Optical Diagnostics

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Design Specification

• Limited space
• High radiation area
• Non-serviceable area
• Passive components only, no active electronics
• Image transmits through flexible imaging fiber bundle

**Optical Diagnostics Principle: Shadowgraphy technique**

• Synchronized arrival of short laser pulses illuminate onto the target
• Freeze the image of events using high speed camera to record transient fluid dynamics.
• 2-dimensional image
Optical Setup

- **d = 0.5 mm sapphire ball lens**: Increase the NA of illumination to $\Phi \approx 45$ degree.
- **Imaging fiber**
- **Illumination fiber**
- **Grin objective lens**
- **FOV : 55mm**
- **10m long fibers**
- **50 x**
- **800 x**

*Brookhaven National Laboratory Ultrafast Laser Laboratory*
High Speed Cameras and Laser Sources

**SMD 64KIM camera**
- **CCD size:** 13.4 x 13.4 mm
- **Pixels:** 960x960
- **Single frame:** 240x240 pixels
- **57,600 picture elements**
- **Frame rate:** 16 frames up to 1 µs/frame

**FastVision (2)**
- **CCD size:** 15.4 x 12.3 mm
- **Pixels:** 1280x1024
- **Single frame:** FPGA programmable
- **1.3 M picture elements**
- **Frame rate:** 500/s @ full resolution
  500k/s @ 1x1280

**CERN Olympus Encore PCI 8000S**
- **4 kHz recording rate, 25 µs electronic shutter**

**Bright Solutions, BDL20-808-F6**
- **Laser diode, SDL-2300-L2**
  - **Power = 1 Watts**
  - **I_{th} = 0.3 Amp**
  - **λ = 850 nm**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Unit</th>
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<tbody>
<tr>
<td>Temperature</td>
<td>25</td>
<td>°C</td>
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<tr>
<td>Rated power</td>
<td>20</td>
<td>W</td>
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<tr>
<td>Current at rated power</td>
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<td>A</td>
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<tr>
<td>Maximum current</td>
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<td>A</td>
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<tr>
<td>Threshold current</td>
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<td>Center wavelength</td>
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<td>Linewidth FWHM</td>
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</table>

**min. pulse width ~150 ns**
Experimental Setup: Schematic Diagram

Master Trigger

TTL Trigger Pulse

Delay Box

Laser Pulse Generator
17 pulse of 100 µs/pulse

SMD Camera

Laser Driver

1W Laser

FV13 Camera
Multi Edge Mode
500 fps, 20µs exp.

Laser Driver

1W Laser

FV13 Camera
Multi Edge Mode
500 fps, 20µs exp.

Laser Driver

1W Laser

CCD Camera

25W Laser

Laser Driver

1W Laser
Experimental Setup: Trigger Pulse Sequence

**FastVision cameras**
- Typically 2 ms/frame
- Total of 256 frames
- Master trigger
- Camera trigger
- Camera exposure time (10-20 μs)
- Laser pulse (0.5 sec pulse width) generated by DG535

**SMD camera**
- Typically 0.1 ms/frame
- Total of 17 frames
- Master trigger
- Camera trigger
- Camera exposure time
- 17 laser pulses (150 ns pulse width) generated by GeGe electronic board

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**Brookhaven National Laboratory**
Instrumentation Division Ultrafast Laser Laboratory
Experimental Setup at ORNL
Viewport Configuration

No leak detected on every 8 windows.
Holds 21 psi for over 17 hrs
Observation of Water Jet

20 m/s shot, Reduced SS nozzle after 180 degree bend (Tested at ORNL, Nov 30, 2006)

20 m/s shot, Reduced Ti nozzle after 180 degree bend, Tested at ORNL, Jan 25, 2007)
Nozzle C showed stable shape and uniform velocity.

Clear typical surface motion should be observed to get accurate velocity measurement. It could lead to measurement error.

For Ti nozzle, jet width decreases as the jet moves to downstream.
Summary

- four 10-meter long imaging fibers assembled on SS primary
- SS primary are pressure tight (20 psi)
- Dynamic image collection on all viewports were tested
- Channel #0 - scintillating fiber
- Channel #1 - 1st viewport, old FastVision camera
- Channel #2 - 2nd viewport, SMD camera
- Channel #3 - 3rd viewport, new FastVision camera
- Channel #4 - 4th viewport, video camera/Olympic Encore
- Magneto hydro dynamic effect to the jet shape will be observed / measured at MIT after solenoidal magnet is integrated.