Department of Energy
Washington, DC 20585

JAN 16 2014

Dr. Stuart Henderson
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Dear Dr. ~~Henderson~~ Stuart:

I have enclosed the report from the Department of Energy Program Review of High Energy Physics (HEP) Laboratory General Accelerator R&D (GARD) held on March 6–12, 2013. It conveys our evaluation of the performance, effectiveness, and quality of the GARD program at each of the laboratories, based on the findings of the review committee, the presentations during the review, the laboratory visit, and our office's assessments. It also provides guidance for your future program planning.

I would like to thank you and your staff for the hospitality shown the review team and for the quality of the review. Despite the threat of unpredictable weather conditions, the review at each laboratory proceeded smoothly as the review committee traveled from one laboratory to the next. All the presentations by the staff of each laboratory were polished, well organized, and informative.

Overall, the review committee was very favorably impressed by the review and its associated materials. They did, however, point out some areas for your consideration and they made some suggestions and recommendations that may improve the quality of your program, details of which can be found in the enclosed report. Please work with L.K. Len of our office to address the review committee's suggestions and recommendations in the coming weeks.

We hope that the review report is helpful to you in planning the next several years of HEP General Accelerator R&D activities at the laboratory.

Sincerely,

Glen Crawford
Director, Research and Technology Division
for High Energy Physics

Enclosure

Report of the DOE Program Review of HEP Laboratory General Accelerator R&D March 6–12, 2013

1 Introduction

The Office of High Energy Physics (HEP) General Accelerator R&D (GARD) program provided $74 million in FY 2013 for accelerator research and technology development, of which $62 million is in support of research efforts at the national laboratories. This program supports a broad research program that includes the following research thrusts: Accelerator and Beam Physics (including theory, computation and simulation); Particle Sources, Beam Instrumentation & Controls; Novel Accelerator Concepts; RF Sources, Normal Conducting High Gradient Accelerator Structures; Superconducting Magnets and Material; and Superconducting RF Accelerator Systems and Material. This review also covers Test Facility Operations at each of the laboratories. The GARD Review on March 6–12, 2013 focused on the work being performed at Argonne (ANL), Brookhaven (BNL), Fermilab (FNAL), Lawrence Berkeley (LBNL) and SLAC (SLAC) national laboratories. The review was chaired by L.K. Len with the review committee consisting of David Bruhwiler, John Galambos, Donald Hartill, Shane Koscielniak, Peter McIntyre, Lia Merminga, Joseph Minervini, George Neil, Steve Russell, and Antonio Ting, along with DOE observers—Eric Colby, Glen Crawford, Michael Procario, and Michael Zisman. To ensure coverage of the program, each reviewer was assigned certain specific topics to review. In addition, each reviewer was encouraged to comment on *all* aspects of the review, not simply those topics specifically assigned.

In what follows, the findings, comments, and recommendations of the review are discussed by thrust area in Section 2. HEP's responses are given in Section 3 and a brief summary of the review is contained in Section 4. Following the main report, the appendices include the charge letter to the review committee and agendas of the review sessions at each institution.

2 Overall Program Evaluation

Overall, the reviewers found the HEP Laboratory GARD program to be healthy, with broad meritorious activities being pursued at all the HEP-funded national laboratories. The research was considered to be of high quality, with little overlap between the research programs in the different laboratories. The program as a whole appeared to be well aligned with the overall HEP mission with the major challenges identified being addressed. The one exception to this is that several reviewers noted the heavy emphasis on electron beam R&D activities and the comparative dearth of proton beam activities. While this emphasis was originally motivated by the expectation that the International Linear Collider (ILC) would be built in the U.S., the GARD program has not fully adjusted to the reduced priority of the ILC and the increased priority of intensity frontier activities for the domestic HEP program. It was also noted that the current portfolio does not include much effort aimed at particle sources, beam instrumentation and controls, though some of the source-related activities are now being supported by other Office of Science (SC) programs—the Office of Nuclear Physics (NP) for ions and the Office of Basic Energy Sciences (BES) for electrons. Given the current budget climate, the resources going into GARD were believed to be well justified and properly matched to the tasks to be done.[1] Better integration within the U.S. community of code developers was recommended to avoid duplication, along with steady support for code maintenance.

2.1 General Accelerator R&D Thrust Areas

In this section we discuss the findings, comments, and recommendations of the review committee organized by the programmatic thrust areas. As noted earlier, various reviewers were specifically assigned to focus on particular thrust areas but all reviewers were encouraged to indicate their views on all topical areas.

2.1.1 Accelerator and Beam Physics

All of the laboratories reviewed have activities in this thrust area. Those institutions currently operating test accelerators (ANL, BNL, and SLAC) emphasize work that makes use of these facilities, though in most cases their program is even broader than that supported by the test facility.

ANL work in this thrust area focuses mainly on novel acceleration techniques (dielectric wakefield acceleration, DWA) making use of the Argonne Wakefield Accelerator (AWA) facility. Their aim in terms of gradient (~300 MV/m) is intermediate between today's technology and the potential of the plasma wakefield accelerator (PWFA) or laser plasma accelerator (LPA) schemes. The DWA scheme may, therefore, be available on a shorter timescale than the more ambitious PWFA and LPA approaches. As a consequence of their high-intensity gun, the AWA team also studies issues related to high-power, high-brightness electron beam generation. At present, they produce the world's highest charge per bunch (100 nC). Recently, they have been involved in the design of an intense positron source that would be of interest for the ILC.[2] Although the AWA is not formally a user facility, they work closely with scientists from Euclid Techlabs, who augment the AWA staff by stationing resident scientists at ANL. This serves as an effective way to leverage SBIR funds.

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[1] Because the other areas of directed accelerator R&D supported by HEP were not within the scope of this review, the overall balance of the entire HEP accelerator portfolio was not addressed.

[2] As ILC activities are no longer supported as directed R&D, some generic activities are now being carried by GARD.

The AWA group is efficient, dedicated, and proud of their facility and, as a consequence, they are very productive and provide good value for GARD. They have produced six Ph.D.s in the past ten years. GARD supports simulations of the facility performance using Parmela, IMPACT-T, and ACE3P. Beam dynamics simulations in the 100 nC regime are unique in this field. Some reviewers noted that the group appears to be a bit isolated at ANL, and would benefit from better integration with the other accelerator groups at the laboratory as part of the Argonne Accelerator Institute.

AWA upgrade plans will be discussed later, in Section 2.2.1.1.

BNL GARD work in this thrust area centers around the Accelerator Test Facility (ATF), which comprises an 80 MeV electron linac, a high-brightness photoinjector, and a mode-locked CO_2 laser. The ATF is a very productive and cost-effective facility for doing beam physics. It generates about 1.5 Ph.D.s per year, which is the most prolific of all the programs reviewed. They have a broad program of beam physics, including high-gradient acceleration, beam-laser interaction studies with their CO_2 laser, and high-intensity beam preparation. The work has high scientific value, as measured by high-impact journal publications and citation indices. Because the ATF is a small facility, the BNL team is adept at supporting its users and takes pride in doing so. The ATF recently lost its director, Vitaly Yakimenko, who has moved into a similar position at FACET. This is a substantial loss to the ATF and it is very important that a new, high-quality permanent director be identified soon. This person should be in place in time to influence the planning for the proposed upgrade of the facility to ATF-II (discussed in Section 2.2.2.1).

Fermilab's accelerator and beam physics program includes accelerator theory, modeling, and simulations. Prior to the closure of the Tevatron, the group used the complex for studying beam-beam effects and their compensation, sophisticated extraction/collimation techniques, electron-cloud studies, and beam diagnostics improvements. They also used the A0 line to develop valuable beam manipulation techniques, such as transverse-to-longitudinal emittance exchange, round-to-flat beam transformers, and custom beam shape generation. Their work on non-linear integrable optics is very interesting and has the potential for changing the paradigm for high-current accelerator design. They hope to test this concept experimentally as part of the proposed Advanced Superconducting Test Accelerator (ASTA), which will be discussed in Section 2.2.2.3. Fermilab's High-Brightness Electron Source Laboratory (HBESL), which can be used for testing new photo-cathode ideas, is a unique and valuable community resource that should be preserved if possible, if not at Fermilab then elsewhere, e.g., ANL. It is currently scheduled to end in 2014.

The Fermilab group has contributed substantially to the development of highly sophisticated and widely used modeling tools, including Synergia, MARS, Lifetrac, and OPTIM, and leads the SciDAC-sponsored accelerator computations program. This state-of-the-art software is world-class and is viewed as essential for advancement of the energy frontier at future U.S. or off-shore particle accelerators.

Looking at Fermilab's future staffing projections, reviewers felt that the projected staffing level for accelerator physics was too low in the out years. Whether this is solely a budgetary issue or a matter of research priorities was unclear[3]. Another concern expressed by reviewers was on the balance between accelerator physics using electrons, which mainly addresses the energy frontier, and using protons, which mainly addresses the intensity frontier. The reviewers were left with the impression that the main priority for the laboratory was to expand heavily into electron beam R&D, whereas the scientific effort at the laboratory is aimed at the intensity frontier using protons. Insofar as Fermilab is the natural center for intensity frontier science, and is thus the most natural venue for carrying out the supporting R&D, the priorities expressed by the laboratory are a concern and should be revisited. Fermilab unquestionably provides the most suitable venue to carry out accelerator R&D with intense proton beams and should be encouraged to have priorities reflecting that fact.

LBNL's GARD activities in the accelerator and beam physics thrust area include studies of laser-plasma acceleration with the Berkeley Laboratory Laser Accelerator, BELLA (LOASIS group), and accelerator design and modeling (Center for Beam Physics, CBP). The BELLA program will be covered in Section 2.1.3 of this report; in this section we discuss the CBP efforts.

CBP is a leader in accelerator modeling, and has historically been the incubator for a number of new accelerator ideas. The group has core competencies in beam dynamics, simulations, precision rf and laser control, rf and general electromagnetic modeling, and accelerator instrumentation. Modeling is a major focus for the group and it has had wide impact on the accelerator field. They have made a concerted effort to support their code user base, which numbers 26 institutions worldwide along with many domestic users, by making their codes more useful and usable and by paying attention to code integration via the Berkeley Laboratory Accelerator Simulation Toolkit (BLAST). They have taken good advantage of the proximity of NERSC, giving access to powerful supercomputers and applied mathematics expertise. In the future they will focus on laser plasma acceleration and they hope to be partners in experiments at Fermilab's ASTA facility. LBNL's efforts to provide useful codes for the community and apply them to current problems are commendable. In reviewing the code capabilities of LBNL, the reviewers noted some overlap between LBNL and SLAC in modeling coherent synchrotron radiation effects, and suggested that this is an area that might benefit from either consolidation or getting additional support from BES for this work. They also noted an overemphasis of electron beam dynamics within the GARD portfolio for beam physics, modeling, and simulation and commented that the WARP code, used for Project X low-energy beam transport and studies of e-cloud effects in proton rings, was a noteworthy exception.

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[3] In Stuart Henderson's introductory slides, which were based on DOE guidance of a decrease in GARD funds of 2% in FY2014 and flat thereafter, the accelerator physics categories (comprising Accelerator and Beam Physics plus Particle Sources, Beam Instrumentation, and Controls) have a head count projected to decrease from 22.1 FTEs in FY2012 to 10.0 FTEs in FY2014, whereas the larger SRF and SC Magnets and Materials categories decrease only by about 4 FTEs over this interval.

Historically, the CBP has made pioneering contributions to e-cloud physics. CBP staff members have participated in LHC-related activities broadly and effectively, including injector upgrade e-cloud studies, beam-beam studies, intrabeam scattering emittance growth, and crab cavity noise simulations. They are now embarking on a study of broadband feedback to combat e-cloud and/or transverse mode coupling instabilities in the SPS. CBP is viewed as really good at using their instrumentation and code expertise in solving specific problems.

An activity that is a bit "off the beaten track" is the CBP participation in the ALPHA experiment at CERN, which involves the trapping of anti-hydrogen atoms. The reviewers felt there are lots of opportunities for beam physics here. Long-term goals of ALPHA include the study of CPT symmetry and doing gravity measurements to ascertain whether antimatter and matter behave identically.

One weakness of the CBP is the dearth of students. Both lack of funding and the concomitant need to focus on programmatic activities that are not well-suited to student participation are the root causes.

The GARD program at SLAC includes experimental and simulation work on laser plasma acceleration (at FACET) and laser-driven dielectric structures (at NLCTA), along with more general beam physics work. The first two activities will be discussed in Section 2.1.3. Here we discuss the last activity.

The SLAC beam physics group comprises 16 FTEs, many of whom are renowned accelerator physicists who have received prestigious awards. Their core competencies include lattice design and single-particle dynamics in storage rings, wakefields and impedances, collective effects in highly charged beams (such as e-cloud and beam-beam effects), simulations and parallel computing. Recent accomplishments include the echo seeding concept and its demonstration at the NLCTA, demonstration of self-seeding in the LCLS, and designs of an "ultimate" storage ring and a ring-based Higgs factory. The work on next-generation rings, in contrast to the approach being studied at Fermilab, is to make the optics as linear as possible. The reviewers characterized this activity as being impressive work. In the next four years they will focus on improvements in beam brightness and pushing the limits of beam dynamics and stability, especially the physics of ultra-short bunches and coherent synchrotron radiation.

A flagship code for the group, developed by the 6 FTEs in the Advanced Computations Department, is ACE3P. ACE3P is a suite of C++-based finite-element electromagnetic codes running at NERSC that is used to model a wide spectrum of phenomena of interest to HEP and other SC programs. In recent years they have studied the rf coupling between the two beam structures of CLIC, the power coupling between photonic band gap structures for dielectric laser acceleration, mode oscillation effects in klystrons, effects of imperfections on Project X cavities, LHC crab cavity design, muon accelerator test cavity design, and design of the accelerator sections for the AWA upgrade at ANL. ACE3P has established itself as the premier parallel electromagnetic code in the accelerator field. It was noted by the reviewers that the code represents a tremendous tool. Plans (motivated by user interest) call for expanding the ACE3P suite to include multi-physics effects and address engineering and beam aspects. Although the code is impressive, reviewers felt that the tool was not as widely available as it should be because it runs only on NERSC, and that some software engineering to allow other platforms would broaden its user base.

2.1.2 Particle Sources, Beam Instrumentation and Controls

In general, the level of activities at the national laboratories in this thrust area is relative small and the efforts are more development than research.

At ANL, the existing high-intensity electron source is adequate for AWA needs, so no further development is being done. They have developed techniques for shaping the bunch train to improve the transformer ratio. They have also completed the design of an undulator-based positron source for the ILC effort. While their source work has always been high quality, there is presently no driving need for more intense beam. Some enhanced beam instrumentation is needed for the AWA upgrade, and thus far the emphasis has been on the primary beam. In order to properly characterize the efficacy of the two-beam system, the instrumentation focus needs to shift to the witness beam, whose quality (e.g., emittance) needs to be well determined. Because of the upstream bend in the witness beam line, this may be somewhat challenging.

One point of concern raised by the reviewers was that the upgraded AWA facility, with more rf structures, is likely to require more substantial control requirements. For example, it is far from clear that multiple structures can be operated open loop and with beam-based rf settings. At best, the setup time to get a high-quality beam will increase, and it might be that closed loop operation is needed. Presently, the AWA team appears to operate mainly in isolation; more interaction with existing ANL accelerator expertise, at least in an advisory capacity, should be encouraged. A reservation was also expressed about using AWA physicists to write the controls software for the proposed upgrade. Insofar as ANL is a founding member of the EPICS toolkit, it would seem prudent to supervise an EPICS engineer to upgrade the controls software, leading to a more easily maintained system.

The ATF at BNL makes use of its tried and true photocathode source technology; major improvements were not reported. They are working on the design of a single-shot, nondestructive emittance measuring system. Their control system was developed in-house using standard tools. It appears to be flexible enough to accommodate user needs. The CO_2 laser operation is currently well supported, but plans to further increase the laser power will lead to increasing support demands. However, other beam line instrumentation needs will also exist, and will need their share of attention.

The Fermilab efforts in this thrust area have diminished markedly with the termination of the A0 and HINS facilities. However, the A0 injector and its beam physics program are being transitioned to activities at ASTA and the High Brightness Electron Source Laboratory (HBESL). The A0 work has demonstrated good understanding of techniques for tailoring bunch properties, both transverse and longitudinal. Real time single-shot bunch length measurements have been developed using electro-optical methods; this represents an advance for this field. Reviewers noted Fermilab's strong record of publication and student training in the accelerator R&D program, and expressed the desire that Fermilab maintain a viable accelerator science staff even in the face of declining budgets. The reductions implied by Fermilab's out-year staff projections potentially represent a long-term vulnerability for the accelerator field insofar as Fermilab is the only institution where intensity-frontier-motivated proton beam R&D is likely to occur. Whether the emphasis on SRF and SC magnets is the proper priority should be discussed with DOE.

LBNL does not maintain an HEP-funded program on either particle sources or controls. The instrumentation effort at LBNL is directed toward timing and synchronization over long spatial distances via stabilized optical fiber links, and they remain world leaders in fs timing distribution. The goal of the timing work is to synchronize all the rf sections of an accelerator complex to a time jitter below 20 fs.

SLAC participated with LBNL in developing and demonstrating a feedback system for the SPS at CERN and demonstrated tune control. It remains to be seen whether the use of higher-bandwidth amplifiers can successfully damp the very broadband electron cloud instability. They have also developed a notched collimator system that will permit two-beam plasma wakefield experiments at FACET and an X-band deflector cavity (installed at FACET) that can kick the beam to permit single-shot temporal measurements. The fast deflector has the potential to provide emittance information, not simply energy spread, and thus will be key to being able to verify emittance preservation in a plasma wakefield accelerator. The X-band test accelerator represents a new capability with the potential to provide a lower emittance electron source.

The quality of work at the SLAC test facilities was judged to be high, and there is a strong record of accelerator science publication and student training. In addition to FACET, which is discussed elsewhere in this report, the NLC Test Accelerator (NLCTA) provides support for a wide range of accelerator science developments. These include X-band modulator and coupler hardware development and beam tests of small accelerating structures. The NLCTA has the ability to quickly test new ideas, a valuable attribute.

2.1.3 Novel Accelerator Concepts

While reaching ever-higher beam energies with standard rf approaches is certainly feasible, we have reached the point where the economics are no longer favorable. This thrust area therefore focuses on developing new ways to achieve very high accelerating gradients that could lead to more compact, and hopefully more affordable, energy frontier accelerators. In a general sense, only a few approaches are being pursued. A plasma channel is capable of producing very high gradients (~GV/m). Creating the accelerating structure in such a plasma can be accomplished either with an electron drive beam (as in plasma wakefield acceleration, PWFA) or with a powerful laser beam (laser plasma acceleration, LPA). In the GARD program, the former avenue is currently being pursued at BNL and SLAC, and the latter avenue is being pursued at LBNL (also at UCLA and UT-Austin, but only the national laboratory programs are being reviewed at this time).

Another approach, being pursued at ANL, is to use the wakefield of the drive beam directly, in a dielectric structure, to accelerate a witness bunch. This can be done either in a coaxial arrangement, where one beam follows the other in the same vacuum pipe, or in a two-beam accelerator configuration, where the wakefield of the drive beam is coupled out of one channel into a second channel where the witness beam is accelerated. The expected gradients are lower (100s MV/m) but still well above typical RF accelerating schemes. A third approach, dielectric laser acceleration (DLA), being pursued at BNL and SLAC, involves using a laser to produce the accelerating fields directly in a dielectric structure.

It was noted by the reviewers that the landscape for novel accelerator concepts has changed in recent years. More sophisticated measures of success are now called for than simply reaching high gradients. For one thing, it is essential to show that the witness bunch can be accelerated with a useful charge per bunch and with good emittance and small energy spread. For another, it is critical to be able to demonstrate staging, that is, the ability to transmit the witness beam from one accelerating stage to another while preserving its quality.

At ANL, novel acceleration methods are tested at the AWA. The AWA group has developed and tested dielectric power extraction and transfer structures for CLIC, demonstrated energy spread reduction in a sub-ps relativistic electron beam using a passive wakefield device, and measured high surface field excitation (300 MV/m) from a high-intensity beam in a diamond structure. It appears that the laboratory has supported the group well, which has helped them be successful to date. In particular, ANL is contributing strongly to the upgrade plan now under way. Though AWA is not a user facility, the AWA team includes world-class researchers and is doing high-quality research with a large number of collaborators, especially a strong involvement with Euclid Techlabs (an SBIR company). The AWA group clearly supports the HEP mission, primarily in advancing the energy frontier accelerator capabilities, but also in terms of accelerator stewardship. However, their impact on the community will be limited until they have *i*) demonstrated significant acceleration of a high-quality witness beam, and *ii*) designed and executed experiments to demonstrated staging. It seemed during the review that item *ii*) was not high on their to-do list; this needs to change. The reviewers felt that additional investment of GARD funds in the AWA effort would increase the chances of success for beam commissioning and operation; reduced funding would have a strongly negative effect on the program. With continued funding, the AWA group should be able to deliver groundbreaking results in dielectric wakefield acceleration and provide solid technical information for choosing between a two-beam or a co-linear scheme for wakefield acceleration.

BNL's novel accelerator concepts work is carried out at the ATF, and is aimed at improved accelerating gradients. Recent and ongoing experiments include beam driven plasma acceleration concepts, beam driven wakefields in various dielectric materials and structures, vacuum laser acceleration, surface-wave acceleration, and use of beam-driven wakefields to manipulate the beam's phase space. During the past four years, 114 groups have conducted experiments at ATF, about half of which were from universities. The users have a good publication record, with 12 Physical Review Letters papers in 2012 alone.

One important tool in their arsenal is a TW-scale CO_2 laser. They are proposing to increase the laser power by a factor of 10 by means of chirped pulse amplification. This work is innovative and has great promise for producing beams of interest to the medical community. With adequate funding, the upgrade is deemed likely to succeed. The reviewers noted that with the proposed ATF linac energy upgrade to 500 MeV, many of the experiments using the 20 GeV linac beam at SLAC could likely be done less expensively and more conveniently at the ATF. Thus far, investigations of staging and witness bunch acceleration have not been priorities of the ATF program.

At present Fermilab does not carry out R&D on novel acceleration schemes, though they desire to enter this field with the proposed ASTA facility if it is approved. In the past, they have worked on electron or ion beam driven plasma wakefield acceleration, and they have the talent to make a big impact on this research if they resume the effort.

LBNL makes use of the newly constructed BELLA facility to study laser plasma wakefield acceleration. The laser system produces 1.3 PW laser pulses (40 J in 30 fs) at 1 Hz. The BELLA team has a near-term goal of producing a 10 GeV electron beam using a meter-scale capillary discharge plasma. The group has made progress in learning how to control the plasma channel, including both longitudinal density control and transverse density tailoring. They also have tools to control the PW laser pulse using a motorized mirror under feedback control. Future plans call for precise addition of higher-order modes to the pulse to yield modified plasma wakefields that will reduce beam emittance growth and energy spread and compensate for beam-loading complications. In contrast to other groups, the BELLA laser operates in the quasi-linear regime. This choice prevents dark currents and is more stable and controllable than the highly nonlinear regime advocated by other groups. Several mechanisms for resonant injection of electron bunches have been developed, though none is fully optimized yet.

The BELLA team uses the WARP code to perform massively parallel simulations of their experiments. They also make use of the commercial Vorpal code from Tech-X Corporation and several other codes, such as INF&RNO for simpler reduced dimensionality quasi-static and PIC simulations. Their aim is to simulate, model, and design all the physical processes and technologies that are key to present and future laser plasma acceleration experiments.

The LOASIS/BELLA team has been very effective in recruiting students. In the past decade, 21 Ph.D. students did all or part of their work with LOASIS, along with 15 post-doctoral fellows, 21 undergraduates, and six senior visitors. They have also been diligent about publishing, with 54 peer reviewed papers, many in prestigious journals such as Nature. Reviewers felt that the quality and impact of LOASIS/BELLA is unequaled by any other novel accelerator concepts group in the world. Present funding levels are considered adequate, although it was noted that additional funding would permit serious exploitation of positron generation experiments.

SLAC has two programs that contribute to this thrust area, FACET and the dielectric laser acceleration program at the NLCTA. In both cases, their scientific merit is viewed to be very high. FACET capabilities, especially its 20 GeV drive beam, are unique but come at the expense of relatively high operating costs and (due to its location in the SLAC linac tunnel) access limitations and a challenging experimental environment. About six experiments per year are being accommodated. FACET progress was initially slow, which is unfortunate because it has only a limited time window before LCLS takes over the portion of the linac where FACET is located. However, the recent hire of Vitaly Yakimenko has done much to turn the situation around in a short period, and was a real coup for SLAC. Reviewers felt that the impact of FACET would remain limited unless and until they demonstrate that they can accelerate witness beams of reasonably high quality.

The cost of FACET experiments is high compared with other GARD facilities, in part due to the need to contribute to operation of the linac that produces the 20 GeV beam. The program directly supports the HEP mission, primarily to advance the energy frontier. A new laser is being used to pre-ionize the plasma channel, and has helped enable the planned experiments. More details on the FACET program will be presented elsewhere in this report. Several successful diagnostic techniques have been developed at FACET, including the transverse cavity sweep to identify the two bunches and the use of betatron x-rays to infer beam properties.

The goal of the dielectric laser acceleration program is to develop laser driven dielectric structures for high-gradient, low cost, power efficient acceleration of electron bunches. Recent years have shown significant progress—fabrication of subcomponents, such as the first fully assembled 17-layer silicon woodpile accelerator, simulations of waveguide coupling techniques and particle transport, design of a novel beam position monitor, and bench-top testing of the system. The leader of the program, Joel England, is a highly competent physicist in Prof. Robert Byer's group at Stanford University. Recently (December 2012), preliminary evidence for modest acceleration of electrons in a laser-excited structure was obtained. Various codes, such as Matlab, ACE3P, and VORPAL are being used for simulations, the latter supported by DARPA funds. A drawback of the present scheme is the absence of a suitably low emittance electron source, which forces the experiment to simply flood the structure with a stream of electrons. As was the case with laser plasma accelerators, it may take a decade or more of dedicated effort to achieve the requisite high-brightness electron bunches. The approach being taken is to develop a laser driven source with needle-tip field emitters to produce nm emittance beams with attosecond timing stability, MeV-scale energies, and about 10^4 electrons per bunch. The required laser source, tentatively based on a mode-locked solid-state thulium and erbium fiber laser, must have high repetition rate (1–50 MHz), μJ pulses, 5–100 ps pulse length, and 1–2 micron wavelength. As with FACET, the dielectric laser acceleration effort is viewed as having a solid program with high scientific merit. This technique too suffers from lack of a demonstration that it is capable of accelerating a sufficiently high-quality witness beam.

2.1.4 RF Sources and High-Gradient Accelerating Structures

At ANL, the rf structure work involves mainly the AWA facility. As part of their energy upgrade, they have prepared six normal conducting L-band structures, along with klystrons providing an additional 80 MW of pulsed power. They have also developed C- and K-band power extraction and transfer structures for two beam acceleration, and tested them to 40 MW and 20 MW, respectively (limited by the AWA drive beam power). The C-band structure is for CLIC, and will be further tested at SLAC up to its rated power of 120 MW. The group has also built a 26 GHz dielectric power extraction structure and a 250 MV/m dielectric accelerating structure to demonstrate two-beam acceleration at their upgraded facility. Development of these structures shows a high level of competence but thus far has had little impact on the wider community. The dielectric power extraction structure should have a high breakdown field, which would favorably affect the two-beam accelerator concept in terms of costs. The scientific merit of the work is deemed to be high.

The group has a three-year plan focused on high frequency high power rf generation, two-beam acceleration, and collinear wakefield acceleration. They are building the infrastructure and rf devices to support those activities. The two-beam accelerator scheme they propose is likely to be essential to increasing the energy reach of the HEP program. However, there is presently no clear indication of what constitutes “success” in the context of staging such devices. For example, what is the minimum transformer ratio to make two-beam acceleration viable and cost-effective? It will be important to define such success metrics as milestones against which to measure progress.

The BNL ATF currently makes use of an S-band klystron, an rf gun, and an 80 MeV electron linac that has been operating since 1992. They have plans for energy upgrades to 300 MeV and finally 500 MeV as part of ATF-II, but there were no details provided in the context of this thrust area.

Fermilab has designed and successfully demonstrated the use of a high-power vector modulator to control six rf cavities driven by a single 2.5 MW pulsed klystron for the High Intensity Neutrino Source (HINS). Because the cost of pulsed klystrons generally decreases as their power increases, a technique that makes possible the amplitude and phase control of multiple individual cavities driven from a single high-power klystron is likely to reduce overall rf system costs. Development of the ferrite vector modulators, cavities, and klystrons demonstrates a high level of technical competence, and is aligned with Fermilab’s intensity frontier priorities.

Unfortunately, the frequency limitations of ferrite and the moderate bandwidth of the modulator are expected to limit the impact of the design on the wider community. At present, Fermilab is focusing on superconducting rf, and placing less emphasis on normal conducting rf structures. When requiring normal conducting rf structures, they contract with external talent, such as the Center for Beam Physics (CBP) at LBNL or experts at SLAC. This is an attractive and workable model.

LBNL work in this thrust area is carried out within the CBP. Much of their work in recent years has focused on rf technology of interest to the Muon Accelerator Program (MAP), but is supported via GARD funds. They developed and fabricated several rf cavities (both 805 and 201 MHz) for muons that have Be windows closing both irises. The design challenge is to operate the cavities in a 3 T axial magnetic field, which has proved difficult in practice. Ten of the lower frequency cavities are being fabricated for the MICE experiment; the first cavity will be tested at Fermilab later this year. Another rf task being carried out by the group involves the design and analysis of a normal conducting 162.5 MHz RFQ for PXIE, which will serve as the front end of the Project X linac. The principal challenge for a CW RFQ is thermal management, which LBNL is analyzing.

Execution of these various design and fabrication projects demonstrates a high level of technical competence. The resources available appear to be matched to those required. The special nature of the muon cavities implies little impact on the broader rf community, but of course their design has high impact in the muon cooling community. Some of the LBNL work is project work for others, and some is being done as an LBNL/MAP contribution to the MICE experiment. SLAC is now collaborating with LBNL on MAP related cavity design.

SLAC's rf activities center on the development and use of their ACE3P electromagnetic code and ILC-related design work that is no longer supported as "directed" ILC R&D. The ACE3P code has been an outstanding success and is broadly used in the accelerator community for cavity design, multipactor, and beam driven wakefields. ACE3P was assessed as being truly transformative in the types of calculations it facilitates, and is well aligned with both HEP's main efforts and its new accelerator R&D stewardship task. The code is moving toward multi-physics capabilities, including mechanical and thermal analysis; this was viewed favorably by the reviewers, who encouraged giving the code's authors the means to make it grow.

SLAC physicists have carried out studies of high gradient cavity geometry and concluded that the peak surface magnetic field must be reduced to achieve high gradients. They have built a test bed to validate their calculations. SLAC also has an experimental program in high-gradient structures, and they have tested some 50 structures for one month each. Hard copper structures are preferred and are believed able to reliably reach gradients of 150 MV/m or more. Hard CuAg structures are even more promising. This work has high scientific merit and has "moved the goal posts" for high-gradient R&D. Optimized designs of input couplers that balance the peak fields across the structure have been proposed and are being modeled. However, it is unclear whether the complexity and cost of this solution are commensurate with the problem being solved. In the future, the group has ideas for increasing the energy efficiency of rf power sources, developing matrix multi-beam klystrons, developing advanced dispenser cathodes for klystrons (to improve lifetime and reliability), and developing compact THz sources. Many of these developments offer good commercialization potential, which the group should be encouraged to pursue. Because the development of solid-state rf sources potentially competes with industry, it will be important to identify areas where there is a need but either no duplication with commercial efforts or an opportunity to collaborate with industry. Pursuit of THz sources is likely to be addressing BES, not HEP, needs and must presumably be motivated by accelerator stewardship.

SLAC has made substantial contributions to the ILC design, and has almost single-handedly designed the rf distribution system for the scenario with 10 MW multi-beam klystrons located on the surface. The work includes sophisticated high-efficiency power combiners[4], transport, dividing and tapping. The group also contributed significantly to the writing of the ILC Technical Design Report. All of this work represents a high level of competence. The Marx modulator has especially been a success in terms of both reliability and cost reduction, and has become the ILC technical baseline. Although the implicit modularity of the Marx modulator lends itself to other applications, it is unlikely to be able to satisfy the broad range of parameters needed (voltage from 50–120 kV, current from 10–120 A) in a single step.

In summary, SLAC continues to demonstrate world-class leadership in high-power rf sources and high-gradient normal conducting rf structures, and these skills should be preserved. Without these intellectual resources, the rf undulator developed for BES is unlikely to have been achieved so quickly, or indeed at all. This is an important fringe benefit of the SLAC rf program. One concern expressed by the reviewers was that there appears to be no heir-apparent for Sami Tantawi, who is the clear intellectual leader of the high-gradient group. There needs to be some effort to identify a successor to continue the program when Tantawi retires.

2.1.5 Superconducting Magnets and Materials

Activity in this thrust area takes place at only three of the institutions covered in this review—BNL, Fermilab, and LBNL. A significant amount of magnet-related R&D at all three laboratories is also funded by HEP's LARP directed R&D program; that effort is not part of the current review and will not be discussed here[5].

At BNL, the GARD program funds R&D in five areas: *i)* wire, cable and conductor testing; *ii)* heat treatment studies on Nb_3Sn restack rod process (RRP) wires; *iii)* flux jump stability in

[4] The concept of coupling 35 10-MW klystrons via a single "big pipe" was developed to address the ILC need for higher power pulsed rf sources. If the matrix multi-beam klystron is compatible with this power level, pursuing its development would be quite consistent with HEP aims.

[5] We note, however, that many of the staff members at the three institutions have roles in both GARD and LARP, so the separation of effort is somewhat imprecise.

Nb_3Sn wires; *iv*) development of RRP Ti-ternary Nb_3Sn wires; and *v*) testing of HTS conductors (Bi-2212 and YBCO tapes). In the next few years, primary efforts will focus on small filament RRP strand development for achieving high J_c Nb_3Sn wires, along with some work on tube process Nb_3Sn, and further development of Bi-2212 and REBCO for fields beyond 20 T (motivated largely by MAP needs). The HTS work will aim at increasing J_c, effects of transverse cable compression, quench propagation, and determination of quench damage thresholds. The REBCO magnet work is unique among the three GARD laboratories. A new test station is being proposed for the HTS work using a split-pair magnet fabricated from REBCO tapes. In actuality, the program is small in size and heavily leverages LARP and MAP efforts. Nonetheless, the measurements performed with GARD funds at BNL are critical for MAP and LARP and are viewed as being well done and cost-effective. The BNL activities should continue in collaboration with, and in support of, activities at Fermilab and LBNL, and also the FSU-ASC. It was noted by several reviewers that the age distribution was skewed toward the high end, that is, they have not brought in younger staff, post-doctoral researchers, or graduate students. Although the current efforts are not being duplicated elsewhere, other institutions do have staff, facilities, and capabilities that overlap the BNL competencies.

The Fermilab GARD program in this thrust area is much larger in scale and scope than that at BNL. They also have a substantial program for LARP, which was not reviewed here. The Fermilab team aims not at simply creating the highest field magnets, but rather focuses on high field *accelerator quality* magnets. That is, they aim for magnets with a realistic aperture, length, and field quality, with control of multipole content during the energy ramp, with acceptable cryogenic heat load, and with adequate quench management. The elements of this program include R&D for magnet development and fabrication, magnet testing, superconducting materials studies aimed at high J_c, low loss Nb_3Sn and Bi-2212 round wires, and development of magnet-scale cables from both LTS and HTS wires. In general, this program is looked upon as being very successful and important to maintain adequately. The DOE plan to move some $4M in (nationwide) GARD funding into LARP and MAP is likely to negatively impact progress substantially in future years.

In the superconducting materials program, the plan is to reduce effort on further development of Nb_3Sn and focus more on Bi-2212 round wire. The remaining effort on Nb_3Sn will focus on achieving higher J_c and lower filament diameter (to reduce the impact of magnetization on field quality during the magnet ramp). The goal is an RRP-217 wire with 40 micron filament diameter. The quadrupole development program used RRP-54/61 strand to build and test a 1 m long, 90 mm bore Nb_3Sn quadrupole with a goal of reaching 200 T/m. The measured performance was good at 4.5 K but not at 1.9 K, probably due to poor low-field stability resulting from the large filament size and flux jumping. They are now developing a 4 m long version that is tested in a mirror configuration. The new coils use RRP-127 sub-element wire with smaller filaments, resulting in higher stability. The dipole development effort is designing and fabricating a 1 m long, twin aperture (60 mm bore) Nb_3Sn dipole to demonstrate accelerator-quality field. If this is successful, a 5.5 m version would be built by 2015, after which the technology would be transferred to CERN. One reviewer noted that CERN is likely to build the final LHC magnets themselves and questioned the need for Fermilab to build full-length coil assemblies that they cannot even test themselves and that will not be used for LHC. Since the fabrication of long coils is expensive the cost-benefit ratio is likely to be unfavorable. They are also collaborating on developing Bi-2212 round wire, with the goals of achieving a 10 kA, 20 T dipole for VLHC and a 30 T or higher solenoid for MAP. Thus far, the main challenge is dealing with the very tight temperature processing window, which is becoming manageable for short wire lengths, but not yet for longer lengths.

Fermilab is the lead laboratory for the development of accelerator quality dipoles and quadrupoles, as they have the requisite infrastructure, assembly, and testing capabilities that the other laboratories do not have. There appears to be good coordination of effort among Fermilab, BNL, and LBNL—Fermilab focuses on accelerator quality and larger scale magnet production, LBNL does detailed magnet design and new developments aimed at the highest possible fields, and BNL plays a supporting role, primarily in materials development, along with wire and conductor characterization and testing. All three laboratories (plus the FSU-ASC) have well-coordinated superconducting wire and materials programs both for Nb_3Sn and Bi-2212. Only BNL is interested in magnet R&D with REBCO HTS tape (motivated primarily by MAP).

Fermilab has been effective in bringing junior and mid-career staff on board, including an Early Career Award winner, Tenming Shen. They have not been as successful in bringing in graduate students as has LBNL (and FSU, which has tightly integrated graduate school connections). GARD funding is becoming more of an issue at Fermilab, due to the overall shortage of HEP funds and the DOE-requested redirection of GARD funds into LARP and MAP. The Fermilab group is getting close to the edge in terms of M&S and equipment, and this may become critical. In the end DOE needs to assess what is the proper balance between core program R&D and directed R&D efforts; a healthy future program requires both.

LBNL has a strong core GARD program in this thrust area. The Superconducting Magnet Group ("Supercon") prides itself on being a complete, vertically integrated research group covering superconductor, cable, magnet design, coil fabrication, structural analysis and fabrication, coil assembly, and magnet testing[6]. The group comprises both scientists from the Accelerator & Fusion Research Division (AFRD) and engineers and technicians from the Engineering Division (ED), with about a 2:1 ratio between engineers and scientists. The GARD program also sponsors a few graduate students.

The Supercon group develops high-field dipole technologies (supported by integrated magnet modeling and analysis) as well as Nb_3Sn and Bi-2212 wire development. Their stated goal is development of a 20 T dipole in the next 5 years. The approach taken involves quick

[6] The testing capability is limited to cold masses only, and device lengths below about 2 m.

turnaround, using reusable parts, of small laboratory-scale magnets that can demonstrate new types of coil structural, assembly, and pre-stress methods. This program has been extremely productive, permitting trials of new technical developments with minimal turnaround time and minimal costs. The group also plays a substantial role in LARP and the MAP effort on MICE magnets. The Supercon group aspires to expand into other superconducting magnet areas, such as undulators for FELs, compact ion beam therapy gantry magnets, and ECR sources, as part of the accelerator R&D stewardship program. LBNL has consistently provided leadership to the entire U.S. program in the development of Nb_3Sn dipole technology, and is viewed as a key resource for future U.S. magnet R&D.

LBNL sees one of its roles as pushing magnet technology to the highest achievable magnetic fields. Of the three GARD laboratories working in this thrust area, they appear to have the most sophisticated and integrated methods for conductor, cable, and magnet design and analysis. They have recently revived an old scheme to use "canted cos θ" magnets. This approach may offer advantages for reducing the size and weight of compact gantry magnets. However, the stress issues for this approach appear to be difficult, so there are technical risks to assess as well.

Recent efforts toward high field magnets have not been as successful as expected. Despite a doubling of the critical current density in Nb_3Sn, recent test magnets with a gap have not improved upon the earlier D20 field result of about 14 T. Although the LBNL team desires to go beyond technology development and participate in LARP magnet production, it is not clear that this is required or even desirable. DOE and LARP management should optimize the role of each laboratory in LARP magnet production, and avoid redundancy except where it has a clear benefit. One reviewer, however, noted the potential of having more than one laboratory participate in the fabrication, based on the idea that the technical problems might benefit from having more minds working on solutions. This *may* represent a clear benefit for some redundancy, and should be considered carefully. Given the lack of progress in increasing the bore field, it may be worthwhile to consider designing, fabricating, and testing a cos θ magnet like D20 but using the recent advances in 2D/3D design techniques and the best available Nb_3Sn strand to see if there are any fundamental limitations to the present approach. On the other hand, it was felt to be premature and unwise to totally abandon the block coil development. A more measured approach was recommended, namely to consolidate the block coil technology while at the same time performing a series of learning experiments to assess the challenges of the canted cos θ technology, permitting a comparative evaluation of the two approaches for subsequent development.

2.1.6 Superconducting RF

ANL has a small program in this thrust area, supported mainly by a single Early Career Award recipient (Proslier). They are looking at cavity coating techniques, both sputtering and atomic layer deposition (ALD). These efforts involve collaboration with Fermilab, Jlab, and LBNL. The ALD program has provided some nice data on the penetration depth (~100 microns) of rf fields in superconducting cavities. The sputtering program is focused on high impulse magnetron sputtering to achieve more robust Nb surfaces. Thus far, only coupons have been studied. Given the modest size of this effort, there would be more progress if only the ALD technique was pursued. Otherwise, there is a risk of not completing either task. Stronger collaboration with Fermilab is also felt to be beneficial. The current funding level is deemed adequate.

BNL does have superconducting rf (SRF) activities in support of their energy recovery and eRHIC programs, but these are not funded by GARD and are not covered in this review.

Fermilab has the largest GARD-funded SRF program, and has become one of the world leaders in SRF cavity development. Their initial motivation was ILC 1300 MHz cavities and the suite of cavities required for Project X. With the phase-out of ILC development, their focus has shifted to Project X, and they are involved in the testing of industrially produced prototypes of the three types of cavities needed for the low-beta sections of the linac. In addition, they are developing environmentally-friendly cavity finishing techniques that yield the required cavity gradients. Barrel polishing, followed by a light buffered chemical polish etch, is a technique they have pioneered for both 9-cell and single-cell 1300 MHz cavities. Results for a single-cell cavity yielded one of the highest *Q*s (4×10^{10}) ever measured. They are well equipped to carry out the surface preparation of cavities, and have excellent testing facilities. They are now working with industry to develop a Faraday electrolysis approach that provides smooth surfaces (similar to those resulting from electro-polishing) without using HF, and have successfully tested one cavity prepared this way. Two complete ILC cryomodules have been assembled and they would like to use them in the proposed ASTA facility at Fermilab.

The Fermilab program is key to the success of Project X. It is staffed by young, enthusiastic scientists and engineers. The group is very competitive in the world of SRF, and they have excellent R&D facilities. Maintaining the current level of support is appropriate and is recommended. That said, there is still some ambiguity between GARD work and Project X pre-construction R&D; and some reviewers questioned the appropriateness of using GARD funds for the latter effort.

LBNL does not have a GARD program in SRF.

SLAC has only a modest program in SRF, focused on an X-band RF undulator. They have tested a normal conducting prototype at the NLCTA, but have not yet constructed a superconducting version. They should be encouraged to collaborate with Fermilab or another laboratory with expertise in superconducting rf undulator technology.

2.2 Test Facility Operations

In addition to the R&D done without beam, the GARD program operates several beam test facilities, namely the Argonne Wakefield Accelerator (AWA) at ANL, the Accelerator Test Facility (ATF) at BNL, the Berkeley Laboratory Laser Accelerator (BELLA) at LBNL, and the Facility for Advanced Accelerator Experimental Tests (FACET) at SLAC. These are discussed in Section 2.2.1. Following that, in Section 2.2.2, we briefly discuss the proposed upgrades to the operating facilities that were presented at the review and a proposed new facility, the Advanced Superconducting Test Accelerator (ASTA) at Fermilab. While the GARD review does *not* represent a "project" review of any of the proposed upgraded or new facilities, which will be needed prior to their being approved, the reviewers' comments from this review do provide some scientific context for subsequent project reviews.

2.2.1 Currently Operating Facilities

2.2.1.1 Argonne Wakefield Accelerator (AWA)

ANL operates the AWA as a small test facility with a staff of 10 FTEs. The system is currently undergoing an upgrade to a beam energy of 75 MeV, with a second, 15 MeV, witness beam available for advanced acceleration tests. Because this facility upgrade is expected to be completed this year, we treat it here as a *fait accompli* and discuss the program in this context. The AWA has a gun capable of delivering very high charge per pulse (with 80 MV/m on its Cs_2Te cathode), and with a profile that is tailored for wakefield acceleration. Generation of high-charge pulses is a particular expertise of this group. New linac tanks designed by ANL together with SLAC, and fabricated by industry, are being installed. These will be powered by three new klystrons, together providing 80 MW of rf power. One concern is that the plan calls for the rf system to be operated open loop, without rf controls. It is not obvious that this will work properly in the more complicated upgraded configuration.

The facility has been producing a Ph.D. about every two years and has published numerous papers covering a broad range of topics, including advanced acceleration by wakefields, GW-scale rf sources, phase space manipulation, and positron acceleration. They completed 10 experiments in the past three years, and 7 are on the books for 2013–2014. As noted elsewhere, they have a strong partnership with Euclid Techlabs, and they are testing a high-pressure rf cavity for Muons, Inc. They also support the ILC and CLIC programs by working on the development of an undulator-based positron source. The AWA is viewed as a very cost-effective program, with a group that, though modest in size, is intellectually fertile and productive. It was noted, however, that the group seems somewhat isolated at ANL, and would benefit from both tighter connections with the other ANL accelerator programs and more student involvement. The AWA group aims at producing accelerating gradients of about 150 MV/m, leading eventually to 200–500 MV/m. Results to date are interesting and point toward future exciting developments. Due to its capability, intellectual strength, and cost effectiveness, ANL appears to be an excellent venue to consolidate high-charge physics studies.

The high charge and phase-space manipulation studies now under way are extremely productive, and the wakefield acceleration work continues to show progress as an alternative to plasma acceleration. One thing seemingly deemphasized in the present program is the study of the staging problem, which is the *sine qua non* of all the advanced acceleration techniques. This aspect needs more focused attention. Issues of the transport of the witness beam in bending magnets likewise need study in the configuration they propose, to make sure effects on the beam quality are understood.

2.2.1.2 Accelerator Test Facility (ATF)

The BNL ATF has been operating since 1992, and has both a flexible electron beam system and a terawatt-power CO_2 laser that can support experiments separately or together. The long wavelength high-power laser is complementary to laser-driven plasma test facilities elsewhere. It has demonstrated proton acceleration that could be very important for the type of proton accelerators of interest to the medical community. The facility has been producing 1.5 Ph.D.s and more than 5 high-impact refereed papers per year on a broad range of topics. It is a mature facility with a rich history of accelerator science discovery. BNL is reorganizing to place the ATF in the Collider-Accelerator Department, which should make additional support resources available.

Not surprisingly, the more than 20 year old facility has outgrown its space. Indeed, several reviewers raised concerns about the crowded conditions and old equipment, which are deemed to be incommensurate with future safe and productive operation of the existing facility. BNL has requested funds for an upgrade (ATF-II) from 80 MeV to 300 MeV to be sited in a refurbished experimental space supplied by BNL. The proposed approach of continuing operation of ATF during the upgrade and then switching over to ATF-II was felt to be sensible, though it will add to the cost. The ATF was urged to hold a user workshop to identify and prioritize the parameters of the upgraded facility to most effectively improve its capabilities to advance the state of the art. The upgrade will be discussed elsewhere in this report. The facility director, Vitaly Yakimenko, recently left, and Ilan Ben-Zvi is serving as interim director. Yakimenko's departure is viewed as a big loss for the ATF[7], and suitably replacing him should be a high priority for BNL; this should be accomplished prior to finalizing their upgrade plans.

The ATF program is viewed as highly productive and comparatively cost-effective. The close collaboration of the ATF staff with their users was favorably noted. The ATF is requesting formal recognition by DOE as a user facility. The reviewers questioned this request, noting that a designation as a user facility, with its additional reporting burden, might not be in the best interest of this small program. DOE was advised to use its discretion concerning this request.

2.2.1.3 Berkeley Laboratory Laser Accelerator (BELLA)

LBNL has recently completed and begun operating the BELLA facility, which has a 1-Hz, 1.3-PW laser (producing 40 J, 30 fs pulses). The programmatic goal of the facility is to produce a 10 GeV electron beam from a meter-scale capillary discharge plasma. The facility incorporates a number of advanced features, such as a deformable mirror for beam quality optimization. The high peak power of the laser means that large optics (18-inch diameter focusing mirrors) must be used to limit damage to the mirror surfaces. Any further upgrades to the facility will need to be justified in view of such optics limitations. They have achieved a pulse amplitude stability of

[7] Already there were some user reports that it is harder to get the required beam quality without Yakimenko's help.

0.3% at 61.3 J, with a 1.2 μrad pointing jitter—excellent performance for any laser system, especially one with this record power capability. BELLA has just achieved initial electron acceleration. Progress in getting the new laser operational, especially the reliability and rapid daily turn-on time, are impressive. The cooperative commissioning activity with the LBNL safety group is commendable, and has not only provided a safe working environment but has facilitated the rapid performance demonstrations.

Unique among the GARD facilities reviewed here, the BELLA group has shown a good recognition of the long-term HEP program requirements and has incorporated activities aimed at meeting those requirements. In particular, they have a dedicated effort to get staging tests underway, both via experiments and modeling. This is encouraging and they should continue to pursue this effort to validate the laser plasma concept. The close interaction of the simulation team (with input from the Center for Beam Physics group and other collaborators) and the experimental program provides a knowledge-based approach for moving forward, and appears to be working well. The BELLA group is paying appropriate attention to practicality and the ultimate utility of the approach, including emittance, energy spread, energy gain per stage, staging, and the influence of capillary diameter on cooling and coupling efficiency. Precision diagnostics now support this effort. To the extent that laser plasma wakefield acceleration proves to be a practical and useful technology for HEP, the innovations and technology development at this facility will prove to be essential, and provide the best prospect for showing what the approach can do.

The group's studies (from LOASIS at present) are judged to be scientifically thorough and most have peer-reviewed publications to document them. The publication record to date and the group's citation record are excellent; BELLA publications should start contributing this year. The team has also received a significant number of awards and external recognition. In addition, the group is doing an excellent job of training future scientists, both graduate students and post-doctoral research associates.

Though no formal upgrade proposal has been submitted, the BELLA group expressed a desire to expand facility capabilities to compete with European and other U.S. groups in the laser plasma area. Their key goals of ion acceleration studies and positron acceleration potentially align with HEP needs but, given the significant expected costs, require more studies to defend the efficacy of the proposed approach.

The reviewers noted some overlap between the BELLA goals and the program desires at SLAC. Both approaches will likely be comparably productive for plasma acceleration science.

2.2.1.4 Facility for Advanced Accelerator Experimental Tests (FACET)

SLAC has a suite of test facilities, including the Next Linear Collider Test Accelerator (NLCTA), the Accelerator Structure Test Area (SLAC-ASTA[8]), and the End Station Test Beam (ESTB). These complementary facilities are now all under a single management and are discussed here under the FACET rubric.

The NLCTA operates for testing dielectric laser acceleration, echo seeding, high-gradient development, X-band gun development, and ILC klystron and modulator development work. This facility delivers low charge but ultra-bright beams. Given adequate support, this facility will go a long way toward answering questions about the feasibility of X-band photoinjectors. Such high-brightness X-band beams would be of great interest to the x-ray FEL community but, since the gradient improvements compared with other technologies are modest, X-band technology is unlikely to play a major role in energy frontier colliders. The bulk of the work done in this facility benefits mainly BES and NP programs, and thus is related to stewardship activities supported by HEP. The possible exception is the dielectric laser acceleration program, which could provide beam for a high energy collider as well as for other customers. Because the beams produced in this way would be very different than conventional beams, the SLAC team needs to do a much better job of motivating why they are useful, that is, justifying why this work should be done.

SLAC-ASTA is a small 50 MeV machine for testing high-gradient rf structures. The ESTB utilizes unused beam from LCLS, primarily for beam instrumentation studies for the HEP community. This facility is presently being commissioned and plans for 1600 hours per year.

FACET is the main beam test facility at SLAC, and makes use of the first two-thirds of the SLAC linac to deliver 20 GeV electron beams, primarily for studies of ultra-high gradient acceleration. Within the GARD portfolio, FACET provides a unique capability for meter-scale wakefield acceleration, and there is science to do there that would be impossible elsewhere. The substantial linac means that the operating cost of FACET is high, though BES covers some of the linac maintenance costs. There are three experimental setups currently implemented, supporting six approved experiments this year. The "non-plasma" experiments will be completed first, after which the focus will be on two-beam experiments. In the past year, a laser pre-ionization system has been installed and made operational. This will be particularly helpful in the two-beam mode, where the single-bunch is split and its intensities reduced.

The access constraints due to FACET being located in the linac tunnel reduce experimental flexibility to a significant degree, and make the facility more suited to collaborative research as opposed to being a true user facility. It is difficult to rapidly switch between users, which impacts productivity when equipment fails, and there are operational limitations associated with the LCLS schedule. In addition, the lack of an elevator makes transporting heavy equipment

[8] Unfortunately, this facility carries the same acronym as the proposed Advanced Superconducting Test Accelerator facility at Fermilab, so we will denote it in this report as "SLAC-ASTA" to avoid confusion.

difficult. All of these constraints compound the substantial pressure to demonstrate significant results prior to having to shut down FACET when LCLS-II takes over the middle one-third of the linac. The limitations have also led to a limited publication record that is just beginning to meet expectations. On the plus side, the production of young scientific talent is excellent, and they have a demographic profile with considerable young talent. FACET staff members provide excellent design and simulation support for other U.S. laboratories as well as international collaborations. There is a high premium on achieving good performance this year as a means to justify for the expense of the proposed facility upgrade, "FACET-II" (see Section 2.2.2.2). Moreover, the impending shutdown of FACET makes it incumbent upon them to carefully choose the suite of experiments to be carried out to maximize the scientific output of the existing facility before it shuts down.

As is true for most of the GARD programs reviewed here, the FACET program does not presently address the critical staging issue, which is necessary to move toward an actual HEP application.

2.2.2 Upgrades and New Facilities

In this section we briefly discuss the proposed facility upgrades that were presented during the GARD review. Although these presentations were outside of the formal scope of the present review, they serve to indicate the scientific ambitions of the ATF and FACET groups, and the areas of interest to ASTA. For this reason, we include the reviewers' comments on the three proposed facilities below.

2.2.2.1 Accelerator Test Facility (ATF-II)

BNL has requested an upgrade of the ATF energy from 80 MeV to 300 MeV, and eventually to 500 MeV. The upgraded facility will be moved to a larger, refurbished BNL-supplied area. An additional 2 FTEs will be required for user support. Although the reviewers were supportive of the need for a larger experimental facility, they questioned the need for an energy upgrade, especially one beyond the initial 300 MeV, and noted that the basis of any proposed energy increase should be user requirements.[9] The reviewers also cautioned that the larger facility should be configured to maintain the kind of flexibility and ease of reconfiguration of the current facility. This will require a higher level of protective measures and resources that need to be accounted for in the cost estimate. They noted that the transition from the current to the upgraded facility should be carefully managed to avoid a prolonged shutdown that would interrupt the user program and especially student training, which might be hard to reestablish. As discussed earlier, the proposed scenario of installing the new equipment while continuing to operate the old facility was viewed favorably, despite the fact that it will likely increase the upgrade cost. It was suggested that the control system should be modeled as closely as possible

[9] It was suggested that BNL hold an ATF Upgrade Workshop that challenges its user community to contribute specific experimental plans making best use of the upgraded facility. This will guide the ATF group in prioritizing plans for their upgrade.

to those of other BNL operating facilities to leverage the wealth of accelerator expertise and support at the laboratory.

2.2.2.2 Facility for Advanced Accelerator Experimental Tests (FACET-II)

The need to upgrade FACET is driven mainly by the need to relinquish its current location at SLAC to accommodate LCLS-II. The LCLS expansion will take over the middle one-third of the SLAC linac, which is the current site for FACET. The concept for FACET-II is to relocate the FACET facility to Sector 10 of the linac, a location upstream of LCLS-II. Because the relocation is anticipated to be expensive, it is critical that FACET work hard to scientifically justify its upgrade plans[10] and consider cost-effective alternatives, if any can be found. As an example, it will be important to assess what minimum beam energy is needed to accomplish the science. One reservation expressed about the FACET-II plan is that the facility would once again be located within the linac housing, with all of the constraints to the experimental program that this implies.

FACET-II, as presently envisioned, will have a maximum beam energy of 10 GeV. The performance of a 10 GeV beam should be verified at the existing facility to confirm that it is useful for driving plasma wakefield acceleration tests.

2.2.2.3 Advanced Superconducting Test Accelerator (ASTA)

Fermilab invested heavily with ARRA funds in creating an area where ASTA could be located, motivated originally by a desire for a test area for ILC superconducting rf cryomodules. The proposed plans for the ASTA electron linac utilize ILC hardware. While this makes sense in the context of qualifying ILC hardware, it does not appear particularly compelling in terms of addressing the accelerator needs for the intensity frontier. Using pulsed superconducting rf technology, as opposed to CW operation, is inherently limiting for intensity frontier beam physics needs. Beam physics phenomena generally depend on either the single-bunch charge or the average beam intensity. However, the instantaneous charge and brightness proposed for ASTA are similar to what already exist at the AWA, and the gun is unlikely to be better than guns currently in operation at SLAC for LCLS and NLCTA. Moreover, the proposed average brightness of ASTA is lower than that already achieved at Cornell and LANL. Thus, the proposed facility contributes little to work on the average electron beam intensity frontier. The proposed ASTA facility also appears to offer little development support for Project X or possible new BES facilities such as the Next Generation Light Source (NGLS), since these potential projects are based on CW modules, for which the operation (rf controls, beam power management, higher-order mode heating, and halo control) is different. Nonetheless, it is felt that completing ASTA in some form is important to maintain an operational machine for R&D studies at Fermilab and to retain the intellectual capability for future advanced accelerator

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[10] Reviewers did not feel the scientific case for FACET-II was made compellingly at this review. Because of the anticipated high cost of relocating the facility, it was felt that before proceeding with FACET-II the advantages of doing so must be made very clear compared with those of the other facilities engaged in novel acceleration techniques.

construction there. Indeed, not completing ASTA in some form would result in a substantial waste of already expended funds.

Fermilab has already begun to solicit proposal ideas from the community, though most of the ideas are "soft" at this early stage. Many of the ideas could be equally well done at FLASH in Germany, though it is not clear that the DESY facility would be available for this purpose. The ideas involving high-charge beam dynamics could be done at the upgraded ANL or BNL facilities. Another drawback of the ASTA plan as it pertains to electrons is that there are no plans to actually use the photons generated. The unique aspect of the proposed work is the continuation of the experiments on emittance exchange and production of flat beams. This work is world leading and could lead to improved machine performance for both HEP and BES accelerators.

What *is* unique about ASTA is the IOTA ring, which explores a new beam dynamics paradigm and may provide opportunities for improved proton beam transport and storage. Developing means to deal with high proton beam intensities contributes directly to intensity frontier goals and is work that will not be duplicated elsewhere. One reviewer noted that the idea of developing ASTA as a hadron user facility, incorporating tests of low- and medium-β hardware, would be of interest, and would offer a facility that leverages Fermilab's expertise and long-term plans. A proposal to develop a PXIE-based facility, for example, would be unique in the GARD user facility portfolio. Other reviewers noted that IOTA was the part of ASTA with the most R&D potential and that the testing of low-β structures seemed not to be a laboratory priority.

Overall, there was a clear sentiment that funding the *full* ASTA facility was not necessary, and that support to finish the injector, install one cryomodule, and build IOTA is the most reasonable course.

3 HEP Responses

While concerns raised by the reviewers are covered above, there are, however, a few that deserve mentioning in this separate HEP responses section.

The research supported by the GARD program was considered by the review committee to be well-aligned with HEP mission and needs. The quality of research in the five laboratories reviewed was high and, in general, the individual programs did not have significant duplication. However, the balance between electron and proton R&D is not commensurate with the current HEP aspiration of becoming world leader in the Intensity Frontier. The GARD program is still adjusting to balance its emphasis on the Energy Frontier and Intensity Frontier. DOE has also completed a review to evaluate three laboratory facility proposals that can potentially address this imbalance. The results of this review, which took place in October 2013, will be used to guide funding decisions on the proposed test facilities.

In addition to the recent GARD test facilities review, it is expected that there will be a HEPAP subpanel formed to examine the HEP accelerator R&D program and provide advice on its balance and overall priorities. Each laboratory will be expected to examine its accelerator R&D portfolio and to make a case for the relevance of its program to overall HEP needs and priorities. Another issue raised at this review that the subpanel is expected to consider is the potential synergies and possible adverse effects on the GARD program resulting from the transfer of funds to LARP and MAP. HEP is already monitoring the impact carefully as it tries to foster synergies between these programs. Adjustments will be made as necessary.

A concern was expressed that the novel acceleration programs at most of the institutions reviewed did not seem to be fully focused on the issues of primary importance to HEP. In particular, the emphasis on staging demonstrations and other practical implementation questions, as opposed to the basic scientific studies of the processes, were either not being considered at all or were given lower priority by the practitioners. To improve this situation, DOE intends to make more effective use of Field Work Proposal (FWP) submissions from the laboratories in setting out timelines, milestones, and specific deliverables associated with the GARD programs. Prior to formal submission, each institution will be asked to submit a draft FWP to the GARD program manager, indicating plans for the upcoming year, milestones, and proposed deliverables that correspond to the anticipated budget for that activity. These plans, milestones, and deliverables, along with the corresponding budget, will be reviewed and approved by the program manager prior to the formal FWP submission, ensuring that the GARD program at each institution is responsive to the overall priorities of HEP[11].

There was a strong concern over filling the ATF director vacancy and some concern over the intention to make ATF a national user facility. HEP has already begun working with BNL to fill the ATF director position, and will continue to work with BNL to ensure no negative impacts resulting from becoming a user facility.

Some reviewers also expressed potential duplication of efforts in some of the accelerator simulation/modeling activities. HEP has encouraged some laboratories (LBNL and SLAC) to explore better coordination and integration of these efforts. Substantive discussions and planning have already taken place and it is expected that an initial structure will be put in place during FY2014.

4 Summary

An on-site review of the HEP GARD program was conducted at ANL, BNL, FNAL, LBNL and SLAC. The review committee found the HEP Laboratory GARD program to be healthy and the

[11] It is recognized that R&D plans are inherently uncertain, and that it is unlikely that all milestones in an aggressive program will be achieved on time. Nonetheless, this approach should provide improved direction for the programs and ensure that the most relevant questions are being addressed in a timely manner.

research to be of high quality, with little overlap between the research programs in the different laboratories. The committee also found the program to be well aligned with the overall HEP mission with two exceptions:

1. the proton and electron R&D are not considered well-balanced; and
2. there were concerns about whether the priorities of the various novel acceleration technique programs are properly emphasizing the key questions of relevance to future HEP machines.

Even though the reviewers consider the research to be of high caliber in each of the laboratories, they were especially impressed by the productivity and cost-effectiveness of the ATF and AWA; the progress achieved by the FNAL superconducting material research and the SRF infrastructure; the thoroughness and world-leading research efforts at BELLA/LOASIS; and the expertise in high-power rf sources and high-gradient normal conducting rf structures at SLAC.

5 Appendices

5.1 Charge Letter

Department of Energy
Washington, DC 20585

FEB 15 2013

MEMORANDUM FOR LK LEN

FROM: GLEN CRAWFORD, DIRECTOR
RESEARCH AND TECHNOLOGY DIVISION
OFFICE OF HIGH ENERGY PHYSICS

SUBJECT: General Accelerator R&D Subprogram

The General Accelerator R&D subprogram, comprising the two subprograms formerly known as Accelerator Science and General Accelerator Development, supports the Department of Energy High Energy Physics (HEP) mission by fostering fundamental research and development in the science and technology of particle accelerators. This subprogram nurtures the technologies needed to design and build the future accelerator facilities that will be used to carry out the HEP research program, thereby advancing our strategic goals for science.

This letter is to request that you conduct an onsite review of HEP-supported laboratory research efforts in the area of General Accelerator R&D during the period of March 6–12, 2013. The purpose of this review is to assess the quality and impact of the recent scientific achievements by these research groups, and the feasibility, relevance and impact of the proposed research on achieving the scientific goals and milestones of the HEP mission. Your panel is also asked to review the operation of user/test facilities at each laboratory, including reliability, facility up-keep and improvement, cost effectiveness, and how well its users are being served. *For each laboratory's General Accelerator R&D research group,* we request a specific evaluation of:

1. The quality and impact of the research by the group in the past four years.
2. The scientific significance, merit, and feasibility of the proposed research in the next four years.
3. The competence and future promise of the group for carrying out the proposed research.
4. The adequacy of resources for carrying out the proposed research, and cost-effectiveness of the research investment.
5. The quality of the support and infrastructure provided by the laboratory.
6. How the group benefits the laboratory's experimental program (as applicable), and how well the group's research activities relate to the overall HEP mission.
7. Where user/test facilities exist, the reliability and cost effectiveness of operation, how well its users are being served, and how the facility's capabilities contribute to the overall HEP mission.

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The research efforts should be presented in terms of the laboratory group's contributions (as applicable) along the following programmatic thrust lines:

- Accelerator and Beam Physics
- Particle Sources, Beam Instrumentation & Controls
- Novel Accelerator Concepts
- RF Sources and High Gradient Accelerating Structures
- Superconducting Magnets and Materials
- Superconducting RF
- Test Facility Operations

The laboratories should provide information in this format on both their accomplished and proposed research in advance of the review, including the level of effort for each thrust line (FTEs and funding).

The final report should outline the laboratory-based General Accelerator R&D program in each of these thrust lines and discuss the unique and important elements that the laboratory programs bring to bear in addressing these research topics. *In this context, we request a comparative assessment of each laboratory's overall performance in these areas relative to its peers, as well as an assessment versus comparable university groups.* The overall evaluation of the laboratories' research will be an important input to the process of optimizing resource allocations within the various research thrusts.

The HEP General Accelerator R&D program supports a wide range of research thrust areas that are important to HEP needs, both in the mid- and long-term time scales. As part of this review, we are also requesting the reviewers to provide additional general findings and comments about the current status and future promise of the programmatic thrust areas listed above, for example:

- What are the expected deliverables of this research thrust in the next 5–10 years?
- Are adequate resources in place to plausibly achieve these goals?
- Do the laboratories have sufficient technical and management infrastructure to reliably deliver the goals for this programmatic area and respond to new developments?
- What would be the benefit of additional investments in this particular thrust?
- What are the likely impacts of reduced investments?

I encourage you to interact with the laboratory groups at the review and provide them with whatever immediate feedback you find appropriate. Upon the completion of the review, reviewers should each separately send a letter summarizing their findings and evaluations, including their overall findings on the General Accelerator R&D thrusts, an assessment of laboratory contributions to these thrusts, and the individual laboratory evaluations. The letters will be confidential within HEP.

Individual laboratory evaluations, along with the findings on each research thrust, and assessment of laboratory contributions thereto, will be incorporated into a summary report. Since I would like to receive the draft individual laboratory evaluations and the summary report from you no later than May 1, 2013, individual letters from the reviewers should be provided to you by no later than April 1, 2013.

Thank you for taking on this important task.

cc: J. Siegrist, DOE
M. Procario, DOE
H. Weerts, ANL
D. Lissauer, BNL
S. Gourlay, LBNL
S. Henderson, FNAL
N. Holtkamp, SLAC

5.2 Meeting Agendas

5.2.1 Argonne National Laboratory

Laboratory General Accelerator R&D Review

Thursday, 7 March 2013 from **08:00** to **17:00** (US/Central)
at **Argonne National Laboratory (Bldg. 360 (A-224))**
9700 S. Cass Avenue Lemont, IL 60439

Material: Charge Letter

Support rezek@anl.gov

Thursday, 7 March 2013

08:00 - 08:30	Coffee and Light Breakfast
08:30 - 09:00	Executive Session *30'*
09:00 - 09:20	Introduction and Overview of the Argonne Wakefield Accelerator and Group's Activities: Mission and Goal *20'* Speaker: Wei Gai (Argonne)
09:20 - 09:40	Progress Report on the AWA Installation and Expansion *20'* Speaker: Manoel Conde (Argonne)
09:40 - 10:05	Preparation for Experimental Beam Line Construction and Beam Diagnostics *25'* Speaker: John Power (Argonne)
10:05 - 10:30	Highlights of Recent Experimental Results and Plans for the Next Phase *25'* Speaker: Chunguang Jing (Argonne)
10:30 - 10:45	Break
10:45 - 12:00	Tour Location: Building 366
12:00 - 12:30	ANL SCRF Activities *30'* Speaker: Thomas Proslier (Argonne)
12:30 - 13:30	Working Lunch:Q&A, Theory and Computational Programs, ILC, CLIC and Others
13:30 - 14:00	Executive Session *30'*
14:00 - 15:00	Management and AOB Session *1h0'*

5.2.2 Brookhaven National Laboratory

BNL 2013 HEP Accelerator Program Review

Wednesday, March 6, 2013 from **07:00** to **18:00** (US/Eastern)
at **Brookhaven National Laboratory (Room B, Berkner Hall)**

Wednesday, March 6, 2013

08:00 - 08:30	Executive Session *30'*
08:30 - 09:00	Overview of BNL Accelerator Activities *30'* Speaker: Dr. Thomas Roser Material: Slides
09:00 - 09:45	Superconductor R&D and Testing *45'* Speaker: Dr. Arup Ghosh Material: Slides
09:45 - 10:00	Coffee Break
10:00 - 10:35	ATF Overview *35'* Speaker: Dr. Ilan Ben-Zvi Material: Slides
10:35 - 11:10	ATF Operation *35'* Speaker: Dr. Igor Pogorelsky Material: Slides
11:10 - 11:45	ATF Users and Upgrade Plans *35'* Speaker: Dr. Mikhail Fedurin Material: Slides
11:45 - 12:15	Executive Session *30'*
12:15 - 13:15	Working Lunch and Q/A *1h0'*
13:15 - 14:30	Tour of ATF and SC Magnet Facility *1h15'*
14:30 - 14:31	Adjourn *1'*

5.2.3 Fermi National Accelerator Laboratory

DOE Review of the Fermilab General Accelerator R&D Program

Friday 08 March 2013 from **08:00** to **17:30** (US/Central)
at WH 2 SE (Comitium)

Material ASTA Proposal | Charge Letter | Fermilab GARD Awards 2009-13 | Fermilab GARD Publications 2009-13 | GARD Slide Template | Past Review Notes | Past Review Notes

Crae S. Tate, Hema Ramamoorthi, Michelle Gleason, Mary-Ellyn McCollum crae@fnal.gov,hema@fnal.gov,michelle@fnal.gov,mccollum@fnal.gov

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Friday 08 March 2013

08:00 - 11:20 GARD Program and Plans

- 08:00 **Executive Session** *30'* (Comitium)
- 08:30 **Welcome** *05'* (Comitium)
  Speaker: Pier Oddone (Fermilab)
- 08:35 **GARD Program Overview** *30'* (Comitium)
  Speaker: Stuart Henderson (Fermilab)
- 09:05 **Superconducting RF Program and Plans** *30'* (Comitium)
  Speaker: Robert Kephart kephart (FNAL)
  Material: Slides
- 09:35 **Superconducting Magnet R&D Program and Plans** *25'* (Comitium)
  Speaker: Giorgio Apollinari (Fermilab)
- 10:00 **Superconducting Materials Program and Plans** *25'* (Comitium)
  Speaker: Lance Cooley (Fermilab)
  Material: Slides
- 10:25 Coffee Break *25'* (Alcove outside the Comitium)
- 10:50 **Accelerator Science Program and Plans** *25'* (Comitium)
  Speaker: Vladimir Shiltsev (FNAL)
  Material: Slides
- 11:15 **Walking Break to move to Breakouts** *05'* ()

11:20 - 12:30 Breakout 1: Superconducting RF Technical Session

- 11:20 **SRF Progress and plans: cavities, CMs** *25'* (Comitium)
  Speaker: Vyacheslav Yakovlev (FNAL)
  Material: Slides
- 11:45 **SRF Materials R&D** *25'* (Comitium)
  Speaker: Anna Grassellino (Fermilab)
  Material: Slides
- 12:10 **Discussion** *20'* (Comitium)

11:20 - 12:30 Breakout 2: Superconducting Magnets Technical Session
Location: WH 2 SW (Curia II)

- 11:20 **High field magnet progress and plans** *25'* (Curia II)
  Speaker: Alexander Zlobin (Fermilab)
  Material: Slides
- 11:45 **Superconducting materials R&D** *25'* (Curia II)
  Speaker: Tengming Shen (Fermilab)
  Material: Slides
- 12:10 **Discussion** *20'* (Curia II)

11:20 - 12:30 **Breakout 3: Accelerator Science Technical Session**

Location: WH 2 NE (Snake Pit)

11:20 **Accelerator Simulation, Modeling and Computation** *25'* (Snake Pit)

Speaker: Alexander Valishev (Fermilab)

Material: Slides

11:45 **AARD Program and Plans** *25'* (Snake Pit)

Speaker: Philippe Piot (FNAL)

Material: Slides

12:10 **Discussion** *20'* (Snake Pit)

12:30 - 13:20 Working Lunch (WH 2 XO (2nd floor crossover))

13:20 - 17:30 ASTA Proposal and Tour

13:20 **ASTA Proposal Overview** *20'* (Comitium)

Speaker: Stuart Henderson (Fermilab)

13:40 **ASTA Science and Facility Overview** *20'* (Comitium)

Speaker: Vladimir Shiltsev (FNAL)

Material: Slides

14:00 **ASTA Scientific Program** *35'* (Comitium)

Speaker: Sergei Nagaitsev (FNAL)

Material: Slides

14:35 Coffee Break *10'* (Comitium)

14:45 **Tour of ASTA, NML, SRF and Magnet Facilities** *1h30'* (Comitium)

16:15 **Wrap-up, Summary and Questions** *15'* (Comitium)

Speaker: Stuart Henderson (Fermilab)

16:30 **Executive Session** *1h00'* (Comitium)

5.2.4 Lawrence Berkeley National Laboratory

Laboratory General Accelerator R&D Review

from Monday, 11 March 2013 at **16:00** to Tuesday, 12 March 2013 at **21:10** (US/Pac
at **LBL-Hill (50B-5132)**

Tuesday, 12 March 2013

08:00 - 08:30 **Executive Session**
Location: 50B-5132

08:30 - 09:30 **Plenary overview**
Location: 50B-5132

- 08:30 **Welcome and overview** *10'*
  Speaker: Stephen Gourlay (LBNL)
- 08:40 **Discussion** *5'*
- 08:45 **Center for Beam Physics** *10'*
  Speaker: John Byrd (LBNL)
- 08:55 **Discussion** *5'*
- 09:00 **Superconducting Magnet Program** *10'*
  Speaker: Soren Prestemon (LBNL)
- 09:10 **Discussion** *5'*
- 09:15 **Laser Plasma Acceleration** *10'*
  Speaker: Wim Leemans
- 09:25 **Discussion** *5'*

09:30 - 12:30 **The Superconducting Magnet Program**
Location: 50B-5132
Convener: Soren Prestemon (LBNL)

- 09:30 **Superconducting Magnet Program Overview** *15'*
  Speaker: Soren Prestemon (LBNL)
- 09:45 **Superconducting Materials R&D** *15'*
  Speaker: Daniel Dietderich
- 10:00 **A new approach to high magnetic fields: CCT** *15'*
  Speaker: Shlomo Caspi
- 10:15 **LARP magnet progress** *15'*
  Speaker: Helene Felice
- 10:30 **Discussion** *30'*
- 11:00 **walk to B77 for Tour** *15'*
- 11:15 **Tour of SMP facilities** *1h0'*
  Speaker: Soren Prestemon (LBNL)
- 12:15 **Return to 50B-5132** *15'*

09:30 - 12:30 **Center for Beam Physics**
Convener: John Byrd (LBNL)
Location: 71B conference room

- 09:30 **Walk to BEG and Bella labs (71)** *15'*
- 09:45 **Tour of Bella and BEG** *1h0'* ( )
  Speakers: John Byrd (LBNL), Wim Leemans
- 10:45 **Return to 50B-4058** *5'*
- 10:50 **Overview** *15'*
  Speaker: John Byrd (LBNL)
- 11:05 **Discussion** *5'*
- 11:10 **Modeling** *15'*
  Speaker: Jean-Luc Vay
- 11:25 **Discussion** *5'*
- 11:30 **Contributions to LHC** *15'*
  Speaker: Alessandro Ratti
- 11:45 **Discussion** *5'*
- 11:50 **MAP and PXIE** *15'*
  Speaker: Derun Li (LBNL)
- 12:05 **Discussion** *15'*
- 12:20 **Return to 50B-5132** *10'*

09:30 - 12:30	**Laser Plasma Accelerators** Convener: Wim Leemans Location: Bella Conference Room	
	09:30	**Walk to BELLA/LOASIS labs** *15'* ( )
	09:45	**Tour of LOASIS and BELLA** *1h0'* Speaker: Wim Leemans
	10:45	**return to Bella conference room** *5'*
	10:50	**Overview** *20'* Speaker: Wim Leemans
	11:10	**Discussion** *5'*
	11:15	**Theory and Simulations** *20'* Speaker: Eric Esarey
	11:35	**Discussion** *5'*
	11:40	**Modeling** *20'* Speakers: Jean-Luc Vay, Cameron Geddes
	12:00	**Discussion** *20'*
	12:20	**Return to 50B-5132** *10'*
12:30 - 13:30	**Follow-up Questions and Discussion** *Location: 50B-5132* Convener: Stephen Gourlay (LBNL)	
13:30 - 17:00	**Final Executive Session** *Location: 50B-5132* *Final executive session for the committee.*	

5.2.5 SLAC National Accelerator Laboratory

General Accelerator R&D Review (2013)

GENERAL ACCELERATOR R&D REVIEW (2013)

Date/time: Monday, March 11th, 2013 : 8.00AM-6.30PM

Place: Kavli 3rd Floor Conference Room

Charge to the Committee   Agenda (xlsx)   Final Presentations

AGENDA

Begin	End	time	Presentation	Presenter
8:00	**9:00**	**1:00**	**Executive Session & Breakfast**	
9:00	9:20	0:20	Introduction & Welcome	Norbert Holtkamp
9:20	9:40	0:20	Overview of Accelerator Physics	Nan Phinney
9:40	***9:40***	***0:00***	***Accelerator and Beam Physics***	
9:40	10:00	0:20	Beam Physics	Yunhai Cai
10:00	10:20	0:20	Accelerator Computation	Cho Ng
10:20	10:40	0:20	Final Focus, Machine Detector Interface, Feedback	Tom Markiewicz
10:40	*11:00*	*0:20*	*BREAK*	
11:00	***11:00***	***0:00***	***Novel Accelerator Concepts***	
11:00	11:20	0:20	Plasma Wakefield Acceleration	Mark Hogan
11:20	11:40	0:20	Direct Laser Acceleration	Joel England
11:40	12:00	0:20	Discussion	
12:00	**13:00**	**1:00**	**Lunch including presentations below**	
		0:10	Linear Collider Collaboration	Nan Phinney
		0:25	Efficient RF Sources / Revolutionary High Power RF Design	Michael Fazio
		0:15	TeraHertz Technology Development	Alan Fisher
13:00	**14:30**	**1:30**	**Tour**	
14:30	***14:30***	***0:00***	***RF Sources and High Gradient Accelerating Structures***	
14:30	15:00	0:30	High Gradient R&D	Sami Tantawi
15:00	15:30	0:30	X-band Test Accelerator & New Initiatives	Tor Raubenheimer
15:30	15:40	0:10	Discussion	
15:40	*16:00*	*0:20*	*BREAK*	
16:00	***16:00***	***0:00***	***Test Facilities Operations***	
16:00	16:20	0:20	Test Facilities Operations	Vitaly Yakimenko
16:20	16:50	0:30	FACET-II Science	Mark Hogan
16:50	17:00	0:10	Discussion	
17:00	**18:00**	**1:00**	**Executive Session**	