NATIONAL SOLAR OBSERVATORY (NSO) **$21,790,000**
+$3,400,000 / 18.5%

National Solar Observatory Funding[1]
(Dollars in Millions)

FY 2019 Actual[2]	FY 2020 (TBD)	FY 2021 Request	Change over FY 2019 Request Amount	Percent
$16.39	-	$21.79	$3.40	18.5%

[1] This table aggregates funding for NSO and DKIST base operations.

[2] Includes $3.50 million in additional FY 2019 one-time funding.

FY 2021 reflects the level of the National Solar Observatory budget commensurate with requirements to operate the Daniel K. Inouye Solar Telescope (DKIST), the construction of which is scheduled to be completed in June 2020. The FY 2021 Budget Request funds both the DKIST operations requirement (science operations and data center) and the NSO Integrated Synoptic Program (NISP).

As a Federally Funded Research and Development Center, NSO is headquartered on the campus of the University of Colorado, Boulder and provides leadership to the solar astronomy community through management of the construction of DKIST as well as its subsequent operation once completed as planned in FY 2020. When completed, DKIST will be the world's most powerful solar observatory, poised to answer fundamental questions in solar physics by providing transformative improvements over current ground-based facilities. DKIST will enable the study of magnetic phenomena in the solar photosphere, chromosphere, and corona. Determining the role of magnetic fields in the outer regions of the Sun is crucial to understanding the solar dynamo, solar variability, and solar activity including flares and coronal mass ejections. Solar activity can affect civil life on Earth through phenomena generally described as space weather and may impact the terrestrial climate. The relevance of DKIST's science drivers was reaffirmed by the National Academy of Sciences 2010 Astronomy and Astrophysics Decadal Survey: *New Worlds, New Horizons*[1] as well as the 2012 Solar and Space Physics Decadal Survey: *A Science for a Technological Society*.[2] In FY 2020, DKIST achieved first sunlight through the entire optical system, with data collected by the first of its instruments installed, the Visible Broadband Imager (VBI).

NSO also operates the NISP program, which consists of the Global Oscillations Network Group (GONG) and the Synoptic Optical Long-term Investigations of the Sun (SOLIS). GONG is a coordinated worldwide network of six telescopes specifically designed to study solar oscillations and, more recently, to provide critical data products for the prediction of space weather. NSO routinely provides detailed synoptic solar data from the NISP program 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.

In 2012, the MPS Division of Astronomical Sciences (AST) conducted a community-based review of its portfolio. Prior to receiving the Portfolio Review Committee (PRC) report,[3] 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 50.0 percent reduction in funding of NISP. The status of the

[1] www.nap.edu/catalog.php?record_id=12951
[2] www.nap.edu/search/?term=13060&x=0&y=0
[3] www.nsf.gov/mps/ast/ast_portfolio_review.jsp

transition 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. In late FY 2018, following a divestment options study and environmental impact analysis, NSF made a five-year award to the Kitt Peak National Observatory Visitor Center, part of NSF's National Optical-infrared Astronomy Research Laboratory, to repurpose the McMath-Pierce facility as an astronomy outreach and education center. This Windows on the Universe Center for Astronomy Outreach will highlight all of NSF's research facilities related to astronomy and astrophysics.
- *Sacramento Peak Observatory, Sunspot, NM*: This facility includes the DST and associated infrastructure. NSO ceased operating Sacramento Peak Observatory as a national user facility at the end of FY 2017. In FY 2019, following thorough programmatic and environmental evaluations of transition options, NSF decided to pursue a potential transition to limited operation of Sacramento Peak by a consortium led by New Mexico State University, which was memorialized in a Record of Decision published in February 2019.
- *NSO Integrated Synoptic Program (GONG and SOLIS)*: GONG now has a component of its operations funding provided through a five-year (August 2016 – August 2021) 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 through August 2021. (Also see Partnerships section below). NSO is in the process of relocating the SOLIS facility from Tucson to the Big Bear Solar Observatory (BBSO) on Big Bear Lake, CA.

Total Obligations for NSO

(Dollars in Millions)

	FY 2019[1] Actual	FY 2020 (TBD)	FY 2021 Request	ESTIMATES[2] FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
NSO Operations & Maintenance	$4.39	-	$4.25	$4.38	$4.52	$4.65	$4.65	$4.65
DKIST Operations	8.50	-	17.54	18.08	18.62	19.13	19.13	19.13
Facility Upgrades	3.50	-	-	-	-	-	-	-
Total	**$16.39**	**-**	**$21.79**	**$22.46**	**$23.14**	**$23.78**	**$23.78**	**$23.78**

[1] Facility Upgrades include $3.50 million in one-time funding for development of DKIST level 2 (advanced) data products. DKIST Operations excludes $2.0 million provided to another awardee for cultural mitigation activities as agreed to during the compliance process and $8.0 million of FY 2019 O&M costs obligated in FY 2018.

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

Facility Upgrades

In FY 2019, NSF awarded $3.50 million (second year of a two-year award) for development of DKIST level 2 (advanced) data products, making DKIST data more accessible to and usable by the solar research community.

Partnerships and Other Funding Sources

The managing organization for NSO is the Association of Universities for Research in Astronomy, Inc. (AURA), which comprises 47 U.S. member institutions and three international affiliate members. NSO partners include NOAA, the National Aeronautics and Space Administration, industrial entities, and universities and institutes that collaborate with NSO on solar instrumentation development. New Mexico State University operates the DST at Sunspot Solar Observatory through a consortium of universities while NSO continues to maintain the site infrastructure. NSO has partnered with BBSO to operate the SOLIS facility in Big Bear, CO.

The Administration's National Space Weather Strategy and Action Plan (March 2019)[4] highlighted the importance of the impacts of space weather on critical infrastructure and society in general, and the importance of operational space weather forecasting. 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. NSO is continuing the process of upgrading the GONG facility with $2.50 million of funding provided in FY 2016, with the upgrade now expected to be completed in FY 2020. NSF and NOAA are currently in the fourth year of a five-year interagency agreement whereby NOAA provides approximately $800,000 per year in funding support for GONG operations.

NSO Operations ($4.25 million)
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. NSO also supports U.S. education goals by promoting public understanding and support of science and by providing education and training at all levels.

DKIST Operations ($17.54 million)
Support for DKIST operations is through the R&RA account, while DKIST construction support was through the MREFC account. FY 2019 was the final year of construction funding for DKIST and the facility is expected to become fully operational in FY 2020.

Management and Oversight

- NSF Structure: NSF oversight is handled by a program officer in AST working cooperatively with staff from MPS, the Office of the General Counsel, and the Office of Legislative and Public Affairs. Within BFA, the Large Facilities Office provides advice to program staff and assists with agency oversight and assurance. Representatives from some of the above NSF offices comprise the NSO Integrated Program Team, which meets on a semi-annual basis to discuss outstanding program issues. The MPS Facilities team and the NSF Chief Officer for Research Facilities also provide high-level guidance and oversight.
- 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 utilizes a users committee for the purposes of self-evaluation and prioritization. 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. The NSF program officer for NSO has frequent (at least weekly) discussions and interactions with NSO management, especially the NSO Director. In addition to NSF reviews of the project, the program officer attends the semi-annual meetings of the Solar Observatory Council and the periodic Users Committee meetings (see below) as an *ex officio* observer. The program officer conducts periodic site visits to NSO facilities and attends community science meetings in order to keep abreast of the latest happenings in the solar community

Reviews
- NSF conducts regular reviews of NSO's Annual Progress Report and Program Plan (APRPP). The most recent APRPP review was in March 2019.
- In July 2019 a comprehensive midterm review of NSO's long-range plan for the second five years of the cooperative agreement was conducted.
- NSO also participates in reviews of the DKIST project. Recent reviews include: a DKIST Project

[4] www.whitehouse.gov/wp-content/uploads/2019/03/National-Space-Weather-Strategy-and-Action-Plan-2019.pdf

Execution Plan and Construction Status review (April 2019), an Earned Value Management system surveillance (April 2019), and an incurred cost audit for the American Reinvestment and Recovery Act award for DKIST construction (August 2018–June 2019).

Renewal/Recompetition/Termination

In August 2014, NSB authorized a renewed cooperative agreement with AURA for management and operation of NSO. The renewal award started in June 2015 and will run through September 2024. In order to prepare for a potential two-year re-competition process, in mid-2022, NSF will evaluate the current status of NSO operations and the performance of the managing organization, AURA. The goal will be to determine whether to begin a re-competition of the award for management and operations of the NSO in accordance with NSF policy