Lawrence Livermore National Laboratory

Multiplexing PDV (MPDV-X16) Heterodyning

PDV Workshop
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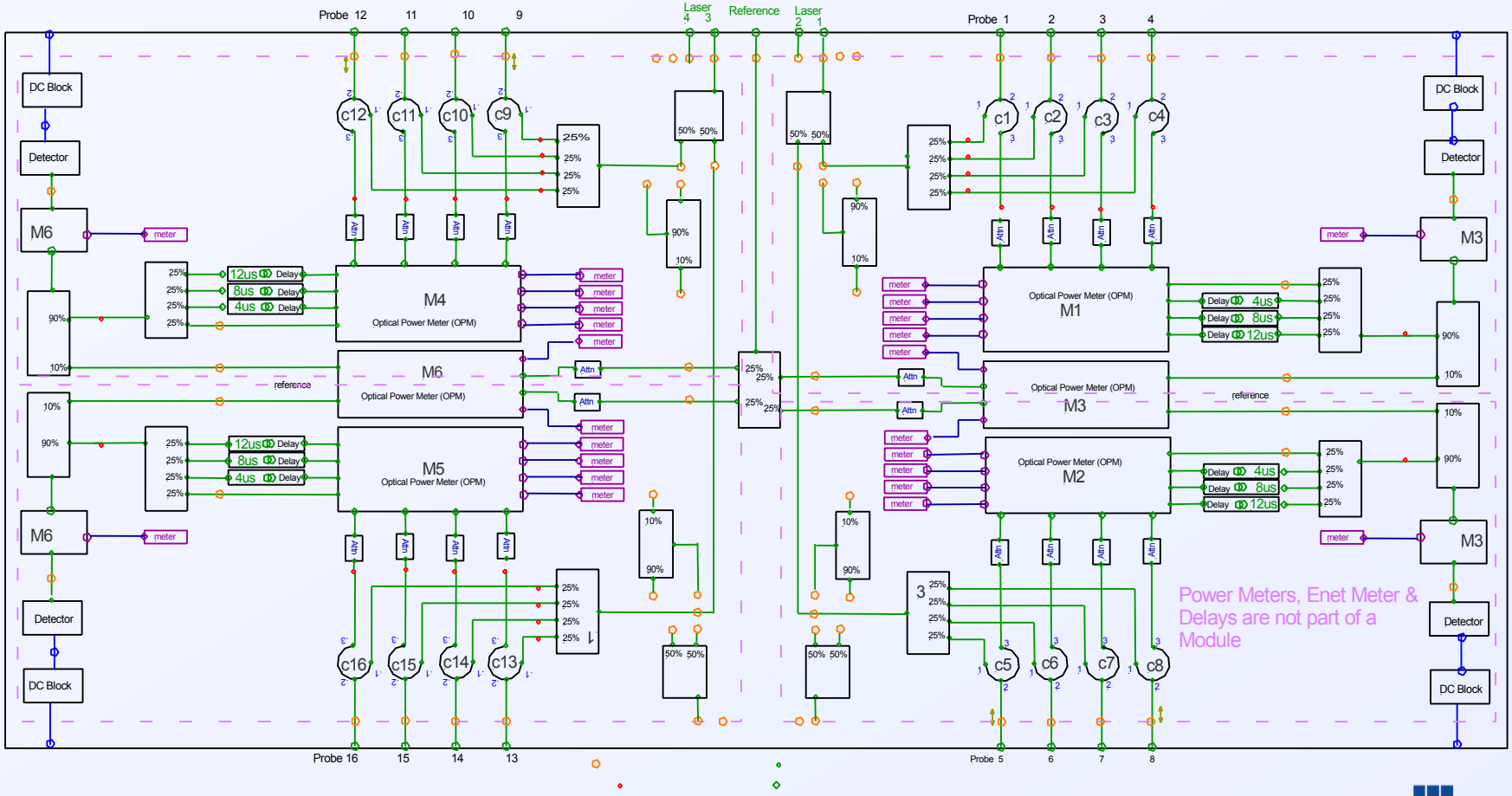
Diagnostic Development of a Multiplexed PDV System

- Combine multiple PDV signals to one detector
  - Each scope channel has => 50us record length
    - Agilent 10GHz / 40GS/s
    - Tektronix 20GHz / 50GS/s
  - Add a 4us delay between each signal
  - Four or Eight signals on each scope channel
    - Four scope channels = 16 or 32 channel system

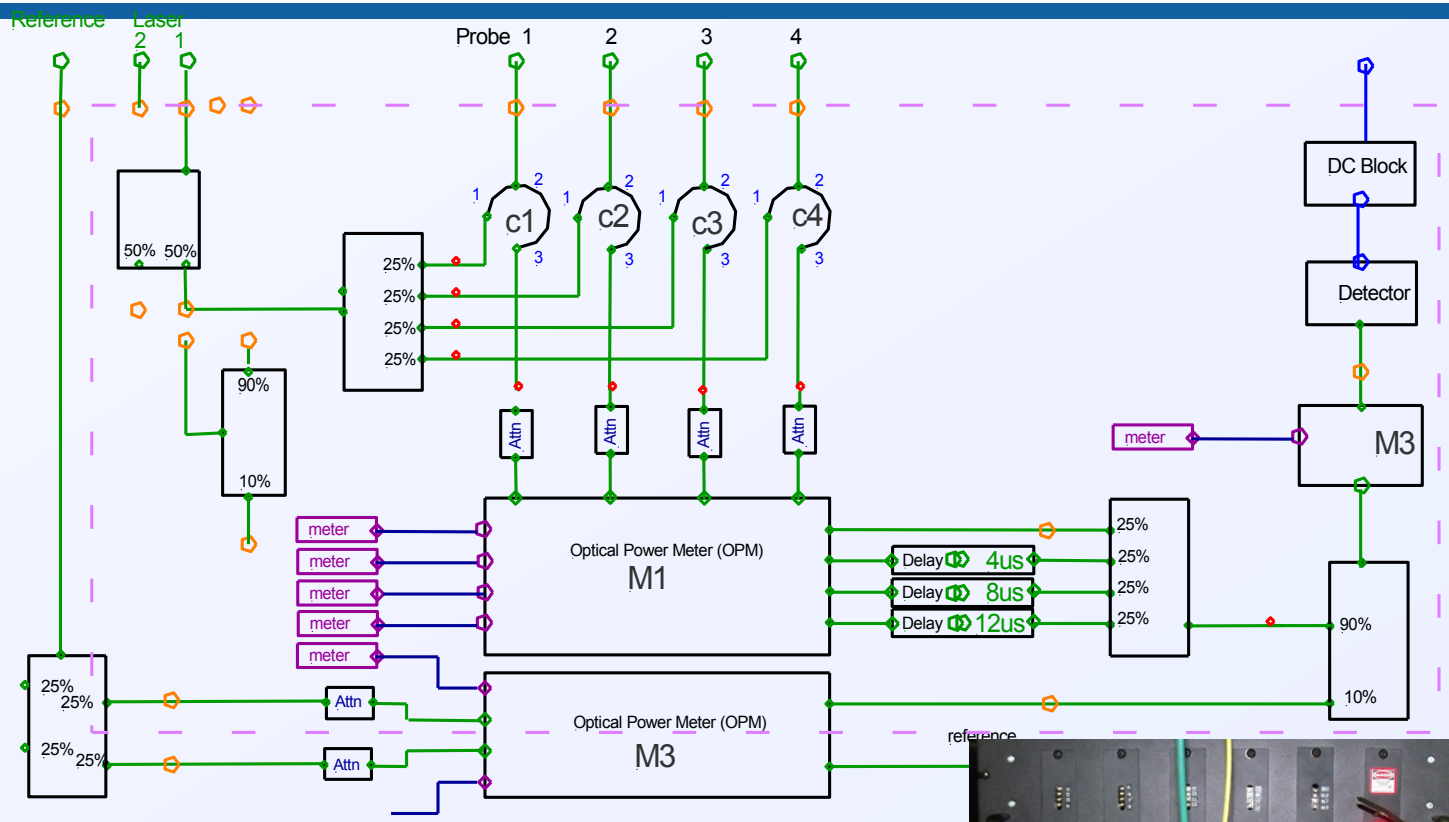
- Independent Single Reference
  - Allows the reference to be set depending on the return signal
  - A tunable reference would allow for optical heterodyning, which would increase the temporal resolution of our short pulse signals

Four Channel 4x Multiplexed PDV Chassis

- MPDVx16

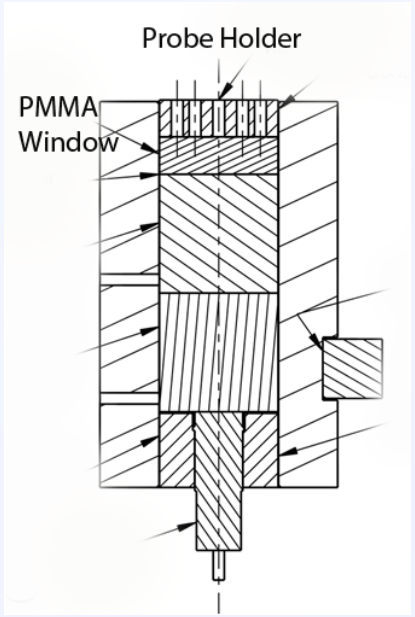


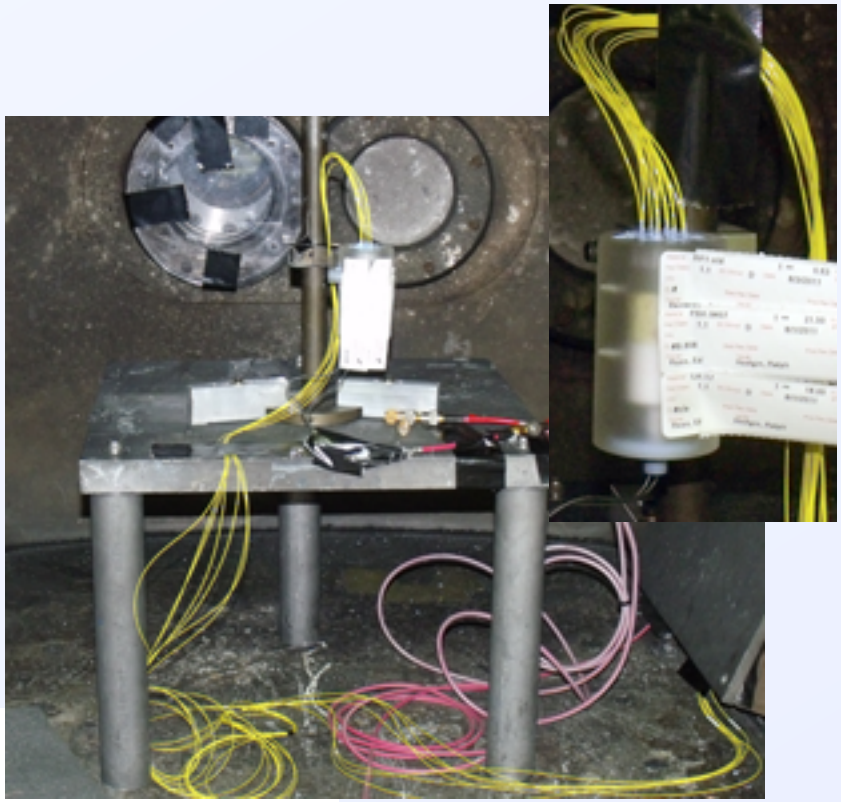
One Module of the 4 x4 Multiplexed PDV Chassis

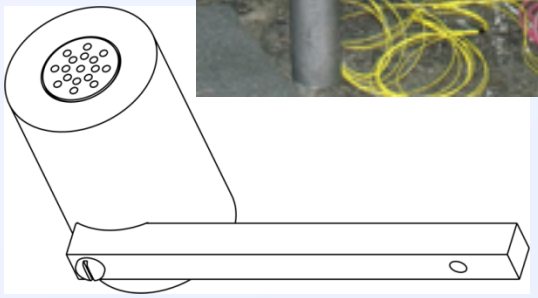


One-D Test – 16 PDV Probes Multiplexed into one 4 channel scope

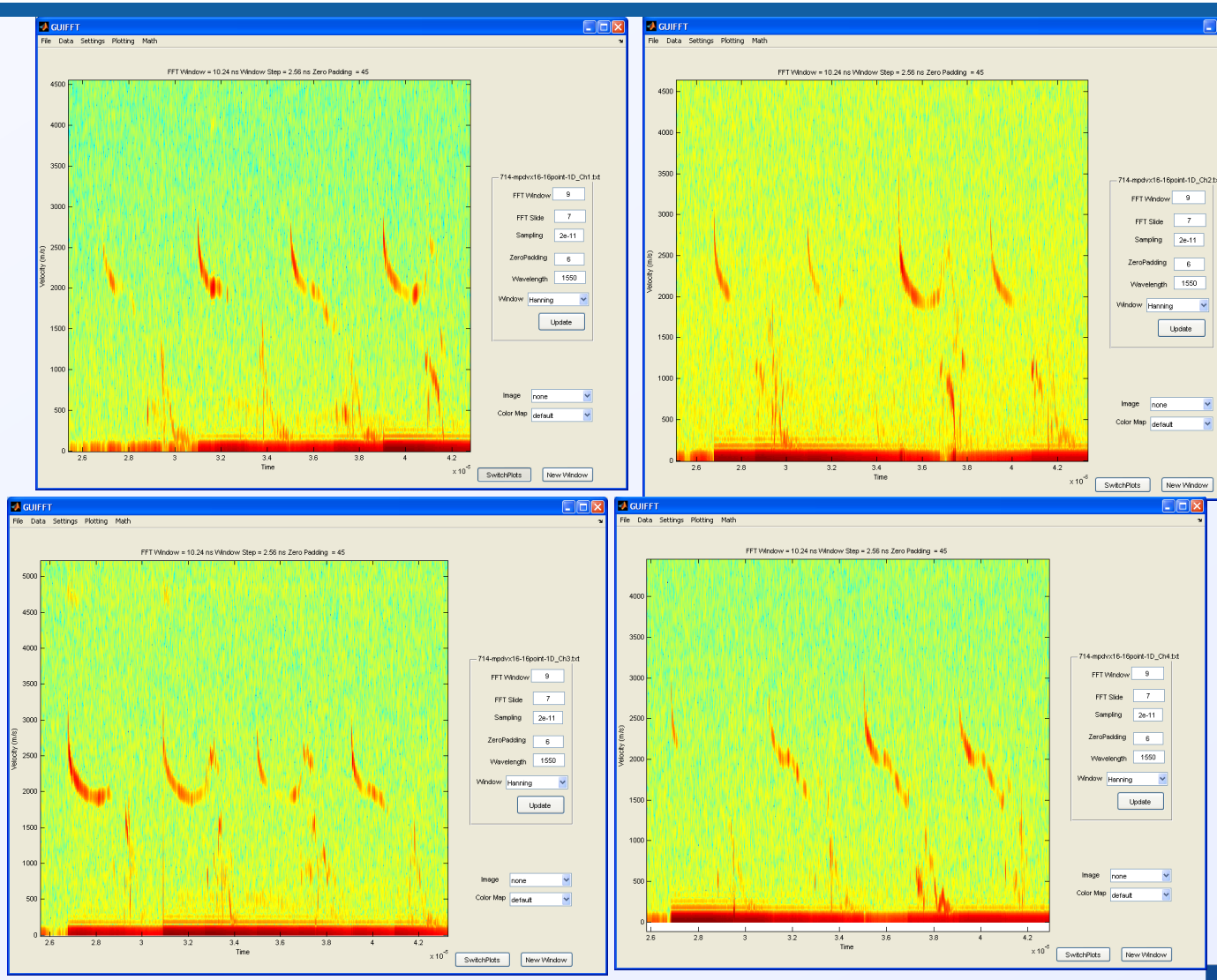
- 16ea 7mm Probes



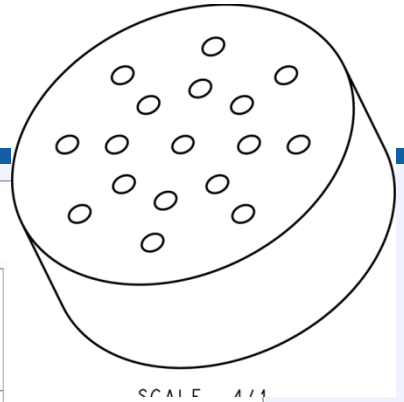


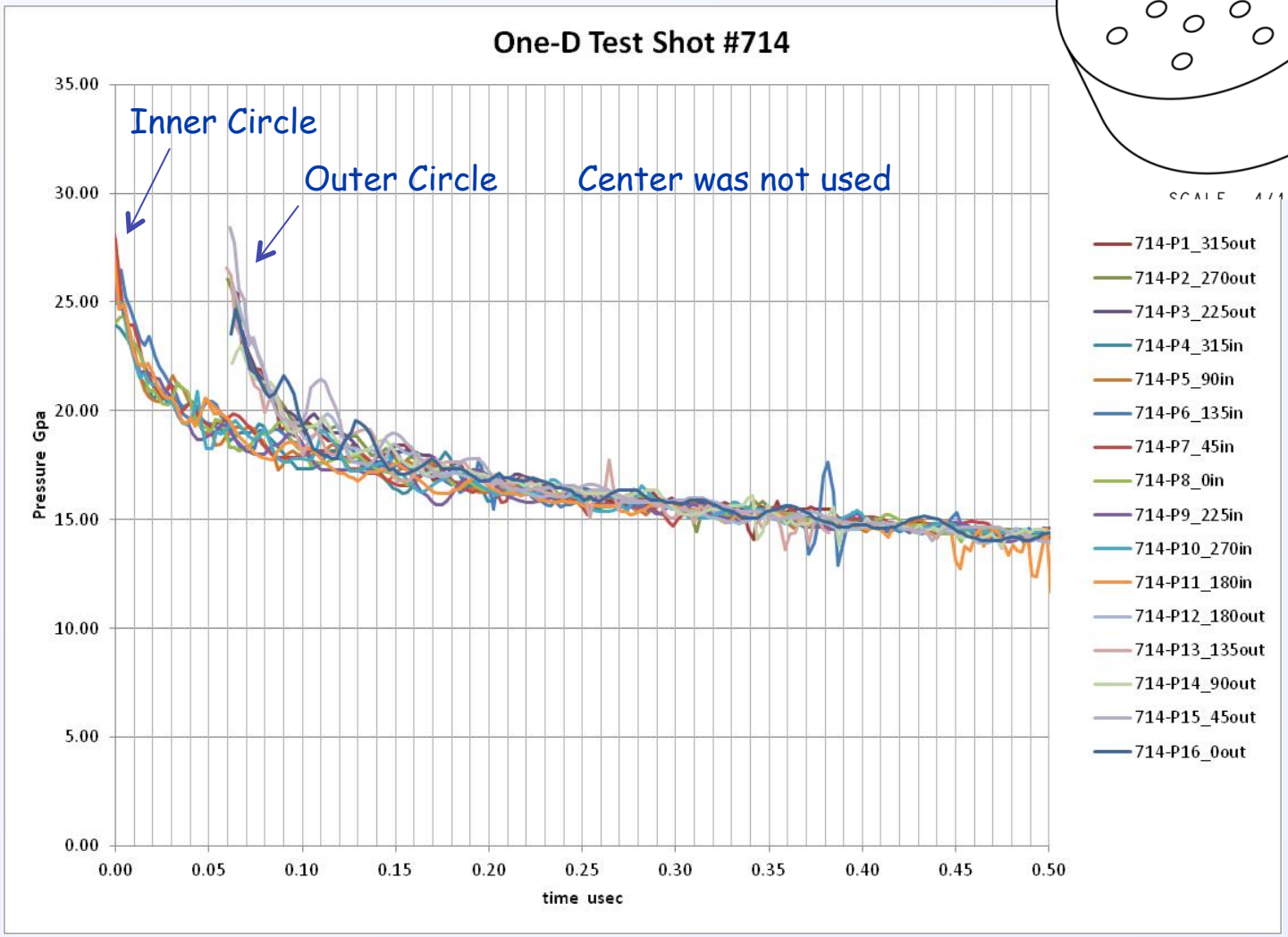


One-D Test Results – 16 Channels Reported



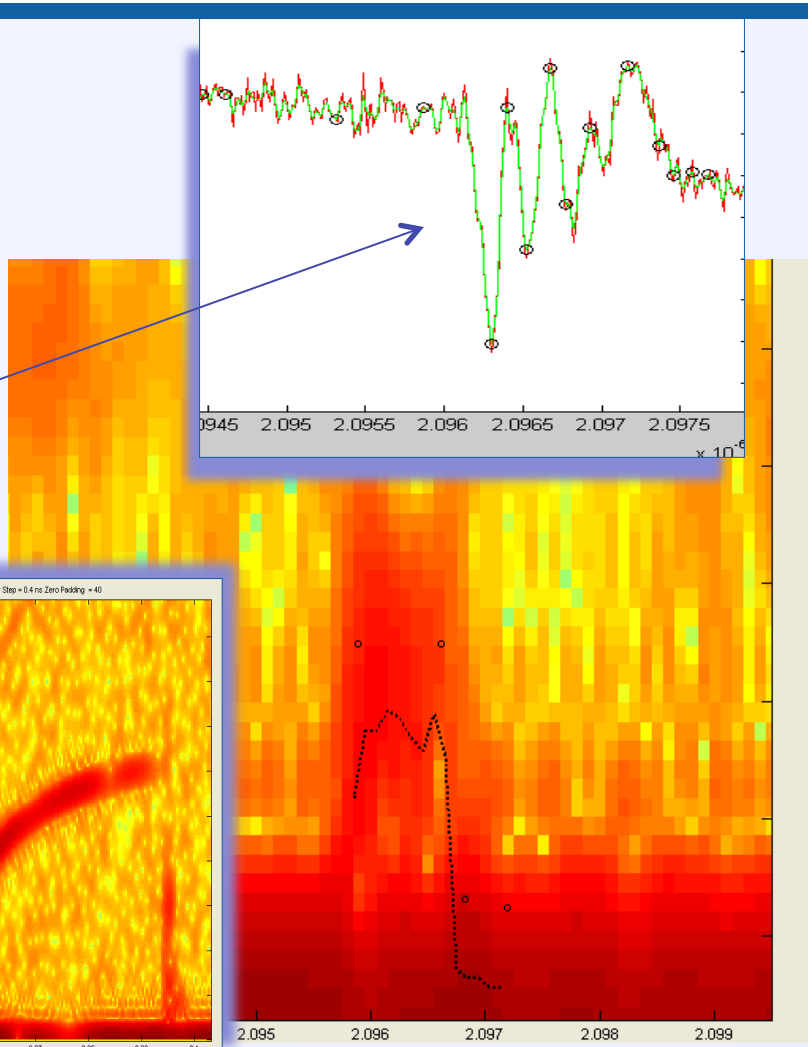
One-D Test Results

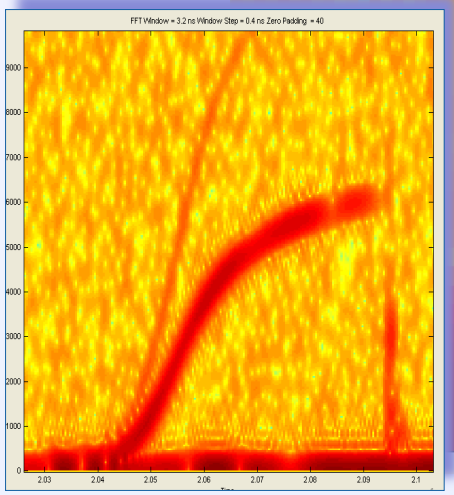


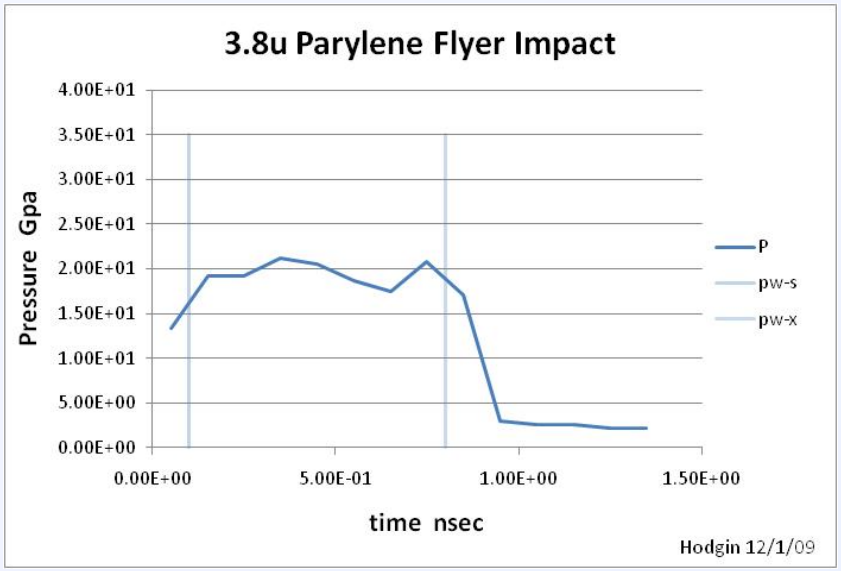


Thin Flyer LiF Impact – Low Resolution

- 3.8um Parylene Flyer
- Impact Velocity = 6km/sec
- Impact Pulse Width =0.7ns
- Pressure = 20GPa
- Only 3 cycles of PDV data!





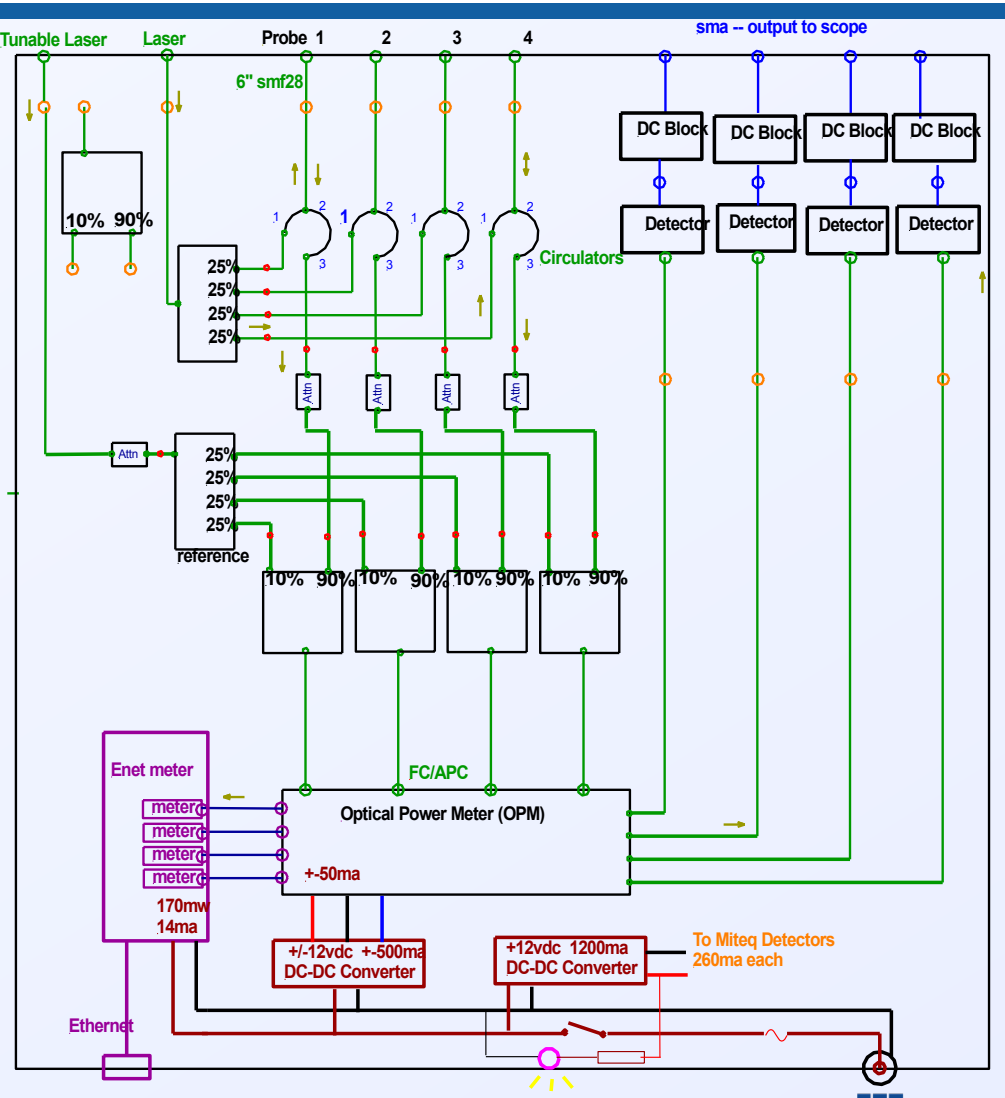


Heterodyning

- Improve temporal resolution of the PDV system
- A second tunable laser is used for the Reference signal
  - Tuned to a slightly different frequency from the main laser
  - Adjust frequency using the Spectrogram on the scope
- A Beat signal is produced and can be seen on the PDV signal
- A minimum of 3 cycles (data points) is needed to make a measurement
  - 1km/s velocity = 2.3ns temporal resolution (3 cycles)
  - 1km/s velocity up-shifted 10GHz = 266ps temporal resolution (3 cycles)

Four Channel Heterodyne PDV Chassis

Design by LLNL, Built by REALM



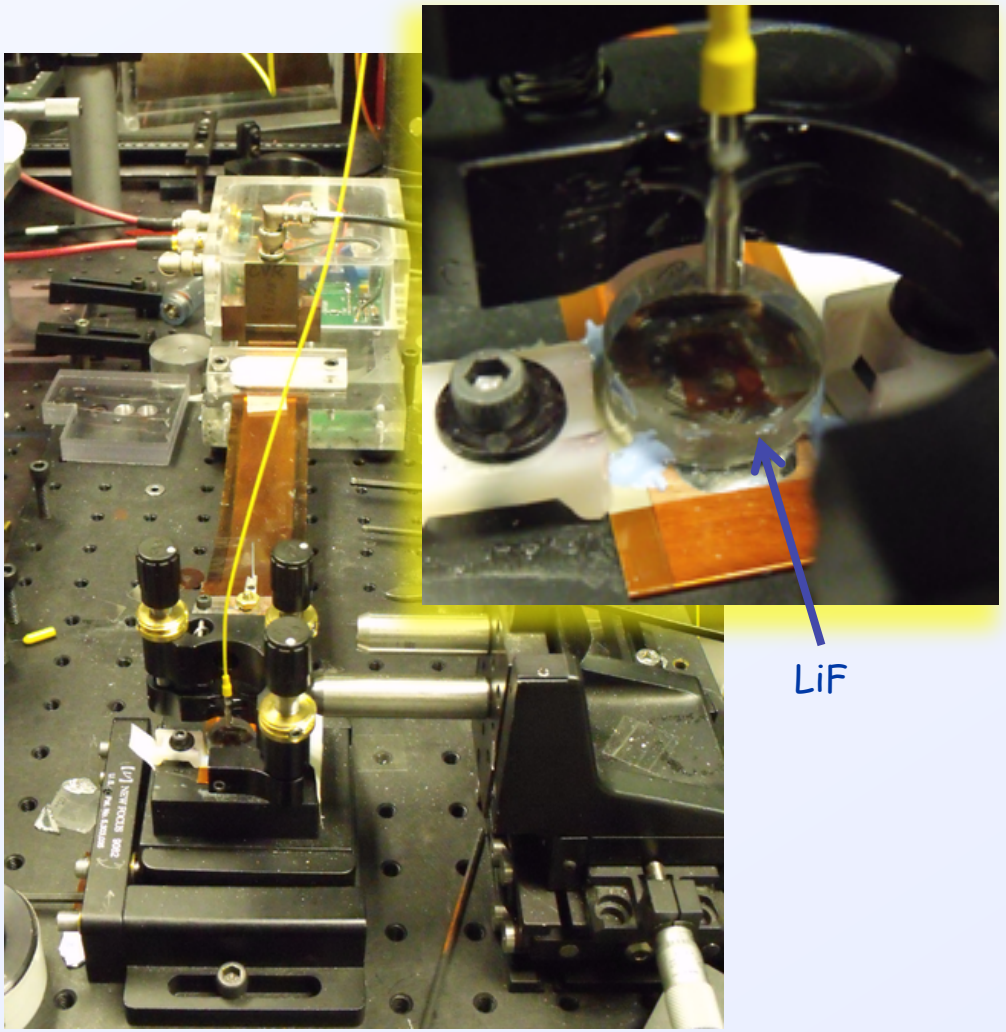
Heterodyne Setup

- Beat Amplitude
  - Observations:
  - >180mV = good data
  - < 120mV = weak data

- Scope Spectrogram
  - Set beat frequency with a tunable laser
  - Shift up or down

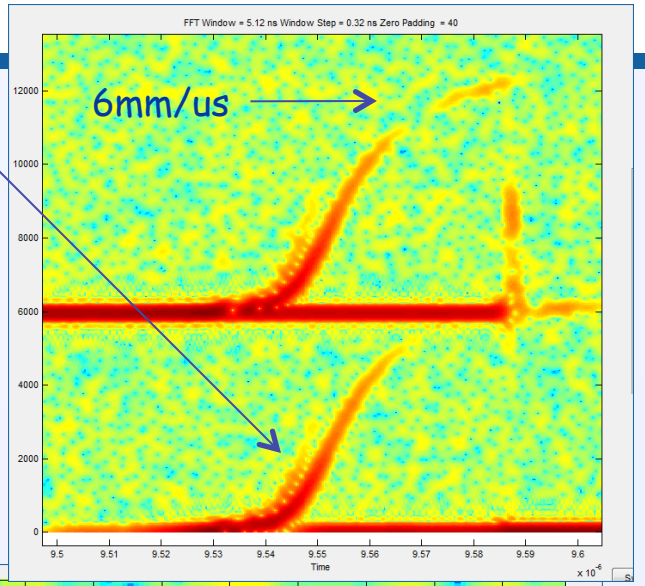
Heterodyne Test Setup

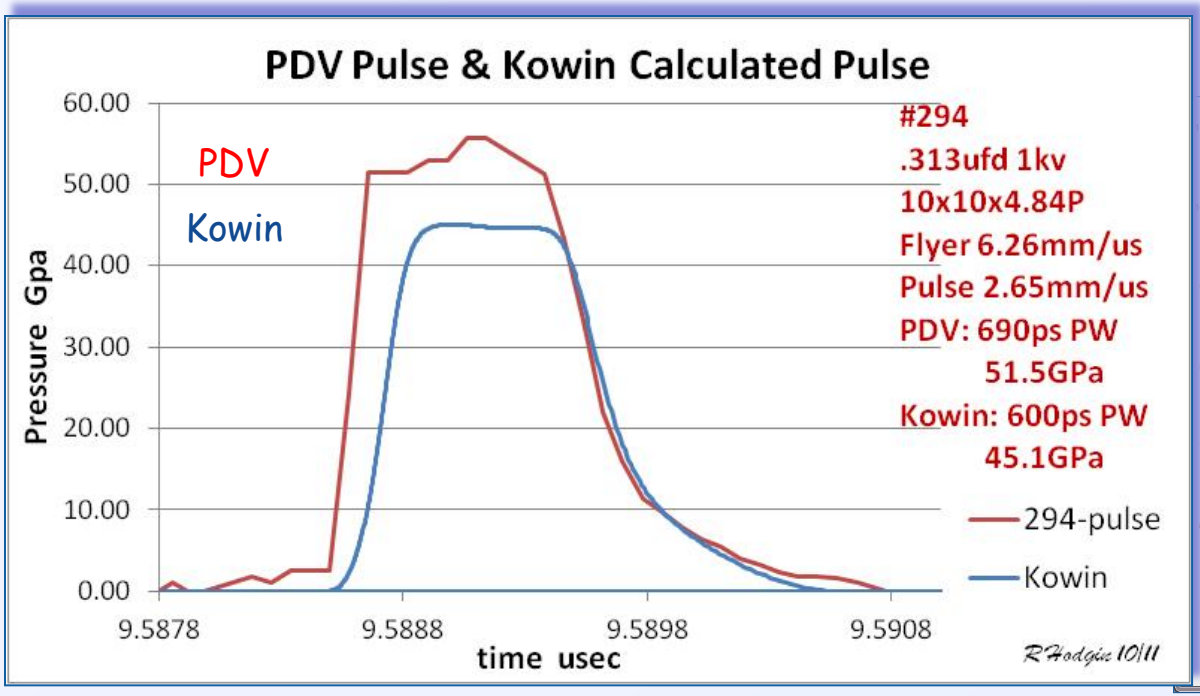
- LiF with 50% Transmission Al Coating @ 1550nm
- Bridge10 x 10 mil 4.84 Parylene Flyer
- 6 mil barrel
- 0.313 uFd fireset
- 1kV

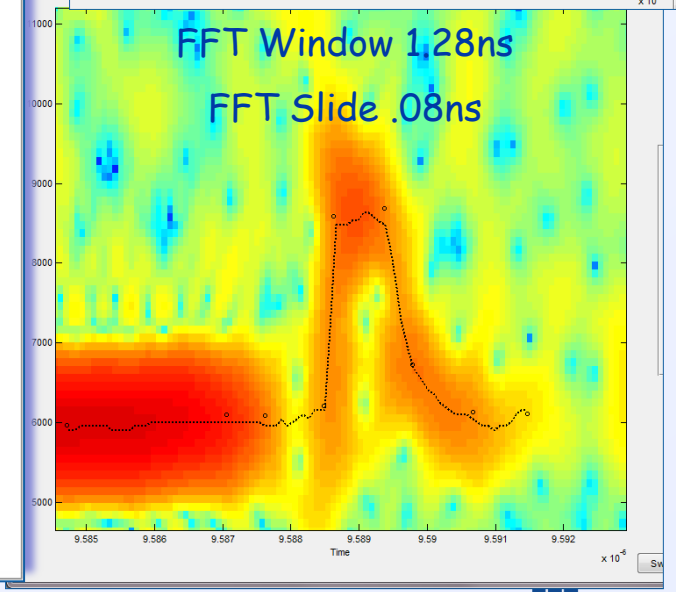


UpShift 7.5GHz

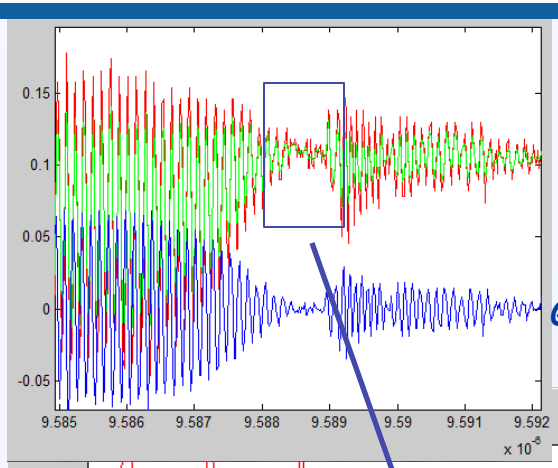
- Second signal is from the Al coating on the LiF
- Kowin and PDV have good agreement on pulse width (90ps)
- There is a difference between the Kowin and PDV Impact Pressure of 6GPa







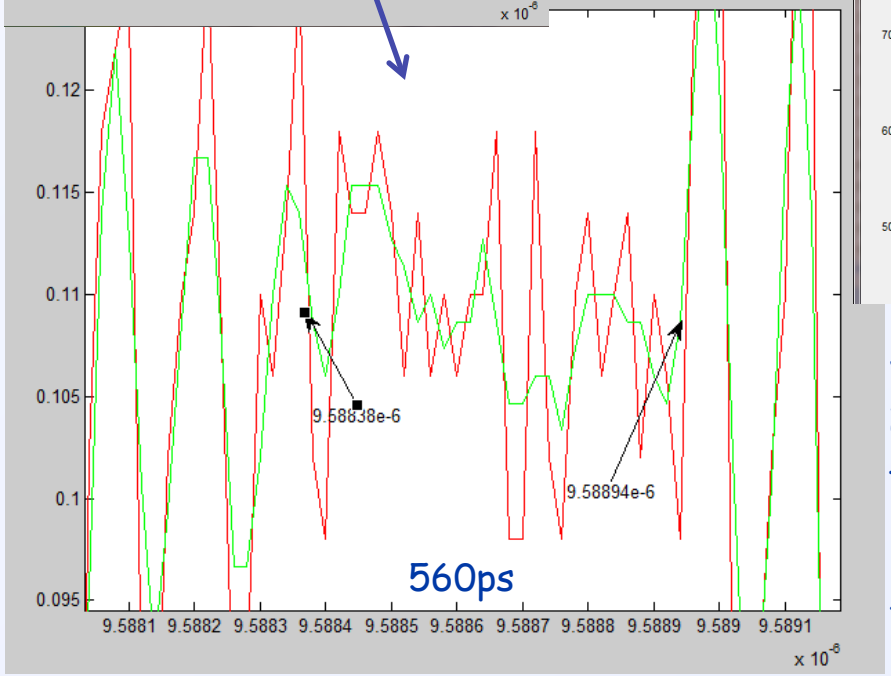
Raw PDV Data & the Data in Matlab

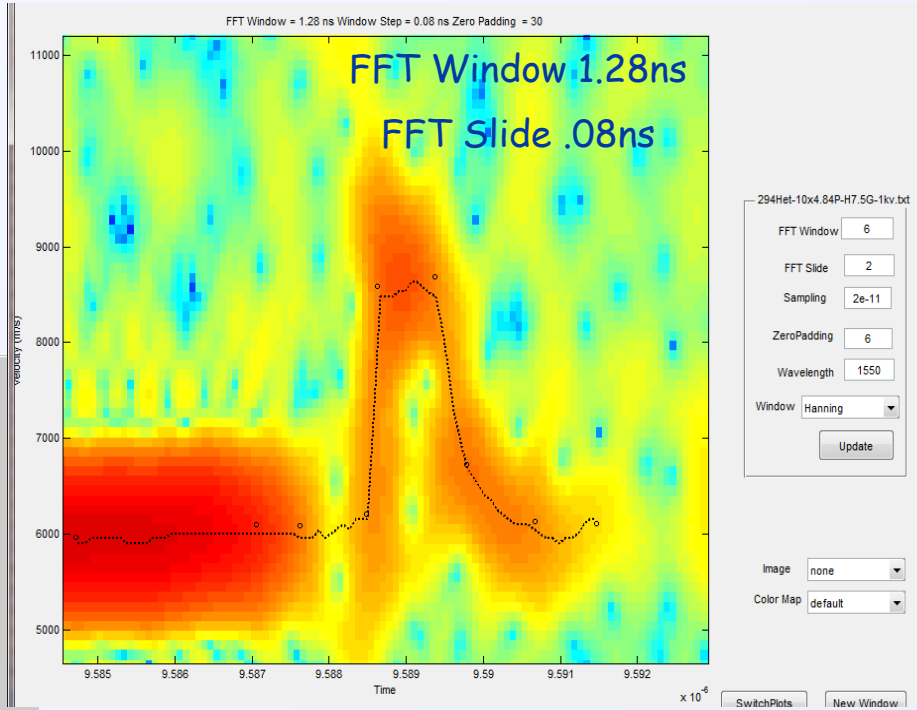


Red: Raw PDV

Green: Smoothed

Blue: Derivative





Spectrogram of PDV Data 690ps Pulse Width

2.65mm/us measured velocity on the pulse

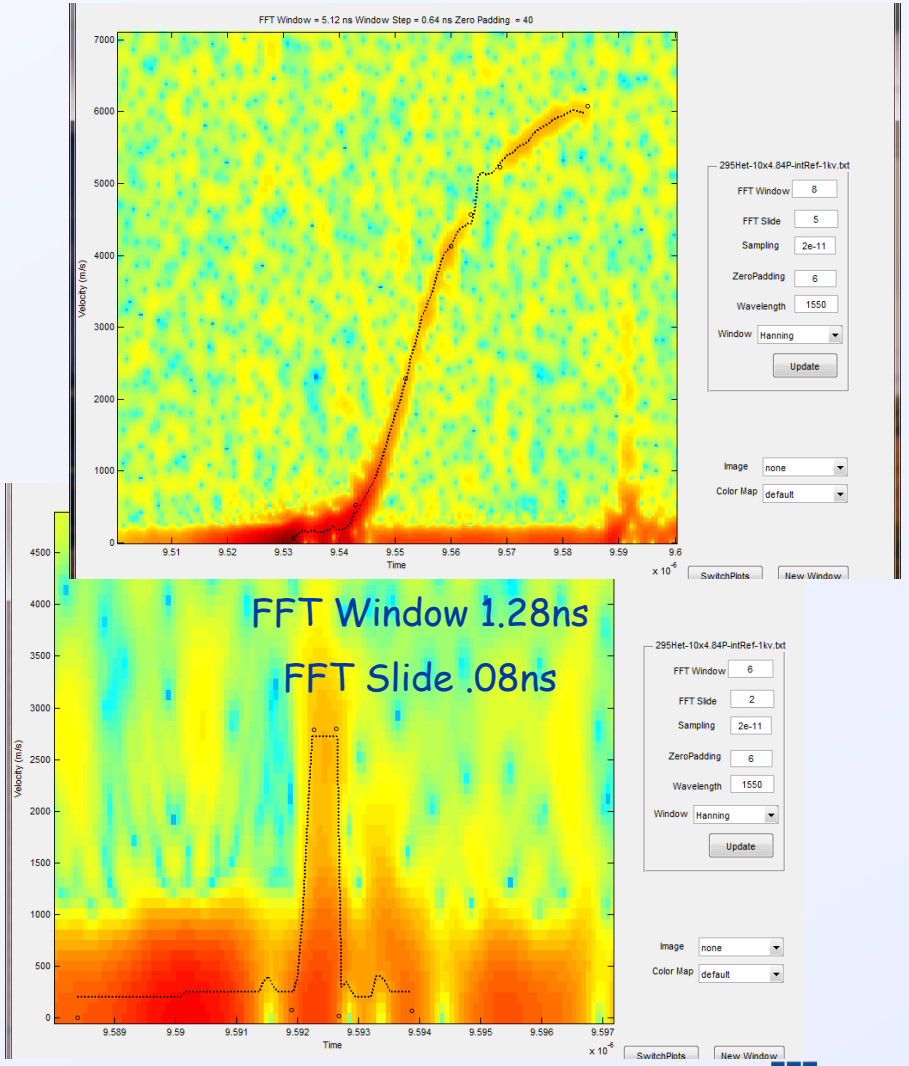
7.5GHz up-shift :

Resolution = 91ps / cycle (x3 = 273ps)

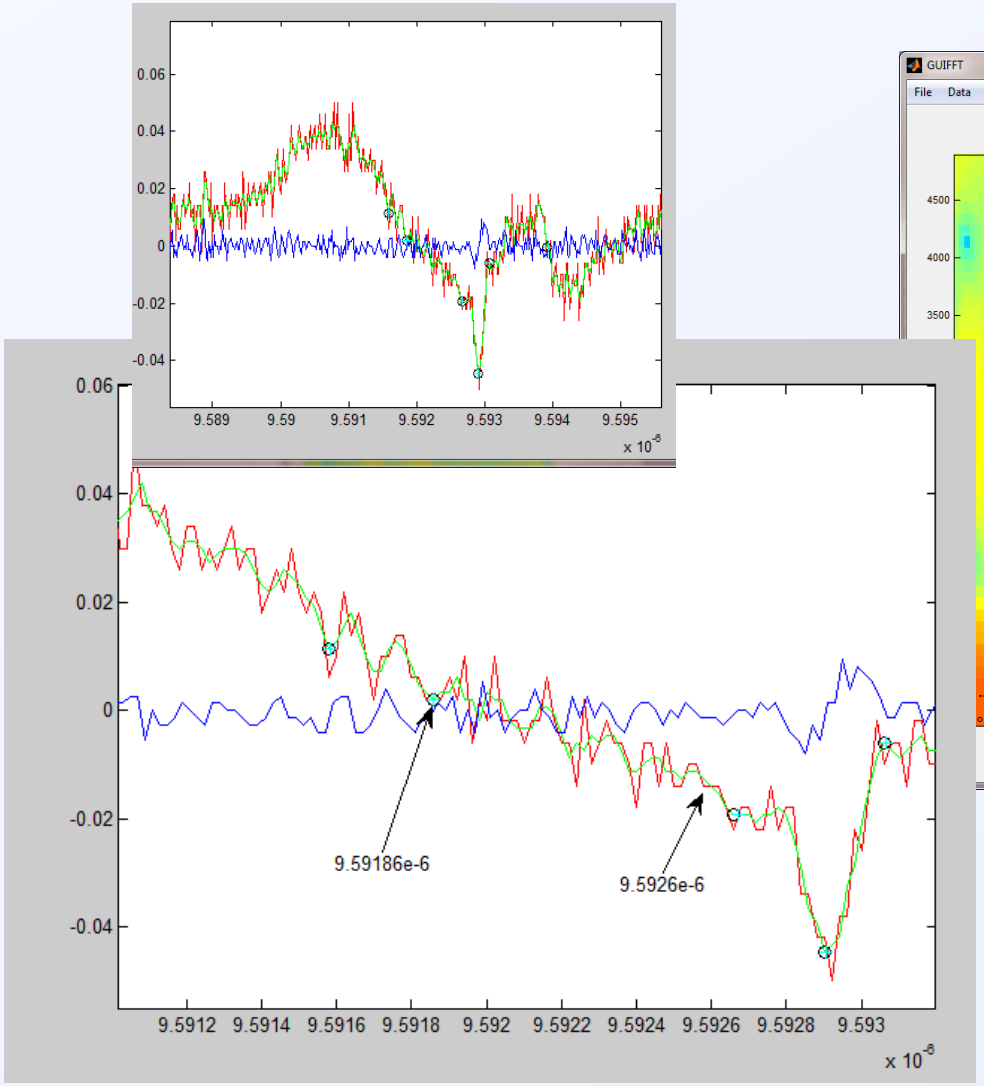
This 690ns pulse width has 7.5 cycles

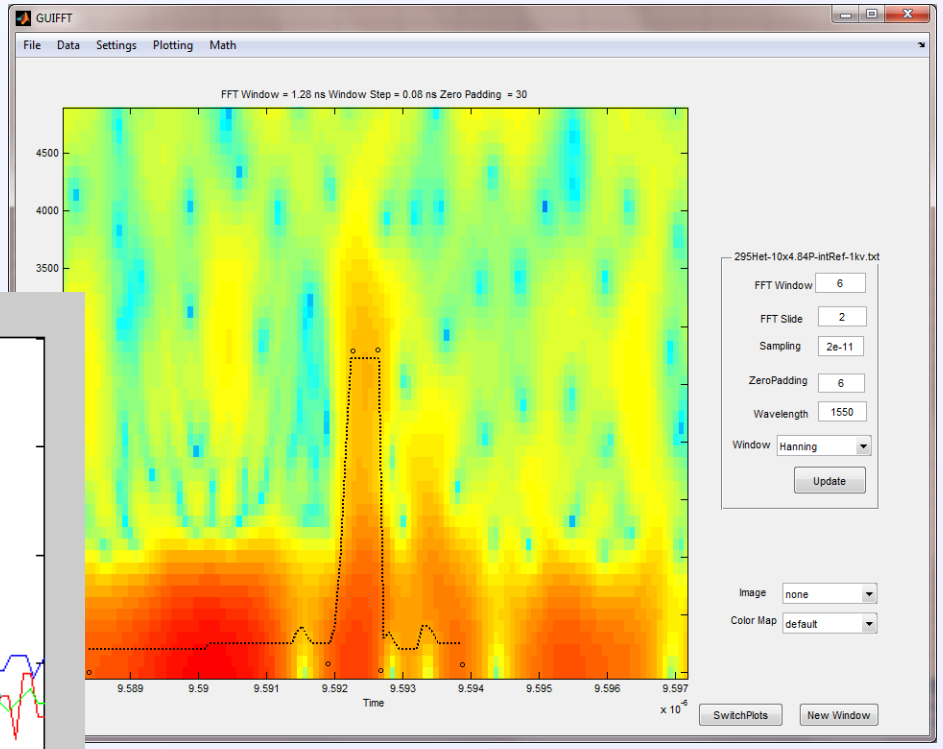
Internal Reference – 4.84P Flyer

- Repeated the previous test with the same conditions, using an internal reference
- Pulse Width =~ 450ps



Internal Reference – 4.84P Flyer





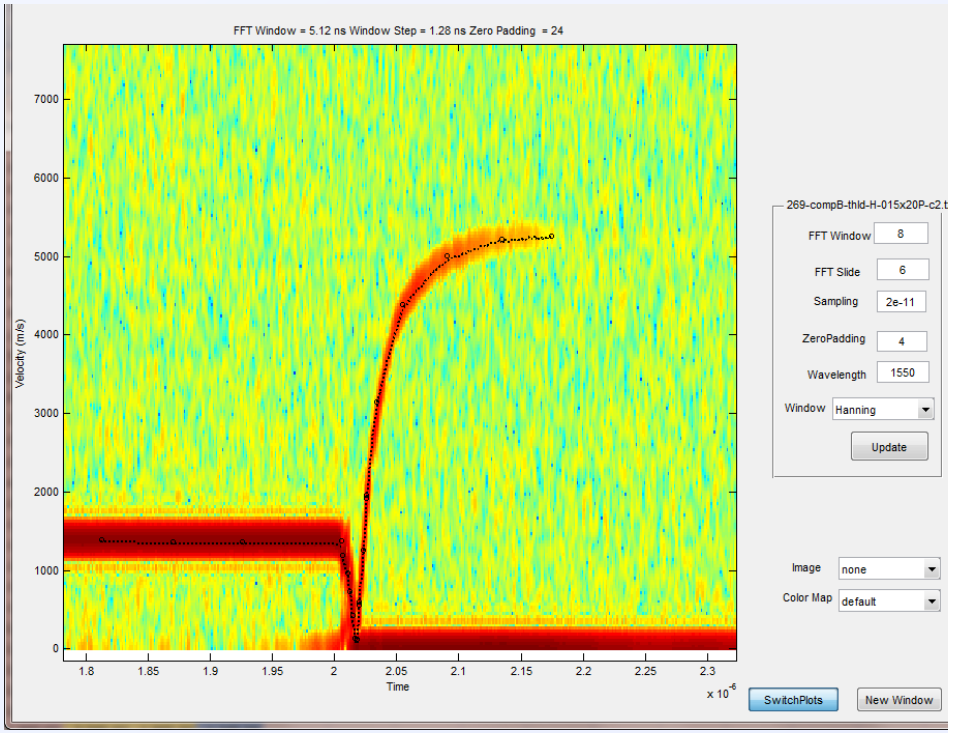
2.5mm/us measured velocity

Resolution: 300ps / cycle (* 3 = 900ps)

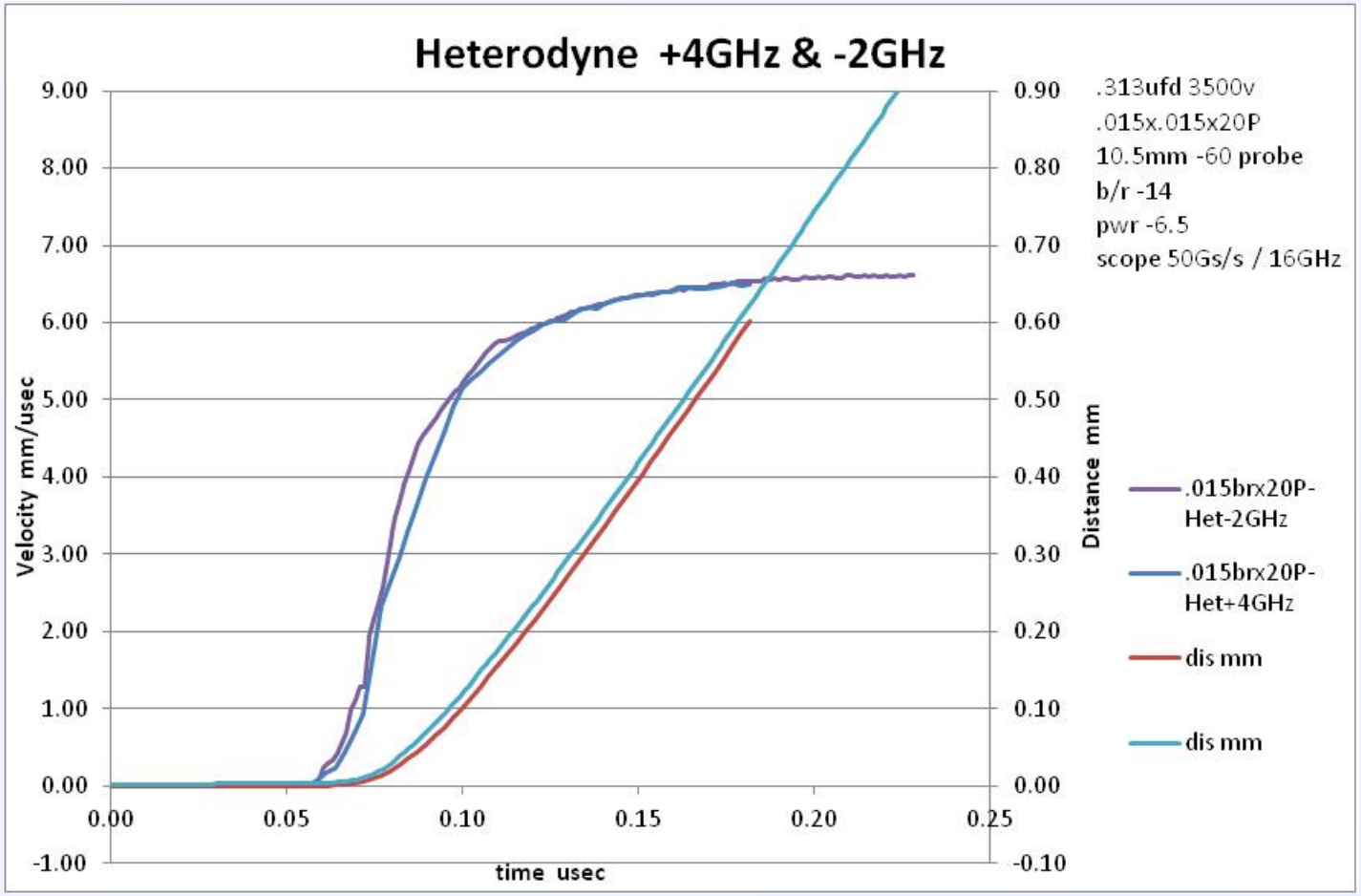
This 450ps pulse has 1.5 cycles of data

Heterodyne – Down Shift

- Adjust tunable laser frequency to 2 GHz on the spectrogram
- Increasing freq. on the tunable causes the freq. on the spectrogram to decrease
- Measure a higher velocity than you normally could
  - Ideally, 2 x the bw of scope
- Measure velocity of objects moving away

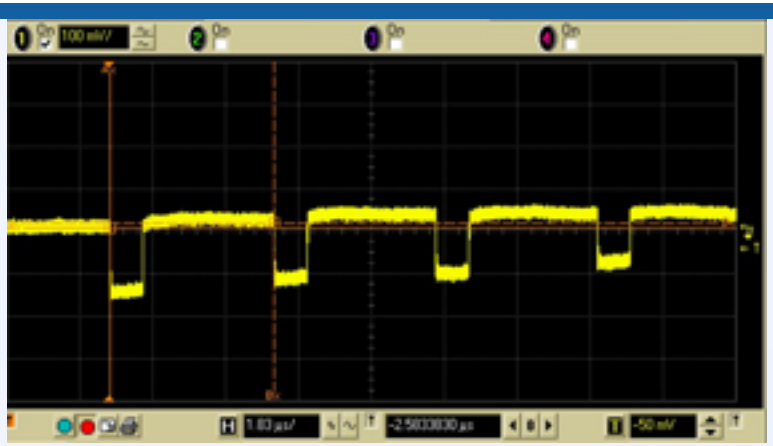


Comparison of Upshift and Downshift

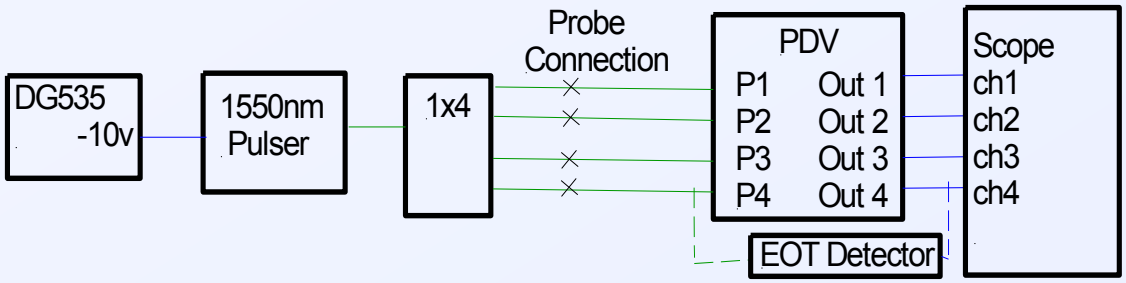


- Two identical shots, one upshifted and one downshifted

1550nm Pulser – Testing the PDV System

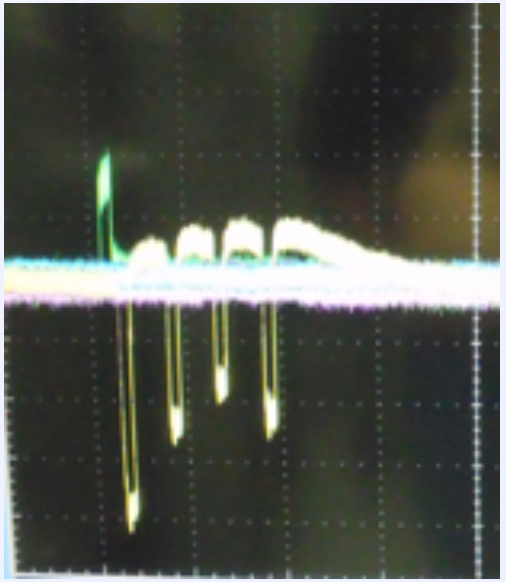


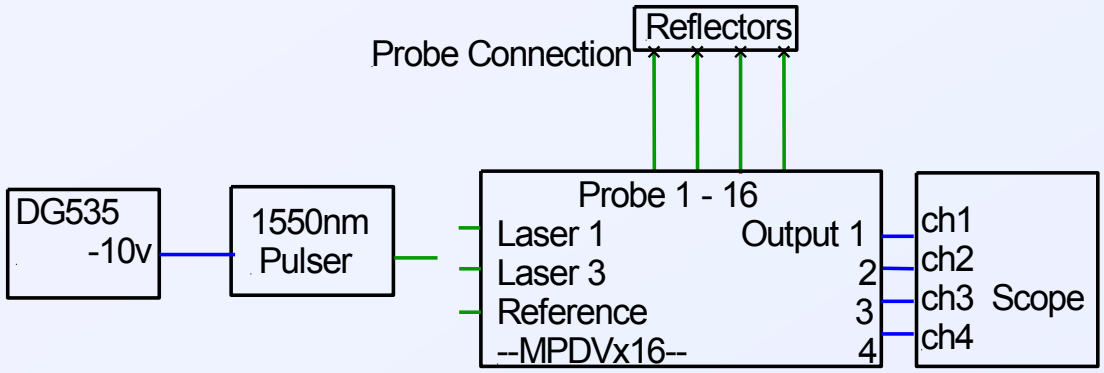
- Use a Pulser to insure the PDV system is operational
- Applying Pulse to Probe Inputs
  - Tests the PDV signal paths
  - Measure delay between channels
  - Measure the throughput signal delay



1550nm Pulser – Testing the PDV System

- Tests the complete PDV system
- Connect reflectors to the
  - End of PDV fibers (probe connection)
- Apply a Pulse to Laser Inputs and Reference Input





Conclusions

- 16 PDV channels of data on One Scope
- Sub nanosecond pulses can be measured