Numbers You Should Know

Part 1

ASTR 8500 Spring 2020 Robert W. O'Connell

Sources?

- American Astronomical Society
- American Institute of Physics
- NSF, NASA, other agencies
- UVa
- Literature and general media sources
- ROMEs = rough order magnitude estimates

A National Perspective on Astronomy

We're #3!

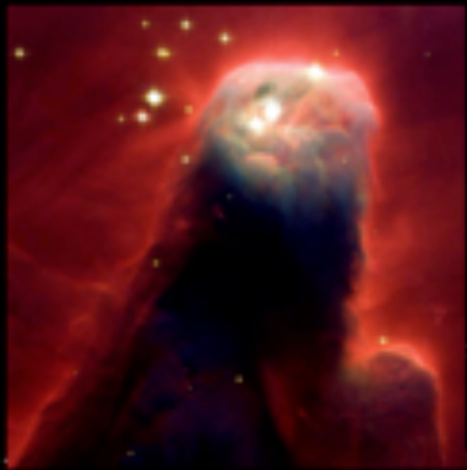
We're #3 among STEMM fields in media impact:

#1 Health & Medicine
#2 Environment
#3 Astronomy & Space

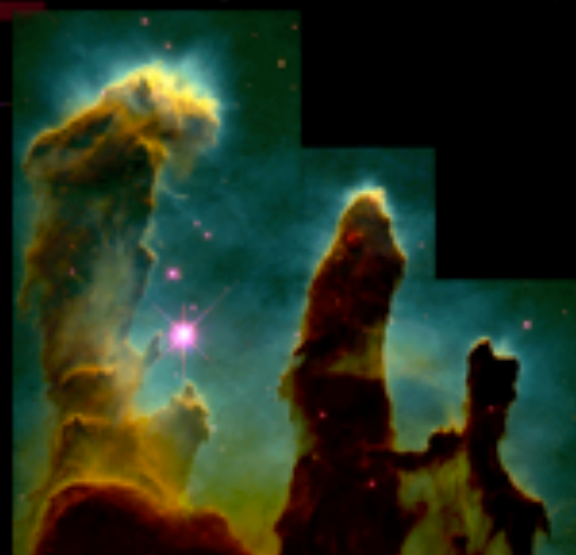
We're #1 in impact per practitioner!

Total STEMM employment: 16 million

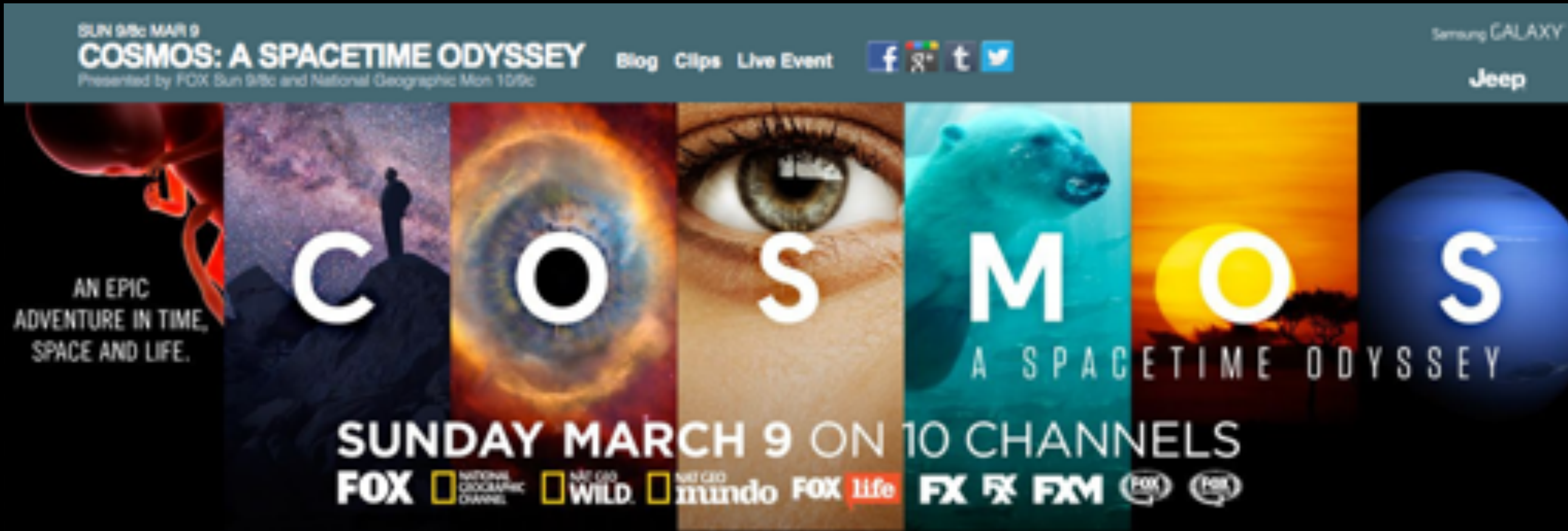
Total astronomy & space science employment: ~20-30 thousand











SUN 9/8c MAR 9
COSMOS: A SPACETIME ODYSSEY
Presented by FOX Sun 9/8c and National Geographic Mon 10/9c
Blog
Clips
Live Event
Samsung GALAXY
Jeep
AN EPIC ADVENTURE IN TIME, SPACE AND LIFE.
COSMOS
A SPACETIME ODYSSEY
SUNDAY MARCH 9 ON 10 CHANNELS
FOX
WILD
mundo
FOX life
FX
FXM

Eclipse USA 2017

The New York Times

215 Million Americans Watched the Solar Eclipse, Study Finds

Todd Heisler/The New York Times

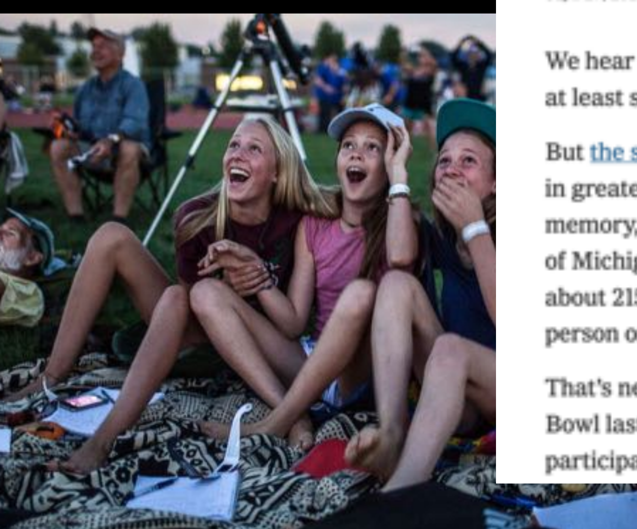
By Jonah Engel Bromwich

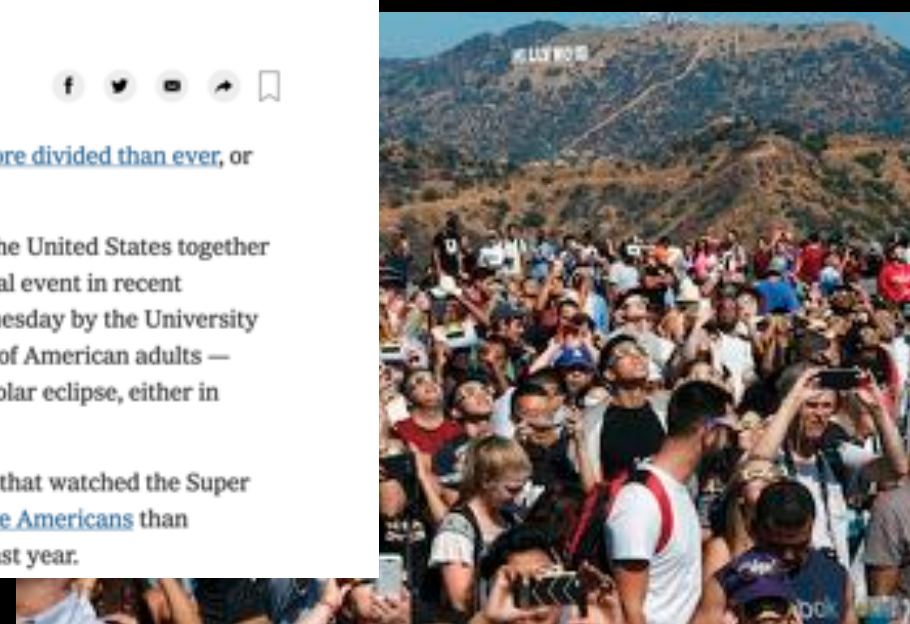
Sept. 27, 2017

We hear it all the time: Americans are more divided than ever, or at least since the Civil War.

But the solar eclipse on Aug. 21 brought the United States together in greater numbers than most any national event in recent memory, according to a study released Tuesday by the University of Michigan. It estimated that 88 percent of American adults — about 215 million people — watched the solar eclipse, either in person or electronically.

That's nearly twice the number of people that watched the Super Bowl last year. It's almost 30 percent more Americans than participated in the presidential election last year.



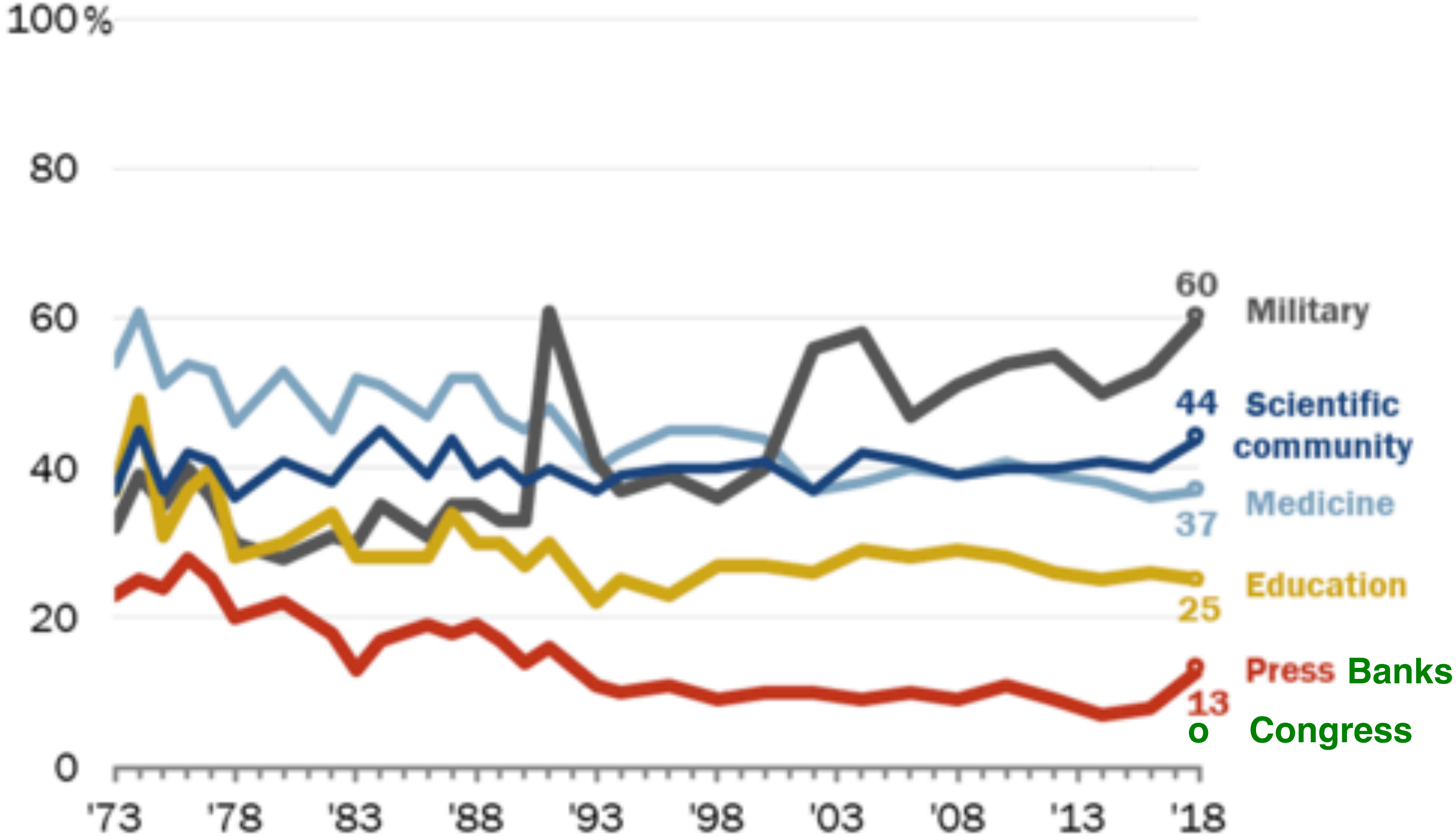


"Scientist" is the #4 most prestigious profession

(Harris Poll, 2014)

Confidence in leaders of the military has gone up; confidence in some other institutions is declining

% of U.S. adults who say they have a great deal of confidence in the people running each of these institutions



Note: Respondents who gave other responses or who did not give an answer are not shown.
Source: General Social Surveys, NORC.

PEW RESEARCH CENTER (2018 data)

250,000

= Number of college students enrolled annually in elementary astronomy courses



$425,000

= National budget for astronomy
<u>per astronomer</u>

THE NATIONAL BUDGET FOR ASTRONOMY (2016)

NSF	NASA	DOE, DOD	Univ/Priv*	Total**	Number Astronomers***	$$/Astronomer
$250M	$2950M	~$50M	~$150M	$3400M	~8000	$425,000

*Research support; excludes basic faculty salaries.

**The federal budget for astronomy is ~0.08% of the total federal budget of $4.0T or $10.09 per US citizen per year.

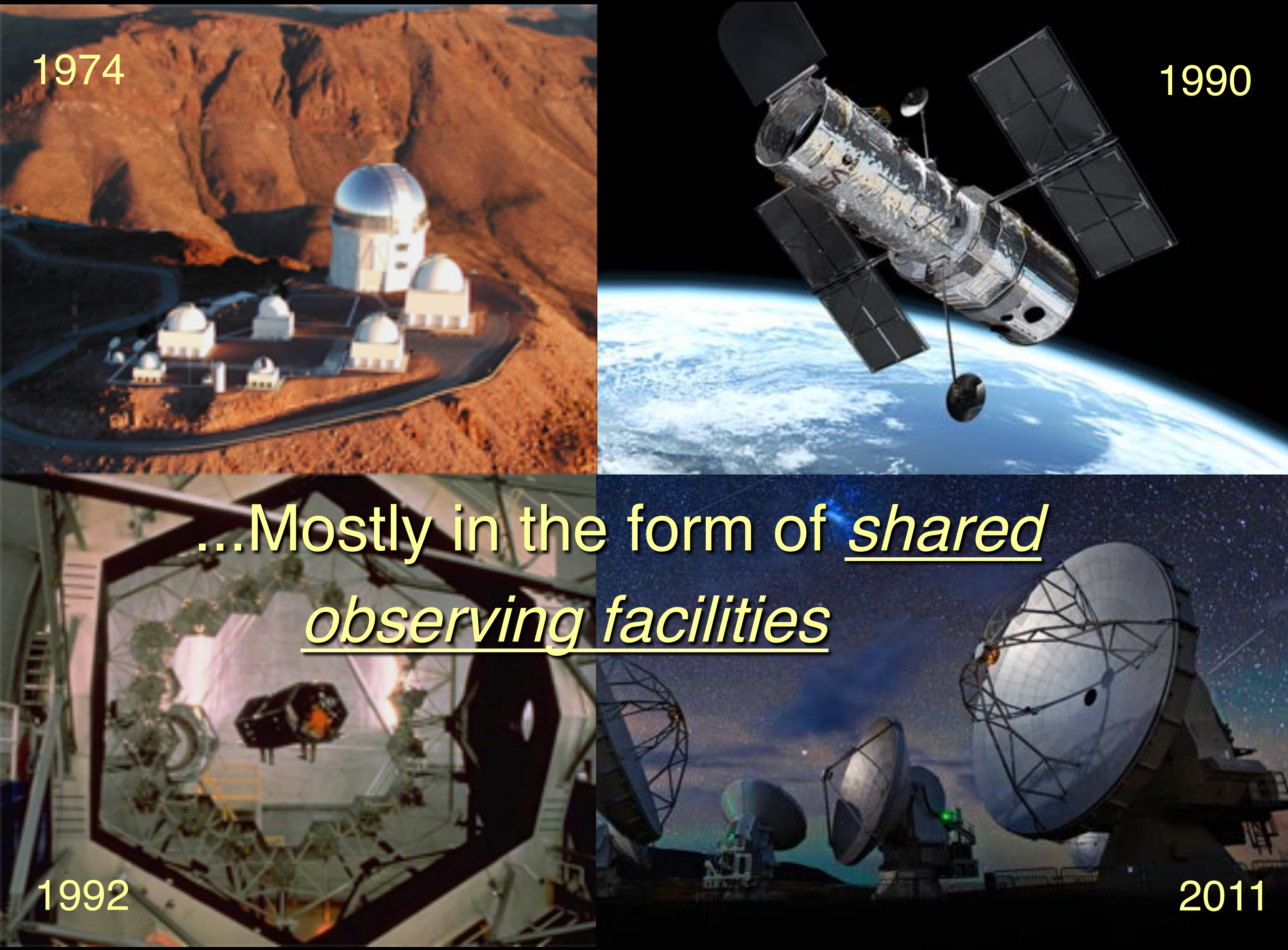
***AAS membership, 2016

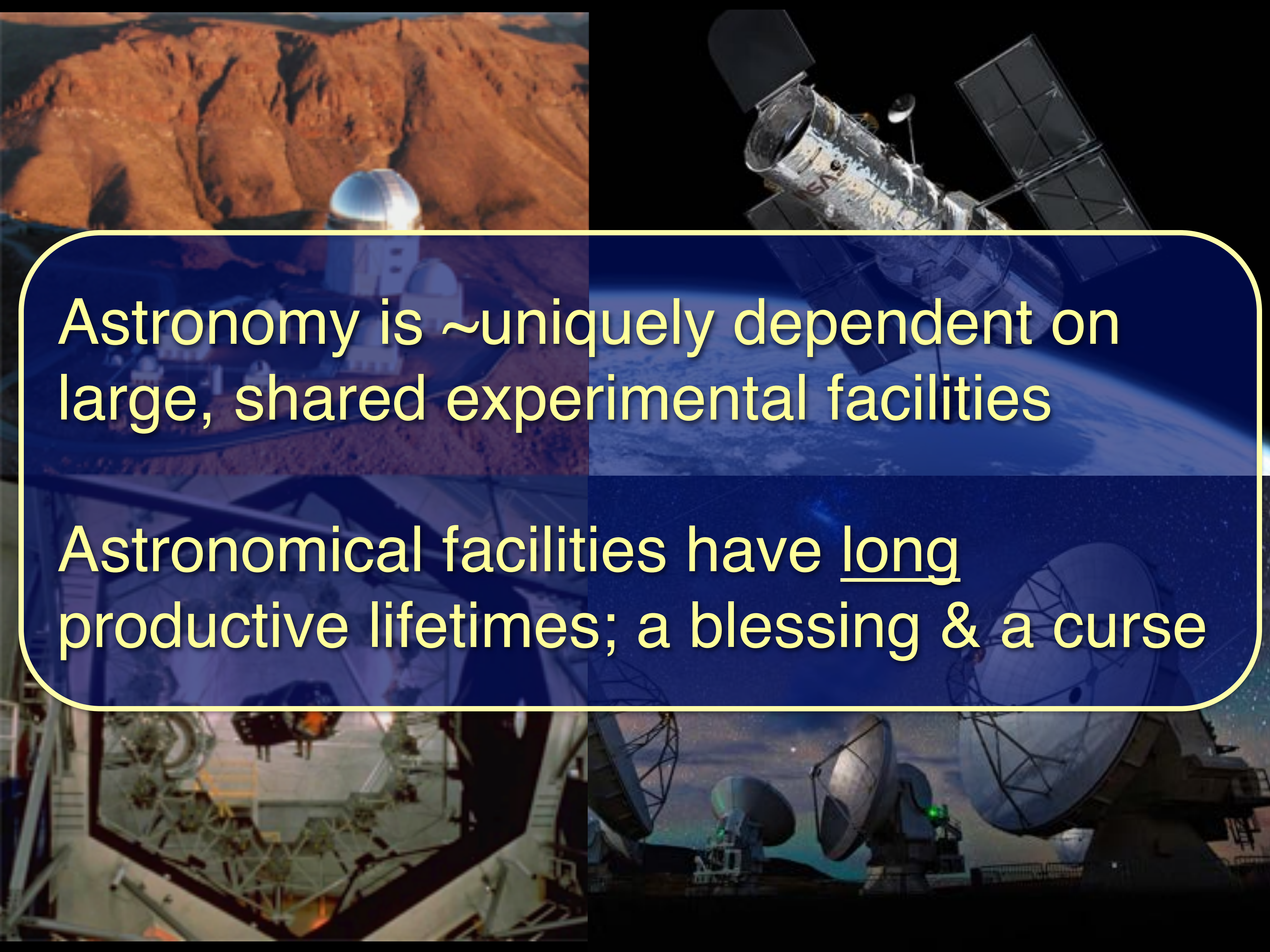
$425,000

$425,000

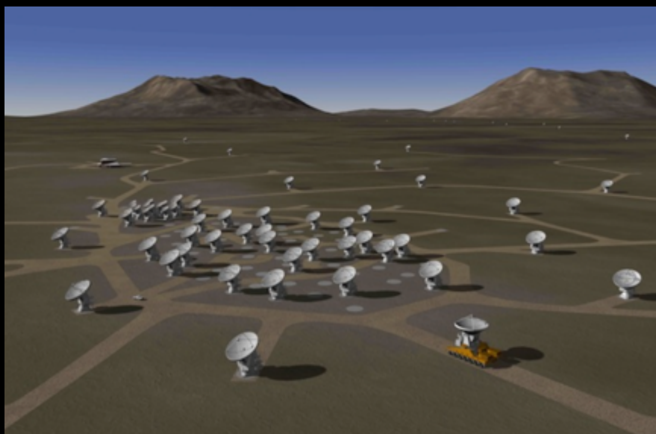
= National budget for astronomy <u>per astronomer</u>

...BUT: mostly in the form of <u>*shared observing facilities*</u>

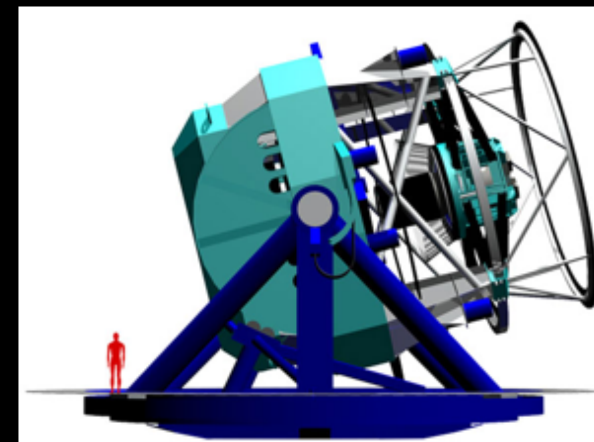

1974
1990
...Mostly in the form of *shared observing facilities*
1992
2011


Astronomy is ~uniquely dependent on large, shared experimental facilities
Astronomical facilities have long productive lifetimes; a blessing & a curse

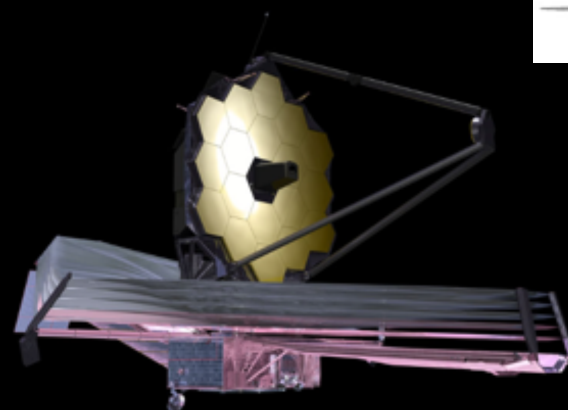
Promise of the Next Decade



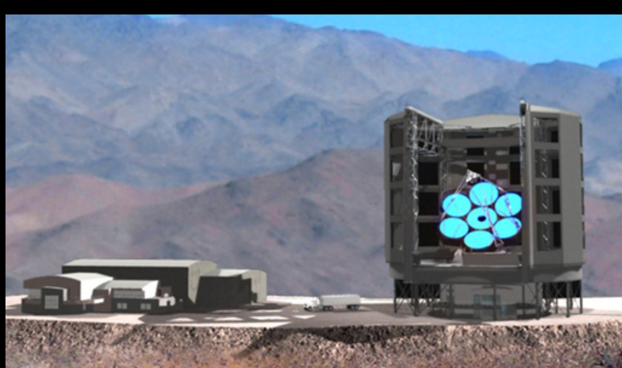
ALMA



LSST



JWST



GMT

WFIRST

The Job Market

Kinds of Jobs for Astronomers

- Postdoctoral
  - Short-term (1-3 yr) research positions (mostly directed)
- Research Scientists
  - Mostly semi-permanent. Large range, from support to independent researchers. Universities, observatories, government labs (e.g. NRAO, NOAO, GSFC, STScI, USNO). Independent contractors (e.g. APL, SWRI).
- University Faculty
  - Short term contractual and permanent (tenured). Research and teaching.
- Non-astro-research Government
  - E.g. NASA, NSF, DOD, DOE, NOAA, etc.
- Non-astro-research Private Sector
  - "Beltway Bandits," computing/big data, aerospace, sensors, optics & imaging, defense, finance...

Kinds of $$$

- "Hard" money (reliable, long-term)
  - Tenured faculty
  - Civil servants
  - Tenured & senior staff at national labs
- "Soft" money (term-limited, grants & contracts)
  - Postdocs
  - "Adjunct" faculty
  - Many "research scientists"
  - Federal contractors (e.g. SWRI)
  - Other private sector

2%

= Unemployment rate for astronomers (~ transition rate -> ~ FULL employment)

2/3

Astronomy Long-term
PhD Employment Pattern
Through the 1990's:

~1/3 Faculty

~1/3 Research Scientists

~1/3 Non Astronomy

Astronomy Long-term PhD Employment Pattern Through the 2000's:

~1/3 Faculty

~1/3 Research Scientists

~1/3 Non Astronomy

65%

(Perley 2019)

How many jobs?

HAPPY 2020

Here's a quick selection of notable accomplishments in 2019:

13 million article downloads from our research journals — the *Astronomical Journal, Astrophysical Journal, Astrophysical Journal Letters, Astrophysical Journal Supplements*, and *Research Notes of the AAS*

2,550 unique presenters at AAS meetings

1,150 talks at AAS meetings

1,600 posters and iPosters at AAS meetings

1,000 new AAS members and affiliates engaged in the astronomical sciences

SKY & TELESCOPE

The AAS acquired *Sky & Telescope* magazine, SkyandTelescope.com, *S&T*'s astronomy-themed tours, and the company's line of star atlases, celestial globes, and other products.

THE PLANETARY SCIENCE JOURNAL

The AAS and its Division for Planetary Sciences launched a new gold open access journal for the publication of planetary science research.

AAS MEMBERS AND COUNTING

8,902

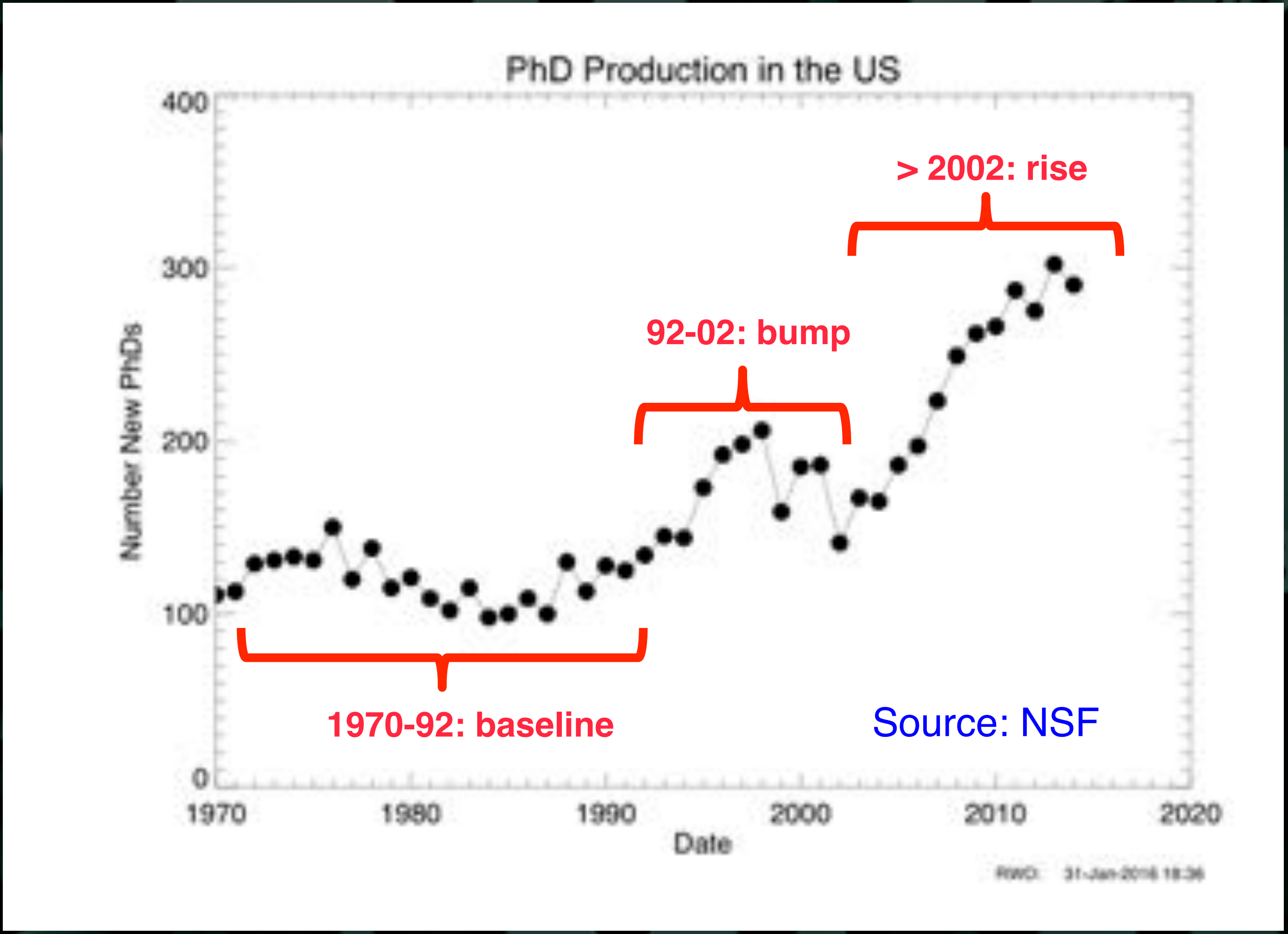
How many jobs?

~8500

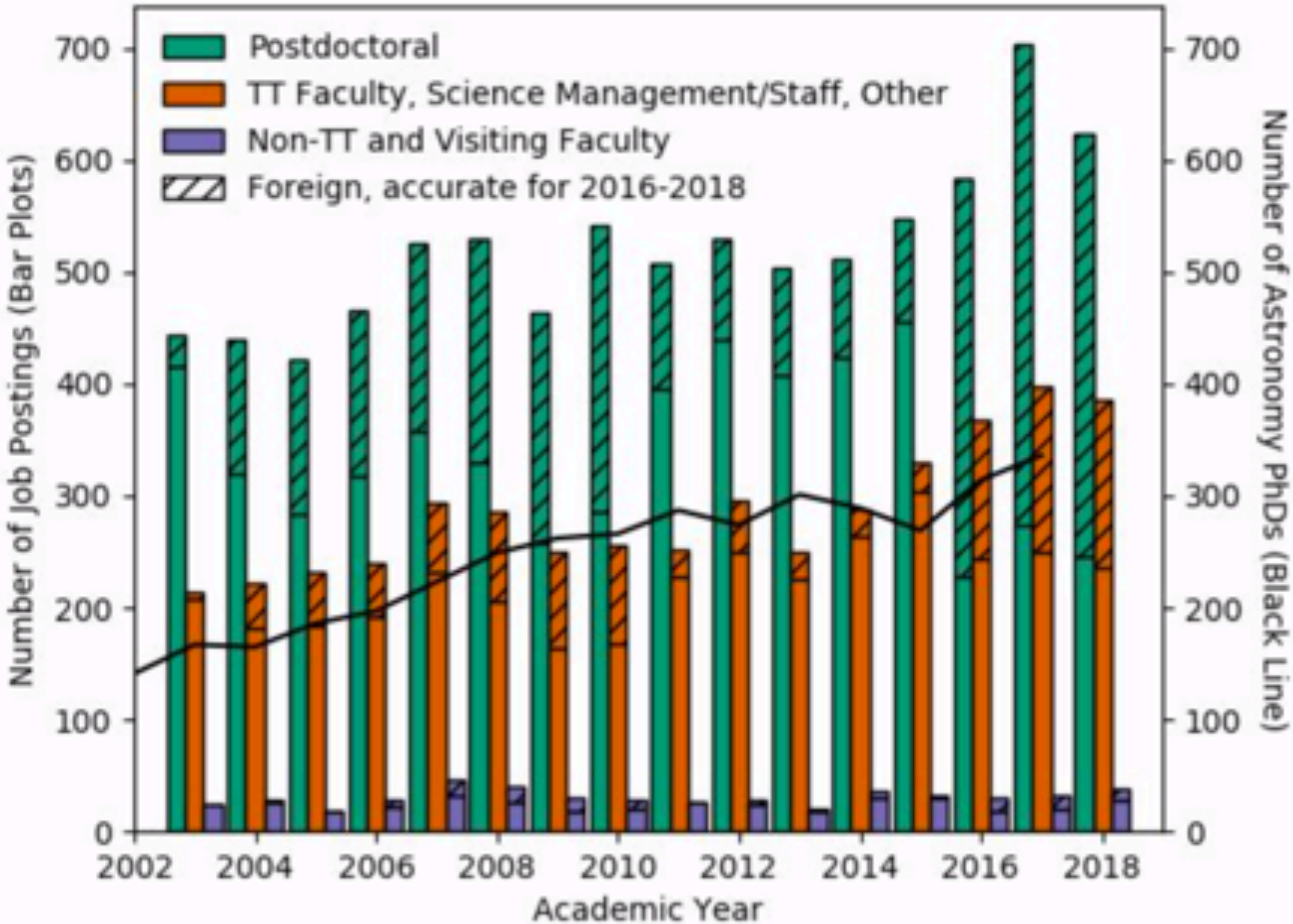
= Membership of AAS + Nonmembers

- Non-grad degrees

Production of New Astronomy PhD's



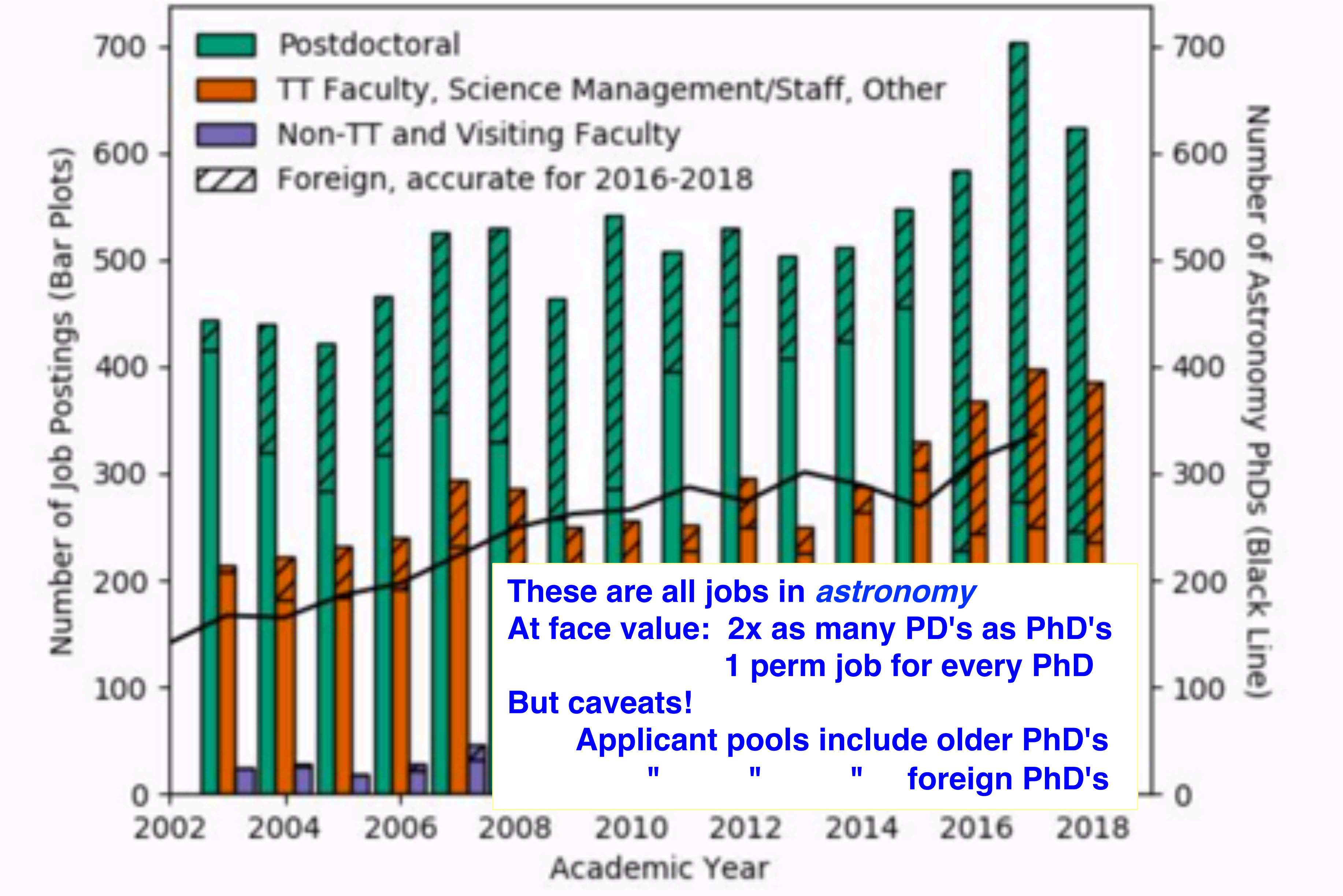
AAS Job Register Statistics



Black line: PhD's produced

(Kamenetzky, White Paper, 2019)

AAS Job Register Statistics



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(Kamenetzky, White Paper, 2019)

Employment Demographics Studies

Metcalf 2008

PUBLICATIONS OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, 120:229–234, 2008 February

The Production Rate and Employment of Ph.D. Astronomers

TRAVIS S. METCALFE

High Altitude Observatory and Scientific Computing Division, National Center for Atmospheric Research, Boulder, CO; travis@hao.ucar.edu

Received 2007 August 03; accepted 2007 December 19; published 2008 February 19

ABSTRACT. In an effort to encourage self-regulation of the astronomy job market, I examine the supply of, and demand for, astronomers over time. On the supply side, I document the production rate of Ph.D. astronomers from 1970 to 2006 using the UMI Dissertation Abstracts database, along with data from other independent sources. I compare the long-term trends in Ph.D. production with federal astronomy research funding over the same time period, and I demonstrate that additional funding is correlated with higher subsequent Ph.D. production. On the demand side, I monitor the changing patterns of employment using statistics about the number and types of jobs advertised in the AAS Job Register from 1984 to 2006. Finally, I assess the sustainability of the job market by normalizing this demand by the annual Ph.D. production. The most recent data suggest that there are now annual advertisements for about one postdoctoral job, half a faculty job, and half a research/support position for every new domestic Ph.D. recipient in astronomy and astrophysics. The average new astronomer might expect to hold up to 3 jobs before finding a steady position.

Online material: color figures

Employment Demographics Studies

Perley 2019

Publications of the Astronomical Society of the Pacific, 131:114502 (7pp), 2019 November
https://doi.org/10.1088/1538-3873/ab0ec4

CrossMark

Gender and the Career Outcomes of Ph.D. Astronomers in the United States

Daniel A. Perley
Astrophysics Research Institute, Liverpool John Moores University, IC2, Liverpool Science Park, 146 Brownlow Hill, Liverpool L3 5RF, UK; d.a.perley@ljmu.ac.uk
Received 2019 February 10; accepted 2019 February 25; published 2019 September 24

Abstract

We analyze the postdoctoral career tracks of a nearly complete sample of astronomers from 28 United States graduate astronomy and astrophysics programs spanning 13 graduating years ($N = 1063$). A majority of both men and women (65% and 66%, respectively) find long-term employment in astronomy or closely related academic disciplines. We find no significant difference in the rates at which men and women are hired into these jobs following their Ph.D.s or in the rates at which they leave the field. Applying a two-outcome survival analysis model to the entire data set, we measure a relative academic hiring probability ratio for women versus men at a common year post-Ph.D. of $H_{F/M} = 1.08^{+0.20}_{-0.17}$ and a leaving probability ratio of $L_{F/M} = 1.03^{+0.31}_{-0.24}$ (95% CI). These are both consistent with equal outcomes for both genders ($H_{F/M} = L_{F/M} = 1$) and rule out more than minor gender differences in hiring or in the decision to abandon an academic career. They suggest that despite discrimination and adversity, women scientists are successful at managing the transition between Ph.D., postdoctoral, and faculty/staff positions.

Key words: sociology of astronomy

Online material: color figures, machine-readable table

Employment Demographics Studies

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Followed actual post-PhD histories of over 1100 individual astronomers, unlike earlier studies using broad statistical measures or unreliable reporting (e.g. the "Rumor Mill" site).

Data for 2000-2012.

Perley 2019

12-Year Post-PhD Statistics (Data 2000-2012)

Frac starting perm job | **Frac leaving field**

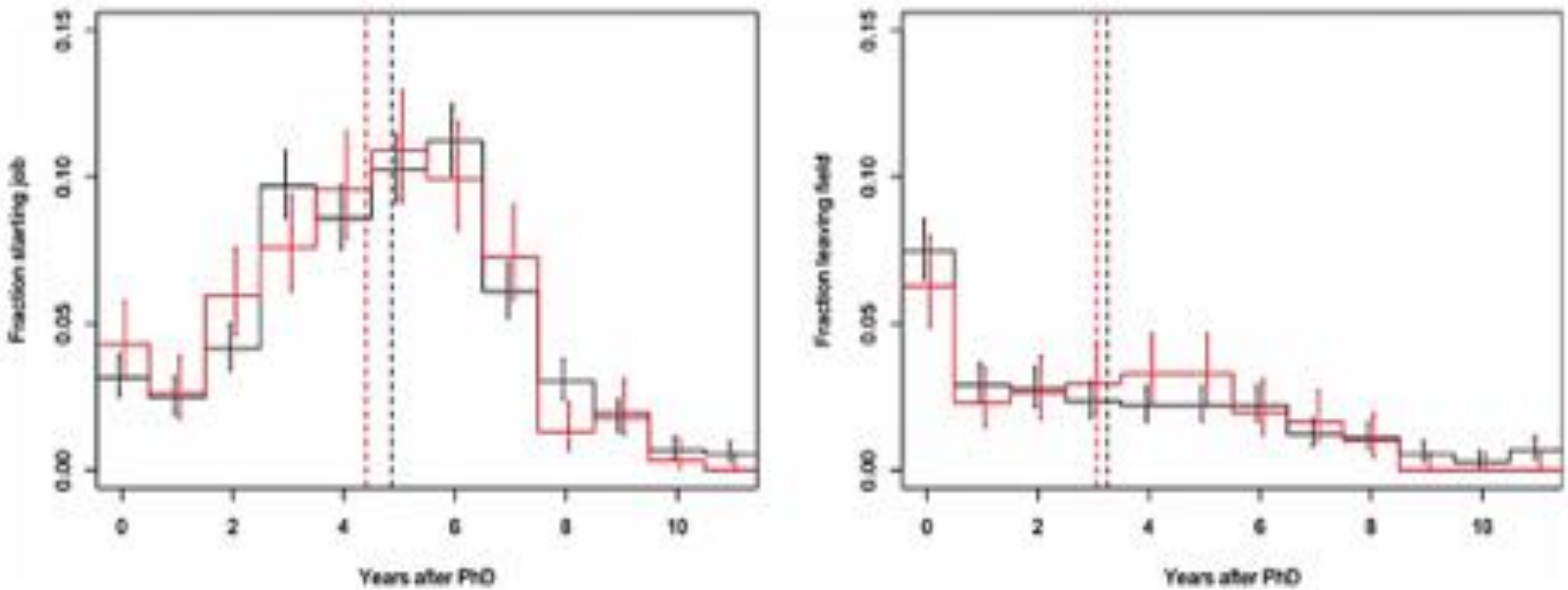
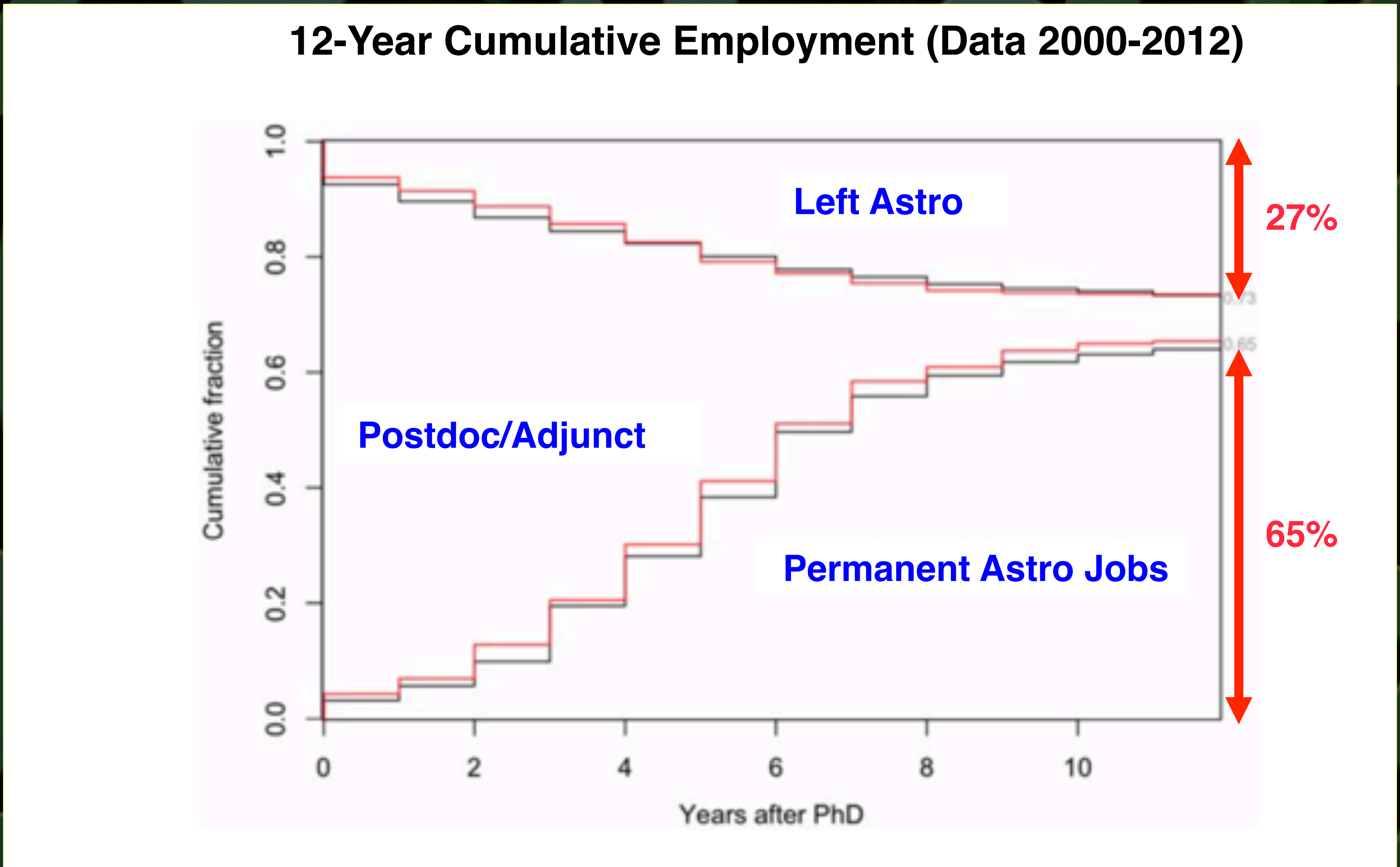


Figure 1. Histograms of recorded times (years after Ph.D.) at which Ph.D.s either: (left) progressed from term-limited to long-term or permanent positions within astronomy, or (right) left the field to pursue other employment. Histograms are normalized using total counts for each gender (regardless of outcome). Error bars show 67% binomial confidence intervals and dashed vertical lines show the means. Male astronomers are shown in black and female astronomers in red.

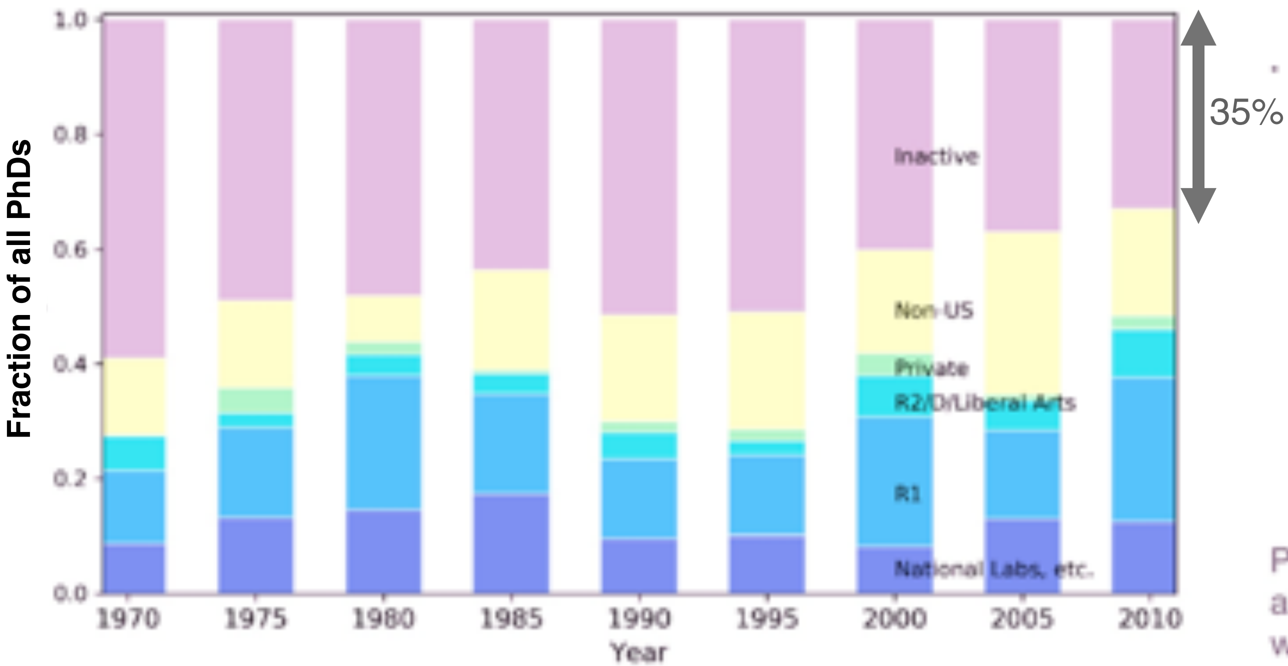
Perley 2019


12-Year Cumulative Employment (Data 2000-2012)
Left Astro
27%
Postdoc/Adjunct
65%
Permanent Astro Jobs
Cumulative fraction
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
Years after PhD

Employment Demographics Studies

Momcheva 2019

"Active" = published in professional literature within 3 yrs



- Of all PhD recipients:
  - non-US: 18%
  - Private: 2%
  - R2, etc.: 5%
  - R1: 19%
  - National labs, etc.: 12%

PhD recipient find employment in a variety of different careers which require a range of skills.

Perley (2019): *"The number of astronomy PhD's is not greatly in excess of the number of careers available within the field."* [Data for 2000-2012]

Kamenetzky (2019): *"The overall number of potentially permanent positions...has slightly increased in the past decade [2010-2019] to $\boxed{\sim 380}$ per year compared to ~270 ten years earlier, roughly keeping pace with the increase in new PhDs."*

~ Permanent jobs in *astronomy*.

Perley (2019): *"The number of astronomy PhD's is n... in excess of the number of care... within the field."* [Data for 20...

Kamenetzky (2019): *"The overal... ...ally permanent positi... ...ncreased in the past ... ...9] to ~380 per year co... ...years earlier, roughly ... ...n the increase in new PhDs."*

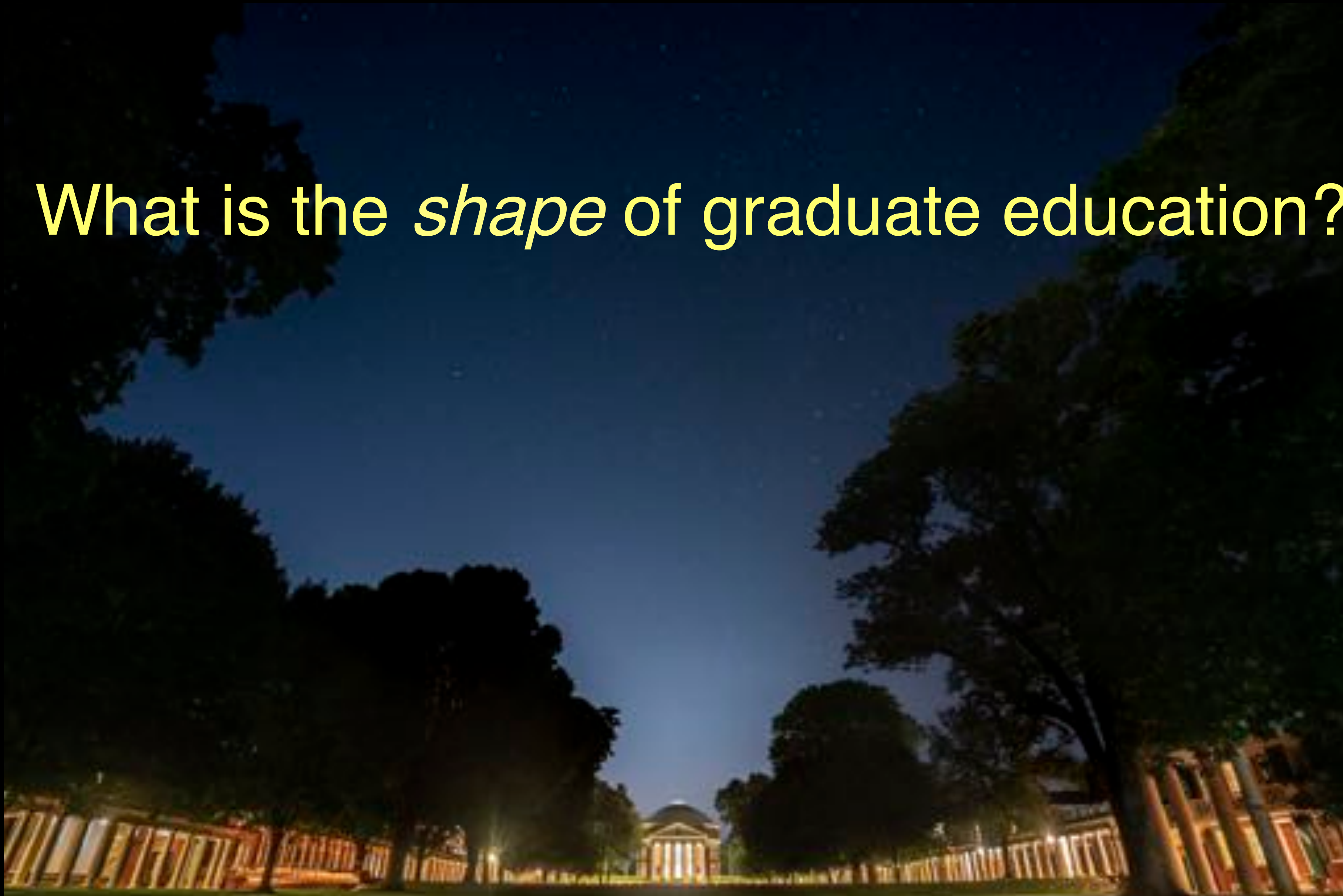
CONCLUDE: NOT GLOOMY, NOT FLUSH. TEMPERED OPTIMISM

Perley (2019): *"The number of astronomy PhD's is not greatly in excess of the number of careers available within the field."* [Data for 2000-2012]

Kamenetzky (2019): *"The overall number of potentially permanent positions...has slightly increased in the past decade [2010-2019] to ~380 per year compared to ~270 ten years earlier, roughly keeping pace with the increase in new PhDs."*

"Available data suggest that [the number leaving the profession] has been much higher than 20% in the past decade."

What is the *shape* of graduate education?



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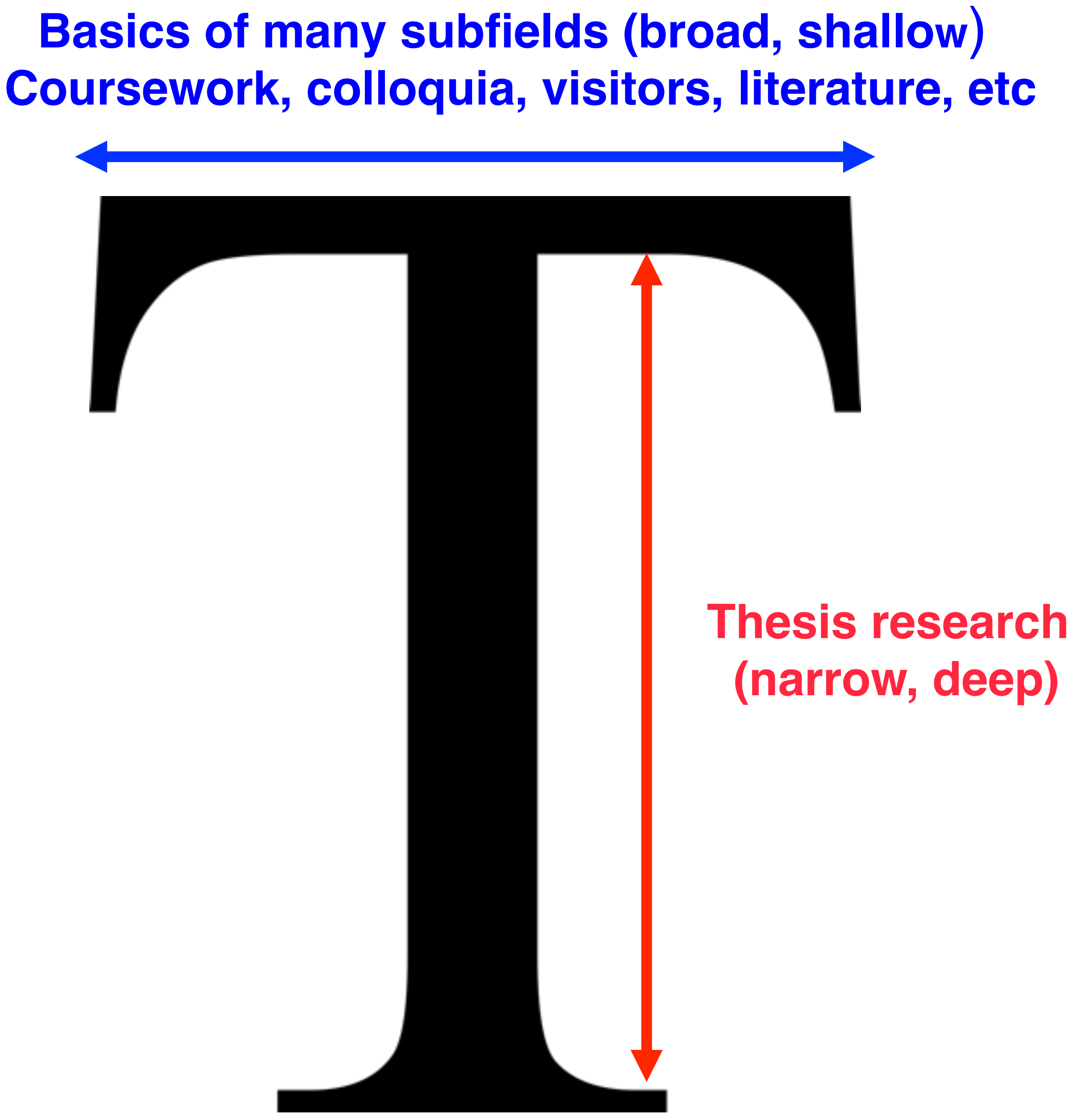
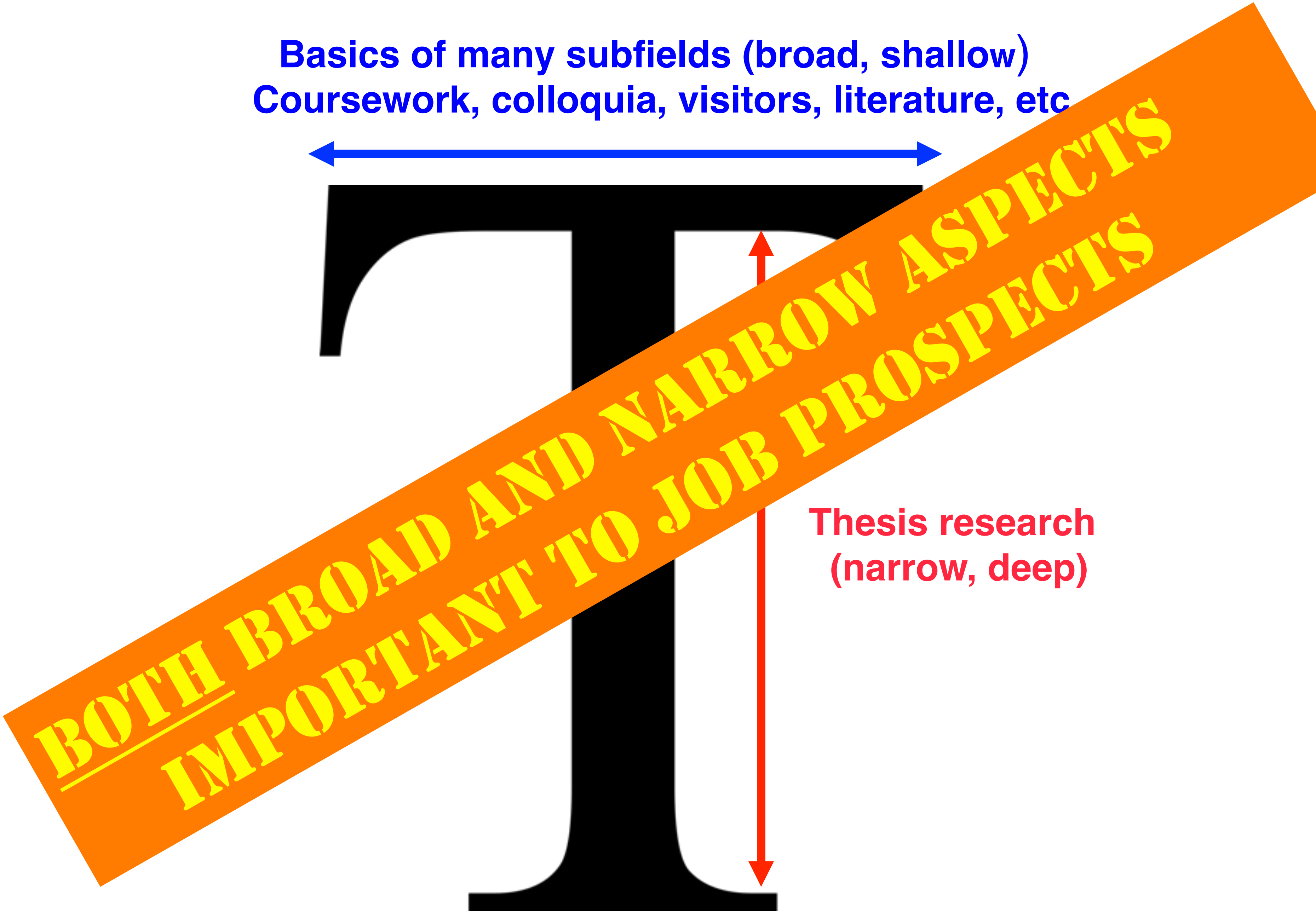

Basics of many subfields (broad, shallow)
Coursework, colloquia, visitors, literature, etc
Thesis research
(narrow, deep)


Basics of many subfields (broad, shallow)
Coursework, colloquia, visitors, literature, etc
Thesis research
(narrow, deep)
BOTH BROAD AND NARROW ASPECTS
IMPORTANT TO JOB PROSPECTS

Numbers You Should Know
Part 2

ASTR 8500 Spring 2020 Robert W. O'Connell

Astronomy Long-term PhD Employment Pattern Through the 2000's:

~1/3 Faculty

~1/3 Research Scientists

~1/3 Non Astronomy

65%

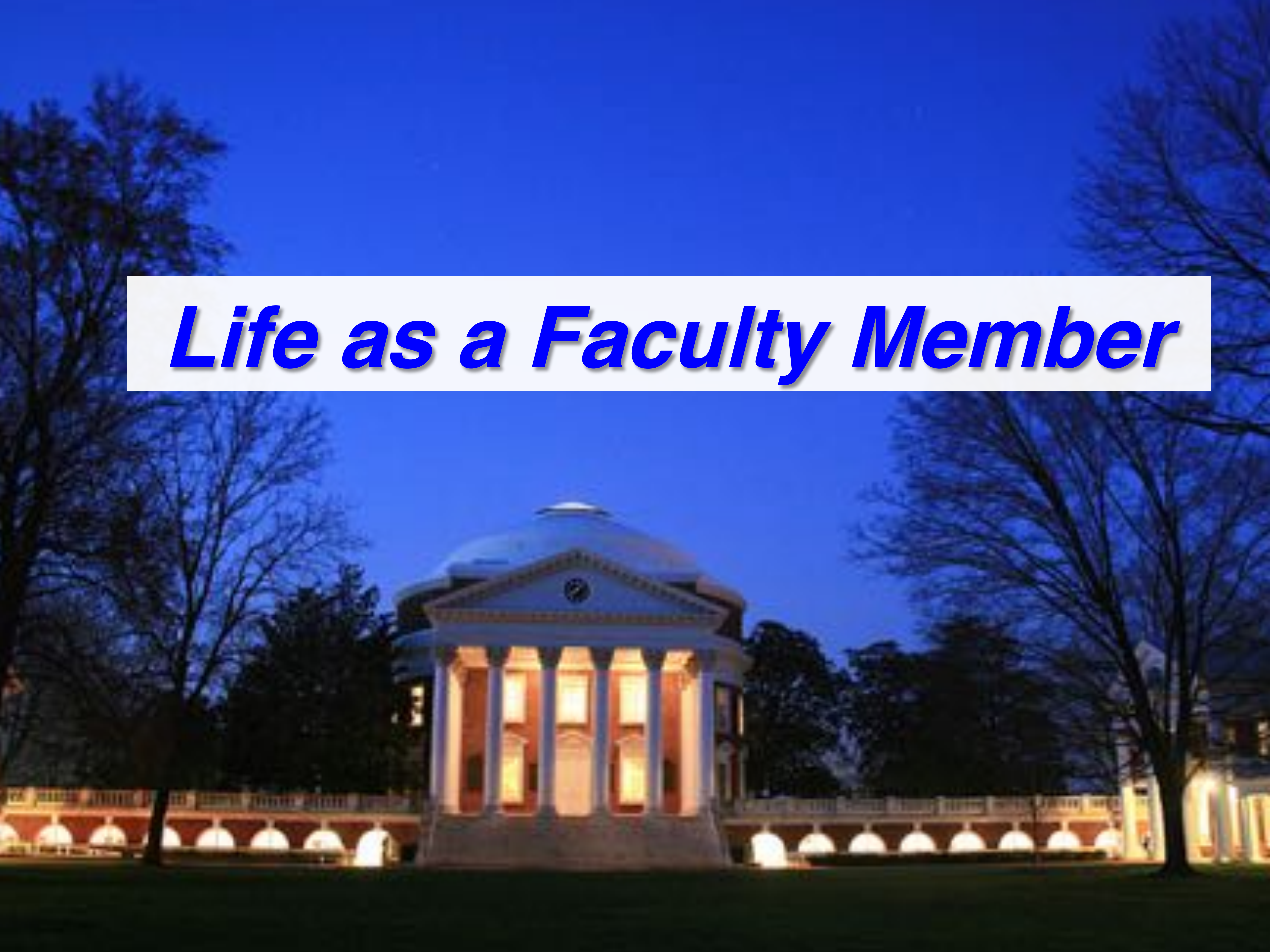
(Perley 2019)

Positions Held by UVa Astro PhD's (1967-2017; 130 Degrees)

Faculty	33%
Research scientists	40%
Non-Astro	13%
Outreach	2%
Secondary ed	1%
Postdocs	11%

~98(?)%

98(?)% of scientists love *most* of what they do


Life as a Faculty Member


13
~ # Responsibilities of
a faculty member

Job Profile of a Faculty Member

- Teaching
  - Classroom teaching (mostly undergrad – 90-95% nonmajors)
  - Tutorial, small group instruction
  - Course, curriculum, & resource development/management
  - Student mentoring, advising, recommendations
  - Outreach
- Research
  - Personal - undirected
  - Supervising grad student & postdoc research
  - Management: lab/group direction, obtaining & administering finances (grants)
- Service/Administration
  - Local department & university administration: operations, governance, policies, personnel evaluation (recruiting, promotions)
  - Refereeing publications, proposal reviews
  - Disciplinary activities, planning, meetings, advocacy
  - National agency policy, planning, review
- Consulting

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  - National agency policy, planning, review
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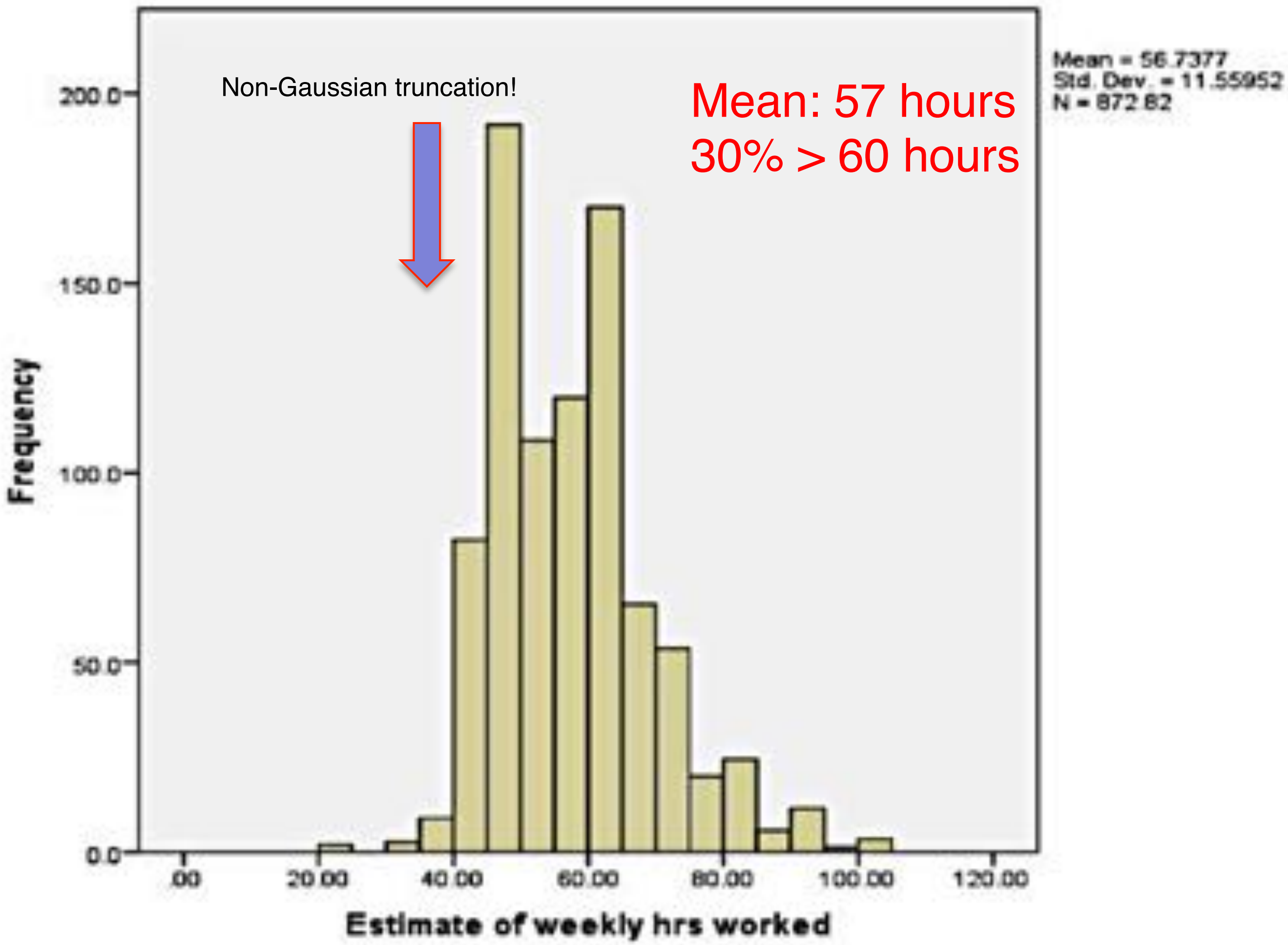
Almost no middle management

~55

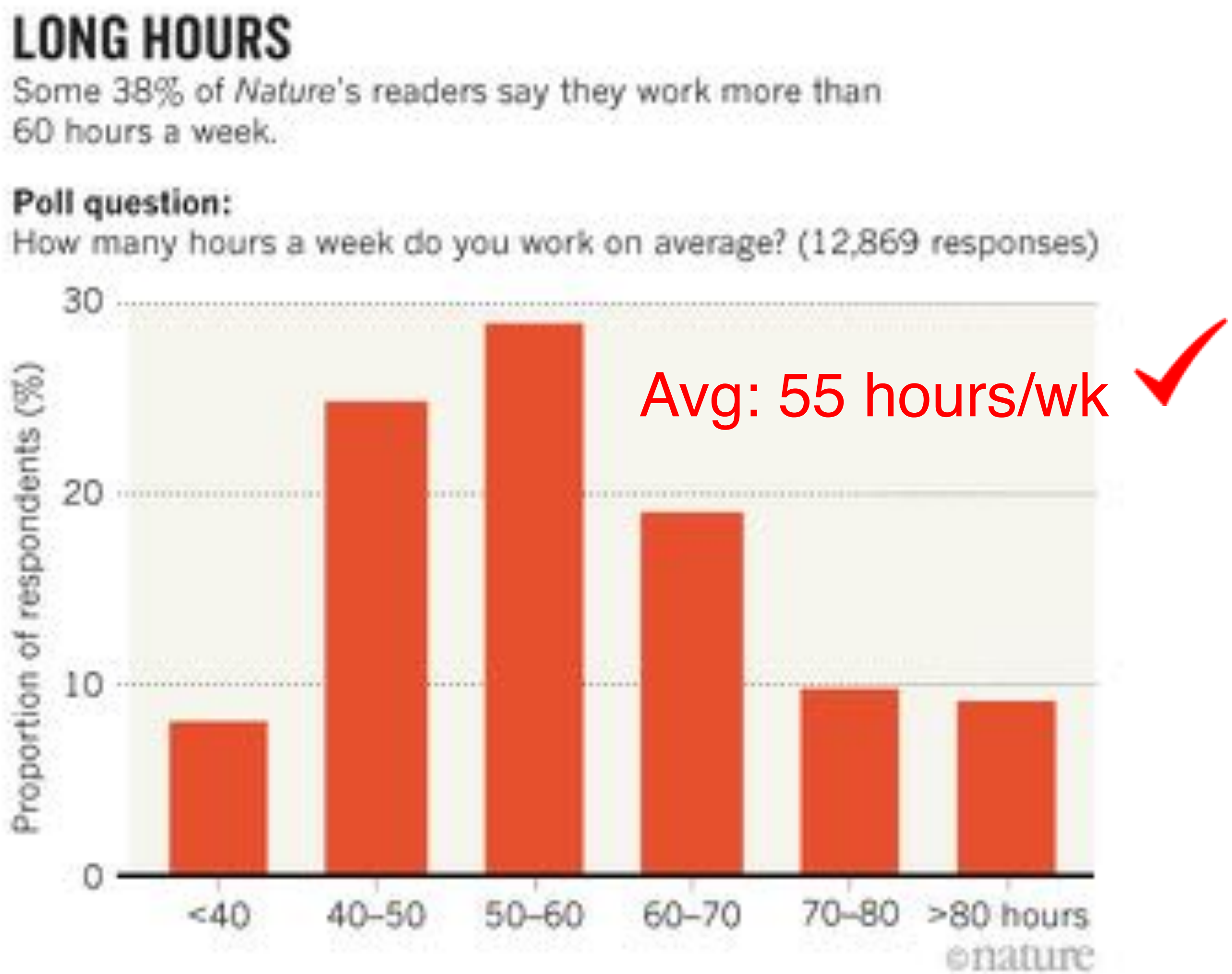
= Number of hours per week professors *claim* to work

UVa Faculty Senate Survey (2012)

Figure VII-1: Frequency Distribution of Hours Worked Per Week, Full Time Faculty Only.



Scientist Survey: Hours Worked (Nature)



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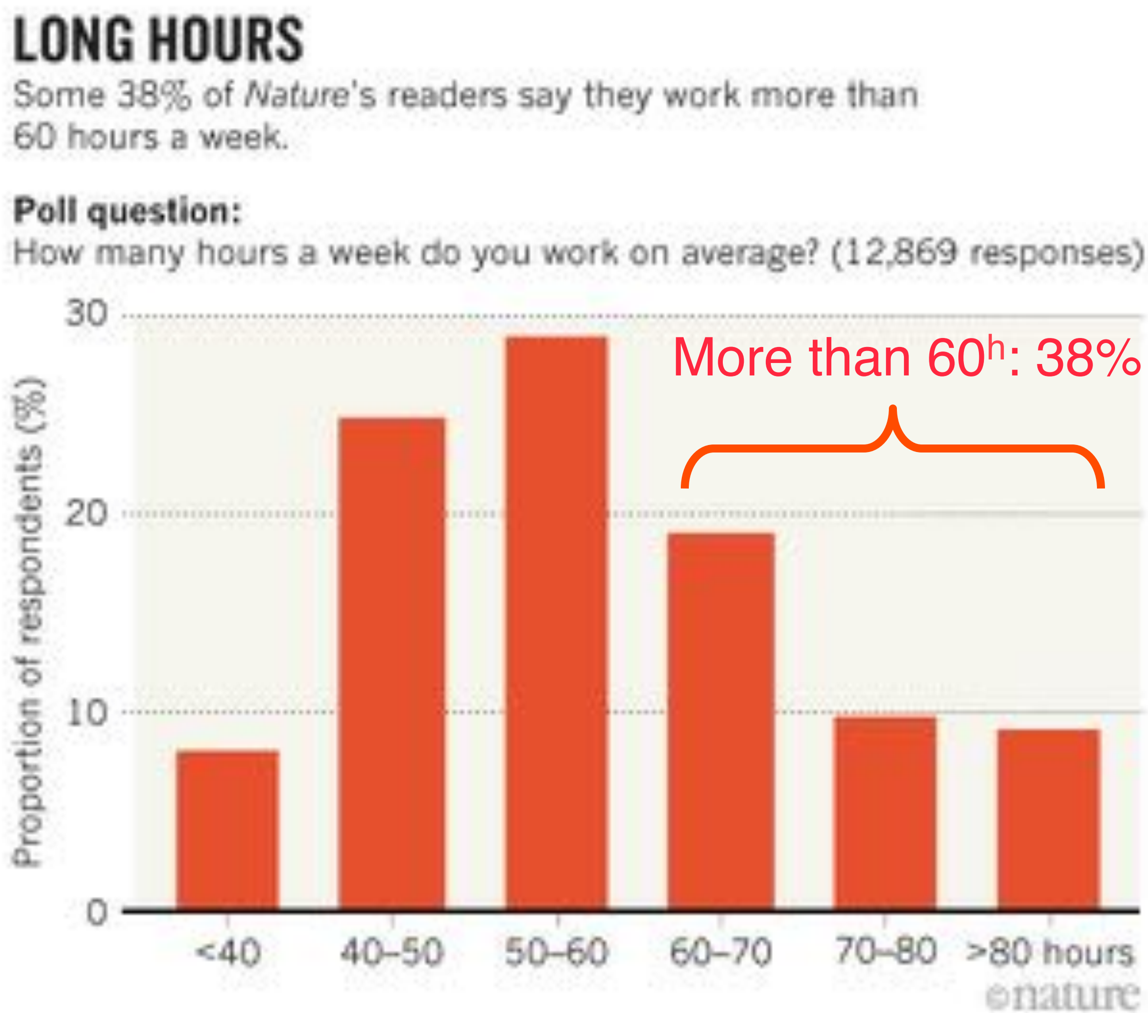


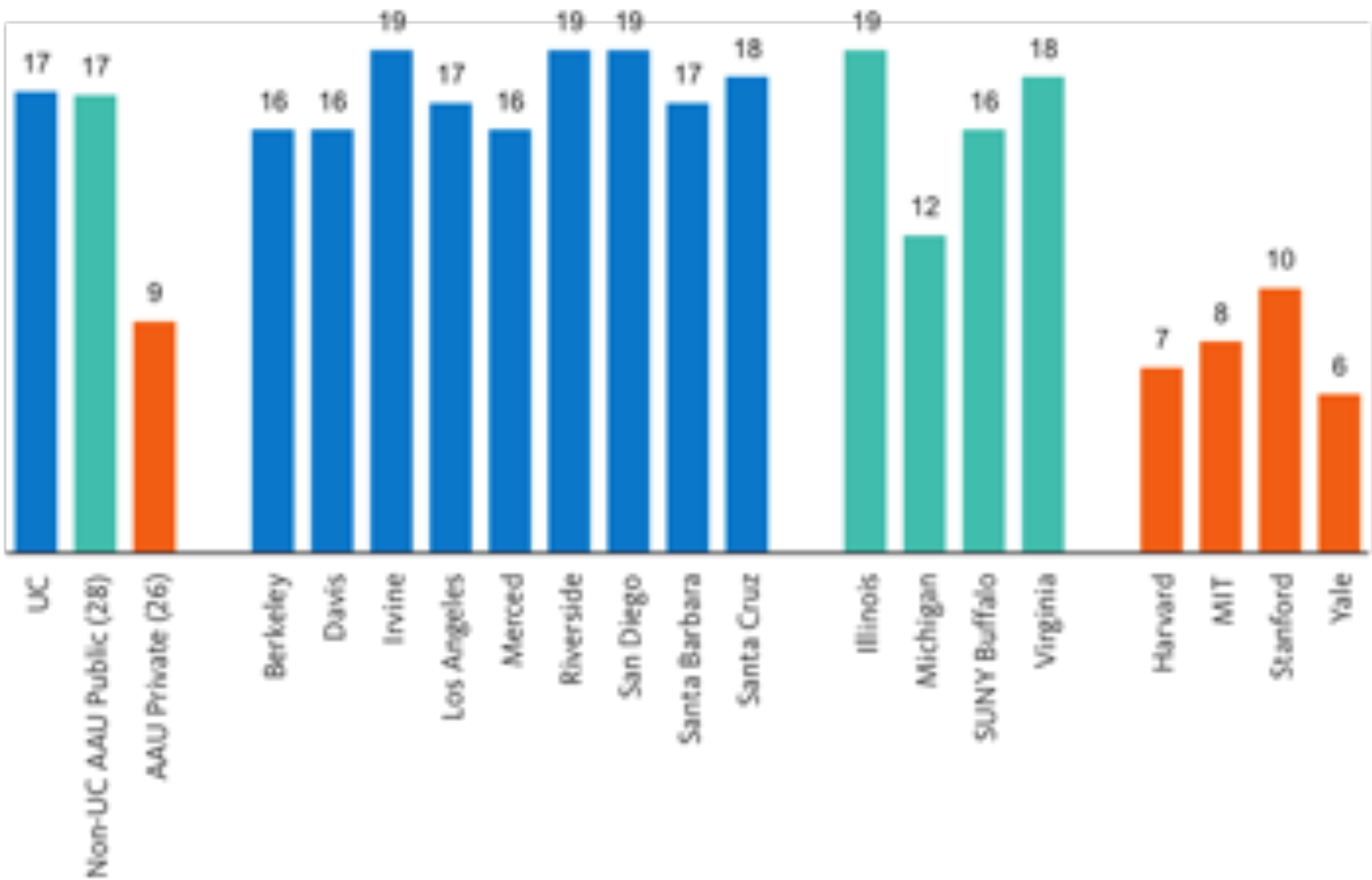
Scientist Survey: Hours Worked (Nature)

~90-200

= Number of UG students the average professor must teach each year

= 10 x S/F (in 3-credit classes)

Student/Faculty Ratios



~7:1

= Career averaged ratio of total teaching time to in-class time

Average effort for a 3-hour course: ~20 hours/wk

New burden for faculty!
Increasing emphasis on ELECTRONICS

* One hour of course video takes 50-100 hours of prep

1:1 to 3:1

= Ratio of real-time rehearsal to delivery time for a well-prepped talk

- An important class lecture
- A job talk
- A review talk
- A news conference
- etc

- An important class lecture
- A job talk
- A review talk
- A news conference
- etc

OPTIONAL TOPIC: "HOW TO GIVE A BAD TALK"

- An important class lecture
- A job talk
- A review talk
- A news conference
- etc

A LIVELY ELECTRONIC COMPENDIUM OF RESEARCH, NEWS, RESOURCES, AND OPINION

Astronomy Education Review

Volume 6
Issue 1

Facts of Life for New Teachers in the Astronomy Nonmajors Curriculum

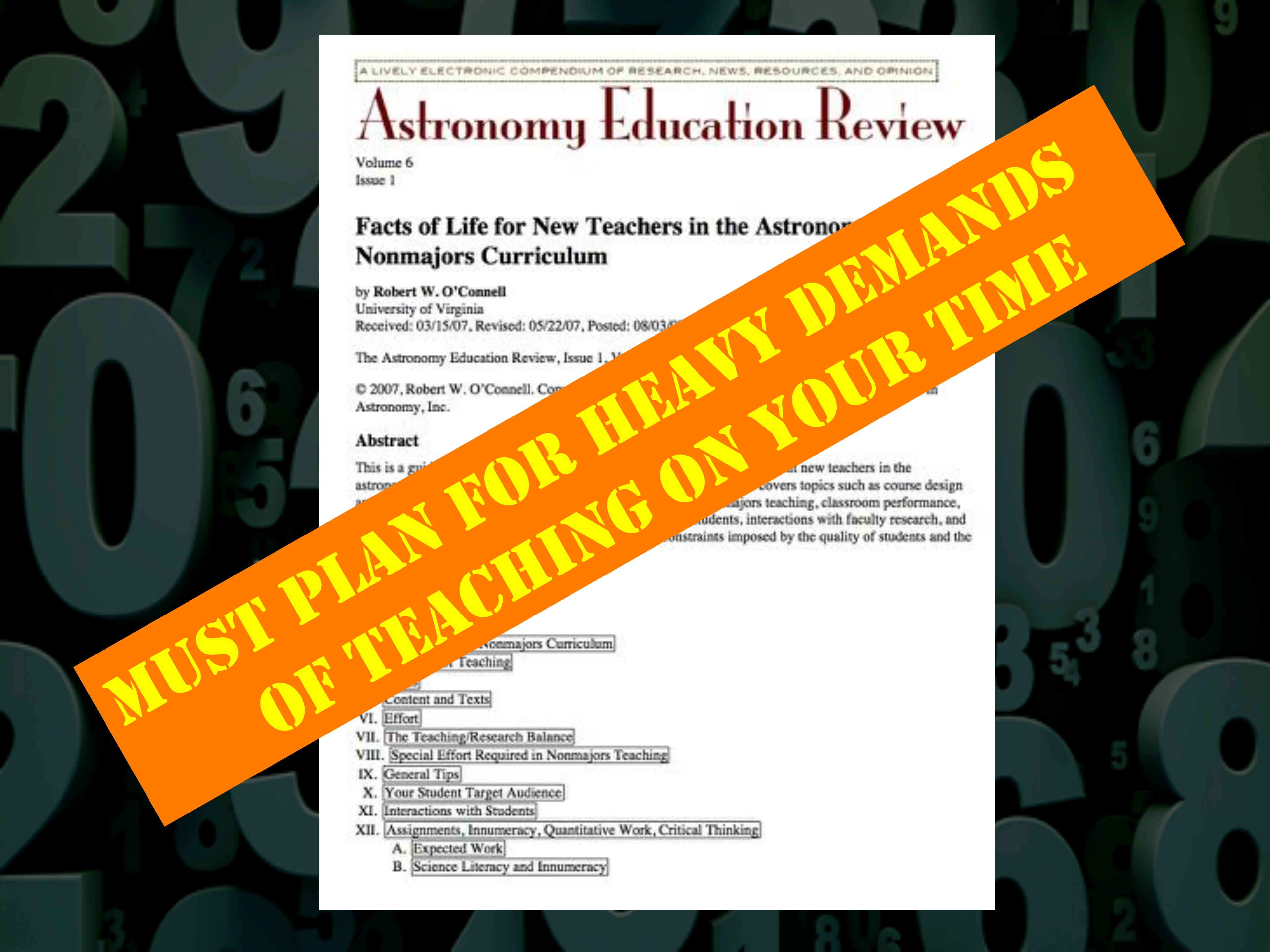
by **Robert W. O'Connell**
University of Virginia
Received: 03/15/07, Revised: 05/22/07, Posted: 08/03/07

The Astronomy Education Review, Issue 1, Volume 6, 2007

Abstract

This is a guide to the most pertinent or difficult practical issues that confront new teachers in the astronomy nonmajors curriculum at large colleges and universities. It covers topics such as course design and infrastructure, required effort, special considerations in nonmajors teaching, classroom performance, use of visual presentations and the Web, interactions with students, interactions with faculty research, and many details of recommended practice in the face of constraints imposed by the quality of students and the amount of institutional support.

Table of Contents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University of Virginia
Received: 03/15/07, Revised: 05/22/07, Posted: 08/03/
The Astronomy Education Review, Issue 1,
© 2007, Robert W. O'Connell.
Astronomy, Inc.
Abstract
This is a
new teachers in the
covers topics such as course design
ajors teaching, classroom performance,
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onstraints imposed by the quality of students and the
Nonmajors Curriculum
Teaching
Content and Texts
VI. Effort
VII. The Teaching/Research Balance
VIII. Special Effort Required in Nonmajors Teaching
IX. General Tips
X. Your Student Target Audience
XI. Interactions with Students
XII. Assignments, Innumeracy, Quantitative Work, Critical Thinking
A. Expected Work
B. Science Literacy and Innumeracy
MUST PLAN FOR HEAVY DEMANDS
OF TEACHING ON YOUR TIME

Job Profile of a Faculty Member

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- Service/Adm
  - Local istration: operations, governance, policies, perso g, promotions)
  - Refereei proposal reviews
  - Disciplinary , planning, meetings, advocacy
  - National age y policy, planning, review
- Consulting

TIME MANAGEMENT IS AN ESSENTIAL SKILL

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  - Discipli ... , planning, meetings, advocacy
  - National ... y policy, planning, review
- Consulting

OPTIONAL TOPIC: "MANAGING YOUR TIME"

Life as a Research Scientist

Job Profile of a Research Scientist

- Research Support
  - Observer support & training
  - Telescope time allocation
  - Software design, development, oversight
  - Data analysis pipelines, data archives, quality assurance
  - Instrumentation development
  - Documentation
  - Facility upgrade projects
  - Policy formulation
  - Personnel administration
- Personal Research
  - Allocation usually specified; typically 15-50% but wide variation
  - Grant support provides buy-outs of service time
- General Service
  - Refereeing publications, proposal reviews
  - Disciplinary activities, planning, meetings, advocacy
  - National agency policy, planning, review
- Consulting

Job Profile of a Research Scientist

- Main occupational hazard of a research scientist?

Meetings

Astronomy Long-term
PhD Employment Pattern
Through the 2000's:

~1/3 Faculty

~1/3 Research Scientists

$\boxed{\text{~1/3 Non Astronomy}}$

65%

(Perley 2019)

"Non-Dedicated Astronomy"

Jobs draw on general training in high-tech field

Could be related to astronomy, but not necessarily

Examples:

- Space science/applications (govt, contractors, commercial)
- High-end computing (databases, AI)
- Computational biology (genomics, neurology)
- Instrumentation (sensors, imaging, optics)
- Medical imaging

→ Be alert for opportunities to develop transferable knowledge and skills

3611

3611

= Largest number of authors on an astronomical paper

The Rise of Group Science

ADS Statistics on published Ast/Ap papers

# Authors	1975	2016
1	40%	7%
>2	26%	78%
>5	3%	39%
Max # to date	40	1187

3611

= Largest number of authors on an astronomical paper.

Abbott et al., "Multi-Messenger Observations of a Binary Neutron Star Merger," ApJL, 848, L12, 2017

Abbott et all !

The Astrophysical Journal Letters, 848:L12 (59pp), 2017 October 20 https://doi.org/10.3847/2041-8213/aa91c9

Multi-messenger Observations of a Binary Neutron Star Merger*

LIGO Scientific Collaboration and Virgo Collaboration, Fermi GBM, INTEGRAL, IceCube Collaboration, AstroSat Cadmium Zinc Telluride Imager Team, IPN Collaboration, The Insight-HXMT Collaboration, ANTARES Collaboration, The Swift Collaboration, AGILE Team, The 1M2H Team, The Dark Energy Camera GW-EM Collaboration and the DES Collaboration, The DLT40 Collaboration, GRAWITA: GRAvitational Wave Inaf TeAm, The Fermi Large Area Telescope Collaboration, ATCA: Australia Telescope Compact Array, ASKAP: Australian SKA Pathfinder, Las Cumbres Observatory Group, OzGrav, DWF (Deeper, Wider, Faster Program), AST3, and CAASTRO Collaborations, The VINROUGE Collaboration, MASTER Collaboration, J-GEM, GROWTH, JAGWAR, Caltech-NRAO, TTU-NRAO, and NuSTAR Collaborations, Pan-STARRS, The MAXI Team, TZAC Consortium, KU Collaboration, Nordic Optical Telescope, ePESSTO, GROND, Texas Tech University, SALT Group, TOROS: Transient Robotic Observatory of the South Collaboration, The BOOTES Collaboration, MWA: Murchison Widefield Array, The CALET Collaboration, IKI-GW Follow-up Collaboration, H.E.S.S. Collaboration, LOFAR Collaboration, LWA: Long Wavelength Array, HAWC Collaboration, The Pierre Auger Collaboration, ALMA Collaboration, Euro VLBI Team, Pi of the Sky Collaboration, The Chandra Team at McGill University, DFN: Desert Fireball Network, ATLAS, High Time Resolution Universe Survey, RIMAS and RATIR, and SKA South Africa/MeerKAT
(See the end matter for the full list of authors.)

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Abstract

On 2017 August 17 a binary neutron star coalescence candidate (later designated GW170817) with merger time 12:41:04 UTC was observed through gravitational waves by the Advanced LIGO and Advanced Virgo detectors. The *Fermi* Gamma-ray Burst Monitor independently detected a gamma-ray burst (GRB 170817A) with a time delay of $\sim$1.7 s with respect to the merger time. From the gravitational-wave signal, the source was initially localized to a sky region of 31 deg^2 at a luminosity distance of 40^{+8}_{-8} Mpc and with component masses consistent with neutron stars. The component masses were later measured to be in the range 0.86 to 2.26 $M_\odot$. An extensive observing campaign was launched across the electromagnetic spectrum leading to the discovery of a bright optical transient (SSS17a, now with the IAU identification of AT 2017gfo) in NGC 4993 (at $\sim$40 Mpc) less than 11 hours after the merger by the One-Meter, Two Hemisphere (1M2H) team using the 1 m Swope Telescope. The optical transient was independently detected by multiple teams within an hour. Subsequent observations targeted the object and its environment. Early ultraviolet observations revealed a blue transient that faded within 48 hours. Optical and infrared observations showed a redward evolution over $\sim$10 days. Following early non-detections, X-ray and radio emission were discovered at the transient's position $\sim$9 and $\sim$16 days, respectively, after the merger. Both the X-ray and radio emission likely arise from a physical process that is distinct from the one that generates the UV/optical/near-infrared emission. No ultra-high-energy gamma-rays and no neutrino candidates consistent with the source were found in follow-up searches. These observations support the hypothesis that GW170817 was produced by the merger of two neutron stars in NGC 4993 followed by a short gamma-ray burst (GRB 170817A) and a kilonova/macronova powered by the radioactive decay of *r*-process nuclei synthesized in the ejecta.

Key words: gravitational waves – stars: neutron

1. Introduction

Over 80 years ago Baade & Zwicky (1934) proposed the idea of neutron stars, and soon after, Oppenheimer & Volkoff (1939) carried out the first calculations of neutron star models. Neutron stars entered the realm of observational astronomy in the 1960s by providing a physical interpretation of X-ray emission from Scorpius X-1 (Giacconi et al. 1962; Shklovsky 1967) and of radio pulsars (Gold 1968; Hewish et al. 1968; Gold 1969).

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GROUPS, not people

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- 62 collaborations
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  - (Normal ApJL total length is 4 pgs)
- 953 institutional affiliations
- Acknowledgements take 6 pgs
- 4 authors are already dead


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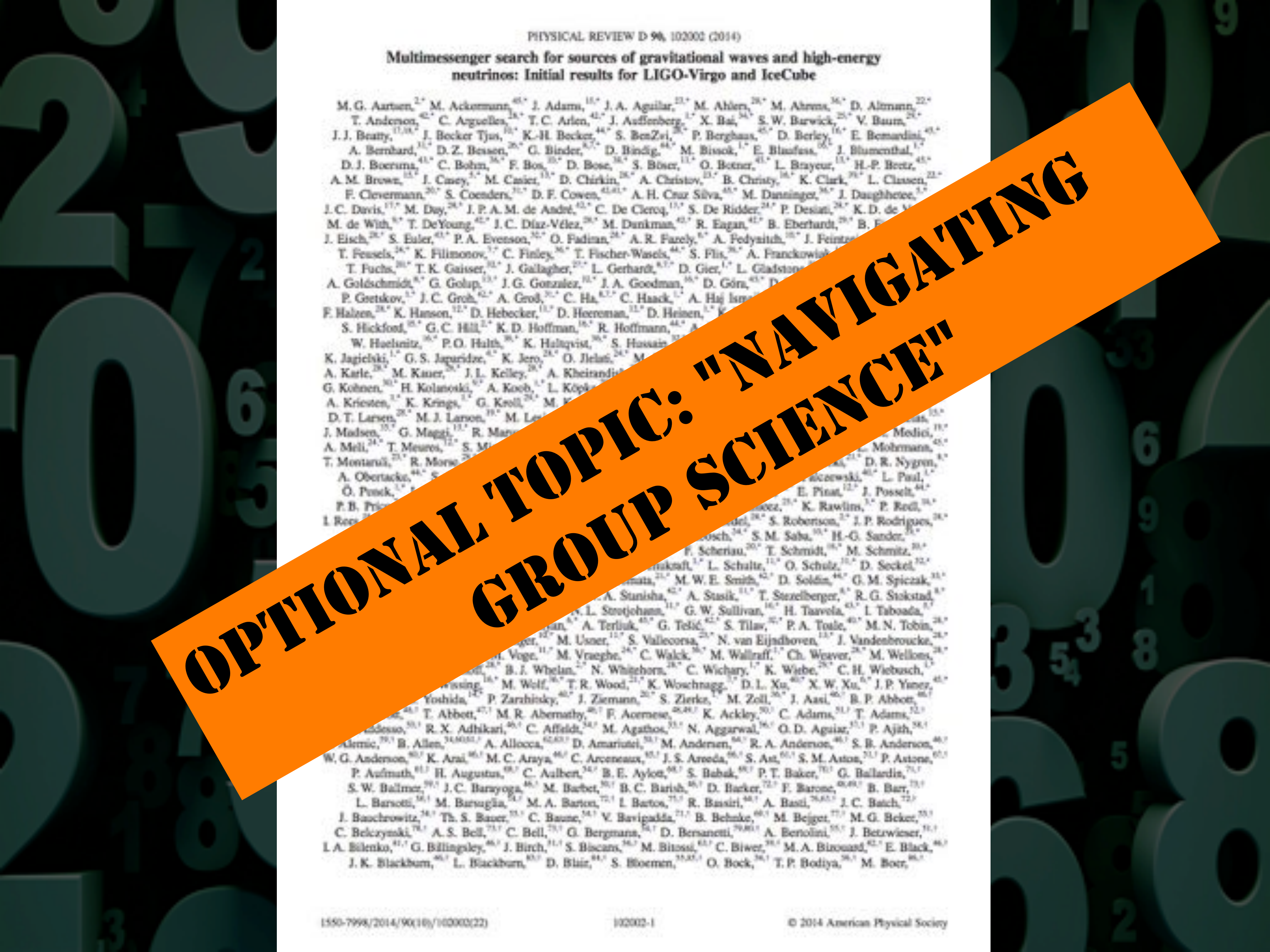
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