HEPAP Informal Working Group on the HEP University Program

Sarah Eno (chair)

HEPAP meeting

22 Oct. 2009

(presented by Dan Marlow)

What is an Informal Working Group?

From Mel Shochet, chair of HEPAP, on 20 Feb. 2009 :

> One of the recommendations of the University Grant Program subpanel was to have a group of people to focus on the HEP university program and bring to the attention of HEPAP and the agencies systemic problems in the program. I am asking a small group of HEPAP members to take on that responsibility. Once per year, tentatively at the fall meeting, the group would present a report on the state of the university program in which issues that broadly affect the program are highlighted. This includes problems affecting all institutions or a subset, for example DOE or NSF funded, large or small institutions, etc.

Initial Members: Martina Artuso (Syracuse, NSF-funded), Alice Bean (Kansas, NSF-funded), Sarah Eno (chair, Maryland, DOE-funded), Dan Marlow (Princeton, DOE-funded), Hank Sobel (Irvine, funded by DOE)

Added Apr. 15, 2009: Boris Kayser (FNAL) (current chair, DPF executive committee)

A very active committee! Sarah wants to thank all the members for their time and effort!

What is it?

"Informal" means this is not a HEPAP subpanel. We therefore did not receive a charge from the agencies. Instead, we have felt free to follow our interests and to develop our own agenda.

Note: Initially all the members of this IWG were experimentalists working at large research universities. Boris Kayser was added on April 15, after our survey had already been developed.

Our Interests

- Basic demographic information to monitor University trends
- Response of the Agencies to the HEPAP Subpanel report on the University Grants Program
- Status of technical infrastructure at Universities

Mail to Agencies

Dear Marv and Glen,

Thanks for the response! Indeed, we were thinking that it would be appropriate for our committee to meet with representatives from each agency for discussion.

We had our committee's first meeting **on Wednesday, March 25**. Let us tell you about our current thinking, and then we can discuss the appropriate timescale for a meeting.

Our understanding is that a member of the committee would give a presentation during the fall HEPAP meeting (Nov?). We would like to include the following in that presentation:

1) basic demographic information and trends (total funding versus Year, and number of people supported in various categories (faculty, postdocs, students, engineers, research scientists, etc) versus year)

2) What fraction of the supplement money went to Universities

3) We would like to highlight and present what the agencies have done in response to the recommendations of the University Grants Program Subpanel Report, to thank the agencies for their efforts

4) present the results of a short, pointed survey that we will send out this summer.

We were thinking we could receive the information for 1) and 2) via email from the agencies. For item 1), we imagine this kind of basic demographic information would be presented in every annual report from this working group since these are the most basic kind of data anyone would need to even begin to access the trends and health of the program. If the presentation is in Nov, it would be useful to get this information by mid-August, to give us some time to digest it.

For 3), we would appreciate to meet with you and hear a presentation from you on your accomplishments in this area. Again, it would be useful to have the meeting during the summer, at your convenience. Perhaps you could suggest a week and I could poll for the group's availability?

For 4), we would need an email list of contact people for each funded institution. We have identified two issues we would like to explore a little, both related to proper mentoring of graduate students, and are currently focusing on developing a very small number of well-focused questions. Needless to say, the sooner we can get the email list the better, as it will take some pushing to get a complete response.

Best,
Sarah (chair) for the committee: Marina, Alice, Dan, Hank

Big thanks to agencies!

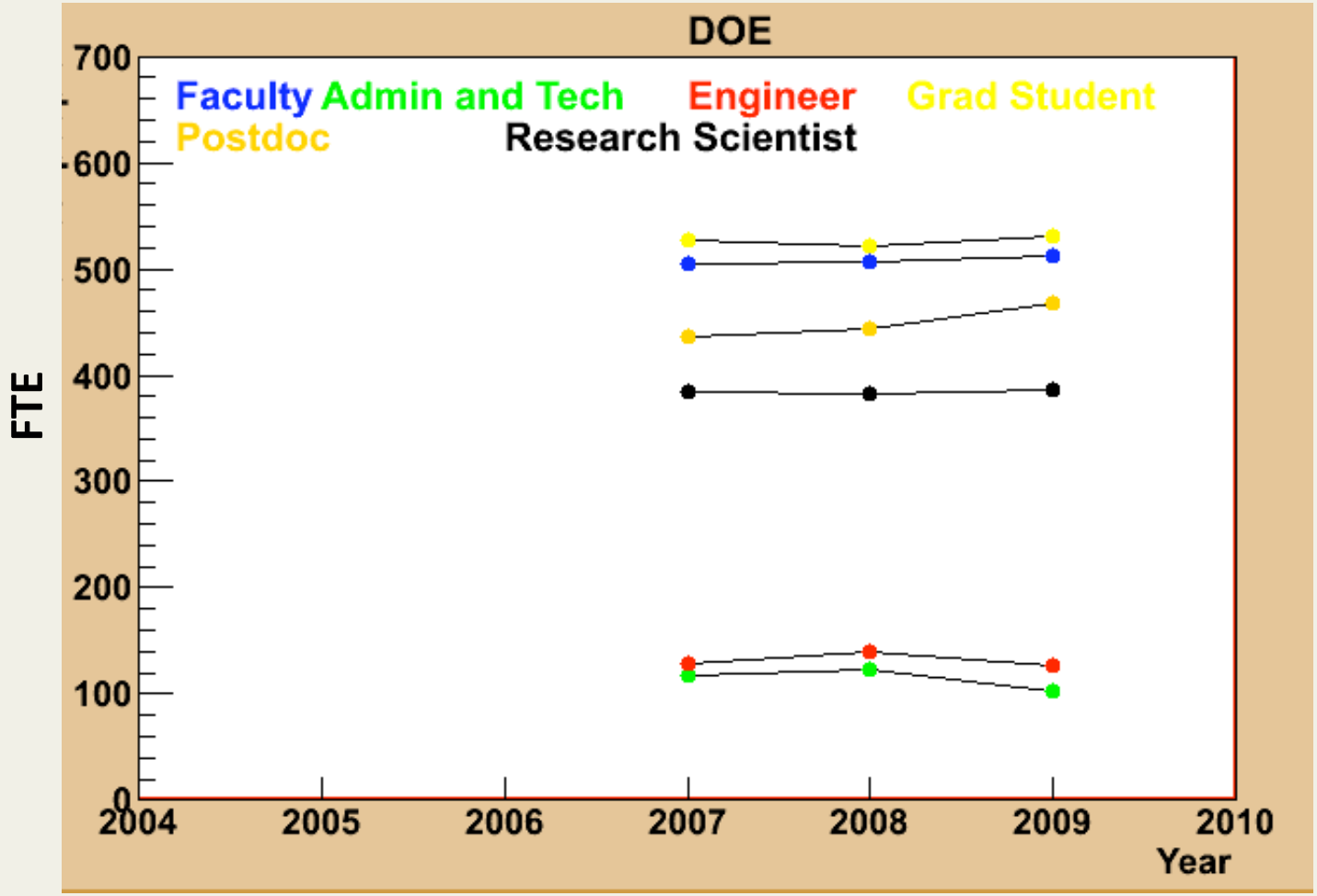
- for providing the demographic information
- for providing their response to subpanel report
- for finding time in their busy schedules to meet with us

Demographic information from agencies

Demographic trends are an important indicator of changes in the program if interpreted with care.

Data is directly from the agencies. They did not have easy access to data before 2005/2007.

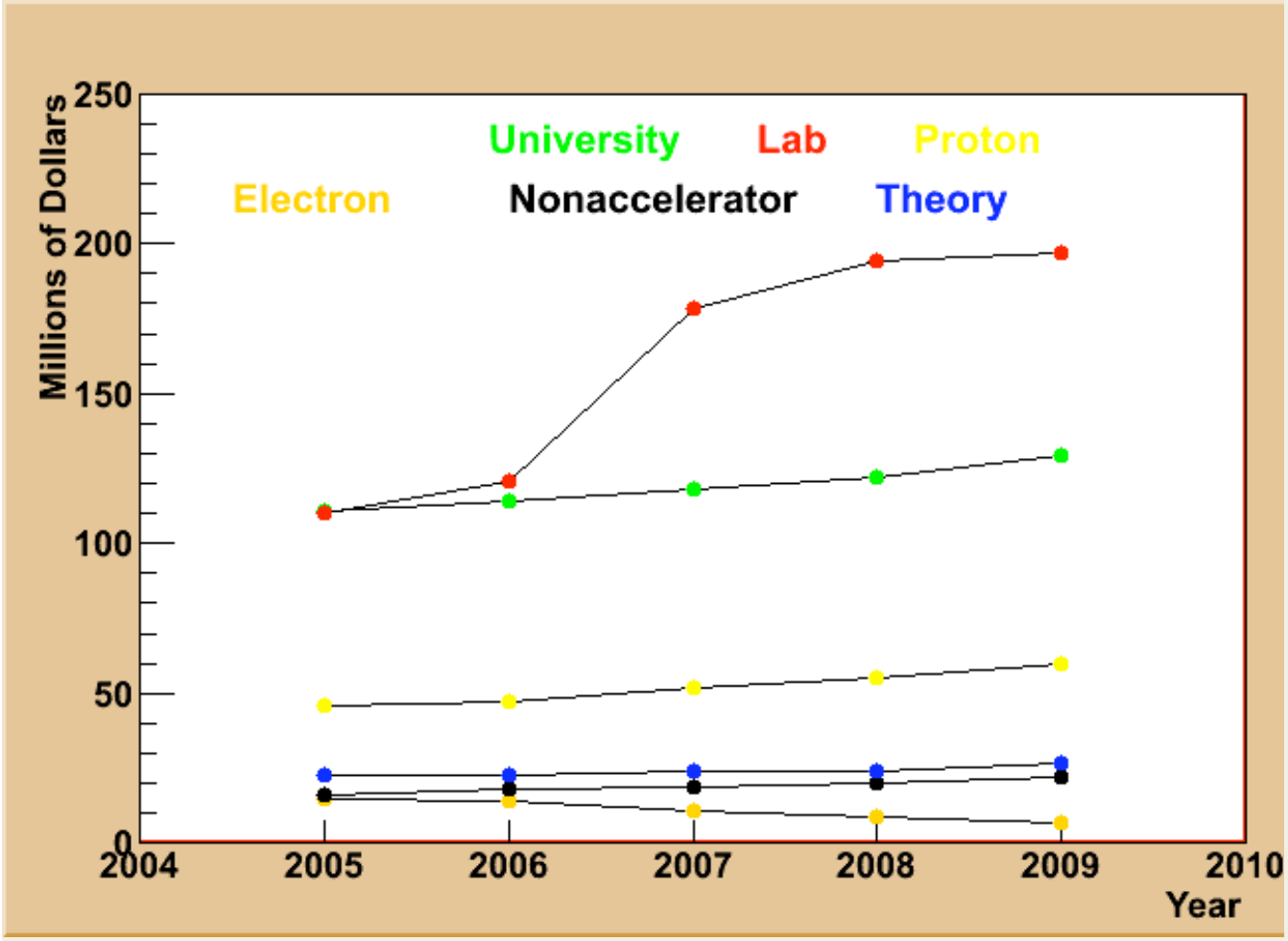
DOE University Demographics



F09 is requested.

Over the short time period for which information is available, distribution of personnel is stable.

DOE Funding by category

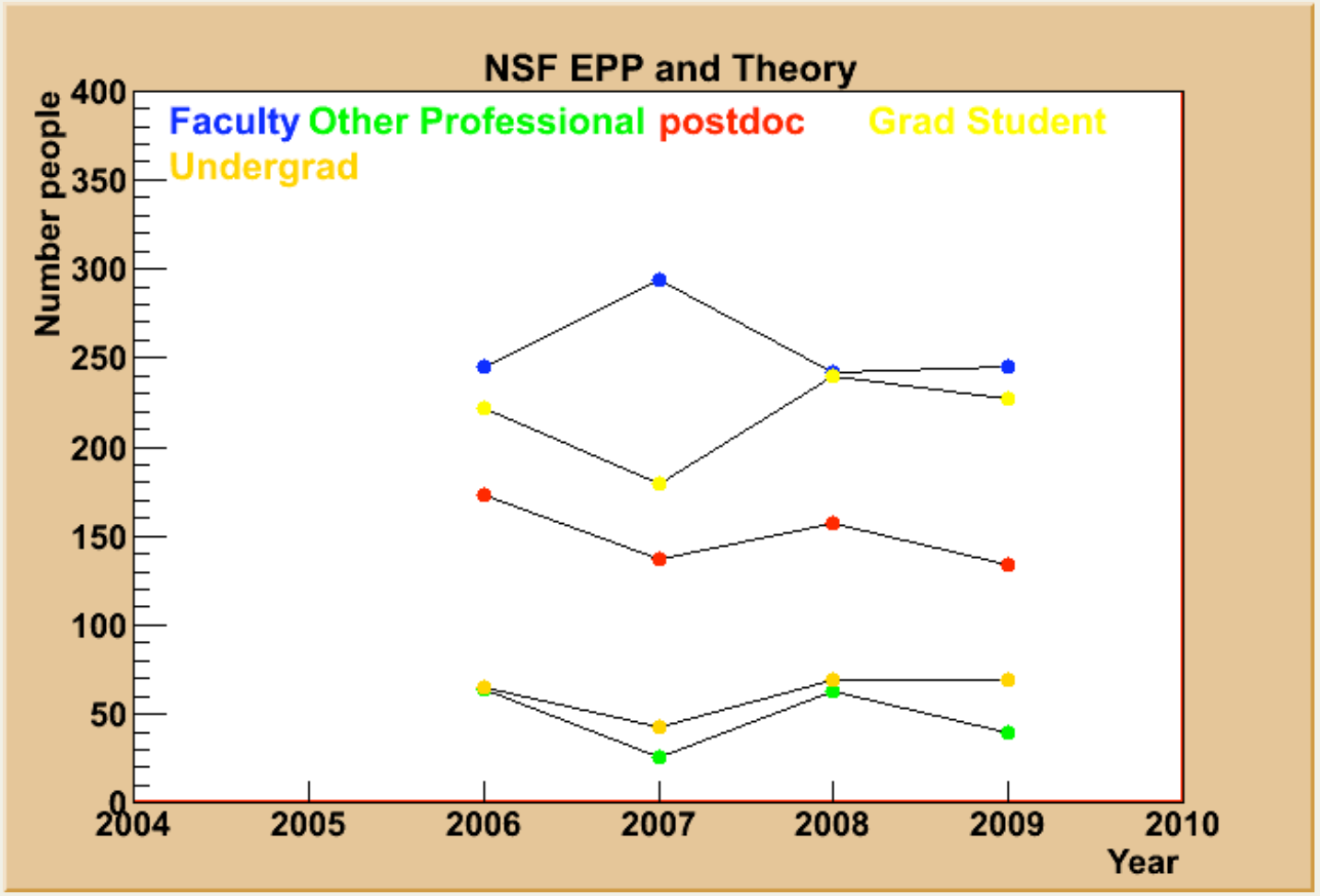


"University" and "Lab" are totals. "Lab" is total across all labs, but "Electron," "Proton," etc. are just for university funding.

The rise in lab research funding is due to labs (mostly SLAC and FNAL) shifting physicist effort from Facility Operations to Research.

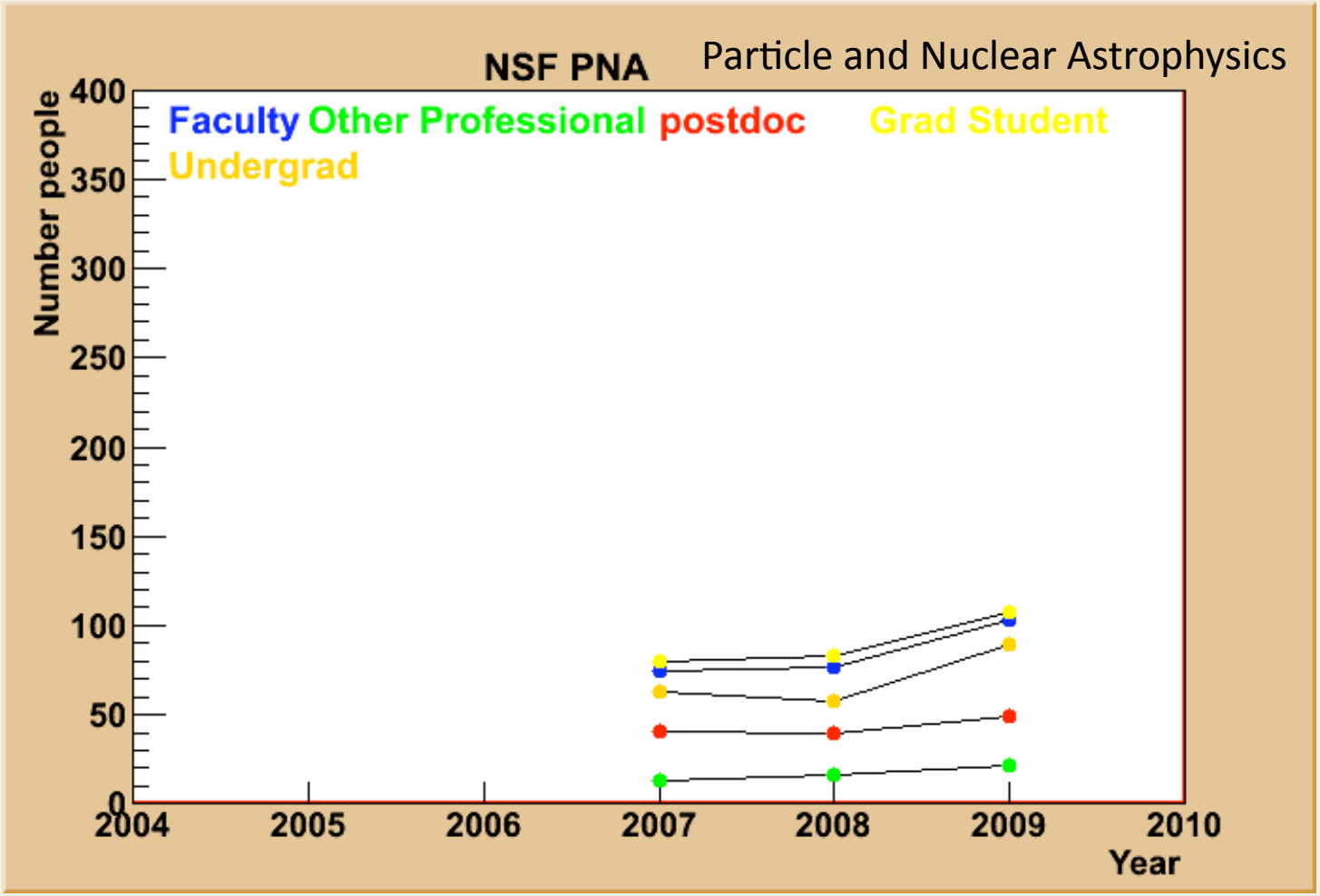
FY09 is requested.

NSF Demographics



NSF personnel distributions more volatile than DOE, but still relatively stable.

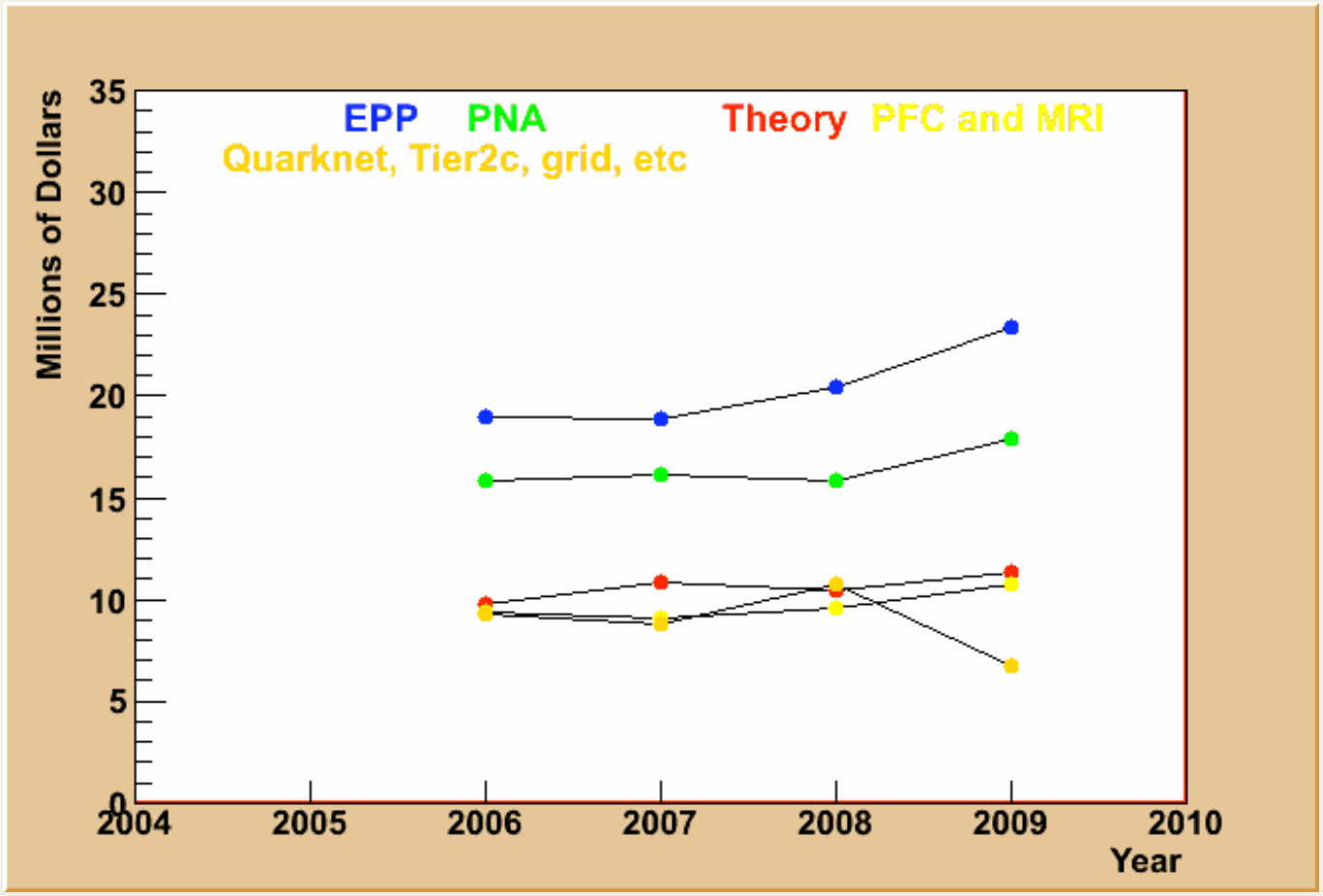
NSF Demographics



For this graph only, for faculty, graduate students, and undergraduates, the y axis is number of people, while for professionals and postdocs it is FTE. In other graphs, the y axis is always number of people.

NSF Money

Does not include CESR, DUSEL, ICECUBE, LHC ops, RSVP, Accel R&D. Includes ARRA funding. Step in 2009 due to ARRA. "quarknet, tier2c, etc" numbers not complete.



PFC=Chicago, Hampton, Notre Dame, ITP.
MRI="Major Research Initiative,
PNA="Particle-Nuclear Astro",
EPP=particle experiment

Stable when excluding ARRA bump.

Universities Subpanel

22 July, 2007

Report is a 96 page document
http://www.er.doe.gov/hep/panels/reports/hepap_reports.shtml

Thomas Appelquist, Yale University
Jonathan Bagger, Johns Hopkins University
Keith Baker, Yale University
James Brau, University of Oregon
Raymond Brock, Michigan State University
Jordan Goodman, University of Maryland
Paul Langacker, University of Pennsylvania
Kevin McFarland, University of Rochester
Homer Neal (Chair), University of Michigan
Steve Olsen, University of Hawaii
Ritchie Patterson, Cornell University
Natalie Roe, Lawrence Berkeley National Laboratory
Randy Ruchti, ex officio, National Science Foundation
Shaevitz, Columbia University
Elizabeth Simmons, Michigan State University
Wesley Smith (Vice-Chair), University of Wisconsin
Chris Stubbs, Harvard University
Andy White, University of Texas at Arlington
P. K. Williams, ex officio, Department of Energy

Thanks

The IWG wants to thank the agencies for all the work they have done to implement the recommendations of the Universities Grant Program Subpanel!

University Grants Program Subpanel Report

The agencies sent us, as requested, written responses. The full response is attached to the agenda page for this meeting. These slides only contain excerpts from the full responses.

The full responses contained very important qualifiers, that I have deleted, such as : " University based technical infrastructure will be funded when there is a case that such infrastructure is important for achieving the goals of the national HEP program. " and "OHEP recognizes the important role theorists—including both graduate students and postdocs--play in data analysis and in the design of new experiments. "

What fits on the slides is missing these **important** qualifiers and softeners.

Added comment from DOE: "We think it is important to note that since the HEPAP University subpanel report was delivered, OHEP has been restructured and no longer has a "university program" per se. While one can talk about various aspects of the program as they apply to university grants it is incorrect to assume that there a dedicated program to address university issues."

Responses to universities subpanel report

1. The University Grants Program must be strengthened in order to achieve the goals of the national high energy physics program, as articulated by EPP2010. This requires increased investment and careful attention to building and sustaining levels of personnel and infrastructure necessary for successful university research groups.

DOE: Our funding in FY 2009 indicates that university groups have done a good job of proposing research that meets the needs of the program, since the funding level for these groups is in excess of cost of living since the FY 2007 report. In addition, in FY 2009 it was determined that a strong case had been made for needed infrastructure for university performers and $10.7M of the $15M of ARRA stimulus funding was provided to nearly 100 proposals. These funds will support a variety of equipment purchases (for example accelerator hardware and magnet and vacuum equipment) as well as enhance computer capabilities, purchase lab equipment, collaborative tools, and other hardware.

NSF: The Physics Division is committed to funding "PI" proposals (as opposed to Facilities or Projects such as LHC Operations) at a level that is more than 50% of the division budget.

Responses to universities subpanel report

2. Group sizes should be sustained, and increased where appropriate and supported by peer review. The agencies should make a special effort to support long-term research scientists as an integral part of this group structure, particularly when they provide expertise essential to the experimental program or leadership at a remote laboratory.

DOE: We do not in general favor open-ended support for long-term research scientists on grant funding (as opposed to, say, support for graduate students or postdocs), but we do consider each individual case on its merits. Overall, university research group sizes increased from FY 2007 to FY 2009 (although the numbers are not final yet).

NSF: no specific response

Responses to universities subpanel report

3. Funding directed at university-based theoretical particle physics for the purpose of increasing the number of HEP-grant-supported graduate students should be given a higher priority in the overall HEP program. Support for students and postdocs doing calculations related to upcoming experiments is particularly urgent.

DOE: Funding for theoretical physics at universities from FY 2007 to FY 2009 increased by over 10%.

NSF: no specific response.

Responses to universities subpanel report

4. University-based technical development should be funded at a level commensurate with its great importance. The investment should be adequate to provide the necessary equipment, technical and engineering support, and infrastructure.

DOE: In FY 2009, ARRA funding of $10.7M was provided to fund proposals submitted in response to a request for proposals to enhance university infrastructure.

NSF: no specific response

Responses to universities subpanel report

5. The University Grants Program should fund the development and mounting of small and mid-scale university-based experiments that are highly rated by peer review and, where appropriate, by the Scientific Assessment Groups (SAGs) and the Particle Physics Project Prioritization Panel (P5). This may require supplements to the University Grants Program.

DOE: it is in the arena of non-accelerator-based experiments that we find experiments with a much larger fraction of university participation. Experiments proposed by university groups go through the same SAGs as lab experiments. Funding is sent to the appropriate site, that is, to a university if it's leading the experiment.

NSF: http://www.nsf.gov/nsb/documents/2007/tr_report.pdf

Responses to universities subpanel report

6. A University Grants Program Committee (UGPC) should be formed to consult with University Grants Program agency managers on the issues facing the University Grants Program. The chair of this committee should be chosen cooperatively by both agencies and by the chairs of the High Energy Physics Advisory Panel (HEPAP) and the American Physical Society Division of Particles and Fields (DPF), Division of Astrophysics (DAP), and Division of Particle Beams (DPB). This chair should serve as a spokesperson for the university community.

DOE: Done. Sarah Eno, chair.

NSF: We are not clear on how this would work with these many organizations. Our initial thought is that this Committee would advise HEPAP and that agency representatives would be available for consultations.

Responses to universities subpanel report

7. The SAGs should regularize their role in reviewing projects.
   - •Each SAG should actively monitor and prioritize the experiments and R&D in its area. It should evaluate both physics goals and technical design.
   - • The SAGs should report to P5, timing their reports so that they are available to P5 when needed.
   - • The SAGs should review all experiments with expected construction costs above $5M, along with smaller ones seeking review. This includes both experiments that are affiliated with a U.S. laboratory and those that are not. Additional SAGs should be created as needed to cover all areas (taking care to avoid proliferation).

No specific response from either agency

Responses to universities subpanel report

8. HEPAP should establish mechanisms for prioritizing experiments whose cost is above $5M but below the P5 threshold. The prioritization process should take advantage of input from the SAGs and should reflect the breadth of the field.

No specific response from either agency

Responses to universities subpanel report

9. We applaud the COV process and endorse its continuation. Among the issues that future COVs should address are:

- Mechanisms for the consistent review of lab- and university-based researchers
- The competitive review of proposals, through panels or other means, within the University Grants Program
- The workload of University Grants Program staff
- Implementation of a DOE database comparable to the one used by NSF that makes institutional, funding, demographic, and programmatic information readily available

DOE: [We] will have [our] next COV review in 2010 and we will endeavor to address these issues.

NSF: We note that the COV praised the EPP program and calls out our many alliances with other programs at NSF. The major co-funding alliances are with Education/Human Resources (EHR), Office of Cyber-infrastructure (OCI), and the Office of International Science and Engineering (OISE). Quarknet, Open Science Grid and PIRE are examples.

Responses to universities subpanel report

10. As much as possible, universities should be funded through merit-based peer reviewed proposals, rather than through specific project-based funds.

DOE: no specific response

NSF: FOR ILC AWARDS WE ARE TRYING "COLLABORATIVE PROPOSALS" IN WHICH AWARDS ARE REVIEWED AND FUNDED IN THE SAME WAY AS BASE GRANTS, BUT HAVE SIGNIFICANT PROJECT DISCIPLINE. FROM THE GRANT PROPOSAL GUIDE

Responses to universities subpanel report

11. The agencies should support university technical infrastructure as part of grants, including hardware development. In addition, project managers should utilize university resources because they are economical and effective, and they should report on this optimization at major project reviews

DOE: no specific response

NSF. THERE IS THE NSF WIDE MRI PROGRAM, WE HOPE TO ESTABLISH A PHY WIDE INFRASTRUCTURE PROGRAM WHEN BUDGETS PERMIT, AND THE REST ARE FUNDED IN MERIT REVIEWED BASE GRANTS

Responses to universities subpanel report

12. The agencies should continue their efforts to ensure that the vision for LHC computing is realized. This includes working across and within agencies to ensure sufficient network and computing capacity.

No specific response from either agency

Responses to universities subpanel report

13. The agencies should support efforts to ensure that both U.S. sites and key sites abroad are equipped with remote videoconferencing systems that are reliable, robust, and readily available.

No specific response from either agency

Responses to universities subpanel report

14. The agencies should support the increased travel and subsistence costs of university researchers participating in the LHC and other overseas experiments.

DOE: no specific response

NSF: -Funded Competitive ATLAS and CMS student support program
-Funded extra travel, and travel supplements for LHC, SuperB; BES III, and Astroparticle Experiments in France, Italy
-Funded REU students to work on experiments in Europe, Russia (with OISE)

Recommendations of Universities Subpanel

15. The agencies should foster outreach by, for example, funding new positions dedicated to facilitating and coordinating university outreach efforts.

16. Additional support should be made available to enable undergraduates and high school teachers to participate in experiments offshore. In addition, support should be continued for an NSF Research Experiences for Undergraduates (REU) program at CERN, following discussion of its structure with representatives of interested university groups.

DOE: no specific response

NSF: http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf
http://www.nsf.gov/pubs/policydocs/pappguide/nsf09_1/gpg_index.jsp
Kathleen McCloud appointed Program director for Education and Interdisciplinary Research (EIR).
http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=5610&org=PHY&from=home

Our poll

One of the recommendations of the subpanel was about university technical infrastructure

11. The agencies should support university technical infrastructure as part of grants, including hardware development. In addition, project managers should utilize university resources because they are economical and effective, and they should report on this optimization at major project reviews

We decided to do a survey to learn more about the state of University technical infrastructure.

Our Survey

Dear Colleagues,

One of the recommendations of the University Grant Program sub-panel of HEPAP was to have a group of people to focus on the HEP university program that would bring to the attention of HEPAP and the agencies systematic problems in the program. The chair of HEPAP, Mel Shocket, and the agencies have therefore convened an informal working group consisting of Marina Artuso, Alice Bean, Sarah Eno (chair), Boris Kayser, Dan Marlow, and Hank Sobel. We have discussed among ourselves some issues which are of concern to us, and we would like some information from those working in high energy physics at your University, funded by either DOE or NSF, on these issues.

We were given your name as the contact person for your institution by Bill Carithers of the Particle Data Group. If you could look at our brief survey, solicit opinions from those at your institution, and send us a response by the end of June, we would appreciate it. Since we were only given one name per institution, could you please contact all those funded by NSF or DOE in the field of high energy physics (both experiment and theory). If you personally do not have the time to do this, can you forward this to somebody at your institution who does?

The summary of the results of our survey will be presented in the fall HEPAP meeting. The report will also include some demographic information from the agencies and information from the agencies on their response to the HEPAP subpanel report on Universities (http://www.er.doe.gov/hep/files/pdfs/ugpsreportfinalJuly22,2007.pdf). Of course, we will carefully protect the anonymity of our responders.

Best
Marina Artuso, Alice Bean, Sarah Eno, Boris Kayser, Dan Marlow, and Hank Sobel.

Our Survey

1) If your base grant was increased by $150,000 and you were assured that this increase would last at least 10 years, and would be adjusted for inflation, how would you spend this money?

2) For the current experimental graduate students at your institution, what fraction contributed directly to the engineering or construction of hardware? (not including computer simulations, software development, test beam analysis, algorithm development, or anything that *only* requires using a computer) Is there a marked difference in the rate for older versus younger graduate students?

3) If your group was involved in the design of hardware during 2008, did any of the work involve a member of your group working directly with an engineer or technician located at a national lab? If not, would your group be interested in doing this?

4) Has the technical infrastructure at your institution deteriorated to the point that it is causing you to miss or have to pass up projects that would contribute to the timely and cost-effective development of future experiments or upgrades to current ones, and to opportunities for ensuring that the future full-time workers in this field (our graduate students) are getting the training they will need to have the technical expertise needed to build the next generation of experiments? What is the minimal level of resources that would enable you to take advantage of these opportunities?

Survey

We received a list of PIs from PDG (Bill Carithers) on Apr 21. Unfortunately, it was quite out of date. Some of the contacts were retired or deceased. Some were no longer funded. We would also prefer one contact per grant instead of one contact per institution.

From the list of institutions we received from PDG, there were 137 institutions that may still have DOE or NSF grants. We received responses from 74% of these institutions (after some reminding).

Of the ones that did not respond, 25% were from theory-only institutes and 17% were from small colleges (Some of these may no longer be funded. It was hard to tell from their physics department's web page).

Q1

1) If your base grant was increased by $150,000 and you were assured that this increase would last at least 10 years, and would be adjusted for inflation, how would you spend this money?

Experiment grants (94 responses)
Postdocs: 50%
New grad student: 43%
Travel: 27%
Engineer: 26%
Non-computing hardware: 23%
Technician: 19%
Fully fund current grad student: 12%
Research scientist: 11%
Computing hardware: 11%
New faculty: 5%
Computing professional: 3%
Undergrads: 3%

Theory grants (18 responses)
Postdocs: 83%
Graduate students 78%
Travel: 28%
Computing: 17 %
Visitors/workshops: 11%
Undergrads: 6 %
New faculty: 6 %

Q1 representative quotes

Some quotes from the responses we received:

- "Often R&D at universities lacks the continuity and experience of a staff researcher who can oversee and coordinate the efforts of postdocs and graduate students and provide the technical oversight that is needed for the development of new hardware."
- "The support for postdoctoral fellows, and graduate students especially, in theory (and not only at our institution), has fallen to a level that it significantly compromises the productivity and vitality of the theory effort."
- "We currently have such a person but his funding has been project based, which has had significant fluctuations over the last few years. We expect to lose him to a better paying job in industry if we cannot offer some degree of reliable future funding."

Q1: Summary

In theory, strong need for postdoc/student funding. Funding for travel also high priority.

In experiment, needs are diverse.

- Many institutions could take on more students if funding were available.
- About half of the institutions would use additional money for some kind of technical infrastructure (engineering, technical support).
- Travel also important.

Q2

2) For the current experimental graduate students at your institution, what fraction contributed directly to the engineering or construction of hardware? (not including computer simulations, software development, test beam analysis, algorithm development, or anything that *only* requires using a computer) Is there a marked difference in the rate for older versus younger graduate students?

71 responses
24% said all students worked on hardware
14% said 70-100% of students worked on hardware
31% said 50-70% worked on hardware
20% said <35% of students worked on hardware

Right now, our responders indicated that neutrino and direct dark-matter detection experiments are currently providing greatest hardware experience.

Q2 representative quotes

- "It is not obvious there is a rate change for more senior and younger students (which we presume is time to completion of degrees). If anything, such timing is really related to startup or operation of the accelerators and experiments, rather than to hardware involvement."
- "On the time scale of 5-6 years, there is no measurable difference, but over 25 years I have seen a huge decrease in instrumentation opportunities for students."
- "What they do get is lots of experience monitoring, maintaining, and fixing already-existing hardware."
- "There's a marked difference because everything we do now is on a professional, industrial level."
- "All of the dark matter students have had a lot of hardware experience."

Q2 conclusions

• There is a high degree of variability in the amount of direct hardware experience students receive. The variability is influenced by the experiment and its timescale. It is also influenced by the importance the student's institution places on this experience and its technical resources. We should consider the impact this is having on our future scientific endeavors.

Q3

3) If your group was involved in the design of hardware during 2008, did any of the work involve a member of your group working directly with an engineer or technician located at a national lab? If not, would your group be interested in doing this?

- not worked with labs & not interested 11%
- worked with lab and not interested (too expensive) 5%
- n/a or blank 18%
- not worked with lab but somewhat interested 7%
- not worked with lab but very interested 12%
- worked with lab and somewhat interested 17%
- worked in a lab and interested 31%

Q3 representative quotes

- "Effective, but we need local people to act as a bridge to lab people."
- "This is the only option as university infrastructure wanes and high-tech experience is needed."
- "The labs are too expensive and too far."
- "Afraid of getting assigned to least competent lab personnel."
- "Much rather have local expertise, more cost effective."
- "Tension between accelerator and non-accelerator. Do non-accelerator get fair access?"
- "When all the technical or engineering support is located at national labs, it is difficult to involve the graduate students in the technical aspects of a project"
- "However, having a mechanical engineer of our own has allowed us independence and to take on large detector-building tasks that we wouldn't have done if we had to go looking for engineering."
- "Any design and development in the modern physics experiments need serious support from the professional engineers and the national laboratories seems to be the natural resources for that. Unfortunately, these resources are already programmed by the funding agencies and not easy available for the new developments to the university groups. There is no way to find an engineering support for the development of the conceptual design and initial cost estimate of a new experiment until the project is approved."

Q3 conclusions

- The technical resources at the labs are a valuable resource for the University community, but many expressed concern regarding their ability to gain access to this resource.
- Many comments that technical work done this way is expensive. Hard to reconcile with declining technical facilities at Universities.
- Another frequent comment was that the hardware development opportunities offered at universities are unique and should be preserved.

Q4

4) Has the technical infrastructure at your institution deteriorated to the point that it is causing you to miss or have to pass up projects that would contribute to the timely and cost-effective development of future experiments or upgrades to current ones, and to opportunities for ensuring that the future full-time workers in this field (our graduate students) are getting the training they will need to have the technical expertise needed to build the next generation of experiments? What is the minimal level of resources that would enable you to take advantage of these opportunities?

We received many detailed comments on this question, showing that it resonates with the community. Some typical comments are given here. A larger sample of comments (but still only a fraction of the total received) are in the backup.

Q4 representative quotes

On Decline/Need

- "It is, in particular, very difficult to compete in the early phases of a project with European institutions that have ready access to engineers and technicians (as we had, once upon a time)."
- "We've received infrastructure grants that have allowed us to stay in the game."

On Complexity

- "What is more of a problem is that the experimental software systems are now so complicated that is is getting harder to carve out enough time for students to get hardware experience."
- "National Labs with numerous ongoing and overlapping projects have a natural advantage in this regard and can maintain the deep resources needed to be able to start up projects when needed."

On University Support

- "For what it's worth, an equal if not greater disaster is the near-collapse of university support for engineering work and for some subsidies of machine and electronics shops."

Q4 representative quotes on resiliency

On Funding Mechanism/Cycles

- "The future of our engineering capability is now at the mercy of Project managers and their decisions, while subject to oversight, are not subject to peer review."
- "US ATLAS commitment to Phase 1 upgrade R&D"

On Resiliency

- "In some sense there is no minimum. We will develop alternate strategies."
- "The situation has deteriorated somewhat but not to the point where it has stopped us from contributing."
- "Well to be frank we probably never "pass up" a project for this reason, if we are interested in the science itself."

Q4 summary

• Most groups commented that they lack infrastructure. Most groups reported a decline relative to previous years, although a few stated that they had never had much in the way of technical infrastructure. A number commented on declining support by their institution in this area.

• Most groups indicated that this lack of infrastructure adversely impacted their ability to participate in hardware projects. Few said that this was so serious as to prevent them from participating in a particular experiment. Rather, it was the nature of their participation that was affected. A number of respondents were concerned that reduced participation in hardware projects adversely impacted the training that their students were receiving.

• Some expressed concern over funding process (need for consistent message on LHC upgrade, worries about project managers instead of peer review controlling funding.)

• Some commented on complexity of modern experiments.

Summary

While a number of universities are finding creative ways to maintain technical capacities and training capabilities, others are struggling. The sources are complex, including the complexity of modern experiments, their international nature, decreased support for their home institution and decreased agency support. This can not fail to have an impact on our ability to build the next generation of experiments.

Conclusions

I always have trouble with what goes here…

Backup

Q4: representative quotes on decline/need

- "We have done our best to survive with limited resources, derived from a variety of sources."
- "The flat funding while NIH doubled will lead to the demolition of 1/2 of HEP's lab space next month."
- "The shifting of technical resources away from the Universities is a real loss to the field."
- "It is, in particular, very difficult to compete in the early phases of a project with European institutions that have ready access to engineers and technicians (as we had, once upon a time)."
- "Restoration of our previous capabilities would require the hiring of a machinist and technician (both of which we used to have)."
- "I don't personally detect any deterioration in technical infrastructure. However, my sense is that our ability to take on major new activities is primarily limited by the time of senior personnel."
- "The technical infrastructure at our institution has never been particularly good."
- "We've received infrastructure grants that have allowed us to stay in the game."

Q4: representative quotes on complexity

- "We find that the lack of computing support causes the physicists to spend an inappropriate amount of time on software management."
- "What is more of a problem is that the experimental software systems are now so complicated that is is getting harder to carve out enough time for students to get hardware experience."
- "National Labs with numerous ongoing and overlapping projects have a natural advantage in this regard and can maintain the deep resources needed to be able to start up projects when needed."

Q4 representative quotes on university support

- "So severe that our physics department no longer supports a simple machine shop or a small electronics shop."
- "It has resulted partly from the lack of funding from agency sources and also from university staff cutbacks."
- "Our experimental groups have one full time technician at their disposal. This person is partly supported by grants and partly by the university. Maintaining this person is critical to our ability to conduct meaningful hardware projects for our new experiments."
- "In addition, in the past, we have had the support of several university supported technical lines."
- "For what it's worth, an equal if not greater disaster is the near-collapse of university support for engineering work and for some subsidies of machine and electronics shops."
- "The universities themselves should think about providing university-based resources."
- " Due to the foresight of our group leadership and support from our college and the University, we are currently substantially improving our electronics capabilities."

Q4 representative quotes on funding mechanisms/ cycle

- "The future of our engineering capability is now at the mercy of Project managers and their decisions, while subject to oversight, are not subject to peer review."
- "US ATLAS commitment to Phase 1 upgrade R&D"