Optical Diagnostics

BROOKHAVEN NATIONAL LABORATORY
Instrumentation Division Ultrafast Laser Laboratory

- tight environment
- high radiation area
- non-serviceable area
- passive components
- optics only, no active electronics
- back illuminated with a single fiber laser - pulsed laser X
- transmit image through flexible fiber bundle

Optical Diagnostics

Nov, 2004 @ Princeton

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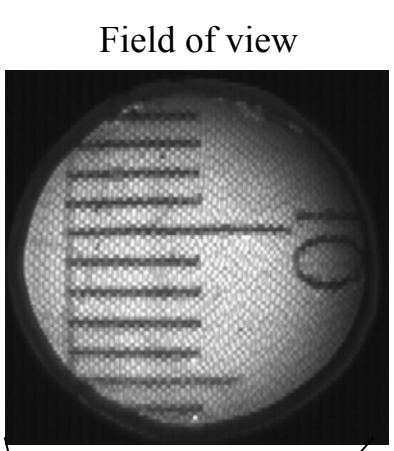
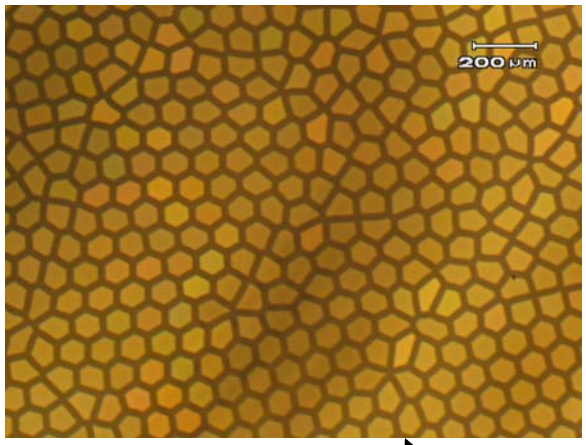
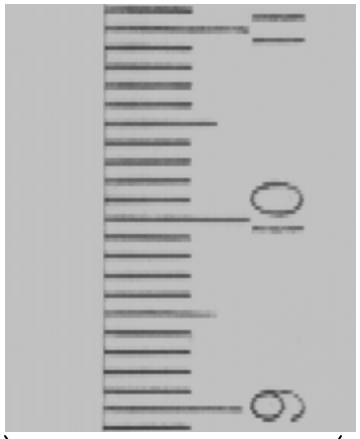
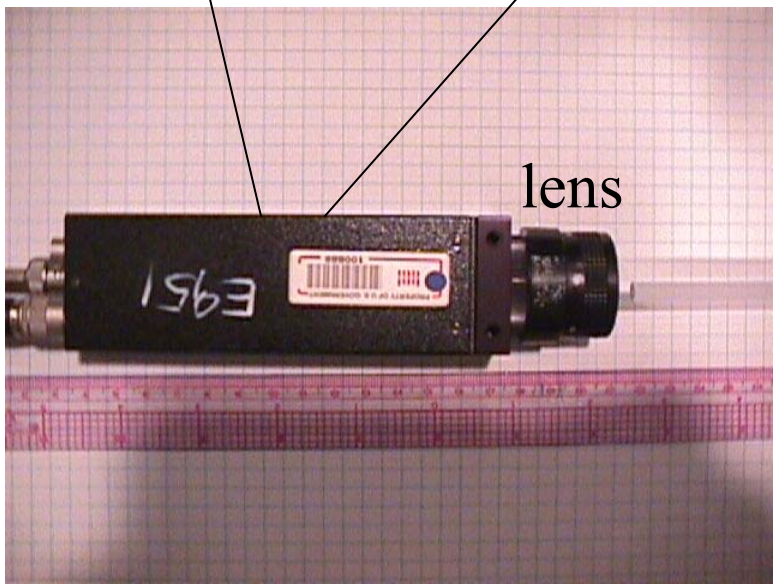
Test target

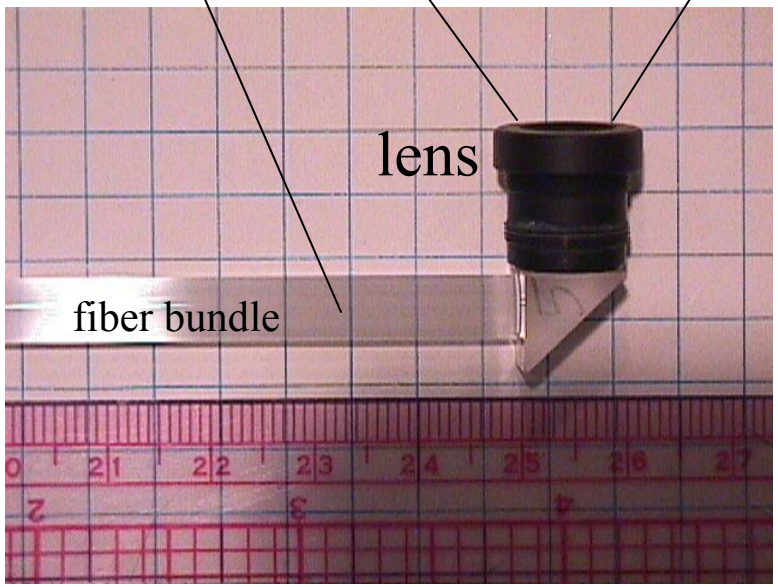
Field of view











Optical Diagnostics

More imaging fibers

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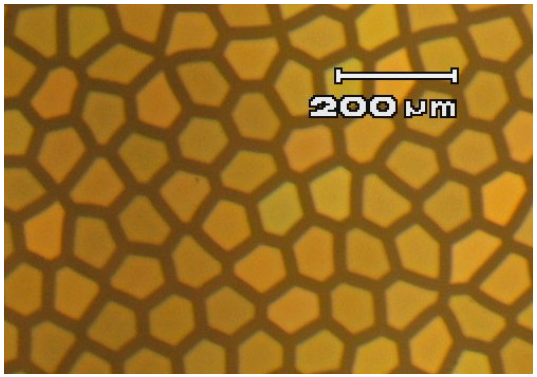
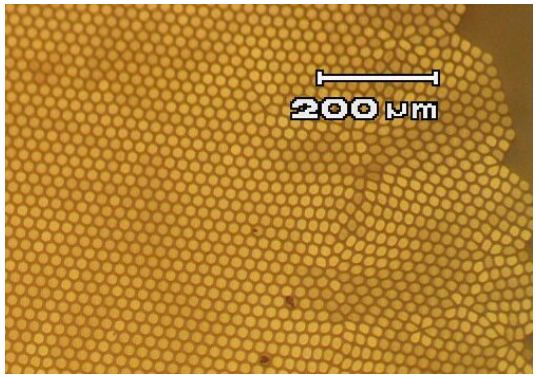
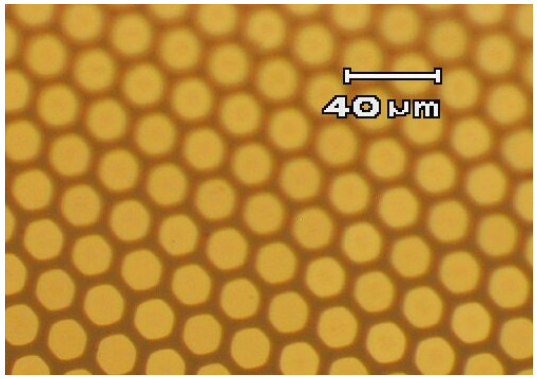
old fiber bundle

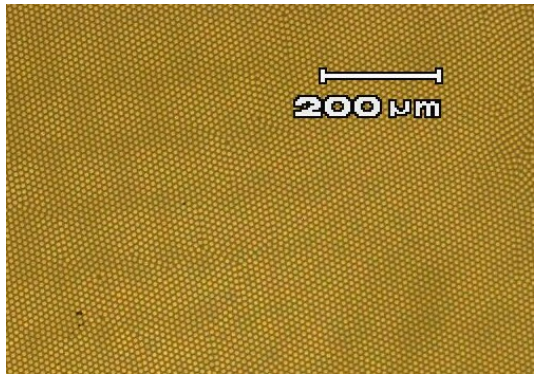


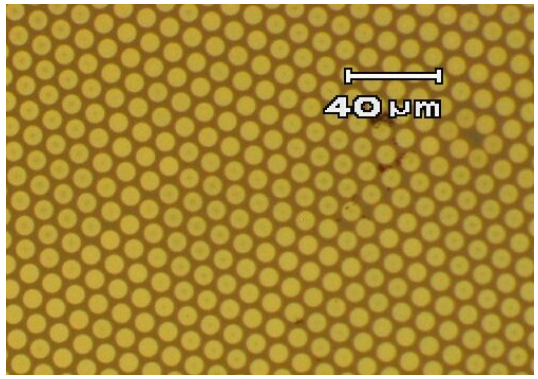
New imaging fiber bundle
Core size: 24 µm, Diameter: 1/4”





New imaging fiber bundle
Core size: 12 µm, diameter: 1/8”





SMD camera

CCD size:	13.4 x 13.4 mm
Pixels:	960x960
Single frame:	240x240 pixels
Reduced pixel size:	56 x 56 um

Total fiber counts ~50,000 in 3.17 mm diameter
Imaging ~243 x 243 fibers on 960 x 960 CCD array

~1 imaging fiber on ~4x4 pixels on full frame

~1 imaging fiber on ~1 pixel on a single frame

Optical Diagnostics

Simple back illumination ?

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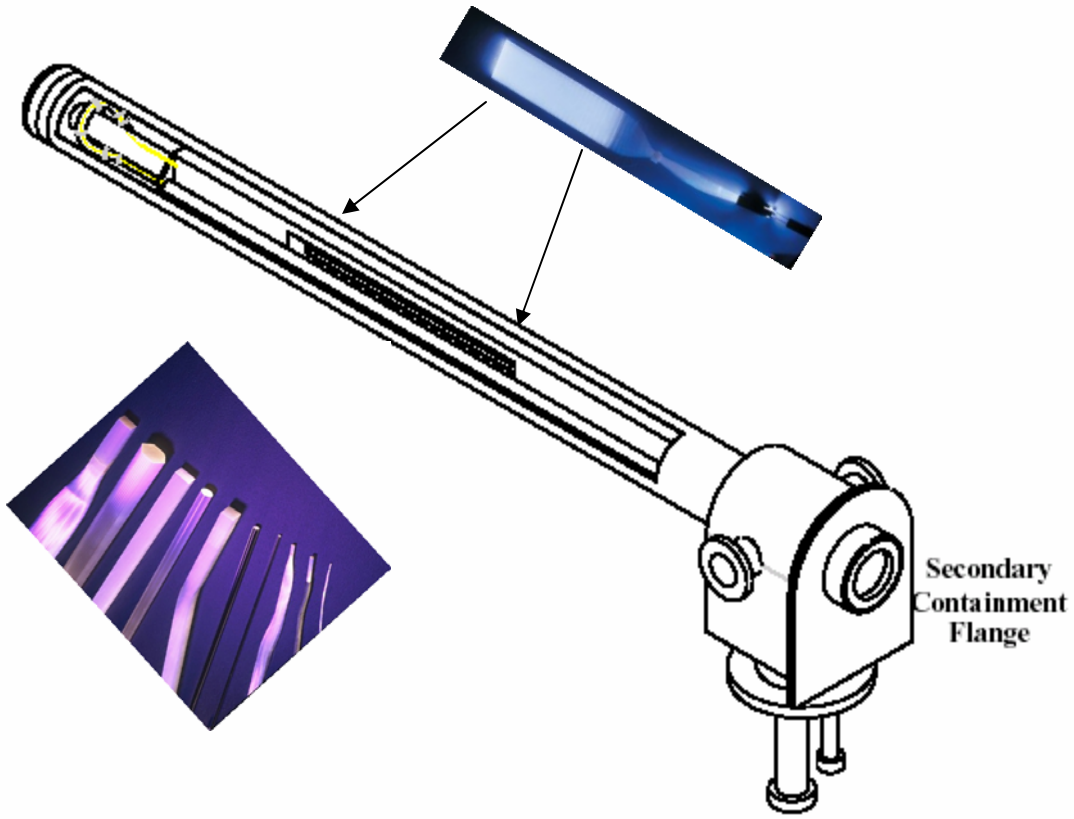
Lumitex® Inc.



Optical Diagnostics

Backlight illumination results

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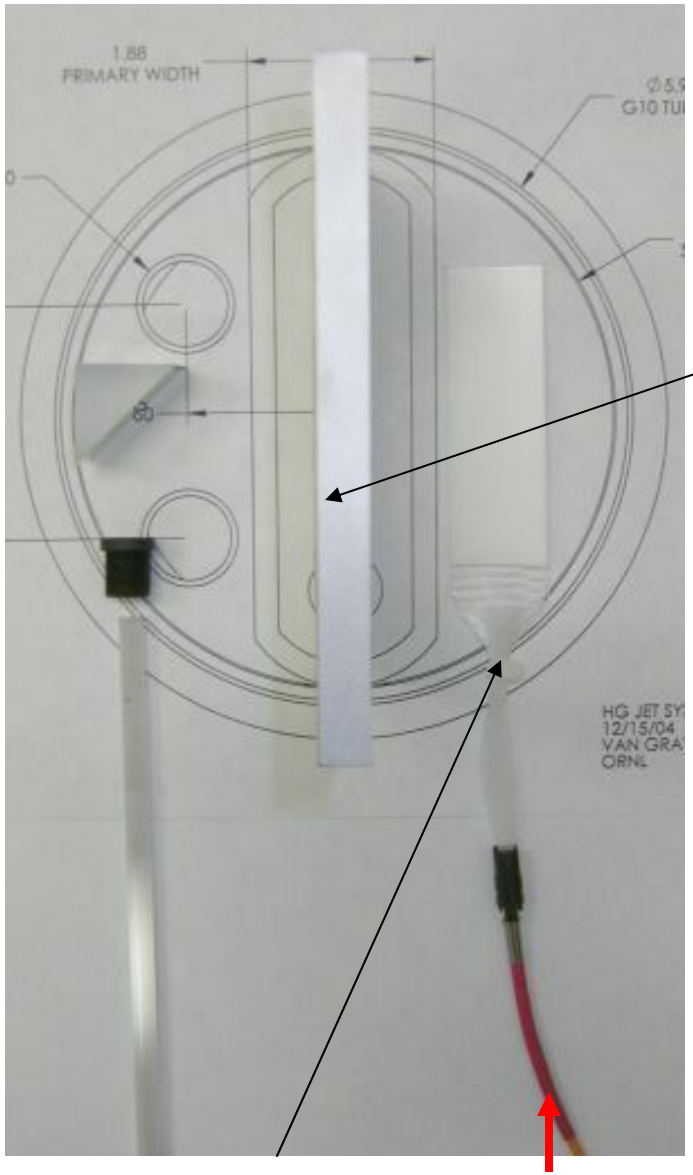
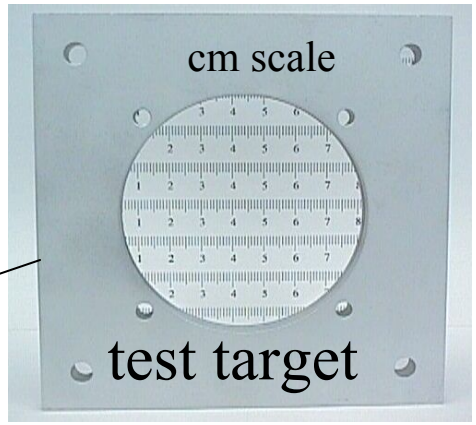
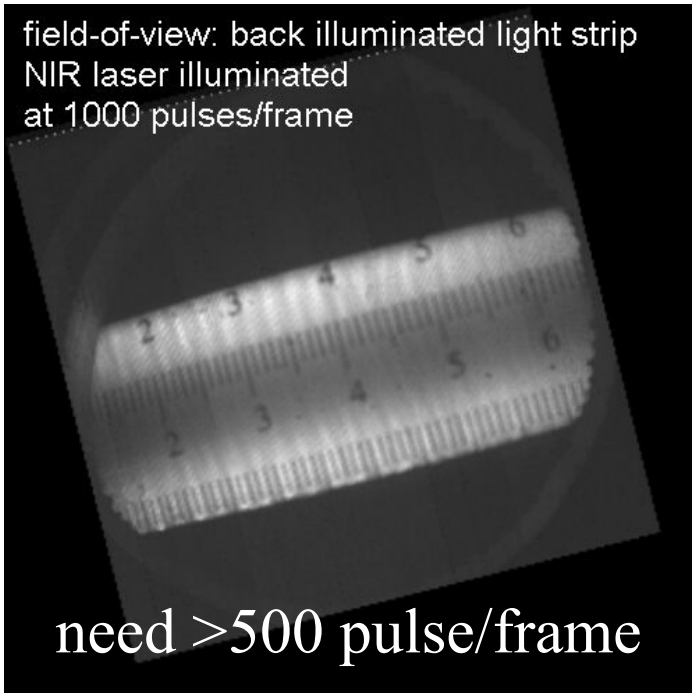


fiber backlight

laser light input





~mJ/pulse in 1-MHz reprate !!

Optical Diagnostics

Conventional shadow illumination approach ?

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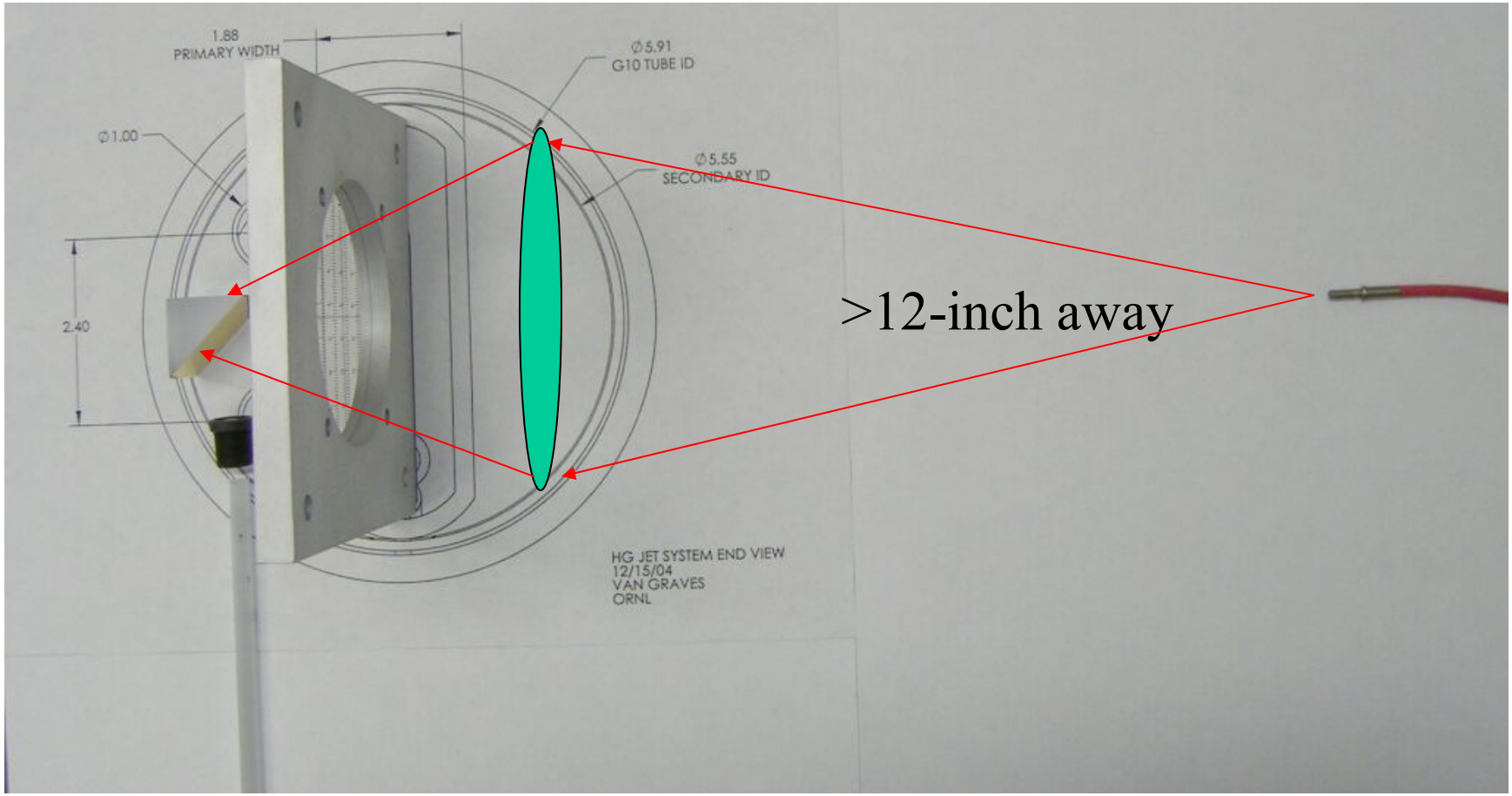

Can NOT be implemented in this tight environment !

Optical Diagnostics

retroreflected illumination

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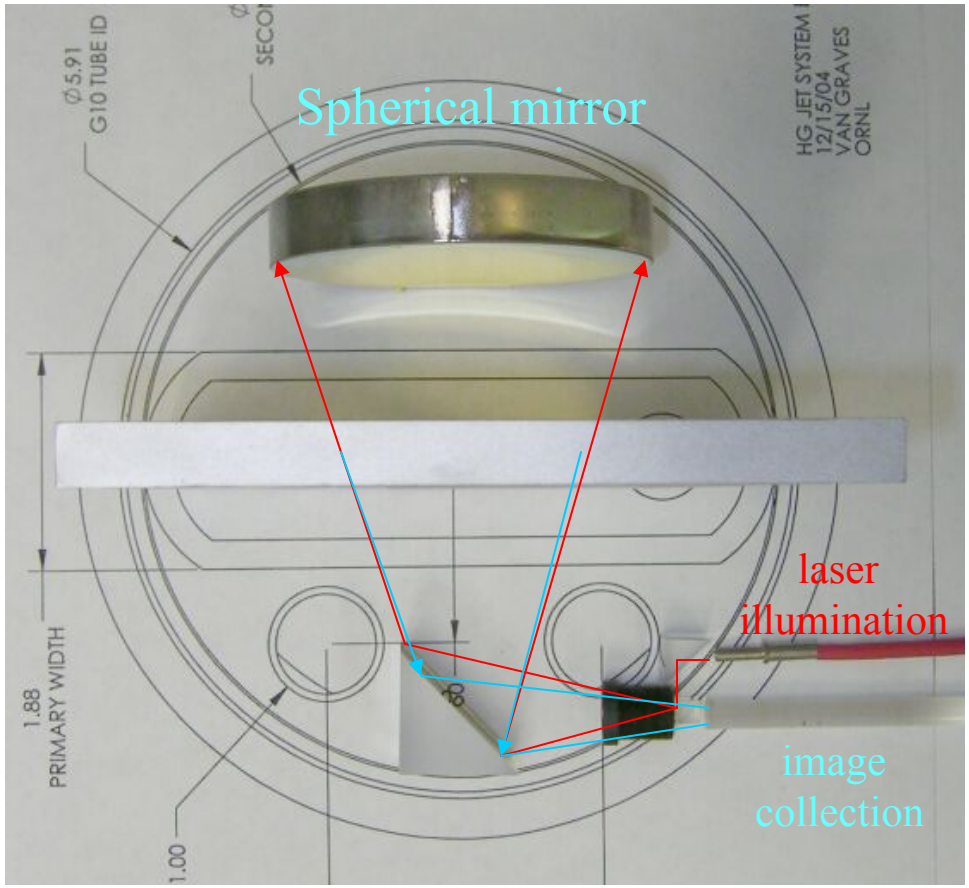

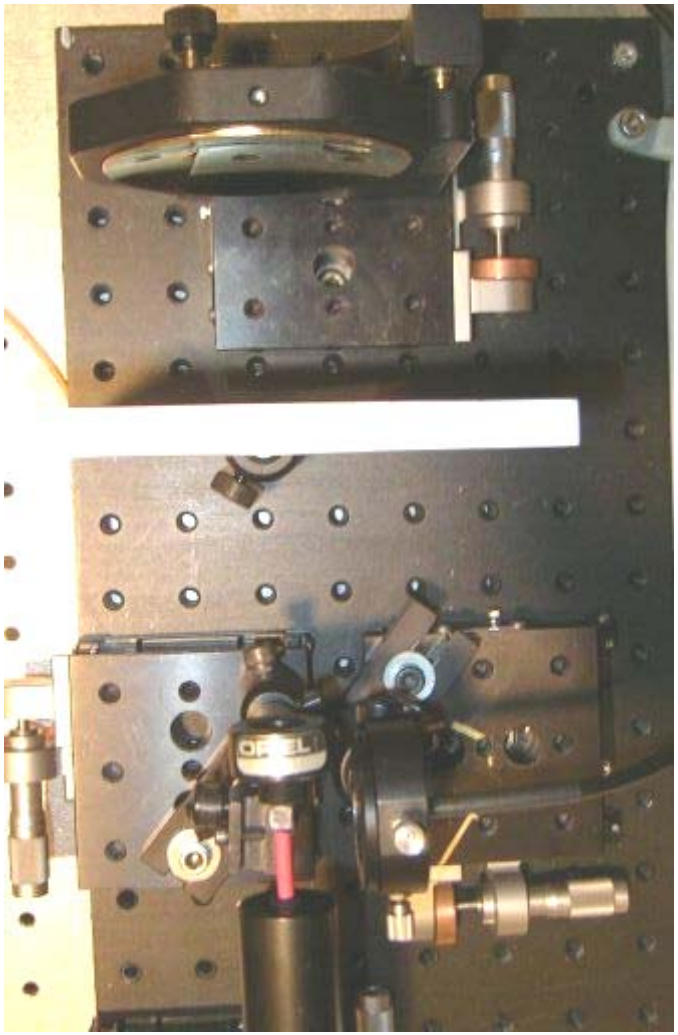

Works OK in this tight environment

Optical Diagnostics

Exp test setup

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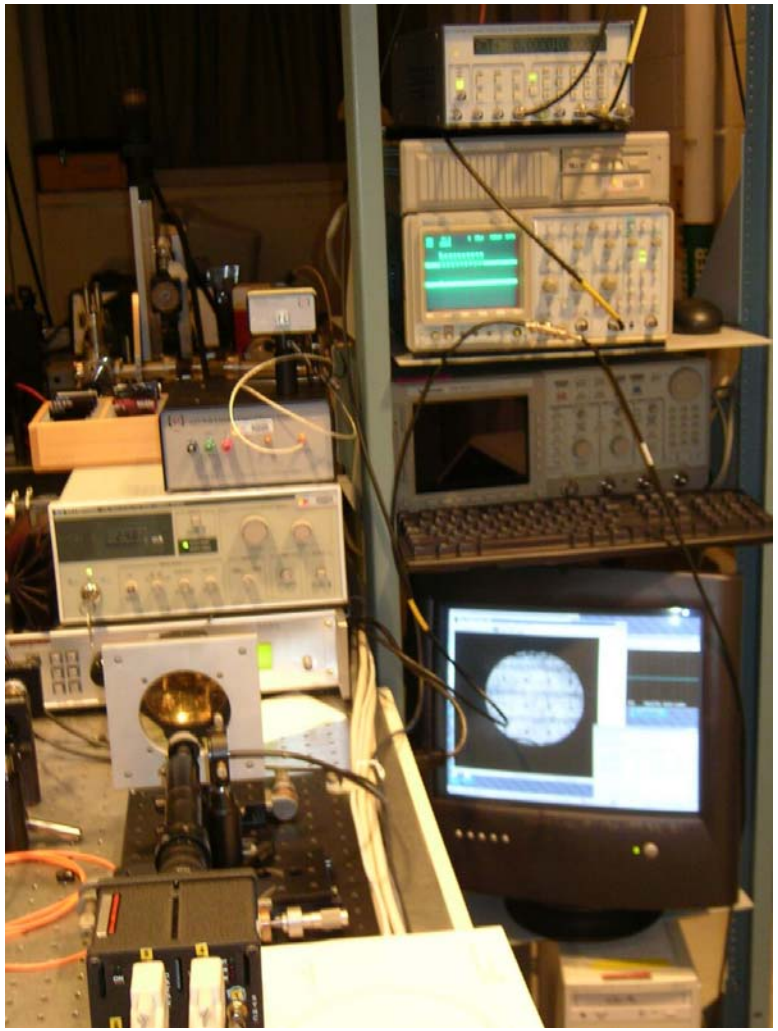

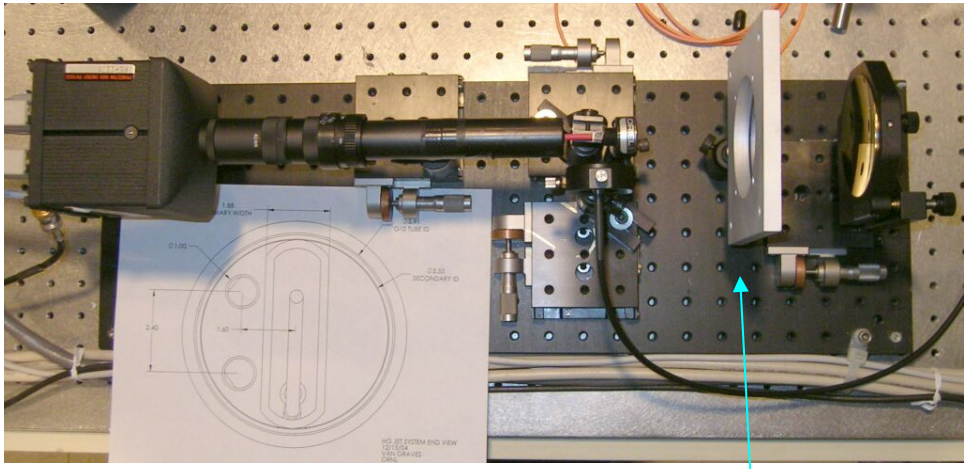

Optical Components

- 50/50 beam splitter: Edmund, 0.5 cm cube
- spherical mirror: Edmund, f=3-in, D=3in< Au coated
- small prism mirror: Edmund, 1x1x1.4 cm, Au coated
- large prism mirror: Edmund, 2.5x2.5x3.54 cm. Au coated
- imaging fiber Edmund: ⅛-in diameter, 12-µm core, 0.55 NA
- illumination fiber: ThorLabs, 0.22 NA, SMA-905 840 -µm core
- imaging lens: Sunex, f=0.38-cm, f/# 2.6, diagonal FOV 54°, φ1.4-cm x 2.0 cm

Optical Diagnostics

Field of view - imaging

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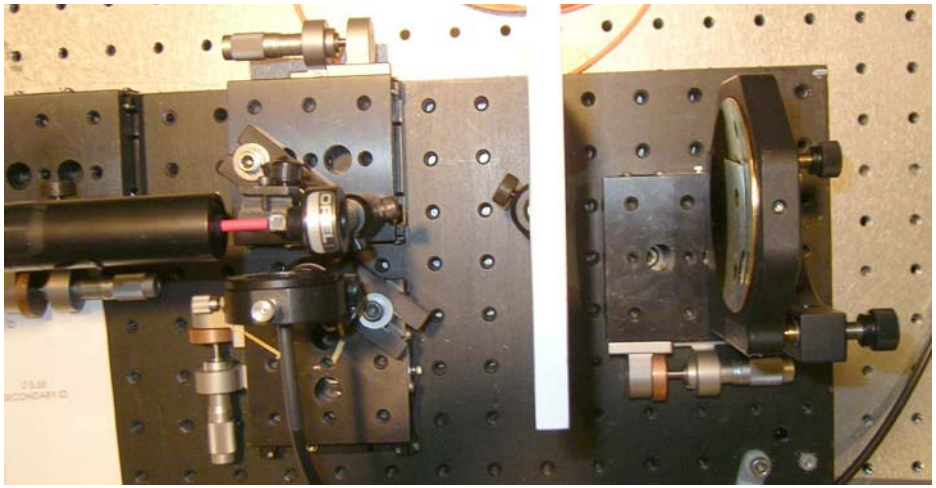

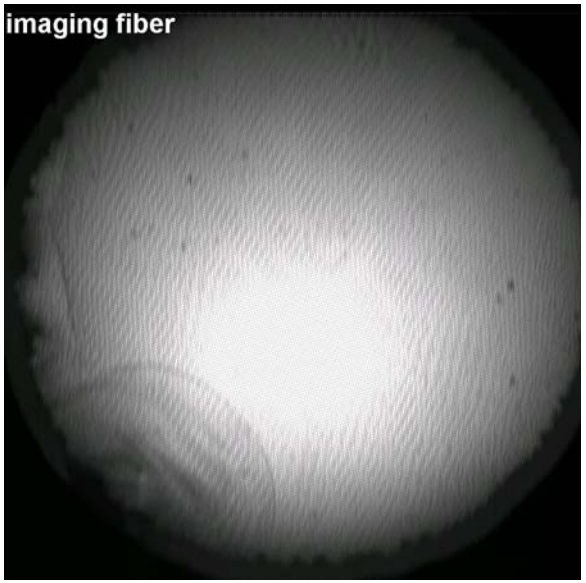

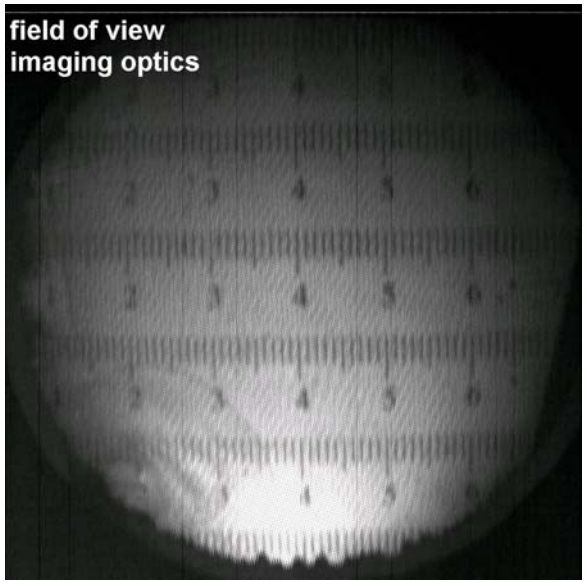

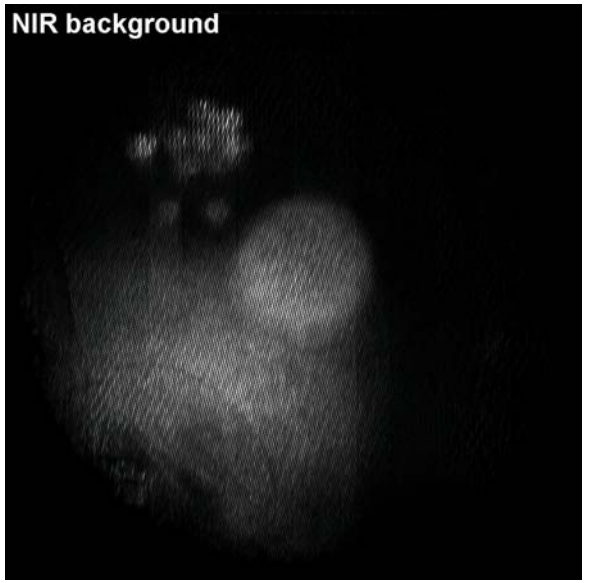

Optical Diagnostics

Field of view – NIR laser illumination & imaging

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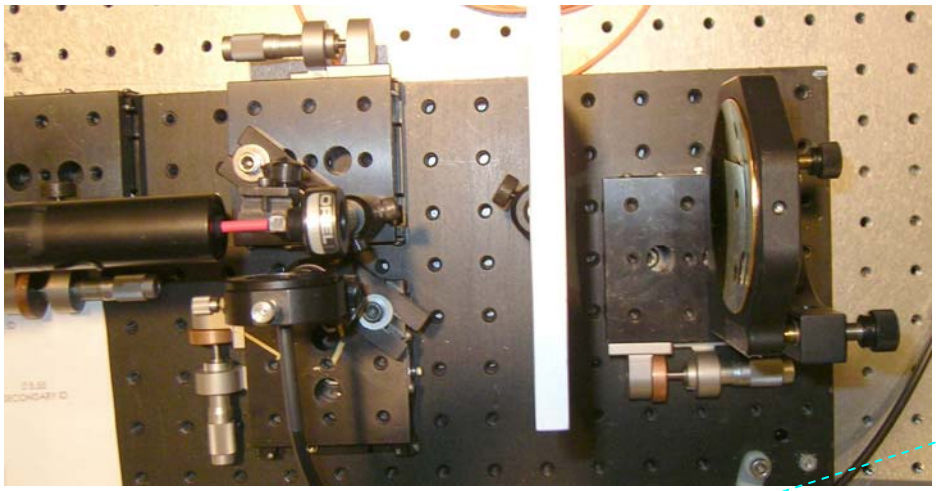

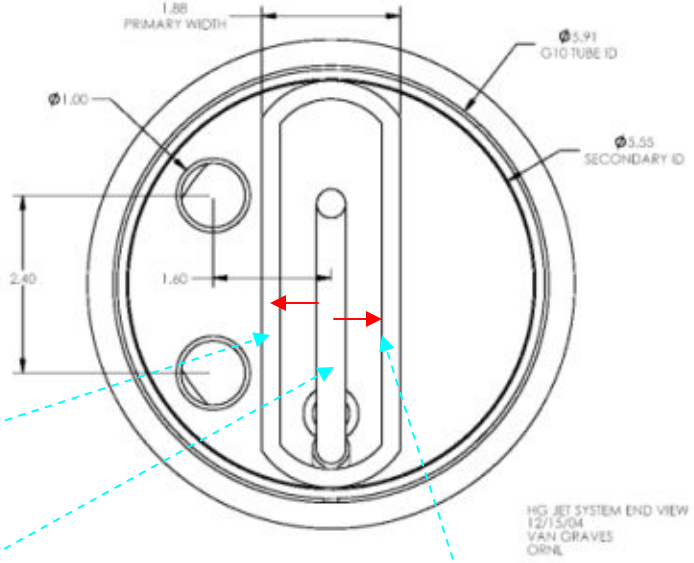

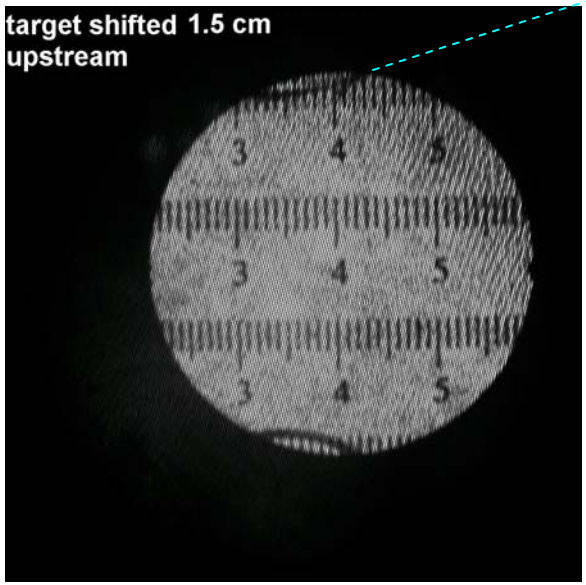

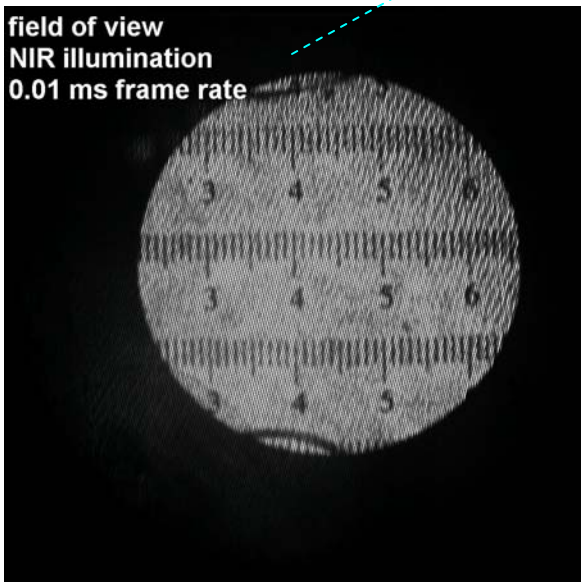

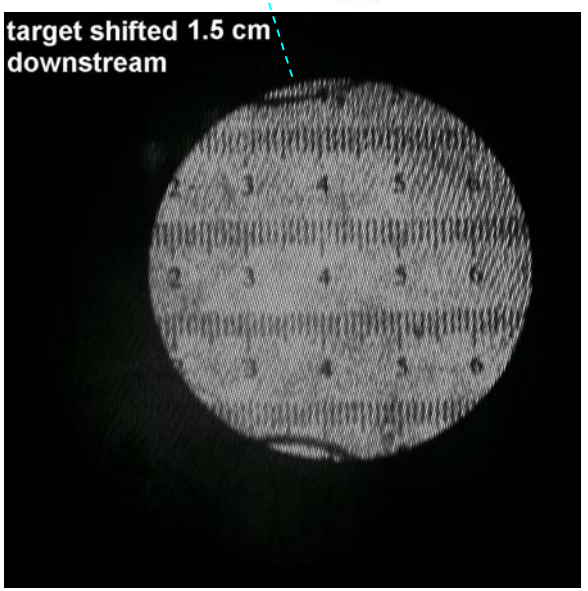

Optical Diagnostics

optical design in secondary containment

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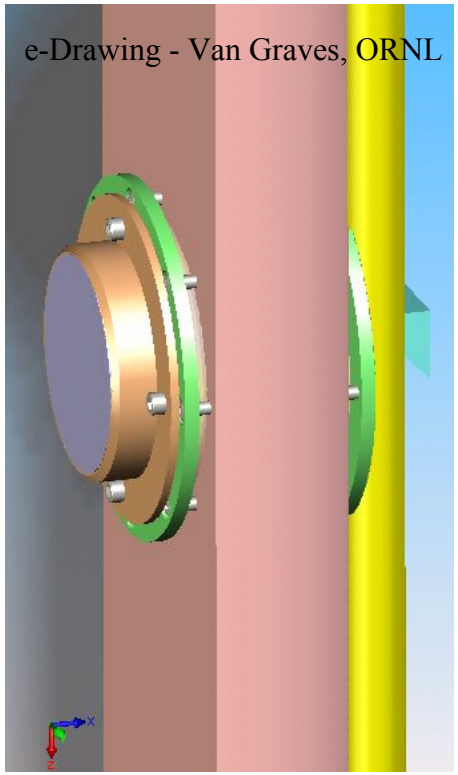

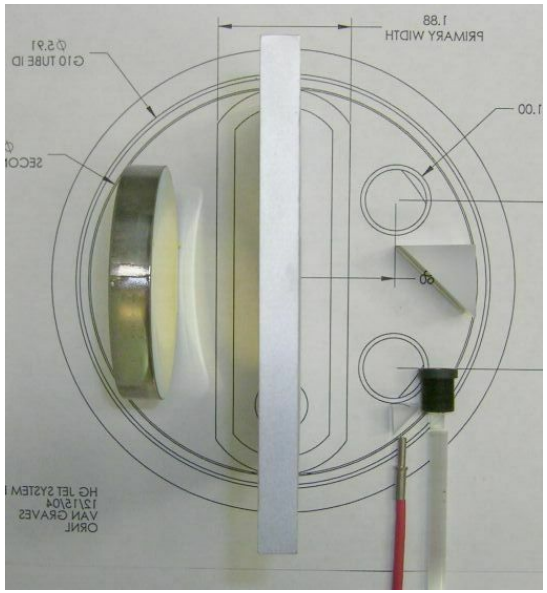

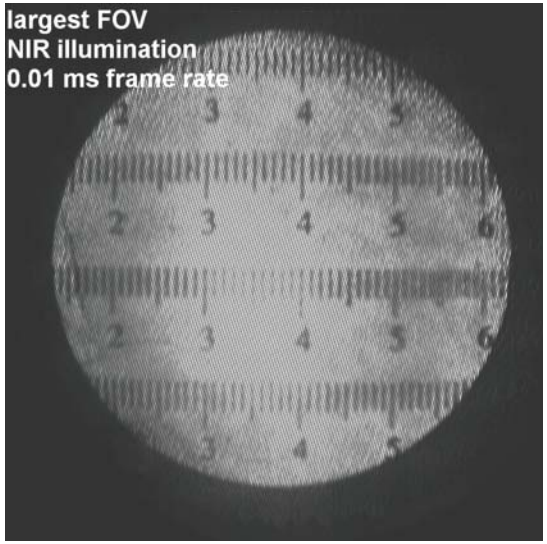

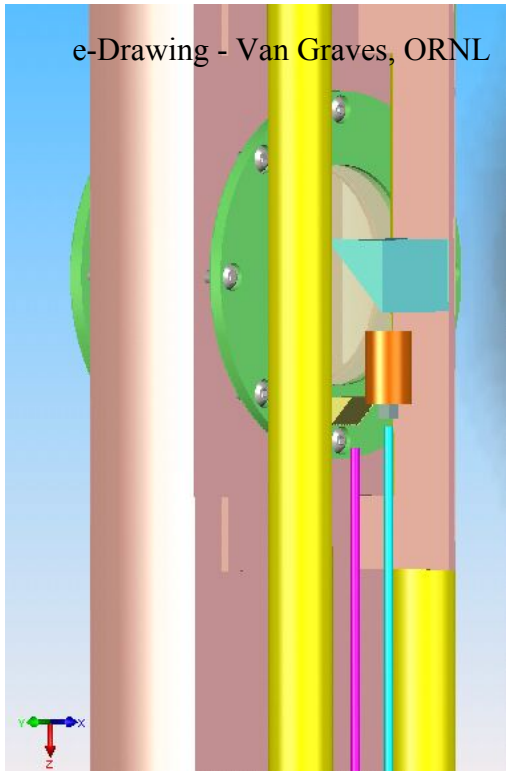

One set of optics per viewport

Conceptual design completed

Optical Diagnostics

An optical chopper in motion @ 4 kHz

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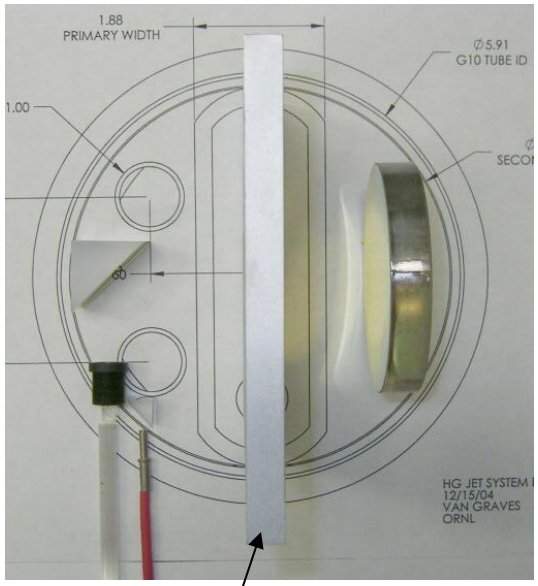
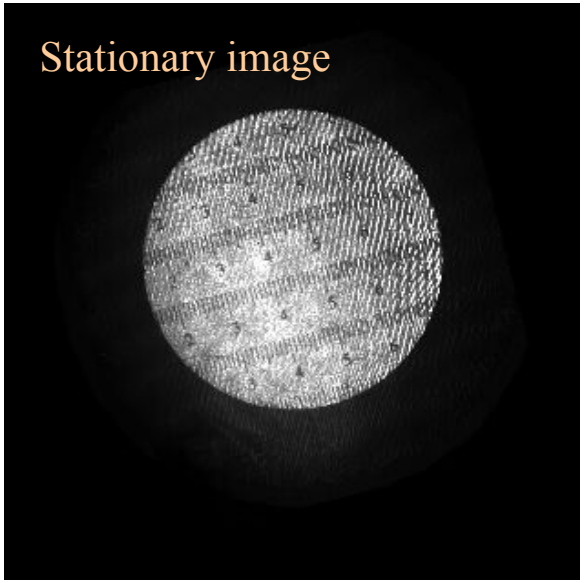
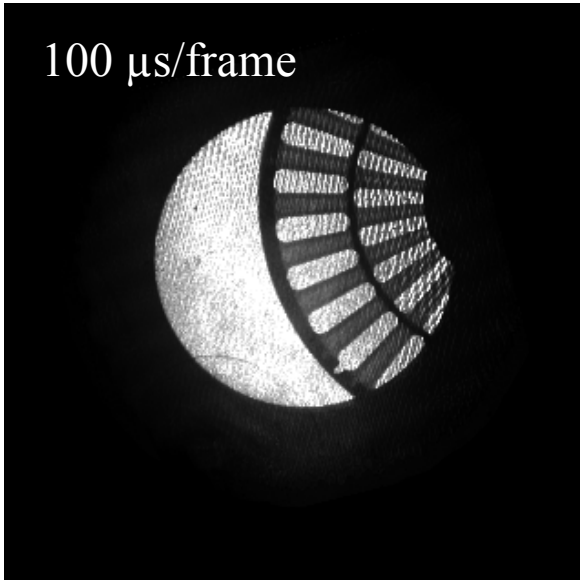
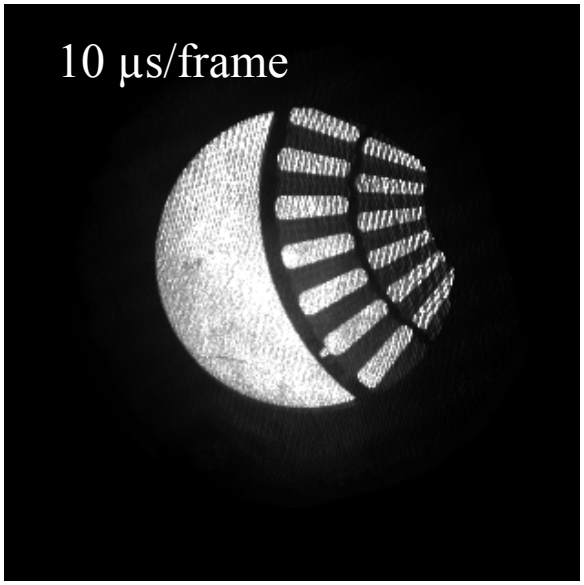
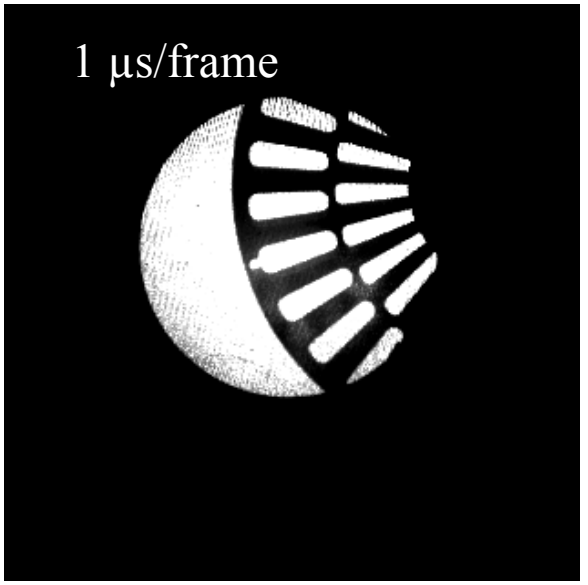


Velocity @ ~40 m/s









Optical Diagnostics

An optical chopper in motion @ 4 kHz cont'

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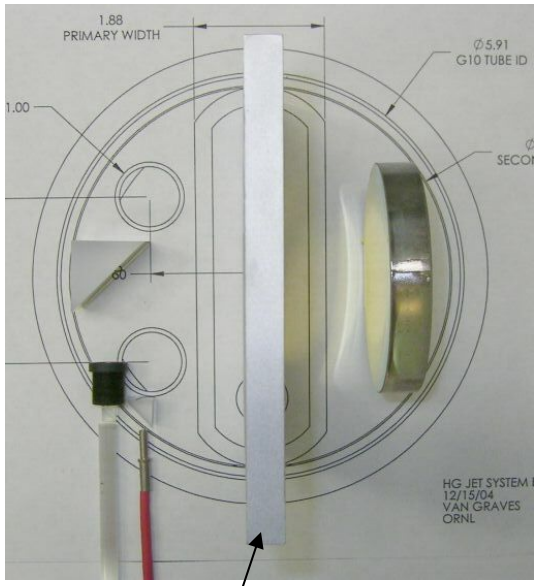
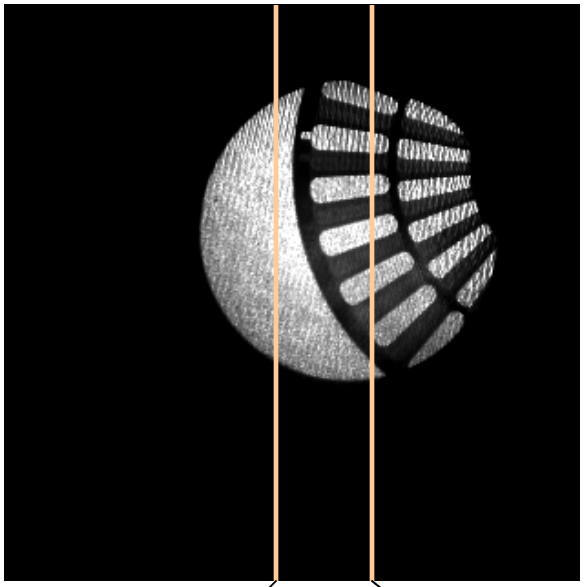
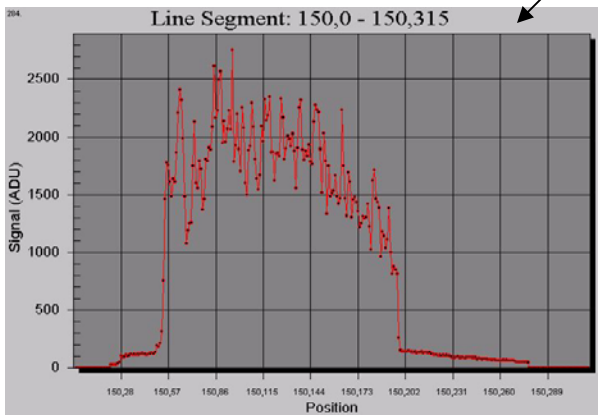
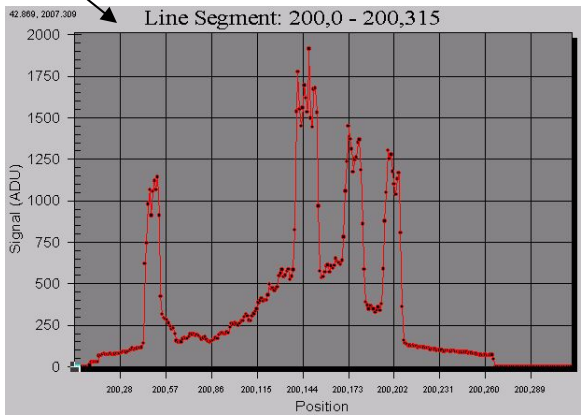


Velocity @ ~40 m/s

100 μs/frame
with reflective mask







frame #12

Optical Diagnostics

Other issues

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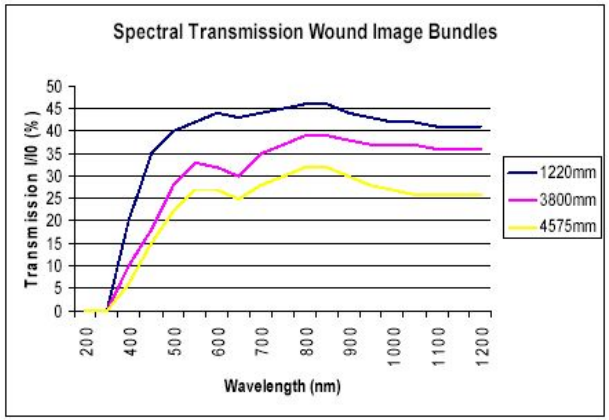
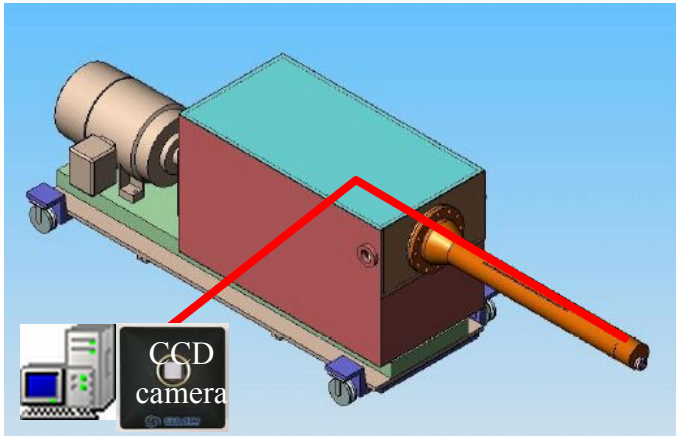
1. Laser power increase to ~40 W/pulse (instead of 10 Watt/pulse)
2. Depth of focus → apparent image size variation
3. 3-in dia. spherical mirror (lens/mirror) with the right focal length
4. Anti-reflection coated (@ 800 nm) viewports
5. ~50-m? long flexible, square shaped imaging fiber bundles – Schott Optics

Wound Fiber Optic Image Bundles

IG-154, 10 µm size
4 mm x 4 mm
4.5 meter long
$5.7K





6. Radiation resistance of imaging fiber bundles and optics ? to be tested.
7. Number of viewports ? minimum of 3
8. Location of the viewports ? 5-inches aparts
9. How many fast CCD camera ? 1 fast (1 µs) camera, 1 slower (250 µs) camera ?
10. Switch from one viewport to the next with one laser/camera system ?
11. …