



Horizon Europe: Coordination  
and Support Actions



# ET-PP 1<sup>st</sup> review meeting

14/12/2023

Grant agreement: N° 101079696

# WP 4: Introduction and objectives

- Duration: M1-M48
- WPL: NIKHEF.
- WP4 chairs: Domenico D'Urso (INFN), Wim Walk (NIKHEF)
  
- General Objective: The general objective of WP4 is to facilitate the site selection process by collecting – and wherever possible quantifying – all relevant site-specific aspects entering the ET site selection process.
  
- Objectives for this period:
  - Report on site-specific characteristics that impact ET sensitivity and its duty cycle
  - Report on a common methodology to estimate impact of site characteristics on ET performance
  - Inventory of Legal Procedures to be taken prior starting excavation

# WP 4: Tasks

- Two sites, in Europe, candidate to host ET:
  - The Sardinia site, close to the Sos Enattos mine
  - The EU Regio Rhine-Meuse site, at the NL-B-D border
- Measurement campaign and data analysis of environmental sensors to understand relevant site characteristics for ET detector performance.
- Data analysis of environmental data. Meetings to discuss results and methodology. Produce intermediate papers and presentations.
- Develop geological and hydrogeological models for ET positioning
- Study of legal scenario of candidate country
- Update overall costs



# WP 4: Critical risks, deviations from Annex I, contingency plans

## Critical risks

- WP4 is the responsible for collecting and processing all the required information necessary for site qualification. Activities are managed directly by site Host Teams, which are implementing different organizational strategies, constrained by the national and regional fundings conditions (in 2022-2023 **42M€ for the EMR team** and **50M€ for the Sardinia team**).
- ET Collaboration is working on the definition of detector specification and on a common definition of standards for site characteristics measurements and of standard modelling and interpretation

# WP 4: Critical risks, deviations from Annex I, contingency plans

## Deviations from Annex 1

### D4.1 Scan of legal procedures, permitting and land acquisitions

- Given that such legal and permitting studies need to account for different regulations, and the possibility to obtain a new legislation tailored for the ET infrastructure, an introductory overview is given in the present document, while the final complete report will be delivered by 31/12/2025. This delay does not interfere with other deliverables and will be complementary information to that in D4.5 scheduled for month 42 (spring 2026) in the ET-PP plan.
- **EMR**: a first study of the engineering, legal, and permitting aspects ordered by the University of Liège using core funding of ULiège, RWTH, Provincie Limburg (NL) and Nikhef is available and it will act as a foundation for a second, more specific and detailed study, currently in development.
- **Sardinia**: a call for tender for “Preliminary studies to the feasibility study of ET infrastructure in Sardinia” using national funding will produce, within a wider framework where an engineering study and a geotechnical investigation will be produced, a complete scan of all the procedures, authorization and permits needed. Consequently, the final outcome of the tender is expected in summer 2025.

## Contingency Plans

- D4.1 is composed of two parallel documents, referring to EMR and Sardinia respectively and reflecting the different strategies. The final and most complete report will be delivered within the 31/12/2025.

# WP 4: Critical risks, deviations from Annex I, contingency plans

## Deviations from Annex 1

### **M4.2 Common methodology to estimate the impact of site characteristics on ET sensitivity and operation and, if required a scheme to compensate it**

- Crucial step towards the definition of a fair site evaluation procedure and it requires a full understanding of the role of environmental noise and site characteristics on detector performance.
- Einstein Telescope is expected to reach a sensitivity, in particular at low frequencies, well beyond those obtained by current 2G detectors (at 3 Hz the difference will be more than 5 order of magnitudes) and that amplifies the importance of environmental noise. Seismic fields need special attention since the main environmental noise predicted to set a low-frequency limit to ET's bandwidth was from gravity perturbations produced by seismic fields, so-called Newtonian Noise (NN).
- Based on the experience of managing current 2G detectors, the ET Collaboration has been able to identify site characteristics that may have an impact on the detector and it is evaluating their effects on the interferometer. NN effects have never been measured since they are well below the 2G GW sensitivity and one can only estimate the resulting NN. Within the ET Collaboration a consensus on how to estimate the NN, starting from seismic measurements, is not yet achieved and a detailed comparison of different approaches is ongoing.

# WP 4: Critical risks, deviations from Annex I, contingency plans

## Contingency Plans

### **M4.2 Common methodology to estimate the impact of site characteristics on ET sensitivity and operation and, if required a scheme to compensate it**

- On Dec. 6<sup>th</sup> and 7<sup>th</sup> in Amsterdam there has been a dedicated workshop to discuss the status of site noise understanding taking into account the experience of VIRGO and KAGRA Collaborations.
- A special common working group has been set up and several additional thematic meetings will be organized to eliminate, where possible, differences between the different approaches.
- Common, shared tools are being made available as starting framework for noise estimation
- A document will be prepared to report a standardization on measurement methodologies and agreements on common tools to be used for noise estimation.
- Conclusion of the processes expected at the end of Q1 2024.

# WP 4: Deliverables and milestones - overview

## **Milestones:**

M4.1-M3: Document detailing the site-specific characteristics that impact ET sensitivity and its duty cycle

M4.2-M10: Common methodology to estimate impact of site characteristics on ET sensitivity and operation and, if required, a scheme to compensate it

## **Deliverables:**

D4.1- M10: Scan of legal procedures, permitting and land acquisitions

D4.2 - M15: Updated socio-economic impact studies. Scan of accessibility, quality of life etc.

D4.3 - M28: Complete quantification of all the aspects impacting the ET performance for each site

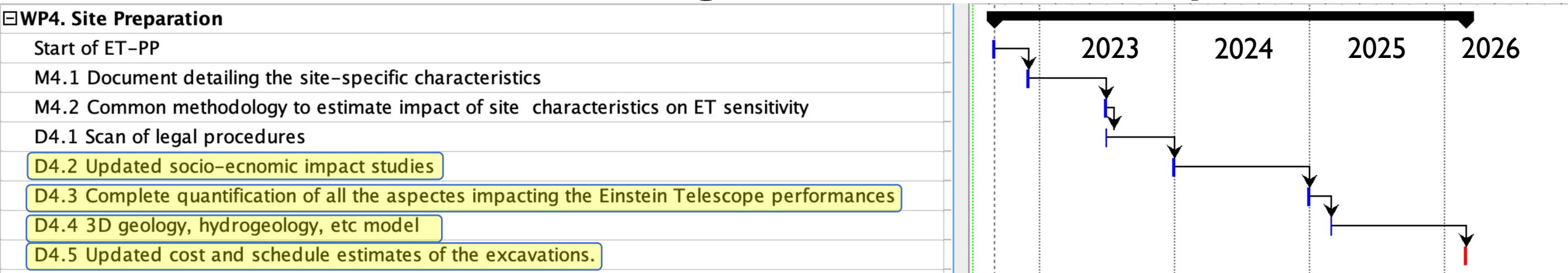
D4.4 - M30: Report on 3D geology, hydrology, etc. model with localisation of the ET infrastructure

D4.5 - M42: Updated cost and schedule estimates of the excavations, including, if necessary: instrumentation for Newtonian Noise cancellation; costs of debris removal; costs of land acquisition, permitting, etc.



# WP 4: Deliverables and milestones - overview

## WP4 Gantt chart. Starting date assumed to be 1-Sept-2022.



### D4.2 Updated socio-economic impact studies

To update the socio-economic studies of the EMR requires a coordination between the three countries and four regions of the EMR. Given that the initial studies were done separately in the different region, an effort has to be made in order to provide a single study over the different countries and regions. The successive crisis (COVID and Ukraine) has also changed the socio-economic landscape significantly requiring a global overhaul of the previous studies rather than performing an update. In general, the socio-economic update will require as well to define ET geometry if it will be a 2-site observatory or 1-site observatory.

D4.3 The delay of M4.2 will imply a delay at least of the same amount.

### D4.4 3D geology, hydrology, etc. model with detailed localisation of the ET infrastructure

The subsurface being complex in the different sites, a longer timeline will be needed to derisk significantly the subsurface and to position in the ET infrastructure. In particular, the study of both geometries is a very demanding task.

D4.5 Updated cost and schedule estimates of the excavations. This deliverable is dependent on previous deliverables and follows their timeline.

# WP 4: Deliverables and milestones – 1 year

- M4.1: Document detailing the site-specific characteristics that impact ET sensitivity and its duty cycle.  
Achieved on 31/01/2023 (due date 30/11/2022)
- M4.2: Common methodology to estimate impact of site characteristics on ET sensitivity and operation and, if required, a scheme to compensate it.  
Not Achieved (due date 30/06/2023, new due date 31/03/24)
- D4.1: Scan of legal procedures, permitting and land acquisitions  
Submitted on 31/10/2023 (due date 30/06/2023)

# WP 4: Milestone M4.1

- **M4.1.Document detailing the site-specific characteristics that impact ET sensitivity and its duty cycle. Achieved on 31/01/2023 (due date 30/11/2022)**
- We define the site characteristics that may have an impact on the Einstein Telescope (ET). The environment of modern fundamental physics experiments assumes an increasingly important role with great impact on infrastructure, cost, and science.
- Site conditions have an effect on the construction feasibility, costs and lifetime of the infrastructure and, at the same time, may impact detector performance while environmental noises (e.g. seismic motion) have a direct impact on the detector sensitivity and duty cycle
- Physical Variables: Seismic field, Geodetic site characterization, Magnetic noise, Other environmental noises like acoustic and barometric noise
- Site characteristics – geological, geophysical and geotechnical information: Sub-surface geology, groundwater flow, rock quality and geomechanical parameters

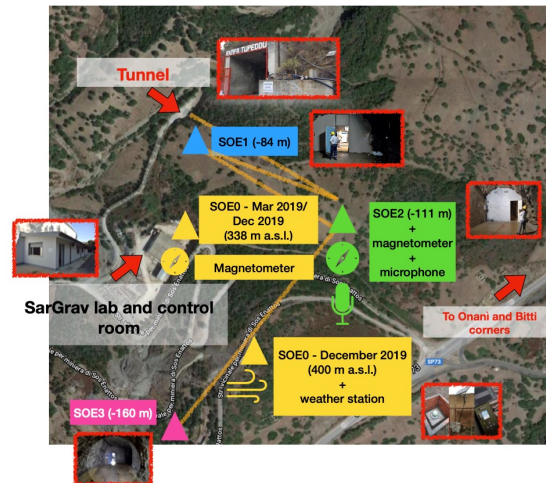
# WP 4: Milestone M4.1

- **M4.1.Document detailing the site-specific characteristics that impact ET sensitivity and its duty cycle. Achieved on 31/01/2023 (due date 30/11/2022)**

## Permanent Instrument Network

Since 2019, in Sos Enattos there are:

- 4 permanent seismic stations for long term studies:
  - Surface: SOE0;
  - Underground: SOE1, SOE2, SOE3;
- 1 weather station;
- 1 microbarometer;
- High precision tilmeter as part of the Archimedes experiment;
- 2 microphones;
- 1 movable array composed of 8 short-period tri-axial seismometers;
- 3 magnetometers;
  - Surface: control room;
  - Underground: SOE2;
- All permanent seismic stations are provided with broadband seismometers (Trillium 240, 360 and 120 Horizon, Guralp 360);



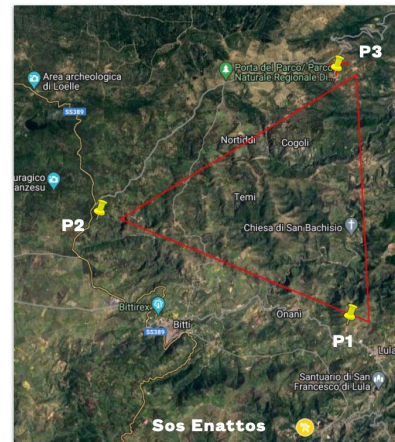
Credits. to M. Di Giovanni

## Permanent Instrument Network

In 2021, more permanent sensors have been installed at 2 of the proposed vertices (P2/3):

- 2 broadband seismometers on surface;
- 2 broadband seismometers in borehole;
- 2 magnetometers at P2

In the near future, more sensors will be installed at P1 as well.



Credits. to M. Di Giovanni

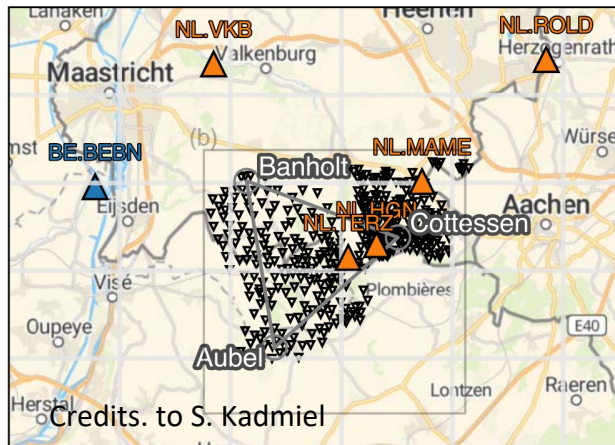


# WP 4: Milestone M4.1

- **M4.1.Document detailing the site-specific characteristics that impact ET sensitivity and its duty cycle. Achieved on 31/01/2023 (due date 30/11/2022)**

## A rich network of seismic sensors

1. Seismic noise characterisation for the optimal location of the ET corner-points.
2. Imaging the subsurface to support geotechnical engineering efforts.
3. Extending the existing seismic network in the region: 15 new broadband seismic stations (surface) & 4 new broadband borehole seismic stations (250 m depth)



# WP 4: Milestone M4.2

## **M4.2. Common methodology to estimate the impact of site characteristics on ET sensitivity and operation and, if required a scheme to compensate it.**

Not Achieved (due date 30/06/2023, new due date 31/03/24)

- Special working group is being set up to standardize noise measurements in general and to eliminate differences between the different approaches.
- At a special SPB workshop (Dec 2023) the current status, intermediate reports and papers and approach to NN has been be discussed.
- Following the workshop, a document will be prepared to report a standardization on measurement methodologies and agreements on common tools to be used for noise estimation.
- To fully understand and eliminate different measurement approaches, as well as to create appropriate standards, as described in the process above, Milestone 4.2 had to be delayed.
- The conclusion of this process and delivery of Milestone 4.2 is expected at the end of Q1 2024.

# WP 4: Deliverable D4.1

- **D4.1 Scan of legal procedures, permitting and land acquisitions**  
**Submitted on 15/11/2023 (due date 31/10/2023)**
- It is composed by two parallel documents, referring to EMR and Sardinia respectively and reflecting the different strategies.
- An overview of the legal, permitting and acquisition procedures with regards to public and private aspects is given, listing public and private stakeholders, private and public authorizations and permits.
- The complete report obtained by the EMR host team has been attached as annex to the EMR document. The study has been done under the following assumption: ET is located in The Netherlands and Belgium, it has a triangular shape, the access to ET are vertical shafts, and the tunnels will be dug at least at a depth of 200 m, more likely at 250 m depth.
- Tender Specifications of the “Preliminary studies to the feasibility study of ET infrastructure in Sardinia” is the annex of the Sardinia document. Assumptions: ET located in the area of Sos Enattos (NU, Italy), considering both triangular (six interferometers inserted in a system of tunnels and caverns with an equilateral triangle layout on a side about 11 km) and L shape (two interferometers inserted in a system of tunnels and caverns with an 'L' layout on a side about 16 km) configurations. The tender includes the execution of surveys and the preliminary environmental impact assessment, for infrastructure works, underground and above-ground, building and plant engineering. The contract expressly includes, in addition to the preparation of the Study, also the execution of all surveys, measurements and surveys necessary for the required level of study

# WP 4: Contribution from each partner

INSTITUTION		PM as per Annex I	PM in the period
1 Nikhef	CONTRIBUTIVES	10	2.74
	REQUESTED EC	0	0
2 INFN	CONTRIBUTIVES	10	0
	REQUESTED EC	0	0
3 UW	CONTRIBUTIVES	12.0	0.9
	REQUESTED EC	0	0
Wigner RCP	CONTRIBUTIVES	13.2	3.3
	REQUESTED EC	0	0
Total Person Months	CONTRIBUTIVES	45.2	4.94
Total Person Months	REQUESTED EC	0	0
		<b>45.2</b>	<b>4.94</b>

% PMs used = 10.9



# WP 4: Outlook and perspectives

Objectives expected for the next period and a summary

- Delivery of Milestone 4.2 is expected at the end of Q1 2024
- Continue measurement campaign and data analysis of environmental sensors to understand relevant site characteristics for ET detector performance.
  - EMR sensor surface of 4C seismic sensors and subsurface downhole network of seismometers at target depth to be installed. Develop and execute measurement plan in Q1-Q4 2024
  - EMR Wind Turbines project to start in Q1 2024, ending Q4 2025
  - General Tender procedure in Sardinia will be closed by the end of 2023, final results expected by June 2025.
  - Overall measurements of site noise in Sardinia on going thanks to a wide network of sensors (seismometers, magnetometers, micro-barometers, weather stations and tiltmeters)
- Initially estimated timeline not easy to follow.
- Activity are managed directly by Host Teams that are implementing different organization strategies strongly affected by the national and regional fundings supporting the activities (42M€ for the EMR team and 50M€ for the Sardinia team). Not always easy to uniform results and products and timeline.



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