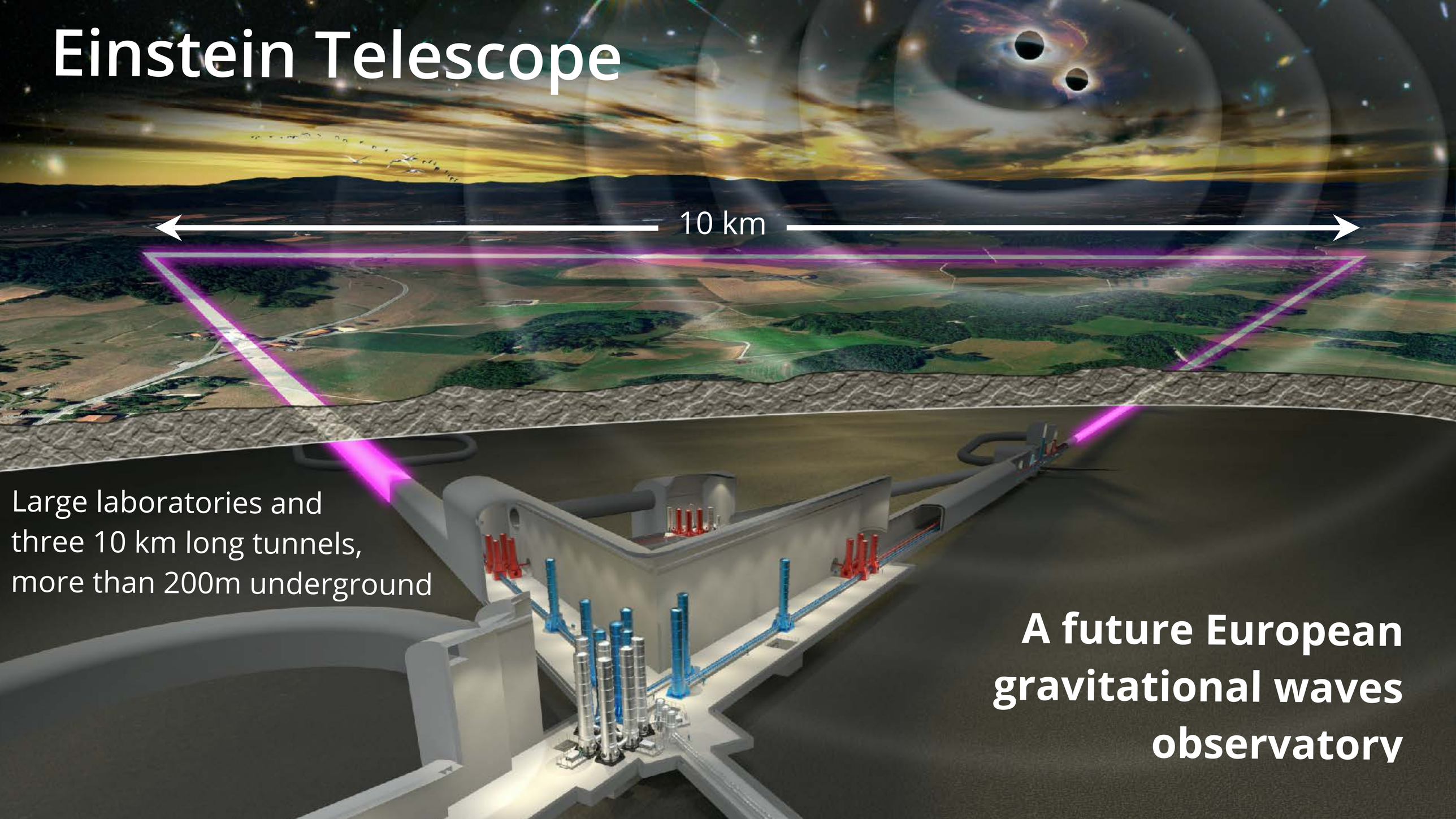
Einstein Telescope

Andreas Freise 17.06.2021
ET document number: ET-0353A-21

Einstein Telescope



Large laboratories and
three 10 km long tunnels,
more than 200m underground

A future European gravitational waves observatory

Slide: Michele Punturo

3G idea

ET CDR

Enabling technologies development

Sites characterisation & decision preparation

Costs evaluation

Building the ET collaboration

Building ET consortium

Raising initial funds

Raising Construction funds

ESFRI proposal

ESFRI decision

Site Decision

ET RI construction

ET detectors construction

Opera-tion

RI operative TDR

Pre-engineering studies

Detector Operative TDR

ET Installation

ESFRI Phases:
- Design
- Preparatory
- Implementation
- Operation

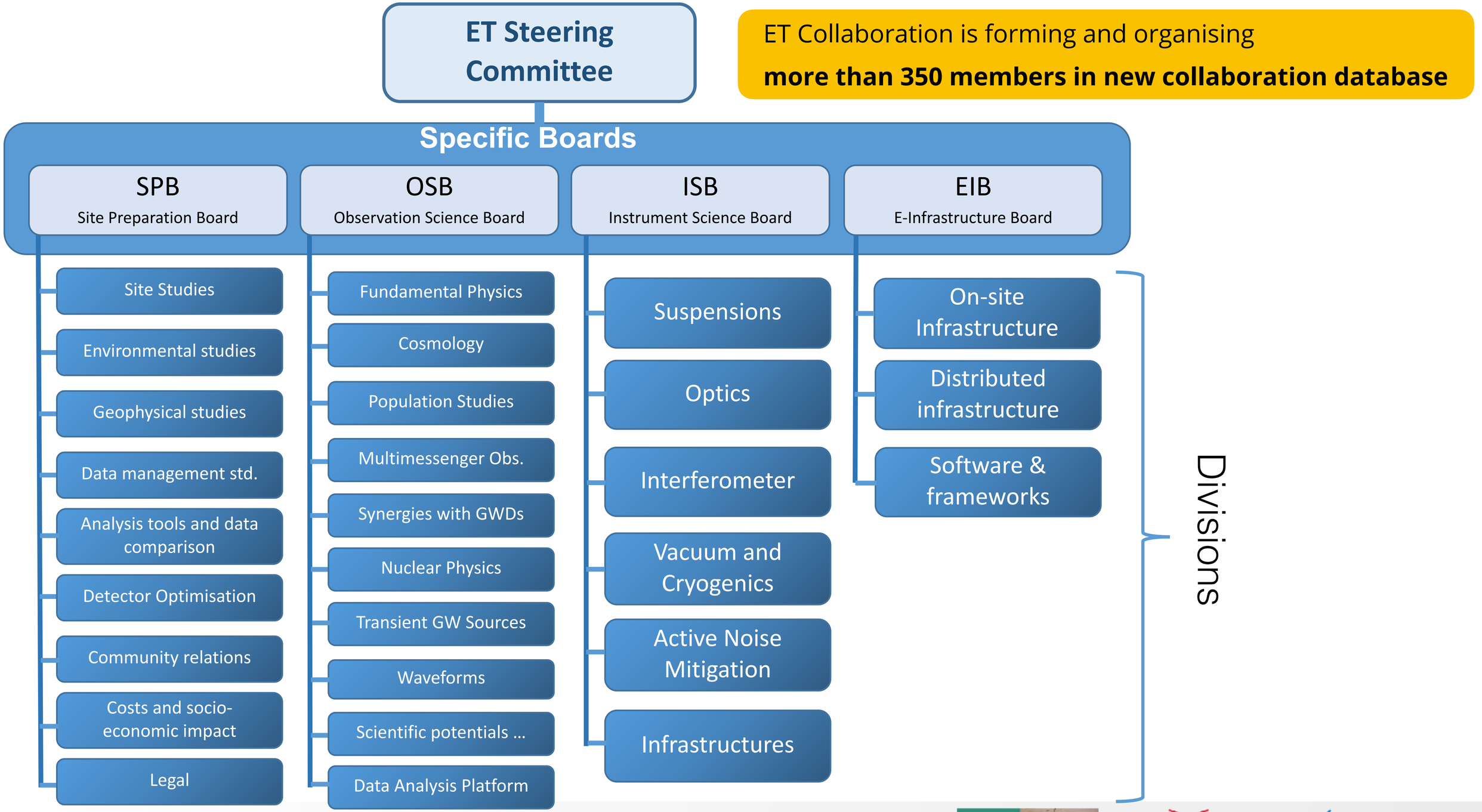
2004 2008 2010 2018 2019 2020 2021 2022 2023 2024 2025 2026 2028 2030 2032

09.09.2020: Submission of the Einstein Telescope ESFRI roadmap application, with strong support of the Dutch Ministry of Education Culture and Science.
Nikhef and INFN are the two coordinators of the project.

Einstein Telescope timeline

The Einstein Telescope is planned as a large underground facility with a **50+ years lifespan.**

- 2010 ET conceptual design completed
- **2020/2021 Design update, forming the ET collaboration, ESFRI application**
- **2024/2025 Site selection**
- 2026 Full technical design
- 2027 Infrastructure realisation start (excavation, ….)
- 2032+ installation / commissioning / operation


ET Steering Committee
ET Collaboration is forming and organising
more than 350 members in new collaboration database
Specific Boards
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Site Preparation Board
OSB
Observation Science Board
ISB
Instrument Science Board
EIB
E-Infrastructure Board
Site Studies
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Geophysical studies
Data management std.
Analysis tools and data comparison
Detector Optimisation
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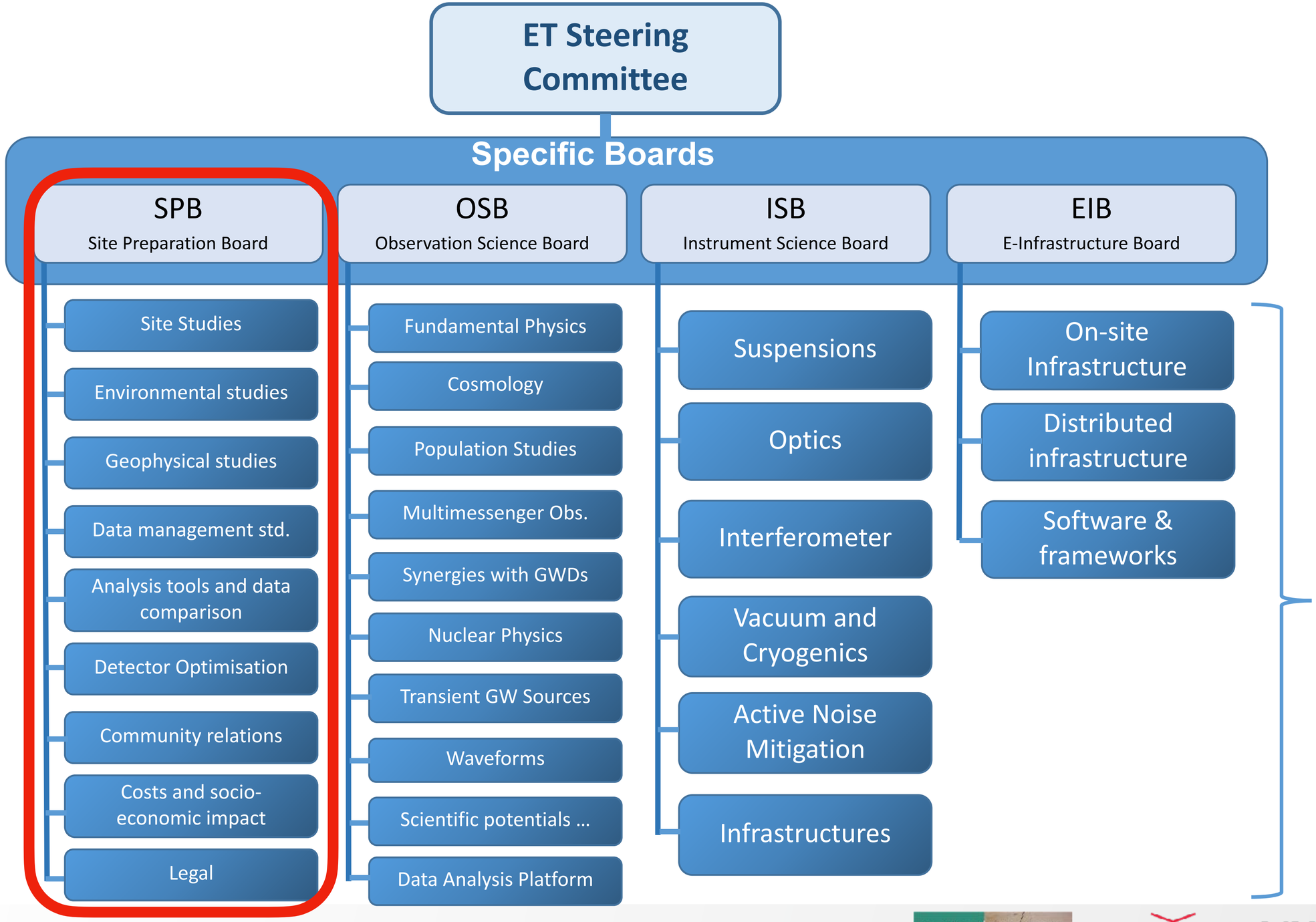
Waveforms
Scientific potentials …
Data Analysis Platform
Suspensions
Optics
Interferometer
Vacuum and Cryogenics
Active Noise Mitigation
Infrastructures
On-site Infrastructure
Distributed infrastructure
Software & frameworks
Divisions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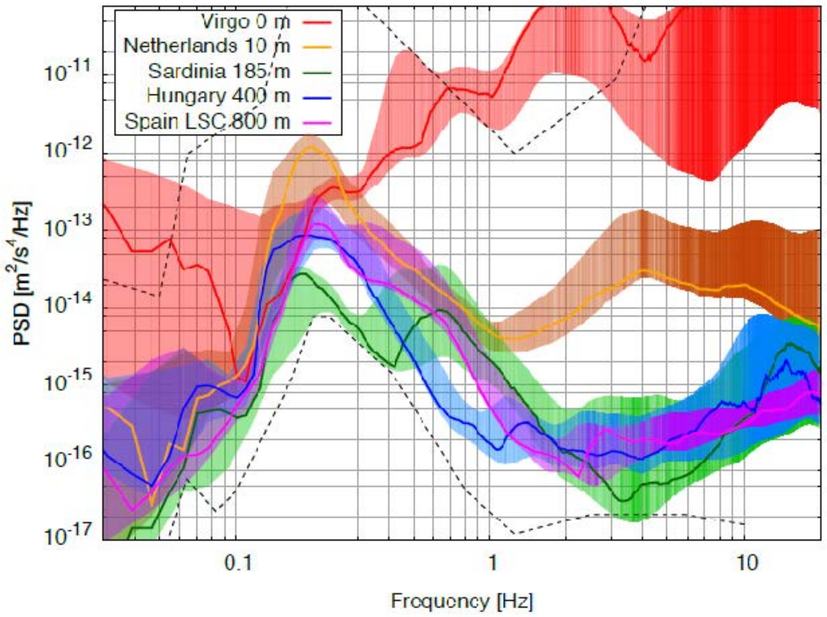
Site Preparation Activities

ET has two site candidates with community support and political support: a) **Euregion Meuse-Rhine**, a cross-border region in the Netherlands, Belgium, Germany, and b) **Sardinia** Italy



Site preparation Board currently forming, coordinators: **Frank Linde** and **Domenico d'Urso**

Planned activities:

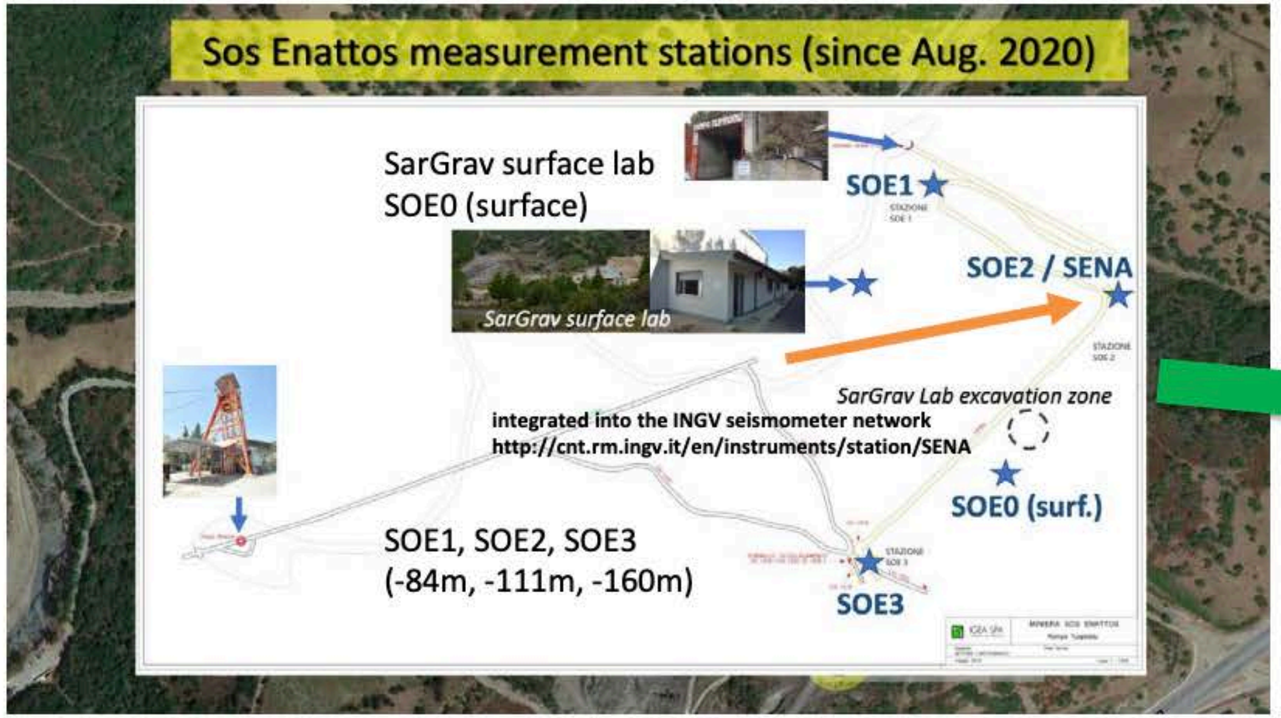
- joint seismic campaigns i.e. exchange ideas/methods/hardware/manpower

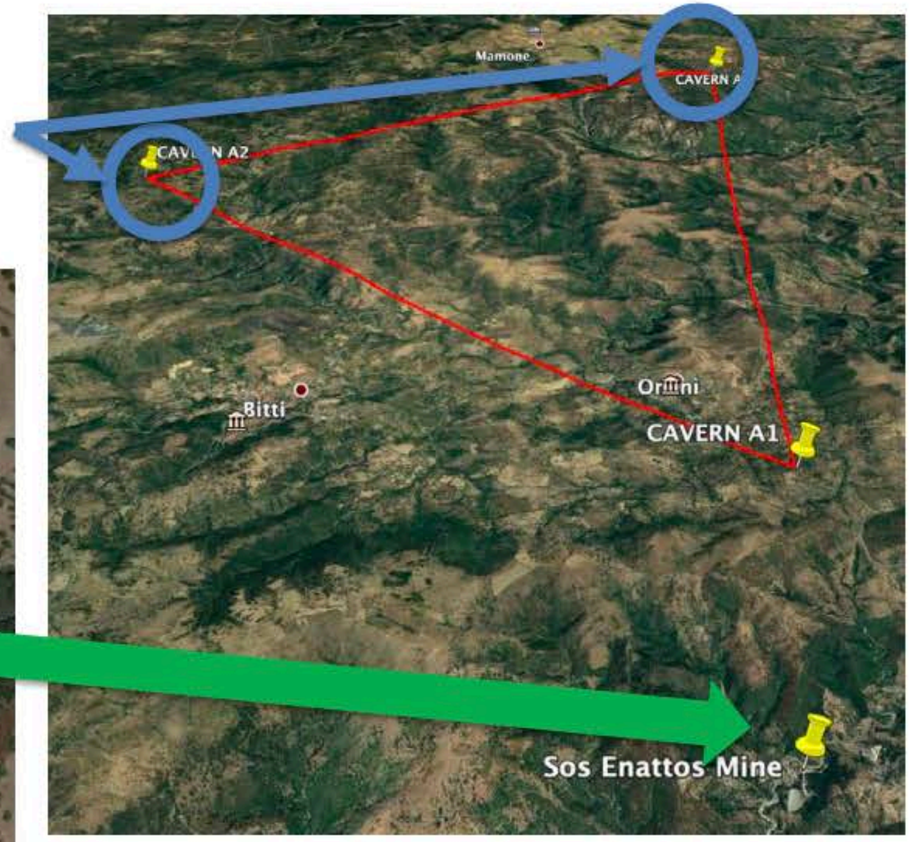
- workshop on data formats, analysis tools accessibility of data (public), etc. Planned for September in person on Sardegna. Possibly combined with a large passive seismic campaign.

Slide: Domenico D'Urso

Measurement in Sardinia

Characterization of the Bitti and Onanì corners:
Surface and underground seismic and
environmental measurements will start soon



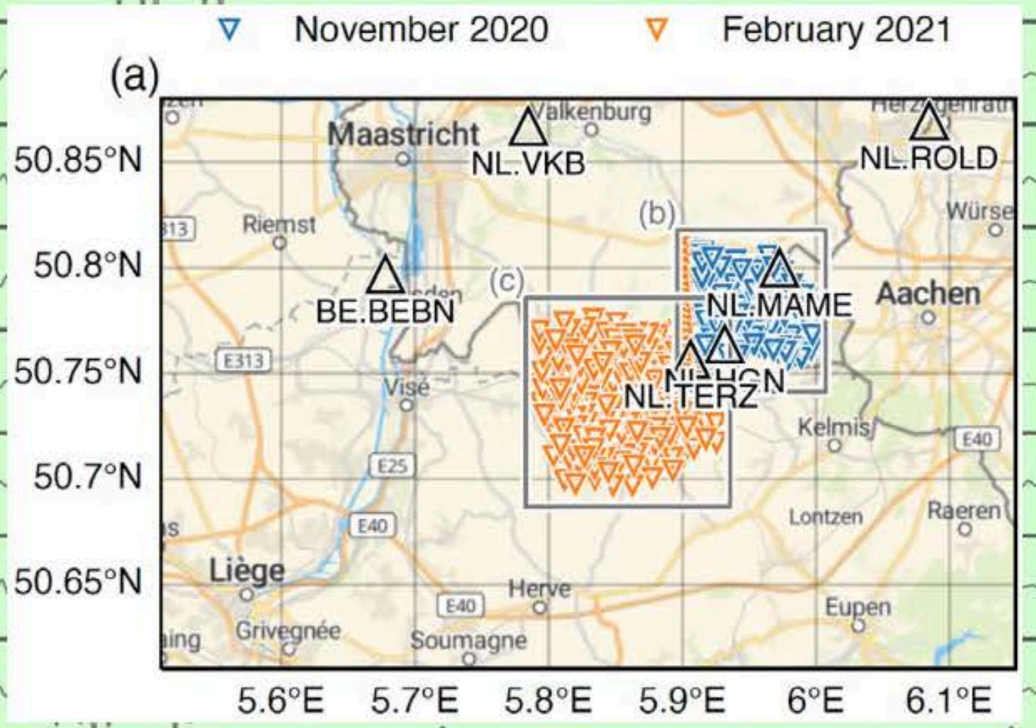


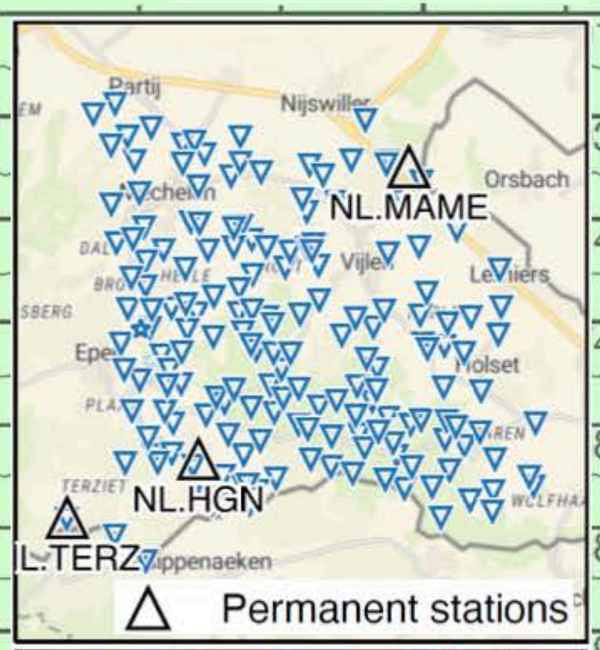
4 broadband seismometers, 3 short-period seismometers, 2 magnetometers,
1 tiltmeter distributed over underground and surface stations

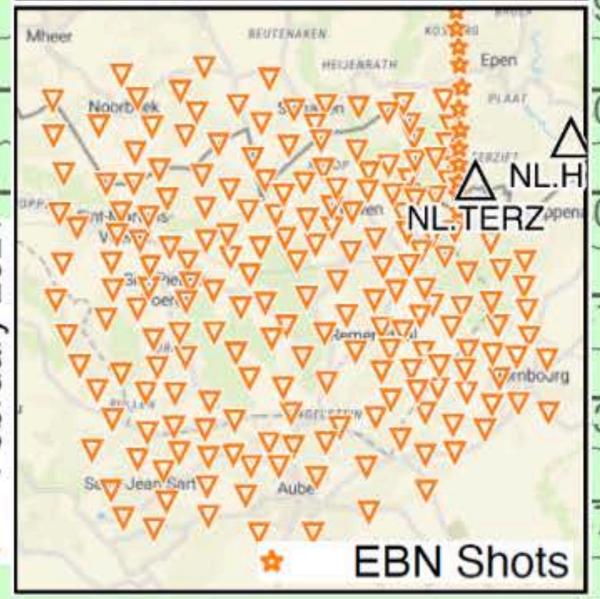
Credits to L. Naticchioni

Measurements in the Euregio Meuse-Rhine

Data: https://www.fdsn.org/networks/detail/3T_2020/



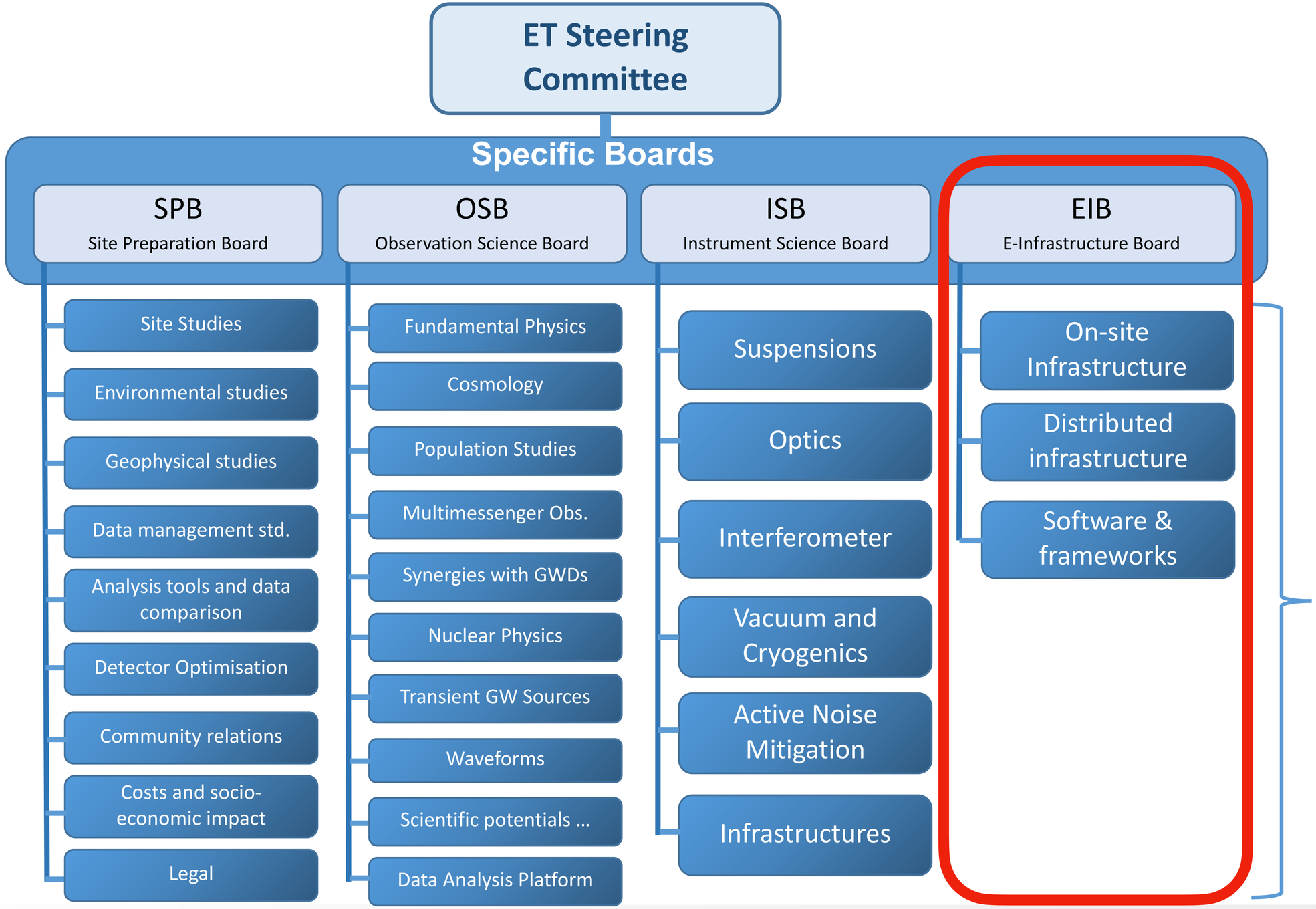




Terziet: Live data: http://www.orfeus-eu.org/data/odc/realtime/?network=NL&station=TERZ

First three: on ground

Lower three: down hole sensor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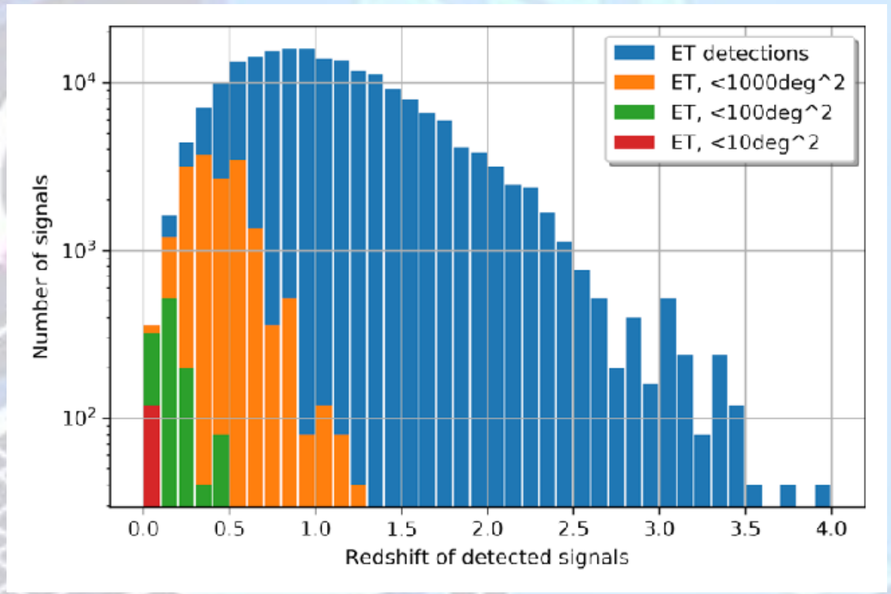
ET Computing Challenges



Data size is not worrisome (tens of PB/year),
but there's much more science in there:

10^4-10^6 GW candidate events per year!

Extracting it from the data will be a computational challenge.

ET will need to:

- design a reliable and powerful data processing infrastructure, both for off-line and low-latency analyses
- optimize analysis code, processes and workflows to make analysis feasible
- design and operate a scalable and robust low-latency alert generation infrastructure
- follow the technology updates in the coming years

Computing Infrastructure Board

We are coordinating computing services for

- operation of the telescope
- analysis of the data
- communication
- adminstration of the collaboration
- outreach

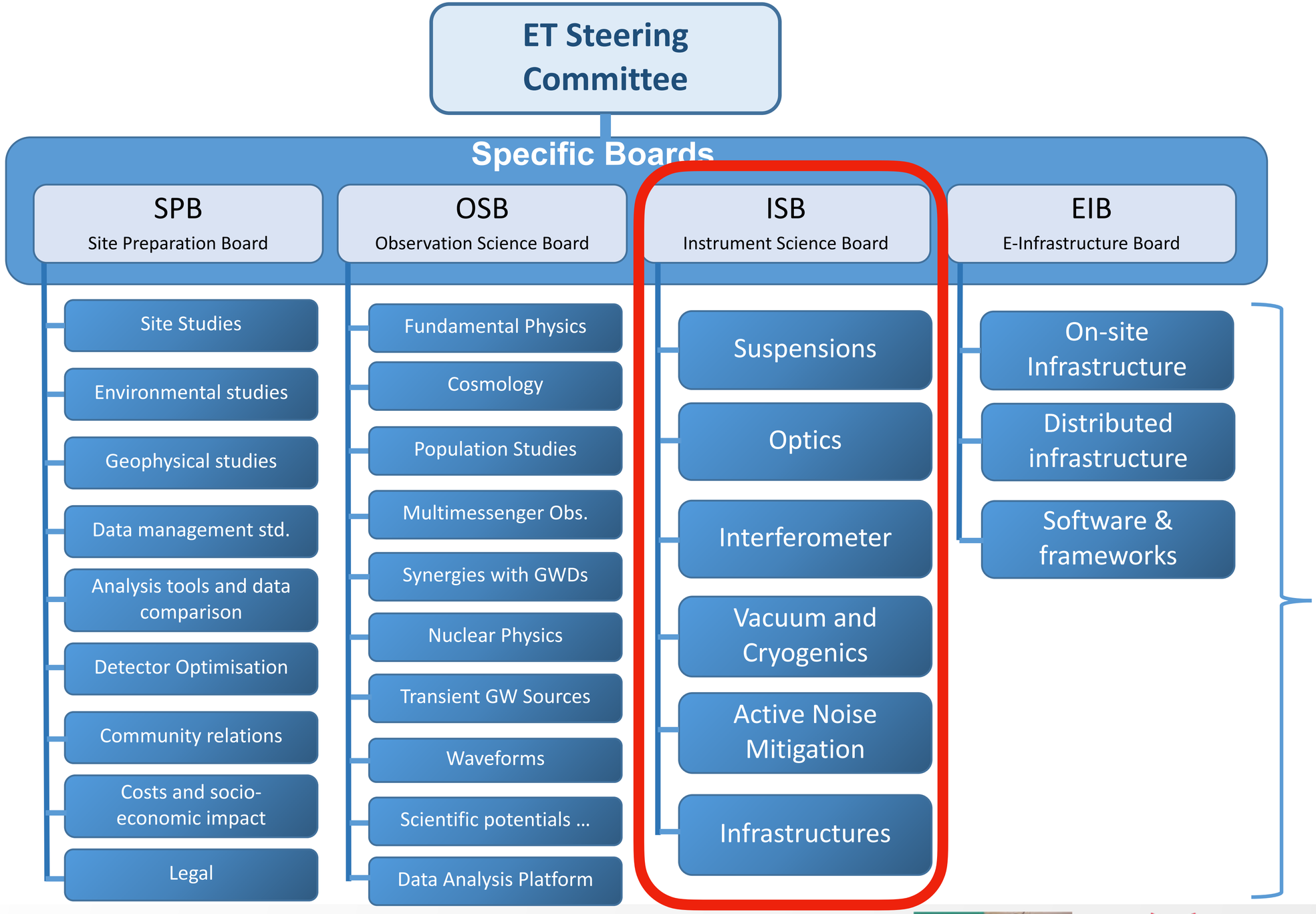
Your contribution would be very welcome!

Stefano Bagnasco

Patrice Verdier

Achim Stahl

If you are interested, let us know: **et-eib-chairs@lists.infn.it**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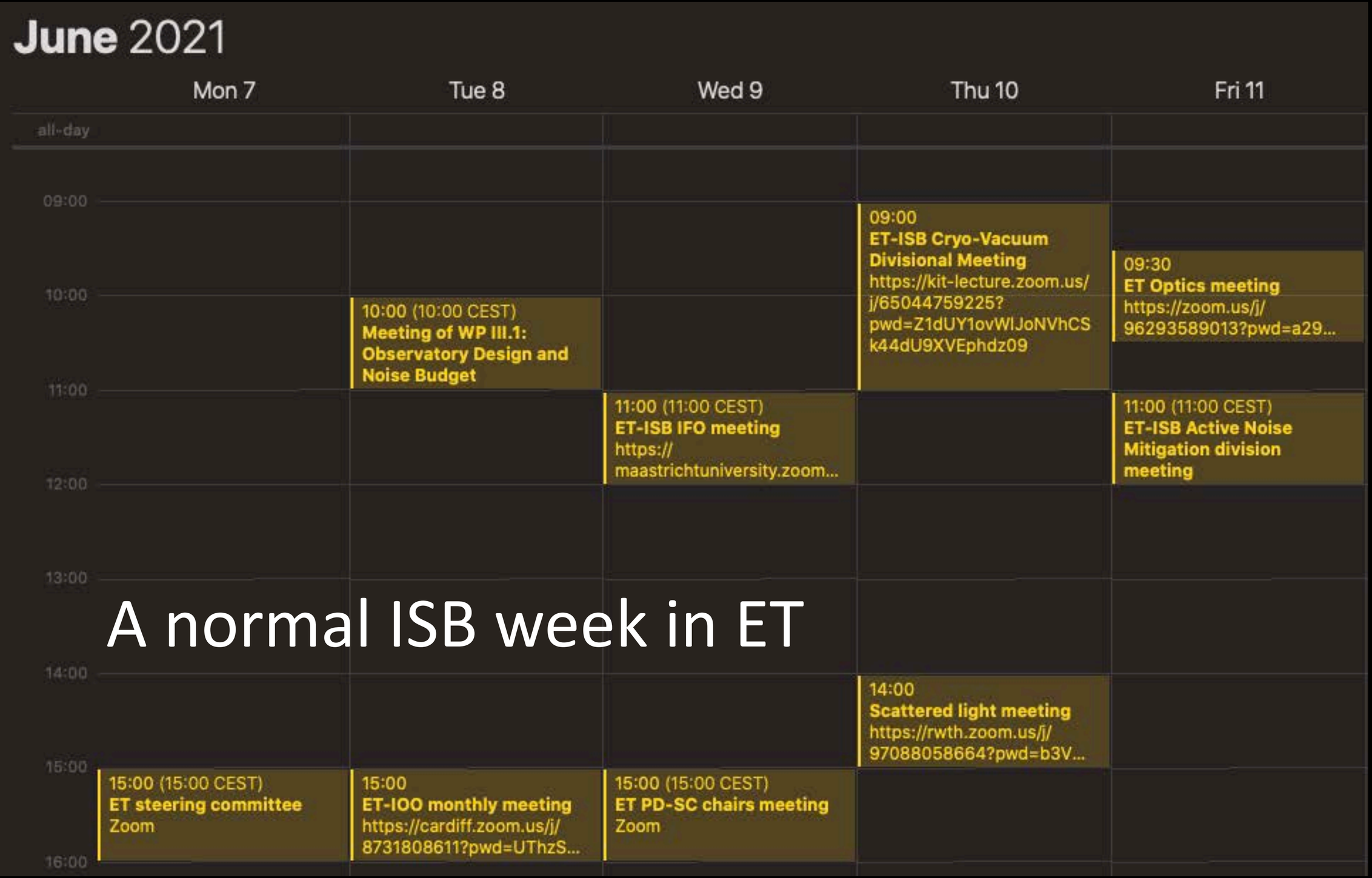


A normal ISB week in ET

Instrument Science

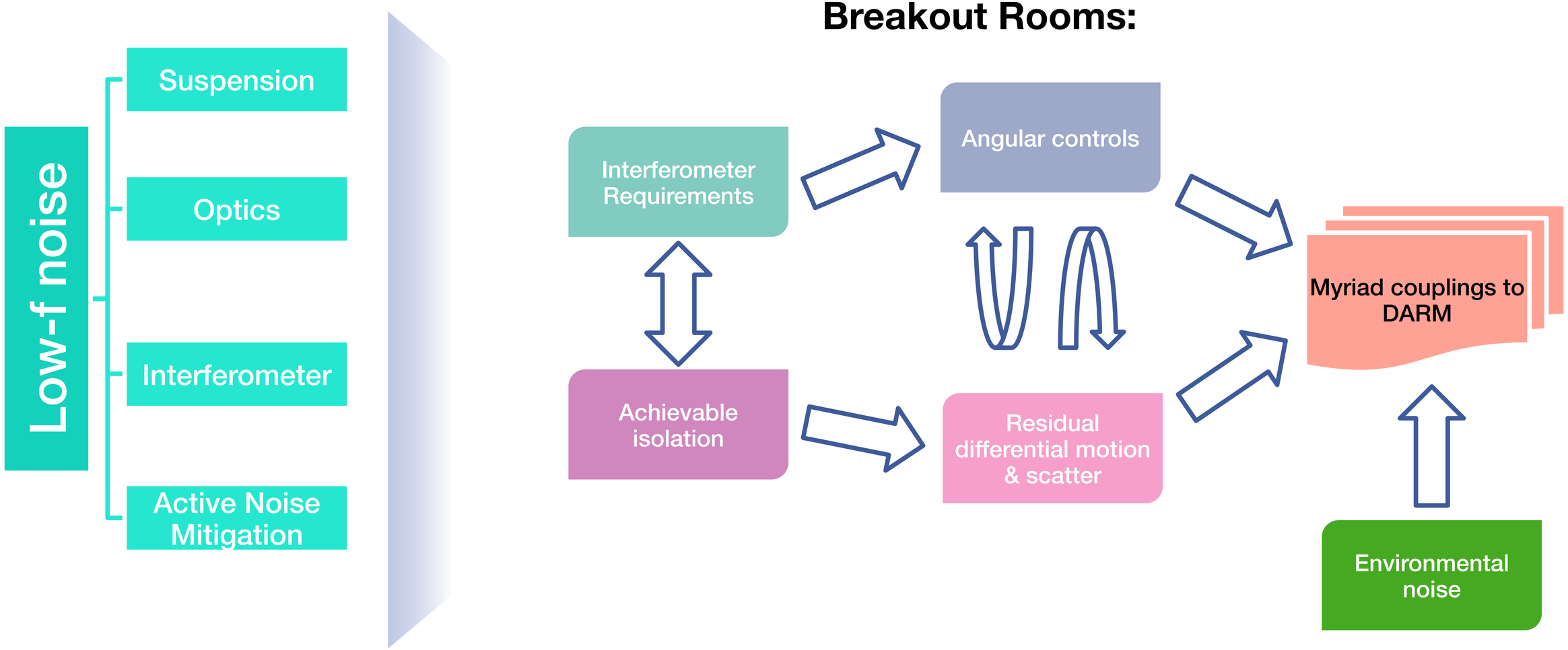
Everyone is welcome to join the ET Instrument Science Board

How to join? It's just four simple steps:

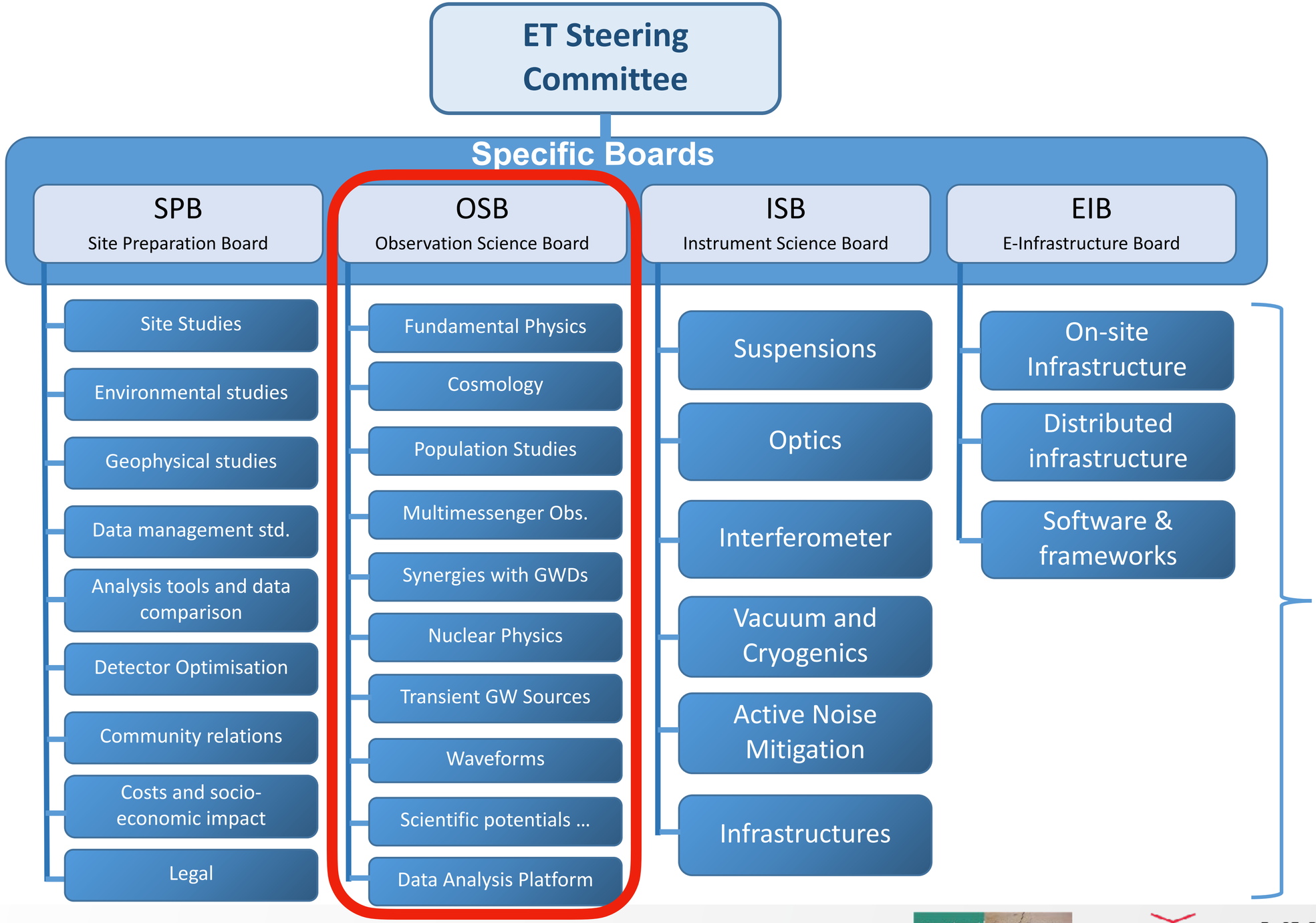
1. Find information at https://wiki.et-gw.eu/ISB/WelcomePage
2. Identify Divisions and Work Packages you are interested in
3. Contact the chairs of these groups by email
4. Receive an email with instructions to sign up for ET accounts

Done!

Low-frequency noise, example topic from recent ISB workshop



Conor Mow-Lowry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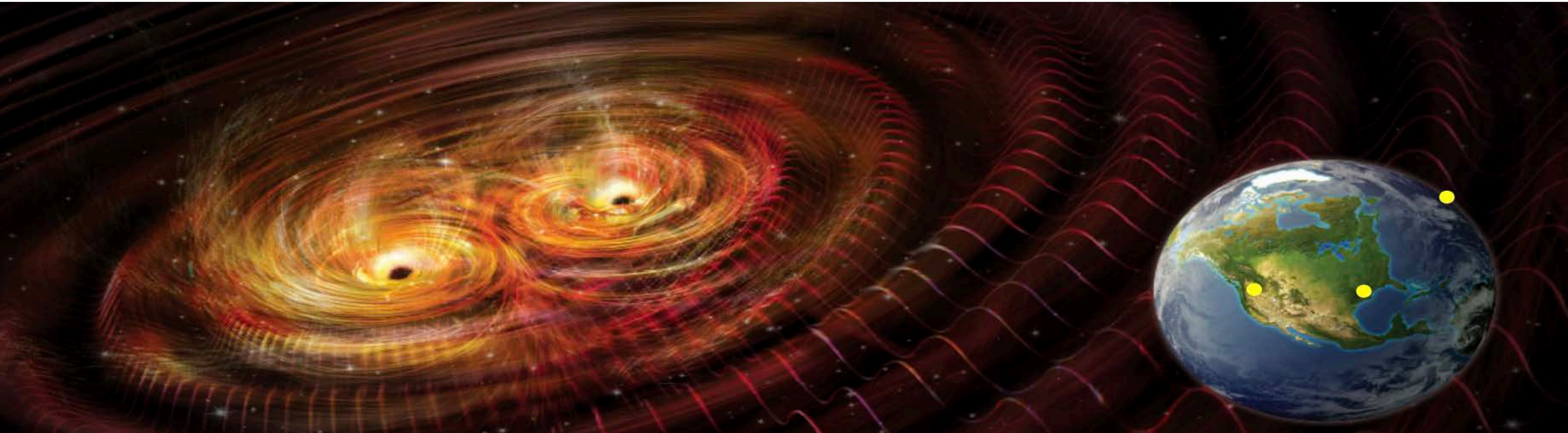
Join the OSB activities!

- The OSB coordinators are currently working to define the major science case to quantify and to organize the division work

- **A kick-off meeting will be held in September/October** for the scientific community to join the OSB



Observational Science Board (OSB)

Chairs: **M.Branchesi, M.Maggiore, E. Porter**

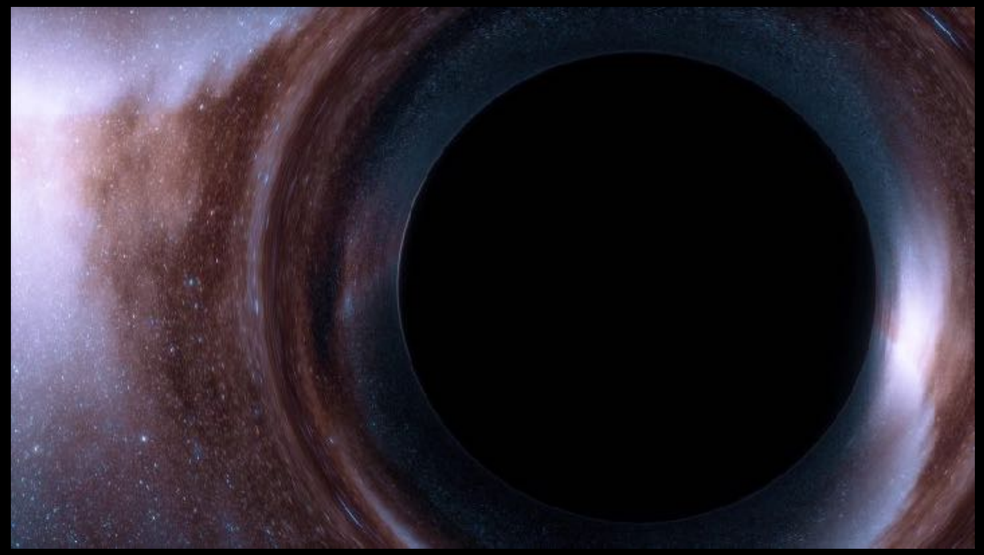
- Develop the **ET science case** to help the instrument technical development and implementation;
- Write a '**Blue Book**', a living document that summarizes and updates original work related to ET;
- **Stimulate the interest of other scientists** involving cosmologists, nuclear physicists, high-energy physicists, astronomers and astrophysicists;
- Build the synergy, collaboration and coordination with other gravitational-wave, electromagnetic, neutrino observatories;
- Identify the specific **data analysis and computing needs** for ET and begin the development of data analysis tools and algorithms.

OSB

- Fundamental Physics
- Cosmology
- Populations Studies
- Multimessenger
- Synergies with GWDs
- Nuclear Physics
- Transient GW sources
- Waveforms
- Scientific capability tools
- Data Analysis Platform

→ Coordinators: **P. Pani, R. Porto, C. van den Broeck**

Physics near BH horizon, tests of GR, exotic compact objects



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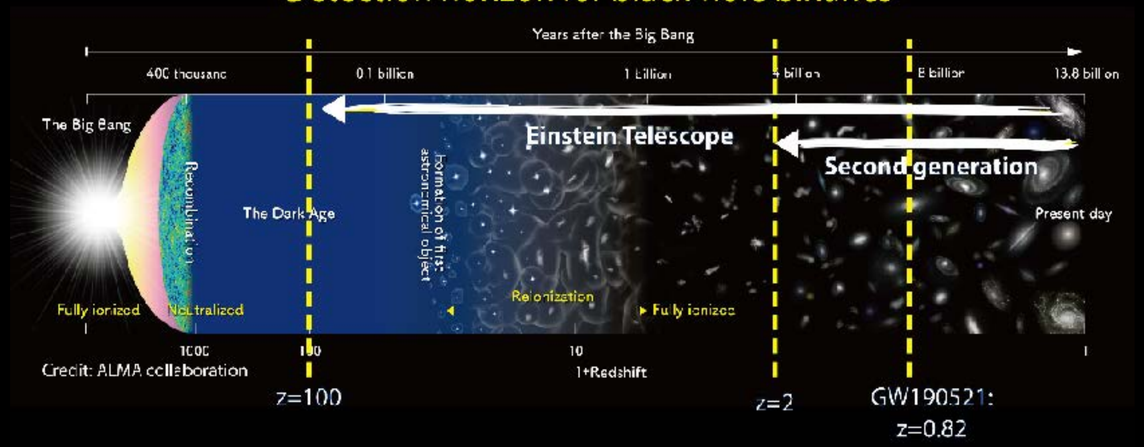
→ Coordinators: A. **Ghosh**, **A. Ricciardone, M. Sakellariadou**

Dark energy, dark matter,
estimation of cosmological parameters,
modications of gravity at cosmological scales,
stochastic backgrounds of cosmological origin

Detection horizon for black-hole binaries



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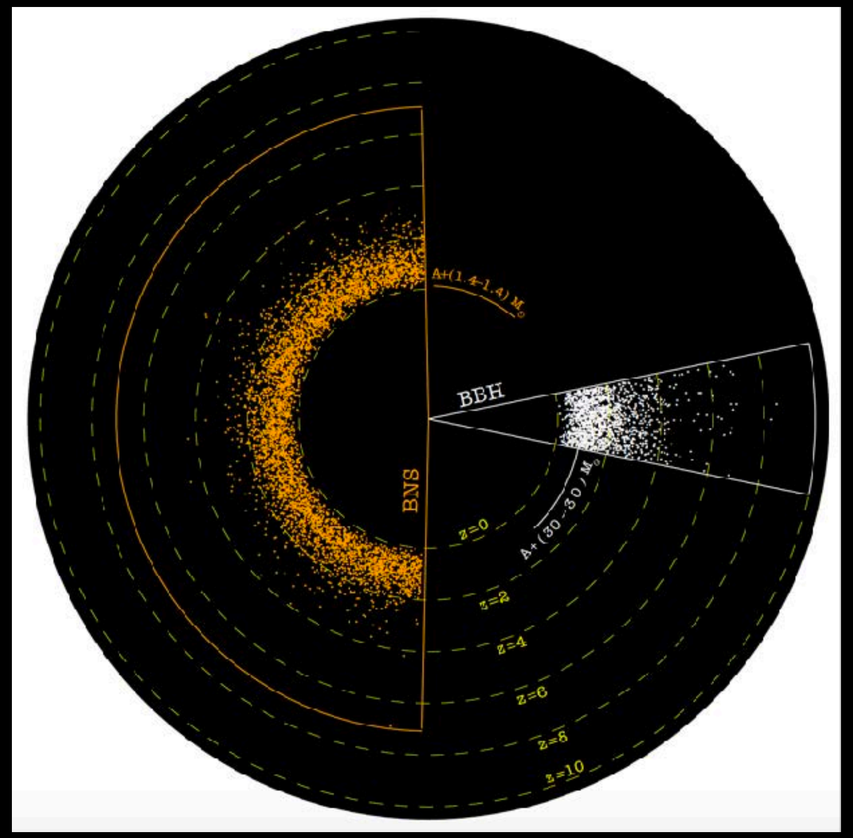
Coordinators: **G. Cusin, M. Mapelli, A. Riotto**

Predictions for astrophysical population,
predictions for primordial BHs,
stochastic backgrounds of astrophysical origin



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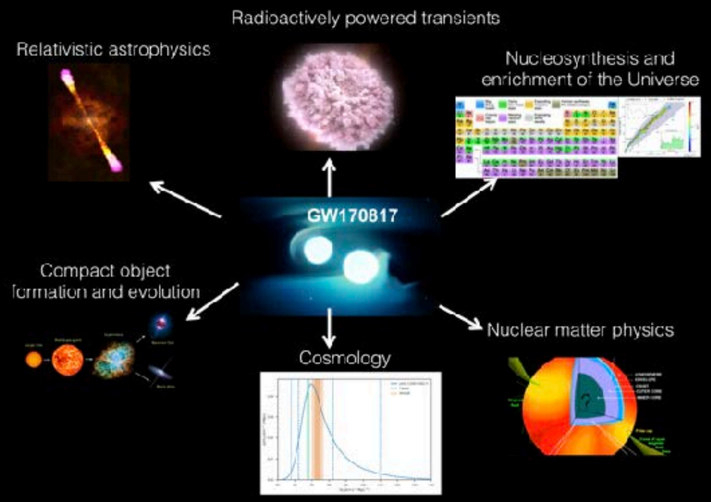

Coordinators: **G. Ghirlanda, S. Smartt, S. Vergani**

MM science with electromagnetic and neutrino facilities

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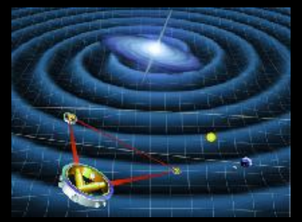

Coordinators: **N. Christensen, S. Nissanke, B. Sathyaprakash**

Synergies with 2G detectors, CE, LISA
ET capabilities in various ground-based network congurations
studies of the potential of multi-band observations with LISA

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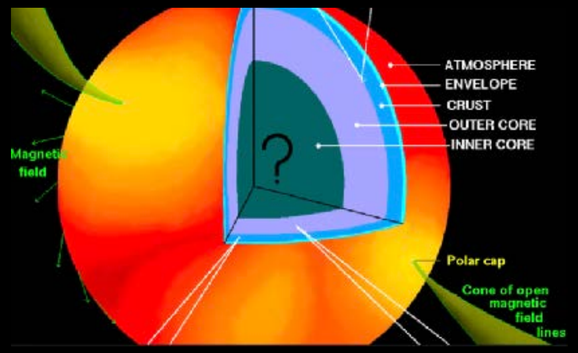

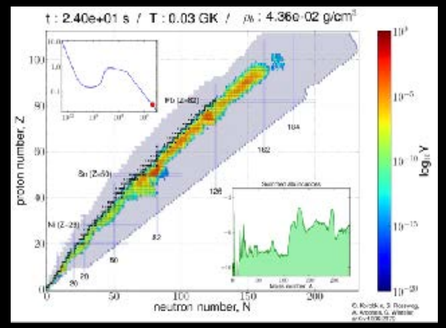

→ Coordinators: **Dietrich, T. Hinderer, M. Oertel**

EoS of neutron stars in isolated and binary systems, nucleosynthesis in BNS merger

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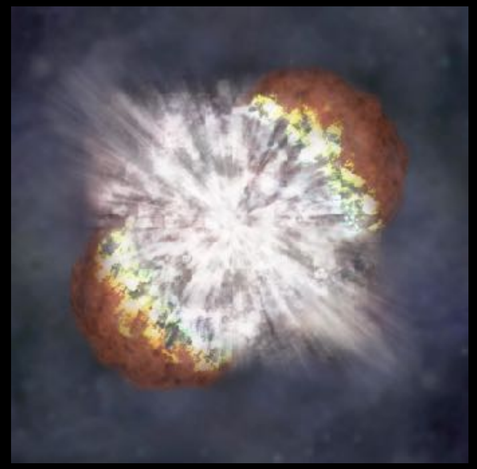
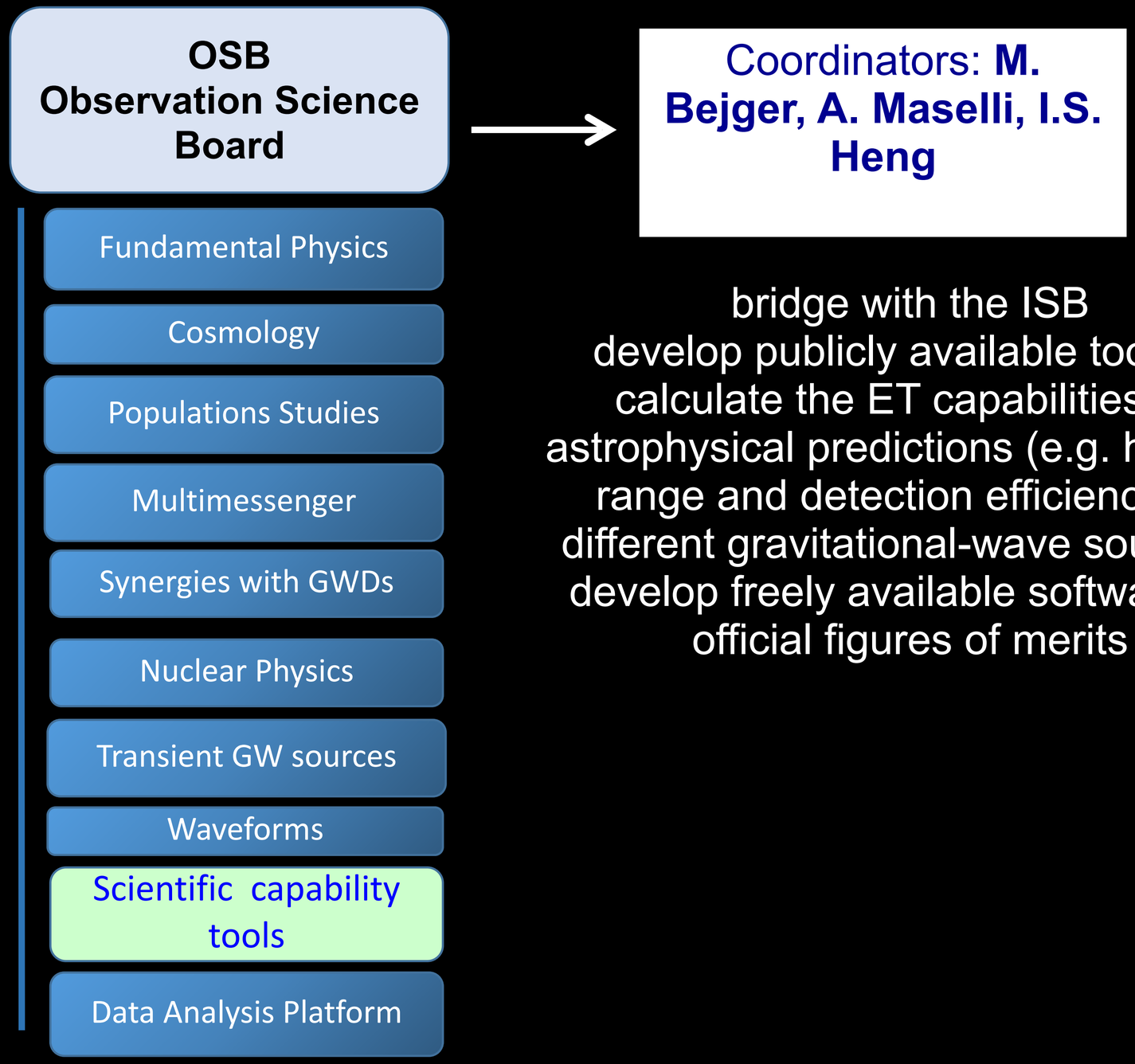
Coordinators: **M.A. Bizouard, P. Cerda-Duran, E. Cappellaro**

Predictions for Supernovae, magnetars, cosmic string bursts,



Coordinators: **L. Bernard, H. Pfeiffer, P. Schmidt**

Study of waveform relevant for ET, Improvement of the waveforms for BBH, NSBH, BNS. Development of waveforms for IMBHs and IMRIs



bridge with the ISB
develop publicly available tools to calculate the ET capabilities for astrophysical predictions (e.g. horizon, range and detection efficiency for different gravitational-wave sources);
develop freely available software for official figures of merits

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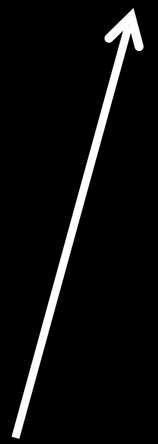
Coordinators: **E. Cuoco, T. Regimbau, J. Veitch**

building a common data analysis platform,
identifying the best option for computing resources (eg shared resources, cloud, etc.),
developing solutions to ET data-analysis problems,
activities toward mock data challenges



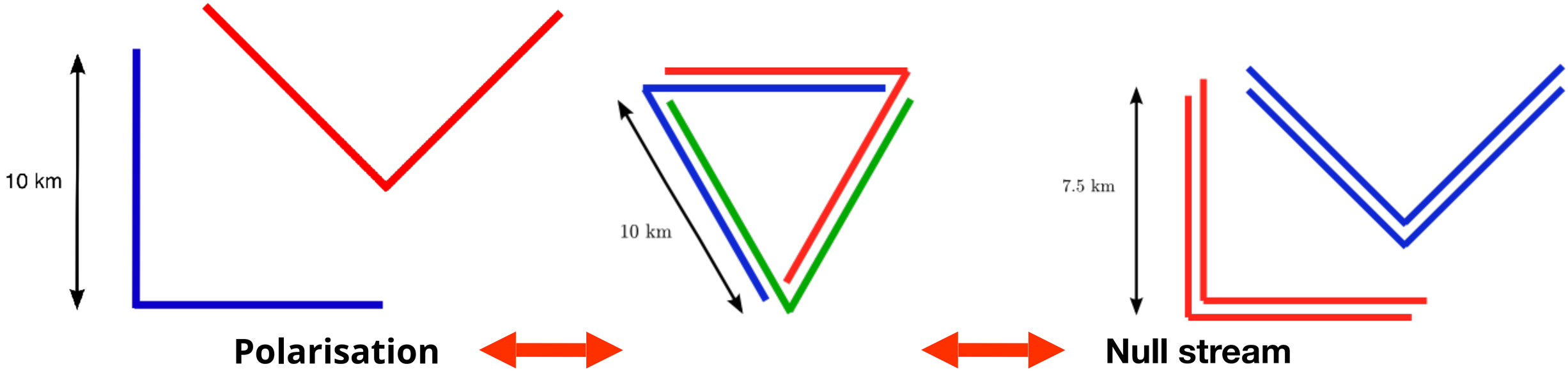
Friday ET Science Discussions

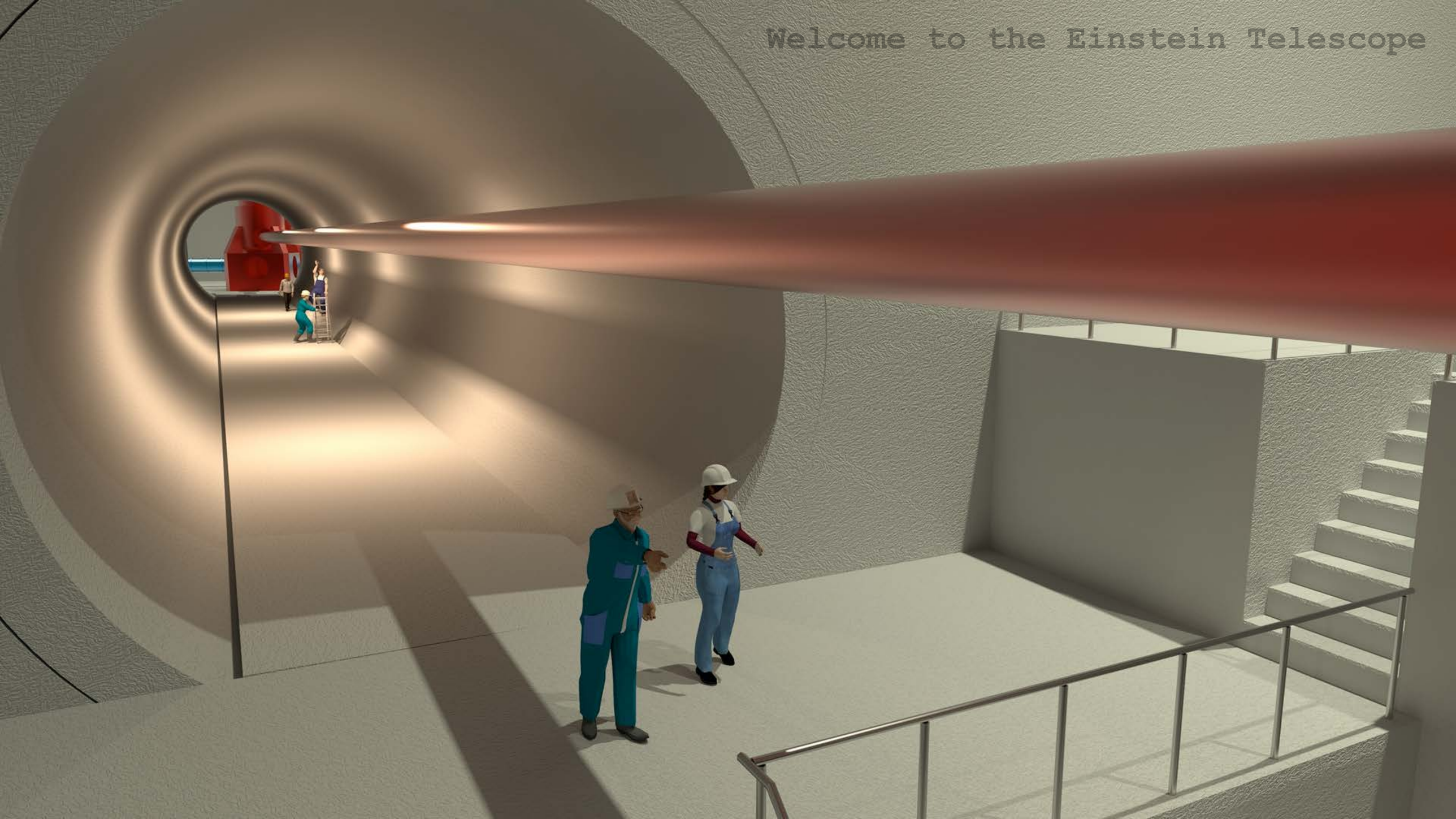
A triangle provides (or is equivalent to):

- interferometers optimised for both polarisation
- co-aligned interferometers (null-streams)

How can we quantify the scientific benefits of both features?

Ongoing discussions every Friday, if you are interested contact myself or **Ayatri Singha**




Welcome to the Einstein Telescope