

ET beam pipe vacuum system

Beam pipe vacuum system is the biggest Einstein Telescope sub-system after the underground excavation (preliminary estimated cost ~ 560 Meuro)

120 Km 1m diameter UHV tubes

Surface: $3.8 \times 10^5 \text{ m}^2$
Volume: $9.4 \times 10^4 \text{ m}^3$

Preliminary vacuum requirements:

H_2 10^{-10} mbar, H_2O 5×10^{-11} mbar, N_2 10^{-11} mbar, Hydrocarbon $< 10^{-14}$ mbar
(> factor 5 more stringent than Virgo)

Exploit 2G detectors experience and push forward the UHV performance

R&D on:

- Cost effective solution for
 - pipe material (austenitic, duplex, low carbon, aluminium)
 - production processing choice (Ruhrstahl-Hausen vacuum process during steel refining,
- Surface treatment to reduce outgassing
 - problem of underground bakeout costs and thermal management (with a 150 °C 10 days bakeout and thermal insulation, estimated tunnels temperature rise of 15-20 °C)
- Corrosion tests -> ET lifetime 50 years



Timing & Planning

- Towards jan 2022 (tentative): Detailed requirements document:
 - Dimensions, considering
 - scattered light,
 - Thickness vs mechanical rigidity
 - industry standards, costs, ..
 - Long vs short sections (production on site, or transport, ...)
 - Surface roughness (impact on outgassing, scattered light, ...)
 - Outgassing properties
 - Corrosion and longevity
 - Other components: pumps, valves, baffles, ...
- Towards 2026: ET TDR
- Installation: > 2029
- Completion: 2032-2033

Today's agenda

- Identify existing expertise in ET Collab
- Identify relevant ongoing & planned R&D
- Ask for commitment of personpower towards:
 - Completion of requirements document
 - Preparation of Beampipe Vacuum part of ET TDR:
 - Drawings
 - Production and welding schemes
 - Installation & bakeout schemes
 - Pumping and monitoring
 - ...

Backup slides

On going R&D projects/initiatives

Discussion on with several steel mills in Europe and metallurgical companies/experts for materials down-selection
Effort to define the standard to be adopted for comparison of results among vacuum labs

Italy

Contacts with: SAES-RIAL, RINA CSM, ENI-SAIPEM, ACCIAIERIE ITALIANE, TECNIMONT

Remodulation of an application to INFN for beampipe materials selection and surface treatments (~600 kE) :

Involved labs:

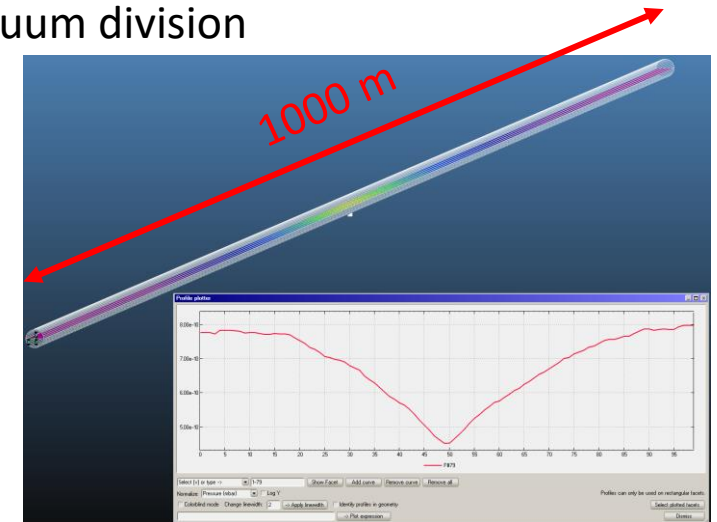
Materials selection: Napoli lab (+ PhD student), Roma, INFN Frascati lab, EGO vacuum division

Surface treatments: Legnaro lab

Netherlands

NIKHEF: EU Regional development funds South-NL: 554k€ for Vacuum

- Specification & Materials testing: alloys and coatings (with VDL and Tata steel)
- Outgassing properties & inventory (with CERN, VDL and Tata steel)
- Preparation & selection of steel samples, incl. lab tests (with VDL and Tata steel)
- Characterisation of non-intrinsic properties: welding, bakeout, interconnects, .. (with VDL)
- Upscaling of production: (with VDL)



H₂ pressure profile along the pipe section between 4.5E⁻¹⁰ and 8E⁻¹⁰ mbar

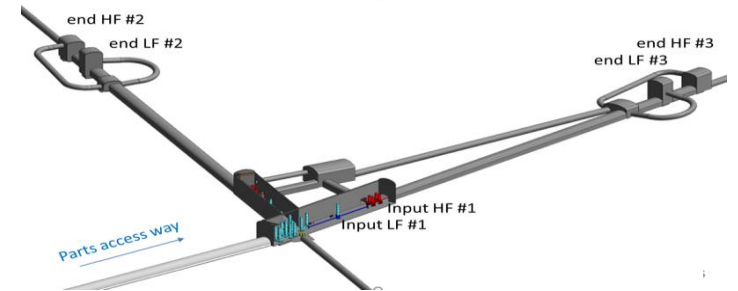
Germany **On going R&D projects/initiatives**

Aachen University

- Investigation on 10 km pipe design: 1 student + support from the vacuum group of the COSY accelerator
- Development of a production scheme for the default pipes, estimate of cost and production time. University spin-off. Funds from interreg project and regional government (Städteregion Aachen).
- CERN participation in characterisation and outgassing measurements of mild steels and surface coatings. One common PhD student with RWTH.
- Development of fiberglass – steel liner composite pipes (first prototype is under vacuum, 0.8 mm 304L liner). Second prototype (0.5 mm liner + embedded pressure & temperature sensor) is under production. Application for a 2-year project submitted to DFG.

Karlsruhe Institute of Technology

- on-going outgassing measurements on steel SR235JR
- Calculation of pressure profiles along the ET beam pipes, for varied in-situ and ex-situ connected pumping speeds, to quantify the particle load on the mirror shielding system



Belgium

No dedicated funding yet, but lots of expertise

- STIM (Strategic Initiative Materials in Flanders): steel alloys, large scale manufacturing, welding, fatigue, abrasion, corrosion, ...
- OCAS (Advanced, market-oriented research centre for steel applications): > 150 Engineers :
Enamelling steel, hydrogen interactions, in-use behavior, joining & assembly, metallurgy & alloy development, surface functionalization & corrosion
- NYRSTAR, ArcelorMittal, APERAM