Project: 101079696 — ET-PP — HORIZON-INFRA-2021-DEV-02

Horizon Europe:
Coordination and Support Actions

ET-PP (WP6.2)
2nd review meeting (RP2)

15/05/2025

Grant agreement: Nº 101079696

WP 6.2: Introduction and objectives (1)

The ET vacuum pipes are metallic tubes through which laser beams propagate in an ultrahigh vacuum (UHV) between the input and end mirrors of the interferometers.

The objectives of WP6.2 (ET-beampipe) are to:

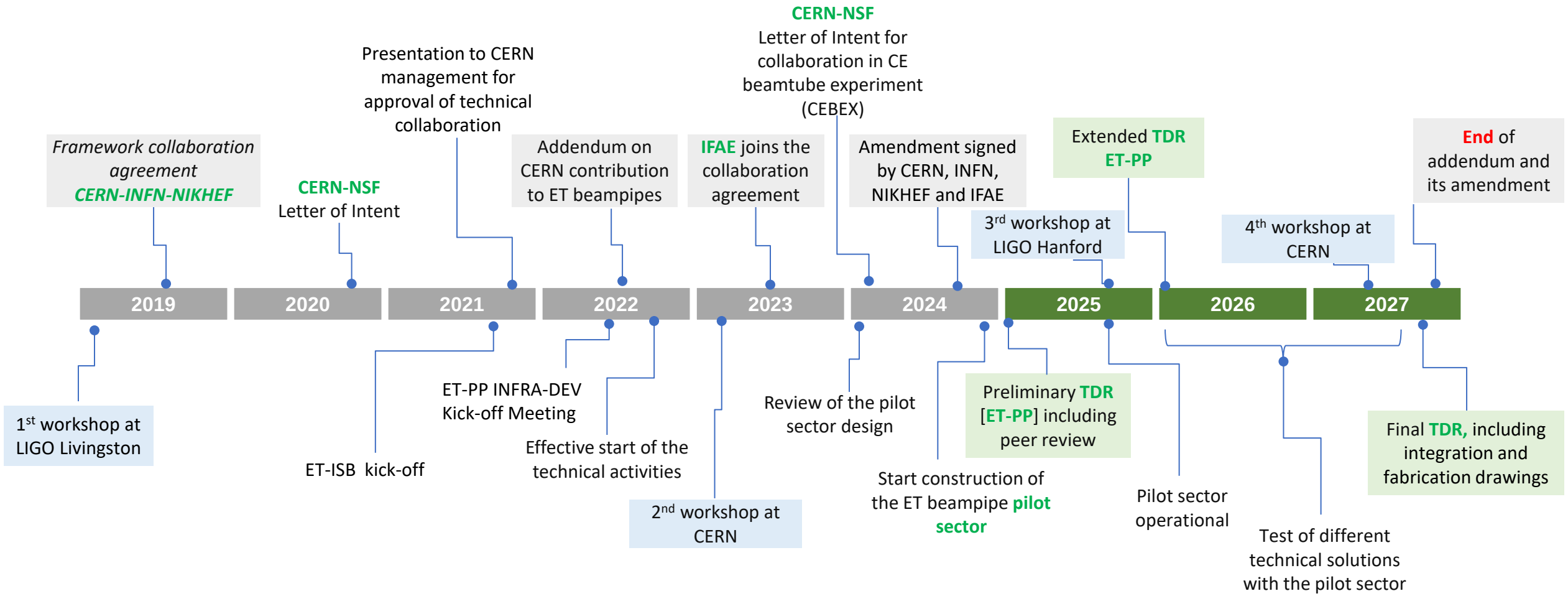
- Design and test technical solutions that meet the ET requirements in a cost-effective manner.
- Manufacture, assemble, and test a pilot sector.
- Produce the **technical design report**, including cost estimates.

The team includes CERN staff members contributing the equivalent of 2 FTEs, along with two CERN graduates. An engineer from the University of Antwerp joined the team in 2024. We are contractually linked to INFN, Nikhef, and IFAE, and maintain open collaboration with LAPP-CNRS (Annecy, FR) and parallel initiatives such as MacBeth (NL) and BeamPipes4ET (DE, BE, NL).

We report to the Engineering Department of the ET Organisation (**ETO**).

The WP6.2 is led by Ana Teresa Perez Fontenla and Paolo Chiggiato.

WP 6.2: Introduction and objectives (2)



WP 6.2: Tasks

Our main task is the progressive preparation of the Technical Design Reports (TDRs), moving toward their final version by incorporating results from the pilot sector and parallel studies (e.g., corrosion, integration, and interfaces with experimental areas).

The TDRs will be revised and adapted to reflect:

- New infrastructure inputs
- Technical results from the pilot sector
- Recommendations from peer reviews

In Q4 2025, we plan to organise two peer reviews focusing on:

- Support systems, once the vacuum pipe envelope and tunnel geometry are defined
- Pipe assembly, alignment, and leak detection within the tunnel

WP 6.2: Critical risks, deviations from Annex I, contingency plans (1)

Critical risks that were **highlighted at the previous review**:

1. **Delay in manufacturing and installing the pilot sector**
   This delay might come from challenges in the procurement process and delays in receiving components from the industry.
2. **Availability of personnel**
   The success of the WP heavily relies on CERN personnel operating on a best-effort basis. Any shifts in CERN's priorities could result in personnel being reassigned to different tasks, potentially impeding progress in ET-related activities.
3. **Technical issues**
   The proposed manufacturing procedure and material for the beampipe are unusual for UHV applications. Incompatibility could appear necessitating a significant alteration in the work plan and the supply chain.

All happened in the last six months!

WP 6.2: Critical risks, deviations from Annex I, contingency plans (2)

1. Delay in manufacturing and installing the pilot sector

- A two-month delay occurred in finalizing the manufacturing specifications and selecting the purchasing strategy.
- A similar delay affected the fabrication of the vacuum tube elements, due to interactions between CERN and the supplier to qualify the welding approach.
- The vacuum tube elements were delivered two weeks ago.
- These elements now require modifications in CERN's main workshop to add the optical baffle frames.

This risk also remains active for any future modifications to the pilot sector.

WP 6.2: Critical risks, deviations from Annex I, contingency plans (3)

2. Availability of personnel

- As the start of the **LHC Long Shutdown 3 approaches**, the availability of CERN internal services requires careful planning and flexibility.
- Welding and manufacturing of the pilot sector extremities were delayed by three months due to scheduling conflicts with new LHC equipment.
- Once the first version of the pilot sector is installed, we expect greater flexibility in the schedule to absorb potential fabrication delays.
- **A partial mitigation involves anticipating and submitting 'job requests' as early as possible**.

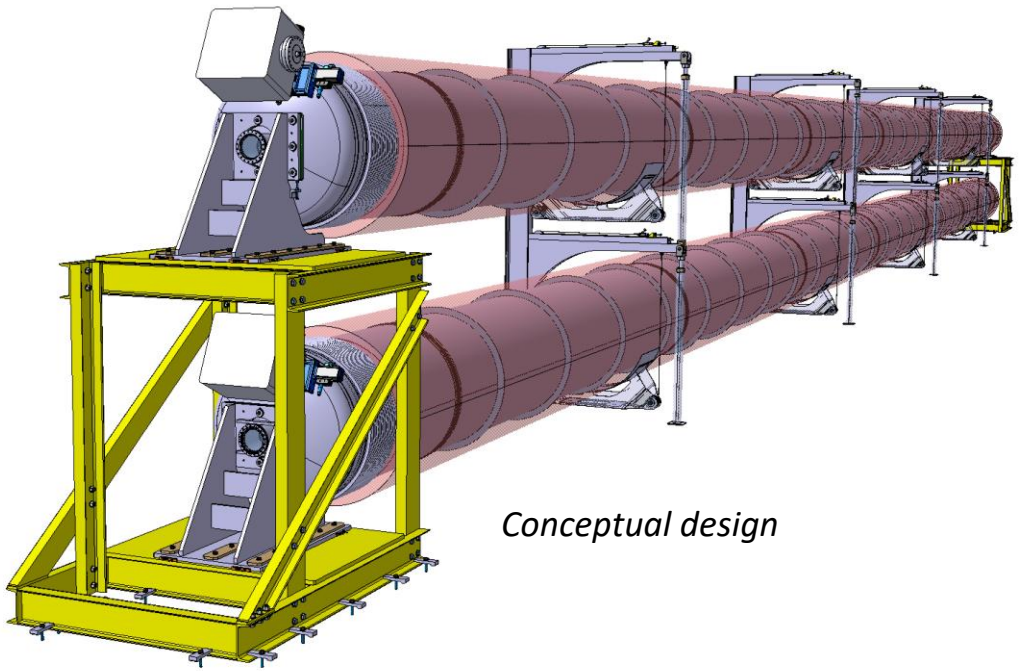
WP 6.2: Critical risks, deviations from Annex I, contingency plans (4)

3. Technical issues

- We encountered a **problem with a mock-up system** used for joining tests: the assembly sleeve was misaligned, and the welding robot developed a water leak during the final phase of the welding process. Notably, all of this occurred in a cleanroom environment.
- We also faced challenges with meeting **concentricity tolerances** — a reminder of real-world complexities.
- These issues led us to **redesign the assembly methods**.
- Such **technical challenges are valuable at this stage of the work package**, as we still have time to address them and update the TDR accordingly.

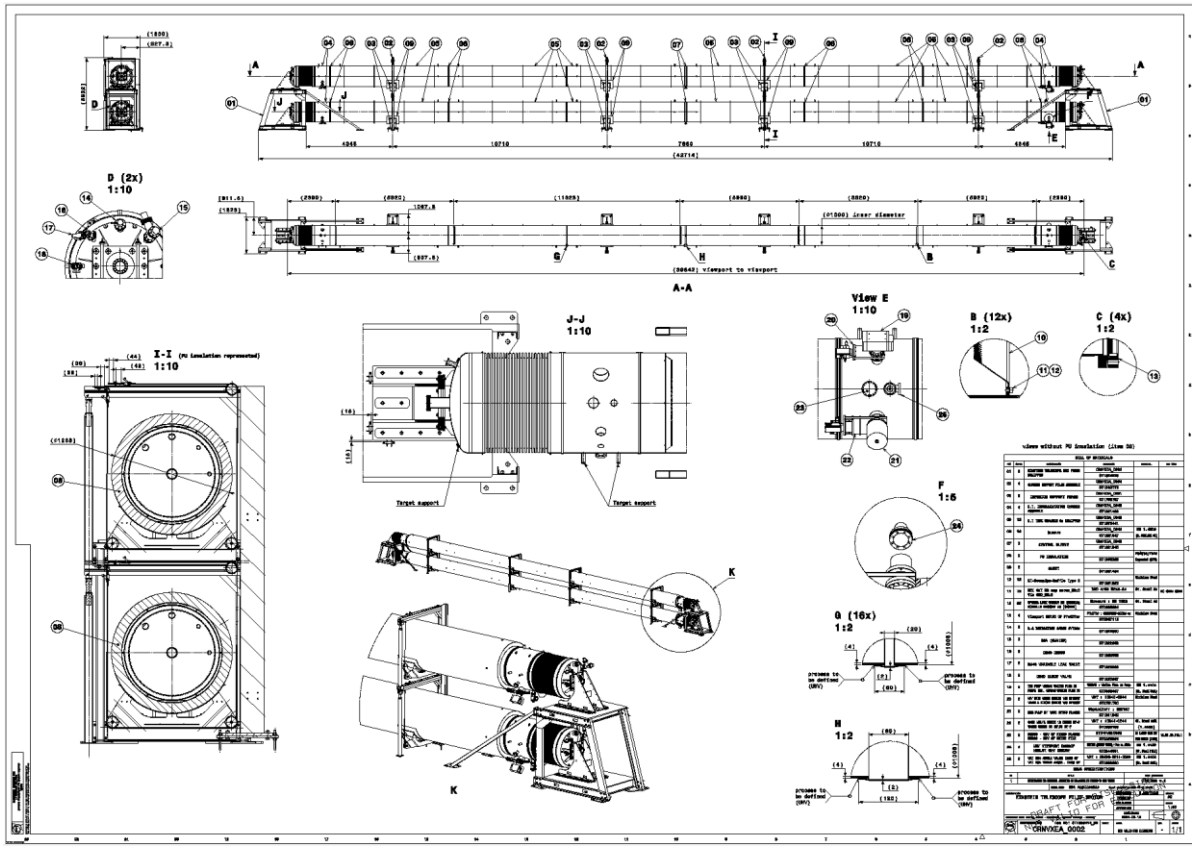
WP 6.2: Deliverables and milestones (1)

Pilot sector: from conceptual design to installation



Conceptual design

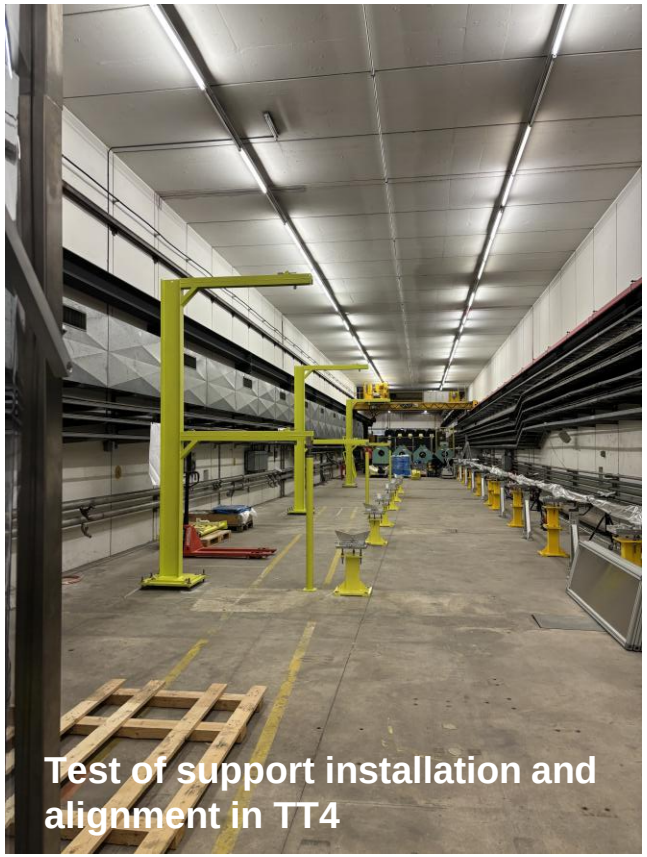
Technical design



WP 6.2: Deliverables and milestones (2)

Pilot sector: from conceptual design to installation

Fabrication and installation



Test of support installation and alignment in TT4

Installation of the extremity support in TT4

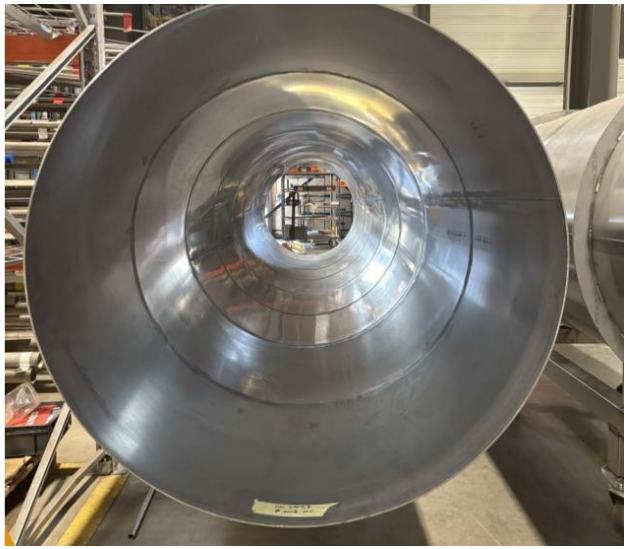
Compensation bellows in the CERN's vacuum firing furnace

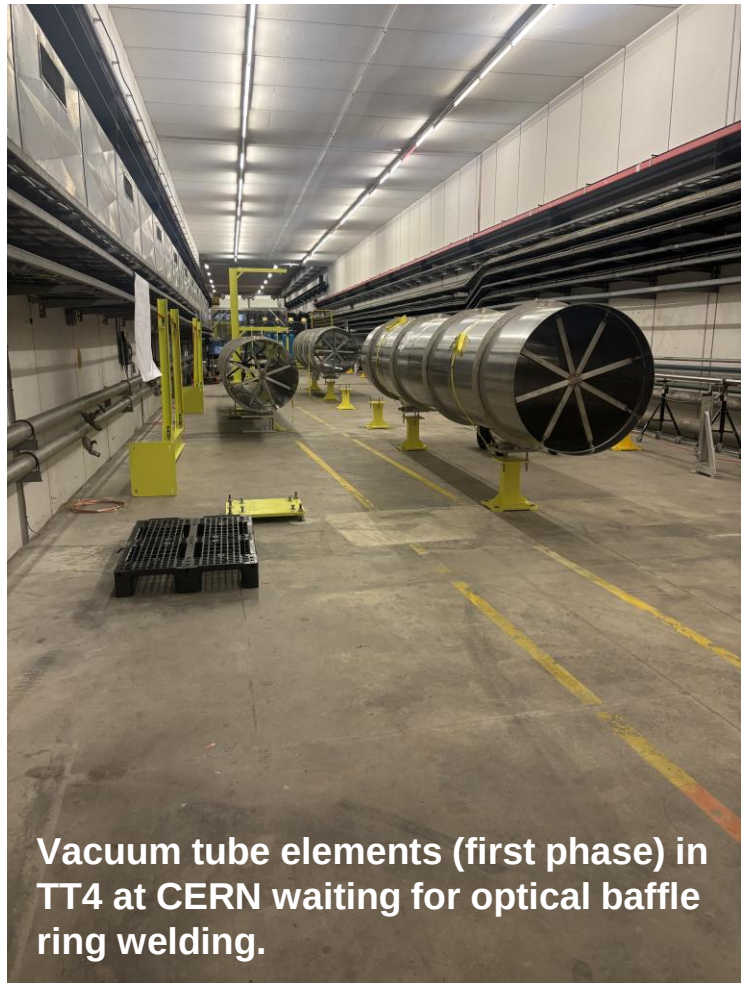
WP 6.2: Deliverables and milestones (3)

Pilot sector: from conceptual design to installation.

Fabrication and installation

Vacuum tube elements (first phase) at the supplier production plant





Vacuum tube elements (first phase) in TT4 at CERN waiting for optical baffle ring welding.

- The **detailed installation and measurement plan** was prepared in January and is updated monthly based on input from the fabrication teams.
- Currently, the measurements are organized into three main steps:

1. **Dust generation** during tube junction assembly.
2. Performance evaluation of **pumps and instrumentation**.
3. Performance evaluation of a **36-metre-long pipe** (scheduled to begin in August).

WP 6.2: Deliverables and milestones (4)

The Pre-TDR was issued in January following a **peer review**.

The review defined the focus areas for our current development activities:

- **Corrosion studies**: Further investigations under realistic conditions relevant to the proposed sites.
- **Support system**: A dedicated review will be organised before the next TDR version.
- **Corrugated pipe design**: In collaboration with Dutch and U.S. initiatives.
- **Gate valve integration**: Joint development with PSI and VAT to design alternative valve solutions.
- **Dust management**: Closer collaboration with the team in Padua is anticipated.
- **Thermal insulation**: In partnership with PIEP (University of Minho, Braga, PT).
- **Leak detection strategy**: A review will be held prior to the next TDR version.


ET EINSTEIN TELESCOPE

Preparatory Phase for the Einstein Telescope Gravitational Wave Observatory

Deliverable 6.2

The Vacuum Pipe of ET

Lead beneficiary:
Delivery Date:
Dissemination level: internal

NAME : ET-PP-Deliverable-6.2 [ET-0005A-25]
Version: 1.0

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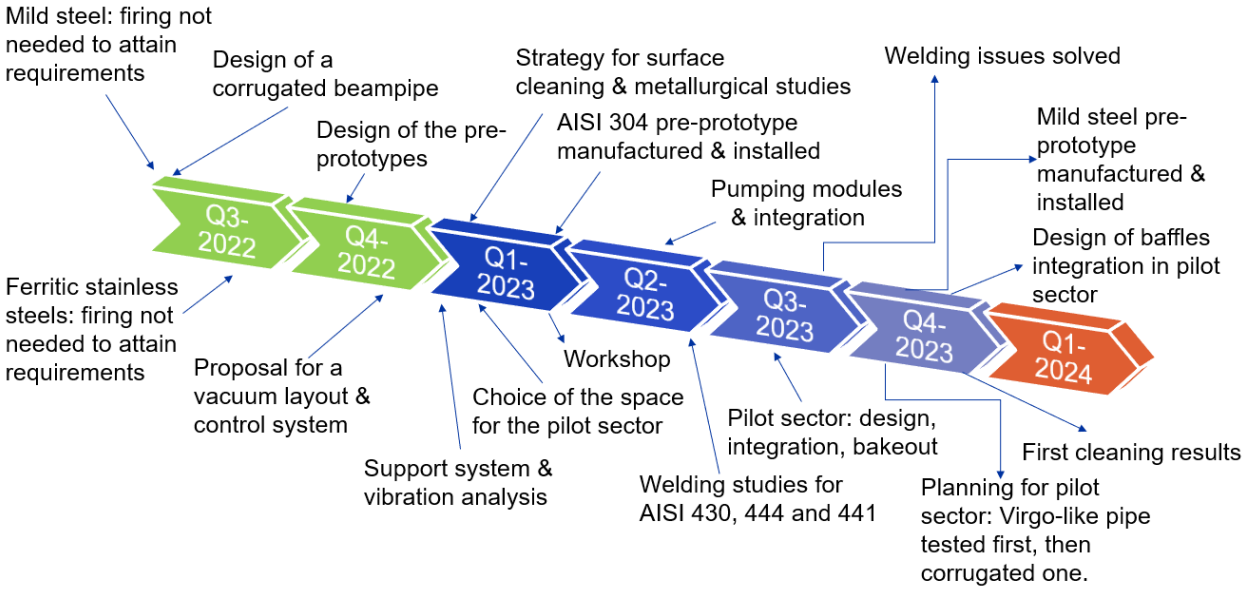
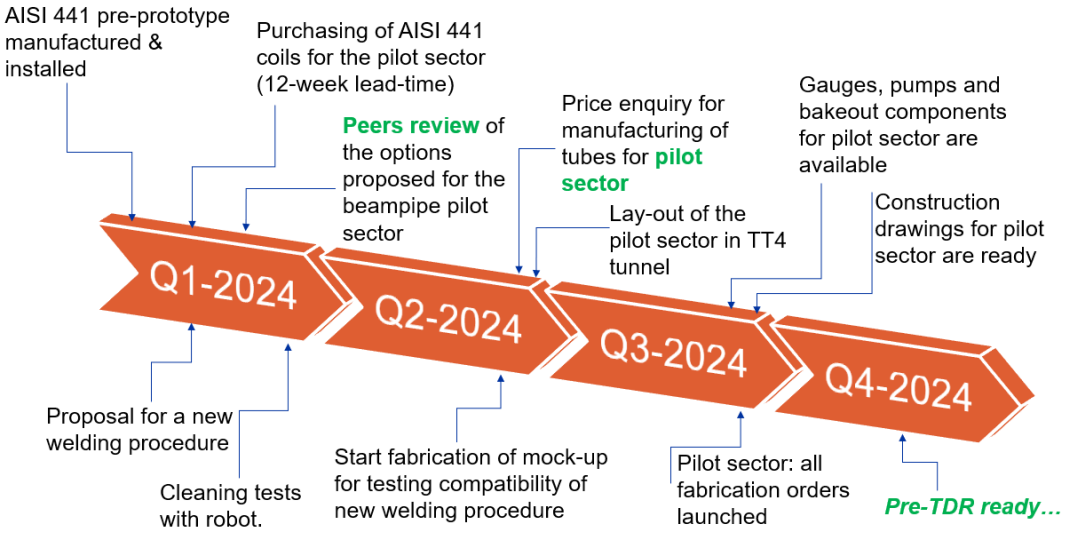
WP 6.2: Deliverables and milestones (5)

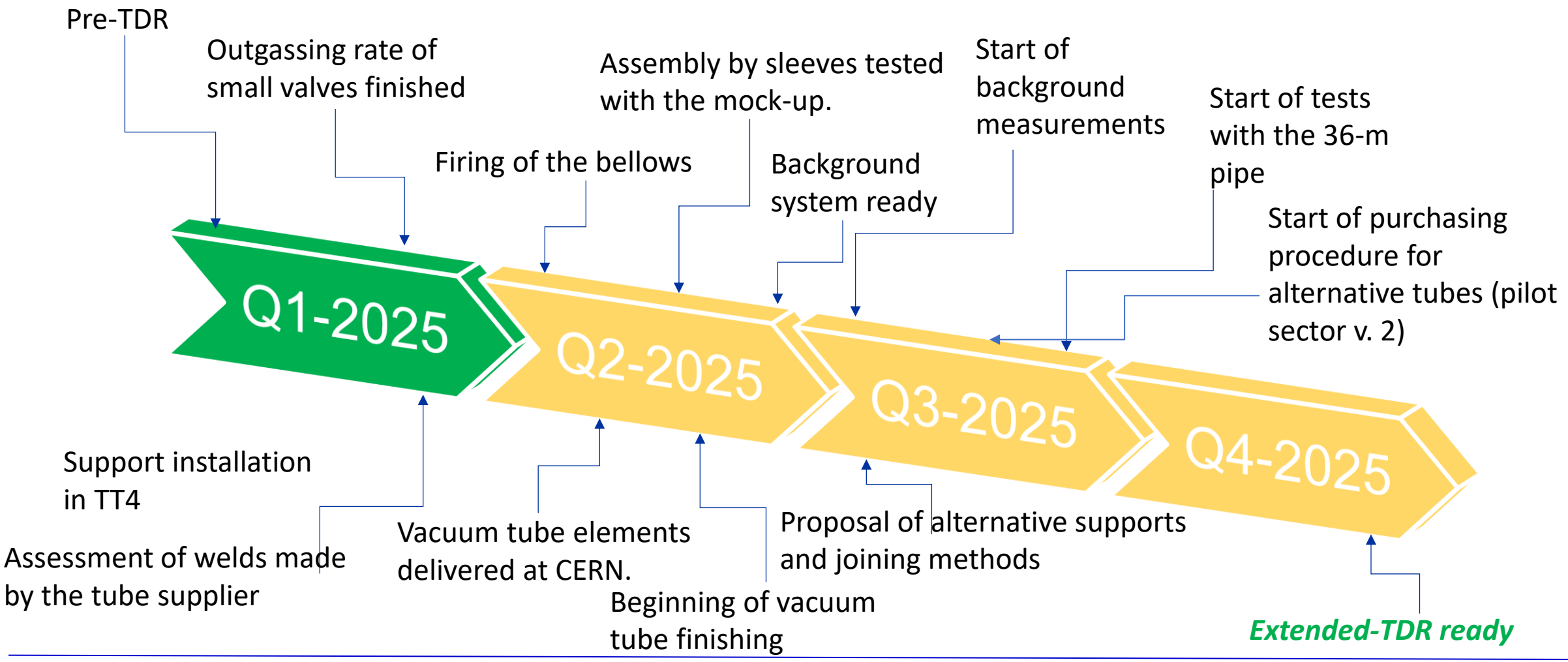
Technical results and achievement presented at the October's review:





WP 6.2: Deliverables and milestones (6)

Expected technical results and achievement in 2025:



WP 6.2: Deliverables and milestones (5)

Updated master plan that includes the new addendum of our collaboration with NIKHEF, INFN and IFAE:

	2025				2026				2027			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Manufacturing and installation of pilot sector												
Measurement with pilot sector (phase 1)												
Extended-TDR												
Purchasing of material for phase 2												
Measurement with pilot sector (phase 2)												
Purchasing of material for phase 3												
Measurement with pilot sector (phase 3)												
Technical documents for ET-beampipe market survey												
Final TDR												

Previous master plan:

	2023				2024				2025				2026			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
TDR writing																
Material removal and cleaning of hosting building																
Installation of services (WiFi, electricity)																
Design of support and beampipes																
Design of tooling																
Design of bakeout system, cabling and instrumentation racks																
Place orders for all required material																
Manufacturing, reception tests and cleaning																
Manufacturing and delivery of the baffles																
Assembly and leak detection																
Test programme																

We are experiencing a **six-month delay** compared to the previous master plan.

The first measurements with the pilot sector were initially planned for Q1 2025 but are now expected to begin in August.

Despite this delay, we aim to deliver the Extended TDR by the end of Q1 2026.

WP 6.2: Outlook and perspectives

We have entered a new phase in our involvement with the ET project. Moving from the conceptual design stage, we are now in the **fabrication and installation phase**.

This execution phase is encountering **typical challenges** related to purchasing, personnel availability, and technical issues.

These challenges provide us with **opportunities to optimize** the design and tolerances, refine installation procedures, and continue with parallel studies (e.g., corrosion, supports, and assembly).

As a result, the **advanced TDR may be delivered a quarter later** than originally planned.

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