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Berkeley Lab Physics Division Strategic Plan

The mission of the Berkeley Lab Physics Division is to discover the particles that compose the universe and to understand the forces that shaped the origin and fate of the universe through an integrated program of theory and experimental science that leverages the unique combination of scientific, engineering and computational resources of Berkeley Lab and the University of California.

In support of this mission the Physics Division will

- Play a leadership role in particle physics experiments and observational cosmology through the development of new initiatives, through the design, construction and operation of new detectors and through the analysis of data from those detectors
- Play a leadership role in formal and phenomenological particle physics theory and theoretical cosmology
- Serve as a resource to strengthen the university-based high energy physics program in the United States through our scientific collaborations, through a program of workshops and visitors and through access to leading edge facilities.
- Carry out long-term research and development to define the detector and computing technologies needed to support the future activities of the national high energy physics program
- Provide service to the international high energy physics program through the compilation of high energy physics data and the publication of the *Review of Particle Physics*
- Educate the next generation of scientific leaders through our graduate and undergraduate programs and through postdoctoral appointments, including strengthening the University's physical science educational mission.
- Communicate the accomplishments of the high energy physics program outside our high energy physics community and transfer our new technologies to other sciences and to the nation
- Contribute to the national program through service on planning panels, advisory committees, program reviews, scientific societies, and University programs.
- Provide a working environment that is nurturing and intellectually challenging and that respects the contributions of our diverse staff
- Protect the safety and health of our employees and the natural environment through a proactive Environment, Health &Safety program

Strategic Analysis

- Opportunities

This is a time of great opportunity for the field and for Berkeley Lab. There is enormous potential for discovery with the commissioning of the LHC and with the Joint Dark Energy Mission. In addition, there is potentially high payoff from directed efforts in neutrino physics and measurement of the polarization of the Cosmic Microwave Background.

The needs of current experiments and future facilities demand extensive detector R&D efforts in areas where Berkeley has historically been strong such as silicon and pixel detectors, integrated electronics, CCDs and bolometers.

In the longer term, the Office of Science Facilities Plan includes new facilities that will have a major impact on the field: the Linear Collider, Underground Double Beta Decay and a Neutrino Superbeam. Berkeley Lab has expertise to contribute significantly to these new programs.

Ongoing programs at the Tevatron and BaBar will continue to produce physics through 2007.

New leadership at the Laboratory, on the UC Berkeley Campus, and UC Systemwide campus offers new opportunities to further invigorate physical sciences in the region.

- Threats

The major threat facing our program is the mismatch between our available resources and our significant commitments to the ongoing and new programs. This could significantly reduce the impact of Berkeley on the physics program at LHC or Berkeley contributions to the Joint Dark Energy Mission.

Changing priorities at NASA may significantly delay the Joint Dark Energy Mission.

Our DOE peer review indicated that the importance of the studies of CMB polarization have not been understood by a large fraction of the particle physics community.

The redirection of resources to high priority programs programs also makes it hard to meet our commitments to postdocs and graduate students who are involved in important but lower priority work.

There may not be sufficient resources to maintain the necessary core program in Engineering and Computing Sciences so that we will have the capabilities needed for future programs.

The generally aged and crowded physical conditions make Berkeley Lab and the UC Berkeley campus less competitive for attracting and retaining leading scientists and faculty.

- Funding Sources

Our major funding source is the High Energy Physics program funded by DOE. The Office of High Energy Physics provides more that 90% of our funding.

Another important funding source is NASA funding, for JDEM and, on a smaller scale for Hubble Space Telescope analysis and for other science, instrumentation and detector development.

There is a potential program in detector development for facilities in the Office of Basic Energy Sciences, the Office of Biological and Environmental Sciences and the National Institutes of Health.

There exist potential markets such as non-federal funding especially for cosmology. This market may be exploited independently of the campus, as we are currently doing, or possibly in conjunction with the campus, should Laboratory and Campus leadership agree on a fund-raising strategy for the physical sciences.

- Competition

The Division faces competition, for funding and for scientific leadership, from other labs and universities. We face strong international competition in the ATLAS physics program. It is important that campus and laboratory activities form unified rather than competitive positions in advancing the future of physics in Berkeley.

- Technology

New technology has a significant impact on planning for the division. Distributed computing and networking, including the Grid, are vital to the physics analysis plans for ATLAS and for other programs. The capabilities of new detector technologies will define the scope of new programs. Full exploitation of computing and engineering will be important to the success of our programs, so that integration of computing resources on the Hill will support our mission and enable stronger alliances.

- Strengths/Limitations

To quote the report of the most recent DOE-HEP peer review,

LBNL is the best in the world in:

- *Dark Energy*
- *Semiconductor detectors (both particle and light detectors)*
- *High-field magnets [AFRD]*
- *Particle data group, education and outreach*

LBNL is as good as the best in the world in:

- *Collider physics analysis and computing*

The major strength of the Physics Division is an outstanding scientific staff in particle physics experiment and theory and in observational cosmology. The staff is further strengthened by strong campus connections, the Berkeley Lab engineering and computing support organizations and major laboratory infrastructure and facilities.

A significant limitation is that the theory program in cosmology is not yet matched to the observational program.

Program management in some areas is not yet optimal to achieve the desired impact on the international program. The physics analysis program in ATLAS needs to be strengthened to prepare for early physics. The Supernova Cosmology Project needs additional experienced personnel to ensure that the staff on the project is able to complete a successful analysis of accumulated observations.

Another major limitation is the age profile of the senior staff and senior faculty. Many of those are expected to retire over the next decade. Because of funding limitations, there have not been enough new staff added to fill the ranks and allow a smooth transition as the more senior scientists retire. Recent efforts to attract Division Fellows, the Berkeley Lab tenure track appointment, are intended to address this issue but additional appointments at Berkeley Lab and on the Berkeley Campus are needed to ensure the long-term health of the program.

- Financial

Current funding projections are for less than 2% growth each year. Costs are expected to rise by 4-5% per year because of inflation and rising health-care costs. Unless improved, this situation will further reduce the scope of the program.

- Products/Services

Our major products are the physics results from the experimental, observational and theory programs, and the new detectors/instrumentation developed for future

experiments. Our major service is the data compilation published as the Review of Particle Physics for the international science community. Additional services include the support of detector development facilities, most notably the Microsystems Lab. Current budgetary limitations reduce access to our advanced facilities by outside university groups.

- Internal Capabilities

In particle physics experiment, the Physics Division has expertise and experience covering all aspects of the program. Berkeley Lab takes a major role in the definition of new initiatives and in realizing them with innovative detectors. The Division plays a major role in commissioning, operations and physics analysis. Continuing detector R&D ensures that the Division also plays a significant role in detector maintenance and upgrades.

The supernova cosmology group provides world-leading expertise in the study of the expansion history of the universe. Other cosmology efforts bring expertise in large-scale detectors using both CCDs and bolometry.

The theory program brings significant strength in both formal theory and phenomenology. A small program in cosmology theory and computation supports the observational program.

Within the General Sciences, collaborations with the Nuclear Science Division and the Accelerator and Fusion Research Division are crucial to the planning and execution of important parts of our program.

The capabilities of the Physics Division are augmented by the support of the Engineering Division, which provides expertise in mechanical, electrical and electronics engineering as well as project management.

The Computing Sciences Directorate provides expertise in software engineering, high-performance computing, networking and computer security. In addition, the Directorate, through the National Energy Research Scientific Computing Center (NERSC) operates computing and storage facilities that are vital to the Division's programs. Consolidation of the NERSC facilities and personnel on the Hill would open up space for stronger alliances and improve the environment for science.

Close ties to the Space Sciences Laboratory ensure that there is adequate expertise in space-based missions for new programs.

Physics Division Strategy

- **Strategy Statement**

The Berkeley Lab Physics Division will focus its staff and financial resources on two flagship experimental efforts: ATLAS at the LHC and the Joint Dark Energy Mission. A strong theory program will complement the experimental efforts. The Particle Data Group will maintain its role as a major resource for the international HEP community. As resources permit, the division will continue a small but visible program in neutrino physics and in studies of the CMB.

This focus requires the following changes:

ATLAS will increase the number of postdocs working on the project. The new staff will work on pixels, commissioning, and on physics analysis and simulation to prepare for the first physics run. In addition, the Division will recruit a (tenure-track) Division Fellow who will be expected to take a leadership role in the ATLAS physics analysis. As pixel fabrication ends, effort will increase on detectors needed for LHC upgrades.

The Supernova Cosmology Program will add additional staff to increase effort on the JDEM Science Definition and to maintain the instrument R&D necessary to plan the mission. The Supernova Cosmology Project and the Nearby Supernova Factory will continue studies directed at better measurements of dark energy and significantly better understanding of Type Ia supernovae as distance indicators. The program has just added a Divisional Fellow to provide long-term leadership in this program.

Resources for BaBar, CDF and D0 will decline as rapidly as possible consistent with meeting commitments to postdocs and students on those programs. Scientific staff will move to our high priority activities.

Modest resources will be allocated to support planning for a reactor neutrino experiment to measure θ_{13} and preliminary work towards a measurement of the B-mode polarization of the CMB, a key indicator of inflation. Further work in these areas will require new funding. Both groups will attempt to enlarge their collaborations and broaden support for the programs in the community.

The Laboratory is providing the resources for detector R&D directed at the Linear Collider with LDRD funding in FY05. It is hoped that this will continue through FY07. The detector R&D is closely aligned with work on RHIC upgrades in the Nuclear Science Division. In FY08 and beyond, funding from DOE will be essential to maintain a Berkeley Lab role in the international Linear Collider program. A partnership with the Accelerator and Fusion Research Division will focus on R&D issues related to the facility and the accelerator-experiment interface.

The Theory Group will partner with the Center for Theoretical Physics on campus to enhance the program. An active visitor program will serve as a focus for national efforts

to understand the particle theory basis for the constituents and evolution of the universe. A Division Fellow search in FY05 and another in FY07 will ensure the long-term vitality of the LBNL Particle Theory Group. New staff in cosmology theory will enhance the interaction with the observational cosmology program.

Our philosophy is to direct our resources toward the highest priority scientific programs. With modest additional funding to support local workshops and travel to universities in the United States, we will significantly enhance our impact on the national program and will increase university participation in the most promising scientific programs.

- **Long-term Objectives:**

Berkeley Lab will be recognized by the international particle physics community as a leader in the physics of the LHC.

Berkeley Lab will be recognized as the leader in the study of dark energy.

Berkeley Lab will provide service to the national university program through its support of detector R&D and through the work of the Particle Data Group. In partnership with NERSC, the lab will provide computing support for the LHC program and will work with other labs and universities to strengthen grid security to protect the integrity of LHC computing resources.

Berkeley Lab will be recognized for significant contributions to neutrino physics, studies of the CMB, and R&D directed at the Linear Collider detector.

- **New Initiatives:**

To further its strategic goals and increase its support for the U.S. university-based program, Berkeley Lab has proposed five new initiatives. Two of these are for new experiments that address fundamental questions in neutrino physics and cosmology:

- A Reactor Experiment to Measure the Mixing Angle θ_{13}

This initiative is directed towards a next-generation reactor neutrino oscillation experiment to discover subdominant neutrino oscillation in the $\nu_e \rightarrow \nu_{\mu,\tau}$ channel and to measure the unknown neutrino mixing angle θ_{13} with reactor neutrinos. The discovery of subdominant effects in $\nu_e \rightarrow \nu_{\mu,\tau}$ oscillation and the measurement of θ_{13} would have profound impact on neutrino physics.

- POLARBEAR: Ultra-high Energy Physics with Measurements of Cosmic Microwave Background Polarization

Observations of Cosmic Microwave Background (CMB) polarization have the potential to be a powerful probe of cosmology and eventually the standard model of physics at the highest energy regimes. Polarbear is a new experiment using a dedicated telescope equipped with a powerful bolometer array receiver that will produce maps of CMB polarization with unprecedented accuracy. The most exciting possibility is that we will detect the signature of gravitational waves from the end of the Inflationary period 10^{-38} seconds after the Big Bang at GUT energy scales, $\sim 10^{16}$ GeV. If detected, these signals will provide an independent verification of Inflation, and allow a test of models for Inflation. Another important scientific motivation is the characterization of gravitational lensing of the CMB polarization.

In addition, we have proposed three initiatives that will serve the high energy physics community and, in particular, will significantly strengthen the university based programs:

- An Integrated CyberSecurity Approach for HEP Grids and Clusters

The physics analysis efforts in the United States can be disrupted for extended periods of time by attacks on their computer systems. The current most difficult cybersecurity threat to deal with is identity theft: A set of real users unknowingly lose control of their "identity." The goal of this initiative is to develop and test a comprehensive approach and a set of tools and procedures that can systematically reduce the cybersecurity risks for the scientific environment while not disrupting scientific collaboration and the use of distributed computing and storage resources.

- A Center for Detector Fabrication and Characterization

The center will focus on the development of next-generation semiconductor devices needed for the future program in particle physics and cosmology. The center will serve as a national resource supporting the detector development efforts in universities and other laboratories with state-of-the-art facilities for microfabrication and readout systems. The initial focus areas will be LHC detector upgrades, R&D for the Linear Collider, and superconducting detectors for studies of the cosmic microwave background. Work currently underway for JDEM/SNAP will be an important continuing activity.

- The Quantum Universe Institute

The next generation of cosmological observations and new experiments at accelerators will bring unprecedented opportunities to better understand the universe. With astrophysical observations, we will explore the parameters of the universe; with accelerator experiments we will search for their quantum explanation. The goal of the Quantum Universe Institute is to understand these deep connections between the physics of elementary particles and the structure and evolution of the universe. The Institute will focus on three closely connected issues as identified in the HEPAP Report *The Quantum*

Universe: How did the universe come to be? How can we solve the mystery of Dark Energy? What is Dark Matter and how can we make it in the laboratory? The development of this institute with the new Laboratory Director, and in conjunction with new Chancellor on the Berkeley campus, and new research office and computing facilities on the Hill offers an outstanding opportunity for in-depth scientific pre-eminence in particle astrophysics.

Facilities and Infrastructure:

The program depends on facilities and infrastructure.

For ATLAS, the major needs are:

- Labs for pixels and for upgrade R&D
- Computing at PDSF and Grid Security support

For JDEM, there is a need for continuing CCD R&D at the MicroSystems Lab (MSL). In the long-term, the MSL is expected to expand its role to support the national program in instrument development.

To support the long-term needs of CMB research, a Superconducting Detector Laboratory is crucial.

Strengthened supercomputing facilities for cosmic simulation and many other applications will strongly underpin the physics programs.

Financial Projections:

Our current funding is strained severely to cover the base program even with the significant reductions in effort for CDF and BaBar to redirect resources to ATLAS. Our projections are that our base funding will increase by at most 2% per year while labor costs will increase by 4 - 5%. This will result in continuing pressure on the non-labor component of our program, which is already at a critically low level.

The new initiatives that we have submitted to DOE can only be accommodated with new funding specific for these programs. We will seek this funding from DOE as well as from other agencies as appropriate.