Update: The Daniel K. Inouye Solar Telescope (DKIST)

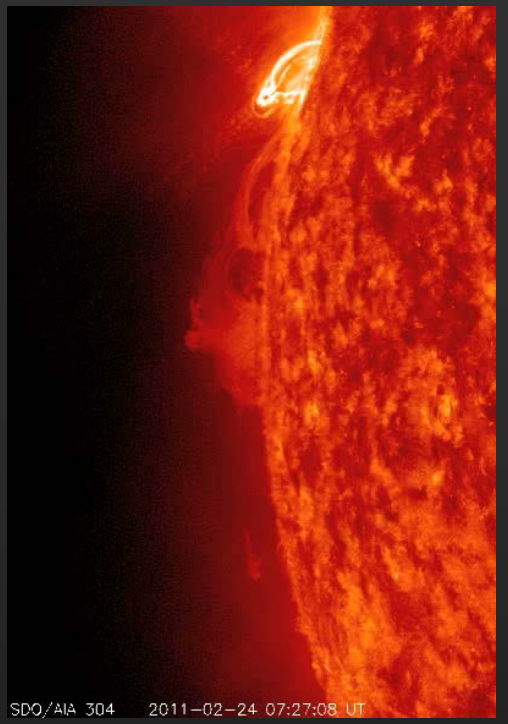
Dave Boboltz (Program Director, NSO/DKIST)

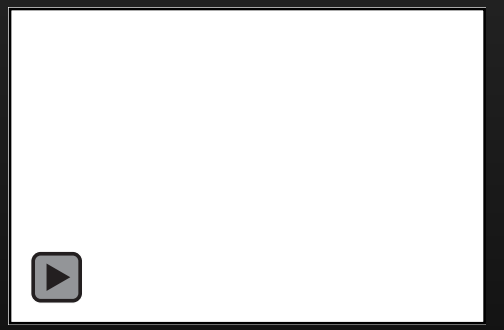
Astronomy and Astrophysics Advisory Committee meeting

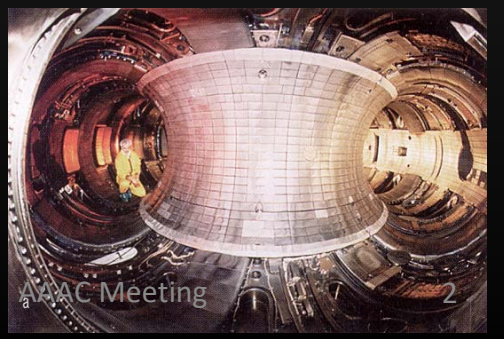
Sept. 27, 2017

The Sun: Our most important astronomical object!

- The Sun is a laboratory for Stellar Astrophysics
  - Because of its proximity it can be resolved and studied like no other star
- The Sun drives the Space Weather that impacts Earth
  - Earth-Sun interactions can shed light on exo-planet systems
- The Sun is a laboratory for Plasma Physics
  - magnetic fields & fusion experiments

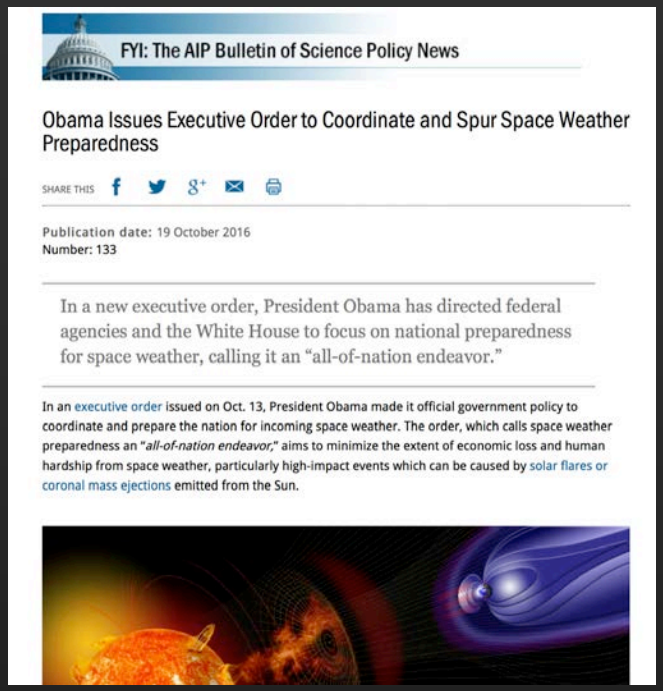






DKIST and Space Weather

- Oct. 2016 Executive Order continues NSWS/NSWAP efforts
- *"The Director of the National Science Foundation (NSF) shall support fundamental research linked to societal needs for space weather information through investments and partnerships, as appropriate."*
- DKIST will help us understand the fundamental physics that drive Space Weather.



FYI: The AIP Bulletin of Science Policy News

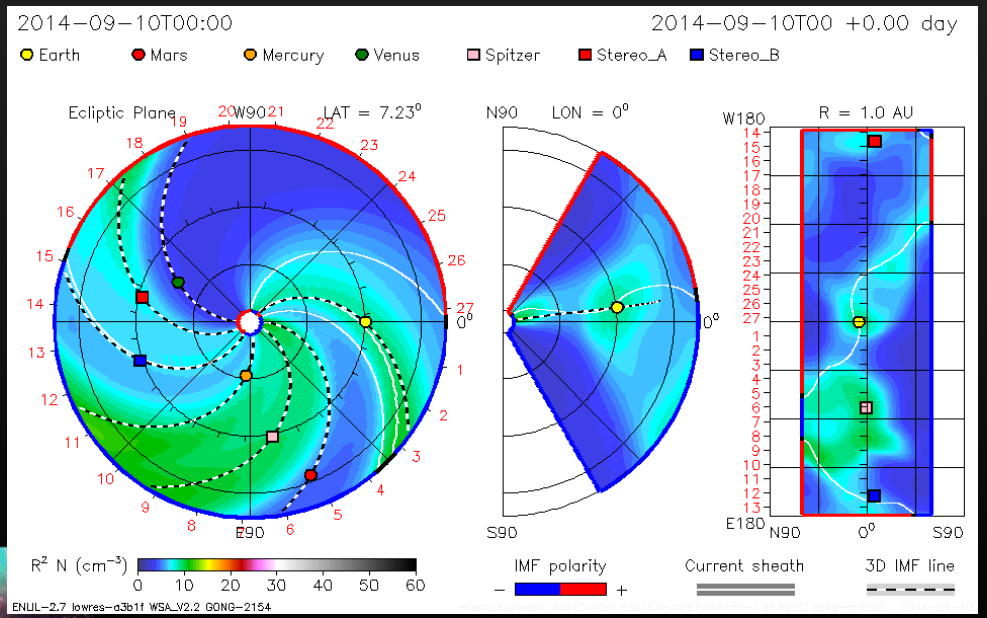
Obama Issues Executive Order to Coordinate and Spur Space Weather Preparedness

SHARE THIS

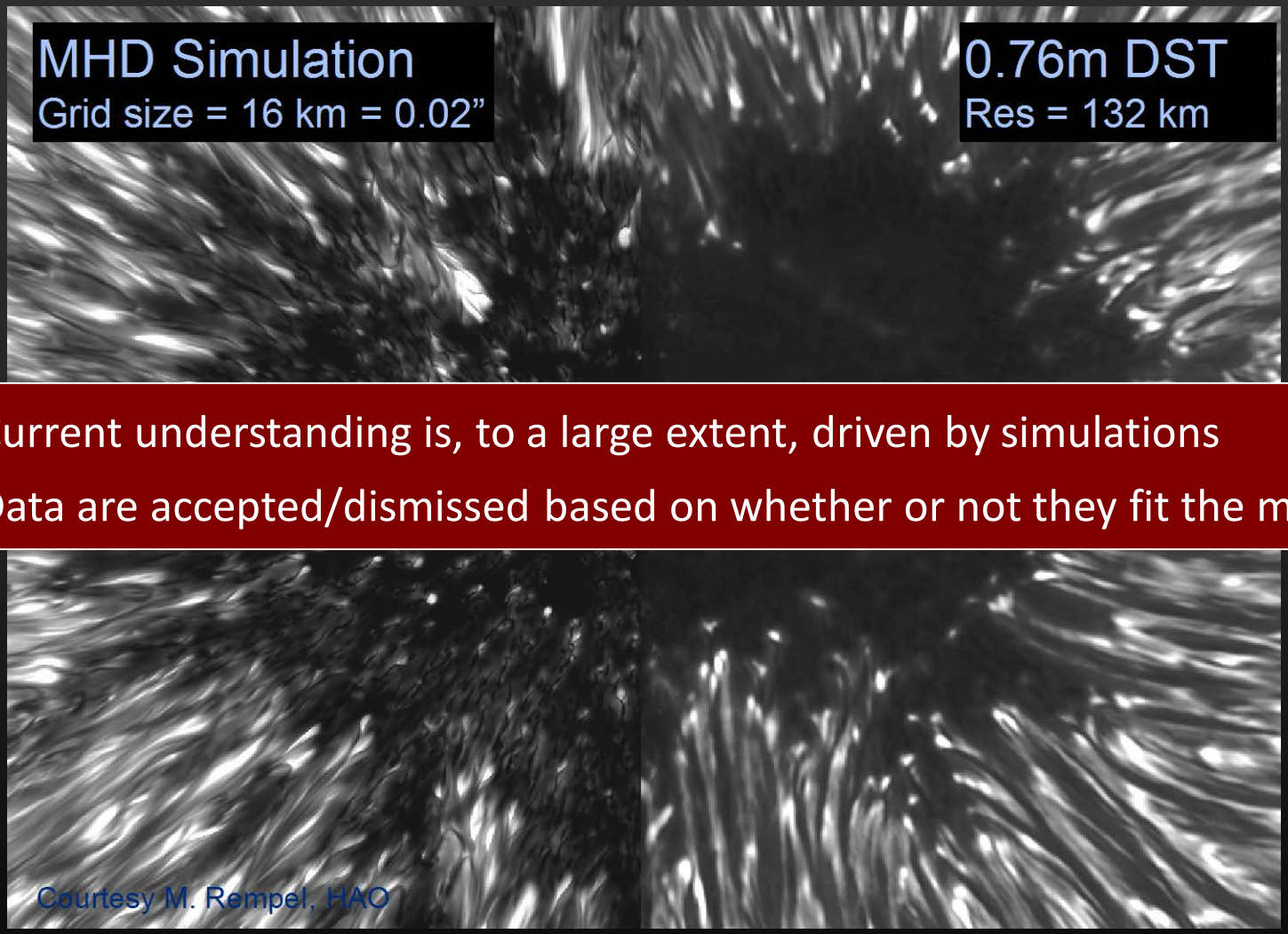
Publication date: 19 October 2016
Number: 133

In a new executive order, President Obama has directed federal agencies and the White House to focus on national preparedness for space weather, calling it an "all-of-nation endeavor."

In an executive order issued on Oct. 13, President Obama made it official government policy to coordinate and prepare the nation for incoming space weather. The order, which calls space weather preparedness an "*all-of-nation endeavor*," aims to minimize the extent of economic loss and human hardship from space weather, particularly high-impact events which can be caused by solar flares or coronal mass ejections emitted from the Sun.



Simulation vs. Observation

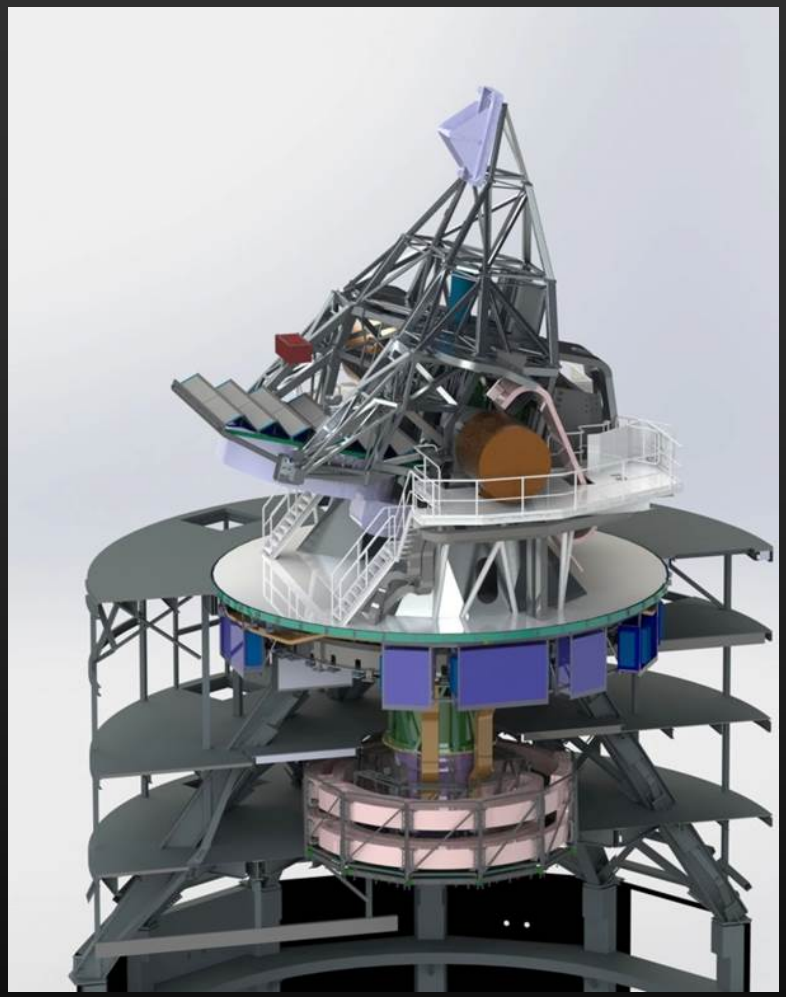


- Current understanding is, to a large extent, driven by simulations
- Data are accepted/dismissed based on whether or not they fit the model

The DKIST Telescope

- 4.2-m, off-axis Gregorian (all reflective), alt-az mount
- Integrated adaptive optics
- Enclosure with thermal control and dust mitigation
- Wavelength sensitivity from 0.3 - 28 microns (near-UV to infrared)
- Field of view: 2 - 5 arcmin
- Angular resolution: <0.03 arcsec (20km at the solar surface)
- Polarization accuracy: 10^{-4} of intensity

DKIST will be the world's flagship facility for ground-based solar physics.



DKIST Site Atop Haleakala, Maui, HI

DKIST Chronology

• Design and Development Study	2001
• Preliminary Design Review	October 2006
• Final Design Review established the project baseline	May 2009
• Awards totaling $298M authorized (NSB-09-57)	August 6, 2009
• Federal environmental compliance completed	December 2, 2009
• Construction funding (ARRA & MREFC) awarded	January 2010
• Anticipated access to Haleakala site pending	June 2010
• CDUP Issued by BLNR	December 2, 2010
• CDUP challenged by Kilakila o Haleakala	December 3, 2010
• Contested case hearing	July 2011
• BLNR issues final decision affirming the CDUP	November 9, 2012
• Final access to site granted	November 30, 2012

30 month delay relative to original baseline – June 2010 to December 2012

• Re-baseline $344.12 authorized (NSB-13-42)	August 16, 2013

Final Hawaiian Supreme Court Ruling: Oct. 6, 2016

abc NEWS Election U.S. World Entertainment ...

Hawaii Supreme Court Affirms Maui Solar Telescope Permit

By JENNIFER SINCO KELLEHER, ASSOCIATED PRESS
HONOLULU — Oct 6, 2016, 11:44 PM ET

SHARE

Hawaii's Supreme Court o
telescope on a Maui moun

The ruling denies a challer
sacredness of the summit
University of Hawaii follow
assessment, the Supreme

khon2

NEWS ▾ WEATHER ▾ WAKE UP 2DAY ▾ LIVING808 ▾ SPORTS ▾ TRAFFIC ▾ REPORT IT

Hawaii Supreme Court upholds telescope construction on Haleakala

By Web Staff
Published: October 6, 2016, 7:58 pm | Updated: October 6, 2016, 10:51 pm

The Maui News

State Supreme Court upholds telescope permit

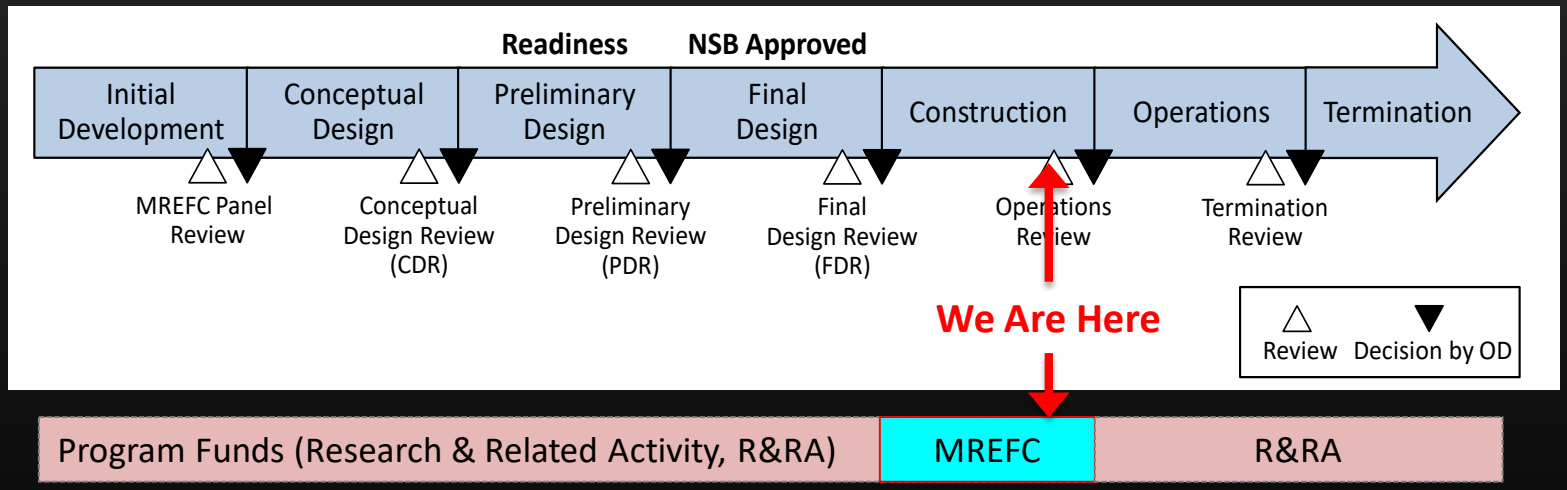
LOCAL NEWS

LEE IMADA
Managing Editor
leeimada@mauinews.com

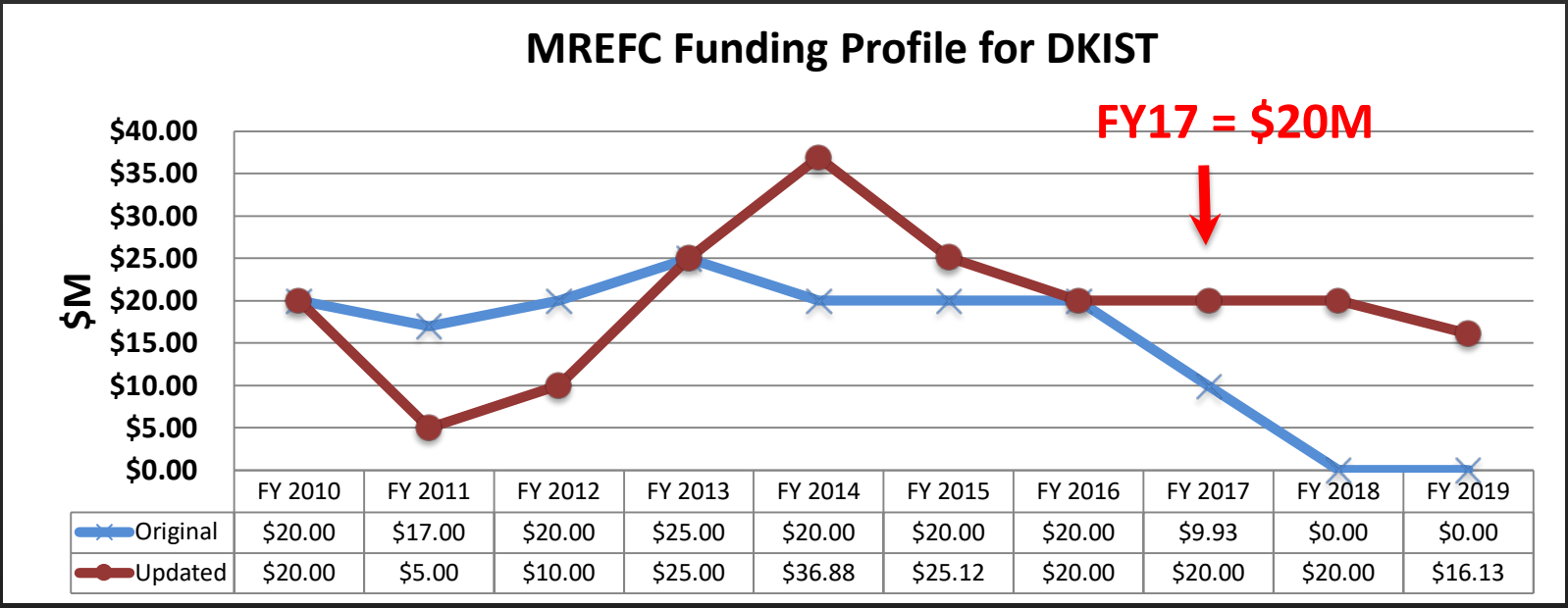
TWEET SHARE

The Hawaii Supreme Court upheld a state permit for the construction of the Daniel K. Inouye Solar Telescope atop Haleakala. This photo was taken of the $340-million telescope was taken in June. The Maui News / MATTHEW THAYER photo

DKIST in the NSF Facility Lifecycle



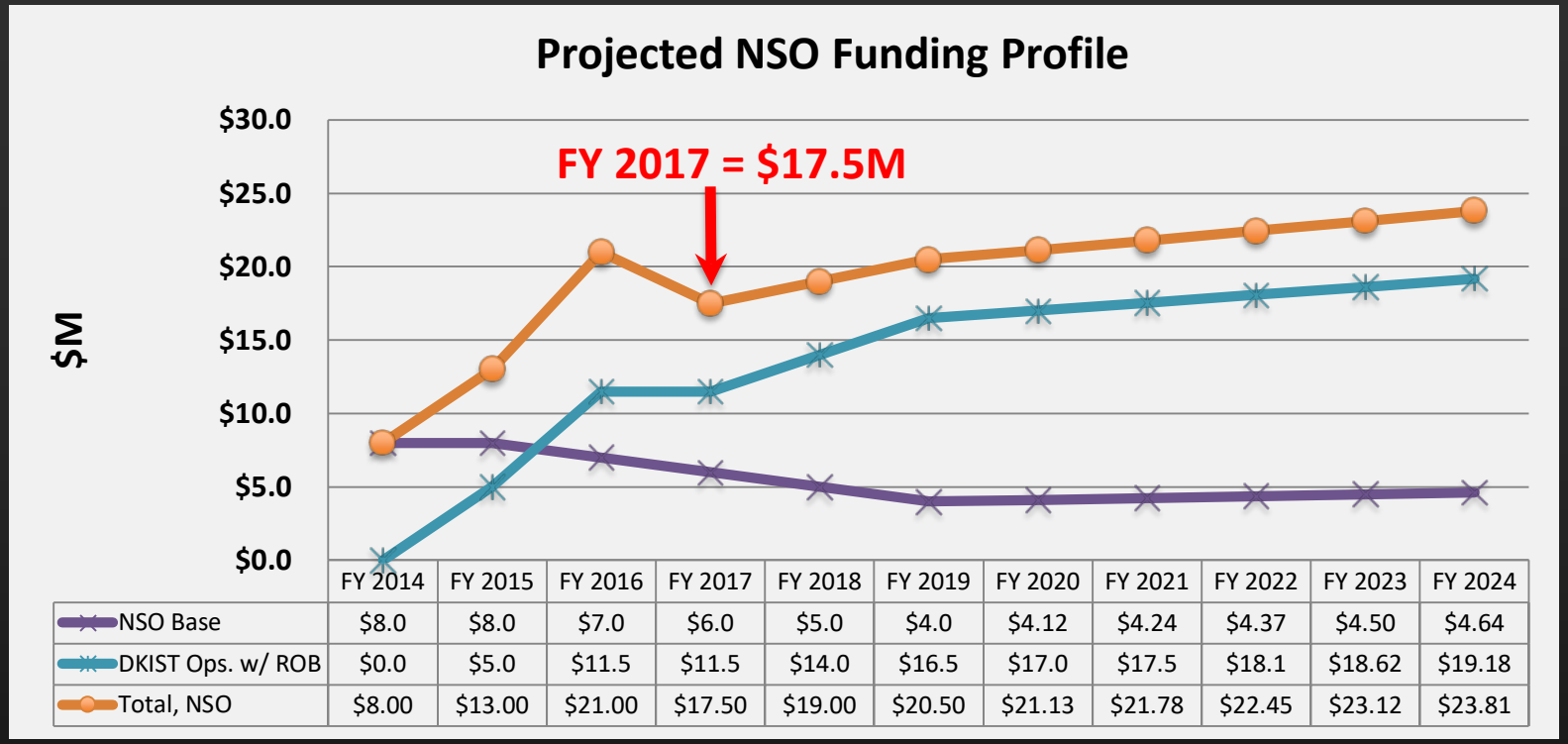
DKIST Construction Funding (MREFC)



	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
- FY 2017 MREFC $20M approved by NSB
  - $18.3M awarded (April 2017)
  - $1.7M (33% of contingency amount) withheld for future allocation

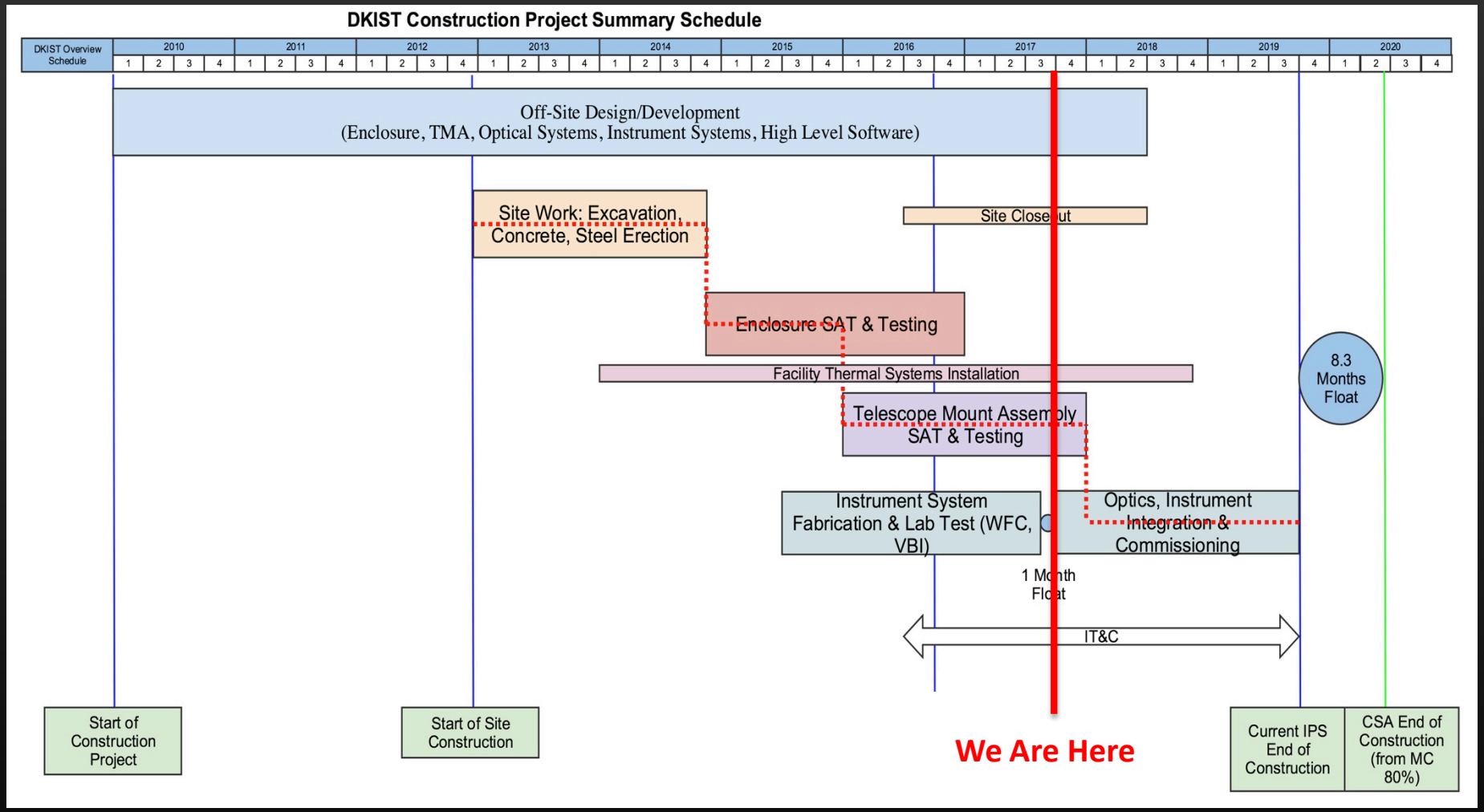
NSO Operations & Maintenance (R&RA)



	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
NSO Base	$8.0	$8.0	$7.0	$6.0	$5.0	$4.0	$4.12	$4.24	$4.37	$4.50	$4.64
DKIST Ops. w/ ROB	$0.0	$5.0	$11.5	$11.5	$14.0	$16.5	$17.0	$17.5	$18.1	$18.62	$19.18
Total, NSO	$8.00	$13.00	$21.00	$17.50	$19.00	$20.50	$21.13	$21.78	$22.45	$23.12	$23.81

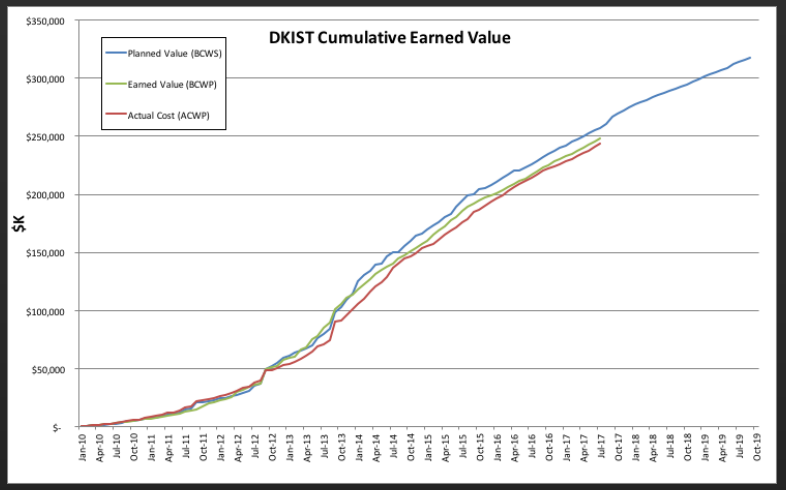
- Total projected through FY 2024 = $201.84M
- FY 2017 O&M awarded = $17.5M
  - NSO base = $6M
  - DKIST ops = $11.5M

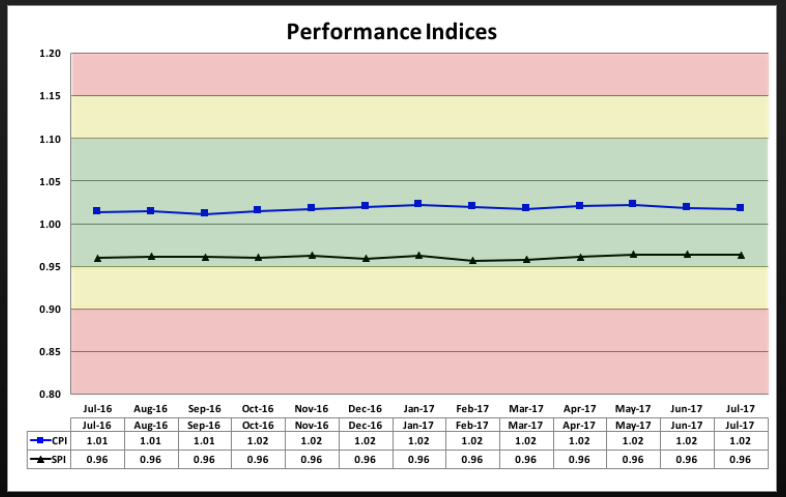
DKIST Summary Schedule



DKIST Cost and Schedule Status (July 31, 2017)

- Project 78% complete
- Budget
  - NSF Funding to date = $306.3M ($146M ARRA)
  - Actuals + Commitments = $263.0M
  - Budget Contingency = $25.9M (36.8% of remaining estimate to complete)
    - Appropriate considering remaining risks.
- Schedule
  - 80% MC CL end date = June 10, 2020
  - Current IPS end date = Oct. 30, 2019
  - Schedule Contingency = 7.3 months

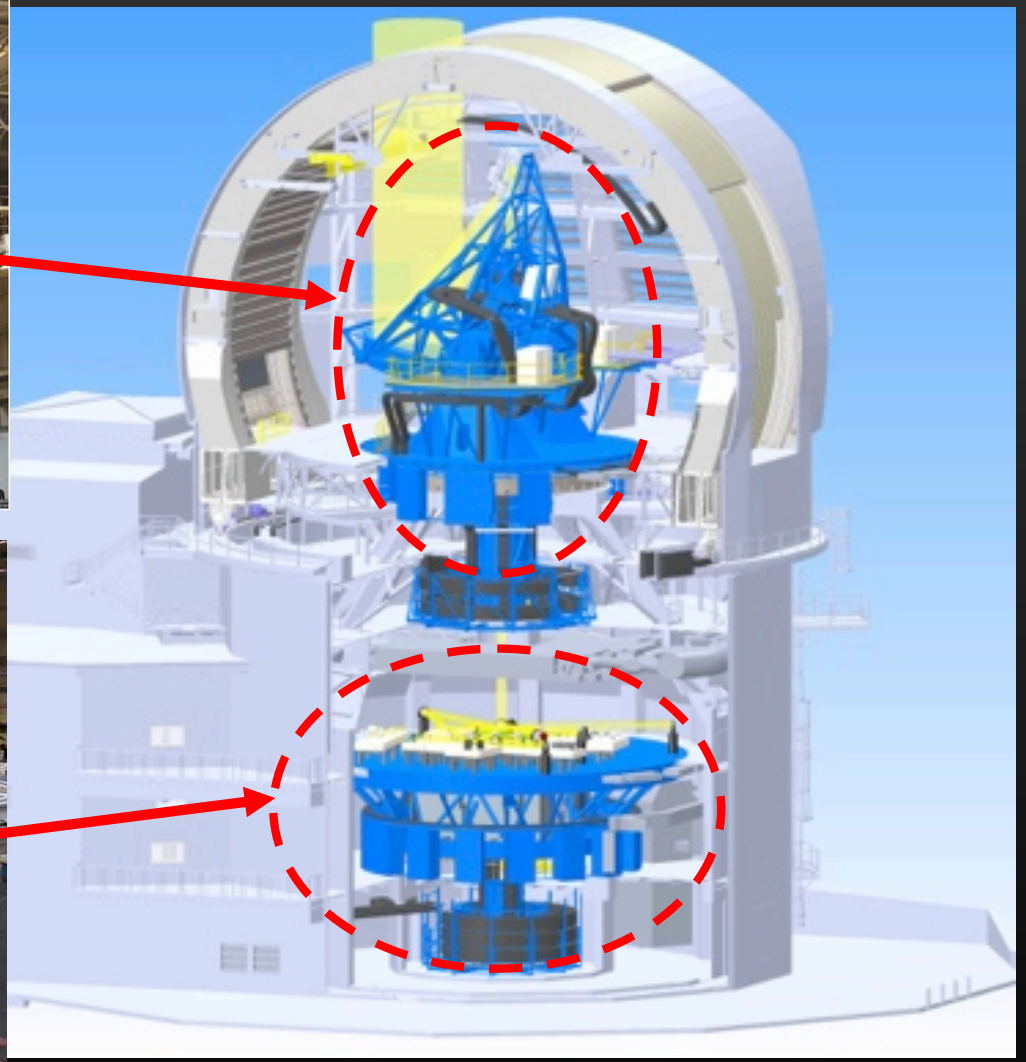




	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17
CPI	1.01	1.01	1.01	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
SPI	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96

Current Construction Site

DKIST Cutaway View



Telescope Mount Progress: Mar. – Sept., 2017

M1 Mirror polishing completed Dec. 2015

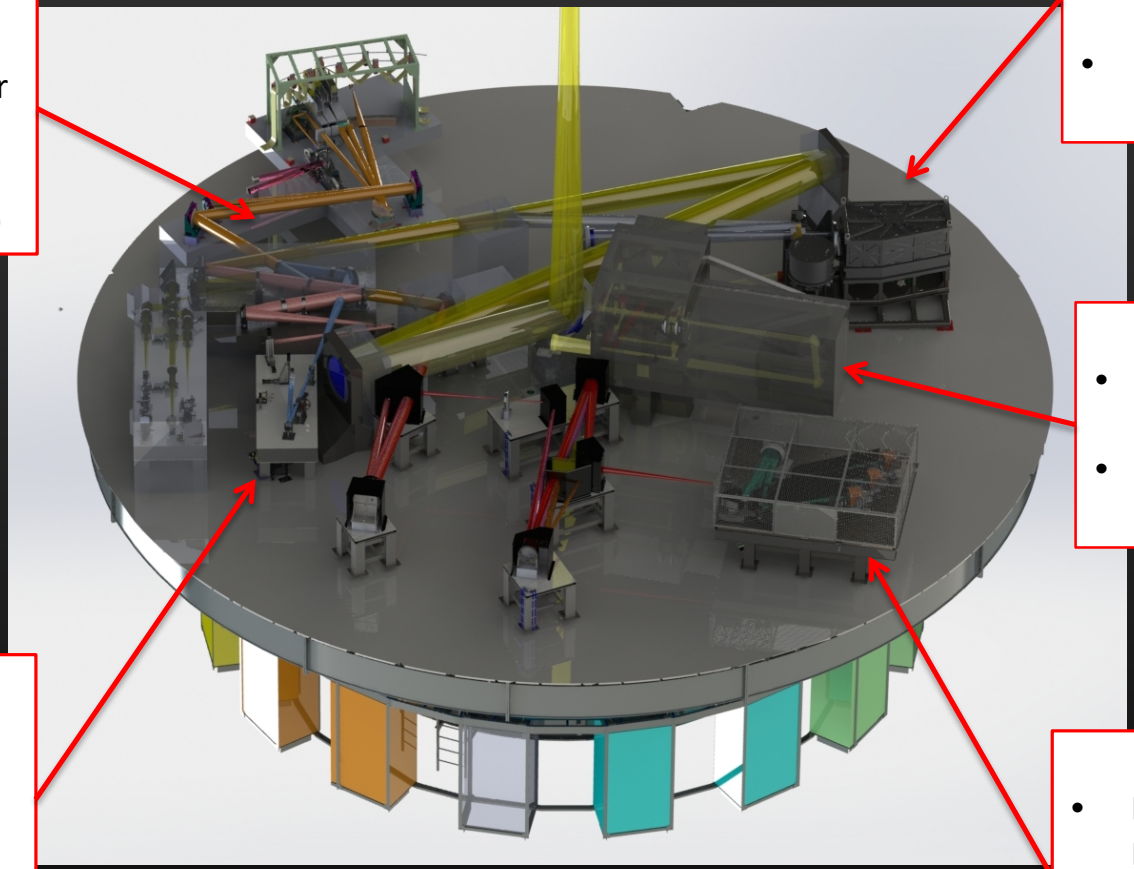
M1 Transport to Summit: August 2, 2017

Success!!!
Last extra-wide load

Instruments

ViSP
- Visible Spectropolarimeter
- Being Built by: the High Altitude Observatory (HAO)

Cryo-NIRSP
- Cryogenic Near-infrared Spectropolarimenter
- Being Built by: University of Hawaii

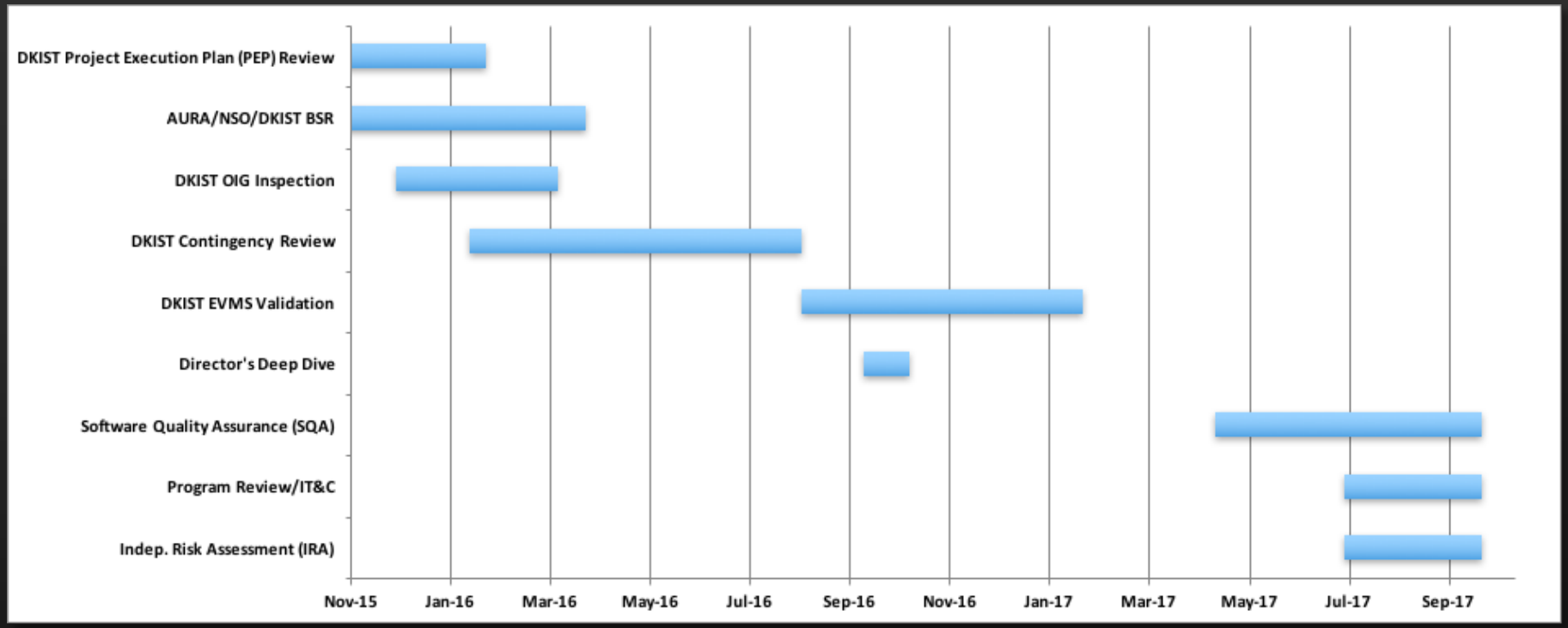


VTF
- Visible Tunable Filter
- Being Built by: KIS, Germany

VBI
- Visible Broadband Imager
- Being Built by: the National Solar Observatory (NSO)

DL-NIRSP
- Diffraction Limited Near-infrared Spectropolarimeter
- Being Built by: University of Hawaii

NSF oversight since last PEP review



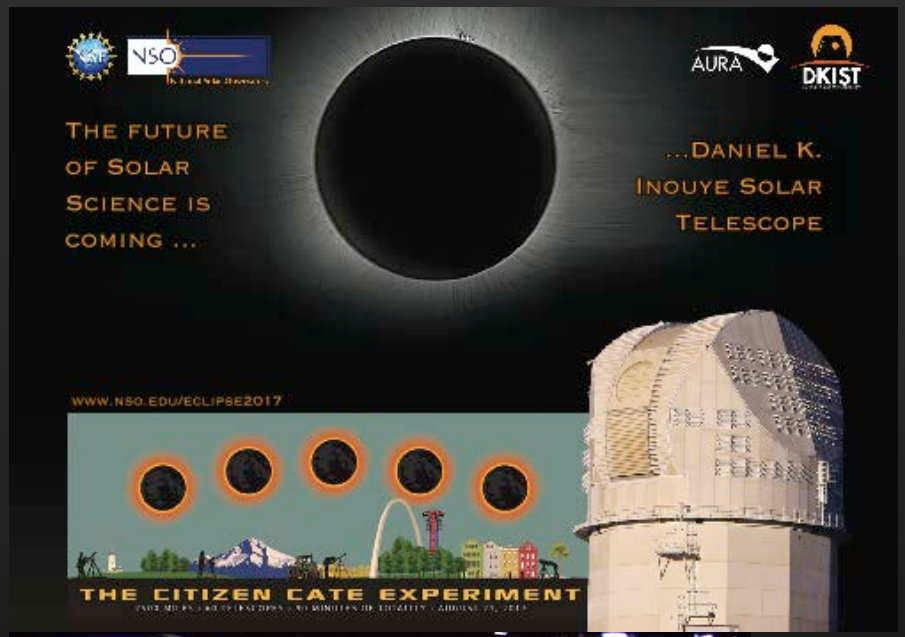
- Recent/ongoing reviews
  - Software Quality Assurance (LFO-led; contractor)
  - PEP and Construction Status (AST-led; external panel)
  - Independent Risk Assessment (LFO-led; contractor)

Community: DKIST CSP Workshops

- NSO issued RFP for topical Critical Science Plan workshops
- 12 workshop proposals received
- Total number of workshops approved: 9
- Total number of scientists in approved proposals: 165
- Expected number of science use cases: 99
- All workshops open to community participation
- Website: http://www.nso.edu/cspw.php

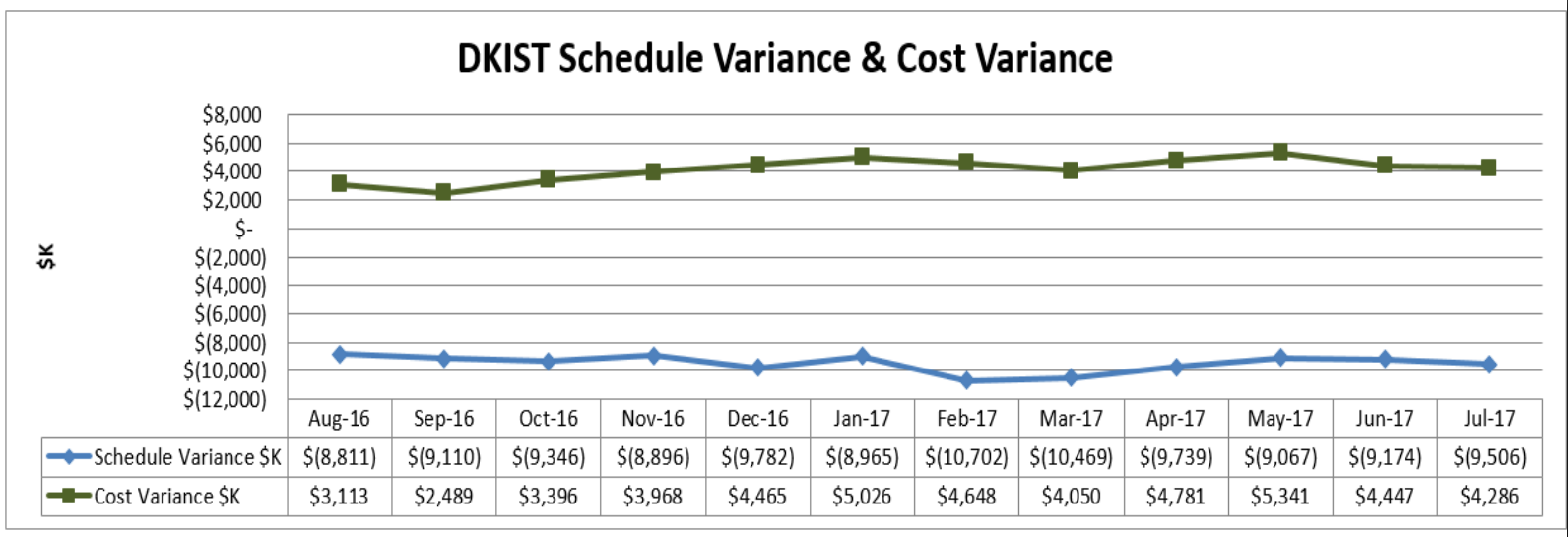
Workshop	Topic	Location(s)
IfA (some CfA)	Corona	Pukalani, Maui, HI
NMSU+UK	Connectivity (waves)	Las Cruces, NM/Newcastle, UK
SO/SPP	SO/SPP	JHU/APL (Laurel, MD)
UAH+Tokyo	Reconnection	Huntsville, AL/Tokyo, Japan
KIS (some CSUN)	MHD and Dynamo Processes	Freiburg, Germany
Rice	Flares	Houston, TX
Catholic U	Connectivity	Washington, DC
NSO/CU Boulder	Synoptic	Boulder, CO
Montana State	Special	Bozeman, MT

The 2017 Eclipse: A Public Outreach Opportunity to Promote DKIST

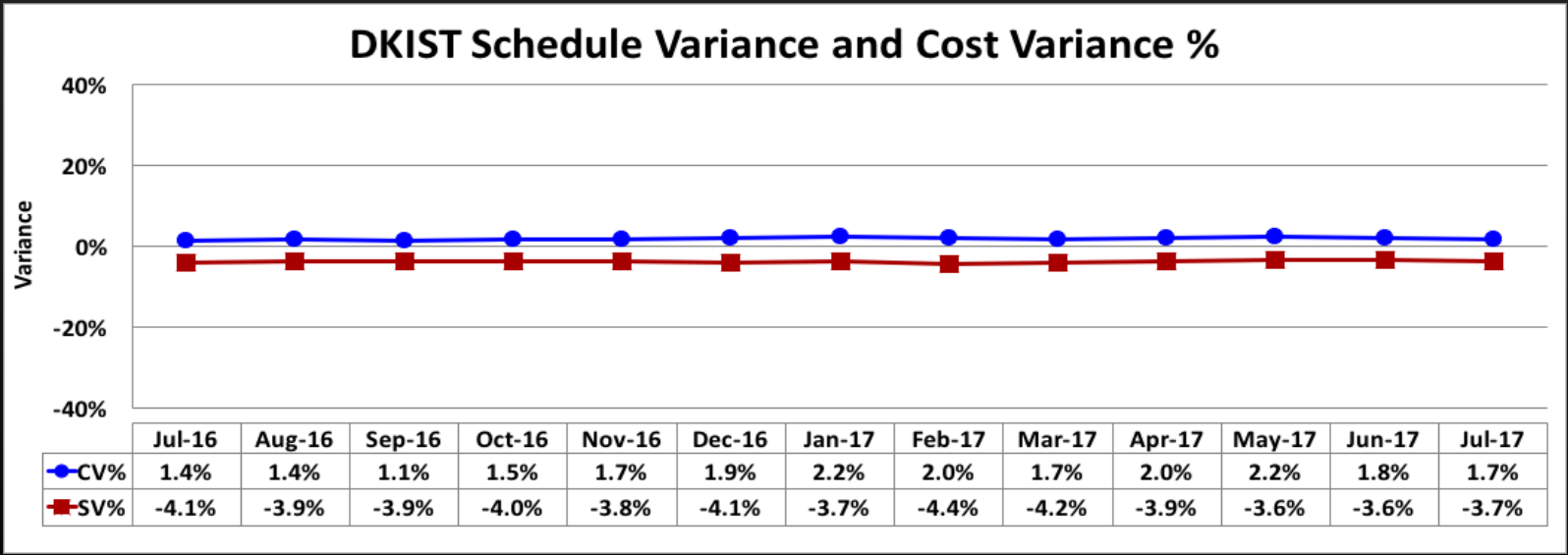


Back-up Slides

Variances

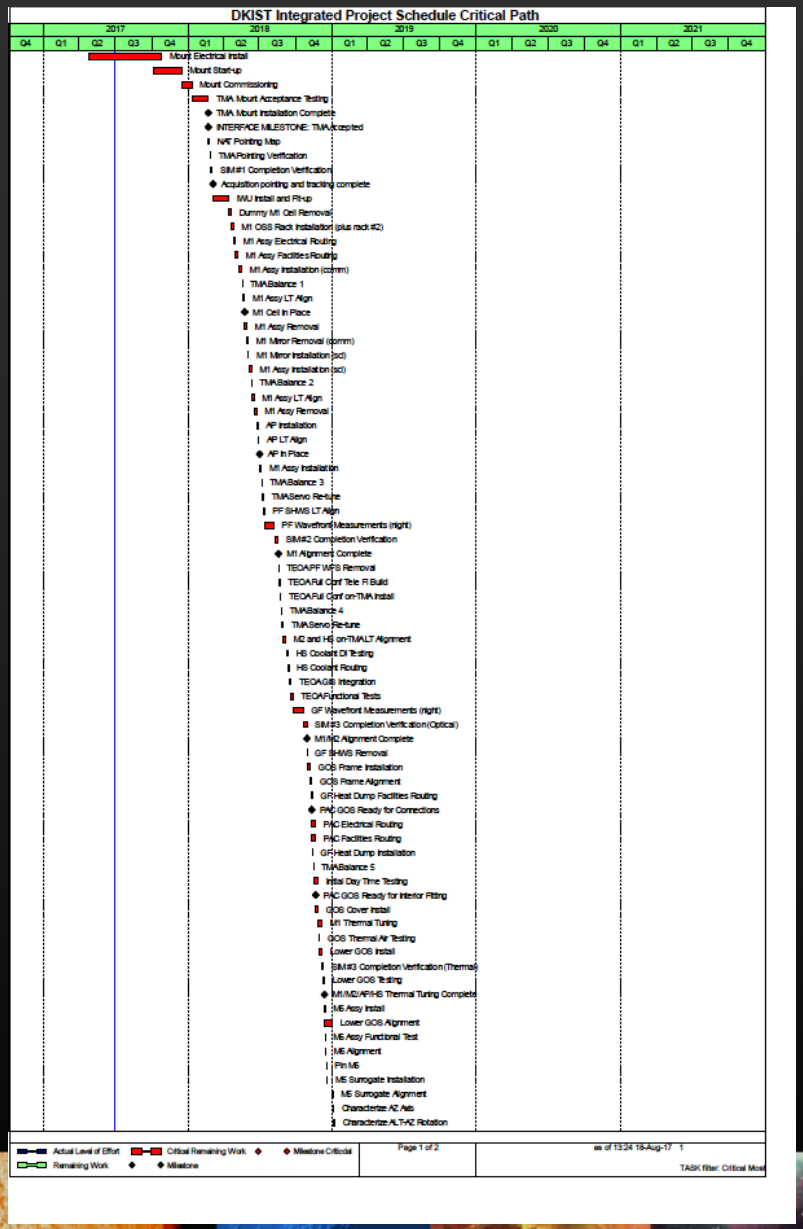


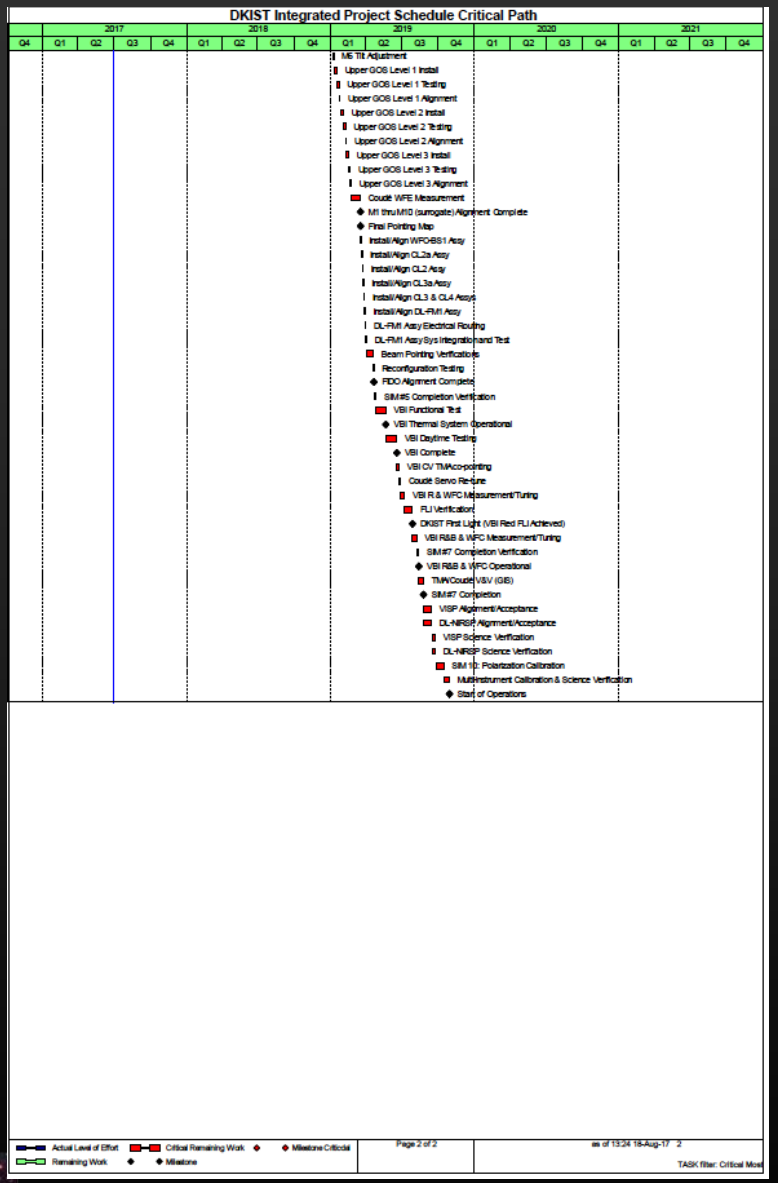
	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17
Schedule Variance $K	$(8,811)	$(9,110)	$(9,346)	$(8,896)	$(9,782)	$(8,965)	$(10,702)	$(10,469)	$(9,739)	$(9,067)	$(9,174)	$(9,506)
Cost Variance $K	$3,113	$2,489	$3,396	$3,968	$4,465	$5,026	$4,648	$4,050	$4,781	$5,341	$4,447	$4,286



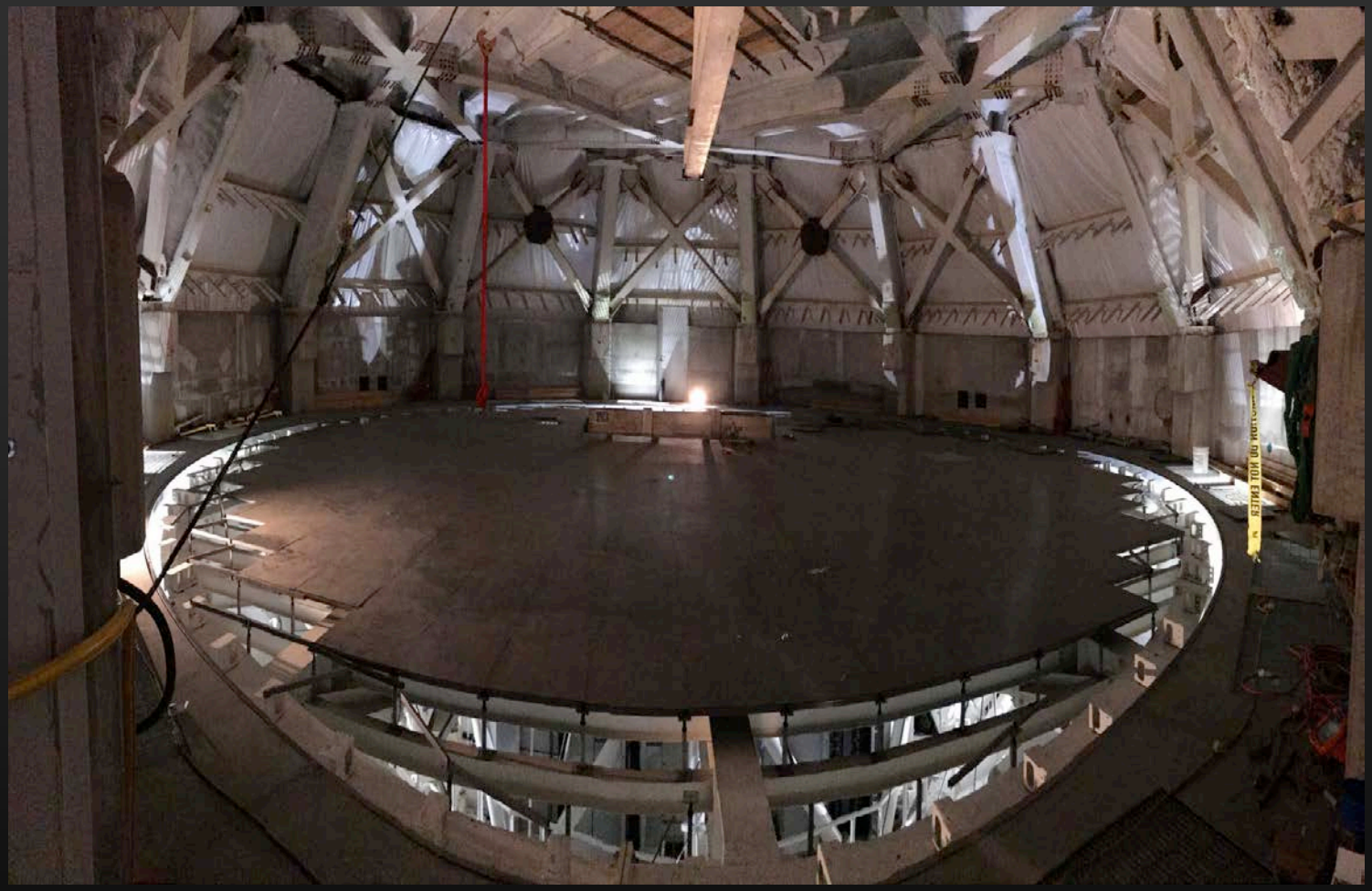
	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17
CV%	1.4%	1.4%	1.1%	1.5%	1.7%	1.9%	2.2%	2.0%	1.7%	2.0%	2.2%	1.8%	1.7%
SV%	-4.1%	-3.9%	-3.9%	-4.0%	-3.8%	-4.1%	-3.7%	-4.4%	-4.2%	-3.9%	-3.6%	-3.6%	-3.7%

DKIST Critical Path CY 2018 - 2019





Coudé Rotator Platform

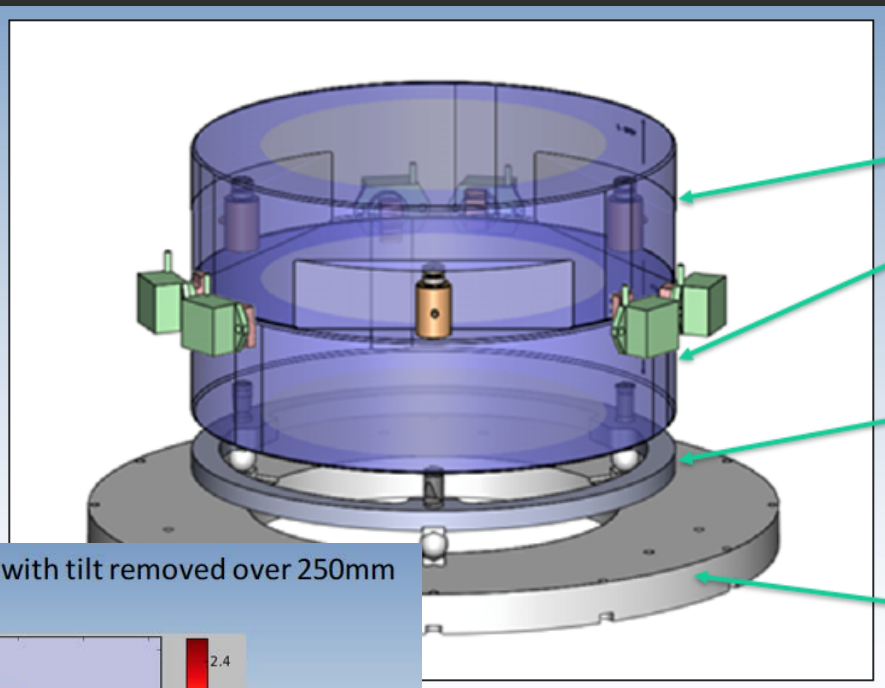


- Completed site acceptance testing (SAT) July, 2017

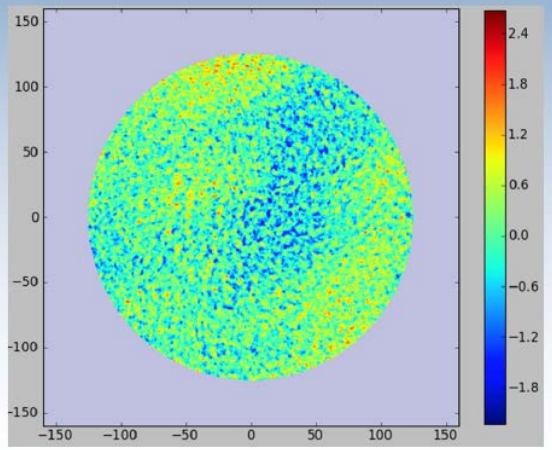
M1 Journey Tucson, AZ – Maui, HI via San Diego, CA, May 8–26, 2017

VTF: Excellent progress with key technology

- Etalon plates manufactured by Zygo Corp.
- Manufactured LIGO mirrors
- Sub-nm tolerances



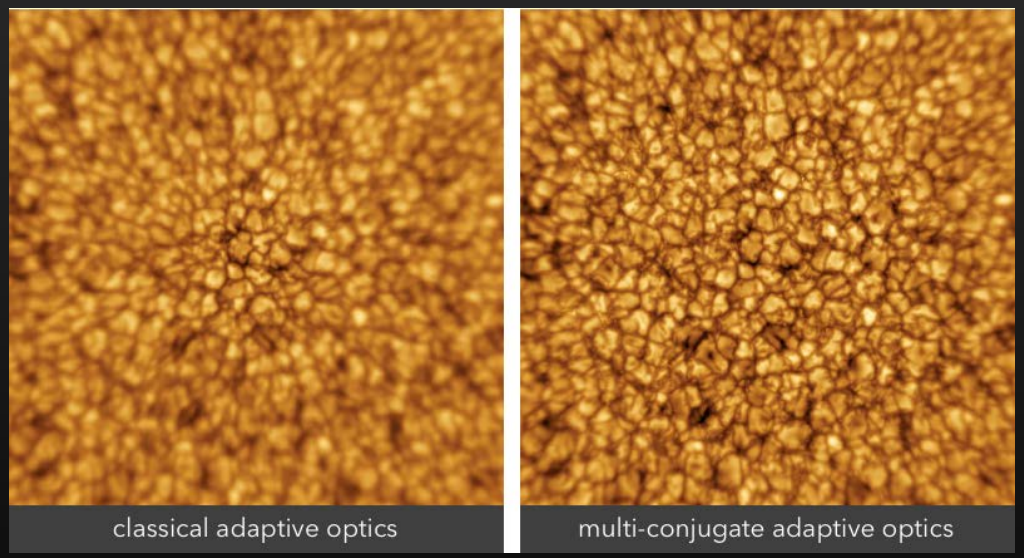
Average of the 3 measurements with tilt removed over 250mm diameter aperture.

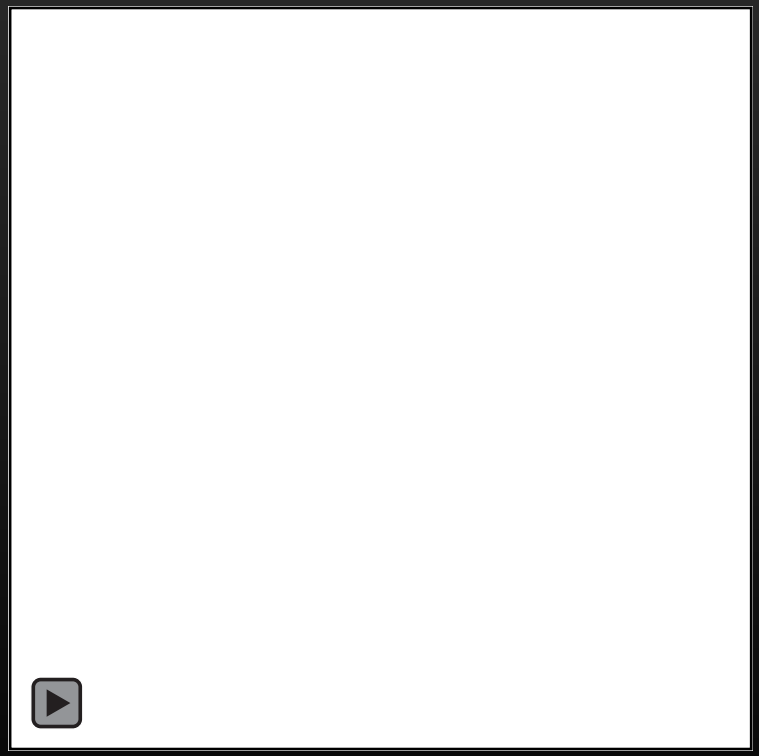


0.542nm RMS 4.895nm PV

Multi-Conjugate Adaptive Optics (MCAO)

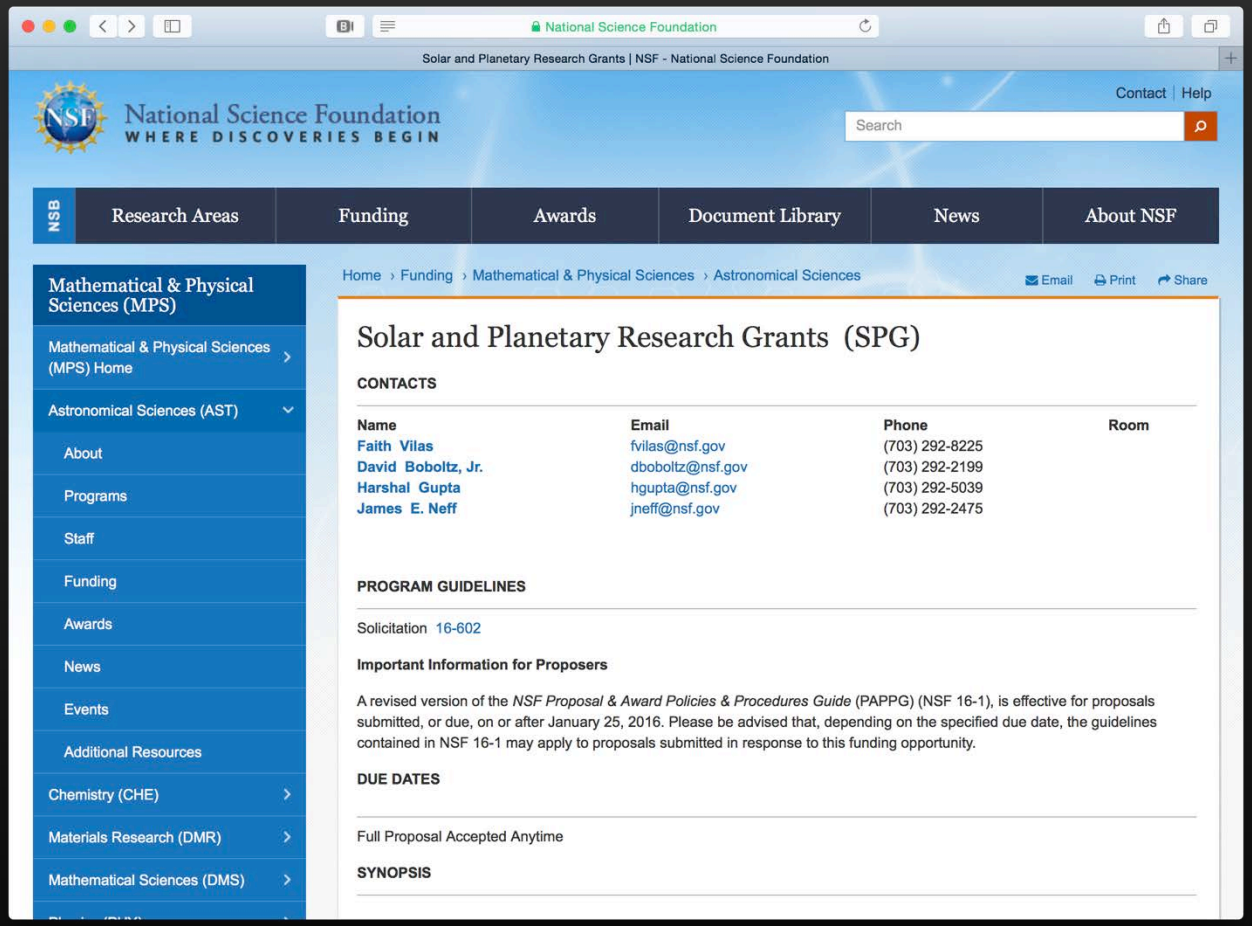
- MCAO under development at Big Bear Solar Observatory (BBSO)
- Uses 3 deformable mirrors to compensate for turbulence at 3 different heights in the atmosphere
- NSO personnel leading the effort
- NSF funded through AST-ATI award
- Pathfinder for DKIST next-generation AO system





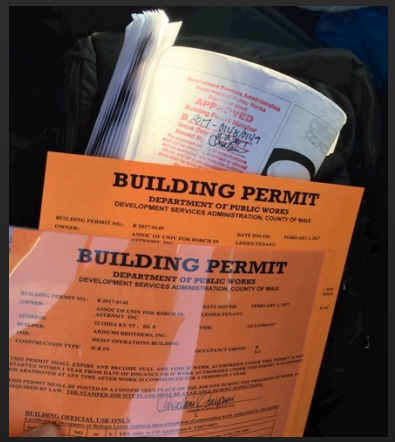
AST No-deadline SPG Pilot Program

- SPG split from AAG; started October 2016
- Individual investigator research into solar and planetary astronomy including exo-planets
- 21 solar projects (35 proposals) received to date
- Solar Panel in May
  - 4 projects funded



DKIST Remote Office Building (ROB)

- Located in Pukalani, Maui, HI next to UH-IfA
- NSF approved the purchase of land by AURA (July 31, 2015)
- AURA closed on the land purchase (Aug. 21, 2015)
- Final EA and Finding of No Sig. Impact (FONSI) (Apr. 6, 2016)
- AURA issued RFP to build the ROB (June 30, 2016)
- Bids received (Sept. 6, 2016)
- Project's Selection approved by NSF (Dec. 2, 2016)
  - Contractor Arisumi Bros.
  - $8.321M
- Construction schedule:
  - Site prep (Feb. 2017)
  - Approx. 15 months to complete



ROB Ceremony: March 3, 2017

ROB Construction Progress