Duplexing—Combining Data from Two Probes onto a Single Digitizer Channel

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WEAPONS
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INTEGRATION

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We are victims of our success

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At LLNL and LANL, we are constantly being asked to field more and more probes on experiments:

Originally, we fielded 4 to 8 probes per test.
Then, it was 16 to 20.
Now, it is 50 to 100.

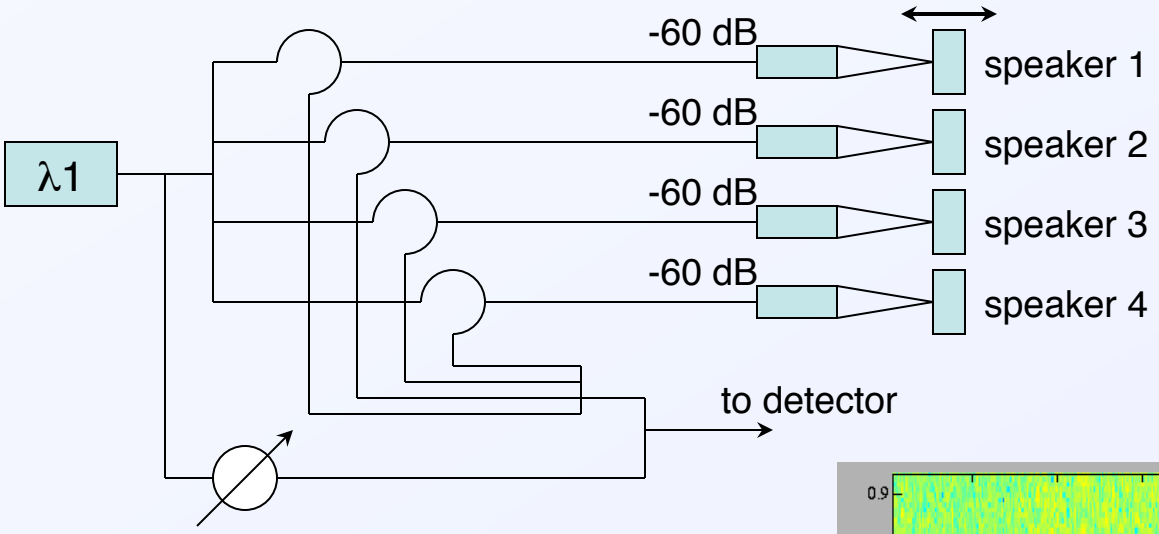
Unfortunately, there is not a corresponding increase in the available $$ to buy additional hardware.

Our digitizers are our most expensive piece of gear.

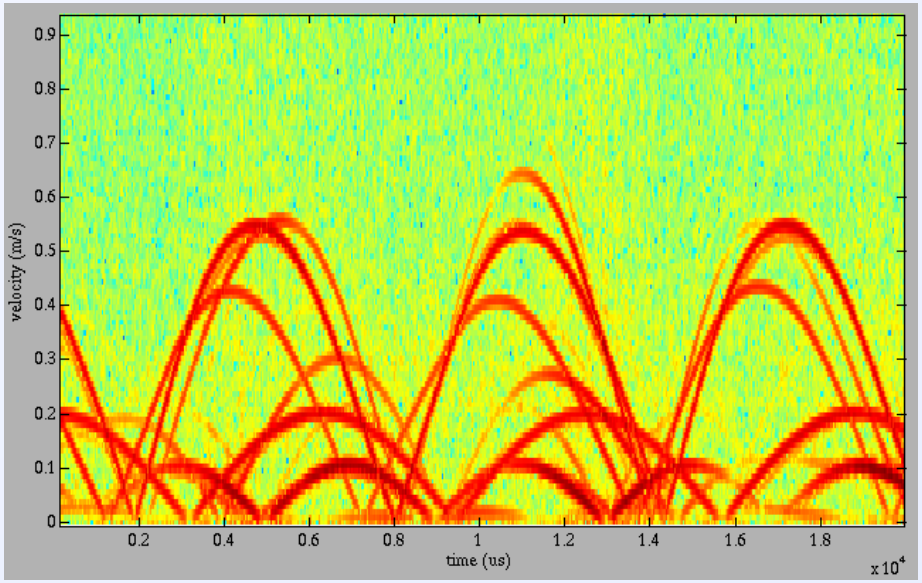
Our solution is to multiplex more than one probe onto each digitizer channel.

The next few talks: duo (2-way multiplexing), Strand
quad (4-way multiplexing), Hodgin
octo (8-way multiplexing), Daykin

This form of multiplexing will work only if the signals do not overlap in time

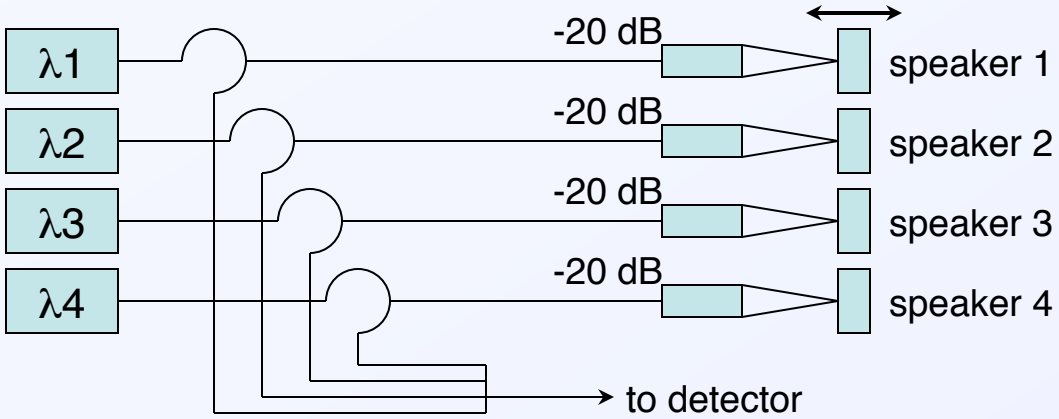


Many cross terms are generated so that the real velocities cannot be determined.



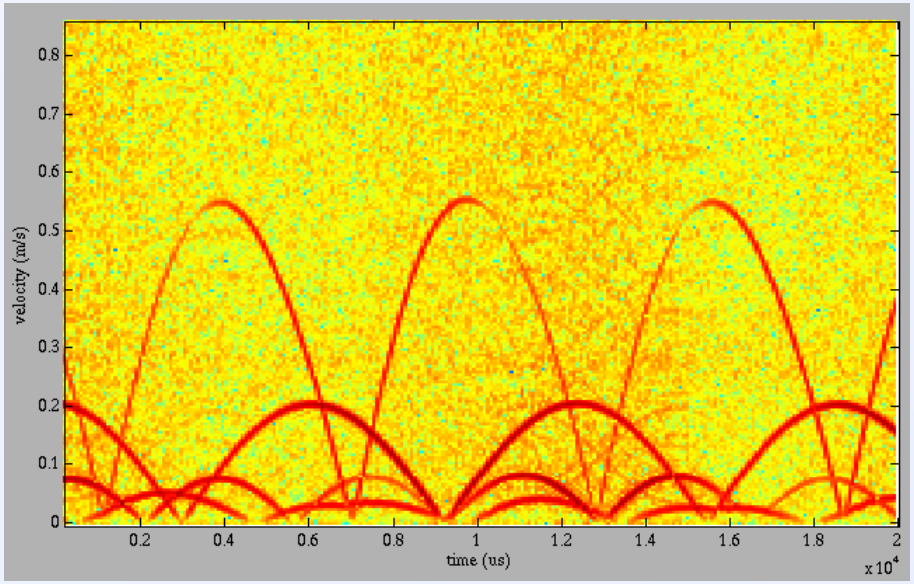
(Bench tests by Ed Daykin of NSTec)

This is an example of successful multiplexing



Each probe has internal BR for reference source

Use laser wavelengths sufficiently separated that cross terms are outside the bandwidth of the PDV system.

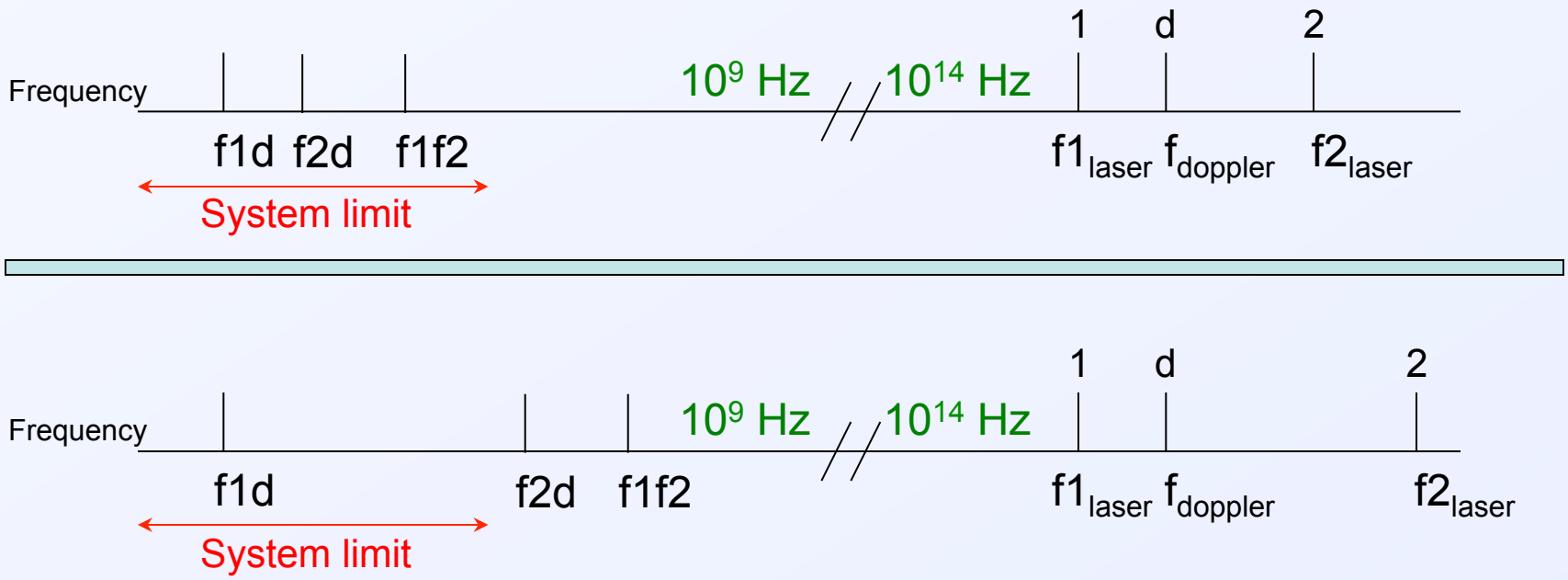


(Bench tests by Ed Daykin of NSTec)

Things to consider when duplexing

We want to avoid having unwanted cross terms in our spectrograms.

→ we need to make sure the laser wavelengths are sufficiently separated



Calculate desired wavelength separation

$$c = f\lambda$$

$$\lambda = \frac{c}{f}$$

$$d\lambda = -\frac{c}{f^2}df = -\frac{\lambda^2}{c}df$$

$$\lambda = 1550nm = 1550e-9m$$

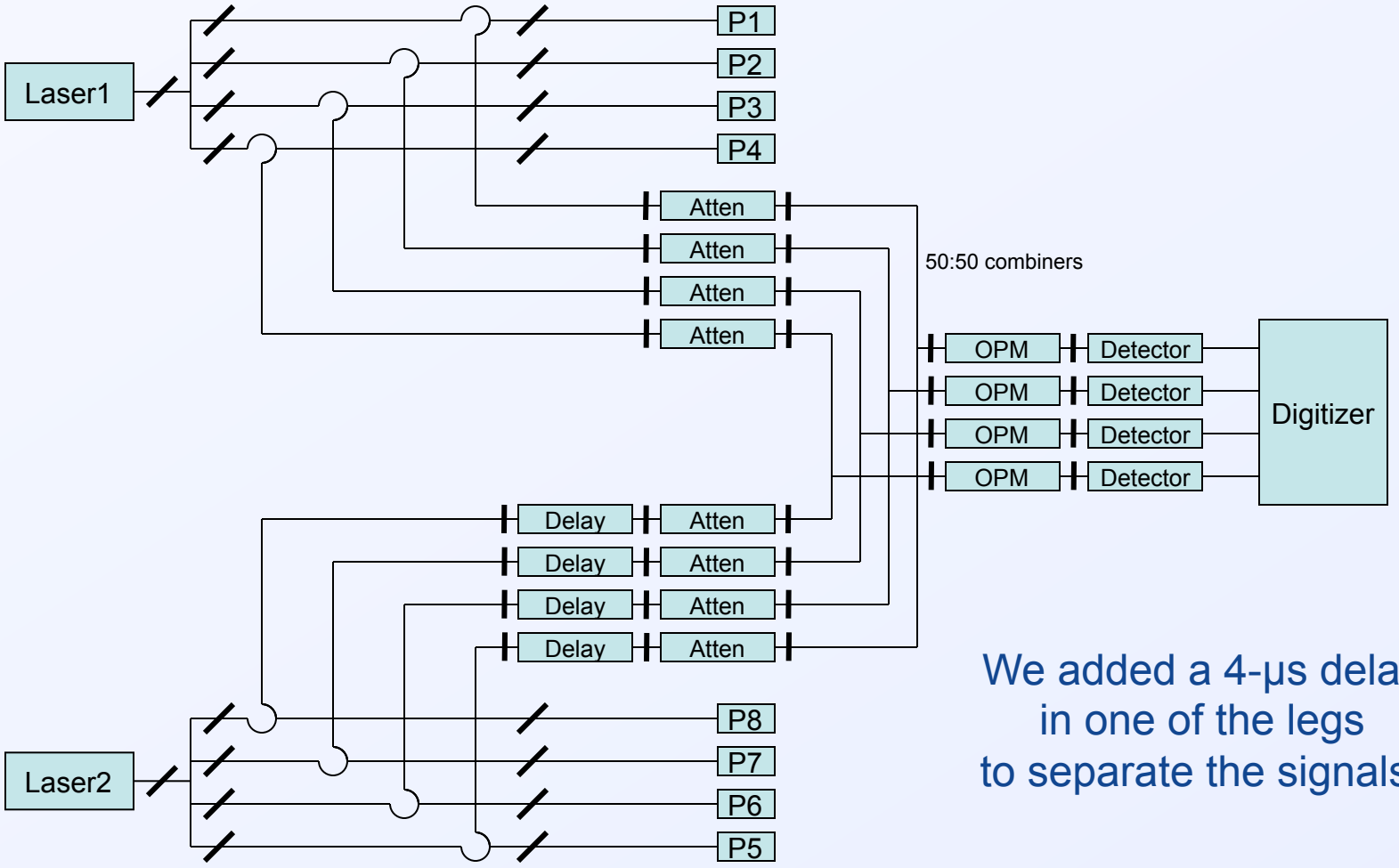
$$c = 3e8m/s$$

$$125 * d\lambda(nm) = -df(GHz)$$

A shift of +1 nm = a shift of -125 GHz

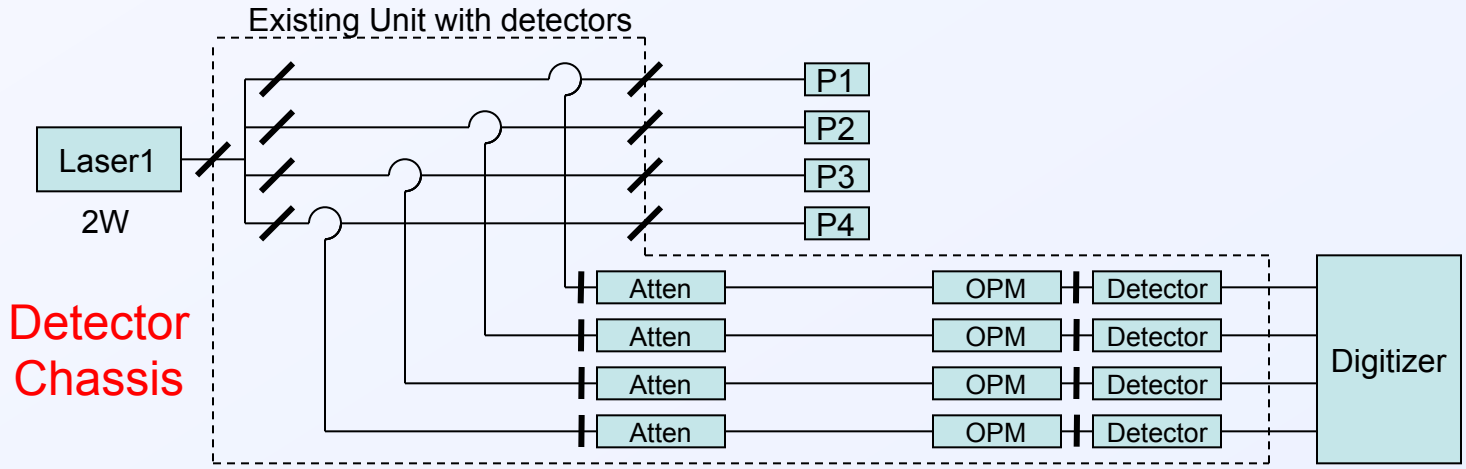
The max frequency of the spectrogram is determined by the Nyquist limit.
Example: if the sample rate is 50 GS/s, the Nyquist limit is 25 GHz.
We need laser wavelengths separated by more than 25/125 = 0.2 nm.

In a schematic sense, this is what duplexing looks like

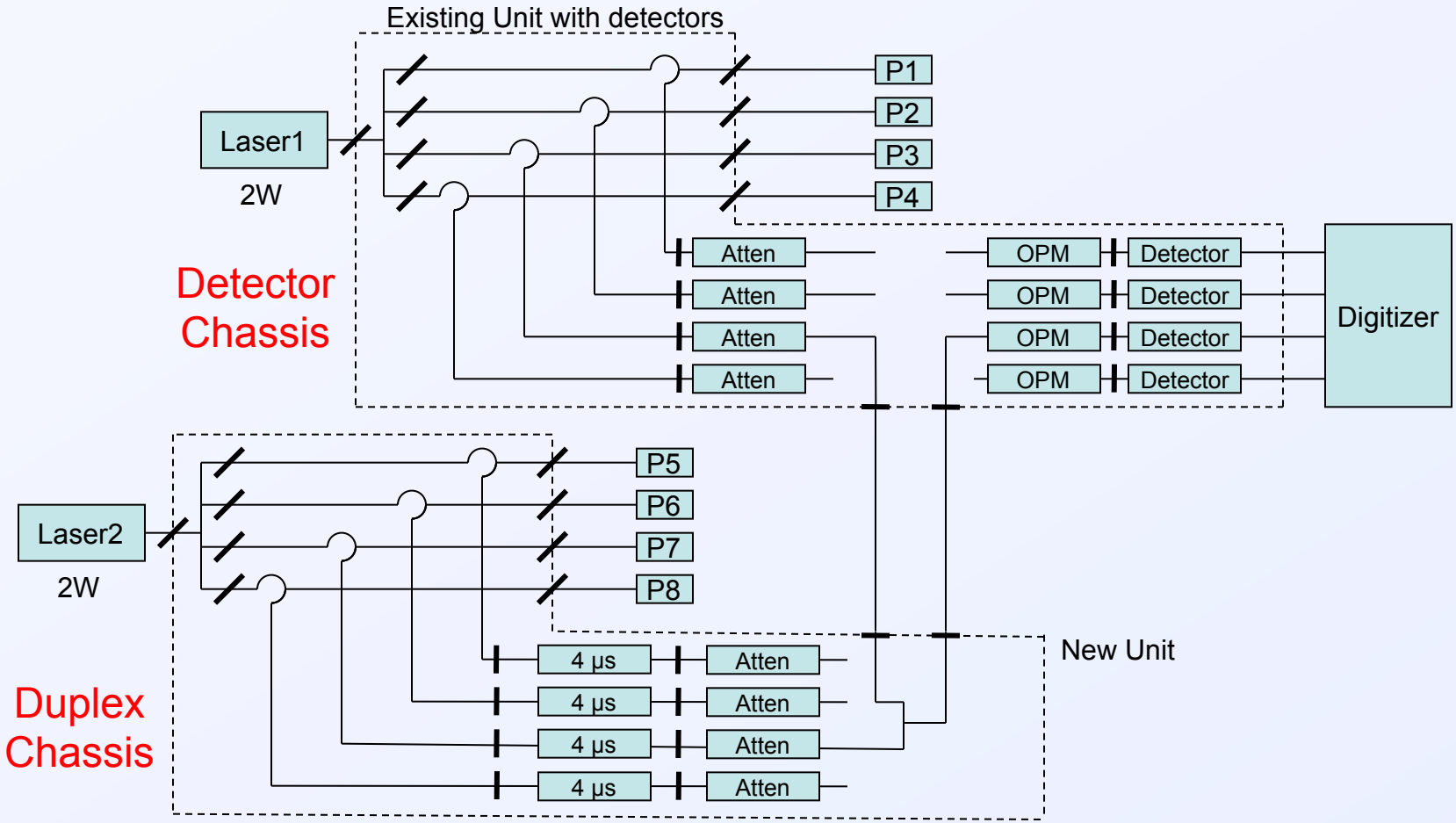


We added a 4-μs delay in one of the legs to separate the signals.

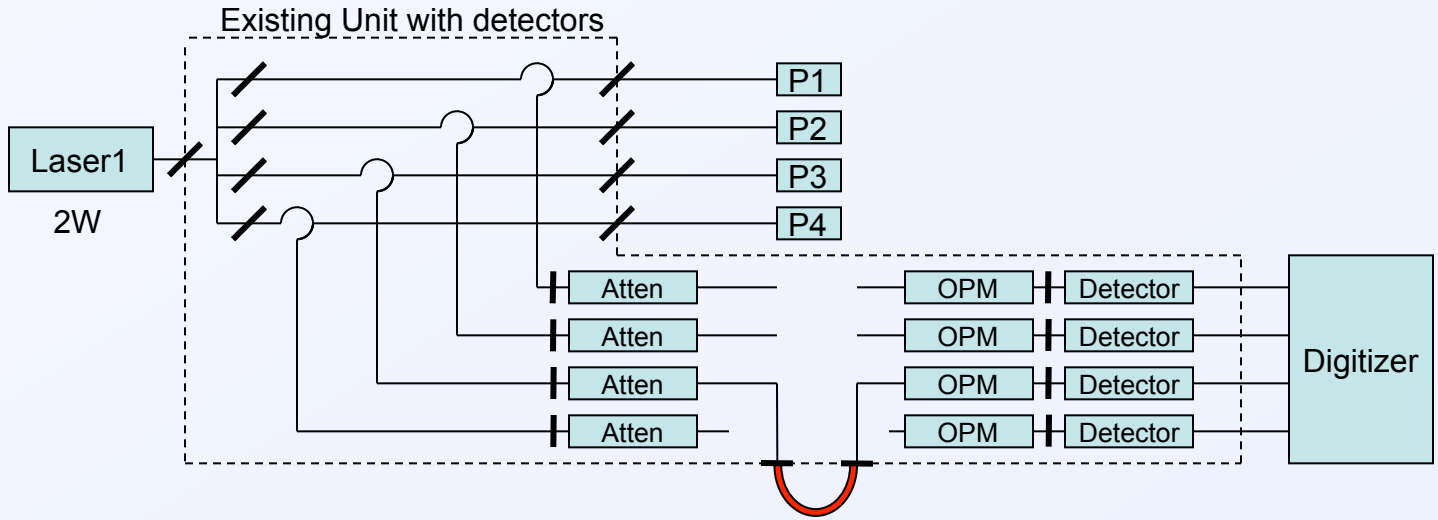
Our PDV systems look like this:



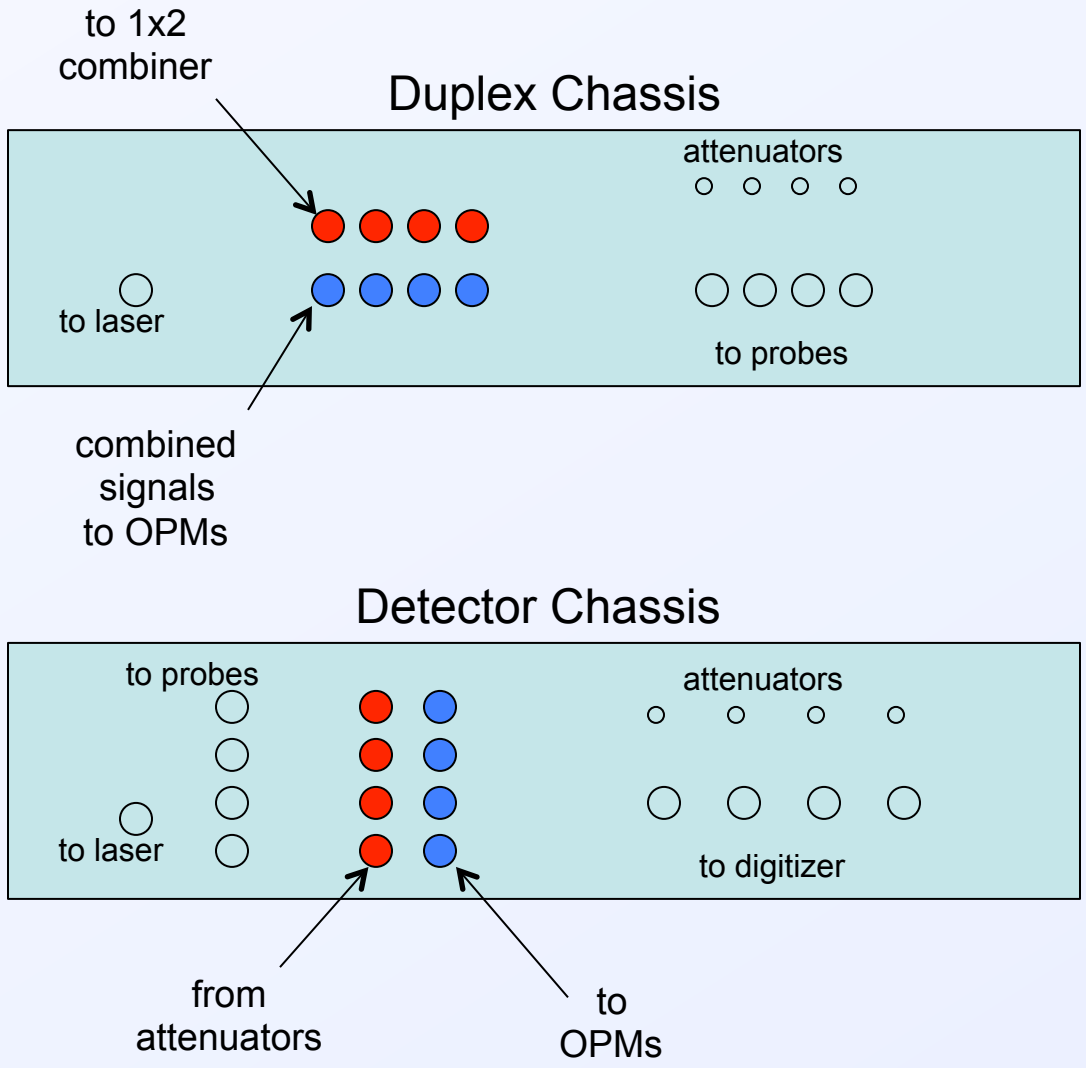
In reality, this is what our duplexing looks like



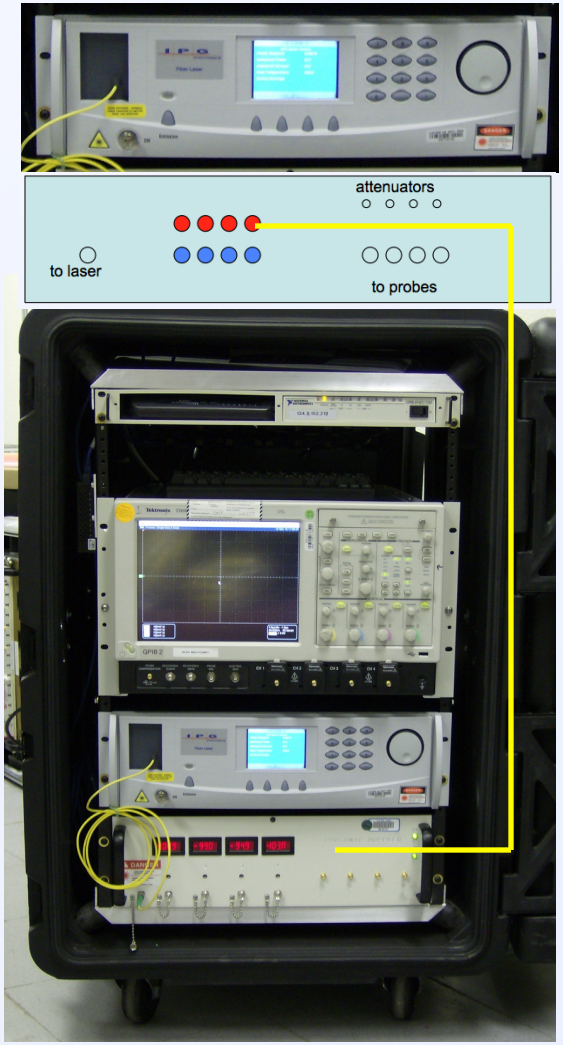
When we don't duplex, we use short fiber jumpers for normal operation



We need optical jumpers between the detector chassis and the duplex chassis



We simply stack the duplex chassis and 2nd laser on top of the roll-around rack



We developed a shot sheet to help with bookkeeping

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PDV Duplex Shot Sheet

System #_____

Shot # _____ Date: _____
Location: _____ Acc't # _____

Detector Chassis # _____
Duplex Chassis # _____

PDV personnel

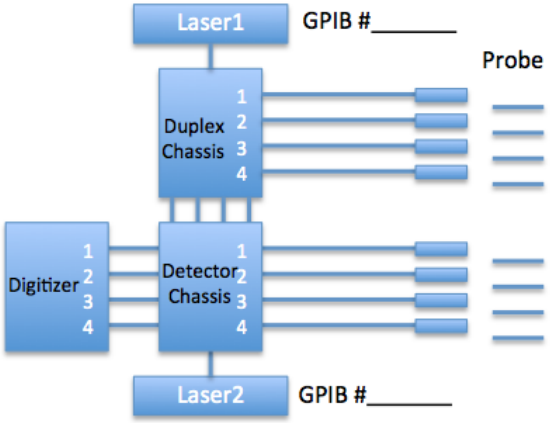
	Serial #	Wavelength
Laser1		
Laser2		

Digitizer Time/div _____
Sample rate _____ # pts _____
mV/div: ch1_____ ch2_____ ch3_____ ch4_____
Trigger source _____ Trigger level _____

Shot fired = _____ µs
Trigger from bunker = _____ µs
Fid from bunker = _____ µs

For MatLab analysis:
Record start = _____ µs
Time per point = _____ ps

Digitizer Channel	Data File Name
1	
2	
3	
4	



Set laser powers							
Laser1 on/Laser2 off			Laser2 on/Laser1 off			Both Lasers On	
Probe	200mW		Probe	200mW		Channel	P(dBm)
						1	
						2	
						3	
						4	

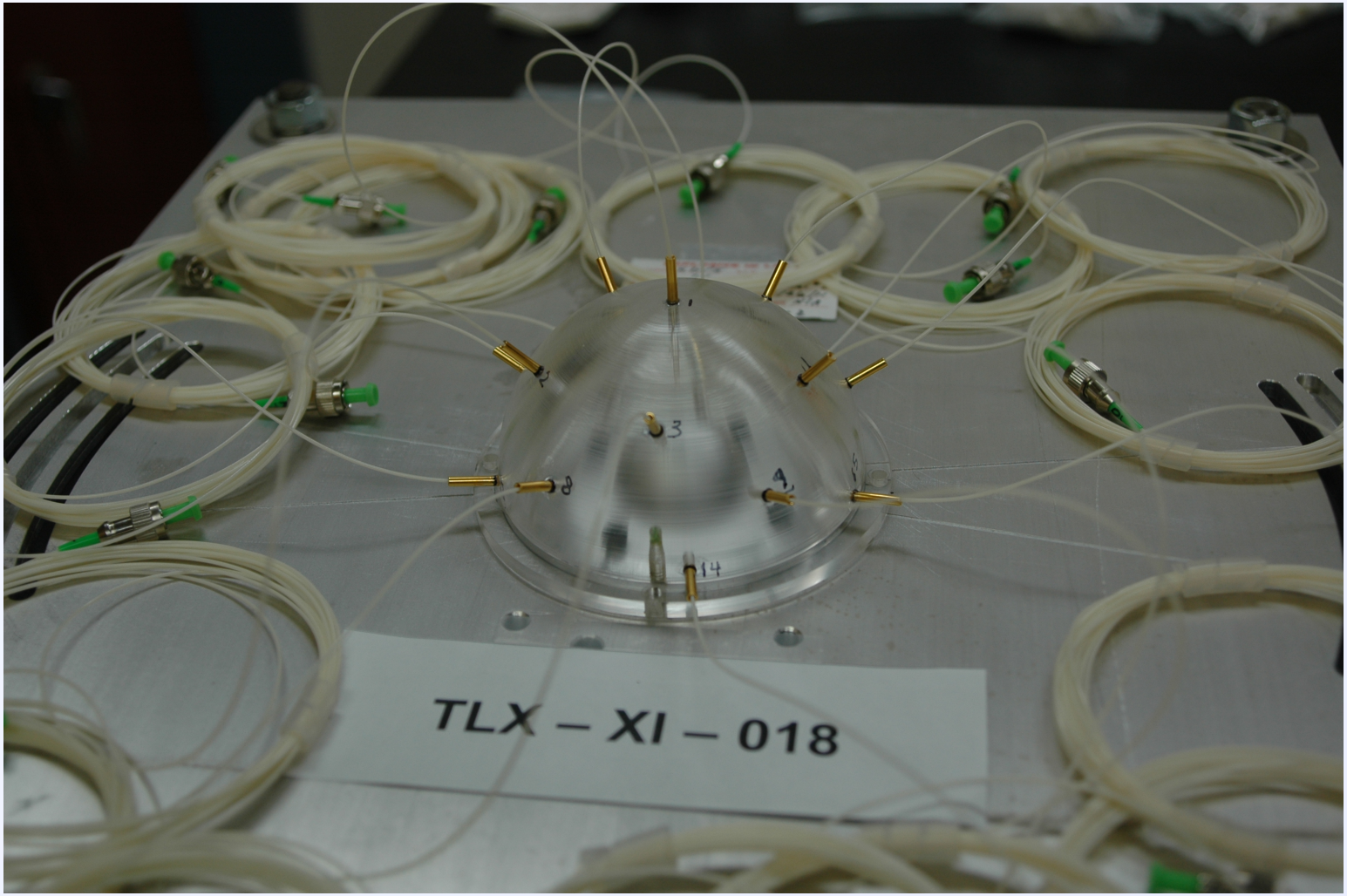
Probe Install Measurements (dB)			
Shot Table			Laser Room
Probe	Ref	Ref + Surf	Ref + Surf

Notes and sketches:

We were asked to field a shot with 16 probes

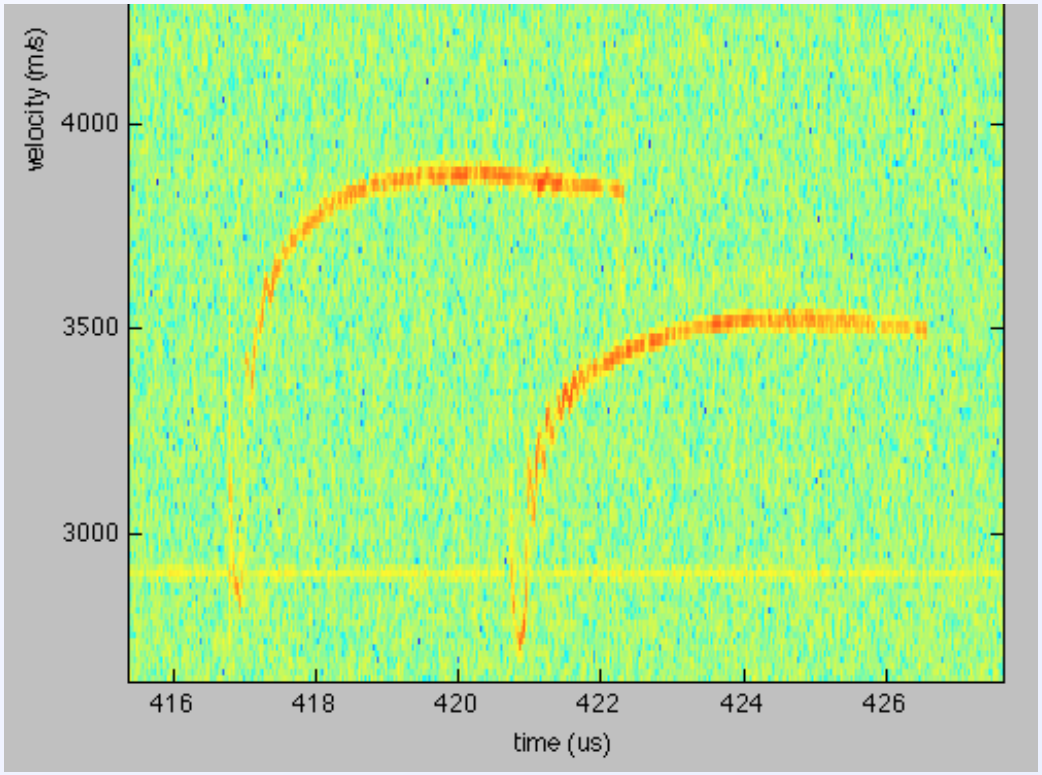
Many thanks to Thomas Lorenz and Ron Chambers
for allowing us to show their set-up and data.

Close up of the assembly with the probes and fibers



Examples of the resulting spectrograms

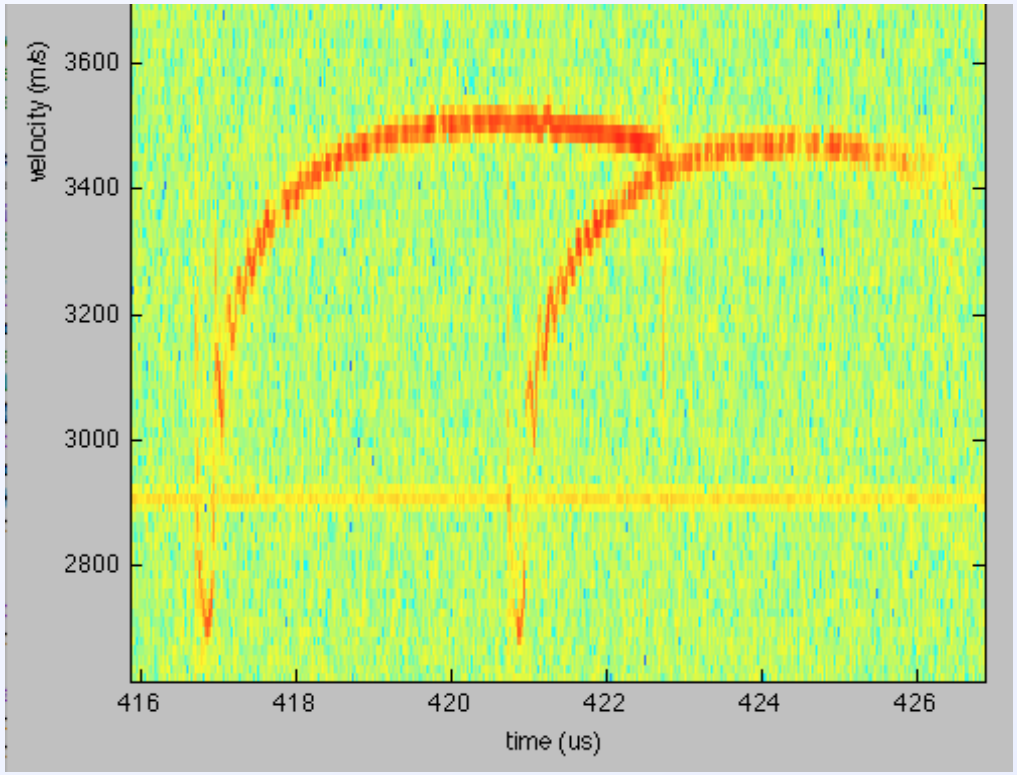
25 ns FT windows



This looks good.

Examples of the resulting spectrograms

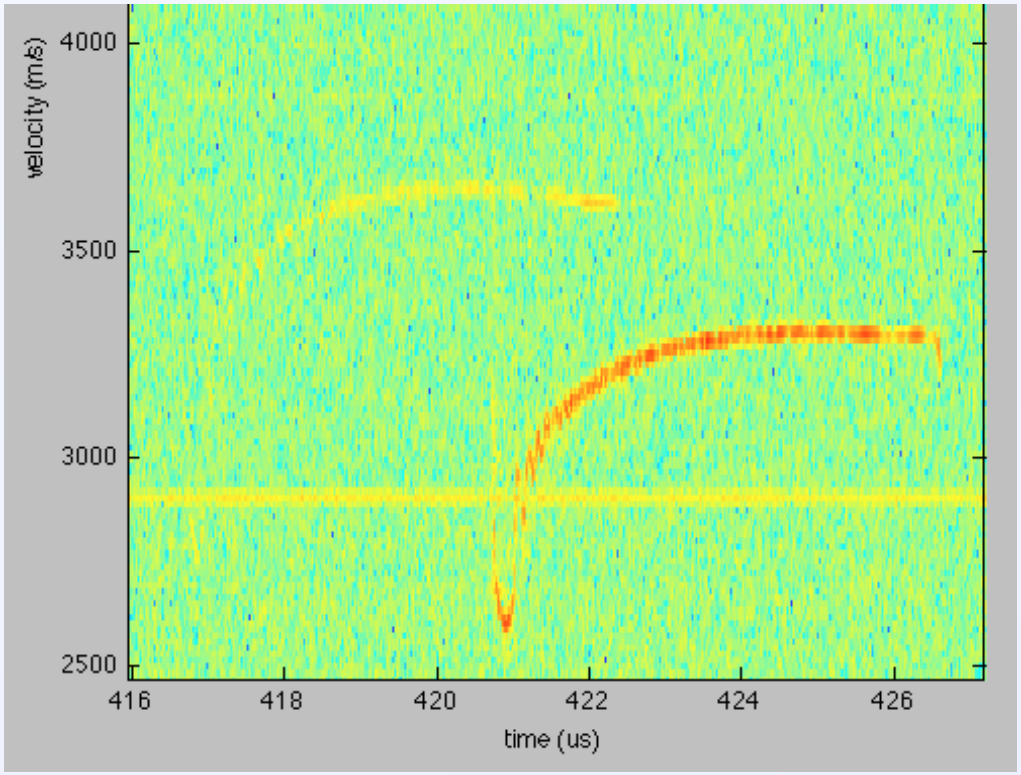
25 ns FT windows



Oops, a little overlap here.

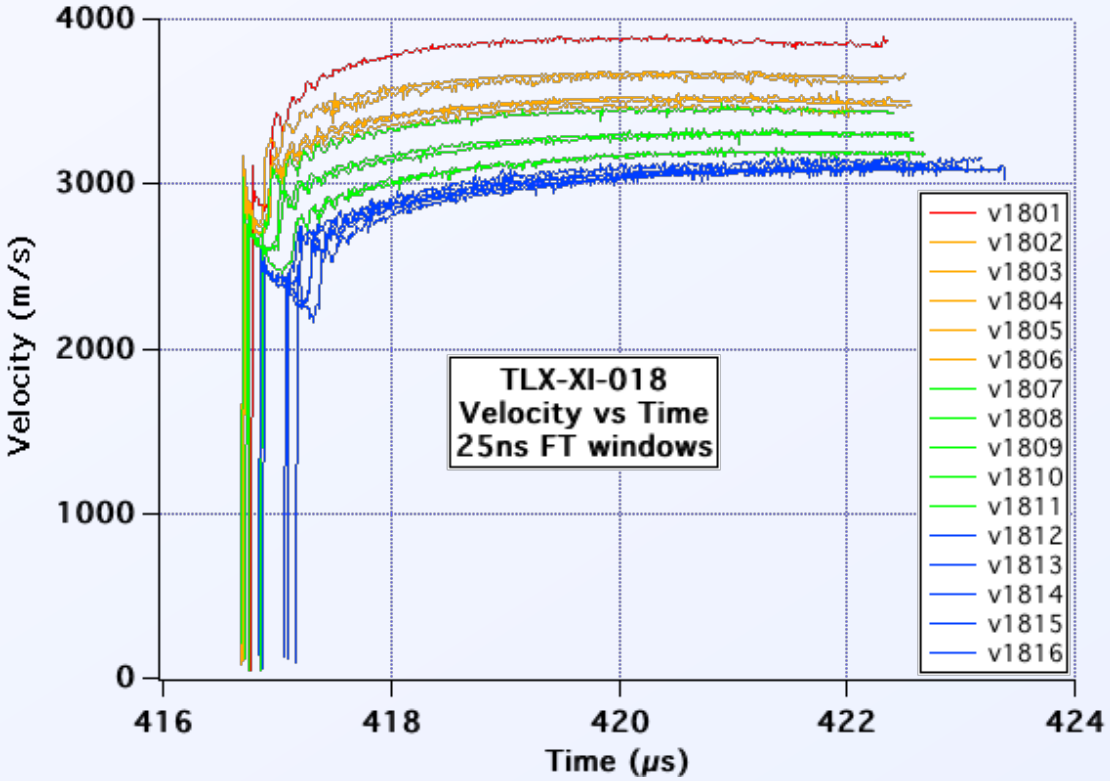
Examples of the resulting spectrograms

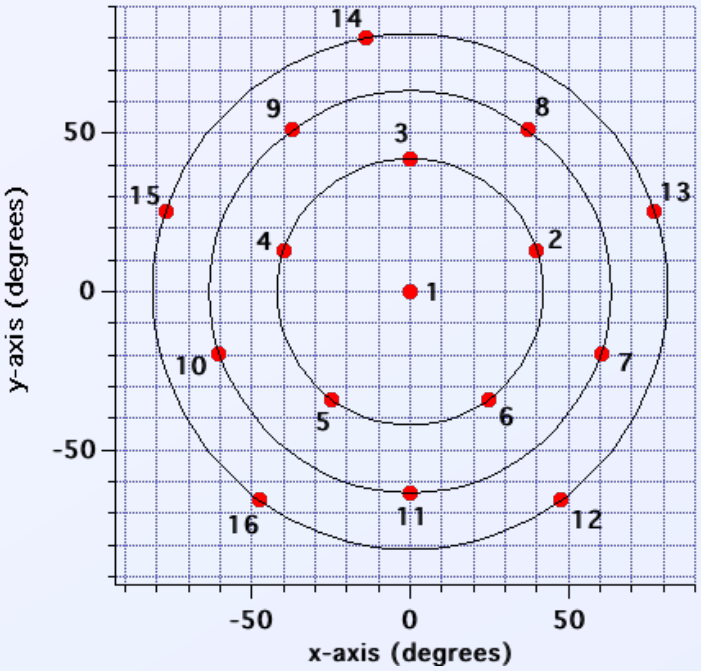
25 ns FT windows



We were able to pull out the 1st trace with longer FFT windows

We obtained data from all 16 probes





We have successfully built and tested our duplex chassis

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Our design minimizes the perturbation to our detector chassis.

The duplex chassis is all-optical and passive.

We built 8 duplex boxes in preparation for a 64-probe test.

We tested our duplex chassis on several tests with increasingly improved results.

Bookkeeping is very important!

Must determine that the two sets of data will not over-write each other.