

NATIONAL SOLAR OBSERVATORY

\$19,000,000
-\$2,000,000 / -9.5%

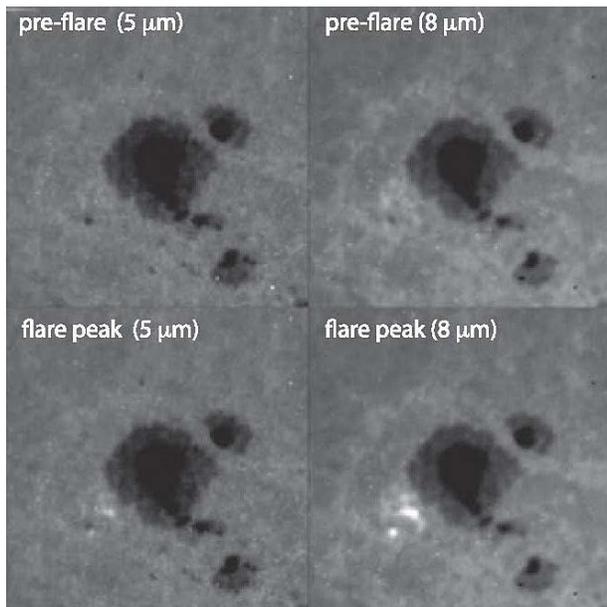
National Solar Observatory

(Dollars in Millions)

| FY 2016 Actual | FY 2017 (TBD) | FY 2018 Request | Change over FY 2016 Actual | |
|-------------------|------------------|--------------------|-------------------------------|---------|
| | | | Amount | Percent |
| \$21.00 | - | \$19.00 | -\$2.00 | -9.5% |

The FY 2018 Budget Request for the National Solar Observatory (NSO) is \$19.0 million. This is a \$2.0 million (-9.5 percent) decrease from the FY 2016 Actual. FY 2018 marks the continuation 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). This profile 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.

As a Federally Funded Research and Development Center (FFRDC), NSO currently operates facilities in New Mexico and Arizona as well as a coordinated worldwide network of six telescopes specifically designed to study solar oscillations. NSO also provides leadership to the solar community through management of the construction of DKIST. (See the Major Research Equipment and Facilities Construction (MREFC) chapter for more information.) NSO makes the world’s largest collection of optical and infrared solar telescopes and auxiliary instrumentation available to qualified scientists to observe the solar photosphere, chromosphere, and corona. NSO provides routine and 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.



The first simultaneous mid-infrared images at 5.2 μm (left) and 8.2 μm (right) of a solar flare. Image taken with the QWIP instrument on the McMath-Pierce solar telescope. Credit: M. Penn, NSO.

NSO telescopes are open to all astronomers regardless of institutional affiliation based on peer-reviewed observing proposals. In FY 2016, 32 unique observing programs from 25 U.S. and 7 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 McMath-Pierce. Students were part of 13 percent of these programs, which included three Ph.D. thesis projects. Nearly 21 terabytes of NSO synoptic data were downloaded from the NSO Digital Library. NSO employed approximately 120 staff members in FY 2016, including 65 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*,²² the NRC committee recommended that “NSF-Astronomy

²² www.nap.edu/catalog.php?record_id=12951

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 Division of Astronomical Sciences within the Directorate for Mathematical and Physical Sciences (MPS/AST) conducted a community-based review of its portfolio. The resulting Portfolio Review Committee (PRC) report, *Advancing Astronomy in the Coming Decade: Opportunities and Challenges*,²³ 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*: A university-based consortium previously expressed interest in continuing operations of the McMath-Pierce at a reduced level; however, this consortium has not materialized. NSO is in the final year of the ramp down of its participation in McMath-Pierce from \$200,000 in FY 2014 to \$0.0 by the end of FY 2017. NSF completed a divestment options study of NSO facilities on Kitt Peak and anticipates beginning the environmental impact statement (EIS) process in FY 2017. On March 31, 2017, NSO/AURA issued a request for proposals from parties interested in taking over operation of McMath-Pierce for scientific and educational purposes. Applicants submitted letters of intent by the May 1, 2017 deadline.
- *Sacramento Peak Observatory, Sunspot, NM*: This facility includes the DST and associated infrastructure including office space, laboratory space, dining facilities, and housing. Funding for full operations of Sacramento Peak ramps down to the end of FY 2017 at which time NSO will cease operating the facility. 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. NSF completed a divestment options study of NSO facilities on Sacramento Peak in Q3 of FY 2016. In compliance with the National Environmental Policy Act (NEPA), NSF began preparation of an Environmental Impact Statement (EIS) in Q4 of FY 2016. The EIS is expected to be completed in FY 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 (see Partnerships section below).

²³ www.nsf.gov/mps/ast/ast_portfolio_review.jsp

Total Obligations for NSO

(Dollars in Millions)

| | FY 2016 Actual | FY 2017 (TBD) | FY 2018 Request | ESTIMATES ¹ | | | | |
|---------------------------------|-------------------|------------------|--------------------|------------------------|----------------|----------------|----------------|----------------|
| | | | | FY 2019 | FY 2020 | FY 2021 | FY 2022 | FY 2023 |
| NSO Base Operations | \$6.75 | - | \$4.73 | \$3.70 | \$3.82 | \$3.92 | \$4.04 | \$4.16 |
| NSO Education & Public Outreach | 0.25 | - | 0.27 | 0.30 | 0.31 | 0.32 | 0.33 | 0.34 |
| DKIST Operations ² | 11.50 | - | 14.00 | 16.50 | 17.01 | 17.54 | 18.08 | 19.13 |
| GONG Refurbishment | 2.50 | - | - | - | - | - | - | - |
| Total, NSO | \$21.00 | - | \$19.00 | \$20.50 | \$21.14 | \$21.78 | \$22.45 | \$23.63 |

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

² Total R&RA account funding for DKIST consists of \$14.0 million in FY 2018 funded through NSO, plus \$2.0 million per year in FY 2011 to FY 2020 for cultural mitigation activities as agreed to during the compliance process that is not funded through NSO. See the MREFC chapter for more information on DKIST.

Partnerships and Other Funding Sources: The managing organization for NSO is the Association of Universities for Research in Astronomy, Inc. (AURA), which comprises 42 U.S. member institutions and five international affiliate members. NSO partners include NOAA, NASA, and industrial entities. Other funding entities include universities and institutes, which collaborate with NSO on solar instrumentation development and on the design and development of DKIST. Industry sub-awardees in aerospace, optical fabrication, and information technology develop new telescopes, instrumentation, and sensor techniques.

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. This was highlighted by the October 29, 2015 rollout of the National Space Weather Strategy²⁴ and the associated National Space Weather Action Plan.²⁵ 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 (SWPC). The 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. Also 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, \$4.73 million, \$2.02 million below the FY 2016 Actual: NSO Base Operations includes the offices at NSO's Boulder, CO headquarters and the world-wide NSO Integrated Synoptic Program consisting of the GONG array and the SOLIS (Synoptic Optical Long-term Investigations of the Sun) telescope. By the end of FY 2017, NSO expects to be disengaged from operations at Sacramento Peak Observatory in Sunspot, New Mexico and from the McMath-Pierce and Vacuum Tower facilities based on Kitt Peak, Arizona. The funding profile for NSO Base Operations has been ramping down in anticipation of the divestment of these redundant facilities by the end of 2017. Beginning in FY 2019, NSO Base Operations will fund NSO Directorate activities and operations of the synoptic program at a steady-state level of about \$4.0 million (\$2.0 million each) per year.

DKIST Operations, \$14.0 million, \$2.5 million above the FY 2016 Actual: Support for DKIST operations is through the Research and Related Activities account (R&RA), while DKIST construction support is through the MREFC account. (See the MREFC chapter for more information on construction.) The FY 2018 Budget Request for DKIST Operations represents the fourth 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

²⁴ www.whitehouse.gov/sites/default/files/microsites/ostp/final_nationalspaceweatherstrategy_20151028.pdf

²⁵ www.whitehouse.gov/sites/default/files/microsites/ostp/final_nationalspaceweatheractionplan_20151028.pdf

Major Multi-User Research Facilities

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, \$270,000, \$20,000 above the FY 2016 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 (REU) 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 efforts in education, public outreach, and broadening participation by establishing an Office of Education and Outreach (OEO). 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 Division of Acquisition and Cooperative Support, the Office of General Counsel, and the Large Facilities Office in the Office of Budget, Finance, and Award Management.
- **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 at the observatory.
- **Reviews:** In addition to reviews held mid-way through all cooperative agreements, NSF conducts periodic and ad hoc reviews, as needed, by external committees. In February 2017, NSF held a review of NSO's Annual Progress Report and Program Plan (APRPP). From December 2015 through March 2016, NSF conducted a Business Systems Review (BSR) covering AURA and NSO. Findings and recommendations from the final NSF report were conveyed to AURA on April 1, 2016, and AURA continues to resolve issues and implement recommendations from the report. 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/Competition/Termination

On August 14, 2014, the National Science Board (NSB) authorized a renewed cooperative agreement with AURA for management and operation of NSO for a period of 10 years from October 1, 2014 through September 30, 2024. Because of additional time required to implement the new agreement, the previous cooperative agreement was extended through May 31, 2015. The renewed cooperative agreement between NSF and AURA was put into place June 1, 2015.