

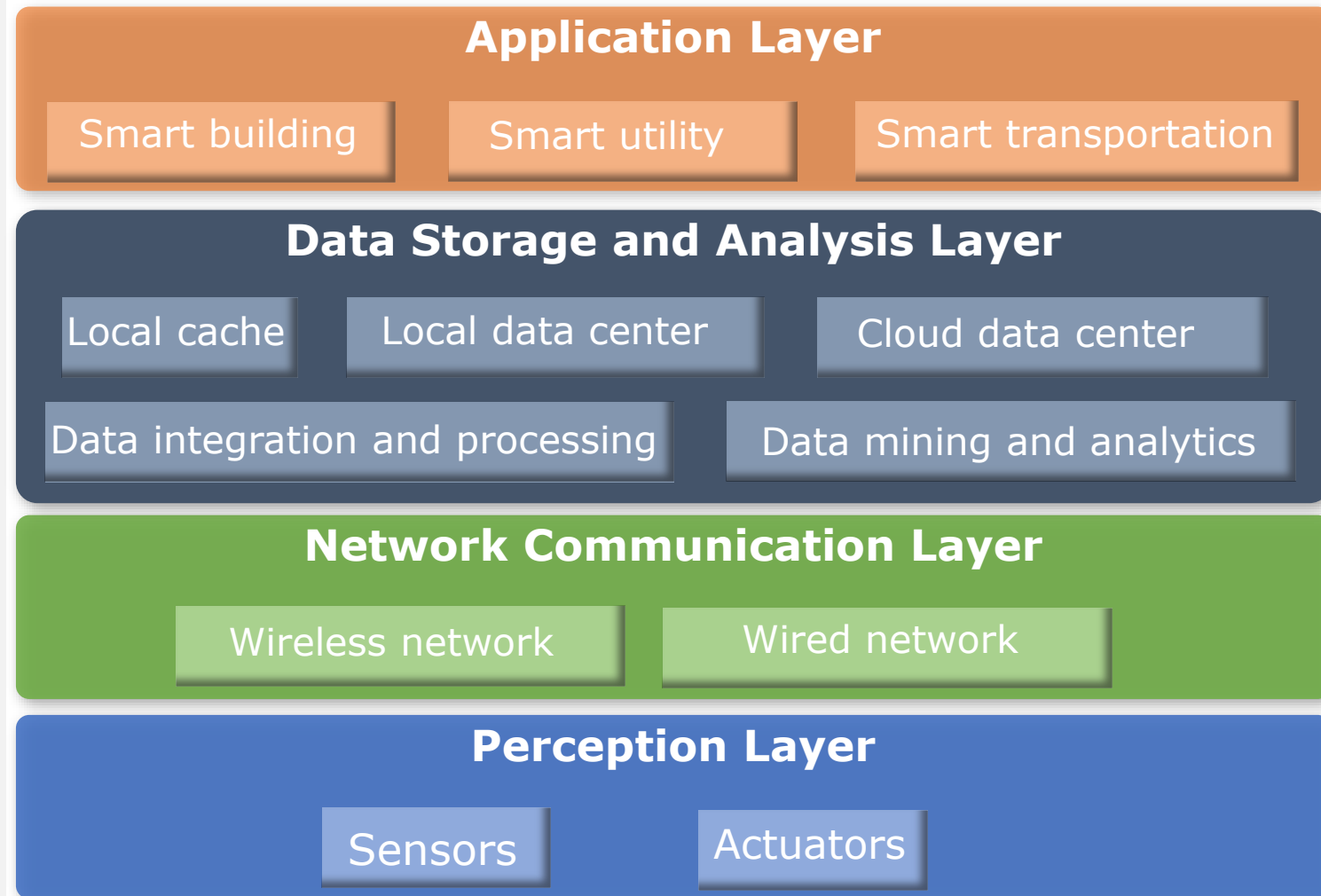
Optical Fiber Sensing Applications in Real-time Assets Health Monitoring for Building Structures

Prof. Xiaoli DING, Dr. Kenneth LAI, Dr. Huan WU

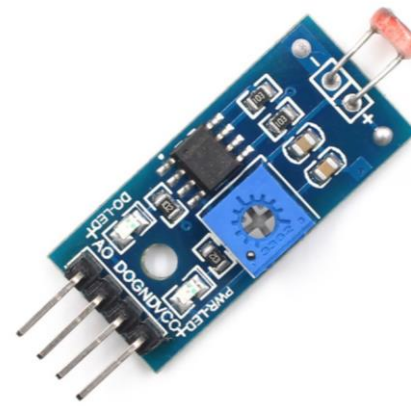
28 Feb 2023



An ICT Perspective on Industrial Automation

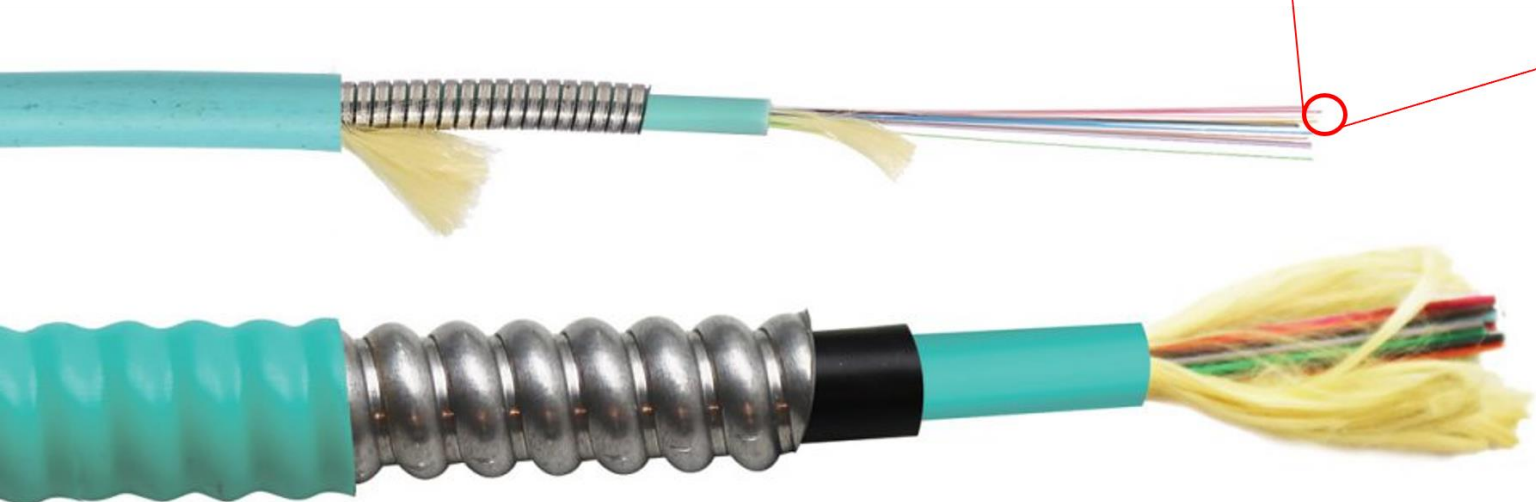
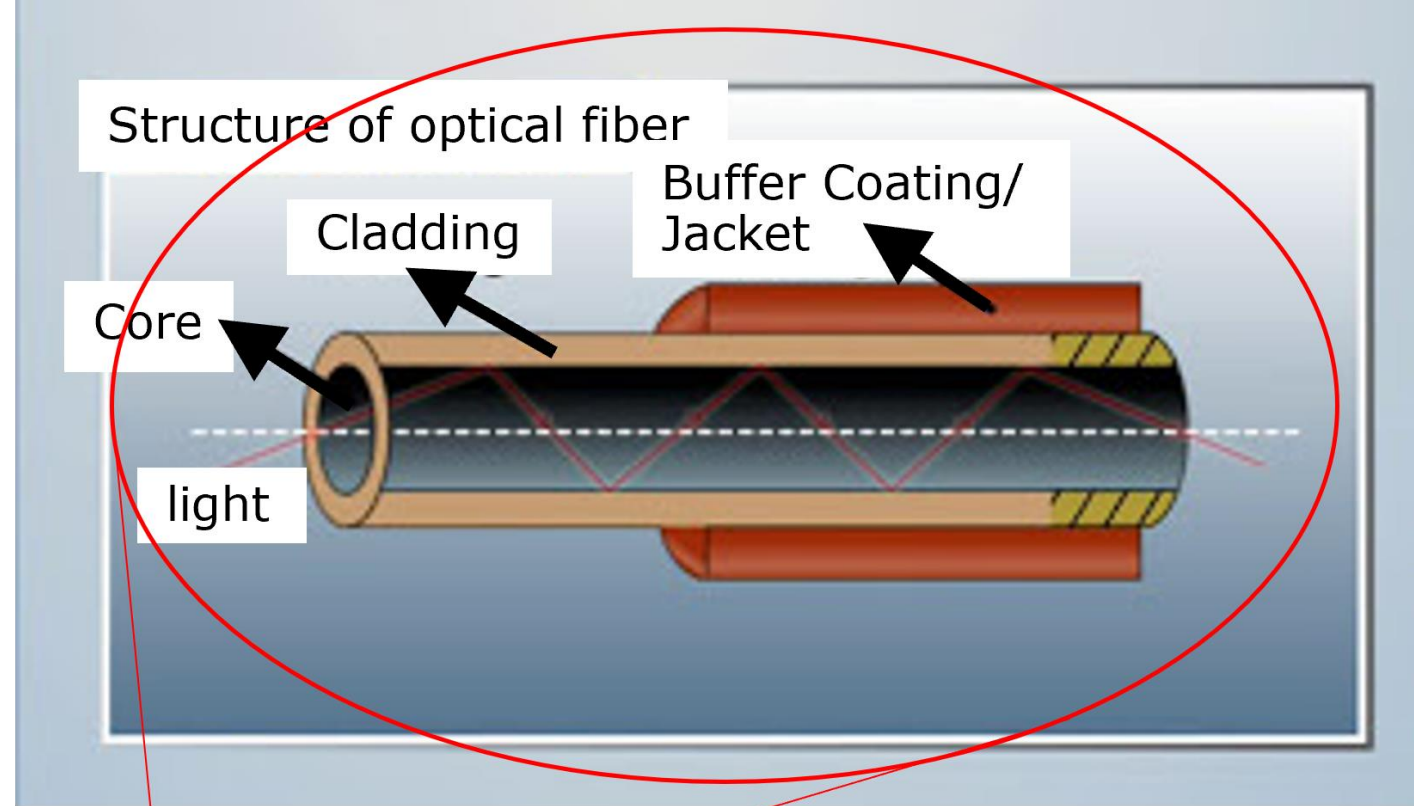


Various sensors

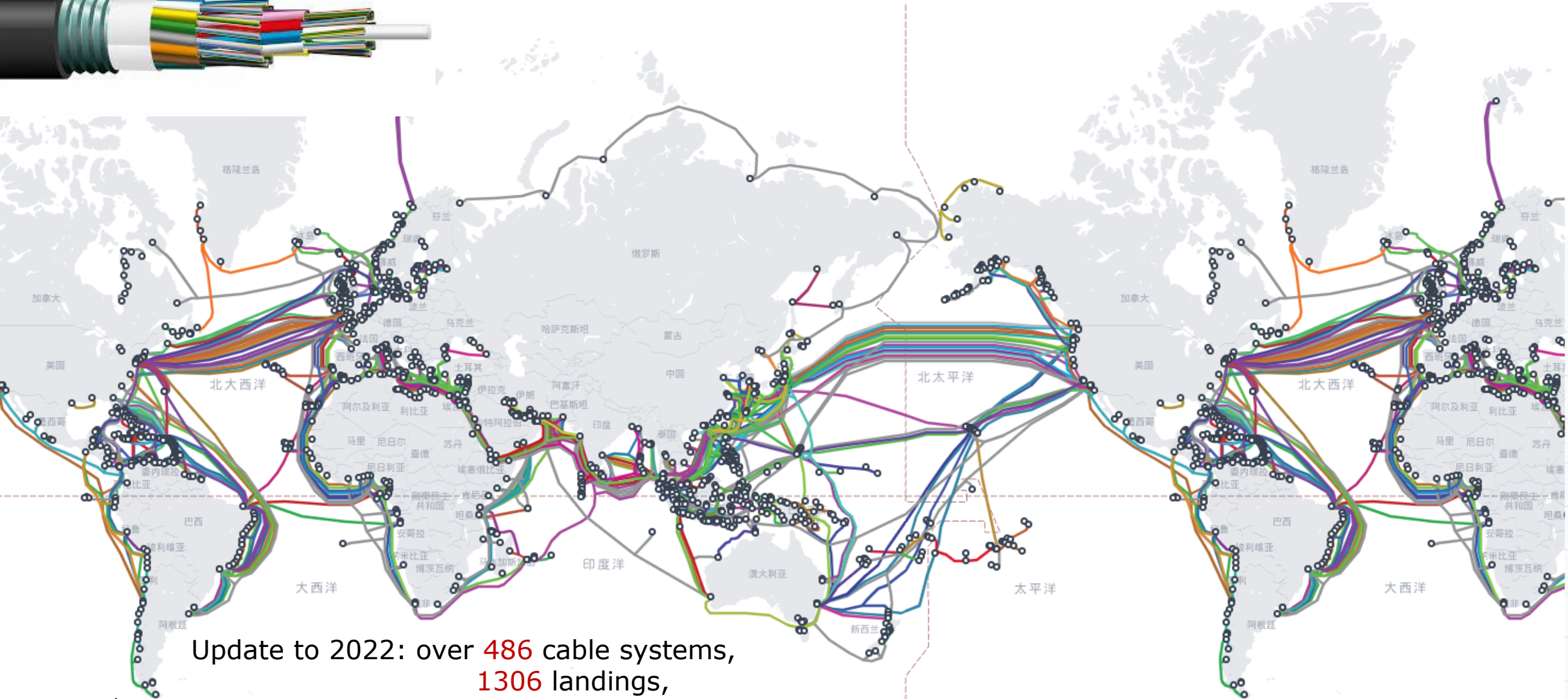


internet photo

Structure of an optical fiber



Current submarine fiber optic cable map



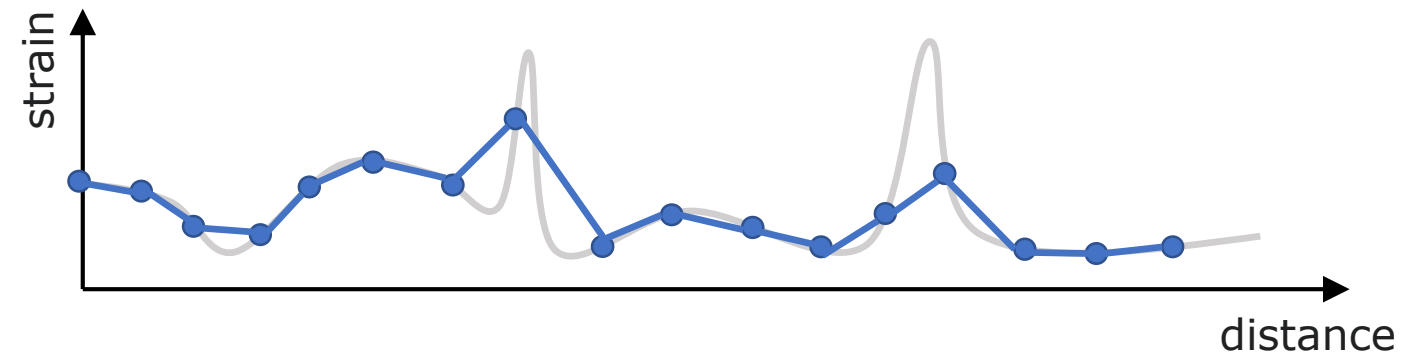
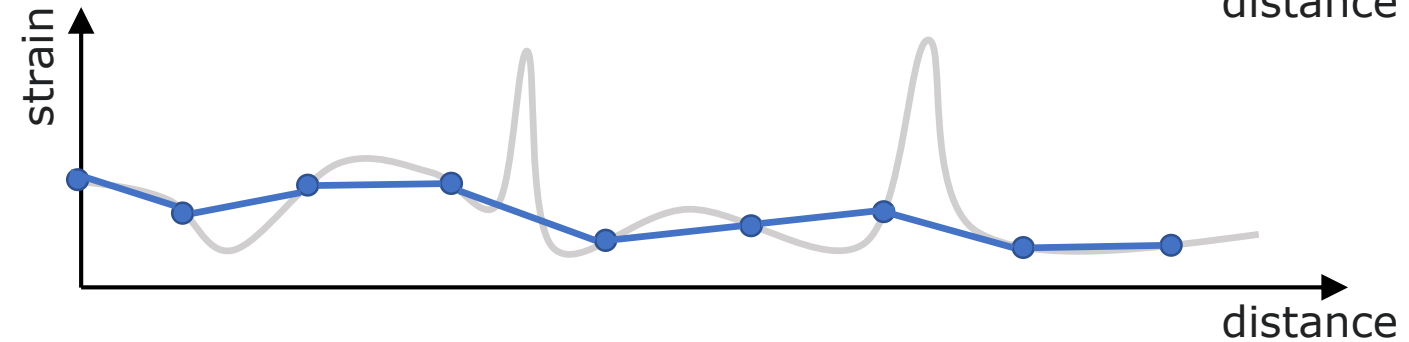
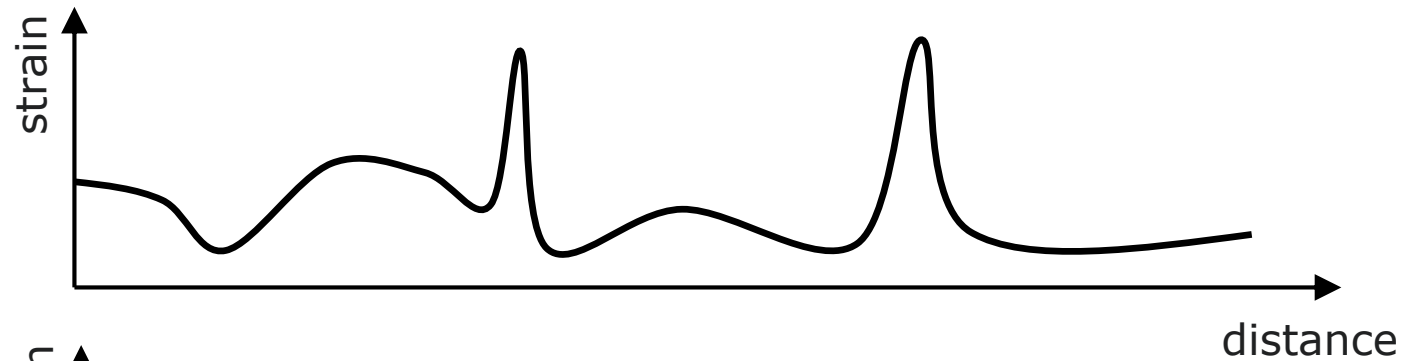
Limitations of point sensors



Tsing Ma Bridge ~ 2 km

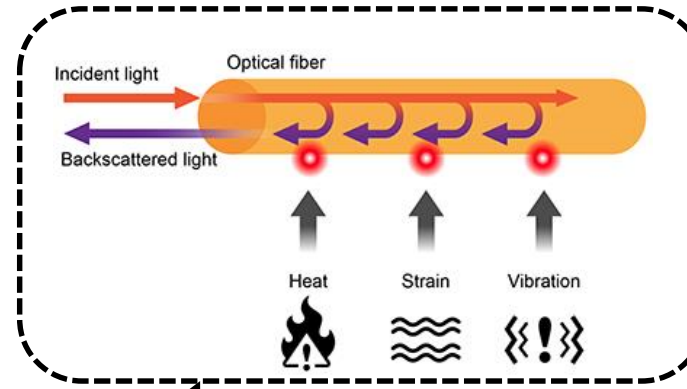
20 sensors $\longleftrightarrow$ 100 m/sensor

200 sensors $\longleftrightarrow$ 10 m/sensor



Limited coverage cause incomplete information!

Distributed fiber optic sensors (DFOSs)

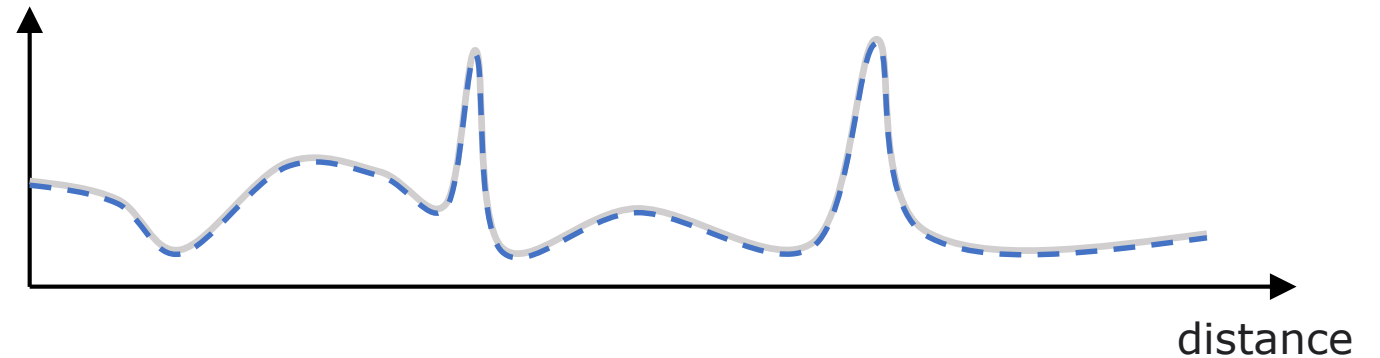


DFOS interrogators



The fiber itself is the sensor!

- **Distributed temperature sensor (DTS)**
- **Distributed strain sensor (DSS)**
- **Distributed acoustic sensor (DAS)**



Point sensors

Single point measurement

Power supply needed

Fail in hostile environment

Electromagnetic interference

Wired/wireless data transmission needed

DFOSs

Distributed measurement

No local power supply needed

Tolerate to hostile environment

Electromagnetic interference free

Sensing and data transmission simultaneously

Applications of DFOSs

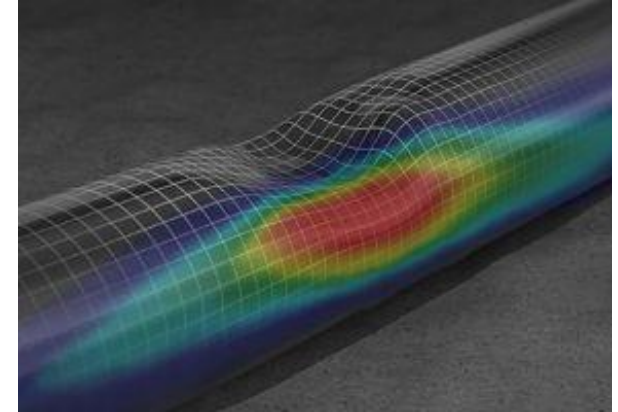
Pipeline monitoring



Leak detection
(DAS,DTS)



PIG tracking
(DAS)

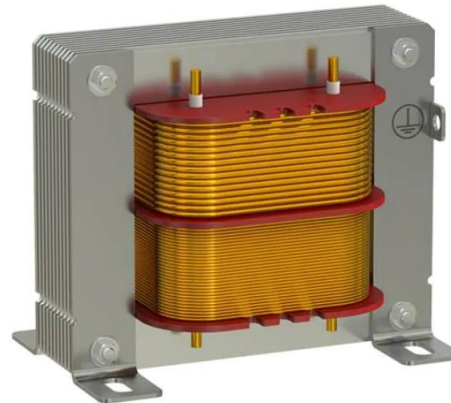


Pipe deformation
(DSS)

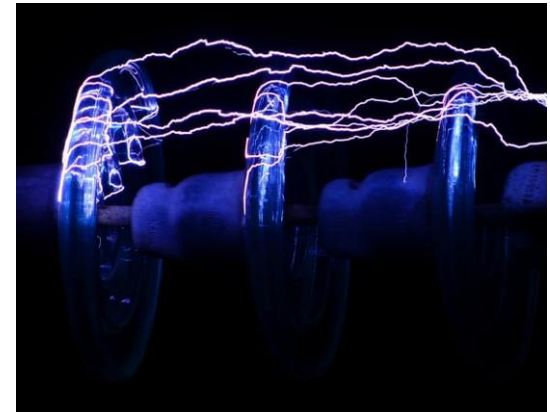
Energy cable monitoring



Dynamic rating of
carrying capacity
(DTS)



Transformer
monitoring
(DTS)



Partial discharge
detection
(DAS)

Applications of DFOSs

Industrial process monitoring



Conveyor belt fault detection (DAS,DTS)



Cement and concrete curing monitoring (DTS)

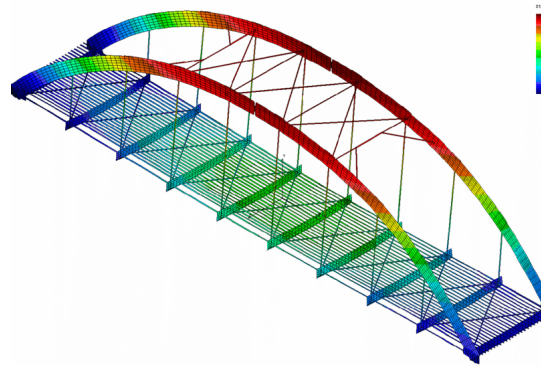


Process plant monitoring (DTS)

Structural health monitoring



Dam seepage detection (DTS)



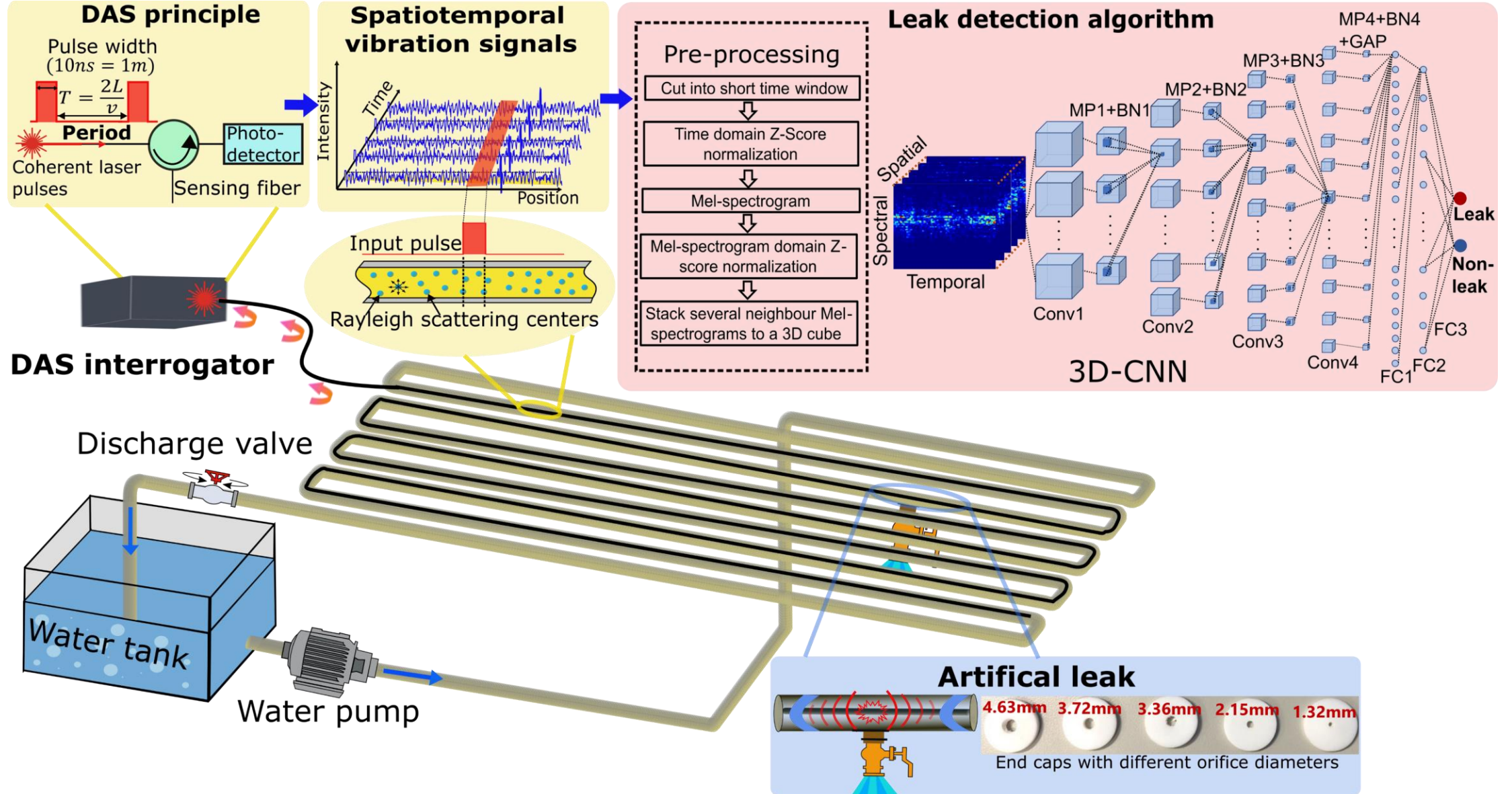
Bridge deformation monitoring (DSS)



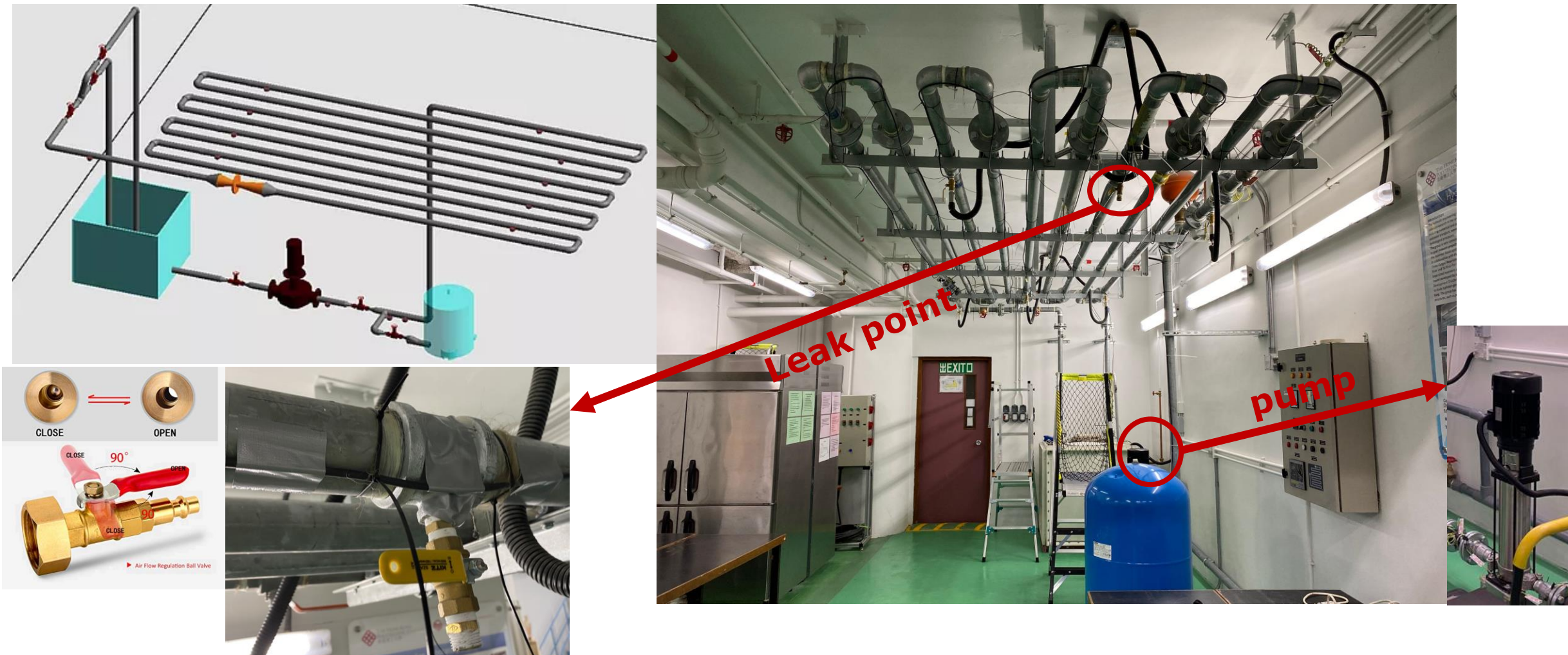
Ground movement and landslide monitoring (DSS)

Our Past Experiences

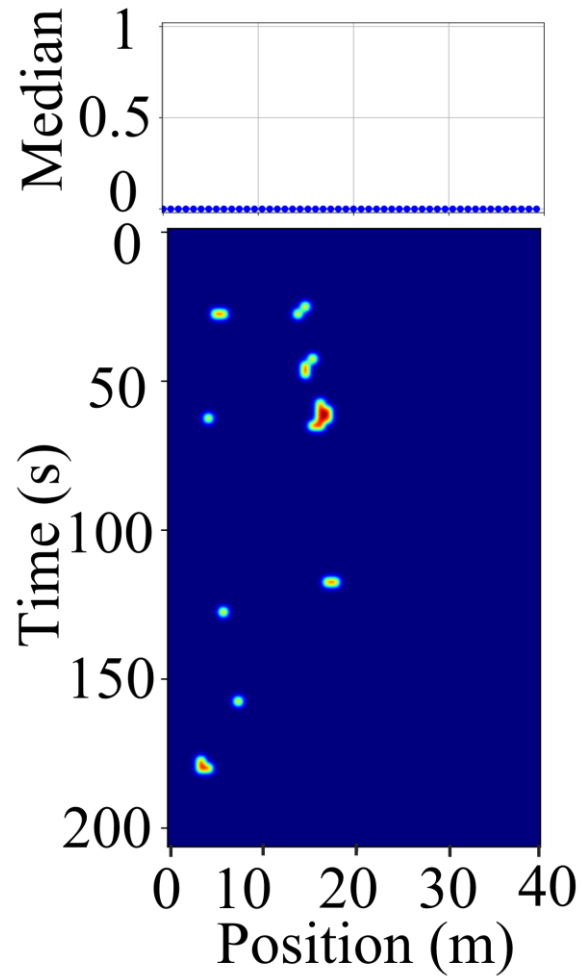
Water pipe leak detection



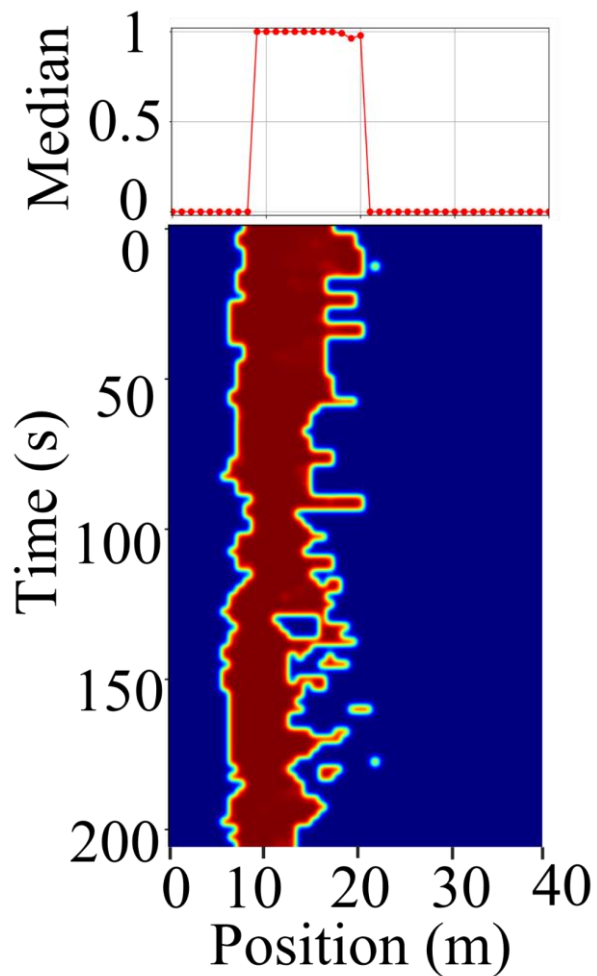
Water pipe leak detection



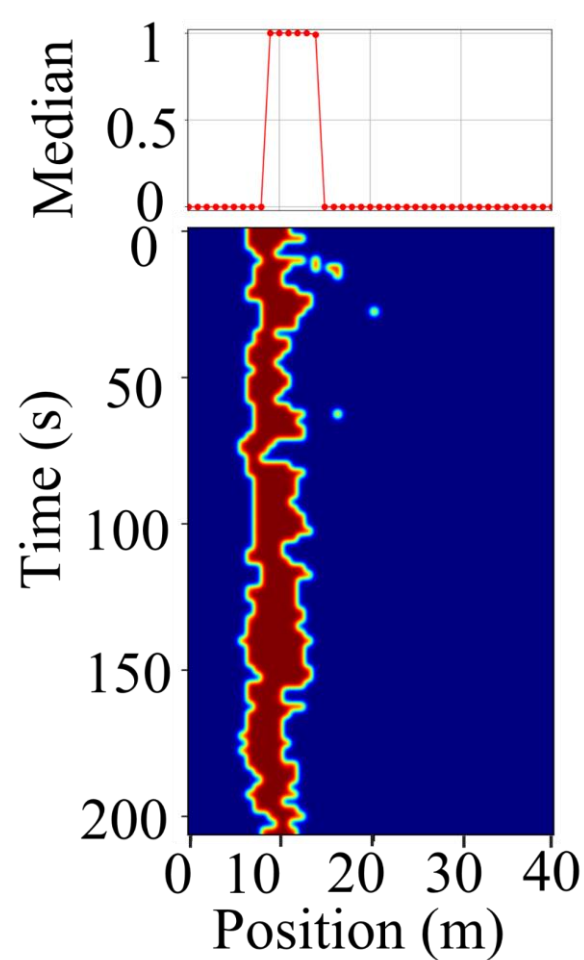
Water pipe leak detection



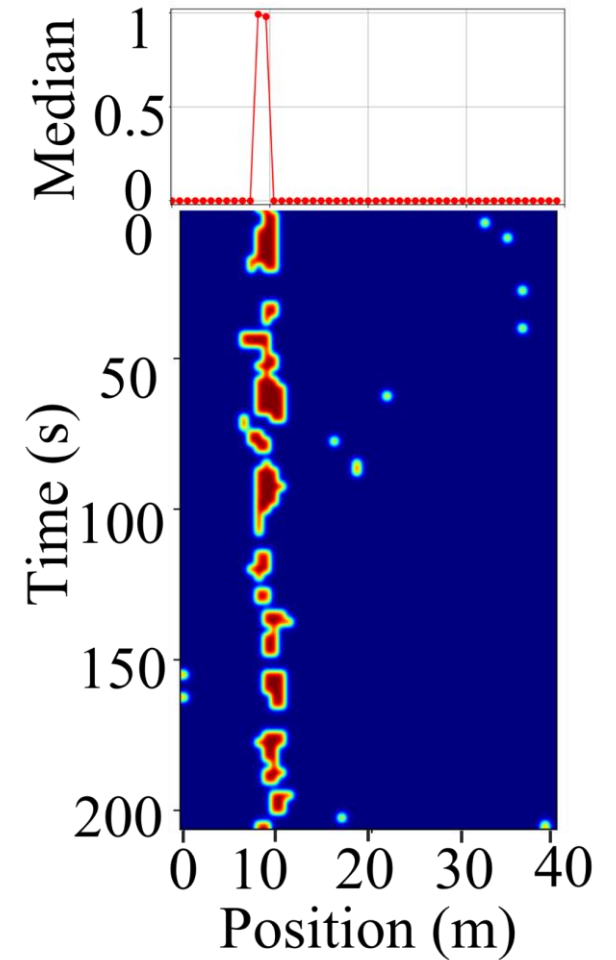
No leak



Large leak



Medium leak



Small leak

Underground water mains leak detection in Q-Leak



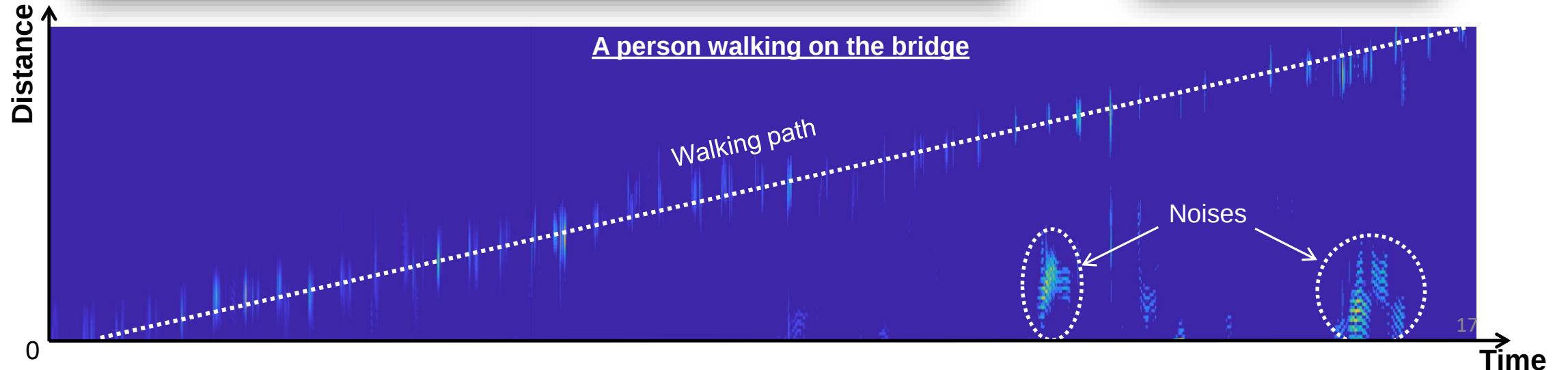
Sound captured by DAS



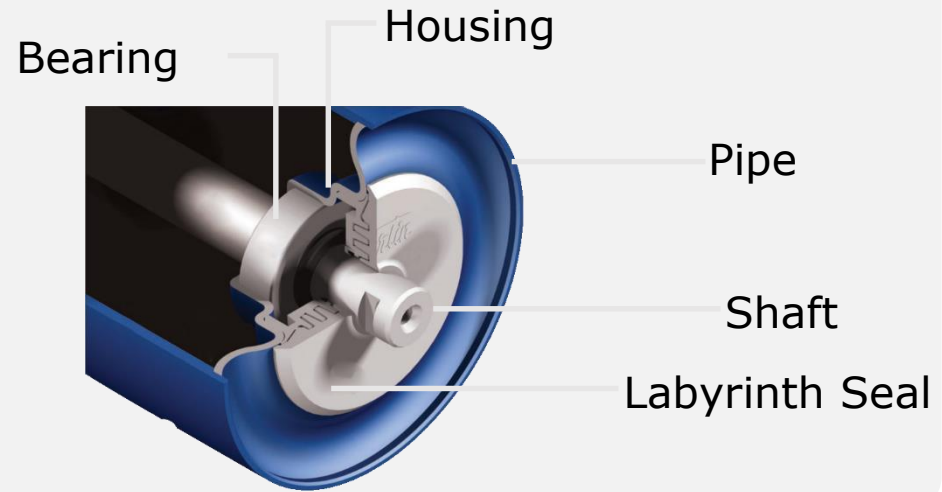
Anderson Road Quarry Development Site



Pedestrian monitoring



Conveyor Belt monitoring

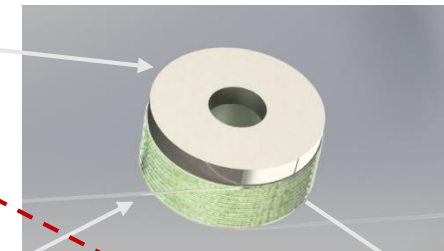


Accelerometer



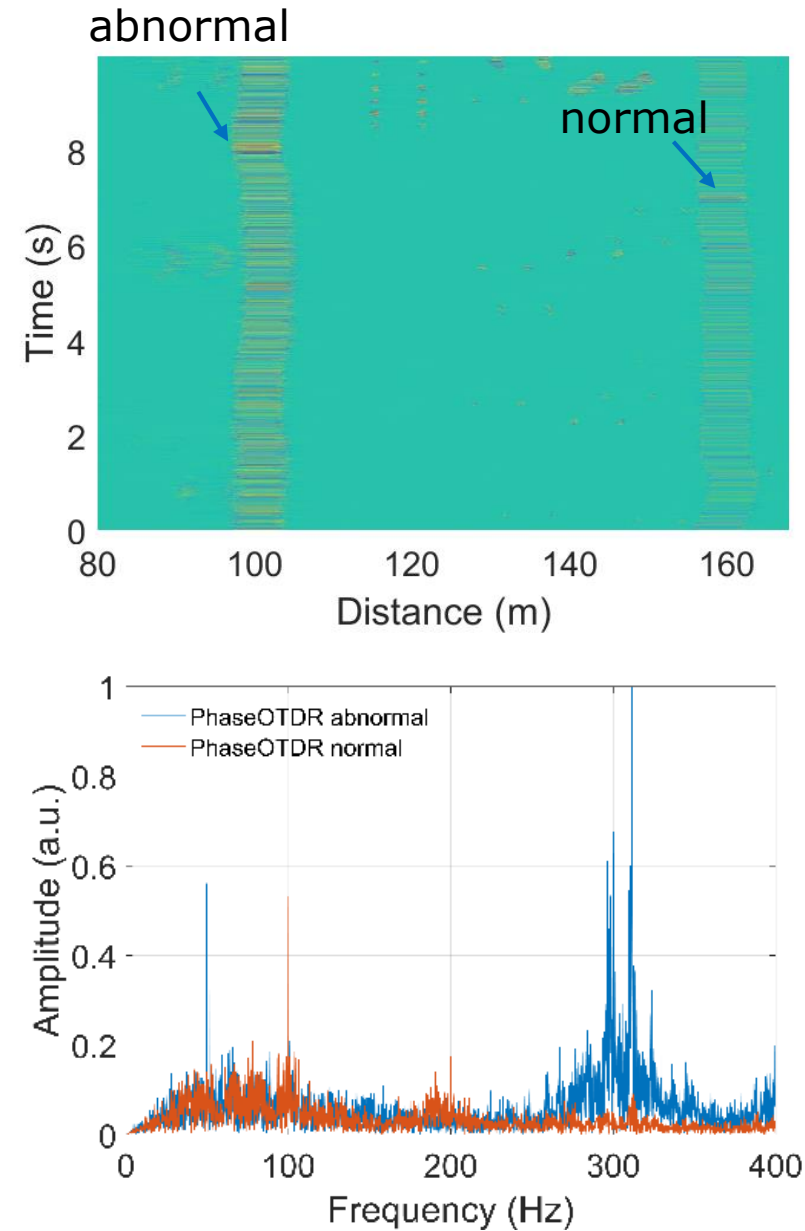
Mass

Optical fiber



transducer¹⁸

Conveyor Belt monitoring

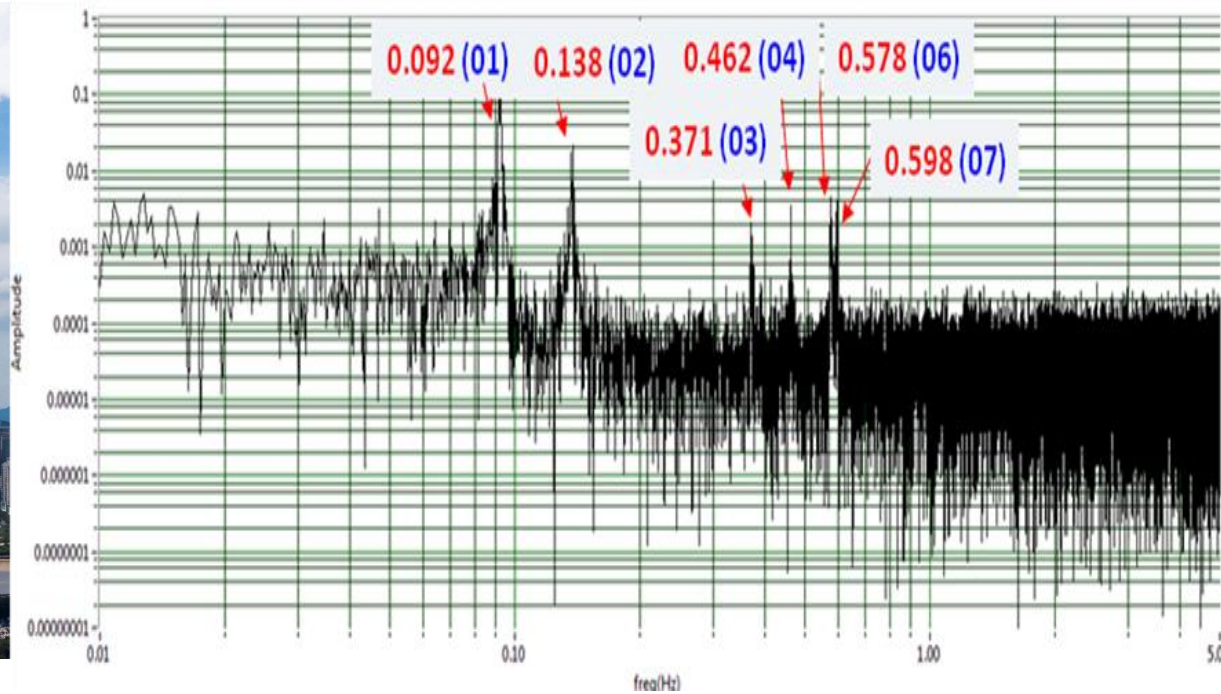


Frequency response curve of the Canton Tower

internet photo



Canton Tower 610m high includes the 156m antenna mast.

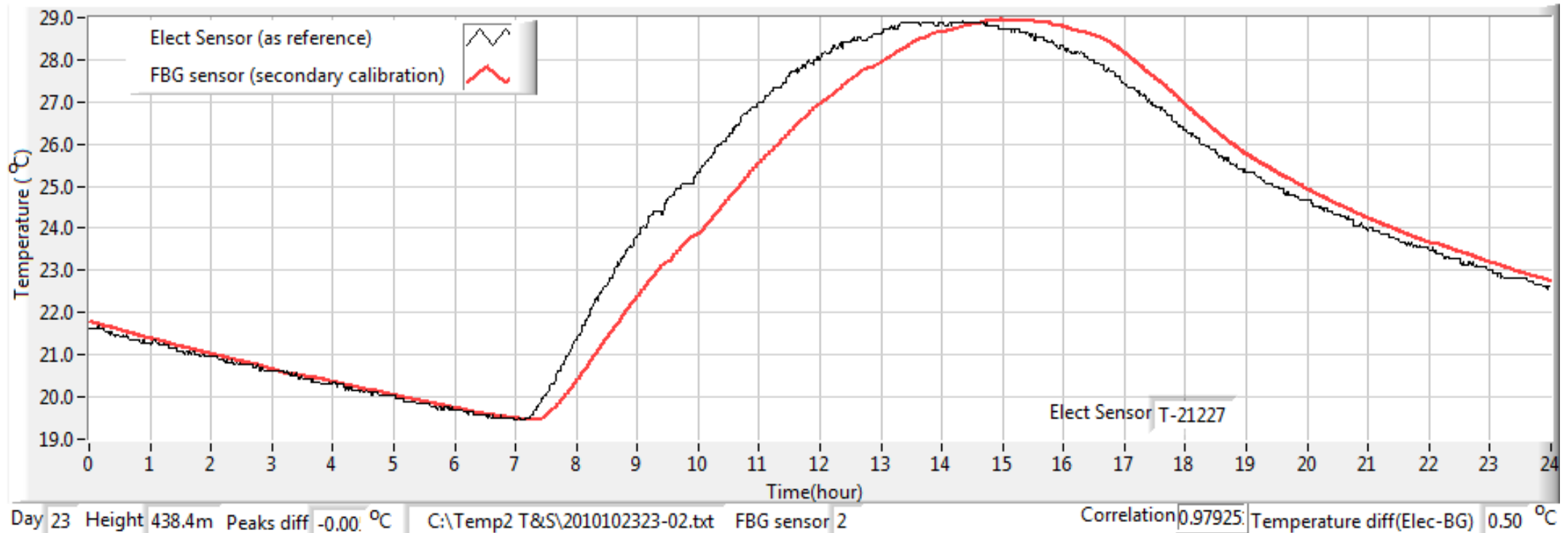


FFT analysis of FBG strain sensor located at column 13 and height of 110m.

Measurement period		Oct 2010	Nov 2010
Vibration mode	Designed value (Hz)	FBG strain sensor (Hz)	Accelerometer (Hz)
01	0.1102	0.092	0.0929
02	0.1590	0.138	0.1404
03	0.3466	0.372	0.3768
04	0.3682	0.464	0.4652
05	0.3995	N/A	0.5025
06	0.4606	0.578	0.5797
07	0.4850	0.598	0.5991

FBG = Fiber Bragg Grating

Electronic sensor vs optical fiber sensor



Temperature measurement obtained by the traditional and FBG temperature sensors with one hour phase lag

Take-home Message

Distributed fiber optic sensors (DFOSs) enable fiber optic cables to be used for sensing purpose

DFOSs transform a single fiber optic cable into hundreds or even thousands of sensors

Need to monitor long, thin structures, consider utilizing DFOSs



THE HONG KONG
POLYTECHNIC UNIVERSITY
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Q & A

