An Accelerator Science Ecosystem

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I. INTRODUCTION

Accelerator science and technology, along with their associated R&D programs, continues to have a major impact on many fields of science and on society at large. The most well-recognized impact is in discovery science, where accelerators are used as tools to probe fundamental physics questions where accelerators are sometimes the only option to provide the answers sought. The most recent example of that is the discovery of the Higgs boson at the Large Hadron Collider [1]. The reach of accelerators, though, extends far beyond high energy physics and even beyond the purview of discovery science. They span today almost all aspects of our lives, while their impact is still not readily recognized. The importance of accelerator science and technology, however, is gaining more attention. In recognition of the role accelerators and the associate technologies play across various Office of Science programs, the Office of Science has recently created the Office of Accelerator R&D and Production under the Office of Engineering and Technology. It will not only address general accelerator R&D but also focus on such technologies as high-field magnets, control systems, materials science and high-power lasers. The goal of this Letter of Interest is to indicate the potential of the creation of an ecosystem for accelerator science that reaches far beyond particle physics.

II. ANTECEDENTS

It is difficult to overstate the impact and prominence of accelerators. The genesis of the field of accelerator physics lies squarely in the quest to understand matter at its most fundamental level. From its humble beginnings it has led to the construction of massive particle accelerators for fixed-target and collider experiments. Notable recent examples in the U.S. include the proton-antiproton Tevatron accelerator at Fermilab, the Relativistic Heavy Ion Collider at Brookhaven and the Stanford Linear Collider at SLAC. These single-purpose facilities have led to the development of accelerator-based user facilities that are unique tools for a broad science community. Electron accelerators are at the core of the various light sources, such as the National Synchrotron Light Source (NSLS-II) at Brookhaven, the Advanced Photon Source (APS) at Argonne, the Advanced Light Source (ALS) at Berkeley, or the Linear Coherent Light Source (LCLS) at SLAC. These facilities serve a very large user community with an impressive scientific breath, ranging from the studies of materials to the development of new drugs. The most recent machines deploy at-scale advanced technologies for both the acceleration as well as manipulation of the beams. Proton-based accelerators drive the generation of neutrons at neutron scattering facilities, such as the Spallation Neutron Source (SNS) at Oak Ridge. A most recent example of the significance of these facilities is the 2016 Nobel prize in physics awarded to David Thouless, Duncan Haldane and Michael Kosterlitz for their theoretical discoveries of topological phase transitions and topological phases of matter, where neutron sources were key to validating their theories.

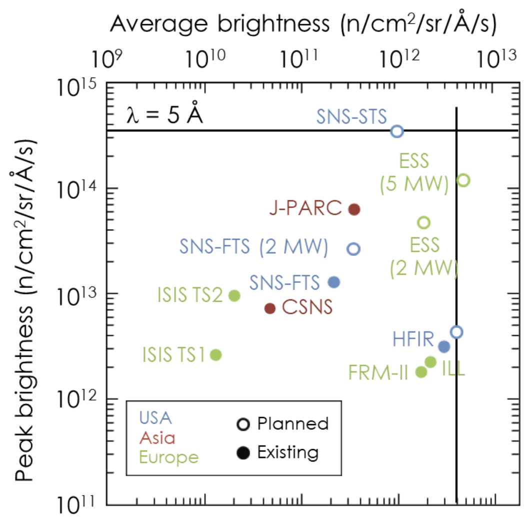

FIG. 1. An example of the advance of proton drivers for neutron scattering facilities using the metric of peak versus average brightness [2]

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III. CURRENT STATUS

Most of the recent accelerator-based science facilities are not in the field of particle physics. Three light sources are undergoing a major upgrade. Under construction are LCLS-II at SLAC, ALS-U at Berkeley and APS-U at Argonne. The Facility for Rare Isotope Beams (FRIB) is nearing completion at Michigan State University for the study of the properties of rare isotopes, nuclear astrophysics and applications for society, including isotope production. The Electron Ion Collider project has just been initiated at Brookhaven to unlock the secrets of the strong force. At Oak Ridge a Proton Power Upgrade (PPU) project is under way that will deliver a 2.8 MW proton beam at 1 GeV to serve a new neutron scattering facility, the Second Target Station (STS) (see Fig. 1). Plans to develop a muon source for Muon Spin Resonance studies is being considered at Oak Ridge as well. The main accelerator project under way for high energy physics is, to the best of my knowledge, the Proton Improvement Plan (PIP-II) at Fermilab that will provide a 1.2 MW proton beam at 120 GeV in support of the long-baseline neutrino program.

The Accelerator R&D Task Force Report [4], commissioned by the Office of High Energy Physics in 2012, identified seven grand challenges for the long-term development of the field of accelerators:

- Extend the energy reach of the collider technology;
- Extend the beam power and intensity reach of hadron accelerator technology;
- Develop high gradient accelerating structures;
- Develop new acceleration methods;
- Develop tools and technologies for the manipulation of particle beams and beam phase-space;
- Increase brightness and coherence;
- Develop compact accelerators;

Many of these challenges remain as valid now as then. To be successful in any of these areas will require collaboration across science disciplines. Not only will institutions with accelerator expertise need to work together, but other expertise such as materials science will have to be brought in to break current technological barriers. Bringing accelerator expertise together, and intersecting it with other science disciplines, will create an energizing ecosystem that will benefit all partners. It will also provide a fruitful training ground and career opportunities for the next generation of accelerator physicists, which will be critical for the health of the field.

IV. CONCLUSION

Accelerator R&D is inherently complex and costly; construction of new facilities is far and few. Other areas of science using accelerators are rapidly making progress in areas that would benefit high energy physics. Maintaining a strong and healthy accelerator workforce is becoming increasingly more difficult for single institutions and single science disciplines. Each institution and every science discipline that uses accelerators, however, has a lot to offer to advance this critical technology. The field of science and, as a corollary, society as a whole, stands to gain tremendously by jointly developing an ecosystem for accelerator science. The creation of a new office within the Office of Science for accelerator R&D and Production is a first step in this direction. It is suggested that the high energy physics community, historically the steward of accelerator physics, takes a proactive role in helping create this ecosystem to benefit science and society.

[1] ATLAS Collaboration, Phys.Lett. B716 (2012) 1-29; CMS Collaboration, Phys. Lett. B 716 (2012) 30.

[2] ORNL/TM-2015/24 `https://neutrons.ornl.gov/sites/default/files/SNS_STS_Technical_Design_Report_2015-01.pdf`

[3] V. Lebedev et al. (PIP-II Collaboration), *The PIP-II Conceptual Design Report*, FERMILAB-TM-2649-AD-APC (2017). `https://pxie.fnal.gov/PIP-II_CDR/PIP-II_CDR_v.0.3.pdf`

[4] Accelerator R&D Task Force Report, `http://www.acceleratorsamerica.org/report/accelerator_task_force_report.pdf`