

Last year's progression on ESSnuSB+

WP2 engineering: MS20, D2.1 and the ETTF

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EUROPEAN SPALLATION SOURCE ERIC



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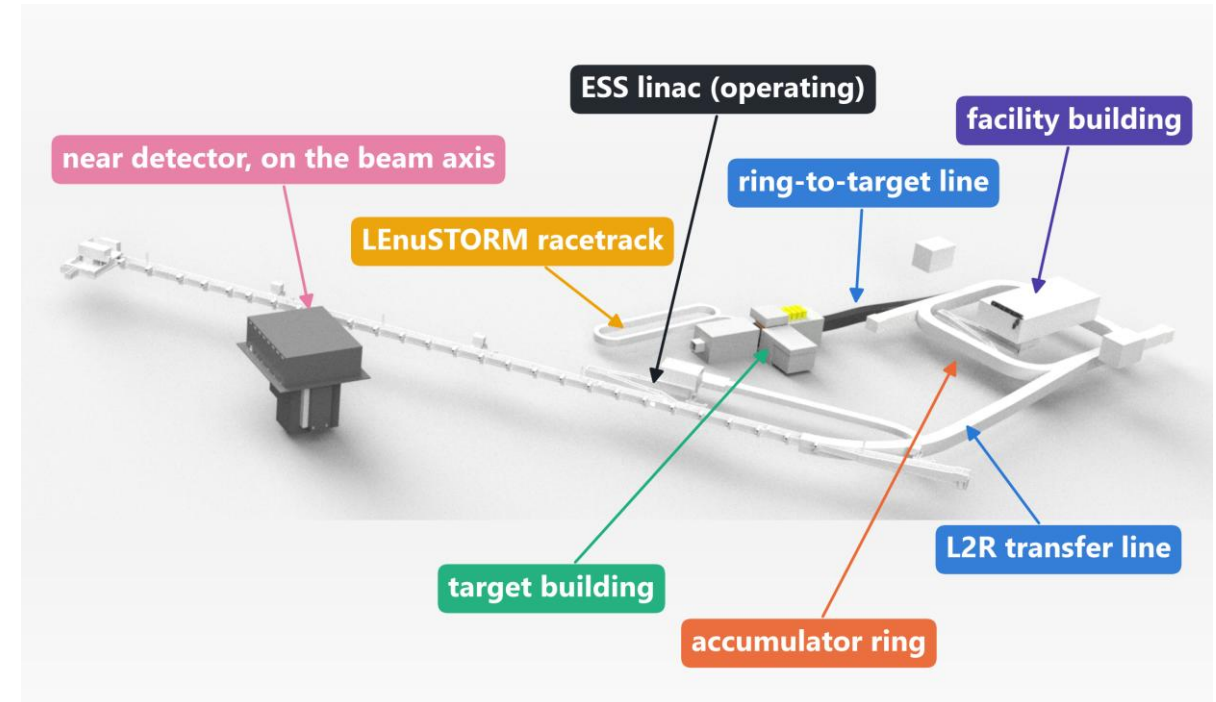




WP2: turning physics into an engineering design

The engineering questions behind the facility

- **Scope:** mechanical, machine and civil design of the facility at the ESS site, one integrated CAD model
- **Constraint:** a new facility beside an operating accelerator, built with minimal disturbance to it
- **Space:** tunnel sections sized from the installation and transport envelopes of the machine
- **Geometry:** tunnels laid out on the lattice, cell by cell, so the civil works follow the beam
 - levels follow the beam; only the racetrack is inclined as a whole
- **Ground:** till over clay shale, dolerite dykes and confined groundwater decide how each structure is built
- **Quantities:** floor areas, lengths and loads per stage, the input to the civil cost estimate of ESS Facility Management



The facility in the integrated CAD model of WP2 (Stage II): the object of the work presented here.

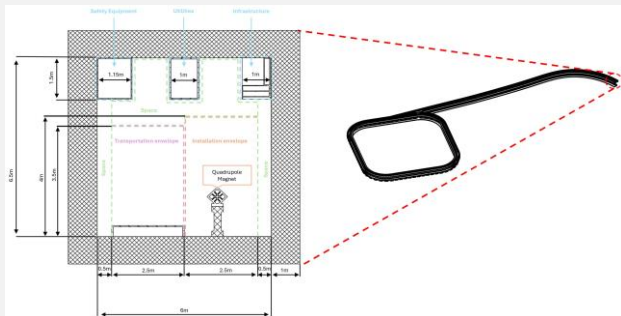
The work in three parts

What WP2 asked for, and what each part delivers

Part 1 · Milestone 20

Conceptual mechanical and machine design of the L2R transfer line and the accumulator ring tunnel section and space envelopes · beam path rebuilt cell by cell, 92 magnets placed · CATIA model and drawings

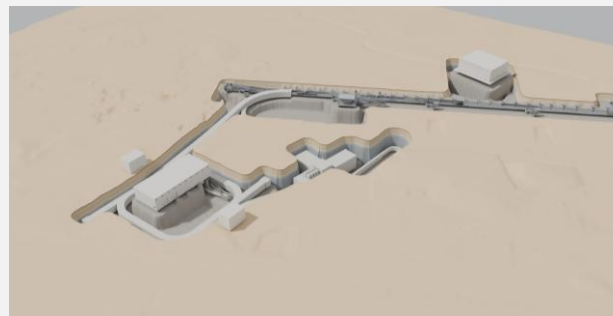
Report on CHESS: ESS-5991478



Part 2 · Deliverable 2.1

Conceptual study of civil works at the ESS site
placement on the real site and in its ground · civil quantities per stage · shielding, long profile and construction methods

Report on CHESS: ESS-6149549



Part 3 · ETTF

ESSnuSB Target Test Facility, the first physical test bench of the project
vessel design by ESS Bilbao · test stand at the ESS MML · loop, instrumentation and data acquisition · air test campaign with ESS Bilbao and U. Hamburg

Formal test report after the campaign

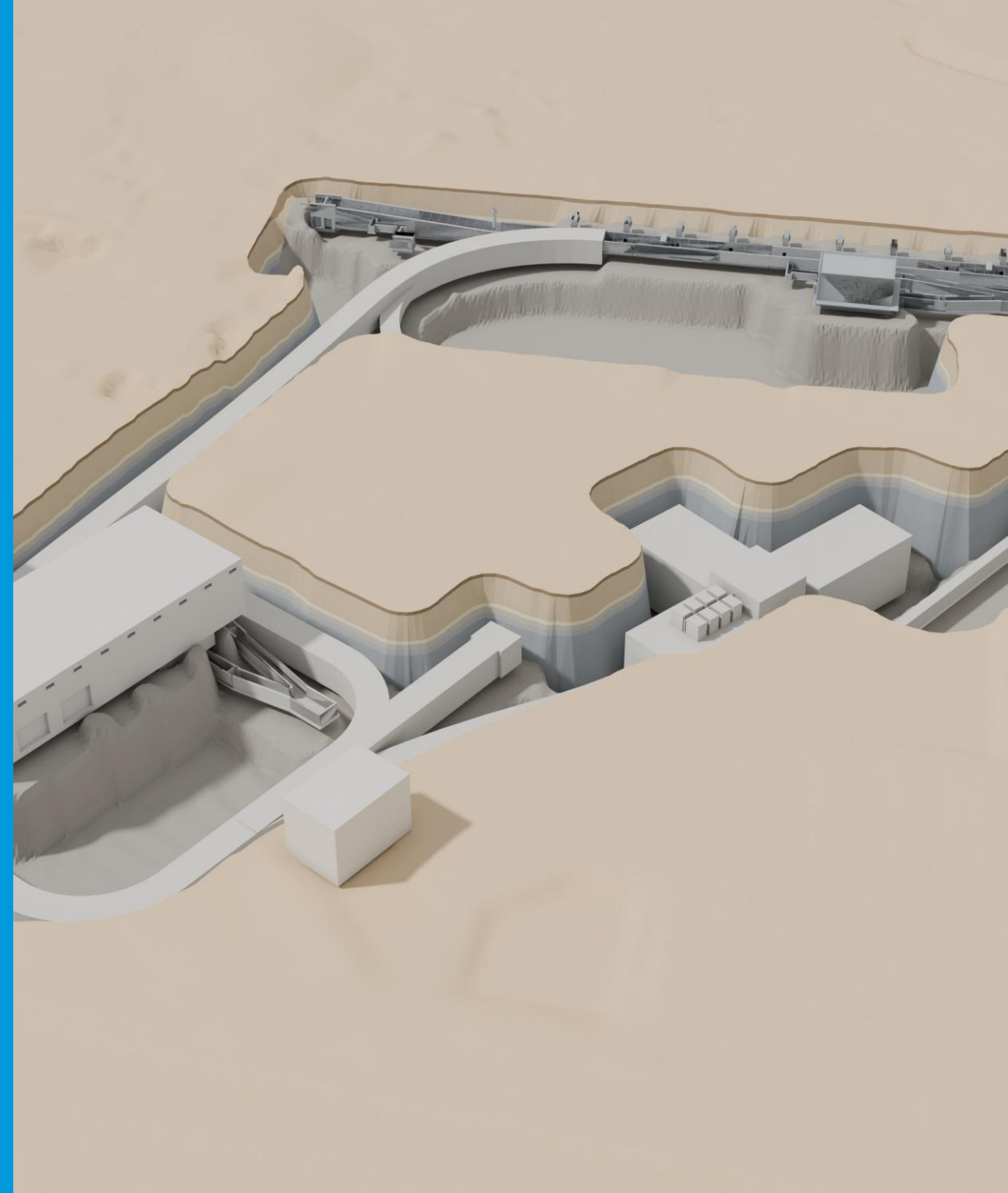


Around the three parts: NuFact 2026 and the project work of a work package. The cost estimation and the indicative timeline are presented in D. Patrzalek's WP2 report talk.

PART 1

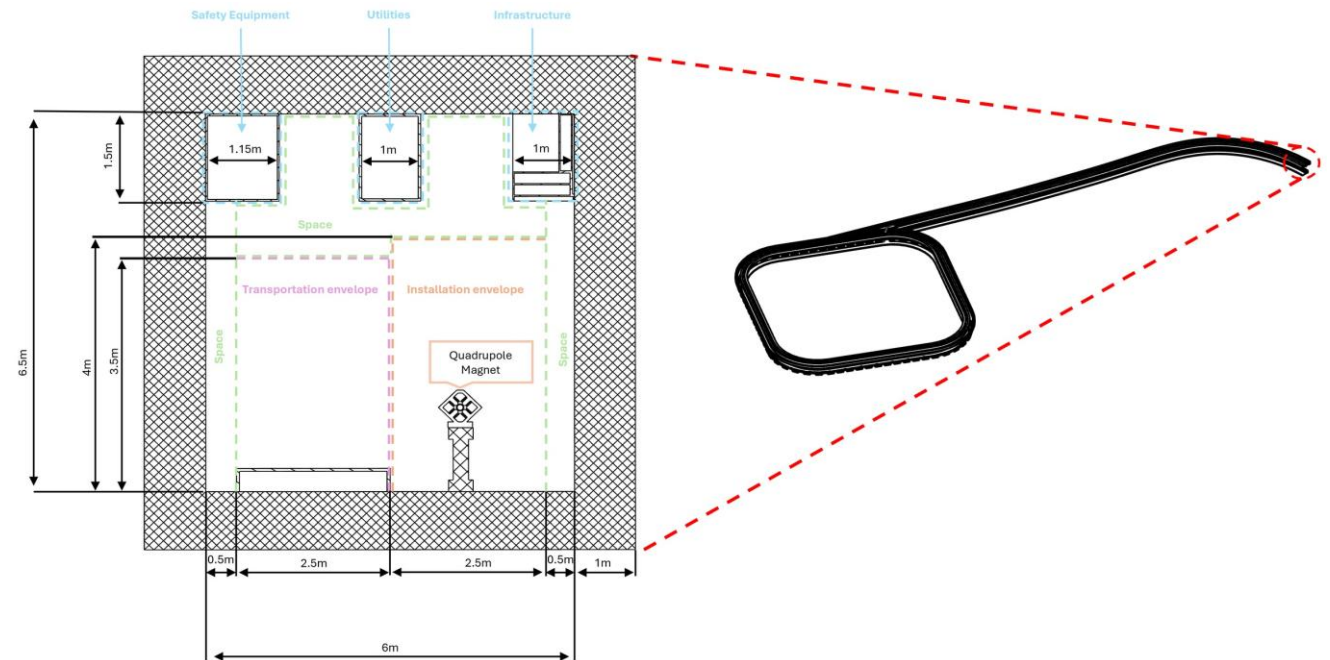
Milestone 20: the transfer line and the accumulator ring

Conceptual mechanical and machine design, released on CHES as ESS-5991478



Sizing the tunnel section

- **What must fit:** the beam line on its supports, infrastructure, cable trays, ducts, safety systems and a walkway
- **Rectangular**, not circular
 - excavation-machine constraints, cable routing near the ceiling, easier space allocation
- Envelopes: installation 2.5×4 m · transport 2.5×3.5 m · 1.5 m service band · 0.5 m spare each side
- → **6.0 × 6.5 m** internal, 2.5 m walkway, overhead crane for installation and maintenance
- Larger than the ESS linac tunnel: water-cooled magnets and crane access; 7.0×8.05 m outside with the ESS shielding (D2.1)



MS20 Figure 2: L2R tunnel section at linac level with the installation and transport envelopes (CATIA drawing).

The L2R transfer-line tunnel

From linac level down to the ring, in one section

- **Route:** 270 m from the linac junction to ring injection, 68.75° bend in plan
- **Descent:** 7.864 m down to the ring level, at no more than 3.38°
- **Section:** 6.0 × 6.5 m all along; installation envelope 2.5 × 4 m over the supports, transport lane 2.5 × 3.5 m beside it
- **Services:** 1.5 m band at the ceiling for infrastructure, utilities and safety systems



Walkthrough of the L2R tunnel in the WP2 CAD model (Stage II), supports only: installation envelope in blue, transport in green, safety systems in red, utilities in purple, infrastructure in orange.

The accumulator-ring tunnel

- **Layout:** 384 m around, four arcs and four 56 m straights, level, 7.864 m below the linac
- **Section:** the same 6.0×6.5 m, the same 2.5×4 m installation envelope, walkway and service band
- **Straights:** space for injection, extraction, RF and collimation equipment
- **Milestone:** model, drawings and report on CHESS, ESS-5991478, ahead of the due date



Walkthrough of the accumulator-ring tunnel in the WP2 CAD model (Stage II), same colours as the transfer line.

PART 2

Deliverable 2.1: civil works, ground and quantities

Conceptual study of civil works with indicative timeline, released on CHES as ESS-6149549



Placing the facility on the real site

Site geometry: where each structure sits

- **Site:** ESS site drawing from Facility Management; proximity study on it in 14 DXF iterations
 - racetrack straight for WP4: 150 m asked, 100 m shown feasible; latest lattice 81 m
- All new structures south of the linac, except the near detector on the beam axis
- **Beam axis:** target building, decay tunnel and near detector on the 2.29° axis to the far detector; near detector ≈ 250 m from the target
- **Auxiliary buildings** (highlighted): cooling circuits, switchgear, sprinkler and media; heat exchangers for the ring and transfer-line magnets
- **Facility building** above the accumulator ring

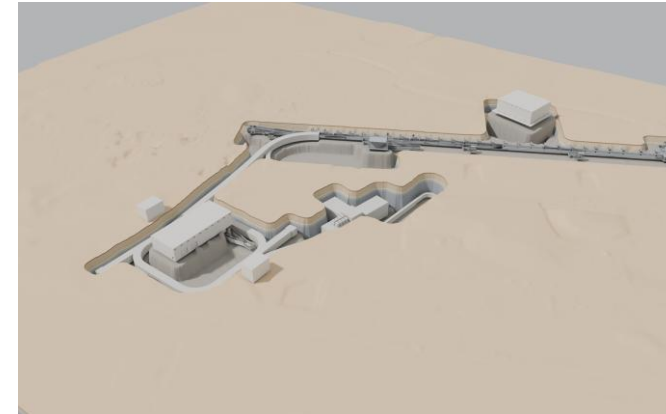


Stage II CAD placed on the ESS site to scale: linac tunnel on the existing ESS tunnel, beam axis into the target building (imagery © Google); auxiliary buildings highlighted.

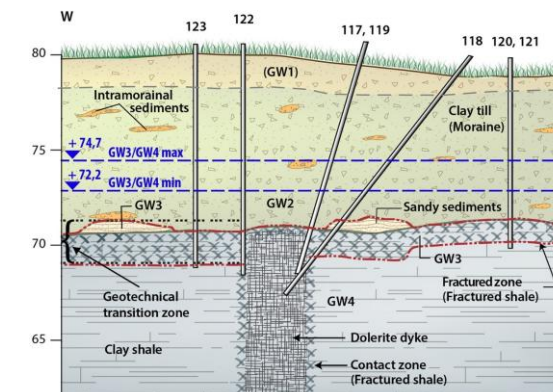
Modelling the ground under the site

Ground content: terrain, strata and groundwater

- **Ground:** terrain and geology model from the national 1 m elevation model and the soil-depth model
 - the facility CAD georeferenced on the ESS site drawing and placed in the ground block
- **Geology** from the ESS site records (GDR, pile-design reports): till over Colonus shale, dolerite dykes, confined groundwater
 - clay till 8–14 m over the shale; dolerite dykes with water-bearing contact zones; several groundwater systems
- **What it gives:** the stratum each structure sits in, the input to the long profile and to the construction methods



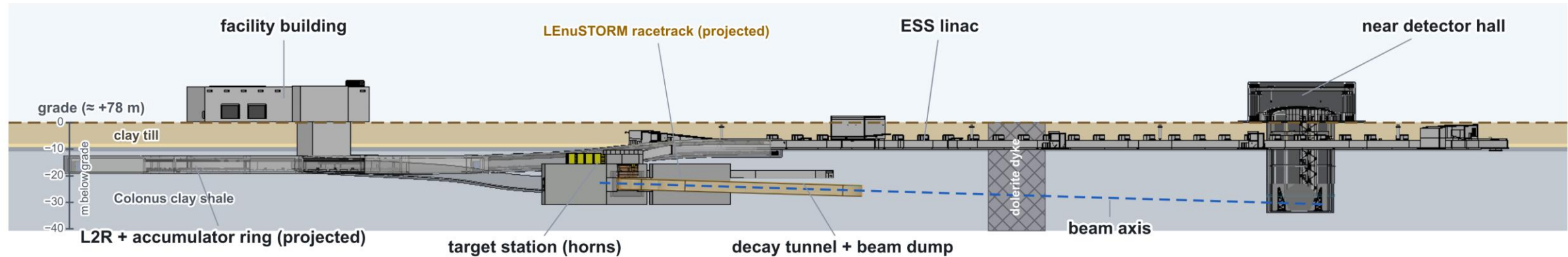
The facility in the ESS site ground model (Blender, Stage II CAD).



ESS geological section (Geotechnical Design Report ESS-0005223).

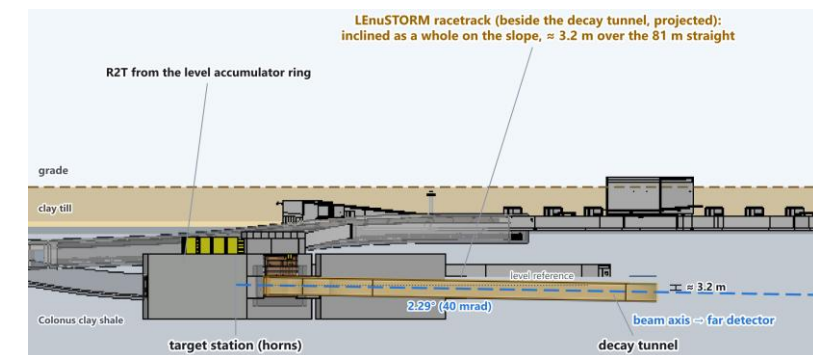
Ground, water and how to build

Why: till over shale, dolerite dykes, confined groundwater



D2.1 long profile along the beam line: side elevation of the CAD model with the geology from the ESS site records drawn to depth scale (levels conceptual).

- Levels from the CAD, conceptual: depth axis on the figure, final depths follow the beam optics
- Tunnel shielding as the as-built ESS linac tunnel: 0.50 / 0.75 / 0.80 m → **7.0 × 8.05 m** external (racetrack 4.0 × 6.55 m)
- Shallow parts cut-and-cover in the till; deep structures as watertight boxes on piles socketed in rock (ESS target-monolith precedent)
- All structures level at their optics level; only the racetrack inclined as a whole (≈ 3 m over its straight)



Racetrack on the 2.29° slope (slope drawn schematically).

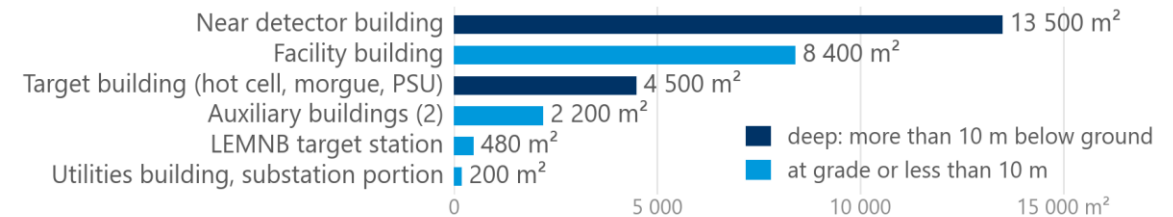
Civil quantities: floor area and power

Facility Management can only cost what is listed, with floors, areas and lengths

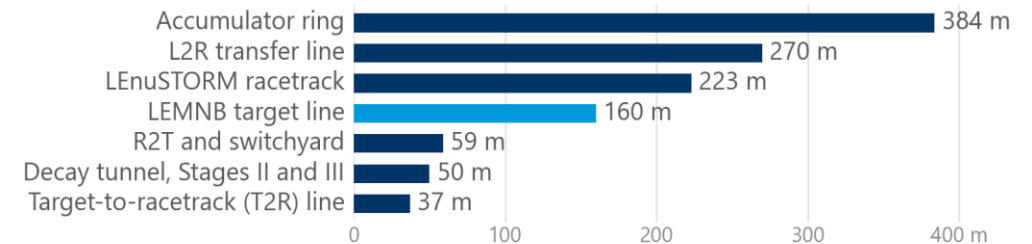
- **Buildings overview by stage:** buildings by floor area, tunnels by length
 - Stage I LEMNB · Stage II LEnuSTORM (ring, L2R, R2T, target building, facility and auxiliary buildings, near detector) · Stage III four-horn upgrade in the same envelope
- **Floor area** $\approx 29\,300\text{ m}^2$ in buildings, 90 % in three; tunnels $\approx 1\,180\text{ m}$, one level
- **Depth drives the civil scope, not length:** the deep buildings, more than 10 m below ground, carry 61 % of the floor area
- **Power** $\approx 4.7\text{ MW}$ (Stage II), $\approx 5.9\text{ MW}$ (Stage III), each + 25 % margin, preliminary: infrastructure and near detector largest; horn supply $\approx 0.3 \rightarrow \approx 1.5\text{ MW}$ with four horns

	Size: m ² or m	Depth below ground
Near detector building	13 500 m ²	34 m
Target building (hot cell, morgue, PSU)	4 500 m ²	31 m
Decay tunnel, Stages II and III	50 m	20–31 m
LEnuSTORM racetrack	223 m	> 20 m
Target-to-racetrack (T2R) line	37 m	> 20 m
Accumulator ring	384 m	10–20 m
L2R transfer line	270 m	10–20 m
R2T and switchyard	59 m	10–20 m
LEMNB target line	160 m	< 10 m
LEMNB target station	480 m ²	$\approx 6\text{ m}$
Facility building	8 400 m ²	at grade
Auxiliary buildings (2)	2 200 m ²	at grade
Utilities building, substation portion	200 m ²	at grade

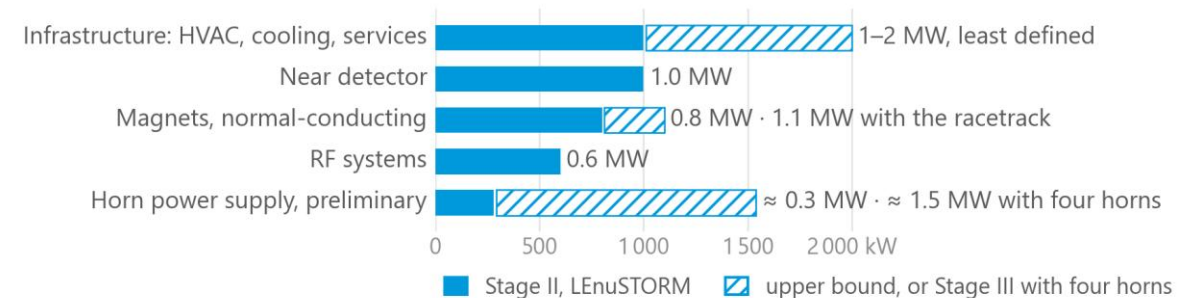
Buildings: gross floor area, 29 280 m²



Tunnels: length, 1 183 m in total, one level



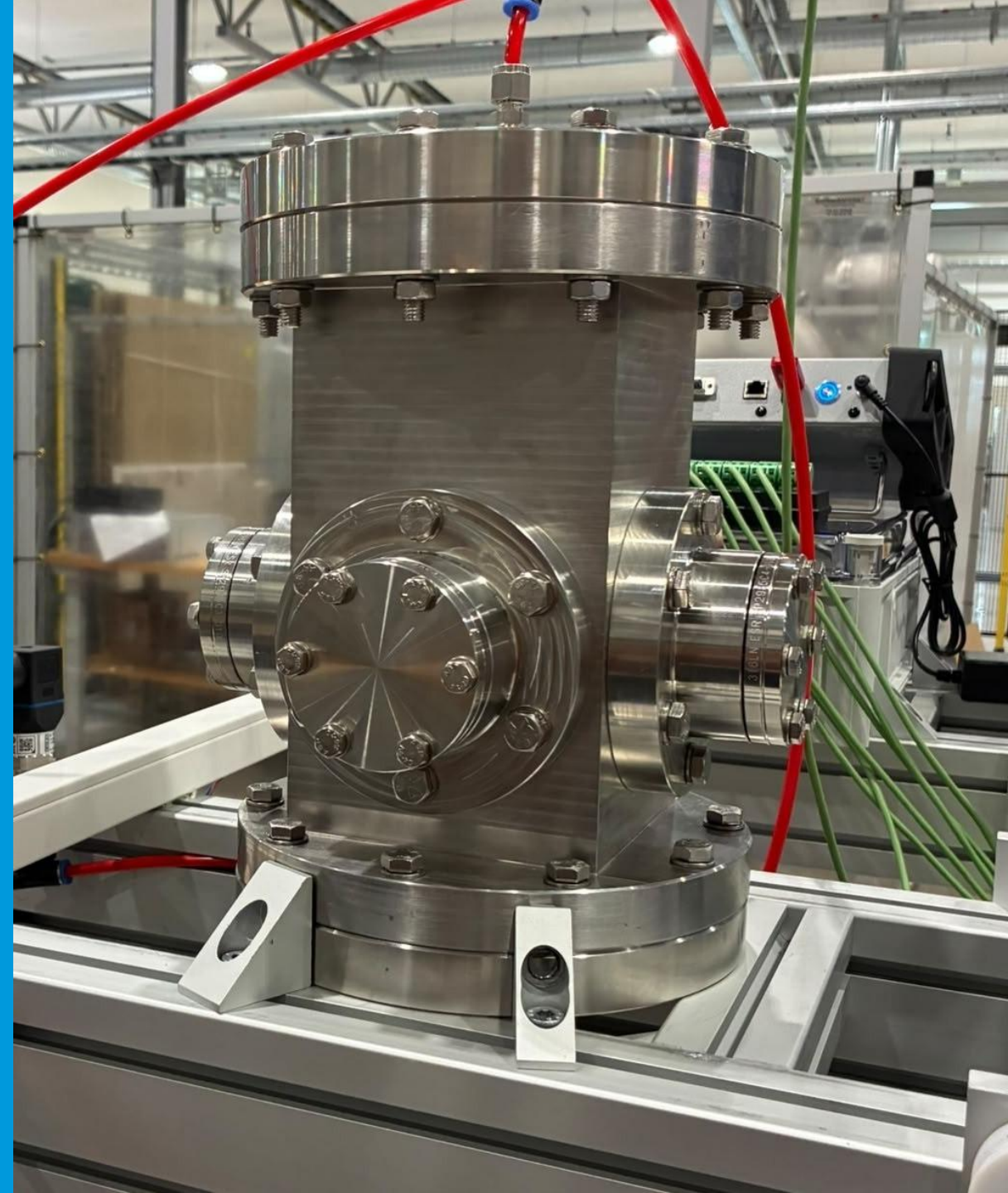
Electrical load per subsystem, preliminary WP2 compilation
 $\approx 4.7\text{ MW}$ (Stage II) · $\approx 5.9\text{ MW}$ (Stage III), each + 25 % margin



PART 3

The ETTF: the target's first physical test bench

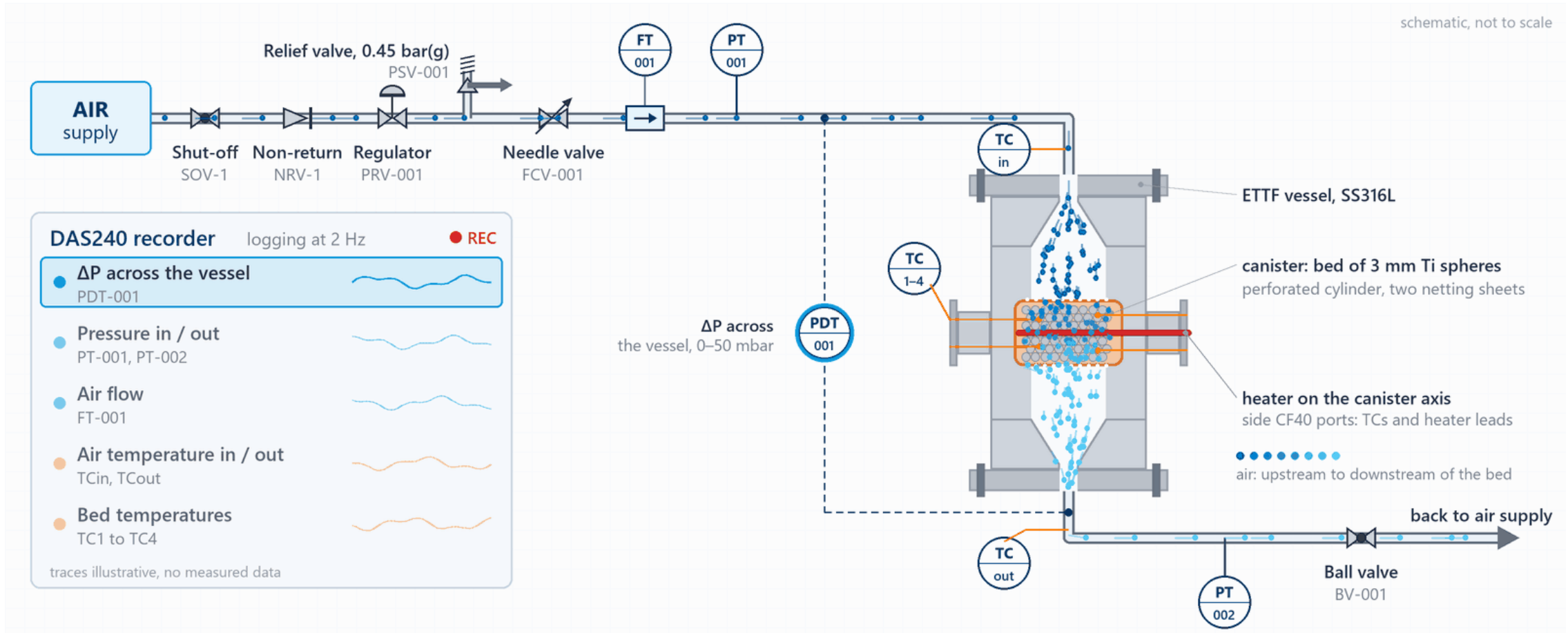
ESSnuSB Target Test Facility: vessel by ESS Bilbao, test stand at the ESS Mechanical Measurement Laboratory



The ETTF air loop and its measurement points

Vessel, test plan and campaign in detail: WP3 session presentations

schematic, not to scale



Air from the supply through shut-off, non-return, regulator and needle valve, past the flow meter, through the packed bed of Ti spheres, and back to the air supply; ΔP, pressures, flow and temperatures recorded by the DAS240 at 2 Hz (schematic).

Test stand at the MML: loop, DAQ, campaign

Why: how the coolant flows through a packed bed should be measured, not only simulated

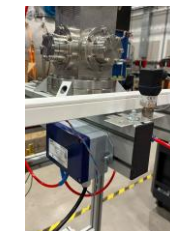
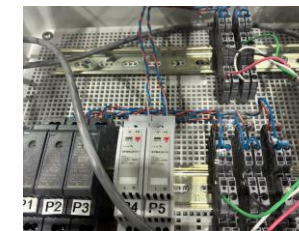
- **Hand-over pack** for the MML lab engineer (M. Snyder): envelope, loop sequence, tag list, checklist
- **Loop**: blower → shut-off → non-return → regulator → needle valve → vessel → vent; relief at 0.45 bar(g)
- **Instruments**: ΔP transmitter 0–50 mbar · supply pressure 0–1 bar · mass-flow meter · 6 type-K thermocouples · certified 24 V panel · 9-channel recorder at 2 Hz
- CATIA sections fixed minor issues with assembly
- **Commissioning**: first air-flow runs of loop and DAQ, 3 records (without the packed bed)
- **Test campaign** with ESS Bilbao and U. Hamburg at the MML: sampling plan at fixed pressures and mass flows

ROLES IN THE TEST CAMPAIGN

ESS commissions loop, DAQ and safety paperwork · ESS Bilbao brings the sampling plan and the target model



ETTF vessel on the air-test stand (ESS MML); the stand ready for the campaign.



Data recorder · instrumentation panel · pressure transmitter and sensor · thermocouple and air inlet on the top flange.

Beyond the deliverables, and what comes next

Conferences, project work and the next steps

- **NuFact 2026, Shanghai:** talk "Carving a Neutrino Factory: a multi-disciplinary conceptual design methodology for ESSnuSB", joint WG1+WG3 session
- Chaired the WG3+WG4 session "Muon Sources & Beams"



NuFact 2026 at the Tsung-Dao Lee Institute, Shanghai (conference photo).

WHAT COMES NEXT

D2.2 (machine integration, target building, site layout): in preparation



Chairing the WG3+WG4 session · the conference excursion on the Bund.

Thank you

None of this was done alone



ESS

Nick Gazis · Dawid Patrzalek · Emmanouil Trachanas · Antoine Lepine · Mamad Eshraqi · Michail Anastasopoulos

Lattice and physics interfaces

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Questions?