

<b>PHYSICS REQUIREMENT DOCUMENT (PRD)</b>	<b>Doc. No. SP-391-000-18 R0</b>	<b>LUSI SUB-SYSTEM XPP</b>
<b>Physics Requirements for the XPP Laser System</b>		
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Revision	Date	Description of Changes	Approved
R0	28NOV07	Initial release	



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## 1. Overview

A short pulse laser system will be used to either stimulate a response in a sample or to probe the response of a sample after exposure to the LCLS beam. This system is a core component to the X-ray Pump-probe instrument. The system properties will ultimately define the scientific scope performed at this endstation and thus a configurable system is envisioned. This document describes the requirements of this system.

## 2. Performance Specifications

### 2.1. Synchronization and Parameter Control Requirements

- 2.1.1.** The repetition rate of the laser system shall be phase locked to the LCLS RF with less than 100 fs rms jitter for a frequency range between 0.00001 Hz and 10 kHz for all laser configurations.
- 2.1.2.** The laser pulse shall be delivered to the sample with a spatial drift, both long and short term, less than 10% of the laser spot size for all configurations.
- 2.1.3.** The following laser parameters shall be remotely controlled via the instrument controls system:
  - 2.1.3.1. Pointing on the sample
  - 2.1.3.2. Polarization state at the sample
  - 2.1.3.3. Pulse energy at the sample
  - 2.1.3.4. Pulse duration (up to 5 ps FWHM) and temporal shape (to the extent possible with a standard pulse shaping system)
  - 2.1.3.5. Arrival time with respect to the FEL pulse to any arbitrary time delay with a 10 fs precision neglecting jitter.
  - 2.1.3.6. Laser repetition rate (gating of the pulse train shall be accommodated)

- 2.2. Medium Energy Ti:Sapphire Amplifier**
  - 2.2.1.** Repetition Rate  $\geq 240$  Hz
  - 2.2.2.** Pulse Energy  $> 2$  mJ at the sample  
 $< 0.75\%$  rms noise over 8 hours
  - 2.2.3.** Pulse duration  $< 50$  fs at the sample
  - 2.2.4.**  $M^2 \leq 1.35$  at the OPA
  - 2.2.5.** Pre-pulse contrast ratio  $> 10^5:1$
  - 2.2.6.** Post-pulse contrast ratio  $> 10^3:1$
  - 2.2.7.** ASE contrast ratio  $> 10^3:1$  [(Total Energy-ASE Energy)/ASE Energy]
- 2.3. High Energy Ti:Sapphire Amplifier**
  - 2.3.1.** Repetition Rate  $\geq 120$  Hz
  - 2.3.2.** Pulse Energy  $> 20$  mJ at the sample,  
 $< 1.5\%$  rms fluctuations over 8 hours
  - 2.3.3.** Pulse duration  $< 50$  fs at the sample
  - 2.3.4.**  $M^2 \leq 1.5$
  - 2.3.5.** Pre-pulse contrast ratio  $> 10^5:1$
  - 2.3.6.** Post-pulse contrast ratio  $> 10^3:1$
  - 2.3.7.** ASE contrast ratio  $> 10^3:1$  [(Total Energy-ASE Energy)/ASE Energy]
- 2.4. OPA**
  - 2.4.1.** Tuning range from  $0.25 \mu\text{m}$  to  $20 \mu\text{m}$
  - 2.4.2.** Pulse Energy  $> 10 \mu\text{J}$  at the sample over entire tuning range  
 $> 100 \mu\text{J}$  at the sample for  $0.475 \mu\text{m}$  to  $2.6 \mu\text{m}$
  - 2.4.3.** Pulse duration  $< 100$  fs at the sample for all wavelengths
- 2.5. Second Harmonic Generation System**
  - 2.5.1.**  $> 25\%$  conversion efficiency for fundamental pulse energies  $\geq 1$  mJ
  - 2.5.2.** Pulse duration  $< 100$  fs
- 2.6. Third Harmonic Generation System**
  - 2.6.1.**  $> 5\%$  conversion efficiency for fundamental pulse energies  $\geq 1$  mJ
  - 2.6.2.** Pulse duration  $< 100$  fs

### 3. Diagnostics

The following laser properties shall be remotely monitored with diagnostics that are fully integrated into the instrument control and data system:

- 3.1. Pulse energy (120 Hz)**
  - 3.1.1.** Recorded in XPP experimental data files
  - 3.1.2.** 5% absolute accuracy
  - 3.1.3.** 1% relative accuracy
- 3.2. Spatial profile (10 Hz)**
- 3.3. Pulse duration (10 Hz)**
- 3.4. Spectrum (10 Hz)**
- 3.5. Contrast ratio for 800 nm amplifiers (on demand - not continuously monitored)**