

**Memorandum of Understanding  
between  
Thomas Jefferson National Accelerator Facility (TJNAF)  
and the  
SC Lattice QCD Computing Project Extension II (LQCD-ext II)**

**Unique Project (Investment) Identifier: 019-20-01-21-02-1032-00**

*Operated at*  
Brookhaven National Laboratory  
Fermi National Accelerator Laboratory  
Thomas Jefferson National Accelerator Facility

*for the*  
U.S. Department of Energy  
Office of Science  
Offices of High Energy and Nuclear Physics

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Approved: (TBD)

**Memorandum of Understanding between TJNAF  
and the SC Lattice QCD Computing Project Extension II (LQCD-ext II)**

**Change Log**

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0.5	Revised entire document (LQCD-ext Project)	April 11, 2013
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1.1	Update and sync to PEP v2.0 org chart. Reformat Appendix 1.	October 17, 2016

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## **1 Project Overview**

The Lattice Quantum Chromodynamics (LQCD) computing project (LQCD Project) provides for the acquisition and operation of computational systems that will serve as a principal computational resource for the national USQCD scientific community. The LQCD Project is operated as an OMB Exhibit 53 IT Investment project under the direction of the DOE Offices of High Energy Physics (OHEP) and Nuclear Physics (ONP).

The numerical study of QCD requires very large computational resources and has been recognized as one of the great challenges of computational science. Recent advances in computer technology, coupled with major improvements in scientific algorithms, have brought the field to a new level. A limited number of crucial quantities have been calculated to a level of accuracy comparable to their experimental determination. Moreover, the experience that has been gained allows confident predictions of the computing resources required for determinations of a broad range of fundamental quantities to an accuracy required for support of the experimental program and to provide guidance to the program in some areas. As a result, there are opportunities to make major scientific advances.

The main objective of the LQCD Project is to support the achievement of the scientific goals described in the Project Execution Plan. Using the computational resources made available through the LQCD Project, members of the USQCD scientific collaboration can better provide theoretical insight and guidance to the community of approximately 4,500 particle and nuclear physicists. In fact, this investment is crucial to advance scientific discovery in the QCD discipline.

The LQCD Project has been funded through a series of proposals and funding extensions. The initial LQCD project was funded from FY2006-2009. The LQCD extension project (LQCD-ext) was funded from FY2010-2014. The LQCD extension II project (LQCD-ext II) is currently funded from FY2015-2019. References to LQCD-ext II in this document refer specifically to this latest funding period.

## **2 Purpose**

This Memorandum of Understanding (MOU) describes the collaboration between Thomas Jefferson National Accelerator Facility (also referred to herein as TJNAF or the Institution) and the OMB Exhibit 53 Investment project titled “SC Lattice Quantum Chromodynamics Computing (LQCD) project” (herein referred to as the LQCD Project). The LQCD Project’s Unique Project (Investment) Identifier is 019-20-01-21-02-1032-00. Other collaborating laboratories include Brookhaven National Laboratory (BNL) and Fermi National Accelerator Laboratory (FNAL).

This document outlines the general agreement between the project and TJNAF regarding the use of laboratory personnel, infrastructure and facilities to meet the performance goals and requirements defined in the approved baseline plan. It will remain effective throughout the lifetime of the LQCD Project, which is currently funded through September 30, 2019.

### 3 Scope of Work

The scope of work for the LQCD Project is defined in detail in the LQCD Project Execution Plan (PEP)<sup>i</sup> and the LQCD Acquisition Strategy<sup>ii</sup>. In summary, the scope of work for the LQCD Project includes:

- Operation through end-of-life of computing hardware purchased and deployed at BNL, FNAL, and TJNAF during FY2010-2014 using LQCD-ext and LQCD-ARRA project funds;
- Acquisition, deployment, and operation of new computing hardware at BNL, FNAL, and TJNAF in FY2015-2019.

The scope of work for the LQCD Project excludes:

- Scientific software development
- System and scientific software support activities

The scope of work specific to TJNAF includes:

- Steady-state operations: This includes continuous operation, until an appropriate end-of-life, of:
  - Existing LQCD computing facility, including the clusters in operation at TJNAF at the beginning of FY2015.
  - Newly deployed hardware at TJNAF during the current MOU period as described above.

Operations may also include software development specifically driven by project operation needs, such as improvements to storage, network, monitoring, or computing system software that are stressed by LQCD operations.

- New hardware planning and deployments: This includes the acquisition and deployment of new computing hardware during the period FY2015 to FY2019 in accordance with the LQCD-ext II Acquisition Strategy and annual LQCD-ext II Acquisition Plans. Project funds are to be used for the purchase of the new hardware and for the labor needed to plan for and deploy this new hardware. Full details of the deployment plan are found in the Acquisition Strategy document.

The LQCD Integrated Project Team (IPT) will determine planned decommissioning dates of computing hardware purchased with project funds after evaluating the cost effectiveness of continued operation. Based on over 10 years of operational experience, the nominal operational lifetime for LQCD computing project hardware is approximately 5 years. LQCD Site Managers will work closely with computing facility managers at each host institution to ensure that LQCD facility needs and project decommissioning timelines are understood and mutually agreeable. Decommissioning and disposal of retired LQCD equipment is the responsibility of the host site. The host site may repurpose, sell, or dispose of retired LQCD equipment as it deems most appropriate.

Work on the LQCD Project will be performed in accordance with the LQCD Project Execution Plan (PEP) and the Work Breakdown Structure (WBS), subject to the availability of funding from OHEP and ONP. Detailed activities to be performed at TJNAF and the required level of effort for

technical personnel are specified in the LQCD Project WBS document. The project WBS will be reviewed on an annual basis and updated as necessary to reflect changing conditions or needs.

## **4 Funding and Costs**

Funding for the LQCD Project will be provided by OHEP and ONP over the project lifetime in accordance with the approved baseline plan and funding profile. TJNAF expenditures will be covered by funds provided by DOE and allocated to the laboratory on an annual basis, following the guidance contained in the annual financial plan that is prepared by the CPM and submitted to the LQCD Federal Project Director and the LQCD Project Monitor prior to the start of each fiscal year. The LQCD Federal Project Director is responsible for managing the allocation of funds from OHEP. The LQCD Project Monitor is responsible for managing the allocation of funds from ONP. TJNAF agrees not to exceed the site budget defined in the annual approved financial plan.

The project funding profile for host sites is provided in Appendix 1. The actual amount of funds allocated to each host site will likely vary from this profile as described in Section 4.1. The current project funding profile involves changes described by project change request CR16-01 which affects some modest site budget items as early as June 2016 and the overall project funding profile beginning in FY17.

### ***4.1 Project Funds Management and Allocation***

In August of each year, the LQCD Project Office works with the LQCD Site Managers to forecast expenditures through the end of the current fiscal year and estimate the potential level of unspent funds remaining at each site, including Management Reserve. The LQCD Project Office factors these estimates of unspent funds into the upcoming year's financial plan to optimize the allocation of new DOE funds across the three host sites to achieve the levels of site funding necessary to accomplish project goals. The optimized financial plan is prepared by the CPM, who shares the plan with the LQCD Site Managers and transmits the plan to the LQCD Federal Project Director and the LQCD Project Monitor. The LQCD Federal Project Director is responsible for managing the allocation of funds from OHEP to each host laboratory. The LQCD Project Monitor is responsible for managing the allocation of funds from ONP to each host laboratory. As the new fiscal year begins, the Project Office works with the LQCD Site Managers to ensure that new project funds have been received and that the funds distribution from DOE to the host sites is in agreement with the allocation guidance provided in the LQCD annual financial plan.

Project funds are not transferred from project site to project site as a rule, and would invoke project change control if such transfers were required for some reason. The LQCD Project Office holds the project funds necessary for its function, project management. Site managers hold the project funds necessary to support their site operations and deployment responsibilities.

### ***4.2 Project Funds Allocated to the Site***

Project funds will be allocated to TJNAF to cover costs in the following categories:

- Labor support for the deployment of new LQCD Project computing systems. This includes new hardware deployment planning and support.
- Labor support for the steady-state operation of LQCD Project computing systems, including system administration, hardware support, storage (including tape costs), and site

management. The budget also provides a modest amount of funds for travel and materials/services.

- Construction and purchase of new computing systems, including clusters or equivalent computing hardware, network switches, tapes, disks, etc. The size, makeup and location of the equipment will be defined on an annual basis to optimize the cost and performance of the machines. New system deployments also include a modest amount of hardware required for the near-line storage.

## **5 Resources**

### ***5.1 Project Management Personnel***

- LQCD Contract Project Manager (CPM): William Boroski
- LQCD Associate Contract Project Manager (ACPM): Robert D. Kennedy

William Boroski and Robert D. Kennedy are FNAL employees.

### ***5.2 Site Management Personnel***

- TJNAF Site Manager: Sandy Philpott
- TJNAF Site Architect: William Watson

Sandy Philpott and William Watson are TJNAF employees. Some functions of these roles may be delegated to others.

### ***5.3 Technical Personnel***

Project work at TJNAF will be performed by TJNAF staff members and/or TJNAF-designated personnel. Job categories required may include computer professionals, engineers, and engineering technologists. The estimated level-of-effort for each year is contained in LQCD Project 5-Year Operating Budget Forecast. On an annual basis and as part of developing each year's financial plan, the Project Office reviews resource needs with each Site Manager and makes mutually-agreed upon adjustments as necessary. These adjusted amounts are used in the preparation of each annual financial plan.

### ***5.4 Equipment***

New equipment for the computing system at the TJNAF site will be procured using DOE funds made available to TJNAF through the process described in Section 4. Existing computing equipment deployed at TJNAF to carry out LQCD computing work at the beginning of FY2015 falls within the scope of the LQCD Project computing system covered under this document.

## **6 Project Management Responsibilities**

The LQCD project management infrastructure and the Project Office reside at FNAL. The LQCD CPM is responsible for the overall management of the project. This person reports to the LQCD Federal Project Director and is the key interface to the Federal Project Director for financial matters, reporting, and project reviews.

### ***6.1 Organization Chart of the LQCD-ext II Project***

Please refer to the LQCD-ext II Project Execution Plan, Section 5, Figure 1.

## **6.2 Laboratory Management at LQCD Project Sites**

Please refer to the LQCD-ext II Project Execution Plan, Section 5.1.6, Figure 2.

## **6.3 Coordination and Reporting**

The TJNAF Chief Information Officer (CIO) is a signatory to this MOU and represents the Institution to the LQCD Project. This person will carry out the coordination with the senior management of the Institution, and possibly other institutions within the LQCD Project collaboration.

During the deployment of a new cluster, the technical progress of the design, implementation, and testing of computer equipment will be reported to the Project Office by the TJNAF Site Manager on a monthly basis, by WBS element. The Site Manager is also responsible for reporting to the LQCD CPM operations metrics and performance measures defined for the project. The LQCD CPM will, in turn, report the consolidated progress report to the DOE Federal Project Director.

Any changes to the scope of work and the associated cost and schedule must be documented in consultation with the LQCD CPM and pre-approved using the change control mechanism established in the LQCD PEP.

## **6.4 Procurement Authorization**

The LQCD CPM approves procurement plans and delegates procurement obligation authority to the Site Manager and as necessary, the appropriate financial officer at the site. The procurement cost ceilings at each host site are documented in the LQCD computing hardware budget. These cost ceilings must not be exceeded without the authorization of the CPM and, when necessary, by invoking change control processes as defined in the PEP.

## **6.5 Reporting to LQCD Project Management**

TJNAF will report all LQCD Project-related expenditures and labor charges in each item of work by LQCD WBS category (cost element level). This detailed reporting will be done on a monthly basis through the Site Manager to the LQCD CPM. Any request for variance from the base cost must be immediately reported to the Site Manager. Any significant variance in schedule from the base schedule must be immediately reported through the Site Manager to the LQCD CPM.

TJNAF agrees to furnish complete documentation of the quality assurance (as defined in the LQCD Project Quality Assurance Plan<sup>iii</sup> and applicable TJNAF Integrated Quality Assurance Program documents), risk management information (as defined in the LQCD Project Risk Management Plan<sup>iv</sup>) and performance testing that is carried out for LQCD. Further, the institution agrees to furnish accurate documentation of all software that it provides to the LQCD Project in electronic format.

TJNAF agrees to set up and maintain ledger cost accounts in a manner compatible with the one used by LQCD Project management. The Institution agrees to provide and maintain this ledger so as to provide timely information to the LQCD Project Office. By this MOU, standard practices used at TJNAF for cost accounting will be applied to the LQCD Project activities by TJNAF.

## ***6.6 Collaboration with Other Groups and Institutions***

BNL and FNAL are the two other institutions participating in the LQCD Project. The LQCD CPM and ACPM will coordinate with these two institutions and present consolidated reports to the DOE Federal Project Director.

## **7 TJNAF Contributions**

Subject to available funding from DOE, TJNAF will provide additional support to the project during this period of performance.

### ***7.1 Effort***

TJNAF will provide support for additional scientific and technical personnel as an in-kind contribution. This contribution refers only to system and scientific software support provided outside of the scope of the LQCD Project.

### ***7.2 Services***

TJNAF agrees to provide support services to the LQCD Project to the degree required to carry out relevant responsibilities, some of which are covered by the overhead paid by the LQCD Project. Support services provided by TJNAF may include:

- Services for generic computing infrastructure, including network
- Services for the lab-wide infrastructure for mass storage. This includes assistance with integrating and accessing the JasMINE software and JLab silos.
- Services for remote backups
- Services for computer security infrastructure
- Services for the system disaster recovery
- Services of the responsible financial officer
- Services for building facilities
- Services for administrative staff.

### ***7.3 Facilities and Equipment***

Adequate facility infrastructure will be made available to the LQCD Project to the degree necessary to carry out the implementation and operation of LQCD Project computing systems at the TJNAF site. TJNAF agrees to pay for all facility and utility costs, such as the power needed to support the computing and HVAC systems.

### ***7.4 Operating Costs***

TJNAF, subject to available funding from DOE, will support the normal operating expenses related to the LQCD Project but not listed in the project scope of work in Section 3, such as administrative support and miscellaneous office supplies.

## **8 General Considerations**

### ***8.1 System Engineering Practices***

TJNAF management agrees to support the implementation of standard system engineering best practices. All major system components will undergo appropriate quality control and validation testing.

TJNAF agrees to provide a high level of reliability and availability for the system, sufficient to meet the Key Performance Indicators defined in the Project Execution Plan. Any outage or abrupt maintenance shutdown shall be recorded and analyzed to minimize future disruptions. Adequate notices must be given to the LQCD Project site management for routine maintenance and upgrades.

### ***8.2 Project Management Practices***

TJNAF management agrees to support project management best practices and guidelines prescribed by DOE, within the scope of the PEP, and within the terms of TJNAF's contract with DOE. Note that during the initial approval of the LQCD-ext II computing project, it was determined by the DOE Federal Project Director that the LQCD-ext II computing project is exempt from the implementation of the Earned Value Management System (EVMS).

All procurement documents must be transmitted to the LQCD Project Office. All procurements must be accompanied by adequate backup documents, including the appropriate LQCD Project charge codes established for the site. All project labor costs must be reported by the appropriate charge codes to the LQCD Project Office on a monthly basis. All equipment items purchased using DOE funds will be properly marked as the property of DOE and identifiable as a part of the LQCD Project computing system.

### ***8.3 Schedules and Milestones***

TJNAF will make every effort to carry out its institutional responsibilities consistent with the schedule and milestones for the LQCD Project. It is understood that these schedules may need to be adjusted as the LQCD Project progresses. TJNAF agrees to notify the LQCD Project Office as soon as possible of any significant changes that would affect the scope, cost, performance, or schedule of the LQCD Project. These changes must be documented in writing and approved using the change control process described in the LQCD PEP. Status of the project milestones for TJNAF will be reported on a monthly basis to the LQCD Project Office.

## Appendix 1. LQCD-ext II Project Funding Profile

The LQCD-ext II project funding profile for host sites is shown below. The actual amount of funds allocated to each host site will likely vary from this profile as described in Section 4.1.

### LQCD-Ext II Cost Forecast - \$14 Million

(as of 08/25/2016)

#### Project Budget, by Site - Baseline 2 (in \$k)

<b>BNL LQCD SITE BUDGET</b>	<b>FY15</b>	<b>FY16</b>	<b>FY17</b>	<b>FY18</b>	<b>FY19</b>	<b>Total</b>
<i>Steady-state Operations</i>	280	283	466	365	409	1,804
<i>New Hardware Deployment</i>	0	0	708	807	0	1,515
<i>Project Management</i>	0	0	0	0	0	0
<i>Management Reserve</i>	0	0	74	50	0	124
<b>Total BNL LQCD Site Budget</b>	<b>280</b>	<b>283</b>	<b>1,248</b>	<b>1,222</b>	<b>409</b>	<b>3,442</b>

  

<b>FNAL LQCD SITE BUDGET</b>	<b>FY15</b>	<b>FY16</b>	<b>FY17</b>	<b>FY18</b>	<b>FY19</b>	<b>Total</b>
<i>Steady-state Operations</i>	809	915	763	728	750	3,966
<i>New Hardware Deployment</i>	0	0	15	377	1,199	1,591
<i>Project Management</i>	118	135	139	144	148	685
<i>Management Reserve</i>	46	0	0	22	94	161
<b>Total FNAL LQCD Site Budget</b>	<b>974</b>	<b>1,051</b>	<b>917</b>	<b>1,271</b>	<b>2,191</b>	<b>6,404</b>

  

<b>TJNAF LQCD SITE BUDGET</b>	<b>FY15</b>	<b>FY16</b>	<b>FY17</b>	<b>FY18</b>	<b>FY19</b>	<b>Total</b>
<i>Steady-state Operations</i>	746	562	471	486	380	2,646
<i>New Hardware Deployment</i>	0	1,021	332	21	19	1,394
<i>Project Management</i>	0	0	0	0	0	0
<i>Management Reserve</i>	0	83	32	0	0	115
<b>Total TJNAF LQCD Site Budget</b>	<b>746</b>	<b>1,667</b>	<b>835</b>	<b>507</b>	<b>400</b>	<b>4,154</b>

  

<b>LQCD-EXT II PROJECT BUDGET</b>	<b>FY15</b>	<b>FY16</b>	<b>FY17</b>	<b>FY18</b>	<b>FY19</b>	<b>Total</b>
<i>Steady-state Operations</i>	1,836	1,760	1,701	1,579	1,540	8,415
<i>New Hardware Deployment</i>	0	1,021	1,055	1,205	1,219	4,500
<i>Project Management</i>	118	135	139	144	148	685
<i>Management Reserve</i>	46	83	105	72	94	400
<b>Total LQCD-ext II Project Budget</b>	<b>2,000</b>	<b>3,000</b>	<b>3,000</b>	<b>3,000</b>	<b>3,000</b>	<b>14,000</b>

  

<b>DOE Project Funding by Fiscal Year</b>	<b>2,000</b>	<b>3,000</b>	<b>3,000</b>	<b>3,000</b>	<b>3,000</b>	<b>14,000</b>

#### Notes:

1. All unspent funds in one year, including Management Reserve, are assigned primarily to New Hardware Deployment in following year.

## Appendix 2. List of Acronyms

ACPM	Associate Contract Project Manager
ARRA	The American Recovery and Reinvestment Act of 2009
BG/Q	IBM Blue Gene/Q model computer
BNL	Brookhaven National Laboratory
CIO	Chief Information Officer
CPM	Contract Project Manager
DOE	Department of Energy
EVMS	Earned Value Management System
FNAL	Fermi National Accelerator Laboratory, a.k.a. Fermilab
IPT	Integrated Project Team
LQCD	Lattice Quantum Chromodynamics
LQCD-ext II	Lattice Quantum Chromodynamics Extension II Computing Project
MOU	Memorandum of Understanding
OHEP	DOE Office of Science-Office of High Energy Physics
OMB	Office of Management and Budget
ONP	DOE Office of Science-Office of Nuclear Physics
PEP	Project Execution Plan
QCD	Quantum Chromodynamics
SC	DOE Office of Science
TJNAF	Thomas Jefferson National Accelerator Laboratory
WBS	Work Breakdown Structure

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<sup>i</sup> LQCD-ext II Project Execution Plan

<sup>ii</sup> LQCD-ext II Acquisition Strategy

<sup>iii</sup> LQCD-ext II Quality Assurance Plan

<sup>iv</sup> LQCD-ext II Risk Management Plan