

# **Funding Opportunities and Plans for the Decadal Survey**

Mark McConnell  
*University of New Hampshire*

# **NASA Funding Opportunities**

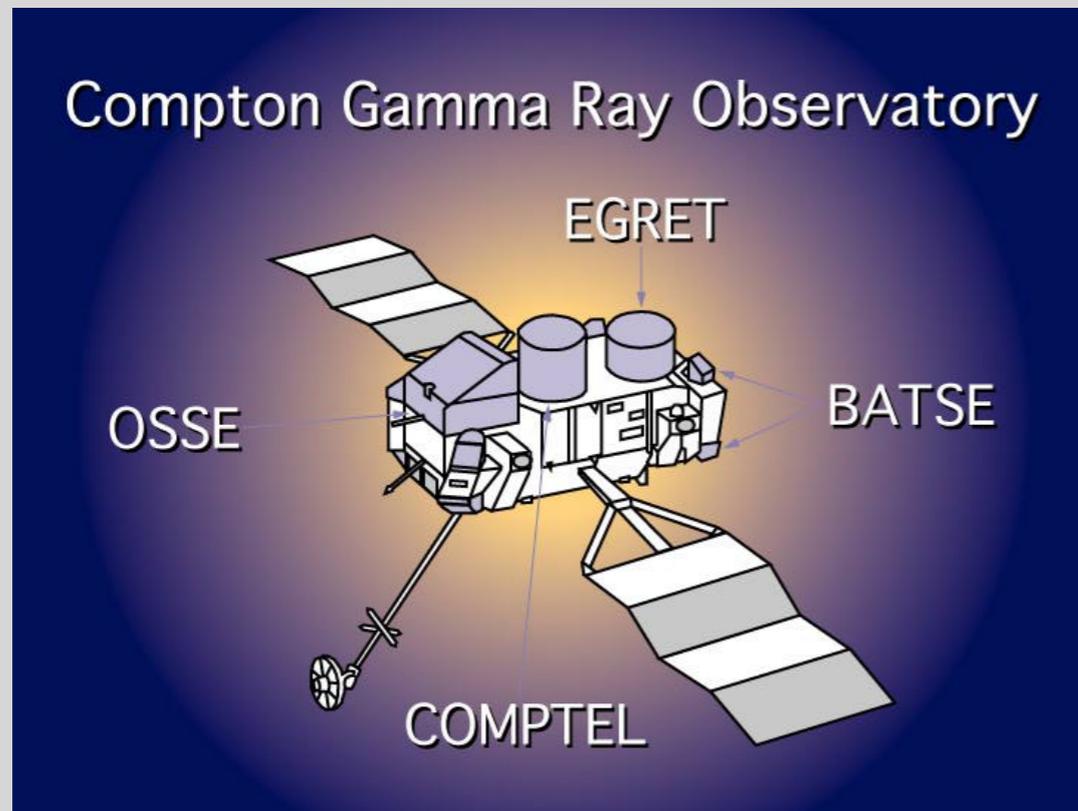
# Mission Classes

---

- ◆ Balloons (\$2-10M)
- ◆ Cubesats (\$2-10M)
- ◆ Explorers
  - MIDEX (< \$250M)
  - SMEX (< \$125M)
- ◆ Probe (Medium) Missions (< \$1B)
- ◆ Flagship (Large) Missions (> \$1B)

# Gamma Ray Balloon Projects

Historically, many gamma ray instruments have been first developed as balloon payloads.



All of the instruments on CGRO were first developed as balloon payloads before being proposed for space.

Typical program costs are \$2-10M.

Balloon projects are typically funded out of the APRA program, but Missions of Opportunity programs are also possible.

# Active Gamma Ray Balloon Projects

---

- ◆ *COSI (UCB - Boggs)*  
*COmpton Spectrometer and Imager*  
Ge Compton telescope (0.2 - 10 MeV)
- ◆ *GRAPE (UNH - McConnell)*  
*Gamma RAY Polarimeter Experiment*  
GRB polarimeter (50 - 500 keV)
- ◆ *ASCOT (UNH - Bloser)*  
Advanced Scintillator COmpton Telescope  
Scintillator Compton telescope (0.4 - 20 MeV)
- ◆ *ComPair (GSFC - Moiseev)*  
COMton PAIR telescope  
Si tracker Compton / pair telescope (200 keV - 500 MeV)
- ◆ *X-Calibur (WashU - Krawczynski)*  
Grazing incidence polarimeter (2-12 keV)

# Inactive Gamma Ray Balloon Projects

---

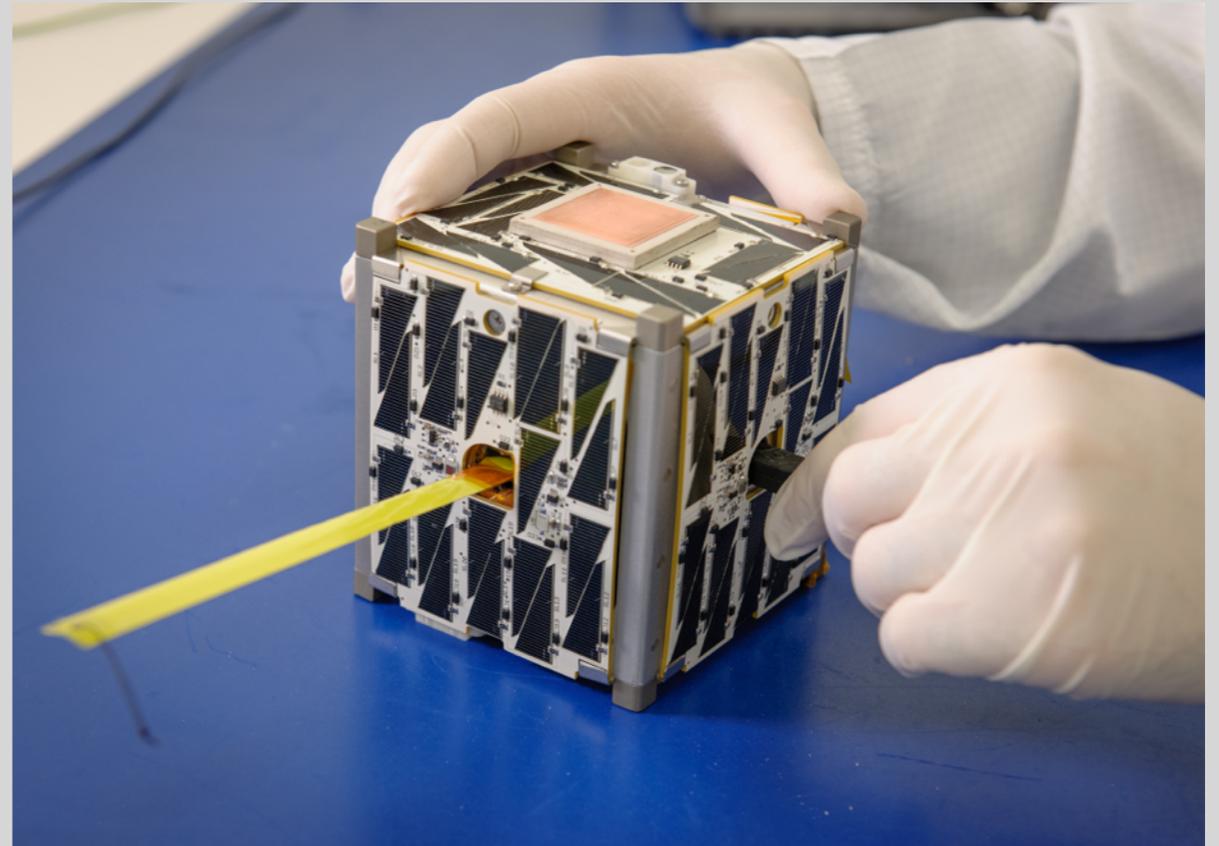
Inactive, but potentially relevant programs.

- ◆ *LXeGRIT (Columbia Univ - Aprile)*  
Liquid Xenon Gamma-Ray Imaging Telescope  
LXe TPC telescope (0.15 - 10 MeV)
- ◆ *TIGRE (UCR - Zych)*  
Tracking and Imaging Gamma-Ray Experiment  
Si tracker Compton telescope (0.3 - 30 MeV)

# Cubesats

Cost range \$2-10M.

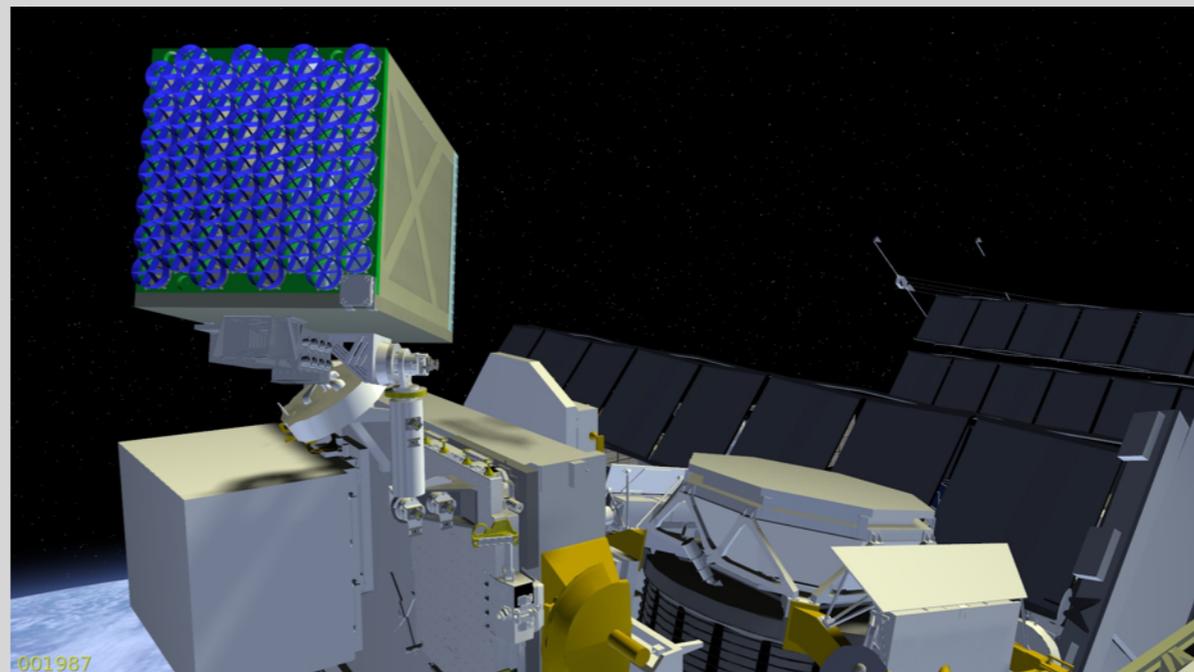
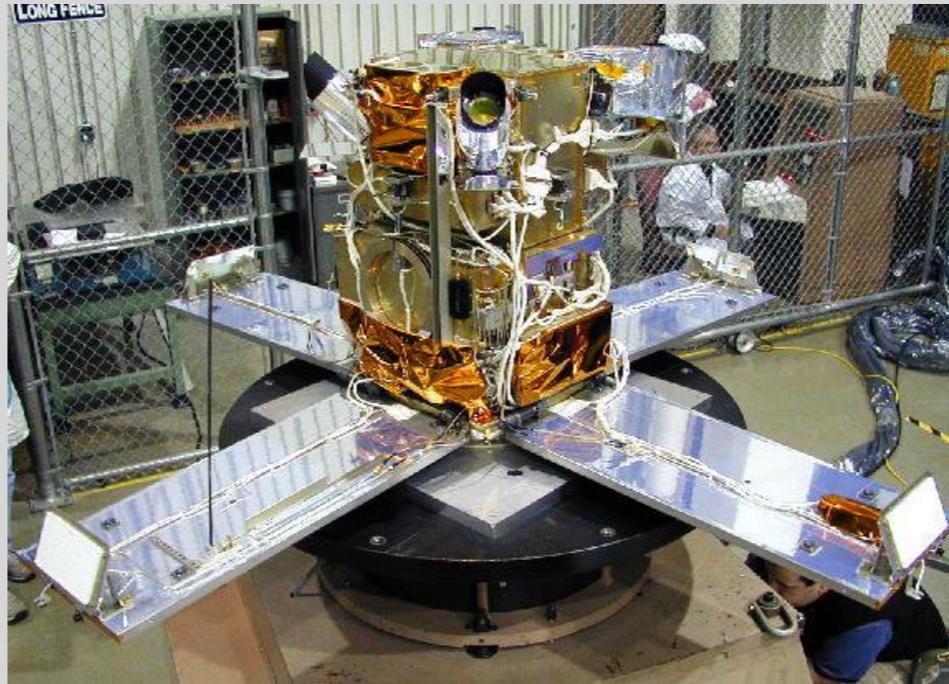
Potentially useful for technology demonstration, but hard to imagine useful gamma ray science being done with such small payloads.



# Mission of Opportunity

Cost cap \$70M

- ◆ **HETE-II**
- ◆ **INTEGRAL**
- ◆ **Astro-E2**
- ◆ **Astro-H**
- ◆ **NICER**



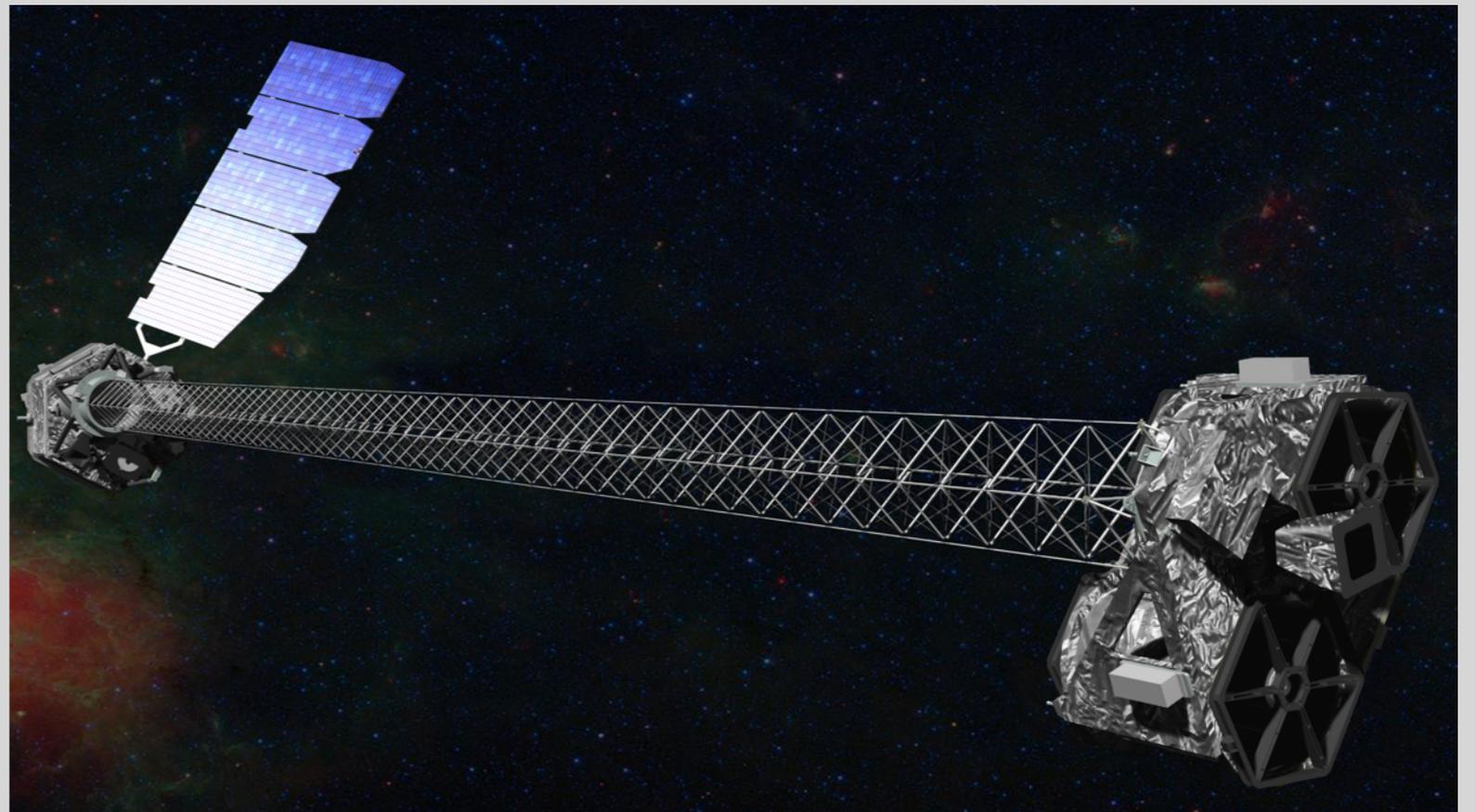
# SMEX – Small Explorers

Cost cap \$125M

## RHESSI



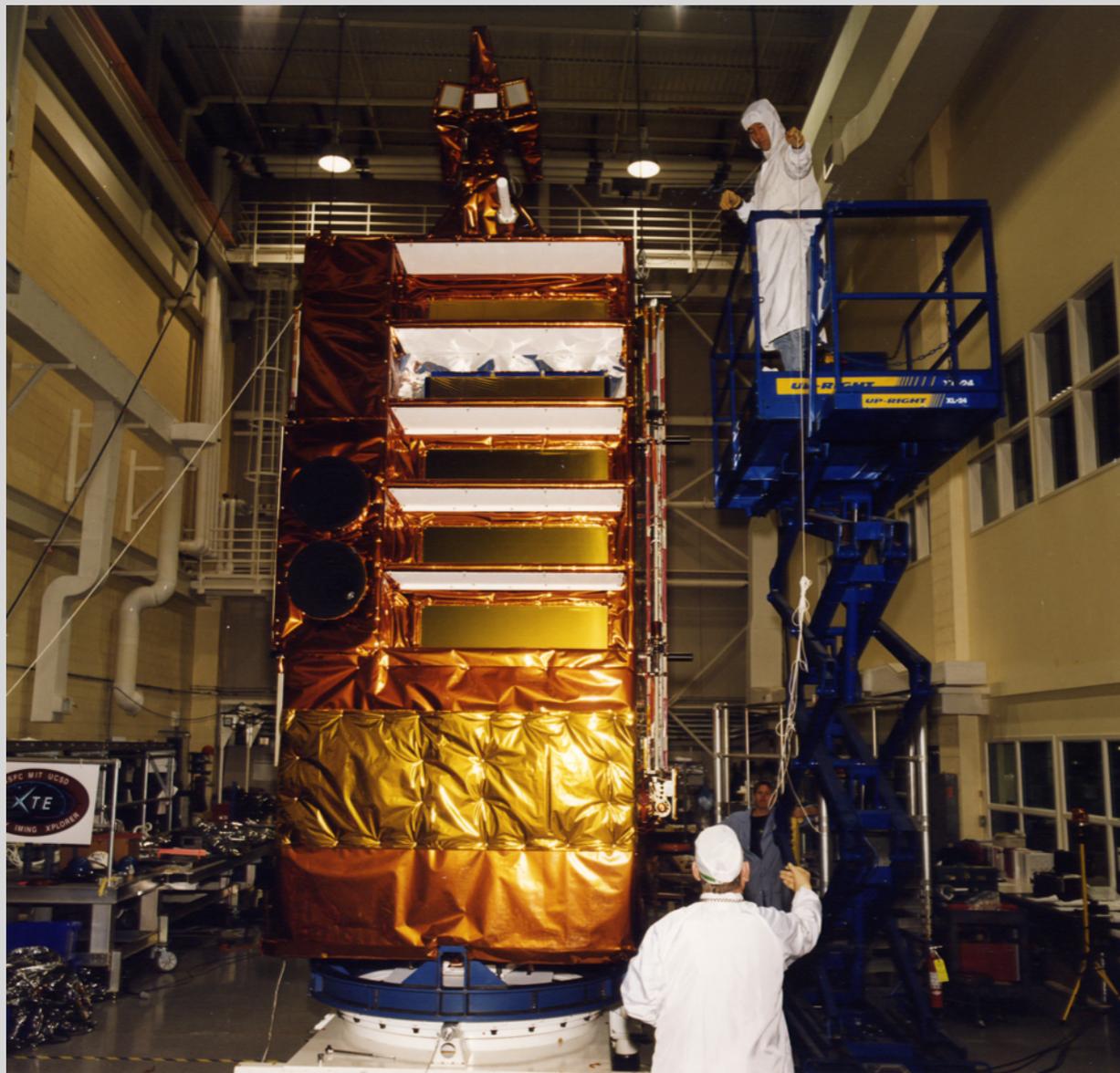
## NuSTAR



# MIDEX – Medium Explorers

Cost cap \$250M

## RXTE



## SWIFT



# Flagship Missions

---

Cost range > \$1B



Hubble and JWST are prime examples.

But CGRO *might* be considered in this range.

The total cost of CGRO was about \$700M (2000).

# Proposed PROBE Class

Cost range \$500M - \$1B

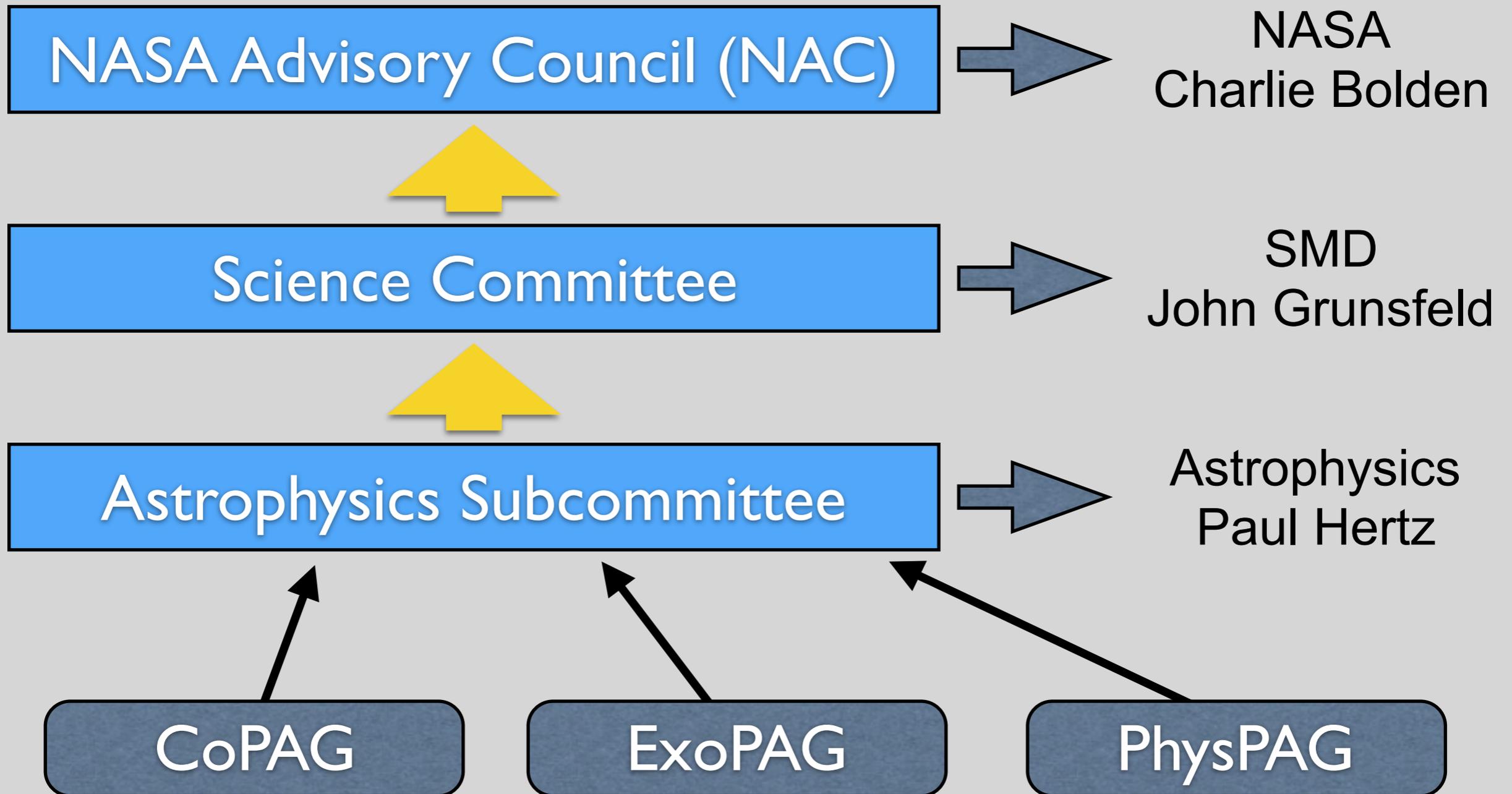


Fermi *might* be considered a typical Probe class mission.

The total cost of Fermi is about \$700M (2009).

**GammaSIG**  
**Gamma-Ray Science**  
**Interest Group**

# NASA Advisory Structure



# Program Analysis Groups (PAGs)

<b>CoPAG</b>	Cosmic Origins	Explore the origin and evolution of the galaxies, stars and planets that make up our universe.	<a href="http://cor.gsfc.nasa.gov">cor.gsfc.nasa.gov</a>
<b>ExoPAG</b>	Exoplanet Exploration	Discover and study planets around other stars, and explore whether they could harbor life.	<a href="http://exep.jpl.nasa.gov">exep.jpl.nasa.gov</a>
<b>PhysPAG</b>	Physics of the Cosmos	Probe the origin and destiny of our universe, including the nature of black holes, dark energy, dark matter and gravity.	<a href="http://pcos.gsfc.nasa.gov">pcos.gsfc.nasa.gov</a>

# PhysPAG

## *Physics of the Cosmos Program Analysis Group*

Science Interest Group	Description	Website
IPSIG	Inflation Probe (CMB)	<a href="http://pcos.gsfc.nasa.gov/sigs/ipsig.php">pcos.gsfc.nasa.gov/sigs/ipsig.php</a>
GWSIG	Gravitational Wave	<a href="http://pcos.gsfc.nasa.gov/sigs/gwsig.php">pcos.gsfc.nasa.gov/sigs/gwsig.php</a>
XRSIG	X-Rays	<a href="http://pcos.gsfc.nasa.gov/sigs/xrsig.php">pcos.gsfc.nasa.gov/sigs/xrsig.php</a>
<b>GammaSIG</b>	<b>Gamma Rays</b>	<b><a href="http://pcos.gsfc.nasa.gov/sigs/gammasig.php">pcos.gsfc.nasa.gov/sigs/gammasig.php</a></b>
CosmicSIG	Cosmic Rays (Particle Astro)	<a href="http://pcos.gsfc.nasa.gov/sigs/cosmicSIG.php">pcos.gsfc.nasa.gov/sigs/cosmicSIG.php</a>
CoSSIG	Cosmic Structure (Dark Energy)	<a href="http://pcos.gsfc.nasa.gov/sigs/cossig.php">http://pcos.gsfc.nasa.gov/sigs/cossig.php</a>

# PhysPAG Executive Committee

Name	Affiliation	Area of Expertise	Term Ends
J. Bock, Chair	Caltech/JPL	CMB	December 2016
M. Bautz	MIT	X-ray astrophysics	December 2016
R. Bean	Cornell University	Dark Energy	December 2016
N. Cornish	Montana State University	Gravitational Waves	December 2016
M. McConnell	Univ. of New Hampshire	Gamma-ray astrophysics	December 2016
Eun-Suk Seo	Univ. of Maryland	Particle astrophysics	December 2016
J. Conklin	Univ. of Florida	Gravitational Waves	December 2017
O. Doré	JPL	Dark Energy	December 2017
H. Krawczynski	Washington University	Gamma-ray astrophysics	December 2017
A. Miller	Columbia University	CMB	December 2017
E. Wollack	NASA/GSFC	CMB	December 2017
I. Moskalenko	Stanford University	Particle astrophysics	December 2018
R. Kraft	SAO	X-ray astrophysics	December 2018

# 2020 Decadal Survey

# 2015-16 Mid-Decade Review

---

[http://sites.nationalacademies.org/SSB/CurrentProjects/SSB\\_161177](http://sites.nationalacademies.org/SSB/CurrentProjects/SSB_161177)

- ◆ The NASA Authorization Act of 2005 requires assessments of NASA's science programs that include mid-decade reviews.
- ◆ The Astrophysics Mid-Decade Review is currently underway.
- ◆ Three committee meetings from Oct to Jan.

# Preparations for 2020 Decadal Survey

---

*January, 2015*

NASA Astrophysics Director Paul Hertz charged the three PAGs to write a report recommending 3-4 large space mission concepts.

NASA plans to set up a Science & Technology Development Team (STDT) for each concept, with funding sufficient to develop the science case and necessary engineering & costing required for a full Decadal submission. Although the reports are to focus on Large missions, he also invited the PAGs to include appendices, at their discretion, discussing Medium class (“Probe”) missions at the <\$1B level.

# PAG Report

---

*Final PAG report was issued in October*

The report recommended consideration of four flagship missions :

- Far IR Surveyor
- Habitable-Exoplanet Imaging Mission (HabEx)
- UV/Optical/IR Surveyor (LUVOIR)
- X-ray Surveyor

Science & Technology Development Teams (STDT) for each concept have recently been organized.

# Probe Class Missions

---

The October PAG report also expressed its support for a new “Probe” class of PI-led Explorer missions.

## **NASA Astrophysics Chief Wants To Put \$1 Billion Missions Out for Competition**

by Dan Leone — October 27, 2015

“For an Astrophysics Probe line to become reality, the White House will have to request annual funding from Congress. This is likelier to happen if astronomers throw their weight behind Hertz’s proposal, which they could do in the next astrophysics decadal survey, which is due in 2020.”

# Probes in the Decadal Survey

---

January 14, 2016

In order to facilitate the Decadal Survey prioritization process, APD has identified the following implementation options to convey ideas for Astrophysics Probes to the Decadal Survey Committee:

1. Issue a solicitation through ROSES for Astrophysics Probe mission concept study proposals. The proposals will be evaluated via a peer-review process and APD will select a few (~10) for one-year studies. A modest (~\$100K) amount of funding would be allocated for each study; cost assessment mechanisms would need to be discussed. The results of the studies would be presented to the Decadal Survey Committee. The Decadal Survey Committee would have the option of asking NASA to conduct further one-year studies at a higher level of detail (and at a higher cost for each study) for a small number (~3) of medium mission concepts.
2. Do nothing and let the community self-organize. Most likely this will result in submission of many white papers to the 2020 Decadal Survey from interested individuals and groups, as during the 2010 Decadal Survey.

# Probe White Papers

---

Of 13 white papers submitted to PhysPAG,  
5 were related to gamma-rays.

- ◆ **All-sky Medium Energy Gamma-ray Observatory (AMEGO)**  
*McEnery et al.*  
Compton / pair production telescope for 0.2 MeV - 10 GeV.
- ◆ **Advanced Particle-astrophysics Telescope (APT)**  
*Buckley et al.*  
Scintillating fiber pair production telescope for 1 MeV - 50 GeV.
- ◆ **The High-Energy X-ray Probe (HEX-P)**  
*Harrison et al.*  
Grazing incidence telescope for 2-200 keV.
- ◆ **Large Observatory For X-ray Timing Probe (LOFT-P)**  
*Wilson-Hodge et al.*  
Large collecting area for 2-50 keV.
- ◆ **Transient Astrophysics Probe (TAP)**  
*Camp et al.*  
Wide field X-ray imager with lobster-eye optics.

# PhysPAG Response to Probes

---

March, 2016

- ◆ We find broad and enthusiastic support in the PCOS community for furthering the development of probe-class missions, conceived as a new large mission class of the PI-led competed missions in the Explorer program.
- ◆ The PhysPAG endorses option 1 given in the charge, undertaking an initial study of ~10 1-year concept studies at ~\$100k each, as an initial step.
- ◆ However we are concerned that the cost information presented to the Decadal review will be insufficient.
- ◆ We suggest that APD develop a second phase of studies to define costs for general probe missions, and to better determine the optimal cost point.

# PhysPAG Response to Probes

---

March, 2016

- ◆ There are several (possibly overlapping) options available to develop a reliable cost model. We do not have a finding for a preferred option.
  - Provide sufficient support for the 10 studies to produce costs
  - Select a reduced number for a second-phase cost analysis
  - Cost “exemplar” concepts that are scientifically defined but apply to general types of likely probe missions
  - Use the inflation probe as one “exemplar” concept

# Gamma Ray Roadmap

# Gamma Ray Roadmap

---

- ◆ Prepare for the 2020 Decadal Review
- ◆ Articulate a common vision for the space-based gamma ray community.
- ◆ The roadmap will...
  - Define the science objectives.
  - Define the instrument requirements.
  - Summarize possible mission concepts.

# Gamma Ray Roadmap

---

## Current list of working groups.

- X-Ray Binaries (Tomsick)
- Pulsars / Magnetars (Baring, Harding)
- SNR / PWNe (Brandt, Hewitt)
- Classical Novae (Cheung, Comiuk)
- Supernovae (Boggs, Grefenstette, Leising)
- Active Galactic Nuclei (Falcone, Finke, Madejski, Ojha)
- Diffuse Galactic Emission (Digel, Hartmann, Moskalenko)
- Cosmic Diffuse Emission (Ajello, Venters)
- Gamma Ray Bursts (Connaughton, Omodei, Zhang)
- Fundamental Physics and Dark Matter (Buckley, Caputo, A. Smith, Krawczynski)
- Solar Physics (Murphy, Pesce-Collins, Ryan)
- Terrestrial Gamma Flashes (Briggs, Dwyer, Grove, D. Smith)

# Gamma Ray Roadmap

---

## *Contents*

- *Science Goals*  
What are the outstanding science issues that should be addressed?
- *Instrument Requirements*  
What are the instrument requirements needed to address the science goals?
- *Technology Requirements*  
What new technologies will be required?
- *Strawman Mission Concepts*  
How many missions would be required? What might they look like?
- *Specific Mission Concepts*  
What are some of the specific mission concepts being investigated by community members?

**Goal is to complete roadmap by Fall of this year.**

# AAS-HEAD Meeting

---

Apr 3-7, 2016 @ Naples, FL

- ◆ Dedicated splinter session is scheduled for Monday, Apr 4 from 7-10 pm.
- ◆ Presentations will focus on mission concepts.

**Anyone interested in making a presentation,  
please let me know.**

# Gamma Ray Science Interest Group

---

GammaSIG Website

(<http://pcos.gsfc.nasa.gov/sags/gammasag.php>)

Mailing List

(<http://pcos.gsfc.nasa.gov/sags/gammasag/gammasag-maillist.php>)

