Abstract

This White Paper presents the compelling scientific case for upgrading the Continuous Electron Beam Accelerator Facility (CEBAF) at Jefferson Lab to 12 GeV. Such a facility will make profound contributions to the study of nuclear matter. In particular, it will allow breakthrough programs to be launched in two key areas:

- *The experimental observation of the QCD flux tubes which cause confinement.* Theoretical conjectures, now confirmed by lattice QCD simulations, indicate that the most spectacular new prediction of QCD – quark confinement – occurs through the formation of a string-like "flux tube" between quarks. This conclusion (and proposed mechanisms of flux tube formation) can be tested by determining the spectrum of the gluonic excitations of mesons.
- *The measurement of the quark and gluon wavefunctions of the nuclear building blocks.* A vast improvement in our knowledge of the fundamental structure of the proton and neutron can be achieved. Not only can existing "deep inelastic scattering" cross sections be extended for the first time to cover the critical region where their basic three-quark structure dominates, but also measurements of new "deep exclusive scattering" cross sections will open the door to a new, more complete characterization of these wavefunctions by providing direct access to information on the correlations among the quarks.

In addition to opening up these qualitatively new areas of research, the Upgrade will:

- *Open important new research domains in key areas already under investigation.* These new research thrusts include:
  - Determining the dynamics underlying the quark-gluon wavefunctions through measurements of the high-momentum-transfer behavior of form factors.
  - Mapping out and understanding the transition from the hadronic to the quark-gluonic description of strongly interacting matter through the study of low-energy duality.
  - Searching for the onset of color transparency effects in the region where they are supposed to exist.
  - Determining the role of color polarization effects in the NN force by measuring the threshold ψN cross section.
  - Executing a unique and global study of short-range correlations in nuclei.
  - Examining the role of quark masses in determining hadron spectra by mapping out the currently obscure $s\bar{s}$ spectrum that straddles the boundary between the rigorously understood heavy-quark systems and the poorly understood light-quark world.

While focusing on science, this White Paper also summarizes reports on the required detector and accelerator upgrades so that it can serve as an overview of the entire plan for the 12 GeV project.