Log number (provided by project office): **CR16-01**		
1) DATE: [date of origination] 10/7/2015 Text last revised: 6/10/2016	**2) Laboratory/WBS**: 1.1.3.2 FY17 BNL plan and deploy system* 3.1.3.2 FY17 TJNAF plan and deploy system 1.1.4.2 FY18 BNL plan and deploy system* 2.1.4.2 FY18 FNAL plan and deploy system 2.1.5.2 FY19 FNAL plan and deploy system * does not exist in baseline WBS	**3) ORIGINATOR:** Robert D. Kennedy, Associate Contract Project Manager

4) DESCRIPTION OF CHANGE

This change request (CR) proposes to add cluster-hosting at Brookhaven National Laboratory (BNL) to the LQCD-ext II Computing Project without reducing the computing delivered by the project.

The LQCD-ext II Computing Project baseline called for compute clusters to be acquired and operated at two sites, FNAL and TJNAF in FY16-19. It also called for the IBM BG/Q system at BNL to be retired in the FY17-18 timeframe, at which time BNL would be left with no LQCD computing resources. After the project was baselined, the LQCD Project Office learned of BNL's interest to begin hosting LQCD clusters in the FY17 time frame. Adding a third site to host LQCD clusters has the potential to increase overall operations costs, which would result in a reduction in the overall computing delivered by the project in order to fit within the approved baseline funding profile. However, in the interest of maintaining a stronger and more diverse project, the LQCD Project Office concurs with BNL's request and plan to provide LQCD cluster-hosting facilities. Therefore, working with the Integrated Project Team, the Project Office has devised a plan to include BNL in the cluster acquisition rotation in a manner that maintains the total computing delivered by the project while remaining within the approved funding profile.

In the new project plan, the annual computing hardware acquisition strategy has been changed to include BNL in the acquisition rotation along with TJNAF and FNAL in a way that balances acquisition funds across the three sites while reducing procurement overheads as much as possible (see Section 5 for details). The revised plan maintains the same level of *Delivered Computing* (a project Key Performance Indicator (KPI)) as the updated baseline "2-Sites" forecast through the inclusion of additional in-kind contributions by BNL. Nevertheless, changes are required for two of the project's KPIs, *Deployed Computing* and *Delivered Computing,* based on the altered cost and timing profile in the acquisition strategy.

5) TECHNICAL DESCRIPTION AND PRIMARY MOTIVATION OF CHANGE:

The LQCD Project Office explored options to allow cluster-hosting at three sites instead of two within the approved project funding profile while still meeting the project milestones. The integrated project team developed an impact study which determined the cost and performance impact for a number of planning models:

- Baseline: Exactly the output of the project CD process. No FY15 actuals or known changes included.
  - o Filename: "LQCD-ext II $14M Cost Forecast (2014-07-07)_CD-2_FINAL.xlsx"

- Reference: Baseline with FY15 actuals included. This is the starting point for subsequent models.

- 2-Sites: Reference with all known changes to future plans included, such as overhead rates. This is the updated and improved forecast of the project if it proceeds with the project baseline.

- 3-Sites FY-Aligned: Adds cluster-hosting using a one-site-per-year rotation as shown in Table 1.

- 3-Sites FY-Straddle: Add cluster-hosting using a "3-sites in 4 years" rotation as shown Table 1. The exact split of acquisition funds is determined by the constraint that acquisition funds are equally distributed amongst the three sites, which forces the split to be closer to 30%-70% in FY17 and FY18.

Table 1. Summary of Planning Models Considered in Impact Study

Plan Name	FY16	FY17 procurement	FY18 procurement	FY19 procurement
Baseline	JLab	JLab (FY16 options)	FNAL	FNAL (FY18 options)
Reference	JLab	JLab (FY16 options)	FNAL	FNAL (FY18 options)
2-Sites	JLab	JLab (FY16 options)	FNAL	FNAL (FY18 options)
3-Sites FY-aligned	JLab	BNL	FNAL	JLab
3-Sites FY-straddle	JLab	1/3 JLab (FY16 options); 2/3 BNL	2/3 BNL (FY17 options); 1/3 FNAL (slide to FY19)	FNAL

The impact study quantified the impact of each of these models on the project KPIs, especially on the *Delivered Computing* metric. The Cost Forecast for each model was updated to determine the level of acquisition funding available year-by-year in that model. The Cost Forecasts take into account the detailed interplay of staff and equipment costs using a spreadsheet model refined by the project during ten years of execution. Using the existing acquisition architecture plan in each year (funds split 50% CPU and 50% GPU by dollars), the expected performance for each model was determined in the Performance Forecast workbook. The IPT determined that both of the 3-Sites models were viable if some means could be found to offset the decrease in *Delivered Computing* due to the added cost of an additional cluster-site host. However, the "3-Sites FY-Straddle" model was preferred since it most equally distributed project acquisition funds among the three sites.

The LQCD Project Office and BNL management negotiated the in-kind contributions necessary to offset the impact of increased cost overheads on the amount of *Delivered Computing* given a fixed project budget. BNL has pledged the following in-kind contributions (see LQCD-BNL MOU for details) to allow the project to deliver the same level of computing as the updated baseline "2-Sites" project forecast would deliver:
- Allocation of about 40 BNL Institutional Cluster nodes, time-averaged, for the duration of the project.
  - USQCD can use up to all of the BNL IC nodes, so long as the monthly average is on target.
- 100-200 TB of performant disk storage on the 1 PB Institutional Cluster storage system.
- 0.5 PB of older disk storage for scratch and/or intermediate-term storage.
- $80k in disk storage in FY17 and FY18.
- Use of BNL mass storage systems, including tape robot and intermediate disk caching system.

With the BNL in-kind contributions, the plan outlined in this CR maintains the same level of *Delivered Computing* as the "2-Sites" forecast, which represents an updated forecast using the baseline project acquisition strategy. These contributions also ensure that the BNL site will offer similar capabilities to users as the existing cluster-hosting sites at FNAL and TJNAF.

6) ASSESSMENT OF COST IMPACT: impact on the project sub-totals

Estimated Labor Cost Increase ($k): 1,011 Difference between Baseline budget and proposed budget
Estimated M&S Cost Increase ($k): (75) includes hardware refresh and repairs, travel
Estimated Equipment Cost Increase ($k): (992) includes computing and storage equipment purchases
Estimated Management Reserve Increase ($k): 56 Note that MR is based on Labor costs
Estimated Project Cost Increase ($k): 0

Note: The values shown for estimated M&S and equipment costs mostly reflect the estimated value of the additional planned BNL in-kind contributions.

Estimated Scientific Impact (high, medium, low): Low (USQCD Executive Committee concurrence, 5/12/2016)

7) ASSESSMENT OF SCHEDULE IMPACT AND AFFECTED MILESTONES:

The new acquisition plan changes the project baseline as follows:
- FY17: Funds split: ~1/3 TJNAF (options on FY16 purchase) + ~2/3 BNL (new cluster purchase)
  - **Changes to baseline**:
  - FY17 Funds were going to TJNAF, now split as shown.
  - Added a BNL acquisition WBS item. There was none in baseline.

- FY18: Funds split: ~2/3 BNL (options on FY17 purchase) + ~1/3 FNAL (prepare acquisition documents in FY18, but execute the acquisition in FY19)
  - **Changes to baseline**:
  - FY18 Funds were going to FNAL, now split as shown.
  - Added a BNL acquisition WBS item. There was none in baseline.
  - FNAL FY18 acquisition using 1/3 of funds will be deferred to FY19, but planning for the FY19 acquisition will begin in FY18.

- FY19: Funds to FNAL per baseline (make available in FY19 Q2, offsets deferred 1/3 deployment in FY18)
  - **Change to baseline**:
  - FNAL FY19 acquisition was to be available in FY19 Q4, but will now be available in FY19 Q2 if funding is available on time. This early deployment offsets the deferral of 1/3 of FY18 funds.

The new *Deployed Computing* and *Delivered Computing* KPIs for Conventional and Accelerated computing are documented in Appendix D of the PEP. The new BNL IC allocation is treated as an FY16 GPU acquisition in the *Deployed Computing* KPI. The change to these KPI's is summarized below (format: Baseline value → CR value). Values increased by at least 10% are marked in green, and values decreased by at least 10% are marked in red.

Deployed Computing [TFlop/s]	FY15 (none)	FY16 ID 7, 8	FY17 ID 15, 16	FY18 ID 23, 24	FY19 ID 31, 32
Conventional	0	10 → 13	14 → 9	28 → 26	36 → 23
Accelerated	0	39 → 85	52 → 36	106 → 100	136 → 89

Delivered Computing [TFlop/s-years]	FY15 ID 1, 2	FY16 ID 9,10	FY17 ID 17, 18	FY18 ID 25, 26	FY19 ID 33, 34
Conventional	88	68 → 91	70 → 73	85 → 63	80 → 73
Accelerated	92	67 → 73	95 → 117	145 → 178	290 → 267

The project will meet its existing total *Delivered Computing* KPI as stated. However, the *Deployed Computing* KPI is being lowered by 7% (see Performance Forecast for details) as the project is deploying less computing earlier than planned in order to deliver the integrated compute cycles in the project time window.

The target date for *Deployed Computing* in FY19 (ID 33, 34) is changed from "Available in Q4 FY19" to "Available in Q2 FY19", reflecting the expedited acquisition at FNAL which begins in late FY18 and concludes as soon in FY19 as funds become available.

8) ASSOCIATED DOCUMENTATION

The following controlled documents are affected by the proposed changes in this CR:
- LQCD-BNL MOU: MOU documents are in the folder "CR16-01 MOUs"
  - Updated boilerplate text and the new BNL in-kind contributions described in Section 5.

- LQCD-FNAL MOU
  - Updated boilerplate text.

- LQCD-TJNAF MOU
  - Updated boilerplate text.

- Project Execution Plan (PEP): The PEP document is in the folder "CR16-01 PEP"
  - Updated boilerplate text and changed costs and performance values throughout the document
  - Updated project organization charts as necessary to reflect organizational changes since the project baseline – unrelated to this CR
  - Adjusted Acquisition Funding levels, found in Appendix C
  - Changed *Deployed* and *Delivered Computing* KPIs in Appendix D
  - Updated Tables and Figures throughout the PEP, based on this CR
  - Integrated the already approved PEP addendum text – unrelated to this CR

- WBS: WBS documents are in the folder "CR16-01 WBS"
  - Added new BNL "plan and deploy system" tasks
  - Changed FNAL acquisition timing and plan for FY18 and FY19

Additional documentation available to support this Change Request:
- Cost and Performance Forecasts, described in Section 5. Documents are in the folder "CR16-01 Forecasts".

9) SECONDARY IMPACT AND OTHER COMMENTS:

Impact: This change request ensures that all three host laboratories will continue to be actively engaged in the LQCD project through FY19. This will make both the project and the USQCD collaboration stronger and more diverse in the long run. The project will be able to work with the BNL Computational Science Initiative at BNL as well as comparable activities at FNAL and TJNAF to take advantage of a broader base of expertise and leverage resources acquired from different funding sources. Finally, USQCD will gain from a more diverse set of advocates and support personnel for the scientific projects and programs it supports.

Change Control Level: Level 4
This change request involves a change of ">$250k in budget distribution between DME and SS O&M costs" since $854k of budget would be moved from equipment acquisition to operations (Labor, M&S, MR) as shown in Section 6. This qualifies the change request for change control level 4 according to the project change control process defined in the Project Execution Plan. This level requires approval up to and including the Federal Acquisition Executive.

Risk Assessment:
1. BNL is new to LQCD cluster-hosting, and something unexpected happens:
   a. BNL has successfully operated high throughput clusters for RHIC and Atlas-T1.
   b. BNL will be operating the large BNL IC cluster before its first LQCD cluster acquisition.
   c. Project accepts remaining risk exposure.

2. Additional user support will be required at BNL due to far more cluster users than BG/Q users:
   a. BNL has successfully supported large user populations for the RHIC and Atlas-T1 programs.
   b. The BNL IC will attract cluster users in late FY16, so the increase in LQCD users should be more spread out over time than a step function when the FY17 BNL LQCD cluster becomes available.
   c. BNL has presented a plan to support a larger LQCD cluster user base based on its modern and existing tools and sufficient personnel, similar to FNAL and TJNAF.
   d. Project is tracking BNL's progress on the Documentation action item from the FY15 User Survey.
   e. Project accepts remaining risk exposure.

3. More cluster sites will mean smaller clusters due to limited acquisition funds:
   a. The BNL IC allocation of about 40 nodes is time-averaged, so this allows USQCD users access to a larger machine (200 nodes) for shorter fractions of time.
   b. Independent of this CR, the project is always considering how to best address the diverse computing needs of USQCD projects, including demand for larger homogeneous clusters, greater memory resources, and new more cost-effective technologies as the marketplace evolves.
   c. Project continues to explore how to mitigate this risk.

10) APPROVALS

Level 4 – Acquisition Executive _____ Date _____

Level 3 – Federal Project Director _____ Date _____

Level 2 - Chair, Change Control Board _____ Date _____

Level 1 - Contractor Project Manager _____ Date _____

11) CCB Approvals

Amber Boehnlein
O APPROVED   O DISAPPROVED   _____
                                                                                              Signature/date

William Boroski
O APPROVED   O DISAPPROVED   _____
                                                                                              Signature/date

Steve Gottlieb
O APPROVED   O DISAPPROVED   _____
                                                                                              Signature/date

Kerstin Kleese van Dam
O APPROVED   O DISAPPROVED   _____
                                                                                              Signature/date

Paul Mackenzie (CCB Chair)
O APPROVED   O DISAPPROVED   _____
                                                                                              Signature/date

Rob Roser
O APPROVED   O DISAPPROVED   _____
                                                                                              Signature/date