



Vers le Einstein Telescope

Michele Punturo

INFN Perugia

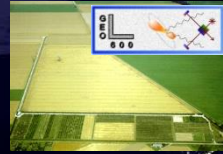


Network of GW detectors

(slide presented at GSO-G7 meeting, Florida May 2018, triggering the invitation to present the global GW network and ET as a case study for Global Research Infrastructure)



aLIGO Hanford, 4 km



GEO, Hannover, 600 m



KAGRA



~2025

It will operate as part of the LIGO Network and Collaboration

2015



aLIGO Livingston, 4 km



AdV, Cascina, 3 km

LIGO Scientific Collaboration:

- 1263 collaborators (including GEO)
- 20 countries
- 9 computing centres
- ~1.5 G\$ of total investment

Virgo Collaboration:

- 343 collaborators
- 6 countries
- 6 computing centres
- ~0.42 G€ of total investment

KAGRA Collaboration:

- 260 collaborators
- 12 countries
- 5 computing centres
- ~16.4 G¥ of construction costs

2029 outlook

- In 2029 we will have a really heterogeneous 2.xG network
 - The concepts of “obsolescence” and “limit of the infrastructure”, that are driving the quest for new research infrastructures (rather more than a new detector) apply differently to the different continents
 - The European infrastructures will be limiting further improvement of the detectors and are risking to give a minor contribute to the world wide network.

Continent	Detector	Obsolescence	Limits
America	LIGO H1		
	LIGO L1		
Europe	GEO600		
	Virgo		
Asia	KAGRA		
	LIGO India		

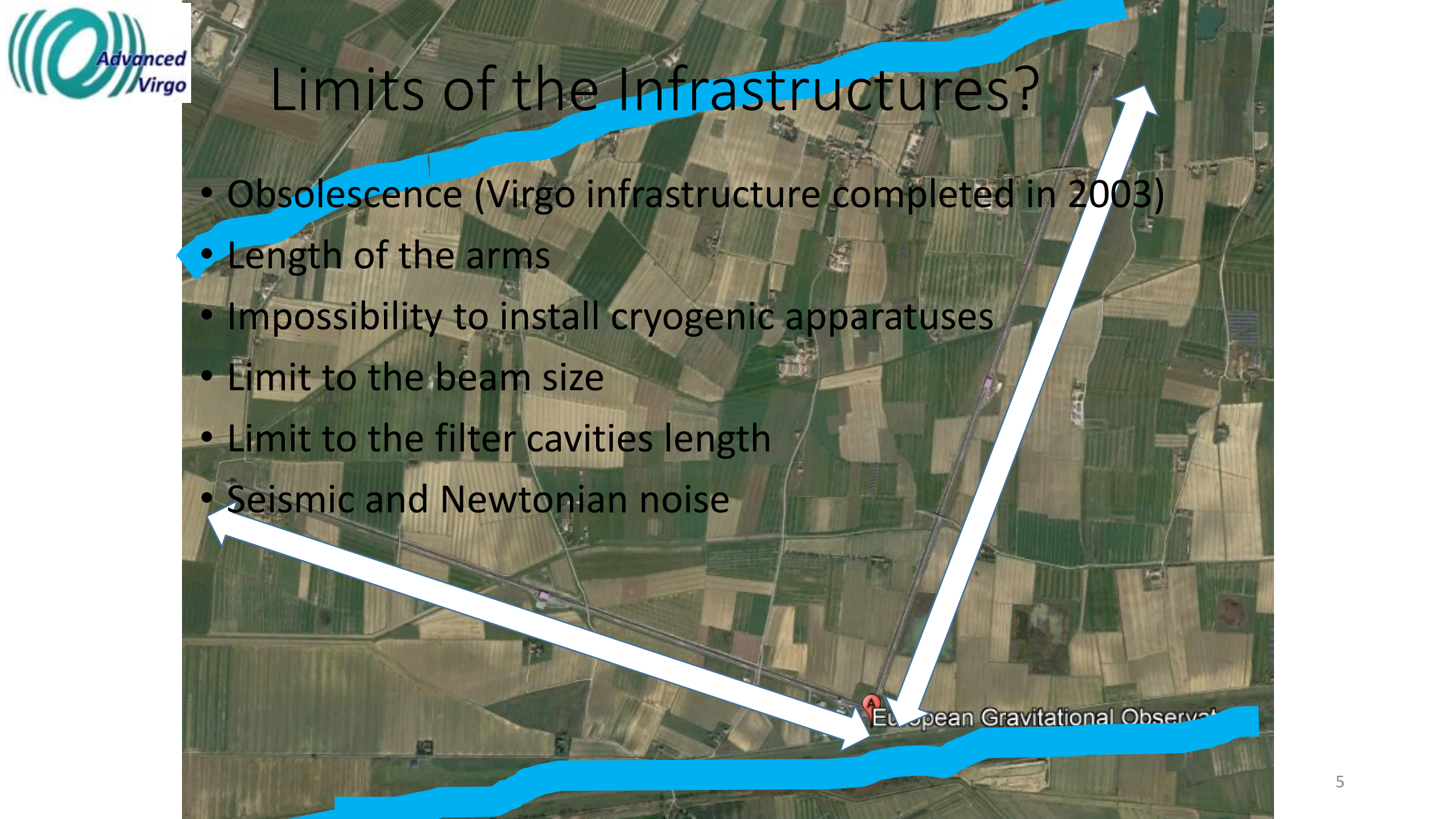


How to keep a scientific relevance in Europe?

Risk: Obsolescence and limits of the European
Infrastructures in a 20 years timeline

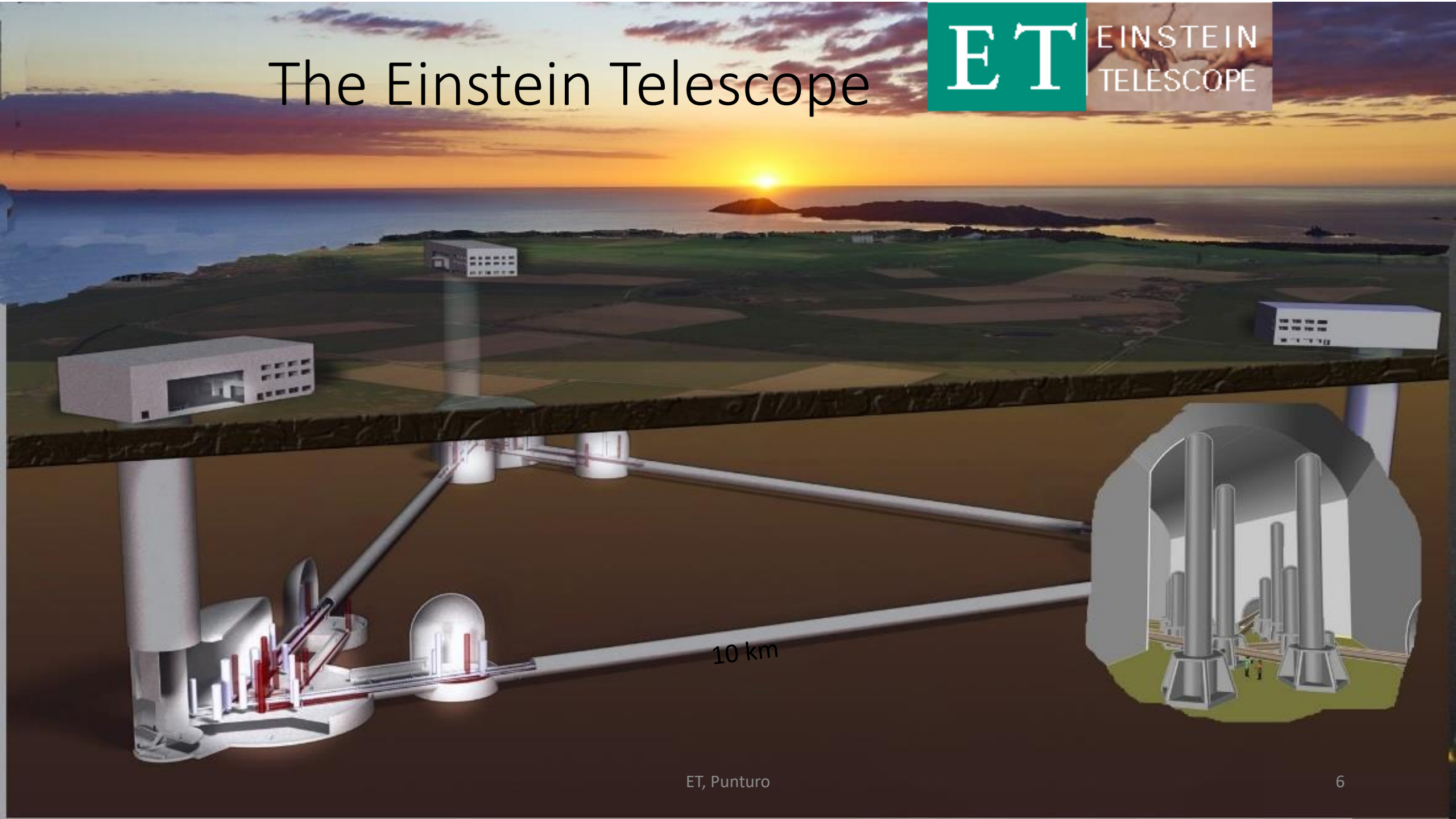
Limits of the Infrastructures?

- Obsolescence (Virgo infrastructure completed in 2003)
- Length of the arms
- Impossibility to install cryogenic apparatuses
- Limit to the beam size
- Limit to the filter cavities length
- Seismic and Newtonian noise

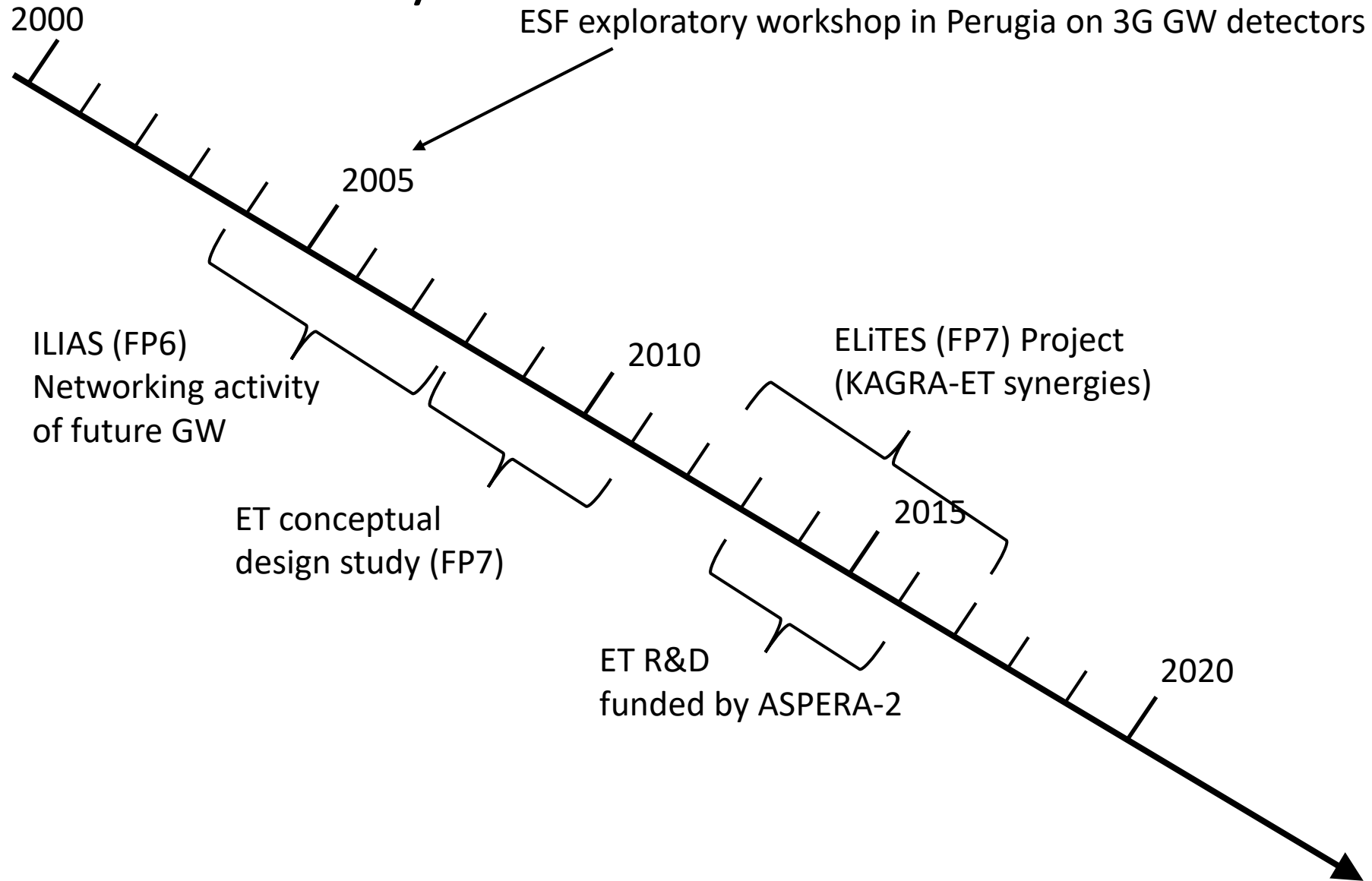


European Gravitational Observat

The Einstein Telescope



ET history

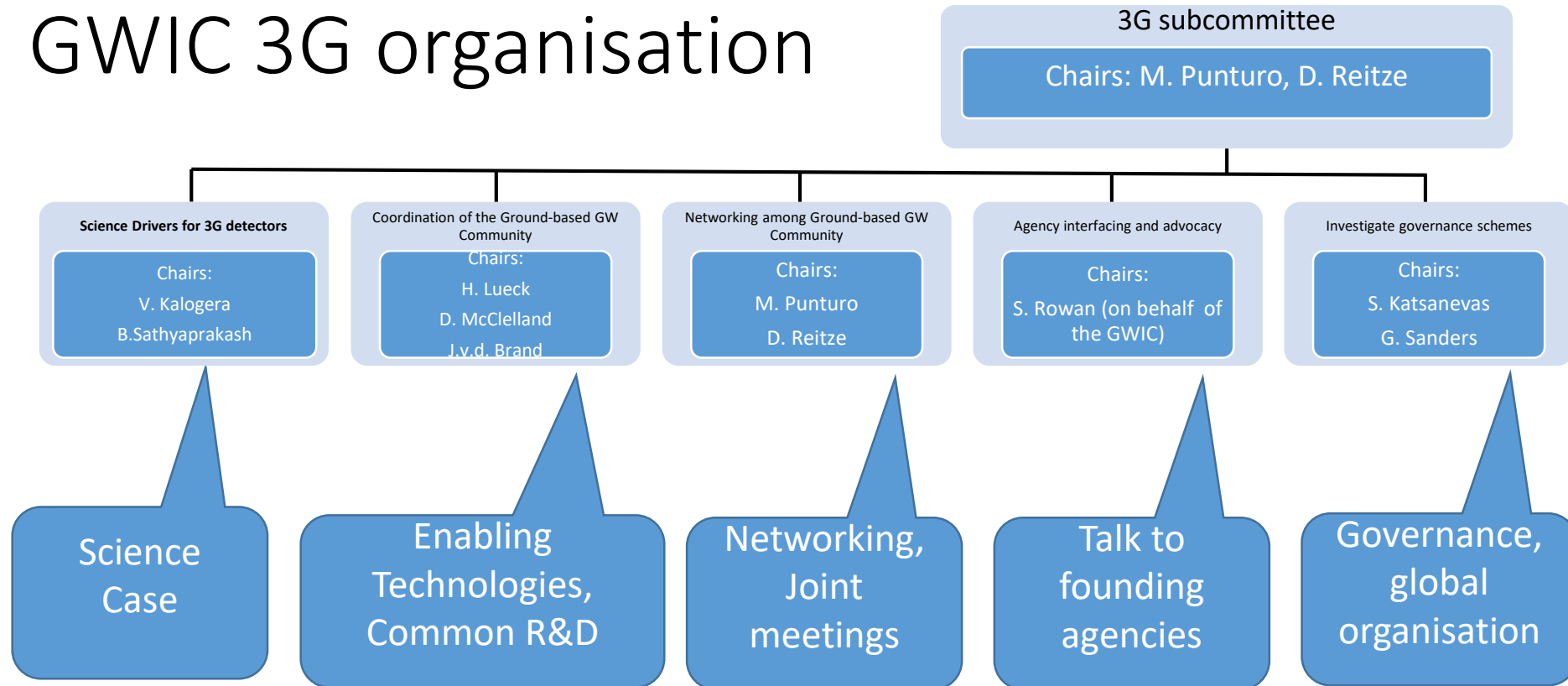


The Global Scenario

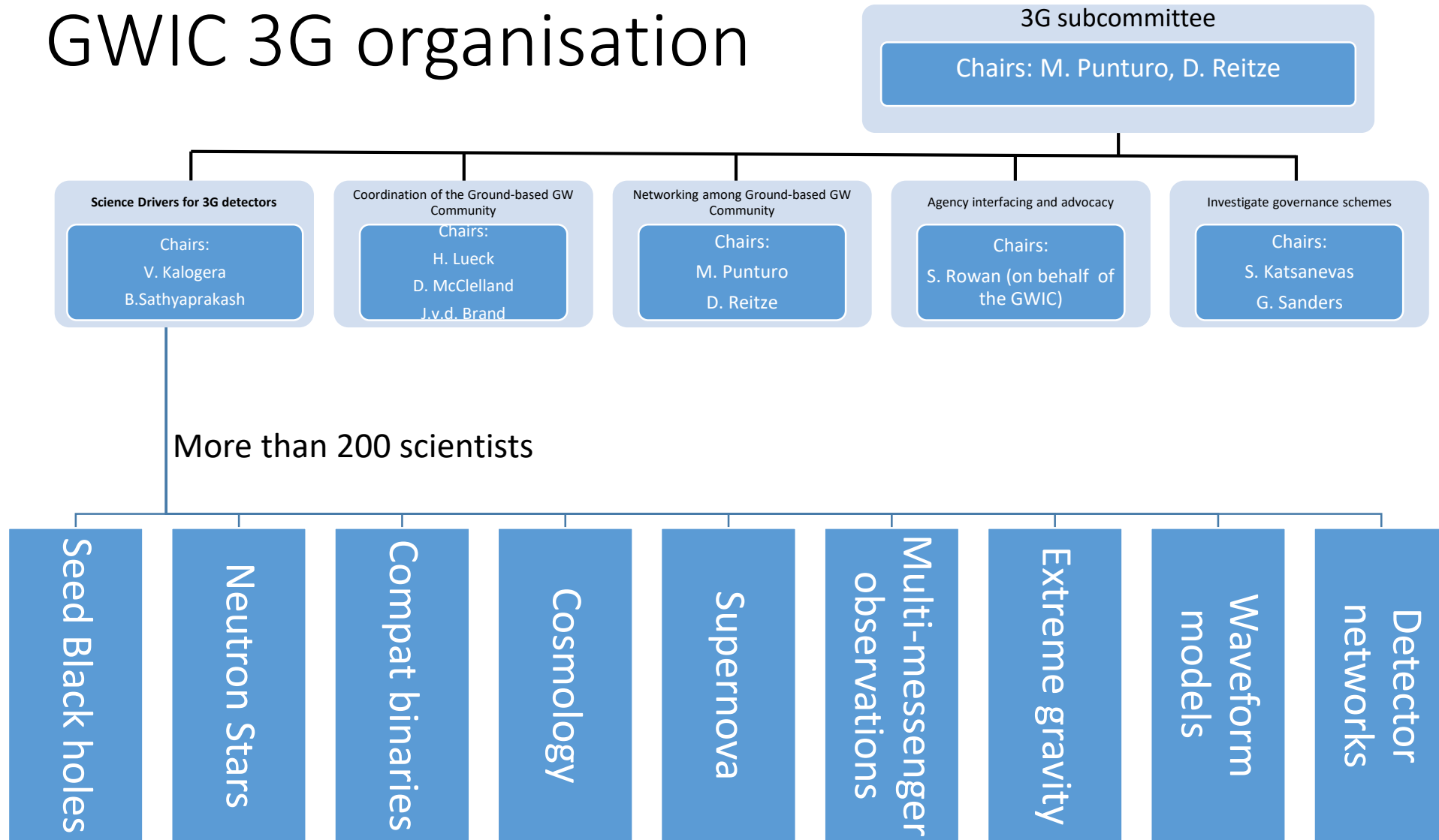


- The GW detection and the beginning of the multimessenger astronomy stimulated a world wide acceleration toward 3G GW observatories
- In Europe we are going toward the formation of a ET collaboration, a competition between ~ 3 sites, candidate to host the infrastructure, the submission of an ET project proposal to the ESFRI roadmap
- In US the idea of a giant 40km detector, named Cosmic Explorer, is now born and supported, as Conceptual Design Study, by NSF
- We set up a global coordination committee (GWIC-3G) that is attempting to harmonise the efforts and to find synergies
 - <https://gwic.ligo.org/3Gsubcomm/>

GWIC 3G organisation



GWIC 3G organisation



Some of the questions addressed by GW (AdV+, ET)

- Fundamental questions in Gravity:
 - New/further tests of GR
 - Exploration of possible alternative theories of Gravity
 - How to disprove that Nature black holes are black holes in GR (e.g. non tensorial radiation, quasi normal modes inconsistency, absence of horizon, echoes, tidal deformability, spin-induced multipoles)
- Fundamental questions in particle physics
 - Axions and ultralight particle through the evaluation of the consequences of new interactions, their impact on two bodies mechanics, in population and characteristics of BHs, NSs
- Probing the EOS of neutron stars
- Exotic objects and phenomena (cosmic strings, exotic compact objects: boson stars, strange stars/gravastars, ...)
- Cosmology and Cosmography with GWs
- Accurate Modelling of GW waveforms
- GW models in alternative theory of gravitation
- The population of compact objects discovered by GWs is the same measured by EM? Selection effects on BHs and NSs?
- What is the explosion mechanism in Supernovae?
- What is the history of SuperMassive black holes?
- GW Stochastic Background? Probing the big bang?
- Multimessenger Astronomy in 3G?

HEPP Fundamental interactions, Dark matter, dark energy

HEPP Inflation, additional interactions, dark matter

HEPP Nuclear physics, quark-gluon plasma


HEPP Cosmology

HEPP Nuclear physics

HEPP Cosmology

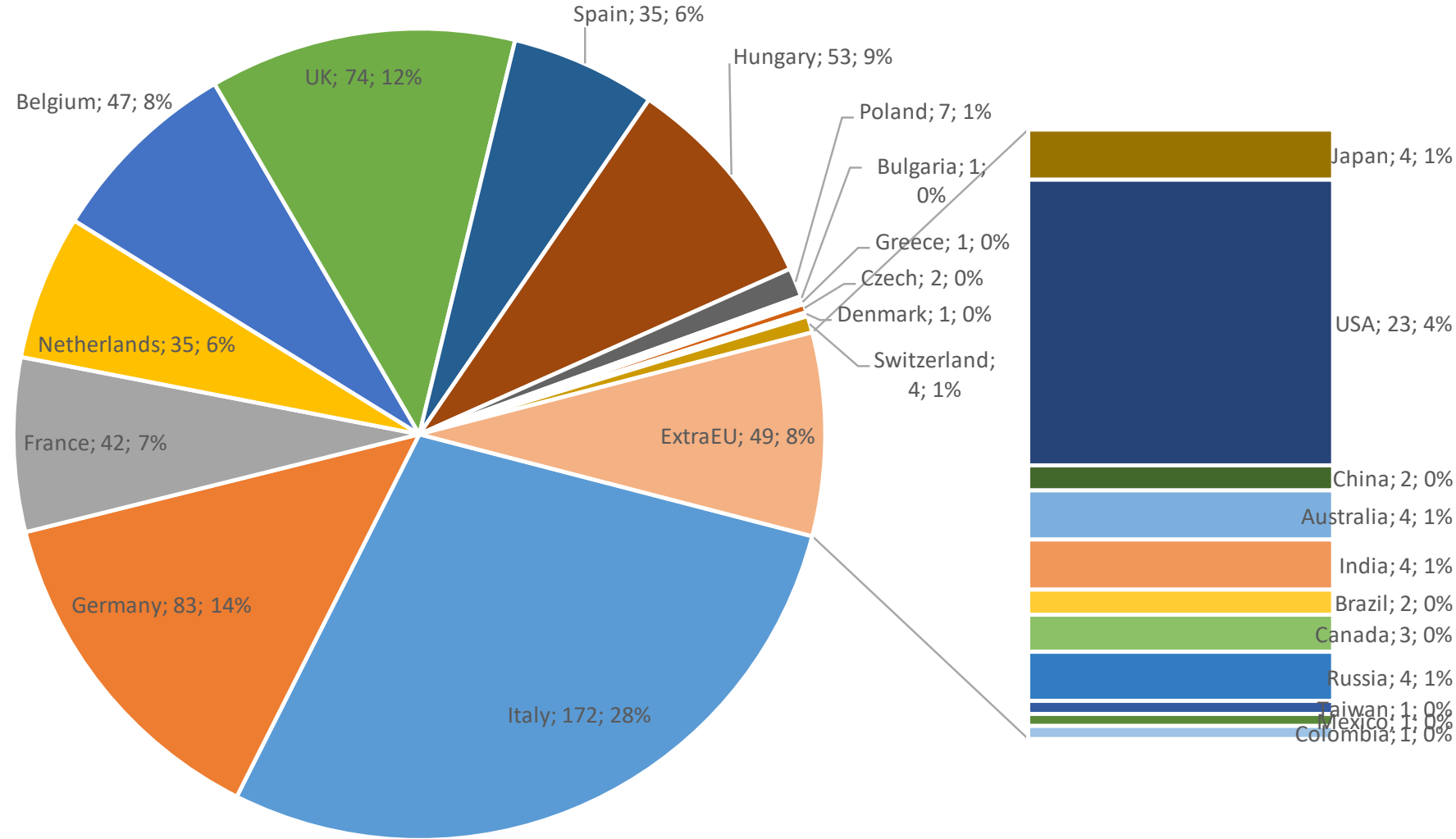
HEPP Astroparticle, GRB, Neutrino Physics

ET, next steps:

- ET has a clearly defined project roadmap, presented to APPEC:
 - 2018 Form the ET collaboration
 - 2019 ESFRI roadmap
 - In Nov 2018 ET and the GW GRI (Global Research Infrastructure) will be presented as case study to the G7 body GSO (Group of Senior Officer)
 - We need to define the site selection parameters before to submit the proposal
 - The requirement to be compliant with alternative design options (Δ vs L) could be a crucial point
 - 2021-2022 Site Selection
 - Technical/political activity
 - Requirements need to be compared with the site characteristics through an intense experimental activity in the next 3 years
 - 2023 Full Technical Design Report  Here, the design options are frozen
 - Cost definition
 - 2025 Infrastructure realization start (excavation,)
 - 2030 -2031 end of infrastructure construction, beginning of installation
 - 2032+: installation / commissioning / operation

ET collaboration: Letter of Intent

- Addressed to all the scientists and engineers interested to the 3G GW science and technology
- The signatories (606 persons, the 24th of August) probably will become the future members of the ET collaboration



<http://www.et-gw.eu/index.php/letter-of-intent>

ET site(s)

- In the Design Study we investigated several EU sites
 - The same instruments and methods have been used to roughly compare the sites
 - Three are survived per quality and/or interest



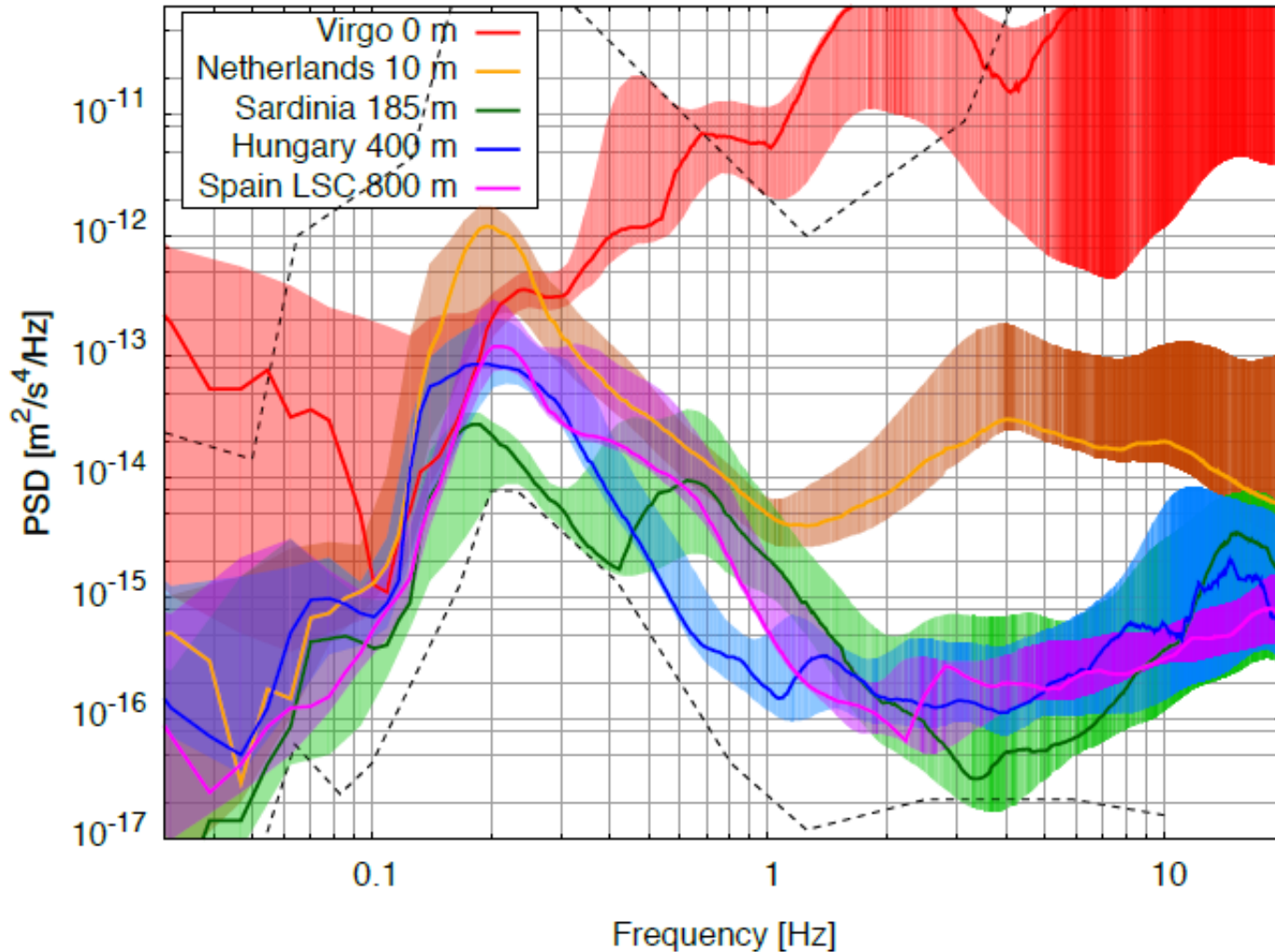

Data collected from these sites


3rd party data obtained and analyzed from these sites



3 site candidates

Horizontal spectral motion at various sites

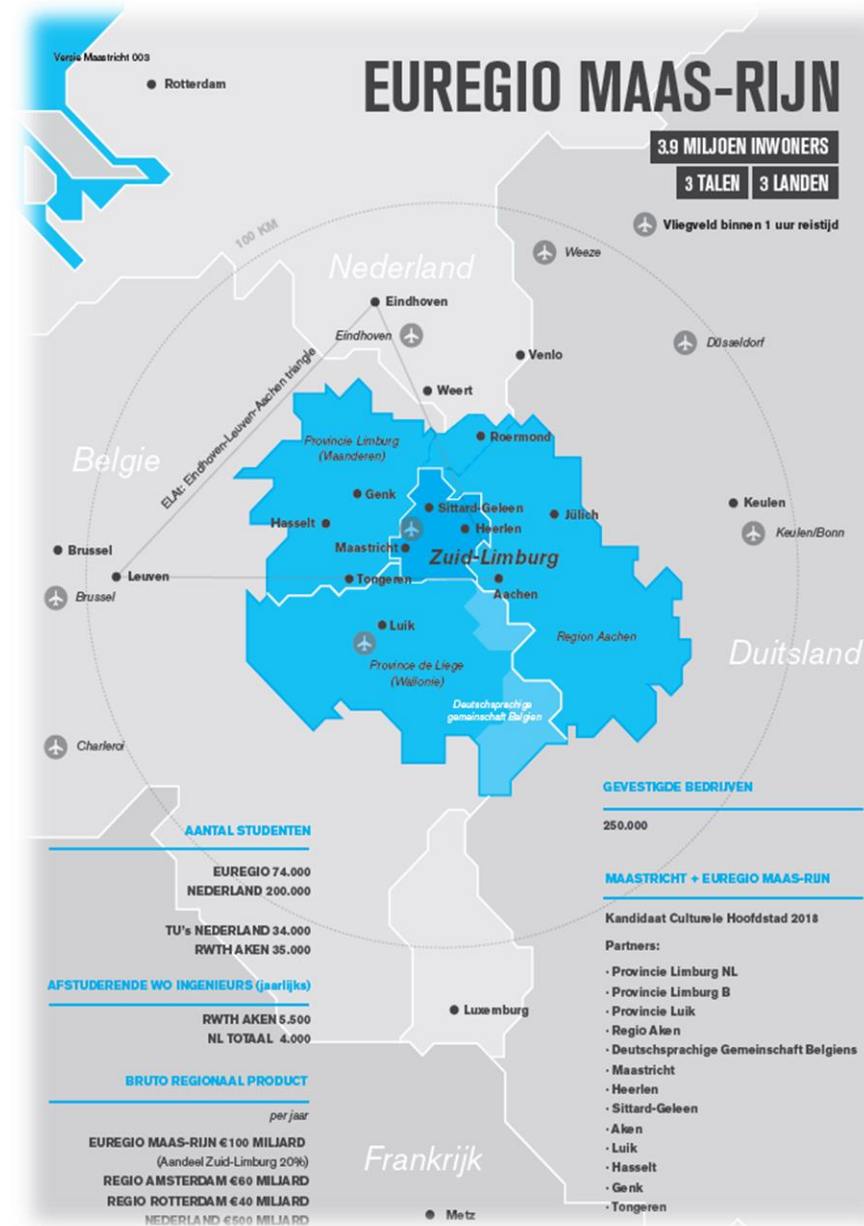


- Belgium-Germany-Netherlands
- Hungary (Matra Mountain)
- Italy (Sardinia-Sos Enattos)

EUREGIO MEUSE-RHINE



- A proposal to realize ET in the Limburg area
- A strong asset: a detector hosted by 3 countries (B-D-NL)
- Initial funding assured by NL government
- Site qualification still in an early phase

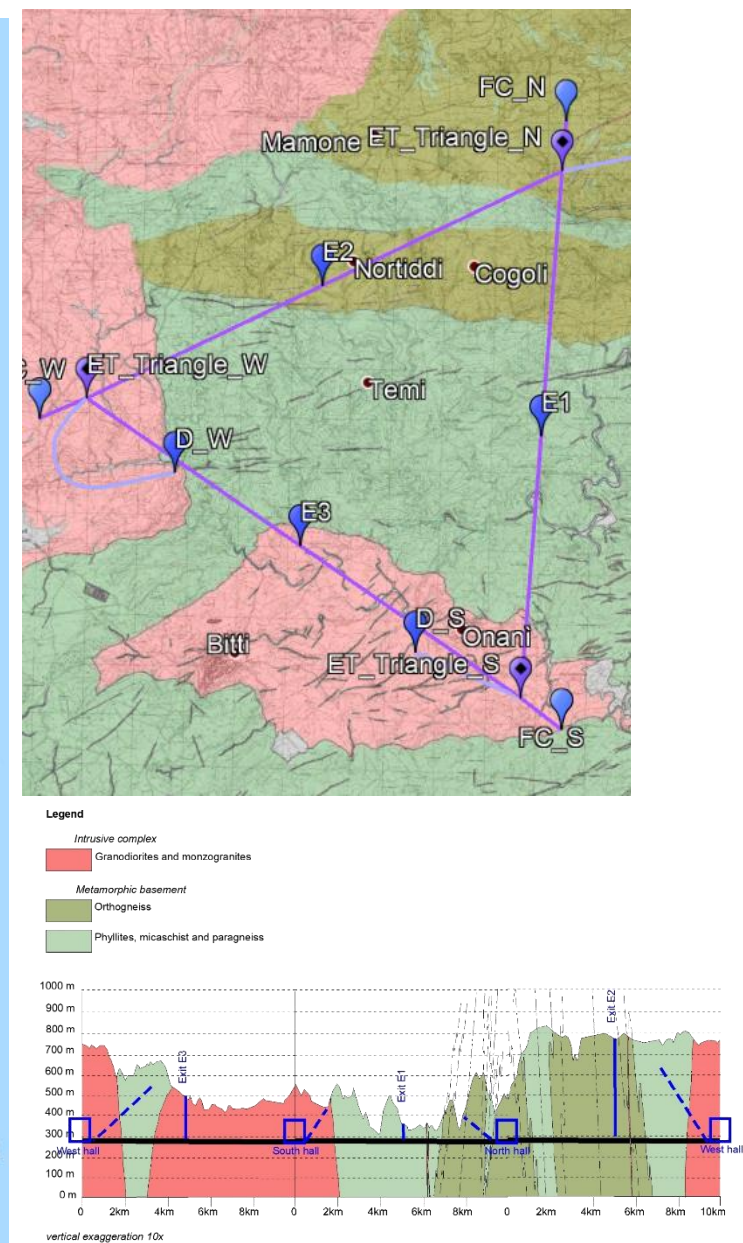


Sardinia, Italy

- Site identified:
 - Sos Enattos, Sardinia
- Site qualification: well advanced
 - Excellent seismic and geological properties
 - Small underground lab under construction funded (1M€) by local region and INFN
- Few M€ support assured by Italian government for the early phase
- International involvement to be structured



Dichiarazione di Intenti
SARDEGNA - CORSICA



Les Exécutifs corse et sarde échangent sur les thèmes majeurs de la coopération entre les deux îles

Lundi 14 Mars 2016



Immediate needs

- Assure the involvement of the institutes and countries leading GW research in Europe
- Support the ET proposal to the ESFRI roadmap update
- Support R&D activities to define the enabling technologies
 - Large overlap with Adv+ technologies:
 - It guarantees a substantial de-risking of the ET project
 - It allows a continuity between the Adv+ phase and the ET phase
- Support the Technical Design Report production:
 - Definitive design of the infrastructure
 - Definitive cost evaluation

The Gravitational Wave Spectrum

