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DEPARTMENT OF PHYSICS AND ASTRONOMY

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June 30, 2014

Dr. Patricia M. Dehmer
Acting Director, Office of Science
Department of Energy
Washington, DC 20585

Dear Dr. Dehmer:

This letter is in response to your charge letter to the Chairs of the Office of Science Federal Advisory Committees, dated February 19, 2014, requesting assessment of workforce development needs in Office of Science research disciplines. Please find on the following pages an assessment of such needs for the Office of High Energy Physics. Needs in three disciplines were identified: accelerator science, instrumentation, and large-scale computing.

The assessment was performed by a HEPAP subcommittee chaired by Ritchie Patterson (Cornell) consisting of HEPAP members Ilan Ben-Zvi (BNL), Tao Han (Pittsburgh), Patty McBride (FNAL), Ian Shipsey (Purdue/Oxford), and me (*ex officio*). The subcommittee reported its findings and recommendations at the meeting of HEPAP held May 22-23, 2014. It subsequently circulated a draft of its report to HEPAP for comment. The final report was approved by HEPAP via email.

The subcommittee and I will be happy to provide any further explanation that would be helpful.

Respectfully yours,

Andrew J. Lankford
Professor of Physics
Chair, High Energy Physics Advisory Panel

cc: Dr. James Siegrist, Associate Director, Office of High Energy Physics
Dr. Glen Crawford, Division Director, Research and Technology Division, HEP

HEP Workforce Development Needs

1 Introduction

This subcommittee was charged to identify disciplines in which lack of workforce development threatens the OHEP mission, and to consider strategies for addressing the shortfalls. Indeed, for one field in particular, the training shortage is severe: this is in the field of accelerator physics, where training falls far short of need. Two other fields suffer from workforce shortages: in instrumentation, graduate education is declining, threatening US capabilities in the long term, and in large-scale computing, intense demand by industry frustrates the retention of experts at the national labs.

The community contributed to the subcommittee's process at several junctures, beginning with a discussion at the March, 2014 HEPAP meeting, which identified the three disciplines described here. The subcommittee solicited further community input through an online survey circulated to the membership of the APS Division of Particles and Fields and Division of Physics of Beams. Questions explored the availability of training, sought suggestions for increasing graduate student and post-doc participation in disciplines with a training deficit, and asked for additional disciplines that should be considered. While the number of respondents was not large, valuable feedback was received, and quotations from the survey responses appear in the text boxes scattered throughout this report. Data on workforce shortages were generously provided by BNL and FNAL. Finally, there was a discussion of the recommendations at the HEPAP meeting in May 2014.

2 Accelerator science

2.1 Accelerator science and the HEP mission

The goal of accelerator science and technology within the OHEP is to enable new accelerator capabilities that advance particle physics research. Progress and innovation in accelerator science and technology has been the main driver of particle physics from its inception. The remarkable exponential growth of the center-of-mass energy delivered by particle accelerators was achieved primarily through innovation.

Today's accelerators are miles in length and exceptionally complex. Subsystems include particle sources, superconducting accelerating cavities, sensitive instrumentation, sophisticated feedback systems, advanced vacuum technology, and optics carefully optimized to achieve the tiniest spot sizes and greatest luminosity. Accelerator scientists advance the state of the art, and design, build and operate these extraordinary devices.

Given the scale of the effort, the number of accelerator scientists produced in the U.S. is tiny: just 10 to 12 PhD's each year[1]. The number is even more sobering because accelerator scientists are also in high demand for x-ray sources and other sectors, including medicine, national security, and industries such as food safety, environment and semiconductor fabrication. The problem is likely to grow: demand for accelerator scientists is increasing at an estimated rate of 10% per year[2].

2.2 Workforce deficit in accelerator science

The shortage of accelerator scientists is apparent at the national labs. FNAL reports that job openings in aspects of accelerator science typically attract two to three applicants, and most of these are foreign. At BNL, 16 searches for accelerator physicists in the last three years turned up fewer than ten qualified applicants. As at FNAL, most of these were foreign, from Europe, Russia, India, China and elsewhere. Historically, the demand for accelerator scientists has been filled by particle physicists who transitioned to accelerator science in order to further their research; however, this pool has diminished as accelerators have moved off campus, and more recently, overseas.

Detailed studies of accelerator workforce needs have been done in Europe by Test Infrastructure and Accelerator Research Area (TIARA). Europe awards approximately 100 doctoral degrees in accelerator science annually, nearly ten times that of the U.S., yet TIARA surveys find that 60% of institutes and 30% of companies in Europe report that they have trouble recruiting accelerator physicists. Furthermore, the demand is growing at a rate of 10% per year[3].

> *We are chronically short of people with a strong, formal background in accelerator physics.*
>
> *-Survey respondent*

The HEPAP Subpanel on the Assessment of Advanced Accelerator Research and Development [4] of 2005-2006 remarked, "A significant problem, which limits the availability of an accelerator science education at the universities, is that accelerator science and technology is not yet broadly recognized as an essential, vital, and exciting frontier research field. In most

[1] William Barletta, private communication.

[2] Report of the "Accelerators for America's Future" symposium, October 2009, available at http://www.acceleratorsamerica.org .

[3] Kircher, F. *et al.*, Education and Training Survey Report, TIARA-REP-WP5-2012-006.

[4] Report of the HEPAP Subpanel on the Assessment of Advanced Accelerator Research and Development, August 21, 2006, http://science.energy.gov/~/media/hep/pdf/files/pdfs/AA_RD_Subpanel_Report_final_amended_aug_21.pdf .

universities it is not considered as an academic subject worthy of faculty lines." The conclusions of this report are still valid.

2.3 Current training in accelerator science

Modern accelerator science is an exciting discipline that is well-suited to academia. It advances by discovering the phenomena at play in beams – non-neutral plasmas with 10's of billions of particles in a tiny volume. As these phenomena are understood, the frontier advances, and new beam phenomena come into view. At each step, accelerator capabilities increase, enabling beams with higher energy, high power and lower emittance. The connections between accelerator science and other disciplines are strong: the physics of microwave superconductivity, which is a key technology for beam acceleration, is deeply connected to modern research in condensed matter physics, the interior of vacuum chambers, photocathodes, and superconducting cavities challenge Materials by Design, collective effects may echo those of plasmas, and studies of beam dynamics draw on and enhance nonlinear mathematics.

Nevertheless, accelerator science is poorly represented in academic curricula, and only a handful of universities offer formal graduate training in accelerator science and technology. In all, U.S. universities award 10 to 12 accelerator-science PhD's each year, about one-tenth the number awarded in Europe. Only six universities in the US offer two or more regular courses in accelerator physics and technology and there are another 14 with some accelerator education activities[5]. Only five have more than two faculty members[6]. By contrast, Europe has 11 institutions that offer 100 contact hours or more of instruction in accelerator science.

> *We are very lacking in university faculty in accelerator physics.*
>
> *-Survey respondent*

The US Particle Accelerator School (USPAS), supported jointly by the NSF and DOE plays an important role in training new accelerator scientists, and major US universities rely on USPAS as an essential partner in education. USPAS offers both introductory courses, and advanced courses in topics such as Magnet Systems, RF Technology, and Plasma & Collective Effects. The courses are highly structured, with homework and exams, and as a result, some universities offer academic credit for successful completion. USPAS allows both universities and national laboratories to enhance and complete the education of young accelerator scientists.

Most U.S. PhD's (70%) have been educated at one of the handful of universities with an on-campus research accelerator. These include (in alphabetical order) Cornell,

[5] W. Barletta, Accelerator Education in America, presentation to the 2012 Accelerator Task Force.

[6] W. Barletta, Educating Accelerator Scientists & Technologists for Tomorrow – A View from the U.S., presentation to the Institute of Physics, March, 2013.

University of Maryland, Michigan State University, and UCLA, and, until recently, Indiana University and the University of Wisconsin. Most past closures of campus accelerator have had fatal consequences for the graduate program, and several of these programs are now at risk.

University groups can access two test accelerators at the national labs. The BNL Accelerator Test Facility, which operates as a user facility that does not charge its users, has enabled the training of an average 1.5 PhD's per year over the last 20 years. With the recently approved upgrade, the ATF user capacity will be greatly increased, and a hands-on graduate accelerator course will be added. SLAC's FACET hosts beam-driven plasma wakefield studies. ASTA at FNAL will be a third lab test accelerator providing university access. The entry of additional universities into the field is hampered by an outdated view of accelerator science as "technical development", rather than as the exciting interdisciplinary field that it has become.

The National Labs also train graduate students and post-docs directly on their complement of production and research accelerators. The Joint University-Fermilab doctoral program in accelerator physics trains students under the direction of laboratory staff, graduating roughly 1.5 students each year. Students from several universities have trained at LBNL's BELLA, though no formal program is in place, and each year BNL and SLAC train a few graduate students from SUNY Stony Brook and Stanford respectively. Laboratory programs are hampered by the lack of visibility of accelerator science at the universities – graduate students are simply unaware of accelerator science as a research opportunity, even when programs are in place that would allow them to pursue it. This problem is mitigated when the university and lab are tightly connected, including joint appointments, as at SLAC/Stanford and BNL/Stony Brook.

Recently, the NSF started a program in Accelerator Science to fund individual investigators. This is important recognition of Accelerator Science as a research discipline and may attract new university faculty to the field. Access to accelerators at the national labs will be important if these new groups are to succeed.

A successful postdoctoral training program is the Toohig Fellowship, which supports promising young postdoctoral scientists and engineers in areas of Accelerator Physics and Technology. The Toohig Fellowships were created as part of the LHC Accelerator Research Program (LARP), and support two years of research, half of which is spent at CERN on LHC commissioning and development, with an optional third year. Typically, two new fellows are selected each year, and 11 have been awarded over the lifetime of the program. The recipients have been very successful in obtaining staff positions at international and national labs.

The U.S. will address national needs and keep pace with international accelerator advances only with a concerted effort to increase the accelerator workforce. The greatest need is to recognize accelerator science as an exciting research discipline that is visible and attractive to students. Effective university graduate programs cannot continue to bite the dust; we must increase the visibility of the field among university faculty and their students so that they seek out the programs at the labs; and we must harness lab-university partnerships to build new programs that capitalize on the strengths of each. Accelerator science, with its fascinating and diverse inquiry and enormous impact, has the potential to be recognized and valued throughout the scientific community. The task before us is to establish a framework of support and partnership in which this promise can be realized.

2.4 Accelerator science recommendations

Recognize accelerator science as a distinct academic discipline, and increase support for university investigators. Increasing the number of university departments offering doctoral degrees in Accelerator Science is the surest way to increase the pipeline of trained scientists. Now largely sequestered at national labs, accelerator science is nearly invisible to starting graduate students, and even though opportunities for studying it are available, for example, through the FNAL-university partnership, relatively few pursue it. The most lasting way to attract graduate students to accelerator science is by establishing additional university research groups. We therefore specifically recommend that SC address this issue through increased research grants to support high quality accelerator science at universities, independent of application. Accelerator science is an exciting discipline in its own right that already fits comfortably into some academic departments, and with additional research support, more would enter the field. The national laboratories should look for mechanisms to enable accelerator scientists to teach or mentor graduate students when a university offers them that opportunity. The exposure of undergraduates to accelerator science is an additional benefit of establishing accelerator science in the universities.

Support test accelerators, and enhance university access to those at national labs. Accelerator access is essential for graduate education in accelerator science, since operation provides exposure to diverse accelerator systems and the complexities of beam dynamics. "Driving" an accelerator can be as important for accelerator students as flying is for new pilots. While training on production laboratory accelerators is possible, their focus on accumulating user days or inverse femtobarns discourages student experimentation. Test accelerators at universities and national laboratories therefore have an important role, and we must preserve those that exist, and increase university access to test accelerators at national laboratories.

Support and recognize graduate student research in accelerator science and facilitate the transition of post-docs from other disciplines into accelerator science. Graduate student support, including both tuition and stipend, can enable participation in research, and if the support is generous and awarded selectively, it also increases the visibility of the discipline as well as the quality of the students. Selection of students should be based on accomplishment, promise and the quality of their proposed research, and should be done by a committee drawn from both national laboratories and universities. The advisor can be a university professor or laboratory staff member. Post-doc programs for accelerator science PhD's are unnecessary since fresh PhD's easily get jobs. However, it would be very beneficial to provide special support for PhD's in other disciplines, including particle physics, who want to make the transition from that discipline to accelerator science. In fact, the insights of other disciplines could be beneficial for cross-fertilization of the science. Such "transfer" postdoctoral awards should last two years, after which awardees will qualify for laboratory staff positions.

Sustain support for the U.S. Particle Accelerator School. The U.S. Particle Accelerator School offers essential courses in accelerator science, including both introductory courses and advanced topics, and is a vital resource for both graduate students and laboratory staff, with roughly 300 students participating annually. USPAS funding should be sustained, keeping up with inflation, and expanded to keep pace with enrollment.

> *Increased funding for USPAS seems to me to be an excellent use of money.*
> *-Survey respondent*

3 Instrumentation for High Energy Physics

3.1 Instrumentation and the HEP mission

The data harvested from particle physics experiments at the Energy, Intensity and Cosmic Frontiers comes from instrumentation, in the form of large-scale detectors. From Galileo's telescope to the LHC, innovation in instrumentation is central to fundamental discoveries. Progress in understanding the laws which govern the most fundamental building blocks of nature has been achieved largely through technological advances in instrumentation that have made increasingly sophisticated experiments and analysis of the data from these experiments possible. The detectors developed by HEP find application in other disciplines, for example photon science.

State of the art custom detector systems developed and used by HEP are not available commercially. For this reason instrumentation training and research in instrumentation are crucial to the mission of HEP.

3.2 Workforce training deficit in instrumentation

Evidence for a workforce training deficit in HEP is provided by a broad poll of the community conducted by the ICFA Instrumentation Panel in February 2010 [7,8]. The poll found that:

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[7] Adam Para, Reflections on Understanding of Detectors and Instrumentation, talk at the Detectors R&D Workshop, Fermilab, October 2010

- A significant fraction of experimentalists are lacking good understanding of their own detectors.

- The principal mode of education in the instrumentation area is 'on the job training' and instruction from peers. A particularly disturbing trend is the diminishing role of university-based instrumentation training among the youngest scientists.

An additional informal poll of various US universities[9] indicates that the area of detectors and instrumentation is poorly covered by the curricula offered in the physics departments at the majority of the schools participating, although there are examples of interdisciplinary courses offered at several schools that partially compensate. The poll conducted by our subpanel confirmed this.

There are at least four reasons why the deficit in training in instrumentation exists.

1) Due to the very long timescales of most HEP experiments, opportunities to participate in the design, prototyping and building of detectors are becoming rarer. In consequence the level of instrumentation experience and expertise among young experimentalists in HEP has declined.

2) In the universities there has been a significant and sustained decline in support of technical infrastructure, which is a needed to provide training in instrumentation.

3) In the national laboratories funds available for instrumentation training and R&D and the associated infrastructure are very limited.

4) Scientific excellence in detectors and instrumentation is given little recognition by the academic community. The perceived scientific value of skills in data analysis is greatly favored over even major scientific advances in detectors and instrumentation. This discourages young scientists from pursing a technical career in experimental high-energy physics, while simultaneously sending a negative signal to students.

In Europe a HEP Ph.D. is often awarded for instrumentation research. This is the exception in the U.S. At most U.S. universities, authority to approve or reject work

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[8] Ariella Cattai and Adam Para, Preliminary results from the survey on the necessity of a Detector and Instrumentation School, April 2010.

[9] Informal Survey of US Universities on the education in Detectors and Instrumentation conducted by the DPF Instrumentation Taskforce, July 2011 http://www.physics.purdue.edu/dpf_instrumentation_taskforce/ .

towards the thesis lies in the hands of the thesis committee, typically a group of faculty within the field of particle physics, or a closely allied field. Without the possibility of a Ph.D. for instrumentation the limited participation of students in leading-edge instrumentation R&D, will remain low. This will cause the US to fall behind in our impact on, and contribution to, developments in detectors to the detriment of both the national and international particle physics communities.

3.3 Current training in instrumentation

Instrumentation schools, such as those initiated by the ICFA Instrumentation Panel, offer introductory detector and instrumentation courses and often include practical laboratory components, thereby providing valuable introductory training. In particular the Excellence in Detectors and Instrumentation Technology (EDIT) school is organized and held at HEP laboratories taking advantage of the advanced equipment and beam available there. Attendance at EDIT has ranged from 50 to 100 students. Another venue for education in instrumentation is provided at IEEE Nuclear Science Symposia, where several technical courses are offered, usually before the Symposium itself. Typically these are one-day courses and about 150 students attend each course.

While schools play an important role, they cannot provide the thorough training necessary to design, construct or operate modern experiments. This can be achieved, in part, with traditional semester-long courses focusing on particle detectors. Today, university particle physics courses often teach detector basics, but courses devoted to particle detectors are not common.

To address a lack of infrastructure at universities the Physics Research Equipment Pool (PREP) at FNAL provides equipment and some services to university researchers, and is a valuable resource, but modern items are unavailable and there is little access to services such as engineering or technical support.

3.4 Instrumentation training recommendations

To address the instrumentation training deficit we make three interconnected recommendations*:*

Support and recognize graduate student training and research in instrumentation. Awards that provide tuition and stipend support to graduate students to train and conduct research in instrumentation will attract the attention of bright, ambitious students. The existence of the awards will also encourage university professors to carry out research and increase training in this area. This support should be awarded competitively, based on past student achievement and promise for the future.

> *Reason will not convince US physics departments -- money will. Provide a fellowship for physics thesis work on instrumentation.*
>
> *-Survey respondent*

Make targeted resources at the national labs, including equipment, test beams, services and expertise, available to members of the university community for detector research and instrumentation training. Graduate training is limited, in part, by lack of access to the equipment and technical support required to develop instrumentation. The national laboratories could make these resources available to university groups, using a proposal review process to ensure the quality of the R&D. It is important that this support be made available not only for work related to lab projects, but also for generic long-term instrumentation development.

Continue to support international and national instrumentation schools offering introductory courses and support new courses in advanced topics. The model for support of these schools may follow the USPAS support model. International schools, such as EDIT, offer important introductory courses that are widely attended, and support for EDIT should continue. The national laboratories may provide the critical hands-on training on advanced detector systems and test beams. To complement the introductory schools a series of semester-long advanced courses on single topics will position students for forefront research. If the advanced courses are structured like university courses, with homework and exams, universities could offer credit for successful completion. Consortia of universities and national labs could offer these advanced courses, or USPAS might do so.

4 Large-scale computing and “big data”

4.1 Large-scale computing and “big data” and the HEP mission

Advances in particle physics often require complex numerical calculations, detailed simulations and the detailed analysis of large volumes of data. Particle physicists work with computing scientists and engineers to adapt state of the art computing techniques in order to address current scientific questions. For this partnership to succeed, the physicists must be well trained in computational science and software techniques and understand more than just the fundamentals of how to access large data stores and use modern computer processors.

The analysis of data from particle physics experiments remains a computing challenge. The storage, processing and analysis of the 10’s of PBytes of data collected each year at the Large Hadron Collider at CERN have led to the development of a worldwide data GRID. The required network and global computing infrastructure took nearly a decade of planning with the US DOE laboratories among the leaders in the development and deployment. The LHC is expected to operate for at least another decade and the challenges are expected to grow as computer technologies evolve. Other HEP programs such as LSST will offer similar challenges of large data sets. Simulations and mathematical modeling play a key role in particle physics. The theory and accelerator modeling communities develop complex algorithms that are adapted to run on the most advanced hardware available. These communities and, in particular, the Lattice QCD community, have made effective use of high performance computing facilities.

4.2 Workforce deficit in large-scale computing and "big data"

The trend towards many-core, multi-core and GPU chips will have a significant impact on software development for both experiment and theory. These developments are further complicated by the need to deal with multiple levels of parallelism. The development of the physics codes will have to be more closely tied to computing and software developments. Software and algorithm developers will need to be experts to work in this increasingly dynamic, evolving and innovative technology landscape. Traditionally many HEP scientists have worked on the development of physics codes. Many of these scientists will require additional training to keep up with the trends in large-scale computing and big data.

The workforce for large-scale computing and big data in HEP is made up of computing professionals and PhD scientists and domain experts with expert level computing skills. The shortage of workforce trained in these areas has been documented at both FNAL and BNL. FNAL reports that searches for application software developers turn up relatively few applicants, typically 10 to 15, and that most of these are foreign. The turnover rate for computing professionals at Fermilab has averaged 7.4% per year over the last 5 years. An FNAL summary lists this discipline as having the greatest need after problem areas of accelerator science. Likewise, BNL reports that 18 searches in the last three years in the area of Controls/Scientific Computing attracted fewer than ten qualified applicants. Only beamline science had more low-yield searches

It remains critical that we continue to attract and retain scientists and computing professionals with expert level computing skills to HEP. Some areas where experts are needed include: physics algorithm and method development and validation; scientific computing framework; workflow data management and distributed system development; advanced computing hardware and software architecture and engineering; and production system deployment, integration, and support. In addition, there is a need for scientists with the expertise to develop codes to simulate the physics of particle detectors. A specific area of need is in theoretical physics to develop Monte Carlo generators for experimental simulations in the Standard Model and beyond, and to perform precision theoretical calculations to advance our understanding. The experts in these areas are in high demand, particularly in locations with a thriving high tech economy. The stimulating challenges of the scientific environment have provided sufficient incentive for many of software and computing experts, but the turnover rates in these areas remain high.

4.3 Current training in large-scale computing and "big data"

The recent report[10] from the Snowmass Summer Study recognized the importance of training of scientists in advanced computing and software and identified the need for additional software training at the entry and advanced levels for students and postdocs. It recommends developing a certification in software engineering, design and languages, and encourages the physics community to consider requiring this certification for a degree in high energy physics. It notes that some universities have created computational science courses in conjunction with their research programs. Existing programs that were called out in the Snowmass report include Indiana's PhD minor in Scientific Computing[11] and the Princeton University graduate computational certificate[12].

Introductory training for research scientists is often done through short introductory computing classes at the national laboratories or online. More extended training is available through regular forums or workshops and updated web materials to follow-up on initial training. This training is reinforced and augmented through close collaboration with experienced software developers. Exercised-based workbooks, hands-on training sessions and interactive online software documentation are used to enhance the training programs in larger scientific collaborations.

The CERN School of Computing (CSC) is a successful example of training for graduate students, post-docs and other entry-level HEP computing specialists. The CERN School of Computing hosts about 60 students from CERN Member States and other countries each year for 2 weeks of lectures and hands-on training. There is an exam at the end and the students can receive academic credit if they successfully complete the exam. The course is oversubscribed each year and there has not been a comparable school offered in North America. Recently, a one-week long thematic school (tCSC) has been added to provide advanced academic training for scientists and computing professionals interested in developing applications to solve complex scientific computing problems.

4.4 Computing recommendations

Support national schools and workshops offering advanced training in Computing. The critical need in Computing is for students and postdocs with advanced training in Computing, of the kind that schools and workshops can provide. The CERN School of Computing, in particular, provides excellent training, in a structured format that echoes a university course. Yet the school is

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[10] D. Brown *et al.*, Snowmass Computing Frontier: Software Development, Staffing and Training, arXiv:1311.2567 [physics.comp-ph].

[11] http://denali.physics.indiana.edu/~sg/CSE/list_of_cse_programs.pdf

[12] http://www.princeton.edu/researchcomputing/education/graduate-certificate-CIS

oversubscribed, and many students are turned away. Workshops can also be effective, especially when they provide online follow-up to initial training. A third vehicle is hands-on training sessions offered by large collaborations, such as ATLAS and CMS, supplemented with interactive online software documentation. Efforts like these should be sustained and new ones added.

June 2014

Appendix A – Subcommittee Membership

Ilan Ben-Zvi, Brookhaven National Laboratory
Tao Han, University of Pittsburgh
Patricia McBride, Fermi National Accelerator Laboratory
Andrew Lankford, UC Irvine, HEPAP chair, ex officio
J. Ritchie Patterson, Cornell University (chair)
Ian Shipsey, Oxford University

Appendix B – Charge Letter

Department of Energy
Office of Science
Washington, DC 20585

February 19, 2014

To: Chairs of the Office of Science Federal Advisory Committees:
Professor Roscoe C. Giles, ASCAC
Professor John C. Hemminger, BESAC
Professor Gary Stacey, BERAC
Professor Mark Koepke, FESAC
Professor Andrew J. Lankford, HEPAP
Dr. Donald Geesaman, NSAC

From: Patricia M. Dehmer Patricia M. Dehmer
Acting Director, Office of Science

Charge: Assessment of workforce development needs in Office of Science research disciplines

The Office of Science research programs have a long history of training graduate students and postdocs in disciplines important to our mission needs as part of sponsored research activities at universities and DOE national laboratories. In addition, the Office of Workforce Development for Teachers and Scientists supports undergraduate internships, graduate thesis research, and visiting faculty programs at the DOE national laboratories.

We are asking the assistance of each of the Office of Science Federal Advisory Committees to help us identify disciplines in which significantly greater emphasis in workforce training at the graduate student or postdoc levels is necessary to address gaps in current and future Office of Science mission needs. As part of your expert assessment, please consider:

- Disciplines not well represented in academic curricula;
- Disciplines in high demand, nationally and/or internationally, resulting in difficulties in recruitment and retention at U.S. universities and at the DOE national laboratories;
- Disciplines identified in the previous two bullets for which the DOE national laboratories may play a role in providing needed workforce development; and
- Specific recommendations for programs at the graduate student or postdoc levels that can address discipline-specific workforce development needs.

Please submit to me, no later than June 30, 2014, a letter report describing your findings and recommendations. These results will be used to help guide future activities and investments.

If you would like to discuss the charge, please do not hesitate to contact me (patricia.dehmer@science.doe.gov). Thank you very much for your help with this important task.

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