APS DPB

Division of Physics of Beams

Newsletter 2016

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Chair's Report

Stephen Gourlay, Lawrence Berkeley National Lab

As the DPB Executive Committee Chair for 2016 it is my duty and pleasure to provide you with a brief report of our activities this past year. But first, I want to thank Sam Posen again for his hard work and persistence in getting out the second consecutive Newsletter. We're on a roll! The DPB has many objectives: promoting research in the science of beams, publication in scholarly journals, education in beam science and technology and a forum for communication via sponsorship of conferences and, of course, this Newsletter. This year we are looking forward to NA-PAC'16 that will be held in Chicago, IL from October 9 – 14. Planning for IPAC'18, the next Particle Accelerator Conference to be held in North America, is well underway. We also organize and sponsor sessions in the April APS meeting which this year was held in Salt Lake City, UT. Our emphasis has been on presenting general topics that would be of interest to a broader community and some of our sessions were co-sponsored with DCOMP, DPF and DNP. This year we had talks on the ILC, SCRF, Wakefield Acceleration of Positrons, Future Colliders, Electron-Ion Colliders, Accelerator Codes for Emerging Architectures and Electron Beams for Parity Experiments. We believe that the April APS meeting is a great opportunity for outreach and we would really appreciate your input on how we can enhance DPB's role in this meeting. Our community is facing new challenges in the coming years, among them is the reduction in research funding in favor of projects and the new Congressional mandate that forced DOE to fund grants under $1M completely upfront which significantly reduced the number of grants. We welcome your input on how DPB can be more effective in dealing with these issues.

From the Editor

Sam Posen, Fermilab

Welcome to the 2016 APS DPB Newsletter! As usual, the newsletter contains useful information for the beam physics community about DPB governance, events, awards, and major news. In this edition, you will also find an editorial on the subject of accelerators in academia, updates from USPAS and PRAB (formerly PRST-AB), and news from several major projects and future facility studies. Towards the end of the newsletter, you will find obituaries of members of our community that we have lost recently, focusing on their work in the field.

I would like to extend a tremendous thanks to our contributing authors. This newsletter would not exist without your hard work. Special thanks also to Ernie Malamud for valuable consultations and for contributing again this year as Associate Editor, to the APS who hosts the newsletter online, and to the DPB executive committee for their strong support.

Recent DPB Bylaw Changes

Stan Schriber, DPB Secretary-Treasurer

The APS-DPB EC discussed our DPB Bylaws at their 2015 EC meeting and decided to make three amendments to the Bylaws. These changes were sent to the APS Corporate Secretary to arrange for APS approval, who in 2016 April suggested a combination of revisions required by governance reform associated with various changes in APS governing documents, and by best practices established by the APS Governance Committee (GC). The APS-DPB EC reviewed and approved these suggested revisions, sending back the overall revised Bylaws to APS for their approval 2016 April. There are three steps required within APS to have Bylaws changed. First, the GC reviews the amendments (interacting with the proposing unit during their meeting for further explanations and making any changes that might be needed); if approved by the GC, the amendments go to the APS Council for their review and approval. Second, if approved by the APS Council, APS sends their suggested Bylaws back to APS-DPB EC for their review and approval to any changes made in the process. Third, assuming that the APS-DPB EC approves the Bylaws returned from APS, the APS-DPB Secretary-Treasurer makes the amended Bylaws available to the APS-DPB Membership for their approval. If approved by the APS-DPB Membership, the Bylaws are then changed in the official APS documents.

Because of urgent APS business, we were asked if it was okay to remove the DPB Bylaws amendments from the GC 2016 May meeting agenda. We are awaiting the GC to review our Bylaw amendments in time for the November APS Council meeting.

The three items that we were interested in making amendments to the APS-DPB Bylaws were:

1. We wanted to add to the APS-DPB list of Objectives a statement on diversity, so decided on adding to the list the following item: Endorses the APS Policy on Equal Professional Opportunity.
2. The most recent amendment to the APS-DPB Bylaws added a Student Member-at-Large to the APS-DPB EC, but the term for this position can easily include the period that the selected individual is no longer a student, so we decided that a more appropriate term would be Early Career Member-at-Large.
3. The most recent amendment to the APS-DPB was confusing as to how a Secretary-Treasurer (S/T) would be trained. An individual would be trained, but there was no guarantee that the individual would be elected. The suggested amendment changes the arrangements for election of a new S/T with the first year having the individual acting as Deputy S/T, being trained during that year by the existing S/T who is finishing the last year of their term as S/T.

Highlights from IPAC'16

Won Namkung, IPAC'16 Conference Chair, Pohang Accelerator Laboratory

The 7th International Particle Accelerator Conference, IPAC'16, was held at the BEXCO Convention Center, Busan, Korea, from May 8 to 13, 2016. There were more than 1,200 attendees from 36 countries, 540 from Asia, 490 from Europe and 190 from Americas. It was hosted by the Pohang Accelerator Laboratory (PAL), the Korea Multi-purpose Accelerator Complex (KOMAC), the Korea Heavy Ion Medical Accelerator (KHIMA), and the Rare Isotope Science Project (RISP). It was organized under the auspices of the Asian Committee for Future Accelerators (ACFA), the European Physical Society Accelerator Group (EPS-AG), and the American Physical Society Division of Physics of Beams (APS-DPB).

The traditional student poster session was held on Sunday. Seventy-six students from all over the world were able to attend the conference through the sponsorship of societies, institutes and laboratories worldwide. The organizers of IPAC'16 are grateful to all sponsors for their valuable support.

Won Namkung (PAL), Chair of the Organizing Committee (OC), In Soo Ko (PAL), Chair of the Scientific Program Committee and Kyung-Ryul Kim (PAL), Chair of the Local Organizing Committee (LOC), opened the conference. Mr. Byung Soo Suh, Busan City Mayor, and Mr. Tae-min Bae, an official from Ministry of Science, ICT (Information and Communication Technology) & Future Planning, both addressed the conference attendees.

Presentation in main auditorium at IPAC'16

Sachio Komamiya (ICEPPE) opened the scientific program with a presentation on *The International Linear Collider, the Latest Status towards Realization.* An inspiring closing presentation was delivered by Wen-Long Zhan (CAS, Beijing) on *Accelerator Driven Sustainable Fission Energy.*

Ninety-eight invited and contributed oral presentations of very high quality were made during the week, including an unusual "Entertainment" presentation by Zev Handel (University of Washington, Seattle) entitled *Learn to Read Korean: An Introduction to the Hangul Alphabet.*

Zev Handel delivers the "Entertainment" presentation on the Hangul Alphabet

The scientific program was developed by the IPAC'16 Scientific Program Committee (SPC). It was truly an international body with coming 50% of the members coming from Asia and 50% from Europe and the Americas. The conference program spanned four and a half days, with plenary sessions on Monday and Friday mornings, and Thursday afternoon. All other sessions were composed of two oral sessions in parallel, with the poster sessions scheduled alone at the end of each afternoon. There were 47 invited talks and 51 contributed oral presentations; 1300 posters were scheduled during the lively afternoon poster sessions.

An industrial exhibition took place during the first three days of the conference. Industrial exhibitors from 86 companies occupied 92 booths with additional 16 booths from non-profit organizations. They presented their high technology products and services to the delegates in an excellent atmosphere conducive to discussions.

Industrial exhibition

The LOC organized companion tours around Busan, to the historical city of Gyeongju, and hiking at Mt. Namsan. After the conference, there were facility tours to PLS-II and PAL-XFEL, KOMAC and KHIMA in the afternoon

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on Friday.

The proceedings of IPAC’16 are published on the JACoW site (www.jacow.org). The processing of the electronic files of contributions prior to, during, and immediately after the conference was achieved by the JACoW "seasoned experts". Thanks to the work of this dynamic team and the careful preparations and guidance of Christine Petit-Jean-Genaz (retired, CERN), Kyung-Sook Kim (PAL) and Dong-Eon Kim (PAL).

Companion program at Bulguksa in Gyeongju

Technical tour in the PAL-XFEL tunnel

Attendees show their appreciation for the members of the local organizing committee.

The high levels of participation and enthusiasm shown at IPAC’16, the third IPAC taking place in Asia, clearly indicate the strong mandate for the International Particle Accelerator Conference series from the worldwide accelerator community. May future events be even more successful than this one. The eighth IPAC will return to Europe and take place in Copenhagen, Denmark from 14-19 May 2017. We are convinced that the collaboration among the three regions, steadily enhanced in recent years, will continue to grow to the benefit of IPAC and the accelerator community worldwide.

The IPAC flag was turned over to IPAC’17.

Invigorating Accelerator Science in Academia

John R. Cary, University of Colorado and Tech-X Corporation

1. Introduction

In 2015 the DOE published the RFI, “Strengthening US Academic Programs in Accelerator Science” [1], which stated, “Approximately 10-12 accelerator science PhDs graduate each year in the US …. This is traceable to the small number of US universities that have accelerator faculty and offer instruction in accelerator science.” The RFI referred to the HEPAP report, “HEP Workforce Development Needs” [2], which stated, “Europe awards approximately 100 doctoral degrees in accelerator science annually,” and implied that US needed to be producing accelerator doctorates at this same rate. The goal of this article is to provide additional information on the status and trends of accelerator science in academia and to ask what sort of investment would be needed to invigorate academic accelerator science.

To put a finer point on this, we distinguish between

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conventional accelerator science and advanced accelerator (concepts) science (as it has come to be known). Conventional accelerator science deals with beam optics, electromagnetics of structures, and so forth as described in the second paragraph of the above RFI; the acceleration is effected by electromagnetic fields oscillating in the 0.1-100 GHz range and, due to material limits, the associated acceleration has been practically limited to roughly 50 MV/m with a hard theoretical limit that is of order 1 GV/m. Advanced acceleration primarily refers to acceleration through beam-plasma or laser-plasma interaction, or by wakes induced in structures by lasers or beams. Advanced acceleration has demonstrated accelerations three orders of magnitude greater, i.e., 100's of GV/m, but there remains a great deal of work before such accelerators are practical. Primarily conventional accelerator scientists go to conferences like LINAC, while primarily advanced accelerator scientists go the Advanced Acceleration Concepts Workshop. Both attend IPAC and NAPAC, but those conferences are dominated by conventional accelerator science.

Given the RFI's statement, "With an estimated 30,000 particle accelerators operating worldwide, there is a significant—and growing—need [1] for a technically competent workforce," the situation is more dire, because the need is specifically for PhDs in conventional accelerator science (cf also [3]). Of those 10-12 accelerator science PhDs graduating each year, a subset are in conventional accelerator science.

2. Status

Reference [2] gives a discussion of the state of academic accelerator science. Here we provide multiple, complementary measures that show that academia is particularly poorly represented in accelerator science. Perhaps easiest is to just visit the websites of the physics departments of the 62 members [4] of the American Association of Universities (AAU). Of those 62 physics departments, only a handful have tenured or tenure-track faculty carrying out research in conventional accelerator physics. (In contrast, nearly all would have condensed matter research.) Probably only 3-4 AAU members have an actual group in accelerator physics, with three or more tenured or tenure-track faculty doing work in this area. This creates a problem in the teaching of courses, as to teach a course, one must get some minimum number of students, and the number of available students is related to the rate of flow of students through accelerator studies. E.g., with three professors each graduating one student per year, there are three students to take the accelerator physics course per year – not enough, but just barely enough to have an accelerator physics course every other year, with some interest from students in other areas.

The lack of representation of accelerator science in academia is reflected in professional organization membership and other publications. The Division of Physics of Beams has the lowest student fraction (15%) of any division of the American Physical Society [5] for which as a whole the student fraction is 39%. This is also reflected in the leadership [6] of the Division of Beam Physics. The current DPB Executive Committee, on which the author serves, has only two members from academia (one is the author) and none in the Chair rotation. By comparison, the Division of Condensed Matter Physics [7] has 12 members from academia, with all four in the chair rotation from academia. (This is in no way a comment on the elected DPB leadership; they are the best leaders, as designated by their colleagues. It is simply to note that the likelihood of university professors being elected to the DPB leadership is small because there are comparatively few university professors in the DPB.) The lack of academic accelerator science programs is also seen in the US News and World Report rankings [8]. None of Accelerator Sciences, Beam Physics, or Accelerator Physics is even on the list.

3. Benefits associated with academic accelerator science

Students as often as not do not know what subfield of physics they wish to pursue when they enter graduate school. Consequently, many students apply to the universities where there is the widest array of opportunities. Additionally, the best physics students go to the research universities with the highest ranked graduate programs in physics. (US News and World Report [8] gives one ranking; membership in the AAU gives another.) Thus, increasing or initiating accelerator science at these universities in particular will give the field of accelerator science access to the best graduate students in physics.

More accelerator science in academia (if properly funded) will also increase cross-talk with other fields, which occurs much more readily in broad departments rather than special-purpose labs. As discussed in the literature [9], high-impact science comes out of interacting with many fields, bringing the ideas from one field to another. (It seems that high-impact science is also more likely generated by longer-term funding rather than the three-year grant cycle, which tends to produce mostly incremental advances.)

Finally, the higher fraction of students correlated with having more faculty in academia leads to a more vibrant field, with more new ideas generated by the younger members. It provides a method of outreach, in that with more students some naturally leave the field, providing benefit to other areas of R&D. By leaving the field of pure research and entering industry, they also communicate the benefit of accelerator science to the broader economy. Finally, having more students also means that those who stay will likely be of higher quality because of the increased selectively for staying in one's initially chosen field.

4. Costs associated with academic research

Getting accelerator science into academia will require funding. There are multiple costs associated with maintaining an academic group at a university, including the per-graduate student cost, the cost of other personnel involved in a research group, summer salary for the faculty member, equipment for both experimentalists and computational theorists, technicians and computer system administrators. There are about 5400 physics faculty at PhD granting institutions graduating 1800 Physics PhD's

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per year [10], i.e., 1/3 PhD per faculty-year. So here we compute the cost of maintaining a modest research group of one faculty member, three students, and a senior (or postdoctoral) researcher. Such a group would ideally produce one PhD/year (though in practice, completing a thesis in 3 years is fast compared with the mean).

The numbers presented here more likely apply to public institutions, but they are probably accurate to within 10's of percent. The faculty member of course holds the endeavor together, ensuring not only that students stay on track, but also that the group obtains resources from the University to carry out its work. Summer salary and benefits along with two conference trips per year is roughly $100k/yr, fully burdened (including fringe benefits, indirect costs, etc.). Each graduate student is about $80k/yr fully burdened and including tuition and some travel. Groups of this size work much better with a more senior researcher, who is able to collaborate with the graduate students more intensely, being devoted to research and not teaching or doing university service work. A senior researcher is now of the order of $180k/yr. So such a group costs $520k/yr. without any equipment or any funding for technical assistance (e.g., lab technicians or computer system administrators). If the students really do graduate in three years (optimistic), then this is the cost per PhD: $520k, or about the cost of one FTE-year at some of the national laboratories. This number contains no funds for equipment, so it is likely an underestimate. One can crosscheck this number in various ways, one of which is to note that the funding per tenured physics faculty member is of order ~$600k/yr at the AAU public universities, which is probably the better estimate but likely still low due to ignored costs and the use of an optimistic PhD productivity.

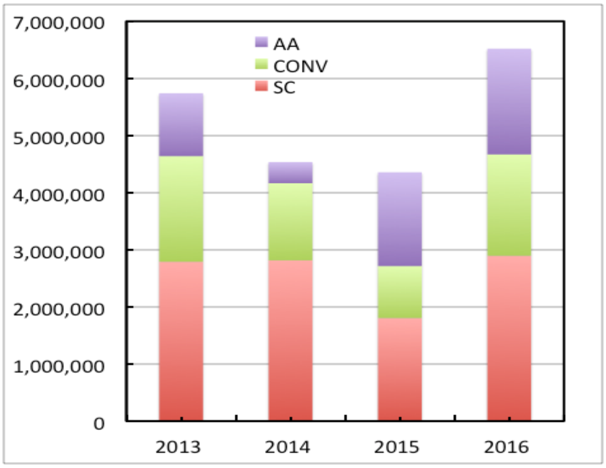

Fig. 1: DOE-HEP funding in USD for accelerator science at universities, categorized by the author as advanced accelerators (AA), conventional acceleration (CONV), and superconductor research (SC). Funding prior to 2013 is not easily obtainable from the awards search web page.

One can, of course, fund smaller grants, but one always gets what one pays for. As one drops below various thresholds, one loses key synergies. For example, as noted above, one must have three professors funded in total at about $1.8M/yr to approach sufficient student flow through to have courses in accelerator science. Without such flow through, each student has to be individually educated in the background needed to do research in accelerator science, thus increasing the time and cost of producing a PhD by 25-30%. If a professor's funding is reduced to below $250k/yr, one loses full attention of that professor, who then needs to find alternate funding to compete with other faculty in research.

Regardless, no matter how one distributes the funds, smaller grants at more places or larger grants at fewer places, the cost per PhD is at least ~$600k, and so if one would like the academic representation to be producing of order 100 PhDs per year, the effort needs to be funded in excess of $60M/yr (within 10's of percent).

This is a large amount of funding. However, compared with the accelerator endeavor, $60M/yr is small. Just the DOE community relying on accelerators is in excess of $2.3B/year ($800M for HEP, $500M for NP, $1B for BES). Perhaps not all missions of these offices rely on accelerators, but then there are many other agencies and private industry that do rely on accelerator science. Relative to $2.3B, $60M is 2.6%.

On a positive note, the funding of academic accelerator science has increased due to the creation of the NSF Accelerator Science program. Historically, the only funded academic accelerator science was through the DOE-HEP University Grants program [11] (see Fig. 1), which saw a drop in funding to a low of $1.7M in advanced accelerators (AA) and conventional acceleration (CONV), i.e., excluding research in superconducting materials. That number has rebounded in recent years to about $3.6M. (The

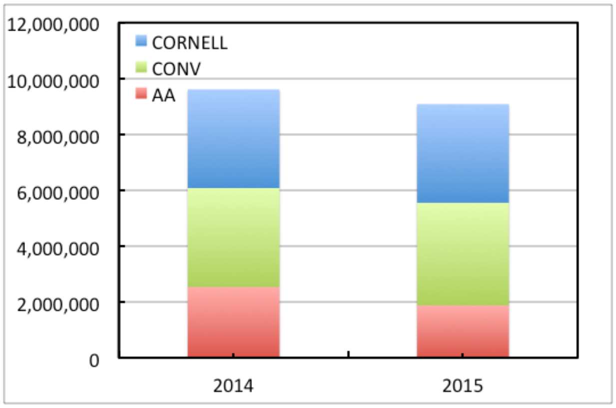

Fig. 2: Funding in USD of the NSF accelerator science program. The funding is separated into three categories. The Conventional (CONV) and Advanced Acceleration (AA) categorization was done by the author upon reading the grant abstracts. The funding marked CORNELL was one large grant to Cornell University for which we assume the funding was spread out over three years. It may contain a mix of accelerator research, including on superconductor materials and preparation. The numbers are approximate because there is some lack of clarity about the fiscal year of some grants.

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drop may have been due to the recent institution of the “full funding” requirement by Congress that funds for grants under $1M be committed at the time of award.) With NSF’s accelerator science program [12], accelerator science support has increased funding (see Fig. 2), with support for AA and CONV summing to $6.5M and total support (how the Cornell funding is categorized is unclear) in the $10M range. (There was support for AA in the NSF-DOE plasma science program, but that has been moved to the accelerator science program). Having multiple sources of funding is a big plus, as the average 3-year grant funding is under $600k ($200k/yr) for DOE-HEP and around $350k ($116k/yr) for NSF, so that a typical professor needs to have multiple grants in place to be supervising the 3-4 graduate students needed to produce one PhD/year. Regardless, one can comfortably say that accelerator science (excluding the superconducting materials research part of the NSF Cornell grant) is funded at about $12M/yr. This is still a ways from $60M, and few schools have formed groups in accelerator science, but the situation is improving. Getting to $60M will likely require involvement of other funding sources, such as other (than HEP) DOE offices and other agencies (AFRL, ONR, ARO, NIH) that also use accelerators in their research.

5. Other barriers

Universities change slowly, over careers, and there is enormous competition for developing new areas of study within departments. In a department that is not growing, this is particularly difficult, as each group will want to ensure that students begin their thesis research well prepared, so that the professor does not have to spend time on individual pre-research education. This requires the ability to teach advanced courses in that area, and that again gets back to a minimum application area number of faculty.

Another barrier is ensuring, at least in a physics department, that “academic research” can be supported. In essence this is curiosity-driven research, research that is often long-range. This can be difficult for accelerator science when it is viewed as mission science, so that funding depends on application to the next machine rather than whether the science is inherently good. The support of academic research in academia is crucial to counteracting the ‘view of accelerator science as “technical development”, rather than as the exciting interdisciplinary field that it has become.’ [2]

Perhaps worse is the ratchet effect that we see in academia. Universities move slowly. Departments make 5-year plans. Perhaps the lone beam physicist (a foothold) convinces the department to make a hire in this area. The dean releases the position a few years later, a hire takes another year. Then the new professor seeks funding, and after that is in place, hires a graduate student, and 4-5 years later one has a new PhD. So it is easily a decade from conception to PhD production, and that is only if someone in beam physics is already there. (These time scales apply to any field, of course.) Hopefully, along the way, they get permission for another hire, so that they have a beachhold, a critical mass of three or more professors studying a common area. Once a beachhold is formed, the goup will work hard to maintain the critical mass and hopefully grow it.

Now let's look at the other end. A beam physicist loses funding. A second proposal is written but that fails. That person will then shift to another field if not old enough to retire. So now an opportunity, a foothold, has been lost; this decrease in University funding for a year or two undoes a decade of work to get to a beachhead.

6. Approaches

Universities, both their faculty and administrators, do respond to opportunity, and other fields have taken advantage of this fact. One way is to fund centers of excellence. An example of one is the $13M “Center of Excellence for Materials Research and Innovation at Yale and Southern Connecticut State University.” These can have the benefit of both providing longer term funding, leading to higher-impact science, and as leverage to get universities to hire in accelerator science. This can be done at a small scale, with solicitations allowing co-funding of faculty on grant funds for the first few years. Other agencies have released such solicitations. Reference [2] gives other suggestions for increasing the presence of accelerator science in academia. But even if the system stays substantially the same, some changes could be made. At the very least, grants should be moved to $300k/yr minimum, so that they can support a significant research endeavor, even though that will result in fewer grants.

7. Costs of not increasing academic accelerator science

In the present system, many scientists who ultimately pursue a career in accelerator science did not get a degree in accelerator science. So this means that the cost of the education of such scientists begins with the cost of the degree they did pursue, ~$600k with the above estimate, followed by some years of on-the-job training, during which they are paid a fully burdened salary. Given such costs at the national laboratories, one can conclude that the cost of training an accelerator scientist in the present system could be twice what it would be with more accelerator science in academia.

There are other hidden costs as well. For example, the hiring process takes more effort when one draws from a smaller pool. Project startup time must increase when one cannot make effective use of a new hire because that hire must first be trained in the basics of accelerator science.

8. Summary

By many measures, accelerator science is poorly represented in academia, with the Division of Physics of Beams of the American Physical Society the most poorly represented in terms of professors or students of any division of the APS. The disparity is so great, that even with any conceivable rate of increase of accelerator science funding, the gap will not be closed for many years. The establishment of an accelerator science program at NSF has been encouraging. If there is a will to invigorate accelerator science in academia, then there are paths forward, including the development of centers and cofunding of faculty. If this is pursued, then ideally one will aim towards critical masses of groups at multiple universities that will

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allow the teaching of advanced courses and higher PhD productivity. Funding agencies will need to figure out how to advance footholds and secure beachheads. Given the time scales at academic institutions, this requires long-term commitment.

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[4] Association of American Universities Member Institutions.

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[6] Past Executive Committees, American Physical Society Division of Physics of Beams.

[7] Executive Committee, American Physical Society Division of Condensed Matter Physics.

[8] Best Grad Schools in Physics 2014, US News & World Report.

[9] R. Fisman and T. Sullivan, We Need More Iconoclasts, Slate, 6/28/2016; J. Wang, R. Veugelers, and P. Stephan, Bias against Novelty in Science: A Cautionary Tale for Users of Bibliometric Indicators, NBER Working Paper No. 22180, 4/2016; P. Azoulay, J. S. Graff Zivin, G. Manso, Incentives and creativity: evidence from the academic life sciences, RAND Jounral of Economics, 9/12/2011.

[10] P. Mulvey and S. Nicholson, Trends in Physics PhDs, AIP Report, 2/2014.

[11] These numbers were obtained by searching the DOE's PAMS system for the awards under DOE FOA's 733, 948, 1140, 1358 with program area containing the word, "accelerator". The amount used is "Amount Awarded this FY" unless that showed zero, in which case the "Amount Awarded to Date" was used.

[12] Accelerator Science Information for Proposers, National Science Foundation Division of Physics.

Update from USPAS:
"After Changes Upon Changes We are More or Less the Same" [1]

William Barletta, USPAS Director, Fermilab

Accelerator science and technology is inherently an integrative discipline that combines aspects of physics, computational science, electrical and mechanical engineering. Despite more than 70,000 peer-reviewed papers with "accelerator" as a keyword being available on the Internet, formal training in accelerator science and technology is absent from all but a handful of American universities. In collaboration with leading research universities, the US Particle Accelerator School (USPAS) has acted decisively to remediate this limitation for thirty-five years by providing instruction in the science and engineering of particle accelerators and their constituent technologies.

The first USPAS session, held at Fermilab, was a symposium style school with much the same symposium-style format that the CERN Accelerator School still uses. In 1987, the USPAS adopted its present, university-style format of eight, graduate-level courses held in parallel. Participants in USPAS sessions choose from a broad spectrum of courses in accelerator physics and technology, most of which would never be covered at a university and very few if any of which are touched on in a physics or engineering department. The courses are academically rigorous and carry direct university graduate credit awarded by the host university of the session. Our most recent academic session has just been completed in Fort Collins hosted by Colorado State University (CSU) with three of the courses being offered by CSU faculty.

From 1992 through 2015, the USPAS had been governed by the USPAS Consortium of DOE national

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laboratories and NSF university accelerator centers with Fermilab as its Managing Institution. The governing institutions, representing all DOE and NSF offices with major accelerator operations, provided direct funds for the USPAS session plus the in-kind contribution of their staff and faculty to teach our courses. In parallel, the DOE Office of High Energy Physics (OHEP) funded all costs of administering the USPAS Office at Fermilab. The DOE relied on the Consortium to evaluate and approve all activities. This structure had been formally sanctioned by the DOE in authorizing letters issued in 1992, 2000, and 2010. The result was 52 highly successful academic sessions, hosted by 34 of America's major research universities, offering 24 courses annually.

In FY15, the DOE Office of Science requested that the High Energy Physics Advisory Panel (HEPAP) conduct a thirty-year retrospective review to examine and assess the USPAS, its programs, its governance, and its impact on the US Accelerator workforce. In its report [2], issued in May 2015, HEPAP concluded that "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 … 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 USPAS program is cost effective."

In early FY16, the DOE Office of Science (SC) articulated a new directive to make the USPAS fully consistent with all of its other programs with respect to the flow of funds, management accountability, and program review. The USPAS is now fully accountable to the Fermilab Director and OHEP program with all funding for both program administration and the semi-annual sessions being provided directly by OHEP to Fermilab. Although the former consortium members no longer contribute direct funds, they continue to act as a formal collaboration to provide the instructors for USPAS courses.

Under the new governance we have now completed two successful sessions. The first was hosted by the University of Texas at Austin where the USPAS introduced a new recognition, the USPAS Ironman Award for accelerator scientists and engineers who have made an extraordinary contribution to our community by teaching at least 12 sessions. This year five awards were given: Mike Syphers (15 classes), Don Cossairt (14 classes), John Byrd (13 classes), William Barletta (13 classes), and Alex Chao (12 classes). All these recipients also taught one or more classes this year. With respect to the longer-standing award, the USPAS "Prize for Achievement in Accelerator Physics and Technology", the Prize Committee is now receiving nominations. The prize will be awarded at our Winter 2017 session that will be hosted by the University of California at Davis.

The Winter 2017 session will offer a full program of three two-week courses and five pairs of one-week courses. Detailed course descriptions can be found on our website (http://uspas.fnal.gov) along with applications for attending that session and for financial assistance. The Summer 2017 session will be hosted by Northern Illinois University (awaiting final approval by the university); the venue in Lisle IL has been selected and the program planning is nearly complete.

Due to the tight budget constraints of our new operational model, the USPAS must implement several targeted cost-saving measures to continue to provide the best possible service. Absent an infusion of new funds, the number of courses offered per year will be reduced from 24 to 16. In addition, the overall level of scholarship support must also be reduced by ~30%. Accompanying these reductions, we must raise the registration fee to reflect more accurately the full cost of conducting sessions.

To effect these reductions, a new policy regarding scholarships for USPAS sessions becomes effective immediately and applies to the Winter 2017 session. It enables us to keep program expenditures consistent with budget guidance from OHEP while seeking to minimize the impact on session attendance. Henceforth, only degree-seeking, graduate or undergraduate students are eligible for scholarship support. Any financial support for students working at or associated with a DOE laboratory will be extremely limited. As always, USPAS scholarships will be awarded on a highly competitive basis without regard to race, gender, or national origin. Consideration will be given to balancing class sizes.

In another major change, with the retirement of Professor S.Y. Lee, Indiana University (IU) will no longer accept new students into the IU/USPAS Masters Program. Those already in the program will not be affected by this change. Anticipating S.Y.'s retirement, we have been working with another university for the past 18 months to take over the USPAS Masters Program. Degree criteria will be similar to those of the Indiana University program. We expect an announcement soon of that new partnership.

This year has been a year of transition. We continue to have the strong support of all the laboratories in the USPAS collaboration. Our goal remains the same as that which inspired Mel Month of BNL to found the USPAS: to provide an outstanding quality graduate program for people interested in accelerator science and technology, whether they build, operate, use, design, or are just fascinated by accelerators.

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Update from Physical Review Accelerators and Beams

Frank Zimmermann, PRAB Editor, CERN

PRAB (formerly *PRST-AB*) is a pioneering Open Access journal, which was launched by the APS in 1998, on the initiative of the founding editor Robert H. Siemann and his colleagues. It is an APS journal covering all aspects of accelerators from fundamental physics to technology. Funding from Sponsors allows its distribution at no cost to authors or readers. Two affiliated professional groups – the EPS-AG and the APS-DPB – are jointly responsible for the health and vitality of *PRAB* by providing advice and encouraging scholarly publication in accelerator science and technology. The journal has been steadily growing, as is shown in Fig. 1. In 2014, for the first time more than 200 articles were published in a year. Fig. 2 illustrates the geographical trends for the receipts, and a long-term rise in the manuscripts from China. At present we are midway through the production of the nineteenth volume of *PRAB* (*PRST-AB*). Of roughly 3,600 manuscripts submitted since the journal inception, about two thirds have been published or accepted for publication. This fraction has remained rather stable throughout the journal history.

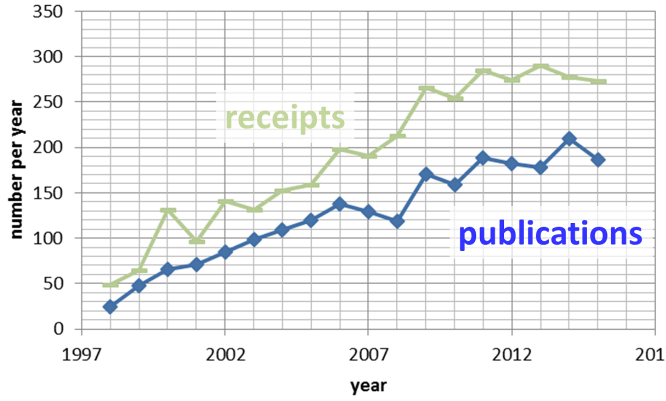

Fig. 1: Annual manuscript receipts and PRAB/PRST-AB publications

PRAB publishes articles about original work, reporting a significant scientific or technical advance, as well as review articles. There have been only a rather limited number of review articles so far, and we are strongly encouraging the accelerator community, and DPB members in particular, to write and submit more of these. Review papers may educate our colleagues, beginners and experts alike. Reviews are also expected to help increase the impact factor of the journal.

The editorial work for the *PRAB* journal is carried out by Journal Manager Debbie Brodbar, the three Associate Editors Brant Johnson (BNL), Jean Delayen (ODU) and Kazuhito Ohmi (KEK), the Senior Editorial Assistant Maria Poko, plus myself as Editor. We are assisted by an Editorial Board, representing the community, with annually rotating three-year membership. The present Editorial Board members are: Riccardo Bartolini (Diamond Light Source), Sergey Belomestnykh (FNAL), Mark Boland (Australian Synchrotron), Bruce Carlsten (LANL), Jim Clarke (STFC Daresbury), Angeles Faus-Golfe (IFIC Valencia & CNRS IN2P3 Paris Orsay), Olivier Napoly (CEA Saclay), Luigi Palumbo (La Sapienza, Rome), Igor Pogorelsky (BNL), Qing Qin (IHEP Beijing), Charles Reece (TJNAF) and Alexander Zholents (ANL).

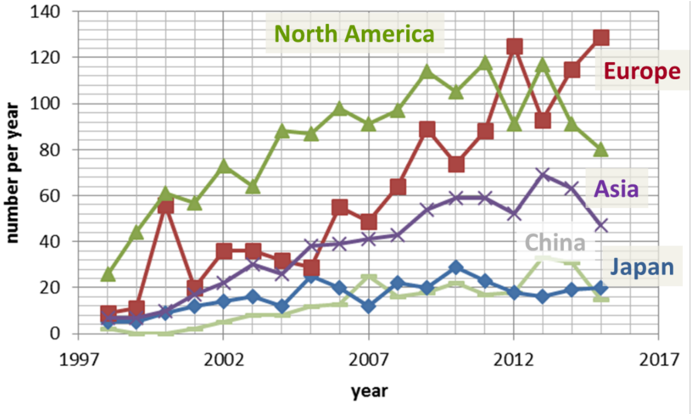

Fig. 2: Annual PRAB/PRST-AB manuscript receipts per region of submitting author. Asian contributions come mostly from Japan and China. These two fractions are also indicated individually.

Two important changes have occurred during the past year: On January 1, 2016, the former journal "*Physical Review Special Topics – Accelerators and Beams (PRST-AB)*" has changed its name to "*Physical Review Accelerators and Beams (PRAB)*", and since 2015 the journal is supported not only by institutional, but also by industrial sponsors.

For many years, the *PRST-AB* Editors, the *PRST-AB* Editorial Board and many *PRST-AB* authors had expressed concerns that the "Special Topics" in the journal title created confusion and diminished the standing of the journal. From various institutes it was reported that the "Special Topics" label had lowered the perceived value of articles published in this journal, despite the fact that its acceptance criteria were (and are) essentially the same as those of the other Physical Review journals. With the arrival of two additional subject-specific journals in the Physical Review family of journal – namely *Physical Review Applied* and *Physical Review Fluids* – it had become apparent that the Special Topics name was definitely no longer needed for any of the APS journals. The removal of "Special Topics" also visually integrates *PRAB* into the Physical Review family of journals and better emphasizes its content. While this name change clearly serves the best long-term interest of the accelerator community, some short-term difficulties may be

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encountered. The most important immediate consequence of this name change will be the lack of a meaningful Impact Factor for up to two years. It may also require some time for readers, authors, referees, librarians, and sponsors to make the proper connections between the old and new names or ISSNs. However, this change in name was fully supported by the *PRST-AB* Editorial Board and had been intensely discussed with the APS leadership. A unanimous agreement had been reached that removing "Special Topics" would not only strengthen the reputation of *PRAB*, but also the Physical Review family as a whole.

In 2015 *PRST-AB* (now *PRAB*) has welcomed its first ever industrial sponsors: COSYLAB, Euclid Techlabs, RadiaBeam Technologies, R&K, and TECH-X. These five industrial sponsors, along with more than 40 established institutional sponsors, ensure that the research published in PRAB is available at no cost to both readers and authors. The present list of institutional sponsors includes APS Division of Physics of Beams (APS-DPB), Argonne National Laboratory, Brookhaven National Laboratory, CEA Saclay, CNRS-IN2P3, The Cockcroft Institute, Cornell Laboratory for Accelerator-based Sciences and Education, Deutsches Elektronen-Synchrotron (DESY), European Organization for Nuclear Research (CERN), Fermi National Accelerator Laboratory, GSI Helmholtzzentrum für Schwerionenforschung GmbH, High Energy Accelerator Research Organization (KEK), Institute of High Energy Physics - Chinese Academy of Sciences, Instituto de Física Corpuscular (CISC/UV), INFN - Laboratori Nazionali di Frascati, the IPAC conference series including IPAC '15 and IPAC '16, The John Adams Institute for Accelerator Science, Lawrence Berkeley National Laboratory, the LINAC conference series including LINAC14 and LINAC16, Los Alamos National Laboratory, National Superconducting Cyclotron Laboratory at Michigan State University, the North American Particle Accelerator Conference series, Oak Ridge National Laboratory, Paul Scherrer Institute, Pohang Accelerator Laboratory, RIKEN Nishina Center, RIKEN SPring-8 Center, Sandia National Laboratories, Shanghai Institute of Applied Physics - Chinese Academy of Sciences, Stanford Linear Accelerator Center, Thomas Jefferson National Accelerator Facility, TRIUMF, Tsinghua University and the University of Maryland. The generous contributions to *PRAB* from all these sponsors cover most of the journal's expenses, which are predominantly editorial, production, and distribution costs. Along with the additional financial support for the journal, including industrial sponsorships validates 1) *PRAB* as the premier journal of accelerator physics and technology, and 2) the contributions *PRAB* is making to the international accelerator community. At the annual Editorial Board meeting held during IPAC'16 in Busan, representatives from the industrial sponsors reported that also these benefit from their sponsorship. RadiaBeam sees additional web-site visitors coming from *PRAB*, resulting in additional sales, which more than compensate for the amount of the *PRAB* sponsorship. COSYLAB values the additional link, thanks to the *PRAB* sponsorship, between the sponsoring company and the accelerator community. The continually updated lists of industrial and institutional *PRAB* sponsors are available at http://journals.aps.org/prab/sponsors . Additional sponsors are always warmly welcome and indeed some more sponsors will ultimately be necessary to render the journal financially self-sustained.

More information about *PRAB* is available at http://journals.aps.org/prab/ .

High Luminosity LHC – Leading US R&D Programs Enabling Upgrades to the LHC

Giorgio Apollinari, Fermi National Accelerator Laboratory
GianLuca Sabbi, Lawrence Berkeley National Laboratory

In June 2016, the CERN Council has formally approved the High Luminosity LHC project, HL-LHC. In the words of Dr. Fabiola Giannotti, CERN DG: "This comes as extremely good news not only for CERN, but also for particle physics globally. HL-LHC is the top priority of the European Strategy for Particle Physics in its 2013 update, and is part of the 2016 roadmap of the European Strategy Forum on Research Infrastructures, ESFRI. It was also identified as a priority in the US P5 strategy process, and in Japan's strategic vision for the field."

Since its start in 2008, the LHC has already made history with the discovery of the long-awaited Higgs boson in 2012. US scientists and engineers have contributed to the construction of the LHC and the experiments operating at this machine. The machine will continue to run at unprecedented energies and luminosities to give physicists access to phenomena that have been out of reach so far, with an integrated luminosity of 300 fb^{-1} by the end of this decade.

In order to extend the reach of physics exploration to its ultimate levels, an upgrade of the LHC in terms of delivered luminosity has been in discussion since 2002 [1].

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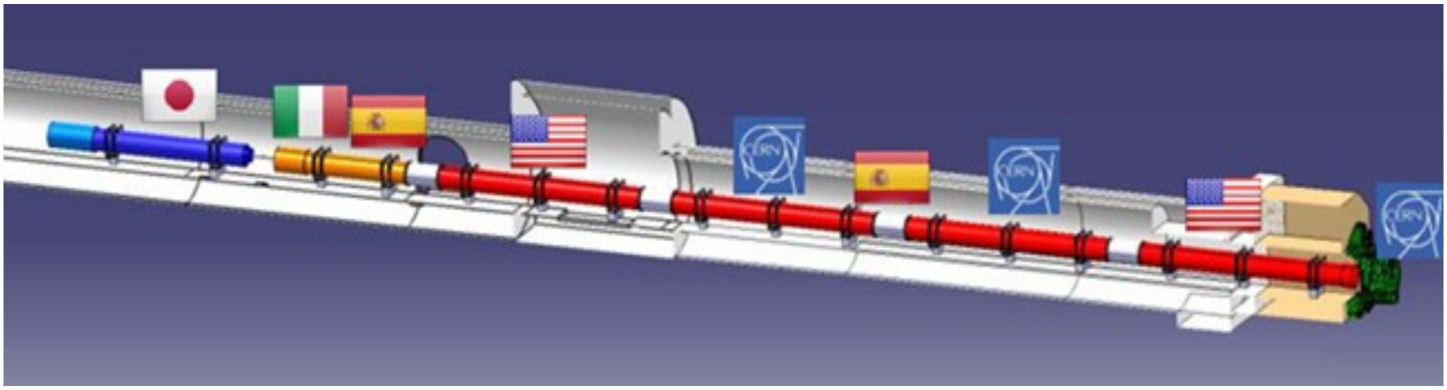

Fig. 1: Pictorial representation of the HL-LHC Interaction regions showing the focusing quadrupole magnets (in red). Potential national contributions are indicated by the flags.

R&D to explore the technical feasibility of the HL-LHC has been seeded in the US by two complementary programs: LARP (LHC Accelerator R&D Program) [2] and CDP (Conductor Development Program) [3]. These two programs, supported by DOE, have demonstrated the technical feasibility of Niobium-Tin (Nb_3Sn) based magnets and superconducting crab cavities for hadron machines.

The new powerful Nb_3Sn-based magnets, capable of reaching ~12T, will be located close to the experimental regions (Fig. 1) and will squeeze the beam to unprecedented levels. Crab Cavities will operate in conjunction to produce a transverse deflection of bunches close to the interaction regions, which will further increase luminosity and reduce beam-beam parasitic events. The combined effect of Nb_3Sn magnets and crab cavities in conjunction with upgrades of the injector chain, LHC beam optics and other critical systems will allow the HL-LHC to deliver 3000 fb^{-1} per experiment in the 2025-2035 decade [4].

LARP history and achievements

The present LHC interaction region quadrupoles are built using multi-filamentary Niobium-Titanium superconductor (NbTi), a ductile alloy with excellent mechanical and electrical properties, and a maximum operational field of about 8 T in practical accelerator magnet designs. Nb_3Sn has the potential to double this field reach, but is brittle and strain sensitive. For this reason, drawing Nb_3Sn into wires, cabling the wires, and winding cables into coils would all lead to unacceptable critical current degradation. To overcome this issue, the wires used for cabling and coil winding contain ductile precursors of the final components, and the superconductor is formed by high temperature heat treatment of the coils. This process requires the use of insulation and coil structural components that can withstand reaction temperatures approaching 700 C. The reacted coils are extremely sensitive to strain, requiring new approaches to magnet assembly, instrumentation and powering in addition to coil fabrication.

Building upon a decade of joint conductor and magnet development by the DOE General Accelerator R&D program together with LARP, Nb_3Sn was established as a viable technology for the High Luminosity LHC through a series of magnets and tests addressing all major technological challenges: the Long Racetrack (LR), approaching for the first time the 4m coil length of interest for the new Interaction Regions (IR); the 90 mm aperture Technology Quadrupoles (TQ) which developed detailed procedures and tooling for shell-type coil fabrication and mechanical support; the Long Quadrupole (LQ), a scale-up of the TQ design to 4 m length; and the High-Field Quadrupole (HQ) which expanded the aperture range from 90 mm to 120 mm while incorporating alignment and field quality features.

Along with the magnet development, LARP included an accelerator systems program to help understand and optimize the LHC machine performance through advanced beam instrumentation, collimation systems, and accelerator physics studies. Among the concepts being explored was the possibility to tilt the orientation of each proton bunch as it approaches the collision point, thereby resembling the sideways motion of a crab (Fig. 2). In order to avoid parasitic collisions the counter-rotating beams approach the interaction point at a crossing angle, which has the drawback of causing less efficient overlap and lower luminosity. The use of RF deflectors (crab cavities) to rotate bunches as they approach the IP and recover a head-on collision had been proposed and used for electrons [5] but never considered for protons. Started as a Toohig fellowship project [6], the crab cavity effort demonstrated effective solutions to all major technical challenges, gaining broad support among the LHC accelerator physics and RF communities.

Recent developments and preparations for HL-LHC construction

In 2010, a task force created by the CERN directorate to define the path toward a high luminosity LHC recognized high field Nb_3Sn quadrupoles and crab cavities as the two key technologies required for the upgrade [7]. Following the selection of a 150 mm coil aperture by the HiLumi Design Study, LARP redirected its resources to design and performance demonstration of the IR Quadrupole (named MQXF) in strong partnership with CERN. The first short model of this design, using two coils fabricated by LARP and two by CERN, was tested at the Fermilab in March 2016, achieving the ultimate gradient requirement, and

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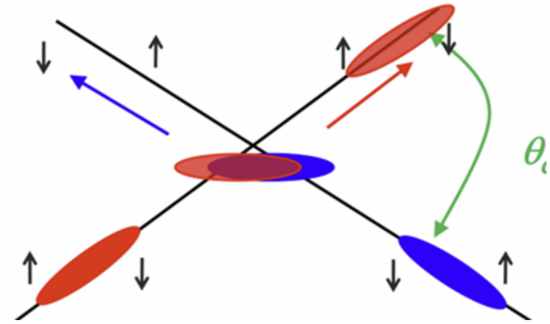

Fig. 2: Effect of the crab cavity on the beam (small arrow indicate the torque on the bunch generated by the transverse RF field) [5]

fully retaining it after a thermal cycle (Fig. 3). Several additional short model tests are planned both in the US and at CERN to fully validate and optimize the design in critical areas such as quench protection and field quality. In parallel, the first full length coils of the US deliverable (MQXFA) are being completed. A first test of a single long coil in a mirror structure is foreseen for this summer (Fig. 4), and the first full quadrupole model is expected in about one year. The successful test of two long prototypes by 2018 will open the way to production and delivery of 10 US-built cold masses for the Q1 and Q3 assemblies.

Fig. 3: MQXFS1 quench training (credit: G. Ambrosio, G. G. Chlachidze)

On the Crab Cavities side, proof of principle cavities have demonstrated - back in 2014 - the feasibility of the basic design to achieve the necessary transverse deflection field for the individual LHC bunches. Prototype cavities have been under production in the last two years at Niowave Inc. (Fig. 5) and are being finalized in a collaborative effort between the company, Old Dominion University and the LARP US national Laboratories with the inclusion of Jefferson Laboratory.

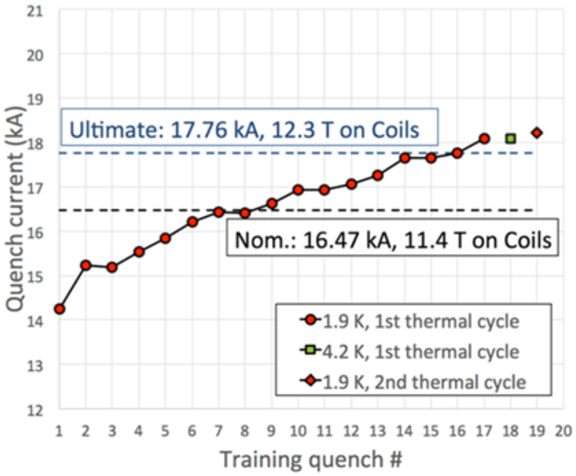

Fig. 5: Prototype radiofrequency dipole (RFD) used as a crab cavity under low-power RF measurements (credit: A. Ratti)

US Accelerator Physicists are also involved in optimizing operations of the HL-LHC working on novel schemes for beam or instabilities control, such as the hollow electron-lens scheme (to remove halo particles in a way similar to what has been done for the Tevatron or RHIC) and the Wide Band Feedback System (to control transverse instabilities by measuring individual buckets and correcting them with a kicker system).

Fig. 4: Long MQXF coil being assembled in a mirror structure (credit: R. Bossert, F. Nobrega)

Following interactions between DOE and CERN, DOE has provided a "Mission Need" approval (also known as CD-0) to the US contribution to the HL-LHC. The Project is likely to include focusing Nb_3Sn magnets and Crab Cavities as deliverables from the US to the HL-LHC, with execution planned for the 2018-2024 timeframe.

The very successful framework of the LARP Collaboration has proven the value of a US National Laboratory network. Hopefully such a framework will continue during the exploitation of the HL-LHC operations as well as for future endeavors in the field of frontier machines.

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Progress of LCLS-II, the X-ray Free Electron Laser at SLAC

John Galayda, SLAC National Accelerator Laboratory

Seven years after the Linac Coherent Light Source (LCLS) free electron laser produced its first X-ray beam at SLAC National Accelerator Laboratory, the Department of Energy has authorized a construction start for the LCLS-II Project. This decision to upgrade is motivated by the scientific productivity of LCLS and the rapid growth of interest in free-electron lasers worldwide.

The LCLS-II project will build a 4 GeV superconducting continuous-wave linear accelerator in the upstream-most 700 meters of the SLAC linac tunnel, displacing the first kilometer of the original 3 km accelerator. The new superconducting linac will send electrons to two new undulators, to be installed in the existing LCLS undulator hall, replacing the fixed-gap undulator built for the LCLS project. The LCLS-II linac will supplement rather than replace the "copper" linac presently serving LCLS; the copper linac, residing at the downstream end of the SLAC accelerator enclosure, will send electrons at energies up to ~15 GeV to the new hard X-ray undulator provided by LCLS-II. This combination will produce pulses of X-rays up to 25 keV.

LCLS-II has a $1 billion budget and a goal of producing first light in winter 2019. The project, which did not have a lot of visibility in the accelerator research literature in 2013, is now well-represented. An overall description of the LCLS-II was presented at IPAC2015 [1], and the LCLS-II electron optics were described at IPAC2016 [2].

The LCLS-II Project is a collaboration of six institutions; SLAC is joined by Argonne National Laboratory, Cornell University, Fermi National Accelerator Laboratory, Lawrence Berkeley National Laboratory and Thomas Jefferson National Accelerator Facility. Construction of LCLS-II at SLAC on the proposed time scale is only possible because of the combined infrastructure, expertise and workforce that each lab brings to the project.

LCLS-II was launched to meet the need for a for a high-repetition-rate/high-*average*-intensity source of coherent X-rays covering, at a minimum, the photon energy range from 200 to 5,000 eV. The scientific goals for LCLS-II were based on recommendations of the Basic Energy Sciences Advisory Committee, issued in a July 2013 report. This report triggered an extremely fast response. The LCLS-II collaborating institutions met for the first time in October 2013, and by February 2014 the collaboration had produced a conceptual design for the facility. This design was presented to, and approved by the Department of Energy in February 2014.

After that, things *really* started to move fast. In August 2016, the first LCLS-II accelerating cryomodule will be tested at Fermilab, while the second cryomodule will be ready for test at Jefferson Lab in October. Presently, a portion of the SLAC linac is being removed from the first kilometer of the accelerator enclosure to make way for LCLS-II.

Perhaps the single requirement with greatest influence on the facility design is the pattern of X-ray pulses, equally spaced at rates up to 1 MHz. This determines many of the design features of LCLS-II. The project has taken advantage of existing capabilities and recent research at the collaborating labs to assemble the ingredients necessary to fulfill LCLS-II goals.

LCLS-II will use a CW electron source designed and constructed at LBNL. It is a 186 MHz RF cavity producing 750 keV electrons from a photocathode (either Cs_2Te or NaKSb). The LBNL design is an engineering update of the APEX gun, already running at LBNL to support research in ultrafast electron dynamics and photocathode R&D. The APEX gun has demonstrated reliable CW operation at one of the target operating points of LCLS-II: 0.2 mm-mrad emittance and 6 Amperes (20 pC). LBNL will use APEX to investigate the 100 pC operating point of LCLS-II over the next few months.

Fig. 2 shows a cartoon of the LCLS-II gun, as originally designed. The design has been modified by adding a right-angle elbow between the coupling loop and the RF window. Experience showed that this was necessary to prevent accumulation of energetic electrons within the

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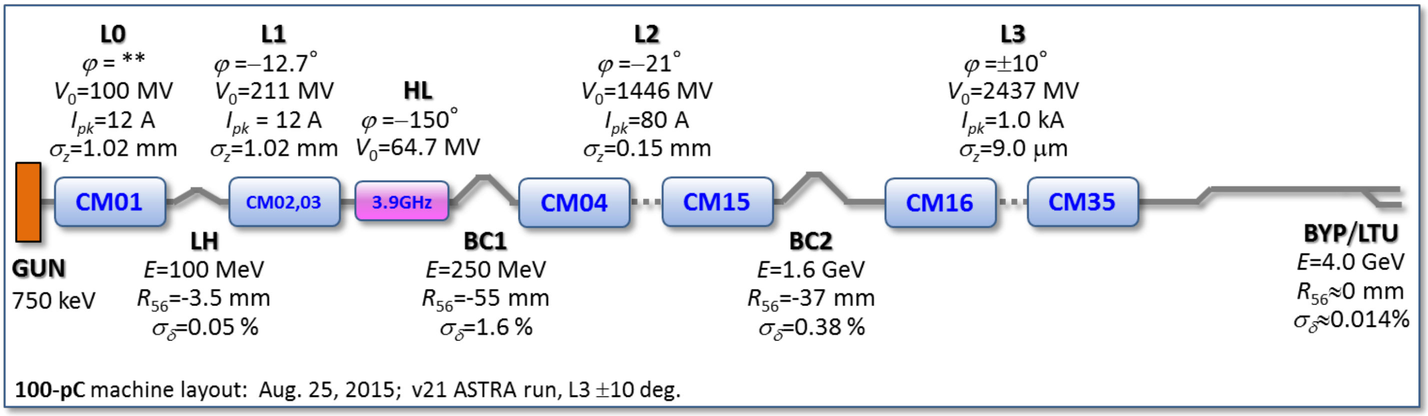

Fig. 1: Schematic layout of the superconducting LCLS-II linac, showing the arrangement of 35 1.3 GHz accelerating cryomodules (CM01 – CM35), the 3.9 GHz cryomodule the "laser heater" chicane (LH), two bunch compressors (BC1 and BC2), the transport bypass line (BYP) and the linac-to-undulator line (LTU).

ceramic window.

The resonant cavities and 12.2-meter-long accelerating cryomodules of the LCLS-II linac are closely patterned after the design of the European XFEL, which was in turn based on the design developed for the International Linear Collider (ILC). Like XFEL and ILC, the LCLS-II cryomodules contain eight 9-cell cavities, designed to operate at 1.3 GHz. Because LCLS-II must run RF continuously, the dominant heat load is RF dissipation in the cavities at 2K.

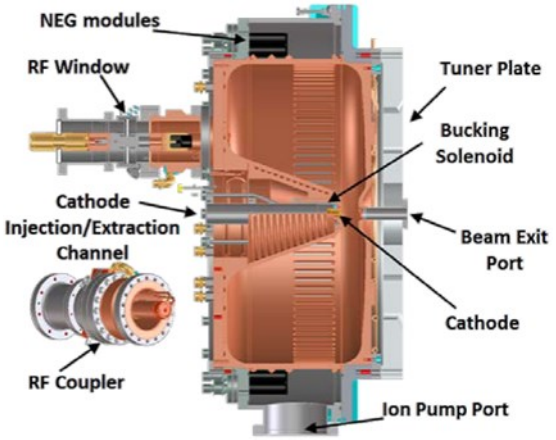

Fig. 2: The LCLS-II gun

The ILC and XFEL were not designed for continuous operation, so experts at Fermilab made a number of important design changes and adaptations so that LCLS-II could handle the much higher heat dissipation at cryogenic temperatures for LCLS-II. This required an enlargement of the two-phase cooling manifold. Because the SLAC linac tunnel was designed with a 5 milliradian downhill slope, the "two-phase" pipe within the cryomodule must be blanked off at each end rather than connected from module to module. An extra layer of magnet shielding was added around the cavities to minimize trapping of magnetic flux as the cavities are cooled through the superconducting transition. For the same reason, two liquid helium feeds are connected to each cavity's helium vessel to provide extra control during the cool-down.

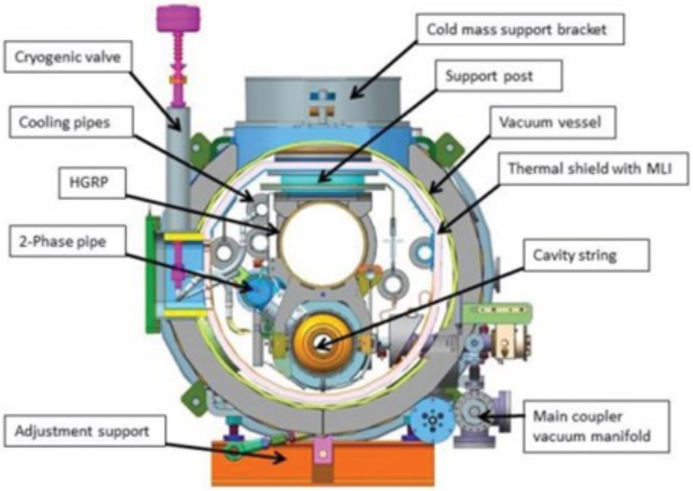

Fig. 3: Cross-section of the LCLS-II accelerating cryomodule

An extremely important feature of LCLS-II cavities will be the employment of a nitrogen-doping treatment discovered at FNAL and developed by the collaboration for use in LCLS-II. Cavities with this treatment have demonstrated "unloaded" quality factors in the range 2.5-3.5 x 10^{10}. For a CW linac, this dramatically reduces the helium refrigeration requirements. Realization of this high-Q performance in a working linac is one of the primary challenges of the LCLS-II project. Of course, all other contributions to the residual resistance must be eliminated. Hence, the additional magnetic shielding on the cavities and special features to facilitate expulsion of magnetic flux.

Achievement of the design goal of $Q = 2.7 \times 10^{10}$ will bring the benefit of an extremely energy-efficient linac, along with a new challenge: control of the cavity resonant frequency in the presence of microphonics and beam loading. This challenge will be handled by a very sophisticated low-level RF control system, developed by LCLS-II collaborators at LBNL, JLAB and SLAC.

LCLS-II will have ample cooling capacity (8 kW at 2K) with two identical cryogenic refrigeration systems designed and installed by JLAB.

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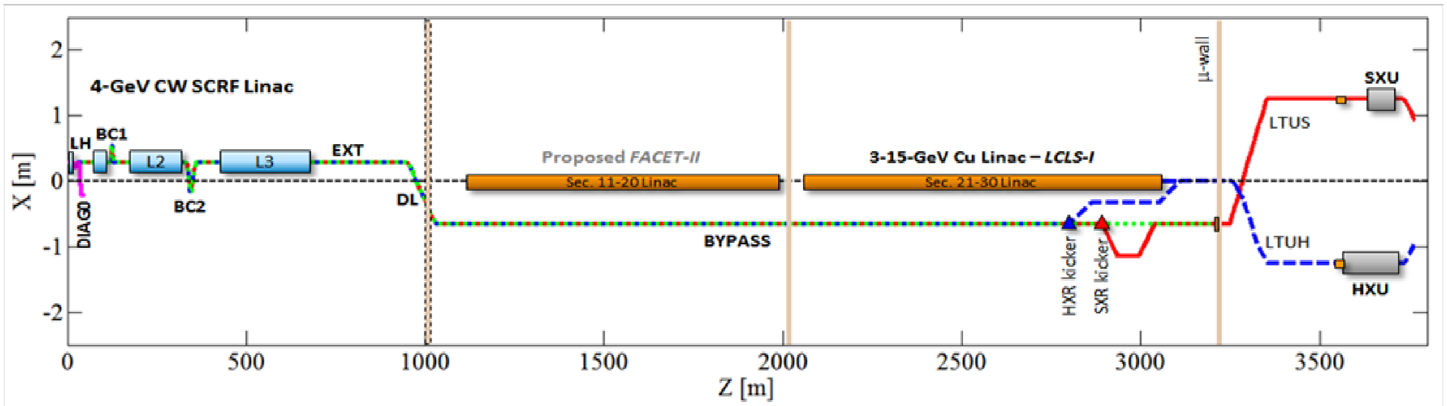

Fig. 4: Schematic of the LCLS-II linac, occupying the first 700m of the 3 km SLAC linac tunnel

Electrons from the SC linac will pass through existing transport lines to bring 4 GeV electrons past the existing copper linacs (which still occupy 2 km of the SLAC tunnel and will continue to operate for LCLS and other research) to the LCLS undulators. Longitudinal space charge effects are significant over this long transfer line, providing unwanted energy modulation in the bunch. Coherent synchrotron radiation emitted in a series of bend magnets bringing the electrons through the beam switchyard can damage the emittance of the electron beam. Simulations predict that localized fine-tuning of the R_{56} transport elements with correction chicanes adjacent to the main transport bends will be used to preserve the beam quality.

LCLS-II will construct two undulator lines; one (called "SXR") will provide "soft" X-rays (200-1,300 eV) while the other ("HXR") will provide X-rays up to 5,000 eV with electrons from the SC linac. As mentioned above, the HXR source can be fed by the copper linac to provide X-ray pulses up to 25 keV at 120 Hz.

Fig. 5: The HXR undulator.

The SXR source will include 21 undulator modules designed and constructed by LBNL. The SXR modules resemble a typical undulator in a modern storage ring. The HXR line will include 32 undulators; their design is an adaptation by LBNL of a design developed some years ago and then prototyped for LCLS-II by Argonne National Lab, the original designer of the LCLS undulator. This new undulator has many novel features; most notable to X-ray experimenters is that it produces vertically polarized radiation. Remarkably, very thin aluminum beams support the magnets and poles. Distortion of the beams and degradation of magnet field quality is prevented by means of springs with compression-dependent spring constant. The springs precisely cancel the gap-dependent attractive forces between poles. The HXR fits in the same space as the original fixed-gap LCLS undulator, and will even sit on the same pedestals.

The pace of the LCLS-II project certainly earns the adjectives "fast and furious." The project is twice the scale of LCLS and will be accomplished in approximately half the time. This is only possible because of the combined talent and effort of the labs participating in the LCLS-II Project, and I feel fortunate to participate in this project and represent this organization.

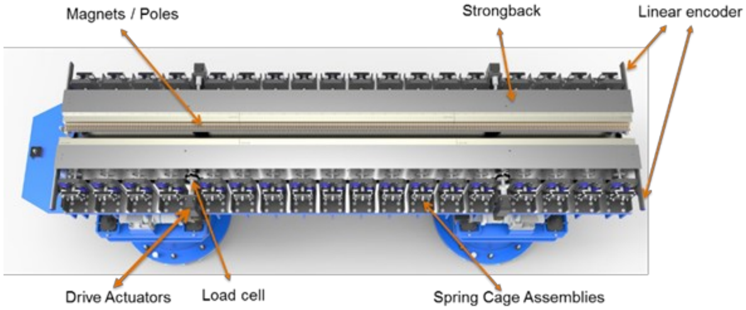

Fig. 6: The HXR undulator, viewed from above.

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An Electron-Ion Collider in the US

Fulvia Pilat, Jefferson Lab
Thomas Roser, Brookhaven National Lab

The US Nuclear Physics community has recommended "a high-energy high-luminosity polarized Electron-Ion Collider (EIC) as the highest priority for new facility construction following the completion of FRIB" in the NSAC 2015 Long Range Plan for Nuclear Science [1]. Below are excerpts from the Long Range Plan of the physics that would be explored by an Electron-Ion Collider and the performance required from such a facility, followed by an updated section on the two existing proposals for the construction of an EIC.

Gluons, the carriers of the strong force, bind the quarks inside nucleons and nuclei and generate nearly all of the visible mass in the universe. Despite their importance, fundamental questions remain about the role of gluons in nucleons and nuclei. These questions can only be answered with a powerful new electron ion collider (EIC), providing unprecedented precision and versatility. The realization of this instrument is enabled by recent advances in accelerator technology.

Our view of the structure of atomic nuclei and the nucleons they contain has made quite a transformation in the last few decades. The most common picture found in textbooks shows a simple three-valence quark structure of the nucleon, yet we now know that the inside of the nucleon is rather a complex many-body system with a large number of gluons and sea quarks.

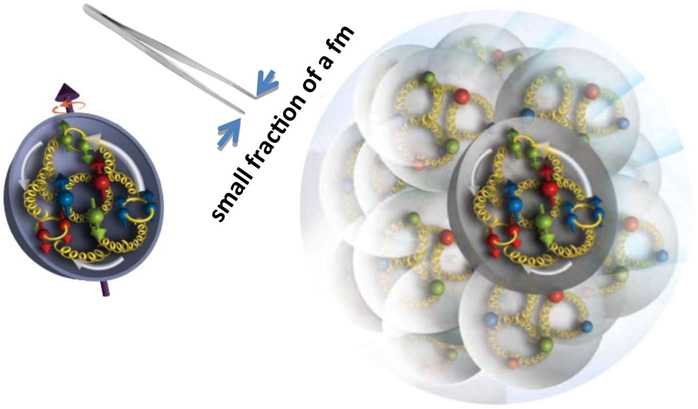

Fig. 1. Schematic view of nucleon and a nucleus

There is unambiguous evidence that the latter play surprisingly important roles for defining the structure of nuclear matter around us. Their quantitative study and understanding require a novel sophisticated tool, the EIC.

The EIC will, for the first time, precisely image gluons in nucleons and nuclei. It will definitively reveal the origin of the nucleon spin and will explore a new quantum chromodynamics (QCD) frontier of ultra-dense gluon fields, with the potential to discover a new form of gluon matter predicted to be common to all nuclei. This science will be made possible by the EIC's unique capabilities for collisions of polarized electrons with polarized protons, polarized light ions, and heavy nuclei at high luminosity.

How Does the Proton Get Its Spin?

The decomposition of the proton's overall intrinsic spin into quark and gluon contributions remains a fascinating open question. State-of-the-art QCD analyses of recent measurements at RHIC have shown that individual gluons that carry more than a few percent of a proton's momentum have a preference to align their own intrinsic spins along that of the proton's overall spin, thereby accounting for approximately 30–40% of the total. This contribution is similar to that from quarks and antiquarks. The EIC would greatly increase the kinematic coverage in parton momentum fraction x and resolving power Q^2 for polarized deep inelastic scattering experiments. By probing the abundant lower-momentum gluons and sea quarks, EIC experiments will reduce the spin contribution uncertainties dramatically, providing a much clearer picture of how the proton's spin emerges from QCD.

Tomographic Images of the Proton

Deep inelastic scattering (DIS) experiments carried out at EIC collision rates will provide for the first time 3D images of gluons in the proton's internal landscape. Of particular interest are exclusive measurements, where one detects an outgoing meson in coincidence with the scattered electron with sufficient resolution to confirm that the proton has been left intact by the scattering process. For example, the detection of exclusive J/ψ meson production would provide unprecedented maps showing how the gluons are distributed in space within a plane perpendicular to the parent proton's motion. These particular maps encode vital information, inaccessible without the EIC, on the amount of proton spin associated with the gluons' orbital motion.

Nuclei as a Laboratory for Emergent QCD Phenomena

The ability of the EIC to collide electrons with nuclei, from light to heavy and at varying energies, presents us with new and exciting ways to study and understand nuclear matter. The use of light nuclei with 2 to 12 nucleons, whose nuclear structure is experimentally well studied and well described by existing models, will allow us to study the nucleon-nucleon force at short distances but from the point of view of quarks and gluons. The recently discovered intriguing correlation between the quark motion inside the nucleus and the nucleon-nucleon force at short distance would be further elucidated by such studies at the EIC. Detection of spectators (those nuclear fragments that do not participate in the DIS process) from a nucleus can identify the active nucleon and study the nuclear binding effects and what role the partons play in

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them.

QCD Matter at Extreme Gluon Density

When fast-moving hadrons are probed at high energy, the low-momentum gluons contained in their wave functions become experimentally accessible. By colliding electrons with heavy nuclei moving at near light speed, the EIC will provide access to an uncharted regime of all nuclear matter, where abundant gluons saturate in density and dominate its behavior. This regime is accessible with heavy-ion beams at the EIC, while much higher collision energies would be required to reach it in electron-proton collisions. The nuclear "oomph" experienced by a high-energy probe arises due to the coherent effects of gluons contributed by many nucleons. The probe no longer resolves individual quarks and gluons in the nucleus but rather samples strongly correlated matter. Gluons in the matter are as closely packed as possible; strong interactions, among the strongest in nature, ensure nuclei are stable against endless gluon proliferation. This maximal close packing allowed by nature in collisions with certain energy establishes a resolution scale, denoted by Q_s, corresponding to sizes smaller than those of hadrons. The existence of this scale allows theorists to compute the properties of this remarkable matter, describing it as a color glass condensate (CGC). Previously, quarks and gluons were believed to form a nearly free gas of weakly interacting partons at very high resolution Q^2 and very strongly interacting confined matter on lower, hadron-size, resolution scales. Gluon saturation suggests a new emergent regime in QCD where matter is not easily characterized as weakly or strongly interacting but has aspects of both.

Formation of Hadrons and Energy Loss

The emergence of hadrons from quarks and gluons is at the heart of the phenomenon of color confinement in QCD. The dynamical interactions of energetic partons passing through nuclei or QGP provide unique analyzers, probing the poorly understood evolution from colored partons to color neutral hadrons. A nucleus in a collision at the EIC would provide a femtometer size "detector" to monitor the evolution from partons to hadrons.

The Electron Ion Collider (EIC)

The key machine parameters the EIC should have to address the compelling questions described above are well established:

- Polarized (>70%) electrons, protons, and light nuclei
- Ion beams from deuterons to the heaviest stable nuclei
- Variable center of mass energies ~20–100 GeV, upgradable to ~140 GeV (e-p collisions)
- High collision luminosity ~$10^{33\text{-}34}$ $\text{cm}^{-2}\,\text{s}^{-1}$
- Possibly more than one interaction region

Two independent designs for a future EIC have evolved in the United States. Both use the existing infrastructure and facilities available to the US nuclear science community. At BNL the eRHIC design (Fig. 2) utilizes a new facility based on an Energy Recovery Linac (ERL) to be built inside the RHIC tunnel to accelerate electron beams and collide them with RHIC's existing high-energy polarized proton and nuclear beams. At JLab, the JLab Electron Ion Collider (JLEIC) design (Fig. 3) employs a new electron and ion collider ring complex together with the 12-GeV upgraded CEBAF, now in operation, to achieve similar collision parameters.

The EIC requirements in terms of beam polarization, beam species, range in center of mass energies, and high collision luminosity will push accelerator designs to the limits of current technology and will, therefore, need significant R&D. Cooling of the hadron beam is essential to attain the ultimate luminosities demanded by the science. The development of coherent electron cooling is now underway at BNL, while the JLab design is based on conventional electron cooling techniques but proposes to extend them to significantly higher energy and to use bunched electron beams for the first time.

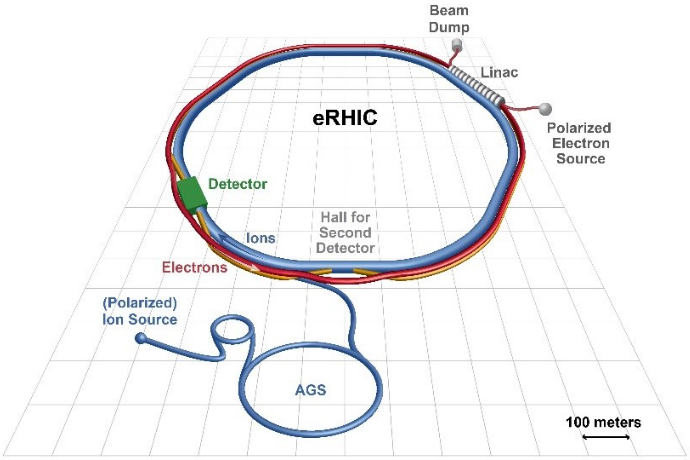

Fig. 2: Schematic of eRHIC at BNL, which would require construction of an electron beam facility (red and gold) to collide with the RHIC blue beam at up to two interaction points.

An energy recovery linac at the highest possible energy and intensity is key to the realization of eRHIC at BNL, and this technology is also important for electron cooling in JLEIC at JLab. The eRHIC design at BNL also requires a polarized electron source that would be an order of magnitude higher in intensity than the current state of the art, while the JLEIC design at JLab would utilize a novel figure-eight storage ring design to maintain beam polarization for both electrons and ions.

The physics-driven requirements on the EIC accelerator parameters and extreme demands on the kinematic coverage for measurements make integration of the detector into the accelerator a particularly challenging feature of the design. Lessons learned from past experience at HERA at DESY in Germany have been considered while designing the EIC interaction region.

Driven by the demand for high precision on particle detection and identification of final state particles in both e+p and e+A programs, modern particle detector systems

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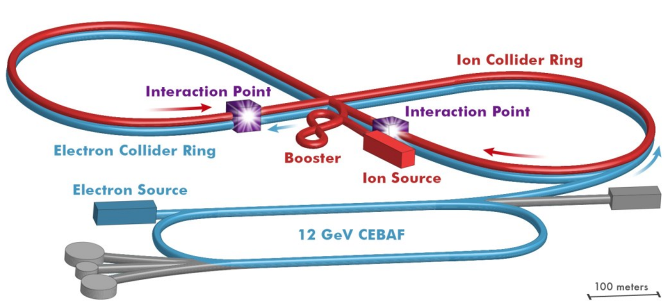

Fig. 3: *Schematic layout of JLEIC at JLab includes the 12 GeV CEBAF and would require construction of an ion linac, booster, an ion collider ring (red), and an electron collider ring (blue) for collisions at two interaction points.*

will be at the heart of the EIC. Generic research and design efforts are under way on various novel ideas for detectors, including compact calorimetry, various tracking and particle identification detectors, and high radiation tolerance for electronics. Meeting these challenges will keep the US nuclear science community at the cutting edge in both accelerator and detector technology.

Conclusion

The recommendation for an EIC in the Nuclear Physics Long Range plan in October 2015 validates the physics case and has been a very important step for the EIC. The National Academy of Science is now reviewing the EIC physics and a positive review will be an important step to establish the EIC mission need or CD0, with a vision of constructing the EIC in the next decade. The EIC community is growing: an EIC User Group has been established that has already coalesced more than 800 nuclear physicists, theorists and accelerator physicist. The realization of the EIC will need the collaboration and support of the entire scientific community.

References

[1] D. Geesaman et al. The 2015 Long Range Plan for Nuclear Science (2015).

FCC Week 2016: Preparing for the Future of Accelerator-Based High-Energy Physics

Panos Charitos (CERN)
Frank Zimmermann (CERN)

From 11 to 15 April 2016, close to 500 participants from all over the world came together in Rome, Italy, for the annual collaboration meeting of the global Future Circular Collider (FCC) study, also called the “FCC Week 2016” (see Fig. 1), organized under the high patronage of the President of the Italian Republic. The participation amounted to a roughly 30% increase both in the number of experts attending and in the number of institutes represented, compared to the 2015 FCC Week in Washington D.C. last year. The strongly increased number of participants and participating institutes (Fig. 2) testifies to the growing momentum of the FCC study. From the United States, so far eight universities plus the US Department of Energy (DOE) have joined the FCC collaboration, and about 50 US scientists attended the meeting in Rome.

Fig. 1: Some of the participants of the FCC Week 2016 in Rome

The rising attractiveness is understandable: A large circular hadron collider is widely thought to be the only approach available over the coming decades, for advancing the energy and luminosity frontiers by another order of magnitude beyond the Large Hadron Collider (LHC). The FCC complex could surely become the work horse of high-energy physics for most of the 21st century.

More concretely, the FCC study explores different options for a post-LHC research infrastructure. The primary goal of the FCC study is a 100 TeV proton

(Continued on page 20)

Fig. 2: World map of institutes participating in the FCC study (status July 2016)

collider in a new 100 km tunnel using high-field 16 T dipole magnets based on Nb_3Sn superconductor (FCC-hh). The FCC study also comprises the design a high-luminosity e+e- collider, operating in a range of c.m. energies between about 90 and 360 GeV – serving as Z, W, Higgs and top factory – as a possible first step (FCC-ee); a lepton-hadron collider option, whose electrons would come from a 60 GeV Energy Recovery Linac (FCC-he); as well as a 25 TeV High-Energy LHC (HE-LHC), which could be realized by using FCC-hh magnet technology in the existing 26.7 km tunnel of the Large Hadron Collider (LHC).

The 2012 discovery of the Higgs boson, a particle profoundly different from all other elementary particles found earlier, calls for further comprehensive studies of its properties. More importantly still, a number of “known unknowns” like the observed asymmetry between matter and antimatter, the dark matter contents of our Universe and the non-zero neutrino masses are only a few of the various indicators that point to new physics beyond the Standard Model. Several questions related to physics at the TeV scale are exacerbated by the lack of evidence of new physics at the LHC so far, while their answers are critical for our understanding of the universe.

The upcoming results from the LHC run 2, which began in 2015, may shatter yet more of our previous theories and could call for a profound change of scientific paradigms, heralding an exciting new era of modern physics. Whether marked by a major discovery or not, they are probably going to put into question our present understanding of fundamental theories. As Gian Guidice, the Head of CERN’s theory department, concluded in his opening talk on “the FCC and the present physics landscape”: “We live in one of the most fruitful periods in physics facing a number of challenges and new opportunities”. A tantalizing sketch from his talk in reproduced in Fig. 3.

With the LHC program underway, the global particle physics community is working hard to develop a common vision for the future. The full exploitation of the LHC including its high-luminosity phase (HL-LHC) sets a time scale of 20 years. Driven by the long lead times, the FCC study is mandated to explore possible options for a next machine, i.e. a machine which could start its physics programme in about 20-25 years from now. "As one of the high-priority items on CERN's agenda, the FCC design study is exploring a potential post-LHC accelerator project that will ensure the continuation of the world’s particle physics programme,” was noted by Frédérick Bordry, CERN’s Director for Accelerators and Technology, who also observed that "the post-LHC accelerator calls for breakthrough technologies to afford the beam energy, intensity and brightness which are required for a future 'discovery machine'." This time scale along with the complexity of the FCC project and the desire to profit from ongoing international studies on other proposed future accelerators make the FCC study a timely effort.

The FCC study is serendipitously aligned with the planning of the United States, as was illustrated by Andy Lankford from UC Irvine, Chair of the High Energy Physics Advisory Panel (HEPAP) for the US Department of Energy and the National Science Foundation, in his presentation of “HEPAP View and US Activities on Future Colliders,”. Recalling the recommendations issued in 2014 by HEPAP’s Particle Physics Project Prioritization Panel (P5), Andy Lankford highlighted that “a very high-energy proton-proton collider is the most powerful future tool for direct discovery of new particles and interactions under any scenario of physics results that can be acquired in the P5 time window [the next 10-20 years]”, that “the US is the world leader in R&D on high-field superconducting magnet technology, which will be a critical enabling technology for such a collider” and that, therefore the US should, and will “participate in global conceptual design studies and critical path R&D for future very high-energy proton-proton colliders” as well as “continue to play a leadership role in superconducting magnet technology focused on the dual goals of increasing performance and decreasing costs.”

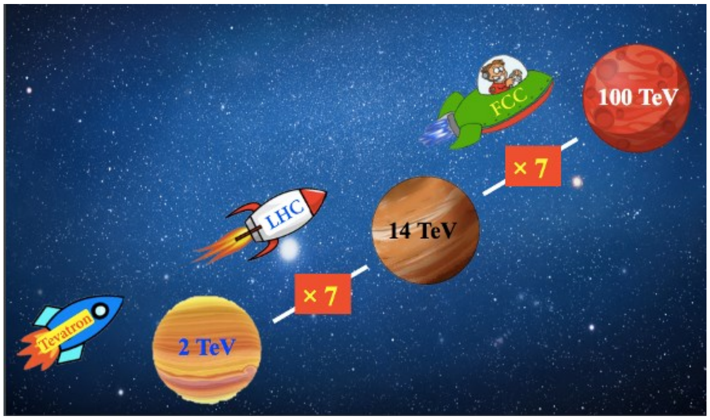

Fig. 3: Succession of past, present and future hadron colliders (shown in Rome by G. Giudice)

North American theorists are developing physics scenarios that could be explored with a 100 TeV collider

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and the possible probes for new physics beyond the Standard Model. US work on these themes has been catalysed by three topical physics workshops organized at SLAC, Fermilab, and the University of Massachusetts Amherst, in 2014 and 2015. High-luminosity proton-proton collisions at a centre-of-mass energy of 100 TeV also pose many challenges for both the detector designers and the accelerator experts. Ongoing American accelerator and detector efforts – including simulations of physics processes and detector responses – were discussed during dedicated sessions in Rome.

The FCC Week 2016 reviewed the physics potential for all FCC scenarios (i.e. proton-proton, heavy ion, electron-positron and electron-proton/electron-ion). Each of these scenarios has its specific virtues, and the options exhibit a strong complementarity. Detector-design concepts for all scenarios were presented in considerable detail. Areas for which further theoretical or experimental input is needed were identified. The physics opportunities for the FCC hadron collider are documented in a report of about 600 pages, which was distributed during the FCC week in Rome and will become available online. This report reveals that the FCC research infrastructure is not a mere follow up of past machines, but could open up fascinating new horizons in our quest to understand nature and the world around us.

Among the main R&D programs launched as part of the FCC study are those on a next generation of high-field superconducting accelerator magnets including improved superconductor cables, cryogenic systems, novel superconducting radiofrequency (RF) cavities, efficient RF power sources, innovative beam vacuum systems for efficient handling of synchrotron radiation, as well as novel detector technologies required to meet the unprecedented physics challenges. The FCC Week 2016 discussed the latest results on all these fronts and defined the next R&D steps.

Substantial progress had also been made in the fields of infrastructure and operation studies. The results of extensive civil engineering studies for a 90-100 km tunnel in the Lake Geneva basin were presented. In addition, numerous operational aspects become ever more crucial for the FCC. The accelerator optics, beam dynamics, controls and machine protection, as well as energy-consumption, reliability and safety were some of the other topics covered during the meeting.

Finally, the FCC Week also featured the work of younger researchers. More than 100 of them presented their latest research in the poster sessions. Three of them received the “FCC Innovation Award” that distinguishes early stage researchers or engineers for outstanding work carried out in the scope of the study.

The efforts presented during the 2016 FCC Week will culminate in a Conceptual Design Report (CDR) by 2019. This CDR will serve as a decision aid for future particle research infrastructures. As Michael Benedikt, the FCC study leader, highlighted in Rome: “We have a high responsibility to keep the present momentum and attract more collaborators in our efforts to design future circular machines that will serve the global scientific community”. Following the hard efforts of the last two years “we must now focus on the established parameters and use them as basis for further optimization of the machines, detectors, and technologies required to realize such a large-scale research infrastructure.”

The results of these efforts can be judged at the next FCC Week, which will take place in Berlin, Germany, from 29 May to 2 June 2017. The FCC Week 2017 will be organized jointly by CERN and DESY, with co-sponsorships from the HORIZON2020 programme of the European Commission (EuroCirCol Project), the German Physical Society, and the IEEE. This next year’s meeting will conduct a major review of the study, discuss the possible impact of latest LHC run 2 results, and mark an important milestone towards the FCC Conceptual Design Report.

More information about the FCC may be found at http://cern.ch/fcc , about the FCC Week 2016 at http://cern.ch/fccw2016 , and about next year’s FCC Week 2017 at http://cern.ch/fccw2017 .

Robert R. Wilson Prize for Achievement in the Physics of Particle Accelerators, 2016

*Awarded to **Vasily Parkhomchuk***

Citation:
"*For crucial contributions in the proof of principle of electron cooling, for leading contribution to the experimental and theoretical development of electron cooling, and for achievement of the planned parameters of coolers for facilities in laboratories around the world.*"

Background:
Vasily Parkhomchuk graduated from the Novosibirsk State University (Novosibirsk, Russia) in 1968 and received his degrees from the Budker Institute of Nuclear Physics (BINP) in Novosibirsk – PhD (candidate degree) in 1975 and Doctor of Sciences (Habilitation) in 1985. In 1971 he started to work on the development of the electron cooling technique at the Institute of Nuclear Physics, first as a postgraduate student of G.I. Budker. V.Parkhomchuk played a pivotal role in the proof-of-principal demonstration and pioneering electron cooling experiments at the storage ring NAP-M in 1971-1980. Later he successfully led the design, construction, and development of the next-generation systems for electron cooling of ions for several leading accelerator centers worldwide, including the GSI Helmholtz Center for Heavy Ion Research at Darmstadt (Germany), the Institute of Modern Physics (IMP, Lanzhou, China), CERN and others.

In 1997 Vasily Parkhomchuk was elected a correspondent member of the Russian Academy of Sciences. Prof. Parkhomchuk is currently the Head of the BINP's Electron Cooling laboratory. His awards include State Prize of Russian Federation "…for the development of the electron cooling method" (2002), Order of Friendship of People's Republic of China (2004), and the "Sino-Russian Friendship Forever" medal (2015).

APS Fellow Nominations by the DPB in 2015

Congratulations to the five APS fellows nominated by the DPB in 2015. Their important contributions to beam physics are briefly summarized here, and there will be a recognition ceremony at NAPAC 2016 in Chicago.

Huang, Zhirong (*SLAC - National Accelerator Laboratory*)
Citation: "For outstanding contributions to the theoretical development and experimental verification of high-gain X-ray free-electron lasers operating as seeded and SASE amplifiers."

Poelker, Matthew (*Jefferson Laboratory*)
Citation: "For sustained and transformative work on the development of polarized electron beams, opening new vistas in their application to nuclear and particle physics experiments at the frontiers of knowledge."

Belomestnykh, Sergey (*Brookhaven National Laboratory*)
Citation: "For outstanding contributions to the science and technology of RF and superconducting RF in beam physics."

Nguyen, Dinh (*Los Alamos National Laboratory*)
Citation: "For an outstanding record of innovation and contribution to the initial development of high-brightness photo-injectors, early experimental validation of self-amplified spontaneous-emission theory, and high average current injectors."

Willeke, Ferdinand (*Brookhaven National Laboratory*)
Citation: "For pioneering contributions advancing the physics of beams and scientific research, by leading the design and construction of frontier accelerator facilities and providing valuable advice to many accelerator facilities worldwide."

The 2017 USPAS Prize for Achievement in Accelerator Physics and Technology

*Awarded to **Alex Chao***

Citation: "*For insightful, fundamental and broad-ranging contributions to accelerator physics, including polarization, beam-beam effects, nonlinear dynamics and collective instabilities, for tireless community leadership and for inspiring and educating generations of accelerator physicists and engineers.*"

*Awarded to **Anna Grassellino and Alexander Romanenko***

Citation: "*For breakthrough discoveries in raising the quality factor of Superconducting RF cavities with nitrogen-doping and related techniques and their impact as baseline technology for new SRF accelerators.*"

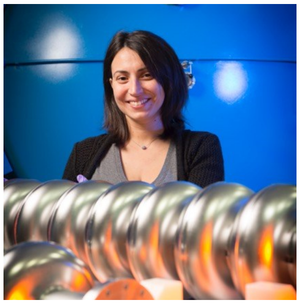
IEEE Particle Accelerator Science and Technology (PAST) Technical Committee Awards, 2016

*Awarded to **Wim Leemans***

Citation:
"*For pioneering development of laser-plasma accelerators.*"

*Awarded to **Anna Grassellino***

Citation:
"*For pioneering nitrogen-doping of superconducting RF cavities.*"



Robert H. Siemann Award for Outstanding Contributions to PRST-AB, 2016

*Awarded to **Vladimir Shiltsev***

Excerpt from PRST-AB Editorial:
"The award citation emphasizes Dr. Shiltsev's numerous initiatives as an Editorial Board member to make PRST-AB optimally serve the accelerator community, to render it ever more attractive, and to increase its impact factor."

Particle Accelerator Science and Technology Doctoral Student Award 2015

*Awarded to **Sam Posen***

Citation:
"*For contributions to the development of Nb_3Sn SRF cavities.*

International Particle Accelerator Conference Prizes, 2016

The Xie Jialin Prize for outstanding work in the accelerator field, with no age limit is awarded to **Derek Lowenstein, BNL, USA**

Derek Lowenstein

Citation: "*For his many years of leadership in the accelerator field especially that in the AGS Booster and BNL Relativistic Heavy Ion Collider (RHIC). He led the construction of the AGS Booster, which culminated in the world-record proton intensity in the AGS. This work also formed the basis for the establishment of the NASA Space Radiation Laboratory. He was instrumental in realizing this dedicated facility to study radiobiological effects important to human spaceflight to Mars or other planetary missions. He continued his leadership in overseeing the commissioning, operation and upgrades of RHIC, the world's first heavy ion and polarized proton particle collider. RHIC is a highly successful accelerator facility with its unprecedented flexibility and outstanding luminosity performance.*"

The Nishikawa Tetsuji Prize for a recent, significant, original contribution to the accelerator field, with no age limit is awarded to **Gwo-Huei Luo, NSRRC, Taiwan**

Citation: "*For his outstanding contributions to accelerators at NSRRC, Taiwan, especially for his leading role in the management, construction, and commissioning of the Taiwan Photon Source (TPS). He has successfully brought the TPS project into a real bright light source. His dedication, broad expertise and leadership has contributed in a critical way to the success of the TPS, which must satisfy a number of challenging conditions that do not exist for a green-field machine. The other challenge was using superconducting cavities towards high current and high RF power. The construction of the superconducting RF system was indeed successful, and within four months after the start of operation of superconducting cavities in summer 2015, TPS has achieved a storage of 520 mA beam current that surpasses the design goal.*"

Gwo-Huei Luo (left) and Shin-ichi Kurokawa (right).

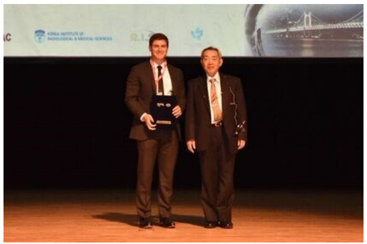
The Hogil Kim Prize for a recent, significant, original contribution to the accelerator field, awarded to an individual in the early part of his or her career is awarded to **Sam Posen, Fermilab, USA**

Sam Posen

Citation: "*For recent important, original contributions to accelerator technology, especially to the development of Nb_3Sn film coated superconducting rf cavities. Dr Posen's achievements include in particular developing a process for producing a special Nb_3Sn film on Nb and demonstration of excellent performance in critical field and Q-factor which are expected to outperform traditional Nb cavities. This discovery promises great improvements in the performance of future accelerator.*"

The Mark Oliphant Prize for a student registered for a PhD or diploma in accelerator physics or engineering, or to a trainee accelerator physicist or engineer in the educational phase of his or her professional career, for the quality of work and promise for the future is awarded to **Spencer Gessner, SLAC, USA**

Citation: "*for his work 'Demonstration of the Hollow Channel Plasma Wakefield Accelerator'*"



Spencer Gessner (left) and Shin-ichi Kurokawa (right).

Summaries by the Winners of IPAC’16 Student Poster Awards

Congratulations to the two winners of the Student Poster Awards at IPAC 2016, Claudio Torregrosa and Mattia Checchin! Below are summaries that the students have written for the general community describing their work.

From left to right: Claudio Torregrosa (CERN, Universitat Politècnica de Valencia), In Soo Ko (POSTECH), and Mattia Checchin (Fermilab, Illinois Institute of Technology).

The HiRadMat 27 Experiment: Exploring High-Density Materials Response at Extreme Conditions for Antiproton Production

Claudio Torregrosa

CERN, Universitat Politècnica de Valencia

The HiRadMat-27 RodTarg experiment explored the limits of high density materials used for production of antiprotons at CERN. In accelerator facilities, intense and high energy proton beams are commonly impacted with fixed materials (targets) in order to produce new particles and secondary beams by the interaction of the proton beam with the atoms and nuclei of these fixed materials. The geometrical design and material selection of these targets is completely specified by the kind of particles and secondary beam desired. A very particular case of target is the Antiproton Decelerator Target (AD-Target) at CERN, in which, due to inherent requirements of antiproton production, the target material is subjected extreme thermal shock and pressure waves each time is impacted by the primary proton beam. In the HiRadMat-27 experiment, these conditions and pressure waves were recreated and measured online in different materials such as Ir, W, Mo, and Ta by subjecting them to impacts of intense proton beams in a controlled environment using the HiRadMat facility at CERN. The experiment allowed us to validate advanced simulations of the materials response at such extreme conditions and study their performance. The experiment found that almost all the tested materials suffered important damage at conditions several times below those reached in the real target. This certainly influences the antiproton production achieved. Targets of tantalum, however, showed a very good and promising response, surviving these extreme conditions and becoming a strong candidate material for a new antiproton target design.

Ultimate Gradient Limitation in Niobium Superconducting Accelerating Cavities

Mattia Checchin

Fermilab, Illinois Institute of Technology

Superconducting radio-frequency resonators are accelerating structures employed to accelerate charged particles in modern particle accelerators. Since such devices are made of superconducting material, usually bulk niobium, they are limited in terms of accelerating gradient by their superconducting nature. Above a certain field – the field of first penetration – the magnetic field is free to penetrate the superconductor abruptly increasing the heat dissipation and quenching the superconducting state. The field of first penetration is experimentally found to range from the lower critical field – the lower limit at which magnetic field is thermodynamically stable in the superconductor bulk – to the superheating field – the upper limit at which the energy barrier to the magnetic flux penetration at the surface is zero.

Ideally the superheating field would be the ultimate gradient limitation, but experimental evidence suggests that only some class of cavities – so-called 120 C baked – can reach fields above the lower critical field. Compared to cavities treated with different treatments (e.g. electro-polishing, nitrogen-doping etc.), 120 C baked cavities present the unique characteristic of having a dirty layer at the surface with thickness comparable to the magnetic field penetration depth on top of a clean bulk. Starting from the Ginzburg-Landau equations, I calculated numerically the energy barrier to flux penetration in the presence of a dirty layer at the surface. Such calculation suggests that the energy barrier is enhanced by the presence of the dirty layer, explaining why 120 C baked cavities can reach higher fields. By cleverly tuning the superficial layer dirtiness it should be feasible to exploit the nitrogen-doping beneficial effect on the quality factor, possibly allowing low dissipation at high accelerating gradients.

In Memoriam

Helen Edwards (1936-2006)

By Andre Salles and Leah Hesla

Helen Edwards, one of the most vital contributors to the success of Fermi National Accelerator Laboratory over its five-decade history, died on June 21, 2016 at the age of 80.

Edwards was a giant in the field of accelerator science, best known for overseeing the design, construction, commissioning and operation of the Tevatron, which for 25 years was the most powerful particle collider in the world. The Tevatron turned on in 1983, when it began delivering particle beams for Fermilab's fixed-target experiments. It recorded its first proton-antiproton collisions in 1985 and was used by scientists to find the top quark in 1995 and the tau neutrino in 2000, two of the three fundamental particles discovered at Fermilab.

"Her vision was superb. She was a great architect — the architect of the Tevatron as a system," said John Peoples, Fermilab's director from 1989 to 1999. "She was terrific for Fermilab, and terrific period."

Her work on the Tevatron earned her the MacArthur Fellowship, also known as the Genius Grant, in 1988 and the National Medal of Technology in 1989. She also received the Department of Energy's E.O. Lawrence Award and the Robert R. Wilson Prize of the American Physical Society.

Edwards began her tenure at Fermilab in 1970 under the laboratory's original director, Robert Wilson. She had previously worked with Wilson as a research assistant at Cornell University and joined him at the nascent lab, eventually heading up the Accelerator Division.

To all who knew her, Edwards was a force of nature. Her colleagues note her forward-thinking vision, her unrelenting determination to get things done and her penchant for coloring outside the lines when it came to solving problems.

"Her continuous drive was something that amazed me," said engineer Paul Czarapata, deputy head of the Fermilab Accelerator Division. "It seemed like nothing could slow her down."

She was also known for her astonishing intellect, working out complex scientific problems by relying almost entirely on her own knowledge, without having to resort to outside references.

"I once asked her a question about a property of an accelerator component, and she disappeared from the office," Czarapata said. "She came back with a handwritten derivation of the formula, complete with the answer."

That deep understanding of physics and her keen intuition was evident to everyone who knew her.

"I was scientifically mesmerized by her," said University of Maryland professor Timothy Koeth, who studied accelerator physics under Edwards' supervision when he was earning his PhD from Rutgers University. "She had this intuitive and innate grasp of the material, and she was always absolutely right – she was never wrong in the 20 years I knew her. She understood complex systems from every aspect – operational or technological."

Edwards wasn't known for conducting business from the sidelines. She got down in the dirt, actively and directly working on accelerator components, sometimes pulling all-nighters to make sure everything was fine-tuned.

"Helen was an incredibly gifted accelerator scientist with a fiery personality and a tendency to move forward very quickly," said scientist Roger Dixon, who formerly headed the Fermilab Accelerator Division. "Those of us who fell into her wake benefited greatly from the experience."

The widespread respect and reverence that Edwards commanded extended to those who worked with her.

"I had what I later termed the 'Helen card' on my side," Koeth said. "I quickly found out that saying 'This is for Helen' made things happen. When I was Helen's student, people said, 'I'll have whatever you need tomorrow morning.' That happened over and over again. It was a living legacy of what she meant to the people of the laboratory."

Edwards had a keen understanding of people and their strengths, with a knack for positioning them in roles where they would excel. She knew how to bring the right people together to carry out a project and how to encourage them to success.

"She was really a brilliant person," said Fermilab scientist emeritus Paul Mantsch. His job in the early days building the Tevatron was related to 250 magnets that helped align the particle beam. It didn't start out well.

"So we worked hard to get the magnets going," Mantsch said. "She gave constant encouragement to think hard about the problem and solve it. And we did solve it. She was very appreciative of the work we'd done. I valued that kind of relationship with my co-workers, and with Helen in particular."

She was just as encouraging as a mentor. Koeth compared Edwards to a mama bird encouraging her baby bird out of the nest.

"She made sure I met people, that I was pushed into the community. I didn't realize what she was doing at the time. Anytime there was a tour at AZero, she had me give it. She was a very good instructor," Koeth said. "Working in her lab led to adventures of high RF power, high voltage, high vacuum, electron beams, and opportunities for traveling the country and the world. It was a form of paradise."

Edwards admired the world around her. She took photos of wildlife, natural scenery and even the rings of Saturn

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with a camera attached to her backyard telescope.

"She loved nature, she loved animals," Koeth said. "She had a heart of gold."

Her kind nature extended to her friends and colleagues.

"She sincerely cared about people," Dixon said. "I am very fortunate to have had the Helen experience in my life."

Fermilab shut down the Tevatron in 2011. As part of a labwide shutdown ceremony, Edwards, wearing a cowboy hat, pushed the buttons that finally turned off the particle beam. It was a fitting end for the trailblazing machine that she brought to life.

Edwards worked at Fermilab for 40 years, serving most recently as a guest scientist from 1992 to 2010. Through the last years of her life, she worked on the next generation of superconducting accelerators, helping to shape the future of particle physics. She focused much of her work on accelerating cavities, and the developments in that arena led to the establishment of a test bed at Fermilab for cutting-edge particle acceleration technology, called the Fermilab Accelerator Science and Technology Facility.

She designed the key features of the Superconducting Super Collider, a planned but never completed 54-mile-around accelerator sited in Texas. Edwards also maintained a position at Deutsches Elektronen Synchrotron (DESY), working on the design for the TESLA superconducting linear accelerator.

Edwards was a member of the American Academy of Arts and Science and the National Academy of Engineering, as well as a fellow of the American Physical Society.

"It is impossible to overstate her role in making Fermilab what it is today," said Fermilab Director Nigel Lockyer.

Michael S. Zisman (1944-2015)

By John Byrd

Dr. Michael S. Zisman, known worldwide as a designer and builder of particle accelerators, passed away early morning on 30 August 2015 at age 71 following a lengthy illness. He is survived by his wife, Andrea, daughter, Nia, sons Matt and Tim, and grandchildren Jacob, Sam, Adam, Arielle, and Zachary.

At the time of his death, Mike was a Senior Scientist with the Center for Beam Physics in Berkeley Lab's Accelerator Technology and Applied Physics Division and a Fellow of the American Physical Society. Mike was well known at Berkeley Lab and around the world as a builder of high-energy accelerators. His energy and drive will be greatly missed.

In 1966, after receiving his bachelor's degree from the University of Michigan, Mike began graduate study in nuclear physics at the University of California, Berkeley, and worked at Berkeley Lab's 88-inch Cyclotron. He earned his PhD in physics in 1972. Following a postdoctoral appointment at the University of Washington, he rejoined Berkeley Lab in 1974 as a member of the scientific staff.

As he worked at the 88-inch Cyclotron, SuperHILAC, and Bevalac, Mike developed his interest in accelerator physics. It was a propitious time to enter that field. The late 1970s and early 1980s were the origin of the Superconducting Super Collider, the most ambitious project in the history of high-energy physics. LBNL hosted its Central Design Group; Mike joined this effort as a member of the Exploratory Studies Group, now known as the Center for Beam Physics.

During the mid-1980s, Mike's interests turned toward a much different challenge that had taken on great scientific importance: a third generation of synchrotron-light sources based on low-emittance electron storage rings. LBNL proposed a facility that would be in the vanguard of the third-generation light sources. It became apparent that the photon-beam performance demanded by their users depended heavily on understanding complex collective effects that dominated the electron-beam behavior. Mike and colleagues developed the accelerator physics design code ZAP, which quantified all of these effects and has been used at many accelerator facilities in the US and abroad for the design of electron storage rings. He also coordinated the Conceptual Design Report, a key document in building from these ideas to envision the Advanced Light Source, a Department of Energy user facility that today serves more than 2000 scientists a year from across the physical and life sciences.

As the decade ended, Mike brought his expertise in highly demanding electron rings back to high-energy physics. Pier Oddone, then director of Berkeley Lab's Physics Division, had put forth an idea for an "energy-asymmetric" electron-positron collider with which to explore charge-parity violation in the beauty sector by creating and studying the decay of B mesons. This collider addressed one of the most fundamental puzzles in physics: why is there far more matter than antimatter in the universe?

The Berkeley Lab team convinced the Stanford Linear

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Accelerator Center that the high-energy ring from the earlier Positron-Electron Project would make SLAC an ideal location for this B-meson "factory." Mike led the production of the PEP-II Conceptual and Technical Design Reports in 1991 through 1993 and subsequently became System Manager for its new Low-Energy Ring. In that capacity, he led its development through its 1998 commissioning. PEP-II became the highest-luminosity e+e - collider in the world until it was surpassed by the KEKB collider in Japan. .

Following his work on B-factories, Mike became fascinated by the challenges of developing neutrino factories and muon colliders—accelerators with tantalizing possibilities for addressing fundamental questions in physics if only they could be built—eventually rising to the position of the Collaboration Spokesperson and DOE Project Manager. In 2001, he became a member of the ad-hoc Steering Group of the Muon Ionization Cooling Experiment (MICE), and served as its Deputy Spokesperson. These efforts have made substantial progress towards a feasibility demonstration and first cost estimate for a high-energy muon-antimuon collider. One of the most vexing technical challenges for muon colliders that Mike worked on is cooling the muon beams to achieve the small final emittances that are necessary for a muon collider. This is the subject of MICE, a dedicated experiment to demonstrate ionization cooling and the associated accelerator technology. Assembly and testing of MICE is currently being completed at the Rutherford Accelerator Laboratory in the UK as part of an international collaboration.

In the course of Mike's career, accelerators had become vital infrastructure not only for many fields of scientific research but also for numerous applied fields, including medical therapy with protons, heavy ions, and X- and gamma rays; production of medical isotopes; and industrial materials processing. In recent years he had helped establish the Accelerator Stewardship Program at the Department of Energy's Office of High Energy Physics. This program supports fundamental accelerator science and technology development, and disseminates accelerator knowledge and training to the broad community of accelerator builders and users.

In 2010, Mike was asked to work in the Office of High Energy Physics with the assignment of making the stewardship program a reality. Detailed to DOE, Mike accepted this responsibility with his usual energy and enthusiasm. The program chose to focus on three areas: ion beam therapy, laser technology, and accelerator applications to energy and environment. Mike worked tirelessly to organize this effort, and finally, in 2014, the program funded the first substantial programs in designs for lightweight gantries for hadron beam therapy and in technologies towards high average and peak power lasers. Establishing a new government program in the current scientific funding environment was a tribute to Mike's patience, skill, and tenacity.

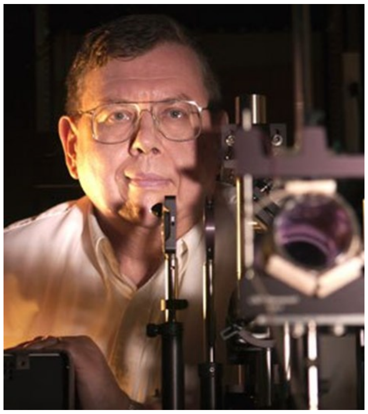
Those of us who worked with Mike will miss his combination of technical acumen, professional drive, and humanity: the master of arcane detail who usually found a way to end a presentation with an on-point cartoon; the hard driver in the Lawrence tradition who described his role in the MICE collaboration as "Deputy Spokesmouse." Though he left us too soon, the Accelerator Stewardship Program is a fitting legacy, establishing a formal basis of support for the critically important field to which he had devoted his career.

The many people who knew Mike are invited to share their memories at this online memorial.

Editor's note: Mike served as Secretary-Treasurer of the APS DPB from 2002-2004.

John Madey (1943-2016)

By Pui Lam, Vladimir Shiltsev, and Frank Zimmermann



The international accelerator community has been deeply saddened to learn about the passing of the pioneer of the free-electron laser, Professor John M. Madey from the University of Hawai'i at Mānoa. Madey has left us on July 5, 2016.

Raised in Clark, New Jersey, John Madey and his older brother Jules took an early interest in ham radio. In 1956, when John was 13 and Jules was 16, they began relaying communications from the South Pole to families and friends in the United States. Madey received a BS degree in Physics and a MS degree in Quantum Electronics from the California Institute of Technology in 1964 and 1965, where he first raised the question whether or not it was possible to enhance the transition rate for bremsstrahlung through stimulated emission. He continued thinking about the stimulated emission question while working on his doctoral degree at Stanford, at which time he invented the free-electron laser.

A free-electron laser device can produce coherent electromagnetic radiation of extremely high intensity and high quality that is tunable over a wide range of

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frequency. This renders the free-electron laser (FEL) of great interest for research in physics, chemistry, biology and medicine. While classical FELs use mirrors or optical cavities, a more recent FEL variant, operating at ever shorter wavelengths, is the linac-based free-electron laser, such as the Linac Coherent Light Source at SLAC or the European X-ray FEL in Hamburg, Germany.

Madey was awarded a PhD in 1970, and appointed as Professor (Research) of Electrical Engineering in 1986. In 1988 he left Stanford, taking a tenured position at the Physics Department of Duke University and moving his FEL research laboratory with him the following year. John Madey joined the Department of Physics and Astronomy at the University of Hawai'i at Mānoa in 1998.

Madey was bestowed with numerous awards and international recognitions, including the Stuart Ballantine Medal from the Franklin Institute in 1989, the 2012 Robert R. Wilson Prize from the American Physical Society and the 2016 Willis E. Lamb Award for Laser Science and Quantum Optics. Madey was the keynote speaker at the 2015 Nobel Symposium on Free-Electron Lasers in Sigtuna, Sweden. He held 13 patents on free-electron laser related technological inventions.

Prof. Madey published many important papers including a seminal PRL publication ("Observation of Stimulated Emission of Radiation by Relativistic Electrons in a Spatially Periodic Transverse Magnetic Field") in 1976, and, more recently, a comprehensive PRST-AB review article on the history of the FEL invention ("Wilson Prize article: From vacuum tubes to lasers and back again").

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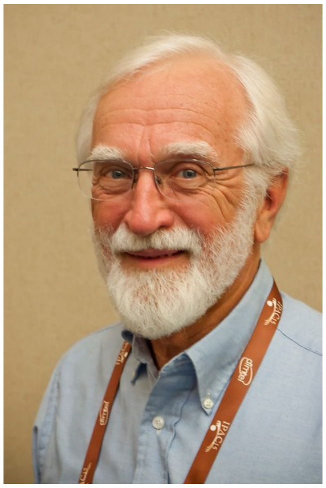
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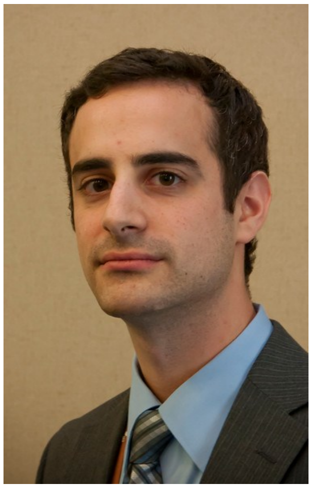
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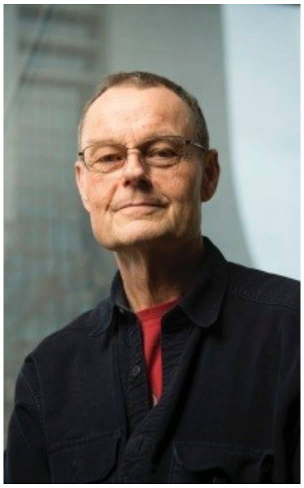
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Upcoming Meetings

October 9 - 14, 2016 • **2nd North American Particle Accelerator Conference (NA-PAC 2016)** • Chicago, IL

October 3 - 7 • **International Workshop on Accelerator Alignment (IWAA 2016)** • Grenoble, France

October 24 - 27 • **ICFA Advanced Beam Dynamics Workshop on High Luminosity Circular e+e- Colliders (eeFACT 2016)** • Daresbury, United Kingdom

October 25 - 28 • **International Workshop on Personal Computers and Particle Accelerator Controls (PCaPAC 2016)** • Campinas, Brazil

October 30 - November 4, 2016 • **24th International Conference on Application of Accelerators in Research and Industry (CAARI 2016)** • Fort Worth, Texas

November 21 - 25, 2016 • **Russian Particle Accelerator Conference (RuPAC 2016)** • Saint Petersburg, Russia

March 13 - 17, 2017 • **APS March Meeting 2017** • New Orleans, Louisiana

January 28 - 31, 2017 • **APS 'April' Meeting 2017** • Washington, DC

May 14 - 19, 2017 • **International Particle Accelerator Conference (IPAC 2017)** • Copenhagen, Denmark

May 29 - June 2, 2017 • **Future Circular Collider Week (FCC Week 2017)** • Berlin, Germany

June 18 - 23, 2017 • **Workshop on Energy Recovery Linacs (ERL 2017)** • CERN, Switzerland

July 17-21, 2017 • **International Conference on RF Superconductivity (SRF 2015)** • Lanzhou, China

September 13 - 17, 2017 • **International Beam Instrumentation Conference (IBIC 2017)** • Grand Rapids, Michigan

October 8 - 13, 2017 • **International Conference on Accelerator and Large Experimental Physics Control Systems (ICALEPCS 2017)** • Barcelona, Spain