Split and Delay System Design and Performance

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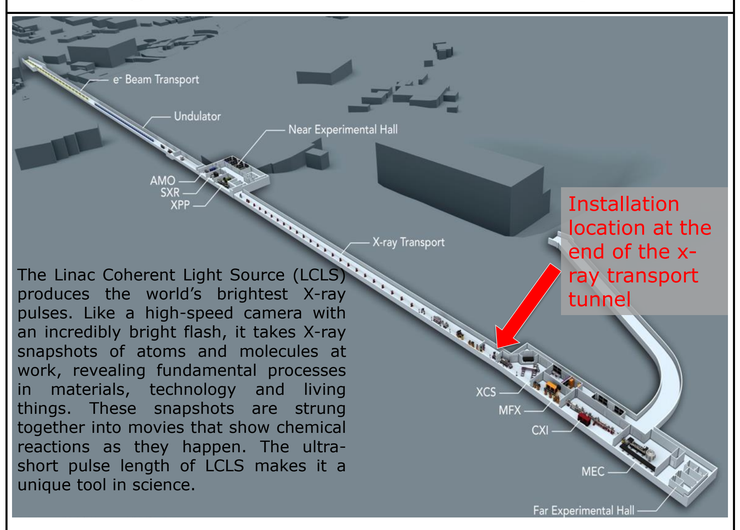
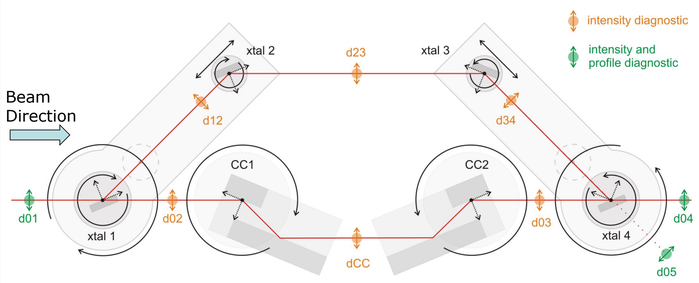
Introduction

The recent commissioning of the XCS Hard Xray Split and Delay (SnD) system has validated a number of the basic design decisions for building a system capable of splitting a mm scale diameter x-ray beam with delays of up to 1ns and recombining the beam while maintaining overlap of the recombined beam at a distance of 10m. This poster reviews the design approaches used to achieve the performance goals and recent system level results.

Design Goals and Assumptions



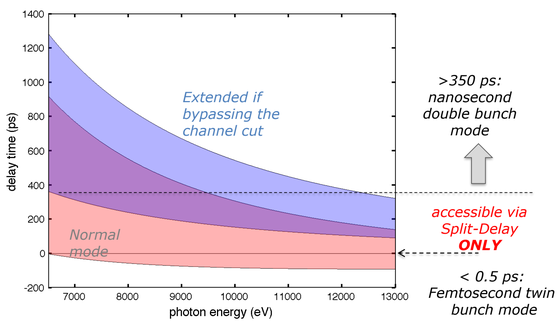
The Linac Coherent Light Source (LCLS) produces the world's brightest X-ray pulses. Like a high-speed camera with an incredibly bright flash, it takes X-ray snapshots of atoms and molecules at work, revealing fundamental processes in materials, technology and living things. These snapshots are strung together into movies that show chemical reactions as they happen. The ultra-short pulse length of LCLS makes it a unique tool in science.



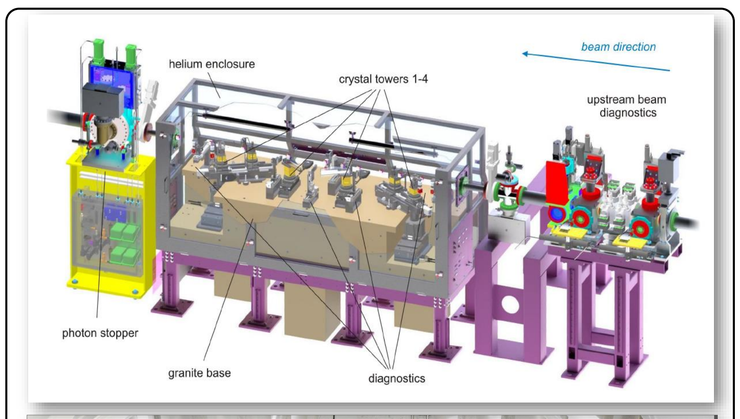
Optical Schematic –Delay Branches & Diagnostics (Top View)

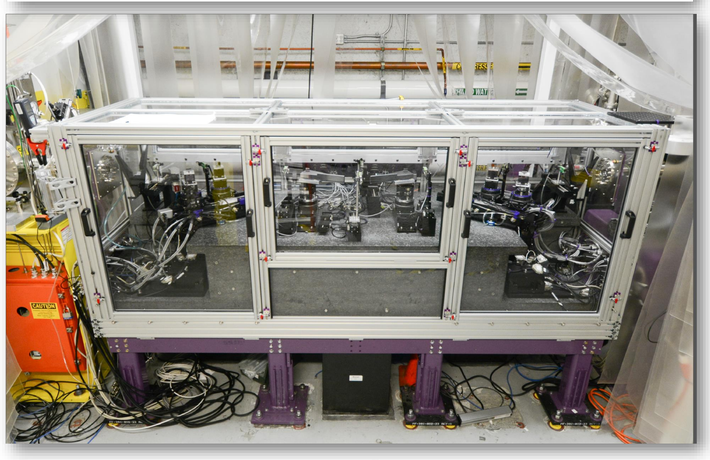
	values	comments
Delay range	-5 to 500 ps at 8 keV, up to 1ns at 7keV in CC-bypass mode	Allows full coverage of delay time gap from various machine double-pulse modes.
Energy range	6.5-26 keV	Covers the primary LCLS and LCLS-II hard x-ray energy range up to 25 keV.
Focal spot size	Down to 1-2 um spot	Within 2X of achievable focal spot size without Split and Delay using same focusing optics.
Overlap precision	10% of beam size at IP	10% based on conventional requirements.
Stability	10% of beam size at IP, combined jitter and drift/hr.	The two branches, after overlap at the focal position, should not move with respect to each other more than 10% of the beam size.

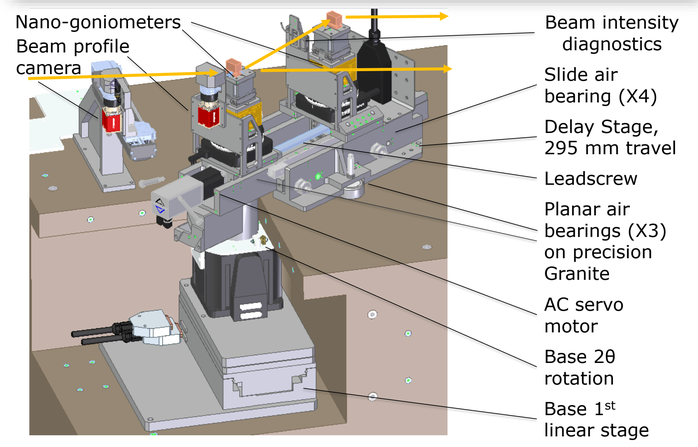
Operational Requirements



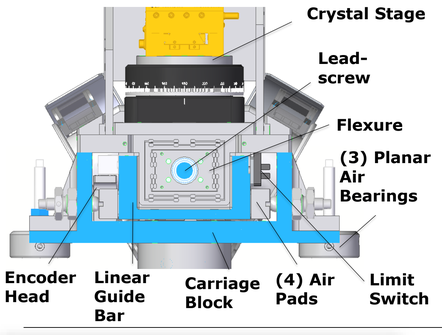
Delay Range



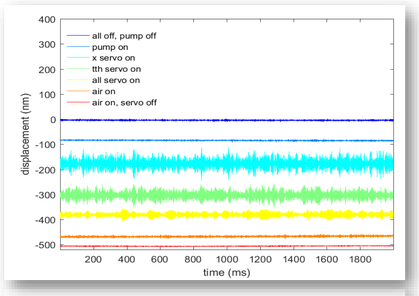




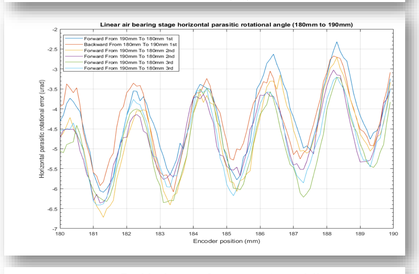
Delay Branch Components



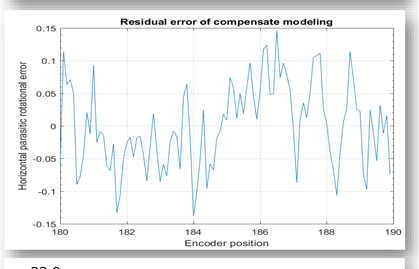
Delay Branch X-section with Planar Air Bearings and Leadscrew Flexure



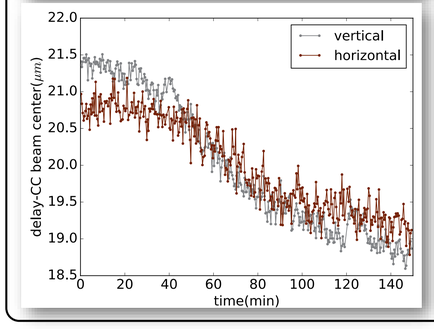
Horiz jitter – air on/off ~50nm pk-pk w/servo on (Single Delay Branch)



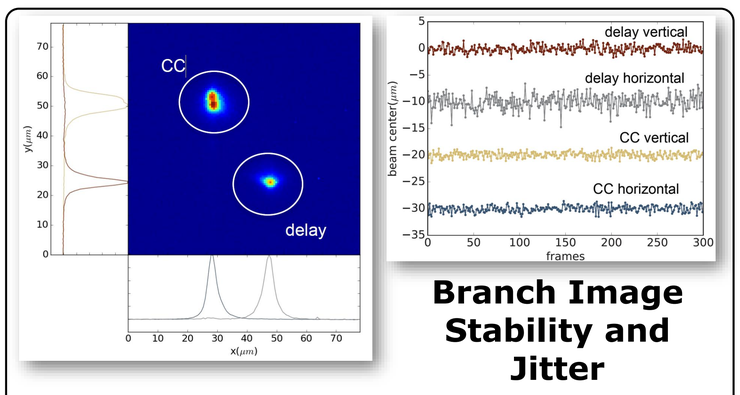
~3uRad Horiz pointing wobble - Uncorrected



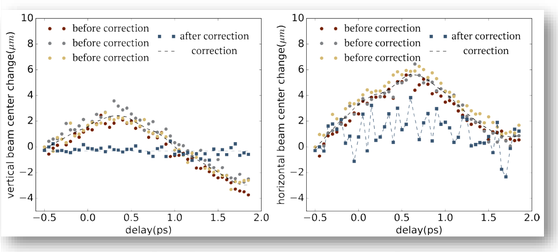
~0.3uRad Horiz pointing wobble -Corrected



~2um H&V Spot Drift Differential over >2hrs

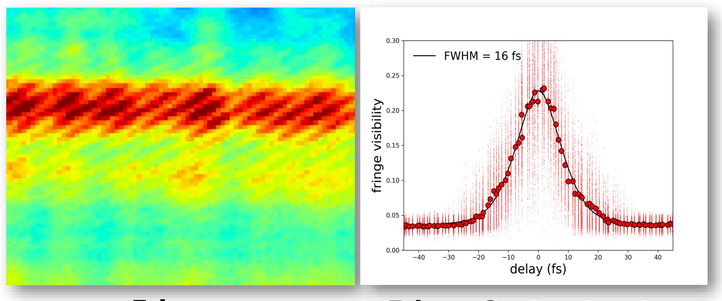


Branch Image Stability and Jitter



H&V Spot Position vs Delay Setting

Vertical **Horizontal**



Fringes **Fringe Contrast vs t_{delay}**

@t_{Delay}=0, spot superposition generates interferograms

Jitter		Vertical(μm)	Horizontal(μm)
delay	beam width(σ)	1.71±0.08	2.2±0.1
	center change(rms)	0.65	1.4
CC	beam width(σ)	2.4±0.2	1.90±0.09
	center change(rms)	0.6	0.63
delay center - CC center (rms)		0.9	1.2
pink beam	beam width(σ)	2.8±0.2	3.6±0.2
	center change(rms)	0.1	0.8

System Level Beam Placement

Conclusions

The recent commissioning of the XCS Hard Xray Split and Delay (SnD) system demonstrated the ability to split the LCLS beam into two branches and recombining them onto a 2um spot at the XCS instrument Interaction Point (IP) with temporal delays of up to 1ns between spots. Horizontal jitter of the delay branch spot is approximately twice that of the CC branch, but upgrades to the delay branch servo controllers is expected to reduce this difference. Continued improvement in system performance and stability is expected from planned hardware upgrades.

Acknowledgments

We wish to thank all of the members of the SLAC SnD Team. This work is supported by the US Department of Energy, Office of Science, Office of Basic Energy Sciences under Contract No. DE-AC02-76SF00515.