University of California
Lawrence Livermore National Laboratory

ENGINEERING

Single-Mode VISAR

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Outline

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- PDV, VISAR Comparison
- Single Mode VISAR
- Calibrations
- What's Next

Motivation

- The time scales associated with HEDP experiments are decreasing while the energy scales are increasing.
  - In order to meet the new requirements physics diagnostics must accurately measure higher velocities.
    - One solution is to expand the system bandwidth of a PDV diagnostic.
    - We propose a second solution which will *not* require an extremely high electronic bandwidth.

PDV, VISAR Comparison

PDV	VISAR
Composed of commercially available single-mode fiber parts	Commercially available using multimode fiber and PMT's
Time resolution and velocity precision are not limited by multimode optics	Time resolution is limited by the multimode fiber and PMT's
Easily implemented	Difficult to Implement
Can be used for time of arrival measurements	Can be used for time-of-arrival measurements
Maximum measurable velocity is limited by the system bandwidth	No practical limit on the maximum measurable velocity

Can we combine selected advantages?

PDV	VISAR
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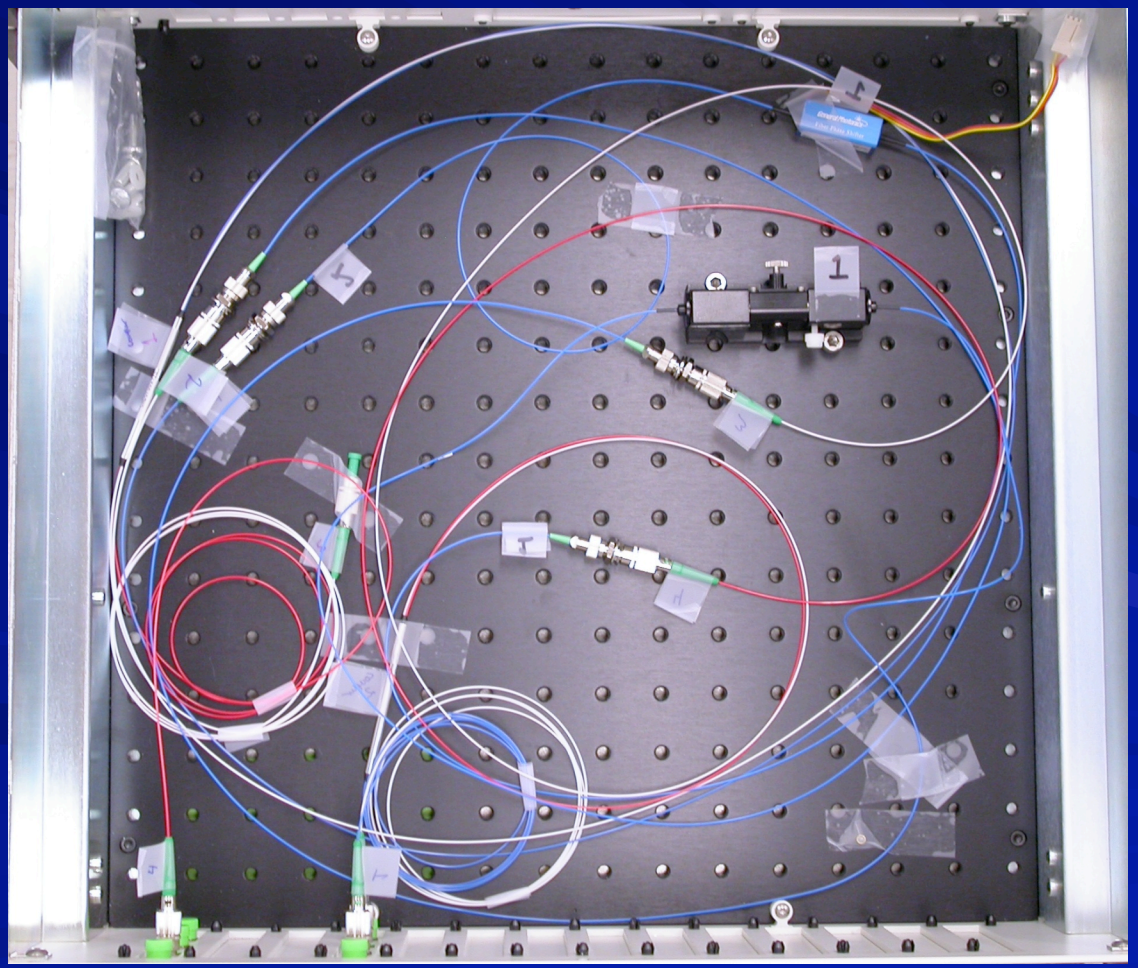
Single-Mode VISAR

- We propose a modified VISAR design based on single mode fiber components.



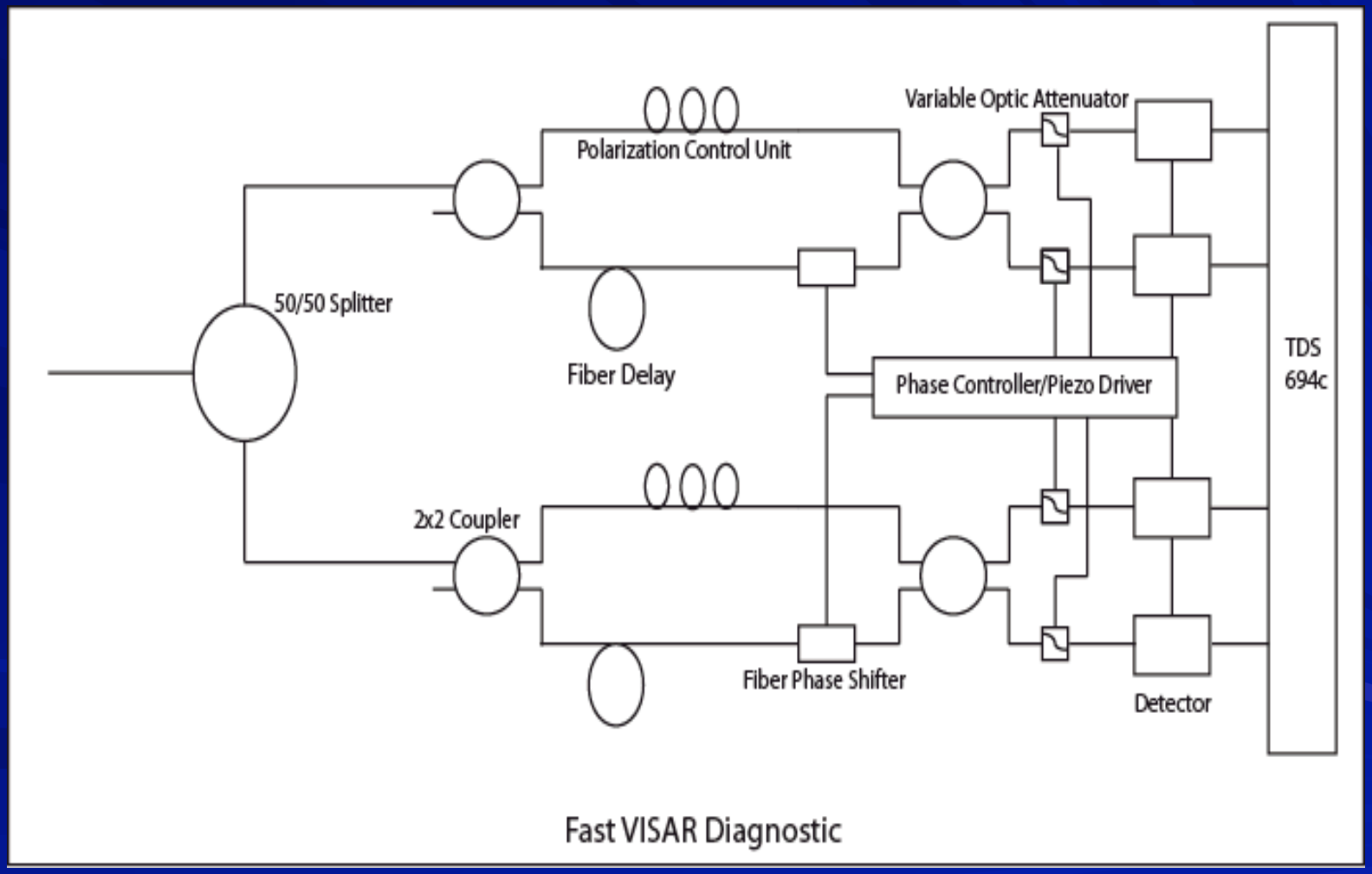
Advantages and Disadvantages

Advantages	Disadvantages
No practical limit on the maximum measurable velocity	Cannot measure multiple velocities on one probe channel
The time-resolution, velocity precision trade-off should be equivalent to PDV	Requires more recording channels
Can be automated to provide nearly turn-key operation	
Laser safety is simple since no open beam operations are required	
Removing the modal distortion introduced by multimode fiber and electronic dispersion simplifies the instrument response to the two delayed copies of the input signal	
Expensive scopes are not required	

Requirements

- Diagnostic must accurately and precisely measure shock or particle velocities
- The diagnostic must be insensitive to light amplitude modulation from the target within the dynamic range of the detectors.
- Diagnostic should be insensitive to rapidly varying polarization changes returned from a target

Single-Mode VISAR Diagram



Why a 90 degree phase shift?

- The interference term is a cosine term where the angle is dependent upon the velocity
  - If the interference term is near a max or min any noise on the signal translates to a huge error.
  - Using the second sine signal the velocity can be pulled out if the cosine signal is near a point of maximum slope and vice versa.
  - Since the two arms are 90 degrees out of phase we can distinguish between positive and negative velocities making this diagnostic useful for vibrometry applications

Working Assumptions

- The polarization control, birefringence, and fringe contrast should not vary with time or ambient temperature.
- The polarization control unit will match the birefringence between the two arms of the interferometer thus enabling high contrast fringes
- The output does not depend on variations of the input polarization
- The free running interferometer phase difference will not be a tremendous function of temperature

Calibrations

- Velocity calibration will be performed using a tunable laser source
- Interferometer characterization, set-up, and adjustment, and phase feedback control will be performed using all fiber phase shifters.

What's Next

- Finish calibration tests
- Test diagnostic on an exploding bridge wire flier
- High velocity experiment

Notes on Additional Components

- The modified VISAR will be composed of Mach-Zehnder interferometers with three additional components
  - An adjustable delay fiber will be used to adjust the delay length between the interferometer arms.
  - A polarization control unit to adjust the birefringence in one arm to match the other arm.
  - A phase control unit to fine tune the length of one arm with respect to the other arm in order to produce a 90 degree phase shift.
    - Sweeping the phase controller will generate fringes for set-up characterization purposes

Notes on Additional Components

- Since the design is entirely based on fiber optics each channel will incorporate two independent interferometers
  - The initial phases and VPFs will be independently adjustable
  - Feedback will be used to establish and hold a fixed, 90 degree DC-Phase relationship between the two interferometers