

30 NOVEMBER - 3 DECEMBER
2020

ET EINSTEIN
TELESCOPE

LAPP

11th Einstein Telescope SYMPOSIUM

Laboratoire d'Annecy
de Physique des Particules
ANNECY - FRANCE

The Sar-Grav Laboratory Status and Perspectives



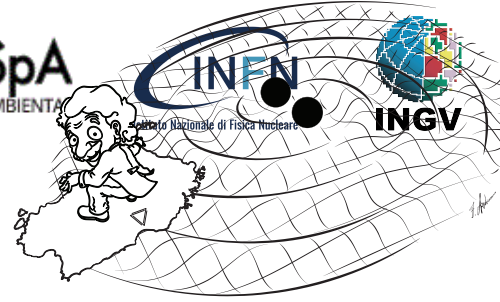
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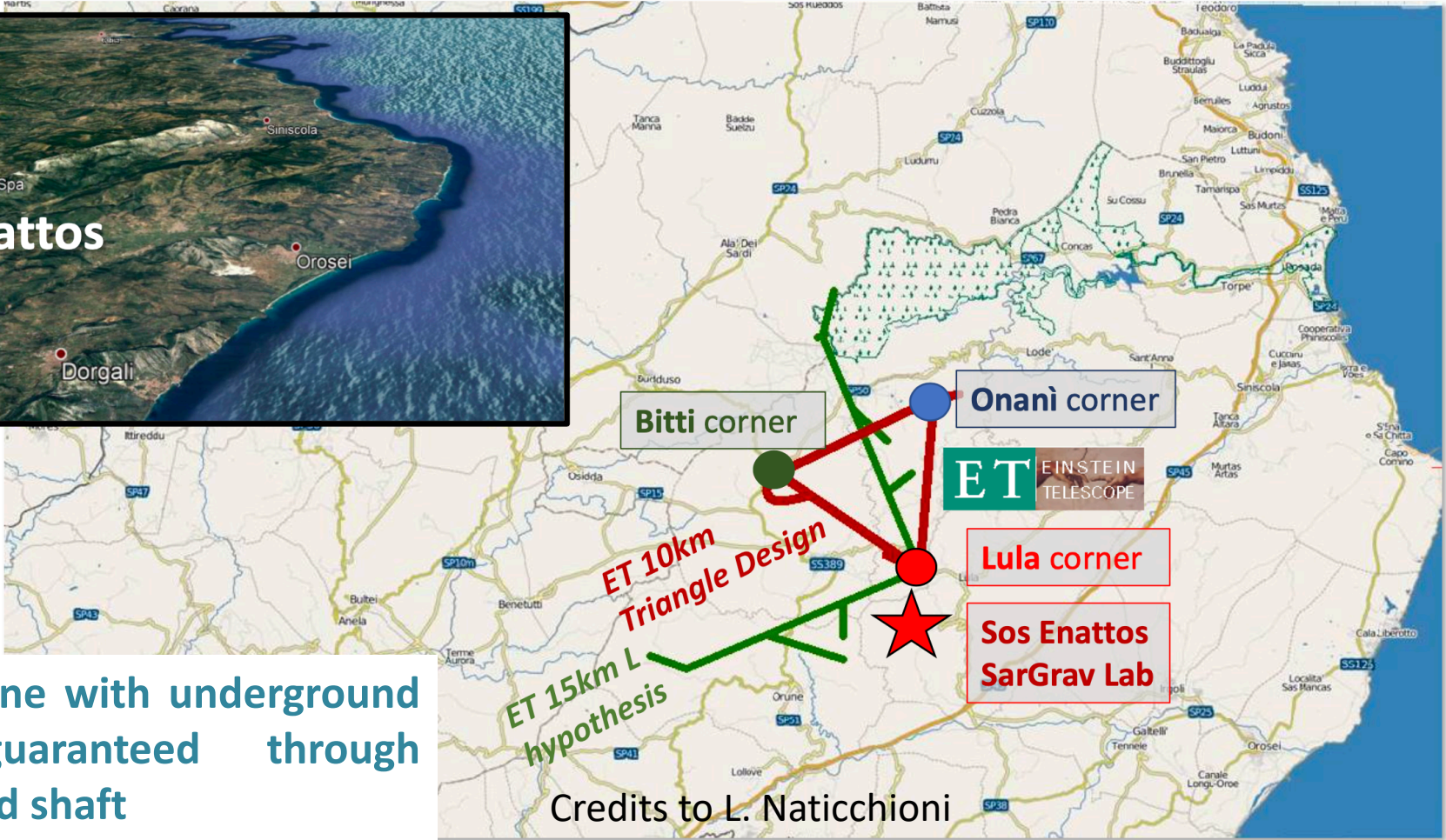
uniss
UNIVERSITÀ DEGLI STUDI DI SASSARI



IGEA SpA
INTERVENTI GEO AMBIENTALI



Sos Enattos Site



Former mine with underground
access guaranteed through
tunnels and shaft

Credits to L. Naticchioni

The SarGrav Laboratory

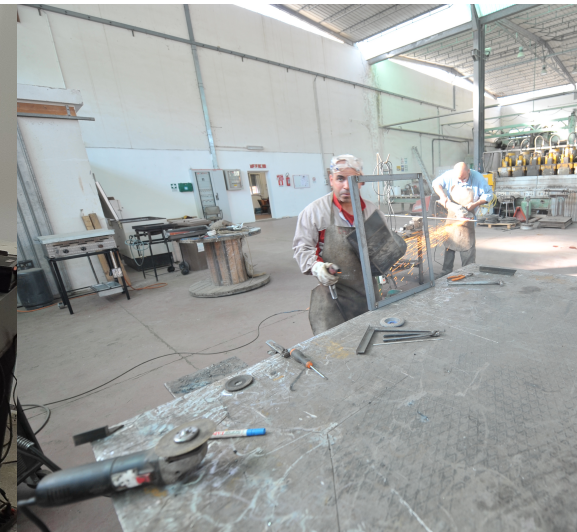
Founded by the Regione Autonoma della Sardegna (RAS) to host low seismic noise underground experiments (low seismic noise experiments, cryogenic payloads, low frequency and cryogenic sensor development)

- ~ 900 m² surface Laboratory with annexed control room
- 120 m² underground Laboratory under construction
- First experiment: Archimedes (founded by INFN)



The SarGrav Laboratory

- Control room
- Optical Lab
- Underground station for measurements at different depths
- Support from miners for mechanics and masonry service



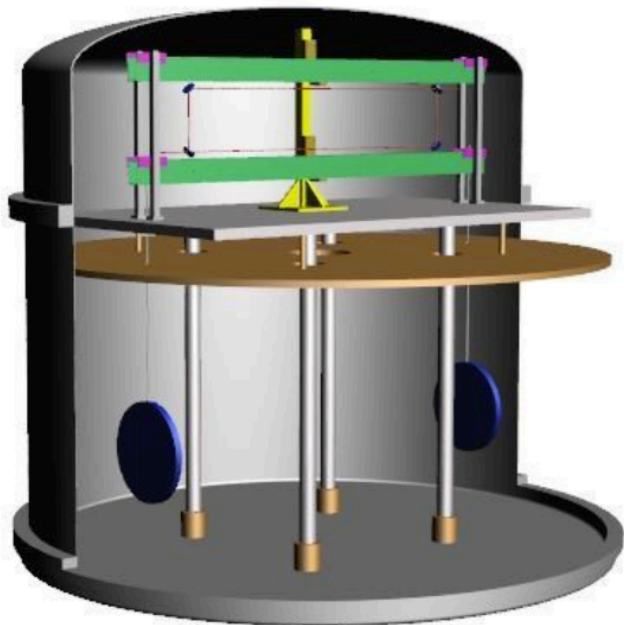
Current Activities

- Activities on Surface
- Underground Lab excavation
- Infrastructure enhancement
- Site Characterization and monitoring

Activities on the Surface

First Experiment: Archimedes

- Experimental Goal: measurement of the interaction between vacuum fluctuations with gravity weighting a Casimir multi-cavity while changing the reflectivity of its layers. A change in the reflectivity corresponds into a variation of the internal vacuum state energy.
- Apparatus: high sensitivity balance working in cryogenic conditions (~ 90 °K)

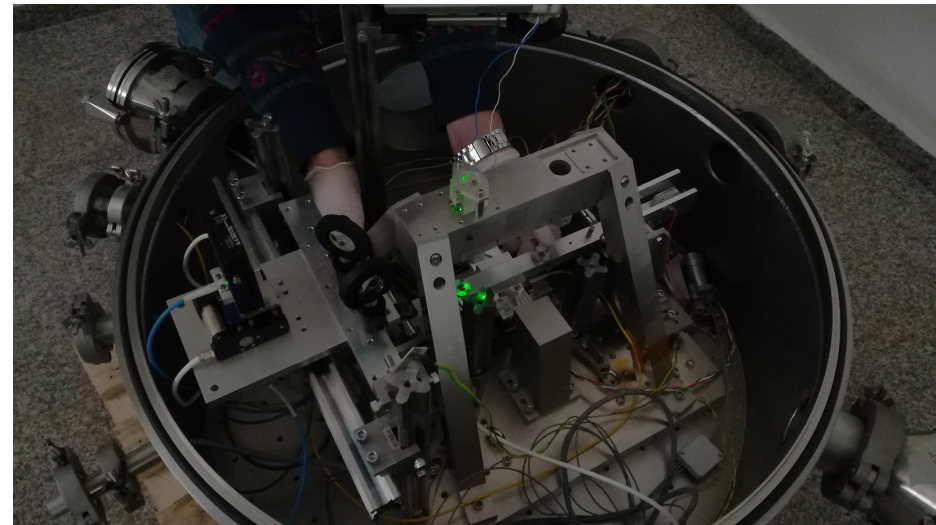


- High- T_c superconductors (i.e. YBCO) as natural Casimir multi-cavities;
- Measurements taken in HV (10^{-8} mbar) at cryogenic temperature ($T = T_c \approx 90$ K);
- Reflectivity changed via thermal actuation;
- Flexible thin joints with low thermal noise;
- Two suspended arms to apply coherent noise subtraction;
- Interferometric read-out system;
- Feedback control;
- Low seismic noise site.

Optics Lab

➤ Optics Laboratory

- ✓ Activity started on February 2020
- ✓ Test of optical components of a Tiltmeter (the Tiltmeter is the one used @ EGO), prototype of the Archimedes balance (see Errico's talk for first results)



Control Room and DAQ

- Multi-purpose control and acquisition system for Archimedes under commissioning based on cRIO controller of the National Instruments (cRIO -9049)

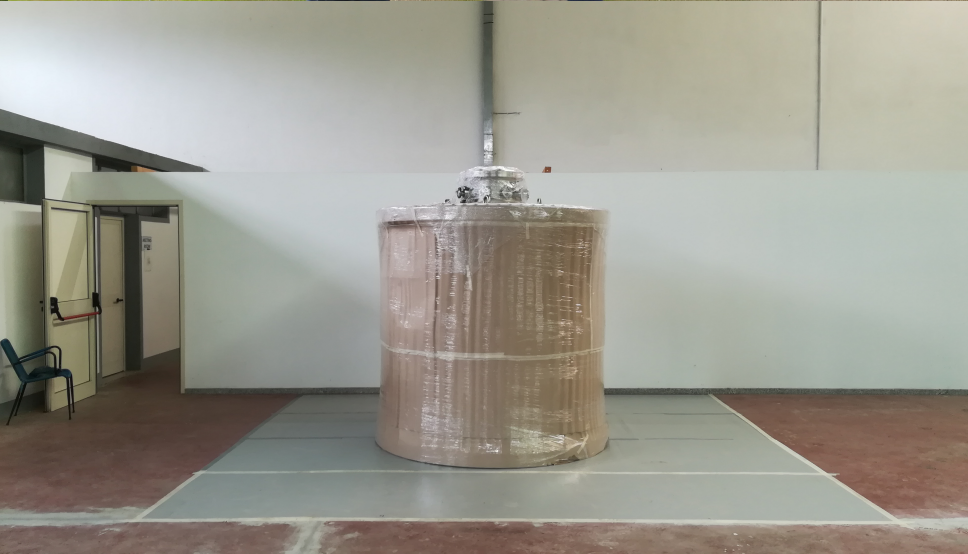


Control Room and DAQ (2)

- Data acquisition/storage system for not seismic probes under commission
 - ✓ DAQ card PCIe-24DSI64C200K
(http://www.generalstandards.com/view-products2.php?BD_family=24DSI64C200K)
 - ✓ Mini PC INTEL NUC
(<https://www.intel.it/content/www/it/it/products/boards-kits/nuc.html>)
 - ✓ Akitio Node eGPU box
(<https://www.akitio.com/expansion/node>) to host the DAQ card and connected to the mini PC via Thunderbolt 3 cable
 - ✓ **DAQ system designed to operate underground**

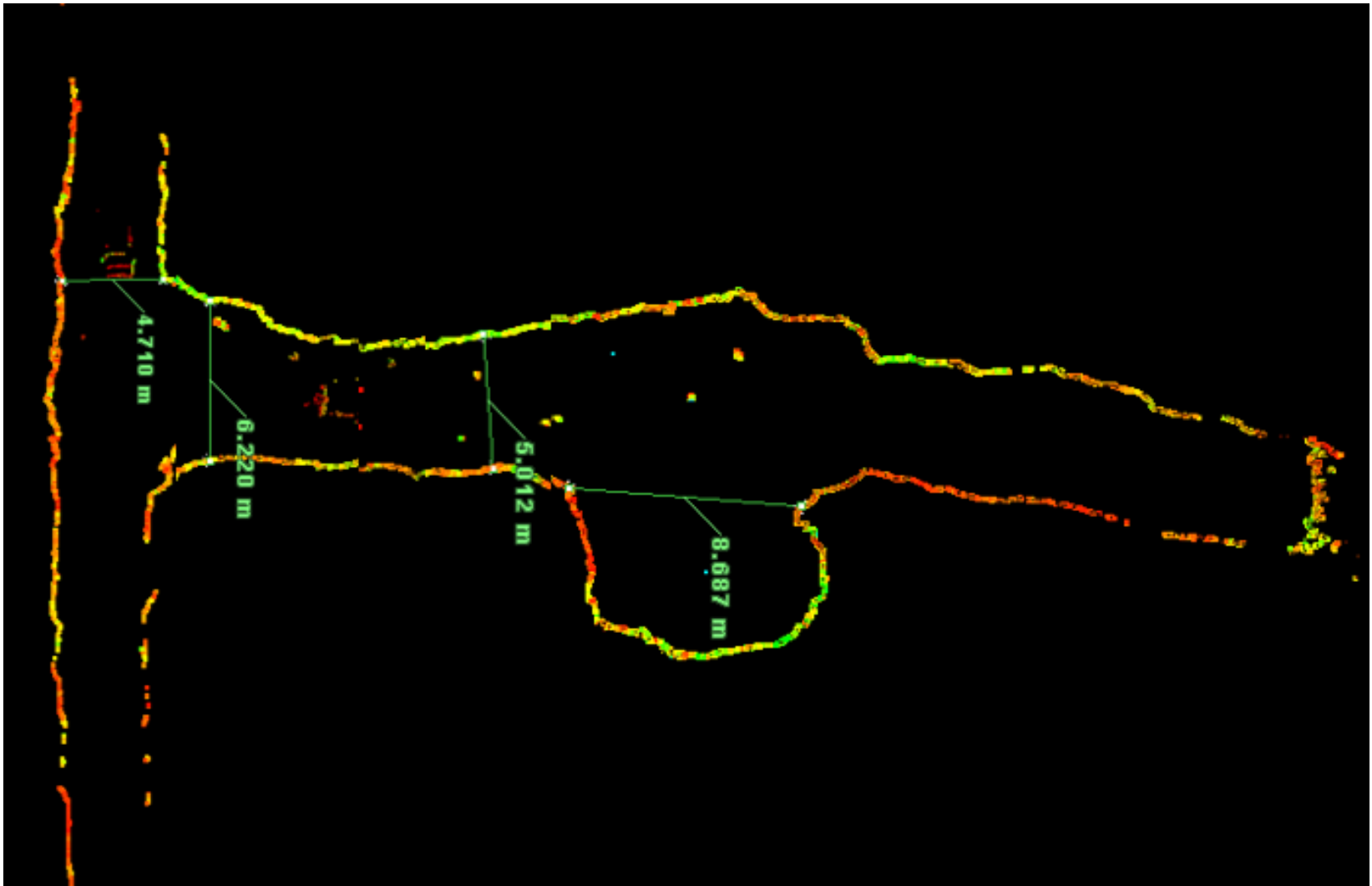


Shipment of the Archimedes cryostat (5t)

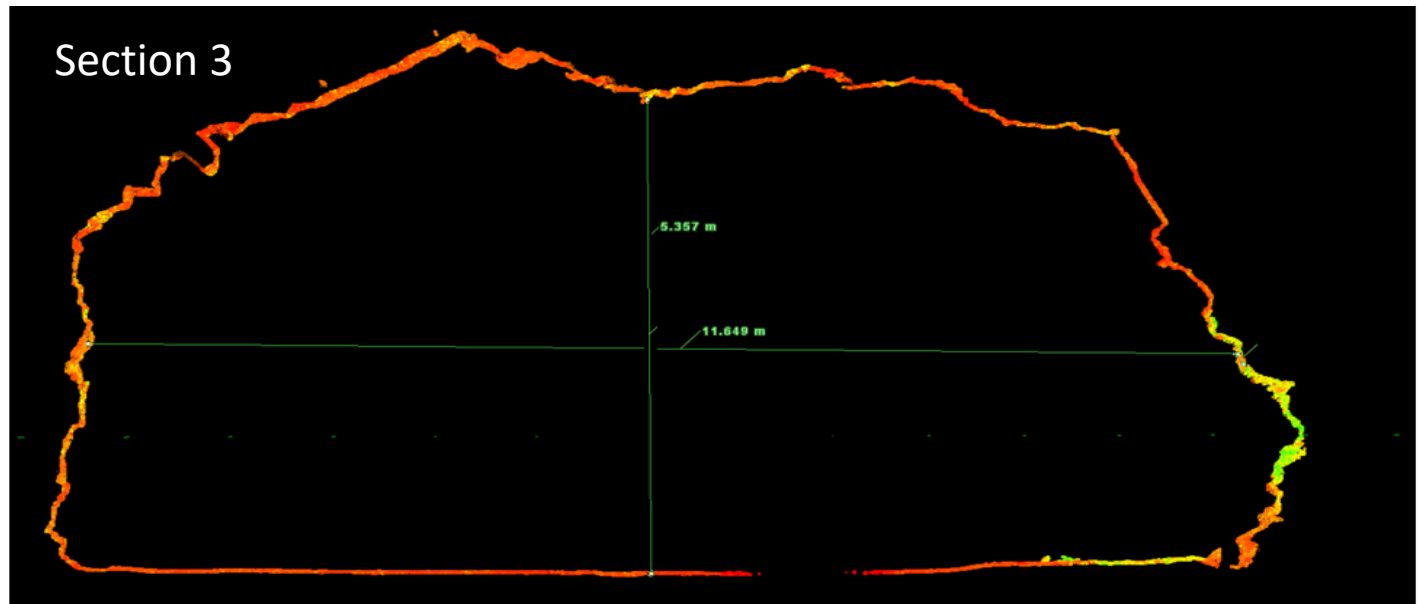
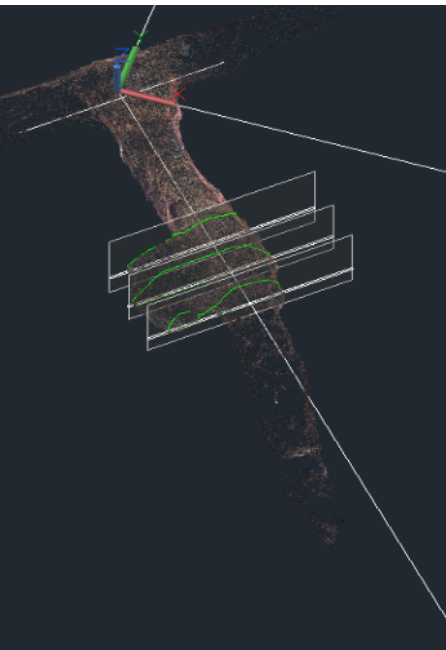
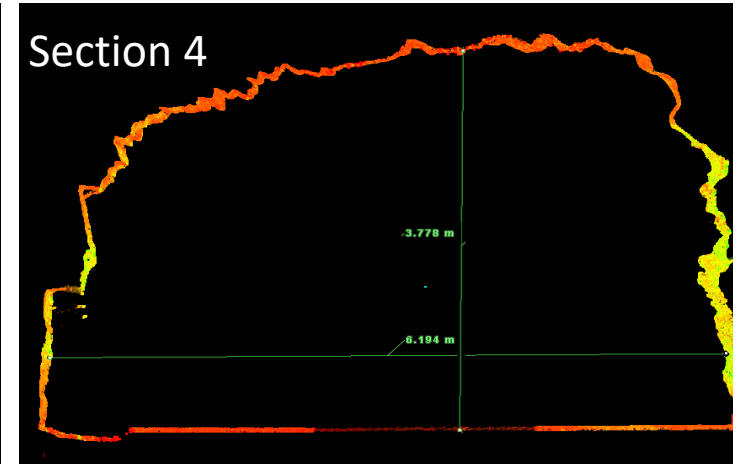
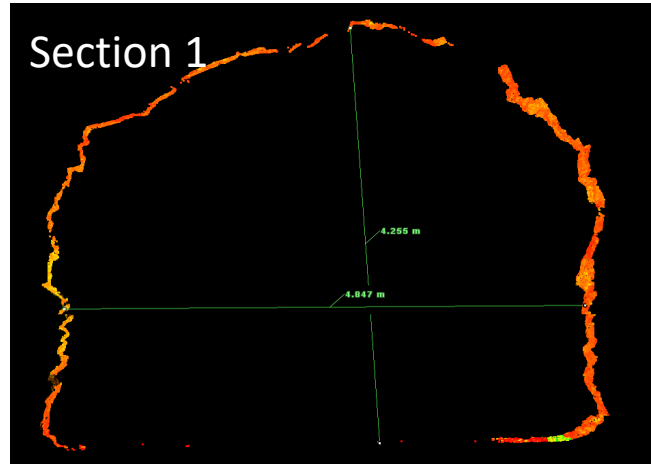
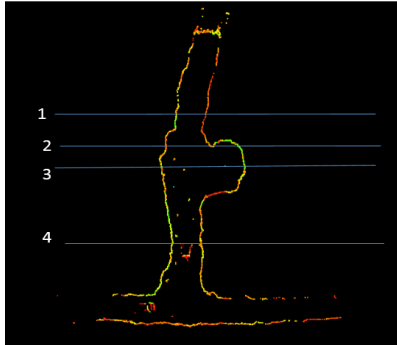


Underground Lab Excavation

Underground Lab: present stage

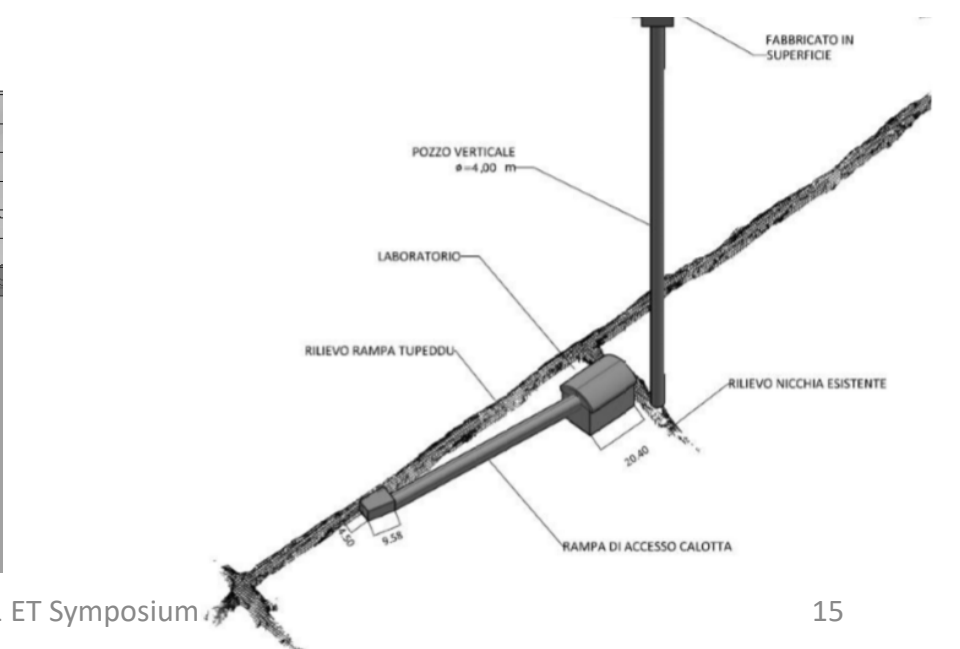
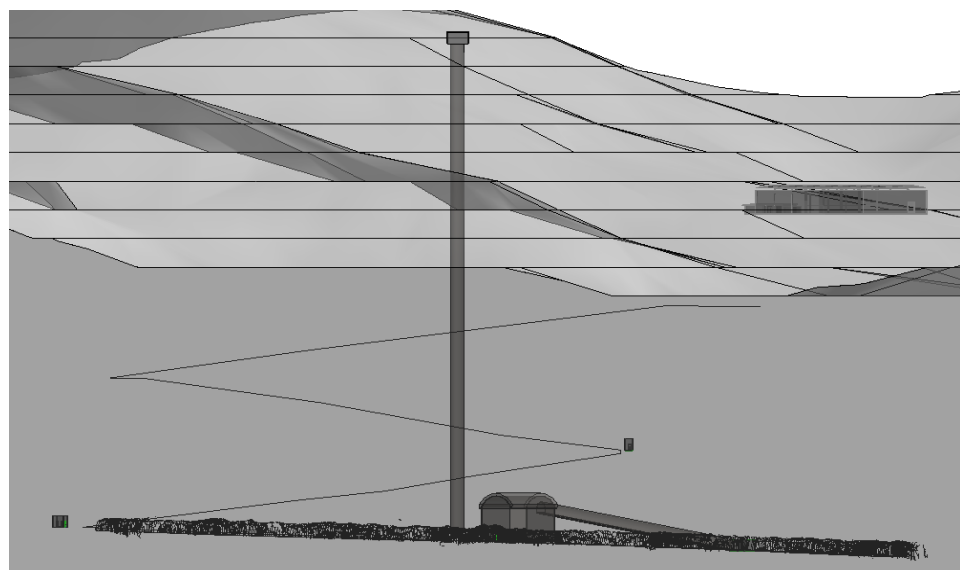
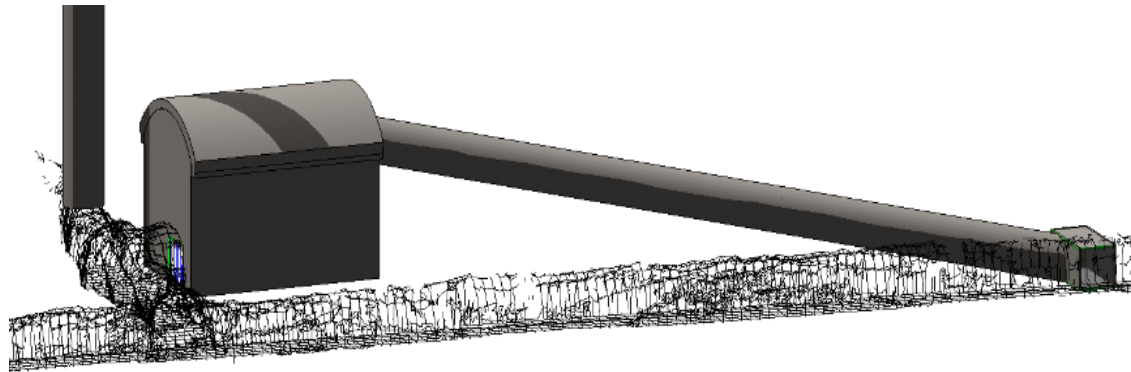


Underground Lab: present stage



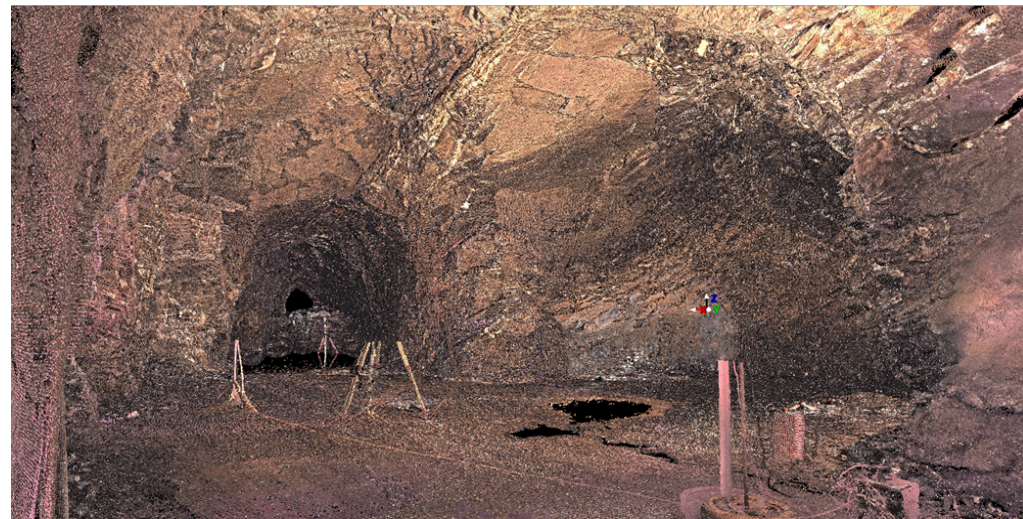
Underground Lab 3D model

See Marsella's talk



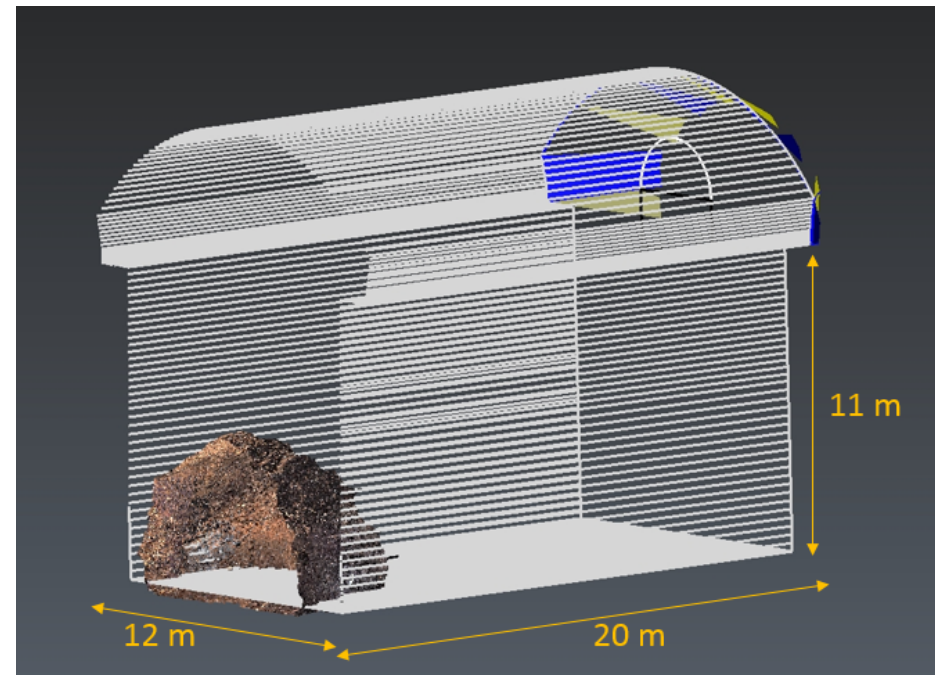
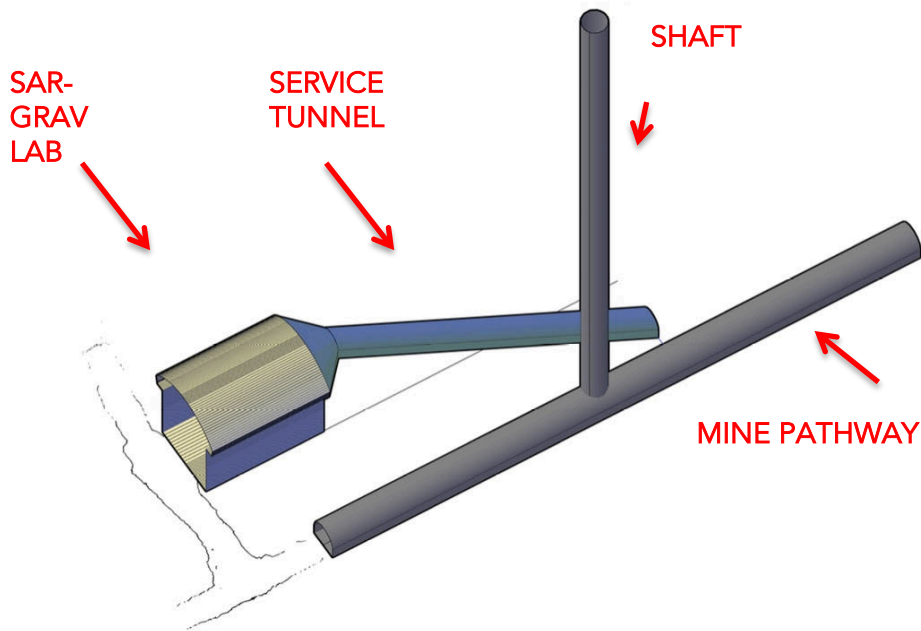
The feasibility study preceding the final design has been completed
See Marsella's talk

- 3D modelling
- Rock characterization analysis
- Modelling of the excavation and consolidation phases
- Geometry of lab and service areas have been defined
- Technological and safety infrastructures have been defined



The procedure for the contracting the construction will start in the next months

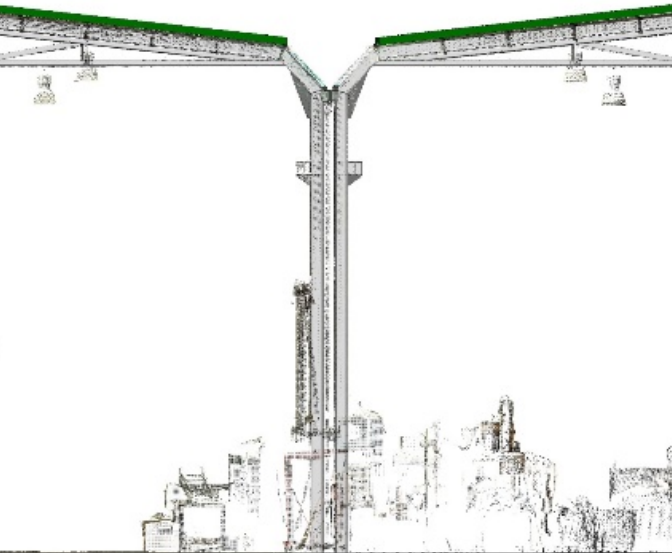
See Marsella's talk



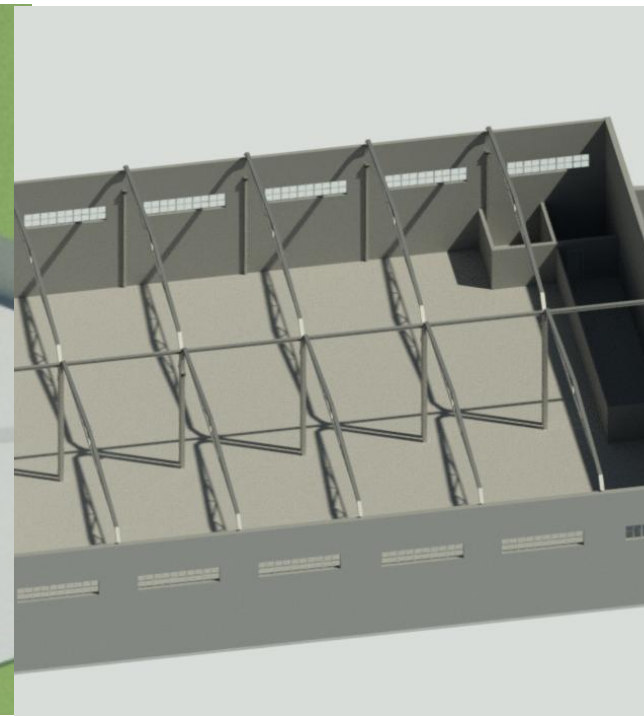
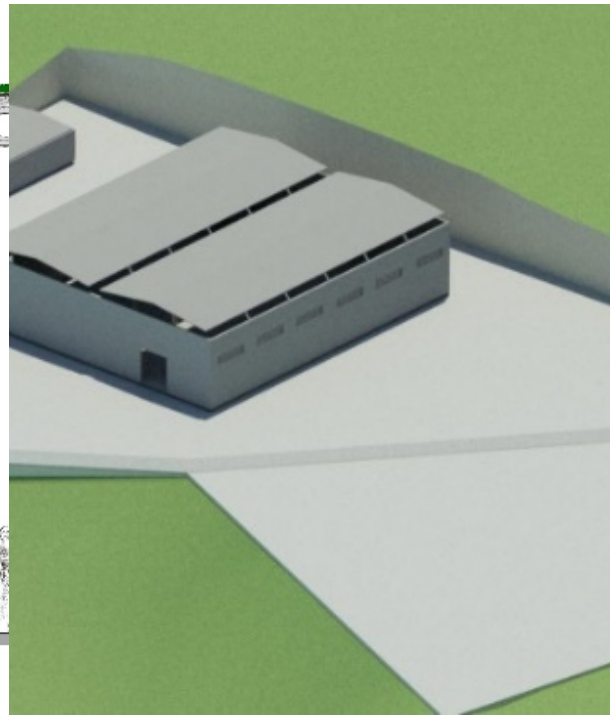
Infrastructure Enhancement

Surface Laboratory

- 3D model
- Structural studies
- Optimization of space



See Marsella's talk



Infrastructure Enhancement

- A plan to equip Sar-Grav lab with additional facilities by the 2021 has been already founded by the RAS
 - ✓ Mechanic Lab equipped with a 20 tons crane
 - ✓ Clean Room on the surface
 - ✓ Data storing and management system
 - ✓ Nitrogen liquefier
 - ✓ Fiber network link

Site Characterization and monitoring

Site Characterization and monitoring

- SarGrav is strongly supporting the ET Characterization in terms of logistics and manpower
- Sensors on site
 - ✓ 4 broadband triaxial seismometers (1 surface vault installation + 3 underground);
 - ✓ 3 short-period triaxial seismometers (first *seed* of a new array);
 - ✓ 2 magnetometers (1 buried at surface, 1 underground);
 - ✓ High precision tiltmeter (Archimedes prototype, see L. Errico's talk)
 - ✓ Weather station
- New sensors expected to be installed at the beginning of 2021 (geophones, microphones, magnetometers)
- Data acquired at the SarGrav control room, transmitted via UMTS link to remote server (INGV-PI server → ET repository), and accessible through an INFN access point.

Measurement stations

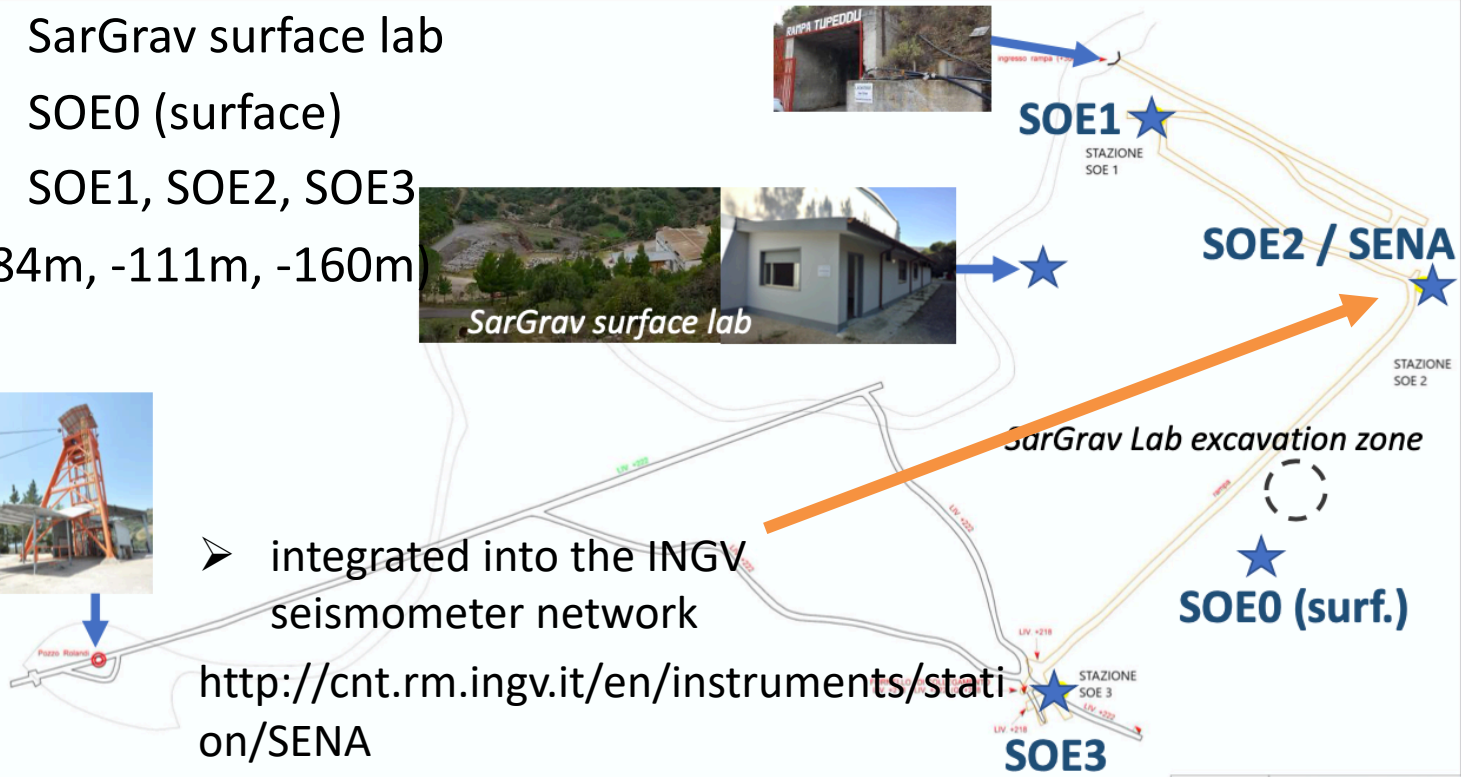
Sos Enattos measurement stations (since Aug. 2020)

- SarGrav surface lab
- SOE0 (surface)
- SOE1, SOE2, SOE3 (-84m, -111m, -160m)



- integrated into the INGV seismometer network

<http://cnt.rm.ingv.it/en/instruments/station/SENA>



Site Characterization and monitoring

- Long-term seismic and environmental monitoring
- First seismic characterization measurements at Sos Enattos published
- Low environmental noise

See Sos Enattos talks in the Site Infrastructure session for further details

Conclusions and perspectives

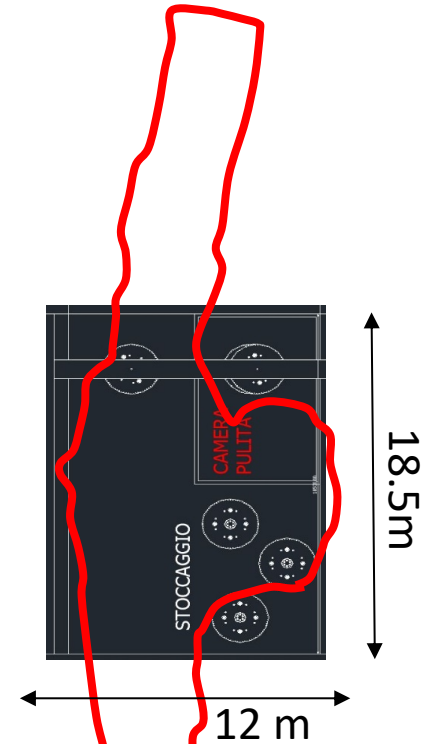
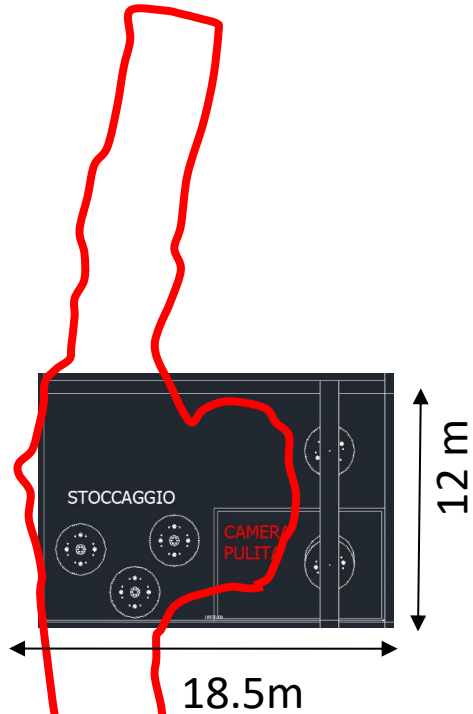
- SarGrav Lab is a very low noise infrastructures, designed to host low seismic noise experiments, cryogenic payloads, low frequency and cryogenic sensor development
- The Archimedes use case will allow assess the site quality and to verify how to implement underground cryogenic and vacuum systems without degrading the site
- Surface activities:
 - ✓ preliminary experimental tests to assembly Archimedes components
 - ✓ DAQ and control systems in commissioning phase

Conclusions and perspectives (2)

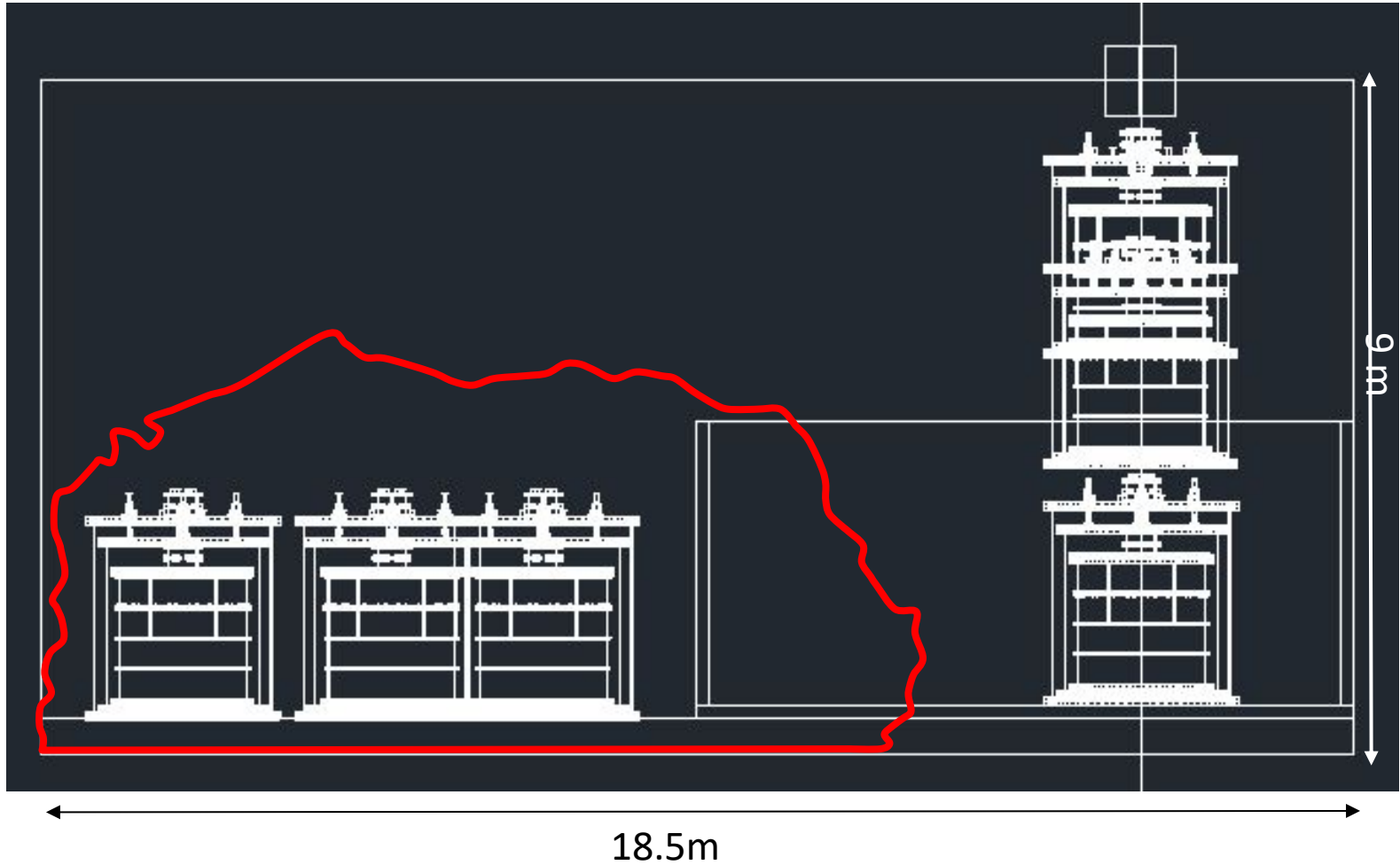
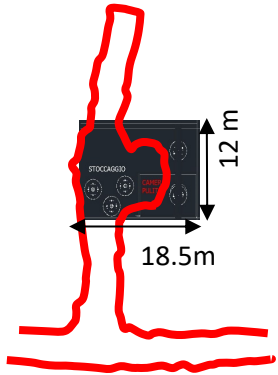
- Underground excavation
 - ✓ feasibility study preceding the final design completed
 - ✓ The procedure for the contracting the construction is going to start
- Enhancement plan of surface infrastructures
- Site Monitoring: synergy with ET Characterization Activities

Backup Slides

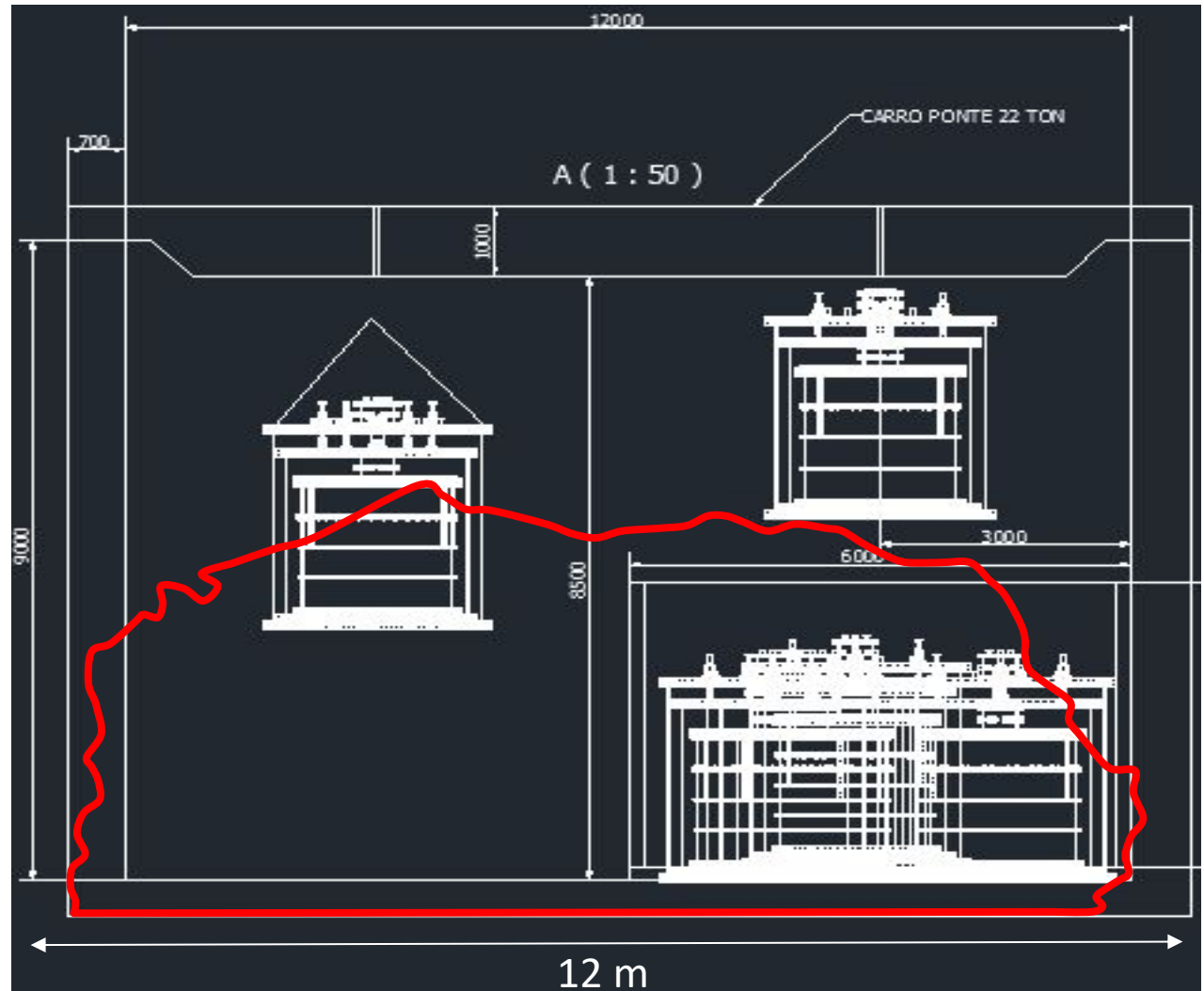
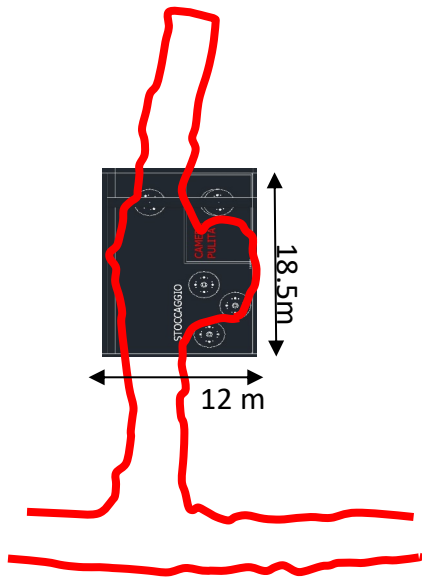
Archimedes underground lab: future configuration



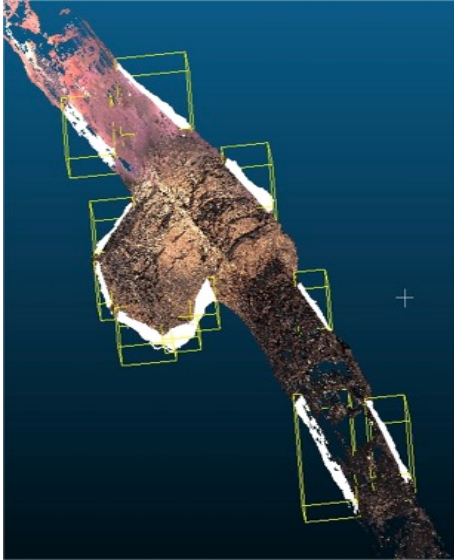
Archimedes underground lab: future configuration



Archimedes underground lab: future configuration

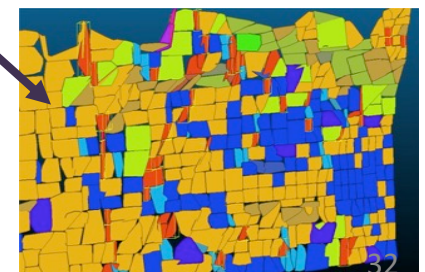
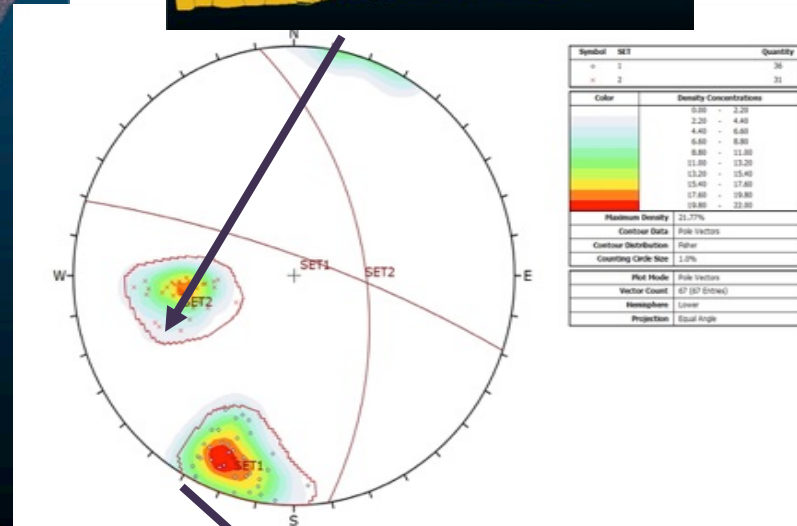
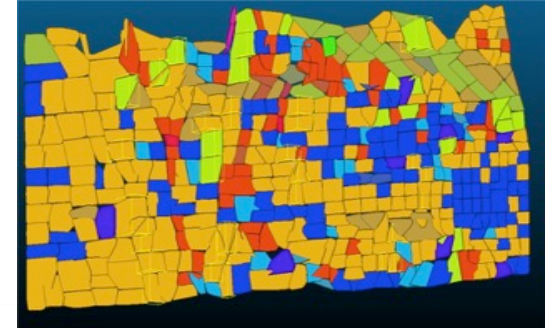


Laser scanning for geo-structural surveying



- ❑ Rock discontinuities identified by the dense laser point cloud
- ❑ Laser scans at different orientations and position along the galleries

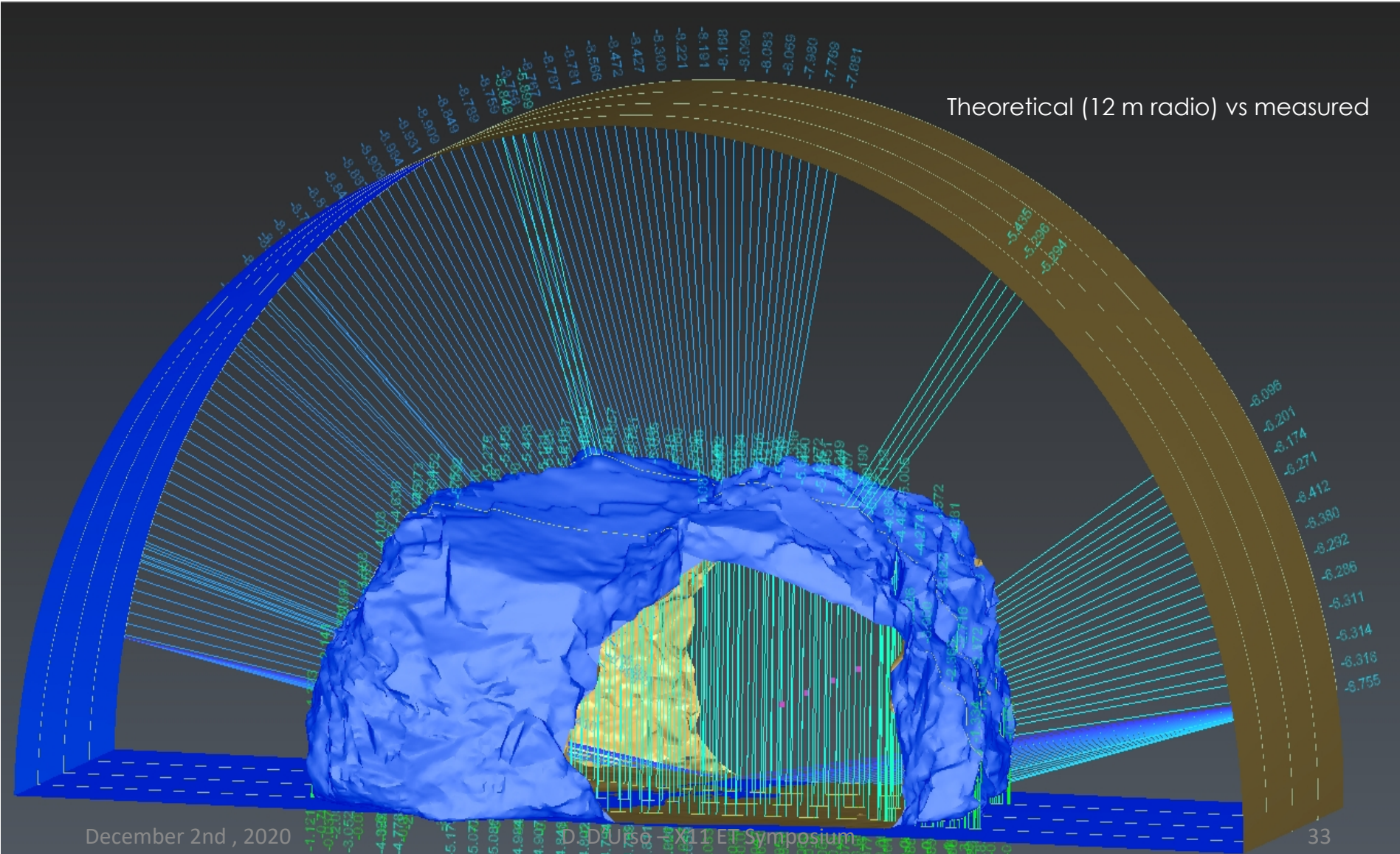
Laser scanning for geo-structural surveying

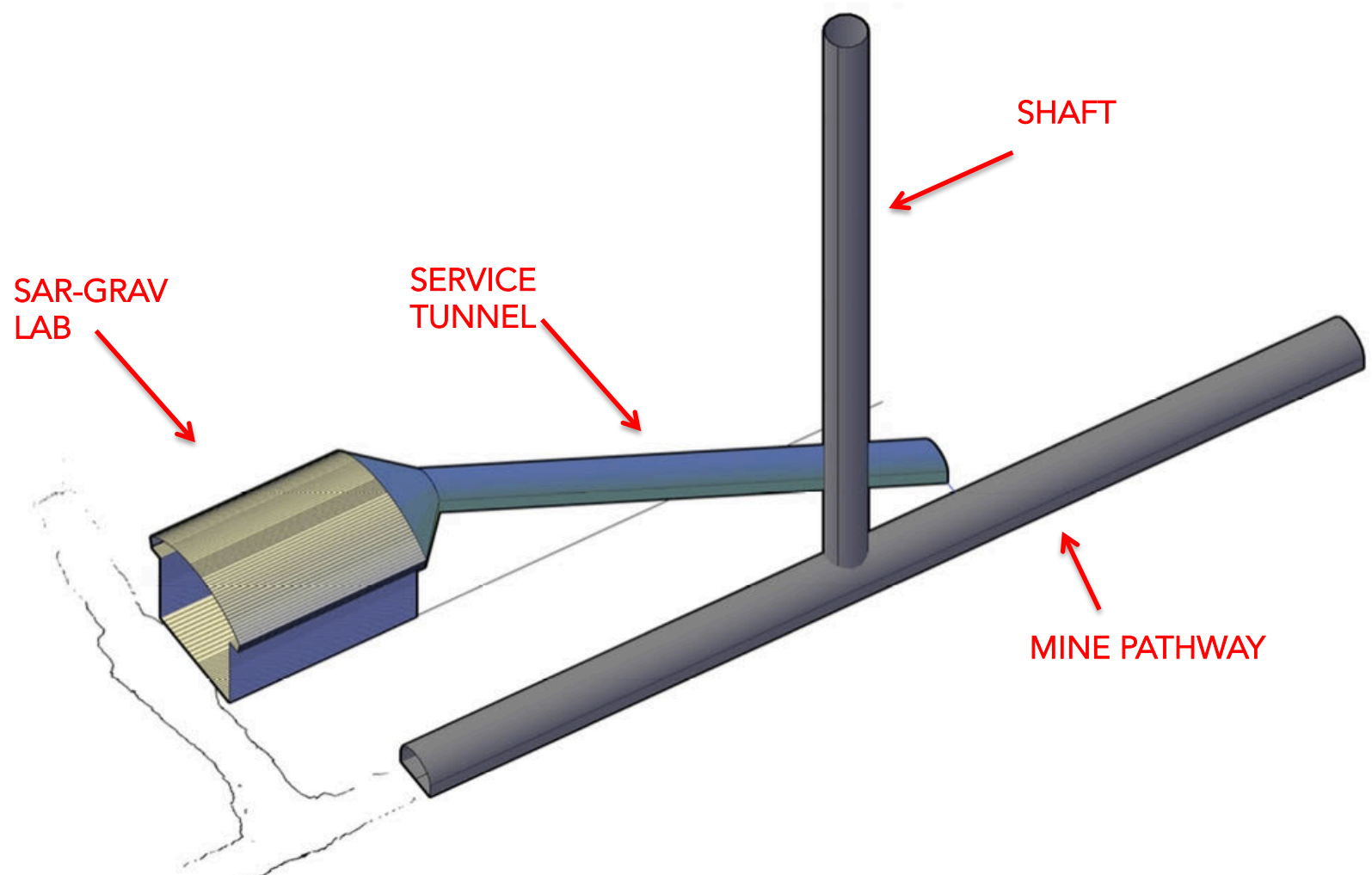


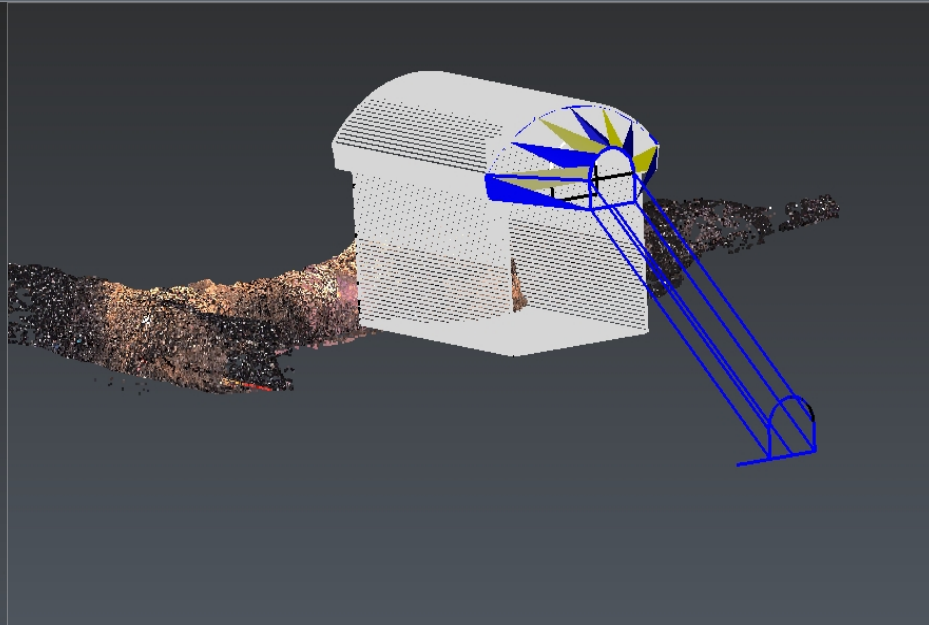
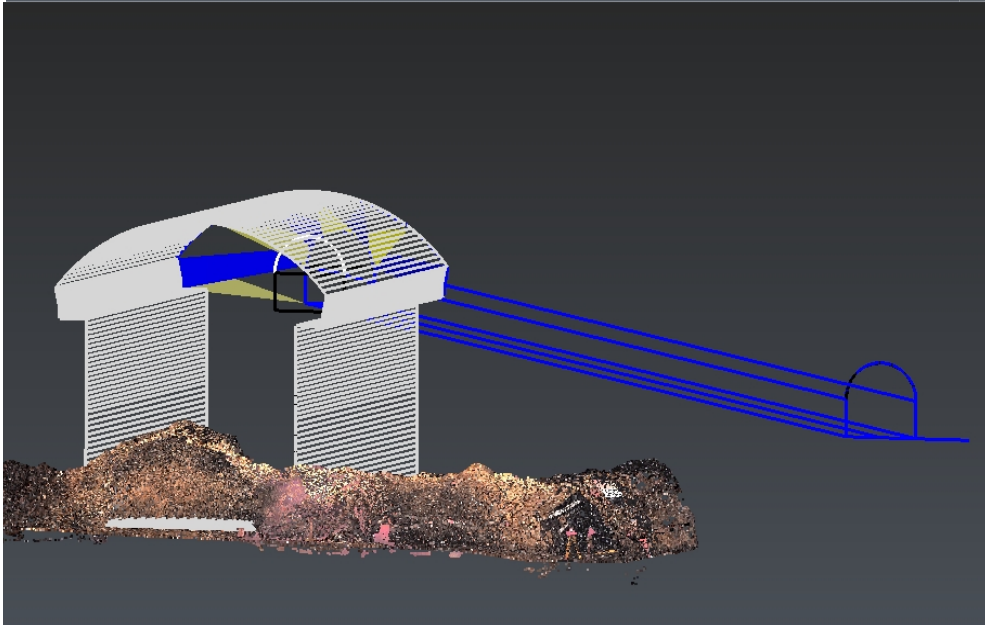
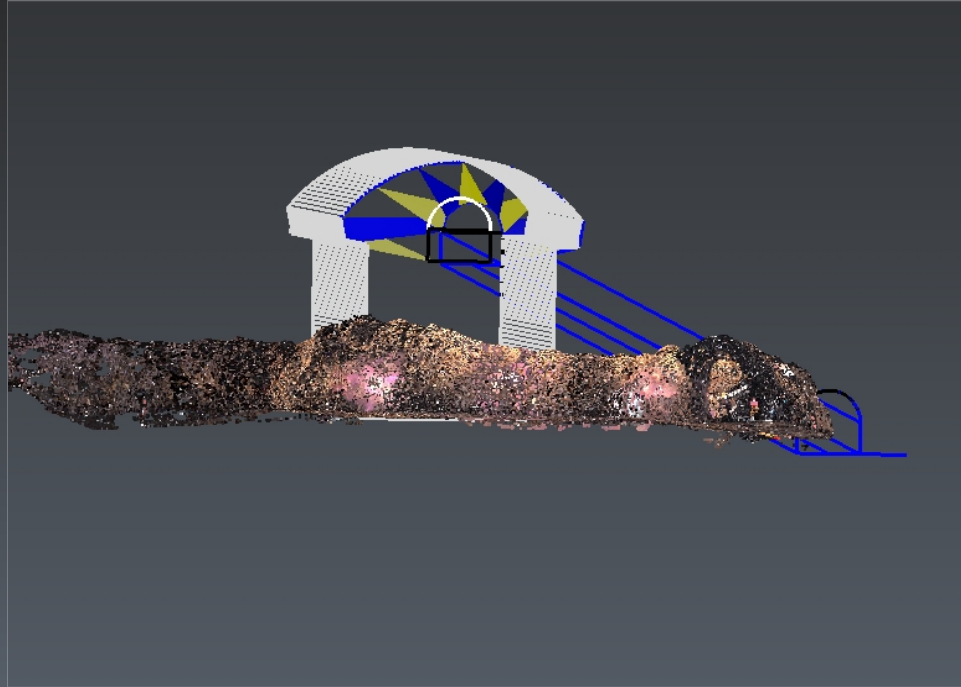
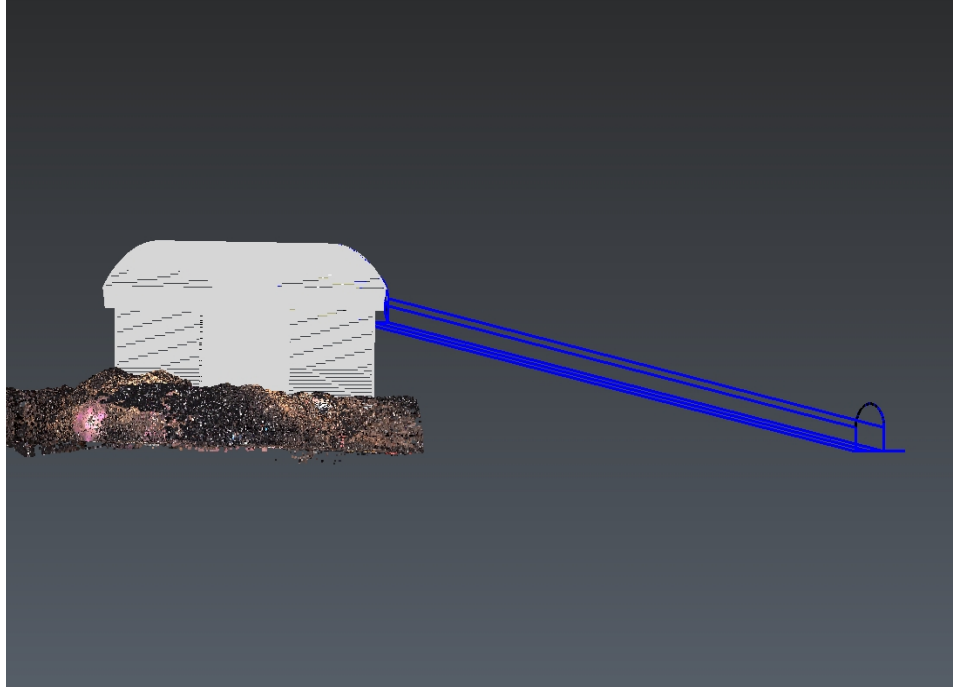
- segmentation
- Semi automatic (supervised) plane extraction
- Set parameters for rock kinematic stability analysis

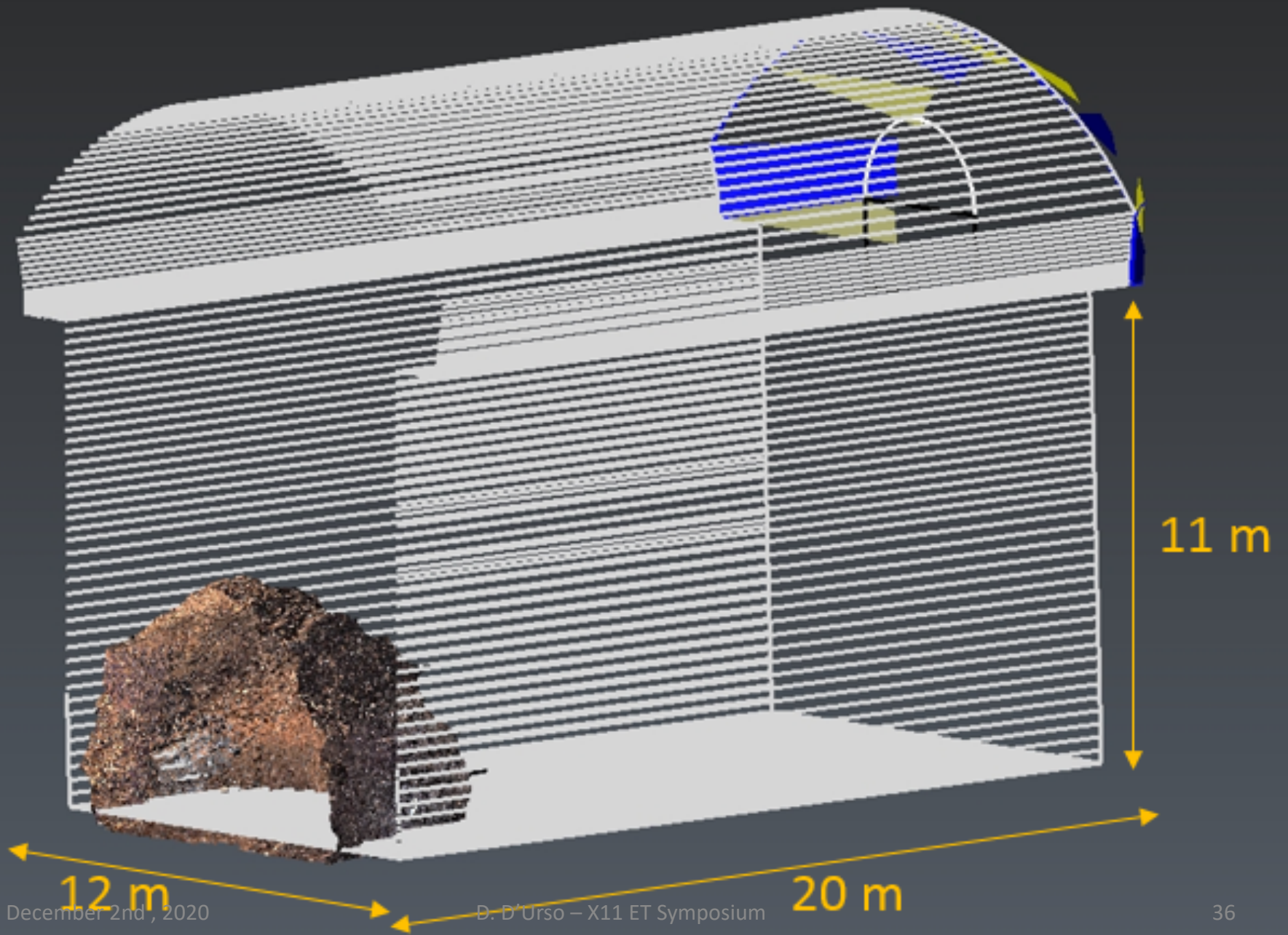
Toward the cavern design

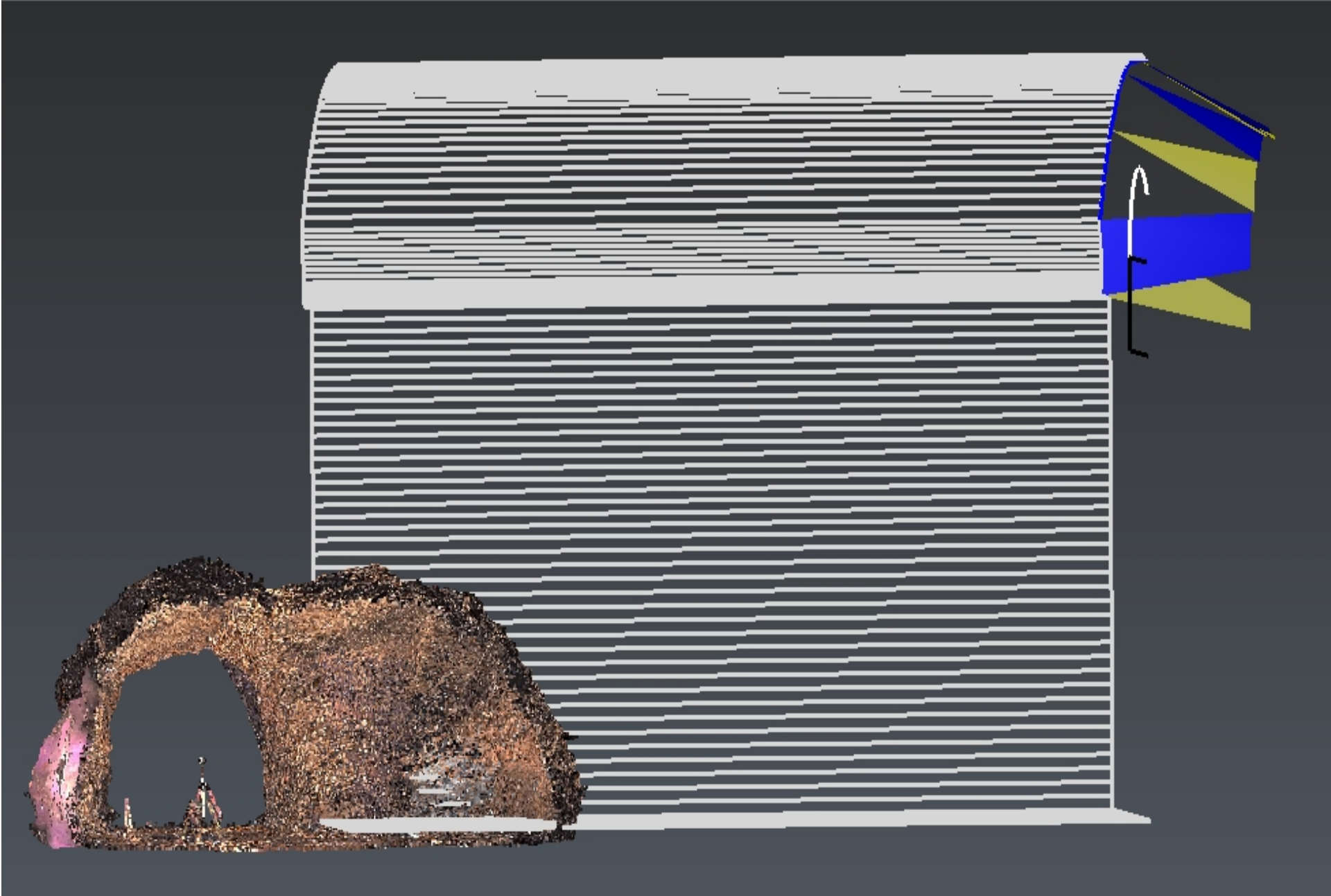
Theoretical (12 m radius) vs measured







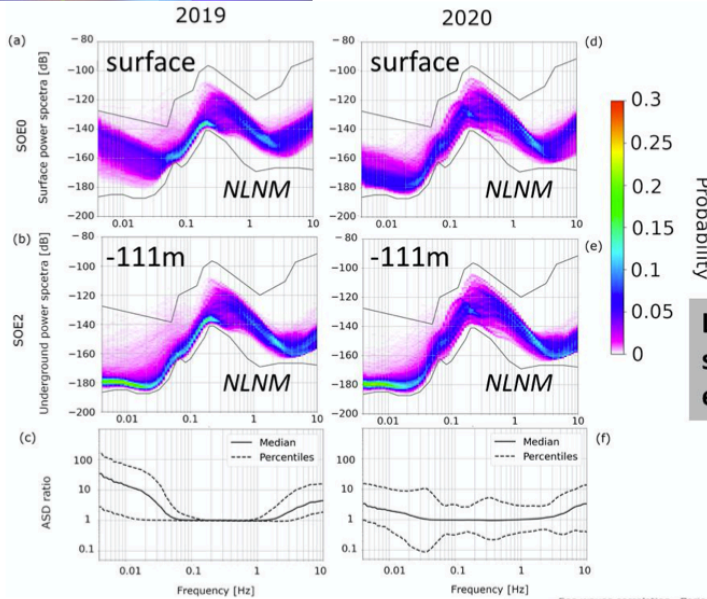




Naticchioni's talk

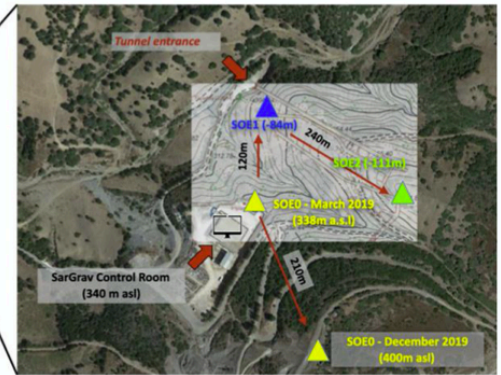


First results at Sos Enattos

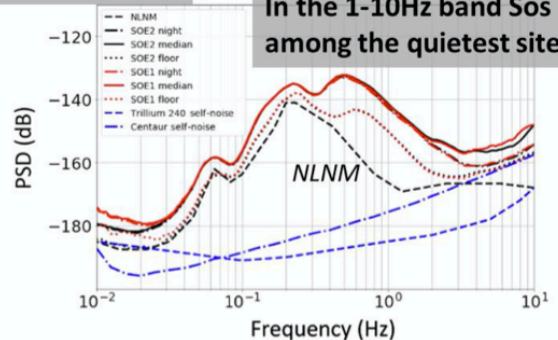


Sos Enattos
Nuoro

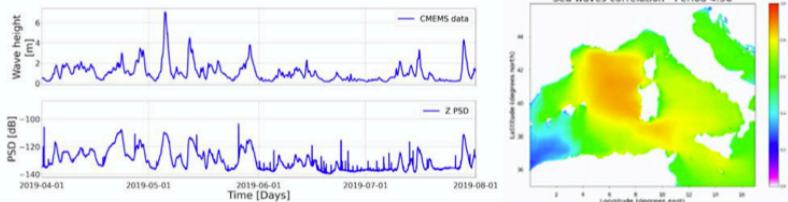
Low anthropic noise, no significant amplification effects



In the 1-10Hz band Sos Enattos is among the quietest sites in the world



→ Talk by G. Saccorotti

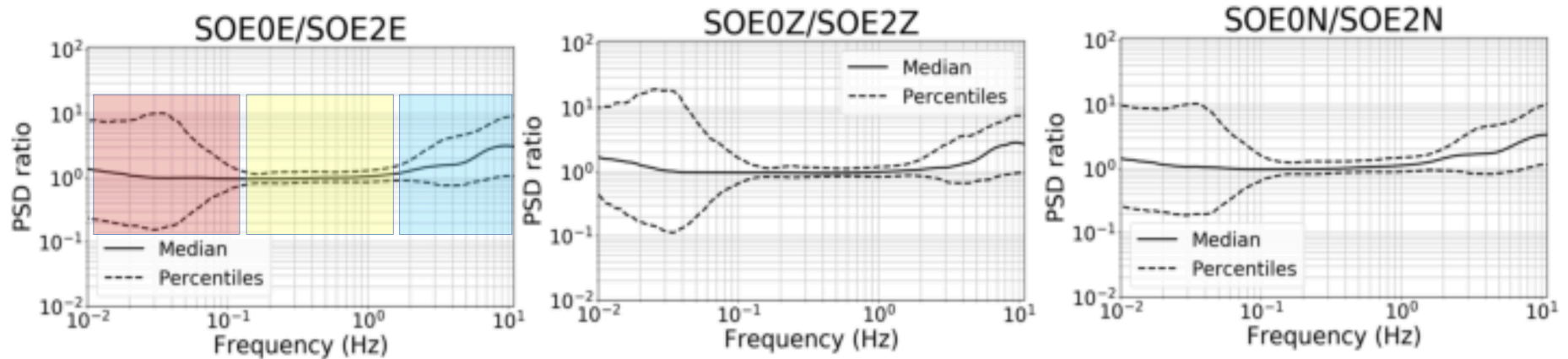


Microseisms correlation with NW 4.5s Med Sea waves

L. Naticchioni – Sardinia Site Characterisation Activities – 1st Dec. 2020

Credits of M. Di Giovanni

Spectral ratios surface / underground



[0.01 - 0.1] Hz $\rightarrow R \sim 1$, as expected. The **large variance** can be explained in terms of (a) P/T influence on the surface sensor, and (b) bad-conditioning of the spectral division (response of the underground sensor close to the instrument's self noise).

[0.1 - 2] Hz $\rightarrow R \sim 1$.

[2 - 10] Hz $\rightarrow R > 1$, **large variance** \rightarrow **not only surface sources.**