

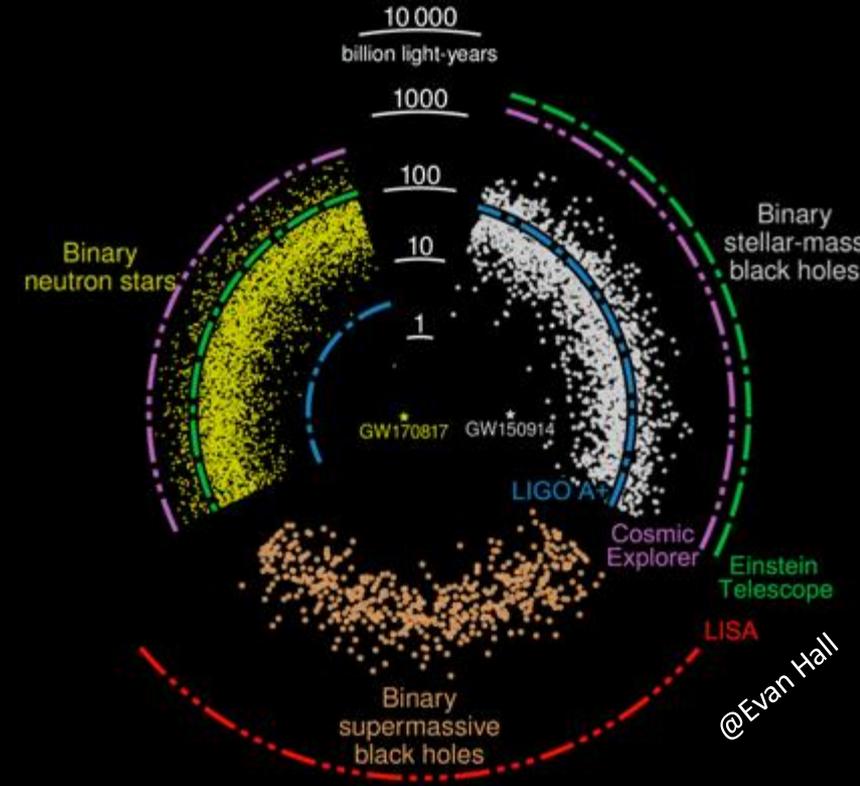
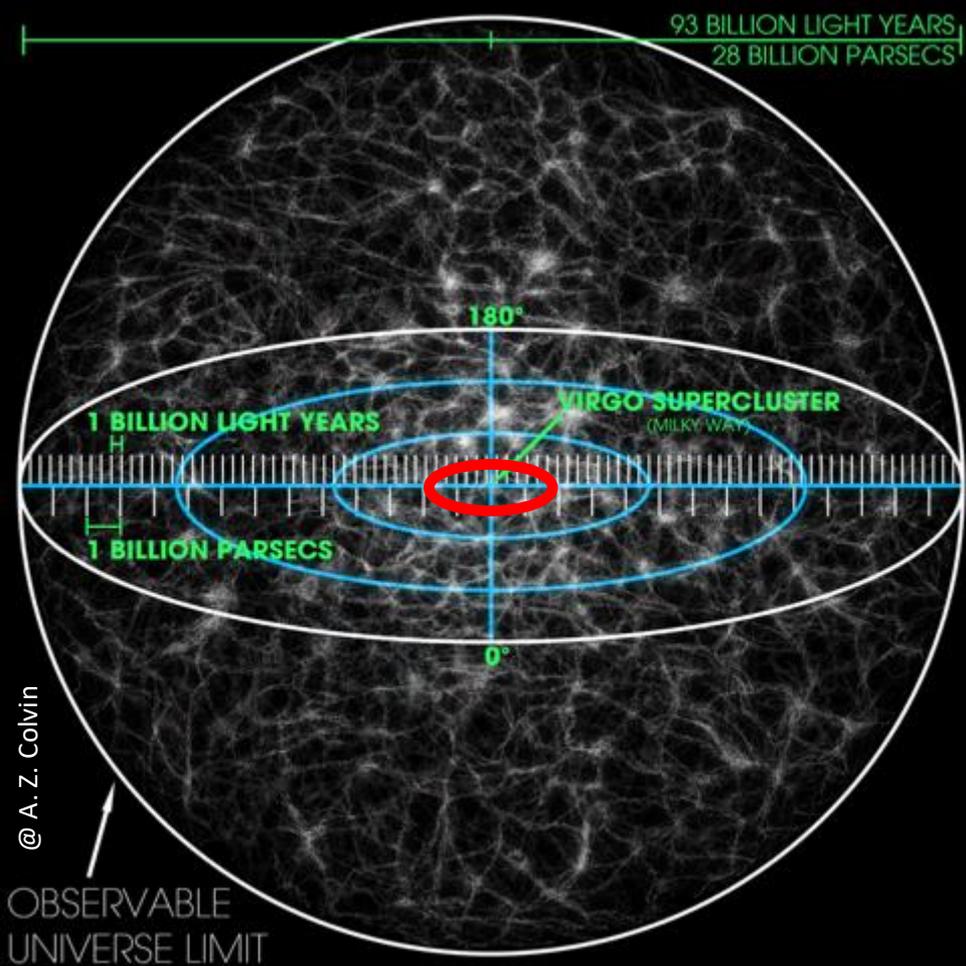
Sustainability, environmental impact, socio-economical impact within the Einstein Telescope project

GDR OG

Paris – February 18th, 2026

Patrice Verdier (IP2I Lyon – IN2P3) - patrice.verdier@in2p3.fr

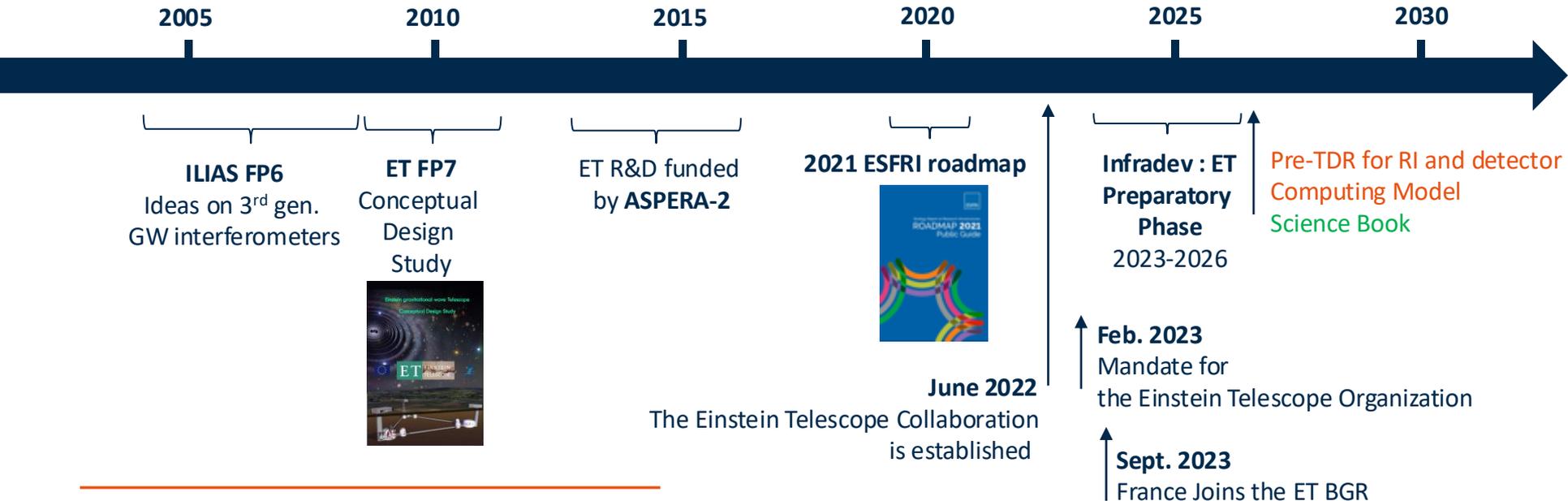
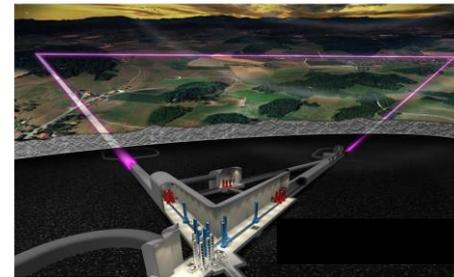
Why a 3rd generation of GW detectors ?



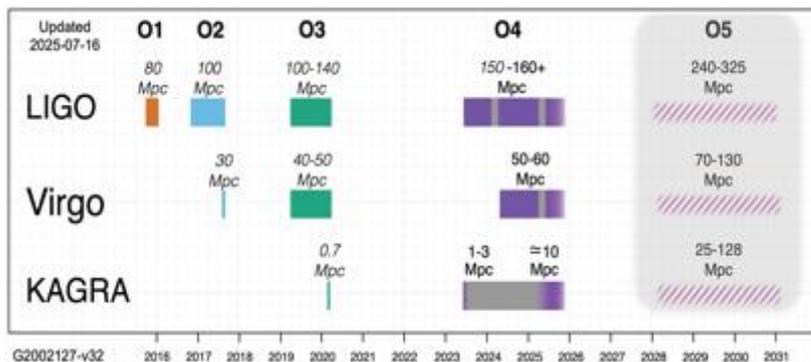
Einstein Telescope aims to study most of the observable Universe

ET pioneered the idea of 3rd generation GW observatory:

- A new infrastructure for >50 years
- Sensitivity at least 10 times better than 2nd generation
- Huge improvement in sensitivity at low frequency (a few Hz to 10 Hz)
- **Essential French contribution since the initial studies**



Current infrastructures



Advanced Virgo+
Advanced LIGO+

New infrastructures

LIGO upgrade A#

Virgo_nEXT

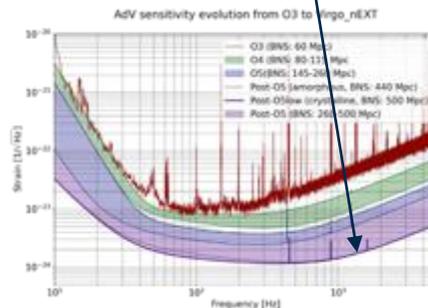
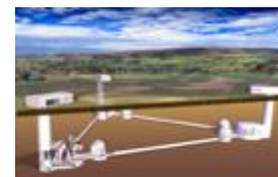
KAGRA upgrade

2030's

Cosmic Explorer

Einstein Telescope

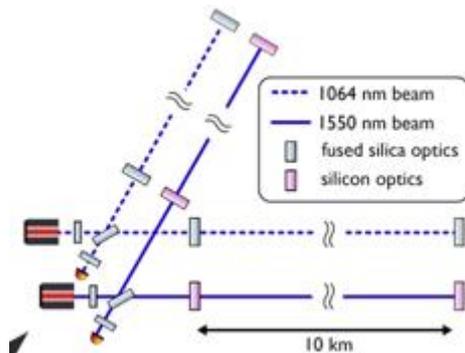
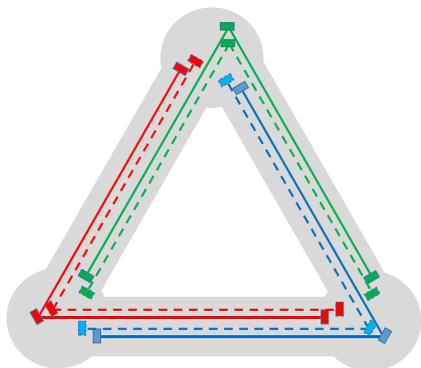
- First light before end of 2030' decade
- Full sensitivity a few years later (TBC)



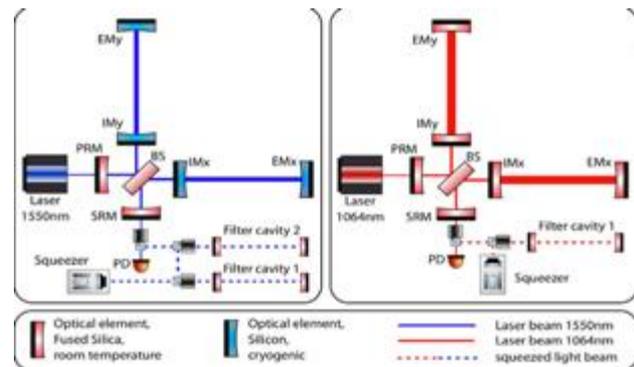
Xylophone design: 2 sensitive interferometers at different frequencies

ET-HF: LIGO-Virgo-like with huge technology improvement

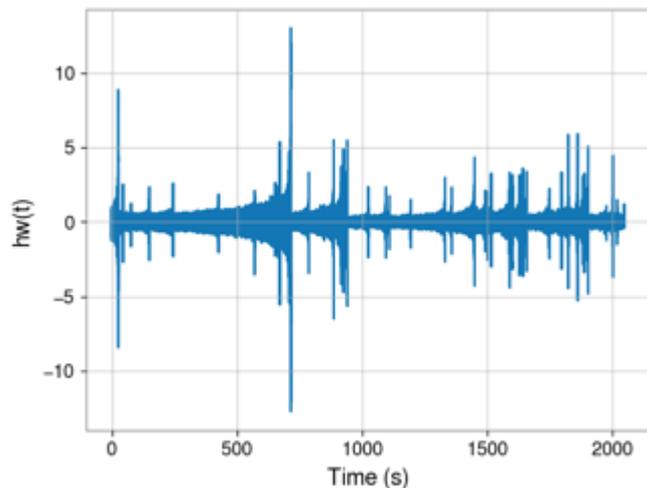
ET-LF: new kind of interferometer – especially : cryogenic, new laser wavelength, new mirror substrate (silicon or sapphire)



4 or 6 interferometers depending on the geometry: L or triangle



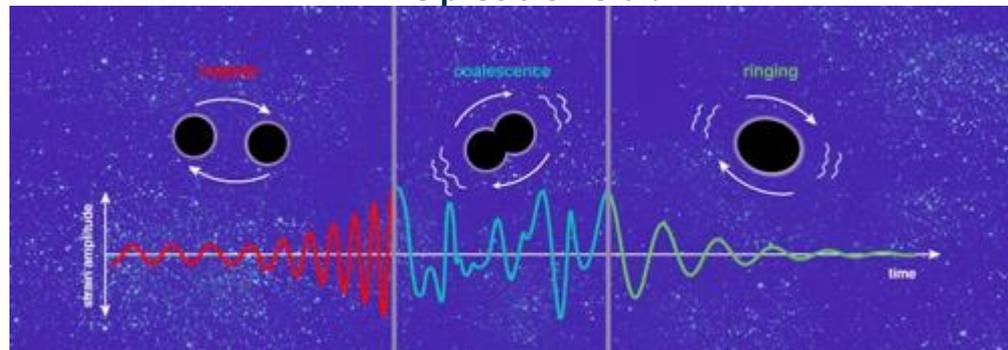
Parameter	ET-HF	ET-LF
Arm length	10 km	10 km
Input power (after IMC)	500 W	3 W
Arm power	3 MW	18 kW
Temperature	290 K	10-20 K
Mirror material	fused silica	silicon
Mirror diameter / thickness	62 cm / 30 cm	45 cm/ 57 cm
Mirror masses	200 kg	211 kg
Laser wavelength	1064 nm	1550 nm
SR-phase (rad)	tuned (0,0)	detuned (0,6)
SR transmittance	10 %	20 %
Quantum noise suppression	freq. dep. squeez.	freq. dep. squeez.
Filter cavities	1x300 m	2x1.0 km
Squeezing level	10 dB (effective)	10 dB (effective)
Beam shape	TEM ₀₀	TEM ₀₀
Beam radius	12.0 cm	9 cm
Scatter loss per surface	37 ppm	37 ppm
Seismic isolation	SA, 8 m tall	mod SA, 17 m tall
Seismic (for $f > 1$ Hz)	$5 \cdot 10^{-10} \text{ m}/f^2$	$5 \cdot 10^{-10} \text{ m}/f^2$
Gravity gradient subtraction	none	factor of a few



Regimbau, Suresh arXiv:2506.12237

- $O(10^5)$ BBH detections per year
- $O(10^4)$ BNS detections per year among which ~ 100 with EM counterparts
- Early universe : up to $z=100$
- High SNR events
- Very long signals (up to minutes or hours): early warning alerts
- Overlapping events

The precision era !



ET with Cosmic Explorer (3G in the US) in a network for multi-messengers astrophysics



ASTROPHYSICS

Black hole properties

origin (stellar vs. primordial)
evolution, demography

Neutron star properties

interior structure, equation of state & properties
of dense 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 (Radio, X, g and GW, FRB, ...)
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, phase transition in dense matter

Tests of General Relativity

post-Newtonian expansion, strong field regime

Dark matter

primordial BHs
axions, 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

The “unexpected” ?

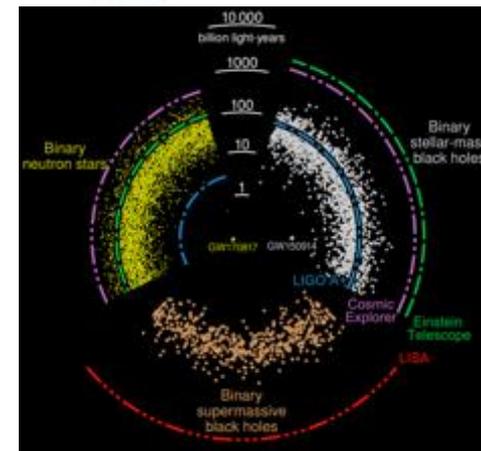
The discovery of GWs has opened a new avenue for the observation and study of the Universe: booming scientific field !

March 2025: ET blue book publication

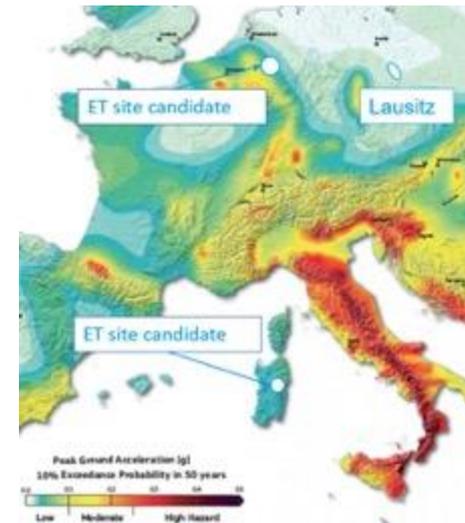
<https://arxiv.org/abs/2503.12263>

Accepted by JCAP

880 pages document



- **Three candidate sites** candidates to host ET: **EMR, Sardinia, and Lusastia**
 - Italy and the Netherlands have pledged to cover nearly half of the cost if their proposed sites are selected
 - Important budget in Italy (50M€), The Netherlands (42M€), and Germany (~90M€) to support **site characterizations** (boreholes, seismometer, environmental studies), **civil engineering studies** (tunnels and caverns), **Instrumental &D and physics studies**
 - **All 3 are underground** :
 - **Seismic noise attenuates with depth**
 - **Newtonian noise is less significant and NN cancelation system can be developed to reach sensitivity below 10 Hz**
- **Geometry:**
 - Studies of physics potential has led to two geometry possibilities which are jointly evaluated: "2L 15 km" is generally better (45° orientation) and less risky than the triangle
 - Site Selection Criteria Committee will provide recommendations to BGR in 2026



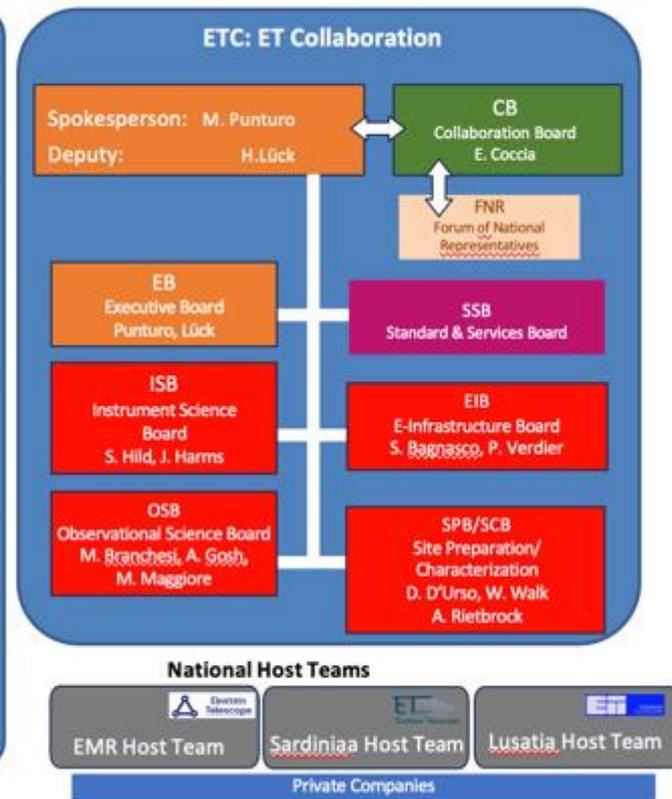
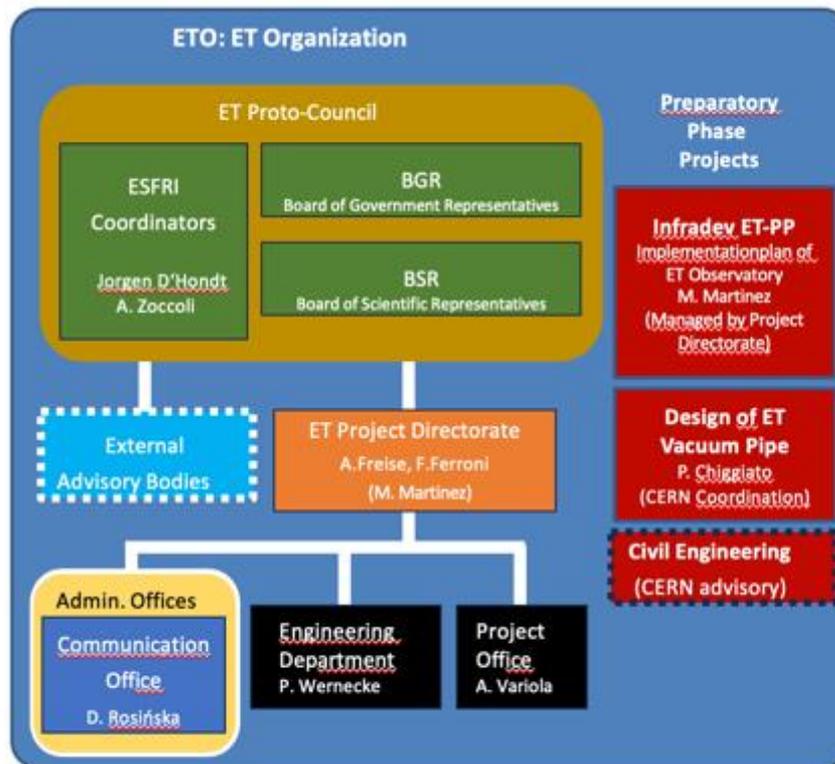
Decisions on site and geometry are expected in 2026-2027



The EU supports the creation of the ET infrastructure (ETO) through the financing of an Infradev project:

Einstein Telescope Preparatory Phase (ET-PP) 2023-2026

The Einstein Telescope Collaboration: 1900 scientists from 271 institutions



Since the summer of 2022, the ET structures are being put in place
French scientists took important responsibilities in ETC



HORIZON-INFRA-2021-DEV-02 : « Developing and consolidating the European research infrastructures landscape, maintaining global leadership » - et donc, accompagnemnt EU au montage des IR nouvellement inscrites ESFRI

<https://etpp.ifaef.es/>

Einstein Telescope Preparatory Phase (ET-PP): projet sur 4 ans (2022-2026)

Coordination: Mario Martinez (Espagne, IFAE) **Pays des instituts & laboratoires participants**:

Allemagne, Autriche, Belgique, Espagne, France, Hongrie, Italie, Pays-Bas, Pologne, Royaume-Uni, Suisse

Financement EU: 3,45 M€

Budget total: 13,9 M€ i.e. in-kind de 10,45 M€ (salaires des permanents)

ET-PP fournira un plan de mise en œuvre détaillé pour l'infrastructure ET:

- l'élargissement du consortium de ET
- le cadre juridique, les régimes de gouvernance et les réglementations financières pour construire et exploiter
- la conception technique détaillée et le chiffrage de l'observatoire ET
- la préparation de la sélection du site
- coûts de l'infrastructure du site, de ses impacts socio-économiques et environnementaux
- les programmes de transfert de technologie, d'approvisionnement et d'implication de l'industrie dans la conception technique et la construction
- le lien requis avec les communautés scientifiques concernées concernant la définition détaillée du programme scientifique
- les services aux utilisateurs et le modèle d'accès aux données

INFRA-DEV ET-PP

Einstein Telescope
Preparatory Phase

ET-PP Horizon EU

3.45M€

12M€

(total value)



COUNTRY	Third parties
GERMANY	RWTH (Aachen), AEI (MPI), LUH (Hannover)
THE NETHERLANDS	VU (AMSTERDAM), UM (MAASTRICHT)
SPAIN	ICCUB (Barcelona), UV (Valencia), UIB (Mallorca) CDTI (Madrid)
POLAND	NCBJ, CAMK, Cyfronet, IMPAN

COUNTRY	Partners
AUSTRIA	U. LEOBEN
BELGIUM	U. ANTWERPEN
BELGIUM	U. LOUVAIN
EGO	EGO
FRANCE	CNRS
GERMANY	DESY
HUNGARY	WIGNER RCP
ITALY	INFN
THE NETHERLANDS	NIKHEF
POLAND	U. WARSAW
SPAIN	IFAE BSC-CNS (affiliated)
SWITZERLAND (associated partner)	U. GENEVA
UK (associated partner)	UKRI CARDIFF GLASGOW

@ Mario Martinez

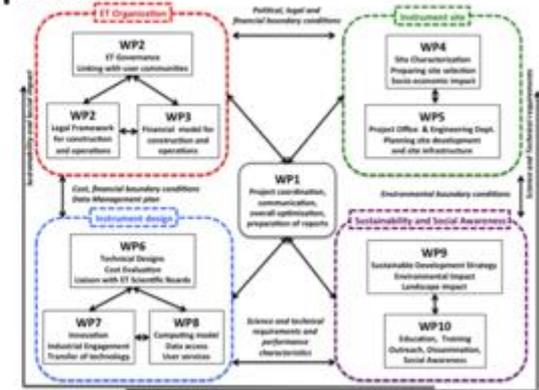
Coordination
CNRS:
Patrice Verdier

We initiated a targeted process to collect additional third parties to strengthen particular needs with significant contributions

→ KU LEUVEN new third party since July 2023

→ We plan for a revisited Grant Agreement in 2024

- WP1 Coordination and Management
- WP2 Organization, Governance and Legal Aspects
- WP3 Financial Architecture
- WP4 Site Preparation
- WP5 Project Office / Engineering Dept.
- WP6 Technical Design
- WP7 Transfer of Technology
- WP8 Computing and Data Access
- WP9 Sustainable Development Strategy
- WP10 Education, Outreach and Citizen Engagement



Co-coordination IN2P3 →

Participation IN2P3 →

Efforts CNRS focalisés sur le WP5: mise en place du Project Office et du Département Ingénierie

Part CNRS du financement EU: 907,5 k€ sur 3450 k€ (INFN=735k€, Nikhef=729 k€)

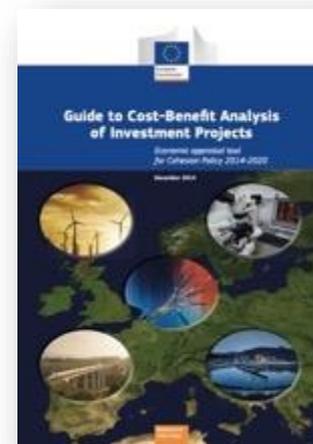
3 CDD ingénieurs environnés (300k€ chacun) pour travailler sur le WP5: APC, IP2I, LAPP

In-kind: 1600 k€, salaires des permanents (essentiellement ingénieurs) impliqués dans ET-PP

275 personnes.mois sur 4 ans soit 4,7 FTE



@Art Institute Of Chicago



EU analysis on RI sustainability

https://www.esfri.eu/sites/default/files/ESFRI_SCRIPTA_SINGLE_PAGE_19102017_0.pdf

Sustainability studies are supported by EU calls

<https://data.europa.eu/doi/10.2777/76269>

Cost-Benefit analysis:

Research Infrastructure guides foresee this approach

Required by ESFRI (evaluation questionnaire in 2025-2026)

EINSTEIN TELESCOPE RESEARCH INFRASTRUCTURE: CHALLENGES AND LONG-TERM SUSTAINABILITY

An academia-industry workshop aims to convene distinguished researchers, experts and industry specialists to address critical environmental sustainability challenges associated with large underground scientific infrastructure, specifically examining the Einstein Telescope project as a paradigmatic case.

16 - 17 FEBRUARY 2026 SAPIENZA UNIVERSITY, ROME
CHIOSTRO SAN PIETRO IN VINCOLI

Key topics

- Life cycle sustainability assessment
- Sustainable transportation and smart energy systems
- Efficient operational strategies
- Advanced underground construction solutions
- Social impact strategies and participatory design
- Industry engagement and sustainable procurement

PROGRAM COMMITTEE

Nicolas Bagard - CERN
 Alessandro Corani - Sapienza
 Giovanni De Camis - KIT
 Liubov Hrybushchak - UH
 Andrea Klump - DESY
 Paul Laycock - Univ. Geneva
 Roberto Lodi - CERN
 Maria Marsella - Sapienza
 Mauro Morandini - INFN
 Julian Ruttan - JRC Council
 Diego Sebastiani - GEEG
 Dennis Voelker - DESY
 Wessam Wubben - FINCW

EVENT SECRETARIAT

Elena Colombo
 Monica Marzano
 Francesca Scipione

INFO : <https://indico.cern.ch/e/ETsustainability2026>

Logos: CERN, ADVS, RIT, Survey Lab, GEEG

Developing a Sustainable Development Strategy for ET

The Einstein Telescope (ET) is a proposed underground gravitational wave observatory that aims to detect gravitational waves with unprecedented sensitivity. While the project holds great promise for advancing our understanding of the universe, it faces several sustainability challenges:

- Environmental Impact Assessment
- Efficient Resource Management
- Waste Generation
- Community Engagement
- Long-term Sustainability Planning
- Climate Change Resilience

The development of comprehensive sustainability strategy is a priority for ET to contribute to scientific advancements while minimizing its environmental and carbon footprint.

Day 1 – Monday 16/02

Session I – Opening & Introduction

- ET project: scientific challenges
- Sustainability Strategy for ET
- Large Research Infrastructures Sustainable Management

Session II – Life Cycle Assessment

- Experience of LCA for ILC/CLIC CERN
- Digital Modeling and Data-Driven approach
- PETRA IV project at DESY

Session III – Sustainable Transportation & Smart Energy

- Real Time Systems for Energy Technologies
- Sustainable transportation
- CERN energy management strategy
- Off-shore wind energy

Session IV – Efficient Operation

- ET computing model
- Green data centers
- Optimization strategy for ET detector/instrument

Day 2 – Tuesday 17/02

Session V – Underground Construction Solutions

- Mechanized excavation technologies
- Circular water management
- Excavated soils and rocks management
- Shaft construction technologies

Session VI – Societal Impact & Participatory Design

- Societal Impact and Participatory Design
- Societal Impact in infrastructural transitions
- Social Innovation in Climate Transitions
- Cosmic Explorer community-based approach

Session VII – Industry Engagement & Sustainable Procurement

- ET trajectory toward construction
- Business involvement in ET
- Sustainable procurement
- Innovation procurement

3:45 PM Tue, February 17

3:45 - 4:05 PM

Conclusions and outlook: Lessons learned and takeaways from the workshop

Session
Location: Chiostro San Pietro in Vincoli (Sapienza University), Sala del Chiostro, Via Eudossiana, 18 - 00184 Roma (RM)

Sustainable Development Strategy – Main Goals

Develop a strategy for the realization of a **long-term sustainable research infrastructure**

- Develop a robust and integrated Environmental Impact Assessment framework aligned with EU EIA Directive (2011/92/EU as amended by 2014/52/EU)
- Define strategies for excavation and material reuse
- Deliver life-cycle based carbon footprint assessment and mitigation roadmap
- Maximize socio-economic benefits and institutional robustness



ET Sustainable Development Strategy - Reports

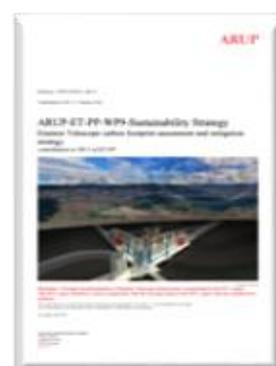
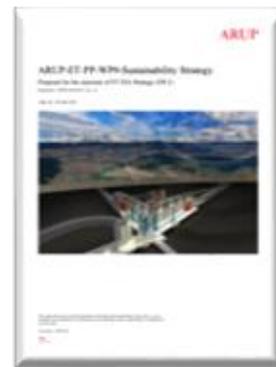
@ M. Marsella & F. Spagnuolo

ET Environmental impact assessment and mitigation strategy

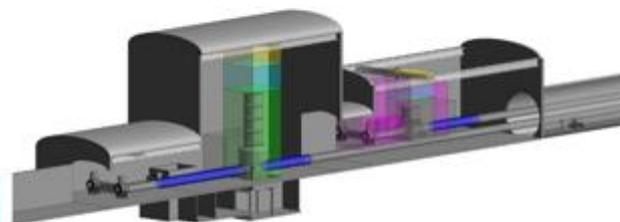
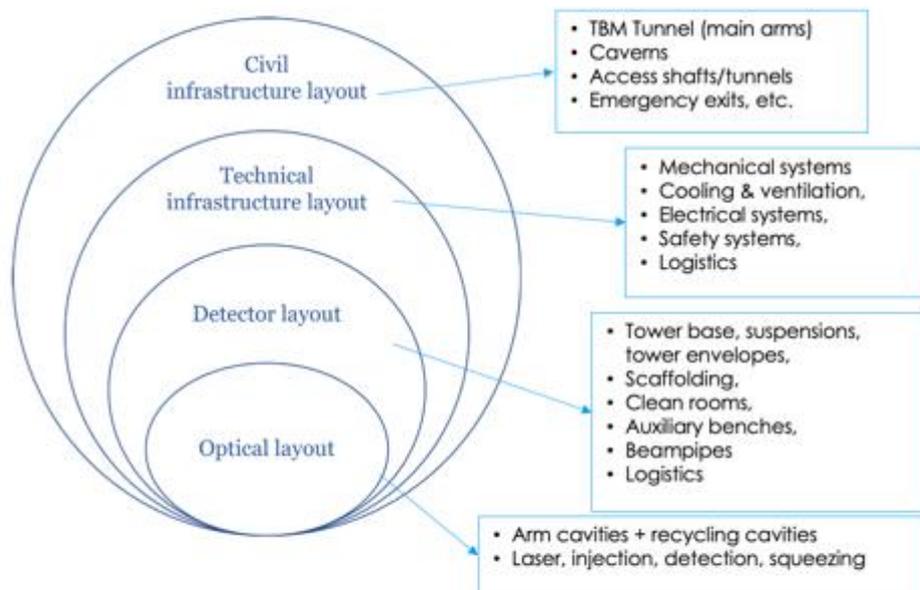
- Scoping and Baseline Assessment
- Alternatives and Mitigation
- Public Participation and Transparency
- Monitoring and follow-up

ET CO2 footprint ET assessment and mitigation strategy

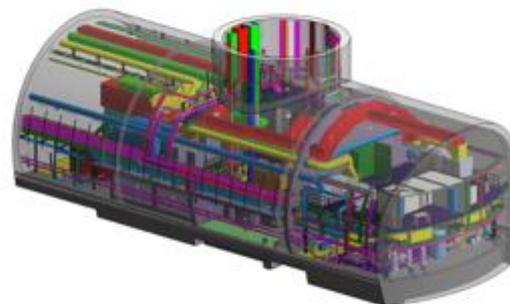
- Compute the key Carbon and Environmental Impacts
- Findings and Mitigation Strategies
- Highlight the most critical insights and recommendations for decision-makers



Breakdown of ET underground research infrastructure



"caverns" and "tunnels" not final

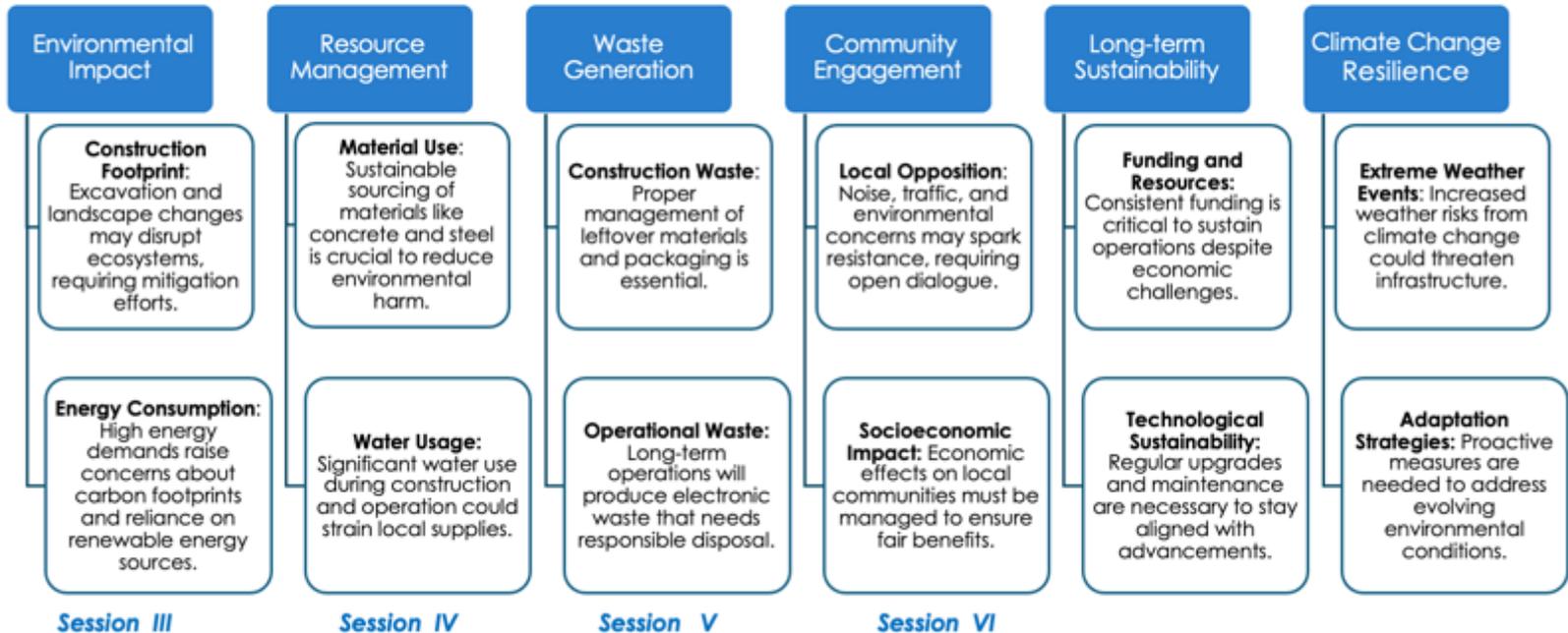


See Talk Sorrentino-Rocchi- Session IV)

Note: Conceptual drawing. Dimensions subject to change
 Volumes estimated using simplified civil engineering criteria

Source ED-ETO (J. Bratanata) -Web viewable 3D Detector Layout(s): <https://wiki.et-qw.eu/ED/WebHome>

ET Environmental impact assessment and mitigation strategy – Key aspects



Environmental Impact Assessment (EIA) - Workplan

Define Sustainability Strategy with environmental, social, and economic themes

Establish **Baseline conditions** using site-specific data (air, water, soil, noise, biodiversity, etc.)

Conduct detailed **Impact assessments** for both construction and operational phases

Develop and implement **Strategic KPIs** (for site comparison) and **Specific KPIs** (for mitigation & performance tracking)

Identify and evaluate **Alternatives and Mitigation Measures** across EIA themes

Analyse and define an overall strategy for reclamation, reuse and recycling of excavated materials (*ref. Prof. Galler presentation – Session V*)

Strategic Priorities:

- Early identification of sensitive receptors (ecological, human)
- Alignment with EU/ISO guidelines (e.g., ISO 14001, WFD, Natura 2000)

Key Priorities



Carbon Footprint Assessment Key Priorities

Scope of Green House Gases Assessment:

- Direct emissions (on-site fuel use, refrigerants)
- Indirect emissions from electricity use
- Supply chain, materials, transport, staff mobility

Strategic Focus:

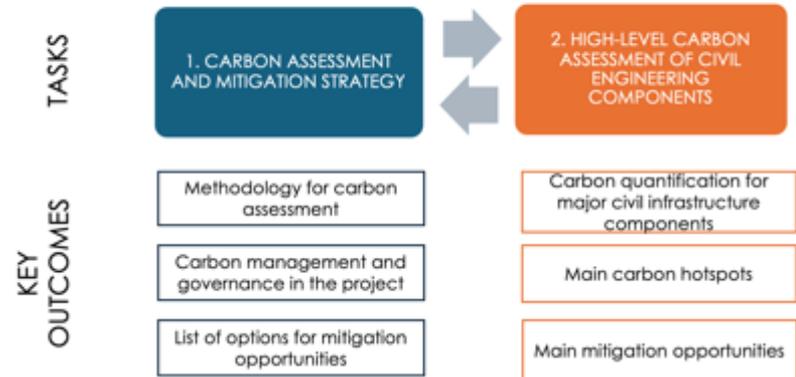
- Construction: Embodied carbon in materials, transport emissions
- Operations: Energy demand, refrigerants, commuting
- Opportunities: Low-carbon design, offsets, carbon capture, renewables

ET High-level carbon assessment for scientific and civil engineering components

- Civil engineering components of the ET infrastructure (for both the triangular and 2L-shaped layouts):
 - Conventional tunnels
 - TBM (tunnel boring machine) tunnels
 - Shafts (access tunnels)
 - Caverns
 - Excavated material from construction of underground infrastructure
 - Surface buildings, including basic MEP (Mechanical, Electrical, Plumbing) services
 - Operational energy use of the whole ET facility
 - Operational water use of the whole ET facility
- Scientific infrastructure components of the ET infrastructure (for both the triangular and 2L-shaped layouts):
 - Interferometer (including Optics)
 - Noise Mitigation (including Sensors)
 - Suspension Systems
 - Vacuum Systems
 - Cryogenics Systems

ET CO2 footprint ET assessment and mitigation strategy - Workplan

@ M. Marsella & F. Spagnuolo



Typical KPIs for baseline pre-assessment related to energy.

With available benchmarks from EU standards and best practices or comparable projects.

KPI	Unit	Purpose	Benchmark
Presence of energy infrastructure	Yes/No	Assess site readiness	N.A.
Accessibility of power lines	Distance	Assess site readiness	N.A.
Available connection capacity	MW	Assess site readiness	N.A.
Share of renewable energy in grid mix	%	Evaluate sustainability of supply	CERN uses French grid (low-carbon mix)
Possibility of local production from renewables (PV, wind, on-site cogeneration)	Yes/No	Identify on-site generation potential	N.A.
Energy reuse potential (e.g., heat recovery)	% of waste heat	Identify circular opportunities	CERN reuses LHC cooling water for district heating
Proximity of the site to centres of thermal demand	Yes/No	Identify circular opportunities	N.A.
Capacity of the local network to absorb recovered heat	Yes/No	Assess site readiness	N.A.



Detector layout

Einstein Telescope Research Infrastructure Challenges and Long-Term Sustainability

2024 reference

new baseline design from Task Force:
~25% volume reduction



Vacuum system – arm cavity beam tube

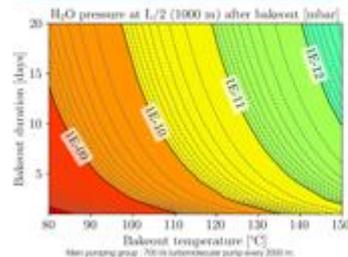
Einstein Telescope Research Infrastructure Challenges and Long-Term Sustainability

@ F. Sorrentino

Bakeout opti

Optimisation of the energy consumption vs vacuum performance.
Water partial pressure prediction after bakeout via adsorption isotherm studies

Sustainable thermal insulation development:
A1 graded thermal insulation shells made with furanic foam and cork (recycled product)
Thickness 10 cm – λ (at 20°C) $\approx 0.05 \text{ W m}^{-1} \text{ K}^{-1}$
Partnerships with PIEP and UMIrto



[3] Sorrentino F., The Einstein Telescope beam pipe vacuum system: Exploring novel techniques and materials for a cost-effective design solution. Doctoral Thesis, 2022



Vacuum system – arm cavity beam tube

Einstein Telescope Research Infrastructure Challenges and Long-Term Sustainability

New structural material

Austenitic stainless steel (AISI 304L)

Face Centred Cubic

- Cubic structure
- Mechanical properties
- Formability
- Weldability
- Corrosion resistance
- H₂ outgassing rate
- Cost [€/ton]
- Beam pipes production rate

Excellent

Excellent

Excellent

Good

High
(requires heat treatments in air or in vacuum)

4000
(+ cost of heat treatment)

Limited by high temperature degassing treatment

Ferritic stainless steel (AISI 441/444)

Body Centred Cubic

Good

Good

Challenging

Good

Low
(See next slides)

~2100

NEW PROPOSAL

Baseline solution (ET CDR 2020⁽¹⁻²⁾)

[1] ET Science Team. Einstein gravitational-wave Telescope conceptual design study. 2011. ET-SC-0000-001
[2] ET Science Team. Einstein gravitational-wave Telescope conceptual design study. 2020. ET-SC-0000-002



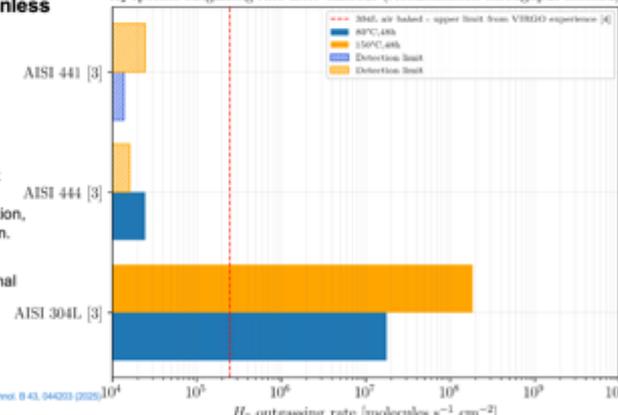
Vacuum system – arm cavity beam tube

Einstein Telescope Research Infrastructure Challenges and Long-Term Sustainability

Impact of the use of ferritic stainless steel

With AISI 441/444 (off-the-shelf):
Low H₂ outgassing rate
= no need of high temperature treatment
= Faster production, lower energy consumption, lower emissions for beam pipe production.
And fewer/smaller pumps needed for equal final pressure requirement.

H₂ specific outgassing rate after bakeout (Accumulation-throughput method)



[3] Sorrentino F., Bregolin G., Di Gregorio P., Weyers I. J. Vac. Sci. Technol. B 43, 044003 (2025)
[4] Brossier V. et al., Vacuum 60 (2011)

Challenges for the climate



Reuse of excavations



Carbon-free transport



Waste water treatment

Use of Energy



Prepare for decommissioning upfront



Protected environments and Natura2000

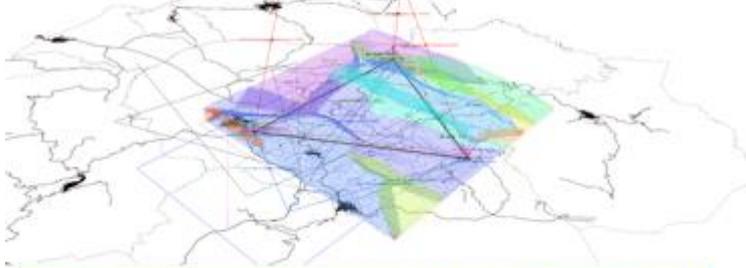


Modelisation

n | w University of Applied Sciences and Arts Northwestern Switzerland

number of swissuniversities

A precise geological model enables smarter alignment, less waste, and lower carbon.



10/20220 Sustainable Digital Design and Data-Driven Research, ET Research Infrastructure: Challenges and Long-Term Sustainability www.riw.ethz.ch

Excavated materials



What is our proposal?



Circular Economy:

- Less transport
- Lower CO₂ emissions
- Use of recyclates with lower carbon footprint

Tunneling

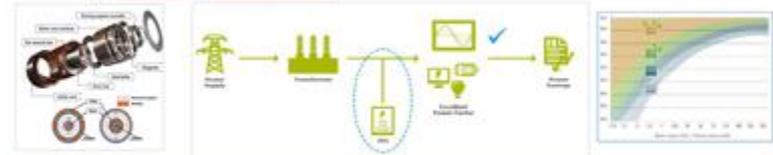


Einstein Telescope Research Infrastructure: Challenges and Long-Term Sustainability

1 Consumption – the Green TBM Concept

TBM manufacturers have been pushed to develop the "Green TBM", a WB concept, that includes features such as:

- Introduction of high efficiency motor, with first use PMSM for the drives in some TBMs
- Variable Frequency Drives (VFD)
- Motors Class IE4 (higher efficiency)
- Improved Power Factor
- Stage V generators for reduced emissions



Project: 10207908 – ET-IP – Horizon WIR-2021-001-001
Grant agreement: 101027908

February 16–17, 2026, Sapienza, University of Rome

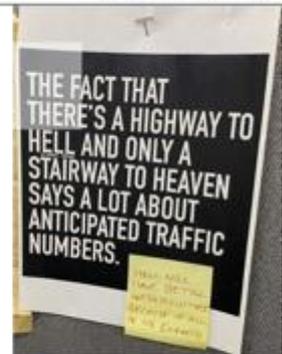
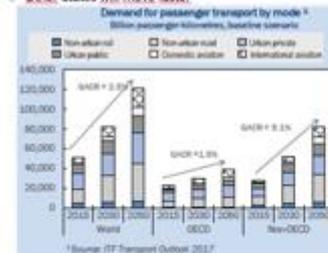
Transport



Einstein Telescope Research Infrastructure: Challenges and Long-Term Sustainability

Sustainable Mobility

- ✓ Sustainable mobility is a big challenge of the modern life
- ✓ A general growth in the transport sector is expected worldwide
 - OECD States will see a moderate growth
 - Other States will move faster



After AC/DC and Led Zeppelin

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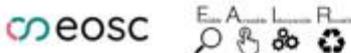
EU policy

The EU's policy framework fosters a **sustainable, sovereign, and innovative digital infrastructure** for science, ensuring that digital growth supports both **research excellence and climate neutrality**.

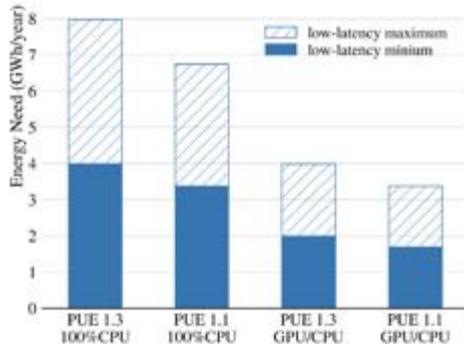
Embedding sustainability, interoperability, and FAIR principles into the design of new RIs, ensures scientific excellence, compliance with EU policies, and long-term viability.

Climate-Neutral and Energy-Efficient Data Centres by 2030: The European Commission has set a clear target: all data centres in the EU must be climate-neutral, highly energy-efficient, and sustainable by 2030

This ambition is part of the broader **European Green Deal and the Green Deal Industrial Plan**, which aim to achieve climate neutrality by 2050 while boosting the competitiveness of Europe's net-zero industry



ET Computing - energy footprint



In the ET computing model, we present an estimate of the energy footprint of ET low latency computing. This is expected to dominate assuming the **full data stream is only** processed by low latency computing

This follows the [methodology used by the WLCG](#) for worldwide computing needs for CERN experiments (beyond the CERN sites)

Power Usage Efficiency (PUE) makes a big difference, as do strategies that leverage GPUs

Sustainable Computing for ET



For ET, the biggest challenge for a sustainable computing model is keeping computing resource needs under control for ET's **50 year lifespan**

There are clear needs for a small, dedicated team of software and computing professionals to provide:

A common software framework

Comprehensive end-to-end testing of all ET software

Intelligent analysis platforms that eliminate duplication

Scalable, portable computing infrastructure

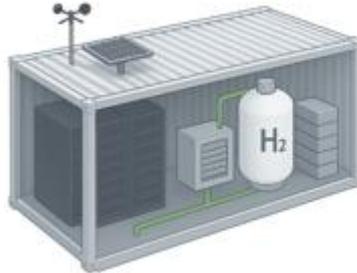
Conclusions

- The existing e-Infrastructure developed for LIGO-Virgo-KAGRA/IGWN is used as a starting point for the Einstein Telescope Computing Model
- However, there are many interesting and new challenges for 3G GW interferometers:
 - A huge number of alerts in the era of multi-messenger physics, i.e. multi-RIs
- The complexity of data processing will require new techniques and technologies, including:
 - Real time monitoring of the infrastructure, the detector and the environment enabling background/noise subtraction and Digital Twin solutions
 - AI/ML techniques (everywhere !)
- Sustainability, and especially energy consumption, is one of the critical aspect of the ET computing model : it require new tools and methods to be centrally integrated in the project organization
 - and a small but dedicated team of software engineers and computing experts
- ET Computing Model and further developments must build on cross-domain expertise developed especially within the European landscape (EOSC, ESCAPE, EVERSE, SPECTRUM, GreenDigit, ...). Tight collaborations with HEP/CERN, KM3NeT, CTA, SKA, LSST is mandatory

The SCOPE Project

General Goal

- Developing a realistic, scalable and sustainable concept for an ET Computing Center
- Adaption of computing power to energy availability
- (Close to) 100% self sustaining with own renewable production
- Efficient cooling & waste heat reusability
- Potential use cases aside ET
- Building a full working prototype inside a shipping container
- Creating a full co-simulation for scale up and testing
- Integrated Techno-Economic & Life-Cycle assessment
- Including transferability to other business cases



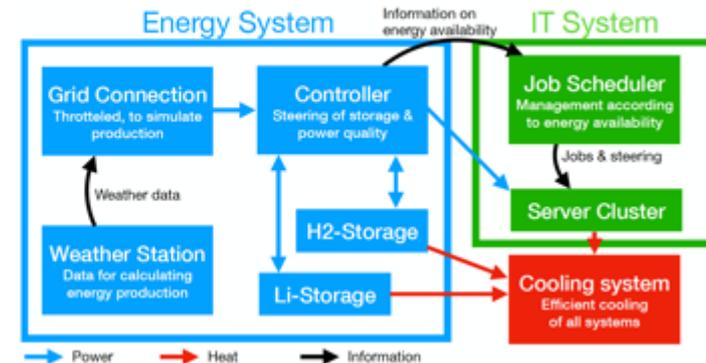
The SCOPE Project

9 Stefan Kriecher | RWTH Aachen University
16.02.2025 | ET Infrastructure Workshop, Rome



Building a Prototype

- Showcase, that components can work hand in hand
- Fully operational „breathing“ computing stack, with realistic ET workload
- Energy storage in battery and hydrogen
- Simulated energy production
- Heat management and measurement of waste heat



ET INDUSTRY COMPUTING WORKSHOP

14 - 15 April, 2026
Nikhef, Amsterdam

- AI-enabled algorithms, tools and approaches for data analysis
- AI tools for software development and more
- Evolution of processor architectures (accelerators, stream processors, neuromorphic...) incl. Quantum
- Storage and data management technologies
- Network technologies and cybersecurity
- Infrastructure and sustainability



The banner features the Einstein Telescope logo on the left, which consists of two stylized telescope structures. To the right, the text 'EINSTEIN TELESCOPE' is displayed in large, white, sans-serif capital letters. Below this, 'INDUSTRY COMPUTING WORKSHOP 2026' is written in a smaller, white font. At the bottom left, the dates '14-15 Apr 2026', location 'Nikhef, Amsterdam', and 'Europe/Paris time zone' are listed. A search bar with the placeholder 'Enter your search term' and a magnifying glass icon is located at the bottom right.

Overview
Timetable
Participant List
Workshop venue
How to reach the venue
Dinner Tuesday 14th April
Accommodation

INDUSTRY COMPUTING WORKSHOP 2026

The Einstein Telescope Preparatory Phase European Project (ET-PP) and the ET Collaboration e-Infrastructure Board are organising a workshop on ET computing, to be held at Nikhef on April 14-15, 2026.

The objective of the workshop is twofold: firstly, to examine the opportunities that the development of information technologies will offer for realizing the scientific potential of the Einstein Telescope; and secondly, to explore possible approaches to collaboration with industry that can be effective in enabling beneficial synergies.

Topics for the workshop will be hardware and software technologies, future trends and sustainability issues related to:

- AI-enabled algorithms, tools and approaches for data analysis
- AI tools for software development and more
- Evolution of processor architectures (accelerators, stream processors, neuromorphic...)
- Storage and data management technologies
- Network technologies

*This Workshop is being organized by **ET-EiB** and **ET-PP WP8**, in collaboration with **ET-PP WP7***

<https://indico.cern.ch/event/1605739/>

RESERVE

4 CNRS Institutes: IN2P3, INP, INSIS, INSU

ET-France web site: <https://et-france.in2p3.fr>

154 French collaborators officially joined the ET Collaboration
(~2/3 are also members of Virgo)

Organized in **8 Research Units** :
FTE threshold to get 1 voting voice at the ET Collaboration Board





Einstein Telescope is applying to enter this roadmap

- April 2025: eligibility application – **OK**
- July 2025: application to enter as IR
- October 2025: audition by the GT PNHE

Next steps:

End of October 2025 : WG evaluation

January March 2026: decision at MESR

February April 2026 : validation of the final list by CD TGIR

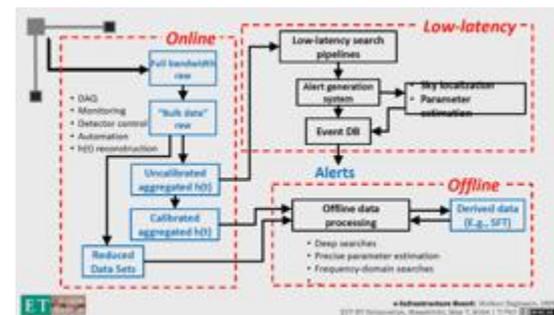
Final publication: September 2026

ET will use a **distributed computing infrastructure** in Europe, based largely on existing infrastructures such as CC-IN2P3 in France : ET = ~10% of an LHC exp. at CERN.

Increasing use of **high-performance parallel computing (HPC)** vs HTC computing.



CC-IN2P3



ET active in EuCAIFCon -- European Coalition for AI in Fundamental Physics

Use of tools and services developed in the framework of the **European Open Science Cloud** and European projects such as ESCAPE for **multi-messenger physics**

Mock-Data-Challenge in progress

ET joined the ESCAPE consortium in 2023 : 2 OSCARs project funded !



ET-PP Deliverables in February 2026

- Computing model
- Data Access Policy
- Sustainability plan



Fostering the uptake of Open Science in Europe

In response to the EU call on EOSC HORIZON-INFRA-2023-EOSC-01-01

€16 MILLIONS
WFP-CALL FOR
OPEN SCIENCE
PROJECTS AND SERVICES

First meeting organized in March 2023 with MESR to present ET to the French industries interested by this project

=> About 30 companies were present and have shown interest to works with us, either through dedicated/joint R&D program, either as manufacturer of components

Follow-up in Sept. 2023 with a network of French companies (PIGES) involved in Big Sciences

We are following and contributing to ET-PP WP7 dedicated to industrial partnerships => Big Science Business Forum at Trieste in Oct. 2024:

ET was very well represented

Preparing an ET + Industry meeting on Computing (Spring 2026)

Contact: patrice.verdier@in2p3.fr



<https://indico.in2p3.fr/event/28704>



<https://www.piges.eu>



<https://www.bsbf2024.org>

From the XIII ET symposium, an incomplete selection of the presented large facilities

Glasgow

OmniSense at Nikhef
• Interferometry among strictly aligned and precise
• High-precision alignment
• Broadband control
• World leading for thermal fluctuations, stability, and fit
• Mechanical complexity, stability or rigidity

VATIKrav and Compact Laser Interferometry
• Interferometry among strictly aligned and precise
• High-precision alignment
• Broadband control
• World leading for thermal fluctuations, stability, and fit
• Mechanical complexity, stability or rigidity

Epathfinder in Maastricht
Main target: provide a solution for ET surface concepts and qualify them in its environment.

Hamburg

Amsterdam

Hannover

Maastricht

Louvain

Goerlitz

The ADI 10 m Prototype Facility
Main goal: test the mechanical behavior of the structure of the telescope in its environment.

DZA On solid ground

E-TEST : Einstein Telescope EMR Site and Technology
• High-precision alignment
• High-precision alignment
• Broadband control
• World leading for thermal fluctuations, stability, and fit
• Mechanical complexity, stability or rigidity

Test facility for experimental investigations of the He-II based ET-LF payload cooling concept
• High-precision alignment
• High-precision alignment
• Broadband control
• World leading for thermal fluctuations, stability, and fit
• Mechanical complexity, stability or rigidity

CoMET - Coating Materials for Einstein Telescope
• High-precision alignment
• High-precision alignment
• Broadband control
• World leading for thermal fluctuations, stability, and fit
• Mechanical complexity, stability or rigidity

LMA - Laboratoire des Matériaux Avancés
• High-precision alignment
• High-precision alignment
• Broadband control
• World leading for thermal fluctuations, stability, and fit
• Mechanical complexity, stability or rigidity

CAOS: Centro per Applicazioni sulle Onde gravitazionali e la Sismologia
• High-precision alignment
• High-precision alignment
• Broadband control
• World leading for thermal fluctuations, stability, and fit
• Mechanical complexity, stability or rigidity

Lyon

Padova

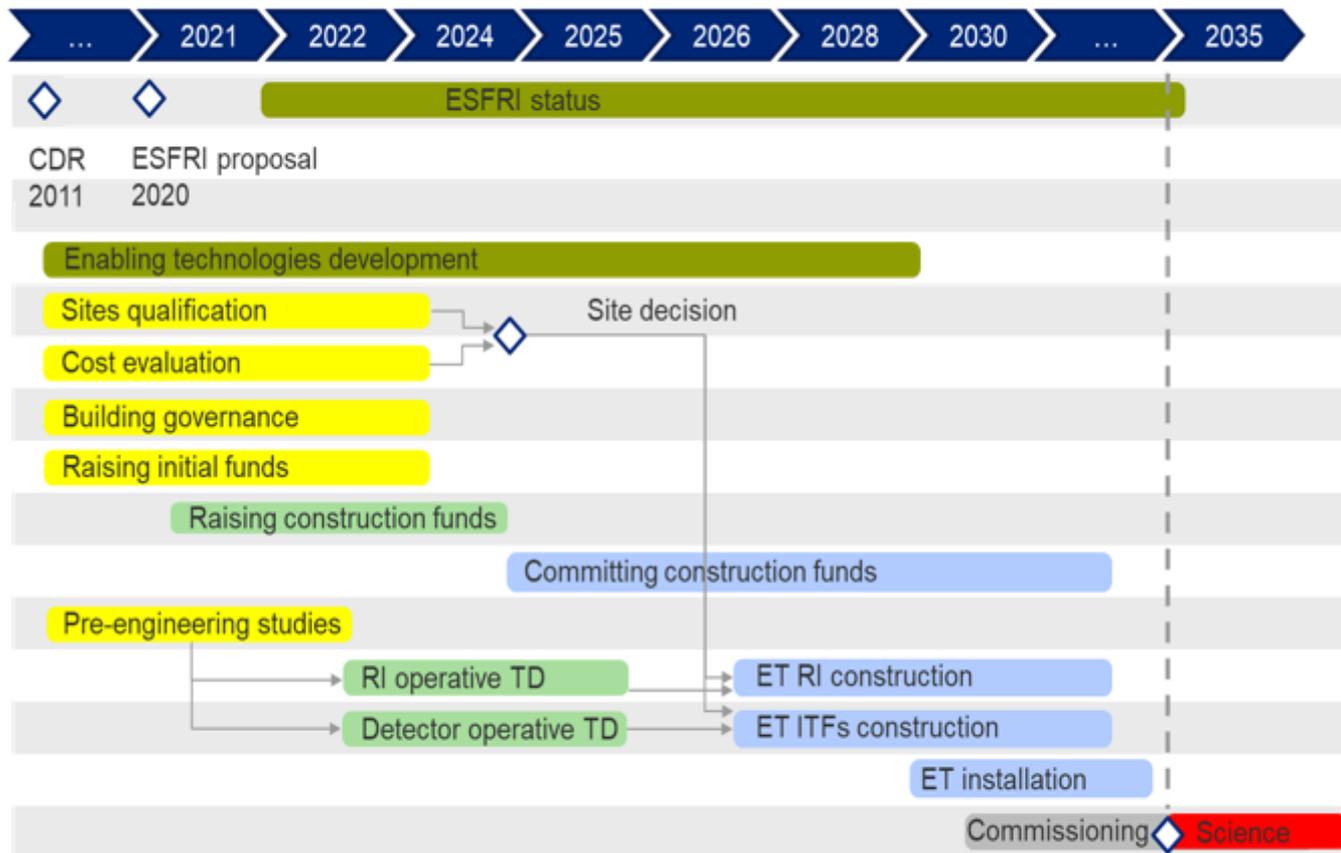
GEMINI at LNGS
• Test the limits of active seismic isolation in an underground environment
• Test platform motion control
• Underground environmental monitoring
• Test new approaches to control optimization
• Test new installation

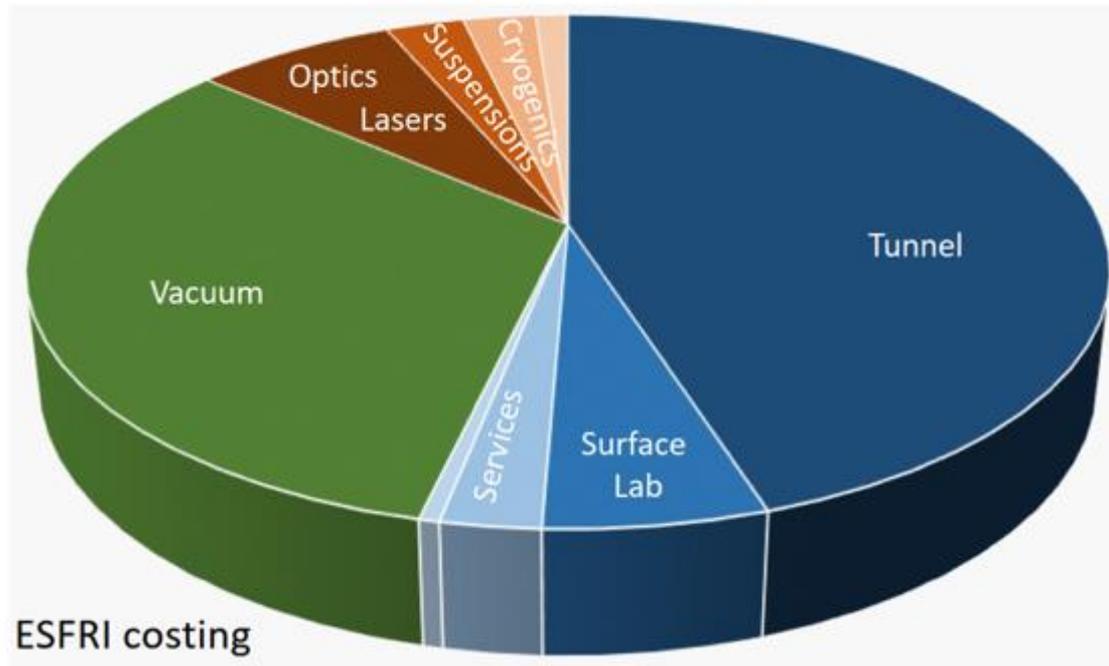
SAR-GRAV Laboratory
• High-precision alignment
• High-precision alignment
• Broadband control
• World leading for thermal fluctuations, stability, and fit
• Mechanical complexity, stability or rigidity

Amaldi Research Center at Roma La Sapienza
• High-precision alignment
• High-precision alignment
• Broadband control
• World leading for thermal fluctuations, stability, and fit
• Mechanical complexity, stability or rigidity

Sos Enatos

* Tentative schedule





Tunnel	781 M€
Surface Lab	98 M€
Underground Services	44 M€
Direction	9 M€
	932 M€
Vacuum Systems	566 M€
	566 M€
Optics & Lasers	125 M€
Suspensions	48 M€
Cryogenics	45 M€
Installation	20 M€
	238 M€