NSF Astronomy Update: The National Solar Observatory (NSO) and the Daniel K. Inouye Solar Telescope (DKIST)

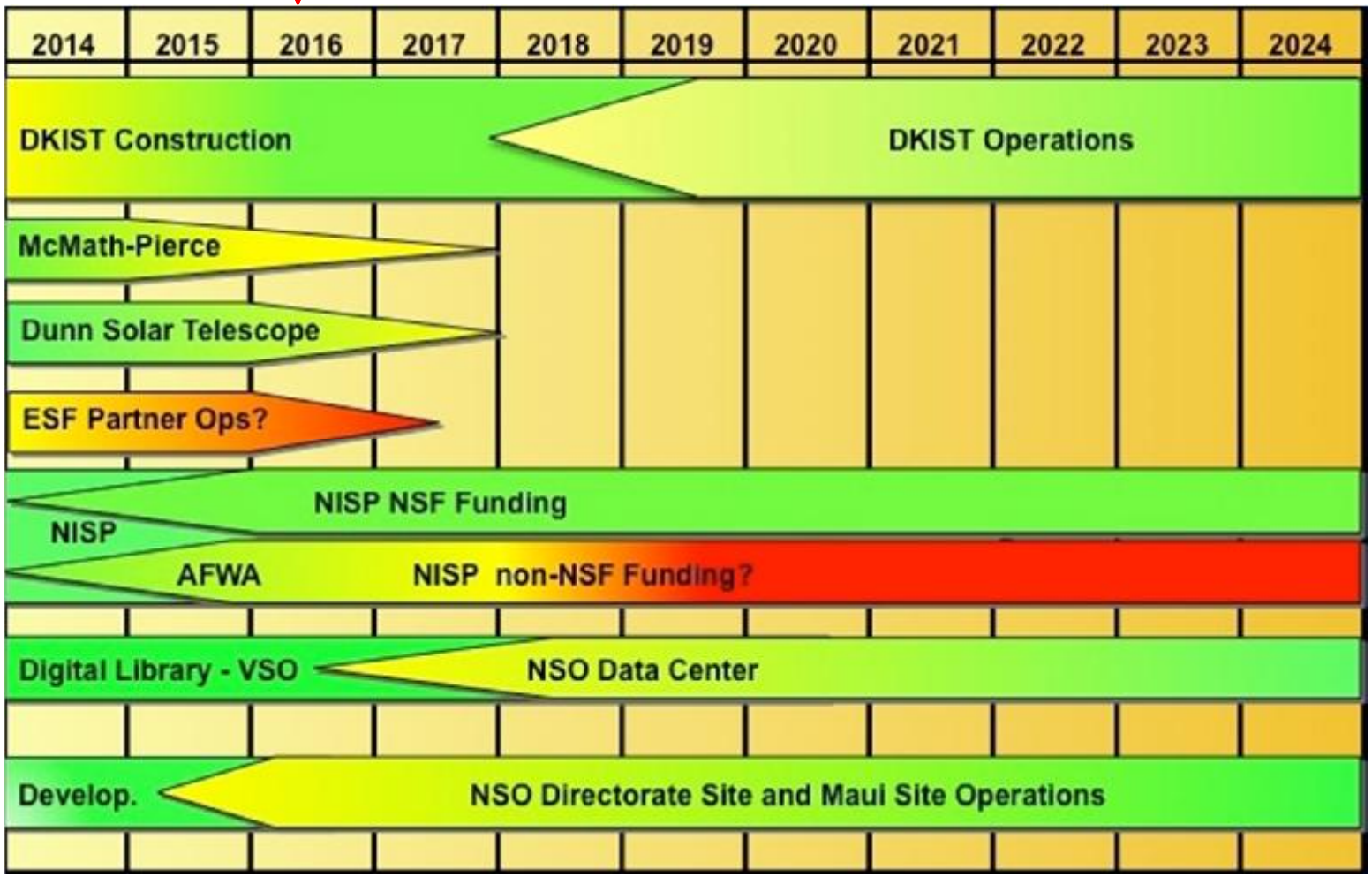
Dave Boboltz (Program Officer, NSO/DKIST)

Committee on Solar and Space Physics (CSSP)

March 29, 2016

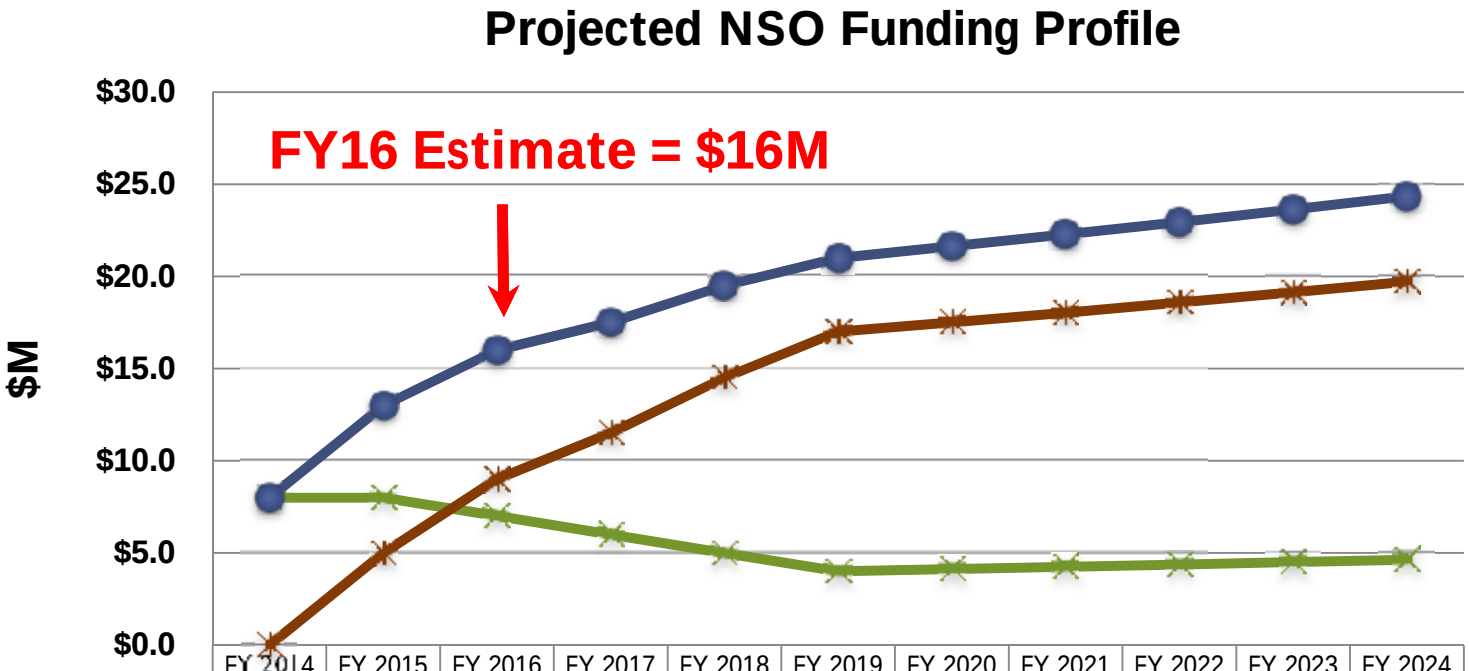
NSO Transition to DKIST Era

We are here



NSO Operations & Maintenance

- Total R&RA through FY 2024 = $201.84M
- FY 2016 estimate = $16M + $2.5M (GONG refurb.)



	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.	$0.0	$5.0	$9.0	$11.5	$14.5	$17.0	$17.51	$18.04	$18.58	$19.13	$19.71
Total, NSO	$8.0	$13.0	$16.0	$17.5	$19.5	$21.0	$21.63	$22.28	$22.95	$23.64	$24.34

NSO Facilities on Sacramento Peak

- Recommended for divestment by the 2012 AST Portfolio Review
- NSF funding ramping down to the end 2017
- NSF engineering/environmental feasibility study underway with contractor (CH2M Hill)
  - Oct. 2015-Feb. 2016: Iteration with contractor over feasibility study
  - April 2016: Final study expected

Partnership Opportunities for Sacramento Peak

- May 2015: Met with National Solar Observatory (NSO) and representatives of universities seeking to create a consortium to operate Sac Peak.
- February 2016: NM State Legislature failed to fund highly rated NMSU request for funds to enable consortium.
- April 2016: Expect final feasibility study. Re-plan with NMSU and NSO. Evaluate cost of bridge from NSO to consortium.
- May-June 2016: Initiate environmental review/alternative consideration.
  - Needed even for continued consortium operations, since cost reduction may require removal of some structures on Sac Peak site.
- Summer 2016: Decide on bridge funding.
- Mid-late 2017: Conclusion of alternative consideration.

NSO Facilities on Kitt Peak

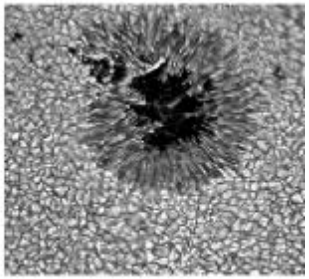
- Recommended for divestment by the 2012 AST Portfolio Review
- NSF minimal operations funding ramping down to 2017
- NSF engineering/environmental feasibility study underway with contractor (CH2M Hill)
  - February 2016: Draft study received
- Still open to partnerships

NSO Integrated Synoptic Program

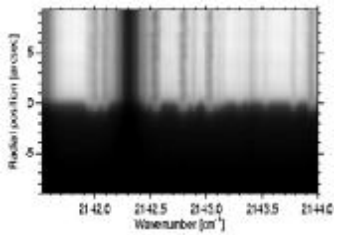
- Consists of SOLIS and GONG
- Recommended for 50% ($2M/year) divestment by the 2012 AST Portfolio Review
- External Federal stakeholders: NOAA-SWPC, AFWA, NASA
- Increased Federal awareness (i.e. NSWS and SWAP) of space weather assets like GONG
- Result: program to "operationalize" GONG in the FY2016 appropriation
  - $2.5M addition to NSF (through AST) for refurbishment
  - $1M/year addition to NOAA for operations
- April 2016: Expect NSF – NOAA MOU to be signed

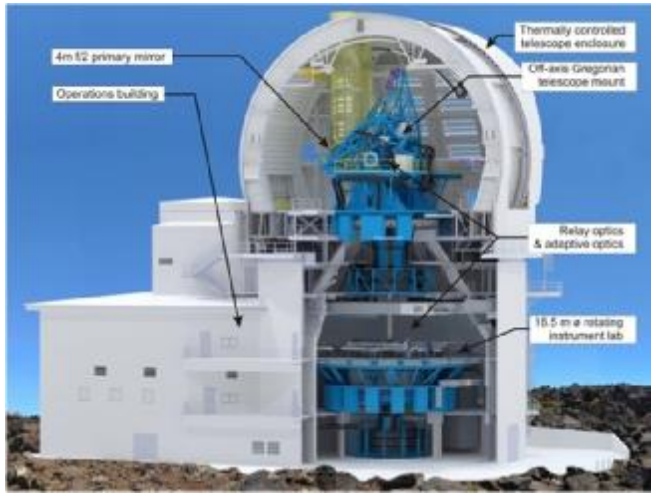
DKIST Will Replace Current National Solar O/IR Facilities

Dunn Solar Telescope
Evans Solar Facility
Sacramento Peak, NM



McMath-Pierce, Kitt Peak, AZ





CSSP: April 2015

CSSP: October 2015

CSSP: March 2016

DKIST Current Site Construction

- Enclosure and S&O Building
  - Some adverse weather this Winter
  - S&O building interior outfitting
  - Upper enclosure nearing completion
- Construction moving inside
  - Coude platform
  - TMA
- On schedule for a 2019 completion

Photo credit: Scott Lacasse

M1 Mirror Polishing Completion: Dec 2015

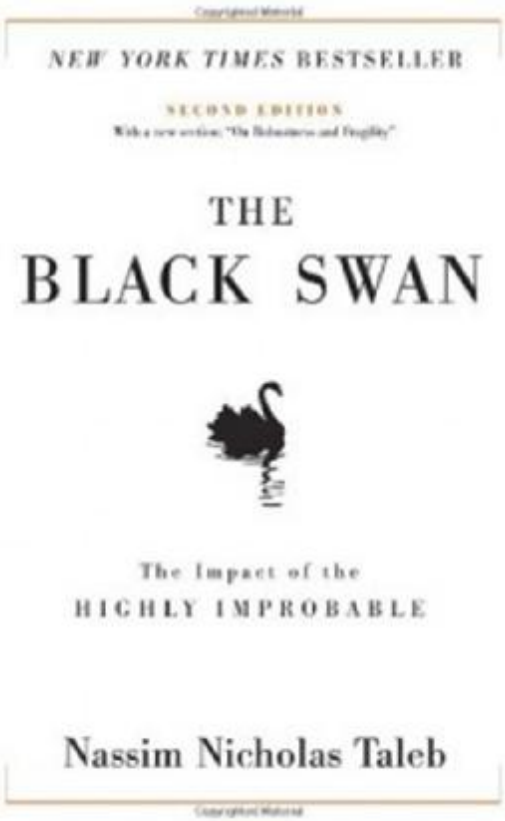
Work Beginning Inside Enclosure

DKIST Project Execution Plan and Construction Status Review

- Panel took place Dec. 7 – 9, 2015 in Tucson, AZ.
- Final Report
  - received Dec. 15, 2015, a month ahead of schedule
- From the Executive Summary:
  - *"The Panel finds DKIST's budget, schedule and scope performance against plan to be excellent, and the project office appears well-supported by a first-class set of tools covering all areas of project needs."*
  - "*We find the DKIST Project Office is doing an outstanding job managing the construction process, and we have confidence in this team being able to successfully execute the remainder of the project.*"

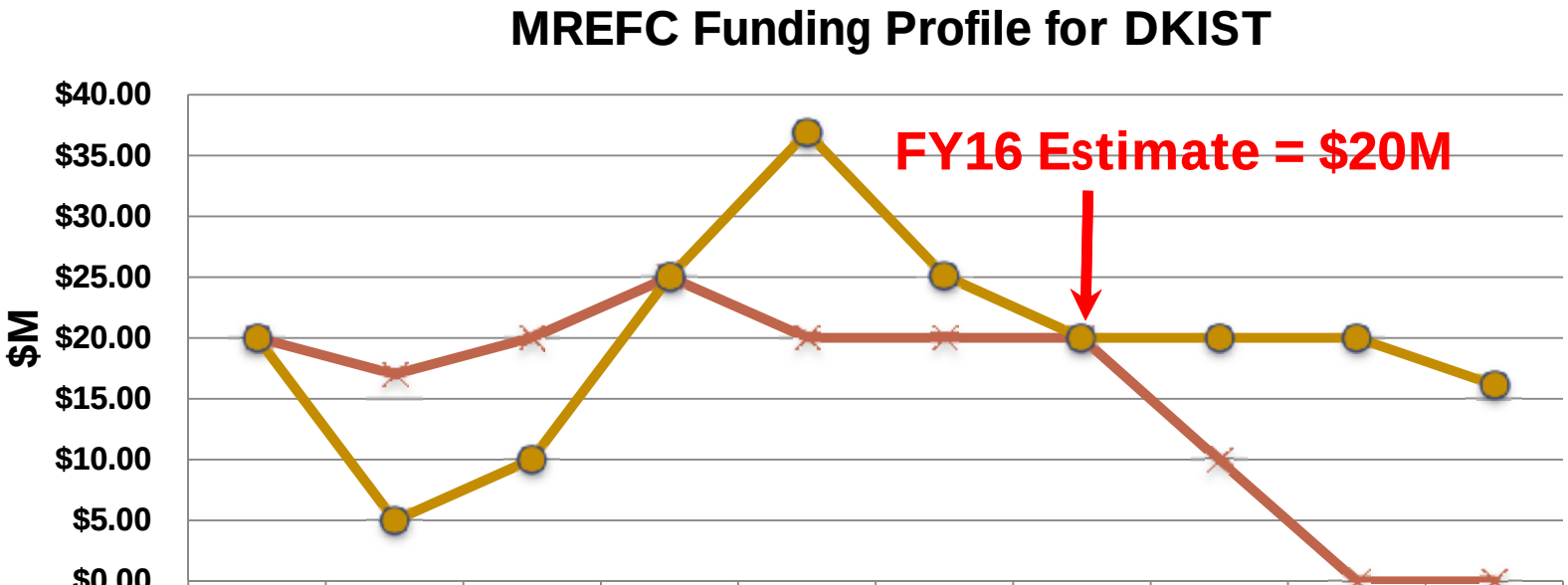
PEP Review: Findings/Recommendations

- There were
  - 27 *FINDINGS*
  - 16 *RECOMMENDATIONS*
- AURA's response
  - received Jan. 31, 2016
- The Panel encouraged the project to consider "black swans" (i.e. low probability/high impact events)



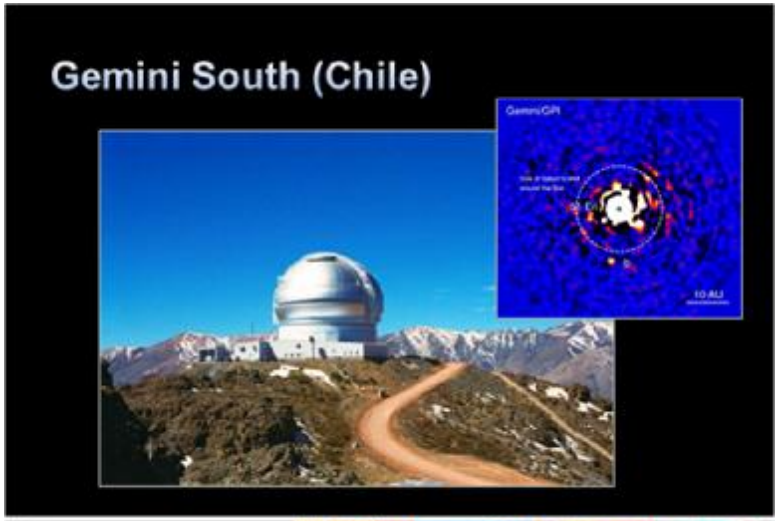
DKIST Construction Funding

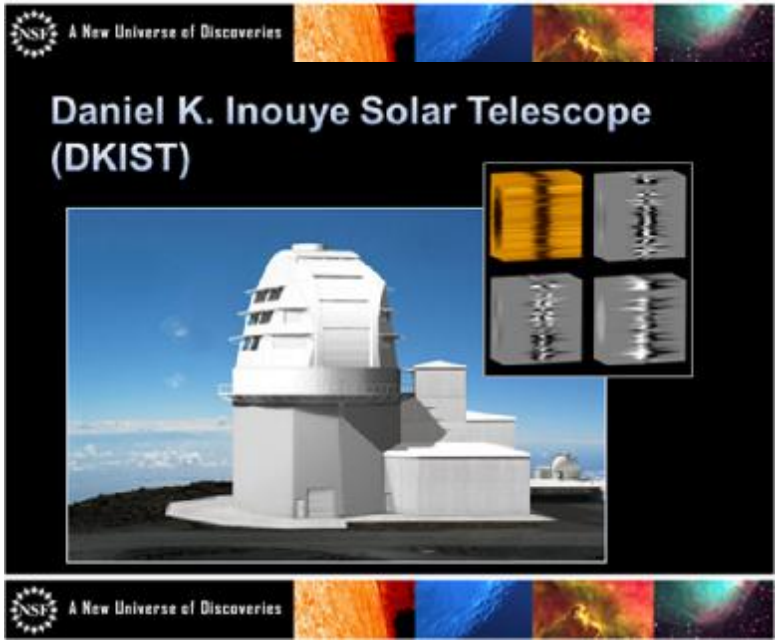
- DKIST Re-baselined Total Project Cost = $344.13M
- ARRA ($146M) expired Sept. 30, 2015, spend-out completed!
- MREFC FY 2016 estimate = $20M

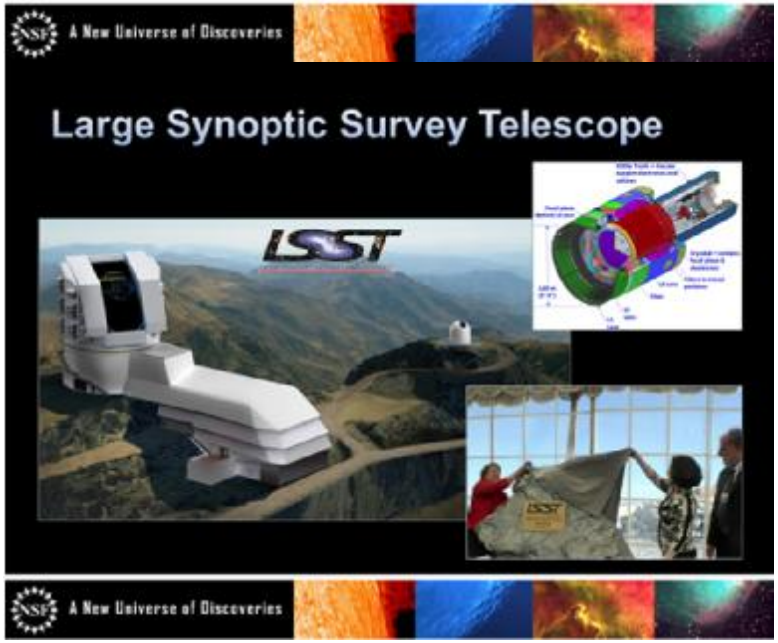


	FY 2010	FY 2011	FY 2012	FY 2013	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019
Original	$20.00	$17.00	$20.00	$25.00	$20.00	$20.00	$20.00	$9.93	$0.00	$0.00
Updated	$20.00	$5.00	$10.00	$25.00	$36.88	$25.12	$20.00	$20.00	$20.00	$16.13

New Flagship Astronomy Capabilities Recently Highlighted by the NSF Director







NSO/DKIST Roadshow: Raising Community Awareness

Community Research Opportunities

Efforts by Mark Rast on behalf of DKIST SWG:

- Multiple talks in 2015 (TESS/SPD, IRIS 4 workshop, IAU, etc.)
- Coordinating proposals to the Astronomy Division's Astronomy and Astrophysics Research Grants (AAG) program
  - More proposals with DKIST in the title than ALMA
  - Result: First-ever solar physics panel in AST

Planned: DKIST CSP workshops

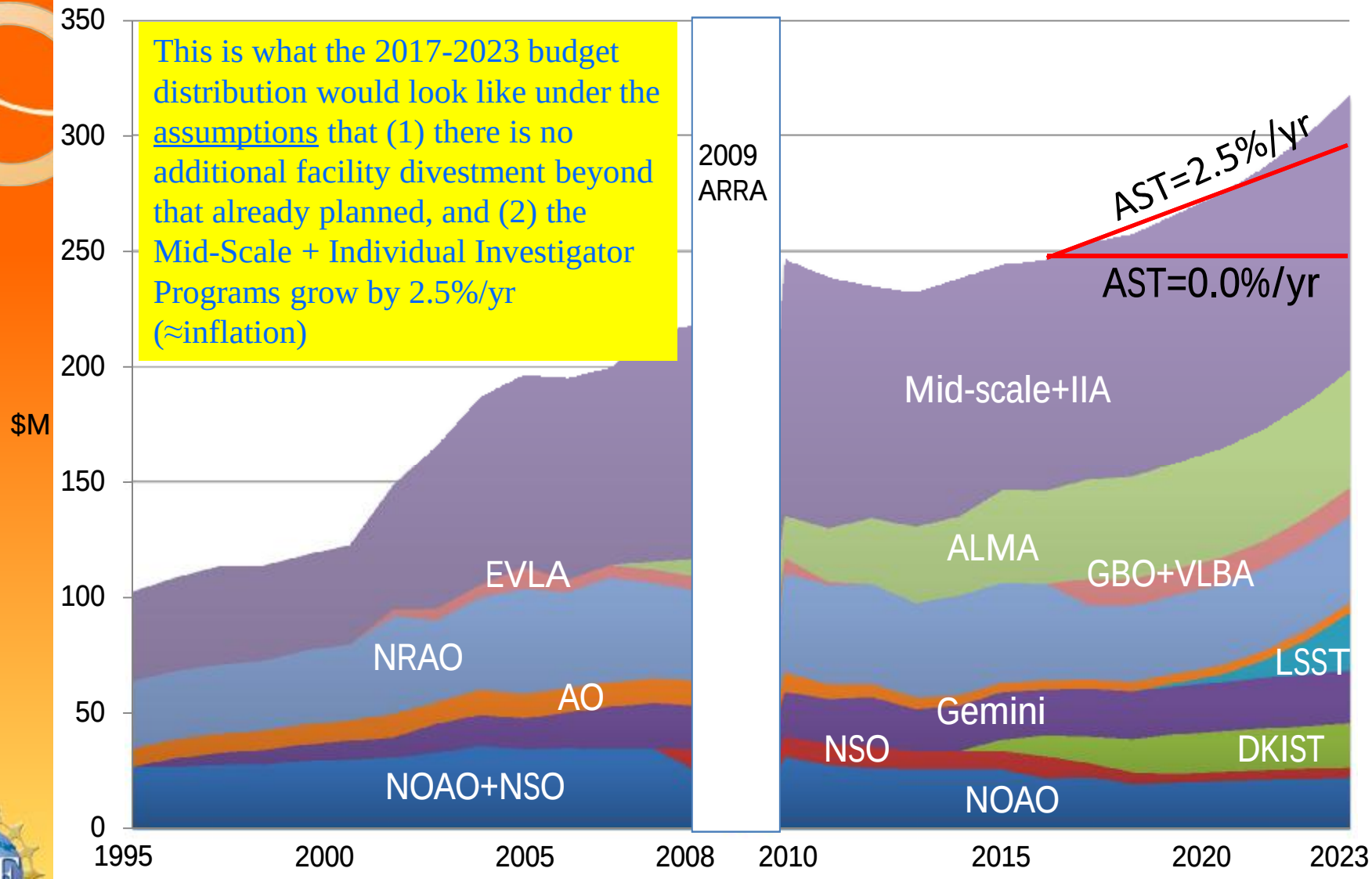
- A series of community workshops to examine and develop Science Use Cases
  - in conjunction with SPD 2016 in Boulder, CO
  - in conjunction with SPD 2017 in Jackson Hole, WY
  - series of workshops during summers 2018 and 2019

AST Budget within MPS and NSF

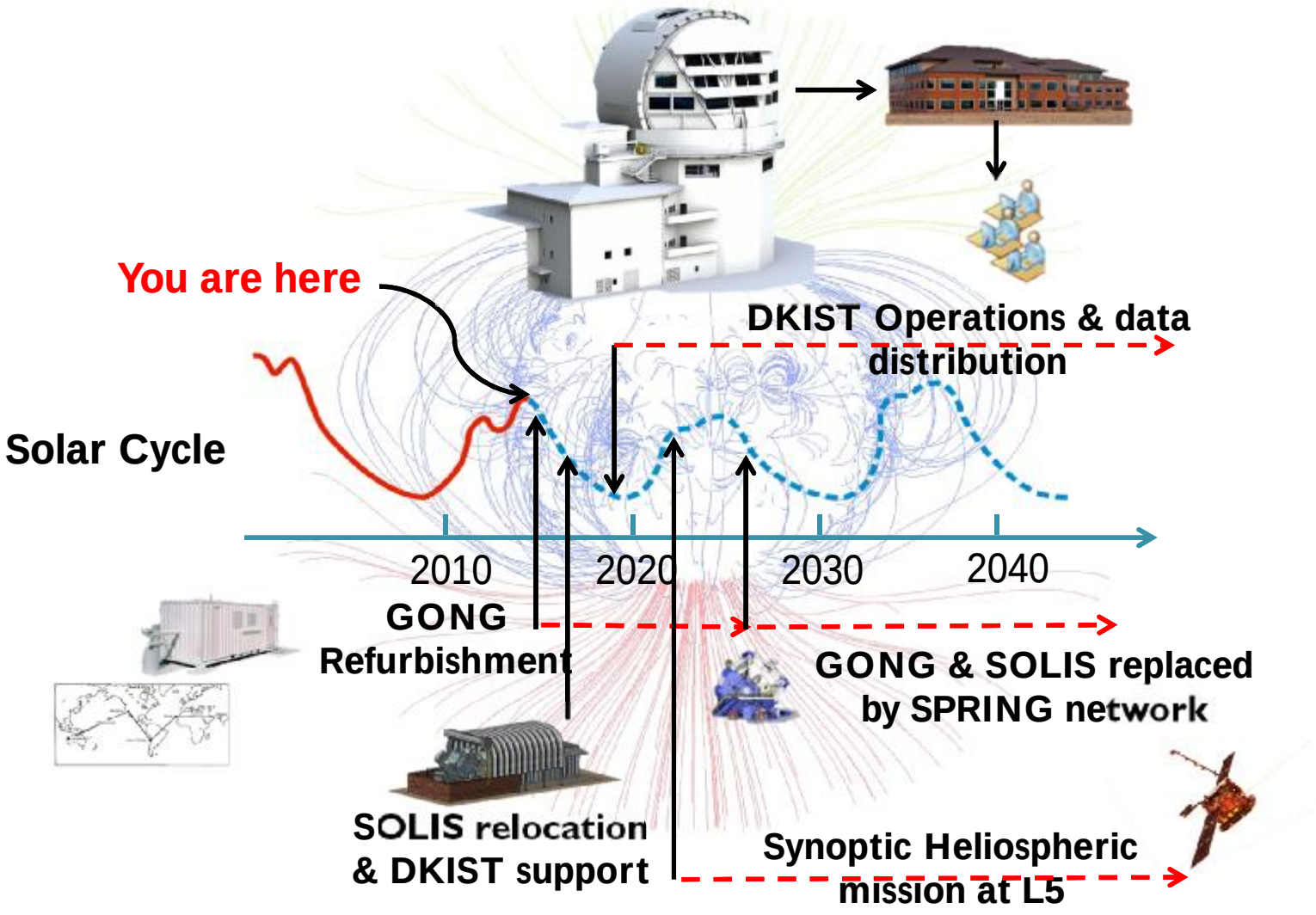
- FY 2017 Request Released on February 9, 2016
- DKIST Construction from MREFC line
- DKIST Operations funding must come from AST line

$M	FY15 Actual	FY16 Request	FY16 Estimate	FY17 Request Total	FY17 Request Disc.
NSF Total	7344	7724	7464	7964	7564
NSF R&RA	5934	6186	6034	6425	6079
MPS	1337	1366	1349	1436	1355
AST	245.2	246.5	246.7	262.6	247.7
MREFC	200.8	200.3	200.3	193.1	193.1

AST Projection through 2023: Hypothetical "Constant" Individual Investigator Program

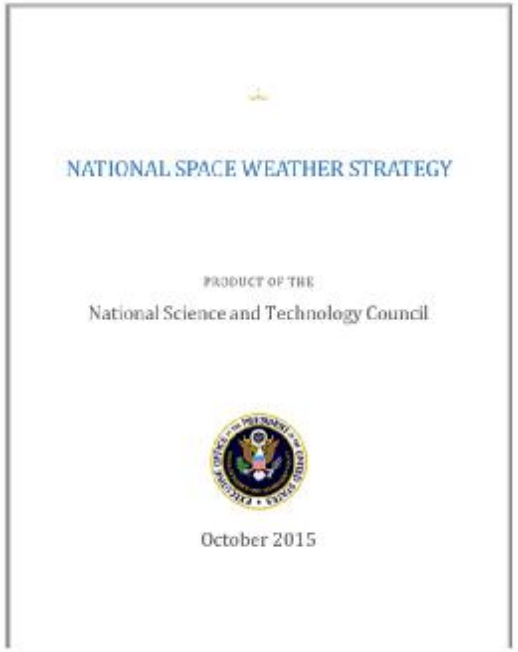


Transformation of NSO



NSO and the NSWS/SWAP

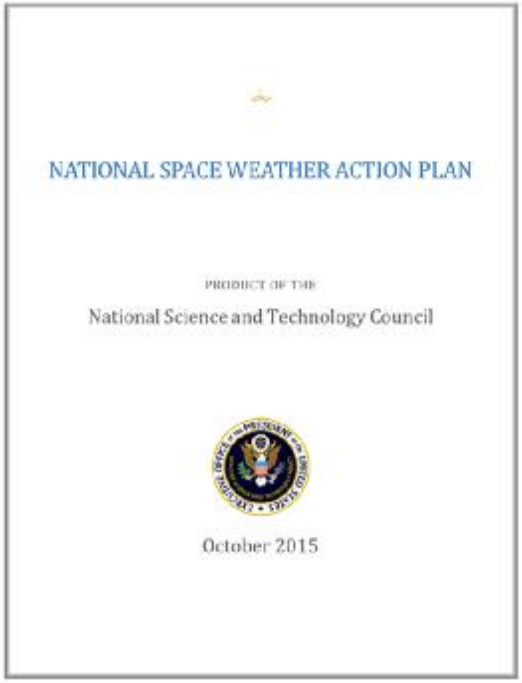
- NSF's National Solar Observatory can contribute to the National Space Weather Strategy and Action Plan through:
  - space weather observations (5.3)
  - forecasting improvement (5.4)
  - enhancing fundamental understanding of space weather (5.5)
  - international cooperation (6.2)
- See NSO White Paper at:
  - http://www.nso.edu/node/1290


NATIONAL SPACE WEATHER STRATEGY

PRODUCT OF THE

National Science and Technology Council

October 2015


NATIONAL SPACE WEATHER ACTION PLAN

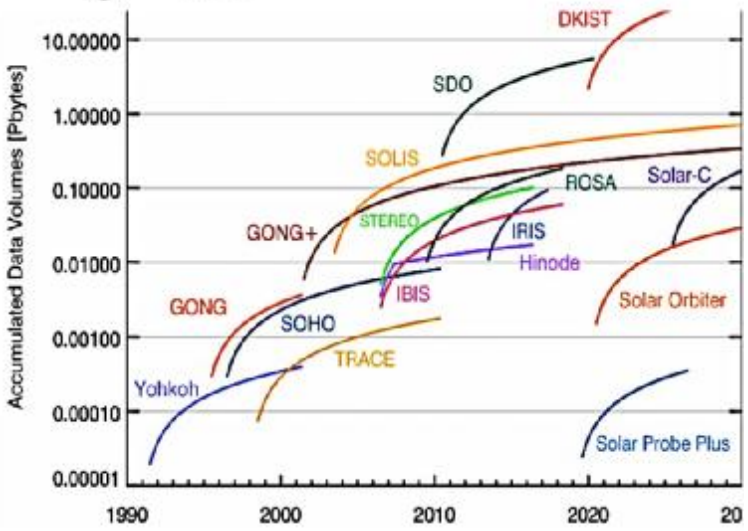
PRODUCT OF THE

National Science and Technology Council

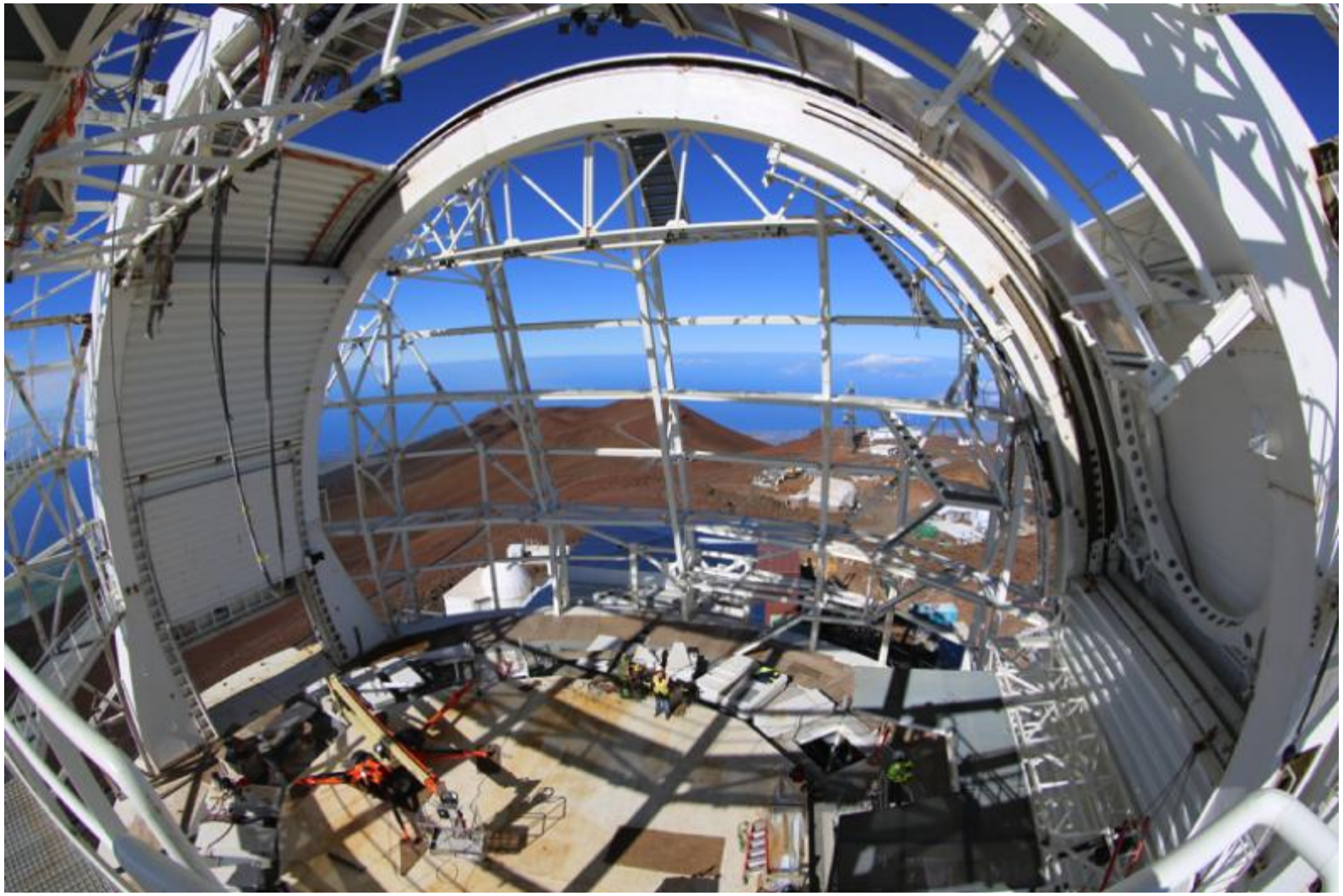
October 2015

DKIST: SWAP 5.3.9, 5.4.2, 5.5.2, 6.2.2

- The Daniel K. Inouye Solar Telescope (DKIST) will host **new sensor technologies** (5.3.9, 5.4.2) and support **basic research opportunities** (5.5.2) through **international partnerships** (6.2.2)
- Key challenges:
  - Construction completion
  - Transition to operations
  - Big Data

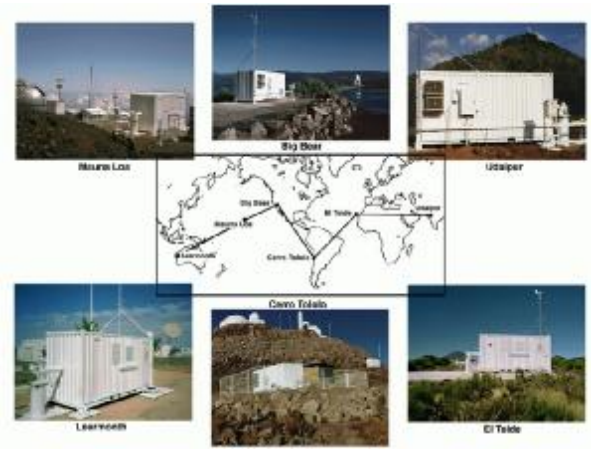


Back-up Slides



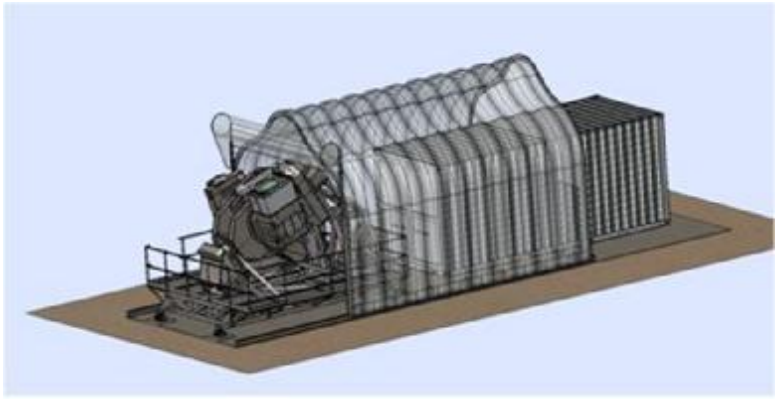
NISP: SWAP 5.3.4

- The NSO Integrated Synoptic Program (NISP) contributes to a sustained or enhanced ground-based solar imaging including solar magnetic field and H-alpha data (5.3.4)
- Key challenges:
  - 2012 Portfolio Review recommended partial divestment
  - U.S. Air Force withdrawal of support for GONG operations
  - Need to integrate SOLIS vector-magnetograms into space weather models
- NSF – NOAA partnership for robust GONG operations

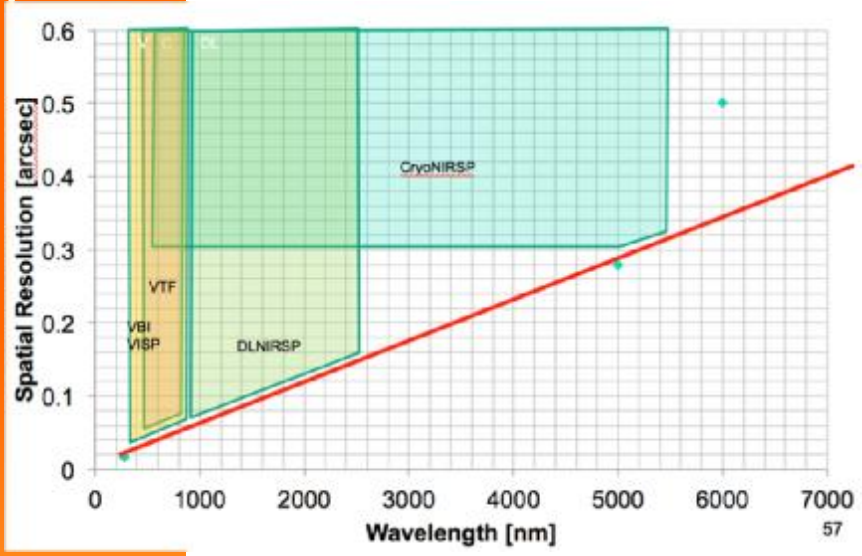


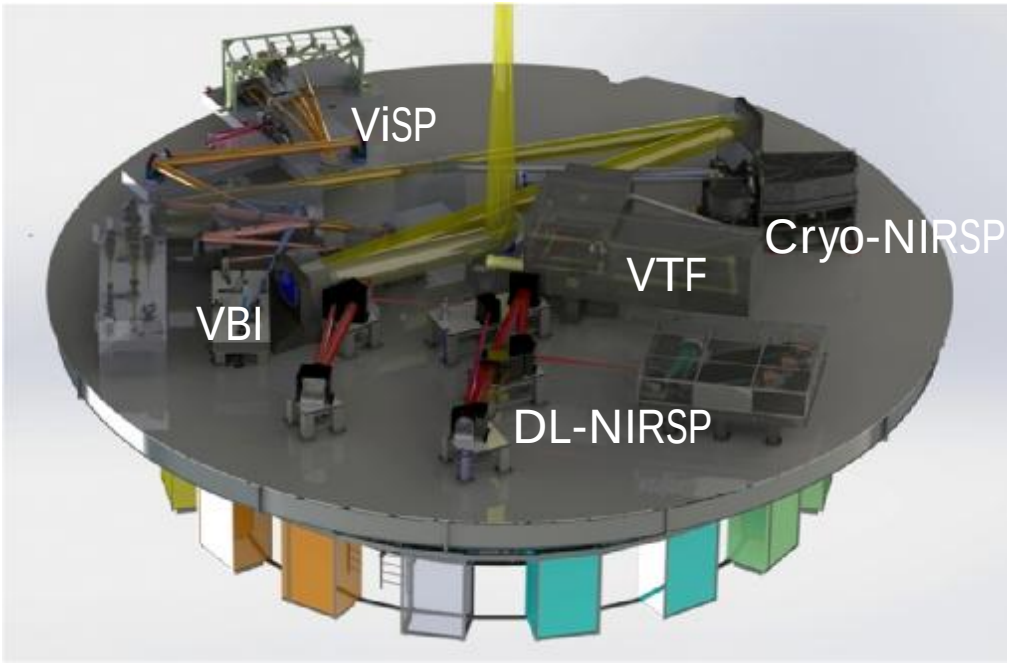
SPRING: SWAP 5.3.9, 5.4.2, 6.2.2

- NSO will contribute to the development and deployment of new operational space weather assets (5.3.9) and novel sensor technologies (5.4.2) leveraging international partnerships (6.2.2).
- Key challenges:
  - The Solar Physics Research Integrated Network Group (SPRING) is an international project currently led by the Kiepenheuer Institut für Sonnenphysik (KIS) in Germany, where science requirements are being written and instrument concepts being developed
  - The U.S. participation is through the NSO as a consultant on the European-led project
  - SPRING is in the conceptual stage and currently has no Federal funding.



DKIST Instrumentation

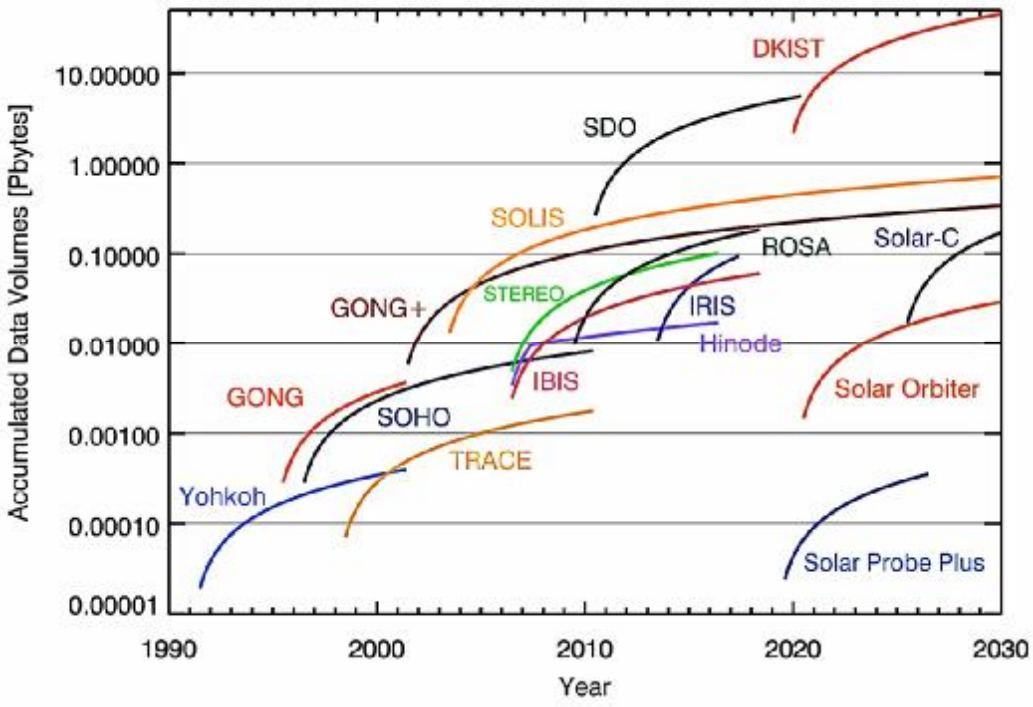




- Visible Broadband Imager (VBI)
- Visible Spectropolarimeter (ViSP)
- Visible Tunable Filter (VTF); Being constructed by Kiepenheuer-Institut fuer Sonnenphysik, Germany
- Diffraction-Limited Near-Infrared Spectropolarimeter (DL-NIRSP)
- Cryogenic Near-Infrared Spectropolarimeter (Cryo-NIRSP)
- Visible cameras 4k x 4k, 30 Hz; Being developed by UK consortium led by Queen's University, Belfast

DKIST is Big Data

Instrument	Data Volume	
	Daily (TB)	Annually (PB)
VBI (reconstructed)	0.3	0.6
VTF	12	4.4
ViSP	7.4	2.6
DL-NIRSP	3	1.1
Cryo-NIRSP	0.6	0.2
Lossless Compression	*x 0.5*	*x 0.5*
Estimated Totals	**12 TB**	**4.5 PB**



- Volume, Velocity, Variety, Veracity, Value
- Calibrated data sets via robust pipelines: Image reconstruction, spectropolarimetry
- Instrument partners to provide prototype code for pipelines
- Metadata: Instrument, Telescope, Thermal, Electrical, AO performance
- Manage data lifecycle: Archival, retention, what to keep? how to keep it?
- Provide search & discovery: Context data (NSO's synoptic program)

DKIST Critical Science Plan (CSP)

- Set of observations that take advantage of the DKIST unique capabilities
- Address critical compelling science: continuously evolving
- Discussed at the DKIST SWG: open to the community
- Outcome: PI led Observing Proposals and publication of first light results
- CSP Feedback: helps DKIST to develop essential operations and data management tools