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TIME MULTIPLEXED PDV IN HE EXPERIMENTATION

FREQUENCY MULTIPLEXED PDV TESTS

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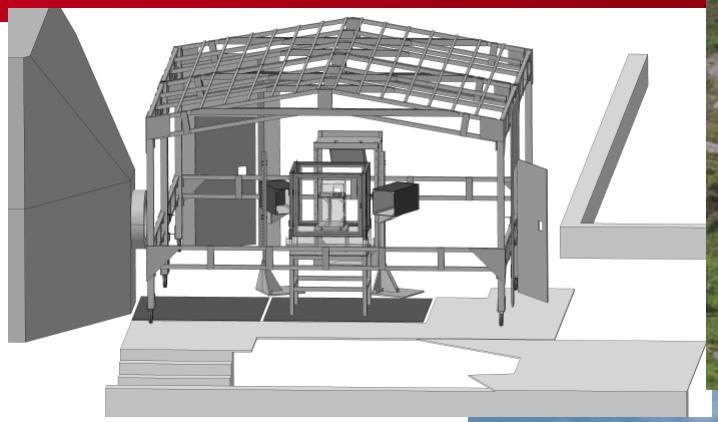
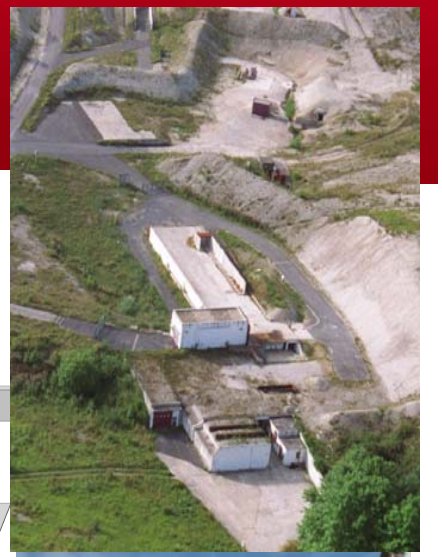
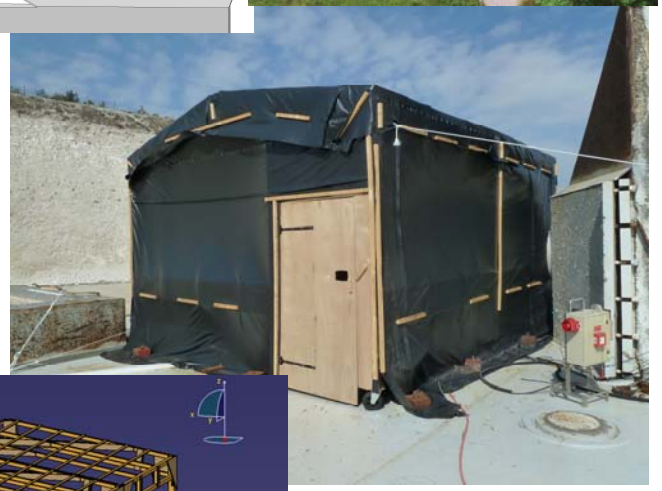
HE experiment setups

- Characterization of new material in HE experimentation
- HE Experimentation setups :
  - High speed frame camera
  - Optical fiber diagnostic (chronometry)
  - PDV measurement
- 4 weeks of preparation
- Team : 4 persons
- Temperature control
- Remote control for each PDV cabinet (over local network)





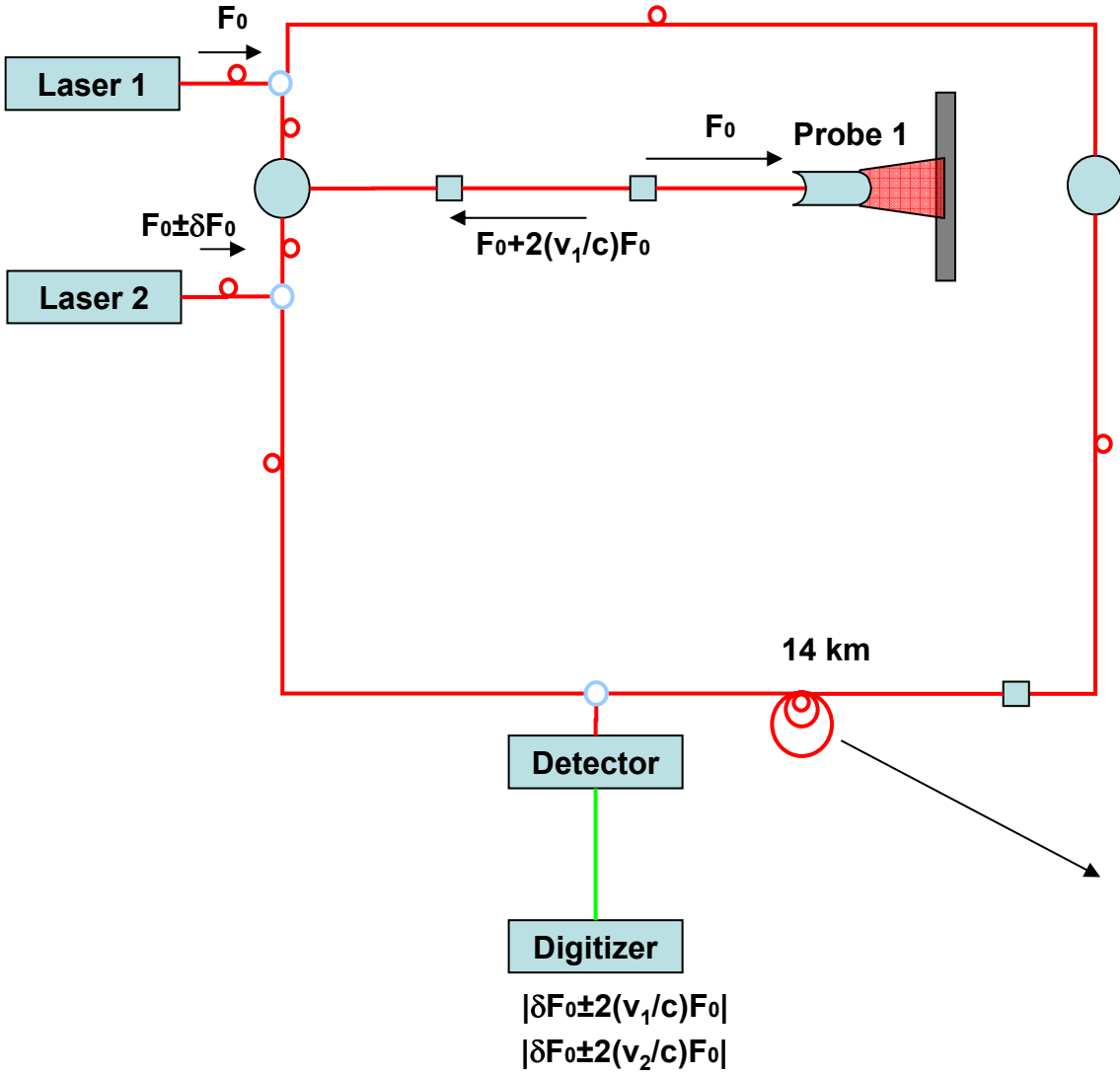


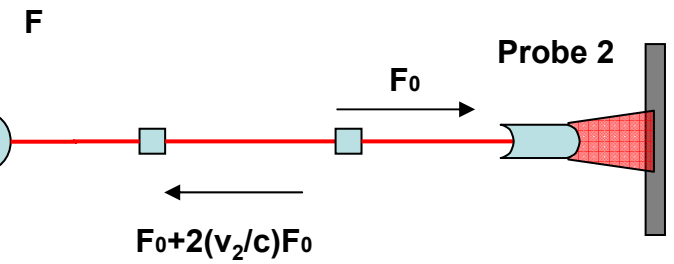
PDV Cabinet with time multiplexing

- Digitizer Tektronix DPO 71254 or Agilent DSO 91204A
  (BW = 13GHz, 50GSa/s) (BW = 12GHz, 40GSa/s)
- Greenfield TTL Delay Generator (adjust laser settings)
- Keyboard and touchpad
- Detectors New Focus (BW = 13 GHz),
  Power monitors
  Variable optical attenuators
- Reference Laser (Pmax =65 mW, λ = 1550 nm)
- Main Laser (Pmax =450 mW / 4, λ = 1550 nm)
- Time multiplexing 2x
  (14 km OF, ~ 70 µs)
- Switch Network

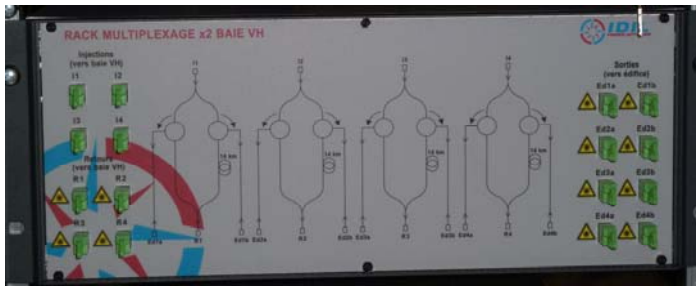
IDIL manufacturer

Time multiplexing PDV



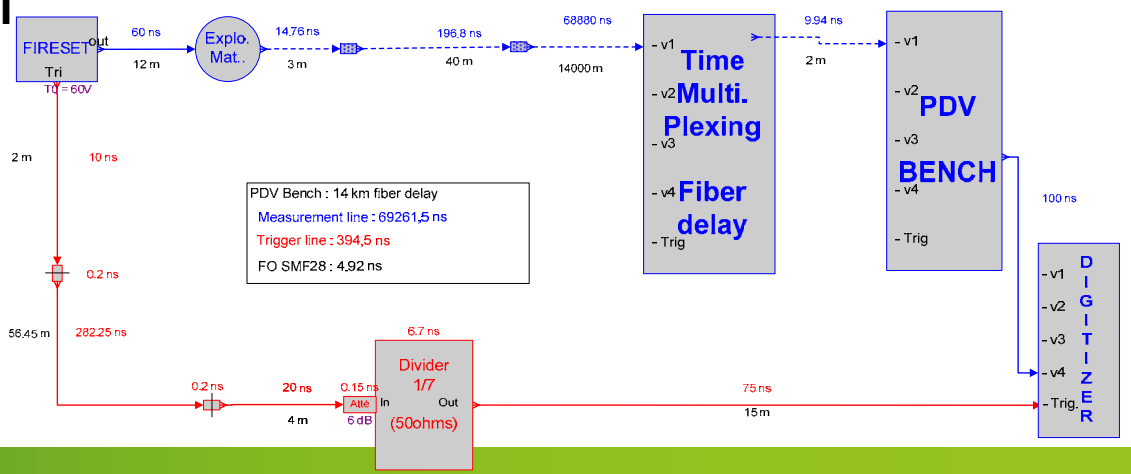


- **Time multiplexing:**
  - **Delay: 14 km ~ 70 µs**
  - **Attenuation: each PDV multiplexed channel is divided by 4**
  - **Max: 2 probes / digitizer channel**

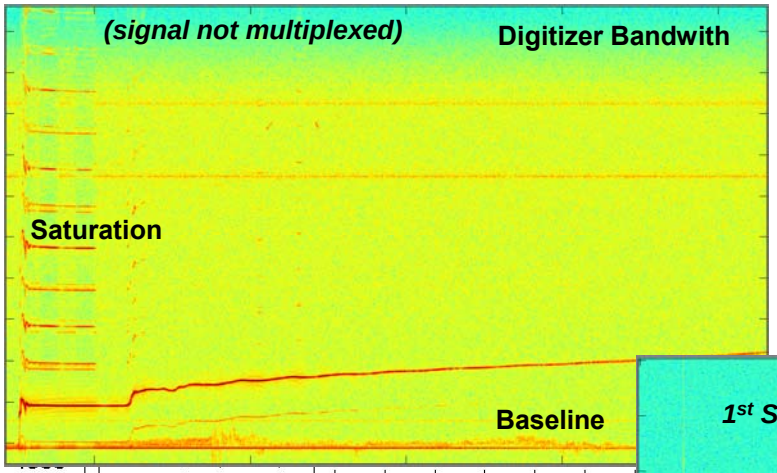


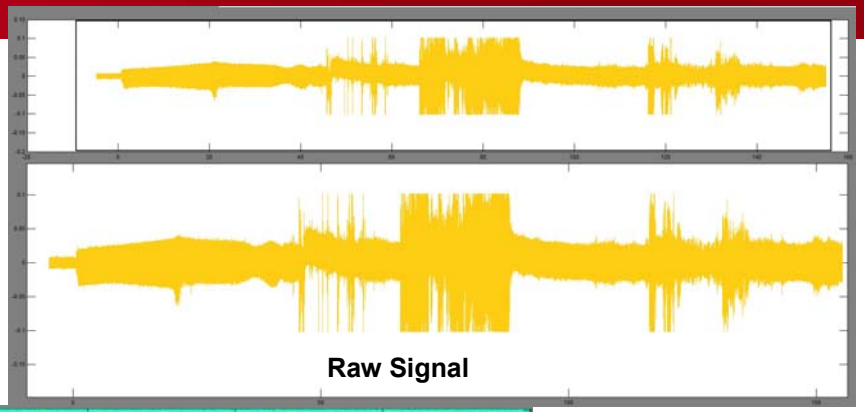
PDV Setup

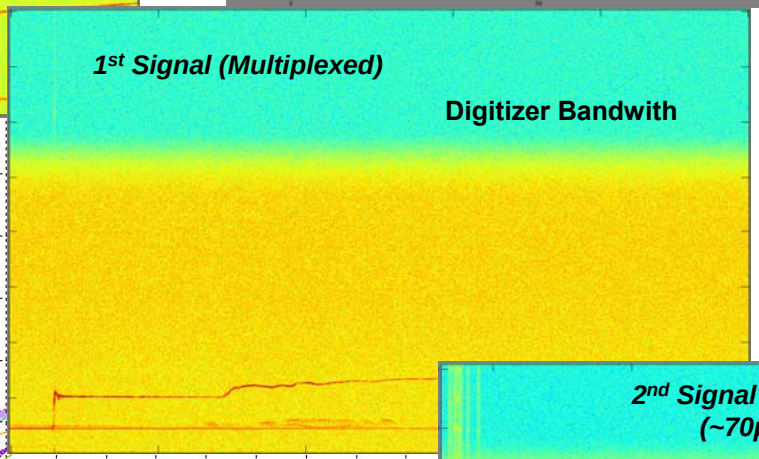
- 10 PDV cabinets (IDIL)
- 66 PDV probes recorded: 65/66 useful
  - Uncertainty : 0.010 µs (16m/s, 2δ)
  - Long duration : > 50 µs
  - 80 % of good quality signals
  - 1 lost signal
  - 18 % low quality signal

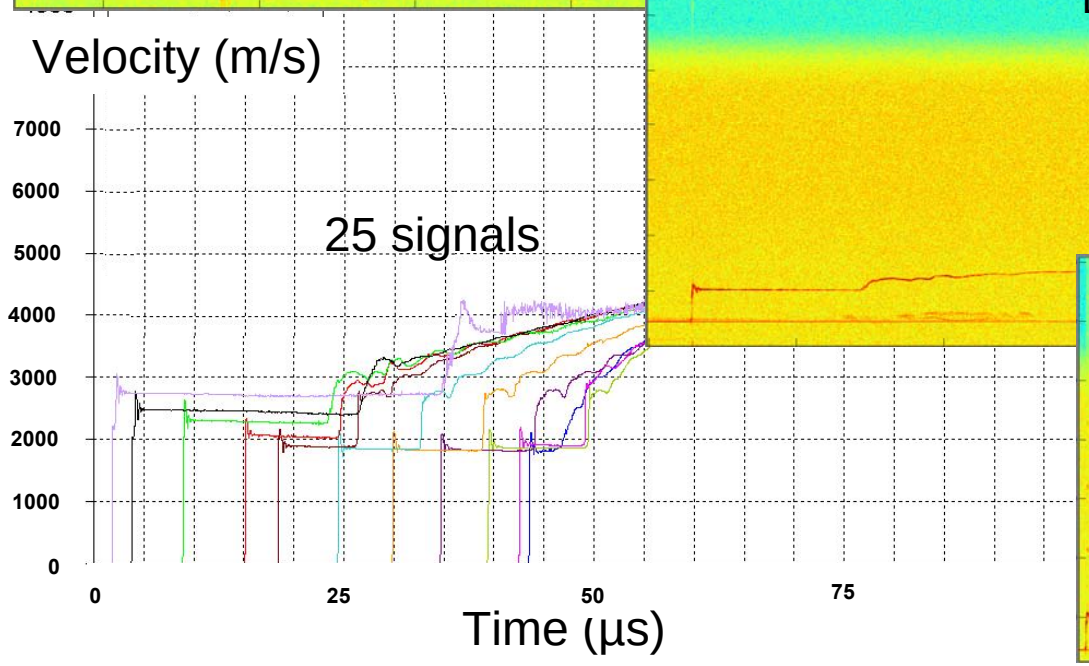


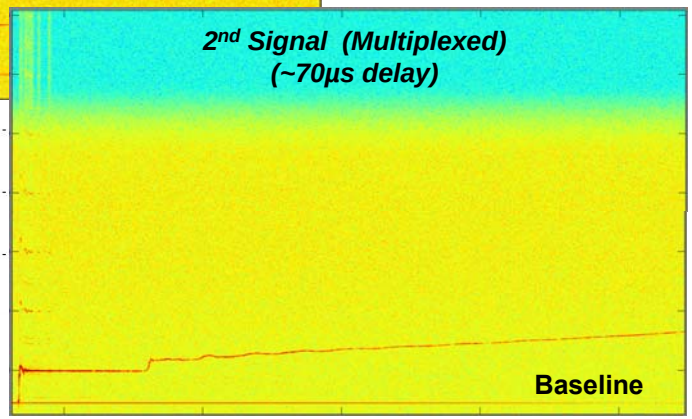
PDV Signals


(signal not multiplexed)
Digitizer Bandwith
Saturation
Baseline


Raw Signal


1st Signal (Multiplexed)
Digitizer Bandwith


Velocity (m/s)
7000
6000
5000
4000
3000
2000
1000
0
25 signals
0
25
50
75
Time (µs)


2nd Signal (Multiplexed)
(~70µs delay)
Baseline

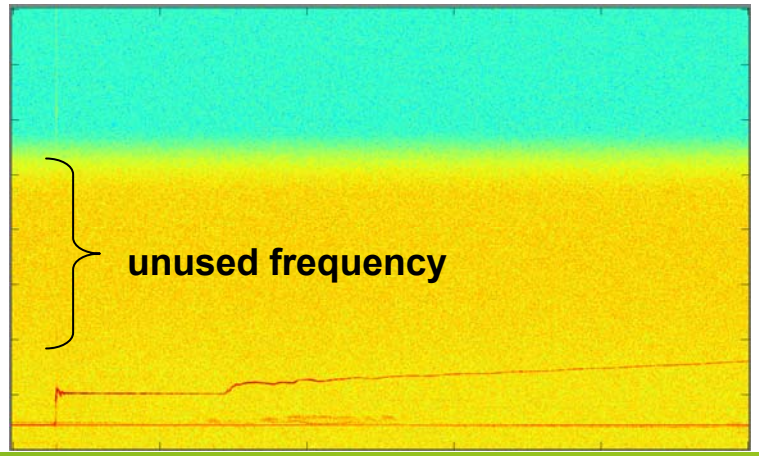
Concluding Remarks…

- Time multiplexing increase the number of PDV channels by 2
  (2 x 4 digitizer channel x10 cabinets = 80 PDV channels)
- Good signal quality
- Easy to use
- Compact system
- Cost effective

BUT

- Check probe efficiency : signals are divided by 4 for each PDV channel
- Same adjustment for coupled PDV signals

However we still need to increase the number of PDV signals: one solution is frequency multiplexing coupled to time multiplexing



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FREQUENCY MULTIPLEXED PDV TESTS

Frequency PDV Multiplexing Tests

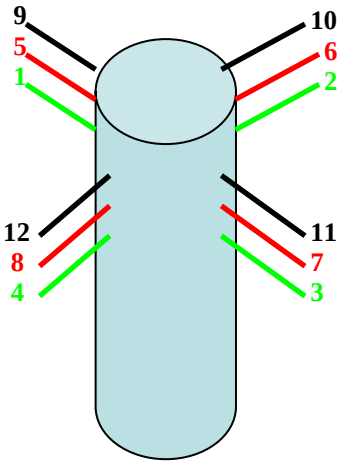
- Main goal: to study 3 frequency multiplexing configurations

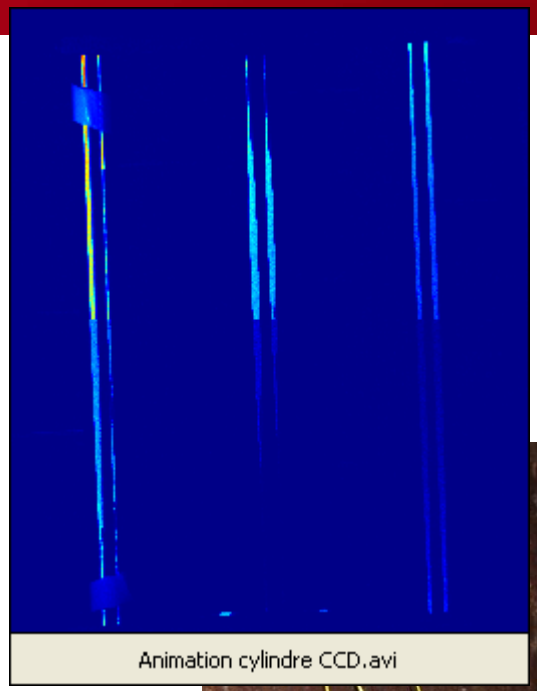
- Additional goals:
  - Laser diode test (IDIL cooperation)
  - Test of new digitizer

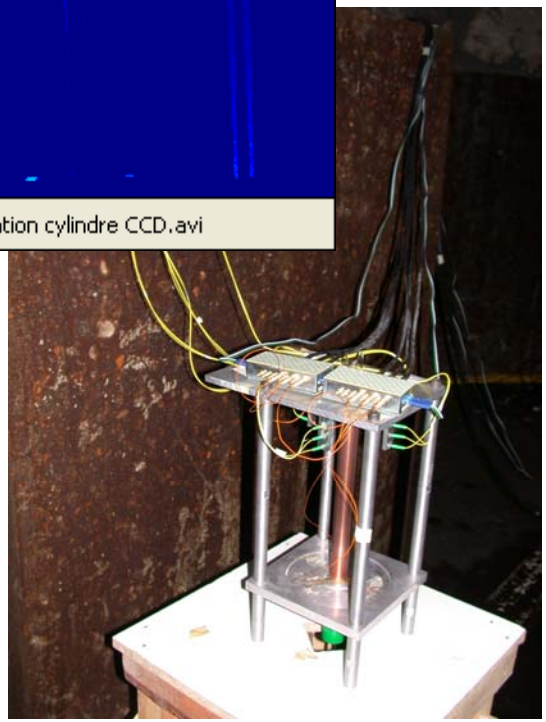
⇒ To cover all of these topics in a single experiment we chose a cylinder test
  - No time multiplexing test
  - 4 PDV cabinets (3 modified)

Experimental Setup

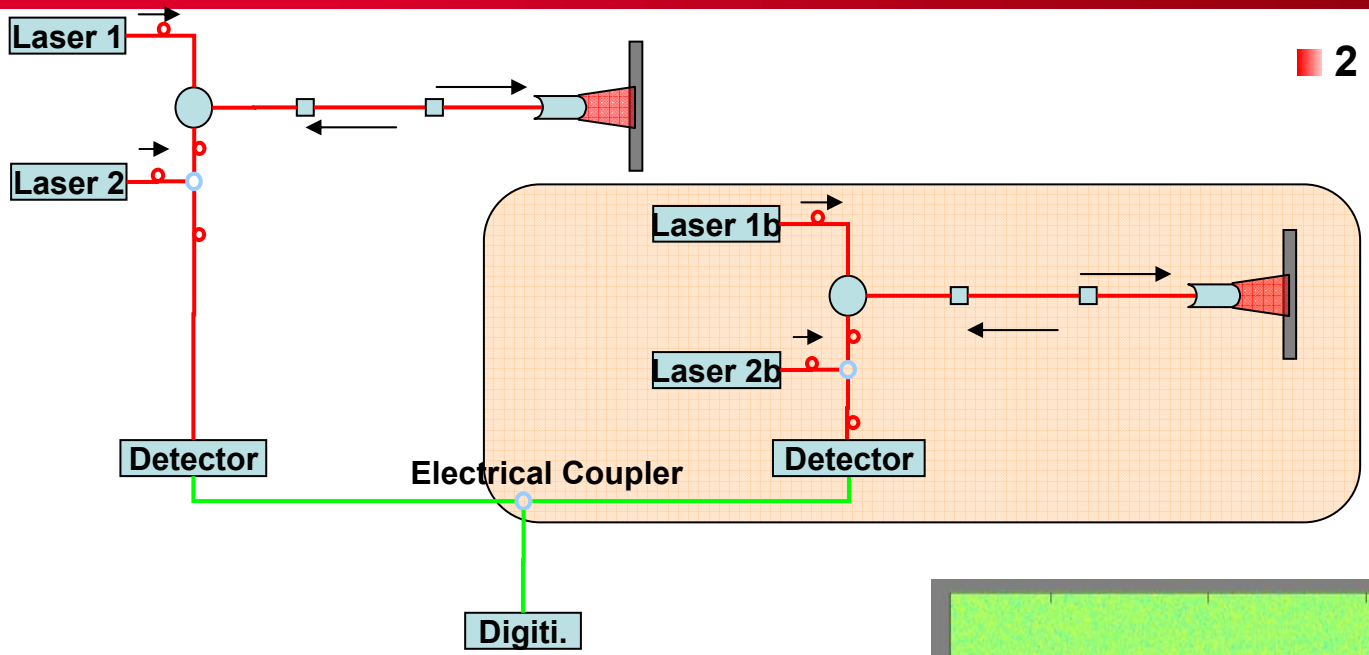
- Experimental device
  - Copper cylinder (∅ 30mm, L 300mm)
  - Well known reactive compound: nitromethane
- Measurement
  - High speed camera
  - 6 electric probes
  - 9 PDV probes







Frequency multiplexing : 1st configuration

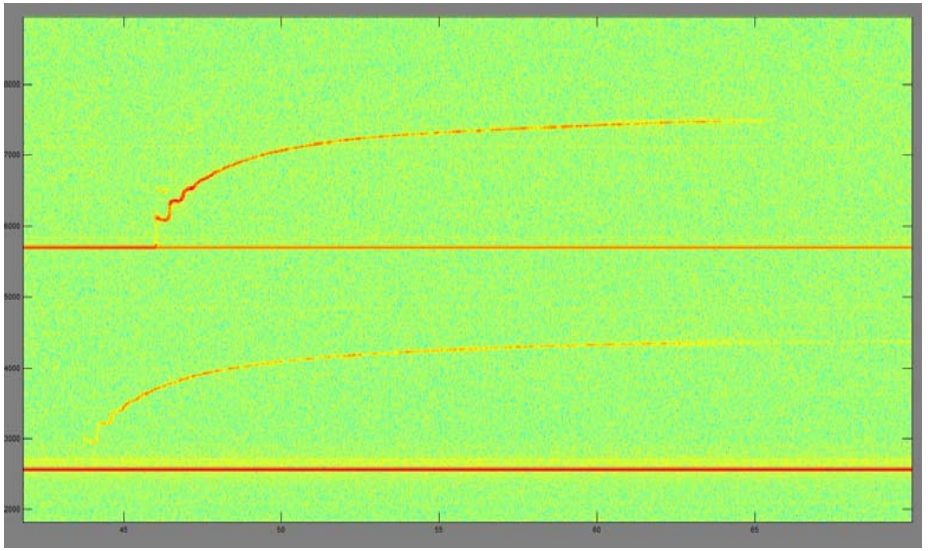


- 2 PDV cabinets
  - 2 Main Lasers
  - 2 Reference Lasers
  - 2 Optical detectors
  - 1 Digitizer
  - 1 Electrical coupler

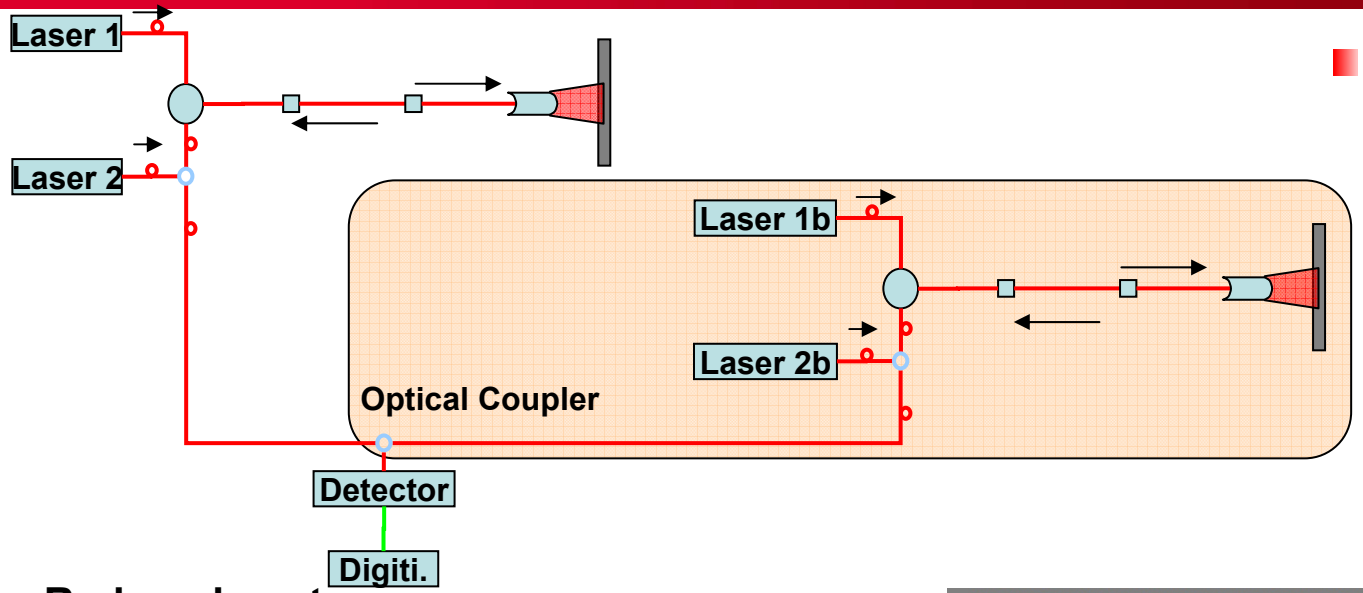
- Spectrogram: easy to analyse
  - no crossover if signals known (adapt baselines)
- Reduced cost
  - Only 1 digitizer channel for 2 optical detectors and 2 PDV channels

BUT

- Velocity range reduced by 2



Frequency multiplexing : 2nd configuration



- 2 PDV cabinets
  - 2 Main Lasers
  - 2 Reference Lasers
  - 1 Optical detector
  - 1 Digitizer
  - 1 Optical coupler

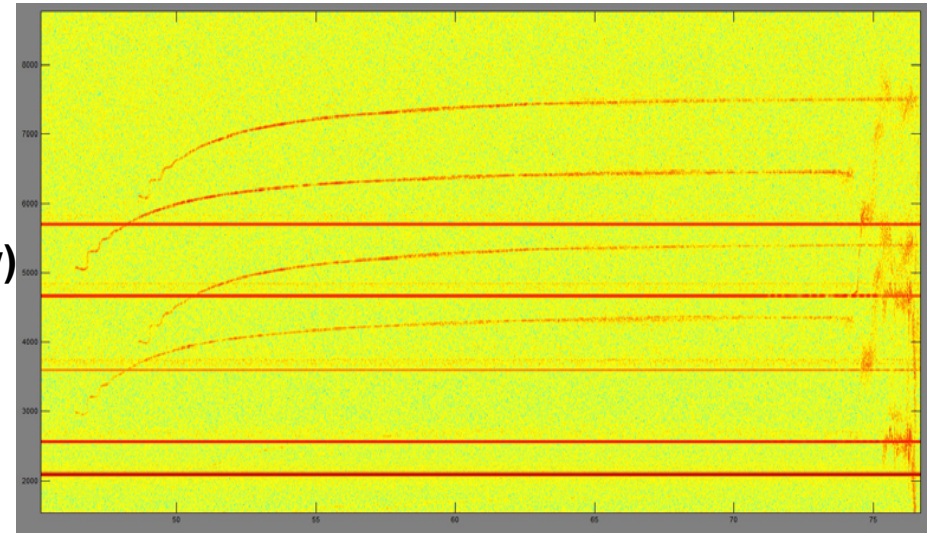
- Reduced cost
  - Only 1 digitizer channel and 1 optical detector for 2 PDV channels

BUT

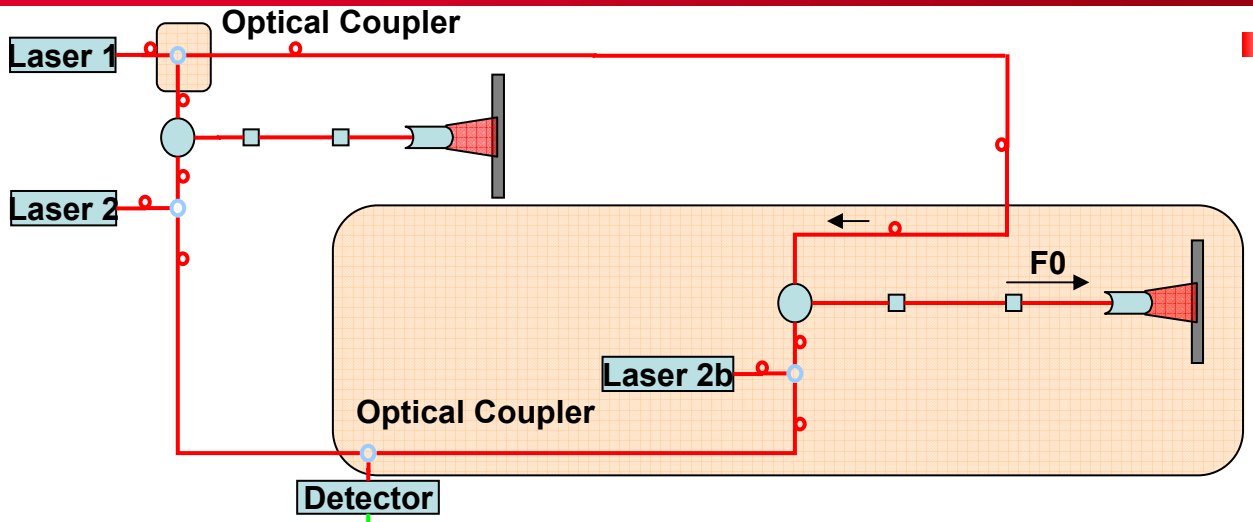
- Multifrequency crossovers (detector window)
  - Optical power detector limited !

- Spectrogram analysis has become too complex…

- Velocity range reduced by 3 or 4



Frequency multiplexing : 3rd configuration

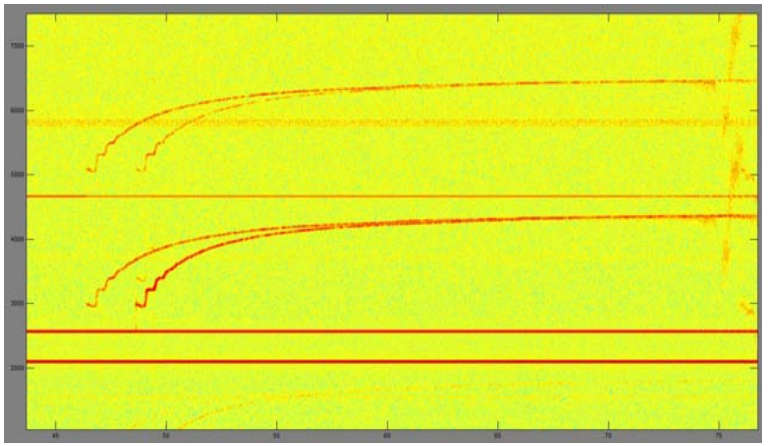


- 2 PDV cabinets
  - 1 Main Laser
  - 2 Reference Lasers
  - 1 Optical detector
  - 1 Digitizer
  - 2 Optical couplers

- Reduced cost
  - Only 1 main Laser and 1 optical detector

BUT

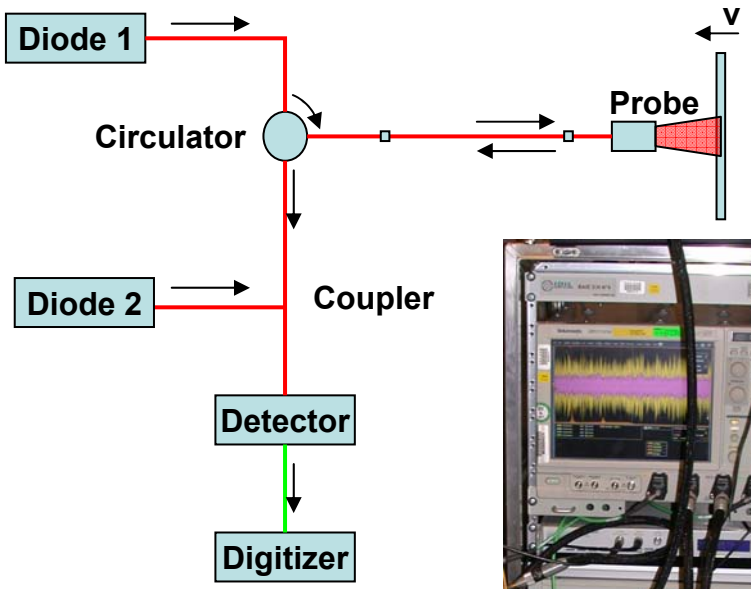
- Simple frequency crossovers (detector window)
- Velocity range reduce by 2
  - Optical power detector limited
- Spectrogram analysis is made more complex, especially when signals are not known

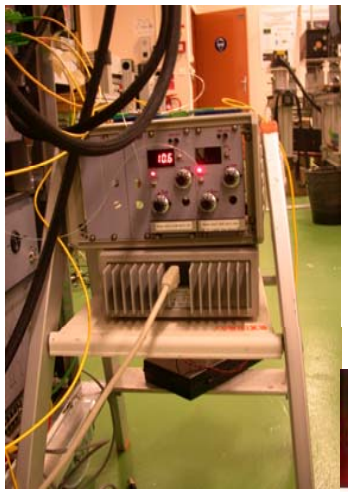


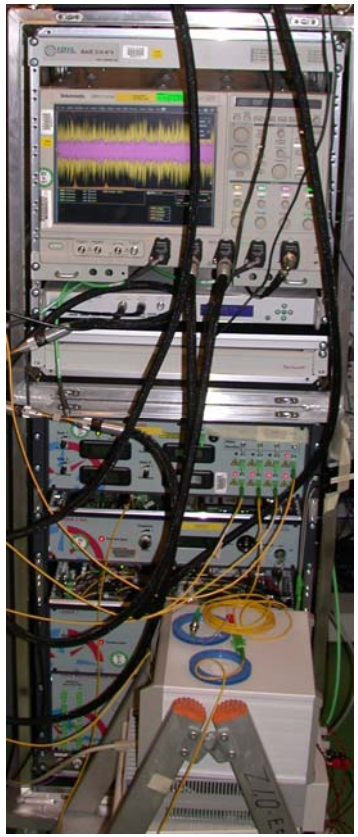
- Modification of optical connections and main power divided by 2

First Diode Laser Test on PDV channel

- Laser Diode: modified cabinet
  - Main Laser: Laser Diode 1
  - Reference Laser: Laser Diode 2
- Laser Diode characteristics
  - Optical power: 10-15 mW
  - Wavelength: 1565 nm
  - Adjustable Wavelength



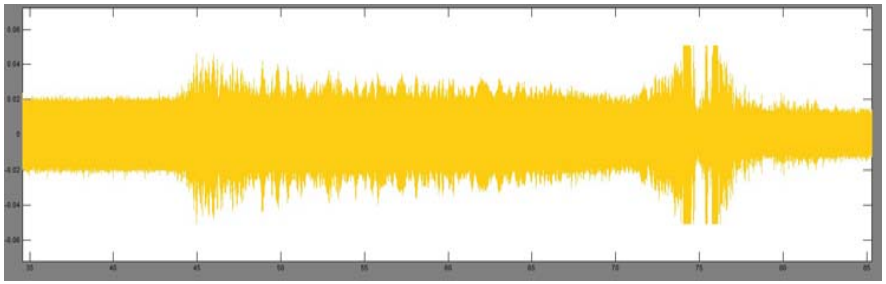




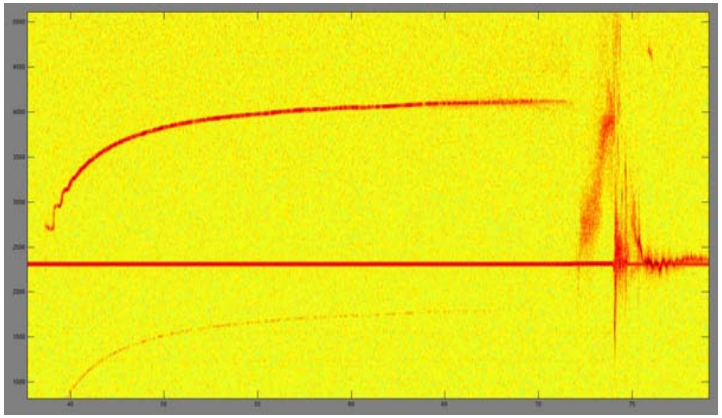
Laser Diode versus Classic Laser

Classic Laser

Raw Signal

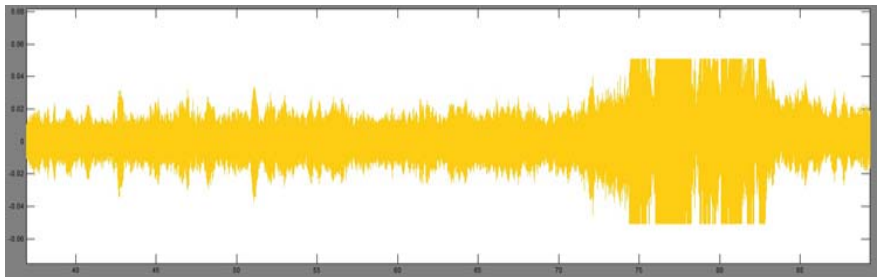


Spectrogram

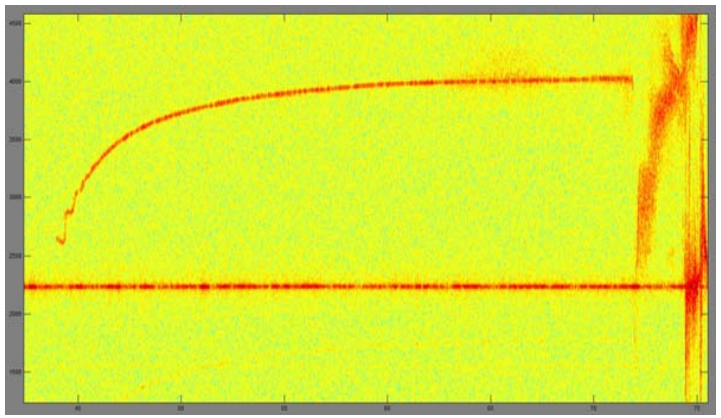


Laser Diode

Raw Signal

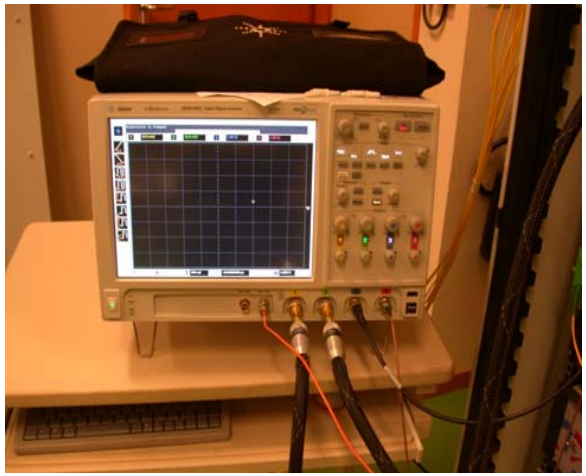


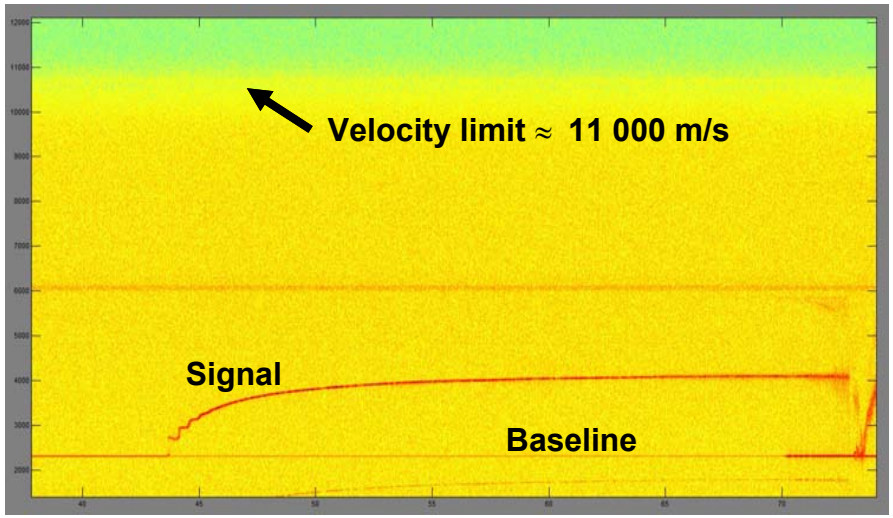
Spectrogram



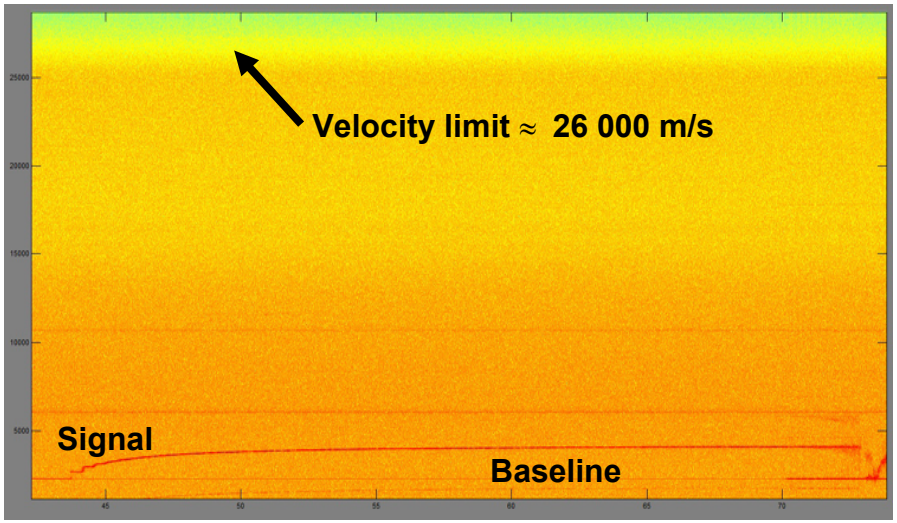
Digitizer Test

Agilent DSO 91204A
12 GHz - 40GSa/s





Agilent DSA X92504A
25GHz - 80GSa/s



Conclusion…

- First test on Laser Diode
  - Good results
  - More flexibility to adjust the reference laser
    - 1 Laser diode for 1 PDV channel : adjust each PDV baseline

  ⇒ Frequency multiplexing possible

- Digitizer comparison
  - New digitizer : increase velocity range (> 25 000m/s)
  - More bandwith for frequency multiplexing

  ⇒ Need large bandwith optical detector

- Frequency multiplexing:
  - 1st configuration
    - Simple to use, good signal quality
  - 2nd configuration
    - Signal extraction is almost impossible
  - 3rd configuration
    - Investigations have to be performed…
- The first solution, including electrical coupler, is the best way for frequency multiplexing

- The Laser Diode solution allows baseline adjustment for each PDV signal…so for frequency multiplexing !

⇒ New IDIL cabinet with 4/8 PDV channels…The first one is on the way…

Thank you for your attention.