EPIC Meeting on Fiber Sensors at HBK FiberSensing

Raman & Brillouin Distributed Sensing
Design Paths to Easy Deployment

Daniele Costantini, Ph.D.
Global Product Marketing Manager – Fiber Test Systems
April 19th 2023

VIAVI Market Leadership

For Complex Network and Sensing Issues

#1 TEST AND MEASUREMENT

Fiber

Enterprise

Cable and Access

Metro and Transport

Lab Production and Manufacturing

#1 WIRELESS AND AVIONICS

5G Test and Assurance

Land-Mobile and Military Radio

Location Intelligence

Aerospace, Nav/Comm, and Transponder

#1 SECURITY, SENSING, AND AUTHENTICATION

3D Sensing

Anti-Counterfeiting

Spectral Sensing

Automotive

Government and Aerospace

VIAVI in Europe

Date: As of June 2022

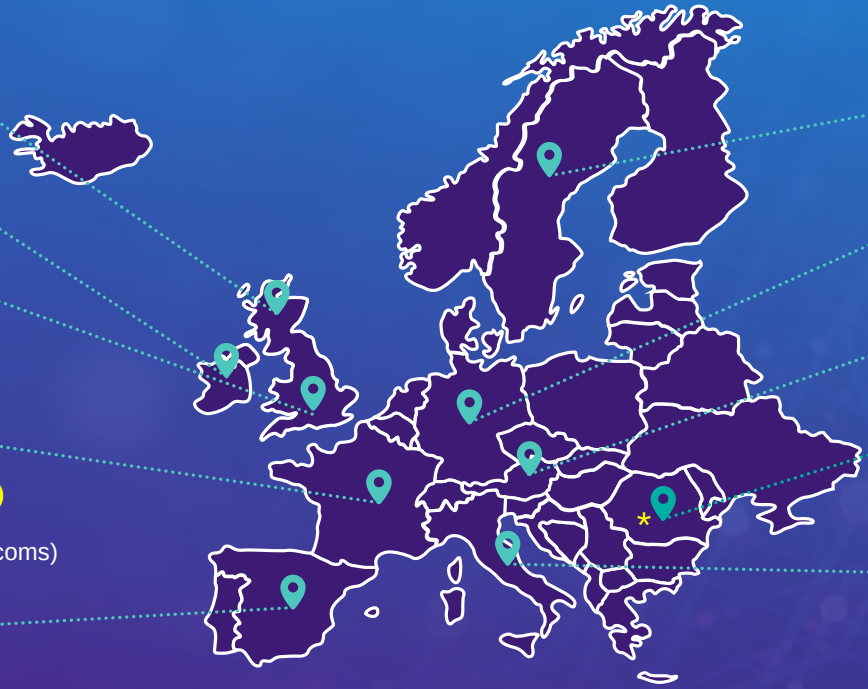
SCOTLAND
- Edinburgh (Services)

IRELAND
- Dublin (Wireless)

ENGLAND
- Newbury (RAN, Geolocation)
- Stevenage (Wireless)

FRANCE
- **Saint-Étienne (Fiber Optics)**
- Plaisir
- Saint-Herblain (Railway Telecoms)

SPAIN
- Madrid



SWEDEN
- Kista

GERMANY
- **Eningen (Optical Transport, Fiber Optics)**

AUSTRIA
- Leobersdorf

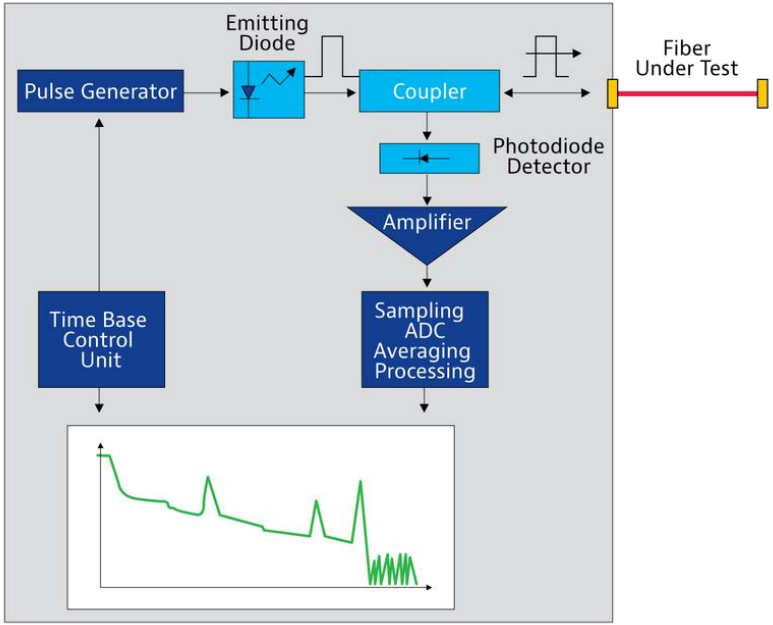
ROMANIA
- Bucharest (Systems Software, Enterprise)
- * R&D Center of Excellence

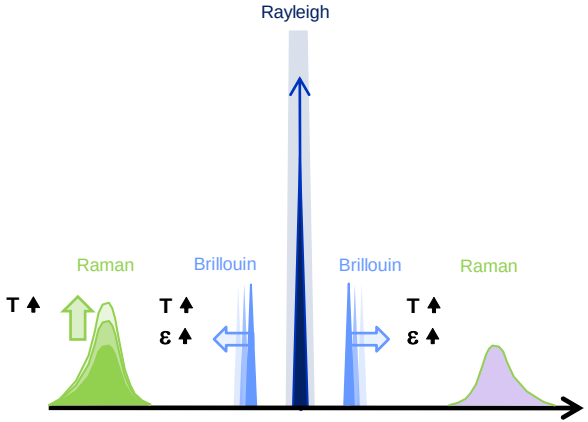
ITALY
- Milan
- Rome
- Torino (Railway Telecoms)

EUROPEAN FUNCTIONAL STAFF SUMMARY

RESEARCH & DEVELOPMENT	PRODUCT & SERVICES MANAGEMENT	SALES & MARKETING	G&A FUNCTIONS	TOTAL EMPLOYEES
455	204	259	78	996

VIAVI OTDRs & Optical Fiber Sensing



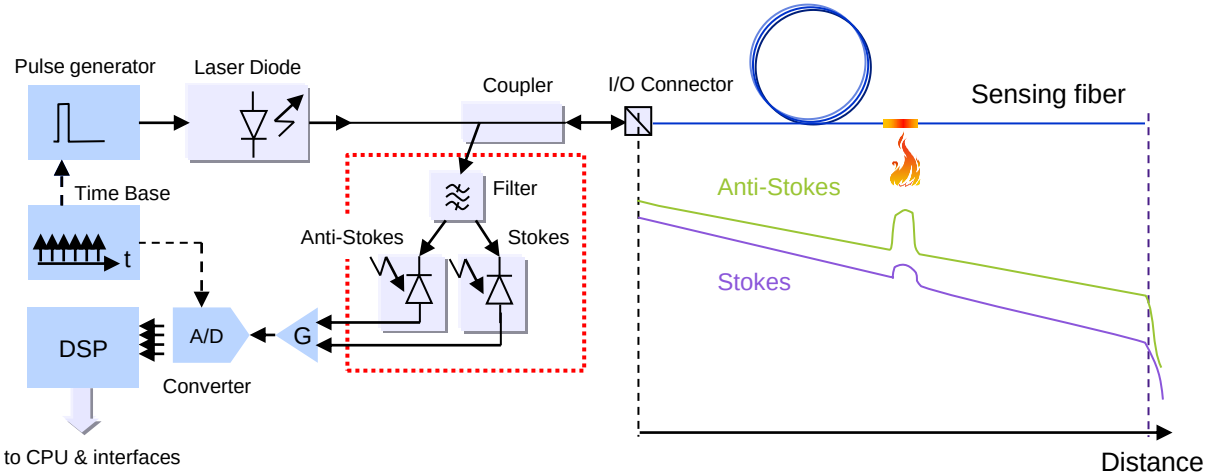


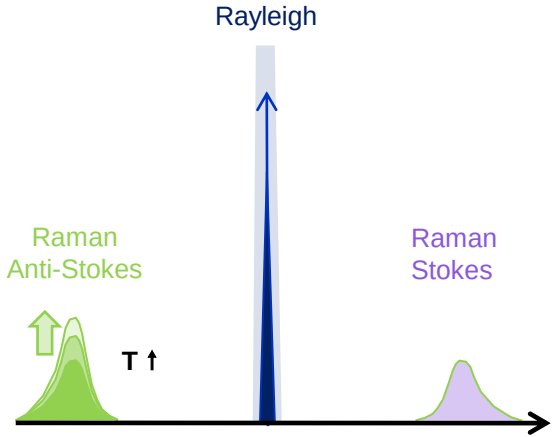
Rayleigh OTDR → Fiber Monitoring - Loss, Reflections & Failures

Raman OTDR → Distributed **Temperature** Sensing (**DTS**)

Brillouin OTDR → Distributed **Temperature & Strain** Sensing (**DTS & DSS**)

Raman OTDR → DTS

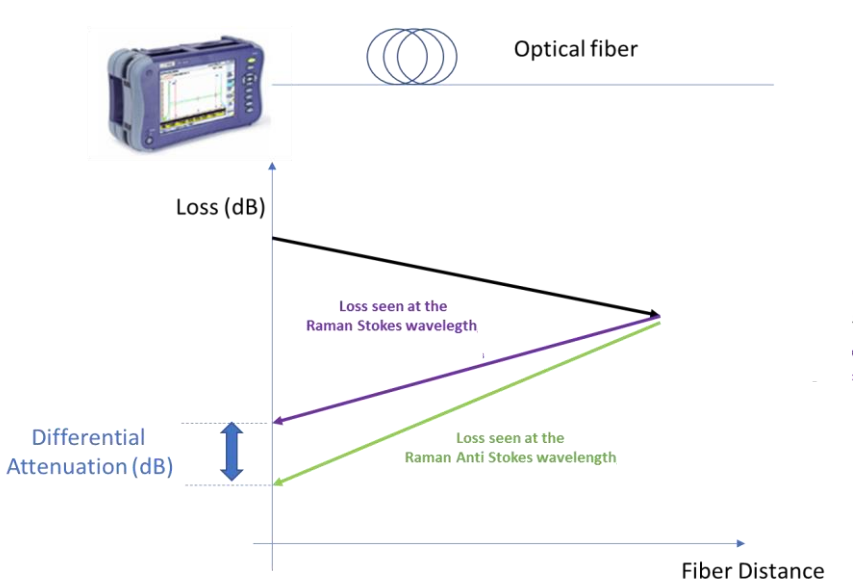


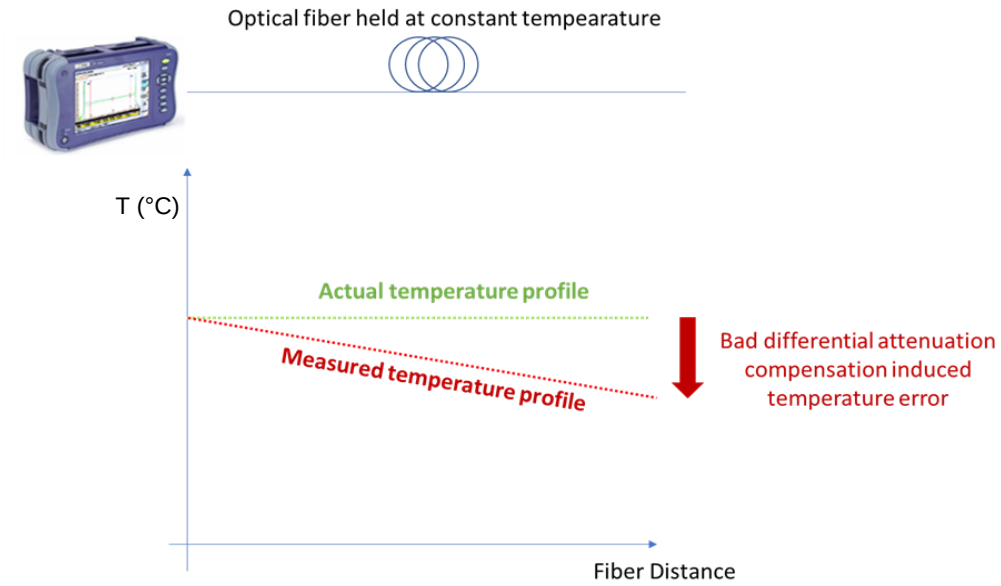


$$T(z) = \frac{\gamma}{ln\frac{P_{s(z)}}{P_{as(z)}} + C - \Delta\alpha z}$$

Differential Attenuation Δα

$$T(z) = \frac{\gamma}{ln\frac{P_{s(z)}}{P_{as(z)}} + C - \Delta\alpha z}$$

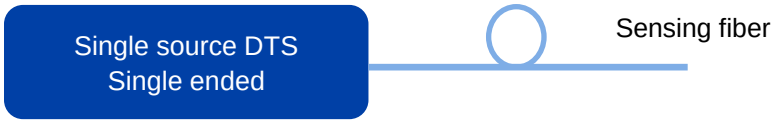




Differential Attenuation $\Delta\alpha$

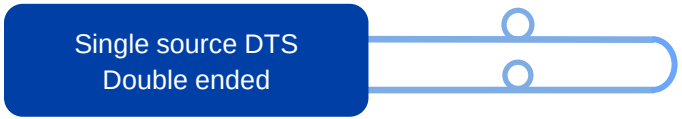
Single Source – Single Ended

- Correction factor to be set for each installed fiber
- Usable only for constant loss vs time & distance

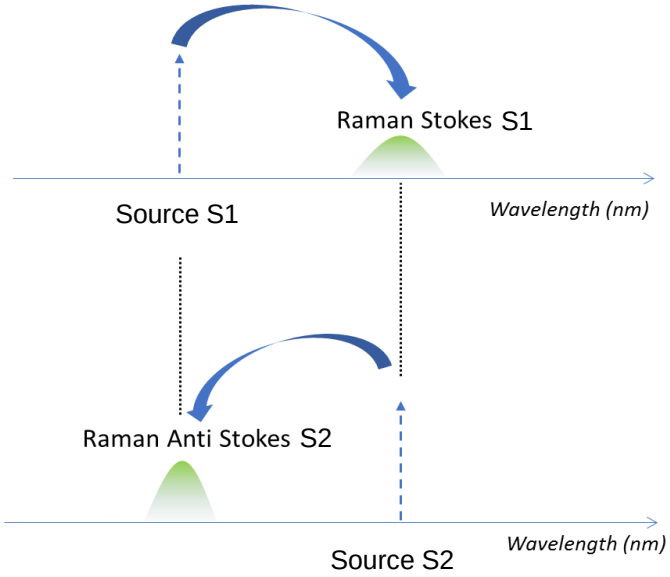


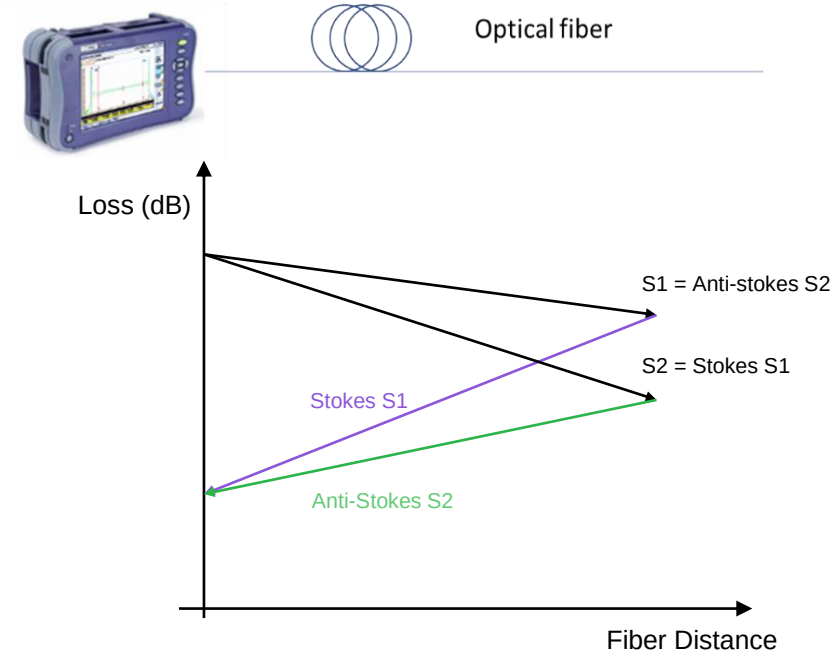
Single Source – Double Ended

- Need to interrogate both sides of sensing fiber
- Complex set-up and only half sensing length



Dual Source – Single ended



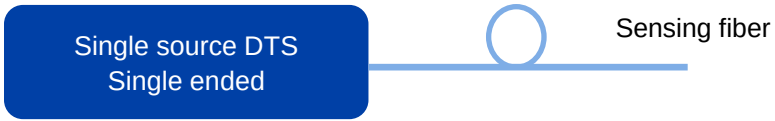


$\Delta\alpha$ Automatic Cancellation → Accurate Temperature Measurements

Differential Attenuation $\Delta\alpha$

Single Source – Single Ended

- Correction factor to be set for each installed fiber
- Usable only for constant loss vs time & distance

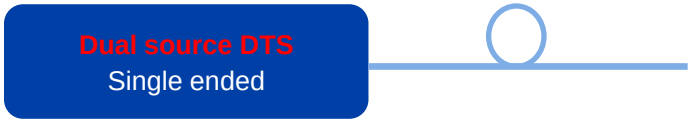


Single Source – Double Ended

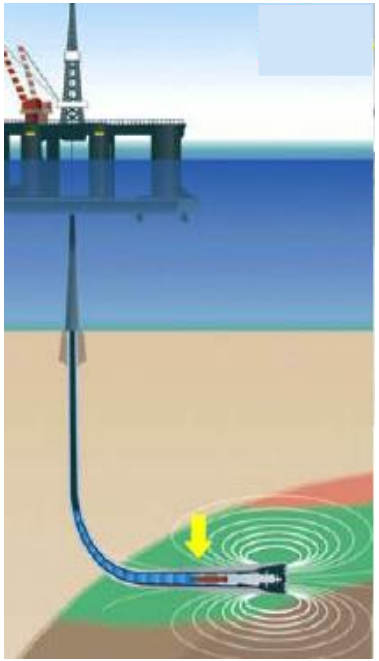
- Need to interrogate both sides of sensing fiber
- Complex set-up and only half sensing length

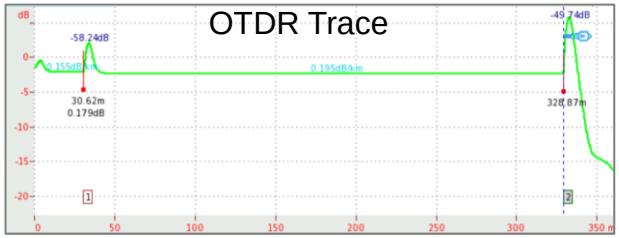
Dual Source – Single Ended

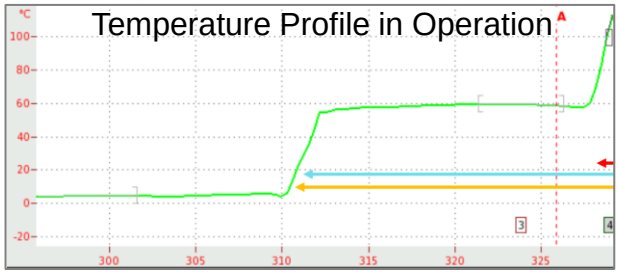
- Simple set-up & full sensing length available
- Automatic and accurate compensation
- Insensitive to variations of attenuation in time

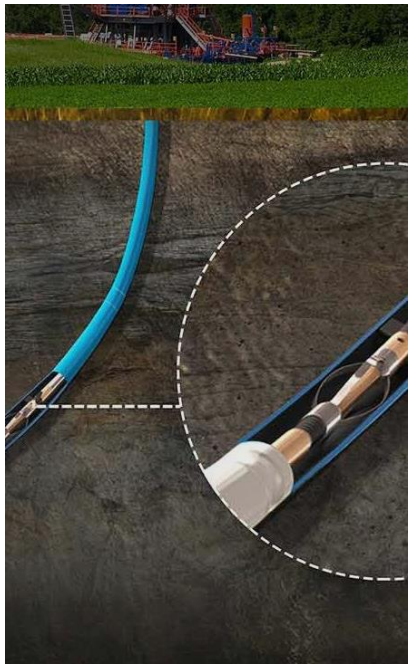


Easy Field Deployment – e.g. MWD Umbilical

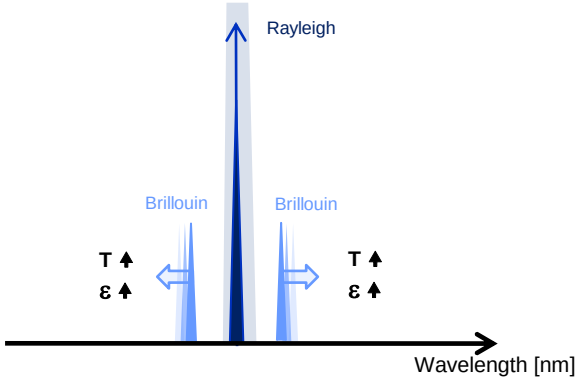


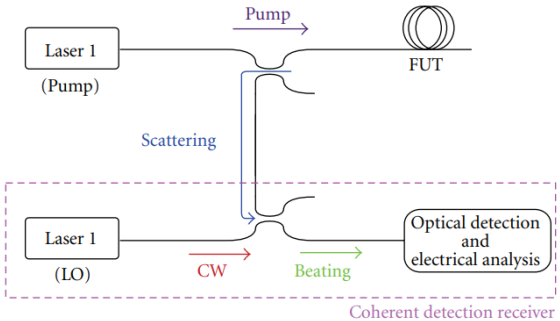






Brillouin OTDR → DTS & DSS





$$\begin{pmatrix} \Delta\vartheta_B \\ \Delta LPR \end{pmatrix} = \begin{bmatrix} C_\vartheta^\varepsilon & C_\vartheta^T \\ C_P^\varepsilon & C_P^T \end{bmatrix} \begin{pmatrix} \varepsilon \\ \Delta T \end{pmatrix}$$

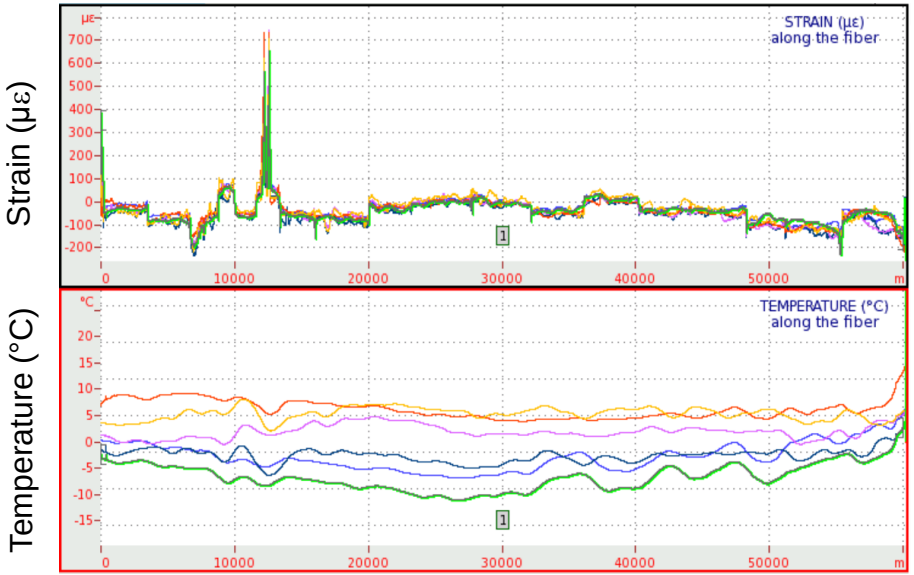
ϑ_B Brillouin Frequency

LPR Rayleigh/Brillouin Power Ratio

$$\textit{Landau-Placzek Ratio} = \frac{P_{Rayleigh}}{P_{Brillouin}} = \frac{f(attenuation)}{f(\varepsilon, T, attenuation)} = f(\varepsilon, T)$$

Easy Field Deployment – e.g. Electrical Power Cables

Aerial OPGW (60km – 6 days & 24h)



Removed requirement for

- special cables & designs with strain-free fibers
- additional instrumentation

VIAVI Solutions

daniele.costantini@viavisolutions.com
+41 78 652 97 59