PREFACE

When the scientific case was made for the facility that became CEBAF, there was unanimous agreement on the importance of a continuous-beam electron accelerator but a great deal of discussion about the optimum beam energy. A subcommittee of NSAC (the Nuclear Science Advisory Committee of the U.S. Department of Energy and the National Science Foundation) chaired by Peter Barnes concluded [Ba82] that the accelerator's design energy should be 4 GeV, rather than the 2 GeV favored by some, because the higher energy would permit its experimental program "to study the largely unexplored transition between the nucleon-meson and the quark-gluon descriptions of nuclear systems". In anticipation of the future need to extend this experimental program to even higher momentum and energy transfers, the CEBAF accelerator was designed in the mid-1980s so that future extensions to energies of order 25 GeV would be straightforward.

As CEBAF's scientific program has progressed, the wisdom of these design choices has become increasingly clear. This White Paper outlines the scientific case for the upgrade of CEBAF to 12 GeV, and documents the accelerator and experimental equipment improvements necessary to carry out the scientific program. It is the result of lengthy discussions within the Jefferson Lab community that began as the 4 GeV program was just underway in the mid-1990s. In this preface we remind the reader of the main activities leading to this White Paper.

As CEBAF neared completion and its experimental program was about to begin, the CEBAF User Group began an examination of the physics accessible with an upgraded CEBAF energy. This decision led to the organization of a workshop held at Jefferson Lab from 14 to 16 April 1994. It was organized into four working groups centered around four main physics topics, by an organizing committee consisting of T. Barnes, R. Ent, B. Frois, R. Holt, R. Milner, P. Mulders, J. Napolitano, M. Petratos, and P. Stoler. Each working group was represented by one or two plenary speakers who were asked to summarize the outstanding physics issues that could be addressed by an upgrade, and by many shorter parallel contributions dealing with specific issues. Members of the organizing committee then summarized their presentations and their personal views on the physics case for an upgrade of CEBAF to higher energies. The result was the "yellow book" report, *CEBAF at Higher Energies*, edited by Paul Stoler for the CEBAF User Group and Nathan Isgur for Jefferson Lab, which marked the first step toward the goal of defining the physics program that would form the basis of an upgrade of CEBAF.

The compelling science which emerged from this workshop led to a study of the upgrade options by a laboratory strategic planning group, and to two "village meetings". These studies indicated that a cost-effective upgrade of CEBAF is possible. These conclusions were presented to

NSAC, which responded in the recommendations of its 1996 Long Range Plan that "the community looks forward to future increases in CEBAF's energy and to the scientific opportunities that would bring".

With this encouragement, the users held a second workshop from 15 to 18 June 1998. This workshop, organized by Steve Dytman, Howard Fenker, and Phil Roos, was structured to review the physics motivation for the Upgrade, but to focus on the specification of the equipment and instrumentation necessary for measurements at 12 GeV. It began with plenary sessions on physics, on the issues faced by Halls A, B, and C at 12 GeV, on the preliminary designs of a new Hall D for photoproduction, and on state-of-the-art detector and polarized-source developments. Next came parallel sessions organized by physics topic on photoproduction, high-Q^2 reactions, hadrons in the nuclear medium, and inclusive and semi-inclusive reactions. These were followed by parallel sessions organized by hall. More than 180 scientists participated in the workshop; their work is recorded in *Physics and Instrumentation with 6–12 GeV Beams*, edited by the three organizers. A remarkable feature of this workshop was the quick consensus reached on the set of detectors needed to exploit the vast new physics potential of the 12 GeV Upgrade within budgetary guidelines established by DOE.

Most recently, in anticipation of the imminent launching of the next NSAC Long Range Plan, the User Group organized a special January workshop devoted to delineating the 12 GeV program for the existing experimental halls. It commissioned five follow-on working groups to develop crisp scientific cases and identify key experiments or key experimental programs in five target areas focused on these halls. Following the January workshop, at their March 2000 meeting the User Group Board of Directors appointed a White Paper Steering Committee consisting of four members selected by the User Group and three members selected by Jefferson Lab. This is the group that has been responsible for editing the present document.

Prior to and in parallel with this effort, the new Hall D Collaboration produced a design for a new meson photoproduction facility designed to discover and investigate the properties of gluonic excitations. Their design underwent a rigorous review in December 1999 by a distinguished external committee; the collaboration emerged from the review having received high praise for both their physics goals and their experimental design.

In 2000 the users reviewed an early draft version of this White Paper at their annual June meeting, which was once again devoted to the Upgrade. At that meeting, key experiments were selected from the many ideas that emerged from the planning for the Upgrade. These experiments were developed in greater detail, for inclusion as part of the scientific case for the Upgrade, and

presented to the Jefferson Lab Program Advisory Committee at a special meeting of that committee. The PAC commented on each proposal in a manner similar to their review of research proposals for the present accelerator. In summarizing their review, the PAC noted:

> *The laboratory and the user community have developed an impressive scientific case that demands this new capability. The Jefferson Lab Program Advisory Committee was charged by the laboratory to review this science, and to review the plans for the associated experimental equipment.*
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> *The committee concludes that an outstanding scientific case has been identified which requires the unique capabilities of the JLab 12 GeV upgrade. The results of these experiments are likely to significantly change the way we think about nuclear physics and the strong (nonperturbative) limit of QCD. Two major new thrusts can produce definitive results: the experimental verification of the origin of quark confinement by QCD flux tubes as predicted by lattice gauge calculations, and the determination of the quark and gluon wave functions of the nuclear building blocks. The full technical capabilities of the upgrade are required for this progress. New research domains are also opened up that show great promise in leading existing research efforts to new levels of understanding.*
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> *The proposed experimental equipment is well suited to addressing these new physics opportunities. The choices capitalize on the powerful existing equipment at the laboratory without compromising the physics goals.*
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> *The Program Advisory Committee was excited by the research potential that the 12 GeV upgrade makes possible. The scope of the upgrade is very well matched to the problems we see driving the field for the next decade. The time has come to bring these opportunities to nuclear physics.*

This White Paper is based on these many workshops, their published proceedings and unpublished presentations, and on the published and unpublished work of many individuals on the physics opportunities that would open up with CEBAF at 12 GeV. A second, more detailed draft of this document was released in October 2000 to provide ample opportunity for community comment to be incorporated prior to the release of a third version in time for the NSAC Long Range Plan Town Meeting at Jefferson Lab in December 2000. Following discussions at that meeting and further comment from the user community, the present final version of the White Paper was published for presentation to the larger nuclear physics community as part of the Long Range Planning process.

The author list at the end of this document includes the names of all contributors to the effort known to us. Many of them commented extensively on the earlier drafts, resulting in a much-

improved document. This White Paper would have been impossible without their intelligence, enthusiasm, time, and just plain hard work. We apologize to anyone whose contributions we have inadvertently failed to acknowledge. We also acknowledge extensive technical help in the production of this document from Mary Beth Stewart and Nilinga Liyanage.

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