O3.5-240

Capabilities of fibre optic cables to characterize seismic and explosion events – Case study in an underground laboratory

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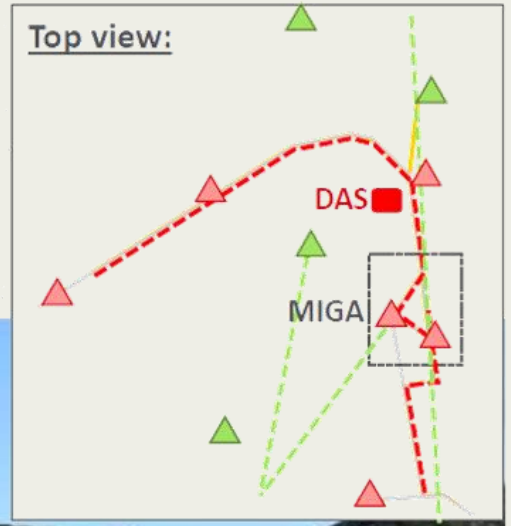
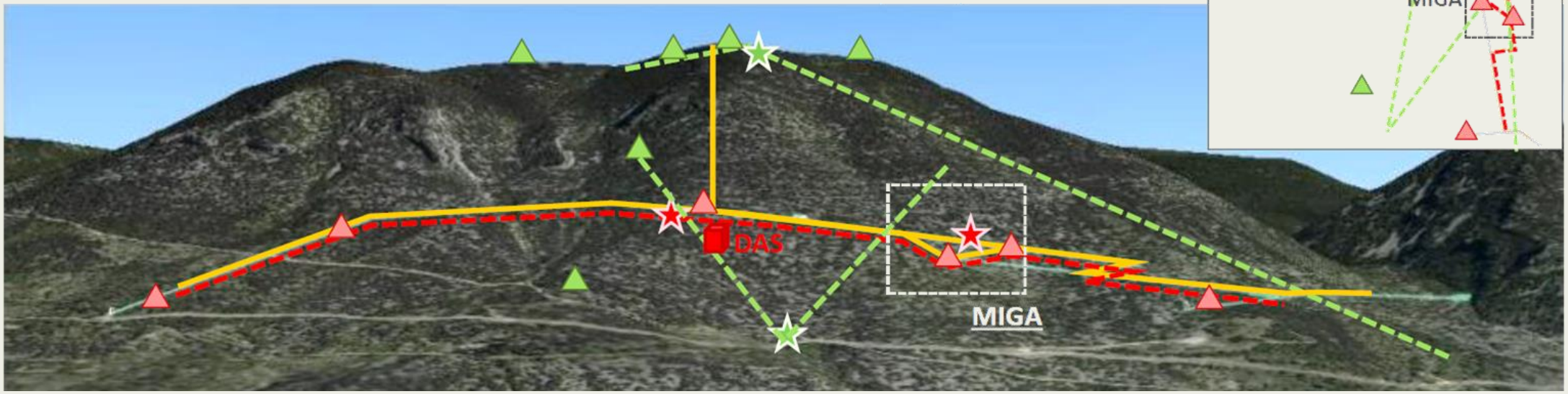
Agenda

1. Description of the DAS experiment
2. Coupling analysis
3. Events location
4. Earthquakes and thunderstorms detections

Design of the experiment

- 3D geometry
  - Seismometer 3C – Short period « Nodes »  + 6 BB sensors
  - Accelerometer 3C – Galeries: 200 « Sercel » Mems  + 6 BB sensors
  - Optic Fiber – Galeries: >3km
- 4 shot zones:
  - different depth: 10m to 500m
- Several specific area:
  - MIGA: Simultaneus recording by a dense seismic array of 3C seismic sensors and Optics Fibers
  - Inside and outside the galeries

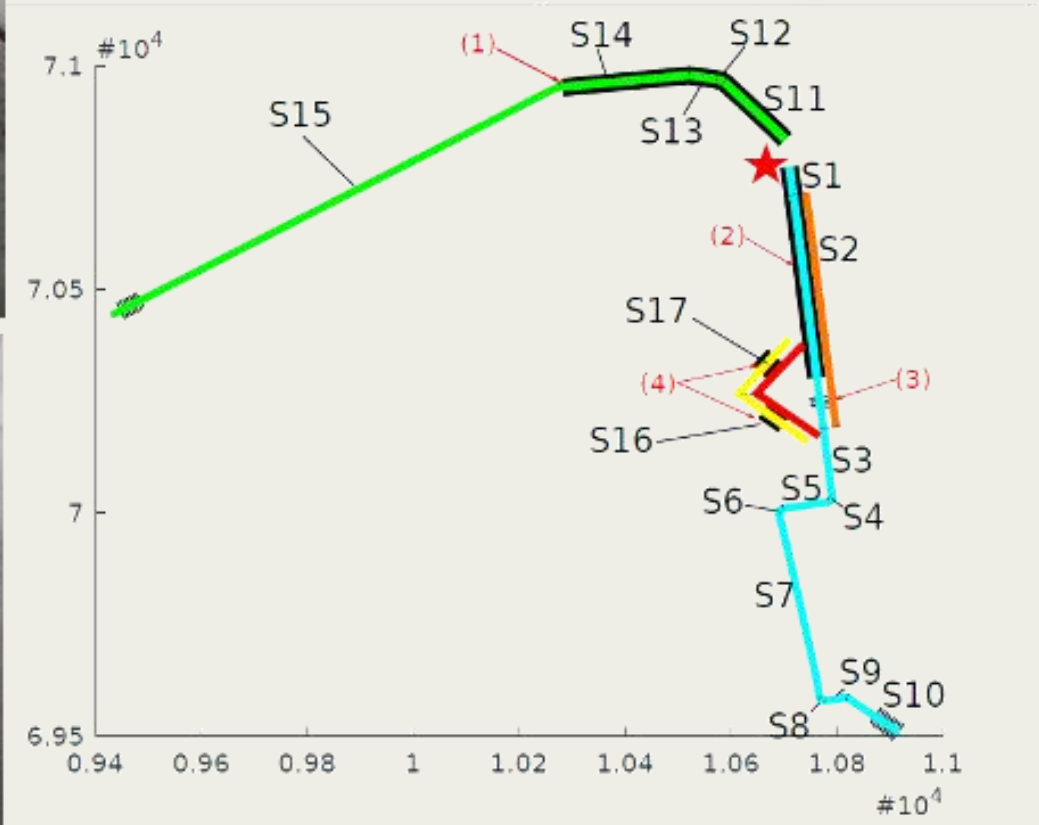




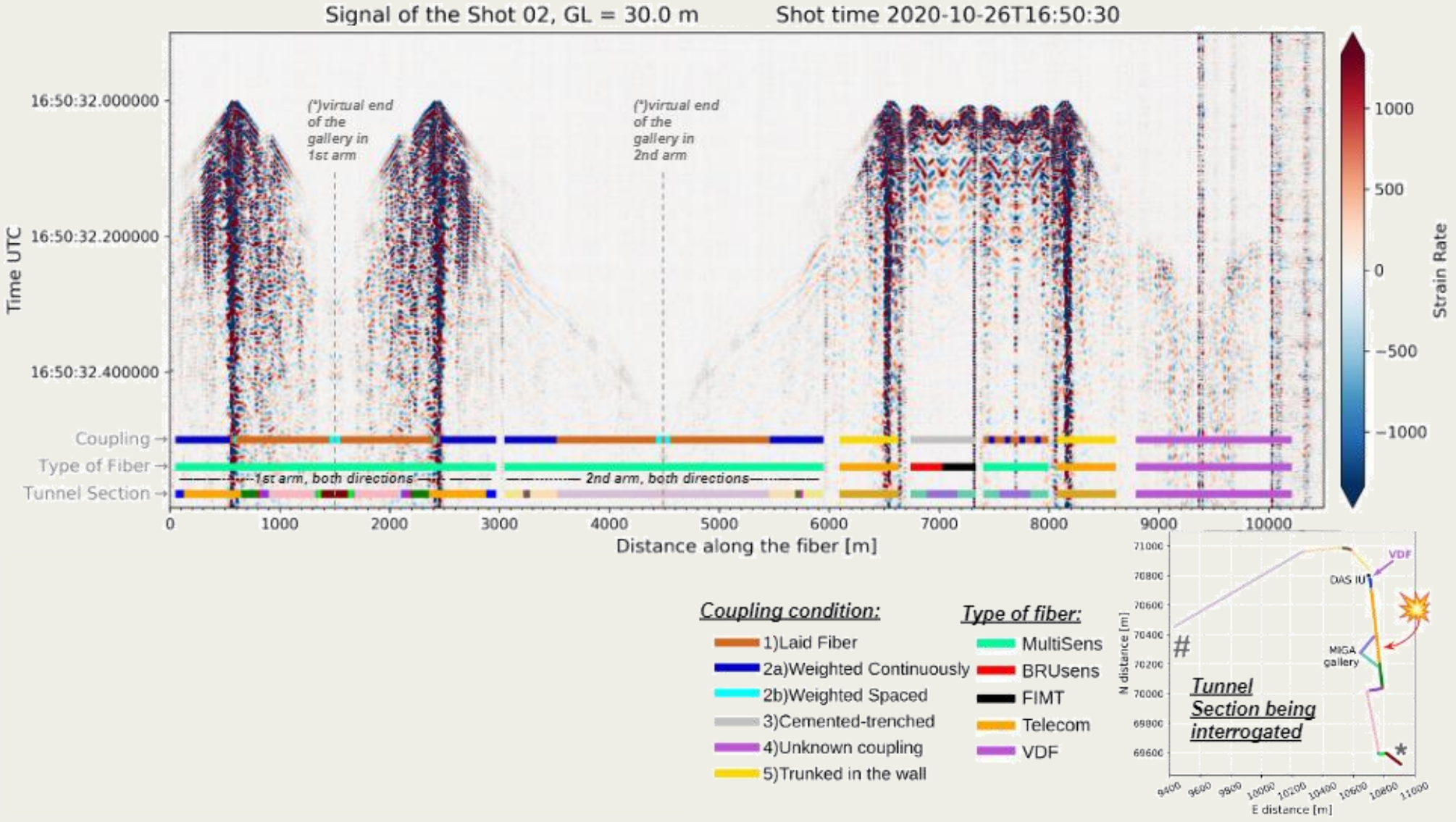
Cloupling settings

- Several fibres
- Several couplings

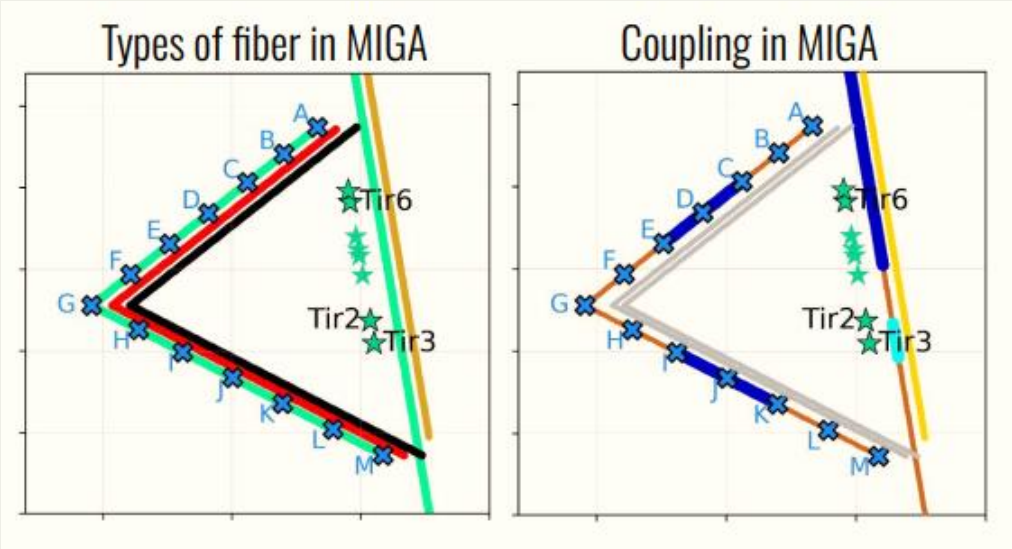
Sand bags (spaced)
Sand bags
Section limits



Event recording example



Coupling – Preliminary results



MULTISENS

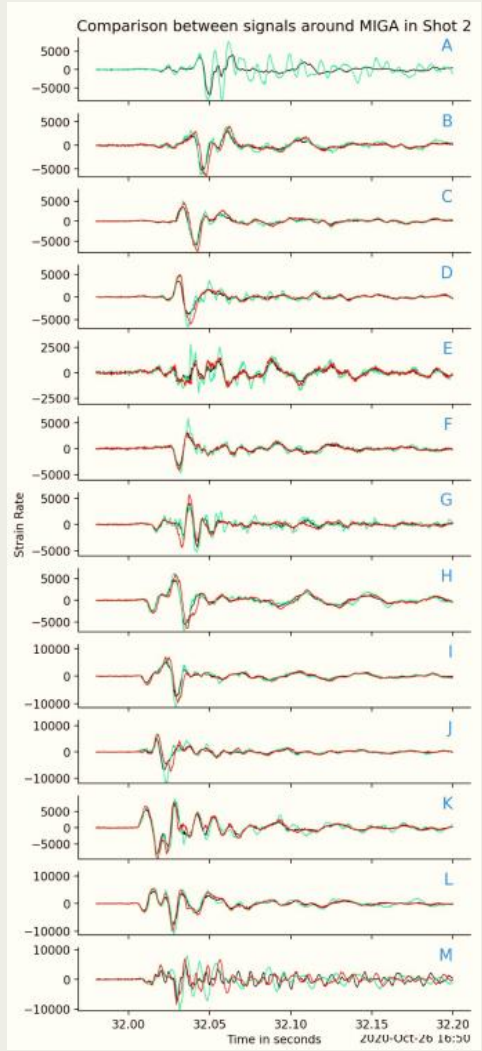
BRUSENS

FIMT

Sand bags on top

Laid on the ground

Cemented

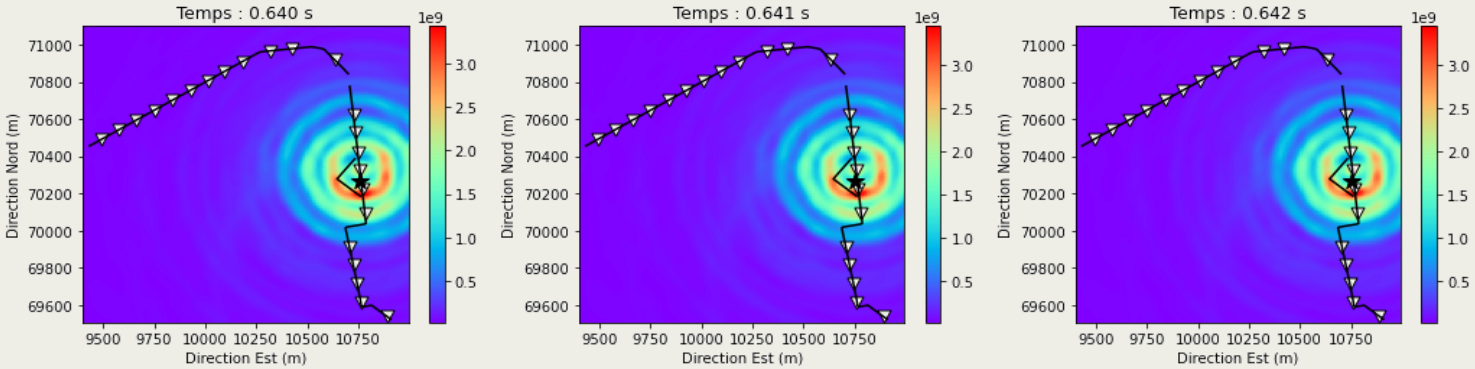


- First order no big differences between cables and couplings
- The coupling seems to have an impact on the high frequencies

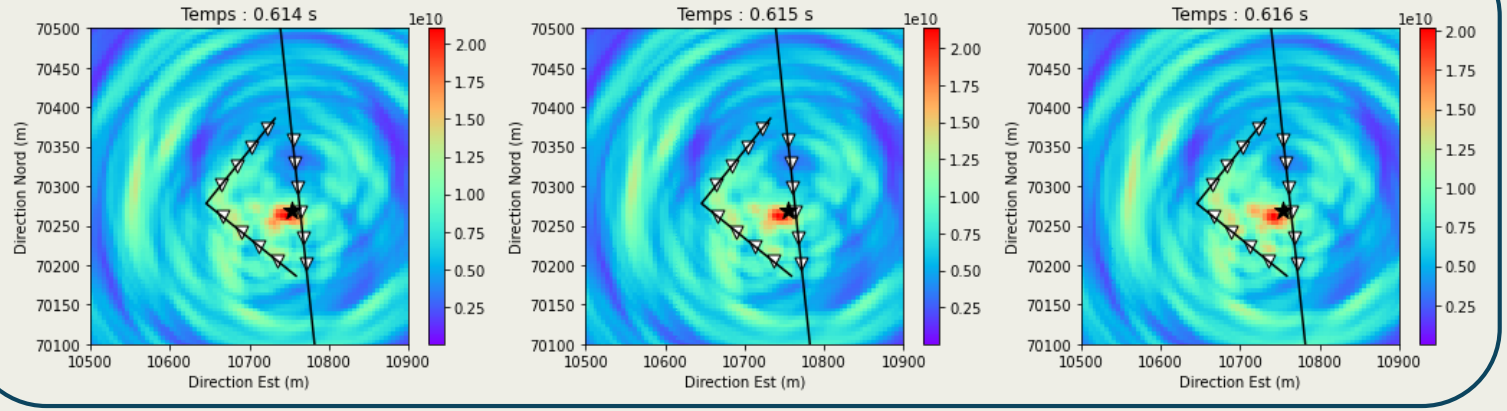
Location – Back projection of DAS data

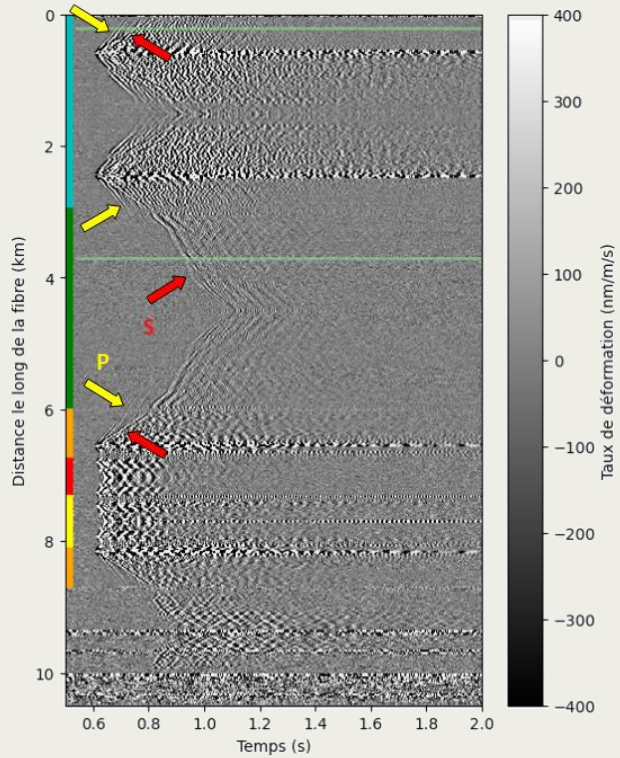
- ▶3 differents models tested : constant P velocity, constant S velocity, velocity depends on incidence
- ▶Filters applied : high cut 30Hz, envelope, envelope + high cut 30Hz

Using 23 traces spread in all galleries



Using 14 traces around the source location





▶ Best location

about 15m from real explosion location

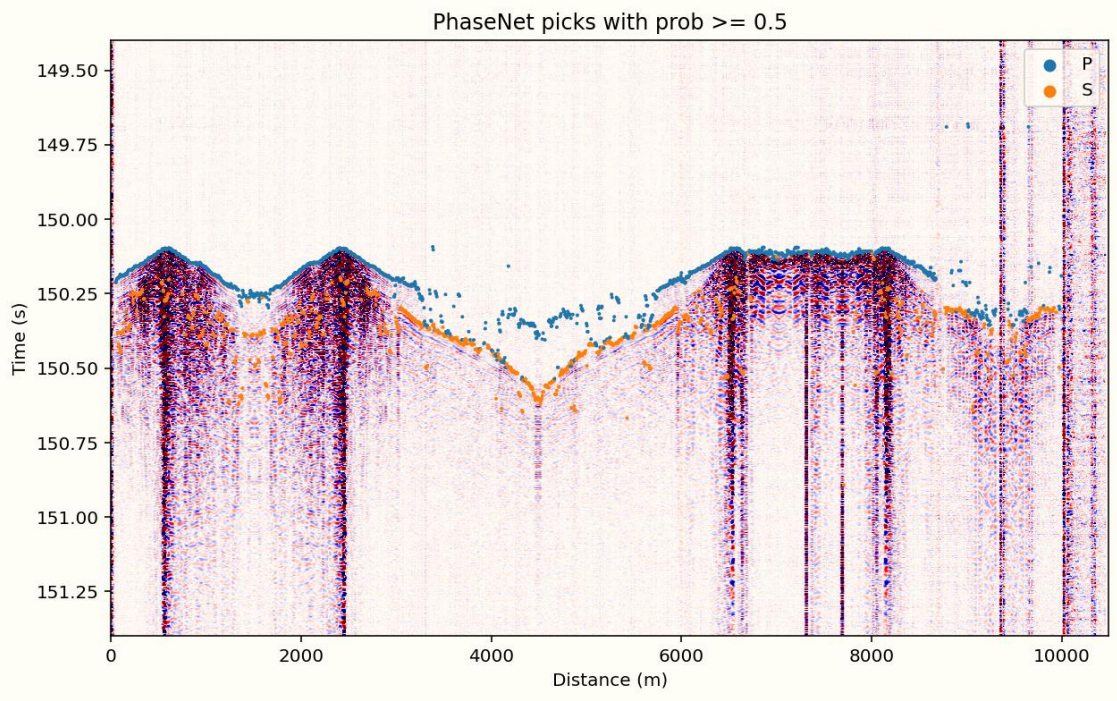
Automatic phase picking - AI

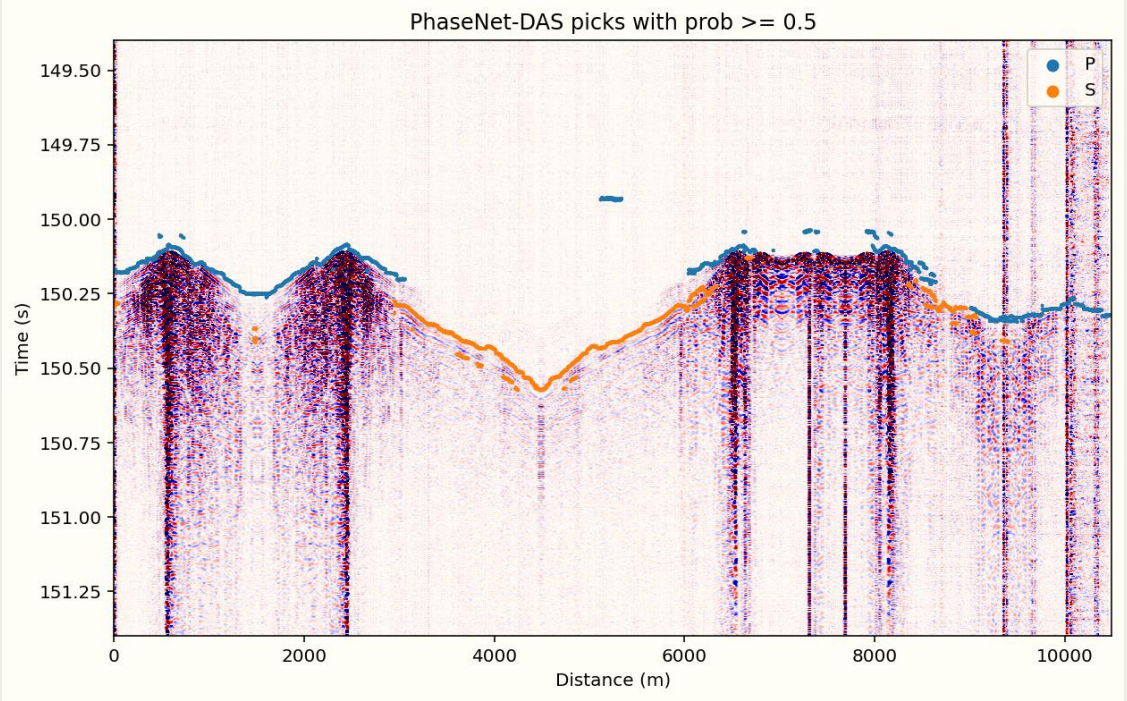
PhaseNet

https://academic.oup.com/gji/article/216/1/261/5129142

EQNet
PhaseNet-Das

https://www.nature.com/articles/s41467-023-43355-3

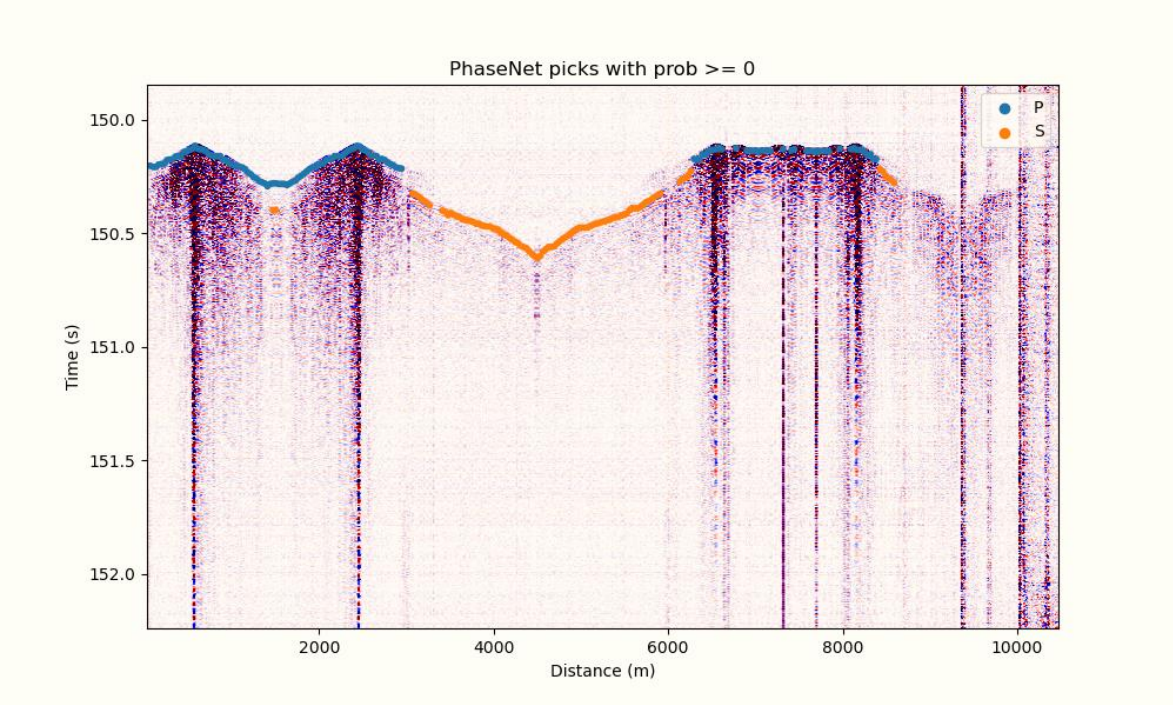


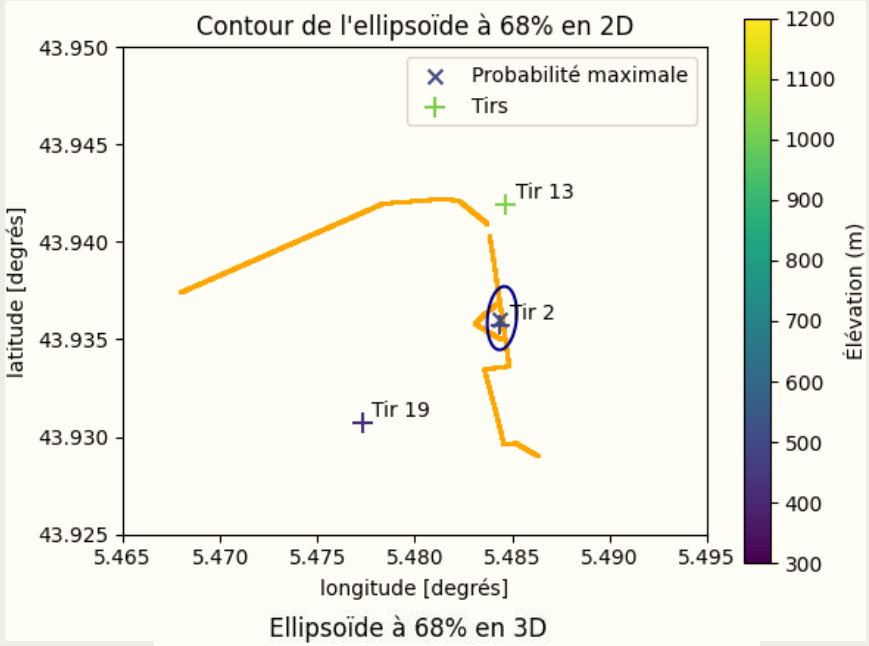


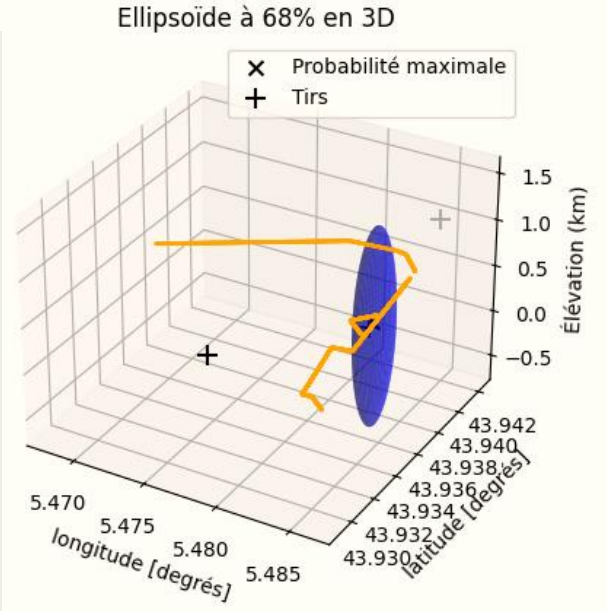
PhaseNet (trace-based picking) provides a **higher number of phase picks.**

PhaseNet-DAS (image-based picking) delivers **more continuous and coherent picks** across the dataset.

Event location



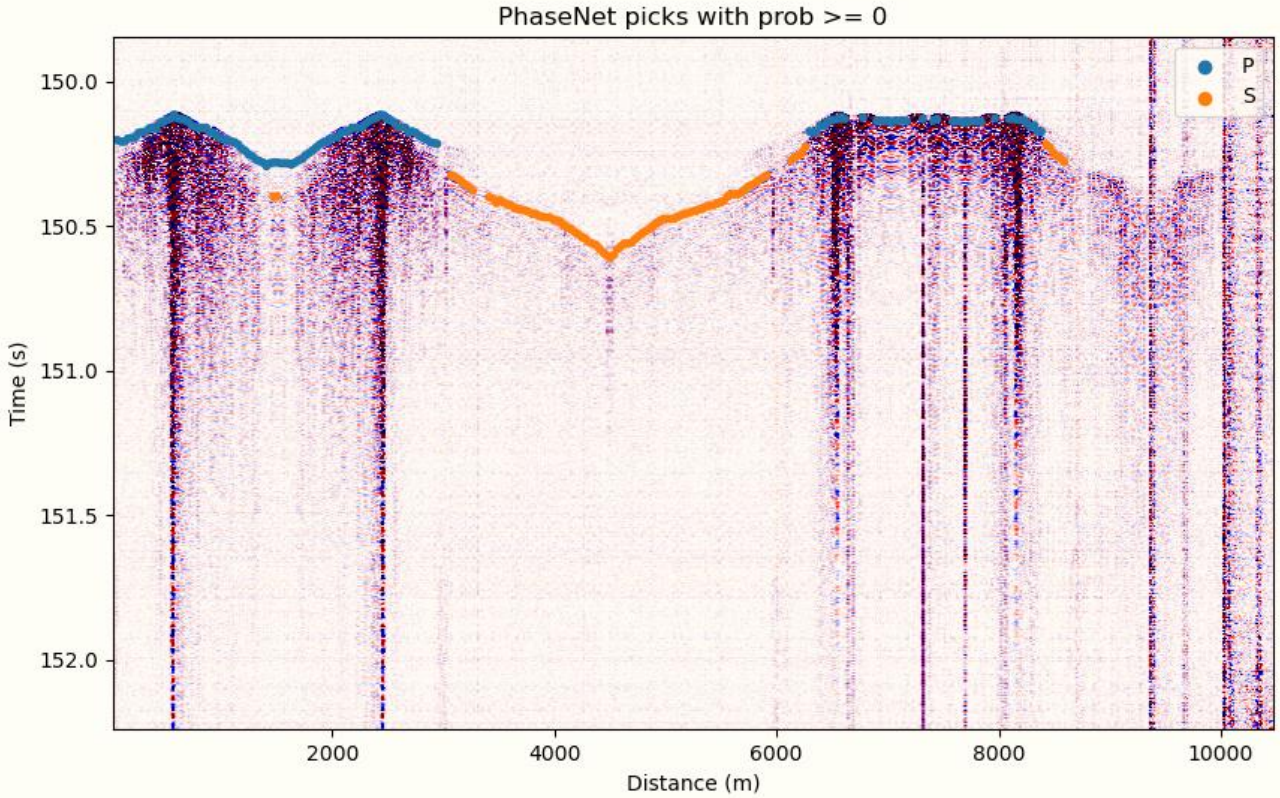


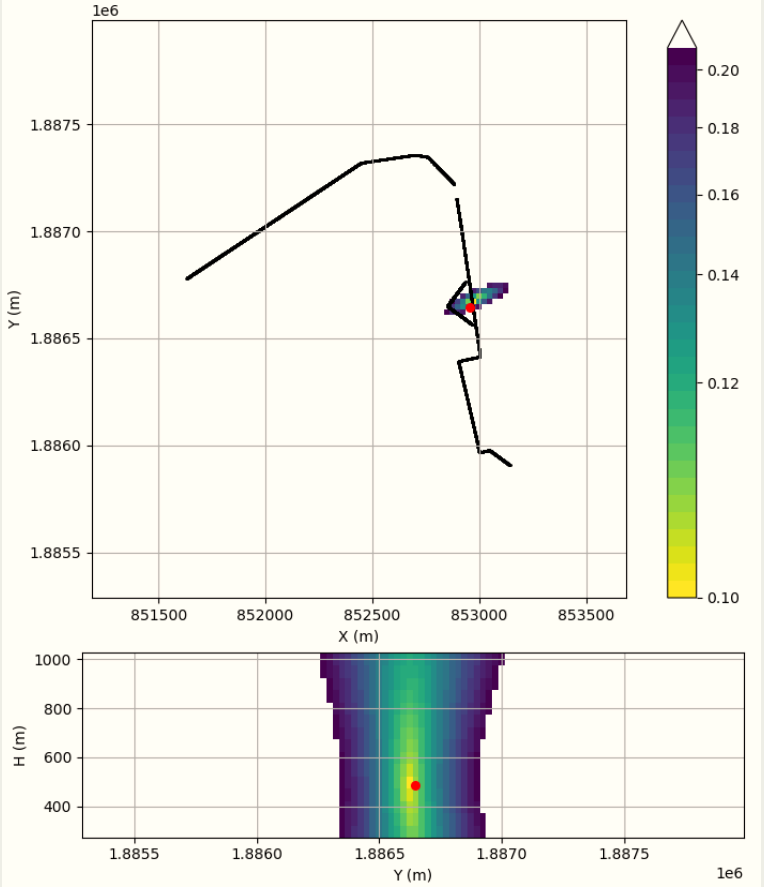


Location method: NonLinLoc
Bayesian Localization and Confidence Ellipsoid Estimation

Shot 2: true source location is inside the confidence ellipsoid

Explosion inside the gallery

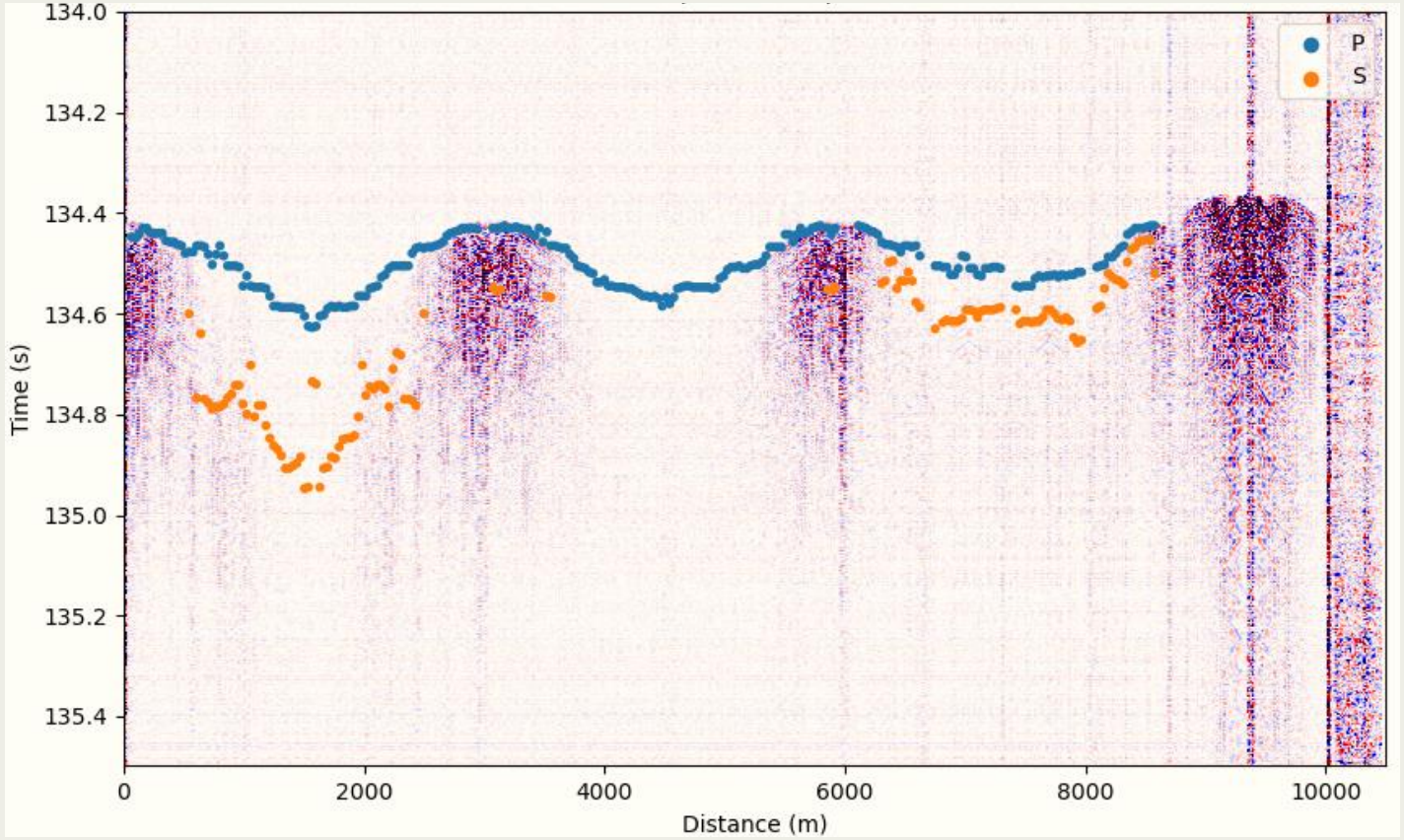


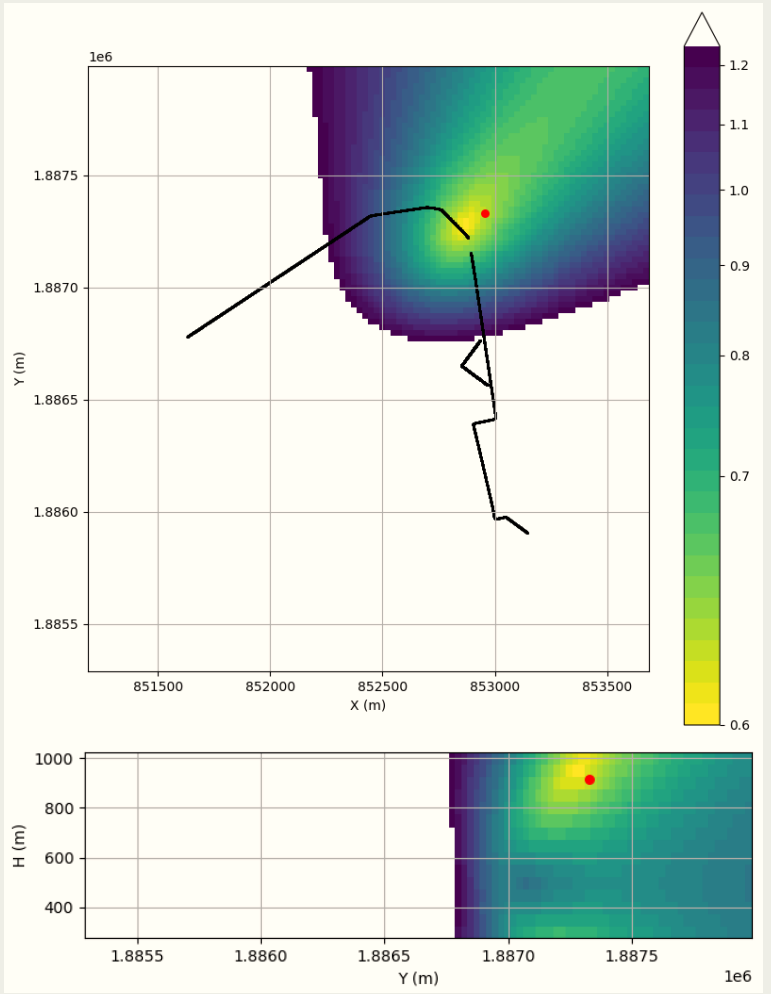


Good picking accuracy for strong events
Grid search method: Good location precision in X, Y and Z

- True explosition location
  gallery elevation: 500m

Explosion at the top of the mountain

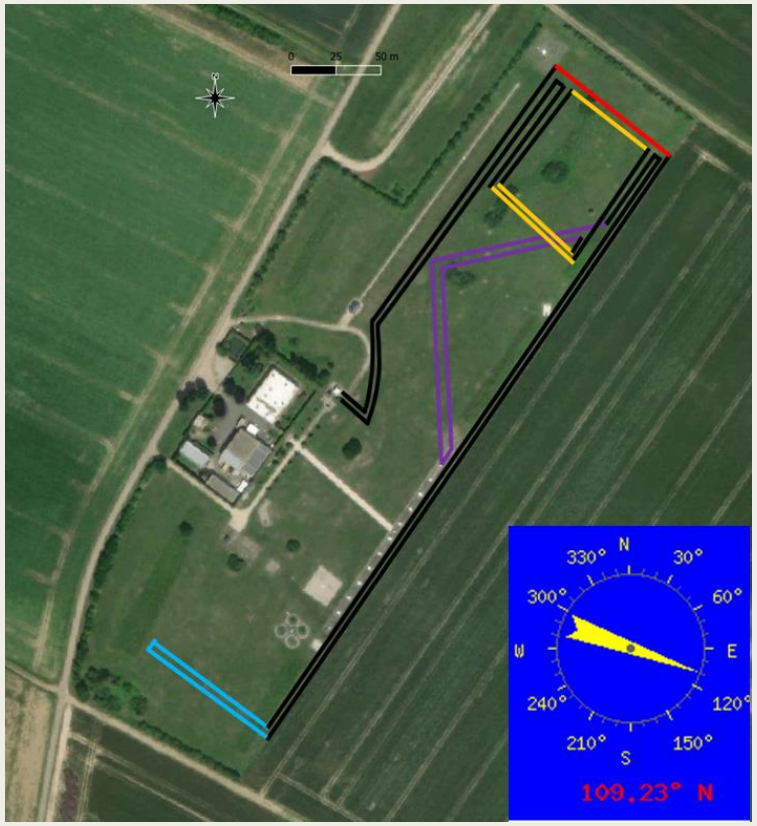




Picking accuracy decreases for less energetic events
Grid search method: Good location precision in X, Y and Z

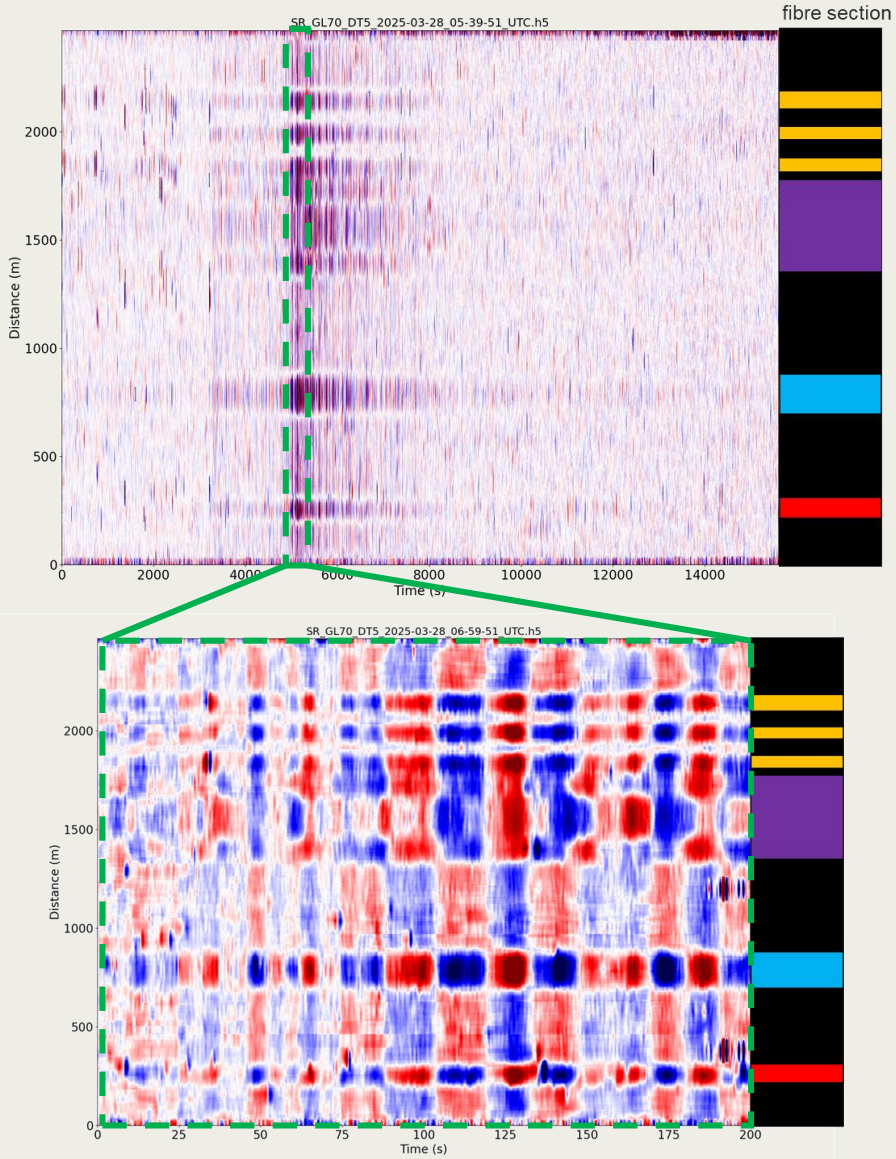
gallery elevation: 500m

Earthquake detection (M 7.7 at 8500km)



Fiber Optic Cable field deployment

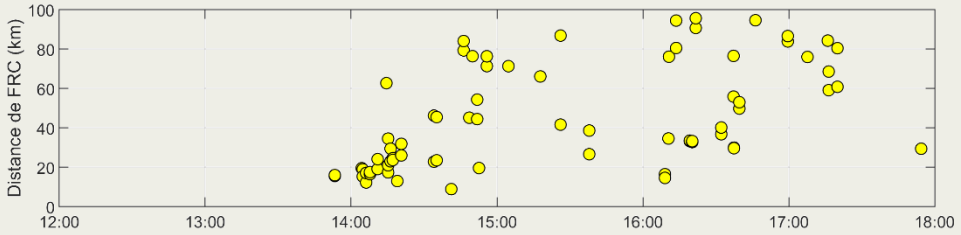
Myanmar earthquake 28/03/2025

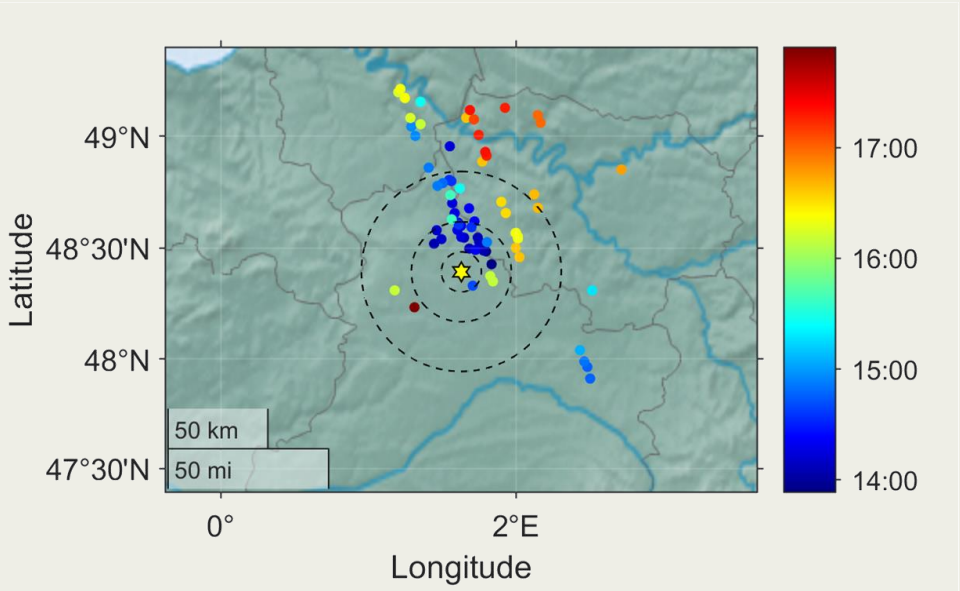


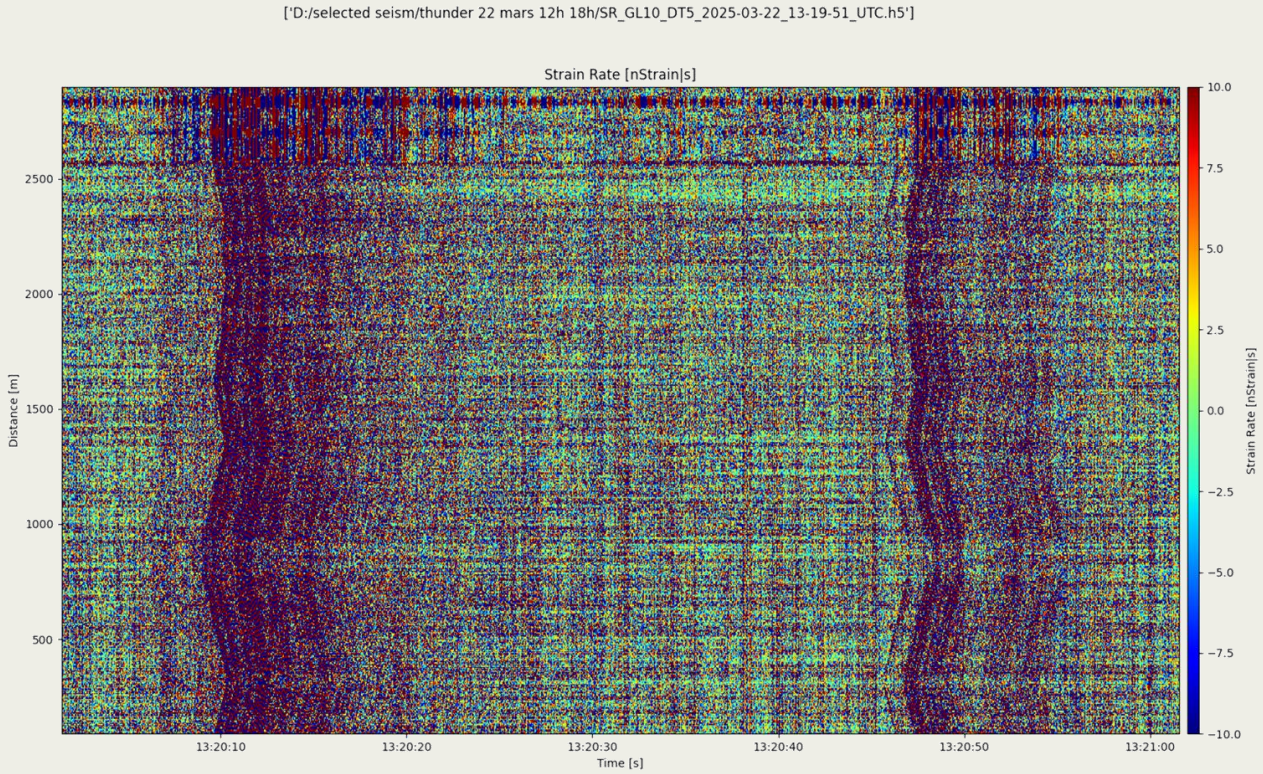
Analysis of signal amplitude as function of event azimuth

Work in progress on DAS sensitivity
(Detection curve as function of Magnitude and distance)

Thunderstorm detection







Fiber cables can detect accoustic and seismic waves induced by thunderstorms
Work in progress to locate these events

Conclusion

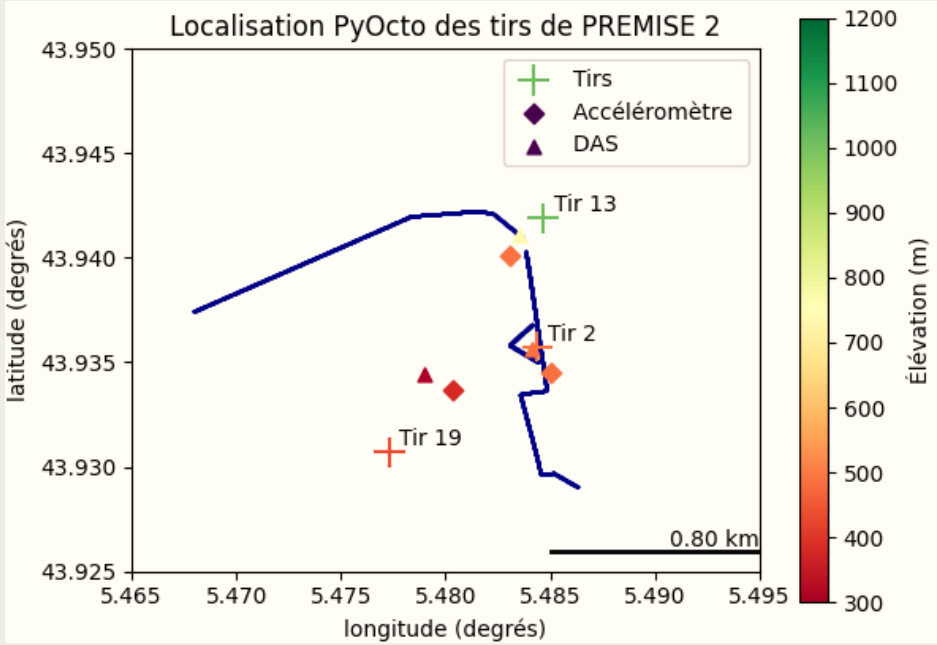
DAS fiber optics delivers cutting-edge performance through:

- **Coupling effect: Critical for accuracy**—optimal cable coupling with its surroundings ensures reliable, high-fidelity data acquisition.

- **Sensitivity:** Detects small events for near-filed detection.

- **Event location/data processing:** Enables real-time localization and advanced analysis of geophysical events.

- **Earthquakes & thunderstorm detection:** Provides early warning and detailed monitoring for natural hazards.



Thank you

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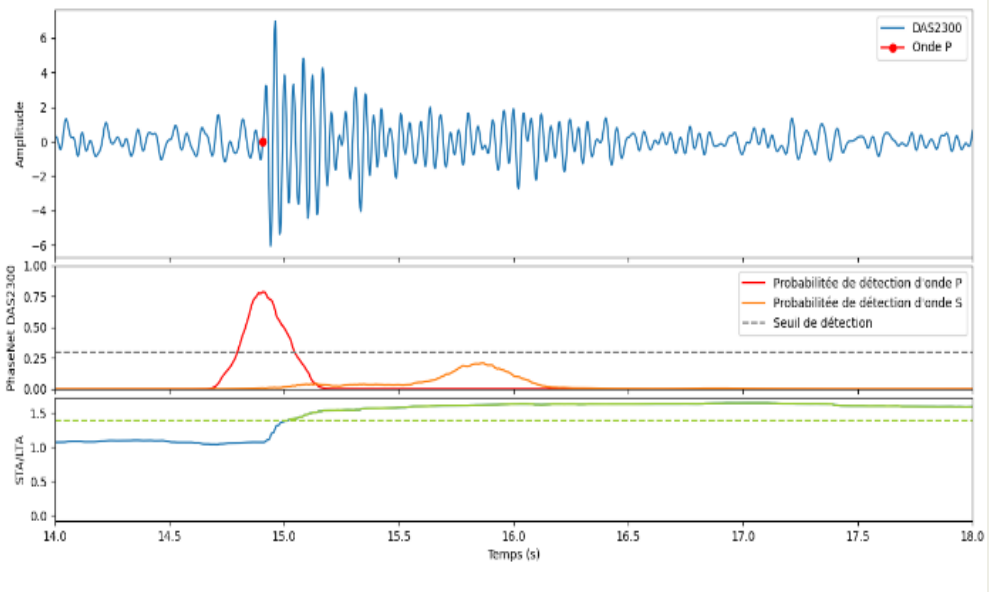
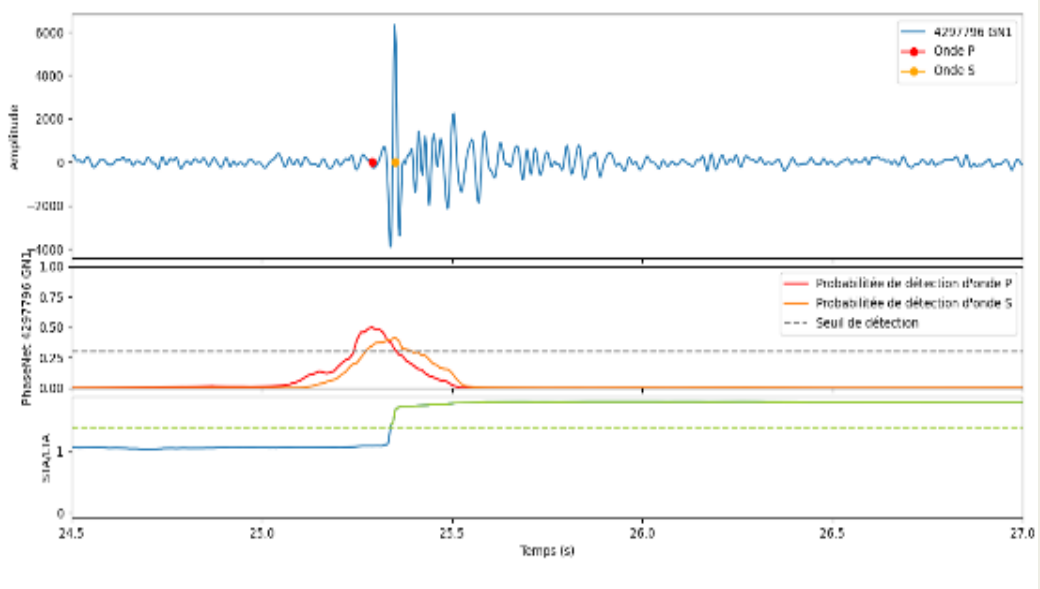
Automatic phase picking

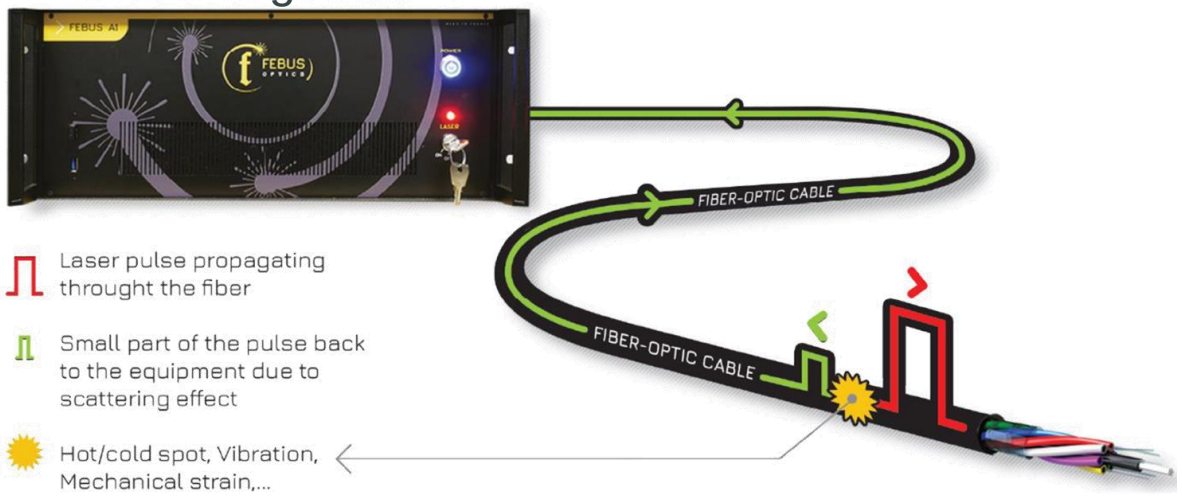


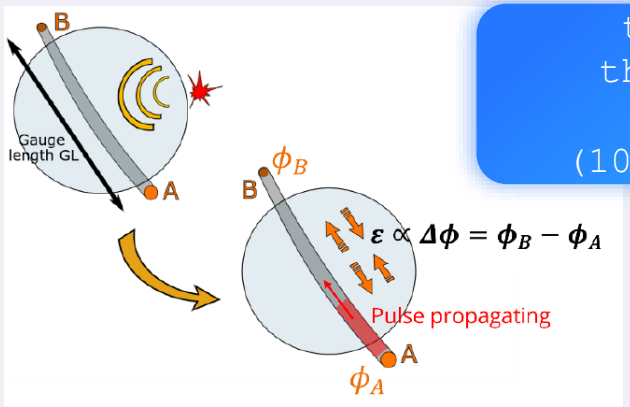


Fibre optique

Submarine cable

Interrogateur





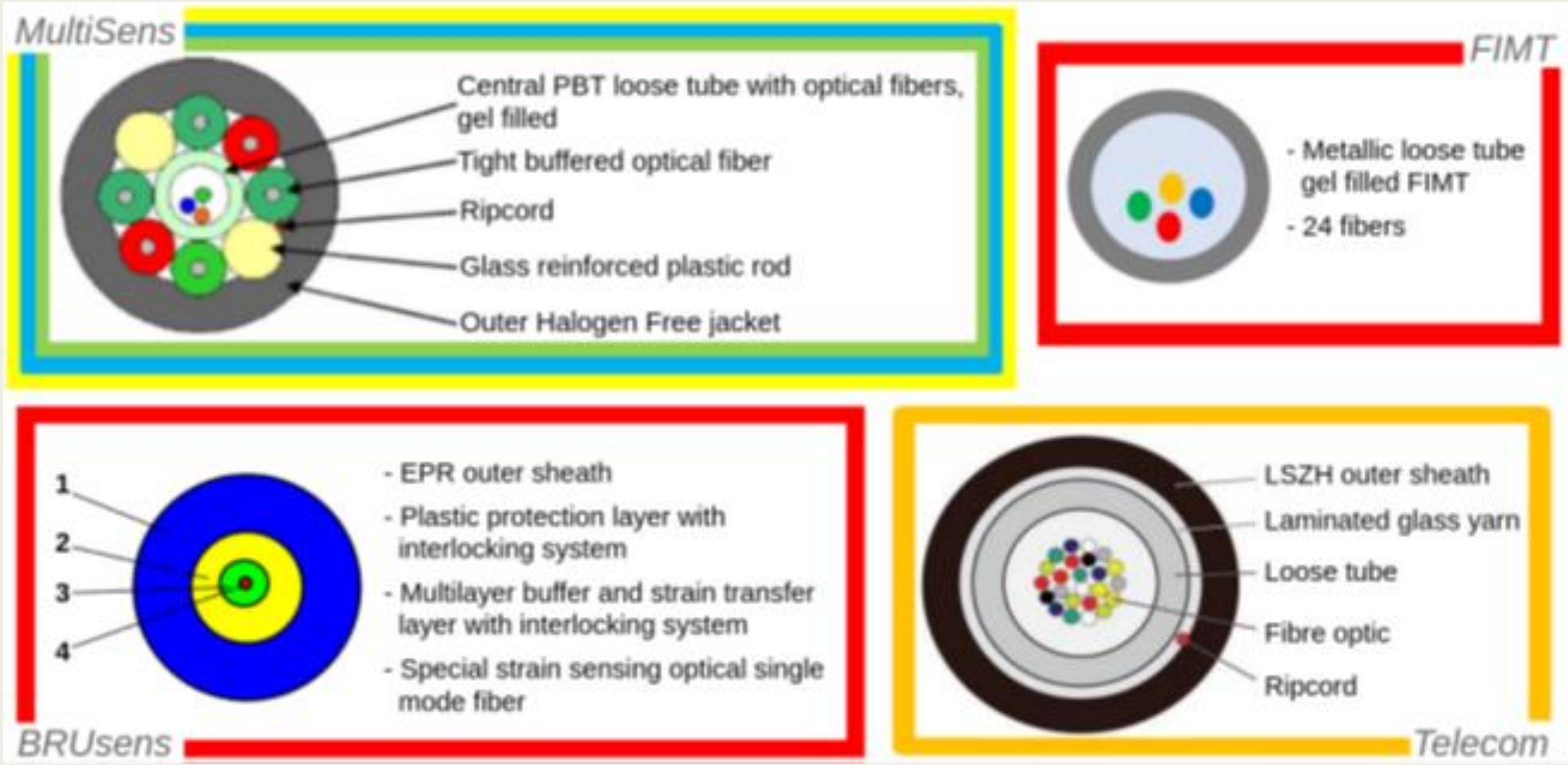
Fiber optic cable turns into thousands of sensors (100km ~ 20 000 sensors)

DTS → Température

DSS → Déformation

DAS → Acoustique

Active and passive seismic


MultiSens
Central PBT loose tube with optical fibers, gel filled
Tight buffered optical fiber
Ripcord
Glass reinforced plastic rod
Outer Halogen Free jacket
FIMT
- Metallic loose tube gel filled FIMT
- 24 fibers
1
2
3
4
- EPR outer sheath
- Plastic protection layer with interlocking system
- Multilayer buffer and strain transfer layer with interlocking system
- Special strain sensing optical single mode fiber
BRUsens
LSZH outer sheath
Laminated glass yarn
Loose tube
Fibre optic
Ripcord
Telecom