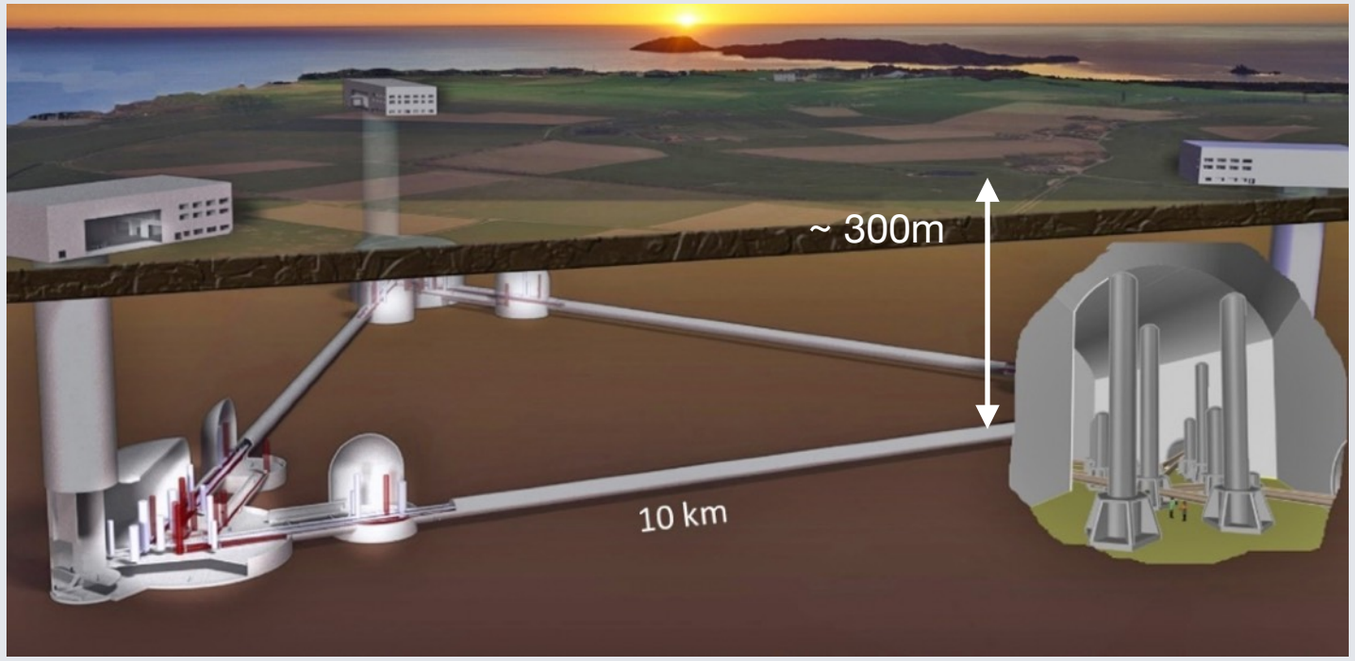
Einstein Telescope
Pre-Project Office @ APC

Ghada Mahmoud | System Engineer
Joseph Martino | System Engineer

Einstein Telescope

New generation of ground based Gravitational Wave Detector

1900 scientists from 271 institutions



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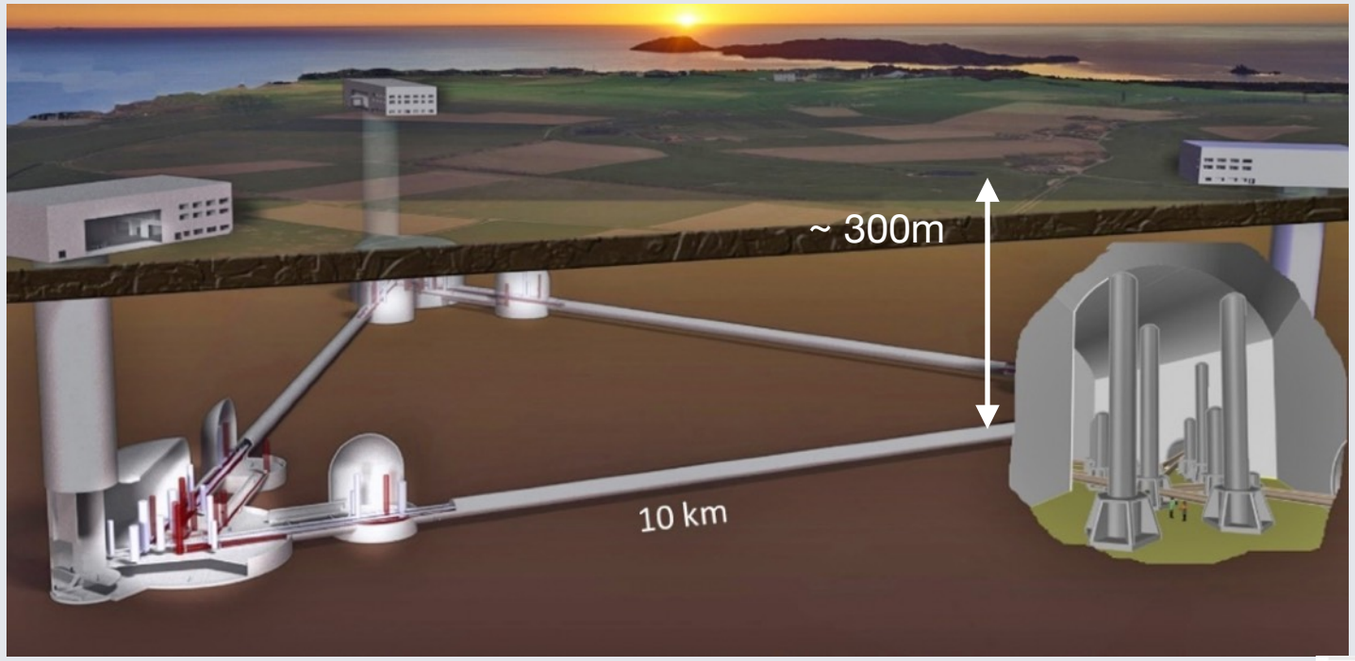

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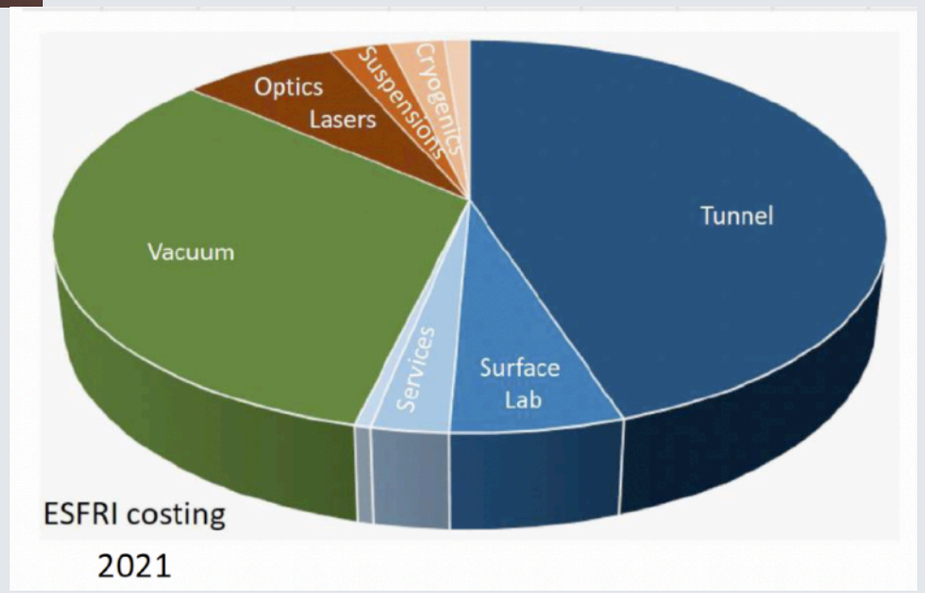

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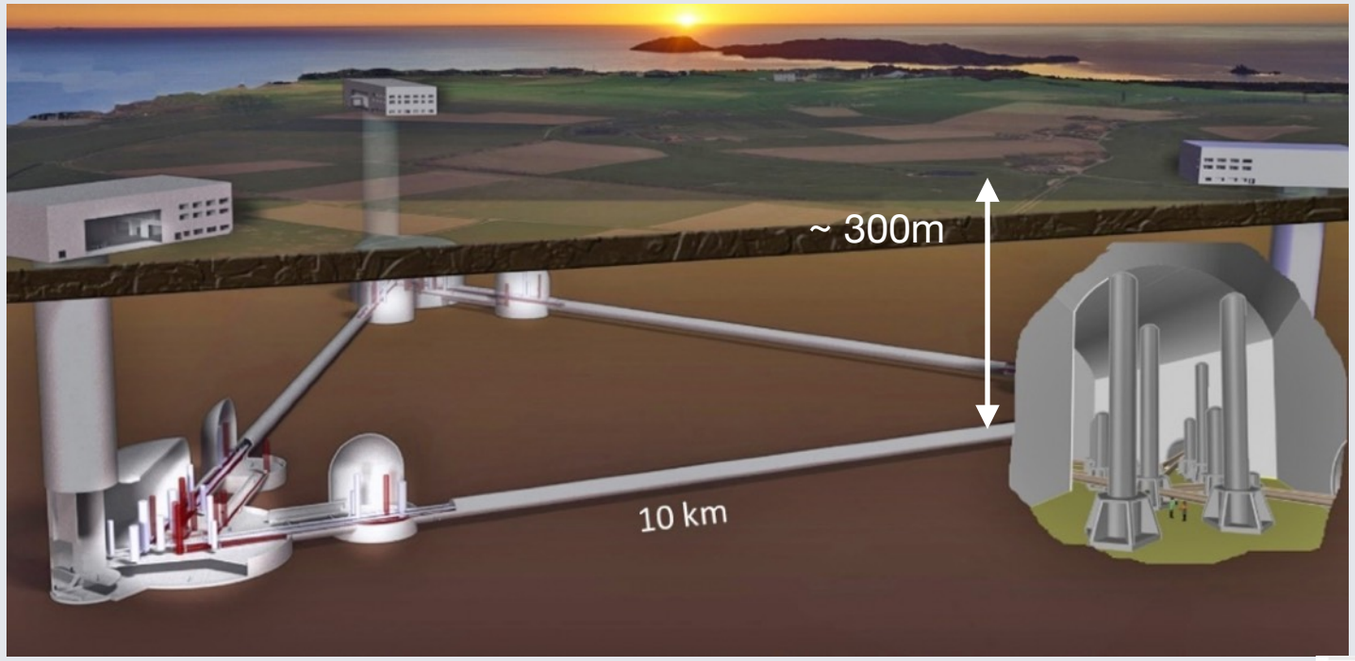

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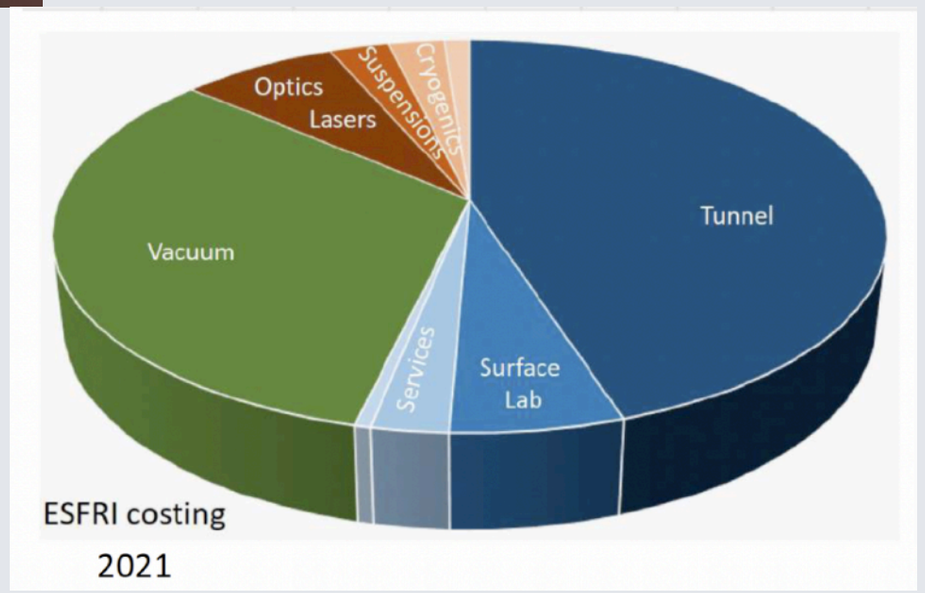

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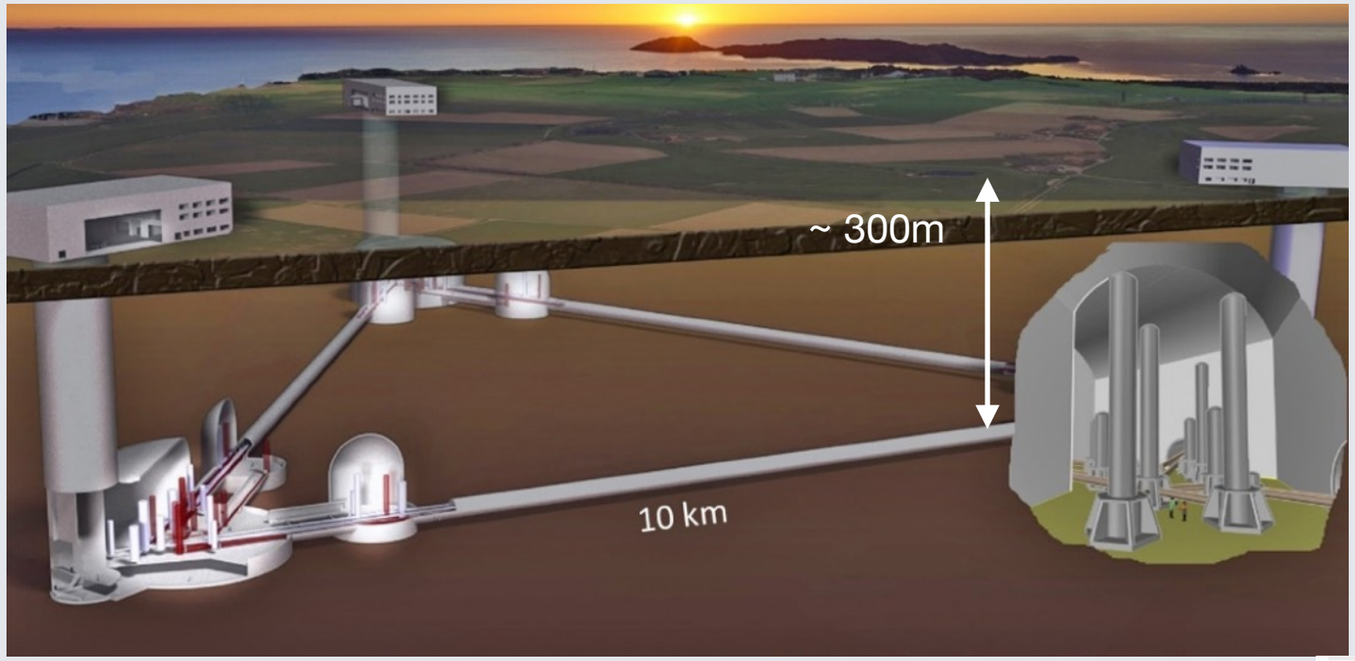

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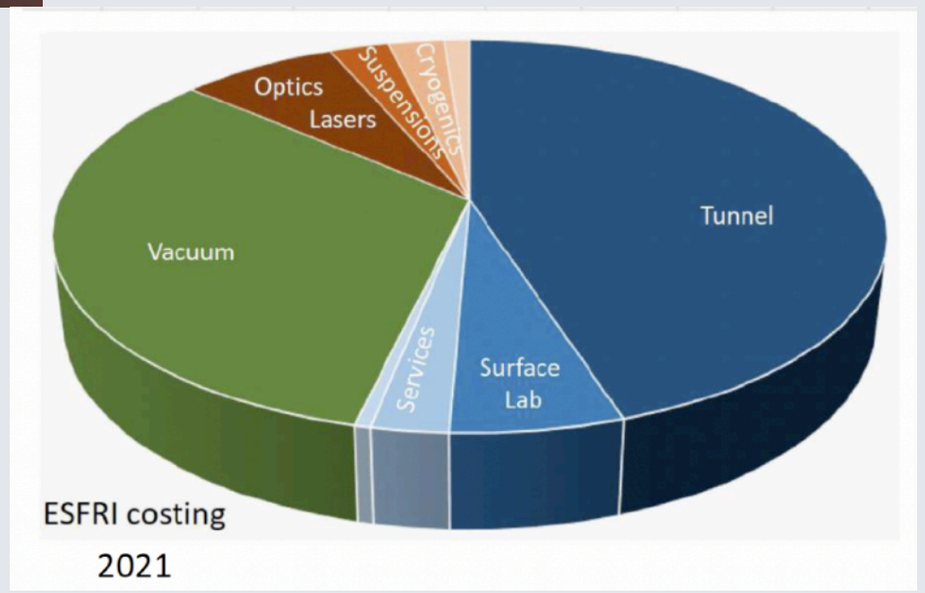

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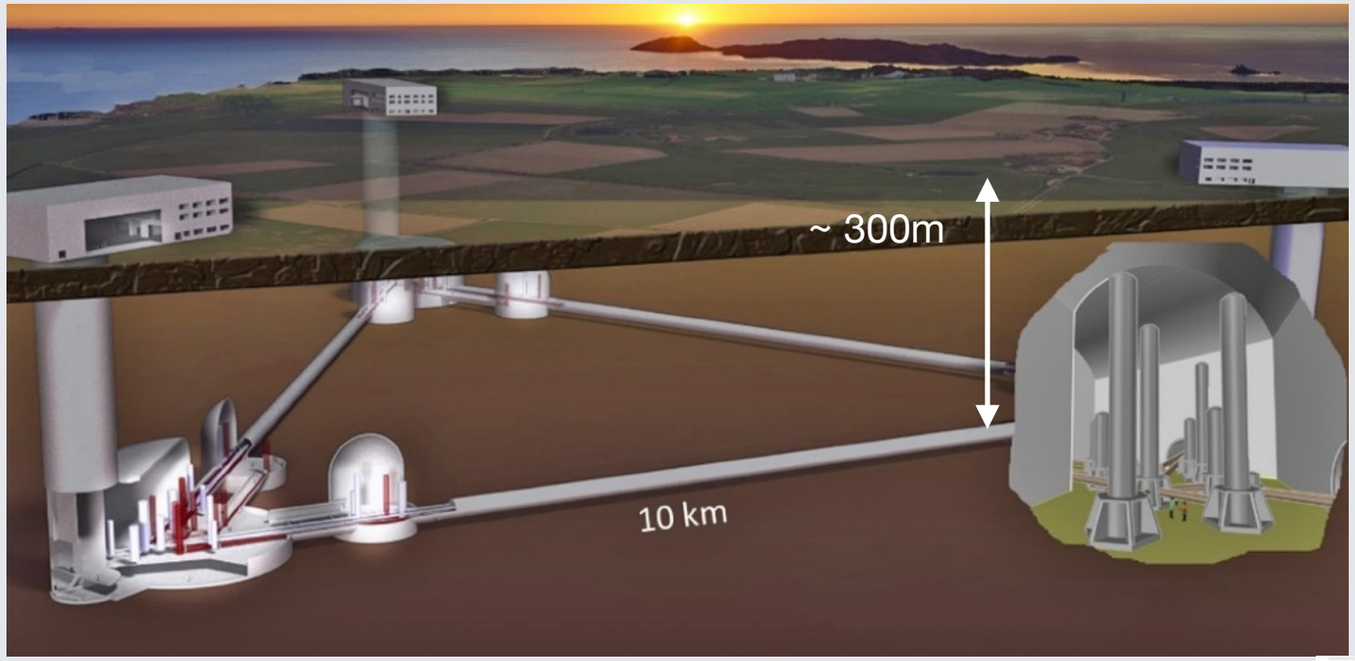

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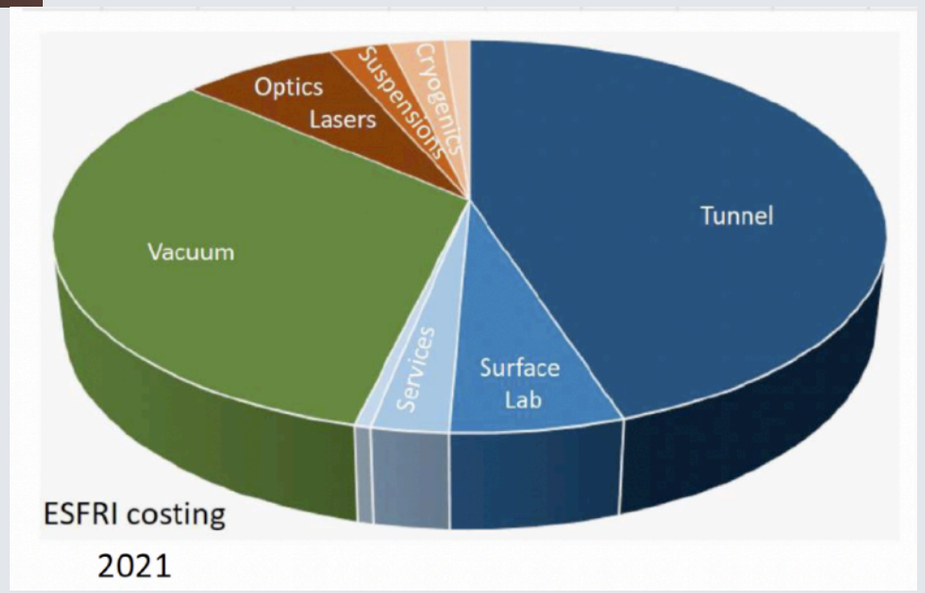
- Project management similar to large space missions or accelerators.



Einstein Telescope Preparatory Phase

Horizon Infra-dev (Preparatory Phase) : EU funding to support the development of new large research infrastructures

- EU Funding: 3.45 M€
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*« The role of this WP is to set-up a project management environment for the ET **construction**. »*

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- Safety
- Schedule
- Quality
- **Risks**
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Technical Team @APC :

Ghada Mahmoud: Risk Manager in Project Office
3 years contract through ET-PP

Joseph Martino: System engineering expertise
(background from LISA, a large class ESA led mission)

APC Contribution to Project Office

- Contribution to a Task Force to reduce cost:
  - Trade Off Analysis
  - Technology Readiness Level assessment

- Definition of a risk management plan tailored with Einstein Telescope needs

- Conduct a Risk Campaign: severity and likelihood assessment
  - 1 year 2024-2025 of interviews
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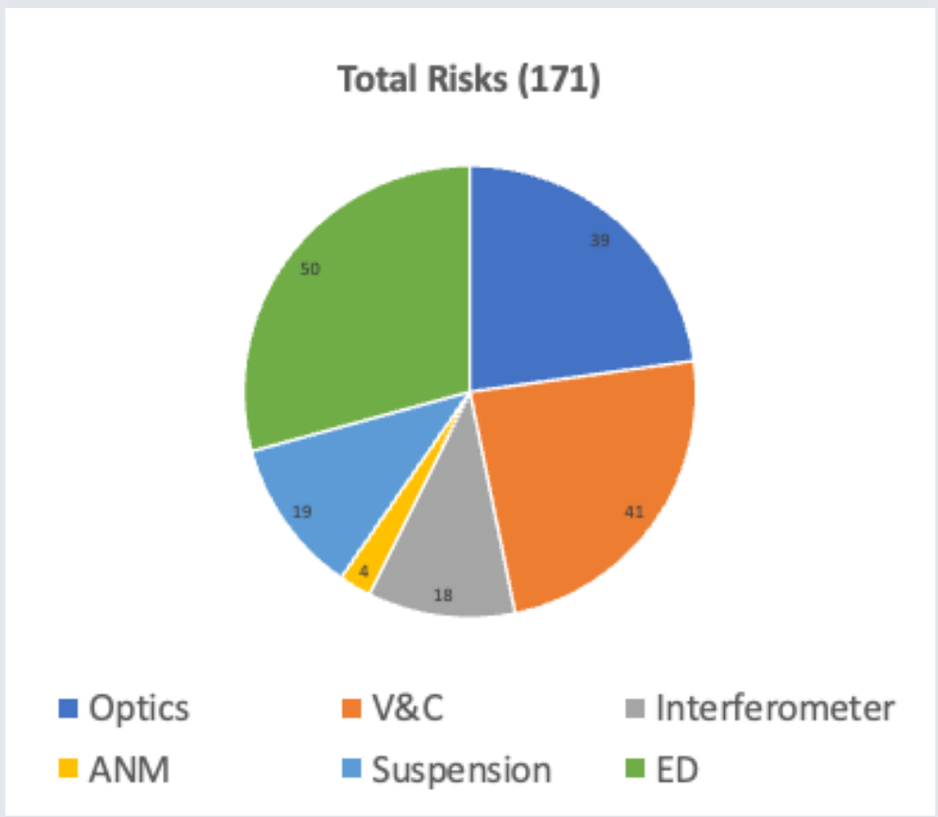

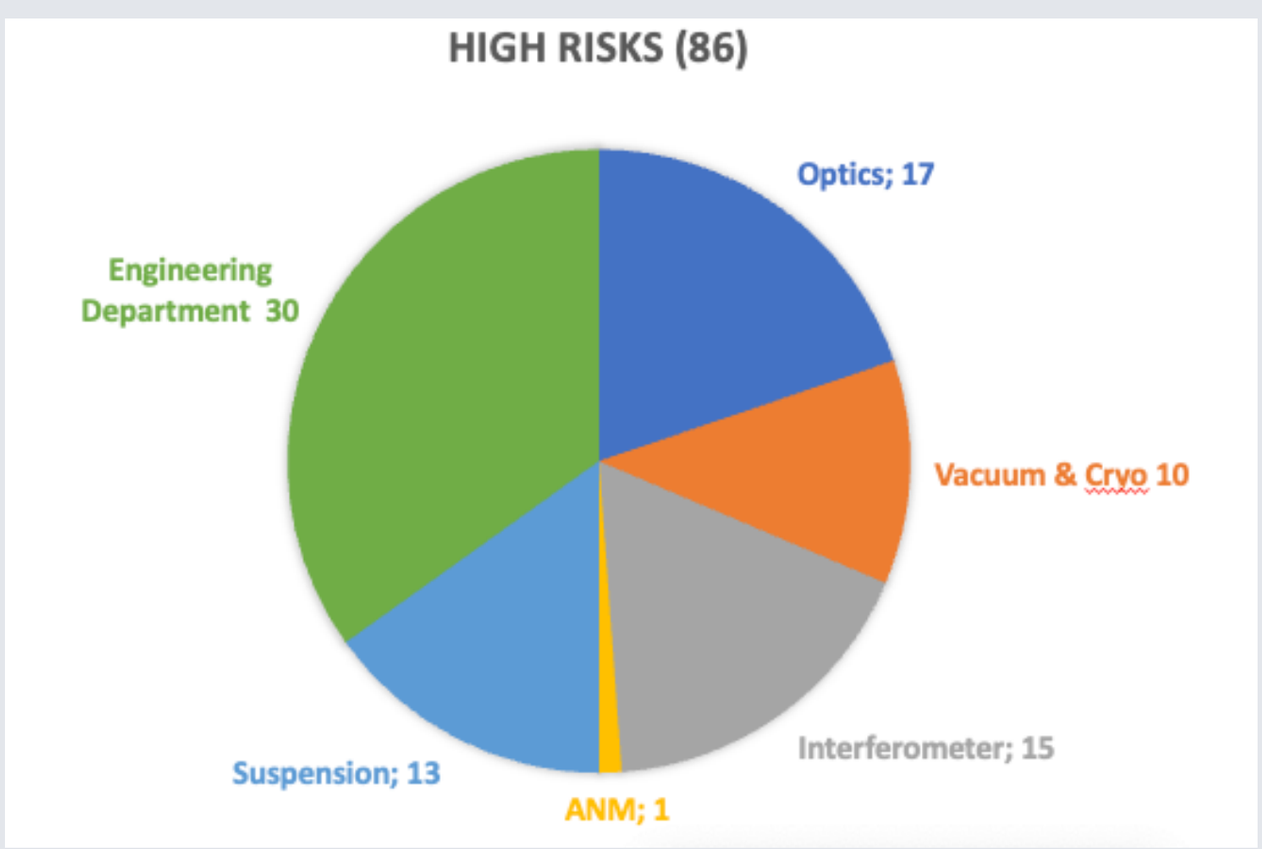

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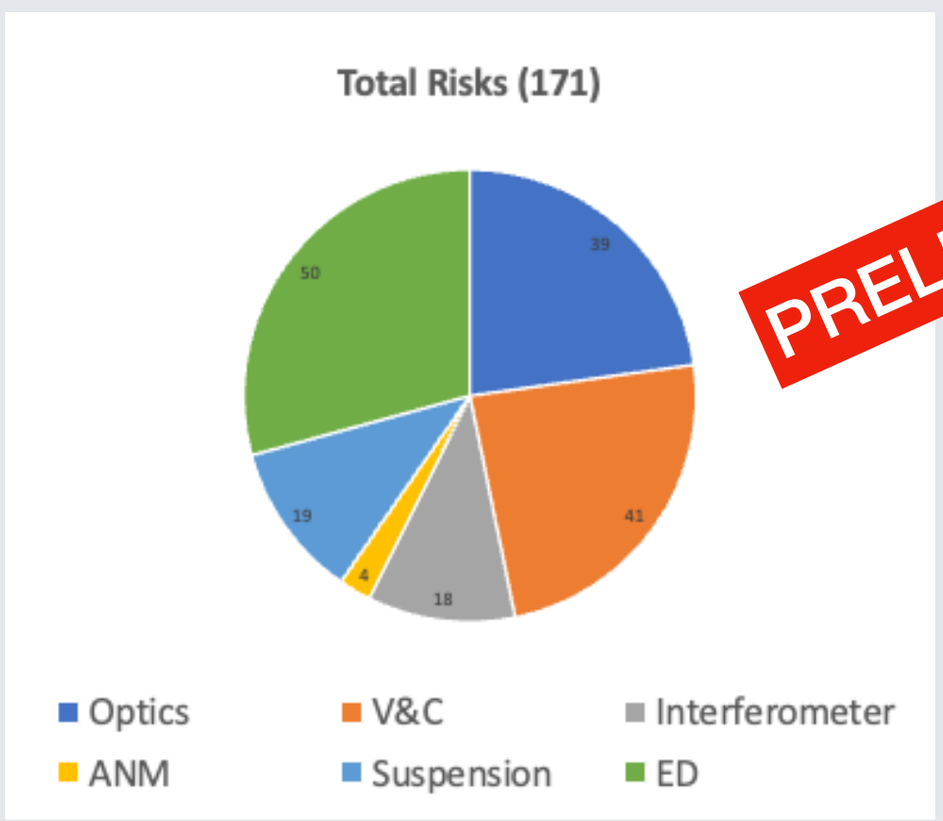
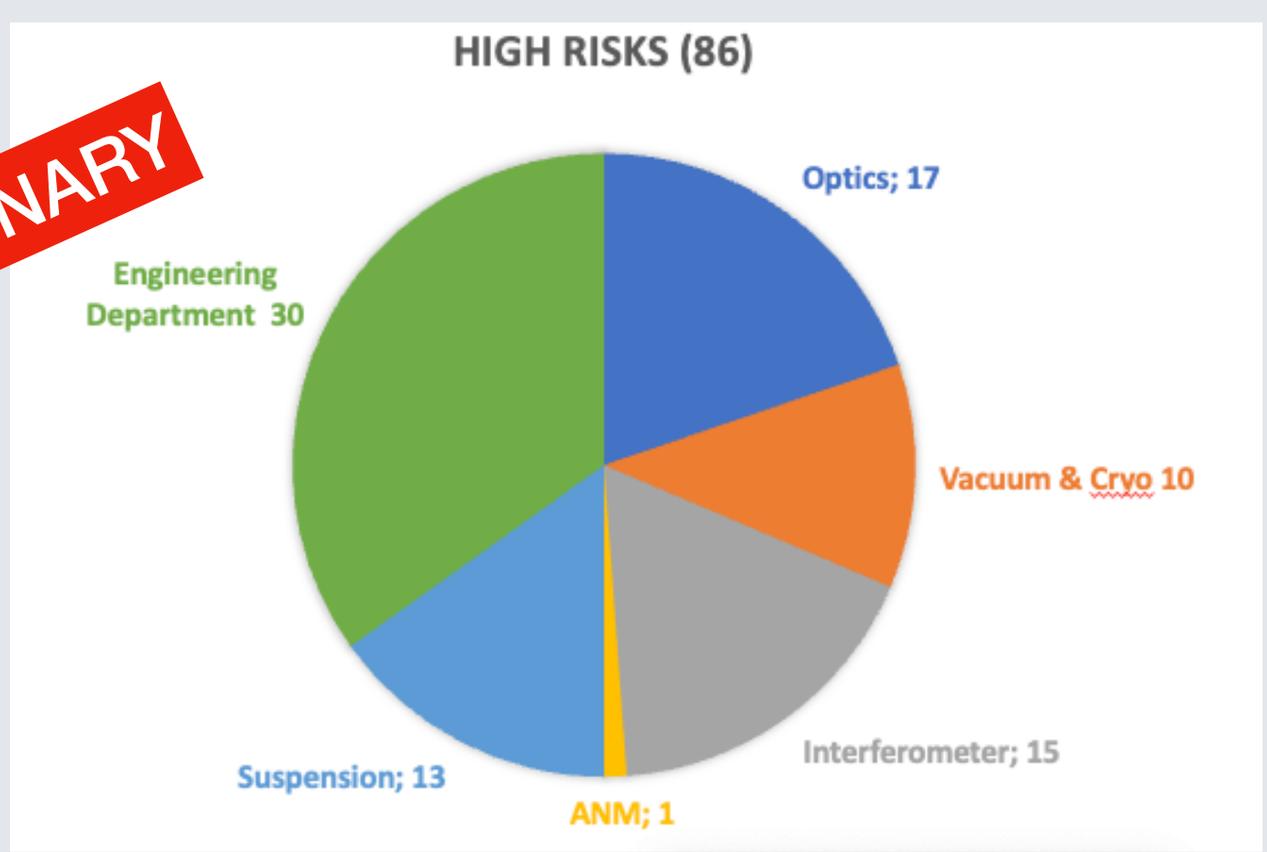


PRELIMINARY



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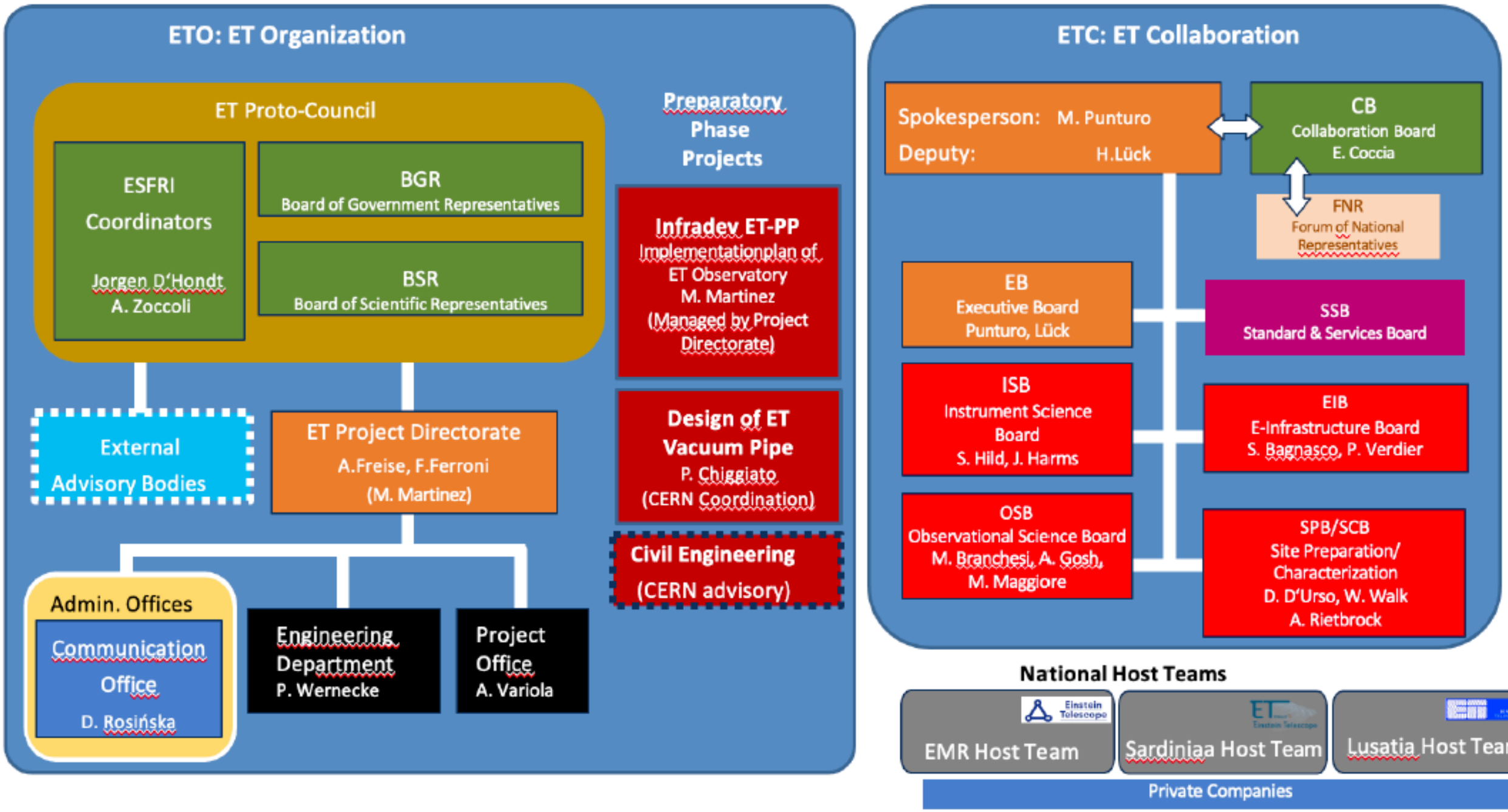
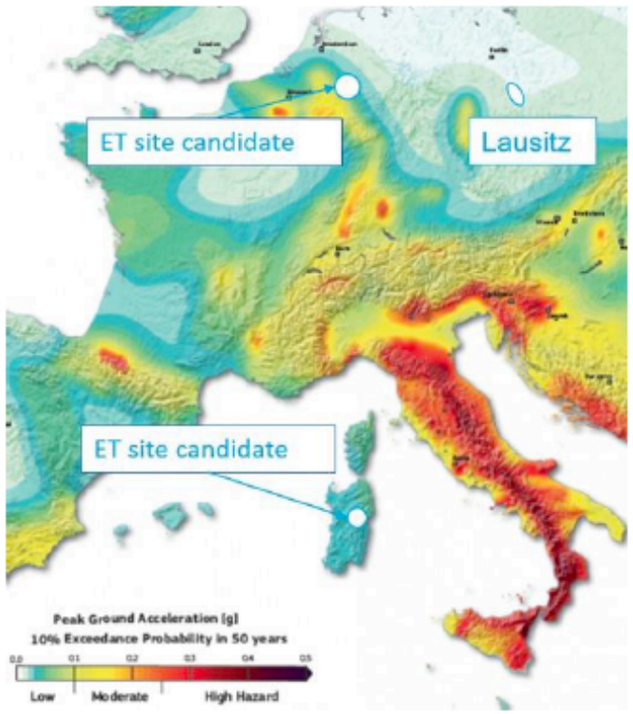
- **Interdependence with Virgo**: not addressed within ET-PP. **Virgo's continued success is essential for ET**, it provides the operational and technological foundation on which ET must build.

BACKUP

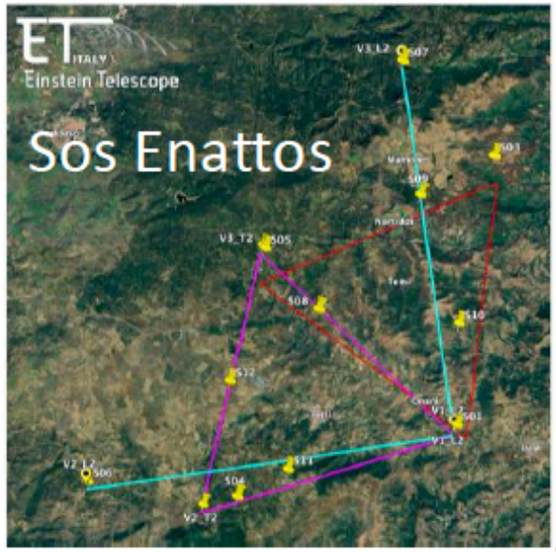
Einstein Telescope Organisation



- **Three candidate sites** candidates to host ET: **EMR**, **Sardignia**, 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**



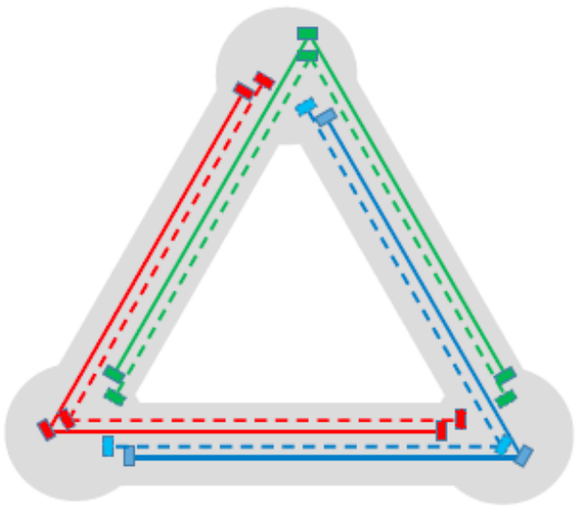
- **Geometry:**
  - Studies of physics potential has led to two geometry possibilities which are jointly evaluated: "2L 15 km" is generally better (45° orientation) and less risky than the triangle
  - Site Selection Criteria Committee will provide recommendations to BGR in 2026

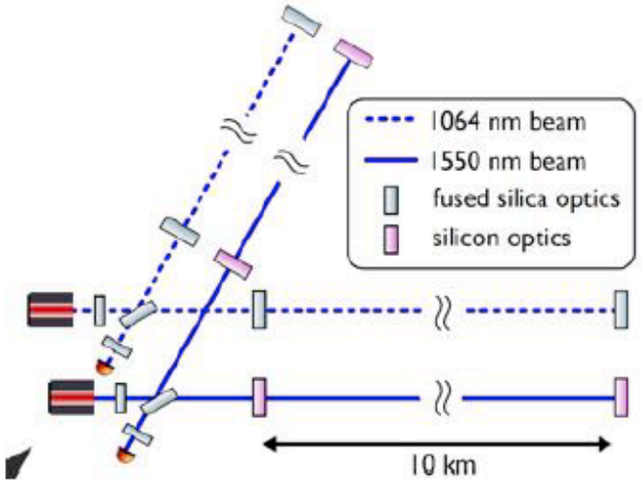


Decisions on site and geometry are expect in 2026-2027

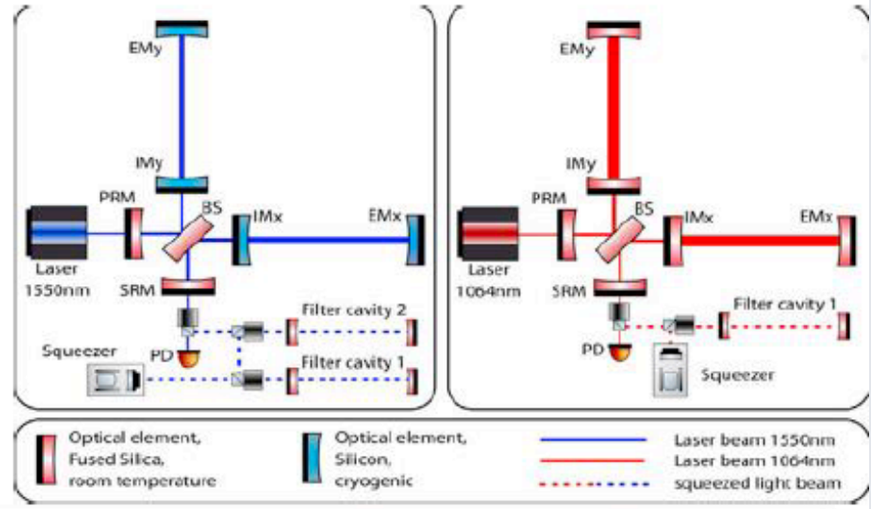
Xylophone design: 2 sensitive interferometers at different frequencies

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	1×300 m	2×1.0 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)	$5 \cdot 10^{-10}$ m/f^2	$5 \cdot 10^{-10}$ m/f^2
Gravity gradient subtraction	none	factor of a few

ESFRI ROADMAP

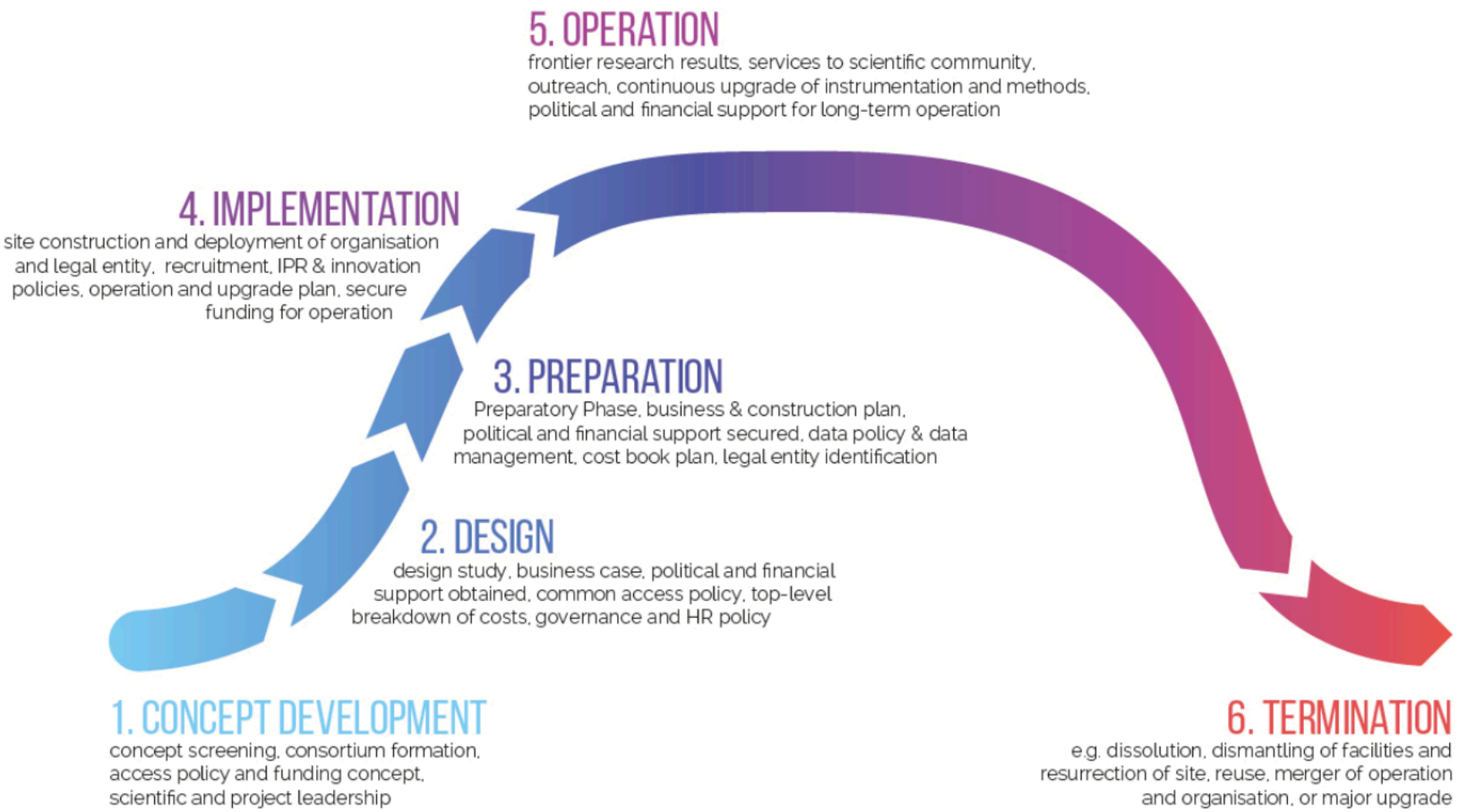
Strategy Report on Research Infrastructures

ROADMAP 2026

Public Guide

European Strategy Forum on Research Infrastructures

ESFRI



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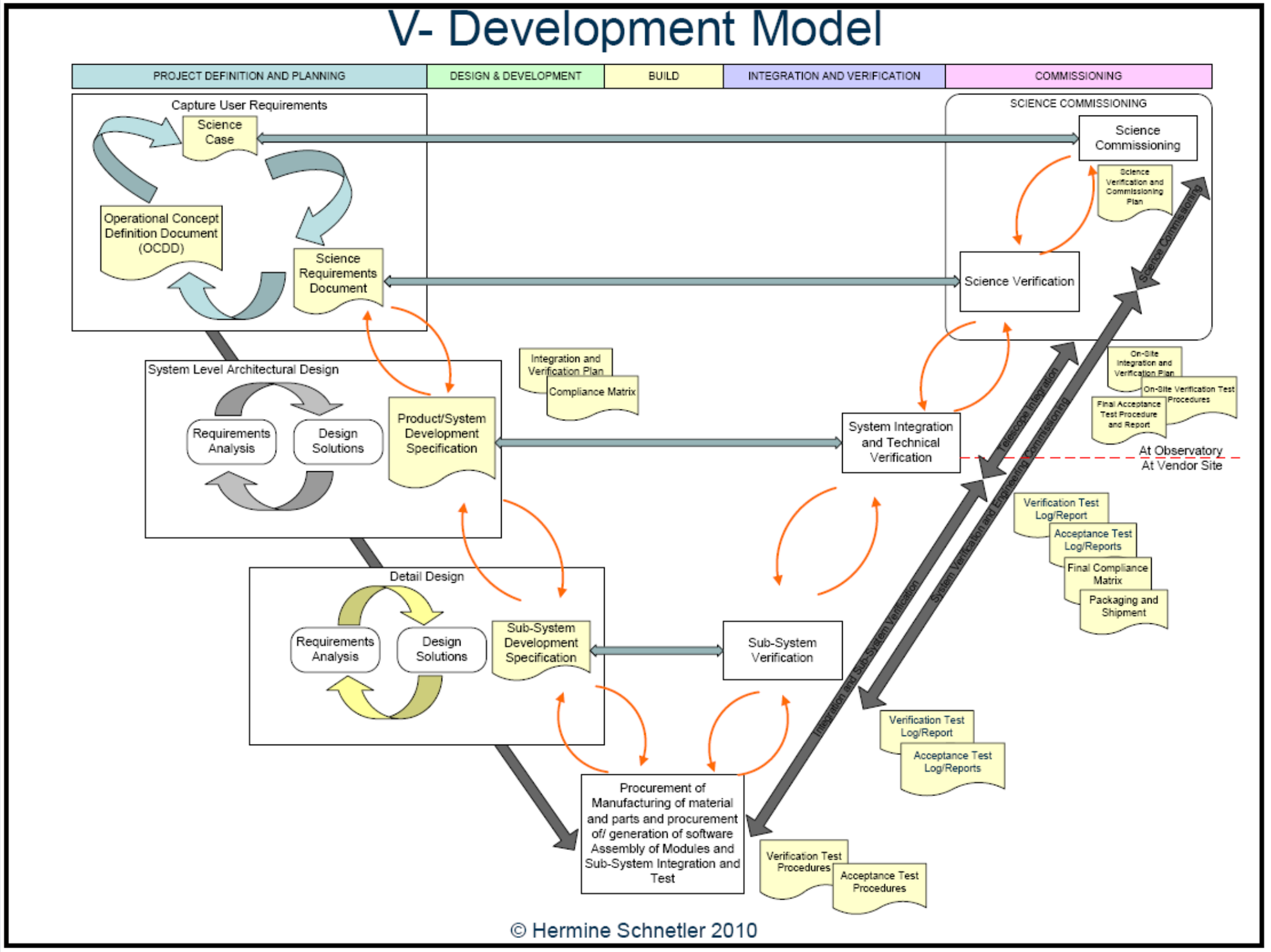

LIFECYCLE APPROACH

ESFRI applies a LIFECYCLE APPROACH coherent and consistent with RI funding under the EU Framework Programme for Research and Innovation (FP) and the GSO concerning GRI. Moreover, the lifecycle of an RI is a reference to understand the needs and targets of RIs at a given time and at various levels.

The CONCEPT of a new RI typically emerges bottom-up from the scientific communities clustering around well identified scientific needs and goals. Such a concept can originate from completely novel approaches to answer scientific questions or to respond to the need of enhanced capacity at pan-European level as well as from new insights in existing RIs – e.g. resulting in a plan for major upgrade or merger.

The DESIGN covers the proof of the scientific concept and technical feasibility of the RI, the analysis of the potential user community – both science and innovation oriented; the outline of a business case and the rationale for the international consortium. It should also cover approaches on the minimisation of the environmental impacts of the new RI. The feasibility study can be carried out with institutional, national or international support – e.g. Framework Programme (FP) Design Study grants. The design also includes an initial analysis of its position in the RI landscape, e-Infrastructure requirements and (open-)data management and policy. Importantly, the RI also foresees the financial and political support from governments and funding agencies necessary for the Preparatory Phase.

The PREPARATION – carried out at institutional, national, European or international level – is directed towards developing the RI as a fully-fledged organisation. Completion of preparation for the RIs in the Roadmap is often carried out through a Preparatory Phase contract under FP resulting in a business plan, a legal entity, an agreed role for the RI also in the context of the landscape of existing RIs at European and global level, and secured funding safeguarding the financial sustainability for the Implementation Phase and extending also for the Operation Phase. Some projects face a gap of funding between the end of their Preparatory Phase contract and the final decisions for implementation – legal, funding and construction – which can lead to the establishment of *ad hoc* interim legal entities and governance to assure appropriate funding to complete the preparation and start construction.