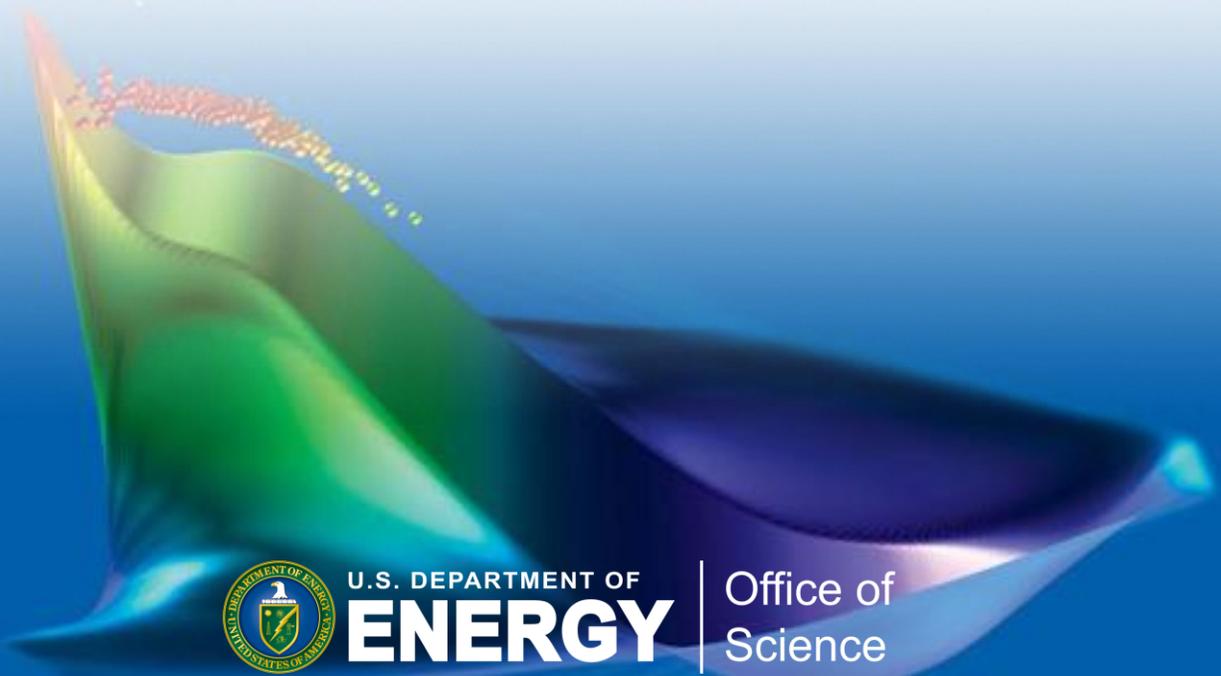


Report of the HEPAP Subcommittee for

# Review of the United States Particle Accelerator School

Short Report (without Appendices F–J)

May 2015



U.S. DEPARTMENT OF  
**ENERGY**

Office of  
Science

*Cover Image: Simulation of a plasma accelerator. Credit: C. Huang, Los Alamos National Laboratory*

## Summary

Noting that the United States Particle Accelerator School (USPAS) “plays a key role in training the next generation of researchers and practitioners who are skilled in harnessing the research potential of particle accelerator technology to advance science and engineering across a broad spectrum of disciplines and applications,” the Department of Energy (DOE) Office of Science charged the High Energy Physics Advisory Panel (HEPAP) to perform a retrospective review to examine and assess, for DOE only, the effectiveness and cumulative impact of USPAS in the context of workforce development and training, as well as to assess the overall quality and breadth of the USPAS program. For this purpose, the Chair of HEPAP assembled a subcommittee to conduct the review and assessment of USPAS. This report summarizes the conclusions of the Subcommittee.

Applications of accelerators are ubiquitous. Accelerators are used in medicine and in industry, as well as for discovery science. Members of the accelerator workforce are found in the public and private sectors. Accelerator scientists produce, accelerate, and manipulate charged particle beams, and develop advanced technologies necessary for these tasks. The realization of accelerators also requires specialized technical skills and engineering in a diverse array of disciplines and technologies. This matrix of theoretical, technical, and practical skills remains essential for operations and maintenance throughout an accelerator’s lifetime. Accelerator science and technology is a multidisciplinary field, and the accelerator workforce is diverse, consisting of scientists and engineers, technologist and technicians, and operations staff. The accelerator staff at the DOE national laboratories numbers nearly three thousand, and the Subcommittee estimates that over half of this workforce requires constant training and retraining in accelerator science or technology.

USPAS very effectively delivers both training and workforce development. USPAS’s effectiveness derives from an organizational model responsive to the workforce development and training needs of the DOE laboratories that simultaneously addresses key needs for workforce development and training. The central feature of the USPAS organizational model is a Consortium of eight DOE laboratories and two universities, this set of institutions, along with the Office of Science, founded USPAS. The Consortium has input to the governance and management of USPAS through representation on a Board of Governors. The Board provides an active mechanism for laboratory input to the definition and evolution of the USPAS. The Consortium member institutions are the

principal source of USPAS instructors, giving rise to further engagement in the USPAS program. The member institutions also contribute to the operating costs of USPAS program sessions, which along with providing instructors, embodies their shared commitment.

The USPAS program model involves two short program sessions per year with curricula that delivers intense training to three basic groups: practicing scientists and technical staff, who attend USPAS as a form of continuing education that will improve their skills and capabilities; scientists transitioning to accelerator science and technology from careers in other fields of science and engineering; and university students preparing for careers in accelerator science. Training for the second and third groups develops new and future members of the accelerator workforce. The structure of the sessions, curricula offering both general courses on accelerator science at various levels and courses of a more specialized technical or topical nature, along with the intense nature, small class size, and high quality instruction, effectively packs into a two-week session as much instruction as is accomplished in a university semester. Each of the two USPAS sessions per year has approximately one hundred and fifty enrollees. Since its first academic session in 1987, USPAS has had more than four thousand distinct individuals enroll. USPAS sessions move geographically around the U.S., hosted at universities and often co-located with a DOE national laboratory, which gives the field of accelerator science increased visibility.

The impact of USPAS on workforce development and training is such that the laboratory members of the Consortium uniformly commend the value of USPAS, and all attest that USPAS is vital for development and training of their laboratory workforce. The cumulative impact of USPAS is also manifest in the number of former USPAS participants who are engaged in accelerator science in the U.S. (more than 2,300), and in the number who now play leadership roles at the laboratories (more than 250) and in the private sector.

The USPAS program is of high quality and remarkable breadth. USPAS offers training in an impressively wide variety of subjects in accelerator physics and technology, which addresses the training needs of the three groups defined above. The selection of subjects stretches from general accelerator science, with these courses ranging from the undergraduate to advanced graduate student level, to special topics in accelerator science or technology, to relevant topics in project management and safety. The training that USPAS delivers is of high quality, as supported by a number of objective metrics

and subjective measures. Input from the laboratories indicates that, and describes how, USPAS addresses their workforce development and training needs. Trainees attest to the program quality in evaluations provided at the time of their attendance and, in letters to the Subcommittee, many trainees attest years later to the impact that USPAS had on their careers.

The nature of the field demands that members of its workforce have a broad general overview of accelerator science and technology as well as specialized, advanced training in beam physics and accelerator technology. The rapid evolution of accelerator technology and its applications creates a near-constant need for training in new accelerator subjects, even for personnel already in the workforce. Well-trained members of the accelerator workforce are highly sought after in both the public and private sectors, to the point that it is often difficult to fill positions at the DOE laboratories. Moreover, there is a worldwide competition for well-trained accelerator scientists and engineers, who are frequently attracted from U.S. labs to non-U.S. accelerator projects.

Opportunities at universities for training to enter the discipline of accelerator science and technology are limited, and few avenues exist for existing workforce to access additional training. University programs are few, and each existing program has small numbers of students and typically only one or two faculty members. University programs produce about 15 to 20 Ph.D. graduates per year and are not capable of addressing the annual need for approximately forty new Ph.D.-qualified members of the DOE laboratory workforce. Consequently, university programs in accelerator science rely on USPAS to deliver courses to fill in the gaps in their own curricula. Nearly all U.S. graduate students studying accelerator science attend USPAS, typically taking two or more courses.

USPAS has developed an effective mechanism for providing workforce development and training in accelerator science and technology with a number of essential, and sometimes unique, capabilities and features. The essential capability of USPAS is serving the combined needs of the three principal audiences: the existing workforce, those seeking transition into the workforce, and students. The two major curricular features, general courses on accelerator science and a wide variety of specialized technical and topical courses, provide essential capabilities for transmitting and maintaining accelerator science and technology knowledge. The close association between USPAS and the DOE laboratories is absolutely essential to the development of the accelerator workforce and has led to very effective delivery of information. The close alignment and re-

relationship between the laboratories and universities is another essential and unique feature; this alignment provides three essential capabilities: university instruction, a workforce pipeline, and visibility of the discipline.

The management structure of USPAS, with a Board of Governors, Curriculum Advisory Committee, and Director and staff is appropriate. The structure and management team are effective. The USPAS program is cost effective. Two features of the management structure seem to be essential. First, the Board being a governing body rather than an advisory group ensures close association between the DOE laboratories and USPAS. Second, hosting USPAS management at a stable facility committed to accelerators provides economies of scale in operations and minimizes budgetary requirements.

USPAS has a good record regarding diversity and has made efforts to increase the percentages of women engaged as instructors and as enrollees. Both percentages have grown, and the percentage of woman enrollees is now in line with national trends in the field. USPAS has also appointed a Minority Outreach Coordinator. Laboratories have noted the positive impact of USPAS on the diversity of their workforces.

In summary, USPAS effectively and efficiently serves the critical needs for accelerator workforce development and training in the U.S., particularly for the national laboratories. The need for accelerator workforce development and training in the U.S. will persist, and is expected to grow with time as application of accelerators expands. The effectiveness of USPAS is very closely connected to addressing training and workforce development; addressing the needs of its three audiences in a single program; the close association of USPAS, the DOE laboratories, and universities; and the support of the Office of Science.

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\* Appendices F–J are included in the full report, available online at:  
<http://science.energy.gov/hep/hepap/reports/>

## 1 Introduction

Accelerator scientists, engineers, and technicians design, build, and operate particle accelerators. These machines are used to produce, accelerate, and manipulate charged particle beams. Accelerators are composed of numerous subsystems, the realization of which pushes the boundaries of technology, at least at the forefront of the field. Producing an accelerator subsystem, such as high-field magnets or high-gradient radio-frequency accelerating cavities, requires understanding of science and engineering in a diverse array of disciplines. These range from classical subjects such as electromagnetism and special relativity to specialized areas such as vacuum systems, cryogenic systems, material science, and high-power microwave technology. Considering the accelerator as a whole, controlling large numbers of charged particles requires a detailed understanding of how they interact with the magnetic and electric fields that they encounter, with their surroundings, and with each other through collective effects. Many of these effects are highly non-linear and require the development of novel techniques. This matrix of theoretical, technical, and practical skills remains essential for operations and maintenance throughout the lifetime of the accelerator.

Applications of accelerators are ubiquitous. For instance, accelerators are used to diagnose and treat tumors, for communications, and for ion implantation in the semiconductor industry. In all, roughly thirty thousand accelerators are now in use worldwide [1]. Accelerator technology is a rapidly expanding area for industry, with a market increasing at a rate of ten percent per year [2]. The most sophisticated accelerators are research accelerators: x-ray light sources, spallation sources, and particle colliders. Arguably among the most powerful scientific tools available, these accelerators in the U.S. advance the research of eighteen thousand scientists each year. While no hard data are available regarding the employment of Ph.D. accelerator physicists in the U.S., approximately half appear to go into industry, about one-third work at the national laboratories, and the remainder join university faculties.

Building these powerful tools requires a highly-trained workforce, with expertise in a wide range of topics, many of which are advancing rapidly. The need for training falls into three categories, which correspond to three workforce populations:

- Professional development of mid-career accelerator scientists and engineers.
- Training of scientists new to accelerator science.
- Courses for undergraduates and graduate students in accelerator science.

**Professional development of mid-career accelerator scientists and engineers:** Even seasoned accelerator physicists and engineers benefit from mid-career training, either to update their knowledge or to become familiar with a new area. Training enables them to harness the latest techniques or move into new areas to meet evolving accelerator demands.

**Training of scientists new to accelerator science:** Approximately one third of accelerator scientists begin as a Ph.D. high-energy or nuclear physicist, or in some similar scientific discipline, and switch into accelerator science early in their careers. Some pitch in to help when the accelerator program serving their research requires assistance, have their professional interests captured, and never look back; others turn to accelerator science as an attractive career path. Those with a Bachelor's degree in physics or engineering, but no prior exposure to accelerator science, and who need a broad introduction to the field are another important category of trainees.

**Courses for undergraduates and graduate students in accelerator science:** Roughly 15 to 20 doctoral degrees are awarded each year in the U.S. for studies in accelerator science, from one of the dozen or so academic programs in the field. While new programs are being initiated at a few universities and the National Science Foundation (NSF) has recently launched an Accelerator Science program, it is too soon to see an increase in the number of students. There exist impediments to increasing the number or size of university programs. Impediments include the relatively small pool of federal research funding available, limited access to hands-on training with operating accelerators, and the prejudices of some university physics departments that accelerator science is too much an applied science or is mere technology. Even the largest academic programs offer few courses in accelerator science, and many of the specialized topics required by accelerators are not offered at all. Radiofrequency (RF) Technology is but one, albeit, an important example.

The United States Particle Accelerator School (USPAS), or an equivalent program with the same essential capabilities, is vital for developing and training the Nation's accelerator workforce by targeting the needs of these three groups.

The need for classroom training outside a university setting for students and early career accelerator scientists was recognized by the accelerator community as early as 1976, when a series of lecture-style courses were held over ten days at the first session of the International School of Particle Accelerators in Erice, Italy. The first session of USPAS was held in 1981 by the Department of Energy (DOE) laboratories in collabora-

tion with the accelerator science community at the initiative of DOE's Dr. Melvyn Month, who had attended the Erice school. Since then, USPAS has continuously held one and usually two sessions annually serving approximately 100–150 participants per session. USPAS began with symposium-style lecture courses, similar to those now used by the CERN Accelerator School, which was started in 1983. USPAS evolved to its present format of academic-style sessions in 1987. Statistical data presented in this report are for the period since 1987.

## 2 Overview of USPAS

### 2.1 Purpose

USPAS plays a key role in training the accelerator science and technology workforce for U.S. government, university, medical, and industrial needs. The need is largely driven by demands at the DOE national laboratories, which together employ an accelerator workforce of roughly three thousand, including scientists, engineers, technicians, and operators, with an expected hiring rate of about one hundred fifty skilled employees per year.<sup>1</sup> The importance of the role USPAS has serving the DOE national laboratories is recognized in the review charge letter and by the Office of Science in memoranda authorizing their support of USPAS from 1992, 2001, and 2010, see [Appendix E](#).

### 2.2 Session Description

USPAS holds two sessions per year, one in January and one in June. The sessions move geographically around the U.S., hosted by a university with a program in accelerator science, accelerator technology, or experimental particle physics, and often co-located with a DOE national laboratory. Each session lasts for two weeks, with both two-week classes and one-week classes. Typically, a choice of four or five two-week courses are offered, and a choice of four or five one-week courses are offered each week. Trainees can enroll either for one two-week course, for one one-week course, or for two consecutive one-week courses. The two-week courses constitute core curriculum offerings plus topical courses, and the one-week courses constitute additional topical curriculum offerings. The broad overview classes in the core curriculum meet degree requirements for graduate students attending USPAS and are attractive to non-degree seeking current employees of the national laboratories who want to learn more about accelerators generally (*e.g.*, accelerator operators). The courses include purely theoretical classes, courses that are a mix of theory and simple practical measurements, and hands-on training at accelerator facilities at a nearby laboratory. Holding the session near a na-

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<sup>1</sup> A 2014 GAO report (available online at: <http://www.gao.gov/assets/670/660449.pdf>) sets the DOE-wide workforce attrition rate at 7%. To be conservative we set the laboratory attrition rate at 5%. This number is also consistent with the totaled estimated need reported by DOE laboratories in reply to committee inquiries.

tional laboratory facilitates participation by employees of that laboratory and access to equipment. The courses offered by USPAS are further described in [Section 4.2](#).

In recent years about one hundred fifty trainees attend each session (with a maximum of about one hundred seventy with the current session model), with slightly more than half being current university students. Most of the university students are Ph.D. students in accelerator science and technology programs.

University credits are available for eligible trainees who take the final examination, with three semester credit hours awarded for a two-week course and half of that for a one-week course. The credits are awarded by the hosting university and by Indiana University but may be transferred, up to a limit, to the university in which the student is enrolled. Direct host-university credit for USPAS courses is attractive to students of the accelerator program at that host university.

An M.S. degree program through Indiana University is supported by USPAS. Typical students involved with the M.S. degree program would be B.S.-level accelerator operators from national laboratories and B.S.-level employees from private companies. Members of both groups substantially benefit from the degree as an incentive and as professional recognition of having achieved a higher-level degree.

[Figure 1](#) shows the number of times each USPAS course has been offered since 1987, and [Figure 2](#) plots the cumulative attendance in these courses. The cumulative attendance largely follows the frequency that courses are being offered, indicating that the demand for course content is being met.

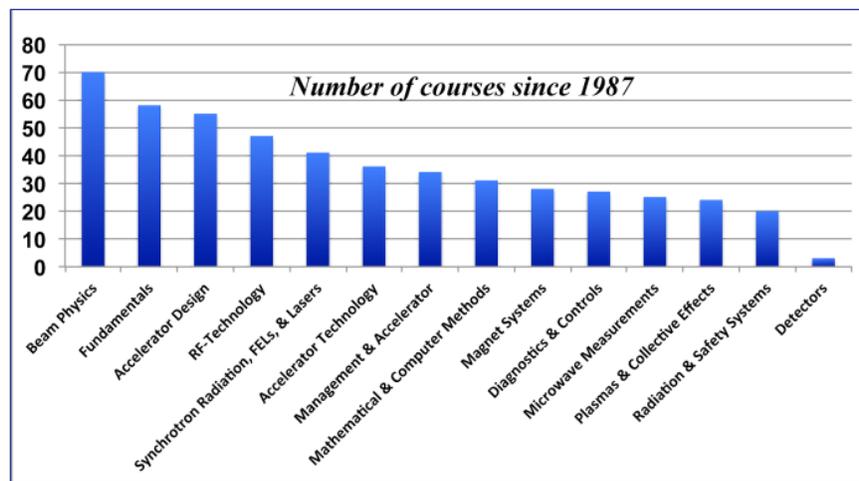


Figure 1: Cumulative USPAS course offerings since 1987. [3]

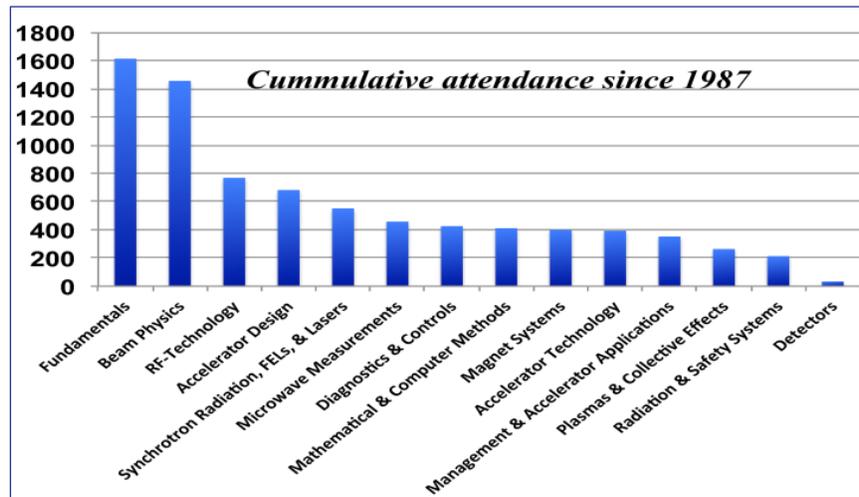


Figure 2: Cumulative USPAS attendance by course since 1987. [3]

## 2.3 Organization

The USPAS staff, which is funded by the Office of High Energy Physics (HEP) in the Office of Science (SC), consists of a Director, an administrator, and an administrative support person (3 FTEs total). The office staff is hosted by Fermi National Accelerator Laboratory (Fermilab). The Consortium that contributes to USPAS session operating costs comprises: seven SC laboratories, including Fermilab, Argonne National Laboratory (ANL), Brookhaven National Laboratory (BNL), Thomas Jefferson National Accelerator Facility (TJNAF), Lawrence Berkeley National Laboratory (LBNL), Oak Ridge National Laboratory (ORNL), and SLAC National Laboratory; one National Nuclear Security Administration (NNSA) laboratory, Los Alamos National Laboratory (LANL); and two NSF-funded universities with accelerator laboratories, Cornell University and Michigan State University (MSU).

One senior manager from each of the ten Consortium member organizations, appointed by the director of that organization, serves on the ten-member USPAS Board of Governors (BOG). BOG members are typically responsible for, or involved with, their organization's workforce planning and are knowledgeable about accelerator workforce needs. The BOG reviews course offerings and planning of future sessions. The Director, with discussions with the BOG, determines the locations of future sessions. The locations are picked to balance the ability of Consortium members' employees to participate and to help develop accelerator programs at universities. The BOG is responsible for hiring and firing of the USPAS Director. The BOG also annually reviews the performance of USPAS Director, who supplies an annual report to the BOG.

A Curriculum Advisory Committee (CAC), with members mostly mapped from the Consortium members, helps outline the USPAS curriculum and session syllabi, and suggests course instructors. CAC members are selected by the Director, with the advice of the BOG. The CAC nominally meets once a year.

The authorization and guidelines for Office of Science funding for USPAS arises from memoranda in 1992, 2001, and 2010 from the directors of the Offices of High Energy Physics, Nuclear Physics, Basic Energy Science, and in 2010 from Fusion Energy Sciences (see [Appendix E](#)).

## 2.4 Financial Overview

HEP funds the USPAS office (the three FTEs) through a contract with Fermilab as the host laboratory at a level of ~\$615,000 per year in direct costs. The ten Consortium members each supply \$30,000 per year (\$300,000 total) to support session costs. USPAS is directly funded with SC, NNSA, and NSF funds through the Consortium, and indirectly through tuition by SC, NNSA, NSF, other government, and industrial funds.

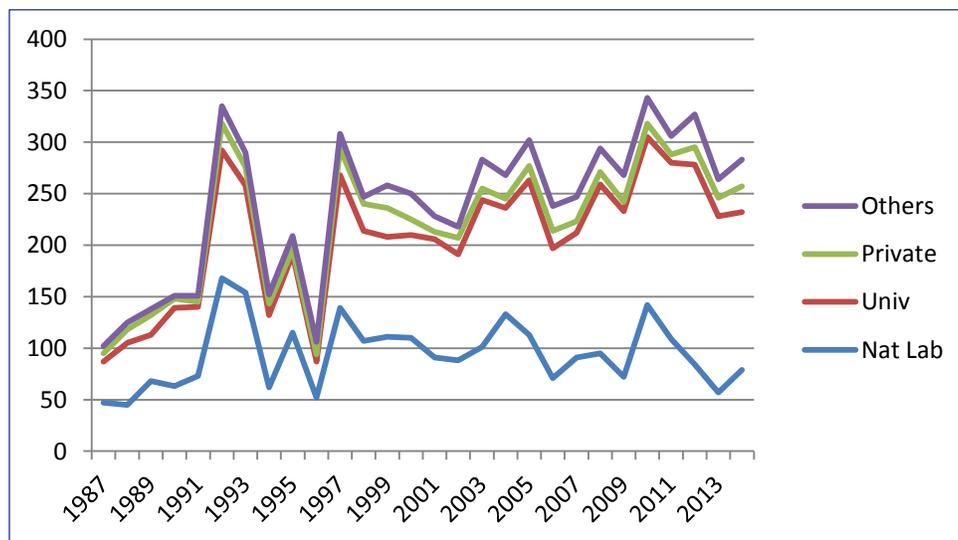
About half of the trainees per session receive scholarships (including all students from the host university), and about half pay the full registration fee (currently ~\$1,400), including all trainees employed by national laboratories. With two sessions per year, in rough numbers, each session is supported by \$150,000 from the Consortium and about \$100,000 from registration fees, for about \$250,000 total per session. The cost per trainee per session is between \$1,500 and \$2,000.

In addition to the direct contributions, Consortium members support USPAS with in-kind contributions by sending members of their staff to teach at USPAS sessions. Instructors also come from organizations that are non-Consortium members, with the same effective in-kind contributions. To date, approximately three hundred national laboratory employees have been primary instructors at the fifty USPAS sessions since 1987, with about fifty of those instructors coming from NNSA laboratories. Over time, a larger number of courses have been offered at USPAS sessions, with a higher fraction of national laboratory instructors (*e.g.*, two of the four classes in the first session, in 1987, were taught by national laboratory employees, whereas nine of the twelve classes in the most recent 2015W session were.) Laboratory staff teach two-thirds of the courses, university faculty teach approximately one-quarter of the courses, and the instructors of the remainder of the courses are drawn from elsewhere.

## 2.5 Trainee Demographics

Approximately six percent of USPAS trainees are from industry. Of the rest, somewhat more than half are university students and somewhat less than half are employees of DOE national laboratories. USPAS moves session by session around the country to facilitate attendance by trainees and instructors from the co-host laboratory and by students of the host university.

**Figure 3** plots the distribution of trainees from industry, laboratories, and universities by year. The blue curve is the attendance of national laboratory employees; the red line additionally includes students from universities; the green line additionally includes U.S. industrial participation; and the violet line is the total attendance. Note that the large increase in attendance in 1992 corresponds to the first offering of two sessions per year and the drop in 1996 occurred because there was only one session that year. The recent drop in fractional attendance from DOE laboratories is attributed to the designation of USPAS attendance as conference travel and thus being subject to conference travel restrictions.



**Figure 3: USPAS trainees per year.** The curves are cumulative, e.g. the “University” curve represents the sum of university and national laboratory trainees, and so on. Data provided by USPAS.

Over the past fifteen years, the percentage of enrollees who travel from overseas to attend a USPAS session has been around twenty percent, which is very similar to the percentage of enrollees in the CERN Accelerator School (CAS) from outside Europe. Approximately 10% of USPAS instructors are from outside the U.S. USPAS and CAS together organize occasional sessions (every three years or so) under the banner of Joint

International Accelerator Schools. At these sessions, instructors and trainees are drawn roughly equally from the two regions.

## 3 Workforce Development and Training

### 3.1 The U.S. Accelerator Workforce

The accelerator workforce at the DOE national laboratories numbers nearly three thousand, as documented by input received from the national laboratories.<sup>2</sup> It is highly diverse, with widely ranging areas of expertise and backgrounds. Specialties range from microwave technology to beam dynamics to klystrons and high voltage supplies. Disciplines represented by this workforce include physics, many forms of engineering, and material science, among many others. Because accelerator science and technology is a transition field spanning both physics and engineering, it is often hard to describe even a high-level accelerator worker as either a physicist or engineer; indeed, accelerator science and technology Ph.D.'s are awarded by both university physics and electrical engineering departments (*e.g.*, UCLA, Colorado State, and Maryland). Additionally, many members of this workforce who entered as a Ph.D.-level nuclear or particle physicist do what would be largely recognized as engineering and many who entered as Ph.D.-level engineers do what would be largely recognized as physics. In rough numbers, the DOE national laboratory accelerator workforce can be considered to consist of about half scientists and engineers (with significantly more than half of this group recognized as doing engineering), with the balance mostly technologists and technicians. Accelerator operators constitute about 10% of the workforce.

There is a constant need for training in new accelerator subject areas even for personnel already in the workforce because of the rapid evolution of accelerator technology and its applications, and the significant movement of personnel within the workforce. Additionally, the Subcommittee estimates that approximately one hundred and fifty new individuals regularly enter the accelerator workforce at the DOE laboratories each year with approximately half of these being accelerator scientists and engineers. New accelerator construction projects create additional growth spurts in the population. The European TIARA study (documents can be found at <http://www.eu-tiara.eu>) deter-

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<sup>2</sup> The Subcommittee is not aware of census data that definitively establishes the overall size and demographics of the U.S. accelerator workforce. Populations by role (*e.g.* scientist, research engineer, engineer, technician, operator), by training (*e.g.* accelerator science, other science, engineering, other field), by degree-level, and by gender and ethnicity would have been useful to this review; however, we believe that improved quantitative understanding would not have changed the conclusions of this report.

mined that the private sector adds an additional twenty-five percent to the overall accelerator workforce, and estimated twenty percent growth in the workforce over the next five years. The Subcommittee estimates that these percentages would also characterize the U.S. accelerator workforce, which is similar in size to Europe (3,000 at the national laboratories in the U.S. vs. 3,600 at the research institutes in Europe), yielding a total U.S. accelerator workforce of approximately three thousand eight hundred, including national laboratories, universities, and industry, with approximately four percent-per-year growth. Overall, the Subcommittee estimates that over half of the workforce requires training in accelerator science or technology in order to perform their jobs, and for most of these personnel, USPAS is the primary formal source of this training.

### 3.2 Pathways into the Accelerator Scientist Workforce

Accelerator scientists and engineers can either enter the U.S. accelerator workforce as graduates of a university program in accelerator science or enter the workforce with degrees in particle physics, nuclear physics, plasma physics, mathematics, or other technical fields. A third important source of accelerator scientists for the DOE laboratories has been accelerator scientists trained abroad. Typically, accelerator scientists enter the workforce with Ph.D. degrees and engineers enter with B.S., M.S., or Ph.D. degrees. Accelerator operators are often hired with B.S. degrees in physics and technicians are often without degree.

Many of the avenues available to bring engineers, operators, and technicians to the accelerator workforce do not extend to accelerator scientists. While being an important source of new accelerator scientists, U.S. university programs in accelerator science alone are insufficient to satisfy the nation's need for new accelerator scientists.<sup>3</sup> They do not produce enough graduates to satisfy the demand; moreover, generally speaking, their programs are not suitable to be used by individuals to retrain in order to shift careers to accelerator science. With graduation rates of about fifteen to twenty Ph.D. degrees per year, university programs fill roughly one quarter of the annual need for ac-

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<sup>3</sup> Here we include Ph.D. engineers who are engaged in accelerator science R&D in the accelerator scientist category. We focus attention on workforce development and training of accelerator scientists, because recruitment to fill engineering positions and positions as technicians and operators is not as difficult as for accelerator scientists.

celerator scientists. The TIARA study reported a similar shortfall in Europe of graduates with respect to need. Note that the majority of university graduate programs in accelerator science rely upon the existence of a program such as USPAS to supplement their own university offerings. Without such a program, not only would there not be a formal mechanism to retrain scientists and engineers entering the accelerator field, the shortfall coming from universities would likely be even greater.

The challenge of worldwide competition renders recruitment from other nations an unreliable source of personnel for the U.S. Trained accelerator scientists are in demand in many of the world's nations, and other nations suffer the same shortage of accelerator scientists that the U.S. suffers. Worldwide competition can even be a drain, rather than a source. Highly-trained accelerator scientists tend to be mobile with respect to job location, and can be attracted away from their positions in U.S. laboratories to interesting projects outside the U.S. For instance, recently U.S. scientists have been attracted to the European Spallation Source. As medical and industrial applications of accelerators broaden, the U.S. private sector is an increasingly important source of competition for the U.S. laboratories with respect to recruitment of trained accelerator staff.

Migration into accelerator science from positions from other technical fields is a critical source for the accelerator workforce. As stated earlier, approximately one-third of accelerator scientists have switched into the field. As discussed later, training through a program such as USPAS facilitates migration, and is in many cases critical to enabling migration.

Based on the reported difficulty of recruiting to fill accelerator science positions at the DOE laboratories, even combined, the above three sources of accelerator scientists are insufficient to meet the annual needs of the laboratories. With roughly one-quarter of accelerator scientists coming as graduates of Ph.D. programs and roughly one-third transitioning to accelerator science from another field, there is a deficit to overcome of roughly forty percent of the approximately forty new Ph.D. accelerator scientists needed per year. Without relying fully on recruitment from outside the U.S., training opportunities in accelerator science must be fostered in order to further develop the pathways into the workforce of accelerator scientists from graduate programs and from other fields.

### 3.3 Effectiveness and Cumulative Impact of USPAS

The program offered by the USPAS addresses the training and development needs of the U.S. accelerator workforce in five primary ways:

1. Complements and supplements university programs in accelerator science, thus increasing the number of, and improving the quality of, new accelerator scientists entering the field from universities.
2. Facilitates transition to the fields of accelerator science or accelerator technology from other fields, such as particle, nuclear, astro-, quantum, and plasma physics.
3. Provides re-training and continued training opportunities for existing scientific and technical staff in advanced and specialized topic areas.
4. Provides basic training in accelerator science and technology for operators of accelerator facilities.
5. Offers an opportunity for accelerator staff to further refine their knowledge and skills through being an instructor.

The following subsections outline how USPAS impacts the workforce development and training needs of each of a number of types of institutions.

#### 3.3.1 DOE Office of Science Laboratories

Over the 27-year history of USPAS academic-style courses, staff members of the national laboratories have enrolled in USPAS courses two thousand six hundred times. **Figure 4** shows the cumulative attendance from each national laboratory.

As discussed earlier, the trends in attendance over time are given in **Figure 3**. Attendance from the national laboratories continues at a high level, with roughly one hundred national laboratory employees attending USPAS per year. Training provided by USPAS benefits the DOE Office of Science laboratories in all five ways outlined above.

USPAS technical and topical courses are essential for re-training and continued training of laboratory scientific and technical staff, and are available nowhere else. As TJNAF writes, “[the technical and topical courses] are highly useful in assuring that our staff has access to state-of-the art ideas and accelerator science,” and as BNL says, “Such

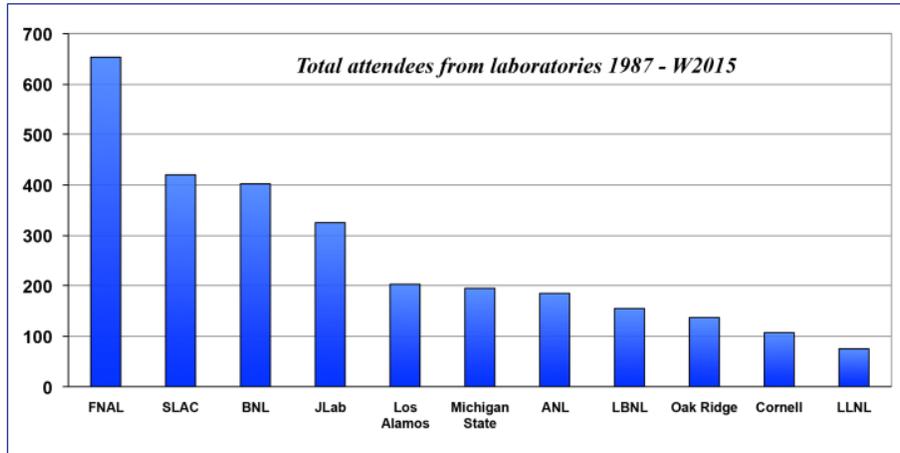


Figure 4: USPAS laboratory attendance. Data provided by USPAS.

topics are not taught anywhere else but are absolutely needed for the development and operation of particle accelerators.”<sup>4</sup> USPAS technical and topical courses also enable laboratory staff to respond to changing demands. The construction of LCLS-II, for example, is triggering a wave of need at the laboratories for expertise in superconducting RF acceleration and in cryogenic engineering. LBNL writes that USPAS courses offer “the latest knowledge in the field.” TJNAF reports that “more senior scientists and engineers will attend these courses in order to rapidly obtain information on forefront topics.” Managers, project administrators, and safety teams also enroll in USPAS courses directed at their needs.

Many USPAS participants from the national laboratories are new to accelerator science. ANL writes about the impact of USPAS on this group, “Without USPAS, Argonne employees would have no access to world class training in accelerator physics, radio-frequency power system engineering, beam diagnostic system engineering, vacuum systems, insertion devices, and x-ray beamline design and engineering.” An important large staff group new to accelerator science is recently hired operators, who typically

<sup>4</sup> The Subcommittee solicited input from the national laboratories that participate in the USPAS Consortium, from the largest university programs, from the private sector companies sourcing the largest numbers of attendees, from the American Physical Society Division of Physics of Beams (DPB), from the USPAS Board of Governors (BOG), and from a number of past attendees chosen at random. Letters from national laboratories can be found in [Appendix G](#), letters from universities in [Appendix H](#), a letter from the DPB in [Appendix I](#), and a letter from the BOG in [Appendix J](#). Quotations are from the letters received in response to the Subcommittee’s requests.

have a B.S. degree in physics but no prior knowledge of accelerators. The laboratories rely on the USPAS Fundamentals intensive courses to give this group basic training in accelerator science and technology. For instance, the Operations Group at Fermilab currently has a staff of twenty five, and fourteen have attended a USPAS course. These figures are typical; the number is limited by how many can be spared to attend. As one lab writes, USPAS is a “rite of passage.”

Another group of USPAS participants from the national laboratories that is new to accelerator science consists of physicists transitioning from other fields. LANL explains, “USPAS provides fundamental accelerator physics training for early-career LANL staff that are transitioning into accelerator science from another field, helping to fill a nationwide hiring gap due to the limited number of U.S. university programs offering courses in accelerator science and technology.” Emphasizing how important USPAS training is to workforce development, ORNL makes a similar remark, “USPAS is an essential part of workforce development and training for ORNL staff that support accelerator science and technology, of which only a very small fraction have degrees in accelerator science and technology.” Staff transitioning from other fields rely on USPAS technical and topical courses to become effective, and frequently enroll in the core graduate-level accelerator physics course. As stated by BNL, “New members of the staff in both operations and engineering are generally not trained in accelerator science and technology but this knowledge is critically needed. USPAS is our main venue to provide this knowledge, in addition to on-the-job training.” The short one- to two-week format of USPAS sessions enables this training to occur without major interruption to work schedules.

USPAS offers an M.S. degree program through Indiana University. This degree is sometimes valuable to trainees from the laboratories who do not have advanced degrees. According to Fermilab, this degree program also serves as an incentive, “In the present formulation, the Indiana University/USPAS Master’s Degree in Beam Physics and Technology is an attractive element of USPAS for a good number of Fermilab’s participants. . . . The degree outcome was a key motivator for the full participation.”

The laboratories benefit from graduate students who enroll in USPAS. Graduate student contributions to research at the laboratories is enhanced by the training that they receive from USPAS courses in which they enroll as part of their doctoral program. Moreover, many of these students will go on to work at one of the national laboratories after graduation. The laboratories have commented on the role of USPAS in the univer-

sity student pipeline into their accelerator workforce; for instance, ANL reported, “Argonne also depends on USPAS to assure a robust talent pipeline of future scientific staff.” An estimated 30% of accelerator science and technology Ph.D. graduates are employed by national laboratories, with about 50% in industry and 20% in academia.

USPAS also benefits the laboratories indirectly, by making undergraduates aware of accelerator science as a potential career path. Through advertising, undergraduates at the host universities near sites of USPAS sessions learn about the opportunity to take USPAS courses and earn course credit, and some of these students go on to pursue accelerator science as a career, a path that is otherwise nearly invisible. This contact with undergraduates increases the pipeline of students into the field, and helps meet the needs of the national laboratories. The Lee Teng Internship Program for undergraduates run by Fermilab and ANL in conjunction with USPAS plays a similar role. In this program, undergraduates do research internships at one of the laboratories and take USPAS courses as part of their program. Additional internship or research experiences for undergraduate programs would be beneficial to the supply of future accelerator scientists.

The majority of USPAS instructors are from the national laboratories. As mentioned above, being an instructor at USPAS proves to be a valuable experience for laboratory staff members. They benefit from consolidating and refining their knowledge of subject areas, which leads TJNAF to remark, “Therefore, we regard teaching a USPAS course as a valuable staff development activity for the instructors too.” LANL goes on to say, “USPAS also allows participation by junior staff as assistants to the more senior expert instructors. This enables the development of these early- and mid-career staff as instructors and increases their level of expertise.” Instructors also benefit from contact with USPAS trainees, who they frequently later recruit.

The need for accelerator training for laboratory staff development will continue in the future. Each year, the labs hire about one hundred and fifty new accelerator staff members to fill openings due to retirements and departures, and the demands of future accelerators may require hiring at even greater rates. Just as they do today, the newly hired staff will need accelerator training. Mid-career training in specialty topics will also continue to be essential. Accelerator science is a dynamic field, with a forefront that is constantly moving, and access to state-of-the-art training at USPAS will keep laboratory capabilities at the frontier.

### 3.3.2 Other Public Sector

The major non-SC public sector stakeholder and beneficiary of USPAS is the National Nuclear Safety Administration. Of the NNSA laboratories, LANL sends the most employees both as trainees (approximately two hundred total since 1987) and instructors (about thirty total). Additionally, LLNL has sent employees as trainees (approximately eighty total) and instructors (about twenty total). LANL is a member of the USPAS Consortium.

Correspondence from senior LANL management, identified the benefit to LANL of all five of the workforce development roles outlined in [Section 3.3](#). Through USPAS, LANL trains three to five accelerator operators per year and two to three scientists and engineers. USPAS addresses both real and anticipated attrition due to retirement and upcoming additional workforce needs (up to fifty near term for the MaRIE Injector Test Stand and up to fifty to one hundred more for the MaRIE XFEL).

### 3.3.3 Private Sector

**Figure 5** shows the historical percentage of trainees from the private sector (*i.e.*, U.S. industries). The running average is about 6%.

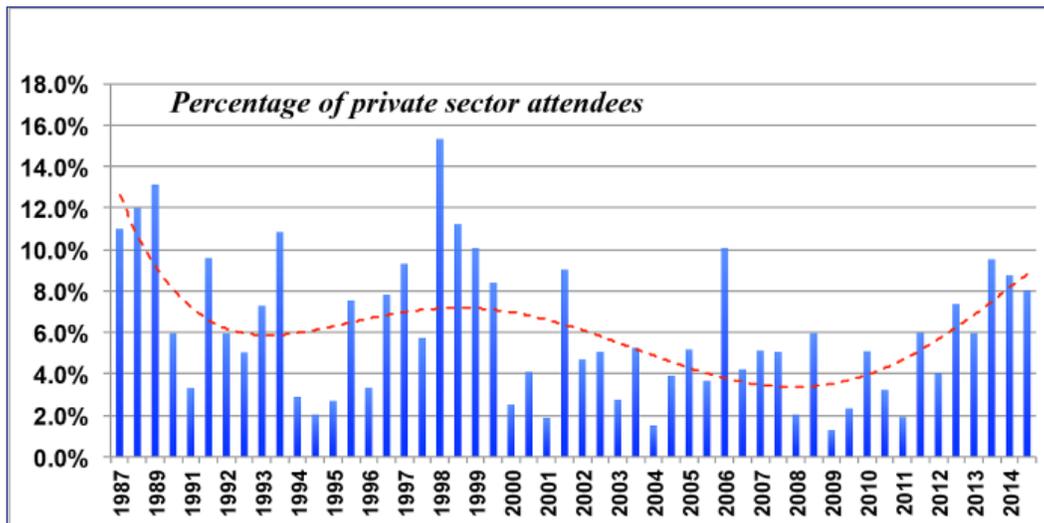


Figure 5: Percentage of USPAS trainees from industry. [3]

**Figure 6** shows the level of historical participation from the companies with the largest overall attendance.

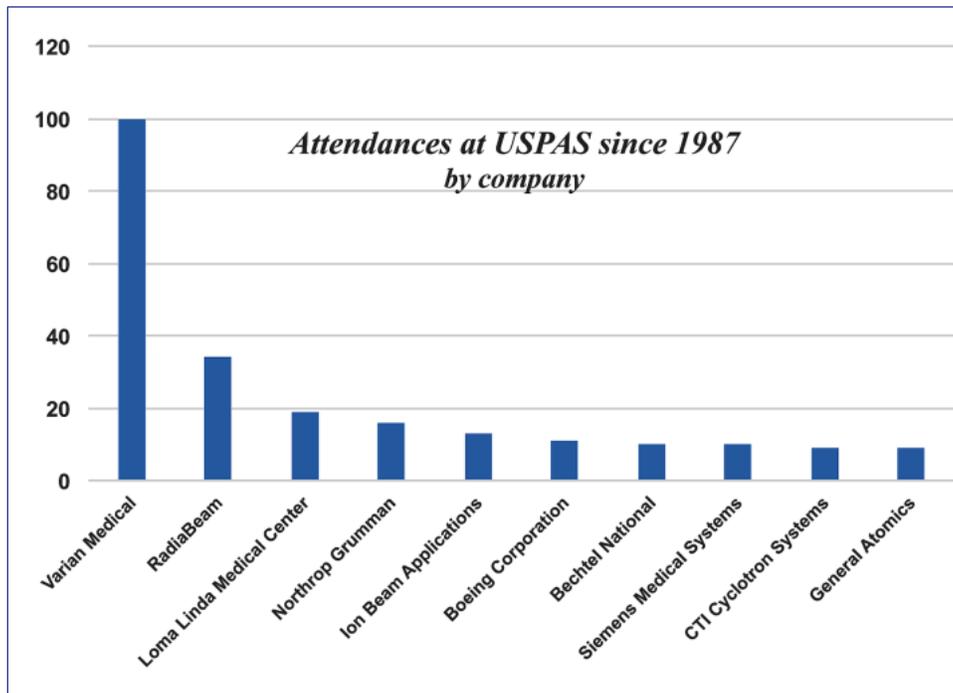


Figure 6: Number of USPAS trainees by company. [3]

The main categories of industrial involvement in USPAS are (with rough percentages of the total industrial involvement):

1. *Medical accelerators:* Varian Medical and previously Siemens build medical linacs, and CTI Cyclotron Systems and Ion Beam Applications build medical cyclotrons. This category corresponds to ~60% of total industrial trainees.
2. *Accelerator components:* RadiaBeam builds accelerator components. (~10% of total industrial trainees)
3. *Training for operating accelerators:* Loma Linda University Medical Center installed a synchrotron for proton therapy in 1990. (~10% of total industrial trainees averaged over time)
4. *Urgent programmatic need for expertise:* Northrop Grumman, Boeing, and General Atomics attendance was likely in short spurts driven by programmatic needs (~20% of total industrial trainees averaged over time)

Much of the industrial attendance is focused on training in traditional RF engineering, which is important to a number of commercial products and which is an area in which USPAS offers arguably the Nation's only remaining full curriculum.

The Subcommittee received a strongly supportive letter from the Chief Technology Officer of RadiaBeam, which states, “USPAS presents a unique and critical opportunity for our scientists and engineers to be exposed to new concepts and to master important techniques. These unique skills are immediately taken back to the company and applied to their work.” Correspondence from the manager at Varian responsible for microwave and accelerator physics and engineering speaks to the training value to his employees, particularly noting the USPAS M.S. program, “I think USPAS offers a unique and rare opportunity for continuing education in the accelerator field and has contributed directly to the strengthening of my group’s technical understanding in our technology.”

At least three former USPAS trainees have started their own accelerator technology companies (*i.e.*, Niowave, Cyclotronics, and D-Pace), and all partially attribute their ability to do so to USPAS. These companies range from a couple of part-time employees to having tens of millions of dollars in annual income. Both Niowave and RadiaBeam support USPAS by providing scholarships. Surprisingly, and in contrast to RadiaBeam, Niowave does not regularly send employees to USPAS for workforce training. The review committee did not receive enough quantitative information from these companies to comment on the impact of the USPAS on their recruitment and staffing needs.

### 3.3.4 Universities

The university community considers USPAS an essential and high quality component of student education in accelerator science and technology. Cornell University states that “USPAS . . . fills an essential need in preparing our students for research, and it provides opportunities for networking that have proven beneficial for many research projects and for many young careers.” Old Dominion University attests, “USPAS has had a clear impact on our ability to offer a high-quality graduate program in accelerator science.” With respect to quality, the letter from Colorado State University characterized both the instructors and coursework as “world class.”

University students have enrolled in USPAS courses over three thousand times since its inception. Participation in USPAS by students enrolled in the largest university graduate programs in accelerator science is shown in [Figure 7](#). At any given time, only about a half dozen programs have more than two faculty in accelerator science, and even these graduate programs tend to be small, usually with enrollments of fewer than a dozen students. Even at the universities with the largest programs, accelerator courses

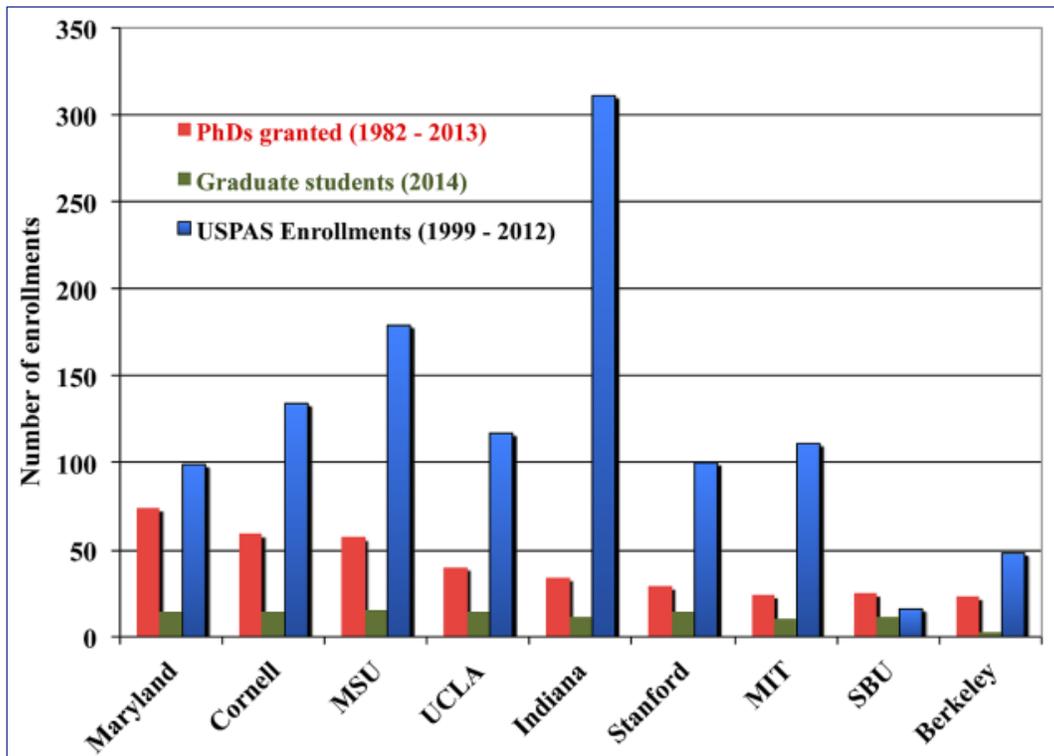


Figure 7: Ph.D. degrees granted from 1982–2013, number of graduate students enrolled in 2014, and USPAS participation from 1992–2012, for eight universities with graduate programs in accelerator science. [4]

can be offered only intermittently, and as a consequence, students rely on USPAS to fill the gaps. In letters to the Subcommittee, almost all the universities point out the role USPAS serves to ameliorate the curricular limitations imposed by small faculty numbers. Most universities report that graduate students typically take two or more basic and special courses. The Northern Illinois University letter highlights the need for technical and topical courses, stating, “some of our students who already started their research are often sent to USPAS to enroll [in] special topics. The latter type of class is an important element of the USPAS as it enables the students to get educated in a very specific topic — this turns out to be very valuable at the early stage of the research work.”

Undergraduates also enroll in USPAS, often when their university hosts a session. For many of these undergraduates, USPAS provides the only exposure to accelerator science as a career path. An estimated thirty percent of university-trained graduate students in accelerator physics go on to careers at the national laboratories.

USPAS has arranged for students at universities around the country to obtain rigorous academic credit. To students of some universities, this credit helps them to meet degree requirements in accelerator science and technology. The USPAS M.S. degree program offered through Indiana University is also of value to some, particularly those pursuing technical careers either at a national laboratory or in the private sector.

USPAS courses have led to several widely used textbooks by laboratory scientists, as well as course notes that are frequently used as reference material.

### 3.4 Need for Program Like USPAS

As discussed above, building and operating the nation's accelerators requires a highly-trained workforce, with need for training in three broad categories: professional development of mid-career scientists and engineers; training of scientists new to accelerator science; and courses for undergraduates and graduate students in accelerator science. USPAS addresses the need for training and workforce development in five primary ways, which benefits the DOE Office of Science laboratories, other public sector institutions particularly NNSA laboratories, the private sector, and universities. In short, laboratory staff, in both public and private sectors, need an extramural program, such as USPAS, that will provide and/or update their specialized skills. The laboratories need such a training program in order that their scientists can continue to develop professionally and can keep up with the recent scientific and technological advances. Furthermore, individuals transitioning from other fields into the accelerator workforce need a program, such as USPAS, that will provide them with both the general background and the specialized training that they need in order to successfully transition. In turn, the laboratories need such a program in order that these scientists can successfully transition to laboratory careers. Finally, universities with graduate programs in accelerator science need an extramural program, such as USPAS, that offers courses to complement and supplement their own course offerings. In turn, the accelerator science community, and the DOE laboratories in particular, need such a program in order that the workforce can be strengthened by the availability of well-trained graduates of university programs.

The input received from the laboratories and universities that are members of the USPAS Consortium attest to the need for a program like USPAS. For example, ANL states, "we have relied on the USPAS to help us train and maintain a cutting-edge workforce" and "USPAS is fundamental to the world-leading research performed at these facilities." LBNL said, "USPAS plays a unique and vital role in the education of

early career scientists, in developing the accelerator science workforce, and ensuring that the most modern developments in accelerator technology are widely disseminated.” Several laboratory letters also comment on the ongoing and/or future need for such a program. For instance, TJNAF explained, “we regard this program an essential element in our future plans.” BNL summed up by stating, “It is not an exaggeration to say that if USPAS didn’t exist it would have to be created.” This statement is not surprising, given that USPAS was created in order to address the needs of the laboratories for workforce development and training.

### 3.5 Unique and Essential Capabilities and Features of USPAS

The essential capability of USPAS is the **development and maintenance of the accelerator workforce** required for the Nation’s scientific and technological enterprise. The workforce serves the laboratories, academia, and industry. With the large, approximately 3,000-member workforce discussed earlier, the DOE laboratories are particularly dependent on USPAS to ensure the availability of a workforce qualified to accomplish the DOE mission. The training provided by USPAS to develop and maintain the accelerator workforce has three principal audiences:

1. the existing accelerator workforce,
2. those seeking professional transition into the accelerator workforce, and
3. undergraduate and graduate students.

The latter group is particularly important as a pipeline of individuals essential for the long-term viability of the accelerator workforce. Over time, USPAS has developed and refined a number of essential relationships and features, some unique, for delivery of content to the three target populations:

The USPAS has **two major curricular features**, basic courses and technical and topical courses, which provide essential capabilities for transmitting and maintaining accelerator science and technology knowledge.

1. The basic courses on accelerator science in areas such as beam physics or fundamentals of accelerator science are essential for delivering content to those attendees entering or transitioning into the accelerator workforce.
2. The wide variety of technical and topical courses such as those on RF technology and magnet systems or *The Physics of Free Electron Lasers* (FEL) serve all three audiences. The topical courses are especially important as the DOE accelerator complex changes over time with changing mission needs. The rise of FELs uti-

lized by the Office of Basic Energy Sciences provides a good example of the changing environment. These technical and topical courses are not available anywhere else in the U.S. and are a unique resource for the accelerator workforce.

The **close association between UPSAS and the DOE laboratories** is absolutely essential to the development of the accelerator workforce and has led to very effective delivery of information by USPAS. Hosting of USPAS management at a single laboratory provides the stability and resiliency needed for the success of the USPAS. There are four major capabilities provided by the close association:

1. Through its Board of Governors, USPAS is highly responsive to the training needs of the laboratories — the principal stakeholders are essentially driving the supply chain. For example, laboratory curricular needs are transmitted by the Board to the USPAS Director. (As mentioned in [Section 5](#), the Board’s role in governance is an essential feature of the USPAS management structure as an avenue to ensure the support of the laboratories.)
2. As the single largest cohort of accelerator scientists in the country, the DOE contingent provides a majority (two thirds) of USPAS instructors. The deep expertise provided by laboratory staff, particularly DOE staff, is another essential aspect of USPAS, particularly with respect to presentation of technical and topical courses.
3. USPAS offers a mechanism for the DOE laboratories to share and leverage their knowledge with one another, and with the larger accelerator community. By sharing curriculum development and instructors, content is available to all laboratories that no one laboratory could provide.
4. To ensure a complete and well-structured curriculum, USPAS must also have access to laboratory facilities and equipment.

The involvement of the DOE laboratories in curriculum oversight and provision of instructors and facilities is essential for ensuring that USPAS meets the needs of the Nation’s and DOE’s accelerator workforce and for DOE’s mission.

The **close alignment and relationship between the laboratories and universities** is another essential and unique feature of USPAS; the alignment provides three essential capabilities: university instruction, a workforce pipeline, and visibility for the accelerator science discipline:

1. Of course, the universities provide instructors for USPAS and no similar relationship exists anywhere between institutions delivering courses on accelerator science and universities.
2. Perhaps more importantly, this relationship provides a key pipeline of students into the national accelerator workforce. The pipeline begins with the undergraduates attracted to accelerator science by USPAS. The USPAS also provides credit hours for graduate degrees that the majority of universities cannot provide themselves, due to limited faculty and low student enrollment. As seen in their letters, students introduced to the discipline through USPAS are captured by the depth of topic and the enthusiasm of the community.
3. Further, by aligning each session with a host university, the USPAS promotes development of accelerator science as an academic discipline, through increased visibility at the academic level and through recruitment of “local” students.

An additional number of important characteristics or capabilities of USPAS, some of them unique, add great value to the enterprise:

1. The periodic and compact, fast delivery of subject matter is very important. For instance, laboratory employees are best served by this format as their time away from work is minimized. Similarly, university students are well served by the summer sessions, for which they can easily interrupt their research with a two-week hiatus. As attested by many of the trainee letters, the one-on-one interactions fostered by intense day-long sessions improves transmission of information.
2. The involvement of laboratory staff also imbues the curriculum with a focus on real-world and practical applications. This attribute of the USPAS makes the transmission of information much more effective for the laboratories.
3. The multidisciplinary nature of the curriculum and of the instructors is unique; nowhere else can trainees find such varied instruction.
4. On the part of the instructors, teaching is an important aspect of professional development. In fact, a number of textbooks, widely used in the field, can trace their origins to course delivery at USPAS.
5. As a broader benefit of the USPAS, the twice yearly convocation of accelerator experts maintains and builds the community and collaborations. As mentioned by BNL, “[USPAS] fosters the development of an accelerator science and technology community.”

## 4 Overall Quality and Breadth

### 4.1 Overall quality

A number of objective metrics and subjective measures attest to the high quality of USPAS. The curriculum is broad with both basic and technical or topical courses and serves the full accelerator community. Instructors are recruited from the deep and broad pool of talent available in the United States; instructors from abroad further strengthen the faculty. The enrollment has been steady or increasing over the past fifteen years (see [Figure 3](#)) and is now near capacity. Trainee assessments show good, very good, or excellent ratings by 95% or more of the trainees. Furthermore, a more subjective measure in the form of letters from universities, trainees, and DOE laboratories shows very high regard for USPAS. The following sections offer further detail on these measures of quality.

### 4.2 Breadth of curriculum and session format

Over the years, USPAS has offered an impressively wide variety of courses in accelerator physics, technology, controls, management, and safety. The full list of courses offered in the years 2000 to 2014 is given in [Appendix F](#). Here the courses are grouped into fourteen categories, and for each course and category the average and total number of enrollments is shown, together with the number of times that the course has been offered.

From the data, an important feature of the USPAS program can be seen. Some courses, such as Accelerator Fundamentals and Accelerator Physics, have appeared thirty times in fifteen years; in other words, they are considered essential and are taught at every USPAS session. Others, such as Microwave Measurements, appear regularly and are taught yearly. The courses mentioned, and others like them, are of two-week duration and form the core part of the curriculum, accounting for about half of the courses offered at any session.

For the rest of the topic areas, courses are provided according to need. In assessing need, the Director consults with members of the BOG and with members of the CAC. These bodies also provide advice and suggestions on suitable instructors for the courses.

Given the breadth and comprehensiveness of the syllabus, a clear definition of the courses (with course numbers, descriptions, durations, and whether a core course or otherwise) and what use the courses might be towards the various academic accreditation schemes would be useful. Similarly, the process for selecting session programs could be made more definite. The core part looks after itself, except perhaps for the choice of instructor; on the other hand, how the content of the variable part is decided appears to be informal. The CAC could be more engaged by meeting on a regular basis and documenting discussions and decisions.

The structure of the sessions provides a solid base for teaching the essentials while allowing flexibility to adapt a session to current needs. The parallel structure serves to keep the number of trainees following any particular course rather low, from a few to a maximum around thirty. The low number allows for quasi one-on-one teaching, given by an expert in the field, which is very much appreciated by the trainees.

### 4.3 Instructors

Even at the introductory level, courses on accelerator science and technology are multidisciplinary in nature. At a higher level, some topics are so specialized that they are currently not taught anywhere else in the U.S. For these reasons, accelerator science and technology has become a specialized field in its own right. The instructors are drawn almost entirely from the Consortium of laboratories and universities involved in USPAS, and this pool allows access to a highly skilled group of experts, many of whom have shown themselves to be excellent teachers. Pooling of resources in this way provides a formidable breadth and depth of expertise that would not be available to any single institution. As noted in the Fermilab letter, "A primary benefit is the exposure to a world-class community of experts represented by USPAS instructors."

### 4.4 Enrollment

Yearly USPAS attendance has increased steadily in the last fifteen years, with the average over the past five years around three hundred (one hundred fifty trainees per session). While up to half of enrollments formerly came from USPAS sponsoring institutions, in recent years this fraction has fallen to approximately thirty percent, with almost sixty percent of attendees now being undergraduate and graduate students from U.S. universities. This fraction highlights the function of USPAS as a pipeline for the national accelerator workforce.

Roughly two-thirds of all trainees enroll for university credit, and a little under half of all trainees (forty-five percent) receive financial aid. The general trend over the last five years is for more requests for financial aid. The stated aim is to reach out to as many as possible through scholarships. This practice tends to increase the number attending USPAS. Very few applicants are refused.

The present enrollment of one hundred fifty trainees per session is judged by USPAS to be close to the limit of what can be accommodated in the present session format. Expansion of an individual session much beyond this number would stretch the capacity of venues and logistics. The straightforward response to increased demand would be to increase the number of annual sessions. In this sense, USPAS is robust and scalable; of course staffing needs would need to be evaluated as the number of sessions increased.

## 4.5 Evaluations

Evaluation data for the 2013 sessions are typical of evaluations routinely collected from the trainees. The 2013 data, shown in [Table 1](#), reflect a high level of satisfaction in both the courses and in the instruction.

Two 2013 sessions	Overall course rating (%)	Instructor performance (%)
Excellent	42	54
Very good	31	28
Good	20	15
Fair	6	3
Poor	1	0

**Table 1:** Trainee evaluation summary for USPAS 2013 sessions. Data provided by USPAS.

The letters sent from the laboratories and universities generally have nothing but praise for USPAS; it is hard to find anything remotely critical. Following are some characteristic remarks:

- “Such topics are not taught anywhere else but are absolutely needed . . .”
- “The broad curriculum and session format make it an ideal mechanism . . .”
- “We have a continuing need to access specialized courses . . .”
- “USPAS provides depth and breadth beyond the reach of a single university”

The letter from the USPAS Board of Governors has many and only positive comments on the breadth and evolution of the syllabus.

The data available on the career evolution of USPAS alumni shows a very positive impact of USPAS on the community. Of the more than four thousand distinct USPAS attendees, more than half work or have worked in the field, with most of these at DOE national laboratories. Some two hundred fifty alumni have taken intellectual or leadership positions in the U.S. accelerator community.

## 5 Management

### 5.1 Management Structure

The overall management structure is appropriate and has some features that are essential to the success of the USPAS.

The governance of USPAS has some parallels to university governance. The Board of Governors (BOG) plays a role similar to that of the Board of Trustees of a university. They hire and fire the Director, as a Board of Trustees would a university president. The Director oversees the Curriculum Advisory Committee (CAC), which plays somewhat the role of the faculty in university governance; namely, responsibility for the detailed curricular content and quality, as well as the selection of their fellow faculty members. In this case, the CAC is more advisory to the Director, who seems to take fuller responsibility for final instructor selection (which is probably appropriate because the instructors are not permanent, but rapidly cycling compared to tenured university faculty). This model with a BOG appears to provide adequate accountability and oversight of the Director. The appointment of the BOG by the Laboratory Directors assures that the goals and budget decisions of USPAS are well aligned with the stakeholders, particularly the Laboratory Directors and DOE. The BOG conducts annual reviews of USPAS and sets priorities for which programs are offered and when. A periodic, more retrospective and external review, perhaps every five to seven years, would be valuable to consider.

Some BOG members are also instructors of the USPAS; consequently, there is some similarity here to the organizational structure of a law firm managed by partners who are also practitioners. The Subcommittee had no real concern with this overlap of roles. Because the teaching roles are unpaid, there is not the conflict of interest there would be in other circumstances.

The management of USPAS is accomplished by three FTEs, which is appropriate to the workload and size of the program, and is comparable to that of the CERN Accelerator School (CAS). The role of Director appears to require a full FTE, and that is the case here and at CAS. The directorship conceivably could be shared among more than one person, though the Subcommittee believes that it is essential that the Director have USPAS as their primary focus, that they have gravitas in the community, and exceptional ability to cultivate collaboration and teamwork.

The Subcommittee found some features of the management structure that appear to be critical to the success of USPAS. First is that the Board be a governing, rather than advisory, board. The empowerment of the Board by the Laboratory Directors and the trust that they have placed in the Board is critical to ensure continuing support by all the laboratories, as well as the smooth and responsive operation of the program. A second essential feature is the hosting of USPAS management at a facility that is both stable and committed to accelerators. The economy of scale of being in a larger organization, including shared services (IT, accounting, *etc.*) and other infrastructure, plays a large role in the success of USPAS and in minimizing budgetary requirements.

There are a number of ways in which the current management structure, though not the only possible structure, is a best practice:

1. Economy of scale of conducting a shared program rather than individual training programs at each laboratory.
2. Cross-pollination of knowledge and expertise across the laboratories, carried physically by the participation of trainees and co-instructors.
3. University involvement is a differentiating advantage for USPAS over CAS, and enhances the role of USPAS. The primary role for both programs is the preservation and transmission of accumulated knowledge in accelerators. The inclusion of universities also enables USPAS to develop the next generation of scientists and engineers who will expand that knowledge.
4. The USPAS is a model for breaking silos between DOE offices, enabling collaboration and dissemination that benefits DOE and the nation.

## 5.2 Effectiveness of Management

The management structure and team have been effective. Over its nearly thirty-year history, the session cost of delivering the program per trainee and course has risen at a rate slower than inflation, and over the past fifteen years has been around \$1,500 per trainee per session. The networking value of USPAS has prompted industry-based instructors to volunteer a significant amount of time, and likewise the university-based faculty time is largely release time, and in that sense, a contribution from the universities, both private and public. Both bring added value and enhance the cost-effectiveness of the program. Laboratory-based faculty members are paid through release time from their other responsibilities, but one should not assume that the taxpayer benefit of this exchange is zero sum. Nobel Laureate Richard Feynman described anecdotally the value of teaching to the creative process of research in his book, *Surely*

*You're Joking, Mr. Feynman!* Years later, the positive correlation between teaching and research effectiveness has been confirmed by social science research, as presented in [5] and [6].

The BOG appears to look closely at budgets and priorities and to ensure cost-effective investment. It appears to have well-aligned incentives to do so. As stated in the presentation to the Subcommittee by Fermilab COO Tim Meyer, "Every dollar saved [in the running of USPAS] is available for research of the member labs."

The CAC performs a number of important roles, and its increased engagement would be of benefit to the program. The benefits of engagement include establishing a pool of knowledgeable (of USPAS) talent to ensure succession and respond to emergencies, and include identifying an even deeper and better pool of instructors for the program.

## 6 Participation of Women and Under-represented Minorities

USPAS has a good record regarding diversity. USPAS has made efforts to increase percentages of women, both as instructors and as enrollees. Both percentages have grown, and the percentage of woman enrollees is now in line with national trends in the field. Gender diversity, for both instructors and enrollees, is comparable for USPAS and the CERN Accelerator School. USPAS has also appointed a Minority Outreach Coordinator.

### 6.1 Women Participants

The number of women attending USPAS sessions has steadily increased through the lifetime of USPAS, as shown in [Figure 8](#). In recent years, a deliberate effort has been made (see below) to have more women instructors at USPAS sessions, in the belief that they act as excellent role models and thereby attract more women to enroll. The evolution of female attendance at USPAS closely follows the steady increase of women in science in the U.S., which can be seen in a recent publication by the American Institute of Physics Statistical Research Center [7].

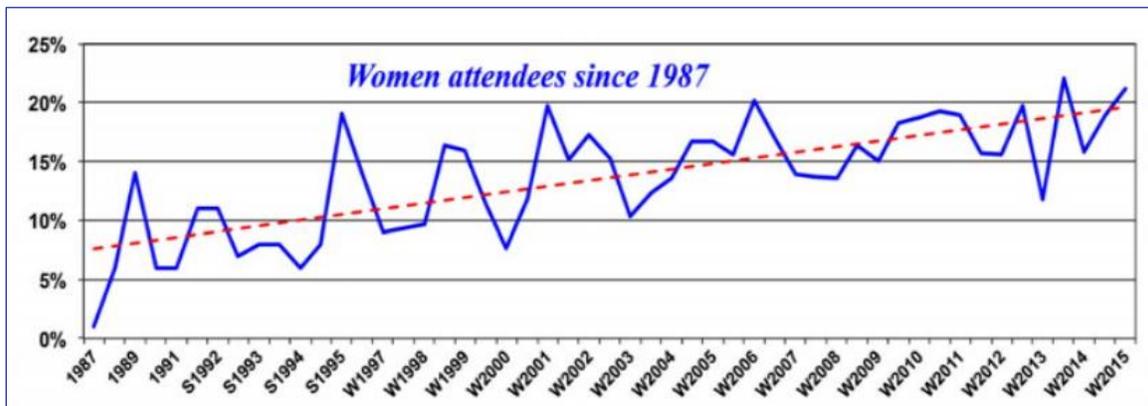


Figure 8: Women attending USPAS sessions as a percentage of all attendees. [3]

The current level of women attending USPAS is around twenty percent. This percentage compares well with the level of women achieving M.S. and Ph.D. qualifications in physics in the U.S. at the end of the last decade, and exactly matches the level of women attending the CERN Accelerator School (CAS) in Europe in recent years.

The percentage of women instructors at USPAS sessions is shown in [Figure 9](#). The recent efforts to increase the number are clearly seen. The average over the whole period is 6.5%; while in the last five years, it is over 10%. For comparison, the average level of women teaching at the CAS in recent years is 7%. Recruitment of more women as instructors and for the CAC may further increase participant gender diversity.

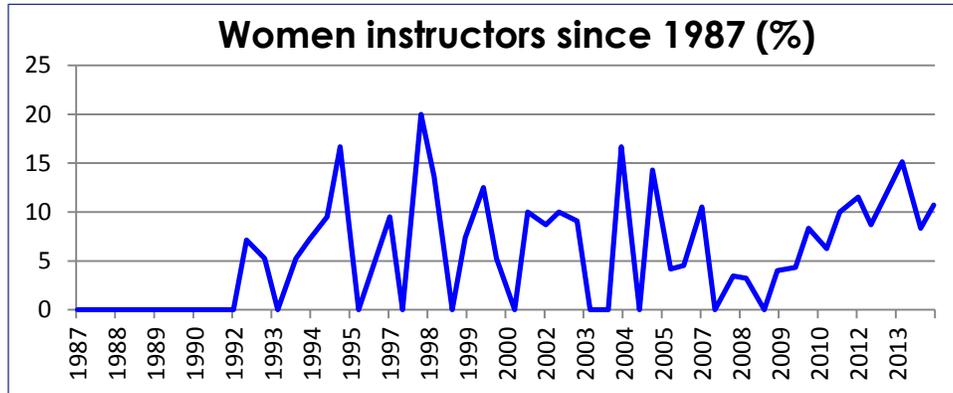


Figure 9: Percentage of women instructors at USPAS sessions. Data provided by USPAS.

## 6.2 Under-represented Minorities

No data is available on the participation of under-represented minorities according to discussions with USPAS management. However, the Subcommittee notes that in 2011 the USPAS Board of Governors voted to name Professor Paul Gueye, of Hampton University and Jefferson Laboratory, as Minority Outreach Coordinator. He assists the USPAS Director in attracting more minorities into accelerator physics and engineering. In the future, diversity data on under-represented minorities should be collected on a regular basis.

## 6.3 Input from DOE Laboratories

In their letters, several of the laboratories note that USPAS has been a vehicle for increasing the diversity of their accelerator staff. For example, BNL points out that their operations group, which draws on students with Bachelor's degrees from across physics, has more than 50% greater proportion of women than the rest of the accelerator division. USPAS enables them to draw from this larger pool. They observe, "With the training provided, the pool of applicants can be significantly enlarged." Other laboratories make similar comments, *e.g.*, "USPAS has provided the opportunity for ORNL to considerably strengthen its demographics within accelerator science and technology.

Key female employees who are 'graduates' of USPAS include the group leader of our Controls Systems Group, two accelerator operations shift supervisors, and one of our best mid-career accelerator physicists."

## 7 References

- [1] U.S. Department of Energy, "Accelerators for America's Future," 2010.
- [2] R. Hamm and M. Hamm, "Industrial Accelerators & Their Applications," World Scientific Publishing, 2012.
- [3] W. Barletta, "Self-Assessment of the USPAS Program," document prepared for HEPAP review of USPAS, 2015.
- [4] W. Barletta, "Annual Report of the United States Particle Accelerator School," 2014.
- [5] M. Qamar uz Zaman, "Review of the Academic Evidence on the Relationship Between Teaching and Research in Higher Education," *UK Department for Education and Skills Research Report RR506*, 2004.
- [6] H. Wei, Z. Cheng and K. Zhao, "On the relationship between research productivity and teaching effectiveness at research universities," *Frontiers of Education in China*, vol. 2, no. 2, pp. 298-306, 2007.
- [7] American Institute of Physics, "Physics Graduate Degrees (p. 6, Figure 3)," July 2011. Available online at:  
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## Appendix A. Charge



U.S. Department of Energy  
and the  
National Science Foundation



FEB 12 2015

Professor Andrew Lankford  
Chair HEPAP  
University of California at Irvine  
Physics & Astronomy Department  
4129H Frederick Reines Hall  
Irving, CA 92697

Dear Professor Lankford:

In addition to advice on broad initiatives and strategic opportunities for particle physics, the Department of Energy (DOE) Office of Science also requires periodic input from the High Energy Physics Advisory Panel (HEPAP) on specific investments of critical importance to the Department. One of these investments is the U.S. Particle Accelerator School (USPAS), a long-standing partnership between several DOE laboratories and the Office of Science. This program plays a key role in training the next generation of researchers and practitioners who are skilled in harnessing the potential of particle accelerator technology to advance science and engineering across a broad spectrum of disciplines and applications. This program also plays an important role in attracting very well qualified researchers to the national laboratories to advance DOE missions.

With this letter, we are charging HEPAP to assemble a sub-committee to examine, for DOE only, the effectiveness and cumulative impact of the USPAS over the past two and a half decades, in the context of both workforce development and training; as well as to assess the overall quality and breadth of the program. The sub-committee should take into account the unique qualifications and skills of accelerator scientists and their role in the public and private sectors, and how USPAS training prepares participants for careers in accelerator physics and accelerator R&D. It should evaluate the need for this kind of program, given the available academic resources and worldwide competition for a skilled technical workforce; and address which unique and essential capabilities are provided to the program via the involvement of the DOE laboratories. It should also address the efficacy of the current USPAS management model, the participation of women and under-represented minorities in this area, and the projected need for trained accelerator scientists to support both DOE science missions and continued U.S. leadership in accelerator science.

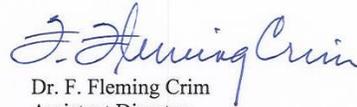
This assessment will be a critical milestone in the development of this activity and can inform the future evolution of the program. We would appreciate the committee's preliminary comments by April 2015 and a final report by May 2015. We appreciate HEPAP's willingness to undertake this important effort.

If you have any questions regarding this matter, please contact either Jim Siegrist, the Associate Director of the Office of Science for HEP or Glen Crawford, the Designated Federal Official for HEPAP.

Sincerely,



Patricia M. Dehmer  
Acting Director, Office of Science  
U.S. Department of Energy



Dr. F. Fleming Crim  
Assistant Director  
Directorate for Mathematical and Physical Sciences  
National Science Foundation

## Appendix B. Subcommittee Membership and Activities

The High Energy Physics Advisory Panel (HEPAP) received a charge (see [Appendix A](#)) from the Department of Energy and the National Science Foundation on February 12, 2015, to review the United States Particle Accelerator School (USPAS). The charge requested a preliminary report by April 2015 and a final report by May 2015. In response, a HEPAP subcommittee was formed and began meeting immediately. The membership included Roger Bailey (CERN), Gerald C. Blazey (Northern Illinois University), Bruce Carlsten (LANL), Tom Katsouleas (Duke), Andy Lankford (chair; UC Irvine), and Ritchie Patterson (Cornell). Brief biographies of the committee members are included in [Appendix B.1](#).

The Subcommittee met four times via teleconference in preparation for a face-to-face meeting March 13–14, 2015, in Chicago, Illinois. In preparation for the face-to-face meeting, the USPAS Director provided extensive and detailed information on the USPAS (see [Appendix D](#)), including a self-assessment based upon guidelines established at the University of Pittsburgh for conducting the evaluation of academic programs (available online at: <http://www.pitt.edu/~provost/guidelines.pdf>). Prior to the Chicago meeting, letters were sent to the accelerator community requesting information about the USPAS and the nation's accelerator workforce; letters were solicited from:

1. the DOE laboratories with accelerator programs,
2. universities with the largest graduate programs in accelerator science,
3. the private sector organizations that have sent the most employees to USPAS sessions, and
4. a random selection of former USPAS trainees.

The Subcommittee received letters from ANL, BNL, Fermilab, LANL, LBNL, NSCL/FRIB, ORNL, SLAC, and TJNAF (see [Appendix G](#)). Universities responding were Colorado State, Cornell, Indiana, MIT, Michigan State (see NSCL/FRIB), Northern Illinois, Old Dominion, Stony Brook, and UCLA (see [Appendix H](#)). Sixteen letters were received from former trainees and two from industry. Letters were also requested and received from the American Physical Society Division of Physics of Beams (see [Appendix I](#)) and the USPAS Board of Governors. (see [Appendix J](#)).

On the first day of the Chicago meeting the Subcommittee discussed relevant information from the 2014 HEPAP report on HEP Workforce Development Needs; heard a

detailed overview of USPAS from William Barletta, USPAS Director, and an overview of European accelerator workforce training; and received information from the USPAS Board of Governors and remarks from Fermilab as host laboratory for the USPAS. There was ample time for discussion of the presentations with the presenters and in executive session to discuss the information received from the community. The Subcommittee spent the second day drafting the major findings for the report. The meeting agenda is included in [Appendix C](#).

Following the meeting, the Subcommittee continued to meet via teleconference and draft the report.

## Appendix B.1. Subcommittee Biographies

### **Roger Bailey**

*CERN Laboratory*

*Geneva, Switzerland*

Roger Bailey obtained a Ph.D. in experimental particle physics from the University of Sheffield, United Kingdom, in 1979. This was followed by a postdoctoral appointment with Rutherford Laboratory, Oxford, United Kingdom until 1983. During both of these activities, he worked on high energy physics experiments at the CERN Super Proton Synchrotron (SPS), being based at CERN from 1977. In 1983, he joined the operations group at the CERN SPS, with responsibility for accelerator operation during the fixed target and proton-antiproton programs at this facility until 1989. He then joined the CERN Large Electron-Positron Collider (LEP) commissioning effort, and subsequent operation, becoming Operations Group Leader in the late 1990s. After closure of LEP, he became progressively more involved in the Large Hadron Collider (LHC), developing the planning and building the team for LHC commissioning with beam. He was actively involved in LHC commissioning and early operation in the years 2008 to 2010. Since 2011, he has been the director of the CERN Accelerator School (CAS) in Europe, which organizes two-week residential courses on accelerator science and technology in the CERN member states three times per year.

**Gerald (Jerry) C. Blazey***Department of Physics**Acting Associate Vice President for Research and Innovative Partnerships**Northern Illinois University*

Gerald Blazey received his Ph.D. in Physics from the University of Minnesota in 1986. Over the past thirty years he has been involved in research at colliding beam experiments and in detector development. He is a Fellow of the American Physical Society. Since joining Northern Illinois University in 1996, he has been appointed a Distinguished Research Professor and has been principal investigator for federally funded grants from the National Science Foundation, the Department of Energy (DOE), the Department of Education, and the Department of Defense. While participating in the Fermi National Accelerator Laboratory collider program he served as co-Spokesperson of the DZero collaboration. He was a program manager for the International Linear Collider in the DOE Office of High Energy Physics and was Assistant Director for Physical Sciences in the Office of Science and Technology Policy in the Executive Office of the President of the United States. Currently he is Acting Associate Vice President for Research and Innovative Partnerships at Northern Illinois University.

**Bruce Carlsten***Senior R&D Engineer**Los Alamos National Laboratory*

Bruce Carlsten received his Ph.D. in Electrical Engineering from Stanford University in 1985. He has been at Los Alamos National Laboratory since 1982, researching the generation and transport of high-brightness electron beams and novel RF source technologies. He built two linacs for accelerator research at Los Alamos in the 1990s, and from 2005 to 2012 was Group Leader of the group High-Power Electrodynamics, overseeing the Laboratory's projects on advanced acceleration schemes, free-electron lasers, and various RF and THz sources. He is a Fellow of both the American Physical Society and Los Alamos National Laboratory, and a 1999 recipient of the USPAS Prize for Achievement in Accelerator Physics and Technology. He holds six U.S. Patents, is a member of several U.S. Government advisory panels, and is a member of the Advanced and Novel Accelerators Panel of the International Committee for Future Accelerators. He is an editor of *Physical Review Special Topics – Accelerator and Beams* and is the chair of the Program Advisory Committee of Brookhaven National Laboratory's Accelerator Test Facility.

**Tom Katsouleas**

*Vinik Dean of Engineering, Pratt School of Engineering  
Duke University*

Tom Katsouleas received his Ph.D. in Physics from UCLA in 1984. He is a specialist in the use of plasmas as novel particle accelerators and light sources. His work has been featured on the covers of *Physical Review Letters*, the *CERN Courier*, and *Nature*. He has authored or co-authored over two hundred publications and given more than fifty major invited talks. He has been at Duke since 2008, where he is the Vinik Dean of Engineering and Professor of Electrical and Computer Engineering and Professor of Physics. Before that Katsouleas was a professor, associate dean, and vice provost at the University of Southern California. He is a fellow of the APS and IEEE and the recipient of the IEEE Plasma Science Achievement Award.

**Andrew J. Lankford**

*Department of Physics & Astronomy  
University of California, Irvine  
Chair, High Energy Physics Advisory Panel*

Andy Lankford received his Ph.D. in Physics from Yale University in 1978. He subsequently held staff positions at Lawrence Berkeley Laboratory from 1978 to 1982, and at the Stanford Linear Accelerator Center from 1982 to 1990. He became Professor of Physics at the University of California, Irvine in 1990. He served as Department Chair from 2002 to 2007. His research area is accelerator-based experimental particle physics, working on experiments using colliding beams at CERN's ISR, at SLAC's SPEAR, PEP, SLC, and PEP-II, at Fermilab's Tevatron, at BEPC at IHEP Beijing, for the SSC, and now at CERN's Large Hadron Collider. He has collaborated on the ATLAS Experiment at the LHC since 1994, and served there as Deputy Spokesperson from 2009 to 2013. He has participated in and chaired numerous DOE and laboratory review committees and participated in two National Academies studies, chairing the Committee to Assess the Science Proposed for a Deep Underground Science and Engineering Laboratory. He is a Fellow of the American Physical Society and a National Associate of the National Research Council. He has served as Chair of the High Energy Physics Advisory Panel for DOE and NSF since 2012.

**Ritchie Patterson**

Department of Physics

Director of the Cornell Laboratory for Accelerator-based Sciences and Education

Cornell University

Ritchie Patterson received her Ph.D. in 1990 from the University of Chicago, and then moved to Cornell, where after a few years as a post-doc, she joined the faculty of the Department of Physics. Patterson's research is in particle physics, where she has contributed to experiments addressing strange mesons at Fermilab, charm and bottom mesons at CESR, and currently, the energy frontier at the Large Hadron Collider. She was an NSF National Young Investigator from 1994 to 1999, an Alfred P. Sloan Fellow from 1994 to 1996, received Cornell's Provost Award for Distinguished Scholarship in 2005, and is a Fellow of the American Physical Society. She has served on numerous professional committees and panels, including the National Research Council decadal study for elementary particle physics, *EPP2010*, and the Physics Policy Committee of the APS. At Cornell, she has chaired the Department of Physics, and since 2012 has led Cornell's accelerator programs as the director of the Cornell Laboratory for Accelerator-based Sciences and Education.

## Appendix C. USPAS Review Meeting Agenda

### USPAS Review

March 13–14, 2015

Chicago, Illinois

Online agenda with links to material available at: <https://indico.cern.ch/event/379681/>

Friday, March 13, 2015

Time	Event	Presenter
07:30 – 09:30	Executive Session	
09:30 – 10:00	Summary of HEPAP Subcommittee on Workforce Development Report	R. Patterson
10:00 – 10:30	BREAK	
10:30 – 11:15	Overview of USPAS	W. Barletta
11:15 – 12:15	Overview of European Situation and CAS, TIARA, JUAS	R. Bailey
12:15 – 13:00	WORKING LUNCH	
13:00 – 13:30	Perspective from USPAS Board of Governors	R. Gehrig
13:30 – 15:00	Remarks from USPAS on specific charge points	Barletta, <i>et al.</i>
15:00 – 15:15	BREAK	
15:15 – 16:15	Fermilab perspectives	T. Meyer
16:15 – 17:45	Executive Session – Summary of input	
17:45 – 18:00	BREAK	
18:00 – 19:30	Executive Session	

Saturday, March 14, 2015

Time	Event	Presenter
07:30 – 09:00	Working Breakfast – Executive Session	
09:00 – 09:30	BREAK	
09:30 – 12:00	Executive Session	
12:00 – 13:00	Working Lunch – Executive Session	
13:00 – 14:30	Executive Session	

## Appendix D. Materials Provided by USPAS Director

1. Annual Report of the United States Particle Accelerator School, December 2014.
2. USPAS Self-Assessment, March 2015.
3. Description of core USPAS courses.
4. Authorizing Letters from Department of Energy Office of Science Associate Directors to Chair of the USPAS Board of Governors (see [Appendix E](#)).
5. Testimonial letters from USPAS students and instructors.
6. W.A. Barletta, S. Chattopadhyay and A. Seryi, "Educating and Training Accelerator Scientists and Technologists for Tomorrow," *Reviews of Accelerator Science and Technology*, vol. 5, pp. 313–331, 2012.
7. Task Force on Accelerator R&D, "Office of High Energy Physics Accelerator R&D Task Force Report," May 2012. Report and Appendices available online at: <http://science.energy.gov/hep/research/accelerator-rd-stewardship/workshop-reports/>
8. Kircher, F., *et al.*, "TIARA Education and Training Survey Report," *TIARA-REP-WP5-2012-006*, 2012. Available online at: <http://cds.cern.ch/search?p=TIARA-REP-WP5-2012-006>
9. Burrows, P., *et al.*, "TIARA Needs for Accelerator Scientists Report," *TIARA-REP-WP5-2013-005*, 2013. Available online at: <http://cds.cern.ch/search?p=TIARA-REP-WP5-2013-005>
10. Nuclear Science Advisory Committee Subcommittee on Workforce Development, "Assessment of Workforce Development Needs in the Office of Nuclear Physics Research Disciplines," July 2014. Available online at: <http://science.energy.gov/np/nsac/reports/>

## Appendix E. USPAS Authorizing Memoranda



Department of Energy  
Washington, DC 20585

SEP 3 1992

Dr. Richard Briggs  
Deputy Director  
SSC Laboratory, MS 1072  
2550 Beckleymeade Avenue  
Dallas, Texas 75237

Dear Dr. Briggs:

We are writing to you in your capacity as Chairman of the Steering Committee for the U.S. Particle Accelerator School. As we are all aware, there has been extensive discussion in recent months within the Department of Energy (DOE) and within your committee about future directions of the School, future funding scenarios, and oversight requirements. We believe, after considerable reflection, that it is timely for the DOE to formally state its position with regard to the future support of the School and to move to a new, less complicated management arrangement.

The DOE Division of High Energy Physics (DHEP) has been the principal financial supporter for the U.S. Particle Accelerator School since the first School was held at Fermilab in 1981. We know of no better way to have expressed the DOE's continuing, enthusiastic endorsement of the School's product than this continuing financial support. The formal training of personnel in accelerator science, engineering, and technology in early schools at national laboratories and recently at universities has been beneficial to all of our programs. The series of seminars on forefront topics held at various U.S. national laboratories have provided a badly needed forum, far more concentrated in content than possible at particle accelerator conferences, to keep all of the U.S. accelerator community abreast of current research. The Joint U.S./CERN School has also contributed strongly to the international exchange and dialogue in the most advanced accelerator science topics, a dialogue essential in a forefront research field. Most significantly, the U.S. Schools have produced a series of books of archival quality, covering in detail and comprehensively every aspect of accelerator science, engineering, and technology. A whole literature has been created where none existed before.

We are concerned, however, about recent difficulties encountered in the business side of this enterprise, specifically in the budgeting, financial management, and oversight areas, which the DOE is bound to manage according to well-established and formal requirements. After examining the process for supporting recent Schools and the School Office, and Dr. Burton Richter's memorandum of May 27, 1992, in which similar deliberations at the School's steering committee meeting of April 22, 1992, are recounted, we have concluded that some changes are needed if the School is to continue to flourish and be of benefit to the wider communities of science and technology that it now wants to support.

Consequently, we propose the following policy to resolve the issues which we see before us. First, the DHEP will continue to provide funding support for the School Office at Fermilab, as it has in the past, as long as this activity continues to have the endorsement of the Fermilab Director. The activities of the Office appear well organized, the staff highly qualified, and the function important to the Schools and to the publication of the School Proceedings. Second, the DHEP will, in response to specific requests, provide funding for the Joint U.S./CERN School whenever it is held in the U.S. Third, we strongly endorse the principal embodied in Dr. Richter's May 27, 1992, memorandum that a single national laboratory be responsible for budgetary and business management oversight, and we believe that it is essential that these activities be performed with care and attention to detail. We note that Dr. Richter's memorandum indicates that Fermilab is to assume this role.

Before continuing to the fourth point, some important facts must be considered. Most significant, the present mode of funding for the university-based Schools routes the funding through two channels: DOE funds for School Office participation on site at a particular university-based School are provided directly to Fermilab, and DOE funds for each specific School are provided directly to the university hosting the School, which as manager for the grant controls the largest portion of that School's funds. This dual arrangement has proved awkward at best and is the source of part of the agency's concern about the business management and financial oversight aspects. Further, Fermilab does not inherently have the necessary legal authority to carry out oversight activities over a grant that DOE has placed with a university. We note also that the primary management responsibility for the activities of the School is through the Steering Committee that you chair, whose present membership includes representatives from Brookhaven National Laboratory, CEBAF, Cornell University, Fermi National Accelerator Laboratory, Stanford Linear Accelerator Center, and the Superconducting Super Collider Laboratory. Moreover, this group of laboratories has provided at least half of the financial support for the June 1992 U.S. Particle Accelerator School at Stanford University.

We believe that good management practice requires the funds for an activity such as this to flow through the same channel as the management control. This consolidates the power of management and finance in a single entity. Therefore, as our fourth point we propose that funding for all future U.S. Particle Accelerator Schools at universities be provided in total, except as noted in points one and two above, directly by the laboratories represented on the steering committee--following the precedent set by the funding for the June 1992 Stanford School. This approach has the additional advantage that the most affected and interested field representatives of the various scientific disciplines supported by accelerator science and technology can decide at the field level what topics the School will address, how often the Schools are to be held, and the amount of financial resources to be applied.

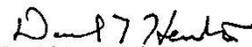
As senior DOE managers for each of the scientific areas identified by the Particle Accelerator School as potential sources of future financial support, we have reviewed the School's history, its successes, and the promised benefits of its continuation. We have determined that if the members of the Accelerator School Steering Committee, representing the relevant scientific

disciplines and national laboratory organizations, decide that a given School is needed for training personnel, we will support that decision, and we will, as a consequence, accept the steering committee's collective judgement as adequate justification for funding the U.S. Particle Accelerator School with the Federal funds that our programs provide to the respective laboratories.

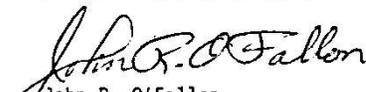
In summary, the major change that we propose is for the funding of future university-based Particle Accelerator Schools to be provided by the interested and benefitting national laboratory program organizations with a single national laboratory (perhaps Fermilab) being responsible for budgetary and business management oversight. We think this approach is fair, equitable, and consistent with the proven success of "field run" science management, and it will become effective as of the start of Fiscal Year 1993. If you wish to discuss further the reasoning behind this plan please feel free to contact any of us. Specific questions can also be directed to Dr. David F. Sutter of the Division of High Energy Physics at (301) 903-5228.

Sincerely,

  
 Robert E. Diebold  
 Director  
 Program Coordination Division  
 Office of Superconducting Super Collider

  
 David L. Hendrie  
 Director  
 Division of Nuclear Physics  
 Office of Energy Research

  
 Louis C. Ianniello  
 Acting Associate Director  
 for Basic Energy Sciences  
 Office of Energy Research

  
 John R. O'Fallon  
 Director  
 Division of High Energy Physics  
 Office of Energy Research

cc:  
 Martin Blume, BNL  
 Hermann Grunder, CEBAF  
 Boyce McDaniel, Cornell  
 Melvin Month, BNL  
 Ewan Paterson, SLAC  
 John Peoples, Fermilab  
 Burton Richter, SLAC  
 Richard Stephens, ST-50



Department of Energy  
Germantown, MD 20874-1290

DIRECTOR'S OFFICE

FEB 20 2001

FEB 15 2001

Dr. Michael S. Witherell  
Fermilab, MS 105  
P.O. Box 500  
Batavia, IL 60510-0500

Dear Dr. Witherell:

This letter is to confirm agreements reached concerning future management and financial support of the U.S. particle Accelerator School (USPAS) during a conference call on November 13, 2000. The parties to the conference call were Stephen D. Holmes, Fermilab Associate Director for Accelerators; William A. Barletta, Chairman of the USPAS Board of Governors; David F. Sutter, Senior Program Officer for Technology R&D, DOE Division of High Energy Physics; and myself. The purpose of the phone call was to review a proposal originating with Mel Month, the founding Director of the USPAS to the University Research Association (URA) that the management responsibility for USPAS be moved from Fermilab to URA where it would become a separate management entity similar to Fermilab. The question of a fulltime USPAS Director was also discussed.

This office has been a strong supporter of the USPAS since its inception in 1981, and we recognize that the benefit to high energy physics has been substantial and ongoing. The expansion of the school's programs to support sciences other than high energy physics has been impressive and greater than anticipated. We would note that this expansion and broadening was in fact one of the anticipated and intended effects of the policy established by the Department of Energy (DOE) in the letter to Richard Briggs, the Chairman of the USPAS steering Committee, the predecessor to the present USPAS Board of Governors, on September 13, 1993, and signed by four Senior DOE Office of Science Program Managers. The letter endorsed funding the USPAS courses through interested, supporting laboratory "customers." The subsequent financial support and management oversight by eleven prestigious DOE and National Science Foundation supported laboratories has, we believe, contributed strongly to the health vigor, and productivity of the USPAS educational activities and confirms the, at that time controversial, policy decision. Continuation of the eleven laboratory support is essential, and we very strongly endorse continuation of their participation in the USPAS management.

We also believe that the necessary, detailed administrative and financial oversight by Fermilab of what is in fact a rather large operation that spends a good deal of money has also contributed in a very important way to the success of the USPAS. It has assured all who contribute financial support and policy backing to USPAS that the many rules and regulations involved in any government funded enterprise are being obeyed. Therefore,



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if the Division of High Energy Physics is to continue its present level of support for the School Office, and in particular, if as noted below, we are to expand that support to include funds for a full time director, then we must insist that management oversight by Fermilab is essential and must continue.

In view of the above points, we do not support the proposal for changing the USPAS school status to that of a contractual entity managed directly by URA. During the above referenced conference call, it was agreed that this would not be pursued.

Finally, we agree with the recommendation in the proposal that the Director of the USPAS needs to be essentially a full time rather than a part time position, and we will work with Fermilab in taking the actions necessary to establish such a full time position at Fermilab. At present, the salary for the USPAS Director is not included in the approximately \$270,000 provided by DOE annually to Fermilab for support of the USPAS school office. The total needs to be adjusted to include the Director's salary, and Fermilab should submit to this office a Field Task proposal requesting appropriate funds for the operation of the USPAS office including the director at Fermilab beginning in FY 2002. We assume that the present support and participation by the eleven laboratories continues. It is our understanding that the goal is to have hired a new School Director by the start of Fiscal Year 2002 and that the present Director, Professor S.Y. Lee of Indiana University has indicated his willingness to continue as Director until the new one is hired.

If you have further questions or wish to discuss the USPAS management further, please do not hesitate to call me. More detailed administrative questions can be addressed to Dr. Sutter at (301) 903-5228.

Sincerely,



John R. O'Fallon  
Director  
Division of High Energy Physics



Department of Energy  
Office of Science  
Washington, DC 20585

NOV 24 2010

Dr. Derek Lowenstein  
Collider Accelerator Department  
Building 911B  
Brookhaven National Laboratory  
Upton, NY 11973-5000

Dear Dr. Lowenstein:

We are writing to you in your capacity as Chairman of the Board of Governors of the U.S. Particle Accelerator School (USPAS). Since 1992, management and support of the USPAS has operated under guidance articulated in a September 13, 1992, letter to Richard Briggs, Chairman, USPAS Steering Committee – the predecessor to the present USPAS Board of Governors and signed by four senior Department of Energy (DOE), Office of Science, program managers. This guidance was reconfirmed and extended in a February 15, 2001, letter from the Director Office of High Energy Physics (HEP), to the Director, Fermi National Accelerator Laboratory, which serves as the managing institution for the USPAS consortium. That letter noted that the impressive expansion of the school's programs to support sciences other than high energy physics was one of the intended effects of the policy established in 1992. Via the Joint U.S./CERN/Japan/Russia School, the USPAS has also contributed strongly to the international exchange and dialogue in the most advanced accelerators.

The DOE (HEP) has been the principal financial supporter for the USPAS since the first school was held at Fermilab in 1981. We know of no better way to have expressed the Department's continuing enthusiastic endorsement of the school's product than this continuing financial support. The formal training of personnel in accelerator science, engineering, and technology in rigorous academic courses hosted by major research universities has been beneficial to all of our programs. Hundreds of graduate students who were trained at USPAS sessions have become internationally recognized intellectual leaders in their field. Many of these graduate students now teach for the USPAS. The United States schools have also led to a series of textbooks covering in detail and comprehensively every aspect of accelerator science, engineering, and technology. A whole literature has been created where none existed before.

Since that time, the structure and management of the DOE Office of Science has changed as has the Management and Operating contractor for many of the consortium laboratories. We believe that it is timely for DOE to formally restate its position with regard to the future support of the school and its management arrangement. The 1992 agreement was intended to maintain the stability of the business side of this enterprise, specifically in the budgeting, financial management, and oversight areas, which the DOE is bound to manage according to well-established and formal requirements.



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We propose the following policy to maintain the strong and well-tested practices that have served the accelerator-based science and technology communities well:

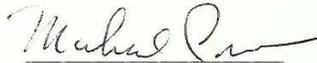
- 1) Good management practice requires the funds for an activity to flow through the same channel as the management control, thereby consolidating the power of management and finance in a single entity. Therefore, funding for all future USPAS at universities should be provided in total, except as noted in points two and three below, directly by the institutions represented on the Board of Governors—continuing the practice adopted since the June 1992 Stanford School. The financial support and management oversight by 11 prestigious DOE and National Science Foundation supported laboratories has, we believe, contributed strongly to the health, vigor, and productivity of the USPAS educational activities. Stable continuing support by the 11 laboratory consortium is *essential* to the financial health of the USPAS, and we very *strongly* endorse continuation of their participation in the USPAS. This approach has the additional advantage that the most affected and interested field representatives of the various scientific disciplines supported by accelerator science and technology can decide at the field level what topics the school will address, how often the schools are to be held, and the amount of financial resources to be applied.
- 2) We reconfirm the principle that a single national laboratory is responsible for budgetary and business management oversight and we believe that it is essential that these activities be performed with care and attention to detail. We further reconfirm that Fermilab should continue to perform this function.
- 3) We reconfirm that HEP will continue to provide funding support for the USPAS office at Fermilab including a full-time USPAS Director, as it has in the past. The activities of the office appear well organized, the staff highly qualified, and the function essential to the schools.
- 4) HEP will, in response to specific requests, provide support for the Joint U.S./CERN/Japan/Russia School whenever it is held in the United States. Partial support for joint schools held outside the United States will be considered on a case-by-case basis.

As senior DOE managers for each of the scientific areas identified by the USPAS, we have reviewed the school's history, its successes, and the promised benefits of its continuation. We have determined that if the members of the USPAS Board of Governors, representing the relevant scientific disciplines and national laboratory organizations, decide that a given school is needed for training personnel, we will support that decision. Furthermore, we will, as a consequence, accept the Board of Governors' collective judgment as adequate justification for funding the USPAS with the Federal funds that our programs provide to the respective laboratories. In summary, we confirm that the funding of university-based USPAS sessions is to be provided by the interested and benefiting national laboratory program organizations plus other institutions that join the USPAS consortium in accordance with its Memorandum of Understanding with a single national laboratory, Fermilab, being responsible for budgetary and business management oversight. We think this approach is fair, equitable, and consistent with the

proven success of "field run" science management and it will become effective as of the start of Fiscal Year 2011.

If you wish to discuss further the reasoning behind this plan, please feel free to contact any of us. Specific questions can also be directed to Dr. Bruce Strauss of the Office of High Energy Physics at (301) 903-3705.

Sincerely,

  
for Dennis Kovar  
Associate Director of Science  
for High Energy Physics

  
Timothy J. Hallman  
Associate Director of the Office of Science  
for Nuclear Physics

  
for Harriet Kung  
Associate Director of Science  
for Basic Energy Sciences

  
for Edmund J. Synakowski  
Associate Director of the Office of Science  
for Fusion Energy Sciences

## Appendices F–J Available in Full Report

Appendices F–J are included in the full report, available online at:  
<http://science.energy.gov/hep/hepap/reports/>