Discussion of HEPAP Accelerator R&D Subpanel Report

HEPAP Meeting

Washington, DC; April 6-7, 2015

Andrew J. Lankford

HEPAP Chair

University of California, Irvine

Recommendations in Scenario A

Multi-MW proton source

Recommendation 1. Fund generic high-power component R&D at a level necessary to carry out needed thermal shock studies and ionizing radiation damage studies on candidate materials that are not covered by project-directed research.

Recommendation 2. Construct the IOTA ring, and conduct experimental studies of high-current beam dynamics in integrable non-linear focusing systems.

C. Gerber, R. Tschirhart

Recommendation 3. Support a collaborative framework among laboratories and universities that assures sufficient support in beam simulations and in beam instrumentation to address beam and particle stability including strong space charge forces.

Recommendation 4. Direct appropriate investment in superconducting RF R&D in order to inform the selection of the acceleration technology for the multi-MW proton beam at Fermilab.

J. Carlstrom, C. Gerber, G. Hofstaetter, R. Tschirhart

Recommendations in Scenario A - continued

Very high-energy proton-proton collider

Recommendation 5. Participate in international design studies for a very high-energy proton-proton collider in order to realize this Next Step in hadron collider facilities for exploration of the Energy Frontier. Vigorously pursue major cost reductions by investing in magnet development and in the most promising superconducting materials, targeting potential breakthroughs in cost-performance.

Recommendation 5a. Support accelerator design and simulation activities that guide and are informed by the superconducting magnet R&D program for a very high-energy proton-proton collider.

Recommendation 5b. Form a focused U.S. high-field magnet R&D collaboration that is coordinated with global design studies for a very high-energy proton-proton collider. The over-arching goal is a large improvement in cost-performance.

Recommendation 5c. Aggressively pursue the development of Nb_3Sn magnets suitable for use in a very high-energy proton-proton collider.

Recommendation 5d. Establish and execute a high-temperature superconducting (HTS) material and magnet development plan with appropriate milestones to demonstrate the feasibility of cost-effective accelerator magnets using HTS.

Recommendation 5e. Engage industry and manufacturing engineering disciplines to explore techniques to both decrease the touch labor and increase the overall reliability of next-generation superconducting accelerator magnets.

Recommendation 5f. Significantly increase funding for superconducting accelerator magnet R&D in order to support aggressive development of new conductor and magnet technologies.

I. Ben-Zvi, M. Bishai, C. Gerber, Z. Ligeti , R. Tschirhart

Recommendations in Scenario A - continued

~ 1-TeV ILC Upgrade

Recommendation 6. Increase funding for development of superconducting RF (SRF) technology with the goal to significantly reduce the cost of a ~1 TeV energy upgrade of the ILC. Strive to achieve 80 MV/m accelerating gradients with new SRF materials on the 10-year timescale.

J. Carlstrom, C. Gerber, G. Hofstaetter, R. Tschirhart

Recommendations in Scenario A - continued

Multi-TeV e^+e^- Collider

Recommendation 7. Vigorously pursue particle-driven plasma wakefield acceleration of positrons at FACET in the time remaining for the operation of the facility. Between the closing of FACET and the operation of a follow-on facility, preserve the momentum of particle-driven wakefield acceleration research using other facilities.

Recommendation 9. Reduce funding for direct laser acceleration research activities.

T. Shutt, R. Wechsler

Recommendation 8. Continue to support laser-driven plasma wakefield acceleration experiments on BELLA at the current level.

Z. Ligeti

Recommendation 10. Convene the university and laboratory proponents of advanced acceleration concepts to develop R&D roadmaps with a series of milestones and common down-selection criteria towards the goal of constructing a multi-TeV e^+e^- collider.

Recommendations in Scenario A - continued

Multi-TeV e^+e^- Collider

Recommendation 11. Continue research on high efficiency power sources and high gradient normal conducting RF structures.

Recommendation 12. Make NLCTA available for RF structure testing using its RF power and beam sources.

T. Shutt, R. Wechsler

Recommendation 13. Focus normal conducting RF R&D on developing a multistage prototype of high-gradient, high-efficiency normal conducting RF technology to demonstrate the effectiveness of the technology for a multi-TeV e^+e^- collider based upon the development of high-efficiency power sources and high-gradient structures.

Recommendations in Scenario A - continued

Further Future Accelerators
(Particle Driven Wakefield Accelerator)

FACET-II would allow significant progress on much lower emittance and energy spread electron beams in the context of very high acceleration gradients. It would eventually have a new small damping ring for positrons that would utilize the existing positron source and a "sailboat" chicane, which would allow adjustable separation of the drive electron and witness positron beams. FACET-II would enable beam matching and transport at the entrance/exit of a single module, but does not permit independent stages with drive beams. Initial staging experiments can be performed at the ATF and AWA facilities.

The cost of this project is substantial and cannot be accommodated within the current GARD budget.

T. Shutt, R. Wechsler

Recommendations in Scenario A - continued

Support for Next Steps and Further Future Accelerators

Recommendation 14. Continue accelerator and beam physics activities and beam instrumentation and control R&D aimed at developing the accelerators defined in the Next Steps and the Further Future Goals. Develop coordination strategies, both nationally and internationally, to carry out these studies in an efficient manner.

Recommendation 15. To ensure a healthy, broad program in accelerator research, allocate a fraction of the budget of the Accelerator Physics and Technology thrust to pursue fundamental accelerator research outside of the specific goals of the Next Steps and Further Future Goals. Research activities at universities should play a particularly important role.

Scenario B

Whereas the current GARD budget (Scenario A) is insufficient to satisfy the expectations of P5, a modest rise in base funding for GARD research (Scenario B: an increase of ~10-20% of GARD research, ~1-2% of HEP) would open numerous critical R&D opportunities that do not fit in the current base, as well as invigorate fundamental accelerator science research.

Recommendation B1. Increase base GARD funding modestly in order to open numerous critical R&D opportunities that do not fit in the current base, as well as to invigorate fundamental accelerator science research, and to step up development of the national accelerator workforce.

Scenario C

The P5 report called for a roadmap for the U.S. to "move boldly toward development of transformational accelerator R&D […] with an aggressive, sustained, and imaginative R&D program […] changing the capability-cost curve of accelerators" in Scenario C. Motivated by the P5 science drivers, the goal is to "make these further-future accelerators technically and financially feasible on much shorter timescales."

Recommendation C1. Hasten the realization of the accelerator of P5's medium-term vision for discovery: a very high-energy proton-proton collider and the realization of the accelerators of P5's long-term vision for discovery: a multi-TeV e^+e^- collider.

Scenario C

For the very high-energy proton-proton collider:

Recommendation C1a. Ramp up research and development of superconducting magnets, targeted primarily for a very high-energy proton-proton collider, to a level that permits a multi-faceted program to explore possible avenues of breakthrough in parallel. Investigate additional magnet configurations, fabricate multi-meter prototypes, and explore low cost manufacturing techniques and industrial scale-up of conductors. Increase support for high-temperature superconducting (HTS) materials and magnet development to demonstrate the viability of accelerator-quality HTS magnets for a very high-energy collider.

I. Ben-Zvi, M. Bishai, C. Gerber, Z. Ligeti , R. Tschirhart

Scenario C

For the multi-TeV e^+e^- collider:

Recommendation C1b. Develop, construct, and operate a next-generation facility for particle-driven plasma wakefield acceleration research and development, targeting a multi-TeV e^+e^- collider, in order to sustain this promising and synergistic line of research after the closure of the FACET facility.

Scenario C

To reach the goal of having a credible design for a multi-TeV *e^+e^-* collider, a number of R&D steps will be needed to determine the most promising acceleration technique and to further develop that technique for a practical collider.

Seven Steps are listed in the report beginning with continue studies of the candidate techniques on existing facilities.

Next generation facilities will be needed followed by perhaps next-to-next generation facilities before a down selection to a single technique.

After enough R&D has been performed with the selected technique a demonstration facility will need to be constructed in order to demonstrate the technique on a scale that gives confidence that further scaling can be done to the multi-TeV scale e^+e^- collider.

Scenario C

Scenario C funding would enable the U.S. accelerator R&D program to “move boldly toward development of transformational accelerator R&D […] with an aggressive, sustained, and imaginative R&D program”, as called for by the P5 strategic plan. By funding R&D projects that would hasten the development of a very high-energy proton-proton collider and of a multi-TeV e^+e^- collider, Scenario C funding would consolidate R&D areas in which the U.S. already has significant strengths and leadership positions. With this additional funding, the U.S. could maintain its traditional leadership in accelerator R&D. The R&D projects chosen would significantly enhance the state-of-the-art; consequently, they can be expected to generate exciting results that will draw new practitioners into the accelerator R&D enterprise, and that can be applied across the Office of Science. Scenario C funding would energize a vibrant accelerator-based U.S. particle physics program.

T. Shutt, R. Wechsler