NSF Astronomy Update

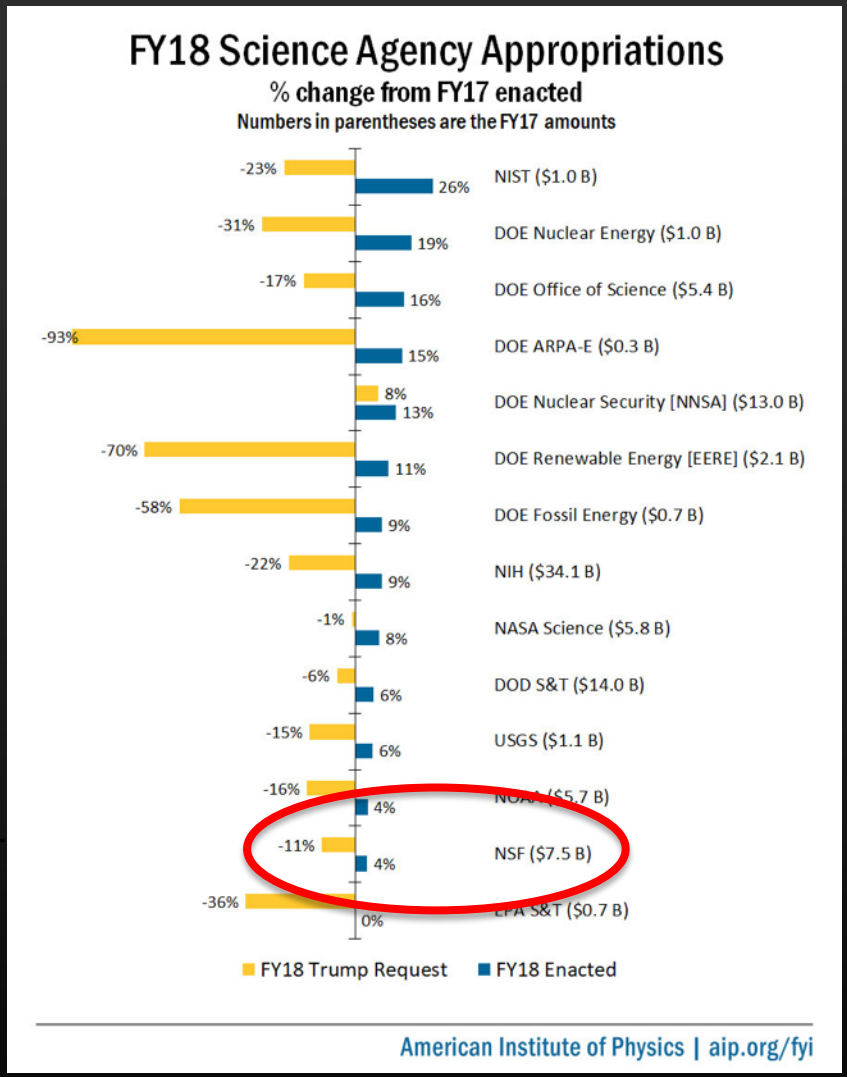
Dave Boboltz (Program Director, NSO/DKIST)

Committee on Solar and Space Physics (CSSP)

March 27, 2019

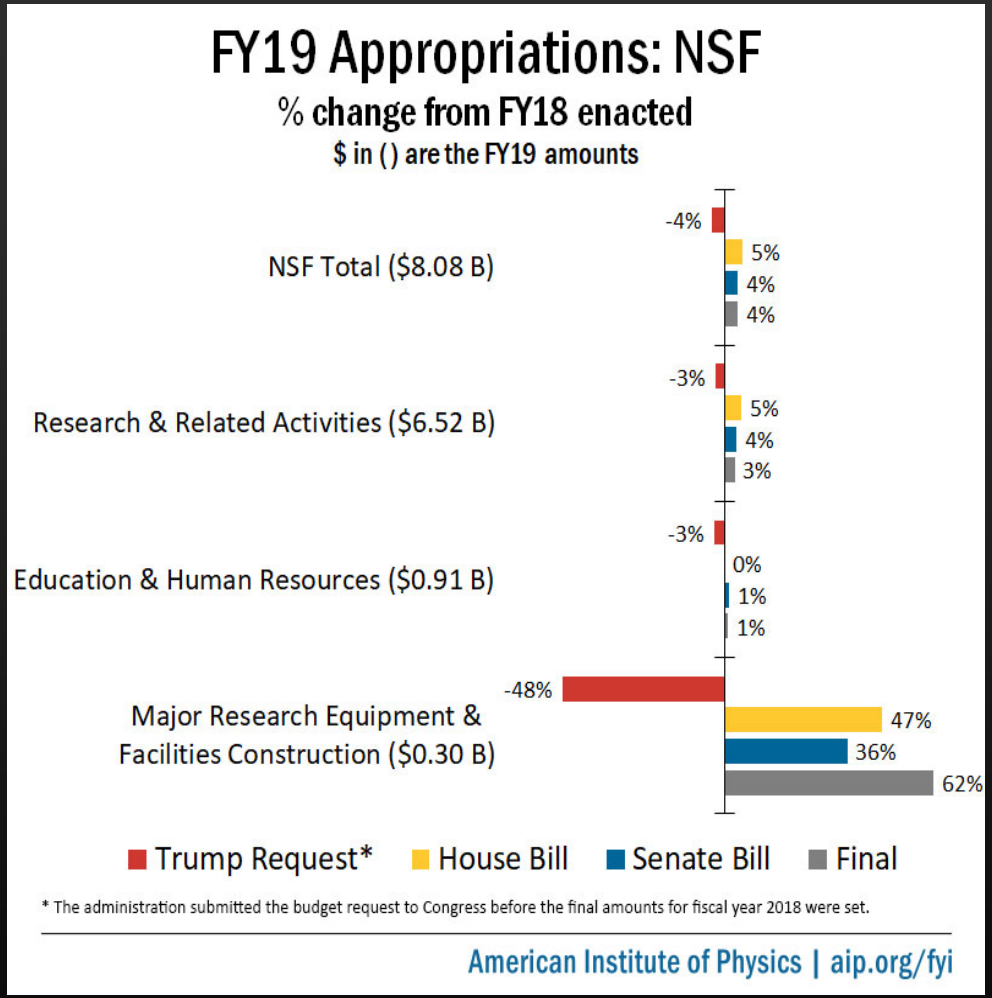
FY 2018 Appropriation Enacted

- NSF top line ~$7.5B
  - up ~4%; ~$295M
- Good outcome for AST
  - Total $307M
  - Up ~22% from $252M in FY17
- Much of the additional funding went to one-time specific projects (some dependent on FY19 availability of funds to complete).
  - Mid-Scale Program (MSIP)
  - Multi-messenger Astrophysics grants
  - DKIST ops forward-funding
  - DKIST Leve-2 Data Products
  - Center infrastructure upgrades



FY 2019 Appropriation for NSF

- President's Budget Request down from FY18 levels
- NSF Appropriation up ~4% from FY18 level
- ~$300M reserved for Big Ideas
- Final AST number not yet known
- NSF awaiting congressional approval of the spend plan



Programs within AST

Research

Technology/ Instrumentation

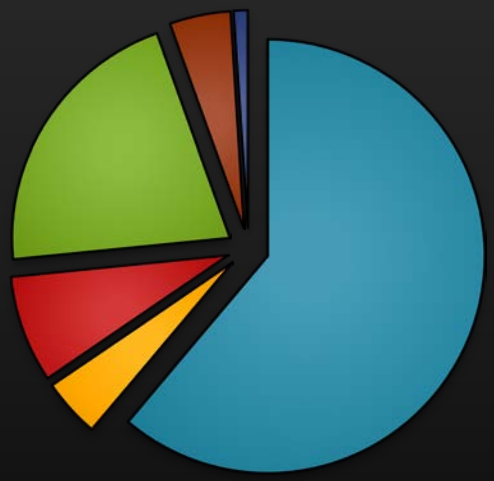
Education and Special Programs

Individual Investigator

- AAG
- CAREER
- AAPF
- ATI
- MRI
- REU
- PAARE

Mid-scale

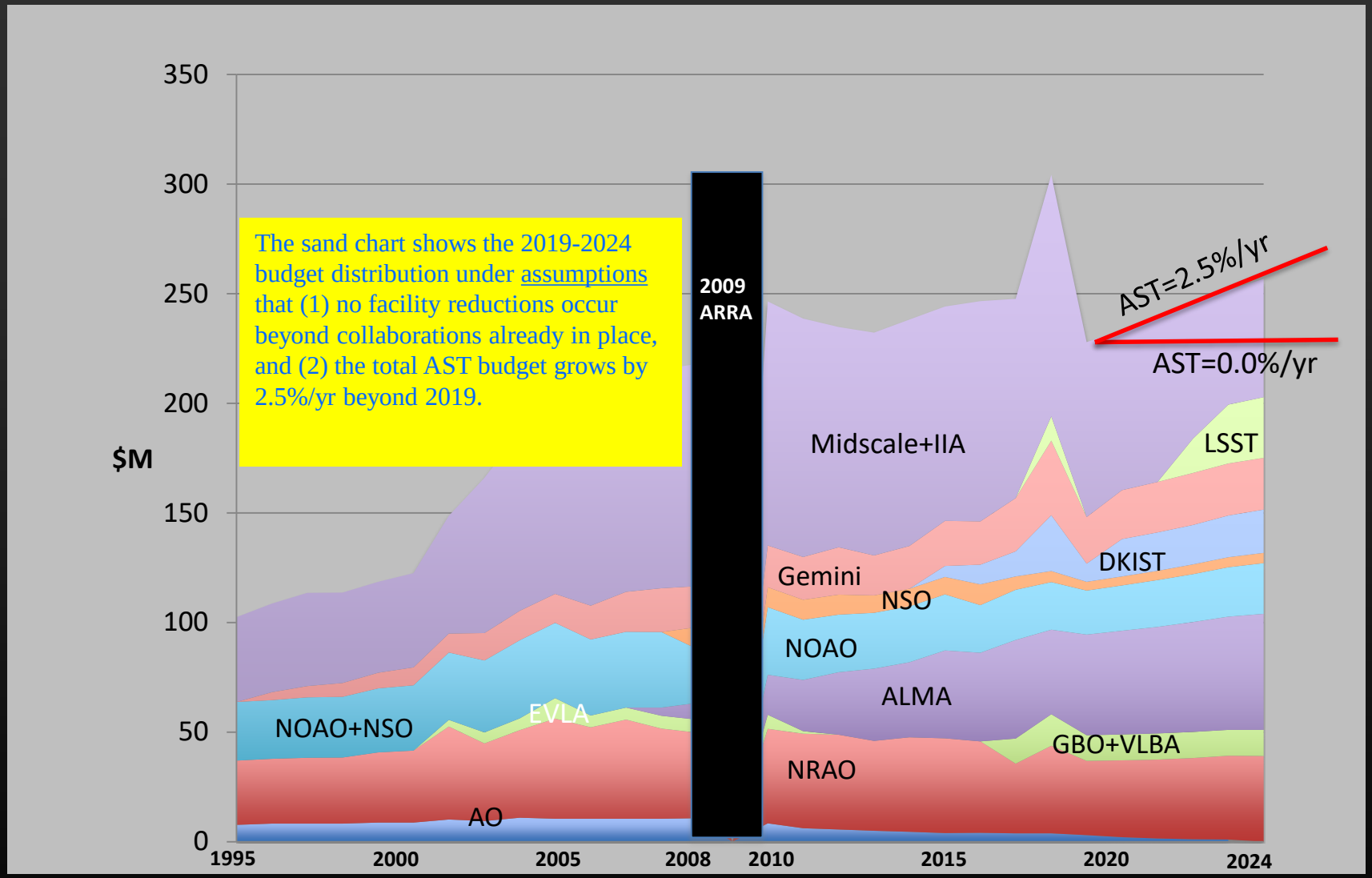
- MSIP



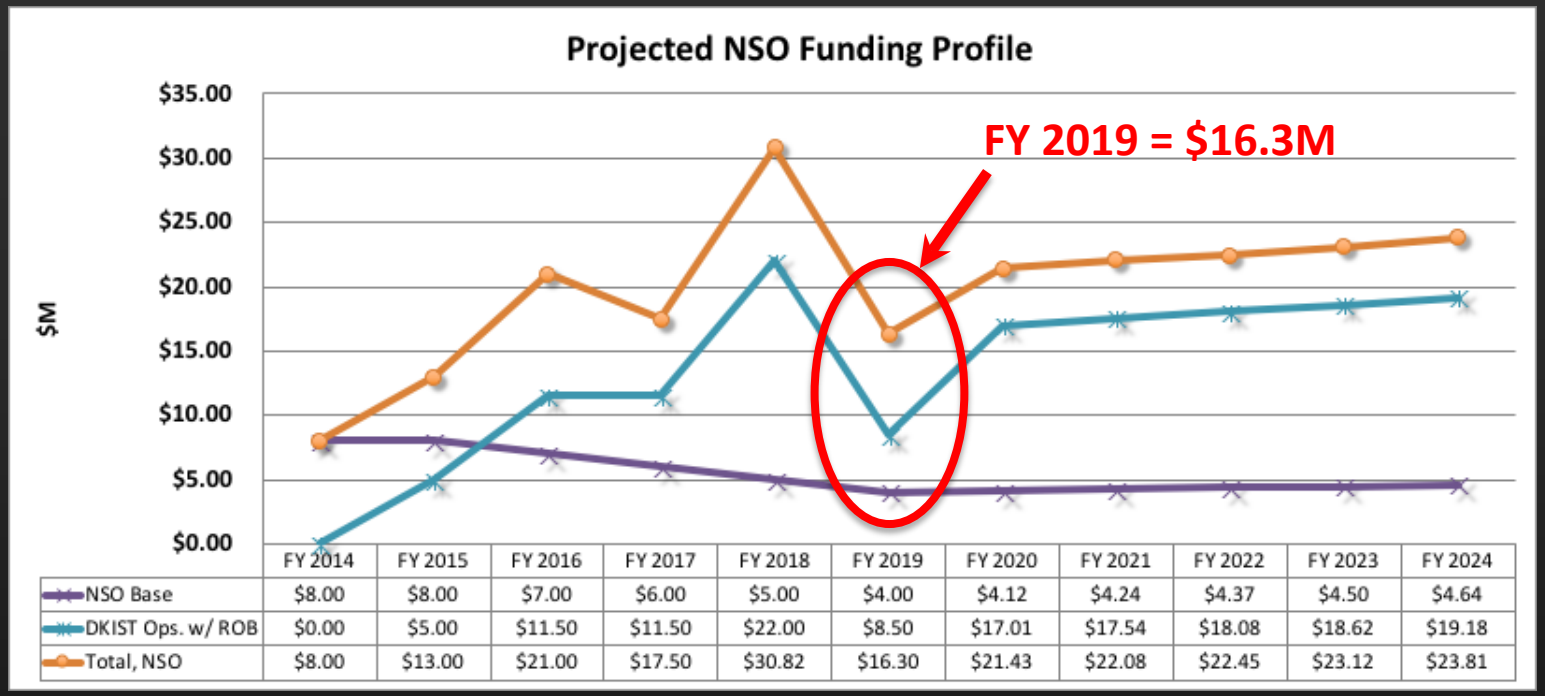
Facilities

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

AST Funding Levels and Future Runout



NSO Operations & Maintenance



	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
NSO Base	$8.00	$8.00	$7.00	$6.00	$5.00	$4.00	$4.12	$4.24	$4.37	$4.50	$4.64
DKIST Ops. w/ ROB	$0.00	$5.00	$11.50	$11.50	$22.00	$8.50	$17.01	$17.54	$18.08	$18.62	$19.18
Total, NSO	$8.00	$13.00	$21.00	$17.50	$30.82	$16.30	$21.43	$22.08	$22.45	$23.12	$23.81

- FY 2018 = $30.8M
- FY 2019 O&M estimated = $16.3M
  - DKIST Level-2 Data Products = $3.5M
  - Legacy facilities = $400K

Transition of NSO Facilities on Sac Peak

- Recommended for divestment by the 2012 AST Portfolio Review
- State of New Mexico recently awarded a $273K grant to NMSU – July 2018
- 3-year NSF-NMSU-NSO plan
  - NMSU ~$200K/year
  - NSO ~$300K/year
- NSB approval for to sign the Record of Decision (ROD) – Nov. 29, 2018
- ROD signed – Feb. 25, 2019

Transition of NSO Facilities on Kitt Peak

- Recommended for divestment by the 2012 AST Portfolio Review
- McMath-Pierce
  - NSF award $4.5M ($3.3M FY18) proposal to the NOAO Visitor Center
  - Will become the Windows on the Universe Center for Astronomy Outreach
  - Plans include exhibit of McMath's contributions to solar physics and NSF astronomy virtual control room

National Optical Astronomy Observatory NEWS

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A nine-hour exposure of the McMath-Pierce Solar Facility on Kitt Peak. The normally white building appears red due to high altitude haze following the 1991 eruptions of Mount Pinatubo. No filters or multiple exposures were used. Credit: Bill Livingston & NOAO/AURA/NSF.

The sun rises behind the McMath-Pierce Solar Telescope on Kitt Peak. Credit: P. Marenfeld & NOAO/AURA/NSF.

McMath-Pierce and NSF's

National Science Foundation to Fund New Windows on the Universe Center for Astronomy Outreach at Kitt Peak National Observatory

A new $4.5 million grant from the National Science Foundation (NSF) has been awarded to the Association of Universities for Research in Astronomy (AURA) for the development of a new "Windows on the Universe Center for Astronomy Outreach" at NSF's Kitt Peak National Observatory. Located in the McMath-Pierce Solar Telescope facility, an iconic structure that was once the world's largest solar observatory, the center will provide the public with a new way to experience the cutting-edge research being carried out at Kitt Peak and NSF's other astronomy facilities around the globe, including ground-based optical, radio, solar, and gravitational wave facilities.

New Windows on the Universe for the Public

The grant will fund the renovation and transformation of the McMath-Pierce into an astronomy visualization and presentation center with potentially global reach. The center will feature data visualization systems, interactive exhibits, and a simulated telescope control room, which will give visitors the virtual experience of being at a telescope and participating in research carried out at NSF facilities around the world, including those in Hawaii, Chile, and the South Pole.

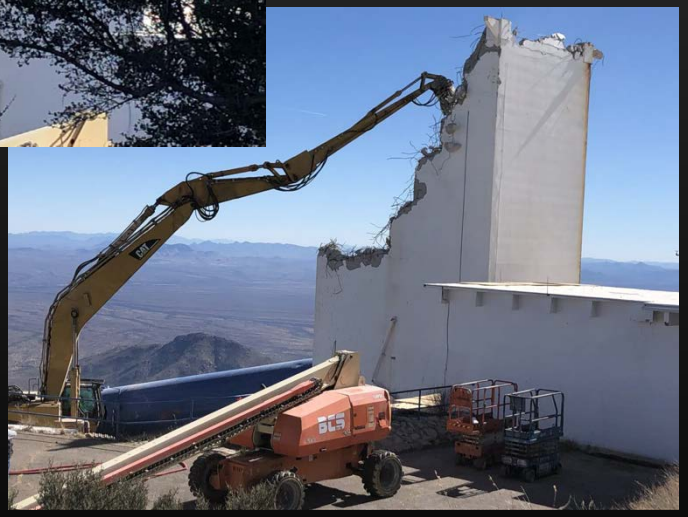
To highlight its location in the McMath-Pierce facility, the Center will feature special exhibits on the history of solar astronomy. The grant will also fund public programs, including educational programs to be developed in collaboration with the Tohono O'odham Nation. Kitt Peak National Observatory, which is located in the Schuk Toak district on Tohono O'odham Nation land, 56 miles west of Tucson, Arizona, is part of the National Optical Astronomy Observatory (NOAO), which is operated by the AURA under an agreement with NSF.

Visitors to the center will explore the wide variety of research carried out at NSF's astronomy facilities, including Kitt Peak, Cerro Tololo Inter-American Observatory, Gemini Observatory, the Large Synoptic Survey Telescope, and the Daniel K. Inouye Solar Telescope—all managed by AURA—as well as the Very Large Array, Atacama Large Millimeter Array, South Pole Telescope, and Laser Interferometer Gravitational-Wave Observatory.

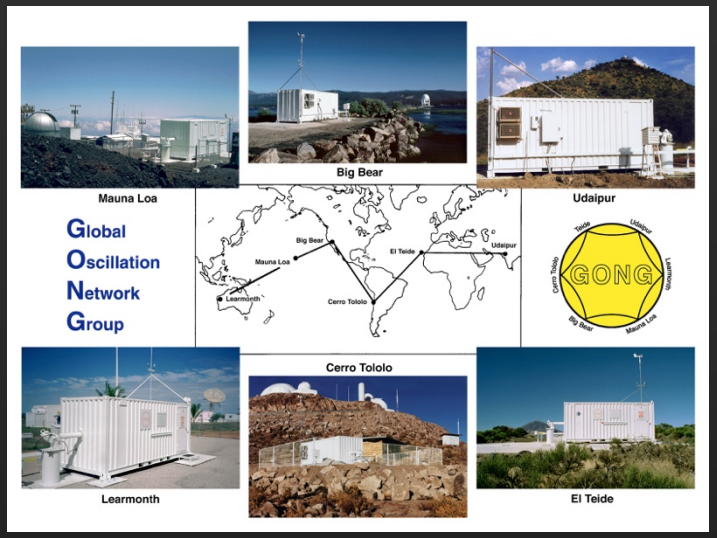
The visualizations created for Windows on the Universe will feature imagery from these NSF facilities and will be designed for export to compatible visualization centers around the world, expanding the center's reach.

Transition of NSO Facilities on Kitt Peak

- Vacuum (SOLIS) tower
  - Request for Bids (RFB) to demolish issued – Sept. 2018
  - Contractor approved – Oct. 2018
  - Demolition – Jan. 2019



NISP: GONG



- GONG engineering site relocation completed - April 2018
- Used for testing, development and EPO
- $2.5M upgrade for space weather operations still ongoing
- NOAA/SWPC still providing partial support ($770K/yr) for operations

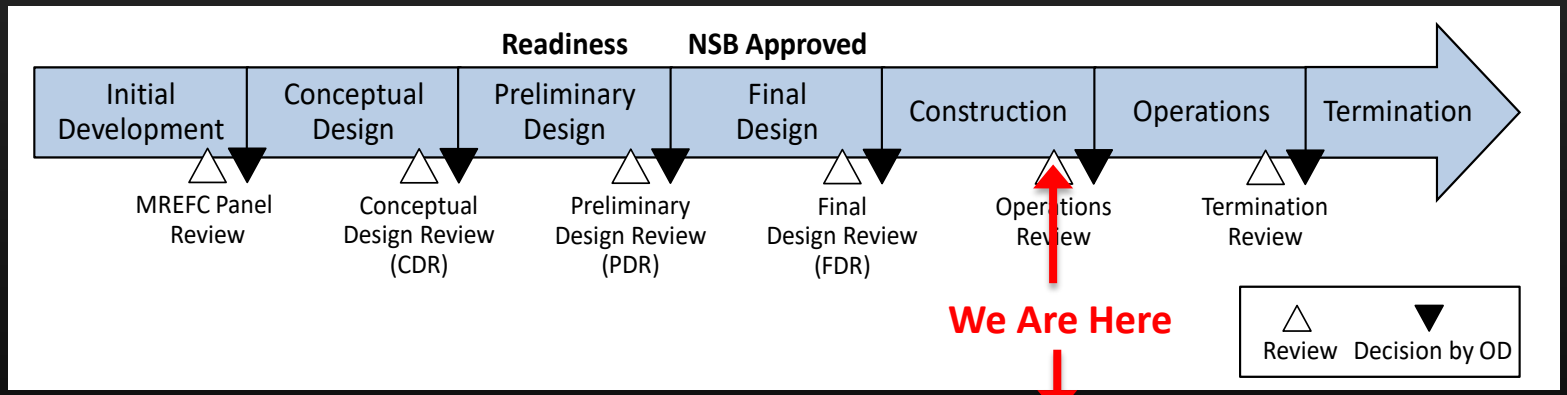
NISP: SOLIS

- Relocation of SOLIS plagued by delays; permitting, engineering firm issues, bald eagle nesting season
- Schedule:
  - Shelter complete and mount installation – July 2019
  - Instrument (ISS, VSM, FDP) installation – August 2019
  - Occupancy and operations restart – September 2019

NISP: GBSON

- Ground-Based Solar Observing Network (GBSON)
- Conceptual design
- Solar science and Space Weather operations
- Meets USAF requirements:
  - Spectrograph-based IR vector magnetograph
  - Full-disk imager (HAO CHROMAG?)
  - Coronagraphs (HAO)
- Additional research components:
  - Multi-wavelength multi-height helioseismic Doppler velocity imager (SPRING)
    - Being developed by KIS (Germany) with NSO involvement
  - On-site compute center
  - Monitoring of filament magnetic fields to estimate B_z

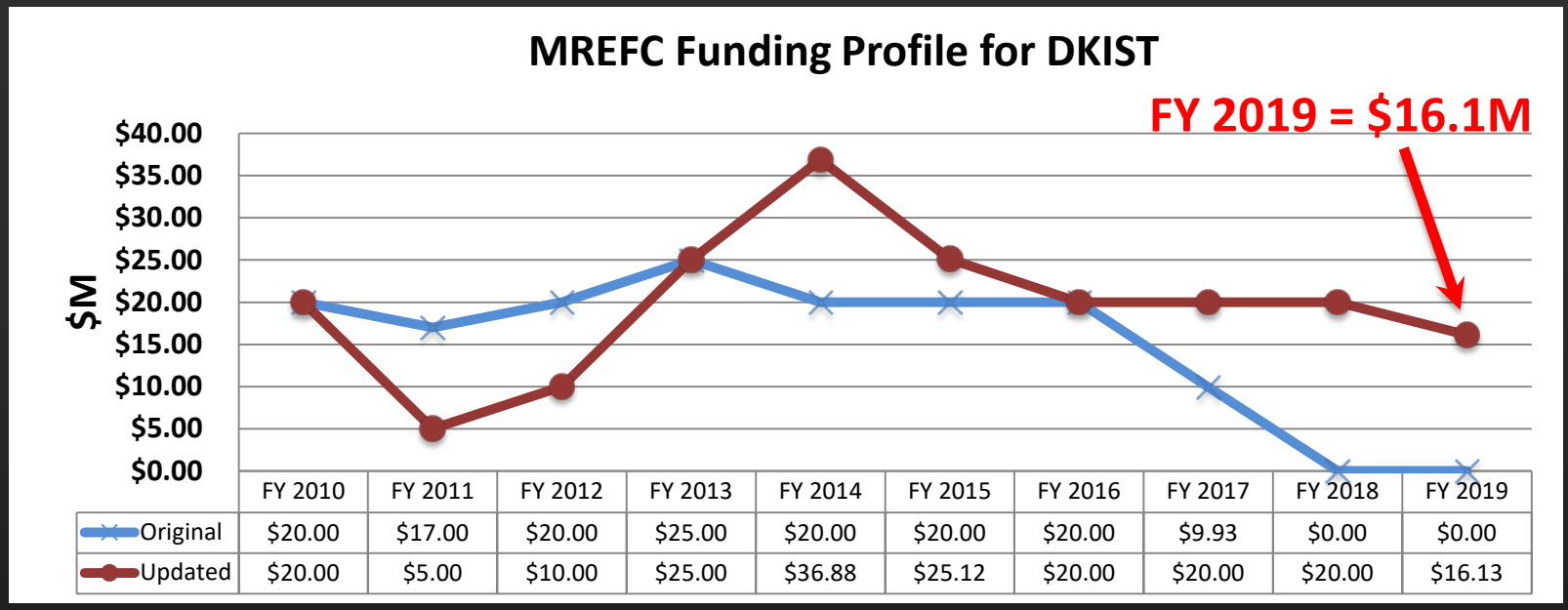
DKIST in the NSF Facility Lifecycle



R&RA funds also support scientific research

Major Research Equipment and Facilities Construction (separate appropriation)

DKIST Construction Funding (MREFC)

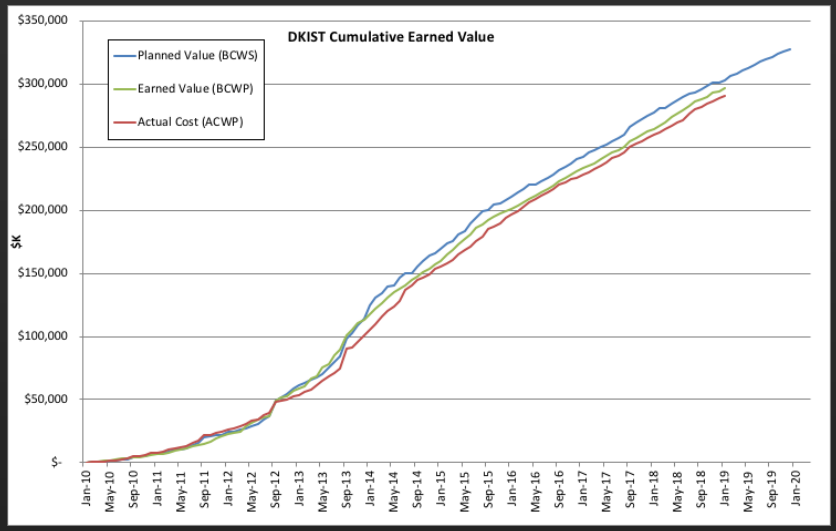


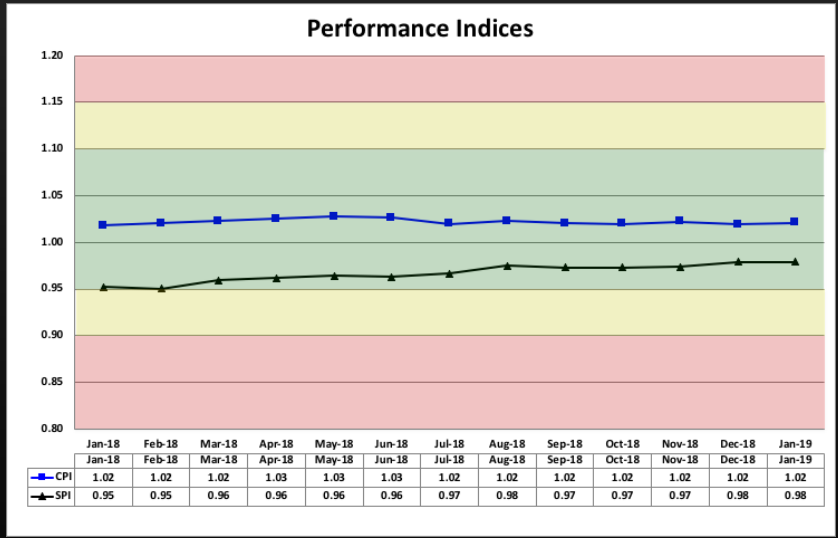
	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Original	$20.00	$17.00	$20.00	$25.00	$20.00	$20.00	$20.00	$9.93	$0.00	$0.00
Updated	$20.00	$5.00	$10.00	$25.00	$36.88	$25.12	$20.00	$20.00	$20.00	$16.13

- DKIST Re-baselined Total Project Cost = $344.13M
- Total MREFC awarded thus far $335.5M
  - $8.6M of contingency withheld for future allocation
- FY 2019 MREFC $16.13M estimated

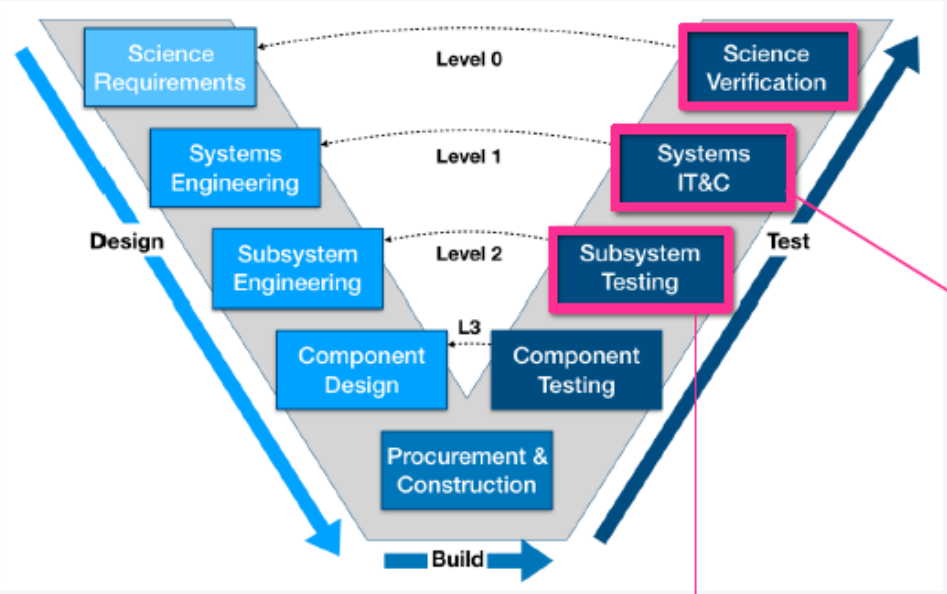
DKIST Cost and Schedule Status (Jan. 31, 2019)

- Project 90% complete
- Budget
  - TPC = $344.1M
  - NSF Funding to date = $335.5M ($146M ARRA)
  - Actuals + Commitments = $302.6M
  - Earned Value = $296.6M
  - Budget Contingency = $14.9M (34% of remaining estimate to complete)
- Schedule
  - 80% MC CL end date = June 10, 2020
  - Current IPS end date = Apr. 17, 2020
  - Schedule Contingency = 1.7 months
- Performance Indices
  - CPI = 1.02
  - SPI = 0.98





DKIST Project Scope – Principal Remaining Work



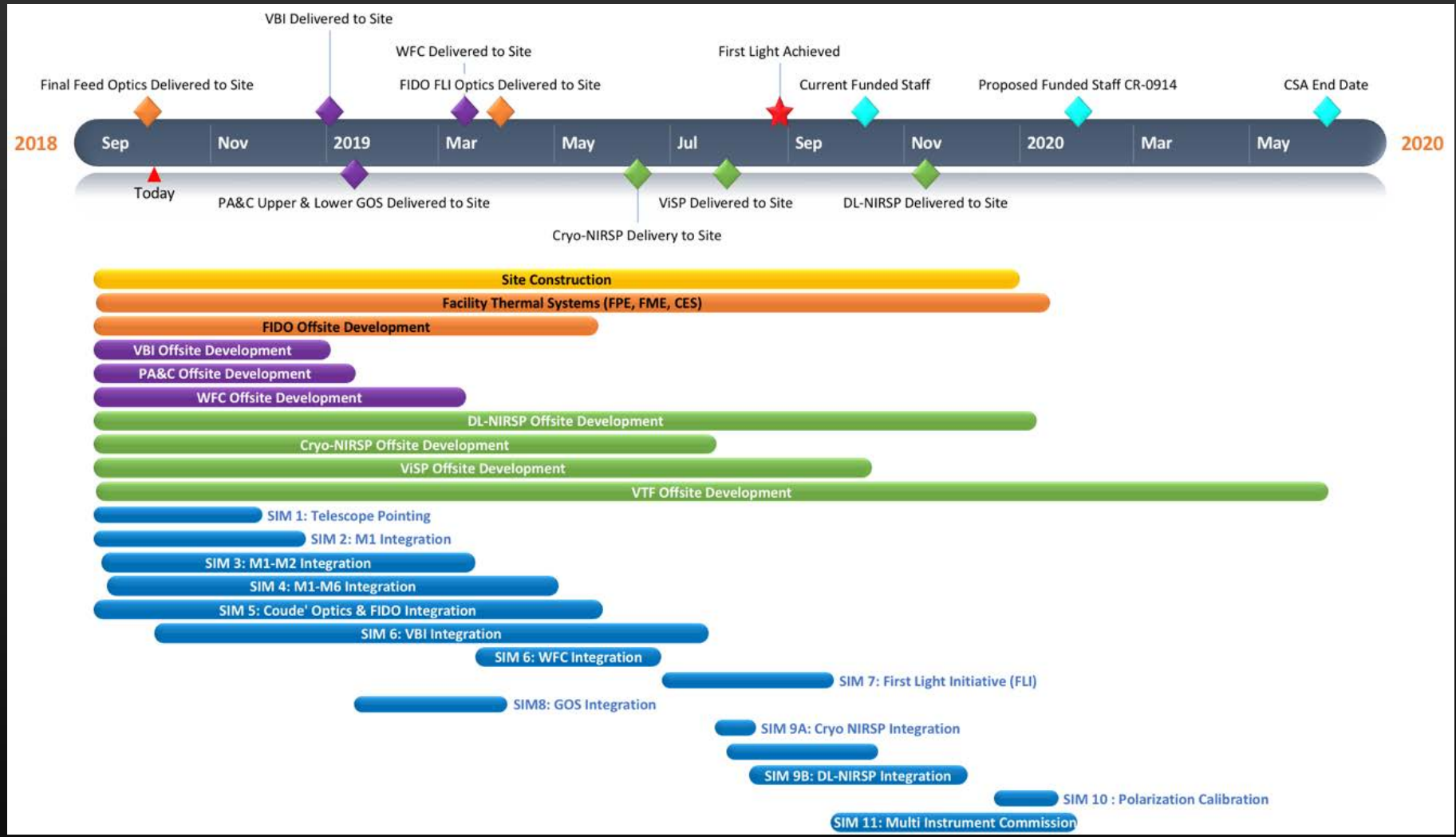
- TI Fit/Finish, FTS, Site Closeout
- M8 Assembly
- FIDO Optics (Beamsplitters)
- Wavefront Correction System
- Visible Broadband Imager
- PA&C / GOS
- Partner Instruments:
  - Cryo-NIRSP
  - DL-NIRSP
  - ViSP
  - VTF
- Visible Cameras (VTF)

Remaining Subsystems to be Delivered

- ~~SIM 1 - Telescope Pointing Map~~
- ~~SIM 2 - M1 Integration~~
- SIM 3 - M1 and M2 Integration
- SIM 4 - M1-M6 Integration
- SIM 5 - Coude Optics + FIDO
- SIM 6a - VBI Integration
- SIM 6b - WFC Integration
- SIM 7 - First Light Initiative
- SIM 8 - GOS Integration
- SIM 9a - Cryo-NIRSP Integration
- SIM 9b - DL-NIRSP Integration
- SIM 9c - ViSP Integration
- SIM 9d - VTF Integration
- SIM 10 - Polarization Calibration
- SIM 11 - Commissioning & Verification

SIM Status

DKIST High-Level Schedule

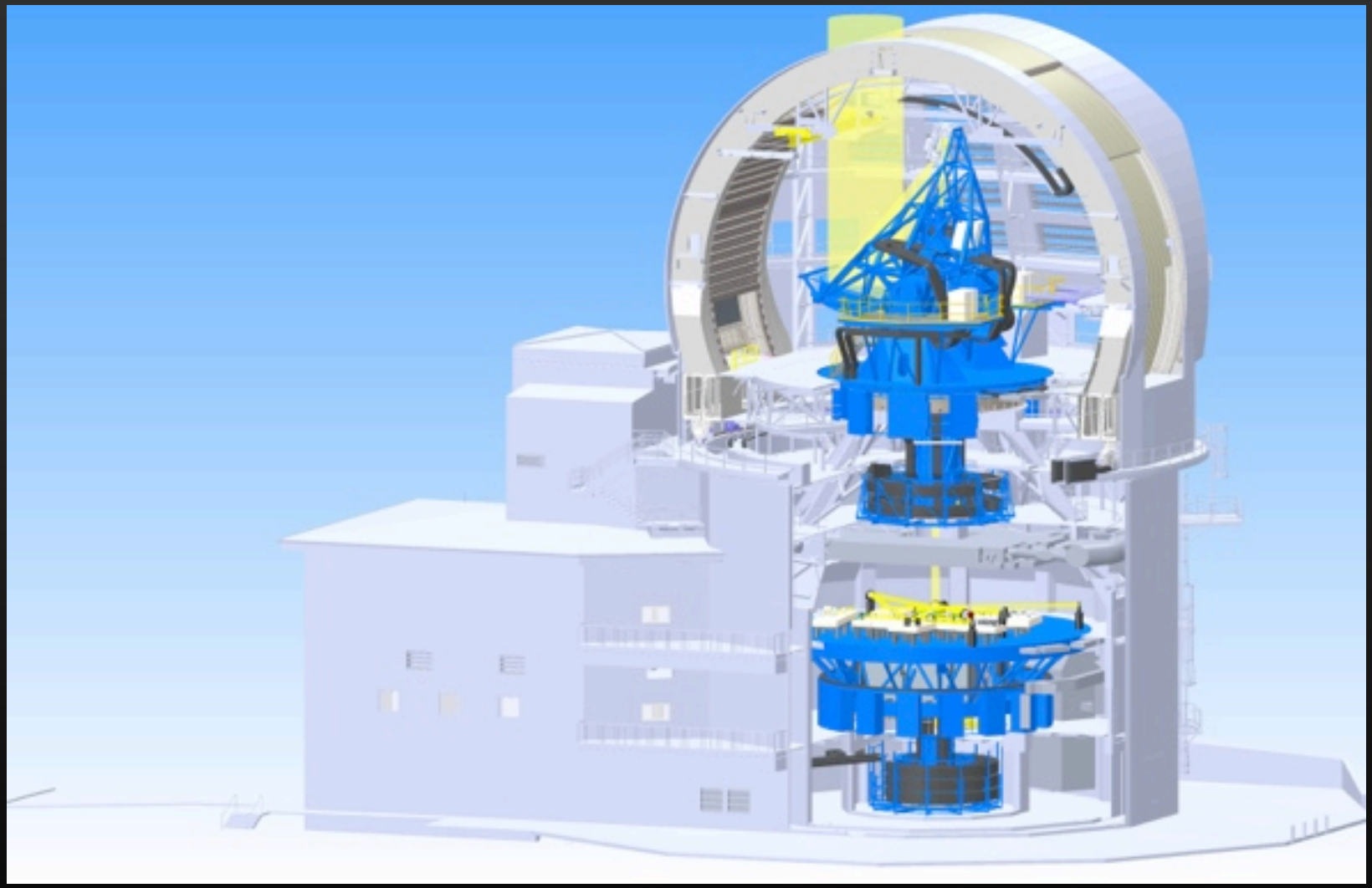


Current Construction Site

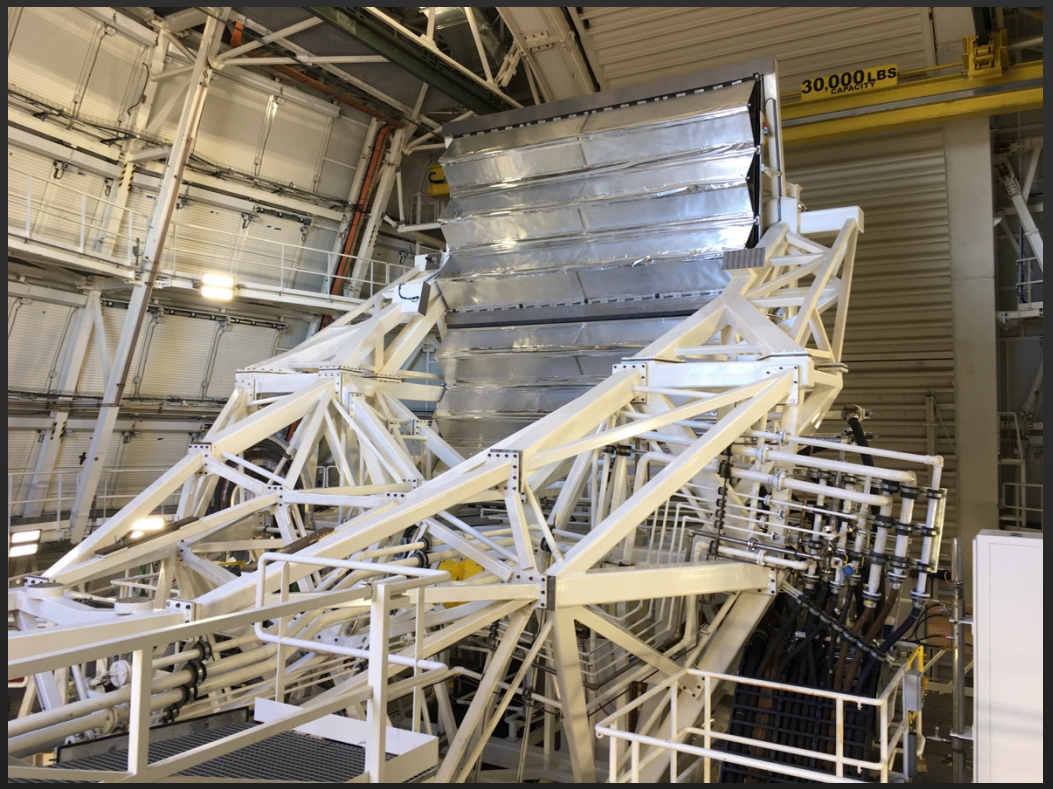
Recent Weather Impacts to Construction

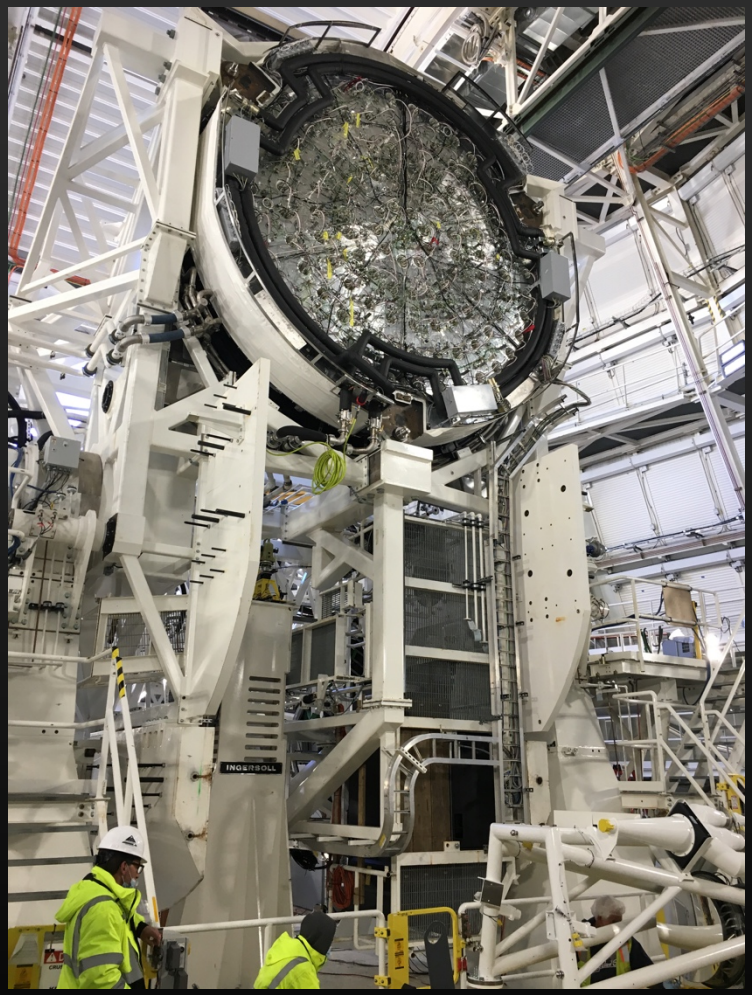
- Storm hit Maui Feb. 10, 2019 bringing snow, ice, and high winds
- Power to the summit knocked out for a month
- Limited construction activities while running on back-up diesel generator
- Power restored March 11, 2019

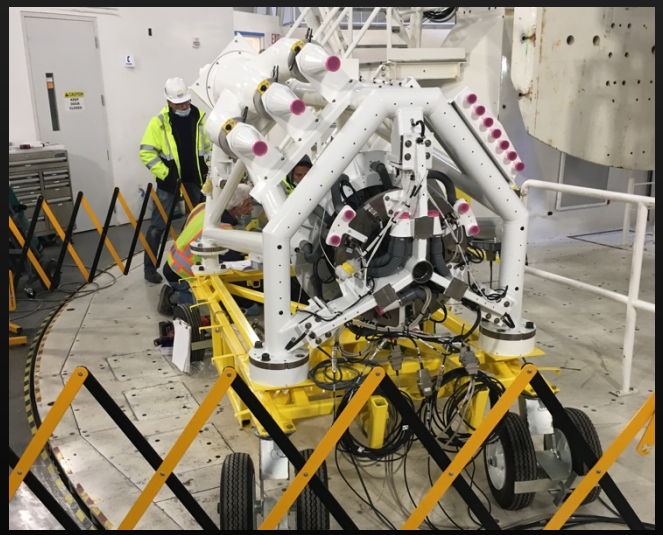
DKIST Cutaway View



Telescope Mount Assembly



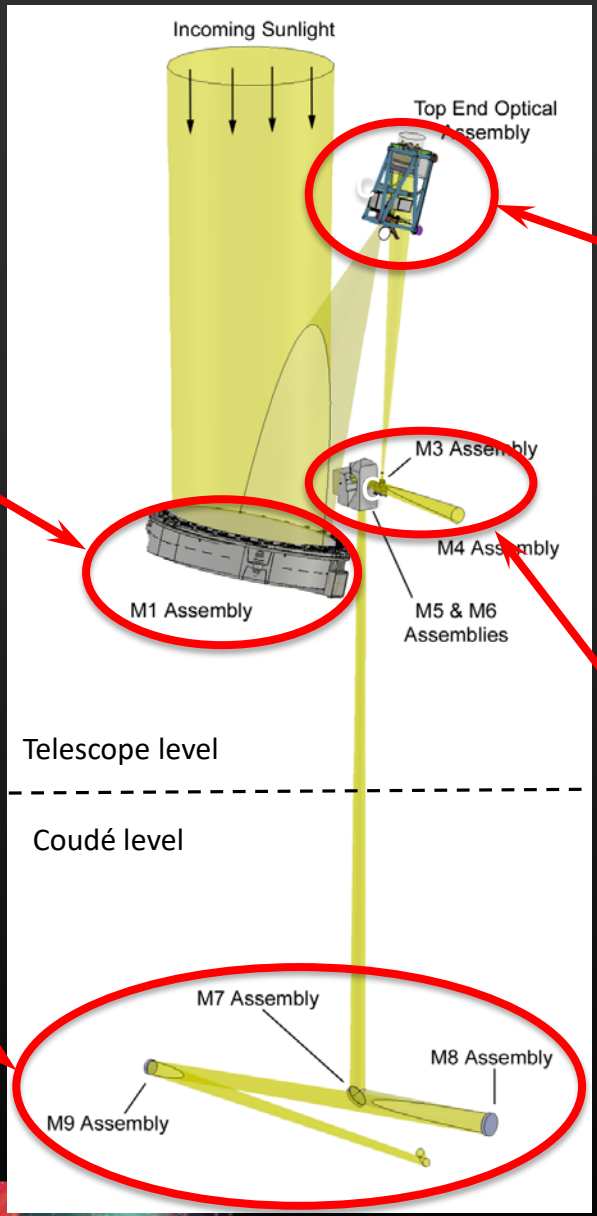




IT&C: Following the DKIST Optical Path

M1 Primary – The M1 is a 4.24-m diameter, 75-mm thick, off-axis paraboloid. The outer 12-cm rim is masked by the aperture plate, thus allowing a 4-m aperture. The mirror is Schott Zerodur glass. The M1 is actively cooled to ambient temperature with active flexure control accomplished by 142 actuators

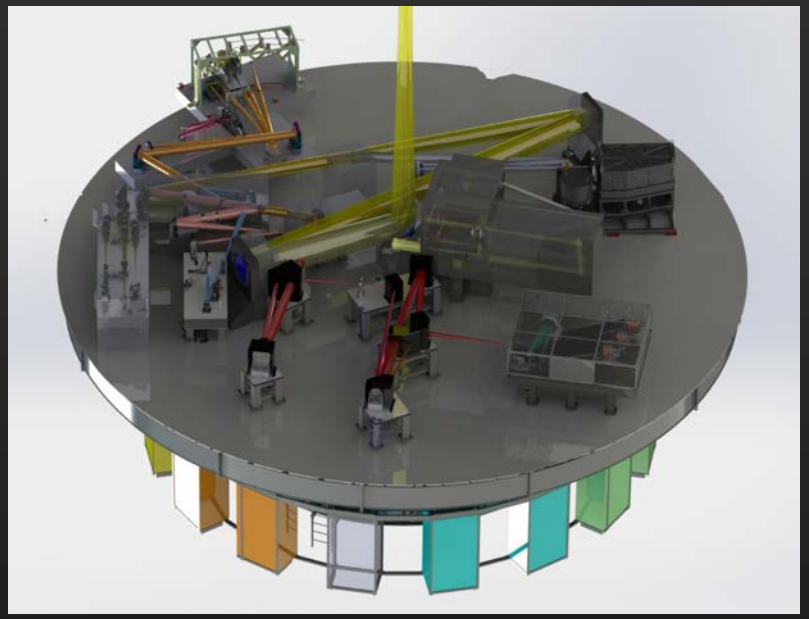
Coudé Optics – Include M7 through M9 with actively cooled mirrors and mounts. These optics convert the vertical beam from the telescope level to horizontal and distribute the light to the adaptive optics (AO) system. All Coudé Optics are mounted to optical benches in the Coudé Lab.

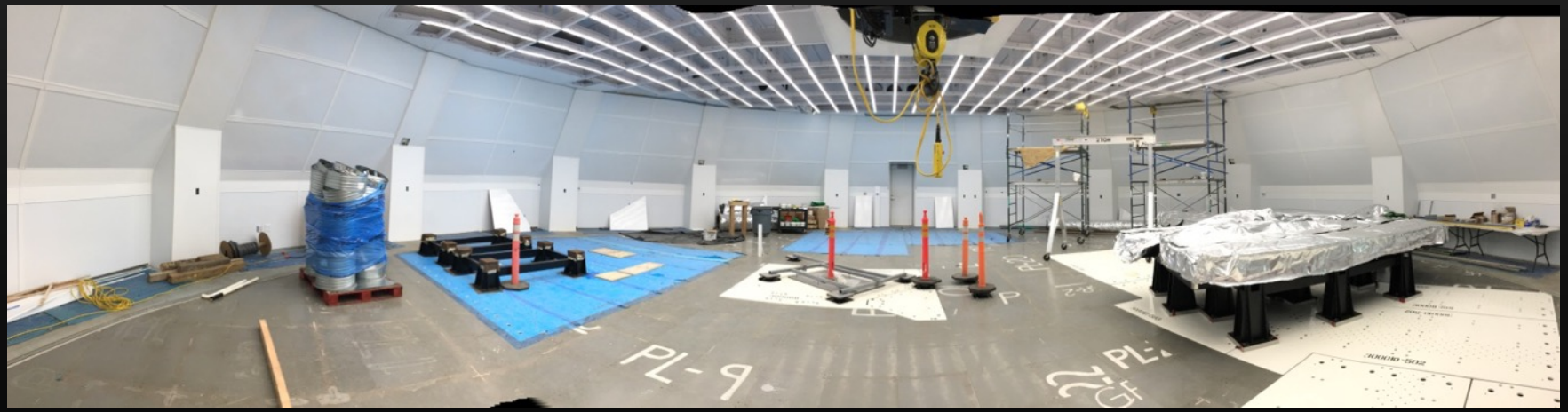


Top End Optical Assembly (TEOA) - The TEOA contains the 62 cm M2 mirror, the Heat Stop Assembly (HSA), the Lyot Stop, the M2 Support Frame and associated control systems.

Transfer Optics - Include M3 through M6 assemblies with their cooled mirrors, mounts, and positioning systems. These mirrors collimate the beam and transfer it across both the elevation and azimuth axes of the telescope down to the Coudé floor one level below.

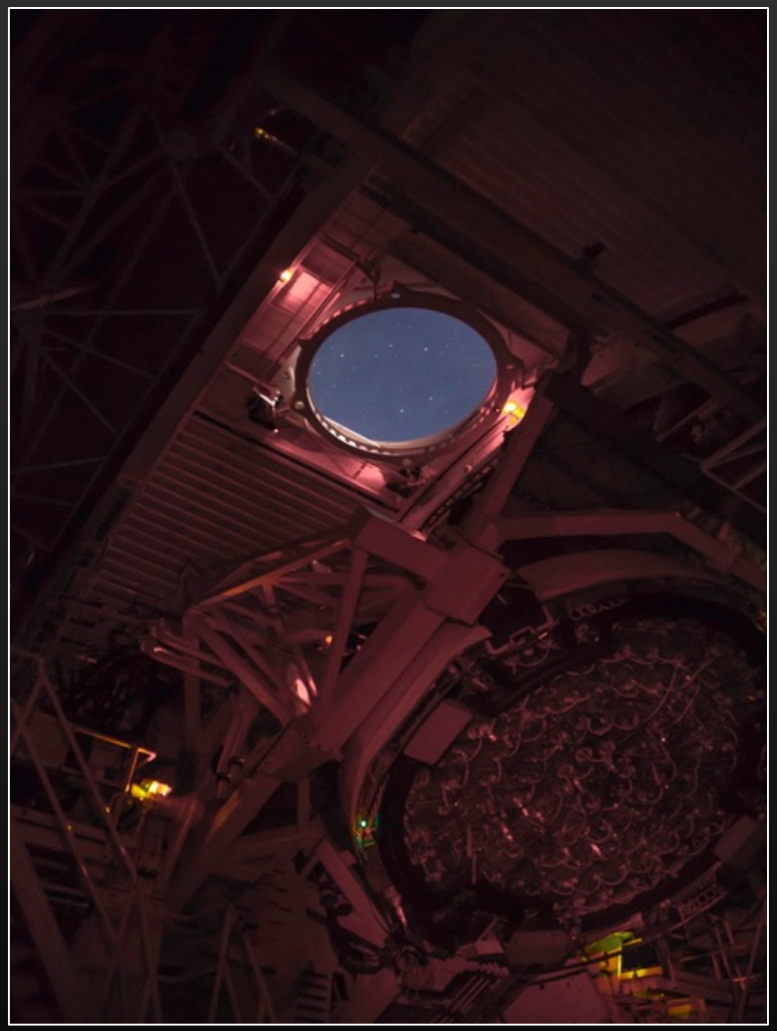
Coudé Rotator Lab

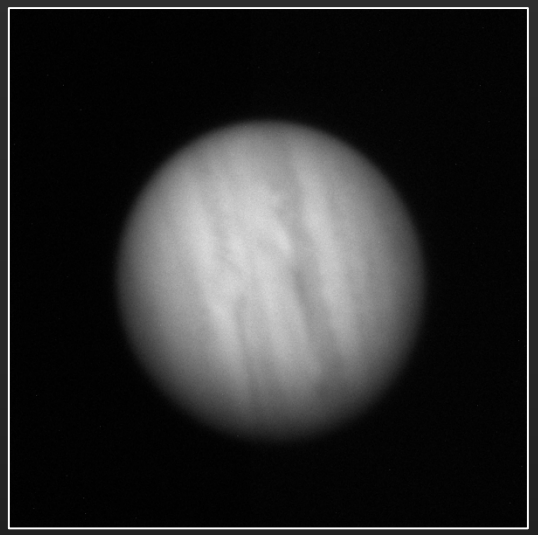




DKIST Nighttime Testing

- Nighttime engineering observations March 22, 2019
- Part of the IT&C Activities
- Testing the M2 mirror alignment on the TEOA
- Wavefront measured at 300nm rms in the center of the field
- Pointing checks on Moon and Jupiter





DKIST Science Support Center (DSSC)

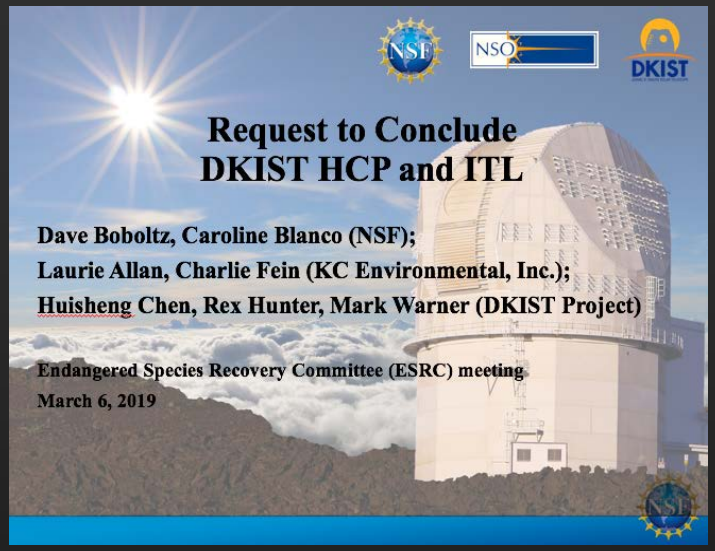
- Formerly know as the Remote Operations Building (ROB)
- Located in Makawao, Maui, HI next to UH-IfA
- NSF approved the purchase of land by AURA - July 31, 2015
- Construction contractor selection approved by NSF - Dec. 2, 2016
  - Arisumi Bros.
  - $8.321M
- Construction completed - May 2018
- Occupancy - June 2018

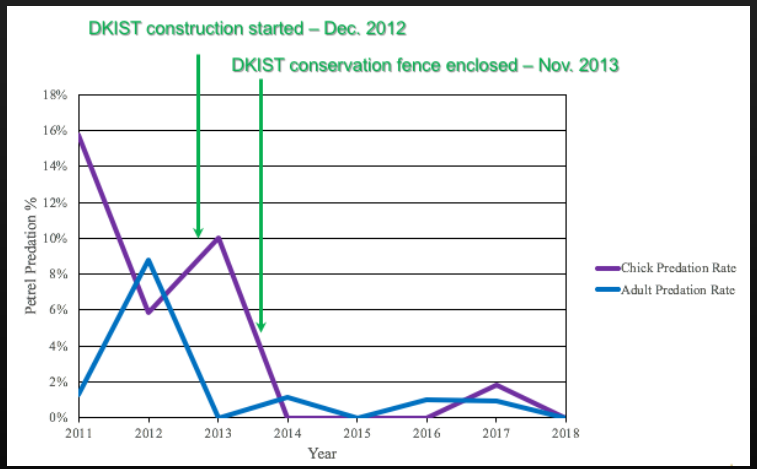
Environmental Compliance Obligations Met

NSF, after extensive consultation with DOFAW and USFWS, sought ESRC concurrence to end the DKIST Habitat Conservation Plan and associated Incidental Take License for the take of 35 Hawaiian Petrels, consistent with BLNR's directive

- ✓ External construction activities are complete (December 2018)
- ✓ There has been zero construction-related take
- ✓ DKIST submitted a Final Report to the ESRC (January 2019) that demonstrated that mitigation and conservation requirements and net recovery benefit (~45 birds) goals have been met

ESRC vote unanimously to approve!





Harnessing the DKIST Data Revolution and Enhancing Career Solar Scientists

- Aligns with NSF Big Idea – Harnessing the Data Revolution
- Supplemental Funding to CSA from NSF
  - FY 2018 supplement awarded $3.5M
  - FY 2019 contingent upon availability of funds ($3.5M)
- Three Initiatives:
  - Data Products: Well defined level-2 data products
  - Community Outreach: Broadening expertise (workshops)
  - University Development: Growing a trained DKIST user base
    - 12 grad students/postdoc support at U.S. Universities

DKIST Data & Access Policy

- DKIST Science Policy Advisory Committee (DSPAC):
  - Lyndsay Fletcher (Univ. Glasgow, UK),
  - Phil Goode (NJIT, DKIST co-I),
  - Michael Knoelker (HAO, DKIST co-I),
  - Jeff Kuhn (IfA, DKIST co-I),
  - James McAteer (NMSU, NSO Users Committee chair),
  - Mark Rast (CU Boulder, DKIST SWG chair),
  - Robert Rosner (U Chicago, DKIST co-I),
  - Barbara Thompson (NASA, GSFC),
  - Oskar von der Luhe (KIS, Germany),
  - NSF ex-officio
- DSPAC will develop a data and access policy for DKIST
- Consistent with 2014 AAAC Principles for Access to Large Federally Funded Projects and Facilities
- Will be presented at the DKIST town-hall during the 2019 AAS/SPD

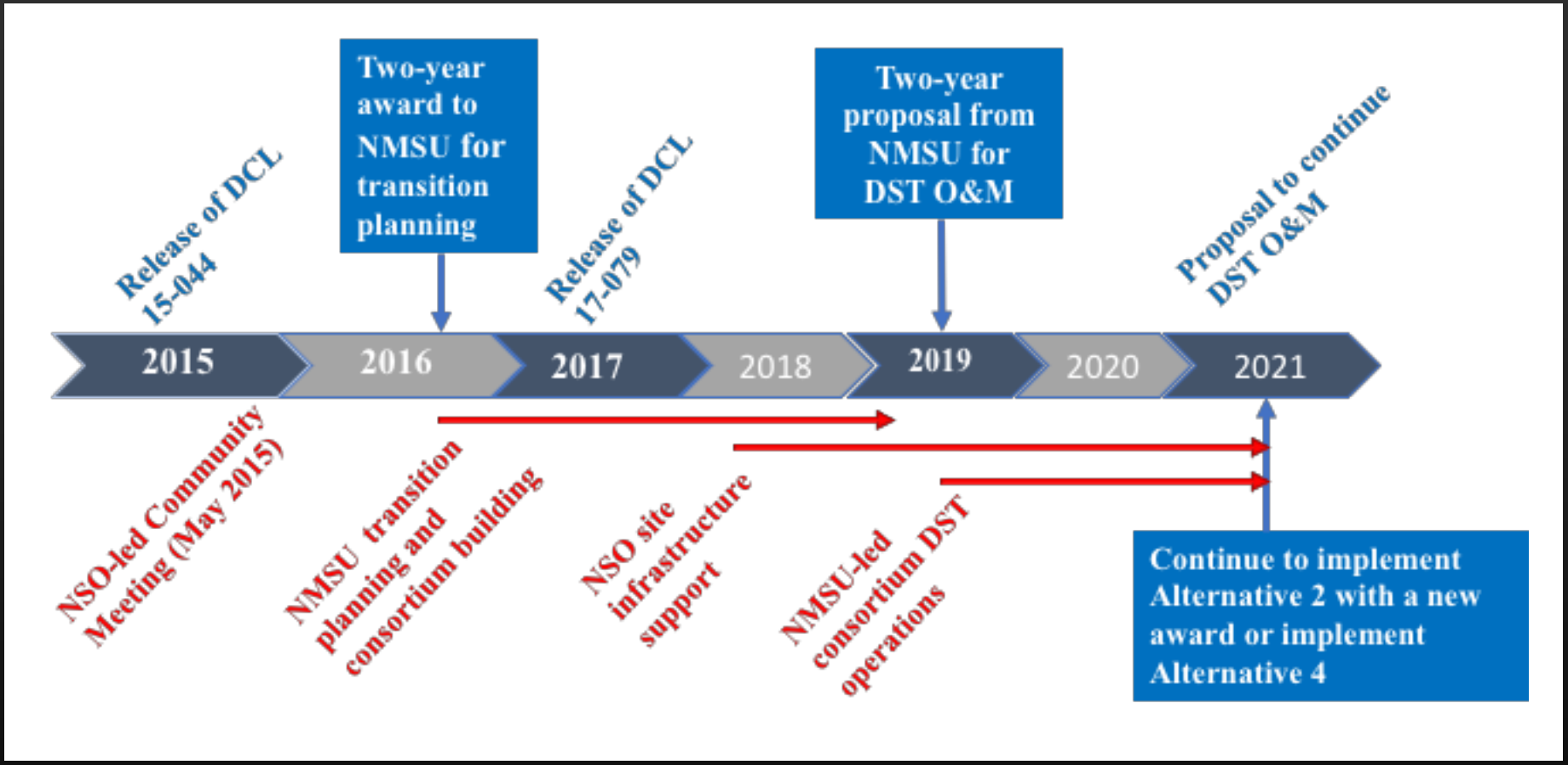
From 2014 AAAC Principles for Access to Large Astrophysics Projects and Facilities

- OPEN DATA: *"The best science occurs when an open data policy enables the global astrophysics community, the broader science community, and the public to extend the science outcomes of the project. A period of limited access to data for the implementing consortium or the funding partners to reap the benefits of their investment is reasonable."*

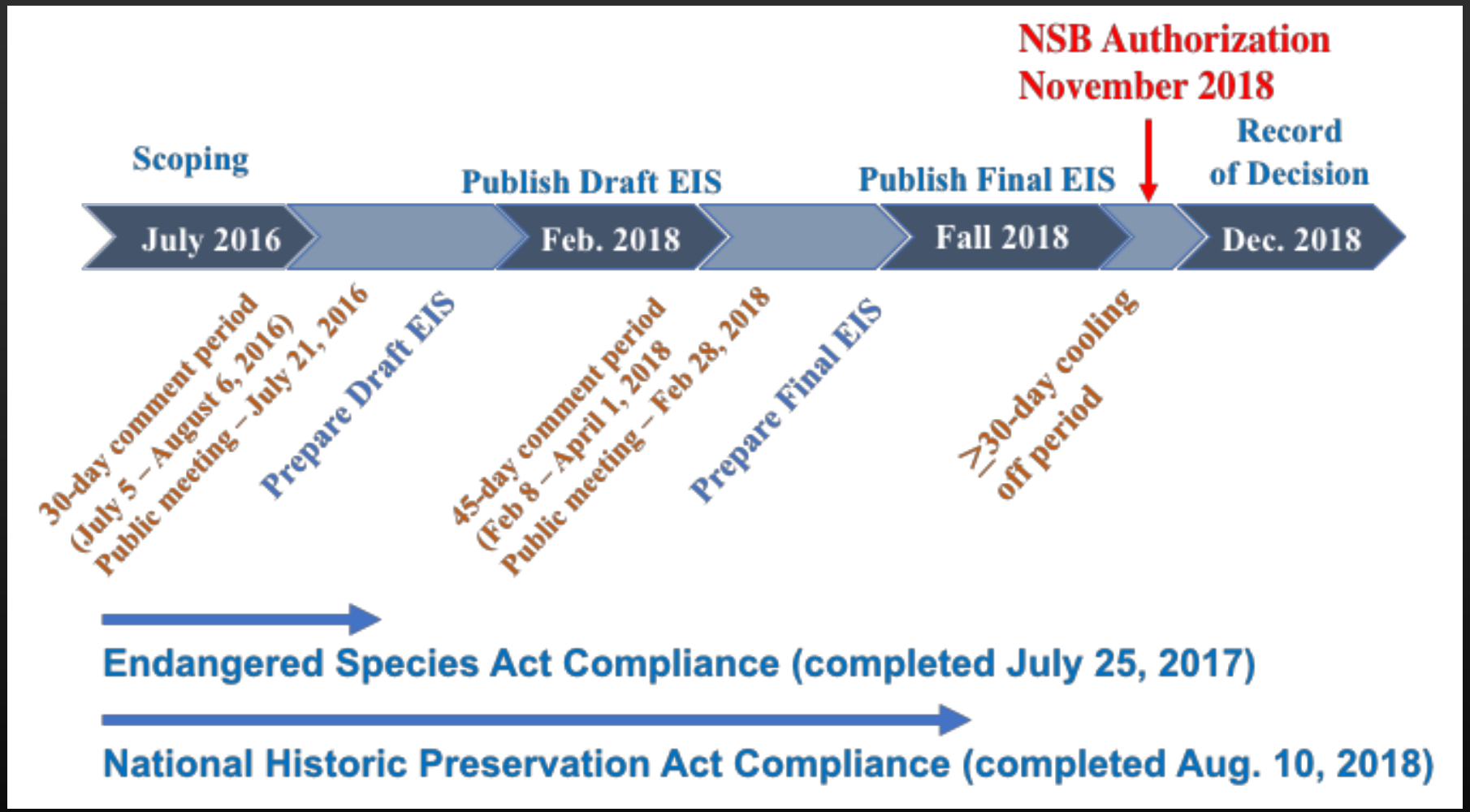
- OPEN ACCESS: *"The best science relies upon selecting the most compelling astrophysics investigations. Access to a large astrophysics project or facility (typically observing time) should be allocated through an open, merit-based process, recognizing that some level of preferred access may be reasonable for the implementing consortium and the funding partners to reap the benefits of their telescope investments. Calls for proposals extending beyond the implementing consortium should be open to the global astrophysics community."*

Back-up Slides

Timeline to Sunspot Solar Observatory



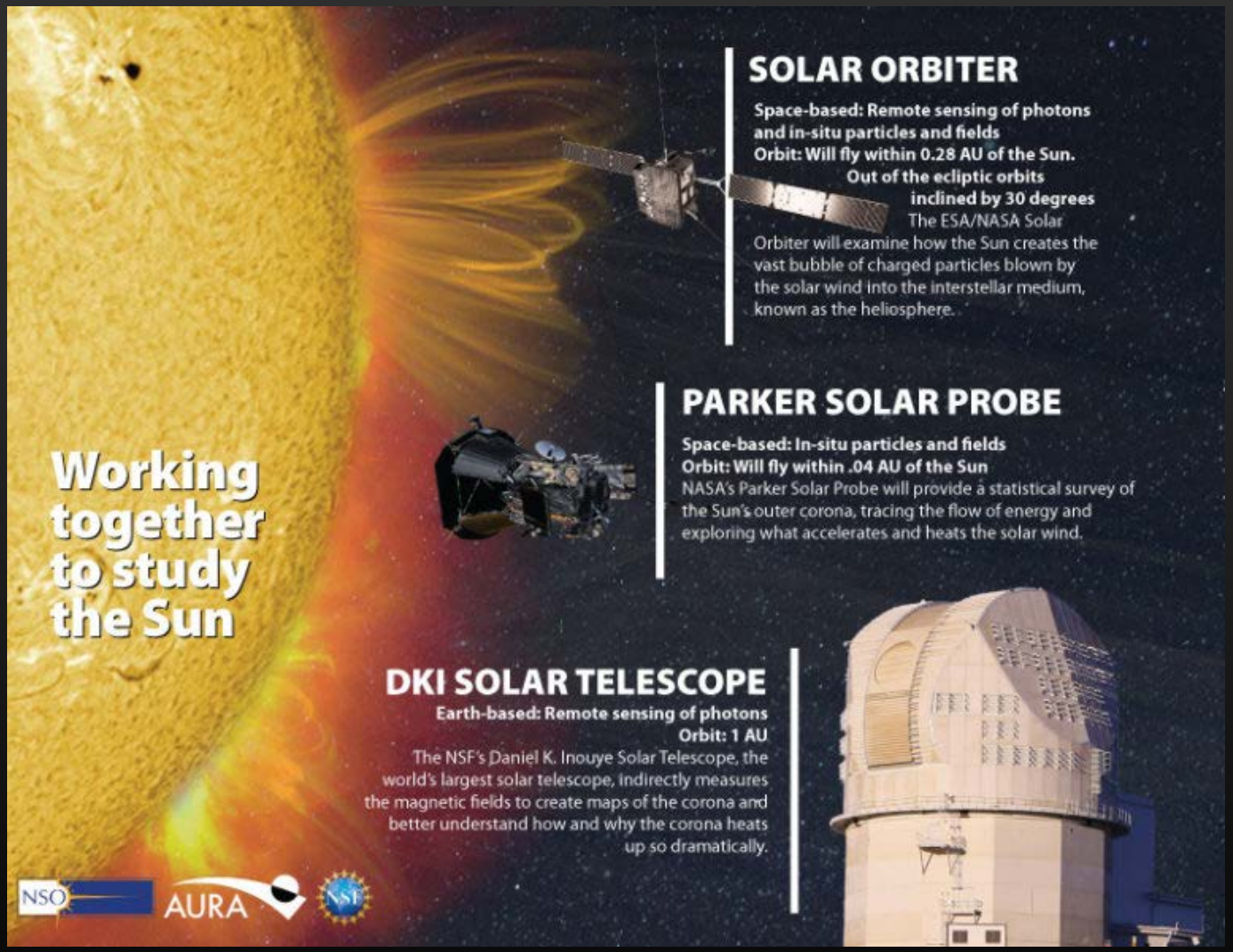
Sac Peak Compliance Schedule



Big Ideas Where MPS/AST Can Compete

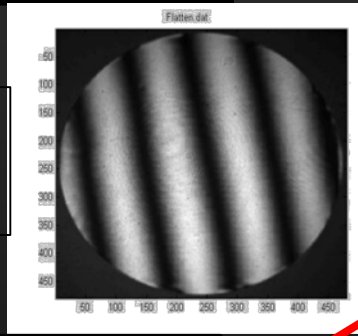
Multi-Messenger Astrophysics of the Sun

From the NSO Director's Blog



The DKIST Coudé Lab level: Feed Optics, AO System, and Instruments

M10 Deformable Mirror – Actively cooled with flexure control accomplished by 1600 actuators



DM flattened to
4 nm RMS
Best ever achieved!

Wave Front Correction (WFC) system – Heart of the AO system, contains sensors and optics used to sense the wave front and provide corrective feedback to the M10 DM.