

ET-France: Introduction

Réunion ET-France – LPC Caen

October 9th, 2024
patrice.verdier@in2p3.fr



154 French collaborators officially joined
the ET Collaboration

4 CNRS Institutes: IN2P3, INP, INS2I, INSU

Mailing list ET-France:

ET-FRANCE-L@IN2P3.FR

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

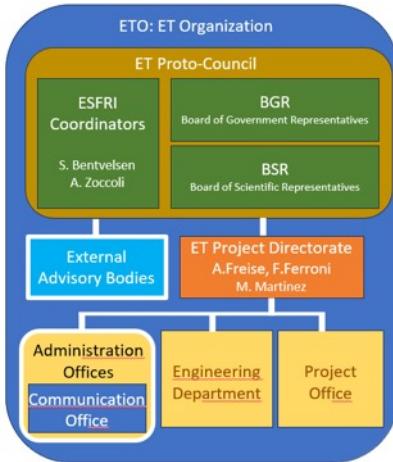
Research Unit (RU)	Laboratories
Artemis	ARTEMIS
Astroparticule et Cosmologie (APC)	APC
	IAS
	SUBATECH
IF-ILM	IF
	ILM
	MSME
IJCLab	IJCLab
	LKB Paris
IP2I - LMA	IP2I Lyon - IN2P3
	LMA - IN2P3
IPHC-L2IT	IPHC
	L2IT
	IRAP
LAPP	LAPP
Paris - Caen	Observatoire de Paris (GEPI, LUTH, SYRTE)
	GANIL / LPC Caen
	IAP

+ CC-IN2P3

Einstein Telescope Organization & Collaboration



ETO est devenu opérationnel
(Amsterdam meeting
in May 2024)

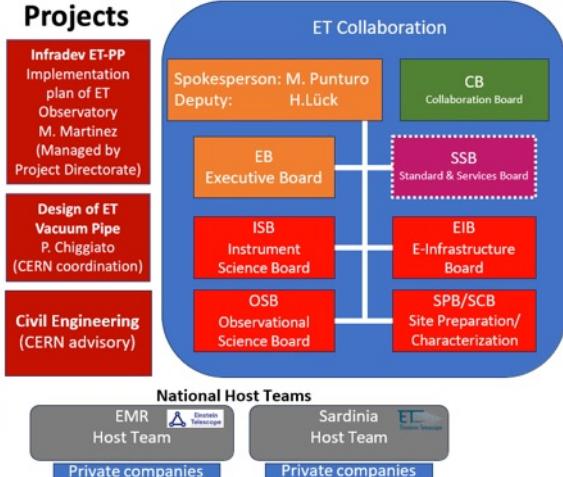


Projects

Infradev ET-PP
Implementation plan of ET Observatory
M. Martinez
(Managed by Project Directorate)

Design of ET Vacuum Pipe
P. Chiggiato
(CERN coordination)

Civil Engineering
(CERN advisory)



La collaboration ET est en place et apprend à travailler comme une grande collaboration internationale

- ETO coordonne les activités avec le CERN (tube à vide, génie civil, ...)
- Des progrès importants au niveau du BGR d'octobre 2024:
Vers un calendrier pour le choix des sites et de la géométrie
Entité légale et gouvernances
Interactions EGO-Virgo-ET
« Update of the ET roadmap » : hiver 2024-2025

Comité de travail en place avec un mandat pour proposer une organisation des responsabilités entre ETO et ETC
(M. Branchesi, P. Verdier, D. Trani, R. Saban)

1726 collaborators from 254 institutes in 30 countries worldwide



ETO scope, responsibilities and relations

BGR
Site selection;
Legal entity;
Financial framework

ET coordinators
Coordinate the EU project - ESFR/

- Host Consortia**
- Feasibility studies civil engineering, installations
 - Feasibility studies subsurface
 - Feasibility studies environment and legal

ET Host
Consortia
(EMR and TETI)

Board of Governmental
Representatives (BGR)

ET Coordinators

ETO
Directorate and Depts

ETO Directorate
Strategic coordination and management

- ET Roadmap
- Technical Design Reports
- Site Evaluation Reports
- Technical Plan report
- Organisation report
- Budget report

ET Collaboration

- Scientific vision
- Detector design
- Requirements,
- Common standards

ET Collaboration
(ETC)

ETO Management team and activities

ETO Management team (still evolving)

- Fernando Ferroni & Andreas Freise (Directors), Mario Martinez (Director of ET-PP INFRADEV)
- Roberto Saban and Daniela Trani (Office of Directors)
- Alessandro Variola (Project Office)
- Fiodor Sorrentino (Technical Coordinator)
- Patrick Werneke (Engineer Department), Maria Marsella (Civil Engineer)
- Martine Oudenhoven (Communication Office)
- Lucia Lilli (Support)
- 2 more coming from KU Leuven
(Benoit Tuybens, administrative support)
(Addis Koeck Siegfried Financial)

**ETO Budget request : essentially to pay CERN
(ET should be « cost neutral » for CERN)**

	In-kind	CERN Fellows Junior		CERN Fellows Senior		Materials [MCHF]	Studies [MCHF]	Studies [M€]	Contributions [MCHF]	Software [M€]
	FTE for 3 years	Number	Person-Years	Budget [MCHF]	Number	Person-Years	Budget [MCHF]			
DIRECTORATE	8.6									
Project Office	2.0									
Engineering Department	10.0	5.00	15.00	1.40	5.00	10.00	1.12	0.66	1.50	0.45
Totals	61.8			1.40			4.03	0.66	1.50	0.09
Total [MCHF]	8.99	9.35 in €								
Total [M€]	1.53									
		exchange rate 1 CHF =								
		1.04 €								
Total in M€	10.88									
+ 10% contingency	11.97									

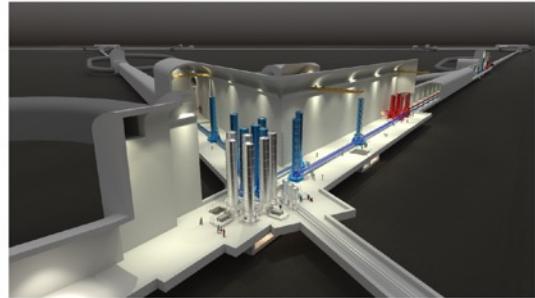
ETO – CERN Activities

IN PROGRESS:

- Civil Engineering
- Vacuum Beampipe

UNDER DISCUSSION:

- Technical Infrastructure
- Occupational Health and Safety
- Integration
- Planning
- Information management
- Costing
- Cryogenics
- Survey



19

Goals of CERN Contracts in short

- Civil Engineering : Consultancy and Review of the documents. Validation of the final choices. Guidance in preliminary TDR formulation **[where most of the cost of the project is]**
- Vacuum Pipe : Choice of pipes technology, TDR for the system [120 km of 1m diameter vacuum system **[second item for cost]**]
- Costing : First release of the cost book
- Engineering Department : Definition of the technical infrastructure equipping the tunnel. **[see next slide]**

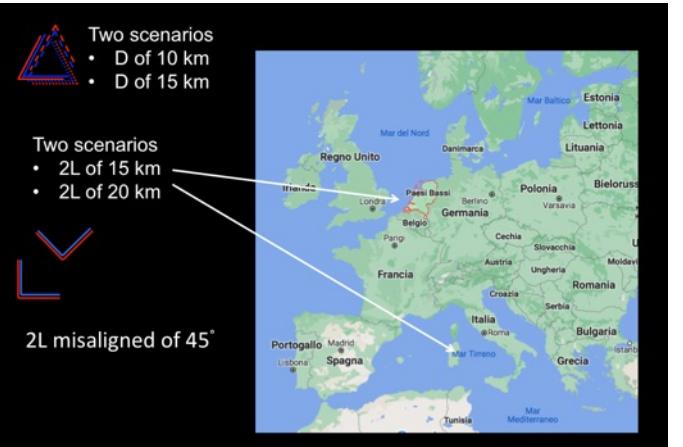
ET Geometry

Highlights 2023-2024

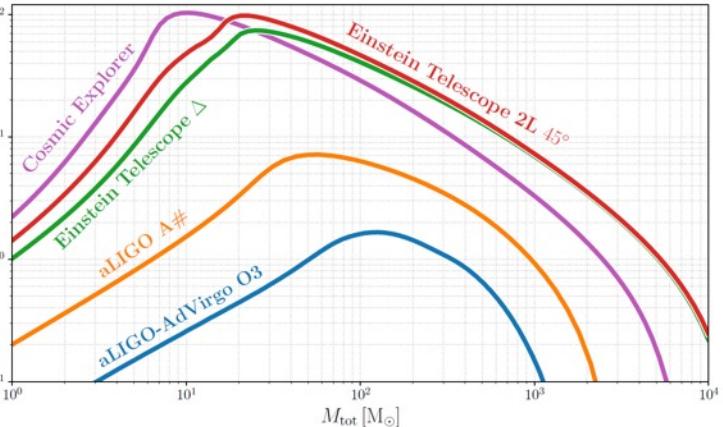
"COBA" (Cost-Benefit Analysis):

- Impact of the geometry on the physics potential
- Essential inputs from ISB
- ETRAC risk analysis

The result of these analyses put strong emphasis on the comparison between the configurations: "1Δ 10km" and "2L 15km"



Physics potential with "2L 15 km" is generally better (45° orientation) and less risky: **Detailed analysis of the costs to be carried out**



[arXiv:2303.15923](https://arxiv.org/abs/2303.15923) - JCAP 07 (2023) 068

Science with the Einstein Telescope:
a comparison of different designs

Marica Branchesi,^{1,2} Michele Maggiore,^{3,4} David Alonso,⁵ Charles Badger,⁶ Biswajit Banerjee,^{1,2} Freija Beimert,⁷ Swetha Bhagwat,^{8,9} Guillaume Bolleau,^{10,11} Sohrab Borhanian,¹² Daniel David Brown,¹³ Man Leong Chan,¹⁴ Giulia Cusin,^{15,16,1} Stefan L. Danilishin,^{16,17} Jerome Degallaix,¹⁸ Valérie De Luca,¹⁹ Arnab Dhami,²⁰ Tim Dietrich,^{21,22} Ulyana Dugdale,^{1,23} Stefano Foffa,^{1,4} Boris Goncharov,^{1,24} Archisman Ghosh,²⁵ Francesco Guarnieri,²⁵ Ish Gupta,²⁶ Pawan Kumar Gupta,^{16,26} Jan Harms,^{1,2} Nandini Hazra,^{1,2,27} Stefan Hild,^{1,2,27} Tanja Hinderer,²⁸ Ik Siong Heng,²⁹ Francesco Iacovelli,^{3,4} Justin Januart,^{16,23} Kamel Janssens,^{10,11} Alexander C. Jenkins,³⁰ Chinmay Kalaghatgi,^{1,26,31} Xhesika Koroveshi,^{32,33} Tjinnie G. F. Li,³⁶ Yufeng Li,³⁶ Eleonora Loffredo,^{1,2} Elisa Maggio,²⁷ Michele Mancarella,^{3,4,27,38} Michela Mapelli,^{39,40,41} Katarina Martinović,⁴² Andrea Maselli,^{1,2} Patrick Meyers,⁴² Andrew L. Miller,^{43,40,42} Chiranjib Mondal,^{1,2} Niccolò Muttoni,^{4,4} Harsh Naikola,⁴² Mirela Oertel,^{1,2} Gor Oganesyan,^{1,2} Camilo Olivares,⁴⁴ Alessandro Palenzona,^{1,2} Paolo Antonino Pasquaré,²⁹ Alfonso Perego,^{42,45} Carole Prigent,^{28,46,47} Mauro Pieroni,^{39,40} Ornella Julianà Piscitelli,³⁴ Anna Puclher,^{30,53,54} Antonio Riotti,^{3,4} Samuele Ronchini,^{1,2} Mairi Sakellariadou,³⁵ Anuradha Samajdar,²¹ Filippo Santoliquido,^{39,40,41} B.S. Sathyaprakash,^{20,53,54} Jessica Steinlechner,^{16,27} Sebastian Steinlechner,^{16,27} Adrienne Utina,^{16,17} Chris Van Den Broeck,^{16,26} and Teng Zhang^{3,17}

WP6 - Deliverables



- D6.1 Refined Science Case (M18) – Feb24
- D6.2 Vacuum pipe Design (M24) – Sept 24
→ CERN (no news over the summer break)
- D6.3 Preliminary RI TDR (M24) Sept24; → ETO
- D6.4 Preliminary DET TDR (M24) – Sept24;
- D6.5 RI TDR (M40) Feb26; → ETO
- D6.6 DMP and Data Access Policy (M46) – Jul26.

D6.1 Refined Science Case

- **Science with the Einstein Telescope: a comparison of different designs ([Published](#))**
Can be submitted as an intermediate step.
- **Blue Book:** Slight delays expected w.r.t. plans reported in June 2024
 - The current plan: have a draft with all chapters at the beginning of October, i.e. in ca. 2 weeks time.
 - Final version beginning of 2025.
 - Plan to submit Feb. 2025 still holds

ETO Deliverables in Phase 1

- Definition and organisation of ETO during Phase 1
- Preliminary Technical Design Reports (TDRs) of all parts of the research infrastructure
- Project Management Plan, including project structure, validation and risk analysis management plans
- Organisational Chart, including financial framework, proposed governance structure etc
- Preliminary Safety Agreement, including a shared and validated understanding of the aspects of safety and applicable laws
- Cost Book
- Project Impact Assessment
- Sites Characterisation
- Configuration analysis
- Risk Report

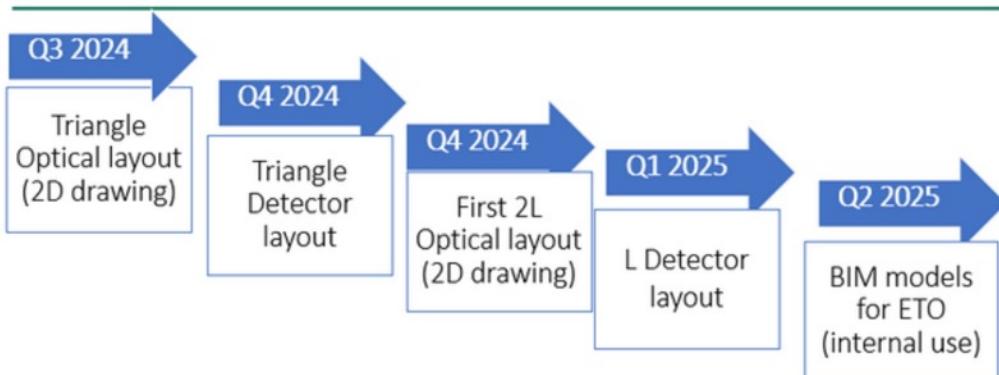
The blue bullets are closely interlinked.
One coherent, well managed activities is required to deliver a feasible design and its associated schedule and cost.

Milestones

We have identified critical milestones, many which are out of our (ETO) control, but are essential for advancing along the defined roadmap (timings are estimated):

- 1) Hierarchical lines, and operative rules between the stakeholders establishment and validation, Q1 2025
- 2) Approval of ETO organisational and legal definition, Q1 2025
- 3) ETO resources available, Q1 – Q4 2025 (money – in-kind personnel)
- 4) Project Baseline definition and release 1.0. (limited to detector and preliminary civil engineering), Q4 2025
- 5) Project structure finalised, Q3 2025
- 6) ET-PP project outcome, Q3 2026
- 7) Recognition of the ET project in CERN's strategy, Q1 2026
- 8) New ESFRI roadmap release, 2026
- 9) The bid process definition, TBD
- 10) The bid-books release. This will trigger the selection process, TBD

Design of the underground civil infrastructure



- ETO will complete the layout of the detector to be adopted as a baseline for the design of the civil infrastructure
- Local Teams should optimise construction solutions for site feasibility studies starting from a common design



- The collaboration updated the 2020 TDR optical 10 km-triangle layout, currently under review to be approved soon.
- Layout shared with EMR and TETI to identify relevant impacts on civil infrastructure, to associated boundary values, tolerances and possible alternatives

EINSTEIN
TELESCOPE

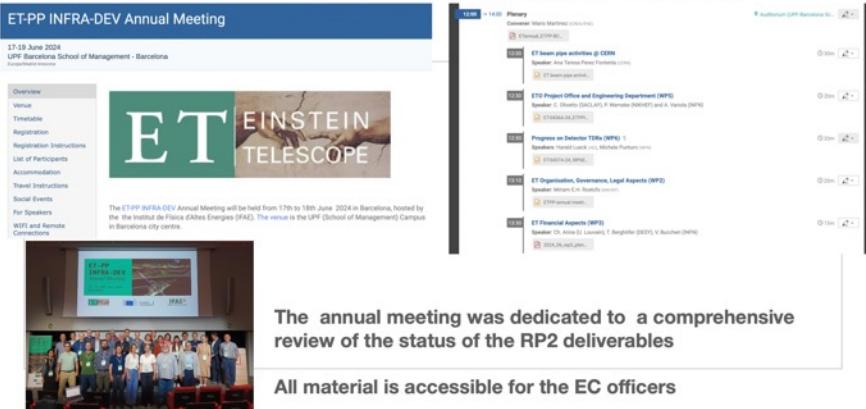
Andreas Freise, 03.10.2024



14

ET-PP annual meeting (17th -18th June)

<https://indico.ifae.es/event/1930/timetable/?view=standard>



The screenshot shows the ET-PP INFRA-DEV Annual Meeting website. The left sidebar includes links for Overview, Venue, Timetable, Registration, Registration Instructions, List of Participants, Accommodation, Travel Instructions, Social Events, For Speakers, ET2024, and Remote Connections. The main content area displays a detailed agenda for the meeting, including sessions like "ET beam pipe activities @ CERN" (Speaker: Ana Teresa Perez Fontaneda), "ET Project Office and Engineering Department (WP5)" (Speaker: C. Oehme (CERN), P. Werner (IN2P3) and A. Vassilis (IN2P3)), and "Progress on Delivery TIRBn (WP9)" (Speakers: Harald Lautenbacher, Michaela Pfeiffer). A photograph of the meeting participants is also shown.

The annual meeting was dedicated to a comprehensive review of the status of the RP2 deliverables

All material is accessible for the EC officers

INFRADEV ET-PP status

ET-PP project reached the equator of its execution (2 more years to go)

- ET-PP passed the first formal review; next one expected by Spring 2025

ETO Directorate meeting with EC official on July 2024 @ Brussels

- Good understanding of the status of the project and its complexity
 - Origin of delays w.r.t original ESFRI planning were identified
 - including ET geometry discussions
 - Discussion on new timelines for different deliverables with emphasis on:
 - Site characterization (WP4) —> needs a new timeline
 - Sustainability (WP9) —> studies not at the required level —> hiring expert services
 - Research Infrastructures (WP6 & ETO) and relation with CERN
 - Good Progress reported in many fronts

At CNRS:

- we are on time for our WP5 and WP8 deliverables
- Issues with WP9 to be solved (next slide)

EC Officer review: October 25th, 2024 - Preparation meeting: October 10th, 2024



@ Art Institute Of Chicago

EU analysis on RI sustainability

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



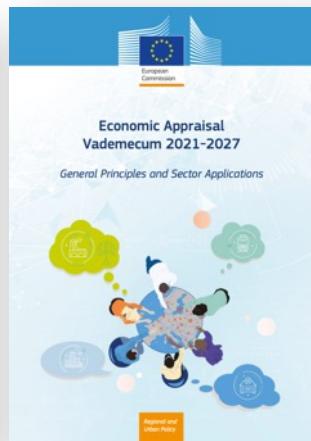
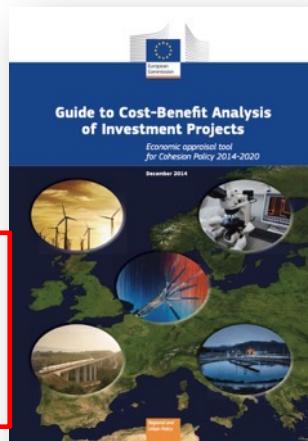
Sustainability studies are supported by EU calls

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

Cost-Benefit analysis:

Research Infrastructure guides foresee this approach

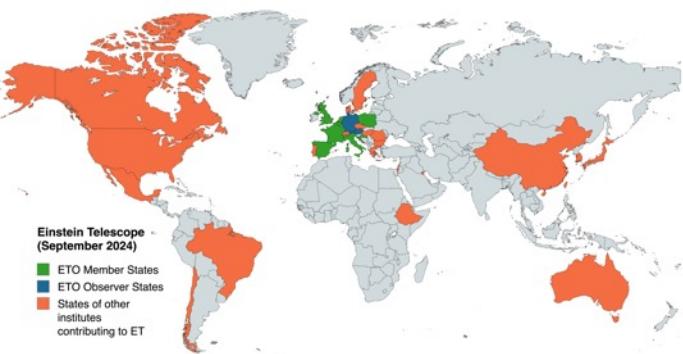
Required by ESFRI



WP9 is in difficulty to achieve its works: new personpower required (=> external company), reorganization mandatory
Anyone interested in your lab ?

ET Board of Government Representatives:

- **Members:** Belgium, Croatia, France, Italy, Netherlands, Poland, Spain, United Kingdom
- **Observers:** Austria, Germany
- **Chairs:** Aldo Covello (Italy) & Lodewijk Smoor (NL)
- **Secretaries:** Roberto Cimino (Italy) & Jérôme Pourbaix (Belgium)

**Significant progress on many aspects:**

- ✓ The role of EGO-Virgo in the preparatory phase of ET
- ✓ Preparation of the update of the ET roadmap
- ✓ Preliminary discussion on the ET geometry
- ✓ Discussion on the ET legal entity: ERIC, IGO, Hybrid (ESRF model)
- ✓ Establish a BGR WG to define the criteria and the decision process for the site selection
- ✓ Clarification needed on the role of CERN (ESPPU impact)

Minutes in preparation...



Muon tomography: pilot run

One of the few French contribution to ET site characterization: J. Marteau *et al*



Muon detectors installed in the Sos Enattos cavern (point Incroce 1) in June 2024 :

- scintillator tracker from the Lyon (France)
- multiwire gaseous tracker from the Wigner (Budapest) team

The pilot run will last 2 months and the detector will be moved to a new measurement point (Incroce 2) to perform the characterization of the overburden."



Funding:

EU Infratech proposal **M2TECH** : 2nd submission, excellent evaluation, but negative result

Roadmap:

See Christelle Buy's presentation at Virgo France 2024 annual meeting :

<https://indico.in2p3.fr/event/33581>

Workshop R&Ds - Développements Instrumentaux / Virgo-ET

4–6 mars 2024
Institut Fresnel - Marseille
Fuseau horaire Europe/Paris

Entrer le texte à rechercher

Accueil
Ordre du jour
Liste des contributions
Inscription
Liste des participants

Matteo Barsuglia, Christelle Buy, Patrice Verdier
✉ barsu@apc.in2p3.fr
✉ christelle.buy@l2it.in2p3.fr
✉ patrice.verdier@in2p3.fr



 Advanced Virgo

 ET EINSTEIN TELESCOPE

Christelle has produced a detailed and exhaustive document about French lab interests in Technology developments for Virgo+ET

Executive summary and R&D roadmap (2-3 pages !!)

- to be prepared during Fall 2024
- to be sent to MESR/DGRI

Industrial partnerships

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 work 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

ET-France has an “Innovative Liaison Officer” (same function as for other RIs like CERN, XFEL, ESRF ...) reporting to MESR-DGRI => Guillaume Olry

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 (but no French ET participant...)

Discussion en cours pour la mise en place éventuelle d'une organisation type **Maison SKA-France**: à suivre <https://ska-france.oca.eu/fr/accueil-ska>

Contacts:

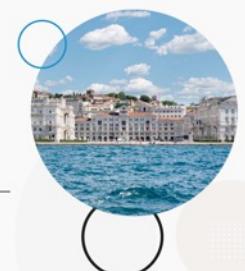
guillaume.olry@ijclab.in2p3.fr and patrice.verdier@in2p3.fr



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



<https://www.piges.eu>



<https://www.bsbf2024.org>

Next-generation GW Observatory in the U.S.

In 2023, NSF convened a review panel to study the landscape of next-generation GW observatories in the U.S. In March 2024 the panel (or MPS AC sub-committee) recommended potential candidates for such observatories as MREFC projects.

Recommendations:



MPS and Physics Division have provided \$14.2M in 2023/24 for CE design work. While these commitments are expected to be carried out in the next years, everything depends on the NSF budget appropriations.



Technologies needed for ET are not yet available. An ambitious R&D program is needed at European level to develop them during the next 10-15 years:

- In synergy with EGO-Virgo which will continue to lead the field in Europe for the next 15 years: the technologies developed for Virgo and its upgrades (Virgo_nEXT) are the ones which will be used for ET-HF (risk reduction for ET)
- Funding dedicated R&Ds for ET-LF is mandatory : ET-LF is the main reason to go underground and to significantly increase the cost of the civil infrastructure, while 6 orders of magnitude (!) in sensitivity must be gained compared to the current state-of-the-art (!)

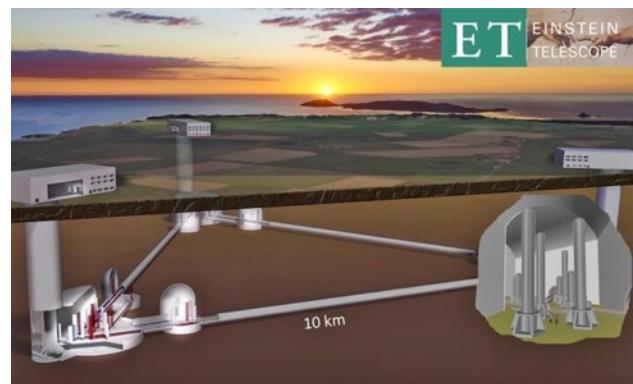
French position:

- Supporting EGO-Virgo remains the top priority for the next years: it is only once Virgo has reached its nominal sensitivity that we will be able to convince decision makers to support and fund ET
- The preparation of ET must be organized as a global European project with tight links with other international projects (Virgo, KAGRA LIGO, Cosmic Explorer)
- French scientists support the idea that ET should favor the configuration with the longest possible arms in order to face the competition with the US project Cosmic Explorer

BACKUP

Site candidates

Sardinia – Italy

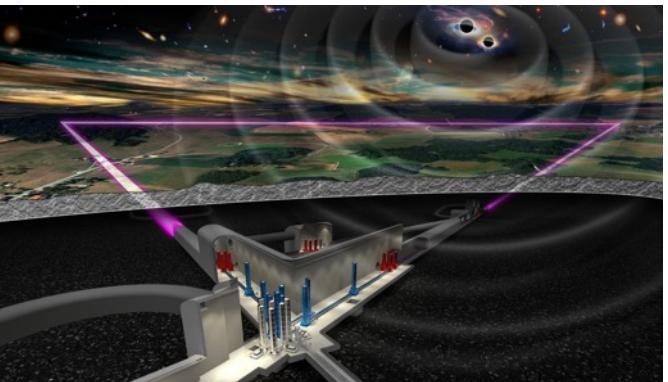


€50 million for R&D and preparatory work

ETIC in Italy

Einstein Telescope Infrastructure Consortium
"Multi-100 M€" financing to support ET's site in Sardinia

Euregio Meuse-Rhin Netherland



€42 million for R&D and preparatory work

ET-Pathfinder in Maastricht

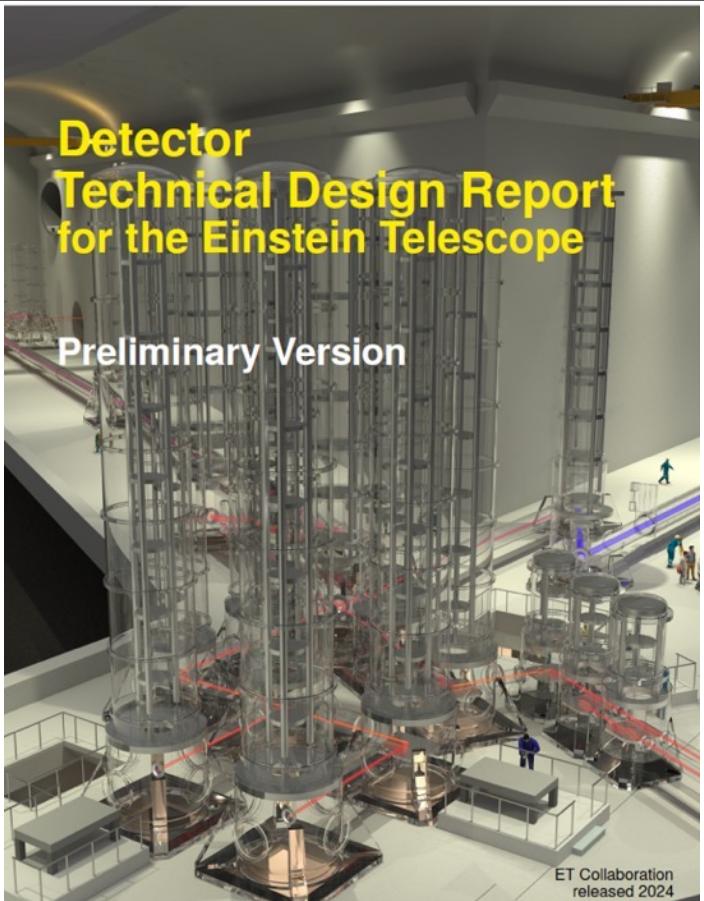
"Multi-100 M€" financing if the ET site is in Euregio Meuse-Rhine

Saxe – Germany



New DZA laboratory (2022)
170 M€/year over 10 years

3 pillars: astrophysics, data science, technology



Nomenclature	9
1 Introduction	19
2 Science Case Overview	21
3 Detector CDR Executive Summary	23
3.1 Main PBS upper systems design criteria summary	23
3.2 Overview of the main PBS systems, subsystems and their functional layouts and characteristics	23
3.3 Integration and installation requirements	23
3.4 Main elements (cost driver or technology challenges) functional and interfaces requirements, definitions	23
3.5 Results of R&D activities	23
3.5.1 Expected Results	23
3.5.2 Characterisation Methodology	23
3.5.3 Experimental Results obtained and TRL Evolution	23
3.5.4 Expected Impact (R&D by RSSd activity)	23
4 PBS element specifications and applied standards	25
4.1 Introduction	25
4.2 PBS elements specifications	25
4.3 PBS elements services and maintenance	25
4.4 PBS elements safety needs	25
4.5 Technical risk analysis of the PBS element	25
5 Detector Risk Analysis	27
6 Sustainability and Environment	29
7 costs	31
Image credits	32

Deadline: July 2025

Preparing the Blue Book

Contents

1 Introduction

2 Detector geometries and sensitivity curves

3 Coalescence of compact binaries

- 3.1 Binary Black Holes
 - 3.1.1 Comparison between geometries
 - 3.1.2 Effects of a change in the ASD
 - 3.1.3 Golden events
- 3.2 Binary Neutron Stars
 - 3.2.1 Comparison between geometries
 - 3.2.2 Effects of a change in the ASD
 - 3.2.3 Golden events
 - 3.2.4 Dependence on the population model
- 3.3 ET in a network of 3G detectors

4 Multi-messenger astrophysics

- 4.1 BNS sky-localization and pre-merger alerts
- 4.2 Gamma-ray bursts: joint GW and high-energy detections
 - 4.2.1 Prompt emission
 - 4.2.2 Afterglow: survey and pointing modes
- 4.3 Kilonovae: joint GW and optical detections

5 Stochastic backgrounds

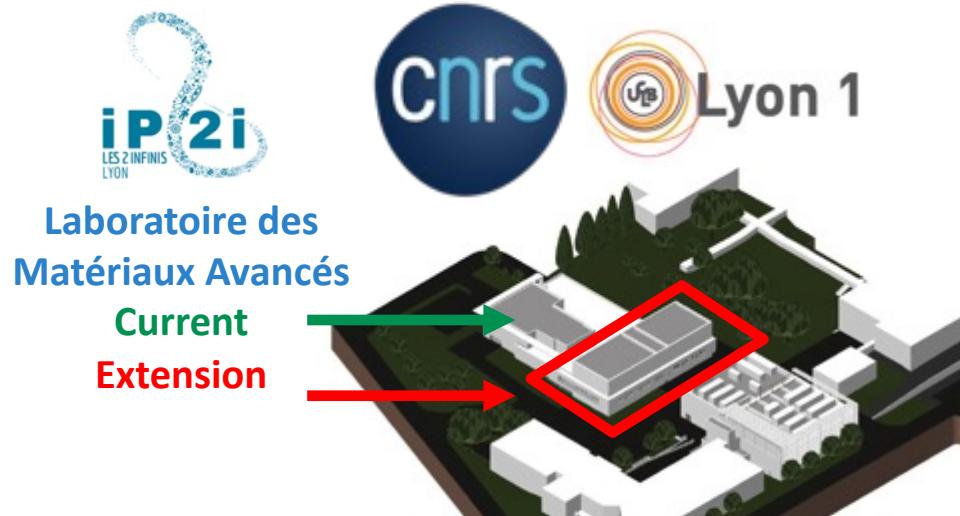
- 5.1 Sensitivity to isotropic stochastic backgrounds
- 5.2 Angular sensitivity
- 5.3 Astrophysical backgrounds
- 5.4 Impact of correlated magnetic, seismic and Newtonian noise
 - 5.4.1 Seismic and Newtonian Noise
 - 5.4.2 Magnetic noise

6 Impacts of detector designs on specific science cases	68
6.1 Physics near the BH horizon	68
6.1.1 Testing the GR predictions for space-time dynamics near the horizon	68
6.1.2 Searching for echoes and near-horizon structures	72
6.1.3 Constraining tidal effects and multipolar structure	74
6.2 Nuclear physics	76
6.2.1 Radius estimation from Fisher-matrix computation	76
6.2.2 Full parameter estimation results	80
6.2.3 Connected uncertainty of nuclear-physics parameters	81
6.2.4 Postmerger detectability	83
6.2.5 Conclusions: nuclear physics with ET	85
6.3 Population studies	85
6.3.1 Merger rate reconstruction	85
6.3.2 Constraints on PBHs from high-redshift mergers	88
6.3.3 Other PBH signatures	91
6.4 Cosmology	94
6.4.1 Hubble parameter and dark energy from joint GW/EM detections	94
6.4.2 Hubble parameter and dark energy from BNS tidal deformability	106
6.4.3 Hubble parameter from high-mass ratio events	108
6.5 Cosmological stochastic backgrounds	113
6.5.1 Cosmic Strings	113
6.5.2 First-order phase transition	114
6.5.3 Source separation	116
6.6 Continuous waves	117
6.6.1 CWs from spinning neutron stars	118
6.6.2 Transient CWs	122
6.6.3 Search for dark matter with CWs	124
6.6.4 Conclusions	126
7 The role of the null stream in the triangle-2L comparison	127
+Summary and Appendix	

- New updated Science Case Paper for ET
- Detailed comparison among different configurations and designs through simple metrics and specific science cases

Deadline: February 2025

Extension of the LMA in Lyon



Contrat de Plan
Etat-Région
2021-2027



RÉPUBLIQUE FRANÇAISE



An investment for:

- the extension of the LMA building
- the construction of a new coater allowing the deposition of thin films on very large substrates: Ø 1.6 m, 600 kg
- associated optical and metrology tools

LMA is a research infrastructure
unique in the world

Developing technologies for future experiments
(e.g. Einstein Telescope)

Conclusion & Perspectives

In France, preparing 3G experiments for ground-based GW detection has been identified as a priority in the Strategic Plan for French Nuclear, Particle and Astroparticle physics in the 2030 Horizon

Compte rendu

Conseil scientifique de l'IN2P3
3-4 juillet 2023

Concernant le lien avec ET, le Conseil s'inquiète du fait que, à l'opposé du mouvement observé aujourd'hui dans la communauté internationale, l'IN2P3 ne s'engage pas dès aujourd'hui plus fortement sur ET. Le Conseil recommande en conséquence de contribuer à Virgo_nEXT prioritairement sur les sujets qui permettront aux équipes de se préparer et de se positionner au mieux dans ET, c'est-à-dire en particulier, sur les enjeux communs aux deux projets que sont la stabilisation des cavités, les développements des revêtements pour des masses d'une centaine de kg pour Virgo_nEXT, qui permettront d'avancer vers les 200 kg prévus pour la détection d'ondes gravitationnelles de haute fréquence avec ET, et la réduction de 10 dB du bruit quantique grâce aux états comprimés visée par Virgo_nEXT, qui est identique aux spécifications d'ET aux hautes fréquences.

