DOE/NV/25946--2128

Multiplexed Photonic Doppler Velocimetry (MPDV)

Musing on Multiplexing and Many Channel Applications

Edward Daykin, Martin Burk, Abel Diaz, Cenobio Gallegos, Adam Iverson, Chan Jung, Kirk Miller, Mike Pena, Carlos Perez, Araceli Rutkowski, Matt Teel (NSTec)

David Holtkamp, Mike Furlanetto (LANL)

Ted Strand, Tony Whitworth (LLNL)

PDV Workshop, Las Vegas, NV
June 24 – 26, 2014

Nevada National Security Site
Managed and Operated by National Security Technologies, LLC

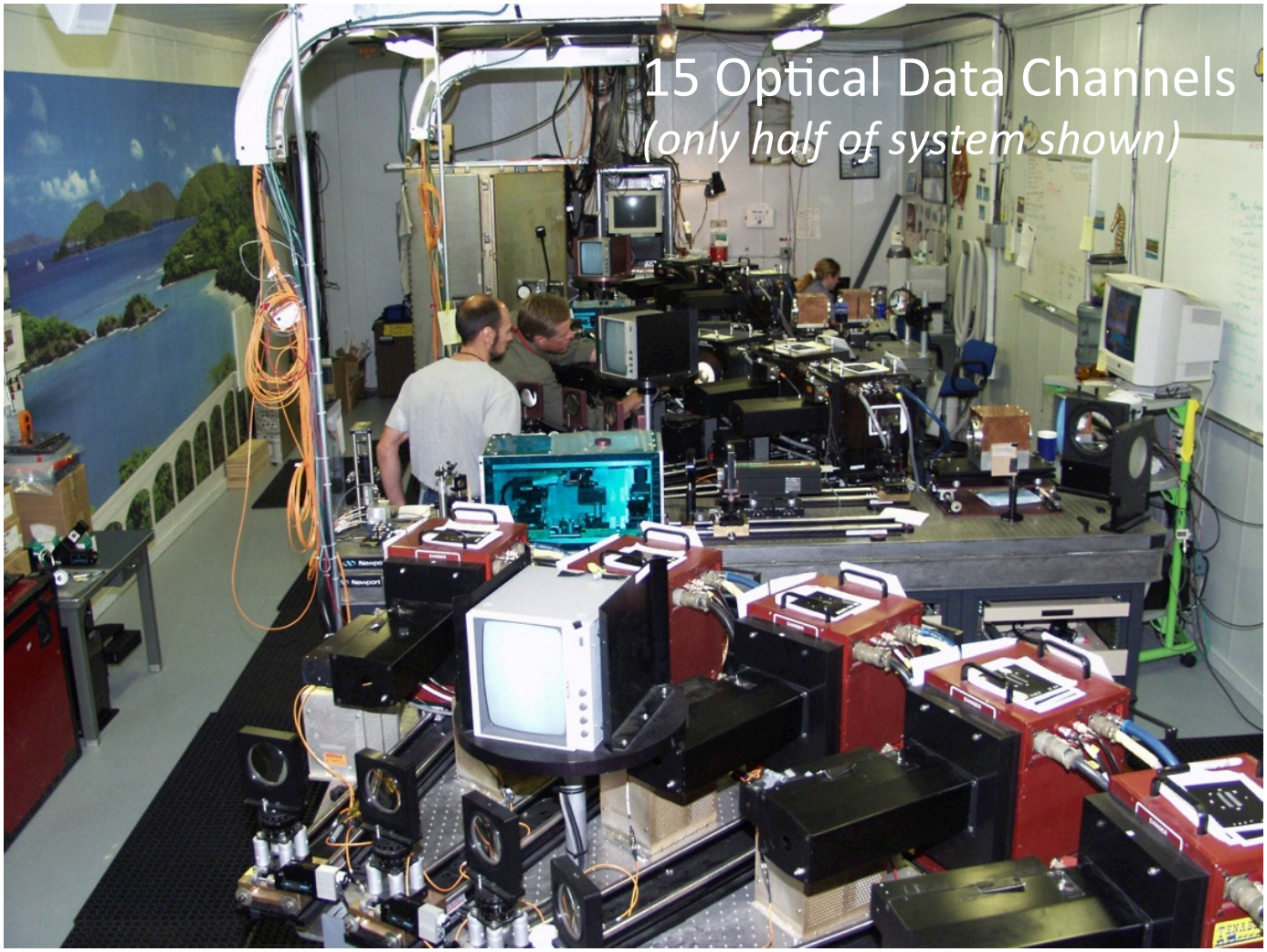
This work was done by National Security Technologies, LLC
Under Contract No. DE-AC52-06NA25946
With the U.S. Department of Energy.

SDRD
SITE-DIRECTED RESEARCH & DEVELOPMENT

Historical Context: VISAR Optical Velocimetry

VISAR Diagnostic Trailer

Historical Context: Fabry-Perot – Capable but Expensive



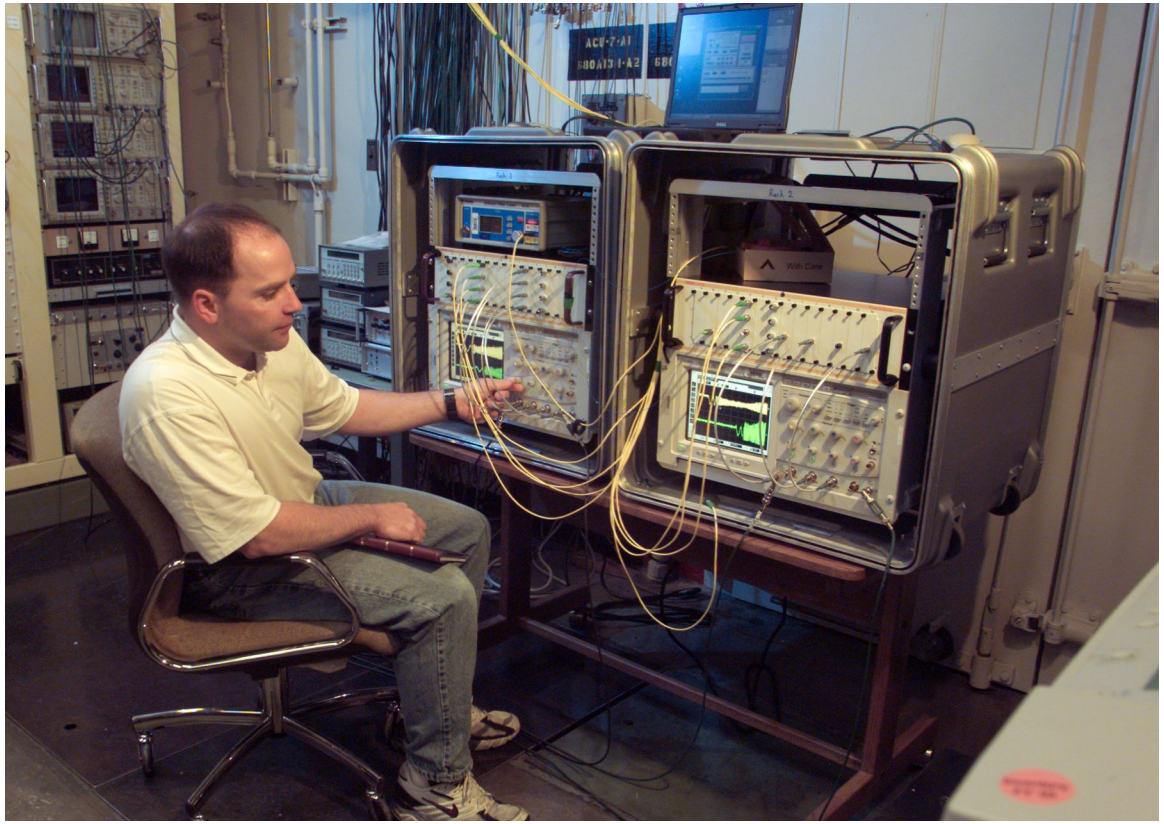
Fifteen Channels of Fabry-Perot Velocimetry at NTS/U1a (circa 2003)

Historical Context: First PDV *(from 2004 LLNL Review)*

"We have an 8-channel system now"
… in 2004

This was our set-up at B341 for two gas gun shots.

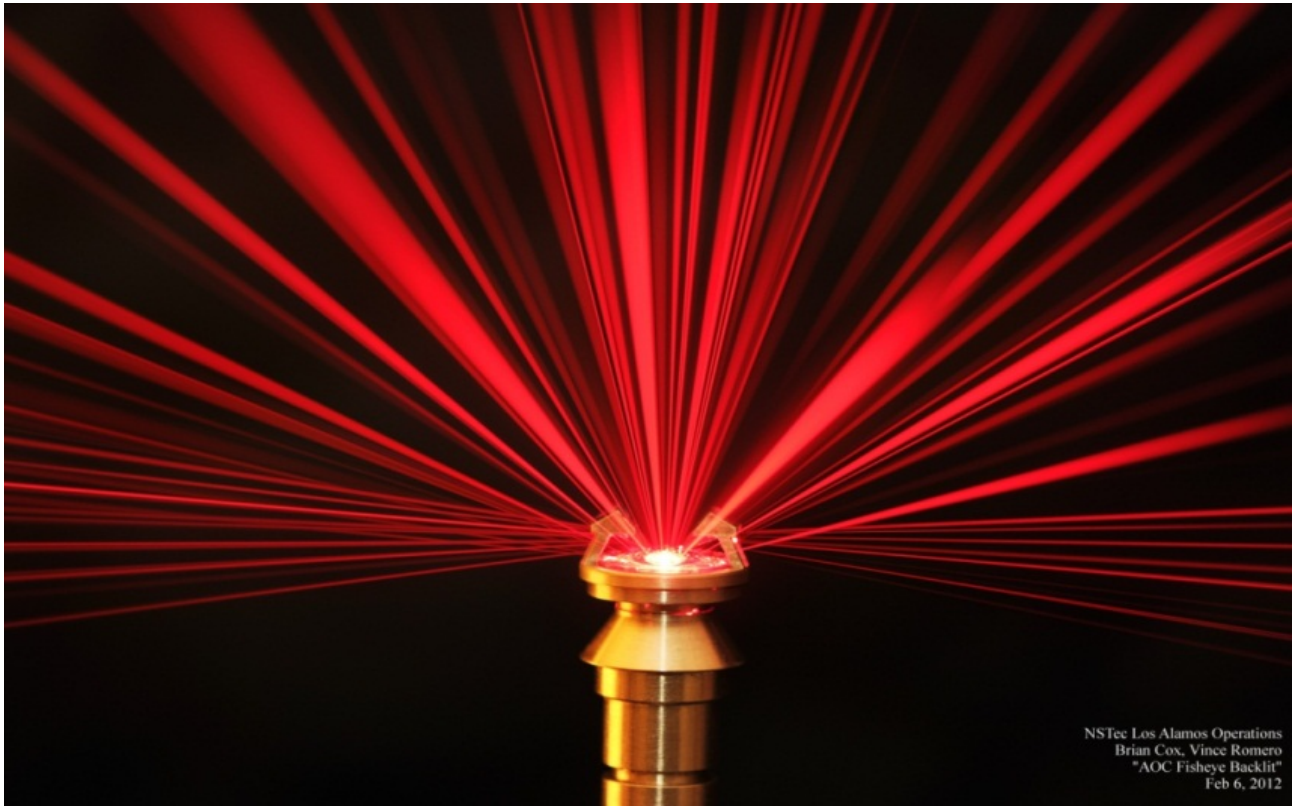
We used our 1-W laser to drive 7 probes.



A New Challenge: An Enabling Capability

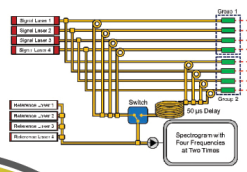
High-Definition Optical Velocimetry

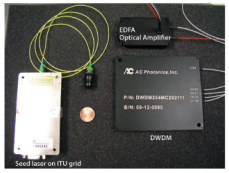
Hundred(s) of high-fidelity velocity vs. time measurements



GEMINI program optical velocimetry imaging system developed for many-point optical velocimetry applications

A Brief Review of MPDV Development





March 2011
Evalution of wavelength and time multiplexing proved concept will work for large numbers of channels

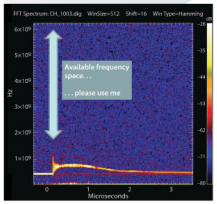
April 2011
Utility identified; assembled subsystems and "demo" 32-channel fielded and tested at STL (in collaboration with LANL)

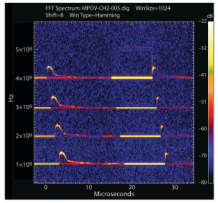
August 2011
Scaled initiative demoshots at LANL's Chamber 8

November–December 2011
Gen-1 MPDV built and tested and at LLNL Site 300 and at high-value experiment at LANL

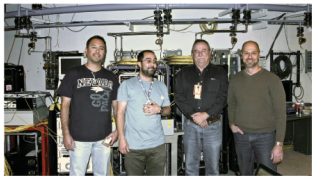
MPDV: TRL 2 to TRL 9 in approximately 24 months

October 2010
SDRD project began investigating the technology concept





March 2012
Gen-1 system completed and fielded on qualification shot at LANL DARHT; system moved to U1a



August 2012
Castor experiment fielded

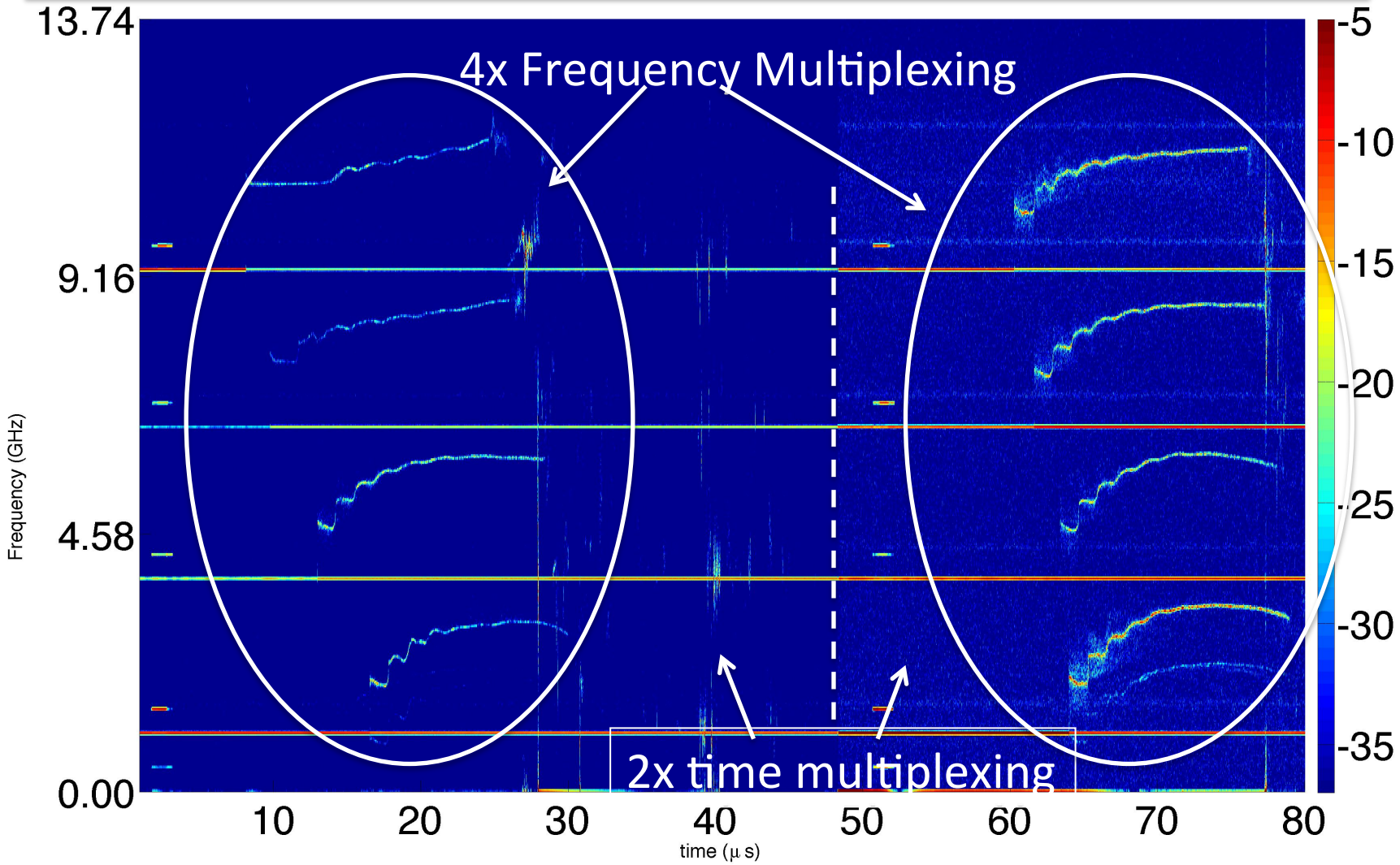
CASTOR POLLUX
Ex pede Herculem
GEMINI+SERIES
LANL • NSTec • SNL • NNSA

December 2012
Pollux experiment fielded

A New Paradigm: MPDV Gen-1 “eight is the new one”

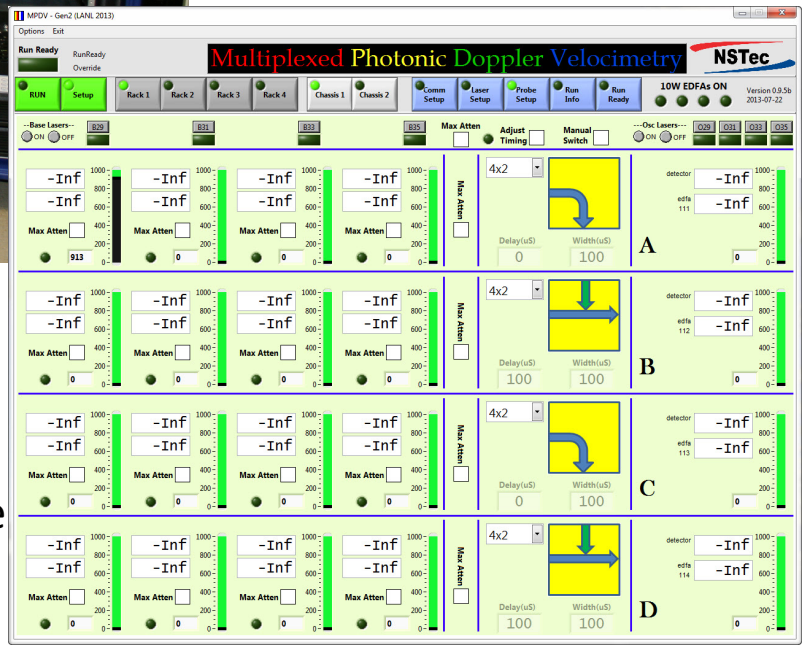
128 channel MPDV system and team just days before deployment to U1A for the Gemini Experiment (circa February 2012). Gen-1 MPDV is designed to consist of portable,32-channel autonomous systems.

MPDV Spectrogram with 8x Multiplexing



Evolutionary Improvements: Gen-2 MPDV

New Control Software
Reduced set-up and tuning time with added control and capabilities.



Improved Operations

- Reduced set-up and tuning time
- Increased signal return sensitivity
- Performs optical back reflection (OBR) measurements with 50 dB dynamic range
- Integrates with LUNA measurements
- Improved LabView based HMI

Optical Velocimetry Methods, Comparison at a Glance

ATTRIBUTE	VISAR	FABRY-PEROT	PDV	MPDV
Typical Channel Count	~ 1 to 10	~ 5 to 10	~ 4 to 20	~ 100 to 300
Velocity Range (approximate)	≥ 2 m/s	≥ 10 m/s	~ 1 m/s - 15 km/s (for 20 GHz BW)	~ 1 m/s - 25 km/s (for down-shifting)
Time Resolution	~ 2 ns	~ 10 ns	~ 2 ns *	~ 2 ns *
Multiple Surfaces (Frequencies)	NO	YES	YES	YES
Nature of Measurement	Intensity	Position	Frequency*	Frequency*
Care and Feeding	Moderate	Very High	Low	Low
Portability	Somewhat	NO	YES	YES
Class IV Laser	YES	YES	YES	NO
Relative Cost	Moderate	Very High	Moderate/Low	LOW

** Frequency domain analysis typical. MPDV requires frequency domain analysis when frequency multiplexed.*

MPDV Impact: Practical Considerations & New Tools

MPDV 'Tuning' and Data QA is a Challenge

- Ensure Data QA and 99% Data Return for 100's data channels
- Managing Shot Operations & Data Flow

Example: Data QA

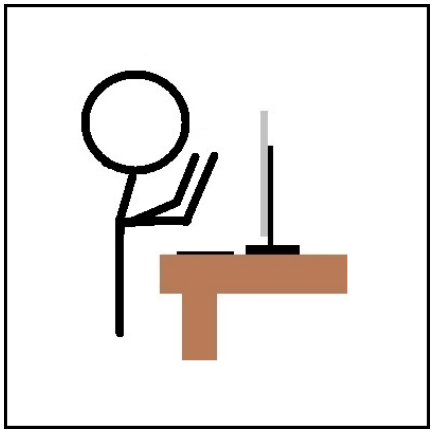
Use of "LUNA" optical back-reflection meter is critical to QA fiber data lines.

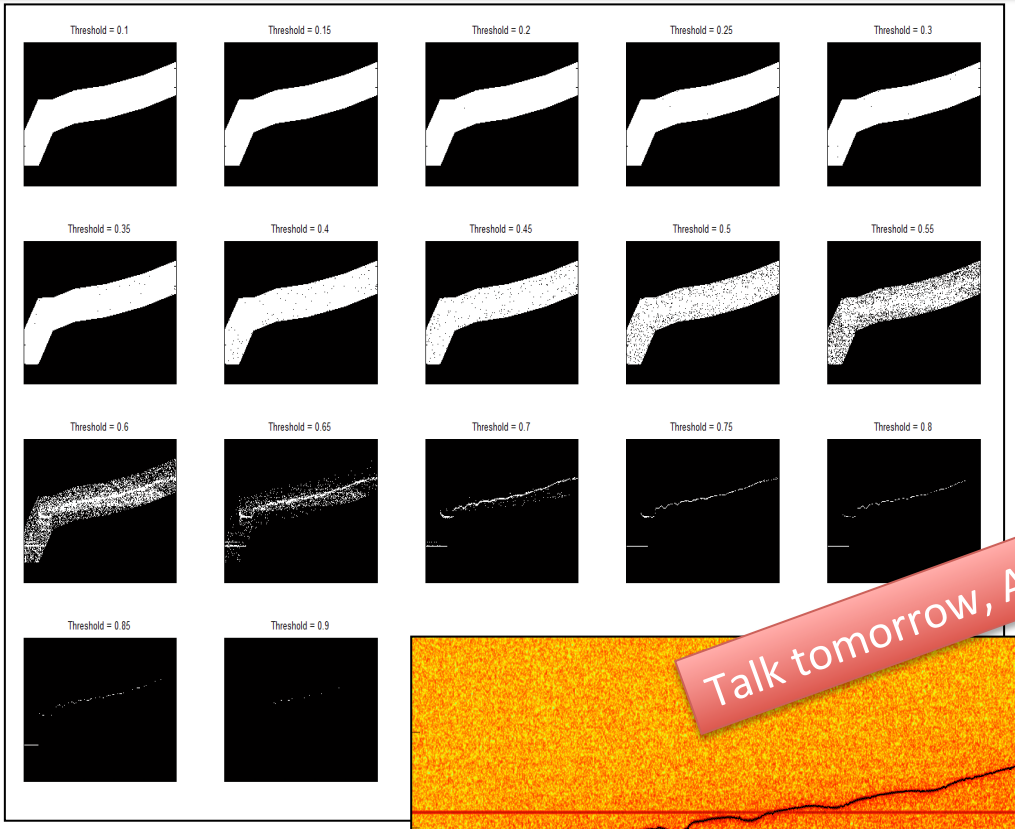
144 Channel automatic scanning-switching system under development

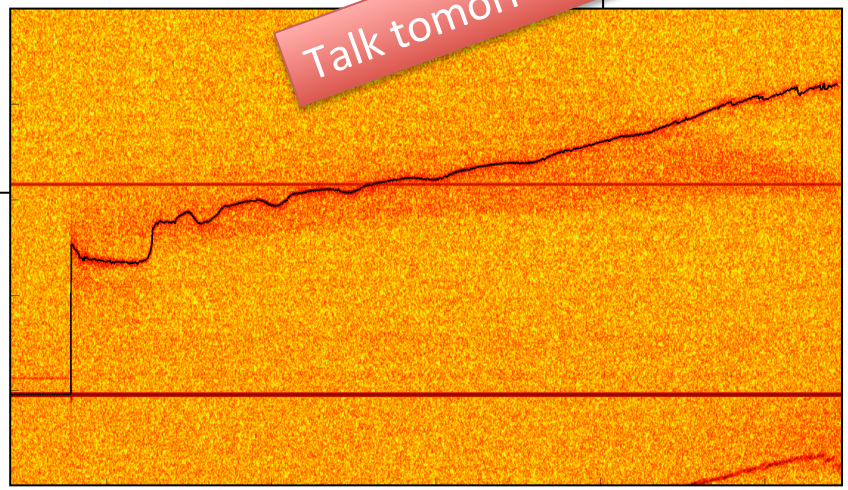
Next Generation Automated Data Analysis

Look, No Hands! An Automated Approach To MPDV Analysis

Abel Diaz (NSTec)







Talk tomorrow, A. Diaz

Create a mask, determine threshold, perform image processing … reduced processing time by more than factor of two.

Future Efforts: Optimize Signal-to-Noise & 'Process'

Multiplexing Architecture

- *Quantify SNR via modeling & dynamic measurements.*
- *Optimize multiplexing for efficiency of 'process': ease of set-up and data analysis.*