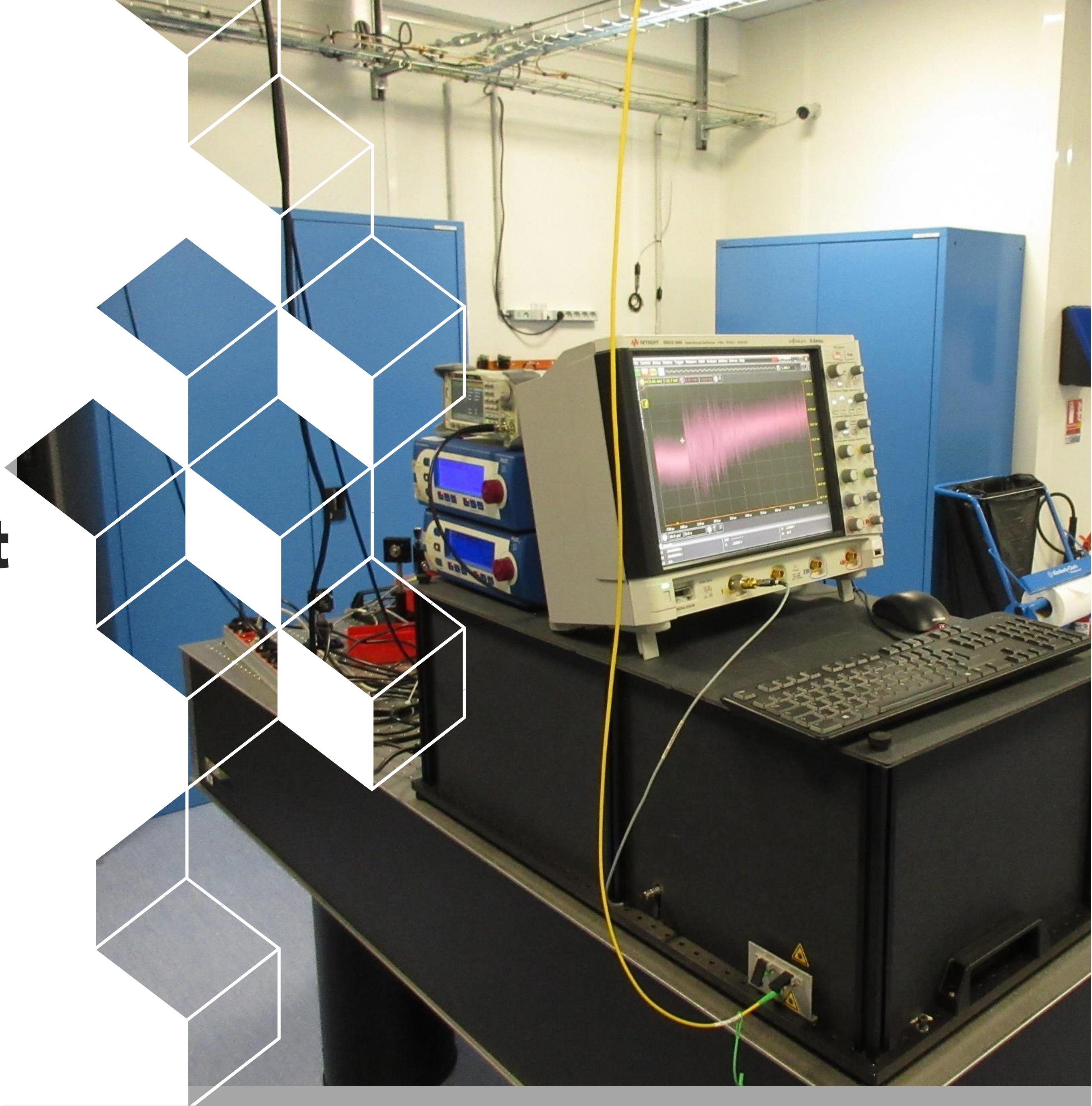
New PDV development at 830 nm



Jacky BÉNIER

Summary

1. New PDV development at 830 nm
2. Comparison between PDV830 nm and PDV1550 nm
3. Ejecta observation
4. Conclusion and prospects

1. New development at PDV 830 nm

Interest of 830 nm

Limit of PDV diagnostic => STFT analysis

Measurement uncertainty => Gabor unequal : $\Delta f \cdot \Delta T \geq \frac{1}{4\pi}$ **and** $\Delta V \cdot \Delta T \geq \frac{\lambda}{8\pi}$

Wavelength (nm)	830	1550
Gabor limit (ns.m/s)	33	62
ΔT for ΔV = 10 m/s (ns)	3,3	6,2

➡ X 2

Wavelength (nm)	830	1550
Attenuation (dB/km)	4	0,2

➡ X 20

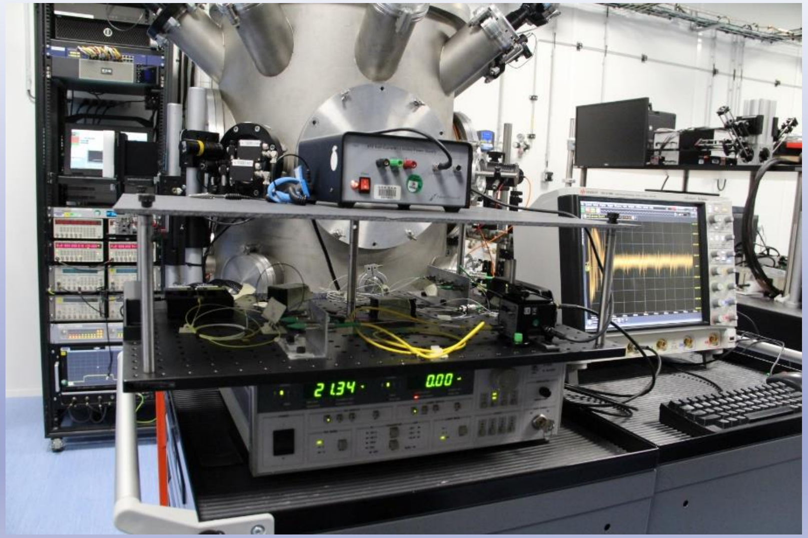
➡ **830 nm is a good compromise between attenuation in fiber (att. 9% for 100 m), availability of components and resolution (in time and velocity)**

STFT : Short-Time Fourier Transform

First prototype's evolution

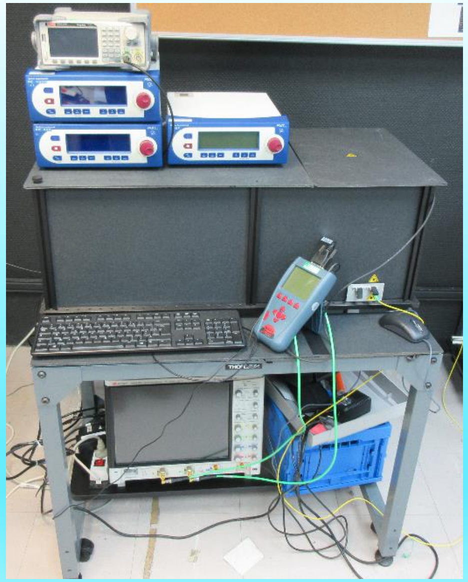
First generation:

- 1 channel
- Power = 10 mW
- CW



Second generation :

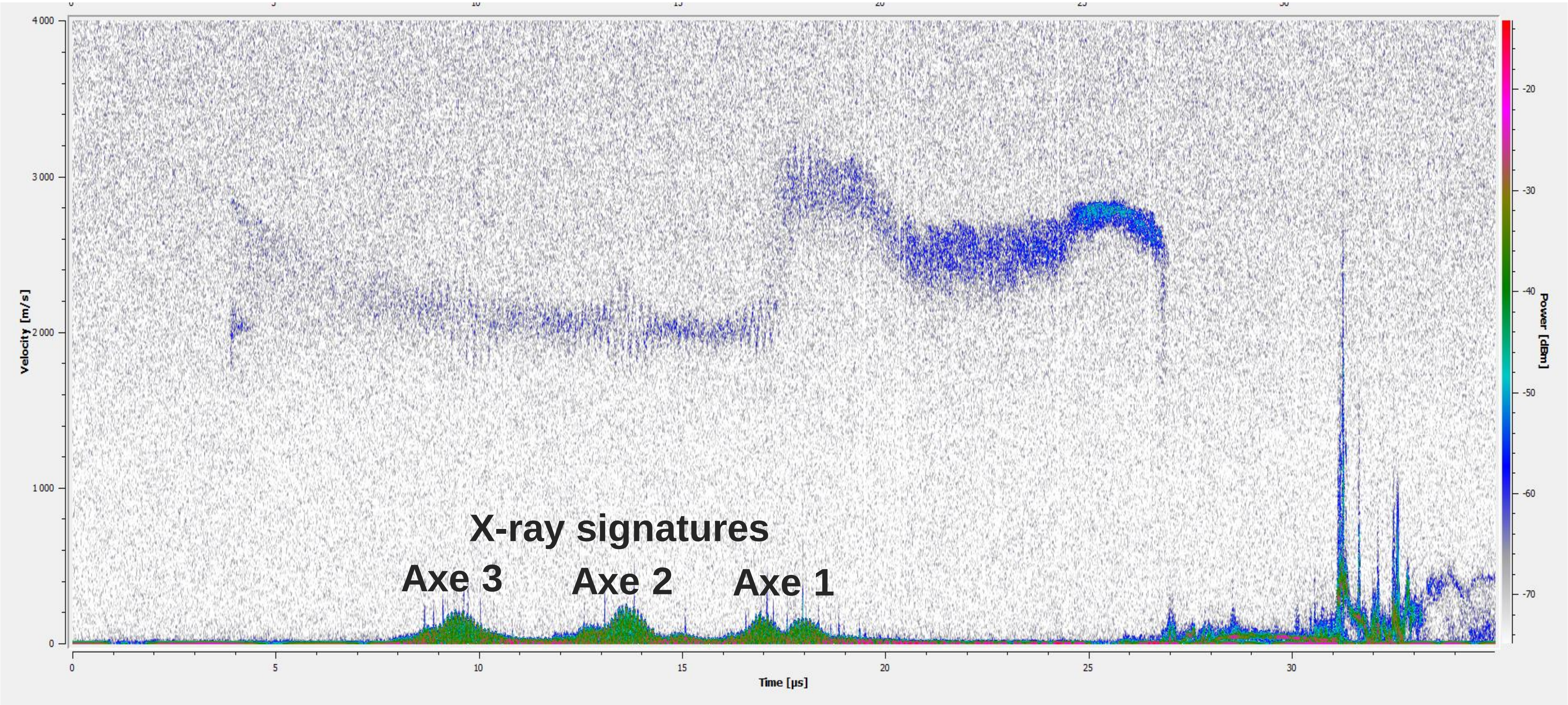
- 2 channels
- PDV with modular ref
- Power > 150 mW
- CW and pulse



System’s limitation

1. Sensitivity to thermal and vibration variations: mechanical laser injection into the fiber (MFD: 5 µm)
2. X Ray interaction in optical fiber (Si and Ge)
3. Optical fiber attenuation
4. IL connector (reduced number of connections)
5. Circulator crosstalk and isolation
6. Noise (NEP)

Signal disturbed by X-ray



Hypothesis : X-ray interaction with silica and germanium induced attenuation (RIA), emission (RIE) and Cerenkov effect.

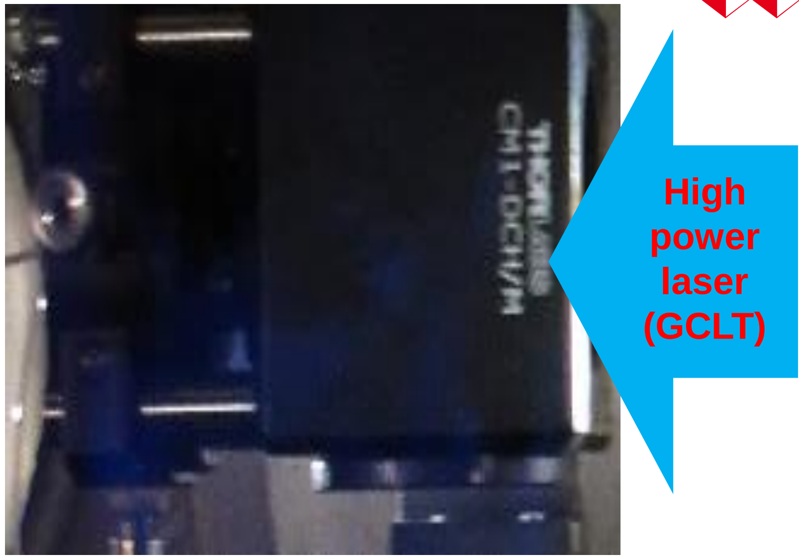
Circular Data sheet comparison

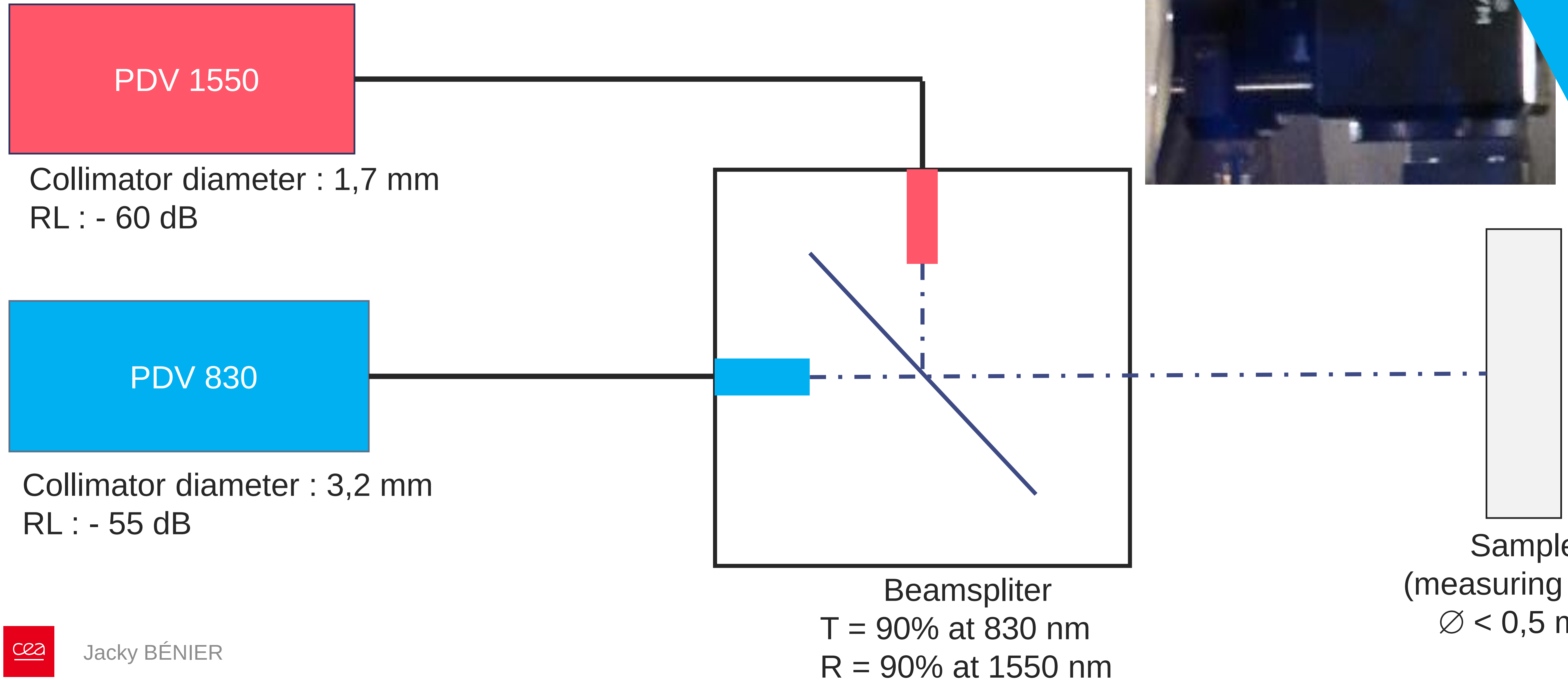
Characteristic	PDV 1550	PDV 830
Crosstalk	> 55 dB	> 45 dB
Insertion Loss	< 0.8 dB	< 1.8 dB
Channel isolation	> 45 dB	> 18 dB
Price	700 €	2000 €

2. Comparison between PDV 830 & PDV 1550 and simulation (ESTER code)

PDV 830-1550 probes set up

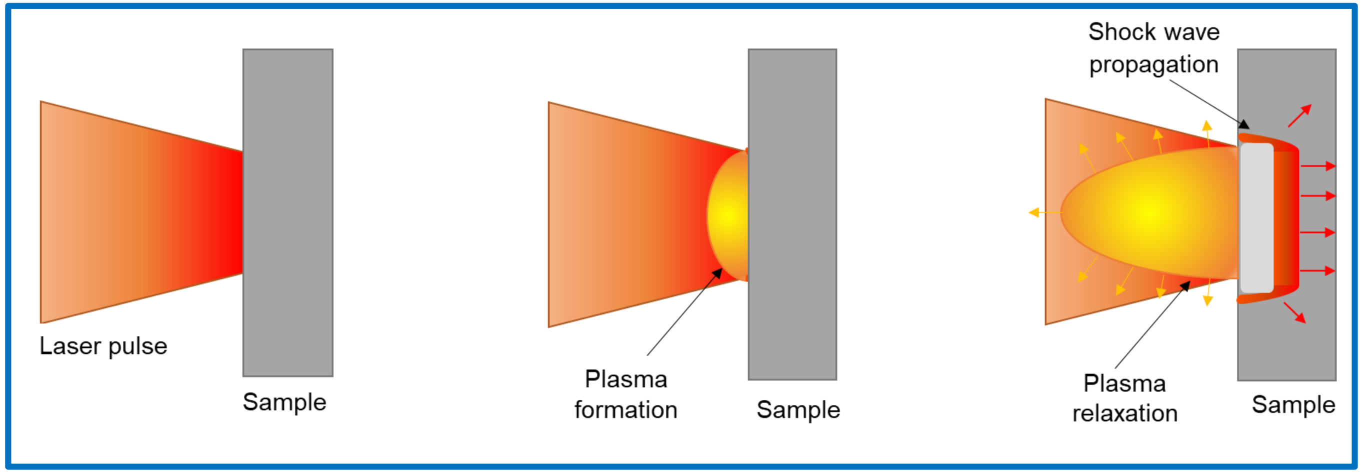
We observe same point of interest at same time





GCLT : Générateur Choc Laser Transportable

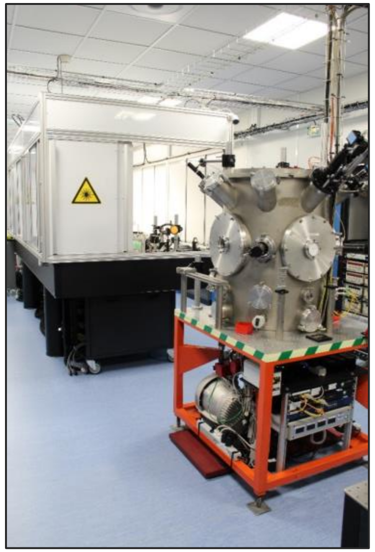
How to generate shock waves with laser power ?



Main characteristics :

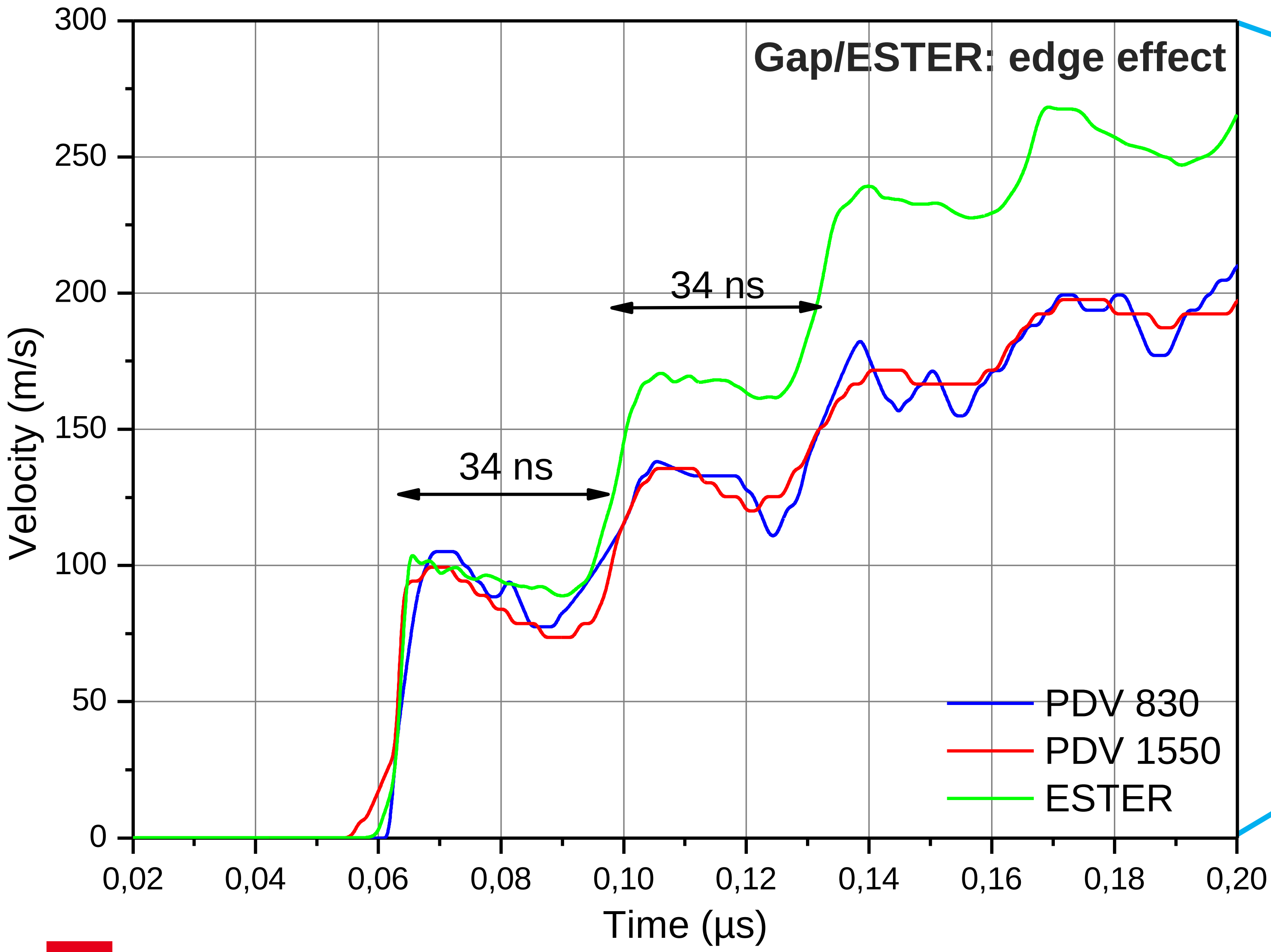
- λ : 1053 nm
- Energy max :
  - ➢ 60 J (4 ns)
  - ➢ 150 J (100 ns)
- 4 ns > Pulse width > 100 ns
- 0.1 mm > spot > 5 mm
- 7 GW/cm² > Power > 190 TW/cm²
- Shot frequency : 1 / 4 min

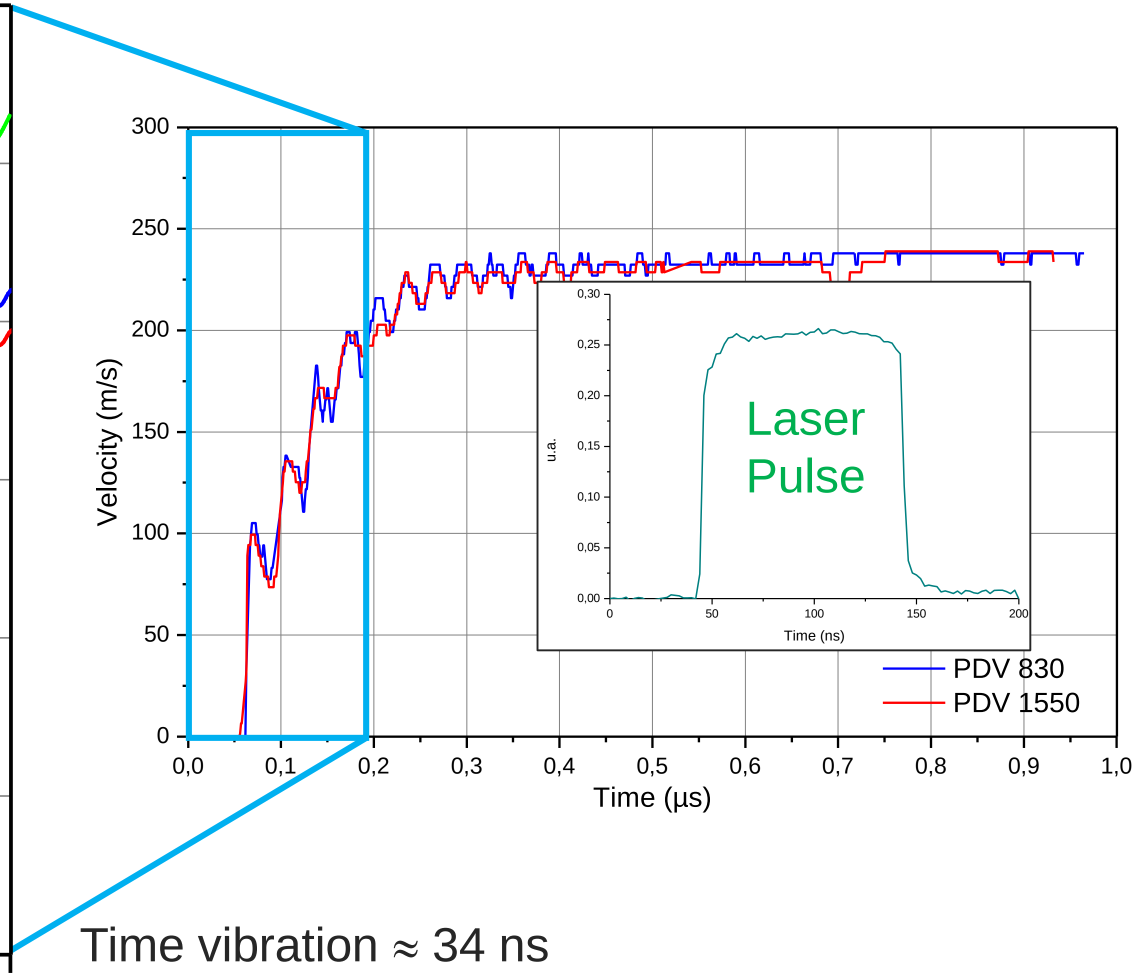
Produce a choc wave in sample and observation of vibrations



Acknowledgements: B. Jodar and T. Géral

Aluminum 100 µm

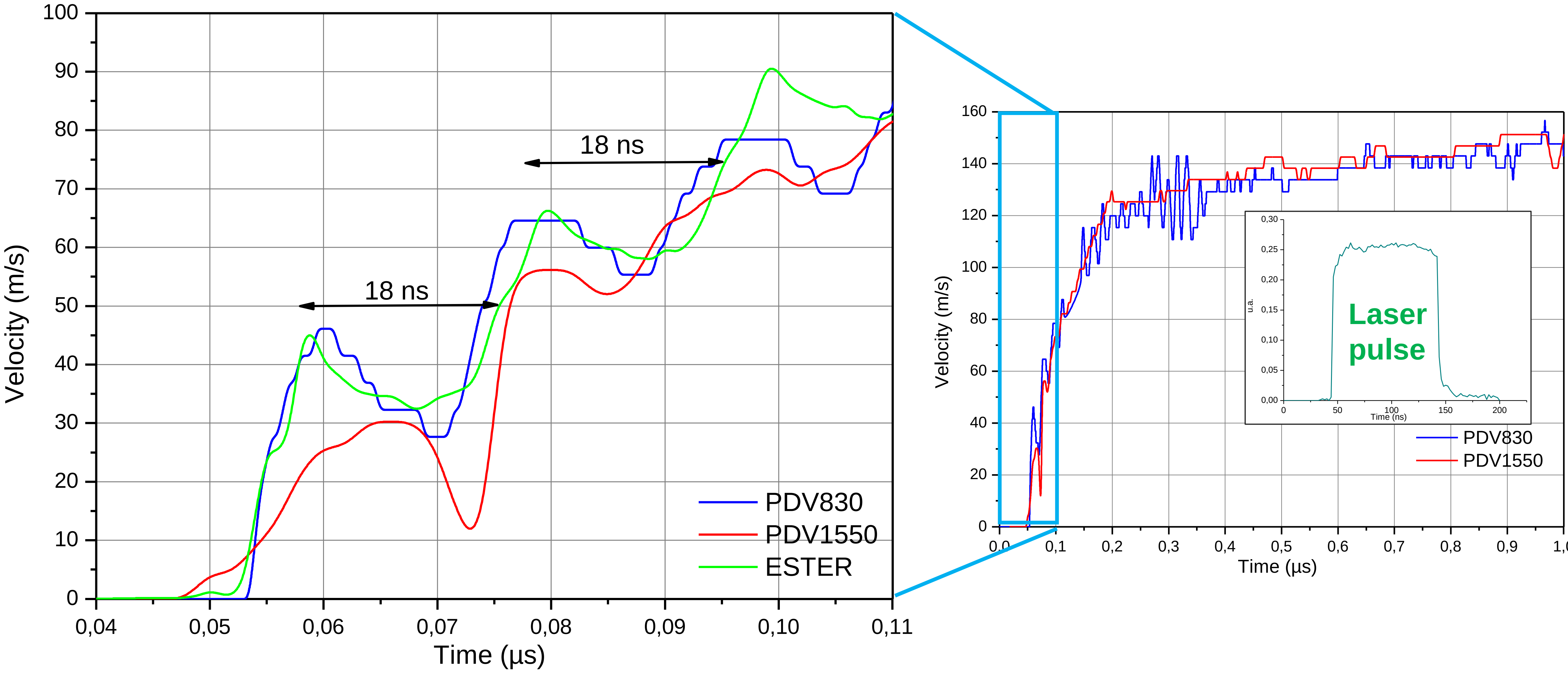




Time vibration ≈ 34 ns

Velocity difference between 2 wavelength: 10 m/s

Stainless steel 50 µm



Good agreement between PDV 830 and simulation during 50 ns

3. Ejecta observation

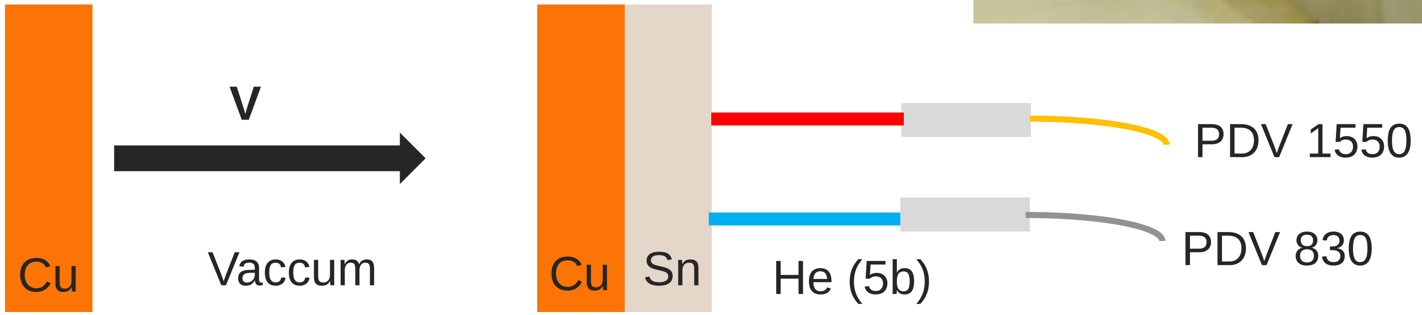
Gun experiment : 5b He

Gun facility ARES

- Diameter : 98 mm
- Lenght : 11 m
- Max velocity: 2300 m/s

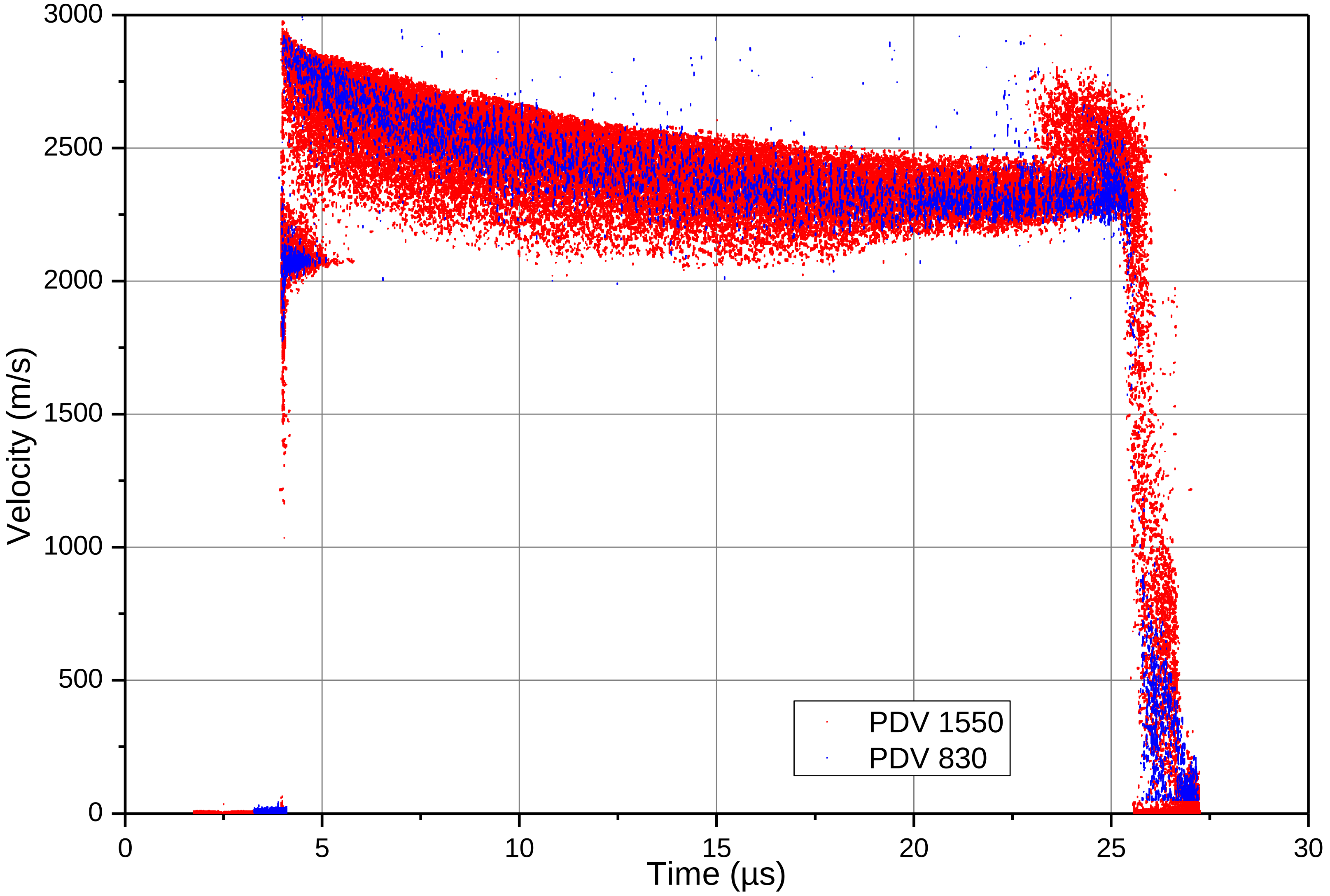
(projectile mass : 1,5 kg)

Experience



Acknowledgements : P. Héreil, C. Chauvin, A. Chauvin and ARES Team

Spectrogram comparison



2 channels at same radius (9 mm)

Signature are very similar
=> Particle sizes are the same ?

Reference : Recovering particle velocity and size distributions in ejecta with PDV

J.A. Don Jayamanne and all, https://doi.org/10.48550/arXiv.2406.14578

Conclusion and prospects

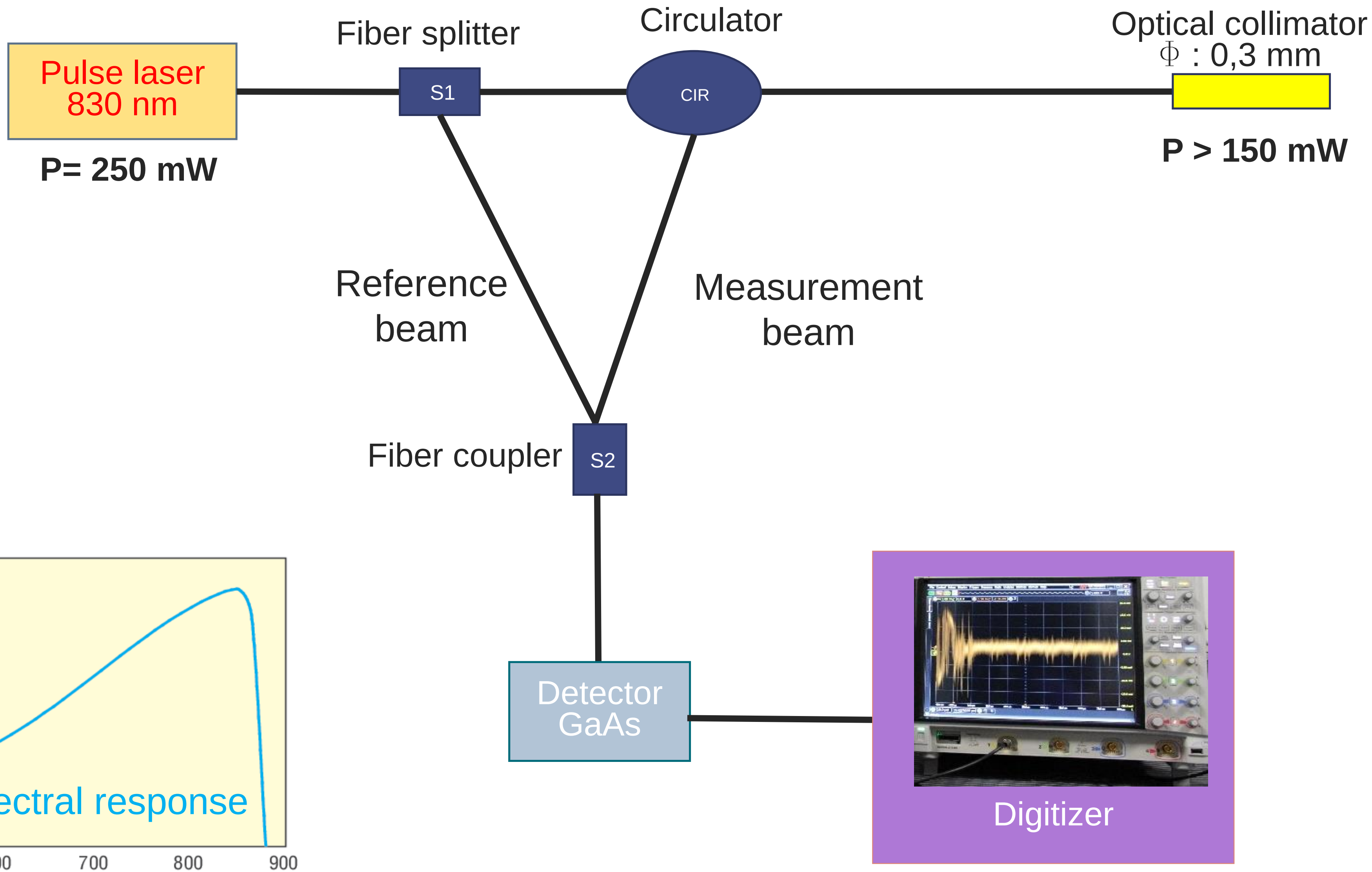
- Main limitation at 830 nm :
  - Components performances
  - Environment (temperature)
  - X-Ray interaction with fiber is visible by detector

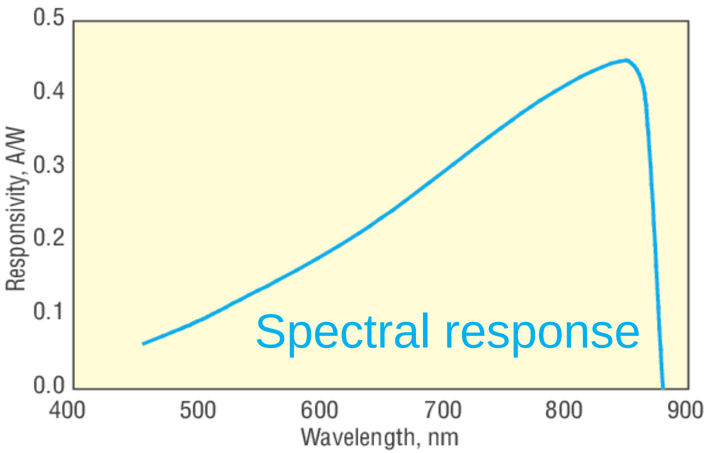
- Comparison PDV with GCLT :
  - Responses for 2 wavelength are similar (more details with PDV 830)
  - PDV 1550 : detection threshold is obtained for a stainless steel sample of 50 µm

- New prototype is more powerful (> 150 mW / channel) and allows to observe particle clouds
- We prospect for components with better performances
- Study at other wavelengths

Thank you for your attention

Optical design (Heterodyne with nul ref)





Optical design (Heterodyne with ref)