Assorted Results from Initiation Train Experiments
PDV Workshop 2011

Mike Bowden

mike.bowden@awe.co.uk
www.awe.co.uk
Introduction

- Explosive Initiation Science (XIS) Group at AWE responsible for initiation train design
- Need velocimetry as core capability
  - But no customer driver for “blue-sky” development
- Historically, VISAR (Sandia ~1991)
- VISAR capability lost (both equipment and expertise)
- PDV capability development began 2006
  - Mike Bowden – Technical Lead, Optical Diagnostics
  - Matthew Maisey – Technical Lead, Modelling and Software Development
Developments since 2009

- We have switched to optically-upshifted PDV
  - NP Photonics locker
- Significant development of MEDUSA 32 channel PDV system
- Fielded on more experiments
- Measured time delay from probe to detector using ps pulsed laser
Optically-upshifted PDV

- Laser 1: 150-2000 mW
- Laser 2: 25 mW
- Combined with 10/90 combiner (~2 mW of laser 2 at detector)
- First tried without solid locking between lasers
  - Offset would vary on a minute to hour timescale
- Now set using NP Photonics locker
  - 2 GHz offset typical
- Typical turn-on time is ~1 hour from cold start to locked offset
- Has *greatly* improved ease of setup, alignment and data quality
- No need to balance signal and reference
A Comparison of Standard and Optically-upshifted PDV

25 \( \mu \)m dielectric flyers. Non-upshifted data courtesy of Gary Liechty (LANL)
Exploding Bridgewires

- Alignment is very hard – most shots have no or very little data

Courtesy of Elizabeth Lee (AWE)
Laser-driven Flyer Plates
Detonator Can Output

- Detonators mounted in a polycarbonate fixture
- PDV probes held at ~ 3-4 mm standoff from detonator output face
- Collimating probes with 0.5 mm beam diameter
- Probe not precision aligned
Explosively-driven Flyer

- Flyers of different diameters studied
- Compared difference between flyer diameter and the velocity after travelling 1.5mm (when flyer would hit target pellet)
Initiation Train Characterisation Experiment (ITraC)

- Fiber optic probes
- Explosive pellet/s
- LiF window
- PDV probes
Typical ITraC Output

Arrival of Detonation Wave at LiF/HE Interface
Arrival of Shock at LiF free surface
Scaled LiF/HE Interface
Adiabatic Release of interface
LiF Free Surface Velocity
(no window correction)

Typical ITraC Output
Half Peach / Onion Skin / Snowball

- This shows the importance of getting your upshift right…
- Data bounces off zero and is inverted – very hard to deconvolve!
MEDUSA 32 Channel PDV System

- Use fibre coils to time-delay return signals (2 km = 10 µs)
- 8 channels multiplexed onto each scope channel
- Optically-upshifted
- All combined signals should share same laser to minimise interference and noise
- Delay legs procured (2, 4, 6 km in 19” rack unit)
MEDUSA System Customer Requirement

- To develop a highly-multipoint PDV system for ITraC and half peach experiments
  - Minimum 8 channels
  - Goal >30 channels
  - Maximum velocity of 5 km/s
  - Time resolution of <1 ns
  - Transportable
Solution

- Time domain multiplexing
- Use delay legs to combine signals
- $2 \text{ km} = 10 \ \mu \text{s}$ spacing
- Oscilloscope record length $10 \ \text{MPts} = 200 \ \mu \text{s}$
  - Maximum 20 channels per oscilloscope channel
- 8 channels per oscilloscope channel
  - 32 channels, room for expansion
- Simpler than frequency-multiplexing
- Twin laser (optical upshifting) to improve signal to noise
  - Aim for 2 GHz upshift
Combination Options

- 8 to 1 combiner
  - Cheap
  - Very high insertion loss (-10 dB)
  - Cross talk between channels

- Fast fibre switch
  - Expensive
  - Fast switching time (300 ns)
  - Low insertion loss (-2 dB)

- Fibre switch recommended
System Architecture

Laser 1
2W
1550 nm

Laser 2
25mW
1550 nm + Δλ

PDV Chassis

Delay Legs 1

Delay Legs 2

Fibre Optic Switch

Stanford DG645
Delay Generator

Tektronix
DPO71604B
50 GS/s, 16GHz

Miteq 20 GHz receivers

Trigger In

Trigger
System Architecture (Detailed)
Fibre Switch
Future Plans

- Integration NP Photonics lasers and locker into 4 channel “COTS” system
- Distributed PDV system
  - 2 lasers, 10 locations, distributed on timeshare basis using optical switch
  - Lasers run 24/7, maximise stability, minimise setup time
- Commissioning of MEDUSA system