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WORK IN PROGRESS

A Multiplexed Many-Point PDV (MPDV)

Techniques and Technologies

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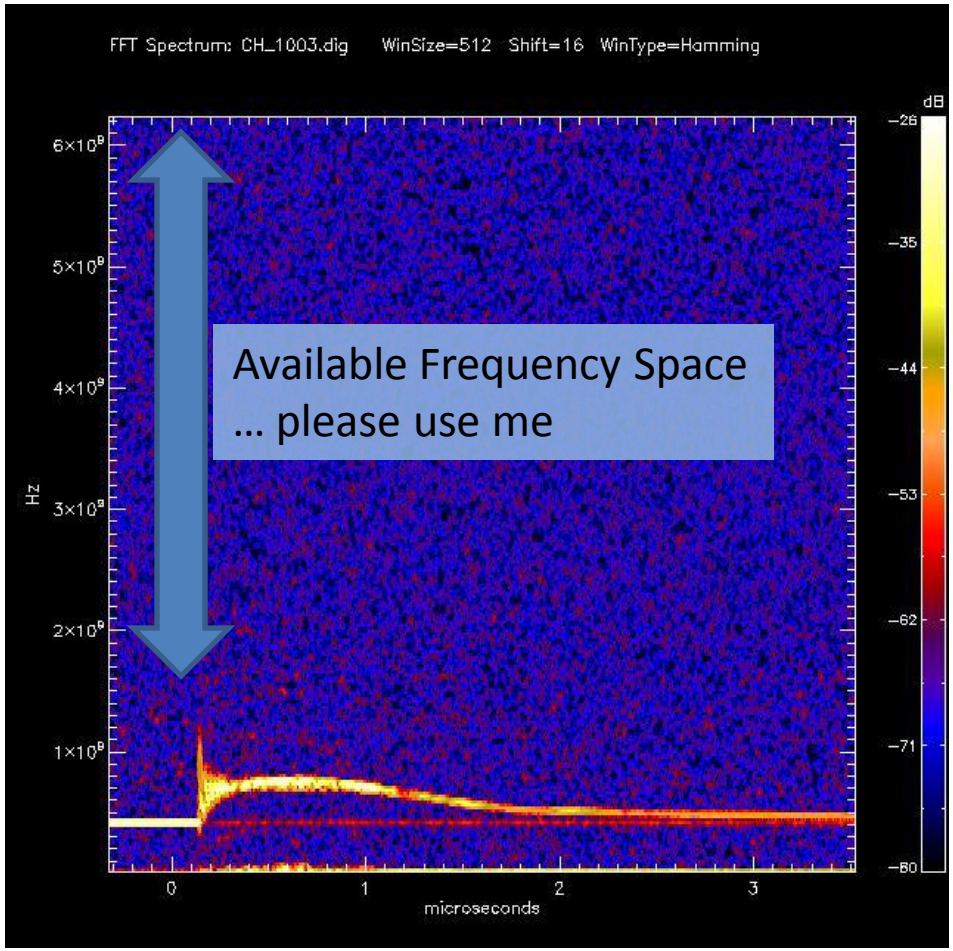
Site Directed R&D SDRD

Motivation: Digitizer Cost & Availability of Digitizer Bandwidth and Memory



<u>Digitizer Bandwidth</u>

Typical data uses a few gigahertz; digitizer bandwidth & sampling allow ~ 10 to 20 GHz

➔ Frequency Multiplexing

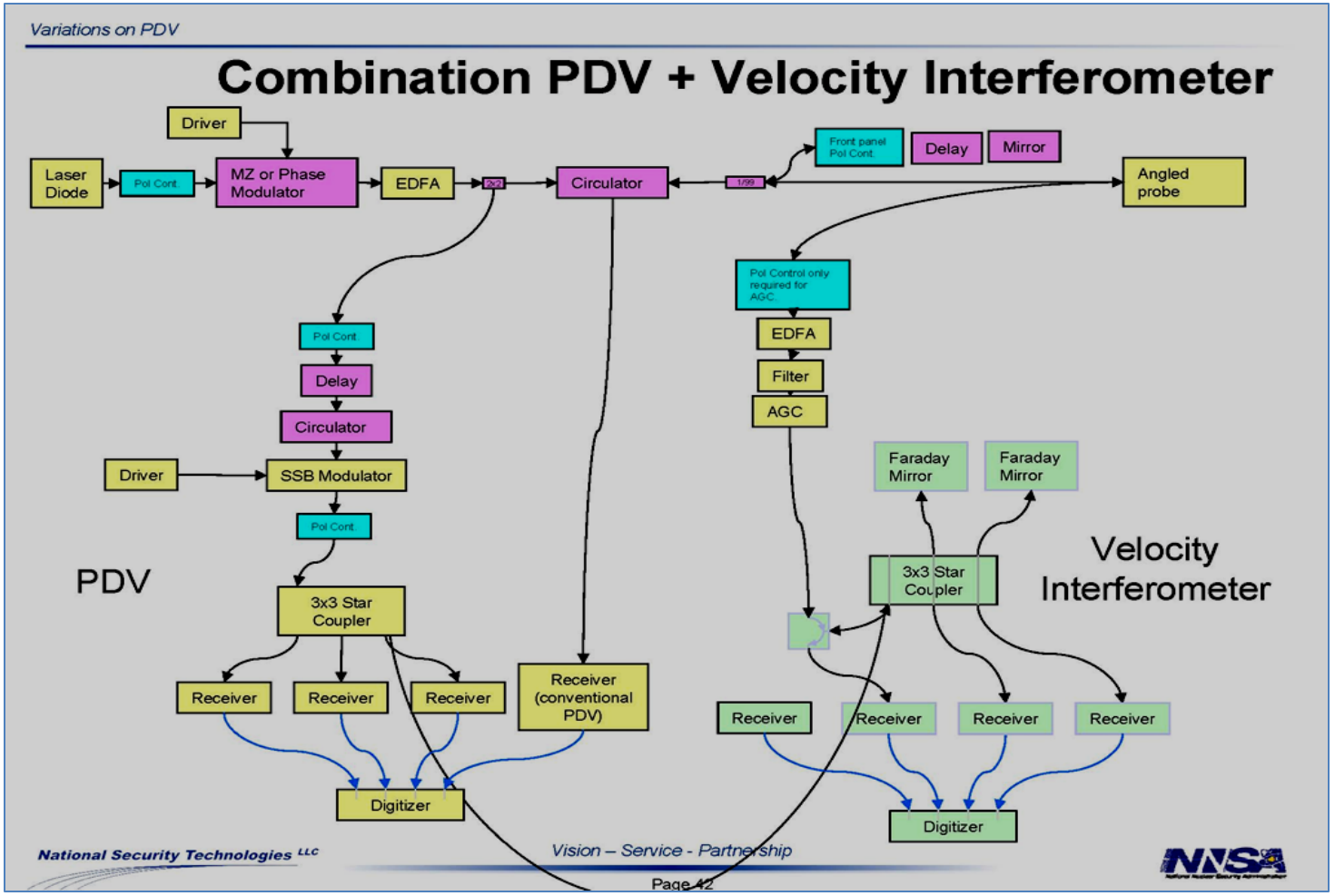
<u>Digitizer Memory</u>

Typical data lasts a few microseconds; digitizer memory allows record lengths ~ millisecond

➔ Time Multiplexing

Inspiration: Bruce Marshall

How to Complicate an Elegantly Simple Measurement without Really Trying … PDV Workshop 2006

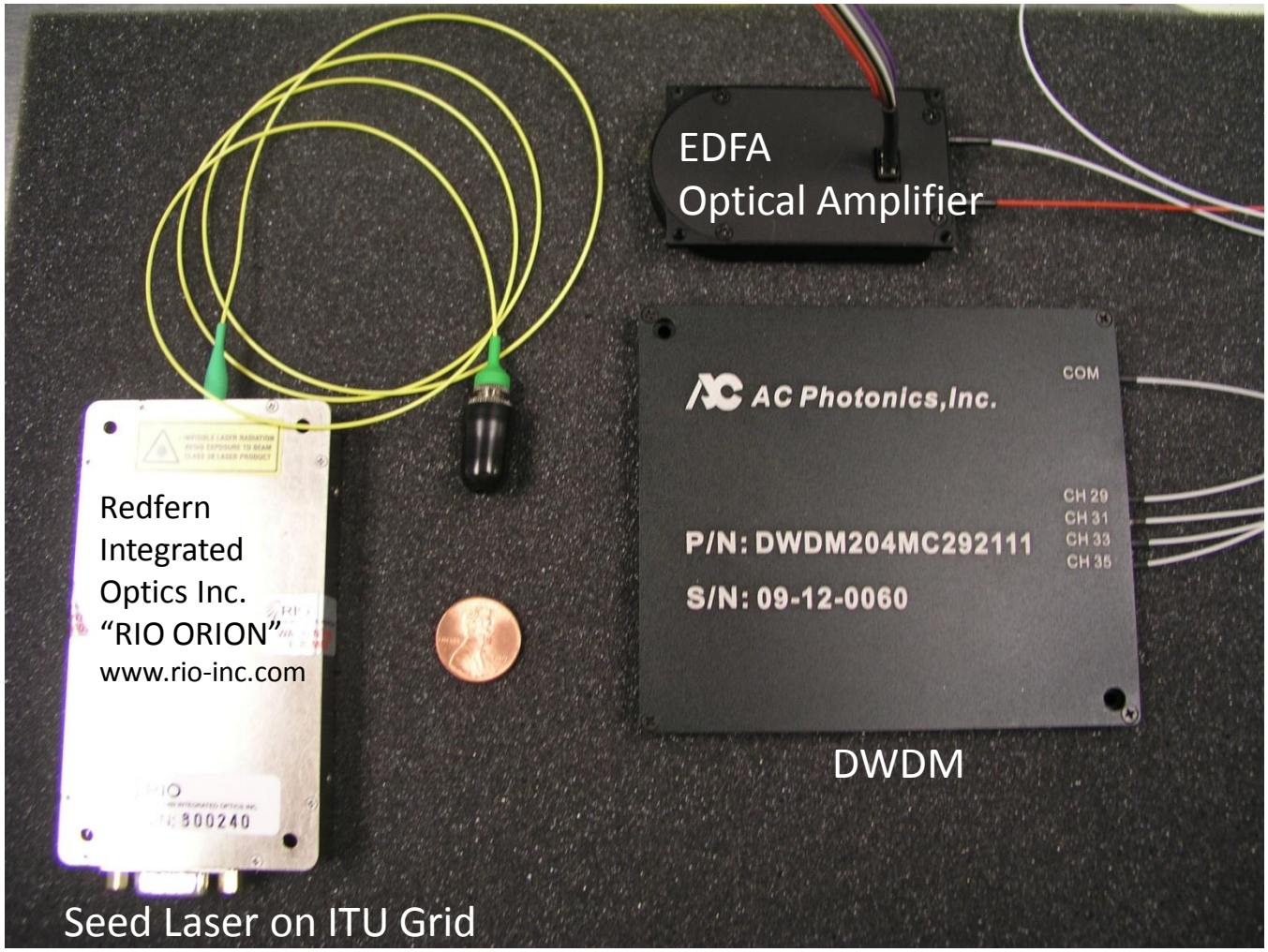


Some Topics of Interest

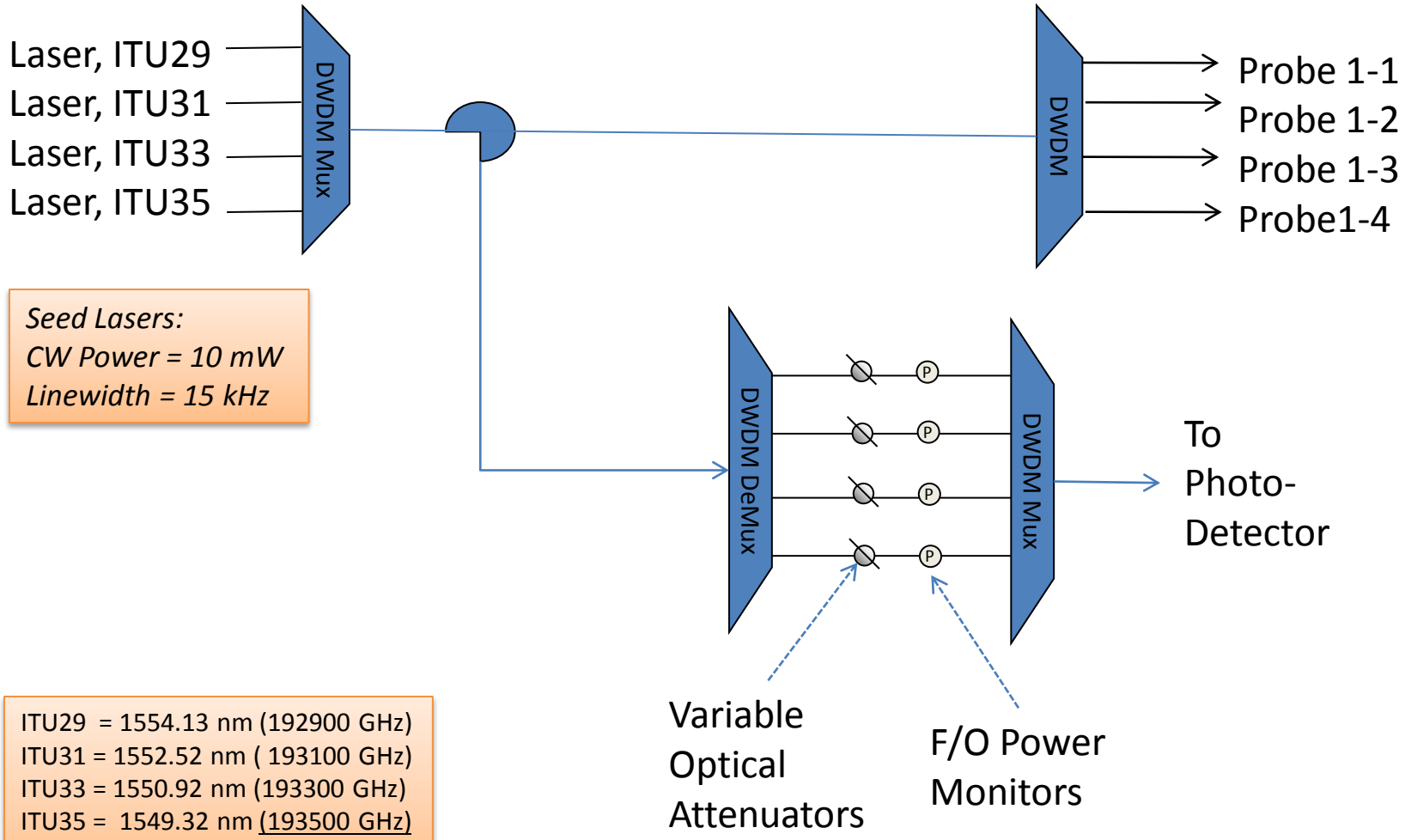
- Wavelength division multiplexing
  - Lasers available on the ITU Grid?
  - Laser frequency 'spacing'?
  - Application of Dense Wavelength Division Multiplexers (DWDMs)?
- Time division multiplexing
  - Coherence length and degree of polarization effects?
- Optical heterodyne approach: optical up-shift OR down-shift
  - Laser wavelength tunable?
  - Laser stable in frequency to ~ 10 MHz for hours?
  - Flexibility to up-shift for increased precision OR down-shift for increased 'effective' bandwidth (e.g. high velocities)?
- A Laser Safe System
  - Optical pre-amplification on the 'back end' vs conventional high power amplification on the 'front end'?
  - Pre-amp gain saturation & dynamic hole burning affects?

Evaluation of Photonic Technologies and Techniques

How can we leverage commercially available Telecom hardware?



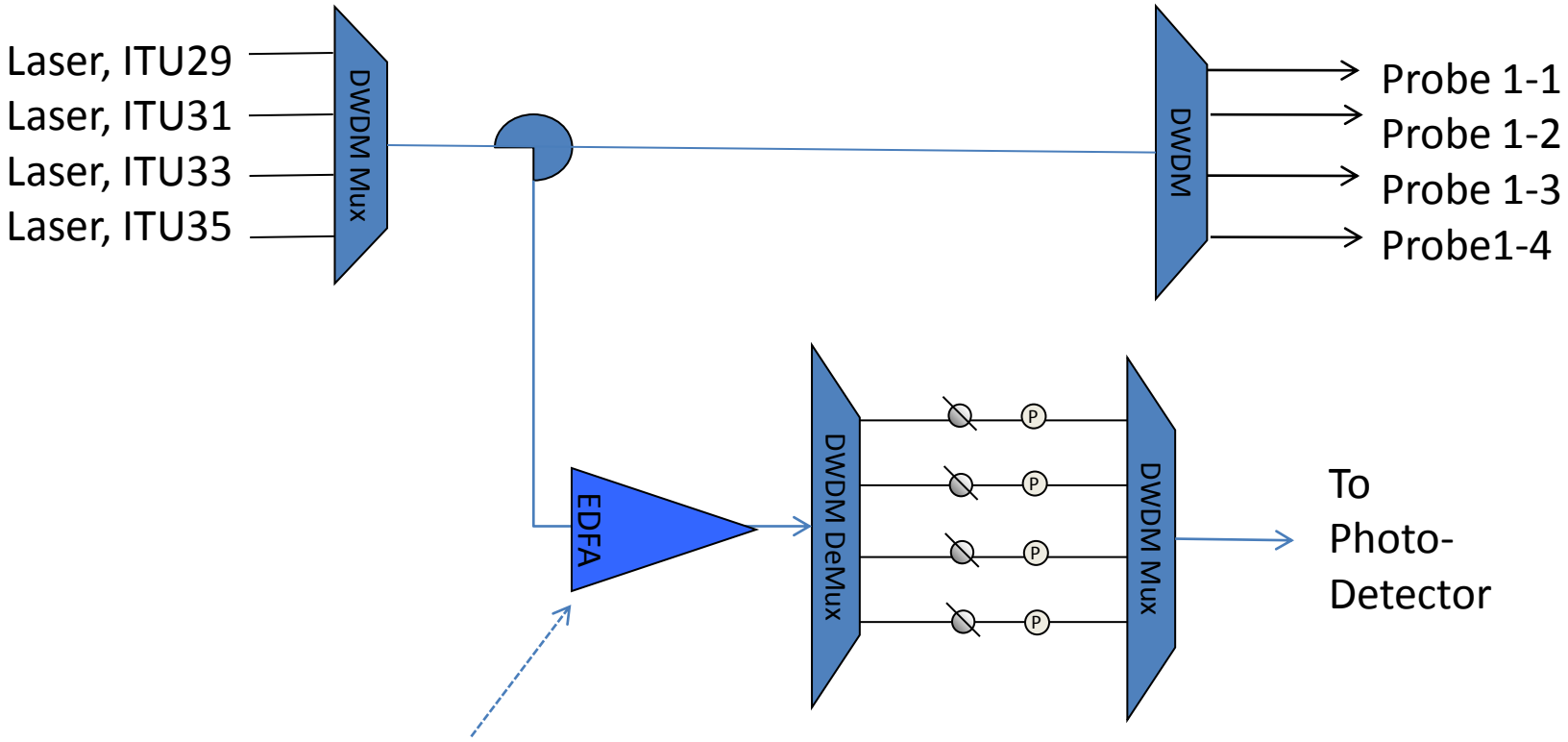
Wavelength Division Multiplexing – Notional



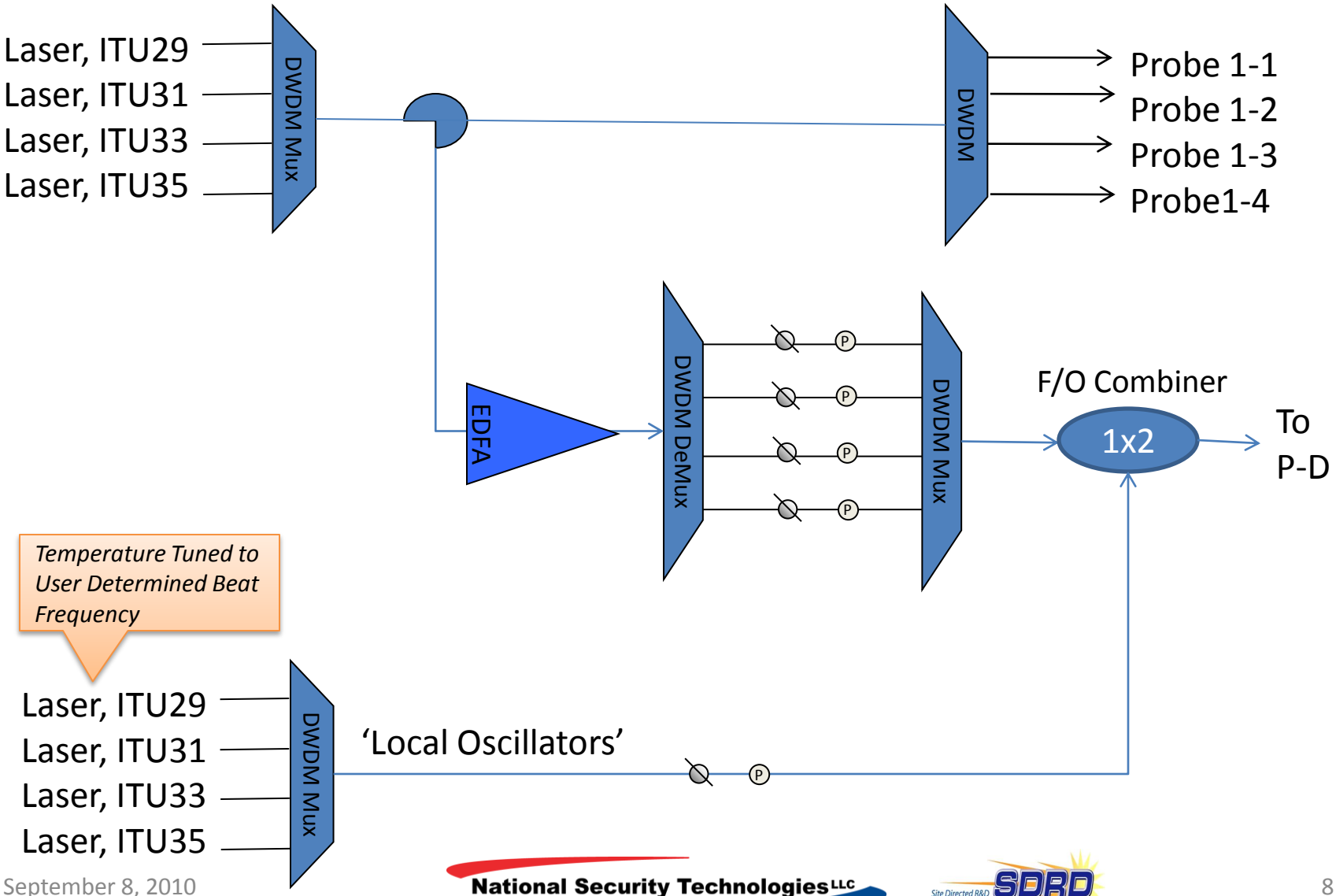
Seed Lasers:
CW Power = 10 mW
Linewidth = 15 kHz

ITU29 = 1554.13 nm (192900 GHz)
ITU31 = 1552.52 nm (193100 GHz)
ITU33 = 1550.92 nm (193300 GHz)
ITU35 = 1549.32 nm (193500 GHz)
Δ = 200 GHz

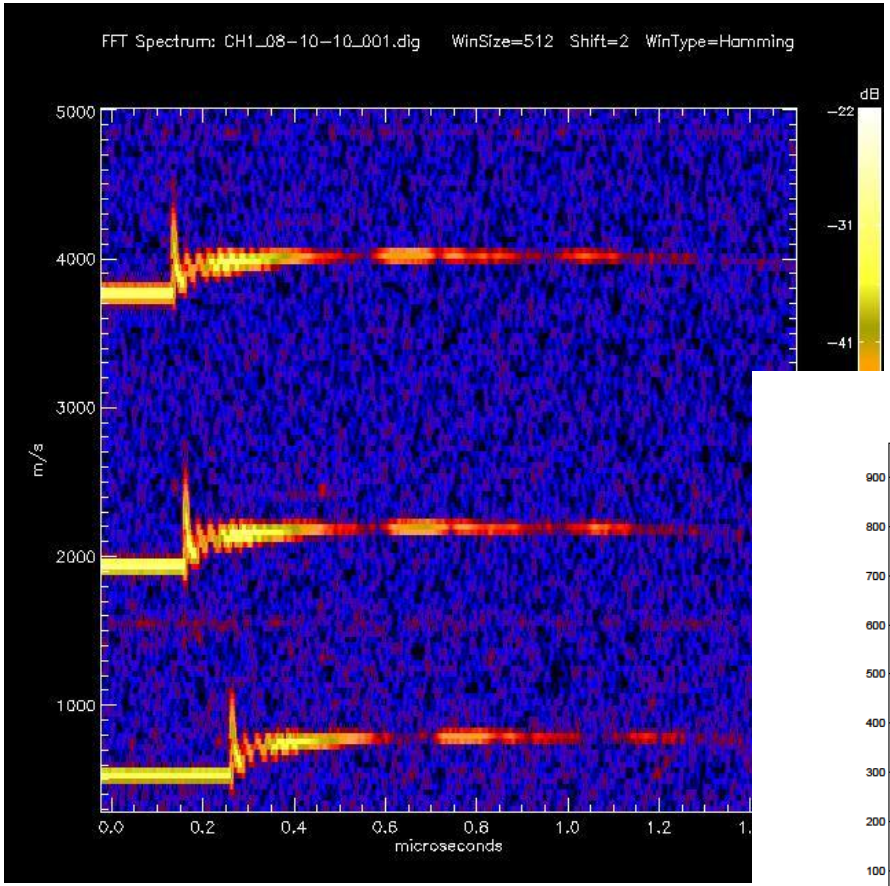
Wavelength Division Multiplexing with Optical Pre-Amplification – Notional

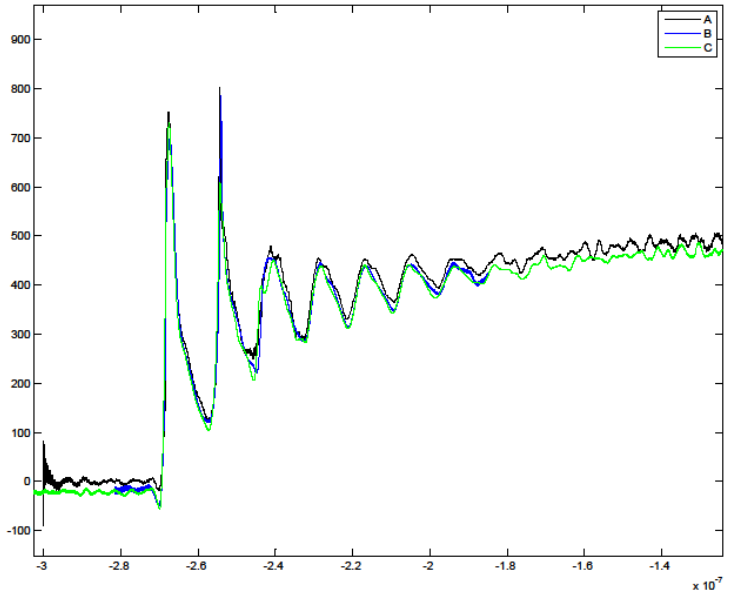


Multiplexing, Pre-Amp & Optical Heterodyne



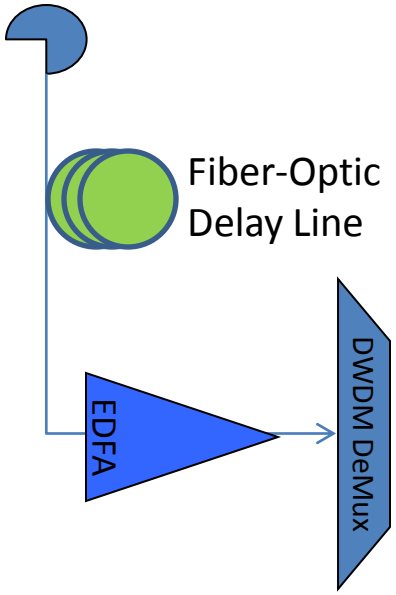
Wavelength Division Multiplexing & Optical Heterodyne Up-Shifting … Lab Data

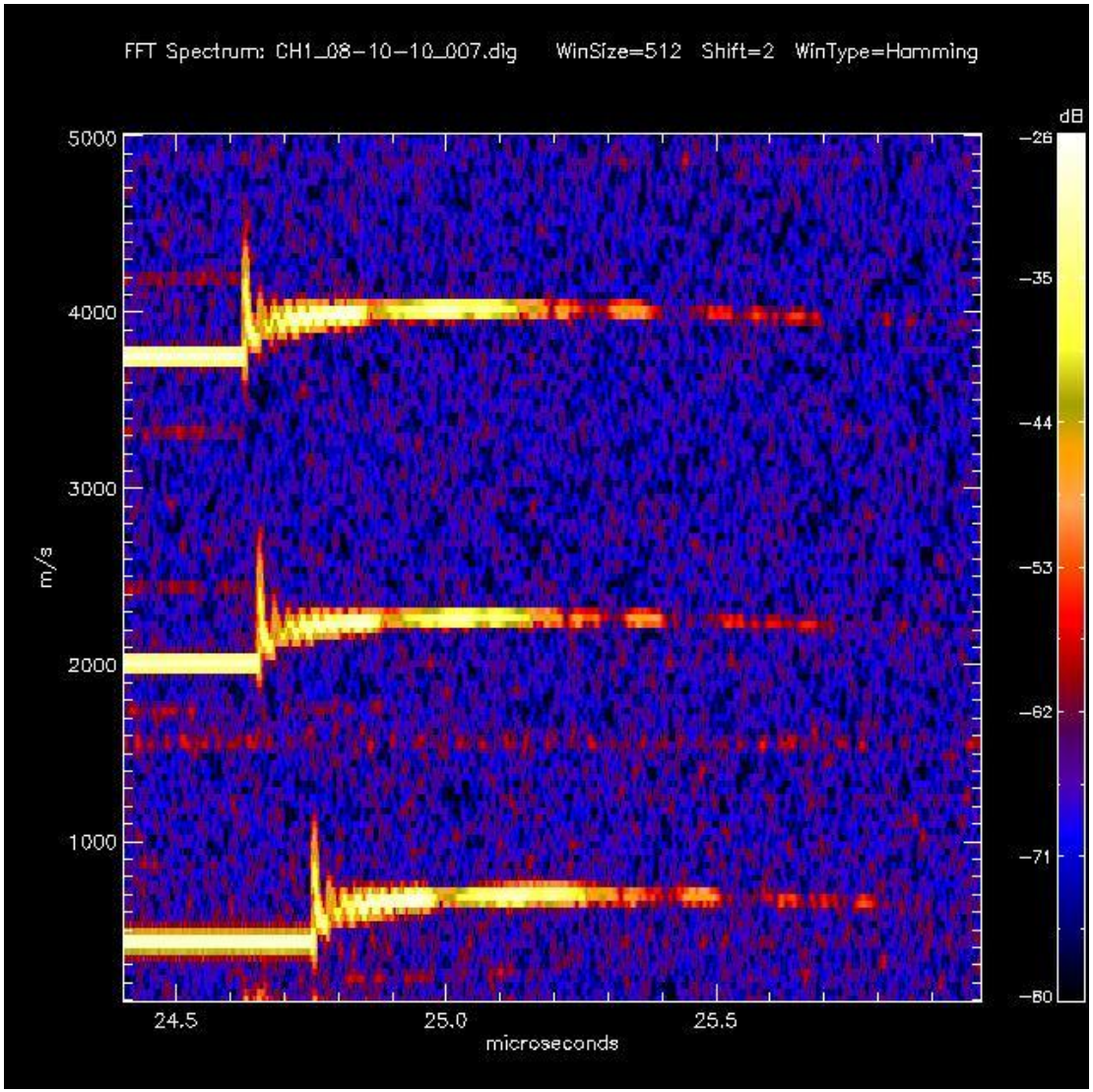




Laser Driven 'Slapper Foil'
Triplexed Lab Data

… and Time Division Multiplexing (~ 25 μs)





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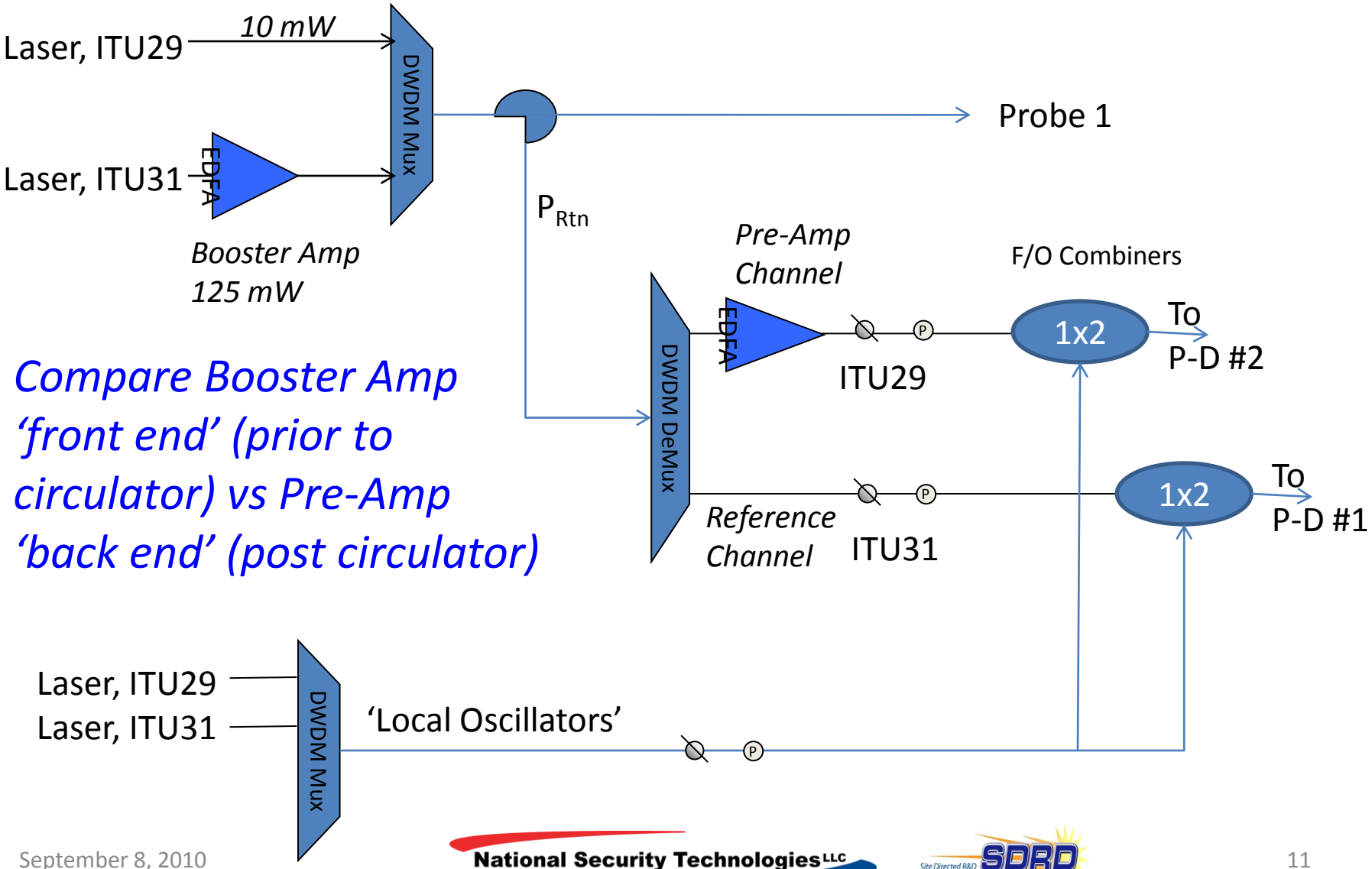
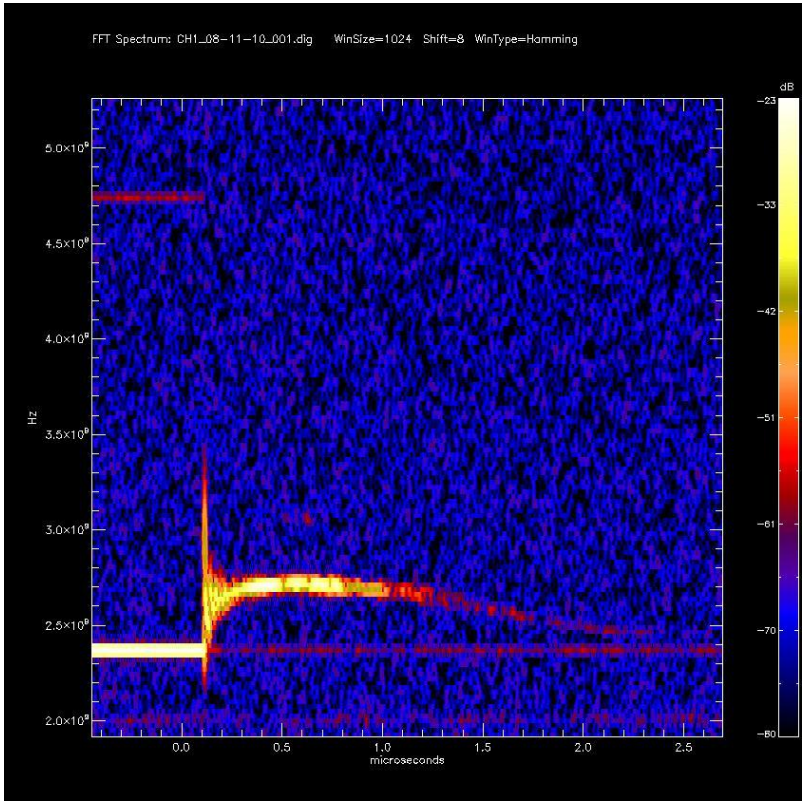
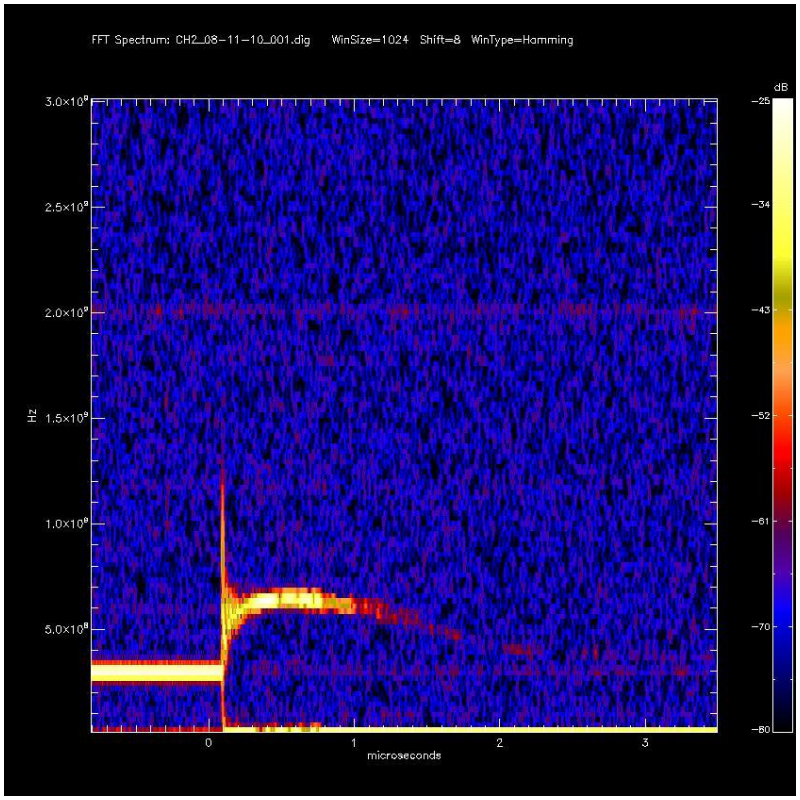
Laser Safe PDV: EDFA Pre-Amplification Benchmark Measurements



Compare Booster Amp 'front end' (prior to circulator) vs Pre-Amp 'back end' (post circulator)

Benchmark Lab Data



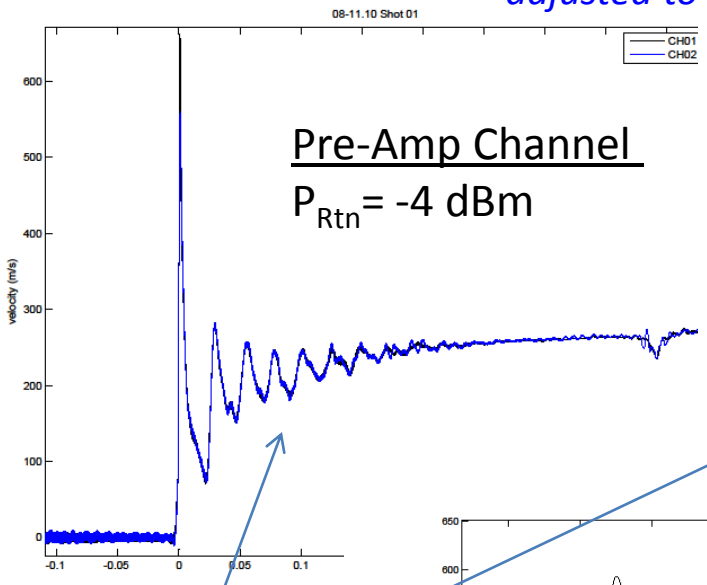


'Conventional' PDV, *No* pre-amp : launch power = 125 mW, probe efficiency =14 dB, recorded onto digitizer channel 1

Laser Safe PDV, *With* EDFA pre-amp : launch power = 10 mW, probe efficiency range 14 dB to 60 dB, recorded onto digitizer channel 2

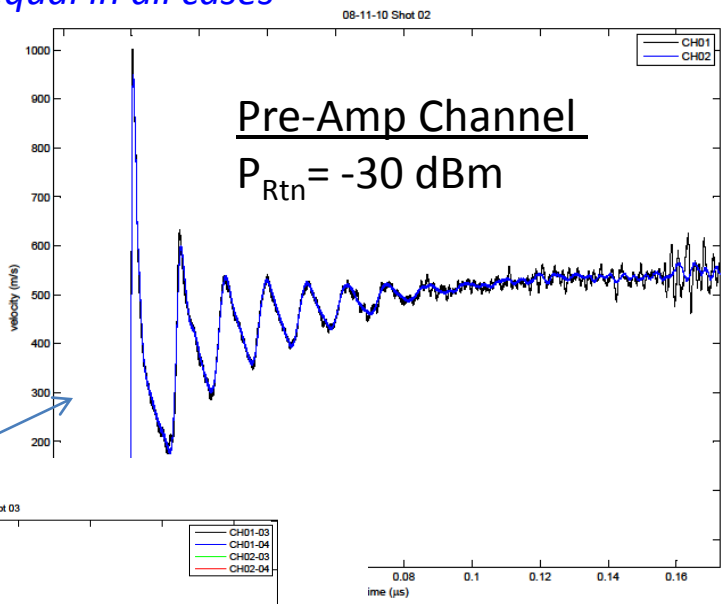
Laser Safe PDV: Benchmark Data

Optical power at photo-diode for Pre-Amp Channel & Reference Channel adjusted to be equal in all cases



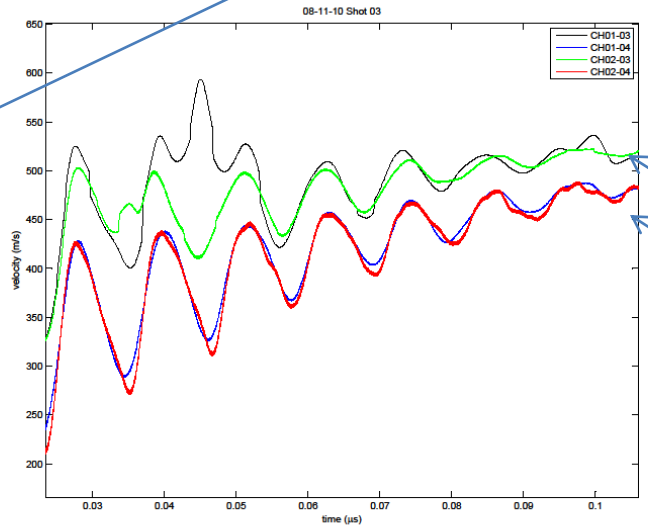
Pre-Amp Channel

P_{Rtn}= -4 dBm



Pre-Amp Channel

P_{Rtn}= -30 dBm



Reference Channel

P_{Rtn}= 7 dBm

(Attenuated to match pre-amp power)

Pre-Amp Channels

P_{Rtn} = -40 dBm

P_{Rtn} = -50 dBm

Concluding Remarks & Future Investigations

- Multiplexing techniques promise increased PDV channel count, improved fidelity and improved cost effectiveness.
- Heterodyning is advantageous – allows user verification of beat signal amplitude (data quality assurance), flexibility to determine beat frequency (up/down shift), improves precision (see D. Dolan).
- Laser safe PDV operations via EDFA pre-amp appear feasible for probe efficiencies greater than ~ 40dB.
- Future Investigations:
  - Complete assembly of a 4x MPDV demonstration system for further testing on high explosive experiments.
  - Investigate methods to 'manage' polarization dependence
  - Investigate methods to 'gain clamp' or 'gain compress' return signals to avoid data loss upon saturation.

Acknowledgements

- Howard Bender, Program manager for NSTec SDRD Program
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