



NSF Report to AAAC



Ralph Gaume
Division Director, MPS/AST
September 27, 2019





Talk Outline

- AST Mission & Implementation
- AST Personnel
- AST Science Highlights
- Response to AAAC 2018/2019 report (prepared by Richard Green)
- AST Program Funding
- AST Facilities
- Astro 2020



AST Mission

- The National Science Foundation's Division of Astronomical Sciences has a mission of enabling excellence in US ground-based astronomy.
- The Division invests in three approaches:
 - Supporting the programs of individual investigators,
 - Providing access to world-class research facilities and datasets, and
 - Enabling the development of new instrumentation and next-generation facilities, all through competitive merit review.
- Other aspects distinguish the mission:
 - Encouraging broad understanding of the astronomical sciences by a diverse population of scientists, policy makers, educators, and the public at large
 - Supporting career development for students and early-career professionals as an explicit priority.
 - Engaging in numerous interagency and international collaborations.
- The formal mission statement is at <https://www.nsf.gov/mps/ast/about.jsp>



AST Implementation

- High-demand Individual Investigator programs.
- Suite of forefront ground-based Optical/IR (OIR), Radio-Millimeter-Submillimeter (RMS), and Solar observing facilities plus data holdings supported by AST for merit-based access.
- Construction through the MREFC line of two major new facilities, DKIST and LSST.
- Reorganization of management of NSF OIR facilities to optimize time-domain science.
- Transition of facilities that were given lower priority by external review process to accommodate operations of new facilities and maintain programmatic balance.
- Sponsoring National Academies decadal survey to set future priorities for scientific direction and facilities development.



AST Personnel



Division of Astronomical Sciences (AST)



Office of the Division Director



Ralph Gaume
Division Director

James Neff
Deputy Division Director (Acting)

Craig McClure
Program Support Manager

Donna O'Malley
Financial & Operations Specialist

Elizabeth Pentecost
Project Administrator

Administration



Matthew Viau
Program Analyst

Allison Farrow
Program Analyst

Renee Adonteng
Program Assistant

Individual Investigator Programs (IIP)



James Neff
Program Director
IIP Coordinator

Richard Barvainis
Program Director
Extragalactic Astronomy & Cosmology (EXC)

Glen Langston
Program Director
Galactic Astronomy

Harshal Gupta
Program Director
Astronomy & Astrophysics Postdoctoral Fellowships

Linda French
Program Director
CAREER; Planetary Astronomy; ESP

Nigel Sharp
Program Director
AAG; CDS&E; cross-NSF programs

Hans Krimm
Program Director
Stellar Astronomy & Astrophysics

Peter Kurczynski
Program Director
Advanced Technologies & Instrumentation; EXC; MRI

Matthew Benacquista
Program Director
REU; EXC; ESP

Kenneth Johnston
Expert
CAREER; AAG

Facilities, Mid-Scale, & MREFC Projects



Christopher Davis
Program Director
Gemini Observatory

Joe Pesce
Program Director
National Radio Astronomy Obs.; ALMA

David Boboltz
Program Director
National Solar Observatory; DKIST

Edward Ajhar
Program Director
Large Synoptic Survey Telescope

Ashley Zauderer
Program Director
Arecibo Observatory

Richard Barvainis
Program Director
Mid-Scale Innovations Program (MSIP)

Luke Sollitt
Program Director
Planetary Astronomy

Harshal Gupta
Program Director
Green Bank Observatory

ESM



Jonathan Williams
Program Director

Ashley Zauderer
Program Director



Science Highlights

EHT Wins 2020 Breakthrough Prize for Fundamental Physics

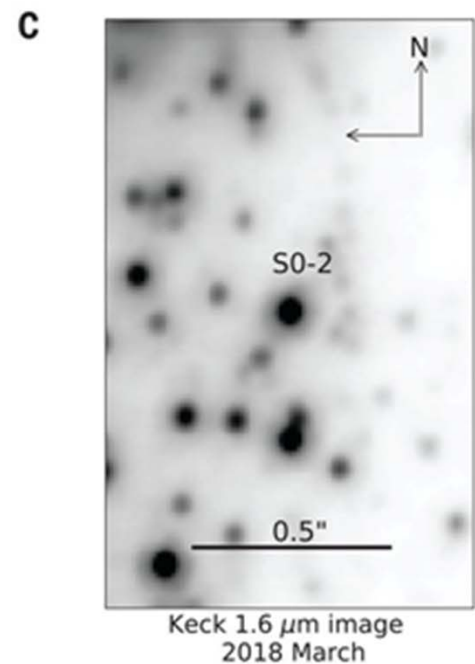
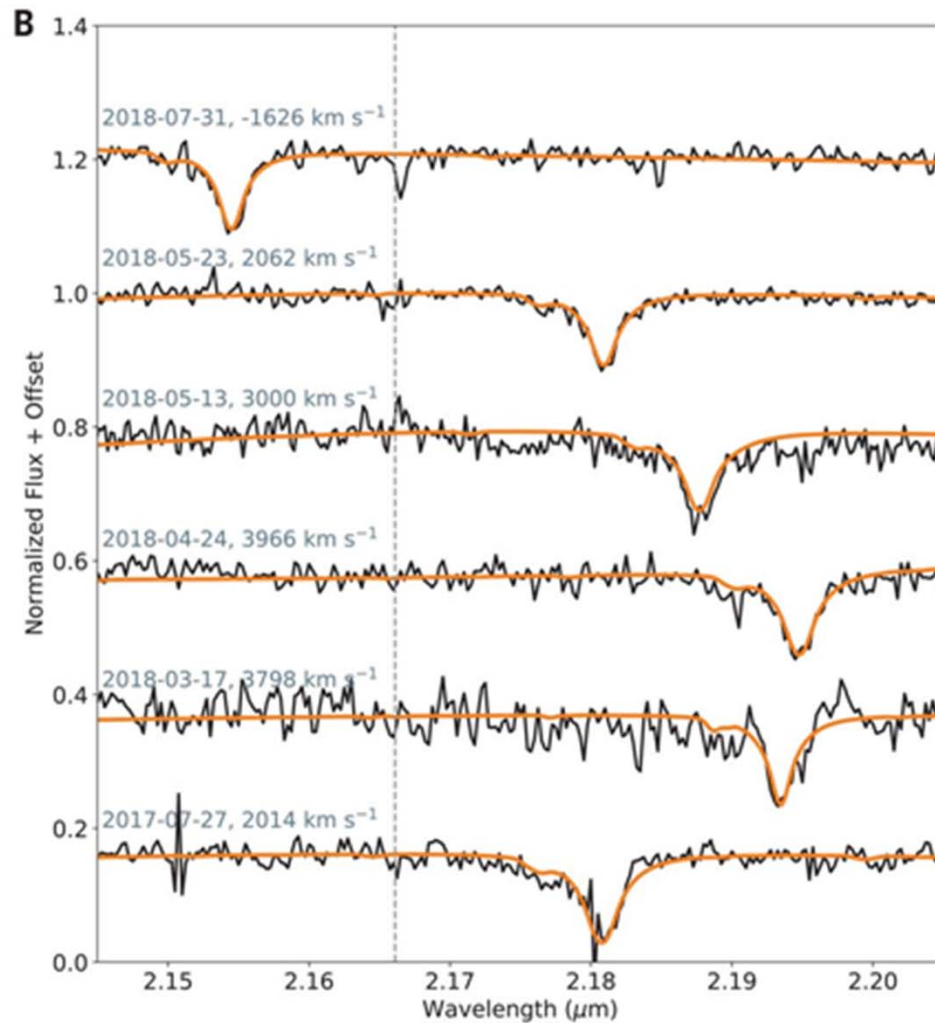
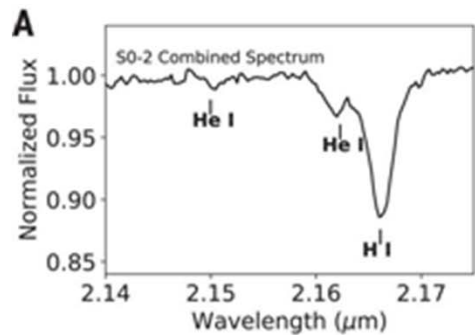


Extreme Redshift changes for Star orbiting Milky Way Galactic Center

An international team of astronomers co-led by UCLA professor [Andrea Ghez](#) published the [results of the study](#) in *Science*, August 2019.

[Tuan Do](#), [Aurelien Hees](#), [Andrea Ghez](#), [Gregory D. Martinez](#), [Devin S. Chu](#), [Siyao Jia](#), [Shoko Sakai](#), [Jessica R. Lu](#), [Abhimat K. Gautam](#), [Kelly Kosmo O'Neil](#), [Eric E. Becklin](#), [Mark R. Morris](#), [Keith Matthews](#), [Shogo Nishiyama](#), [Randy Campbell](#), [Samantha Chappell](#), [Zhuo Chen](#), [Anna Ciurlo](#), [Arezu Dehghanfar](#), [Eulalia Gallego-Cano](#), [Wolfgang E. Kerzendorf](#), [James E. Lyke](#), [Smadar Naoz](#), [Hiromi Saida](#), [Rainer Schöde](#), [Masaaki Takahashi](#), [Yohsuke Takamori](#), [Gunther Witzel](#), [Peter Wizinowich](#)

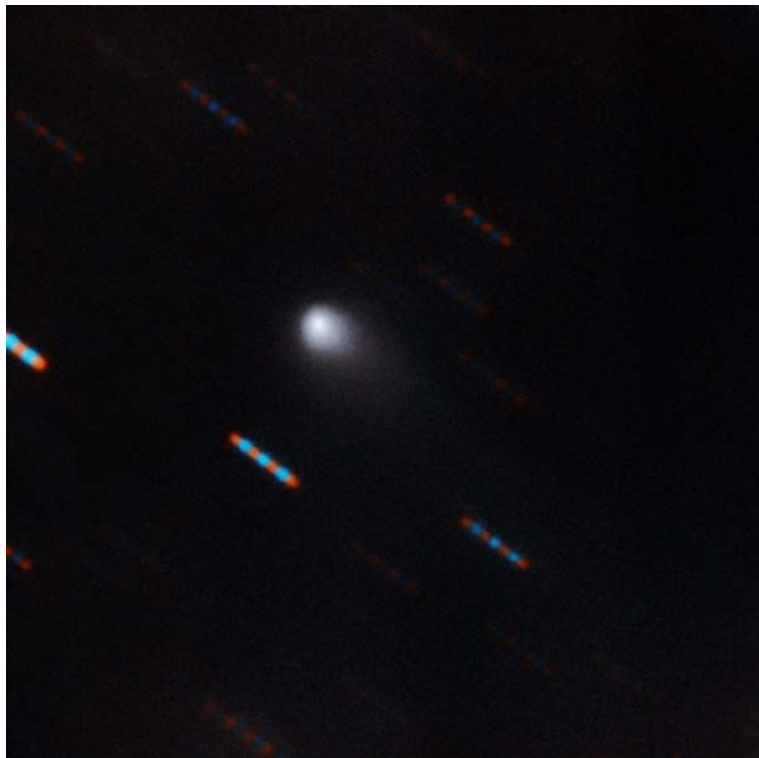
Figure Credit: [Nicolle R. Fuller/NSF](#)



Two-decade study tracked light traveling from the center of the Milky Way, confirms Einstein's predictions.

(A) Weighted-average spectrum of S0-2 from data obtained during 2006–2018 at the Keck Observatory. The strongest feature, which provides most of the RV constraint, is from the H i line at $2.1661 \mu\text{m}$. (B) Sequence of S0-2 spectra observed in 2017 and 2018 (black lines). The RV of the star changes by more than 6000 km s^{-1} throughout 2018. The dashed line shows the rest wavelength of the H i line.

Gemini Observations of C/2019 Q4 and AEPN





AST Response to AAAC 2018/2019 Recomms.



Data Science and Curation - 1

- The following three recommendations have sufficiently broad implications that they are being considered by two internal policy groups: the **NSF-wide Cyberinfrastructure Working Group** led by the Office of Advanced Cyberinfrastructure and the **MPS Directorate Cyberinfrastructure Working Group**. Initial responses will give context from AST, but subsequent reports to the AAAC will include conclusions from these more extensive deliberations on issues such as open source code and protocols for linking pipeline software to data releases.



Data Science and Curation - 2

- **Recommendation:** All current and planned surveys supported by NSF, NASA and DOE/Cosmic Frontier should publicly release their data with suitable access tools and documentation. This is consistent with the AAAC Principles of Access recommended by the AAAC in their 2013-2014 annual report. In addition, the surveys should endeavor to use open source code to create the data products in order that the community can learn how those data products were created. We are aware that support for continued use of the source code is a much larger endeavor, and the additional benefit of such support is not clear at this time. Agencies should include in survey budgets funding to enable adequate public access to the data, software, and data products of these surveys.
- **Response:** The DKIST and LSST projects are expending considerable effort to produce user-accessible databases. With FY2018 funds, AST provided a supplement to NSO for community-developed data access tools for DKIST spectropolarimetry. The recently revised data model for LSST will allow more partner resources to be devoted to data access tools. AST has provided continuing support to assure that the Dark Energy Survey data are accessible. NRAO will be supporting access to the Very Large Array All-Sky Survey and the NOAO Datalab is hosting a considerable collection of ground-based surveys, including the SDSS.



Data Science and Curation - 3

- **Recommendation:** The three agencies should coordinate on the guidelines and expectations for the public releases of data sets, data products, data access tools, and related software used to produce future surveys, astrophysical simulations, and missions. The goal of this coordination should be to help researchers efficiently provide access to the data they produce through tools useful for the broad scientific community with minimal duplication of effort between agencies and stakeholder groups. Release and documentation of the software used to generate and analyze the data will enhance the quality of current and future science by enabling more cost effective reproducibility and extension of the scientific results from the initial studies.
- **Response:** We note that the protocols for data structures and middleware developed and employed by the Virtual Astronomical Observatory are in broad use by the Agencies for astronomical data; LSST is a prime example. We therefore interpret this recommendation to apply largely to the uniformity of user tools independent of data source and the linking of pipeline or simulation codes as documentation.



Data Science and Curation - 4

- **Recommendation:** The AAAC recommends that NSF develop a policy to support the archiving and distribution of data sets generated by large and mid-scale observatories beyond the lifetime of the individual experiments. Ideally, this policy would include interoperability with existing archives. This policy will principally apply to the data products from public surveys and will require the periodic evaluation of the value of extant data sets, to ensure that resources are efficiently allocated.
- **Response:** With growing emphasis on time domain, this recommendation has particular relevance. NSF will need to provide a careful examination of long-term curation/migration costs for a data holding like the LSST archive and to give creative thought to any long-term charge in the context of Federal regulation defining a Federally Funded Research and Development Center as a having a 5-year lifetime, renewable on successful review of mission.



LSST and Tri-Agency Working Group - 1

- **Recommendation:** The AAAC urges NSF and DOE to put in place a long-term operations plan that will, while maintaining a balanced overall portfolio, ensure that the US science community can capitalize on the substantial investment in LSST.
- **Response:** While NSF cannot discuss the specifics of any proposal under review, we can make some general comments regarding the agency's goals regarding LSST operations. We agree with the AAAC recommendation and note that it is consistent with NSF's and DOE's planning and actions taken to date. Recent actions taken by the agencies in planning for LSST operations are intended to stabilize operations funding throughout the project, to leverage federal investment in LSST, and to expand resources available to the US astronomical community that will increase the scientific productivity of LSST. These recent actions will position the US scientific community to capitalize on NSF's investment not only in LSST but also in its other flagship facilities, such as ALMA and LIGO.

A key aspect in maintaining portfolio balance will be NSF's response to the NSB report on facilities operations and maintenance support. The Office of the Director is actively exploring options for implementation; when a decision is made, it will be shared with the AAAC, along with notional budget run-outs to illustrate AST's efforts in maintaining a balanced portfolio.



LSST and Tri-Agency Working Group - 2

- **Recommendation:** We continue to recommend that the three agencies either broaden the current discussions or create parallel discussions to consider broadly the costs and benefits of coordination on the science areas of interest to both the Euclid and LSST communities. We recognize that if a decision is made to plan for coordination between LSST and Euclid during construction of LSST and to execute such a plan during LSST operations, the budgets for both the construction and operation of LSST would likely need an augmentation.
- **Response:** The Tri-Agency Working Group is prepared to receive the results of the NASA-funded study on the scientific gains from joint pixel-level processing of LSST, Euclid, and WFIRST data. NSF/AST holds the opinion that this processing mode not be considered an incremental change of scope for LSST, but be proposed and supported as an independent project, should the scientific justification be sufficiently strong. A Decadal Survey recommendation in this area would guide Agency funding choices.



Spectrum Management - 1

- **Recommendation:** Given their common interests in access to the spectrum, NASA and NSF should enhance their collaboration with each other and with other groups, including international agencies and commercial interests, to protect the accessibility of essential astronomical wavelengths to researchers.
- **Response:** NSF fully agrees with the assessment that enhanced collaboration between science agencies, as well as collaboration with other public, private, and international entities, is vital to maintaining crucial access to the radio spectrum for scientific purposes, and is actively pursuing such collaboration. Ongoing collaborative activities include the co-funding of the Committee on Radio Frequencies, discussion of ongoing frequency deconfliction, and international work at the ITU international and regional meetings. Moving forward, NSF Program Officers in the Electromagnetic Spectrum Management Unit will have monthly meetings with NASA to find ways of enhancing this collaboration, exploring workshops and joint efforts. Collaboration with commercial interests has a natural avenue via required formal Coordination Agreements. NSF will continue to work to raise awareness among commercial interests of the specialized needs of science, forging new partnerships to work together towards the protection of the spectrum for science.

Spectrum Management - 2



- **Recommendation:** Efforts, ideally coordinated with all three agencies, should be made to increase awareness of spectrum management issues among astronomers, the general public, and government agencies. Possible agents for meeting this recommendation might include the NSF-funded national facilities for operations at radio and optical wavelengths. Efforts to engage and coordinate with other international agencies should continue.
- **Response:** Increasing awareness of spectrum management issues is a very critical recommendation. NSF has begun this effort, speaking, for example at the “Radio/Millimeter Astrophysical Frontiers in the Next Decade” conference in June of 2019. NSF has also advocated that spectrum needs be considered as part of the Decadal survey, a technical requirement which will raise awareness among the community. NSF will work to continue and enhance the effort to increase awareness of spectrum management issues among astronomers. To raise awareness among government agencies, NSF has been accepting every speaking opportunity, for example presenting at the annual DOE Spectrum Interagency Collaboration Meeting and regularly attending meetings of NTIA, where issues of concern to the scientific community are raised. NSF will continue and look to enhance these efforts. Little has been done to increase awareness among the general public. Opportunities abound in collaboration with the science agencies, other federal agencies, and commercial interests, and NSF will work to develop a plan to increase this communication to the general public. NSF will continue its efforts to engage with international agencies. In the coming year, NSF plans to help co-organize a Science Workshop at the CITEL regional meeting to highlight the importance of science in all of the Americas. Effective international collaboration requires a sustained ongoing effort. In this regard, NSF has committed funds specifically for international travel for the Electromagnetic Spectrum Management Unit and the Program Officers will continue their efforts to maintain and increase engagement and coordination with international agencies.



AST Program, Mid-Scale - 1

- **Recommendation:** NSF/AST should continue to grow and develop the MSIP program in the context of a balanced portfolio. Care should [be] taken to evaluate the progress and management of these programs after the award and to ensure that the promises for community access to the facilities and data are realized. NSF/AST should review the impact of community access to MSIP funded programs periodically throughout the life of the award.
- **Recommendation:** NSF/AST agrees that the value of and demand for the kinds of projects funded through MSIP justify continued growth of that funding opportunity. Rich Barvainis, the MSIP Program Officer, provides active oversight of awarded projects, with detailed annual progress reporting and site visits. Not all MSIP projects offer public access to facilities and data, but review panels do value that offer in their considerations, and AST oversight is exerted to assure that such promises are kept. The recommendation of tracking the impact of community access for the duration promised is worthwhile.



AST Program, Mid-Scale - 2

- **Recommendation:** NSF/AST should ensure that the astronomical community is aware of the MSRI opportunities and in particular the range of infrastructure projects that can be supported by this program.
- **Response:** NSF/AST will be sure to highlight those MSRI opportunities in expanded communications to the community, particularly when the deadlines for those solicitations are approaching.



AST Program, Mid-Scale - 3

- **Recommendation:** The AAAC recommend[ation]s that the NSF facility divestment process be completed and that the agencies work to ensure that individual investigators are funded, in order to capitalize on and leverage the full capabilities of the new facilities and large projects that represent such important and substantial investments by the agencies.
- **Response:** With the signing of the Record of Decision for the Environmental Impact Study and the granting of the 5-year renewal of the operations award to AUI for the Green Bank Observatory, the process of divestment/transition of facilities has been completed. The total annual savings is estimated to be ~\$35.5M, including non-facilities programs. The FY 2019 execution plan has ~61% for facilities operations and maintenance (O&M), with the rest toward various investigator-led programs, including MSIP. The balance in future years will depend in part on how NSF responds to the NSB report on facilities O&M costs for next-generation facilities.

AST Program, Mid-Scale - 4



- **Recommendation:** Efforts by AURA, and NCOA to implement the recommendations of the OIR System Report should be supported by NSF as long as they can be accommodated while maintaining a balanced investment across the portfolio of NSF/AST.
- **Response:** The OIR System (Elmegreen) Report presented a number of worthwhile system development recommendations. Many of them were oriented toward efficient integration of observing assets into a system for time-domain observation, discussed below in the context of the GBS subcommittee recommendation. NOAO->NCOA has traditionally catalyzed community planning, most recently for white paper submission to the Decadal Survey. Response to their recommendations for new observing capabilities, such as Southern Hemisphere multi-object spectroscopy or investment in US-supported ELTs will await the findings of the Decadal Survey. NSF/AST accepts the recommendation for continuing healthy investment in technology development, particularly appropriate to ATI. Approaches such as a market-oriented telescope time exchange would require an expansion of scope for NCOA along with adequate additional resources. To the extent that Division budgets allow, and appropriate consideration is given to programmatic balance, NSF/AST will encourage NCOA management to include those system recommendations in its planning. Workshops and other training vehicles for the next generation of expertise in instrumentation and software are typically supported in response to community demand; NSF/AST can publicize that such demand can receive a positive response.

AST Program, Mid-Scale - 5



- **Recommendation:** [T]he NSF should work towards implementing the recommendations of the GBS subcommittee, particularly those that affect the impact of the GBS system over the next ~5 years, before the Decadal Survey recommendations take precedence.
- **Response:** A major thrust of the Gemini-Blanco-SOAR subcommittee recommendations was efficient coordination for time domain observations aiming toward LSST follow-up. That was the primary scientific rationale for consolidating nighttime OIR operations of the NSF-supported observatories into NCOA. Examples include the current NOAO Datalab development of event brokers and LSST data analysis tools. The major supplement to Gemini in 2018/2019 included development of observatory control protocols to accommodate automated target of opportunity scheduling and event-driven observations. The integration of those previously separate software and controls development groups and their projects is a major focus in the upcoming year. Significant upgrade of the Gemini N adaptive optics system has also been supported, and the low-dispersion, high-efficiency, broad wavelength coverage spectrograph is under development for Gemini time-domain follow-up. The key aspect of their recommendation is the continuing utility of the Gemini and Blanco telescopes to the scientific priorities of the US community, which will be taken explicitly into account when negotiating the renewals for the international agreements.



AST Program Funding

AST Division Programs



Individual Investigators

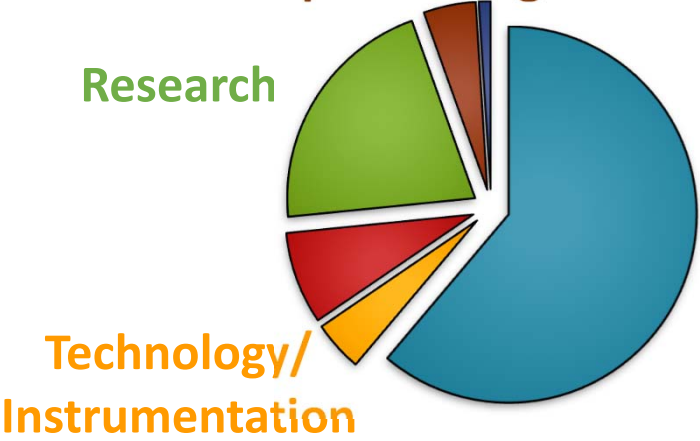
- AAG
- * CAREER
- AAPF
- ATI
- * MRI
- * REU

* NSF Wide

Mid-scale

MSIP

Education and Special Programs



Facilities

- ALMA
- NRAO
- Gemini
- NOAO
- LSST
- Arecibo
- NSO
- GBO

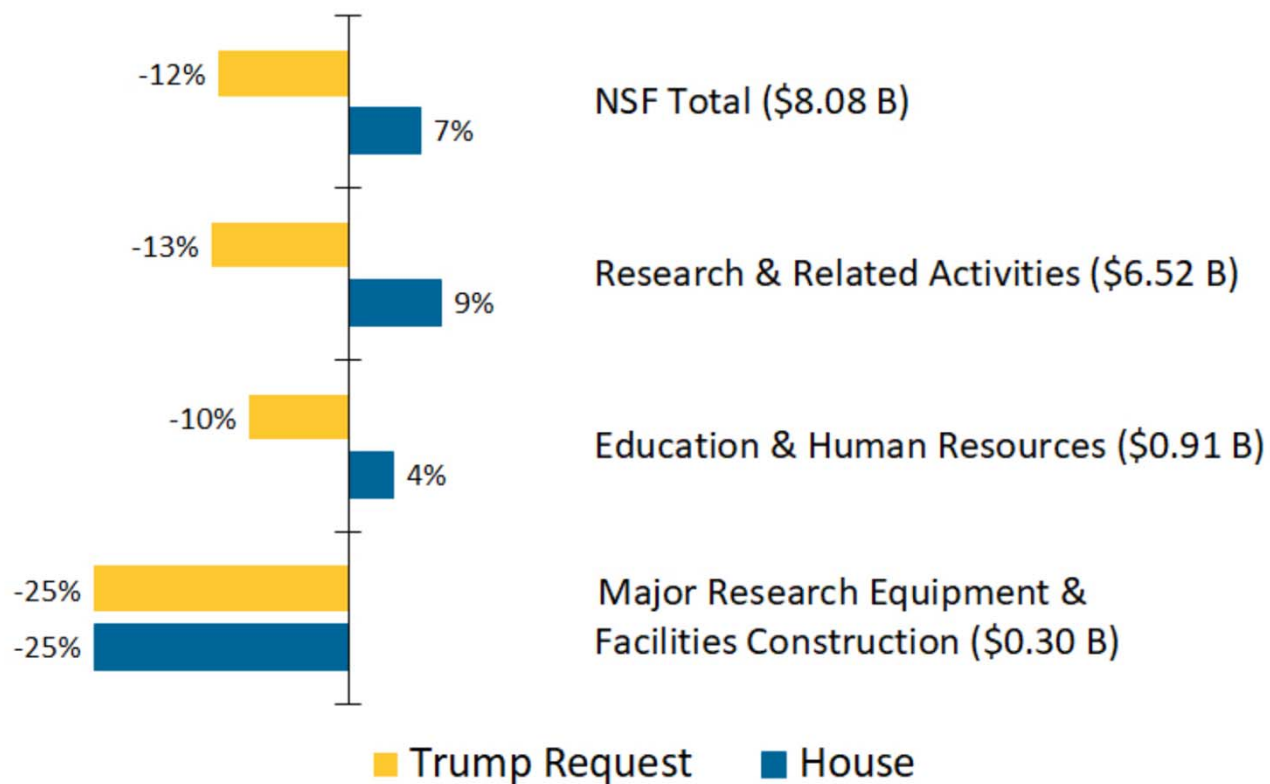
AST Budget: FY 2018/2019/2020



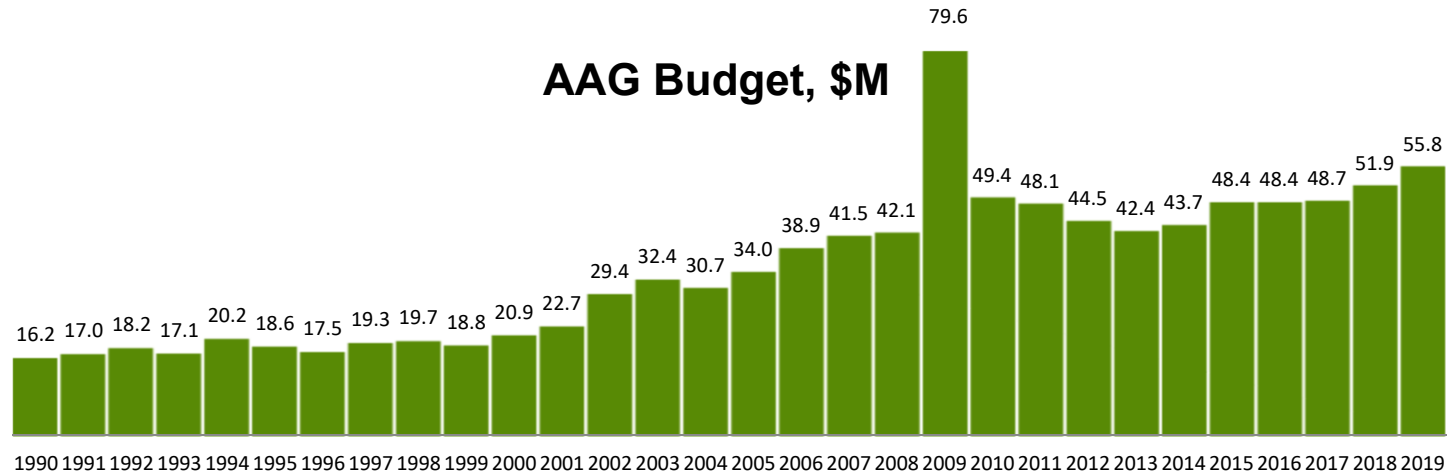
\$M	FY2018 (execution)	FY2019 (prelim. execution)	FY2020 Pres. Budget Request
AST Total (include MREFC)	384.66	389.13	259.27
Facilities (ops, hurricane repairs, infrastructure improve., fwd fund, decadal)	200.06	202.42	162.54
AAG+ATI (including WOU-MMA for FY 2019)	52.05	73.36	30.29
Education/CAREER	10.55	10.6	9.7
MSIP and MSRI-1	33.0	25.8	5.0
Other (mostly grants)	11.2	12.0	5.4
MREFC	77.8	64.95	46.34

FY20 Budget Proposal: NSF

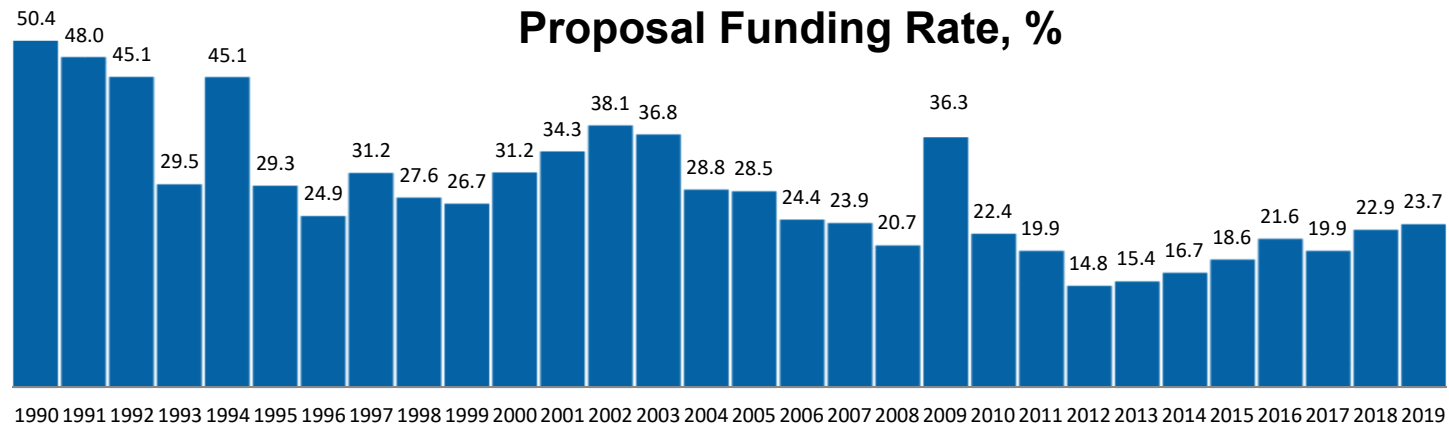
\$ in () are the FY19 amounts



AAG Budget, \$M



Proposal Funding Rate, %





Facilities

Forefront Facilities



- Radio-Millimeter-Submillimeter
 - Atacama Large Millimeter-Submillimeter Array
 - Jansky Very Large Array
 - Very Long Baseline Array
 - Green Bank Observatory
 - Arecibo Observatory
- Optical/Infrared
 - Gemini 8-m North and South (+Subaru exchange)
 - Blanco 4-m
 - SOAR 4.2-m
 - WIYN 3.5-m
 - Community access to SMARTS, LBT, CHARA, LCO, AAT
- Solar
 - GONG, SOLIS, DKIST



Facility Challenges

- Major 35-day FY 2019 shutdown presented a challenge for NSF in maintaining flow of funds to facilities awardees.
 - Ultimately, none of the AST facilities had to curtail operations.
- As a lesson learned, NSF will maintain 3 months funding in each facility “account” to mitigate against an extended interruption in funding.
 - Carryover funds count toward 3 months.
 - AST received \$16.5M in FY 2019 agency funding to address forward funding for facilities with less than 3 months carryover.

AST Facility Transition Summary



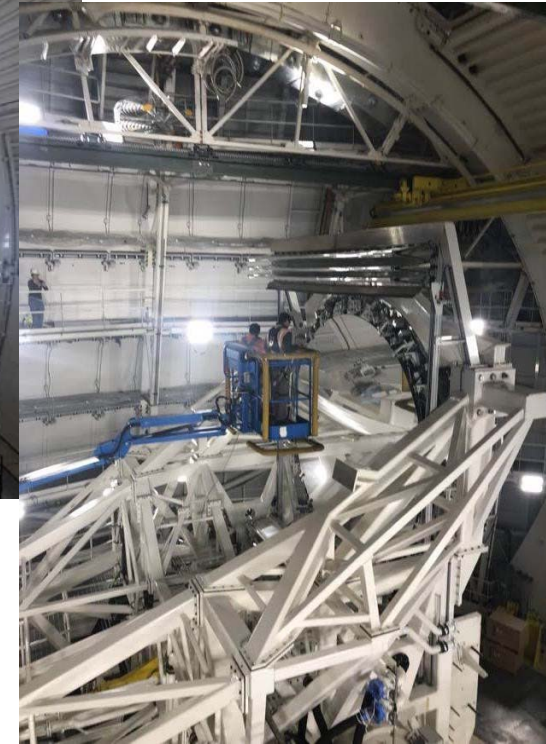
Telescope	Status
KPNO 2.1m	Caltech-led consortium operating for FY 2016-2020.
Mayall 4m	DESI; NSF to DOE; NSF/DOE MOA for operations .
WIYN 3.5m	NOAO share to NASA-NSF Exoplanet Observational Research Program; NSF/NASA MOU in place; NASA instrument under development.
GBO	Separation from NRAO in FY 2017; New CA Sept 2019, Collaborations in place for operations; MOA for new partner; more new partners desired.
LBO/VLBA	Reintegrated into NRAO; MOA with US Naval Observ. in place for 50%.
McMath-Pierce	Funding for utilization as science outreach center.
GONG/SOLIS	GONG refurbishment; Interagency Agreement with NOAA signed to share GONG operations costs. SOLIS moved from Kitt Peak to Big Bear.
Sacramento Pk.	Initial NSF and State funding for consortium led by NMSU; NSO to provide continuing site support; NSB approval for ROD.
Arecibo	UCF new operator, plans to increase funding share from UCF partners; hurricane recovery funding awarded; staffing challenges.
SOAR	AAAC subcommittee (GBS)recommended continuing renewal



NSF's National Center for Optical-Infrared Astronomy (NCOA) integrates the NSF-funded entities -- National Optical Astronomy Observatory (NOAO), Gemini Observatory, and Large Synoptic Survey Telescope (LSST) operations -- under a single organizational framework, managed by one management organization as an FFRDC.

- NCOA inauguration/kick off on 1 Oct 2019.
- Joint NSF/AURA press release to mark the event.
- LSST operations received initial funding in FY 2019.

DKIST Telescope



- Telescope optics in place, M1 & M2 aligned.
- Current challenges largely with instrument completion and delivery, as well as data policy.
- Commissioning of thermal control loops also a significant task.
- Still on schedule and within budget contingency.

LSST Sept 20, 2019





Astro 2020



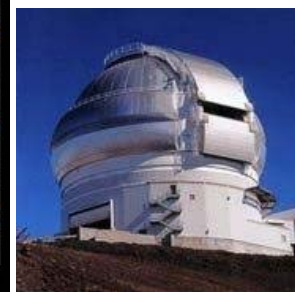
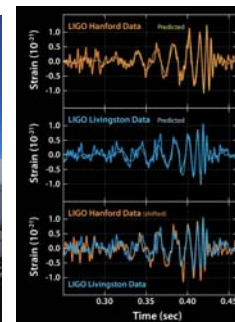
Astro 2020 decadal survey

- Planning is now well underway for input to the next Astronomy & Astrophysics Decadal Survey.
- NSF/AST and NASA Astrophysics Division are the primary sponsors of the survey. DOE Cosmic Frontier in the Office of Science is also a sponsor.
- NSF is including all ground-based astrophysics (i.e., gravitational wave detection and astro-particle detection) for scientific consideration, not limited to AST.
- AST is supporting development of three major projects, two through activities in national centers, and one through a continuing series of grants. OPP/PHY support a fourth.
- AST does not explicitly support preparation of mid-scale proposals for Decadal submission via a dedicated solicitation, but may support this through the AST MSIP solicitation and/or the N



NSF: Astro 2020

Ralph Gaume
Saul Gonzalez
Vladimir Papitashvili



NSF Goals for Astro2020



- Astro2020 will be most effective if it is *aspirational, inspirational, and transformative*.
- Astro2020 will be most effective if it is based on *community consensus science priorities*.
- The agencies are the *customers*. Astro2020 will be conducted independently of the customer, but must provide *recommendations, clear priorities, and actionable advice* to the customer.

NSF Goals for Astro2020



- NSF wants to know:
 - What are science priorities for next decade?
 - What projects address these priorities?
 - Which projects are ready to go now and later? When?
 - What are costs, risks, development needs of projects?
 - What is the priority order for these projects?
 - What budgets are needed to support the priorities, and are they realistic?

NSF Goals for Astro2020



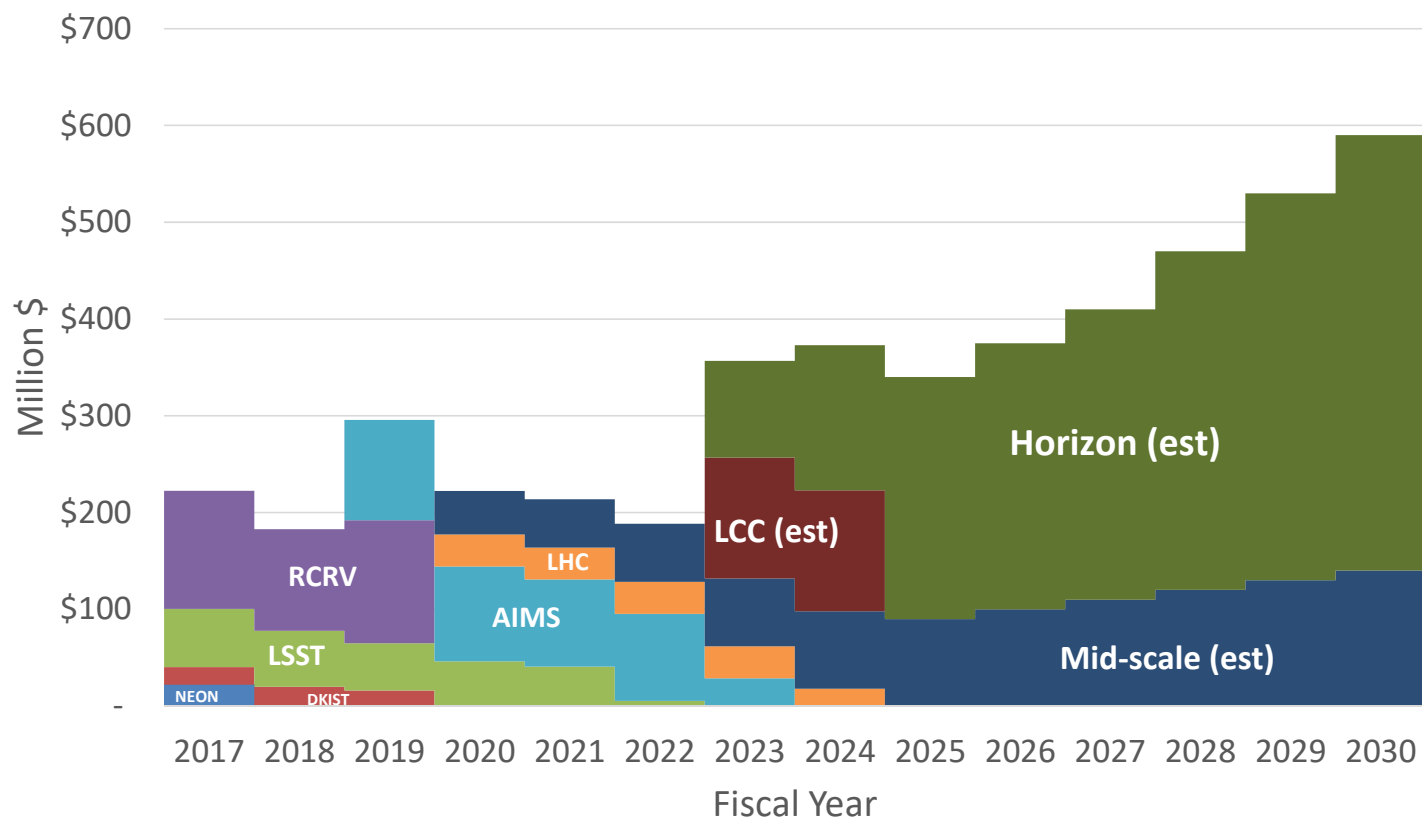
- NSF wants to know (continued):
 - How does the current NSF portfolio address priorities?
 - What is the state of the profession?
 - Recommendations for the agencies.
 - Division specific:
 - AST: Decision rules for MSIP.
 - PHY: Welcome recommendations on promising Technology R&D for next gen. facilities
- Let NSF sweat implementation details.
 - One NSF Astronomy/Astrophysics program
- Provide clear priorities with explanatory decision rules leading to the priorities.



Notional NSF Budgets: Construction and Operations



Notional (Ambitious) Future NSF MREFC Account Profile





NSF Operations and Maintenance

- NSB: [Study of O & M costs for NSF Facilities](#) May 2018
- Recommendation 1: *NSB and the NSF Director should continue to enhance agency-level ownership of the facility portfolio through processes that elevate strategic and budgetary decision-making.*
 - *...a scientifically robust Foundation-wide strategy that is both transparent and fiscally responsible is critical.*
 - *Planning horizons that are longer than the current 5-year projections required by statute could inform this strategy. The Department of Energy's Office of Science has found notable success using a 10-year planning model.*
 - *While NSB does not believe that it is necessary to establish a central O&M account at this time, greater flexibility in use of the MREFC account would enhance visibility and agency-level ownership.*

