Snowmass ’21: Letter of Interest

At Risk: University-based Accelerator Science and Education

Topical groups:
AF1: Beam Physics and Accelerator Education
AF6: Advanced Accelerator Concepts
AF7: Accelerator Technology R&D

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Abstract:
University-based accelerator research has resulted in important advances in accelerator science and educates students in this critical field, yet support for this research is declining. NSF has terminated its program in Accelerator Science and university funding by DOE through GARD and Accelerator Stewardship has been steady or declining. The declining support for university-based accelerator research will slow advances and threaten student training in accelerator science.

Improving our understanding of beam phenomenology and the related devices will open new opportunities, both for large-scale accelerators and small ones. Accelerators that are just out of reach include not only better X-ray sources and colliders, but also university-scale xFELs capable of femtosecond imaging; ultrafast electron diffraction set-ups that can image not only nanoscale, but also molecular assemblies; and electron microscopes equipped with bright sources that directly investigate phonon-coupling dynamics, opening new pathways for quantum materials. Accelerator technology contributes to quantum information science and is a platform for Machine Learning, which promises new and unanticipated operating modes and designs.

The universities contribute to progress toward these goals and, importantly, educate young scientists with the expertise needed to lead programs in academia and the national labs. Yet university funding is declining. Funding for university-based R&D through the DOE OHEP GARD program, which was once ~$10M annually, has been falling. The Stewardship program provides approximately $4M and BES and NP each contribute approximately $1M.

Tight budgets at DOE are accompanied by steady decline at NSF. At NSF, accelerator science was historically supported by the Elementary Particle Physics program and the NSF Division of Materials Research (DMR). By 2014, this support had ended, and NSF established a dedicated program in Accelerator Science with annual funding of ~$9M. This program was terminated after 2017 due to lack of competition. A few investigators continue to be supported through the NSF plasma physics program and for superconducting magnet R&D through the National High Magnetic Field Lab and DMR.

Today, NSF support for accelerator science is primarily through the Center for Bright Beams (CBB), a Science and Technology Center (STC) launched in 2016 with an annual budget of $4.7M. As described in a separate Snowmass LOI, CBB takes an interdisciplinary approach to a few specific topics: photoemission, superconducting RF, and beam dynamics and control. It also trains young scientists in accelerator science and related fields, and currently supports 30 graduate students, 10 postdocs and 20 undergraduates. CBB is effective, but STCs have a maximum ten-year lifespan and after CBB closes, in 2026 at the latest, there is no well-developed plan for further NSF support of accelerator science.

An immediate consequence of the decline in university funding is compromised student training, and this will get dramatically worse after CBB sunsets. Despite the importance of accelerators, the U.S. educates few students in beam physics and accelerator science and technology [1]. Approximately a dozen U.S. universities offer doctoral degrees in accelerator science [2], together producing 15–20 doctoral accelerator scientists per year; but the estimated need at labs and in industry is three to four times that number [2]. By contrast, Europe and increasingly Asia educate far more [3]. In response to the demand, OHEP has established Traineeship programs at MSU, IIT/NIU, and Stony Brook, but the gap remains. The graduates of university accelerator programs are high impact and hold many leadership positions at the DOE labs.

This decline in university funding will also slow progress in accelerator science. Universities have contributed to laser and plasma-based acceleration, superconducting RF cavity development, electron cloud, space charge and other collective effects, storage ring lattice design, and energy recovery linac development, as well as exciting directions in small-scale accelerators, including UED beamlines, compact XFELs, and electron microscopes.

The declining funding to universities threatens to put a hole in US accelerator science and stunt the training of the next generation of accelerator scientists needed to carry the field forward. It is not too late to reverse the trend: University capabilities remain strong, interdisciplinarity is sparking academic interest, and graduates find compelling job opportunities. For success, funding must be sufficient to draw talent, support students through to graduation, provide on-campus student-oriented research facilities, and allow training at specialized schools like the US Particle Accelerator School and at national laboratories. For a strong university program, Snowmass and the subsequent P5 process will be critical.

References

[1] HEPAP Subcommittee, "OHEP Workforce Development," May 2014. [Online]. Available: https://www.energy.gov/sites/prod/files/migrated/sc/hep/hepap/pdf/May-2014/Patterson_HEPAP_DOEWorkforce_v1-1.pdf.

[2] HEPAP Subcommittee, "Review of the United States Particle Accelerator School," May 2015. [Online]. Available: https://science.osti.gov/-/media/hep/hepap/pdf/Reports/HEPAP_USPAS_Subcommittee_Final_Report.pdf.

[3] V. Shiltsev, "Particle beams behind physics discoveries," *Physics Today*, vol. 73, no. 4, pp. 32–39, Apr. 2020, doi: 10.1063/PT.3.4452.