Pirates, Spark Plugs, and Cell Phones:

Physicists in Global R&D Careers

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Pirates, Spark Plugs, and Cell Phones

- **How much physics do we need to know?**
- **What skills and behaviors make us successful?**
- **Alumni surveys**

- **Anecdotal evidence about physics career paths**
- **Career preferences of physics Ph.D. students**
- **NSF survey on physics careers**

- **Providing information on industrial career paths**
- **Teaching behaviors required for success in industry**
- **Acknowledgement: NSF DMR-11104934**

Introductory Questions

How many of you have

- **Worked for a company (after your Ph.D.) ?**
- **Spent a sabbatical in industry ?**
- **Started a company ?**
- **Consulted for a company ?**
- **Written a GOALI NSF proposal ?**
  (Grant Opportunities for Academic Liaisons with Industry)
- **Filed a patent application ?**
- **Licensed a technology to a company ?**
- **Organized an international conference for 1000 people**

What skills do these things require ?

How much physics does a department chair need to know ?

Activity (index cards)

Write down 2-3 skills that make YOU successful as a physics department chair?

1)

2)

3)

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How do we teach these skills to our students ?

How much physics does a department chair need to know ?

My biggest worries:

- **Paying people (on time, correct amount, correct account)**
- **Conflict resolution (faculty, staff, students, parents)**
- **Assist faculty and students to navigate the university bureaucracy**
- **Evaluations (courses & people), program assessment & accreditation**
- **Managing limited resources, managing multiple constraints**

Responses from alumni surveys (detail on next slide):

- **Navigating the federal bureaucracy**
- **Written and oral communication skills**
- **Working with interdisciplinary teams, Life-long learning**

How do we teach these skills to our students ?

Alumni Surveys: Skills and Challenges (Engineering Physics BS; not in grad school)

- Skills for success:
  - Problem solving skills in a broad range of topics
  - Working with interdisciplinary teams
  - Commitment to life-long learning, willing to change
  - Written/oral communication skills
- Greatest challenges:
  - Complexity of federal bureaucracy
  - Written/oral communication skills (documentation)
  - Living in a large east-coast city.
  - Consider return on investment (time management).

Physics Degree Holders: What do they do?

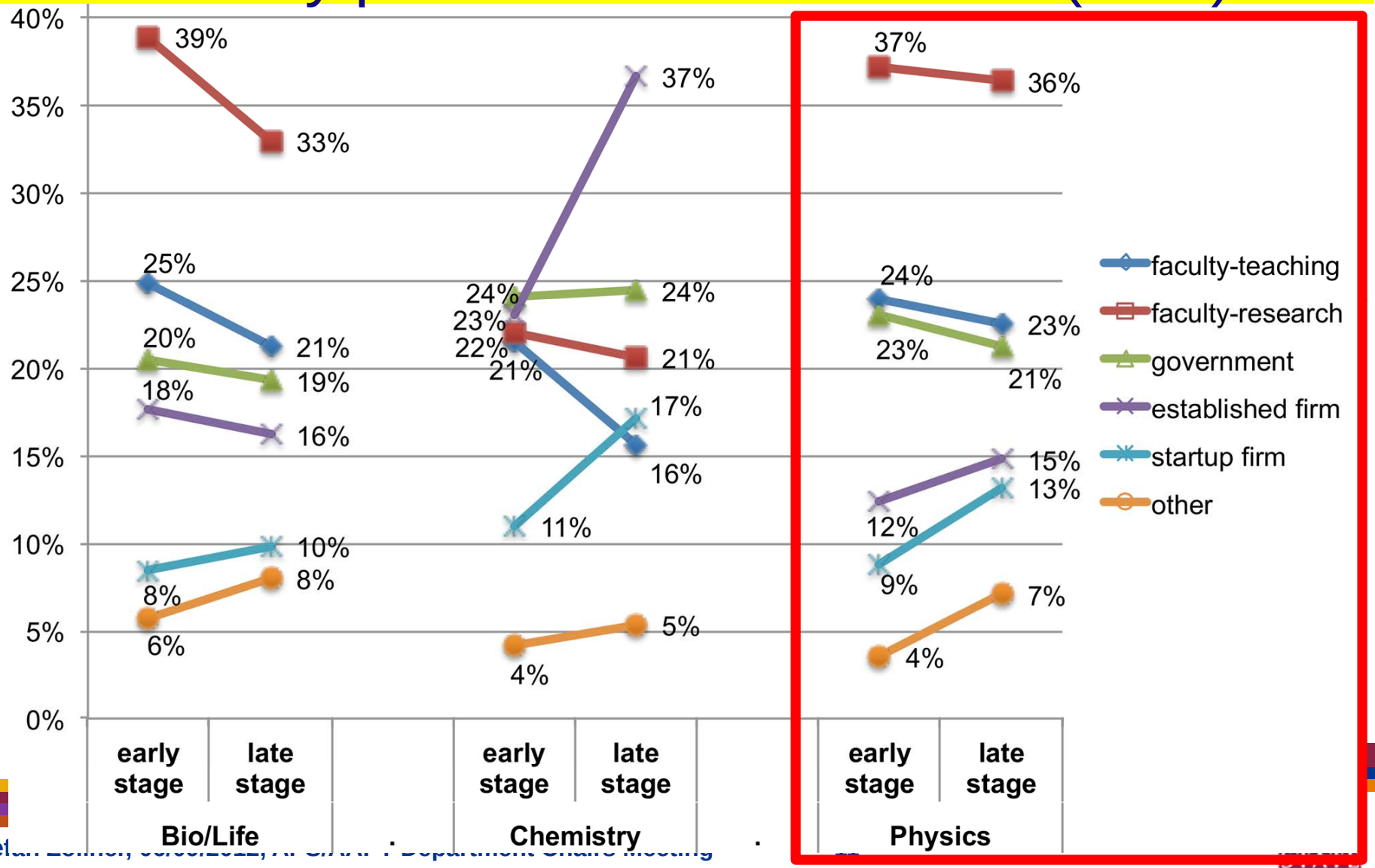
- My classmates:
  - Hans-Peter Wagner: University of Cincinnati (physics)
  - Martin Muscholl: University of South Florida (physics)
  - Heidrun Schmitzer: Xavier University (physics)
  - Norbert Kaiser: TU Munchen (physics)

  - Tobias Ruf: Director of spark plug R&D at Bosch GmbH
  - Diego Olego: CTO of Philips Health Care
  - Thorsten Heyen: CFO Wacker Polysilicon

Physics Degree Holders: What do they do?

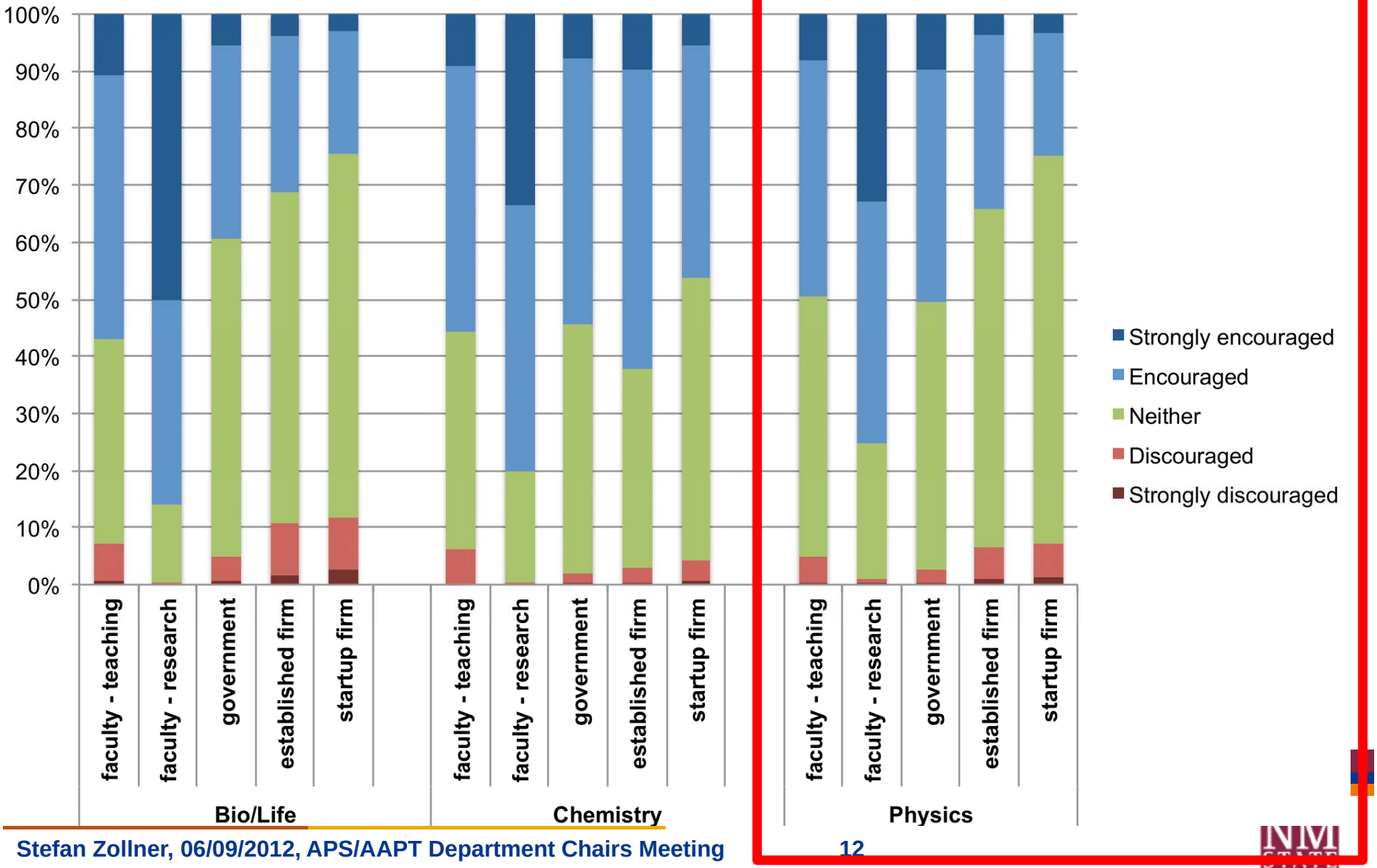
- Entrepreneurs:
  - John Woollam: J.A. Woollam, Inc (scientific instruments)
  - Keith Bowen: Bede Scientific (scientific instruments)
  - Phil Wyatt: Wyatt Instruments (homeland security)
  - Sam Wurzel: Octopart.com (retail startup)
- Physicists in industry (etc)
  - Ed Stanek: (former) Director of the Iowa Lottery
  - Avoiding pirates !
  - Building cell phones
  - Physicists on Wall Street
  - Many other examples

Physics Career Preferences: Faculty positions most attractive (58%)



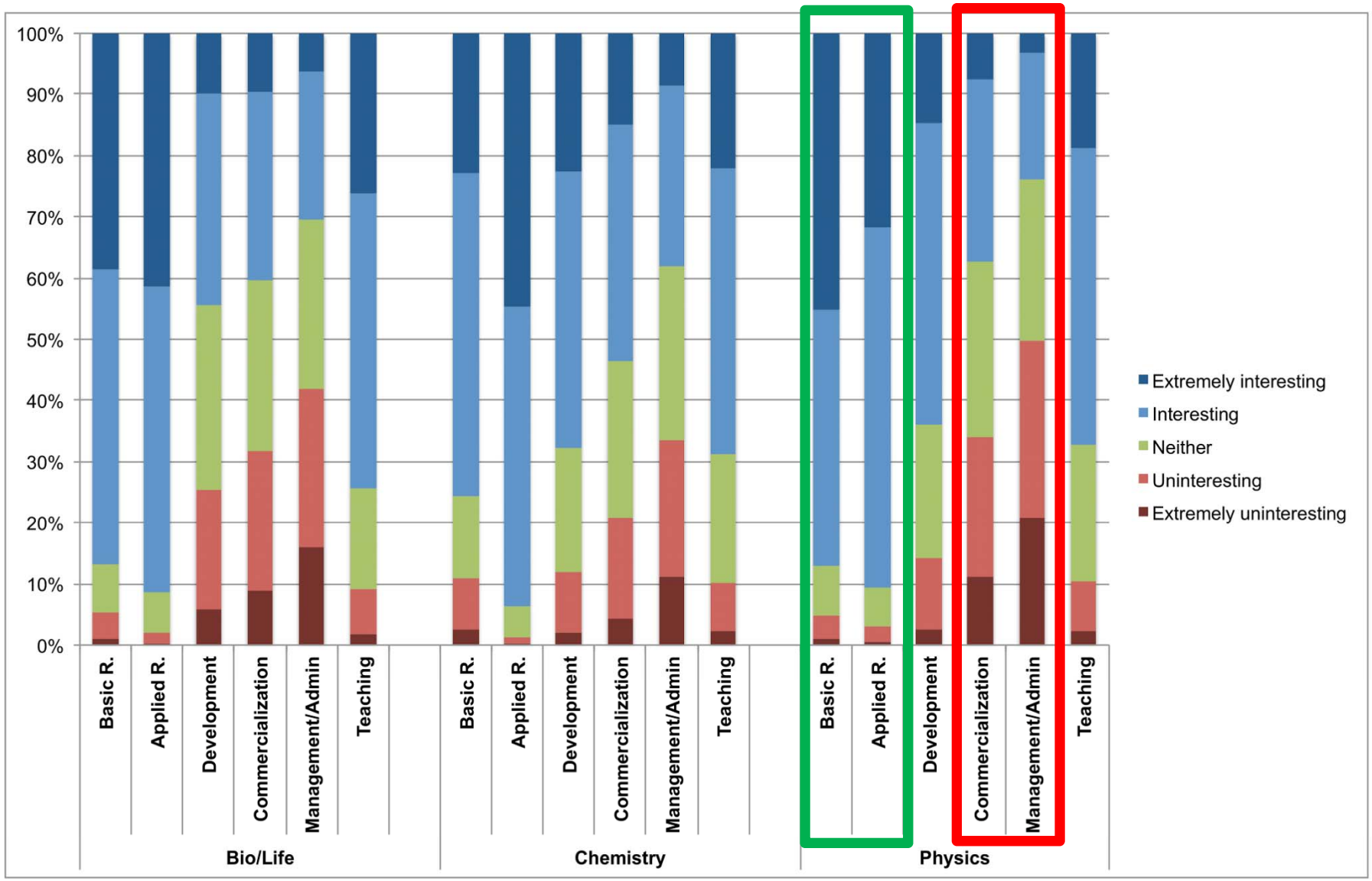
Source: H. Sauermann and M. Roach, PLoS ONE **7**, e36307 (2012).

Advisors encourage faculty careers (75%)



Source: H. Sauermann and M. Roach, PLoS ONE **7**, e36307 (2012).

Which activities are interesting to students?



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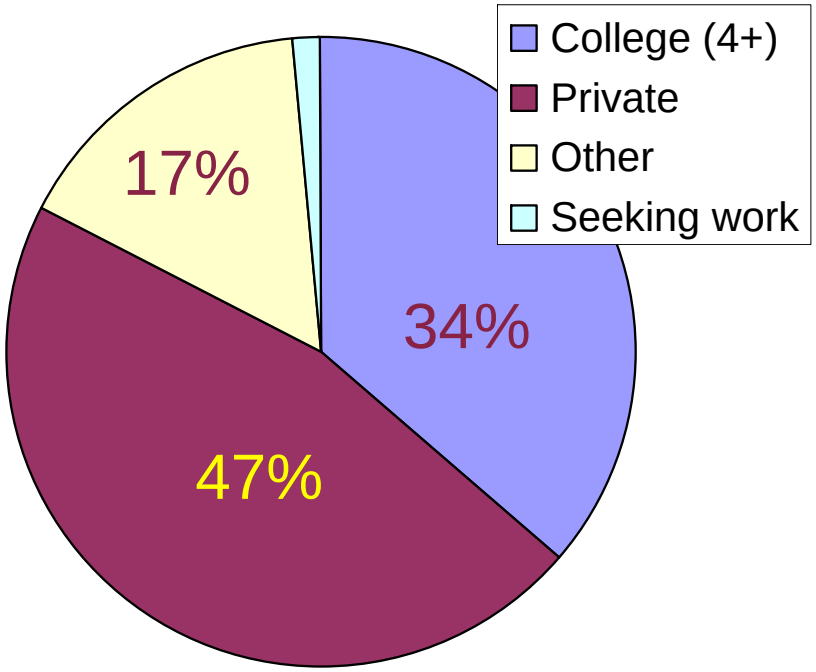
Statistical Employment Data for physicists (NSF 2006)



Primary or secondary activity:

28% Basic research

32% Applied research

24% Teaching (instructors)

19% IT

34% Mgmt, Sales, Admin.

36% Design & Development

12% Other (incl. services)

34% of ~34300 Ph.D. physicists at colleges (4+)
This includes 1710 postdocs.

Less than 50% list “physicist” as occupation

- **Sources:**
- AIP Statistics
  http://www.aip.org/statistics/trends/emptrends.html
- **Characteristics of Doctoral Scientists & Engineers in the US, NSF, September 2009, April 2011 Erratum**
  http://www.nsf.gov/statistics/nsf09317/, Tables 12, 15, 36, 75
- APS Industrial Member Survey (2006)
  http://www.aps.org/about/governance/committees/commemb/index.cfm

Statistical Employment Data (NSF 2006)

Median Ph.D. Physicist Salaries:

$ 99,900	Physics Ph.D. overall
$ 52,400	Teachers (High school, community college)
$ 74,700	Colleges and universities (4+)
$ 109,200	Private sector (for-profit)
$ 117,200	Federal government

- **Source:**
- Characteristics of Doctoral Scientists & Engineers in the US, NSF, September 2009 http://www.nsf.gov/statistics/nsf09317/, Table 54

Sources of information on non-academic careers

- Alumni visits (seminars and informal visits)
- Keep in touch with your alumni. Social networking (Linkedin).
- Give credit to faculty whose alumni go into industry
- Get alumni in touch with current students
- Include modern applications in physics courses
  (NMSU course on Modern Materials)
- GOALI proposals, interdisciplinary research
- Sabbaticals/internships in industry, consulting for industry
- FIAP: Forum on Industrial and Applied Physics
  Sessions at March and April APS meetings.
- Professional or technical conferences (with industry)
- Engineering Physics BS, Professional Science MS

Space Physics Agreement with AFRL

- AFRL at Kirtland Air Force Base (Albuquerque, NM)
  - Space Vehicles Directorate
  - Directed Energy Directorate
  - AFRL leadership has NMSU ties
- Educational Partnership agreement signed in 2012.
- Two physics undergrads flew on President Couture's plane to attend the signing ceremony in ABQ.
- Space Physics MS concentration:
  Physics core, space weather courses, interdisciplinary electives, optional space physics thesis at AFRL.

- DOE EPSCoR partnership grants provide similar links to National DOE Laboratories (not funded since 2009).

Should students take courses in other fields ?

- Engineering
- Computer science (C++, Java)
- Finance
- Management, HR policies
- Technical writing
- Foreign languages (especially Asian)
- Should the APS offer seminars for our members?

This question misses the point:
More courses won't help, we need activities.

Companies measure results and behaviors

- **Results**
  - Describe the employee's contributions to the goals of the organization.
  - Based on SMART goals
- **Behaviors** (also called competencies)
  - Describe HOW the results were obtained

If I meet my goals, why does it matter if I'm in a good mood or not?

Baldridge winner states:

Our leaders are held accountable for both results and behaviors and we are driving this mental framework down through the rest of our population.

5 E's of success (adopted from General Electric)

- **Envision:**
  Creates the future, imagines what's next.
  Thinks in terms of the big picture and how the pieces fit together.
  Comes up with the **vision, strategies, and viable plans** that turn a dream into reality.
  Questions assumptions and challenges conventional thinking.
  Generates breakthrough ideas that improve the way the organization operates.
- **Energize:**
  Creates energy among employees to work on projects.
  Excites coworkers around activities, projects, and events.
  Creates an atmosphere where everyone has passion to excel and opportunity to contribute.
  Sustains a **positive attitude in the face of difficult** challenges or adversity.
- **Edge:**
  Makes **tough decisions** when needed to achieve goals. Takes responsibility for problems.
  Convinces people to **collaborate**. Challenges people to do their best.
  Holds people accountable, takes action when their performance does not meet expectations.
- **Execute:**
  Completes projects on time and on budget. Meets **commitments** and keeps promises.
  Follows tasks/projects through to successful **completion**. Communicates about projects to ensure completion. Has strong **problem-solving skills.**
- **Ethics:**
  Professional integrity while working on projects. Is honest at all times.
  Builds personal credibility. Treats all people with respect and dignity (diversity)

Source: Chris Galvin Interview, Business Week Online, 17 April 2000.

Implementation in a physics curriculum

- **Results**
  - Students are trained to achieve results
    - through formal physics courses (homework, exams, grades, etc)
    - and with their research (experiments, calculations, data analysis)

- **Behaviors** (also called competencies)
  - We also need to include activities in our physics curriculum, which teach desirable behaviors.

- **Results and behaviors must be balanced.**

Less is more (FIAP Newsletter summer 2012)

- Teaching behaviors means teaching less physics.
- **"Information about industrial careers does not help students make progress with their research."**

- FIAP tutorial on industrial careers (not much interest).
- FIAP Lunch with the Experts (first to sell out, 30/4000).

- **FIAP Newsletter: "The APS needs to raise … networking opportunities (at the March meeting)."**
  "I barely remember talks and sessions", but many networking events.

Extracurricular learning opportunities

- **Teaching assistants (2-3 years, lab TAs)**
  - Communication skills (oral and written)
  - Professionalism (fairness, dependability, on time, follow instructions)
- **Participate in student organizations (department & university-wide)**
  - Governance (many students from less democratic countries)
  - Planning and budgeting activities (open house)
  - Graduate student speaker series
  - Community service (science fair, outreach)
  - Applying for institutional travel funds
- **Advising undergraduate research**
- **Teaching an introductory course (rare: 1-2 students)**
  - Preparing students to be future faculty
- **Team-teaching:** exams, clicker quizzes, lecture demos
- **Professional societies:** APS unit ExComm may have student members

Performance = Results + **Behaviors**

- **Results**
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Behaviors for physics graduate students

- Behaviors are used to achieve goals.
- Define SMART goals!
  - Courses, exams, teaching, research
  - Hold students accountable for success or failure.
- Define behavioral standards! (4e+E will work)
- **Assign tasks to train behaviors:**
  - Teaching: Tardiness, recordkeeping, ethics, customer focus, communication, execution
  - Team teaching, team research
  - Interdisciplinary assignments
- Provide **feedback** on goals and **behaviors**!

Milestones in our NMSU Ph.D. Program

- English language skills (international students):
  - Written test (can student write a thesis?) or high TOEFL (>79)
  - **Oral test (can student teach a lab/recitation section?)**
- Core courses and electives (GPA>3.0)
- **TA performance affects financial support (5-year limit).**
- Qualifying and comprehensive exams (2 attempts)
- **Find an advisor who support the student (w/ RA)**
- Research, publications, conference presentations
- Thesis, defense

- **Most milestones are outcomes-based.**
  Behaviors don't matter much!

Conclusions

- Only 20% physics Ph.D.s become physics faculty. (Half of these 20% will be at undergrad institutions.)
- Almost half of physics Ph.D.s work in the private sector.
- Inform students about industrial and government careers.
- Use activities to teach behaviors that ensure the success of your students in industry and government.

- Acknowledgment: Partly supported by NSF (DMR-11104934).