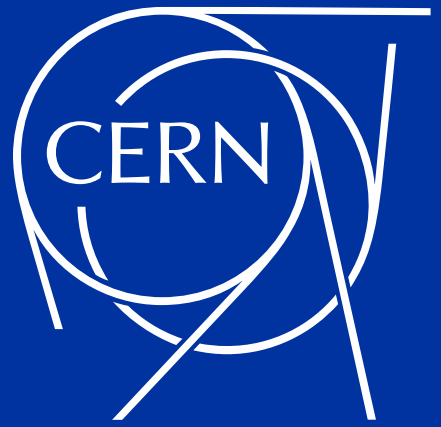


CERN's vacuum technology for the Einstein Telescope
1st Kick-off meeting of the beam vacuum working group

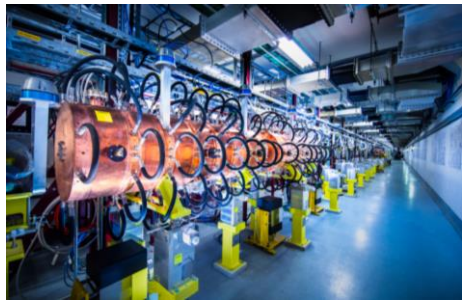
Giuseppe Bregliozzi on behalf of the Vacuum, Surfaces and Coatings group (Technology department)

November 5th, 2021

Content

- Vacuum systems at CERN.
- The CERN's Vacuum, Surfaces and Coatings (VSC) group.
- A selected number of facilities and competences of the VSC group
- Overview of ongoing activities for the cosmic explorer
- Conclusions

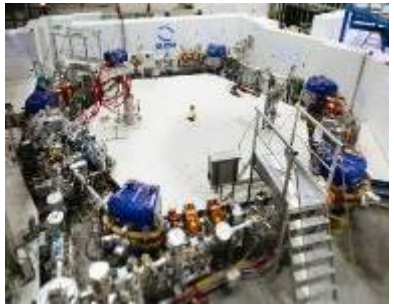
Vacuum systems at CERN



Linac4 <2*10^{-7} mbar*

PSB <5*10^{-8} mbar*

PS <2*10^{-8} mbar*



ELENA <4*10^{-12} mbar

SPS LSS <10^{-7} mbar*

LHC arcs <10^{-8} mbar

LHC LSS <10^{-10} mbar

* After 24 h pumpdown

Unbaked systems
TMP, ion pumps, Ti sublimators

Cryogenic systems
Cryopumping

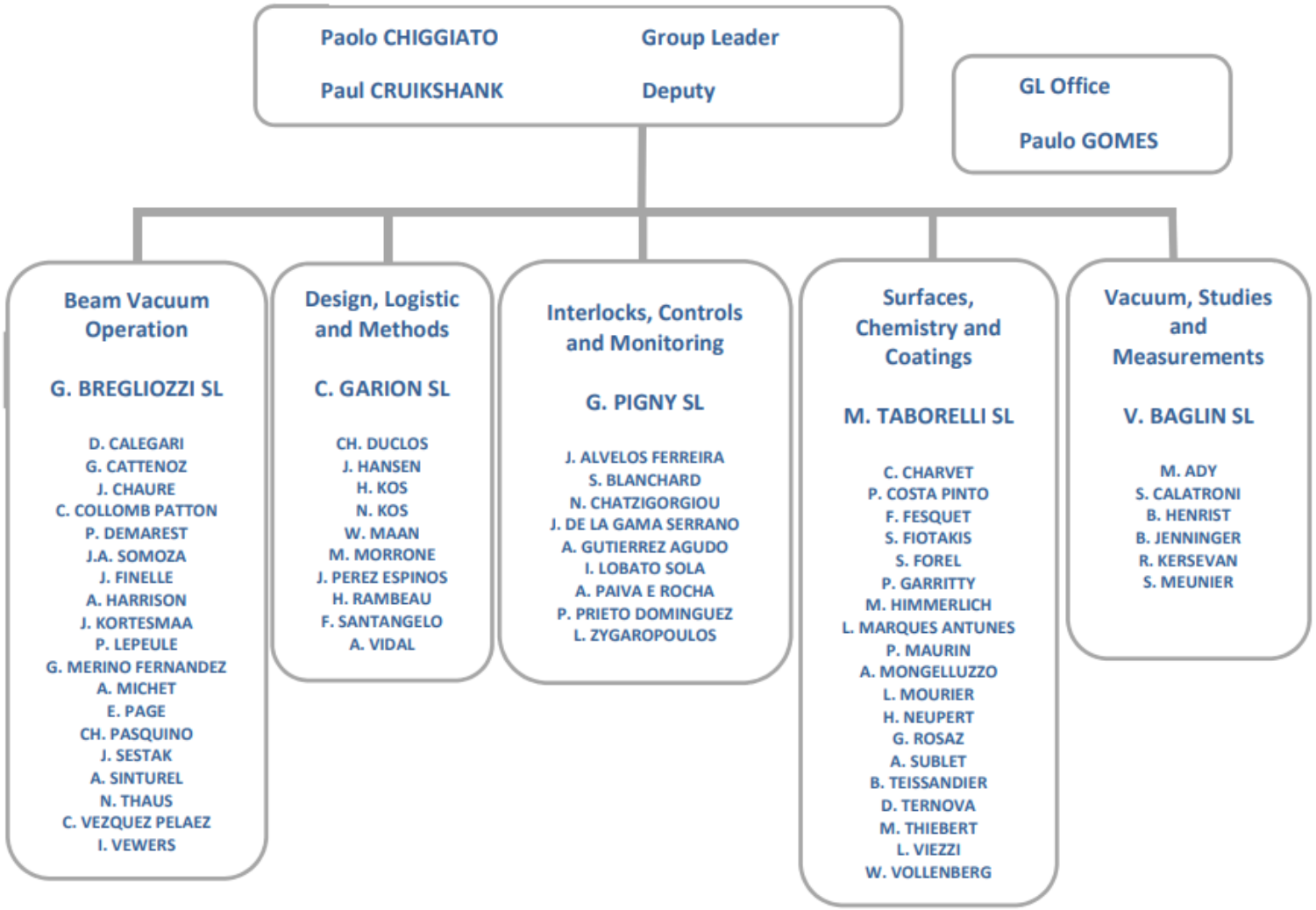
Baked systems
Ion pumps, NEG coating

127 km long vacuum system, 99.98% availability in 2017

CERN's Vacuum, Surfaces and Coatings (VSC) group

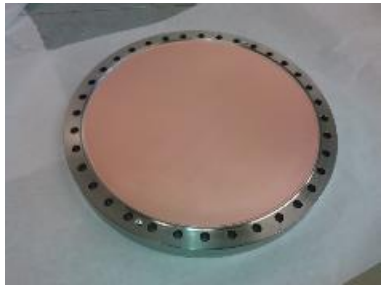
January 2021

Vacuum, Surfaces and Coatings

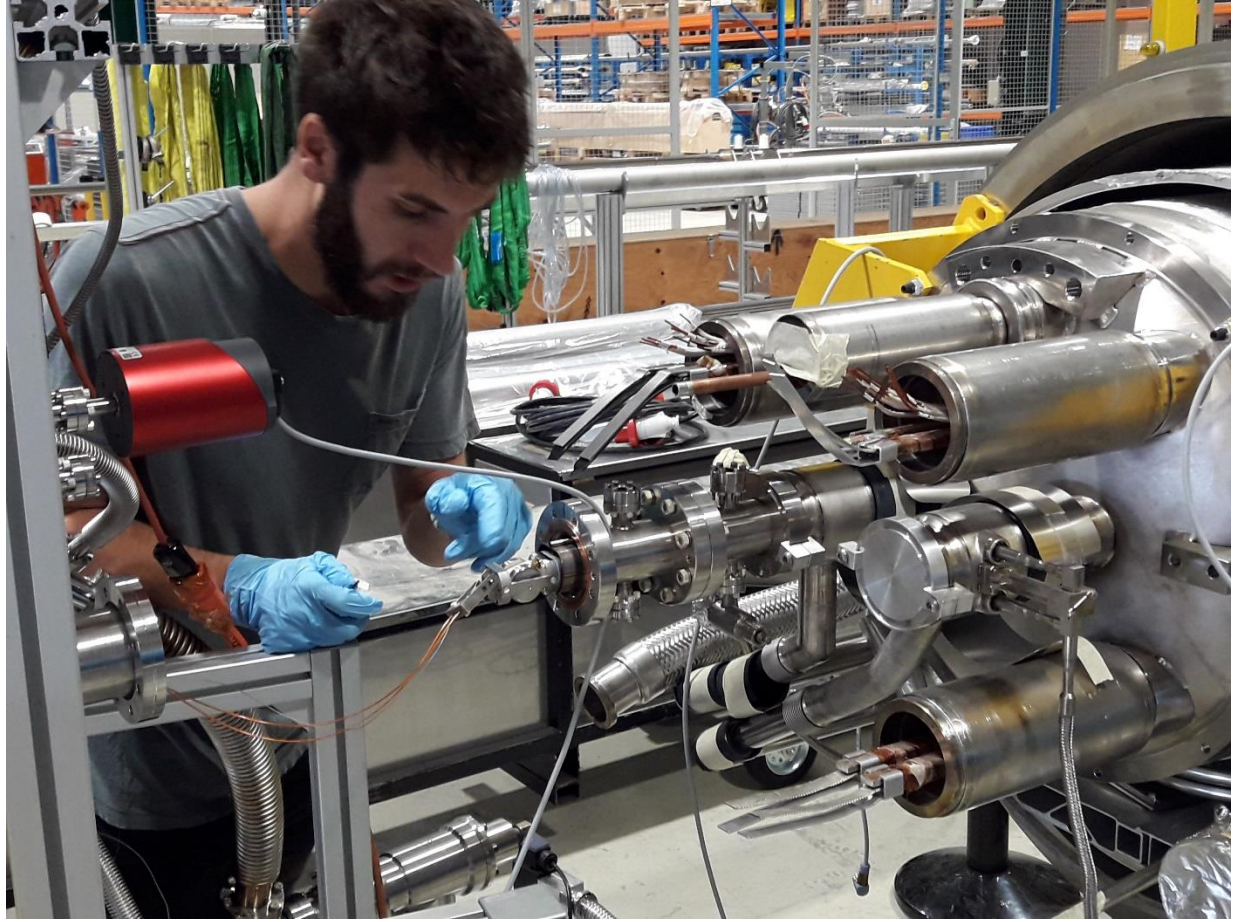


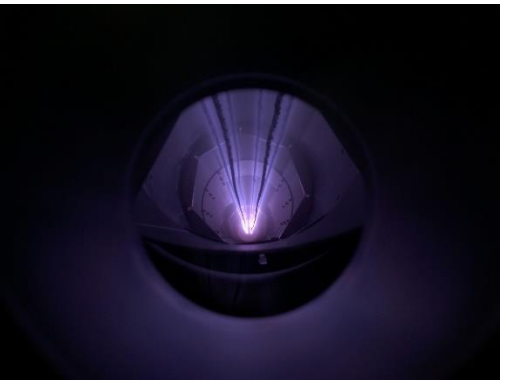
Staff members: 75
PhD students: 7
Master students: 7
Fellows: 19
Trainees: 7
Project associates: 9

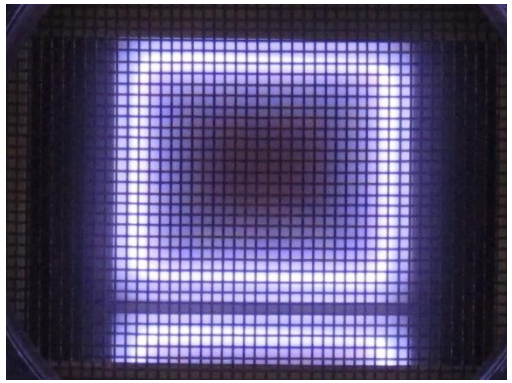
Chemical surface treatments

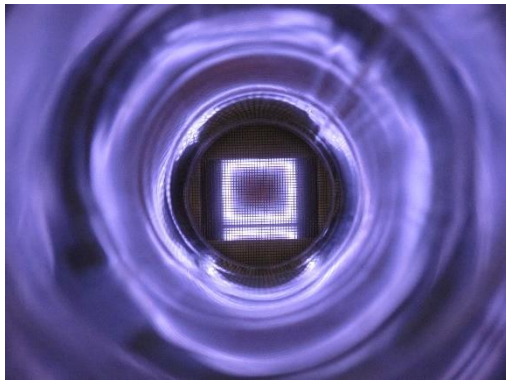


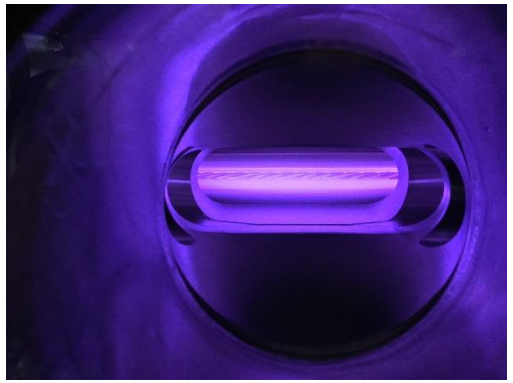
Amorphous Carbon Coating

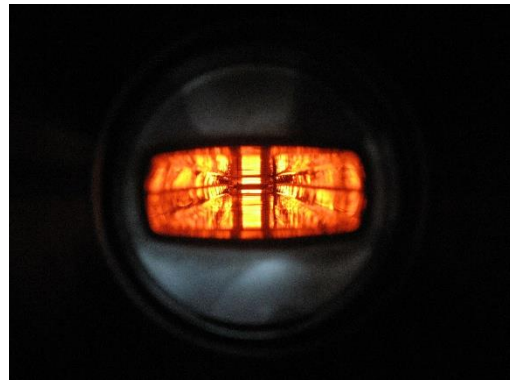




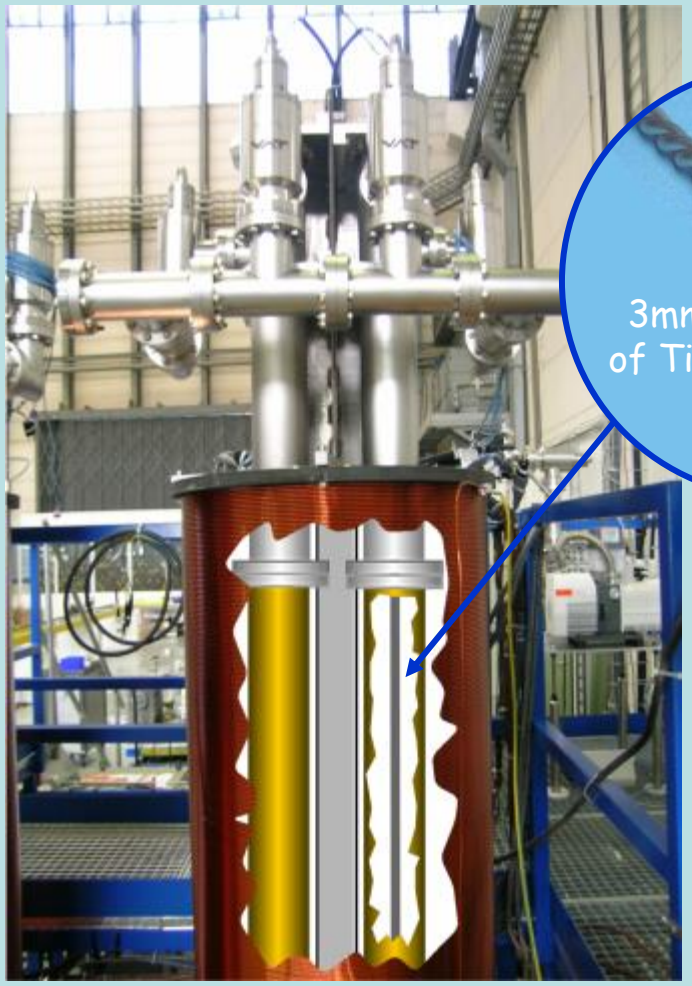


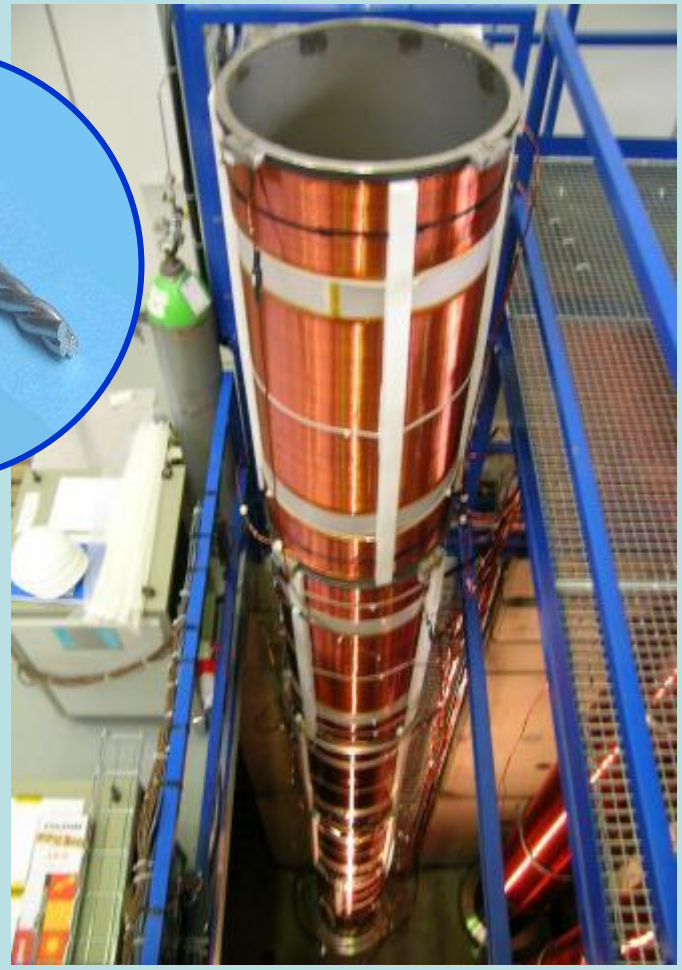




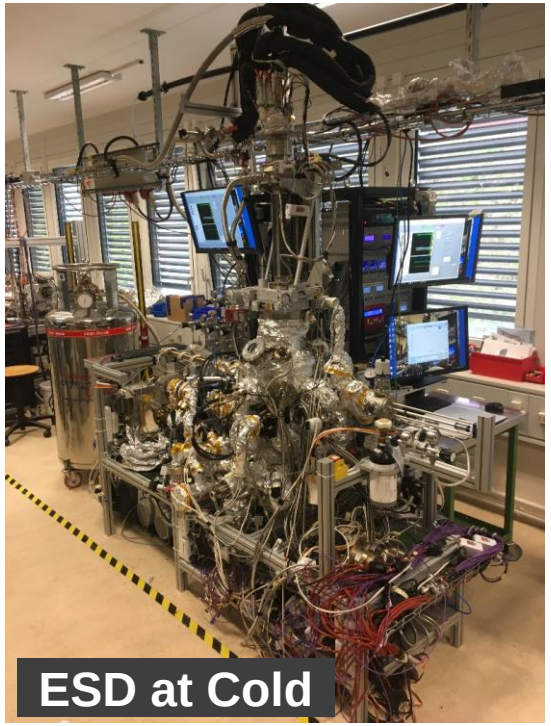


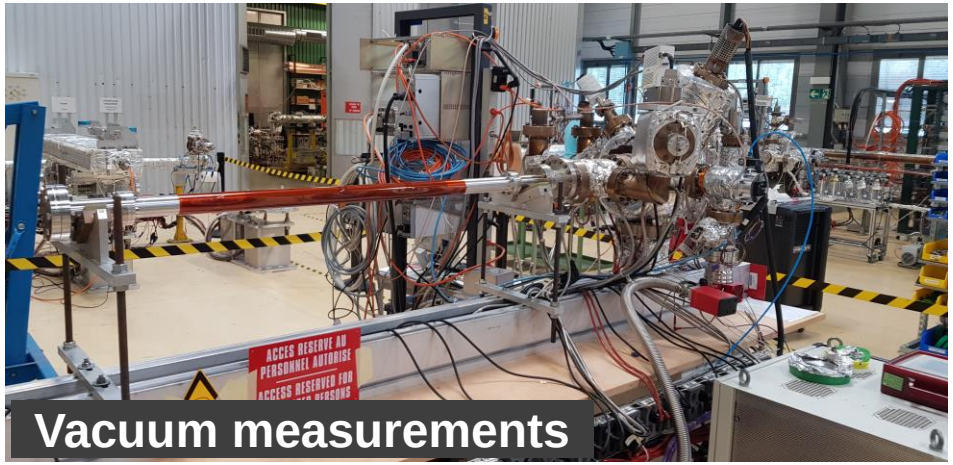
NEG Coatings



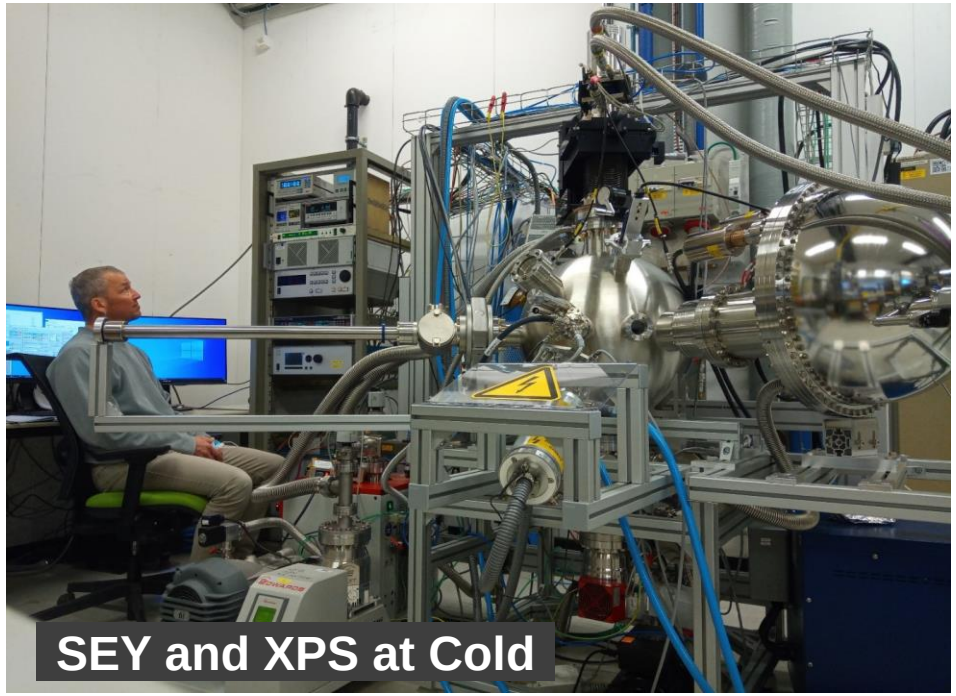


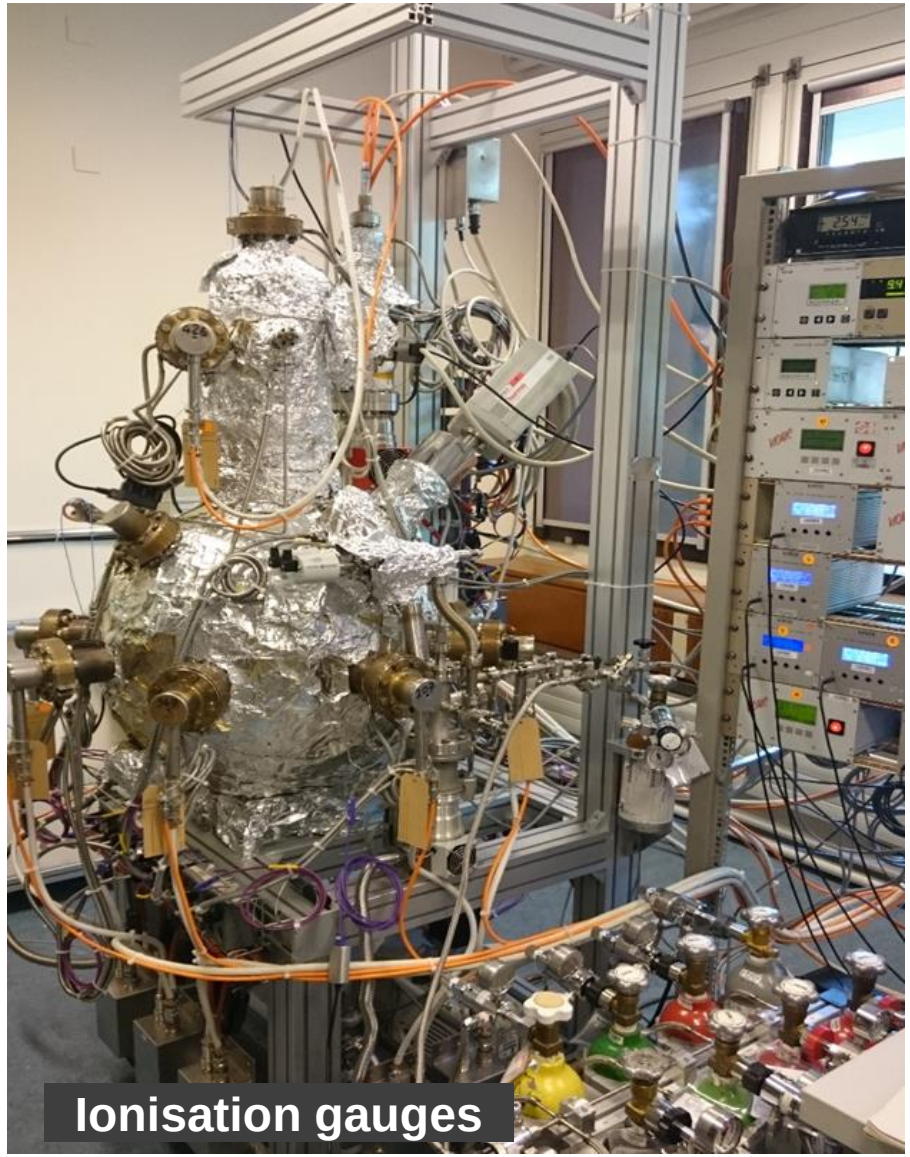
Vacuum measurements, Calibration and Surface Analysis


ESD at Cold



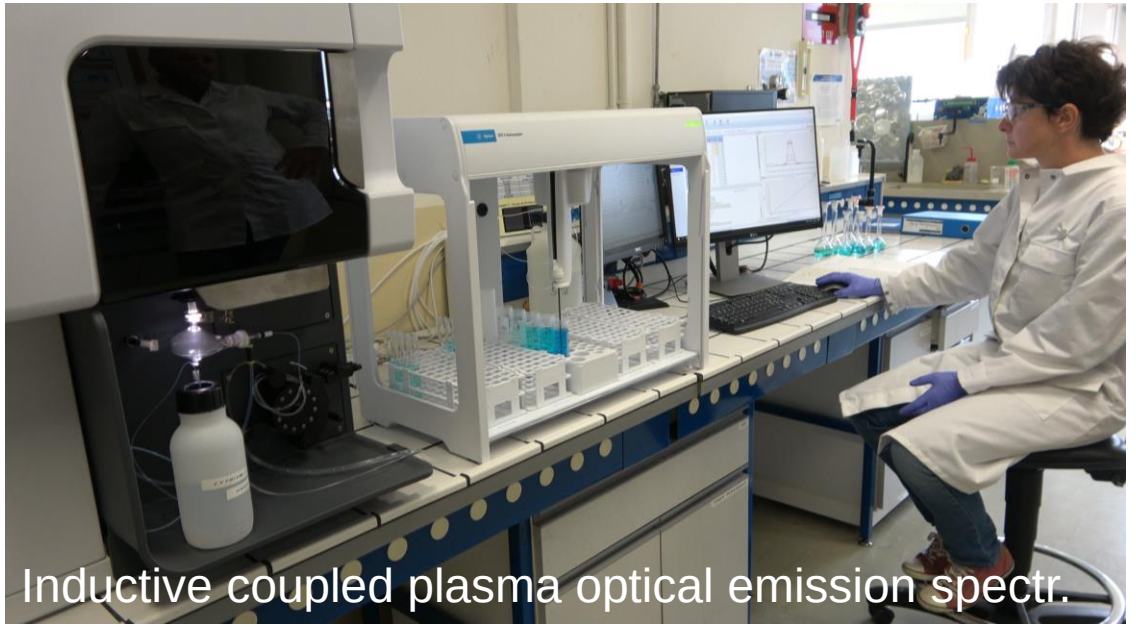
Vacuum measurements


SEY and XPS at Cold


Ionisation gauges

Chemical analysis


Chromatography gas phase

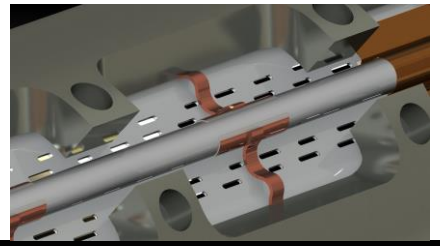

Inductive coupled plasma optical emission spectr.


Thermogravimetry


Atomic absorption spectr

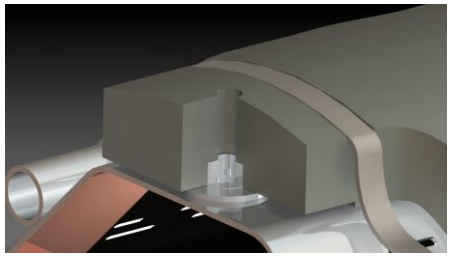
Mechanical Design
HL-LHC shielded beam screens

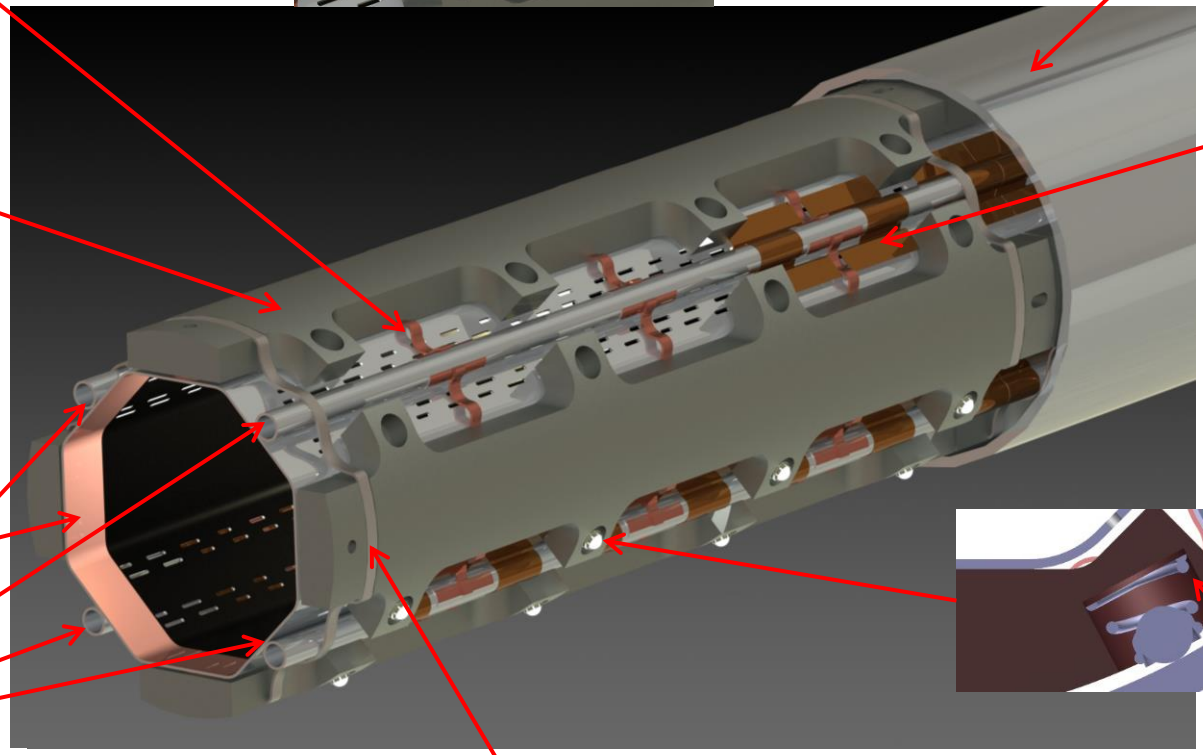
Thermal links:
- In copper (multilayer and solid part)
- Interface plates
- Connected to the absorbers and the cooling tubes



Cold bore (CB) at 1.9 K: 4 mm thick tube in 316LN

Tungsten alloy blocks:
- Chemical composition: 95% W, ~3.5% Ni, ~ 1.5% Cu
- Mechanically connected to the beam screen tube: positioned with pins and titanium elastic rings
- 40 cm long





Pumping slot shields: CuBe foil clipped on the cooling tube to intercept electrons

Beam screen octagonal tube at 60-75 K:
- Perforated tube (~2%) in High Mn High N stainless steel (1740 l/s/m (H2 at 50K))
- Internal copper layer (75 μm) for impedance
- a-C coating for e- cloud mitigation
- Made of ~3m long segments

P506 cooling tubes:
- Outer Diameter: 10 mm
- Laser welded on the beam screen tube

Elastic compression rings

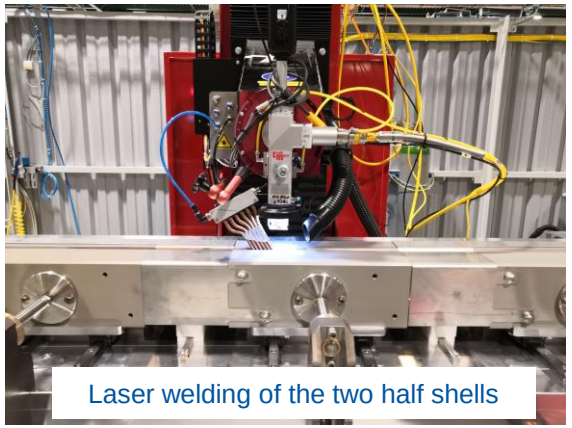
Low thermal conductance elastic supporting system: Ceramic ball and titanium spring

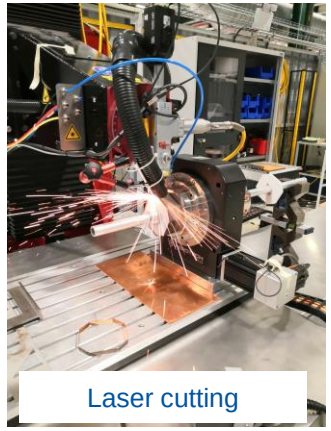
Manufacturing steps for HL-LHC shielded beam screens

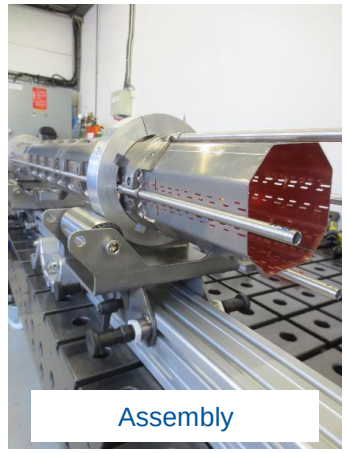
Beam screen tubes and thermal links are manufactured at CERN as the shielded beam screen assembly.

Beam screen tube production:


Forming of 3m long sheets


Laser welding of the two half shells

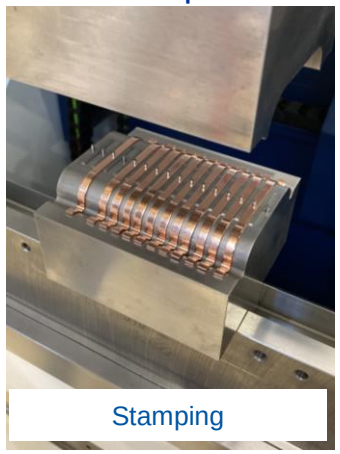

Laser cutting

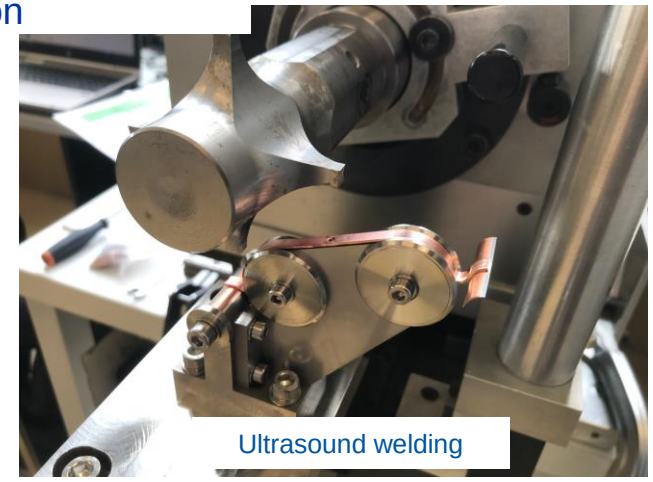

Assembly

Thermal link production

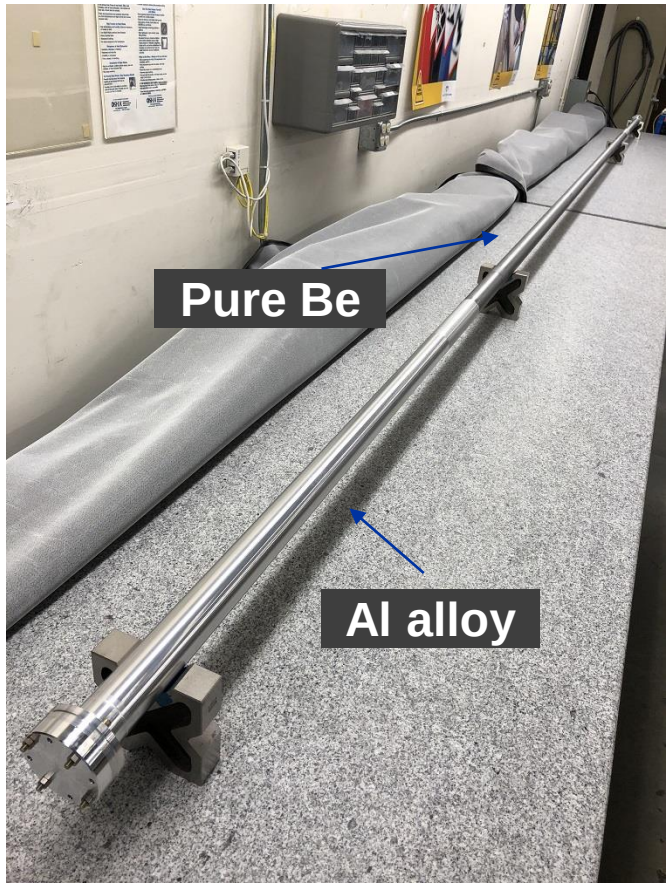

Forming of 3m long sheets

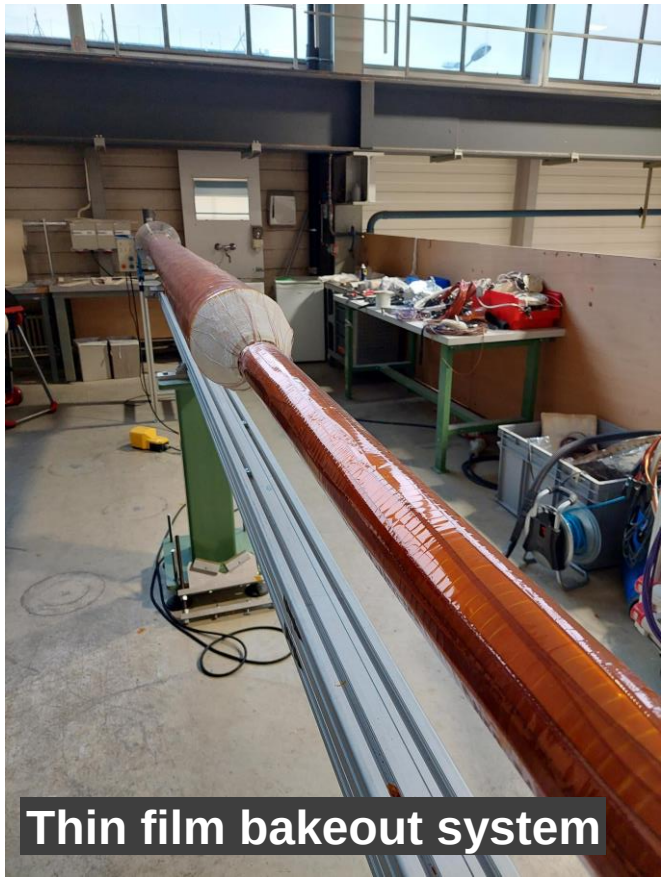

Electron beam welding


Stamping

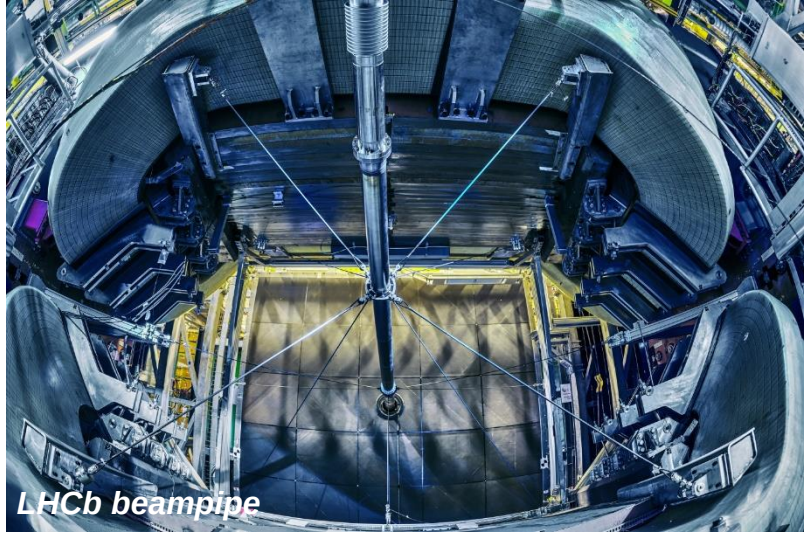

Ultrasound welding

Complex beam pipes for LHC Experiments

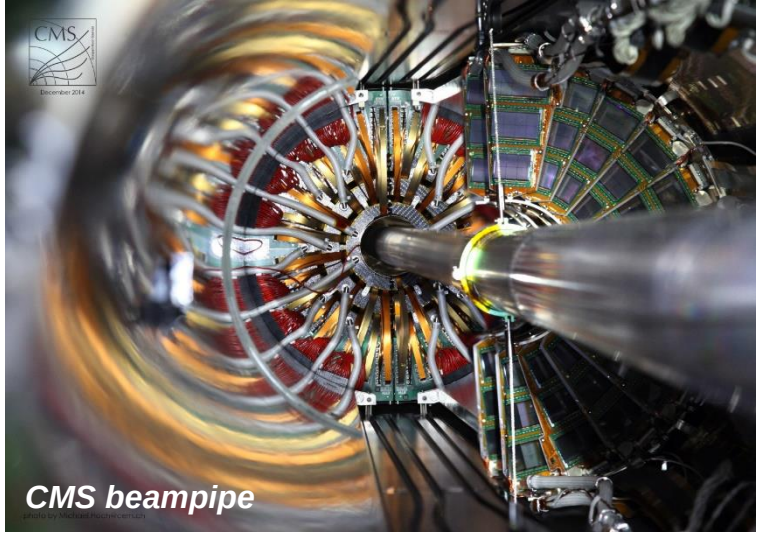




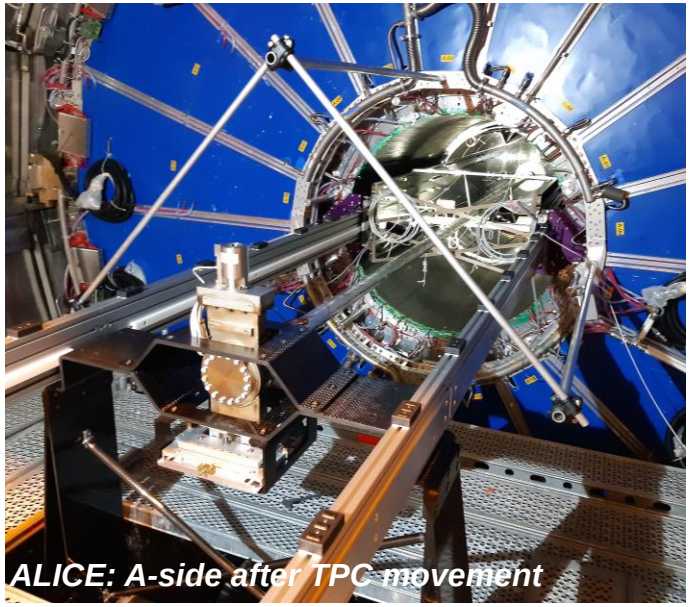
CMS experimental vacuum chamber: From design to installation, through NEG coating, acceptance tests and final installation.

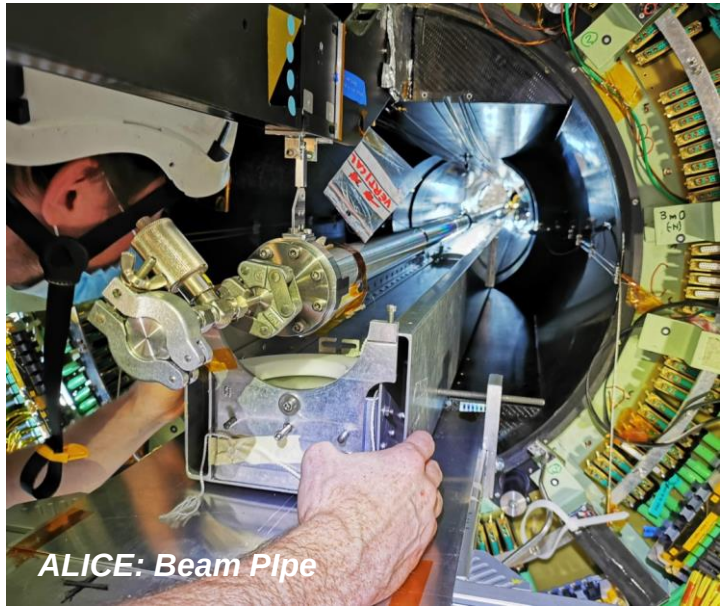

LHCb beampipe


LHCb beampipe



CMS beampipe


ALICE: A-side after TPC movement


ALICE: Beam Pipe


ATLAS beampipe dismounting

Operation, maintenance, consolidation and upgrade of LHC experimental vacuum system

Overview of ongoing activities triggered by discussion with Rainer Weiss and Fred Dylla for the Cosmic Explorer.

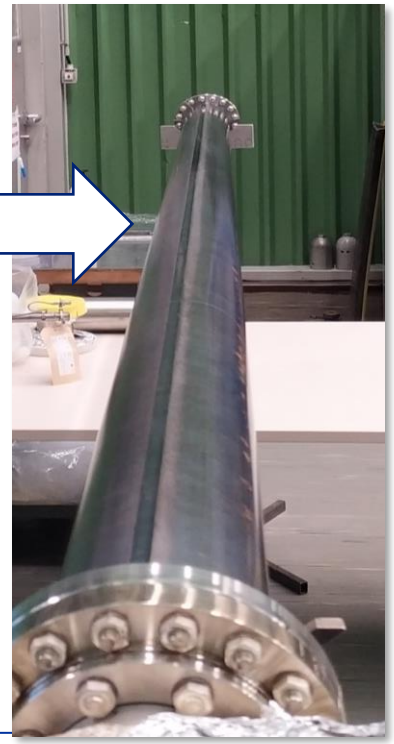
Data shared with College of William & Mary (W&M), Jefferson Lab' (JLab) and National Institute of Standards and Technology (NIST).

- Is it possible to convert pipelines into large ultrahigh vacuum systems at an affordable cost?
- Is it possible to avoid bakeout? Which solutions? Are they scalable to ET? and affordable?

Mild steels tested

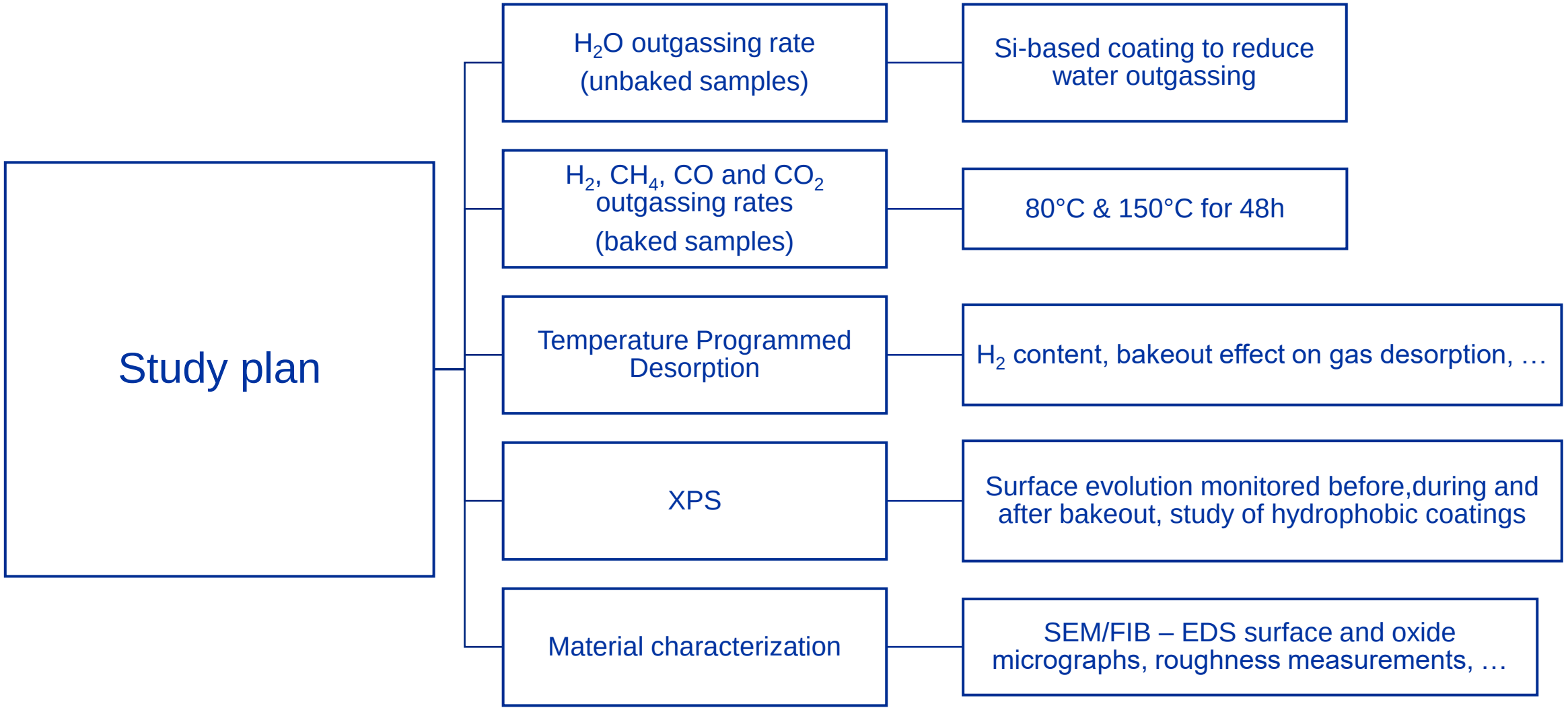
Blocks
- Structural app. (As Rolled)
- Structural app. (Normalized)

Tubes
- Structural app.
- Pressure app. (Normalized)
- Engineering app. (Cold drawn)



Before being tested, all the samples/tubes underwent solvent based cleaning

Summary of the measurements



Existing and needed resources

Present team: 1FTE PhD student, 0.5 FTE technical engineer, 0.2 FTE engineer

PHD Student financed by German Doctoral Student Programme at CERN (Wolfgang Gentner Scholarship)	→	**Materials and coating characterization, modelling and vacuum simulations. Proof of principle for bakeout system & prototyping, R&D on new materials and coating, etc..** ✓
Mechanical Engineer	→	**Mechanical and structural analysis, modelling, prototyping, weldability, R&D on new materials for beam tube, etc..** ✗
Steel industry contact	→	**Optimization of mild steel production from vacuum and mechanical point of view** ✗
Material Engineer or Applied Physicist	→	**Investigation of an alternative design based on thin walled vacuum chambers w/o bakeout** ✗

Conclusions

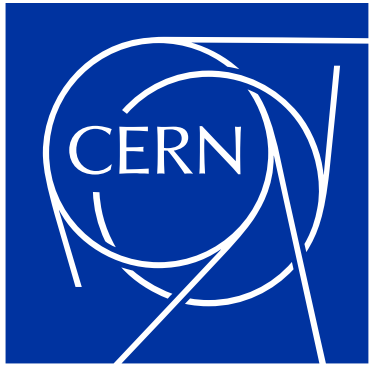
Conclusions

- CERN has **competences and facilities in vacuum technology** that could be useful for the Einstein Telescope (ET).

- **Sharing** our experience in design, prototyping, construction, and operation of large vacuum systems might be **profitable for the ET** study at different level.

- Our involvement in the ET study would be **beneficial for CERN** studies and future operation of the present accelerators. Cost reduction, innovative and fast pumping, characterisation of alternative materials and treatments are shared interests.

- A collaboration between CERN and ET is in line with the recent **Update of the European Strategy** for Particle Physics which calls for strengthening of synergies ‘in areas of **common interest** and **mutual benefit**’.



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