Optical System Redesign for Phase Contrast Imaging Detector

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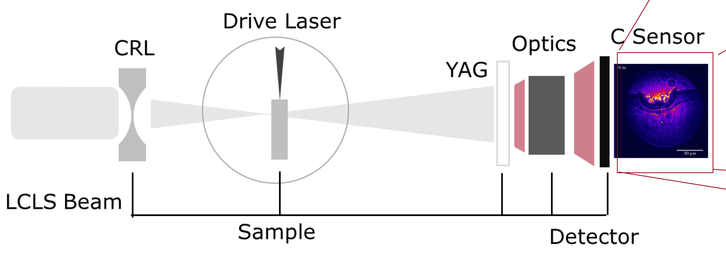
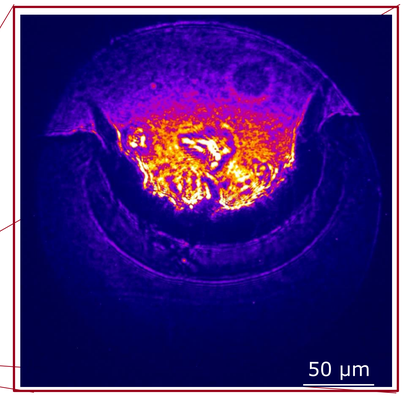
Introduction

- LCLS's MEC experimental hutch provides revolutionary capabilities to study the transient behavior of matter in extreme conditions.
- MEC phase contrast imaging technique propagates shock waves through a solid medium and uses LCLS beam to measure the difference in the refractive index.

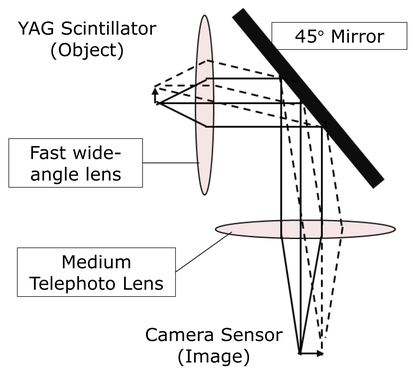


CURRENT SETUP



Conceptual Design

Infinite Optical System



Motivation

- Phase contrast efficiency is a function of the magnified image illumination per sCMOS sensor pixel.
- Ideal optics specifications for MEC phase contrast imaging technique aren't satisfied by most mass produced finite optical lenses.

Aperture (NA)	Resolvable Distance	Magnification (M)
>0.5	>500 nm	3-4

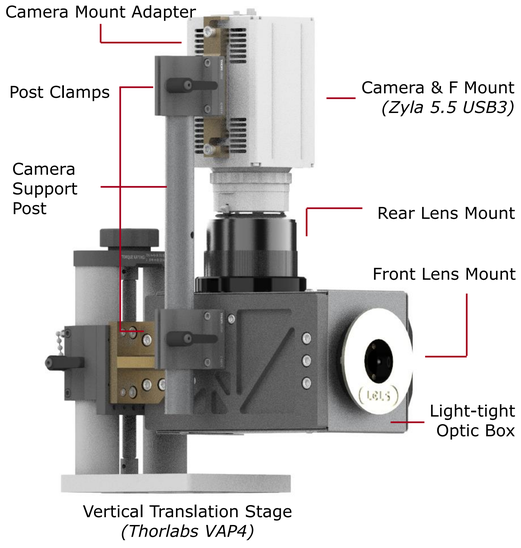
Objective

- Redesign detector optical system configuration.
- Improve light gathering efficiency of camera sensor
- Validate design with the MEC's constrains.

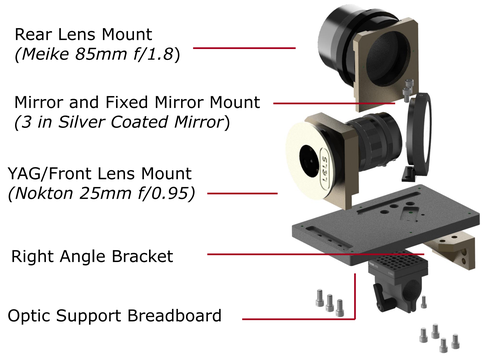
SCIENTIST NEEDS

List of Requirements	Imp.
One degree of freedom: vertical/z-axis translation.	6
Image linear magnification must remain the same	5
Scintillator material remains align LCLS beam.	8
Lens remains fix through the design process.	5
Packaging must maximize compactness.	5
Main frame must be lightweight.	7
Length is limited by its neighbor optical systems.	5
Interchangeable/Replaceable optical components.	9
Light tightness and nonreflective cover surface.	7
Easy and accessible camera installation.	6
Scintillator material must be easily accessible.	10
Negligible deflection along the beam line.	5

Optical System Redesign



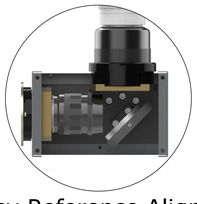
Optic Box Subassembly



- Light Tight Design

- Adaptable Camera Mount

- Compact Optical System



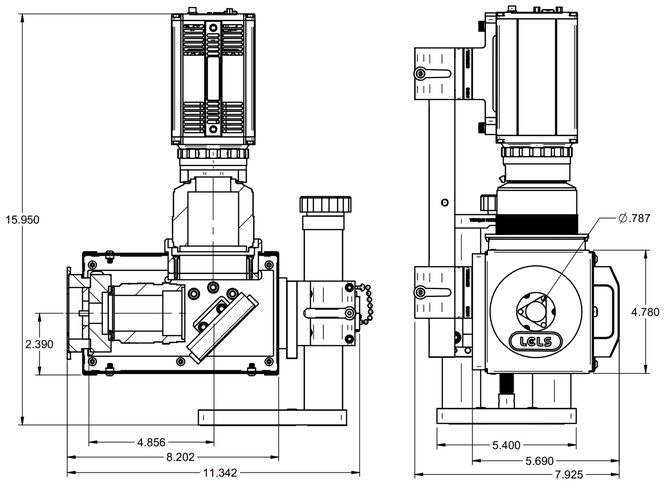
- Easy Reference Alignment

Optical System Design Process

Needs to Satisfy → Conceptual Design → CAD Design Refinement → Preliminary Analysis → Validate with Design Criteria

CAD Assembly Drawings

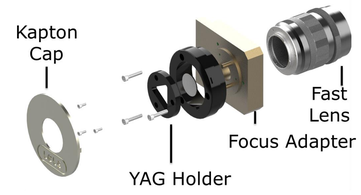
- Less Diffraction of the beam image
- Bigger aperture, same field of view
- Shorter focal length and compact design
- Repeatable image's resolution
- Easier Maintenance / Optics Adaptability



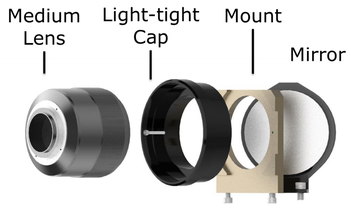
CRITERIA

Design Criteria	Ideal	Current Design	New Design	Units
Vertical Translation of the YAG	+/- 1.0	N/A	+/- 2.3	in
Linear Magnification	3.4	4	3.4	-
Setup Longitudinal Dimension	<12	13	11.3	in
Setup Width Dimension	<7.5	13	7.9	in
Light tight design	Yes	No	Yes	-
Weight	<12.0	~15	11.1	lbm
Reference Planes (DOF)	1	6	2	#
Numerical Aperture	0.5	0.4	0.7	-

YAG/Front Lens Mount



Rear Lens & Mirror Mount



Conclusion

- System provides a compact, lightweight, easy-to-assemble, and great accessibility to optical components.
- New design will increase light gathering and reduce noise for better and repeatable phase contrast imaging capabilities.
- Manufacture of the new optical system is currently in process.

Acknowledgments

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Contributors: Vadim Shoffman, Hae Ja Lee, Yoshio Ichii, Brice Arnold