Applications des fibres optiques pour les mesures distribuées de contraintes, de température et de vibrations en environnement extérieur

Jean-Charles Beugnot

FEMTO-ST Institute,

Université Bourgogne Franche-Comté,

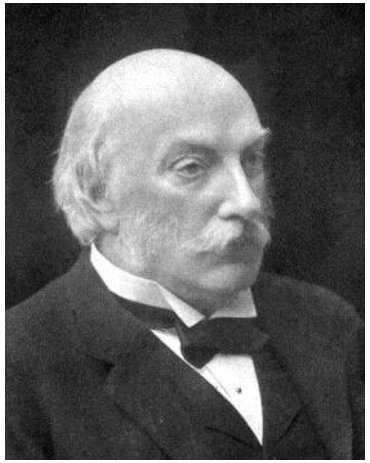
CNRS 6174, Besançon, France

OSU Journée Capteur, 21 Octobre 2021

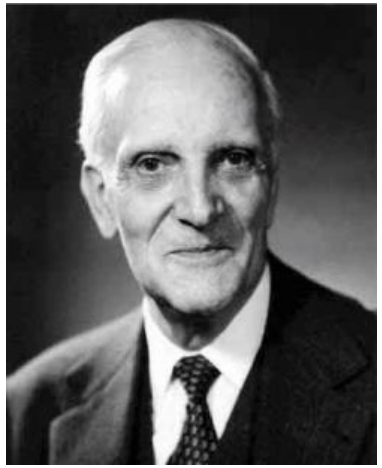
Plan

- **Les fibres optiques**

- **Les mesures distribuées par diffusion de la lumière**



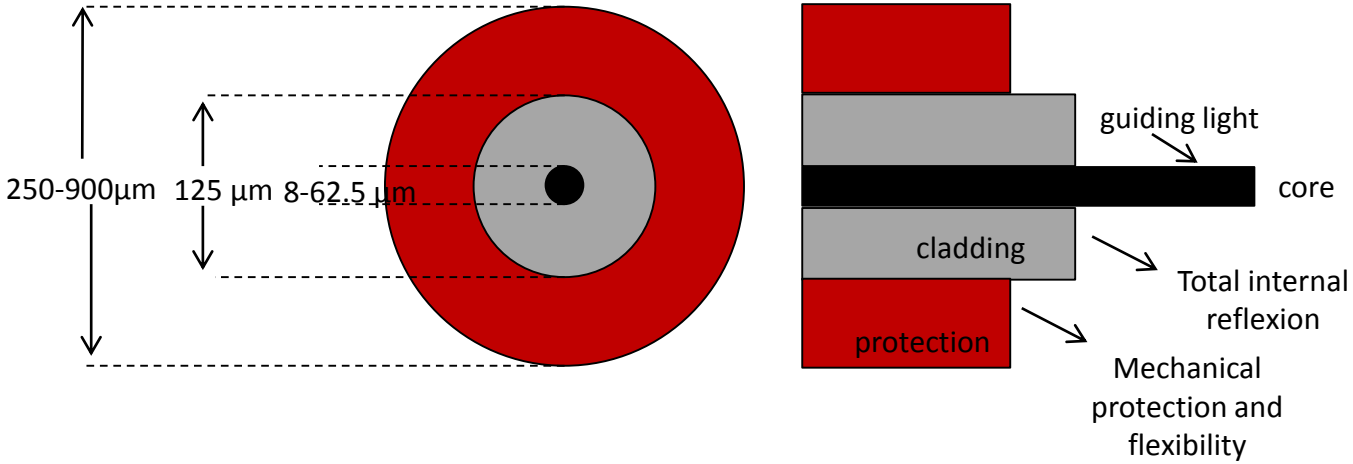
J. W. Rayleigh (1842-1919)

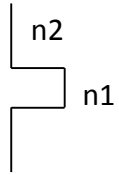


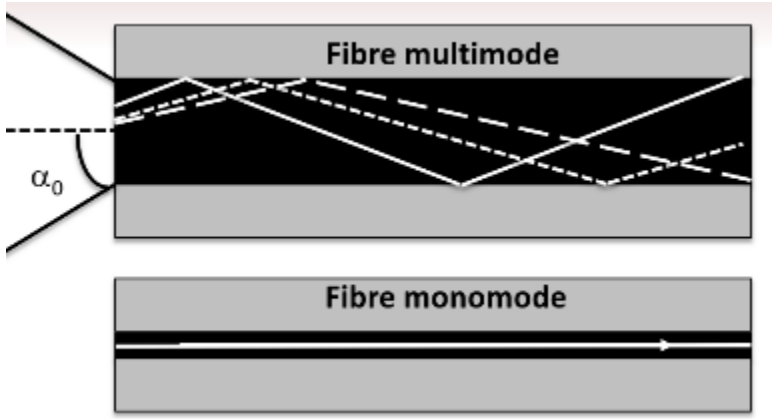
L. Brillouin (1889-1969)

C. V. Raman (1888-1970)

Les fibres optiques en silice

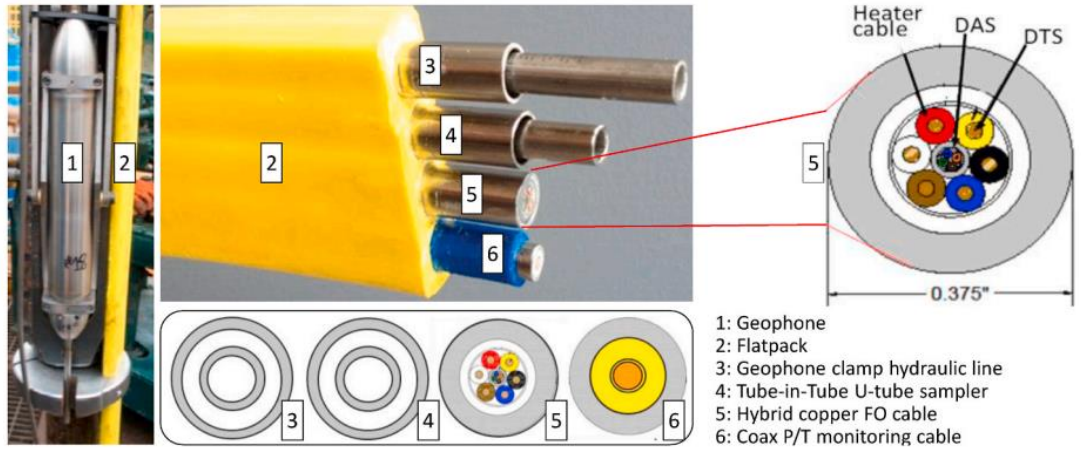


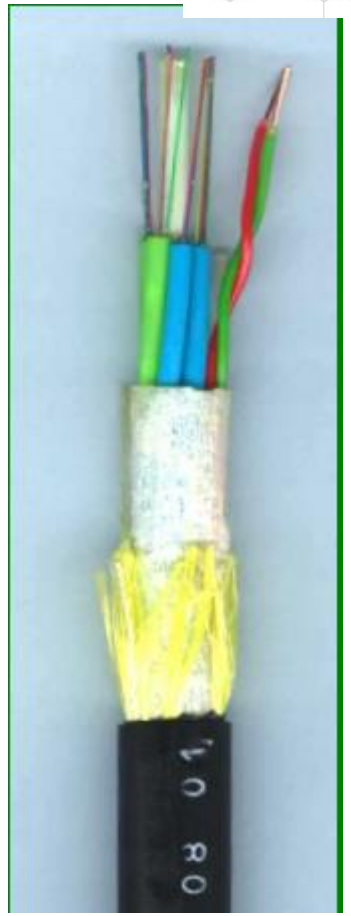




➔ Les fibres optiques sont insensibles et non génératrice de parasites….
mais fragiles

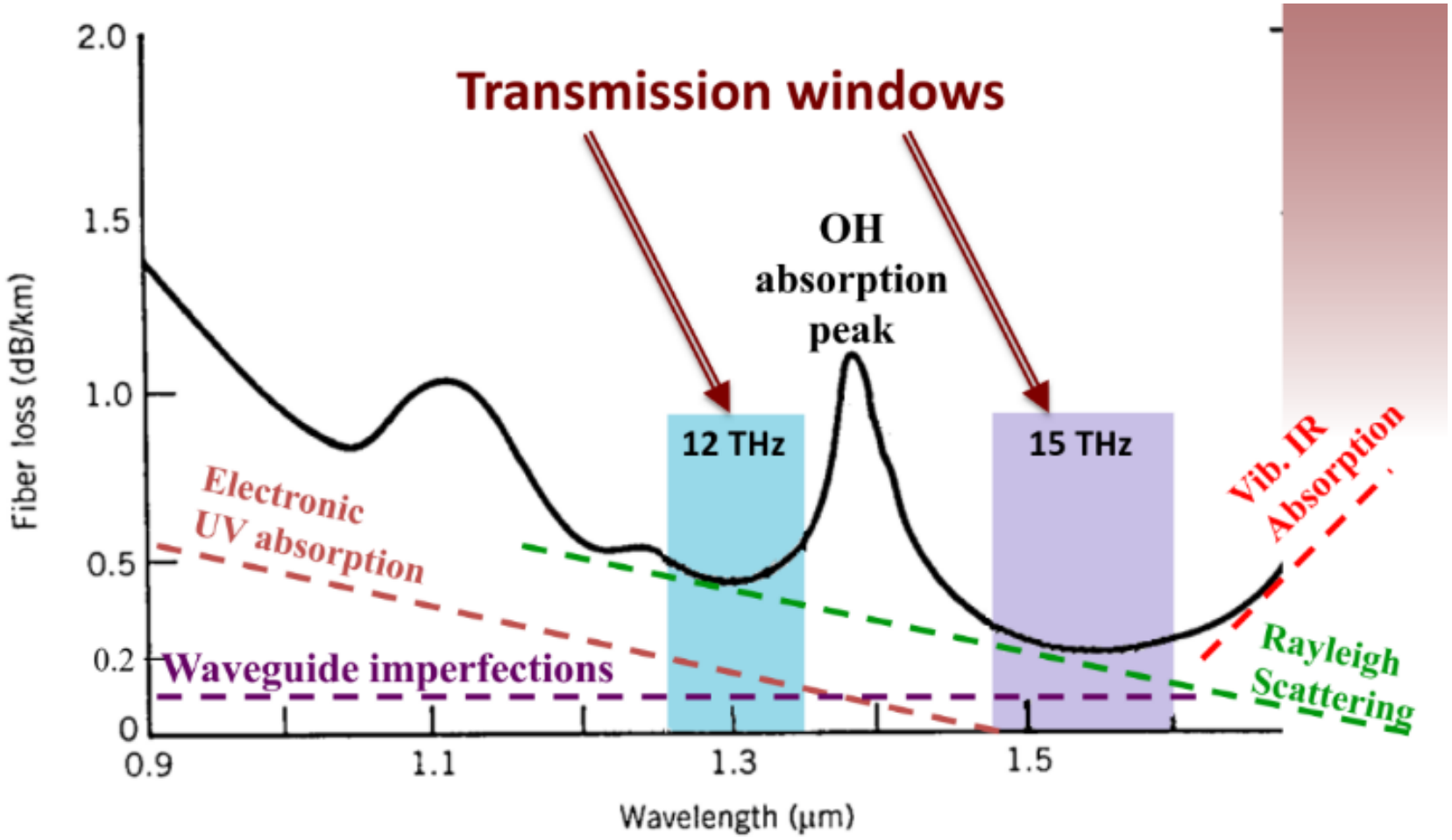
Les fibres optiques en silice





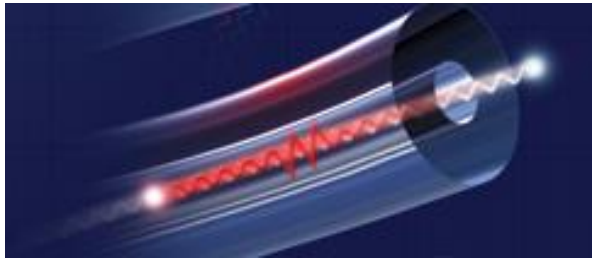
➔ Les câbles fibres optiques sont très résistants

Les fibres optiques en silice

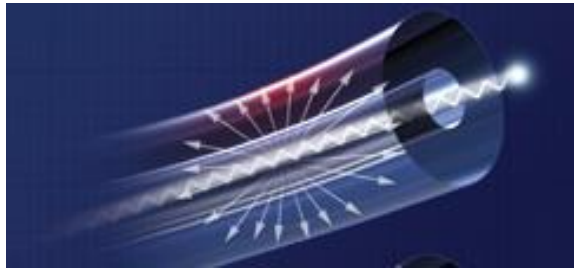


SMF-28 : 0,23 dB/km

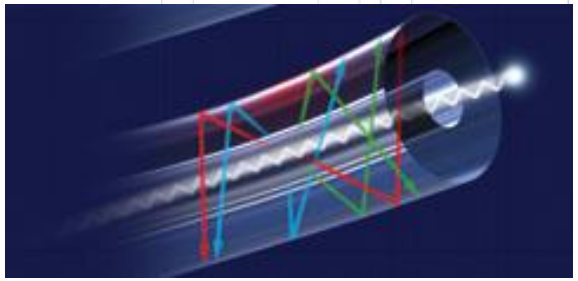
Les diffusions de la lumière



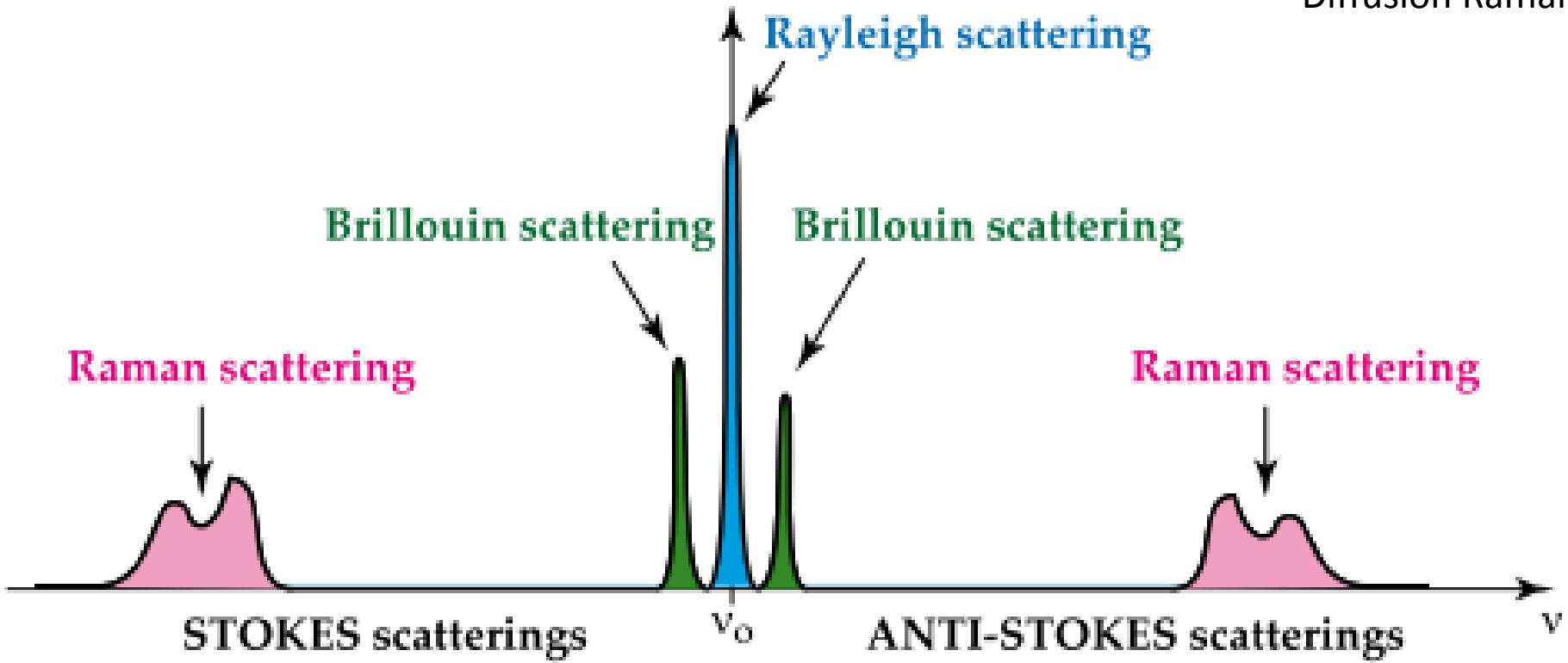
Diffusion Brillouin



Diffusion Rayleigh

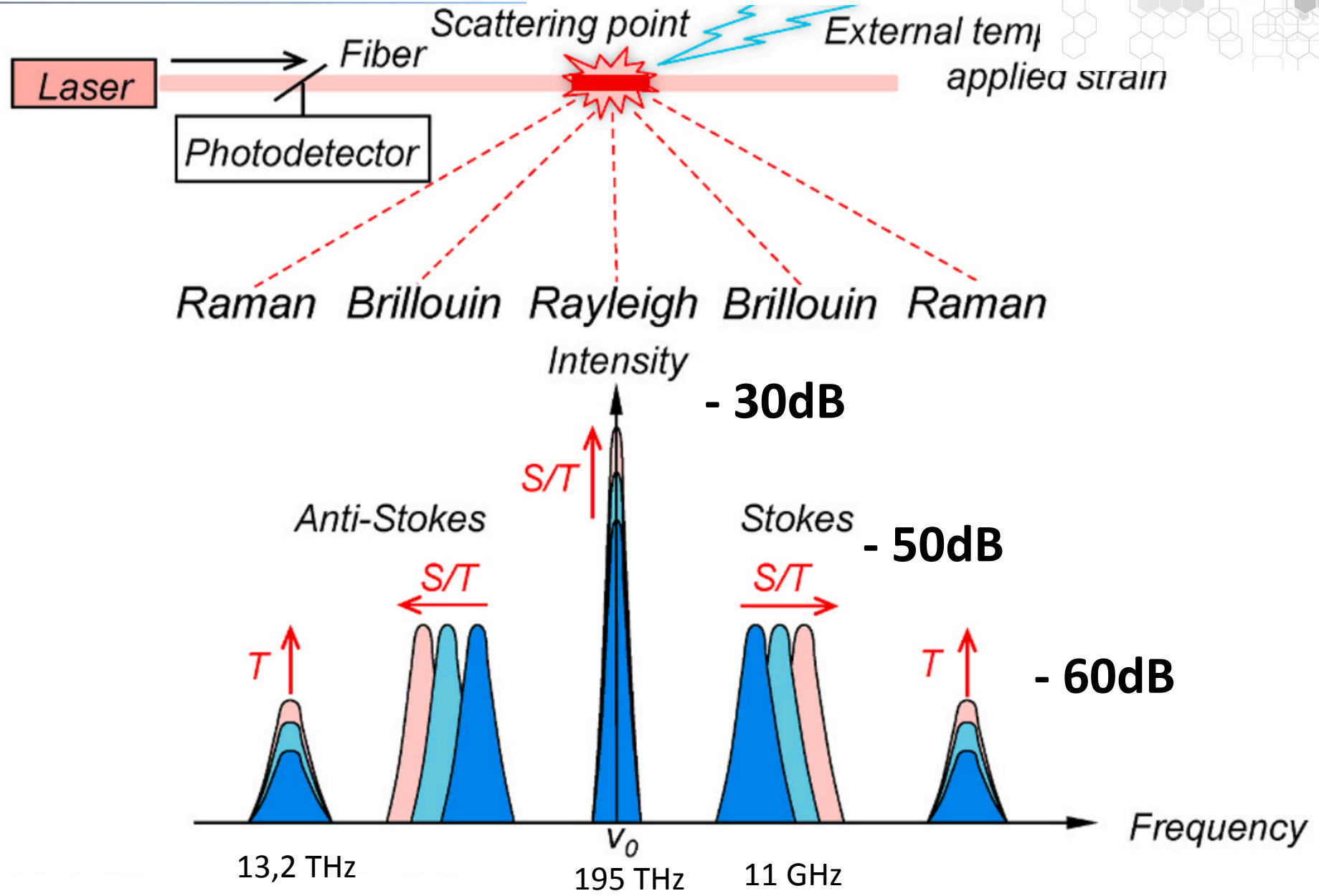


Diffusion Raman

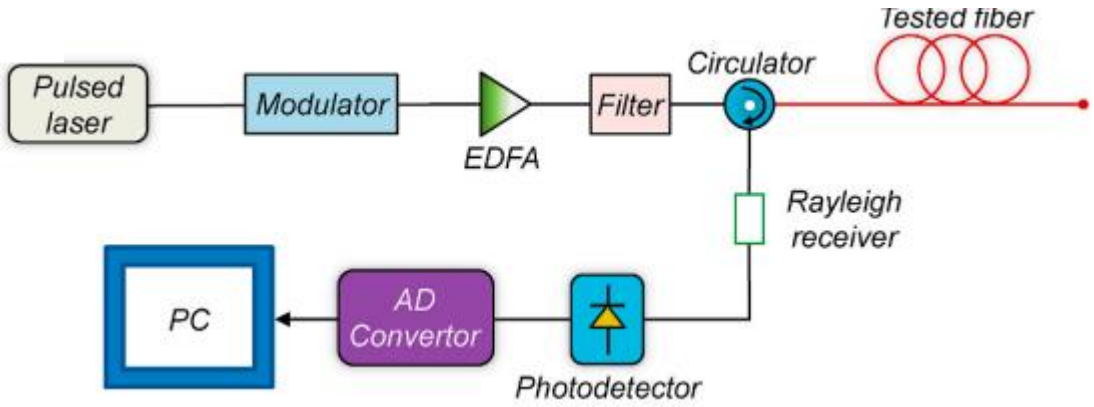


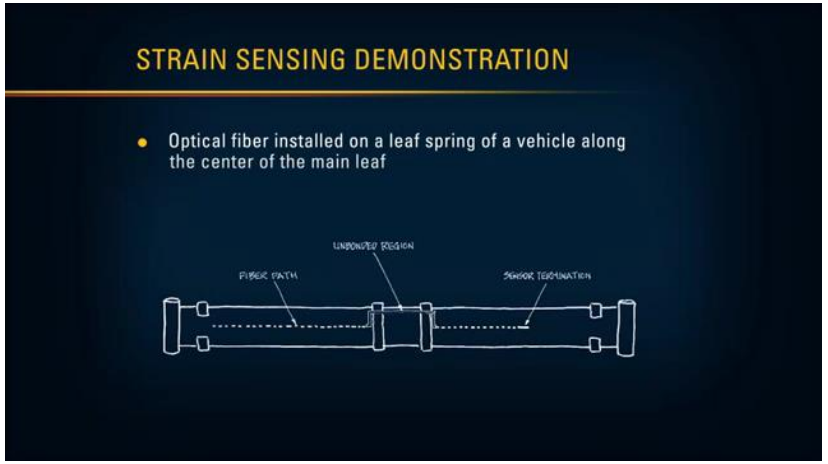
L. Thévenaz *et al.*, Advanced Fiber Optics, EPFL press (2011)

Les diffusions de la lumière



Les capteurs distribués Rayleigh, OTDR





Distance : 2 km

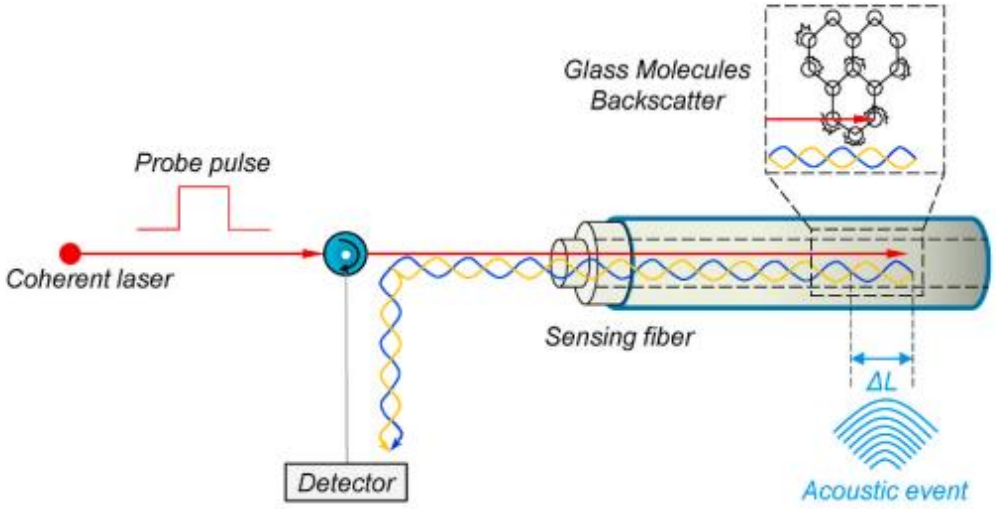
Résolution : 1 mm

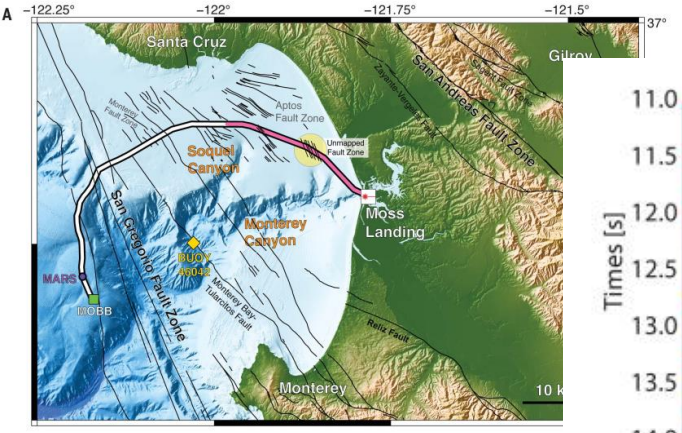
Sensibilité : 0,1°C, 1g

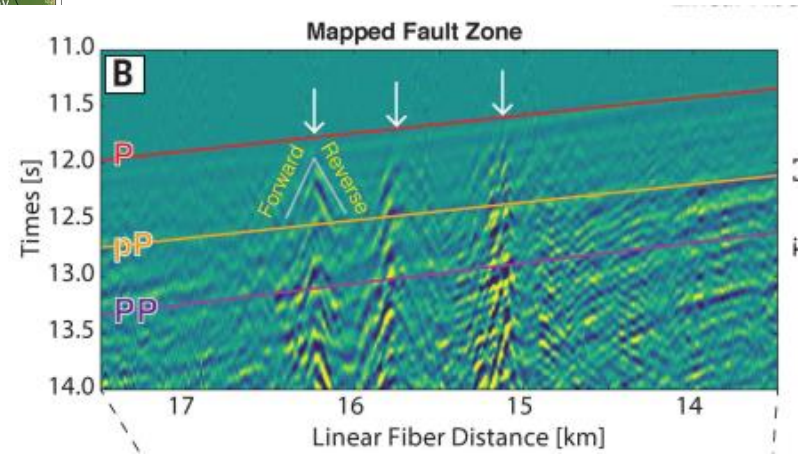
➔ Mesure relative

➔ Très sensible

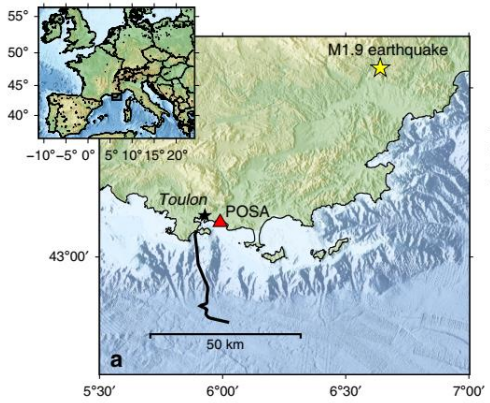
Les capteurs distribués Rayleigh, DAS

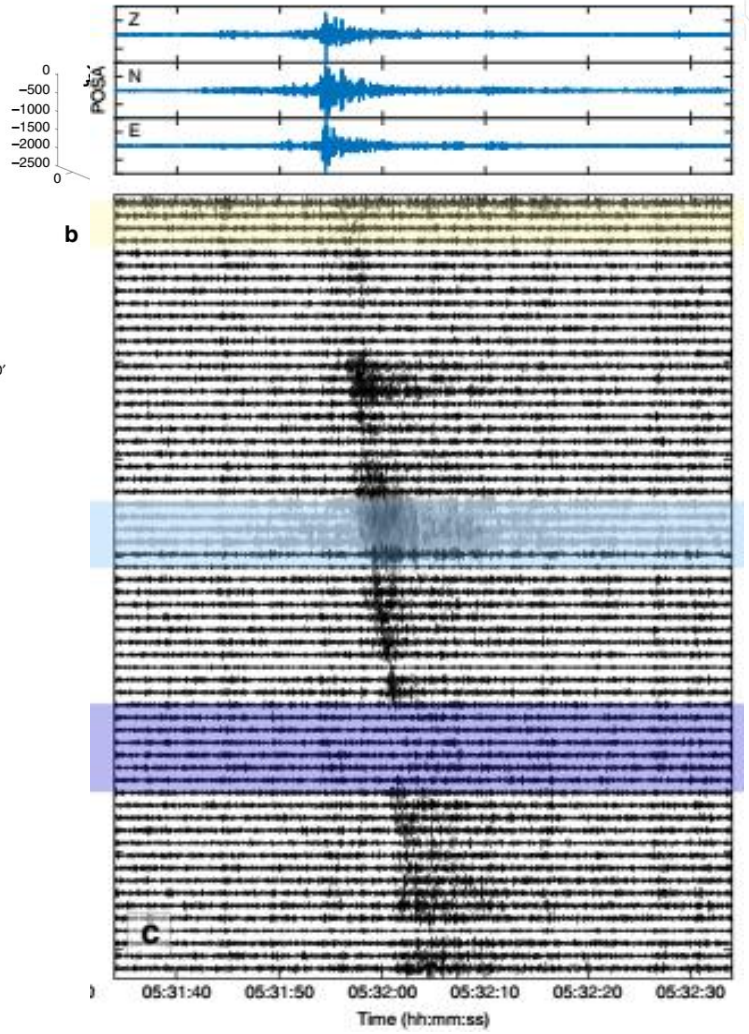






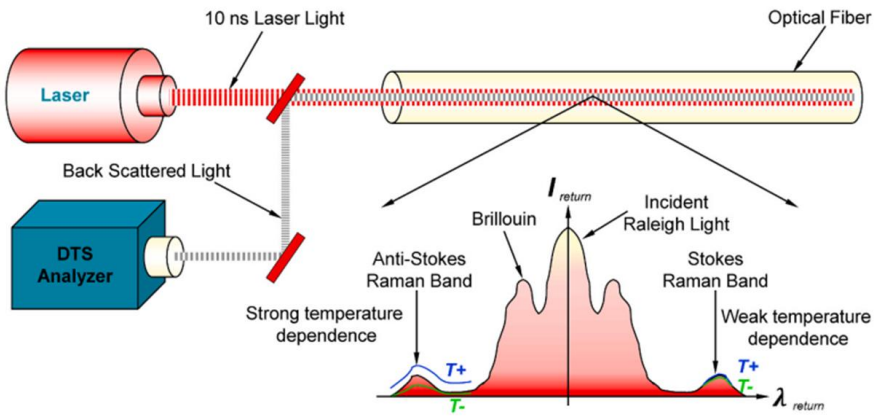
N. J. Lindsey et al., Illuminating seafloor faults and ocean dynamics with dark fiber distributed acoustic sensing, Science, 2019





A. Sladen *et al.*, Distributed sensing of earthquakes and ocean-solid Earth interactions on seafloor telecom cables, Nat Comm, 2019

Les capteurs distribués Raman, DTS



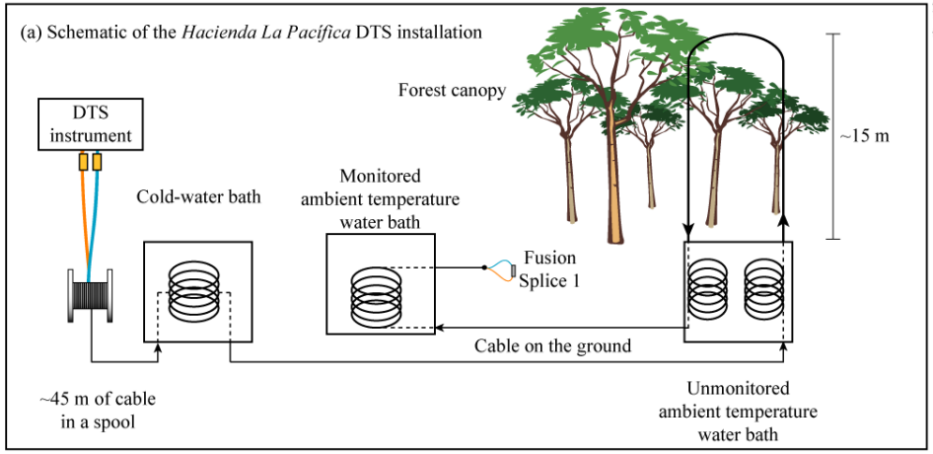
Distance : 30 km

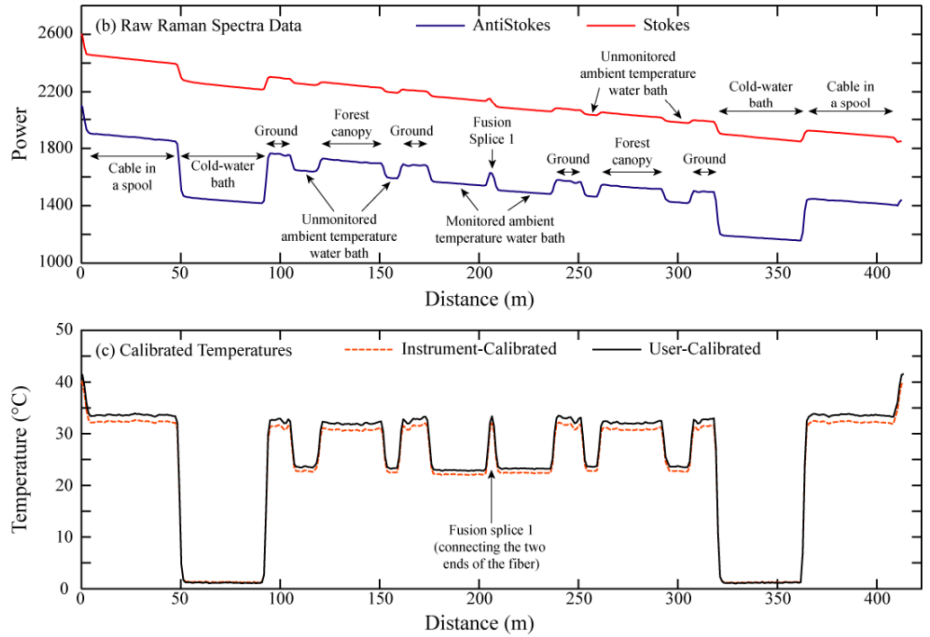
Résolution : 0,5 m

Sensibilité : 0,5 °C

➔ Mesure relative

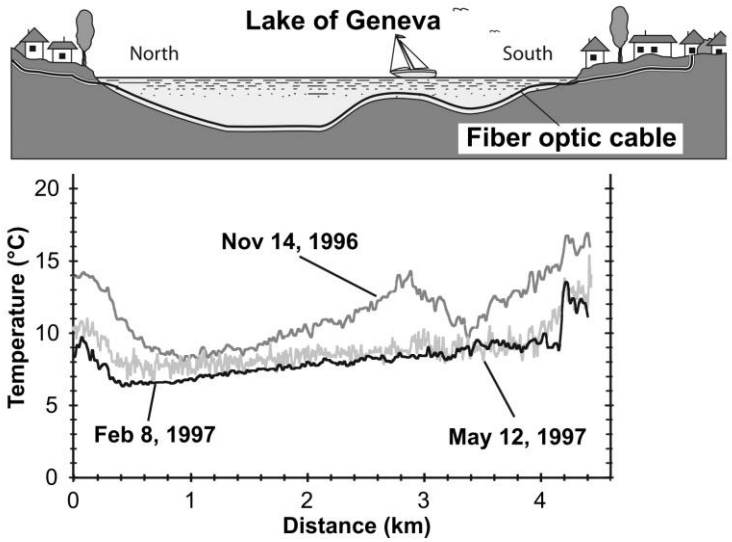
➔ Nécessite une double calibration



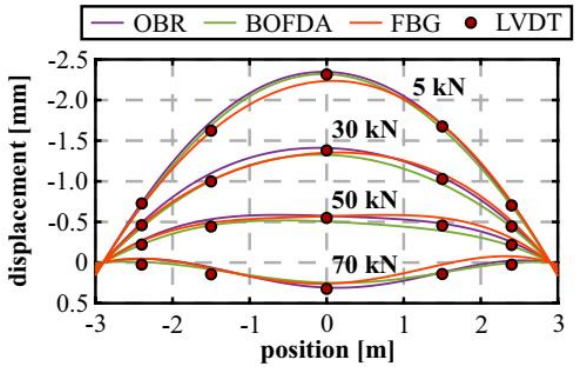


M. B. Hausner *et al.*, Sensors 2011

Les capteurs distribués Brillouin, Température & Contraintes



J. S. Selker *et al*.,, Distributed fiber-optic temperature sensing for hydrologic systems, Water resources research, 2006.



C. M. Monsberger, Distributed Fiber Optic Shape Sensing of Concrete Structures, Sensors 2021.

Distance : 80 km

Résolution : 0,5 m

Sensibilité : 1 °C, 20 g

➔ Mesure absolue

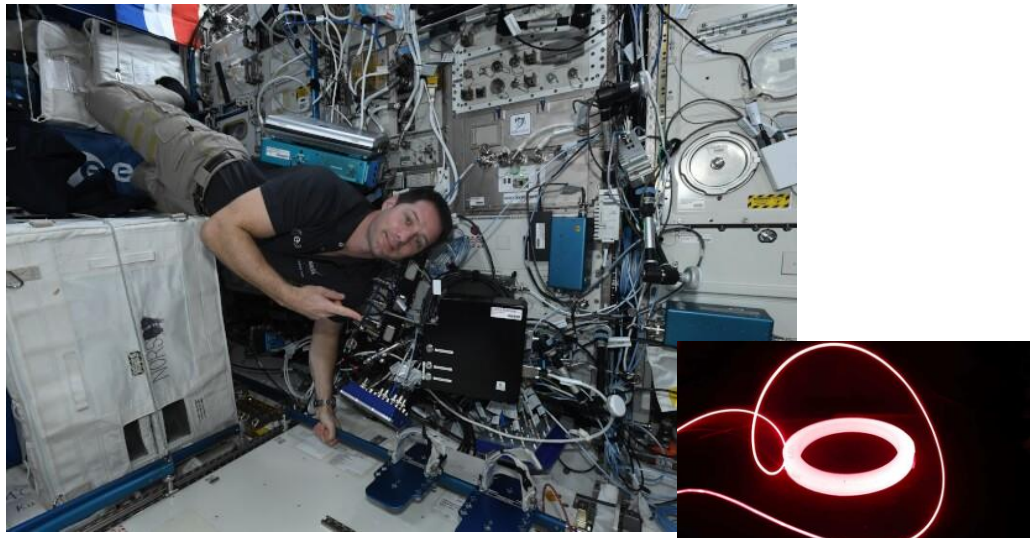
➔ Lent

Performances : Ordre de Grandeur

	Longueur	Résolution	Sensibilité	Avantages	Limitations	Prix, €
Rayleigh, OTDR	2 km	1 mm	0,1 °C 1 g	Résolution, dynamique 100 Hz	Très sensible vibrations… Calibration	150 000
Brillouin, Ditest	Single 40 km Double 80 km	1 m 0,5 m	1 °C, 20 g	Mesure Absolue	Lent	70 000
Raman, DTS	30 km	0,5 m	0,5 °C	Rapide	Calibration Pertes différentielle	30 000

Conclusions

➔ Les fibres optiques ne font plus peur!



20 August, 2021 : Astronaut Thomas Pesquet has activated Lumina, an optical fibre-based dosimetry experiment on board the International Space Station

➔ Capteurs distribués à fibres optiques hybrides Brillouin/Rayleigh ou Raman/Brillouin…