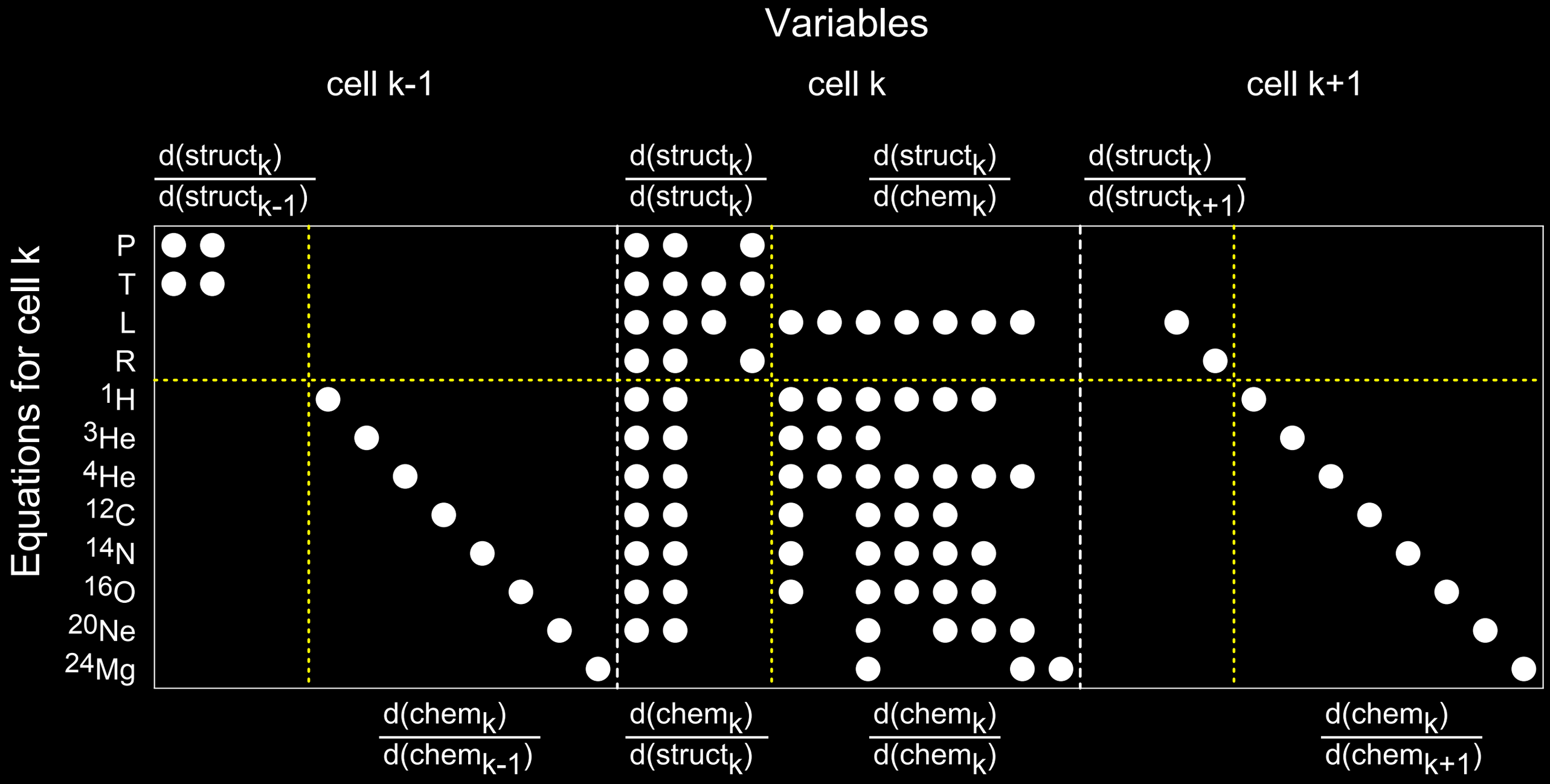
Modules for Experiments in Stellar Astrophysics

MESA solves the 1D fully coupled structure, mixing, and composition equations governing stellar evolution with an implicit finite volume scheme.



# Core Development and Support Team

Rob Farmer

Josiah Schwab

Bill Paxton

First Author

Pablo Marchant

Frank Timmes

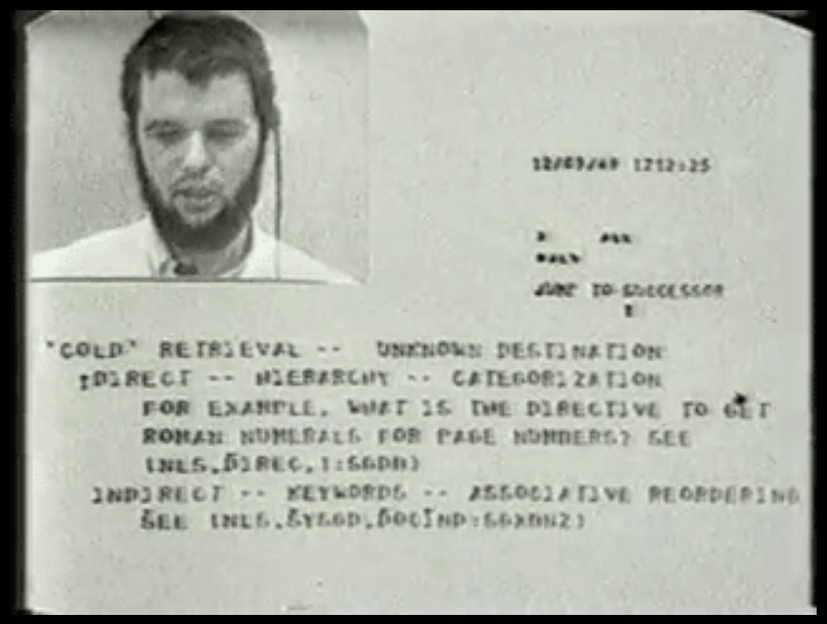
Rich Townsend

Matteo Cantiello

Lars Bildsten

# “Mother of All Demos”
# December 8, 1968


Douglas Engelbart




Bill Paxton

“The 90-minute presentation demonstrated almost all the fundamental elements of modern personal computing: windows, hypertext, graphics, efficient navigation and command input, video conferencing, the computer mouse, word processing, dynamic file linking, revision control, and a collaborative real-time editor”.

After a stint at Xerox PARC,
Paxton became Adobe's 5th Employee in 1983.

Bill invented scalable font technology.

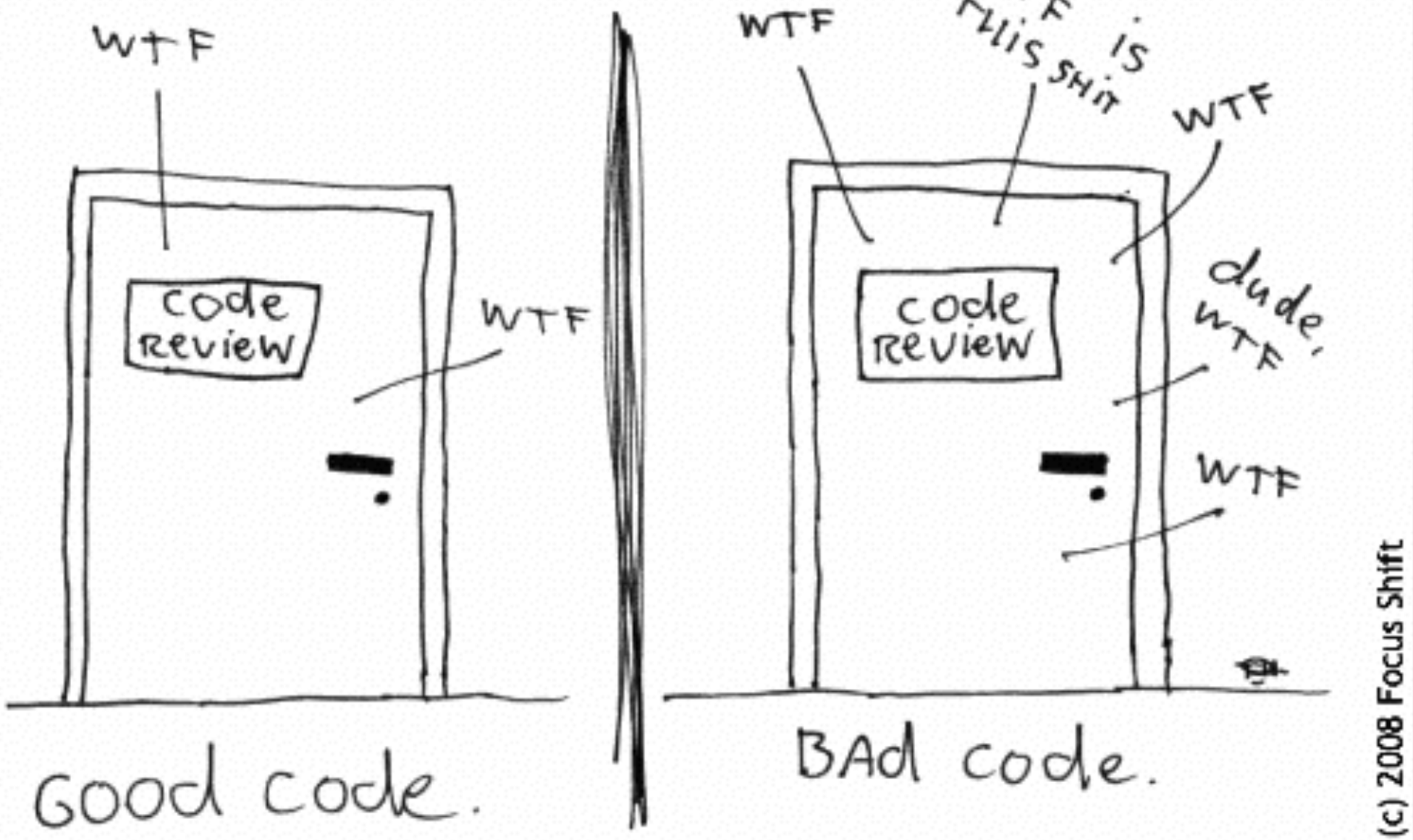
The public facing part of this invention was Postscript, which evolved into today's PDF. Bill also co-authored version 1.0 of Adobe Illustrator.

Bill retired in 1990.

“Hello, my name is Bill Paxton. My I please use the gorgeous tools posted on your website?
Jan, 8 2005

Bill is now a
Senior Fellow in Computational Astrophysics
Kavli Institute for Theoretical Physics
University of California, Santa Barbara

# The ONLY VALID MEASUREMENT OF Code QUALITY: WTFs/MINUTE



Potential Breakout session topics:

01) How do you conduct code reviews?

02) How do you measure code quality?

03) What role does code standards play?

04) Should existing apps be used or re-written?

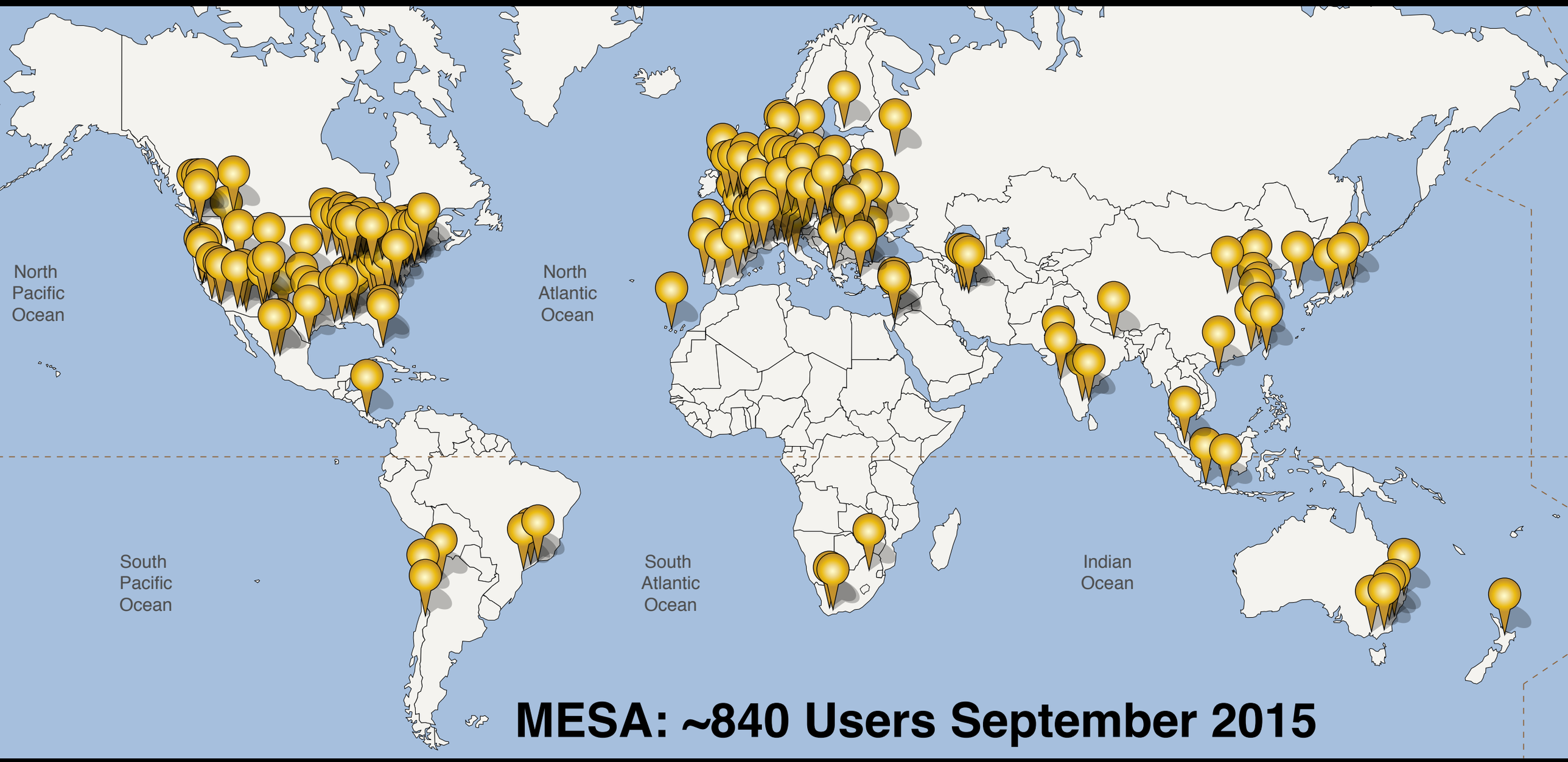
05) How can productivity in developing software be raised?

06) When to develop for the next generation of hardware?

State-of-the-art modules provide

01) adaptive mesh refinement
02) sophisticated timestep controls
03) bit-for-bit consistency for all results
    across all supported platforms
04) oscillation capabilities
05) explosion capabilities
06) binary star capabilities
07) equation of states
08) opacities
09) nuclear reaction networks
10) element diffusion
11) boundary conditions and
12) changes to the mass of a star.

# MESA has attracted over 840 registered users world-wide.

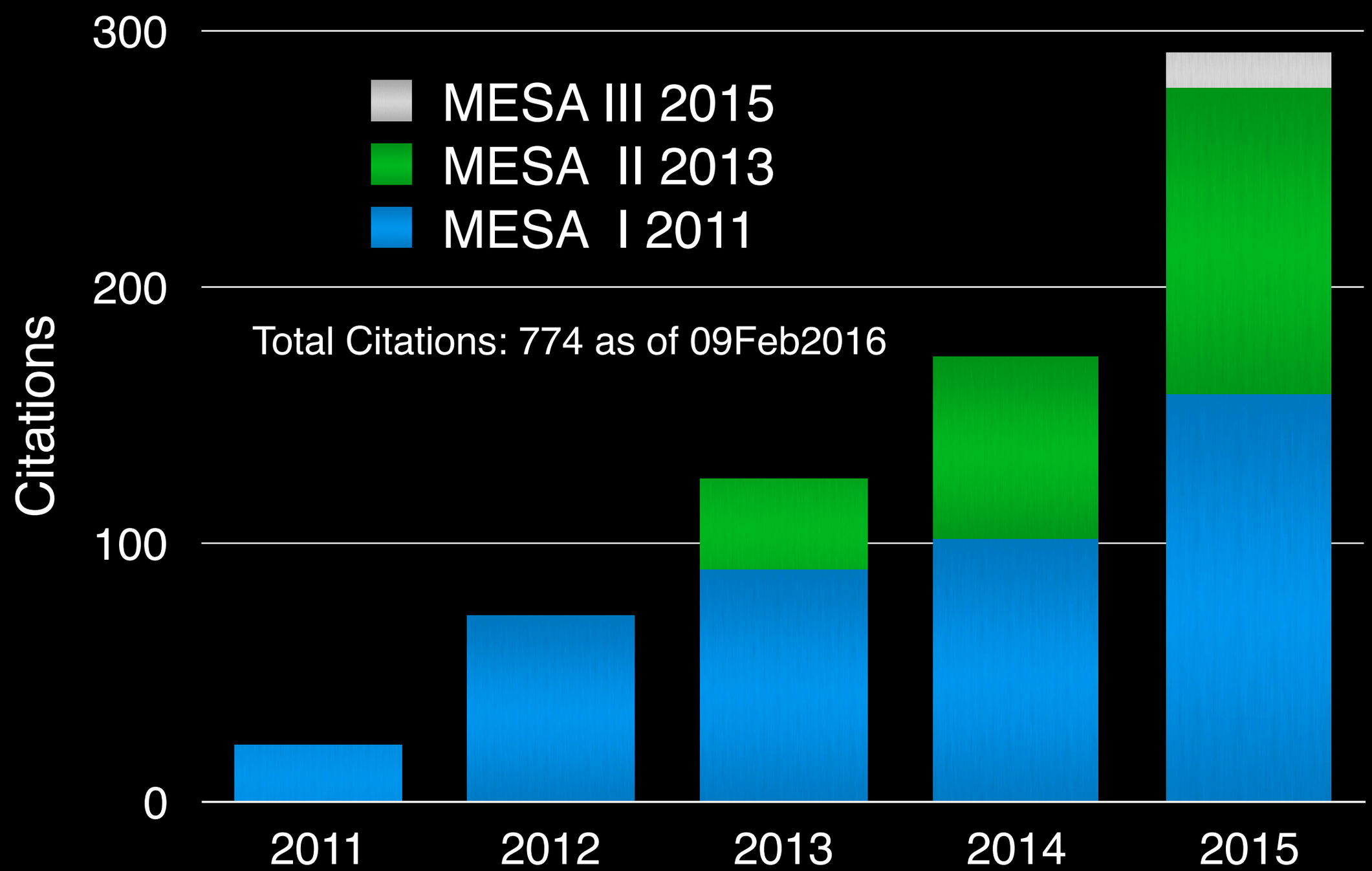



Worldwide market focused on stars is ~2400 researchers, with ~1200 on theory.

# MESA: ~281 Registered Users from USA Sep 2015

US market focused on stars is ~1200 researchers, with ~600 on theory.

The software instrument papers
MESA I (2011), MESA II (2013), and MESA III (2015)
have been cited by the community over 770 times.



# MESA I and II rank within the 25 most cited astrophysics papers published in 2011 and 2013 respectively.

| | | |
|---|---|---|
| 1 | 2011ApJS..192...18K<br>Komatsu, E.; Smith, K. M.; Dunkley, J.; Page, L.; and 14 coauthors | 5532.000<br>Seven-year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Cosmological Interpretation |
| 2 | 2011ApJS..192...16L<br>Larson, D.; Dunkley, J.; Hinshaw, G.; Komatsu, E.; Nolta, M. R.; Hill, R. S.; Jarosik, N.; and 14 coauthors | 1183.000<br>Seven-year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Power Spectra and WMAP-derivedParameters |
| 3 | 2011ApJ...737..103S<br>Schlafly, Edward F.; Finkbeiner, Douglas P. | 1037.000<br>Measuring Reddening with Sloan Digital Sky Survey Stellar Spectra and Recalibrating SFD |
| 4 | 2011ApJS..192...14J<br>Jarosik, N.; Bennett, C. L.; Dunkley, J.; Gold, B.; Greason, M. R.; Halpern, M.; Komatsu, E.; and 14 coauthors | 824.000<br>Seven-year Wilkinson Microwave Anisotropy Probe (WMAP) Observations: Sky Maps, Systematic Errors, and Basic Results |
| 5 | 2011ApJ...730..119R<br>Riess, Adam G.; Macri, Lucas; Li, Weidong; and 8 coauthors | 804.000<br>A 3% Solution: Determination of the Hubble Constant with the Hubble Space Telescope and Wide Field Camera 3 |
| 6 | 2011ApJS..193...29A<br>Aihara, Hiroaki; Allende Prieto, Carlos; and 178 coauthors | 690.000<br>The Eighth Data Release of the Sloan Digital Sky Survey: First Data from SDSS-III |
| 7 | 2011AJ....142...72E<br>Eisenstein, Daniel J.; Balbinot, Eduardo; and 239 coauthors | 677.000<br>SDSS-III: Massive Spectroscopic Surveys of the Distant Universe, the Milky Way, and Extra-Solar Planetary Systems |
| 8 | 2011ApJ...736...19B<br>Borucki, William J.; Koch, David G.; DeVore, Edna; and 66 coauthors | 553.000<br>Characteristics of Planetary Candidates Observed by Kepler. II. Analysis of the First Four Months of Data |
| 9 | 2011ApJS..197...35G<br>Grogin, Norman A.; Kocevski, Dale D.; Ashby, Matthew L. N.; and 104 coauthors | 546.000<br>CANDELS: The Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey |
| 10 | 2011ApJS..197...36K<br>Koekemoer, Anton M.; Faber, S. M.; Ferguson, Henry C.; Grogin, Norman A.; and 120 coauthors | 538.000<br>CANDELS: The Hubble Space Telescope Observations, Imaging Data Products, and Mosaics |
| 11 | 2011MNRAS.416.3017B<br>Beutler, Florian; Blake, Chris; and 8 coauthors | 513.000<br>The 6dF Galaxy Survey: baryon acoustic oscillations and the local Hubble constant |
| 12 | 2011MNRAS.413..101G<br>Guo, Qi; White, Simon; Boylan- and 7 coauthors | 493.000<br>From dwarf spheroidals to cD galaxies: simulating the galaxy population in a ΛCDM cosmology |
| 13 | 2011ApJS..192....3P<br>Paxton, Bill; Bildsten, Lars; Dotter, Aaron; Herwig, Falk; LaSaffre, Pierre, Timmes, F.X. | 458.000<br>Modules for Experiments in Stellar Astrophysics (MESA) |

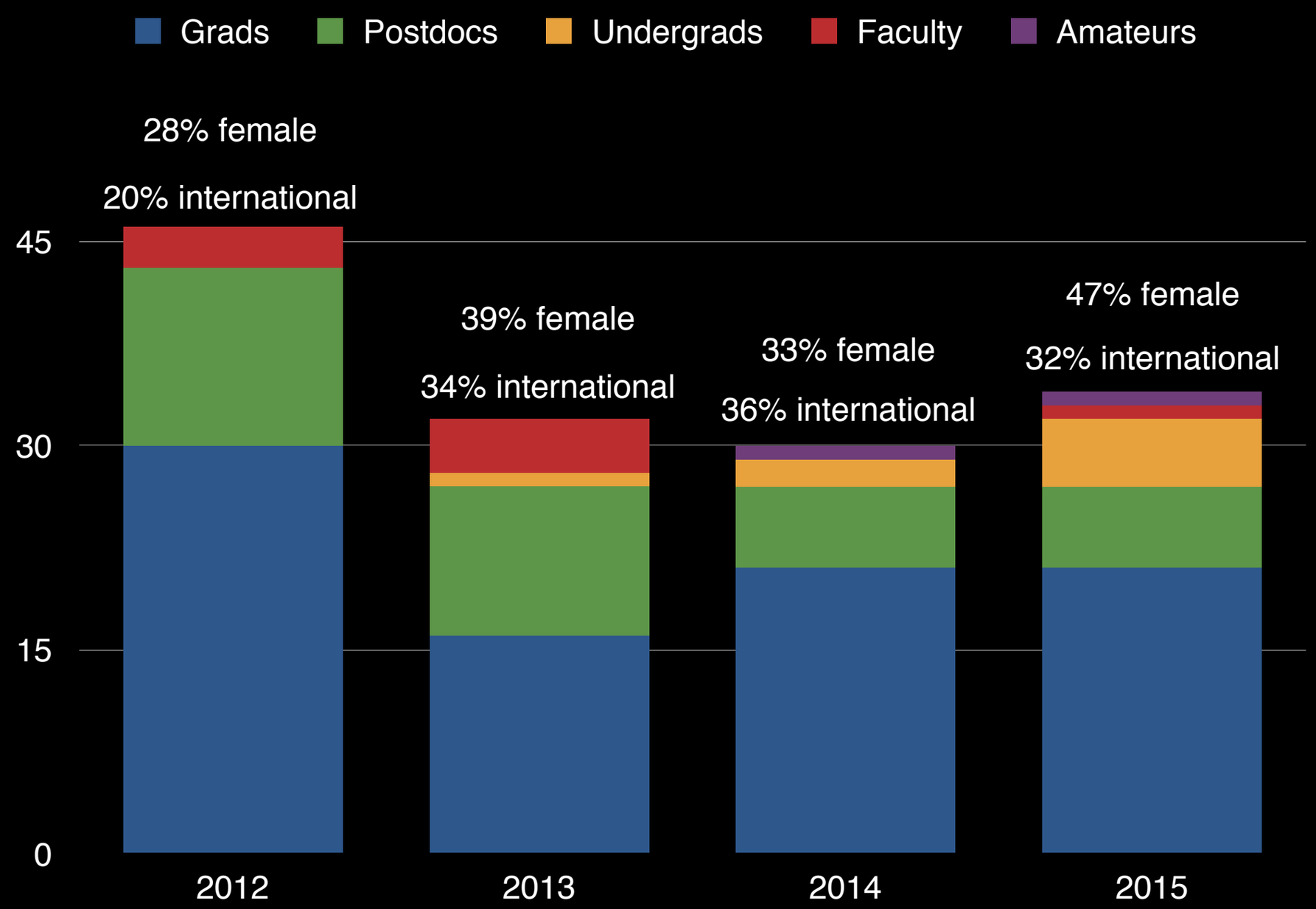
MESA II was one of 15 papers selected by the *American Astronomical Society* for “high-impact research” published between 2012 and 2015.

AMERICAN ASTRONOMICAL SOCIETY

Enhancing and sharing humanity's scientific understanding of the universe since 1899.

ΨΑU

The annual MESA Summer School offers a week of extensive hands-on labs. The cadre of instructors, TAs and students (now over 120) are creating their own MESA user infrastructure at ~40 institutions around the world, accelerating research.



MESA has been used in ~27 courses since 2011,
impacting ~300 undergrads, grads, postdocs, and faculty.

MESA provides portals for the community to openly share knowledge: users and developers have exchanged ~7126 messages since 2011.

MESA-WEB is a cloud resource for education that has served up over 800 models to 157 unique users in just over 6 months of operation.

http://mesa-web.asu.edu

MESA is the only stellar evolution software instrument that is

1) open source, thread-safe, and multi-core

2) employs modern numerical and software approaches,

3) solves the coupled equations as a single unit,

4) combines the numerics and physics into modules that have wide composability and interoperability with other software ecosystems

5) has wide applicability - spanning giant planets to massive stars to binary stars to modified theories of gravity to particle physics beyond the standard model, and more. All other instruments cover a restricted range.

There are three other open source but unsupported codes, TYCHO, CESAM and EZ; two web interface applications, YSEC and EZ, and about a dozen proprietary codes.

None of these alternatives offer the community the unique advantages of the MESA project.

MESA has seen significant adoption
by the astrophysics community.

MESA is well on its way to becoming the *de facto* world standard for evolving stars, providing a crucial community resource at just the right time.