

# Einstein Telescope Status

Image taken @  
XII. ET Symposium  
7th + 8th June 2022  
Budapest

## Hannover ET Germany Meeting 21 October 2022

Harald Lück

Institute für Gravitationsphysik  
of the Leibniz Universität Hannover;  
Albert Einstein Institut  
Max-Planck Institut für Gravitationsphysik



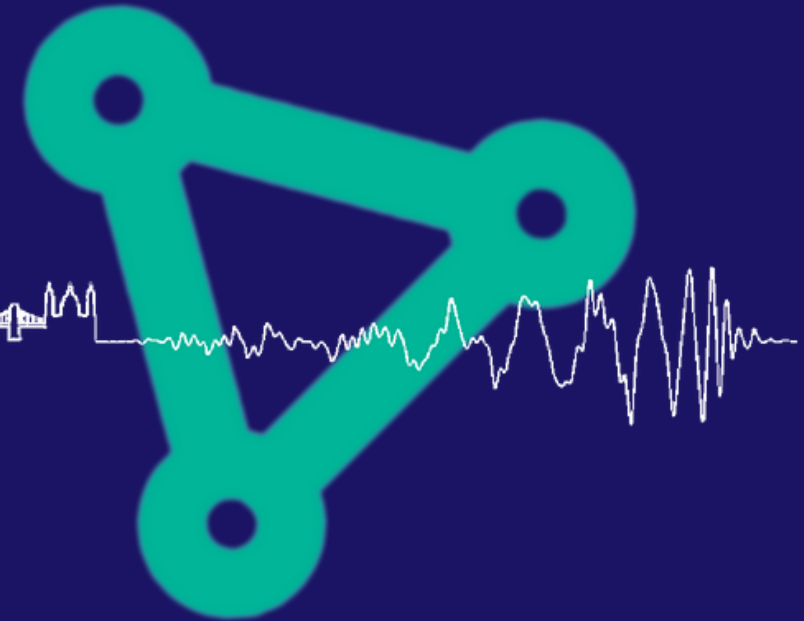
# ET Collaboration formed



<https://indico.ego-gw.it/event/411/>



XII Einstein Telescope  
Symposium



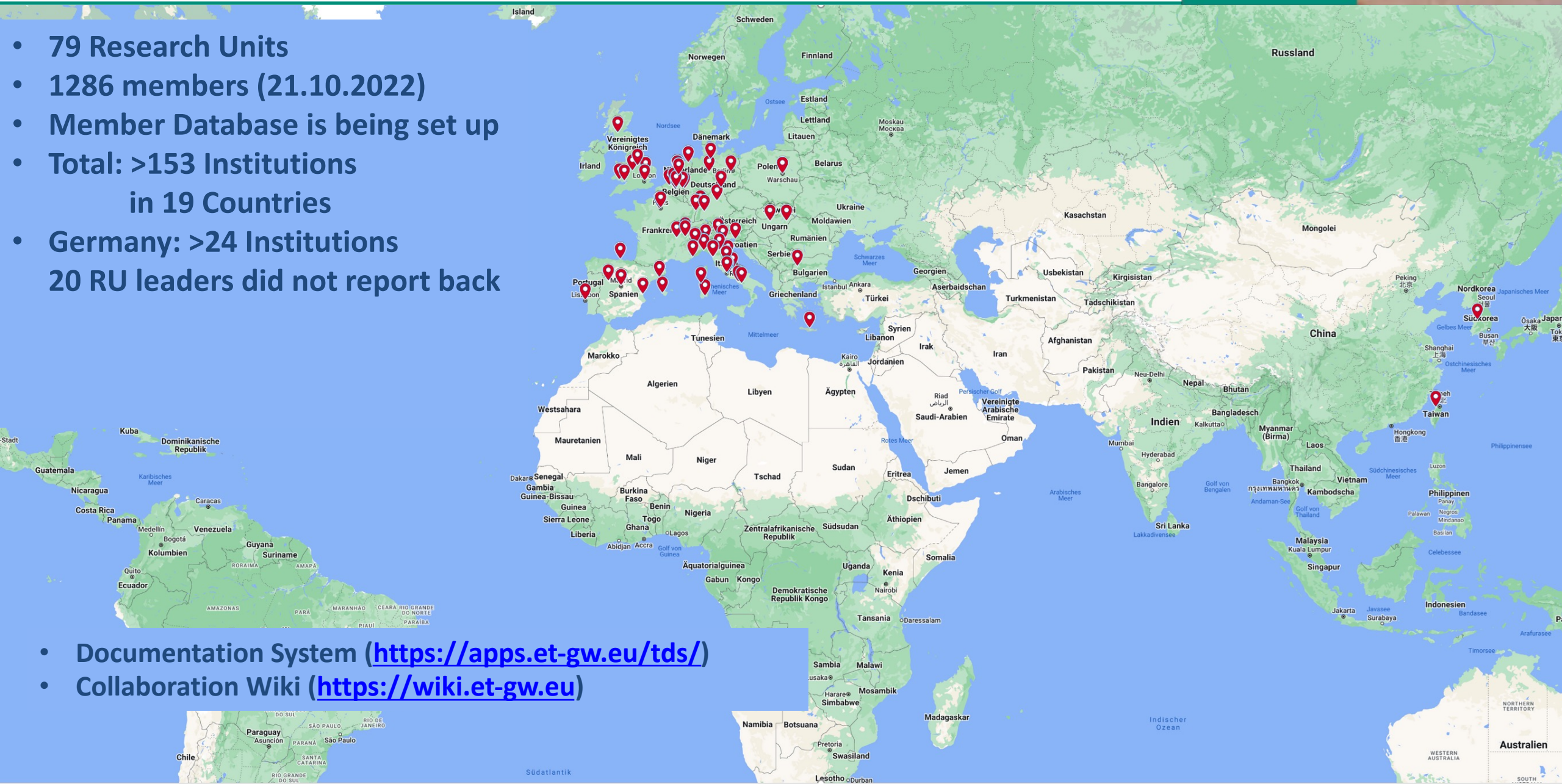
## Birth of the ET Collaboration

XII ET Symposium, Budapest on **June 7th - 8th**



# The Einstein Telescope Collaboration

- 79 Research Units
- 1286 members (21.10.2022)
- Member Database is being set up
- Total: >153 Institutions  
in 19 Countries
- Germany: >24 Institutions  
20 RU leaders did not report back

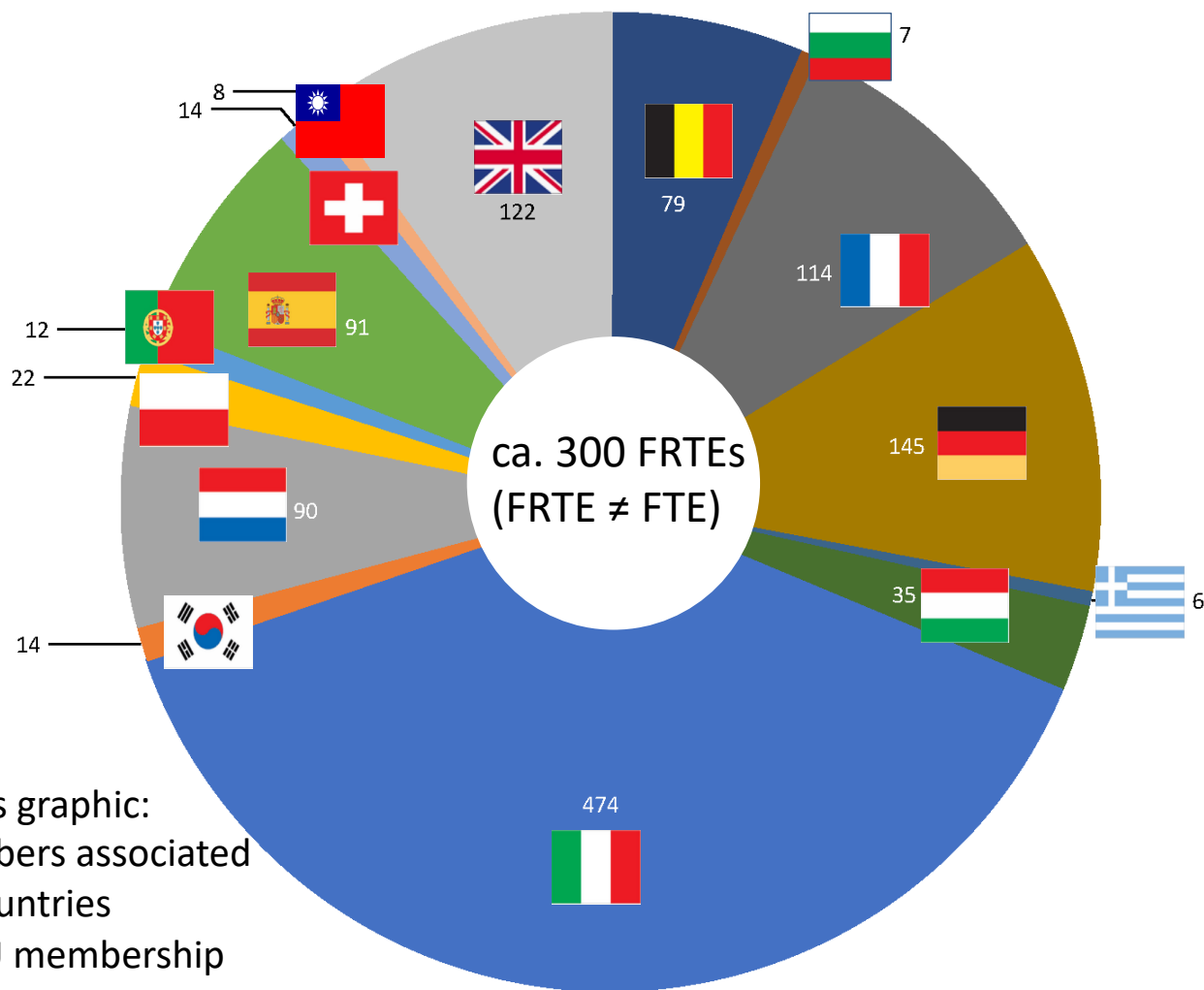
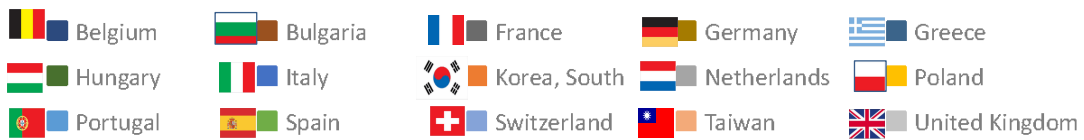


- Documentation System (<https://apps.et-gw.eu/tds/>)
- Collaboration Wiki (<https://wiki.et-gw.eu>)

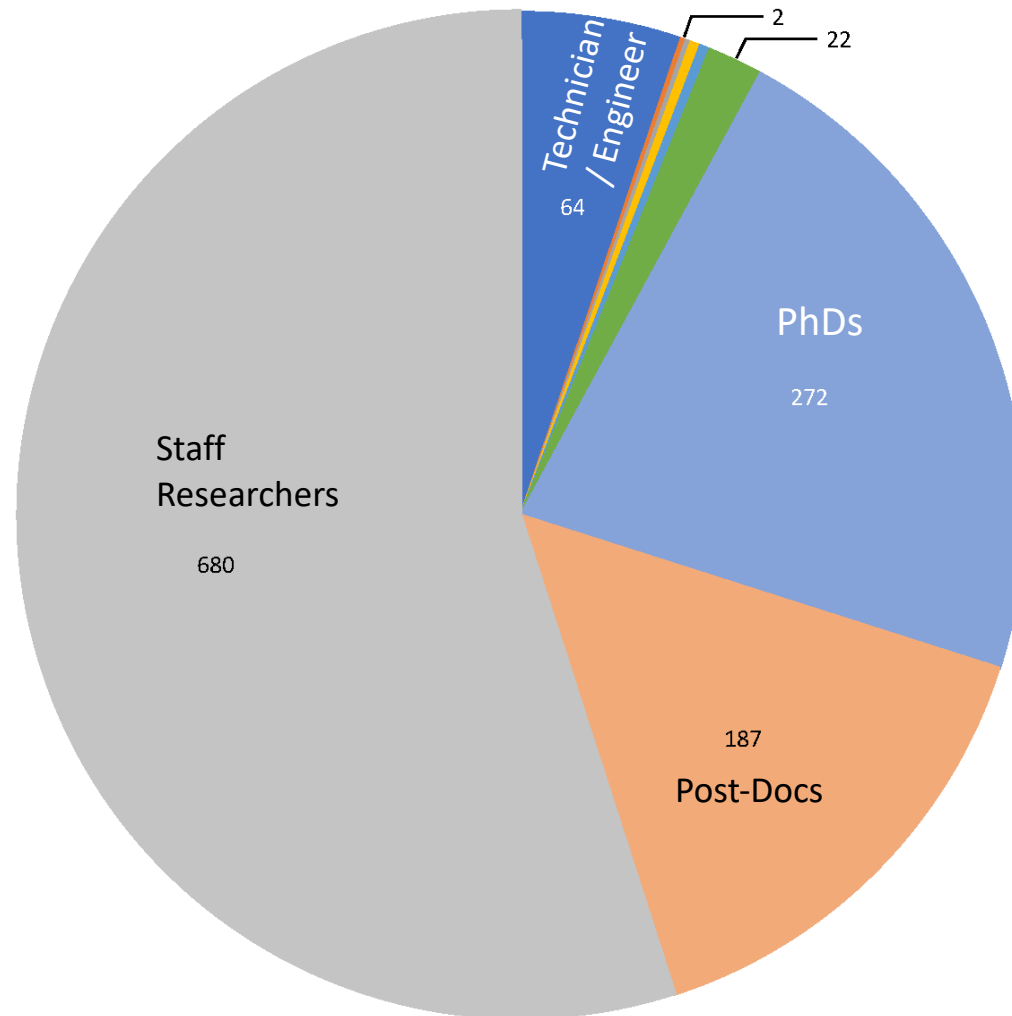
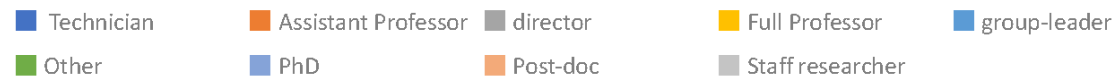
# ET Membership



ET Collaboration Members per Country



Collaboration Composition



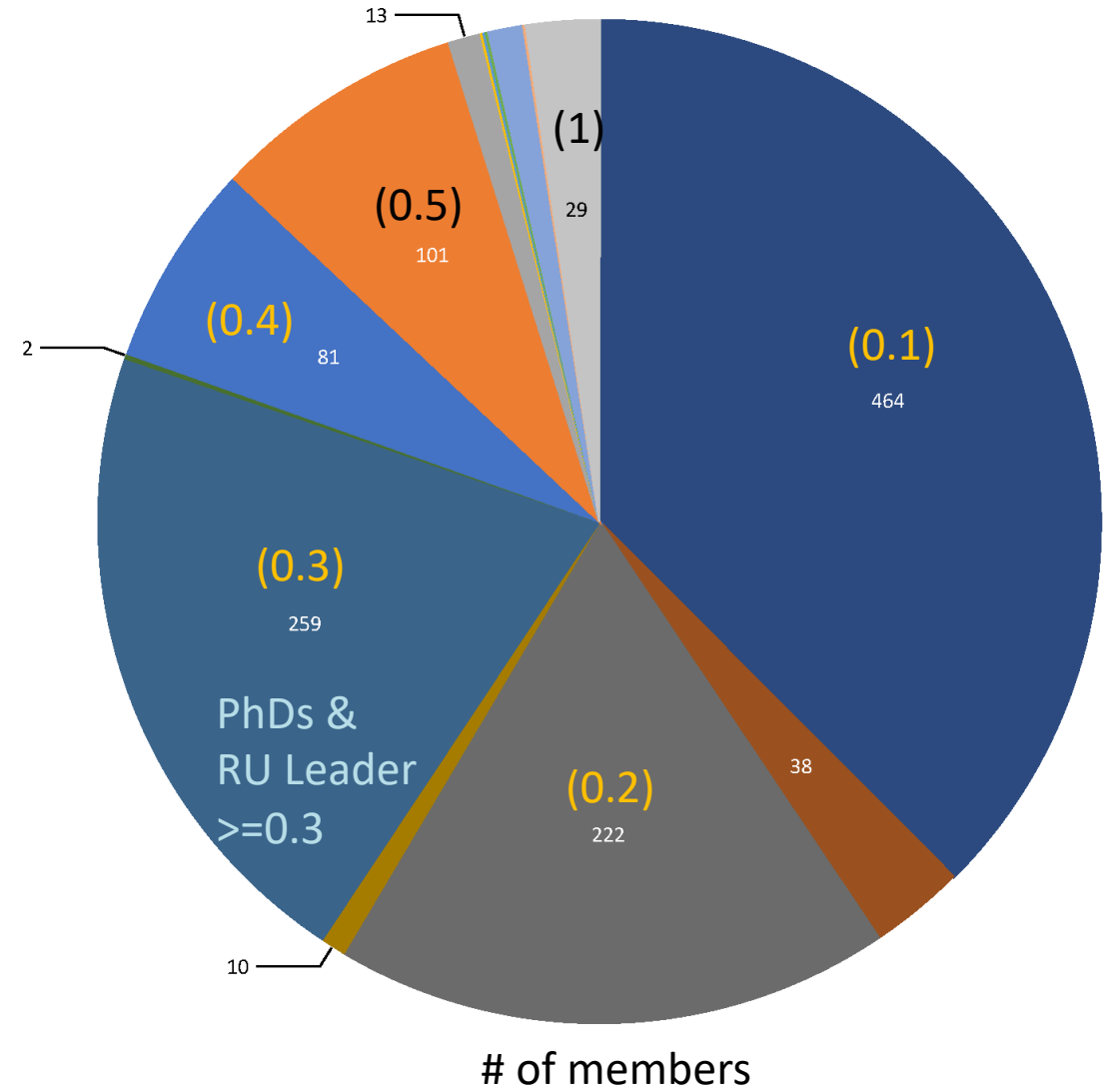
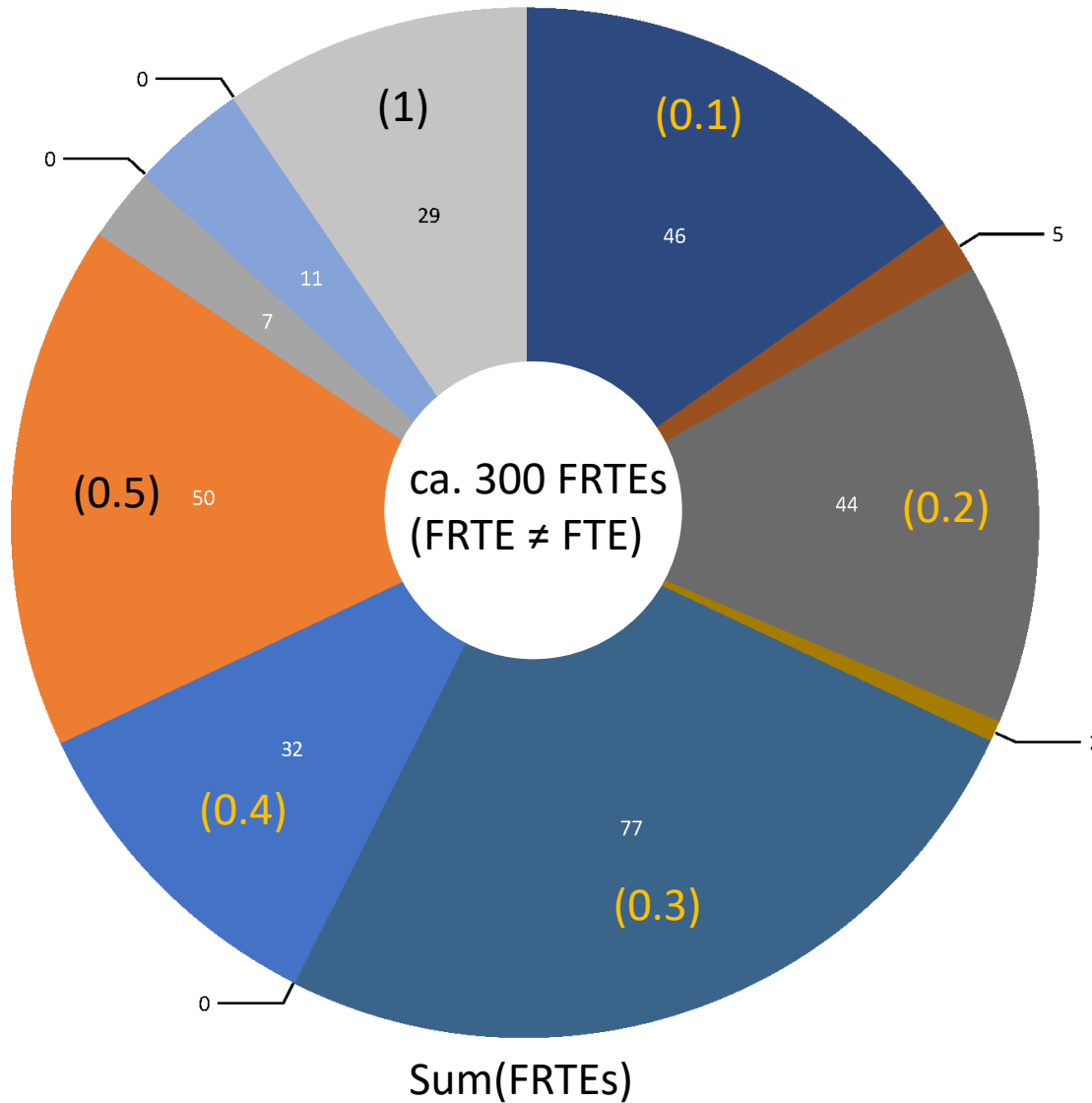
In this graphic:  
Members associated  
to Countries  
by RU membership

# ET Collaboration Workforce [FRTEs]



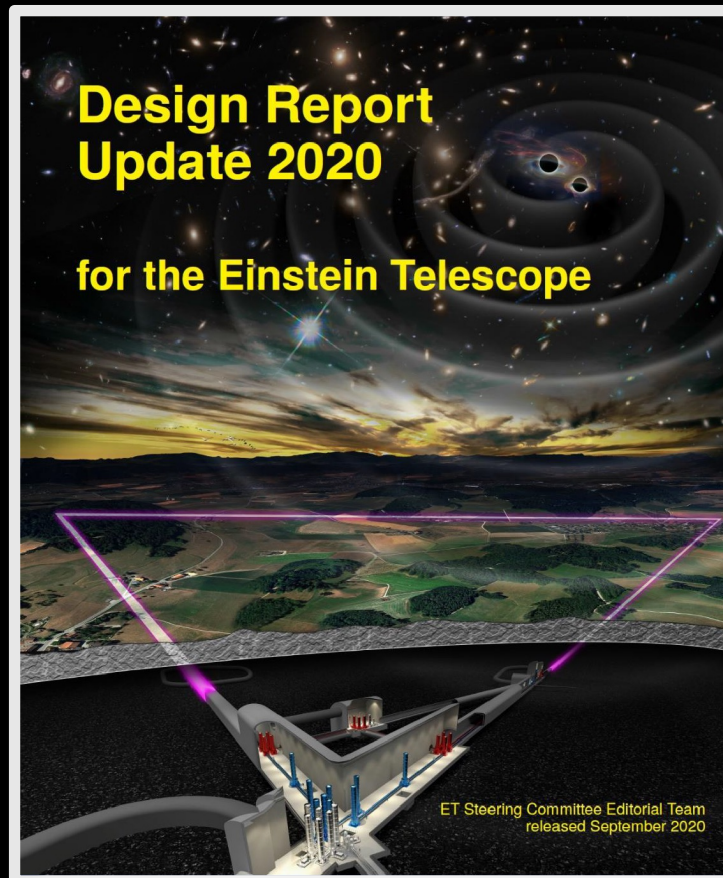
■ 0,1 ■ 0,15 ■ 0,2 ■ 0,25 ■ 0,3 ■ 0,35 ■ 0,4 ■ 0,5 ■ 0,6 ■ 0,65 ■ 0,7 ■ 0,75 ■ 0,8 ■ 0,9 ■ 1

Number of FRTEs  
 ■ 0,1 ■ 0,15 ■ 0,2 ■ 0,25 ■ 0,3 ■ 0,35 ■ 0,4 ■ 0,5 ■ 0,6 ■ 0,65 ■ 0,7 ■ 0,75 ■ 0,8 ■ 0,9 ■ 1

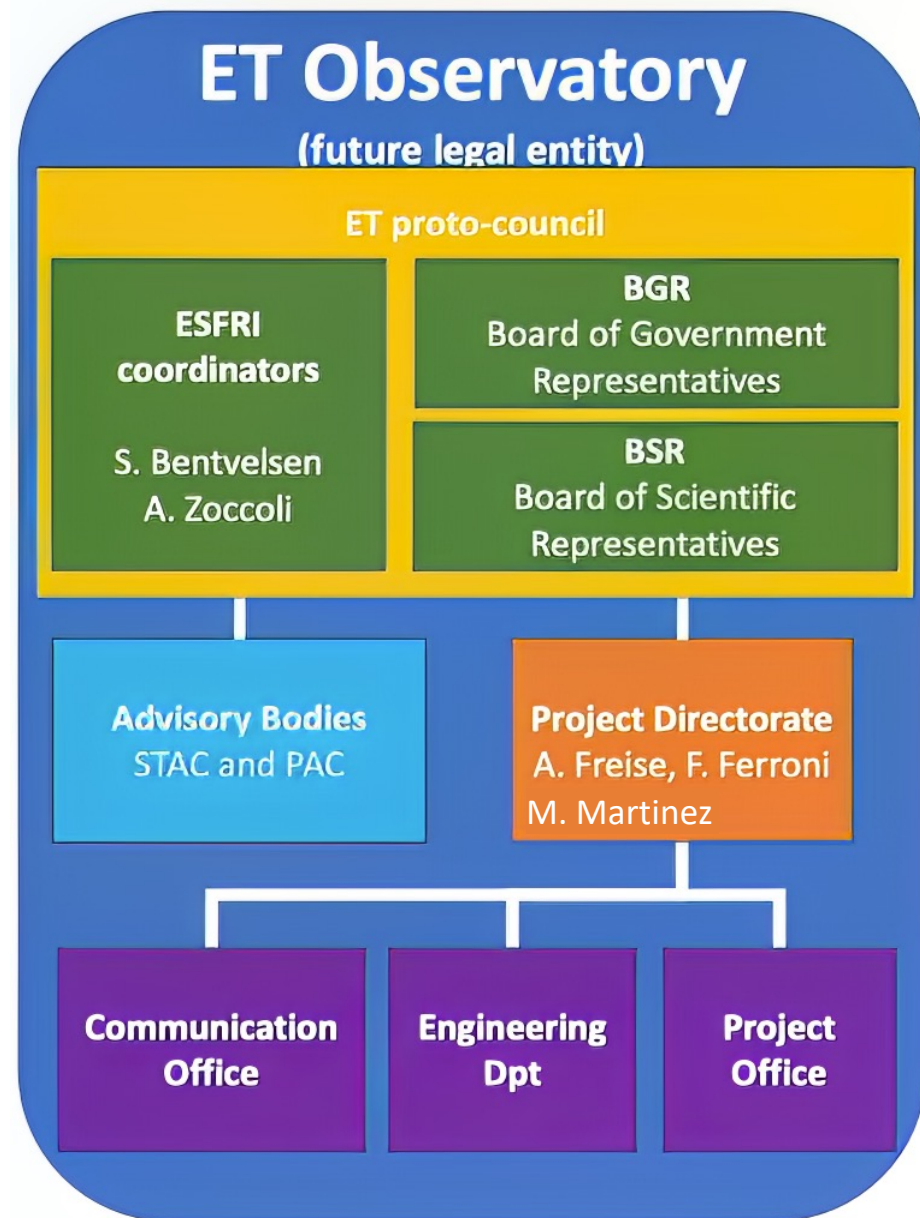


[https://tds.virgo-gw.eu/?call\\_file=ET-0106C-10.pdf](https://tds.virgo-gw.eu/?call_file=ET-0106C-10.pdf)

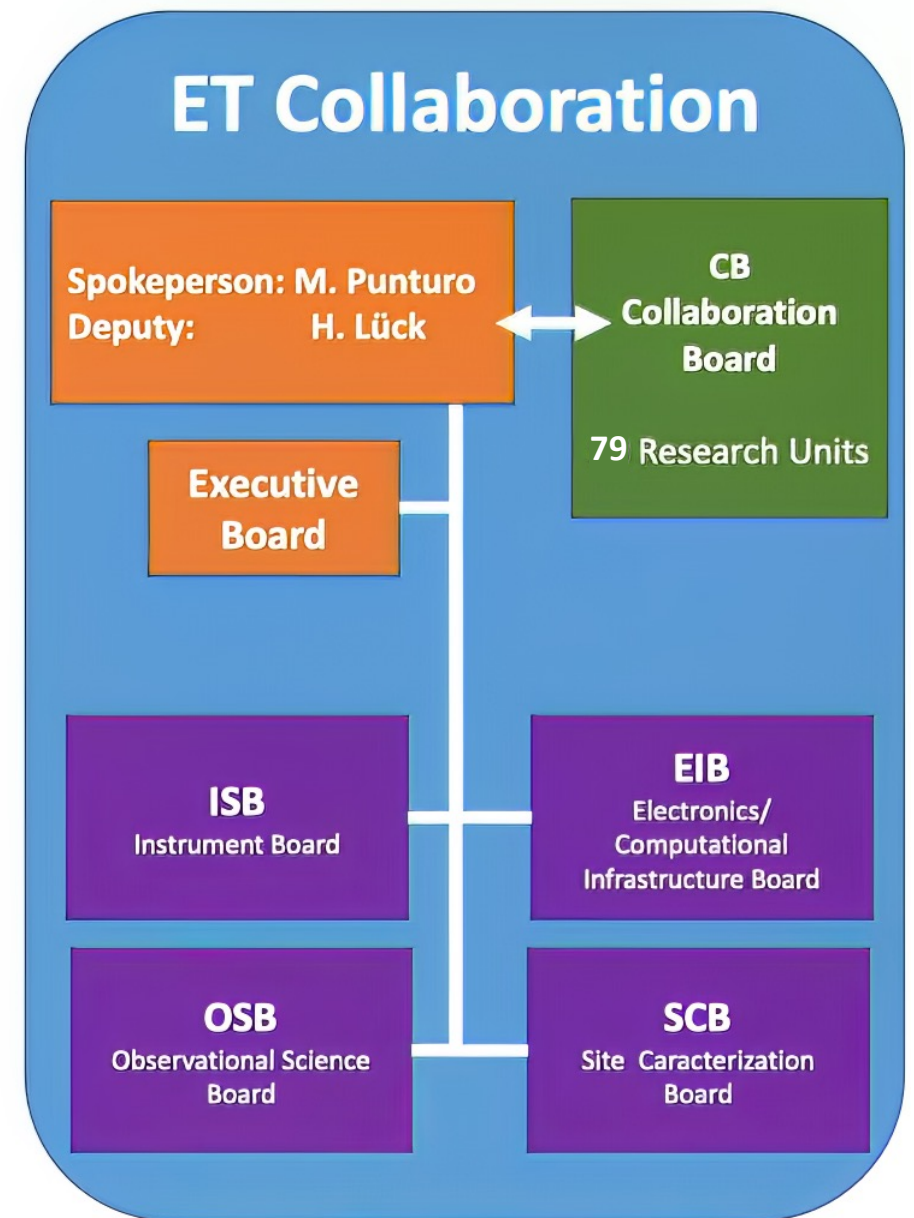
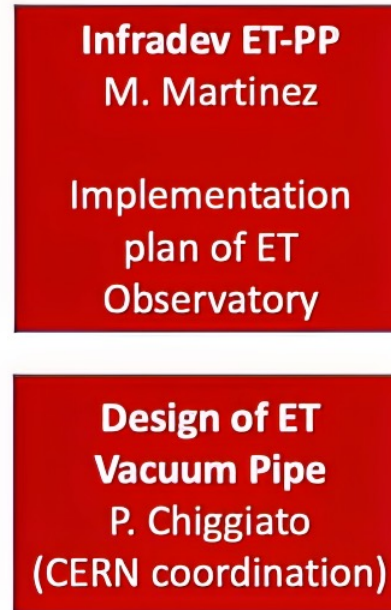
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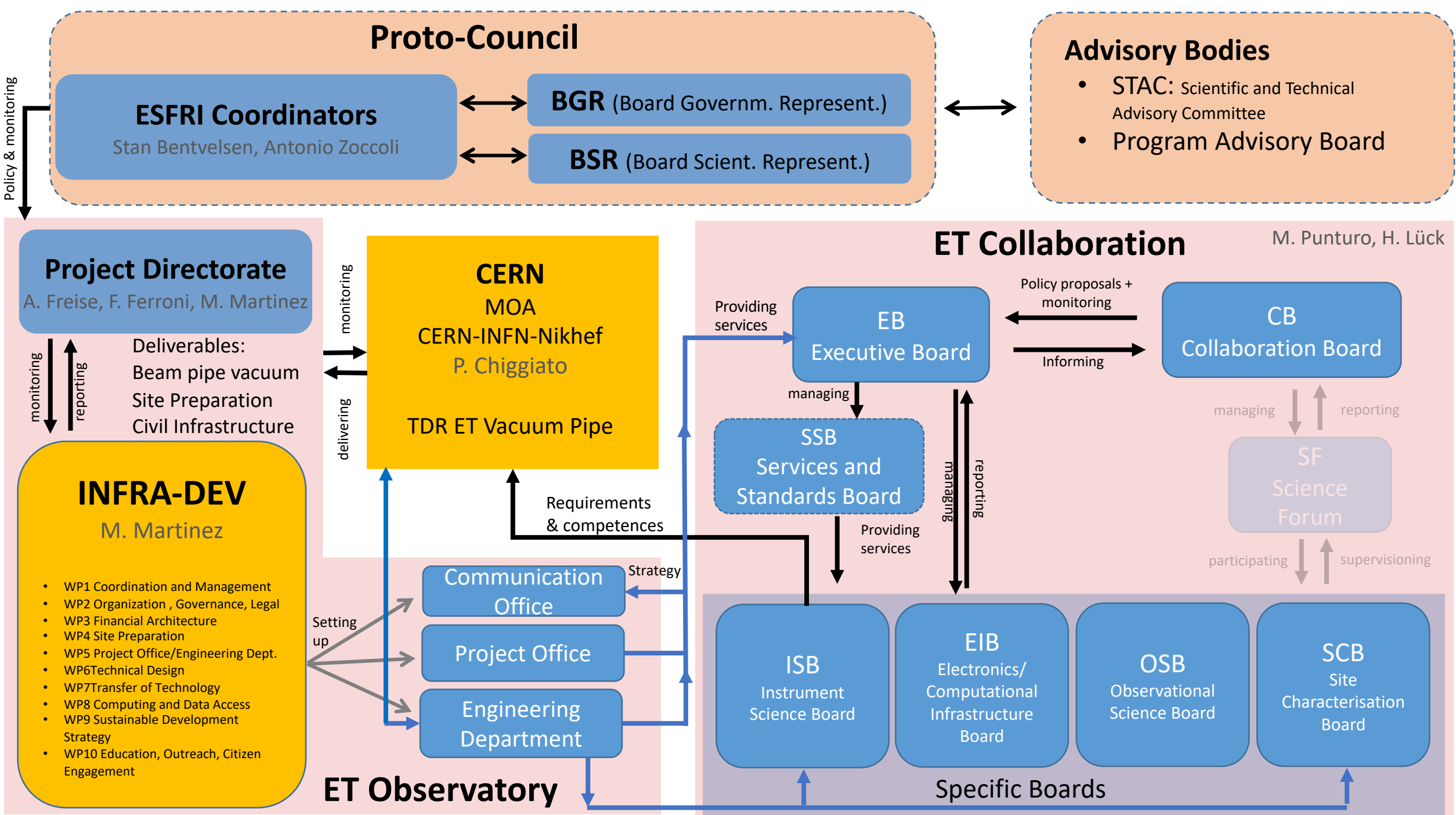


- In 2020 **governments of 5 EU countries** (Italy [lead], the Netherlands, Belgium, Spain and Poland) submitted the ET application to ESFRI (European Strategy Forum on Research Infrastructure).
- July **2021 ET obtained ESFRI status**, as the highest value project ever on an ESFRI roadmap.
- **Now in „Preparatory Phase“**



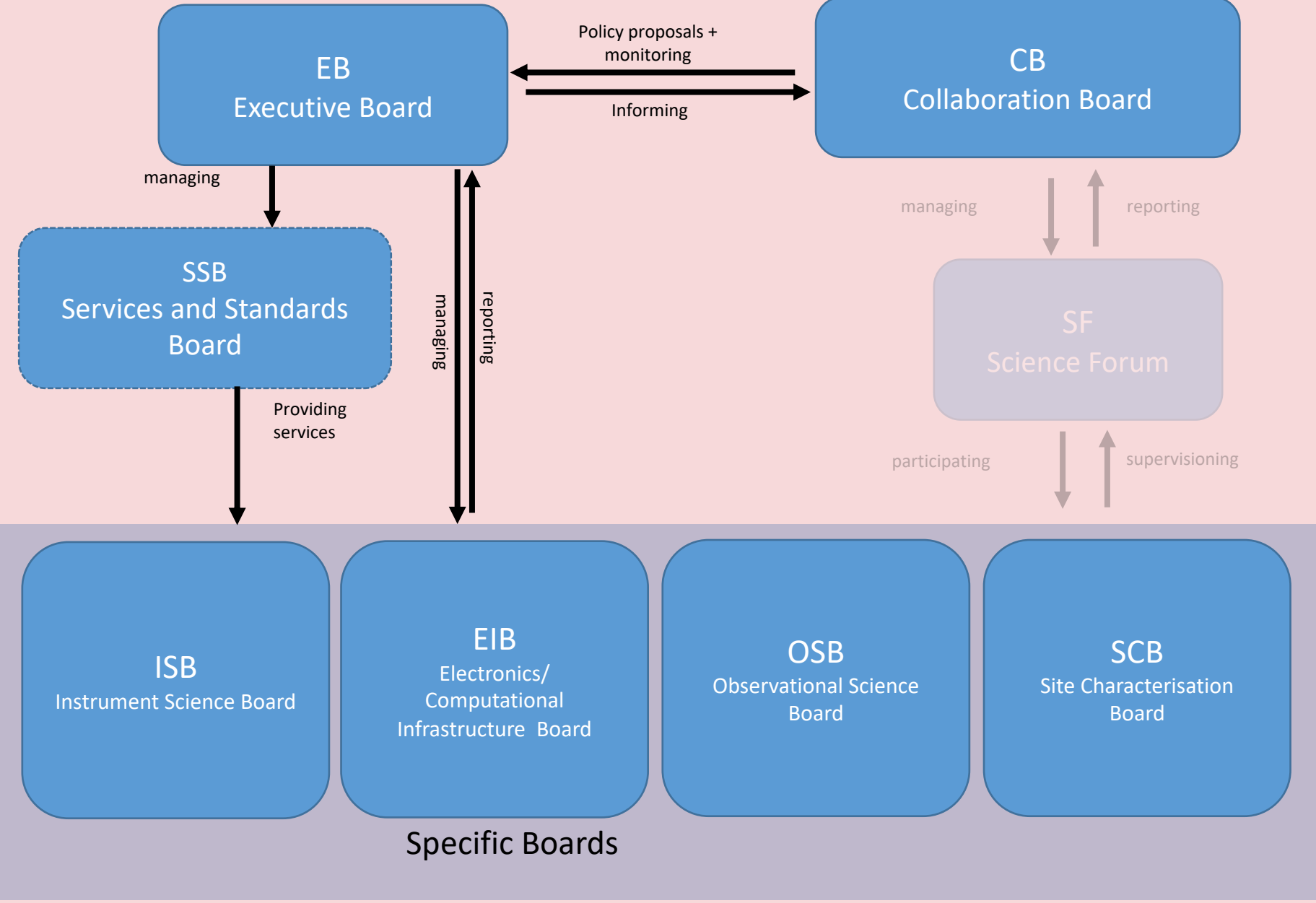
## Projects







# ET Collaboration



# ET ISB: Instrument Science Board



[subscription request link](#)

# ISB workshop, GSSI, L'Aquila

Oct 17 – 21 2022

[indico.ego-gw.it/event/465/](https://indico.ego-gw.it/event/465/)

185 registered participants, 81 in person

## Plenary & parallel sessions

Small-group work on key topics of the instrument design

## Parallel Sessions:

- ET-LF lower stage
- Cryostats, payload
- Arm pipes
- Site characterisation
- Recycling cavities
- ET-LF core optics & suspensions
- Sensitivity curves update

- **Next months** will be mostly focused on:
  - **Review of the timeline** (together with EB and other boards)
  - Develop **hierarchical Product Breakdown Structure & corresponding Work Breakdown Structure**
  - **Define Interfaces and inter dependencies** among systems/subsystems
  - Prioritize and harmonize **R&D efforts**
  - Definition of **requirements for the vacuum system** → CERN

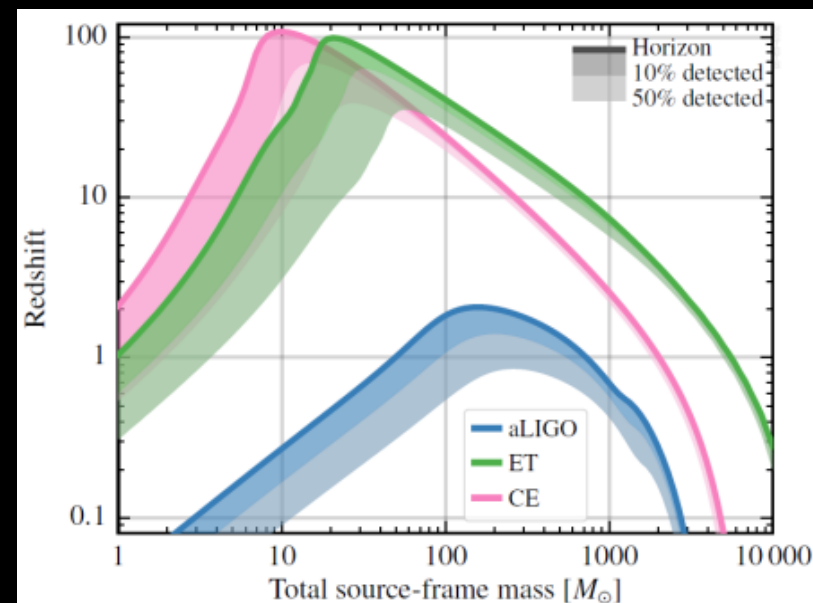
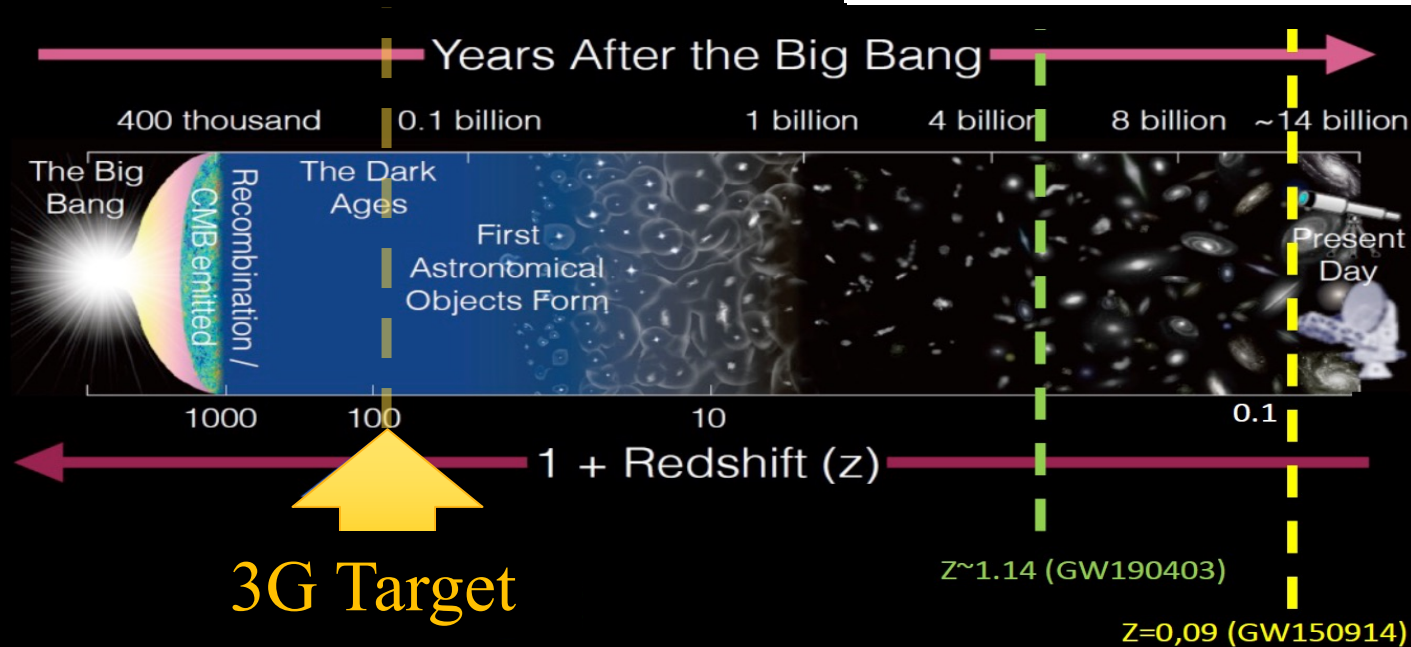
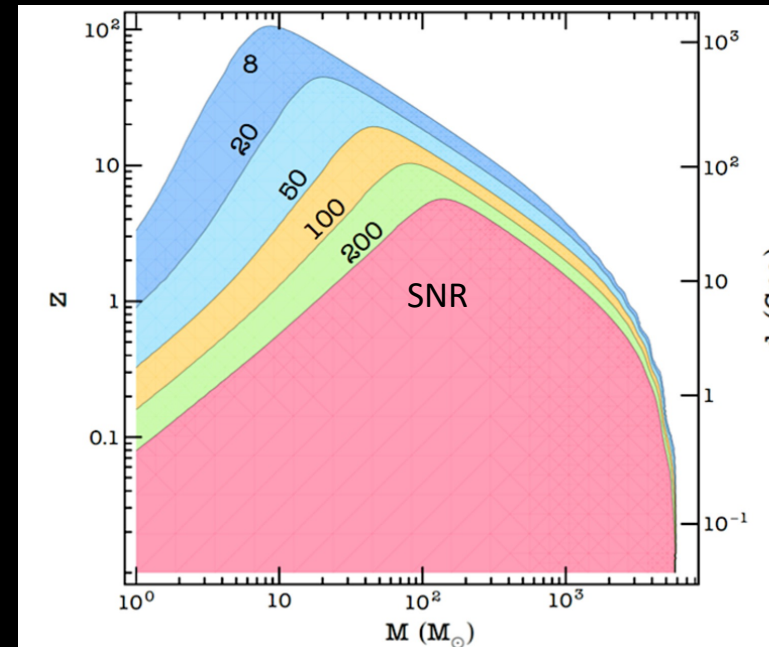
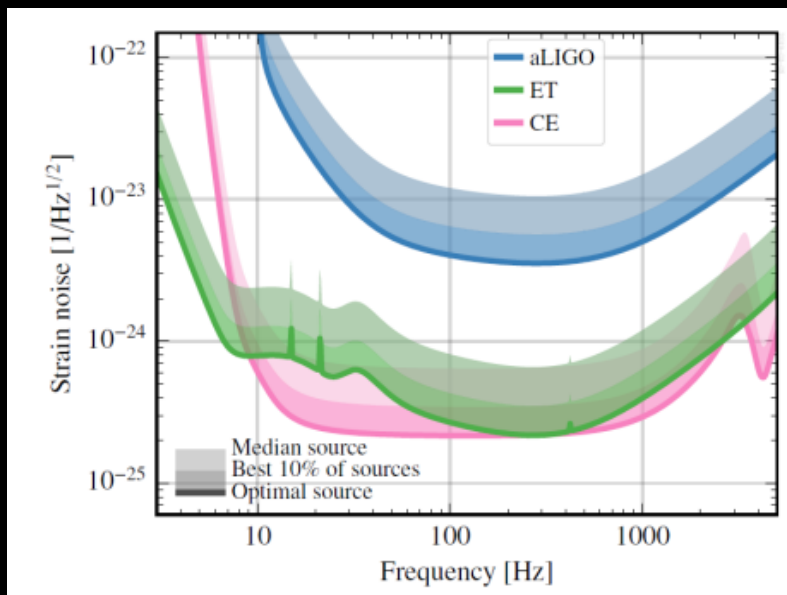


## Michele Maggiore - Ed Porter - Marica Branchesi

Fundamental physics	Cosmology	Population Studies	MM observations	Synergies w. other GW observ.	Nuclear physics	Stellar collapse and isolated neutron stars	Waveforms	Science Potential	DA platform
Chris v.d. Broeck Paolo Pani Raphael Porto	Archisman Ghosh Angelo Ricciardone Mairi Sakellariadou	Giulia Cusin Michela Mapelli Antonio Riotto	Giancarlo Ghirlanda Stephen Smartt Susanna Vergani	Nelson Christensen Samaya Nissanke B. Sathyaprakash	Tim Dietrich Tanja Hinderer Michaela Oertel	Marie-Anne Bizouard Enrico Cappellaro Pablo Cerda-Duran	Laura Bernard Harald Pfeiffer Patricia Schmidt	Michal Bejger Ik Siong Heng Andrea Maselli	Chris v.d. Broeck Elena Cuoco Tania Regimbau John Veitch
<div>Physics near BH horizons</div> <div>Tests of GR</div> <div>Exotic compact objects</div>	<div>Dark Energy</div> <div>Dark matter</div> <div>Estimation of cosmological parameters</div> <div>Modifications of gravity at cosmological scales</div> <div>Stochastic background of cosmological origin</div>	<div>Predictions of population of astrophysical origin</div> <div>Predictions of primordial BHs</div> <div>Stochastic backgrounds of astrophysical origin</div>	<div>ET / high-energy</div> <div>ET / optical</div> <div>ET / radio</div> <div>ET / neutrinos</div>	<div>Synergies with 2G+ detector</div> <div>Synergies with CE, 3G</div> <div>Synergies with LISA</div>	<div>EoS of NSs in isolated systems</div> <div>EoS in NSs in binary systems</div> <div>Nucleo-synthesis in BNS mergers</div>	<div>Predictions for Supernovae</div> <div>Predictions for magnetars</div> <div>Predictions for cosmic string bursts</div>	<div>Waveforms relevant for ET</div> <div>Improvement of waveforms for BBH</div> <div>Improvement of waveforms for NSBH</div> <div>Improvement of waveforms for BNS</div>	<div>Science potential for various detector configurations</div> <div>Common tools</div>	<div>DA platform</div>

# OSB task: Data → Science

- BBH up to  $z \approx 50$  !!
  - $10^5$  BBH/yr
  - masses up to  $10^3 M_{\odot}$
- BNS to  $z \approx 3-4$ 
  - $10^5$  BNS/yr
  - possibly  $O(10-100/\text{yr})$  with e.m. counterpart
- high SNR



Evans and Hall 2019

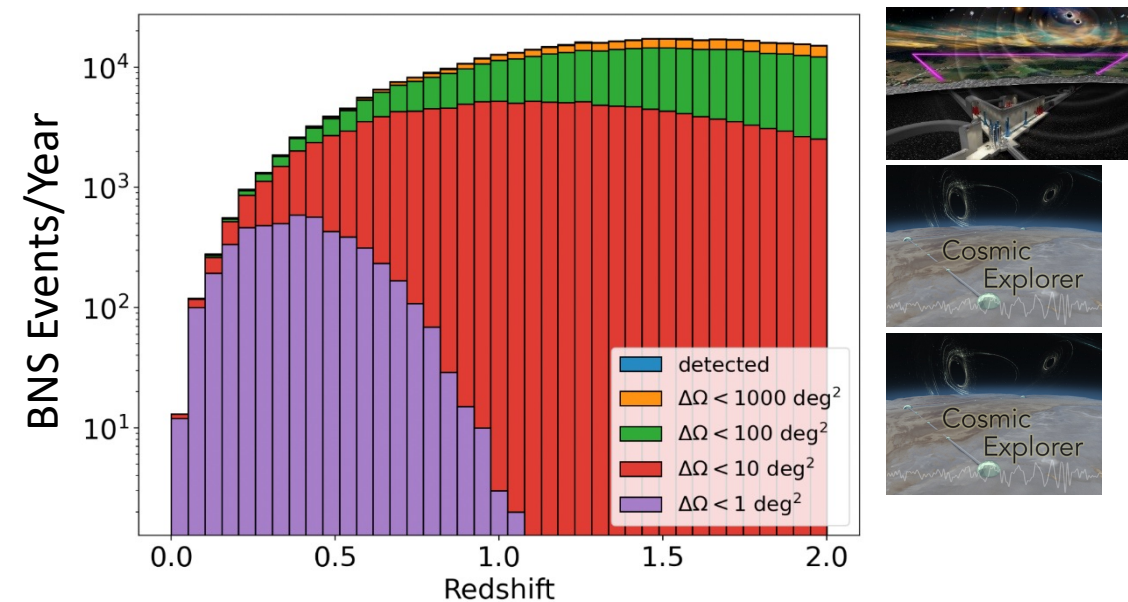
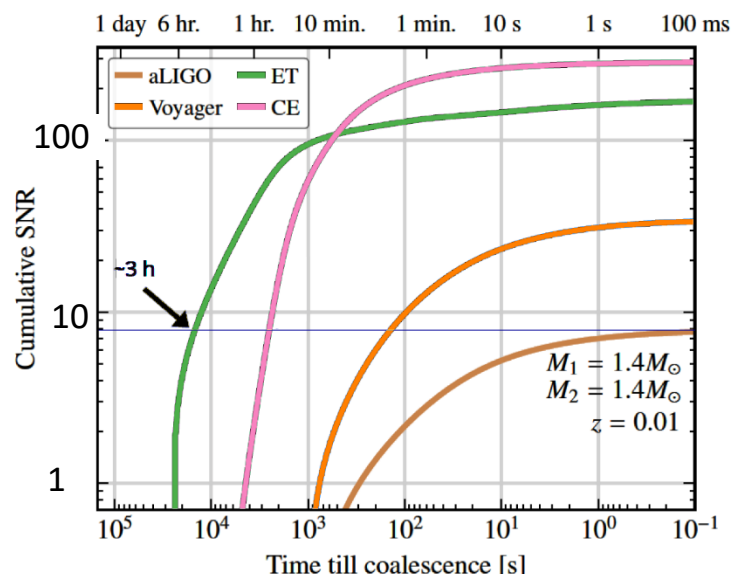
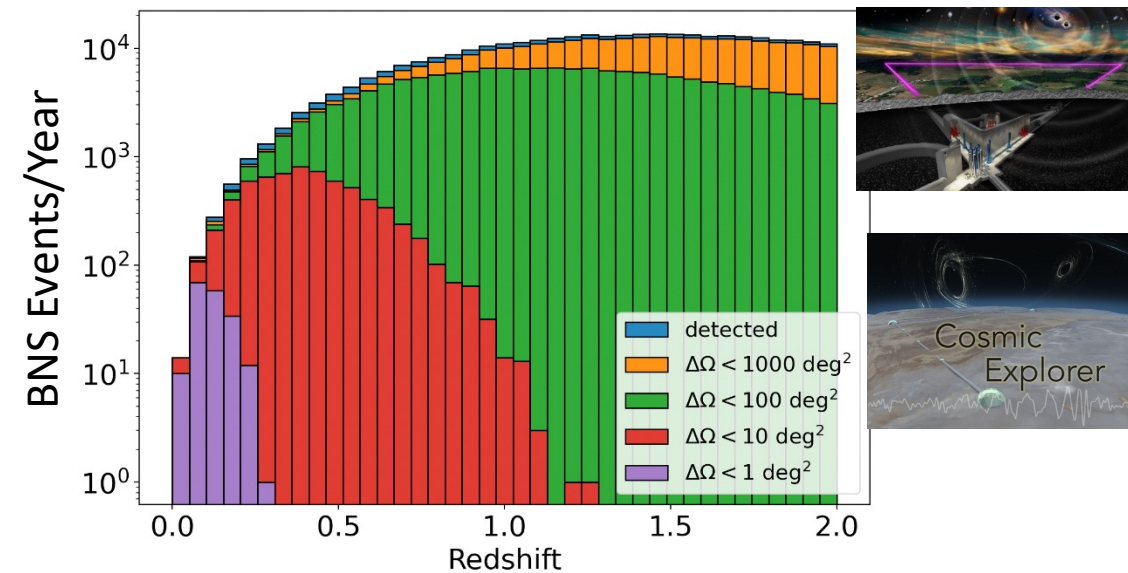
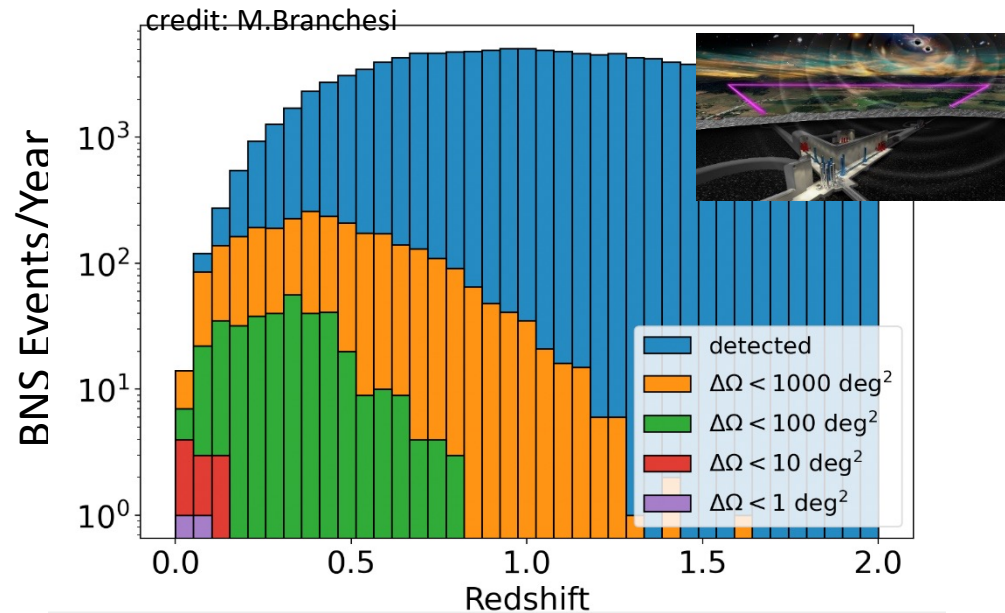
## ASTROPHYSICS

- **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
- **Stochastic backgrounds of cosmological origin**
  - inflation, phase transitions, cosmic strings

# Sky-localization capabilities





**Chairs:** Patrice Verdier, Stefano Bagnasco (Collaboration)

**Achim Stahl**, Sergi Girona, Nadia Tonello (Observatory through INFRA DEV)

## The ET e-Infrastructure Board

**Division 1:** Software, frameworks, and data challenge support

**Division 2:** Services and Collaboration Support

**Division 3:** Computing and data model, Resource Estimation

**Division 4:** Multimessenger alerts infrastructure

**TTG:** Technology Tracking working Group

<https://indico.ego-gw.it/event/411/timetable/#20220607.detailed>

Currently two site candidates:

- Sardinia
  - EU Regio Meuse-Rhine / Limburg
- Geological and seismic properties being analysed
- Third option being studied in Germany. Not a site candidate (yet)

## Site selection procedure in Preparatory phase

Decision and site selection procedure will be determined at government level



## • Site Characterization/Preparation Board

WD1 Physical variables and characterization

WP1.1  
Seismic noise

WP1.2  
Gravimetry and Geodynamics

WP1.3  
Magnetic measurements

WP1.4  
Other Env.

WD2  
Geology

WP2.1  
Structural Geology

WP2.2  
Hydro-Geology

WP2.3  
Geophysics

WP2.4  
Geotechnics

WD3  
Bidbooks

ET Collaboration

WD4 Cost timing and risk assessment (with ISB/Infra-Osb)

WD5  
Legal and site preservation

WD6  
Socio-Economic and environmental impact

Project Directorate

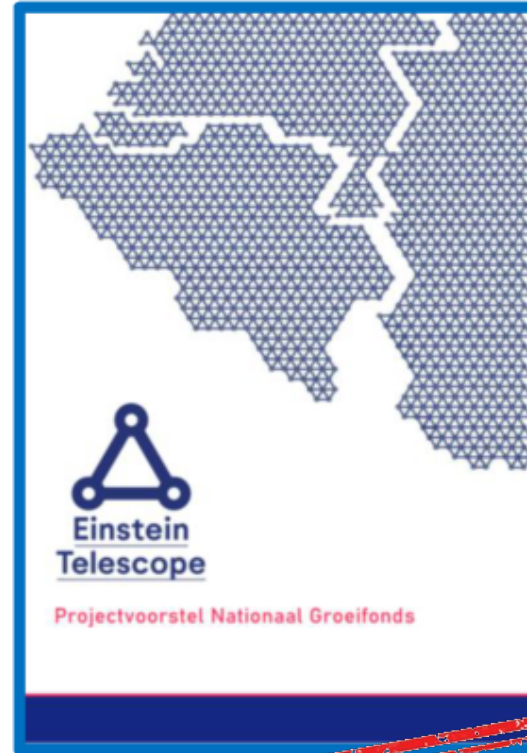
**Lots of activities going on** at the candidate sites:  
Characterisation of geology, hydrology, seismic noise, environmental noises  
Analysis of:  
Impact on environment (site preservation),  
impact on society, economy,...

# 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)*

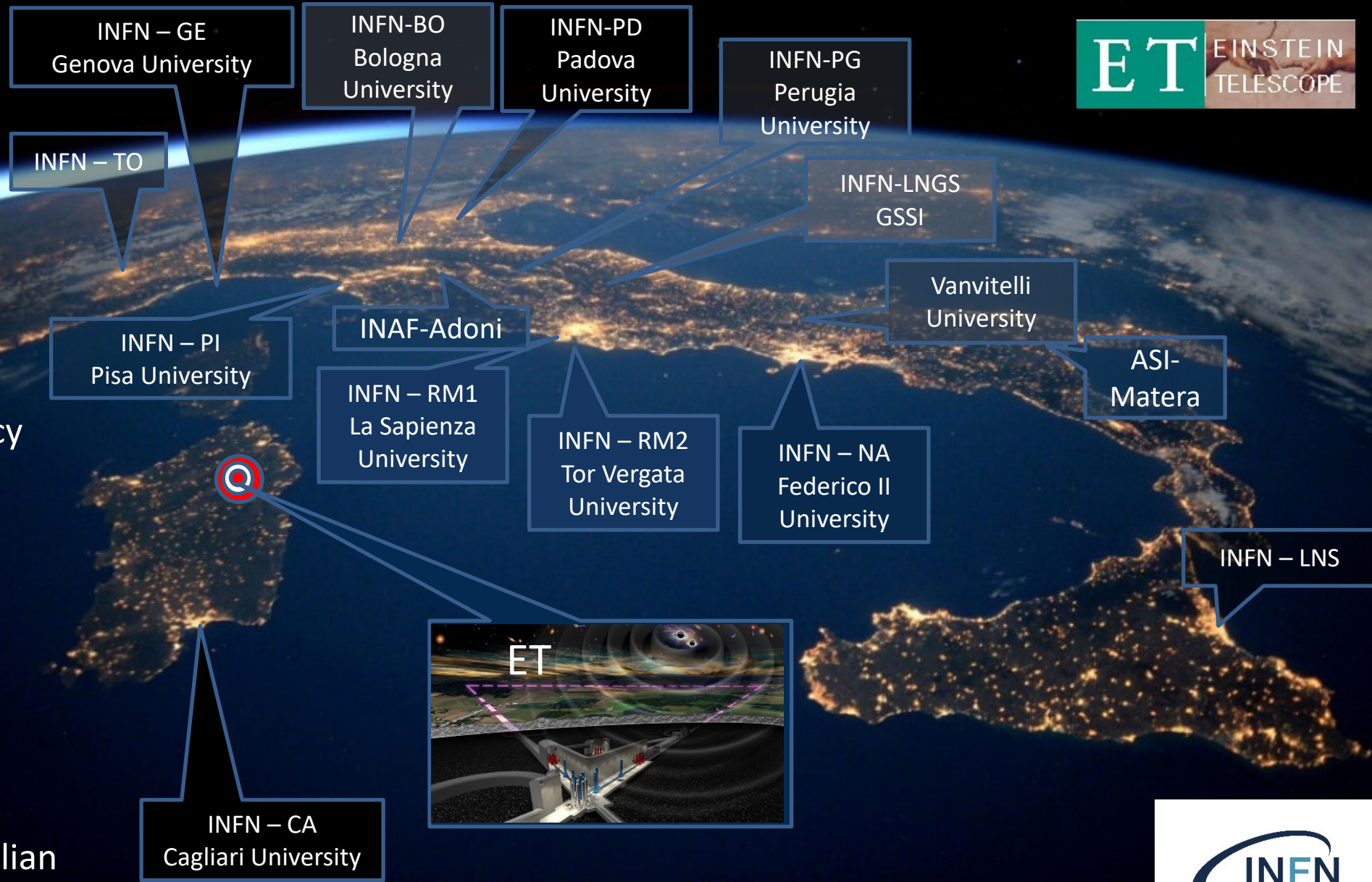
*Supported by ~70  
Dutch  
industry institutions*

In October 2021, the Netherlands submitted large funding proposal within context of the 'Nationaal Groeifonds'. Decision in 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 focused on ET  
enabling technology and  
Sardinian site candidature  
support

Led by INFN,  
Partners:  
11 Universities  
INAF and Italian Space Agency

Budget 50M€ approved

Start of the project:  
1<sup>st</sup> December 2022

Discussion ongoing with the  
Italian Government on an Italian  
share toward ET realization



# Consolidate ET Timelines

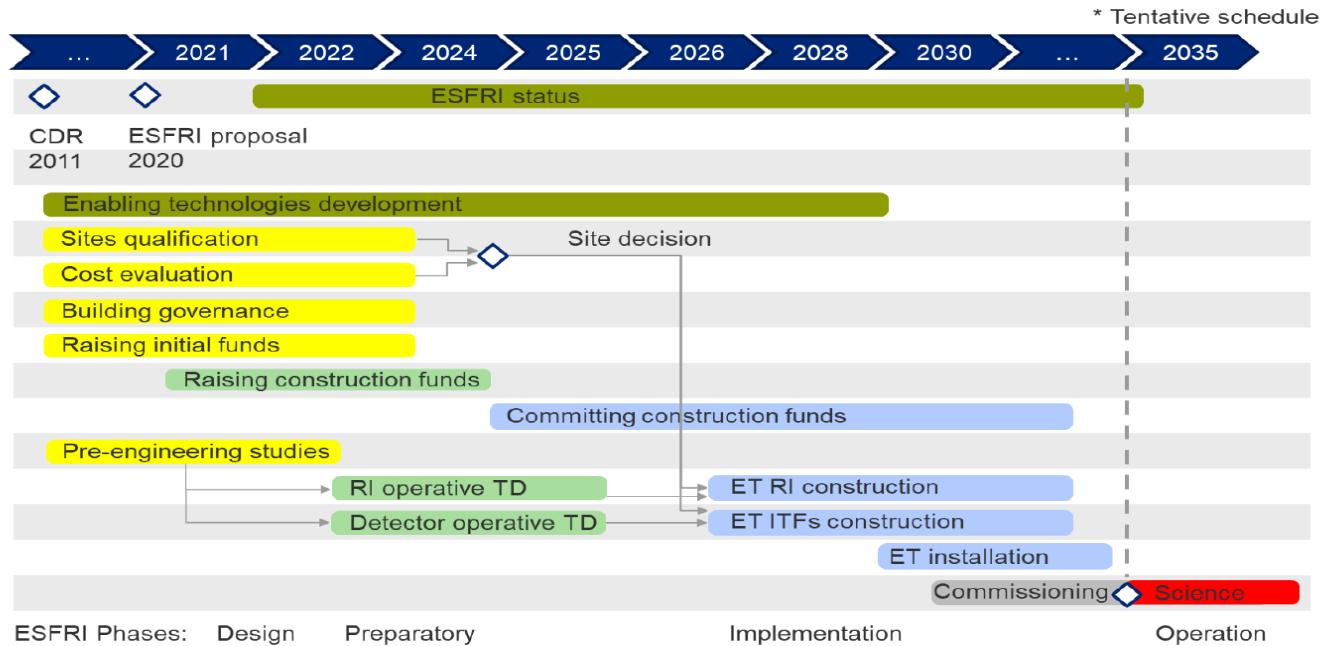


## Various Timelines:

- ESFRI proposal
- INFRA-DEV
- CERN MOU on vacuum
- SPB/SCB
- National activities

## Project timeline

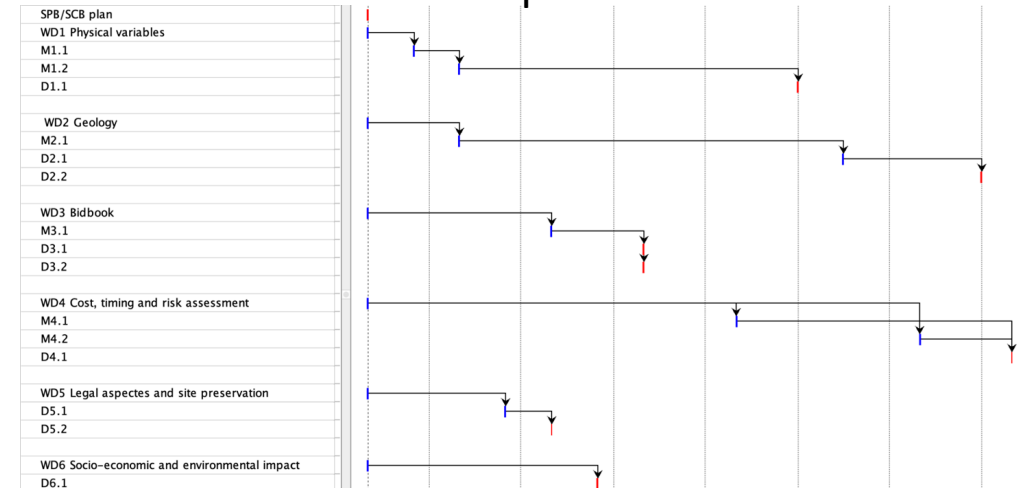
Approved by ESFRI for the 2021 Roadmap



## Beamtube Vacuum Timeline

	First year				Second year				Third year			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Functional specifications	Yellow	Yellow										
Roles and agreement with Institutes	Yellow	Yellow										
Optimisation of baseline, including cost analysis	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue				
Definition of alternative solutions	Grey	Grey										
Cost & performance of alternative solutions		Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey	Grey
Optimisation of interfaces with services/infrastructures									Orange			
Decision about vacuum system CERN solution									Orange	Orange	Orange	Orange
Prototyping of the selected solutions											Green	Green
Technical design report (ET vacuum system)												

## Site Preparation Board



# Next steps



- Define TDRs & consolidate timelines
- Build Project Office, Engineering department
- Develop PBS & WBS
- Collaboration: Set up „Service&Standards Board“ and committees
- Build up stronger/wider political support
- Secure finances
- Characterise Sites, prepare bidbooks

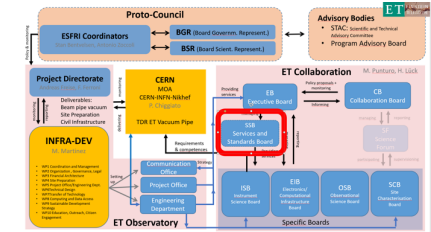
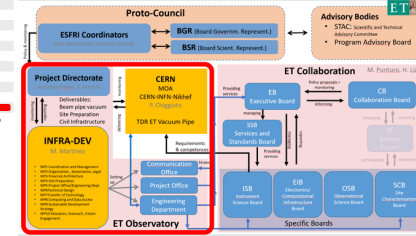
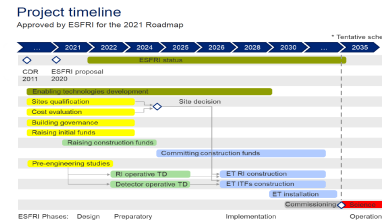
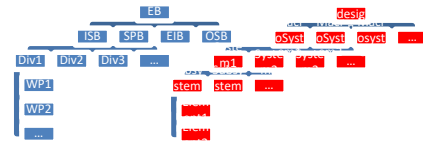




Image Source: hightperformance.com

## Becoming an ET member:

- **Join an existing RU:** Speak to an RU leader of ET
- **Form a new RU:** Contact the ET Executive Board  
([michele.punturo@pg.infn.it](mailto:michele.punturo@pg.infn.it))