Astrophysics Update
Presented to the
NAC Science Committee

Dr. Jon Morse

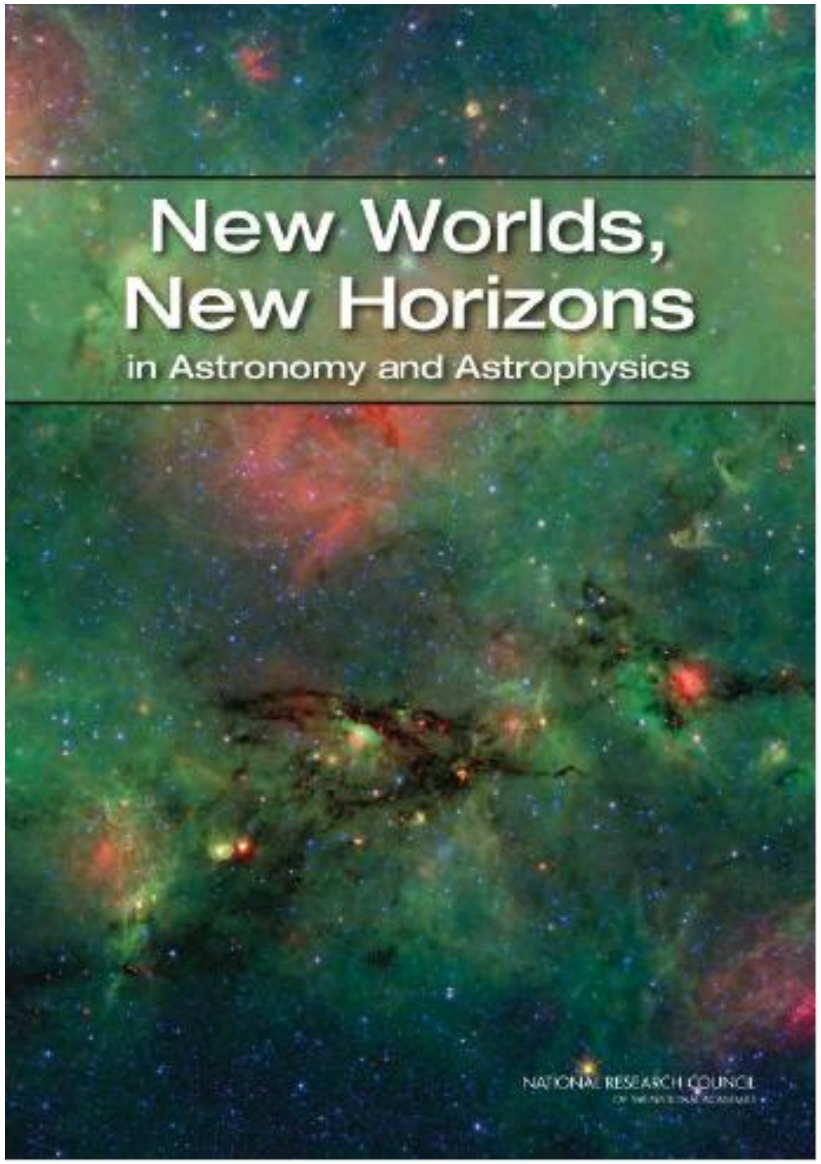
Director, Astrophysics Division
Science Mission Directorate
NASA Headquarters

October7-8, 2010

Outline

- Initial plans for responding to Astro2010 decadal survey
- Astrophysics science highlights
- Astrophysics programmatic highlights

Astro2010 Decadal Survey



Released 13 August 2010

Panel Reports 30 August

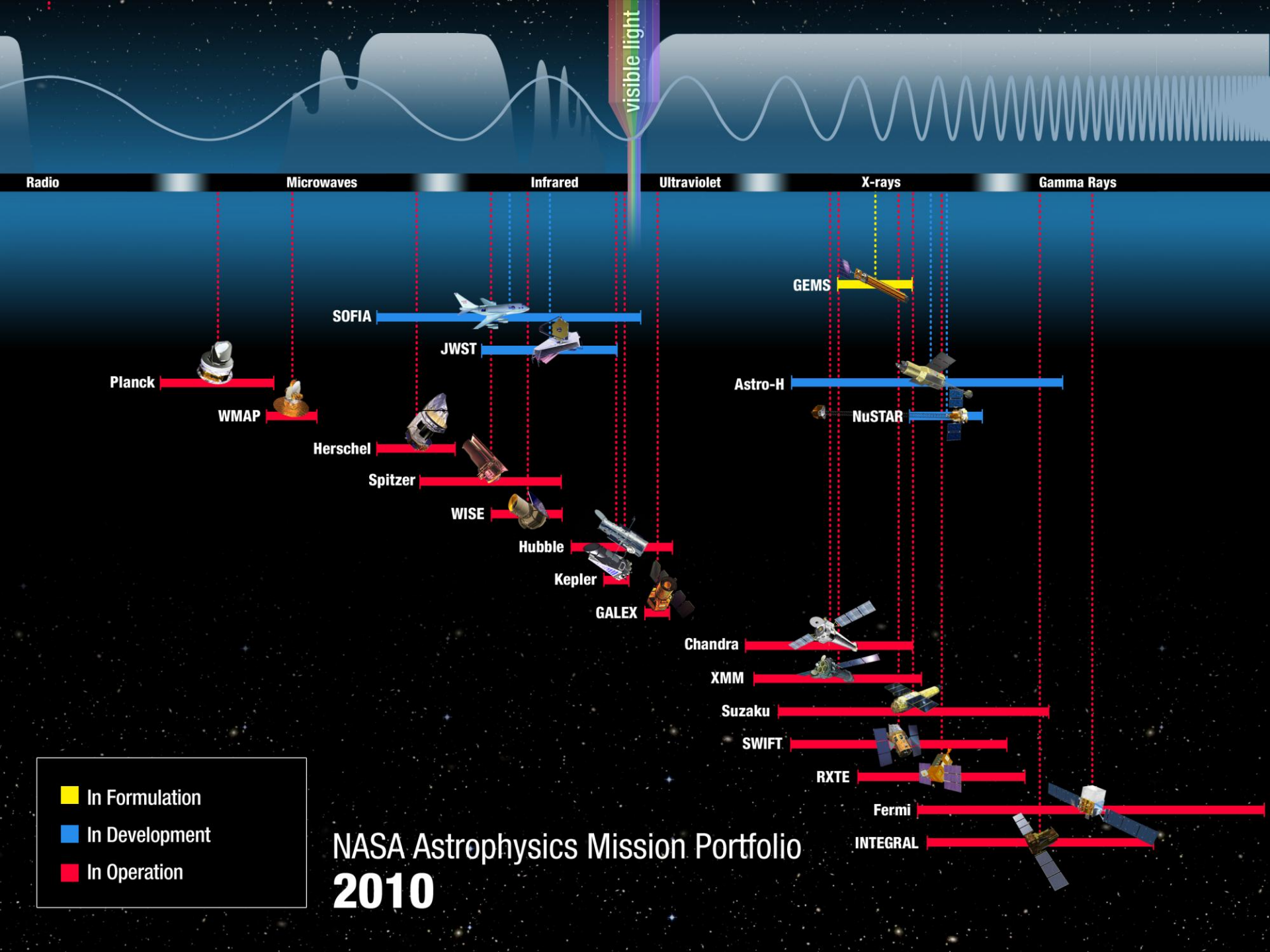
Decadal Survey Recommendations

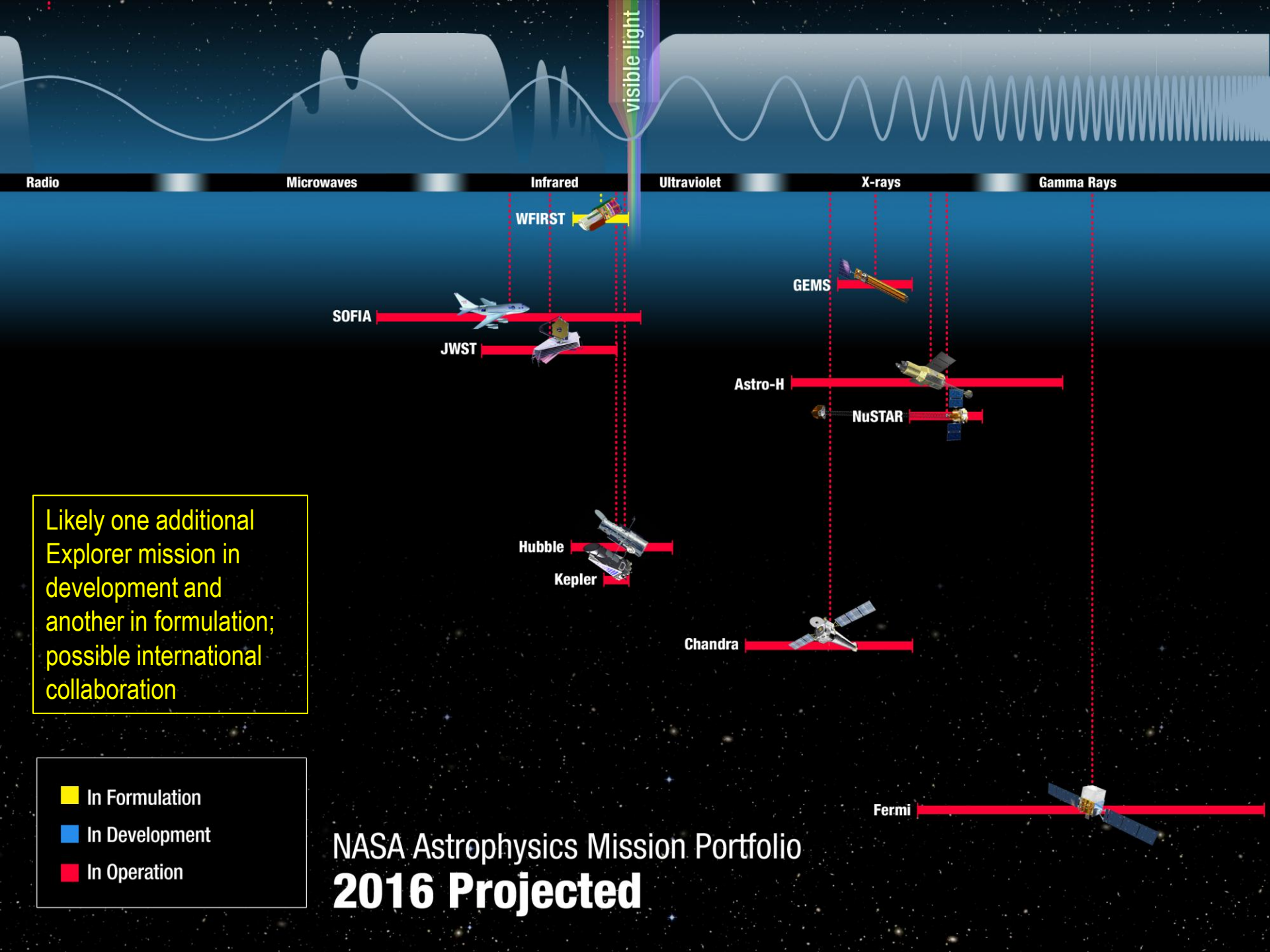
- Science themes
  - **Cosmic Dawn** – early universe, first stars and galaxy formation
  - **New Worlds** – search for nearby, habitable, rocky or terrestrial planets with oxygen and liquid water
  - **Physics of the Universe** – understand fundamental physical laws and principles
- Highest priority Large space mission is Wide Field Infrared Survey Telescope (WFIRST); second Large priority is Explorer Program augmentation
- LISA (~2025) contingent on successful LISA Pathfinder mission and ESA L-class prioritization
- IXO (2020s) contingent on technology readiness and ESA L-class prioritization
- EXIST and SIM missions deemed not as compelling as other priorities; not included in the recommended program for the decade
- Recommends augmented investment in core research and technology programs, including the suborbital program
- Recommends chartering a Decadal Survey Independent Advisory Committee (DSIAC)
- NASA will work with NSF, DOE and EOP on overall response to Astro2010 and coordination of ground-based and space-based initiatives.
  - Implementation will occur under budgetary conditions realized over the next decade, all current proposals are tentative

Astrophysics Division

Decadal Survey Recommendations for Space

Program Scale	Recommendation	Science	Total Cost (U.S. share)	Launch Date
Large	**WFIRST** (potential interagency & international partnerships)	Dark energy, exoplanets, and infrared survey-science	$1.6B	2020
Large	**Explorer Program** Augmentation	Enable rapid response to science opportunities; augments current plan by 2 MIDEXs, 2 SMEXs, & 4 MoOs	$463M	Ongoing
Large	**LISA** (partnership with ESA)	Open low-frequency gravitational-wave window for detection of black-hole mergers and compact binaries and precision tests of general relativity	$2.4B ($1.5B)	2025
Large	**IXO** (partnership with ESA and JAXA)	Black-hole accretion and neutron-star physics, matter/energy life cycles, and stellar astrophysics	$5.0B ($3.1B)	2020s
Medium	**New Worlds Technology Development Program**	Preparation for a planet-imaging mission beyond 2020, including precursor science activities	$100-200M	>2020
Medium	**Inflation Probe Technology Development Program**	CMB/inflation technology development and preparation for a possible mission beyond 2020	$60-200M	>2020
Small	**Astrophysics Theory Program** Augmentation	Broad	$35M additional	
Small	(Definition of) a **future UV-optical space capability**	Technology development benefiting a future UV telescope to study hot gas between galaxies, the interstellar medium, and exoplanets	$40M	
Small	**Intermediate Technology Development** Augmentation	Broad; targeted at advancing the readiness of technologies at TRL 3 to 5	$2M/yr additional, increasing to $15M/yr additional by 2021	
Small	**Laboratory Astrophysics** Augmentation	Basic nuclear, ionic, atomic, and molecular physics to support interpretation of data from JWST and future missions	$2M/yr additional	
Small	**SPICA** instrument (U.S. contributions to JAXA-led mission; possibly w/ ESA)	Understanding the birth of galaxies, stars, and planets; cycling of matter through the interstellar medium	$150M	
Small	**Suborbital Program** Augmentation	Broad, but including especially cosmic microwave background and particle astrophysics	$15M/yr additional	
Small	**Theory and Computation Networks** (NASA, NSF, DOE)	Broad; targeted at high-priority science through key projects	$5M/yr NASA	


visible light
Radio
Microwaves
Infrared
Ultraviolet
X-rays
Gamma Rays
GEMS
SOFIA
JWST
Planck
WMAP
Astro-H
NuSTAR
Herschel
Spitzer
WISE
Hubble
Kepler
GALEX
Chandra
XMM
Suzaku
SWIFT
RXTE
Fermi
INTEGRAL
In Formulation
In Development
In Operation
NASA Astrophysics Mission Portfolio
2010


visible light
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SOFIA
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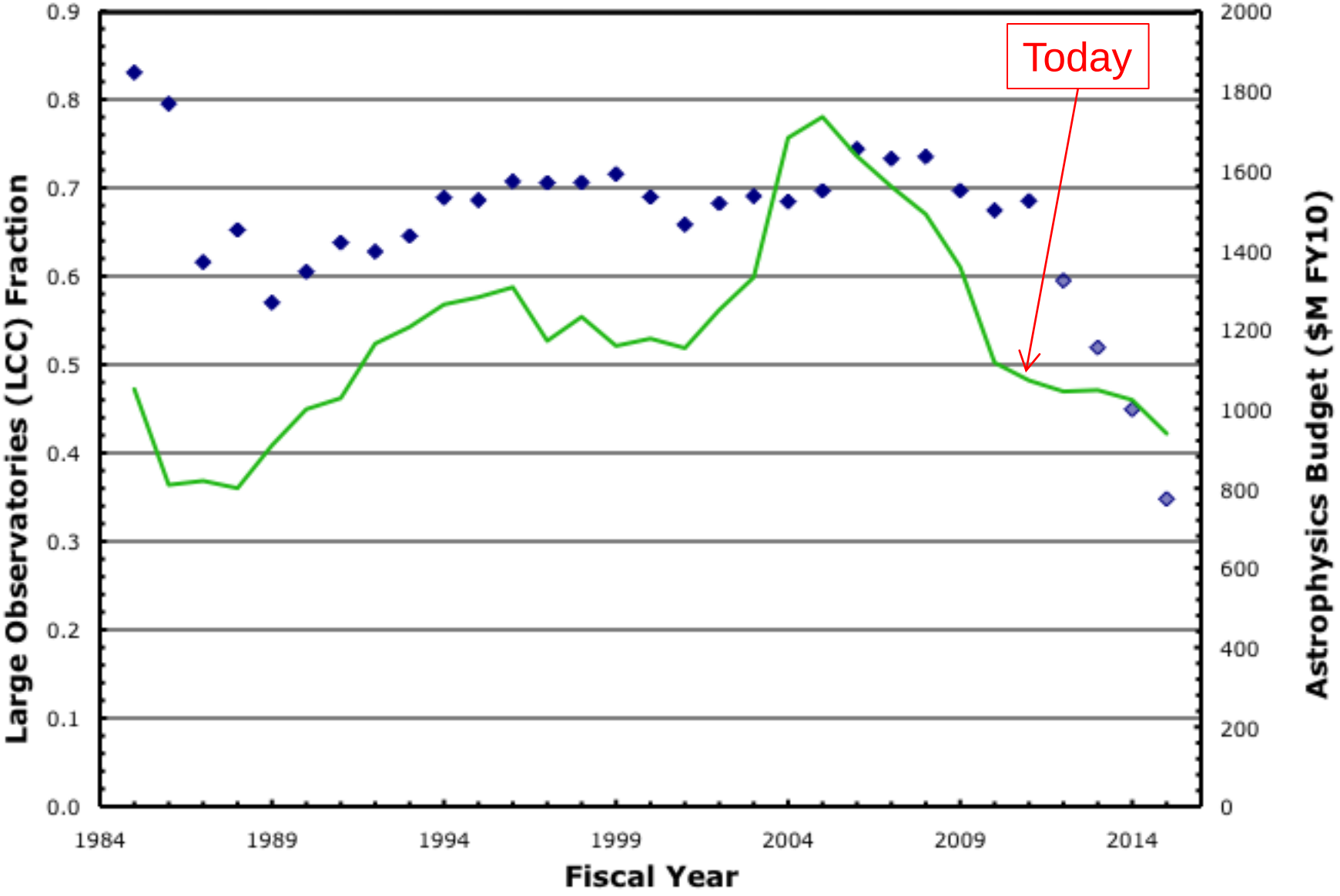
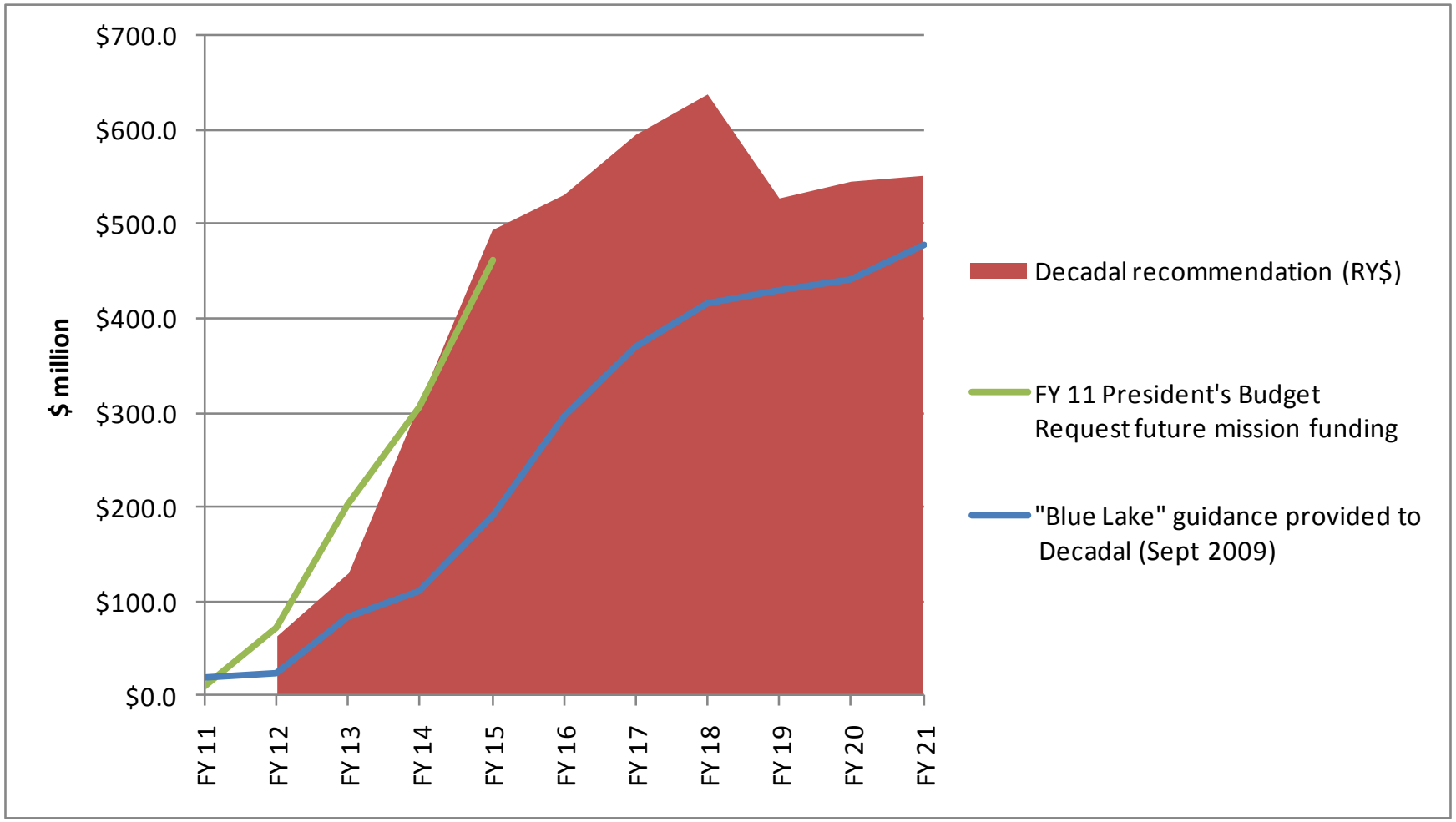
NuSTAR
Hubble
Kepler
Chandra
Fermi
Likely one additional Explorer mission in development and another in formulation; possible international collaboration
In Formulation
In Development
In Operation
NASA Astrophysics Mission Portfolio
2016 Projected

Astrophysics Division Funding History



Astro2010 Portfolio Compared to Agency Guidance



Wide-Field IR Survey Telescope (WFIRST)

- WFIRST is the top recommended Astro2010 Large project for a near-IR space observatory to do wide-field imaging and low-resolution spectroscopy
  - Designed to conduct cosmic expansion, exoplanet census, and other galactic and extragalactic large-area surveys, including pointed guest observer programs
- Near-term mission concept study (pre-formulation) activities
  - Initiate Science Definition Team (SDT) formation through open call, with scientists representing complete range of all recommended science programs/investigations/techniques
    - Science goals and implementation determined/optimized by SDT, and later through competitively selected PI-led science investigations
    - **WFIRST SDT community announcement released this week; Dear Colleague Letter will follow by mid-October**
  - Begin technical/engineering support as resources permit, for example continuing relevant technology development from other activities (e.g., detectors, optical concepts, etc.)
- Collaboration/coordination
  - Exploratory consideration of involving interagency and/or international partners, which may include SDT representation

WFIRST Considerations

- The budgetary and science environment in which WFIRST is developed will impact its implementation
- Budget environment:
  - Budget profile and schedule for JWST dominate considerations of when WFIRST development may begin
    - As imparted to Astro2010, and acknowledged in the committee and panel reports, significant funds for the next Astro flagship do not become available until after JWST launches
  - NASA budget only formally estimated for 5 years, always subject to being revisited in the annual budget process
- Science environment:
  - LSST and other ground-based telescopes
  - Investigations by Hubble, Chandra, Spitzer, JWST, etc.
  - Potential Explorer selections
  - Potential missions under development by other nations (e.g., Euclid)

ESA M-class astrophysics mission candidates: Euclid, PLATO

- Prior to Astro2010 release:
  - February 2010 invitation for NASA to consider a ~20% partnership on each mission (targeted LRD 2018; described in a letter from NASA to Astro2010 in early April)
  - 2 US scientists and engineering support teams supported by NASA have participated in planning and optimization studies for each concept since May 2010 (ESA has issued AOs for Euclid and PLATO consortia)
  - NASA indicated that participation would depend on compatibility with Astro2010 science priorities and recommendations (and would be contingent on availability of funds and upon ESA's next downselect)
- PLATO:
  - NASA finds that the PLATO transiting planet investigation is *not* well-aligned with Astro2010 priorities for an exoplanet census (recommended WFIRST survey uses microlensing technique, complementary to current Kepler transiting survey), and does not intend to pursue a strategic partnership

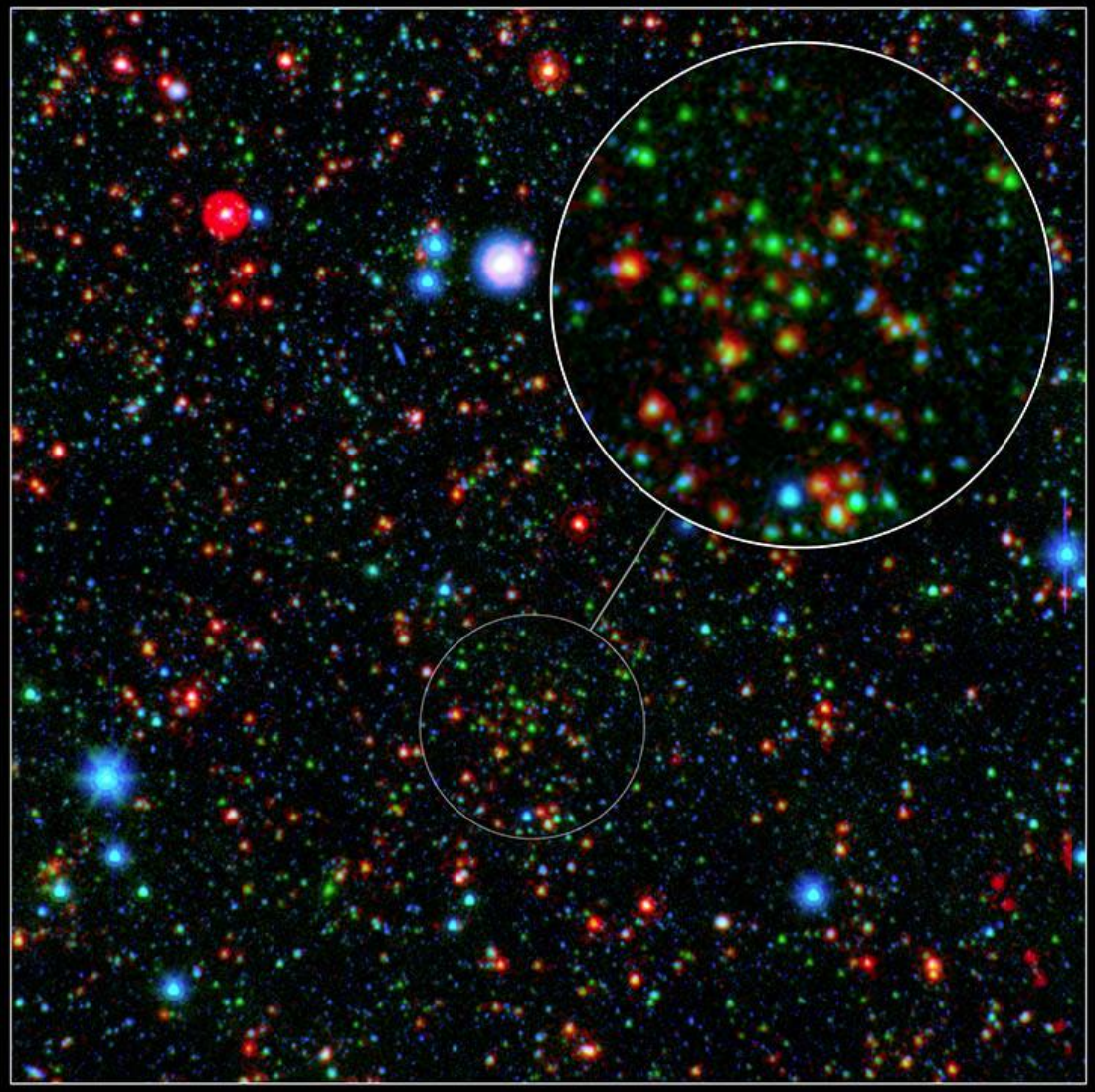
ESA M-class astrophysics mission candidates

- Euclid:
  - NASA finds that the dark energy investigation using BAO and WL techniques is similar to WFIRST; participation in Euclid could provide the US community with access to these types of dark energy data sooner than a WFIRST launch can be supported
  - In light of updated programmatic information (esp. JWST) about available resources in the Astrophysics Division budget during the decade, NASA is assessing a coordinated NASA-ESA approach to space-based observations
  - Community announcement released this week for Euclid NRA consistent with current assumptions of ESA AO and Science Management Plan (20% level)
    - Target NRA release mid-October
    - CA states: “As of the release of this announcement, NASA and ESA are continuing to discuss the potential for a strategic collaboration on the Euclid mission. NASA participation will depend upon the outcome of decisions informed by an assessment of the proposed ESA-NASA Euclid collaboration. NASA reserves the right to defer selection decisions, to make no selections, or to terminate selected investigations.”

JWST Summary Update

- James Webb Space Telescope (JWST) currently has a planned launch date in mid-2014.
- Testing Assessment Task (TAT) group found the time required for testing could be shortened by a period of 2 to 6 months without incurring unacceptable risk.
- Independent Comprehensive Review Panel (ICRP) is underway with a report due in October to the NASA Administrator's Office.
- NASA HQ and the JWST project are continuing to evaluate the content of the JWST fabrication, integration and test flow through launch, and will incorporate these independent reports into its planning approach.
  - Agency-level assessment currently scheduled for late-November

Science Highlights



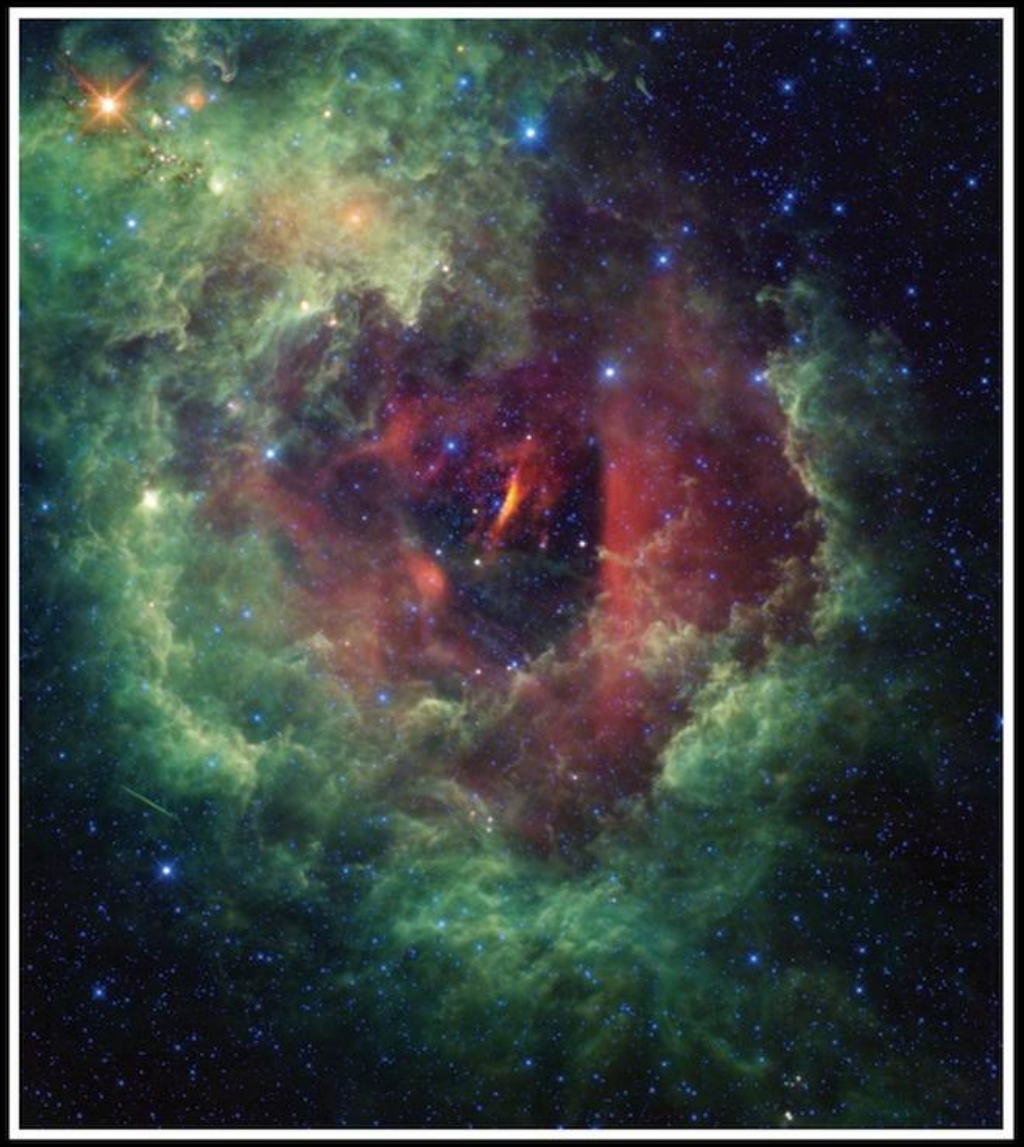
Star Formation in the Galaxy Cluster ClG J02182-05102

Spitzer Space Telescope • IRAC • MIPS / Subaru

NASA / JPL-Caltech / K. Tran (Texas A&M University)

sig10-018

This observation from the Spitzer SWIRE survey indicates that ancient galaxies are still actively forming stars, even near the core of a cluster. The most distant galaxies stand out clearly in the infrared, rendered here in green and red.



Rosette Nebula

Wide-field **I**nfrared **S**urvey **E**xplorer

NASA/JPL-Caltech/WISE Team

WISE 2010-030

WISE completed a survey of the entire sky in four mid-infrared wavelength bands. Preliminary data product release in Spring 2011.

Recent Releases

July 28 – **Spitzer** - Into the Wild: Spitzer Surveys the Milky Way's Outback.

Aug 2 – **WISE** - AFGL 490.

Aug 6 – **Hubble/Chandra/Spitzer** - Antenna: A Galactic Spectacle.

Aug 9 – **WISE** - Small Magellanic Cloud.

Aug 10 – **Hubble** - An "Island Universe" in the Coma Cluster.

Aug 10 – **WISE** - Spacecraft Warming Up.

Aug 11 – **GALEX** - Giant Ultraviolet Rings Found in Resurrected Galaxies.

Aug 11 – **SOFIA** - Observatory Completes Open-Door Flight Tests.

Aug 12 – **Hubble** - NGC 4696: A Cosmic Question Mark.

Aug 12 – **Fermi** - Detects 'Shocking' Surprise from Supernova's Little Cousin.

Aug 13 – NASA Statement on Release of NRC's 2010 Astrophysics Decadal Survey.

Aug 16 – **WISE** - Omega Centauri.

Aug 17 – **RXTE** - Eclipsing Pulsar Promises Clues to Crushed Matter.

Aug 18 – **Chandra** - M87: Galactic Super-Volcano in Action.

Aug 18 – **Spitzer** - Ancient Galaxy Cluster Still Producing Stars.

Aug 19 – **Hubble** - Cosmic Lens Used to probe Dark Energy for First Time.

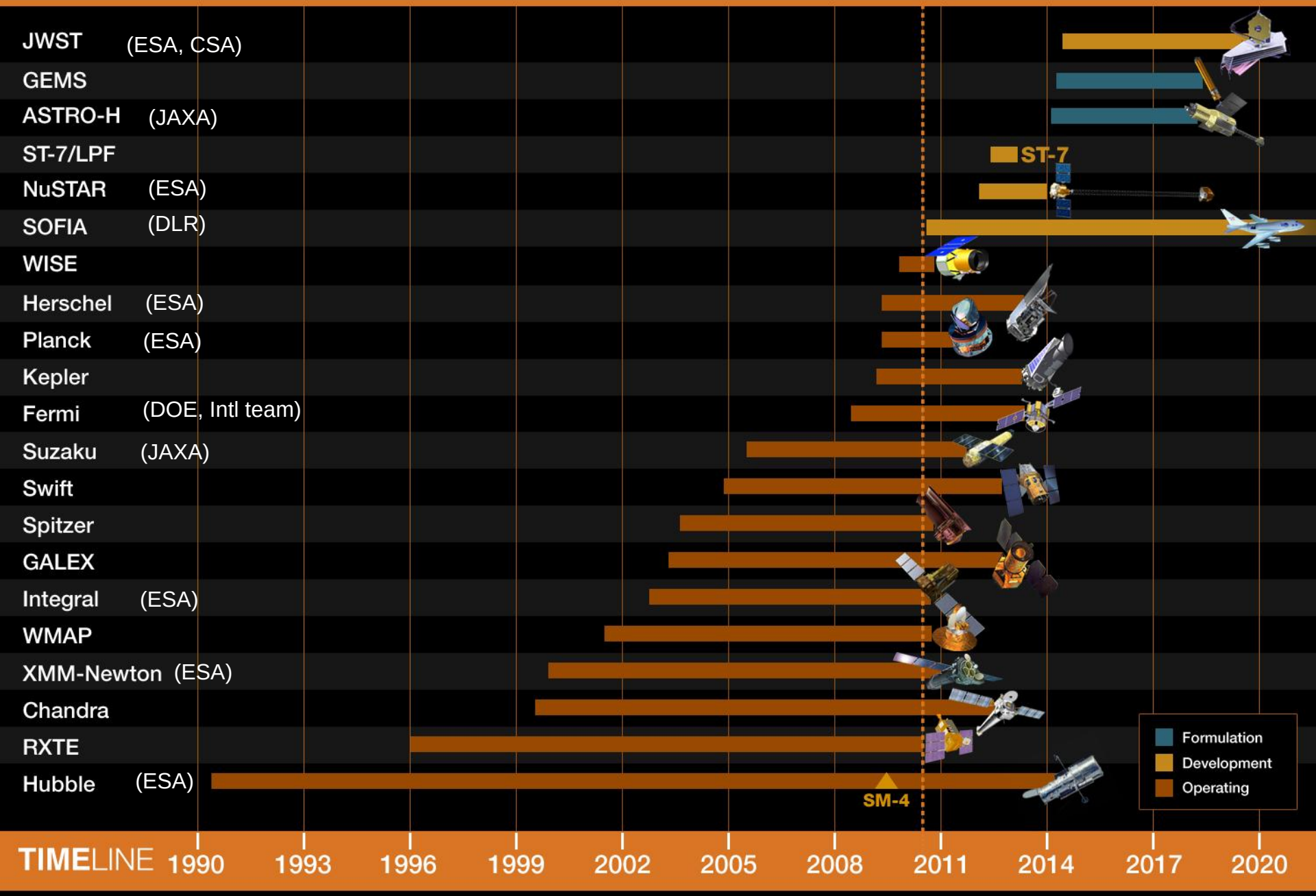
Aug 23 – **Spitzer** – Pulverized Planet Dust May Lie Around Double Stars.

Aug 26 – **Kepler** - First Multi-Planetary System to be Detected by Transit Photometry. (media telecon)

Programmatic Highlights

Astrophysics Missions timeline

Next Operating Missions Senior Review in 2012



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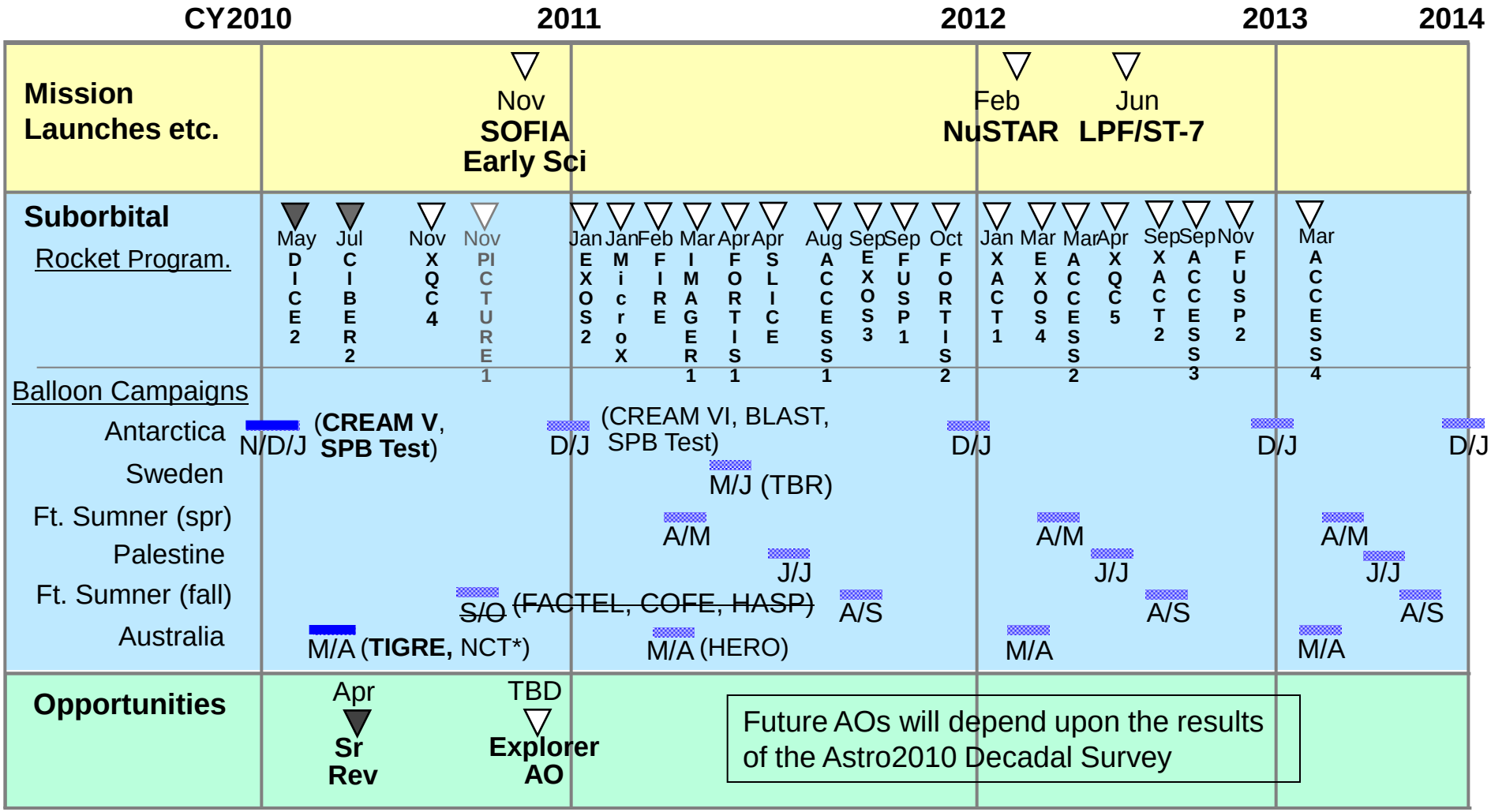

Last Updated: August 20, 2010

Legend

* - NCT Balloon flight aborted.

Grey - Backup 2010 suborbital launch

Accomplishments and Significant Events

SOFIA

- Completed replan APMC Aug 4. Action to update FOC definition: Provide full science operational capability with 4 available instruments.
- Completed flight envelope testing to 45K ft altitude and 40 deg telescope elevation.
- Completed FORCAST instrument line operations as precursor to early science mission planned for November.

NuSTAR

- First flight x-ray optics module assembly completed August 6. Assembly of second optics module initiated.

Astro-H

- Science working group Design Meeting, Sept 7 @ISAS, Japan.

WMAP

- Completed nominal science data collection on Aug 10.
- End-of-mission observing mode testing executed Aug 11-19.
- Decommissioning Review held Aug 26.

WISE

- Completed full sky survey in 4 bands in July.
- Cryogens exhausted; science payload warming up; Band 4 no longer operational; Band 3 integration time set to minimum

Events

- Australia NCT Balloon Mishap Investigation Board (MIB) final report due soon.
- “Astronomy of Exoplanets with Precise Radial Velocity”, Aug 15-19 @ Penn State.
- Calls for 2011 Sagan, Einstein, and Hubble Fellowships are out - applications due Nov 4.
- JWST – Launch Vehicle Technical Interchange meeting, Sept 21-23, Evry, France.
- WISE – End of Mission Review, Sept 22.
- Eighth INTEGRAL Workshop, “The Restless Gamma Ray Universe”, Sept 27-30, Dublin, Ireland.
- JWST – APMC Nov 2010.
- LBTI First light, Oct 14-16.
- U.S. Science & Engineering Festival, Oct 23-24, Washington, DC (participating: Hubble, Chandra, JWST, Kepler, and SOFIA).
- Einstein Fellows Symposium, Oct 19-20, Harvard-Smithsonian Center for Astrophysics.
- “Stormy Cosmos – The Evolving ISM from Spitzer, Herschel and Beyond” conference, Nov 1-4 @ Pasadena, CA.
- Gamma Ray Bursts 2010 conference, Nov 1-4, Annapolis, MD.
- First Kepler Science conference, Dec 5-7, 2011, NASA Ames.

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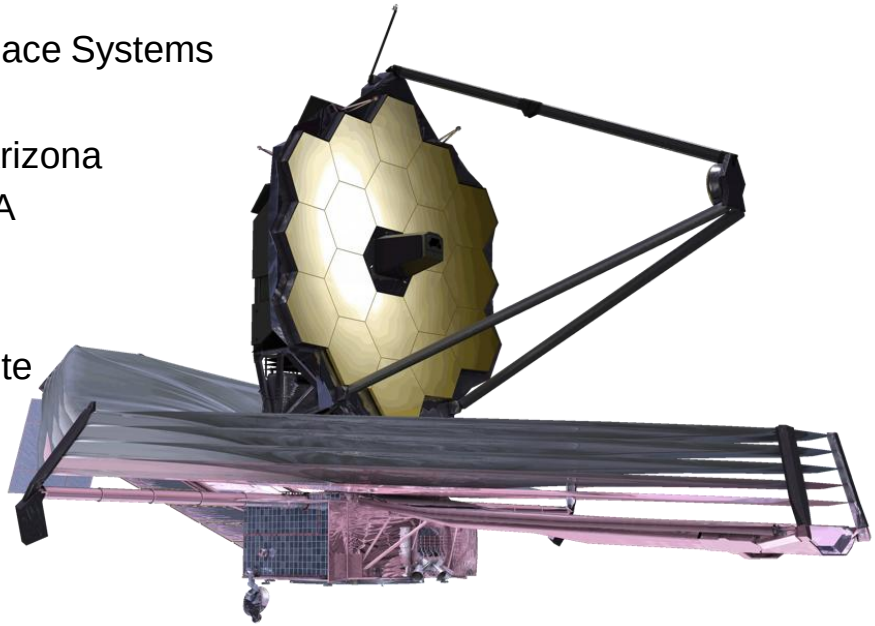
JWST Mission Overview

Organization

- Mission Lead: Goddard Space Flight Center
- International collaboration: European Space Agency & Canadian Space Agency
- Prime Contractor: Northrop Grumman Aerospace Systems
- Instruments:
- Near Infrared Camera (NIRCam) – Univ. of Arizona
- Near Infrared Spectrograph (NIRSpec) – ESA
- Mid-Infrared Instrument (MIRI) – JPL/ESA
- Fine Guidance Sensor (FGS) – CSA
- Operations: Space Telescope Science Institute

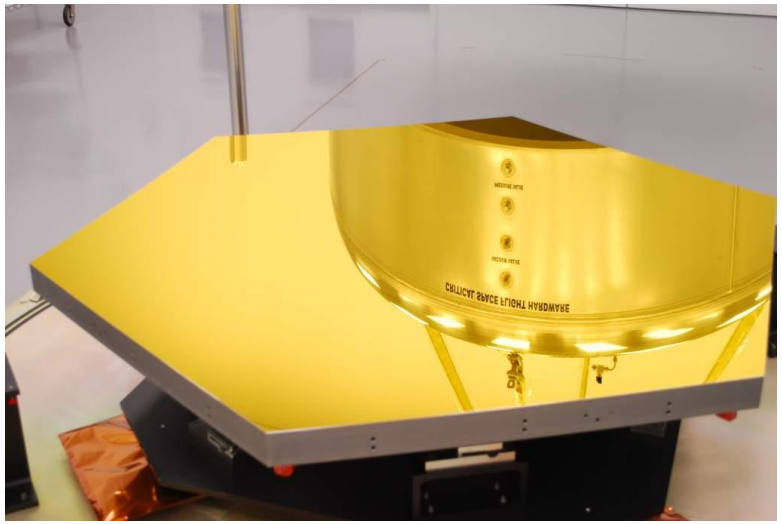


Description

- Deployable infrared telescope with 6.5 meter diameter segmented adjustable primary mirror
- Passively cooled, cryogenic temperature telescope and instruments for infrared performance
- Launch June 2014 on an ESA-supplied Ariane 5 rocket to Sun-Earth L2
- 5-year science mission (10-year goal)

JWST Project Summary

- **Launch Readiness Date is currently June 2014**
  - Working re-planned schedule and budget
  - Supporting TAT and ICRP activities
    - TAT report released
    - ICRP report expected by mid-October
- **Engineering or Verification Models for the science instruments are complete**
  - All four have been delivered to the GSFC
  - Integration of the flight instruments are well underway
    - Flight instrument deliveries are scheduled for next year
- **Continuing to make good progress on critical path items**
- **Accomplishments since KDP-C have gone a long way towards improving the project's technical risk posture**
- **Preparing to start Integration and Test Activities in FY11**



First flight primary mirror segment (A4) coated.

"Senior Review" of APD Research &Technology

- Senior Review (SR) of APD's Research, Analysis and Enabling Technology Programs to be started this fall.
- NRC's Fisk Report said APD's research & technology program should be clearly linked to NASA's strategic goals and metrics should be used to actively manage the portfolio of investments.
- Additional recommendations and guidance in the Astro2010 report on the core research program objectives and funding levels.
- Look for AAS Newsletter announcement requesting suggestions for panel membership
- NASA expects to brief the ApS in early 2011 on the progress of the review, and then to make the final report publically available.
  - Setting up public comment session at the January AAS in Seattle

Backup charts

Astrophysics Division

NASA FY2011 SMD Budget Overview

	FY2009	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015
Science	$4,903.1	$4,493.3	$5,005.7	$5,248.7	$5,509.7	$5,709.9	$5,814.1
Earth Science	$1,702.3	$1,420.7	$1,801.7	$1,944.5	$2,089.5	$2,216.6	$2,282.2
Planetary Science	$1,288.1	$1,341.3	$1,485.8	$1,547.3	$1,591.3	$1,630.2	$1,649.5
Astrophysics	$1,304.9	$1,103.9	$1,076.3	$1,109.3	$1,149.1	$1,158.7	$1,131.6
Heliophysics *	$607.8	$627.4	$641.9	$647.6	$679.8	$704.4	$750.8

* includes future Astro Explorers

Astrophysics Program Content

	FY09	FY10 *	FY11	FY12	FY13	FY14	FY15
FY11 President's Budget	1,304.9	1,103.9	1,076.3	1,109.3	1,149.1	1,158.7	1,131.6
Astrophysics Research	136.0	147.7	156.1	178.1	188.4	194.6	199.6
Research and Analysis	60.0	60.0	60.2	64.7	65.8	67.4	69.1
Balloons	25.6	26.7	27.1	32.4	32.7	35.3	36.8
ADCAR / ADP / Senior Review / Admin	50.4	61.1	68.7	80.9	89.8	91.9	93.7
Cosmic Origins	850.0	686.3	687.7	669.4	667.5	640.5	599.2
James Webb Space Telescope	466.9	440.3	444.8	379.2	335.2	259.3	119.2
HST	203.1	112.6	102.7	104.5	99.8	98.0	98.6
SOFIA	77.4	72.8	79.6	80.1	79.2	81.1	81.3
Spitzer	61.7	27.1	22.6	14.0	0.3		
SR&T	3.2	5.2	7.0	10.1	11.5	12.5	15.0
Herschel	17.2	23.0	24.5	24.0	20.8	15.8	5.8
Future Missions/Servicing/Management	20.5	5.3	6.5	57.6	120.8	174.0	279.3
Physics of the Cosmos	111.1	115.8	103.3	114.4	151.7	176.4	202.0
Fermi (GLAST)	13.2	22.2	22.7	25.9	25.5	25.1	25.1
Planck	6.4	8.9	8.1	6.5	6.5	3.0	0.8
Chandra / INTEGRAL / XMM	69.7	64.8	59.4	59.0	59.3	59.7	59.8
SR&T	2.8	4.3	5.6	9.8	11.7	13.0	15.0
JDEM	8.5	4.4					
LISA, IXO, Future and Management	10.5	11.1	7.5	13.2	48.7	75.6	101.3
Exoplanet Exploration	72.1	46.2	42.5	54.1	83.0	93.8	117.6
Kepler	31.7	20.1	16.9	19.1	13.8	0.2	
SIM	20.0	2.0					
Keck/LBTI	3.7	5.3	4.1	3.2	3.3	3.4	3.5
SR&T	11.0	13.3	12.7	16.3	17.8	18.2	18.8
Future Missions/Management	5.7	5.6	8.8	15.5	48.0	72.0	95.4
Astrophysics Explorer	135.7	107.9	86.7	93.3	58.5	53.3	13.2
WISE	69.2	13.0	6.8	2.7	0.2		
NuSTAR	38.7	59.9	32.1	10.8	6.2		
Astro-H	6.4	10.9	12.5	7.0	7.4	12.6	11.1
GEMS	1.7		21.0	57.7	44.7	40.8	2.1
Operating Explorers	19.6	24.0	14.4	15.1			

* FY10 Enacted Budget

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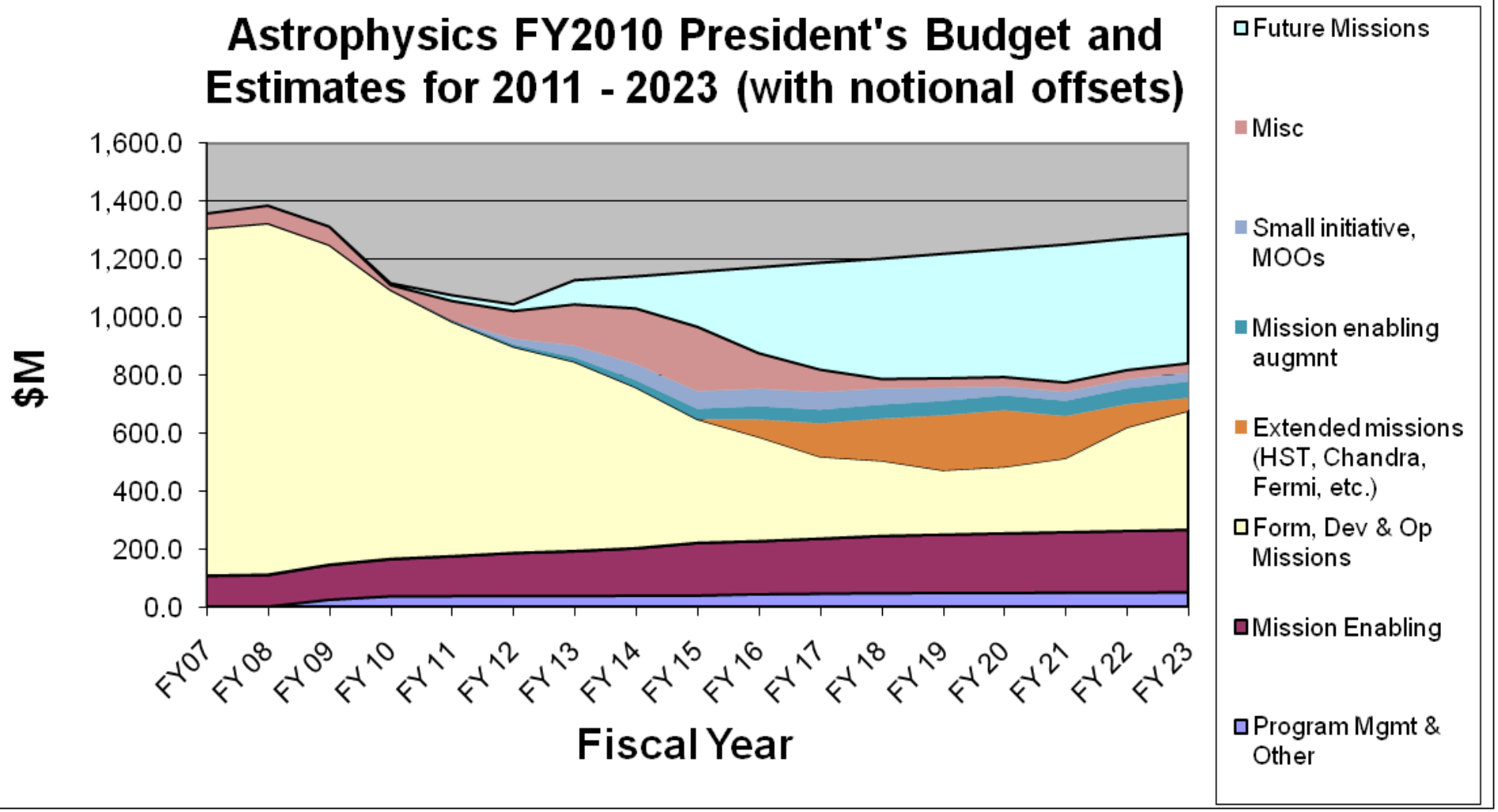
Astrophysics Budget Changes

	FY10	FY11	FY12	FY13	FY14	FY10-14 Total
Changes from FY10 Budget	-17.0	2.2	66.6	22.7	19.1	93.6
GEMS transfer from Helio		21.0	57.7	44.7	40.8	164.2
JWST		59.7	24.5	-0.5	-0.5	83.2
HST / SOFIA / Astro-H / WISE		9.5	19.1	13.9	17.6	60.1
Fermi / Chandra / Keck / Kepler		-0.8	7.8	16.4	7.5	30.9
Future Missions / SR&T / Mgmt	-10.4	-76.6	-54.1	-51.1	-47.6	-239.8
All other	-6.6	-10.7	11.5	-0.6	1.4	-5.0

Astro2010 Decadal Survey – Notional Forward Look



- Assumed operating missions beyond 2016 include JWST, SOFIA; plus HST, Chandra, Fermi, etc. (e.g., Astro-H)
- HST De-orbit mission development ramps up ~2020
- "Future Missions" wedge is for strategic missions recommended by the Astro2010 decadal survey
- The amount of "Future Missions" funding available between 2013 – 2020 in such a scenario would be ~$2.3B

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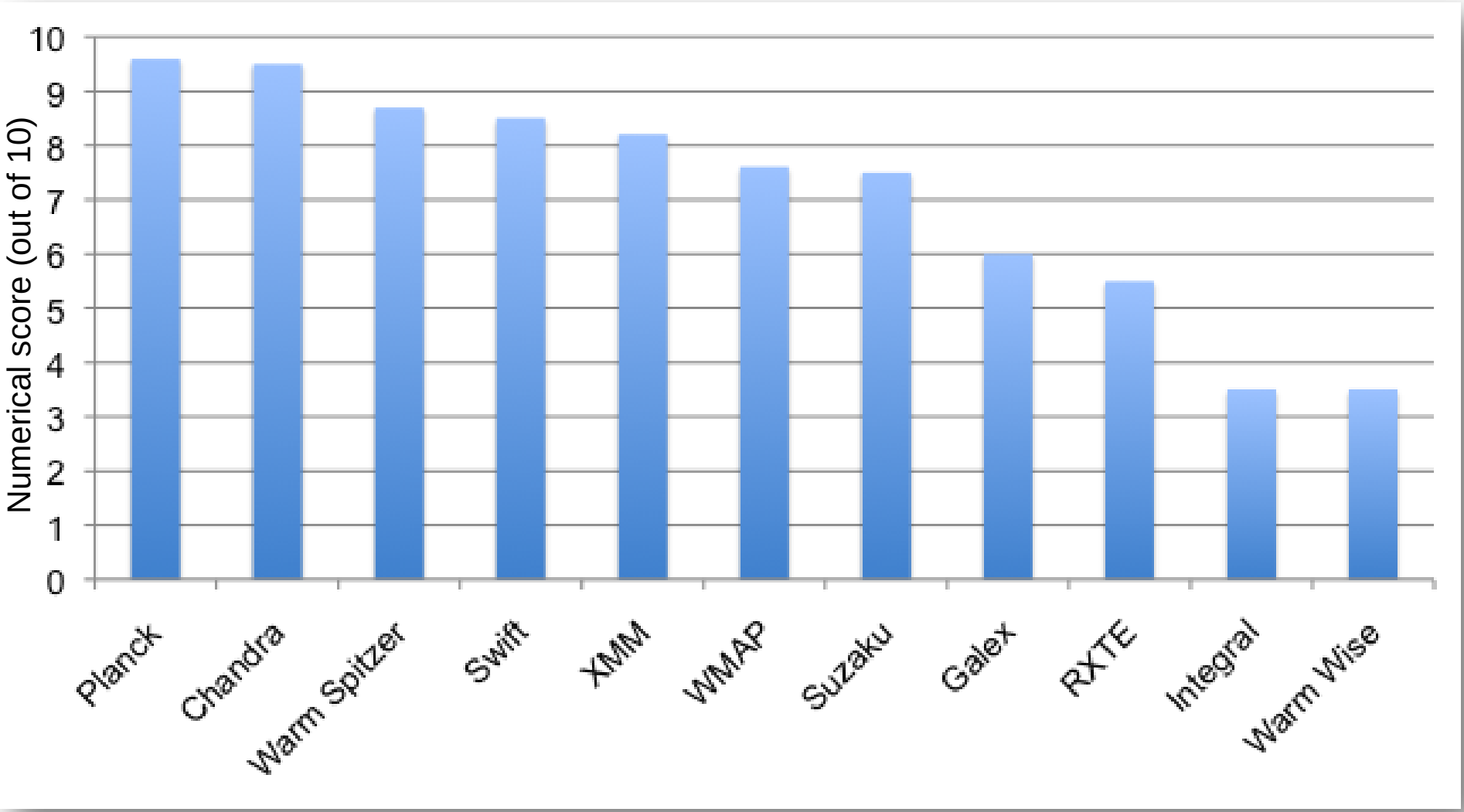
2010 Astrophysics Senior Review of Operating Missions



- Total expenditures on extended operating missions is ~10% of annual budget