

A Pot Load of Data

MPDV Development, Techniques and Technologies

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The Challenge

- **Capability.** Enable future stockpile stewardship experimental efforts which require large data channel counts (~100) by leveraging existing diagnostic techniques and commercial technologies to expand and enhance optical velocimetry capabilities.
- **Physics.** Determine whether frequency multiplexing and heterodyne techniques could expand upon Photon Doppler Velocimetry (PDV) measurements of surface velocity.
- **Economy.** Develop economical methods to record high fidelity optical velocimetry data via frequency and time division multiplexing coupled with commercially available telecom technologies and components.
- **Operations and Logistics.** Develop an 'experimenter friendly' diagnostic capability: portable, robust, and operable within a laser safe environment

The History: Fabry-Perot – Capable but Expensive



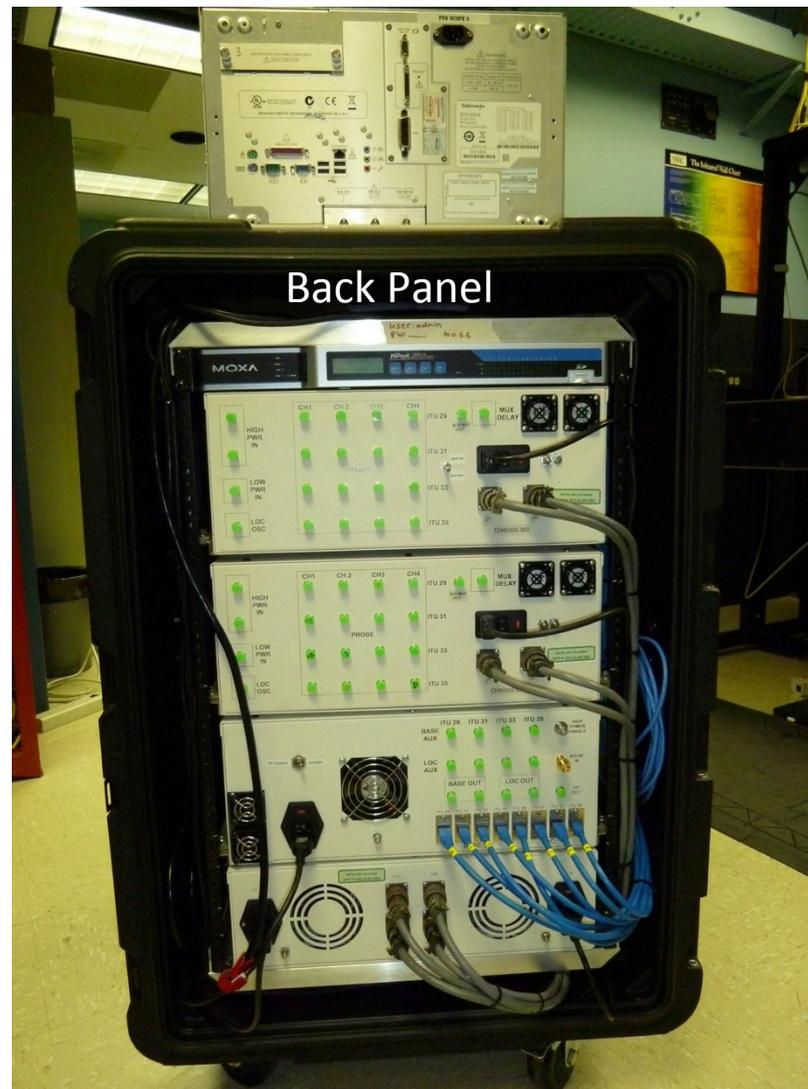
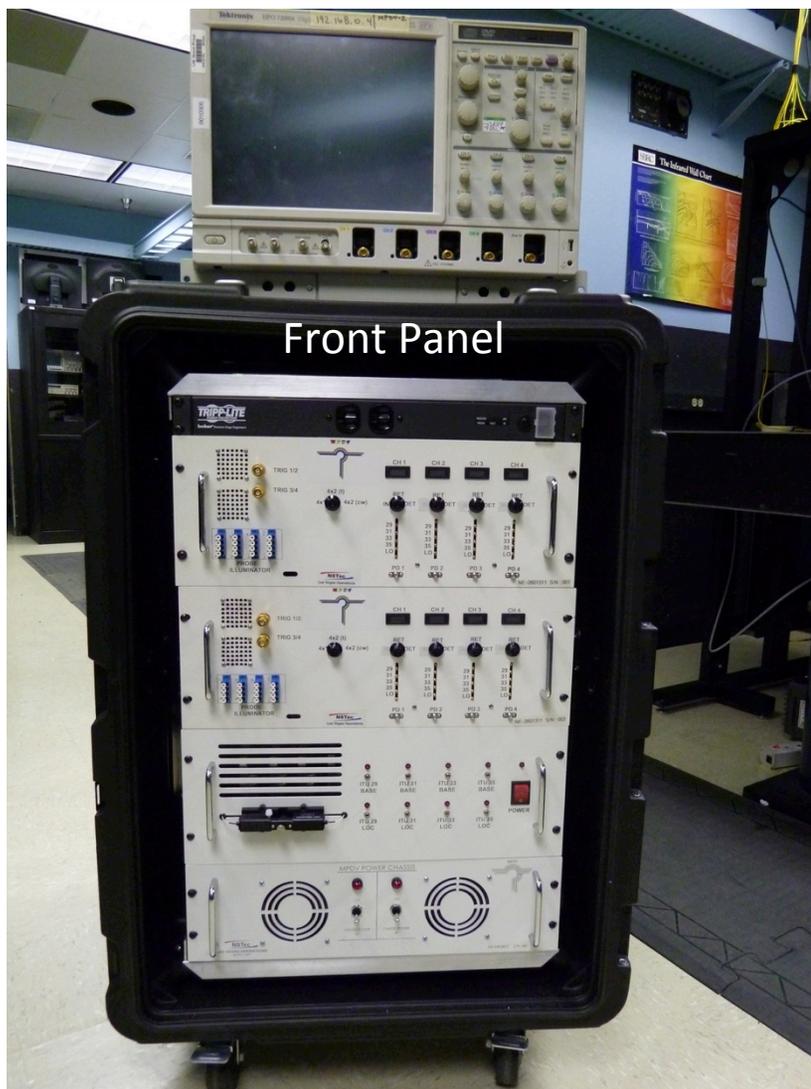
Fifteen Channels of Fabry-Perot Velocimetry at NTS/U1a (circa 2003)

The History: VISAR – Capable, Portable but Limitations



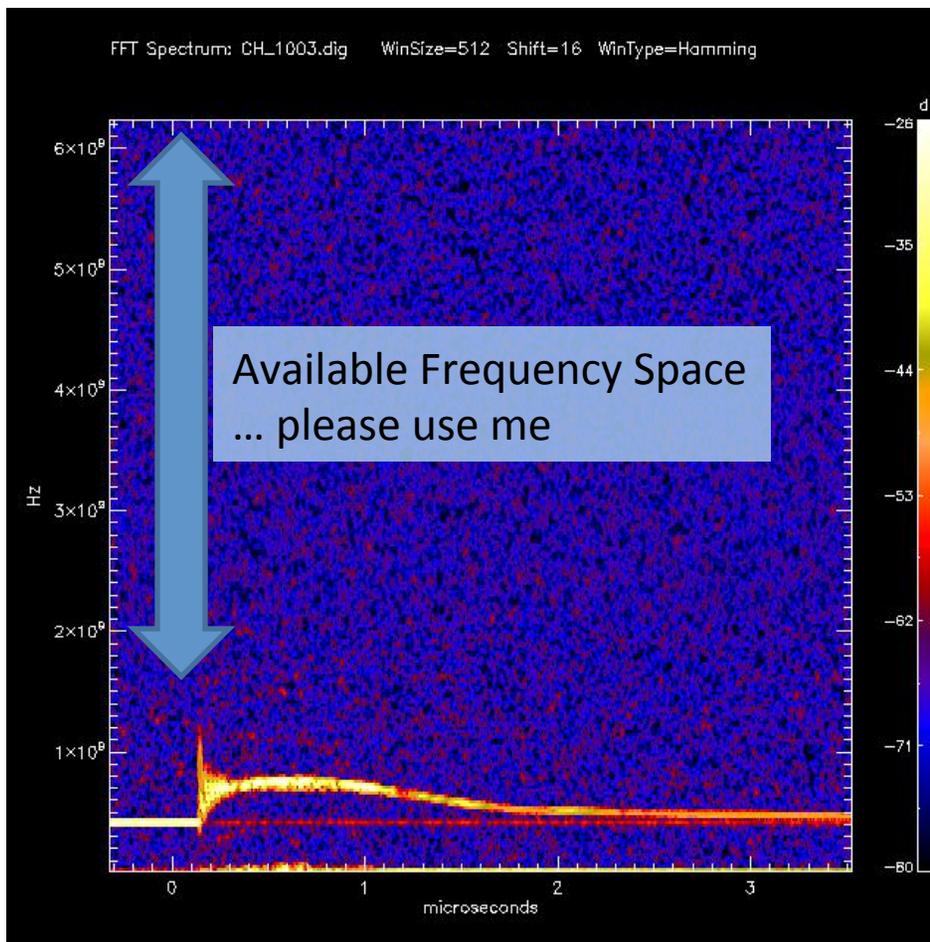
Nineteen channel VISAR system (circa 2007)

Recent History – MPDV



MPDV Prototype 32-Probe System (circa September, 2011)

The Motivation: Digitizer Cost & Availability of Digitizer Bandwidth and Memory



Digitizer Bandwidth

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

➔ Frequency Multiplexing

Digitizer Memory

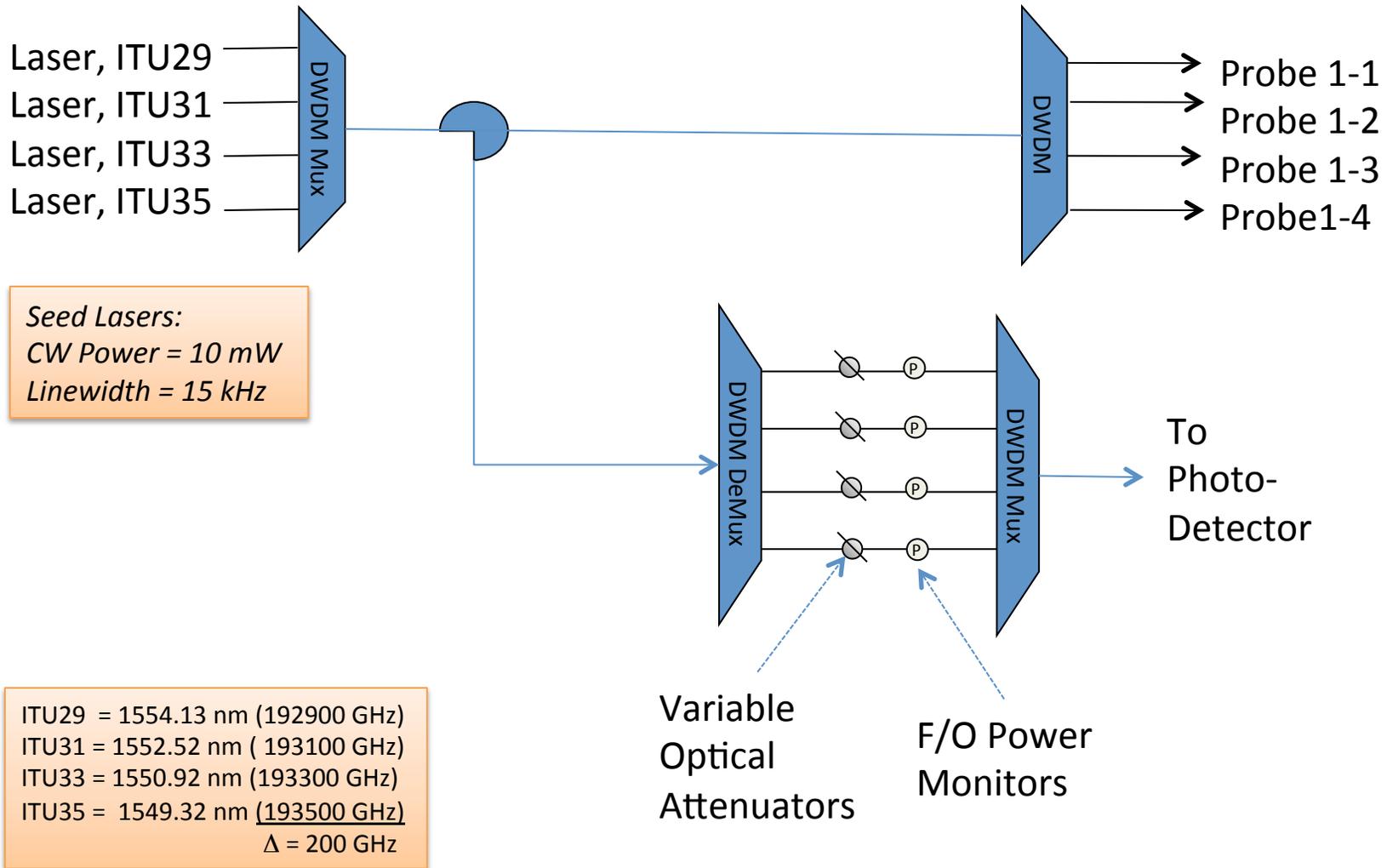
Typical data lasts a few microseconds; digitizer memory allows record lengths ~ millisecond

➔ Time Multiplexing

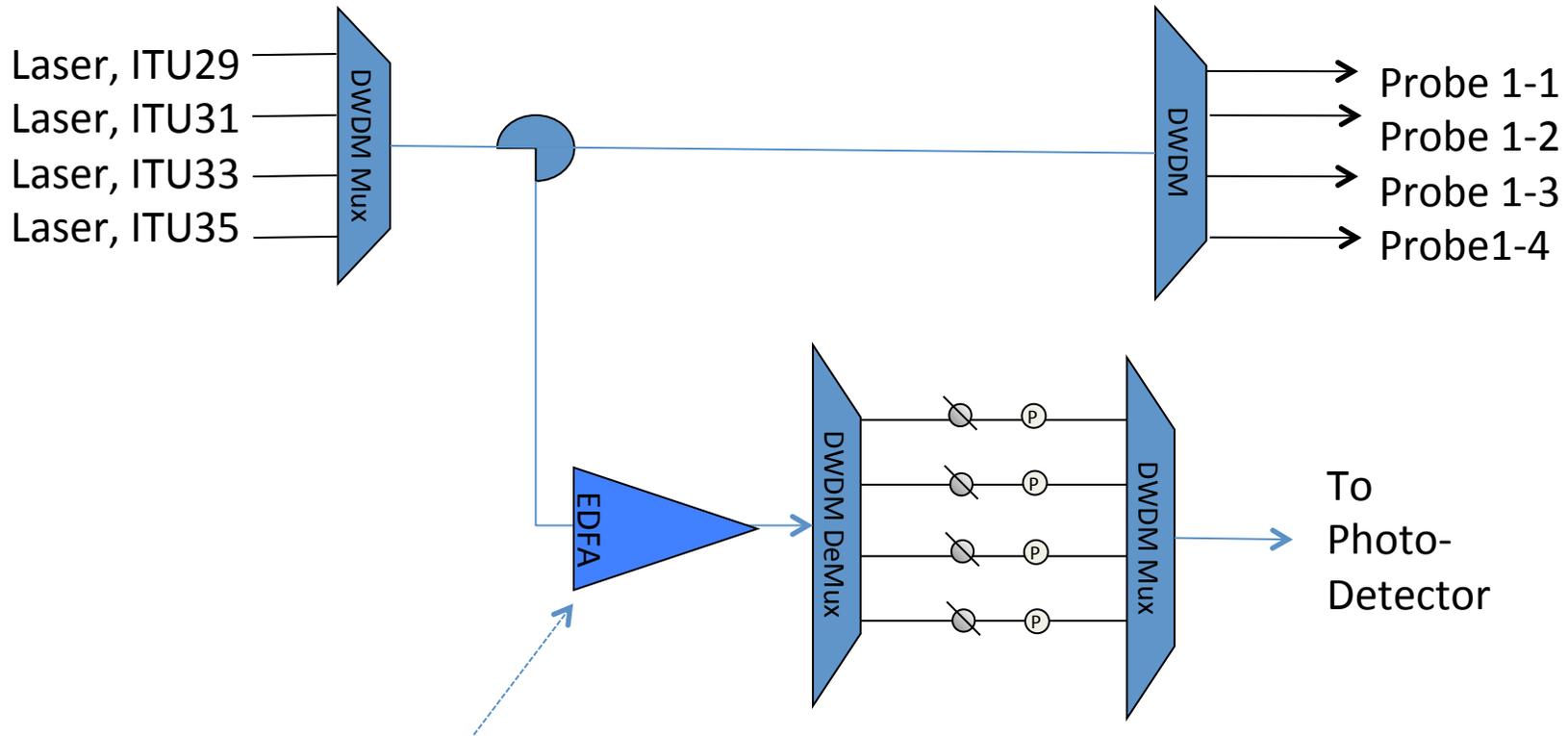
The Innovation

- **Frequency and time division multiplexing in optical velocimetry.** Developed diagnostic system architecture for a Multiplexed PDV (MPDV) which incorporates frequency and time division multiplexing into existing PDV methodology to provide increase channel count. Current MPDV design increases number of data records per digitizer channel 8x, and also operates as a laser safe (Class 3a) system.
- **Increased velocity range.** Applied heterodyne interferometry to allow for both direction-of-travel determination, and enable high velocity measurements (> 10 km/s) via optical downshifting.
- **Portable, economical and rugged.** Leveraged commercially available, inexpensive and robust components originally developed for telecom applications. Proposed MPDV architectures employ only commercially available, fiber coupled hardware.

Wavelength Division Multiplexing – Notional

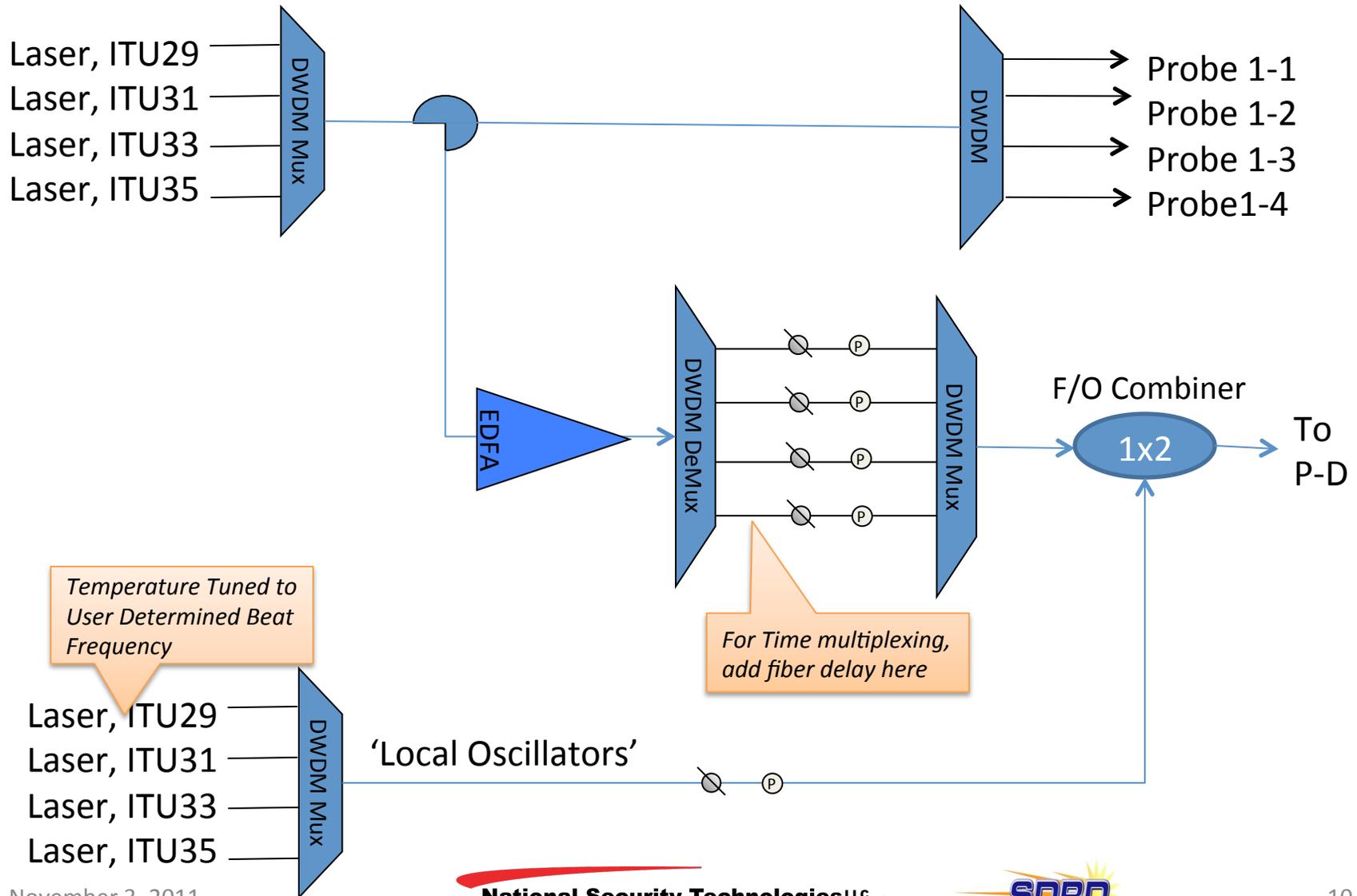


Wavelength Division Multiplexing with Optical Pre-Amplification – Notional



Optical Pre-Amp
Erbium Doped Fiber Amplifier (EDFA)

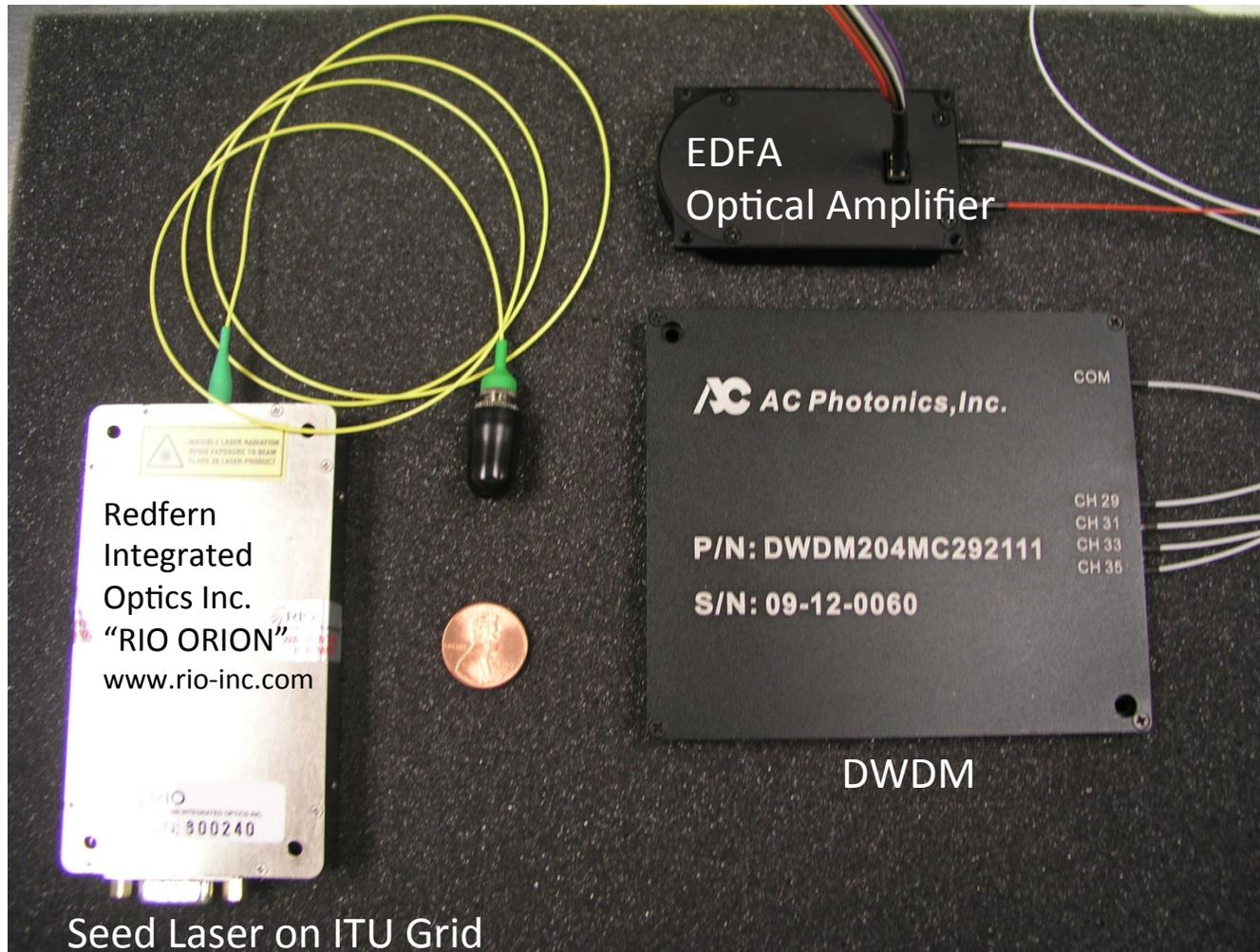
Multiplexing, Pre-Amp & Optical Heterodyne



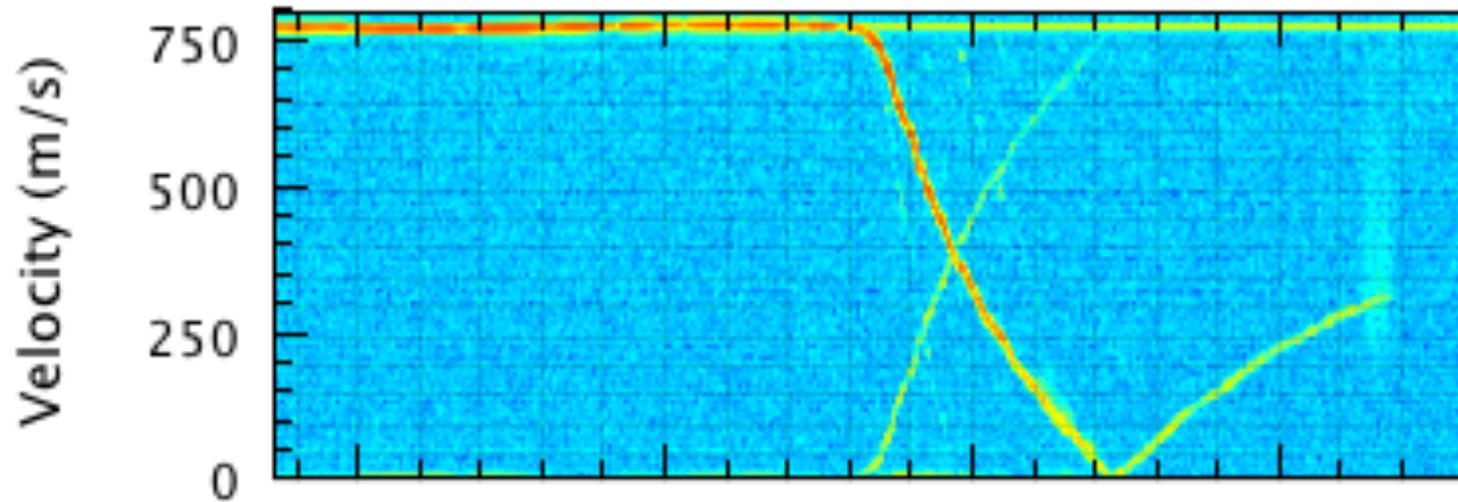
November 3, 2011

Evaluation of Photonic Technologies and Techniques

Leverage commercially available Telecom hardware ... robust and economical?

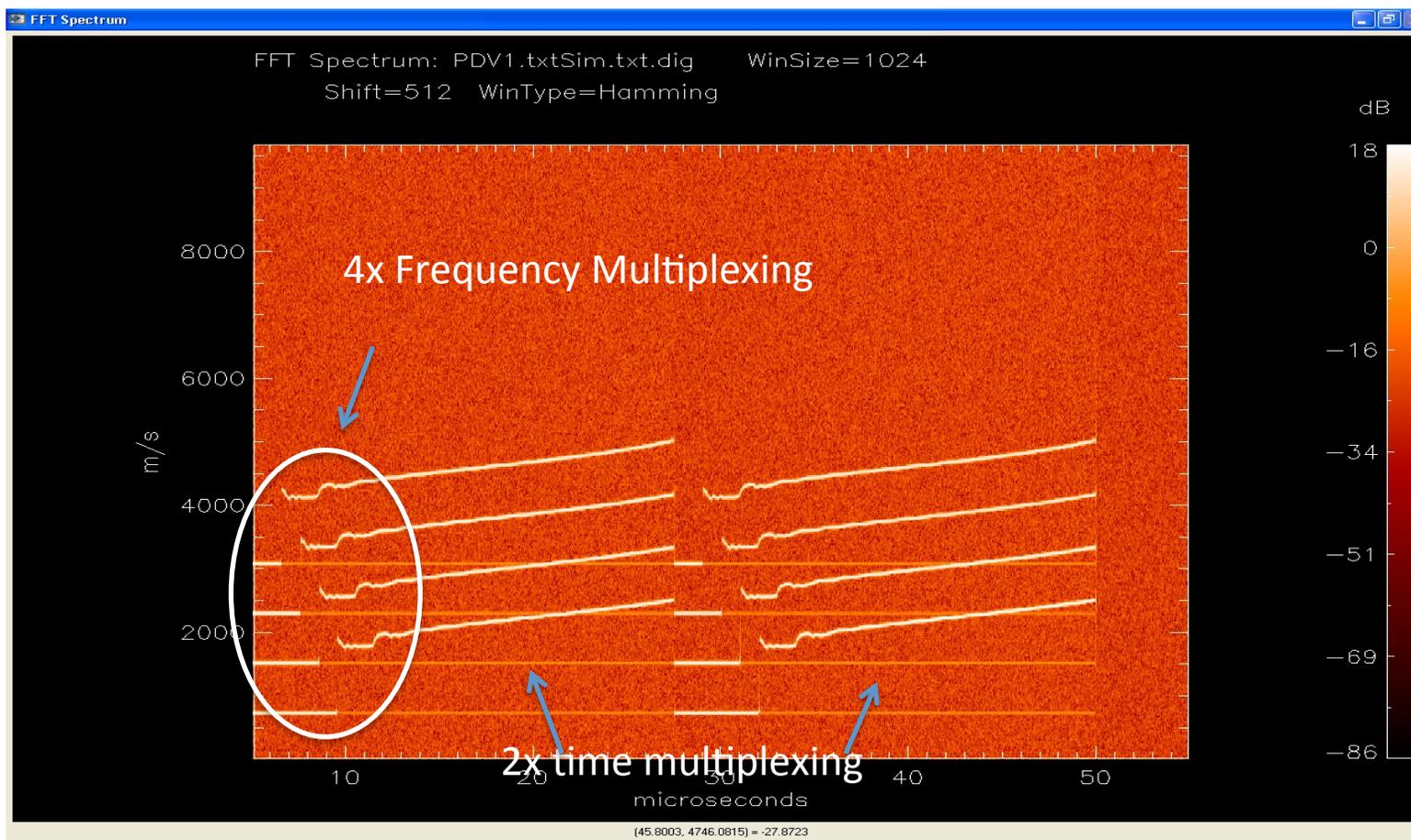


Increased Velocity Range via Optical Down-Shift



Experimental example of optical down-shifting. (M. Briggs, LANL)

Multiplexed PDV Data Simulation



Simulation of eight data records (probes) multiplexed and recorded onto a single digitizer channel, i.e. 8x multiplexing.

Concluding Remarks & Future Investigations

- Multiplexing techniques promise increased PDV channel count, comparable data fidelity* and improved cost effectiveness.
 - *SNR limitations exist for low probe efficiency (< 40 dB) configurations
- Heterodyning is advantageous – allows user verification of beat signal amplitude (data quality assurance), flexibility to determine beat frequency (up/down shift), improved precision (see D. Dolan).
- Laser safe operations
- Extended baseline effects may be problematic
- Future Investigations:
 - Methods to reduce extended baselines.
 - Better quantify SNR performance; affects of EDFA and filtering on SNR
 - System Engineering: a modular and more compact MPDV
 - Expanded time and frequency multiplexing: coherency and polarization effects
 - Experiment on high velocity applications.

Acknowledgements

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 “You can accomplish much if you don’t care who gets the credit”, R. Reagan
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