



NSF Division of Astronomical Sciences (AST) Report

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Outline

- AAAC and NSF Background
- Recent Highlights
- Budget Status and Outlook
- Decadal Survey and Portfolio Review
- Summary



AAAC



AAAC Background

- Established by Congress in 2002
- Three duties
 - Assess and make recommendations regarding coordination of astrophysics among NSF, NASA, and DOE
 - Assess and make recommendations regarding status of activities from 2000 decadal survey and other similar NRC reports
 - Report findings and recommendations on these items, by March 15 of each year, to NSF, NASA, DOE, and both houses of Congress
- Membership: 13 members (typically 3-yr terms)
 - 4 each appointed by NSF and NASA; 3 by DOE; 2 by OSTP
- Minimum of four meetings per year
- Committee activities are governed by Federal Advisory Committees Act



Some Past AAAC Actions

- Task Forces: Dark Energy Task Force, Exoplanet Task Force, Task Force on CMB Research, Dark Matter Scientific Assessment Group
- Recommended recent NSF study of Optical/Infrared Telescope System in era of LSST
- Recommended Principles of Access to Data and Large Projects in Astrophysics
- AAAC members and other community members are currently working on an assessment of proposal pressures in the three federal agencies



NSF Background



NSF Background

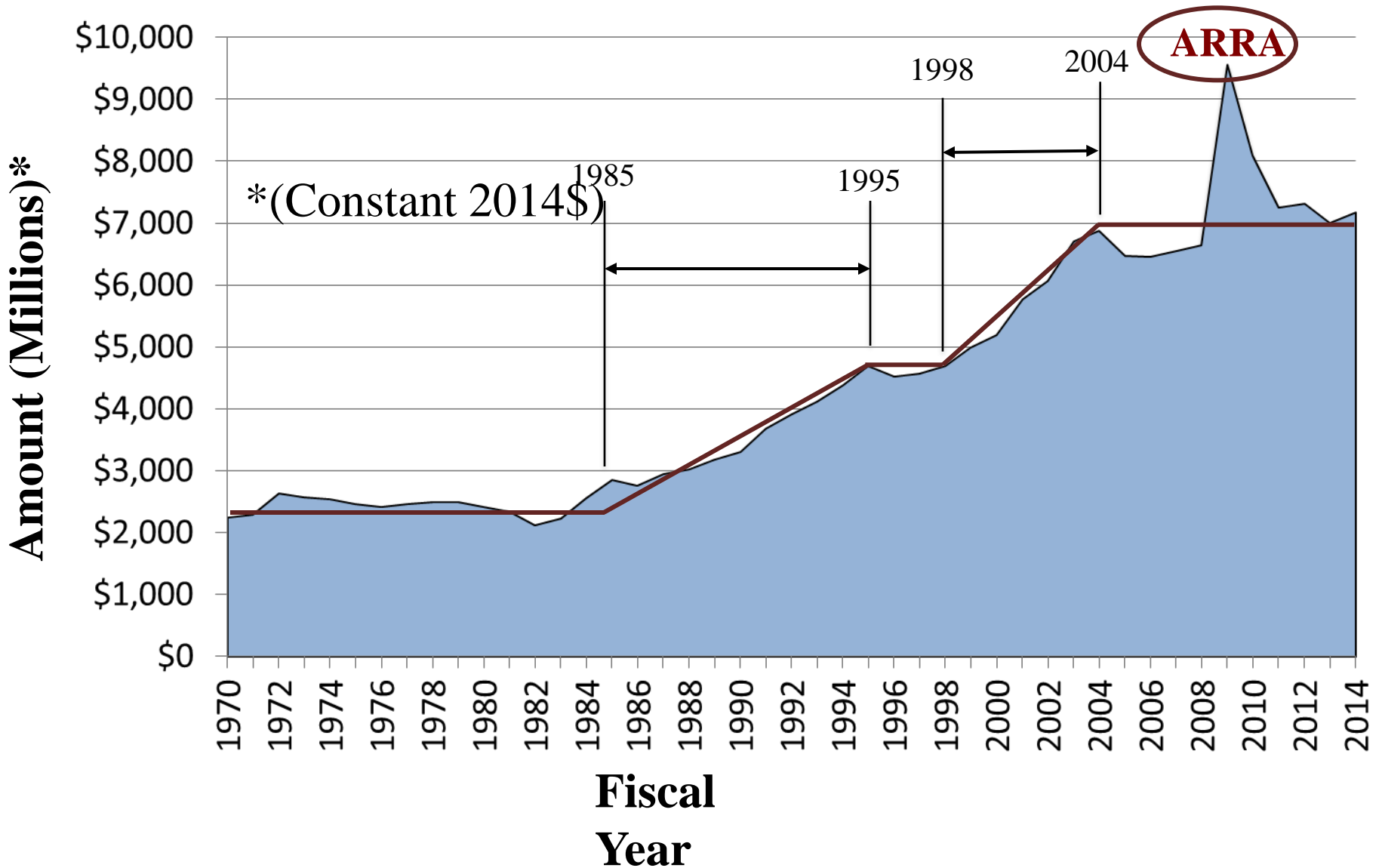
- Only ~100% basic research agency in federal government
- FY 2015 budget was \$7.3 billion, and President's Request Budget for FY 2016 is \$7.7 billion (+5.2%)
- AST is in Directorate for Mathematical and Physical Sciences (MPS), which has ~\$1.3B budget
- AST is the lead organization for federally funded, ground-based astronomy and astrophysics
 - Annual budget this decade has ranged from \$232M to \$246M
 - Major construction projects (>\$130 million) are funded from a separate budget line, Major Research Equipment and Facilities Construction (MREFC)
 - Related research supported in Physics Division (PHY, in MPS) and Directorate for Geosciences (GEO)



What is AST?

- Staff consists of ~20 Ph.D. astronomers, 7 administrative support staff
- Most scientists are permanent federal employees, while a few are “rotators” (Intergovernmental Personnel Act; Visiting Scientist, Engineer, and Educator; Fed Temp)
- Roughly 60% of AST budget is spent on operations of major national facilities, while the remaining 40% is spent on mid-scale projects and smaller individual investigator awards

NSF Funding History

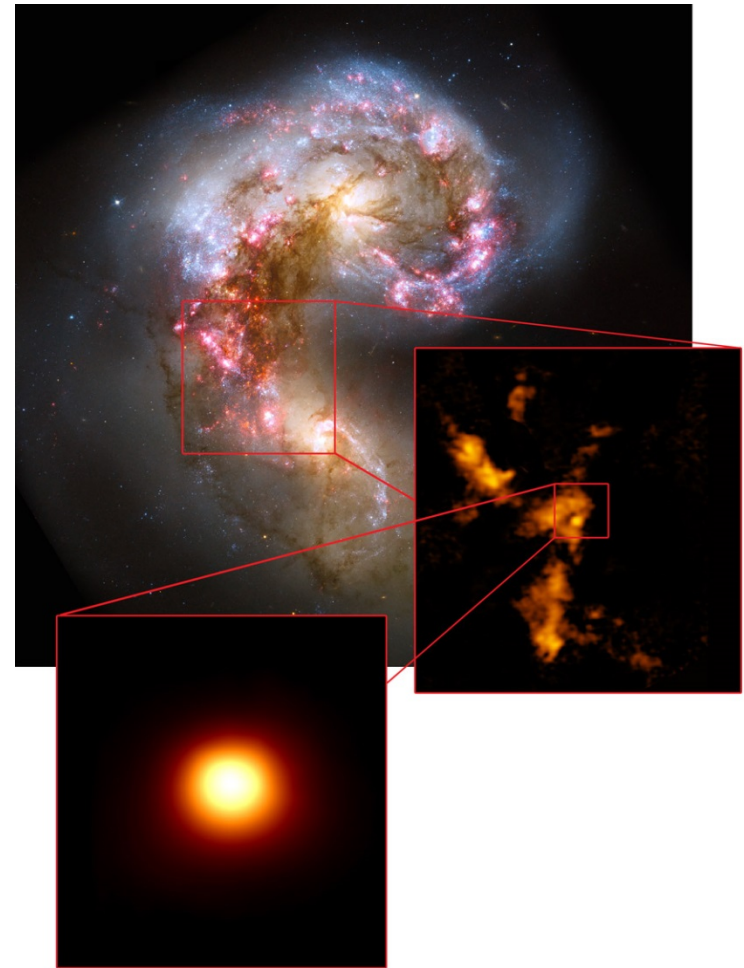




Recent Highlights

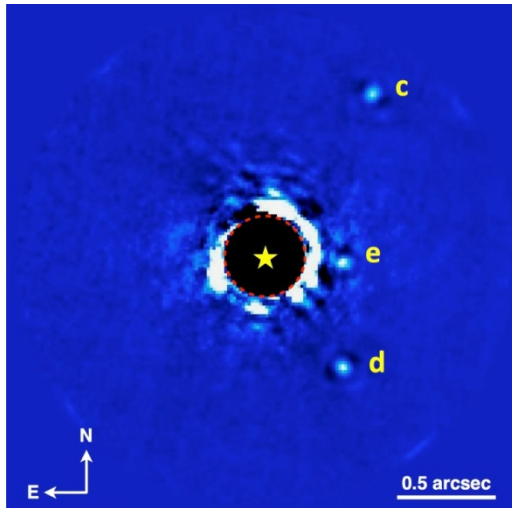
Atacama Large Millimeter/Submm Array (ALMA)

- 1990 and 2000 decadal surveys
- Construction of ALMA was officially completed in 2015.
- ALMA is a joint project of North America (led by NSF), the European Southern Observatory, and East Asia, with a total construction cost of \$1.4 billion.
- At upper right, an optical image of the merging “Antennae” galaxies is shown, progressively zoomed into a compact but intense source of millimeter radiation imaged with ALMA. This massive, dense, star-free cloud may be the first known example of a globular star cluster about to be born.

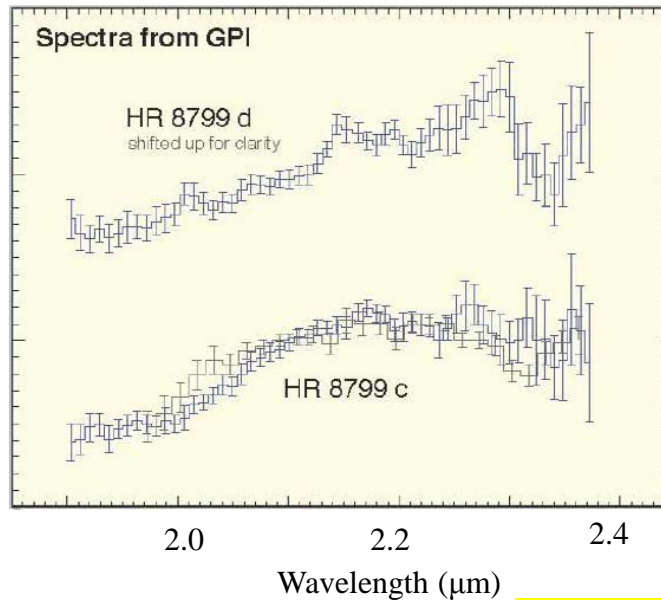


Credit: B. Saxton (NRAO/AUI/NSF); Images from NASA/ESA Hubble, B. Whitmore (STScI); K Johnson (U.Va.); ALMA (NRAO/ESO/NAOJ). (ApJ, 2015, 806, 35)

Gemini: GPI First Results



Credit: Marois, Ingraham, & GPI Team

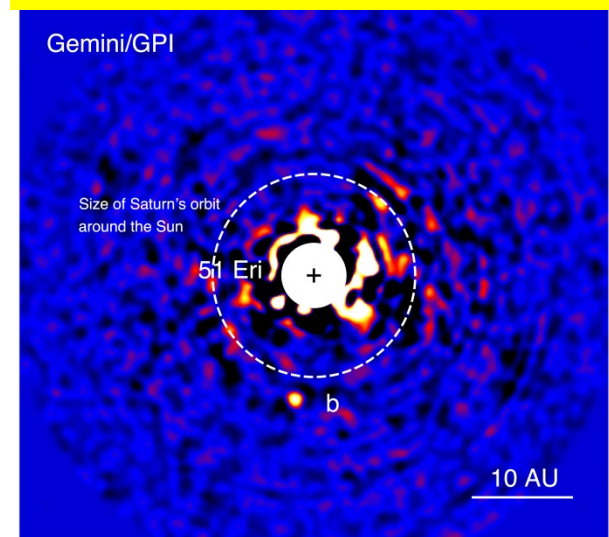


The GPI spectra, of HR8799c and d, shown here, indicate large differences in atmospheric clouds or composition

Credit: Ingraham, Marley, Saumon, & GPI Team

- Commissioning data from GPI, above left, show three exoplanets circling the nearby star HR8799
- The image to the right shows the exoplanet 51 Eridani b (bottom of frame); this object is the most similar to our Solar System's gas giants of any known exoplanet (Macintosh et al., Science, August 13, 2015).

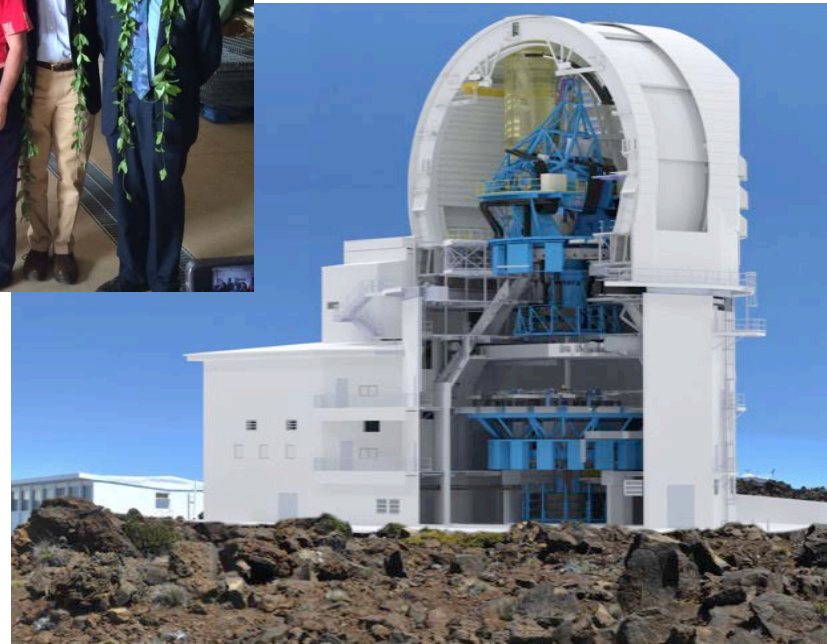
Credit: J. Rameau (UdeM) and C. Marois (NRC Herzberg)





Daniel K. Inouye Solar Telescope

- MREFC project, with total construction budget of \$344 million
- Scheduled for completion in 2019





South Pole CMB Telescopes

SPT and BICEP3/Keck Array



Photo by Dennis Perkins

2015 SPT highlights

- Best constraints on the B-mode power spectrum at sub-degree scales.
- High s/n mass maps from gravitational CMB lensing, including polarization data.
- High s/n tomography of mass in the universe from cross correlation of SPT CMB lensing and Dark Energy Survey galaxy density.
- Final SZ galaxy cluster catalog from the SPT/SZ survey and cosmological constraints.

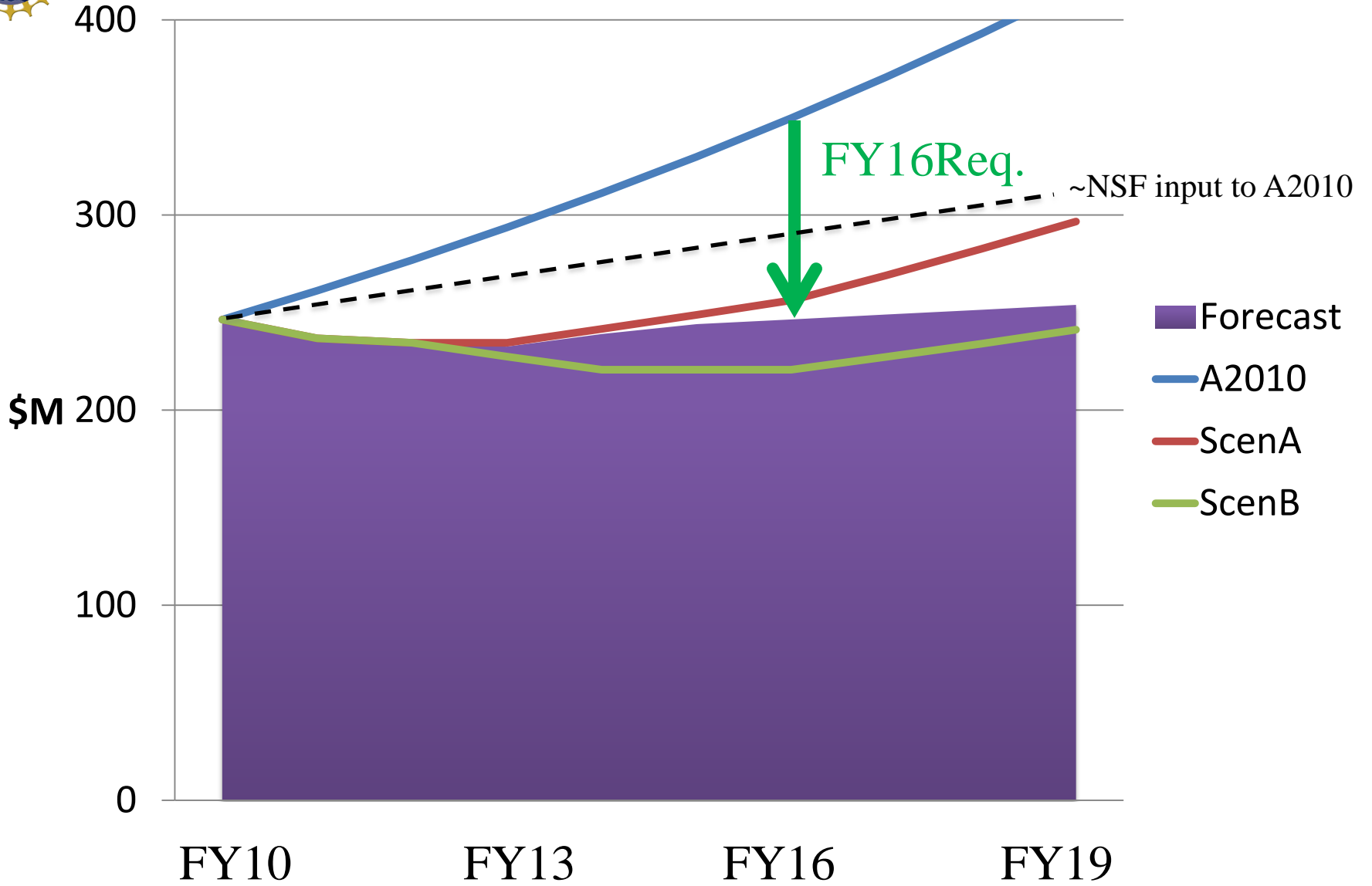




Budget Status and Outlook

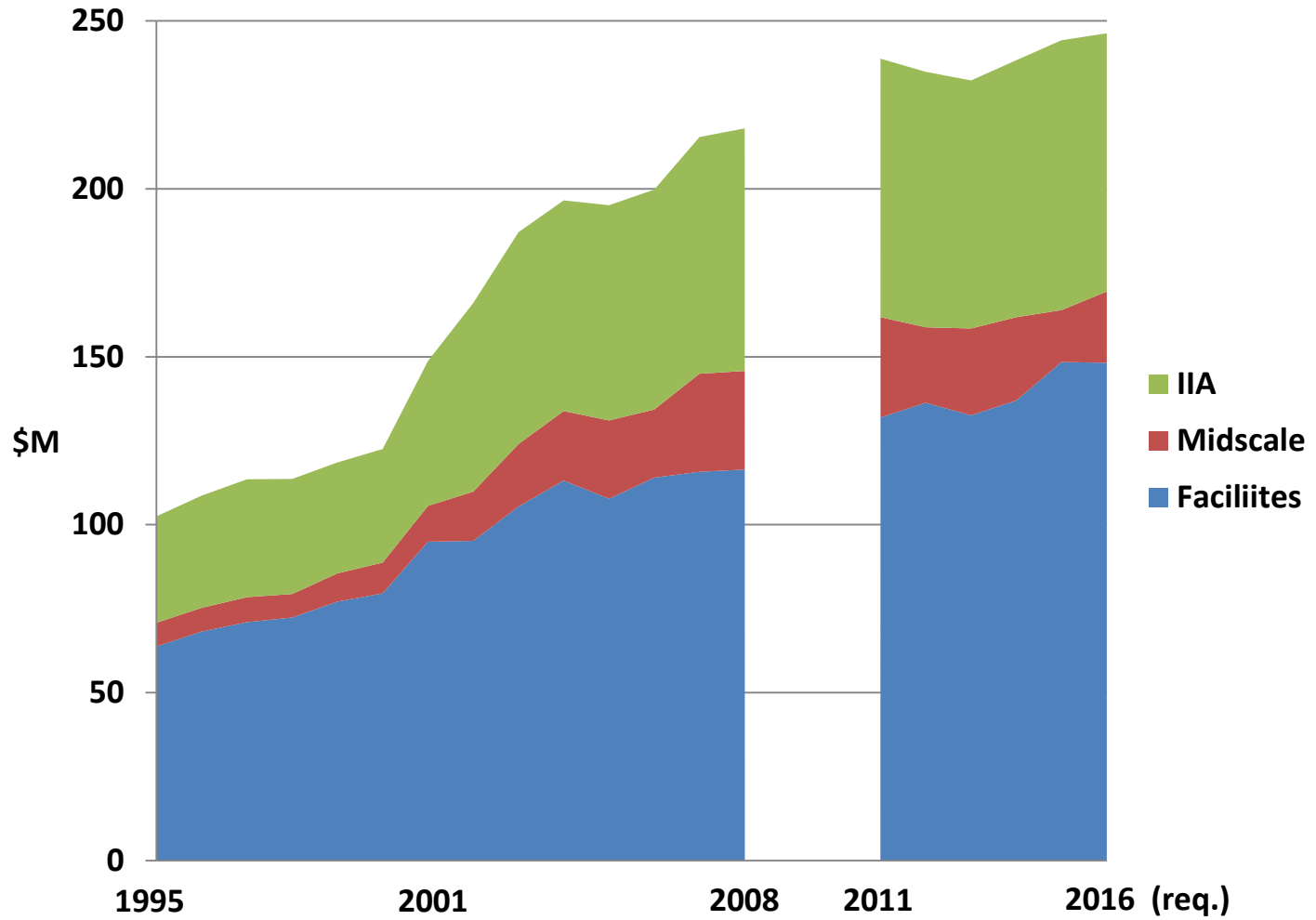


NWNH Budget vs. Actual AST Budget





AST Budget Breakdown, 1995-2016



- Facility fraction was 62%-65% from 1995-2001, dropped as low as 53% in 2008, and rose gradually to 60% in 2016 request



FY 2016 Budget Status

- President's Request Budget for NSF was \$7.72 billion
 - Congressional committee marks were \$7.39 billion (House) and \$7.34 billion (Senate)
- Recent Congressional action on discretionary budget levels relieves sequester caps for FY 2016 and 2017
 - Funding marks not yet given to individual committees
- President's Request Budget for AST in FY 2016 is \$246.5 million, a \$2.4 million increase over FY 2015, and essentially equal to the AST budget in FY 2010
 - Also \$120 million in MREFC line for DKIST and LSST
- Appropriation bills needed by the time the Continuing Resolution expires on December 11



FY 2016 Congressional Language-1

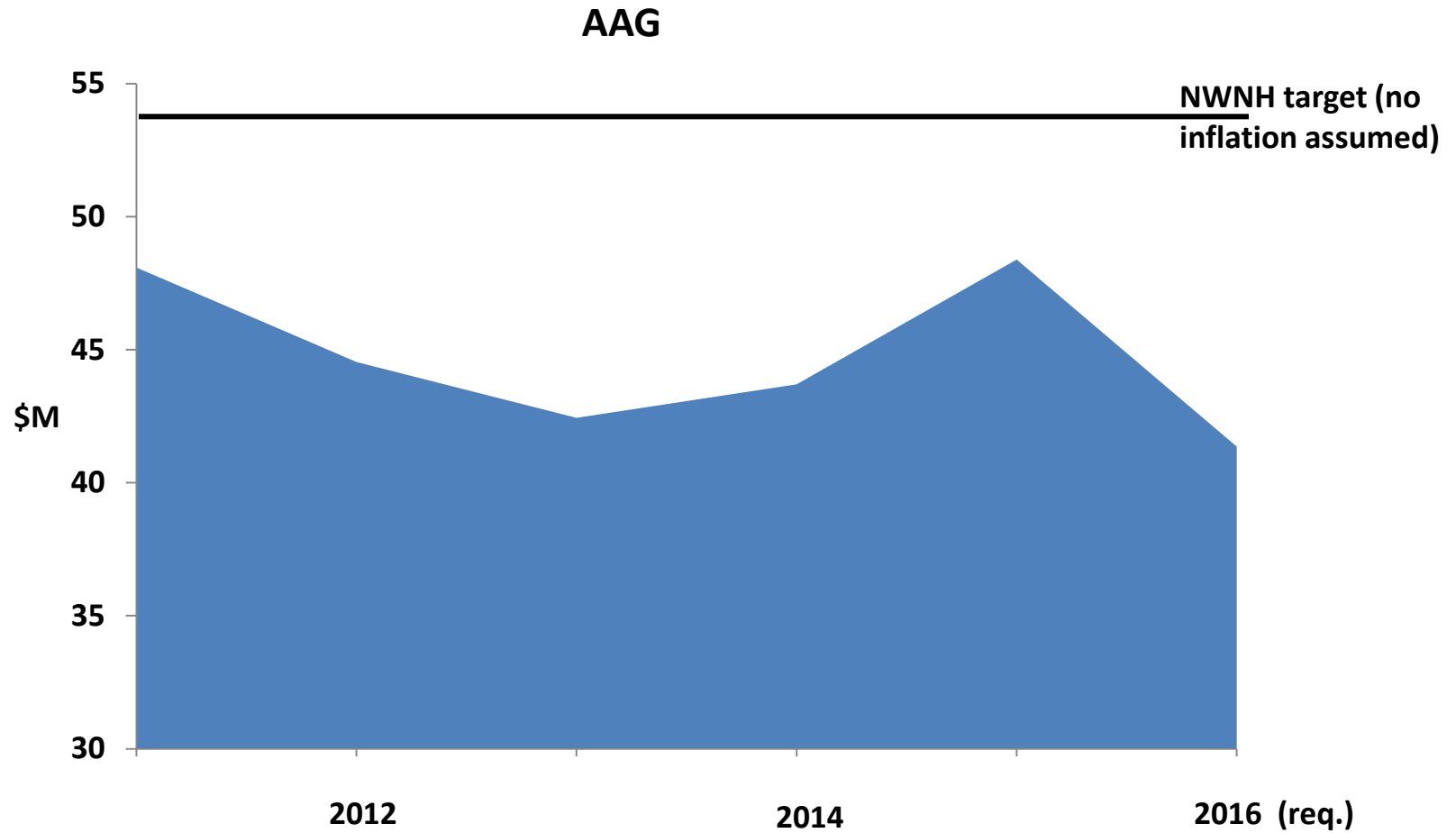
- Congressional committee language needs to be resolved in final appropriation
- House CJS language
 - 70% of Research & Related Activities line to four directorates: MPS, CISE, ENG, and BIO
 - “NSF shall not implement any final divestment of infrastructure tied to the findings of its 2012 Astronomical Sciences Portfolio Review without first reporting such actions to the Committee. Further, such actions shall be carried out in accordance with any relevant reprogramming requirements.”



FY 2016 Congressional Language-2

- Senate CJS language:
 - No language about specific funding to directorates
 - “The Committee encourages NSF to sustain support for the programs and scientific facilities funded by the Astronomical Sciences division, including the National Radio Astronomy Observatory. NSF is also directed to report to the Committee no later than 1 year after enactment of this act on a 5-year transition plan for the continued use of existing solar observatories. Additionally, NSF is expected to request sufficient funding to maintain operations at both new and existing observatories as additional facilities come online in future years.”

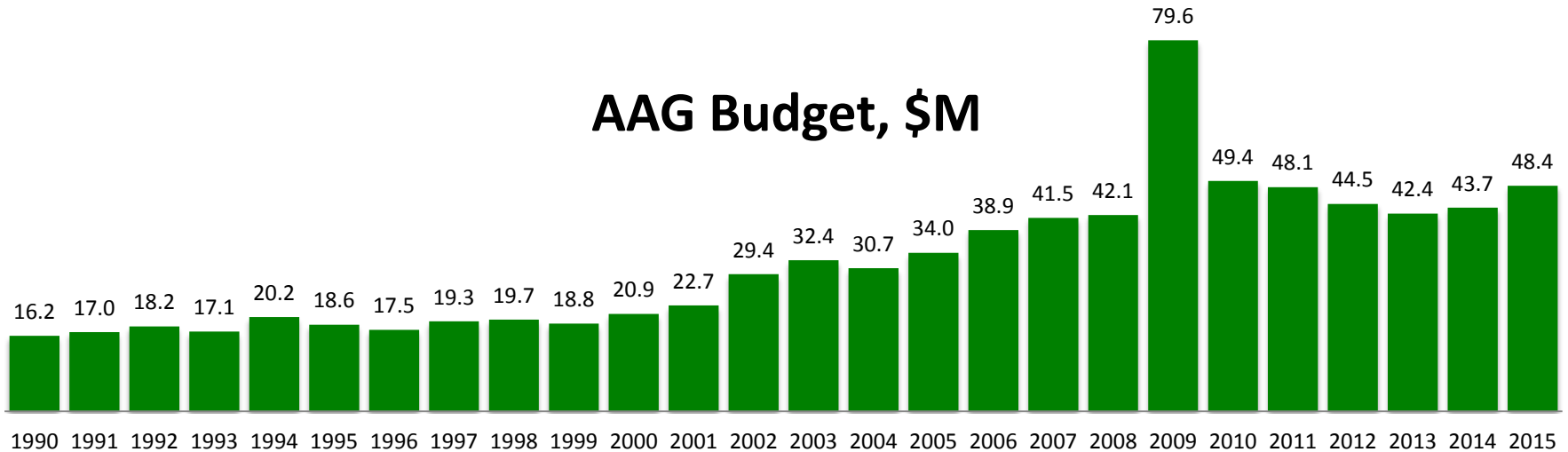
Astronomy & Astrophysics Research Grants



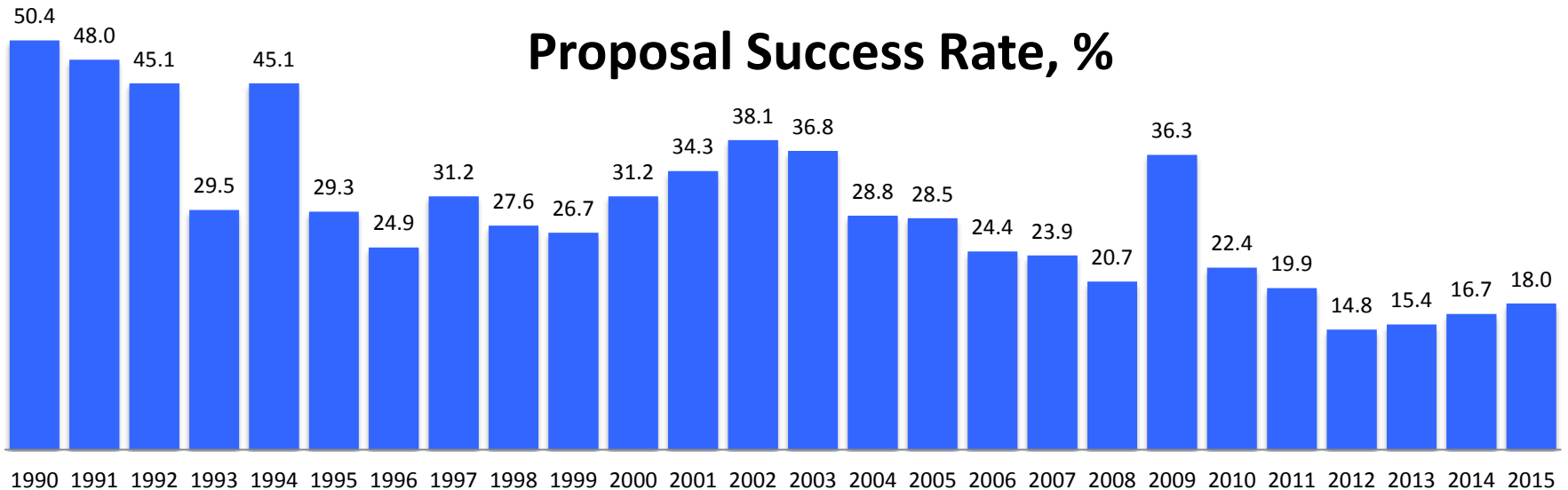


AAG Funding History, 1990-2015

AAG Budget, \$M

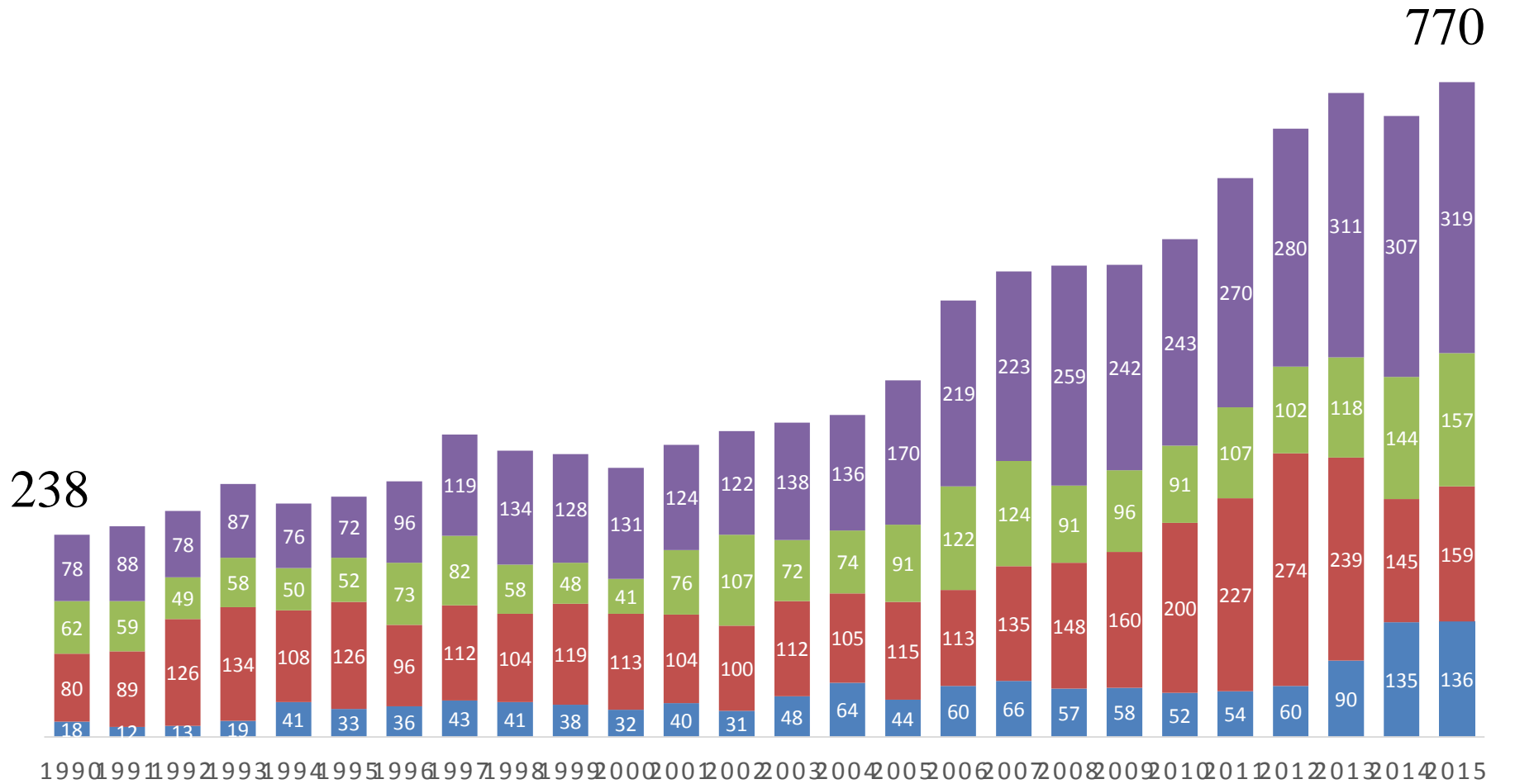


Proposal Success Rate, %





Proposals in AAG, 1990-2015



1990

2015



NSF/NASA Coordination on Grants

- NSF/AST and NASA Astrophysics Division are discussing coordination issues for research grant programs
 - What information can and should be shared to facilitate reviews and reduce duplication of effort?
- Can/should we better constrain boundaries between agencies, and funnel proposers to appropriate agency?
- Examples of possible boundaries between NSF/NASA
 - NSF could decline to accept proposals that are primarily based on analysis of space astronomy data (new or archival)
 - NASA could no longer accept proposals for ground-based exoplanet studies that don't directly support NASA missions
 - Are there any logical boundaries in laboratory astrophysics or theoretical/simulation studies?



Decadal Survey Status



High-Level Look at the Decade So Far

- AST has successfully started the two highest priority “Large Ground-Based Projects” from *New Worlds, New Horizons in Astronomy and Astrophysics (NWNH)*
- Budgetary realities have prevented realization of most other recommendations that require additional funding
 - Available funding has been far less than envisioned by *NWNH*
- *NWNH*, p. 240: “If the realized budget is truly flat in FY 2010 dollars, ... very few new activities could be started within NSF-AST”



NWNH Response Summary

- Complete summary of AST response to *NWNH* is in a Dear Colleague Letter (DCL), NSF 15-044, available at

http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf15044

- Includes status of all major, actionable recommendations, plus status of Portfolio Review response



NWNH Large Ground Projects-1

- 1. Large Synoptic Survey Telescope (LSST)
 - NSF construction award in August 2014
 - Strong NSF/DOE partnership in construction and operations



Large Synoptic Survey Telescope (LSST)

A photograph of the LSST building, a large, white, multi-story structure with a distinctive, angular design, situated on a rocky mountain peak. A dirt road leads up to the building.A photograph of a star field, showing numerous stars of various colors (red, white, blue) against a dark background.A photograph of three people (two women and one man) standing in front of a large window, unveiling a large, grey, rectangular object (likely a component of the LSST) with a yellow sign that says 'LSST'.



LSST Cost Profile and Future Schedule

Appropriated and Requested MREFC Funds for the Large Synoptic Survey Telescope
(Dollars in Millions)

FY 2014 Actual	FY 2015 Estimate	FY 2016 Request	FY 2017 Estimate	FY 2018 Estimate	FY 2019 Estimate	FY 2020 Estimate	FY 2021 Estimate	FY 2022 Estimate	Total Project Cost
\$27.50	\$79.64	\$99.67	\$67.12	\$55.80	\$47.89	\$45.75	\$39.90	\$9.73	\$473.00

Totals may not add due to rounding.

- Total estimated NSF project cost of \$473.0 million, including contingency
- Survey start planned for October 2022
- Expect operations proposal in late 2016
 - Annual operations cost at FDR was \$37 million in FY 2013 dollars, ~\$50 million in FY 2023 dollars
 - NSF aiming to cover half the cost, consistent with *NWNH* recommendation



NRC/CAA OIR System Study

- “A Strategy to Optimize the U.S. Optical and Infrared System in the Era of the Large Synoptic Survey Telescope (LSST)”
- Recommended by AAAC in 2013
- Committee chaired by Debra Elmegreen, Vassar College
- Three face-to-face meetings
 - July 31/August 1; October 12-13; December 2-3
- Report delivered in April 2015
- NSF initial response in Dear Colleague Letter NSF 15-115, issued in August 2015
 - Extensive discussions and planning ongoing, with both NOAO and LSST



NWNH Large Ground Projects-2

- 2. Mid-Scale Innovations Program (MSIP)
 - AST Portfolio Review Committee recommended rolling University Radio Observatories (UROs), Telescope Systems Instrumentation Program (TSIP), and large-facility design and development into MSIP
 - Necessary to enable start of MSIP
 - Solicitation issued in 2013, with categories modified from *NWNH*. Six awards were made at various levels, including co-funding of a Physics Frontiers Center
 - Total AST funding of \$27.1M in FY 2014 and 2015
 - Second solicitation was released in June 2015, with pre-proposals received in September 2015, and conclusion of two-stage evaluation expected in summer 2016



Next “Senior Review”

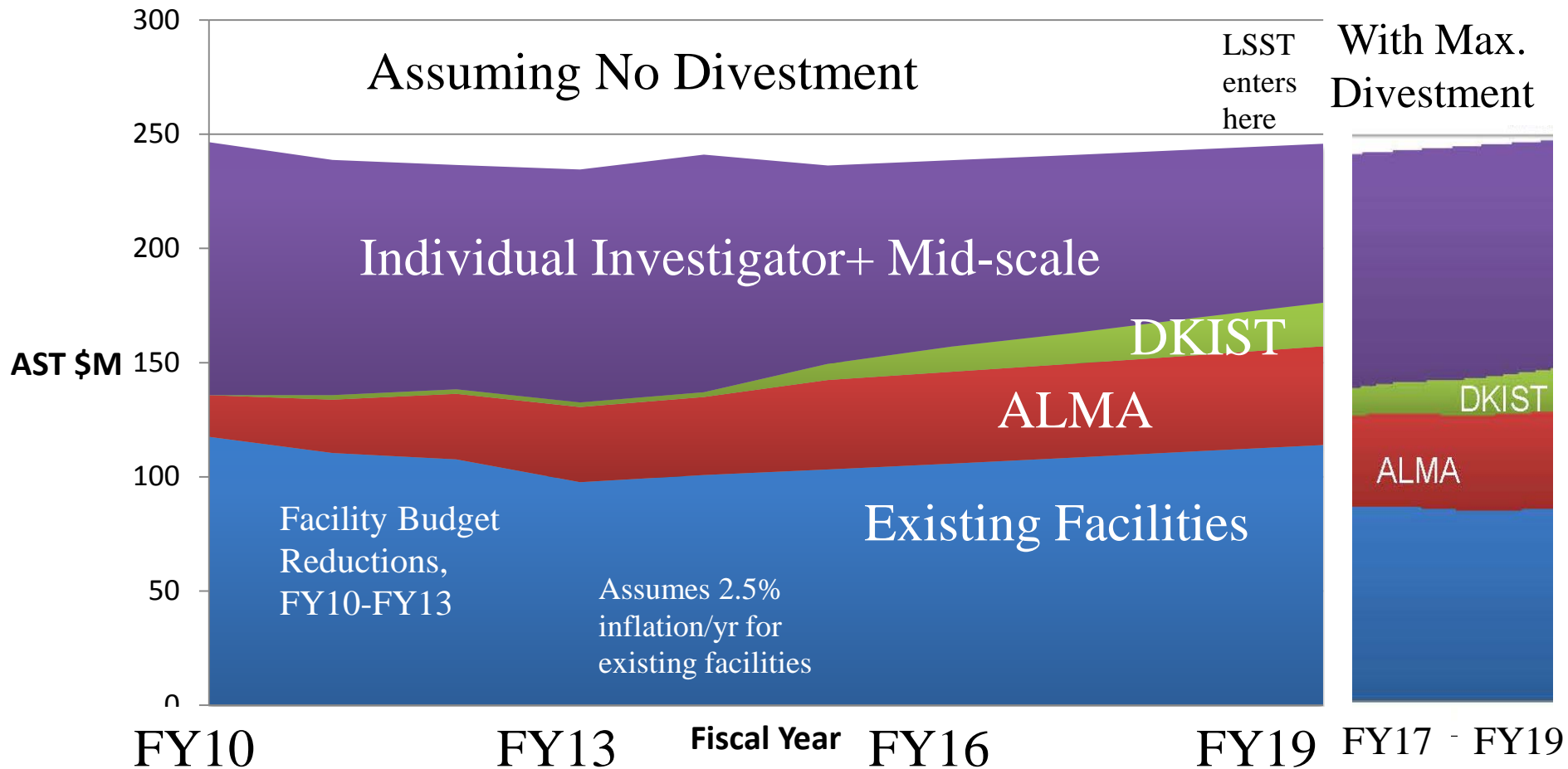
- *NWNH*, p. 32:
 - “NSF-Astronomy should complete its next senior review before the mid-decade independent review that is recommended elsewhere in this report, so as to determine which, if any, facilities NSF-AST should cease to support in order to release funds for (1) the construction and ongoing operation of new telescopes and instruments and (2) the science analysis needed to capitalize on the results from existing and future facilities.”
- This became the AST Portfolio Review (PR), with committee report delivered in August 2012



Portfolio Review Status



AST Portfolio Scenarios



- Chart above shows the maximum impact of divestment (or non-divestment) within a likely budget scenario



General Portfolio Review Comments

- Portfolio review report recommended significant facility divestment to enable support of *NWNH* priorities
- Process is inevitably slower than hoped
 - NSF (through a contractor) is currently concluding engineering studies and baseline environmental surveys for a number of telescopes and observatories recommended for divestment. Results of these studies will inform more detailed assessments.
- Most divestments are not clean 100% divestments, but are evolutionary changes to new partnership arrangements
 - Less financial free energy than recommended by PR
 - More complexity in management and oversight
- To date, most capabilities have remained available for science in some form
 - Open access availability has inevitably been reduced



Facility Futures

Telescope	Status
KPNO 2.1m	Caltech took over operations for 3 yr, starting October 2015
Mayall 4m	Slated for DESI, pending DOE funding; bridge from NSF
WIYN 3.5m	NOAO share to NASA-NSF Exoplanet Observational Research Program
GBT	Partner discussions; Breakthrough Prize Foundation partnership starting in 2016; engineering study under way
VLBA	Partner discussions in progress; engineering study under way
McMath-Pierce	Bridging to university-led consortium; engineering study
GONG/SOLIS	SOLIS moved off Kitt Peak; GONG MOU with NOAA in development
Dunn Solar Tel.	Partner discussions in progress; engineering study under way
Arecibo	Post-2016 status in discussion; Dear Colleague Letter released
SOAR	Post-2020 status to be reviewed



Summary



Primary Interagency Activities

- NSF/DOE
 - Large Synoptic Survey Telescope
 - Dark Energy Survey: DOE camera on Blanco 4m telescope
 - Dark Energy Spectroscopic Instrument: Future DOE spectrometer on Mayall 4m telescope
 - PHY collaborations on LHC, Dark Matter, VERITAS, HAWC
- NSF/NASA
 - NASA-NSF Exoplanet Observational Research Program (NN-EXPLORE)
 - NASA to fund spectrometer for use in NSF share of WIYN 3.5m telescope
 - Theoretical and Computational Astrophysics Network
 - Planetary Radar on Arecibo Telescope (NASA Planetary Division)
 - Discussion of coordination on grant funding



Status Summary

- Outstanding new science opportunities
 - ALMA, EVLA, Gemini/GPI, Blanco/DECam, DKIST, LSST
 - ~110 research awards/yr in AAG, plus MSIP, ATI, AAPF, REU, PAARE
 - Interagency: DES, DESI, NN-EXPLORE, LSST
 - Beyond AST division budget, NSF spent over \$100 million on construction of AST facilities in FY 2015
- No expectation for significant budget increases this decade
 - Divestment process to date does not cover ramp to DKIST ops
 - LSST operations will begin ramp in FY 2019 to ~\$25M/yr by FY 2023
 - Ongoing AST budget shift toward facilities in flat-budget era
- Partnerships with NASA and DOE have strengthened
- Data-enabled science continues to grow in importance
- Challenges are many, but our community continues to make progress at the science frontiers



Some Upcoming Strategy Issues

- Impact of facility divestment
 - Positive: some financial resources freed up; intellectual benefits of increased partnerships
 - Negative: partnership complexity, loss or restriction of some community capabilities
- Relation among NSF OIR observatories in Chile after initiation of LSST operations?
- Relations among LSST and WFIRST (and EUCLID)?
- Future of astronomy in Hawaii?
- Facility choices take 5-10 years to implement, and are based on unknowable budgetary futures. What level of risk to individual investigator programs funds is appropriate in order to commit to operations of additional new facilities?
- What assumptions should be made for next decadal survey?