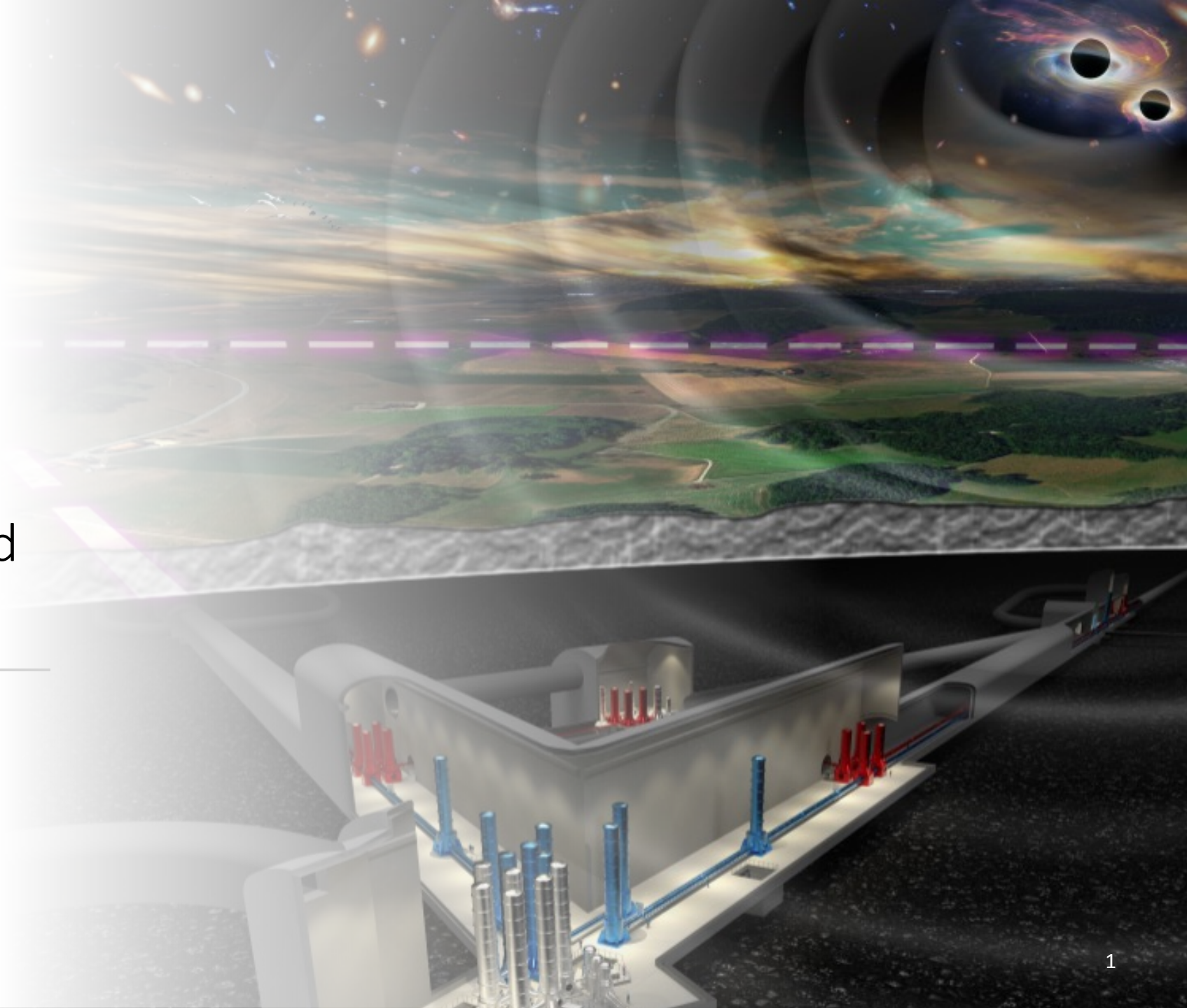




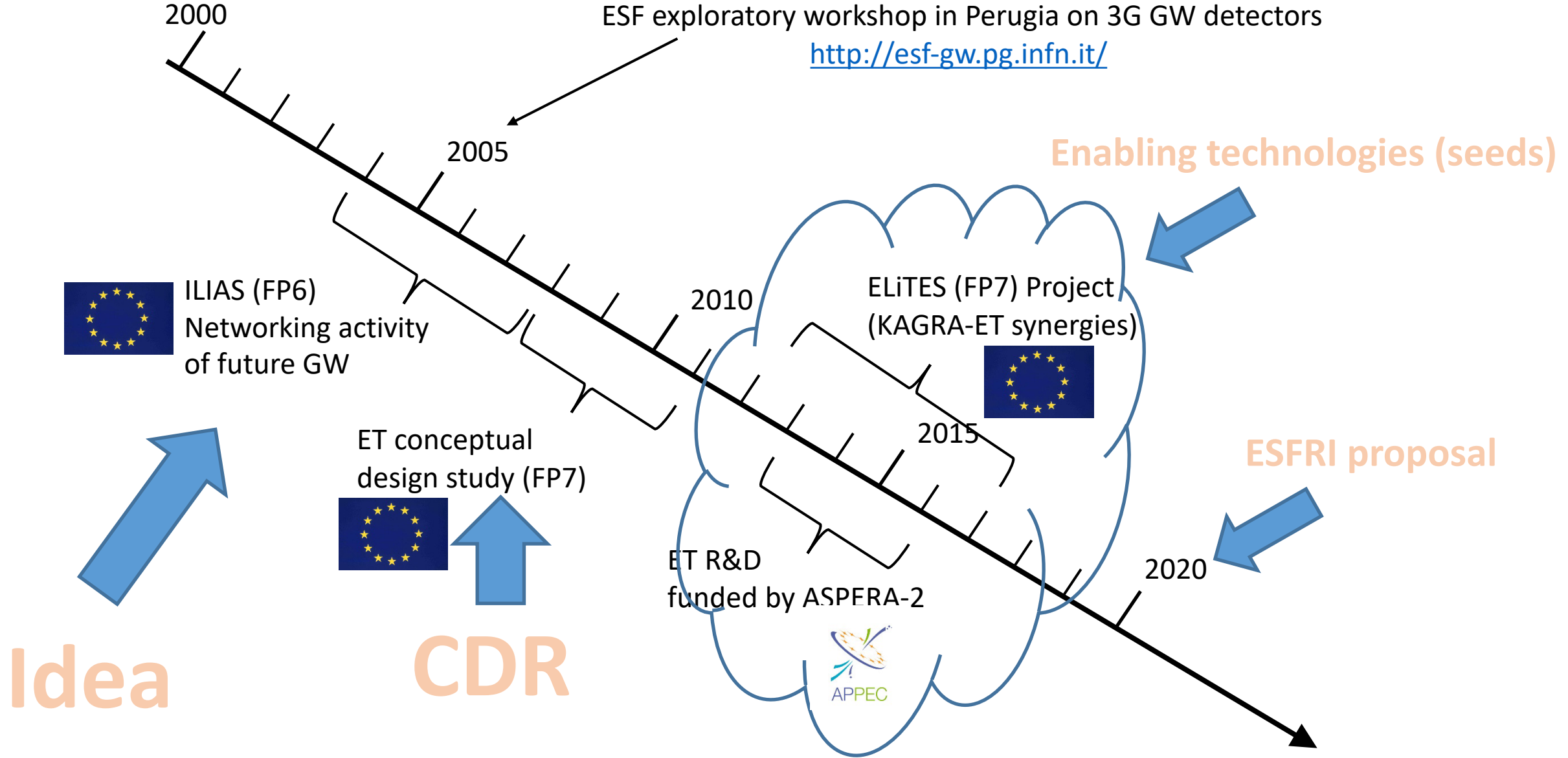
# Einstein Telescope

## Status of the project and of the collaboration

Plagiarised from:  
ET-0127A-22 by M. Punturo

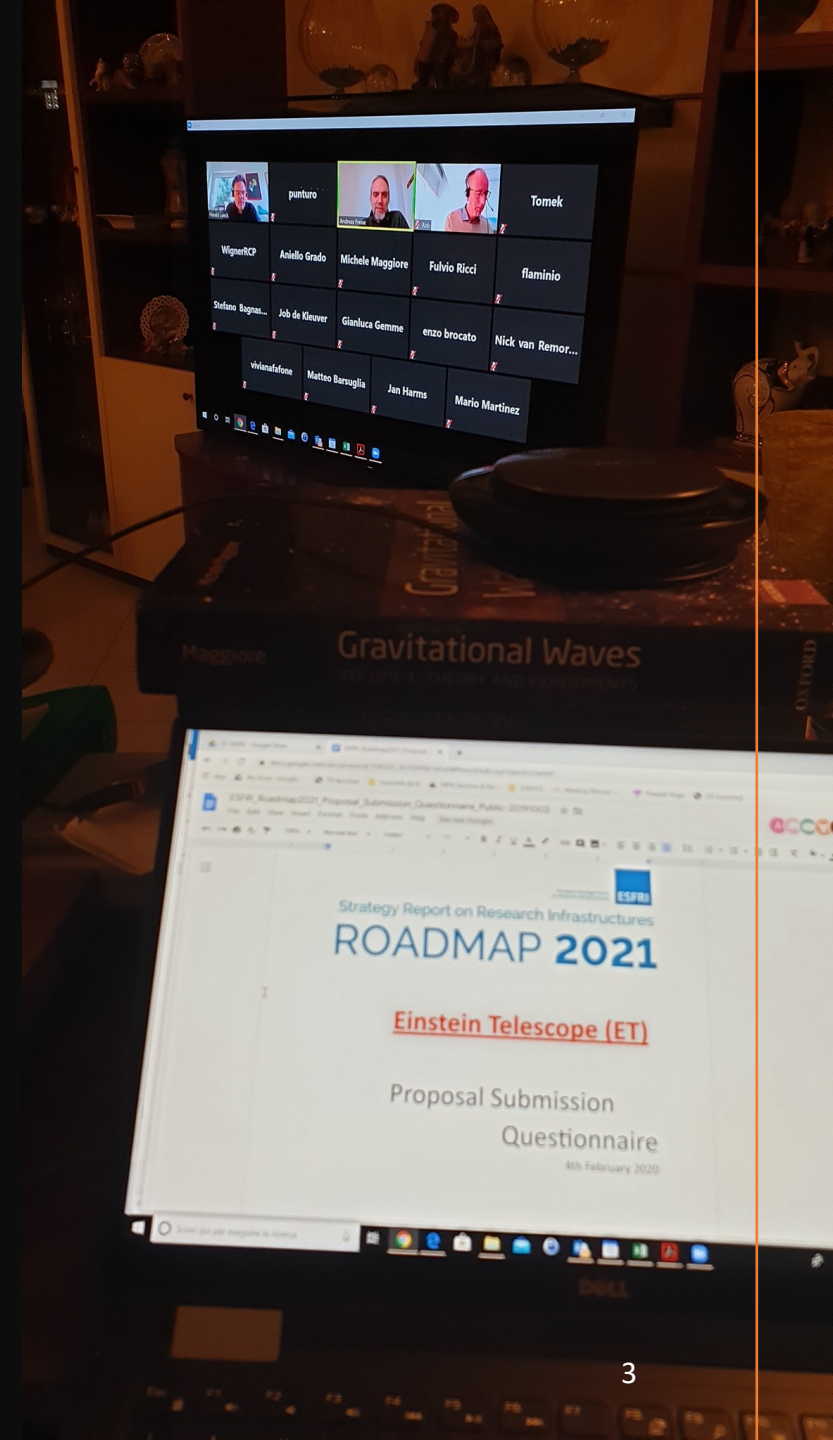


# ET long path



# ESFRI Proposal

- From the ESFRI web site:
  - ESFRI, the European Strategy Forum on Research Infrastructures, is a strategic instrument to develop the scientific integration of Europe and to strengthen its international outreach.
  - It is an emanation of the EU Council, composed by delegates representing the Ministers responsible for Research in each Member and Associate Country
  - The mission of ESFRI is to support a coherent and strategy-led approach to policy-making on research infrastructures in Europe, and to facilitate multilateral initiatives leading to the better use and development of research infrastructures, at EU and international level
- The ESFRI ET proposal writing team had a unique challenge preparing the ET proposal during the pandemic period in Europe:
  - No-stop videoconferences
  - Remote contacts with governments through the national agencies







Proposal submitted by:

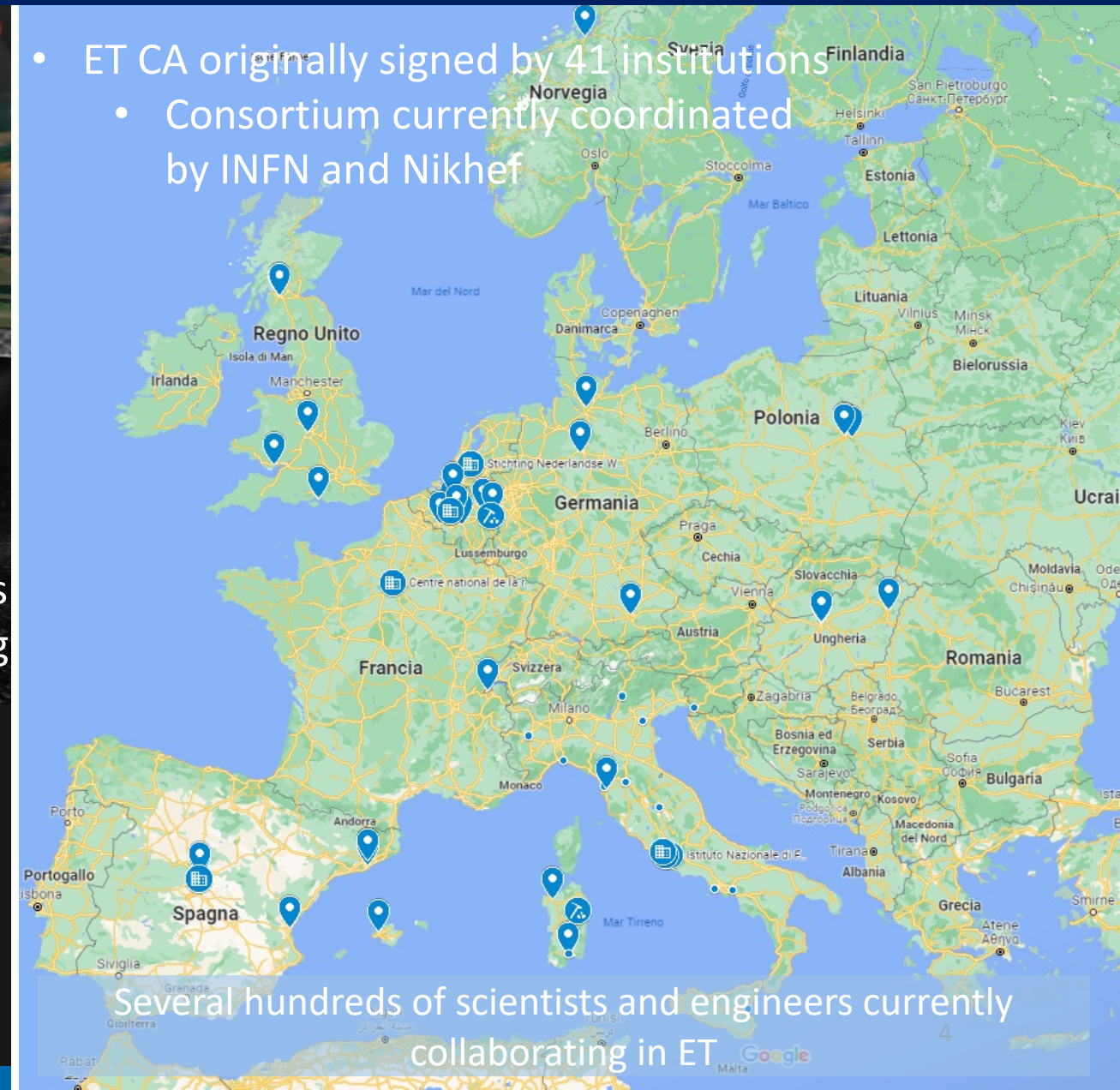
- Italy
- Belgium
- Netherlands
- Poland
- Spain

The project and the collaboration activities now also include agencies and institutions belonging to:

- Austria
- France
- Germany
- Hungary
- Switzerland
- UK

Large preparatory funds available in some country (IT, NL, ...), an EU INFRA-DEV proposal just approved with a grant of 3.45M€ and an EU INFRA-TECH proposal has been just submitted

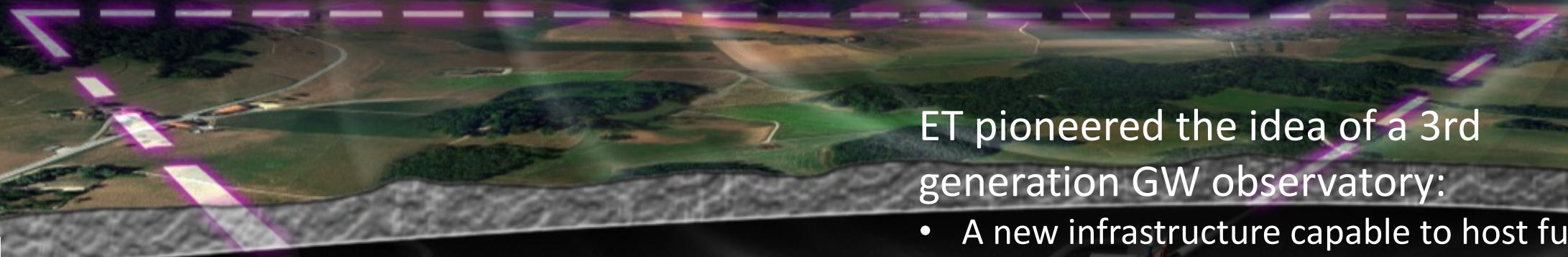
- ET CA originally signed by 41 institutions
- Consortium currently coordinated by INFN and Nikhef





# Einstein Telescope (ET)

←  $\geq 10\text{km}$  →



Corner halls  
depth about  
200m



ET pioneered the idea of a 3rd generation GW observatory:

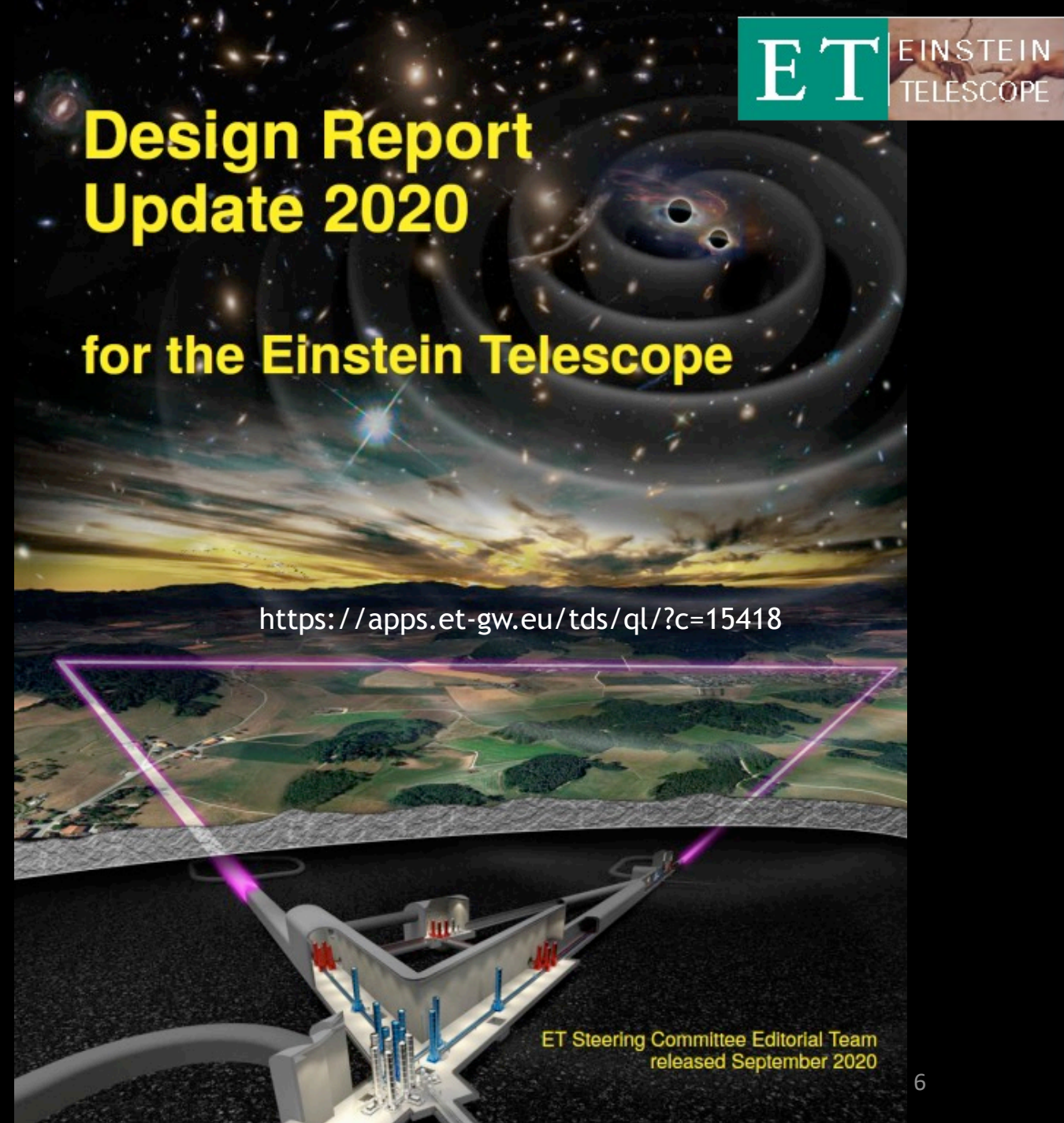
- A new infrastructure capable to host future upgrades for decades without limiting the observation capabilities
- A sensitivity at least 10 times better than the (nominal) advanced detectors on a large fraction of the (detection) frequency band
- **A dramatic improvement in sensitivity in the low frequency (few Hz – 10Hz) range**
- **High reliability** and improved observation capability
- **Polarisation disentanglement**



# Design of ET



Updated CDR driven by the  
ESFRI needs in terms of  
releasing time and contents



# ET Science Case in a nutshell



## ASTROPHYSICS

- **Black hole properties**
  - origin (stellar vs. primordial)
  - evolution, demography
- **Neutron star properties**
  - interior structure (QCD at ultra-high densities, exotic states of matter)
  - demography
- **Multi-band and -messenger astronomy**
  - joint GW/EM observations (GRB, kilonova,...)
  - multiband GW detection (LISA)
  - neutrinos
- **Detection of new astrophysical sources**
  - core collapse supernovae
  - isolated neutron stars
  - stochastic background of astrophysical origin

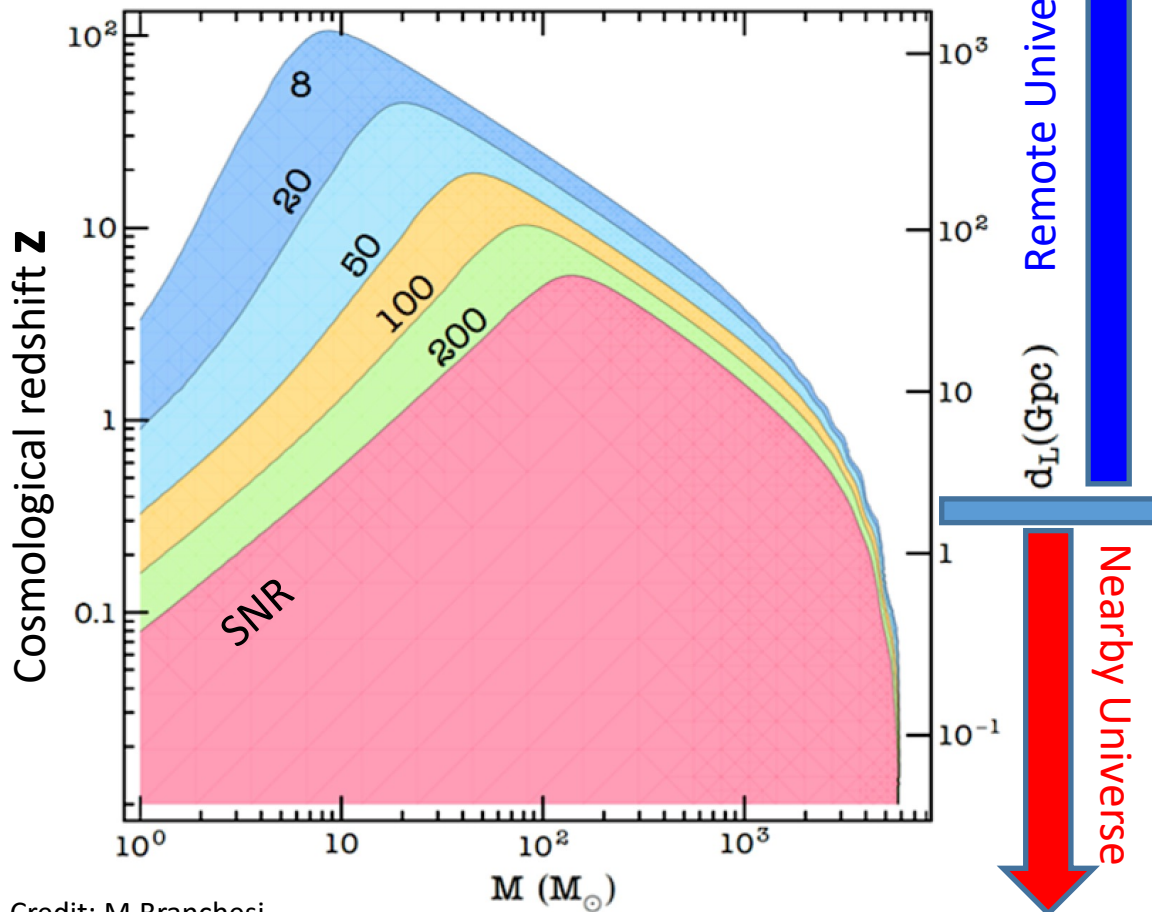
## FUNDAMENTAL PHYSICS AND COSMOLOGY

- **The nature of compact objects**
  - near-horizon physics
  - tests of no-hair theorem
  - exotic compact objects
- **Tests of General Relativity**
  - post-Newtonian expansion
  - strong field regime
- **Dark matter**
  - primordial BHs
  - axion clouds, dark matter accreting on compact objects
- **Dark energy and modifications of gravity on cosmological scales**
  - dark energy equation of state
  - modified GW propagation

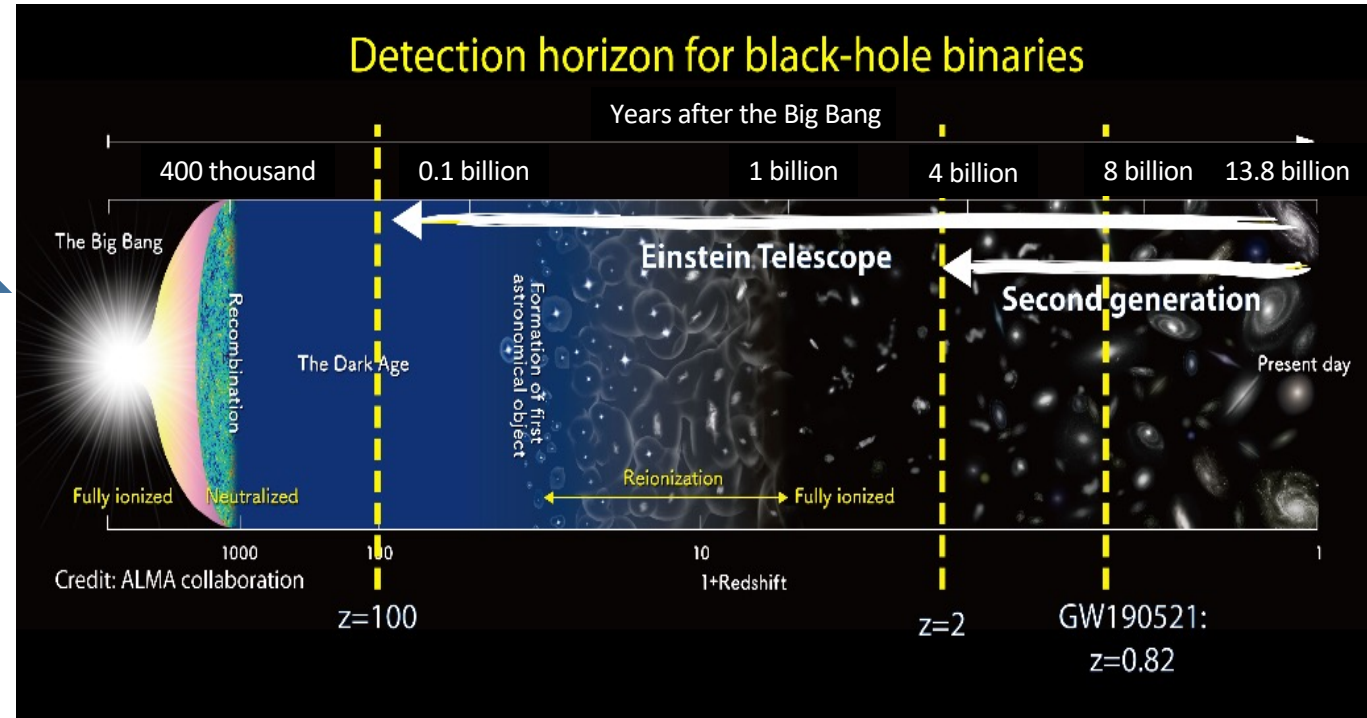


# ET Science in a nutshell: double nature

- ET will be a new discovery machine:
  - ET will explore almost the entire Universe listening the gravitational waves emitted by black hole, back to the dark ages after the Big Bang



Credit: M.Branches



- ET will be a precision measurement observatory:
  - ET will detect, with high SNR, hundreds of thousands coalescences of binary systems of Neutron Stars per year, revealing the most intimate structure of the nuclear matter in their nuclei

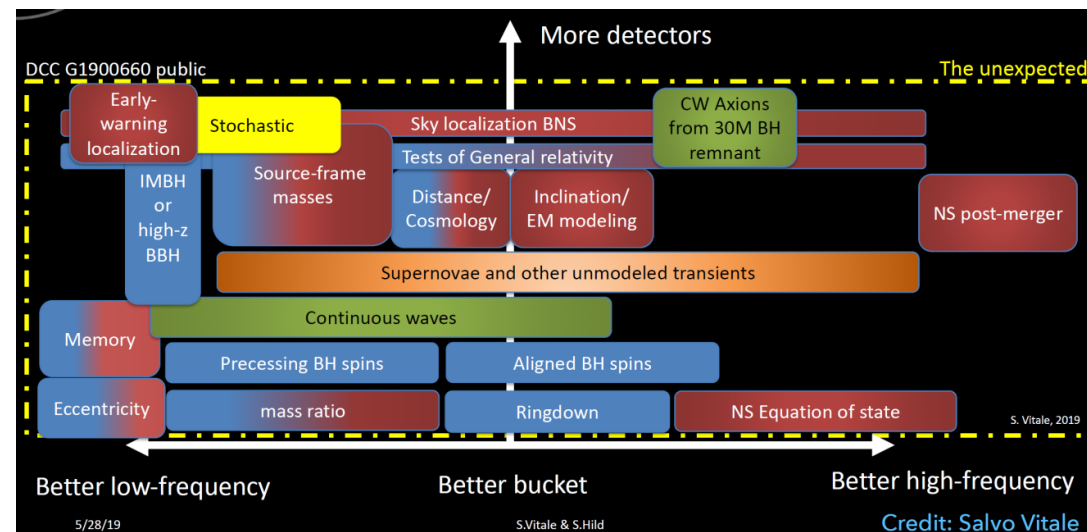


# ET Science in a nutshell: double nature

- ET science must be excellent both operating as unique observatory of 3<sup>rd</sup> generation in the world and (better) as a node in a global 3G network
  - Develop as much as possible the 3G networking with Cosmic Explorer
    - Joint developments in Science (OSB) and Technology (Vacuum, ...)
    - Strong and positive relationships at the management level (SC, CB, ...)
    - Keep our competitiveness in a global scenario
  - Protect as much as possible the huge EU countries investment from external factors:
    - EU decisional process is slow, complex and fragile
    - ET design must keep valid the original idea of standalone observatory

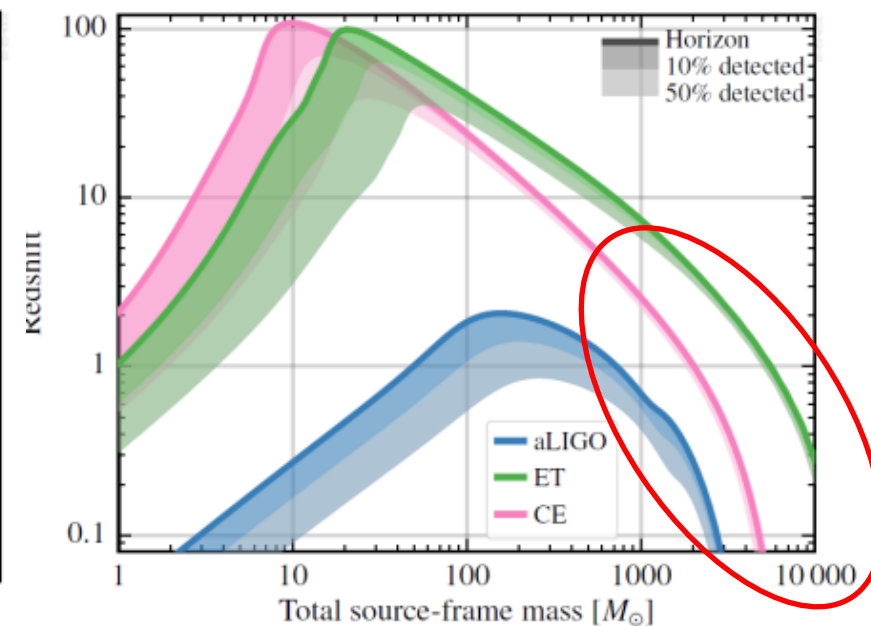
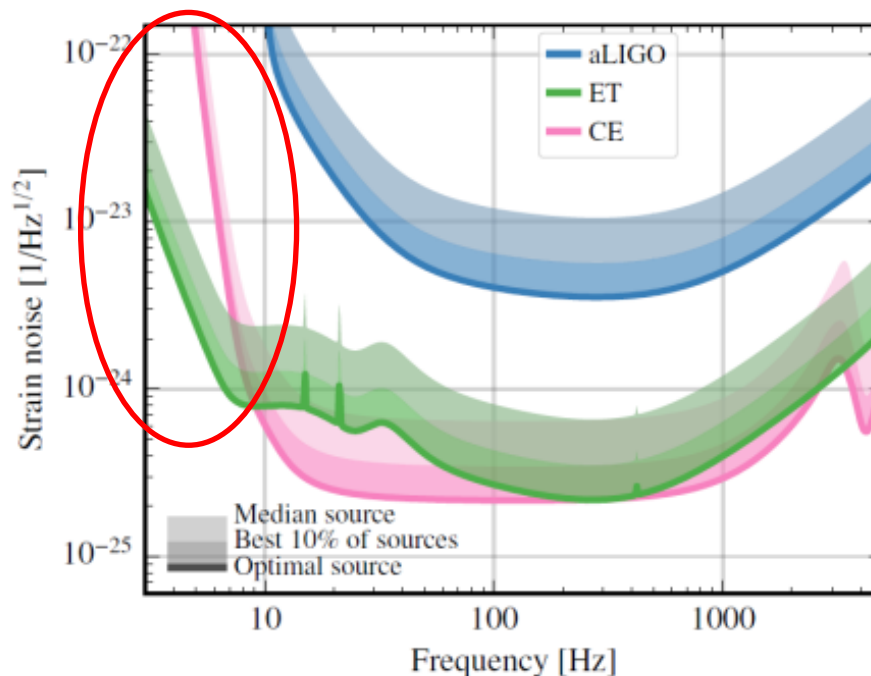
# ET Science in a nutshell: double nature

- GW science targets are almost equally distributed in the frequency range accessible by terrestrial GW detectors (but technical difficulties aren't)
- We want to have access both to low and high frequency targets



- ET will be a wide band observatory with a special focus on (intermediate) massive compact object:

- Low frequency!





# Where?

- A crucial point in this phase of ET is where to realize it?
- The site selection is a process that has to evaluate several and heterogeneous aspects:
  - Physical aspects
    - Impact of the seismic, geophysics, environmental and anthropogenic properties of the site on the noise performance of the detectors and then on the science targets
  - Engineering, geological and geotechnical aspects
    - Quality of the rocks, hydrogeology, fractures impacting on the constructive feasibility, cost, durability and safety of the ET infrastructure
  - Legal aspects
    - National legislation has a strong impact on the timing and on the feasibility of such a complex infrastructure
  - Financial aspects
    - ET is a 2G€ enterprise. The civil infrastructure construction will be mainly on the hosting country/countries. Financial support and plans of the candidate sites are crucial
- National host teams are operative since years in the officially candidate sites qualifying them, recently coordinated by a collaboration/project body
  - The Site Preparation/Characterization Board

14:30

→ 16:30

ET Symposium: Specific Boards 2 and CE

14:30

Site Preparation Board (SPB)

Speaker: Tomasz Bulik

# ET site(s)

- Currently there are two sites, in Europe, candidate to host ET:
  - The Sardinia site, close to the Sos Enattos mine
  - The EU Regio Rhine-Meuse site, close to the NL-B-D border
- A third option in Saxony (Germany) is under discussion





# ET sites under characterisation

## Euregio Meuse-Rhine

- A 250-m deep borehole has been excavated and equipped
  - Seismic data under acquisition and analysis
- A set of other boreholes under excavation
- Extensive active and passive site characterisation with sensor arrays in 2021
- Good seismic noise attenuation given by the particular geological structure
- Characterisation funded through Interreg grants
- Large proposal for qualifying the site essentially approved to the Dutch government

## Sardinia

- Long standing characterisation of the mine in one of the corners continuing
  - Seismic, magnetic and acoustic noise characterisation ongoing at different depth in the mine
- Underground laboratory under preparation (SarGrav)
- Two ~290m boreholes have been excavated, equipped and data taking is ongoing
- A set of other boreholes expected in 2022
- Intense & international surface investigations programme ongoing
- Characterisation funded on regional and national funds
- Large proposal for technology development and engineering design submitted to the Italian government

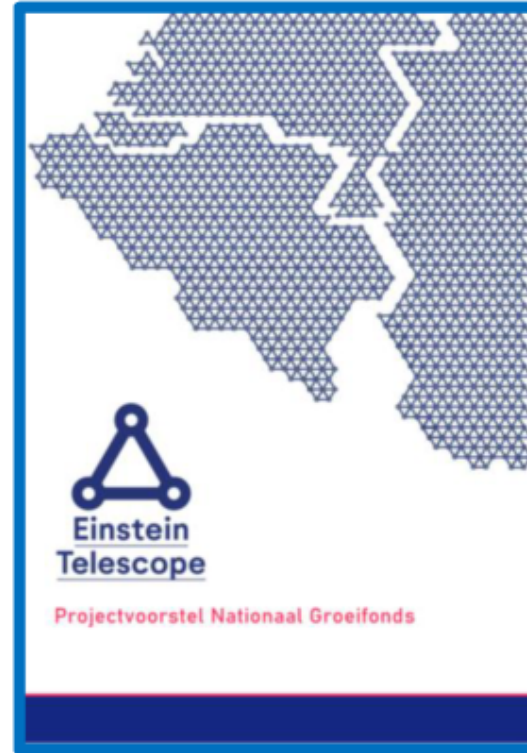


# Einstein Telescope in Euregio Meuse-Rhine (EMR)



**Connected institutions in:  
Belgium,  
Germany &  
the Netherlands**

## Nationaal Groeifonds (the Netherlands)



*Emphasis on  
potential  
socio-economic  
Impact*

*Submitted by  
OCW Ministry  
(EZK Ministry support)*

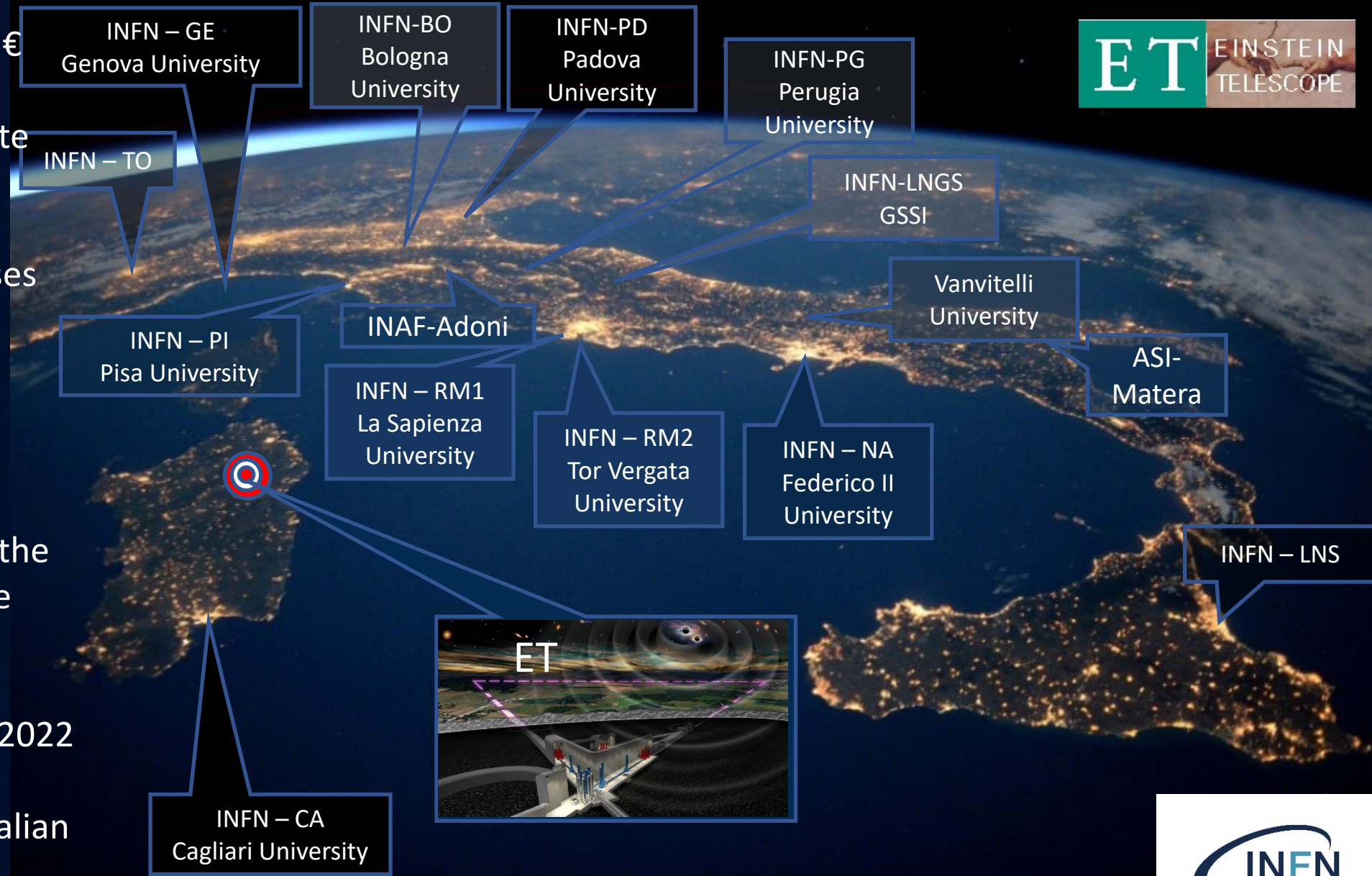
*Supported by ~70  
Dutch  
Industries/institutions*

In October 2021 the Netherlands submitted large funding proposal within context of the 'Nationaal Groeifonds'. Decision **Approved** April 2022.

Includes 42 M€ for geology, R&D & organization as well as possible Dutch share towards ET realization



# ETIC – Einstein Telescope Infrastructure Consortium



Next Generation EU  
Investment proposed 100M€  
focused on ET enabling  
technology and Sardinian site  
candidature support

- 8% Human Resources
- 30% Scientific apparatuses
- 12% Distributed Infrastructures
- 28% ET design
- 12% Training

Additional 5M€ funding on the  
same framework for the site  
characterization

Feedback expected in June 2022

Discussion ongoing on an Italian  
share toward ET realization



# ET Computing

- ET will be operative in the second half of 2030s, do we need to think now about computing?
- Obviously yes
  - Immediate needs
    - Support to the collaboration life and activities
    - “Limited” computing resources
  - Future needs
    - Computing model
      - Requirements
      - Specifications
      - Custom and “standard” solutions

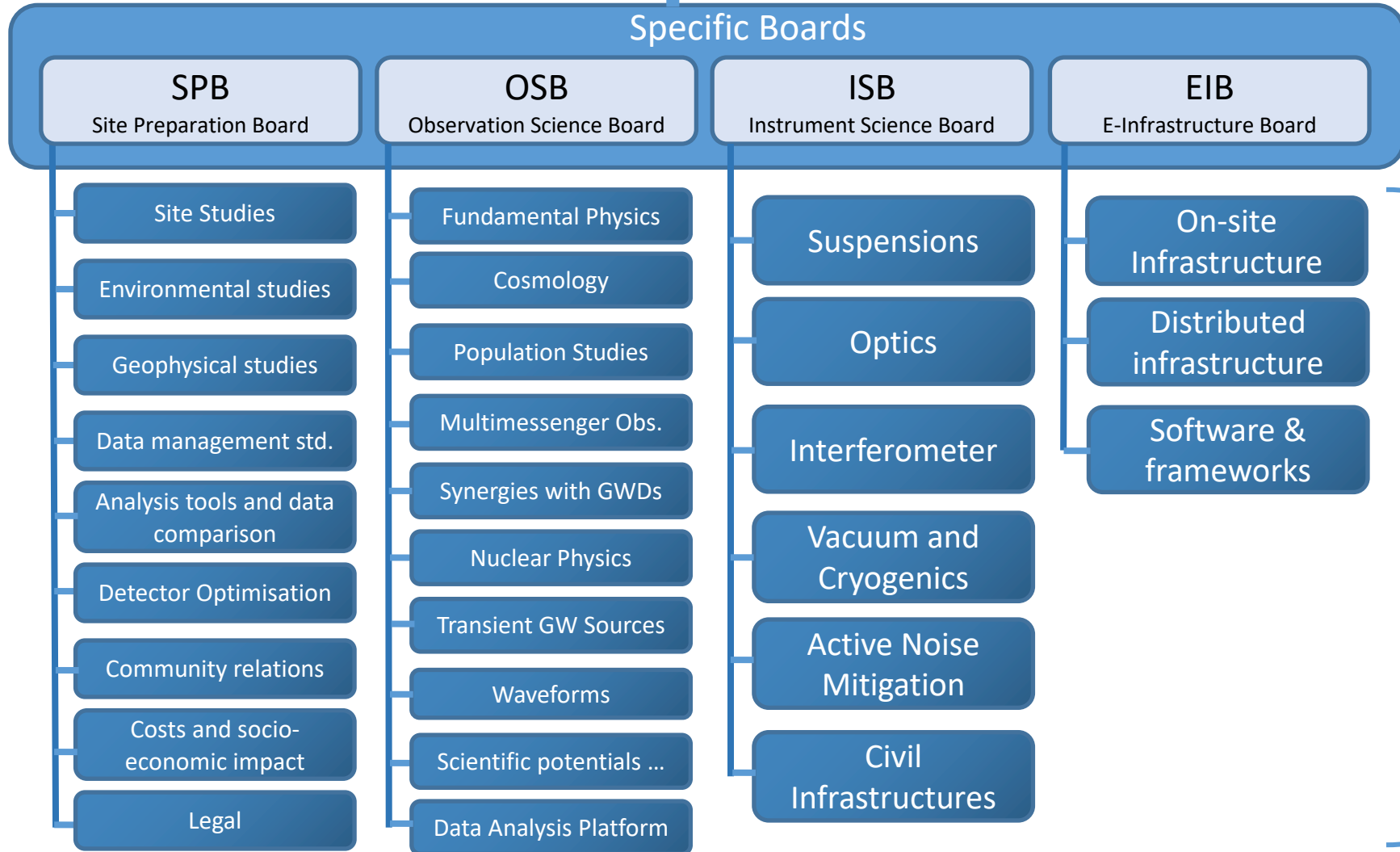


# ET proto-collaboration (past) organisation



ET Steering Committee

<http://www.et-gw.eu/index.php/et-steering-committee>



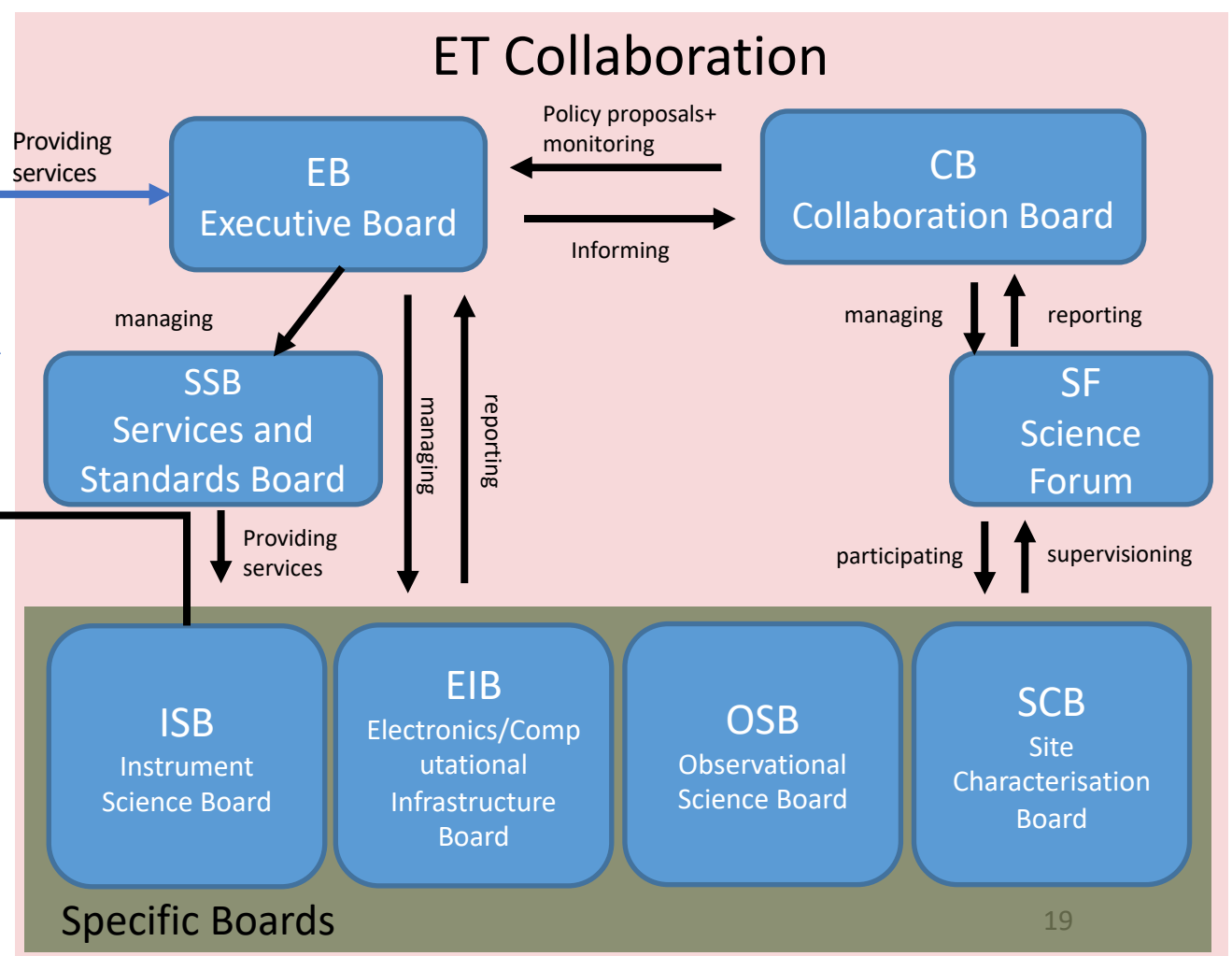
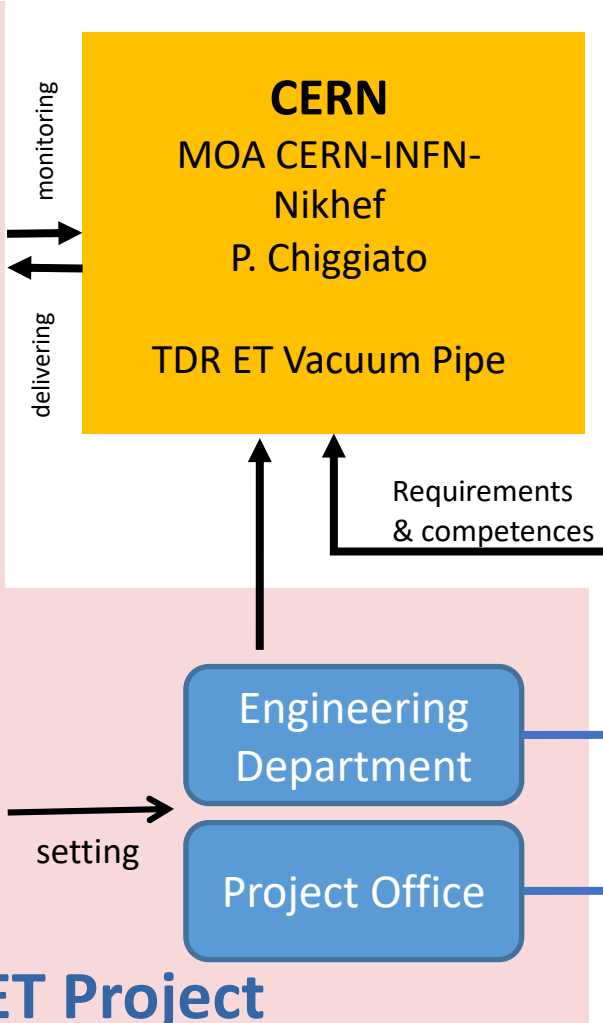
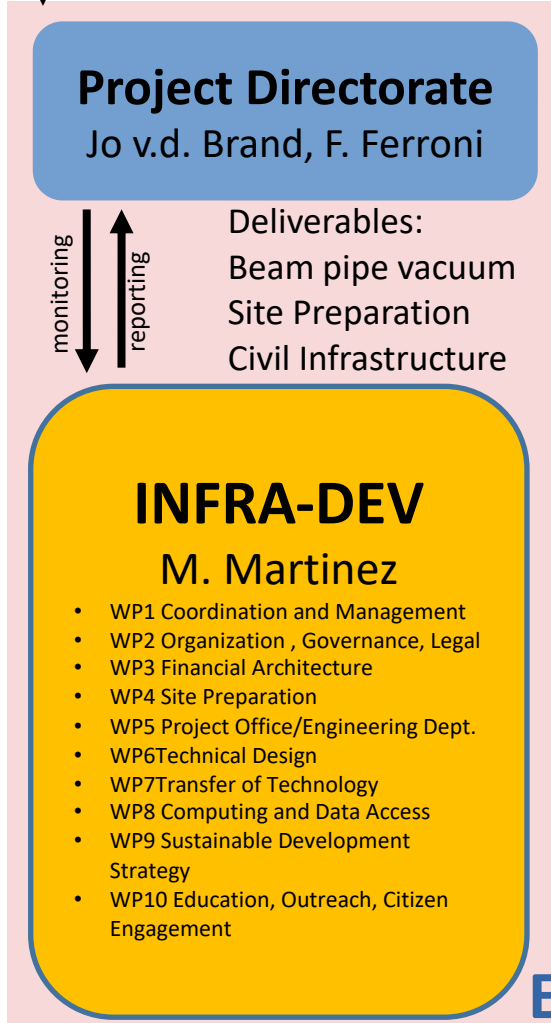
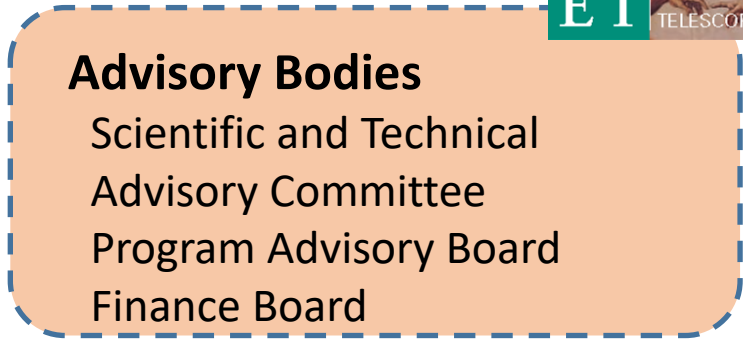
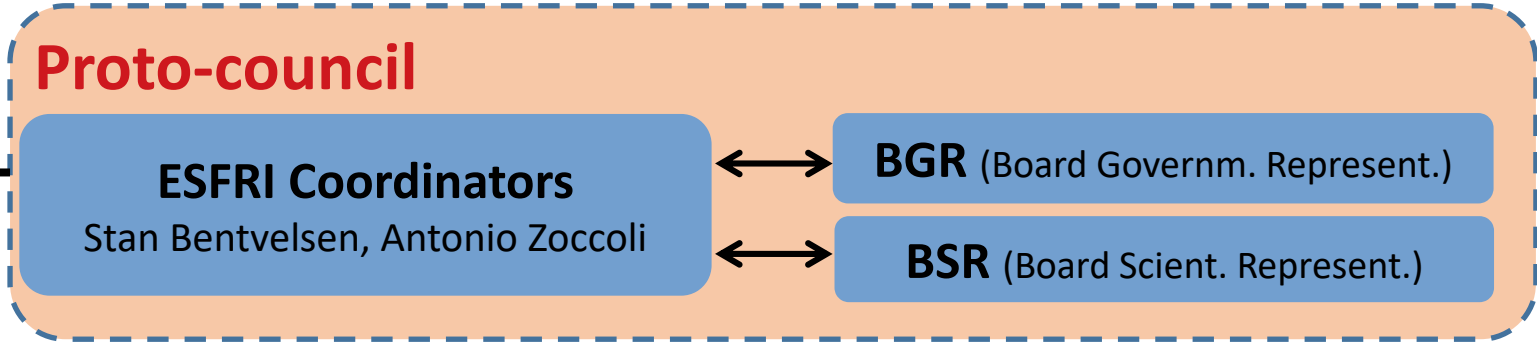
- The ESFRI writing team steered the ET community activities in the last two years
- A proto-collaboration organization has been achieved in order to prepare the big jump:
  - The ET collaboration

## Divisions

# The ET framework

- Einstein Telescope is a complex enterprise
  - The ET scientific collaboration is only one of the elements of the mechanism
  - Governments have started to discuss in order to support the whole effort
  - Agencies and national institutions started to set up the “ET Observatory project”
    - Inter-agency bodies (Project Directorate)
    - External Agreements (MOA with CERN on vacuum pipe design)
    - EU project for the ET preparatory phase (INFRA-DEV)
- My personal understanding of the ET Framework:





Policy & monitoring

monitoring  
reporting

monitoring  
delivering

setting

ET Project

# Next Step and Priorities: WWW

- What:
  - The Collaboration priorities are:
    - Collaboration Board:
      - Evaluation and admission of the RUs, voting mechanisms, completion of the bylaws, election of the CB chair, election of the spokesperson and deputy spokesperson
    - Executive Board
      - Define the interfaces and the integration level with the Project Office, Engineering department and Vacuum pipe team
      - Evolve the ET CDR in the detector TDR
      - Coordinate the definition and the development of the ET technologies
      - Complete the ET science book
      - Develop the tools



# Next Step and Priorities: WWW

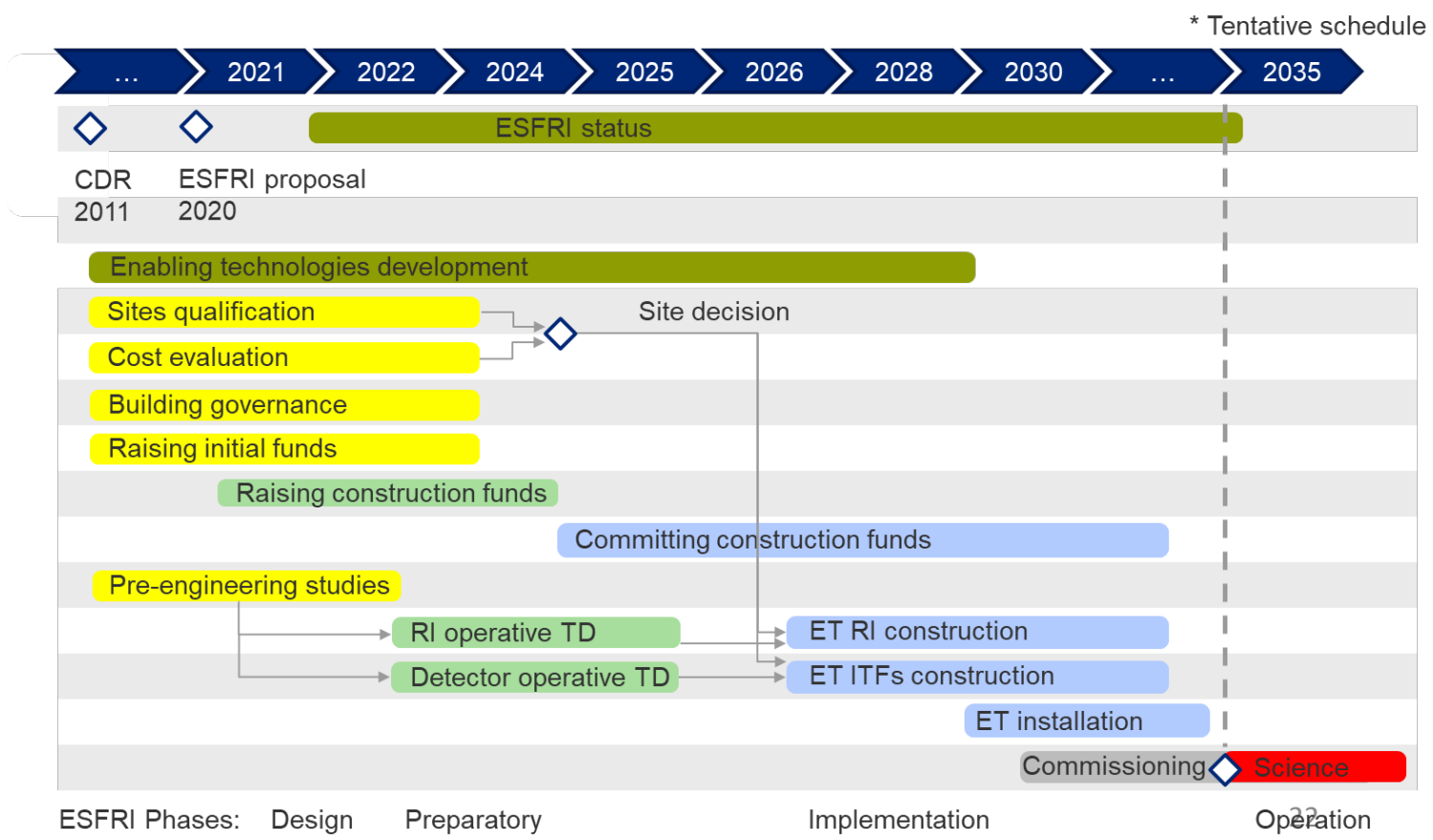
- Where:
  - Support the site selection procedure through the National Host Teams
  - The collaboration and the EB in particular have the duty to support the SPB/SCB in all the site characterization activities, defining the noise requirements, validating the analysis methods and tools, analyzing the impact of the site characteristics on the ET science performance

# Next Step and Priorities: WWW



- When:

- This is one of the most critical point of the current ET status.
- The ET roadmap has been proposed in the ESFRI document:
- ET milestones and deliverables have been partially revisited in the INFRA-DEV proposal
- TDR deliverability is affected by the timing declared in the CERN document for the vacuum pipe
- It is urgent, and we just started it with the PO, to analyze all the activities and their interfaces to define correctly the timing



# Conclusions

- ET is a huge enterprise
- The interest of large community and the actions of a reduced set of scientists pushed it through more than a decade
- In the last few years ET acquired a large momentum and now it is a global scale project:
  - It is time to have a global scale collaboration:

7<sup>th</sup> of June, 2022

# Welcomed ET Scientific Collaboration