

NATIONAL SOLAR OBSERVATORY (NSO)

\$20,500,000
+\$3,000,000 / 17.1%

National Solar Observatory Funding

(Dollars in Millions)

FY 2017	FY 2018	FY 2019	Change over	
			FY 2017 Request	Percent
Actual	(TBD)	Request	Amount	
\$17.50	-	\$20.50	\$3.00	17.1%

FY 2019 marks the final year of a five-year funding ramp that will bring the NSO budget to a level commensurate with requirements to operate the Daniel K. Inouye Solar Telescope (DKIST), the construction of which is nearing completion. (See the MREFC chapter for more information). This budget request will fund the development of the DKIST science operations and data center concepts in preparation for full DKIST operations expected to begin in late 2019-early 2020. The FY 2019 Budget Request fully funds the DKIST operations requirement and the NSO Integrated Synoptic Program (NISP).

As a Federally Funded Research and Development Center (FFRDC), NSO is headquartered on the campus of the University of Colorado, Boulder and provides leadership to the solar community through management of the construction of DKIST. When completed, DKIST will be the world most powerful solar observatory. Life on Earth is critically dependent upon the Sun. Solar phenomena such as space weather (e.g. geomagnetic storms) can significantly impact our increasingly technological society. DKIST will investigate the structure and evolution of magnetic structures on the Sun on spatial scales of tens of kilometers, the fundamental length scales of the processes that drive space weather. With DKIST poised to answer fundamental questions in solar physics by providing transformative improvements over current ground-based facilities, solar research enabled by DKIST will benefit all of humankind. NSO also operates a coordinated worldwide network of six telescopes specifically designed to study solar oscillations. NSO routinely provides detailed synoptic solar data used by individual researchers and other government agencies through the NSO Digital Library. NSO data are also made available to the user community via the Virtual Solar Observatory.

NSO telescopes are open to all astronomers regardless of institutional affiliation based on peer-reviewed observing proposals. In FY 2017, 27 unique observing programs from 18 U.S. and seven foreign institutions were carried out using NSO facilities. This is a reduction from previous years as NSO ramps down its involvement in Sacramento Peak and the McMath-Pierce Solar Telescope. Students were part of 14 percent of these programs, which included three Ph.D. thesis projects. Nearly 12 terabytes of NSO synoptic data were downloaded from the NSO Digital Library. NSO employed approximately 138 staff members in FY 2017, including 59 FTEs employed on the DKIST construction project funded via the MREFC account as mentioned above.

In 2010, the National Research Council (NRC) conducted its sixth decadal survey in astronomy and astrophysics. In their report, *New Worlds, New Horizons in Astronomy and Astrophysics*,²⁵ the NRC committee recommended that “NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities.” In response to this recommendation, the MPS Division of Astronomical Sciences (AST) conducted a community-based review of its portfolio. The resulting Portfolio Review

²⁵ www.nap.edu/catalog.php?record_id=12951

Major Multi-User Research Facilities

Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*,²⁶ was released in August 2012 and included recommendations about all of the major AST telescope facilities.

Prior to receiving the PRC report, NSF had instructed NSO to begin divestment of the facilities on Kitt Peak, including the McMath-Pierce Solar Telescope and the Vacuum Tower (no longer in use), thereby accelerating the already-planned divestment by a few years. The PRC endorsed this decision. The PRC recommended continued operation of the Dunn Solar Telescope (DST) at Sacramento Peak through 2017 and a 50 percent reduction in funding of the NSO Integrated Synoptic Program (NISP). The status of the divestment of NSO operated facilities is as follows:

- *McMath-Pierce Solar Telescope, Kitt Peak, AZ*: NSO ceased operating the McMath-Pierce Solar Telescope as a national user facility at the end of FY 2017. NSF completed a divestment options study of NSO facilities on Kitt Peak and anticipates beginning an environmental impact analysis process in FY 2018, consistent with the National Environmental Policy Act. On March 31, 2017, NSO/Association of Universities for Research in Astronomy (AURA) issued a request for proposals from parties interested in taking over operation of the McMath-Pierce Solar Telescope for scientific and educational purposes, but received no viable proposals. The path forward for the McMath-Pierce is currently under discussion.
- *Sacramento Peak Observatory, Sunspot, NM*: This facility includes the DST and associated infrastructure including office space, laboratory space, dining facilities, and housing. NSO ceased operating Sacramento Peak Observatory as a national user facility at the end of FY 2017. A proposal from New Mexico State University (NMSU) to transition operations of the facility from NSO to an NMSU-led consortium was funded in FY 2016. As discussions on the future of Sacramento Peak continue with NMSU, in parallel NSF began the preparation of an Environmental Impact Statement (EIS) in late 2016, which is examining a range of paths for Sacramento Peak Observatory. Fully compliant with the National Environmental Policy Act, the final EIS is expected in late 2018.
- *NSO Integrated Synoptic Program*: NISP consists of the Global Oscillations Network Group (GONG) and the Synoptic Optical Long-term Investigations of the Sun (SOLIS). GONG now has a component of its operations funding provided through a 5-year (FY 2016 – FY 2020) interagency agreement with the National Oceanic and Atmospheric Administration (NOAA). This NOAA funding supports the use of GONG and its data products for operational space weather forecasting. (Also see Partnerships section below). NSO is in the process of relocating the SOLIS facility to the Big Bear Solar Observatory (BBSO) on Big Bear Lake, CA. On September 29, 2017, NSO received a permit from San Bernardino County to install SOLIS on the site. Shortly thereafter, NSF’s Record of Environmental Compliance was signed on October 2, 2017 allowing the project to move forward.

Total Obligations for NSO

(Dollars in Millions)

	FY 2017	FY 2018	FY 2019	ESTIMATES ¹				
	Actual	(TBD)	Request	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
NSO Base Operations	\$5.74	-	\$3.70	\$3.82	\$3.92	\$4.04	\$4.16	\$4.29
NSO Education & Public Outreach	0.26	-	0.30	0.31	0.32	0.33	0.34	0.35
DKIST Operations ²	11.50	-	16.50	17.01	17.54	18.08	19.13	19.71
Total	\$17.50	-	\$20.50	\$21.14	\$21.78	\$22.45	\$23.63	\$24.35

¹ Outyear funding estimates are for planning purposes only. The current cooperative agreement ends September 2024.

² Excludes funding for cultural mitigation activities as agreed to during the compliance process. See the MREFC chapter for more information on DKIST.

²⁶ www.nsf.gov/mps/ast/ast_portfolio_review.jsp

Partnerships and Other Funding Sources: The managing organization for NSO is AURA, which comprises 44 U.S. member institutions and four international affiliate members. NSO partners include NOAA, NASA, industrial entities, and universities and institutes that collaborate with NSO on solar instrumentation development. NSF is currently under discussions with New Mexico State University (NMSU) regarding future operations of Sacramento Peak Observatory and New Jersey Institute of Technology (NJIT) on future operations of SOLIS at BBSO.

Due to the increasing national and international awareness of the impacts of space weather on critical infrastructure and society in general, the importance of operational space weather forecasting has become apparent to U.S. policy makers. Space weather forecasting requires both accurate models of the heliospheric environment and precise observational data inputs to those models. NSO's GONG program provides operational data products on a routine basis that are used as inputs to predictive space weather models from the U.S. Air Force and the NOAA Space Weather Prediction Center. FY 2016 support for NSO included a one-time \$2.50 million investment in GONG to increase its robustness for future space weather predictions. NSO is in the process of upgrading the GONG facility with this funding, with completion expected in FY 2018. In FY 2016, NSF and NOAA signed an interagency agreement whereby NOAA is providing approximately \$800,000 per year in funding support for GONG operations.

NSO Base Operations, \$3.70 million, \$2.04 million below the FY 2017 Actual: NSO Base Operations includes the offices at NSO's Boulder, Colorado headquarters and the world-wide NSO Integrated Synoptic Program consisting of the GONG array and the SOLIS telescope. At the end of FY 2017, NSO ceased operating the Sacramento Peak Observatory in Sunspot, New Mexico and the McMath-Pierce Solar Telescope on Kitt Peak, Arizona as national user facilities. The funding profile for NSO Base Operations has been trending downward in anticipation of these divestments.

DKIST Operations, \$16.50 million, \$5.0 million above the FY 2017 Actual: Support for DKIST operations is through the R&RA account, while DKIST construction support is through the MREFC account. (See the MREFC chapter for more information on construction.) The FY 2019 Budget Request for DKIST Operations represents the final year of a five-year funding ramp that will bring the NSO budget to a level commensurate with requirements to operate DKIST. This profile is funding the development of the DKIST science operations and data center in preparation for full DKIST operations, which is expected to begin late 2019-early 2020.

Education and Public Outreach, \$300,000, \$40,000 above the FY 2017 Actual: NSO supports U.S. education goals by promoting public understanding and support of science and by providing education and training at all levels. NSO introduces undergraduate students to scientific research by providing stimulating environments for basic astronomical research and related technologies through NSF's separately funded Research Experiences for Undergraduates program. NSO has diverse education programs, including teacher training and curriculum development, visitor centers, and a web portal at www.nso.edu.

In preparation for the total solar eclipse in August 2017, and with the imminent arrival of DKIST, NSO significantly increased its education, public outreach, and broadening participation effort by establishing an Office of Education and Outreach. In FY 2016, NSO hired a new office head and recently filled a second EPO position, based in Maui, focused on DKIST.

Management and Oversight

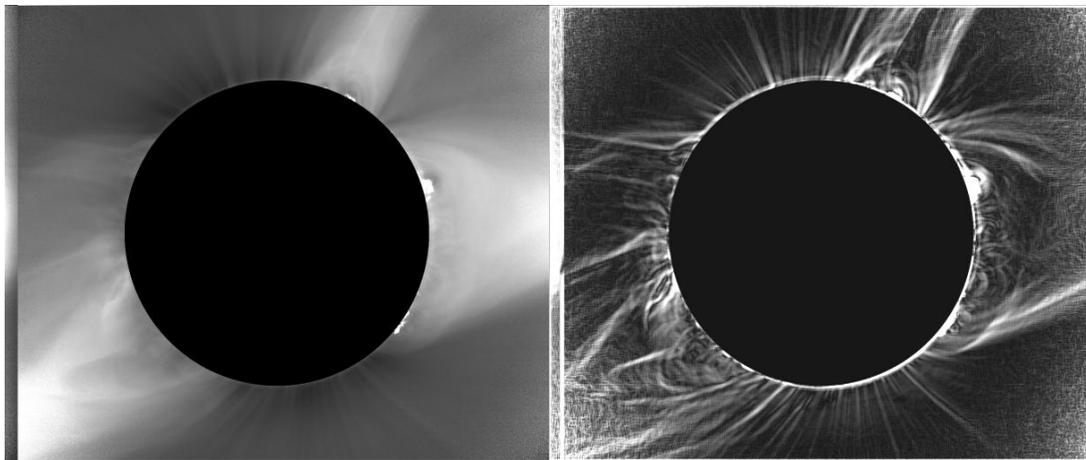
- NSF Structure: An NSF program officer in AST provides continuing oversight, including consultation with an annual NSF program review panel. The program officer makes use of detailed annual program plans, annual long-range plans, quarterly technical and financial reports, and annual reports submitted by NSO as well as attending AURA Solar Observatory Council meetings. The latter committee is formed from the national solar physics community and provides a window into community priorities

and concerns. The AST program officer works closely with other offices at NSF, particularly the Office of General Counsel, the Division of Acquisition and Cooperative Support, and the Large Facilities Office.

- **External Structure:** AURA is the managing organization for NSO. The NSO director reports to the president of AURA, who is the principal investigator on the current NSF cooperative agreement. AURA receives management advice from its Solar Observatory Council, composed of members of its scientific and management communities. NSO uses visiting and users committees for the purposes of self-evaluation and prioritization. The visiting committee, composed of nationally prominent individuals in science, management, and broadening participation, reviews for AURA all aspects of the management and operations of NSO. The users committee, composed of scientists with considerable experience with the observatory, reviews for the NSO director all aspects of NSO that affect user experiences.
- **Reviews:** In addition to reviews held mid-way through all cooperative agreements, NSF conducts periodic and ad hoc reviews by external committees. In February 2017, NSF reviewed NSO's Annual Progress Report and Program Plan. From December 2015 through March 2016, NSF conducted a Business Systems Review covering AURA and NSO. Findings and recommendations from the final NSF report were conveyed to AURA in April 2016, and AURA continues to resolve issues and implement report recommendations. NSO also participated in reviews of the DKIST project in FY 2016 including: a contingency assessment (Feb. – July 2016) and an Earned Value Management System validation review (Sept. 2016), both of which are described in the DKIST narrative in the MREFC chapter.

Renewal/Recompetition/Termination

On August 14, 2014, the National Science Board (NSB) authorized a renewed cooperative agreement with AURA for management and operation of NSO. The renewed award was put into place in June 2015 and will run through September 2024.



Two snapshot images of the 2017 Great American Eclipse for the NSO-led Citizen CATE project. Left: Original image after processing with a mathematical transform that enhances faint structures in the outer solar corona. Right: Original image after processing with a mathematical transform that enhances the edges of faint structures in the outer solar corona. *Credit: M. Penn, NSO.*