Comparison of Triature Doppler Velocimetry (TDV) and VISAR

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TDV

- The Triature Doppler Velocimeter (TDV) is a photonic Doppler velocimeter (PDV) with three identical outputs that are separated in phase by 120°.

- The phase shift is accomplished by using a $3 \times 3$ single-mode splitter. The fusing process in the construction of the $3 \times 3$ splitter has the inherent property of the output fiber signals to be $\sim 120°$ out of phase from each other.

- By applying the quadrature concept, improved temporal resolution is obtained, where the fast Fourier transform (FFT) analysis is limited.
Objectives

- Set up a repeatable fast shock source
- Develop a Positive Light laser flat-top pulse at the target
- Test optical up-conversion methods
- Test results of aluminum tape over target
- Perform comparison tests of the Araceli 450 and 800 MHz avalanche photodiode (APD) detectors
- Compare performance of VISAR and TDV
Laser-induced Shock

• A 120 mJ Positive Light laser with a 145 ps rise time and 300 ps FWHM pulse at 532 nm

• Target: 10-microns-thick copper or aluminum layered on a 49 × 49 × 1 millimeter glass plate

• 1 mm flat-top pulse at target
TDV Face Plate
1-mm Laser Imaged on Aluminum
1-mm Laser Imaged on Copper

Shot A 1.03-mm Diameter

Shot B 1.05-mm Diameter
Profile of Target Spot
# Comparison of Triature Doppler Velocimetry and VISAR

## Velocity Position Map

![Velocity Position Map Image](image)

### Aluminum Target

<table>
<thead>
<tr>
<th>Shot/Position</th>
<th>Velocity</th>
<th>Shot/Position</th>
<th>Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1 KM/sec</td>
<td>6</td>
<td>1.2 KM/sec</td>
</tr>
<tr>
<td>2</td>
<td>1.3 KM/sec</td>
<td>7</td>
<td>1.3 KM/sec</td>
</tr>
<tr>
<td>3</td>
<td>1.5 KM/sec</td>
<td>8</td>
<td>1.3 KM/sec</td>
</tr>
<tr>
<td>4</td>
<td>1.4 KM/sec</td>
<td>9</td>
<td>0.95 KM/sec</td>
</tr>
<tr>
<td>5</td>
<td>1.7 KM/sec</td>
<td>Average</td>
<td>1.31 KM/sec</td>
</tr>
</tbody>
</table>

### Copper Target

<table>
<thead>
<tr>
<th>Shot/Position</th>
<th>Velocity</th>
<th>Shot/Position</th>
<th>Velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>379 M/sec</td>
<td>6</td>
<td>303 M/sec</td>
</tr>
<tr>
<td>2</td>
<td>378 M/sec</td>
<td>7</td>
<td>341 M/sec</td>
</tr>
<tr>
<td>3</td>
<td>303 M/sec</td>
<td>8</td>
<td>341 M/sec</td>
</tr>
<tr>
<td>4</td>
<td>379 M/sec</td>
<td>9</td>
<td>870 M/sec</td>
</tr>
<tr>
<td>5</td>
<td>455 M/sec</td>
<td>Average</td>
<td>416 M/sec</td>
</tr>
</tbody>
</table>
Optical Up-conversion

- TDV operates in the frequency domain, combining a Doppler-shifted light with the original unshifted light
- The operating range of the MITEQ 20 GHz detectors is 100 kHz to 20 GHz
- Optical up-conversion moves the database line into the operating range of the detectors
Mach-Zehnder with Unshifted Light
Mach-Zehnder Optical Up-conversion

- Up-converted Data
- Up-converted Base Line
- Mirror Image of Up-converted Data
- Data
- Zero Base Line

FFT Spectrum: TDL/DET3_004.dig  WinSize=2048  Shift=512  WinType=Hemming

National Security Technologies LLC
National Nuclear Security Administration
Mach-Zehnder with Tunable Unshifted Light

2-W WPQ laser (Main Laser)

Agilent Tunable Laser

Mach Zehnder Interferometer

RF Signal Generator (4-GHz)

2-W WPQ laser (Main Laser)

Mach Zehnder Interferometer

RF Signal Generator (4-GHz)

Tektronics DPO 72004

Source Laser / Source (Unshifted)

Return Doppler (Shifted)

Auxiliary (Unshifted-Up converted)

Electrical
Mach-Zehnder Data with Tunable Laser and 4 GHz Modulation Unshifted Light
Optical Up-conversion with Tunable Laser
Optical Up-conversion with Tunable Laser Data
Sandia Fast VISAR

- Tests were subsequently performed with the Sandia fast VISAR (developed by Bruce Marshall)
- Two fringe constants (short = 0.7946 meters per second/fringe and long = 0.5855 meters per second/fringe)
- Araceli 450 MHz APD detectors and 800 MHz prototype APD detectors
- Brent Frogget PDV/VISAR probe
PDV/VISAR Probe

- Outer 21 fibers are 100/125 microns
- Inner fiber is a single-mode fiber, angle polished at 8°
- Single-mode fiber is focused separately from the 100-micron fiber
Probe Irradiance at Target

PDV/VISAR NIR 60/35 vpdvg.len

irradiance

Total flux 0.10114E-05 Watts
Max irradiance 0.12643E-01 Watts/CM^2
Min irradiance 0.00000E+00 Watts/CM^2
Sandia VISAR Aluminum Tape Data
High-current Calibration Source

- Designed and built by Bart Briggs of NSTec Los Alamos Operations
- 5 µF at 4.6 kV, generating ~14.5 kA
- Current channeled to a copper strip that is 0.05 inch by 0.25 inch
VISAR/PDV Calibration Data
450 and 800 MHz APD Detectors
VISAR-TDV-PDV Analysis
Comparison of Triature Doppler Velocimetry and VISAR

VISAR/TDV Overlay

ALUMINUM TARGET

VISAR

TDV
Conclusions

- The Positive Light laser is a repeatable flat-top light source for testing velocimetry
- Optical up-conversion eliminates baseline noise to determine an accurate breakout
- Aluminum tape over aluminum target produces a velocimetry system check comparable to a High-current calibration source
- VISAR is limited by detector and recording bandwidth
- TDV provides better than 1 ns resolution
- Coaxial probe is feasible
Araceli 8-channel Rack-mount PDV