I. DAVIS-BACON ACT COVERED □

A. Construction alteration, repair, including painting over $2,000.
B. Installation involving substantial construction.
C. Demolition when indispensable and preliminary to scheduled new construction.
D. Other□

II. DAVIS-BACON ACT APPLICABLE □

Section 1801 of the Atomic Energy Act, Work pertaining to the new construction, however, pursuant to Section 1804 of the Atomic Energy Act as amended by the National Energy Policy Act of 1992 (P.L. 102-486) the Davis-Bacon will apply.

The work is essentially with or for:
A. Supplies and Equipment
B. Servicing or maintenance
C. Decontamination
D. Demolition
E. Railroad and RR employees
F. Performance outside USA
G. State or political subdivision
H. Other□

III. DAVIS-BACON ACT NON-COVERED □

A. Estimated to cost $2000 or less [705.2204(a)(1)]
B. Operational and maintenance activities or very closely and directly involved therewith [705.2204(a)(2)]
C. Off a routine or recurring nature to preserve usefulness.
D. Affordably, modification, installation, replacement, rearrangement, connection, etc., of machinery and equipment [705.2204(c)(3)]
E. Experimental development of equipment processes and devices, including installation [705.2204(a)(4) & 705.2204(a)(5)]
F. Experimental work - Peaceful uses [705.2204(a)(5) & 705.2204(c)(1)]
G. Emergency work - Fire, Flood, etc., and to sustain operations [705.2204(a)(6)]
H. Decontamination [705.2204(a)(7)]
I. Demolition (No construction activity is anticipated or contemplated in the site within five years)
J. Burial of Contaminated Material [705.2204(a)(8)]
K. Supplies and Equipment
L. Servicing or maintenance [705.2204(a)(9)]
M. Railroad and RR employees
N. Performance outside USA
O. State or political subdivision
P. Other□

Note: The Service Contract Act applies to all contracts entered into by the United States or the District of Columbia, the principal purpose of which is to furnish services in the United States through the use of service employees. DOE M&O contractors are exempted from the SCA, but M&O contractors and M&O subcontractors are not exempted from the SCA. [705.2210]

IV. PROFESSIONAL SERVICES □

A. □ Engineering
B. □ Procurement
C. □ Project Management and Oversight
D. □ Other□

V. EXCEPTION □

The Committee recommends that the Head of Contracting Activity determine that participation includes work and services which involve material risk to continuity of operations, to life or property, to or DOE operating requirements [705.2204(a)(23)]

Approves □ Disapproves □

Manager □

Date □

Reference number [□] paragraphed above subject to Part 850 of DOE Acquisition Regulations (483.6(b)(Rev 4/30)
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Revision Record

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<th>Rev</th>
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<tr>
<td>00</td>
<td>Initial Release</td>
<td>August 2005</td>
</tr>
<tr>
<td>01</td>
<td>Added Experimental Equipment section 8, and section 1.3.4 in Appendix A</td>
<td>July 2009</td>
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General Description

The Linac Coherent Light Source (LCLS) is a new X-Ray facility located at the Stanford Linear Accelerator Center (SLAC). The LCLS utilizes the SLAC linac and produces sub-picosecond pulses of short wavelength x-rays with very high peak brightness and full transverse coherence. The first two-thirds of the SLAC linac are used for injection into the PEP-II storage rings. The last one-third will be converted into a source of electrons for the LCLS. The electrons will be transported to the undulator hall and through 130-m undulator system. In passing through the undulators, the electrons will be bunched by the force of their own synchrotron radiation to produce an intense, spatially coherent beam of x-rays, tunable in energy from 0.8 keV to 8 keV. The LCLS will include two experimental halls as well as x-ray optics and infrastructure necessary to make use of this x-ray beam for research in a variety of disciplines such as atomic physics, materials science, plasma physics and biosciences. A laboratory office complex will also be constructed to house the scientific and support staff for the new LCLS X-Ray facility.

The project is described in the LCLS conceptual Design Report dated April 4, 2002, an overview of the engineering portion of which is provided as Appendix A to this document.

The following recommendations are based on this review of the subject work in light of the relevant regulations and previous Davis-Bacon recommendations for similar work on SLD, PEPII, and SPEAR3 projects. It should be noted that in this document the term “Photon Beamline” refers to an arrangement of vacuum components which transports the intense X-ray photon beams to experimental stations, whereas the term “beam line” refers to an assembly of magnets, instrumentation and related utilities for the containment and definition of a charged particle beam.

The LCLS project, for the purposes of Davis-Bacon determination, will be described in two major systems; Conventional Facilities and Technical Systems. The material that follows is separated into the following headings.

1. Conventional Facilities
2. LCLS Preparation, Removal and Related Tasks
3. Utilities
4. LCLS Technical Component Installation
5. Radio Frequency System
6. Controls System
7. Vacuum Systems
8. Experimental Equipment

Appendix A: LCLS Project, Conventional Facilities and Technical Component Installation Summary
Appendix B: Clarification of LCLS Davis-Bacon Non-covered activities

All work under the recommendation “Covered” on the following pages is deemed to fall within one or more of the descriptions found at DEAR 970.2204-1-1.
1. Conventional Facilities

The LCLS Conventional Facilities include the construction of seven major facility buildings and modifications to some existing support facilities of the Stanford Linear Accelerator Center (SLAC). Each of these facilities will contain infrastructure to support the technical components such as, water, power, and HVAC, as well as a cable plant system. The major conventional facilities of the LCLS are the Sector 20 Facility, Magnetic Measurement Facility (MMF), Beam Transport Hall (BTH), Undulator Hall, Beam Dump & Front End Enclosure (FEE), Near Experimental Hall (NEH), and Far Experimental Hall (FEH). A number of support buildings will be constructed to house the control racks and Instrumentation & Control (I&C) for the technical components. The last facility to be built will be the Central Laboratory and Office Complex (CLOC) which will contain conference rooms, laboratory space, and will house approximately 250 staff members. (See Appendix A, Sections 1.1)

1.1 Covered

A. Earthwork, excavation, tunneling, and construction of facility buildings.
B. Installation of HVAC systems
C. Construction of Service buildings to house mechanical HVAC and control racks
D. Installation of conventional AC electrical distribution to and within facility buildings
E. Installation of new Fire Detection System
F. Unloading of fabricated components
G. Installation of gas distribution piping within buildings and tunnels
H. Construction of parking areas for new facilities
I. Construction or modification of research yard by-pass roadway
J. Re-location of office equipment and materials in buildings scheduled for demolition
K. Re-location of shielding and/or material stockpiles requiring Riggers to alternate areas at SLAC to prepare for LCLS construction
L. Transportation of components from the staging area to the LCLS installation site

1.2 Non-Covered

A. Intentionally left blank (moved to 1.1J)
B. Re-location of hardware storage to alternate areas at SLAC
C. Re-location of shielding and/or material stockpiles not requiring Riggers to alternate areas at SLAC
D. Disconnection of utilities in buildings scheduled for demolition
E. Temporary repositioning or removal of existing services in tunnels to facilitate access
F. Temporary removal of Personnel Protection System cabling
G. Temporary removal of Machine Protection System cabling  
H. Remote fabrication and assembly of all components  
I. Taking components from the fabrication site to the LCLS storage/holding area away from the LCLS construction site  
I.1 Relocating components from the RCA storage areas to the staging area outside of the LCLS construction site  
J. Vacuum system leak checking and performance checkout
2. LCLS Preparation, Removal and Related Tasks

To prepare for construction of new LCLS buildings and installation of new technical components, existing equipment that lies within the LCLS construction boundary will be removed. This includes modification or removal of buildings, removal of scientific equipment such as magnets, vacuum chambers, support stands, and power supplies and cabling, and radiation shielding. Changes will be made to some equipment, which will be utilized in the new construction and re-installed. Some of the equipment will be removed, refurbished, and reinstalled in the tunnels. Some tunnel shielding will be removed to clear the area for new construction (See Appendix A, Sections 1.1.3)

2.1 Covered

A. Removal of components which will not be re-used. Approximately 400 tons, hardware and concrete shielding, are involved.
B. Demolition of existing buildings
C. Removal of un-used cable and cable trays
D. Re-location of office equipment and materials in buildings scheduled for demolition
E. Re-location of shielding and/or material stockpiles requiring Riggers to alternate areas at SLAC to prepare for LCLS construction
F. Transportation of components from the staging area to the LCLS installation site

2.2 Non-Covered

A. Temporary removal of shielding blocks, existing vacuum components, and equipment, which will be re-installed at a later date
B. Disconnection of utilities from technical equipment
C. Disconnection of vacuum flanges and connection of blank-off flanges
D. Removal of vacuum pumping systems
E. Temporary repositioning or removal of existing services in tunnels to facilitate access
F. Intentionally left blank – moved to 2.1.D
G. Re-location hardware storage to alternate areas at SLAC
H. Re-location of shielding and/or material stockpiles not requiring Riggers to alternate areas at SLAC
I. Temporary removal of Personnel Protection System cabling
J. Temporary removal of Machine Protection System cabling
K. Remote fabrication and assembly of all components
L. Taking components from the fabrication site to the LCLS storage/holding area away from the LCLS construction site
L.1 Relocating components from the RCA storage areas to the staging area outside of the LCLS construction site
M. Vacuum system leak checking and performance checkout
N. Modifications SLAC Fire Alarm system in altered buildings
O. Modifications or alterations to utilities or equipment which require Radiation Worker Training and special procedures for contamination containment
3. Utilities

Utilities are the magnet power supplies, low conductivity water (LCW), cooling water, AC and DC services, various control units and instrumentation racks and manifolds for control and timing and data acquisition sensors and systems for machine protection and personnel protection, and the cable plant of various kinds in the surface buildings, utility pads, and tunnels (See Appendix A, sections 1.1.3, 1.1.8, 1.2)

3.1 Covered

A. Connection of LCW between existing header and new distribution lines.
B. Installation of LCW pumps, heat exchangers, temperature controls, and associated piping.
C. Removal of existing high voltage AC distribution cables.
D. Removal of existing power supplies.
E. Installation of main AC services to the power supply and I&C areas.
F. Mechanical installation of racks in buildings, including AC and DC services to the racks
G. Installation of all conduit and cable trays.
H. Installation of fixed permanent cabling in tunnels, and between tunnels and the control and power supply areas. All cables to be terminated on trunk side of cross-connect racks in the control area, including I&C and magnet power supplies.
I. Installation of main DC power cables.
J. Installation of termination blocks in the tunnels.
K. Mechanical installation of magnet power supplies, both standing and in racks.
L. Installation of AC services, water cooling, and DC cables to magnet power supplies.
M. Installation of cable between the terminal blocks within the control room or power supply room racks and the tunnel trunk line terminal blocks.
N. Upgrade of existing Fire Detection System.
O. Unloading of fabricated components.
P. Transportation of components from the staging area to the LCLS installation site

3.2 Non-Covered

A. Remote fabrication and assembly of all components
B. Taking components from the fabrication site to the LCLS storage/holding area away from the LCLS construction site
B.1 Relocating components from the RCA storage areas to the staging area outside of the LCLS construction site
C. Maintenance of existing LCW system.
D. Temporary removal of air and liquid nitrogen distribution
E. Connection of equipment to main utilities.
F. Installation of experimental measurement, control and data acquisition electronics into racks, or in other locations around the experimental apparatus at the experimental site.
G. Intra-rack wiring and cross-connects between all equipment within electronic racks.
H. Installation, termination and connection of cables requiring precise timing and control, involving laboratory equipment.
I. Installation, termination and connection of all high voltage measurement, control and signal cables for experimental equipment.
J. Installation, termination and connections of fiber optic cables for experimental equipment
K. Installation of ancillary equipment installed in support of the experimental equipment.
L. Installation and connections on the distribution side of cross-connects, manifolds, plenums and headers including, but not limited to, liquids, gases, and liquid and gaseous cryogens
M. Vacuum connections of flanges and pump-down of components
N. Connection of vacuum pumping system
O. Vacuum system leak checking and performance checkout
P. Modifications or alterations to utilities or equipment which require Radiation Worker Training and special procedures for contamination containment
4. Technical Component Installations

The Injector system provides the electron source and waveguide structure to accelerate particles into the existing SLAC Linac. The magnet system in LCLS provides the guide fields that bend and focus charged particles, using the LCLS dipoles and quadrupoles. This section describes the installation of beam transport components with related subsystems, hardware, cabling, and instrumentation. (See Appendix A, Section 1.2, 1.3 for further details).

The LCLS project will provide a new Injector system, new magnet and vacuum system, new beamline, which will transport the electron beam through the Undulator system which in turn generates intense X-rays that are transported to the experimental stations through Photon Beamlines. Installation of new chicane magnets in the existing SLAC Linac requires removal of existing accelerator waveguide structures and replacing those sections with modified accelerator sections or chicane magnets.

4.1 Covered

A. Marking of general support locations on floor from existing tunnel monuments (also called “blue line” alignment).
B. Installation of fixed supports (typically grouted in place).
C. Installation of vacuum chambers which are not part of an assembly, if any.
D. Installation of main DC power cables.
E. Installation of trunk cables terminated on the trunk side of cross-connect blocks.
F. Installation of power supplies.
G. Installation of beam diagnostics units, if not part of a vacuum assembly.
H. Unloading of fabricated components.
I. Transportation of components from the staging area to the LCLS installation site

4.2 Non-Covered

A. Refurbishment of existing power supplies
B. Remote fabrication of all components
C. Taking components from the fabrication site to the LCLS storage/holding area away from the LCLS construction site
C.1 Relocating components from the RCA storage areas to the staging area outside of the LCLS construction site
D. Precision alignment of components prior to vacuum connections
E. Pump down of vacuum components
F. Precision alignment of components after pump down
G. Connection of equipment to main utilities
H. Installation of experimental measurement, control and data acquisition electronics into racks, or in other locations around the experimental apparatus at the experimental site.
I. Intra-rack wiring and cross-connects between all equipment within electronic racks.
J. Installation, termination and connection of cables requiring precise timing and control, involving laboratory equipment.
K. Installation, termination and connection of all high voltage measurement, control and signal cables for temporary diagnostic equipment used for startup and/or commissioning.
L. Installation, termination and connections of fiber optic cables for temporary diagnostic equipment used for startup and/or commissioning.
M. Installation and connections on the distribution side of cross connects, manifolds, plenums and headers including, but not limited to, liquids, gases, and liquid and gaseous cryogens.
N. Vacuum connections of flanges and pump down of components
O. Connections of vacuum pumping system
P. Vacuum system leak checking and performance checkout
Q. Installation of vacuum Laser transport tubes
5. Radio Frequency System

Description

The Radio Frequency System transfers energy into the electron beam causing it to accelerate. To achieve the design high beam currents in the injector and linac, the radio frequency system must be modified. This will be accomplished by the re-distribution of the RF vacuum waveguide network system and accelerating structure cavities in the Linac. (See Appendix A, Sections 1.2.3, 1.3.1)

5.1 Covered

A. Installation of low-level RF in support building.  
B. Installation of klystron support structures in support building.  
C. Installation of high conductivity cooling system for klystrons.  
D. Installation of high conductivity cooling systems for the RF loads.  
E. Installation of RF cavities (358 or 476 MHz)  
F. Installation of klystrons (358 or 476 MHz)  
G. Unloading of fabricated components  
H. Transportation of components from the staging area to the LCLS installation site

5.2 Non-Covered

A. Temporary removal and reinstallation of existing components.  
B. Removal of existing RF system for reuse elsewhere.  
C. Remote fabrication and assembly of all components.  
D. Taking components from the fabrication site to the LCLS storage/holding area away from the LCLS construction site  
D.1 Relocating components from the RCA storage areas to the staging area outside of the LCLS construction site  
E. Alignment of RF cavities.  
F. Installation of vacuum RF waveguide  
G. Connection of klystrons and cavities to waveguides, including waveguide vacuum windows  
H. Connection of vacuum chamber to RF cavities  
I. Precision alignment prior to vacuum connections.  
J. Vacuum connections of flanges and pump-down of components  
K. Connection of vacuum pumping systems  
L. Precision alignment of components after vacuum pump down.  
M. Connection of equipment to main utilities  
N. Installation of experimental measurement, control and data acquisition electronics into racks, or in other locations around the experimental apparatus at the experimental site
O. Intra-rack wiring and cross-connects between all equipment within electronic racks.

P. Installation, termination and connection of cables requiring precise timing and control, involving laboratory equipment

Q. Installation, termination and connection of all high voltage measurement, control and signal cables for temporary diagnostic equipment used for startup and/or commissioning

R. Installation, termination and connections of fiber optic cables for temporary diagnostic equipment used for startup and/or commissioning.

S. Installation of ancillary equipment installed in support of the temporary diagnostic equipment used for startup and/or commissioning.

T. Installation and connections on the distribution side of cross connects, manifolds, plenums and headers including, but not limited to, liquids, gases, and liquid and gaseous cryogens.

U. Vacuum system leak checking and performance checkout.

V. Installation of SLAC 5045 and X-band klystrons
6. Controls System

Description

Existing and new control systems, devices, and related equipment and software govern and regulate the active components that affect the charged particles. This experimental equipment will require some modification. (See Appendix A, Sections 1.2.7 & 1.3.2)

6.1 Covered

A. Mechanical installation of racks in buildings, including AC and DC services to the racks.
B. Installation of trunk cables terminated on the trunk side of cross-connect blocks.
C. Unloading of fabricated components
D. Transportation of components from the staging area to the LCLS installation site

6.2 Non-Covered

A. Remote fabrication and assembly of all components.
B. Taking components from the fabrication site to the LCLS storage/holding area away from the LCLS construction site
B.1 Relocating components from the RCA storage areas to the staging area outside of the LCLS construction site.
C. Connection of BPM cables to BPM feed-through
D. Intra-rack wiring and cross-connects, including all equipment within electronics racks
E. Connection of technical components to cables at tunnel trunk line terminal blocks
F. Connection of equipment to main utilities.
G. Installation of experimental measurement, control and data acquisition electronics into racks, or in other locations around the experimental apparatus at the experimental site
H. Installation, termination and connection of cables requiring precise timing and control, involving laboratory equipment.
I. Installation, termination and connection of all high voltage measurement, control and signal cables for temporary diagnostic equipment used for startup and/or commissioning.
J. Installation, termination and connections of fiber optic cables for temporary diagnostic equipment used for startup and/or commissioning.
K. Installation of ancillary equipment installed in support of the temporary diagnostic equipment used for startup and/or commissioning.
L. Installation and connections on the distribution side of cross connects, manifolds, plenums and headers including, but not limited to, liquids, gases, and liquid and gaseous cryogens
M. Vacuum connections of flanges and pump-down of components.
N. Connection of vacuum pumping system
O. Vacuum system leak checking and performance checkout.
7. Vacuum Systems

Description

The electron beam accelerates in a highly evacuated copper vacuum structure confined by the guiding magnetic and RF fields. The Linac accelerator structures have welded vacuum connections which require in-field grinding and welding. High Vacuum S-band waveguide structures form the network to transmit the RF energy from the Klystrons to the RF Gun and accelerator structure cavities. Ultra-High Vacuum beamline transport equipment guide the particle beam by use of focusing magnets, these sections are flanged so that they can be bolted together, with stainless steel bellows between them to allow for thermal excursions. The accelerator and beamline vacuum chamber sections contain various vacuum producing and monitoring devices so that they are best regarded as machines in their own right, rather than simple pipes. The vacuum components selected, the commensurate requirements on cleanliness and contamination-free manipulation, and the precision with which the vacuum systems must be assembled, require several special installation processes. (See Appendix A, Sections 1.2, 1.3.1)

7.1 Covered

A. Initial installation of vacuum chambers that are not part of an assembly, if any.
B. Unloading of fabricated components.
C. Transportation of components from the staging area to the LCLS installation site

7.2 Non-Covered

A. Remote fabrication and assembly of accelerator structures, electron Gun, straight sections, transport vessels, Undulator vacuum components, and associated components for Injector, Linac, transport facility, and Photon Beamlines.
B. Taking components from the fabrication site to the LCLS storage/holding area away from the LCLS construction site
B.1 Relocating components from the RCA storage areas to the staging area outside of the LCLS construction site
C. Final connection of accelerator structures, electron Gun, straight sections, transport vessels, Undulator vacuum components, and associated components to each other.
D. Connection of vacuum chambers to RF cavities
E. Connection of instrument sections
F. Temporary removal and reconnection of injection equipment
G. Temporary removal and reconnection of Photon Beamline components
H. Connection of equipment to main utilities
I. Installation of experimental measurement, control and data acquisition electronics into racks, or in other locations around the experimental apparatus at the experimental site.

J. Intra-rack wiring and cross-connects between all equipment within electronic racks

K. Installation, termination and connection of cables requiring precise timing and control, involving laboratory equipment

L. Installation, termination and connection of all high voltage measurement, control and signal cables for temporary diagnostic equipment used for startup and/or commissioning

M. Installation, termination and connections of fiber optic cables for temporary diagnostic equipment used for startup and/or commissioning

N. Installation of ancillary equipment installed in support of the temporary diagnostic equipment used for startup and/or commissioning.

O. Installation and connections on the distribution side of cross connects, manifolds, plenums and headers including, but not limited to, liquids, gases, and liquid and gaseous cryogens.

P. Connection of vacuum pumping system

Q. Vacuum connections of flanges and pump-down of components

R. Vacuum system leak checking and performance checkout.
8. LCLS Experimental Equipment

Description

The experimental equipment and instruments of LCLS need to be installed and tested on an on-going basis and interleaved with operations of the machine. Each experimental instrument contains elements that are designed to be removed from the beamline to extend or alter the science capability, and as such are connected to utilities (electrical and mechanical) in a fashion to allow quick disconnection.

Each experimental instrument requires a control system and cable plant to enable operations of the instrument remotely. The control system is commonly made up of a set of equipment racks with cable trays and cables run to each component and AC power to each rack.

Installations activities require the participation of the professional personnel who are responsible for the experimental equipment or instruments (See Appendix A, Section 1.3.4).

8.1 Covered

A. None

8.2 Non-Covered

A. Installation of experimental equipment and instruments into the LCLS hutches or stations.
B. Installation of cable plant and racks required to operate the experimental instrument.
C. Installation of supports to mount experimental equipment and instruments inside the hutch.
D. Installation and connection of vacuum hardware that is part of the experimental instrument.
E. Installation, connection and testing of robotic equipment that is part of the experimental equipment or instrument.
F. Connection of instrument sections to the beamline or other instrument sections.
G. Installation of raised flooring in hutch as needed to clear floor mounted components in support of the experimental equipment.
H. Installation of laser systems, controls and laser safety system
I. Connection of equipment to main utilities
J. Installation of experimental measurement, control and data acquisition electronics into racks, or in other locations around the experimental apparatus at the experimental site.
K. Intra-rack wiring and cross-connects between all equipment within electronic racks
L. Installation, termination and connection of cables requiring precise timing and control, involving laboratory equipment
M. Installation, termination and connection of all high voltage measurement, control and signal cables for temporary diagnostic equipment used for startup and/or commissioning

N. Installation, termination and connections of fiber optic cables for temporary diagnostic equipment used for startup and/or commissioning

O. Installation of ancillary equipment installed in support of the temporary diagnostic equipment used for startup and/or commissioning.

P. Installation and connections on the distribution side of cross connects, manifolds, plenums and headers including, but not limited to, liquids, gases, and liquid and gaseous cryogens.

Q. Connection of vacuum pumping system

R. Vacuum connections of flanges and pump-down of components

S. Vacuum system leak checking and performance checkout.
### Glossary of Terms/Acronyms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
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<tbody>
<tr>
<td>Accelerator housing</td>
<td>A structure or tunnel, often underground, for the containment of a beam line and related equipment. Access during operations is usually limited or excluded.</td>
</tr>
<tr>
<td>Beamline</td>
<td>An assembly of magnets, instrumentation and related utilities for the containment and definition of a charged beam.</td>
</tr>
<tr>
<td>Photon Beamline</td>
<td>An assembly of vacuum chambers used to contain and transport synchrotron radiation to an experimental station.</td>
</tr>
<tr>
<td>BPM</td>
<td>Beam Position Monitor</td>
</tr>
<tr>
<td>DEAR</td>
<td>Department of Energy Acquisition Regulation</td>
</tr>
<tr>
<td>DLWG</td>
<td>Disk-Loaded-Waveguide, a UHV accelerator cavity structure powered by microwave energy used to move a charged beam.</td>
</tr>
<tr>
<td>HV</td>
<td>High Voltage</td>
</tr>
<tr>
<td>I&amp;C</td>
<td>Instrumentation and Control</td>
</tr>
<tr>
<td>Klystron</td>
<td>An electron tube (microwave generator)</td>
</tr>
<tr>
<td>LCW</td>
<td>Low Conductivity Water, used to cool beamline components, RF systems and power supplies</td>
</tr>
<tr>
<td>MW</td>
<td>Megawatt</td>
</tr>
<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>RWT</td>
<td>Radiation Worker Training</td>
</tr>
<tr>
<td>Shielding</td>
<td>Material, such as concrete, lead, polyethylene or steel, in various regular shapes, used for radiological protection</td>
</tr>
<tr>
<td>SLAC</td>
<td>Stanford Linear Accelerator Center</td>
</tr>
<tr>
<td>Synchrotron Radiation</td>
<td>Intense photons which are a by-product of the bending of electrons</td>
</tr>
<tr>
<td>UHV</td>
<td>Ultra-High-Vacuum, technical components that require special cleaning and handling requirements</td>
</tr>
<tr>
<td>Utilities</td>
<td>LCW, air lines, electrical power, liquid nitrogen lines, instrumentation and control wiring</td>
</tr>
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</table>
Appendix A

LCLS Project and Installation Summary

The LCLS Project comprises elements from the Photo injector which generates the source particles of the LCLS, accelerated through the 150 MeV Linac (Sector 20 Injector), bent on axis with the main SLAC Linac and further bunched and accelerated up to 14.3 GeV, then transported into the ~130 meter long Undulator Hall. After passing through the Undulator system the electrons are bent downward into a beam dump while the photons continue through the Front End Enclosure and into the first experimental hutch located in the Near Experimental Hall (NEH) Facility. There will be 3 experimental Hutches in the NEH for scientific study and another 3 Hutches in the Far Experimental Hall (FEH). Electron and Photon beams will be transported to the NEH and FEH via Ultra-High-Vacuum (UHV) piping systems incorporating a series of valves, diagnostics, UHV pumps, Personnel Protection System (PPS) stoppers, ultra high vacuum sections and controls.

The LCLS Conventional Facilities include the construction of seven major facility buildings and modifications to some existing support facilities of the Stanford Linear Accelerator Center (SLAC). Each of these facilities will contain infrastructure to support the technical components such as, water, power, and HVAC, as well as a cable plant system. The technical facilities of the LCLS can be divided into six major sections comprising the Injector, Linac and Linac to Undulator (LTU), Undulator, Beam Dump and FEE, and X-Ray Transport Optics and Diagnostics (XTOD) systems.

1.1 LCLS Conventional Facilities - Overview

The LCLS Conventional Facilities include the construction of seven major facility buildings and modifications to some existing support facilities of the Stanford Linear Accelerator Center (SLAC). Each of these facilities will contain infrastructure to support the technical components such as, water, power, and HVAC, as well as a cable plant system.
LCLS Facilities from BTH to Far Experimental Hall

The major conventional facilities of the LCLS are the Sector 20 Facility, Magnetic Measurement Facility (MMF), Beam Transport Hall (BTH), Undulator Hall, Beam Dump & Front End Enclosure (FEE), Near Experimental Hall (NEH), and Far Experimental Hall (FEH). A number of support buildings will be constructed to house the control racks and Instrumentation & Control (I&C) for the technical components. The last facility to be built will be the Central Laboratory and Office Complex (CLOC) which will contain conference rooms, laboratory space, and will house approximately 250 staff members.
The LCLS Central Laboratory Office Complex

The overall LCLS Conventional Facilities (CF) construction schedule is shown below. Along with the seven major facility projects are additional modifications to existing SLAC systems in support of the LCLS technical components.

LCLS CF Construction Schedule
1.1.1 LCLS Conventional Facilities – Sector 20

Sector 20 Facility

The Sector 20 Facility, located directly above the LCLS Injector, will house the main laser system for the Injector, a control room for local operations, power supplies and cable plant for the Injector system, and a small clean room facility for handling UHV equipment. The construction subcontract cost is estimated to be approximately $1.1M with additional subcontracts for electrical in the order of $300k. The project will require demolition of an existing 1700 ft$^2$ alcove building and the construction of a new 2200 ft$^2$ building in the same location, a 300 ft$^2$ RF building, cable trays and supports, and an electrical distribution system fed from a new substation, K-10B. The new construction will have a laser room which will be a class 100,000 clean room with surface mounted cable trays running along the interior of the room.

![Sector 20 Facility Floor Plan](image-url)
### Sector 20 Facility Schedule

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LCLS Davis-Bacon Determination Document
Rev- July 6, 2009
1.1.2 LCLS Conventional Facilities – Magnetic Measurement Facility (MMF)

The purpose of the Magnetic Measurement Facility (MMF) for the LCLS is to carry out an integrated measurement and pre-assembly of the Undulator units before final assembly. The MMF will be a 4,800 ft$^2$ floor space facility built inside an existing SLAC building, Building 081, will have temperature controlled measurement and assembly areas, and a magnet loading and storage space.

SLAC building 081 is currently in use as a warehouse and will require relocation of the racks/shelves, cubicles, and components supporting the warehouse in the area designated for the MMF.
The MMF floor plan will be divided into three functional areas with temperature stability ranging from ±0.1° in the magnetic measurements room to ±2.5° in the storage area. The measurement area layout is driven by the requirement to match the earth’s magnetic field conditions of the Undulator Hall within the MMF, i.e. azimuth and magnet gap orientation need to be identical in the measurement facility as when installed in the final location ~0.8 kilometers away.

The MMF will require a new Motor Control Center (MCC) for AC distribution throughout the facility as shown in the figure below. The total estimated cost for the MMF is ~$2.1M with the construction subcontract approximately $1.5M. Construction is scheduled to begin in early August 2005.
The MMF will house elaborate measurement and calibration equipment which will be used to characterize each Undulator unit. The layout below shows general locations for the measurement equipment and staging areas. Included in the MMF will be an alignment bench with Hall Probe to minimize phase errors, Coordinate Measurement Machine (CMM) to finalize fiducialization, Hall Probe Calibration, Temperature measurement system, Wire measurement system to check field integrals, and electronic control system and data acquisition system.
1.1.3 LCLS Conventional Facilities – Beam Transport Hall

The Linac Coherent Light Source (LCLS) project includes construction of an above ground concrete tunnel, called the Beam Transport Hall (BTH), which will house a beamline transport systems with magnets, vacuum chambers, Personnel Protection System shutters and cabling, and instrumentation to precisely control the particle beam. The tunnel is required to have ~6’ thick concrete walls to meet rigid radiation protection criteria. The BTH will contain general lighting, fire detection system, water cooling pipes, cable trays, entry mazes, and special cable penetrations. Service buildings will be constructed on top of the BTH which will house the electronic controls, racks, and power supplies for the technical equipment.

The BTH is located in the Research Yard of SLAC and will require modifications to existing buildings to clear the area for BTH construction. Buildings 102 and 113 will be modified, buildings 407, 422 and storage containers will be removed entirely.
Road modifications are required prior to construction of the BTH as the Research Yard will be bisected after construction is complete. The by-pass, or cross over, road will be widened to allow access for emergency equipment into the North side of the Research Yard.

The existing Final Focus Test Beam (FFTB) housing and components will be removed completely. This involves removal of several hundred tons of concrete shielding and ~100 meters of technical beamline components and placement of same in special locations within the SLAC site boundary.
1.1.4 LCLS Conventional Facilities – Undulator Hall

The Undulator Hall will be an underground tunnel construction and will be ~600’ in length. The Undulator tunnel will house 33 precision aligned undulator units and be a temperature controlled environment. The Undulator Hall will contain standard lighting, water cooling for technical components, AC distribution outlets, cable trays, support buildings to house electronic control racks for the technical equipment, and HVAC system for thermal control.

Underground Undulator Hall facility

1.1.5 LCLS Conventional Facilities – Beam Dump, FEE & Near Experimental Hall

The Beam Dump and Front End Enclosure (FEE) will be cut and cover construction as will be the Near Hall. The Beam Dump area is concrete construction and will house the components that deflect the particle beam downward and into a beam stop or dump. The Front End Enclosure (FEE) is the beginning of the Photon Beam diagnostics area and attaches to the Near Experimental Hall (NEH). Both the Beam Dump and FEE will contain conventional AC distribution, lighting, cable trays and entry/exit maze areas.
Beam Dump and FEE housings

The Near Experimental Hall (NEH) is the first of the LCLS experimental areas which house experimental stations, control area, and working areas for staff. The NEH has two floors and ~13,000 sq feet of floor space to house 3 experimental stations, machine shop, laser bay, optics lab, electronics shop, and control area.

The Near Experimental Hall will be constructed to allow future expansion with experimental stations on the far side of the hall. The Photon beam will be capable of passing through the 3 experimental stations, out the end of the Near Hall (lower portion of NEH floor plan picture), into the X-ray tunnel and travel down beam to the Far Experimental Hall.

1.1.6 LCLS Conventional Facilities – X-ray Tunnel and Far Experimental Hall

Tunnel construction will be used to extend the photon beam beyond the Near Experimental Hall. The X-ray Tunnel will be ~20’ in diameter and extend ~200 meters in length when it branches into the wider tunnel construction of the Far Experimental Hall (FEH). The FEH tunnel will be ~46’ in diameter and ~220’ in length, and will house photon experimental stations. Service buildings will be constructed to support the utilities required for the FEH which will include HVAC, AC distribution, and lighting.
1.1.7 LCLS Conventional Facilities – Central Laboratory Office Complex

The Central Laboratory Office Complex (CLOC) building will be ~68,000 sq feet of office and laboratory space and will house approximately 250 engineers, technicians, researchers, administrative staff and visiting experimentalists. This will be a 3 story facility entirely above grade level. The CLOC will have wings of the facility divided into experimental and research clusters, computer & network support center, laser lab, and office pods.
1.1.8 LCLS Conventional Facilities – Facility Upgrades

It will be necessary to upgrade the AC distribution premises wiring to the last 2/3 of the main SLAC Linac to provide adequate power for the LCLS components. Substations will be reconfigured and cable distribution to components will be rearranged or replaced.

The SLAC Main Control Center (MCC) is the central location from which the Linac and other accelerator systems are controlled by the Operations staff. The addition of LCLS operation will require reconfiguration of the control stations to add new workstations and control modules to operate LCLS. This will include new racks, cabling, monitoring stations and computer control stations.
1.2 LCLS Technical Components - Overview

The LCLS Technical Facilities comprise elements from the Photo injector which generates the source particles of the LCLS, accelerated through the 150 MeV Linac (Sector 20 Injector), bent on axis with the main SLAC Linac and further bunched and accelerated up to 14.3 GeV, then transported into the ~130 meter long Undulator Hall. After passing through the Undulator system the electrons are bent downward into a beam dump while the photons continue through the Front End Enclosure and into the first experimental hutch located in the Near Experimental Hall (NEH) Facility. There will be 3 experimental Hutches in the NEH for scientific study and another 3 Hutches in the Far Experimental Hall (FEH). Electron and Photon beams will be transported to the NEH and FEH via Ultra-High-Vacuum (UHV) piping systems incorporating a series of Valves, diagnostics, UHV pumps, Personnel Protection System (PPS) stoppers, and

The technical facilities of the LCLS can be divided into six major sections comprising the Injector, Linac and Linac to Undulator (LTU), Undulator, Beam Dump and FEE, and X-Ray Transport Optics and Diagnostics (XTOD) systems.
1.2.1 LCLS Injector Technical Components

The LCLS Injector will produce a single 150-MeV bunch of charge 1.0 nC and 100 A peak current at a repetition rate of 120 Hz with normalized rms transverse emittance of 1.0 µm. The design employs a solenoidal field near the cathode of a specially designed rf photocathode gun. Acceleration is accomplished through two modified SLAC style S-band accelerator structures mounted after the rf gun. Beam from the injector will pass through a shield wall separating the injector vault from the main SLAC linac and either into a diagnostic spectrometer or bent into the last 1/3 of the SLAC Linac.

The Injector system begins with an RF Gun which is mounted on a precision, adjustable support system that will allow alignment of the Gun with the solenoid magnet system. The gun is powered by a SLAC 5045 Klystron fed through a vacuum S-band waveguide network. The gun is followed by the solenoid magnet and then two SLAC-type 3-meter S-band accelerator sections separated by a drift space. A laser heater and transverse RF cavity are the last elements before the shield wall which separates the Injector from the main SLAC Linac. The beam is transported through the walls via UHV beam pipe, Personnel Protection Stoppers, vacuum valves and focusing magnets. Injector beam can be delivered into a straight ahead spectrometer for diagnostics purposes or bent at 35° to be injected into the last 1/3 of the Linac and accelerated up to the 15GeV design electron energy.

1.2.1.1 Laser System
The electron source in the RF Gun requires a Laser system to deliver a 500 µJ pulse of UV photons to the photocathode at a repetition rate of 120 Hz. The anticipated design will be based on a titanium-sapphire laser system that provides the ultraviolet light pulses for the RF gun. It is anticipated that a commercially available product will be purchased and installed by the successful vendor in the Injector Laser building. The laser light will be transported from the Laser building to the RF gun via high-vacuum beam pipes.

1.2.2 LCLS Linac & Linac to Undulator Technical Components

In order to reach Self-Amplified-Spontaneous-Emission (SASE) saturation in a reasonable length undulator, a high electron peak current is required. The values which meet the high peak current and undulator parameters correspond to an rms bunch length of 22 µm and charge of 1 nC, which is not possible in present rf photo-injectors due to space charge limitations. Therefore the bunch is accelerated and compressed in a series of
linacs and magnetic chicanes before entering the undulator. The Linac to Undulator (LTU) transport line consists of 275 meters of focusing magnets, diagnostics, and bend magnets surrounding UHV beamline hardware.

1.2.2.1 Linac
The LCLS accelerator is composed of four S-band linac sections (2.856 GHz), one short X-band section (11.424 GHz) and four separate bending sections (bunch compressors). Modifications to the SLAC Linac will include re-allocation of RF power from existing klystrons to newly installed accelerator sections. The SLAC disk loaded waveguide (DLWG) accelerator sections in the Linac do not have vacuum flanges and they require in-field UHV welding to create the vacuum seal. Conversely, to remove a Linac DLWG it is necessary to grind away the weld ring while under positive dry nitrogen purge maintaining the UHV conditions. This requires specialized training and will be done using SLAC trained staff.

![Nominal LCLS Linac Parameters for 1.5-A FEL](image)

The first bunch compressor (BC1) section is a magnetic chicane designed to introduce the energy dependence of a particle’s path length needed to compress a 830 μm bunch to 200 μm. The design consists of a four-dipole magnet bump that bends the particle beam and focusing magnets to maintain the small beam properties. An Instrumentation section is added in the center of the BC to determine the particle beam size.

The second bunch compressor (BC2), like the first compressor, is a four-dipole magnet chicane. It is designed to compress a ~200 μm bunch to ~20 μm.
1.2.2.2 Linac to Undulator (LTU)
The Linac to Undulator (LTU) components are assembled as an UHV beamline which transports the particle beam from the end of the Linac to the Undulator system over a distance of ~500 meters. The requirements to transport the beam from the linac to the undulator include vertical bends to adjust out the 0.3° downward linac angle so the photon beams will be level to gravity, provide adjustable undulator-input beta-matching for the various beam energies desired, include precise transverse emittance and matching diagnostics for final verification/tuning prior to the undulator, and to not alter the bunch length among others.

1.2.3 RF System
The LCLS accelerator is composed of four S-band linac sections (2.856 GHz) and one short X-band section (11.424 GHz). The S-band accelerator sections are fed from standard SLAC 5045 Klystron through high vacuum copper waveguide structures.
The waveguide network feeds the RF gun, cavity structures L0a & L0b, and the T-Cavity. The RF Gun and structures will be fed from existing Linac-20-6, 7, & 8 SLAC style 5045 klystrons. Other cavity structures in the Linac will have the high-vacuum waveguide network modified to accommodate minor changes. Modifications to the SLAC Linac will include re-allocation of RF power from existing klystrons to newly installed accelerator sections. The X-band klystron will be mounted in the position of klystron modulator 21-2 which is adjacent to penetration 21-3. Vacuum waveguide will run from the gallery down to the X-band accelerator section.

1.2.4 LCLS Undulator Technical Components

The LCLS undulator system is an assembly of 33 individual units totaling 175 meters in length which have been precision measured in a temperature controlled environment. These 33 units are mounted onto support girders fastened to the concrete tunnel floor.
The LCLS Undulator segment has a fixed ~6-mm gap with a canted pole design. Precision assembly tolerances are required for the undulator and a titanium strongback will be used to take advantage of its strength and low thermal expansion coefficient. Temperature stability is very important to keep the magnetic field from changing significantly.

Each undulator segment will be mounted on support a beam which has precision rollers used to position the Undulator relative to the electron beam. The undulator units have 5 degrees of freedom for remote alignment capability along with the ability to remove the undulator magnet without disturbing the vacuum system. The undulator vacuum system
is constructed using small rectangular shaped stainless steel, aluminum coated on the inside, with beak sections containing BPM, bellows, vacuum pump, radiation detector and wire-style beam locator. Each undulator segment will be pre-assembled in a special magnetic measurement facility to carefully align vacuum chamber, undulator, quadrupole, and instrumentation section relative to each other prior to installation. Each of the 33 undulator sections will be vacuum connected together and precision aligned in the field. Focusing quadrupoles are installed on each undulator section and precision aligned along with the UHV chamber relative to the magnetic center of the undulator.

1.2.5 LCLS Beam Dump Technical Components

The Beam Dump elements are shown schematically in the Undulator figure above. The beam dump components are used to deflect the 14 GeV electron beam downward to provide separation from the photon beam. This is the location where the electron beam ends and the X-ray photon beam begins. After leaving the undulator system, the “spent” electron beam is separated from the x-ray by an array of five permanent magnet vertical dipoles flanked on either side by an electromagnet dipole. These magnets deflect the $e^-$ beam downward to a beam dump. The reason for the permanent magnets is based on the SLAC Beam Containment System (BCS) philosophy, which discourages power supply excited electromagnets, which could fail. The dump line UHV chambers are complex designs that contain the 15GeV electron beam, which is being deflected downward, and the intense x-ray beam which continues in a straight line toward the experimental stations.

1.2.6 LCLS X-Ray Transport Optics and Diagnostics (XTOD) Components

The X-Ray Transport Optics and Diagnostics system is the photon beamline of the LCLS. Photon beamlines in all synchrotron facilities contain the elements to deliver the photons to the experimental enclosures or hutches. The first elements of the photon beamline contain safety shutters, photon beam stops and other components to coarsely define the emerging x-ray beam, and if required to stop the x-ray beam and provide adequate radiation protection to areas outside the shielding tunnel. Other elements of the photon beamline contain hard x-ray optical elements, such as crystal monochromators, filters and/or mirrors, which are designed to handle the power loads and tailor the characteristics of the photon beam to satisfy the user requirements. The schedule for the installation of the Technical Components is commensurate with the beneficial occupancy of the LCLS facility buildings and halls. Fabrication and pre-assembly of the X-Ray Transport components will be done at remote sites at SLAC or through local vendors.
The X-Ray beam transport mechanical and vacuum system contains approximately 400 meters of vacuum beam pipe and is maintained at $10^{-8}$ Torr by ~70 ion pumps. The basic design is a long section of Stainless Steel pipe with a vacuum instrumentation vessel.
attached, a UHV gate valve and support system will complete the assembly. These sections are repeated through the halls and tunnel, except in areas where special instruments are required.

![Vacuum section diagram]

Typical section of vacuum beam pipe

1.2.7 LCLS Controls System

The LCLS incorporates several new systems into the existing SLAC accelerator complex. The parts of the existing accelerator complex used for LCLS will also serve non-LCLS functions. The control system architecture for the LCLS will be the same as that used currently for running the SLAC accelerator complex.

The LCLS Controls System will cover the Injector and Accelerator controls; the Undulator controls which include undulator movers and diagnostics; the X-ray Beamline Electronics and controls that include motion control, feedback and timing systems; Machine Protection System, Personnel Protection System and Power Supplies, Cable Plant and RF controls.

The LCLS technical components extend over a distance of 2,120 meters from the Injector to the Far Experimental Hall. Over this distance will be several support buildings that will house control system racks and power supplies from which the cable plant will extend into the LCLS tunnels and connect to the technical components.

The accelerator controls include requirements for manipulating and transporting the electron beam through two compressors, S-band RF cavities, X-band RF structure as well as standard diagnostics for BPMs, wire scanners, and feedback systems. The undulator controls require manipulation of the undulator segments which are mounted on five-cam movers (x, y, roll, pitch, and yaw), and each motion will be driven by a stepper motor. X-ray Photon Beamline electronics and controls can be divided into two parts; x-ray transport line and x-ray photon beamline. The controls system will handle diagnostic equipment such as differential pumping sections, isolation valves, horizontal and vertical
adjustable collimators, and calorimeters. Motion controls, Feedback Systems, and Timing systems are also part of the LCLS Controls System.
1.3 LCLS Installation Plan

The major installations of the LCLS will take place over a 3 year period and will be planned around the beneficial occupancy dates of the conventional facilities and the SLAC Linac downtimes. The SLAC Linac is in operation 24 hours per day and seven days per week to support User experiments on the PEPII storage ring and FFTB experiments. There are 3 downtime periods scheduled in 2005, 2006 and 2007 during which LCLS hardware will be installed in the Linac tunnel. LCLS hardware which is not located inside the Linac tunnel will be scheduled for installation based on facility beneficial occupancy and overall integration efforts to complement a comprehensive commissioning plan.

Installation work is typically separated into two basic categories of work activities, electrical and mechanical, with vacuum being incorporated into the mechanical description.

1.3.1 Mechanical Systems
The LCLS is constructed of almost entirely ultra-high vacuum components over its full 2,000 meter length beginning with the Injector Gun through the X-ray transport components and ending in the Far Experimental Hall. The technical components of the LCLS will be assembled and tested at SLAC assembly areas or in the metrology laboratory clean rooms. After transport and positioning on the tunnel floor, the components are integrated by the vacuum specialists. The vacuum pumps are hooked up and vacuum instrumentation connected and the systems are pumped down and leak checked. Water cooling systems are connected, flow/pressure instruments installed and checked, and flow balancing is done. Additional mechanical work will be performed such as precision alignment to prepare the systems for startup.

Ultra-High-Vacuum (UHV) systems are assembled in-house in clean room conditions because they require high precision assembly, delicate instrumentation, and UHV (<10^{-9} torr) or High-Vacuum (HV) conditions. Vacuum system installation is handled by specially trained technicians who install the ion pumps and mount and terminate all necessary vacuum instrumentation. Critically positioned and vacuum-leak-tight beam transport components are assembled and installed to provide the necessary vacuum conditions.

Utility (water, air, cables) terminations of the components are done by SLAC/LCLS technicians to ensure error-free installation and certification. All final check-outs of the flow system/instrumentation and sign-off is also conducted by the in-house technicians who are responsible for the maintenance and correct functioning of these components during operations.

1.3.2 Electrical Systems
The electrical tasks include routing and termination of various signal, detector, control, interlock, coaxial and RGA cables, connection of vacuum pumps, and motors according to required specifications and written documentation. Additionally, numerous pre-calibrated and sensitive instruments, such as remote monitoring pressure gauges and flow
Various control, interlock and readout chassis will be installed at numerous positions along the beamline, near the technical components which they will control and monitor. The grounding of all equipment will be checked and confirmed. After installation and initial checkout, all items have to be provided with identification signs, as well as ES&H signs. Many of the checkout activities are done in conjunction with the checkout of the mechanical systems. Items that are not functioning at acceptable levels will be replaced.

In order to assure proper installation, connection and operation of all LCLS technical components, the instrument cable installation and termination will be done by SLAC/LCLS personnel. This allows the SLAC/LCLS personnel to perform checks for proper identification, testing and trouble shooting prior to, during, and after commissioning of the beamline. These same people will be responsible for the maintenance and operation of the system. This is essential for the safety and continuity of operations of the LCLS and SLAC Linac.

The SLAC/LCLS technicians are familiar with the requirements and procedures for the LCLS technical components and subsystems, such as controls, vacuum gauges, and stepping motor controls. They will be familiar with the cable termination points, kinematic mounts, and stepping motor controls, as well as with associated calibration, trouble shooting modules, and other such diagnostic electronics for the vacuum valves and instrumentation.

1.3.3 MPS – PPS/BCS
The LCLS beamline has sophisticated interlock safety systems incorporated in their designs to guard against incidents that could damage or incapacitate equipment (Machine Protection System, MPS) and also to protect personnel (Personnel Protection System, PPS/Beam Containment System, BCS) from radiation in the beamline. The interlock and safety system, as stated above, is composed of two parts; the personnel and the equipment safety systems (PPS – MPS), which are very complex systems based mostly on programmable logic controllers (PLC) and, to a lesser extent, on relay interfaces. In order to assure proper installation of the interlock and safety systems for the LCLS, connections to the respective controls and components will be done by SLAC/LCLS personnel. This allows the SLAC/LCLS personnel to perform checks for proper identification, testing, and trouble shooting prior to, during, and after commissioning of the LCLS. These same personnel will be responsible for the maintenance and operation of these systems.

Completion of the above tasks by in-house technicians is essential for the smooth commissioning and the subsequent safety and continuity of operations of the LCLS. All of these exemption tasks will be performed by specially trained, experienced technicians under the supervision of likewise trained engineers and physicists. On an average, these people will have a minimum of three years hands-on experience in the respective tasks. For installation of the vacuum systems, the average technician experience needed is longer than three years, and may be closer to six years.
SLAC/LCLS staff are defined as competent technicians who are familiar with the requirements and procedures for SLAC/LCLS systems installation and who are familiar with the design specification and identification system for the LCLS electrical and mechanical systems.

1.3.4 *Experimental Equipment and Instruments*

The Linac Coherent Light Source (LCLS) project includes six (6) experimental stations that will be used by experimental users during FEL beam operations. The experimental equipment that will be installed in these experimental hutches vary in complexity but most contain the same basic function; delivery of the FEL photon beam to the user sample and obtain data through the use of diagnostics, sample chambers and detectors. The current suite of instruments planned for the six LCLS experimental stations are:

- Soft X-ray Science (SRX)
- X-Ray Pump Probe (XPP)
- Coherent X-ray Imaging (CXI)
- X-ray Correlation Spectroscopy (XCS)
- Atomic, Molecular and Optical Science (AMO)
- Matter in Extreme Conditions Instrument (MECi)

The LCLS project will provide one experimental apparatus to be located in hutch 1 of the Near Experimental Hall, this experiment is the Atomic, Molecular and Optical Science instrument or AMO. The remaining instruments will be funded through the Office of Science as MIE projects (LUSI and MECi).

The instruments are described below to show the general makeup and assembly within an experimental area on the LCLS. Much of the instruments will be mounted onto stands which are then rolled into the hutch, aligned, and mounted. Support equipment such as racks and flooring will be installed after the instrument has been installed.
The Xray Pump Probe (XPP) Instrument is comprised of a laser system, diagnostics, optics, supports, robotic detector, and controls as shown in figure 8-1 below.

Components of this will be mounted onto support stands and large granite tables which provide the required thermal stability. A raised computer type floor under control racks will be installed to allow instrument cables to be run from components to their appropriate controllers while maintaining the necessary walkway space. The laser system will be mounted onto an optic table and totally enclosed to allow operation during access mode for trained laser operators. The optical laser system will be mounted onto the table after installation in the hutch.

A robot system will be used to position the detector as needed during a typical experimental run. This system will be mounted to the hutch ceiling adjacent to the beamline and detectors, calibrated and tested through all motions. The Photon beamline is comprised of ultra high vacuum components, valves, diagnostics and optics. These devices require trained vacuum technicians to ensure the quality and cleanliness is maintained during the installation process.
A sample positioner, termed Gonimeter, will be installed as an element in the x-ray beamline. This device includes a precision support and alignment mechanism to allow a horizontal shift of the apparatus. As is shown in figure 8-2, the equipment installed for the XPP instrument rest on movable strong-backs which provide position and stability to the precision required for these experiments.
Instruments in the LCLS require a control system consisting of controls racks, AC power to racks and cable plant to enable operations of the experimental equipment remotely. Control racks will be mounted inside the experimental hutch and short runs of cable trays installed to guide cables to each of the beamline or experimental components. In some cases the cable trays will be floor mounted under a section of raised floor to maintain needed walkway space. Seismic restraints are incorporated into the equipment design and installed after initial component alignment.

The AMO instrument, shown in figure 8-3, is designed in removable sections to facilitate addition or insertion of new x-ray user equipment chamber. Similarly the CXI Instrument shown in figure 8-4 is designed to have a sample environment that can accommodate multiple user configurations. Each of these instruments, as described for the XPP, AMO and CXI Instruments, will require a full control system with racks and cable plant installed to test and become operational.

The XCS Instrument is comprised of X-ray optics and diagnostics, monochromators, diffractometer system, large angle detector mover and hutch facilities as shown in figure 8-5. This instrument has several components upbeam of hutch 4 and located in the X-ray Transport tunnel (XRT) which is a controlled area when any of the experiments in the Far Experimental Hall are functioning.
Laser systems are required for some experimental instruments requiring installation of laser tables, enclosures, and laser transport hardware and safety system. Commercial hardware is typically purchased for laser systems with component installation occurring in the field by laser technicians. A complete laser system may be installed inside of the experimental hutch if there is sufficient space or in the case where access may prohibit full installation then the controls portion of the laser system may be mounted above in the 2nd floor or on a mezzanine which will be the case for the Matter in Extreme Conditions (MEC) Instrument located in hutch 6 (see figure 8-6).

The MEC instrument will include the installation of a FEL beamline with optics and diagnostics to be mounted on stands already installed in the XRT and on support stands inside the hutch 6. Target Diagnostics, like a visible interferometer (VISAR), will be attached to the high vacuum Target Chamber with controls and cable plant coming from racks installed inside the hutch and above the hutch on a mezzanine.
Figure 8-6: Matter in Extreme Conditions Instrument in Hutch 6 of the LCLS

Installation of experimental instruments on LCLS requires personnel trained in vacuum techniques, laser systems, and familiarity with the instrument design.
July 15, 2005
DRAFT

APPROACH TO THE DAVIS-BACON DETERMINATION
OF THE LINAC COHERENT LIGHT SOURCE (LCLS)

The Linac Coherent Light Source (LCLS) project includes construction of conventional facilities and installation of technical components within the LCLS division of SLAC. The conventional facilities portion of the project comprises five major facilities, including tunneling for an experimental hall and a laboratory office complex to house approximately 250 scientific and technical staff. The estimated cost of the conventional facility portion of the project is ~$75M.

The LCLS technical components are mostly first-of-a-kind or state-of-the-art components. Very often the technical staff has been trained over years to develop, build, test, integrate and checkout such components. Almost all such components are also progressively developed by the technical staff through extensive R&D effort which started as early as 1999, and has continued relying on both theoretical designs as well as research conducted by other divisions within SLAC and other contributing laboratories. The successful operation of these components and the LCLS as a whole will be determined by the continued efforts of the technical staff in final integration, connection, adjustments, testing, calibration and certification.

The following general criteria were used in developing the Davis-Bacon determination.

1. If the craft skills required by the task are closely coupled with or normally used in the installation of the system (e.g., deionized water, power distribution, etc.) the work is assigned to the Davis-Bacon subcontract.
2. In cases where normal craft skills do not have familiarity or expertise with R&D equipment or installation tasks, or where their inclusion in the tasks represent a risk to continuity of operations, meeting physics goals or successful testing and data collection, the task has been designated to non-Davis-Bacon personnel.
3. The LCLS/SLAC technician and engineering hours required for final acceptance testing and commissioning of technical components were estimated as part of the overall project. Those hours are not included in this submittal, and it should be noted that final acceptance test activities are not part of the installation activities for the LCLS.
Appendix B  
Clarification of LCLS Davis-Bacon Non-Covered activities

It must be understood that during the construction and installation process of the LCLS project, SLAC will be in full operation with the Linac, PEPII and SPEAR3 storage rings, the BABAR detector, End Station A experiments, FFTB and SPPS experimental programs among others. It is the intent of the specified non-covered activities to prevent or minimize any impact on these programs by the LCLS construction activities, and as we cannot identify each individual task as such, we categorize the areas where the impact would cause material risk to continuity of operations.

Section 1.2 Conventional Facilities

1.2.A: Re-location of office equipment and materials in buildings scheduled for demolition

The removal of SLAC staff office equipment, its staging in temporary locations, and installation in new locations is considered part of operational and maintenance activities as the staff being moved have continuous operational responsibility during the move process and requires coordination between staff availability and movers. (Determination: This activity is determined as Covered work, move to 1.1.J)

1.2.B: Re-location hardware storage to alternate areas at SLAC

This is considered a maintenance activity as it requires SLAC personnel to evaluate the material disposition to be sent to SLAC salvage or alternate storage area. This also involves relocation of material from storage bins in an operational SLAC Stores process where hardware is inventoried, tracked, and made available for staff procurement to be used on SLAC equipment.

1.2.C: Re-location of shielding and/or material stockpiles not requiring Riggers to alternate areas at SLAC

This is considered a maintenance activity as it requires SLAC personnel to evaluate the material disposition, SLAC Operational Health Physics (OHP) to perform appropriate radiation measurements, and Riggers to subsequently move the material to other designated locations with SLAC. (Determination: Work requiring Riggers within construction site is determined as Covered work in this category, other activities non-covered)

1.2.D: Disconnection of utilities in buildings scheduled for demolition

Utilities are defined as LCW, air lines, electrical power, liquid nitrogen lines, instrumentation and control wiring, telephone, and gases. In some cases these utilities are part of an active experiment of an on-going accelerator based program and it is vital that the disconnections of these types of utilities be coordinated with SLAC Operations and accomplished by SLAC Maintenance staff that is familiar with the systems to ensure proper termination is achieved to preserve the Operational Program.
1.2.E: Temporary repositioning or removal of existing services in tunnels to facilitate access
When applicable, this involves services of operational systems at SLAC and must be done by trained SLAC Maintenance staff. This task description, similar to 1.2.D, is to cover utilities that need to be temporarily removed but maintained in functional order to preserve operational integrity.

1.2.F: Temporary removal of Personnel Protection System cabling
In many cases the PPS and/or MPS cables will be disconnected and "rolled back" to allow some construction work to proceed and then re-connected again to allow the SLAC operational program to continue. In these cases, it requires trained SLAC/LCLS staff to do this disconnection and reconnection to verify the integrity of safety systems.

1.2.G: Temporary removal of Machine Protection System cabling
In many cases the PPS and/or MPS cables will be disconnected and "rolled back" to allow some construction work to proceed and then re-connected again to allow the SLAC operational program to continue. In these cases, it requires trained SLAC/LCLS staff to do this disconnection and reconnection to verify the integrity of safety systems.

1.2.I: Taking components from the fabrication site to the LCLS storage area/holding area away from the LCLS construction site
1.2.I.1 Relocating components from the RCA storage areas to staging area outside of the LCLS construction site
This is requested to be non-covered to eliminate the requirement for subcontractor workers to enter Operations or Radiation Controlled Areas (RCA) at SLAC and to avoid interference with operational activities at SLAC. Our intent is to set the components aside in storage/holding areas and then move the components to a common staging area where the subcontractor can arrange for pickup and delivery to the installation site, and installation of said items. In many cases, we will have the subcontractor pickup the material at the fabrication or storage site if it is outside the RCA and/or does not interfere with ongoing SLAC Operations. In some cases, components will be stored in buildings or areas inside RCA's which require special training to enter, such as the Klystron Gallery, which may be in operation during removal of items.

Please note that FAR 22.402.a.(2)(i) indicates that DBA requirements not apply to the manufacturing of components or materials off the site of the work or their subsequent delivery to the site by the commercial supplier or materialman. SLAC is fabricating these components and is proposing that SLAC's subsequent relocation of the fabricated components to a SLAC holding area and then to a SLAC staging area near the actual LCLS construction site is analogous to the non-covered delivery to the site specified by FAR 22.402.a.(2)(i).

(Determination: Transportation of components from staging areas to Installation site is Covered work; Moving of components from fabrication site to storage areas
is Non-Covered work; moving of components from RCA storage areas to staging area is Non-Covered work)

Section 2.2 LCLS Preparation, Removal and Related Tasks

2.2.A: Temporary removal of shielding blocks, existing vacuum components, and equipment, which will be re-installed at a later date

We request this to be non-covered for these reasons; vacuum hardware, precision equipment and shielding.

The removal of vacuum hardware that will be re-used requires the same UHV training and experience as needed to install UHV equipment. The UHV components require boiloff LN2 purges for flange disconnection and system cleanliness; many of the items are small and will be removed as they are disconnected, items like Ion Pumps, Ion Gauges, Mirror tanks, or in some cases Disk-Loaded-Waveguide that have no flanges, which require special handling until they reach the clean room facility at other locations within the SLAC site. Some of the components will be removed with their supports attached and some without. Large UHV items which require special rigging effort will be vacuum prepared (blank UHV flanges installed to maintain the cleanliness) and left for a subcontractor to remove and relocate. It is our intention to use subcontractor labor to remove as much UHV hardware as can be made vacuum safe because this is the most efficient and cost effective approach. However, we cannot specify the number of small UHV items, nor can we specify what constitutes a "large" UHV item which will remain and removed by a subcontractor, therefore we request removal of all UHV items which will be re-used to be non-covered.

Some of the equipment to be removed includes precision alignment monumentation stands, hydrostatic leveling system, and wire leveling systems, to be used later on the LCLS. These components have been assembled with micron precision and require special handling to maintain their accuracy for future use. The SLAC Metrology department staff, who have been trained in the use of this equipment and in some cases have installed the equipment, will be used to prepare and remove this precision hardware.

With regard to shielding; shielding includes concrete blocks, lead bricks, and steel billets or steel bricks. These items are used in virtually all accelerators and storage rings at SLAC, including the Stanford Synchrotron Radiation Laboratory (SSRL) storage ring SPEAR and in the Photon Beamlines. In many cases the shielding surrounds UHV equipment inside the accelerator housing and requires special handling to ensure the integrity of the vacuum hardware during the shielding removal (usually lead bricks in this case). Handling of lead requires special safety controls and medical monitoring of personnel; SLAC had this monitoring in place for their staff.

Concrete shielding is used to cover accelerator hardware to create an accelerator housing above ground, this is the case for the FFTB and SPEAR ring housings at SLAC. For the FFTB, virtually none of the shielding blocks will be re-used and therefore will be removed by a subcontractor and is not an issue for Davis-Bacon determination. However, as in the past D-B documents for PEPII and SPEAR3...
this item has been approved as written to allow SLAC to removed concrete shielding as needed to install temporary accelerator hardware, maintain equipment inside these housings, and re-install such concrete shielding blocks without the need to request a determination. It has been our belief that this determination may have an adverse impact on the continuity of operations of accelerators like SPEAR or experiments like BABAR if removal and replacement of a concrete roof block or steel shield (which costs more than $2k) were considered a D-B item.

2.2.B: Disconnection of utilities from technical equipment
This item covers the disconnection of utilities (LCW, nitrogen, power connections, etc) to technical equipment which could be damages if done by non-trained personnel. The technical equipment includes delicate vacuum components, Beam Position Monitors (BPM), or instrumentation which if handled incorrectly would jeopardize the integrity of the technical components.

2.2.C: Disconnection of vacuum flanges and connection of blank-off flanges
Handling of vacuum components and vacuum connections requires several years of special training. This is explained in LCLS Davis-Bacon Recommend Findings document, Appendix A, section 1.3.1 and exempt status has been requested for similar items in sections 2.2.M and 4.2.E and 4.4.N.

2.2.D: Removal of vacuum pumping systems
Handling of vacuum components and vacuum connections requires several years of special training. This is explained in LCLS Davis-Bacon Recommend Findings document, Appendix A, section 1.3.1 and exempt status has been requested for similar items in sections 2.2.M and 4.2.E and 4.4.N.

2.2.E: Refer to 1.2.E
2.2.F: Refer to 1.2.A
2.2.G: Refer to 1.2.B
2.2.H: Refer to 1.2.C
2.2.I: Refer to 1.2.F
2.2.J: Refer to 1.2.G
2.2.K: Remote fabrication and assembly of all components
Fabrication and pre-assembly of components will occur in locations within the SLAC site and off the SLAC site during the life of the LCLS project, but will not be assembled or installed in any permanent location of the LCLS project. Installation of components in their final location is subject to this D-B determination.

2.2.L: Refer to 1.2.I
2.2.O: Modifications or alterations to utilities or equipment which require Radiation Worker Training and special procedures for contamination containment
In some areas of the Linear Accelerator complex utilities such as water lines become contaminated or radioactive. Modification of this type of utility requires draining the water into containment vessels and proper disposal by SLAC trained staff. Cutting of the copper water pipe also requires containment procedures and the SLAC Operational Health Physics (OHP) department has determined that welding or soldering on water pipe which contained the contaminated fluid requires Radiological Training. In some cases a piece of technical equipment will become radioactive and the handling of such equipment requires RWT I or RWT II level training. SLAC will use their Radiation Worker trained staff for the containment and modification of these types of utilities and equipment.

Section 3.2 Utilities
3.2.B Refer to 1.2.I

3.2.E Connection of equipment to main utilities
This task is the inverse of item 2.2.C of this document where the connection of utilities (LCW, nitrogen, power connections, etc) to technical equipment which could be damaged if done by non-trained personnel. The technical equipment includes delicate vacuum components, Beam Position Monitors (BPM), or instrumentation which if handled incorrectly would jeopardize the integrity of the technical components. Task items 3.1.A & B allow for connection of utilities between headers and distribution lines as covered activity, however we request that connection of utilities to technical components be non-covered work.

3.2.K Installation of ancillary equipment installed in support of the experimental equipment
Experimental equipment, by its nature, is meant to be a temporary installation for periods of a few weeks to a few months. Ancillary hardware in support of experimental equipment include I&C racks, rack mounted power supplies, cabling, motor controls, and gas bottles. Experimental equipment may include diagnostics equipment to calibrate or monitor the charged particle or photon beam generated by the LCLS project; or special photon gas attenuators installed to reduce the beam intensity during commissioning.

3.2.P Refer to 2.2.O

Section 4.2 Technical Component Installations
4.2.A Refurbishment of existing power supplies
This task identifies fabrication work remote to the installation site to rebuild existing power supplies (PS) that are removed as part of the construction process. These PS will be refurbished either at external vendors or within the electronics fabrication facility at SLAC. Removal may be covered under 2.2.A (if small rack mounted PS) and installation of such PS’s falls under section 4.1.K.
4.2.C Refer to 1.2.I

4.2.Q Installation of vacuum Laser transport tubes
   Laser light will be transported from the Laser lab to the Gun Cathode via high vacuum pipes with vacuum flange connections. These laser transport tubes require trained vacuum technicians to do proper UHV procedures to maintain the cleanliness of the system during installation.

Section 5.2 Radio Frequency System
5.2.A Temporary removal and reinstallation of existing components
   This task justification is identical to 2.2.A where the requirements of removing a delicate RF system amount to several years of on-the-job training. The RF system, as described in Appendix A, section 1.2.3, comprises UHV components, coaxial cable connections, local lead radiation shielding covers, vacuum connections and control electronics. Removal of these items, storage and reinstallation is requested as non-covered.

5.2.B Removal of existing RF systems for reuse elsewhere
   This task justification is the same as 5.2.A, where the handling of these UHV components, RF structures and coaxial cable connections, require trained RF personnel.

5.2.D Refer to 1.2.I
5.2.M Refer to 3.2.E
5.2.S Refer to 3.2.K
5.2.V Installation of SLAC 5045 and X-band klystrons
   The SLAC 5045 and X-band RF Klystrons require special fixtures, tooling and handling for installation and are done by the SLAC RF Group. These styles of Klystrons are used to power the SLAC 2-mile Linac, the SSRL Linac, and will be used to provide RF to the LCLS Injector. The 5045 and X-band klystrons, different from 476 MHz Klystrons, require vacuum connections during the installation process and therefore requested to be non-covered.

Section 6.2 Controls System
6.2.B Refer to 1.2.I
6.2.K Refer to 3.2.K

Section 7.2 Vacuum System
7.2.B Refer to 1.2.I
7.2.H Refer to 3.2.E
7.2.N Refer to 3.2.K

Section 8.2 Experimental Equipment & Instruments
8.2.A Installation of experimental equipment and instruments into the LCLS hutches or stations
The experimental equipment and instruments of LCLS need to be installed and tested on an on-going basis and interleaved with operations of the machine. Each experimental instrument contains elements that are designed to be removed from the beamline to extend or alter the science capability, and as such are connected to utilities (electrical and mechanical) in a fashion to allow quick disconnection. Installation activities require the participation of the professional personnel who are responsible for the experimental equipment or instruments (See Appendix A, Section 1.3.4)

8.2.B Installation of cable plant and racks required to operate the experimental instrument

The experimental equipment and instruments of LCLS require control cabling and control racks; these items are installed after the experimental equipment and instruments are installed in the experimental area or hutch. Extreme care is required to work around the installed instruments to avoid damage. Cable plant runs are relatively short emanating from a rack close by the instrument and running through a cableway on the floor or mounted between systems depending upon the experimental setup.

8.2.C Refer to 8.2.B.

8.2.E Installation, connection and testing of robotic equipment that is part of the experimental equipment or instrument

Robotic equipment used for sample or detector manipulation must work extremely close to the beamline hardware and instrument sections. The installation and testing of these devices and their support systems require inherent knowledge of the beamline or instrument and the range of operation of the robotic device as well as the facilities surrounding the instrument.

8.2.G Installation of raised flooring in hutch as needed to clear floor mounted components in support of the experimental equipment

Spacing surrounding the experimental equipment or instruments inside an experimental hutch is very limited and at time requires a raised floor to be installed to allow cable plant to be directed to areas of the experiment while maintaining standing or walk space. The raised floor must be installed around the sensitive equipment requiring a knowledge base of the equipment gained only by trained personnel at SLAC.