Fiber optic sensors integration in magnets and in test facilities

Antonella Chiuchiolo

(TE-MSC-TF)

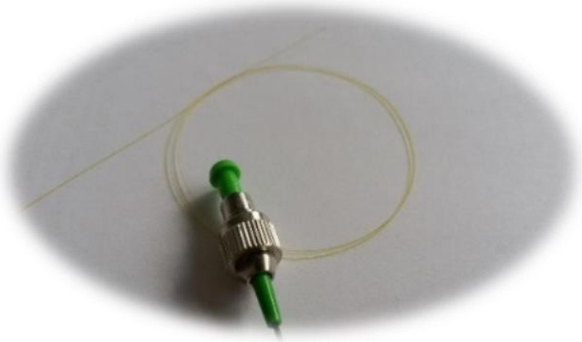
CERN | TE Technology Department

Outline

- Fiber Optic Sensors (FOS) integration in the test facility
- Example of magnets equipped with FOS
- Example of FOS configuration

Fiber integration in the test facility SM18

- **Sensors procurement**
  - Single Mode fiber
  - Commercial sensors for *temperature* and *strain* monitoring
  - Customized sensors layout



- **Data Acquisition System**
  - Optical Interrogators: sm125, sm130 and Hyperion modules and Enlight software
  - From 4 to 16 channels , 2 Hz - 1 KHz, 90 – 160 nm

- **Connections and feedthrough**
  - Fusion Splice Machine for fiber reparation
  - Optical connectors, feedthrough, cable extentions to equip the test facility

10⁻ⁿ mbar VACOM

fischer CONNECTORS

Fujikura

OZ Optics

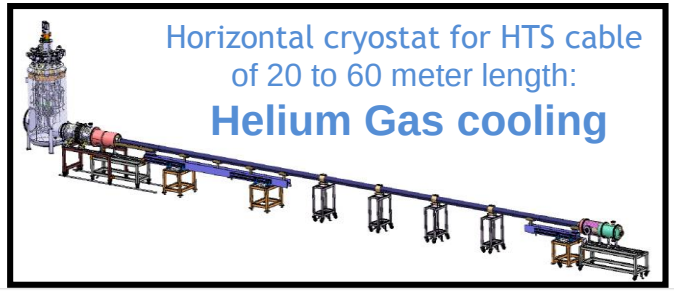
Fiber integration in the test facility SM18

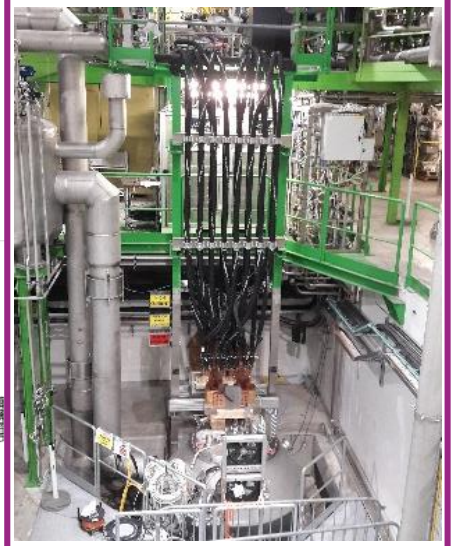
Vertical cryostat for testing magnets down to 4.2 K and 1.9 K:

Liquid and Superfluid Helium

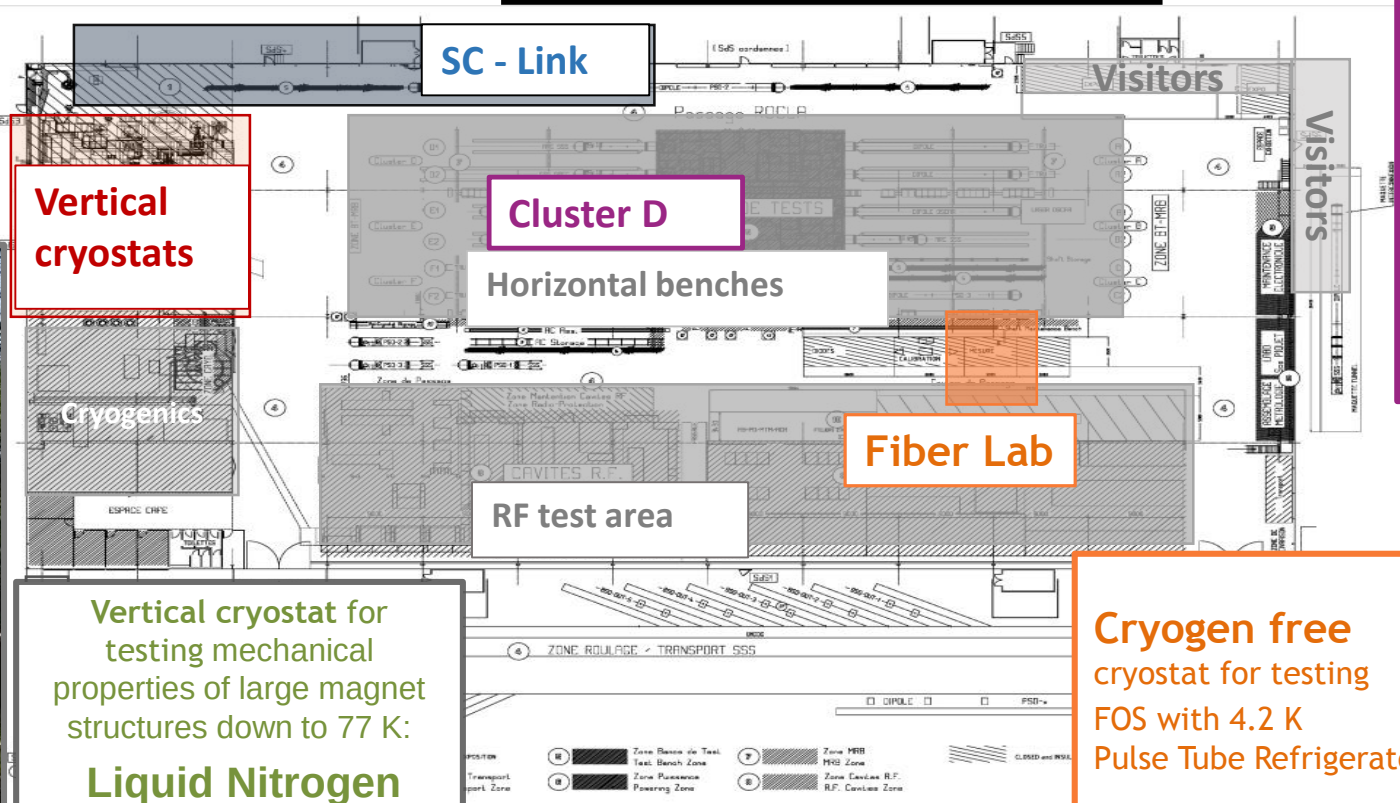
Horizontal cryostat for HTS cable of 20 to 60 meter length:

Helium Gas cooling





For magnet cold **powering** up **to 30 kA**

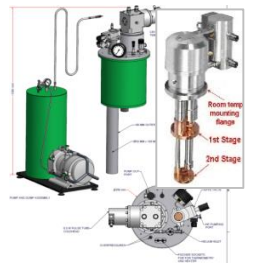


Vertical cryostat for testing mechanical properties of large magnet structures down to 77 K:

Liquid Nitrogen

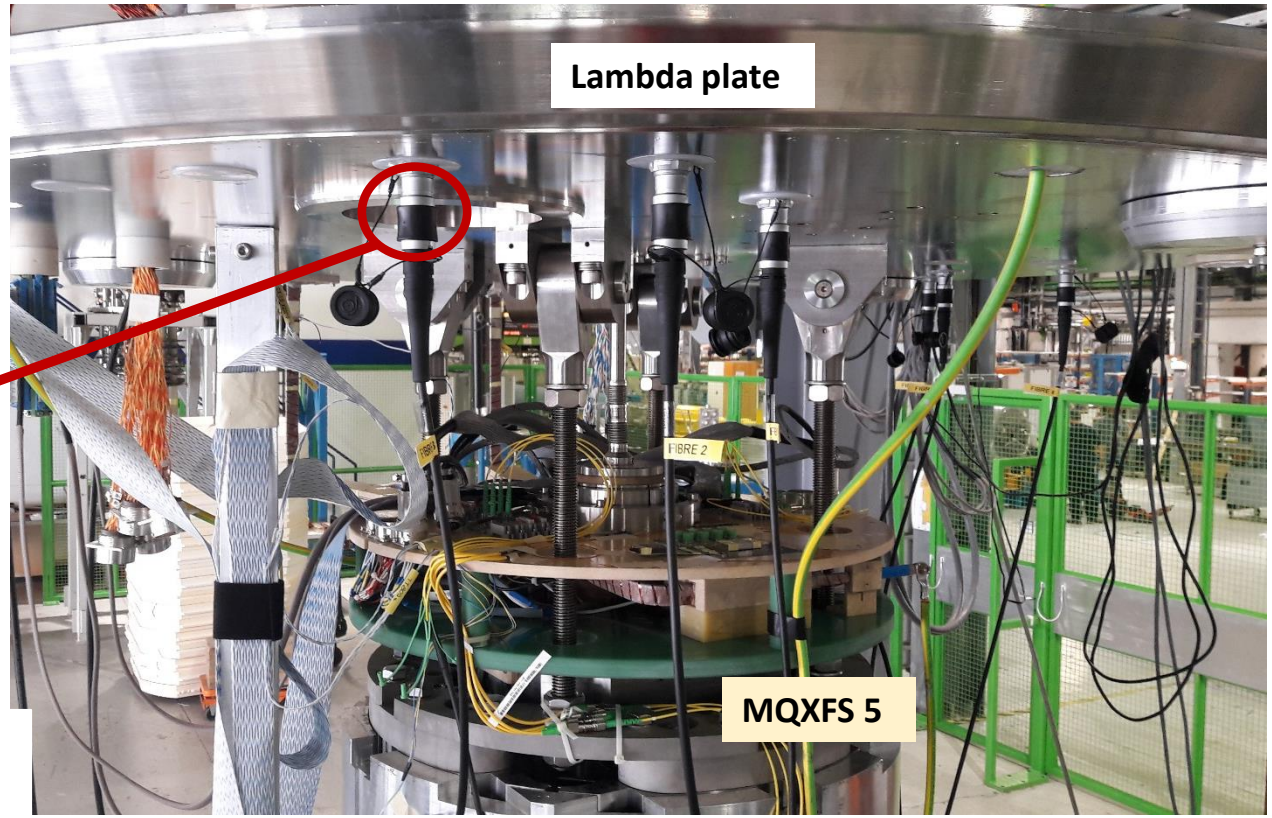
Cryogen free

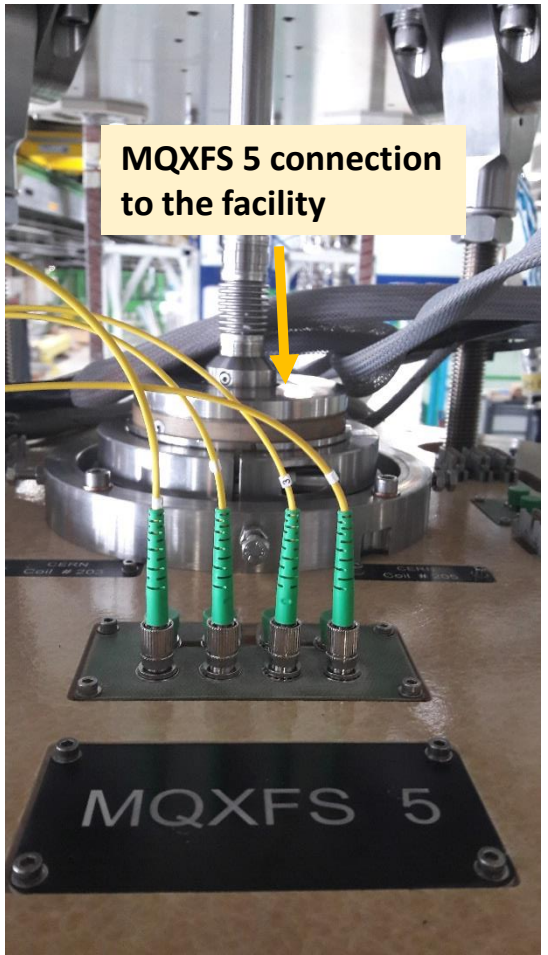
cryostat for testing FOS with 4.2 K Pulse Tube Refrigerator



Example MQXFS 5 installation on the insert

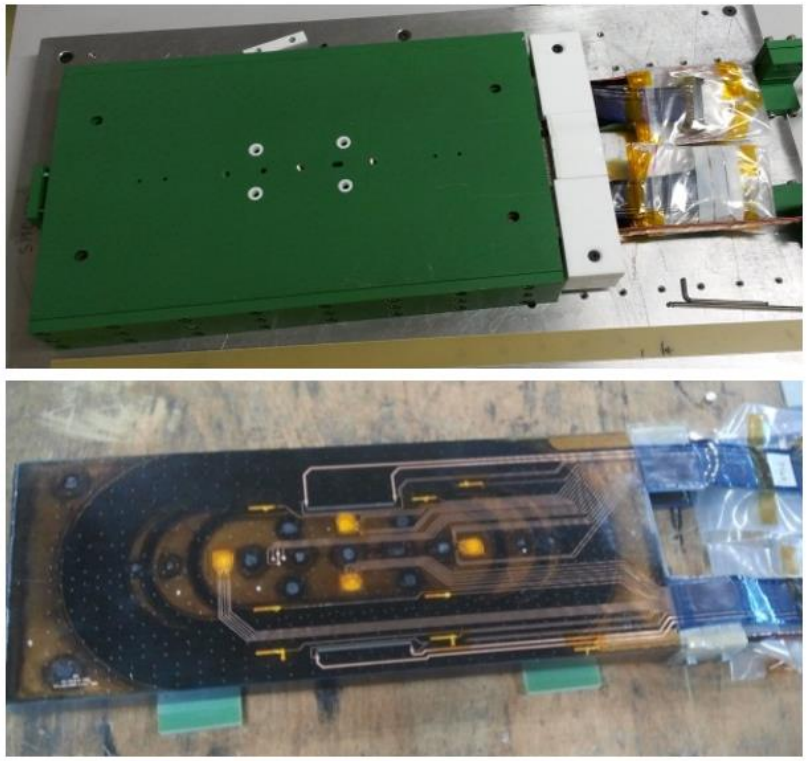
Fischer connectors:
4 fibers each connector



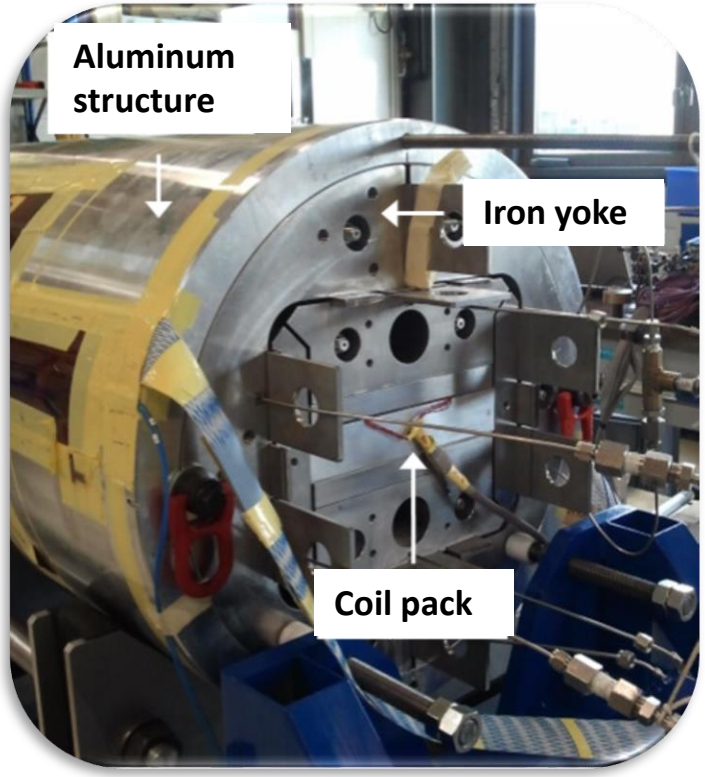


Integration in the magnets

- **Embedding in the *impregnated* Racetrack model coils**
- **Gluing on the Al structure**

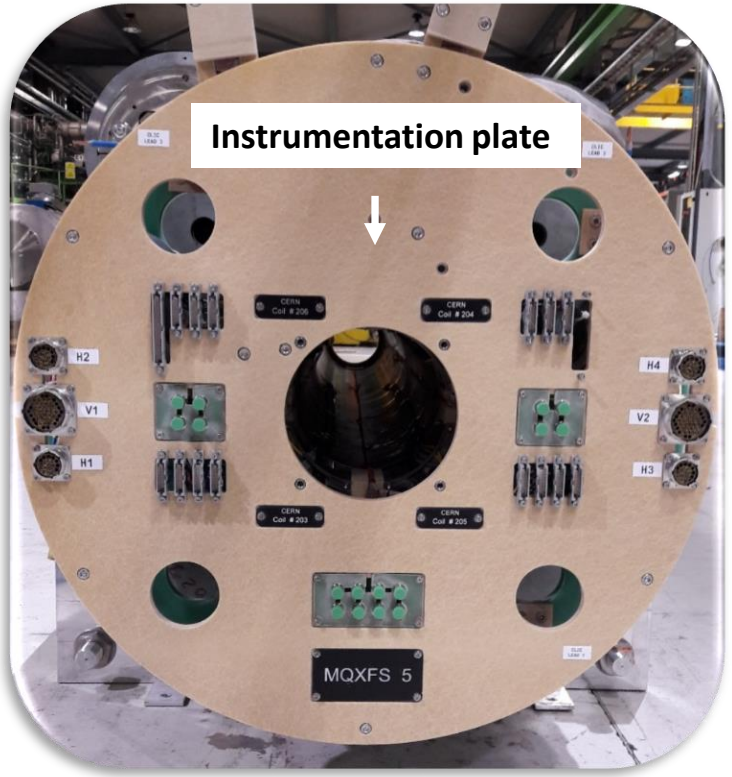


SMC



RMC

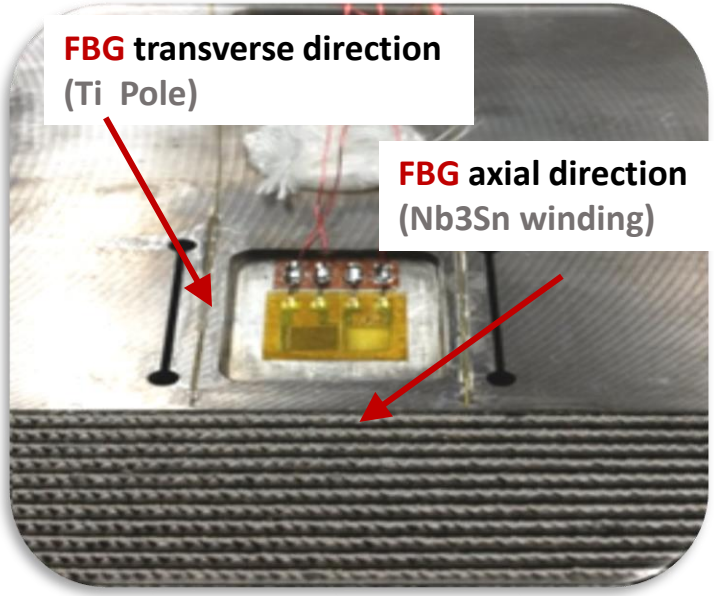
- **Gluing on the Al structure and on the Ti pole**



MQXFS

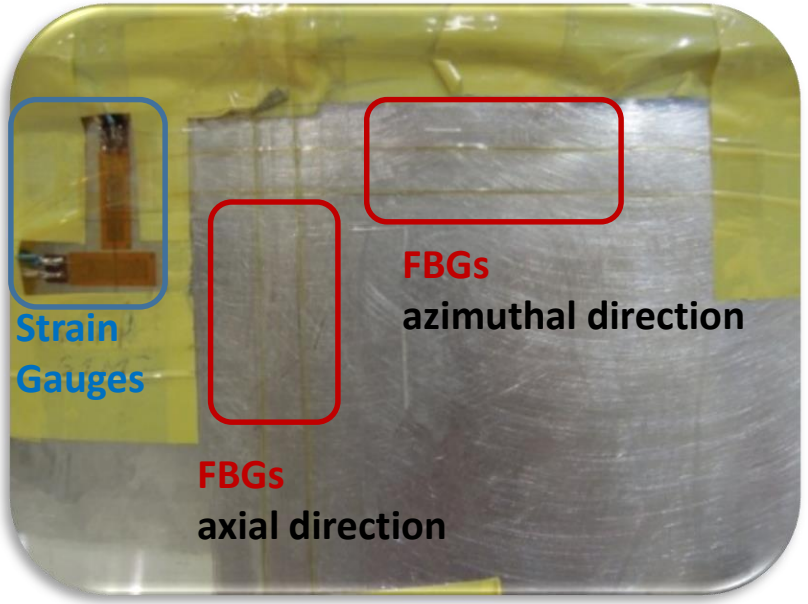
Integration in the magnets

- **Embedding in the impregnated Racetrack model coils**
- **Gluing on the Al structure**



- **Strain and Temperature**

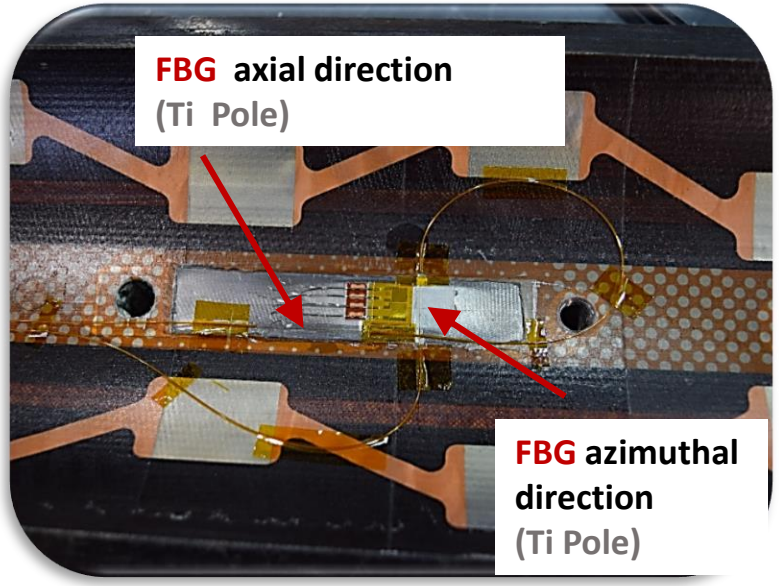
SMC



- **Strain**

RMC

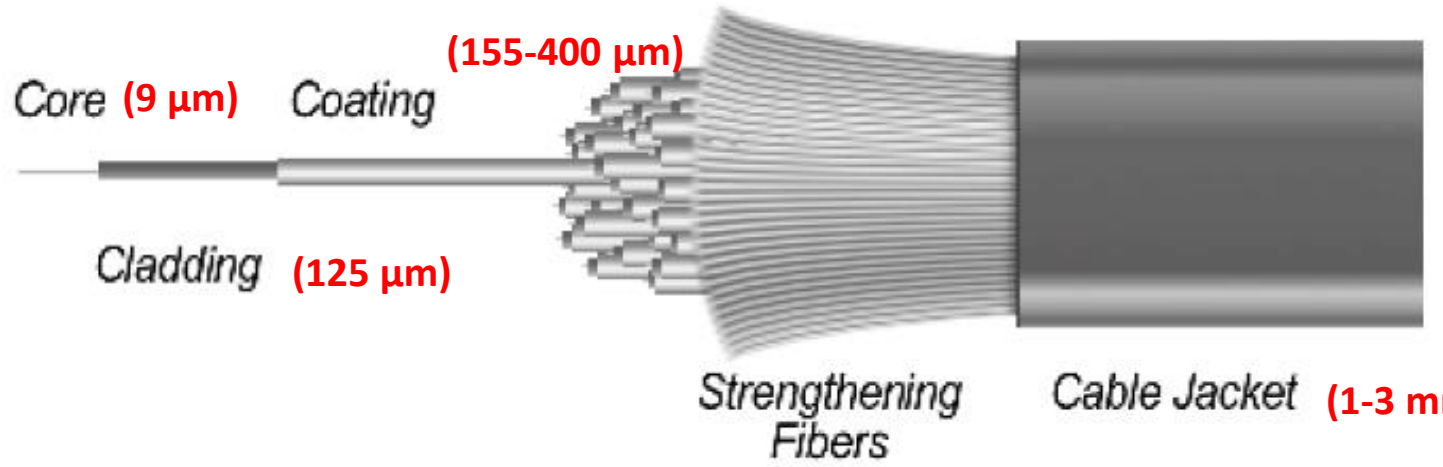
- **Gluing on the Al structure and on the Ti pole**



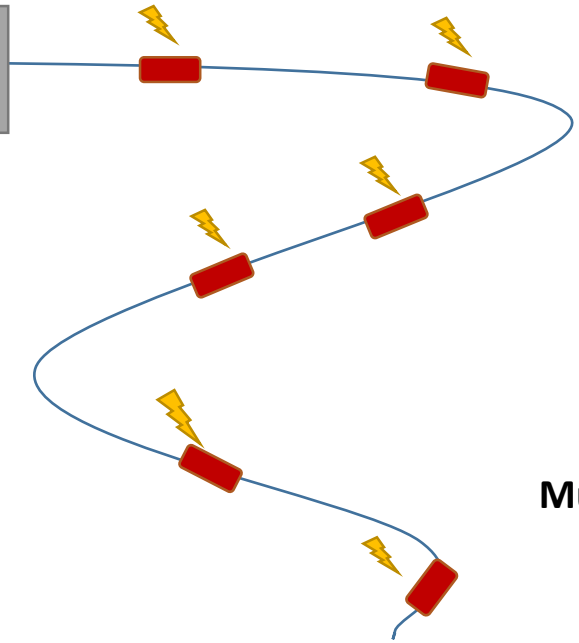
- **Strain**

MQXFS

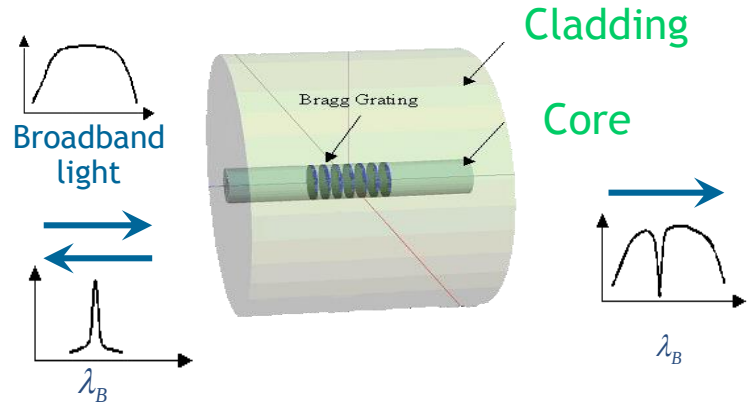
Fiber optic sensors configuration



Optical Interrogator

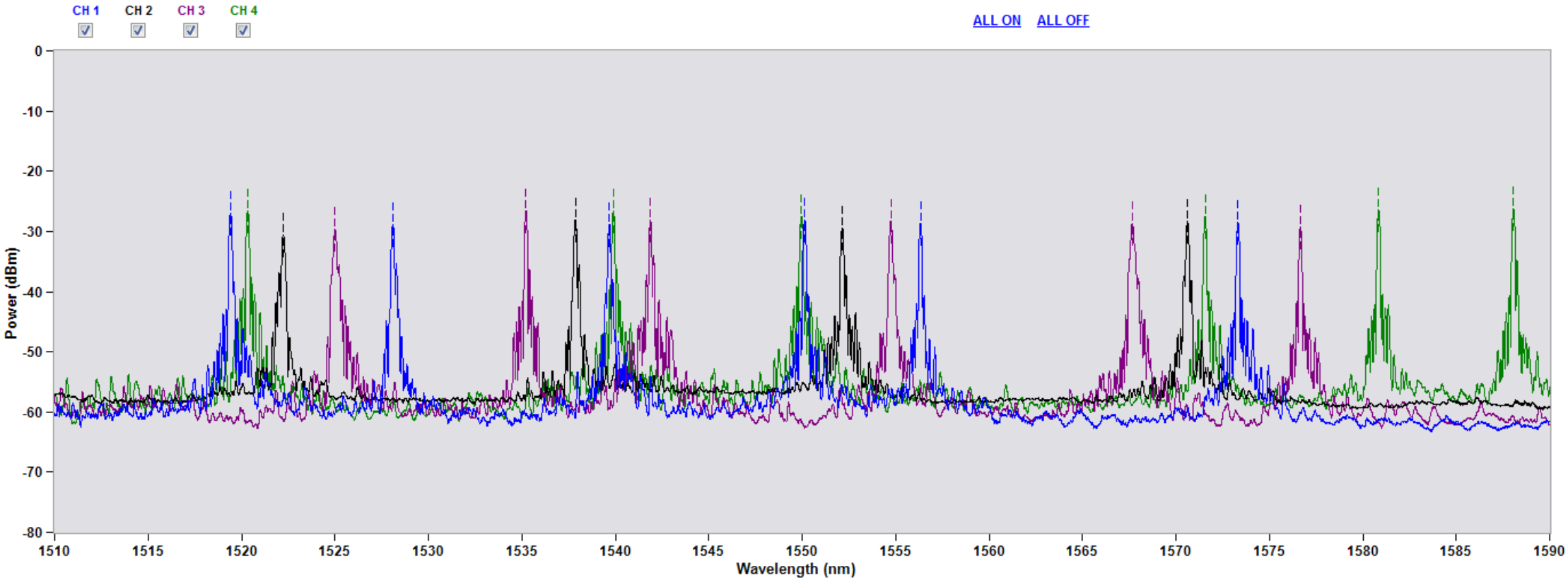


Fiber Bragg Grating sensor



Multiple sensing points along a single fiber

Fiber optic sensors configuration



22 FBG sensors on 4 channels

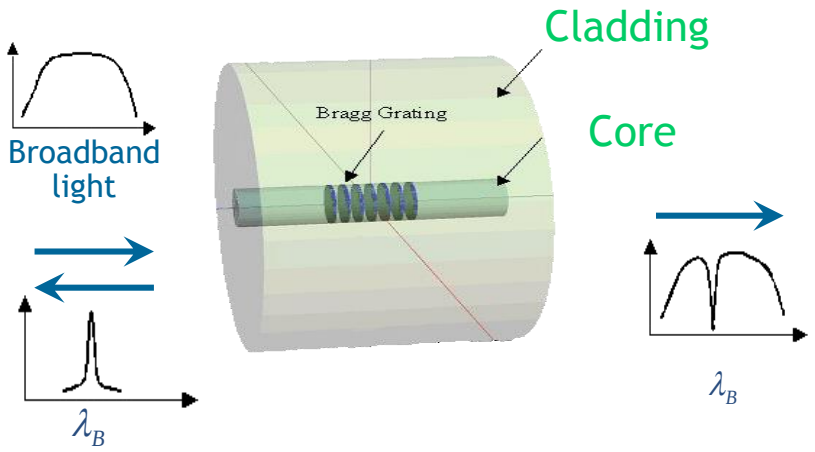
Channel 1		Channel 2		Channel 3		Channel 4	
Threshold (dBm):	-54.00	Threshold (dBm):	-47.00	Threshold (dBm):	-48.00	Threshold (dBm):	-46.00
Rel. Threshold (dB):	-7.00	Rel. Threshold (dB):	-8.00	Rel. Threshold (dB):	-8.00	Rel. Threshold (dB):	-12.00
Width (nm):	0.10	Width (nm):	0.10	Width (nm):	0.10	Width (nm):	0.10
Width Level (dB):	3.00	Width Level (dB):	3.00	Width Level (dB):	3.00	Width Level (dB):	3.00
Detect Valleys		Detect Valleys		Detect Valleys		Detect Valleys	
Reset		Reset		Reset		Reset	
# Peaks:	6	# Peaks:	4	# Peaks:	6	# Peaks:	6

Thank you for you attention

- Backup slides

Fiber Bragg Grating working principle

Longitudinal periodic variation of the refractive index in the optical fiber core



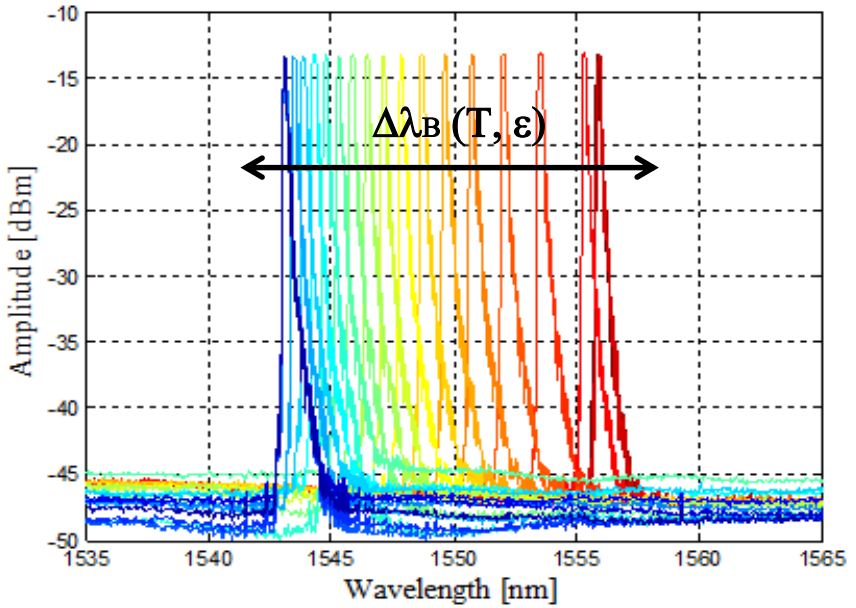
$$\lambda_B = 2 n_{eff} \Lambda$$

λ_B: Bragg Wavelength

n_{eff}: effective refractive index of the core

Λ : grating period

Strain and Temperature sensitive:



$$\frac{\Delta\lambda_B}{\lambda_B} = (1-\rho_a)\Delta\varepsilon + (\alpha+\xi)\Delta T$$

ρ_a : photo elastic coefficient

ξ : thermo-optic coefficient

α : **thermal expansion coefficient**