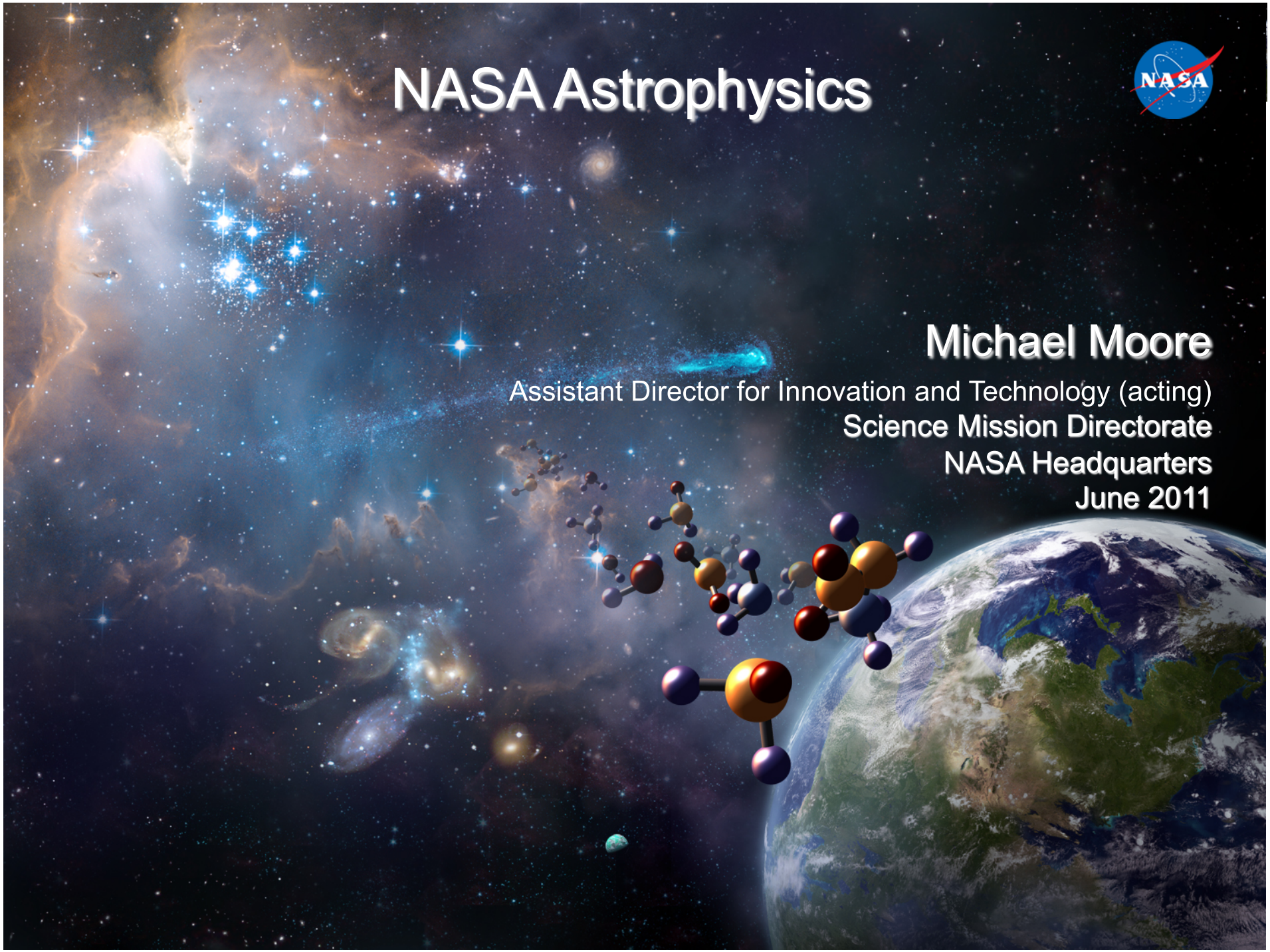

NASA Astrophysics
Michael Moore
Assistant Director for Innovation and Technology (acting)
Science Mission Directorate
NASA Headquarters
June 2011

# Programmatic Update


# 2011 Fellowships

## Sagan Fellows

| Name | Host Institution |
|---|---|
| David Kipping | SAO, Cambridge, Mass. |
| Bryce Croll | MIT |
| Wladimir Lyra | JPL |
| Katie Morzinski | Univ. of AZ, Tucson |
| Sloane Wiktorowicz | UC Santa Cruz |

## Einstein Fellows

| Name | Host Institution |
|---|---|
| Akos Bogdan | SAO |
| Sam Gralla | UM, College Park |
| Philip Hopkins | UC Berkeley |
| Matthew Kunz | Princeton Univ. |
| Laura Lopez | MIT |
| Amy Reines | NRAO |
| Rubens Reis | Univ. of MI |
| Ken Shen | LBNL |
| Jennifer Siegal-Gaskins | Caltech |
| Lorenzo Sironi | Harvard Univ. |

## Hubble Fellows

| Name | Host Institution |
|---|---|
| Gurtina Besla | Columbia Univ. |
| Jo Bovy | Inst for Adv Study |
| Sean Couch | Univ. of Chicago |
| Nathalie Degenaar | Univ. of MI, Ann Arbor |
| Steven Finkelstein | Univ. of Texas, Austin |
| Evghenii Gaburov | Northwestern Univ. |
| Markus Janson | Princeton Univ. |
| Linhua Jiang | ASU Tempe |
| Jeyhan Kartaltepe | NOAO |
| Mansi Kasliwal | Carnegie Obs. |
| Christiaan Ormel | UC Berkeley |
| Joshua Peek | Columbia Univ. |
| Daniel Perley | Caltech |
| Ralph Schoenrich | Ohio State Univ. Columbus |
| Roman Shcherbakov | UM College Park |
| Daniel Stark | UA Tucson |
| John Tobin | NRAO |

Watch for call for public comment of new Astrophysics Technology Fellows Program

# Explorers

- The schedule for the current round of NASA Explorer proposals is:
  - Step 1 Selections announced (target) .....Sept 2011
  - Phase A Concept Study Reports due (target) ....August 2012
  - Down-selection for flight (target) .....February 2013

- There are:
  - 15 Astrophysics EX mission proposals - $200M plus launch costs
  - 11 Astrophysics SALMON/Missions of Opportunity proposals - $55M includes both Partner MOs and Small Complete Missions

- APD expects to release the next SALMON/MoO AO late-2011

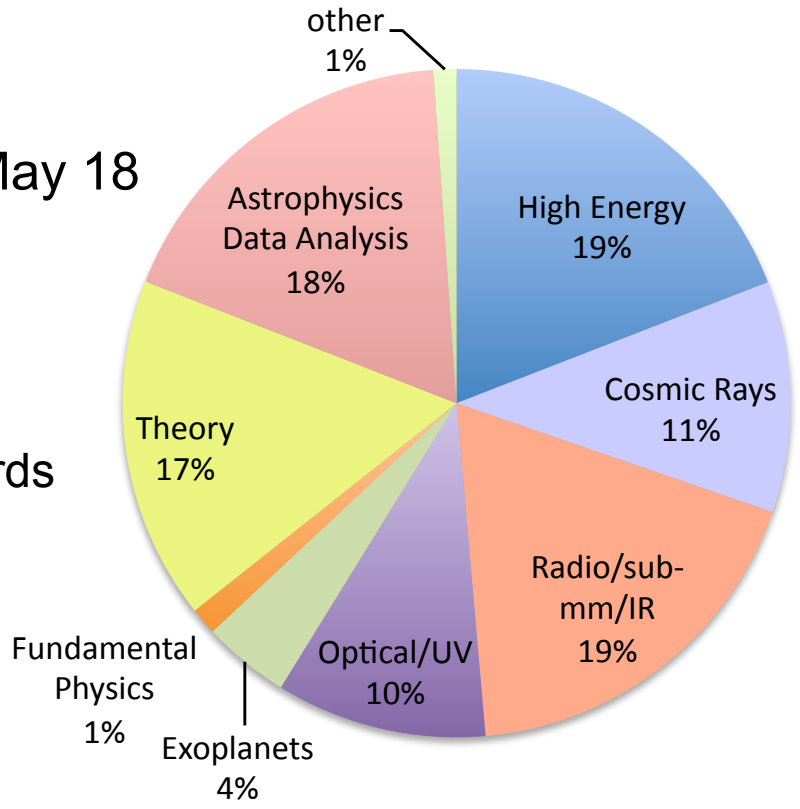
- As recommended by NWNH, a Future Astrophysics Explorer missions budget was created to increase the flight rate to achieve the recommended four missions and four missions of opportunity selected by the end of the decade. Notional Mission Selection Dates:
  - 2013 EX 1 (current AO)
  - 2014/15 SMEX 1
  - 2016 EX 2
  - 2018/19 SMEX 2

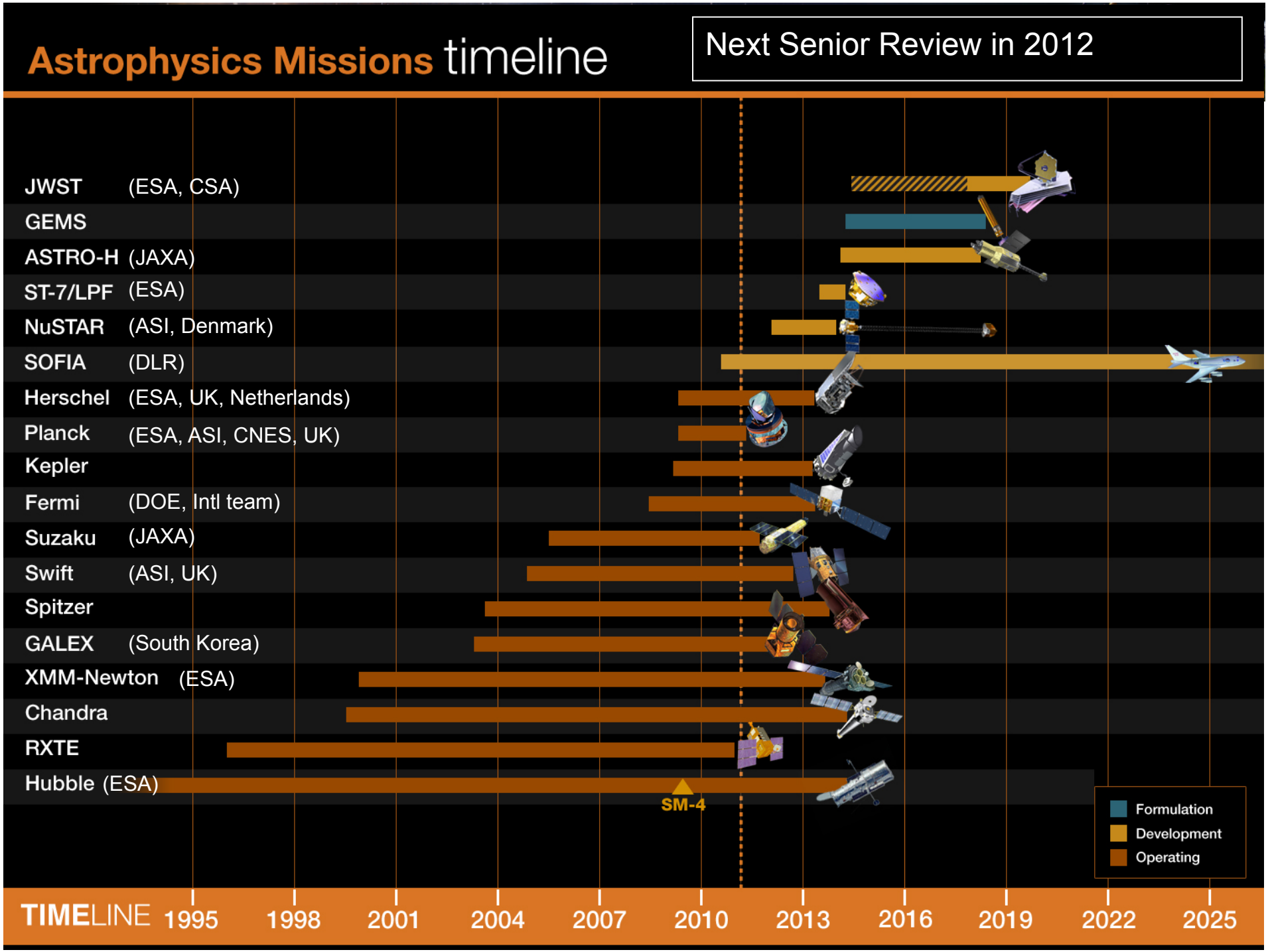
# Astrophysics Research Program

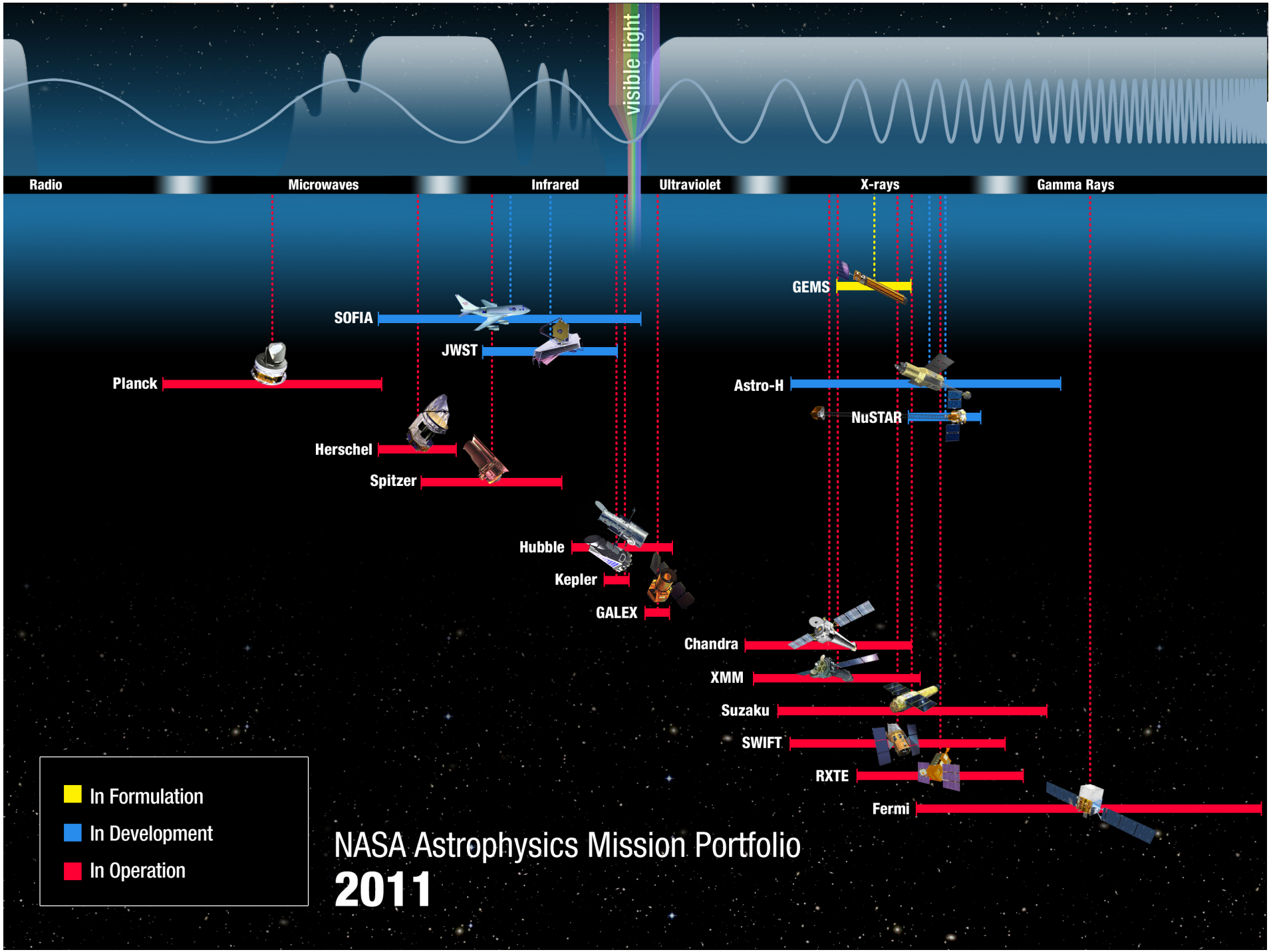
- Strategic Astrophysics Technology: new in ROSES-10
  - SAT funds technology development from TRL-4 for strategic missions
  - 57 proposals received:  22 for Exoplanet Exploration,15 for Cosmic Origins, 20 for Physics of the Cosmos

- Research Program Review 2010-11
  - 14-member panel has met 3 times
  - Draft report delivered to NASA on May 18

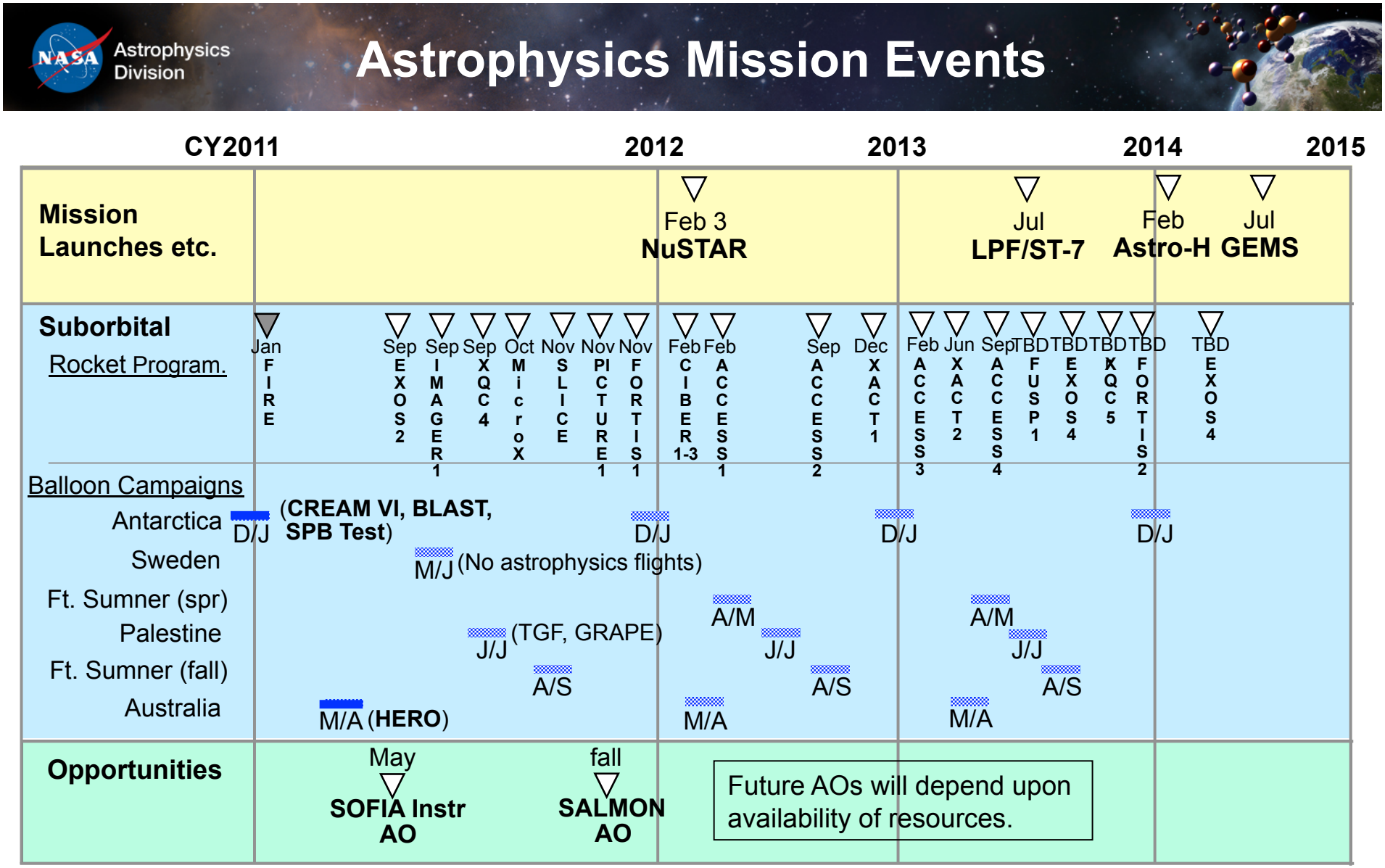
Astrophysics Research Awards
$74M total in FY2010




Astrophysics Missions timeline
Next Senior Review in 2012
JWST (ESA, CSA)
GEMS
ASTRO-H (JAXA)
ST-7/LPF (ESA)
NuSTAR (ASI, Denmark)
SOFIA (DLR)
Herschel (ESA, UK, Netherlands)
Planck (ESA, ASI, CNES, UK)
Kepler
Fermi (DOE, Intl team)
Suzaku (JAXA)
Swift (ASI, UK)
Spitzer
GALEX (South Korea)
XMM-Newton (ESA)
Chandra
RXTE
Hubble (ESA)
SM-4
Formulation
Development
Operating
TIMELINE
1995
1998
2001
2004
2007
2010
2013
2016
2019
2022
2025


visible light
Radio
Microwaves
Infrared
Ultraviolet
X-rays
Gamma Rays
GEMS
SOFIA
JWST
Planck
Astro-H
NuSTAR
Herschel
Spitzer
Hubble
Kepler
GALEX
Chandra
XMM
Suzaku
SWIFT
RXTE
Fermi
In Formulation
In Development
In Operation
NASA Astrophysics Mission Portfolio
2011

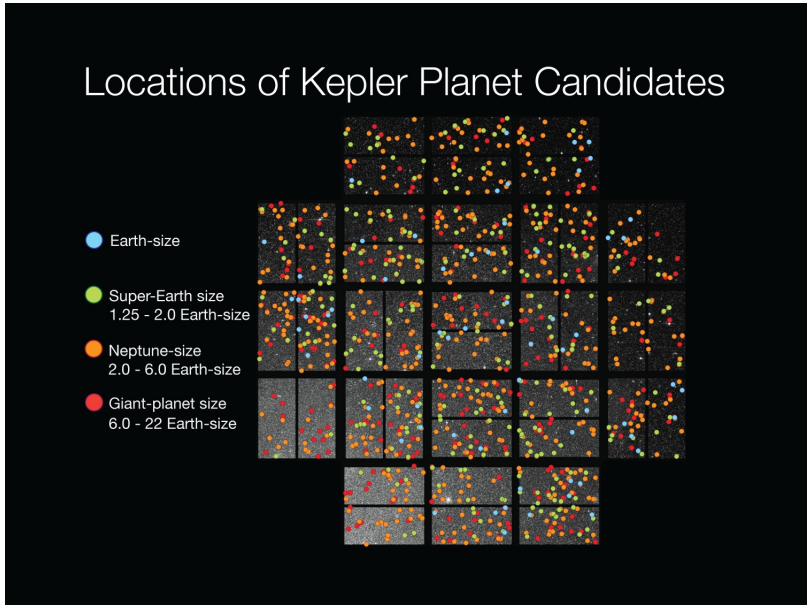
# Astrophysics Mission Events




Last Updated: April 25, 2011

# Accomplishments and Significant Events

- Kepler:
  - February 2011, released of all Quarter 2 mission data, as well as Quarter 1 data for sequestered targets. Quarter 2 data was released 5 months ahead of schedule to make the data eligible for the 2011 Astrophysics Data Analysis Program (ADAP).
  - Science Team announced the identification of 1235 exoplanet candidates -68 of candidates are Earth-sized in in short period orbits close to their host star. -54 of the candidates lie in the habitable zone of their host star. -170 stars exhibit transits by two or more planets, one of which (Kepler-11) exhibits transits from 6 different planets.



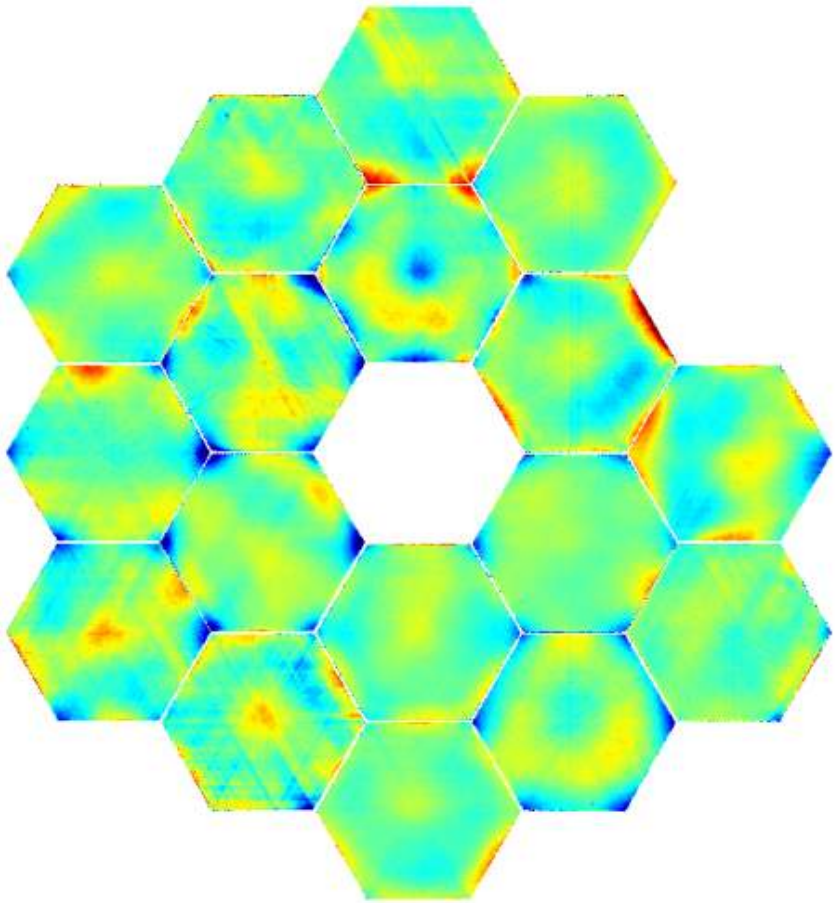

- WISE
  - Decommissioned February 17, 2011. Preliminary catalog released April 14, 2011. Analysis continues for final data catalog release.
- GP-B
  - Paper published in Physical Review Letters confirming the geodetic effect and frame dragging effects predicted by General Relativity. Press event held at NASA Headquarters celebrating the legacy of GP-B on May 4, 2011
- Spitzer
  - Awarded a Rotary National Award for Space Achievement Stellar Award last. Spitzer was one of 7 teams selected from 36 nominees
- Planck
  - Early Release Compact Source Catalog (ERCSC) released on January 11, 2011, with many new Sunyaev-Zeldovitch effect clusters and cold cores in star forming regions.

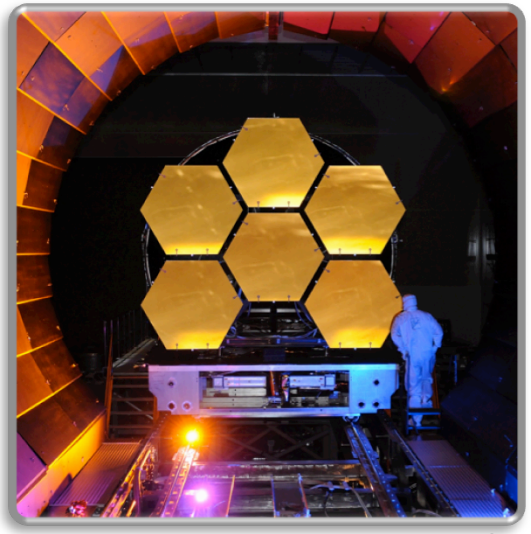
# JWST Primary Mirror Polishing & Testing

## Optical Telescope Team making excellent progress

All mirrors polished by the end of June, all coated by the end of August (Tinsley & Ball, QCI)
Significant progress has been made on the primary mirror assembly equipment (ITT), delivery to GSFC in October
Flight structure work continues with delivery of pathfinder and flight build continuing (ATK)

Tinsley Final Measurement Requirements
*Total Figure* *< 17 nm rms*



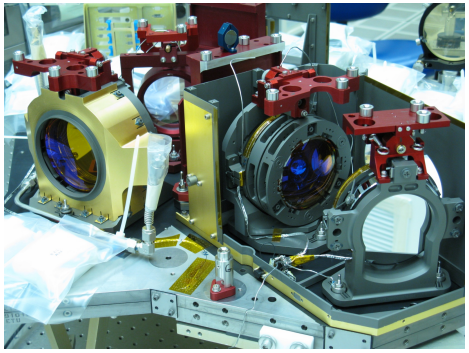



6 segments under test at XRCF

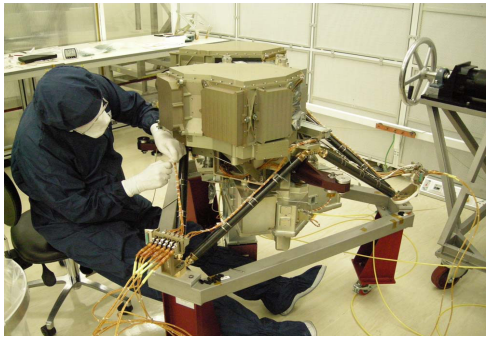
# JWST Science Instruments

## Integrated Science Instrument Module (ISIM) making good progress

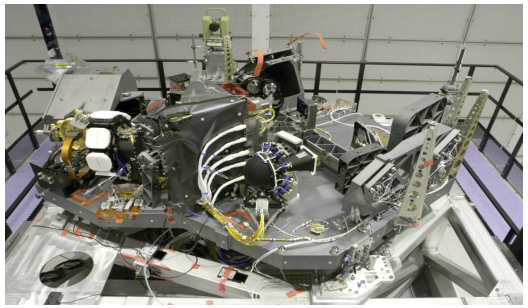
- ISIM level Integration activities begin later this Summer
- NIR Detector “hot-pixel” problem diagnosed, improved manufacturing process being developed
- NIRSpec microshutter contamination cleaned, wire harness coating behavior after cryo-vac also being studied
- Delivery of CSA and ESA instruments this Fall



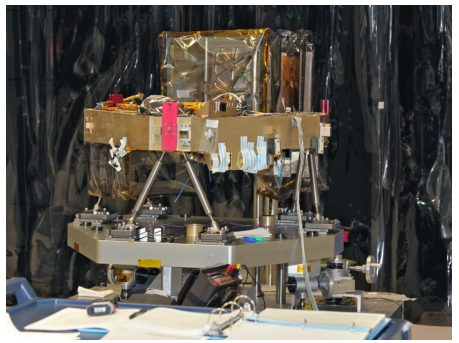
B-side Flight NIRCam



Flight Mid-Infrared Imager (MIRI; ESA)



Flight Near-Infrared Spectrograph (NIRSpec; ESA)

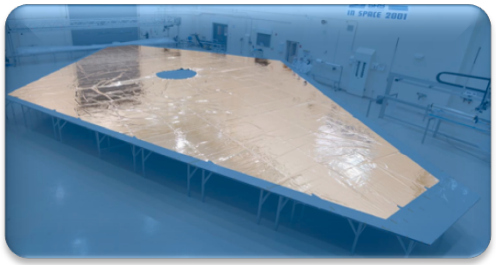


Flight Fine Guidance Sensor/ Tunable Filter (CSA)

# Other JWST Program Elements

- Spacecraft & Sunshield
  - Component level engineering units being developed
  - Sunshield templates under test
  - Project Integration and Test Activities continues
    - Upgrades to JSC Chamber A making it the largest cryogenic vacuum chamber in the world continues

Solid State Recorder EQM

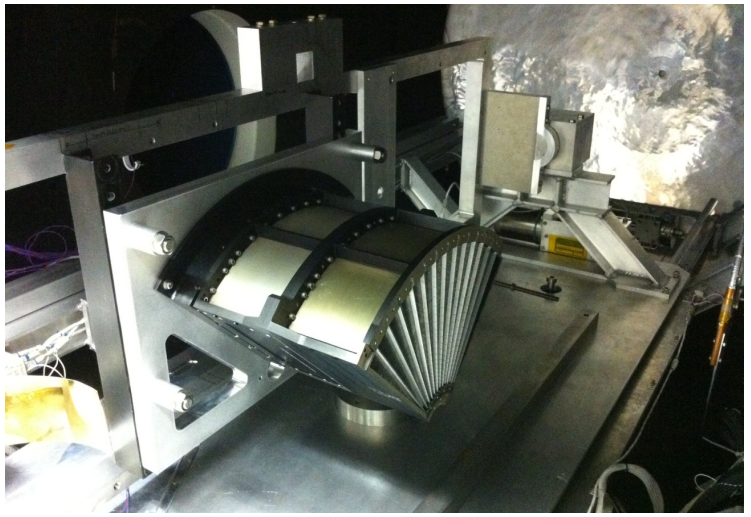


SS Membrane Template Layer #3 and Shape Verification Fixture

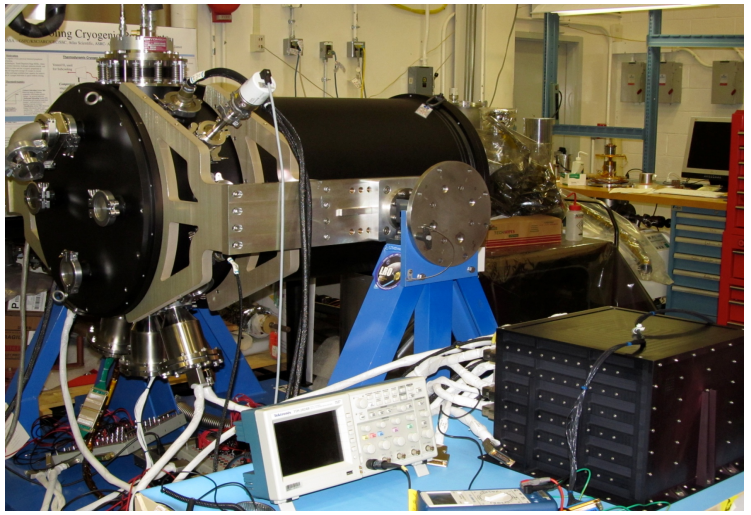
- Programmatic
  - Replan activity on schedule to conclude by July
    - New schedule and budget to be included in NASA FY13 request

# Astro-H

- Japanese Disaster has had modest impact on Astro-H thus far.
  - Delays in environmental testing for JAXA hardware due to black-outs and energy conservation efforts in Tokyo area.
  - JAXA has asked NASA to maintain our existing schedule and interfaces.
- Engineering Model (EM) Mirror Quadrant completed.
  - Damaged during testing, replaning underway.
- EM model Adiabatic Demagnetization Refrigerator (ADR) has completed vibration testing and is ready for EM Integration and test.
- Science Working Group Meeting held at JAXA 2/23-2/24.
- Next Science Working Group Meeting at SLAC 7/18-7/19.
- NASA hardware Critical Design Review (CDR) to be held 6/21-6/23 at GSFC.



EM SXT quadrant in the X-ray beam line facility. Delivery planned for early June.

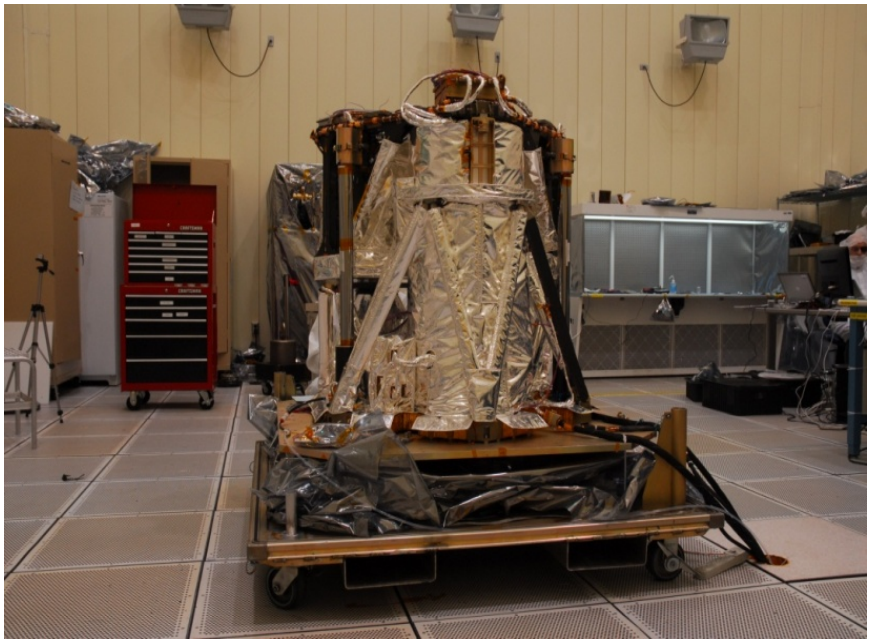


The EM ADRC connected to the Test Dewar and EM ADR.

Astrophysics Division

# NuSTAR

- NuSTAR Instrument delivered to Orbital Sciences Corp. and Observatory I&T underway.
  - Instrument mechanical integration to spacecraft bus successfully completed.
  - Observatory TVAC testing planned for June 17- July 28.
  - Completion of Observatory I&T planned for November 22.
  - Launch scheduled for February 3, 2012 on a Pegasus from Kwajalein Atoll.



NuSTAR Instrument Delivery to OSC (4/25/2011)


NuSTAR Instrument Mechanical Integration to S/C Bus (5/9/2011)

# SOFIA

- **Completed the Basic Science #1 campaign, with 10 successful flights in 10 attempts**
  - Achieved more than 90% of planned flight research hours
  - Fixed problem with nose wheel landing gear with no schedule slips
  - Some issues in Mission Control & Communication System (MCCS) and telescope assembly (TA)
    - to be addressed during new Basic Science 2 Software integration testing and Line Operations
- **High-speed Imaging Photometer for Occultation (HIPO) instrument delivered to DAOF**
  - Will be third instrument to conduct science on SOFIA (Pluto occultation on 6/22)
  - Will establish telescope performance at the short end of the SOFIA wavelength range
- **Completed PDR for Segment 3 Avionics Upgrades**

# Cosmic Origins Program Analysis Group (COPAG)

- Provides community input to NASA via the NAC Astrophysics subcommittee (APS) on future direction and possible technology investments for the Cosmic Origins program. Chris Martin, Chair

- COPAG Tasks:
  - **Task 1: Determine technology focus areas for a stand-alone, Large Aperture UV/ Optical mission -** Task leads: Ken Sembach, STScI, Jonathan Gardner, GSFC
  - **Task 2: Determine technology focus areas *that make possible* a joint UV/Optical & Exoplanet mission -** Task lead: Chuck Lillie, NGST
  - **Task 3: Determine technology focus areas for future Far IR Instruments –** Task Lead: Paul Goldsmith, JPL

- First joint meeting of COPAG (SAG 1) and ExoPAG was held at STScI on April 26, to begin to explore a joint 4-m mission study mentioned by the Decadal Survey Committee. Information and viewgraphs for this meeting are posted at: *http://cor.gsfc.nasa.gov/copag/mtgs/stsci_apr2011/*

- The COPAG had a community meeting here on at the AAS meeting, May 24, at the Fairmont Copley

- Website: *http://cor.gsfc.nasa.gov/*

# Physics of the Cosmos Program Analysis Group (PhysPAG)

- Provides community input to NASA via the NAC Astrophysics subcommittee (APS) on future direction and possible technology investments for the Physics of the Cosmos program.

- Currently 3 actively working Study Analysis Groups (SAG):
  - Technology SAG
    - Provided input to NRC on NASA's technology roadmap
    - Collecting community input on PCOS technology availability and needs
  - Inflation Probe SAG
    - Discussing concept and technology needs for future inflation probe missions
  - Community Interactions/Interfaces/communication

- **PhysPAG face-to-face meetings are public – It's your community – participate!**

| Past Meetings | |
|---|---|
| January 2011 | 217th winter AAS, Seattle, WA |
| April 2011 | American Physical Society (APS) meeting , Anaheim, CA |

| Upcoming Meeting 219th Winter AAS, Austin TX | |
|---|---|
| Sunday Jan 8, 2012 | General meeting |
| Date TBD | Joint session with COPAG & EXOPAG |

- Website: http://pcos.gsfc.nasa.gov/physpag.php

# Exoplanet Exploration Program Analysis Group (ExoPAG)

- Provides community input to NASA via the NAC Astrophysics subcommittee (APS) on future direction and possible technology investments for the Exoplanet Exploration program.

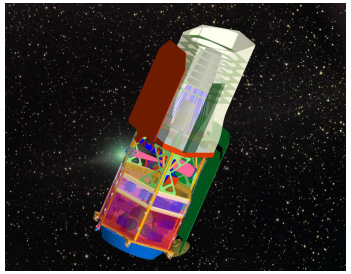
- Next Meeting: ExoPAG-4, 1-2 June 2011, Alexandria, VA
  - *Information and registration: http://exep.jpl.nasa.gov/exopag/exopag4/*
- Ongoing Activities – Science Analysis Groups (SAGs)
  - *1. Debris Disks and Exozodiacal Dust.*
  - *2. Potential for Exoplanet Science Measurements from Solar System Probes.*
  - *3. Exoplanetary System Architecture and Dynamical Stability.*
  - *4. Measurements Needed for Exoplanetary Characterization.*
  - *5. Exoplanet Flagship Requirements and Characteristics (joint SAG with COPAG)*
  - *8. State of Precision RV Measurements for and Exoplanetary Census.*

- Joint COPAG/ExoPAG SAG formed to analyze and articulate the capabilities, requirements, and technological demands that would be associated with developing a future flagship-class UVOIR space observatory with exoplanet direct-detection capability.
  - *Organizational meeting held 26 April at STScI.*

- Website: http://exep.jpl.nasa.gov/exopag/

# WFIRST

- The Wide-Field Infrared Survey Telescope (WFIRST) is a NASA observatory designed to address essential questions in both exoplanet and dark energy research and to perform an IR survey of the sky.
- Astro2010's highest priority large space mission.
- Update:
  - SDT members selected
  - SDT kickoff telecon on Jan 3, 2011
  - 3 face-to-face meetings have been held
  - Subgroups have been formed on focused report topics and have met via telecons
- Next Steps:
  - Next face-to-face meeting June 8-9 at GSFC
  - Delivery to NASA of ad-interim report due June 2011



http://wfirst.gsfc.nasa.gov

**Members of the Science Definition Team (SDT):**

J. Green, CU/CASA, *Chair*
P. Schechter, MIT, *Chair*

R. Bean, Cornell University
C. Baltay, Yale
C. Bennett, JHU
D. Bennett, Univ. of Notre Dame
R. Brown, STScI
C. Conselice, Univ. of Nottingham
M. Donahue, Michigan State University
S. Gaudi, Ohio State University
T. Lauer, NOAO
B. Nichol, Univ. of Porthsmouth
S. Perlmutter. Univ. of Berkeley/LBLN
B. Rauscher, GSFC
J. Rhodes, JPL
T. Roellig, Ames
D. Stern, JPL
T. Sumi, Nagoya University
A. Tanner, Georgia State University
Y. Wang, Univ. of Oklahoma
E. Wright, UCLA

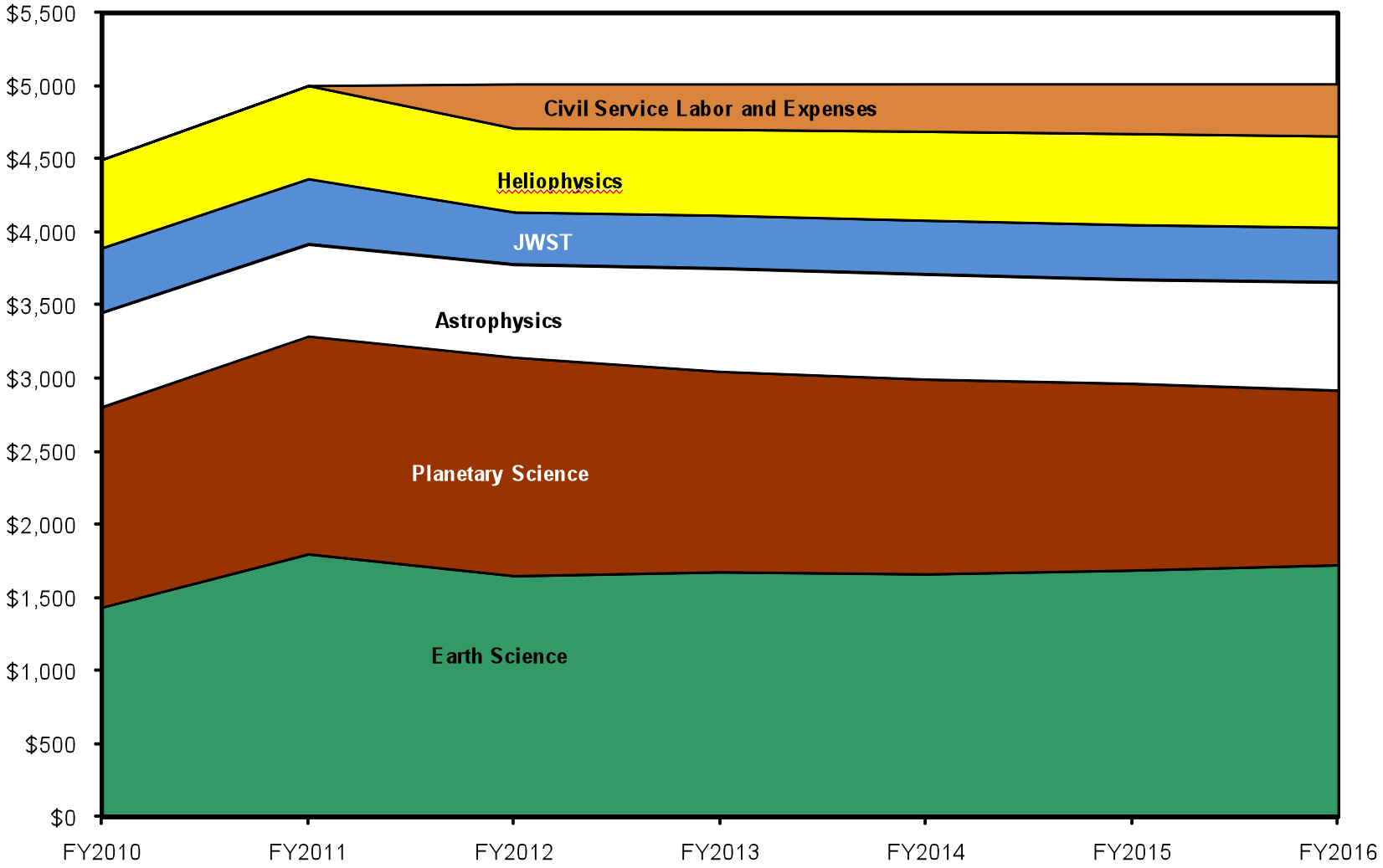
# LISA and IXO

- 3 candidate concepts were competing for ESA's L1 2020 opportunity: LISA, IXO and EJSM/ Laplace, each with a significant NASA partnership
- None of these were recommended as top priority by the US decadal surveys
- The decadal rankings combined with the constrained projected out-year resources in the FY12 President's Budget Request led ESA to conclude that a 2020 schedule is not feasible for any of the 3 candidates
- ESA started an exploratory activity to see which, if any, of the science goals of the three L missions could be implemented as a ESA-led mission targeting an early 2020's launch date
  - European "Science Teams" were formed for a rapid mission definition effort: Athena (Advanced Telescope for High ENergy Astrophysics) and NGO (New Gravitational waves Observatory)
  - A "NASA HQ-empowered scientist" is participating on each of the Study Teams: Nick White for Athena and Tuck Stebbins for NGO
  - L1 plan to be discussed at June ESA SPC meeting; tentative plan for downselect foreseen at Feb 2012 SPC meeting
- Consideration of the LISA and IXO concepts with the scale and partnerships as proposed to the NWNH decadal survey is ended
- NASA plans to continue the base funding for the US LISA and IXO teams through FY11
- NASA will consult with the community about strategic investments in gravity wave and X-ray astrophysics in future years in the context of the NWNH recommendations and projected resource availability
  - APD will engage the community through discussions and possible solicitations for new concept studies, in parallel with on-going interactions with the ESA re-scoped L1 mission candidates

# Budget Update

Astrophysics Division

# SMD Budget by Theme (RY $M)



# NASA FY2012 Budget Request

| Budget Authority ($M) | FY 2010 Actual | FY 2011 CR | FY 2011 Auth Act | FY 2012 | FY 2013 | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|---|---|---|---|---|
| **FY 2012 President's Budget Request** | **4,497.6** | **4,469.0** | **5,005.6** | **5,016.8** | **5,016.8** | **5,016.8** | **5,016.8** | **5,016.8** |
| Earth Science | 1,439.3 | | 1,801.8 | 1,653.0 | 1,679.2 | 1,665.3 | 1,691.4 | 1,727.3 |
| Planetary Science | 1,364.4 | | 1,485.7 | 1,488.9 | 1,365.7 | 1,326.4 | 1,271.0 | 1,188.9 |
| Astrophysics | 1,085.9 | | 1,076.3 | 637.7 | 708.3 | 721.0 | 713.5 | 741.9 |
| James Webb Space Telescope | | | | 354.6 | 359.3 | 365.3 | 371.6 | 371.6 |
| Heliophysics | 608.0 | | 641.9 | 577.9 | 591.0 | 612.4 | 627.2 | 628.6 |
| SCMD Civil Service Labor and Expense | | | | 304.7 | 313.2 | 326.5 | 342.2 | 358.6 |

# Astrophysics Program/Budget Strategy

- Respond to decadal survey recommendations with **augmentations** to the Explorer program, Balloon program, Astrophysics research program, and **technology development**, but defer initiating the next large mission beyond JWST
- Support missions in prime operations (Herschel, Planck, Fermi, Kepler, and HST)
- Complete integration of NuSTAR for a Feb 2012 launch
- SOFIA will continue to ramp up science flight hours to achieve full operating capability (FOC) by 2014 and will develop the second generation of instruments
- Continue development/implementation of Astro-H for a Feb 2014 launch
- Continue formulation and development of GEMS for an Apr 2014 launch
- Use Senior Review recommendations to prioritize funding for missions in extended operations

*Innovate, Educate, Build*

*"To reach new heights and reveal the unknown so that what we do and learn will benefit all humankind."*

# What's Changed and What's the Same

**What's changed:**

- JWST project was moved to its own Theme within the Science Mission Directorate
- The Explorer program is being split into two pieces such that Astrophysics and Heliophysics will manage their own Explorers resources beginning in 2012
- ➢ **A Future Astrophysics Explorer missions budget was created in response to the Decadal Survey recommendation to increase the flight rate of astrophysics missions and missions of opportunity.**
- Support for concept planning and technology development for decadal survey large mission priorities (WFIRST, LISA, IXO) under supporting research and technology lines
- *Augmented budgets for decadal survey medium &small technology and R&A initiatives*
- ➢ **SOFIA budget increased to restore science and preserve 2nd generation instrument selection and development**
- NuSTAR LRD now February 2012 to accommodate launch services availability
- ASTRO-H confirmed for implementation; GEMS approved for Phase B and budget re-phased
- Extended support for top ranked missions in the 2010 Senior Review, but support for RXTE and GALEX extended operations and the INTEGRAL and Suzaku Guest Observer programs will terminate by the end of FY2011
- JDEM &SIM projects have been closed out; not recommended by the Decadal Survey
- Reductions to operations and guest observer programs for Chandra, HST, and Swift

**What's the same:**

- Herschel, Kepler, Fermi, and Keck operations


# Astrophysics Program Content

| | FY 2010 | 2011 Pres Bud | FY 2012 | FY 2013 | FY 2014 | FY 2015 | FY 2016 |
|---|---|---|---|---|---|---|---|
| **Astrophysics** | **$647.3** | **$631.5** | **$637.7** | **$708.3** | **$721.0** | **$713.5** | **$741.9** |
| *Astrophysics Research* | *$149.1* | *$156.1* | *$161.6* | *$200.1* | *$211.8* | *$229.3* | *$238.6* |
| Astrophysics Research and Analysis | $59.6 | $60.2 | $64.3 | $82.8 | $83.9 | $85.1 | $88.0 |
| Balloon Project | $28.2 | $27.1 | $29.3 | $32.8 | $33.6 | $34.1 | $35.3 |
| ADCAR/ADP/Senior Review/Admin | $61.3 | $68.7 | $67.9 | $84.5 | $94.3 | $110.1 | $115.4 |
| *Cosmic Origins* | *$225.3* | *$242.9* | *$219.7* | *$219.4* | *$209.9* | *$195.2* | *$184.5* |
| Hubble Space Telescope (HST) | $100.8 | $102.7 | $94.0 | $93.4 | $93.1 | $88.8 | $84.5 |
| Stratospheric Observatory for Infrared Astronomy (SOFIA) | $73.6 | $79.6 | $71.4 | $73.3 | $77.2 | $77.4 | $75.0 |
| Spitzer | $17.6 | $22.6 | $17.8 | $9.8 | | | |
| SR&T | $6.0 | $7.0 | $9.2 | $17.3 | $19.0 | $19.0 | $19.9 |
| Herschel | $24.0 | $24.5 | $24.0 | $20.8 | $15.8 | $5.8 | |
| Future Missions/Management | $3.2 | $6.5 | $3.4 | $4.7 | $4.8 | $4.1 | $5.1 |
| *Physics of the Cosmos* | *$116.0* | *$103.3* | *$100.3* | *$112.4* | *$111.9* | *$98.1* | *$96.8* |
| Fermi | $22.1 | $22.7 | $23.6 | $23.1 | $22.5 | $15.4 | $11.0 |
| Planck | $9.5 | $8.1 | $7.2 | $6.8 | $4.6 | $0.8 | |
| Chandra/INTEGRAL/XMM | $77.3 | $59.4 | $55.5 | $55.7 | $55.5 | $53.7 | $53.6 |
| SR&T | $4.3 | $5.7 | $11.4 | $22.0 | $24.5 | $24.1 | $27.2 |
| Future and Management | $2.9 | $7.4 | $2.7 | $4.9 | $4.8 | $4.1 | $5.1 |
| *Exoplanet Exploration* | *$43.4* | *$42.5* | *$48.2* | *$65.5* | *$63.6* | *$62.1* | *$69.8* |
| Kepler | $15.4 | $16.9 | $17.6 | $12.3 | $0.1 | | |
| Keck/LBTI | $4.8 | $4.1 | $5.6 | $6.4 | $5.6 | $4.8 | $3.5 |
| SR&T | $12.7 | $12.7 | $17.9 | $38.7 | $50.4 | $50.2 | $50.4 |
| Future Missions/Management | $10.5 | $8.8 | $7.2 | $8.1 | $7.6 | $7.1 | $15.9 |
| *Astrophysics Explorer* | *$113.5* | *$86.7* | *$107.8* | *$110.9* | *$123.7* | *$128.7* | *$152.0* |
| Nuclear Spectroscopic Telescope Array (NuStar) | $56.2 | $32.1 | $11.4 | $4.0 | $1.1 | | |
| Astro-H | $15.8 | $12.5 | $9.8 | $5.0 | $1.9 | $0.5 | $0.6 |
| Gravity and Extreme Magnetism | $3.1 | $21.0 | $69.4 | $41.0 | $20.8 | $1.4 | |
| Operating Explorers | $38.4 | $21.2 | $8.1 | $4.0 | $3.8 | | |
| Astro Explorers Future Missions | | | $9.2 | $56.9 | $96.1 | $126.8 | $151.4 |

***• Amounts in $M; JWST is managed separately as its own Theme***
***•FY 2010-2011 amounts include Civil Service Labor and Expenses (CSLE)***
***•FY 2013-2016 estimates are notional***
***• FY 2012-2016 amounts do not include CSLE***

# Astro2010 Decadal Survey Summary

- New Worlds, New Horizons Decadal Survey science themes well aligned to those of NASA's Astrophysics Program:
  - Cosmic Dawn → Cosmic Origins
  - New Worlds → Exoplanet Exploration
  - Physics of the Universe → Physics of the Cosmos
- The survey chose a budget scenario comprising constant FY10 dollars into the future, which is higher than NASA's guidance and the projected Astrophysics budget
- This was the first NRC decadal survey for NASA that included independent cost analysis of candidate mission concepts
- The survey aimed for an integrated scientific program of space-based and ground-based observation and science.
- Agency Response:
  - Support for mission concept planning and technology development relevant to the survey's highest priority Large space mission: Wide Field Infrared Survey Telescope (WFIRST). NASA is also exploring a potential partnership with the European Space Agency (ESA) on its proposed Euclid dark energy mission consistent with Option B (A Joint WFIRST/Euclid Mission) from the National Research Council's "Report of the Panel on Implementing Recommendations from the New Worlds, New Horizons Decadal Survey."
  - A Future Astrophysics Explorer missions budget was created to increase the flight rate to achieve the recommended four missions and four missions of opportunity selected by the end of the decade.
  - *Augmenting investments in core research and technology programs, including the suborbital program (sounding rockets and balloons), theory, laboratory astrophysics, etc.*

Astrophysics Division

# Research & Analysis Distribution (notional)

($ in thousands, does not include civil servant labor)

| | FY11 PBR | FY12 | FY13 | FY14 | FY15 | FY16 |
|---|---|---|---|---|---|---|
| **Research & Analysis** | **57,881** | **64,312** | **82,836** | **83,932** | **85,105** | **87,995** |
| Suborbital payloads | 21,964 | 23,779 | 29,604 | 30,803 | 30,992 | 31,958 |
| Lab Astrophysics | 3,193 | 3,544 | 4,692 | 4,692 | 4,957 | 5,016 |
| Rest of APRA/APRET | 20,751 | 22,966 | 27,657 | 27,690 | 27,152 | 27,892 |
| Astrophysics Theory Program | 11,805 | 12,723 | 15,178 | 15,274 | 15,751 | 15,982 |
| Theory and Computation Networks | | 500 | 3,000 | 3,077 | 3,127 | 4,000 |
| Technology Fellows | | 800 | 2,705 | 2,396 | 3,126 | 3,147 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Large Suborbital (MO) | | 2,000 | 8,000 | 9,000 | 9,000 | 9,000 |
| R&A Suborbital payloads | 21,964 | 23,779 | 29,604 | 30,803 | 30,992 | 31,958 |
| **Total Suborbital Program** | **21,964** | **25,779** | **37,604** | **39,803** | **39,992** | **40,958** |

| | | | | | | |
|---|---|---|---|---|---|---|
| **ADAP** | **14,132** | **16,957** | **18,451** | **18,937** | **19,466** | **19,832** |

# Supporting Research & Technology (notional)

Astrophysics Division

($ in thousands, does not include civil servant labor)

| | FY11 PBR | FY12 | FY13 | FY14 | FY15 | FY16 |
|---|---|---|---|---|---|---|
| **COR SR&T** | **7,343** | **9,164** | **17,341** | **19,015** | **19,040** | **19,915** |
| Technology (core & competed) | 813 | 3,264 | 8,941 | 9,002 | 8,970 | 9,595 |
| Hubble fellows | 5,100 | 5,100 | 5,200 | 6,135 | 6,220 | 6,420 |
| Strategic SOFIA Instr Tech | 630 | 450 | | | | |
| HST development (de-orbit) | 400 | 250 | 250 | 250 | 250 | 250 |
| UV/Optical Space Capability | 400 | 100 | 2,950 | 3,628 | 3,600 | 3,650 |

| | FY11 PBR | FY12 | FY13 | FY14 | FY15 | FY16 |
|---|---|---|---|---|---|---|
| **PCOS SR&T** | **9,438** | **11,442** | **22,032** | **24,460** | **24,096** | **27,178** |
| Technology (core & competed) | 0 | 0 | 0 | 0 | 0 | 0 |
| Einstein fellows | 3,780 | 3,970 | 4,230 | 4,646 | 4,758 | 4,872 |
| LISA tech awards | 180 | | | | | |
| Inflation probe tech | | 160 | 3,500 | 4,095 | 4,000 | 5,000 |
| LISA/ST-7 | 3,185 | 3,312 | 7,947 | 8,700 | 8,315 | 10,000 |
| IXO | 2,293 | 3,000 | 6,355 | 7,019 | 7,023 | 7,306 |

| | FY11 PBR | FY12 | FY13 | FY14 | FY15 | FY16 |
|---|---|---|---|---|---|---|
| **EXEP SR&T** | **12,450** | **17,867** | **38,652** | **50,388** | **50,248** | **50,438** |
| Technology (core & competed) | 6,150 | 8,569 | 19,683 | 24,014 | 25,737 | 28,892 |
| Wide Field IR Imaging and Spectroscopy | | 1,790 | 10,582 | 18,217 | 16,191 | 13,064 |
| Sagan Fellows | 3,360 | 3,760 | 4,050 | 4,700 | 4,865 | 4,957 |
| NExSci | 720 | 1,648 | 2,212 | 2,480 | 2,549 | 2,601 |
| Astrobiology | 1,500 | 1,500 | 1,500 | 102 | | |
| COROT | 720 | 600 | 625 | 875 | 906 | 924 |