Demographics of the Planetary Science Profession

The Data

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Background – These slides present data on demographics on the planetary science research community that were gathered to support the State of the Profession Writing Group of the Planetary Science and Astrobiology Decadal Survey 2023-2032.

Reference: Demographics of the Planetary Science Profession, DOI to be provided

9 December 2021

3-slide summary

Academic Department Surveys 2011 & 2018

Planetary Science:

54 Departments >1 PS faculty
250 faculty
100 Undergraduates / year

PhDs: 50-65 / year
40-45% women
30% non-US
8% minority

Astronomy (AIP) For comparison**:**

93 Departments (40 Astro, 53 Astro+)
550 faculty
666 Undergrad degrees / year
159 PhDs / year

https://www.aip.org/statistics/reports/roster-astronomy-2019

- Planetary Science: Very interdisciplinary, dispersed, poorly defined
- Astrobiology & Exoplanets not included
- Only a dozen universities dominate field
- 7% growth in faculty over 7 years
- Fraction of women faculty increasing 14%->20%
- Untenured women -> 30%

Note: These surveys were ad hoc – initiated and carried out by a small group. Needs to be developed as a systematic evaluation of the production of planetary scientists and astrobiologists.

Planetary Science Workforce surveys 2011 & 2020

by American Institute of Physics' Statistical Division

- 2011 DPS, LPSC, AGU – Funded by NASA
- 2020 DPS, LPSC, GSA – Funded by AAS/DPS
- Populations differed between surveys
- Questions varied between surveys
- Both suggested ~1100-1500 PhD scientists identifying as planetary scientists and working in the US primarily on research
- Similar numbers of people working in planetary exploration in engineering, management, operations, teaching, etc.
- 2020 survey only: 26% Astrobiology, 31% Exoplanets research
- Surveys further explored gender, race/ethnicity demographics. Percentage of women increasing.
- Black and Latinx scientists are MOST underrepresented groups and that representation is NOT increasing in proportion to the population
- Surveys further explored social factors on careers.
- Needs more & better data on race/ethnicity, social factors

Note: Need to find way to systematically gather <u>workforce</u> data
(community agreement on scope of planetary science & astrobiology, comprehensive, consistent & repeatable questions, mechanism for data collection, analysis, posting, etc)

NASA Proposal Data

- **Office Chief Scientist staff are gathering and analyzing data submitted to NSPIRES** online data base by researchers on teams submitting proposals for research grants (2014-2020)

- The Personal Profile data on NSPIRES have 10-20% "Prefer Not to Answer" entries which increases the uncertainty of statistical analysis. May be indication that questions could be asked better.

- The quantity and quality of data are well below that gathered by other federal agencies (NIH, NSF, etc)

- **Analysis of demographics of competed mission teams** 2006-present includes comparisons across:
  - SMD divisions – planetary, helio, astro, Earth
  - Mission size – Small, medium, large, MO, instruments
  - Names PIs & Co-Is used to infer gender
  - PIs & Co-Is and proposal institution

- While planetary is doing better than other divisions with respect to percentage of women on competed mission teams, with 30% team membership comparable to workforce pool, there's considerable way to go for representation in race/ethnicity.

Note: Quantity & quality of data gathering and analysis at NASA is behind other federal agencies and needs to be improved to guide NASA in development of workforce needed to achieve NASA's mission.

Overview

Planetary Science Workforce: Six Primary Data Sets

Name of Survey	Year of Survey	Fields Surveyed	Population	Owner	Total N (number sent to)	Link
2011 Survey of US Planetary Science University Departments	2011 (Academic Years 2008-2009, 2009-2010)	US university departments that include planetary science	US, University	Fran Bagenal	54 depts at 40 univ.	https://lasp.colorado.edu/home/mop/files/2015/08/DeptSummary3.pdf
2018 Survey of US Planetary Science University Departments	2018 (Academic Years 2016-2017 and 2017-2018)	US university departments that include planetary science	US, University	Fran Bagenal	36 depts at 29 univ.	https://lasp.colorado.edu/home/mop/files/2021/07/DeptComparison2011-2018.pdf
2011 Survey of the Planetary Workforce	2011	AAS Division of Planetary Science, LPSC, AGU Section on Planetary Science	Reside in US, have PhD, no international responses	AIP	4252	https://lasp.colorado.edu/home/mop/files/2015/08/Report.pdf
2020 Survey of the Planetary Workforce	2020	AAS Division of Planetary Science, LPSC, GSA Planetary Geology Division	Students & international responses included	AIP	4965	https://lasp.colorado.edu/home/mop/files/2020/12/2020PlanetSciWorkforce.pdf
NASA Science Mission Directorate Demographics Data	2021	Personal profiles on NSPIRES	All PIs & Co-Is of non-mission proposals to NASA 2016-2020	NASA	31,172 PIs & Co-Is of planetary proposals	https://science.nasa.gov/science-red/s3fs-public/atoms/files/07-Barbier-Demographics-061421.pdf
NASA Announcement of Opportunity Science Team Demographics	2021	Mission leadership of competed missions	All PIs & Co-Is of mission proposals 1995-2019	NASA	933 proposals	https://www.nationalacademies.org/event/06-16-2021/increasing-diversity-and-inclusion-in-the-leadership-of-competed-space-missions-meeting-6

Surveys of Workforce & University Departments that Include Planetary Science - 2011 & 2018 Reports

Quick history:

- It's 2010. About to start Decadal Survey of Planetary Science. But we – the profession – had little knowledge about how many planetary scientists we have in the field – or where/how they are trained.
- A group works with the American Institute of Physics to do a workforce survey
- Fran Bagenal contacts ~50 academic departments that have some planetary connection
- 2011 Results:
  https://lasp.colorado.edu/home/mop/resources/planetary-science-workforce-survey/2011-planetary-science-survey/
- 2017. Time to repeat surveys. Fran contacts departments. NASA stalls on funding workforce survey. And stalls. And stalls. Finally DPS picks up the ball and does the 2020 workforce survey
- 2020 Results:
  https://dps.aas.org/sites/dps.aas.org/files/reports/2020/Results_from_the_2020_Survey_of_the_Planetary_Science_Workforce.pdf
- 2021. Next Decadal includes a State of the Profession Working Group. They not only want to know how the workforce has changed over the past decade – but also what how the departments might have changed
- We compare the 2010/11 departmental survey with the 2017/18 numbers
- Some key departments are missing....
- We chased up – but less complete than 2011

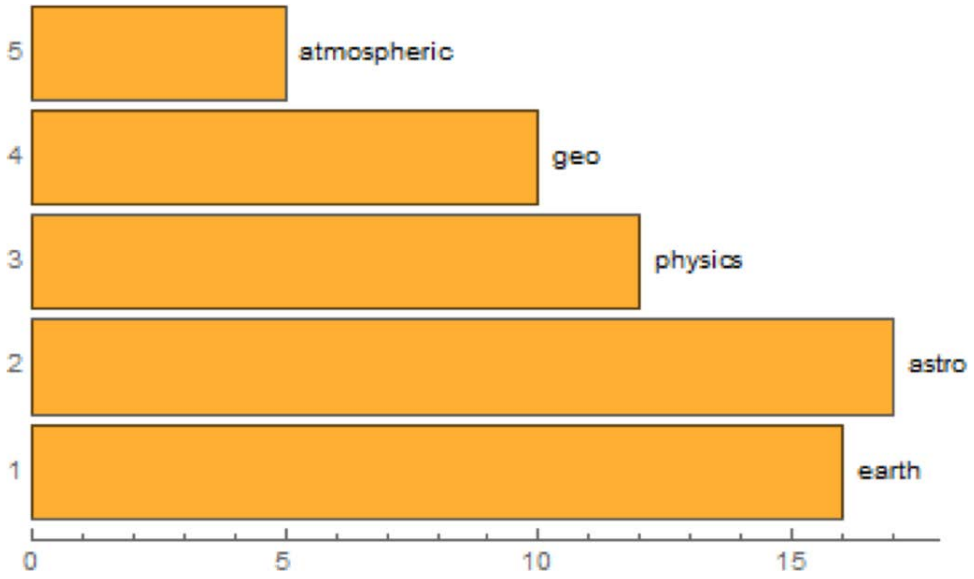
Academic Department Surveys 2011 & 2018

2011 & 2018 Departmental Surveys

- Sent to American university depts thought to have PS faculty and/or offer PS Bachelors/Masters/PhD
- Emailed by Fran Bagenal to dept chairs
- Only U. of Arizona has a dept called just Planetary Science
- Planetary science faculty in multiple depts at same university

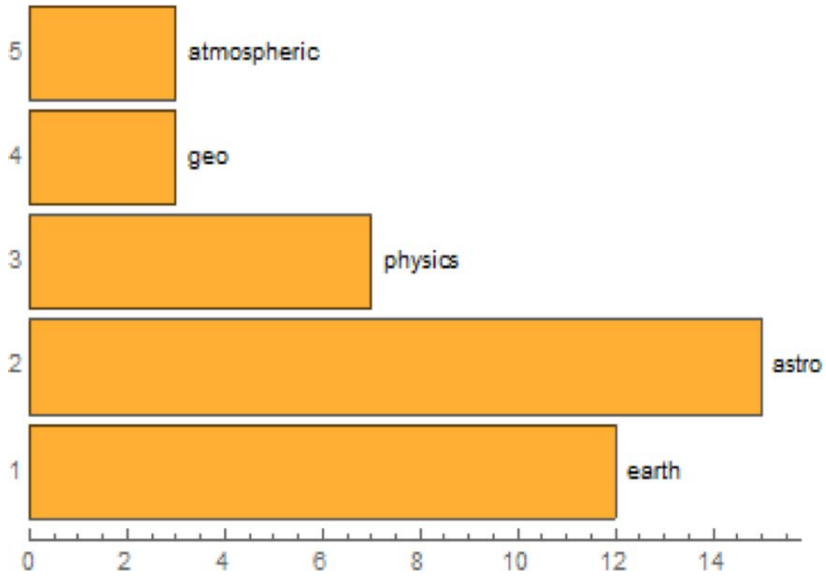
2011 Survey:

- 40 universities, 54 departments
- words appearing in department names:

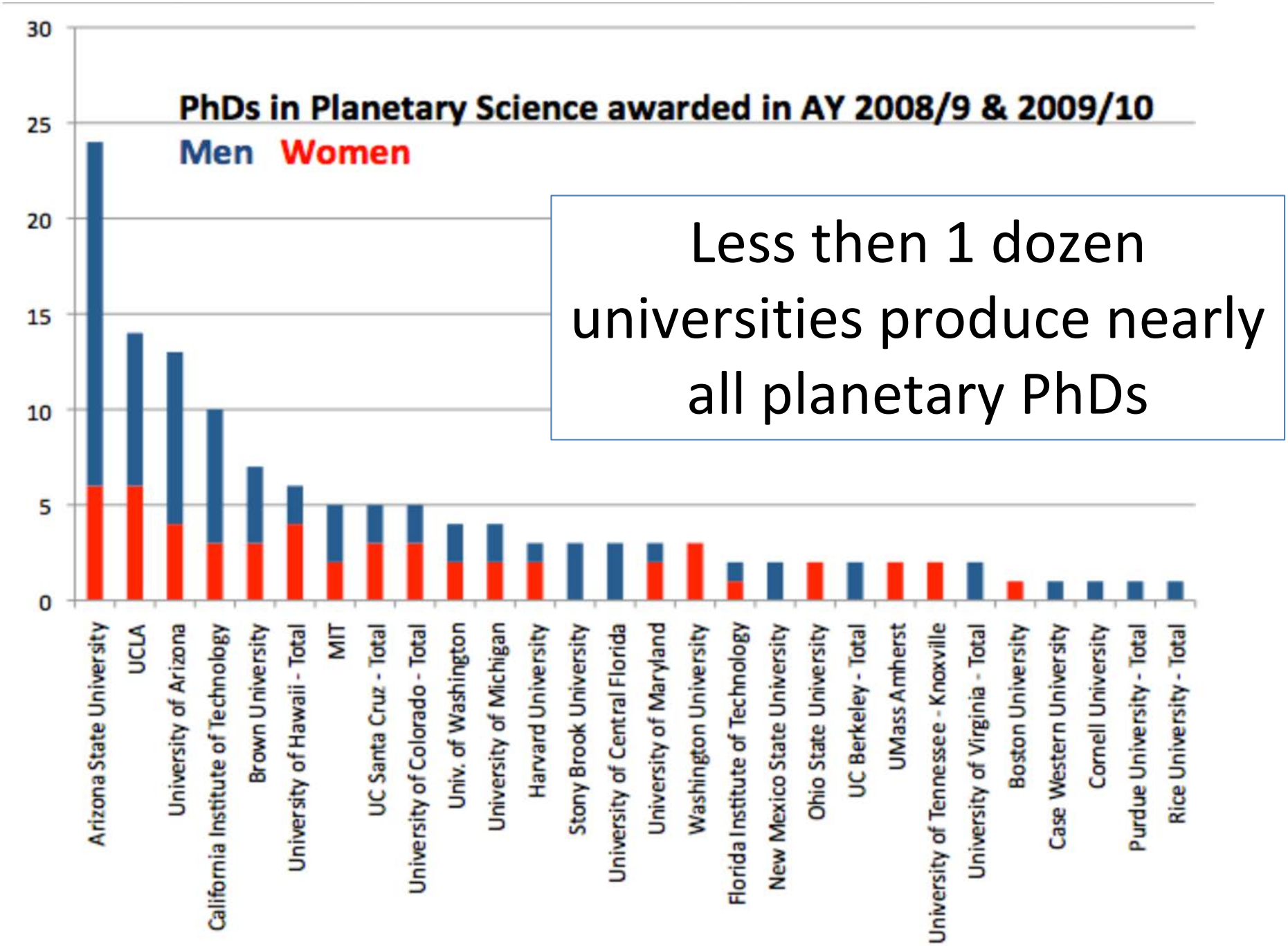


2018 Survey:

- 29 universities, 36 departments
- words appearing in department names:

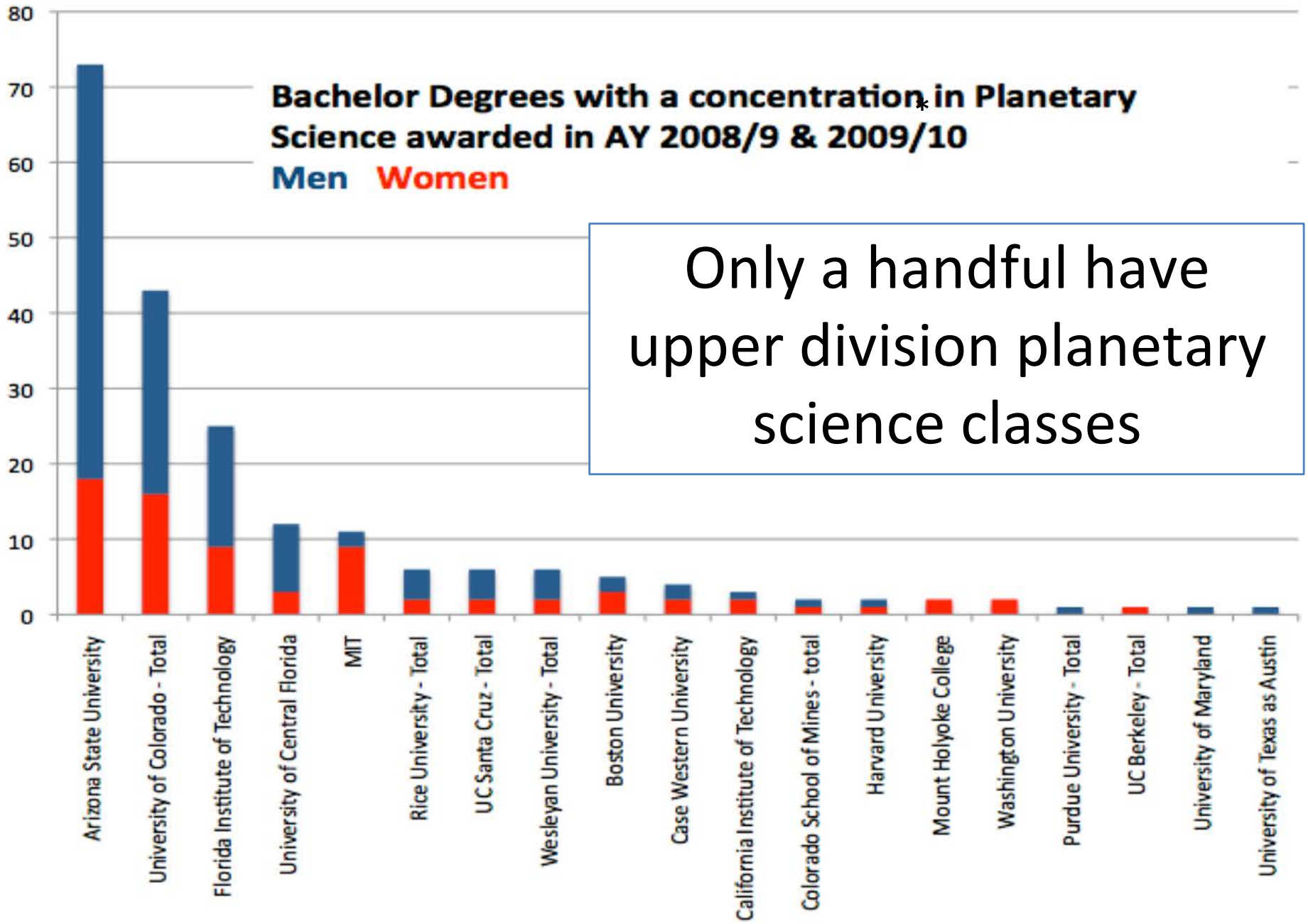


2011 Department Survey



Less then 1 dozen universities produce nearly all planetary PhDs

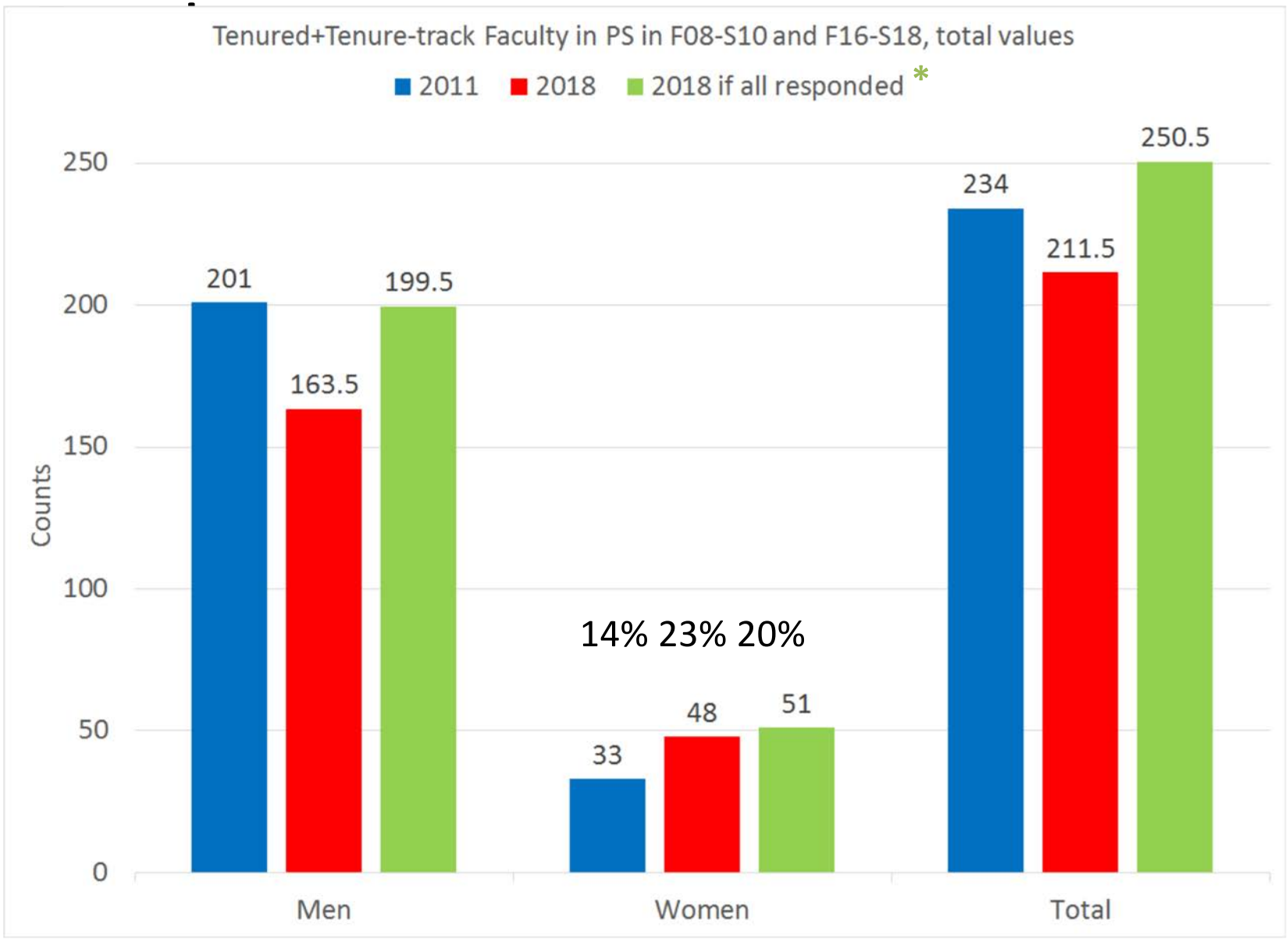
2011 Department Survey Results



Only a handful have upper division planetary science classes

* took 2 or more upper division courses in planetary science

2011 & 2018 Departmental Surveys:

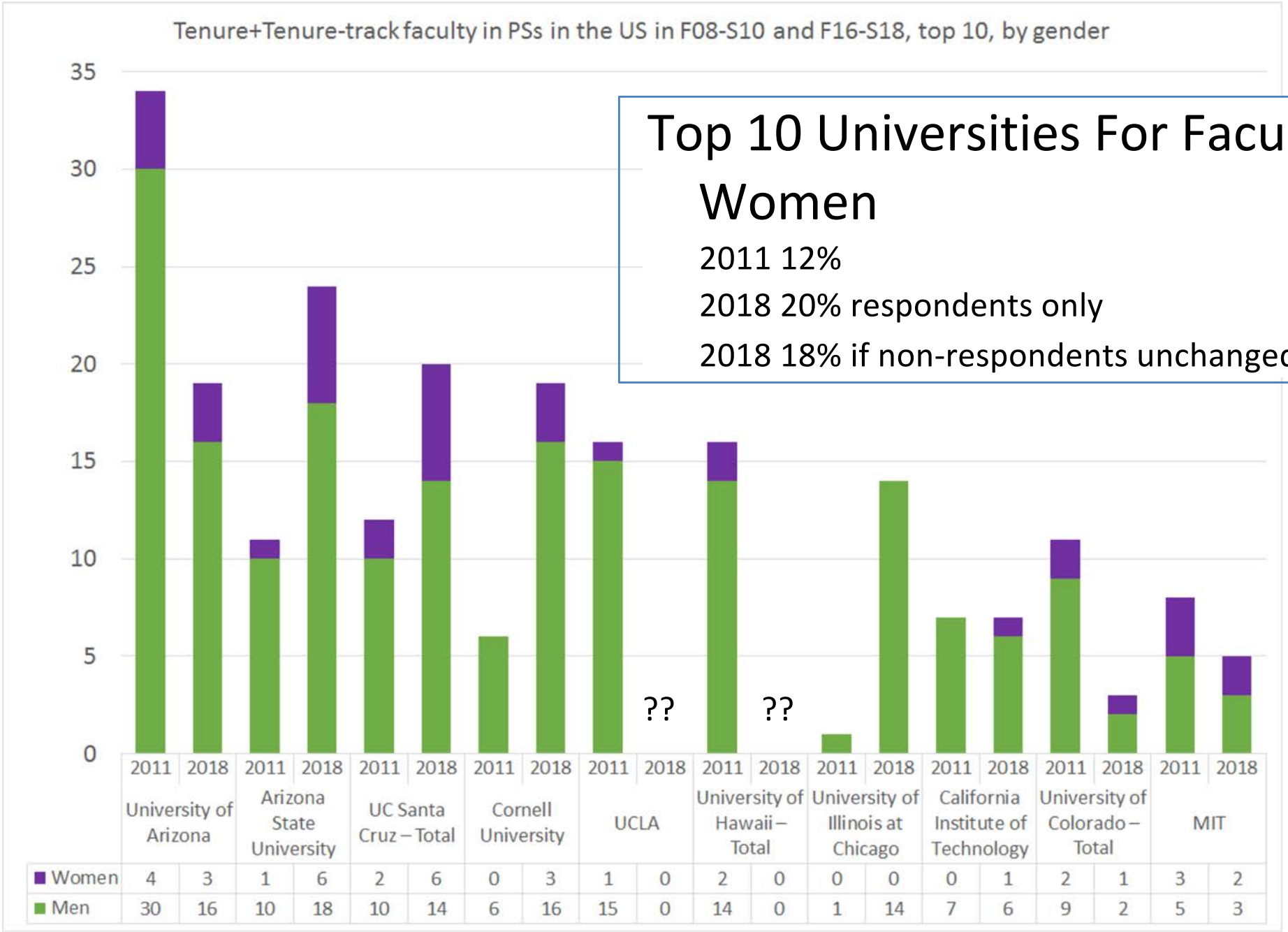


* Assuming no change for non-responding departments

234->250
= 7% growth

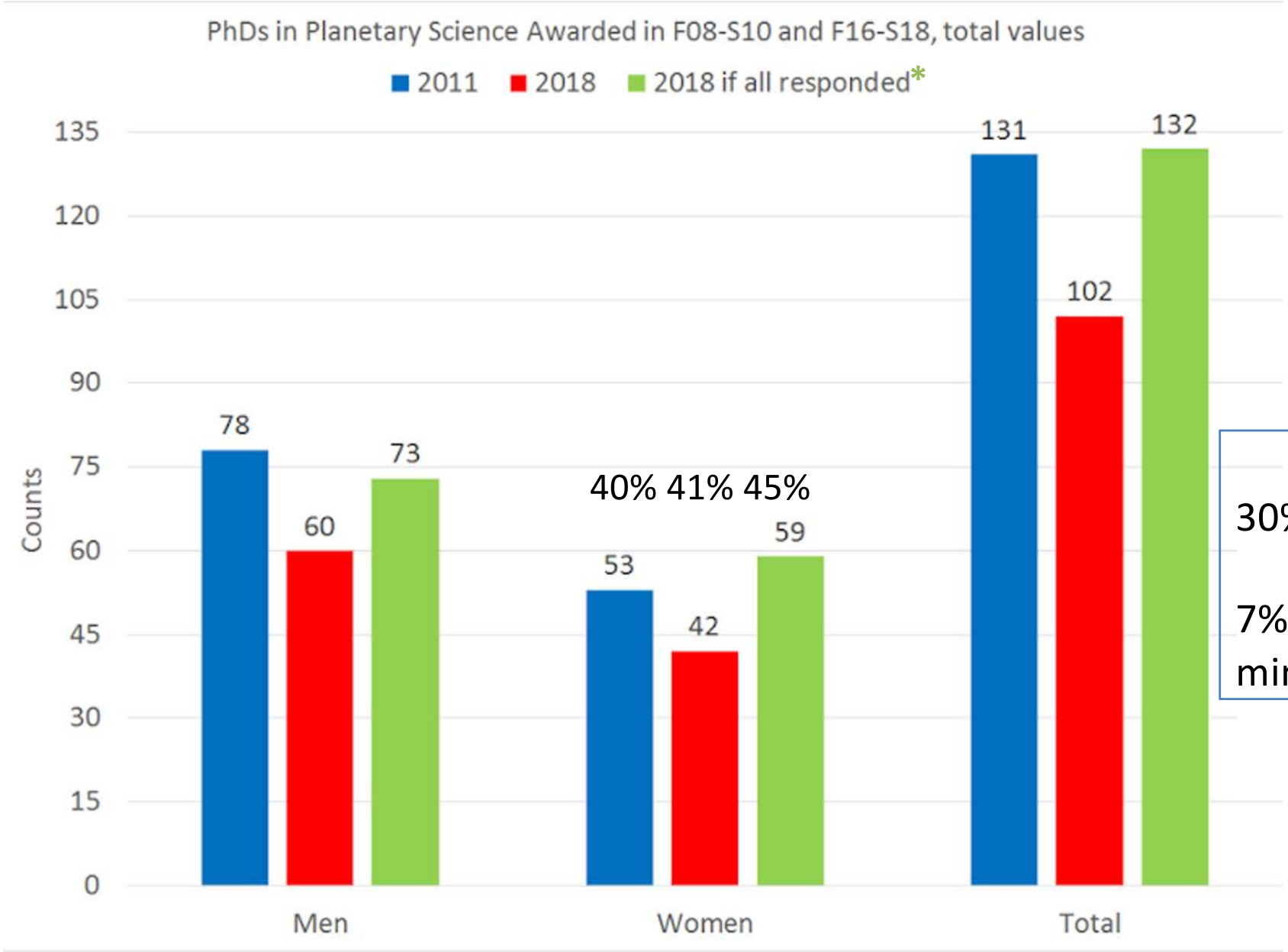
Non-tenured 24%, 35%, 30% suggests increase in women recruited

2011 & 2018 Departmental Surveys: Faculty



	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018
	University of Arizona		Arizona State University		UC Santa Cruz – Total		Cornell University		UCLA		University of Hawaii – Total		University of Illinois at Chicago		California Institute of Technology		University of Colorado – Total		MIT	
Women	4	3	1	6	2	6	0	3	1	0	2	0	0	0	0	1	2	1	3	2
Men	30	16	10	18	10	14	6	16	15	0	14	0	1	14	7	6	9	2	5	3

2011 & 2018 Departmental Surveys: PhDs

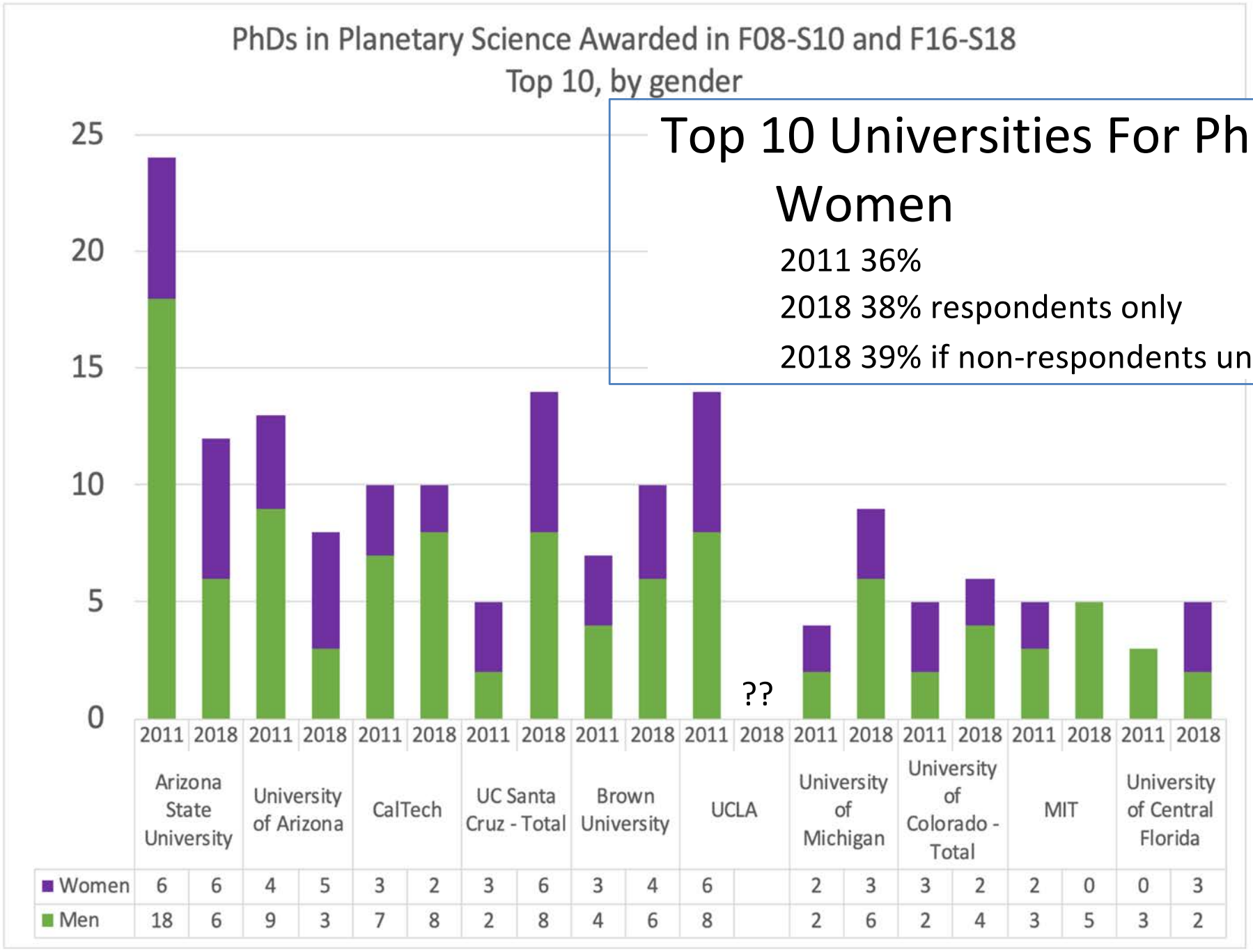


* Assuming no change for non-responding departments

2018
30% non-US

7% race/ethnic minority

2011 & 2018 Departmental Surveys: PhDs



	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018
	Arizona State University		University of Arizona		CalTech		UC Santa Cruz - Total		Brown University		UCLA		University of Michigan		University of Colorado - Total		MIT		University of Central Florida	
Women	6	6	4	5	3	2	3	6	3	4	6		2	3	3	2	2	0	0	3
Men	18	6	9	3	7	8	2	8	4	6	8		2	6	2	4	3	5	3	2

Top 10 Universities For PhDs

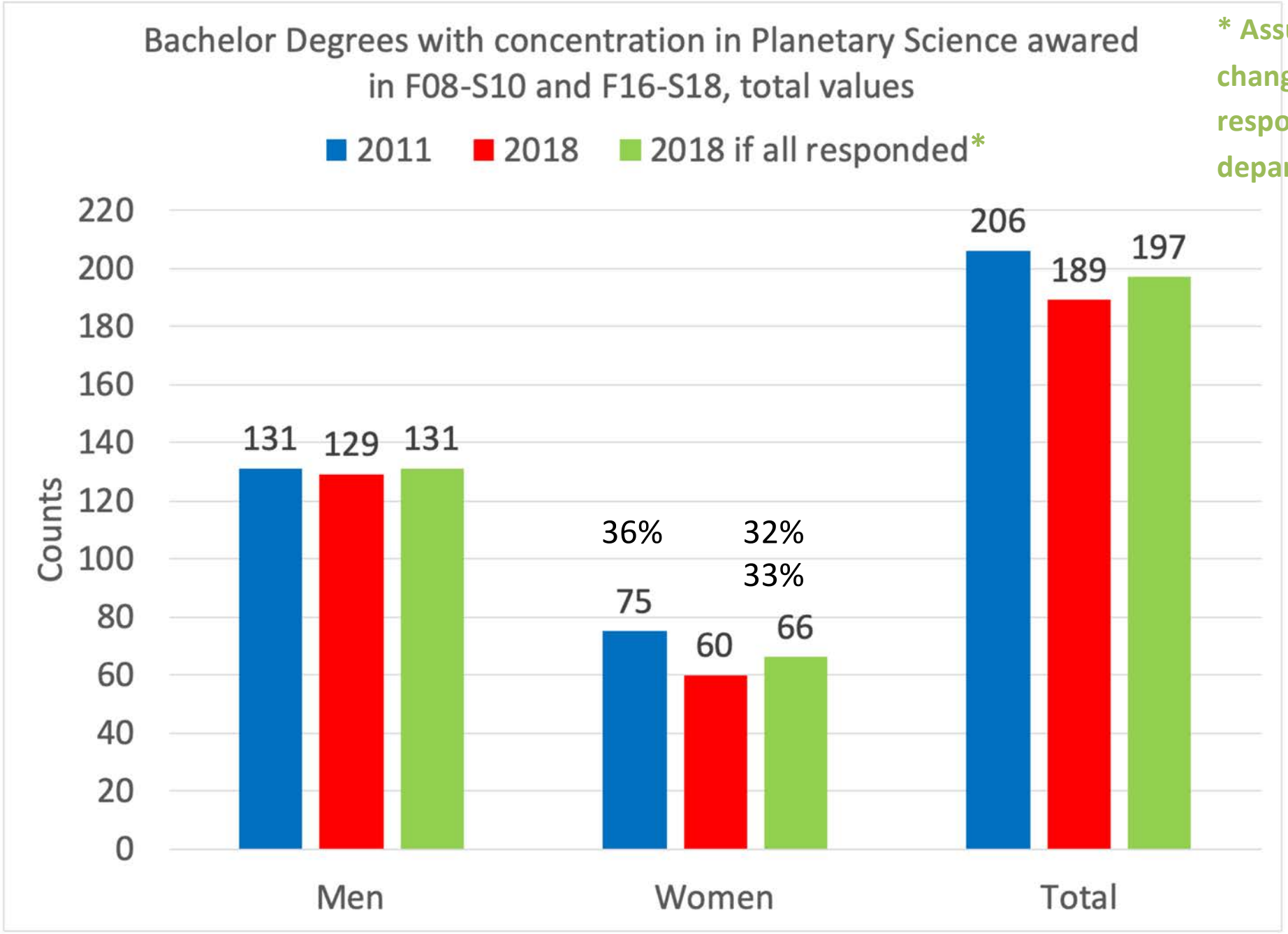
Women

2011 36%

2018 38% respondents only

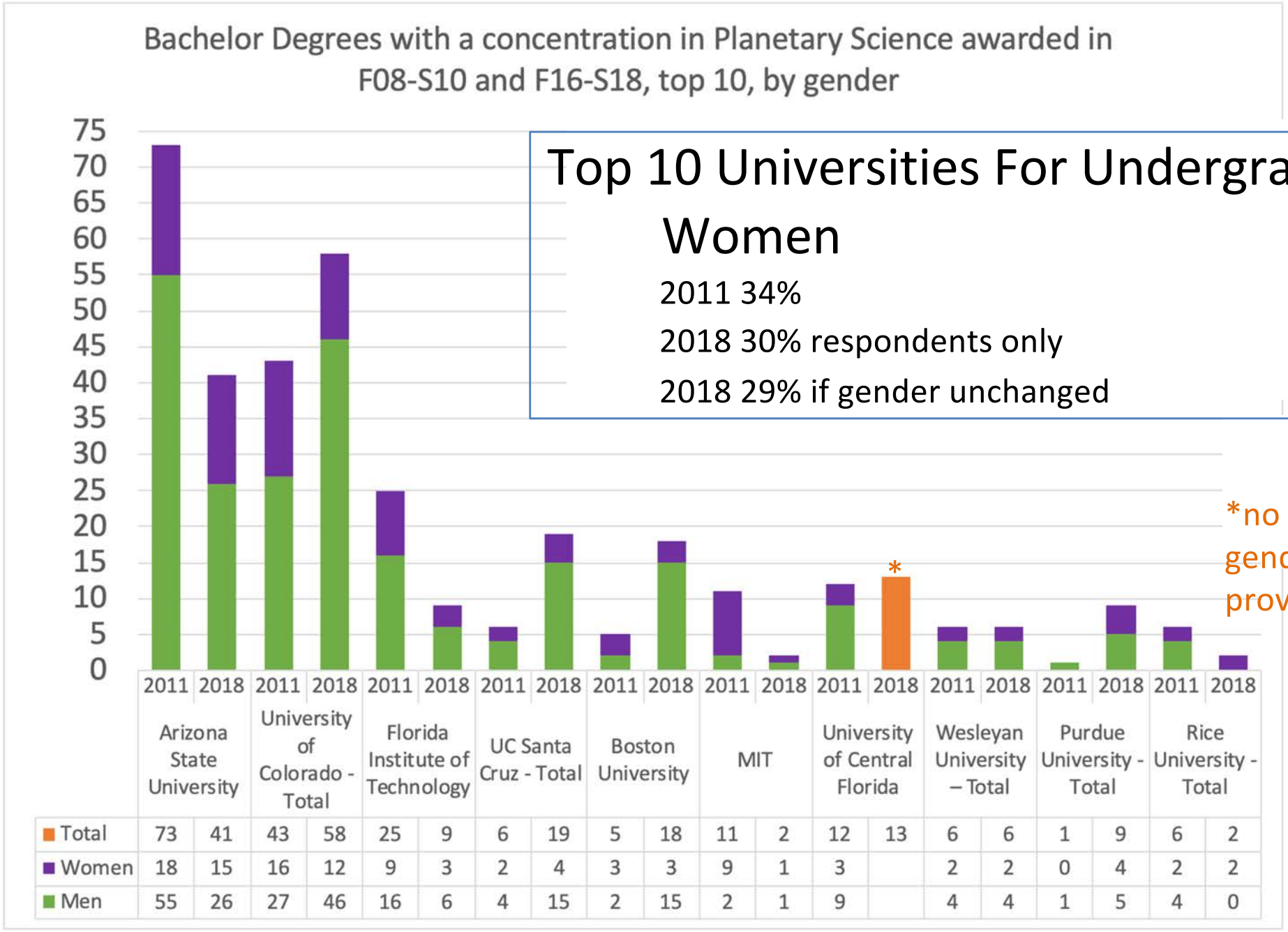
2018 39% if non-respondents unchanged

2011 & 2018 Departmental Surveys: Undergrad



* Assuming no change for non-responding departments

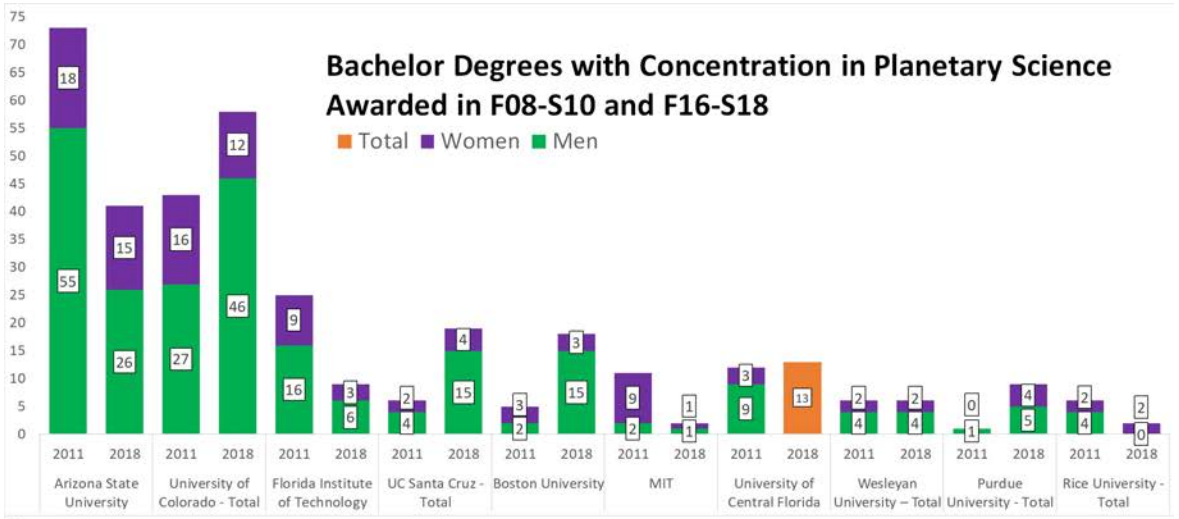
2011 & 2018 Departmental Surveys: Undergrad

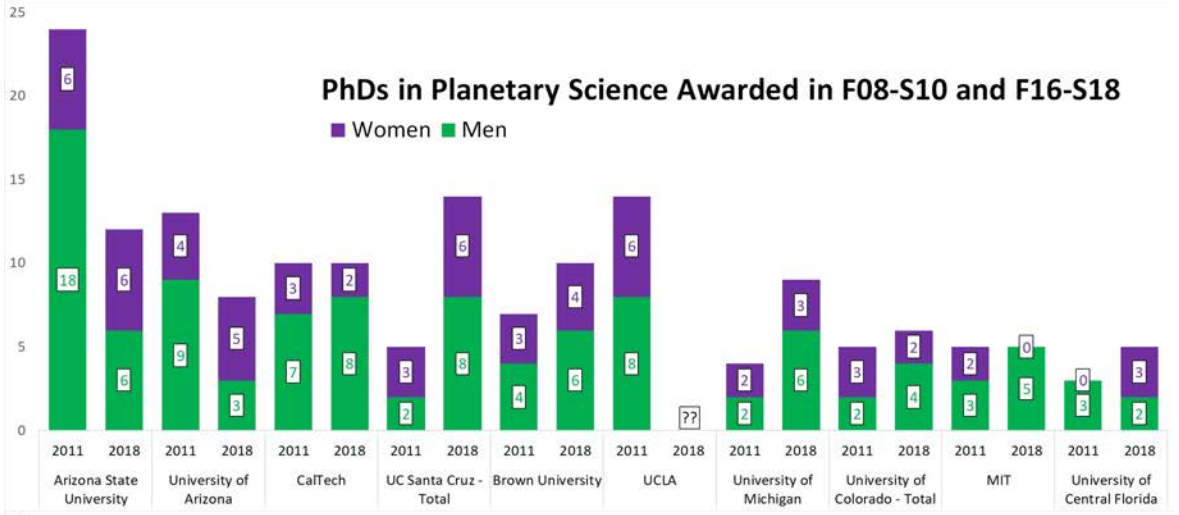


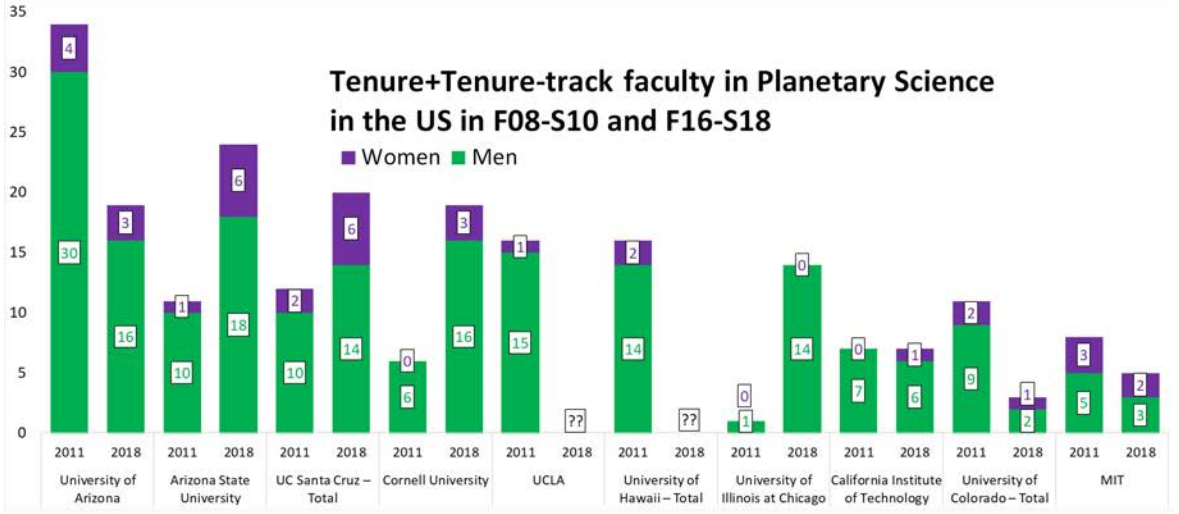
	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018	2011	2018
	Arizona State University		University of Colorado - Total		Florida Institute of Technology		UC Santa Cruz - Total		Boston University		MIT		University of Central Florida		Wesleyan University – Total		Purdue University - Total		Rice University - Total	
Total	73	41	43	58	25	9	6	19	5	18	11	2	12	13	6	6	1	9	6	2
Women	18	15	16	12	9	3	2	4	3	3	9	1	3		2	2	0	4	2	2
Men	55	26	27	46	16	6	4	15	2	15	2	1	9		4	4	1	5	4	0

Counts of (top) bachelors degrees, (middle) PhDs, and (bottom) faculty derived from the two departmental surveys (responses side-by-side). For each category we show top 10 ranked (by total number) departments in the US.

(https://lasp.colorado.edu/home/mop/files/2021/07/DeptComparison2011-2018.pdf)







2011 & 2020 Planetary Workforce Surveys

Primary Goals:

- How many professional PhD planetary scientists are there in the US workforce?
- What are demographics of the workforce? Are they changing?

AIP Planetary Workforce Surveys – 2011 & 2020

2011

Attendees/Members of Planetary Conference/Section

	LPSC	AGU	DPS	All Three
LPSC	1280	345	90	
AGU		264	124	
DPS			358	
All Three				161

- LPSC, DPS, AGU
- US only
- w/PhD
- 62% response
- 71% identify as planetary scientist
- 56% in research

2020

	LPSC	GSA	DPS	All Three
LPSC	1372	122	139	
GSA		113	7	
DPS			587	
All Three				23

- LPSC, DPS, GSA
- 48% response
- Includes students, international

Missing: – Astrobiology

– American Meteoritical Society

– Exoplanets, space physics, ...

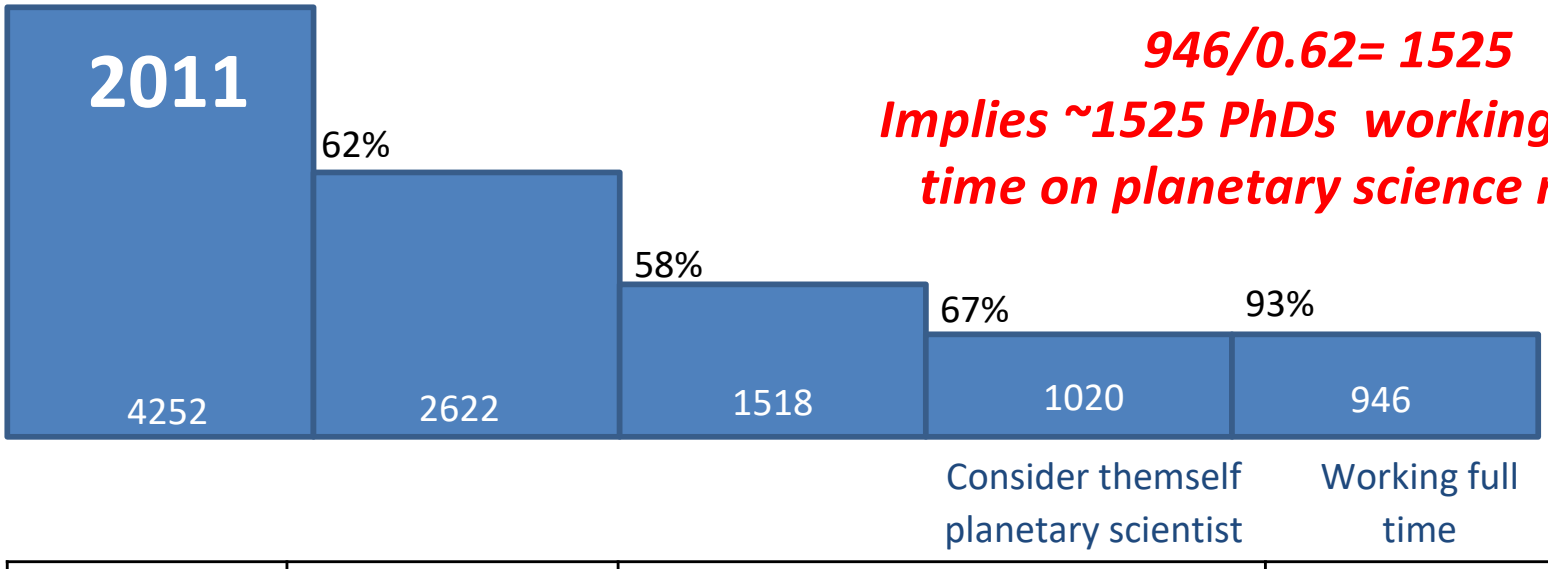
Total Numbers Of Scientists in the Workforce

WARNING!!! These numbers are approximate. The questions in the 2 surveys were different, the populations surveyed were different. Surprisingly, the 2011 and 2020 surveys produced similar numbers.....

Note: This estimate does not include students, engineers, part-time workers, researchers who work in an area related to planetary science (e.g., astrobiology, magnetospheres, sample analysis, etc) but the researchers themselves do not self-identify as primarily planetary scientists – and people outside the 3 mailing lists.

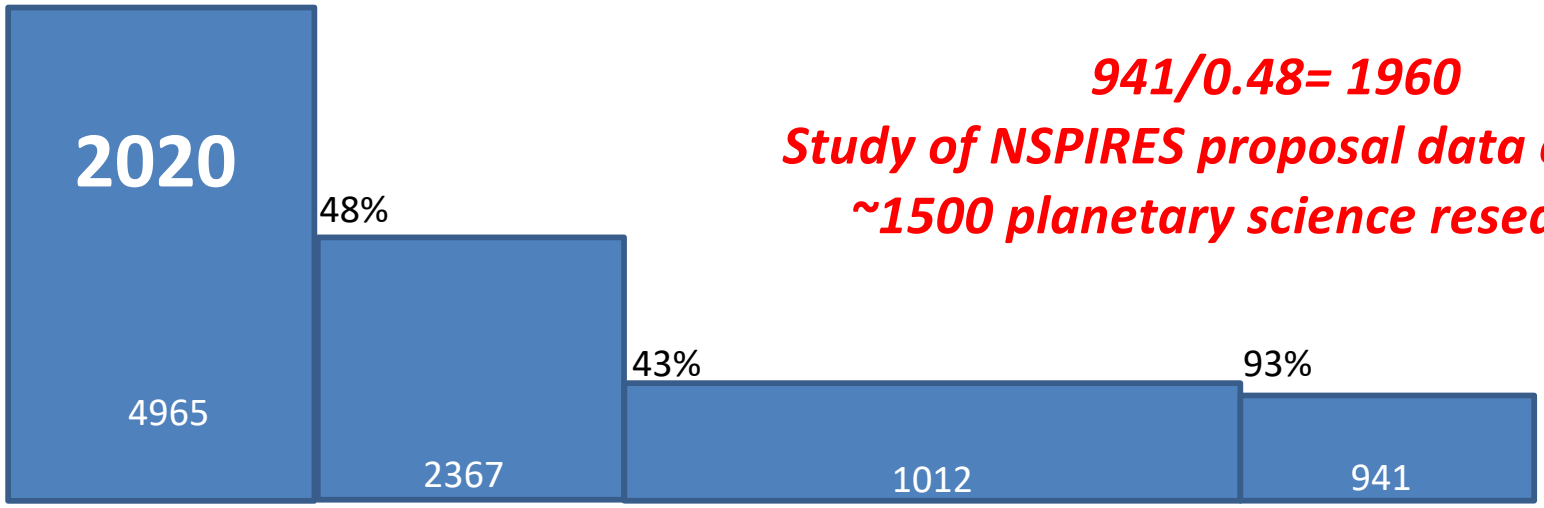
Caveat Emptor!

AIP Planetary Workforce Surveys – 2011 & 2020



946/0.62= 1525

Implies ~1525 PhDs working in US full time on planetary science research



941/0.48= 1960

Study of NSPIRES proposal data estimates ~1500 planetary science researchers

Suggests ~25% growth over decade..... perhaps

AIP survey For 2020: - "in US" = eligible to apply for US funded grants – may exclude post-docs

Need more & better – systematic survey of workforce to find out how many PhD Planetary Scientists in the workforce

Gender & Race/Ethnicity

Planetary Science Demographics 2020

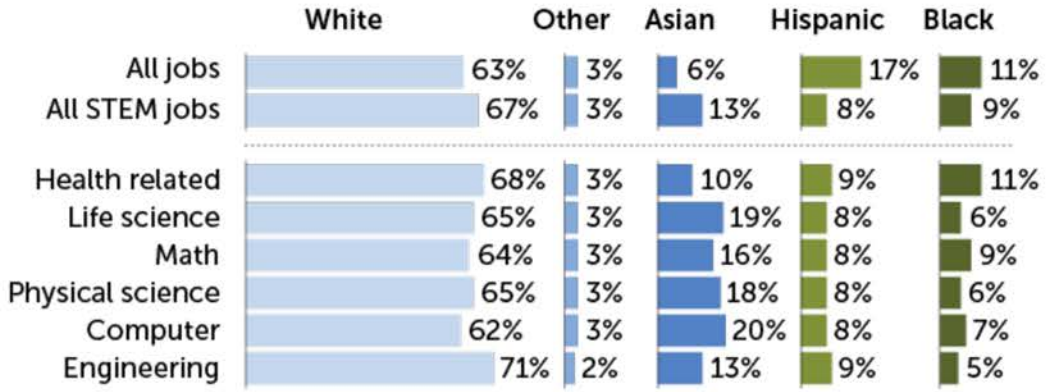
All respondents to 2020 Survey – includes students	Percentage
Male	62%
Female	37%
Other gender identity	1%
LGBTQ+	10%
Disability	15%
White	83%
Asian / Asian American	13%
Latinx / Hispanic	5%
American Indian or Alaska Native	1%
Black / African American	1%
Native Hawaiian / other Pacific Islander	<1%
Other race / ethnicity	4%

Planetary Science Demographics

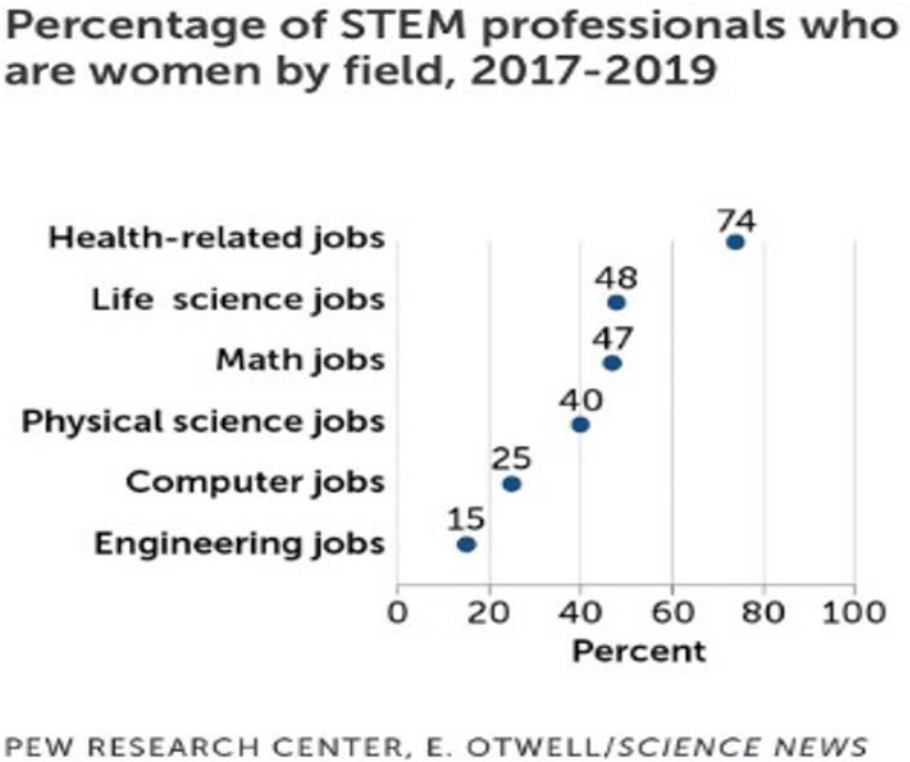
Rivera-Valentin et al. 2021

Demographic	% in survey
White	83%
Women	35%
Nonbinary	0.7%
Asian American/Pacific Islander	11%
Latinx / Hispanic	4%
Black / African American	1%
American Indian / Alaskan Native	0.6%

2020 Planetary Workforce



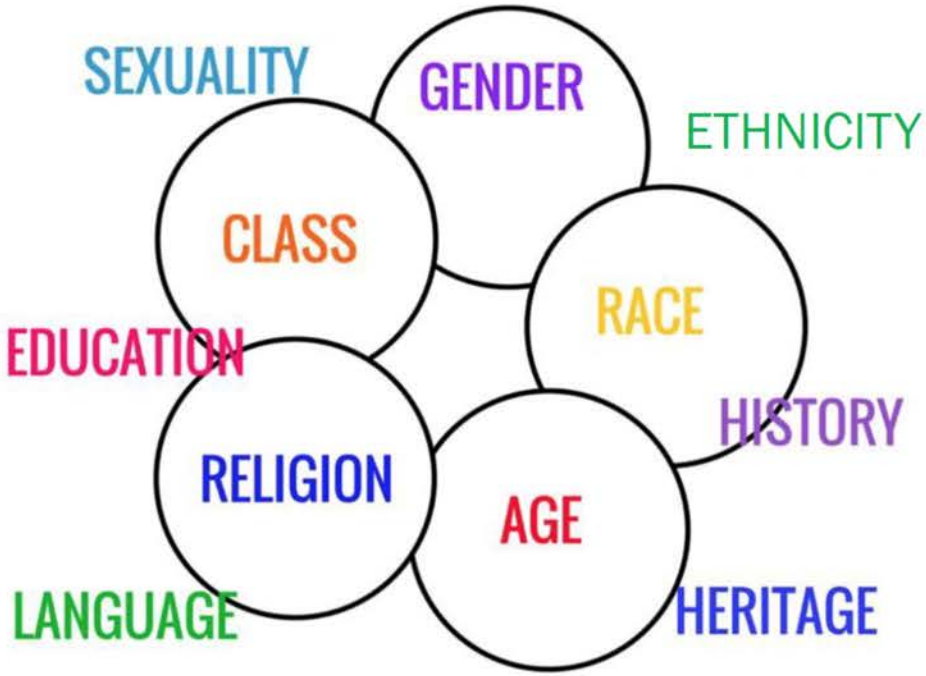
Pew Research Center, E. Otwell/Science News
https://www.sciencenews.org/article/science-technology-math-race-ethnicity-gender-diversity-gap



Acknowledge Intersectionality

Rathbun et al. 2021a,b

- There are multiple axes an individual can be affected by
- Culture and therefore location impacts which biases are prominent
- Important to acknowledge that people are complex



"For every 3 white men that make it through the pipeline, there is 1 white woman. But, for every 20 white women, there are only 1-2 women of color. This means that more than 95% of potentially talented women of color are being left behind and thus are unable to contribute to the planetary science community."
Julie Rathbun, White Paper

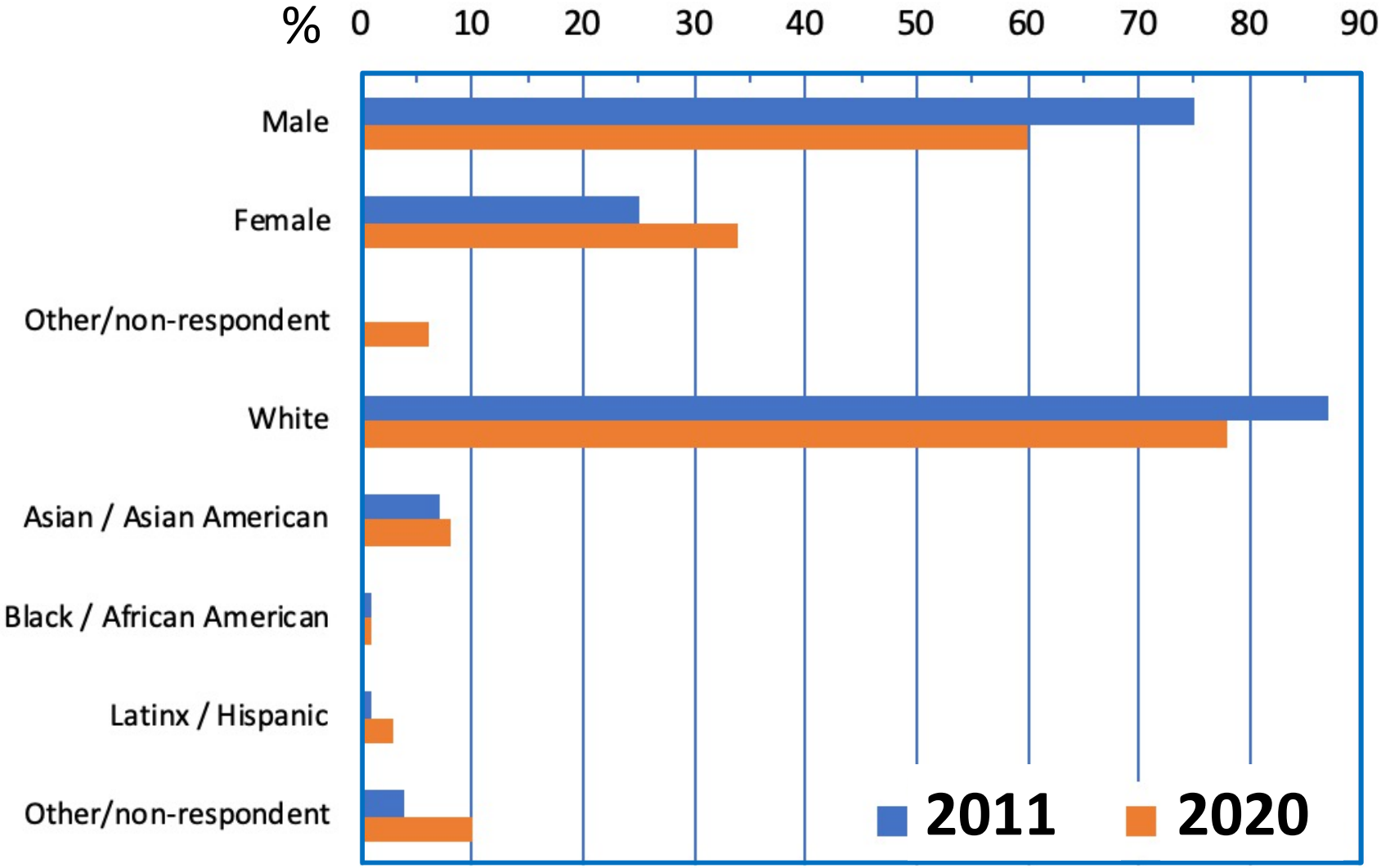
Planetary Science Demographics 2020

	Underrepresented Groups in Planetary Science		Not Underrepresented in Planetary Science	
	Black, African American, or Other Race/Ethnicity*	Hispanic or Latinx	Asian or Asian American	White
Women	48%	50%	38%	37%
Men	51%	47%	62%	62%
Another Gender Identity	1%	3%	0%	1%

* Findings were statistically significant, $p < .05$. Other Race/Ethnicity included respondents who are Native American/Alaska Native, Native Hawaiian/Other Pacific Islander, or wrote in another race/ethnicity. These groups were too small to report separately and were combined for analysis.

Planetary Science Demographics

~1500-2000 have PhD & work in US*



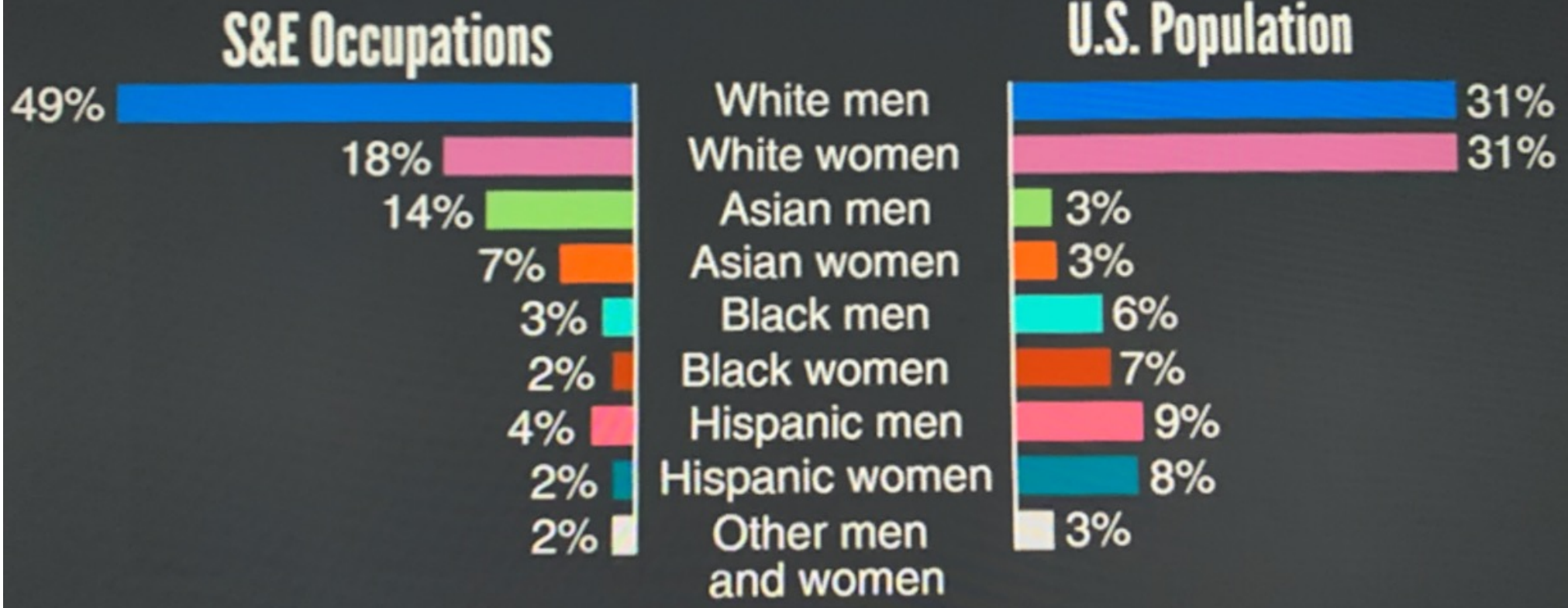
**AIP survey For 2020: - limited to those with PhDs*

- "in US" = eligible to apply for US funded grants – may exclude postdocs

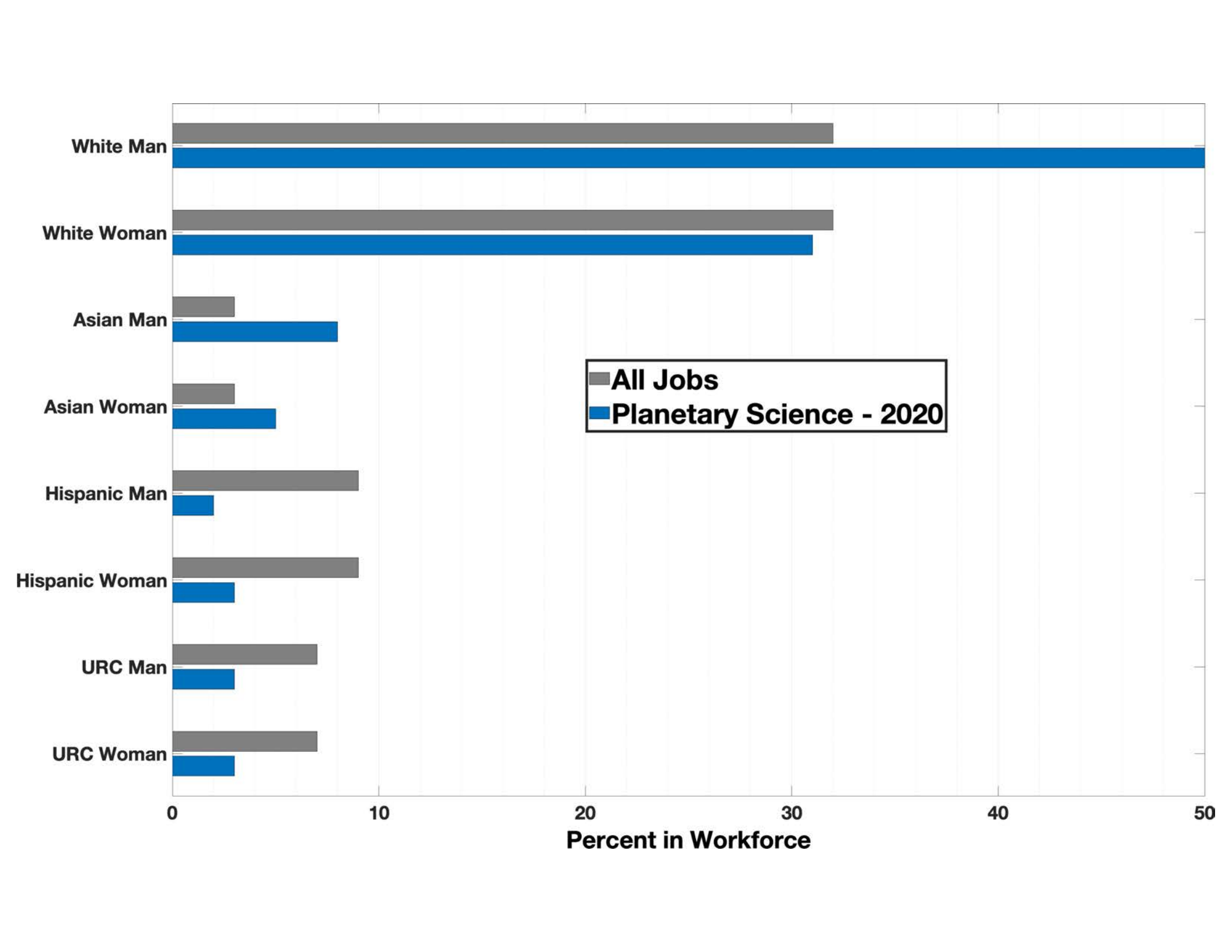
- Disability reported by 1.4% PhD, in US

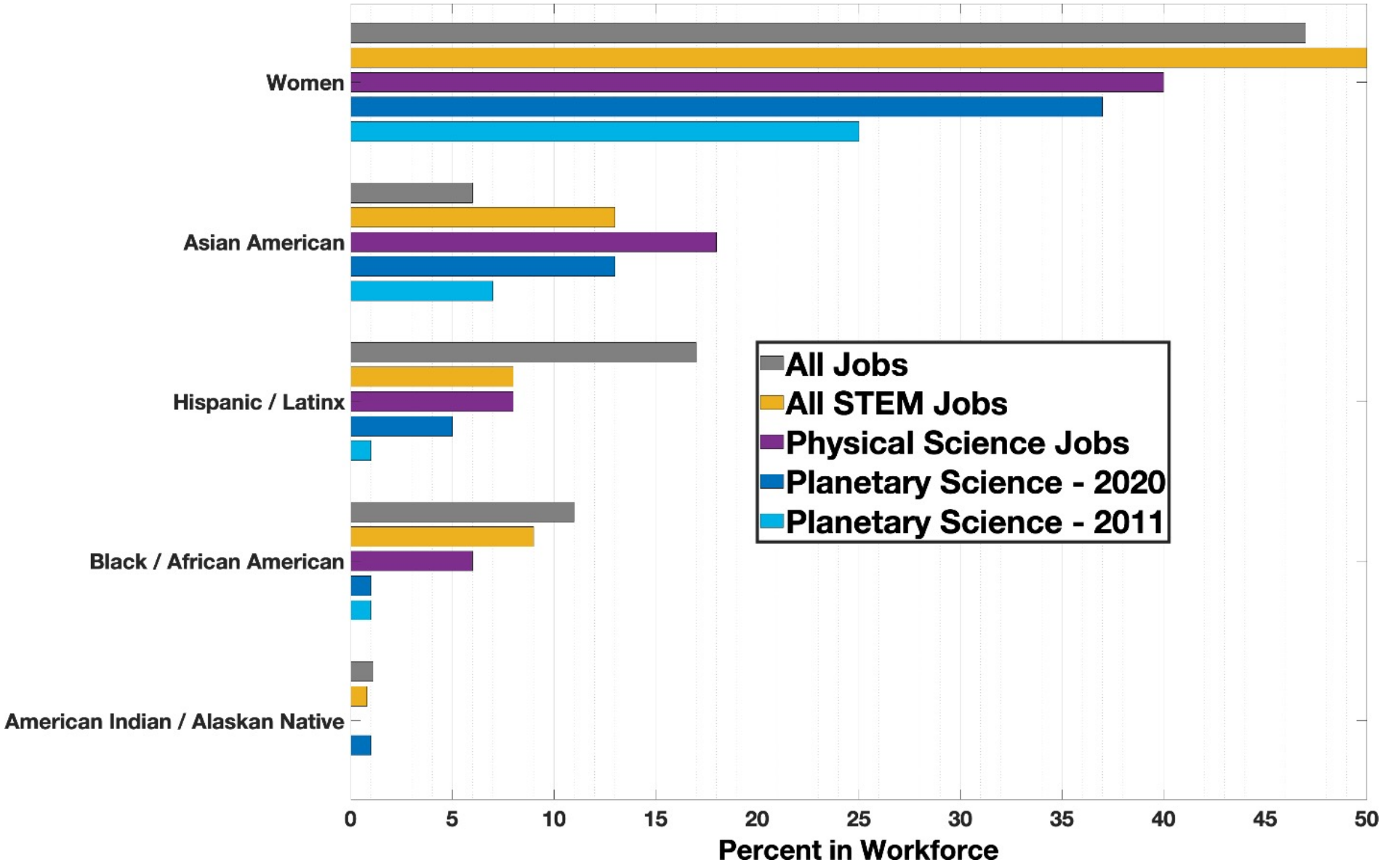
Workers in science and engineering occupations

In 2015, women and some minority groups were represented less in science and engineering (S&E) occupations than they were in the U.S. general population.



Source: National Center for Science and Engineering Statistics, National Science Foundation
Women, Minorities, and Persons with Disabilities in Science and Engineering: 2017
https://nsf.gov/statistics/wmpd/


White Man
White Woman
Asian Man
Asian Woman
Hispanic Man
Hispanic Woman
URC Man
URC Woman
All Jobs
Planetary Science - 2020
0
10
20
30
40
50
Percent in Workforce



Demographics, by women, race, and ethnicity, of the planetary science workforce from the 2011 and 2020 surveys compared to the demographics of physical science jobs, all STEM jobs, and all US jobs as reported by a Pew Research Center study. Note that data for American Indian/Alaskan Native is from a NASA report on the demographics of its workforce. Data is lacking for physical sciences and from the 2011 planetary science survey for American Indian/Alaskan Natives.

Demographics of the planetary science workforce be year of Ph.D. degree conferral as presented in the 2020 AIP planetary science workforce study.

Year of Degree	Black, African American or other race /ethnicity[1]	Hispanic/Latinx	Asian American	LGBTQ[2]
1970 or earlier	5%	0%	3%	4%
1971 - 1980	3%	0%	5%	4%
1981 - 1990	3%	3%	4%	2%
1991 - 2000	4%	2%	11%	6%
2001 - 2010	4%	5%	10%	6%
2011 - 2020	5%	6%	17%	12%

[1]Other race/ethnicity included respondents who are Native American/Alaskan Native, Native Hawaiian/Other Pacific Islander, or wrote in another race/ethnicity.

[2]LGBTQ included respondents who are gay, lesbian, bisexual, transgender, nonbinary or another gender identity, or another sexual orientation.

Planetary Science Demographics 2020

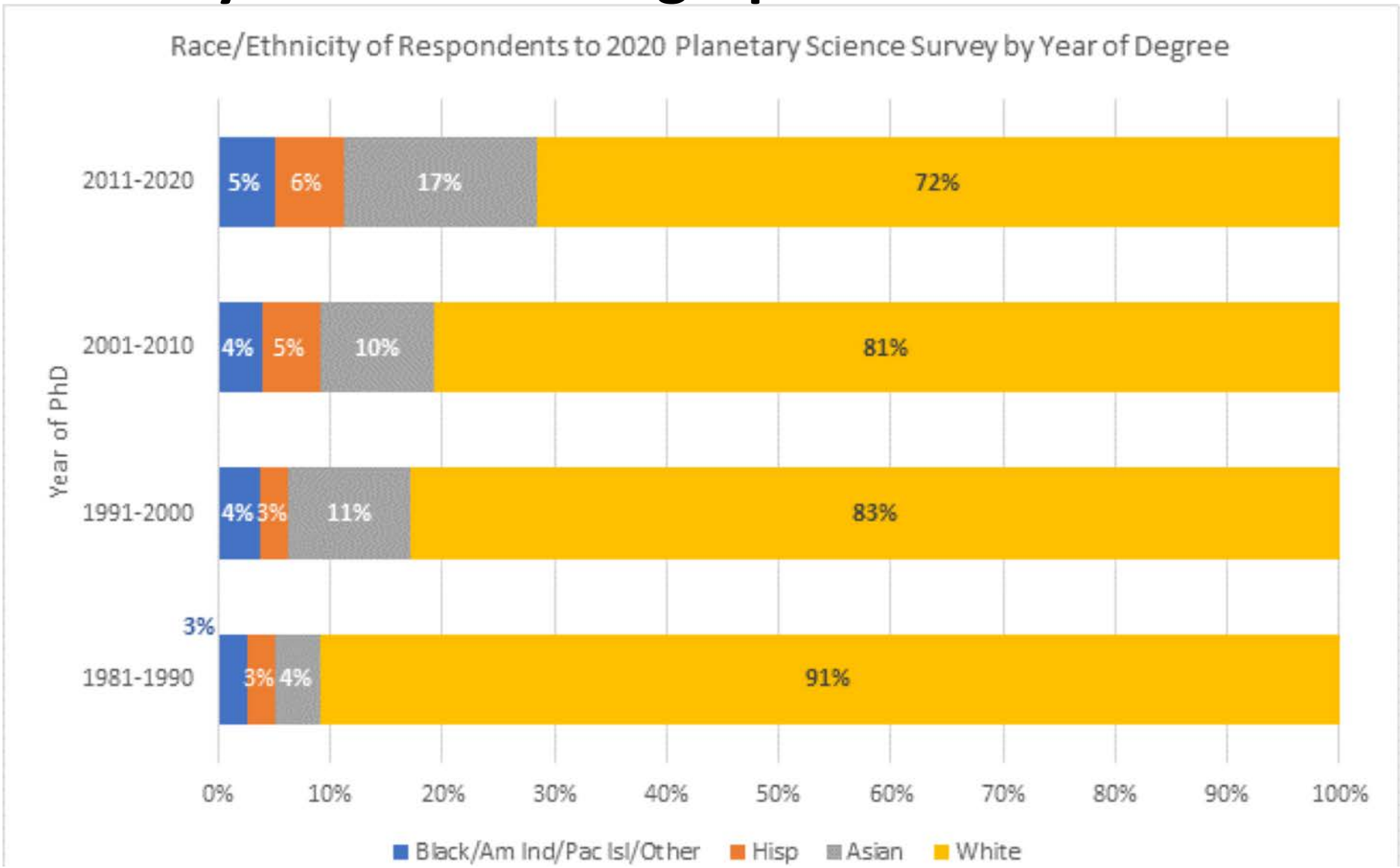


Chart of PhDs who are US citizens/residents. For the 122 who checked multiple races, we used this hierarchy:

1) Hispanic or Latinx + any other race as Hispanic (86% of these selected white as their second race)

2) After doing that: Asian or Asian American + any other race/ethnicity (except Hispanic) as Asian (79% of these also selected white)

3) All others into Black / American Indian / Pacific Islander / Other

2020 Survey: Year of Highest Degree

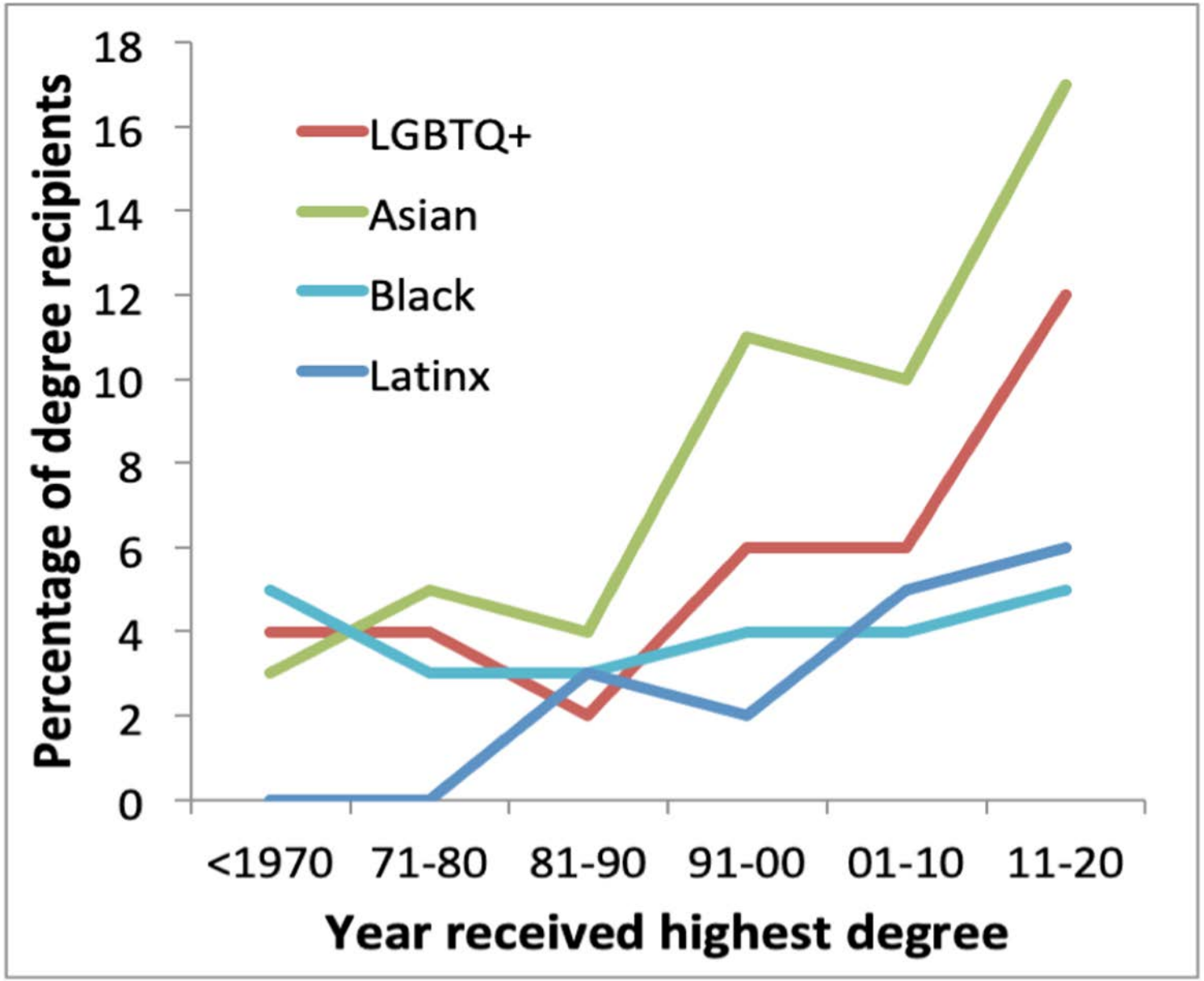
Percent of all respond-ents	Year of Degree	LGBTQ+	Black, African American, or Other Race/Ethnicity*	Hispanic or Latinx	Asian or Asian American	White
5%	<1970	4%	5%	0%	3%	92%
7%	1971-1980	4%	3%	0%	5%	92%
13%	1981-1990	2%	3%	3%	4%	90%
18%	1991-2000	6%	4%	2%	11%	83%
22%	2001-2010	6%	4%	5%	10%	81%
35%	2011-2020	12%	5%	6%	17%	72%

Percentage of all respondents who obtained highest degree in year range

Percentage of degrees awarded to groups underrepresented in planetary science

Percentage of degrees awarded to groups not underrepresented in planetary science

2020 Planetary Science Survey
Demographics of Ph.Ds



All but Black population show increase with time

Latinx growth is less than US population

Rivera-Valentin et al. 2021

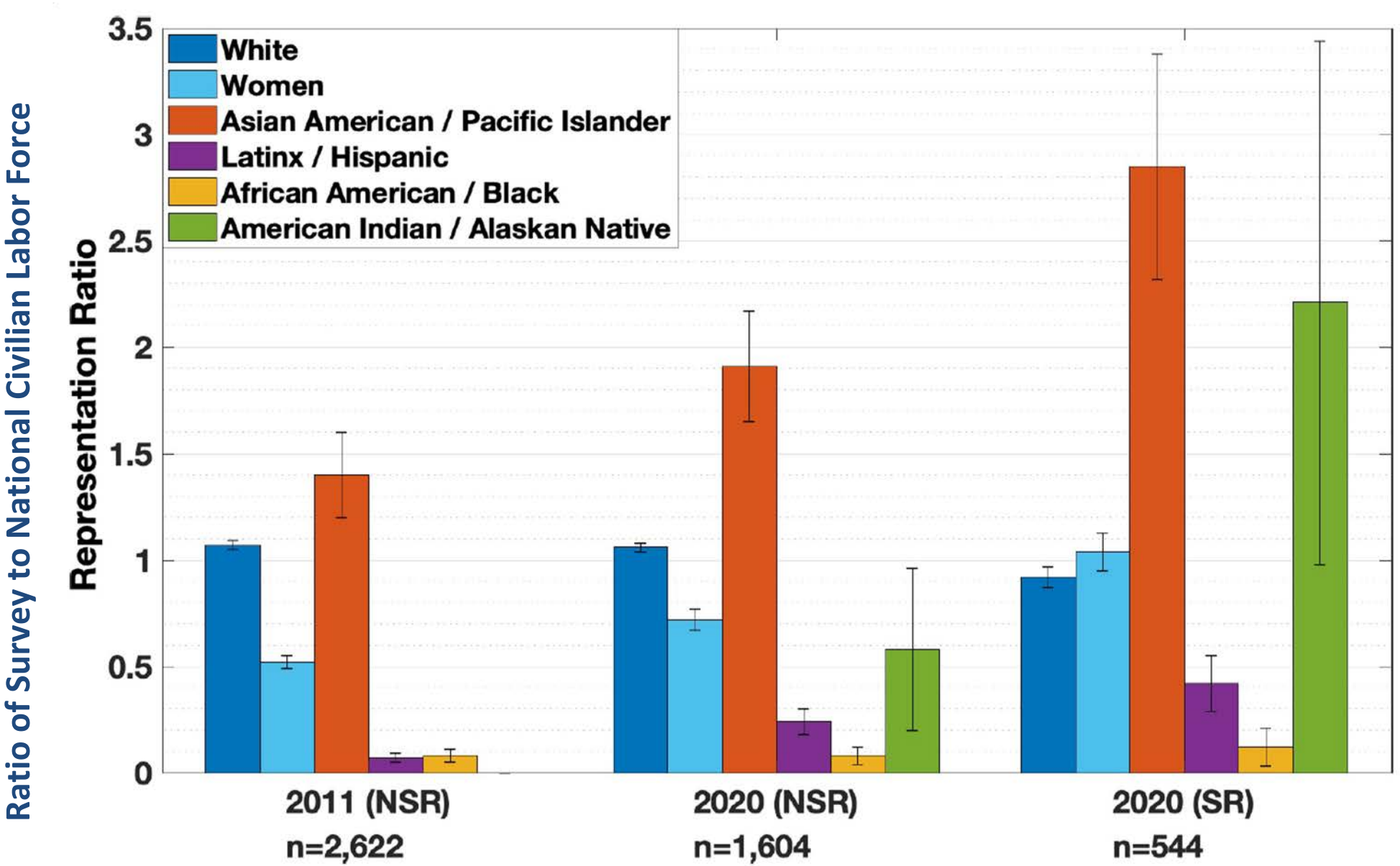
Planetary Science Demographics

Demographic	2020 Planetary Workforce % in survey*	National Civilian Labor Force % in NCLF
White	83%	78%
Women	35%	49%
Nonbinary	0.7%	*No data*
Asian American/Pacific Islander	11%	6%
Latinx / Hispanic	4%	17%
Black / African American	1%	11%
American Indian / Alaskan Native	0.6%	1%

* Excluding responses from students

Planetary Science Demographics

Rivera-Valentin et al. 2021

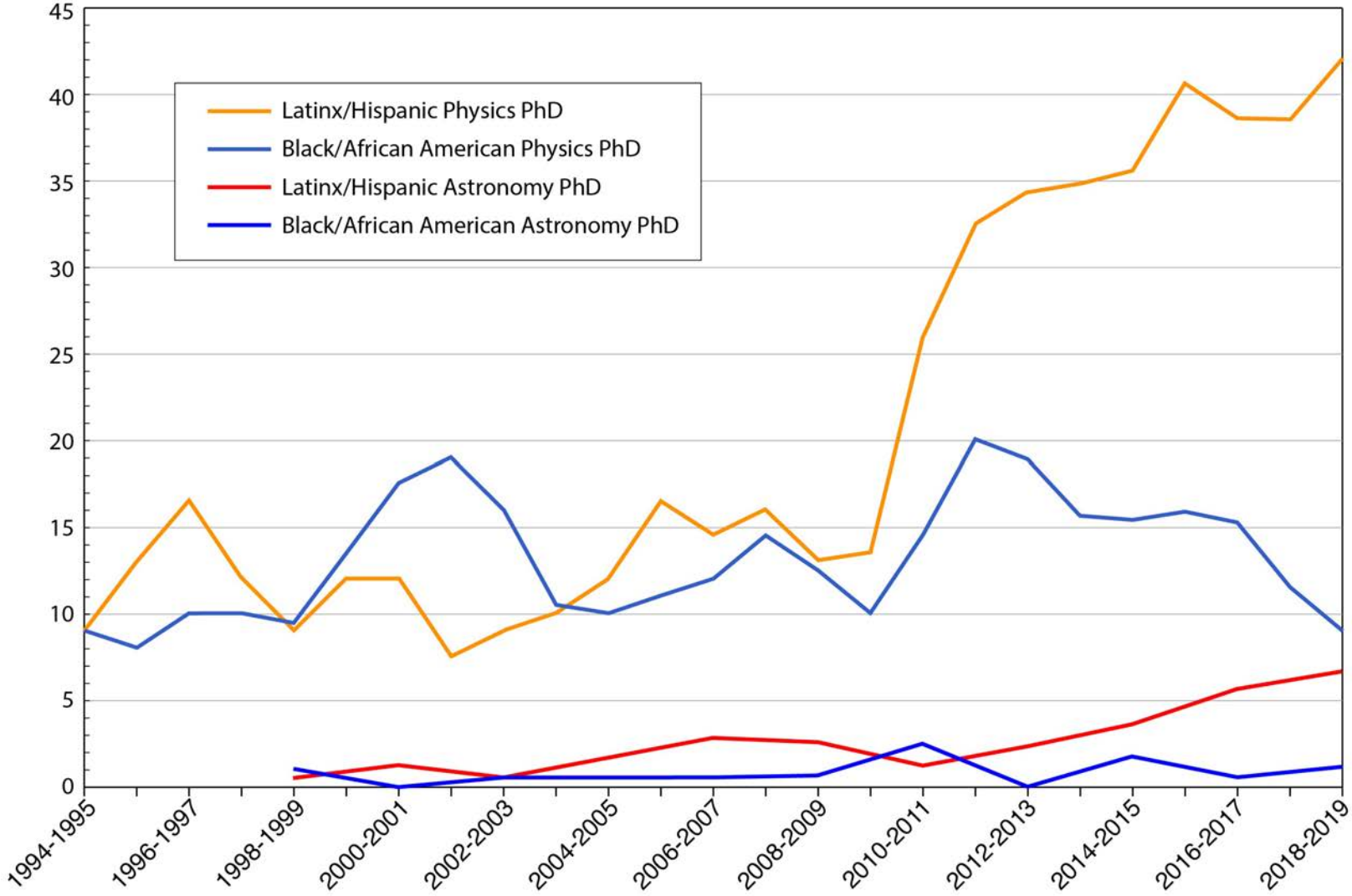


NSR = Non-Student Researchers

SR = Student Researchers

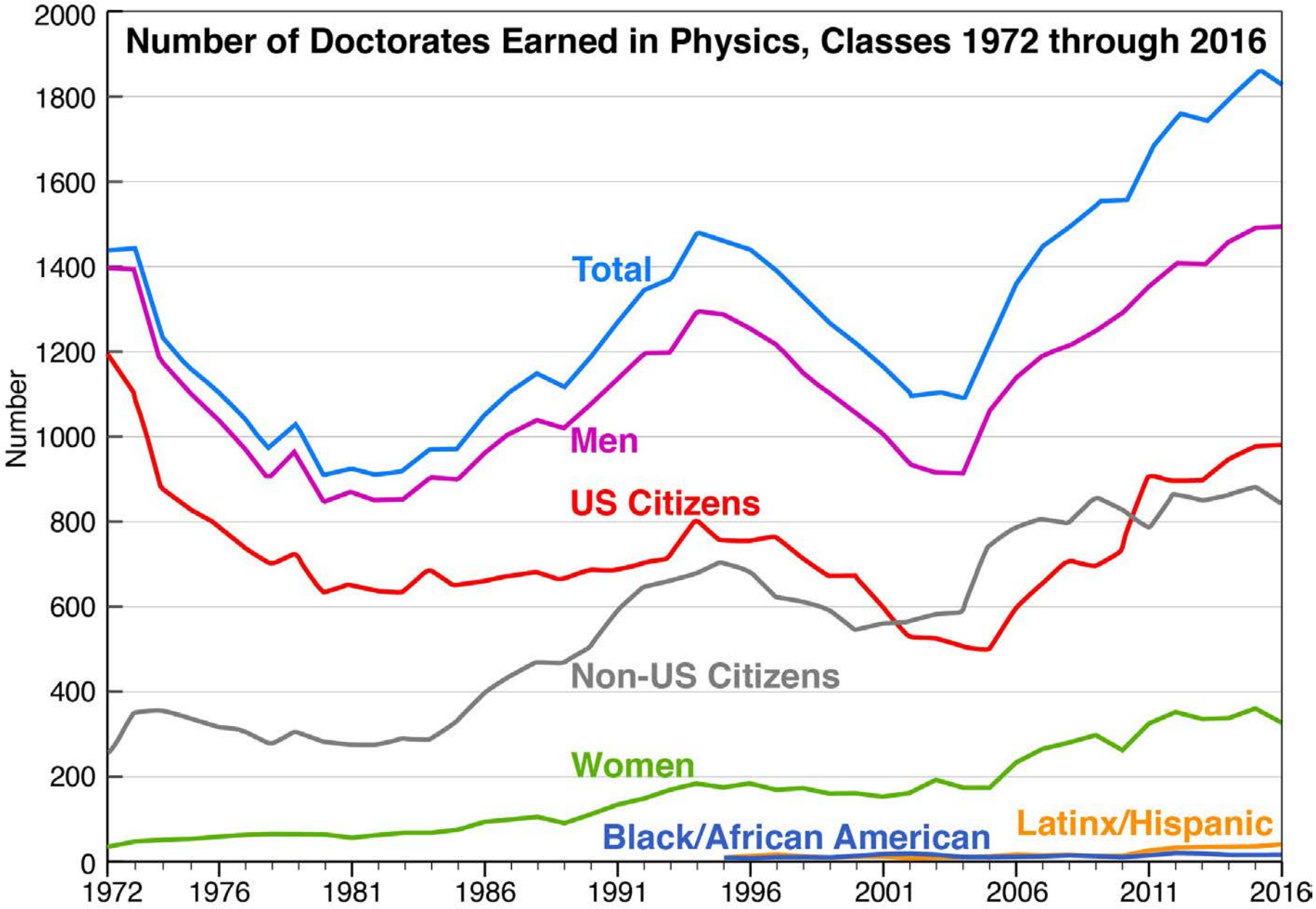
- ***Student population more diverse***
- ***2020 more diverse than 2011***

Number of PhD Degrees for Latinx/Hispanic & Black/African Americans in Physics and in Astronomy

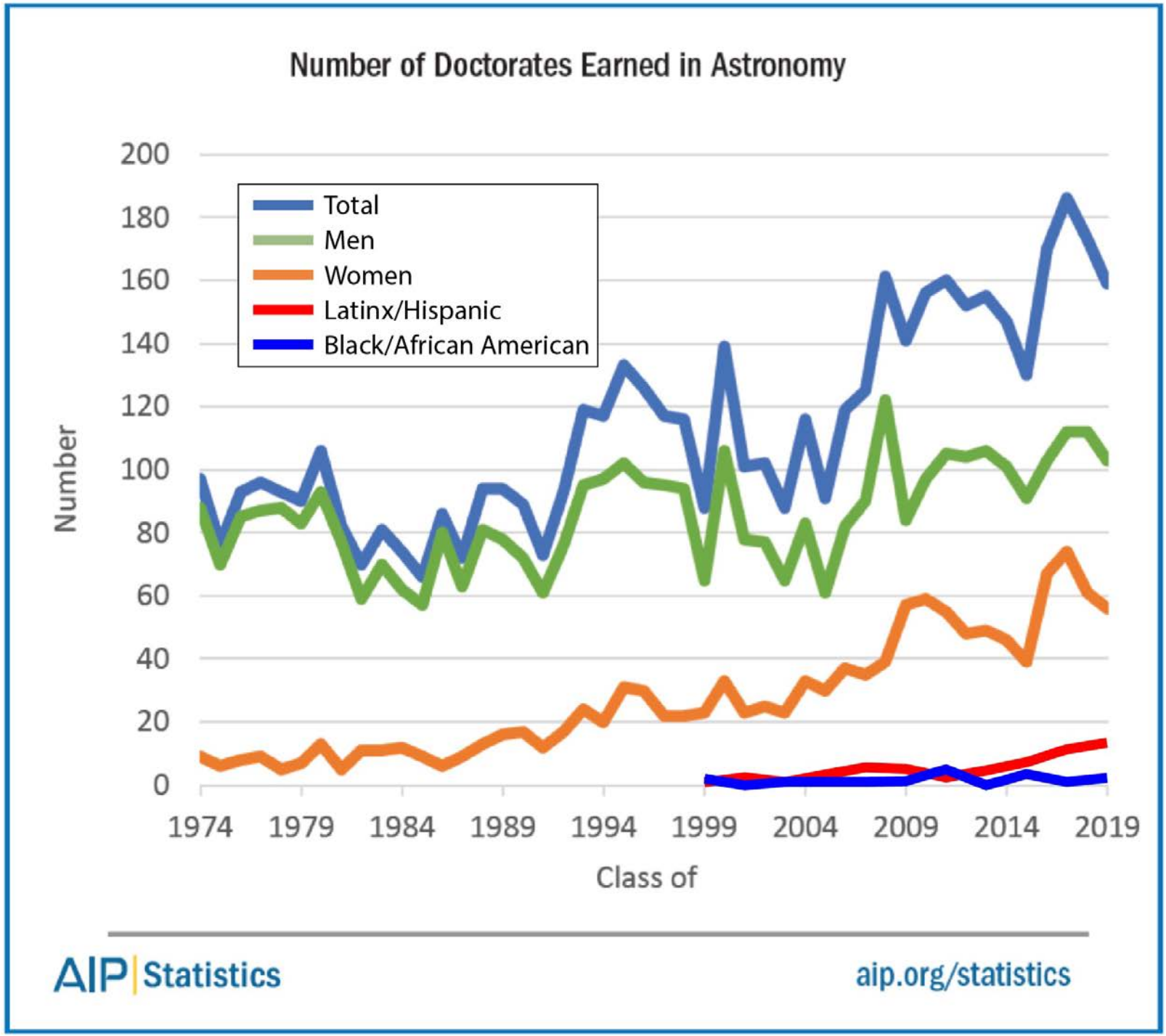


Astronomy numbers 2-year averages because of small numbers

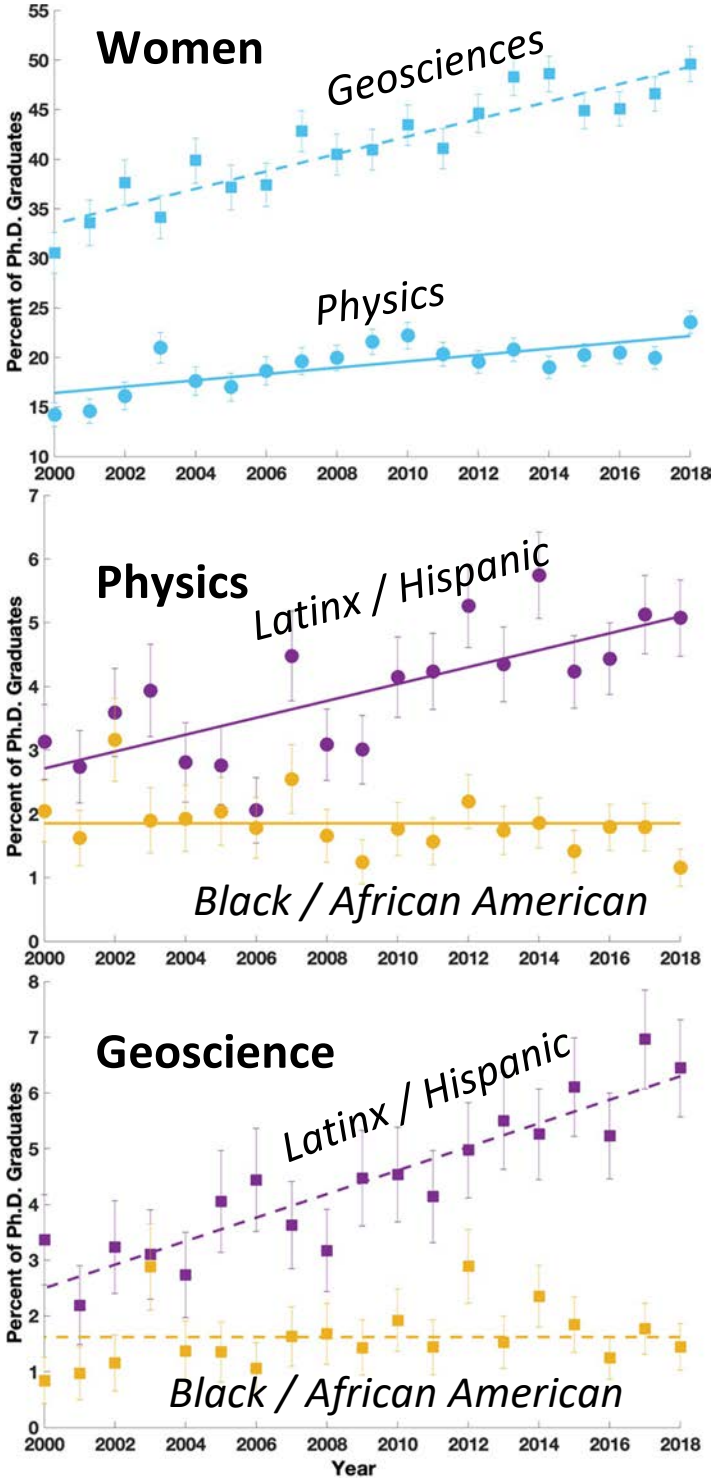
AIP – Statistics



AIP – Statistics


Number of Doctorates Earned in Astronomy
200
180
160
140
120
100
80
60
40
20
0
Number
Total
Men
Women
Latinx/Hispanic
Black/African American
1974
1979
1984
1989
1994
1999
2004
2009
2014
2019
Class of
AIP Statistics
aip.org/statistics

Rivera-Valentin et al. 2021

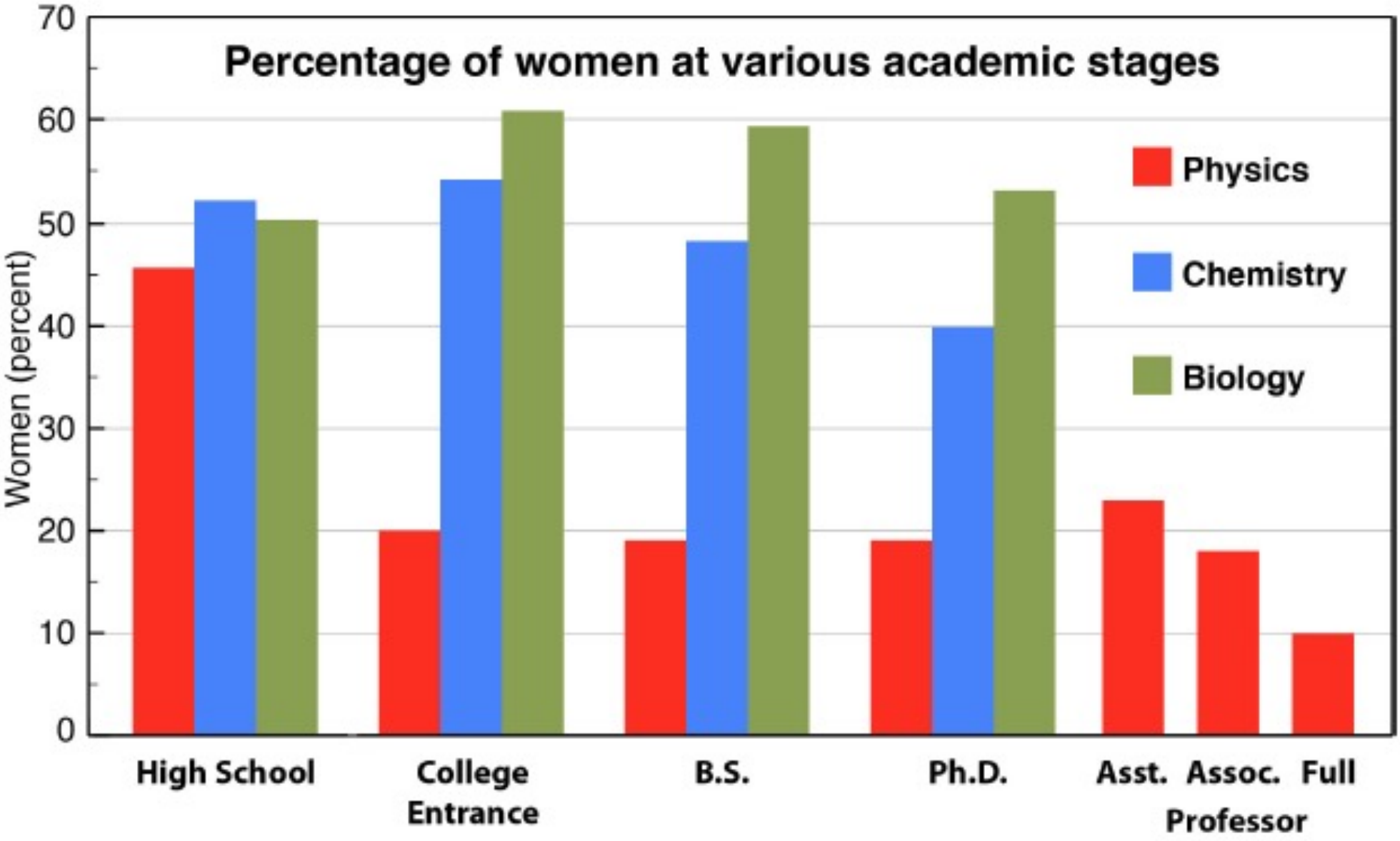


Student Demographics

	2020 Planetary Science Student Researchers	2020 Geoscience PhD	2020 Physics PhD
Women	50%	50%	24%
Latinx / Hispanic	7%	6%	5%
Black / African American	2%	1.4%	1.2%

- ***All but Black population show increase with time***
- ***Latinx growth is less than US population***

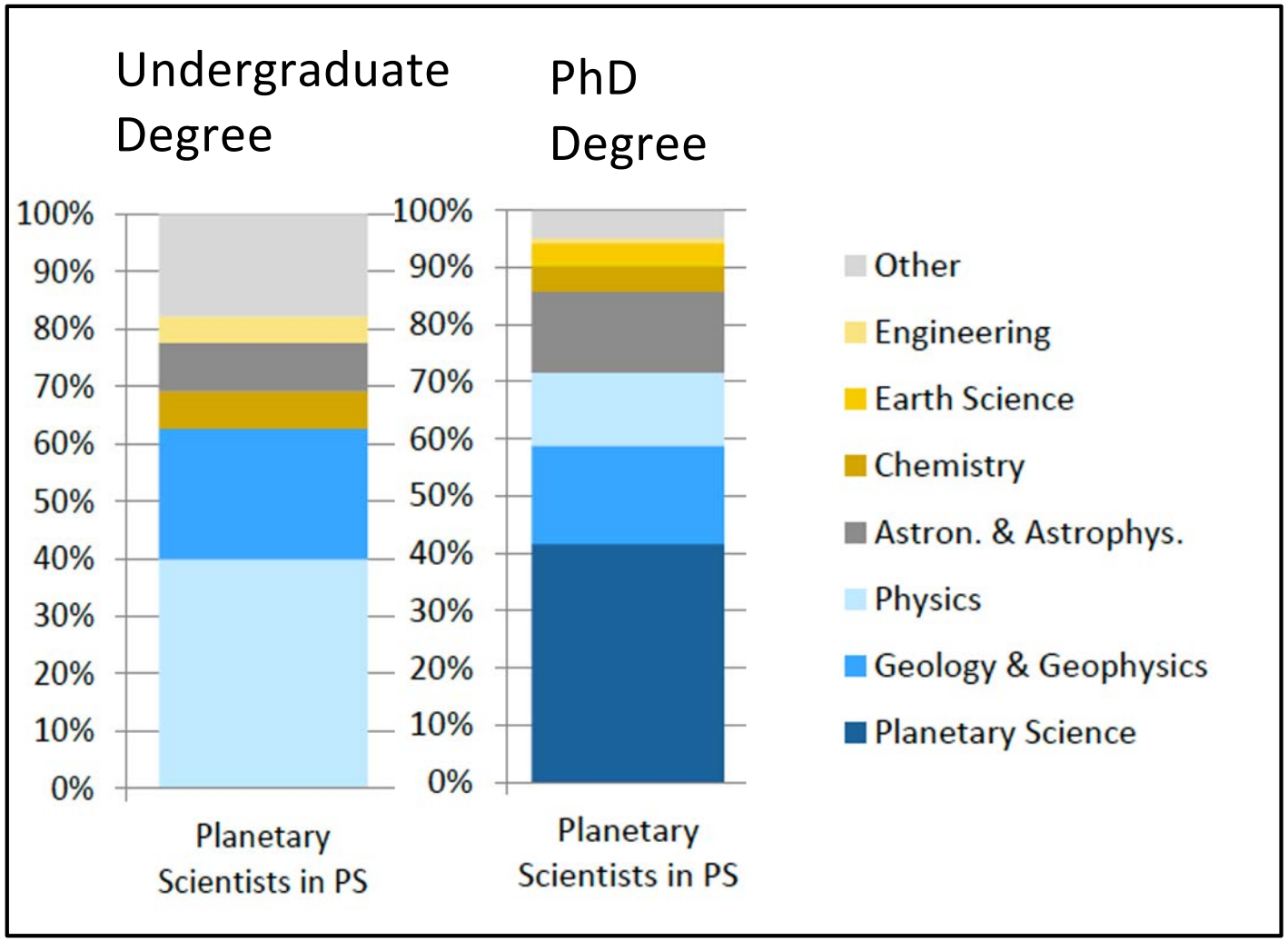
Data from NSF's National Center for Science and Engineering Statistics https://ncsesdata.nsf.gov/ids/sed



AIP, HERI, & IPEDS.
https://www.aps.org/programs/education/su4w/upload/stepup4women-020318.pdf
https://www.aip.org/statistics/reports/women-among-physics-and-astronomy-faculty

Area of Degree & Research

2011 Planetary Survey

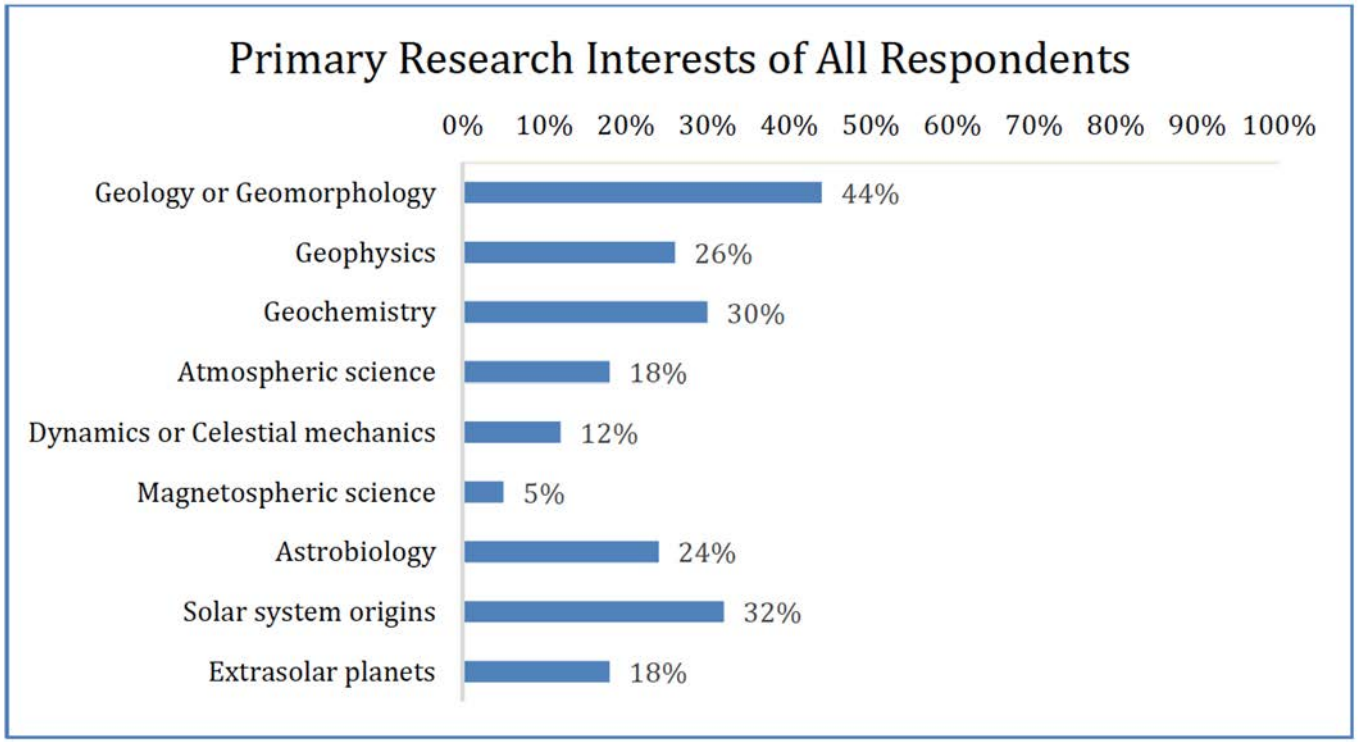


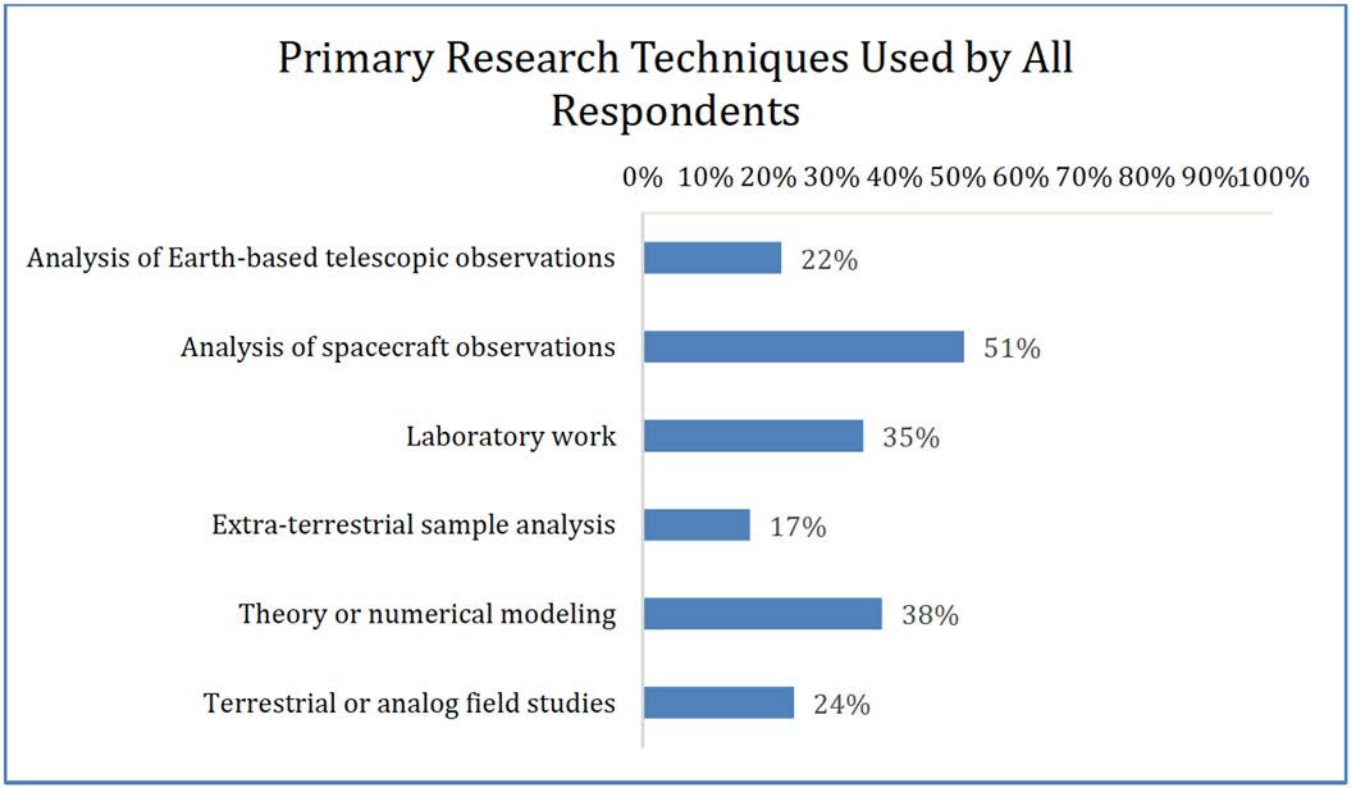
Respondents limited to having PhD & working in US & identify as planetary scientist

Planetary Science is very interdisciplinary

2020 Planetary Survey

- LPSC, DPS, GSA
- Not AGU
- Includes students, international

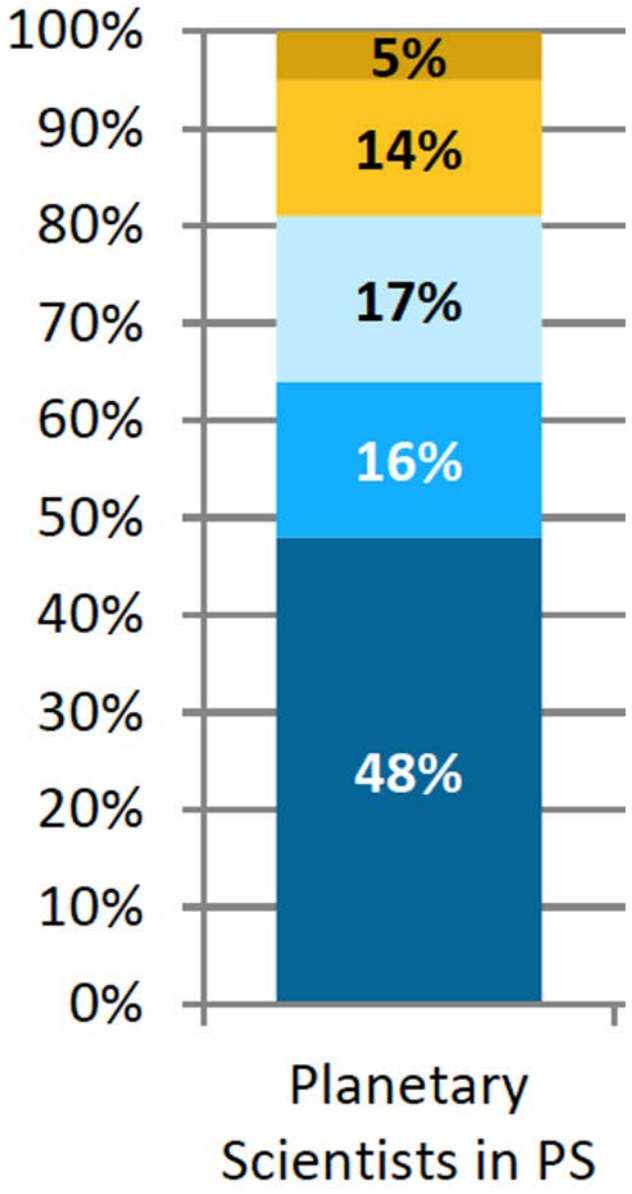




Employment

2011 Planetary Survey

Respondents limited to having PhD & working in US & identify as planetary scientist

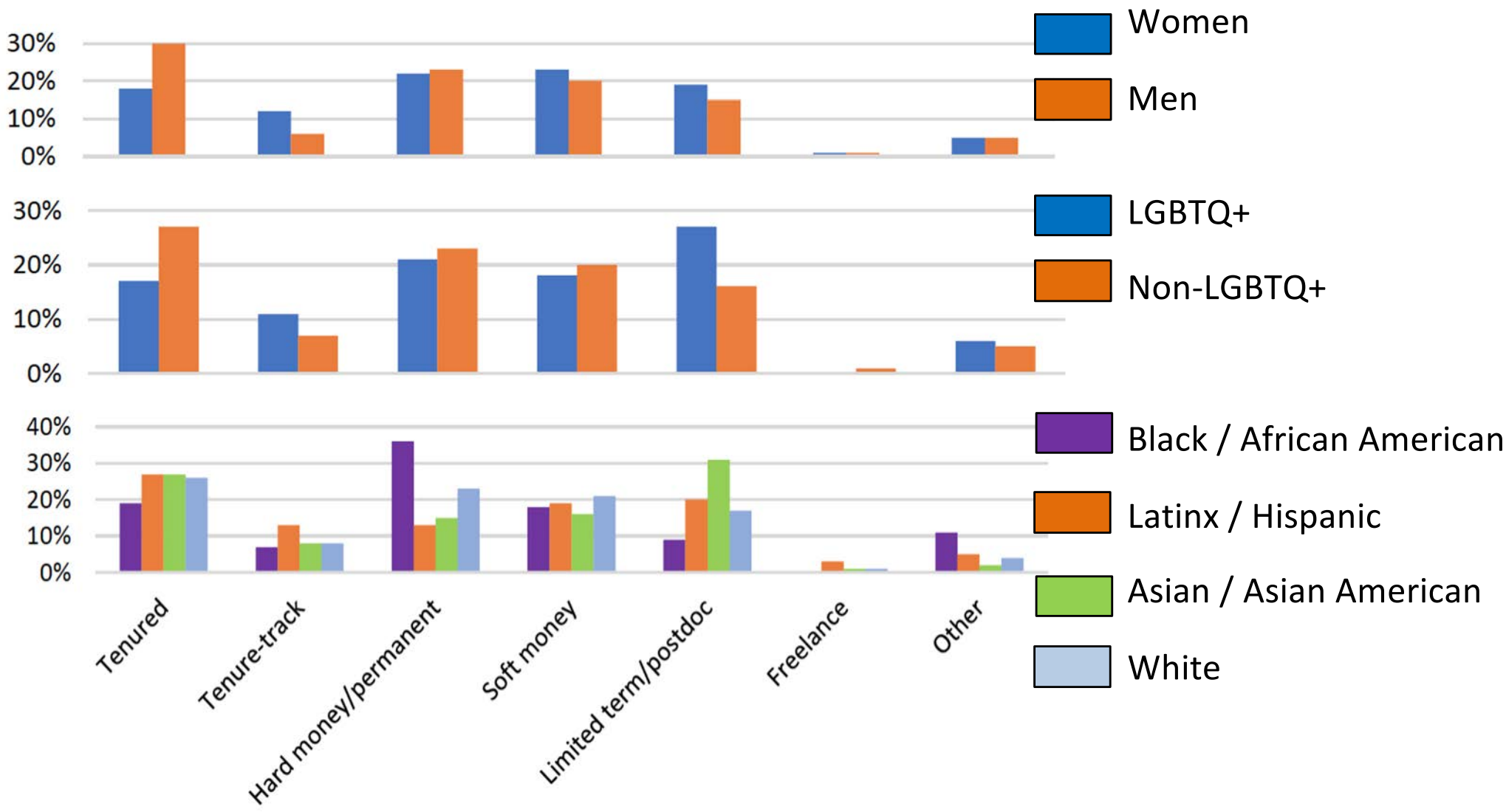


EMPLOYMENT

- Industry & Other
- NASA labs
- FFR&DCs & Other Fed. Labs - includes JPL, APL, LPI
- Non-profit - includes SwRI, SSI, PSI
- University

Contrary to public viewpoint, relatively few planetary scientists work at NASA labs.

2020 Planetary Survey

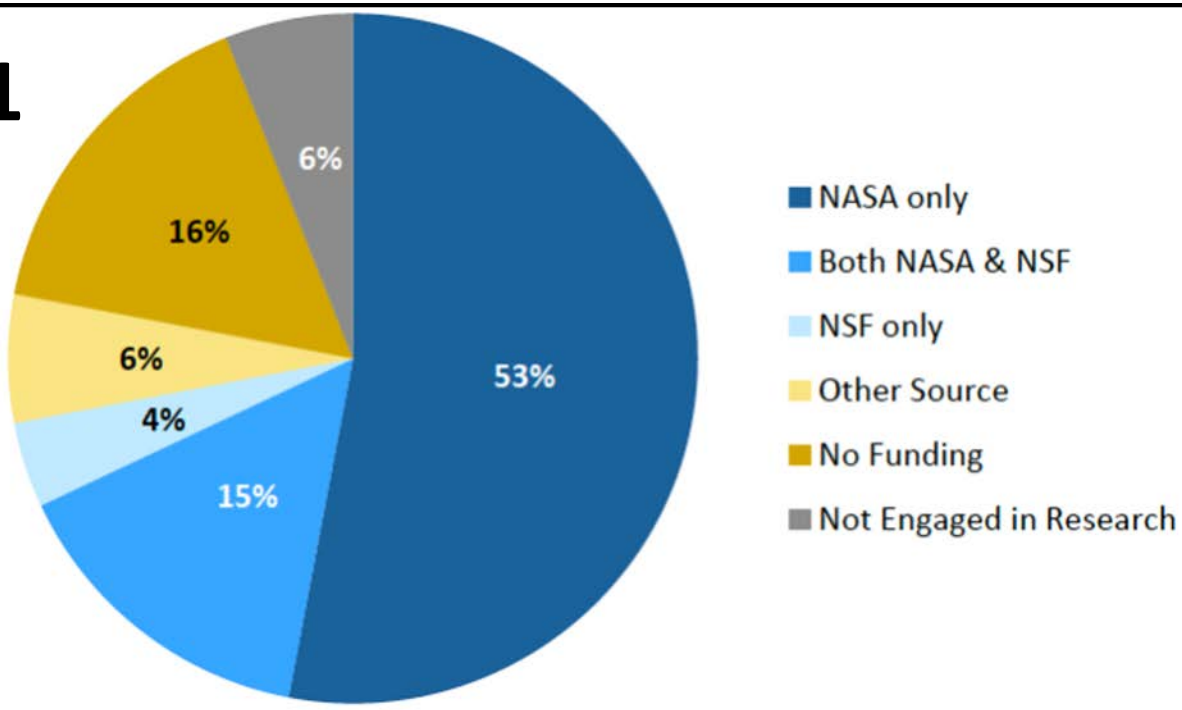


Position Type

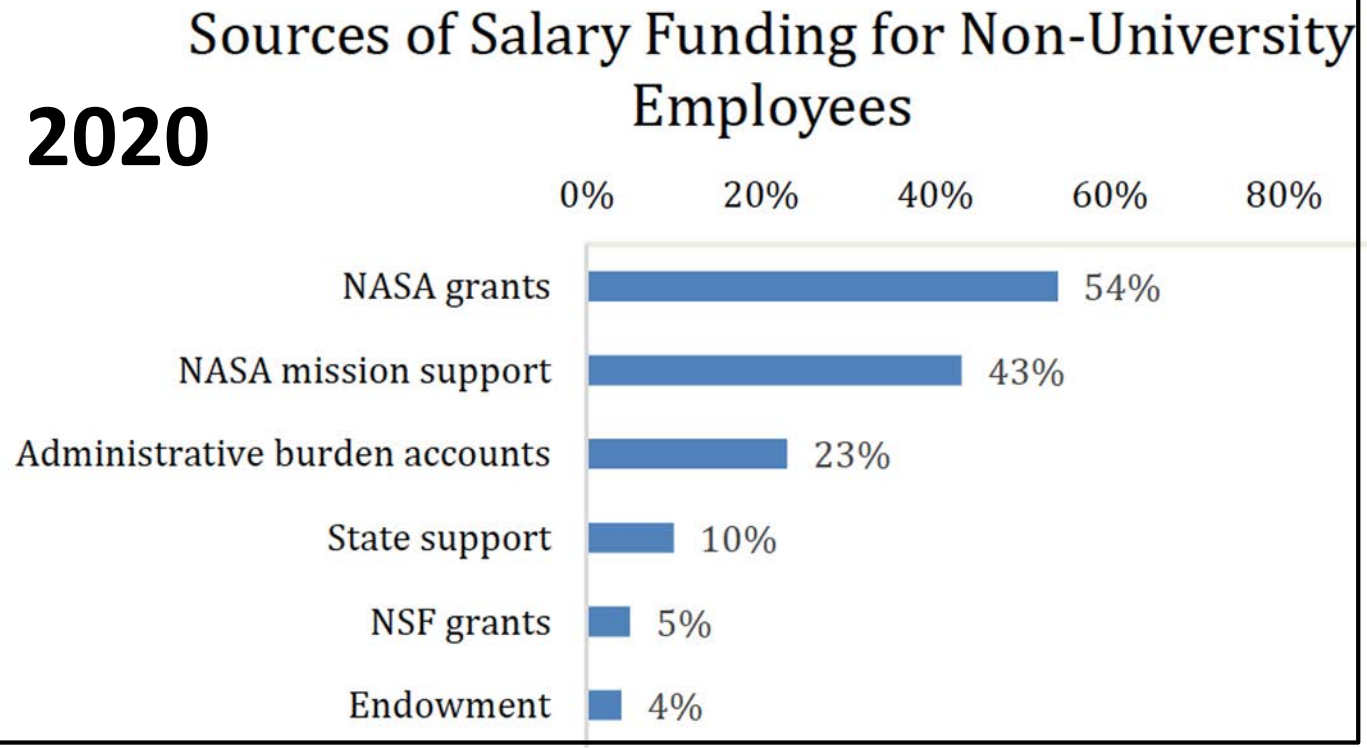
Planetary Surveys

Source of Funds to Support Research

2011



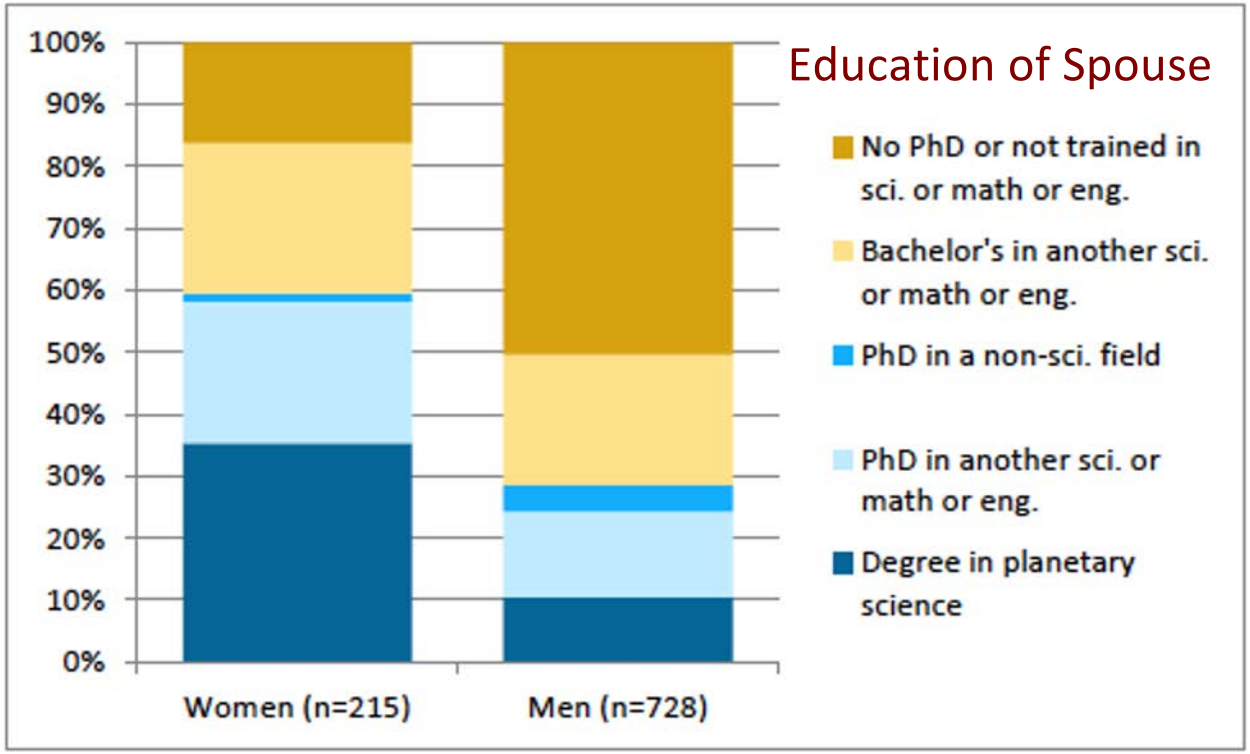
2020

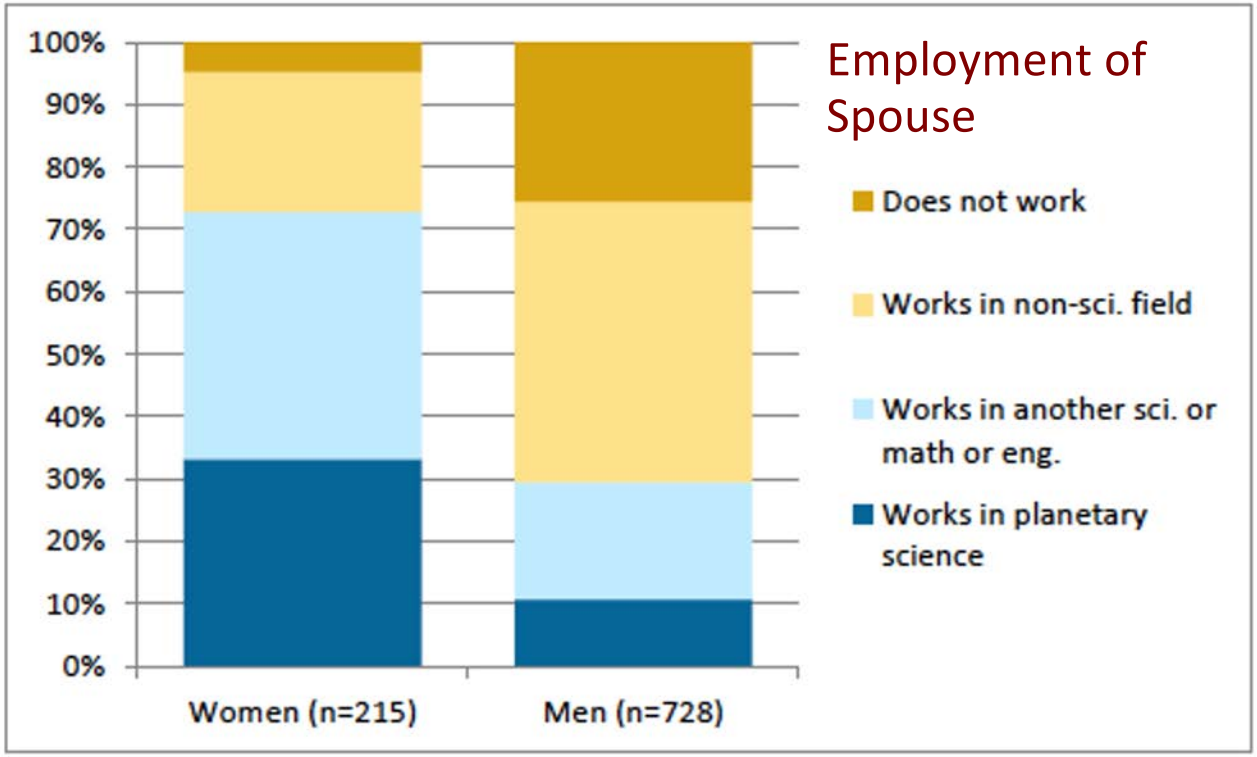


Relatively small NSF funding for Planetary Sciences
– compared with Astro, Helio and Earth sciences

2011 Planetary Survey

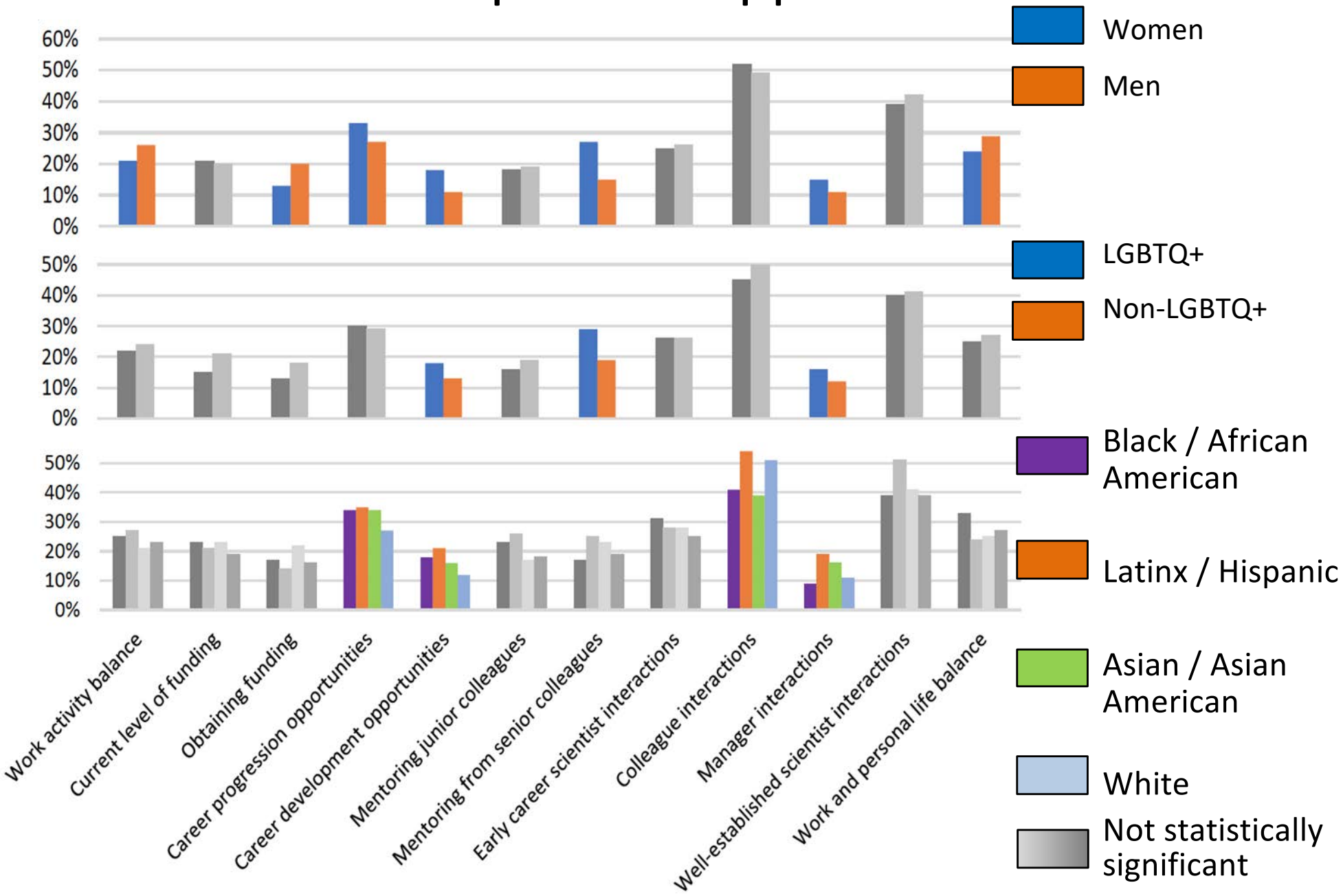
2 –Two-Body Problem





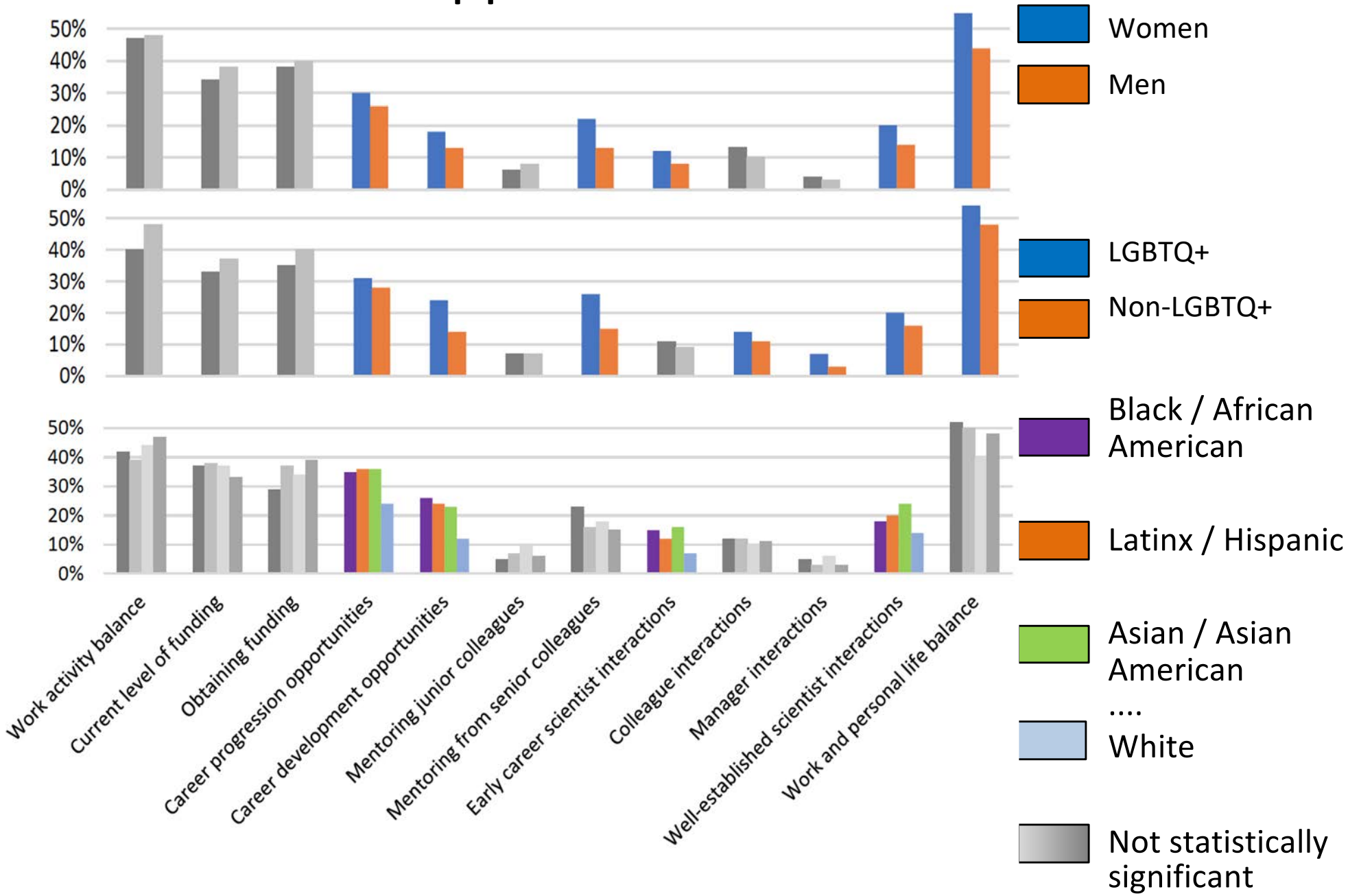
2020 Planetary Survey

Positive Career Impacts & Opporunities



2020 Planetary Survey

Lack of Career Opporunities



Planetary Surveys

Analysis of Open-Ended Word Questions

What has helped you **succeed**?

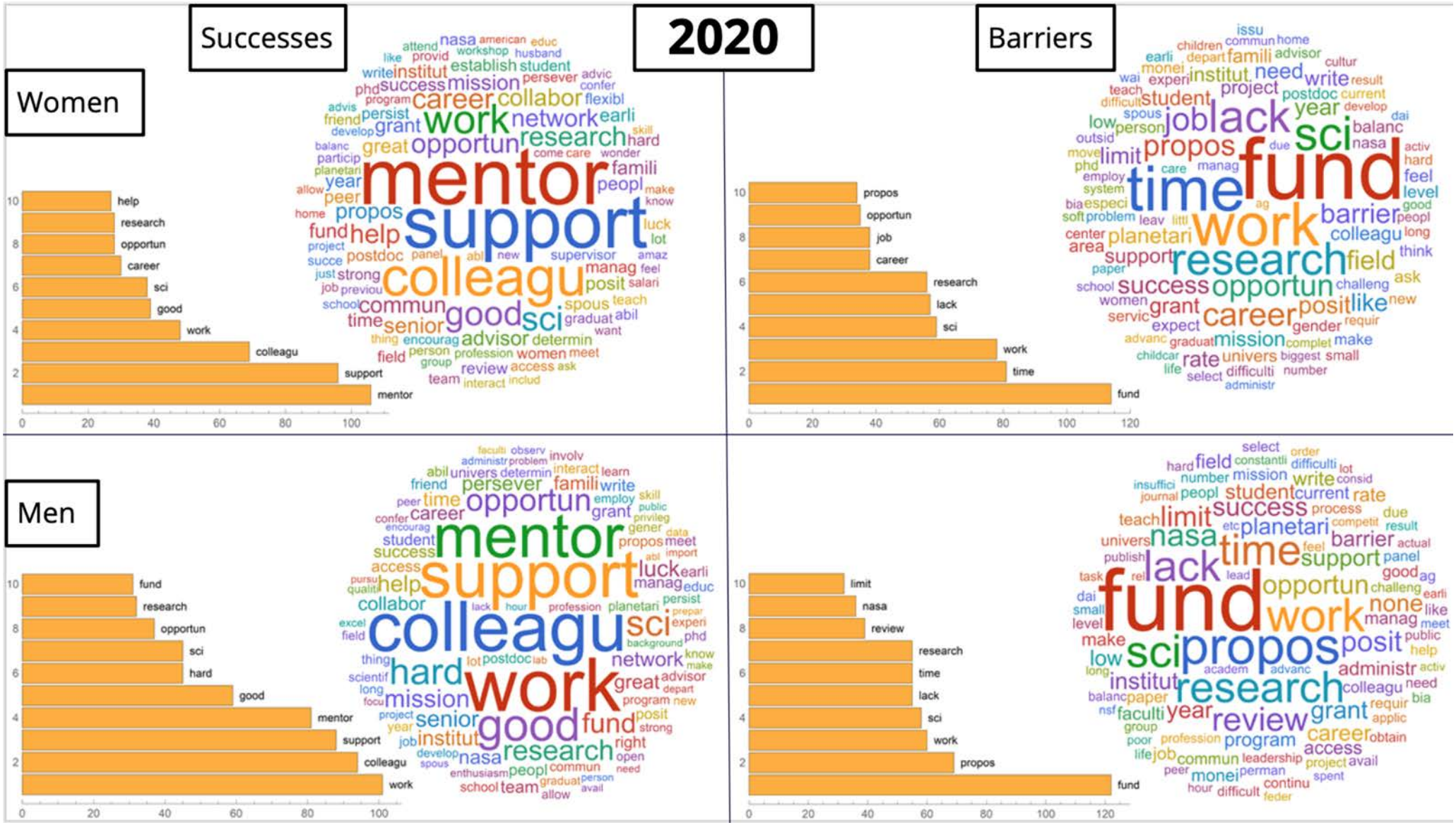
What are **barriers** to your success?

Planetary Surveys

Analysis of Open-Ended Word Questions

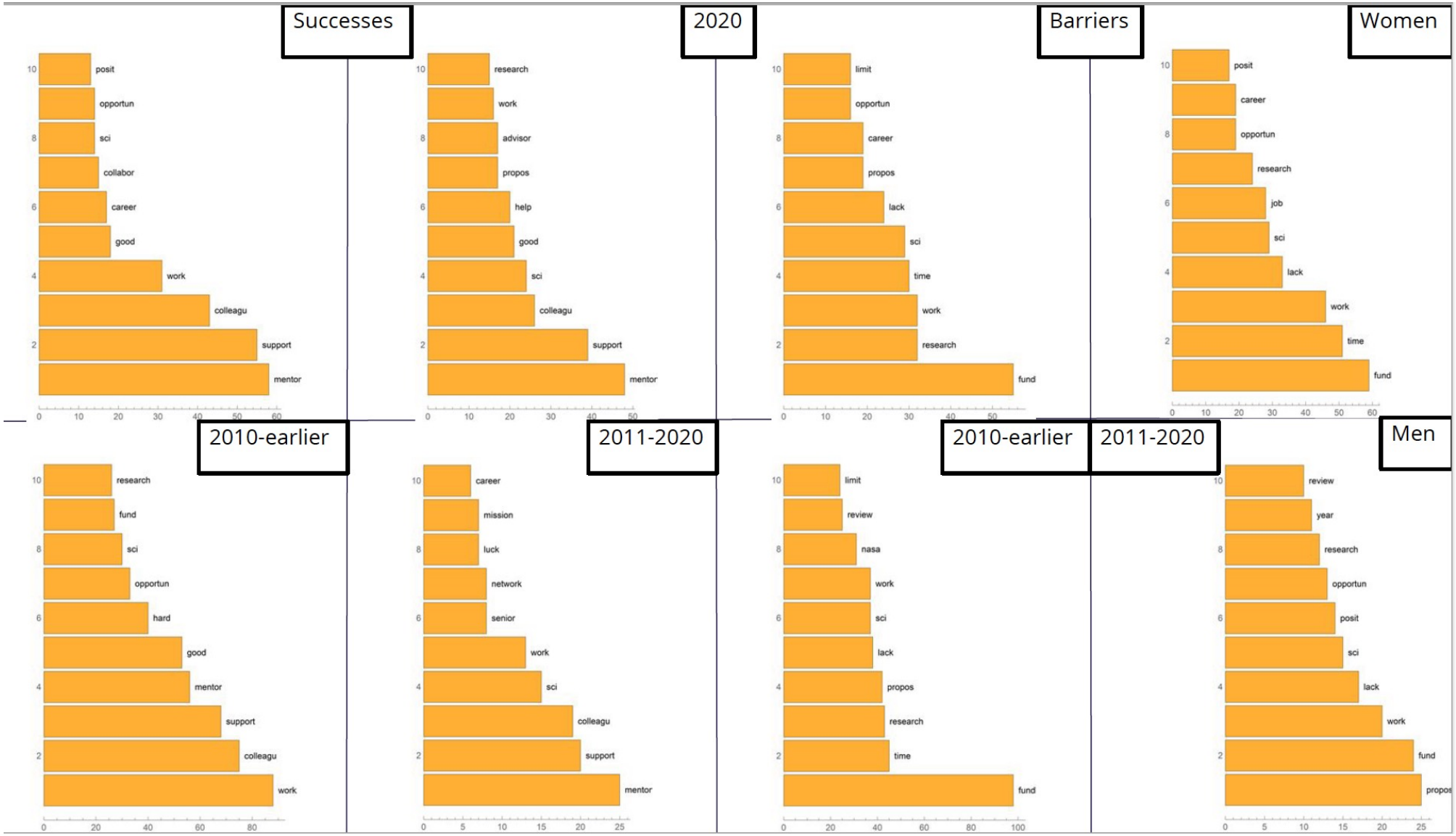
What has helped you **succeed**?

What are **barriers** to your success?



Planetary Surveys

Analysis of Open-Ended Word Questions
What helped you **succeed**?
What are **barriers** to your success?



Year of PhD

Year of PhD

Note: No strong variations with age

Planetary Surveys

Analysis of Open-Ended Word Questions

What has helped you **succeed**? What are **barriers** to your success?

- Men and women generally mention same barriers (funding, proposals, time) and successes (mentors, colleagues, support)
- Word frequencies fairly consistent from 2011 to 2020, though some words change rankings
  - e.g., “work” (contexts such as “hard work”, “good work”) is brought up most frequently as a success for women in 2011 vs. 4th most frequently in 2020
- Words may mentioned at different frequency levels/rankings, but difficult to ascertain if the ranking is important without further analysis with machine learning - though total words may not be sufficient for meaningful results.

It would be useful to also break this down by race, disability and LGBTQ+ status - TBD

Other Sources of Planetary Demographics Data

AGU Planetary Sciences Section 2018

Planetary Sciences	Student	Early Career	Mid-Career	Experienced	Retired
Female	39%	33%	23%	13%	6.5%
Male	60%	65%	76%	86%	93%
Prefer Not to Answer	1%	1.5%	1%	1.2%	0%

2011 Planetary Science Workforce Survey

Attendees/Members of Planetary Conference/Section

	LPSC	AGU	DPS	All Three
LPSC	1280	345	90	
AGU		264	124	
DPS			358	
All Three				161

PhDs, in US

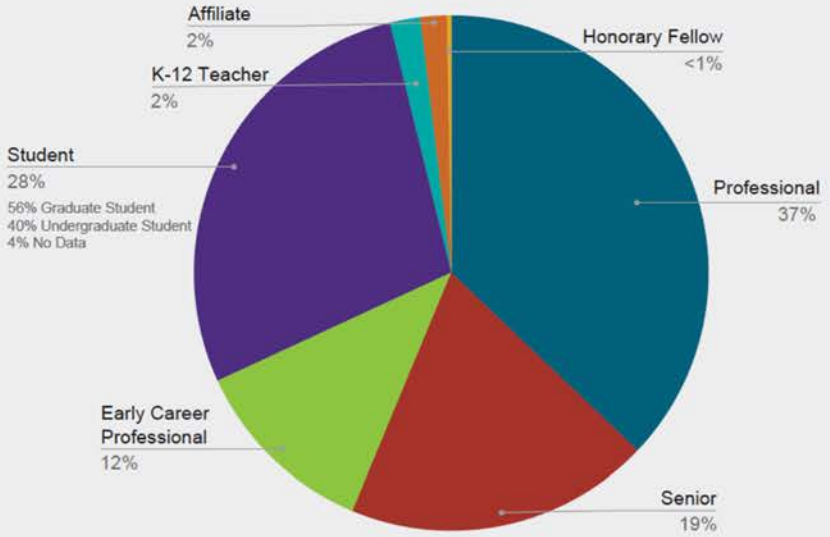
Geological Society of America

GSA Membership Demographics

Total Membership as of 31 December 2019 - 20,588

Membership is on a calendar year basis.

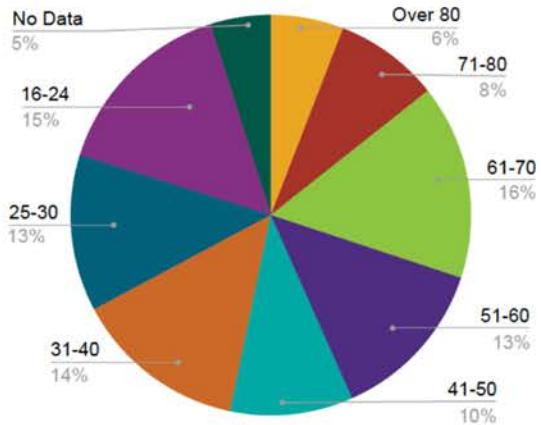
Member Type



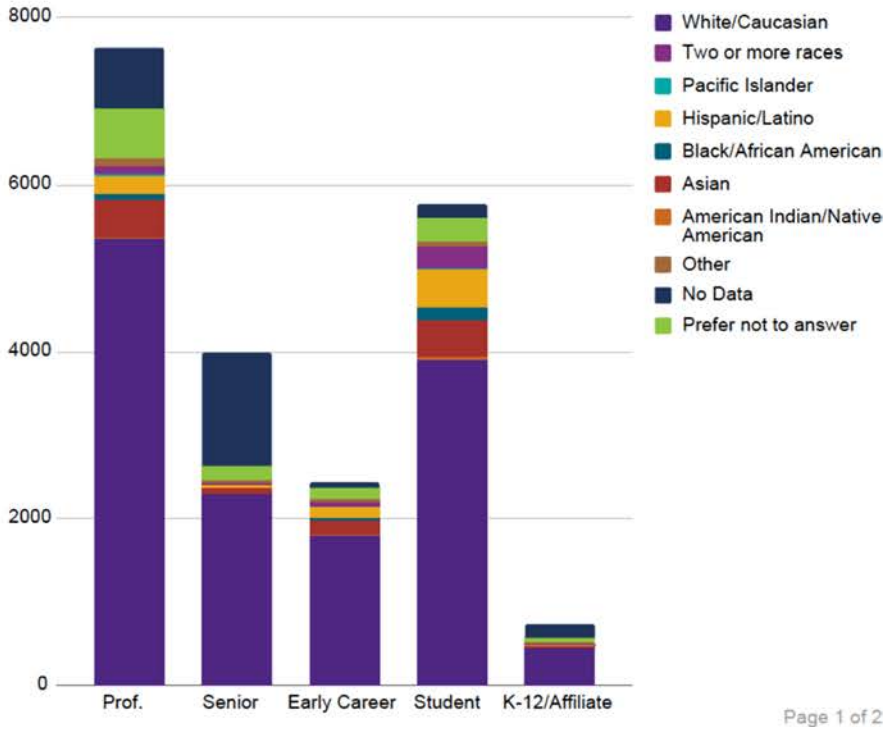
Gender

Member Type	Male	Female	Non-Binary	No Data
Professional	71%	28%	0%	0%
Senior Member 70+age/30+mbrshp	79%	21%	0%	0%
Senior Member 65+ age/ 25+mbrshp	92%	7%	0%	0%
Honorary Fellow	89%	5%	0%	5%
Early Career Professionals	53%	46%	0%	0%
Student Member	48%	50%	0%	2%
K-12 Teacher	45%	33%	0%	22%
Affiliate	76%	21%	0%	3%
Total %	**66%**	**33%**	**0%**	**1%**
Total #	**13,508**	**6,804**	**17**	**259**

Age



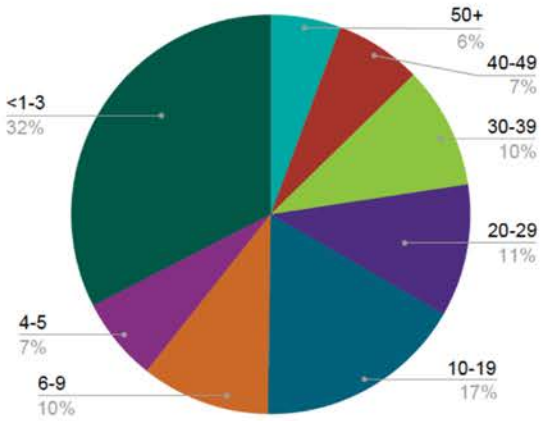
Ethnicity



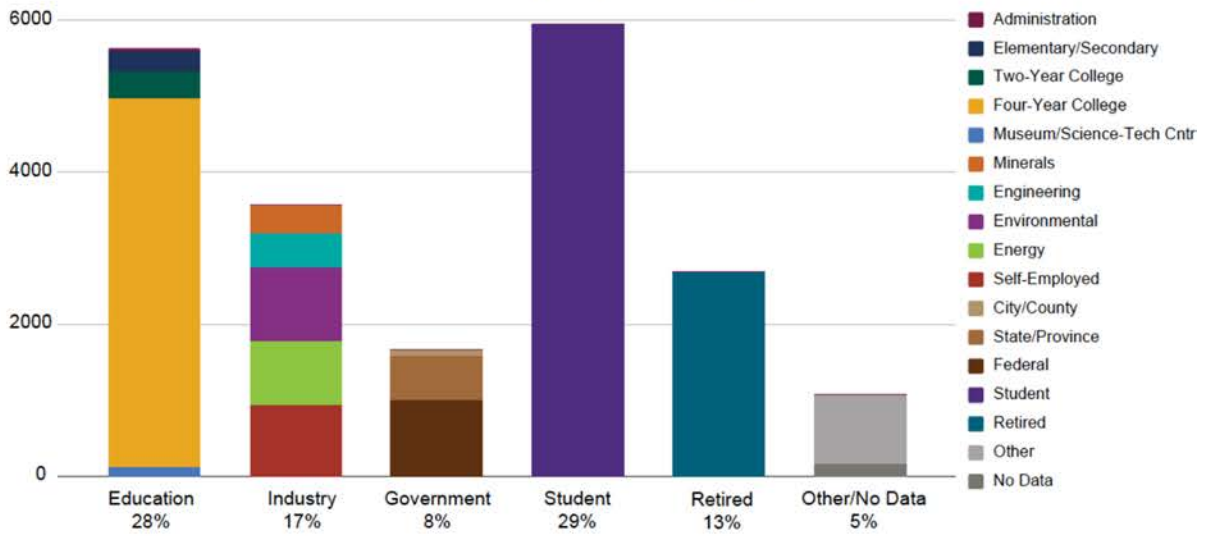
Geological Society of America

GSA Membership Demographics

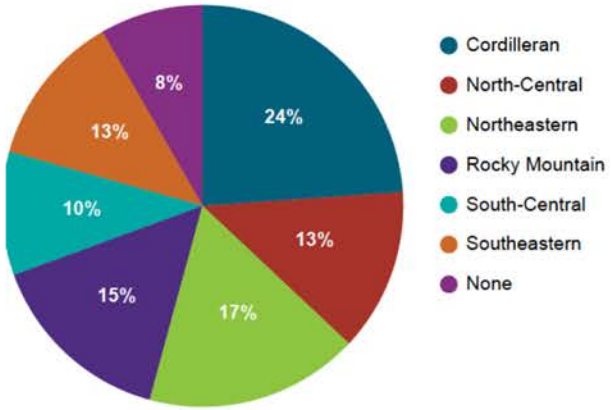
Length of Membership (years)



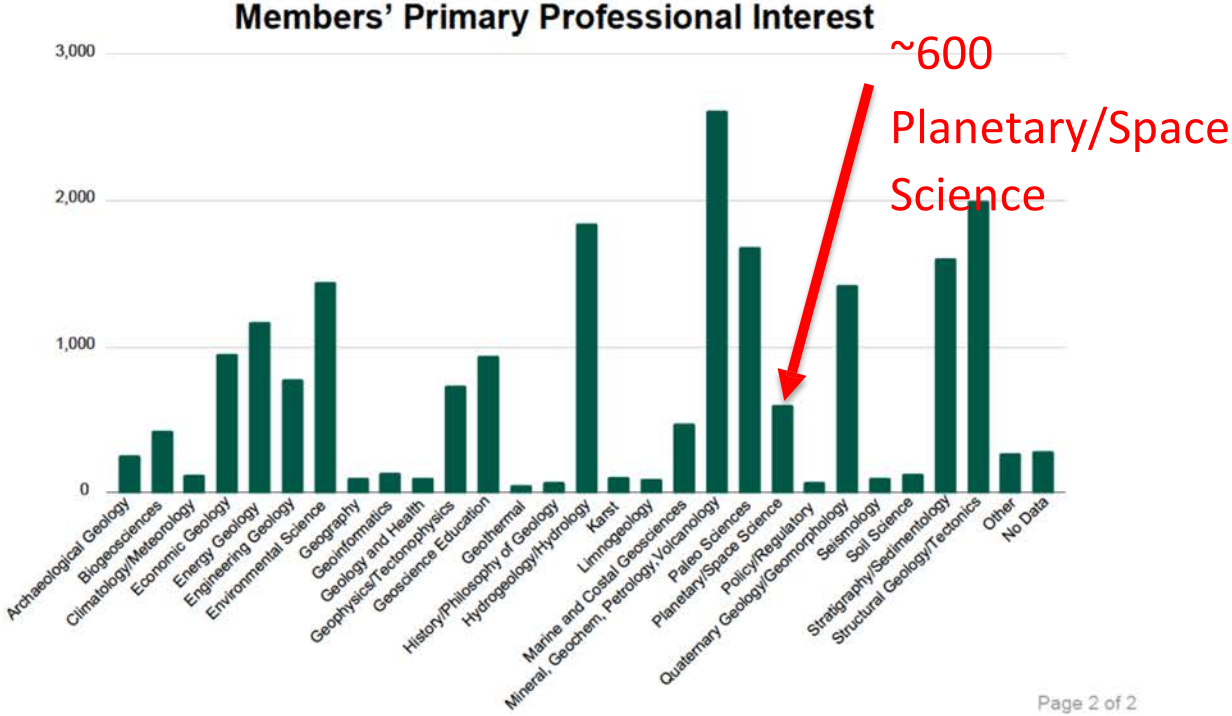
Employment Type



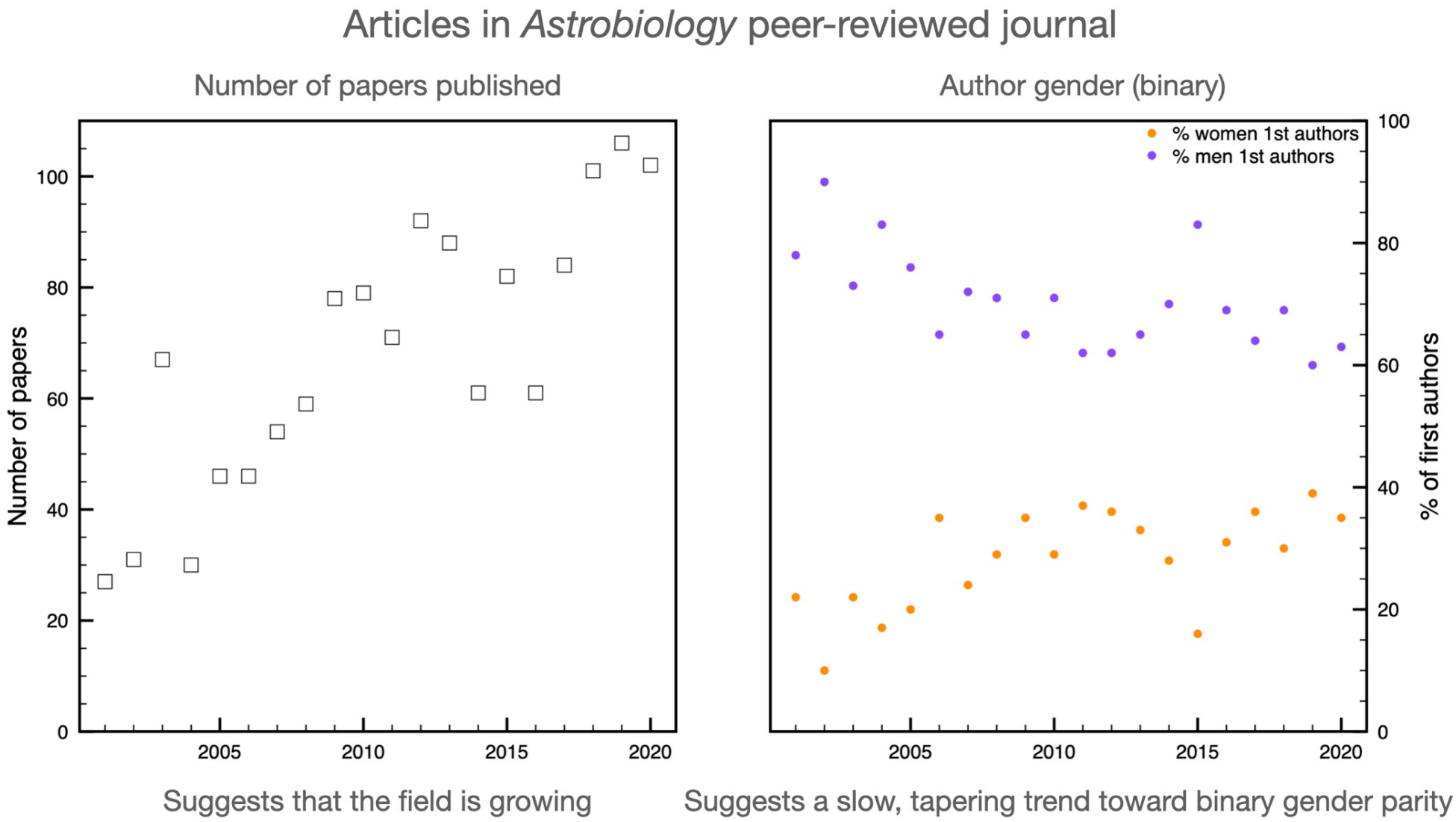
Primary Section Affiliation



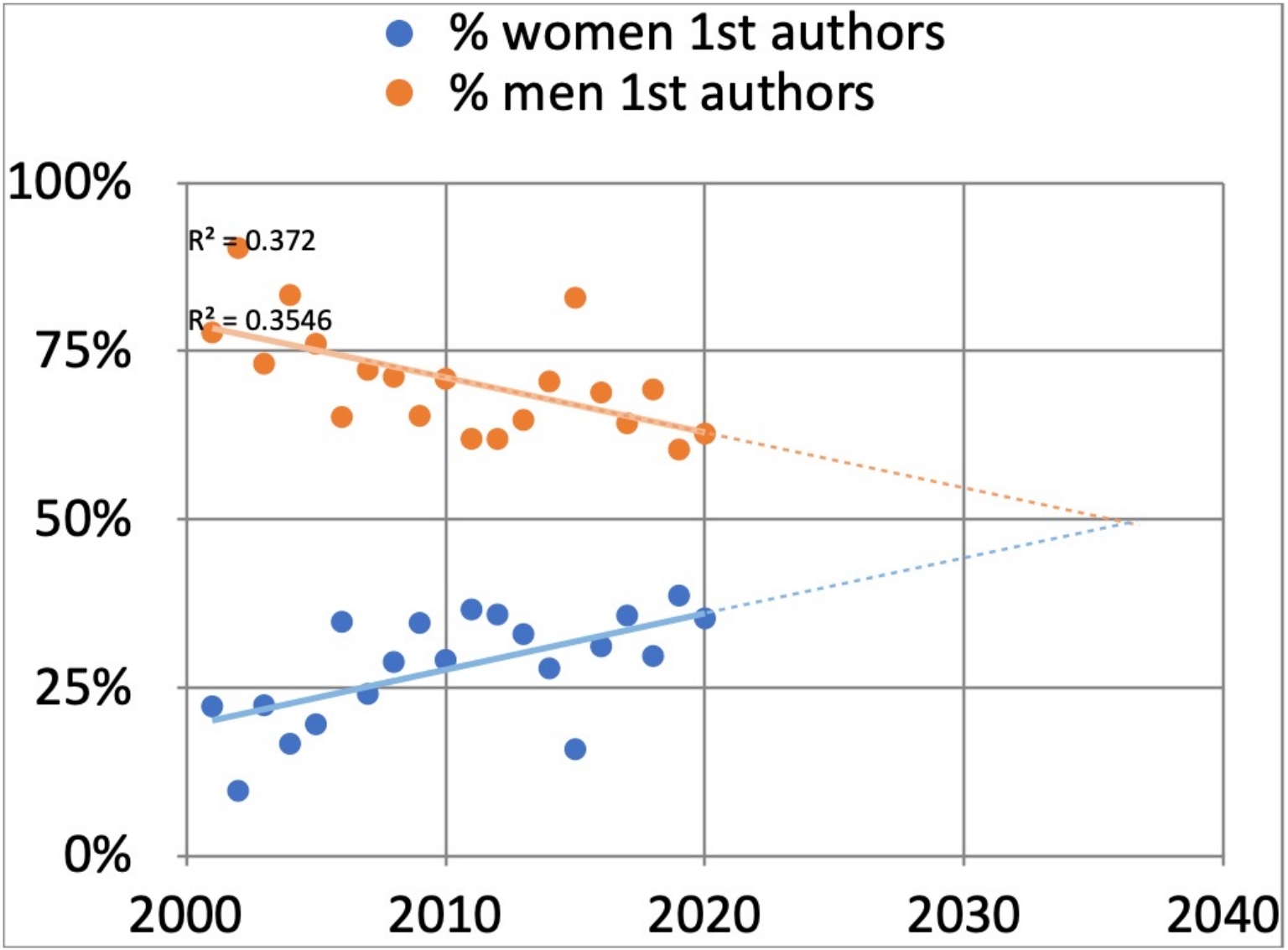
Members' Primary Professional Interest



Astrobiology



Astrobiology

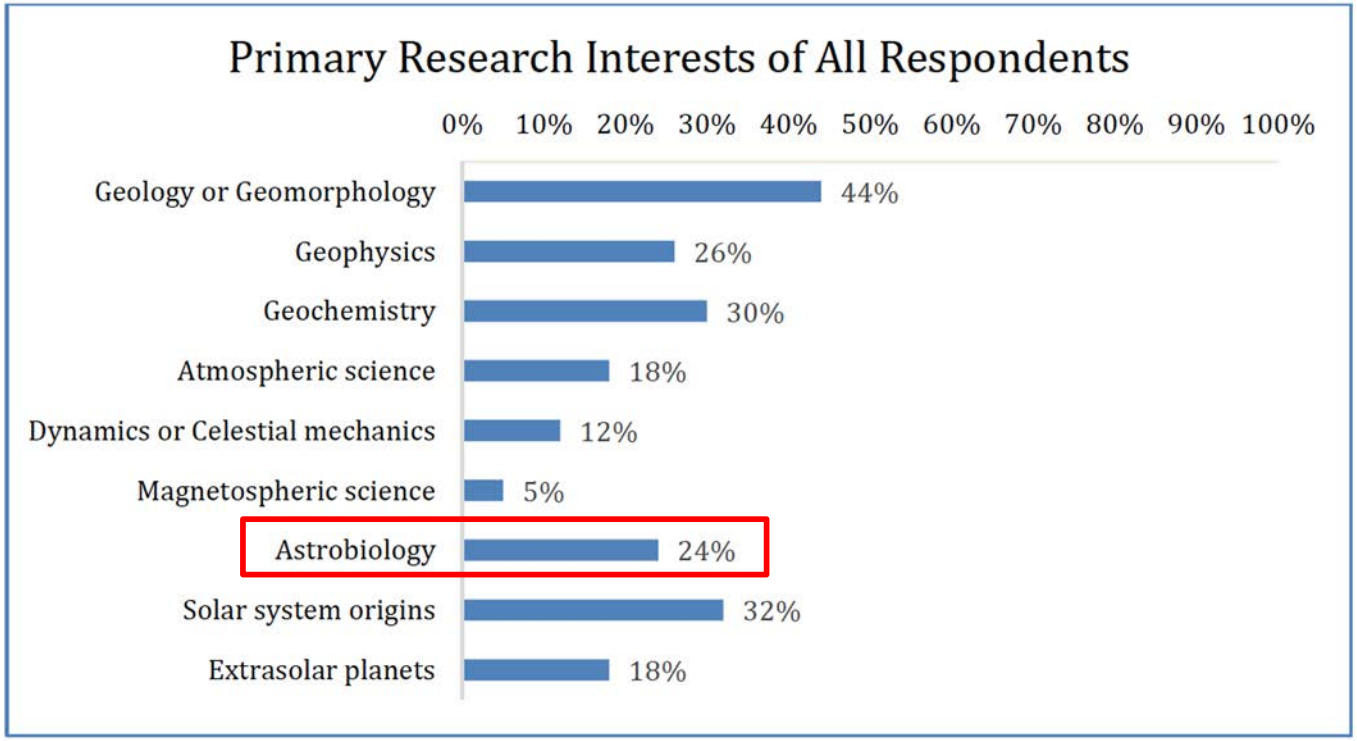


NASA Postdoctoral Program Astrobiology Applicants

	Man	Woman	White	Asian American	Black / African American	Latinx / Hispanic	Native American / Alaskan Native	Multi-Racial / Other
%	55%	45%	71%	16%	2.4%	5.7%	1.6%	3.8%
error (2σ)	4.9%	4.9%	4.6%	4%	1.6%	2.4%	1.3%	1.9%

Inferred base population of astrobiology NPP applicants based on the demographics of NPP applicants.

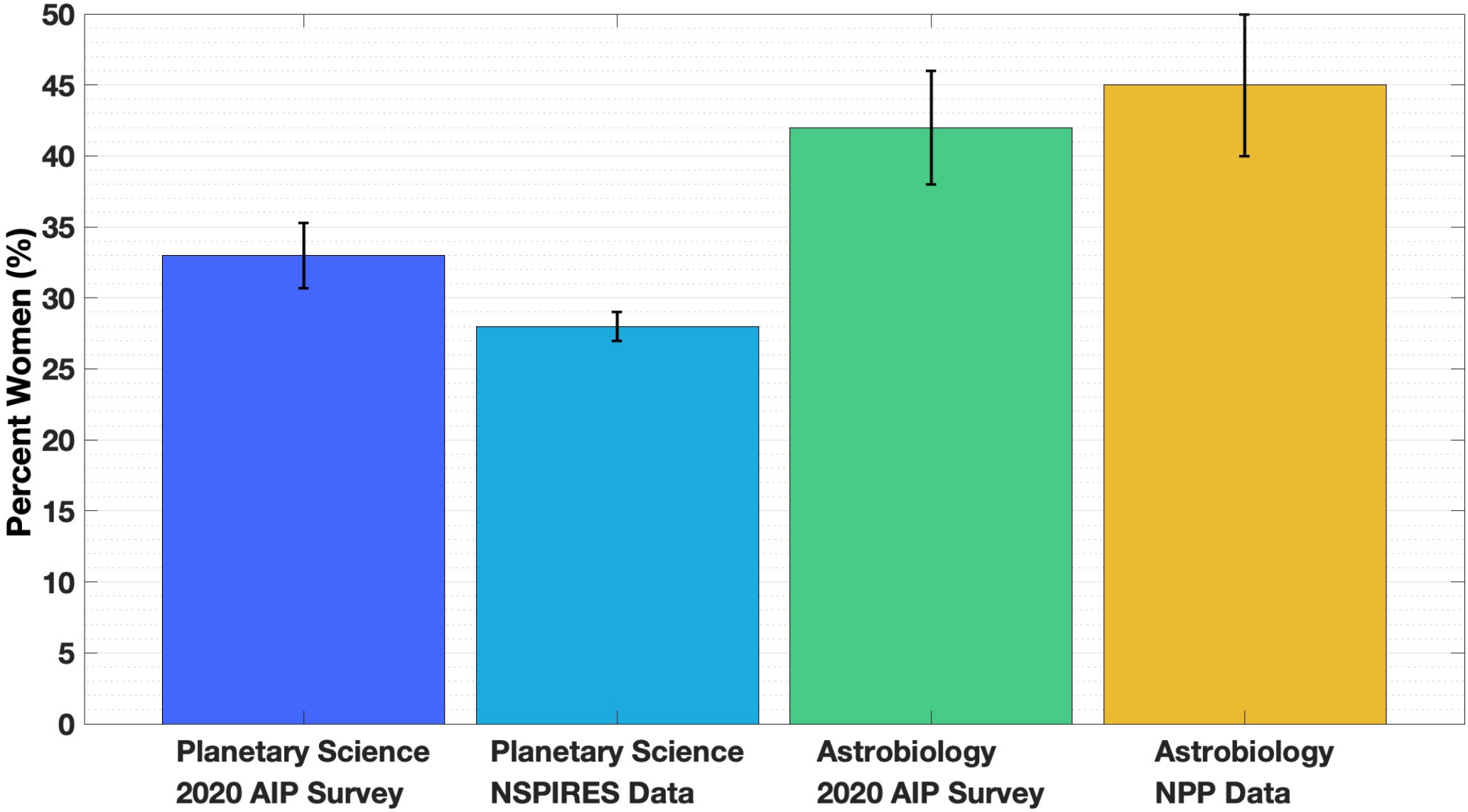
2020 Workforce Survey Question on Astrobiology



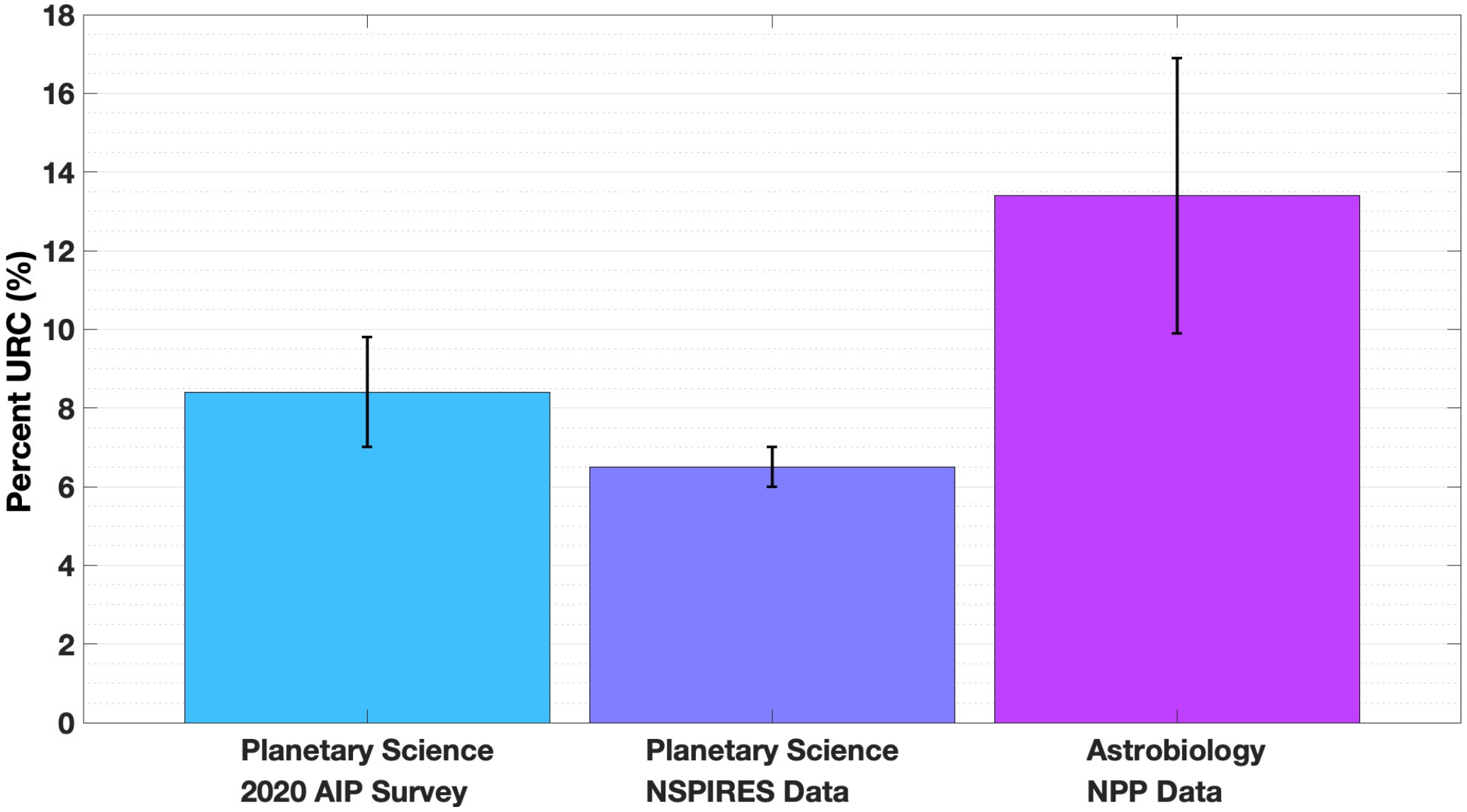
Gender Distribution of Astrobiologists:

	Woman	Nonbinary / Other	Man
Astrobiologists	42%	0.75%	58%
Error (2-σ)	4.2%	0.73%	4.2%
All respondents	37%	1%	62%

Comparing Astrobiology to Planetary Science: Binary Gender



Comparing Astrobiology to Planetary Science: Race/Ethnicity



Notes

- Some comments about need for other sources of demographics data?
- e.g. diversity of Astrobiology compared with rest of planetary?

- GSA, AGU.....

Comparisons with Other SMD Divisions – Helio, Astro, Earth

Planetary, Astrophysics, Space Physics

Astrophysics: 2018 AAS Survey by AIP
60% response = 2018 Respondants (including students)

-> 2040 PhD astrophysicists in US

Solar & Space Physics: 2011 NRC Decadal
Survey AGU-SPA, AAS-SPD, Space Weather Week
51% response = 1305 Respondants

-> 2300 PhD solar, space & upper atmos. in US

Planetary: 2011 AIP Survey – LPSC, DPS, AGU
62% Response = 2622 Respondants

-> 1140 PhD planetary scientists in US

2020 AIP Survey – LPSC, DPS, GSA
47% Response = 2400 Respondants

update

-> 1100 PhD planetary scientists in US

Workforce Surveys

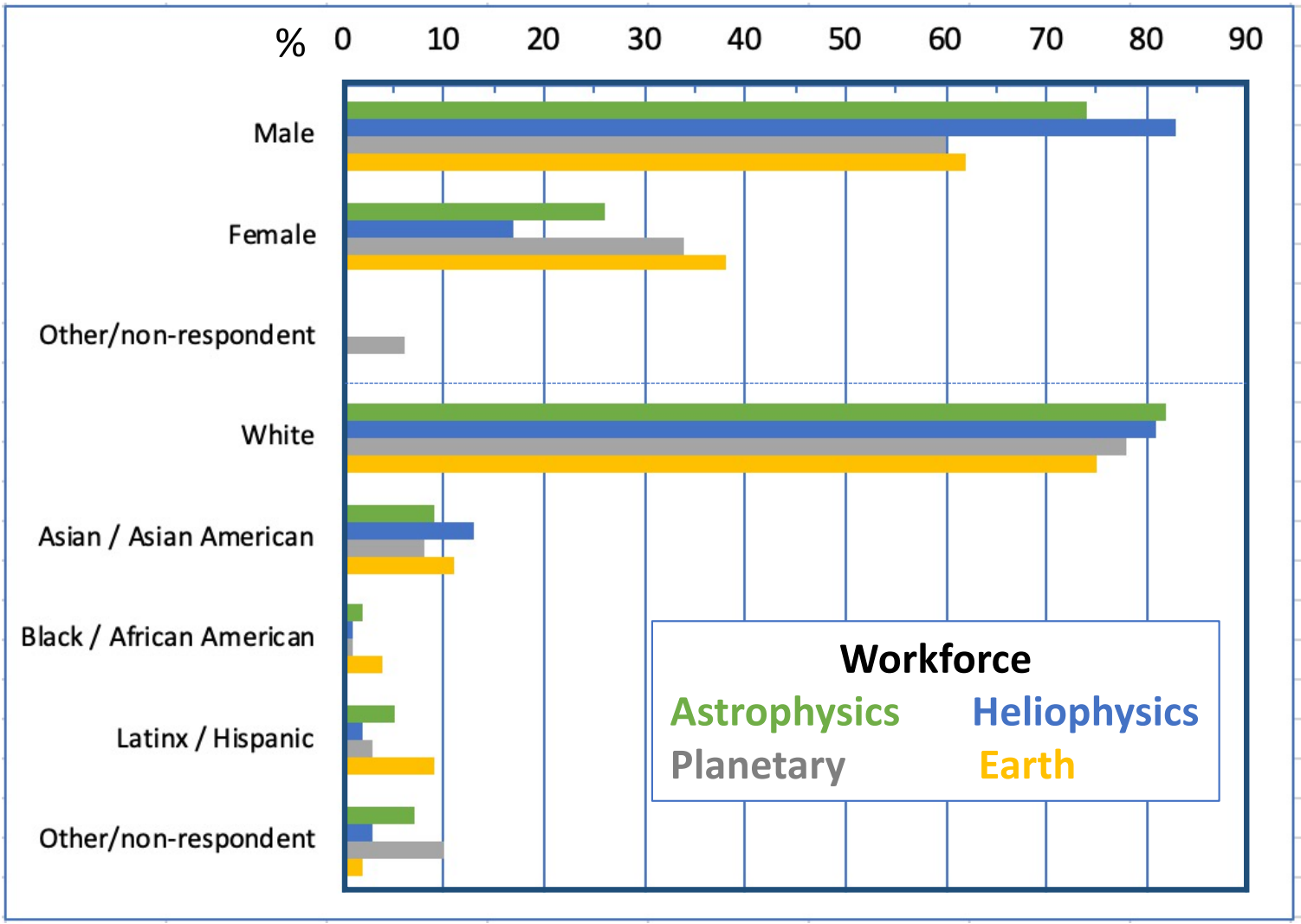
Astrophysics – AAS Survey 2018

Heliophysics – Solar, Space & Upper Atmosphere Physics 2011

Planetary – AAS-DPS, LPSC, GSA Survey 2020

Earth Science – no space-science focused workforce surveys available.
Nature article Rachel E. Bernard and Emily H. G. Cooperdock, 2018

Respondants with PhDs, in the US


%
0
10
20
30
40
50
60
70
80
90
Male
Female
Other/non-respondent
White
Asian / Asian American
Black / African American
Latinx / Hispanic
Other/non-respondent
Workforce
Astrophysics
Heliophysics
Planetary
Earth

	ASTRO	HELIO	PLANETARY	EARTH
Percentage				
Male	74	83	60	62
Female	26	17	34	38
Other/non-respondent			6	
White	82	81	78	75
Asian / Asian American	9	13	8	11
Black / African American	2	1	1	4
Latinx / Hispanic	5	2	3	9
Other/non-respondent	7	3	10	2

NSF 2019 PhD recipients	Total	Male	Female	%F
Atmospheric science and meteorology	236	147	89	37.7
Atmospheric physics, meteorology	45	33	12	26.7
Atmospheric chemistry, atmospheric sciences-general, atmospheric sciences-other	191	114	77	40.3

NASA Proposal Data

1-NSPIRES Personal Profiles
2-Competed Mission Proposals

Demographic Data from NASA NSPIRES data base of Personal Profiles

Background:

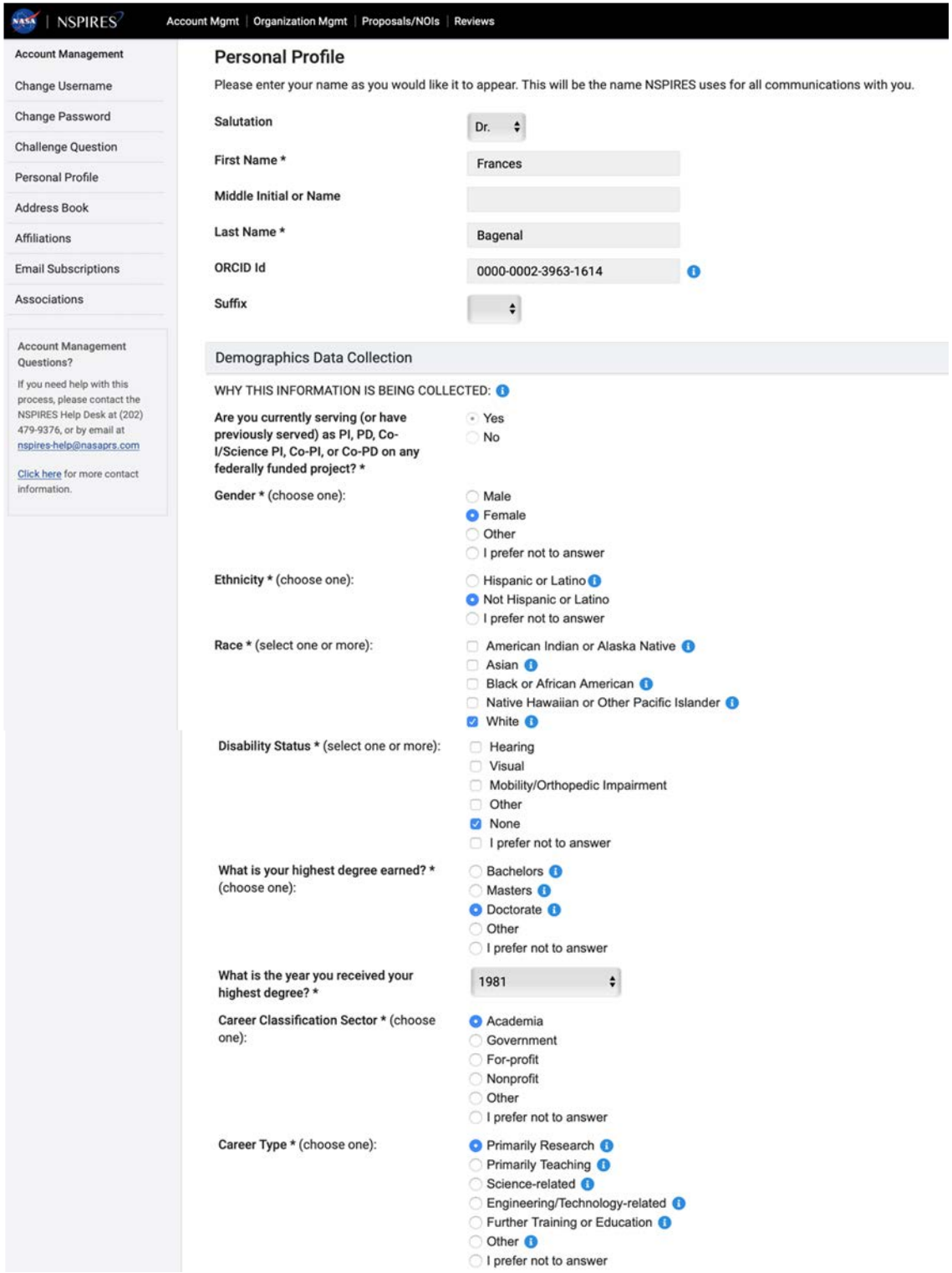
- NSPIRES is NASA's online portal for uploading proposals
- An individual needs to log in to submit a proposal to NASA
- Filling in the Personal Profile page is optional, there are options of "prefer not to answer" for most questions

- NASA's Office of the Chief Scientist – Jim Green = NASA Chief Scientist – started gathing data from NSPIRES to compare proposal submittions/selections with demographic data (from corresponding personal profiles)
- To date (July 2021) data have been analyzed for Planetary, Heliophysics & Astrophysics – with Earth Science in progress

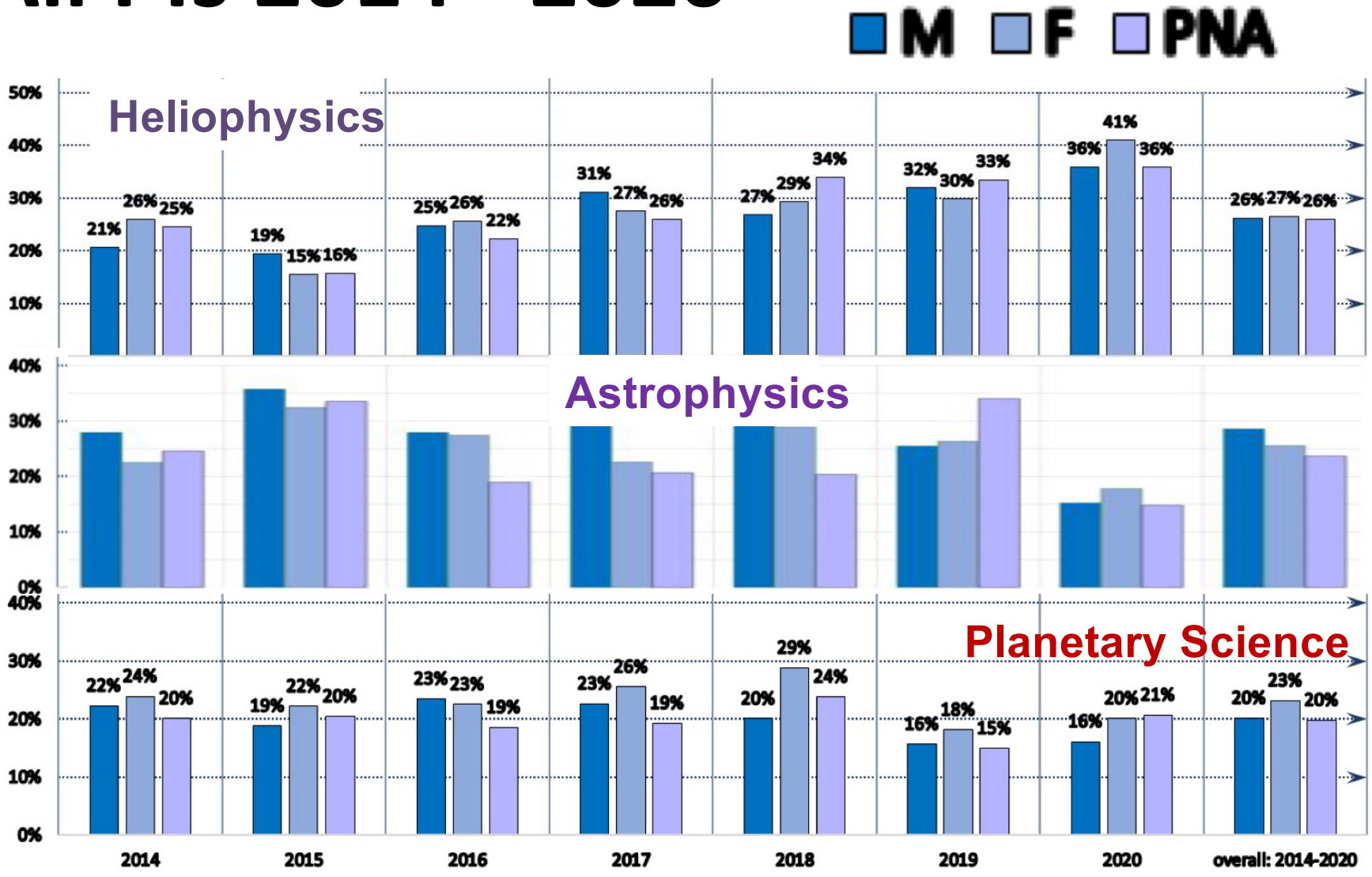
- Data and some graphics from:
- https://science.nasa.gov/science-red/s3fs-public/atoms/files/07-Barbier-Demographics-061421.pdf

Fran Bagenal's NSPIRES personal profile to provide an example of what is asked for online database

This is all public information – Fran Bagenal



Success Rate by Gender:
All PIs 2014 - 2020



Planetary Science Division: PIs Only

BASIC NUMBERS FOR GENDER: 2014-2020				
	M (%)	F (%)	PNA (%)	totals
selections	61%	27%	12%	2101
submissions	63%	25%	13%	10074
selections/submissions	20%	23%	20%	

- High PNA rates suggest people are reluctant to submit their Personal Profiles to NSPIRES
- Demographic question (particularly non-binary gender) do not follow current best practices leading to people chosing PNA
- Common wisdom is that PNAs more likely male than female, as well as LGBTQ+ where choices are limited.
- In any case, < 30% selection rates are disheartening

Planetary Science Division: PIs Only

Gender distribution for Submissions - 2014 to 2020				
year	**total**	**M (%)**	**F (%)**	**PNA (%)**
2014	1497	64%	22%	15%
2015	1632	62%	25%	13%
2016	1602	65%	23%	12%
2017	1486	60%	26%	15%
2018	1605	62%	24%	13%
2019	1496	63%	27%	10%
2020	756	64%	28%	8%
All combined	10074	63%	25%	13%

Average of 1553 submissions per year

*Note that 2020 selections were incomplete at the time the data was made available

Planetary Science Division: PIs Only

Year	Total	White	Asian American	URC	PNA
2014	1500	63.5%	9%	4.3%	23.1%
2015	1635	64%	9.3%	4.9%	21.9%
2016	1603	64.1%	9.2%	5.7%	21.1%
2017	1486	61.9%	9.2%	4.8%	24.1%
2018	1606	61.5%	11.5%	4.6%	22.4%
2019	1496	62.3%	11.5%	5.6%	20.5%
2020	756	65.3%	12.3%	6.7%	15.7%
Combined	10082	63.1%	10.1%	5.1%	21.7%

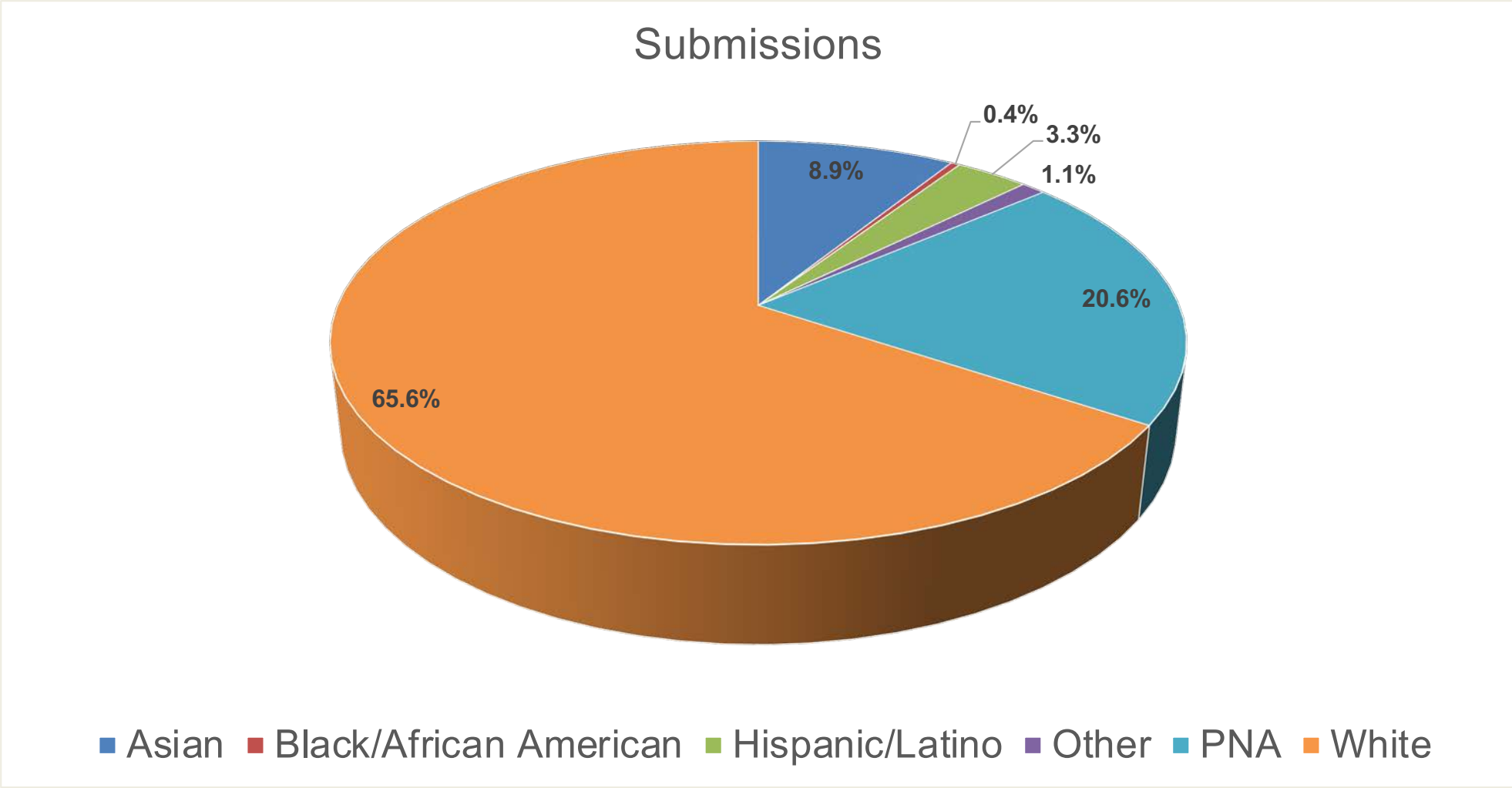
*The publicly available data is re-binned here to preserve anonymity. URC (Underrepresented Racial/Ethnic Community) includes American Indian / Alaskan Native, Black / African American, Latinx / Hispanic, Native Hawaiian or other Pacific Islander, Multi-Racial, and individuals who identify as another race/ethnicity

Participation – by Race/Ethnicity

Planetary Science

Total PI + Co-I = N = 31,172 ~ 5200/year

Dividing by total researchers ~1500 -> 3.5 PI+CoI/proposal



Ed Rivera-Valentín's Analysis of the NSPIRES Selection Rates

Preamble

- Caveats:

- We did not have access to the base / raw data, nor were we involved in the setup of the survey. This implies we may not have full insight into potential sources of uncertainty.

- Statistics wording is used when making a statistical conclusion from a test (e.g., statistically significant, moderate evidence), but softer language is used when stating an overall conclusion in light of the above caveat.

- The main objective here is to identify potential evidence that should motivate further action, rather than a detailed study because again, see caveat above.

Test 1

Is there a significant difference between the demographics of the population of proposal submissions and the demographics of the planetary science community as inferred from the DPS 2020 survey?

Caveats:

- The NSPIRES inferred base population is not necessarily equivalent to the DPS survey base population. For example, not all DPS survey respondents may regularly PI a proposal submitted to NASA PSD. Proposal PI ages may not be equivalently distributed as DPS survey respondents. Thus, a true comparison is difficult.

- Tests here can only find some evidence potentially indicative of differences.

Test conducted:

- *t*-test for differences

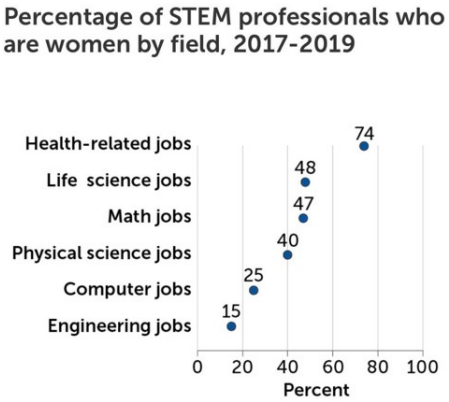
- PNA was considered missing data. This decreases the base population thereby increasing the survey margin of error.

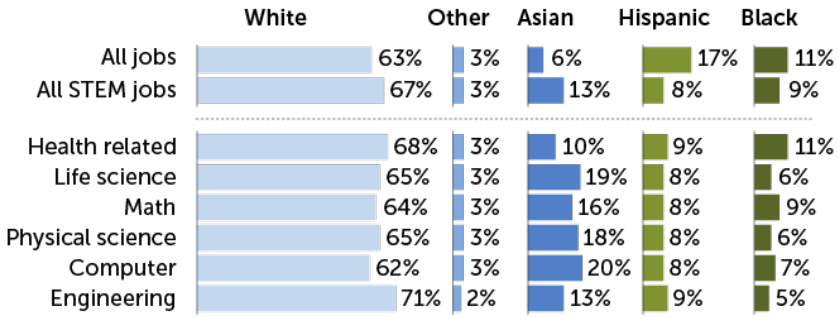
Comparison

Survey	Man	Woman	White	Asian American	URC
NSPIRES	71.6% ± 1%	28.4% ± 1%	80.6% ± 1%	12.9% ± 0.7%	6.5% ± 0.5%
DPS	67% ± 2.3%	33.0% ± 2.3%	80.8% ± 1%	10.8% ± 0.8%	8.4% ± 0.7%

Uncertainty is 2-σ

Pew Research Center results on STEM profession demographics provided for context.





Comparison between NSPIRES and 2020 survey

		p<0.01			p<0.01
Survey	**Man**	**Woman**	**White**	**Asian American**	**URC**
NSPIRES	71.6% ± 1%	28.4% ± 1%	80.6% ± 1%	12.9% ± 0.7%	6.5% ± 0.5%
DPS	67% ± 2.3%	33.0% ± 2.3%	80.8% ± 1%	10.8% ± 0.8%	8.4% ± 0.7%

- There exists a significant difference between the NSPIRES inferred base population based on PI led proposals and the DPS inferred base population.
- Specifically, women and URC are leading proposals less often than expected.

Test 1 - Conclusions

There exists some evidence to suggest that women may be less likely to lead a proposal submitted to NASA PSD than expected.

There exists some evidence to suggest that American Indian / Alaskan Native, Black / African American, Latinx / Hispanic, Native Hawaiian or other Pacific Islander, Multi-Racial, and individuals who identify as another race/ethnicity may be less likely to lead a proposal submitted to NASA PSD.

Test 2

Are there gender or race/ethnicity-based biases in the selection rate of proposals submitted to Planetary Science Division?

Tests conducted:

- χ^2 to test for significant differences between the submitting and selected populations at a per year basis and overall

- *t*-test to test for significant differences between the submitting and selecting categorical populations at a per year basis and overall

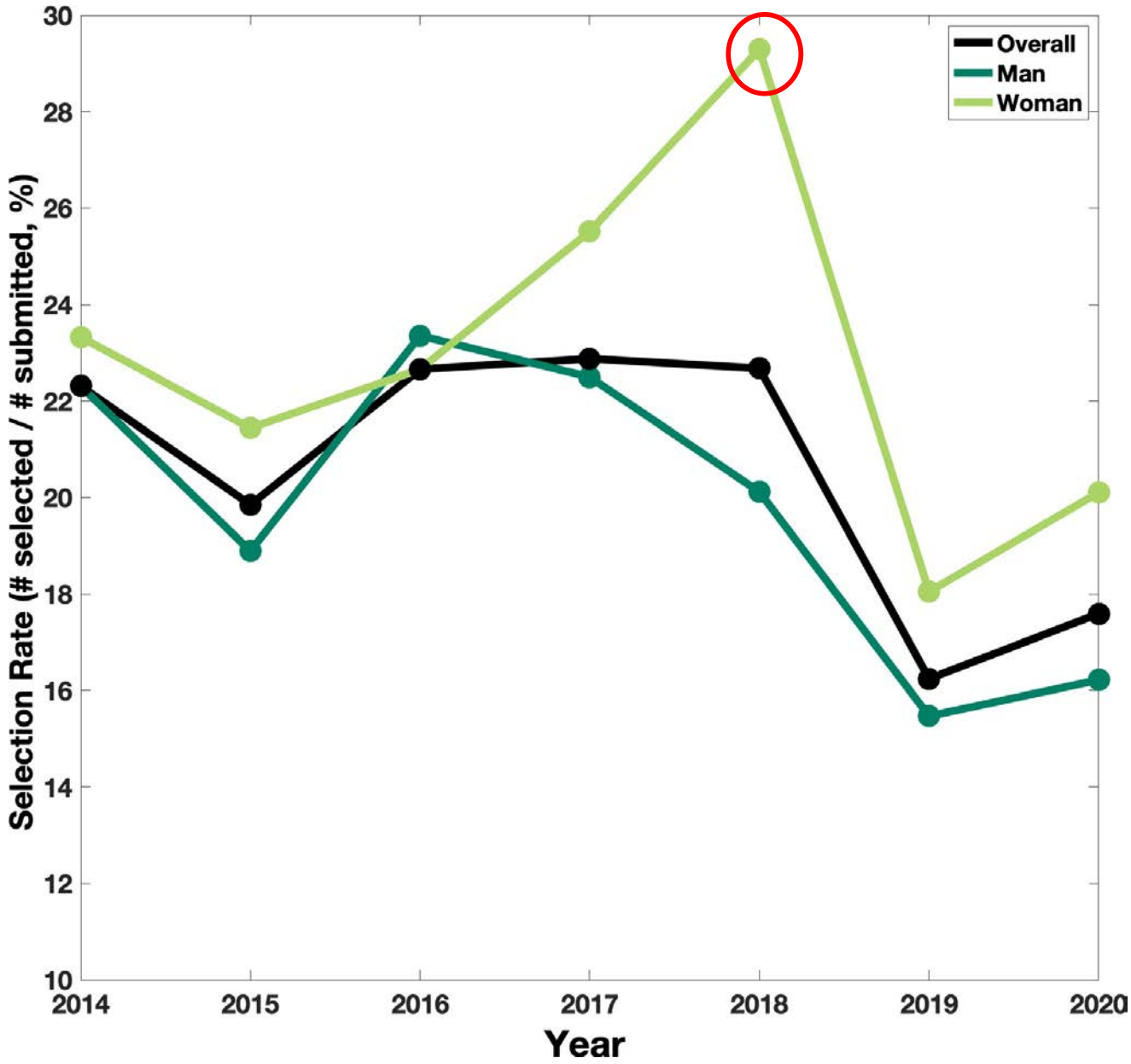
- Evidence for differences is noted only if both tests find significant evidence ($p<0.1$)

- Each test was carried out twice, once including PNA and another assuming PNA was missing data

Selection Rates – Binary Gender

All Years Combined

Man	20% ± 3%
Woman	23% ± 4%
Overall	21% ± 3%

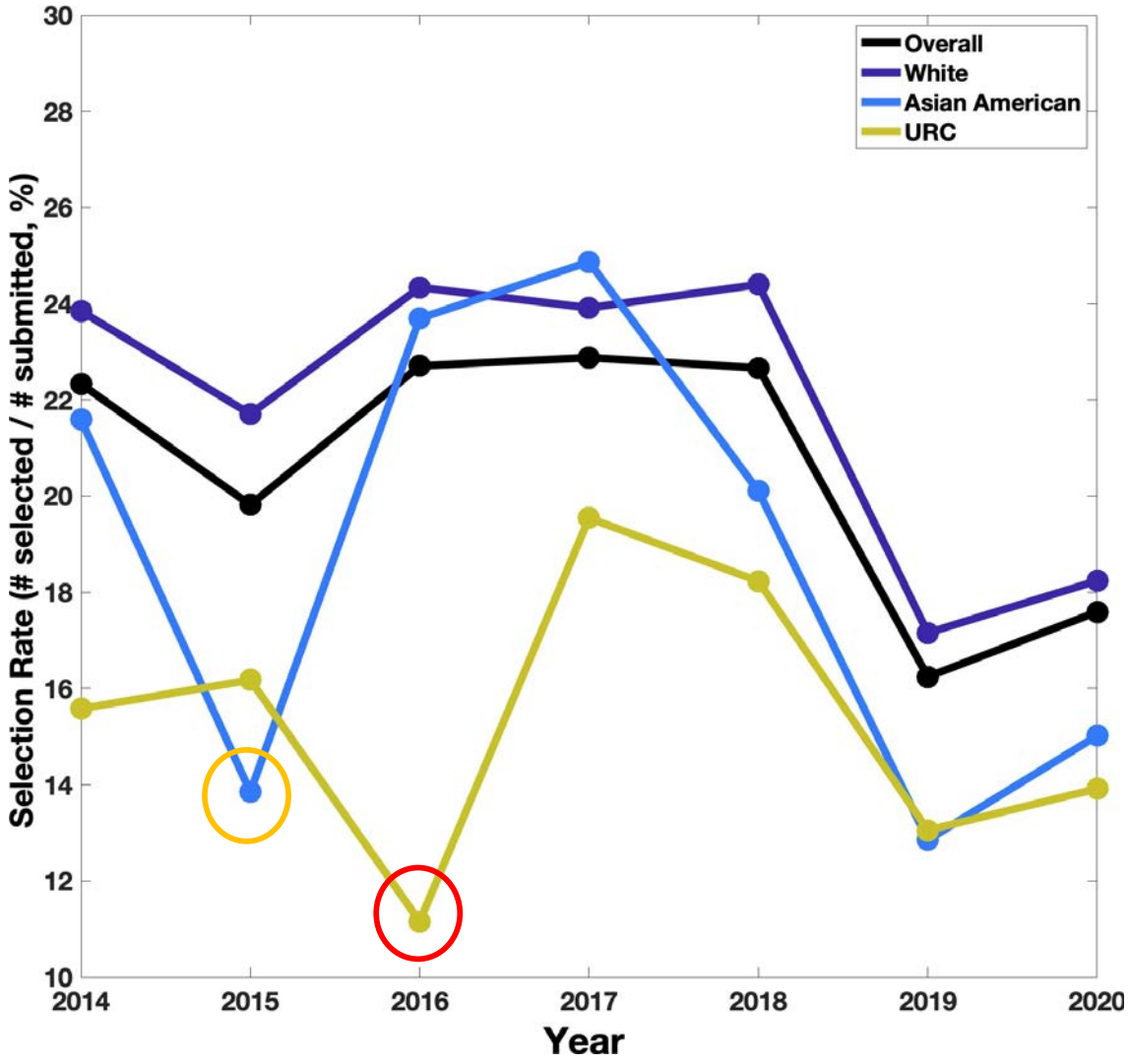


- In 2018, there is a significant difference in selection rate ($p<0.01$)
- Overall, though, there is no significant difference ($p>0.1$) between the submitting and the selection population during this time period.

Selection Rates – Race/Ethnicity

All Years Combined

White	22% ± 3%
Asian American	19% ± 5%
URM	15% ± 3%
Overall	21% ± 3%



- In 2016, there is moderate evidence to suggest that there is a difference for the selection rate of URC ($p<0.05$)
- In 2015, there is weak evidence in support of a difference in the selection rate of Asian Americans ($p<0.1$)
- Overall, there is strong evidence in support of a selection rate difference for URC ($p<0.001$) during this time period.

Test 2 continued

- Because the first tests did not identify gender-based bias in selection rates, here we only conduct further studies on race/ethnicity

- *Are there race/ethnicity based systematic biases in the selection rate of proposals submitted to PSD?*

- Tests conducted:
  - Following the work of Reid (2014), which was the basis for motivating DAPR in HST and later NASA PSD, employed a quasi-Poissonian analysis

  - Monte Carlo modeling – Generated 10,000 realizations of randomly selected populations from a submitting population as described by the NSPIRES data. Identified the mean selection rate and standard deviation (2-σ) of the ensemble for each demographic group.

(Reid (2014) PASP 126, 923-934; Gender-correlated systematics in HST proposal selection.)

Quasi-Poissonian Analysis

Follows

$$\frac{N_a - N_e}{\sqrt{N_e}}$$

where N_a = actual number of proposals selected

N_e = expected number of proposals selected based on the demographics of the submitting population

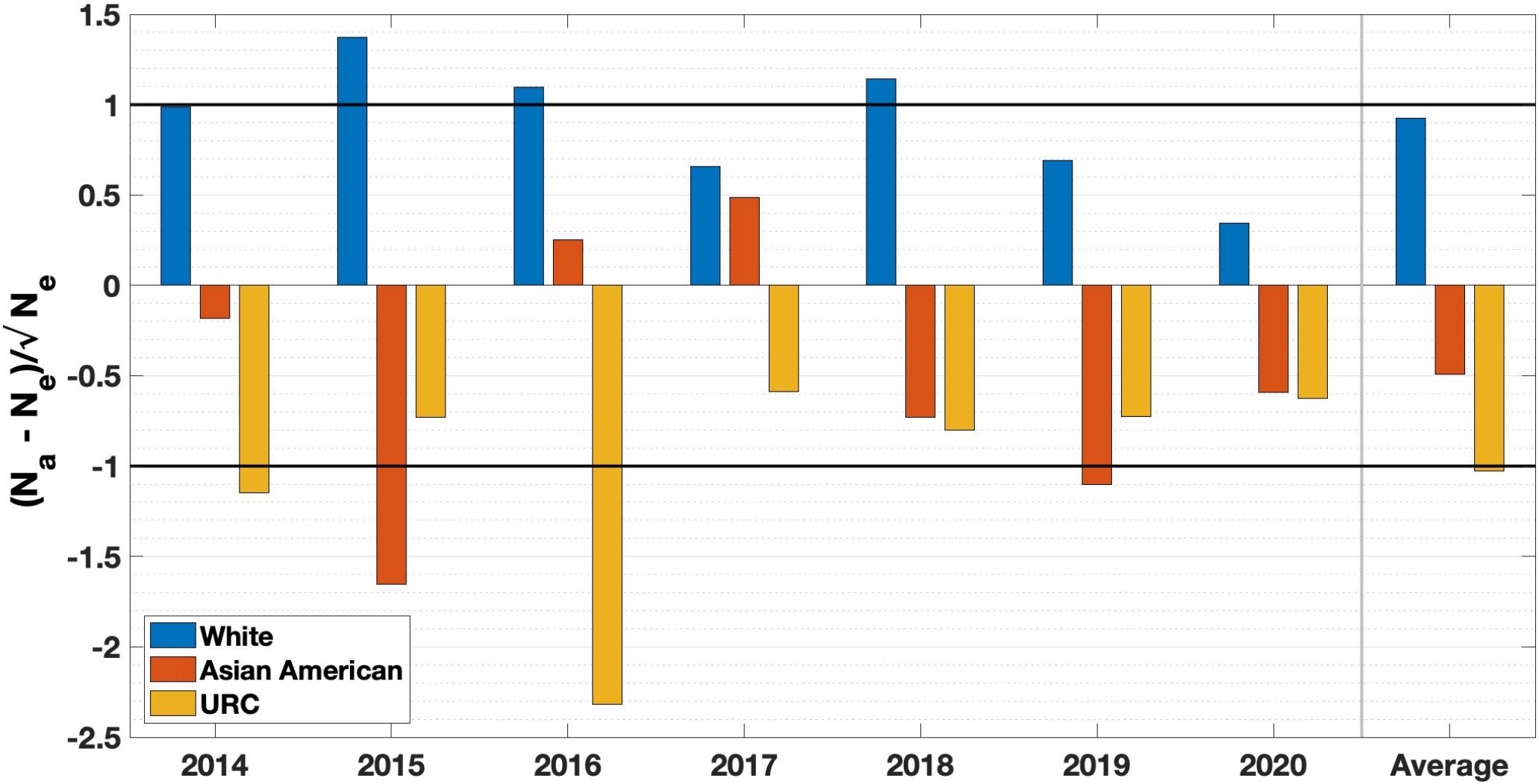
If the ratio >1, implies significant over selection above Poissonian noise.

If the ratio < -1, implies significant under selection above Poissonian noise.

If the ratio is always < 0, implies evidence indicative of systematic under selection.

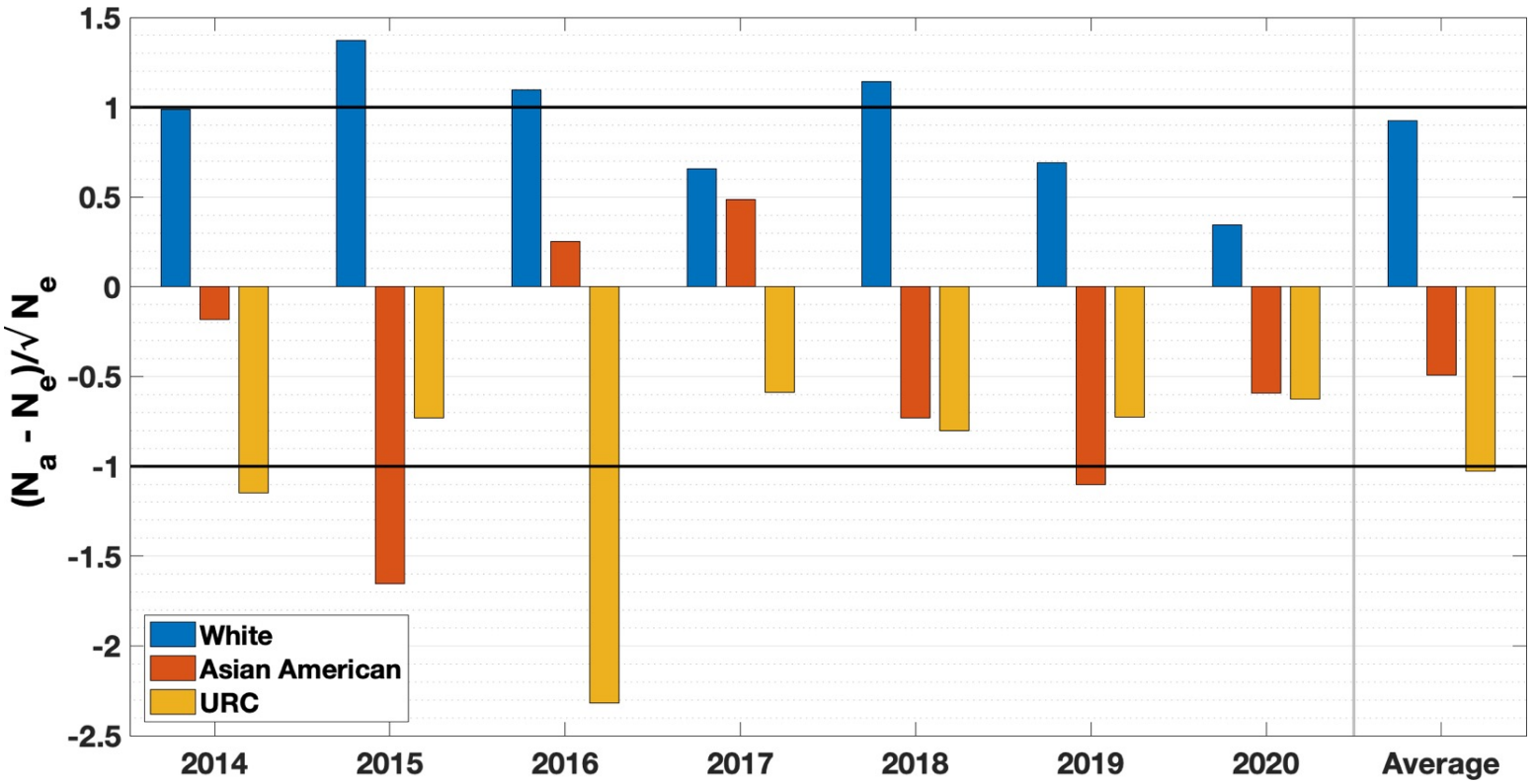
If the ratio is always > 0, implies evidence indicative of systematic over selection.

Race/Ethnicity: Correlated Systematic Underselection



Na = actual number of selections; Ne = expected number of selections
Follows the methods by Reid (2014)

Systematic Bias in Selection Rates

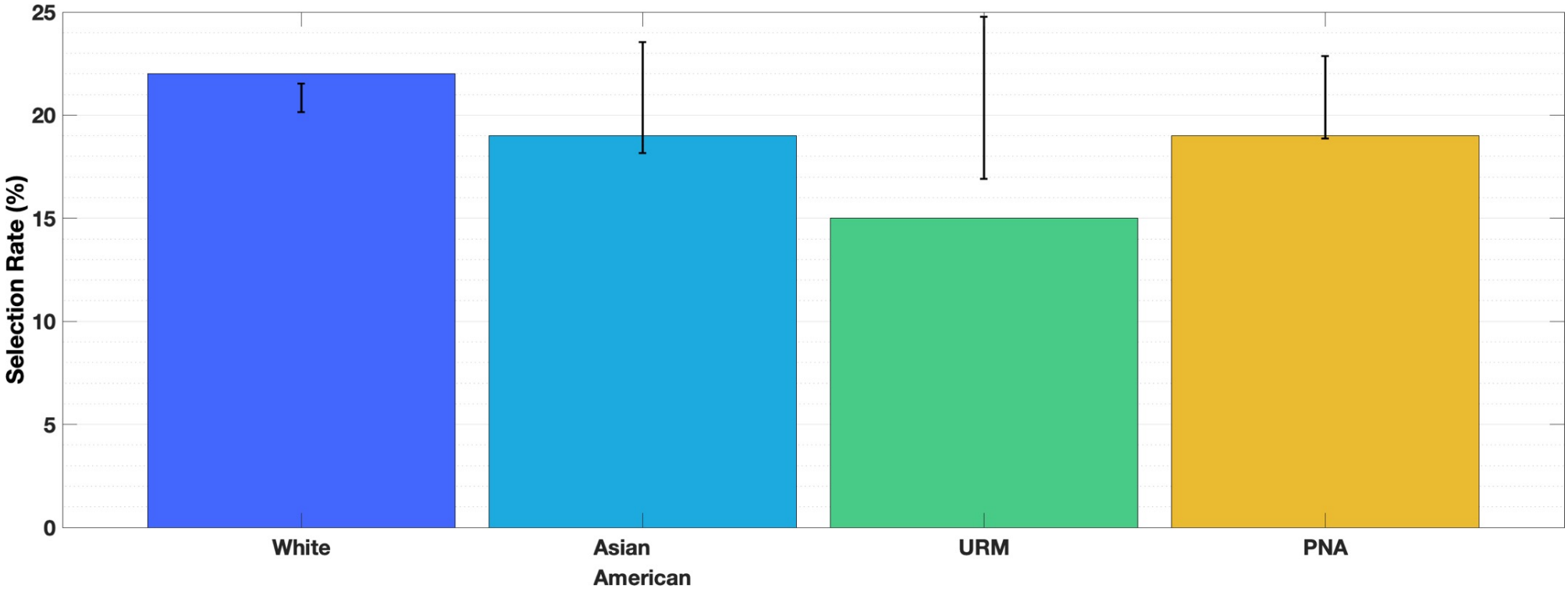


- There is a systematic and overall under selection of proposals led by URC PIs.
  - In 2014 & 2016 the under selection is greater than Poisson noise.

- Overall there is an under selection of proposals led by Asian Americans PIs, though it is below Poisson noise
  - In 2015 & 2019, under selection is greater than Poisson noise.

- There is a systematic and overall over selection of proposals led by White PIs.
  - In 2015, 2016, & 2018 the over selection is greater than Poisson noise.

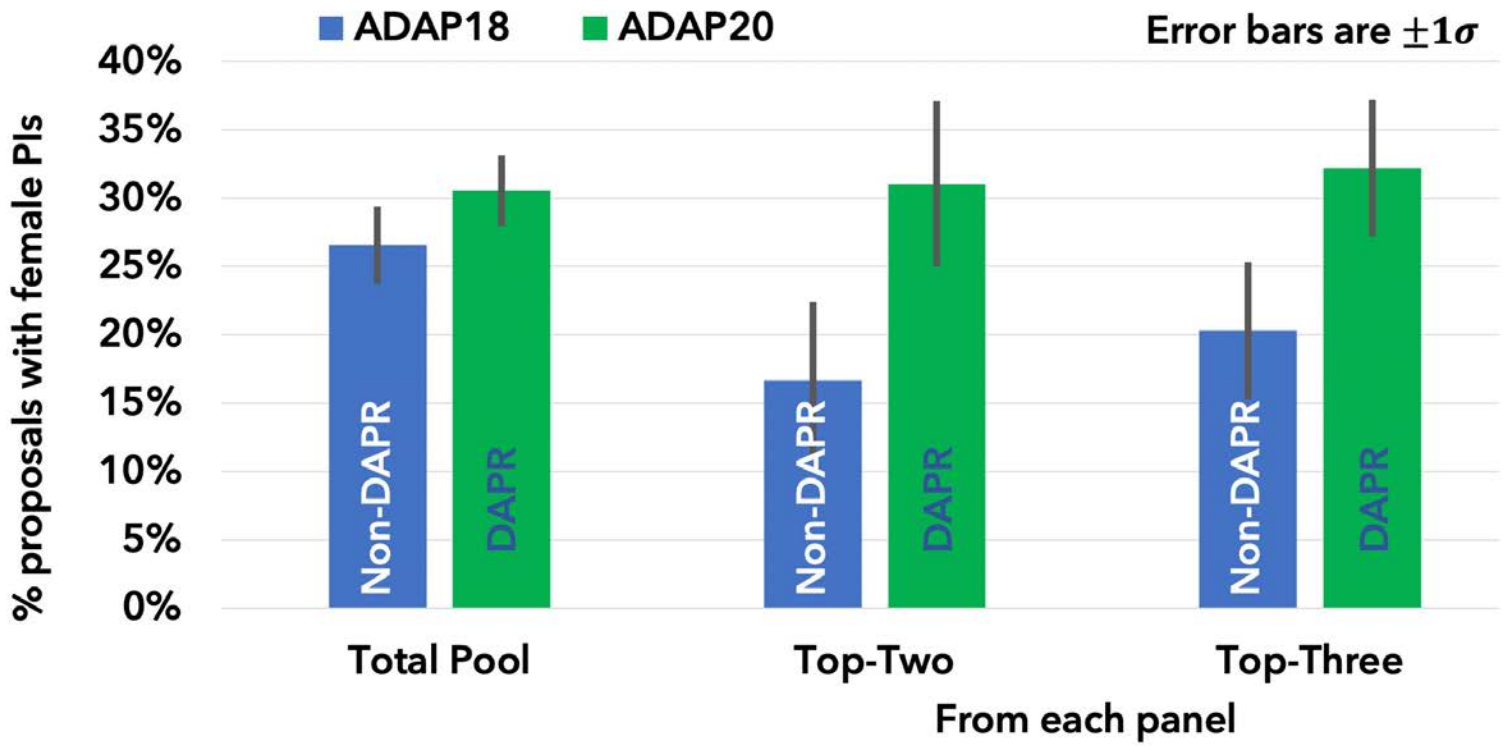
Monte Carlo Modeling



- Bars indicate actual selection rates. The black lines indicate the ± 2-σ Monte Carlo expected selection rate.
- The actual selection rate of URM led proposals is far less than expected by Monte Carlo methods showing that selections are likely not random.

Test 2 - Conclusions

- The selection rates of proposals led by women and men are reasonably similar.
- However, the test case for DAPR of ADAP provides evidence that proposals led by women PIs are underscored by the review panel.



https://science.nasa.gov/researchers/dual-anonymous-peer-review

Test 2 - Conclusions

- Proposals led by PIs from URCs have been systematically under selected over the past seven years. There is some indication that the under selection may be far below reasonable expectation on multiple years.

- There is some indication that proposals led by Asian American PIs may have experienced selection rates below reasonable expectation on multiple years during the past seven years.

Summary Notes

- There exists some evidence to suggest that women may be less likely to lead a proposal submitted to NASA PSD than expected.

- There exists some evidence to suggest that individuals from underrepresented racial/ethnic communities (URC) may be less likely to lead a proposal submitted to NASA PSD.

- The selection rates of proposals led by women and men are reasonably similar.

- Proposals led by PIs from URCs have been systematically under selected over the past seven years. There is some indication that the under selection may be far below reasonable expectation on multiple years.

- There is some indication that proposals led by Asian American PIs may have experienced selection rates below reasonable expectation on multiple years during the past seven years.

Analysis of Demographics Data from Competed Mission Proposals

Demographic Data from Completed Mission Proposals

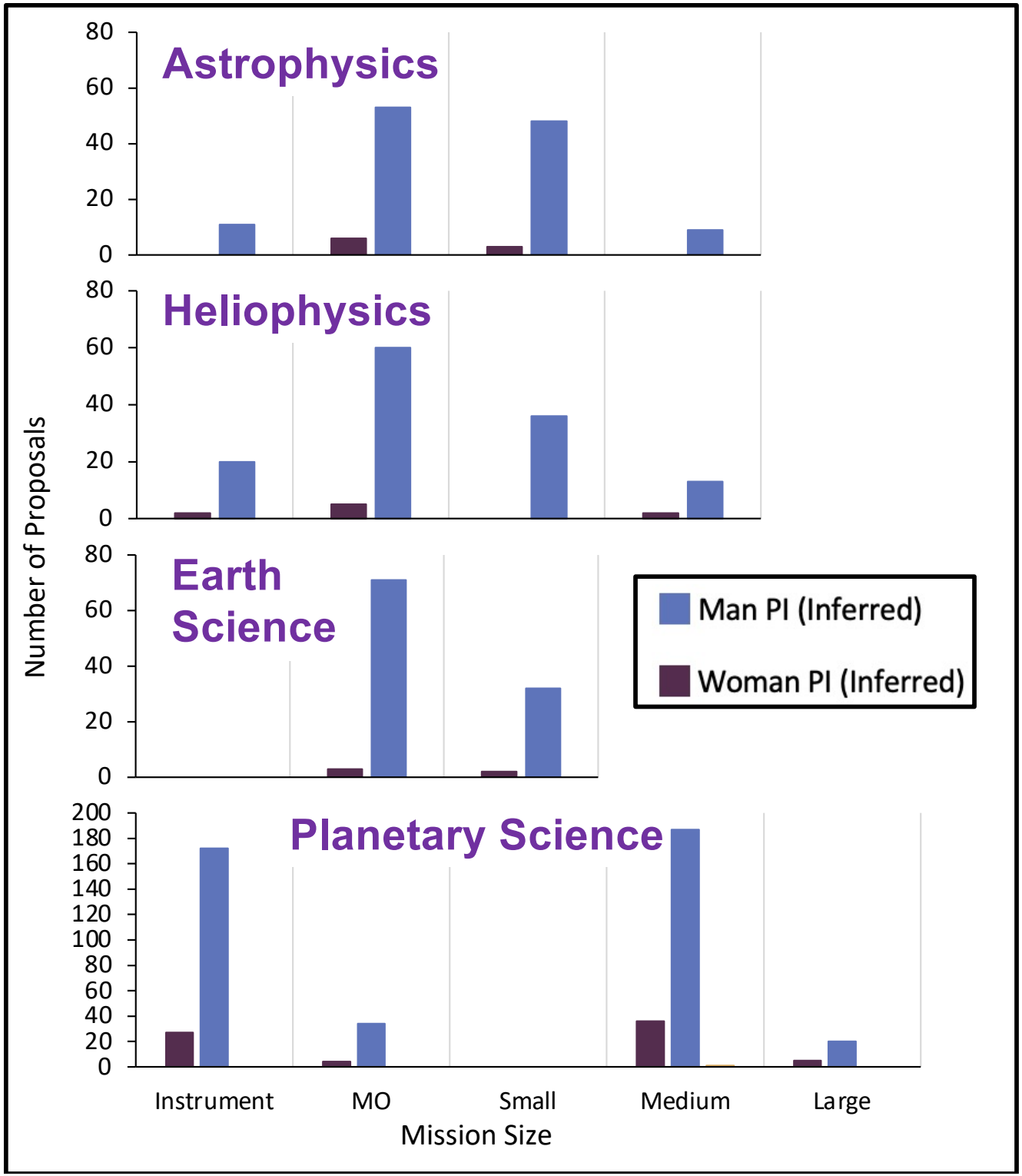
Background:

- Michael New (NASA Deputy Associate Administrator for Research, SMD) & staff have been analyzing the demographics data of leadership – PIs & Co-Is – of competed mission proposals submitted to NASA – and selected

Data Sources

- AO proposal data
  - 2006-present: NSPIRES proposal reports
  - 1996-2005: legacy database from paper proposals
- Inferred Gender
  - Free, online lookup tool (API)
  - Additional research for low inferred gender accuracy values
- Career Stage
  - Final degree year from CV text in proposals or online research

Note: inferred binary gender – see white paper by Beck


Astrophysics
Heliophysics
Earth Science
Planetary Science
Number of Proposals
Man PI (Inferred)
Woman PI (Inferred)
Instrument
MO
Small
Medium
Large
Mission Size

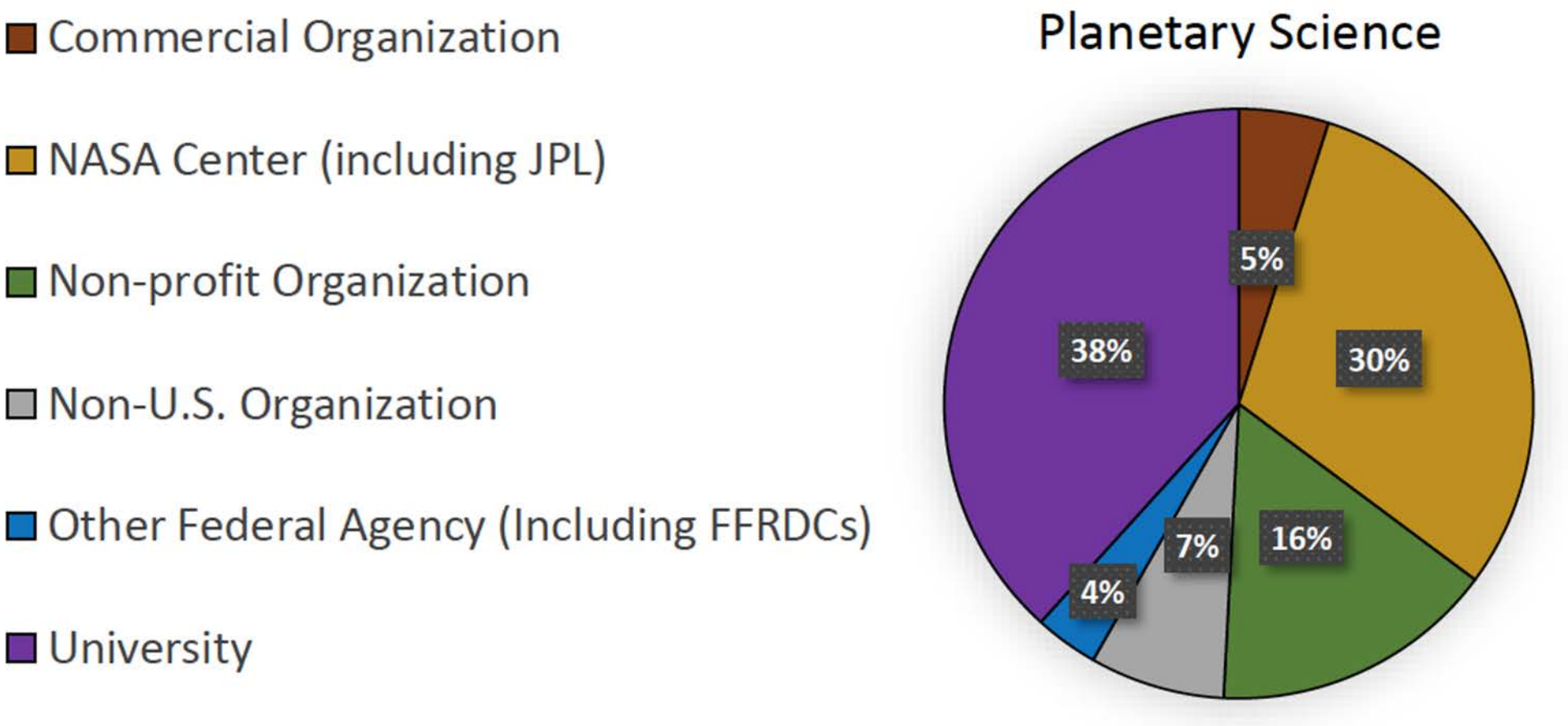
Proposal Submissions & Selection rates

- All SMD Divisions by Mission Size 1996-present

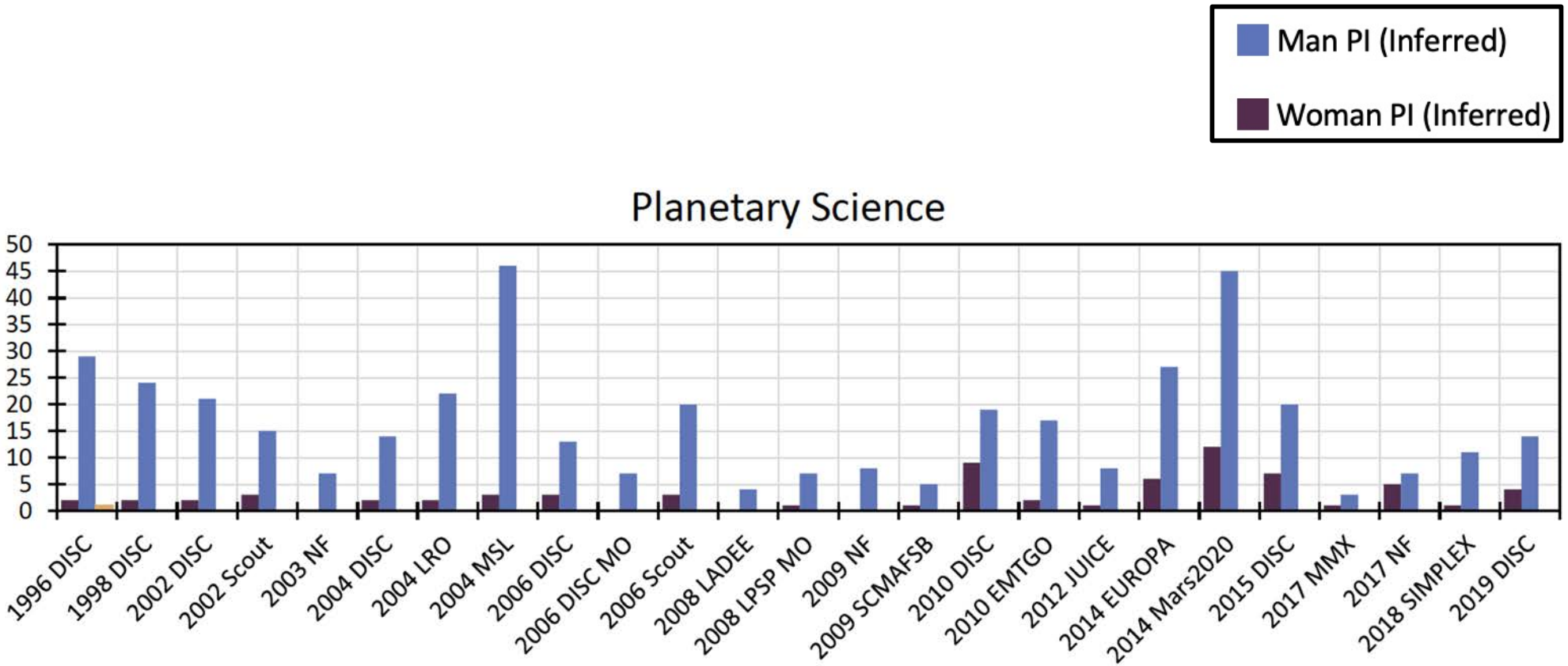
Mission Size	Cost Cap	Number of Calls*	Total Number of Proposals	%W PI	Total Selected	%W PI Selected
Instrument	<$125M	11	232	13%	46	13%
MO	<$125M	18	249	7%	52	8%
Small	<$250M	9	179	4%	34	9%
Medium	<$750M	12	248	15%	48	33%
Large	>$750M	3	25	20%	9	22%
Mission Total		42	701	9.5%	141	18%
Overall Total		53	933	10%	187	16%

MO = Mission of Opportunity
* Some calls include more than one mission size

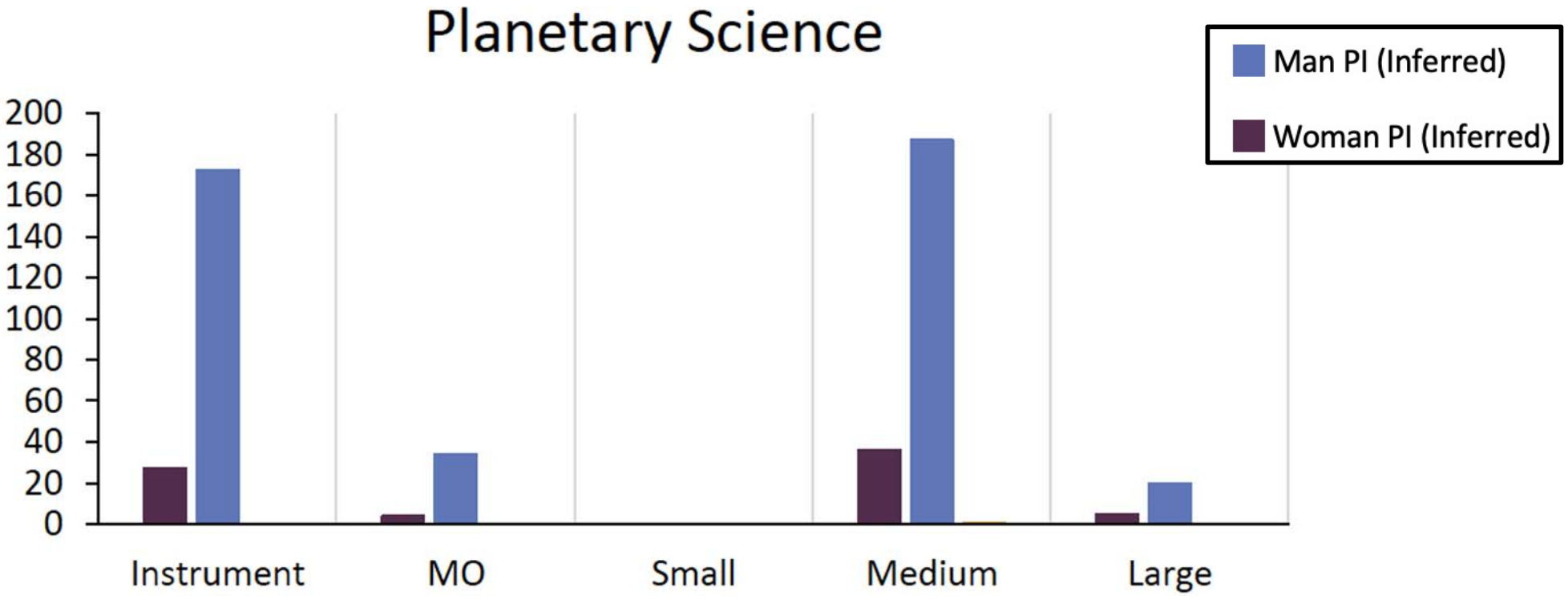
Submitting Organization Type:
1996-present AO proposals SMD Divisions



PI Inferred Gender: 1996-present AO Submissions SMD Divisions by AO

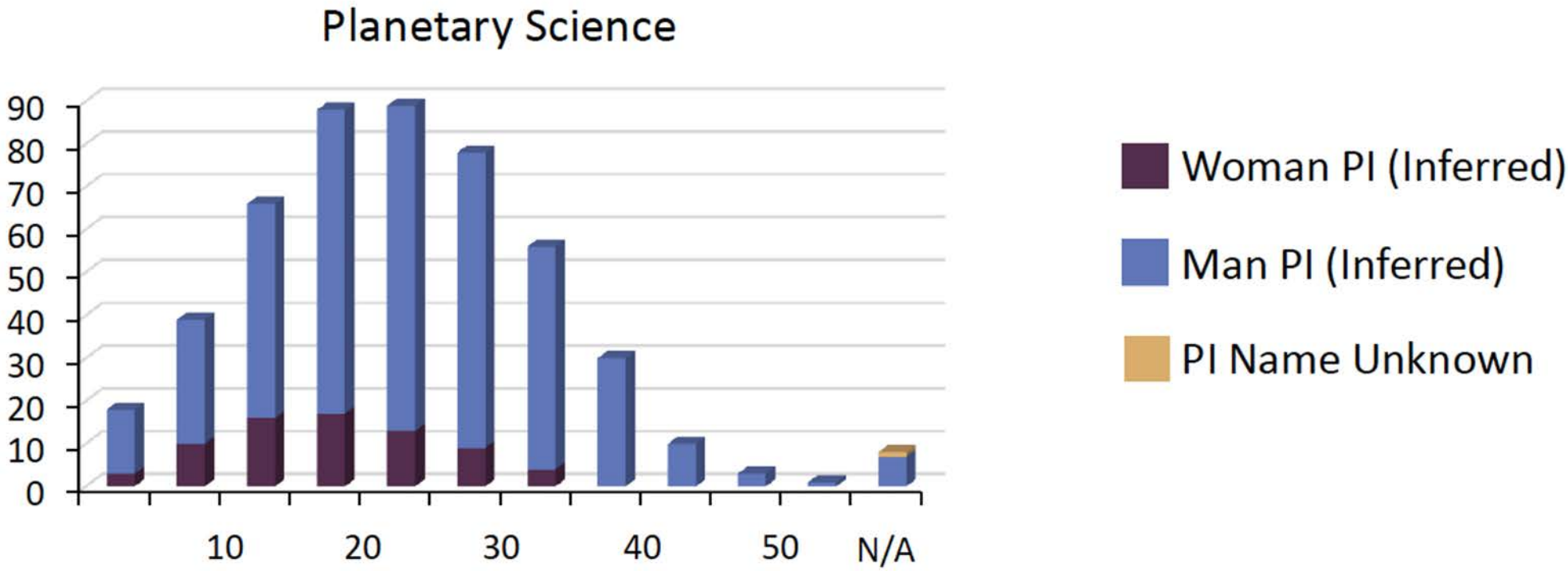


PI Inferred Gender: 1996-present AO Submissions - SMD Divisions by Mission Size



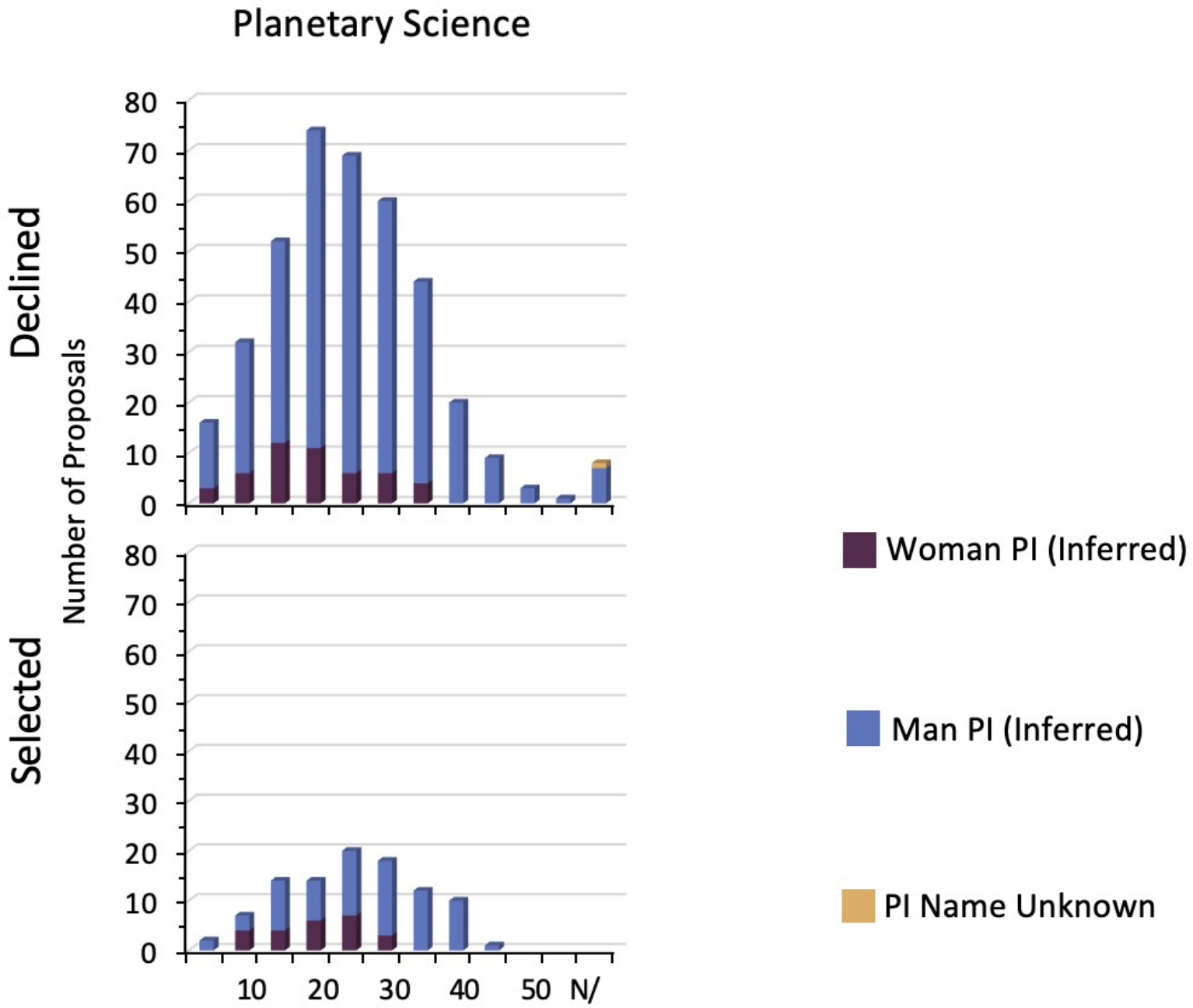
Note: Small missions tend to be Earth orbitting – none in Planetary

PI Academic Age: 1996-present AO Submissions SMD Divisions

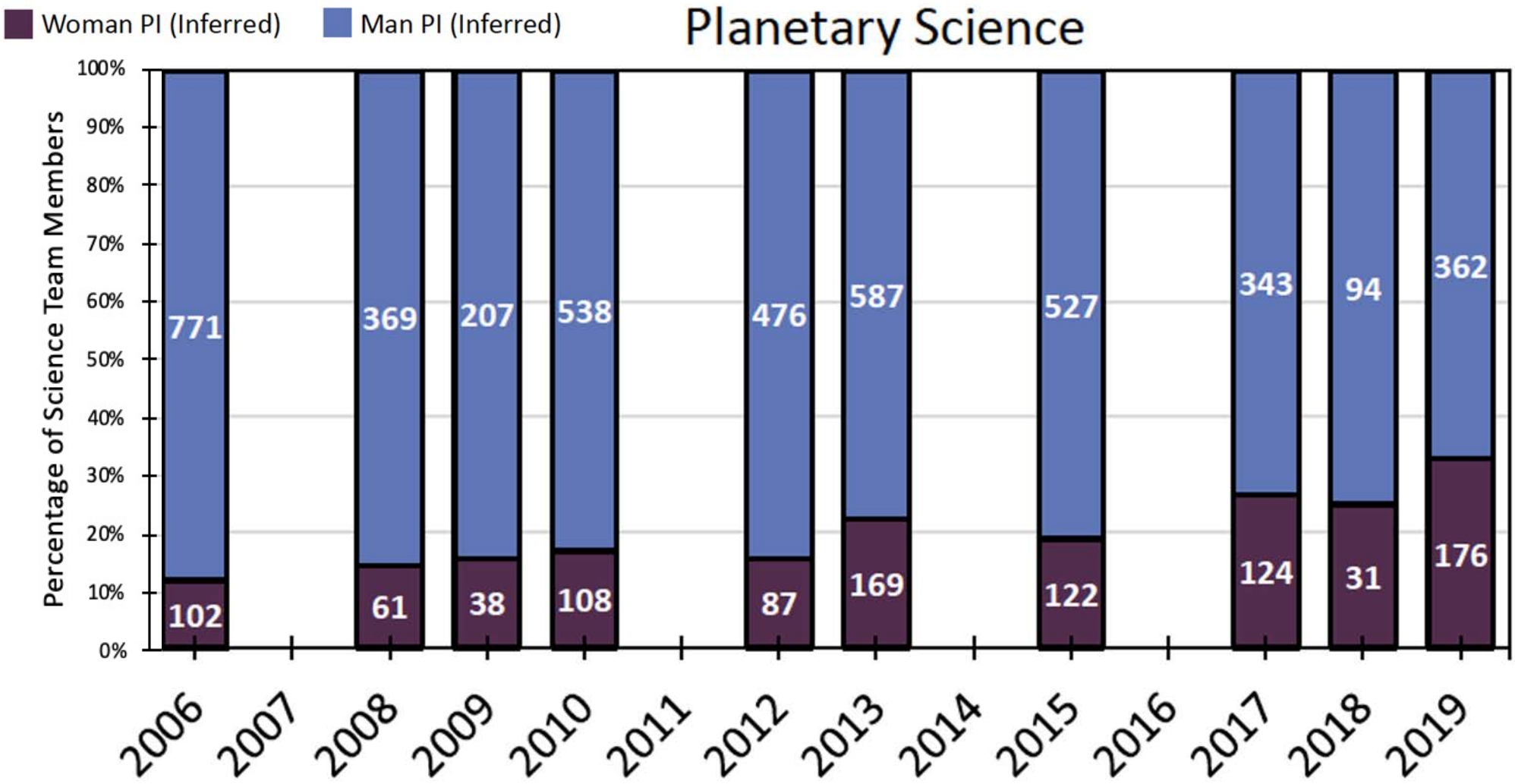


Academic Age = No. years since PhD

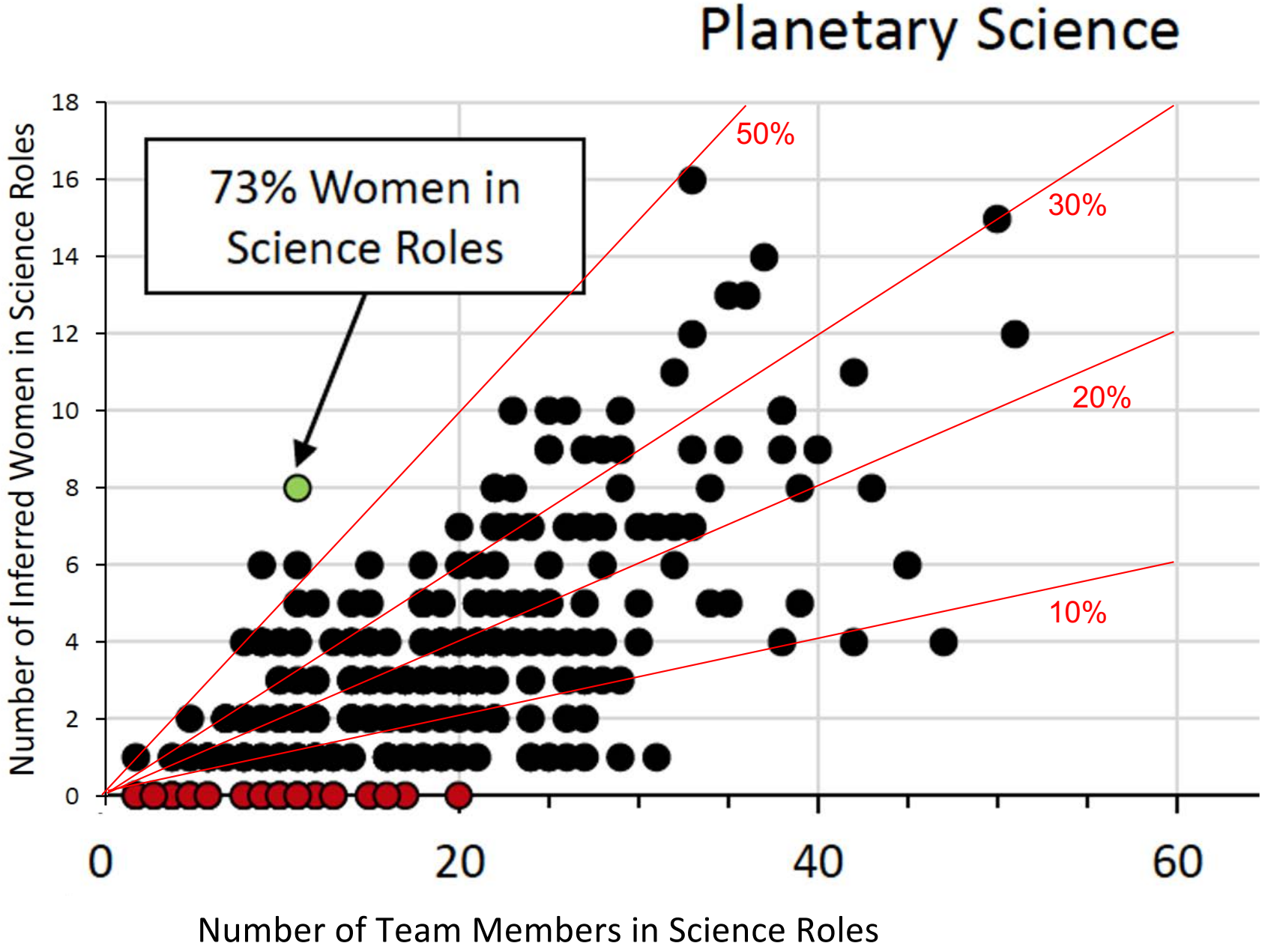
PI Academic Age: Declined and Selected Proposals

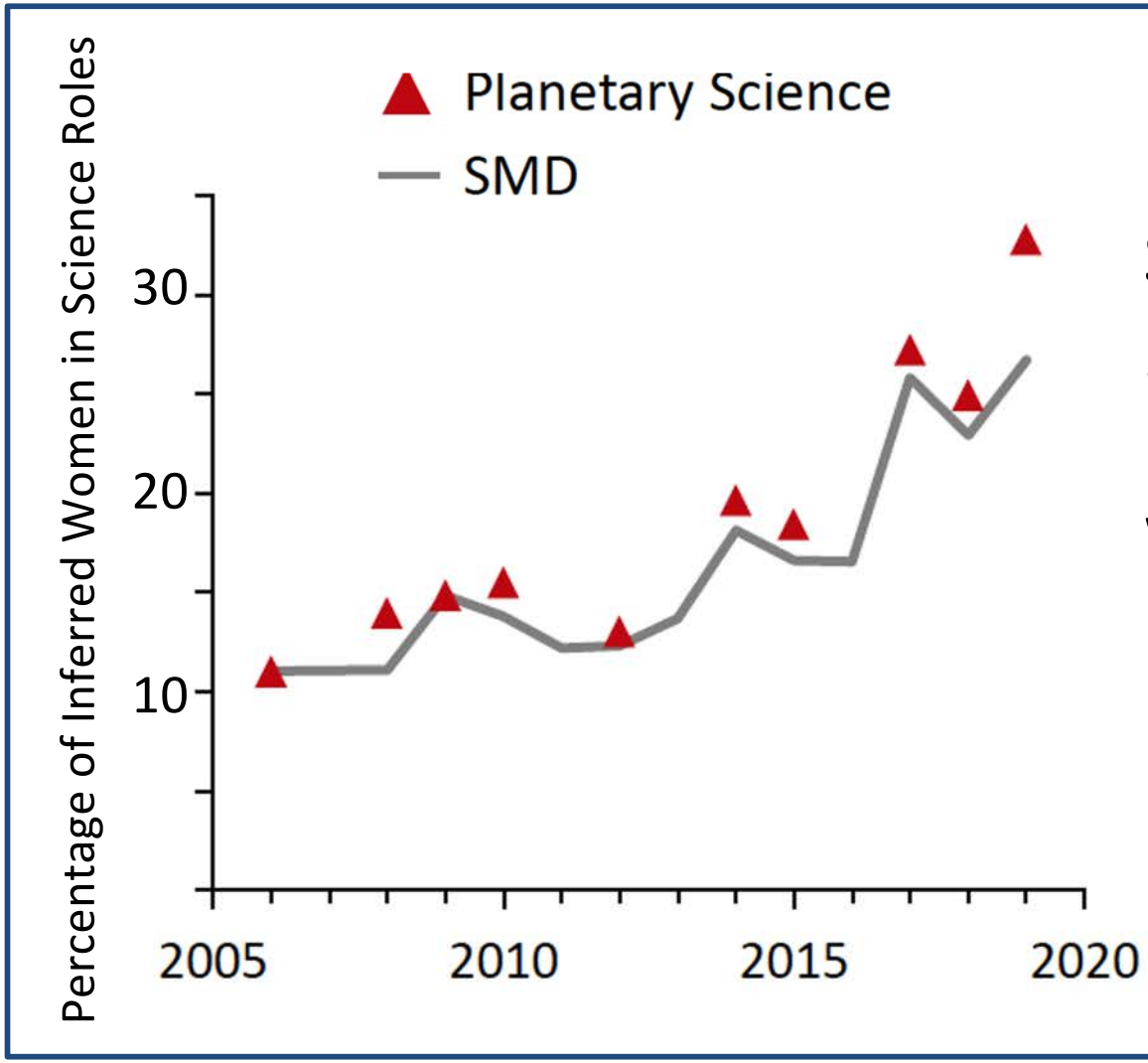


Science Team Inferred Gender: Proposals per Submission Year



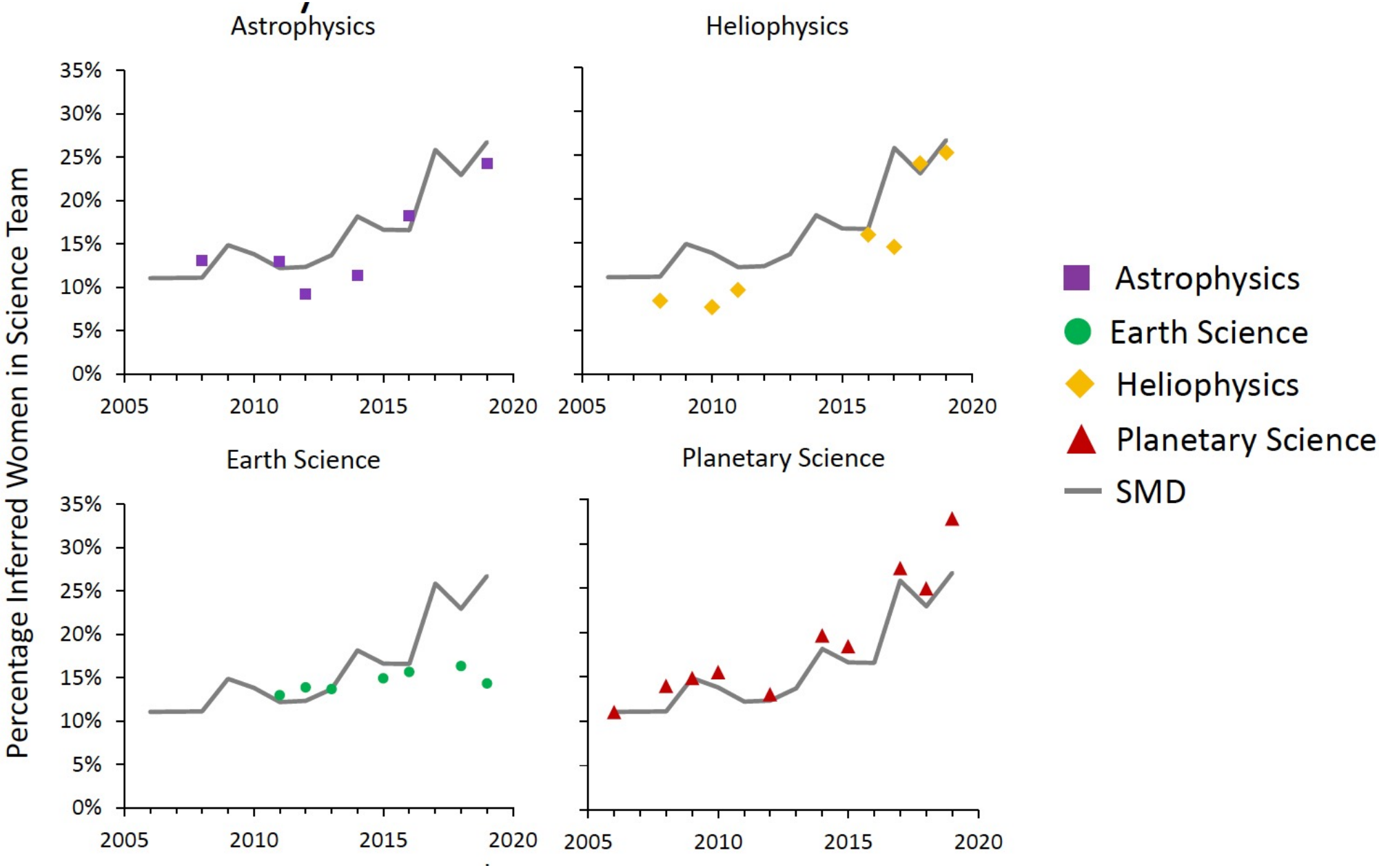
Science Teams: 2006-present
Submitted Proposal Participation by Women



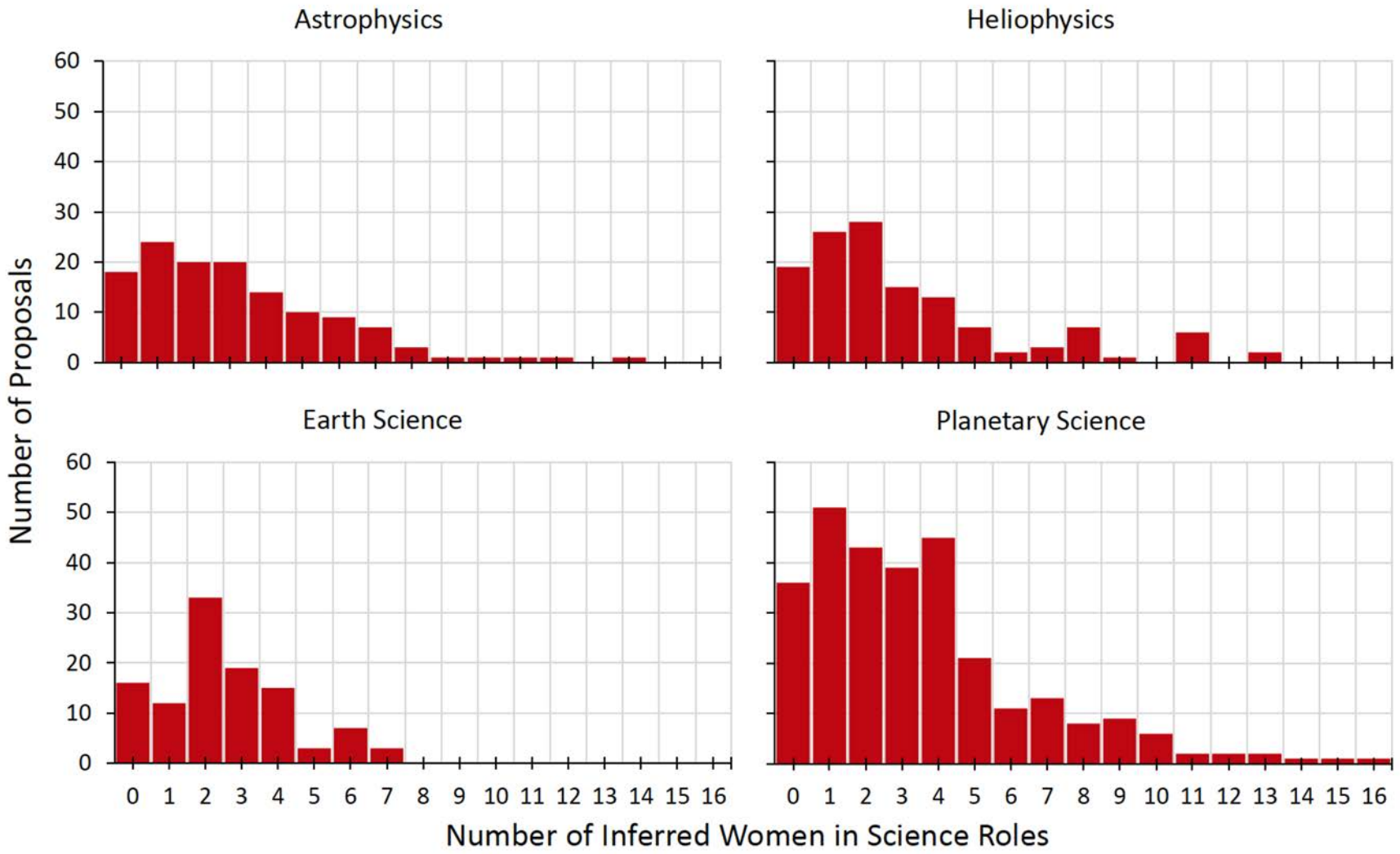


Science Teams:
2006-present
Participation by
Women in Planetary
Missions
by Submission Year

Science Teams: 2006-present AO Participation by Women in SMD Divisions by Submission



Science Teams: 2006-present AO Participation by Women SMD Divisions



Planetary's doing pretty good!

White Papers to Decadal Survey

Before the start of the Decadal Survey of Planetary Science and Astrobiology, the community was invited to submit White Papers on related topics.

Related to the State of the Profession there were a total of 36 White Papers submitted.

On the gender axis, 52.5% of white paper authors were women, 37.9% were men, and 9.6% were non-binary.

About 28% of papers did not offer substantial evidence or propose recommendations; these were mainly “views” and treated as such. 48% of white papers offered light evidence and did propose recommendations. About 23% of papers offered reliable and substantial evidence; most of these also offered recommendations. 50% of papers mentioned race, 41.7% focused on multiple groups and raised concerns of general interest, 30.6% discussed issues concerning gender, followed by 16.7% on aspects of ability (e.g., disability, neurodiversity), 13.9% on socioeconomic class, specifically the loss of talent from groups that today have little opportunity, and 13.9% on issues of sexual identity and orientation.

White paper contents were categorized into 17 broad topics. These topics concern the work produced by planetary scientists and astrobiologists (e.g., education, grants, tenure) as well as issues concerning quality of life that impact work (e.g., childrearing, service work, awareness of bias, workplace culture). Many of the most concerning issues are at the core of the profession (e.g., grants, collaboration, conferences).

White Papers to Decadal Survey - 1

Principal Author	White Paper Title	**Link**
Alessandra Aloisi	(Un)conscious Bias in the Astronomical Profession: Universal Recommendations to improve Fairness, Inclusiveness, and Representation	https://baas.aas.org/pub/2021n4i010/release/1?readingCollection=7272e5bb
Elizabeth Frank	Normalizing non-academic career paths in planetary science	https://baas.aas.org/pub/2021n4i405/release/1?readingCollection=7272e5bb
Kathleen Vander Kaaden	Creating Inclusive, Supportive, and Safe Environments in Planetary Science for Members of the LGBTQ+ Community	https://baas.aas.org/pub/2021n4i411/release/1?readingCollection=7272e5bb
Matija Cuk	Pathways to Sustainable Planetary Science	https://baas.aas.org/pub/2021n4i419/release/1?readingCollection=7272e5bb
Zahra Khan	Military Work by Space Exploration Organizations: A Barrier to Inclusion and Safe Workspaces for Marginalized Communities	https://baas.aas.org/pub/2021n4i421/release/1?readingCollection=7272e5bb
Christopher Carr	Space Drones: An Opportunity to Include, Engage, Accelerate, and Advance	https://baas.aas.org/pub/2021n4i425/release/1?readingCollection=7272e5bb
Britney Schmidt	Diversity in action: Solutions for a more diverse and inclusive decade of planetary science and astrobiology	https://baas.aas.org/pub/2021n4i426/release/1?readingCollection=7272e5bb
Steven Vance	Addressing Mental Health in Planetary Science	https://baas.aas.org/pub/2021n4i429/release/1?readingCollection=7272e5bb
Julie Rathbun	Who is Missing in Planetary Science?: Strategic Recommendations to Improve the Diversity of the Field	https://baas.aas.org/pub/2021n4i435/release/1?readingCollection=7272e5bb
Moses Milazzo	The Growing Digital Divide and its Negative Impacts on NASA's Future Workforce	https://baas.aas.org/pub/2021n4i436/release/1?readingCollection=7272e5bb
Julie Rathbun	Enabling the Planetary Workforce to do the best science by funding work that is a service to the Profession	https://baas.aas.org/pub/2021n4i437/release/1?readingCollection=7272e5bb
Julie Rathbun	Ensuring Inclusivity in the 2023 Planetary Science and Astrobiology Decadal Survey	https://baas.aas.org/pub/2021n4i438/release/1?readingCollection=7272e5bb
Christina Richey	A Call to Planetary2023 Panels to Implement Actionable Recommendations from Recent National IDEA Studies	https://baas.aas.org/pub/2021n4i441/release/1?readingCollection=7272e5bb
Beck Strauss	Nonbinary Systems: Looking towards the future of gender equity in planetary science	https://baas.aas.org/pub/2021n4i442/release/1?readingCollection=7272e5bb
Edgard Rivera-Valentín	Who is missing in planetary Science?: A demographic study of the planetary science workforce	https://baas.aas.org/pub/2021n4i443/release/1?readingCollection=7272e5bb
Jennifer Piatek	Breaking Down Barriers: Accessibility in Planetary Science	https://baas.aas.org/pub/2021n4i444/release/1?readingCollection=7272e5bb
Christina Richey	Recommendations from the CSWA Survey on Workplace Climate	https://baas.aas.org/pub/2021n4i445/release/1?readingCollection=7272e5bb
Moses Milazzo	DEIA White Papers for Planetary 2023 supported by the Cross-AG EDI Working Group	https://baas.aas.org/pub/2021n4i446/release/1?readingCollection=7272e5bb

White Papers to Decadal Survey - 2

Principal Author	White Paper Title	**Link**
Jacob Richardson	Building Safer and More Inclusive Field Experiences in Support of Planetary Science	https://baas.aas.org/pub/2021n4i447/release/1?readingCollection=7272e5bb
Serina Diniega	Ensuring a safe and equitable workspace: The importance and feasibility of a Code of Conduct, along with clear policies regarding author. & team mem.	https://baas.aas.org/pub/2021n4i448/release/1?readingCollection=7272e5bb
Monica Vidaurri	Absolute Prioritization of Planetary Protection, Ethics, and Avoiding Imperialism in All Future Science Missions: A Policy Perspective	https://baas.aas.org/pub/2021n4i450/release/1?readingCollection=7272e5bb
Christina Richey	Lessons Learned on IDEA from the Astro2020 Decadal Survey	https://baas.aas.org/pub/2021n4i456/release/1?readingCollection=7272e5bb
Matthew Tiscareno	Planetary Nomenclature and Indigenous Communities	https://baas.aas.org/pub/2021n4i462/release/1?readingCollection=7272e5bb
Frank Tavares	Ethical Exploration and the Role of Planetary Protection in Disrupting Colonial Practices	https://baas.aas.org/pub/2021n4i461/release/1?readingCollection=7272e5bb
Matthew Tiscareno	Planetary Nomenclature and Indigenous Communities	https://baas.aas.org/pub/2021n4i462/release/1?readingCollection=7272e5bbb
William Bottke	Tenets of an Effective and Efficient Research and Analysis Program for NASA	https://baas.aas.org/pub/2021n4i463/release/1?readingCollection=7272e5bb
Jani Radebaugh	The Value of a Dual Anonymous System for Reducing Bias in Reviews of Planetary Research and Analysis Proposals and Scientific Papers	https://baas.aas.org/pub/2021n4i464/release/1?readingCollection=7272e5bb
Ingrid Daubar	Extended Missions in Planetary Science: Impacts to Science and the Workforce	https://baas.aas.org/pub/2021n4i465/release/1?readingCollection=7272e5bb
Kathryn Gardner-Vandy	Relationships First and Always: A Guide to Collaborations with Indigenous Communities	https://baas.aas.org/pub/2021n4i471/release/1?readingCollection=7272e5bb
Ryan Watkins	Professional development in the next decade: Supporting opportunities in all career paths and life events	https://baas.aas.org/pub/2021n4i472/release/1?readingCollection=7272e5bb
Amanda Hendrix	Results of the 2020 Planetary Science Workforce Survey Conducted by the AAS-DPS	https://baas.aas.org/pub/2021n4i473/release/1?readingCollection=7272e5bb
Kristen Bennett	The Preventing Harassment in Science Workshop: Summary and Best Practices for Planetary Science and Astrobiology	https://baas.aas.org/pub/2021n4i474/release/1?readingCollection=7272e5bb
Daniella Scalice	Power and Responsibility	https://baas.aas.org/pub/2021n4i493/release/1?readingCollection=7272e5bb
Abbie Grace	Promoting the ‘A’ in SPACE: ‘Arts’ run the places STEM takes us	https://baas.aas.org/pub/2021n4i499/release/1?readingCollection=7272e5bb
Heather Kaluna	Creating Spaces for Indigenous Voices within Planetary Science - Part 1	https://baas.aas.org/pub/2021n4i502/release/1?readingCollection=7272e5bb
Brittany Kamai	Creating Spaces for Indigenous Voices within Planetary Science - Part 2	https://baas.aas.org/pub/2021n4i503/release/1?readingCollection=7272e5bb

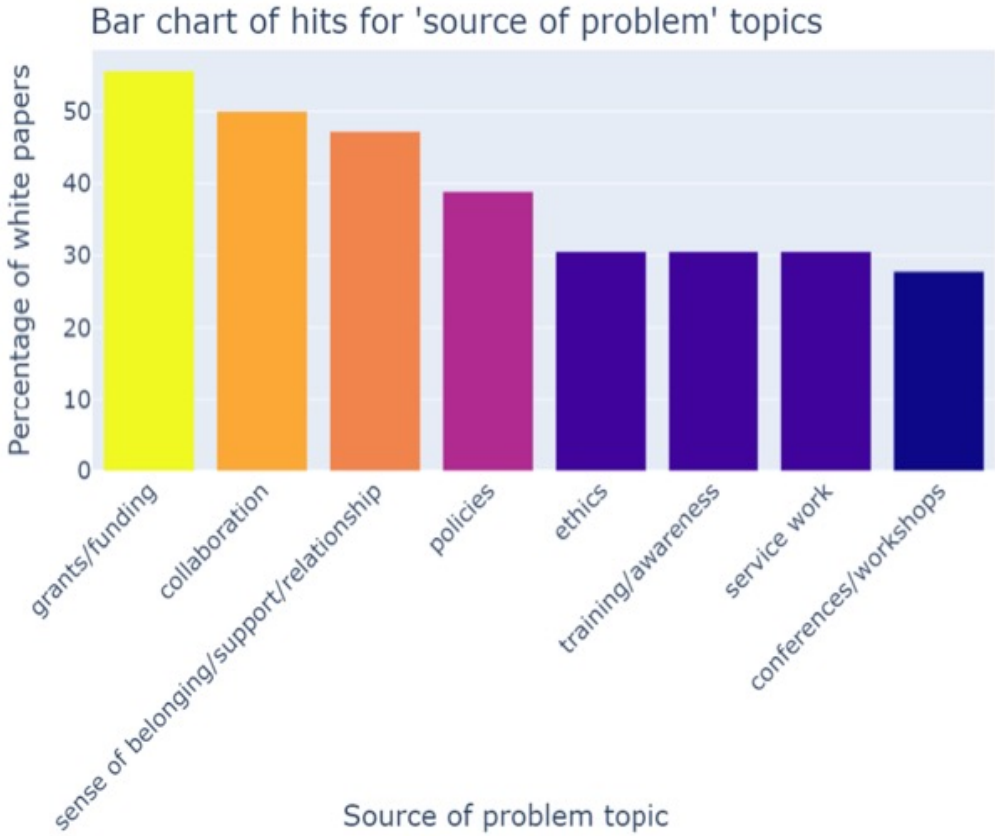
White Papers to Decadal Survey

What is being said?

Encoding for where the problem might lay

1. pre-undergraduate education
2. tenure & high-status faculty position/career pipeline
3. childrearing/family-care/work-life balance
4. grants/funding
5. dual-anonymous review process
6. lack of transparency
7. policies
8. ethics
9. authorship
10. service work
11. lack of sense of belonging/support/relationship
12. collaboration
13. lack of training/awareness
14. mentorship/role models
15. science missions/field sites
16. conferences/workshops/course
17. sexual harassment/hostile culture

The top 8 sources authors are pointing to are...



Notes

- Demographics data help NASA develop the workforce needed to achieve mission objectives.

- The 2 NASA teams are making well-meant effort to gather demographics data.

- NASA needs to find an SMD-wide system of gathering demographics information about proposal submissions
  - PIs, Co-Is, students on grants proposals
  - PIs, Co-Is, teams of competed mission proposals

- NASA can learn from other federal research agencies about effective methods for gathering of (voluntary) demographics data from proposers.

White Papers & References

Barbier, L. (2021) https://science.nasa.gov/science-red/s3fs-public/atoms/files/07-Barbier-Demographics-061421.pdf

Rathbun, J., Richey, C., Cohen, B. A., Piatek, J. L., Roberts, J. H., Daubar, I. J., … Venkatesan, A. (2021a). Ensuring Inclusivity in the 2023 Planetary Science and Astrobiology Decadal Survey. Bulletin of the AAS, 53(4). https://doi.org/10.3847/25c2cfeb.07d5698a

Rathbun, J., Rivera-Valentín, E. G., Keane, J. T., Lynch, K., Diniega, S., Quick, L. C., … Brooks, S. M. (2021b). Who is Missing in Planetary Science?: Strategic Recommendations to Improve the Diversity of the Field. Bulletin of the AAS, 53(4). https://doi.org/10.3847/25c2cfeb.da96f3af

Rivera-Valentín, E., Rathbun, J., Keane, J. T., Lynch, K., Richey, C., Diniega, S., & Vertesi, J. (2021). Who is missing in planetary Science?: A demographic study of the planetary science workforce. Bulletin of the AAS, 53(4). https://doi.org/10.3847/25c2cfeb.968ed505