## Diagnostics & Common Optics Design, Baseline, & Risks

Yiping Feng – DCO Lead Scientist Eliazar Ortiz – DCO Lead Engineer LUSI CD-2 Lehman Review August 20, 2008

> Lead Engineer: Eliazar Ortiz Mechanical Engineer: Marc Campell Mechanical Engineer: Nadine Kurita Design Engineer: Rick Jackson Designer: Don Arnett Designer: Ben Bigornia





- Physics requirements
- Safety
- Components distribution
- Engineering/design status
- Value engineering/management
- Basis of estimate
- Procurement strategy
- Costs & schedule
- Critical path
- Risk analysis
- Summary







### Specifications and component concept developed by

- DCO scientific/technical team
  - Yiping Feng, DCO lead scientist
  - Instrument liaisons & DCO scientists
    - David Fritz, XPP instr., attenuator, harmonic rejection mirrors
    - Marc Messerschmidt, XPP instr.
    - Sébastien Boutet, CXI instr., slits system, pulse picker
    - Aymeric Robert, XCS instr., focusing lens, offset monochromator
  - Niels van Bakel, X-ray detectors support
  - Gunther Haller/Dieter Freytag, EE support
- Components engineered by
  - DCO engineering team
    - Eliazar Ortiz Lead Engineer
    - Marc Campell Mechanical Engineer
    - Nadine Kurita Mechanical Engineer
    - Rick Jackson Design Engineer
    - Don Arnett Designer
    - Ben Bigornia Designer





# **DCO Scope**



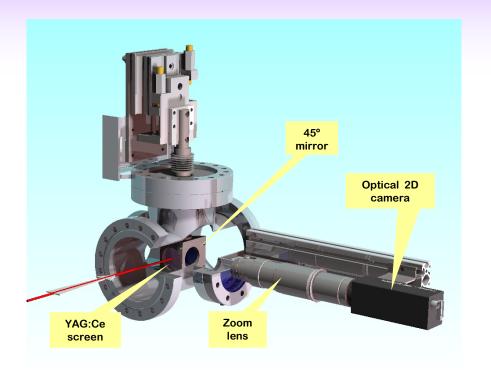
Scope/CD-2 Includes:								
Physics support & engineering integration (WBS. 1.5.1)								
Diagnostics (WBS 1.5.2)								
Pop-in Profile/Wavefront Monitor (WBS 1.5.2.1)								
Pop-in Intensity Monitor (WBS 1.5.2.2)								
Intensity-Position Monitor (WBS 1.5.2.3)								
Common Optics (WBS 1.5.3)								
Offset Monochromator (WBS 1.5.3.1)								
X-ray Focusing Lenses (WBS 1.5.3.2)								
Slit System (WBS 1.5.3.3)								
Attenuators/Filters (WBS 1.5.3.4)								
Pulse Picker (WBS 1.5.3.5)								
Harmonic Rejection Mirrors (WBS 1.5.3.6)								





# Pop-in Profile Monitor (WBS 1.5.2.1)





#### Requirements

- Destructive; Retractable
- Variable FOV and resolution
  - At 100 μm resolution, 24x24 mm<sup>2</sup> FOV
  - At 8 μm resolution, 2x2 mm<sup>2</sup> FOV
- Capable of per-pulse op. @ 120 Hz if required

#### Purposes

- Aid in alignment of X-ray optics
  - FEL is serial operation, automation enables maximum productivity
- Characterization of X-ray beam spatial profile
  - FEL spatial mode structure
  - Effects of optics on fully coherent FEL beam
- Characterization of X-ray beam transverse spatial jitter
  - FEL beam exhibits intrinsic spatial fluctuations

#### Implementation

- X-ray scintillation
  - 50-75 μm thin YAG:Ce single crystal scintillator
- Optical imaging
  - Capable of diffraction limited resolution if required
  - Normal incidence geometry w/ 45° mirror
  - Motorized zoom lens
  - 120 Hz optical 2D sensor

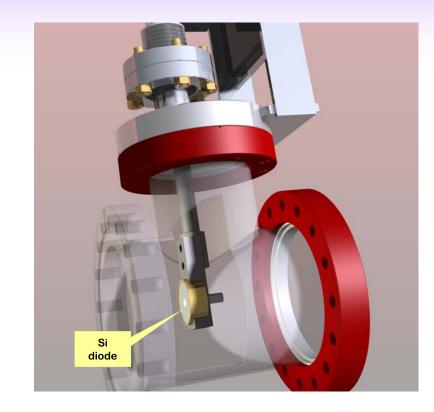




# Pop-in Intensity Monitor (WBS 1.5.2.2)

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#### Requirements

- Destructive; Retractable
- Relative accuracy < 1%</p>
- Working dynamic range 100
- Large sensor area 20x20 mm<sup>2</sup>
- Per-pulse op. @ 120 Hz



#### Purposes

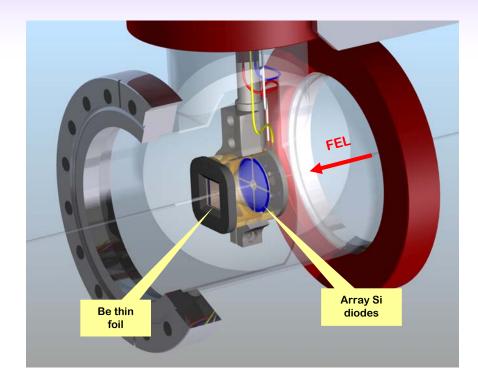
- Aid in alignment of X-ray optics
  - FEL is serial operation, automation enables maximum productivity
- Simple point detector for physics measurements
  - In cases where 2D X-ray detector is not suitable

#### Implementation

- Direct X-ray detection using Si diodes
  - Advantageous in cases of working w/ spontaneous or mono beams
  - Capable of high quantum efficiency (> 90% at 8.3 keV)
    - 100 500 μm depletion thickness
  - Using charge sensitive amplification
    - Applicable to pulsed FEL
  - Commercially available
  - Large working area (catch-all) easily available simplifying alignment procedure



# Intensity-Position Monitor (WBS 1.5.2.3)



#### Requirements

- In-situ, retractable if necessary
- Highly transmissive (> 95%)
- Relative accuracy < 0.1%</p>
- Working dynamic range 1000;
- **Position accuracy in xy < 10**  $\mu$ m;
- Per-pulse op. at 120 Hz;



#### Purposes

- Allow precise measurement of the intensity for normalization
  - Critical to experiments where signal from underlying physics is very small
- Characterization of FEL fluctuations
  - Positional jitter ~ 10% of beam size
  - Pointing jitter ~ 10% of beam divergence
  - Slitting beam down creates diffraction which may cause undesirable effects

#### Implementation

- Based on back scattering from thinfoil
  - Detecting both Compton scattering & Thomson scattering
  - Using Low-z (beryllium) for low attenuation especially at low X-ray energies
- Using Si diode detectors
  - Array sensors for position measurement
  - Pointing measurement using 2 or more monitors

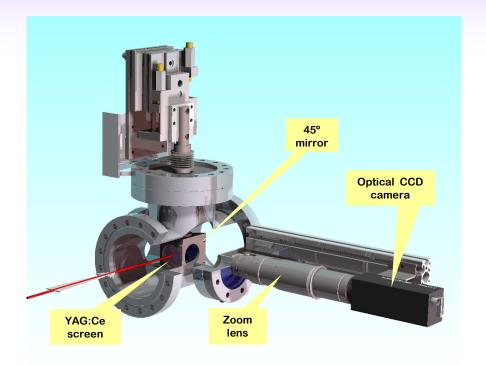
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# Wavefront Monitor (WBS 1.5.2.1)



#### [in lieu of wavefront sensor]



#### Requirements

- In-situ; Retractable
- Variable FOV and resolution
  - At 100 μm resolution, 24x24 mm<sup>2</sup> FOV
  - At 50 μm resolution,12x12 mm<sup>2</sup> FOV
  - At 4 μm resolution, 1x1 mm<sup>2</sup> FOV
- Per-pulse op. @ 120 Hz

#### Purposes

- Wavefront characterization of focused X-ray beam at focal point
  - Wavefront measurement at focal point is not feasible by conventional methods due to damages
- Providing supplemental scattering data in low Q w/ high resolution
  - Resolution obtained using X-ray direct detection is limited by detector technology, i.e., pixel sizes and per-pixel dynamic range

#### Implementation

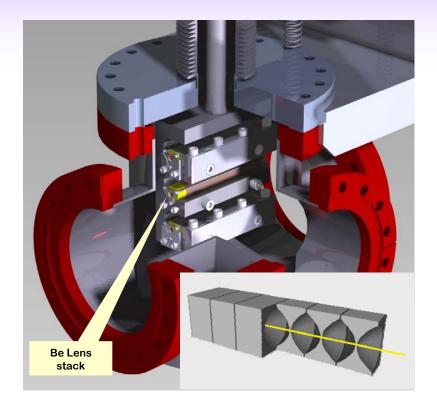
- X-ray scintillation
  - 50-75 μm thin YAG:Ce single crystal scintillator
- Optical imaging
  - Capable of diffraction limited resolution if required
- Using computational algorithm for reconstruction of wavefield at focus
  - Iterative, post processing only if no large computer farm





# X-ray Focusing Lenses (WBS 1.5.3.2)





#### Requirements

- Produce variable spot size
  - For XPP instrument
    - **2-10** μ**m in focus**
    - 40-60 μm out-of-focus
- Minimize wavefront distortion and coherence degradation
- Withstand FEL full flux



#### Purposes

- Increase the X-ray fluence at the sample
- Produce small spot size in cases where slits do not work due to diffraction,
  - i.e., sample too far from slits
- Implementation
  - Based on refractive lenses concept\*
    - Concave shape due to X-ray refractive index 1-δ+iβ
  - Using Beryllium to minimize attenuation
    - In-line focus
    - Simpler than KB systems
    - no diff. orders as in Fresnel lens
    - Chromatic
      - Con: re-positioning of focal point
      - Pro: Providing harmonic isolation if aperture used
    - Some attenuation at very low X-ray energies ~ 2 keV

\*B. Lengeler, et al, J. Synchrotron Rad. (1999). 6, 1153-1167

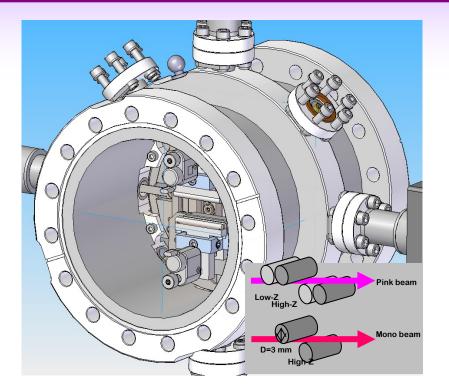
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# Slits System (WBS 1.5.3.3)





#### Requirements

- Primary, guard, and mono types
- Precise (0.5 μm) & coarse (5 μm)
- 0 10 mm gap setting
- 10<sup>-9</sup> in transmission from 2-8.3keV
- 10<sup>-8</sup> in transmission at 25 keV

#### Purposes

- define beam transverse sizes
  - Pink and mono beam
- Clean up scatterings (halo) around beam perimeter
- Implementation
  - Based on cylindrical blades concept\*
    - Minimize scattering from edges and external total reflections
    - Offset in Z to allow fully closing
  - Using double-blade or single-blade configurations for pink or mono beam applications
    - Primary coarse & precise
      - 1<sup>st</sup> blade: Si<sub>3</sub>N<sub>4</sub>, 2<sup>nd</sup> blade Ta
      - sample distance < 1m</p>
    - Guard coarse & precise
      - Single blade Si<sub>3</sub>N<sub>4</sub>
    - Mono coarse & precise
      - Single blade Ta

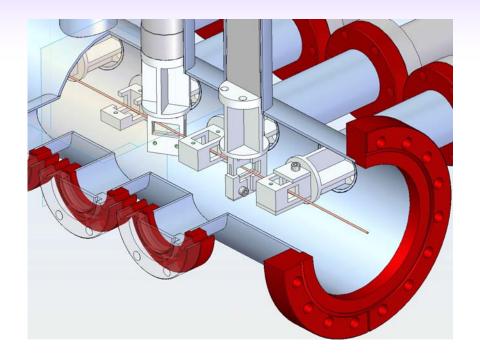
\*D. Le Bolloc'h, et al, J. Synchrotron Rad. (2002). 9, 258-265





# Attenuator/Filters (WBS 1.5.3.4)





#### Requirements

- 10<sup>8</sup> attenuation at 8.3 keV
- 10<sup>4</sup> attenuation at 24.9 keV
- 3 steps per decade for > 6 keV
- Minimize wavefront distortion and coherence degradation
- Withstand unfocused flux



#### Purposes

- Reduce incident X-ray flux
  - Sample damage
  - Detector saturation
  - Diagnostic saturation
  - Alignment of optics and diagnostics

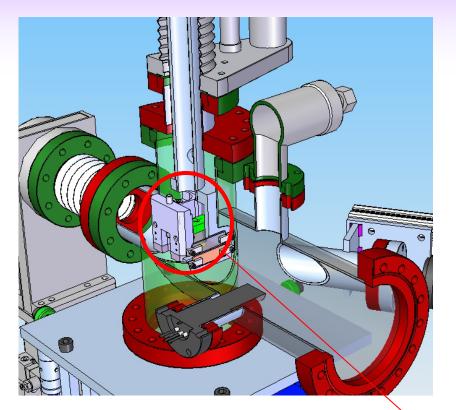
#### Implementation

- Using Si wafers of various thicknesses
  - Highly polished to minimize wavefront distortion & coherence degradation
  - For a given attenuation, use one wafer whenever possible
  - Commercially available (< 1 nm rms roughness)</li>
- For energies < 6 keV in NEH-3 and in pink beam
  - Employing a pre-attenuator, i.e., LCLS XTOD gas/solid attenuators



# Pulse Picker (WBS 1.5.3.5)





#### Requirements

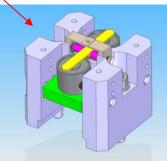
- < 3 ms switching time</p>
- < 8 ms in close/open cycle time</p>
- Only for < 10 Hz operation</p>
- Withstand full LCLS flux

# PurposesSelect

- Select a single pulse or any sequence of pulses
- Reduce LCLS repetition rate to < 10 Hz
  - Important if longer sample recover time is needed
  - Damage experiments sample needs to be translated

#### Implementation

- Based on a commercial mechanical teeter-totter\*
  - Steel blade fully stops beam
  - Capable of ms transient time
  - Simple to operate
    - Use TTL pulses
  - Requires 100  $\mu$ m Si<sub>3</sub>N<sub>4</sub> to protect the steel blade

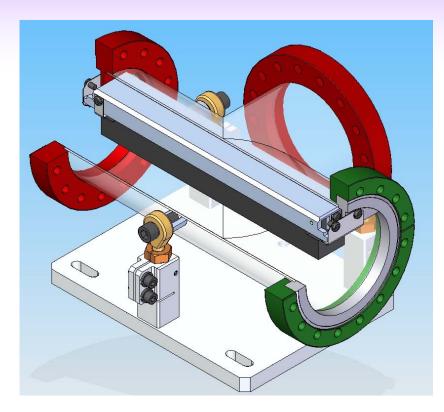


\*http://www.azsol.ch/



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# Harmonic Rejection Mirrors (WBS 1.5.3.6)



#### Requirements

- Energy range: 6-8.265 keV
- 10<sup>4</sup> contrast ratio between fundamental and the 3<sup>rd</sup> harmonic
- 80% overall throughput for the fundamental



#### Purposes

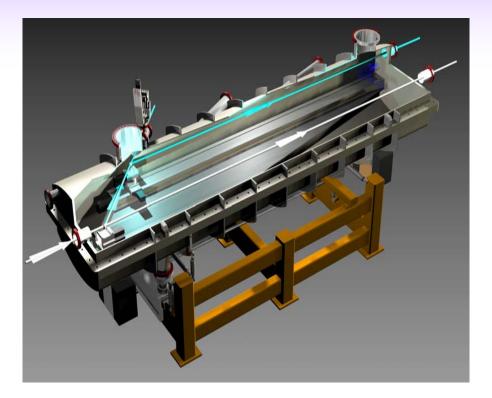
- Provide isolation of FEL fundamental from high harmonics
  - LUSI detectors not designed to be energy resolved
- Implementation
  - Low pass filter using X-ray mirrors at grazing incidence
  - Using highly polished Si single crystal substrates
    - **3.5 mrad incidence angle**
    - 300 mm long
    - No pre-figure, no bender
    - Figure-error specs defined to ensure FEL natural divergence not effected
    - Roughness specs to minimize wavefront distortion and coherence degradation

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# Offset Monochromator (WBS 1.5.3.1)





#### Requirements

- Provide large 600 mm offset
- 6-25 keV operating energy range
  - Continuously tunable
- Mechanical stability at 10% of beam size



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#### Purposes

- **Obtain narrower X-ray spectrum** 
  - Mitigate spectral fluctuations of the LCLS
  - Increase longitudinal coherence length
- Create offset for mono beamline to move off main line
- Implementation
  - Si double-crystal monochromator
    - Non-dispersive configuration







- Safety issues are considered at every stage of the design, fabrication and installation process per SLAC Integrated Safety and Environmental Management System
  - Define Work
  - Analyze Hazards:
    - Identify hazards associated with the design and operation of the LUSI project
    - Each design review addresses appropriate safety considerations for the level of completion of the design and the particular item covered
  - Develop Controls
    - Controls are planned to mitigate or eliminate hazard capable of causing injury to personnel, harm to the environment, or damage to critical hardware
  - Perform Work
  - Obtain feedback and improve
- The Hazards Analysis Report (HAR), PM-391-001-34 R0, documents the safety analysis of the LUSI instrument design/build/install & test
- Safety considerations (some examples)
  - Pressure/Vacuum Vessel Safety
    - Compliant with 10CFR851
  - Seismic Safety
    - Designs compliant with: Seismic Design Specification for Buildings, Structures, Equipment, and Systems, SLAC-I-720-0A24E-002-R002
  - Mechanical
    - **Engineered solutions that prevent potential "pinch-points" with moving machinery**
  - Hoisting and Rigging
    - Hoisting and rigging is performed by qualified personnel only with an approved lift plan.

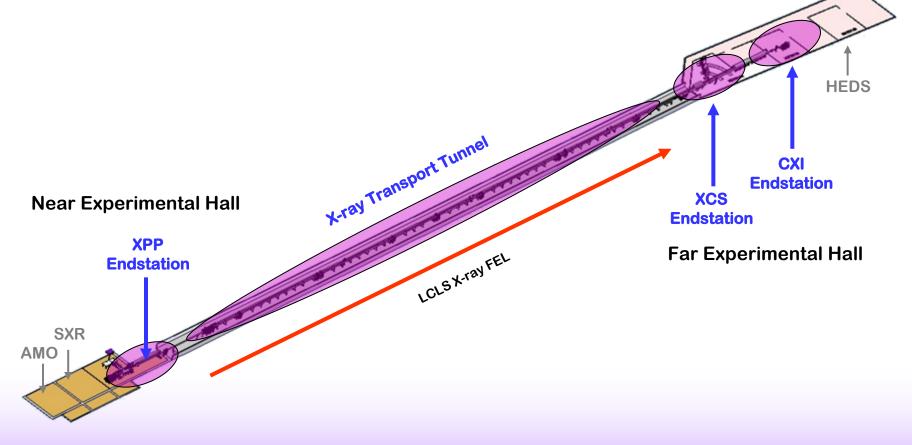






### Components locations

Distributed throughout the XPP, CXI, and XCS instruments, including X-ray transport tunnel



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Diagnostics/Optics	ХРР	СХІ	XCS	Total	PRD	ESD
Pop-in Profile Monitor	3	4	5	12	Released R1	pre-release
Wavefront Monitor		1		1	Released R0	In Work
Pop-in Intensity Monitor	2	2	5	9	Released R1	pre-release
Intensity-Position Monitor	3	3	5	11	Released R1	pre-release
Monochromator			1	1	pre-release	N/A
X-Ray Focusing Lenses	1		1	2	Released R1	Pre-release
Slit System	3	4	6	13	Released R1	pre-release
Attenuators-Filters	1	1	1	3	Released R1	pre-release
Pulse Picker	1	1	1	3	Released R1	In Work
Harmonic Rejection Mirrors	1		1	2	Released R1	In Work

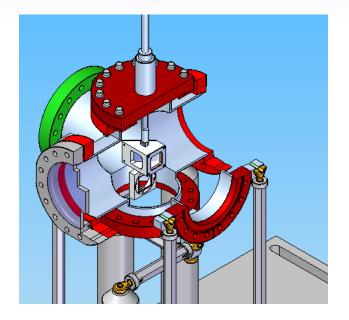
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# **Engineering Status - Diagnostics**

### Pop-In Profile & Intensity Monitor – WBS 1.5.2.1 & WBS 1.5.2.2

- Destructive to the beam
- Measures profile & intensity
- PRD released
- ESD nearly ready for release
- Preliminary designs in process
- Current plan to combine the two devices
- PDR scheduled for Q4FY08
- Intensity-Position Monitor WBS 1.5.2.3
  - Non-destructive to the beam
  - Measures intensity & position
  - PRD released
  - ESD nearly ready for release
  - Investigating customized "off the shelf units"
  - Preliminary "in house" concept developed
  - PDR scheduled for Q4FY08





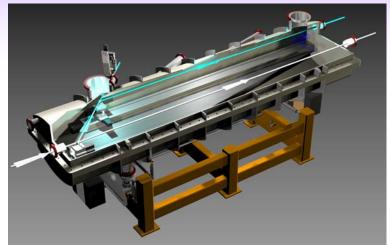


# **Engineering Status – Optics**



### Monochromator– WBS 1.5.3.1

- Added to the scope in June 2008
- Design-build project
- PRD in work
- ESD/Technical Specification will be based off of recent Statement of Work for Argonne monochromator
  - Larger energy range and offset



- LUSI device is twice as long with more stringent pointing stability requirements
- Submit Budgetary Inquiry soon
  - Vendor capabilities
  - Feedback on specifications
  - Cost and schedule
    - Based on Argonne quotation
    - SLAC in house bottoms up estimate



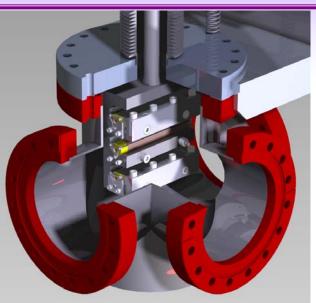


## **Engineering Status - Optics**

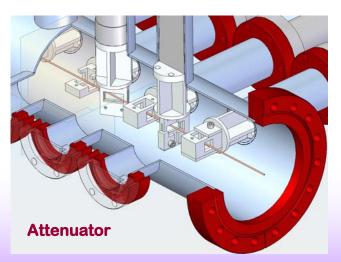


## Be Lens System – WBS 1.5.3.2

- Focuses beam and sets the focal length and waist size.
- PRD Released
- **ESD** out for signature
- Conceptual design in work
- Design based on proven ESRF design
- PDR scheduled for Q4FY09
- Attenuators WBS 1.5.3.4
  - PRD Released
  - ESD out for signature
  - Conceptual design complete
  - PDR scheduled for Q4FY09



X-ray Focusing Lens





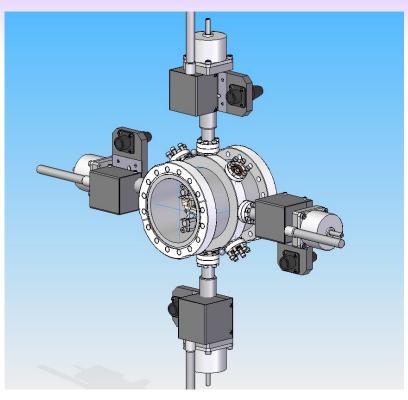


## **Engineering Status – Optics**



### Slits- WBS 1.5.3.3

- Defines the beam size & position
- PRD released
- Slit ESD out for signature
- Off the shelf slit device with custom polished cylindrical blades
- Obtained Silicon Nitride Material for evaluation
- Investigating "dual blade" slit device
  - Employs pico-motors to tip the blades to perform beam based alignment of the blades relative to each other (1µm).
  - Use 2 single blade devices
- PDR is scheduled for Q1FY09



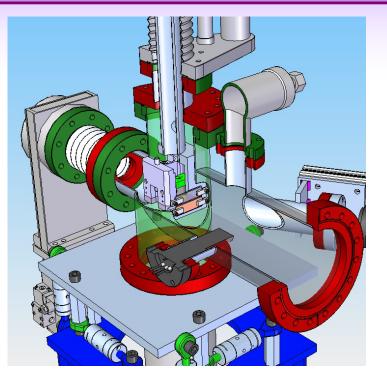




## **Engineering Status - Optics**



- Pulse picker WBS 1.5.3.5
  - Picks a single pulse or any pattern less than 30 hertz
  - PDR released
  - ESD in work
  - Shared design with AMO
    - Employs same commercial pulse picker
    - Need to compact the AMO design
  - First article pulse picker received
  - PDR scheduled for Q4FY09









## **Engineering Status – Optics**





- Harmonic rejection mirror (HRM) WBS 1.5.3.6
  - HRM conceptual design in process
  - PRD released
  - ESD in work
  - Required for late XPP operation and XCS operation
  - PDR scheduled for Q3FY09







### Major Upcoming Milestones

- Q4 FY2008 PDR Pop-In Profile Monitor
- Q4 FY2008 PDR Pop-In Intensity Monitor
- Q4 FY2008 PDR Pulse Picker
- Q1 FY2009 PDR Intensity-Position Monitor
- Q1 FY2009 PDR Slit System
- Q1 FY2009 FDR Slits system
- Q1 FY2009 FDR Pulse picker

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## Value Engineering / Management



 Many trade-offs have been considered throughout the design of DCO components
The DCO team will continue to purse cost effective approaches for all the component aspects (design, fabrication, testing,

Component Value Management /Design Alternatives Considered **Diagnostics** All the diagnostics requirements were optimized to meet the experimental needs for all the instruments. Significant cost savings can be realized from common designs, both in PED, as well as in manufacturing. **Optics** The following optical components requirements were optimized to meet the experimental needs for all the instruments: Pulse Picker, Attenuator, Harmonic Rejection Mirror and Be Lenses. Significant cost savings can be realized from common designs **Pop-In Profile** Design alternatives were studied for functionality and cost Monitor & Popsavings, as well as space savings was found in combining the In Intensity Pop-In Profile Monitor with the Pop-In Intensity monitor. Monitor Intensity-Investigating cost savings for modifying commercial units Position Monitor versus SLAC in house design Slit System Investigating alternative designs for the double blade slits. Also re-examined the functionality and requirements for this unit. Cost comparison of using 2 commercial slit units versus a new double slit design. Actuators Planning on using common actuators to limit the number of designs. Performed a cost comparison of the controls between pneumatic actuators and steppers with smart motors. Vacuum Combining units to reduce the number of vacuum chambers, thus reducing material cost, as well as labor for assembly. Assemblies Yiping Feng and Eliazar Ortiz **LCLS Ultrafast Science Instruments** vfeng@slac.stanford.edu ortize@slac.stanford.edu

Installation)



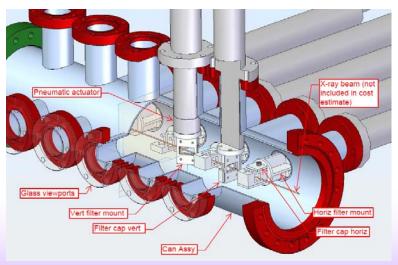


## **Basis of Estimate**



#### Contains the following

- Description of the component
- 3D model if applicable and available
- Detailed cost estimate
  - Part number, drawing number, vendor, notes, weight, qty, and cost.
- Supporting quotations, drawings, catalogs, etc.
- Configuration controlled with the CD2 baseline
- Cross referenced to P3 activity ID's



		LUSI "X-Ray Optics"																	
		WBS 1.5.3.4	Attenuator 10 Way																
		Estimator	Defever/Amett/Kurita																
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06960		Actuator Assy	391-900-02		0.50	Designer	20												\$1.36K
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107020		Vacuum Assembly	391-900-00			Designer	20												\$1.36K
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107100		commits (b)				Engineer	+0		-		-								\$0.296
107140		Manufacturing documents			1.00	Engineer	40												\$2.30K
		Support Design for Dual Pop-In																	
107155		Preliminary				Engineer	16												\$0.92K
07155		E				Designer	32												\$2.18K
07160		Final			0.04	Engineer Designer	8												\$0.46H \$1.09H
07160		Detail Drawings (5 drawings)			0.05	Designer													\$1.094
07165		neren niennige (niennige)				Engineer	25												\$0.294
107170		Check and Release				Designer	15												\$1.024
		1101			_				-									-	<u> </u>
		MSL	1				1		1										i







- A variety of sources are used to design, build, test and install DCO components.
  - SLAC effort where skill set exists.
  - Vendor design build used where available.
  - Previous designs and Off-The-Shelf components are used whenever available.

	DCO Work Breakdown Structure	Re	Resource Source					
WBS	TITLE	Design	Design Build Test/Insta					
1.5	Diagnostics & Common Optics							
1.5.01	Diagnostics & Common Optics System Integration &							
1.5.02.01	Pop in Profile/Wavefront Monitor							
1.5.02.02	Pop in Pop intensity Monitor							
1.5.02.03	Intensity Position Monitor							
1.5.03.01	Monochromator							
1.5.03.02	X ray Focusing Lenses							
1.5.03.03	Slit System							
1.5.03.04	Attenuators / Filters							
1.5.03.05	Pulse Picker							
1.5.03.06	Harmonic Rejection Mirrors							

Previous Design/OTS	
SLAC	
Domestic Vendor	
Foreign Vendor	
Long Lead Procurement	

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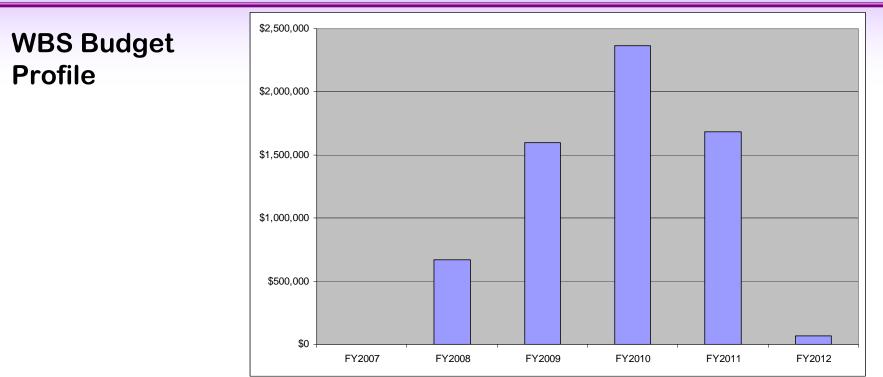




**Profile** 

## **DCO Cost & Schedule**





Control Account	FY2007	FY2008	FY2009	FY2010	FY2011	FY2012	Cumulative
1.5.01 Diagnostics & Common Optics System Integration & Design	\$0	\$425,202	\$321,933	\$308,333	\$211,124	\$66,793	\$1,333,385
1.5.02.01 Pop-in Profile Monitor	\$0	\$41,893	\$156,295	\$219,317	\$148,664	\$0	\$566,169
1.5.02.02 Pop-In Intensity Monitor	\$0	\$42,092	\$64,342	\$108,047	\$111,602	\$0	\$326,083
1.5.02.03 Intensity-Position Monitor	\$0	\$44,616	\$122,512	\$308,170	\$212,393	\$0	\$687,692
1.5.03.01 Monochromator	\$0	\$0	\$387,623	\$845,895	\$0	\$0	\$1,233,518
1.5.03.02 X-ray Focusing Lenses	\$0	\$14,385	\$148,711	\$13,148	\$183,500	\$1,520	\$361,263
1.5.03.03 Slit System	\$0	\$66,154	\$92,598	\$251,284	\$250,285	\$0	\$660,321
1.5.03.04 Attenuators / Filters	\$0	\$4,427	\$99,061	\$75,773	\$150,270	\$0	\$329,531
1.5.03.05 Pulse Picker	\$0	\$32,350	\$138,987	\$164,443	\$139,546	\$0	\$475,327
1.5.03.06 Harmonic Rejection Mirrors	\$0						
Control Account Totals	\$0	\$671,120	\$1,594,457	\$2,365,170	\$1,683,879	\$69,369	\$6,383,995

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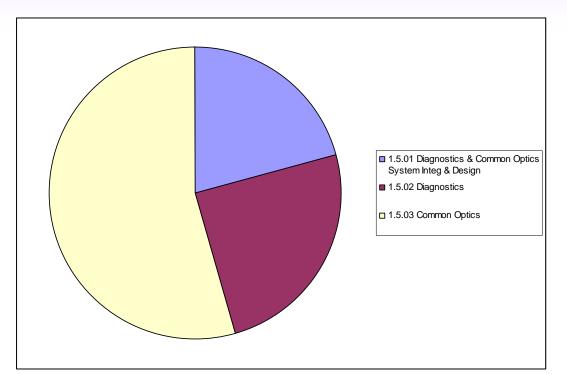


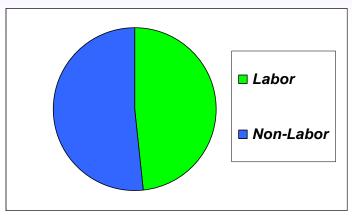
**LCLS Ultrafast Science Instruments** 





### Cost by account and resource





WBS 1.	5
Resource Type	Value
Labor	\$3,093,109
Non-Labor	\$3,290,886
Total BAC	\$6,383,995

WBS 1.5	FY07	FY08	FY09	FY10	FY11	FY12	Cumulative
1.5.01 Diagnostics & Common Optics System Integ & Design	\$-	\$ 425,202	\$ 321,933	\$ 308,333	\$ 211,124	\$ 66,793	\$ 1,333,385
1.5.02 Diagnostics	\$-	\$ 128,602	\$ 343,149	\$ 635,534	\$ 472,659	\$-	\$ 1,579,943
1.5.03 Common Optics	\$-	\$ 117,316	\$ 929,376	\$ 1,421,303	\$ 1,000,096	\$ 2,576	\$ 3,470,667
WBS Totals:	\$-	\$ 671,120	\$ 1,594,457	\$ 2,365,170	\$ 1,683,879	\$ 69,369	\$ 6,383,995

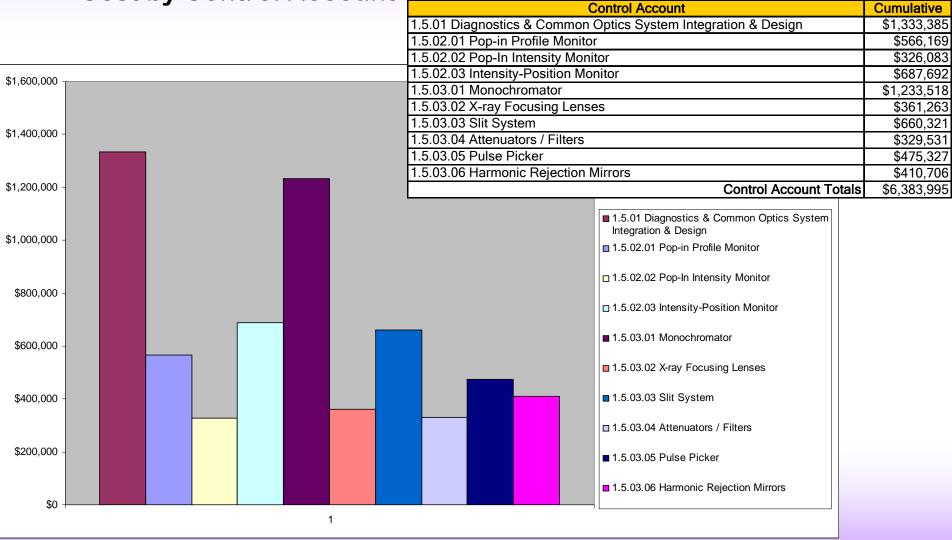
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### Cost by Control Account



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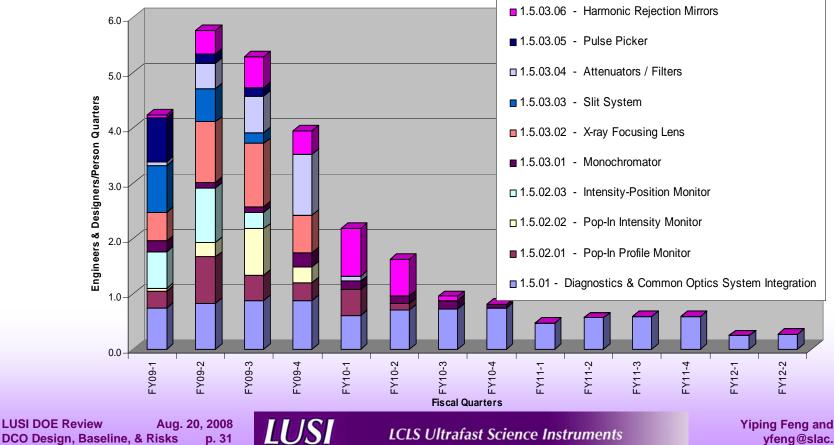
### Resource Loading

### Durations

**DCO Design, Baseline, & Risks** 

- Person quarter = 444h
- Person year = 1776h
- Person month = 148h

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### Long Duration Procurements

Activity ID	Activity description	Budgeted cost
DI 60440	AWARD: XCS Monochromator (FOREIGN)	1,158,831.40
DI 09560	AWARD: PO - XPP XFL Long Lead Parts	11,770.00
DI 14200	AWARD: PO - XCS XFL Long Lead Parts	12,320.00
DI 41040	AWARD: PO - XPP Slits Long Lead Parts	75,881.19
DI 41210	AWARD: PO - CXI Slits Long Lead Parts	103,066.04
DI 42110	AWARD: PO - XCS Slits Long Lead Parts	158,854.08
DI 12820	AWARD: PO - XPP Pulse Picker - Long Lead Parts	14,980.00
DI 14105	AWARD: PO - CXI Pulse Picker - Long Lead Parts	15,260.00
DI 16005	AWARD: PO - XCS Pulse Picker - Long Lead Parts	15,680.00
DI 10445	AWARD: PO - XPP HRM Long Lead Parts	49,280.00
DI 14840	AWARD: PO - XCS HRM Long Lead Parts	49,280.00







#### Deliverables

	CD-4A	CD-4B	CD-4C
ХРР	Pop-In Profile Monitor Pop-In Intensity Monitor Intensity-Position Monitor Slit System Pulse Picker		Harmonic Rejection Mirrors X-Ray Focusing Lens Attenuators
схі		Pop-In Profile Monitor Pop-In Intensity Monitor Intensity-Position Monitor Wavefront Monitor Slit System Pulse Picker Attenuators	
xcs			Pop-In Profile Monitor Pop-In Intensity Monitor Intensity-Position Monitor Attenuators Harmonic Rejection Mirrors X-Ray Focusing Lens Slit System Pulse Picker Monochromator







### 1<sup>st</sup> Critical Path

Driven by funding milestones on long duration part procurement
AWARD: PO - XCS XFL Long Lead Parts

- 2<sup>nd</sup> Critical Path
  - PDR Prelim Design Review Intensity Position Mon
  - AWARD: PO XPP IO Mon 1st Article Parts
  - AWARD: PO XCS HRM Long Lead Parts
- Additional float could be generated by allocating procurement funds to DCO earlier
- **TOTAL SCHEDULE FLOAT for DCO is 80 days.**





## **DCO Schedule Critical Path**



Activity	Activity	Total	Early	Late							
ID	Description	Float	Finish	Finish	FY08	SONDJ					
80										اقفقف تفقفت	القيفية فتقف فيقا
DI 14180	Procurement Preps - XCS XFL Long Duration	80	10/01/10	02/08/11			P	rosurement Preps - XCS XFL Long Duratio	! ! ! !		
DI 14200	AWARD: PO - XCS XFL Long Lead Parts	80	10/04/10	02/09/11					XFL Long Lead Par		
DI 14220	Vendor Fab - XCS XFL Long Lead Parts	80	06/01/11	09/21/11				Nentior Fab - XC8	XFL Long Lead Part		
DI 14240	RCV: XCS XFL Long Lead Parts	80	08/01/11	09/21/11						RQV: XD8 XFL Long Load Part	
DI 14340	Inspect Procured Parts - XCS XFL Long Lead	80	06/15/1	10/05/11					Inspe	ot Proound Parts - KCS KFL Long Lea	
DI 14380	Clean - all XCS XFL Parts	80	06/29/11							Clean - all XC8 XFL Party	
DI 14400	In-House Assembly - XCS XFL Parts	80	08/10/11	12/07/11						In House Accemply - KCS XFL Party	
DI 14420	Inspect & Fiducialize - XCS XFL Parts	80	08/24/11	12/21/11		$\checkmark$				inspect & Fiduolalize - XC8 XFL Parts	
DI 14440	Vacuum Process - XCS XFL Parts	80	09/07/11	01/12/12						Vaouum Procece - XCS XFL Parts	
DI 14460	Testing - XCS XFL	80	10/19/11	02/28/12						Tedting - XC3 XFU	
DI 14480	AVAIL: XCS XFL Ready for Installation	80	10/19/11	02/28/12						AVAIL: XC\$ XFL Ready for installation	
84 DI 02960	Generate ESD - Intensity-Position Mon	84	07/08/08	11/03/08	Genera	ESD - Intensity-Positi	an Mon	<u>≺</u>			
DI 02960		84	10/06/08	02/17/09		Prelim Decign &					
DI 03000 DI 03190	Prelim Design & Analysis - IPM Prelim Design & Analysis - IPM Support	84	10/06/08	03/03/09			& Analysis - IPM Support				
DI 03190	Prenim Design & Analysis - IPM Support Prep for PDR - IPM	84	11/03/08	03/03/09	Prep for PD						de al ava a ff a st
DI 03025	PDR - Prelim Design Review - Int Position Mon	84	11/03/08	03/18/09			Decign Review - Int Position M	on		DCO has one	design effort
DI 03040	Finalize Design - IPM	84	01/15/09	05/13/09	Finalize De	TI					
DI 03080	Prep for FDR - IPM	84	01/29/09	05/27/09		Prep for FDR - IPM				and multiple p	rocurements
DI 03095	FDR - Final Design Review - Int Position Monitor	84	01/30/09	05/28/09	FDR - Final Decign Revi	w - Int Position Monito					
DI 02320	Finalize Design - IO Pop-In Monitor	84	04/10/09	08/06/09		ign - IO Pop-In Monito				to support the	e instrument
DI 02320	Detail Piece Part Drawings - IO Pop-In Monitor	84	06/05/09	10/01/09	- i i <b>-</b> i i	art Drawings - 10 Pop-	h Monito				
DI 02340	Check & Release Dwgs - IO Pop-In Monitor	84	07/03/09	10/29/09		Cheok & Release Dwg	¢ - IO Pop-In Monito			requirements	. I ne project
DI 02342	COMP: Part Drawings - IO Pop-In Mon & Support	84	07/06/09	10/30/09		COMP: Part Drawings	10 Pop-In Mon & Suppo				
DI 02580	Procurement Preps - XPP IO Mon 1st Art. Parts	84	07/27/09	11/20/09	4 : :   : :	Procurement Preps	KPP IO Mon 1st Art, Par			will monitor	strings of
DI 02600	AWARD: PO - XPP IO Mon 1st Article Parts	84	07/28/09	11/23/09	4 1 1 1 1 1	AWARD: PO	XPP IO Mon 1st Article Par				the least fleet
DI 02620	Vendor Fab - XPP IO Mon 1st Article Parts	84	12/17/09	04/28/10		Vendor Fab	XPPIO Mon 16t Artiole Part			activities with	ine least lioat
DI 02640	RCV: XPP IO Mon 1st Article Parts	84	12/17/09	04/28/10			R¢V: XPP IQ N	fon 1st Article Part			-
DI 02760	Inspect Procured Parts - XPP IO Mon 1st Article	84	01/14/10	05/12/10			Inspect Prooured Parts - XP	P IO Mon 1st Artio			
DI 02780	Clean - all XPP IO Mon 1st Article Parts	84	01/28/10	05/26/10			Cipan - all XPP	IQ Mon 1st Article Part			
DI 02800	In-House Assembly - XPP IO Mon 1st Article Parts	84	03/11/10	07/07/10			In-House Ascembly X	PP IO Mon 1st Article Part			
DI 02810	Inspect & Fiducialize - XPP IO 1st Article Parts	84	03/25/10	07/21/10			inspect & Fic	dudialize - XRP IO 1st Artiole Par			
DI 02820	Vacuum Process - XPP IO Mon 1st Article Parts	84	04/08/10	08/04/10			Vaouum Pr	ooess - XPP IO Mon 1st Artiole Part			
DI 02840	Testing - XPP IO Monitor 1st Article	84	04/22/10	08/18/10	1			Testing - XPP ID Monitor 1st Artiol			
DI 02860	AVAIL: XPP IO Monitor Ready for Installation	84	04/22/10	08/18/10	1		AVA	IL: XPP IO Monitor Roady for Installatio			
85	-										
DI 10440	Procurement Preps - XPP HRM Long Duration	85	11/12/10	03/29/11	]			Procurement Preps 7 XP			
DI 14820	Procurement Preps - XCS HRM Long Duration	85	11/12/10	03/29/11				Prooudement Preps J XC	1 [ [ ] ]		
DI 14840	AWARD: PO - XCS HRM Long Lead Parts	85	11/15/10	03/30/11				-i   i i   i i   i	- XCS HRM Long Lo		
DI 14860	Vendor Fab - XCS HRM Long Lead Parts	85	05/18/11	09/14/11				Vendor Fab	- XCS HRM Long Le		
DI 14880	RCV: XCS HRM Long Lead Parts	85	05/18/11	09/14/11						RCV: KC8 HRM Long Lead Part	
DI 14980	Inspect Procured Parts - XCS HRM Long Lead	85	06/08/11	10/05/11					Inspect		
DI 15020	Clean - all XCS HRM Parts	85	06/22/11	10/19/11						Clean <sup>i</sup> - all XCS HRM <sup>i</sup> Part	
DI 15040	In-House Assembly - XCS HRM Parts	85	08/10/11	12/14/11						In-House Assembly - XCS HRM Part	
DI 15060	Inspect & Fiducialize - XCS HRM Parts	85	08/24/11	01/05/12						inspect & Fiduolalize - XCS HRM Part	
DI 15080	Vacuum Process - XCS HRM Parts	85	08/31/11	01/12/12						Vpouum Proces - XCS HRM Parts	
DI 15100	Testing - XCS HRM	85	10/12/11	02/28/12						Teeting - XCS HRM	
DI 15120	AVAIL: XCS HRM Ready for Installation	85	10/12/11	02/28/12						AVAIL: KCS HRM Ready for Installation	

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LCLS Ultrafast Science Instruments

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## **DCO Schedule Critical Path**



Activity	Activity	Total	Early	Late					
		Float			FY08	FY09	FY10	FY11	FY12
ID	Description	Float	Finish	Finish	ΙΙΙΑΙΟΝΓ	DJFMAMJ	JASONDJEMAMJJAS	ONDJFMAMJJA	S O N D J F M A M J J A S C
91							REGD: XPP IPM Controls HW/8V		
DI 03575	REQD: XPP IPM Controls HW/SW	91	03/30/10	08/04/10			i i   i i   i i <u> </u> i i   i i		
DI 03580	Testing - XPP IPM 1st Article	91	04/13/10	08/18/10			Tecting - XPP IPM 1st Action		
DI 03600	AVAIL: XPP IPM 1st Article Ready for Install	91	04/13/10	08/18/10			AVAIL: XPP IPM 1st Article Ready for Insta		
93									
DI 02345	Prep for FDR - IO Pop-In Monitor	93	04/24/09	09/02/09	Prep for FDR -	- IQ Pop-In NonIto			
DI 02360	FDR - Final Design Review - IO Pop-In Monitor	93	04/27/09	09/03/09	FDR - Final Design Revie	w - 10 Pop-ih Monito			
DI 02380	Incorp FDR Changes - IO Pop-In Monitor	93	05/25/09	10/01/09	I Inborp FDRICharige	es - IO Rop-in Monito			
DI 02480	Check & Release Dwgs - IO Monitor Support	93	06/22/09	10/29/09	Cheok & Rolease D	Dwgs - ID Monitor Suppor			
97									
DI 13805	REQD: XCS IO Controls HW/SW	97	08/11/11	01/10/12				REQD: XCS IO Controls HW/SI	
DI 14125	REQD: XCS IPM Controls HW/SW	97	08/11/11	01/10/12				REGD: XCS IPM Controls HW/S	
DI 13820	Testing - XCS IO Monitor	97	08/25/11	01/25/12				Tecting -XC2 IO Monito	
DI 13840	AVAIL: XCS IO Monitor Ready for Installation	97	08/25/11	01/25/12				AVAIL: XCS IO Monitor Ready for Installatio	
DI 14140	Testing - XCS IPM	97	08/25/11	01/25/12				Testing - XCS IPM	
DI 14160	AVAIL: XCS IPM Ready for Installation	97	08/25/11	01/25/12				AVAIL: XCS IPM Ready for Installatio	
98									
DI 13485	REQD: XCS PM Controls HW/SW	98	07/13/11	12/05/11				REQD: XC8 PM Controls HW/S	
DI 13500	Testing - XCS PM	98	08/24/11	01/25/12				Testing - X¢8 PM	
DI 13520	AVAIL: XCS PM Ready for Installation	98	08/24/11	01/25/12				AVAIL: XCS PM Ready for Installatio	

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Sheet 2 of 2

LCLS Ultrafast Science Instruments





Resource loaded schedule completed and has been fully implemented into the project management

DCO

- 139 milestones L4 and L5 specific to DCO
  - L4 = systems
  - L5 = interface-handoff
- 37 milestones L6
  - L6 = commitments-awards

21803	CONP: Pece Part?		-		r Float Start Finish 10		-	and the summer			- From -		
21425	P165 101 FDR - P60	Activity ED			Activity Orig Total E escription Dur Float 3	2	Early Finish	Has	ource D	Budgeted Cost	Predecessors ET08	E 1025	ETT2
21622	FDR - Final Design	0+0+286	Div. 5	Activity	Activity	Orig	Total	Carty		Resource	Dudgeled Predecessors	L LYON	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
21602	Income FOR Change	0+0+290	Dia 8	15 0440	Description INOSTICS & COMMON OPTICS	Dur	Hoat	Start	Finish	•	Cost		
21642	Deal, Check, Aste	0101000	DIA 5		agement / Administration								
121682	Generate hits Doos	0101010	014.5										
01470	Pres for Design Dia	0101020	014.5	0120112	COMPLOCO Design Ready for XRP FLOR	•	27		09/52/08		0.00 D1 31660, D1 02300, D1 03040, D1 06640 D1 21640		Commit and Design Revery Texture Hain
01480	Design Dialus Revis	0+01036	Dia 8	0+30112	COMP. DCD Design Ready for CXI. RCM	°			08/31/09		0.00 DI 21580, DI 02500, DI 03040, DI 06040 DI 0640, DI 07540	e.	COMP. DOO Design Ready for CoolRDR
01490	CONF. Design Pro	0101040	D14.5	0100114	COMP: DCD Design Ready for XDS FIDR		18		111505		8 00 B- 30168, B- 37528, D- 37520, D- 40000	-	COMP: Doo desar resay to too Hox
121713	Pretire Design & Art	0101040	215.8	0120123	CONFLOR & Common Optos Final Design	•	132		01/26/10		6.00 D1 21436, D1 02386, D1 03120, D1 06140 D1 24166, D1 01046, D1 01146, D1 0400	6.0	🔮 Ó Chill <sup>a</sup> Cho à Commun Callus Rinel Ceange
01720	Private Design - Pt	0101060	DIALS	0120160	COMP: Disprositios & Common Optics COMA RFI	•	34		06/10/10		0.00 DI 32130, DI 02130, DI 02040, DI 00400 DI 10440, DI 10340	a.	ODRY: Diagnostics & Control Dated CO-46 R71
+ 0 - 750	Generate Detail Dra	0+0+370	Dials	0120162	COMP: Disprositios & Common Outlos CO-46 R/I	•	20		0611/01	1	0.00 D1 25540", D1 10640, D1 11160, D1 1120 D1 11440, D1 12606, D1 11160, D1 1120	8	comm Diagnostics a Dominion Optics (D)-48 81
101740	Charle & Release D	0-0-045	D14.5	DI 20172	CONP: Diagnosities & Common Optics CO-vic RP1	•	120		11002011		0.00 D1 10180. D1 10820. D1 10460. D1 12780	9	DOBF Organistics & Dimensio Optim/CDIm( #8)
121742	DON'T Drawnes of	0+01080	24.5	1.5.01 D	iagnostics & Common Optics Sy:	meta	Integra	tion &		1	providence, doi 10440, doi 1440, doi 14400		
01745	Darwale PRD - Ita	0101400	215.5		n / Engineering								
			Dist		Diag Common Optics Physics Supt &								
01762	COVP: PAD Rees	0101#10			STHAT: Disgnastics	•		09/54/014			8.00	PROFILE PARTY	
01766	Generate Engr Lon	0101430	DIA 8	D121063	Diagnostic Physics Dupport Physic	19		09/04/074	09/28/01A		0.00 D1 21040		nine England #107
01762	CONF: ESO Relea	1.5.02.01		0121080	Diagnostic Physics Deport P128-01 & 02	121		10/01/01A	050108A	107_188, 107_1085	(28,97).00 01 01080		provide Physical Rainpell P108-G (4) 82
01780	Preto Design 5 An	02 Desi 9110521		9100481	Diag Specs, Design & Engr	-							
01800	Finalize Design - W	01010021	DTAR.		Engineering integration & Evaport Frit?	12			09/26/07 A		0.00 0101040		egnition & Eupdoit P107
01643	Detail Piece Part D	0101460	Sene		Engineering Integration & Support From-21 & Co	121		1001/014	C20108A	H01_L&R, H01_H00	\$2,700.00 DI 31170	1	prevening integristion & buggioint Piote Gri & Gzi
121862	Pres to: FOR - Pop	01.01.000	1ere		Design & Engr - Diag Common Optics	1.22		1001034	Carge Card	here an	342.00 01 21170		A Option Dyn Integ & Contyr F108-01-5-32
0.01993	FDR - Final Design	0101806	-	0101000	Dot & Calley Propert System Trauel FY28-D1 & C2			100010010		Concern .		TITLE	A CODING PRODUCT READING THEME PRODUCT & CC
01860	Check & Release 0	0.0.827	2.044										
01680	Detail Assembly Dri	010100			DVK.5 Optics Like Supplies FYOR-O1 5 G2	121		1001/014	53/01/08A		0.00 01 01170	1.1.1.1	a optica una supplieu entre d'il a da
+ 0+900	CONP: First Desig	01 01 520	0.044	9110511	Design & Engr - Diag & Common Opti Degreest Protect Patients 4 04	141	126	0101044	09-30-04	10.000	116.400.7180121040		Chipments Physical Support PV36-04 (A/Sac
3 Proc	curement			010100	Depende Product Pr25	348		100108	09/30/09	1	10.117.44.0121040.0121040		Page of the Report Fully
110522	Procurement	0101540	[***		Disgraphic Physics Dynamit Physics	340		100100			156.326.62 01 01100		V Displayed Provide Report First
+ 0 + 920	Procurament Preps	0101660	1000	0101140	Disease Production Provider	240		100110	09-30-11	0	10.117.40 0.01107	-1888	Programme Progra
01540	A31A80.P0-399	Q1 Q1 895	<b>***</b> *										
121962	Vendor/Feb - XPP 1	0+0+540	POR-		Diagnostic Physics Dussoft Ph12	140		1003/11		5,748	41,148.80 D121140*		Cognession Property and Support Fire
01960	NOV: XPP PM Part	0101580	<b>Trail</b>	D121185	Engineering integration & Support From-20 & Cr	121		0101084	09/30/08	26,0466	111,846.44 0131180		Vingineering ethquetion a support Pros. (21 s de
		0101600	<b>Sere</b>		Engineering Integration & Support F108	348		100108	09-30-09	5.,488	114,448,84 0101180, 0101188*		Annual Physics and programs & Support Filds
		0101602	Creat	0101200	Engineering Integration & Support Fints	340	125	100109	09/3010	DL_MEE	80.430.84 D121150*		Attended and Attended and Attended and Attended and Attended and Attended
			-	0101210	Engineering Integration & Evaport F111	240	105	100110	09/30/11	DL,MEE	93.006.57 D1 21200*	1	Registering Stephenesk Register Fright
				0+2+222	Engineering integration & Dupport First2	142	126	10/00/11	09/05/12	25_2486	16,267.20 Dr 21160*, Dr 01210*		Shalleering Bingellering Bageller (d. Bageleri Prop.

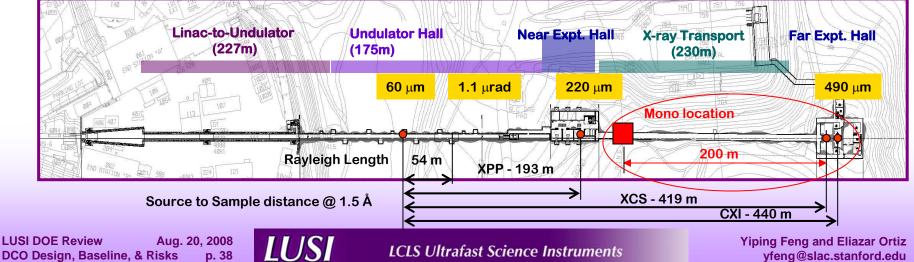






ortize@slac.stanford.edu

- DCO major risks identified per LCLS risk management plan, PMD 1.1-002-r4
  - Risk: Mono mechanical stability not met
    - Required to maintain position stability to 10% of beam size
  - Mitigation:
    - Ensure requirements are clearly stated and agreed prior to award and fabrication
    - Implement a stringent vendor selection process
    - Implement regular visits to vendor
    - Implement frequent and measurable status reports
    - Maintain constant communication with the vendor prior to and during design and fabrication







- Scope of DCO components for XPP, CXI, and XCS instruments fully defined
- The design of key diagnostics devices and optical components is mature and based on proven developments
  - at FLASH, SPPS, synchrotron sources worldwide
  - by LCLS-XTOD group
- DCO components have a consistent cost estimate.
- Resource loaded schedule developed through end of project
- Critical Path is defined
- Advanced Procurements identified
- DCO is ready for CD2 approval!

