	186.57	20.07	12.1%
Total	**$1,530.12**	**$6.00**	**$1,580.48**	**$1,690.74**	**$110.26**	**7.0%**

[1] Funding for FY 2020 and FY 2021 is adjusted for comparability to reflect the movement of I-Corps™ to TIP in FY 2022. See the R&RA Overview for more details.

About MPS

Research in the foundational physical sciences is the central theme of work supported by MPS. The core areas of MPS science (astronomical sciences, chemistry, materials research, mathematical sciences, and physics) continue to advance and transform knowledge and support the development of the next generation of scientists. Science funded by MPS spans an enormous range: from the smallest objects and shortest timescales ever studied to distances and timescales that are the size and age of the universe. MPS continues to foster and support interdisciplinary scientific programs that span in scope and complexity, ranging from individual investigator awards to large, multi-user facilities. Individual investigators and small teams receive most awards, but centers, institutes, and facilities are all integral to MPS-funded research. This convergence of disciplines and various ways to organize researchers allows MPS to invest in compelling basic science that will underpin and enable advances in the technologies of the future and helping to support a strong U.S. economy for decades to come.

Through its Centers and Institutes programs, MPS will continue to support leading-edge science and the development of the next generation of scientists engaged in research covering fundamental basic science through translational science. The MPS Centers and Institutes span a broad range, from addressing challenges in fundamental mathematics to the development of new materials.

Research tools and infrastructure are key priorities that MPS will continue funding. Mid-scale research infrastructure in astronomical sciences, chemistry, materials research, and physics continue to be critical to the advancement of these disciplines. Large scale research infrastructure is also critical and provides opportunities for partnerships with international groups, other federal agencies, and private foundations, as is evidenced by facilities such as the Atacama Large Millimeter/submillimeter Array (ALMA), the Gemini Observatory, the Large Hadron Collider (LHC), and National High Magnetic Field Laboratory. Upgrades to the Large Hadron Collider (LHC), designed to prepare the NSF-funded LHC detectors for High Luminosity operations of the particle accelerator, began construction activities in April 2020, and the Vera C. Rubin Observatory Project is advancing the physical infrastructure on the summit of Cerro Pachón in Chile as well as a state-of-the-art data management system and the largest digital camera ever constructed. The Daniel K. Inouye Solar Telescope (DKIST) is approaching its anticipated completion near the end of 2021, atop Haleakalā on Maui, Hawai'i, and is poised to become the world's most powerful solar observatory. DKIST achieved a key milestone in FY 2020, first light on the sun, producing spectacular images of the solar surface at the highest resolution ever made. Since its detection of gravitation waves for

the very first time in 2015, the Laser Interferometer Gravitational-Wave Observatory (LIGO) has been reporting event alerts on a regular basis, including a neutron star-neutron star merge and a collision of heavy and light black holes.

MPS' FY 2022 Request builds on past efforts and aligns with NSF's priorities articulated for FY 2022. There are exciting new opportunities emerging, research efforts that are maturing, and established programs and activities that continue to meet important goals and support science that will transform the Nation's future. MPS investments are influenced by the following key priorities: (a) sustaining core research programs, (b) supporting the highest priority centers, institutes, and facilities, (c) supporting early-career investigators, (d) providing funding for targeted basic research in NSF-wide investments including the NSF Big Ideas, (e) advancing support for emerging industries, such as quantum information science (QIS), advanced manufacturing (AM), Biotechnology, the spectrum innovation initiative (SII), and artificial intelligence (AI), and (f) increasing support for clean energy and climate research.

There will also be great emphasis placed on supporting racial equity efforts. MPS will enhance funding of a variety of programs geared to broaden the participation of groups underrepresented in STEM research and MPS fields, including the MPS-Ascend Postdoctoral Research Fellowship, Partnerships for Research and Education in Materials (PREM), Partnerships in Astronomy and Astrophysics (PAARE), and the Alliances for Graduate Education and the Professoriate – Graduate Research Supplements (AGEP-GRS).

In partnership with other research directorates and offices, MPS will continue to provide support for the following research Big Ideas: WoU, HDR, and URoL. These are the outcome of numerous community workshops and reports, as synthesized by NSF into robust and far-reaching programs. MPS is the steward of funds designated for QIS and WoU. These convergent activities will enable pursuit of fundamental research in quantum-enabled sciences and technologies and in multi-messenger astrophysics. By exploiting quantum phenomena such as superposition, entanglement, and squeezing, QIS activities will develop the foundations for and enable quantum computing, quantum sensors, quantum communications, quantum simulators, and other inherently quantum technologies. In addition, these activities will contribute to the development of the Nation's quantum-ready workforce. WoU activities will bring together fundamental research in electromagnetic waves, high-energy particles, and gravitational waves; advance the study of the universe; and grow the Nation's multi-messenger astrophysics, engineering, and data science workforce. While financial stewardship for these investments will be the responsibility of MPS, these convergent activities will be overseen and managed collaboratively by QIS and WoU leadership and management teams. MPS is also the steward of funds designated for the Spectrum Innovation Initiative (SII). For more information about the QIS, WoU, and SII, see the related narratives in the NSF-Wide Investments chapter.

MPS provides 47 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[1,2]	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Advanced Manufacturing	$160.62	$123.03	$123.13	$0.10	0.1%
Advanced Wireless Research	17.00	17.00	17.00	-	-
Artificial Intelligence	71.67	62.48	71.76	9.28	14.9%
Biotechnology	73.48	51.20	52.20	1.00	2.0%
Climate: Clean Energy Technology	92.62	90.00	118.56	28.56	31.7%
Climate: USGCRP	-	10.00	14.63	4.63	46.3%
Microelectronics and Semiconductors	35.07	15.20	25.20	10.00	65.8%
Quantum Information Science	125.46	136.13	146.13	10.00	7.3%
Secure & Trustworthy Cyberspace	1.18	1.25	1.25	-	-
NSF's Big Ideas					
QL Stewardship[3]	*30.00*	-	-	-	*N/A*
WoU Stewardship	*30.00*	*30.00*	*30.00*	-	-

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

[2] This table reflects this directorate's support for selected areas of investment. In other directorate narratives, areas of investment displayed in this table may differ and thus should not be summed across narratives.

[3] Starting in FY 2021, all Quantum Leap stewardship activties are managed with the broader Quantum Information Science (QIS) portfolio. See the NSF-Wide Investments chapter for detail on QIS.

- Advanced Manufacturing: MPS will invest in activities that develop new methods, processes, analyses, tools, or equipment for new or existing manufacturing products, supply chain components, or materials. These will yield advantages such as reduced time to market, new performance attributes, improved small-batch production, cost, and energy savings, and reduced environmental impact.
- Advanced Wireless—Spectrum Innovation Initiative: As the steward of this initiative, MPS will coordinate agency-wide investments that catalyze research and development in spectrum research, addressing key challenges related to an increasingly congested radio frequency environment and outdated approaches to spectrum allocation. The funding will primarily support three cross-cutting initiatives: (1) a novel mechanism for piloting, testing, and rolling out the most innovative approaches to dynamic spectrum sharing in specialized geographic regions, "National Radio Dynamic Zones"; (2) a national center for wireless spectrum Research (SII-Center); and (3) education and workforce development specifically related to spectrum research.
- AI: Together with other NSF directorates/offices, MPS will increase support for AI research, with a focus on supporting basic research in machine learning and deep learning and development of tools and technical driven by physical sciences.
- Biotechnology: MPS, together with other NSF directorates/offices, will invest in fundamental research, infrastructure, and education that advance foundational knowledge needed to understand and harness biological processes for societal benefit.
- Climate Research and Clean Energy Technology: MPS, together with other NSF directorates/offices, will increase investment in activities that focus on research of clean energy systems and sources as well as energy sources that are renewable or otherwise alternative to traditional fossil fuels.
- Microelectronics and Semiconductors: MPS will support research that addresses fundamental science questions on the concepts, materials, devices, circuits, and platforms necessary to sustain progress in semiconductor-microelectronic technologies, with a focus on materials. This research is critical to

future advances and security in information technology, communications, sensing, smart electric grid, transportation, health, advanced manufacturing, and other areas.

- QIS: As the steward for QIS, MPS will work together with other NSF directorates and offices to increase support for quantum information science research and development. These investments align with the National Quantum Initiative[1] to coordinate and expand the United States' world-leading position in fundamental quantum research. QIS investments will deliver proof-of-concept devices, applications, tools, or systems with a demonstrable quantum advantage over their classical counterparts. Research in QIS examines uniquely quantum phenomena that can be harnessed to advance information processing transmission, measurement, and fundamental understanding in ways that classical approaches can only do much less efficiently, or not at all. Current and future QIS applications differ from prior applications of quantum mechanics, such as lasers, transistors, and magnetic resonance imaging, by using distinct quantum phenomena—superposition and entanglement—that do not have classical counterparts. MPS will continue the investment in QIS workforce development and in targeted activities designed to grow the participation of investigators and students from institutions currently under-represented in QIS.
- SaTC: MPS will continue to invest in fundamental research in cybersecurity.
- WoU: MPS is the steward for WoU, and together with GEO/OPP, will support research in the "windows"—electromagnetic waves, high-energy particles, and gravitational waves—of multi-messenger astrophysics (MMA). Through WoU investments, NSF will also grow the workforce not only for multi-messenger astrophysics but also for engineering, data science, and many other areas in our modern society. For more information about the Big Ideas, see the narratives in the NSF-Wide Investments chapter.

MPS Funding for Centers Programs and Major Facilities

MPS Funding for Centers Programs
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Artificial Intelligence Research Institutes	$11.20	$2.70	$6.00	$3.30	122.2%
Centers for Chemical Innovation (CHE)	23.66	24.00	27.70	3.70	15.4%
Materials Centers (DMR)	55.50	53.48	56.80	3.32	6.2%
Quantum Leap Challenge Institutes (OMA)[1]	23.10	50.00	36.00	-14.00	-28.0%
STC: Center for Integrated Materials (DMR)	5.00	4.15	3.73	-0.42	-10.1%
STC: STC on Real-Time Functional Imaging (DMR)	5.01	5.00	5.00	-	-
STC: Center for Bright Beams (PHY)	4.66	5.00	5.00	-	-
Spectrum Innovation Initiative Center (OMA)	4.62	5.00	5.00	-	-
Total	**$132.75**	**$149.33**	**$145.23**	**-$4.10**	**-2.7%**

[1] Since FY 2020, Quantum Leap Challenge Institutes (QLCI) funding has been a vital part of NSF's overall $50 million investment in multidisciplinary centers for quantum research and education.

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

MPS Funding for Major Facilities

(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Arecibo Observatory[1]	$3.75	$32.68	$18.00	-$14.68	-44.9%
Green Bank Observatory (GBO)[2]	9.42	8.90	9.12	0.22	2.5%
IceCube Neutrino Observatory (IceCube)	3.50	3.50	3.65	0.15	4.3%
Large Hadron Collider (LHC)	20.00	20.00	20.50	0.50	2.5%
Laser Interferometer Gravitational-Wave Observatory (LIGO)	45.00	45.00	45.00	-	-
National High Magnetic Field Laboratory (NHMFL)[3]	34.59	25.98	38.91	12.93	49.8%
National Radio Astronomy Observatory (NRAO)	89.25	88.13	91.16	3.03	3.4%
NRAO O&M[4]	*41.98*	*39.45*	*40.53*	*1.08*	*2.7%*
Atacama Large Millimeter Array (ALMA) O&M	*47.27*	*48.68*	*50.63*	*1.95*	*4.0%*
National Solar Observatory (NSO)	21.79	22.09	25.46	3.37	15.3%
NSO O&M	*4.78*	*4.55*	*5.88*	*1.33*	*29.2%*
Daniel K. Inouye Solar Telescope (DKIST) O&M[5]	*17.01*	*17.54*	*19.58*	*2.04*	*11.6%*
National Superconducting Cyclotron Laboratory (NSCL)[6]	22.00	15.50	-	-15.50	-100.0%
NSF's National Optical-Infrared Astronomy Research Laboratory (NOIRLab)	57.86	57.93	54.44	-3.49	-6.0%
NOIRLab O&M (Mid-Scale Observatories & Community Science and Data Center)[7]	*35.54*	*29.95*	*26.26*	*-3.69*	*-12.3%*
Gemini Observatory O&M	*22.31*	*22.98*	*22.98*	-	-
Vera C. Rubin Observatory O&M	*0.01*	*5.00*	*5.20*	*0.20*	*4.0%*
Total	**$307.16**	**$319.71**	**$306.24**	**-$13.47**	**-4.2%**

[1] Includes $28.88 million in FY 2021 and $15.0 million in FY 2022 in supplemental funding for cleanup of the Arecibo site.

[2] FY 2020 Actual includes $1.75 million from a technical deobligation/reobligation action from a previous award.

[3] FY 2020 Actual includes $12.0 million to fund part of FY 2021 operations costs, and excludes $14.20 million obligated in FY 2019 for FY 2020 operations.

[4] FY 2020 Actual includes one-time funding of $3.50 million for a special project associated with NSF's Spectrum Innovation Initiative.

[5] FY 2021 Estimate excludes funding of $2.0 million for cultural mitigation activities as agreed to during the compliance process.

[6] FY 2021 is the final year of NSF stewardship of NSCL, after which NSCL will transition into the Department of Energy's Facility for Rare Isotope Beams. Since FY 2019, $4.50 million has been provided on an annual basis for continuity of operations into the subsequent fiscal year; O&M funding is reduced by this amount in FY 2021.

[7] Includes $2.0 million in FY 2020 for transition activities associated with the creation of NOIRLab, as well as special projects funding of $13.63 million in FY 2020, $9.44 million in FY 2021, and $5.13 million in FY 2022.

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

Funding Profile

MPS Funding Profile

	FY 2020 Actual Estimate	FY 2021 Estimate	FY 2022 Estimate
Statistics for Competitive Awards:			
Number of Proposals	8,617	8,900	9,500
Number of New Awards	2,557	2,600	3,000
Regular Appropriation	2,519	2,600	3,000
CARES Act	38		
Funding Rate	30%	29%	32%
Statistics for Research Grants:			
Number of Research Grant Proposals	7,560	7,800	8,350
Number of Research Grants	2,131	2,200	2,400
Regular Appropriation	2,093	2,200	2,400
CARES Act	38		
Funding Rate	28%	28%	29%
Median Annualized Award Size	$130,637	$131,000	$135,000
Average Annualized Award Size	$166,130	$167,000	$169,000
Average Award Duration, in years	3.1	3.1	3.1

In FY 2022, the number of research grant proposals is expected to remain level with FY 2021 Estimates. MPS expects to award approximately 1,800 research grants to support research and infrastructure activities in both core and crosscutting areas. Average annual award size and duration as well as funding rate are not expected to materially fluctuate from FY 2021 to FY 2022. In FY 2022, MPS maintains its commitment to Science and Technology Centers, Materials Centers, Centers for Chemical Innovation, and SII Center and will invest $103.23 million, accounting for roughly six percent of the total MPS budget. Operations and maintenance funding for MPS-supported major multi-user facilities comprises approximately 23 percent of MPS's FY 2022 Request.

Program Monitoring and Evaluation

The Performance and Management chapter provides details regarding the periodic reviews of programs and portfolios by external Committees of Visitors and directorate Advisory Committees. Please see this chapter for additional information.

People Involved in MPS Activities

Number of People Involved in MPS Activities

	FY 2020 Actual Estimate	FY 2020 CARES Act Actual Estimate	FY 2021 Estimate	FY 2022 Estimate
Senior Researchers	9,233	61	9,500	10,200
Other Professionals	2,303	8	2,400	2,500
Postdoctoral Associates	2,009	21	2,000	2,200
Graduate Students	9,291	35	9,600	10,300
Undergraduate Students	6,328	9	6,500	7,000
Total Number of People	**29,164**	**134**	**30,000**	**32,200**

DIVISION OF ASTRONOMICAL SCIENCES (AST)

$294,050,000
+$17,000,000 / 6.1%

AST Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Percent
Total	**$279.10**	**$277.05**	**$294.05**	**$17.00**	**6.1%**
Research	**64.99**	**52.92**	**72.47**	**19.55**	**36.9%**
CAREER	4.74	4.81	4.81	-	-
Education	**4.27**	**4.60**	**5.10**	**0.50**	**10.9%**
Infrastructure	**209.85**	**219.53**	**216.48**	**-3.05**	**-1.4%**
Arecibo Observatory[1]	3.75	12.68	8.00	-4.68	-36.9%
AST Portfolio Review Implementation	0.05	-	-	-	N/A
Green Bank Observatory[2]	9.42	8.90	9.12	0.22	2.5%
Midscale Research Infrastructure	23.30	20.80	19.50	-1.30	-6.3%
National Radio Astronomy Observatory (NRAO)	85.75	88.13	91.16	3.03	3.4%
NRAO O&M	*38.48*	*39.45*	*40.53*	*1.08*	*2.7%*
Atacama Large Millimeter Arrary (ALMA)	*47.27*	*48.68*	*50.63*	*1.95*	*4.0%*
National Solar Observatory (NSO)	21.79	22.09	25.46	3.37	15.3%
NSO O&M	*4.78*	*4.55*	*5.88*	*1.33*	*29.2%*
Daniel K. Inouye Solar Telescope (DKIST) O&M[3]	*17.01*	*17.54*	*19.58*	*2.04*	*11.6%*
NSF's National Optical-Infrared Astronomy Research Lab (NOIRLab)	57.86	57.93	54.44	-3.49	-6.0%
NOIRLab O&M (Mid-Scale Observatories & Community Science and Data Center)[4]	*35.54*	*29.95*	*26.26*	*-3.69*	*-12.3%*
Gemini Observatory O&M	*22.31*	*22.98*	*22.98*	*-*	*-*
Vera C. Rubin Observatory O&M	*0.01*	*5.00*	*5.20*	*0.20*	*4.0%*
Research Resources	7.92	7.00	8.80	1.80	25.7%

[1] Includes $28.88 million in FY 2021 and $15.0 million in FY 2022 in supplemental funding for cleanup of the Arecibo site.

[2] FY 2020 Actual includes $1.75 million from a technical deobligation/reobligation action from a previous award.

[3] FY 2021 Estimate excludes funding of $2.0 million for cultural mitigation activities as agreed to during the compliance process.

[4] Includes $2.0 million in FY 2020 for transition activities associated with the creation of NOIRLab, as well as special projects funding of $13.63 million in FY 2020, $9.44 million in FY 2021, and $5.13 million in FY 2022.

About AST

AST is the federal steward for ground-based astronomy in the United States, funding research via cooperative agreements for the operation of large telescope facilities and through awards to individual investigators and small research groups. The telescope facilities provide world-leading, one-of-a-kind observational capabilities on a competitive basis to thousands of astronomers each year. These facilities enable scientific advances by ensuring that state of the art, leading edge facilities and instrumentation are available to scientific researchers. AST supports the development of advanced technologies and instrumentation and manages the electromagnetic spectrum for scientific use by the entire NSF community.

The AST portfolio includes 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, the possibility of life on planets circling other stars, and the nature of the mysterious dark matter and dark energy that comprise more than 95 percent of the universe. AST also supports research that probes the universe through diverse "windows"—electromagnetic waves, high-energy particles, and gravitational waves.

In general, about 28 percent of the AST portfolio is available for new research grants. About 75 percent of

AST’s budget supports the instrumentation and facilities needed for progress at the frontiers of observational astronomy, while 25 percent supports the research of individual investigators. Through the MREFC appropriation, AST also oversees the construction of the Vera C. Rubin Observatory. For detailed information on AST's individual facilities, see the Facilities chapter. For detailed information on the construction of the Vera C. Rubin Observatory, see the MREFC chapter.

DIVISION OF CHEMISTRY (CHE) **$284,140,000**
+$24,430,000 / 9.4%

CHE Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Total	**$260.37**	**$259.71**	**$284.14**	**$24.43**	**9.4%**
Research	**190.79**	**196.73**	**217.61**	**20.88**	**10.6%**
CAREER	28.93	26.00	26.00	-	-
Centers Funding (total)	23.66	24.00	27.70	3.70	15.4%
Centers for Chemical Innovation (CHE)	23.66	24.00	27.70	3.70	15.4%
Education	**4.88**	**4.55**	**4.55**	**-**	**-**
Infrastructure	**12.11**	**8.43**	**8.28**	**-0.15**	**-1.8%**
Midscale Research Infrastructure	3.00	0.60	0.60	-	-
NHMFL	1.73	1.88	1.73	-0.15	-8.0%
National Nanotechnology Coordinated Infrastructure (NNCI)	0.30	0.30	0.30	-	-
Research Resources	7.08	5.65	5.65	-	-

About CHE

CHE supports discovery research and workforce development in chemistry that have the potential to be transformative to major commercial sectors of the U.S. economy: energy, pharmaceuticals, medical applications, plastics, electronics, food, agriculture, and transportation. CHE investments also support highly competitive and rapidly evolving fields that include advanced manufacturing, quantum information sciences, data mining and artificial intelligence, sensor and instrument development, biotechnology, and climate research. Experimental, computational, and theoretical chemical research is integrated into core programs focused on new synthetic and catalytic methods; measurement/imaging tool and technique development; understanding the structure, dynamics and mechanistic relationships between function and reactivity; environmental chemical sciences; the chemistry of biological processes; and macromolecular, supramolecular and nanochemistry leading to higher ordered structures and materials. CHE programs have a strong emphasis on sustainability and the protection of natural resources. The division uses multiple funding mechanisms to support individuals and team science as well as interdisciplinary user facilities.

CHE encourages researchers to apply chemical understanding and tools to other fields, including biology, engineering, materials research, geosciences, mathematics/statistics, computing, and social sciences. Investments across fields not only expedite chemical learnings, invention, and innovation, but also have significant ramifications for training and employment of the workforce of the future.

In general, about 71 percent of the CHE portfolio is available to support new research grants. The remaining 29 percent supports research grants made in prior years and the research infrastructure needed by the chemistry community.

DIVISION OF MATERIALS RESEARCH (DMR)

$349,920,000
+$20,140,000 / 6.1%

DMR Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Total	**$330.15**	**$329.78**	**$349.92**	**$20.14**	**6.1%**
Research	**150.04**	**181.52**	**189.54**	**8.02**	**4.4%**
CAREER	30.56	25.00	25.00	-	-
Centers Funding (total)	65.51	62.63	65.53	2.90	4.6%
Materials Centers (DMR)	55.50	53.48	56.80	3.32	6.2%
STC: Center for Integrated Materials (DMR)	5.00	4.15	3.73	-0.42	-10.1%
STC: STC on Real-Time Functional Imaging (DMR)	5.01	5.00	5.00	-	-
Education	**7.02**	**2.50**	**2.50**	**-**	**-**
Infrastructure	**77.02**	**58.13**	**67.35**	**9.22**	**15.9%**
Center for High Energy X-ray Science (CHEXS)	10.00	9.00	8.00	-1.00	-11.1%
Midscale Research Infrastructure	25.53	18.00	15.14	-2.86	-15.9%
National High-Magnetic Field Laboratory (NHMFL)	32.86	24.10	37.18	13.08	54.3%
National Nanotechnology Coordinated Infrastructure (NNCI)	2.58	2.58	2.58	-	-
Other MPS Facilities	3.00	3.00	3.00	-	-
Research Resources	3.05	1.45	1.45	-	-

About DMR

Materials research is defined by the broad intersection of many disciplines with materials science & engineering (MS&E), including chemistry, physics, biology, mathematics, and other engineering disciplines that naturally converge in the pursuit of understanding the properties of materials and the phenomena they host. Materials are abundant and pervasive, serving as critical building blocks in technology and innovation. This research impacts life and society, as it shapes our understanding of the world and enables significant advances in electronics, communications, transportation, and health-related fields. The development and deployment of advanced materials are major drivers of U.S. economic growth.

DMR invests in the discovery, prediction and design of new materials and the explanation of materials phenomena, as well as in the development of the next generation of materials scientists, which includes increasing the pathways for participation by underrepresented minorities. DMR supports fundamental experimental and theoretical materials research and education via programs focused on condensed matter physics, solid-state and materials chemistry, and the science of materials that are ceramic, metallic, polymeric, nanostructured, biological, electronic, photonic, and multifunctional. This enterprise is dependent on investments across scales, including single investigators, teams, and centers; singularly focused research and areas requiring interdisciplinarity; and infrastructure ranging from small instruments to large-scale facilities. DMR supports materials-relevant instrumentation and technique development broadly in x-ray and neutron science as well as in nanofabrication. Specifically, DMR investments have contributed to U.S. leadership in high-field magnet science and further aims at democratizing national access to high-magnetic fields.

In general, about 35 percent of the DMR portfolio is available to support new research grants. The remaining 65 percent supports research grants made in prior years and the research infrastructure needed by the materials research community.

DIVISION OF MATHEMATICAL SCIENCES (DMS) **$259,470,000**
+$15,930,000 / 6.5%

DMS Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Percent
Total	**$244.09**	**$243.54**	**$259.47**	**$15.93**	**6.5%**
Research	**214.24**	**217.65**	**230.32**	**12.67**	**5.8%**
CAREER	16.35	12.24	15.00	2.76	22.5%
Education	**13.50**	**13.65**	**14.15**	**0.50**	**3.7%**

About DMS

DMS provides the major U.S. federal support for fundamental research in the mathematical sciences, leading to accelerated discovery and innovation in all science and engineering fields. Modern computing and communication systems, medicine, manufacturing, energy, transportation, finance, and national security all rely on advances in the mathematical sciences. DMS investments support research at the forefront of fundamental, applied, and computational mathematics, and statistics that accelerates discovery and innovation. DMS partnerships with science and engineering in turn inspire development of effective mathematical and statistical theories and methodologies applicable to current and future national priority areas such as artificial intelligence, quantum information science, biotechnology, and climate science. Another DMS priority is the development and advancement of future researchers in the mathematical sciences, through dedicated workforce and development programs.

DMS also provides leadership in emerging research fields through its support of the Mathematical Sciences Research Institutes program, which advances mathematics and statistics research through thematic programs and workshops on current and emerging trends.

DMS continues to develop strong partnerships to expand the impact of its research investments. Examples of partnerships within NSF include the Transdisciplinary Research in Principles of Data Science program with CISE and a program for developing new models for uncovering phenomena in biology with BIO. DMS also forms partnerships with other federal agencies including: a program in biosciences with NIH, the Joint DMS/National Institute of General Medical Sciences Initiative to Support Research at the Interface of the Biological and Mathematical Sciences; a program with the National Geospatial Intelligence Agency to develop the next generation of mathematical and statistical algorithms for threat analysis; and a program on algorithms for modern power systems with DOE. Finally, DMS partners with private foundations such as the Simons Foundation on programs that support research centers on the Mathematics of Complex Biological Systems and on the mathematical foundations of deep learning.

In general, about 67 percent of the DMS portfolio is available to support new research grants each year. The remaining 33 percent supports research grants made in prior years.

DIVISION OF PHYSICS (PHY)

$316,590,000
+$12,690,000 / 4.2%

PHY Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Change over FY 2021 Estimate Percent
Total	**$304.39**	**$303.90**	**$316.59**	**$12.69**	**4.2%**
Research	**175.08**	**187.32**	**203.22**	**15.90**	**8.5%**
CAREER	10.24	7.30	7.30	-	-
Centers Funding (total)	7.45	7.70	11.00	3.30	42.9%
Artificial Intelligence Research Institutes	2.79	2.70	6.00	3.30	122.2%
STC: Center for Bright Beams (PHY)	4.66	5.00	5.00	-	-
Education	**5.76**	**4.92**	**4.92**	**-**	**-**
Infrastructure	**105.86**	**96.66**	**90.15**	**-6.51**	**-6.7%**
IceCube	3.50	3.50	3.65	0.15	4.3%
LHC	20.00	20.00	20.50	0.50	2.5%
LIGO	45.00	45.00	45.00	-	-
Midscale Research Infrastructure	15.36	12.66	18.50	5.84	46.1%
NSCL	22.00	15.50	2.50	-13.00	-83.9%
Research Resources	-	1.00	2.50	1.50	150.0%

About PHY

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, and optical physics, elementary particle physics, gravitational physics, nuclear physics, particle and cosmology, physics of living systems, plasma physics, and quantum information science.

PHY is the primary supporter of all U.S. research 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. The development of the most advanced cutting-edge computational resources, innovative technology, and new instrumentation is a key part of physics research. Tools developed by the physics community continuously have major impacts in other scientific and engineering fields, allowing PHY to contribute in major ways to emerging new frontiers such as quantum information science and artificial intelligence.

In general, about 22 percent of the PHY portfolio is available for new research grants. The remaining 78 percent is used primarily to fund continuing grants made in previous years and to support operations and maintenance for three facilities that are a key part of the division portfolio (about 25% percent). Through the MREFC appropriation, PHY also oversees the construction of HL-LHC. For detailed information on PHY's individual facilities, see the Facilities chapter. For detailed information on the construction of HL-LHC, see the MREFC chapter.

OFFICE OF MULTIDISCIPLINARY ACTIVITIES (OMA) **$186,570,000**
+$20,070,000 / 12.1%

OMA Funding
(Dollars in Millions)

	FY 2020 Actual	FY 2021 Estimate	FY 2022 Request	Change over FY 2021 Estimate Amount	Percent
Total	**$112.01**	**$166.50**	**$186.57**	**$20.07**	**12.1%**
Research	**-**	**-**	**-**	**-**	**N/A**
CAREER				-	N/A
Centers Funding (total)	27.72	55.00	41.00	-14.00	-25.5%
Quantum Leap Challenge Institutes[1]	23.10	50.00	36.00	-14.00	-28.0%
Spectrum Innovation Initiative Center	4.62	5.00	5.00	-	-
Education	**-**	**10.00**	**10.00**	**-**	**-**
Infrastructure	**4.65**	**20.00**	**10.00**	**-10.00**	**-50.0%**

[1] FY 2021 and FY 2022 include other QIS-related center and institutes, that combined with QLCIs, total $50M.

About OMA

In partnership with MPS division and programs, OMA strategically invests in research and education to support novel, challenging, and multidisciplinary projects of varying scale that are not readily accommodated by traditional organizational structures and procedures.

OMA funding will focus on priority areas relevant to MPS: Quantum Information Science, Windows on the Universe, Artificial Intelligence, Spectrum Innovation Initiative, and Climate Research. As the steward for QIS, OMA will work with all MPS divisions, BIO, ENG, CISE and OISE that engage several relevant disciplines in a convergent and interdependent manner to advance quantum science and technology. Societal benefits of this science and technology are expected to be significant, as it is poised to include proof-of-concept devices, applications, tools, or systems with a demonstrable quantum advantage over their classical counterparts. MPS is also the steward for WoU, supporting AST, PHY, and GEO/OPP in activities that bring together fundamental research in electromagnetic waves, high-energy particles, and gravitational waves; advance the study of the universe; and grow the nation's multi-messenger astrophysics, engineering, and data science workforce. OMA will collaborate with all MPS divisions to support their investments in AI for sciences and the science of AI. OMA is the steward for the Spectrum Innovation Initiative that promotes transformative use and management of the electromagnetic spectrum, resulting in profound benefits for science and engineering, industry, and other national interests. OMA will foster broadening participation through the new Mathematical and Physical Sciences Ascending Postdoctoral Research Fellowship (MPS-Ascend) program and the Launching Early-Career Academic Pathways in the Mathematical and Physical Sciences (LEAPS-MPS) and continue to place high priority on the Alliances for Graduate Education and the Professoriate Graduate Research Supplement program and the MPS Graduate Research Supplements to Veterans program.

In general, about 40 percent of the OMA portfolio is available to support new research grants. The remaining 60 percent supports multidisciplinary research infrastructure and education activities needed by the MPS community.