Los Alamos NATIONAL LABORATORY

Out Brief on PDV Hands-On Class

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The Idea for a Hands-On Class came from our 2018 PDV Workshop…

- We were going to have a class as part of the 2020 PDV Workshop, however it was COVID Cancelled. This original effort was led by Dale Tupa.
- When we started to organize the 2023 PDV Workshop, it was natural to again think about having a Hands-On Class. As part of splitting up the work for organizing the Workshop, I took on the task of leading the Hands-On Class.
- I enlisted Matt Briggs, Jackie Mirabal, Ted Strand, Brian Cata, Ruben Manzanares, Louie Chacon, and Carl Trujillo as instructors.
- We also had a practice session. Steve Sandoval, Lauren O'Brien, John Schmidt, and Rohan Jillapalli were our guinea pigs.
- **THANK YOU VERY MUCH!**
- The interest in the class was very substantial. Over 40 people sent in applications. Additional people said they were interested.
- Our goal was a very much HANDS-ON class.
- This necessarily meant a small class, <10. We selected nine people to participate this week.
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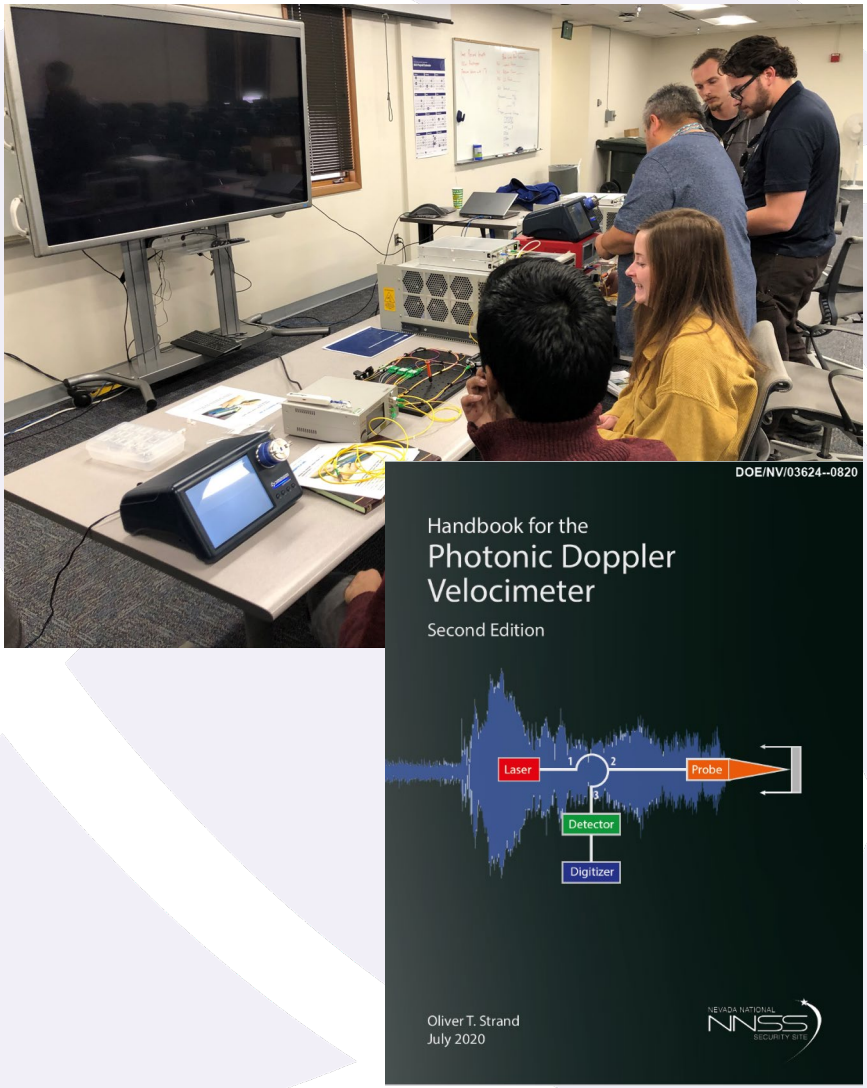
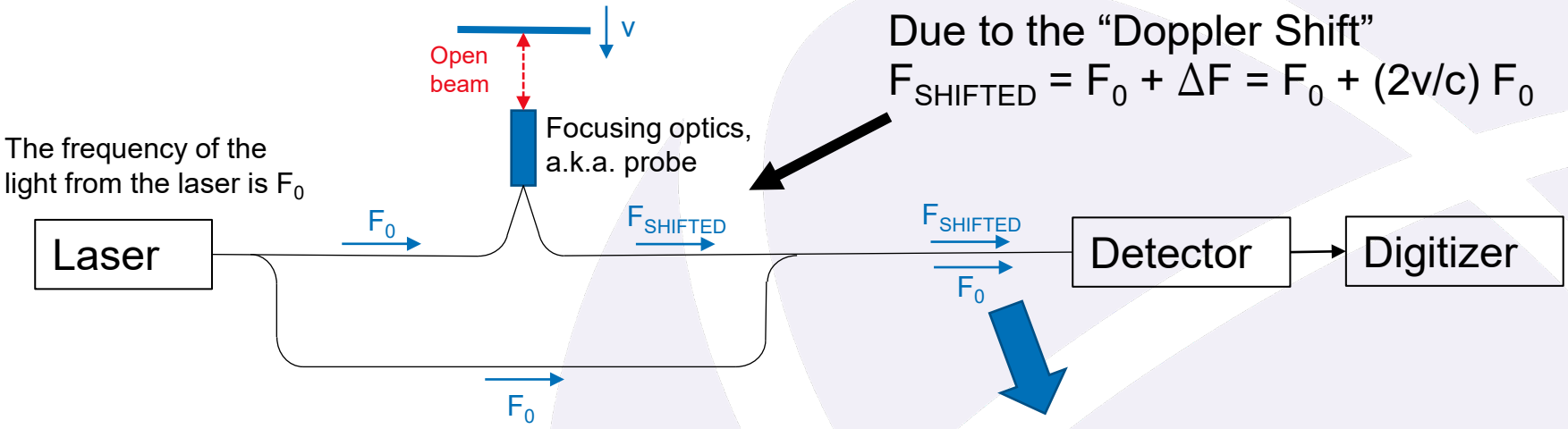
The class was held at the LANSCE campus of Los Alamos National Lab

- Monday, Feb 6, 8:30 to 5:00.
- It was an Intensive Class.
- For most activities, participants worked in teams of two.
- The goal: “You will know enough to assist in PDV fielding and have a solid base for further learning about PDV and associated diagnostics”.
- The scope did not include teaching the skills to safely operate hazardous lasers.
- The class content is publicly available.
- Please ask me if you want a copy.
- Everyone got a copy of the “Handbook for the Photonic Doppler Velocimeter”, by Ted Strand. **THANK YOU NNSS!**

The Trial Run of the Hands-On Class.

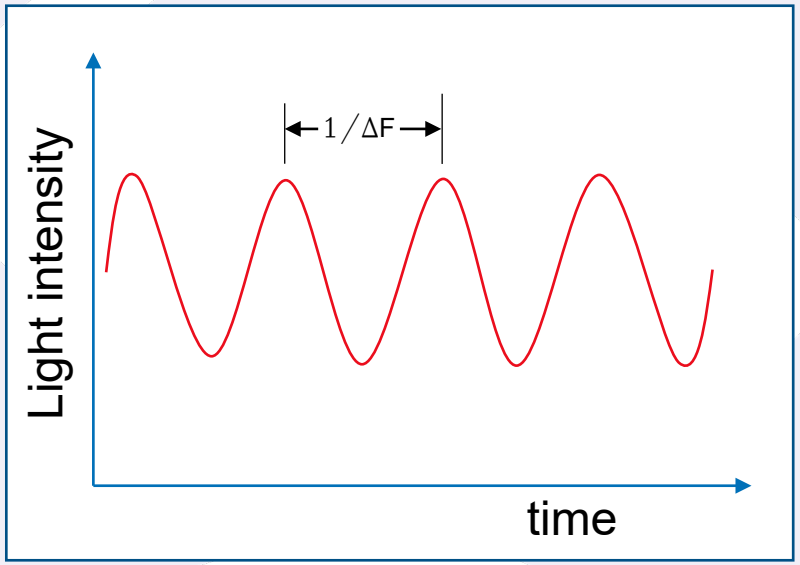


The lecture part of the class was about 30 minutes at the beginning. Example Slide below:

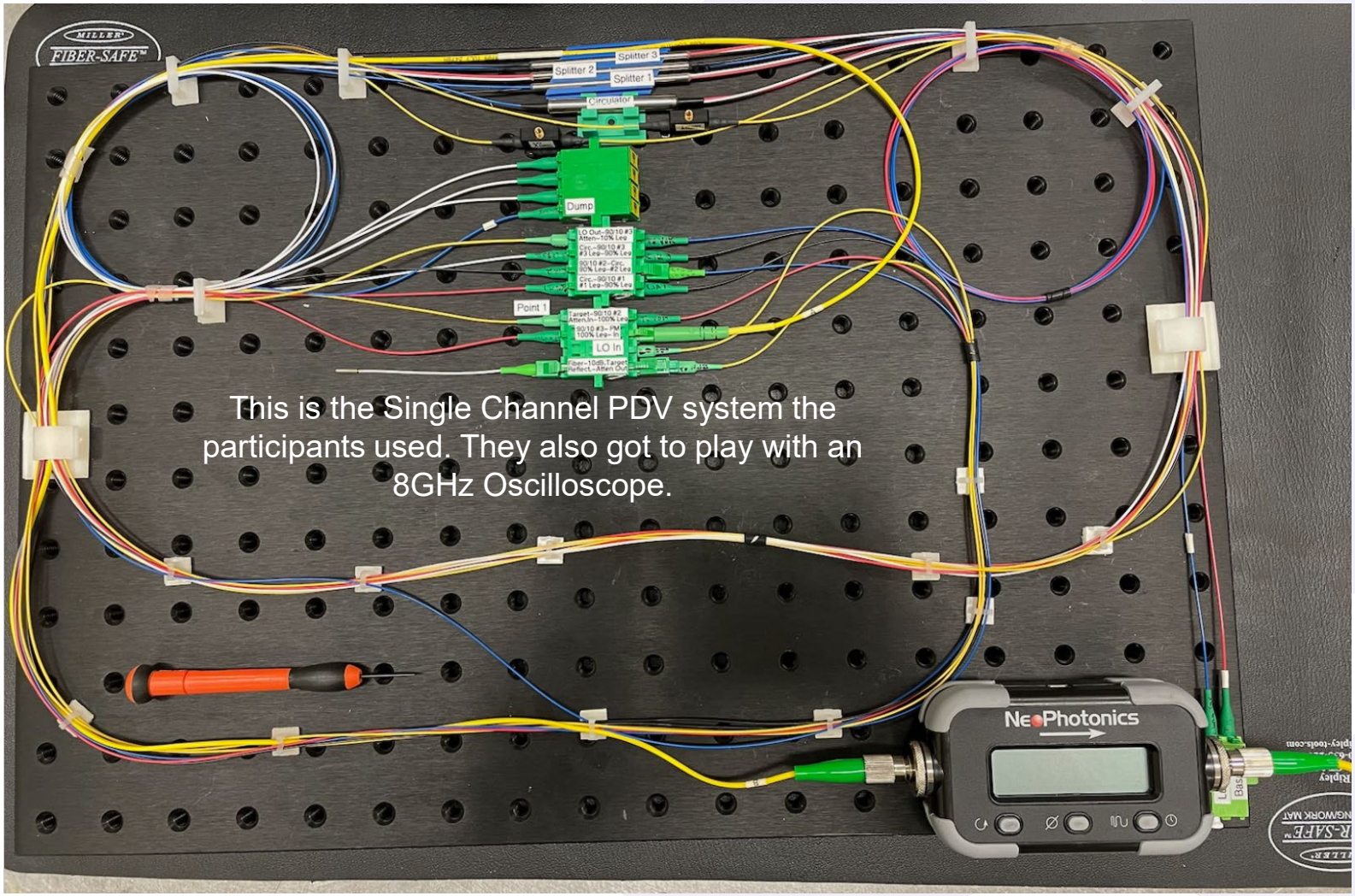


Due to the "Doppler Shift"
$F_{SHIFTED} = F_0 + \Delta F = F_0 + (2v/c)\, F_0$

- c = 2.99e8 m/s and typically F_0 = 193 THz, so approximately:
  v = 1.29 GHz/(km/s) ΔF.
- Only the velocity along the line-of-sight of the laser beam contributes to the Doppler Shift (not transverse velocity).
- **We measure the component of velocity along the line-of-sight.**



For the rest of the morning, participants worked through a series of guided activates to learn the operation and tuning of a PDV system.



This is the Single Channel PDV system the participants used. They also got to play with an 8GHz Oscilloscope.

This slide is an example activity during the morning session.

- With the lasers on and fringing waveform displaying on the oscilloscope, adjust the LO VOA so that the Power Meter reads -10 dBm.
- How does this change the waveform?

  _____
- Use cursors to measure the height of the peak in the PSD plot relative to the noise floor. Then fill out the table below.

LO Power (dBm)	Return Power (dBm)	CH1 Vertical (mV/div)	Peak (dB)	Noise Floor (dB)	Signal-to-Noise Ratio
0	-35	100			
-5	-35	100			
-10	-35	100			
-15	-35	100			
-20	-35	100			

- **Greater LO Power results in a greater Signal-to-Noise Ratio.**
- What is the maximum LO Power that we can have before damage to the photodetector? _____dB.
- Also…. Eventually large LO Powers will increase the noise floor and the signal-to-noise will not improve anymore. For our system this actually occurs around an LO power of 0 dBm.

We included reviews that were done as classroom discussions. Example below:

- True or False: If you suspected that a surface will return little light, you should try to maximize the amount of light power on target. _____.
- Surfaces can be characterized by their “Return Loss”, i.e. how much light is reflected by the surface and collected by the optics back into the fiber. If a surface has a return loss of 1 part in 100,000 (50 dB) and you launch 100 mW (20 dBm), what is the return power? _____mW or _____ dBm.
- Based on your experience so far, will you be able to measure the velocity of this surface with PDV? _____.
- What is an optimum setting for the LO Power? Why ?

  _____

  _____
- What is an optimum setting for the scope sensitivity? Why?

  _____

  _____

After Lunch we took a tour of our Proton Radiography Facility

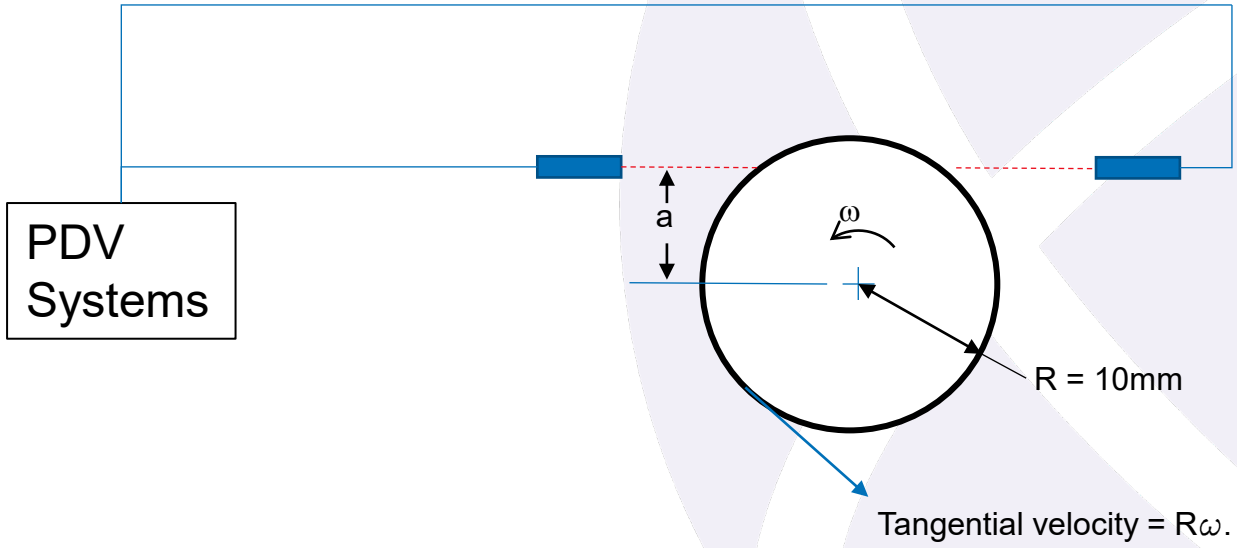
- Here the participants saw PDV systems in an operational environment.

After pRad, we practiced fiber inspection, cleaning, and connecting.

- Part of this process was to configure their PDV system from heterodyne to homodyne and to hook up their long jumper.
- This work was in preparation for their Capstone project…

Capstone: Two teams of two were assigned to field two PDV points on a wheel spinning at 28,000 rpm.

- We thought this would give good practical experience of working as a larger team, e.g. coordinating dry runs, etc.
- During this time, the other participants reviewed and further discussed PDV components, specifications, and theory.



We taught the best practice of using a Check Sheet for tuning diagnostic systems.

Laser Tune

Base Laser Setting: Power: _____dBm Frequency: _____THz

Pt1 Launch Power: _____dBm

Pt1 Return Power: _____dBm

Pt1 LO Power: _____dBm

Scope Tune

CH1 Vertical: _____mV/div

Horizontal: _____us/div _____GS/sec

Trigger: Pretrigger: _____us

□ Rising Edge □ 1V Level □ Ext. □ Norm □ Single

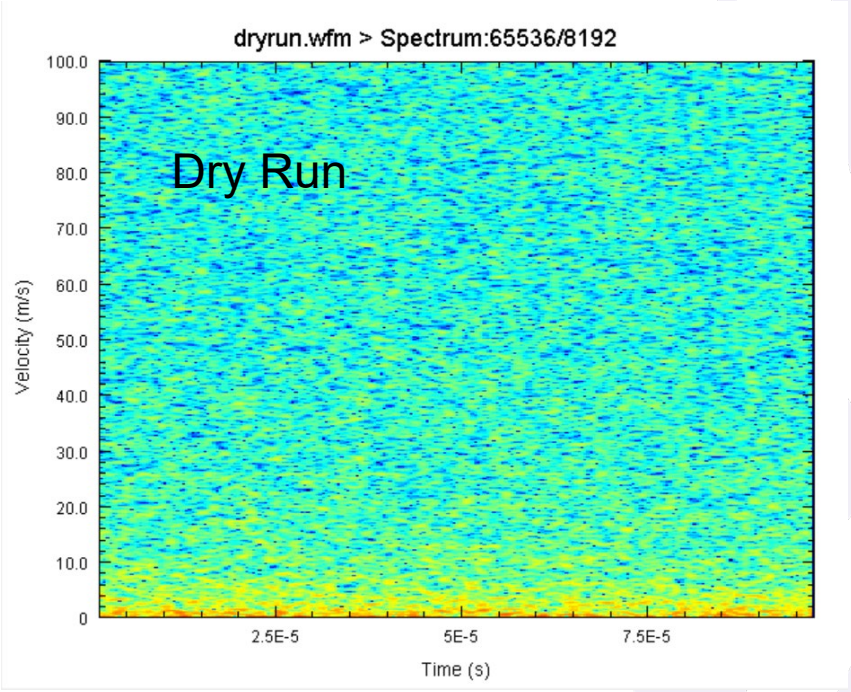
Final Checks

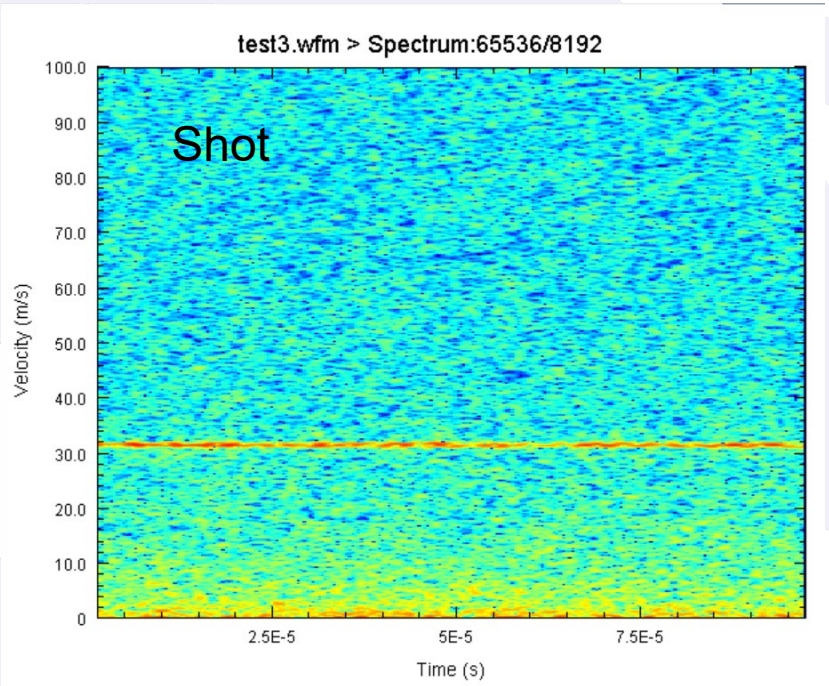
Scope in Single	□ □ □ □
Lasers On and Power Verified	□ □ □ □
Execute Shot	□ □ □ □
Lasers Off	□ □ □ □
Save Data	□ □ □ □
Review Data	□ □ □ □

Notes

We only had time to briefly talk about data analysis. A proper review is a multi-lecture class.

Results from the Spinning Wheel Test





We ended with a final review….

- True or False:
  - For PDV, a fiber interferometer is the fundamental design of the optical system. _____
  - At the output of the interferometer, the light intensity modulates at a frequency:
    ΔF = v (1.29 GHz/(km/s)), where v is the velocity along the line-of-sight. _____
  - The fiber type used is single mode, Corning SMF-28 or similar.
  - For the PDV system that you used today, if you received -35 dBm of light back from the surface-of-interest, you would expect a quality velocity measurement. _____
  - If you received -70 dBm of light back from the surface-of-interest, you would NOT expect a quality velocity measurement. _____
  - For the PDV system that you used today, an optimum LO power is about 0 dBm. _____
  - For the PDV system that you used today, a reasonable scope sensitivity is 100mV/div. _____
  - The State-of-Polarization can affect the SNR, but it rare for SOP to totally eliminate our ability to measure a velocity. _____
  - Fiber Optic connections are easily made dirty, which causes loss of light and may cause burning at higher powers and catastrophic loss of light. _____
  - PDV Systems recently brought to a firing site need to be verified as fully operational. _____
  - It is important to precisely measure the signal path delay. _____
  - The best practice is to use a Check Sheet to complete the checks of the diagnostic system before an experiment. _____
  - PDV lasers are typically narrow line-width, Erbium fiber lasers. _____
  - The typical data analysis is to make a spectrogram using a Short-time Fourier Transform. _____

We hope that this one-day intensive class serves as a base for further learning on PDV, associated diagnostics, and the measurements of dynamic phenomena.

- **This class does not cover all the knowledge and skills to become a fully qualified operator.**
- If you are interested further, please let me know.
- Thank you for your attention.