

**Memorandum of Understanding  
between  
Brookhaven National Laboratory (BNL)  
and the  
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  
Offices of High Energy and Nuclear Physics

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and the Lattice QCD Computing Project Extension II (LQCD-ext II)**

**Change Log**

<b>Revision No.</b>	<b>Description/Pages Affected</b>	<b>Effective Date</b>
0.0	Entire document (LQCD-ext Project)	04/20/2010
0.5	Revised entire document (LQCD-ext Project)	04/11/2013
0.9	Adapted & updated entire document for LQCD-ext II Project	02/03/2016
1.0	Adjust document for CR16-01 where necessary. Declare v1. Add description of project funds management and allocation. Adjust document text for feedback. Add Appendix 1.	05/24/2016
1.1	Adjust wording of BNL-specific terms in Section 3 and Subsection 7.2 to improve intent definition and remove ambiguity. Update and synchronize to PEP v2.0 org chart. Reformat Appendix 1.	10/17/2016
2.0	Revised entire document to reflect transition to institutional cluster operating model. Defined FY18 Statement of Work and Budget in Appendix A. Removed the baseline funding profile and planned budget that had been included as Appendix B.	12/21/2017

CONCURRENCES:



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12/21/2017  
Date



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## **1 Purpose**

This Memorandum of Understanding (MOU) describes the collaboration between Brookhaven National Laboratory (herein referred to as BNL or the Institution) and the OMB Exhibit 53 Investment Project titled “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 Fermi National Accelerator Laboratory (FNAL) and Thomas Jefferson National Accelerator Facility (JLAB).

The scope of the LQCD Project is described in detail in the Project Execution Plan (PEP). This document outlines the general agreement between the project and BNL 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 in effect throughout the lifetime of the LQCD Project.

Appendix A contains the BNL Statement of Work (SOW), which defines the work that BNL agrees to perform for the LQCD Project. The SOW is reviewed and updated annually as part of the LQCD Project annual planning process.

## **2 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. BNL expenditures will be covered by funds provided by DOE and allocated to the laboratory on an annual basis. Annual funding levels will follow guidance contained in the annual financial plan that is prepared by the LQCD Contractor Project Manager (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. BNL agrees not to exceed the site budget defined in the annual approved financial plan.

The project funding profile plan for host sites is provided in Appendix B. The actual level of funding allocated to each host site will likely vary from this profile based on annual needs.

### ***2.1 Management and Allocation of Project Funds***

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. The LQCD Project Office factors this information into the upcoming year’s financial plan to optimize the allocation of unspent prior year funds and new DOE funds across the three host sites to achieve the levels of site funding necessary to accomplish project goals. The annual financial plan is prepared by the CPM, who develops the plan in coordination 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 each 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 agrees 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 will invoke project change control if such transfers are required. 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's operational responsibilities.

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

Project funds will be allocated to BNL to cover the following costs:

- Purchase of computing and storage services from institutional clusters operated by BNL. The type and quantity of services will be determined annually based on the needs of the LQCD Project.
- Management and oversight of LQCD activities at BNL.
- Travel funds for the Site Manager and Site Architect to participate in the USQCD All-hands Meeting and the Annual DOE Review of the LQCD Computing Project.
- Participation in technical activities related to the identification and evaluation of present and evolving computing architectures that may be relevant to LQCD user needs.

## **3 Project Management Responsibilities**

The LQCD project management infrastructure and the Project Office reside at FNAL. The LQCD Contractor Project Manager (CPM) is William Boroski. 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.

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

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

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

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

### ***3.3 Coordination with BNL Management***

The BNL Director of the Computational Science Initiative (CSI) 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.

Any changes to the statement 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.

### ***3.4 Reporting to LQCD Project Management***

The Site Manager is responsible for reporting BNL performance measures monthly to the LQCD Project Office. These performance measures include:

- BNL operations metrics and performance measures defined in the PEP.
  - Delivered computing (TF-yrs)
  - System uptime (%)

- System utilization, in aggregate, by user, and by USQCD project (in units used by site monitoring systems. Examples include # of node-hrs, # of core-hrs, etc.)
- Allocation usage by node-hrs, by user, by IC (node-hrs)
- Percent of allocation used, by IC (%)
- # of help desk tickets received
- # of help desk tickets resolved within two business days
- # of unique users, per system
- Status of project milestones related to BNL work.
- Project-related expenditures and labor costs by WBS category (i.e., steady-state operations, Institutional Cluster charges, new acquisitions/deployments). Actual costs should be reported for the following categories:
  - Personnel
  - Travel
  - Materials and Services (M&S)
  - Other

The LQCD CPM will, in turn, prepare and present a consolidated progress report to the DOE Federal Project Director.

The Site Manager is responsible for promptly reporting significant variances and/or variance requests to the LQCD CPM. These include:

- Any request for variance from the approved budget.
- Any significant variance in schedule from the approved schedule.
- Any significant variance in delivered computing from the approved plan.

During the deployment of new institutional cluster computing or storage hardware that will be used by LQCD, the technical progress of the design, implementation, and testing shall be reported monthly to the Project Office by the BNL Site Manager until service is declared to be in production by both parties.

BNL agrees to set up and maintain ledger cost accounts in a manner compatible with that used by the LQCD Project Office. Standard practices used at BNL for cost accounting will be applied to LQCD Project activities by BNL.

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

FNAL and JLAB are the two other institutions participating in the LQCD Project. The LQCD CPM will coordinate activities amongst all institutions performing work for the project.

## **4 BNL Contributions**

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

### ***4.1 Effort***

BNL agrees to cover costs for system and scientific software activities performed by BNL that are outside the scope of the LQCD Project.

## 4.2 Services

BNL agrees to provide the following services as part of an agreement for the LQCD Project to acquire cluster systems at BNL:

1. An allocation of 40 nodes on the BNL Institutional Cluster from June 2016 through September 2018 inclusive to make up the deficit in the Project's Delivered Computing due to acquiring and supporting clusters at BNL.
  - a. LQCD usage will be based on a monthly average. More or fewer nodes may be used at any one time.
  - b. The same rules for managing allocations applied to USQCD proposals will be used for the LQCD BNL IC allocation, for instance, in the partial loss of unused allocations from quarter to quarter.
2. 200 TB of disk storage on the 1 PB Institutional Cluster GPFS storage system.
  - a. This storage system will have a peak bandwidth of 24 GB/s that is shared between all users of the BNL Institutional Cluster.
  - b. LQCD access to this storage will continue through at least FY19.
3. 0.5 PB of older disk storage for scratch and/or intermediate-term storage on the existing storage systems for BG/Q systems at BNL. This storage will only exist through FY18, and BNL will provide best-effort support only, relying on the existing pool of hardware replacement parts.
  - a. This storage will have lower bandwidth than the Institutional Cluster storage system.
  - b. LQCD access to this disk storage will end six months after access to the BG/Q by LQCD users is terminated.
    - i. The BNL Site Manager will notify the LQCD Project Office when LQCD access is officially terminated.
    - ii. LQCD users will be responsible for transferring their data from the BNL disk storage system within six months of the termination date.

BNL agrees to keep the LQCD Project informed of changes planned or made to Institutional Computing Clusters resources. This will allow the LQCD Project to assess the potential impact of such changes and to make adjustments if necessary or appropriate.

BNL agrees to allow the LQCD Project to request changes in agreed-upon allocation levels on any Institutional Computing Cluster resources during an allocation year. This provides the LQCD Project with the flexibility to adjust its computing hardware portfolio to meet changing needs of the USQCD scientific community. Requested changes will be reviewed and approved by the Computational Science Initiative and are subject to resource availability and the ability of CSI to accommodate the request.

The LQCD Project understands that there is work associated with changing allocations and agrees to limit allocation change requests to a reasonable level. The LQCD Project also agrees to provide sufficient notification to CSI to allow changes to be made in a controlled and well-managed manner.

Changes in allocation levels throughout the year will be documented by the LQCD Project and reflected in the metrics used by the Site Manager to track and report performance monthly.

#### ***4.3 Other Operating Costs***

BNL 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. Examples include financial and administrative staff, and miscellaneous office supplies.

## **5 General Considerations**

### ***5.1 System Engineering Practices***

BNL agrees to provide a high level of reliability and availability for systems used by the LQCD Project, sufficient to meet the Key Performance Indicators defined in the Project Execution Plan. The BNL Site Manager is responsible for informing the LQCD CPM of all unplanned outages or abrupt maintenance shutdowns as well as planned routine maintenance and upgrades.

### ***5.2 Schedules and Milestones***

BNL 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. BNL 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 BNL will be reported monthly to the LQCD Project Office.

### ***5.3 Decommissioning of Dedicated Hardware***

The LQCD Integrated Project Team (IPT) will determine planned decommissioning dates of dedicated 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.

### ***5.4 Performance Feedback***

On an annual basis, the LQCD Project will provide feedback to BNL regarding the level of satisfaction for services provided in accordance with the approved Statement of Work. Areas for consideration include system performance, user support, user documentation, responsiveness in addressing issues, and delivery of performance information as documented above.



## **Appendix A. BNL Statement of Work – FY2018**

This Statement of Work (SOW) describes the resources that Brookhaven National Laboratory (BNL) will provide to the LQCD Project to support the goals and objectives defined in the LQCD Project Execution Plan.

This agreement covers LQCD operations for FY2018 (October 1, 2017 through September 30, 2018). It is anticipated that BNL will continue to provide services through the end of the LQCD-ext II project, which is currently funded through September 30, 2019. It is also anticipated that the LQCD Project will continue to provide BNL with funding at planned levels through the end of the LQCD Project, subject to funding availability. It is understood that the statement of work and budget for future years will be reviewed and revised annually.

### ***FY18 Scope of Work for BNL***

The FY2018 scope of work for BNL includes:

- Overseeing and coordinating LQCD Project activities at BNL. (Site Manager)
- Serving as the primary liaison between the LQCD Project Office and BNL Institutional Cluster management. (Site Manager)
- Participating in technical activities related to computing architectures that may be relevant to LQCD user needs. Associated activities include participating in the maintenance of the LQCD Acquisition Strategy, evaluating evolving technologies for suitability to LQCD needs, assisting with LQCD-specific performance benchmarking, and participating in the development and review of LQCD Annual Computing Resource Plans. (Site Manager and Site Architects)
- Providing Institutional Cluster computing cycles and data storage at agreed-upon levels to meet the needs of the LQCD Project. Based on the successful experience with the 40-node allocation from the BNL-IC, the LQCD Project intends to increase its allocation of BNL Institutional Cluster services. Details regarding the FY18 allocation levels and costs for computing and storage, by specified architectures, are contained in separate MOUs describing the agreement between the BNL Computational Science Initiative as Operator of the BNL Institutional Computing Cluster resource, the LQCD Project, and other projects, groups, and departmental stakeholders of the system. Three such MOUs will be executed in FY2018 for the LQCD Project:
  1. BNL Institutional Cluster (BNL-IC) Memorandum of Understanding, dated 12/21/17.
  2. BNL Knights Landing (BNL-KNL) Memorandum of Understanding, dated 12/21/17.
  3. BNL Skylake (BNL-SL) Cluster Memorandum of Understanding, dated 12/21/17.

Work on the LQCD Project will be performed in accordance with the LQCD Project Execution Plan and the Work Breakdown Structure, subject to the availability of funding from OHEP and ONP. Detailed activities to be performed at BNL 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.

***FY18 Resource Allocations and Costs***

The following tables document the FY18 allocation of Institutional Cluster Computing Resources that BNL will provide to the LQCD Project, as well as the cost that the Project will pay BNL for these services, subject to funding availability.

Table 1. Institutional Cluster Compute Allocations

<b>Line</b>	<b>System</b>	<b>Compute Allocation (# nodes)</b>	<b>Compute Allocation Period</b>	<b>Unit Cost (\$/node-hr)</b>	<b>Compute Allocation (node-hrs)</b>	<b>Compute Allocation Cost</b>
1	BNL-IC	40	Oct 1, 2017 – Sep 30, 2018	\$0	349,440	\$0
2	BNL-IC	25	Jan 14, 2018 – Sep 30, 2018	\$0.99	155,400	\$153,846
3	BNL-IC	15	Feb 1, 2018 – Sep 30, 2018	\$0.99	86,760	\$85,892
4	BNL-KNL	66	Jan 14, 2018 – Sep 30, 2018	\$0.51	410,256	\$209,231
5	BNL-SL	64	Feb 26, 2018 - Sep 30, 2018	\$0.91	331,776	\$301,916
	<b>Total</b>				<b>1,333,632</b>	<b>\$750,885</b>

Table 2. Institutional Cluster Storage Allocation

<b>Storage Allocation (TB)</b>	<b>Storage Allocation Period</b>	<b>Unit Cost (\$/TB-mo.)</b>	<b>Storage Allocation Cost</b>
200	Jan 14, 2018 – Sep 30, 2018	9.50	\$16,150

As described in Section 4.2, BNL has agreed to provide a 40-node allocation on the BNL-IC at no cost to the Project through September 2018. This allocation is shown in line 1 of Table 5.

The BNL Skylake (BNL-SL) cluster system, shown in line 5 of Table 1, is in the process of being procured, installed, and commissioned and is projected to be ready for production use in late February. The production release date relies on many factors and LQCD usage of the cluster will only begin after the successful completion of all commissioning activities and the production release of the system. Accordingly, the actual allocation start date for the BNL-SL may vary from that shown above.

BNL will invoice the LQCD Project monthly for cluster and storage usage. Each invoice will document the number of node-hours delivered per BNL cluster resource, as well as the number of node-hours consumed per approved user.

***BNL Site Management Personnel***

- BNL Site Manager: Tony Wong
- BNL Site Architects: Alex Zaytsev and Bob Mawhinney

Tony Wong and Alex Zaytsev are BNL employees. Bob Mawhinney is a Visiting Senior Scientist at the RIKEN-BNL Research Center at BNL and an employee of Columbia University. Some functions of these roles may be delegated to others.

***BNL Technical Personnel***

With the transition from operating dedicated hardware to purchasing time on institutional clusters, the cost for technical personnel is now included in the cost per node-hour associated with each cluster.

***FY18 Budget and Effort Summary***

Table 3 summarizes the FY18 budget to cover the work described in this SOW. Project funds provided to BNL in FY17 have been earmarked to cover expenses incurred in FY18.

Table 3. LQCD-ext II Budget for BNL Activities in FY18

<b>Item</b>	<b>Budget (\$K)</b>
Personnel	60
Travel	5
Computing Cluster Allocations	750
Storage	20
Total	835

The LQCD Project will provide fully-loaded salary support for 0.2 FTEs of effort to execute the Site Manager and Site Architect duties as defined in the LQCD-ext II Project Execution Plan. In addition, the Project will provide funding to cover travel expenses of the Site Manager and Site Architect to attend the annual USQCD All-hands Collaboration Meeting and the Annual DOE Review of the LQCD-ext II project. Finally, the Project will pay BNL for computing and storage services delivered at the levels defined in Tables 1 and 2 above.

## **Appendix B. 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	Contractor Project Manager
CSI	Computational Science Initiative
DOE	Department of Energy
EVMS	Earned Value Management System
FNAL	Fermi National Accelerator Laboratory, a.k.a. Fermilab
IC	Institutional Cluster
IPT	Integrated Project Team
JLAB	Thomas Jefferson National Accelerator Facility, a.k.a. Jefferson Lab
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
SOW	Statement of Work
WBS	Work Breakdown Structure