ETO Engineering Department

EMR Internal Meeting

26 November 2025

EINSTEIN TELESCOPE

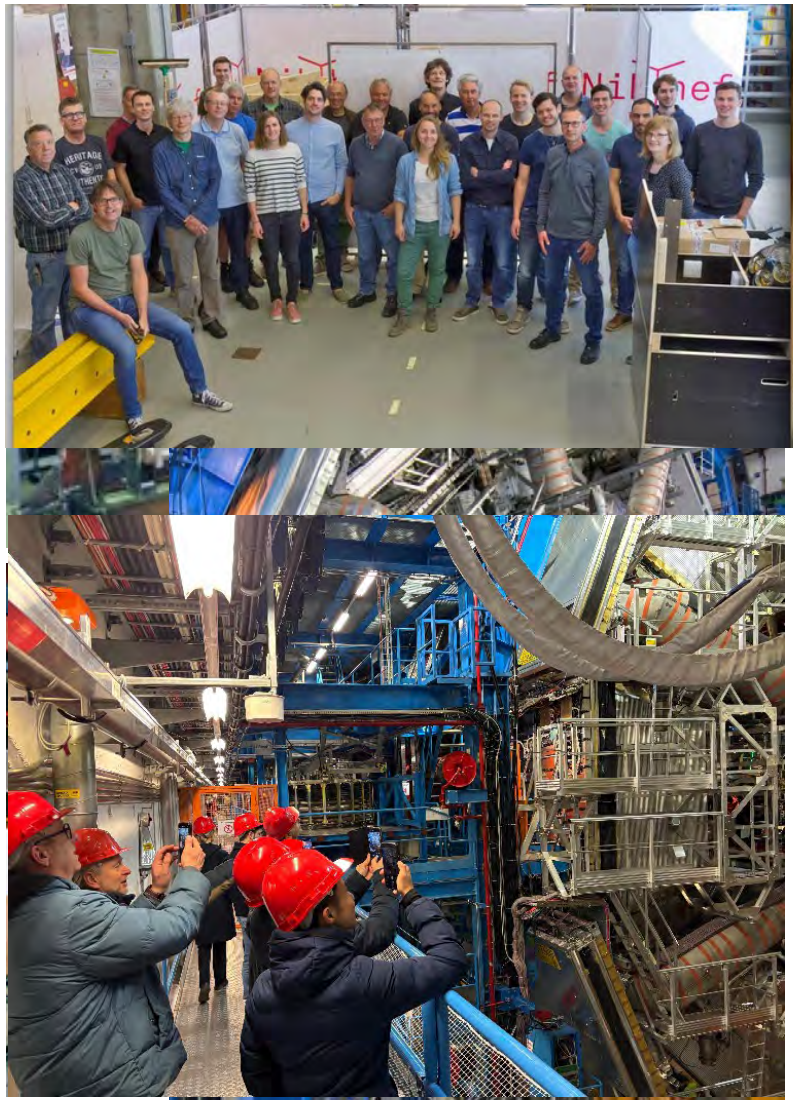
Engage. Innovate. Explore.

Patrick Werneke

- Aeronautical Engineering and Business Administration
- Almost 33 years working @Nikhef
- First 15 years on ATLAS: MDT and later SCT
- Second 15 years as Head of the Mechanical Technology
- Now already 3 years involved in the Einstein Telescope Organisation (ETO) as Head of the Engineering Department

@Nikhef

- Unique Combination of Science and Technology
- Inspiring environment and once in a life time projects
- Opportunities to grow personally and professionally



Einstein Telescope Organisation

- ETO -

ETO in Short

- ETO is an international professional organisation (i.e. not a scientific collaboration), independent from the proposed site location.

- ETO is not yet a legal entity. We are hosted by INFN and Nikhef (national institutes in Italy and Netherlands). ETO can become the blueprint for the future legal entity.

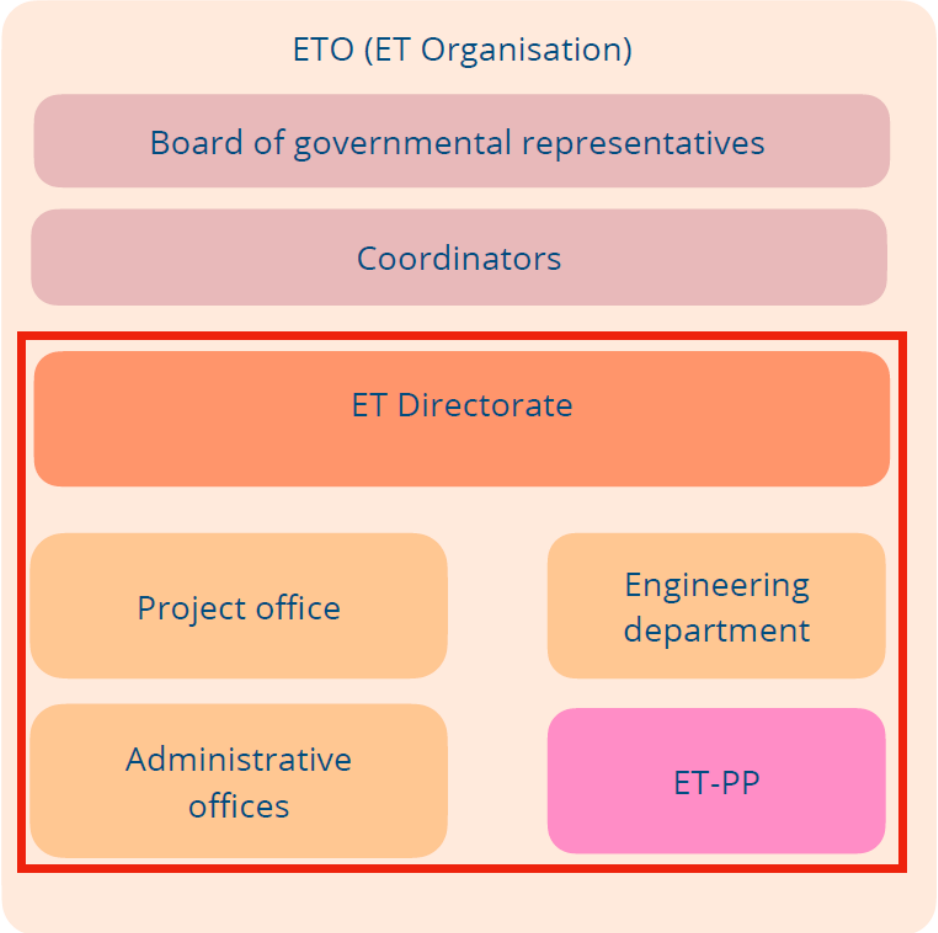
- We are a small ‘distributed’ team (~40 people, 20 FTE).

- ETO has been endorsed by the governments, but has not been fully integrated into the ET community.

Courtesy slide Freise, Ferroni, ET annual meeting 13.11.2025

ET Organisation Structure

- ET Collaboration
- Einstein Telescope Organisation (ETO)
  - Board of Governmental Representatives
  - Einstein Telescope Coordinators
  - ETO Directors
  - ETO Departments
    → Engineering Department
    → Project Office
    → Communication Office
  - ET-PP: Einstein Telescope Preparatory Phase
- Host Consortia: EMR, Sardinia and Lusatia



Timeline set by the BGR

Date	Action
28-29 Jan. 2026 *tbc*	BGR meeting (BE)
Early May 2026	**Report on site selection criteria by SiSe WG**
29-30 June 2026 *tbc*	BGR meeting (DE) *tbc*
End Sept./early Oct. 2026	**Geometry comparison report by ETO** Bidbook template
26-27 Oct. 2026	BGR meeting (ES or IT)
Dec. 2026	**Open of call for tenders**
June 2027	**Closing of call for tenders (or earlier if all sites are ready earlier)**
Q3 2027	**Site selection decision (after review by international panel)**

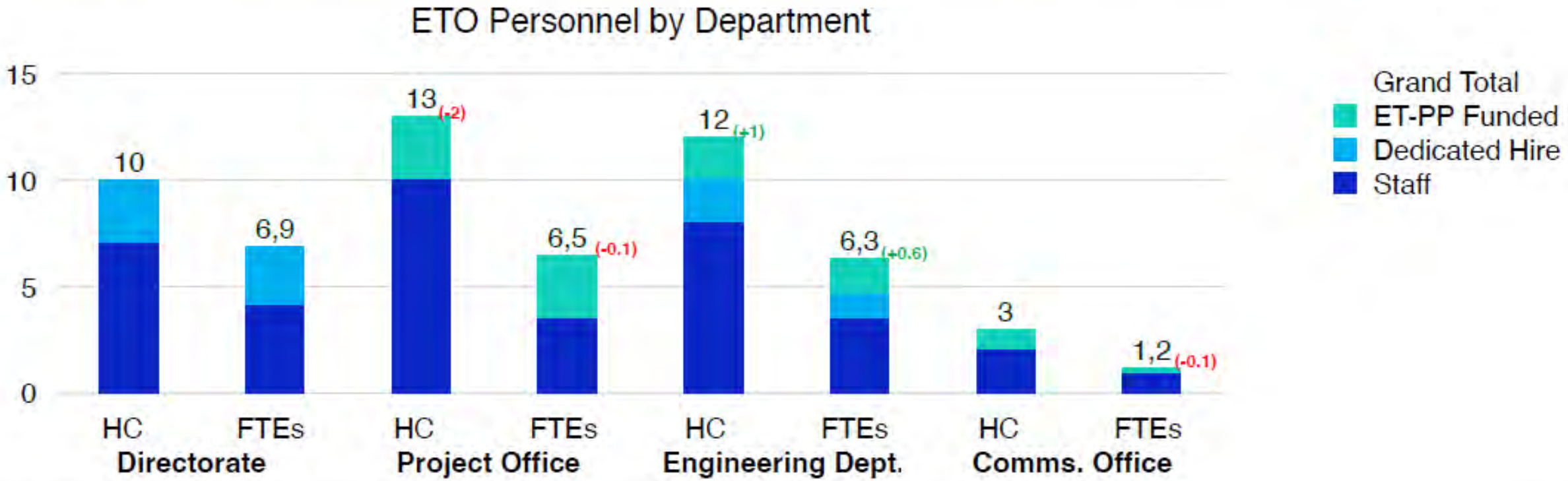
Note: this timeline was neither proposed by nor developed with ETO. Instead it can be seen as targets for the ET community as a whole.

ETO personnel by department

Slide from ETO Funders Group meeting, October 2025

A total of 38 people are currently working directly within an ETO Department

- Over **40% of our capacity** in Fulltime Equivalents (FTEs) **are working under temporary contracts or funding**
- Changes are shown in brackets in the graph below



Bringing together the leadership from ETO, ETC and the ET HC

Courtesy slide Freise, Ferroni, ET annual meeting 13.11.2025

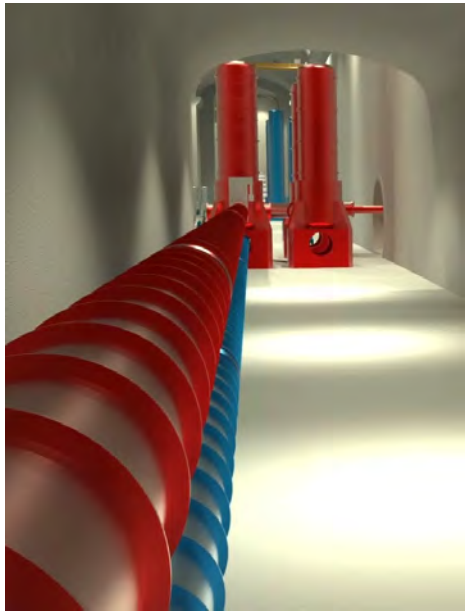
Courtesy slide Freise, Ferroni, ET annual meeting 13.11.2025

ETO Engineering Department

ETO Engineering Department Mandate:

Design, procure, install, commission, operate, maintain and eventually, dismantle:

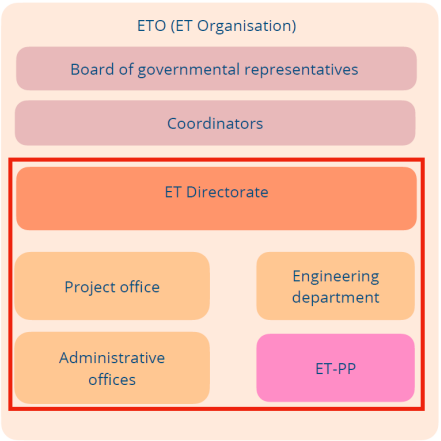
1. **The infrastructure needed to operate the interferometer**
   - Civil Engineering: shafts, caverns and tunnels, surface buildings and landscaping, …..
   - Technical Infrastructures: cooling and ventilation, access and safety, power distribution, …..
2. **The special systems associated with the gravitational wave detector**
   - Arm vacuum pipe
   - Cryogenics infrastructure
   - Survey
3. ***Tasks associated with on-site responsibilities***
   - Logistics, handling, transport and installation
   - Engineering Integration
   - Safety in the field



The scope of the ETO Engineering Department :

ETO Directorate
ETO Departments
ET-PP

ETO Directorate
Strategic coordination and management



ET Collaboration (ETC)

ETO Engineering Department
Coordination challenge

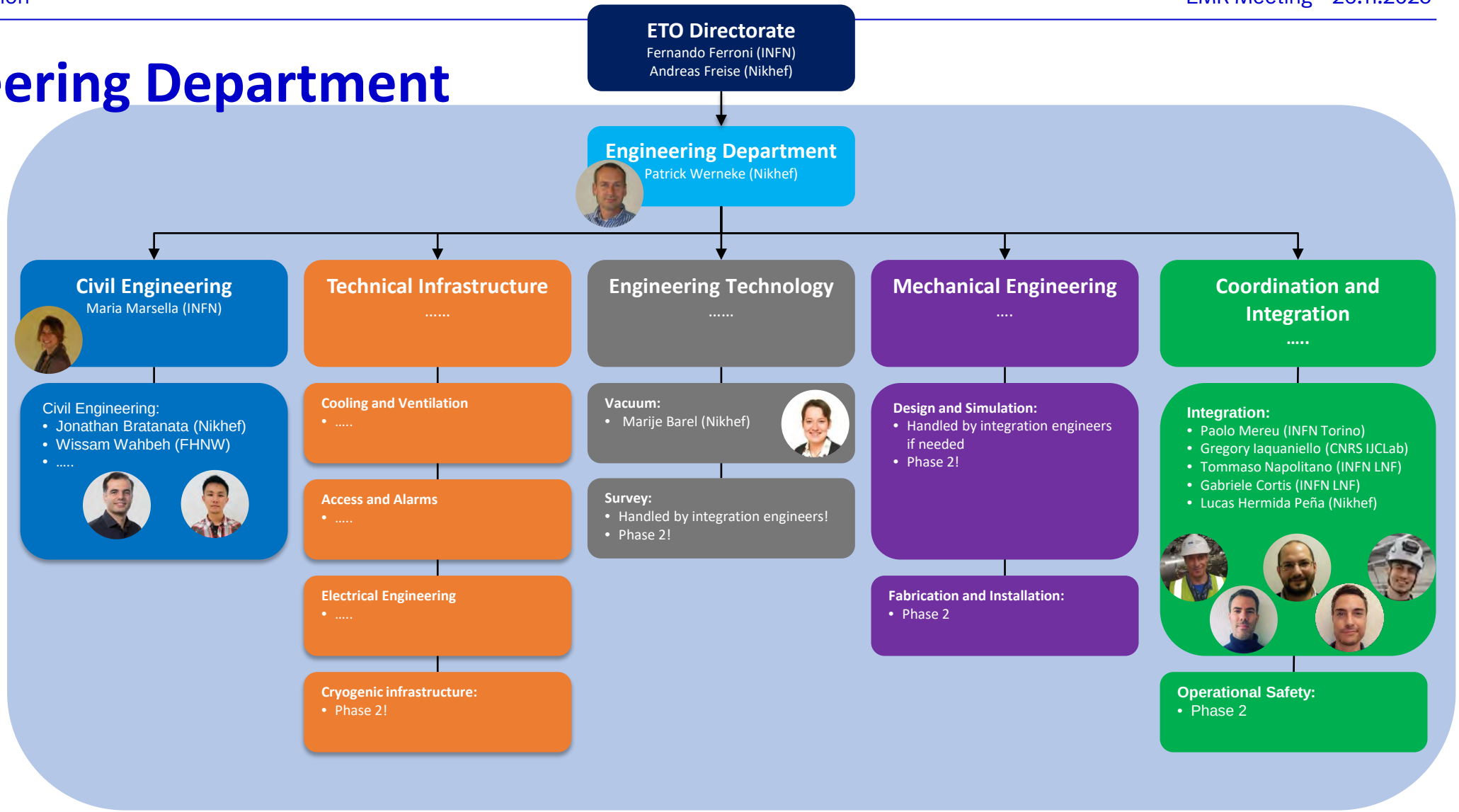
ET Host Consortia (EMR - TETI - Lusatia)

CERN Departments
TE-VSC, SCE-SAM-FS, EN and HSE-OHS

ET Collaboration
- Scientific vision
- Requirements
- Detector design
- Common standards

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

ETO Engineering Department



ETO Engineering Department

ETO Directorate
Fernando Ferroni (INFN)
Andreas Freise (Nikhef)

Engineering Department
Patrick Werneke (Nikhef)

Collaboration Agreement CERN
Luigi Scibile (CERN Coordinator)

Civil Engineering
Maria Marsella (INFN)

Technical Infrastructure
.....

Engineering Technology
.....

Mechanical Engineering
....

Coordination and Integration
.....

Civil Engineering
Responsibles:
CERN:
- John Osborne (SCE-SAM-FS)

ETO Coordinators:
- Maria Marsella (INFN)
- Mario Martinez (IFAE)
- Patrick Werneke (Nikhef)

Vacuum Beampipe
Responsibles:
CERN:
- Paolo Chiggiato (TE-VSC)

ETO Coordinators:
- Fernando Ferroni (INFN)
- Patrick Werneke (Nikhef)

EN and HSE
CERN:
- Jean-Philippe Tock
- Saverio La Mendola

ETO Coordinators:
- Paolo Mereu (INFN)
- Patrick Werneke (Nikhef)

- Cooling and Ventilation
- Access and Alarms
- Electricity Engineering
- Integration
- Health and Safety

Civil Engineering:
- Jonathan Bratanata (Nikhef)
- Wissam Wahbeh (FHNW)
- .....

Cooling and Ventilation
- .....

Access and Alarms
- .....

Electrical Engineering
- .....

Cryogenic infrastructure:
- Phase 2!

Vacuum:
- Marije Barel (Nikhef)

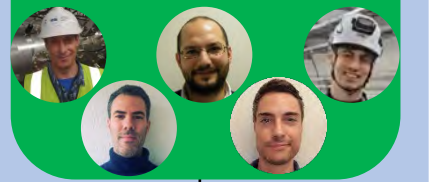
Survey:
- Handled by integration engineers!
- Phase 2!

ET-PP Vacuum:
- *Rafael Garcia (IFAE)*
- *Julia Mundet (IFAE)*
- *Purnalingam Revathi (UAntwerp)*
- *Alexandre Lacroix (CNRS LAPP)*

Design and Simulation:
- Handled by integration engineers if needed
- Phase 2!

Fabrication and Installation:
- Phase 2

Integration:
- Paolo Mereu (INFN Torino)
- Gregory Iaquaniello (CNRS IJCLab)
- Tommaso Napolitano (INFN LNF)
- Gabriele Cortis (INFN LNF)
- Lucas Hermida Peña (Nikhef)



Operational Safety:
- Phase 2

Collaboration Agreement with CERN

Collaboration Agreement with CERN

ETO has a Collaboration Agreement with CERN for their support in technical topics.

- Several similarities between ET and CERN projects

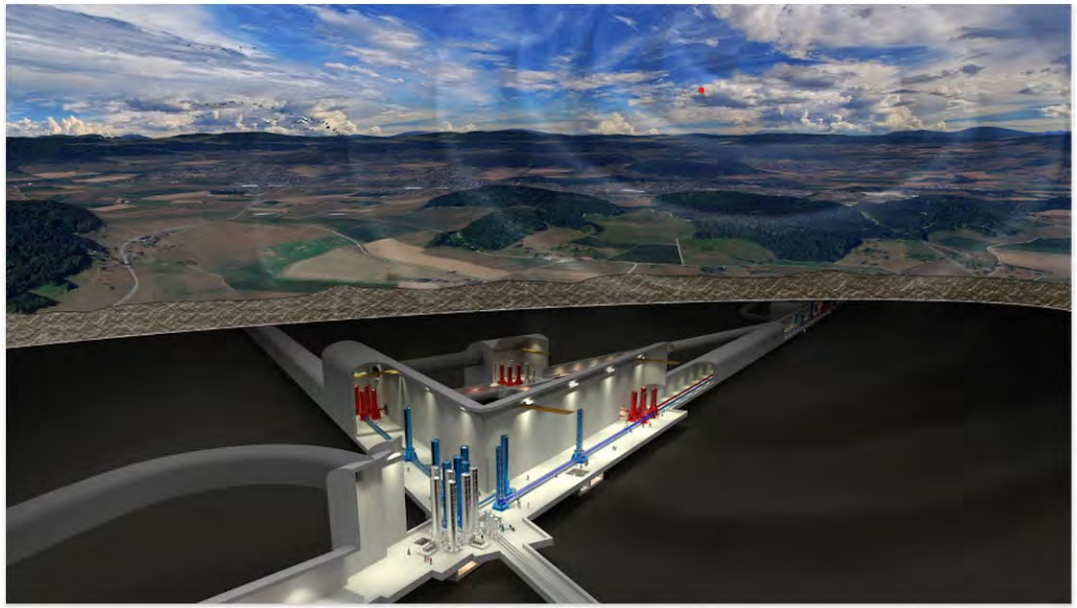
Signed agreements:

- On Vacuum System for the Arm Vacuum Pipe: ends Q3 2027
- Civil Engineering: ends Q4 2026
- Engineering Department and Safety Unit: ends Q2 2028

CERN expands its collaboration on the Einstein Telescope

CERN and the Einstein Telescope collaboration have signed a new collaboration agreement in the field of engineering and safety to advance Europe's next-generation gravitational-wave observatory

20 MAY, 2025 | By Chetna Krishna & Anaïs Schaeffer



Artist's impression of the Einstein Telescope. (Image: Marco Kraan/Nikhef)

https://home.web.cern.ch/news/news/knowledge-sharing/cern-expands-its-collaboration-einstein-telescope

ETO's current costs – the CERN Collaboration

Slide from ETO Funders Group meeting, October 2025

The costs defined in the agreements with CERN total €7.4M*

- ET partners cover around €6.5M
- CERN provides the remaining €0.9M as in-kind contributions
- ETO Fund obligations under the CERN agreements total €3.9M

Agreement	Start Date	End Date	Total Value [k€]	ET Share [k€]	ETO Fund Share [k€]
Collaboration On Vacuum Systems	01/08/2022	31/07/2025	1 749	1 189	N/A
Civil Engineering Study	01/10/2023	31/12/2026	353	353	N/A
Commitments Before ETO Fund Setup			**2 102**	**1 542**	**N/A**
Extension of Vacuum Collaboration	01/03/2025	20/12/2027	2 102	1 813	1 679
Safety and Engineering Study	01/04/2025	31/03/2028	3 149	3 149	2 203
Commitments Since ETO Fund Setup			**5 251**	**4 952**	**3 882**
Grand Total			**7 353**	**6 494**	**3 882**

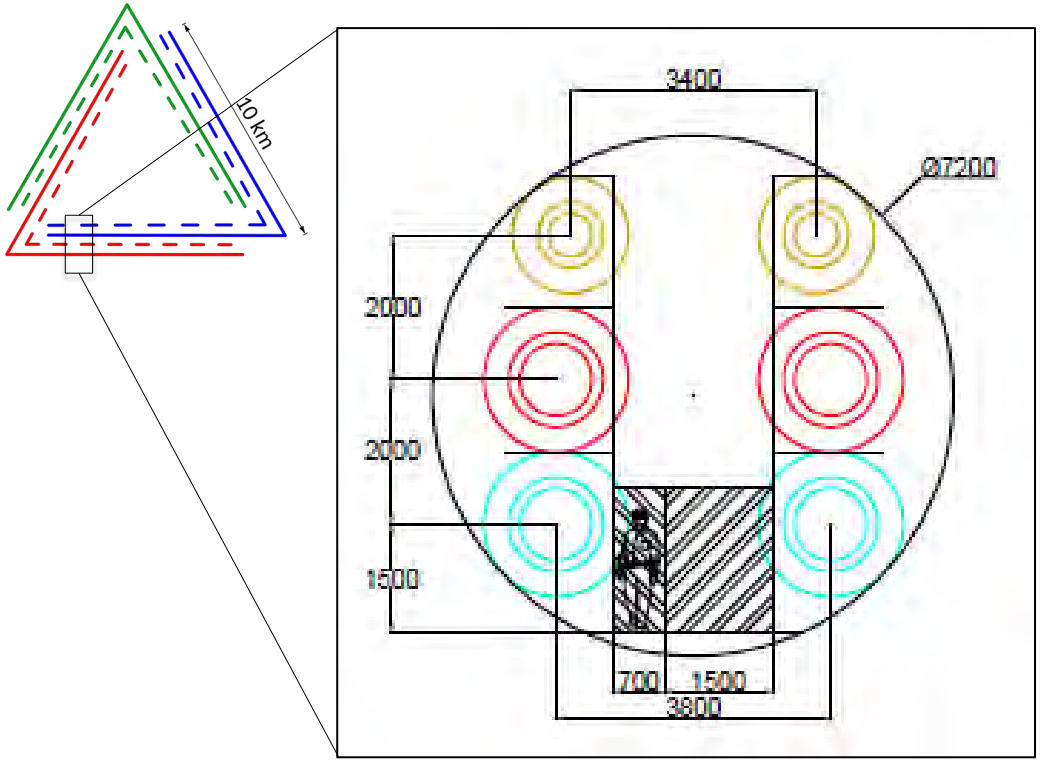
** Assuming an exchange rate of 1.0820 EUR/CHF – The least favourable rate since 2000*

https://indico.cern.ch/event/1514758/overview

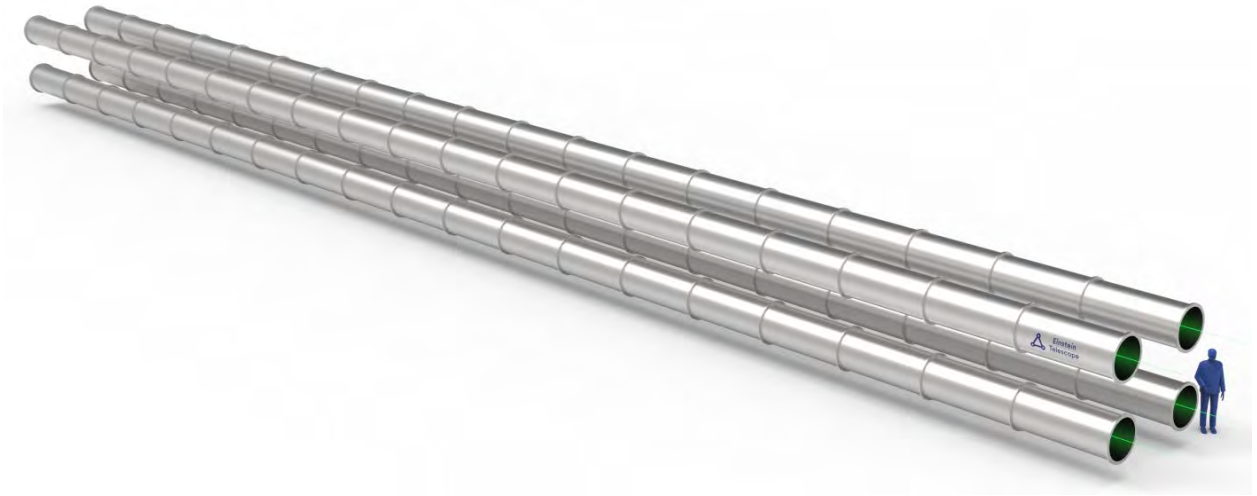
14:00	**The Virgo Vacuum System and Next-Phase Upgrades**	*Antonio Pasqualetti*
	Sint-Janskerk, Maastricht, NL	14:00 - 14:30
	ET @ CERN (beam line)	*Dr Carlo Scarcia*
	Sint-Janskerk, Maastricht, NL	14:30 - 15:00
15:00	**ET tower (vac & cryo)**	*Fulvio Ricci*
	Sint-Janskerk, Maastricht, NL	15:00 - 15:30

Einstein Telescope Beampipe Vacuum System

The 10 km long optical cavities require ultrahigh vacuum to reduce the noise due to gas pressure fluctuations along the laser trajectory.



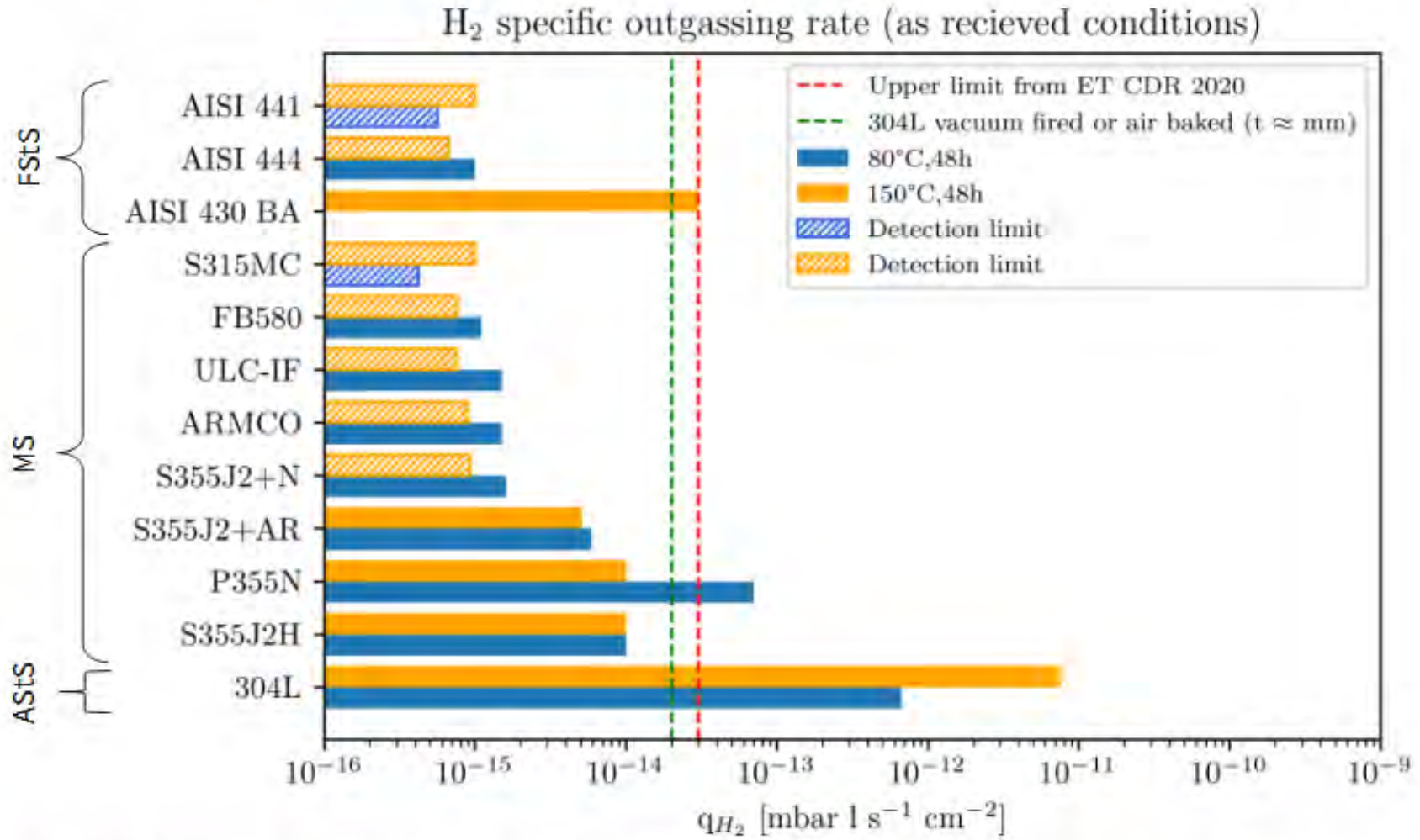
- Beampipe diameter: 1 meter
- Total Beam Pipe length: 120 km
- Pressure requirements < 10^{-10} mbar



Examples of ongoing activities: Materials

Ferritic alloys
Mild steel and ferritic SS

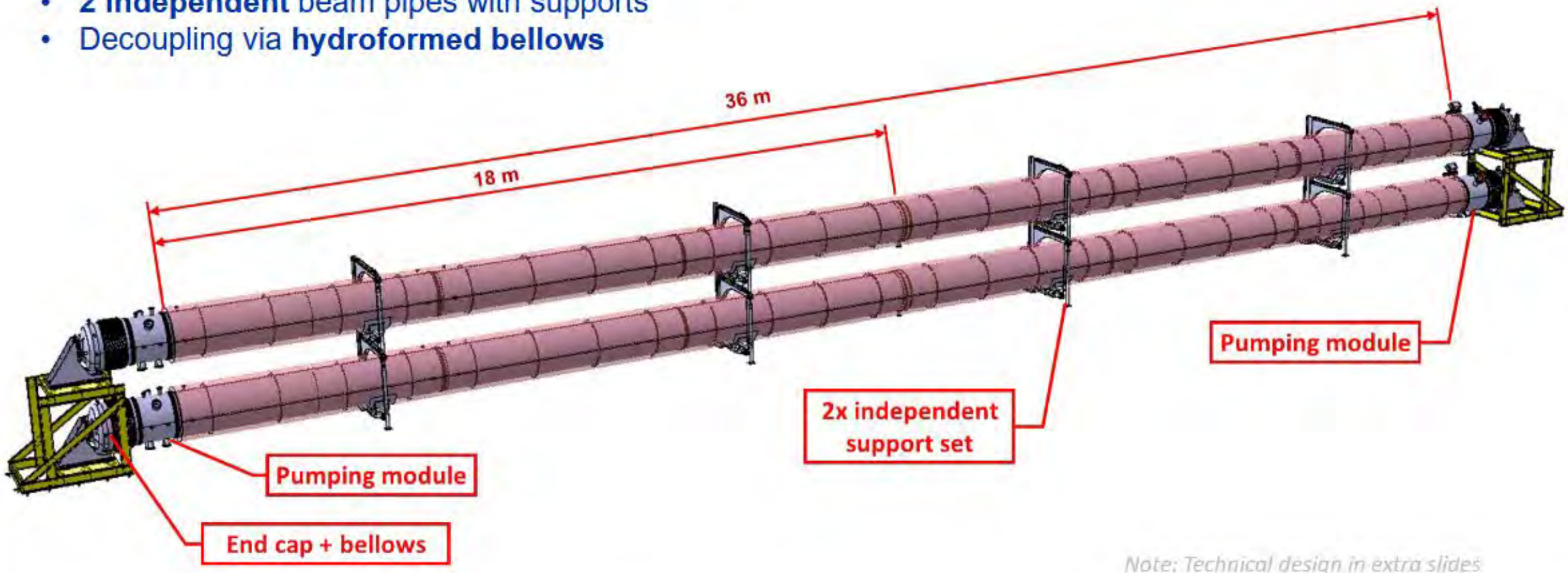
- **Outperform austenitic SS outgassing rates without requiring HT treatment**
- **Lower (>30%)** raw **material cost**



AStS: Austenitic Stainless Steel, FStS: Ferritic Stainless Steel, MS: Mild Steel. Vacuum Fired (950°C, 2h), Air baked (450 °C, 5d). Measurement error: ±40%; Detection limit: 50% of background

Pilot Sector at CERN

- Installed in **tunnel TT4** at CERN
- 40 m total length (**36 m pipes + end modules**)
- **2 independent** beam pipes with supports
- Decoupling via **hydroformed bellows**



Note: Technical design in extra slides

Beamtubes: Installation

Cleaning for UHV

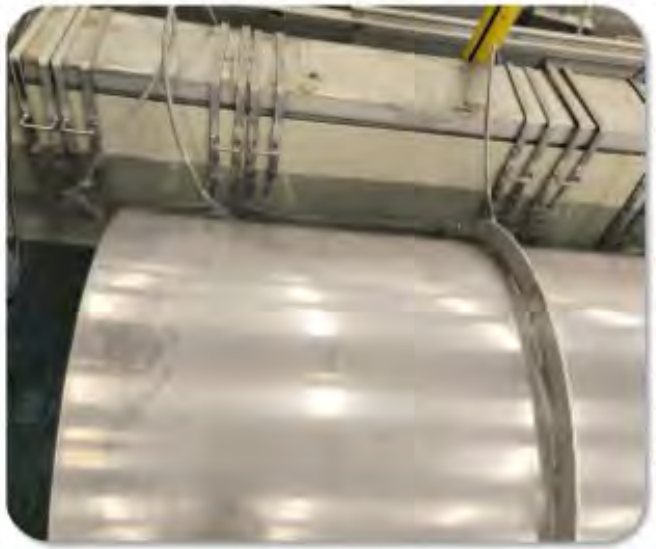
- Large size & handling challenges
- CERN UHV procedure → detergent cleaning by ultrasound agitation + rinsing
- Cleanliness verified via witness samples

Dust control

- Critical to meet ET requirements
- ISO 6 standard (ISO 14644-1) expected
- Laminar flow at extremities during drying

Portable Cleanroom (ISO 6)

Horizontal laminar flow wall



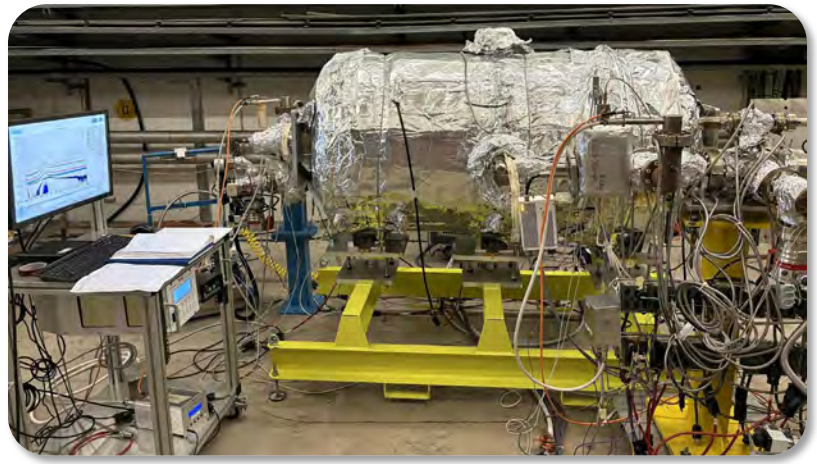
First line pilot sector

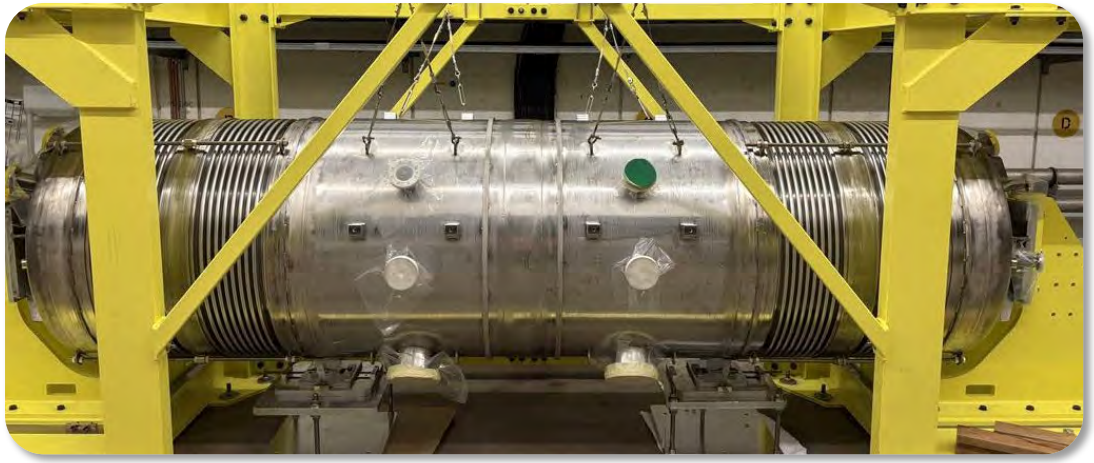
→ **First 3*6m tube : done !**

→ **Second 3*6m tube : on-going**

- Some trouble due to the circularity of the pipes to fit sleeve with 1mm gap.
  - **For second line: tubes with <u>calibrated ends</u>.**

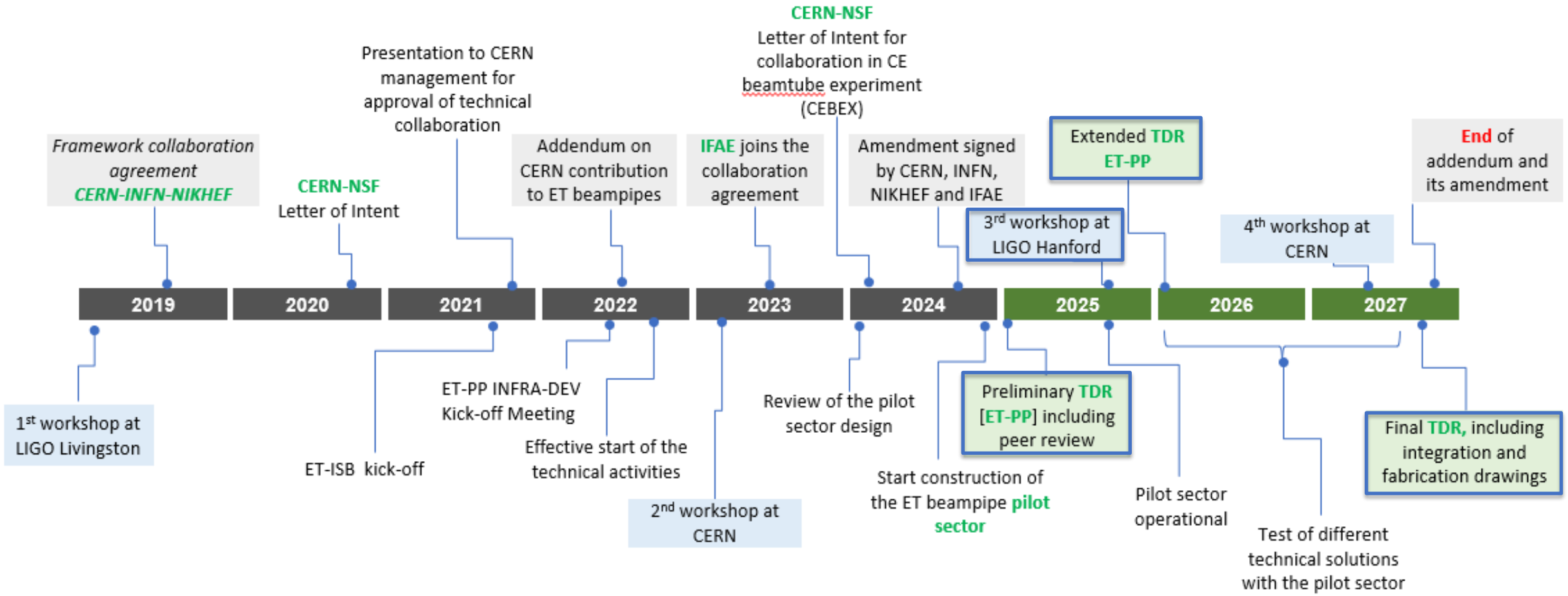
Development of the Vacuum Beampipe



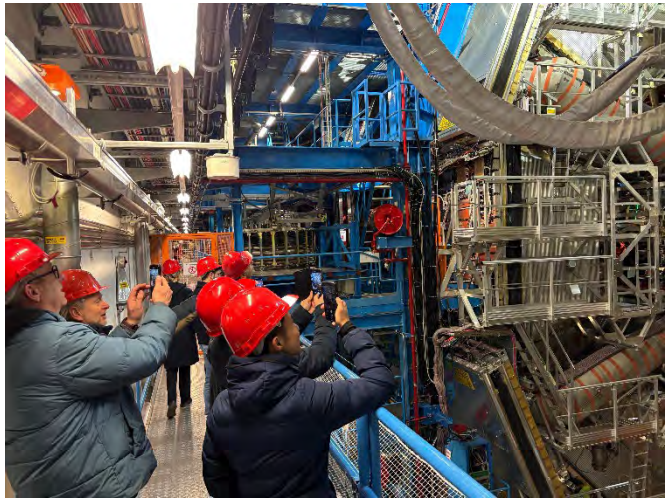


Development of the Vacuum Beampipe

Pre-TDR: https://apps.et-gw.eu/tds/?call_file=ET-0005A-25_ETPPDeliverable62VacuumPipeDes.pdf
3rd vacuum workshop: https://dcc.ligo.org/public/0203/G2502144/001/Pilot%20Sector%20of%20the%20ET%20Vacuum%20Pipe_BTW3_v.2.pdf



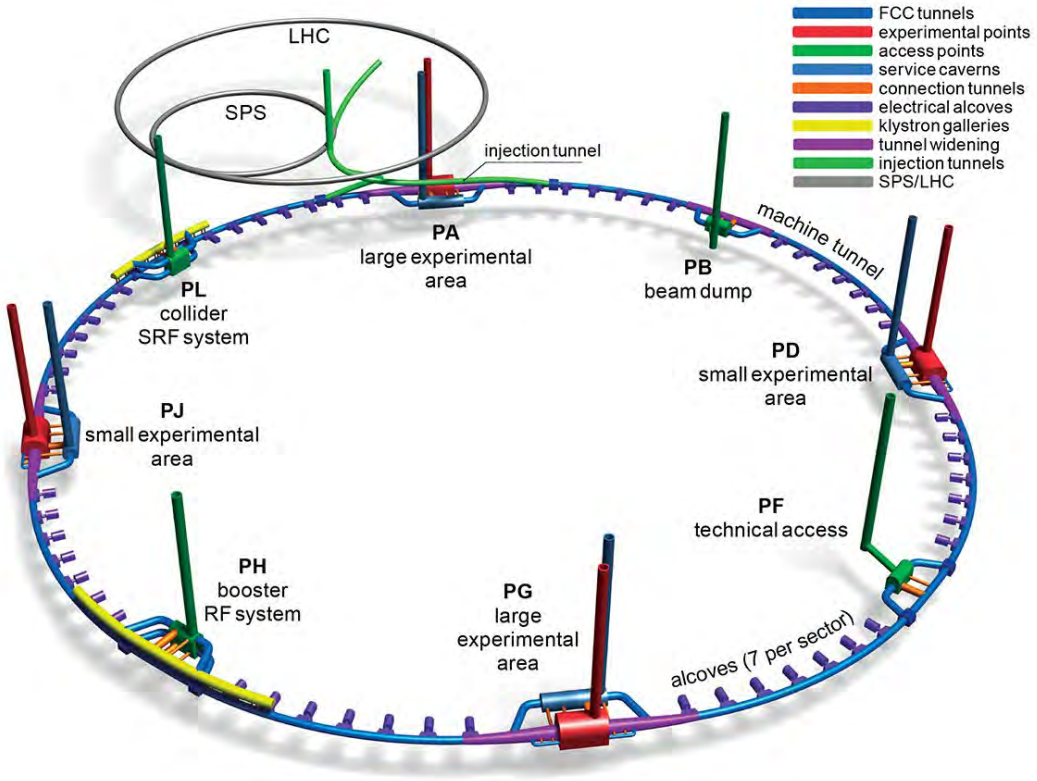
Development of the Civil Infrastructure

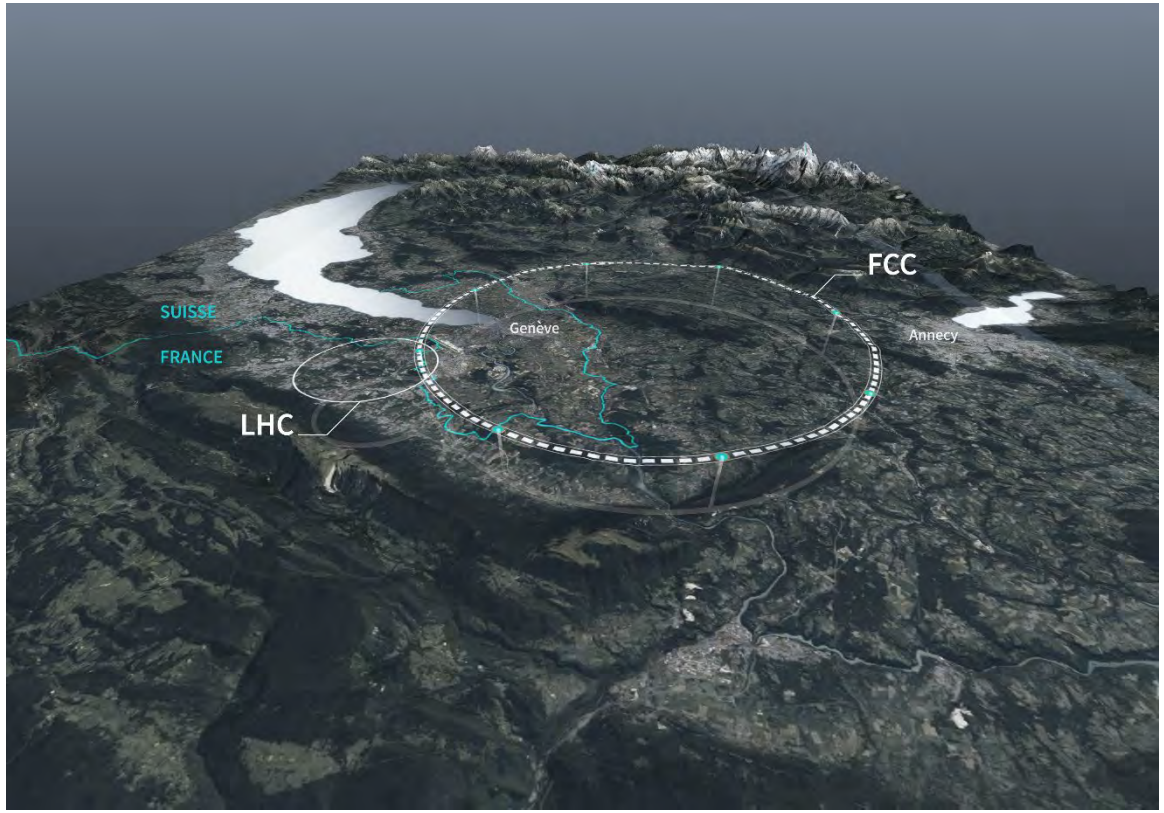


CERN Provides guidance and support to ETO Civil Engineers:

- Share experience from FCC site investigation
- Infrastructure roadmap for Preparatory Phase 1
- Two workshops and underground visits for Host Consortia
- Supporting the Task Force for baseline documentation
- Paper for World Tunnel Congress 2026

CERN: Future Cirular Collider





https://home.cern/news/news/accelerators/cern-releases-report-feasibility-possible-future-circular-collider

Developments of the Technical Infrastructure and Safety

Signed an agreement with CERN Engineering Department (EN) and Occupational Health and Safety Department (HSE - OHS): up to Q2 2028

- Cooling & Ventilation (CV)
- Electrical Engineering (EL)
- Access & Alarms (AA)
- Accelerator Coordination and Engineering (ACE)
- Information Management (IM)
- Safety (OHS)


HVAC building for the HL-LHC @CERN


HVAC for the central clean room @LHO

Developments of the Technical Infrastructure and Safety

- All 10 graduate contracts are signed:
  - 8 graduates have started
  - 1 graduate starts in December
  - 1 graduate starts in January 2026

#	Dep.	Gr	Q/O	Duration [months]	Profile / Description	Contract Start
1	EN	AA	Quest	30	Electrical Engineer	01.12.2025
2	EN	ACE	Quest	30	Configuration / Integration	01.10.2025
3	EN	ACE	Quest	30	Scheduling / Management	01.11.2025
4	EN	CV	Quest	30	HVAC Engineer	01.10.2025
5	EN	CV	Quest	30	Cooling Engineer	01.11.2025
6	EN	EL	Quest	25	Electrical Engineer	01.01.2026
7	EN	IM	Origin	30	Software Engineer	01.10.2025
8	HSE	OHS	Quest	30	Fire Safety Engineer	01.10.2025
9	HSE	OHS	Origin	30	Safety Engineer	01.10.2025
10	HSE	OHS	Origin	30	Mechanical Engineer	01.10.2025

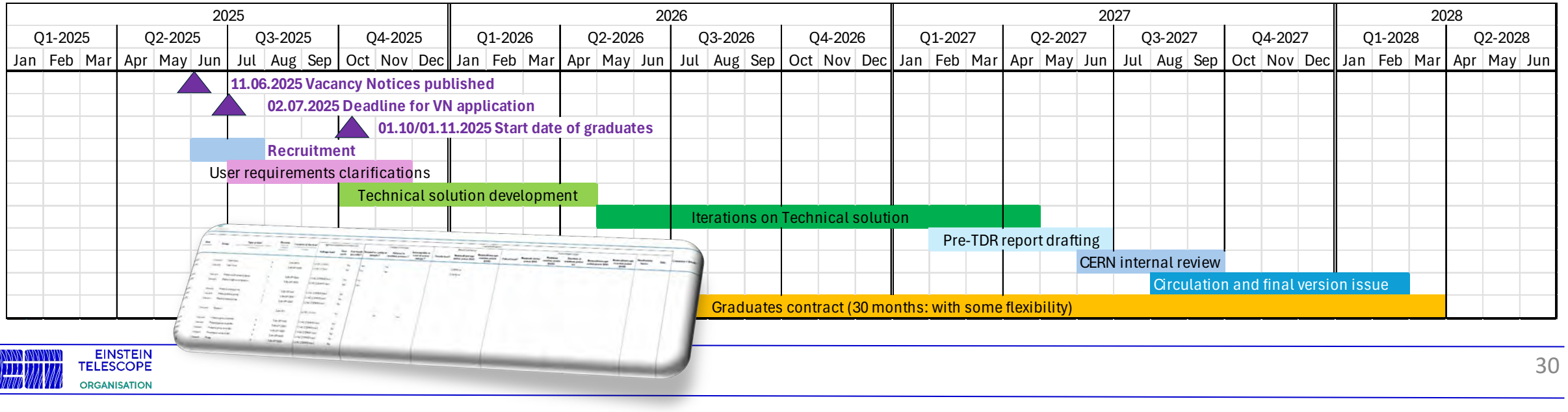
Graduates and CERN Staff – photo taken after the 4th CERN internal meeting (Nov. 6)

Developments of the Technical Infrastructure and Safety

Requirements for the technical infrastructure and safety studies:

- Bases for the development: Task Force Baseline Detector Layout + requirements
- Next step: improve towards more mature requirements:
  - On nomenclature, locations, electrical loads, racks, dissipated power, people, safety, coordinate systems, configuration, etc……

EN-CV Roadmap – F. Dragoni (CERN)

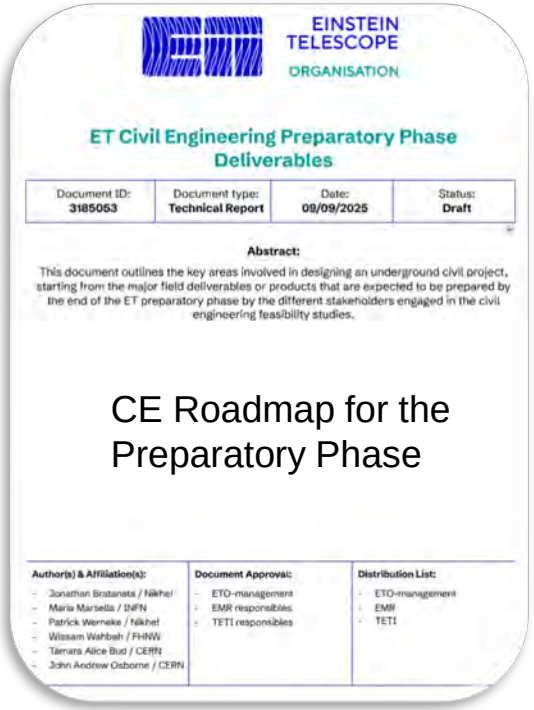


ETO Engineering Department and Host Consortia

ETO Engineering Department and Host Consortia

- Coordinating role between ET Collaboration and Host Consortia for the civil and technical infrastructure
  - Baseline Detector Layout and requirements for the Host Consortia civil infrastructure development
  - Organize by-weekly meetings Restarted in November (stopped during Task Force and sumemr)
  - Organized 2 workshops @CERN

  - Deal with competition between Host Consortia
    Very limited sharing of information


EINSTEIN TELESCOPE ORGANISATION

ET Civil Engineering Preparatory Phase Deliverables

Document ID:	Document type:	Date:	Status:
3185053	Technical Report	09/09/2025	Draft

Abstract:

This document outlines the key areas involved in designing an underground civil project, starting from the major field deliverables or products that are expected to be prepared by the end of the ET preparatory phase by the different stakeholders engaged in the civil engineering feasibility studies.

CE Roadmap for the Preparatory Phase

Author(s) & Affiliation(s):	Document Approval:	Distribution List:
Jonathan Bratanets / Nikhef Maria Marsella / INFN Patrick Werneke / Nikhef Wissam Wahbeh / FHNW Tamara Alice Bud / CERN John Andrew Osborne / CERN	ETO-management EMR responsibles TETI responsibles	ETO-management EMR TETI

ETO Task Force

ETO Task Force

ETO developed a preliminary Detector Layout based on updated ETC - ISB Optical Layout: “2024 Reference”:

- “Detector Layout” as baseline for the Host Consortia civil infrastructure development
- **Issue: expected much higher cost of the civil infrastructure compared to 2020 ESFRI proposal**

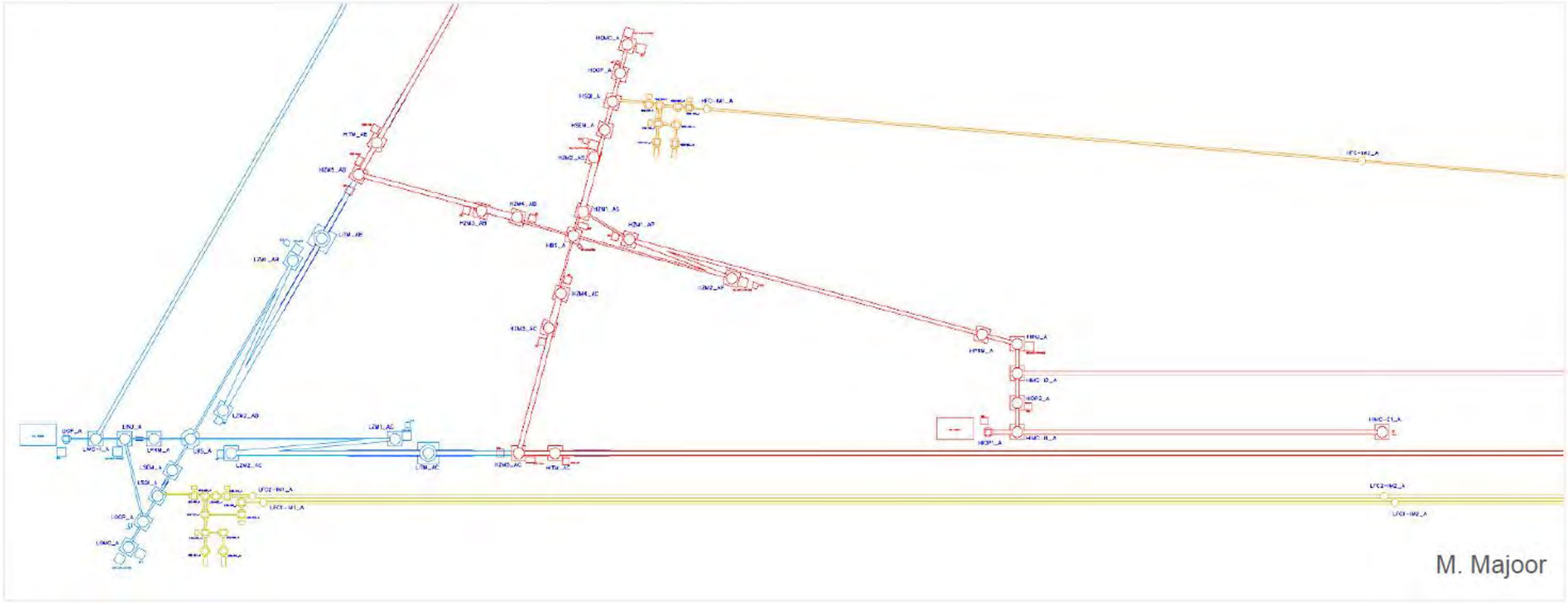
Task Force: optimize the layout to reduce cost without compromising on the ET sensitivity

- Team: ETO, ETC, Host Consortia and CERN

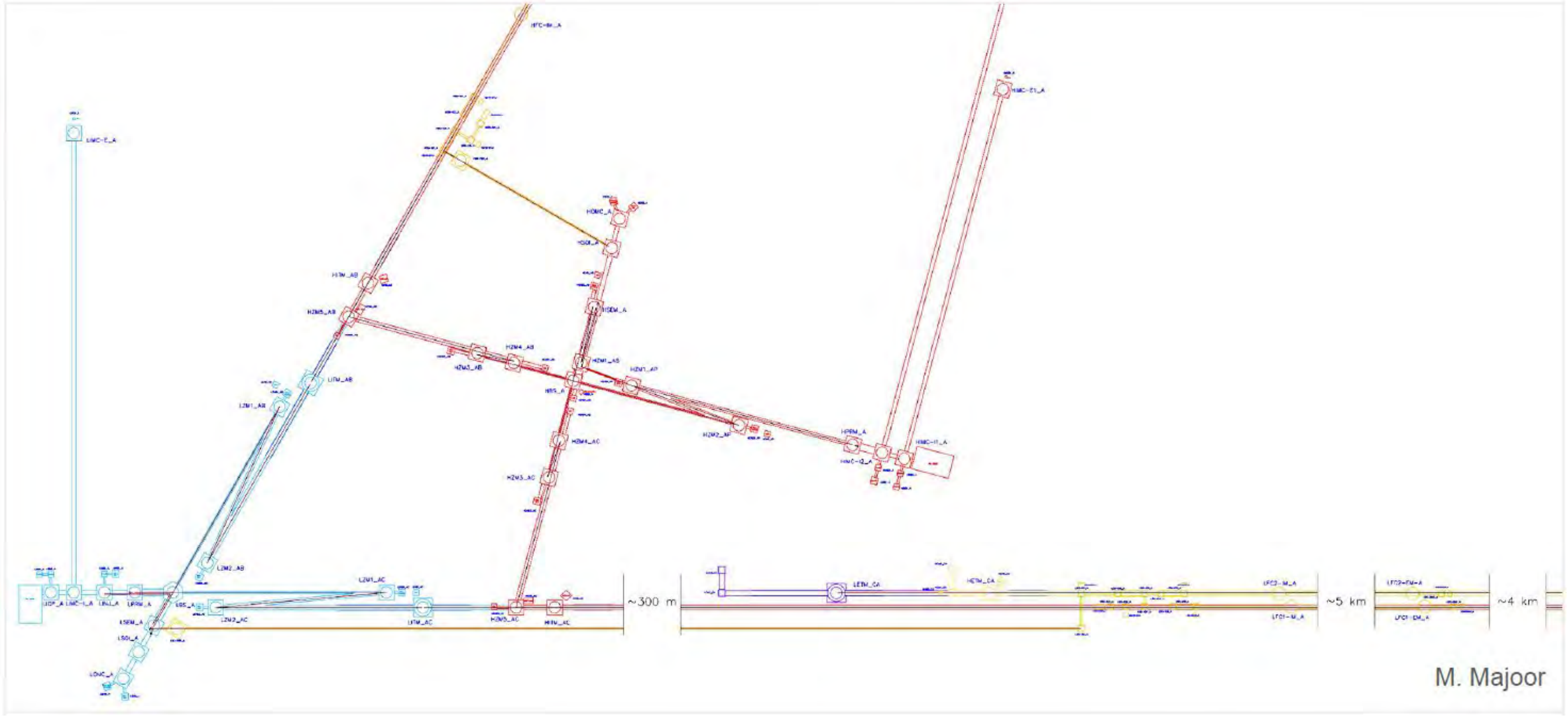
Task Force documents published at CERN EDMS:

- https://edms.cern.ch/project/CERN-0000274753

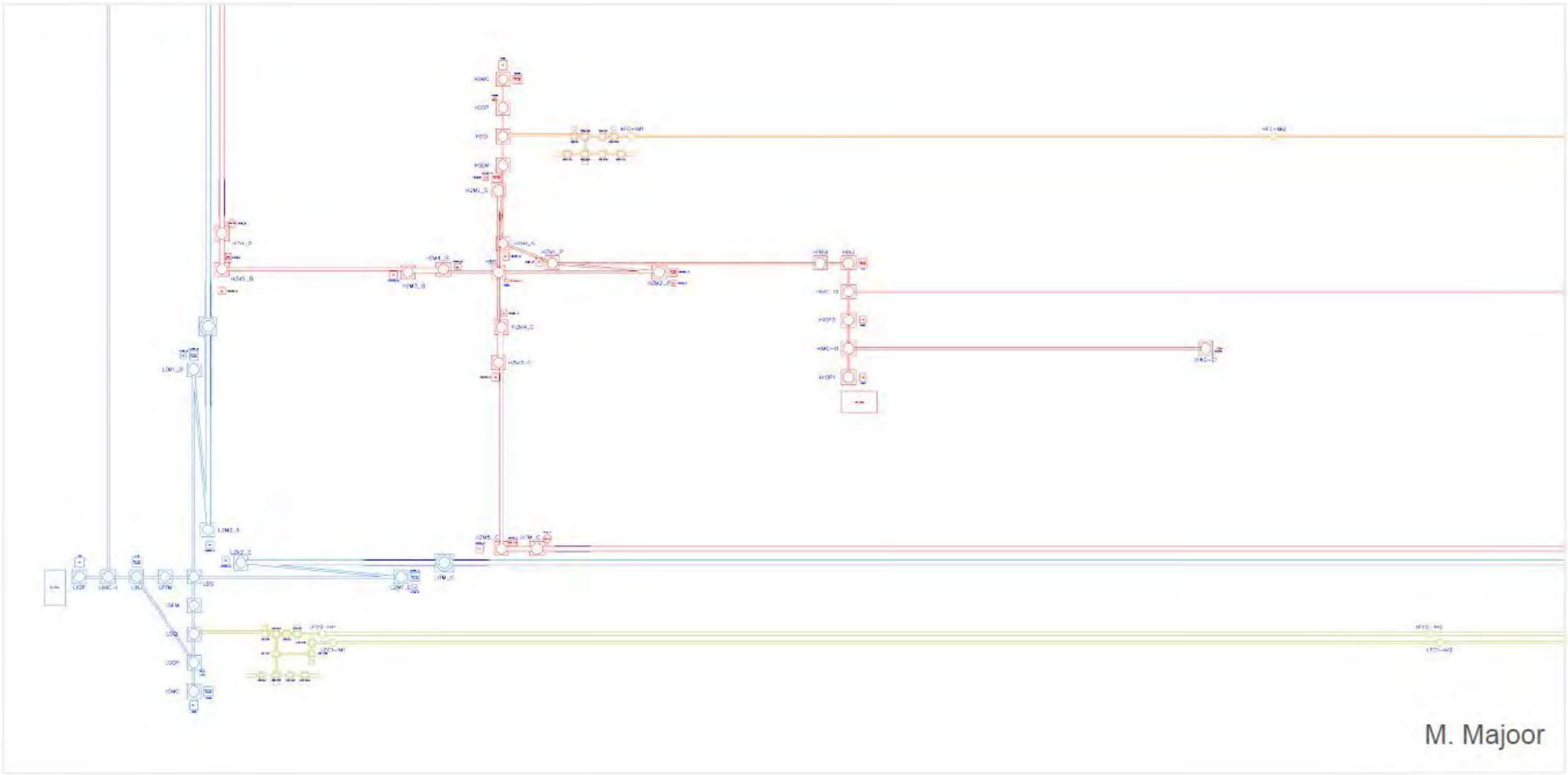
Triangle: 2024 Optical Layout



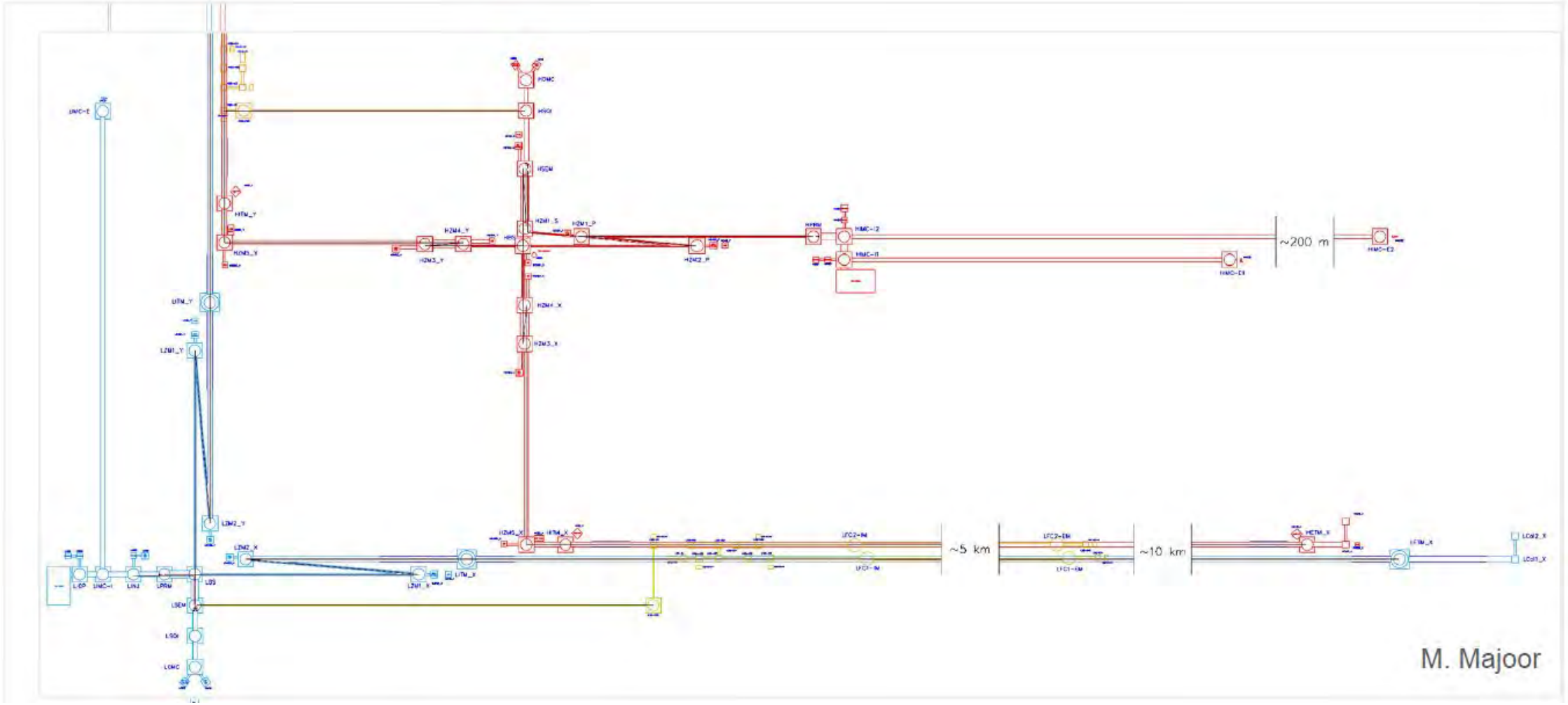
Triangle: 2025 Optical Layout



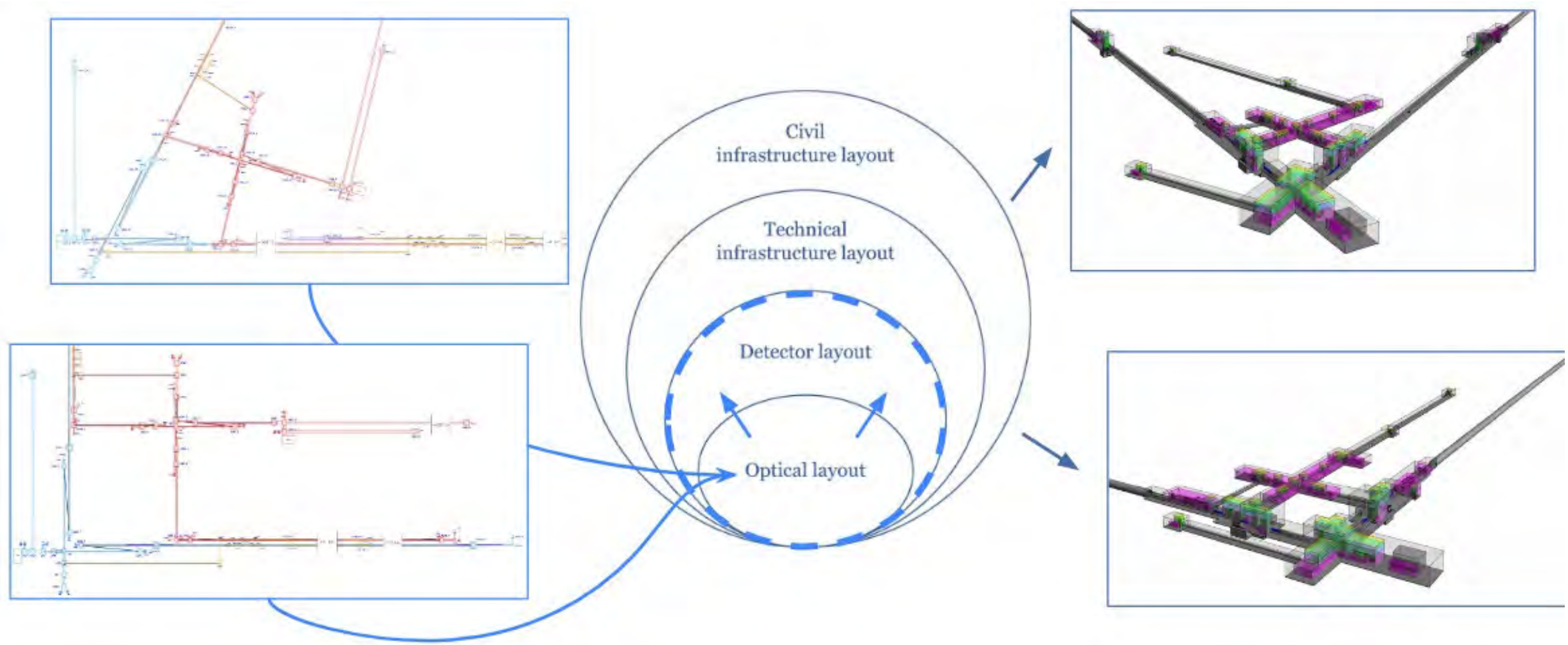
2L: 2024 Optical Layout



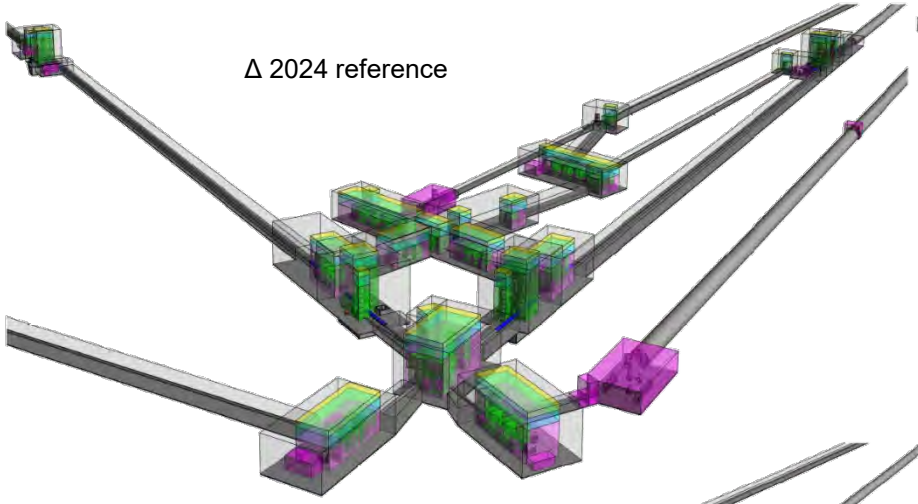
2L: 2025 Optical Layout



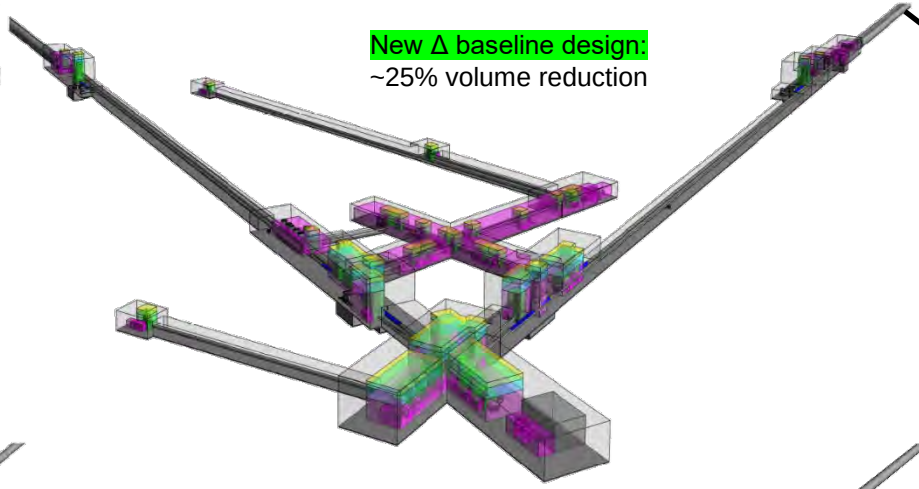
From Optical Layout to Detector Layout



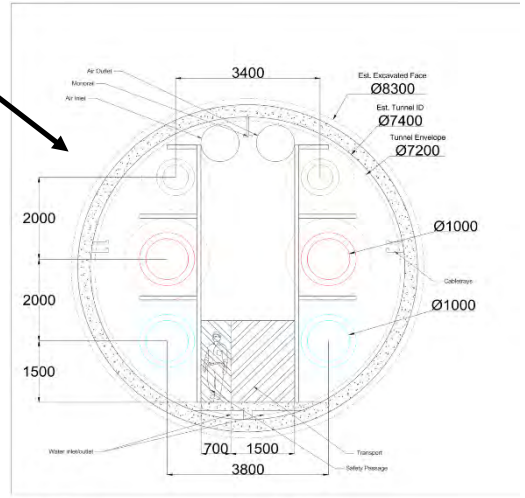
Task Force Baseline Detector Layout as a starting point



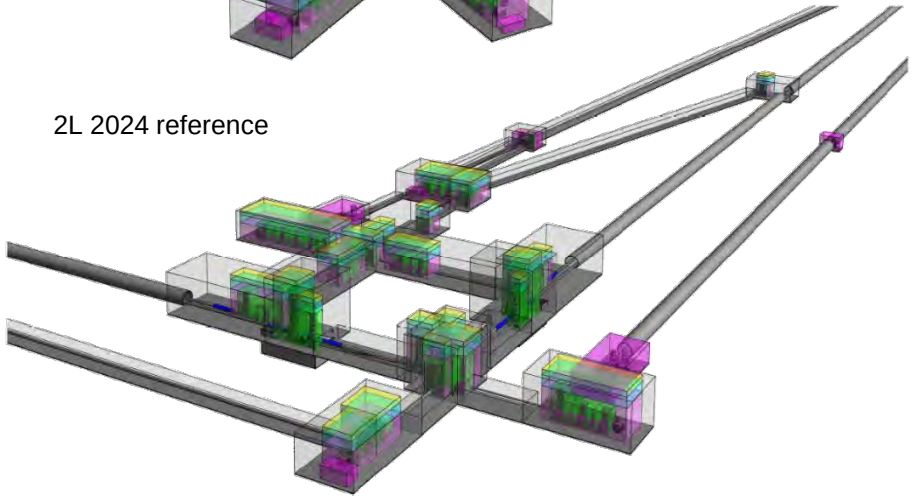
Δ 2024 reference



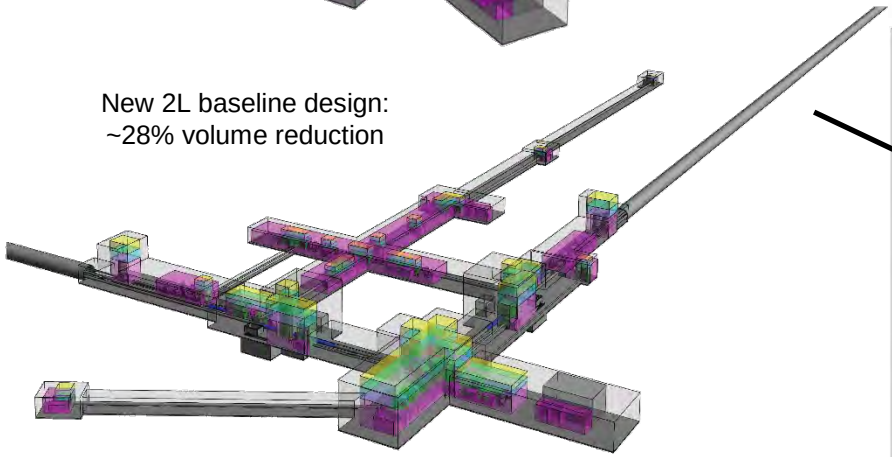
New Δ baseline design:
~25% volume reduction



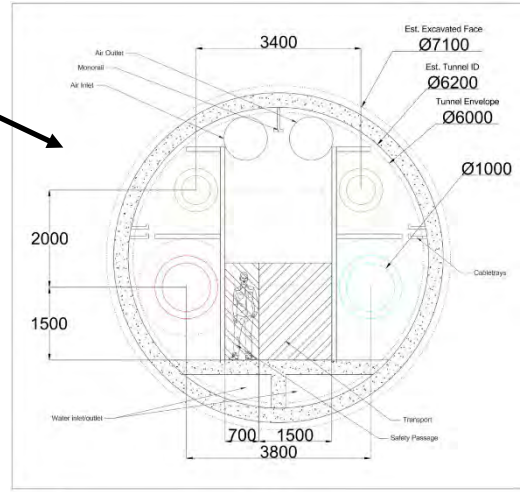
AC-arm 0 - 5 km



2L 2024 reference



New 2L baseline design:
~28% volume reduction



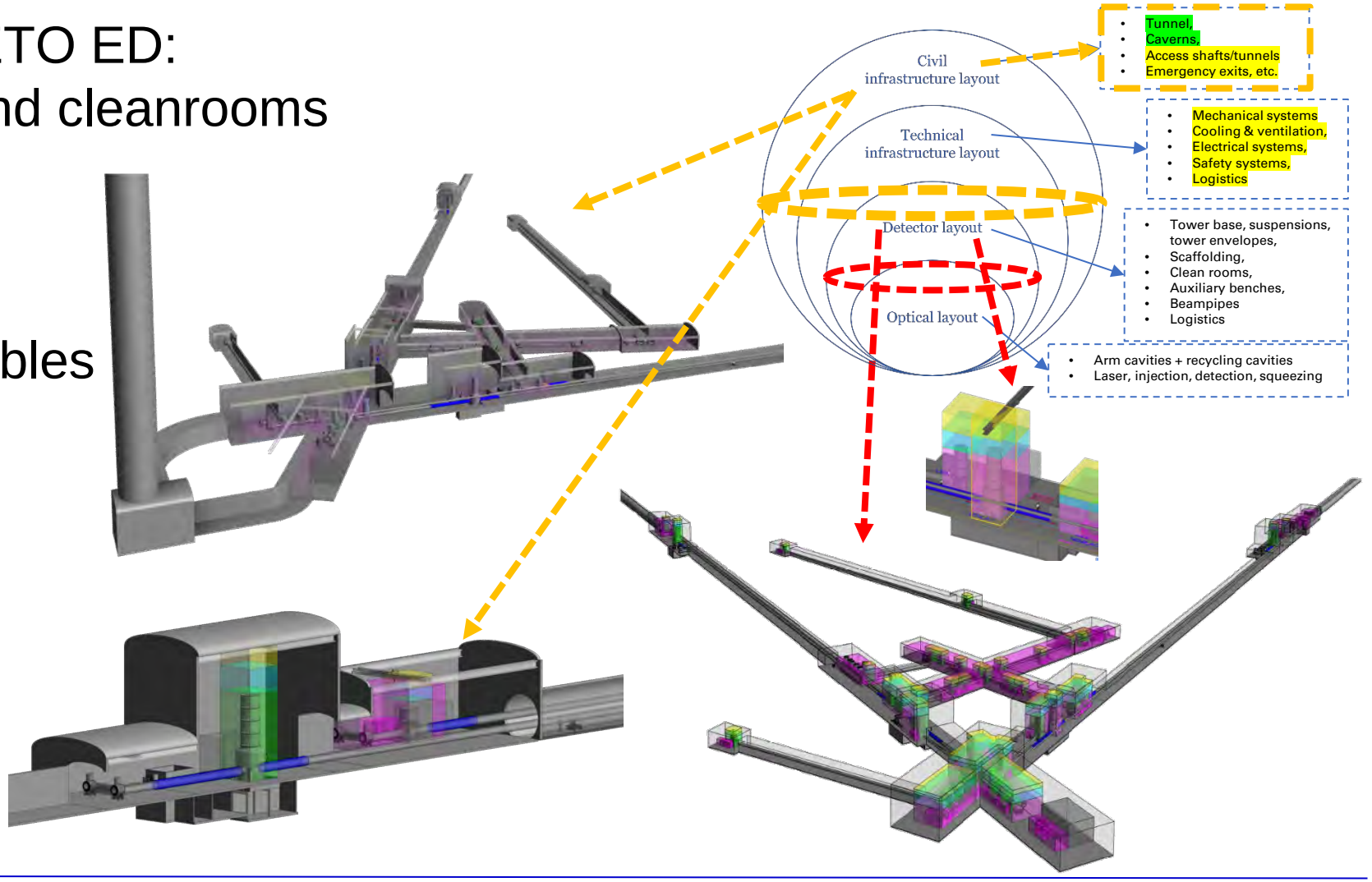
X-arm 0 - 5km

Technical Design (3D Integration Model)

Next to be developed by ETO ED:

- Update of scaffolding and cleanrooms
- HVAC
- Electrical
- Safety
- Routing of pipes and cables
- Update of logistics plan


HVAC for the central clean room @LHO



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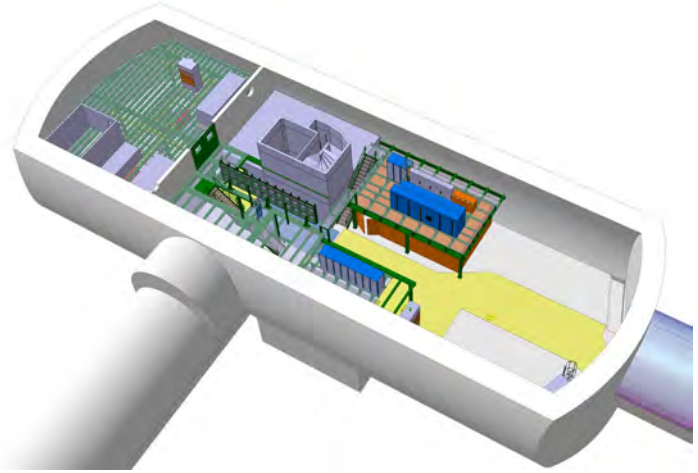
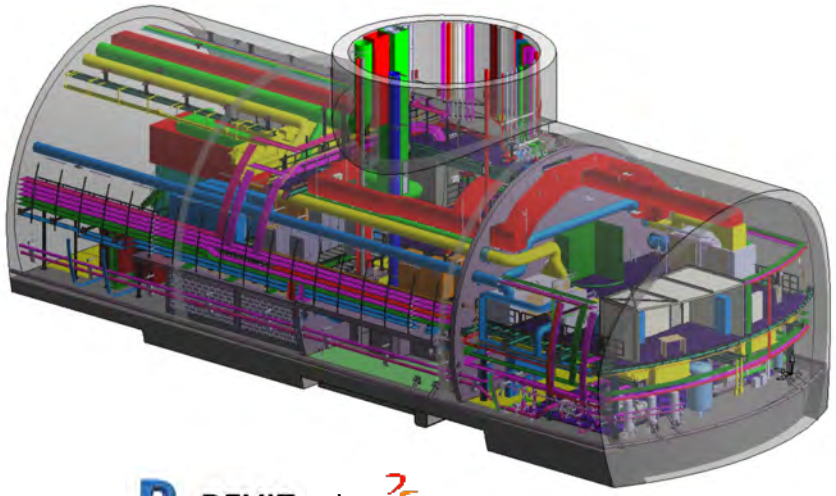


CATIA + REVIT

Native Converted

HL-LHC – Preliminary Revit model
w/ integration in Catia



REVIT + CATIA

Native Exported & Linked

HL-LHC Cavern: As-built CE Revit model
+ Catia integration linked as coordination model (Naviswork file)

What's next for the ETO Engineering Department

- Strengthen the Engineering Department with more engineers
- Keep providing support to the Host Consortia:
  - Requirements will evolve: deadline Task Force updates end April 2026
- Work with CERN on vacuum, civil and technical infrastructures, and safety designs
- Further develop integrated 3D models for civil infrastructure and technical systems
- Conduct scoping and descoping reviews to optimize the technical design
- Select and role out digital tools to support technical design and coordination (PLM, CAD & BIM)
- Keep working closely with the ETC and Host Consortia on all technical topics
- Provide support for additional technical design activities as required

Thank you

EINSTEIN TELESCOPE

Engage. Innovate. Explore.