Student Involvement in Space Exploration: The Next Generation

Planetary Science Vision 2050 No. 8237

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Involvement of students in space missions exposes students to the technical realities of space exploration – delivers deep learning experience and feeds the professional pipeline.

Venetia Burney Student Dust Counter:

SDC is part of the Education and Public Outreach (EPO) effort of the New Horizons mission and is the first science instrument on a planetary mission to be designed, built, tested and operated by students. The SDC project has an unusual history. A similar professional dust instrument was part of a competing proposal to New Horizons in a parallel Phase A study. After the selection of New Horizons, motivated by the potential scientific contribution of a dust instrument, the idea emerged to redirect some of the funds from traditional EPO activities so that a group of students could try their hands at building space hardware. The advanced state of the rest of the New Horizons payload and the risk of involving unexperienced students made this request difficult. With the strong support of the mission PI, the NASA EPO board agreed to try the “SDC experiment.”

CU student Chelsey Bryant-Krug prepares for a calibration run of SDC in the dust accelerator in Heidelberg, Germany in 2004. She is now a LASP professional engineer.

To minimize the risk SDC might pose to the mission, all quality assurance inspections and the final flight assembly was done by NASA-certified personnel, and student activities were supervised by professionals. However, the student team, consisting of up to 20 engineering and physics undergraduate and graduate students, was responsible for the work done in all phases of this project, including presentations at all NASA milestone reviews.

The flight-qualified electronics box of SDC.

SDC was built and tested to the same NASA engineering standards as every other flight instrument.

SDC provides the first set of dedicated dust measurements in the solar system beyond 18 AU, and will continue its observations while traversing into the Kuiper Belt (KB). Its data already provided unique and valuable science results, including an estimate of the total dust production rate in the KB. To date five publications on SDC data have been published in refereed scientific journals, and the results have been used in several other studies on the effects of dust influx to bodies in the outer solar system.

A total of 26 students have been involved in SDC with new students taking over responsibility for data processing and analysis through the extended mission. Due to the long duration of the New Horizons mission, multiple generations of students continue to be involved, handing over their skills to the groups that follow them. These SDC-trained students have moved on to a wide variety of professions. All undergraduates who applied to graduate school on graduation from CU were accepted to their first choice school (e.g., Stanford, New Hampshire). Several of them were hired at LASP as professional space scientists or engineers. Many continued in the space business at places such as NASA, SWRI, Orbital ATK, Ball, and Blue Canyon. All speak enthusiastically about the experience of being involved in SDC.

Jamey Szalay & Andrew Poppe. Now researchers at SWRI and Berkeley.

Students operate missions:

The real-world experience in mission operations is a valuable balance to the academic training of their University coursework and these students are keenly recruited into a range of professions.

The LASP Mission Operations & Data Systems (MO&DS) group staffs several Mission Operations Centers and Science Operations Centers for the day-to-day operations of NASA spacecraft and instrument missions. LASP is one of very few university-based mission operations centers. One of the most exciting and unusual aspects of mission operations at LASP is the opportunity for CU undergraduate students to become certified mission operators. The student operators, who must pass a summer-long course held at LASP, work under the super-vision of professional staff and perform mission operations for NASA satellites – from LASP-built student cubesat missions to national facilities such as Kepler. Each day, more than 100 gigabytes of data come through LASP servers to support ongoing space missions, as well as the scientific data that scientists from all over the world rely on.

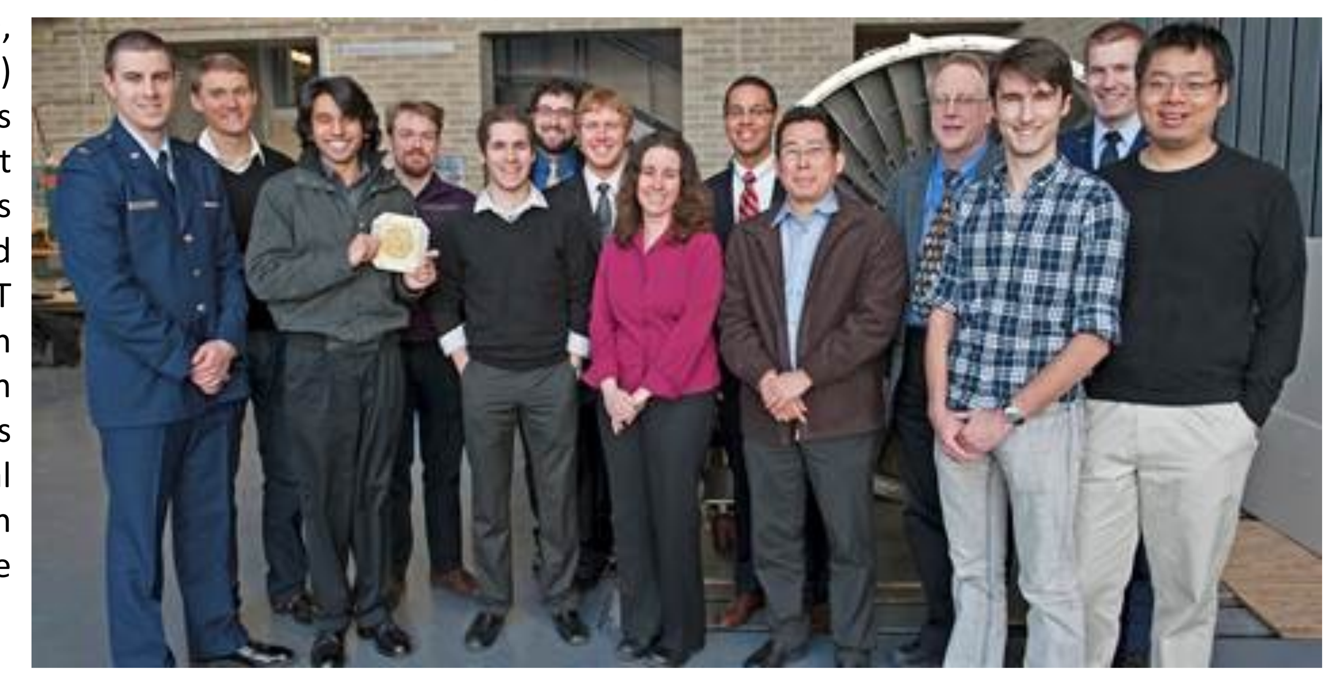
2050 vision for student involvement in planetary missions:

- To supply the creative workforce to implement NASA’s Planetary Science Division’s vision for solar system exploration in 2050 there needs to be a healthy pipeline of experienced scientists and engineers.
- An effective way to maintain such a trained workforce is through direct university involvement in space missions. The best training for students comes from hands-on involvement throughout all phases of missions via student-based missions and/or instruments on planetary missions.
- What types of missions or instruments are we proposing be student-based? Students have demonstrated they can build a successful instrument that has made space measurements for 11 years and out to 33 AU. Students have built and operated a cubesat that has outlived its original design life by a factor of 5.
- **We see every reason to provide students the opportunity to explore every corner of the solar system.**

Students on OSIRIS-REx:

The REXIS team strives to design and build a robust instrument through the innovative MIT-Harvard Conceive, Design, Implement, Operate (CDIO) Curriculum, in which students take a lead role in instrument development. The REXIS team is made up of graduate and undergraduate students at MIT and Harvard, as well as research scientists and faculty at both institutions. As students graduate, multigenerational continuity is achieved through faculty, scientist, and graduate student mentors.

THE REXIS TEAM: STUDENTS DESIGN, BUILD AND LEAD



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- Demographics of Planetary Sciences
  - *What are the implications for future planetary scientists?*
  - *What are implications for academia? NASA labs? Industry?*
- *PART A: Survey of Departments* Spring 2011
- *PART B: Survey of active scientists*
  (members of AGU, DPS, LPSC attendees) Fall 2011

http://lasp.colorado.edu/mop/resources/links/PlanetaryScienceWorkForceSurvey2011/
Reports, summaries for both studies

Also – DPS Surveys http://dps.aas.org/reports

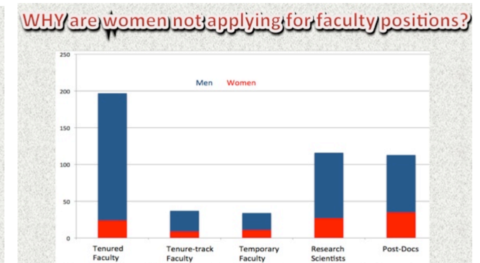
Part B: 2011 Survey of 4,252 on mailing lists of potential planetary scientists associated with the LPSC, AGU and DPS
2,622 (62%) respondents

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

The numbers in the highlighted cells on the diagonal belonged to that group only, except the bottom right cell that shows 161 respondents belong to all 3 groups.
• The off-diagonal numbers refer to the number of respondents belonging to two groups
• A total of 1,876 were associated with the LPSC; 894 were members of AGU; and, 733 belonged to DPS.

Age	Men Respondents	Women Respondents
Lower quartile	38	33
Median	48	38
Upper quartile	58	48

WHY are women not applying for faculty positions?



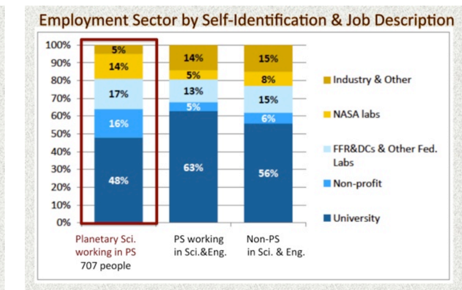
- Men tend to apply for more positions than women do
- Women tend to be more likely to have a 2-body problem

Demographics of Planetary Sciences

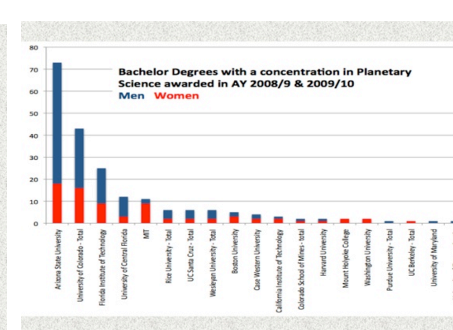
Purpose: To understand the broad, diverse community of planetary scientists in the US.

- PART A: Survey of Departments Spring 2011
- PART B: Survey of active scientists (members of AGU, DPS, LPSC attendees) Fall 2011

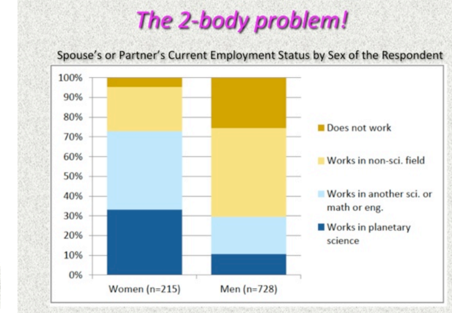
Employment Sector by Self-Identification & Job Description

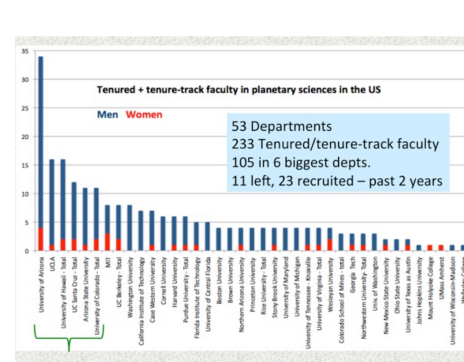


Note: The University sector includes university affiliated observatories and research institutes. FFR&DCs include JPL, APL, and LPI. Non-profit includes SwRI, SSI, and PSI.



The 2-body problem!

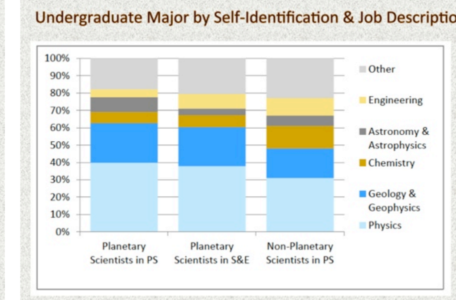




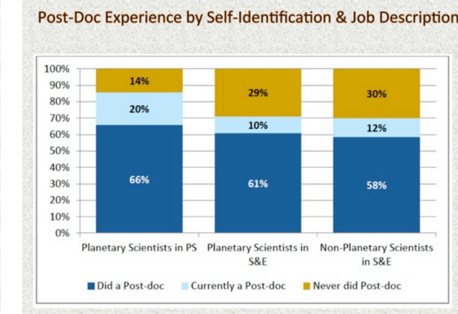
- *Of the 2,622 respondents, 1,518 (58%) have PhDs and live in the US*
  – the population we targeted for this survey
- *Of the 1,518 PhDs in US 1018 (i.e. 2/3) call themselves planetary scientists*
- *Of these 741 are planetary scientists whose job is primarily planetary science*
- *Since response rate was 62% we can estimate that total working planetary scientists in US*
- *741/0.62 = 1200 professional planetary scientists*

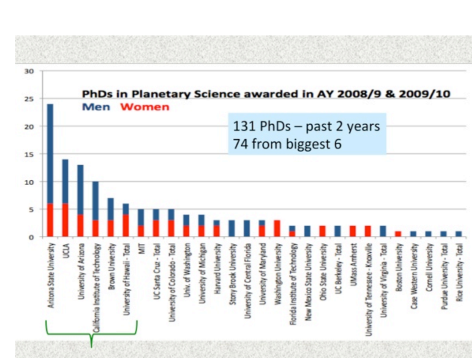
Probably over-estimate since perhaps working planetary scientists are more likely to respond

Undergraduate Major by Self-Identification & Job Description

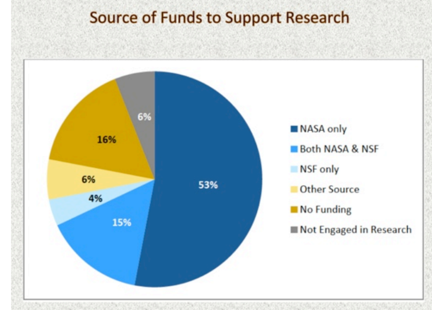


Post-Doc Experience by Self-Identification & Job Description

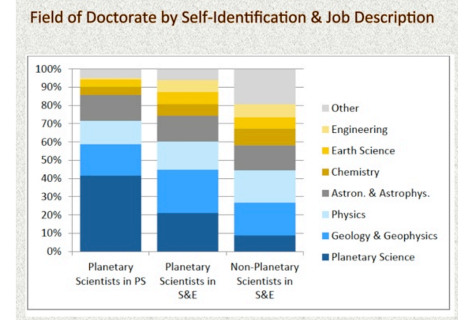




Source of Funds to Support Research



Field of Doctorate by Self-Identification & Job Description



- 229 planetary science faculty
- Say they are on the faculty for 30 years, then replacement is <8 per year
- 131 PhDs per year
- If this is somewhat exaggerated / wrongly classified by the big depts (ASU, UCLA, CU) then it’s more like 75/year
- *This would mean 1 in 10 get a faculty position.*
- *Probably more like 1 in 8.*
- 206 Bachelors degrees per year – again, could be exaggerated by some depts.

Let’s check some numbers….
- 11 faculty left over 2 years, 23 new faculty appointed
- 131 PhDs over 2 years
- This means there are faculty positions for 18% of graduating PhDs (1 in 5.7)

Total Soft-money Funding
Let’s do some rough numbers…..
- Total professional planetary sci. workforce ~1200

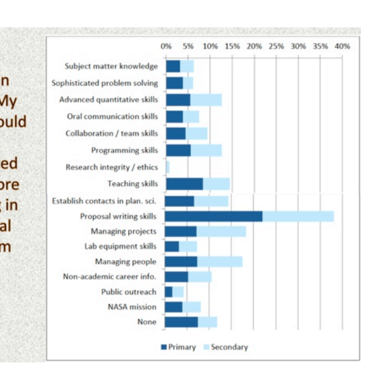
Estimate #1:
- 46% are on soft-money = 550 people
- Say cost/person ~$80k/yr x 2 (that’s 100% overhead)
- Total ~ $80 million / yr

Estimate #2:
- 100% soft-money = 1200 people -> $192 million
- Basic research R&A budget ~$180 million / yr

Does not include faculty, civil servants, students….

Respondents Ratings of How Well their Doctoral Program Prepared Them

Areas in Which My Career Could Have Benefitted from More Training in Doctoral Program



2010 DPS Survey - Institutions
- 55% at college or university
- 15% at FFRDC (SwRI, PSI, etc)
- 13% at NASA + JPL
- 10% other Govt./National Observatory
- 8% industry or other

Pretty much consistent with larger survey

2010 DPS Survey
- 40% response of 1290 members
- 419 responded are employed at an organization as a planetary scientist
- 54% permanent, tenured/tenure-track civil servant or equivalent
- 46% soft-money or fixed-term post-doc

Variations with Time?
- DPS membership
  – 1995 = 831
  – 2005 = 1300
  – 2010 = 1290
- No significant change in past 10 years?

What Next?
- What questions are not answered?
- What should be followed up?
  – Reporting on grad students and UGs from major universities – get numbers right!
  – Update faculty numbers
- Ask employers for their opinion of workforce?
- What do *you* think?

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