LSBB
Laboratoire Souterrain à Bas Bruit
Low Noise Inter-Disciplinary Underground Science & Technology

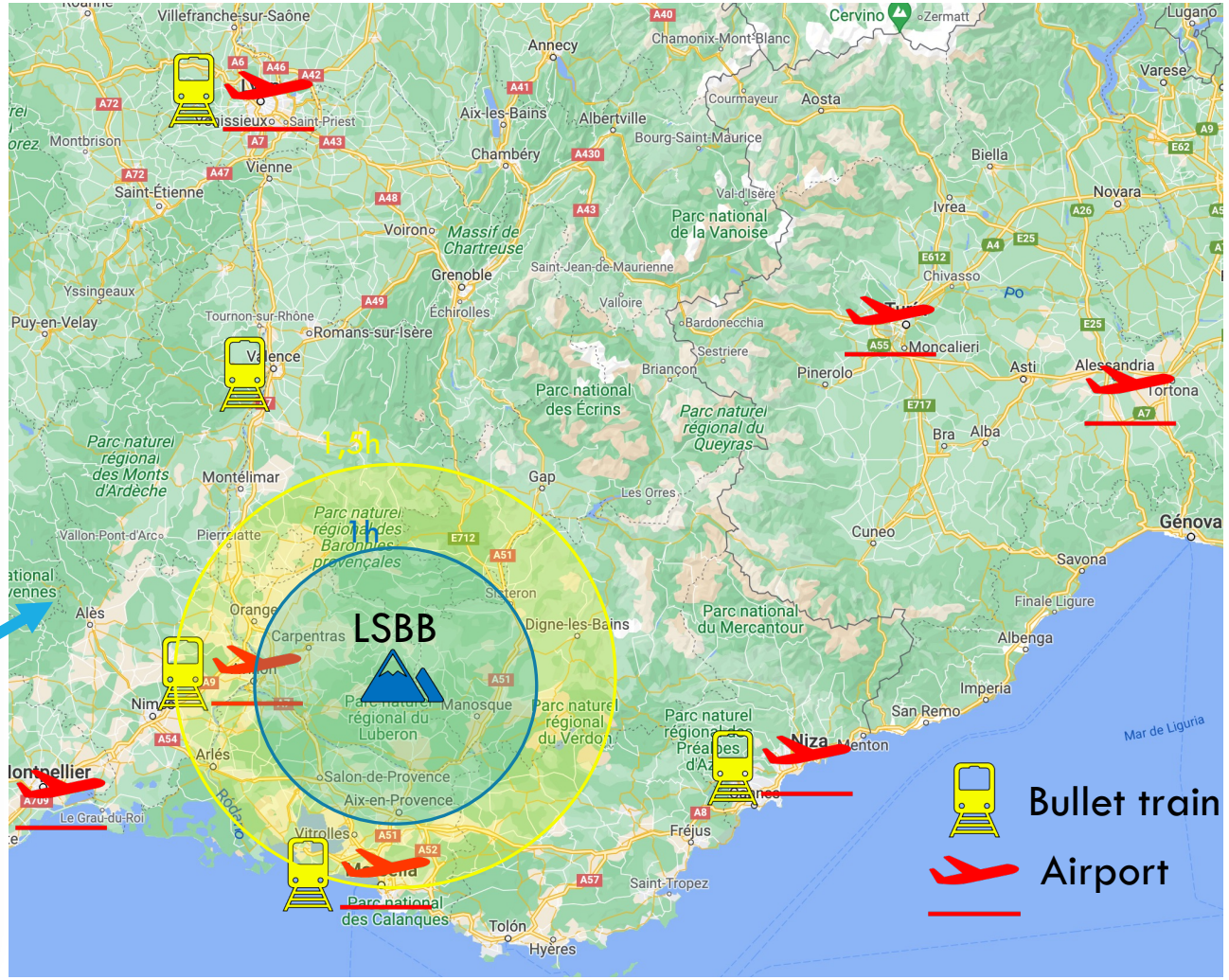
Interdisciplinary possibilities at the Low Background Noise Underground Lab. (LSBB)

Ignacio LÁZARO ROCHE

for APOGEIA meeting 2022

CONVENIENT LOCATION

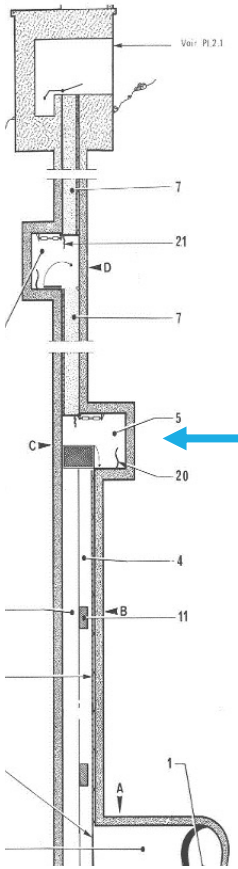
Figure from MODIS project by NASA.



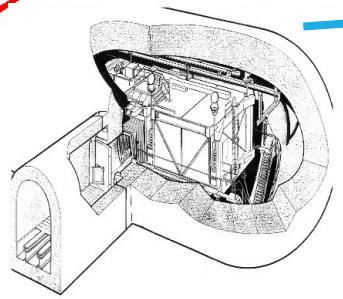
CONCEIVED TO RESIST A NUCLEAR ATTACK… AND STRIKE BACK

Safety exit well

(-30m)



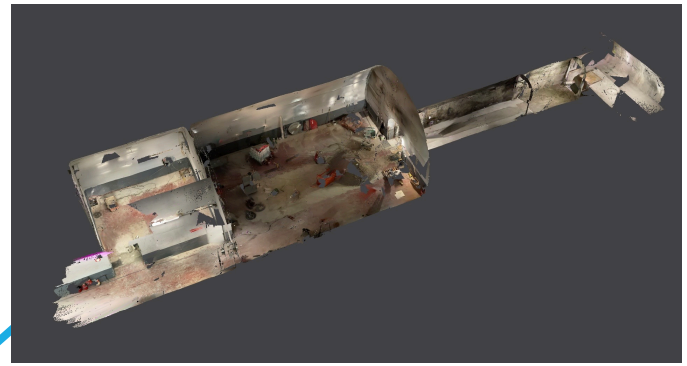
EM shielded capsule
∅8 × 28 m^3
(-500m)



Surface antenna on the top of the mountain
(1.016 MAST)

Two antiblast

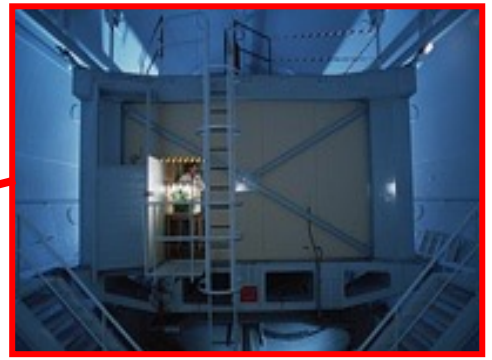
galleries

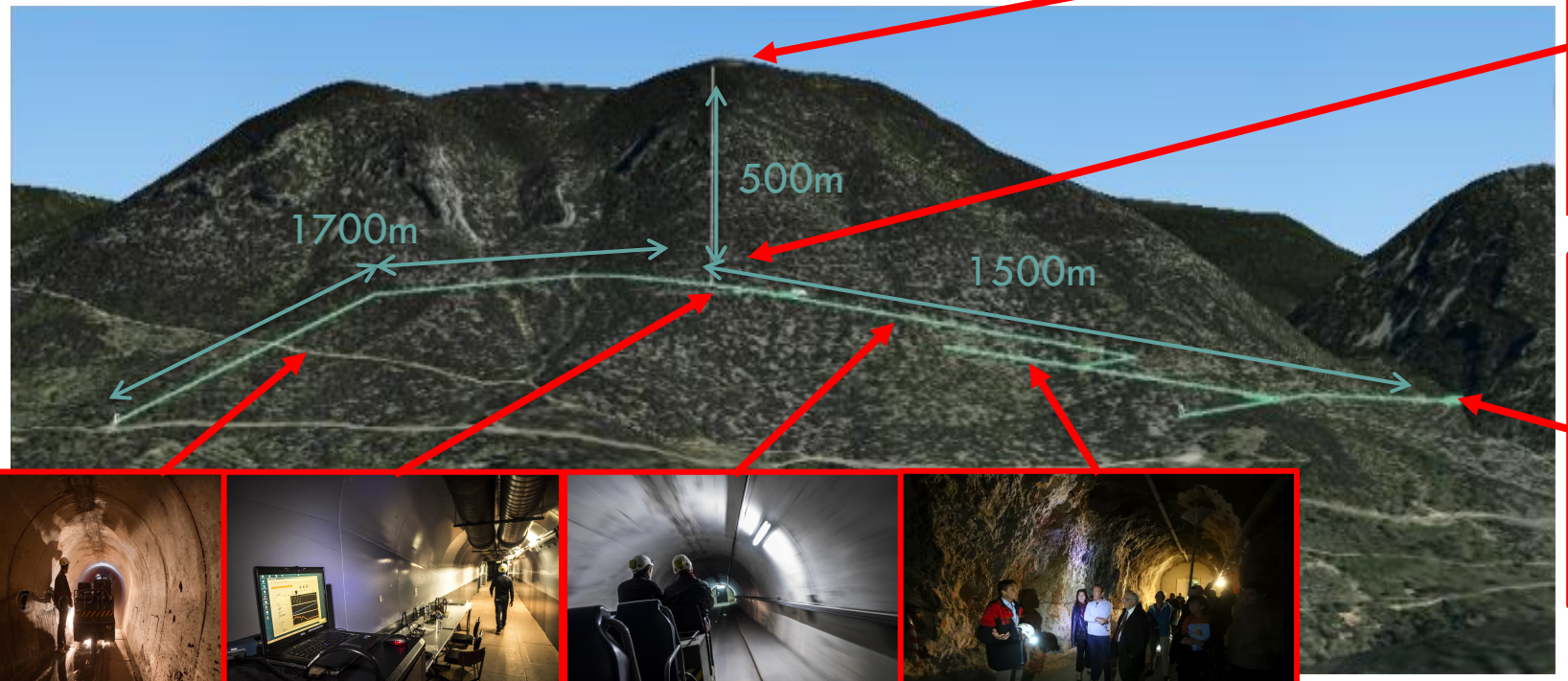


New metrology hub
(under construction)
1000 m^2, 6m height (-64m)

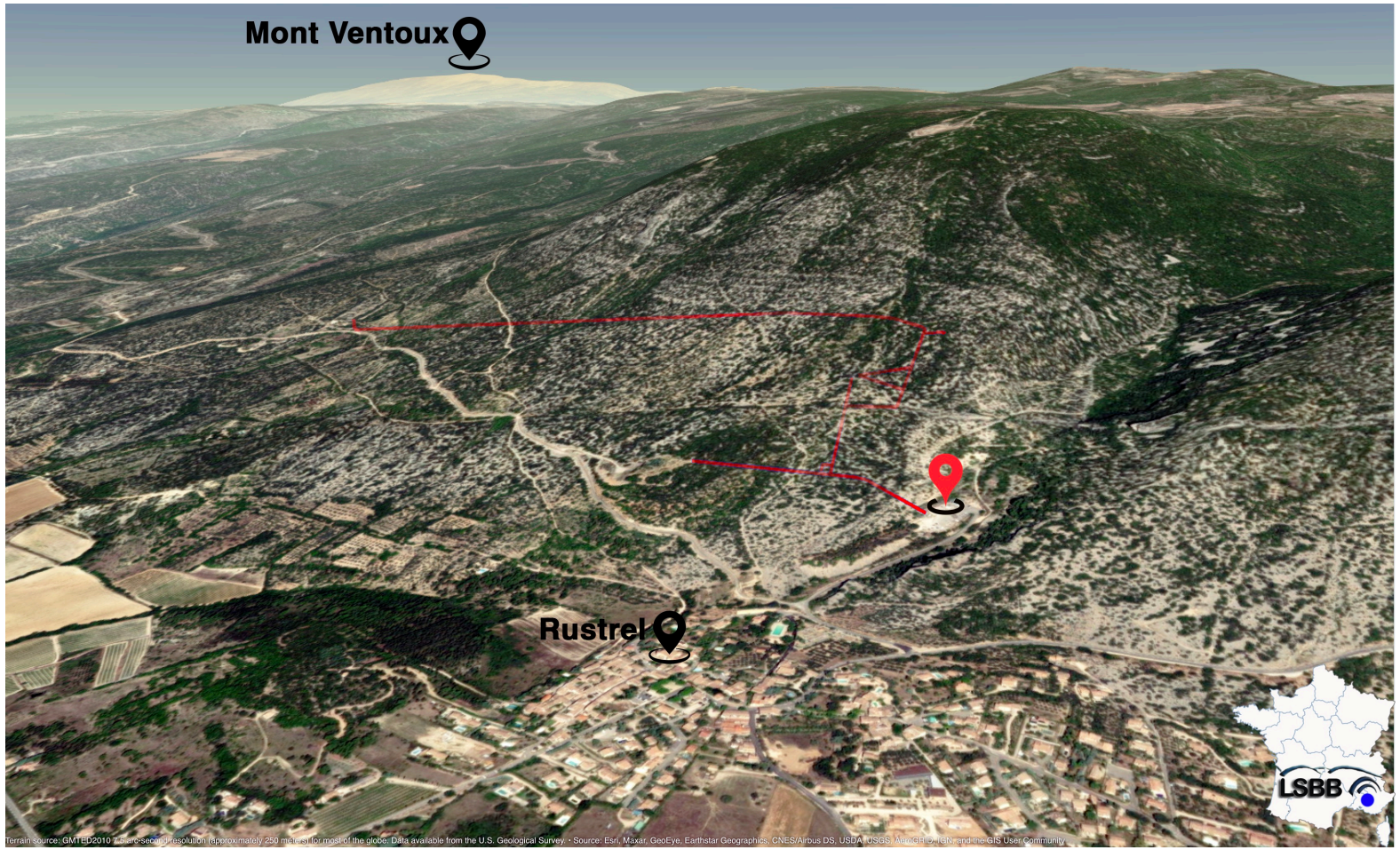
LSBB, A HISTORIC LEGACY

- Underground **and** surface unique facilities
  - 4.3 km of galleries
  - 53 ha of surface





WELL KNOWN ENVIRONMENT



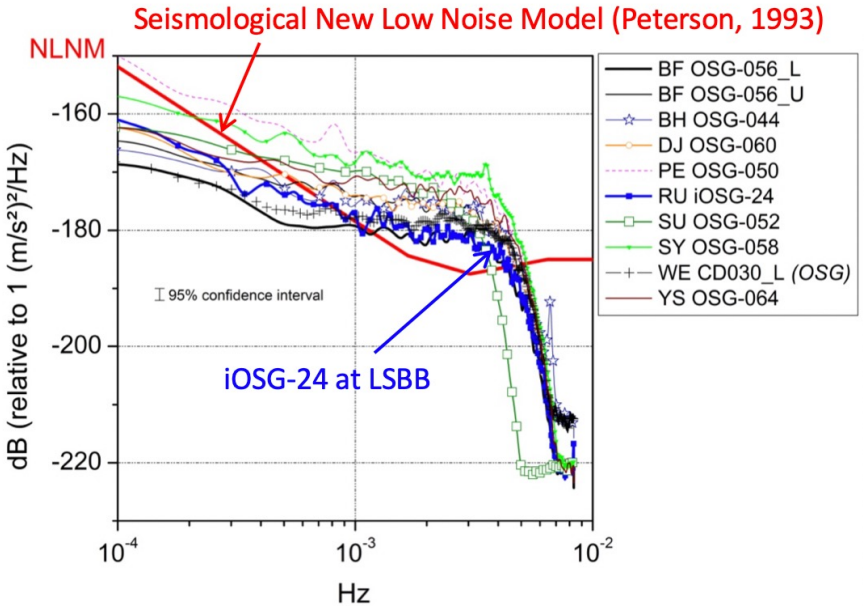
- More than 20 years of data
- Over 60 PhD thesis
- Several permanent networks of detectors
- Periodic and punctual measurement campaigns

THE INFRASTRUCTURE IS AT THE CORE OF CROSS-FERTILIZATION

Resources	Environment/ fluid interactions	Waves, radiation and astrophysics	Instrumentation and metrology	Life	Human science & society
• Karst • Underground Water Resources • Carbonated platform	• Processes and thermo-hydro-mechanical couplings • Poroelasticity • Geomechanics	• Seismology • Magnetism • Gamma • Neutrons • Muons • WIMPs (DM) • Atmospheric electrical phenomena	• Magnetometry • Gravimetry • Densitometry • Seismometry • Rotation • Clinometry • Optic fiber • Electronics characterization • New tools development	• Geobiology • Brain imaging	• Contemporary History vs Cold War • Anthropization vs Global Changes

Open to everyone respecting the environment to limit the inter-experiment interactions

OUTSTANDING ENVIRONMENT

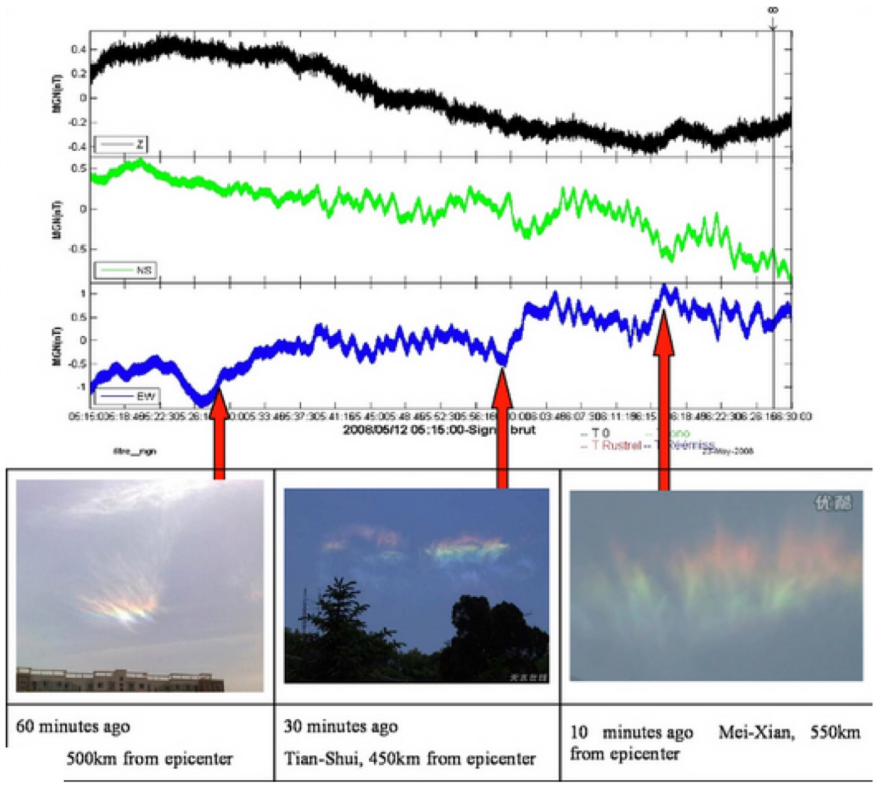


Superconducting gravimetry

One of the quietest sites in the world

Ultra-sensitive magnetometry

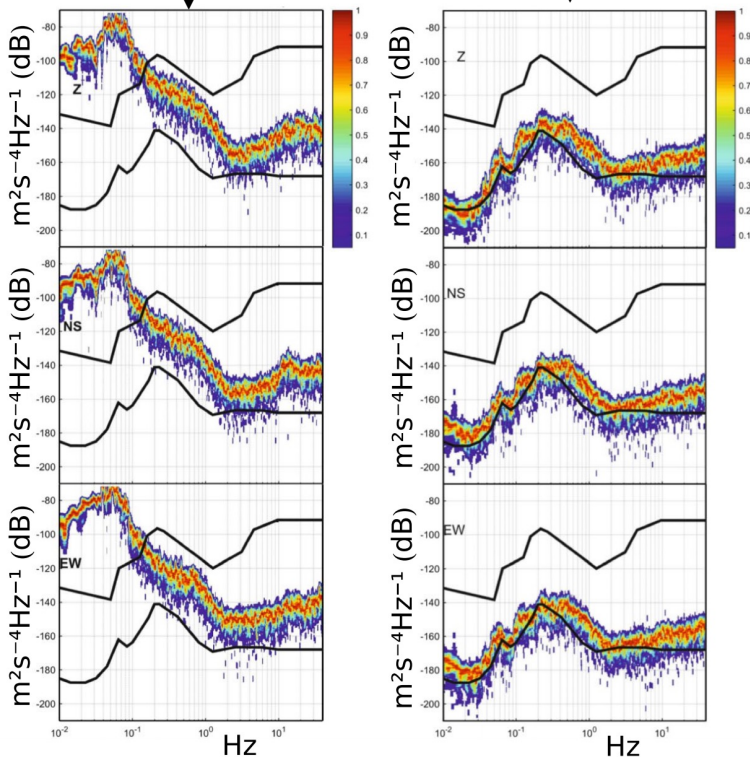
Earth/ionosphere couplings



Sichuan-Wenchuan Earth Quake, May 12, 2008 (Mw 8.1)

Tohoku-Oki earthquake (11/3/11)

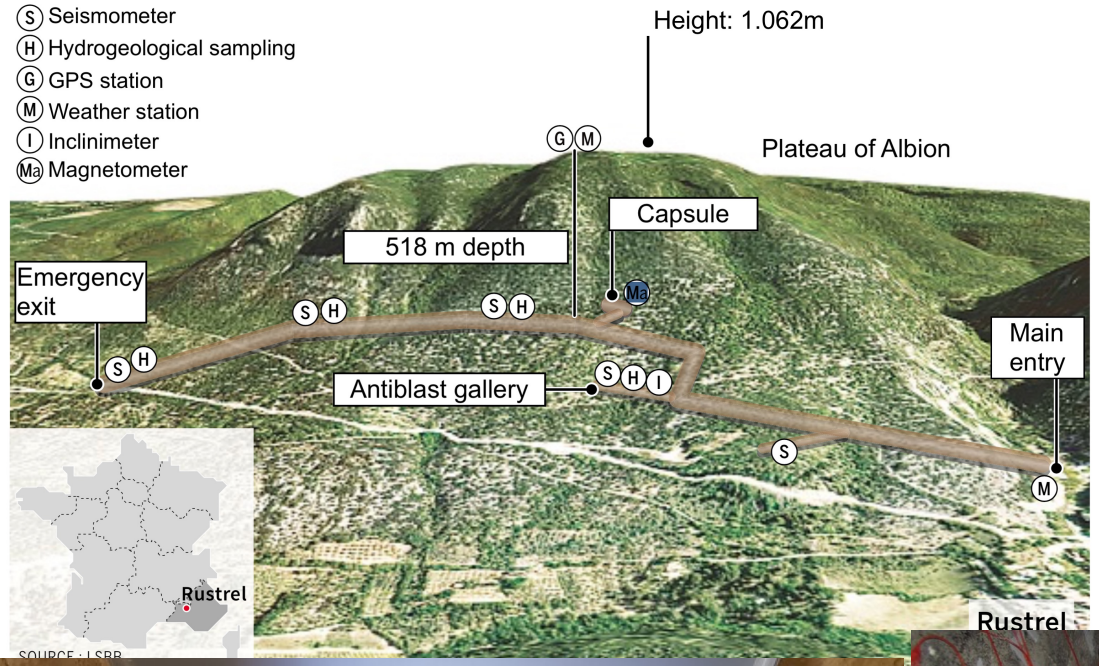
Quiet day

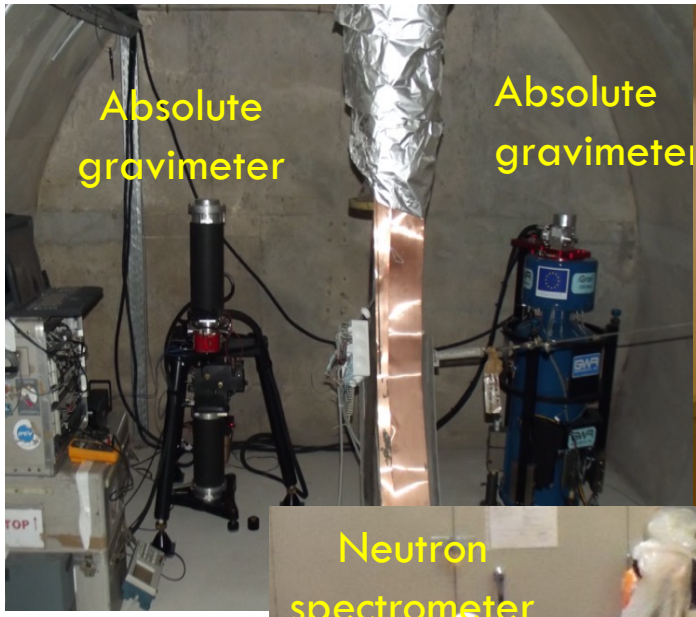


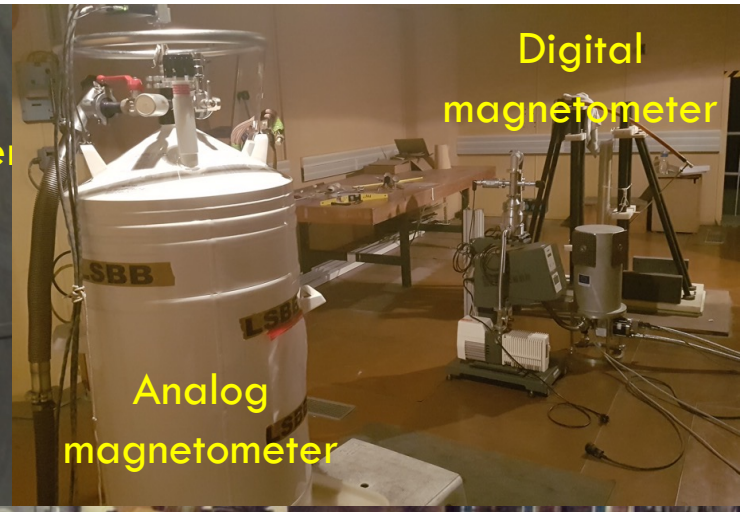
Low-noise seismic properties

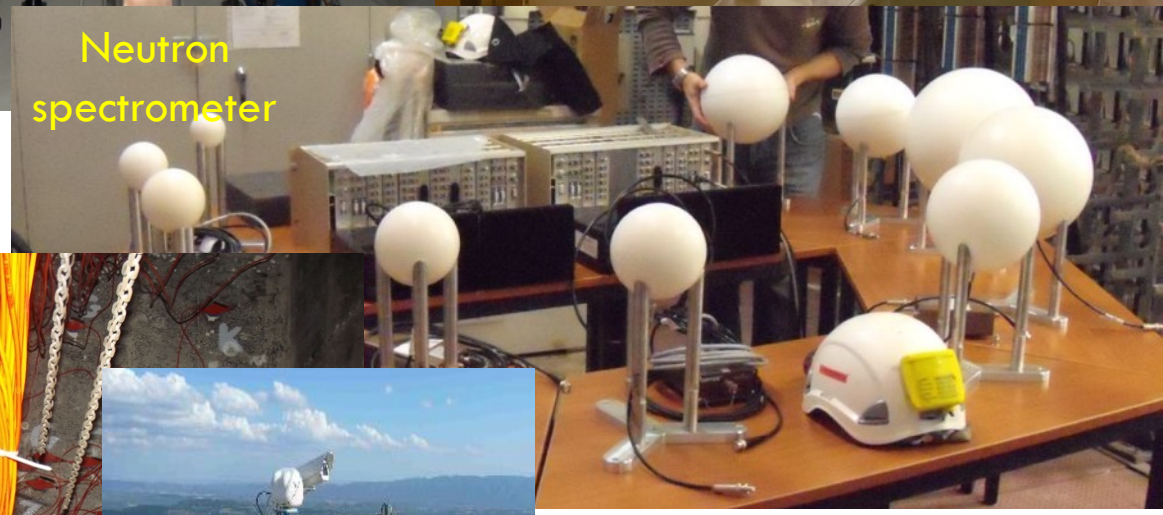
Seismic noise PSD for three components (top, Z; middle, NS; bottom, EW) compared to Peterson's high and low noise models (black lines).

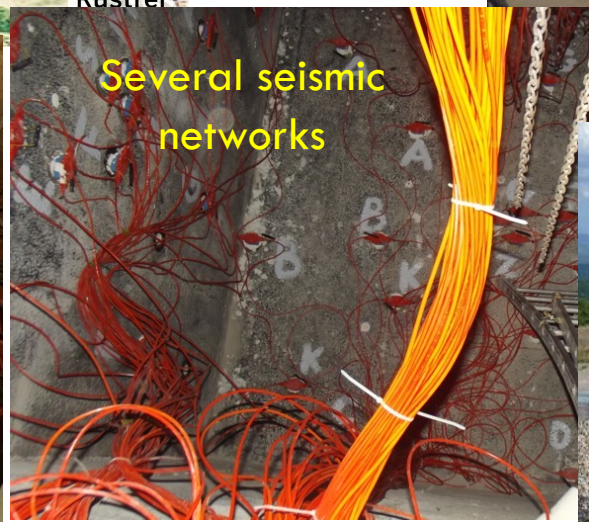
ALREADY DEPLOYED ONSITE

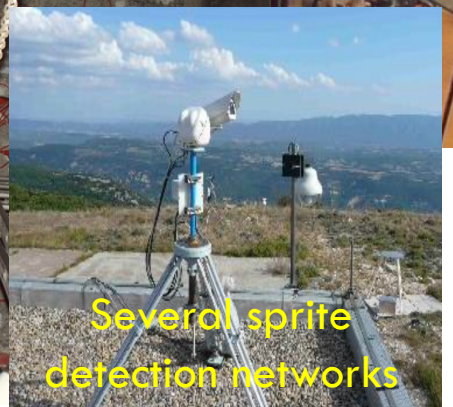












And many more…

PREMISE 2 experiment

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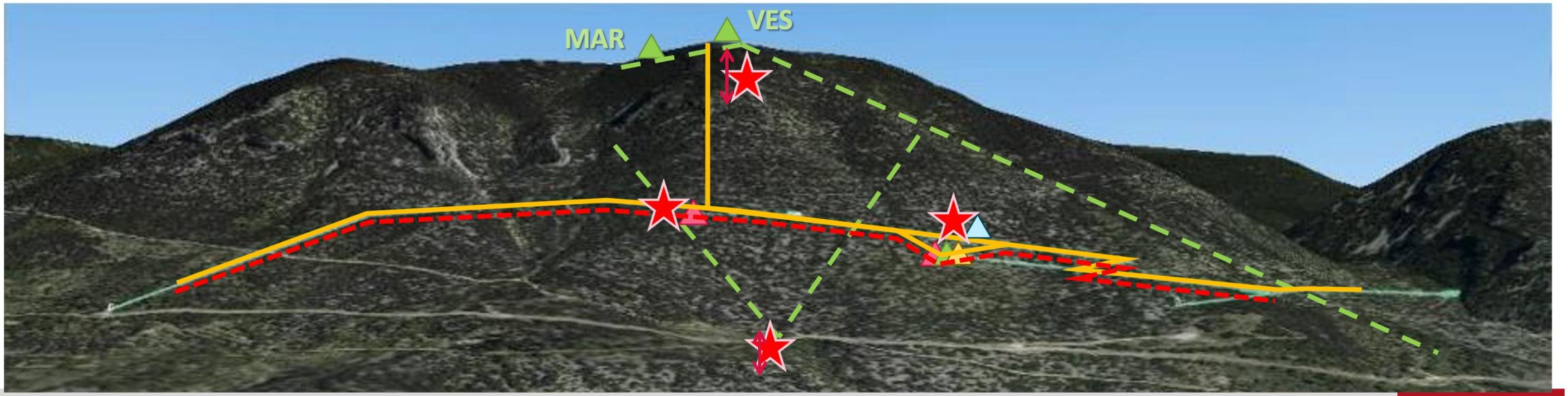
3D geometry :

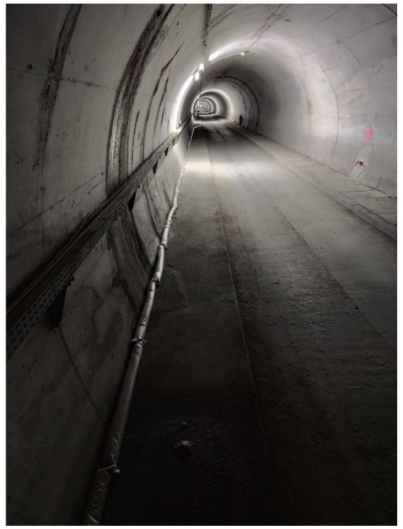
- Seismometer 3C - surface : 105 sensors
- Accelerometers 3C – galleries : 200 sensors
- 3km fiber - galleries

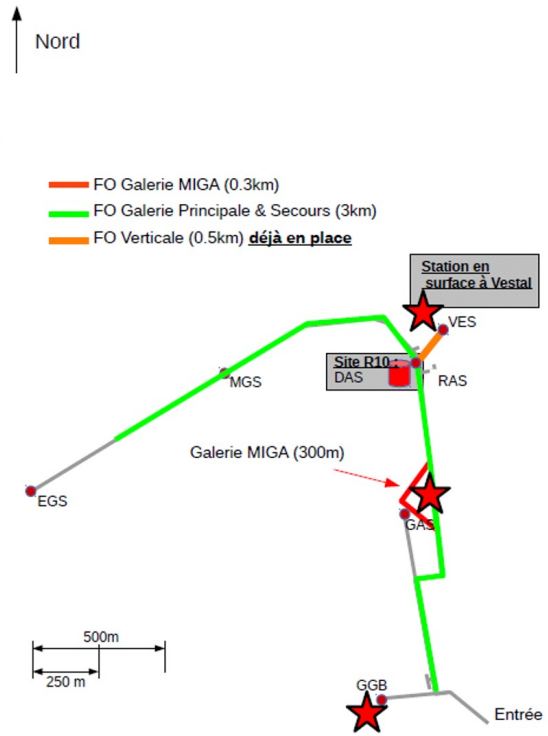
- Shot zone : depth 10 à 500m
  - Inside and outside galleries

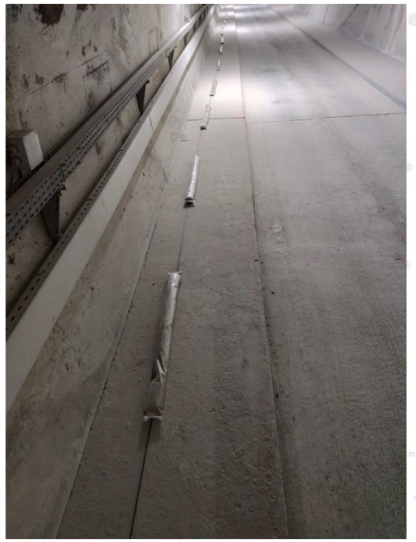


Fiber installation

- 3 km long optical fiber
- 5 Big Bag = 7 tons of sand
- 1200 bags - 1m long







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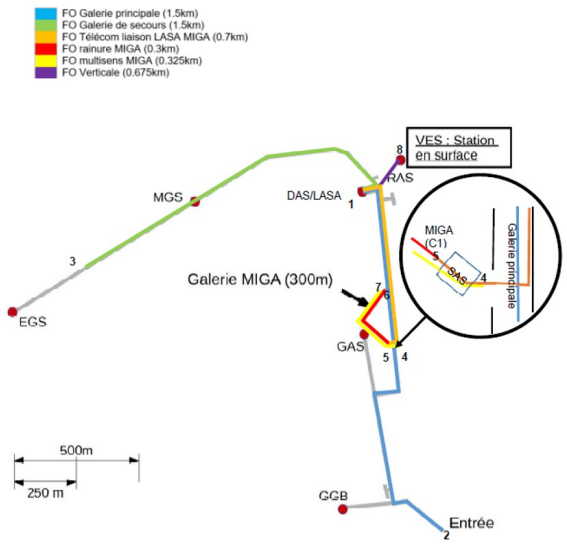
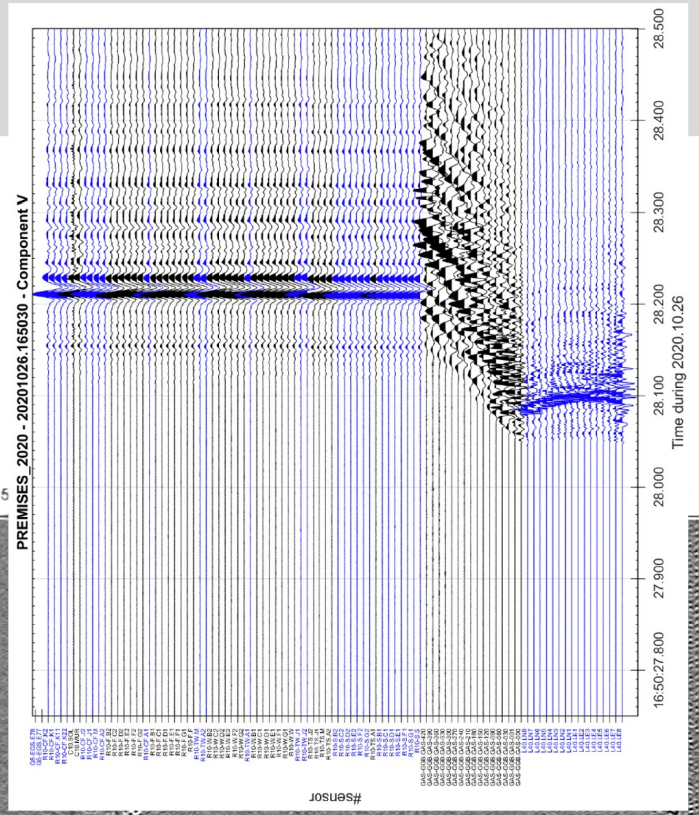
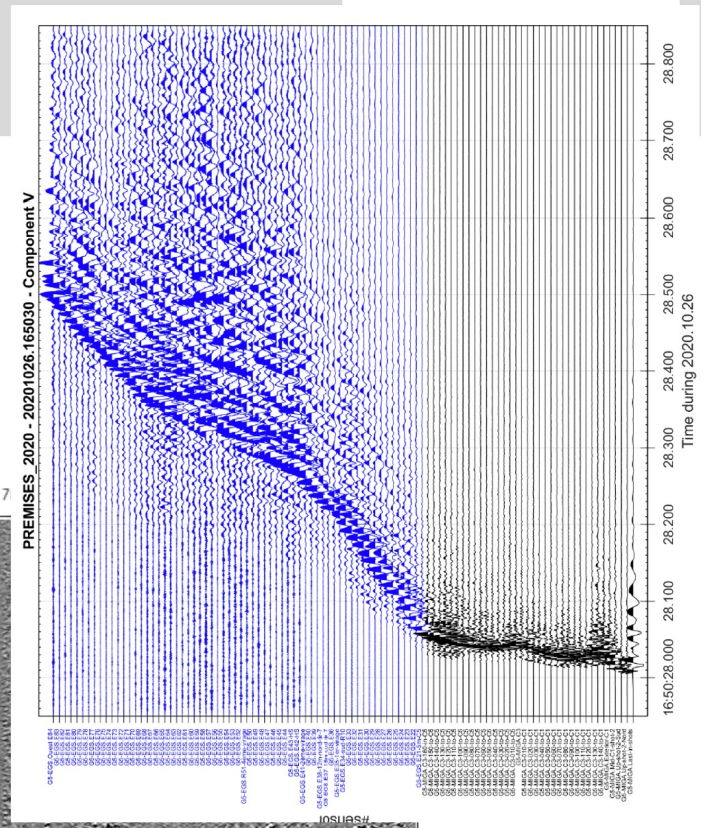
cea

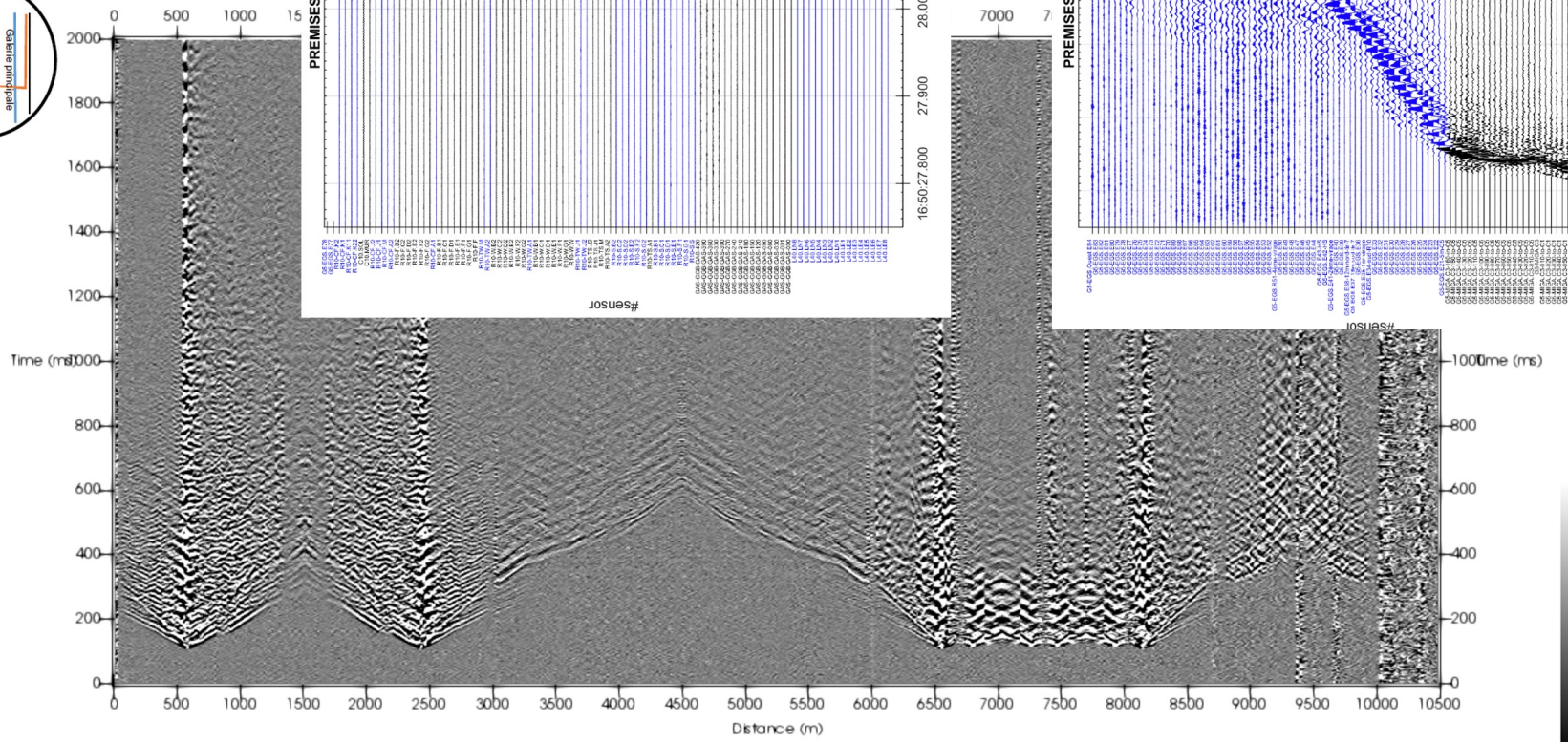
Preliminary results

Gauge length : 20 m









Preliminary comparison

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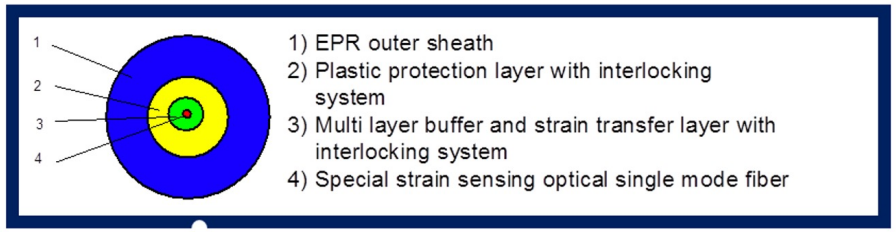
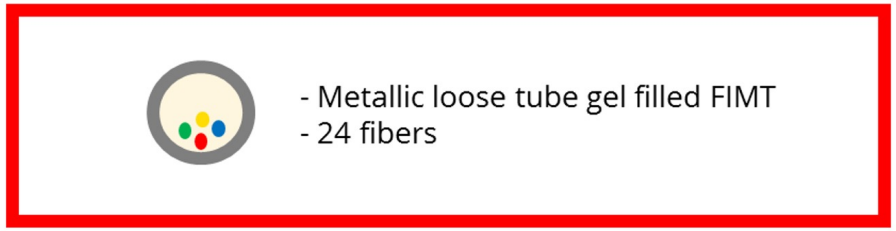
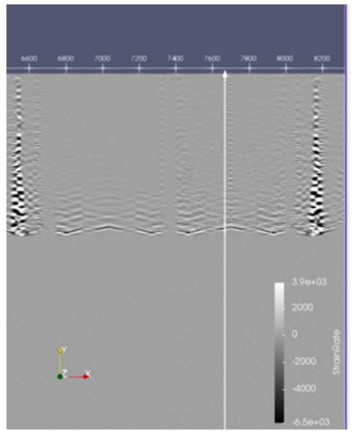
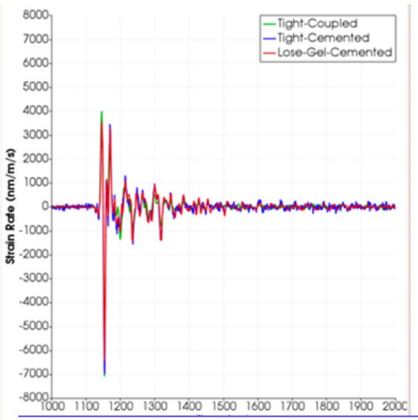
Cross-sections of fiber optic cables used



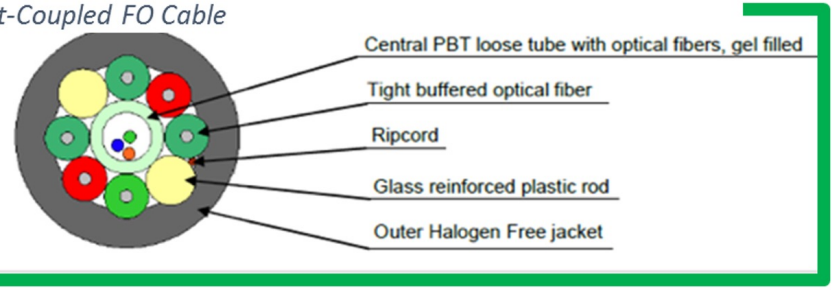


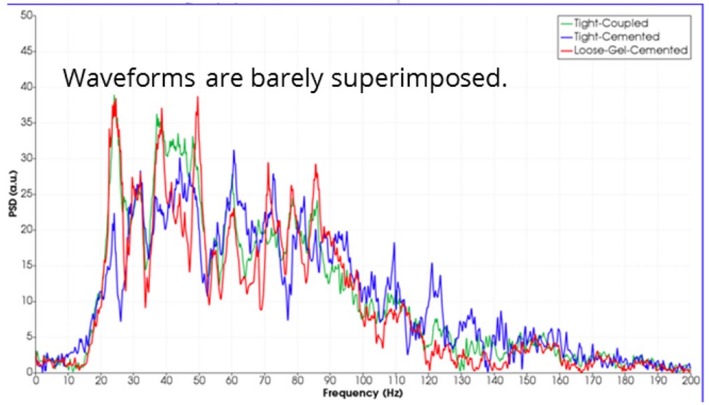


Strain Rate, Time series



Tight-Coupled FO Cable

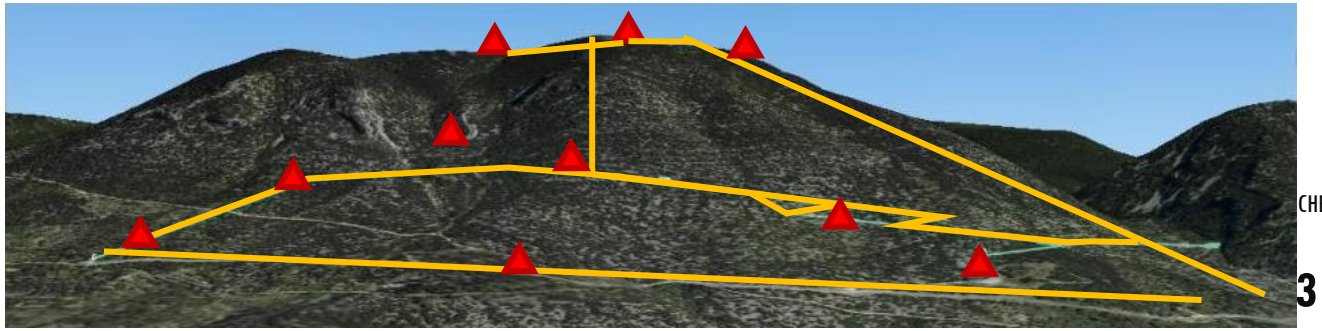




- **Influence of coupling might not be neglected when performing distributed acoustic sensing**
- **During the experiment, we saw that the quality of the contact has more influence than cable choice**
- **However, a continuous contact with the material (here performed with sand bundles) gives results comparable with coupling made by cement.**

(CEA) ENVIRONMENT "NOISE" MONITORING BASED ON SEISMIC SPATIAL GRADIENT

- A continuous measurement of the « seismic » wavefield and its spatial gradients by different sensors: — WP6, WP11
  - Seismometer dense 3D antenna: Derive local deformation and rotation motion
  - 3D fiber optic Network: deployment at surface and underground for continuous DAS measurement
- A comparative study of the environment noise measurements efficiency in a well calibrated environment: — WP6, WP8
  - Effects of depth, surface, temperature, pressure (infrasound), geological structure, atmospheric condition etc…
- Optimize the extraction of the relevant geophysical data: — WP9
  - Geophysical noise characterization and classification
  - Data mining and Data amount Reduction for continuous time monitoring
- Need for funding :
  - DAS system
  - Support for a dedicated Optic fibers for strain measurement and installation



MUOGRAPHY TEAMS AND LSBB

T2DM2 (from 2012)

Micromegas in TPC + plastic scintillators

CPPM (2012-2015)

Liquid scintillators

Onera (2012-2016)

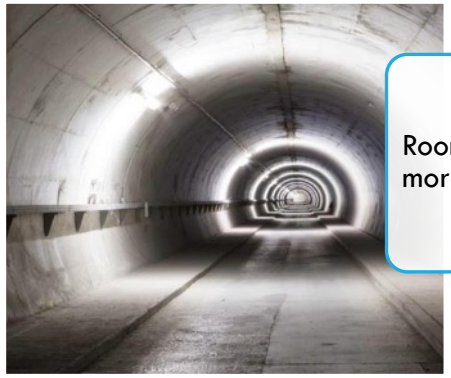
CEA/Iris Inst (2017-2018)

Genetic Micromegas in multilayer configuration

Diaphane (2018-2019)

Plastic scintillators

????



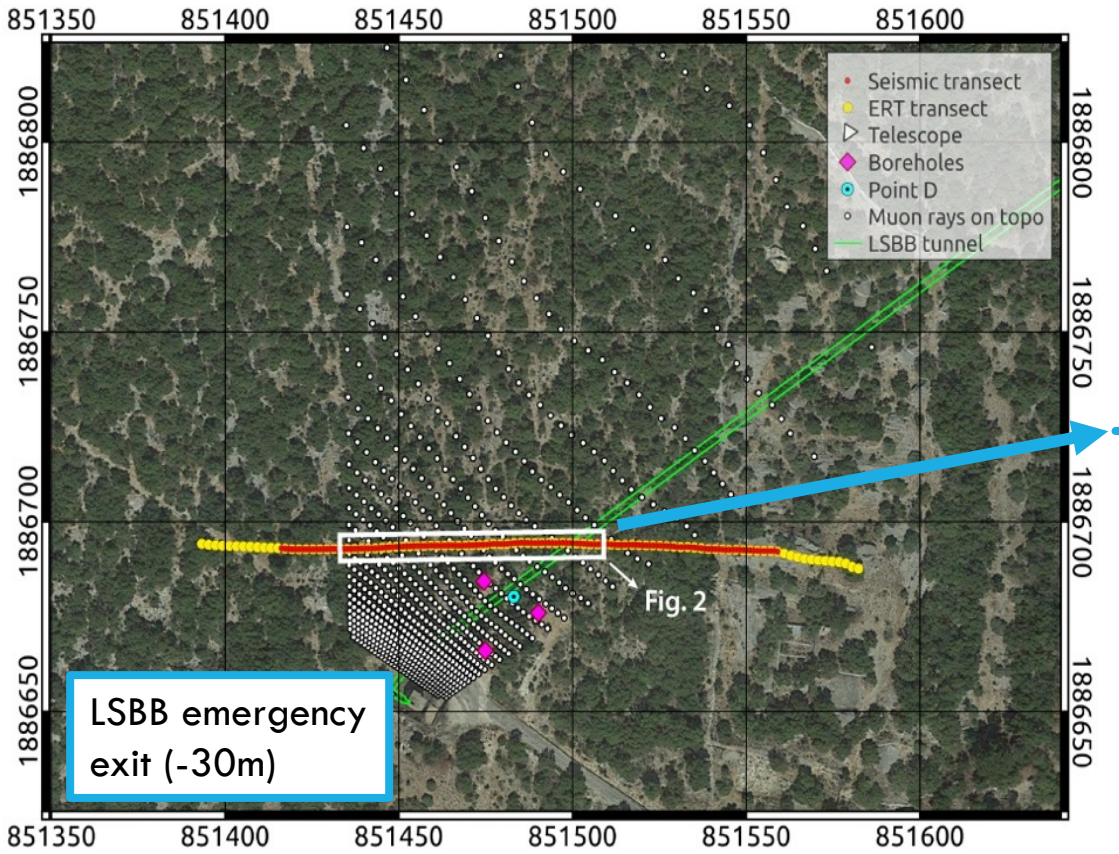
Room for more

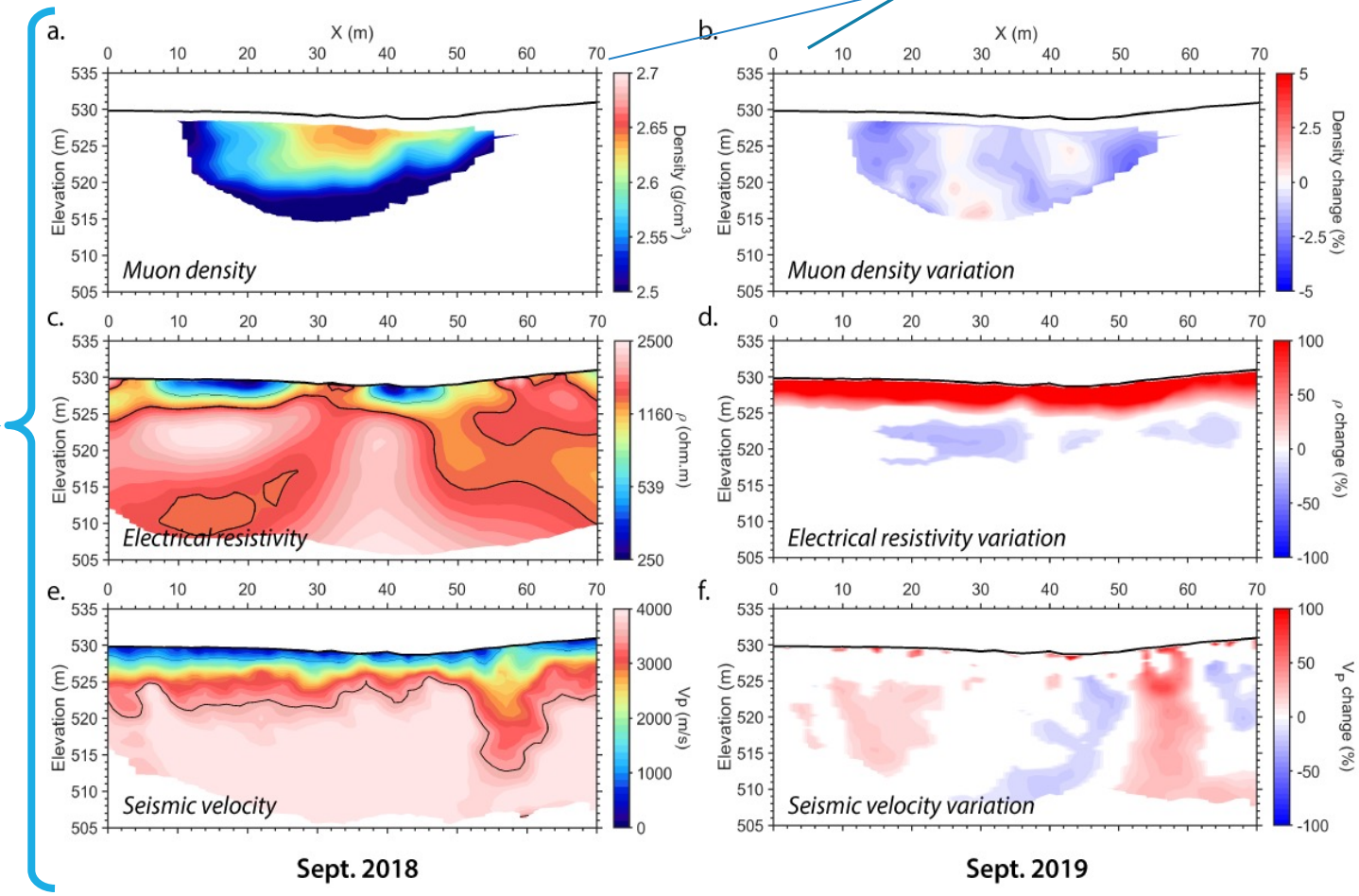
MUON TOMOGRAPHY

- LSBB is ready to **become the benchmarking site for borehole, underground and infrastructure muographic characterization**.
- Local network of 20 autonomous muon trackers for the study of water transfer at the critical zone and infrastructure monitoring (TRUST-ME project).
- Depths ranging from 0 to 518m. Low background noise conditions (including radon) and outstanding thermal stability. Versatile facilities; access to bare rock, concrete walls, electromagnetically shielded vaults, wells, surface and underground boreholes, electronics and optics clean room for detection assembly and servicing, data server…
- All partners are invited to perform multi-technique/multi-technology joint campaigns in a well-known, convenient environment. (See)

A GOOD EXAMPLE: THE BUISSONIÈRE EXPERIMENT

Obtained with DIAPHANE equipment





Ref: Lázaro Roche, I.; Pasquet, S.; Chalikakis, K.; Mazzilli, N.; Rosas-Carbajal, M.; Decitre, J.B.; Batiot-Guilhe, C.; Emblanch, C.; Marteau, J.; et al.
Water resource management: The multi-technique approach of the Low Background Noise Underground Research Laboratory of Rustrel, France, and its muon detection projects.
In Muography: Exploring Earth's Subsurface with Elementary Particles. **2021**, Geophysical Monograph Series; Oláh, L., Tanaka, H., Varga, D., Eds. American Geophysical Union , USA. DOI:10.1002/9781119722748.ch10

UNDERGROUND TECH

- Groundwater monitoring:
- (AU) underground water sampling, borehole tests and surface geophysical campaigns to survey the water transfer in the CZ
- (ENS) several tiltmeters for assessing massif deformation
- (ITES): 2 relative gravimeters, 1 on the top of the mountain and the other in the deepest point (beneath it)
- Magnetometry :
- (AU,USMB) 2 types of quantum gravimeters (analogic and digital) at the deepest, shielded point of the LSBB and a loop at the top of the mountain the excite them. Mechanical/EM coupling

Both techniques are complementary to muon tomography as they track underground structural and/or density changes on a wide range of time scales.

Consumables and manpower required to operate the devices and analyze the produced data for sharing among the partners

FUNDS NEEDED

- **72 person.months**. 2 engineers in situ fully dedicated to ensuring the assistance in deployment, maintenance, servicing, data management and transfer, dismantling and shipping for all the equipment from the different partners.

- **50.000€ per year** to cover the use of the facilities and the cost overrun so generated (Use of facilities, equipment amortization, consumables and wear and tear, staff, utilities…).

- The resources are meant to be shared by the all the working packages (not just muography) and at least 5 teams/partners.

CONCLUSIONS

- The LSBB is a multidisciplinary platform with unique infrastructure in a remarkable environment
- Well-stablished, organized, multidisciplinary user community
- Willing to welcome new partners and projects
- Most of the working packages are in symbiosis at the LSBB with costly infrastructures functioning
- Relatively small manpower investments will lead to optimized innovative transverse cooperation with meaningful scientific impact