

National Aeronautics and
Space Administration



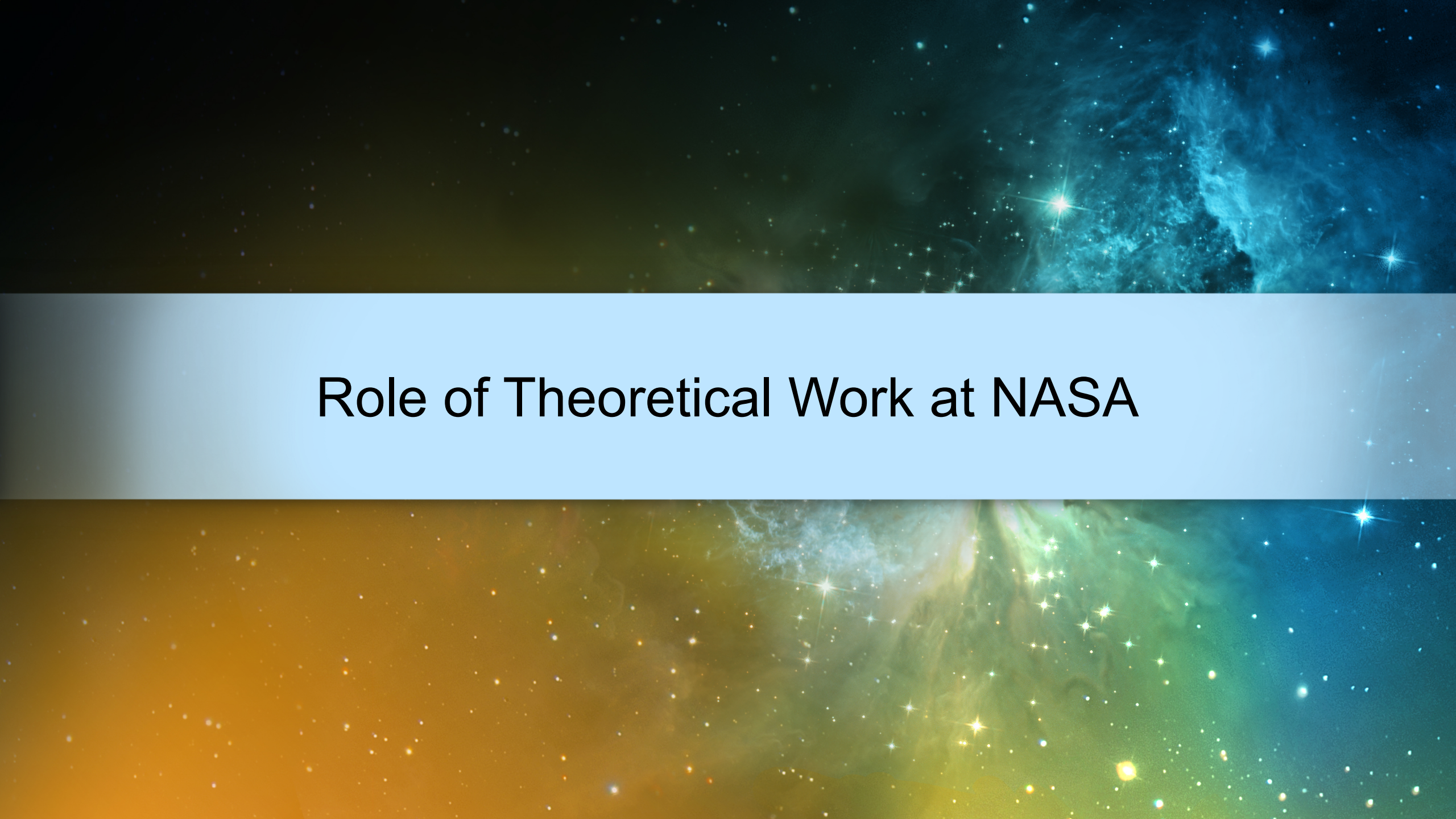
EXPLORE SCIENCE

Theoretical Astrophysics at NASA

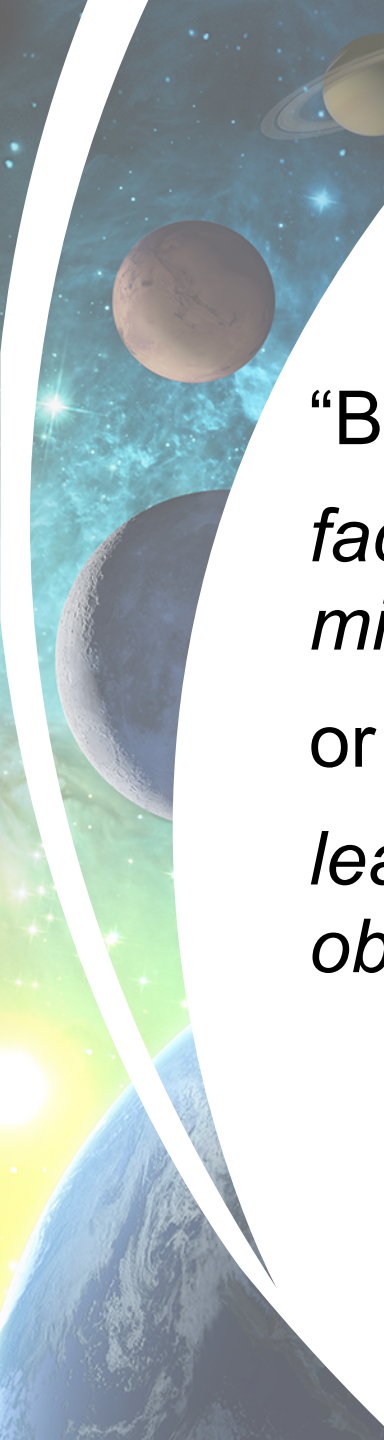
Astro2020: Panel On An Enabling Foundation for Research
National Academies Keck Center, Washington DC
February 3, 2020

Evan Scannapieco, Paul Hertz

Astrophysics Division
Science Mission Directorate

The background of the slide is a composite image of space. The top half features a dark blue and black sky with a bright, glowing blue nebula on the right side. The bottom half is a gradient of orange and yellow, also filled with numerous stars and some faint greenish nebulae. A horizontal light blue band runs across the middle, containing the title text.

Role of Theoretical Work at NASA

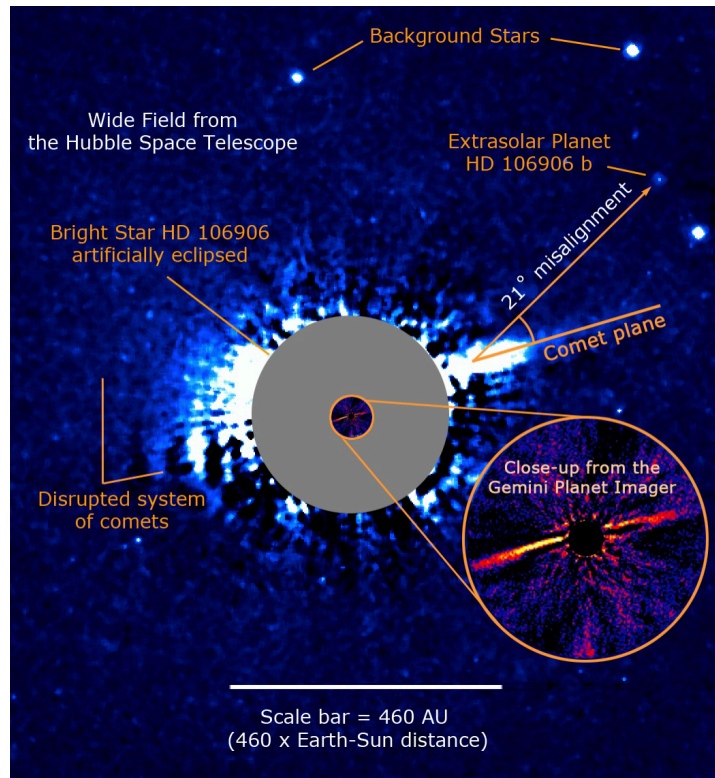


What do you see as the role of theoretical work in your agency's portfolio?

“Be directly relevant to space astrophysics goals by:
facilitating the interpretation of data from space astrophysics missions
or by
leading to predictions that can be tested with space astrophysics observations.”

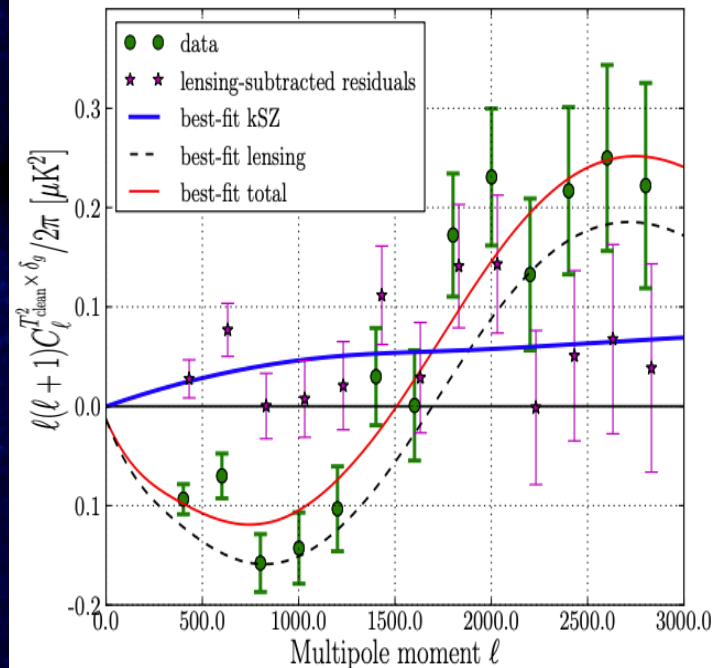
What do you see as the role of theoretical work in your agency's portfolio?

Hubble



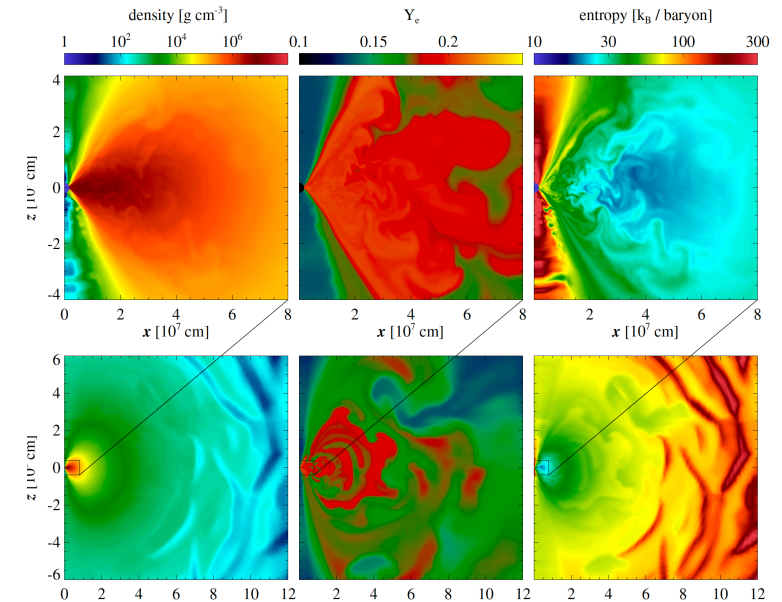
ATP19-0107 - Debris Disk Morphology due to Stellar Encounters
PI: Gongjie Li

WISE + Planck



ATP11-34: Cosmic Microwave Background as a Probe of the Low Redshift Universe
PI: David Spergel

Swift



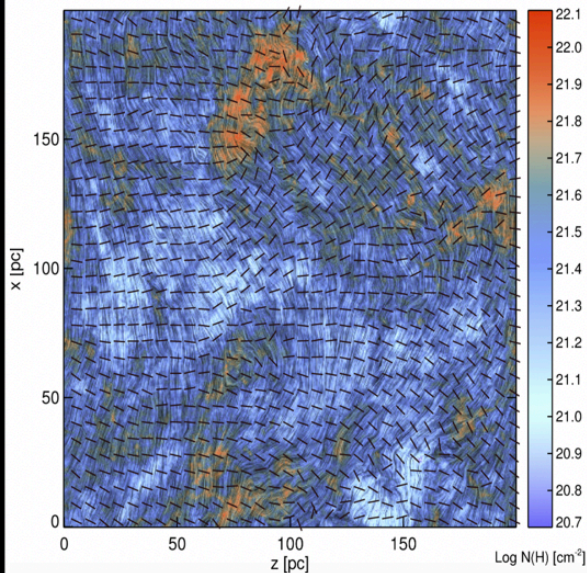
ATP14-79: Accretion Disk Outflows from Compact Object Mergers
PI: Brian Metzger

Extragalactic GRBs predicted by NAGW 626 (1984)
PIs: Edward Turner / Bohdan Paczyński

Theoretical and Computational Astrophysics Networks (TCAN)

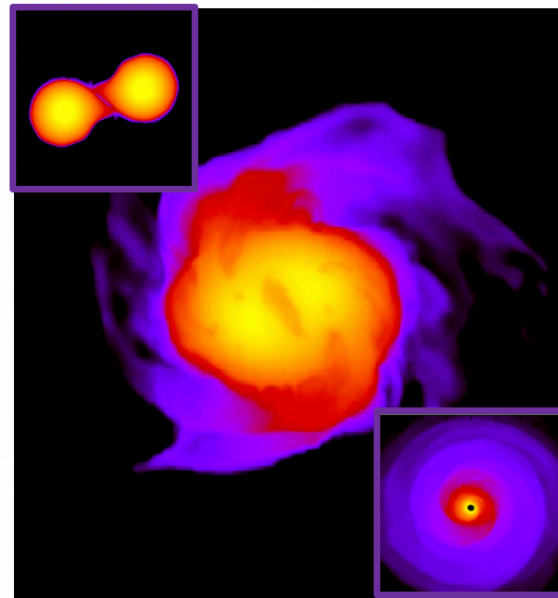
Astro2010: *“To enable the large-scale theoretical investigations identified as science priorities by this survey, the committee proposes a new competed program to support coordinated theoretical and computational research—particularly that of fundamental relevance to upcoming space observatories.”*

Modeling Polarized Galactic Background for Cosmic Microwave Background Missions



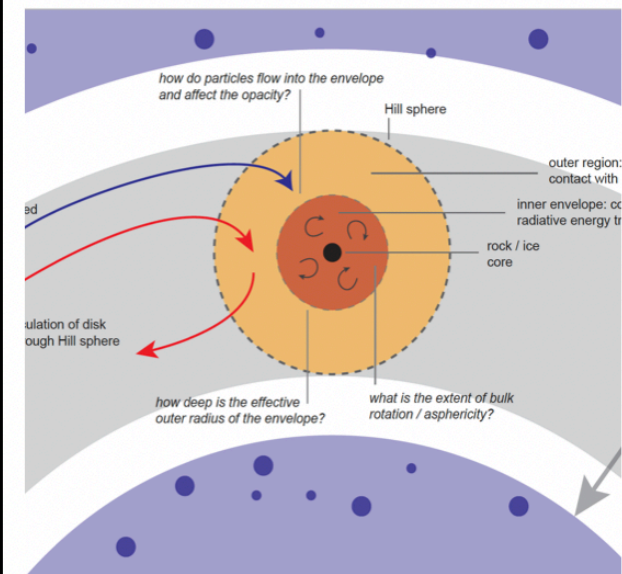
UCB, Princeton, UCSD, Wisc.

Advancing Computational Methods of the Dynamics of Ejection, Accretion, Winds & Jets in Neutron Star Mergers



U Colorado, U. Arizona, UNLV

Origin of the Giant Planet Dichotomy: Multi-Scale Modeling of Planetary Envelope Accretion

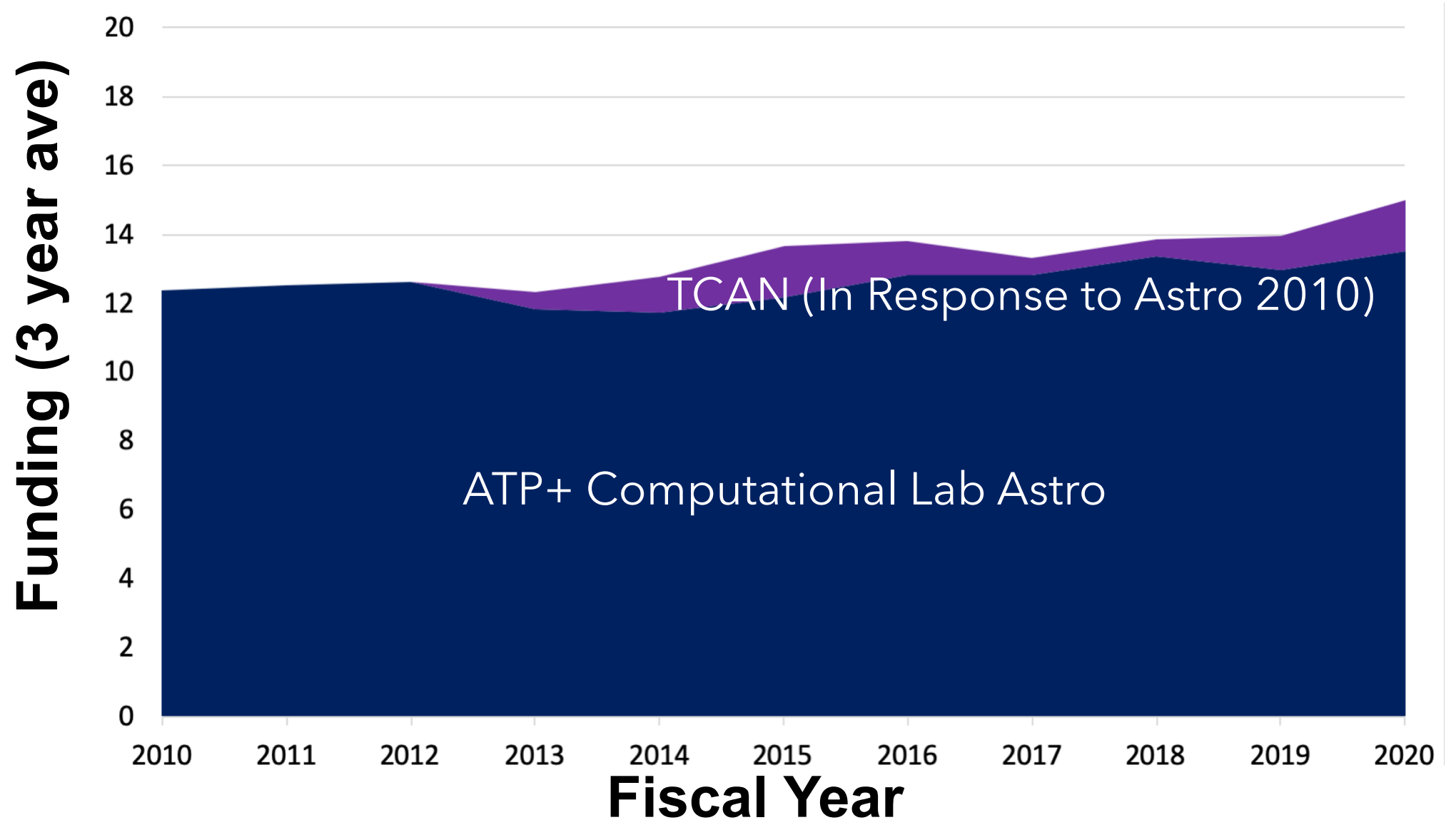


RIT, GSFC, John Hopkins, West Va.

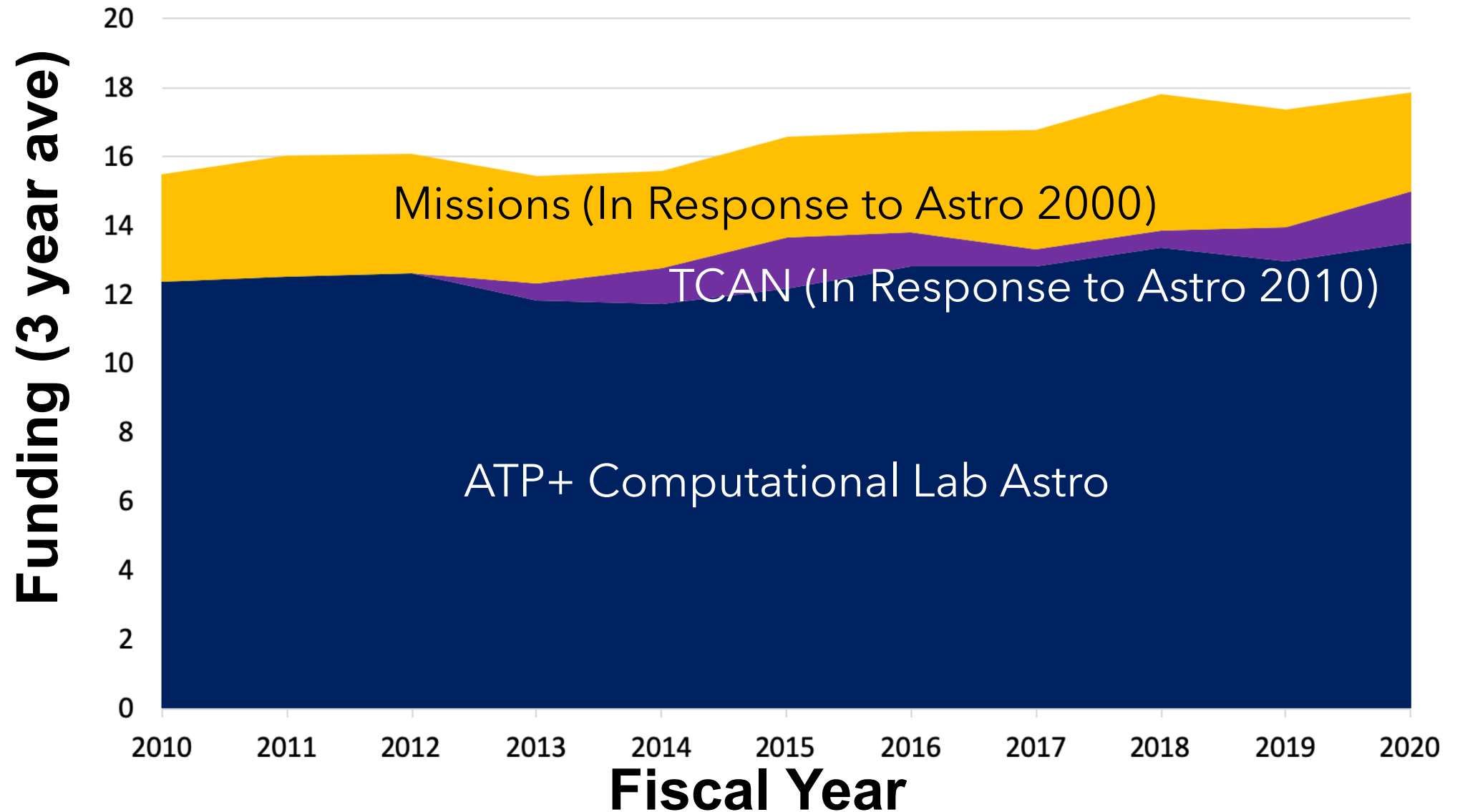
The background of the slide is a cosmic image featuring a dark space filled with stars and nebulae. The top half shows a blue and teal nebula against a dark background. The bottom half shows a bright orange and yellow nebula. A horizontal light blue band runs across the middle, containing the title text.

Support of Theoretical Work Over the Past Decade

How has support of theoretical work changed over the past decade?

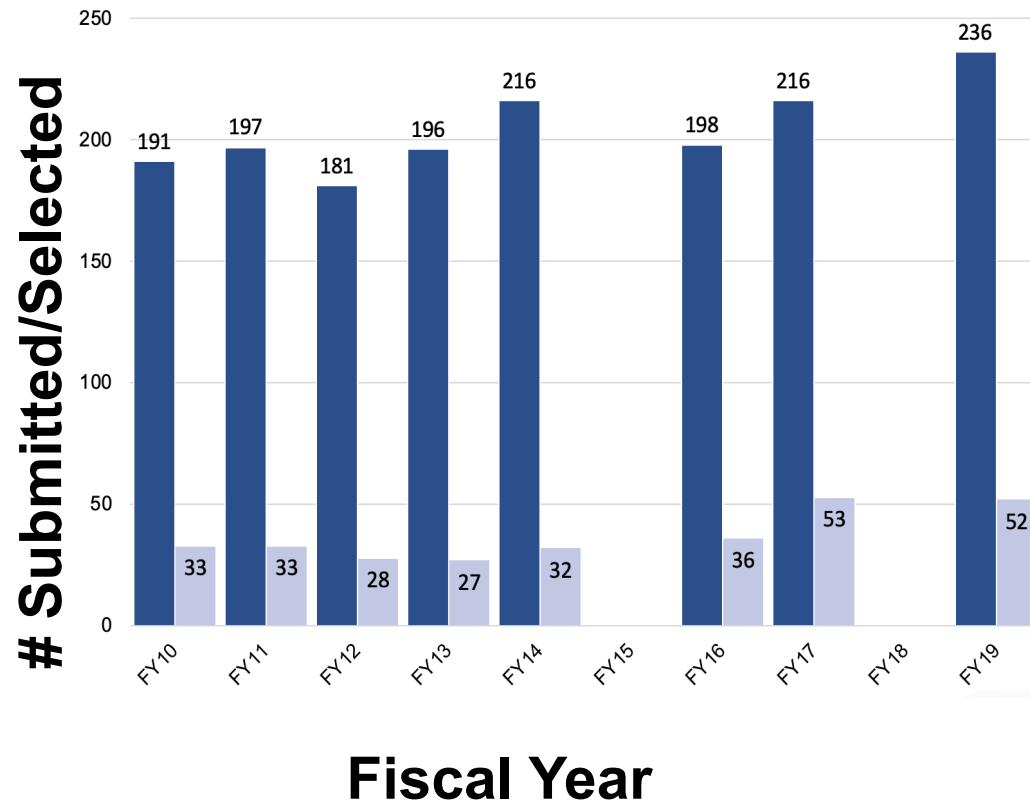


How has support of theoretical work changed over the past decade?

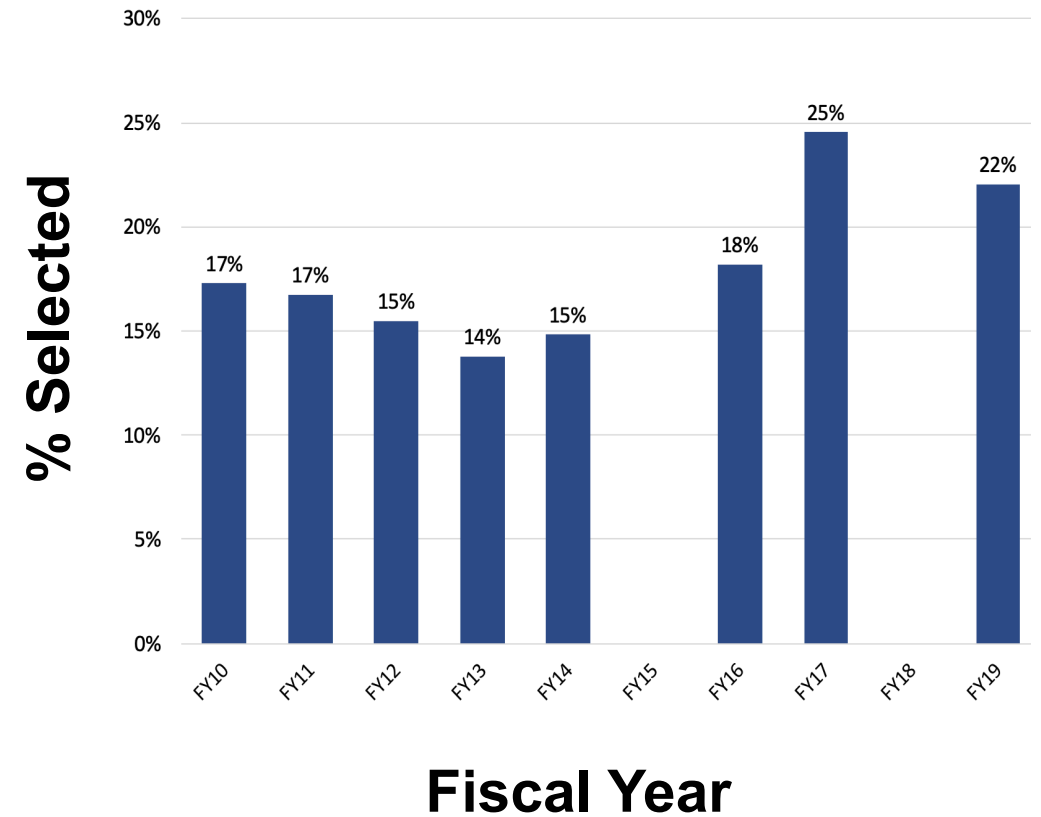


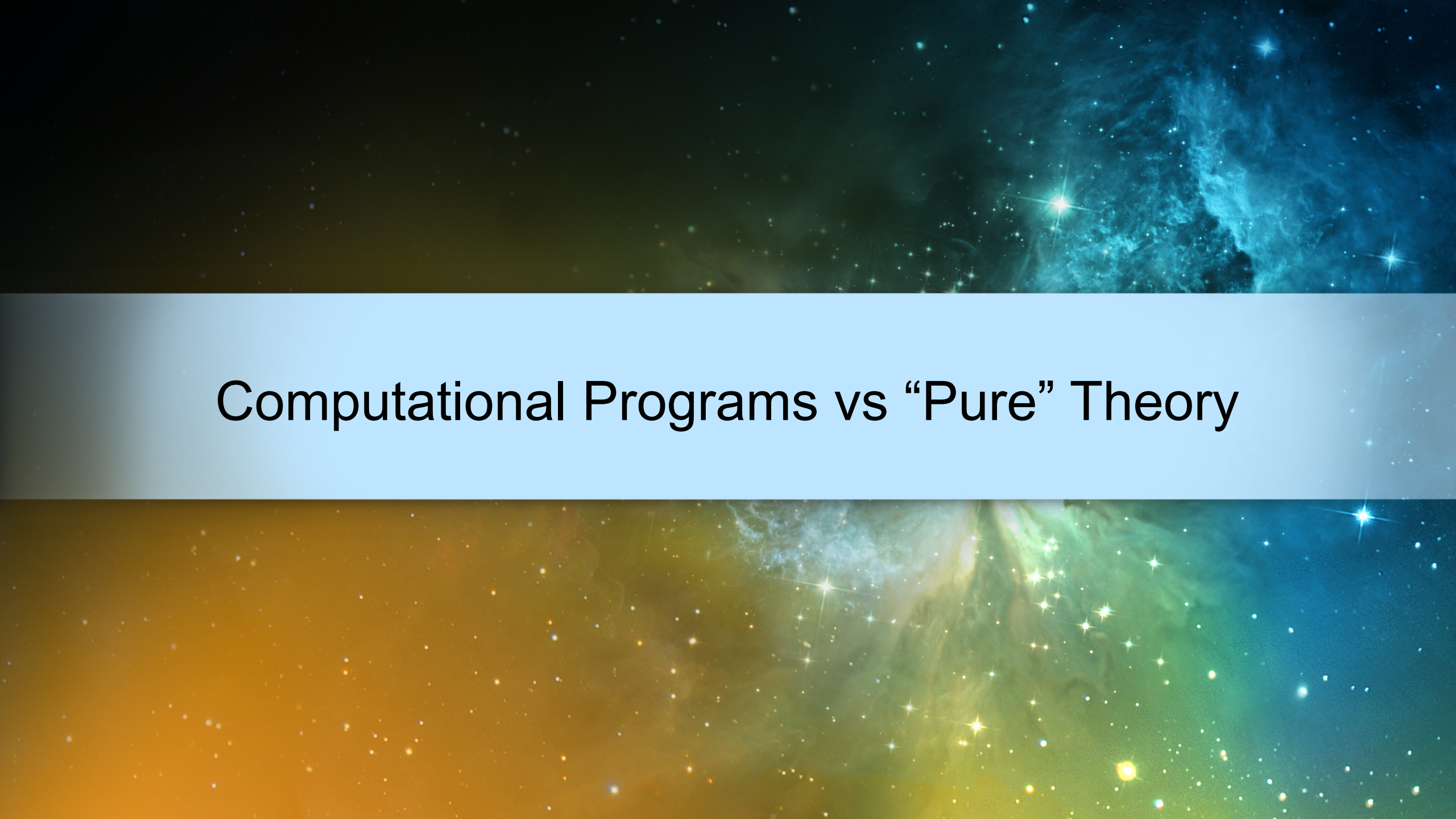
How has support of theoretical work changed over the past decade?

ATP Proposals Submitted/Selected



% ATP Proposals Selected

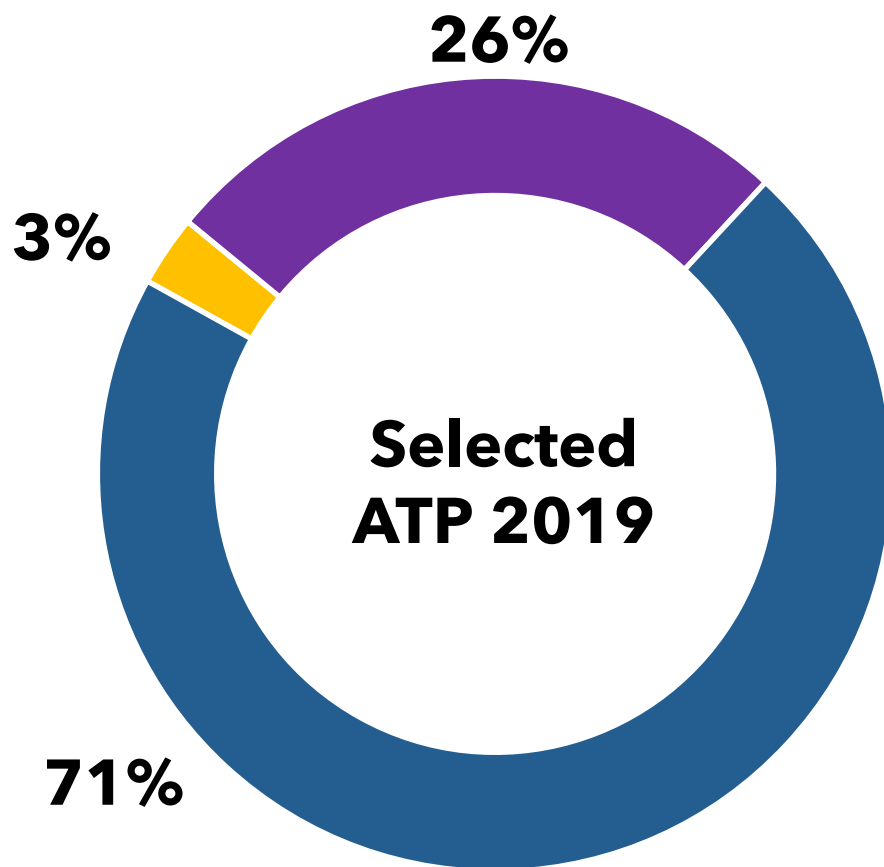
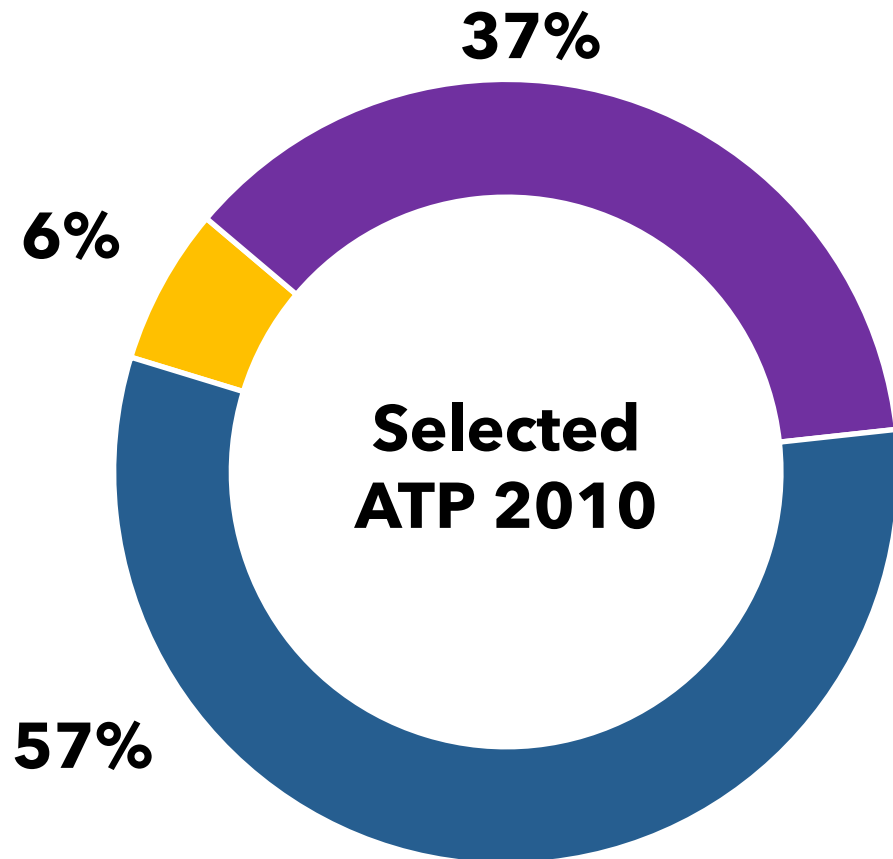
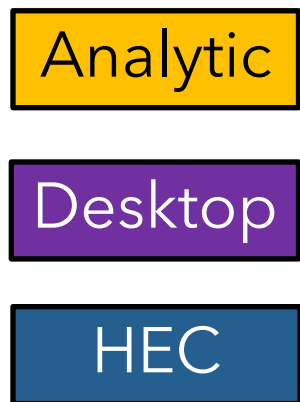


The background of the slide is a composite image of cosmic phenomena. The top half features a dark blue and black space with a prominent blue nebula on the right and several bright stars. The bottom half is a gradient of orange and yellow, also filled with stars and some greenish nebulae. A light blue horizontal band across the middle contains the title text.

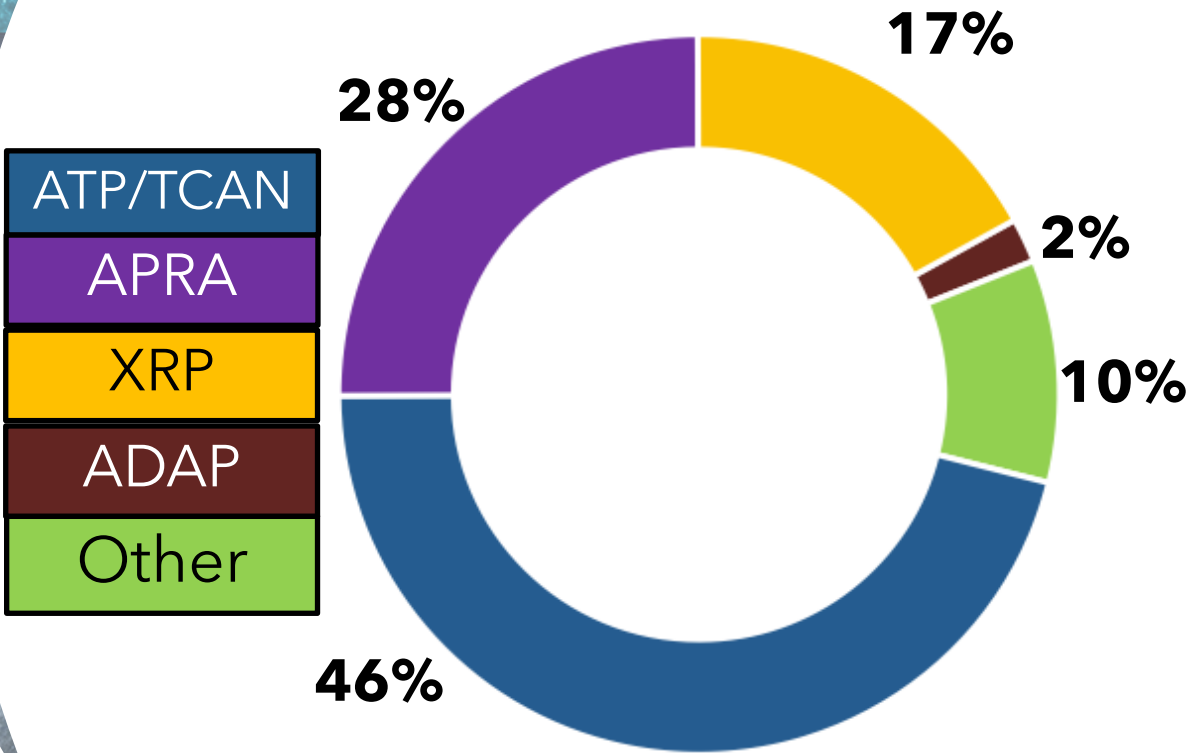
Computational Programs vs “Pure” Theory

What is the balance between large computational programs and smaller “pure” theory projects?

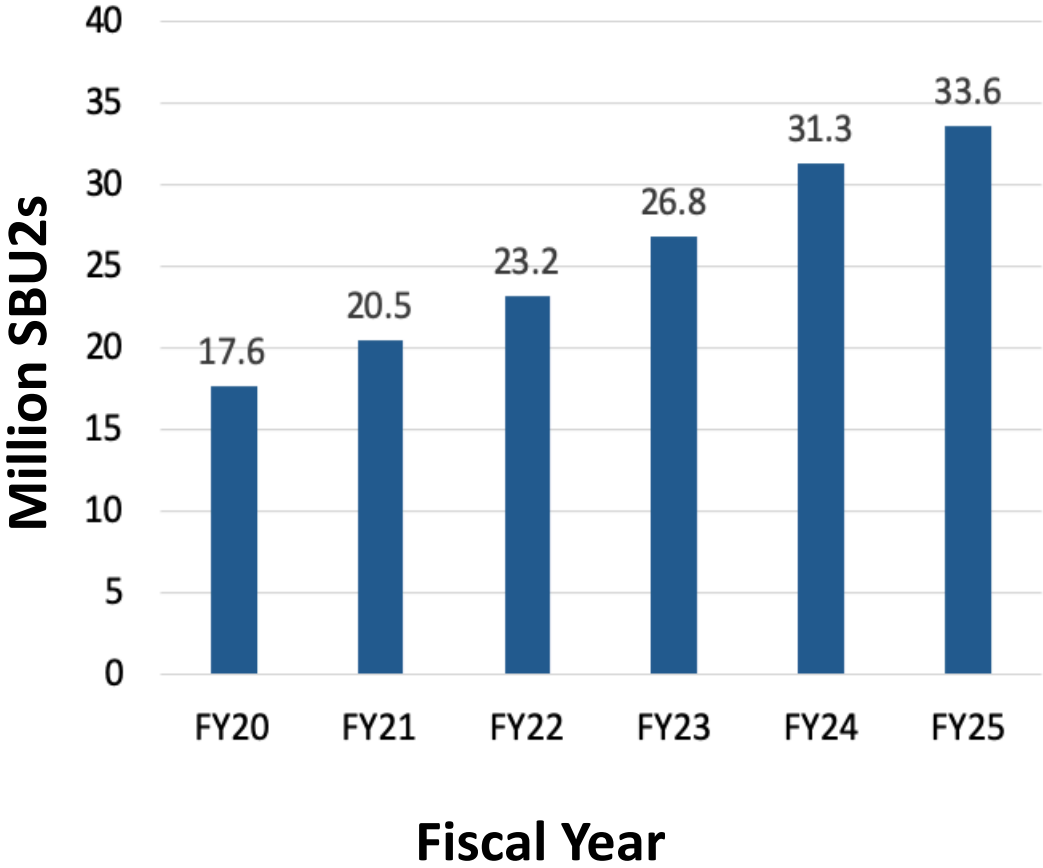
We don't set this mix. It is driven by the PIs and the reviews panels.
It is responsive to the community.



Computational Capabilities



Astrophysics Allocations



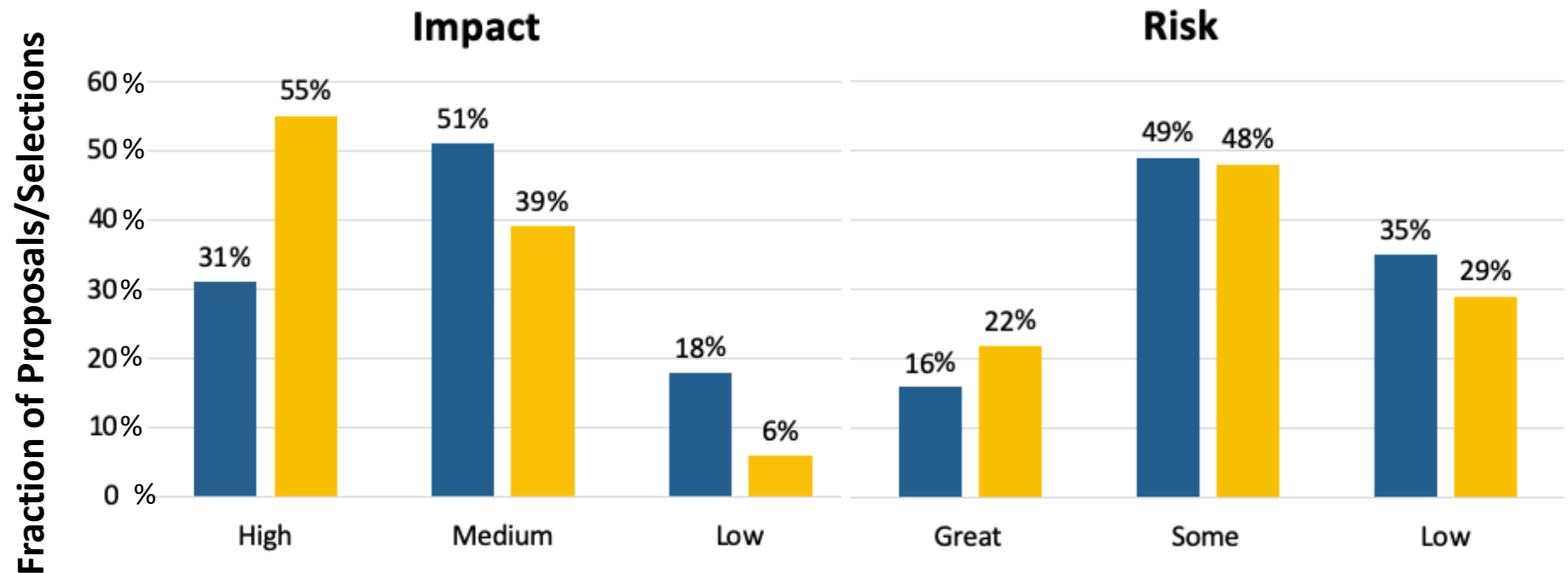
The background of the slide is a composite image of space. The top half features a dark blue and black nebula with bright, star-like points of light. The bottom half is a gradient of orange and yellow, also filled with numerous small, bright stars. A horizontal white band runs across the middle of the image, serving as a background for the title.

High-Risk Programs

What are the challenges in supporting innovative high-risk theory programs?

Perception is that panels are risk averse

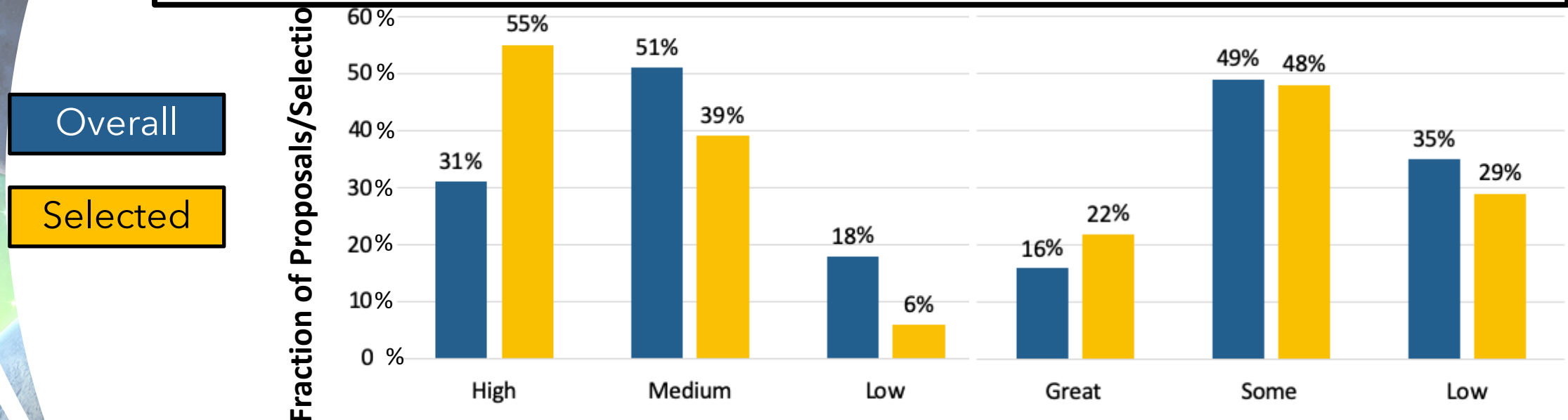
NASA undertook a survey of all proposals peer reviewed for ROSES-2017.



Selection of “risky proposals” as classified by reviewers matches the expectation given their impact distribution.

What are the challenges in supporting innovative high-risk theory programs?

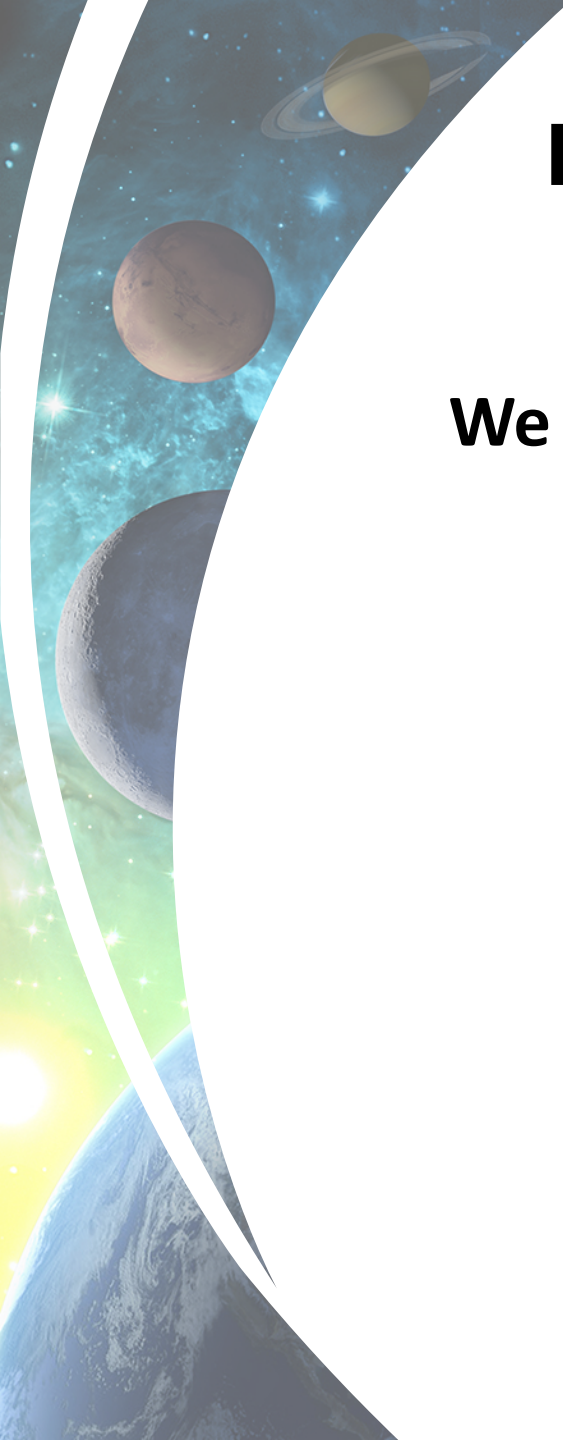
To reinforce SMD's interest in High-Risk/High-Impact Research a special review process will be implemented in ROSES 2020 to select HR/HI proposals not selected through the normal process.



Selection of “risky proposals” as classified by reviewers matches the expectation given their impact distribution.

The background of the slide is a composite image of space. The top half features a dark blue and black nebula with bright, star-like points of light. The bottom half is a gradient of orange and yellow, also filled with numerous small, bright stars. A horizontal white band runs across the middle, containing the title text.

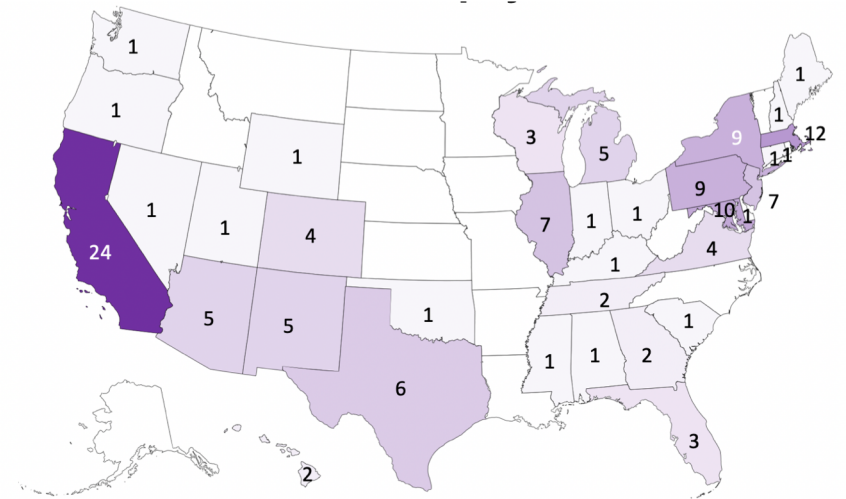
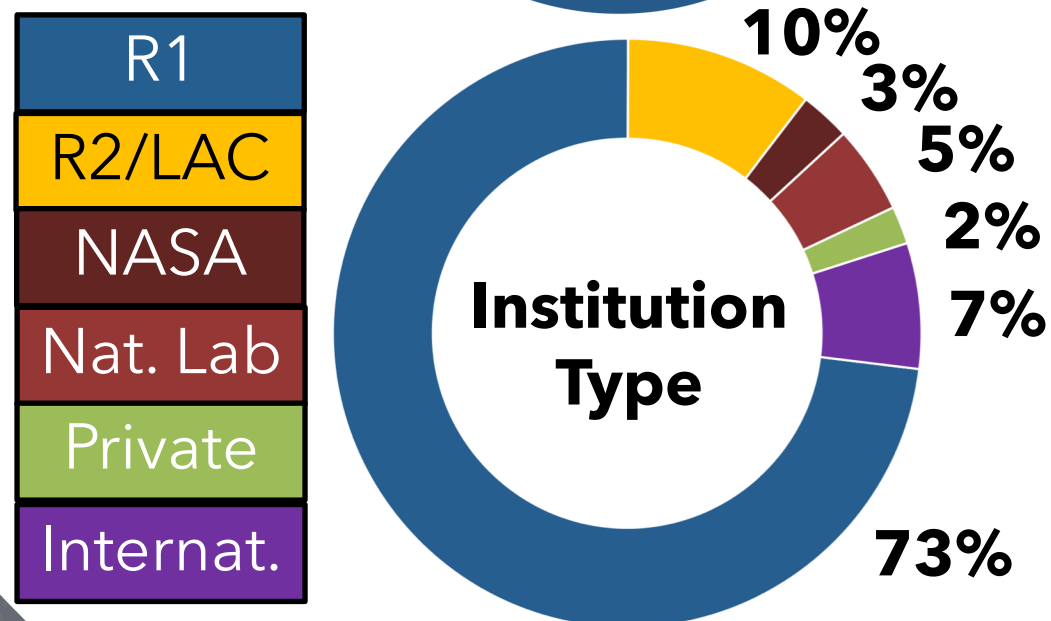
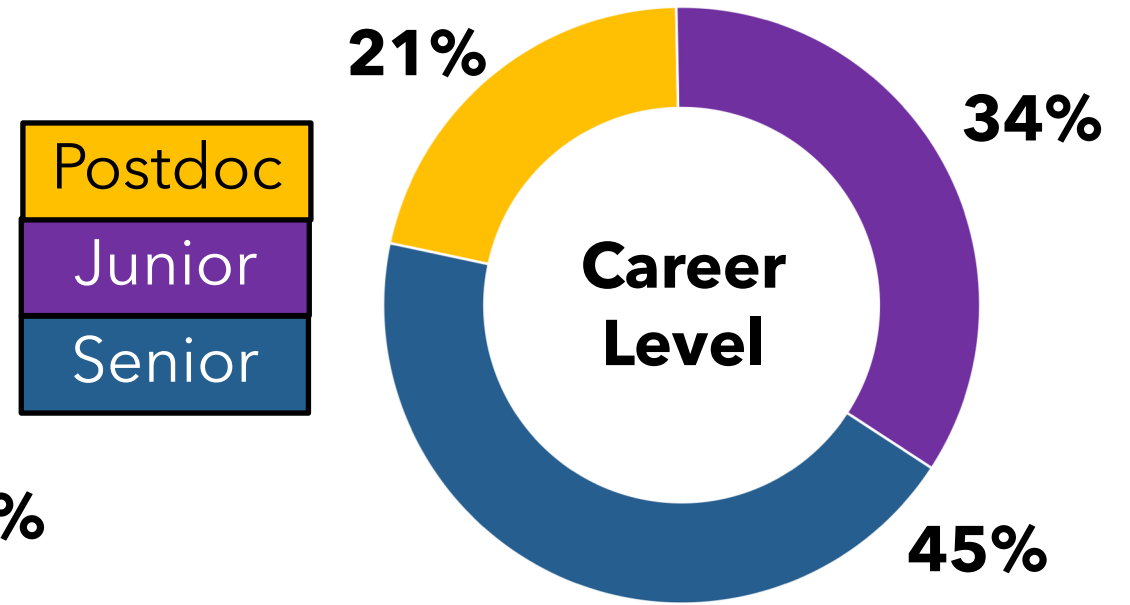
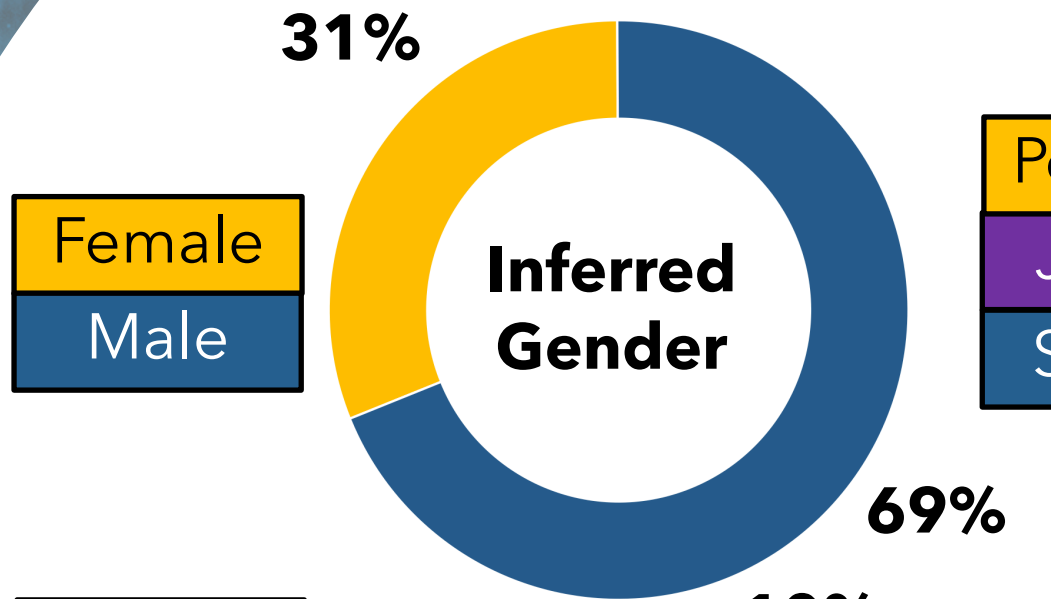
Supporting a Diverse Workforce in Theoretical Astrophysics

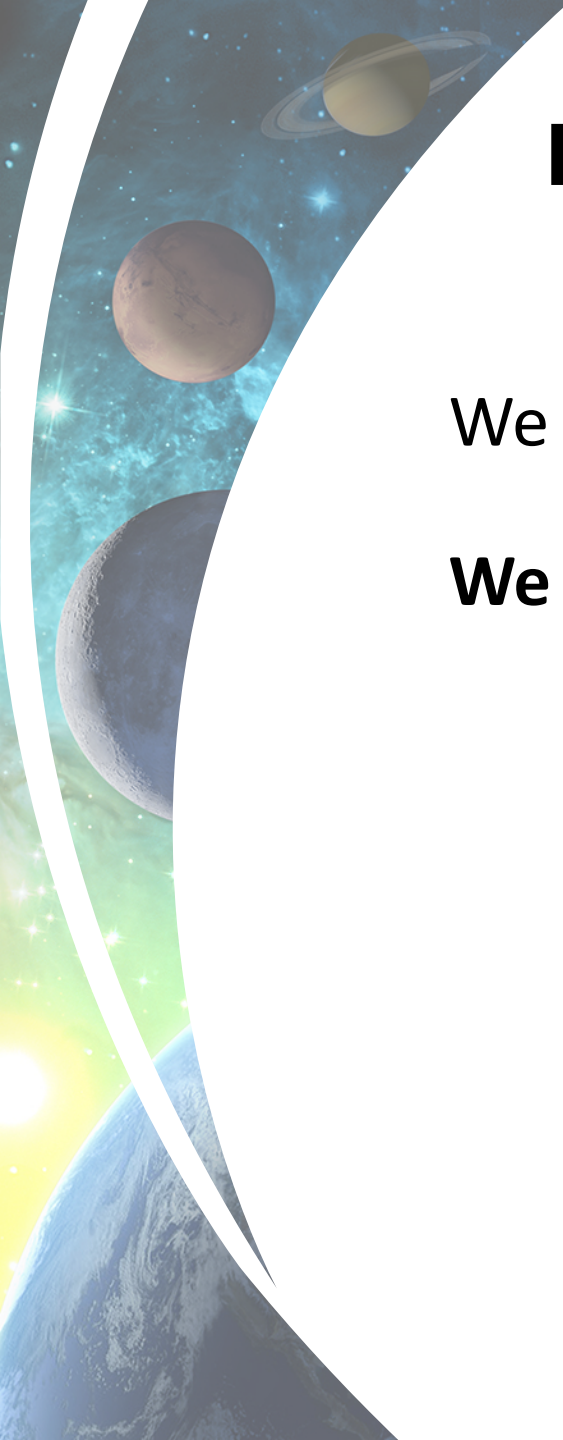


How do we support a diverse workforce in theoretical astrophysics?

We create panels that look like the astrophysics community.

Snapshot: ATP19 Panelists





How do we support a diverse workforce in theoretical astrophysics?

We create panels that look like the astrophysics community.

We address cognitive bias and methods for its mitigation.

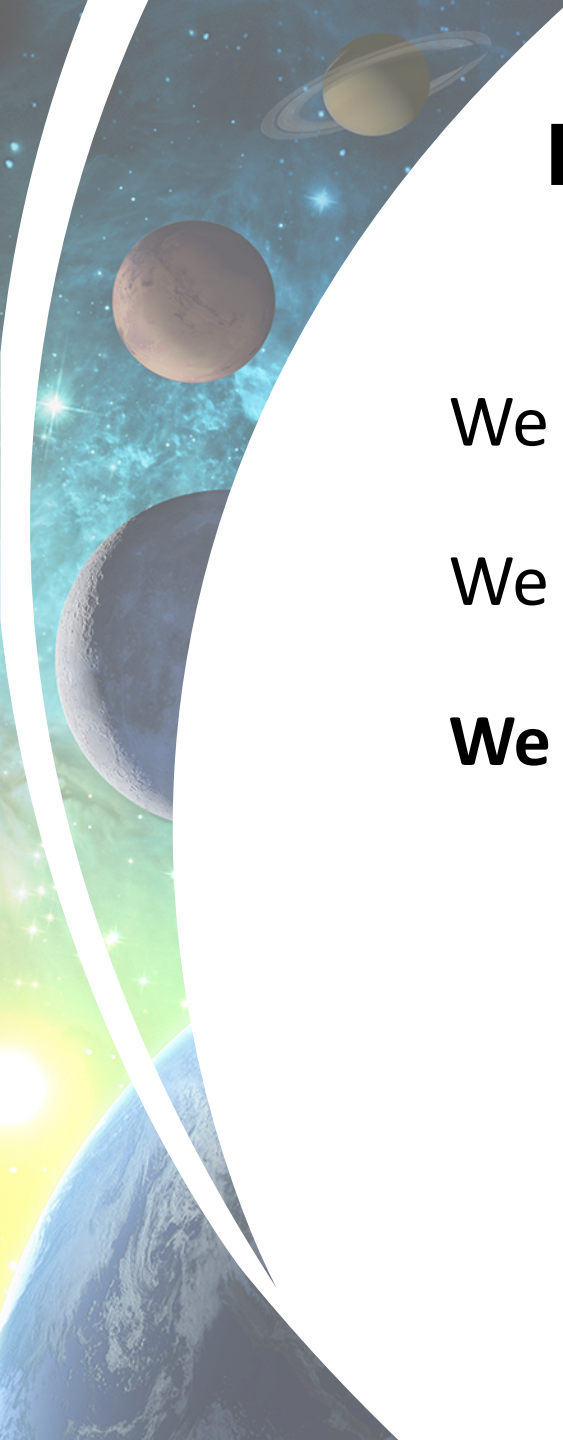
Cognitive Bias



Present the reasoning behind your statements.

Keep the discussion focused on the proposal.

Focus on expertise as needed for project, not vague “experience” or “qualifications”

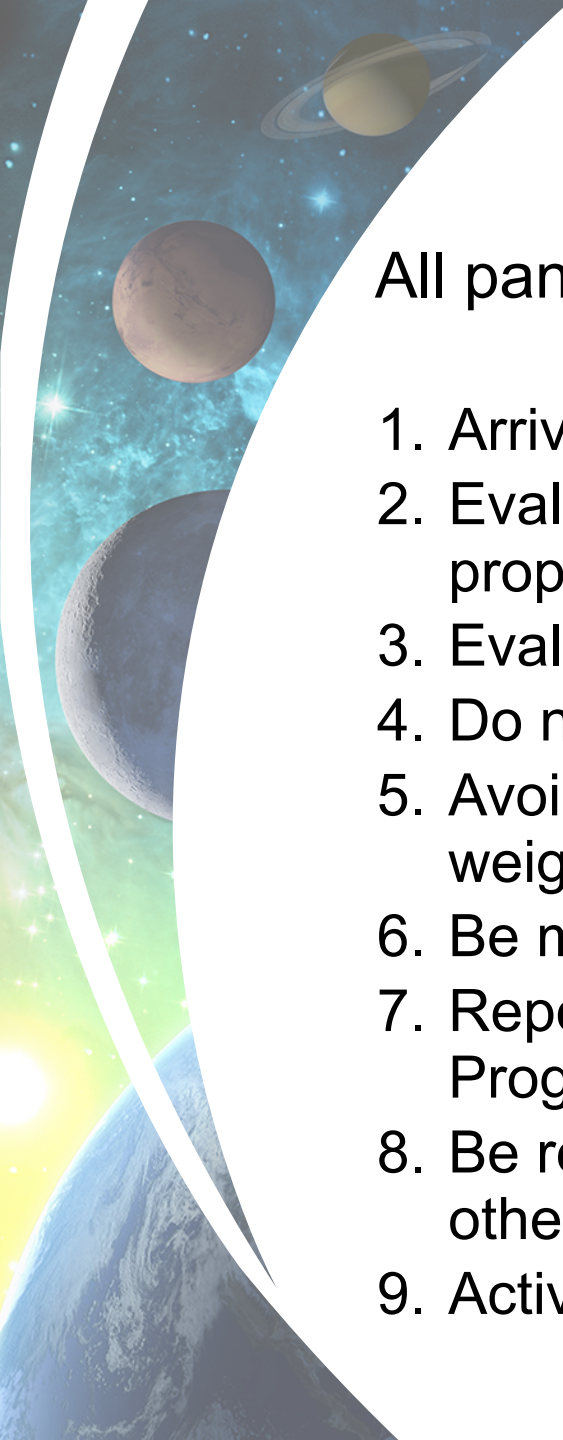


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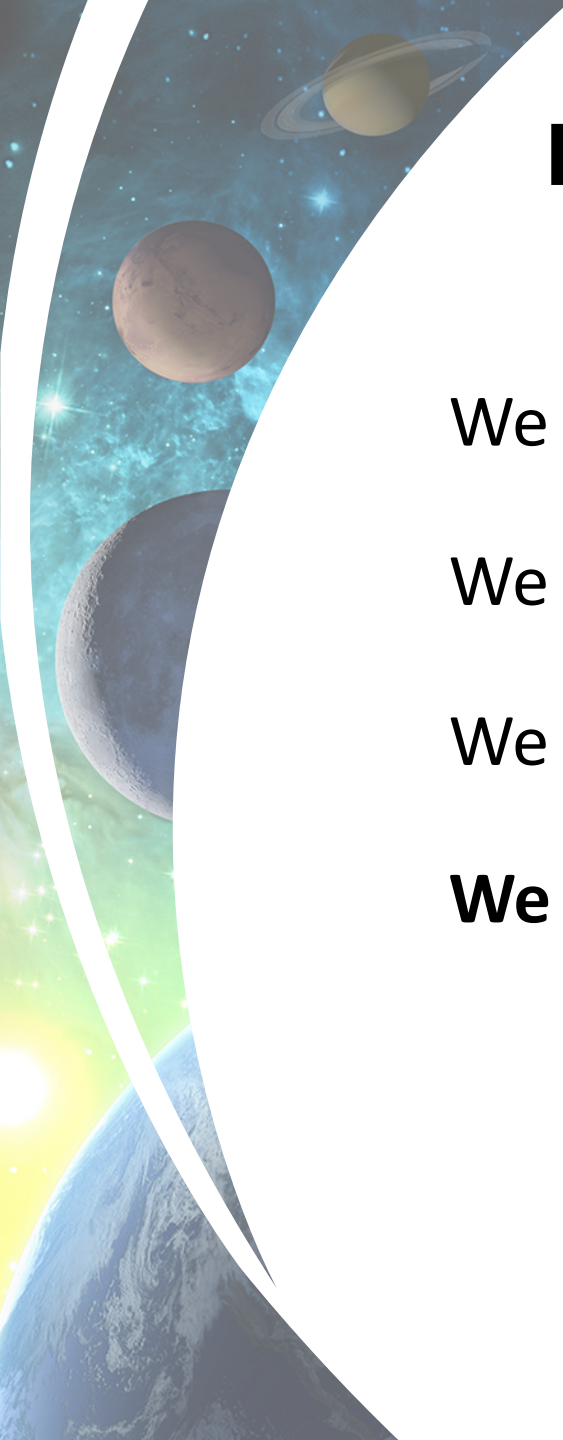
We adopt an explicit code of conduct for all reviews.



Panelist Code of Conduct

All panelists observe the following code of conduct:

1. Arrive at the review prepared and actively participate in panel activities;
2. Evaluate the merit of the proposed investigations and the qualifications of the proposing team, not the members of the proposing team as individuals;
3. Evaluate expertise and not “experience”;
4. Do not interrupt or talk over others;
5. Avoid “monopolizing” this discussion; make sure everyone an opportunity to weigh in on discussions;
6. Be mindful of bias in all contexts;
7. Report abusive or bullying behavior to a cognizant HQ Scientist and/or the ATP Program Officer immediately;
8. Be respectful of your colleagues regardless of differences (professional or otherwise);
9. Actively help promote an environment free of harassment.



How do we support a diverse workforce in theoretical astrophysics?

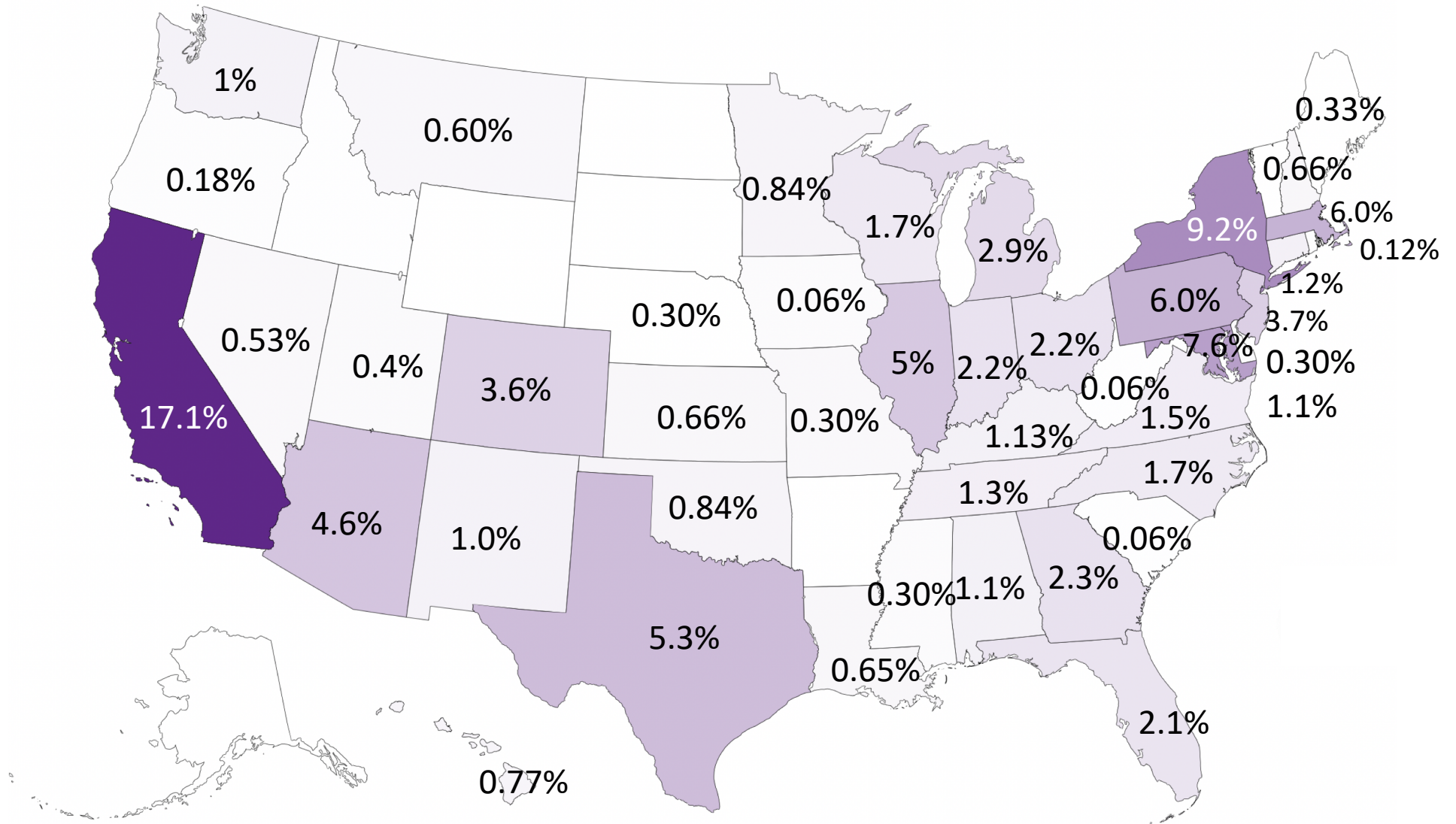
We create panels that look like the astrophysics community.

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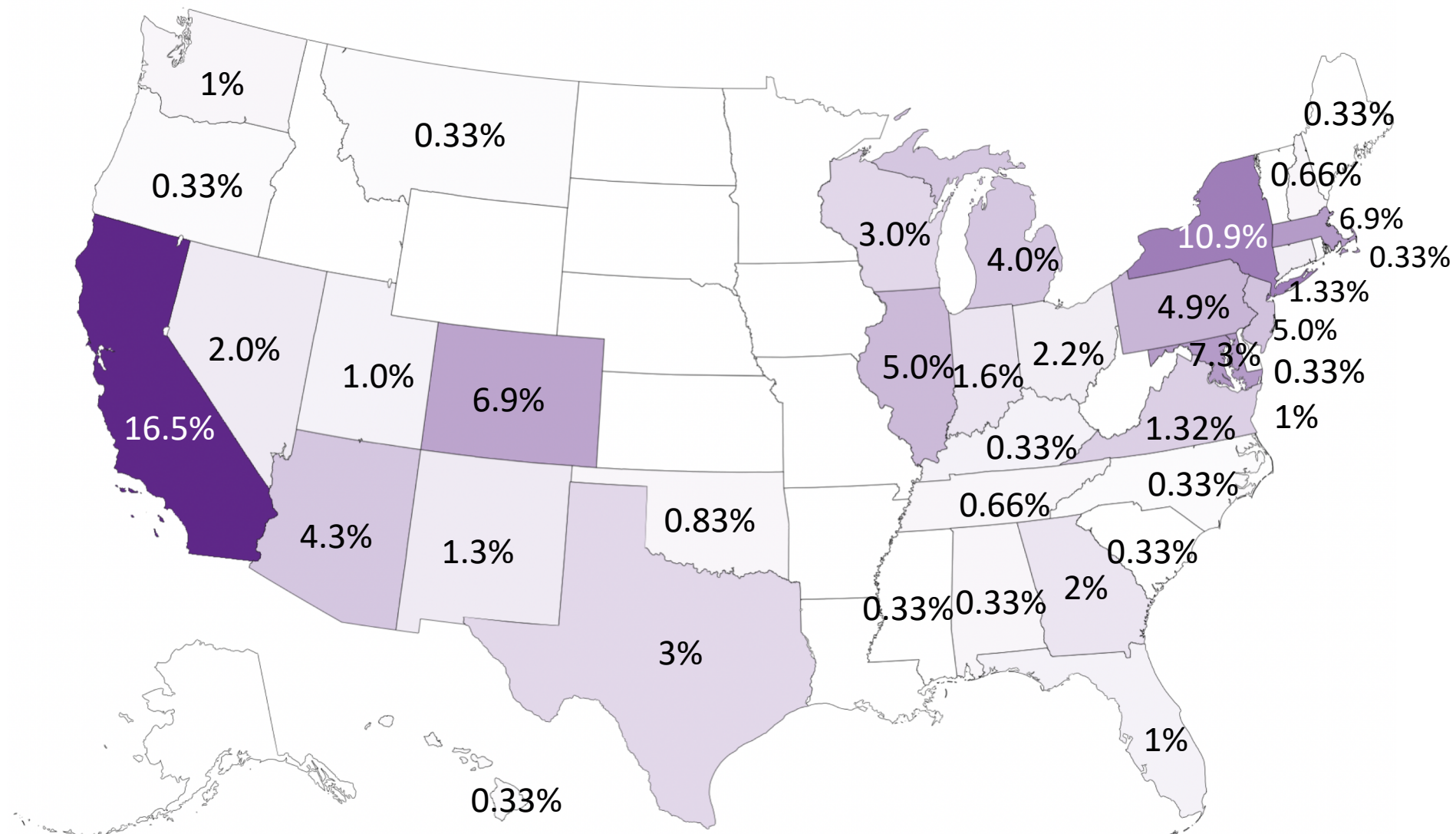
We adopt an explicit code of conduct for all reviews.

We monitor how we are doing.

ATP+TCAN Proposals in Last Decade

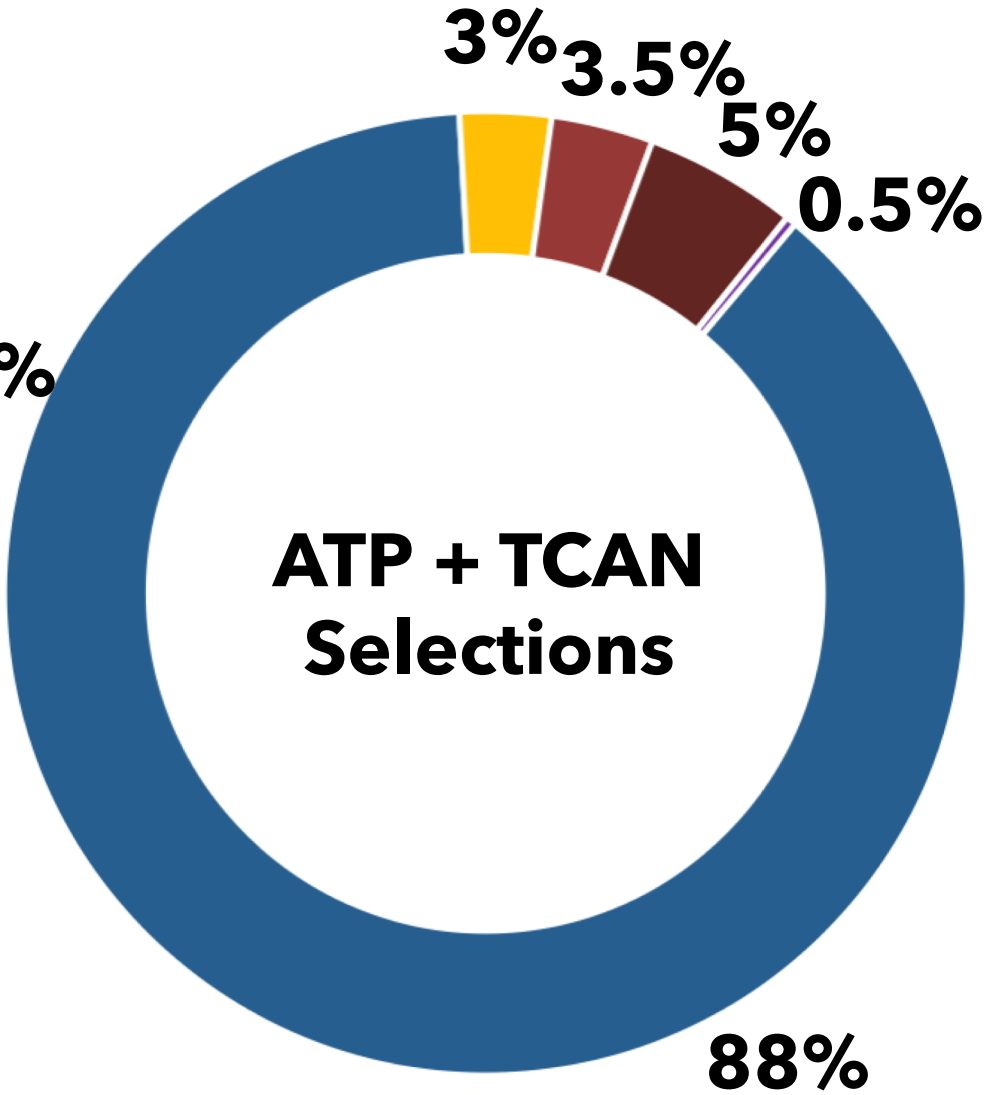
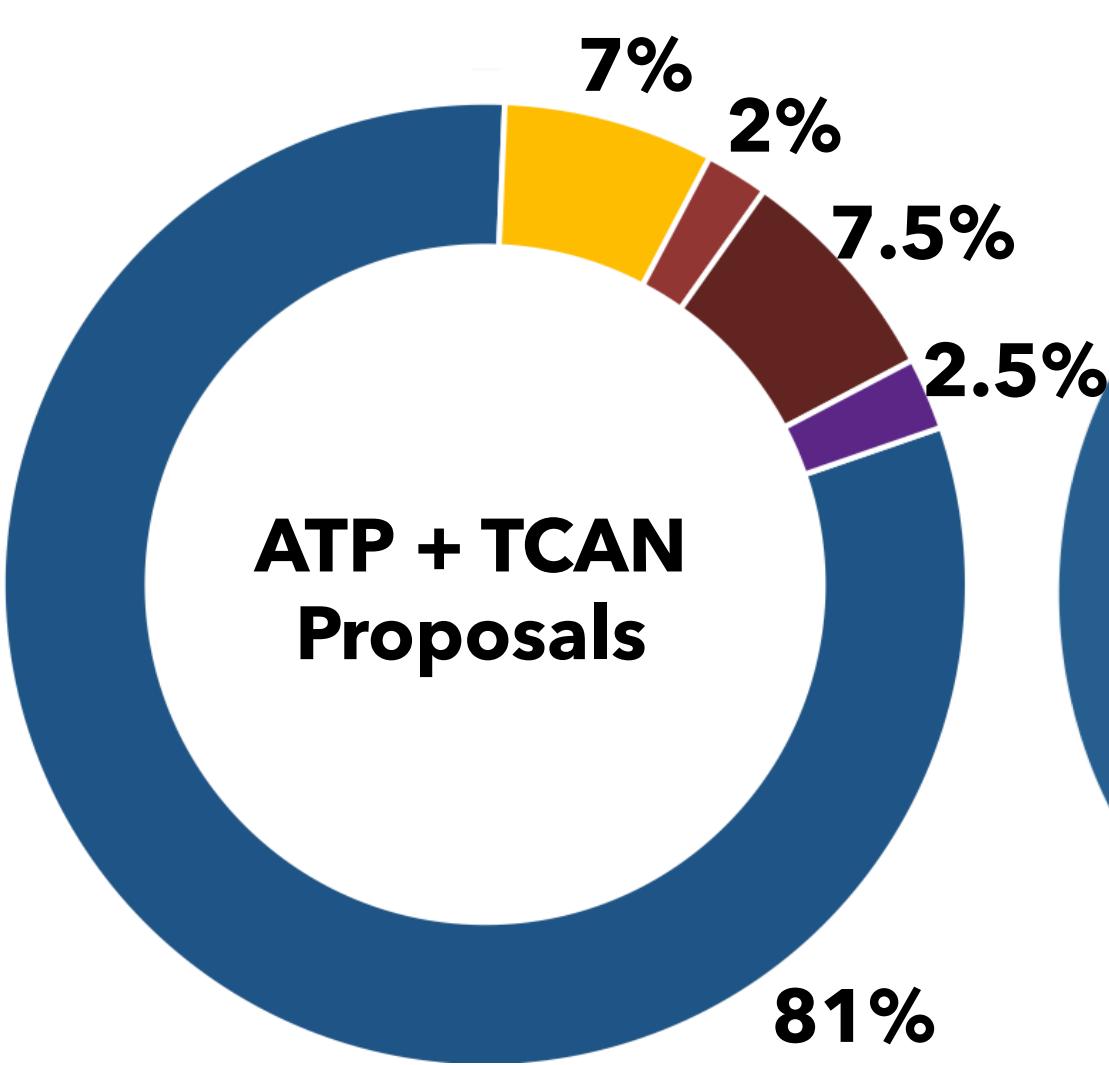


ATP+TCAN Selections in Last Decade



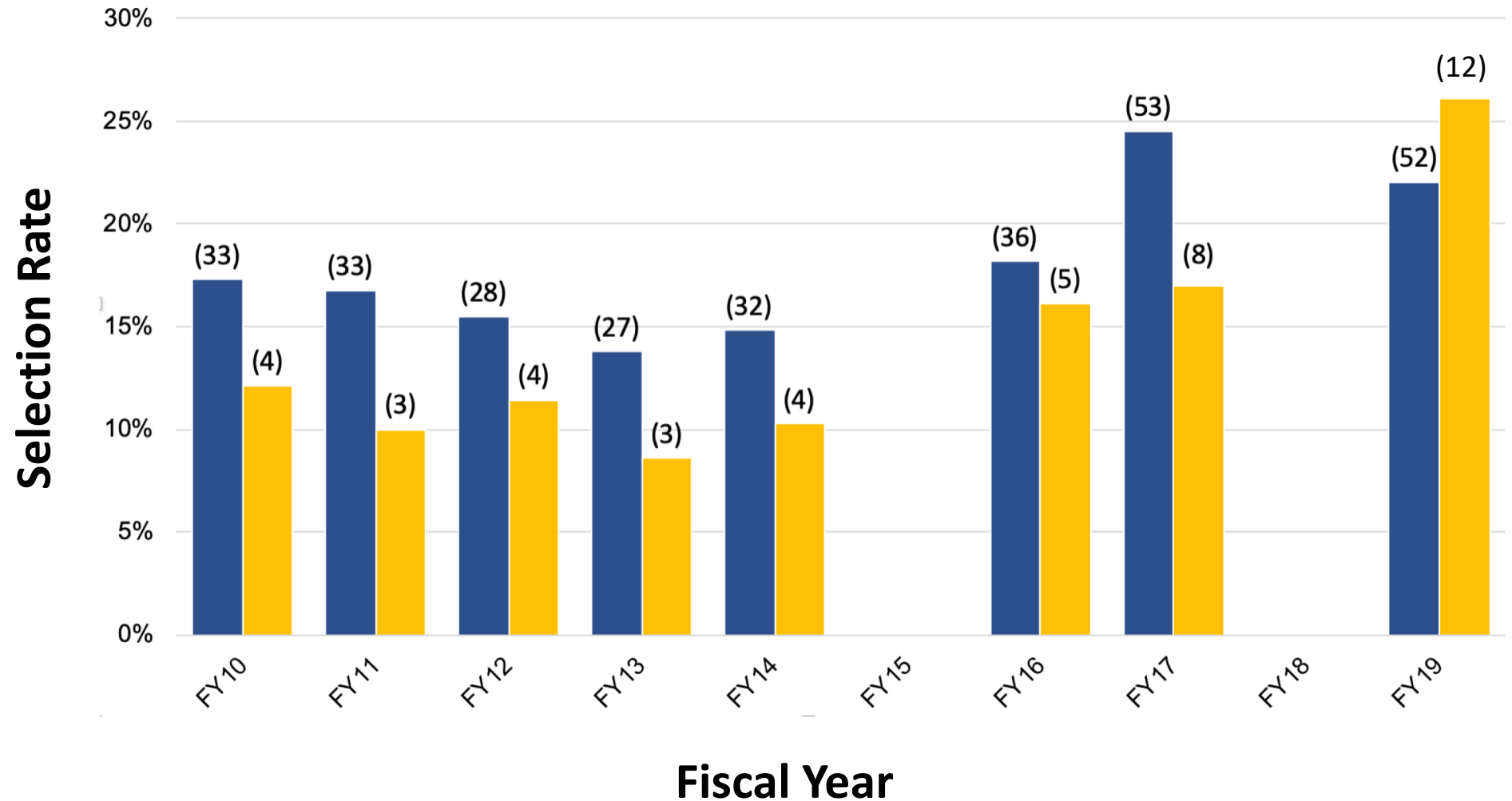
ATP+TCAN Proposals ATP+TCAN Selections

R1
R2/LAC
Nat. Lab
NASA
Private



How do we support a diverse workforce in theoretical astrophysics?

% (number) of Selected proposals by Inferred Gender



Overall

Female PIs

Questions?

NASA



EXPLORE
with us

The background of the slide is a cosmic scene. The top half features a dark blue and black space filled with numerous small, bright stars. A prominent, wispy blue nebula is visible in the upper right corner. The bottom half of the image transitions into a vibrant orange and yellow nebula, with a greenish-blue nebula appearing on the right side. The word "Backup" is centered in a white, sans-serif font across the middle of the image.

Backup

- Formulation
- Implementation
- Primary Ops
- Extended Ops

+ SMEX/MO (2025),
MIDEX/MO (2028), etc.

WFIRST
Mid 2020s

Euclid (ESA)
2022

SXG (RSA)
7/13/2019

Webb
2021

Ariel (ESA)
2028

Chandra
7/23/1999

XMM-Newton (ESA)
12/10/1999

TESS
4/18/2018

NuSTAR
6/13/2012

Fermi
6/11/2008

IXPE
2021

Swift
11/20/2004

XRISM (JAXA)
2022

SPHEREx
2023

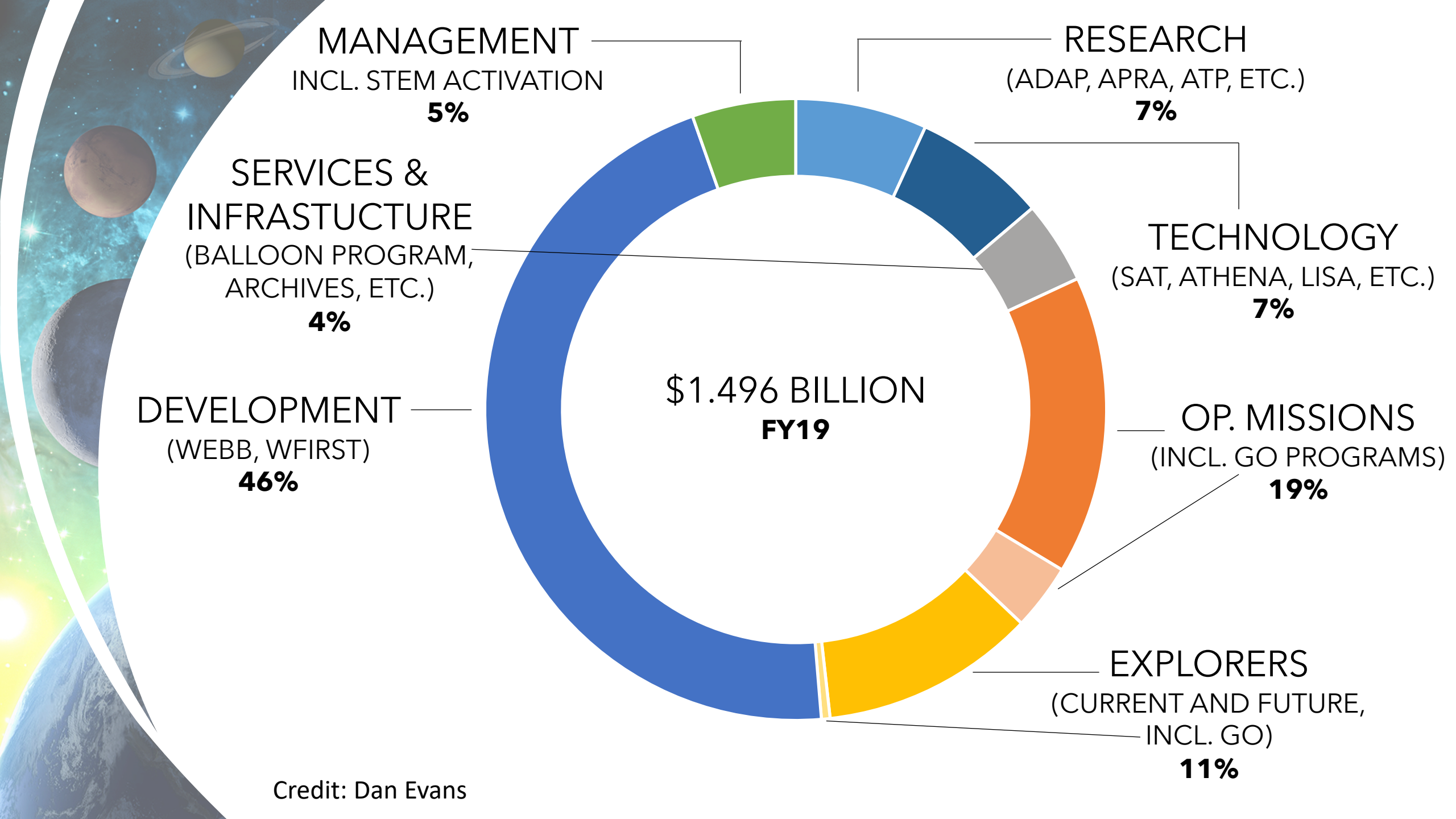
Hubble
4/24/1990

ISS-NICER
6/3/2017

GUSTO
2021

SOFIA
Full Ops 5/2014

+ Athena (early 2030s),
LISA (early 2030s)



\$1.496 BILLION
FY19



Q. How much theory is supported in programs more directly associated with missions in addition to ATP and TCAN?

\$15M

ATP+TCAN
(AVERAGE OF
FY18 AND FY19)

\$750k

**CHANDRA
THEORY**
(APPROX. PER
YEAR)

\$500k

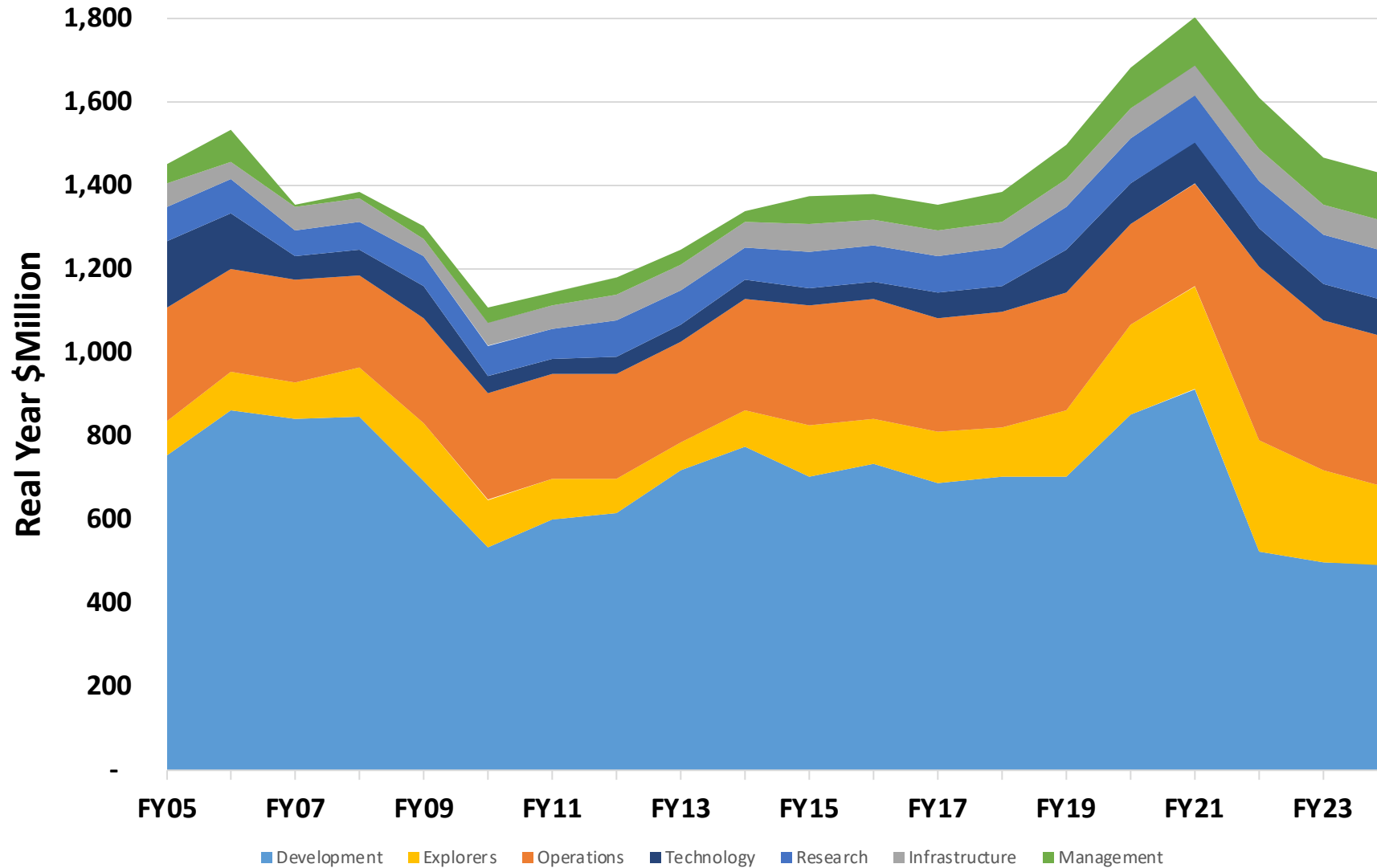
**FERMI
THEORY**
(APPROX. PER
YEAR)

\$1M

**HUBBLE
THEORY**
(APPROX. PER
YEAR)

Astrophysics Budget by Function

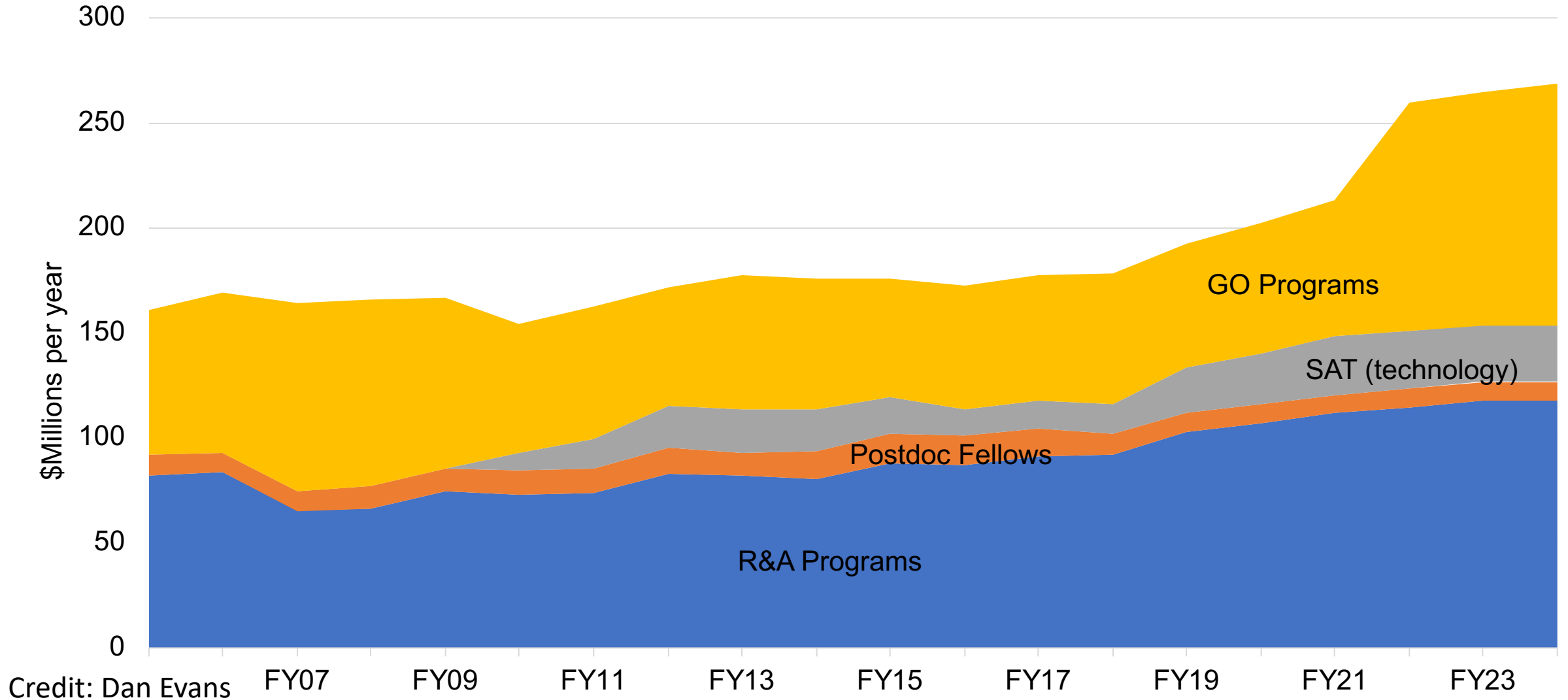
FY05-FY18 Actual, FY19 Op Plan, FY20-FY24 Request
+ WFIRST FY20-FY24



Credit: Dan Evans

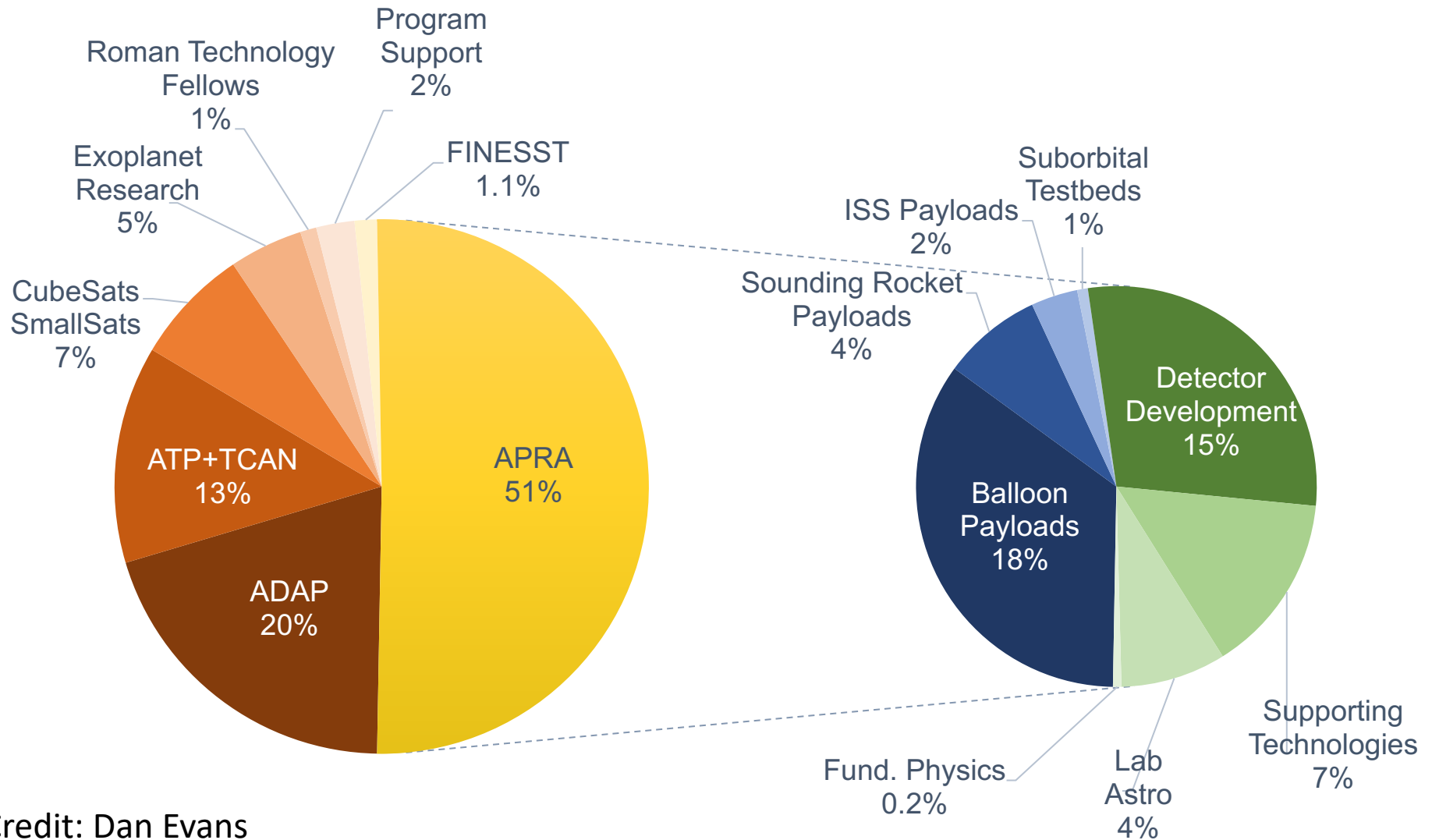
Astrophysics Community Funding

FY05-FY18 Actual, FY19 Op Plan, FY20-FY24 Request



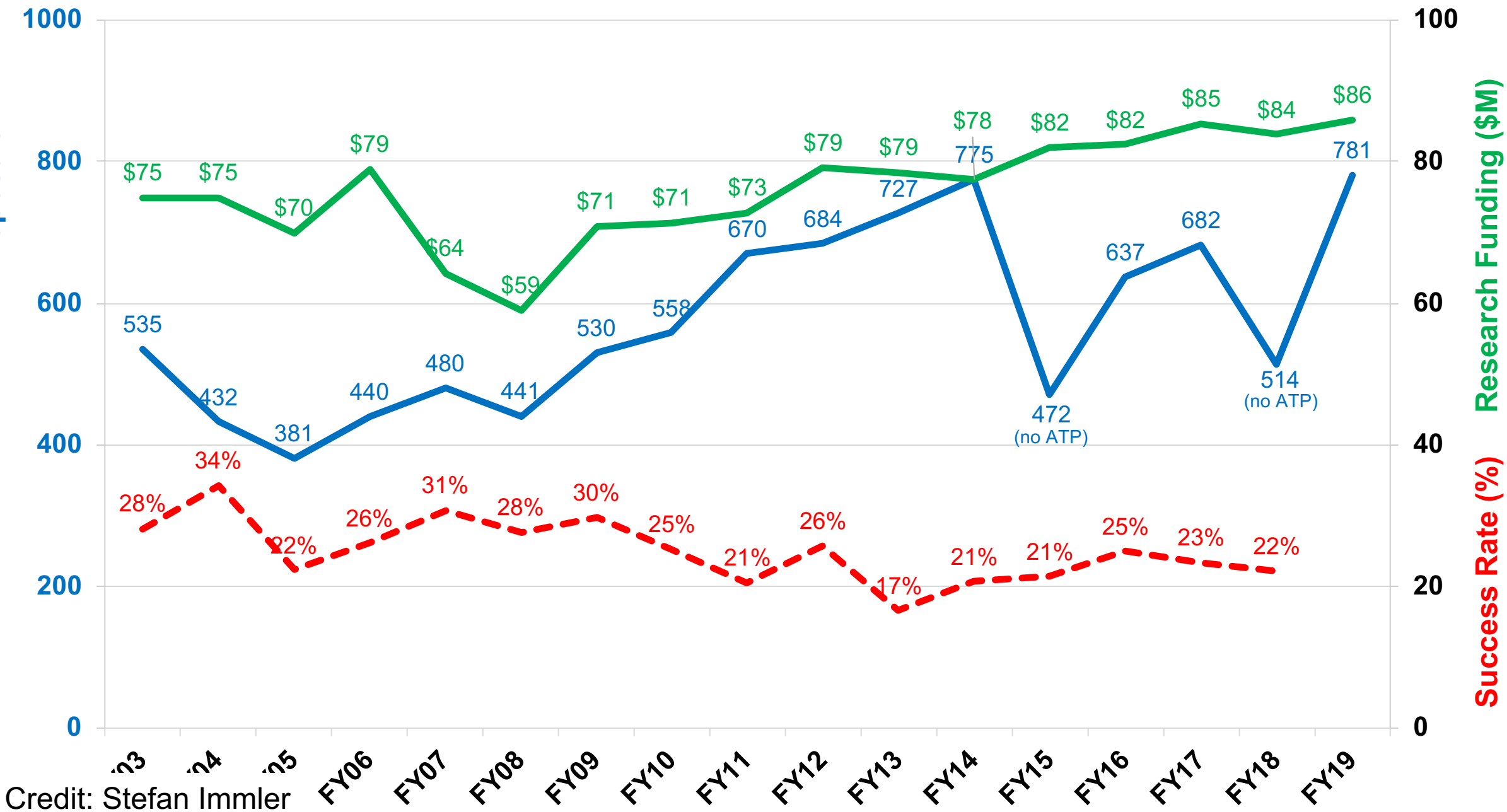
Credit: Dan Evans

FY19 R&A Elements (excludes GO Programs and SAT)



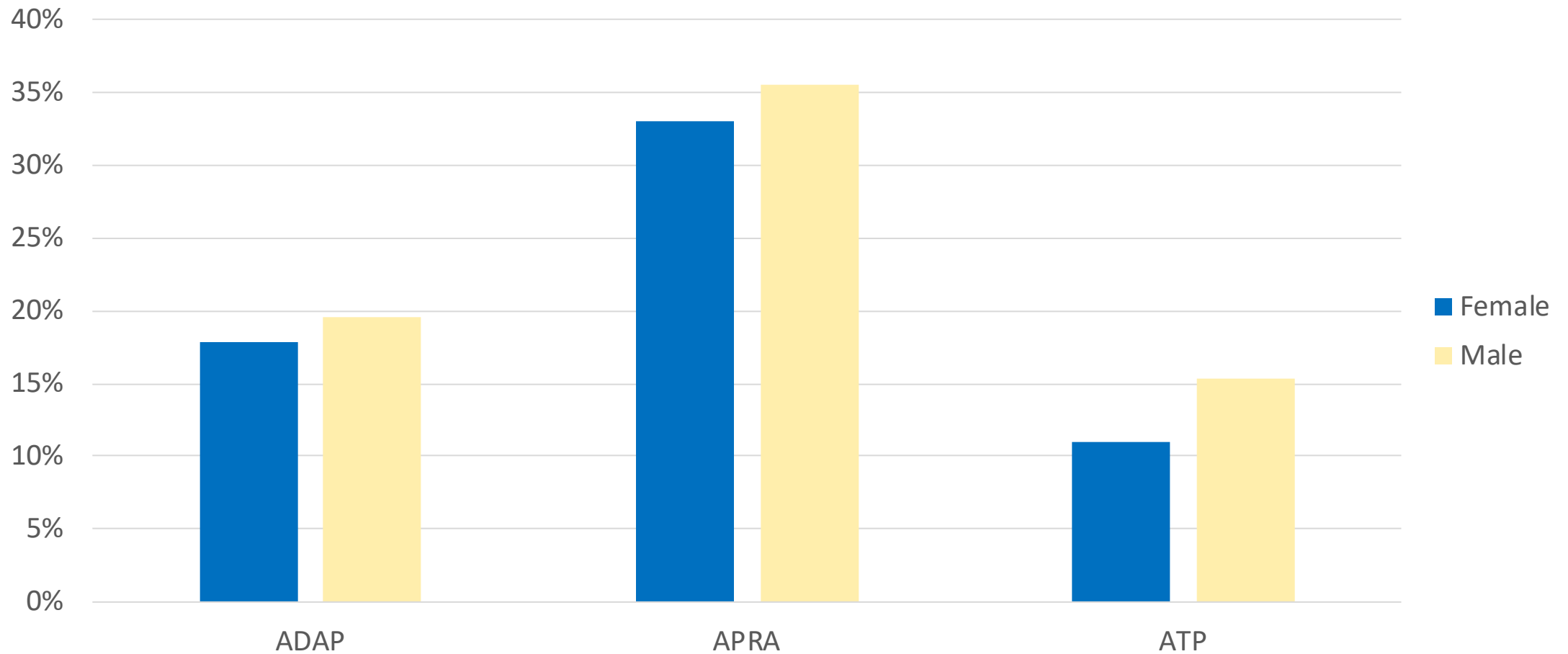
Credit: Dan Evans

APRA + ADAP + ATP + XRP Proposals



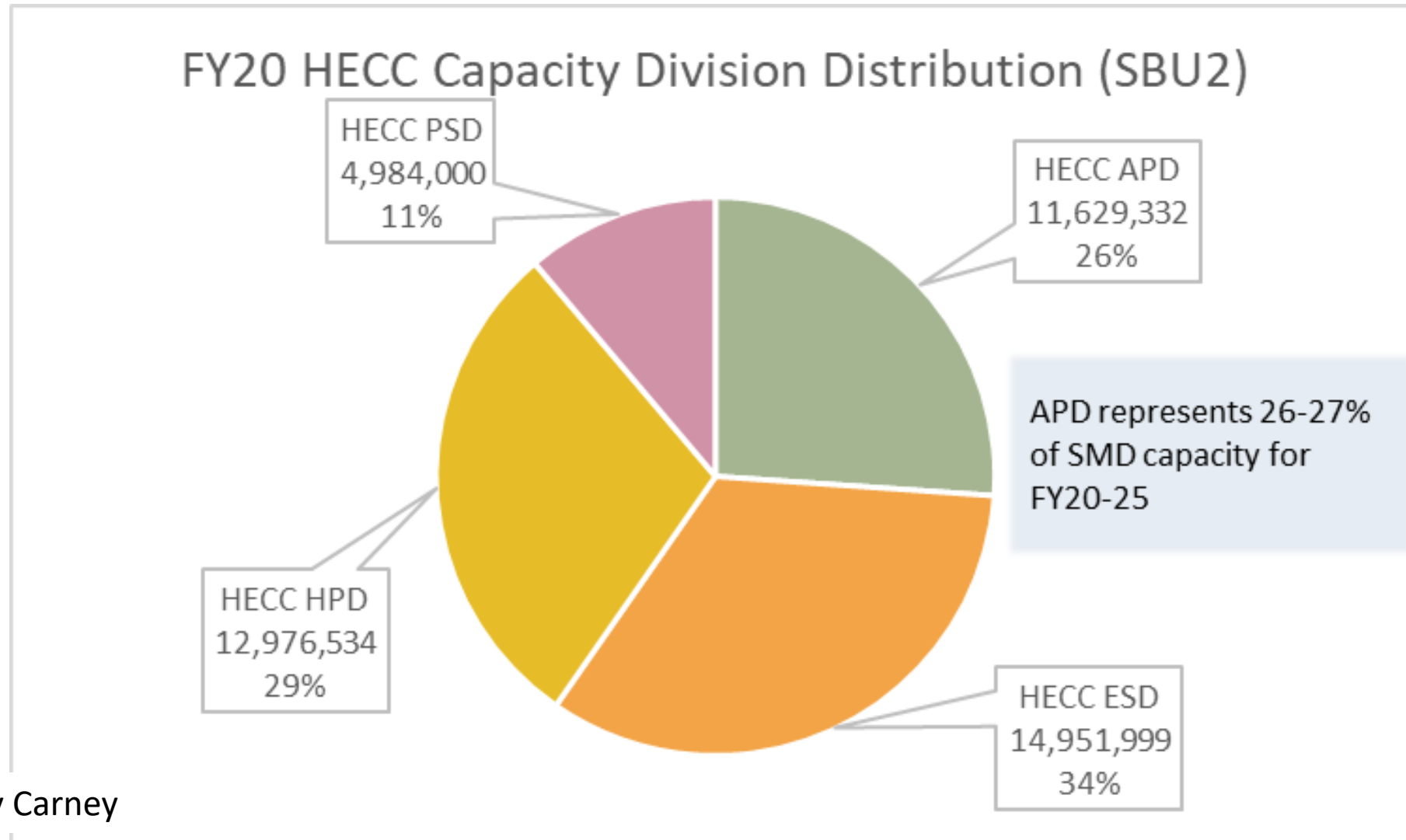
Credit: Stefan Immler

NASA Astrophysics Success Rates by Inferred Gender (ADAP+APRA+ATP, Past 5 Cycles)



Credit: Dan Evans

FY20 SMD HECC Resource Distribution



Credit: Nancy Carney

Current HECC Capability

HECC Hardware Assets

5 Compute Clusters

- Pleiades 158 ½ Racks / 11,215 nodes / 7.85 PF / 8,222 SBU/hr
- Electra 24 Racks / 3,422 nodes / 8.32 PF / 4,815 SBU/hr
- Aitken 4 E-Cells / 1,152 nodes / 3.69 PF / 2,290 SBU/hr
- Merope 56 ½ Racks / 1,792 nodes / 252 TF / 520 SBU/hr
- Endeavour 3 Racks / 2 nodes / 32 TF / 44 SBU/hr

1 Visualization Cluster 245 million pixel display / 128 node / 703 TF

10 Lustre File Systems 46.0 PF

6 NFS File Systems 1.5 PB

Archive System 1,000 PB

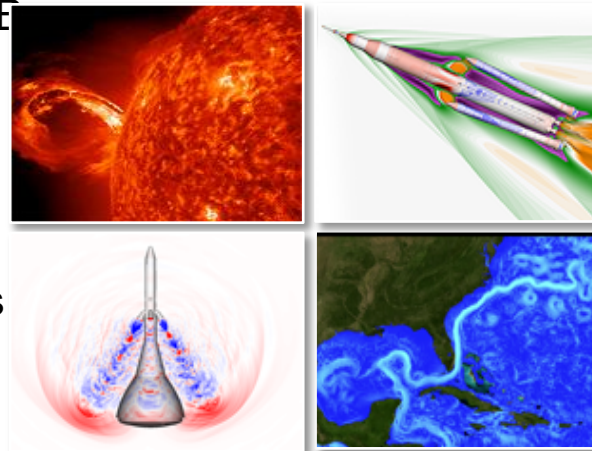
D-Wave 2000Q quantum system

- Whistler processor with 2031 qubits

NAS Facility Extension

- A one-acre site with 30 MW power to house HPC systems in modules.

Credit: Nancy Carney



HECC Services

HECC provides a suite of complimentary services to the user community to enhance the scientific and engineering results obtained from the hardware assets.

- Systems: Customized solutions including compute and storage solutions to meet specific project or mission requirements. Cloud access for immediate or non-standard computing.
- Application Performance and Productivity: Software solutions provided to research/engineering teams to better exploit installed systems.
- Visualization and Data Analysis: Custom visualization during traditional post-processing or concurrent during simulation to understand complex interactions of data.
- Networks: End-to-end network performance enhancements for user communities throughout the world.
- Data Analytics: Exploitation of data sets through neural nets and emerging new techniques.
- Machine Learning: Custom environments to enable learning through advanced data techniques.
- Custom Data Gateways: Custom data portals to support diverse programs and projects.

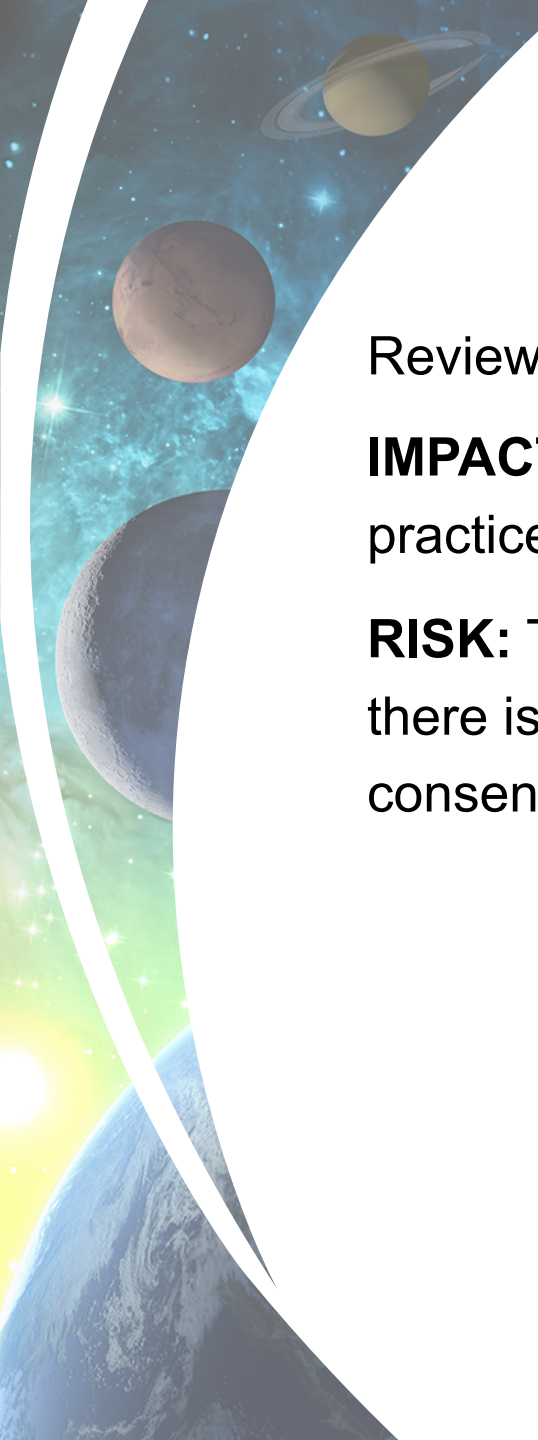
What's an SBU2?

Distributed Memory Machines:

Pleiades: 2,016 Broadwell Nodes (2 x 14 Cores)	1.00 SBU	≈70,000,000 SBUs/yr
2,052 Haswell Nodes (2 x 12 Cores)	0.80 SBU	
5,256 Ivy Bridge Nodes (2 x 10 Cores)	0.66 SBU	
1,800 Sandy Bridge Nodes (2 x 8 Cores)	0.47 SBU	
Electra: 2,304 Skylake Nodes (2 x 20 Cores)	1.59 SBU	≈42,000,000 SBUs/yr
1,152 Broadwell Nodes (2 x 14 Cores)	1.00 SBU	
Merope: 1,792 Westmere Nodes (2 x 6 Cores)	0.29 SBUs	≈4,500,000 SBUs/yr
(Discover: 129,000-core Climate Simulation Cluster)		

Shared Memory Machine:

Endeavor: 1504 Cores	0.024 SBU/cor	300,000 SBU/yr
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What are the challenges in support innovative high-risk theory programs?

Review forms for all ROSES-2017 peer reviews (1577 proposals including ATP).

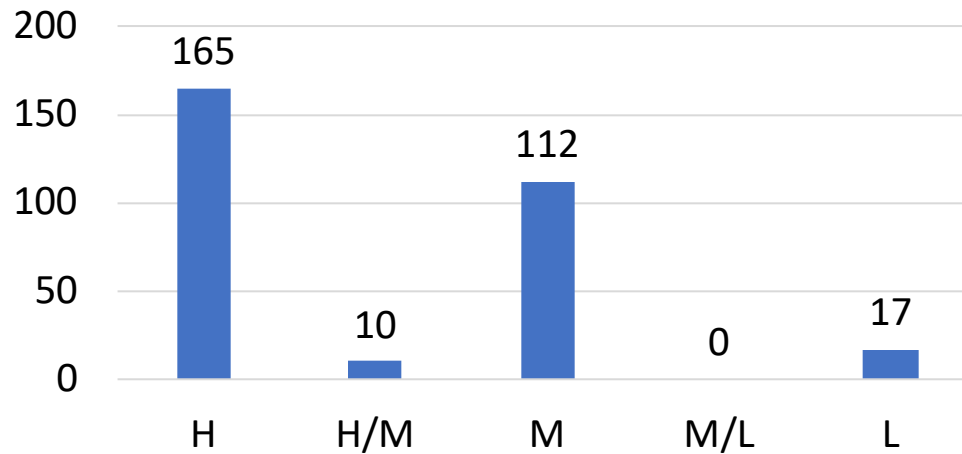
IMPACT: How large an effect would this project have on current thinking, methods, or practice? high (H), medium (M), low (L)

RISK: To what extent would this proposal test novel and significant hypotheses, for which there is scant precedent or preliminary data or which run counter to the existing scientific consensus? A great extent (G), to some extent (S), little or none (L)

		IMPACT				
		H	H/M	M	M/L	L
RISK	G	159	8	66	1	15
	G/S	3	3	2		
	S	240	13	413	3	77
	S/L	1	2	10	2	3
	L	64	9	289	11	166

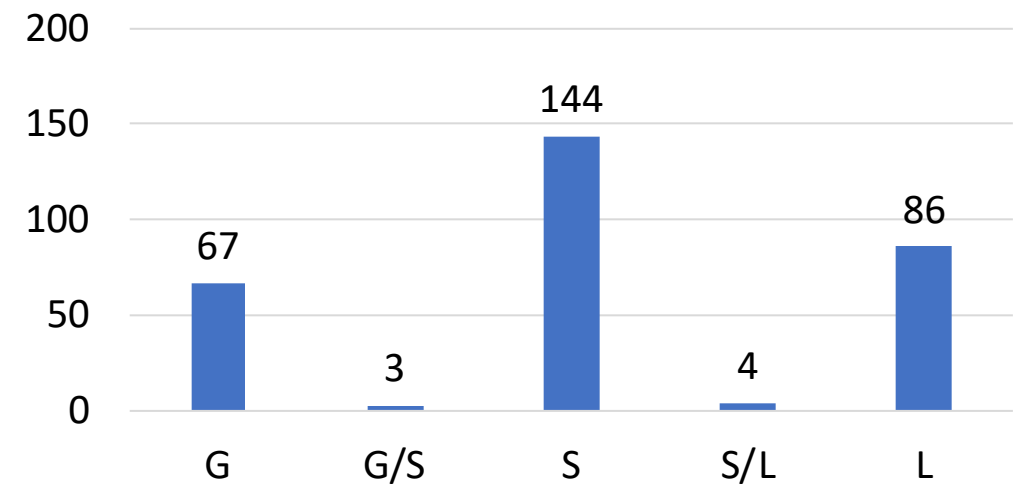
What are the challenges in support innovative high-risk theory programs?

Impact of Selected Proposals



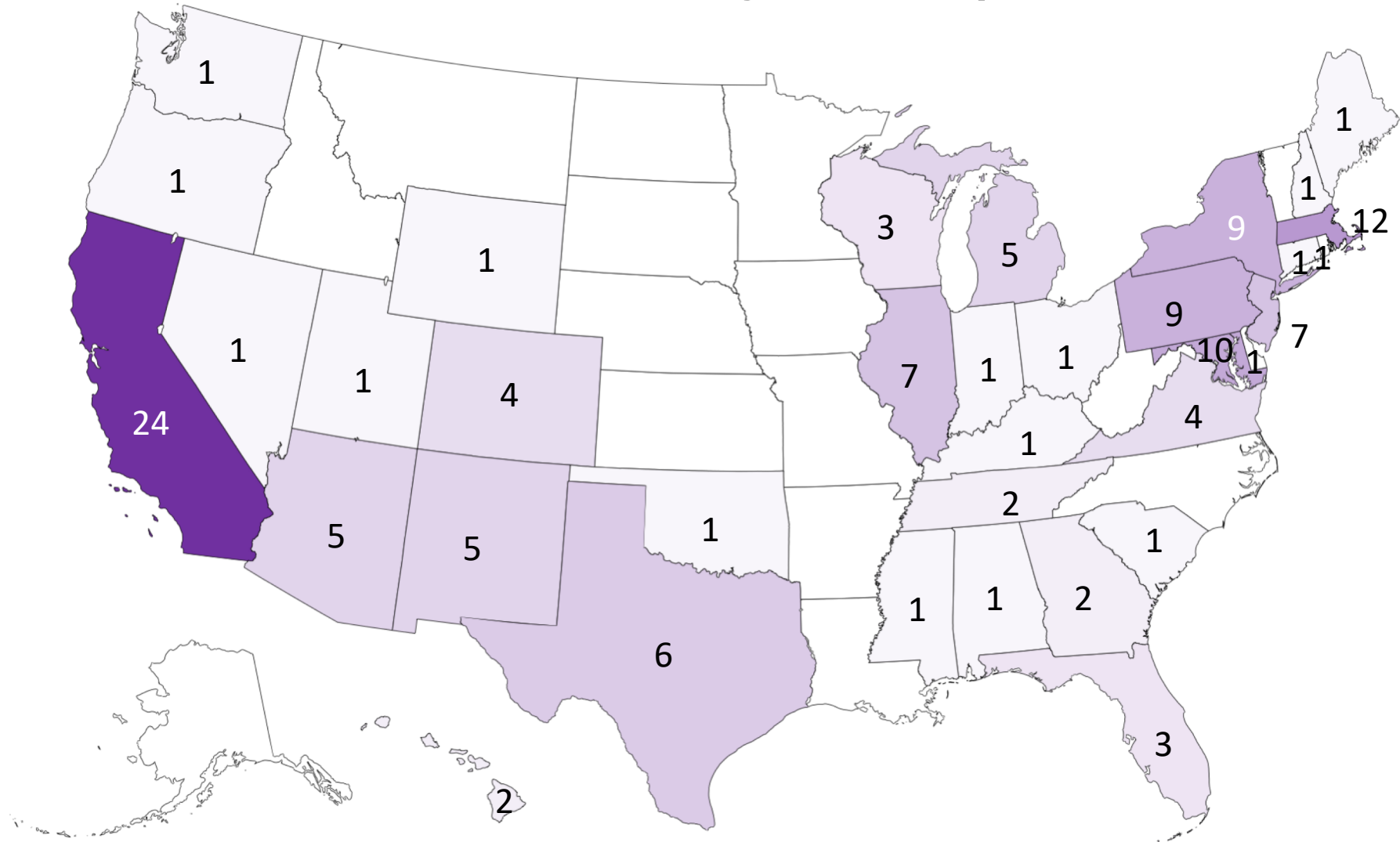
	Pct All	Pct Selected
H	30%	54%
H/M	2%	3%
M	50%	37%
M/L	1%	0%
L	17%	6%

Risk of Selected Proposals

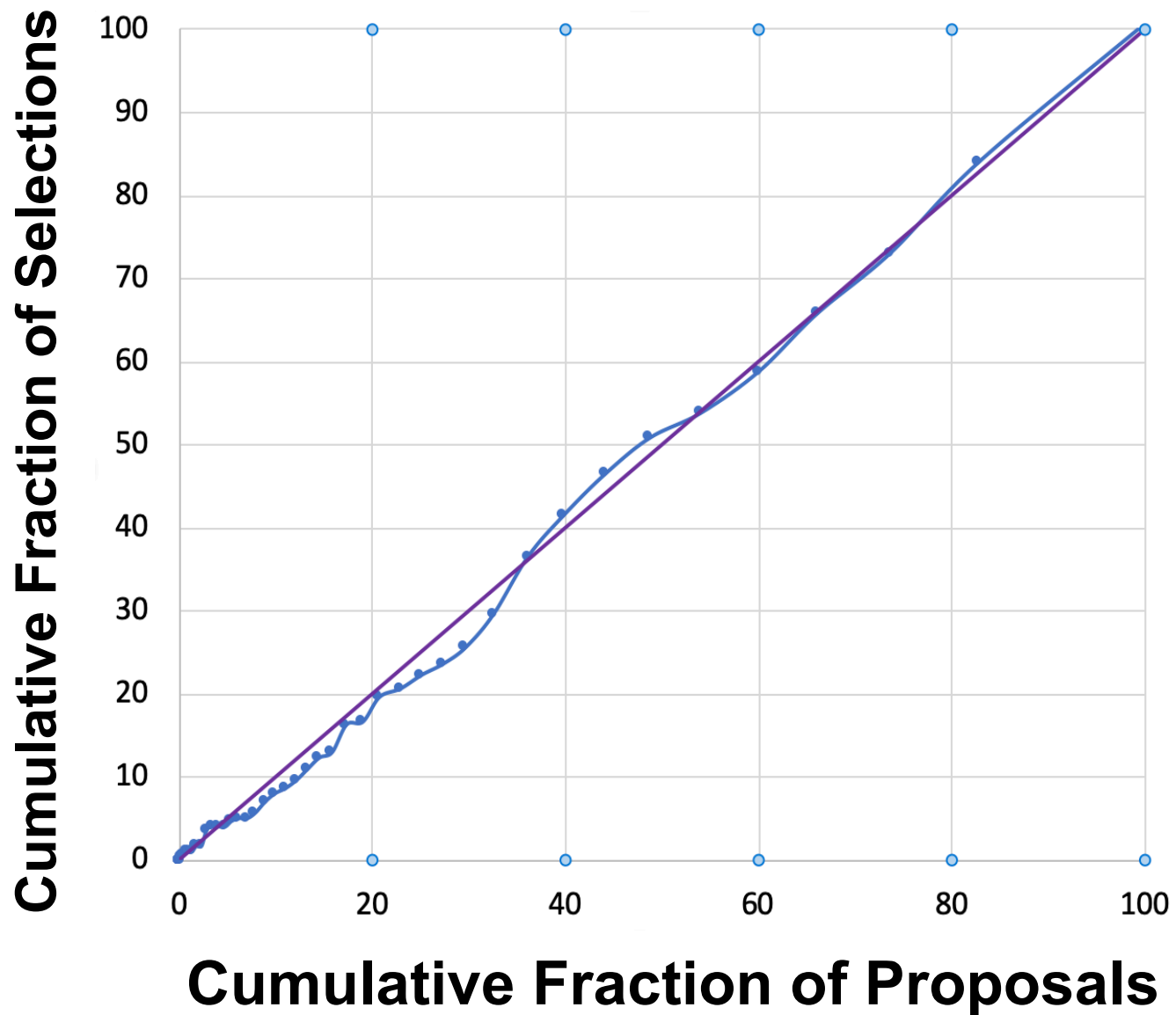


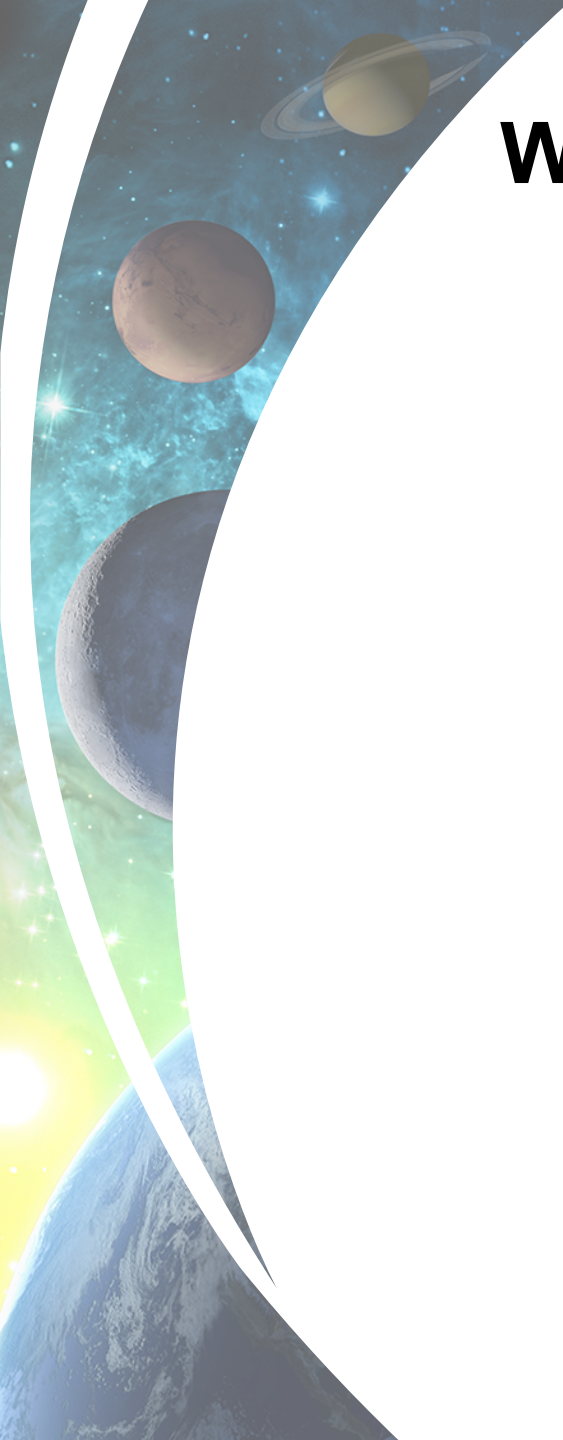
Risk	Pct All	Pct Selected
G	16%	22%
G/S	1%	1%
S	48%	47%
S/L	1%	1%
L	35%	28%

How do we support a diverse workforce in theoretical astrophysics? (ATP19 Panelists)



ATP+TCAN Selections in Last Decade By State

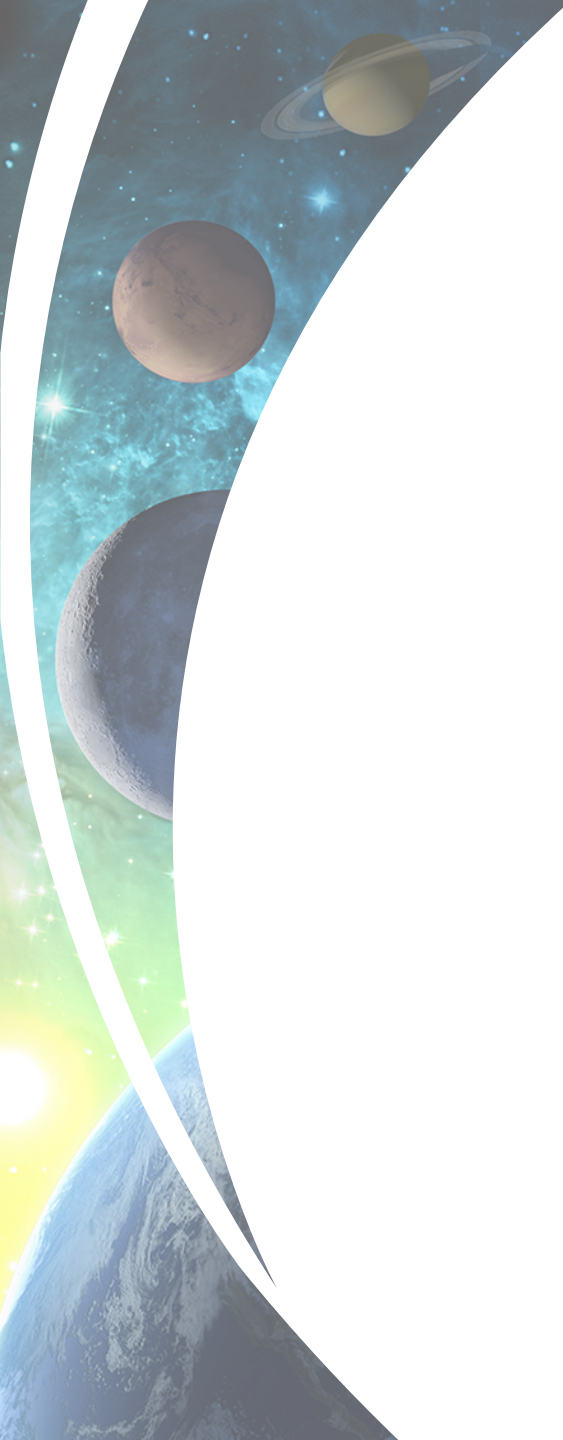




What is Dual-Anonymous Peer Review?

In dual-anonymous peer review, not only are proposers unaware of the identity of the members on the review panel, but the reviewers do not have explicit knowledge of the identities of the proposing team during the scientific evaluation of the proposal.

- The primary intent of dual-anonymous peer review is to eliminate “the team” as a topic during the scientific evaluation of a proposal, not to make it absolutely impossible to guess who might be on that team.
- This creates a shift in the tenor of discussions, away from the individuals, and towards a discussion of the scientific merit of a proposal.

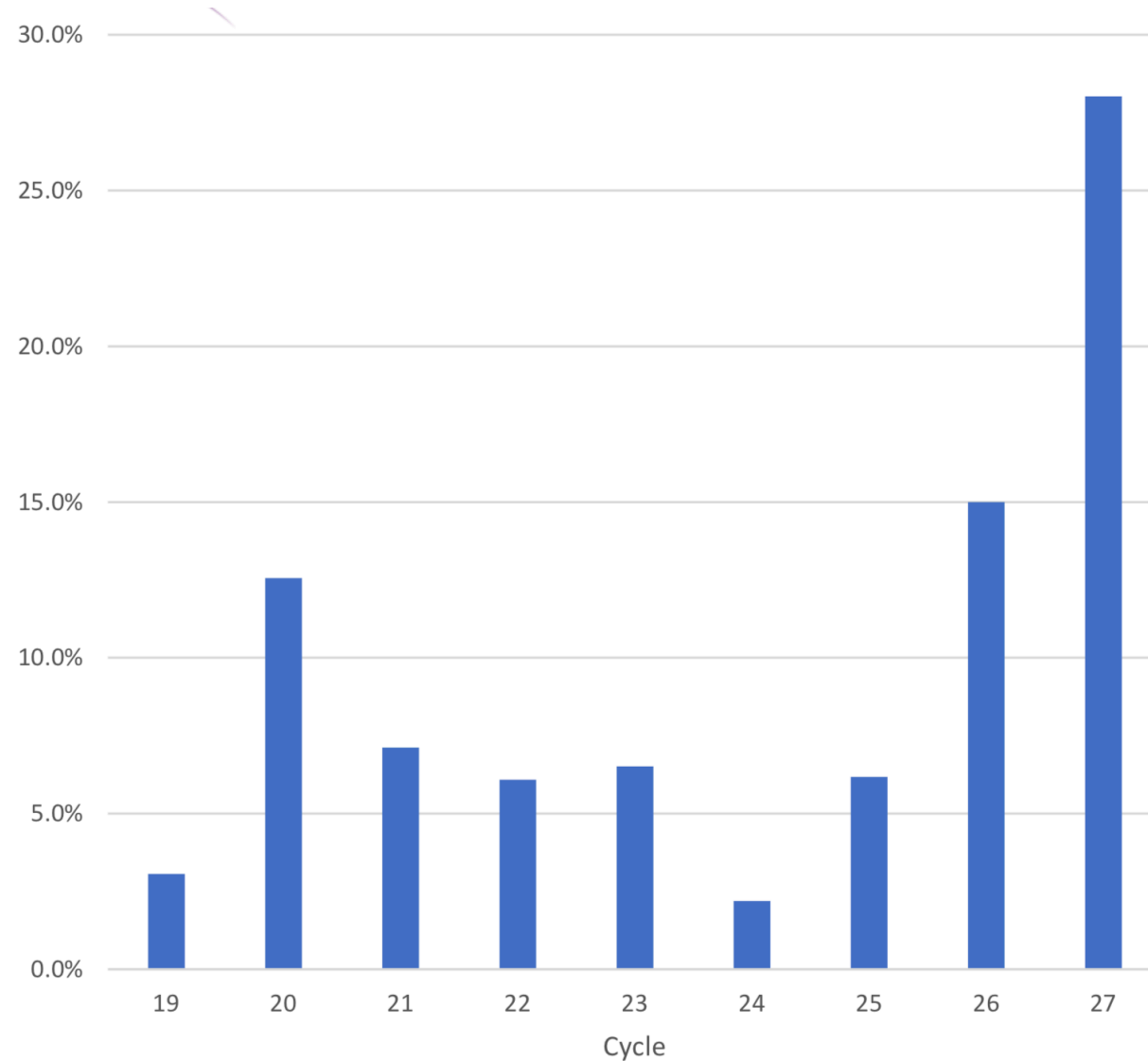


Rollout of Dual-Anonymous Reviews

Format	Program	Proposal due date
Traditional	NICER Cycle 2	11/13/2019
Traditional	TESS Cycle 3	1/16/2020
Dual-Anonymous	NuSTAR Cycle 6	1/24/2020
Traditional	Fermi Cycle 13	2/19/2020
Dual-Anonymous	Hubble Cycle 28	3/4/2020
Traditional	Chandra Cycle 22	~3/2020
Dual-Anonymous	Webb Cycle 1	~5/2020
Dual-Anonymous	Swift Cycle 17	~9/2020
Dual-Anonymous	NICER Cycle 3	~11/2020
Dual-Anonymous	TESS Cycle 4	~1/2021
Dual-Anonymous	NuSTAR Cycle 7	~1/2021
Dual-Anonymous	Fermi Cycle 14	~2/2021
Dual-Anonymous	Hubble Cycle 29	TBD
Dual-Anonymous	Chandra Cycle 23	~12/2021 ?

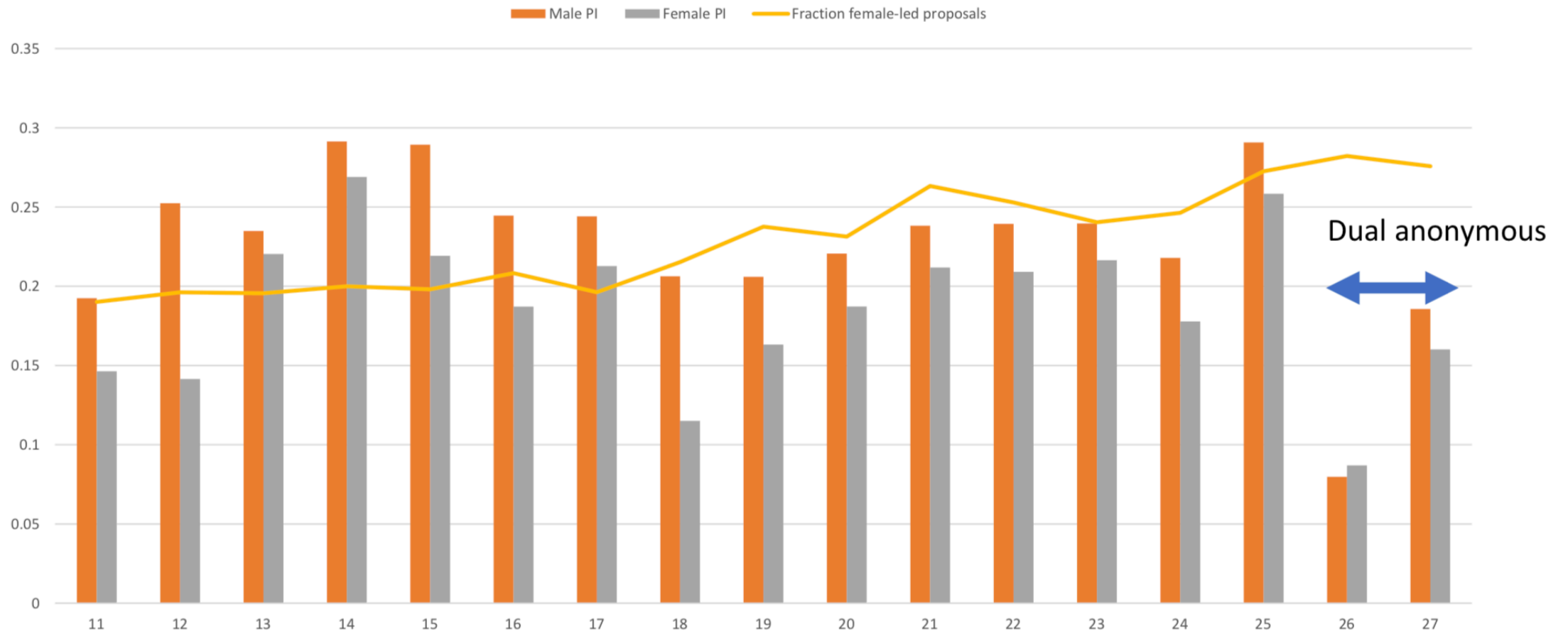
Hubble Statistics

Fraction of
New PIs by
Cycle



Credit: Neill Reid, Lou Strolger, and STScI

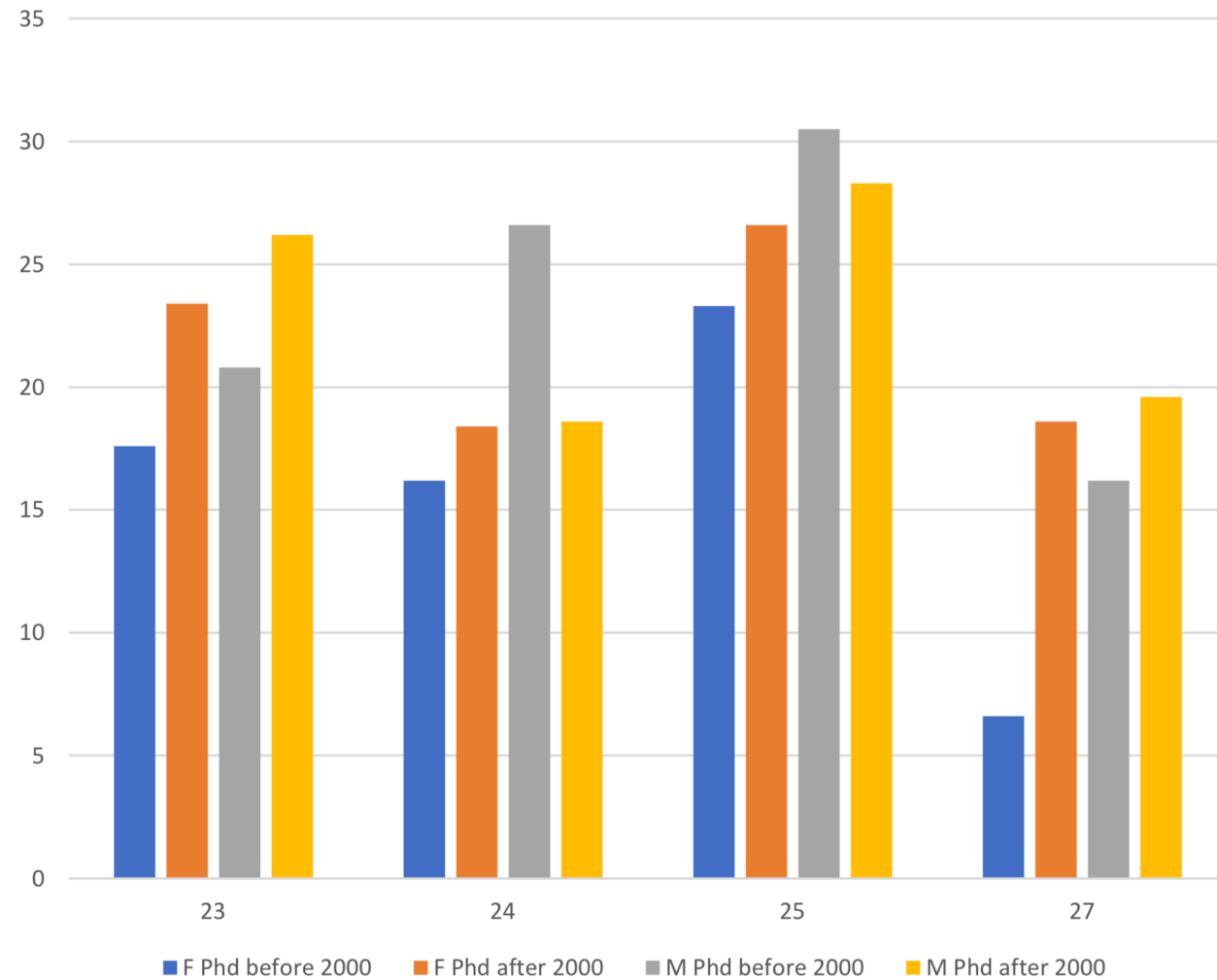
Hubble Overall Statistics



Credit: Neill Reid, Lou Strolger, and STScI

Hubble Statistics

Breakdown by
Inferred
Gender and
PhD Year



Credit: Neill Reid, Lou Strolger, and STSci