



PCOS Program Office Update

ANN HORNSCHEMEIER

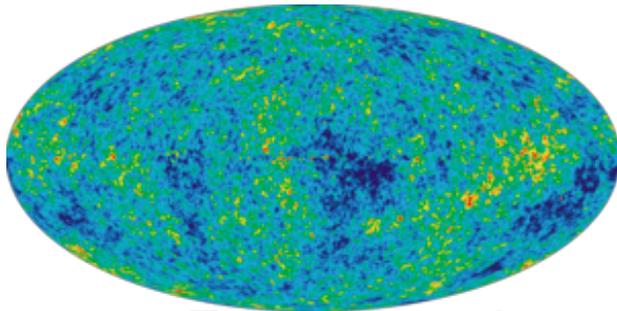
Chief Scientist, Physics of the Cosmos Program

Deputy Chief Scientist: Alan Smale

HQ Program Executive: Jaya Bajpayee

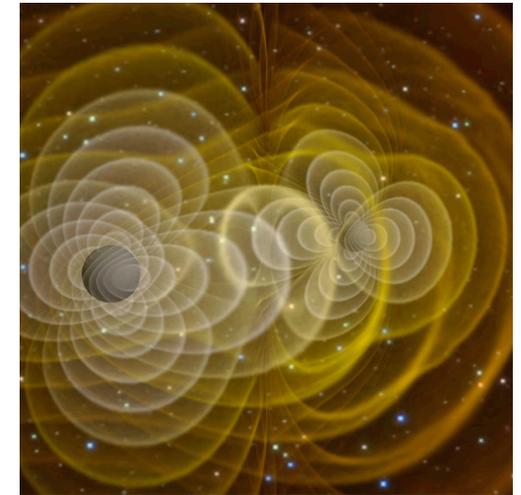
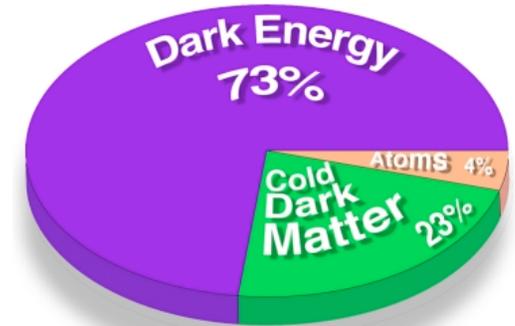
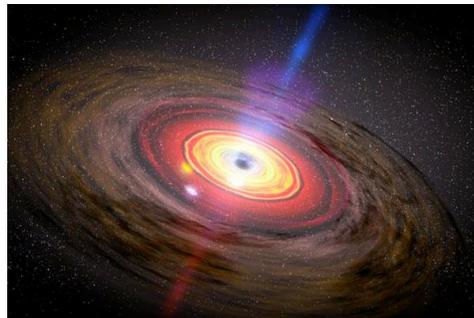
HQ Program Scientist: Rita Sambruna

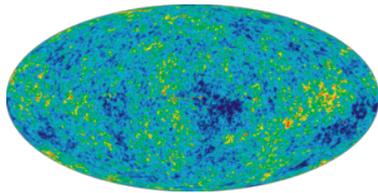
HQ Deputy Program Scientist: Wilt Sanders



Physics of the Cosmos Science Objectives

- Expand our knowledge of dark energy
- Precisely measure the cosmological parameters governing the evolution of the universe and test the inflation hypothesis of the Big Bang
- Test the validity of Einstein's General Theory of Relativity and investigate the nature of spacetime
- Understand the formation and growth of massive black holes and their role in the evolution of galaxies
- Explore the behavior of matter and energy in its most extreme environments





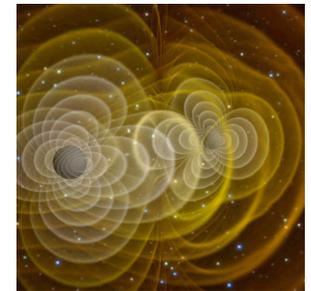
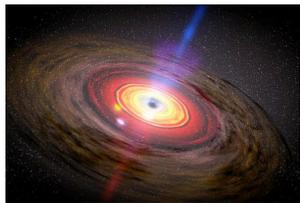
Physics of the Cosmos

Activities by Science Discipline

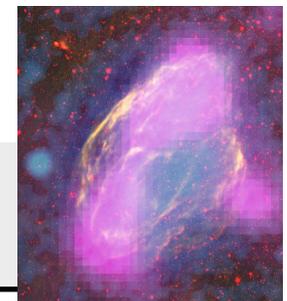


- **Across all disciplines:**

- Through PCOS@HQ: TPCOS, The Strategic Astrophysics Technology (SAT) call
- Technology monitoring and needs prioritization through PCOS Advanced Concepts and Technology Office (ACTO)
- PAO and EPO activities supporting the program



Science Area	Program Activity
Dark Energy	Euclid project Support of WFIRST DE
Inflation/Cosmology	IPSAG + plans for future study
General Relativity	GW mission architecture study ST7 and LISA PF + GWSAG
SMBH/Galaxy Evolution	X-ray mission architecture study + XRSAG
Behavior of matter under extreme environments	CRSAG, GammaSAG white papers (starting now)



Current PCOS Portfolio Across the Electromagnetic Spectrum



Operating PCOS missions



Operating Explorers (PCOS Science)

+ Suborbital (not shown)

NuSTAR



Suzaku

Swift



XMM-Newton



Fermi

Planck



Chandra

Submm

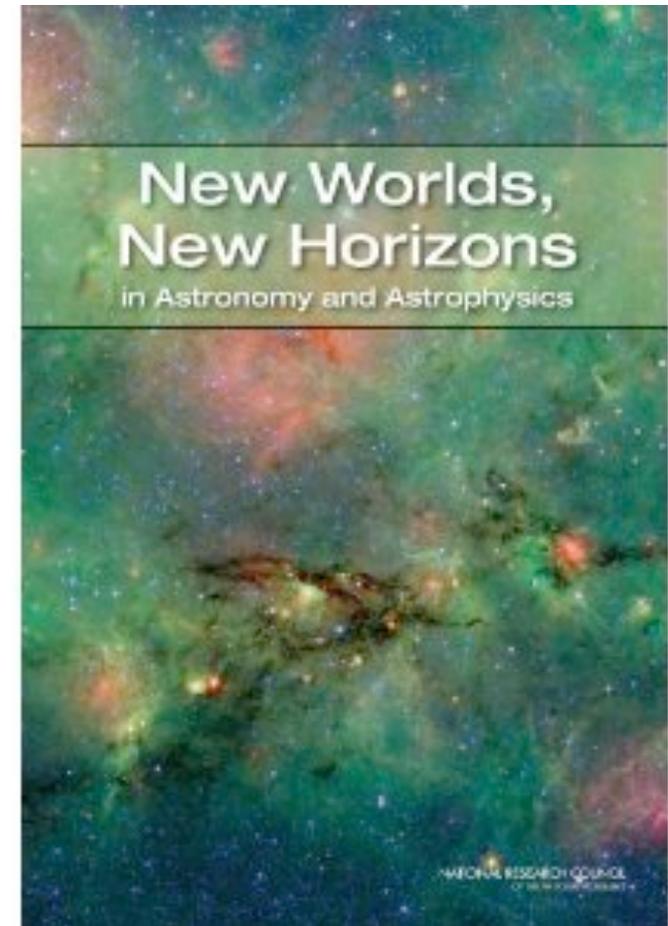
Optical/UV

X-rays

Gamma-rays

Physics of the Cosmos (PCOS): Scientific and Technical Stewardship for future missions

- **Provide scientific and technical stewardship for decadal-survey recommended missions:**
 - Of the six highly-ranked medium and large-scale space-based priorities in NWNH, THREE fall within the PCOS science program:
 - Inflation Probe (medium-scale)
 - LISA
 - IXO
 - NOTE: WFIRST is located within the Exoplanet Program and the science of dark energy is within PCOS





MOONI

PCOS Program Office Leadership

- **Program Manager: Mansoor Ahmed (Mooni)
- Deputy PM: Thomas Griffin
- Chief Scientist: Ann Hornschemeier
- Deputy Chief Scientist: Alan Smale
- **Chief Technologist: Mark Clampin
- **ACTO Chief: Mark Brumfield
- **ACTO Chief Technologist: Thai Pham



TOM



THAI

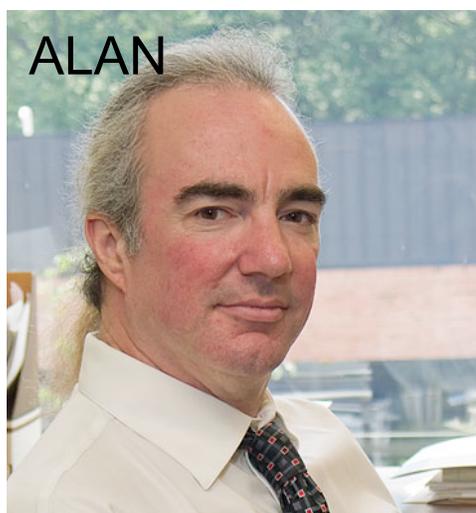


MARK B

**** = Shared with COR, Cosmic Origins**



ANN



ALAN

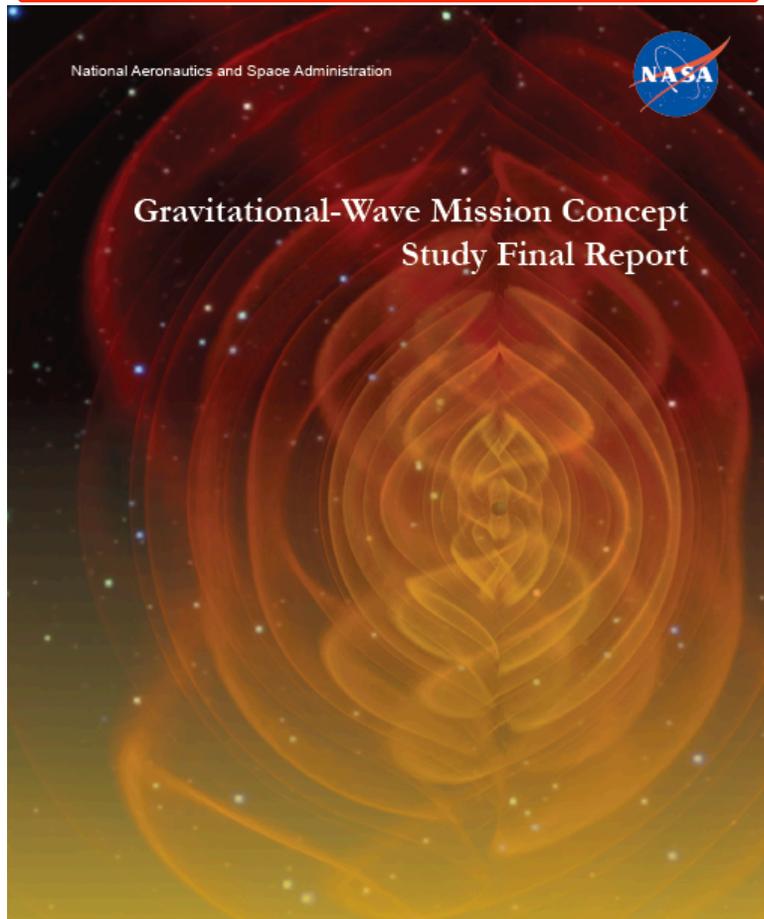


MARK C

Gravitational Wave study report (Study scientist: Tuck Stebbins, Gravitational Wave Community Science Team co-chairs: Rai Weiss & Ned Wright)

13:45 Presentation by Jeff Livas & Ira Thorpe

NB: Gravitational waves likely will be detected by LIGO before JWST launches

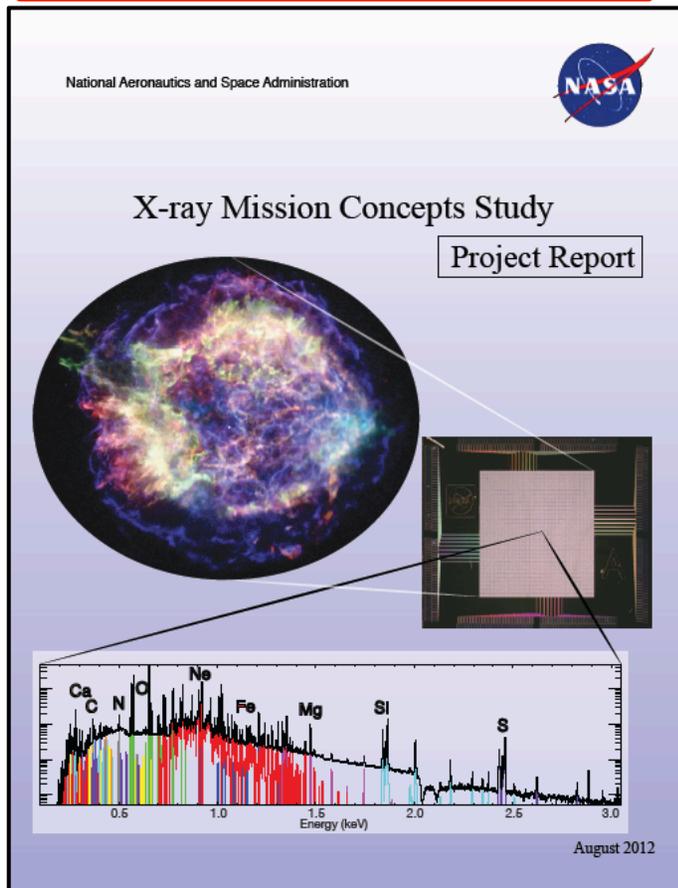


GENERAL FINDINGS

- 1. Study did not uncover any new technologies that can make dramatic reductions in cost or risk**
- 2. No concepts were found near or below \$1B**
- 3. A sustained and significant program supporting technology development and science studies is needed if the US is to participate in the first space-based gravitational mission.**

X-ray study report (Study scientist: Robert Petre, X-ray Community Science Team chair: Joel Bregman)

11AM Presentation by Robert Petre



Report Bottom Line:

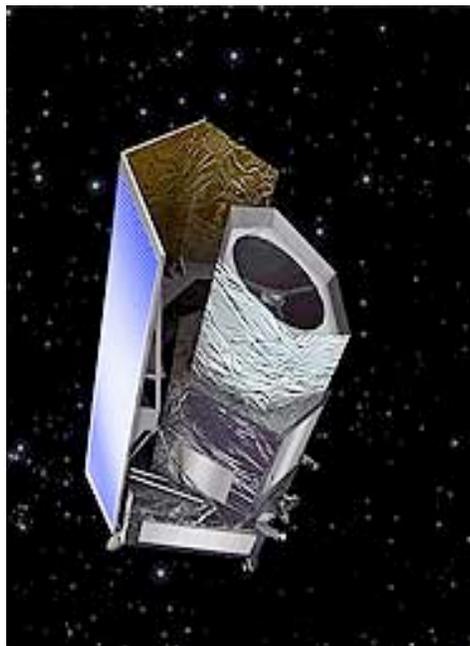
X-ray observatories in the \$1B class that address all or most of the IXO science objectives are feasible for start within this decade, but only if technical risk is controlled through advance development of key technology to TRL-6

The notional missions that were studied were all in this cost range -- less than the current X-ray flagship missions (*Chandra*, *XMM*) -- yet will greatly outperform current missions in critical ways, producing breakthrough science around which the *IXO* concept was developed.

Euclid – NASA Contribution

HQ Program Executive: Lia LaPiana

HQ Program Scientist: Richard Griffiths



**9:30 Wednesday
presentation by
Paul Schechter
on WFIRST and
Euclid Science**

- NASA's contribution to ESA's Euclid mission: Near Infrared Spectrograph and Photometer (NISF) flight subassemblies (detector+ASIC+cryo-cable='triplet') that meet ESA's requirements for testing & characterization
- NASA-ESA MOU will be signed after after the full ESA Council meeting in December 2012.
- Euclid project is being assigned to NASA's JPL under NASA's PCOS Program:
 - JPL Euclid Project Manager – Ulf Israelsson
 - JPL Euclid Study Scientist – Mike Werner (acting)
- PCOS Program Office has worked with NASA HQ on tailoring to NPR 7120.5 for Euclid, setting up the project office, and convening an Independent Review Team
- ROSES call for Science Team Membership is open until August 31st. For FAQs please visit the PCOS-managed Euclid website: euclid.gsfc.nasa.gov

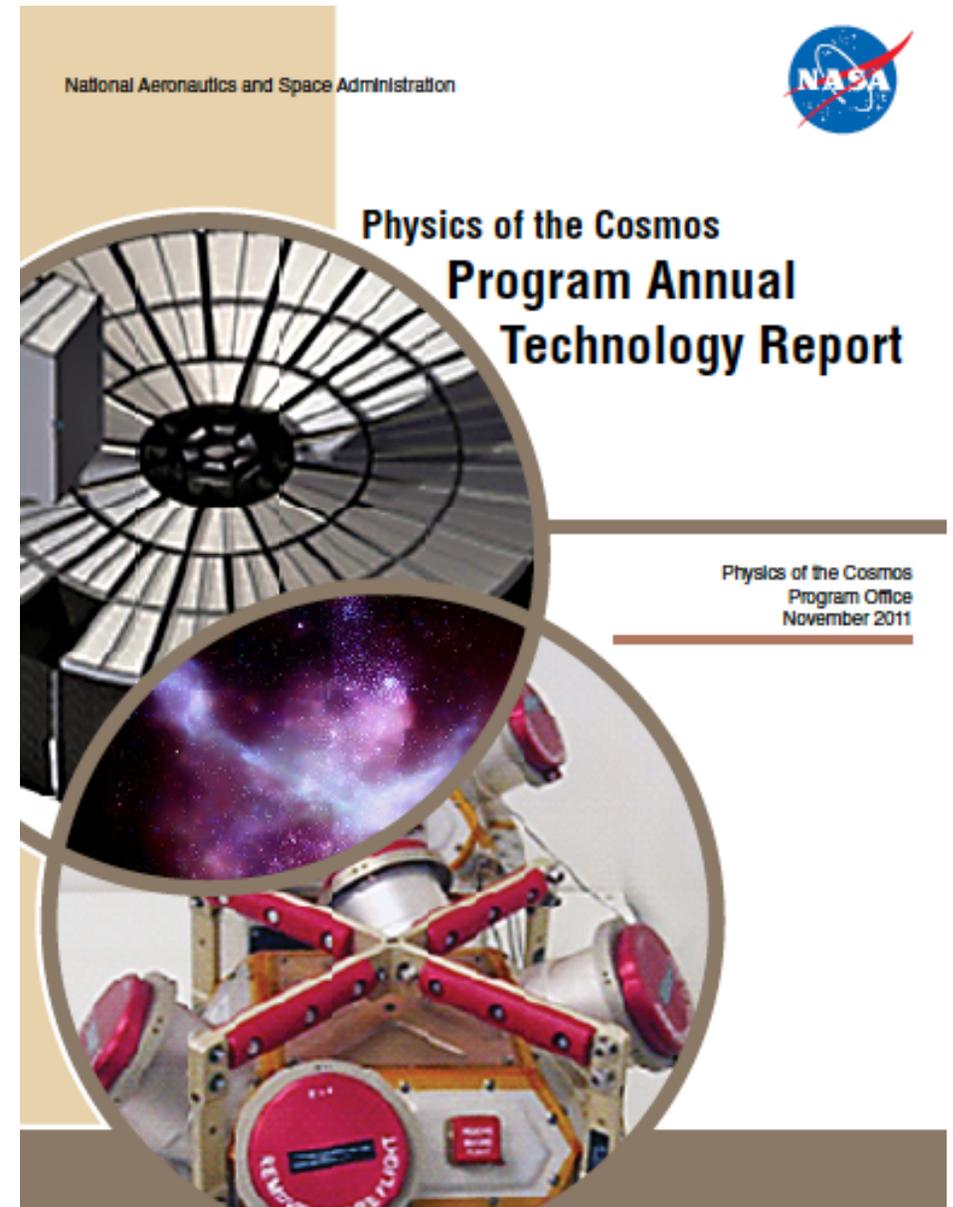
PCOS: technology development funding

- **NWNH priorities and NASA strategic roadmaps inform technology development funding. For example these were the projects funded by the 2010 ROSES SAT under PCOS:**

Schattenburg, M.	MIT	Development of Fabrication Process for Critical-Angle X-ray Transmission Gratings
Bautz, M.	MIT	Directly-Deposited Blocking Filters for Imaging X-ray Detectors
Bock, J.	JPL	Antenna-coupled Superconducting Detectors for Cosmic Microwave Background Polarimetry
McEntaffer, R.	Univ of Iowa	Off-plane Gratings Arrays for Future Missions
Reid, P.	SAO	Development of Moderate Angular Resolution Full Shell Electroplated Metal Grazing Incidence X-ray Optics

Technology Prioritization

- The PCOS Program Annual Technology Report (PATR) describes the Program's technology management activities
- **The PATR defines priorities for technology investments for the upcoming year.** The technology needs are prioritized using a set of criteria (described in the report).
- The PCOS Program Analysis Group (PhysPAG) is the main conduit for collecting technology needs identified by the community. Technology needs were submitted following a community call in June 2012.



2011 PCOS PATR Technologies

Priorities 1-3 (grouped by priority)

Priority	Technology	Science
1	X-ray calorimeter: central array (~1,000 pixels): 2.5 eV FWHM at 6 keV; extended array: 10 eV FWHM at 6 keV.	X-ray
	Telescope: Classical optical design. Surface roughness $<\lambda/30$, backscatter/straylight. Athermal design with temp gradient dimensional stability: pm/sqrt(Hz) and μm lifetime, angular stability $<8\text{mrad}$	Gravitational Wave
	Laser: 10 yr life, 2W, low noise, fast frequency and power actuators	Gravitational Wave
	lightweight, replicated x-ray optics. Lightweight precision structure	X-ray
2	High resolution gratings (transmission or reflection)	X-ray
	High-throughput, light, low-cost, cold, mm-wave telescope operating at low backgrounds	Inflation
	Large format (1,000-10,000 pixels) arrays of CMB polarimeters with noise below the CMB photon noise and excellent control of systematics	Inflation
	Phasemeter: Quadrant photodetector: low noise. ADC: 10 yr life, low noise (amplitude and timing). Alignment sensing, optical truss interferometer, refocus mechanism	Gravitational Wave
	μN thrusters: 10 yr. life, low contam, low thrust noise. Not formation flying.	Gravitational Wave
3	Cryocoolers for detectors and other instrument HW	X-ray
	Low CTE materials	Gravitational Wave
	Passive Spitzer design plus cooling to 100 mK	Inflation
	Anti-reflection coatings	Inflation

2012 PCOS Technology Prioritization

- **92 technology needs across the five scientific areas of PCOS were received**
- **Still making use of the 2011 TechSAG technology list, a community effort led by Roger Brissenden (THANK YOU!). This was updated, in consultation with the PhysPAG EC and community, this year.**
- **The PCOS Technology Management Board met over the course of three weeks to score all technologies using the 11-point evaluation system advertised on the pcos website, in last year's PATR and in the March 2012 PCOS newsletter**
- **The resulting list will be published as part of the 2012 PCOS PATR and referenced by the ROSES 2013 SAT call.**
- **Next year we will improve the process:**
 - In October the PCOS TMB and program office will conduct another lessons learned on the process.
 - The goal is to simplify the evaluation criteria and gain better definition of technologies and missions
 - The PCOS TMB and program office will work with the SAGs and PhysPAG in this process, with a plan forward to be presented at the Long Beach AAS

What else is going on in the PCOS program?

National Aeronautics and Space Administration



March 2012

Vol. 2 No. 1

Program Manager's Perspective

Mansoor Ahmed, *PCOS Program Manager*

The PCOS program accomplished a great deal this quarter. The X-ray and Gravitational Wave study teams evaluated the RFI inputs and are formulating notional mission concepts and evaluating each science case relative to the science priorities outlined in the New Worlds New Horizons (NWNH) decadal survey. By this summer, these teams will have determined what fraction of the IXO and LISA science can be achieved at different cost points. The results of these analyses will be presented to the science community, through the National Research Council's Committee on Astronomy and Astrophysics (CAA). Assuming that the CAA will endorse the science case for a particular cost range, the PCOS program will continue working with the community to develop science and mission requirements for the mission concept(s) and define specific technology development plans for the mission concept(s). These studies are critical in program strategic planning and preparations for a mid-decadal review. Interested community members can follow the progress on the study websites: (see "Studies" under pcos.gsfc.nasa.gov)

Following the release of the Program Annual Technology Report (PATR) in December 2011, we are now into our first quarter of the new technology management process. This process was designed to link technology funding to science objectives through discussions with the community about technology needs and a transparent prioritization of those needs by the PCOS program. The PATR is referenced in the call for Strategic Astrophysics Technology (SAT) proposals, which was also released in December 2011. I highly encourage technology developers proposing to the SAT to review the PCOS PATR as part of their process.

Contents

Program Manager's Perspective	1
PCOS Science	1
News from the Astrophysics Division at NASA Headquarters	3
PhysPAG Report	4
X-ray Astronomy Mission Concept Study	5
Gravitational Wave Mission Concept Study	7
Meet the Einstein Fellows Any Reines	7
News from the Advanced Concepts and Technology Office	8

<http://www.nasa.gov>

With the release of the PATR, the next phase of our conversation with the community begins. Each year technology needs from the community are collected in late June, throughout the year we are interested in feedback about needs, priorities, the prioritization criteria and the overall process. I encourage you to join this conversation through participation in the PhysPAG and by visiting the PCOS website at <http://pcos.gsfc.nasa.gov/>.

We in the Program Office look forward to continuing our discussions with the community to plan the future of PCOS science. Even with the travel restrictions, the Program Office will have a presence at the AAS Anchorage meeting in June and the SPIE Instrumentation meeting in Amsterdam in July. We are also supporting the PhysPAG workshop in Washington, D.C., in August. Please take advantage of these opportunities for face-to-face discussions even as you engage in other ways.

PCOS Science

Ann Hornschemeier, *PCOS Chief Scientist*

The Physics of the Cosmos (PCOS) program spans the fields of fundamental physics, cosmology, and high-energy astrophysics, and includes a wide range of science goals. Below I give a snapshot of program activities divided by the five core PCOS science areas in our program plan. Note that I highlight a single area of future scientific measurement under each topic, although of course there is significant scientific overlap (e.g., gravitational wave facilities will study the formation and growth of massive black holes, and X-ray facilities will investigate the nature of spacetime around compact objects and constrain cosmological parameters via studies of clusters). Please consider this to be the start of a scientific conversation with your new PCOS program chief scientist.

Test the validity of Einstein's General Theory of Relativity and investigate the nature of spacetime. LISA was named as a top-ranked mission under NWNH large space-based projects. PCOS is currently supporting a study of possible space-based gravitational wave observatories at lower cost points, which involves engineering studies via the TEAM-X facility at JPL; please see Tuck Stebbins report (p. 7). The NASA Advisory Committee Astrophysics Subcommittee (NAC ApS) has also approved a new Gravitational Wave Science Analysis Group

- Three published PCOS newsletters giving updates to the community on the X-ray and GW studies, the technology management process, news from NASA HQ, science updates for operating missions
- PCOS program website (pcos.gsfc.nasa.gov), continues to be the interface between all program and PhysPAG activities and the community:

The screenshot shows the PCOS program website with the following elements:

- Header:** NASA logo, National Aeronautics and Space Administration, Goddard Space Flight Center.
- Navigation Tabs:** Overview, Projects, Science, Technology, Studies, Program Office, Education.
- Overview Section:**

The Physics of the Cosmos (PCOS) Program lies at the intersection of physics and astronomy. Its purpose is to explore some of the most fundamental questions regarding the physical forces and laws of the universe: the validity of Einstein's General Theory of Relativity and the nature of spacetime; the behavior of matter and energy in extreme environments; the cosmological parameters governing inflation and the evolution of the universe; and the nature of dark matter and dark energy. PCOS takes us beyond Einstein and beyond the Standard Model.

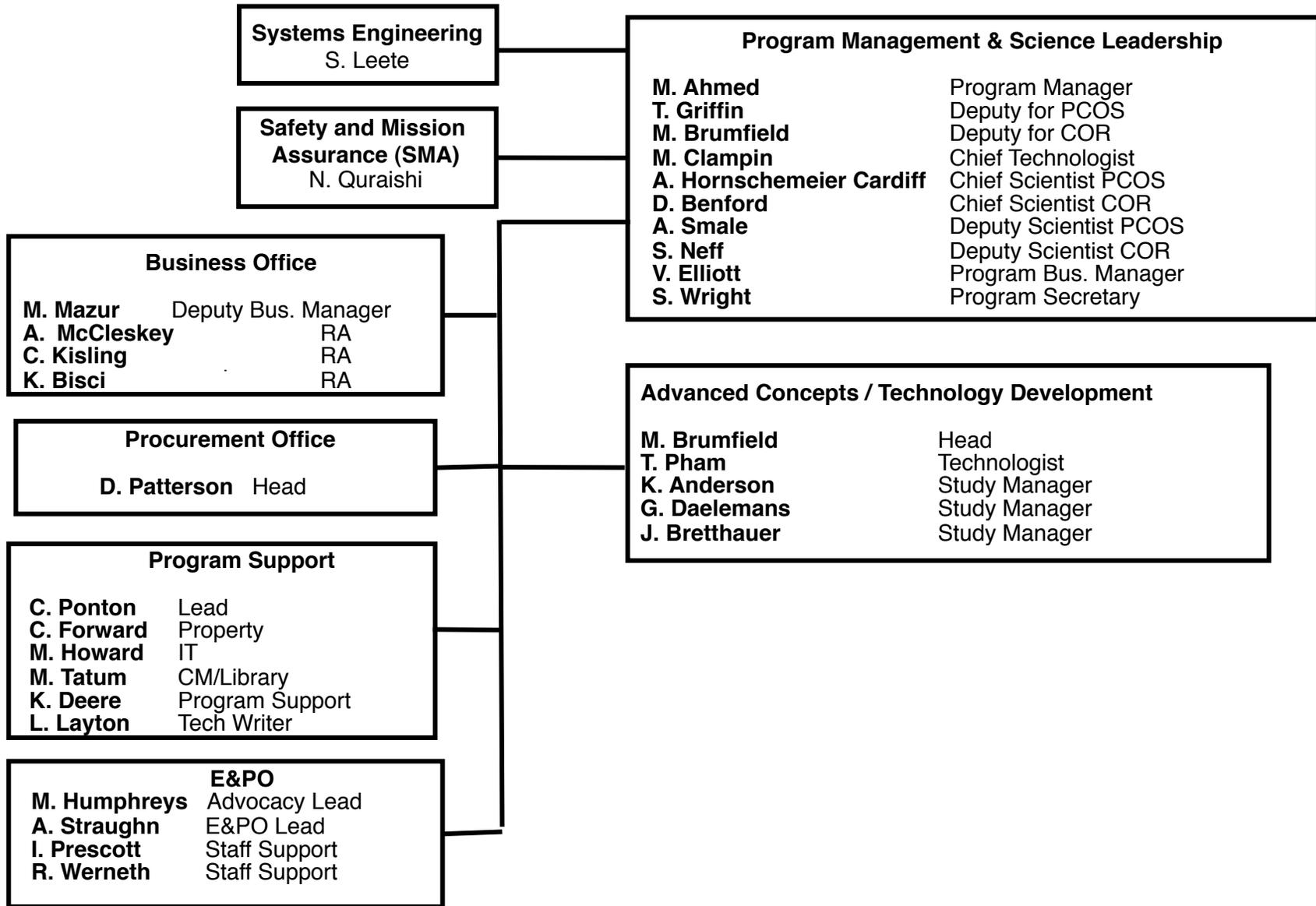
The PCOS Program consists of a suite of operating science missions and possible future missions that focus on specific aspects of these questions. The Chandra and XMM-Newton observatories probe the universe in X-rays using detailed images and spectroscopy to study matter under a broad range of physical conditions. INTEGRAL and now Fermi study the phenomena with the highest energy emission looking for new physics in the
- Links Section:**
 - Documents
 - PhysPAG
 - Multimedia Library
 - Sign up for PCOS News and Announcements
- Program News Section:**
 - 13 March 2012: Presentation by Robin Stebbins at the NASA Advisory Committee Astrophysics Subcommittee Meeting on February 23, 2012. [PDF]
 - 13 March 2012: Presentation by Andy Ptak at the NASA Advisory Committee Astrophysics Subcommittee Meeting on February 23, 2012. [PDF]
 - 5 March 2012

Upcoming PCOS Community Interaction Opportunities

- **January 2013, Long Beach:**
 - Sunday all-day PhysPAG meeting with all interested members of the community
 - Monday PCOS-sponsored lunchtime townhall on the Gravitational Wave and X-ray mission architecture reports
- **April 2013, HEAD meeting in Monterey**
 - PhysPAG/PCOS special session proposal submitted
- **April 2013, APS (DAP) meeting in Denver**
 - PhysPAG/PCOS special session proposal submitted
- **CONSULT:** pcos.gsfc.nasa.gov/phypag for more info

BACK-UP

PCOS/COR Program Office Organization



PCOS 2011 PATR

Prioritized Technologies

	Gigapixel X-ray active pixel sensors	X-ray
	Polarization modulating optical elements	Inflation
	Lightweight adjustable optics to achieve 0.1 arcsec high resolution grating spectrometer	X-ray
	Molecular clocks/cavities with 10E-15 precision over orbital period; 10E-17 precision over 1-2 year experiment.	Fundamental Physics
	Cooled atomic clocks with 10E-18 to 10E-19 precision over 1-2 year experiment	Fundamental Physics
	Cryocooler <100 mK with 1 mK stability (IXO heritage)	X-ray
4	Large throughput, cooled mm-wave to far IR telescope operating at background limit	FarIR
	Cooling to 50-300 mK	FarIR
	Very large format (>10 ⁵ pixels) FPA with background-limited performance and multi-color capability	FarIR
	Megapixel microcalorimeter array	X-ray
	High rate Si detector (APS).	X-ray
	passive thermal shielding	Gravitational Wave
	Coupling of ultra-stable lasers with high-finesse optical cavities for increased stability	Fundamental Physics

PCOS 2011 PATR Prioritized Technologies (Priority 5)

5	Coded aperture imaging: ~5 mm thk W and ~2.5 mm holes; ~0.5 mm W and ~0.2 mm holes	X-ray
	Cooled Ge	Gamma
	Arrays of Si, CZT or CdTe Pixels	Gamma
	1 m ² Si (~0.2 mm strips)+~6 m ² CZT (~1.2 mm pixels)	X-ray
	ASIC on each ~20x20 mm crystal	X-ray
	Arc second attitude control to maintain resolution	X-ray
	LHP to radiators for ~-30 deg (Si) and ~-5 deg (CZT) over large areas	X-ray
	Large area atom optics	Gravitational Wave
	Long booms or formation flying	Gamma
	Gratings, single and multilayer coatings, nano-laminate optics	X-ray
	~5" aspect req. over ~6x~3x~ 1.5 m telescope structures	X-ray
	Compton telescope on single platform	Gamma
	1 m precision optics (1/1,000)	Gravitational Wave
	wavefront sensing with cold atoms	Gravitational Wave
	Sun-shield for atom cloud	Gravitational Wave
	Active cooling of germanium detectors	Gamma
	Passive cooling of pixel arrays	X-ray
	Low power ASIC readouts	X-ray
	No optics; source isolation by collimator	X-ray
	ASIC readouts	Gamma
	Laser interferometer ~1 kWatt laser	Gravitational Wave
	extendable optical bench to achieve 60 m focal length	X-ray
	Scintillators, cooled Ge	Gamma
	>3 m ² Si (or CZT or CdTe) pixel arrays or hybrid pixels -- possibly deployable	X-ray
	10 W near IR, narrow line	Gravitational Wave
	Gravity Reference Unit (GRU) with ~100x lower noise	Gravitational Wave
	Photocathodes, microchannel plates, crossed grid anodes	X-ray
	3 m precision optics	Gravitational Wave
	Active cooling of germanium detectors	Gamma
	focusing elements (e.g., Laue lens) on long boom or separate platform	Gamma
Megapixel ccd camera	Gravitational Wave	
Thermal stability/control less than 10E-8 K variation	Fundamental Physics	

PCOS/COR Education and Public Outreach

Award-winning Team

- Team members have won numerous awards, including NASA Exceptional Public Service Medal (2011), NASA Honor Awards (2009, 2011), Goddard Team Award for Outreach (2008), Goddard Honor Award for Outreach (2011) and ASD Peer Awards (2011, 2012)

Substantial Achievements

- AfterSchool Universe Program: 12-session astronomy program for middle-schoolers, has reached >12,000 children in 3 yrs; 900+ facilitators in 44 states; 58 certified trainers
- Big Explosions & Strong Gravity: day-long Girl Scouts event reaching thousands of girls
- Blueshift Podcast/Blog: behind the scenes look at PCOS/COR science, missions, news, has 15,500+ Twitter followers; 3,000+ Facebook fans

Strong Future

- Continuing involvement/expansion of the above, plus:
- Space Forensics: presents astronomical mysteries in the style of crime scene investigations
 - Cornerstone project of PCOS/COR EPO effort – piloted in 2007 – four cases currently under development – standards-based classroom packages developed 2013-2014 – interactive website, traveling museum kiosk planned for future years
- Multiwavelength Universe Tour: video clips + online interactive photo studio to provide the public with a multiwavelength view of astronomical objects
- Science on a Sphere, cross-program science audiovisual platform: adding voice-overs to astrophysics visualizations



Communicating with NASA Astrophysics via the Program Analysis Groups (PAGs)

- **The Physics of the Cosmos Program Analysis Group (PhysPAG) serves as a forum for soliciting and coordinating input and analysis from the scientific community in support of the PCOS program objectives.**
- **The Program Analysis Groups (PAGs) include all members of the community interested in providing input to NASA on issues of strategic importance via analysis studies**
- **PAGs hold regular public meetings to provide their members the opportunity to hear about their work and voice their input**
- **PAGs report to NASA via the NAC's Astrophysics subcommittee**
- **PhysPAG Executive Committee (EC) members: S. Ritz (Chair), J. Bookbinder, S. Hanany, G. Mueller, E. Hays, J. Rhodes**
- **The EC is NOT the PhysPAG**

PhysPAG and SAGs

- **The PhysPAG identifies specific, well-defined topics for further detailed studies, and sets up taskforces of volunteers to perform the analysis – Study Analysis Groups (SAGs)**
- **PhysPAG has four SAGs in operation or in development:**
 - Inflation Probe SAG (Chair: Shaul Hanany)
 - Gravitational Wave SAG (Chair: Guido Mueller)
 - X-ray SAG (Chair: Jay Bookbinder)
 - Gamma ray SAG (Chair: Liz Hays)
- **NEW!!: CosmicSAG (Cosmic Ray SAG) approved by Astrophysics subcommittee on July 31st. An email list will be set up shortly. Contact Ann Hornschemeier (Ann.Hornschemeier@nasa.gov) for more info**