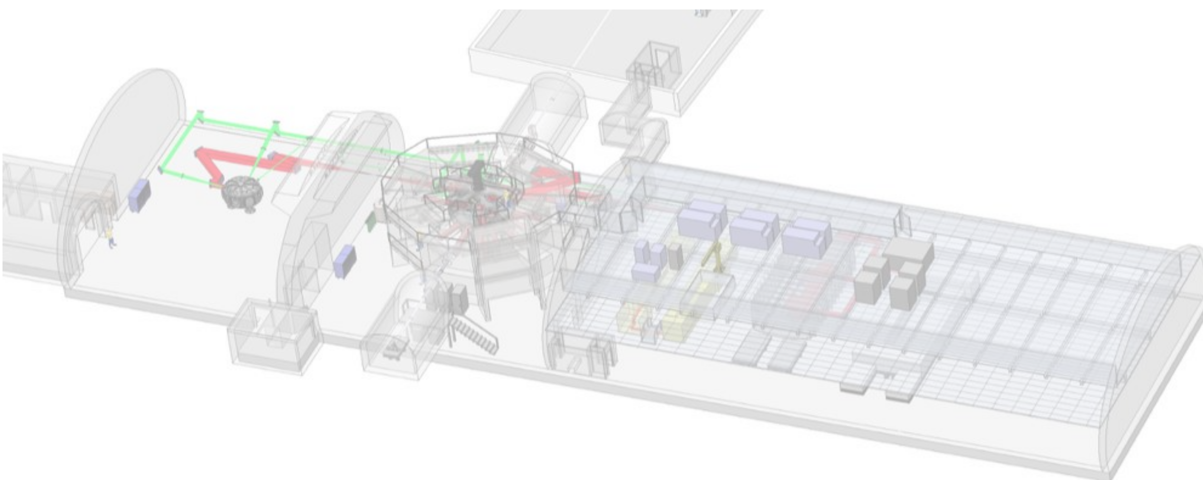
RRL On-Project Requirements Verification Plan

MEC Upgrade – Rep Rated Laser System

September 19, 2022, v0



Document Approval: **Date Approved**

Originator: Tom Spinka, RRL Subsystem Manager	Thomas M. Spinka Thomas M. Spinka (Oct 20, 2022 17:22 PDT)
Approver: Liz Hill, HE-LP Subsystem Manager	
Approver: Steven Yang, Integrated Lasers System Manager	Steven Yang Steven Yang (Oct 23, 2022 20:06 PDT)
Approver: Jing Yin, Controls System Manager	Jing Yin Jing Yin (Oct 21, 2022 16:40 PDT)
Approver: Tyler Johnson, Laser Controls System Manager	Tyler Johnson Tyler Johnson (Oct 21, 2022 09:55 PDT)
Approver: Corey Hardin, Experimental System Manager	Corey Hardin Corey Hardin (Oct 24, 2022 14:04 PDT)
Approver: Kai LaFortune, Systems Engineer	Kai LaFortune Kai LaFortune (Nov 14, 2022 12:37 PST)
Approver: Alex Wallace, Controls Architect	T. Alex Wallace T. Alex Wallace (Nov 11, 2022 13:18 PST)
Approver: Mikael Martinez, Project Engineer	Mikael Martinez Mikael Martinez (Oct 24, 2022 15:00 PDT)
Approver: Marc Weibel, ES&H Manager	Marc Weibel Marc Weibel (Nov 15, 2022 12:37 PST)
Approver: Ian Evans, ES&H Major Projects Department Head	Ian Evans Ian Evans (Oct 21, 2022 10:30 PDT)
Approver: Al Cook, Quality Assurance Engineer	Al Cook Al Cook (Oct 21, 2022 11:33 PDT)
Approver: Alan Conder, Project Technical Director	Alan Conder Alan Conder (Nov 7, 2022 07:24 PST)

Revision History

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R0	TBD	Original Release

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1. Scope

This documents the MEC-U Project's decisions regarding the on-project requirements and verification and validation plan for the Rep-Rated Laser (RRL) system during the construction and activation phases at both LLNL and SLAC. The on-project requirements are distinct from the design requirements that were reviewed in the RRL System Requirements Review (SRR). On-project requirements document the minimum intended demonstration criteria at various stages of the Project. The design requirements represent the final intended performance of the RRL system, some aspects of which will not be demonstrated or achieved until after the MEC-U Project is complete. The activation plans to be executed at LLNL (prior to shipment) and after RRL installation (in the SLAC XEH) are also described.

2. Context and Goals

The primary goal of the FES-sponsored MEC-U Project is to deliver a world-leading experimental science capability. Conceptually, the Project is responsible to FES for demonstrating the Project Threshold Key Performance Parameters (Threshold KPPs), which represent integrated capabilities of delivering laser light from both the LLNL RRL and the LLE HE-LP laser systems to the x-ray target chamber (TCX) in the x-ray target area (TAX) within the to-be-excavated eXtreme Experimental Hall (XEH). These KPPs are currently in draft form (until the CD-2 milestone of the FES-sponsored 413.3(b) Project) and contain only 3 requirements relevant to the RRL system, as shown in Table 2.1. The other important and relevant requirement for Project completion is that the hardware produced and delivered on-Project must be shown (via analysis) to be capable of meeting a higher performance level consistent with a set of Objective KPPs.

Key Performance Parameter	Threshold	Objective
Pulse Energy	≥30J	≥150J
Pulse Duration	≤300fs	≤150fs
Repetition Rate	≥1Hz	≥10Hz

Table 2.1: Draft Threshold and Objective KPPs relevant to the RRL. Note that these parameters are measured in TCX, and the RRL subsystem must be able to accommodate the passive optical losses of the Beam Transport system to meet these Project KPP requirements.

Flowback of requirements from TCX to the RRL subsystem is complete, but preliminary. Significant effort has been made to be comprehensive, but detailed subsystem design in either Beam Transport (BT) or the RRL may alter the final requirements at the interface between the RRL subsystem and the RRL Beam Transport subsystems at either the RRL SP BT Treaty Point or the RRL LP BT Treaty Point. Some of these key interface requirements (physical location, beam size, collimation, image relay, polarization, etc.), will be documented in the Facility Interface Control Document (Facility ICD).

In addition to the three laser performance requirements that are derived from Project KPPs, LLNL conducted an extensive effort to capture and document additional latent requirements for the RRL subsystem via: discussions with future experimenters / users, technical exchanges with other Project subsystem leads (particularly those that have direct interfaces to the RRL), clarification of the flagship experiments documented in the Project CDR document, prior knowledge of expectations of high peak-power laser systems, and via standard Systems Engineering tools and techniques including additional stakeholder interviews. The additional expectations for the RRL system identified via this process were synchronized with the Project

Objective KPPs and distilled into a RRL Design Requirements document. The full set of Design Requirements were reviewed in detail at the LLNL RRL System Requirements Review (SRR) in June/July of 2022.

However, there is intentionally a significant difference between the Threshold KPPs and the Design Requirements. The purpose of this document is to clarify what requirements verification will take place as part of the MEC-U Project scope, and what performance ramping scope (towards meeting the more stringent Objective KPPs) will be deferred to a performance ramping effort to be executed under operations funds after MEC-U Project completion.

3. Design, Construction, Activation, and Acceptance Testing at LLNL

3.1. Design

The RRL System will be defined and then designed during the design phase of Project, occurring between CD-1 and CD-2. The RRL system design requirements define the level of performance (at the RRL system boundaries) and functionality desired and/or required to meet the Mission Need as defined at CD-0, and consistent with the draft project Objective KPPs (defined in the Target Chamber for MEC-U). The derived RRL system requirements have been presented in a System Requirements Review (SRR), conducted at LLNL with collaborator (SLAC and LLE) institutional involvement during June and July of 2022. The SRR documented and approved (in draft form) the full and complete set of Design Requirements for the RRL system.

The RRL system design will be documented prior to CD-2 using the LLNL Integrated Product Review Board (IPRB) Design Review process that is intended to ensure that the as-designed RRL system hardware will be capable of meeting the design requirements (documented in the SRR) with high confidence. The LLNL IPRB process includes a Conceptual Design Review (CDR), a Preliminary Design Review (PDR), and a Final Design Review (FDR) that is mostly consistent in scope to the SLAC 80% Design Review.

3.2. Construction

Once the MEC-U Project successfully completes the CD-3 process, the construction phase of the Project will begin. The majority of the RRL hardware will be first constructed, integrated, and commissioned as subsystems, at LLNL. The primary exception to this is the Compressor subsystem, which is described in more detail in Section 3.5.

Key RRL subsystems will go through a standardized Installation Qualification (IQ), Operational Qualification (OQ), and Performance Qualification (PQ) process to ensure that the subsystems are ready for integration with the other key RRL subsystems. IQ, OQ, and PQ details are determined at the subsystem level. The IQ serves the purpose of confirming that the relevant subsystem hardware and software are physically present (installed) and capable of being configured as required for operations. The OQ confirms the basic functionality of a system or subsystem (motors move on command, laser diodes emit when pulsed, cameras provide images to a readback, etc.). The PQ ensures that the integrated performance of a particular subsystem or set of subsystems meets the requirements for that subsystem (subsystem outputs are confirmed to be within the required specifications, e.g., chiller flow rate >12GPM at 13degC, coolant pressure drop is 1psi < P_{drop} < 2psi, laser energy >0.55J, etc.).

3.3. Activation

When the RRL subsystems have been performance qualified, the Activation phase will begin in the LLNL construction facility for the RRL system, though the subsystems may not all be ready for activation at the same time. The purpose of the activation phase is to exercise the RRL system and demonstrate its major functions to gain confidence that it can operate as intended, and to collect sufficient benchmarking data to ground model-based extrapolation to Objective KPP performance levels, some of which will not be demonstrated until the completion of the MEC-U Project and the hardware is transitioned to Operations.

In this phase, measurements or even measurement campaigns will be conducted to assess performance and benchmark models to as-built performance. This process may also involve decisions to spend Project time and resources on demonstrating or improving the performance of subsystems (or even integrated portions of the RRL system) beyond the Threshold KPPs level to gain experience in different operating regimes, understand the performance ramping process and risks, and to minimize the need for and amount of model-based (and/or measurement-based) extrapolation.

This will have additional benefits of providing training opportunities for SLAC operations staff on the as-built hardware and exercising the system (in a responsible way) in the physical location with the greatest access to the RRL laser Subject Matter Experts (SMEs) at LLNL.

Specific verification activities, along with tests and measurements to be conducted are itemized in Table 7.1 and Table 7.2. In addition to the laser performance tests, Activation will include testing, configuration, and qualification of the Laser Protection System which will need to be operational for protecting laser hardware during many Activation activities. EPICS compatibility will be tested to the extent reasonably possible at LLNL, given the constraints of the surrogate SLAC controls test environment that the RRL will be operating in while at LLNL.

3.4. Factory Acceptance Test

The Factory Acceptance Test is intended to be a single isolated event on the MEC-U Project that takes place at LLNL and conclusively demonstrates that the integrated and activated RRL laser system performance will exceed that required to meet the Project Threshold KPP performance level. The Factory Acceptance Test will involve collaborator SME observations and may include both live demonstrations and reviews with off-Project SMEs for improved credibility and impartiality. *Integrated performance during the Factory Acceptance Test will significantly exceed the Threshold KPP level to balance on-Project risks with credible extrapolation to Objective KPP performance levels.*

The number and scope of the parameters measured during the Factory Acceptance Test is intentionally much more limited than the number of measurements and measurement campaigns completed during the Activation phase to avoid duplication of effort and to simplify the communication of the approach to Project completion to key reviewers.

Specific completion criteria for the Factory Acceptance Test are captured in Table 7.1 and Table 7.2.

3.5. Compressor Testbed at LLNL

Full-aperture, full-energy compressed-pulse performance testing or demonstrations at LLNL are not currently planned on-Project. The physical size of the compressor vessel and the effort involved in installation, activation, and integration of the in-vacuum compressor at LLNL is infeasible due to space constraints in the currently intended build facility, and its implementation is not expected to provide sufficient return-on-investment. Prior experience has demonstrated that, if attempted at LLNL on a sub-scale energy beam, the quality of results would be questionable and of limited value due to laser beam residual wavefront deformations and diffraction effects at small beam size.

This does potentially increase the Project risks associated with short pulse performance, which needs to be mitigated as much as reasonable. There is expected to be significant value in producing and integrating the parts of the compressor vessel interior in an in-air compressor testbed that integrates production mounting hardware and optomechanics and allows for training opportunities as well as the development of functional procedures for installation and activation of compressor components and Line Replaceable Unit (LRU) assemblies. This set of activities that will be conducted at LLNL is known collectively as the LLNL Compressor Testbed. Integration of the in-vacuum full-aperture compressor with the rest of the RRL and with SP Beam Transport will be done for the first time at SLAC in the XEH.

4. Shipping and Installation

The successful completion of the LLNL Factory Acceptance Test, along with additional documentation and engineering deliverables, will serve as a transition between laser development and optimization efforts and laser deployment to the XEH.

After beneficial occupancy of the XEH (all facility work is completed, cleanrooms clean/active, etc.), RRL subsystem hardware shipping, receiving, and installations can begin.

The RRL system will be shipped to SLAC after the successful LLNL Factory Acceptance Test and not before the XEH is ready to receive it. The design of the RRL system is intended to be modular and “shippable”, such that substantial portions or entire subsystems of the system can remain in final assembly configuration during shipment. Interface panels (where reasonable) will facilitate rapid cabling disconnect (at LLNL) and reconnect (at SLAC), and much of the laser hardware will remain installed on optical tables. Depending on weight and configuration, controls hardware may remain installed in racks, and interconnect cables may be pre-routed and pre-tested.

The RRL is likely to be the last major MEC-U system to start installation activities and will incorporate SLAC and LLNL labor resources. All work performed on-site at SLAC (described in Sections 4 and 5) will be conducted under SLAC’s established work control, safety, and facility management and scheduling processes.

After the physical installation of hardware, cabling connections, software, etc., modified versions of the original IQ, OQ, and PQ tests of subsystems will be executed as determined by subsystem and commissioning leads.

5. Activation and Acceptance Testing in the XEH

5.1. Reactivation

In the reactivation phase, subsystem and commissioning leads will do initial testing of subsystems and integration, but this is intended to be a more abbreviated version of the LLNL activation phase with much less emphasis on reconfiguration and optimization. Notably, this phase will not yet include the RRL compressor integration. This Reactivation task will take another snapshot of laser system performance (up to the compressor input in SP mode, and up to the RRL LP BT Treaty Point in LP mode) to verify that there were no unexpected impacts of shipping and reinstalling the system into the XEH.

Additional changes to the LLNL configuration that may require additional effort include (but are not limited to): environmental parameters (absolute temperature, humidity), additional or altered cabling connections, cable lengths, coolant pressures (due to relocation of utilities to the mezzanine), etc.

The controls interfaces and environment will be potentially the largest change for this phase. The emulated SLAC controls environment deployed during construction and activation at LLNL will be replaced with the real SLAC controls environment and hardware, which may require significant effort to reintegrate.

5.2. Site Acceptance Test Part 1

When fully installed and re-activated, the RRL will undergo the first part of the Site Acceptance Test. This is intended as a short-duration, integrated test that will mirror only the SP mode aspects of the LLNL Factory Acceptance Test as much as reasonably possible. Some details may be different (for example, the temporary SP diagnostics may not make sense to redeploy in the XEH) but changes will be kept to a minimum. Successful completion of this portion of the Site Acceptance Test will confirm that the RRL is ready for integration with the Compressor. This first part of the Site Acceptance Test will not include LP mode tests, though both the prior Reactivation and subsequent Site Acceptance Test Part 2 phases will include LP mode verifications.

5.3. Compressor Integration

Prior to this next phase of the installation and activation of the RRL hardware in the XEH, the Compressor subsystem IQ, OQ, and PQ activities will take place. Examples of these activities include: verification of all control points and actuators on optomechanical components (in vacuum), compressor coarse and fine alignment with offline laser sources, characterization of the dispersion characteristics (via a Group Delay Diagnostic measurement, or similar), activation of automatic alignment systems, integration with local controls hardware, activation of vacuum components and vacuum interface and control, and beam dump verification. Importantly, it is also anticipated that the compressor will be integrated with the primary on-shot SP diagnostics suite.

Once the compressor subsystem (with SP diagnostics) is fully qualified and the rest of the RRL system has completed the first portion of the Site Acceptance Test, the two will be integrated for the first time. This will involve co-alignment, verification of compression, online throughput measurements, operations into a local beam dump for verification of the SP diagnostics configuration, average power operations and stray light management, etc.

At the conclusion of the Compressor Integration phase, the operational characteristics and expected performance of the entirety of the RRL system will be effectively characterized, models will be benchmarked, and diagnostics calibrated. The RRL system will be ready for operations after the final portion of the Site Acceptance Test, which is intended to be concise demonstration.

5.4. Site Acceptance Test Part 2

The second portion of the Site Acceptance Test will certify that the RRL System is complete and meets all On-Project requirements. Operation in both SP and LP modes will be qualified per Table 7.1 and Table 7.2.

Successful completion of the Site Acceptance Test will lead to the Project integration and commissioning phase; it also gates the primary hand-off of responsibility for all RRL hardware from LLNL to SLAC. LLNL will continue to participate in and support RRL-related activities through the end of the MEC-U project (and beyond), but the leadership and stewardship role for the RRL hardware and configuration will transition to SLAC.

5.5. Integration and Commissioning

After the handoff of primary responsibility for the RRL hardware, SLAC will take responsibility for integration of the RRL system with the rest of the MEC-U facility. LLNL SMEs will continue to support the Project through consultation and participation in integration activities. This integration and commissioning phase will test the Concept of Operations of experiments in the new facility, including topics such as alignment to experimental target chambers, wavefront optimization, target acquisition, data management and pipeline, timing measurement and control, target back-reflection monitoring, target chamber beampath selection, multi-laser shot operations, data pipeline setup, management, access controls, remote and extended duration operations, etc.

SLAC will define and execute integrated experiments to demonstrate: 1) the completion of Project Threshold KPPs, and 2) the capabilities of the as-delivered hardware towards Project Objective KPPs, utilizing data and models developed and benchmarked in commissioning activities and/or previous portions of the Project.

6. Post-Project Performance Ramping

After the conclusion of the MEC-U 413.3(b) Project, when the MEC-U facility has fully transitioned to operations, it is anticipated that performance ramping (from the level at which the RRL was commissioned on-Project to the full Objective KPP performance level) will be desired to support experiments at the higher level of laser performance. These performance ramping activities may need to be interleaved with experimental operations. It is expected that SLAC will lead the RRL laser performance ramping activities with LLNL involvement, but the scope, timing, and prioritization of these activities is outside of the scope of this document.

7. Verification and Validation Tables

At the LLNL Final Design Review, the design requirements will be verified to the greatest extent feasible using analysis and sub-scale offline prototype demonstrations. This is intended to confirm that the design is consistent with the level of performance listed in the first data column in Table 7.1 below, which are consistent with MEC-U Project Objective KPPs. The values listed are current as of the date of this document and are only intended as succinct summaries of the full requirements text reviewed at the SRR and to be documented and maintained in Jama. The Jama requirements database (the official MEC-U Project requirement repository) and relevant configuration managed ICDs should be referenced as the sources of truth. Activation activities at LLNL will include measurements or measurement campaigns to assess the performance of the system in the manner described, but with the potential for adjusting and/or improving the system during this phase. The LLNL Factory Acceptance Test will explicitly verify only a subset of the performance requirements, but within a limited-duration test in which modifications to the RRL system are minimized. Activation at SLAC will mimic the LLNL activation effort, but with the compressor subsystem integrated. Site Acceptance Testing mimics the LLNL Factory Acceptance Test and, in conjunction with other engineering deliverables, will conclude with transitioning the RRL hardware to SLAC responsibility for directing MEC-U Integration activities. See Sections 3.3, 3.4, 5.2, and 5.4 for additional descriptions.

7.1. Short-Pulse Mode

	Design Requirements	Activation Activities at LLNL	LLNL Factory Acceptance Test	Activation Activities in XEH	SLAC Site Acceptance Test
Polarization	>95% linearly polarized, s-pol (parallel to gravity)	Test uncompressed at the Power Amplifier aperture at lower energy. Scaling analysis to full aperture / energy.			
Beam Size and Aperture[1]	330×330mm FWHM, TBD×TBDmm Clear Aperture	Measure beam size and shape at compressor input equivalent plane.		Measure at compressor input plane and at RRL SP BT Treaty Point.	
Spatial Contrast	<1.65 p-m, goal of <1.4 p-m	Measure high-resolution NF at compressor input equivalent plane via a temporary stretched output diagnostic pickoff.		Analysis of fully implemented, dedicated, on-shot SP NF Diagnostic.	

[1] Current decisions about the configuration of the post-G4 intentional residual spatial chirp may impact both the beam size and spatial contrast. Because this is a compressor design choice, the beam size measured at LLNL will remain square, but the beam size and nominal shape will necessarily be different at SLAC at the RRL SP BT Treaty Point if non-zero spatial chirp is implemented.

	Design Requirements	Activation Activities at LLNL	LLNL Factory Acceptance Test	Activation Activities in XEH	SLAC Site Acceptance Test
Energy Range and Adjustability	>164J, adjustable to <16J at the RRL SP BT Treaty Point ***Threshold KPP: 30J (at TCX)***	Test uncompressed energy to >100J at power amp output. Model-based extrapolation analysis to nominal >164J compressed.	>100J at power amp output	Test compressed energy to >82J at RRL SP BT Treaty Point. Test may rely on calibrated on-shot energy diagnostic. Model-based extrapolation analysis to nominal >164J compressed.	>82J at output of compressor
Energy Stability	<3% rms, goal of <1% rms over >5min	Test via calibrated temporary energy diagnostic.		Test via calibrated on shot pulse energy diagnostic.	
CWL	1060±5nm	Test via diagnostic spectrometer viewing a temporary power amp output pickoff.		Test via the on-shot SP spectral diagnostic.	
Compressed Pulse Duration and Duration Range	<150fs, Incomplete compression to >5ps ***Threshold KPP: 300fs***	Analysis to <200fs based on the Fourier transform of the measured amplified spectrum via spectral diagnostic above. Dispersion of stretcher and PWC will be verified via group delay diagnostic.	<200fs FWHM TL from power amp output spectrum	Measure <200fs via SS SHG-FROG (or equivalent) in short pulse diagnostics package.	<200fs FWHM
Interpulse Power / Prepulse Contrast	$<10^{-12}$ before -9ns $<10^{-10}$ before -200ps $<10^{-8}$ before -50ps $<10^{-6}$ before -2.5ps max TBD_MW between +2ms (N) and -2ms (N+1)	Measure unseeded energy and temporal shape at power amp output. Measure unseeded FF spatial distribution.		Measure via dedicated scanning 3rd-order cross-correlator to before -200ps. Measure prepulse landscape to before -10ns via fast photodiode.	
Peak Power	>1.08PW	Analysis to >0.40PW (peak power in this context is defined as Energy / FWHM duration). Energy is equivalent energy at compressor output (extrapolated via best available data on compressor throughput) divided by the FT of the measured spectrum on the temporary power amp output spectrometer.	Goal of >0.40PW via analysis	Measure >0.40PW via the dedicated on-shot SP Energy and SP Pulse Duration data (derived from the SS SHG-FROG or equivalent).	>0.40PW at output of compressor

	Design Requirements	Activation Activities at LLNL	LLNL Factory Acceptance Test	Activation Activities in XEH	SLAC Site Acceptance Test
Spatial Strehl	>0.4	Analysis via measured uncompressed residual wavefront measurement from temporary main beam power amp output diagnostics.		Analysis via measured on shot residual wavefront on dedicated SP output diagnostics.	
Pointing Stability / Drift	Passive <7.5µrad rms, Active <1.5µrad rms at RRL SP BT Treaty Point, goal of <2.5µrad rms at TCC	Measure passive and actively stabilized pointing performance via centroid of FF on temporary power amp output diagnostics.		Measure passive and actively stabilized pointing performance via centroid of FF on dedicated SP output diagnostics.	
Timing	<200fs rms jitter, adjustable from -500ps to +10ps at TCC	Demonstrate oscillator lock-to-clock capability against an external RF oscillator. Demonstrate adjustment of oscillator rep rate via DC voltage trim on PZT.	Demonstrate lock-to-clock and TimeScan. Goal of <200fs rms jitter w.r.t. RF oscillator	Demonstrate oscillator lock-to- clock capability against LCLS facility clock. to test jitter against LCLS timing signal using SLAC standard hardware.	Demonstrate lock-to-clock and TimeScan. Goal of <200fs rms jitter w.r.t. LCLS clock
Repetition Rate Modes	10Hz, 3⅓Hz, 1Hz, 0.1Hz, SoD and Burst Mode ***Threshold KPP: 1Hz***	Demonstration of operations in SoD (derived from 0.1Hz), Burst Mode (derived from 0.1Hz), and at 3⅓Hz. Also demonstrate capability of SOD and Burst Mode derived from 3⅓Hz.	0.1Hz w/ SoD and Burst Mode, 3⅓Hz	Demonstration of operations in SoD (derived from 0.1Hz), Burst Mode (derived from 0.1Hz), and at 3⅓Hz. Also demonstrate capability of SOD and Burst Mode derived from 3⅓Hz.	0.1Hz w/ SoD and Burst Mode, 3⅓Hz
All Rqmts Met on >99% of Shots	>99% of shots		Goal of >95% of shots		Goal of >95% of shots

Table 7.1: Key laser performance requirements when the RRL is configured for operating in SP mode, and how and at what level and location the laser performance is verified.

7.2. Long-Pulse Mode

	Design Requirements	Activation Activities at LLNL	LLNL Factory Acceptance Test	Activation Activities in XEH	SLAC Site Acceptance Test
Pulse Shaping Range / Resolution	>65ns window, <250ps resolution, TBDbit	Subsystem demonstration of fiber front end capabilities (nJ level) and front end temporally shaped pulses (J level).		Subsystem demonstration of fiber front end capabilities (nJ level) and front end temporally shaped pulses (J level).	
Power Accuracy	<1% from request above 10% of peak, 1min average	Test with 10ns FIT and TBD pulse shape using dedicated on-shot temporal diagnostics.		Test with 10ns FIT and TBD pulse shape using dedicated on-shot temporal diagnostics.	
Power Stability (Shot-to-Shot)	<1.5% rms at 10:1 pulse shape at 2w (2ns boxcar, 500ps boxcar goal)	Test with 10ns FIT and TBD pulse shape using dedicated on-shot temporal diagnostics.		Test with 10ns FIT and TBD pulse shape using dedicated on-shot temporal diagnostics.	
Polarization	>95% linearly polarized, s-pol (parallel to gravity)	Test at lower 2w energy at RRL LP BT Treaty Point. Analysis for extrapolation to higher extraction energy.			
Beam Size and Aperture	64×64mm FWHM, 74×74mm Aperture	Test using dedicated on-shot NF diagnostics.		Test using dedicated on-shot NF diagnostics.	
Spatial Contrast	<1.5 p-m	Measure high-resolution NF at RRL LP BT Treaty Point via diagnostic pickoff.		Measure high-resolution NF at RRL LP BT Treaty Point via diagnostic pickoff.	
Energy Range and Adjustability	>200J in 10ns FIT, adjustable down to <10J at RRL LP BT treaty point	Test to >50J 2w in 10ns FIT. Test to >TBDJ 2w in TBD pulse shape. Analysis via energetics model-based extrapolation to >200J 2w in 10ns FIT.[2]	Goal >50J 2w in 10ns FIT, goal >TBDJ 2w in TBD pulse shape	Test to >50J 2w in 10ns FIT. Test to >TBDJ 2w in TBD pulse shape. Analysis via energetics model-based extrapolation to >200J 2w in 10ns FIT.	Goal >50J 2w in 10ns FIT, goal >TBDJ 2w in TBD pulse shape
CWL	526.5±1.5nm (2w)	Test (1w) oscillator cw wavelength.			

[2] Demonstration of the pulse shaping capabilities will be via a mixture of demonstrations at the Front End level and a pair of energetics demonstrations with different pulse shapes. The primary pulse shape for most activities is the nominal 10ns Flat-In-Time pulse, but a second pulse shape (still TBD) will also be tested through the power amplifier and conversion crystal to 2w.

	Design Requirements	Activation Activities at LLNL	LLNL Factory Acceptance Test	Activation Activities in XEH	SLAC Site Acceptance Test
SSD[3]	Yes, design TBD	Inspection. All other LP mode demonstrations and tests occur while SSD is active.	SSD bandwidth at FE goal >TBDGHz 10-90% Enclosed Energy		SSD bandwidth at FE goal >TBDGHz 10-90% Enclosed Energy
Pointing Stability / Drift	Passive <15urad, no active	Test using dedicated on-shot FF diagnostics.		Test using dedicated on-shot FF diagnostics.	
Timing	±500ns Range, <50ps jitter	Demonstration where all other tests will occur with output triggered via external TTL signal. Measure 2w timing jitter against TTL trigger rising edge.	Stable timing w.r.t. external trigger signal, goal <50ps rms jitter	Demonstration. Show timing adjustment capability. Test jitter against LCLS timing signal using SLAC hardware.	Stable timing w.r.t. external trigger signal, goal <50ps rms jitter
Repetition Rate Modes	10Hz, 3⅓Hz, 1Hz, 0.1Hz, SoD and Burst Mode	Demonstration of operations in SoD (derived from 0.1Hz), Burst Mode (derived from 0.1Hz), and at 3⅓Hz. Also demonstrate capability of SOD and Burst Mode derived from 3⅓Hz.	0.1Hz w/ SoD and Burst Mode, 3⅓Hz	Demonstration of operations in SoD (derived from 0.1Hz), Burst Mode (derived from 0.1Hz), and at 3⅓Hz. Also demonstrate capability of SOD and Burst Mode derived from 3⅓Hz.	0.1Hz w/ SoD and Burst Mode, 3⅓Hz
All Rqmts Met on >99% of Shots	>99% of shots		Goal of >95% of shots		Goal of >95% of shots

Table 7.2: Key laser performance requirements when the RRL is configured for operating in LP mode, and how and at what level and location the laser performance is verified.

[3] The implementation details of Smoothing by Spectral Dispersion (SSD) for the RRL in LP mode are still being determined. The intent for activation and acceptance testing is to verify the SSD modulation parameters before the majority of the other performance testing, because SSD will remain active for as many subsystem and integrated RRL system tests during most Activation activities and for the duration of the Acceptance Tests (at LLNL and SLAC).