Project Execution Plan

for FY2025 to FY2029

Nuclear Physics Lattice QCD Computing Program

at the

Thomas Jefferson National Accelerator Facility
Newport News, Virginia

For the U.S. Department of Energy
Office of Science
Office of Nuclear Physics

April 8, 2024

1. INTRODUCTION

This Project Execution Plan (PEP) describes the technical scope, schedule, cost, management organization, and control processes for the Nuclear Physics (NP) Lattice Quantum Chromo Dynamics (LQCD) Computing program at the Thomas Jefferson National Accelerator Facility (JLab). The goal of this program is to deploy and operate a significant dedicated computing and storage resource for Lattice QCD calculations at JLab. This resource will play an important role in expanding our understanding of the fundamental forces of nature and the basic building blocks of matter.

The computing hardware will be housed at JLab and will be available to lattice gauge theorists at national laboratories and universities throughout the United States. The program is proposed to start in FY25 and run through the end of FY29. The program includes two hardware procurements and five years of operations. The total program cost of $7.6M ($1.52M/year) includes hardware, effort and training as listed in table 1 with a detailed breakdown of cost in section 3.5 table 4.

FY	Compute	Storage	Effort	Training	TOTAL	Status
25	0.60	0.40	0.50	0.02	1.52	Storage Deployment
26	*0.60* + 0.92	-	0.58	0.02	1.52	Compute Purchase Order Issued
27	0.57	0.40	0.53	0.02	1.52	Storage + Compute Deployment
28	*0.57* + 0.95	-	0.62	0.02	1.52	Compute Purchase Order Issued
29	0.94	-	0.56	0.02	1.52	Compute Deployment
	7.6					

Table 1 – Funding profile for the program lifetime. Compute hardware funds are carried over (*in italics*) from one year to the next for a major acquisition every other year. FY26 and 28 effort includes acquisition planning costs. All labor estimates have been inflated using escalation rates of 3% per year. All numbers in millions of $'s.

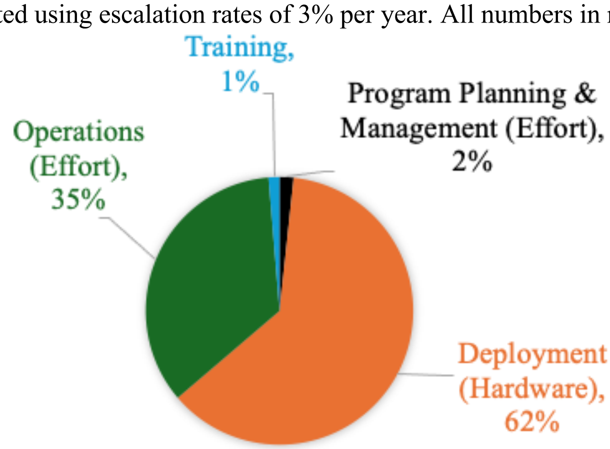

Figure 1 – Distribution of $'s across the various funding categories for the program lifetime.

The major performance goals, also elaborated in section 4, for the program are:

- to deploy new resources capable of an aggregate of at least 517 TFlops. As a point of comparison, this would imply an aggregate Linpack performance across the two new systems of close to 0.9 PFlops.

- to operate existing and future resources to deliver, over 5 years, at least 3,560 TFlop-years of integrated performance.

Over the past two decades members of the USQCD collaboration have worked together to plan the computational infrastructure needed for the study of QCD. With support from the Department of Energy (DOE) Offices of High Energy Physics (HEP) and Nuclear Physics (NP) commodity hardware has been deployed and the software needed to exploit them has been developed.

Historically, by simplifying features of Lattice QCD calculations, it has been possible to build computers for this field that have significantly better price/performance than typical high-end supercomputers or even high-end clusters. The guiding principle has been to purchase hardware that best advances the science and complements the portfolio of existing resources across all three sites. To support the selection of hardware, software research and development on specialized systems and commercial computers has been done under the lattice gauge theory SciDAC grant as well as under the Exascale Computing Project. Further ongoing development of software and algorithms under the SciDAC-5 grant will provide additional support for this program.

In the remainder of this Project Execution Plan (PEP) the relevance of the program to the DOE mission is described, and the program's technical scope, management organization, schedule, cost scope, and change control are set out.

2. MISSION NEED

This NP LQCD computing program directly supports the mission of the DOE's Nuclear Physics Program "to foster fundamental research in nuclear physics that will provide new insights and advance our knowledge on the nature of matter and energy...". The program also supports the Scientific Strategic Goal within the DOE Strategic Plan to "Provide world-class scientific research capacity needed to: advance the frontiers of knowledge in physical sciences...[and] provide world-class research facilities for the Nation's science enterprise."

Quantum Chromodynamics (QCD) is the fundamental theory of quarks and gluons that has far-reaching implications for understanding hadrons, nuclei, and other aspects of matter. The long-range interactions of QCD are essential for describing these phenomena, and the phenomenon of color confinement ensures that strongly interacting particles are detected as hadrons. This makes hadrons useful for experiments, where they are often used as beams or targets. Because of the importance of QCD, it is necessary to have a deep understanding of the theory at nonperturbative scales. Numerical lattice gauge theory is the only comprehensive, quantitative method for investigating nonperturbative QCD from first principles.

The purpose of these simulations is to attain a deep understanding of the physical phenomena that are encompassed by QCD. Additionally, these simulations aim to make precise calculations of the theory's predictions and test the validity of the Standard Model. Lattice simulations are indispensable for solving fundamental problems in high-energy and nuclear physics, which are central to the DOE's extensive experimental endeavors in these fields.

Major goals of the experimental programs in high energy and nuclear physics on which Lattice QCD simulations will have an important impact are to: 1) discover the limits of the Standard Model, 2) answer basic questions about the structure of matter, including the masses and excitations of hadrons and nuclei, 3) understand the fundamental symmetries of nature and their violations, 4) determine the properties of strongly interacting matter under extreme conditions, such as those that existed immediately after the "big bang" and are produced today in relativistic heavy ion experiments. Lattice QCD calculations are essential to the research in all these areas.

3. FUNCTIONAL REQUIREMENTS

3.1.Computational Requirements

Lattice QCD calculations depend on two key classes of computing. In the first class, a simulation of the QCD vacuum is carried out, and a time series of configurations, which are representative samples of the vacuum, are generated and archived. Multiple ensembles with varying lattice spacing and quark masses are generated, and sets of ensembles are generated using several different numerical approaches. This class of computing requires machines capable of sustaining hundreds of TFlops to PFlops for days or weeks at a time.

The second class of calculations, the analysis phase, use thousands of archived configurations from each ensemble to calculate quantities of physical interest. A wide variety of different quantities can be calculated from each ensemble. These analysis computations also require large floating-point capabilities; however, the calculations performed on individual configurations are independent of each other. Thus, analysis computing can rely on multiple machines or partitions each capable of sustaining 1% of the performance of the largest jobs (i.e. hundreds of GFlops to a few TFlops), with a total aggregate computing capacity of tens to hundreds of TFlops.

In summary, to meet the requirements of 517 TFlops, it is sufficient to have (for example) of order 100 machine partitions, each with of order 5,170 GFlops performance. It is the purpose of this program to address this second class of jobs, with typical jobs using 1-8 nodes within a medium size cluster.

3.2.I/O and Data Storage Requirements

During vacuum configuration generation, data files specifying each representative configuration must be written to storage. These files are of order of 10 to 100 GB in size. A full ensemble may involve a 1,000 to 10,000 of these configurations. During the analysis stage, propagation of quarks must be calculated on each configuration. This requires the numerical solution of large sparse linear systems of equations – the Dirac equation – with multiple right-hand-sides, on order of 100k. The resulting "propagators" are combined to compute Euclidean correlation functions. These functions are represented as graphs involving thousands of vertices corresponding to fundamental particles and edges corresponding to the propagators. Because of the large computational resources needed to generate the propagators, they are often written to external storage for later reuse. Because many independent analysis streams can run on a given Lattice QCD machine, substantial aggregate I/O rates (GB/sec) are required during the loading of configurations and the storage of results to achieve the target computational requirement of 517 TFlops. The current JLab system has the needed bandwidth, and anticipated replacements should provide a modest amount of additional headroom.

3.3.Network Requirements

Configuration files will be generated at supercomputing centers and transferred to JLab. This represents a very modest network bandwidth requirement, less than 1 Gbit/s on average today, growing to perhaps 5 Gbps on average. The larger propagator files will typically be generated and consumed at the same site (JLab in this case) and so do not represent a large wide area network bandwidth requirement. Jlab's current 10G WAN connection is more than adequate and will grow to 100G which will easily accommodate future the LQCD growth.

4. TECHNICAL SCOPE

The proposed NP LQCD Computing Program consists of the purchase of two medium scale high performance computing resources, plus 5 years of operations. The first compute resource will be across the FY26-FY27 fiscal boundary (deployed in calendar 2027), and the second compute resource across the FY28-FY29 boundary (deployed in calendar 2029 in two phases).

4.1.Computing Systems - Nodes and Networks

The current USQCD portfolio of computing resources have evolved to include a mix of resources, including Intel's Knight's Landing (KNL), conventional x86 and GPU clusters. NP applications have done particularly well on all the before mentioned architectures and going forward those applications will drive the procurement choices, except for KNL's which were discontinued by Intel in summer of 2018.

As the software evolves and the hardware landscape changes (including costs), the most cost-effective architecture will also change. All solutions for the mid-range resources over the last decade, however, have remained cluster solutions, where the software uses MPI to span a small number of nodes to reach the desired memory footprints and performance per job.

In the period of this program, cluster solutions are expected to remain optimal, and the program will evaluate Infiniband, Omni-Path and Ethernet network fabrics, as well as several alternative node configurations, including ARM (e.g., NVIDIA Grace CPU), conventional x86 (e.g., AMD, Intel) and GPU (e.g., AMD, Intel, NVIDIA) accelerated superchips and nodes.

4.2.Operations

The operation of the Lattice QCD systems will involve physical facilities (data center space, power, cooling), system administration, hardware and software maintenance, configuration management, cyber security, data storage, and data movement.

The computers will be installed in the CEBAF Data Center at JLab, which has adequate space, cooling, and power for the proposed resources based on decommissioning of out-of-warranty hardware at a regular cadence as noted in table 2.

Archival storage of physics data will utilize the existing JLab tape library, an in-kind contribution by the laboratory. This program will cover the cost of tape media and slots but not the maintenance of the library itself, and the tape cost is counted in the storage budget.

On a periodic basis, currently twelve months, US collaboration members will be allocated computing time by the USQCD Scientific Program Committee. This committee allocates time in an integrated fashion for the supercomputers (including DOE INCITE awards), the HEP LQCD program facilities, and this NP LQCD Computing Program.

It is proposed that this program continue operations of the existing USQCD resources at JLab, which includes the:

- 2019 32-node 256-gpu NVIDIA GPU cluster "19g",
- 2021 8-node 64-gpu AMD GPU cluster "21g",
- 2024 100-node Xeon CPU cluster "24s",
- 2 PB Lustre file system,
- ~20PB of data stored on archival tape storage.

The "19g" and "21g" clusters will be retired as noted in table 2 to make room (power, cooling, space) for the 2027 and 2029 machines respectively.

4.3.Deliverables

The two major deliverables for the program are (1) new compute resources deployed in FY27 and FY29, and (2) annual operations of the resources for science. In all discussions of performance, unless otherwise noted, performance reflects an average of domain wall fermion (DWF) and Clover algorithms.

As depicted in figure 2, the first compute resource "27x" will be procured and deployed in two steps across the fiscal year boundaries of FY26-27. Once hardware funds are available, a purchase order for the equipment will be placed in late FY26 with a deployment to production slated for early FY27.

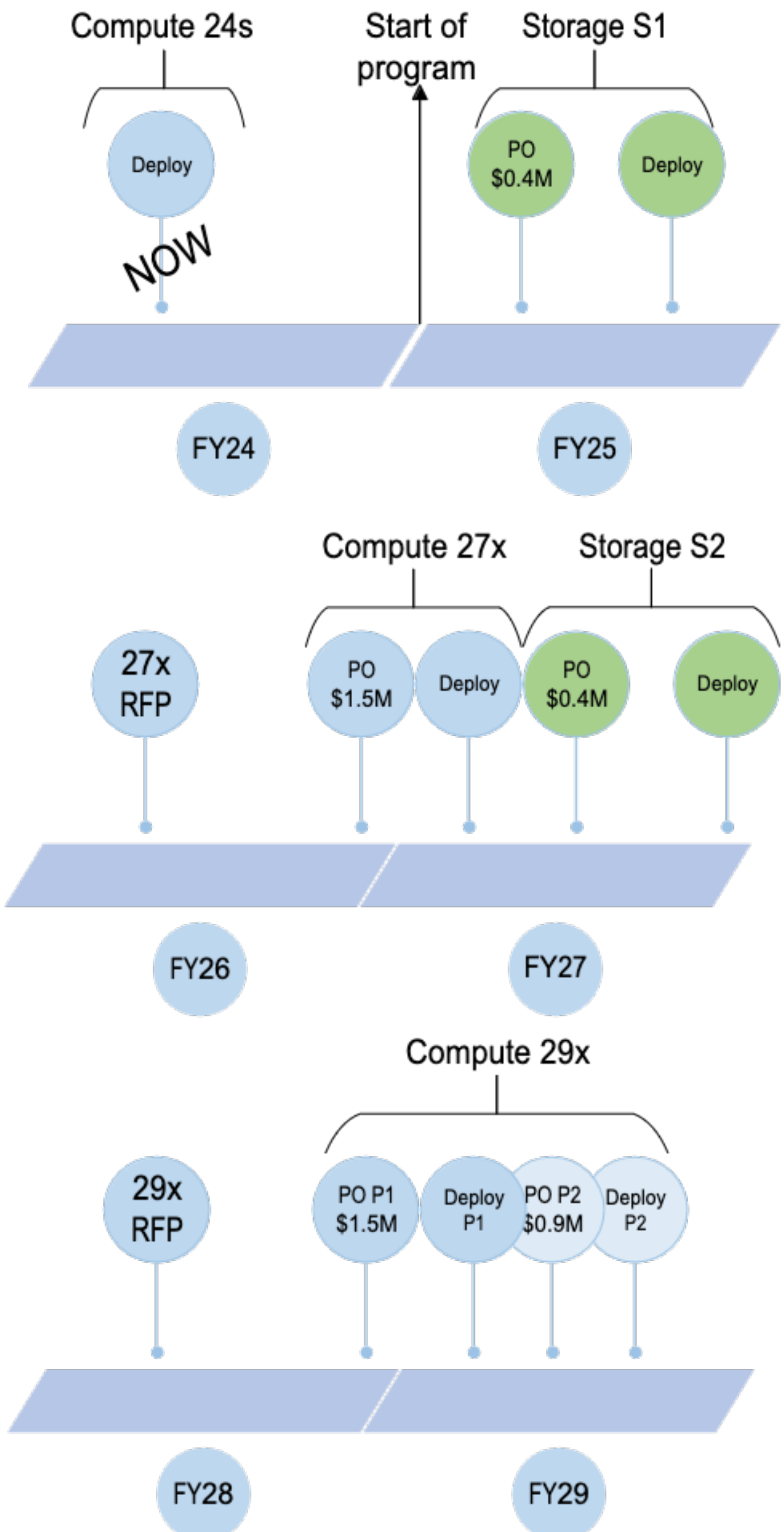

Figure 2 –Deployment schedule for the program lifetime. Historically, hardware funds have been made available in their entirety in FYQ3 hence a Purchase Order is issued in FYQ4. All numbers in millions of $'s.

The second compute resource “29x” will be procured in two phases across the fiscal year boundaries of FY28-29. Once hardware funds are available, a purchase order for the equipment will be placed in late FY28 with an option to purchase additional equipment of similar configuration in FY29. Deployment in this case will be in two phases, an initial deployment to production slated for early FY29 and then an extension to the initial deployment added in late FY29.

The first storage resource “S1” will be procured and deployed in FY25 and the second storage resource “S2” will be procured and deployed in late FY27.

System	TFlops	TFlop-year					
		FY25	FY26	FY27	FY28	FY29	TOTAL
19g	42	42					
21g	63	63	63	63	63		
24s	78	78	78	78	78	78	
27x	156			156	156	156	
29x	360					360	
Integrated Delivered		183	324	621	919	1,514	3,560

Table 2 – Annual sustained operations performance based on average of DWF and Clover. Planned decommissioning of 19g and 21g for FY26 and FY29 respectively.

Each year the NP LQCD Computing Program will have a deliverable running time measured in Teraflop-year, corresponding to running the resources from the target date of production running with an uptime of 90%. Operations funded by this program will continue through the end of FY29, or approximately 5 years. Over the life of the program, as shown in table 2, this will be 3,560 Teraflop-years of integrated performance.

The following steps by FY break down the delivered and deployment schedule as summarized in table 2:

- FY25: the first year of the program, there is an operation deliverable on the existing resources for 183 TFlops-year.
- FY26: with the decommissioning of the “19g” cluster (42 TFlops) this deliverable reduces to 324 TFlops-year of integrated running.
- FY27: deployment of a 156 TFlops new compute resource yields an increase to 621 TFlops-year of integrated running.
- FY28: there is an operation deliverable on the existing resources of 919 TFlops-year of integrated running.
- FY29: at the end of the program, with the possible decommissioning of the “21g” cluster (63 TFlops) and the deployment of a 360 TFlops new compute resource will yield an increase to 1,514 TFlops-year of integrated running for FY29.

Based on the above-mentioned plan, the overall major goal of the program is to operate existing and future resources to deliver, over 5 years, at least 3,560 TFlop-years of integrated performance.

Basis of estimates: Class A allocation i.e. major projects within USQCD, on the JLab clusters is for 6,480 hours/year and is measured in units of Sky-Core-Hour (Skch). Skch units are relative to a dual-socket Intel Xeon "Skylake" CPU. 1Skch = 7.5 GFlops (average of DWF + Clover). Moore's law growth is assumed at the conservative rate of 1.2 per year.

5. MANAGEMENT ORGANIZATION

This section presents the management organization for the NP LQCD Computing Program. The management plan also facilitates the involvement of the scientific community that will be the ultimate users of the infrastructure. The figure below shows the management structure.

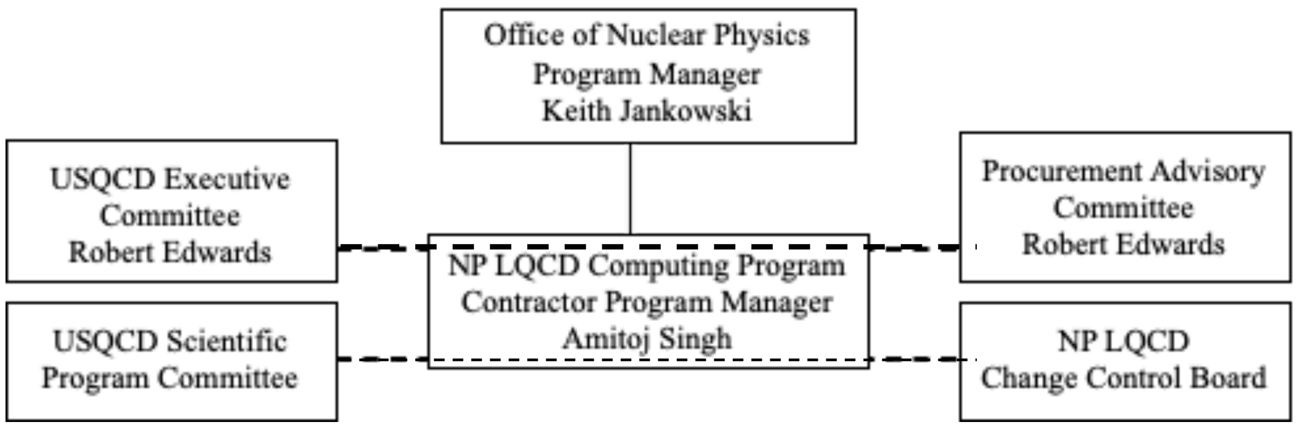

Figure 3 - Management Organization Chart for the NP LQCD Computing Program. Vertical lines indicate reporting relationships. Horizontal dashed lines indicate advisory relationships.

5.1.DOE Program Manager

Within the DOE's Office of Science (SC), the Office of Nuclear Physics (NP) has overall DOE responsibility for the NP LQCD Computing Program. The NP Program Manager will be Keith Jankowski. The DOE Program Manager responsibilities include:

- Provide programmatic direction for the NP LQCD Program.
- Function as DOE headquarters point of contact for NP LQCD Program matters.
- Oversee NP LQCD Computing Program progress and help organize reviews as necessary.
- Budget funds for the NP LQCD Program.
- Control changes to the NP LQCD Program baselines in accordance with the PEP.

5.1.1 Contractor Program Manager

The Contractor Program Manager (CPM), responsible for the overall management of the program, manages program execution. This person is responsible for insuring that the program is well defined (via a work breakdown structure, WBS) and tracked (via milestones), and is the key interface to the DOE for financial matters, reporting, and reviews of the program. As the manager of the program, the CPM has significant budgetary control and is in the approval chain for all major program commitments and procurements. The CPM will be Amitoj Singh. This person will be referred to as CPM in all program documents. The CPM responsibilities include:

- prepares detailed planning documents for the program, including a work breakdown structure (hierarchical list of tasks, with each task defined at a level that can be externally reviewed, and with individuals responsible for those tasks well identified, and a set of program milestones to rigorously track progress)
- prepares and approves proposed budgets consistent with the detailed planning documents.
- provides final approval for the program of all major (> $50K) procurements.
- prepares quarterly and/or annual program status / progress reports.
- provides internal program oversight and review, ensuring that funds are being expended according to the program plan, and identifying weaknesses in the execution of the program plan which need to be addressed.
- establishes and manages a program change control mechanism.

5.1.2 USQCD Committees

The charter of the USQCD **Executive Committee** is to provide leadership in developing the computational infrastructure needed by the US lattice gauge theory community to study quantum chromodynamics (QCD). This responsibility spans the current program and other QCD computing programs and computing allocations. The Executive Committee has responsibility for setting scientific goals, determining the computational needs to achieve these goals, developing plans for creating the infrastructure, obtaining funds to carry out these plans, and overseeing the implementation.

Current members of the Executive Committee are expected to serve for the duration of the program. If a vacancy occurs, it will be filled by a vote of the remaining members of the committee. The current chair is Robert Edwards of JLab. EC responsibilities are to:

- set the scientific goals and determine the computational needs to achieve them.
- establish procedures for the equitable use of the infrastructure by the national lattice gauge theory community.

- arrange for oversight of progress in meeting the scientific goals.
- arrange regular meetings of the national lattice gauge theory community to describe progress, and to obtain input.
- appoint members of the Scientific Program Committee.

The charter of the **Scientific Program Committee** is to assist the Executive Committee in providing scientific leadership for the Lattice QCD Infrastructure Effort. The Program Committee monitors the scientific progress of the effort and provides leadership in setting new directions.

The Scientific Program Committee is charged with allocating time on all the hardware that will be operated under the program, as well as other resources shared by the USQCD Collaboration. The Committee has instituted the following allocation process. Once a year it solicits proposals for use of the computational resources that will be available to the user community during the allocation period. The Committee reviews the proposals, and makes preliminary allocations based on its reviews. It then organizes an open meeting of the user community to discuss the proposals and the preliminary allocations. The Committee makes final allocations following this meeting. The objective of this process is to achieve the greatest scientific benefit from the resources through broad input from the community. The Committee is also charged with organizing an annual meeting of the user community to review progress in the development of the infrastructure and scientific progress achieved with the infrastructure, and to obtain input on future directions.

Members of the Scientific Program Committee are appointed by the Executive Committee. The current members are expected to serve for the duration of the program. If a vacancy occurs, it will be filled by the Executive Committee. SPC responsibilities are to:

- organize the annual meeting of the user community.
- solicit proposals for using LQCD computational resources.
- allocate computing resources.

5.1.3 Procurement Advisory Committee

The Procurement Advisory Committee provides additional input to the program on hardware alternatives under consideration for each of the even year procurements. The advice includes input on the software maturity and software developments planned within the NP LQCD SciDAC-5 program. The committee is chaired by Robert Edwards, who is also the P.I. of that program.

5.2.Change Control Board

The Change Control Board (CCB) is composed of the Contractor Program Manager (representing the program), the Chairman of the Procurement Advisory Committee (representing software development and science), and the JLab Chief Information Officer (representing the host institution). The purpose of this committee is to assure that changes to the program are managed with the primary focus on the advancement of the scientific goals of the program. The CCB acts on change requests according to the procedures described in section 7 below.

Responsibilities

- evaluates feasibility, cost, and impact of proposed changes to the program which result in more than a minimal cost or schedule change.

Interactions

- gathers input from the program participants and the user community about program scope changes.

Interaction of Host Laboratory Management and the Program

Management of the host laboratory, JLab, provides oversight and supplemental support to the program including all line management duties such as staffing, safety, etc. Management authorities for DOE and senior upper management of the host laboratory are shown in Figure 4.

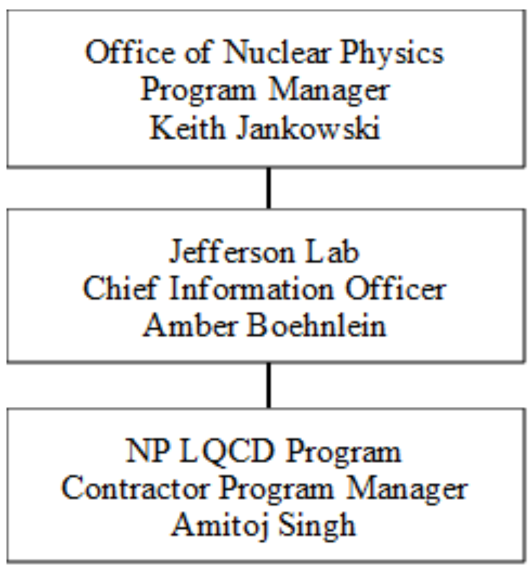

Figure 4 - Management Authorities Chart for the LQCD Computing Program.

6. SCHEDULE AND COST

The program is organized into a WBS for purposes of planning, managing, and reporting program activities. Work elements are defined to be consistent with discrete increments of program work and the planned method of program control. LQCD has three major WBS Level 1 components as follows:

Planning: Includes all program management activities
Deployment: Includes all site preparation, acquisition, and deployment of the LQCD resources.
Operations: Includes operation of the facility to serve the LQCD researchers for the duration of the program.

6.1.Program Milestones

The Level 1 program milestones defined in the program WBS are shown in Table 3. "27x" and "29x" are the FY27 and FY29 compute clusters respectively. As described in section 4.3, "29xP1" and "29xP2" represent the two phases of deployment planned for "29x". Any significant changes to milestone schedules will be processed according to the change control procedure.

Milestones	**Date (MM/YY)**
Program Start	10/25
27x: Issue Request for Proposal (RFP) for compute cluster	5/26
27x: Purchase Order Placed for compute cluster	9/26
27x: Compute cluster installed and deployed for friendly user access	4/27
27x: Compute cluster released to production; Issue RFP for disk cluster	5/27
29xP1: Issue Request for Proposal (RFP) for second compute cluster	5/28
29xP1: Purchase Order Placed for second compute cluster	9/28
29xP1: Compute cluster installed and deployed for friendly user access	4/29
29xP1: Compute cluster released to production	5/29
29xP2: Purchase Order placed for extension to second compute cluster	5/29
29xP2: Compute cluster released to production	7/29

Table 3 – Program milestones as defined in the WBS.

6.2. Budget

The total program cost for the NP LQCD Computing Program is $7.6 million ($1.52M/year). Equipment costs include system acquisitions (computers, networks) and storage (disk and tape). Labor costs include system administration, engineering and technical labor, and program management. Indirect costs will be applied according to JLab standards. All labor estimates have been inflated using escalation rates of 3% per year.

WBS	Name	Total Cost K$	FTE
1	**Program Planning & Management (Effort)**	**129**	
1.01	FY26 acquisition planning	63	0.25
1.02	FY28 acquisition planning	66	0.25
2	**Deployment (Hardware)**	**4,717**	
2.01	FY25 disk cluster purchase "S1"	400	

2.02	FY26 compute cluster purchase "27x"	1,523	
2.03	FY27 disk cluster purchase “S2”	400	
2.04	FY28 Phase 1 compute cluster purchase "29x P1"	1,457	
2.05	FY29 Phase 2 compute cluster purchase "29x P2"	937	
3	**Operations (Effort)**	**2,655**	
3.01	FY25	500	2
3.02	FY26	515	2
3.03	FY27	530	2
3.04	FY28	546	2
3.05	FY29	563	2
4	**Training**	**100**	
4.01	FY25	20	
4.02	FY26	20	
4.03	FY27	20	
4.04	FY28	20	
4.05	FY9	20	
	Total Program Cost	**7,600**	

Table 4 – Cost Summary by WBS. All costs in K$’s. All effort estimates have been inflated using escalation rates of 3% per year

6.3. Procurement Strategy

The overall strategy for the acquisition of a computational resource is the same strategy that has been used by the LQCD Computing Program for more than a decade: procure the system based on user demand and one that provides the best performance for the anticipated workload, under the constraints of what the software can support.

As described above, the program has been divided into two procurements, with two types of components planned for the computational system: cluster nodes, file storage nodes. The target job performance is set at about 1% of the performance now being achieved on leadership class machines doing configuration generation, as described in section 3.a. above.

The first procurement will likely include some amount of GPU accelerated resource to replace the 19g NVIDIA GPU cluster. Within the USQCD collaboration there is sufficient code maturity to make effective use of an accelerated resource. Superchips, a novel architecture, which include both the CPU, memory and GPU on the same die will be under consideration, but they are expected to be pricey in the beginning. It is too early to be able to predict with any level of confidence the possible architecture of the second procurement. It will likely be a mix of conventional and GPU accelerated resource to replace the 21g AMD GPU cluster.

The relative merits of different hardware choices will be evaluated by the hardware selection committee and expressed as benchmark applications for the best value procurement, where the selected benchmarks reflect anticipated running for the coming 2 years, and consider the existing USQCD hardware portfolio, with a view towards optimizing aggregate performance for science across all systems.

Disk server capacity and performance requirements are projected based upon a roughly 2x increase from 156 Tflops to 360 Tflops sustained at Jefferson Lab. Budget was set assuming an average over 3 years of $80/TB at the bandwidth needed.

All procurements will be “best value” with a firm fixed price award, acquiring as much performance or capacity as can be obtained within budget (build to cost).

6.4. Training

The hardware project will support a traineeship program with access to HPC resources through the “junior investigator” proposal track and through facilitating mentoring connections outside the trainee’s home institution as appropriate. USQCD sees great benefit in such traineeships and USQCD members will engage with the DOE Office of Nuclear Physics regarding expanding this project to also involve training in LQFT for nuclear physics applications building upon the insights gained from the LGT4HEP project.

Two summer trainings per FY on the use of the LQCD clusters at JLab are requested. The trainees will intern at the LQCD project lab.

7. CHANGE CONTROL

Changes to the technical, cost and schedule baselines will be controlled using the thresholds described in Table 5, below.

Level	Cost	Schedule	Technical Scope
DOE Program Manager (Level 0)		> 3-month delay of a Level 1 milestone date	Change of any WBS element that could adversely affect program performance specifications
CCB (Level 1)	A cumulative increase of more than $200K in WBS Level 2	> 1-month delay of a Level 1 milestone date	Any deviation from technical deliverables that does not affect expected program performance specifications.
Contractor Program Manager (Level 2)	Any increase of > $50K in the WBS Level 2	> 1-month delay of a Level 2 milestone date	Technical design changes that do not impact technical deliverables.

Table 5 - Summary of Change Control Thresholds

All changes that include or exceed Level 2 approval thresholds are to be documented by the Contractor Program Manager. For changes exceeding Level 2, the Contractor Program Manager will document the change using a Change Request (CR) form and transmit the CR to the Change Control Board (CCB, section 5.4 above) with recommendations. If the request exceeds the Level 1 threshold, the CCB will submit the CR to the DOE Program Manager for approval or rejection of the request.

The CCB must approve all changes resulting in a shift of more than $200K (10%) between equipment and labor budgets, or any one month or greater delay of a level 1 WBS milestone. The Contract Program Manager will present such changes to CCB for approval before executing any changes. All changes approved by CCB will be reported to DOE. Changes that might result in any increase in the total program cost or a 3-month or greater delay in a level 1 WBS milestone or a change that could adversely affect program performance specifications must in addition be approved by DOE prior to executing the change.

If a change is approved, a copy of the approved CR, together with any qualifications or further analysis or documentation generated in considering the request is to be kept by the Contractor Program Manager as part of the program documentation. If approval is denied, a copy of the CR, together with the reasons for denial, is to be filed.

8. SAFETY AND RISK MANAGEMENT

8.1. Environment, Safety and Health

8.1.1. Integrated Safety Management (ISM) Plan

Environment, safety, and health (ES&H) will be integrated into all phases of planning, acquisition and maintenance of the program using appropriate procedures defined by the host laboratory. The Program will follow the five core functions of ISM:

- Define work and identify the potential hazards.
- Analyze potential hazards and design the equipment or activities to appropriately mitigate or eliminate those hazards.
- Establish controls for hazards that cannot be eliminated through design features.
- Perform work in accordance with the procedures.
- Review the effectiveness of the hazard analyses and controls and provide feedback for improvement.

The line management of the laboratory retains supervisory authority of their personnel and responsibility for the safety of work at the laboratory. Line management will keep the Contractor Program Manager informed about their laboratory's management and ES&H organization structures. Any safety concerns by Program personnel are to be communicated to the Contractor Program Manager and to the line management where the concern occurs.

The Contractor Program Manager will work with safety officers at the laboratory to ensure that the specific hazards found in the program are documented according to plans and procedures of the laboratory and mitigated appropriately. Information pertaining to these hazards will be documented. Also, laboratory personnel will receive specific training required or recommended for program to perform their job in a safe and proper manner. The Contractor Program Manager is responsible for verifying that the staff members have received appropriate training and that this training is documented.

Applicable electrical, mechanical, etc. codes, standards, and practices, will be used to ensure the safety of personnel, environment, equipment, and property and will be integrated into the program. Where these codes, standards and practices are in conflict, the most stringent or most appropriate will be selected. Reviews will assess compliance with these codes, standards, and practices. All equipment purchased from manufacturers must comply with Underwriters Laboratories Inc. or equivalent requirements, or it will be reviewed for safety. The results and conclusions of these reviews, when applicable, will be documented.

8.1.2. NEPA

There is no direct construction activity associated with the program. From experience at the three USQCD deployment sites covering a range of research and related activities, it is anticipated that the Program will be determined to be included under Categorical Exclusion.

8.1.3. Quality Assurance

The NP LQCD Program defines Quality as the "fitness of an item or design for its intended use" and Quality Assurance (QA) as "the set of actions taken to avoid known hazards to quality and to detect and correct poor results." NP LQCD will follow established quality control procedures of the host laboratory.

Risk Assessment

Because of the build-to-cost nature of the program, LQCD has low risk of not completing on cost. The cost estimates are based on the actual cost of labor for deploying and operating the existing facilities. Hardware component cost variances will result in adjustments to the sizes of the computing systems deployed. There is a modest contingency (10%) on labor and deployment costs other than the major procurement purchases. Out year operations are well known to an accuracy smaller than this. If deployment labor costs exceed this contingency, a small adjustment in the FY28 procurement could be done to compensate (most deployment costs occur prior to the FY28 award).

The performance risks associated with the planned computing and network systems are estimated to be low due to the successful R&D performed during the ongoing SciDAC-5 program, and due to the use of common off the shelf components whenever possible. The performance milestones are based primarily upon the performance of existing systems and by knowledge of near-term new hardware. Contingency is built into the estimates of the performance of the systems that will be acquired during the program using conservative estimates of vendor pricing.

The most important schedule risks are delays in releasing new systems to production after their procurement caused by difficulties in integrating the computer, network, and software subsystems, and delays resulting from slippage in vendor schedules. Integration delay risks are low when new systems are based on components previously used on earlier LQCD clusters, specifically Infiniband clusters and file servers.

Cyber Security

The Program resources will be installed under the JLab Scientific Computing network enclave. This enclave has access control which makes it inaccessible directly from offsite and has rules governing access from onsite. The compute nodes will be in non-routed subnet(s), and access is only via interactive gateway notes. All nodes except the compute nodes are scanned for vulnerabilities daily, with a deeper scan conducted once a week. The systems are maintained according to the JLab cyber security policies, and the system will be operated under Jlab's Authority to Operate. Cyber monitoring of the scientific computing enclave is performed by the cyber security group; this service is an in-kind contribution from the laboratory.