

# QUANTIFI PHOTONICS™

AN OPEN PLATFORM AND MODULAR BASED APPROACH FOR  
BUILDING PHOTON DOPPLER VELOCIMETRY (PDV) SYSTEMS

Ren Hong

[r.hong@quantifiphotonics.com](mailto:r.hong@quantifiphotonics.com)

# 4-POINT PDV SYSTEM COST SUMMARY

In-House Built 4-Point PDV System Cost Breakdown*	
Ramp Up, Research, Concept...	\$6k - \$12k
Component Cost	\$61k - \$79k
Packaging	\$12k - \$18k
Control System/UI Development	\$36k - \$48k
Procurement	\$1.5k
Total	\$116k - \$159k
⋮	⋮

\*Estimated with an engineering cost of \$150/hr. Exclude cost of probes and digitizer/scope

Avg. Commercial-Off-The-Shelf (COTS) PDV Systems Cost	
Per PDV Point	\$30k - \$35k
4-Point PDV System	\$120k - \$140k

- Components
- Development Time
- 
- Purchasing Effort
- Training
- Documentation
- User Interface
- Lab Space
- Calibration
- Repair
- Expansion
- Obsolescence
- ⋮

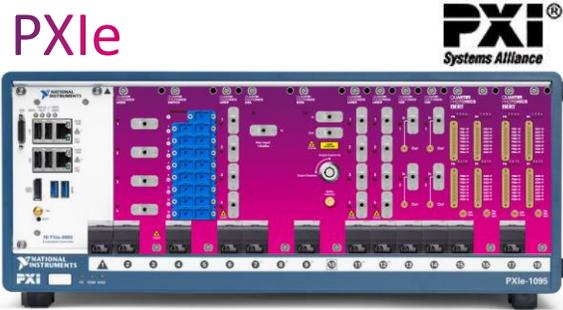


# ABOUT QUANTIFI PHOTONICS

Quantifi Photonics designs and manufactures advanced test and measurement solutions for the global photonics industry.



PXIe modules  
(primary design platform)



PXIe



MATRIQ™



EPIQ™



Lasers & Amplifiers



Doppler Module



O2E Detectors



Optical Power Meters



Polarization  
Controllers



Variable Optical  
Attenuators



Optical Switches



Passive Component  
Integration

# INTUITIVE & MODERN SOFTWARE CONTROL

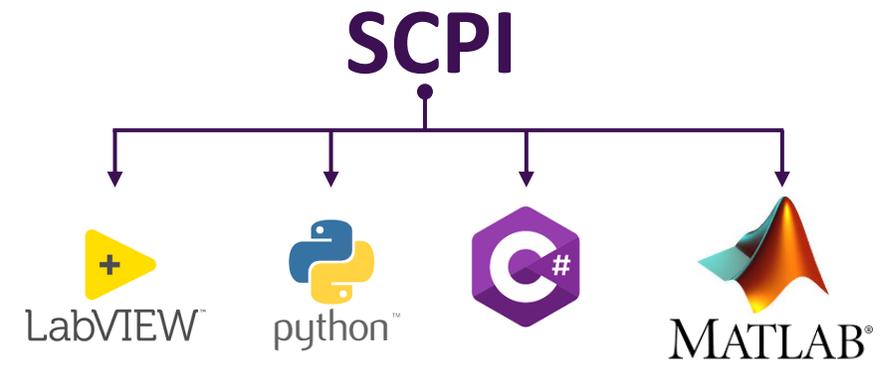
QUANTIFI PHOTONICS

HOME  
MODULES  
SETTINGS  
Large Format  
INFO

### LASER-1001 SLOT 8

1001-2-SC-CSL-195107 HW0.01.00FW0.01.20 ACTUAL | SET VALUE

CHANNEL 1		CHANNEL 2	
STATE	OFF	STATE	OFF
FREQUENCY	193.548400 THz 193.548400 THz	FREQUENCY	193.548400 THz 193.548400 THz
FINE TUNE OFFSET	0.000000 THz	FINE TUNE OFFSET	0.000000 THz
POWER	10.10 dBm 10.10 dBm	POWER	-16.02 dBm 10.00 dBm
WHISPER MODE	ON	WHISPER MODE	ON



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HOME  
MODULES  
SETTINGS  
Large Format  
INFO

### O2E-1101 SLOT 7

1101-2-SC-PXIE CSL-195107 HW0.01.00FW0.01.20 ACTUAL | SET VALUE

CHANNEL 1		CHANNEL 2	
PD POWER	10.00 dBm	PD POWER	10.00 dBm
GAIN	9575.736 V/W	GAIN	9575.736 V/W
AVERAGING TIME	0.020 s		
WAVELENGTH	1310.000 nm		
DARK NULLING			

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HOME  
MODULES  
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Large Format  
INFO

### DOPPLER-1001 SLOT 12

1001-1-SC-PXIE CSL-195112 HW0.01.00FW0.01.20 ACTUAL | SET VALUE

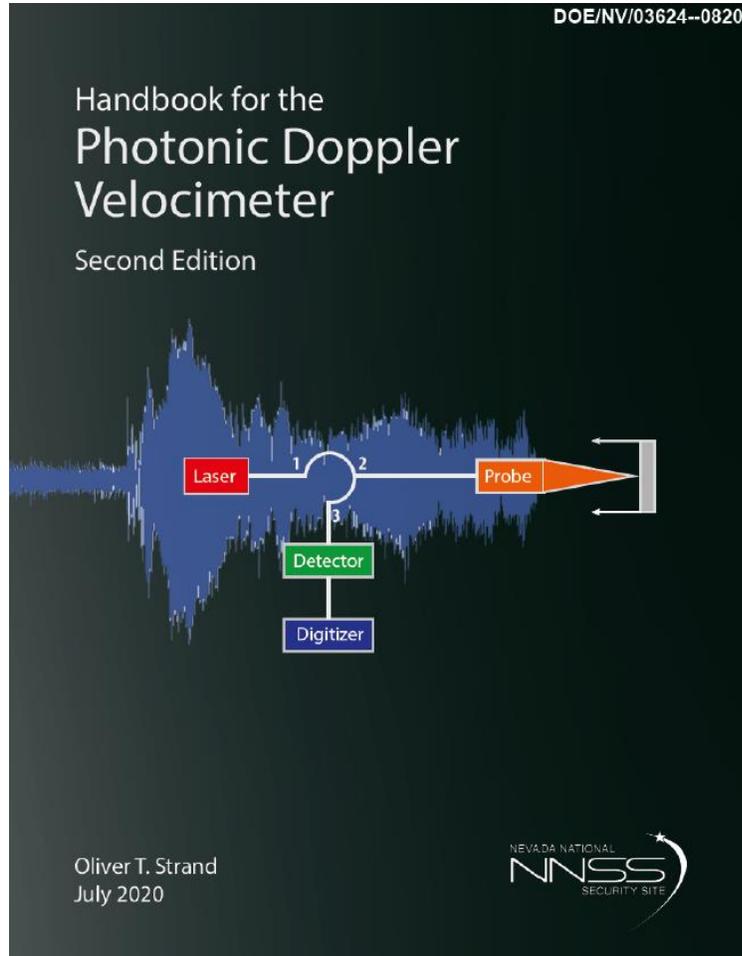
CHANNEL 1 PROBE IN/OUT		CHANNEL 2 REFERENCE INPUT	
AVERAGING TIME	0.100 s	AVERAGING TIME	0.100 s
WAVELENGTH	1550.000 nm	WAVELENGTH	1550.000 nm
ATTENUATION	9.79 dB 4.12 dB	ATTENUATION	9.79 dB 4.12 dB
INPUT OFFSET	0.00 dB	INPUT OFFSET	0.00 dB
OUTPUT POWER	-89.58 dBm 0.00 dBm	OUTPUT POWER	-89.58 dBm 0.00 dBm
OUTPUT OFFSET	0.00 dB	OUTPUT OFFSET	0.00 dB
MODE	ATTENUATION>	MODE	ATTENUATION>
ATTENUATION MODE	ABSOLUTE>	ATTENUATION MODE	ABSOLUTE>

# WHO DO WE WORK WITH

We have built a global reputation for excellence, winning business from over 130 of the world's leading technology companies, research organisations and universities from over 25 countries.

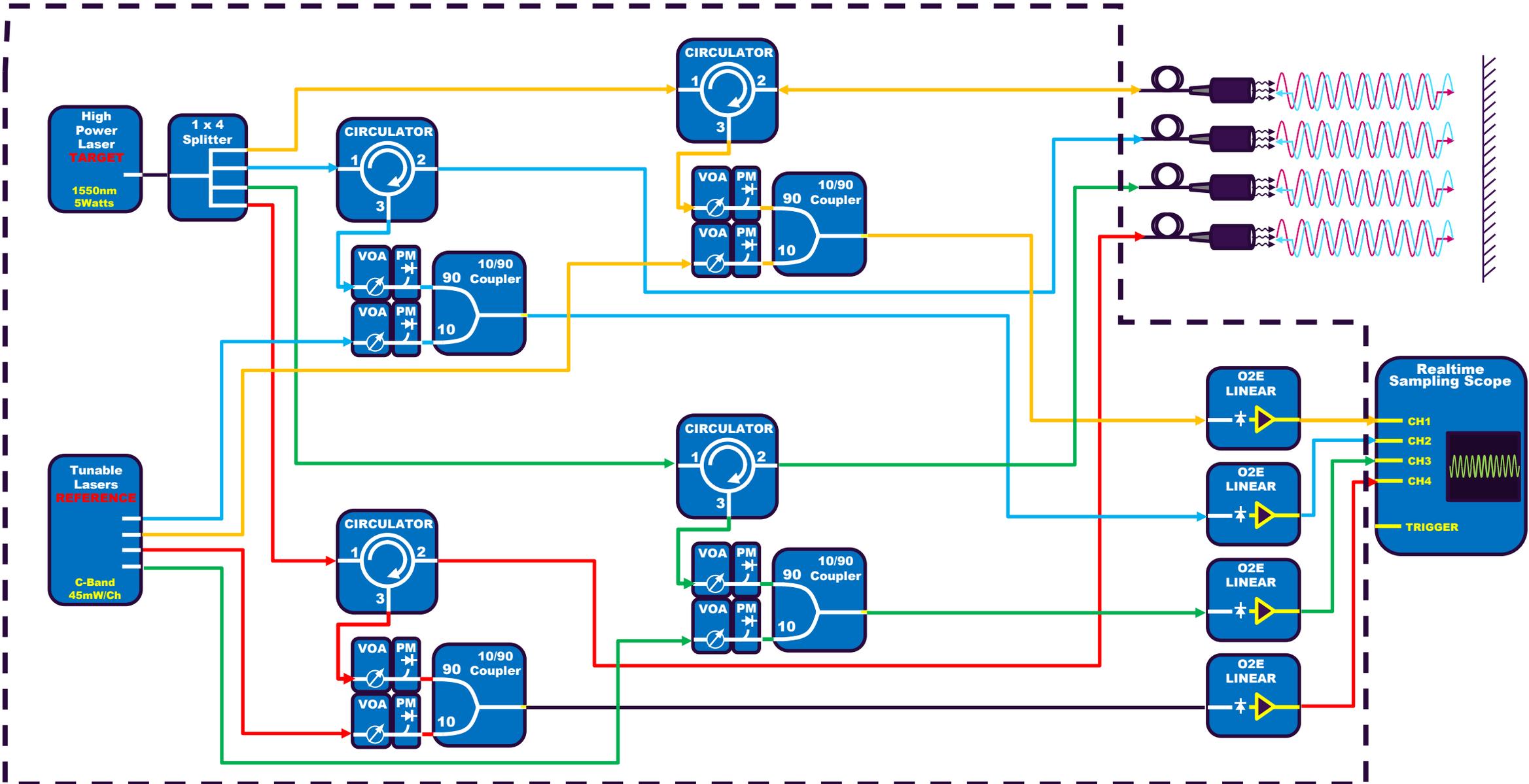


# STEP 1 – SYSTEM DESIGN AND RESEARCH

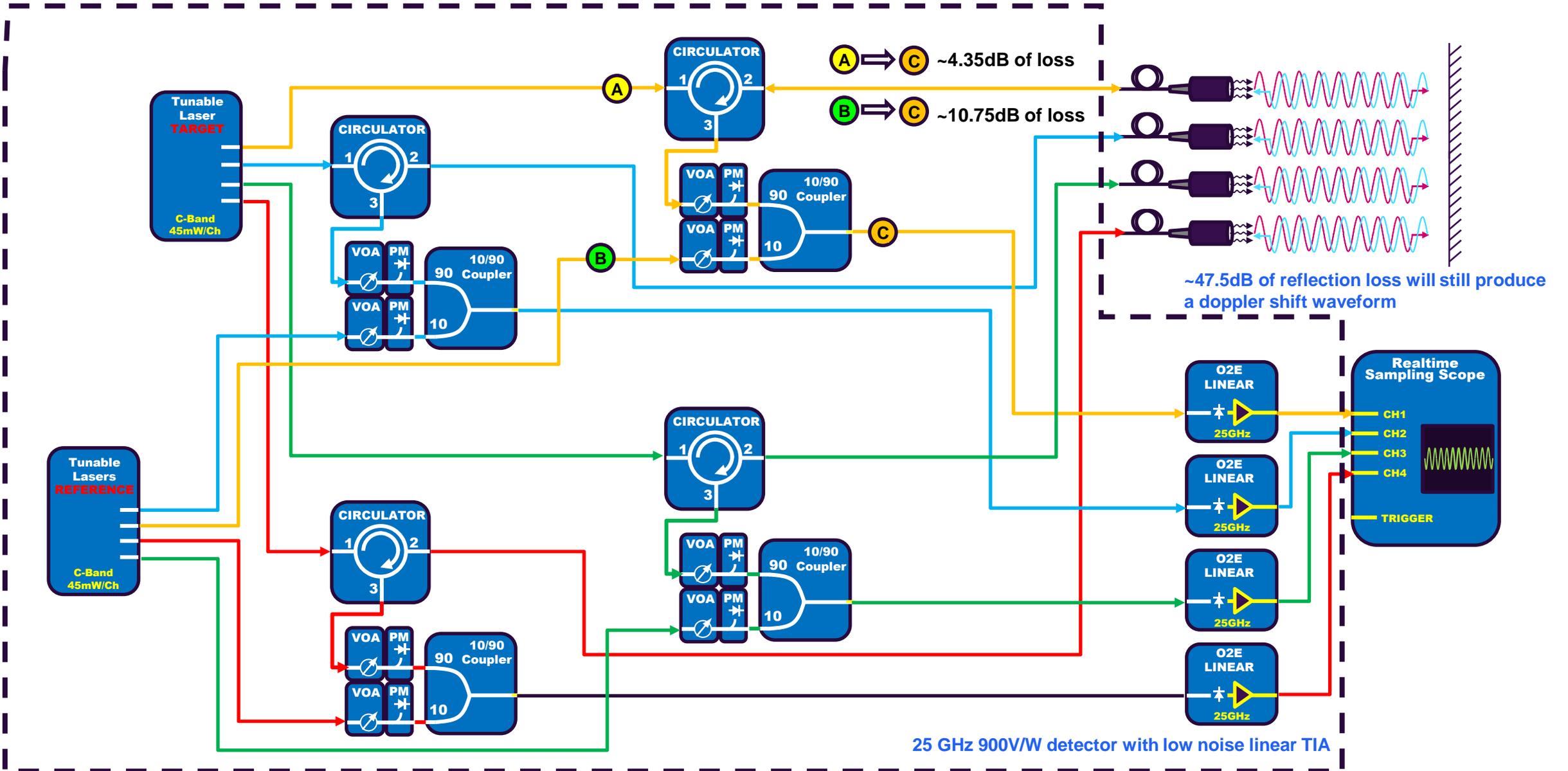


- Important to consider the time to learn about PDV systems. There are many papers on the topic, and Dr. Strand's PDV Handbook is a great resource.
- An estimated engineering cost of \$150/hr.
  - \$150k avg. salary for Sr. Engineer or 3 graduate students
  - Cost of employment → 2x annual salary
- 1-2 Weeks → \$6k-\$12k

# 4-POINT PDV SYSTEM DIAGRAM (5W TARGET LASER & SPLITTER)



# 4-POINT PDV SYSTEM DIAGRAM (INDIVIDUAL CLASS 1M LASERS)

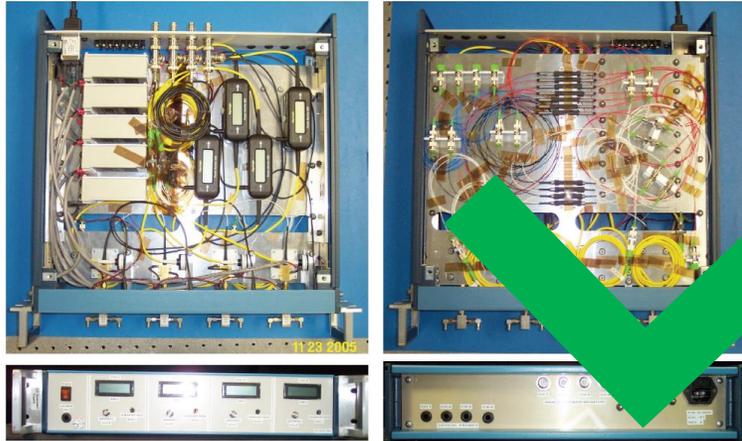


# 4-POINT PDV SYSTEM COMPONENT COST

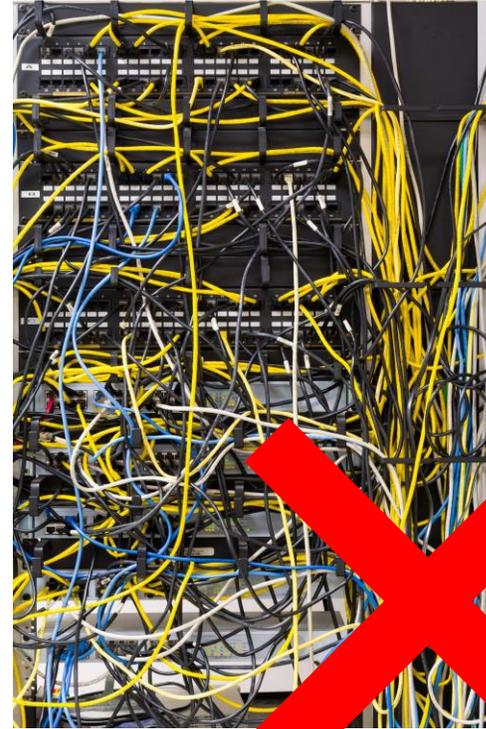
Component Type	Description	Quantity		Unit Cost
Laser Source	Class 1M Laser	4	8	\$5k
	2W - 5W Laser	1	0	\$11k - \$26k
Splitter	1x4 High Power			\$1k
Circulator	500mW	4		\$200
	High Power (5W)			\$500 - \$1k
VOA	Manual	4		\$50 - \$100
	w/ Analog Control			\$100 - \$200
Power Meter	Inline Power Monitor	8		\$650
Detector	12.5GHz BW	4		\$6.4k
<b>Total Cost</b>				<b>\$61k - \$79k</b>

- Cost of Procurement: 7-8 different suppliers, average procurement cost is about \$217 per PO
- More complicated shipping and receiving

# PACKAGING & CONSTRUCTION



(from A. Iverson, <http://kb.osu.edu/dspace/handle/1811/52657>)



- Assuming research lab has access to internal machine shop and ignore cost of building a custom enclosure
- 2 - 3 weeks of mechanical design and construction → \$12k - \$18k
- Patch cords and adapters might be needed



## Firmware:

- Laser modules tend to be instruments with API
- VOA, power meters and detectors often have analog I/O, require a controller
  - Custom firmware and driver design can take months
  - Assume use COTS controller (perhaps Raspberry Pi or MIO modules)

## Software/UI:

- UI feature, API integration, server integration
- Testing and documentation

Overall: 6-8 weeks effort → \$36k - \$48k

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HOME  
MODULES  
SETTINGS  
Large Format  
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**DOPPLER-1001** SLOT 12 1001-1-SC-PXIE CSL-195112 HW0.01.00FW0.01.20 ACTUAL | SET VALUE

CHANNEL 1 PROBE IN/OUT		CHANNEL 2 REFERENCE INPUT	
AVERAGING TIME	0.100 s	AVERAGING TIME	0.100 s
WAVELENGTH	1550.000 nm	WAVELENGTH	1550.000 nm
ATTENUATION	9.79 dB 4.12 dB	ATTENUATION	9.79 dB 4.12 dB
INPUT OFFSET	0.00 dB	INPUT OFFSET	0.00 dB
OUTPUT POWER	-89.58 dBm 0.00 dBm	OUTPUT POWER	-89.58 dBm 0.00 dBm
OUTPUT OFFSET	0.00 dB	OUTPUT OFFSET	0.00 dB
MODE	ATTENUATION	MODE	ATTENUATION
ATTENUATION MODE	ABSOLUTE	ATTENUATION MODE	ABSOLUTE

# COST SUMMARY

- Start Up Cost: \$6k - \$12k
  - Component Cost: \$61k - \$79k
  - Procurement Cost: \$1.5k
  - Packaging & Construction Cost: \$12k - \$18k
- } \$116k  
to  
\$159k

Building a PDV system is a multi-disciplinary project. The engineers/researchers can use their time for other projects.

Also Important:

- Calibration (once 1-2 years)
- Sparing and repair at component level

Expansion/Obsolescence

- Let's do this all over again
- Performance verification
- Training

Ignored:

- Material cost for packaging/enclosure
- More complicated planning effort with multiple vendors and delivery timelines
- Cost of patch cords/adapters, resulting in additional procurement and planning effort



# COMMERCIAL OFF THE SHELF (COTS) APPROACH

Warranty & Calibration Services

Extended warranties and calibration plans



Over specified with regular intervals of time. With an Extended Warranty, you're not worrying about maintenance.

PEAK PERFORMANCE: Ensure your equipment is its best for reliable and accurate measurements.

Extend your equipment's life. Guarantee years of operation.

LOOK IN & OUT: Order a Calibration Plan. On-site calibration.

With an instrument built to last, you can rely on it. Comprehensive calibration, end-to-end inspection, and working and care. We recommend Quantifi.

Contact your Quantifi sales@quantifiphotonics.com

\*Standard Warranties and Calibration discount only apply.

Quantifi Photonics | Doppler Specification Sheet | 8 of 12 | Version 1.0

General Specifications		PXI
Bus connection		PXIe
Number of PXI slots		8
Chassis type		8047-08
Optical connector type		FC/APC/PC/FC/APC or SC/APC
Dimensions H x W x D		130 x 20 x 235 mm (5.1 x 0.8 x 9.3 inches)
Weight		~1 kg (~2.2 lbs)
Operating temperature range		5 °C to 45 °C (33 °F to 113 °F)
Storage temperature range		40 °C to 70 °C (104 °F to 158 °F)

Model Number	1001	1002
Wavelength	850 to 1600 nm	850 to 1600 nm
Probe output operating range	-50 to -20 dBm	-50 to -20 dBm
Reference output operating range	-80 to -10 dBm	-80 to -10 dBm
Damage level	>23 dBm	>23 dBm
Return loss (target input, probe output)	-3 dB	-5 dB
Return loss (target input, reference output)	-5 dB	-3 dB
Return loss (reference input, probe output)	-14 dB	-14 dB
Return loss (reference input, reference output)	-14 dB	-14 dB
Wavelength dependent loss	-0.02 dB/m	-0.02 dB/m
Return loss*	>45 dB	>45 dB
Circulator Directivity	>45 dB	>45 dB
Warm-up time	<20 minutes	<20 minutes

Attenuator	1001	1002
Calibration wavelength	1650 nm	1650 nm
Attenuation range (typical)**	-45 dB	-45 dB
Attenuation range (guaranteed)**	-40 dB	-40 dB
Resolution	0.25 dB	0.25 dB
Attenuation speed	0.1 s	0.1 s

Power Meter	1001	1002
Calibration wavelength	1650 nm	1650 nm
Resolution dependent repeatability**	-0.2 dB	-0.2 dB
Linearity**	±0.1 dB	±0.1 dB

Sampling time: 100 ns to 10 μs | 100 ns to 10 μs  
Resolution: 0.25 dB | 0.25 dB  
Data logging: 1 to 1024 per channel | 1 to 1024 per channel

Backed by spec sheets, calibrated & tested

Scalable & footprint reduction

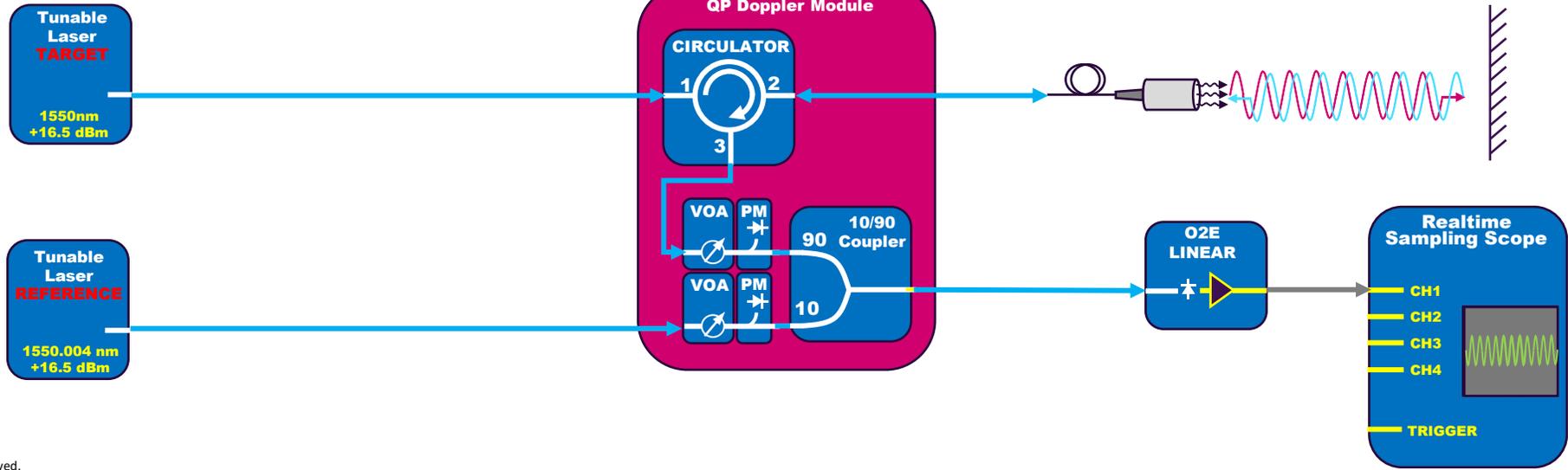
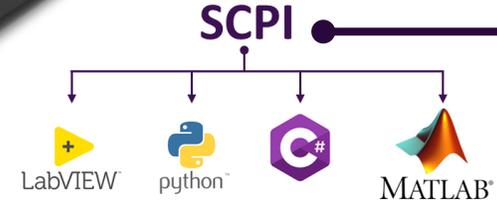
**DOPLER-1001** SLOT 12 1001-1-SC-PXI-E-CSI-195112-HWO-01-DOFWO-01-20

CHANNEL 1	PROBE IN/OUT	CHANNEL 2	REFERENCE INPUT
AVERAGING TIME	0.100 s	AVERAGING TIME	0.100 s
WAVELENGTH	1550.000 nm	WAVELENGTH	0.000 nm
ATTENUATION	9.79 dB	ATTENUATION	9.79 dB
INPUT OFFSET	0.00 dB	INPUT OFFSET	0.00 dB
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OUTPUT OFFSET	0.00 dB	OUTPUT OFFSET	0.00 dB

Web-Based CohesionUI™

USB & Ethernet control

User manual & SCPI API with example code



# COMMERCIAL OFF THE SHELF (COTS) APPROACH

## DOPPLER

### PDV Module

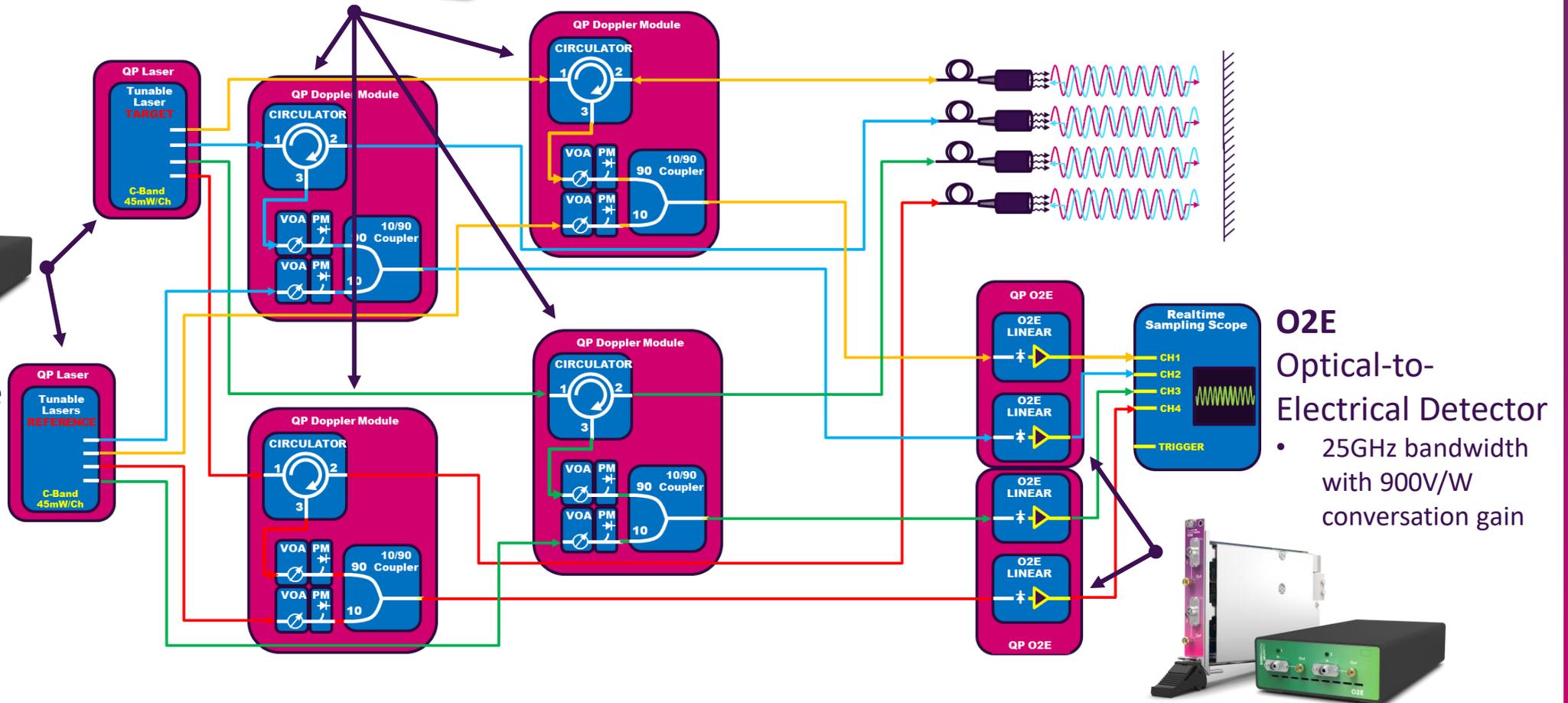
- Power meter, variable optical attenuator and coupler all in one compact, space saving unit



## LASER

### Tunable Laser Source

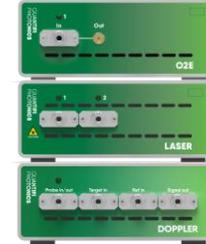
- Continuous Wave tunable laser, narrow 100kHz linewidth
- 0.01pm resolution tunability



# SCALABLE PDV SYSTEMS (1 TO 4 POINT)

## 1-Ch Setup

- LASER-1054-2 (2-Ch Laser)
- DOPPLER-1001 (1-Ch Doppler Module)
- O2E-1101-1 (1-Ch Optical-to-Electrical Detector)
- Optional 8-Slot PXIe Chassis and Controller



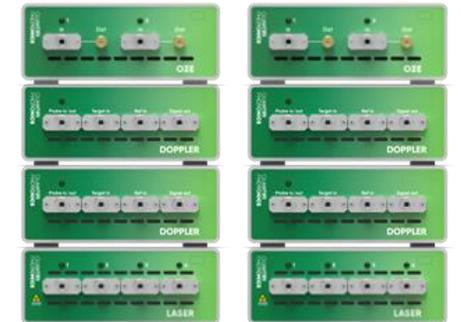
## 2-Ch Setup

- LASER-1054-2 (4-Ch Laser)
- 2 x DOPPLER-1001 (1-Ch Doppler module)
- O2E-1101-2 (2-Ch Optical-to-Electrical Detector)
- Optional 8-Slot PXIe Chassis and Controller



## 4-Ch Setup

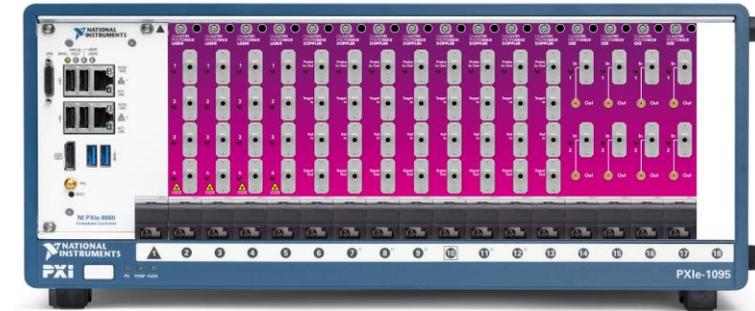
- 2 x LASER-1054-4 (4-Ch Laser)
- 4 x DOPPLER-1001 (1-Ch Doppler Module)
- 2 x O2E-1101-2 (2-Ch Optical-to-Electrical Detector)
- Optional 8-Slot PXIe Chassis and Controller



# SCALABLE PDV SYSTEMS (8 POINT AND MUX SETUP)

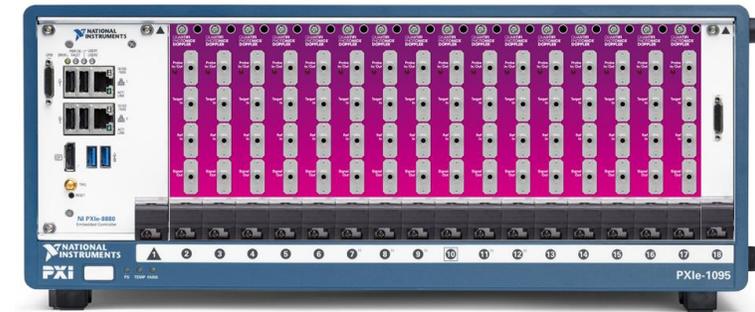
## 8-Ch Setup

- 4 x LASER-1054-4 (4-Ch Laser)
- 8 x DOPPLER-1001 (1-Ch Doppler Module)
- 4 x O2E-1101-2 (2-Ch Optical-to-Electrical Detector)
- 17-Slot PXIe Chassis and Controller



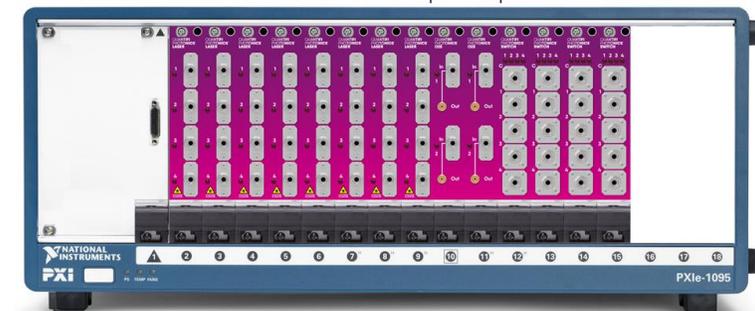
## 16-Ch Setup with 4-Ch MUX Grouping

- 8 x LASER-1054-4 (4-Ch Laser)
- 16 x DOPPLER-1001 (1-Ch Doppler Module)
- 2 x O2E-1101-2 (2-Ch Optical-to-Electrical Detector)
- 4 x PASSIVE-1016 (MUX/DEMUX Module)
- 17-Slot PXIe Chassis and Controller with Daisy Chaining Modules



16-Ch Doppler Modules

4-Ch O2Es



32-Ch Laser Modules

4 4-Ch MUX Modules

# 4-POINT PDV SYSTEM IN-HOUSE VS COTS COMPARISON

	In-House	COTS
Total Cost	\$116k - \$159k	\$120k - \$140k
Purchasing Effort	Multiple POs for components	Single PO for instruments
Packaging/Scalability	Single box, not easily expandable	Chassis and module
Control SW and UI	Commonly limited to initial setup, sometime manual	Web based, API support for automation, expand with system
Documentation	Highly depend on the system designers and developers	Consistent formats, hosted online, update with product updates
Footprint	Often larger	More compact
Calibration	Done at component level	ISO17025 if needed. Optical loss value specific to reach module
Warranty/Repair	Can keep sparing components. In-house repair often needed. More efficient if initial system designers and developers are available	Warranty plans often included or available. High quality modules used in production environments in commercial space
Customization	Unlimited	Depending on the supplier

# CUSTOM SYSTEM & MODULE DEVELOPMENT

We would love to get more feedback on our PDV approach and how our modules meet your PDV system design requirements. Feel free dropping by our booth.

We also have the expertise and agility to build customized solutions to match your exact requirements.



Test.  
Measure.  
Solve.

We solve complex test and measurement challenges in photonics with innovation and experience.

[www.quantifiphotonics.com](http://www.quantifiphotonics.com)

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