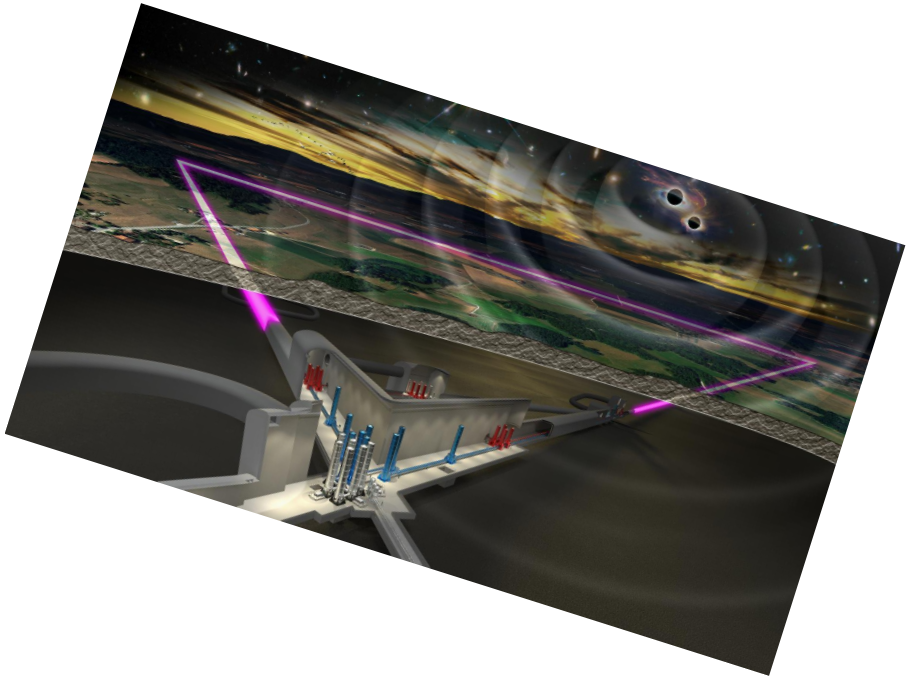
ETO: Project Organisation for the Einstein Telescope

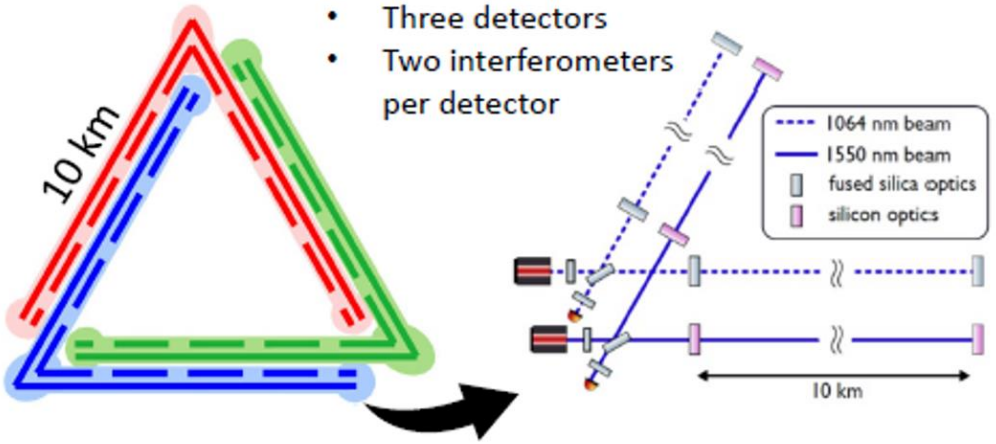
Status of the project, planning and requirements for the beampipe vacuum system

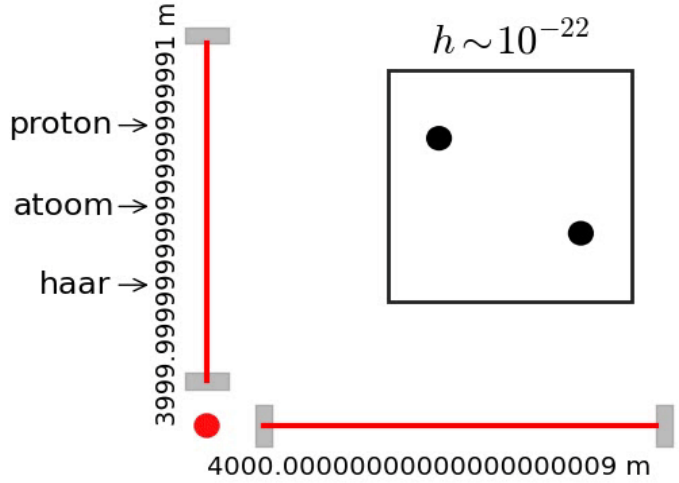


Patrick Werneke

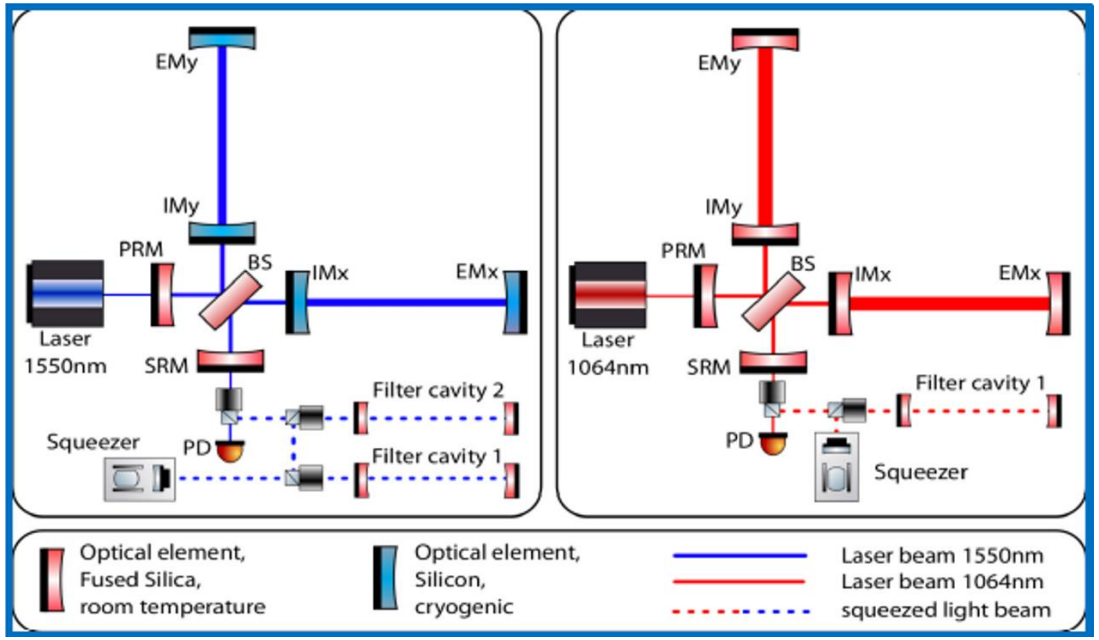
27.03.2023

ET Concept

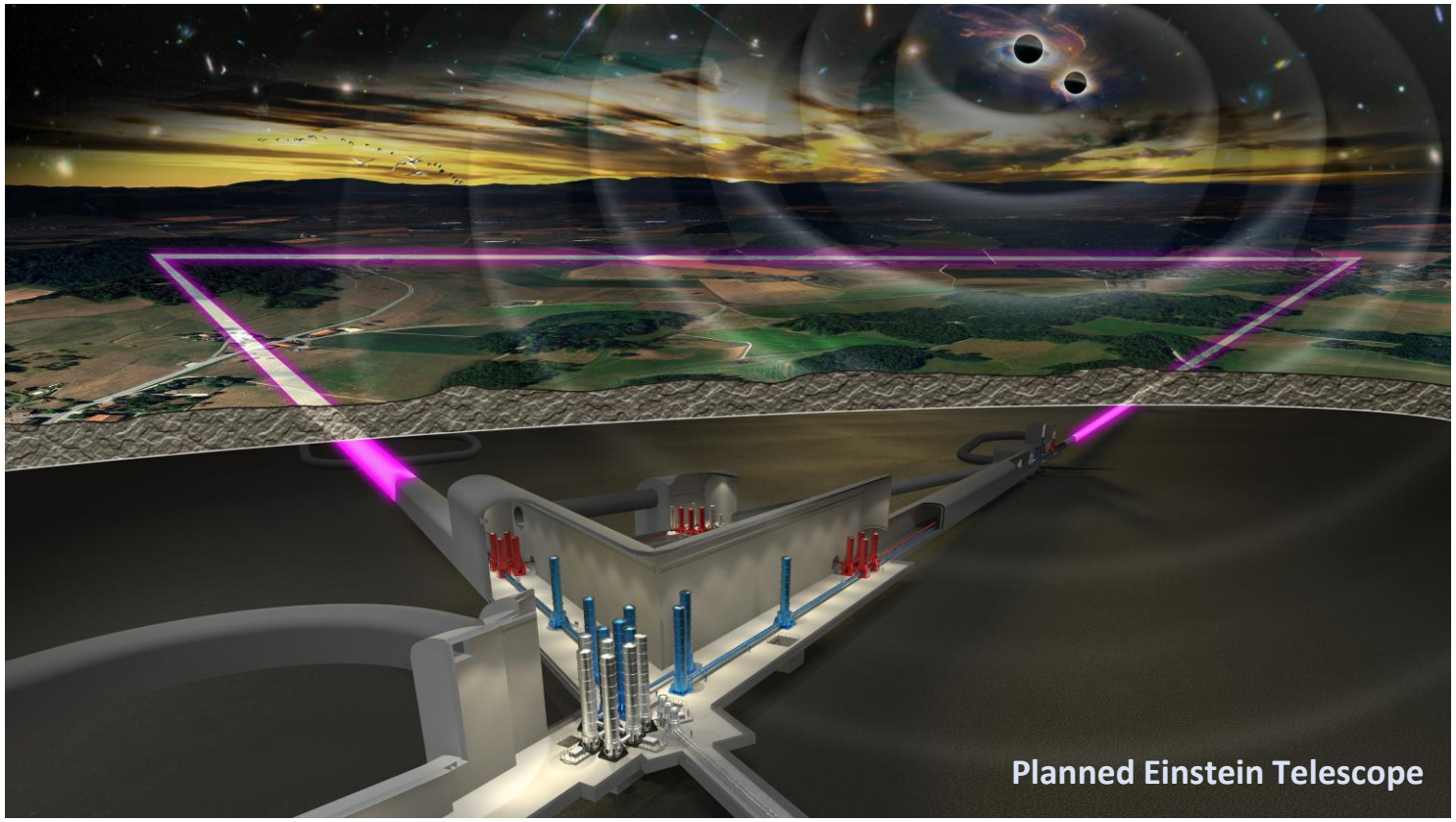




- Underground Infrastructures: 200 – 300 meter
- Probably largest UHV system ever built
- ET – Low Frequency (LF): large cryogenic (10 – 20 K) silicon test masses, seismic suspensions, new wavelength, FDS, ……..
- ET – High Frequency (HF): high power laser, high circulating light power, thermal compensation, large test masses, FDS, …..



From current detectors to ET



- Current detectors observe about one signal per week.
- ET will observe about 100.000 to 1.000.000 binary black holes mergers per year! And many other new sources!

Possible ET Sites

Currently there are two candidate sites to host the Einstein Telescope:

1. The Sardinia site, close to the Sos Enattos mine
2. The Euroregion Meuse-Rhine site close to the NL-B-D border

3. A third option in Saxony (Germany) is under discussion, but still too preliminary to be a candidate.

ET dual organisational structure

1) project organisation (towards legal entity) and 2) scientific collaboration

ETO (ET Organisation)

A project organisation to construct a legal entity to build and operate a research infrastructure.

ET Collaboration

The collaboration defines the scientific goals and requirements of the detector.

ET dual organisational structure

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ET Collaboration

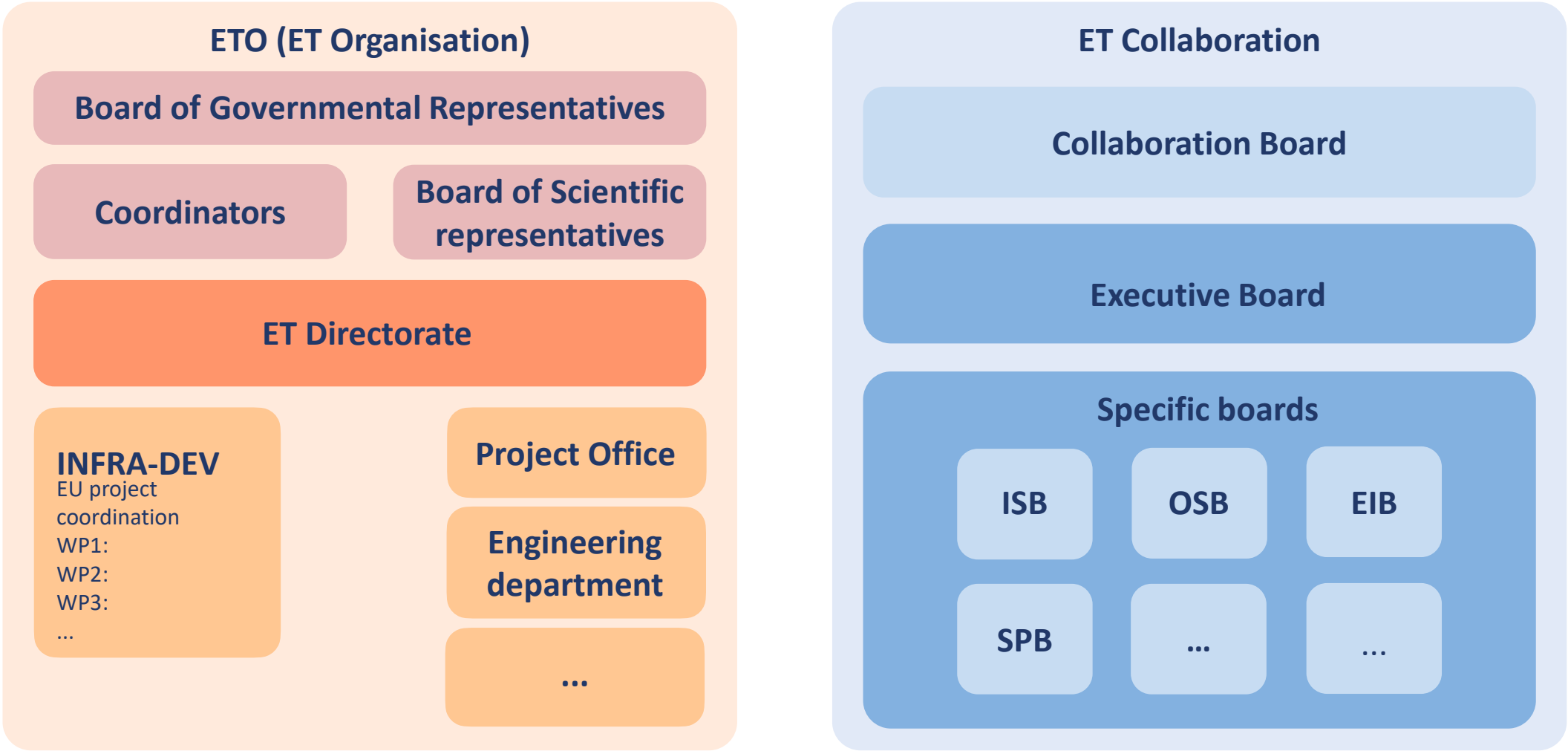
The collaboration defines the scientific goals and requirements of the detector.

Local teams

- **Site characterisation** with seismic and geological studies.
- Deliver design and implementation plans that are **unique to the region**.
- Develop **economic case** and deliver socio-economic impact plan.

ET dual organisational structure

1) project organisation (towards legal entity) and 2) scientific collaboration



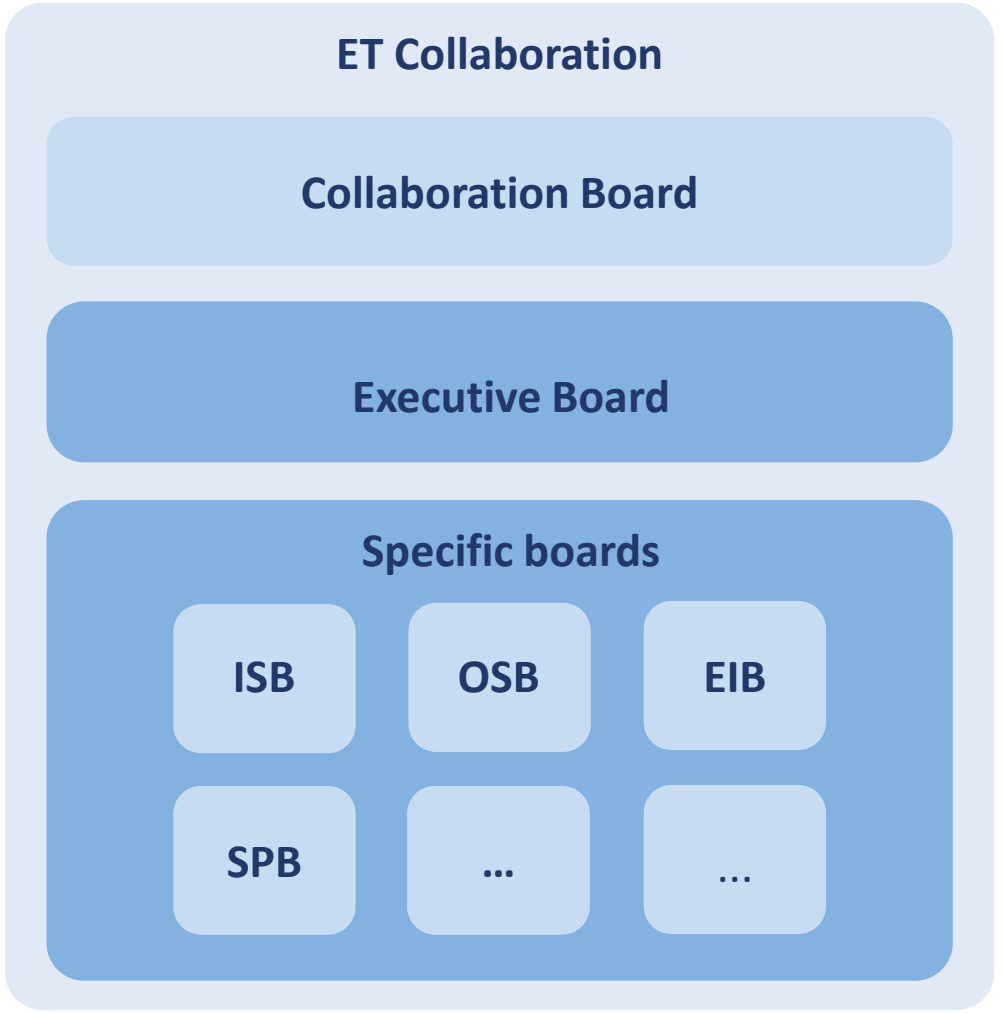
ET dual organisational structure

1) project organisation (towards legal entity) and 2) scientific collaboration

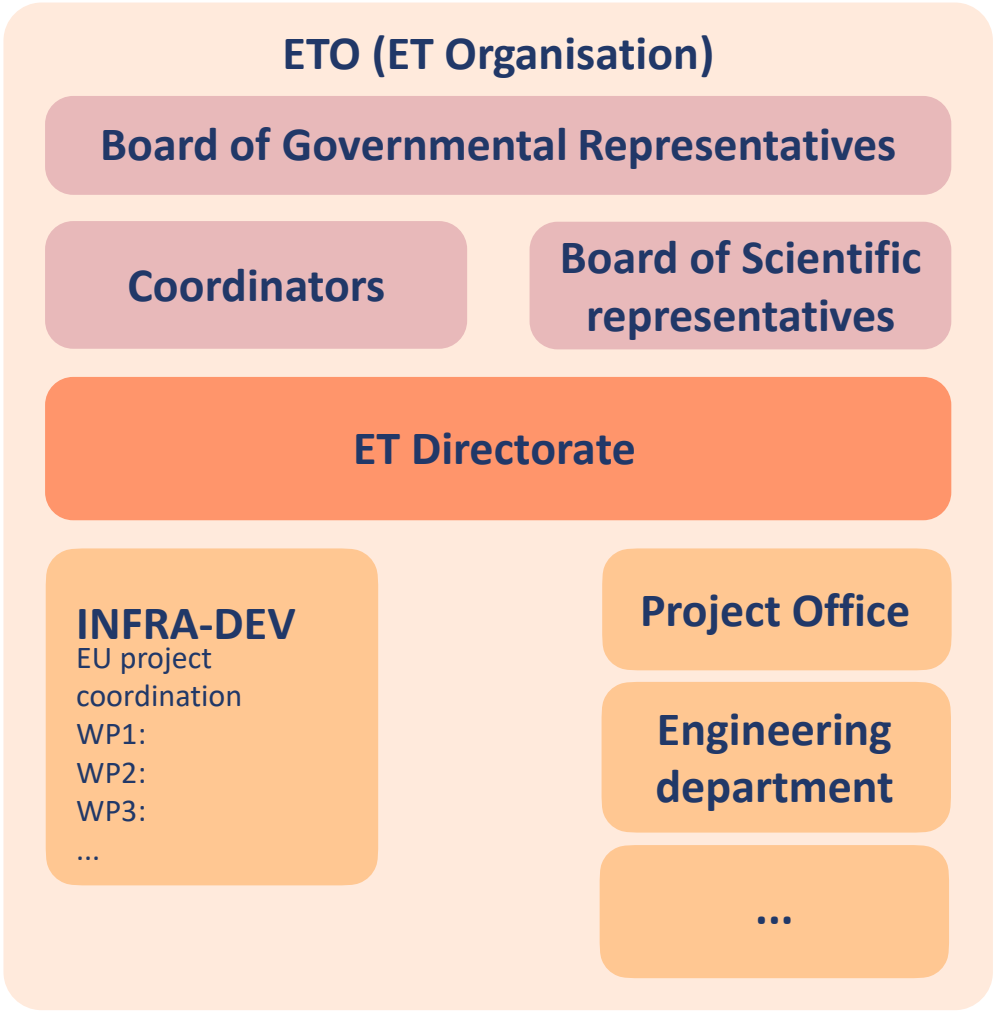
Coordinator **and** **vice-coordinator**

Michele Punturo
INFN, Italy

Harald Lück
Institut für Gravitationsphysik
Hannover, Germany



ETO: work in progress for organisation of management structure



Aim is the realisation of a legal entity to build and operate a research infrastructure: the ET Organisation (ETO).

This part of the organisation is relatively new, **in addition to the ET Collaboration**.

Currently, during the preparation phase, we are setting up and operating an interim organisation. The final form of the ET Organisation is one of the outcomes of the Prepatory Phase.

INFRA-DEV: Developing, consolidating and optimising the European research infrastructures landscape, maintaining global leadership (INFRADEV)

September 1st 2022 – August 31st 2026 (4 years)

ETO: work in progress for organisation of management structure

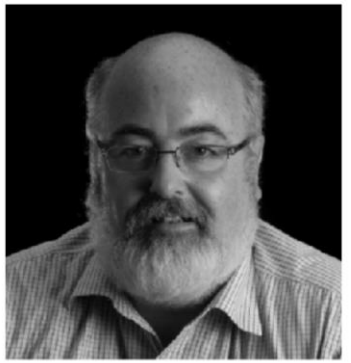
ETO (ET Organisation)

- **Board of Governmental Representatives**
- **Coordinators**
- **Board of Scientific representatives**
- **ET Directorate**
- **INFRA-DEV**
  - EU project coordination
  - WP1:
  - WP2:
  - WP3:
  - …
- **Project Office**
- **Engineering department**
- **…**

ET Directorate

Fernando Ferroni
(INFN, Italy)

Andreas Freise
(Nikhef, NL)



Mario Martinez
(IFAE, Spain)

A mandate of the ET Directorate and its roles have been agreed and signed by the ET Coordinators in February 2023.

ETO: work in progress for organisation of management structure

ETO (ET Organisation)

- **Board of Governmental Representatives**
- **Coordinators**
- **Board of Scientific representatives**
- **ET Directorate**
- **INFRA-DEV**
  EU project coordination
  WP1:
  WP2:
  WP3:
  …
- **Project Office**
- **Engineering department**
- **…**

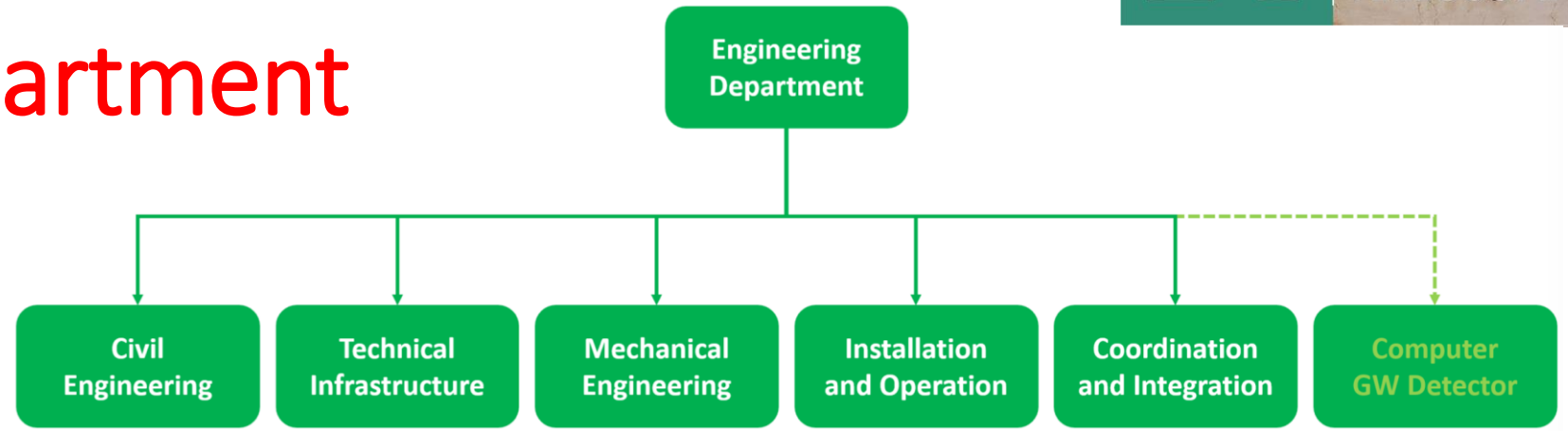
Head of Project Office

Alessandro Variola (INFN)

Head of Engineering Department

Patrick Werneke (Nikhef)

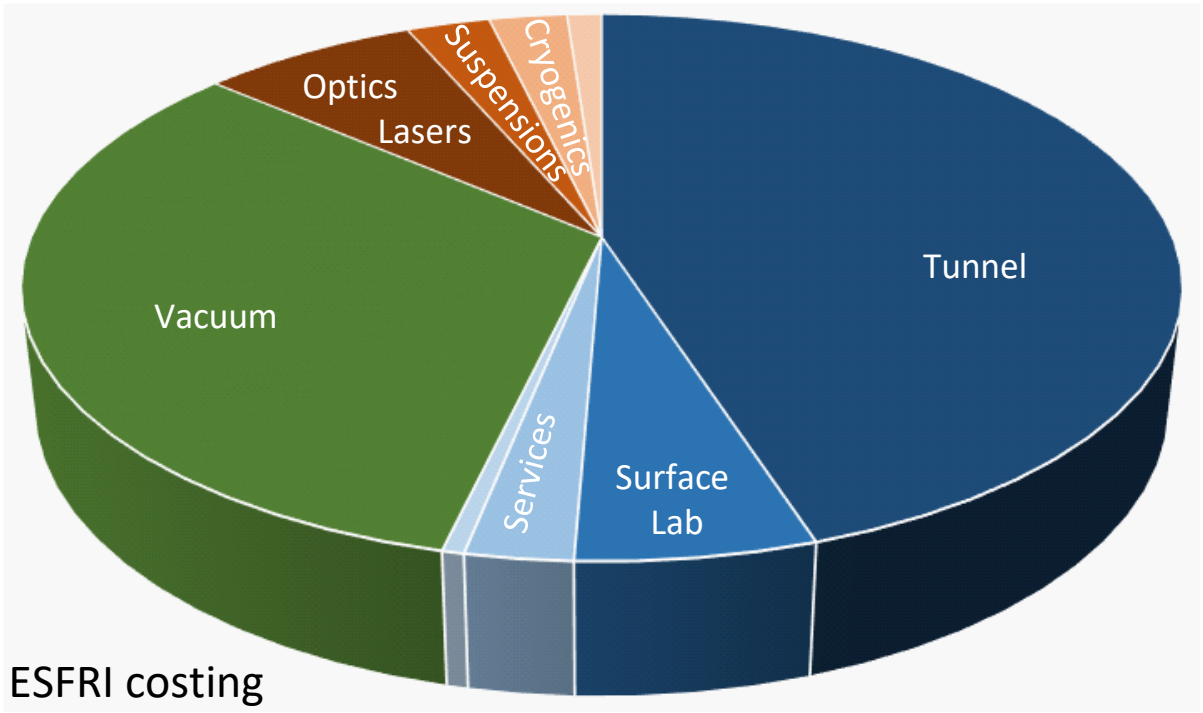
Engineering Department



<u>The activities of the Engineering Department are in the following fields:</u>

- The technical infrastructure: civil engineering, cooling, ventilation, electricity, transport, handling, access and alarms;
- The technical systems associated with the gravitational wave detector: vacuum, cryogenics and survey;
- Giving technical support to the ET collaboration and local teams.

Einstein Telescope: construction costs



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€

Underground infrastructure for
more than 50 years of operation

Plus design and development cost: ~200 M€
Total cost (excluding personnel): ~1.900 M€

Costing is based on conceptual design, requires updates based on technical designs!

Collaboration with CERN

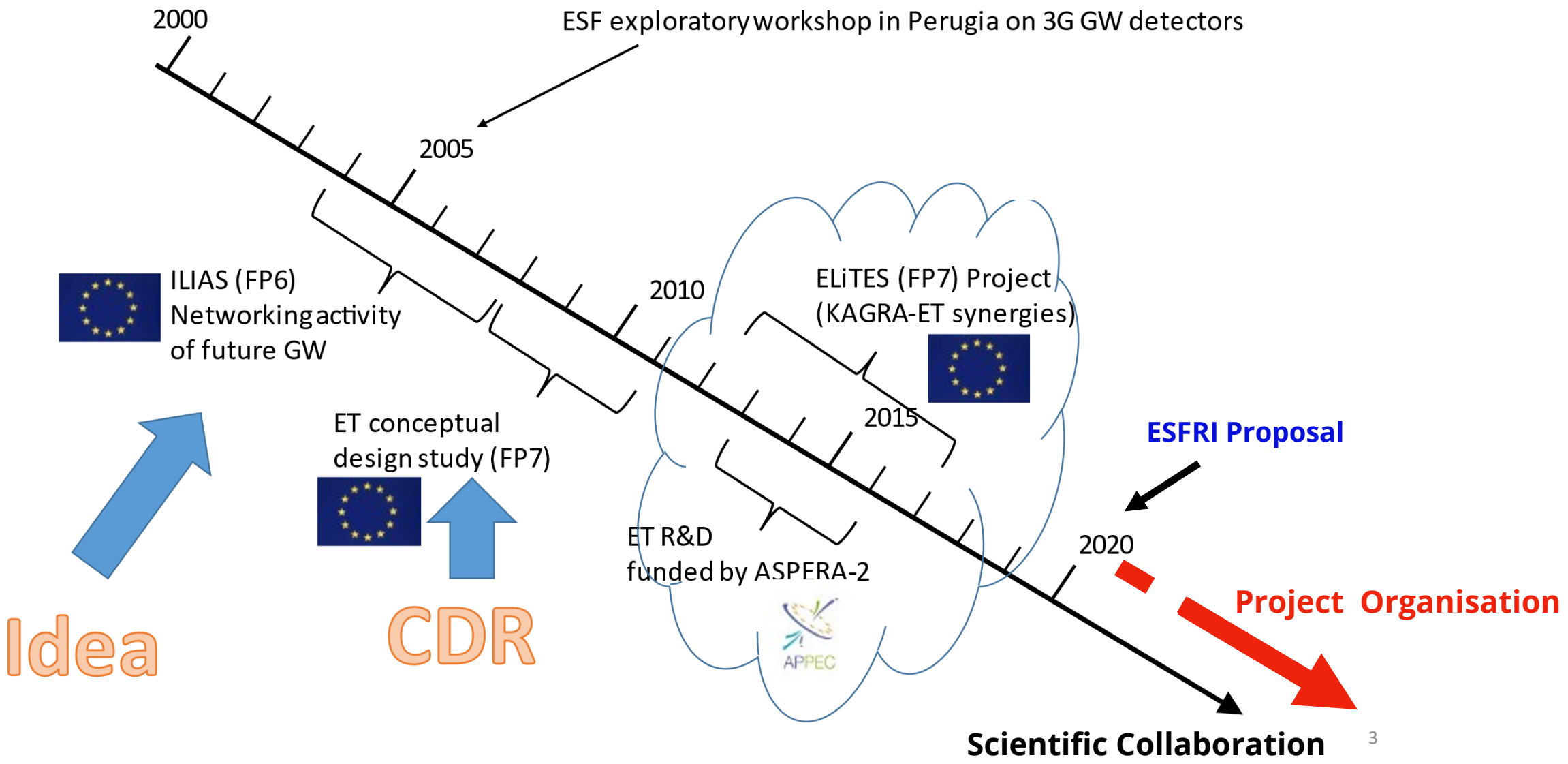
- We have an MOU with CERN for their support on technical topics. The MOU was setup with INFN and Nikhef. Recently IFAE has joined as a fourth partner. **We hope that more national partners will join in the future.**

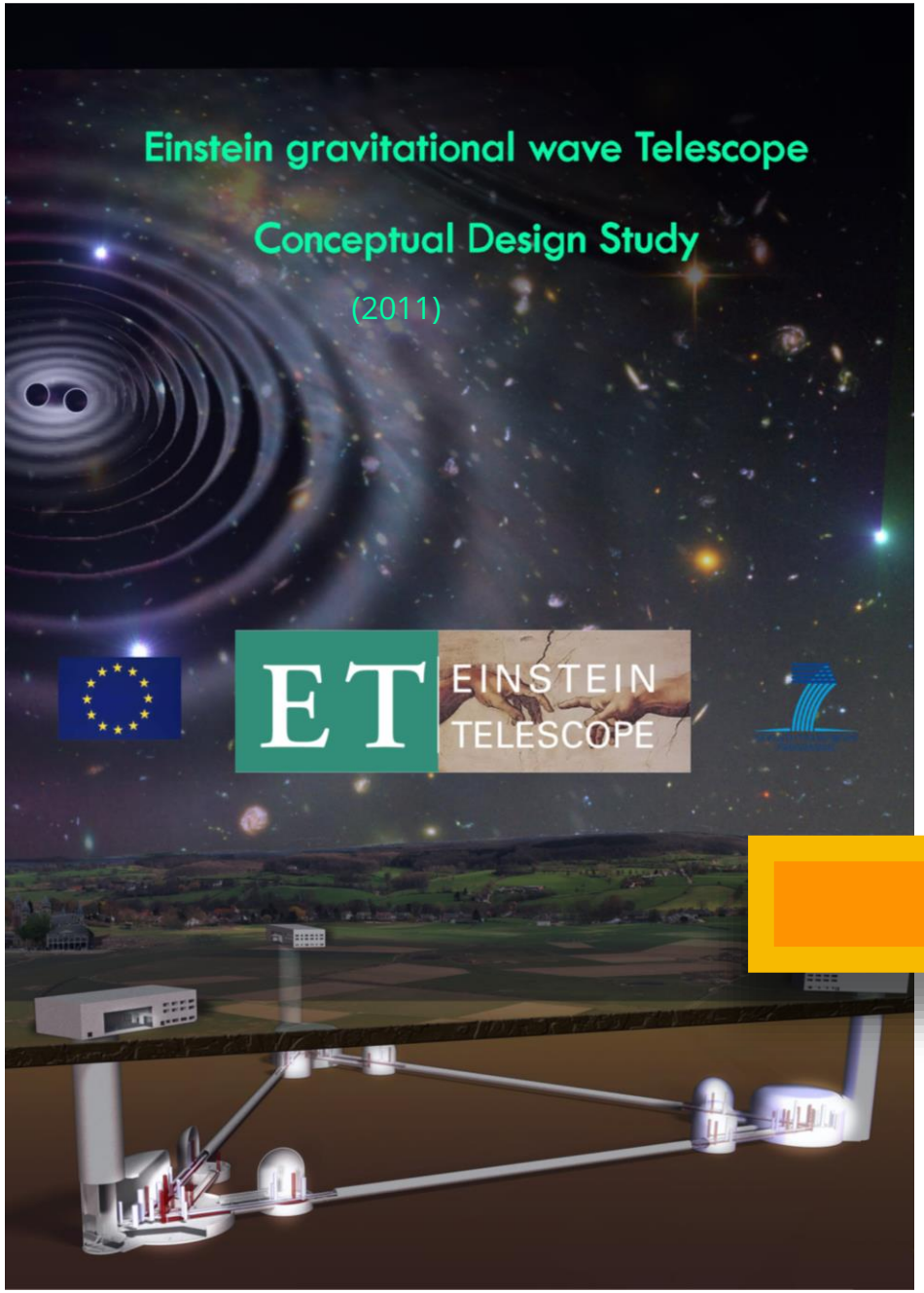
- The MOU so far covers the work for the ET beampipe. The CERN vacuum team has the responsibility to deliver the **technical design for the ET beampipe** at the end of a three year project. MOU partners will provide financial support for related CERN fellowships.
  - **Coordinate the efforts** of the institutes that work for the ET beampipes;
  - Ensure **the link with** the vacuum community of the **CE**.
  - **Propose less expensive** technical **solutions** that fulfil the requirements
  - Leading to a **pilot sector** and a **TDR** by end of **2025.**

- A second MOU appendix has been agreed on and is now being formalised: CERN will provide support towards the **technical design for the underground structure** (civil engineering and technical infrastructure).

- We are also in discussion with teams at CERN on other topics, in particular **safety** and **document management.**

Historic timeline of the Einstein Telescope



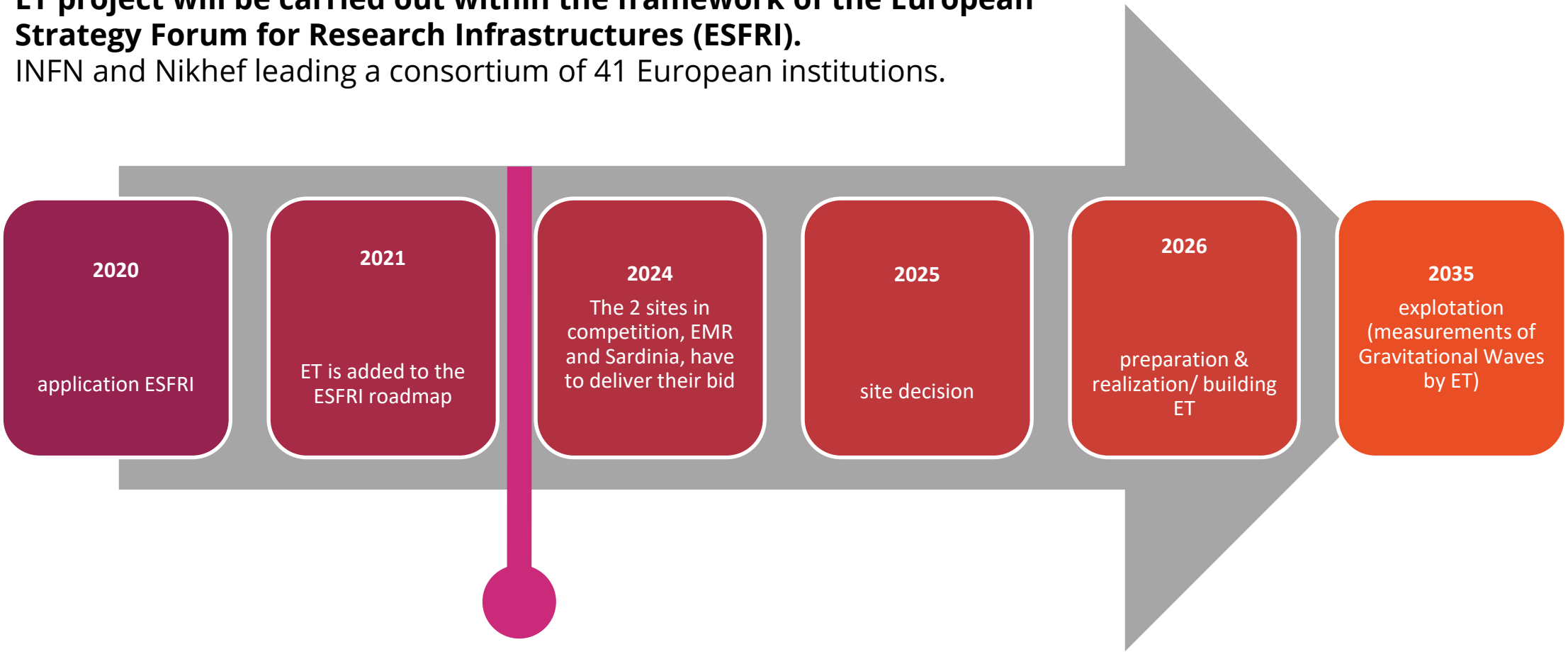


ESFRI

Document available in the ET document system:
https://apps.et-gw.eu/tds/ql/?c=15418

The Einstein Telescope ESFRI proposal timeline

ET project will be carried out within the framework of the European Strategy Forum for Research Infrastructures (ESFRI).
INFN and Nikhef leading a consortium of 41 European institutions.



The ESFRI timeline is now out of date. We are starting the process of defining a new, robust schedule, based on a full definition of the Product and Work Breakdown Structures.

Priority task: towards an updated schedule

- ET is currently in Phase I of a **Design and Preparation Phase**, which ends with a the **selection of a site** for ET.

- **The timeline presented in the ESFRI proposal is now out of date**. We are starting the process of defining a new, robust schedule.

- We are producing a detailed description of the work needed in Phase 1. This will be the basis for a schedule update (and for estimating the additional resources required).

- We expect to have a better overview of the situation by summer this year.

Requirements

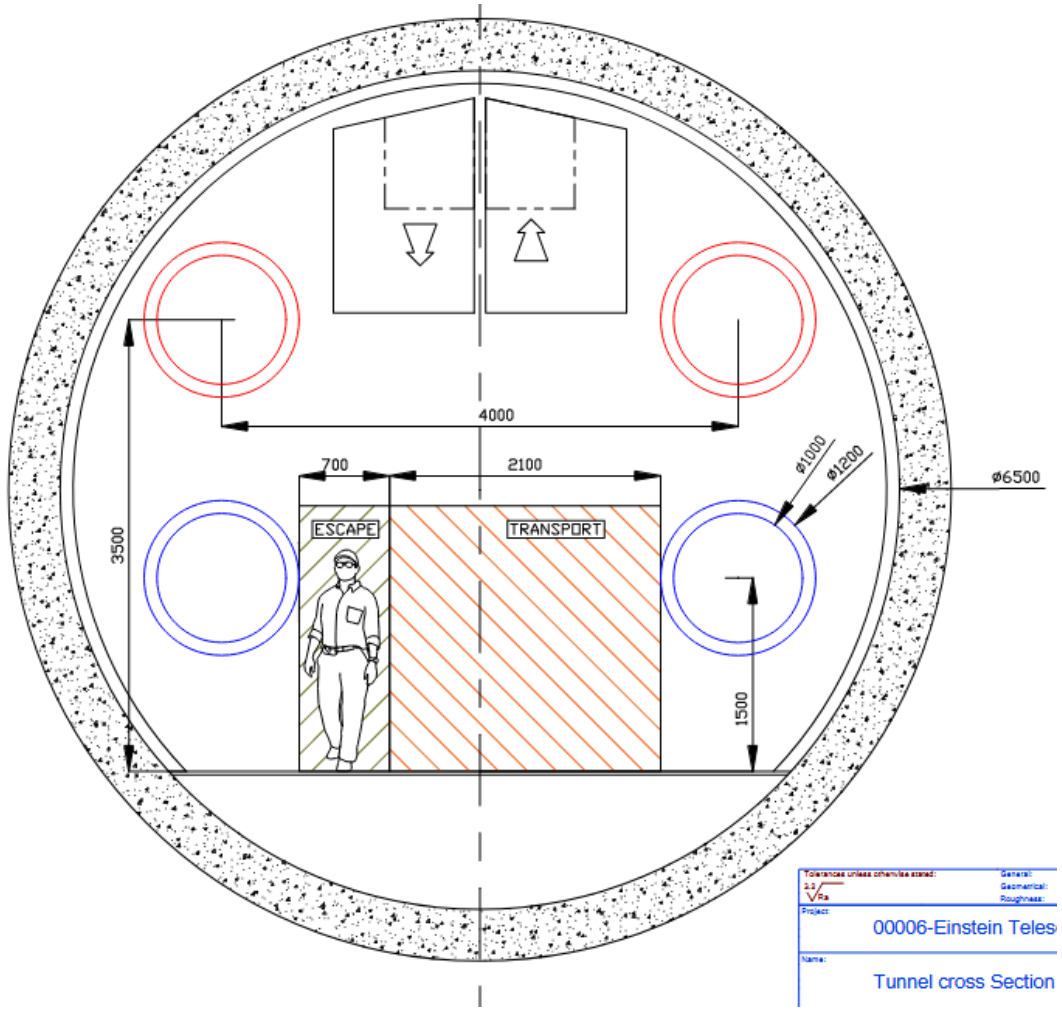
- The Design Report Update 2020 is a good starting point for finding requirements, however they are not complete and some will probably change.
  - The Project Office is setting up a Change Request process to approve and follow changes.

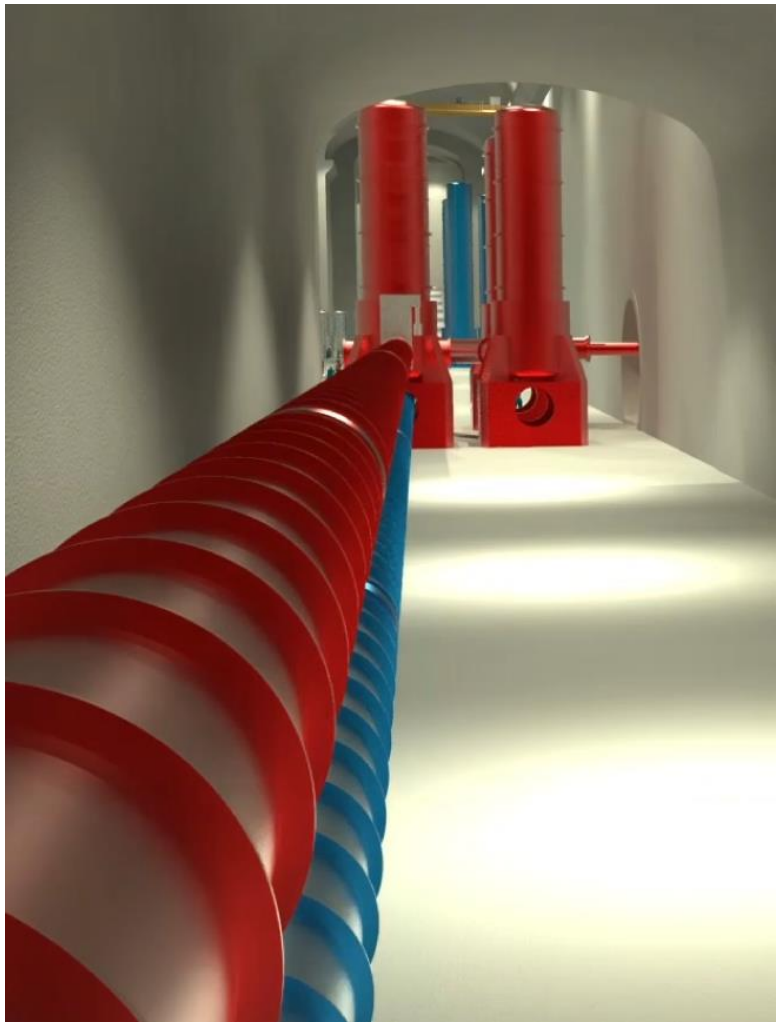
- A PBS (Product Breakdown Structure) working group was created:
  - Provide input for the costing.
  - Provide the backbone for the WBS that will define the **project schedule.**
  - Provide the backbone for **requirements** breakdown and hierarchy.

- PBS is work in progress with the aim to close the PBS end of April 2023

- Working towards an approved functional (optical) layout.

Tunnel layout from Design Report Update 2020





The ET beampipe: the main input from physics

ET design report update 2020, p. 137

Main specifications

1 m diameter

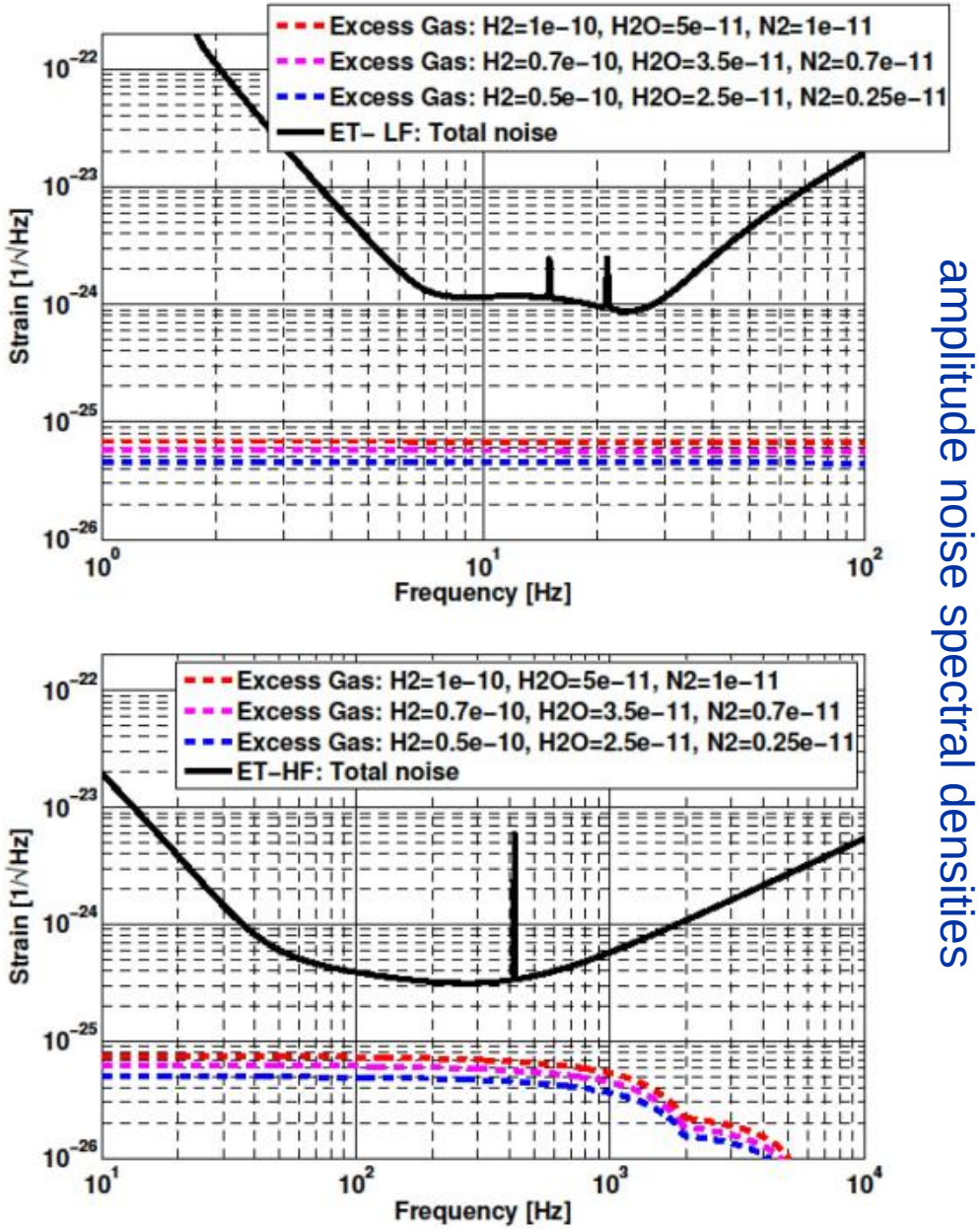
$P_{H2} \approx 10^{-10}$ mbar
$P_{H2O} < 5*10^{-11}$ mbar
$P_{CxHy} < 10^{-14}$ mbar (M>100 amu)

No surface roughness and reflectivity constraints.

CDR:

'For the maximum acceptable residual gas pressure, a safety factor of 10 was applied with regard to the pressure at which the detector sensitivity would be limited by phase fluctuations of the residual gas at the frequency of highest sensitivity'

Main input to beampipe vacuum system: Noise level below 10^{-25} $Hz^{-1/2}$



amplitude noise spectral densities

ET-HF is the most critical

Triangular versus 2L

- Requested to compare the **triangle** geometry with the geometry of **two L-shaped** infrastructures in **scientific potential, risk analysis and costs.**

- **However baseline is the Triangular configuration with 10km arms.**

- For the beampipe the impact is considered minimal: supports only?

Summarizing

- ET is currently in Phase I of a **Design and Preparation Phase**, which ends with a the **selection of a site** for ET.
- **Dual organization**: ET collaboration and ETO which is under construction + local teams
- Collaboration with **CERN** on beampipe and civil engineering
- **The timeline presented in the ESFRI proposal is now out of date**. We are starting the process of defining a new, robust schedule: bottom up
- Group working on the **PBS** → WBS, **Requirements** and functional (optical) layout
- The Design Report Update 2020 is a good starting point for finding R**equirements**
- We expect to have a better overview of the situation by summer this year and more complete by the end of the year.

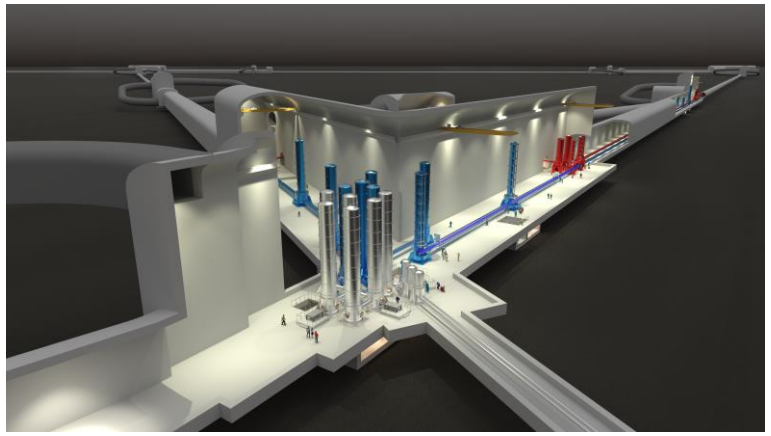
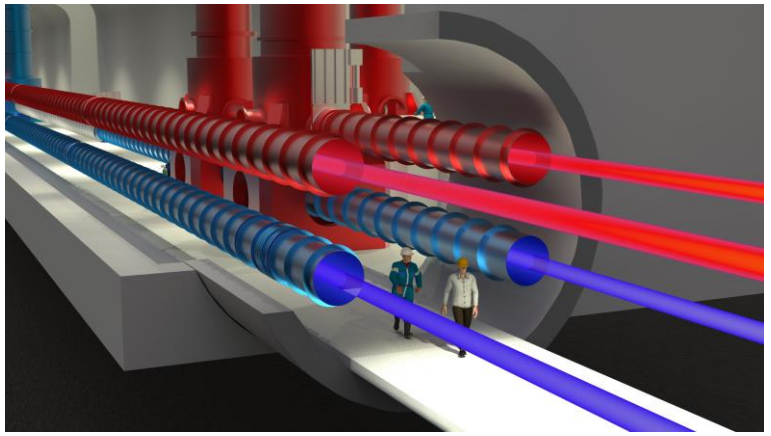
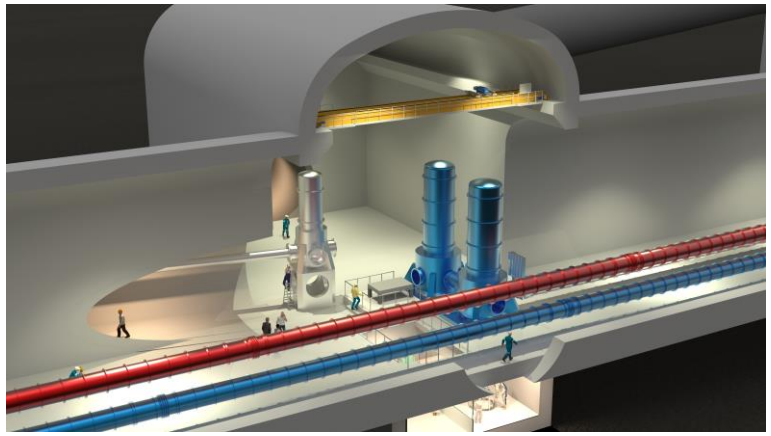
Summarizing

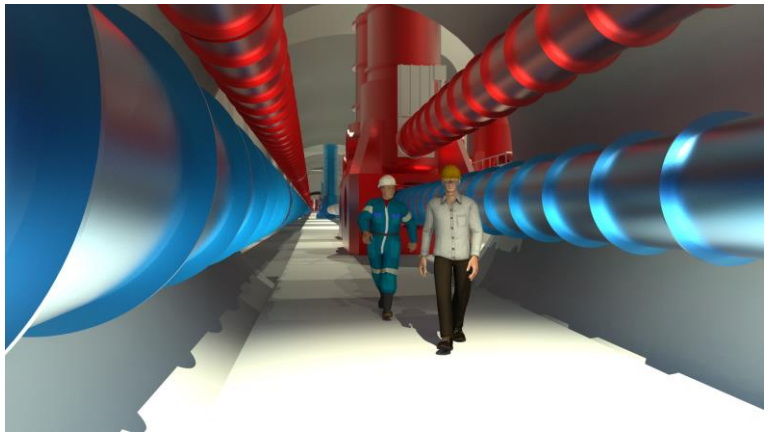
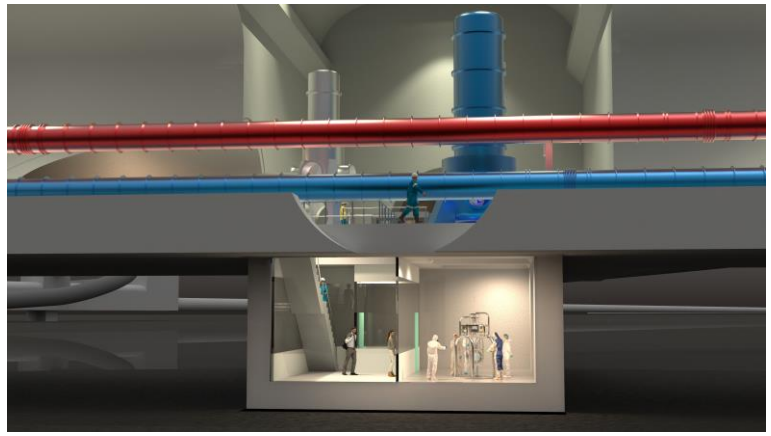
Do not hesitate to contact the Project Office of Engineering Department if you questions or need any support.

Project Office
Alessandro Variola (INFN)
alessandro.variola@roma1.infn.it

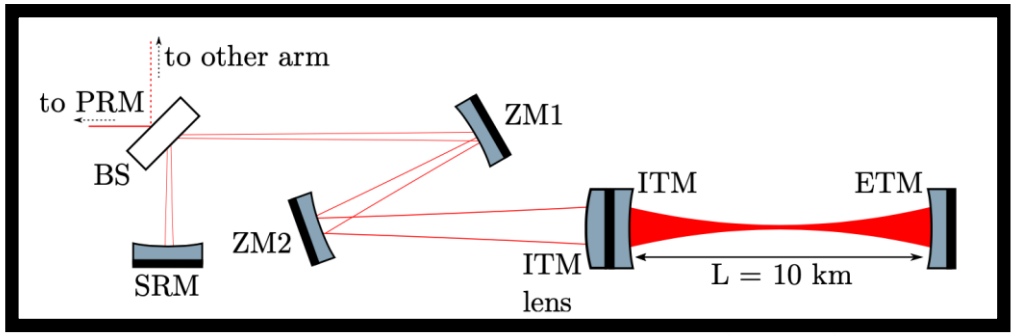
Engineering Department
Patrick Werneke (Nikhef)
p.werneke@nikhef.nl

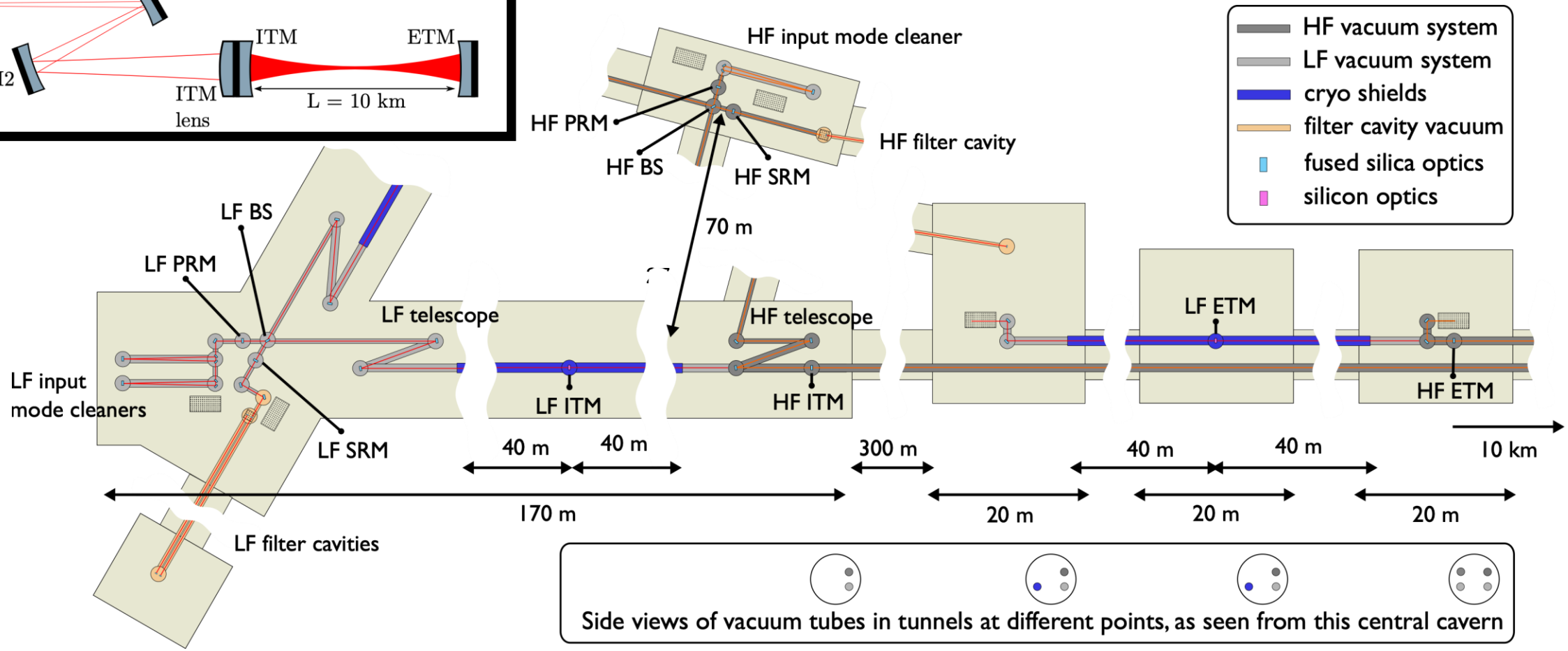
End

Optical layout





S. Rowlinson: Feasibility study of beam-expanding telescopes in the interferometer arms for the Einstein Telescope https://arxiv.org/abs/2011.02983