Infrastructure issues --- Civil Engineering

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Why a new infrastructure

- Increase the arm length to gain in sensitivity
- Implementation of new technological plants requiring more space (cryogenics system)
- Reduce the seismic impact of the sensitivity (Underground detector)
- Permit longer data taking runs of the 2G detectors by relaxing the needs to implement new technologies on 2G
- Prepare the transition from obsolete to new infrastructures

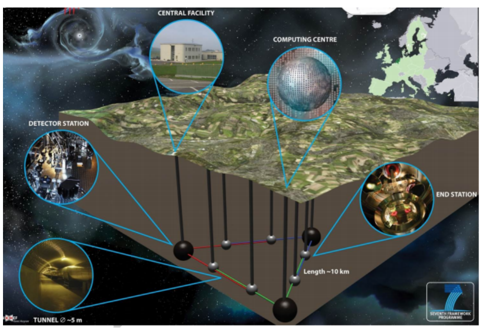
The target should be to realize a 3G-infrastructure in the next decay choosing sites that must have specific features that can enhance the planned investments.

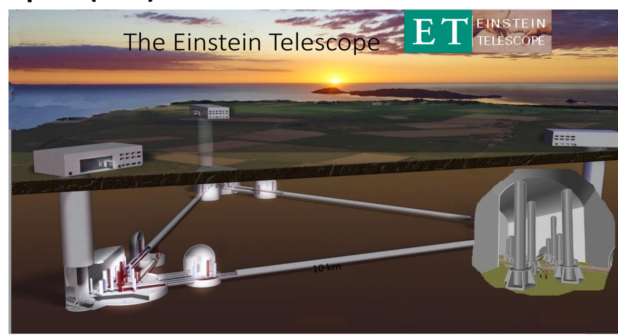
The 3rd GENERATION: site basic requirements

- lower seismic motion, meteorologically generated seismic noise, anthropogenic activity anthropogenic activity (local infrastructure, population density, etc.);

- lower Newtonian noise originates from fluctuations in the surround geologic and atmospheric density, causing a variation in the Newtonian gravitational field.

The Einstein Telescope (ET) case



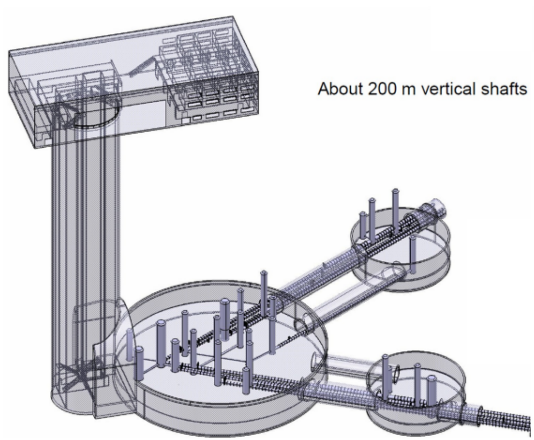


The Einstein Telescope will be located underground at a depth of about 100 m to 200 m and, in the complete configuration, will consist of three nested detectors each in turn composed of two interferometers

THE UNDERGROUND INFRASTRUCTURE

2011 design (CD) provided for the construction of substantial underground infrastructure:

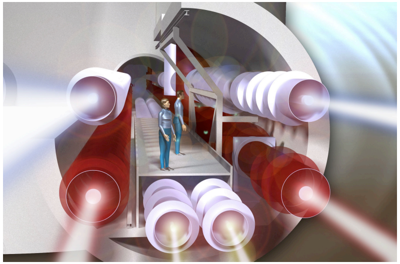
- three corner stations connected by 10 km long;
- each corner station will have 2 caverns with diameters of 30 m and a height of 30 m and a main cavern with a diameter of about 65 m and a height of 30 m;
- the connection tunnels hosts the interferometer arms and have an inner diameter of 5.5 m



CD Design: Corner station of Einstein Telescope. In total 3 such corner stations are connected by 10 km tunnels.

The civil engineer case of ET

Since 2011 we re-analyzed in-depth the CD from the point of view of underground works: modification emerged in order to avoid a series of critical issues:



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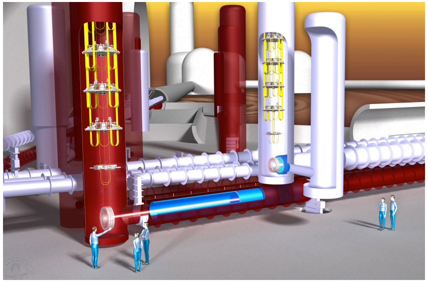
1. seen the hypnotized size (ϕ=5.5m) tunnels are too crowded (***issue nowadays under discussion because the tunnel diameter affects significantly the project cost***)



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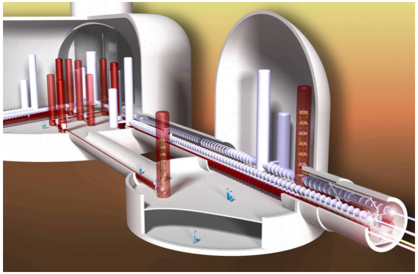
2. unrealistic tower footprint: conflict with pipes



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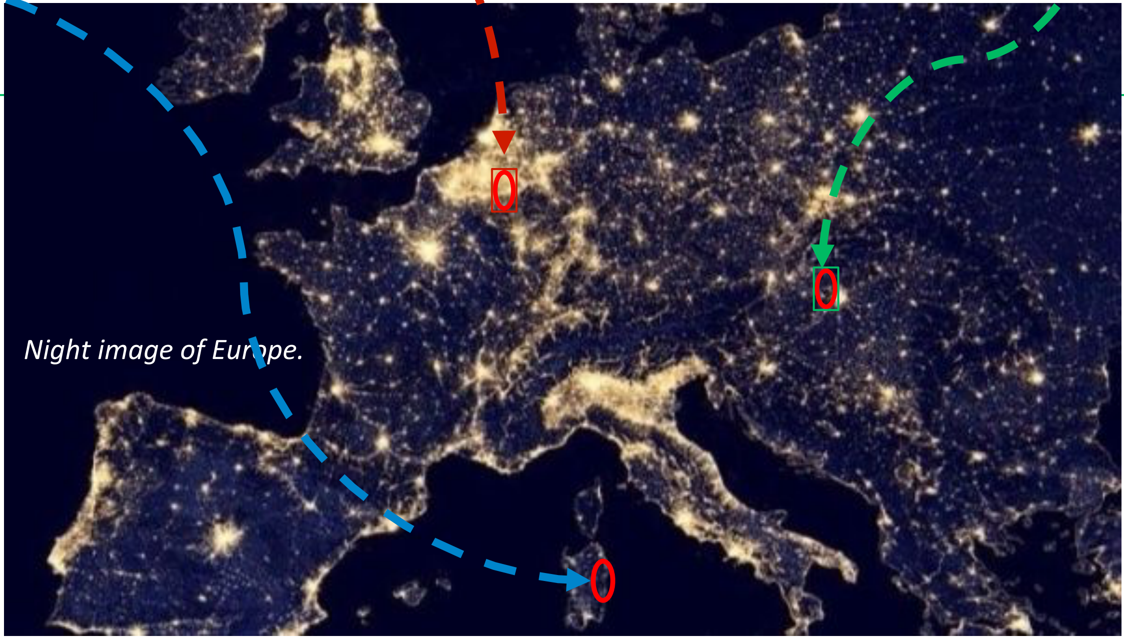
3. cavern dimensions the provided dimension (65 m diameter) too challenging from engineering point of view

Sites studies already started

- G-B-N Site, in the Meuse-Rhine region between Netherland, Belgium and Germany
- Mátra Mountain Site, in the northern of Hungary (first cancelled and now revived?)
- Lula Site, in the Sardinia - Italy.



My personal use case: the Sos Enattos (Lula – SARDINIA)

We (**) have studied the placement of the ET detector in the SOS ENATTOS area.

We tried to fulfill the following requirements:

- Vertexes placed in solid rock
- Access to caverns through tunnels rather than shafts

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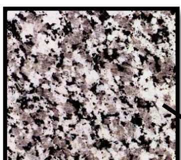
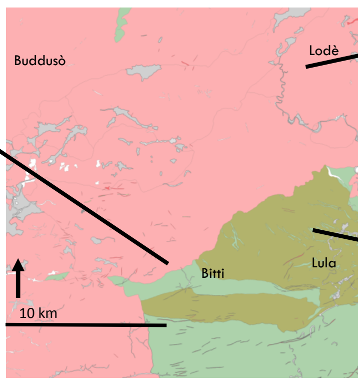
(**) A. Paoli, G. Losurdo, G. Oggiano, D. D'Urso, IGEA and SWS company et al. ……

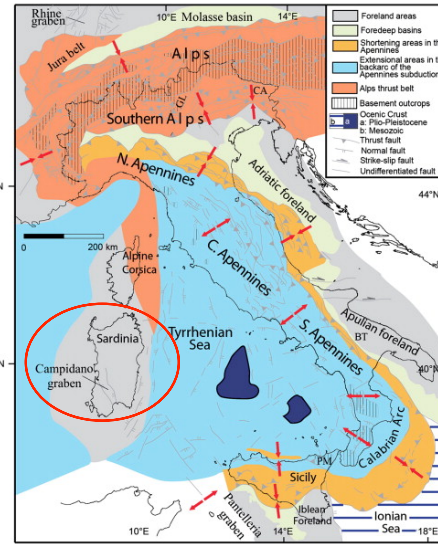


Granodiorite “Bitti type”
UCS: 72.1 MPa



Orthogneiss “Lodè type”
UCS: 92.6/60.8 MPa

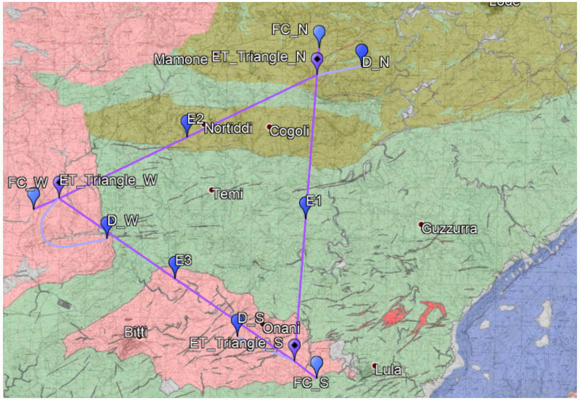
Micaschist / Paragneiss / Quartzite
UCS: 8.8/68 MPa



Ancient rocks, European continental landmass: seismically quiet. Since 16 Million Years, and after the opening of the south Thyrrenian basin, Sardinia has been excluded from the active dynamics affecting Italy along with Dinarides and Hellenides

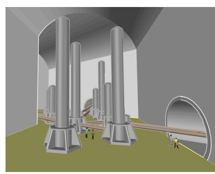
Revision of the ET Conceptual Design (CD)

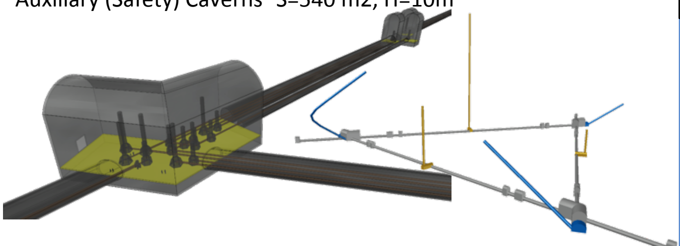
TRIANGULAR SCHEME



Main features:

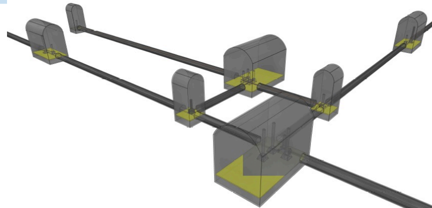
- Main Tunnel excavation: Diameter=11.4m, total length L= 30 km
- Main Caverns: S=2730 m^2, H=36m
- Satellite Caverns:S=256 m2, H=32m / 22m
- Access Tunnel Caverns S=315 m2, H=18m
- Auxiliary (Safety) Caverns S=540 m2, H=10m



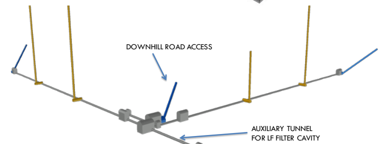


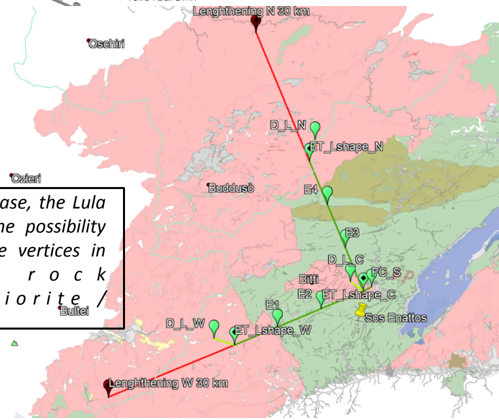
Within the Lula site it is possible to locate the vertices in sound rock (Granodiorite / Orthogneiss)

L-TOPOLOGY



In the one critical vertex area, subdivision of the necessary spaces in smaller portions





Also in this case, the Lula site offers the possibility to locate the vertices in sound rock (Granodiorite / Orthogneiss)

Main features:

- Main Tunnel excavation: Diameter=6.6m, total length L= 30 km
- Main Caverns: S=1581 m^2, H=37.5m
- Satellite Caverns: S=861 / 256 m2, H=36.5m / 22m
- Access Tunnel Caverns S=315 m2, H=18m
- Auxiliary (Safety) Caverns S=540 m2, H=10m

GEO-STRUCTURAL ISSUES APPLIED TO THE LULA SITE

- The underground structure design was focused on assessing the feasibility of the project works, by evaluating the stability of the excavations and the stabilization interventions necessary for it.

- Particular attention was paid to the design aspects related to the cavern, which represent the most critical element in the project works.

Procedure - I

- location of the vertices within the competent geological formations (“Granodiorite of Bitti” and the “Orthogneiss of Lodè”);

- definition of an estimate of the geomechanical reference properties of the masses involved in the works

Based on the current knowledge, the geotechnical model is assumed as an “equivalent continuum", starting from the information related to the characteristics of the intact rock, the parameters of rock mass have been defined through the criterion of Hoek and Brown for the rock masses, on the basis of values of the parameter mi equal to 30-28 and a quali-ty of the rock mass equal to RMR=50÷60 / GSI=45÷55.

Procedure - I I

- defining the longitudinal profile of the works to associate the properties with and evaluate the stress state

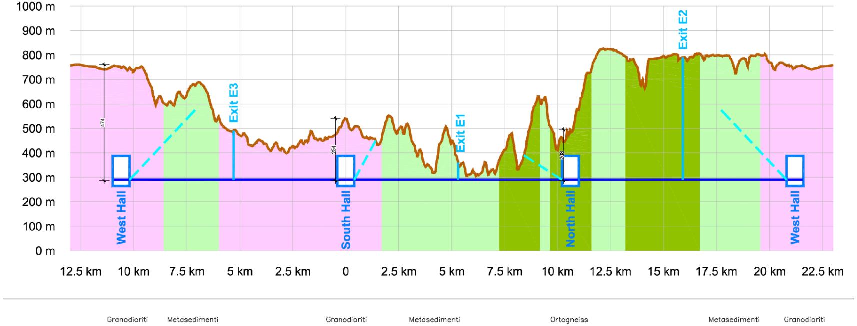
- the simplified evaluation of the various parameters to provide identification of the complexity of the excavation and the response of the rock mass (confinement method)

- first step analysis through 2D numerical models, in order to take into account also the real transversal shape of the excavations;

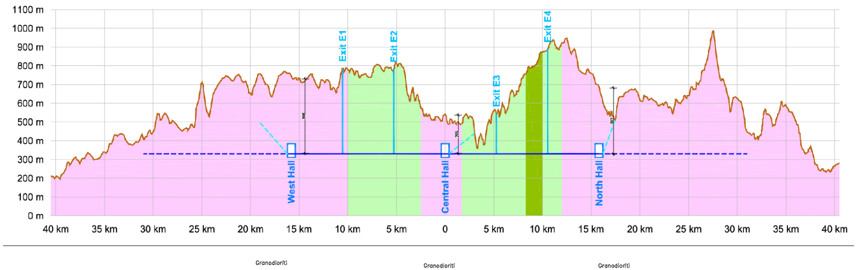
- second step analysis through 3D numerical models, in order to complete the evaluation of the behavior on the basis of the real three-dimensional shape and the interactions between the various excavations

GEO-STRUCTURAL ISSUES APPLIED TO THE SARDINIA SITE

Schematic works profile for triangular scheme



Schematic works profile for L scheme



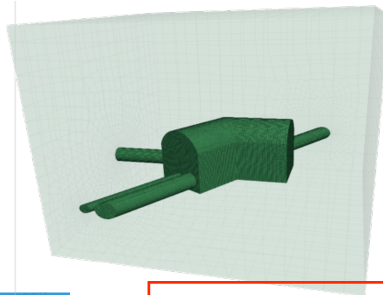
Granodiorite

Orthogneiss

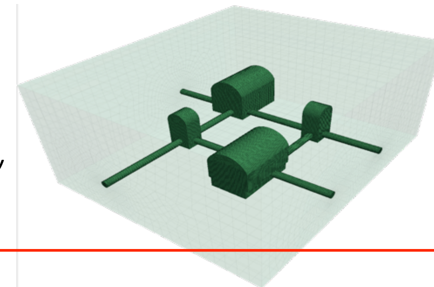
Micaschist/ Paragneiss/Quartzite

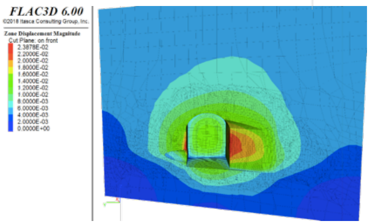
GEO-STRUCTURAL ISSUES APPLIED TO THE SARDINIA SITE

ET Triangle scheme

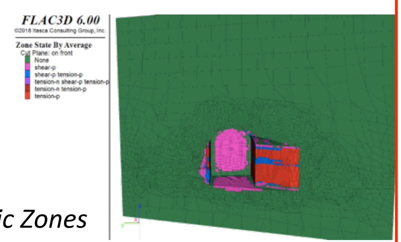


L Topology scheme

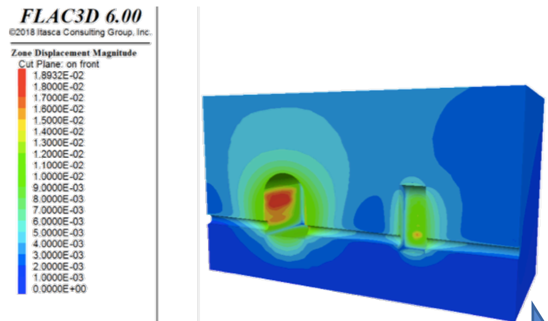


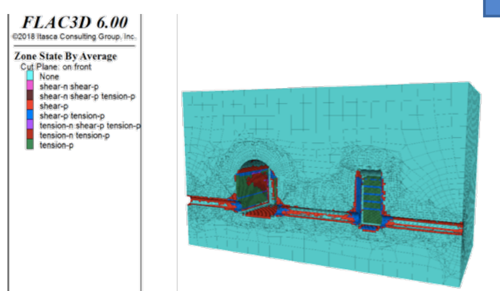


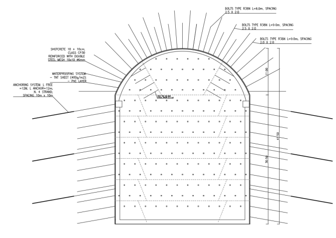
Total Displacements



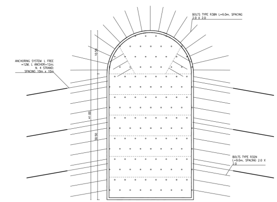
Plastic Zones







Excavation support definition



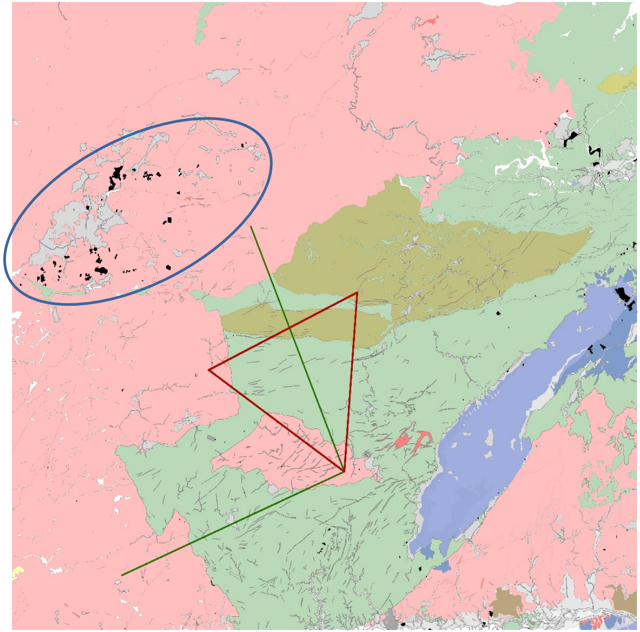
LOOK AT THE ENVIRONMENTAL IMPACT

MUCK DISPOSAL

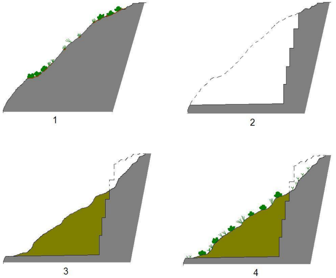
The excavated rock could be employed in the recovery of the nearby quarry sites.

The quarried surfaced in the Buddusò District (granite extraction) covers few Millions of m^2.

The muck produced by the excavations could be easily used for landscape rehabilitation



Looking for sites available to accommodate provisionally excavation material



FURTHER DEVELOPMENTS

First of all it should be noted that the final technical plant layout has not yet been defined and the construction site in still unknow

From the point of view of underground works, the activity carried out is preliminary, in order to evaluate the feasibility of the works, and the further developments are:

- a series of investigations are needed in order to define in more detail the geological and geo-mechanical condition of the areas involved in the excavations;
- evaluation of the logistics issues, due to the important tunnel lengths and dimensions of the caverns

- From the point of view of choice of layout and site, we hope with this activity to have highlighted some critical points, which should be analyzed for each of the candidate sites.

- In this way it will be possible to make a homogeneous comparison (*leaving the choice to the political aspects only*), so as to allow the execution of the works with definite times and costs, and at the end of this the scientific activities can subsequently be carried out efficiently

EXTRA ISSUES TO BE STUDIED

- External access to the site vertices
- Surface stations
- Tunnel and cavern ventilation (low acoustic noise)
  - ❖ Shaft dimensions
  - ❖ Service pits (?)
- Safety
  - ❖ Gas
  - ❖ Radioactivity
  - ❖ Cryogenic fluid
  - ❖ Fire
  - ❖ Water

MY PRESENT CHALLENGE : THE EXCAVATION OF THE ***SARGRAV*** laboratory

The Sos Enattos mine site of Lula is *included in a recovery project of mining heritage approved by Unesco (Parco Geominerario della Sardegna) and will host the underground lab for <u>low seismic noise experiments</u>*

SARGRAV

The 3 G - - Challenge

THANK YOU FOR THE ATTENTION