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PIANO NAZIONALE  
DI RIPRESA E RESILIENZA



# CAOS

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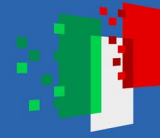
## First steps in site characterization: seismic measurements and fiber sensor installation



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## Contents

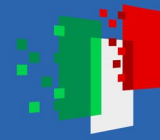
### Seismometry of the site

(ack Luca Naticchioni, INFN-Rome)

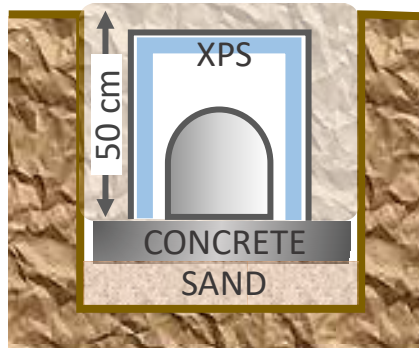
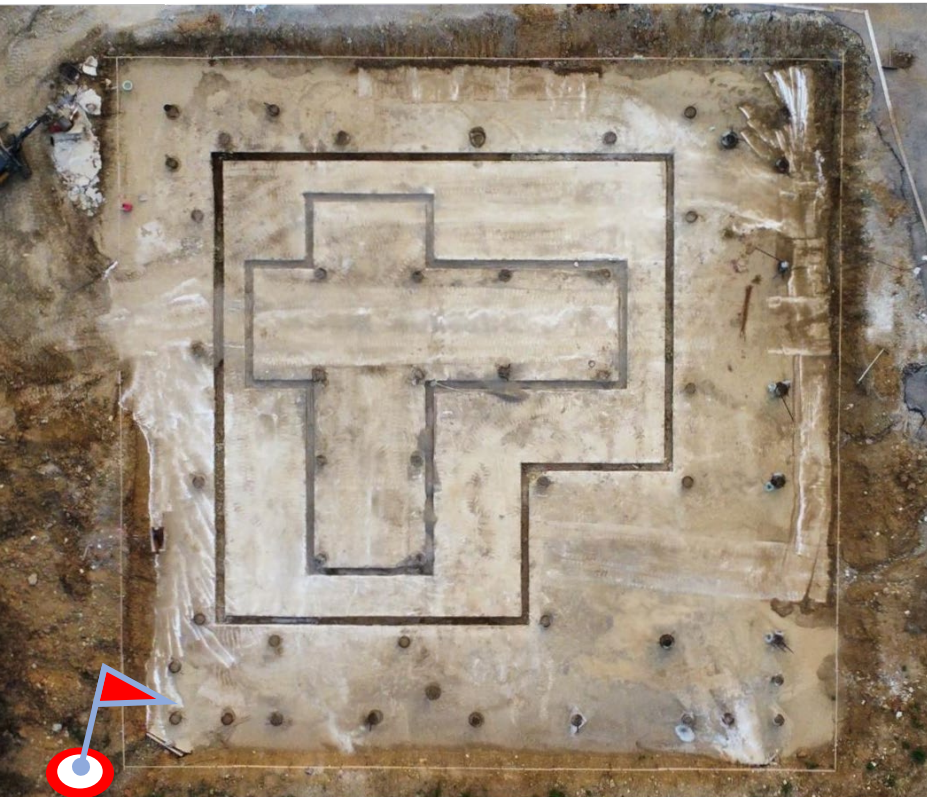
### Implementation of fiber sensors

(ack Nicola Piana Agostinetti, Università Milano Bicocca,  
and Raffaello Pegna, INGV-Pisa)

on behalf of the Environmental Characterization coordinator in CAOS  
and the experimental GW group of INFN-PG and Unipg



# Seismometry of the construction site



## Instrument TRILLIUM HORIZON 360

**Sensitivity:** 2000 V-s/m (reference User Guide for precise value)

**Precision:**  $\pm 0.5\%$  relative to User Guide specification

**Bandwidth:** -3 dB points at 360 s and 136 Hz

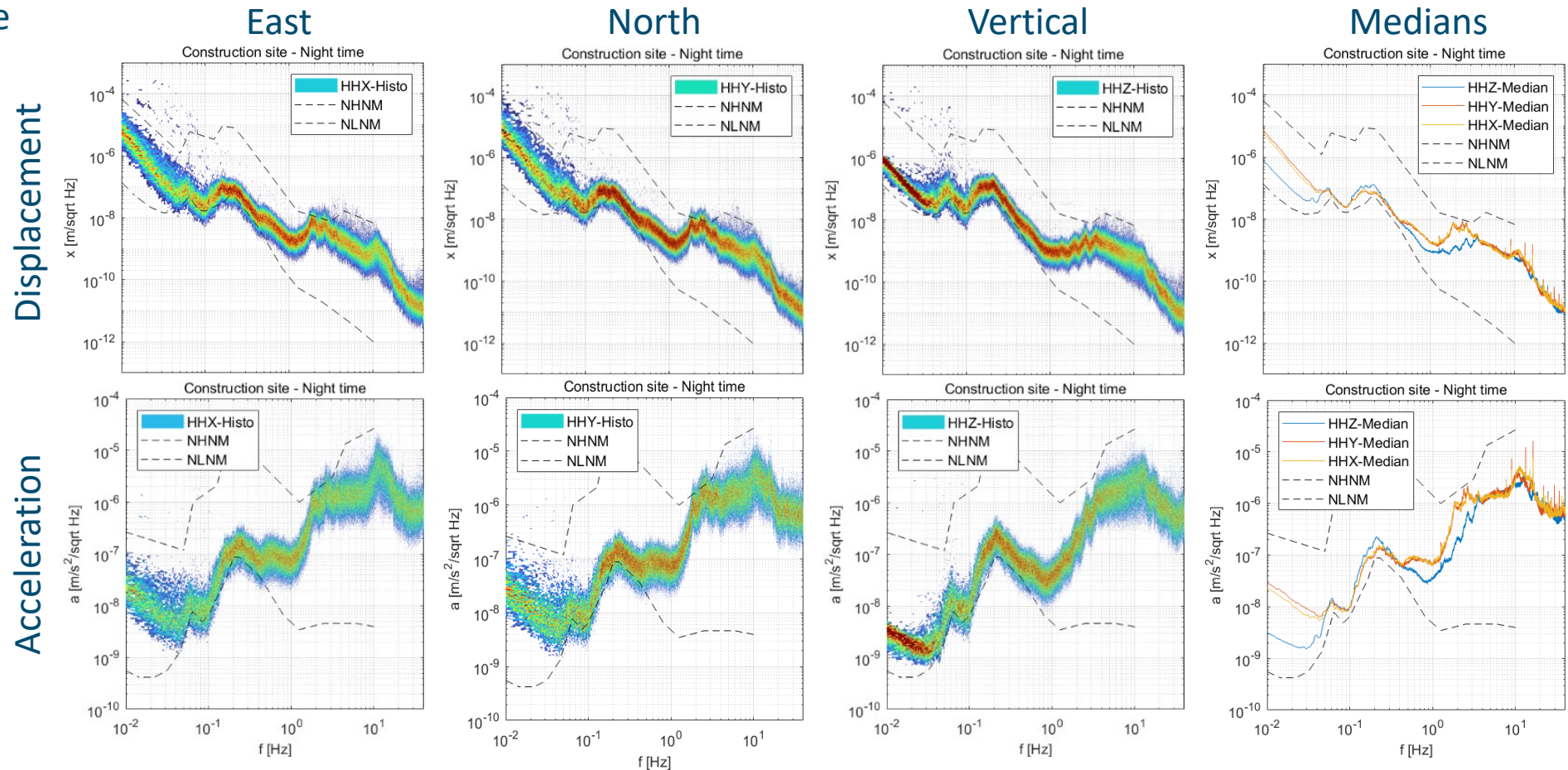
in collaboration with Luca Naticchioni (INFN-Rome)

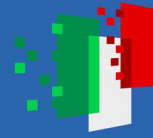




# CAOS construction site

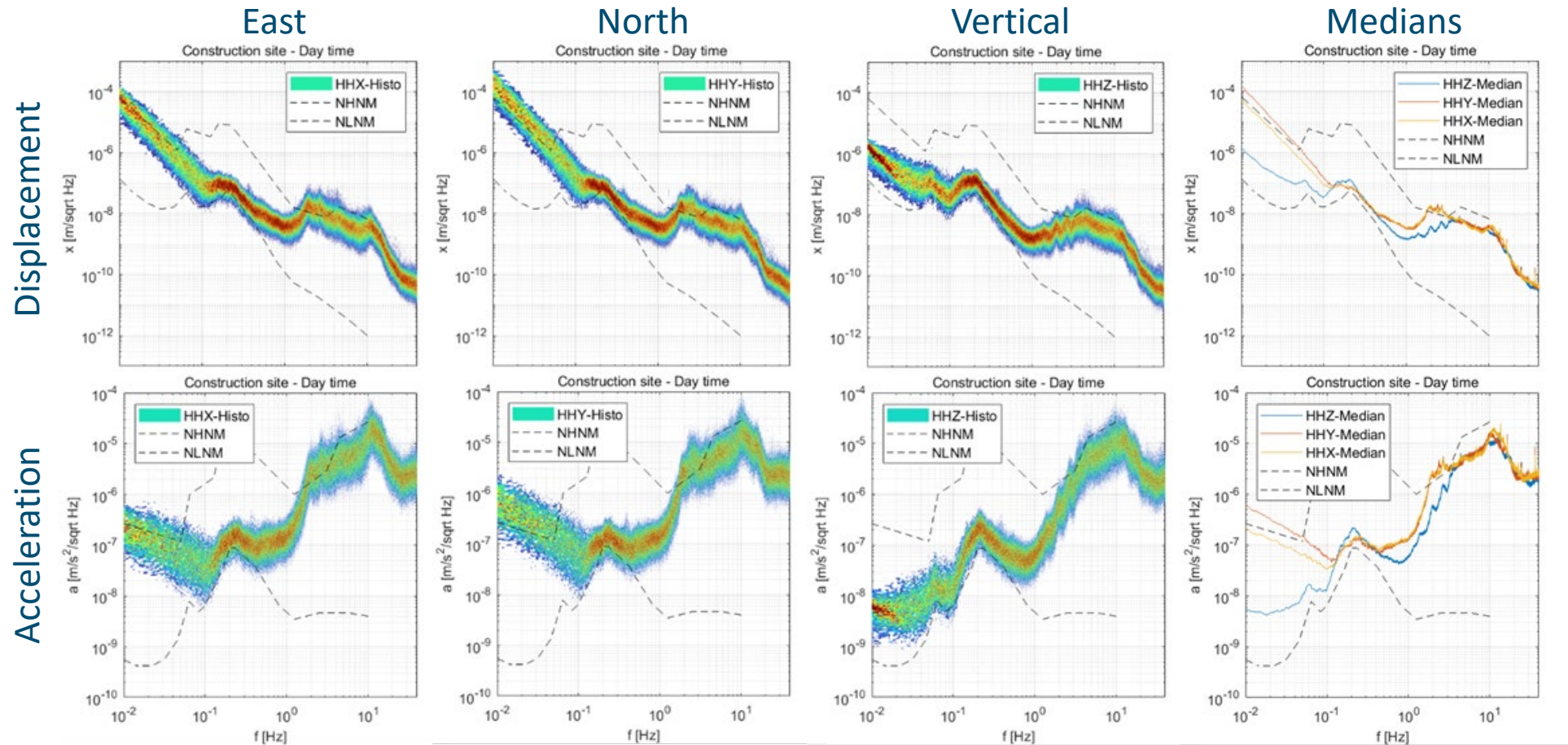
6 days, 8h in NIGHT time





# CAOS construction site

6 days, 8h in DAY time

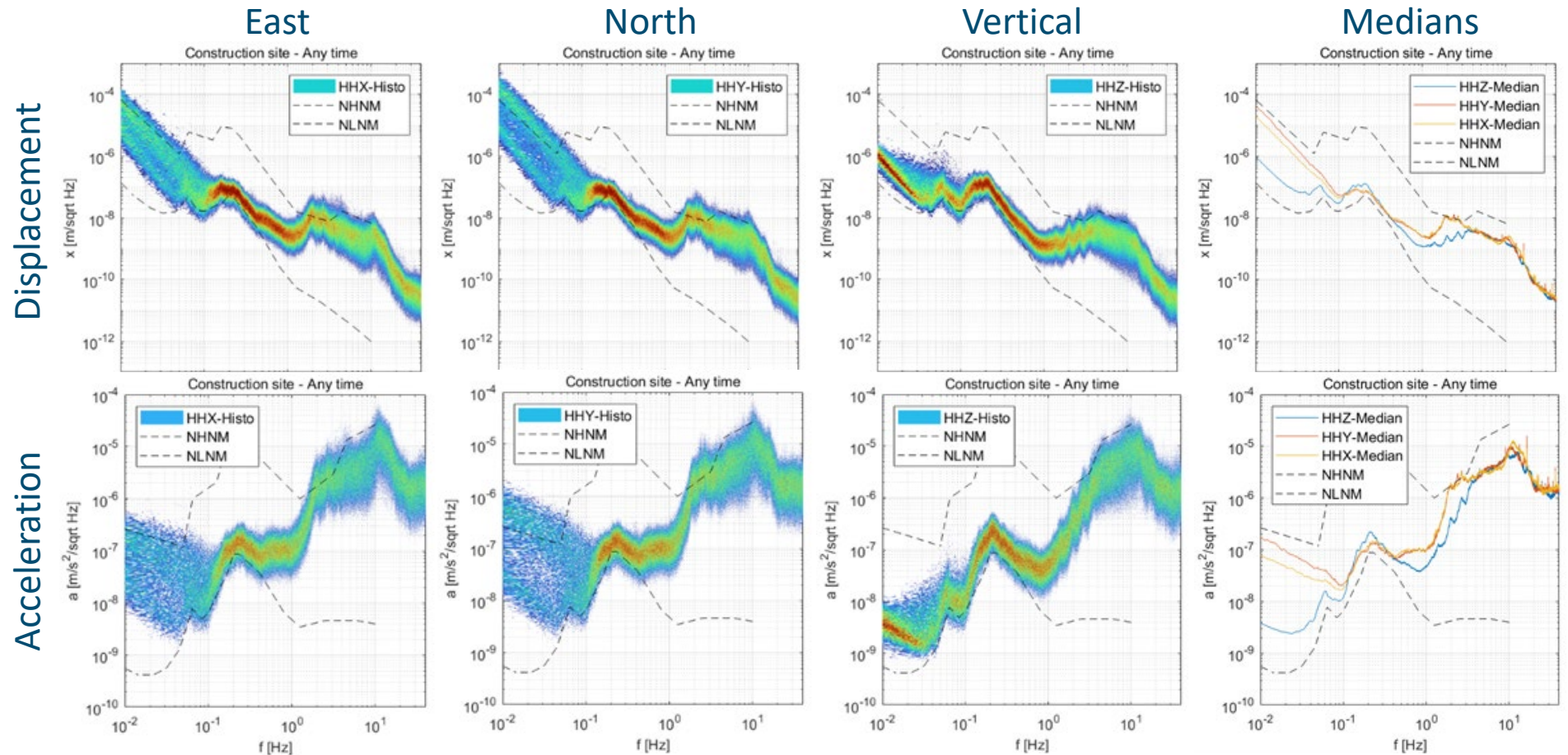


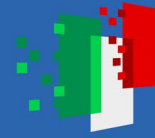




# CAOS construction site

6 days, ANY time





# Distributed Acoustic Sensing (DAS)\*

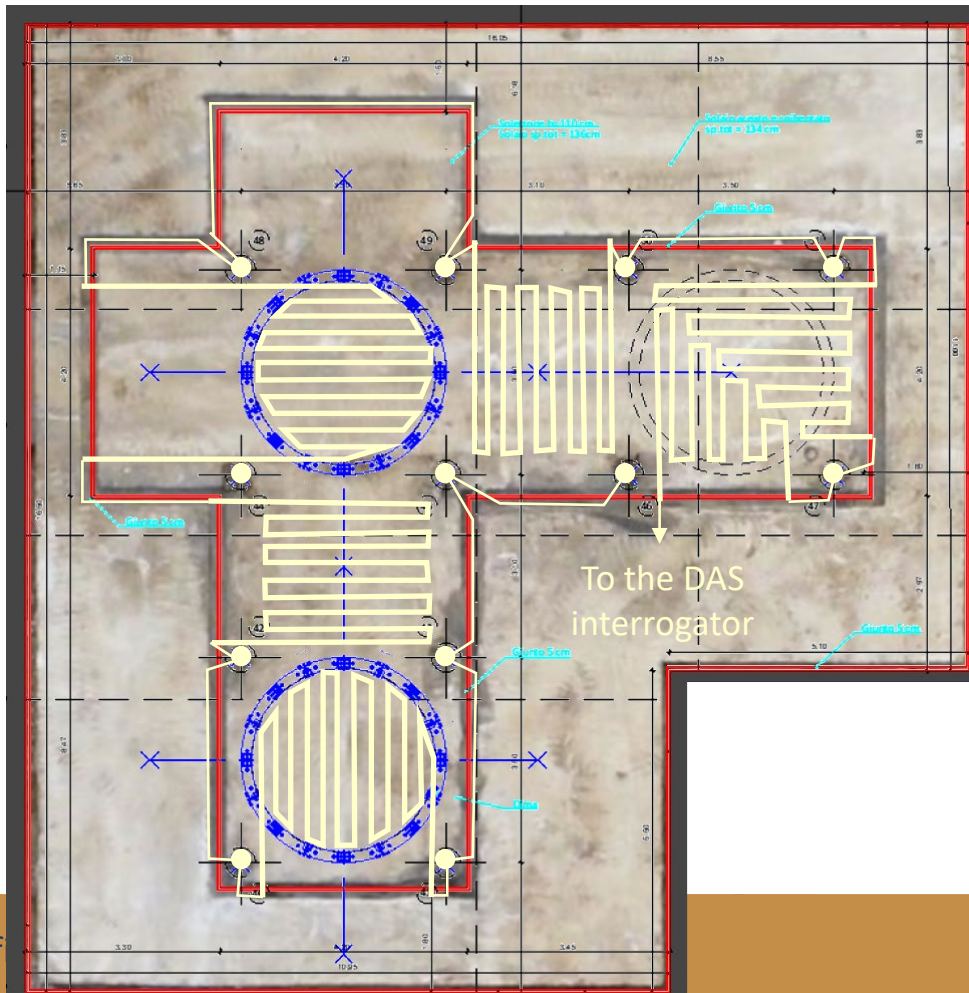
A distributed strain sensing plant is being studied and implemented based on optical fibers.

## Tentative Scheme

Thick yellow lines:  
horizontal sensors in concrete floor

Yellow circles:  
vertical sensors in foundation poles

Thin yellow lines:  
connections (no actual sensing)



DAS systems allow in principle to measure strain variations along an optical fiber with space-time resolution ( $\Delta x \sim 1\text{m}$ ,  $\Delta t \sim 10\mu\text{s}$ ).

The DAS system was not scheduled in the original project. Currently we have vertical fiber sensors implemented in foundation poles and a preliminary design of the cable ducts.

The horizontal section of the plant is under study.

\* See, for instance,

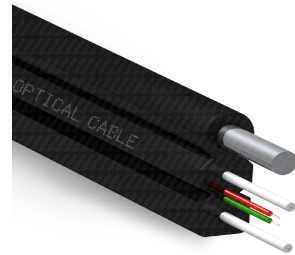
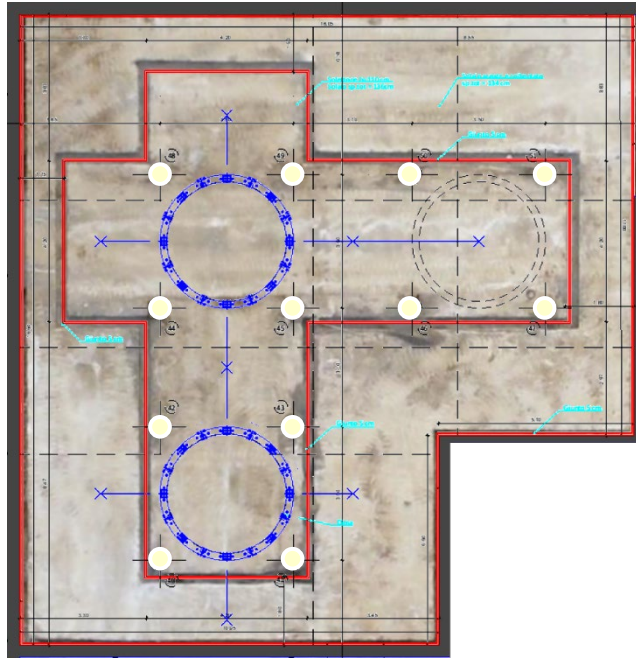
- Hartog, Arthur. (2017). An Introduction to Distributed Optical Fibre Sensors. 10.1201/9781315119014.
- Lindsey, Nathaniel & Rademacher, Horst & Ajo-Franklin, Jonathan. (2020). On the Broadband Instrument Response of Fiber-Optic DAS Arrays. Journal of Geophysical Research: Solid Earth. 125. 10.1029/2019JB018145.





# Distributed Acoustic Sensing (DAS)

## Vertical sensors in foundation poles



SM G.657.A2 type fibers are standard monomodal 9/125 fibers with good flexibility. The implemented fiber has no Teflon coating and couples effectively to the vibrations of the surrounding medium.

Fibers have been tied to the iron bars of the pole reinforcements and drowned in the concrete pour.







## Conclusions and perspectives

A first seismic characterization of the site is available.

Data can be studied and applied to design more detailed studies to come.

Further characterization is planned with geophones.

Budget has been requested for a Horizon Trillium 120 seismometer.

Vertical sensors are implemented in the foundation poles of the experiment.

Horizontal sensor plant is been designed.

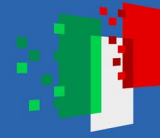
Budget has been requested for a DAS interrogator.



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# BACKUP SLIDES





# Indoor, nearby (130 m distance)

6 days, 8h in NIGHT time

