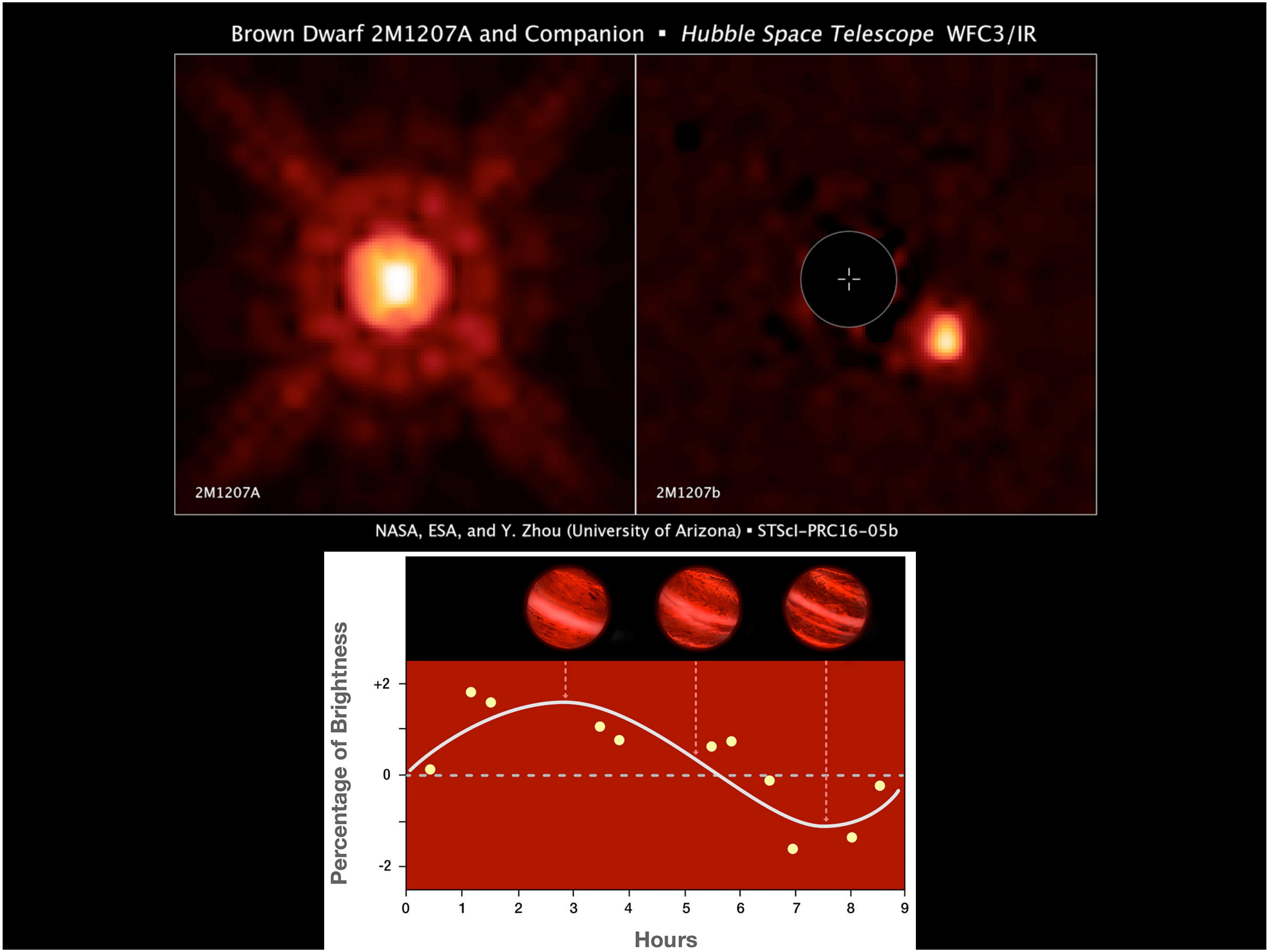
Astrophysics Subcommittee Report

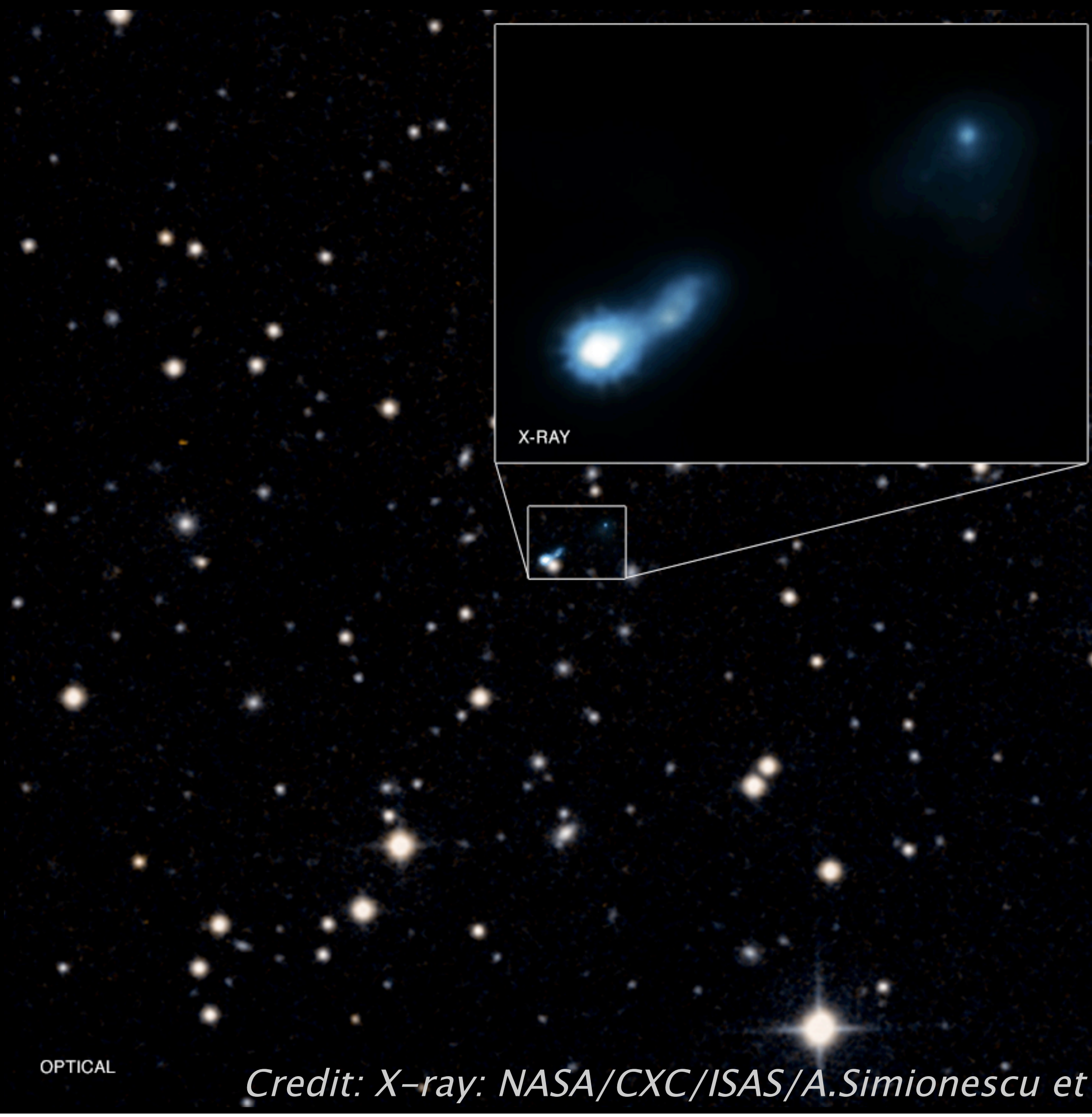
Scott Gaudi
(Astrophysics Subcommittee Chair)

NAC Astrophysics Subcommittee Membership

• **Scott Gaudi (**Chair)	The Ohio State University
• **Hashima Hasan (**Exec. Secretary)	NASA Headquarters
• **Joel Bregman** (Vice Chair)	University of Michigan
• **Natalie Batalha**	NASA Ames Research Center
• **Marshall Bautz**	Massachusetts Institute of Technology
• **Jamie Bock** (PhysPAG EC Chair)	California Institute of Technology
• **Alan Boss** (ExoPAG EC Chair)	Carnegie Institution
• **Patricia Boyd**	NASA Goddard Space Flight Center
• **Neil J. Cornish**	Montana State University
• **Mark Devlin**	University of Pennsylvania
• **Brenda Dingus**	Los Alamos National Labora**tory**
• **Giovanni Fazio**	Harvard-Smithsonian CfA
• **Jason Kalirai**	Space Telescope Science Institute
• **Paul A. Scowen** (COPAG EC Chair)	Arizona State University
• **Rachel Sommerville**	Rutgers University
• **Yun Wang**	California Institute of Technology
• **Beth Willman**	LSST/University of Arizona

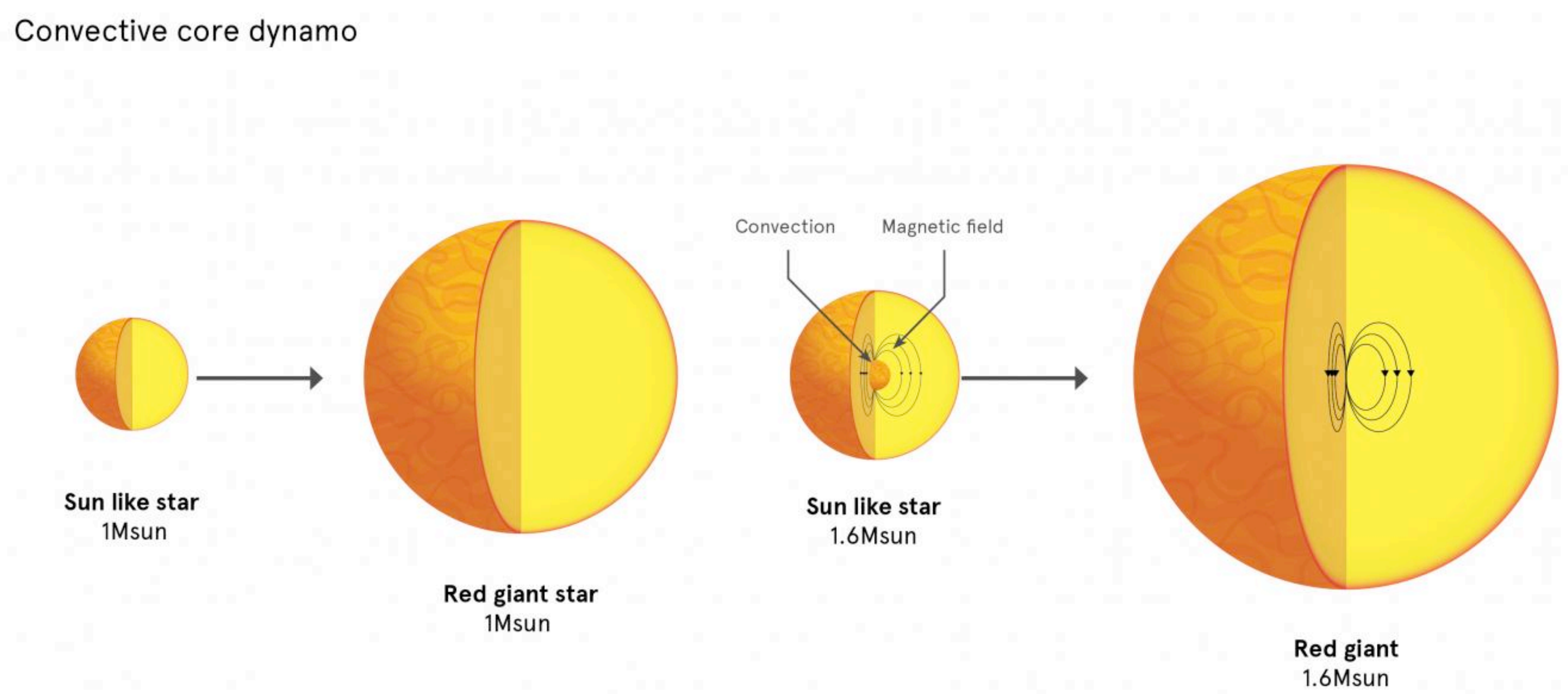

Brown Dwarf 2M1207A and Companion ▪ *Hubble Space Telescope* WFC3/IR
2M1207A
2M1207b
NASA, ESA, and Y. Zhou (University of Arizona) ▪ STScI-PRC16-05b
Percentage of Brightness
+2
0
-2
0
1
2
3
4
5
6
7
8
9
Hours

Glow from the Big Bang Allows Discovery of Distant Black Hole Jet (B3 0727+409)



Credit: X-ray: NASA/CXC/ISAS/A.Simionescu et al, Optical: DSS

Strong Magnetic Fields Discovered in Majority of Stars



Agenda for Next Meeting: March 15+16.

- COPAG, ExoPAG, and PhysPAG Reports.
  - Probe discussion.
- WFIRST Update.
- Gravitational Wave Presentations.
  - LIGO Science and EM Follow-up.
  - LISA Pathfinder Status.
  - L3 Study Team Status.
- Discussion of various funding opportunities.
  - NESSF Update.
  - Exoplanet Research Program.
- Astro-H update.
- Lightweight optics technology development update.
- Large Mission Science and Technology Definition Team Studies Planning.
  - Far-IR Surveyor.
  - Habitable Exoplanet Imaging Missions.
  - Large UV/Optical/IR Surveyor.
  - X-ray Surveyor.

Paul’s Charge to the PAGs on Astrophysics Probes.

“NASA and the community are interested in providing appropriate input to the 2020 Decadal Survey regarding medium-sized mission concepts (i.e., Astrophysics Probe concepts); Astrophysics Probes are astrophysics missions with life cycle costs […] greater than a MIDEX but less than ~$1B.

[…]

I hereby charge each of the three astrophysics Program Analysis Groups […] with providing 2-page written reports to the Astrophysics Subcommittee by March 7, 2016 […] for discussion and assessment of the proposed implementation options.”

– Paul Hertz, January 14, 2016

Implementation options.

- Issue a solicitation through ROSES for Astrophysics Probe mission concept study proposals. ~10 will be selected for one-year ~$100K studies. The Decadal Survey would have the option of asking NASA to conduct further one-year studies at a higher level for ~3 mission concepts.
- Do nothing and let the community self-organize.

PAG's Approach to Responding to the Probe Charge.

- All PAGs
  - Held a joint PAG session at the AAS in January 2016.
- ExoPAG:
  - Drew heavily on previous discussions stemming from the large mission charge, which resulted in a broad pre-existing consensus on several probe missions.
- COPAG
  - Solicited 2-page white papers (16 received).
- PhysPAG
  - Solicited probe mission concepts at the July 2015 AAS HEAD meeting.
  - Initiated a call for 2-page white papers (14 received).

Joint PAG Statement.

The COPAG, ExoPAG, and PhysPAG all agree that NASA should support the development of a probe class of competed missions for the Decadal survey. **All three PAGs strongly support the first option proposed by Paul Hertz** in his formal charge to the PAGs of January 14, 2016. Based on the input the three communities have received, there exists a wide range of community science goals that are both consistent with current National Academy priorities and that can be enabled with medium-class missions. The three PAGs also note that the work of preparing high quality white paper proposals to the 2020 Decadal Survey, for missions of this class, cannot be performed absent funding. In particular, all three PAGs agree that competed NASA HQ funds should allow at least 10 concepts for probe-class missions to be studied in some depth. However**, the main concern associated with this first option is that limiting the funds available for each concept study to ~$100K will likely severely limit the veracity of the CATE analyses at this early phase,** even though funds would be provided for more detailed CATE analyses when requested at a later phase by the Decadal Survey committee. ***We recommend that APD consider apportioning sufficient funds to carry out multiple CATE analyses that would apply to the general category of probe missions in advance of the Decadal Survey.***

PAG-Specific Conclusions.

- COPAG:
  - Broad range of science, implementations, technologies, and risk in proposed missions.
- ExoPAG:
  - Three primary missions concepts: starshade for WFIRST, Transit Characterization, and Astrometry Missions.
- PhysPAG:
  - Broad range of science, implementation, technologies, and risk in proposed missions.
  - Notes that the Inflation Probe is unique in that it was recommended by the 2010 Decadal Survey. Studies for its development would directly apply to developing the probe mission category for the 2020 Decadal Survey.

Final Reports.

- Submitted to Paul on March 7, 2016.
- Not yet posted… stay tuned!

Backup Slides.

CoPAG.

COPAG Probe Mission Charge

- As part of the charge by Paul Hertz to the PAGs on the question of how to solicit input on Probe missions, the COPAG did the following:
  - Initiated a call for 2-page white papers
  - Analyzed the input received for both the science and mission capabilities called out
  - Worked with the ExoPAG and PhysPAG to compare inputs received to author a short joint statement
  - Wrote a report on the input received to submit to the APD
  - Will present the results to the March meeting of the APS
- Bottom Line: all three PAGs supported funded concept studies, but were concerned that $100k each was not enough – also concerned that if a line was established that it be openly competed and not restricted like PSD New Frontiers

Probe Mission White Papers

- In anticipation of the charge in January, the COPAG issued a call for 2-page white papers in December 2015
- We received a total of 16 white papers that covered a range of science, wavelength and instrument technology
- A summary table of the input was submitted to the APD and is available to others if needed – the range of input received was taken to demonstrate that the community had a wide range of science and technological implementations that a Probe-class mission could enable
- Some authors took the approach of providing low risk, OTS mission designs, while others used much more cutting edge technology to adopt a higher risk profile.

Range of Science

- Dark Ages – the first star and galaxy formation, reionization
- Recycling of matter between galaxies and the IGM
- Galaxy cluster formation and assembly
- Large scale structure of the ISM & stellar feedback
- Understanding gamma ray bursts
- Hard X-ray monitor of the sky
- Massive star evolution and death
- Large telescope assembly tech demo
- Census of massive star formation sites – survival rates for new stars and planets

Range of Science

- Space-based follow-up on LSST science
- Identification of asteroids and Kuiper Belt objects
- High resolution IR interferometer
- BAO study of 500 million galaxies – IR spectroscopy
- THz imaging and study of the earliest stages of molecular gas assembly
- Use of the FUV to identify ISM diagnostics, protoplanetary disks, filamentary structure
- Use of the THz band to identify and study water content and formation

Range of Capability

- Wavelength bands proposed: FUV, UV-visible, NIR, FIR, THz, Radio, X-ray
- Instrument types: spectrometers, imagers, interferometers
- Fields of view – generally large, from the smallest of 6’ up to all-sky
- Cryogenic and ambient telescope and instrument temperatures

Implementation

- Range of payload masses: 1000-5000 Kg, most did not provide this number.
- Orbit: most at Sun-Earth L2, a couple in GEO or CISlunar, most did not provide.
- Cost: $350M-$2B - most not provided - the COPAG call did not hard-cap the costs at $1B in an effort to see if allowing some overrun past the arbitrary $1B number really enabled additional compelling capabilities - those that did exceed either had multiple instruments or were low- to non-heritage.
- Basis: most were Center studies and parametric estimates, some heritage.
- New technologies: radio signal processing, large x-ray arrays, electronics, power, data storage, GaN MCPs, modularized mirror deployment, large UV-Vis focal planes, linear variable filters, slit generators, DMDs, inflatable reflectors, optical coatings.

ExoPAG.

ExoPAG Response to Probe Charge

- The ExoPAG fully supports this effort by the APD to prepare for a possible medium-class mission line in the next Decadal Survey portfolio, and specifically supports the first option suggested.
- The first option is preferred, as it will ensure that at least 10 probe-class concepts will have been given a serious first look.
- These ~10 concept studies should be sufficient to cover the wide-ranging scientific interests of the APD and of its three PAGs.
- They should specify the basic science goals, instrumentation suites, mirror sizes, rough costs and TRLs, etc., sufficient for the Decadal Survey to consider and possibly recommend further, more detailed studies.
- These concept studies will help to level the playing field for principal investigator-led studies at universities or institutions that may not have funding support from NASA centers.
- The main concern raised with the first option was whether ~ $100K per study would allow even a rudimentary CATE analysis to be performed prior to a more detailed CATE that might be requested by the Decadal Survey.

PhysPAG.

PhysPAG Probe Mission Charge

- In response to Paul's Hertz's charge, the PhysPAG collected community input as follows:
  - Solicited probe mission concepts at the July 2015 AAS HEAD meeting
  - Held a joint PAG session at the AAS in January 2016
  - Received input from Aerospace CATE process at AAS EC meeting
  - Initiated a call for 2-page white papers
  - Worked with the ExoPAG and COPAG to compare inputs received to author a short joint statement
  - Wrote a separate 2-page PhysPAG response
- Joint statement: all three PAGs support funded concept studies as an initial step, but are concerned that $100k each was not enough. Complete cost analysis must be carried out prior to the Decadal that applies to the general probe mission category.

PhysPAG Response Findings

1) Broad PCOS support for probe-class missions, competed as in the Explorer program. The ESA M-class mission category testifies to the scientific effectiveness of such a program. Several NASA missions close to this cost point have also been successful in astronomical science (e.g. Fermi, Kepler, Spitzer).

2) 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.

3) However we are concerned that the cost information presented to the Decadal review will be insufficient. The initial $100k studies will not have the financial resources required. Costing these mission concepts during the Decadal study may not be successful given the inevitable time pressure of a Decadal review.

4) We suggest APD develop a second phase of studies to define costs, and to better determine the optimal cost point. It appears that certain concepts could fit well below the $1B total. If so, this would be an important finding for Decadal survey planning as it bears on the frequency of mission opportunities. While the cost studies may be best developed on specific scientific concepts, the findings must apply generally to the probe mission class.

5) We note that the Inflation Probe is unique in that it was recommended by the 2010 Decadal Survey. Studies for its development would directly apply to developing the probe mission category for the 2020 Decadal Survey.

PCOS Probe White Papers (1/2)

Name	First Author	Type	Spectral Range	Science	Cost	Launch & ops?
High-Energy X-Ray Probe (HEX-P)	F. Harrison	X-Ray	2-200 keV	Resolve X-Ray background, evolution of black hole spin, faint X-ray populations in nearby galaxies	$500M	Included
A Wide-Field X-Ray Probe	A. Ptak	X-Ray	~1-10 keV	Measure mass and spatial distribution of clusters and AGN, define LF of AGN	$540M / $740M	Not included
An X-Ray Grating Spectroscopy Probe	M. Bautz	X-Ray	5-50 Angstrom	Role of SMBH feedback in galaxy formation, distribution of hot baryons, characteristics of Galaxy's hot halo, GW counterparts	$784M	Included
AMEGO: A Medium-Energy Gamma-Ray Surveyor	J. McEnery	Gamma-Ray	0.2 MeV - 10 GeV	Time-domain GW counterparts, improved MeV surveying, nuclear line emission	$600-$800M	Included
Advanced Particle-Astrophysics Telescope (APT)	J. Buckley	Gamma-Ray	100 MeV - 50 GeV	Definitive dark matter search, all-sky transient survey, GW counterparts	Probe-class	Not stated
A Large Observatory for X-Ray Timing Probe (LOFT-P)	C. Wilson-Hodge	X-Ray timing	2 - 30 keV	Strong gravity and BH spins, matter in neutron stars, surveying the dynamic X-Ray sky, multi-messenger studies	$770M	Included
Death of Massive Stars (DoMaS)	P. Roming	Transients	X-ray/UV/IR	Study massive stars at reionization via GRBs and SNs.	$760M	Not stated

PCOS Probe White Papers (2/2)

Name	First Author	Type	Spectral Range	Science	Cost	Launch & ops?
Transient Astrophysics Probe (TAP)	J. Camp	Transients	X-ray/IR	Epoch of reionization from high-z GRBs and SNs, survey of the X-Ray sky, GW counterparts	$750M	Included
The Time-Domain Spectroscopic Observatory (TSO)	J. Grindlay	Transients	0.4 - 5 um	Epoch of reionization from high-z GRBs studies, growth of SMBHs over cosmic time, GW counterparts, transient discoveries	$650M	Included
GreatOWL: A Space-Based Mission for Charged-Particle and Neutrino Astronomy	J. Mitchell	Cosmic Ray	-	Nature of ultra-high energy cosmic rays, GZK-induced neutrinos	$540M	Not included
The Inflation Probe	NASA IPSIG	CMB	30 - 300 GHz	Inflationary gravitational wave background, reionization, large-scale structure, neutrinos	Probe-class	Not stated
Probe-Class Mission Concepts for Studying mHz Gravitational Waves	M. Tinto	Gravitational-wave	1 mHz – 10 Hz	Spiraling massive and super-massive black holes, BH formation, tests of strong gravity,distribution of white dwarf binaries	$560M / $900M	Not stated
A Probe-Class Gravitational-Wave Observatory	S. McWilliams	Gravitational-wave	1 mHz – 10 Hz	Massive BH binary mergers, stellar-mass BH and NS mergers, probe dark energy via z-L measurements	$830M - $1.2M	Included
99 Luftballons	T. Eifler	UV/Optical	270 - 1000 nm	Nature of dark energy, neutrino masses, tests of gravity	Not stated	ULDB