National Aeronautics and Space Administration

NASA Townhall
AAS 219th Meeting
Austin, TX

John Grunsfeld

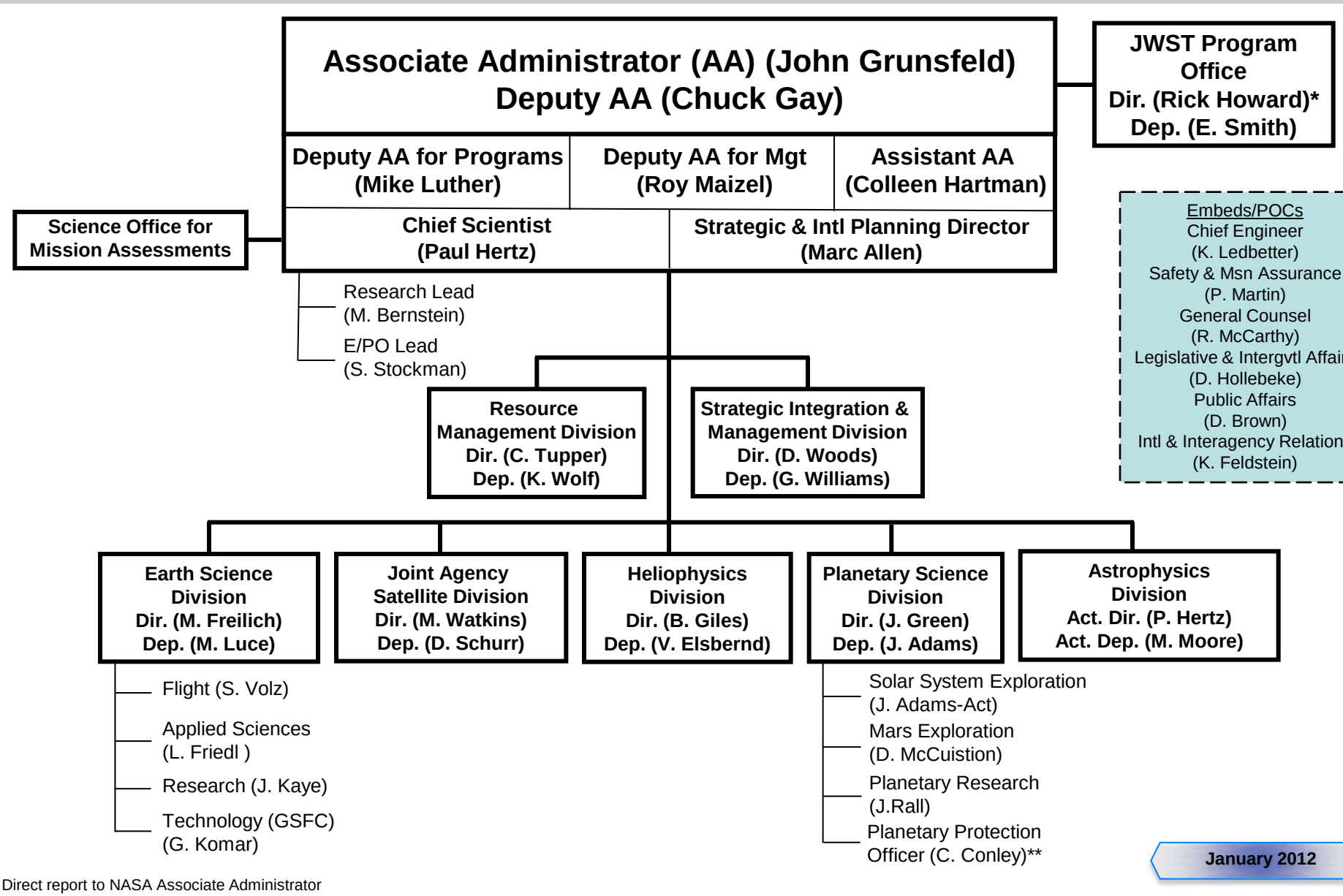
Associate Administrator
Science Mission Directorate

Paul Hertz

Acting Director
Astrophysics Division
Science Mission Directorate

January 11, 2012

SMD Organization



January 2012

* Direct report to NASA Associate Administrator
** Co-located from the Front Office

Astrophysics Division Organization Chart

January 5, 2012

Resource Management
Holly Degn +
David Darbouze +

Director (Acting)
Paul Hertz
Deputy Director (Acting)
Michael Moore

Lead Secretary (acting): Leslie Allen
Secretary: Leslie Allen
Program Support Specialist: Sheila Gorham

Asst Dir for Innovation & Technology: Michael Moore (acting)
PE for Tech & Ops Missions: William (Billy) Lightsey *
Asst Dir for Policy & Planning: Vacant

Communications
Division E/PO POC: Hashima Hasan (Lead)
Division PAO POC: Ilana Harrus *
Information Manager: Lisa Wainio *

Astrophysics Research

Program Manager: Linda Sparke
Program Support: Tina Swindell *
Astrophysics Data Analysis: Doug Hudgins
Astrophysics Theory: Linda Sparke
Origins of Solar Systems: Mario Perez *
APRA lead: Ilana Harrus *
Cosmic Rays, Fundamental Physics: Vernon Jones
Gamma Ray/X-ray: Ilana Harrus *, Wilt Sanders *
Lou Kaluzienski
Optical/Ultraviolet: Mario Perez *
Hashima Hasan
IR/Submillimeter/Radio: Chris Davis *, Doug Hudgins
Glenn Wahlgren *, Bill Danchi *
Lab Astro: Glenn Wahlgren *
ADCAR:Archives/High End computing: Hashima Hasan
Astrophysics POC for Sounding rockets: Wilt Sanders *
Balloons Program: Vernon Jones (PS), Mark Sistilli (PE)

Programs / Missions

	Program Scientist	*Program Executive*
Exoplanet Exploration (EXEP)		
LEADS	**Doug Hudgins**	**Lia LaPiana**
Keck	Mario Perez *	Mario Perez *
Kepler	Doug Hudgins	Jaya Bajpayee *
LBTI	Mario Perez *	Michael Moore
NExScI	Mario Perez *	Lia LaPiana
Cosmic Origins (COR)		
LEADS	**Mario Perez ***	**Michael Moore**
Herschel	Bill Danchi *	Jaya Bajpayee *
HST Ops	Richard Griffiths *	John Gagosian
JWST	Hashima Hasan	N/A
SOFIA	Chris Davis *	John Gagosian
Spitzer	Bill Danchi *	Jaya Bajpayee *
Physics of the Cosmos (PCOS)		
LEADS	**Rita Sambruna**	**Jaya Bajpayee ***
Chandra	Wilt Sanders *	Jaya Bajpayee *
Fermi	Ilana Harrus *	Jaya Bajpayee *
Planck	Bill Danchi *	Jaya Bajpayee *
ST-7/LPF	Wilt Sanders *	Anne-Marie Novo-Gradac
XMM-Newton	Lou Kaluzienski	Jaya Bajpayee *
Astrophysics Explorers (APEX)		
LEADS	**Wilt Sanders ***	**Anne-Marie Novo-Gradac**
Astro-H	Lou Kaluzienski	Anne-Marie Novo-Gradac
GALEX	Mario Perez *	Jaya Bajpayee *
GEMS	Richard Griffiths *	Lia LaPiana
NuSTAR	Lou Kaluzienski	Mark Sistilli
RXTE	Ilana Harrus *	Jaya Bajpayee *
Suzaku	Lou Kaluzienski	Jaya Bajpayee *
Swift	Ilana Harrus *	Jaya Bajpayee *
WISE	Bill Danchi *	Jaya Bajpayee *
WMAP	Bill Danchi *	Jaya Bajpayee *

\+ *Member of the Resources Mgmt Division*
* *Detailee, IPA, or contractor*
JWST now part of the JWST Program Office.

Visiting Scientists at NASA HQ

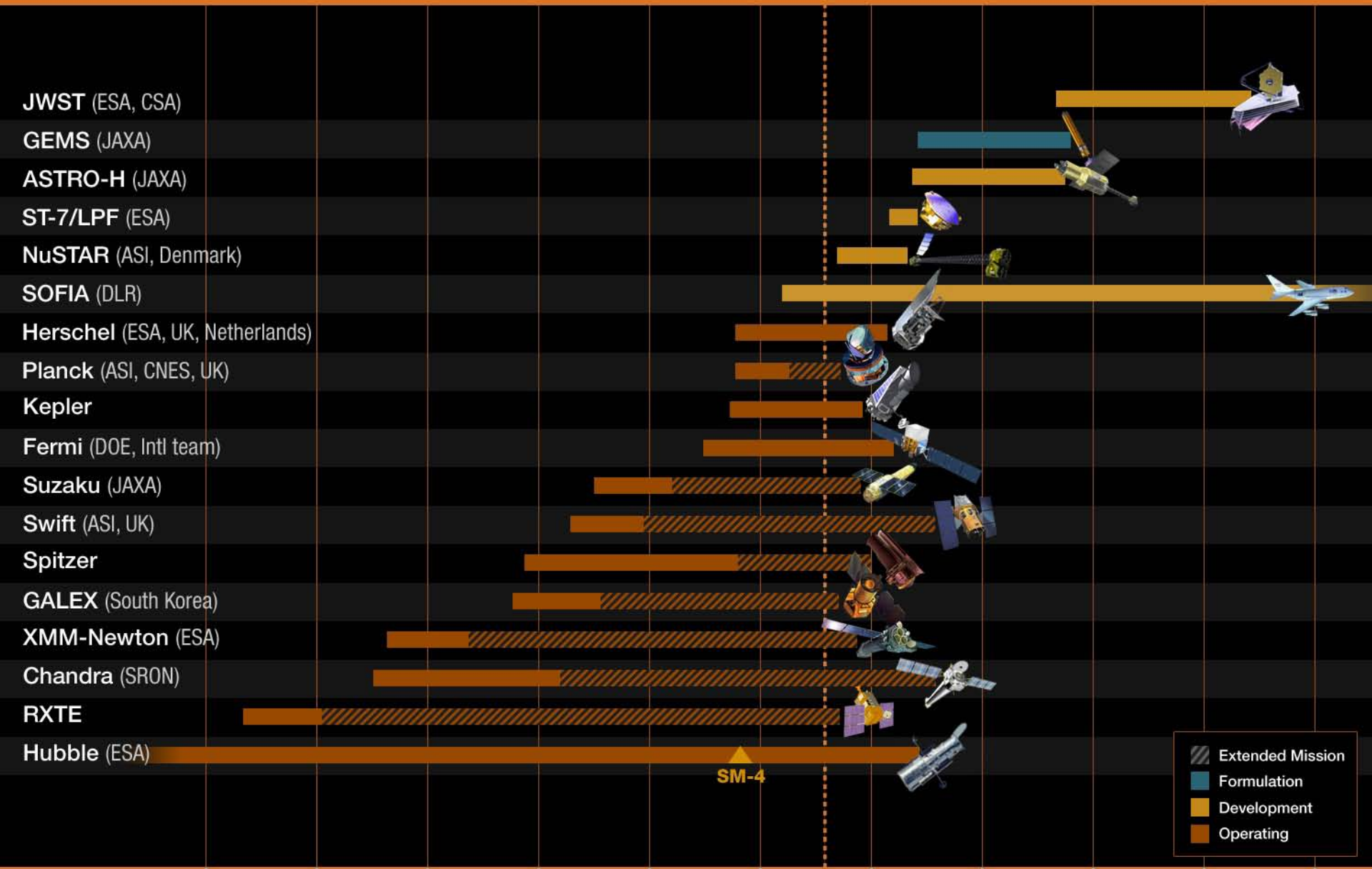
Looking for a few good astrophysicists….

- Seeking one or more experienced scientists
  - to take leave from their U.S. home institution
  - for a 2-year visiting position (can extend up to 6 years)
  - to work in Astrophysics at NASA Headquarters
- Duties include management of the Astrophysics grants programs, and planning, development, and management of NASA missions.
- Requires Ph.D. or equivalent, relevant research experience, familiarity with NASA research award programs, and the ability to communicate effectively.
- Expertise in astrophysics theory and exoplanet exploration is of particular interest.
- For additional info, talk with any of the Astrophysics HQ staff.
- **Apply by January 16, 2012**

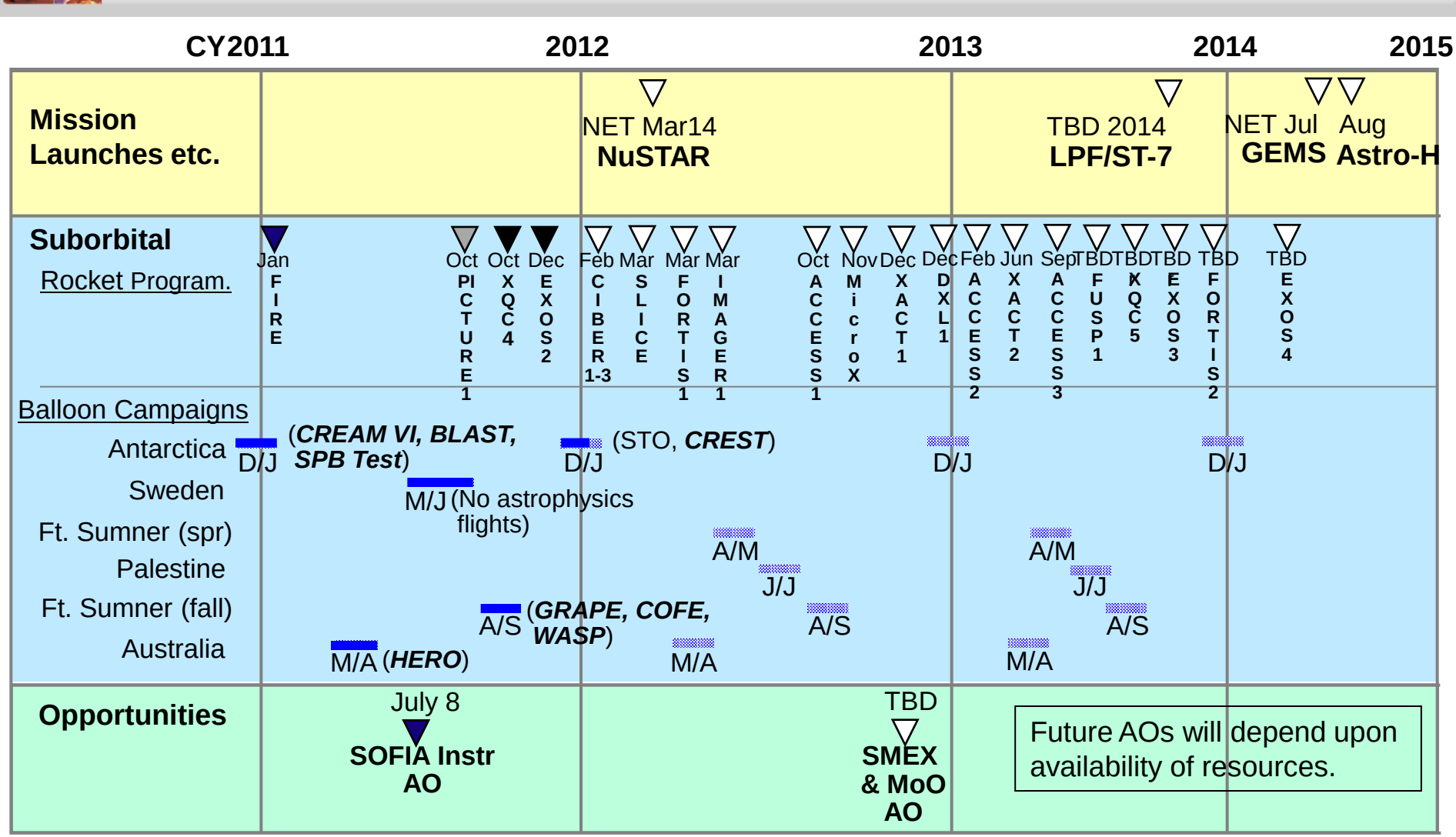
http://jobregister.aas.org/job_view?JobID=41008

Astrophysics Missions timeline

Last updated: January 4, 2012



Astrophysics Mission Events



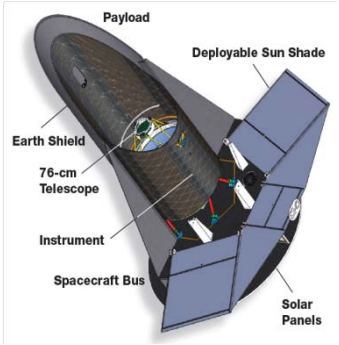
Last Updated: January 3, 2012

Looking to the Future: Explorer Full Mission
Explorer 2011 Announcement of Opportunity Candidates

(Downselect in early 2013)

These mission concepts in the area of **Exoplanet Exploration** address different, equally-important, objectives as articulated in *New Worlds, New Horizons*, the 2010 Decadal Survey of Astronomy and Astrophysics.

FINESSE
Fast INfrared Exoplanet Spectroscopy Survey Explorer

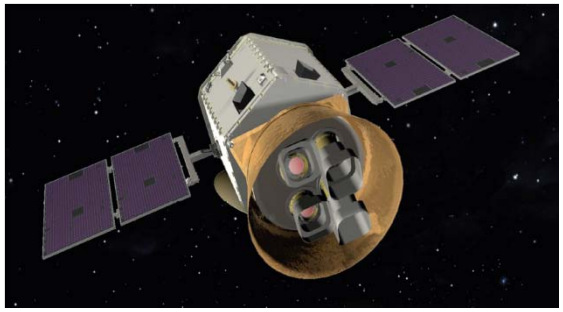


… will employ transit spectroscopy in the near-IR to measure the composition and temperature structure of **exoplanet atmospheres** and their variation with time.

ASTRO2010 Science Objective:
"Use imaging and spectroscopy transit techniques to study the atmospheres of exoplanets…"

PI: Mark Swain / JPL
PM: JPL
S/C: Ball Aerospace

TESS
Transiting Exoplanet Survey Satellite



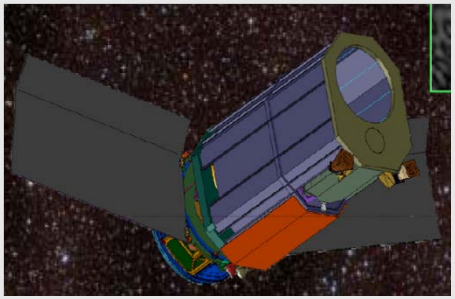
… will employ the transit technique to conduct an **all-sky survey of exoplanets** and exoplanetary systems around the nearest and brightest stars.

Astro2010 Science Objective:
"Locate the prime targets for hosting habitable, terrestrial planets among our closest stellar neighbors."

PI: George Ricker / MIT
PM: GSFC
S/C: Orbital

TECHNOLOGY DEVELOPMENT FUNDING ONLY

EXCEDE
EXoplanetary Circumstellar Environments and Disk Explorer



…will employ coronagraphy to characterize **circumstellar dust environments of nearby stars**.

Astro2010 Science Objective:
"Characterize the dust environment around stars like the Sun, so as to gauge the ability of future missions to directly detect Earth-size planets..."

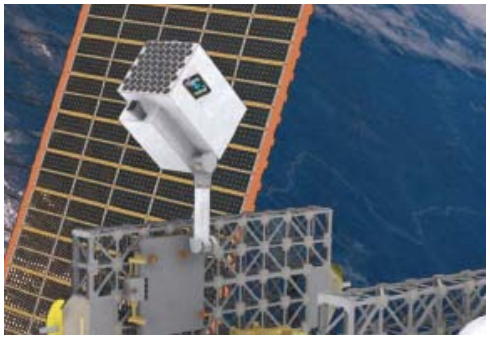
PI: Glenn Schneider / U. Arizona
PM: U. Arizona
S/C: Lockheed Martin

Looking to the Future: Missions of Opportunity

Explorer 2011 Announcement of Opportunity Candidates (Downselect in early 2013)

NICER

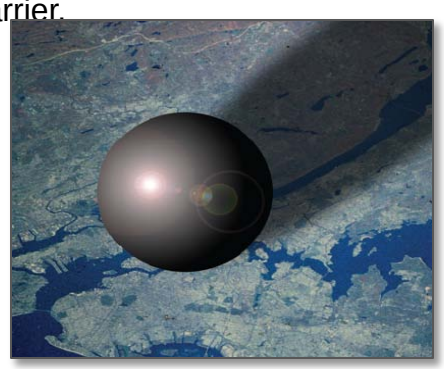
Neutron Star Interior Composition Explorer



… will resolve the nature of matter at the threshold of collapse to a black hole. NICER will probe the nature of matter at the extremes of gravity, density, and electromagnetism.

CER is a high precision X-ray timing instrument to be deployed as a small complete mission on the ISS/ExPRESS Logistics Carrier.

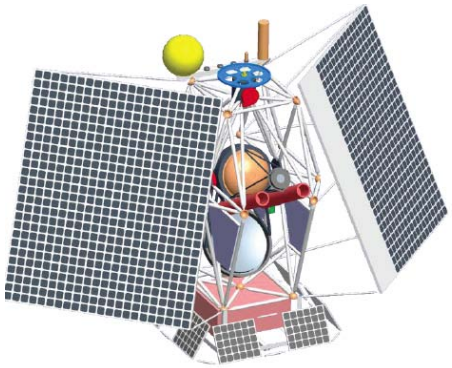
Neutron Stars: What happens when you pack more than 1.4 solar masses into something the size of New York City?



PI: Keith Gendreau / GSFC
PM: GSFC
Small Complete Mission on ISS

GUSSTO

Gal/Xgal U/LDB Spectroscopic/Stratospheric TeraHertz Observatory



… will determine the constituents and life cycle of interstellar gas in the Milky Way

- witness the formation and destruction of star forming clouds
- understand the dynamics and gas flow to and in the Galactic Center
- Understand the interplay between star formation, stellar winds and radiation, and the structure of the interstellar medium.

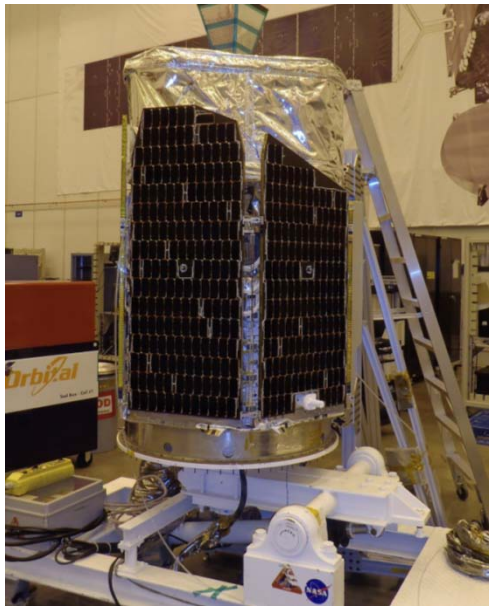
GUSSTO is a small complete mission to be deployed on an Ultra Long Duration Balloon.

PI: Chris Walker/ U. Arizona
PM: U. Arizona
Small Complete Mission on Long Duration Balloon

Missions in Development Status

NuSTAR

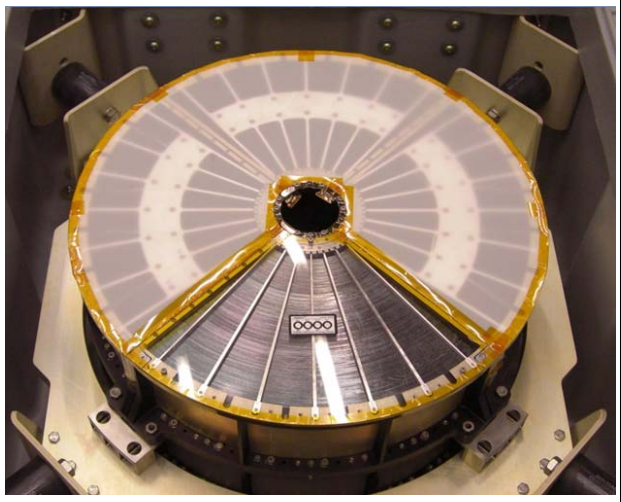
- NuSTAR finishing Observatory I&T.
- Ship to VAFB late January 2012.
- Launch Vehicle integration and test at VAFB.
- Ship to Kwajalein early March 2012.
- Launch no earlier than March 14, 2012.



NuSTAR Observatory

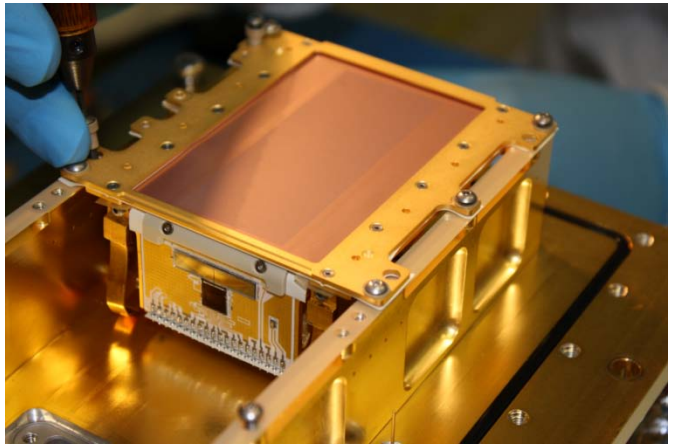
Astro-H

- The Engineering model mirror quadrant for the soft X-ray telescope was completed and shipped to Japan Oct 7, 2011. The flight model mirror is in fabrication.
- The flight model detector array is complete. The flight spare is in fabrication.
- Passed Instrument CDR November 14-16, 2011.
- Mission CDR planned for early February in Japan.
- Launch readiness date moving to NET August 2014 due to Japanese Earthquake issues.



Astro-H EM soft X-ray mirror shipped to JAXA

Missions in Development Status



Polarimeter Engineering Test Unit

SOFIA in Stuttgart Germany

GEMS

- Passed Spacecraft PDR (Oct 4-5, 2011)
- Polarimeter Instrument
  - Completed TRL-6 activities.
  - Peer Review completed.
  - Met flight requirements.
  - Low instrument mass and power margins.

SOFIA

- Pluto Occultation completed June 23, including 150-mile repositioning with in-flight replan.
- Released AO for 2nd Generation Instruments Jul 8, 2011. Proposals received Oct 7. Selection in Mar 2012.
- Completed Early Science.
- First Intl Deployment to Germany (Sept 15-21). Joint Base Andrews AFB stopover (Sept 22-23). ARC stopover (Oct 14-17).
- Cycle 1 Observing proposals due Jan 27.
- Observatory upgrades started mid-Dec 2011, no flights for 5-6 months.

James Webb Space Telescope

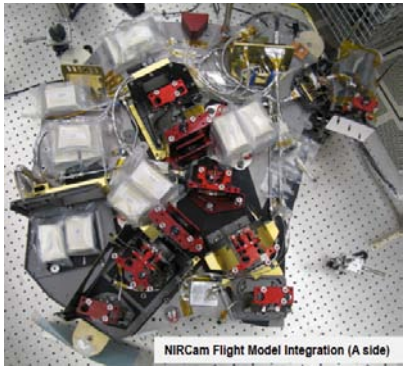
Final Set of Mirrors at the XRCF

09-2011: Replan Complete

12-2011: All Mirrors Complete

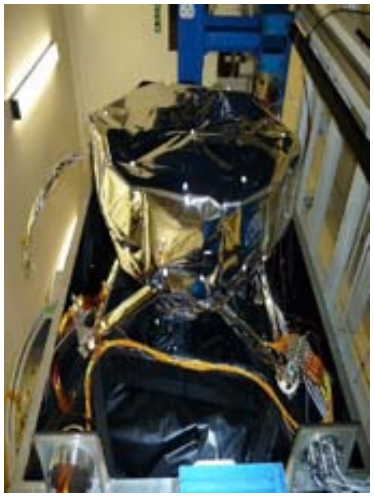
2012: Flight Instruments Begin Deliveries

2012: Thermal Vac Test Chamber Complete



NIRCam

NIRSpec



MIRI

FGS/NIRISS

WFIRST (Wide-Field Infrared Survey Telescope)

- Science Definition Team (SDT) has delivered its interim report in July 2011.
  - Copy of the report can be found at: *http://wfirst.gsfc.nasa.gov/science/WFIRST_Interim_Report.pdf*
  - The Interim Design Reference Mission (IDRM) is a proof of concept that a mission can be constructed that is compliant with the *New Worlds, New Horizons* (2010 Decadal report) recommendation for groundbreaking observations in Dark Energy, Exoplanet and NIR sky surveys.
- Updated guidance given to Science Definition Team Dec 8, 2011.
  - Accounts for updated events since initial kickoff meeting.
  - Two separate Design Reference Missions.
- Final report due June 2012.

ESA's Euclid

- On September 19, 2011, ESA sent its recommendations to the Science Programme Committee (SPC). Adopted by Working Group/SSAC on October 4, 2011. Decision by SPC in November 2011 on invitation to tender release.
    - ESA recommended that Solar Orbiter and Euclid be selected as M1 and M2, respectively, and will propose that PLATO continue in the competitive process for the M3 mission.
    - ESA has asked for a longer definition phase for Euclid than previously planned and ESA will propose that the SPC adopt the mission in July 2012 instead of February 2012. The launch would be in Q4 2019.
- July 2012, SPC adoption of missions (Cost-at-Completion and Payload Formal Agreement).
- September 2012, missions enter Implementation Phase.
- The National Research Council (NRC) will organize an ad hoc study to assess if a proposed NASA plan for a U.S. hardware contribution to the European Space Agency Euclid mission, in exchange for U.S. membership on the Euclid Science Team and science data access, is a viable part of an overall strategy to pursue dark energy, exoplanet detection, and infrared survey science goals articulated in the *New Worlds, New Horizons* decadal survey report.

Astrophysics Archives Senior Review Results
(Held in May 2011)

- The Senior Review evaluated the scientific productivity, technical status, data dissemination, future plans and budget of the six active archives and data centers in the Astrophysics Data Curation and Archival Research (ADCAR) program and ranked them as follows:
  - Astrophysics Data System (ADS) – *Excellent*
  - High Energy Astrophysics Science Archives Center (HEASARC) – *Excellent*
  - Multi-Mission Archive at Space Telescope Science Institute (MAST) – *Excellent*
  - The NASA/Infrared Processing and Analysis Center (IPAC) archives/centers
    - Infrared Science Archive (IRSA) – *Very Good*
    - Extragalactic Database (NED) – *Very Good*
    - NASA Star and Exoplanet Database (NStED) – *Fair*
- **NASA response:**
  - In-guide funding for ADS, HEASARC, MAST provided.
  - IRSA, NED provided updated plan in response to SR report and HQ directions.
  - NStED redirected to focus on supporting Kepler mission and follow-on of Exoplanet candidates. Version 1 of the new NASA Exoplanet Archive released in December 2011.

2012 Senior Review of Operating Missions

Invited Missions	
Planck	Hubble
Chandra	Fermi
Warm Spitzer	Kepler
Swift	
XMM-Newton	
Suzaku	

2012 Senior Review Schedule	
Draft Call for proposals	Jul 1, 2011
Call for Proposals	Aug 10, 2011
EPO SR Proposals Due	Dec 15, 2011
SR Proposals Due	Jan 18, 2012
EPO Section Review	Jan 23 - 25, 2012
SRC Meets	Feb 28 - Mar 2, 2012
Final Report	Mar 30, 2012

Changes to the 2012 Senior Review

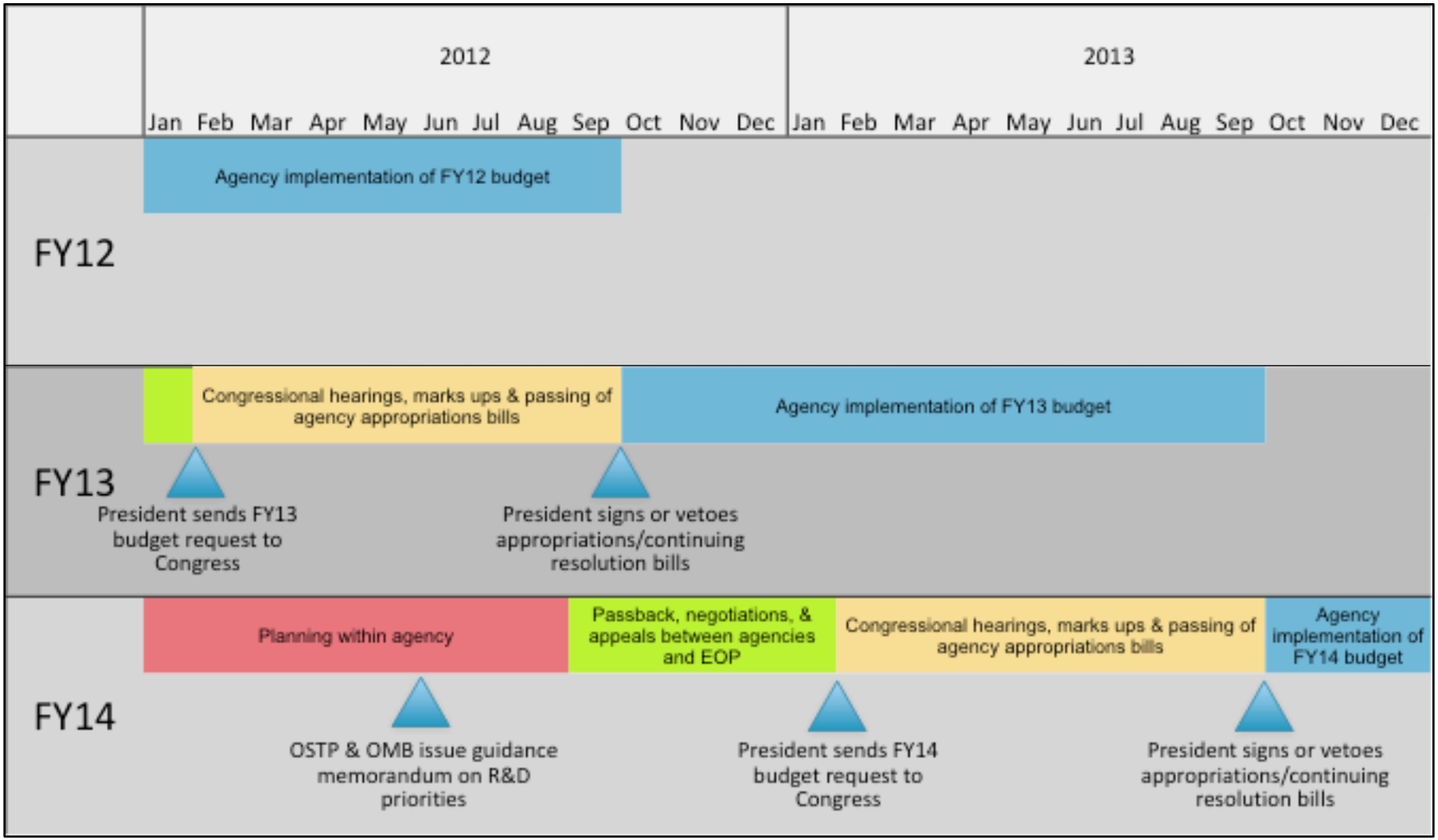
- Expanded Senior Review invitation list to cover all astrophysics missions in or entering extended operations.
- EPO review part of 2012 Senior Review.
  - In 2010, the EPO review was performed separately, after the Senior Review.

New Projects in the Senior Review

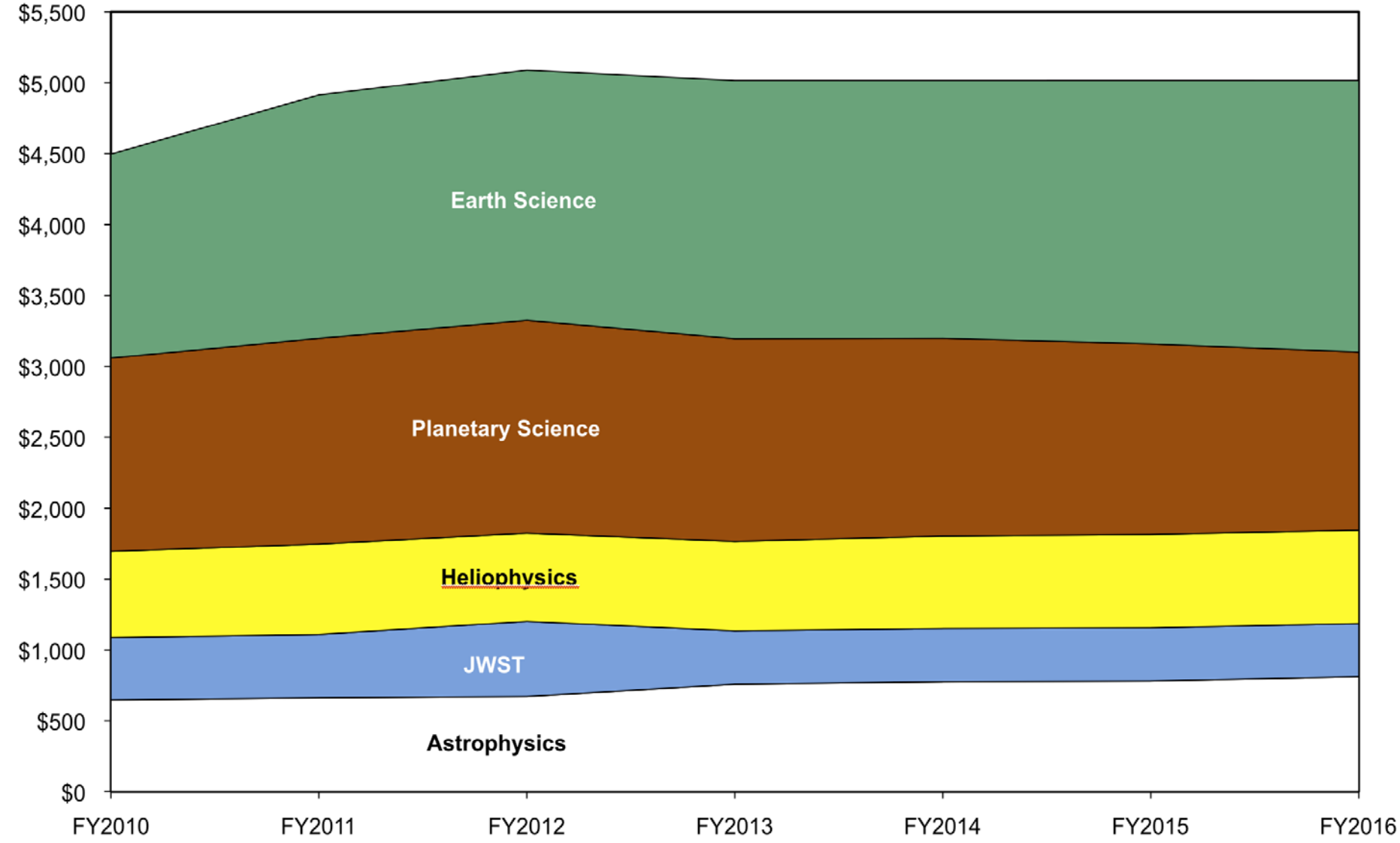
- Kepler and Fermi were invited to participate in the 2012 Senior Review - completed Level 1 requirements review.
- In 2009, the Astrophysics Subcommittee recommended that Hubble be invited to the 2012 Senior Review.

http://science.nasa.gov/astrophysics/2012-senior-review/

The Budget Cycle

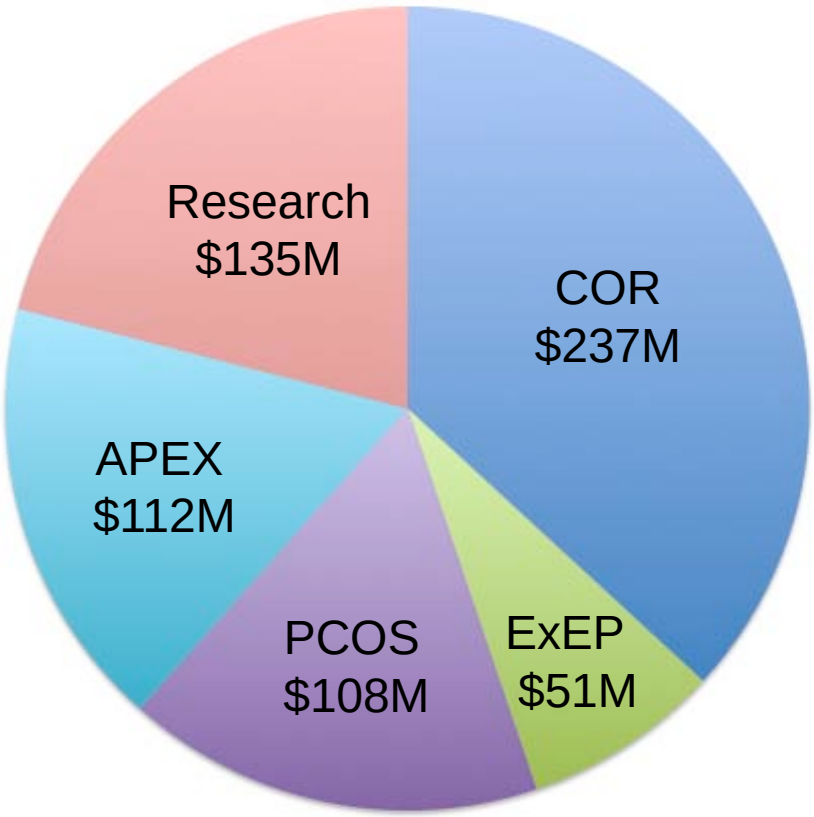


SMD FY12 President's Budget Request by Theme (RY $M)



Includes actual budgets in FY10-11 and Enacted budget for FY12

FY2012 Budget

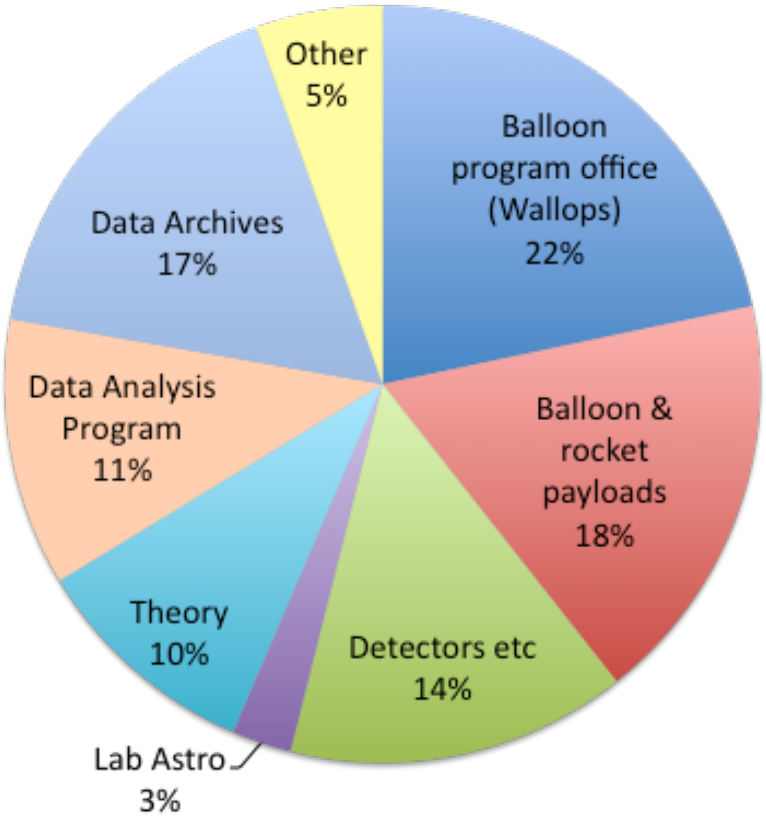


*Final funding levels pending the concurrence of Congress on NASA's initial operating plan

- Research includes:
  - R&A
  - Balloon Program
  - ADAP
  - ADCAR (data analysis and archiving)
- COR includes:
  - Hubble, SOFIA, Herschel, Spitzer, technology development
- PCOS includes:
  - Chandra, Fermi, Planck, XMM, technology development
- ExEP includes:
  - Kepler, Keck Ops, LBTI, Keck Interferometer, technology development
- APEX includes:
  - GEMS, Astro-H, NuSTAR, Swift, WISE, WMAP, Suzaku, GALEX

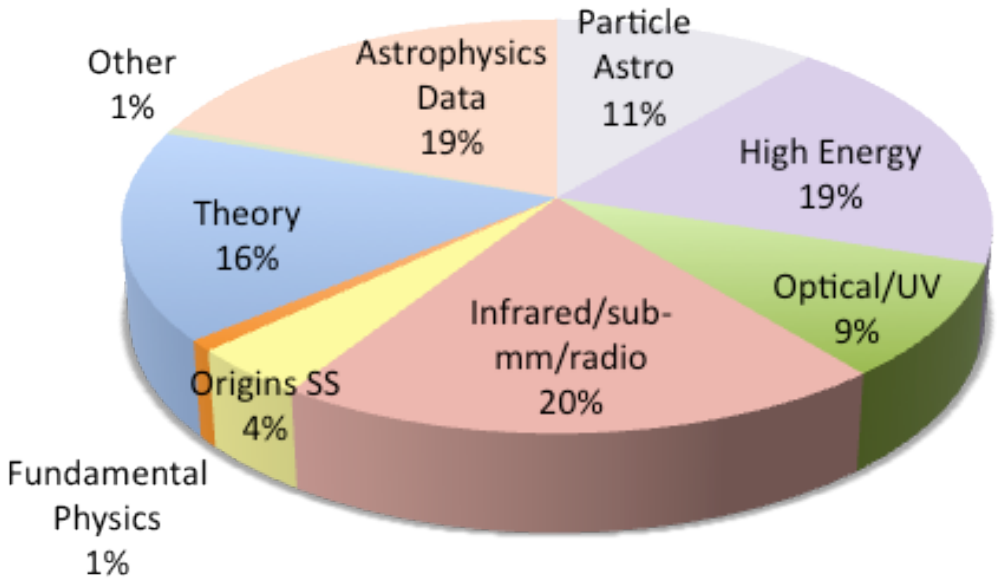
Research Program Funding in FY11

Astrophysics
Research program: $124M



Astrophysics Division's
Total Research program Budget

R&A awards
through ROSES: $74M



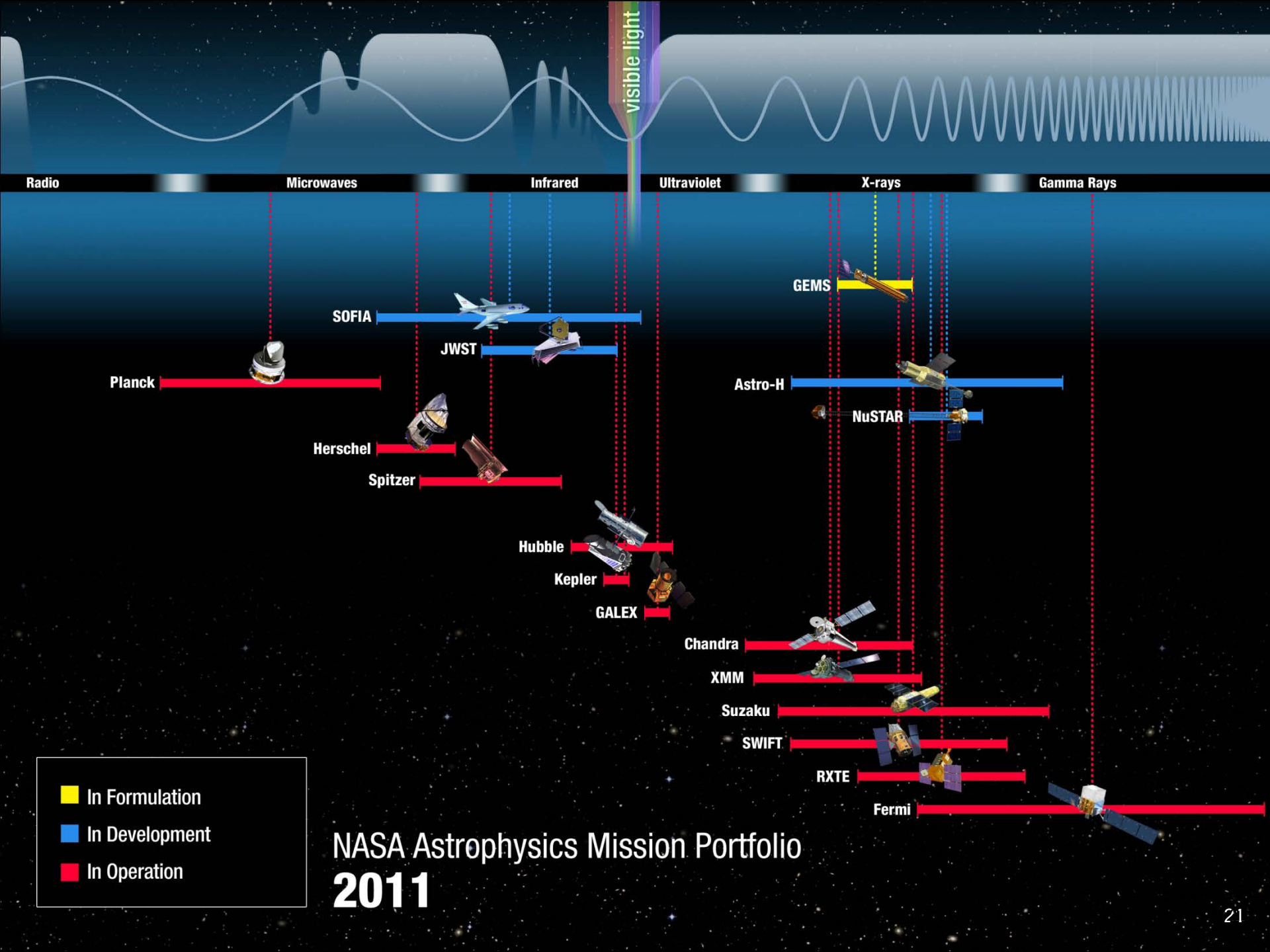
Core Research
(APRA/OSS/ATP/ADAP)

Does not include GO programs or SAT.

R&A funding lookback

	FY04 Final $k	FY05 Final $k	FY06 Final $k	FY07 Final $k	FY08 Final $k	FY09 Final $k	FY10 Final $k	FY11 Final $k	FY12 Projected
Particle Astro	$ 8,248	$ 7,671	$ 8,544	$ 7,631	$ 6,672	$ 8,201	$ 8,260	$ 8,243	$ 8,585
High Energy	$ 14,548	$ 13,693	$ 14,779	$ 12,782	$ 12,406	$ 13,886	$ 14,110	$ 13,904	$ 14,548
UV/Opt/IR/ Sub-mm	$ 20,409	$ 18,742	$ 21,851	$ 17,442	$ 19,094	$ 22,353	$ 21,534	$ 21,300	$ 23,032
Other	$ 1,019	$ 854	$ 338	$ 394	$ 594	$ 670	$ 673	$ 642	$ 1,627
APRA Total	$ 44,224	$ 40,960	$ 45,511	$ 38,250	$ 38,765	$ 45,110	$ 44,577	$ 44,090	$ 47,791
Orig Solar Systems	$ 4,209	$ 3,872	$ 4,150	$ 3,673	$ 2,965	$ 3,000	$ 2,807	$ 2,445	$ 2,978
Astro Theory Program	$ 7,860	$ 7,363	$ 10,245	$ 10,227	$ 11,696	$ 11,890	$ 12,262	$ 12,577	$ 13,226
R&A (399131)	$ 56,293	$ 52,195	$ 59,906	$ 52,150	$ 53,426	$ 60,000	$ 59,646	$ 59,111	$ 63,995
ADAP/LTSA	$ 16,986	$ 15,700	$ 15,189	$ 12,641	$ 12,013	$ 14,384	$ 13,258	$ 14,132	$ 16,320
Core R&A	$ 73,279	$ 67,895	$ 75,095	$ 64,791	$ 65,439	$ 74,384	$ 72,904	$ 73,243	$ 80,315
TPF/FS	$ 2,000	$ 2,000		(Foundation Science; now in ATP)					
Beyond Einstein FS	$ 4,000	$ 3,000	$ 2,000						
ASMCS (399131)	Mission concept studies				$ 3,452	$ 442			
PCOS SR&T				(Fundamental Physics; now in APRA)			$ 968	$ 184	
Technology Fellows									$ 600
TOTAL R&A	$ 79.3M	$ 72.9M	$ 77.1M	$ 64.8M	$ 68.9M	$ 74.8M	$ 73.9M	$ 73.4M	$ 80.9M
		$7M R&A cut	smaller R&A cut	15% R&A cut	partial recovery	more R&A recovery	flat	flat	growth!

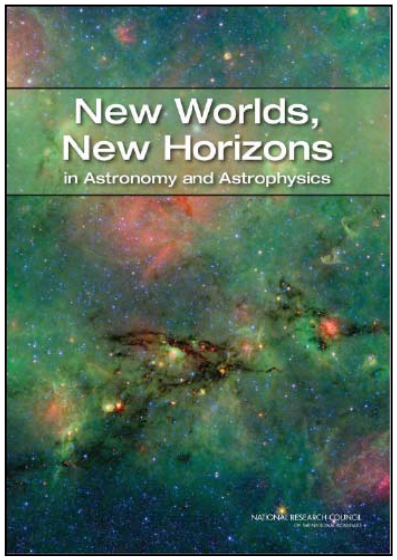
The R&A budget has grown in FY12 in response to the Decadal Survey recommendations


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

Backup Slides

Astro2010 Decadal Survey

Summary of *New Worlds, New Horizons* Decadal Survey



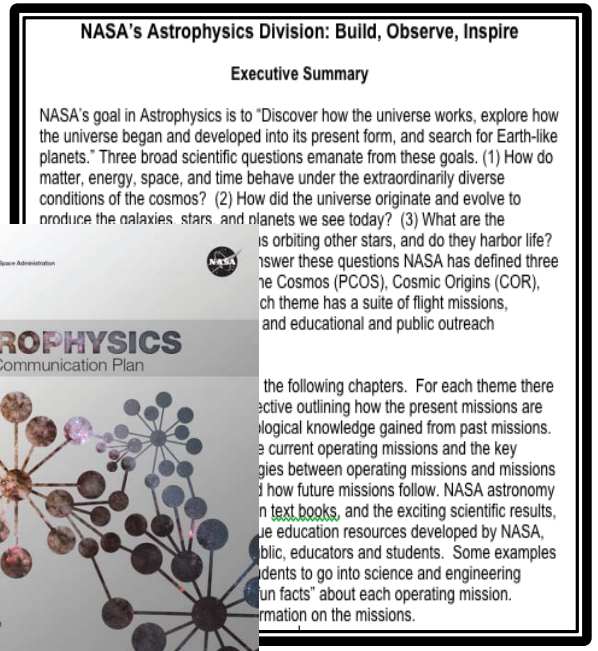
- The survey aimed for an integrated scientific program of space-based and ground-based observation and science.
- This was the first NRC decadal survey for NASA that included independent cost analysis of candidate mission concepts.
- The survey chose a budget scenario comprised of constant FY10 dollars into the future, which is higher than NASA's guidance and the projected Astrophysics budget.

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.
- 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.
- Decadal web page: *http://sites.nationalacademies.org/BPA/BPA_049810*

Improving Communications

- Astrophysics Division Communication Plan created.
  - Concise, accurate, and timely communication to internal and external stakeholders is critical.
  - Improve communication with the scientific community and the public.
  - SMD Astrophysics website will evolve to provide additional info.
- NASA's Astrophysics Division: Build, Observe, Inspire (in preparation):
  - Building Upon the Past.
  - New Observations, New Discoveries.
  - Synergies between missions.
  - Building the Future.
  - Inspiring the Public, Educators and Young Audiences.
- Astrophysics Division Website:
  - *http://science.nasa.gov/astrophysics/*

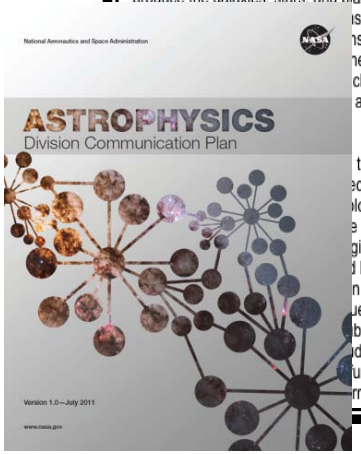

NASA's Astrophysics Division: Build, Observe, Inspire

Executive Summary

NASA's goal in Astrophysics is to "Discover how the universe works, explore how the universe began and developed into its present form, and search for Earth-like planets." Three broad scientific questions emanate from these goals. (1) How do matter, energy, space, and time behave under the extraordinarily diverse conditions of the cosmos? (2) How did the universe originate and evolve to produce the galaxies, stars, and planets we see today? (3) What are the

s orbiting other stars, and do they harbor life?
nswer these questions NASA has defined three
e Cosmos (PCOS), Cosmic Origins (COR),
ch theme has a suite of flight missions,
and educational and public outreach

the following chapters. For each theme there
ective outlining how the present missions are
ological knowledge gained from past missions.
e current operating missions and the key
gies between operating missions and missions
how future missions follow. NASA astronomy
n text books, and the exciting scientific results,
e education resources developed by NASA,
blic, educators and students. Some examples
dents to go into science and engineering
un facts" about each operating mission.
rmation on the missions.



Astrophysics PAGs

PhysPAG

- TechSAG completed its assessment of the near-term and long-term PCOS technology needs. The report was used to formulate the Program Annual Technology Report (PATR).
- The IPSAG is working to provide quantitative metrics and assessments to NASA in regard to a future Inflation Probe mission.
- Creation of Gamma-Ray SAG approved by APS in Oct 2011.
- PhysPAG website: *http://pcos.gsfc.nasa.gov/physpag.php*

COPAG

- SAG1: Science Objectives for an UVOIR Flagship Mission (4-8 m).
- SAG2: Determine technology focus areas for a monolithic 4m Aperture UV/Optical/NIR mission with Internal Coronograph for Exoplanet Imaging.
- SAG3: Determine technology focus areas for a segmented 8 m Aperture UV/Optical/NIR mission with External Occulter for Exoplanet Imaging.
- SAG4: Determine technology focus areas for future Far IR Instruments.
- Technology assessment concluded in 2011 and input was incorporated in the Cosmic Origins PATR.
- COPAG websites: *http://cor.gsfc.nasa.gov and http://copag.pbworks.com/*

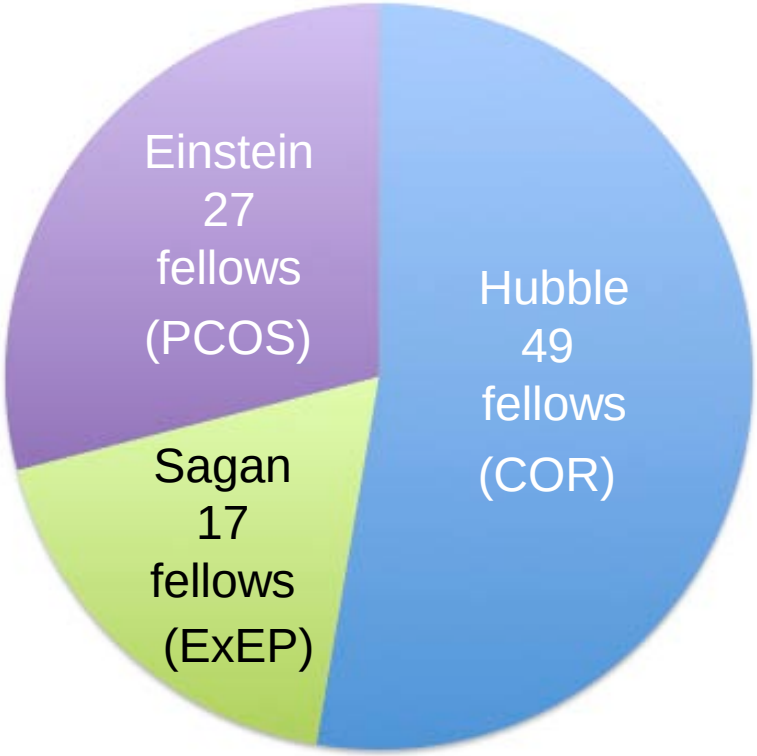
ExoPAG

- Current Dear Colleague is out for 3 new members of the Executive Committee to replace members rotating off.
- 7 Science Analysis Groups (SAGs) currently active:
  - Debris Disks & Exozodiacal Dust; Potential for Exoplanet Science measurements from Solar System Probes; Planetary Architecture and Dynamical Stability; Planetary Measurements Needed for Exo-planet Characterization; ExoPlanet Flagship Requirements and Characteristics; State of Precision RV measurements for planetary census; ExoPlanet Probe Requirements and Characteristics
- ExoPAG website: *http://exep.jpl.nasa.gov/exopag/*

Education and Public Outreach

- **Competitive opportunities for community participation:**
  - Education and Public Outreach for Earth and Space Science (EPOESS) is an annual solicitation through ROSES.
  - Education and Public Outreach supplements for any funded NASA research investigation.
  - NASA Earth and Space Science Fellows solicitation for graduate students
  - SOFIA Airborne Astronomy Ambassadors
- **Science Education and Public Outreach Forums:** NASA's Forums can help you share your science with educators, students, or the public (see *http://smdepo.org/node/305*).
  - The Astrophysics Forum is creating an education and outreach resource partner network where you will be able to share ideas and connect with NASA programs.
  - Contact email address: *AstroForum@stsci.edu*
- **Astrophysics E/PO Splinter Meeting:** Connecting Scientists with NASA Astrophysics Education and Public Outreach (E/PO), Thursday, Jan 12, 2012, 9:30 AM -11:00 AM Room 19B

Astrophysics Fellowships 2011



Hubble, Einstein and Sagan postdoc fellowships now support 93 fellows at a cost of ~$11M/year

- The new Nancy Grace Roman Technology Fellowship in Astrophysics will:
  - Provide early career researchers the opportunity to develop the skills necessary to lead astrophysics flight instruments/projects and become principal investigators of future astrophysics missions.
  - Develop innovative technologies that have the potential to enable major scientific breakthroughs.
  - Foster new talent by putting early-career instrument builders on a trajectory towards long-term positions.
- Expected budget ~$1M.

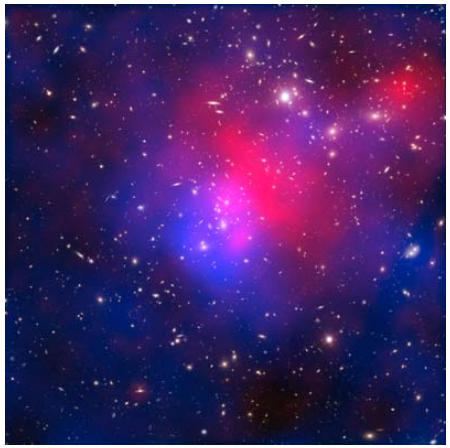
Top 10 Science Highlights of the Year

- **Kepler** Mission Discovers Its First Rocky Planet (January 10, 2011)
- **Fermi** Catches Thunderstorms Hurling Antimatter into Space (January 10, 2011)
- **Swift/Hubble/Chandra** Observe Black Hole Devouring a Star (April 7, 2011)
- **Hubble/Spitzer** Telescopes Discover Surprisingly Young Galaxy (April 12, 2011)
- **Gravity Probe B** Confirms Two Einstein Space-Time Theories (May 4, 2011)
- **GALEX** Helps Confirm Nature of Dark Energy (May 19, 2011)
- **Herschel** Helps Solve Mystery of Cosmic Dust Origins (July 7, 2011)
- **WISE** Discovers Coolest Class of Stars (August 23, 2011)
- **RXTE** Smallest Known Black Hole (December 15, 2011)
- **Kepler** Discovers First Earth-sized Planets Orbiting a Sun-like Star Outside Our Solar System. (December 20, 2011)

Cosmic Origins Science Highlights

RCW 86 is the oldest documented example of a supernova. X-ray images from the ESA's **XMM-Newton Observatory** and NASA's **Chandra X-ray Observatory** form the blue and green colors in the image. The X-rays show the interstellar gas that has been heated to millions of degrees by the passage of the shock wave from the supernova. Infrared data from the **Spitzer Space Telescope** and the **Wide-Field Infrared Survey Explorer** are shown in yellow and red, and reveal dust radiating at a temperature of several hundred degrees below zero, warm by comparison to normal dust in our Milky Way galaxy. (October 24, 2011)

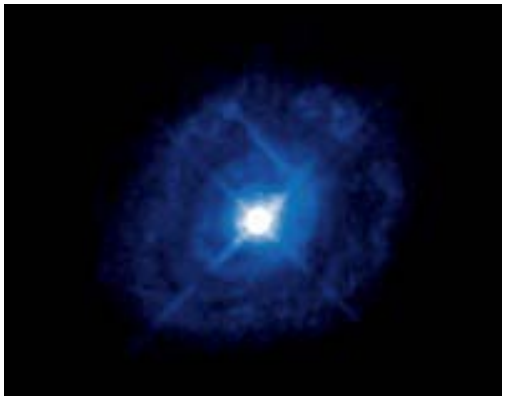
VV 340, also known as Arp 302, provides a textbook example of colliding galaxies seen in the early stages of their interaction. Data from the **Chandra X-ray Observatory** (purple) are shown here along with optical data from the **Hubble Space Telescope** (red, green, blue). The edge-on galaxy near the top of the image is VV 340 North and the face-on galaxy at the bottom of the image is VV 340 South. Millions of years later these two spirals will merge - much like the Milky Way and Andromeda will likely do billions of years from now. VV 340 is located about 450 million light years from Earth. (August 11, 2011)



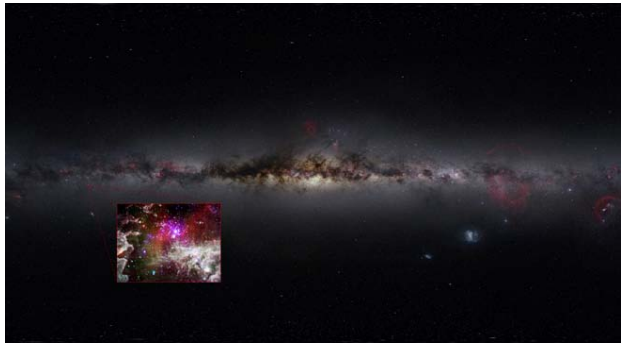
Scientists studying the galaxy cluster Abell 2744 have pieced together the cluster's complex and violent history using the **Hubble Space Telescope**, the **Chandra X-ray Observatory**, the **European Southern Observatory's Very Large Telescope**, and the **Japanese Subaru telescope**. The giant galaxy cluster appears to be the result of a simultaneous pile-up of at least four separate, smaller galaxy clusters. The crash took place over a span of 350 million years. The galaxies in the cluster make up less than 5% of its mass. The gas (around 20%) is so hot that it shines only in X-rays (colored red in this image). The distribution of invisible dark matter (making up around 75% of the cluster's mass) is colored in blue. (June 22, 2011)

Physics of the Cosmos Science Highlights

A study using data from NASA's **Fermi Gamma-ray Space Telescope** finds that the tumult of star birth and death in Cygnus X has managed to corral fast-moving particles called cosmic rays. Gamma-ray emission detected by Fermi fills bubbles of hot gas created by the most massive stars in Cygnus X. The turbulence and shock waves produced by these stars make it more difficult for high-energy cosmic rays to traverse the region. When the particles strike gas nuclei or photons of starlight, gamma rays result. (November 28, 2011)



Astronomers have uncovered striking features around a supermassive black hole in the core of the distant galaxy Markarian 509. They found a very hot corona hovering above the black hole and cold gas "bullets" in hotter diffuse gas, speeding outward with velocities over 1 million miles per hour. This corona absorbs and reprocesses the UV light from the accretion disk encircling the black hole, energizing it and converting it into X-rays. The campaign consisted of visible, X-ray, and gamma-ray observations with ESA's **XMM-Newton** and **INTEGRAL** satellites, followed by long observations with NASA's **Chandra** and **Hubble**. Prior to these observations short snapshots were taken by the **Swift** satellite. (September 29, 2011)



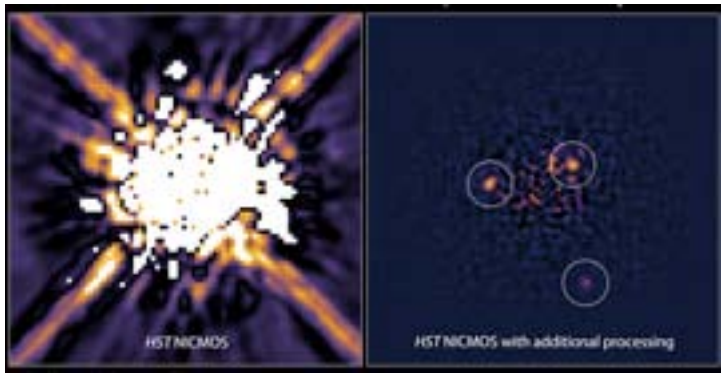
This composite image of NGC 281 contains X-ray data from **Chandra** (purple) with infrared observations from **Spitzer** (red, green, blue). The high-mass stars in NGC 281 drive many aspects of their galactic environment through powerful winds flowing from their surfaces and intense radiation that heats surrounding gas, "boiling it away" into interstellar space. This process results in the formation of large columns of gas and dust, as seen on the left side of the image. These structures likely contain newly forming stars. The eventual deaths of massive stars as supernovas will also seed the galaxy with material and energy. (September 28, 2011)

Exoplanet Exploration Science Highlights

Artist Conception

The **Kepler** mission has discovered the first Earth-size planets orbiting a sun-like star outside our solar system. The planets, called Kepler-20e and Kepler-20f, are too close to their star to be in the so-called habitable zone where liquid water could exist on a planet's surface, but they are the smallest exoplanets ever confirmed around a star like our sun. Kepler-20e is slightly smaller than Venus, measuring 0.87 times the radius of Earth. Kepler-20f is a bit larger than Earth, measuring 1.03 times its radius. The new planets are thought to be rocky. They reside in a five-planet system called Kepler-20, about 1,000 light-years away in the constellation Lyra. (December 20, 2011)

The **Spitzer Space Telescope** picked up indications that one or more comets was recently torn to shreds after colliding with a rocky body. The spectral signatures of water ice, organics and rock, key ingredients of comets, were found around Eta Corvi. This is the first time that evidence for such a comet storm has been seen around another star. Eta Corvi is about the right age, about one billion years old, to be experiencing a bombardment of comets akin to what occurred in our own solar system at 600 to 800 millions years of age. (October 19, 2011)



In a re-analysis of **Hubble Space Telescope** images from 1998, astronomers have found visual evidence for two extrasolar planets that went undetected back then. Finding these hidden gems in the Hubble archive gives astronomers an invaluable time machine for comparing much earlier planet orbital motion data to more recent observations. It also demonstrates a novel approach for planet hunting in archival Hubble data. (October 6, 2011)