Thomas Jefferson National Accelerator Facility

INSTITUTIONAL PLAN

FY 1998 - FY 2002

Jefferson Lab
12000 Jefferson Avenue
Newport News, Virginia 23606

December 1997

Jefferson Lab is managed and operated for the U.S. Department of Energy by the Southeastern Universities Research Association (SURA) under contract DE-AC05-84ER40150.

Initiatives are provided for consideration by the Department of Energy. Inclusion in this plan does not imply department approval of or intent to support an initiative.

CONTENTS

This page intentionally left blank.

EXECUTIVE SUMMARY

The experimental program at Jefferson Lab is underway, fulfilling the top priority of the U.S. nuclear science program since the 1970s: the construction of a multibillion-electron-volt, continuous-beam electron accelerator with three complementary experimental facilities capable of supporting a broad range of innovative research in nuclear physics. Jefferson Lab serves the Department of Energy mission to develop and operate major cutting-edge scientific user facilities. Jefferson Lab's CEBAF (Continuous Electron Beam Accelerator Facility) is a unique tool for exploring the transition between the regime where strongly interacting (nuclear) matter can be understood as bound states of protons and neutrons, and the regime where the underlying fundamental quark-and-gluon structure of matter is evident. The nature of this transition is one of the last frontiers in our understanding of matter. A three-year backlog of approved experiments proposed by 615 scientists from 120 institutions in 20 countries awaits beam time in the three halls. Our user-customers have been delighted with the accelerator's performance and the quality of the data they are obtaining. Based on their expressed need for energies higher than the 4 GeV design energy and on the outstanding performance of our novel superconducting accelerator, the laboratory expects to be able to approach an energy of 6 GeV in 1998.

The vision for Jefferson Lab is to:

- Foster user-driven nuclear physics research of international significance as part of the U.S. national laboratory system.
- Leverage resources to support national goals for economic competitiveness.
- Prepare a broadly educated next generation of scientists and engineers for a globally competitive research environment and economy, including in the process traditionally underrepresented populations.
- Contribute to public science literacy through outreach and motivational/educational programs for math and science.
- Develop a world-class workforce.
- Lead in environmental responsibility by conducting environmentally sound and safe operations.

This vision translates into specific goals that underlie Jefferson Lab's strategic and institutional planning:

1. Enable and conduct a user-driven physics research program of the highest scientific priority at the interface between nuclear and particle physics.
2. Continue world leadership in underlying core competencies.
3. Apply Jefferson Lab technologies to enhance national industrial competitiveness.
4. Improve laboratory productivity and cost-effectiveness to accomplish more physics research, reduce the unit cost per running hour, and create new paradigms of effectiveness.
5. Continue as a recognized leader in environmentally sound and safe operation.
6. Serve as an asset to our community.

Jefferson Lab's Strategic Plan includes, at the summary level, the following six elements:

- As the highest priority, conducting its internationally preeminent nuclear physics research program.
- Increasing the beam energy toward 8 GeV, as warranted by scientific priorities and endorsed by the DOE/NSF Nuclear Science Advisory Committee, to extend the laboratory's scientific reach.
- Advancing Jefferson Lab's core competencies and enabling technologies, specifically superconducting radio-frequency (SRF) technology, polarized and high-intensity electron sources, and detector technologies, to support Jefferson Lab's program, other DOE missions, and potential spinoffs.
- Applying our expertise and core competencies for national benefit, symbiotic with the nuclear physics mission, with an SRF free-electron laser for industrial, defense, and scientific applications as a first step.
- Participating in partnerships mutually beneficial to DOE, the lab, the region, and the nation.
- Discussing with diverse stakeholders and customers their interests and needs in light of Jefferson Lab's capabilities and core competencies, and developing initiatives that will create a dynamic and responsive portfolio of challenges and opportunities appropriate to our mission.

I. LABORATORY DIRECTOR'S STATEMENT

To advance our understanding of the fundamental nature of matter and energy, the U.S. Department of Energy's Office of Energy Research has constructed and maintains four major centers for accelerator-based research in high energy and nuclear physics. DOE built the Thomas Jefferson National Accelerator Facility (Jefferson Lab) to conduct user-driven research into how nucleons are built from quarks and gluons, and how this structure leads to the standard nucleon-based picture of the nucleus. With experiments focusing on such fundamental topics as quark confinement, the proton spin crisis, and gluon excitations, Jefferson Lab is poised to become one of the world's leading laboratories through its unique capabilities for exploring and elucidating the quark structure of matter.

The highest priority for Jefferson Lab is to continue running the approved experimental program, where we have a backlog of 80 experiments involving 615 physicists. The experiments are conducted in the three experimental halls of Jefferson Lab's CEBAF (Continuous Electron Beam Accelerator Facility). We have completed five experiments and half each of two others, and our user group has grown to over 1200 members. Complementary scientific programs are underway as of this year in all three halls, with research productivity benefiting from the CEBAF accelerator's ability to serve all three halls simultaneously. Our success in developing our superconducting radio-frequency (SRF) technology will allow us to meet physics demand to approach 6 GeV (well above the 4 GeV design energy) in 1998. The machine capabilities coupled with advanced detector technology make Jefferson Lab's CEBAF a forefront research tool capable of gathering data at the rate of 1 terabyte per day.

To conduct its scientific research mission, Jefferson Lab developed core competencies in which it has attained a world leadership position. These competencies, particularly SRF accelerating technology, have led to derivative missions. At Jefferson Lab, guided by the advice of our Industrial Advisory Board, we are building an SRF-driven high-average-power free-electron laser for industrial processing and for defense and basic research applications. Our understanding of and success with SRF technology led to the recommendation that the design for the Accelerator Production of Tritium incorporate it. Continuing R&D in SRF technology, pushing toward a 50 MV accelerator cryomodule (2 1/2 times the original CEBAF design), is synergistic with our primary and derivative missions. This synergy allows us to pursue such advances in a cost-effective manner.

Our performance-based contract supports a culture that maintains high scientific productivity and safe and environmentally sound operation within constrained budgets. Central to our success is a highly educated and motivated work force. We are striving to develop this valuable asset through continued training and educational opportunities to reach greater effectiveness in an atmosphere that is both challenging and professionally satisfying.

From its inception, Jefferson Lab has cultivated a relationship with the local community and the region through active outreach programs. Jefferson Lab actively participates in regional economic development through its technology transfer programs. This is evidenced in the rising structure of the seven-story Applied Research Center under construction by the city of Newport News at Jefferson Lab to provide space for industry, lab, and university partners to work together, and to act as a flagship building for a planned research and development park being sited adjacent to the lab. We conduct a monthly Science Series lecture to increase awareness of science and technology issues for the educated layman. We run motivational programs designed to increase interest in science and math at vulnerable times (upper elementary and middle school) and in underrepresented populations (females and minorities) within our local community. And we have built partnerships with universities in our region to strengthen both education and the science and technology base in the southeastern United States.

Jefferson Lab is the latest example of the real strength contained in the Energy Research laboratories where a talented, highly trained and motivated workforce utilizes its core competencies to conduct research at the frontier of science and to develop technologies in collaboration with universities and industries. It is by doing this that Jefferson Lab, along with her sister laboratories, can best benefit the communities in which we work, and the nation we serve.

Hermann A. Grunder, Director

II. LABORATORY MISSION AND CORE COMPETENCIES

Jefferson Lab's major facilities, key R&D roles, enabling capabilities, and key partnerships are summarized below.

Major Facilities

CEBAF
Superconducting Radio-Frequency Accelerator:
A 4 GeV, 200 microampere, continuous-beam electron accelerator, upgradable to 10+ GeV.

End Station A:
Two 4 GeV/c high-resolution magnetic spectrometers.

End Station B:
A large acceptance superconducting toroidal magnet detector system for multiparticle final states.

End Station C:
A 7 GeV/c magnetic spectrometer and a 2 GeV/c short-orbit magnetic spectrometer.

Test Lab
Superconducting Radio-Frequency Technology Facility:
Superconducting accelerator cavity fabrication, surface treatment, and research facilities.

FEL User Facility:
Free-electron laser development, initially with a 1 kW test-bed FEL (to be operational in 1998).

Key R&D Roles

Science and Technology
- Explore and understand the quark-gluon structure of matter.
- Understand the origin and nature of the standard nucleon picture of the nucleus, and discover its limits.
- Improve superconducting radio-frequency accelerator technology for research, industrial, and other uses.
- Design and build free-electron lasers for industrial, defense, and research use.

Enabling Capabilities

- Nuclear and particle physics (experimental and theoretical).
- Superconducting radio-frequency technology.
- Accelerator physics (experimental and theoretical).
- Accelerator-driven light sources (FELs).
- Advanced detector and data acquisition technology.
- 2 K cryogenics.
- Very large real-time systems for process control.

Key Partnerships

- The worldwide CEBAF user community, currently over 1200 users from 120 institutions and 20 countries.
- Universities, including minority institutions, with an emphasis on the southeastern region.
- The Commonwealth of Virginia and the city of Newport News.
- Industries of the Laser Processing Consortium and the U.S. Navy.
- Schools and businesses in support of education.

III. LABORATORY SCIENTIFIC AND TECHNICAL VISION AND STRATEGIC PLAN

Context and Trend Analysis

The experimental program now underway at Jefferson Lab fulfills a major, two-decade-old priority of the U.S. nuclear science program: the construction and scientific use of a 4 GeV, continuous-beam electron accelerator capable of supporting a broad range of innovative research in nuclear physics. Jefferson Lab serves the Department of Energy mission to develop and operate major scientific user facilities. Jefferson Lab's CEBAF is a unique facility for exploring the energy region where the transition occurs between the regime where the standard picture of the nucleus as a group of protons and neutrons interacting through potentials is appropriate, and the regime where the quarks and gluons inside the nucleons must be explicitly included. At the high-energy end of this transition region, the essentially exact calculations of perturbative quantum chromodynamics (QCD) are applicable. In the lower-energy, non-perturbative region, characteristic of normal nuclear matter, a new "strong QCD" framework is required. Elucidating the nature of this transition is one of the last frontiers in our understanding of ordinary matter.

A growing excitement is evident in the over 1200-member user group now that the experiments they have been preparing are running. A three-year backlog of approved experiments awaits beam time in each of the three experimental halls. The accelerator is providing cw electron beams simultaneously to independent experiments exploiting the complementary capabilities of the halls' experimental equipment, and we now anticipate meeting user-driven demand by approaching 6 GeV in 1998.

As a program-dedicated lab, we have basic research as our primary mission. To accomplish that mission, we developed key technologies which we are now sharing with industry and the military. Collaboration between universities, industry, the military, and national laboratories is particularly important in an environment where resources are becoming scarce. Fiscal constraints have hit the scientific community particularly hard since the community has only recently incorporated into its long-range planning the assumption that constant effort is the most likely funding scenario.

One of the biggest challenges facing all federally funded research facilities is finding support for the ongoing R&D needed to maintain our unique core competencies at the cutting edge. The synergy that comes from partnerships such as those Jefferson Lab has developed with industry in the Laser Processing Consortium and the Navy provide real leverage for our efforts in SRF accelerator technology and in detector development, allowing us to advance these core competencies cost-effectively.

Vision and Goals

The vision for Jefferson Lab is to:

- Foster user-driven nuclear physics research of international significance as part of the U.S. national laboratory system.
- Leverage resources to support national goals for economic competitiveness.
- Prepare a broadly educated next generation of scientists and engineers for a globally competitive research environment and economy, including in the process traditionally underrepresented populations.
- Contribute to public science literacy through outreach and motivational/educational programs for math and science.
- Develop a world-class workforce.
- Lead in environmental responsibility by conducting environmentally sound and safe operations.

This vision translates into specific goals underlying Jefferson Lab's strategic and institutional planning:

1. Enable and conduct a physics research program of the highest scientific priority at the nuclear/particle physics interface.
   - Provide technical and theoretical support for the user-driven experimental program.
   - Maximize beam time and accelerator and experimental equipment reliability.
   - Increase the maximum beam energy toward 8 GeV to extend the scientific reach of the advancing experimental program.

2. Continue world leadership in underlying core competencies.
   - Superconducting radio-frequency technology.
   - Electron source development.
   - Innovative detector technologies.

3. Apply Jefferson Lab technologies to enhance national industrial competitiveness.
   - High-power, energy- and cost-efficient, compact infrared/ultraviolet free-electron lasers.
   - Detectors for medical diagnostics and other applications.

4. Improve laboratory productivity and cost-effectiveness to accomplish more physics research, reduce the unit cost per running hour, and create new paradigms of effectiveness.
   - Accelerator and experimental equipment availability.
   - Business systems efficiency and effectiveness.
   - Demonstration through quantitative metrics (performance contract, DOE productivity metrics).

5. Continue as a recognized leader in environmentally sound and safe operation.
   - Recognized for good performance by regulators.
   - Continue to implement "work-smart standards."

6. Serve as an asset to our community.
   - Outreach programs to increase science literacy.
   - Motivation of students in math and science through participation in science.
   - Partnerships with regional universities.

Strategic Plan

At the summary level, Jefferson Lab's Strategic Plan includes the following six elements:

- As the highest priority, conducting its internationally preeminent nuclear physics research program.
- Increasing the beam energy toward 8 GeV, as warranted by scientific priorities and endorsed by the DOE/NSF Nuclear Science Advisory Committee, to extend the laboratory's scientific reach.
- Advancing Jefferson Lab's core competencies and enabling technologies, specifically superconducting radio-frequency (SRF) technology, polarized and high-intensity electron sources, and detector technologies, to support Jefferson Lab's program, other DOE missions, and potential spinoffs.
- Applying our expertise and core competencies for national benefit, symbiotic with the nuclear physics mission, with an SRF free-electron laser for industrial, defense, and scientific applications as a first step.
- Participating in partnerships mutually beneficial to DOE, the lab, the region, and the nation.
- Discussing with diverse stakeholders and customers their interests and needs, including preservation of environment, health, and safety, in light of Jefferson Lab's capabilities and core competencies, and developing initiatives that will create a dynamic and responsive portfolio of challenges and opportunities appropriate to our mission.

Table III-1 summarizes Jefferson Lab’s funding and performance goals for the planning period. Table III-2 reports FY 1996 contract performance measure results.

Table III-1
Jefferson Lab Nuclear Physics Funding and Key Performance Goals

	FY94 Baseline (Actual)	FY95 (Actual)	FY96 (Actual)	FY97 (Actual)	FY98 (PB)	FY99* (Guidance*)	FY2000 (Requirements)
Actual, President’s Budget (PB), Guidance, or Requirement Budget (AY$M)	73	72	67	68	67	71	79
Weeks of Accelerator Running for Physics	N/A	Commis.	28	28	28	30	40
Key Performance Goals:							
Halls in Operation			1	2	3	3	3
Experiment Multiplicity			N/A	1.3	2	2	2.5
Accelerator Availability (%)			55†	70	78	80	80

* The FY99 Guidance does not include $500K in new funding to university groups for fabrication, installation, and maintenance of key detector elements currently the responsibility of Jefferson Lab.
† 65% actual.

Table III-2
FY 1996 Contract Performance Measure Results

Performance Measure	Points Earned	Points Available
Science and Technology	27.0	30.0
Operations	24.5	25.0
Institutional Management	9.0	10.0
EH&S	9.0	10.0
Business and Administrative	8.7	10.0
Corporate Citizenship	7.2	7.5
Education	7.5	7.5
Total	92.9	100.0

Summary

Jefferson Lab represents a considerable investment of public funds as well as physics, engineering, and management expertise over the past decade. As a federal laboratory, we are accountable for achieving the maximum benefit for the nation from this investment in the years ahead. The scientific payoff started in 1995 as we began the approved experimental program. Effective management stewardship of Jefferson Lab will involve a continued commitment to excellence in all areas, beginning with the delivery of beam and the conduct of forefront physics experiments. Also important are partnerships with industry and educational institutions to help the nation capitalize in the near term on the knowledge, products, supporting technologies, and intrinsic excitement of Jefferson Lab's efforts. All of our efforts must be based on quality management, on employee, subcontractor, and user health and safety, and on sound environmental and business practices.

IV. SUMMARY OF MAJOR NEW PROGRAM INITIATIVES

1. CEBAF AT 8–10 GeV

The physics opportunities of a CEBAF energy upgrade were endorsed by the 1996 NSAC (Nuclear Science Advisory Committee) Long Range Plan. This upgrade requires: increased voltage gain in the accelerating structures, and/or additional structures; increased magnetic fields in the transport channels; and modestly increased cryogenic capacity to maintain the crucial feature of cw operation. Up to an energy between 8 and 10 GeV, the dominant effort and cost are in the area of increased voltage gain, i.e. accelerating gradients. To avoid any impact on ongoing operations and to live within the tight budgets projected for nuclear physics in the near term, the strategy at Jefferson Lab to upgrade CEBAF's energy has been put on an evolutionary, two-pronged approach.

The first line of attack focuses on improving the maximum energy available from the installed machine (without the addition of major new components) through in-situ processing of cavities and peripherals, and through a better understanding and relaxing of presently imposed operational limits. This effort will have two desirable outcomes: much improved availability of the accelerator for 4 GeV operation, and the capacity to run at 6 GeV with acceptable reliability for selected, high-priority experiments. Work in this area has already permitted us to demonstrate operation of the linacs at the energy gain necessary for 5.5 GeV beam, and, on the basis of these tests, we expect to approach 6 GeV for a few experiments in 1998.

Based on early experience with in-situ cavity processing, we are confident that this first approach will eventually lead to acceptable 6 GeV operation, providing CEBAF with a new and very important physics reach. Meanwhile, a second, parallel effort will lead in an evolutionary fashion to even higher energies. This second effort involves reworking and/or adding — in a mixture to be optimized — cryomodules with accelerating gradients above 10 MV/m. These and significantly higher gradients have been achieved consistently in vertical tests at Jefferson Lab, so we are left with the engineering challenge of retaining this performance in an installed and operational cryomodule. Surmounting this challenge will require a focused, ongoing R&D effort, and AIP funding for implementation; the necessary funds to start this effort have been requested in our FY 1999 Field Work Proposal. The R&D effort will address chemical processing, cleaning, and clean room techniques leading to a reduction in particulate contamination of cavities; cavity high-temperature treatment and high-power processing; and advanced rf control of microphonics. Applying the results to reworking or adding new cryomodules a few at a time, in an operationally transparent way, will steadily increase the attainable energy to the 8–10 GeV range. The maximum energy obtainable through this evolutionary approach will become apparent only as we determine more precisely the additional effort in magnets and cryogenics needed to exceed 8 GeV. The R&D and AIP funding necessary to carry out this effort corresponds to a very modest increase in the investment already made in CEBAF, and can be expected to yield spectacular advances in the laboratory's physics output.

2. A FUTURE CEBAF 20 GeV UPGRADE

Many studies (including one by our users and another by physicists associated with the ELFE Project in Europe) have made it clear that there is a strong physics case for a CEBAF-like machine operating at energies in the 10–30 GeV range. However, the total cost of upgrading CEBAF to a 20 GeV machine with appropriate detectors would be only a fraction of that for a new machine like ELFE. The "practical R&D" of the first approach described above, along with expected improvements in attainable gradients from the second approach, should make it possible to build such a machine in the existing CEBAF tunnel early in the next decade.

To put this objective into perspective, we note that accelerating gradients equivalent to 75 MV cryomodules have been demonstrated in vertical cavity pair tests at Jefferson Lab. The gradients required for a 50 MV cryomodule—2.5 times the original CEBAF design specification—have in fact been attained. Gradients four times that required for CEBAF's original design energy of 4 GeV can be expected, and since the accelerator tunnel has free space for the installation of 25% more cryomodules, an energy of 20 GeV actually constitutes a conservative objective technologically. (The free space resulted from a cost-saving design-optimization opportunity that arose in the late 1980s, after the CEBAF construction project was underway.) At 20 GeV, synchrotron radiation induced in the beam recirculation arcs would not affect beam quality for the physics program significantly.

We expect early in the next decade to see an international consensus develop concerning the need to build such a machine as an international facility, and we are planning through the R&D described above to be in a position to compete successfully to be chosen as the site for it.

3. 10–50 KILOWATT FREE-ELECTRON LASER (FEL)

The designs of the IR Demo FEL—described in detail in Chapter V—and the FEL User Facility allow an evolutionary expansion of the FEL to shorter wavelengths and higher powers. A proposal is under discussion with the Department of the Navy and defense committees in Congress for committing FY 1997 and FY 1998 funds to upgrade the baseline IR Demo FEL to higher power (approximately 10 kilowatts) and shorter wavelengths (1 micron). The order of magnitude increment in power would be of significant interest to all stakeholders in the program. The extension in wavelength to 1 micron would enable overlap with the optimum windows for atmospheric propagation (1, 1.4, and 1. 6 microns) essential to the defense community in the prototyping of this device for defense purposes. In addition, operation of the FEL at the third harmonic of the shortest wavelength accessible to the upgrade would provide significant power in the ultraviolet (333 nanometers). The IR FEL upgrade is based on adding two cryomodules to the baseline FEL's SRF driver accelerator, extending its energy to 100 MeV. A new injector based on upgrading the design of the present FEL photocathode gun and a new 500 megahertz injector cryounit would be developed off-line from FEL operations in the Jefferson Lab Injector Test Stand. Finally, a higher-efficiency wiggler would be developed with the industrial partners who have collaborated with Jefferson Lab in the development and fabrication of the IR Demo wigglers. If the requested funding is available through FY 1999, the planned IR Demo upgrade could be installed early in FY 2000. With this upgrade in place, a third-phase upgrade to extend the kilowatt power capability to the ultraviolet range (190–350 nanometers) would be relatively modest in scope. Using a short-wavelength wiggler which could be lent to the project from DOE's Advanced Photon Source, the high-power ultraviolet regime could be accessed by adding a second recirculation arc to the IR Demo FEL's SRF driver accelerator to raise the final energy to 200 MeV.

Higher-power upgrades to the IR Demo FEL in both the infrared and ultraviolet could be implemented early in the next decade by substituting lower-frequency (500–700 megahertz) SRF cryomodule technology for the baseline 1500 megahertz hardware in the FEL driver.

V. OPERATIONS AND INFRASTRUCTURE STRATEGIC PLAN

1. SCIENTIFIC AND TECHNICAL PROGRAMS

A. Physics Program

Our understanding of the fundamental structure of matter has undergone a profound transformation in recent years. We now believe that quarks and gluons — not protons and neutrons — are the basic components of nuclei, and that they, together with electrons and photons, are the fundamental constituents of matter. Along with the discovery of quarks and gluons has come a fundamental understanding of their interactions — the “strong interactions” — so that now nuclear and subnuclear physics have, for the first time, a basis as solid as the theory on which atomic and molecular sciences are built. In fact, the analogy here is quite deep: the proton and neutron are now believed to be “quark atoms” (bound states of quarks held together by gluons) just as ordinary atoms consist of electrons bound by photons to the atomic nucleus; nuclei themselves may be considered analogous to molecules, both being relatively weakly bound compounds of their respective “atoms.”

The fundamental theory of strong interactions, call quantum chromodynamics (QCD), guides experimentation at Jefferson Lab’s CEBAF. Although it is assumed that QCD is exact, it has only been tested in the very high-energy regime, where the interaction becomes weak and perturbative calculations are feasible. The scientific goal of CEBAF is to investigate the transition region between this “asymptotically free” high-energy regime and the strongly interacting regime, where our understanding of the underlying physics is very rudimentary, and where the matter we see around us is formed. CEBAF’s 4 GeV, continuous-wave electron beam is, in many respects, an ideal probe for the study of this transition region, since the electromagnetic interaction is well understood, the electron has no internal structure, and the electron’s wavelength at this energy is a few percent of the nucleon's size.

The small cross sections of the electromagnetic interaction and the systematic nature of the required investigations mean that experiments often require months of beam time. The productivity of the scientific program is thus enhanced significantly by the accelerator’s ability to provide three simultaneous beams of independent current and independent but correlated energy, permitting as many as three experiments to run in parallel. The availability of polarized electron beams extends the capabilities of the facility to include both spin-transfer reactions and parity-violation experiments, which probe, respectively, the spin and the weak neutral current structures of the system under study.

The three halls have been equipped with instrumentation that was carefully selected to emphasize complementary aspects of the scientific program, further enhancing the versatility of the facility. Hall A has a pair of high-resolution magnetic spectrometers optimized for precision electron-scattering coincidence experiments. Hall B has a large acceptance (nearly 4π) detector and ancillary equipment (including a photon tagger) that supports broad-ranging studies of both electron- and monochromatic photon-induced reactions with loosely correlated particles in the final state and in situations involving low luminosity. Hall C has a pair of moderate-resolution spectrometers, with one capable of high-momentum particle detection and the second optimized for the detection of short-lived reaction products. Hall C also has additional space and infrastructure for supporting major new setups optimized for specific measurements not well suited to any of the halls’ basic instrumentation.

Hall A

Hall A is the second experimental hall to come into operation; initial commissioning activities began in spring 1996. Hall A is equipped with the two optically identical, high-resolution (10^{-4}) magnetic spectrometers (HRS) shown in Figure V-1; each has a relatively large solid angle and a maximum momentum of 4 GeV/*c*. The detector packages have been optimized differently — one for detecting electrons and one for detecting hadrons. The detector in the hadron spectrometer includes a focal plane polarimeter. The two spectrometers have been commissioned, and the first experiments began in the spring of 1997.

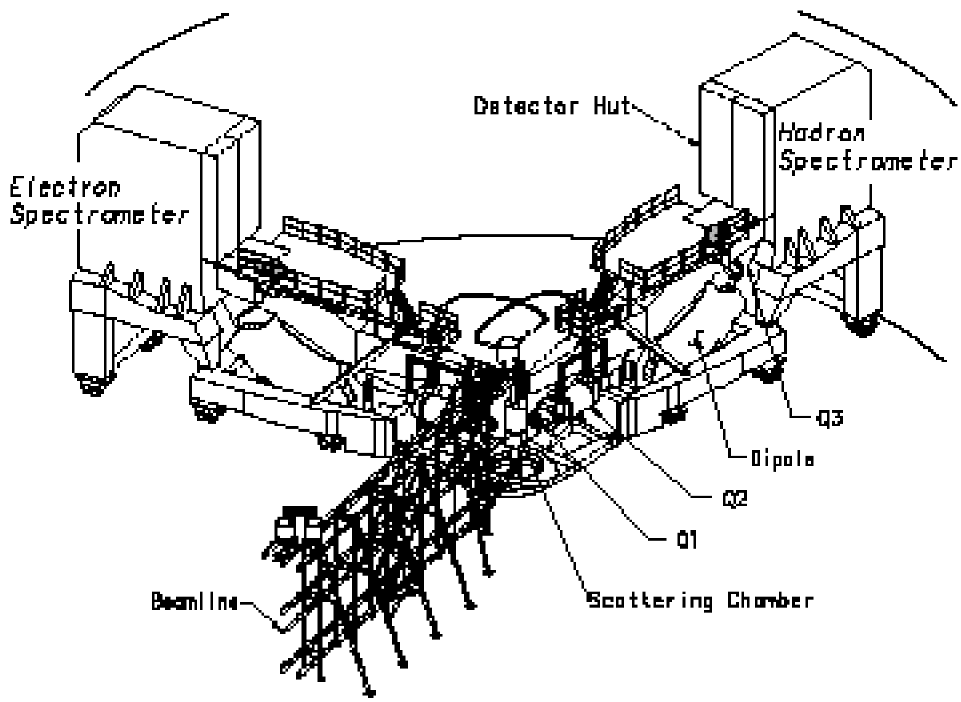


Figure V-1: The Hall A High Resolution Spectrometers (HRS).

One use of the Hall A spectrometers will be the detailed investigation of the structure of nuclei, mainly using the $(e, e'p)$ and $(\vec{e}, e'\vec{p})$ reactions. The measurements will extend the range of momentum transfers and internal nucleon momenta well beyond the presently known region. Such measurements could reveal the limitations of the standard (and presently adequate) picture of nuclear structure based on nucleons interacting via meson exchange. Experiments of this type in heavy nuclei will expand our understanding of nuclear structure and provide information on how the nucleon’s properties change when it is embedded in the nuclear medium. In few-body systems, where exact calculations can be performed for interacting nucleons, these experiments may reveal the complete breakdown of the nucleon-meson picture. More realistically, one will probably discover that, at some point, quark models will offer a much more economical description of the experimental data. The spectrometers must have high resolution to be able to isolate the different reaction channels in nuclei so that a clean comparison with theory can be achieved. High absolute accuracy will be required to separate the various types of contributing electromagnetic currents.

Studies of the electromagnetic and weak neutral current structure of the nucleon will also be an important component of the Hall A program. The HRS spectrometers will measure the charge and magnetic form factors of nucleons with greatly improved accuracy, virtual Compton scattering experiments will probe both the low-energy structure of the proton and its excited state, and a detailed study of spin observables in the $N \rightarrow \Delta$ transition will be performed. In addition, these spectrometers will be used to investigate the strange-quark contributions to the charge and magnetization distributions of the nucleons via very precise parity-violating electron-scattering experiments, which will provide stringent tests for microscopic models of the nucleon.

Hall B

Hall B is the final hall to begin physics operations. It has been equipped with a large acceptance (nearly 4π) detector, the CEBAF Large Acceptance Spectrometer (CLAS), as shown in Figure V-2. Its main missions are to carry out experiments that require the simultaneous detection of several loosely correlated particles in the hadronic final state, and to permit measurements at limited luminosity.

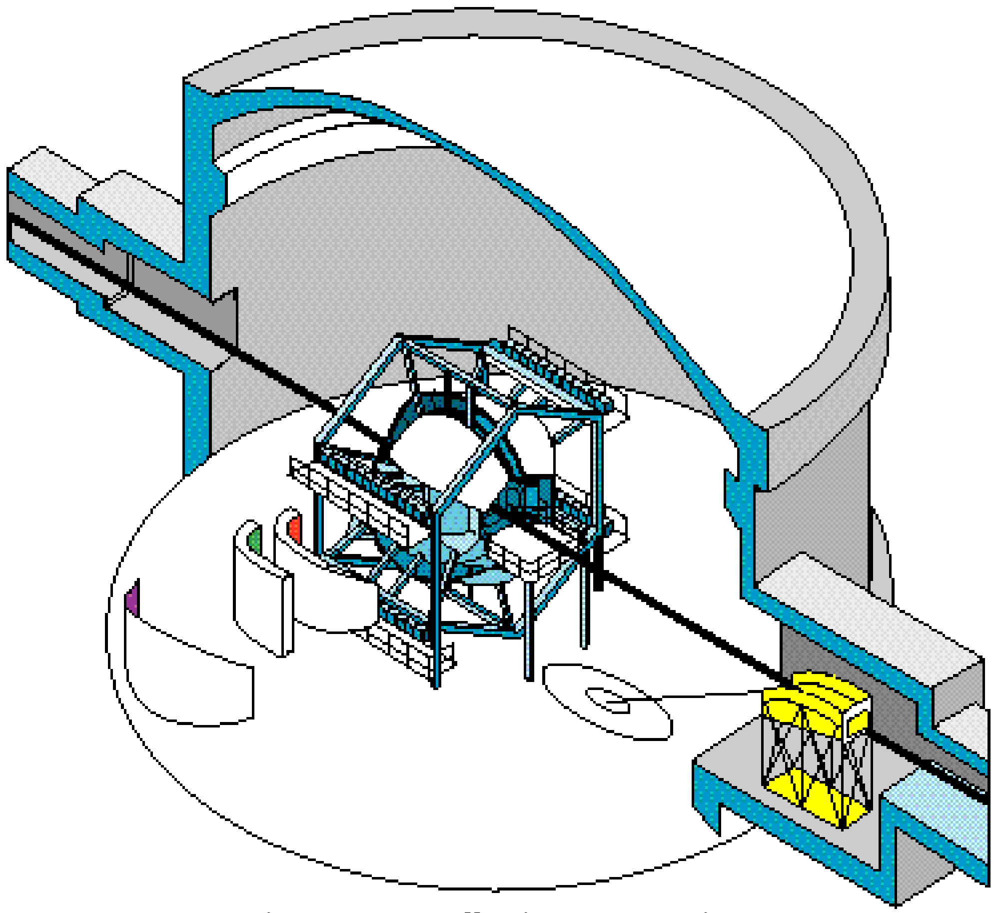


Figure V-2: Hall B instrumentation.

The magnetic field in the CLAS has a toroidal configuration generated by six iron-free superconducting coils. Its particle detectors consist of drift chambers to determine the trajectories of charged particles, Cherenkov counters for the identification of electrons, scintillation counters for the trigger and for time-of-flight measurements, and electromagnetic calorimeters to identify electrons and to detect photons and neutrons. The continuous nature of the CEBAF beam is critical to the functioning of such a multiparticle coincidence detector. Hall B also includes a bremsstrahlung photon tagging facility so that the CLAS can investigate real as well as virtual photon processes.

The superconducting coil and almost all of the detector systems are installed in the CLAS, and beam tests began late in December 1996. The last of the detectors will be installed by spring 1997. Commissioning, which began in earnest in early 1997, will be a complex process, but we anticipate that the first group of experiments will begin to take data early in fall 1997.

A major research program for the CLAS will be the investigation of the quark-gluon structure of the nucleon, especially the detailed study of its spectrum of excited states. As in atomic physics, the spectrum of this system contains vital information on the nature of its constituents and the forces between them. It is not understood why the naive constituent quark model is so successful in explaining the particle spectrum discovered so far. CLAS will either prove this model by discovering the complete pattern of states it predicts or, more likely, it will reveal its shortcomings.

One reason it is doubtful that the simple quark model will continue to be successful is that it ignores the gluonic degree of freedom. While there is no evidence yet for states involving gluon excitation, model calculations indicate that most of the predicted "gluonic" states will decay in complicated many-particle-modes that would not have been observed with the previous generation of detectors. The broad acceptance in both momentum and solid angle of the CLAS spectrometer should greatly facilitate the search for such states. This is one of the areas in which the accelerator's ability to deliver 6 GeV is critical.

The CLAS spectrometer will also be used in a variety of other investigations requiring data on multiparticle final states, including short-range correlations between nucleons in nuclei, the importance of three-body forces in nuclei, and the modification of the nucleon's properties in the nuclear medium.

Hall C

Hall C has been in operation since late 1995; the first five experiments and phase 1 of a sixth have been completed, and a seventh is in progress. The hall's initial complement of equipment, shown in Figure V-3, includes two general purpose magnetic spectrometers: the High Momentum Spectrometer (HMS), which has a large solid angle, a moderate resolution (10^{-3}), and a maximum momentum of 7 GeV/*c*, and the Short Orbit Spectrometer (SOS), which has a large momentum acceptance and a very short (7.4 meter) optical path to facilitate the detection of particles having short lifetimes, such as low momentum π's and K's. The HMS and SOS were fully commissioned by the end of FY 1995. The spectrometers have demonstrated operation at their design specifications. The first five experiments completed (from the start of the physics program through March 1997) are a study of proton propagation in the nuclear medium, an investigation of the validity of quark counting rules in the photodisintegration of the deuteron, two studies of kaon electroproduction, and measurements of inclusive scattering from nuclei at x>1 and large q^2. We are currently running the first experiment requiring a major installation of new equipment — the "t_{20}" experiment. It will allow us to separate the electromagnetic form factors of the deuteron to very high values of momentum transfer, completing our information on the electromagnetic structure of this fundamental nucleus down to subnucleonic distance scales.

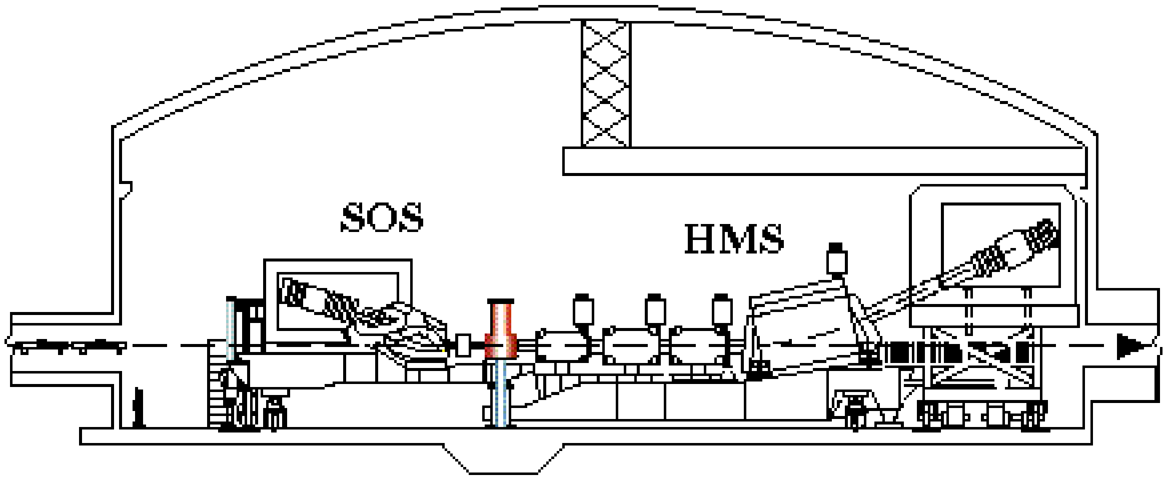


Figure V-3: Hall C and its initial complement of equipment.

Hall C was planned to support the installation of specialized detectors to investigate specific problems; the t_{20} experiment is the first of these. A second such experiment will use a polarized deuterium target together with the polarized electron beam to measure the electric form factor of the neutron (G_{En}). A third will use a prototype spectrometer system that is being constructed to investigate the feasibility of performing hypernuclear physics experiments in which a nucleon in the nucleus is replaced by its strange counterpart, the Λ hyperon. A major new specialized apparatus planned for Hall C is the G^0 spectrometer, an eight-sector, focusing spectrometer to be used in precision measurements of parity violation in the scattering of polarized electrons from protons to investigate their weak neutral current structure and possible contributions from strange quarks. Construction of this spectrometer is about to begin with substantial funding from the NSF.

Theory

Jefferson Lab maintains a strong nuclear theory group in partnership with Hampton University, Old Dominion University, and the College of William and Mary. The group includes expertise spanning a broad range from the nuclear many-body problem to perturbative QCD, as required at a laboratory working at the interface between nuclear and particle physics. In addition to supporting the CEBAF experimental program directly, the Jefferson Lab theorists collaborate closely with other theory groups around the world on CEBAF-related problems.

Last year was a typically productive one for the Theory Group. The group published over 38 new papers, gave 28 invited talks at international conferences and workshops and another 22 contributed talks, and sponsored or co-sponsored three workshops on specialized topics related to the CEBAF program. Theory Group's papers continue to be so frequently cited that several have appeared on "top ten citations" lists. Finally, Theory Group continues its sponsorship of a seminar program aiming to bring important new developments in theory to the attention of the laboratory and user community. To supplement this program, this year the Theory Group began its Mini-Lecture Series of short courses for experimentalists on key new developments in nuclear theory.

Accelerator and Experimental Area Operations and Hours Available for Research

Jefferson Lab has an innovative, performance-based contract with DOE that emphasizes the goal of maximizing the research productivity of the laboratory. Key metrics for the operation of the research program include the availability of the accelerator and the experimental equipment and the experiment multiplicity (the number of experiments that are receiving beam simultaneously, on average). As we learn how to run the accelerator and the experimental equipment, we anticipate the availability to increase significantly; the goals for accelerator availability increase from 55% in FY 1996 (65% was achieved) to 80% in FY 1999 and beyond. Similar escalating goals have been set for each experimental hall, with the starting year being the first year of its physics operation. As Halls A and B come into full operation we anticipate the experiment multiplicity to double. The combination of the increased productivity represented by the availability of beam and experimental equipment, the enhanced experiment multiplicity, and the extension of the running period from 30 to 40 weeks, would result in the hours of beam on target for experiments roughly doubling from FY 1996 to FY 1997, and doubling again from FY 1997 to FY 1998. A modest increase in the technical support staff for CEBAF, together with increased support for user groups to station research staff here, would permit us to increase the average hall multiplicity from 2 to 2.5, providing 25% more science for the same accelerator running period.

New Experimental Equipment Initiatives

There has been a large investment in the initial equipment for the three experimental halls for CEBAF at Jefferson Lab, as outlined above. This base equipment will be CEBAF's "workhorse" equipment, but it will always be necessary to construct both new and ancillary devices to carry out "standard" high-priority experiments that have already been approved and new instrumentation to respond to exciting new scientific initiatives. Over time it will be necessary to modify the existing equipment to keep its performance at the state-of-the-art. Eventually, it will be necessary to replace major end station apparatus to keep the facility's capability at the cutting edge of nuclear physics research. We request equipment funds each year to respond to these needs. The funds are divided between Jefferson Lab and collaborating user groups in a manner similar to that used for the construction of the base equipment in the halls.

Funding for such initiatives began in this year, and is already serving many useful purposes. It is supporting work on the installation of the t_{20} deuteron channel in Hall C, and on a high-power cryogenic hydrogen target for Hall A. A number of multiyear projects have also begun, including the G^0 spectrometer for parity violation experiments in Hall C, polarized hydrogen and deuterium targets for use in conjunction with the HMS in Hall C (for the G_{En} measurement) and with CLAS in Hall B, and two beam-line polarimeters — a Compton polarimeter for Hall A and a Møller polarimeter for Hall B. Funds will also be used to improve beam-line instrumentation and to develop general-purpose infrastructure for polarized and cryogenic target development and support at the laboratory. A series of important upgrade projects will be undertaken for the CLAS itself, with the highest priority being the implementation of a level-two trigger capable of selecting trajectories in the drift chambers. There will also be a number of smaller-scale projects. Continued funding of this type is critical to the long-term success of the research program.

Data Acquisition, Reconstruction, and Analysis

Data acquisition systems are already in operation for production running in Hall C and for commissioning in Halls A and B. Enhancements to these systems are in progress as Halls A and B move to their first experiments in the spring and fall of 1997 respectively. In the longer term, the data acquisition systems for all of the halls will be upgraded to support higher data rates, the addition of level-two triggering, and enhanced features in the associated controls systems.

May 1997 has seen the "beta release" of version 0.9 of the Jefferson Lab Off-line Batch System (JOBS) for data reduction. The system includes the software and hardware, i.e. computers, disks and networking, required to perform first-pass data reduction on approximately half of the full data flow from Hall B and all of the current data flows from Halls A and C. In the autumn of 1997 the JOBS hardware will be upgraded to process all of the initial data flow from Hall B. This is when Hall B is anticipated to first reach its terabyte per day data flow, and when version 1.0 of the software will become available. Over the course of the next several years, JOBS will be upgraded further to process the expanded data sets and to process the raw data flows of up to two terabytes per day anticipated when certain experiments run in Hall A. The existing 300 terabyte near-line tape storage system must be upgraded to 1 petabyte capacity by about the year 2000.

While most of the data analysis is planned to take place at user institutions, Jefferson Lab must provide an appropriate level of on-site data analysis support. Some user groups are also bringing data analysis systems on-site. Those systems running standard versions of supported operating systems are usually integrated into the site's Common Unix Environment (CUE). It is anticipated that over the next year or two, the systems running the NT operating system will also be integrated with CUE and JOBS.

Networking

Because most of our 1200-plus users are off-site, Jefferson Lab actively participates in networking projects such as the Next Generation Internet. The lab's current T3 (45 Mb/s) wide area network connection to ESnet is anticipated to be increased to OC3 (155 Mb/s) in 1998–1999, and to OC12 (622 Mb/s) by 2000. The lab also supports the ESnet Site Coordinating Committee's activities.

Collaboratory Development

Jefferson Lab is working with the DOE 2000 National Collaboratory (NC) and Advanced Computational Testing and Simulation (ACTS) initiatives so that the lab can take advantage of the tools anticipated to come from this work over the next several years. The goal is to integrate Jefferson Lab's controls (EPICS) and data acquisition (CODA) systems with the DOE 2000 NC and ACTS tool kits.

The Experimental Program

CEBAF's research program was planned with the active participation of our user group, which has over 1200 members. Collaborations were formed within this group to build the spectrometers, detectors, and data acquisition systems and to propose experiments. These users have contributed over 400 man-years of effort to the construction of the experimental equipment. A total of 615 scientists from 120 institutions in 20 countries are collaborators on one or more of these experiments; their home institutions are classified in Table V-1. Table V-2 presents a breakdown of the approved and conditionally approved experiments by physics topic and by hall. The recommended beam time allocations for these experiments, shown in Table V-3 by hall, correspond to over three years of 30-weeks-per-year operation for each of the halls. During the first year of research operations, roughly one-quarter of the days of physics approved for Hall C were run.

Table V-1
User Institutions, 1997

User Home Institution	Number of Experimenters	Number of Organizations
Universities (U.S.)	349	72
International	191	40
Other Federal Laboratories	40	7
Jefferson Lab	35	1
TOTAL	615	120

Table V-2
Approved Experiments by Physics Topic

Topic	Number of Experiments: Hall A	Hall B	Hall C	Total
Nucleon and Meson Form Factors and Sum Rules	4	3	4	11
Few Body Nuclear Properties	9	5	4	18
Properties of Nuclei	3	8	3	14
N* and Meson Properties	4	20	4	28
Strange Quarks	3	8	4	15
TOTAL	23	44	19	86

Table V-3
Experimental Program Status, February 1997

Hall	Approved Experiments		Conditionally Approved Experiments
	Number	Total Days	
A	23	538	6
B	44	447	5
C	19	370	2
Total	86	1355	13

The process for deciding which experiments should be run and the order for running them is critical to the productivity of the research program of CEBAF at Jefferson Lab. A key element in this process is the traditional mechanism of an external Program Advisory Committee (PAC), consisting of distinguished physicists who are expert in the field of nuclear physics and chosen to provide broad perspective and expertise. Prior to presentation to the committee, the Physics Division's Technical Advisory Committee (which includes representatives from the Accelerator Division) reviews each proposed experiment for feasibility and impact on the laboratory's resources. The PAC reviews proposed experiments on the basis of their scientific merit, technical feasibility, and manpower requirements, and makes recommendations to the laboratory's director, who makes the final decision.

Experiments in the set originally approved in the 1980s — by the early PACs as part of the process of deciding on the equipment complement for the experimental halls — were not rated explicitly for scientific merit. The rating process was postponed until closer to the operation of the facility to permit inclusion of new information on experimental and theoretical developments in our rapidly changing field. As the accelerator and experimental equipment neared completion two years ago, the rating process began; it was completed in January 1996 with the deliberations of PAC 10. Subsequent PACs provide ratings of new experiments as they are recommended for approval, as well as updates on selected experiments where new information warrants their re-examination.

To develop the running schedule for the accelerator, the PAC ratings are considered together with the demonstrated technical capabilities of the accelerator and experimental equipment and a detailed understanding of the long-term goals of the research program. This schedule is released at the end of the second and fourth quarter of each fiscal year, three months before the beginning of a six-month running cycle. The schedule for major new experiments requiring long lead times and large-scale equipment installation is determined a year in advance.

An element of the experiment approval process that is important to the long-term evolution of the program is "jeopardy": any experiment that has not run within three years of approval, for whatever reason, must return to the PAC for a new review (which will include a new rating for its scientific priority) or lose its place in the queue. This system provides a means of continually improving the overall quality of the science as the field moves forward, and avoids the situation where an old, modest-priority experiment waits in the queue for an unconscionably long time. Because many experiments were approved well before accelerator operations began, “jeopardy” is being implemented separately in the three halls; the three-year period is measured in each hall from the start of physics operations in the hall or the date of approval of the experiment, whichever is later. The PAC is also an important component of the process for deciding among the many new directions that can (and must) be taken to enhance facility capabilities. Its advice is augmented by high-level input from the laboratory’s Science and Technology Peer Review Committee.

The experimental program that has resulted from this deliberate and thoughtful process is broad in scope and covers many of the most interesting topics in nuclear science today. The approved experiments are listed by title in Table V-4. Running this program successfully is the laboratory’s highest priority and the central focus of our near-term planning.

Table V-4
CEBAF Approved Experiments

Exp #	Hall	TITLE
E-89-003	A	Study of the Quasielastic $(e,e'p)$ Reaction in ^{16}O at High Recoil Momenta
E-89-019	A	Measurement of Proton Polarization in the $d(\gamma,p)n$ Reaction
E-89-021	A	Elastic Electron ^3He - ^4He Scattering at Large Momentum Transfers
E-89-028	A	Polarization Transfer Measurements in the $D(\vec{e},e'\vec{p})n$ Reaction
E-89-033	A	Measurement of Recoil Polarization in the $^{16}O(\vec{e},e'\vec{p})$ Reaction with 4 GeV Electrons
E-89-044	A	Selected Studies of the ^3He and ^4He Nuclei Through Electrodisintegration at High Momentum Transfer
E-91-004	A	Measurement of Strange Quark Effects Using Parity-Violating Elastic Scattering from ^4He at Q^2=0.6 (GeV)^2
E-91-006	A	Study of Nuclear Medium Effects by Recoil Polarization up to High Momentum Transfers
E-91-010	A	Parity Violation in Elastic Scattering from the Proton and ^4He
E-91-011	A	High-Precision Separation of Polarized Structure Functions in Electroproduction of the Δ and Roper Resonances
E-91-026	A	Measurement of the Electric and Magnetic Structure Functions of the Deuteron at Large Momentum Transfers
E-93-024	A	Measurement of the Magnetic Form Factor of the Neutron at Large Momentum Transfers
E-93-027	A	Electric Form Factor of the Proton by Recoil Polarization
E-93-049	A	Polarization Transfer in the Reaction $^4He(\vec{e},e'\vec{p})^3H$ in the Quasi-elastic Scattering Region
E-93-050	A	Nucleon Structure Study by Virtual Compton Scattering
E-94-004	A	In-plane Separations and High Momentum Structure in $d(e,e'p)$
E-94-010	A	Measurement of the Neutron (^3He) Spin Structure Function at Low Q^2; a Connection between the Bjorken and Drell-Hearn-Gerasimov Sum Rules
E-94-012	A	Measurement of Photoproton Polarization in the $H(\gamma,\vec{p})\pi^0$ Reaction
E-94-021	A	The Electric Form Factor of the Neutron Extracted from the $^3\vec{He}(\vec{e},e'n)pp$ Reaction
E-94-104	A	The Fundamental $\gamma n \rightarrow \pi^- p$ Process in ^2H, ^4He, and ^{12}C in the 1.2 - 6.0 GeV Region
E-94-107	A	High Resolution 1p Shell Hypernuclear Spectroscopy
E-95-001	A	Precise Measurements of the Inclusive Spin-dependent Quasi-elastic Transverse Asymmetry $A_{T'}$ from $^3\vec{He}(\vec{e},e')$ at low Q^2
E-89-004	B	Electromagnetic Production of Hyperons
E-89-015	B	Study of Coincidence Reactions in the Dip and Delta-Resonance Regions
E-89-017	B	Electroexcitation of the $\Delta(1232)$ in Nuclei
E-89-024	B	Radiative Decays of the Low-Lying Hyperons
E-89-027	B	Coincidence Reaction Studies with the CLAS
E-89-031	B	Study of Multi-Nucleon Knockout with the CLAS
E-89-032	B	Study of Local Properties of Nuclear Matter in Electro-Nucleus and Photon-Nucleus Interactions with Backward Particle Production Using the CLAS
E-89-036	B	Study of Short-Range Properties of Nuclear Matter in Electron-Nucleus and Photon-Nucleus Interactions With Backward Particle Production Using the CLAS Detector
E-89-037	B	Electroproduction of the $P_{33}(1232)$ Resonance
E-89-038	B	Measurement of $p(e,e'\pi^+)n$, $p(e,e'p)\pi^0$ and $n(e,e'\pi^-)p$ in the Second and Third Resonance Regions
E-89-039	B	Amplitudes for the $S_{11}(1535)$ and $P_{11}(1710)$ Resonances from an $ep \rightarrow e'p\eta$ Experiment
E-89-042	B	A Measurement of the Electron Asymmetry in $p(e,e'p)\pi^0$ and $p(e,e'\pi^+)n$ in the Mass Region of the $P_{33}(1232)$ for $Q^2 < 2$ (GeV/c)^2
E-89-043	B	Measurements of the Electro-production of the Λ(gnd), $\Lambda'(1520)$ and $f_0(975)$ via the K^+K^-p and $K^+\pi^-p$ Final States
E-89-045	B	Study of the Kaon Photo-production on Deuterium
E-91-002	B	The Study of Excited Barons at High Momentum Transfer with the CLAS Spectrometer
E-91-008	B	Photoproduction of η and η' Mesons
E-91-014	B	Quasi-Free Strangeness Production in Nuclei
E-91-015	B	Helicity Structure of Pion Photoproduction
E-91-023	B	Measurement of Polarized Structure Functions in Inelastic Electron Proton Scattering using CLAS

Exp #	Hall	TITLE
E-91-024	B	Search for "Missing" Resonances in the Electro-production of ω Mesons
E-93-006	B	Two Pion Decay of Electroproduced Light Quark Baryon Resonances
E-93-008	B	Inclusive η Photoproduction in Nuclei
E-93-009	B	The Polarized Structure Function G_{1n} and the Q^2 dependence of the Gerasimov-Drell-Hearn Sum Rule for the Neutron
E-93-012	B	Electroproduction of Light Quark Mesons
E-93-017	B	Study of $\gamma d \rightarrow p\pi$ and $\gamma d \rightarrow p\Delta^0$ Reactions for Small Momentum Transfers
E-93-019	B	Photoabsorption and Photofission of Nuclei
E-93-022	B	Measurement of the Polarization of the $\phi(1020)$ in Electroproduction
E-93-030	B	Measurement of the Structure Functions for Kaon Electroproduction
E-93-031	B	Photoproduction of Vector Mesons at High t
E-93-033	B	A Search for Missing Baryons Formed in $\gamma p \rightarrow p\pi^+\pi^-$ Using the CLAS and CEBAF
E-93-036	B	Measurement of Single Pion Electroproduction from the Proton with Polarized Beam and Polarized Target Using CLAS
E-93-043	B	Measurement of the $\Delta\Delta$ Component of the Deuteron by Exclusive Quasielastic Electron Scattering
E-93-044	B	Photoreactions on ^{3}He
E-94-002	B	Photoproduction of Vector Mesons Off Nuclei
E-94-005	B	Determination of the $N\Delta$ Axial Vector Transitions Form Factor $G_1^{N\Delta}$ from the $ep \rightarrow e'\Delta^{++}\pi^-$ Reaction
E-94-008	B	Photoproduction of η and η' Mesons from Deuterium
E-94-015	B	Study of the Axial Anomaly using the $\gamma\pi^+ \rightarrow \pi^+\pi^0$ Reaction Near Threshold
E-94-016	B	Measurement of Rare Radiative Decays of the ϕ Meson
E-94-017	B	The Neutron Magnetic Form Factor from Precision Measurements of the Ratio of Quasielastic Electron-Neutron to Electron-Proton Scattering in Deuterium
E-94-019	B	Nuclear Transparency in Double Scattering Processes
E-94-102	B	Electron Scattering from a High Momentum Nucleon in Deuterium
E-94-103	B	The Photoproduction of Pions
E-94-109	B	Photoproduction of the ρ Meson from the Proton with Linearly Polarized Photons
E-95-003	B	Measurement of K^0 Electroproduction
E-89-008	C	Inclusive Scattering from Nuclei at $x>1$ and High Q^2
E-89-009	C	Investigation of the Spin Dependence of the ΛN Effective Interaction in the P Shell
E-89-012	C	Two Body Photodisintegration of the Deuteron at Forward Angles and Photon Energies Between 1.5 and 4.0 GeV
E-91-003	C	A Study of Longitudinal Charged Pion Electroproduction in ^{2}D, ^{3}He, and ^{4}He
E-91-007	C	Measurement of the Nuclear Dependence and Momentum Transfer Dependence of Quasi-elastic $(e,e'p)$ Scattering at Large Momentum Transfer
E-91-013	C	The Energy Dependence of Nucleon Propagation in Nuclei as Measured in the $(e,e'p)$ Reaction
E-91-016	C	Electroproduction of Kaons and Light Hypernuclei
E-91-017	C	"G^0": Measurement of the Flavor Singlet Form Factors of the Proton
E-93-018	C	Longitudinal/Transverse Cross Section Separation in $p(e,e'K^+)\Lambda$ (Σ) or $0.5 \le Q^2 \le 2.0$ $(\mathrm{GeV}/c)^2$, $W \ge 1.7$ GeV, and $t_{min} \ge 0.1$ $(\mathrm{GeV}/c)^2$
E-93-021	C	The Charged Pion Form Factor
E-93-026	C	The Charge Form Factor of the Neutron
E-93-028	C	Deformation of the Nucleon
E-93-038	C	The Electric Form Factor of the Neutron from the $d(\vec{e},e'\vec{n})p$ Reaction and The Magnetic Form Factor of the Neutron from the $d(\vec{e},e'\vec{n})p$ Reaction
E-94-014	C	The $\Delta(1232)$ Form Factor at High Momentum Transfer
E-94-018	C	Measurement of the Deuteron Tensor Polarization at Large Momentum Transfers in D$(e,e'\vec{d})$ Scattering
E-94-110	C	Measurement of $R = \sigma_L/\sigma_T$ in the Nucleon Resonance Region
E-95-002	C	Direct Measurement of the Lifetime of Heavy Hypernuclei at CEBAF

B. CEBAF Accelerator Operations

The mission of CEBAF accelerator operations is the delivery of electron beams meeting world-class standards and users' expectations to Jefferson Lab's three nuclear physics experimental halls. During the period covered by this Institutional Plan, accelerator operations will continually improve its capability to routinely deliver reliable, simultaneous beams to three halls with individually chosen energy and current, and with beam polarization available in at least two halls simultaneously.

Performance Objectives

The CEBAF accelerator:

- has as its primary objective to provide reliable user service with all the required beam properties: duty factor, energy, energy spread, current, emittance, polarization, and reproducibility,
- is designed for continuous operation, and
- is most productive when run for the longest period compatible with the accelerator's annual maintenance requirements.

The primary objectives for enhancing the accelerator capabilities are steady improvements in the area of polarized beams from 35% polarization in FY 1997 to 75% polarization in FY 1998, with the capability of simultaneously providing 25 µA of current to another hall; increasing this current capability to 100 µA with acceptable cathode lifetime preserved in FY 1998; and provision of multiple lasers for independent operation of polarized beam to all three halls, also in FY 1998. The design and implementation of diagnostics and/or feedback systems to stabilize and minimize the energy spread will be required for Hall A in FY 1997, and the other halls will follow soon after. The feedback systems should also improve the effective beam size for the experiments by reducing jitter, particularly at line frequency (60 Hz) and the first few harmonics (120 Hz and 180 Hz).

For accelerator operation, the most important figure of merit is the useful number of beam hours for physics data taking. To achieve the maximum number of beam hours, we plan for:

- running time to exceed 30 weeks per year and two-hall multiplicity,
- systematic effort to raise the accelerator availability to 80%,
- in situ cryomodule rework/conditioning to approach 6 GeV by 1998, and
- cryogenic plant work to maintain continuous-beam operations.

The accelerator availability and hall multiplicity goals through FY 2000 are given in Table III-1. Currently, the main limitation to high reliability is the controls network, which is receiving heavy emphasis. An additional factor is the continued work required to complete the full functionality foreseen. This means that maintenance periods are also used for completing upgrades (such as the Hall B beam lines in FY 1997) and that recovery from maintenance periods also involves a component of commissioning. When these projects are complete, the best way to operate will be to try to run the accelerator for extremely long periods, keeping the tunnel closed up as much as possible. This provides more accelerator operating weeks and tends to give higher availability. Our experience in this regard mirrors that of other laboratories.

Routine maintenance is scheduled every two weeks, and this is expected to continue. Some accelerators operate on the principle of "perform maintenance only when something is broken" due to the difficulties involved with accelerator start-up. We intend to continue with scheduled maintenance, albeit with a frequency that may evolve with time, as this operating mode is preferable for the users. January will continue to be the preferred month for an annual long shutdown to enable high-radiation areas to cool off over Christmas and New Year holidays. This decision limits the radiation exposure of the crews that perform maintenance, an ALARA issue.

The main limitation to high hall multiplicity is the availability of manpower to stage experiments. For example, every experiment would prefer to perform its annual major maintenance and large-scale new experiment installation during the accelerator shutdown in January. This will not be possible within the present limitations in staffing levels, so that some experiments will necessarily be undergoing tear-down or installation while the accelerator is running. This is a severe limitation on the average experiment multiplicity. Additional staffing would diminish this inefficiency substantially.

C. Free-Electron Laser (FEL)

The Jefferson Lab Free-Electron Laser (FEL) Program developed from the laboratory's desire to exploit its unique core competency in superconducting radio-frequency (SRF) accelerator technology. SRF’s capability to produce electron beams with high beam quality and high average power—two essential characteristics of CEBAF accelerator beams—afforded the opportunity to design SRF-accelerator-driven FELs as high-average-power light sources. In 1991, the laboratory formed an Industrial Advisory Board with scientists selected from major industrial research laboratories to explore the potential opportunities and requirements for SRF-driven FELs as unique tools for advanced manufacturing based on the laser processing of materials. In 1993, the group of stakeholders for the FEL Program was enlarged with the formation of the Laser Processing Consortium, which included a group of SURA universities and the Naval Post Graduate School. Specifications were developed for the design and implementation of a kilowatt-level demonstration FEL, with output in both the infrared (IR) and ultraviolet (UV) wavelength domains. Because of the synergy between industry and the Navy, significant common specifications were developed. This commonality eventually led to the initial funding by the Navy of the Jefferson Lab FEL Program in FY 1996. A 1 kilowatt demonstration FEL is now under construction to produce infrared (IR) light: the IR Demo FEL (Figure V-4).

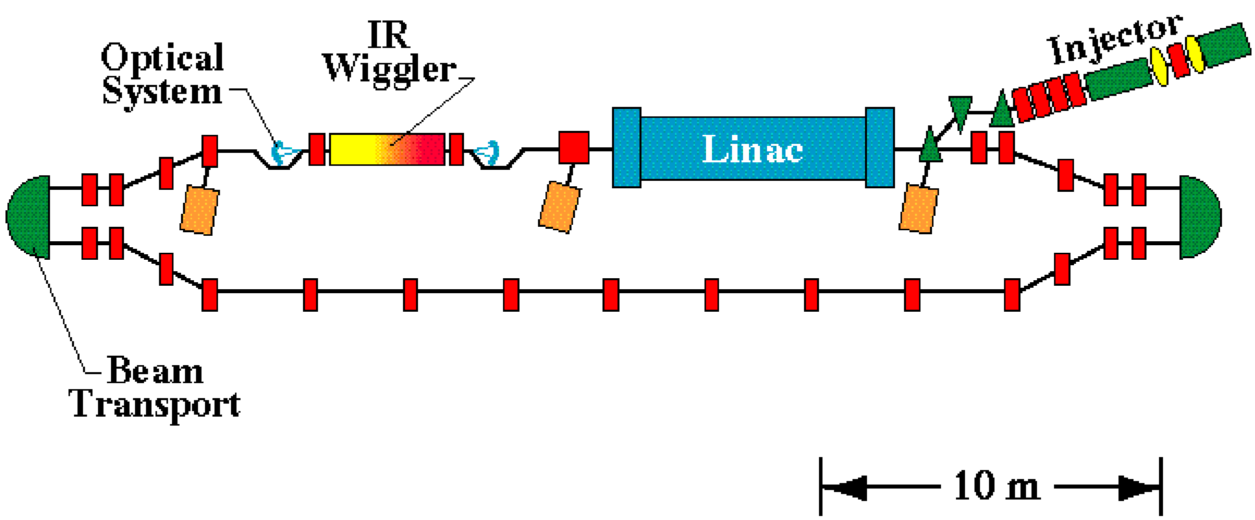


Figure V-4: The Jefferson Lab IR Demo FEL.

For the basic research community, SRF-driven FELs represent a natural extension in light-source technology that DOE has provided to the atomic physics, chemical physics, and materials science communities: a factor of more than 10^5 increase in source brightness (at 0.1% bandwidth) in the infrared and the ultraviolet compared to the present generation of synchrotron light sources. For the industrial community, the high average power of an SRF FEL, and the broadband tunability and short pulse length for efficient coupling to materials, represent important advantages over conventional lasers for materials processing applications. For both the industrial and defense communities, the possibility of extrapolating the FEL technology from the power level of the kilowatt IR Demo to much higher-power systems with lower net costs per unit of delivered power are significant design assets.

The first phase of the Jefferson Lab FEL Program began in June 1996 with the start of construction of the IR Demo FEL and the FEL User Facility on the CEBAF accelerator site. Construction is scheduled for completion in September 1997, followed by commissioning activities in the succeeding nine months. The IR Demo project was kicked off when $8.1M of FY 1996 Navy funding was made available to the laboratory, in addition to previous DOE support for the injector test stand ($5.5M) and Commonwealth of Virginia funding ($5M) of the user facility building and injector prototyping. Several industrial members of the Laser Processing Consortium provided additional support (approximately $3.0M) for design and engineering of the laser and the user facility.

Twice-annual Laser Processing Consortium workshops are held to provide the laboratory with guidance on the planning and implementation of the FEL Program and, specifically, for planning initial outfitting and use of the application laboratories in the user facility. In 1996, user working groups were formed within the consortium to focus on planning experiments in polymer processing, metal processing, microfabrication, and laser propagation. Lead institutions have been identified in each working group and have committed themselves to underwrite the costs of the required equipment for the respective laboratories. In February 1997, the DOE Basic Energy Sciences Program Office held a review of the Jefferson Lab FEL Program to examine potential basic research applications of the planned facility when it becomes operational in 1998. Many of the currently planned experiments can be viewed as process research or applied research. However, all of the identified industrial applications of the FEL bring with them basic research questions of interest to the scientific community. University members of the consortium have identified several of these research questions for the development of follow-up proposals to Basic Energy Sciences. These areas for prospective research include the fundamentals of short-pulse interactions with materials, the conditions for producing amorphous metals with laser-surface processing, the optimization of laser pulsed deposition, and enhanced polymer surface modification at specific infrared resonant wavelengths. There is also a clear potential for basic research with the FEL, with no current application in mind.

2. INFRASTRUCTURE

A. Human Resources

Laboratory Personnel

As of September 30, 1996, the staff of Jefferson Lab numbered 506 employees plus 16 Commonwealth of Virginia employees. Table V-5 shows full and part-time laboratory staff composition including FEL staff and Advanced Computation, Communications Research and Associated Activities staff, excluding commonwealth employees.

Table V-5
Laboratory Staff Composition
(As of September 30, 1996)

Occupations	Total #	Ph.D. # (%)	MS/MA # (%)	BS/BA # (%)	AS/AA # (%)	Other # (%)
Professional Staff						
Scientists	93	89 (95.7%)	1 (1.1%)	2 (2.2%)	0 (0.0%)	1 (1.1%)
Engineers	67	3 (4.5%)	19 (28.4%)	39 (58.2%)	2 (3.0%)	4 (6.0%)
Exempt Tech.	73	0 (0.0%)	4 (5.5%)	11 (15.1%)	9 (12.3%)	49 (67.1%)
Mgmt & Admin	45	6 (13.3%)	10 (22.2%)	19 (42.2%)	3 (6.7%)	7 (15.6%)
Computer Scientists	27	1 (3.7%)	8 (29.6%)	16 (59.3%)	1 (3.7%)	1 (3.7%)
Support Staff						
Technicians	121	0 (0.0%)	2 (1.7%)	26 (21.5%)	30 (24.8%)	63 (52.1%)
All Other	80	0 (0.0%)	0 (0.0%)	9 (11.3%)	12 (15.0%)	73 (73.8%)
Totals	**506**	**99 (19.6%)**	**44 (8.7%)**	**122 (24.1%)**	**57 (11.3%)**	**184 (36.4%)**

Since Jefferson Lab is a small laboratory with many one-of-a-kind positions, our greatest staffing challenge is recruiting and selecting individuals with highly specialized scientific, technical, and managerial skills required to manage, operate, use, and/or maintain state-of-the-art accelerator systems and experimental equipment. Section VI addresses an additional challenge: Jefferson Lab's impending need to compensate for user group understaffing. The laboratory maintains an international recruiting program utilizing professional conferences, collaborative working arrangements, scientific and technical journals, and university contacts as a means of identifying potential candidates for key positions.

The laboratory also has programs to train, update, and enhance the capabilities of existing staff. These programs include on-site courses; on-the-job training; attendance at professional conferences, workshops, skill-enhancement training, and specialized training; and tuition assistance for employees in job-related degree programs.

Affirmative Action and Equal Employment Opportunity

The Affirmative Action Profile (Tables V-6 and V-7) shows that Jefferson Lab staff increased by approximately 242% between the end of FY 1987 and the end of FY 1996. During this period, the total number of minorities on the Jefferson Lab staff increased by 459% from 17 to 95, and the number of female employees increased 180% from 41 to 115. During this period, there has been significant increase in staff diversity, particularly in job groups in which minorities and/or females were underutilized, such as scientists/engineers and technicians. The Affirmative Action Plan submitted annually to DOE in the first quarter of each fiscal year provides details.

Table V-6
Affirmative Action Profile
Full- and Part - Time Employees
(As of End of FY 1987)

Occupational Codes	Total=148		Minority Total=17		White		Black		Hispanic		Native American		Asian/Pacif. Islander	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Professional Staff														
Scientists/Engineers	51 (94%)	3 (6%)	7 (13%)	0 (0%)	44 (81%)	3 (6%)	0 (0%)	0 (0%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)	6 (11%)	0 (0%)
Mgmt & Admin.	31 (66%)	16 (34%)	0 (0%)	2 (4%)	31 (66%)	14 (30%)	0 (0%)	1 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (2%)
Support Staff														
Technicians	23 (85%)	4 (15%)	2 (7%)	0 (0%)	21 (7%)	4 (15%)	0 (0%)	0 (0%)	1 (4%)	0 (0%)	1 (4%)	0 (0%)	0 (0%)	0 (0%)
All Other	2 (10%)	18 (90%)	0 (0%)	6 (30%)	2 (10%)	12 (60%)	0 (0%)	3 (15%)	0 (0%)	1 (5%)	0 (0%)	1 (5%)	0 (0%)	1 (5%)
Totals	107 (72%)	41 (28%)	9 (6%)	8 (5%)	98 (66%)	33 (22%)	0 (0%)	4 (3%)	2 (1%)	1 (1%)	1 (1%)	1 (1%)	6 (4%)	2 (1%)

Table V-7
Affirmative Action Profile
Full- and Part-Time Employees
(As of End of FY 1996)

Occupational Codes	Total=506		Minority Total=95		White		Black		Hispanic		Native American		Asian/Pacif. Islander	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Professional Staff														
Scientists/Engineers	237 (91.2%)	23 (8.9%)	38 (14.6%)	5 (1.9%)	199 (76.5%)	18 (6.9%)	9 (3.5%)	2 (0.8%)	6 (2.3%)	1 (0.4%)	0 (0.0%)	0 (0.0%)	23 (8.9%)	3 (1.2%)
Mgmt & Admin.	23 (51.1%)	22 (48.9%)	2 (4.4%)	6 (13.3%)	21 (46.7%)	16 (35.6%)	2 (4.4%)	5 (11.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (2.2%)
Support Staff														
Technicians	104 (86.0%)	17 (14.0%)	18 (14.9%)	3 (2.5%)	86 (71.1%)	14 (11.6%)	10 (8.3%)	3 (2.5%)	4 (3.3%)	0 (0.0%)	2 (1.7%)	0 (0.0%)	2 (1.7%)	0 (0.0%)
All Other	27 (33.8%)	53 (66.3%)	6 (7.5%)	17 (21.3%)	21 (26.3%)	36 (45.0%)	6 (7.5%)	13 (16.3%)	0 (0.0%)	3 (3.8%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (1.3%)
Totals	391 (77.3%)	115 (22.7%)	64 (12.6%)	31 (6.1%)	327 (64.6%)	84 (16.6%)	27 (5.3%)	23 (4.5%)	10 (2.0%)	4 (0.8%)	2 (0.4%)	0 (0.0%)	25 (4.9%)	5 (1%)

B. Environment, Health, and Safety (EH&S)

EH&S Policies, Organization, and Management

Jefferson Lab utilizes line management to achieve environment, health, and safety (EH&S) goals and objectives. The Jefferson Lab director has the ultimate responsibility and authority for the development, oversight, and implementation of EH&S policies. Fundamental to the laboratory's EH&S program is the commitment that line management bears primary responsibility for EH&S issues in line managers' areas of operation. Consequently, the EH&S effort is accomplished programatically by line managers who have advisory input from EH&S staff distributed throughout the organization where their specific expertise is needed most.

Guidance for the accomplishment of EH&S policies is issued by the directorate to the line divisions of Jefferson Lab via the *Jefferson Lab EH&S Manual*. Each line division takes full responsibility for the EH&S aspects of its operations and activities, including self-assessments. EH&S staff resources are positioned within the divisions for optimum alignment with the operations. Institution-wide EH&S support, reporting, oversight activities, and internal appraisals are performed by the Office of Technical Performance, which is represented on the Director's Council by an Associate Director.

Jefferson Lab Work Smart Standards Process

SURA (the Southeastern Universities Research Association), in cooperation with DOE, has carried out the "Work Smart Standards" (WSS) process, formerly called the "Necessary and Sufficient" process, for more effective EH&S management of Jefferson Lab. The goal of the WSS process at Jefferson Lab was to enable an EH&S system that is both effective and cost-efficient. The WSS process was conducted between November 1995 and January 1996 in accordance with the DOE's guidance. It has identified the set of laws, regulations, and standards necessary and sufficient to ensure health and safety and to protect the environment.

As a follow-up to the WSS process, an EH&S Directives Review Team was chartered. This joint DOE Site Office/Jefferson Lab team was composed of scientists, engineers, technicians, administrators, and EH&S professionals. The team was charged with improving the overall EH&S program at Jefferson Lab by clearly defining requirements and expectations tailored to specific mission and site characteristics.

The team examined each of over 1500 EH&S requirements in 31 DOE EH&S and related (including quality assurance and conduct of operations) orders to recommend its inclusion or exclusion in the contract between the DOE and SURA. The team determined which requirements were clearly needed to be specifically included in the contract. The remaining requirements are either based in law or regulation (and thus already covered in other contractual references), are not applicable to work performed at the facility, or, on the basis of a net positive benefit assessment, could not be recommended for inclusion.

The team was selected in early 1997 for Vice President Albert Gore's Hammer Award as a part of the president's National Performance Review (NPR) initiative. The NPR's principles are: putting customers first, getting back to basics, and staff empowerment. The vice president expressed his appreciation to the team for "building a government that works better and costs less." The award was presented at a March 1997 awards program at Jefferson Lab.

EH&S Performance Measures

Environment, health, and safety are important dimensions of SURA's performance-based contract with DOE for managing and operating Jefferson Lab. Objective performance measures have been identified for evaluating Jefferson Lab's EH&S performance. The DOE/SURA performance-based contract has two key and eight secondary EH&S performance measures. The two primary measures are SURA injury avoidance performance as measured by the DOE Injury Cost Index and environmental exceedance performance. The secondary performance measures include reportable radiation exposures, reportable hazardous substance exposures, material recycling effectiveness, hazardous/radioactive waste generation, and fire protection program effectiveness. Emergency management and radiation protection peer reviews are conducted in alternating years to measure the effectiveness of these two programs.

EH&S Plans

Jefferson Lab's EH&S Management Plan considers the areas of industrial hygiene, radiation protection, environmental coordination, fire protection, emergency preparedness, industrial safety, occupational medicine, and internal appraisal. The current Jefferson Lab plan was submitted to the DOE in March 1997. Since the site is new, the EH&S Management Plan is dominated by the conduct, documentation, and continuous improvement of programs in the discipline areas listed. There are no significant cleanup or remediation needs. All required permits are in place.

Jefferson Lab's Environmental Protection Program Plan was revised in 1996, and includes the Laboratory's plans for environmental protection implementation, long-range environmental protection, groundwater protection management, the waste-minimization program, and pollution-prevention awareness. This comprehensive program is evidence of Jefferson Lab's commitment to the preservation, protection, and enhancement of our environment in all areas of operation. A Jefferson Lab Environmental Protection Implementation Plan (EPIP) has been provided annually since 1993 as a separate document. The EPIP provides summary descriptions of Jefferson Lab and DOE environmental roles. The EPIP emphasizes the implementation of sound environmental practices for Jefferson Lab operations.

Jefferson Lab has produced an annual Site Environmental Report (SER) since 1993. This SER document is prepared to provide to the DOE and to the public information on the level of radiological and non-radiological pollutants, if any, added to the environment as a result of Jefferson Lab activities. The SER also describes environmental initiatives, assessments, and programs for each year.

Jefferson Lab intends to submit an Integrated Safety Management System Plan, fully consistent with DOE P450.4. This Plan requires relatively minor changes in Jefferson Lab's EH&S Program. The Plan will provide a road map for ease in understanding the lab's EH&S Program.

Jefferson Lab Implementation Of 10 CFR 835

Jefferson Lab has implemented the DOE's radiation protection rule, 10 CFR Part 835, "Occupational Radiation Protection." Part 835 addresses worker safety in radiological activities. Jefferson Lab's Radiation Protection Program and 10 CFR 835 Implementation Plan provide a programmatic approach to both evaluation and implementation of the requirements of 10 CFR 835 for Jefferson Lab radiological activities. Both documents have received DOE approval.

Additional DOE worker radiation protection requirements were issued in DOE Notice 441.1 following the publication of 10 CFR Part 835. These radiation protection requirements have been implemented at Jefferson Lab using a graded approach.

C. Administrative Practices

The completion of Jefferson Lab construction and the beginning of our experimental program brought new challenges for our administrative infrastructure. This timing coincided with DOE initiatives to adopt quality management practices that empower and enable individuals, focus on high performance, and seek to achieve results in a cost-effective manner. We have increasingly leveraged our limited resources in support of the lab's vision and goals. This progress is documented by the fact that we have improved substantially our research-to-support ratio in the past three years (from 2.3 in 1995 to 2.7 in 1997) while maintaining our high level of excellence in the administrative and management support functions.

Performance-Based Contracting

Our contract with DOE has enabled our administrative infrastructure to move toward a true performance-based organization committed to clear objectives with measurable goals, focused on high customer service standards and satisfaction, and integrated with continuous system improvement. We have accordingly implemented systems that emphasize management flexibilities with adequate internal controls — the result of which has been improved performance at a reduced administrative cost. The framework within which our business and administrative functions are assessed is Section 6 of Appendix B of our contract. The evaluation process is based on a key performance measure (an annual peer review by a panel of chief-administrative-officer-equivalents from private industry, national labs, DOE, and the scientific community) along with a set of secondary measures. Our FY 1996 assessment resulted in a rating of 87.3 out of 100 points for an adjectival rating of *Excellent*. Table V-8 shows these results as well as the result of our FY 1997 peer review.

Table V-8
Peer Review Results

KEY MEASURE: PEER REVIEW	Available Points	Points Achieved	Adjectival Rating	Available Points	Points Achieved	Adjectival Rating
	FY96	FY96	FY96	FY97	FY97	FY97
Division Office (Associate Director, General Counsel, Internal Audit, Quality Assurance, Environment, Health & Safety)	10	9	Outstanding	10	9.5	Outstanding
Finance	10	7	Good	10	8	Excellent
Human Resources	10	7	Good	10	7.5	Good
Plant Engineering	10	8	Excellent	*20	18	Outstanding
Procurement	*20	18	Outstanding	10	9	Outstanding
Public Information	5	4	Excellent	3	3	Outstanding
Information Resource Management	Not Rev'd.			7	6	Excellent
Budget Program (Institutional Planning)	5	4.5	Outstanding	Not Rev'd.		
*Special Focus Area						
Total Peer Review	**70**	**57.5**	**Excellent**	**70**	**61**	**Excellent**
SECONDARY MEASURES	Available Points	Points Achieved	Adjectival Rating	Available Points	Points Achieved	Adjectival Rating
	FY96	FY96	FY96	FY97	FY97	FY97
Facilities Management	6	5.75	Outstanding	6		
Property Management & Protection	6	6	Outstanding	6		
Financial Management	6	6	Outstanding	6		
Procurement	6	6	Outstanding	6		
Human Resources & Services	6	6	Outstanding	6		
Total Secondary Measures	**30**	**29.8**	**Outstanding**	**30**		
TOTAL: SECTION 6	**100**	**87.3**	**Excellent**	**100**		

Improvement Initiatives

As summarized in the subsections below, we have conducted improvement initiatives in each of our administrative areas of procurement, finance, human resources and services, and plant engineering. Achievements have come through business process re-engineering, elimination of nonessential activities, and adoption of best business practices. Many of the initiatives were the brainchildren of quality improvement teams or groups representing not only the process owners but our customers and stakeholders (including DOE) as well.

In the procurement area, our cost to purchase goods and services compares favorably with that of other labs and with benchmarks set by the aerospace and construction industries. We have made substantial progress in adopting commercial procurement practices:

- Over 99% of the lab’s subcontracts are awarded on a fixed-price rather than a cost-reimbursement basis.
- We increased usage of purchase credit cards over 200% in a one-year period.
- We implemented just-in-time contracting for recurring purchases.
- Our consolidation and out-sourcing of copier/reproduction services resulted in a 45% reduction in the number of copiers on the site — and a 25% reduction in the number of copies made—while achieving consistently exceptional quality.

We have also focused on streamlining the way we handle procurements within the lab. The cycle time for simplified purchases has been cut by over 50% in a four-year period. Streamlined processes include:

- An automated requisition system that allows electronic input and transmission of purchase requisitions, and that includes electronic signature authorization.
- A paperless purchase order system that reduces the time of administrative tasks by over 40%.
- A decentralized micro-purchasing system that delegates purchase authority to specific procurement “customers” within the lab for more responsive purchasing actions and less bureaucracy.
- A representations and certifications process with over 50% reduction in paperwork as well as improved vendor response.
- Reduction from 23 days to six days in the average time to attain a Davis-Bacon determination.

For the past six years in the procurement area we have also exceeded our socio-economic goals for conducting business with small, small disadvantaged, and small woman-owned businesses. We received the Secretary of Energy's Small and Disadvantaged Business Subcontracting Award for FY 1990, FY 1991, FY 1992, FY 1994, and FY 1995.

Table V-9 summarizes subcontracting and procurement expenditures for FY 1996 through those projected for FY 1999. Table V-10 summarizes procurement business in FY 1996 and FY 1997 with small and disadvantaged companies.

Table V-9
Subcontracting and Procurement

($ in Millions -- Obligated)	FY 1996	FY 1997	FY 1998	FY 1999
Subcontracting and Procurement from:				
Universities	2.8	3.0	3.2	3.4
All Others	30.4	27.4	27.2	28.6
Transfers to Other DOE Facilities	0.1	0.2	0.2	0.1
Total External Subcontracting and Procurements	**33.3**	**30.6**	**30.6**	**32.1**

Table V-10
Small and Disadvantaged Business Procurement

($ in Millions -- B/A)	FY 1996	FY 1997
Procurement from S&DB	2.5	1.5
Percent of Annual Procurement	13%	11%

In finance, we implemented an electronic time reporting system that reduced total staff report preparation time at an estimated cost savings of $45K per year. We modified our fringe pool allocation methodology for reporting labor costs, thereby simplifying the budgeting process. In FY 1996, we took cash discounts in over 99% of our invoice payments, for savings totaling more than $65K.

In human resources and services, we made a variety of enhancements in the areas of staff relations, staff development, employment services, electronic resources, and staff services. Enhancements in staff relations included a streamlined performance appraisal process allowing for greater employee involvement through self-assessment, and a new user-friendly, informative employee handbook for employee orientation and reference. We enhanced labwide staff development by providing on-site or off-site access to training in Covey (7 Habits), leadership and teamwork, management, facilitation, conflict resolution, and service as a Baldrige examiner, as well as access to management focus group training and to Motorola University. In the area of employment services, we ran recruitment announcements in some 150 external sources at colleges and universities, in female and minority institutions and associations, at businesses, and at other labs. We also used Web-based advertisement of employment opportunities for increased international visibility and for decreased advertising costs. For term staff members ending their employment periods, we implemented a transition program that includes an internal job hotline, 24-hour job-search leaves of absence, résumé writing support and assistance, and job-search workshops. In FY 1996, our highly diverse student intern program was 46% female and 42% minority, with about 50% of all interns working in technical positions. In the area of electronic resources, increased patron access to these and to library services resulted in savings of about $15K per year. In staff services, we expanded the city-financed residence facility by 16 rooms and continued to achieve high guest satisfaction ratings. We out-sourced cafeteria and catering services, and increased sales by 23% through a campaign to increase customer patronage and satisfaction. We also implemented a user-friendly conference coordination policy and established procedures to streamline the process, to provide better controls for budget monitoring, and to achieve higher customer satisfaction.

In the area of plant engineering, we have devised a dynamic and highly effective outsourcing program, implemented an EH&S incentive program for construction subcontracts, streamlined work processes, and achieved a property loss rate of under one-half percent in our latest wall-to-wall inventory. The outsourcing program for major facilities and maintenance functions promotes active price and performance competition with effective quality inspection and control and with a high level of customer satisfaction. Functions outsourced include security, janitorial, refuse collection/disposal, pest control, materials management, meeting room setups and office moves, grounds maintenance, HVAC/mechanical maintenance, electrical (high and low voltage) maintenance, fire systems maintenance, pager service, controls systems maintenance, cooling water chemical treatment, plumbing, painting, and architect/engineering design. The EH&S incentive program provides monetary incentives to subcontractors for exemplary EH&S performance. It has been recognized by DOE in successive reviews for its effectiveness in improving subcontractor safety. In the effort to streamline processes, we have created a Web-based work-order system that provides data for statistical analysis by project managers and provides real-time customer feedback on job status and actions. We have also implemented use of bar-coded gauges, thereby reducing data input requirements, improving data accuracy, and making the steps in the process more timely.

In other administrative areas, we have:

- Developed a cost-effective management information system (MIS) that supports administrative processes and improvement initiatives. The system is based on central, sitewide, internally accessible information and data to support decision-making and daily operations. It includes information on lab population, buildings and building access, mailstops, telephones, property, purchases and deliveries, computer system access, material safety data sheets, training, lab conferences, library holdings, and staff publications.
- Reduced by over 50% in a one-year period the number of DOE reviews and appraisals and the number of reports and transaction approvals required by DOE. This effort was conducted in partnership with our DOE Site Office, and is described in more detail earlier in this chapter.
- Conducted general administrative surveys and individual function-specific surveys of customer satisfaction. These involved regular one-on-one interactions with customers to gauge effectiveness of services and to solicit suggestions for improvement and efficiency.
- Conducted benchmarking and comparison studies in three areas. In the areas of finance and procurement, we participated in national benchmarking studies that included government and private industry. In the area of plant engineering, we participated in the Logistics Management Institute survey to benchmark facilities support services. We also conducted comparison studies with other labs, government agencies, and private industry on staffing levels and ratios.

Future Improvement Goals and Initiatives

Our attention to high-value, cost-effective performance results — monitored through a strong self-assessment program — dictates that we proactively target improvement opportunities. The following are our major improvement goals:

- Renegotiate and reform contract Appendix A (the personnel appendix) to allow for prudent, cost-effective management of our compensation system.
- Expand use of commercial procurement practices. For example, we plan to increase use of just-in-time contracting (including Web-based ordering) to areas such as office supplies and personal computers, thereby eliminating our warehousing system, saving staff resources and warehouse space, and providing better service with less paperwork. We also will give continued attention to possibilities for increasing our outsourcing.
- Evaluate and implement more flexible time-reporting policies that have potential additional cost savings. Internal audit recommendations for such flexible policies estimate substantial savings.
- Implement a major upgrade to our financial information and reporting system, allowing for direct user access to appropriate financial data for responsible budget monitoring and reporting.
- Migrate all multi-user MIS applications to an intranet using Web technologies. We will continue to standardize the information environment for administrative data systems, including sitewide applications such as word processing, spreadsheets, databases, and calendar and scheduling functions.

D. Public Communications And Trust

Through a variety of means including a comprehensive but low-resource-demand public information program, Jefferson Lab actively seeks to maintain constructive, effective communication and trust with the public. In particular, the lab enjoys a high level of mutual trust with the city of Newport News. This relationship is quite important. Since well before CEBAF construction began in 1987, the city has been farsighted about the lab's significance in economic diversification and in other areas of civic life, and has therefore striven to support the lab and to advance its prospects. The most obvious examples of this support have been the city's funding for some of the land the lab is sited on, for the residence facility where visiting user-scientists stay, and for the Applied Research Center mentioned earlier and described in more detail later in this chapter. To maintain and cultivate this mutually beneficial relationship, Jefferson Lab personnel serve on important city committees in such diverse areas as economic development, building design, education, and transportation. Both the lab and the city value the overall relationship and have high hopes for it in the future.

This partnership also extends to police and fire protection. The city and Jefferson Lab host joint emergency drills to ensure the city can respond to our unique circumstances. Tours are conducted regularly to keep city personnel well acquainted with the site as it evolves. In 1997 this coordination effort has been extended to include a visit by key Jefferson Lab staff to the city's 911 Emergency Response Center to sharpen our and their preparedness to coordinate smoothly and quickly in the event of an actual emergency.

Jefferson Lab has used a variety of methods to maintain constructive, effective communication with the community. Lab personnel regularly visit local civic and social organizations as guest speakers on topics relating to the lab. The Jefferson Lab Science Series, now in its sixth year, is advertised in the local newspaper and draws over 200 students, teachers, and parents each month for exposure to scientists and engineers who are good at presenting science and engineering in interesting ways. This series is videotaped by the local school system and is re-broadcast four times daily on the city's cable channel. Lab personnel visit local elementary school systems as guest speakers on high-technology jobs and careers. The yearly Jefferson Lab Open House typically brings 6000 guests to the lab on a Saturday to visit us and to understand our mission. On the state level, Jefferson Lab expands its outreach by participating in the Virginia State Fair, where 200,000 people visit the lab's display booth each year and are treated to hands-on activities and cryogenics demonstrations over an 11-day period.

Also at the state level, Jefferson Lab participates in regional technology transfer committees sponsored by the governor, and in partnerships such as the Virginia Physics Consortium, a statewide consortium of physics Ph.D.-granting institutions. This participation has led to a reputation of responsible stewardship of the funds allocated by the state to the lab. Because of this reputation, the state is now funding four local universities to conduct research in the Applied Research Center, and is also providing lease money for the laboratory space the researchers will use there. In addition to their contribution to the Applied Research Center, state and local governments have contributed over $37 million to Jefferson Lab in direct appropriations over the past ten years.

Similarly, a good relationship is in place with the local print and broadcast media. Reporters and our public information staff know and respect each other, and the reporters routinely ask for information that can be used to generate news stories. This extends to the state level as well, and in 1997 the national press has also played an increasing role in helping Jefferson Lab educate the public about the importance of fundamental research. Honest communication and high-quality, specialized media kits are the key to each level of the lab's media effort, targeting particular media audiences. The lab also cultivates its relationship with the media by arranging for direct contact with lab and user subject-matter experts—the scientists and others who have the actual first-hand technical knowledge and who are sensitive to the difficulties of communicating about it to a wide audience.

The Jefferson Lab Public Information Office received high marks in its Appendix B–based peer reviews (Table V-8). Its activities were deemed commendable considering the small size of the staff.

E. Education

In addition to its natural role in undergraduate and graduate education as a national accelerator laboratory in support of university research, Jefferson Lab has taken on two special roles in its community: partnerships with Historically Black Colleges and Universities (HBCUs) and Minority Educational Institutions (MEIs), and community outreach to area public schools and citizens.

Historically Black Colleges and Universities and Minority Educational Institutions

The Jefferson Lab initiative to make HBCUs and MEIs a vital part of its university-based research community, and thereby to foster the education in science and technology of the next generation of minority students, has been based on two types of partnerships with various universities. Under joint-faculty arrangements, new faculty are appointed to local university positions on a permanent cost-shared basis with Jefferson Lab. Jefferson Lab agrees, in these cases, to reimburse the university for one-half of the salary and benefits of a faculty member. In return, the university agrees to release that faculty member to spend half time doing research at Jefferson Lab. In a second type of arrangement, Jefferson Lab pays a fraction of the salary and benefits of a new faculty member for a fixed short term (a "bridging" period). In return, the university releases this faculty member on a pro rata basis to devote time to Jefferson Lab programmatic activities (including equipment building, software development, and research) and to agrees take over full responsibility for this faculty member upon the expiration of the "bridge."

Partnerships with local HBCUs were struck in 1989 with Hampton University (an HBCU in Hampton, about 20 minutes by car from Jefferson Lab), and in 1992 with Norfolk State University (an HBCU in Norfolk, about 40 minutes from Jefferson Lab). Hampton University has added five new faculty to its physics department, while Norfolk State University has added three faculty and intends to add two more. These faculty are all being hired on a long-term cost-shared basis.

In addition to these local partnerships, Jefferson Lab has made bridging arrangements with other nonlocal HBCUs and MEIs. Current partners include Florida International University, North Carolina Agricultural and Technical State University, North Carolina Central University, and New Mexico State University and its sister institution, the University of Texas at El Paso.

By any reasonable measure, these partnerships are immensely successful. Undoubtedly the best example is the oldest: Hampton University. Under the MOU signed in 1989, the Hampton University Department of Physics has grown from a small department with a master's degree program and a few students into a major international player in quark and nuclear physics. With the support of the laboratory, the Hampton University group working at Jefferson Lab received in 1991 a $5M grant from the National Science Foundation. Based on their outstanding performance, this grant was renewed in 1996 for a second five years. In 1992, Hampton University was certified to grant doctoral degrees in physics, making it one of only three such HBCUs in the country. The university’s experimentalists are leaders on research proposals that have been awarded one-third of the beam time in CEBAF Hall C, where they focused their program. Hampton faculty are actually the spokespersons for ten approved and conditionally approved experiments. In the fall of 1996, Hampton University became the first HBCU ever to lead a major experiment at a national accelerator laboratory. The Hampton University Department of Physics has become a major center for education of the next generation of minority scientists and engineers. In 1997, the department has an enrollment of 17 undergraduates and 45 M.S./Ph.D. students. Nine of the 45 M.S./Ph.D. students are expected to complete their Ph.D. thesis work by August of 1997. Two of these nine students are currently finalizing their thesis work on the experiment mentioned above conducted in the fall of 1996.

Such transformations do not, of course, occur overnight: five to ten years, as with Hampton University, are required to create the appropriate environment. However, Jefferson Lab has every reason to believe that with its continued support, its other partners will enjoy comparable success both scientifically and in the training of the next generation of minority scientists and engineers.

Community Outreach

In partnership with the local school divisions and the surrounding community, Jefferson Lab is dedicated to:

- motivating students to continue learning, and
- explaining math and science to students, teachers, parents, and the general public.

Jefferson Lab's resources to achieving these goals are the staff scientists and engineers themselves. During FY 1997, about 8000 students and 750 teachers will interact with Jefferson Lab staff who share their knowledge, experience, and enthusiasm. In FY 1996, 34% of the staff volunteered to support these programs.

The BEAMS—Becoming Enthusiastic About Math and Science—week-long program is a vehicle to bring classes of fifth- and sixth-grade students with their teachers to Jefferson Lab for:

- formal interaction with Jefferson Lab staff via science and math interactive activities,
- casual interaction with staff and leadership, and
- ongoing education with the classroom teacher.

Metrics have been developed to assess the impact of this unique experience. Short-term, anecdotal data gathered from teachers, parents, administrators, and students have been quite positive. These results sparked the "BEAMS at Siemens" program, a replica of Jefferson Lab's BEAMS program at Siemens, Inc., in Newport News. Siemens plans to host four classes of BEAMS students each year. More formal metrics require an ongoing interaction between the lab, students, and the school administration. A natural step to achieving such continuity is providing the lab's resources to students throughout middle school (grades 6–8), which will facilitate the evaluation process by providing anecdotal information over a three-year period.

Other community-based partnerships include:

- the monthly Jefferson Lab Science Series showcasing diverse scientific fields and topics,
- Cooperating Hampton Roads Organizations for Minorities in Engineering (CHROME), which sponsors school-based science and math clubs throughout southeast Virginia,
- summer research internships for high school students, and
- the inclusion of precollege teachers in Jefferson Lab's technical and scientific activities so they can experience applications of math and science in a high-technology workplace.

F. Technology Transfer

The Jefferson Lab Technology Transfer Program emphasizes technology development and transfer activities built upon core competencies derived from our basic research mission: superconducting radio-frequency (SRF) technology and detector technology. Opportunities for commercialization of Jefferson Lab's federally funded research efforts will be enhanced by leveraging our core technologies in collaboration with industry, educational institutions, and other federal agencies.

Jefferson Lab's major technology transfer effort is in its role as the lead institution in the Laser Processing Consortium (LPC), our key link to industry. The LPC was established by Jefferson Lab's Industrial Advisory Board to develop and apply free-electron laser (FEL) technology. The FEL Program and the LPC are described in section V.1.C. This consortium meets twice yearly to provide guidance on the planning and implementation of the FEL Program and to plan initial outfitting and use of the FEL User Facility application laboratories. As pointed out in Chapter VI, LPC members' matching funds and in-kind contributions for FEL Program activities total $14M.

A second area of concentration for Jefferson Lab's technology transfer, medical imaging, derives from the laboratory's core competency in detector technology. In a milestone achievement in 1996, Jefferson Lab negotiated a Cooperative Research and Development Agreement (CRADA) and awarded a license to a small business partner to jointly further the development of a scintimammography medical imaging device. This device, which is based on six Jefferson Lab patents and additional pending patents, has the potential for significant improvements in breast cancer detection work. This work is being conducted jointly with the University of Virginia Medical School and Johns Hopkins University Medical School, and has won the recognition of the Women's Health Office of the Department of Health and Human Services.

Another key partnership is the lab's relationship with the city of Newport News. From the lab's start in the 1980s, it has always received the city's generous and farsighted support. With the realization that Jefferson Lab and its technology transfer development program could lead to increased economic development, the city is now building a high profile, seven-story building, the Applied Research Center or ARC, that will house lab personnel, four local university R&D efforts, and key industry partners. This building is a $14.4 million investment the city is using to jump-start a new 200 acre high-technology business park, the Jefferson Center for Research and Technology, adjacent to the Jefferson Lab campus. Jefferson Lab personnel have actively participated in the design and development of both the park and the ARC building, and the city counts on this support for continuing efforts to strengthen and diversify the local economy.

Intellectual property management is a significant element of the Jefferson Lab Technology Transfer Program. In 1996, SURA contributed in excess of $50,000 to the lab's patent processing programs and has planned an additional $50,000 in 1997 corporate funding, which is used by the Laboratory Invention and Patent Review Committee to fund patent reviews, applications and various other related actions. In addition, SURA established an oversight board which periodically reviews the committee's authorizations and activities. Jefferson Lab has processed 47 patents to date, has received 8 patents, issued 3 licenses (1 in 1997), and currently has 19 patent applications under active consideration. We expect at least five new patents in 1997. Modest royalty income from these activities should materialize in 1997.

G. Site Facilities And Description

Site Description

The Jefferson Lab site, located in Newport News, Virginia (Figure V-5), includes 162 acres owned by the DOE and 8 acres owned by the Commonwealth of Virginia. SURA owns 44 acres adjacent to the site. The facilities include the accelerator complex serving three experimental halls, a central office building (CEBAF Center), two major laboratory buildings, and various other support structures. The replacement value of conventional facilities and utilities is $165 million.

The accelerator enclosure is a 7/8-mile racetrack-shaped concrete tunnel, 25 feet underground. The tunnel houses a 45 MeV injector, two 400 MeV linacs — one in each straight section of the racetrack — and 6 kilometers of beam transport lines. The Central Helium Liquifier (CHL), a 75,000 liter, 4800 watt refrigerator plant located in the interior of the racetrack, supplies liquid helium at 2 K to the accelerator for the ultracold needed for superconducting operation. The Machine Control Center (MCC) houses the computer systems that control and monitor accelerator operations.

The experiment area consists of three large domed concrete halls, partially underground and mounded with earth for shielding. The floors are about 36 feet below existing grade, and the domes extend up to 45 feet above grade. Hall C is 150 feet in diameter, Hall A 174 feet, and Hall B 98 feet. The major support building for the experimental physics area is the Counting House, where physicists control and monitor the experimental runs. Some 35 support structures in the accelerator/experimental area complement these major structures.

Major structures on the remainder of the site provide administrative, laboratory, and technical support facilities. CEBAF Center provides office space, an auditorium, and a cafeteria, and houses the computer center. The Experimental Equipment Laboratory (EEL) provides light laboratory space for detector fabrication and machine shops. The Test Lab is a high-bay building housing major component assembly, test, and maintenance functions.

The city of Newport News is presently constructing an Applied Research Center (ARC) on a site directly adjacent to the Laboratory. The 121,000 SF structure, slated for completion in the fall of 1997, will provide office and light laboratory space for lease to qualified tenants. Jefferson Lab has leased 35,000 SF. Several collaborating universities have also reserved space. The ARC will be the anchor for the 200 acre Jefferson Center for Research and Technology, a technology park for high-technology R&D and production activities.

Tables V-11 and V-12 and Figures V-6, V-7, and V-8 provide additional data about facilities on the site.

Site Development and Major Facility Maintenance

Site development continues to be guided by the area themes identified by Jefferson Lab's Site Development Plan, written in 1988 and last revised in 1993. An important principle of this plan is to co-locate compatible functions and to reserve the maximum amount of space near the accelerator site for future additional end stations or technical facilities benefiting from proximity.

With the completion of the CEBAF project in 1995, Jefferson Lab entered a period of projected slower site development. Currently funded civil construction is limited to the Free-Electron Laser (FEL) User Facility, which was funded by the Commonwealth of Virginia. This structure is under construction with completion scheduled for the fall of 1997. Development of the IR Demo FEL is also underway, with support systems installation progressing concurrently with civil construction activities on the user facility. In support of the FEL Program, a 10,000 SF Accelerator Technical Support Building (ATSB) was constructed in FY 1996 with FEL funding.

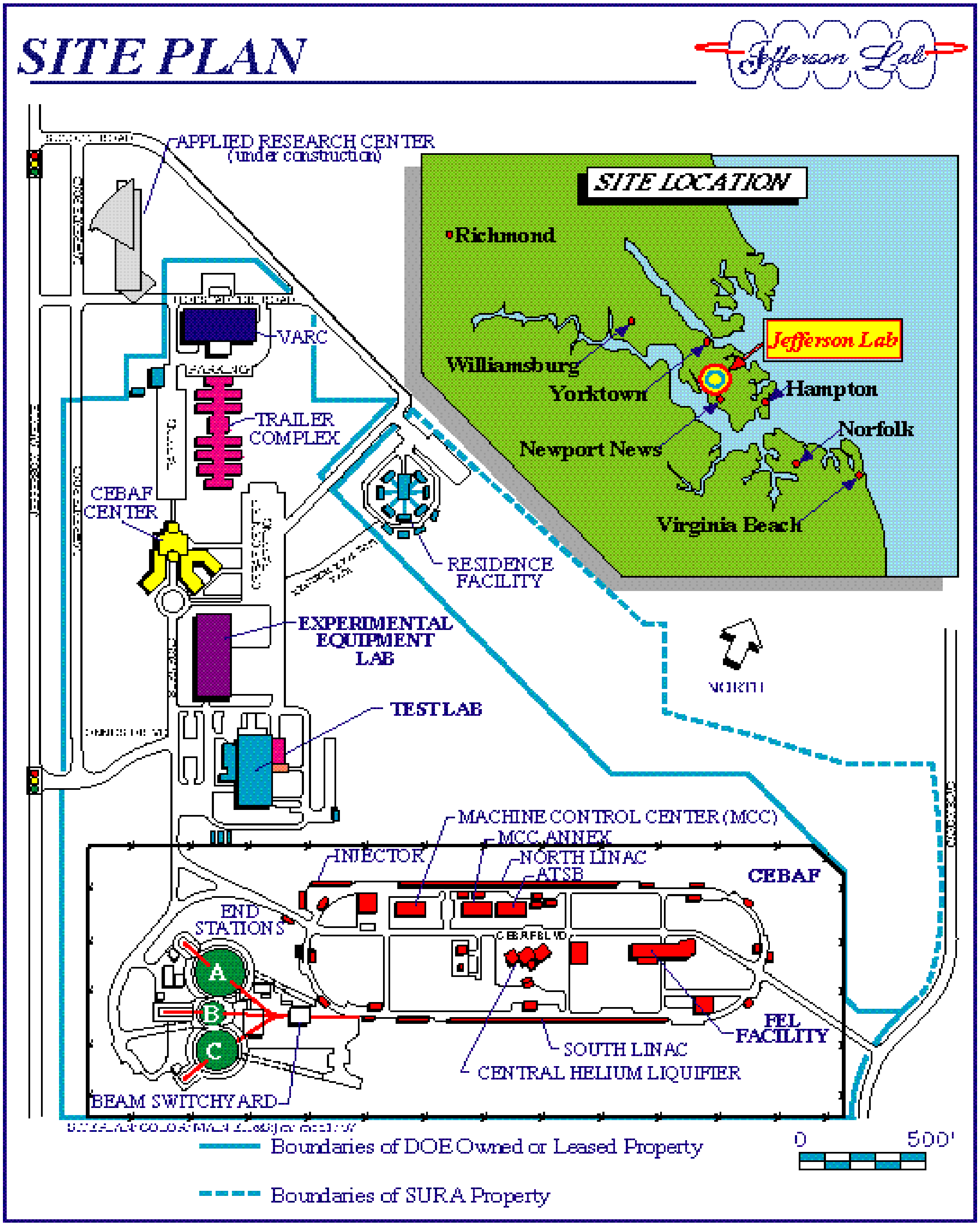


Figure V-5 Jefferson Lab Site

Table V-11
Laboratory Space Distribution

Location	Area (Sq. Ft.)
Main Site	545,379
Leased -Off Site	17,200
	562,579

Table V-12
Facilities Replacement Value (FY97 M$)

Facility Type	Replacement Value
Buildings	140
Utilities/Roadways	25
Accelerator Technical Syst	270
Experimental Equipment Fa	160
TOTAL	595

Figure V-6
Age of Laboratory Buildings (Years)

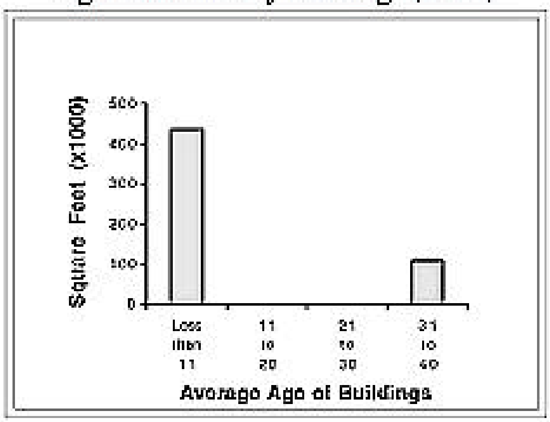


Figure V-7
Conditions of Laboratory Space

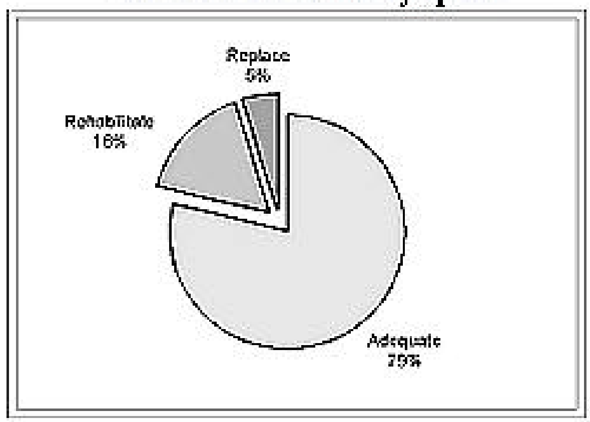
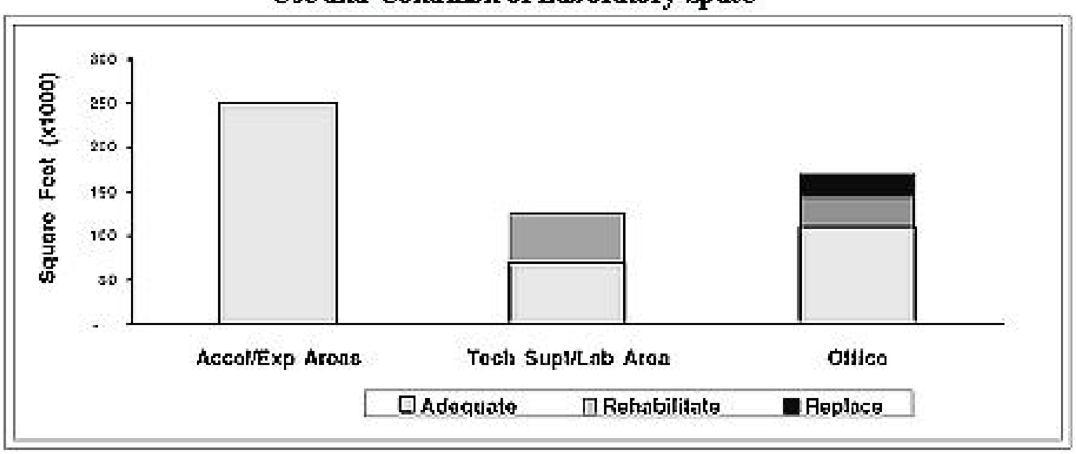


Figure V-8
Use and Condition of Laboratory Space



The most immediate site development needs at Jefferson Lab are to provide adequate office space for the growing population of scientific users now on site, and to provide technical, staging, and storage facilities to support experiments and operations. The lab has very limited facilities of this type, and their absence has already begun to hamper laboratory productivity and user support. Relocation of staff to the ARC will enable suitable office/work space to be provided to the majority of the visiting scientific users and remediate that immediate concern. Among the remaining critical needs, the most urgent is a 15,000 GSF staging/storage building close to the endstations. Furthermore, roads and parking areas in the accelerator site must be completed, and a variety of aging cooling towers, chillers, and boilers await upgrades or replacement to ensure reliability and energy efficiency.

The current major maintenance/improvement backlog indicates that an average $1M annual expenditure will be required to keep the lab's conventional facilities sound and capable of supporting operational requirements. This amount is slightly less than 1% of the value of existing conventional facilities.

VI. RESOURCE PROJECTIONS

Table VI-1 reflects actual, projected, and requirements funding from the Office of Energy Research in FY 1996 through FY 2000 for nuclear physics at Jefferson Lab. We show funding separately for operating, general-use capital equipment, experimental equipment modifications and upgrades, and GPP/AIP (General Plant Project/Accelerator Improvement Program). Priorities emerging in each fiscal year are likely to dictate some variation in the allocation from that projected in the table to optimize mission productivity. In addition to the FEL state funding which appears in the table, the Commonwealth of Virginia provides annual funding of $560K for Jefferson Lab.

The table raises two important issues with regard to the funding of DOE-supported user groups carrying out experiments at Jefferson Lab. First, our budget estimates for experimental equipment are based on the assumption that the users would be funded directly for their contribution to such apparatus. We have been asked recently to assume responsibility for managing this funding directly; we estimate that this would cost at least an additional $2M per year. Second, the current level of staffing (Table VI-2) at the laboratory was established by DOE based on NSAC guidance that assumed strong funding of Jefferson Lab user groups so that they could provide on-site effort for installation and operation of their experiments and for maintenance of equipment they built. Most of our user groups do not receive sufficient funding to provide this assumed and very necessary support function. This situation must be rectified, or long-term operational reliability and our ability to continue to mount important new physics experiments will suffer.

Table VI-1
Laboratory Funding and Performance Summary

(AY$ in Millions - BA)	FY96 (Actual)	FY97 (Actual)	FY98 (President's Budget)	FY99 (Guidance)	FY2000 (Requirements for Effective Ops)
WEEKS OF PHYSICS OPERATION	28	28	28	30	40
EXPERIMENT MULTIPLICITY	N/A	1.3	2.0	2.0	2.5
Office of Energy Research					
Operating	58.4	60.3	60.5	63.5	68.3
Capital Equipment	1.7	2.3	2.3	2.2	2.9
Experimental Equipment	6.5	3.7	3.7	4.0	4.5
GPP/AIP	0.7	2.0	0.9	0.9	2.8
TOTAL PROGRAM FUNDING	67.3	68.3	67.4	70.6*	78.5
FEL					
DOD	8.1	†			
State	5.0				
DOE			‡	‡	

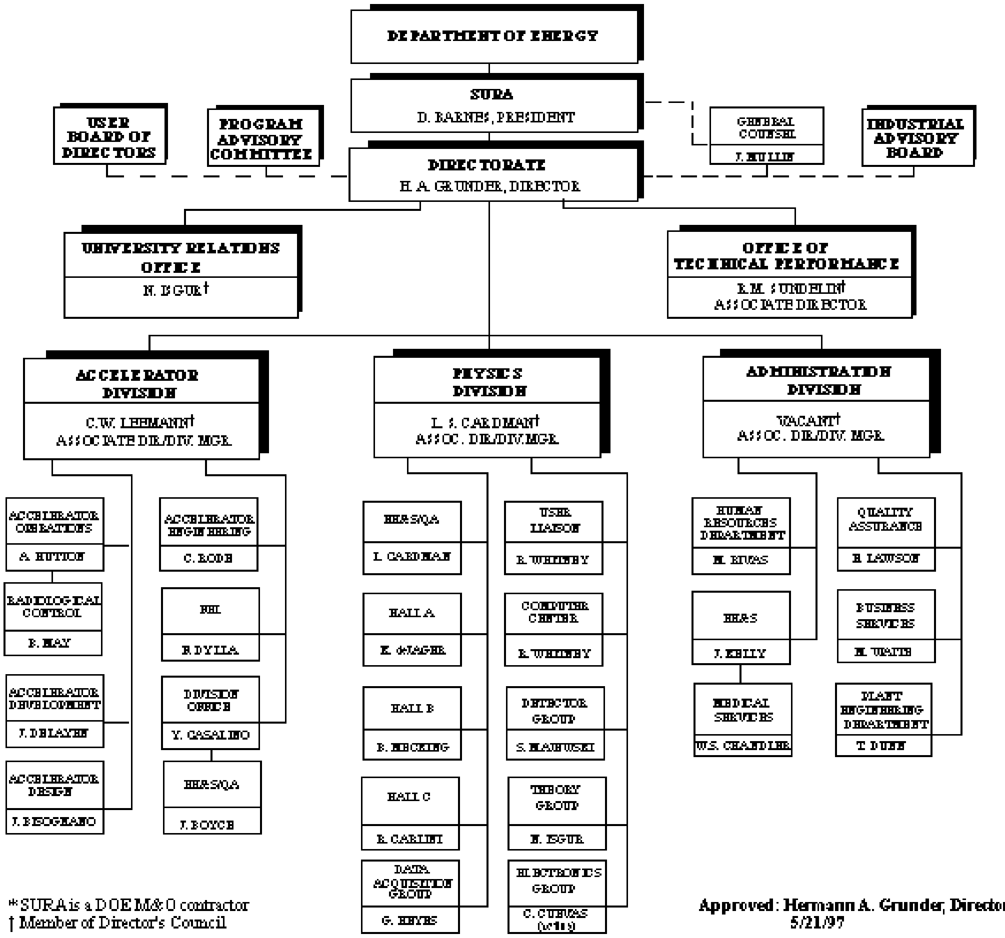
*The FY 1999 Guidance does not include $500K in new funding to university groups for fabrication, installation, and maintenance of key elements currently the responsibility of Jefferson Lab.
†FY 1997 FEL funds have been appropriated but not yet allocated by the Department of Navy.
‡A Field Work Proposal (FWP) for the FEL User Facility has been submitted to DOE requesting $2.5M of Basic Energy Science (BES) funding in FY 1998 and FY 1999.

Table VI-2
Laboratory Manpower Summary (Average)

	FY96	FY97	FY98	FY99	FY2000
Total Projected Staffing	534	477	470	470	485
Others On Site					
Physics Users	80	110	130	150	150
Students	60	80	80	100	120
DOE	9	8	8	8	8
Subtotal	149	198	218	258	278
TOTAL SITE POPULATION	683	675	688	728	763

The IR Demo FEL development was funded in FY 1996 for $13.1M by the U.S. Navy and the Commonwealth of Virginia. Matching funds and in-kind contributions totaling $14M additional to implement the industrial processing labs have been pledged by members of the Laser Processing Consortium. The city of Newport News is presently constructing an Applied Research Center (ARC) at a cost of $14.4M. The 121,000 SF structure is being built on a site directly adjacent to the laboratory and will provide office and light laboratory space.

SURA*/JEFFERSON LAB ORGANIZATION



*SURA is a DOE M&O contractor
† Member of Director's Council

Approved: Hermann A. Grunder, Director
5/21/97

APPENDIX

GLOSSARY OF JEFFERSON LAB ACRONYMS

AIP	Accelerator Improvement Project
ALARA	As Low As Reasonably Achievable
APT	Accelerator Production of Tritium
ARC	Applied Research Center
BEAMS	Becoming Enthusiastic About Math and Science
CHL	Central Helium Liquifier
CHROME	Cooperating Hampton Roads Organizations for Minorities in Engineering
CLAS	CEBAF Large Acceptance Spectrometer (Hall B)
CODA	CEBAF Data Acquisition Software
CRADA	Cooperative Research and Development Agreement
CUE	Common Unix Environment
EH&S	environment, health, and safety
EEL	Experimental Equipment Lab
EPIP	Environmental Protection Implementation Plan
ESnet	Energy Science Network
FEL	free-electron laser
FTE	full-time equivalent (equivalent to one full-time employee)
FY	fiscal year
GPP	General Plant Project
GSF	gross square feet
HBCU	Historically Black College or University
HMS	High Momentum Spectrometer (Hall C)
HRS	High Resolution Spectrometer (Hall A)
IR	infrared
JOBS	Jefferson Lab Off-line Batch System
LPC	Laser Processing Consortium
MCC	Machine Control Center
NSAC	Nuclear Science Advisory Committee
NSF	National Science Foundation
PAC	Program Advisory Committee
rf	radio frequency
SER	Site Environmental Report
SOS	Short Orbit Spectrometer (Hall C)
SRF	superconducting radio-frequency
SURA	Southeastern Universities Research Association
UV	ultraviolet