



Big Science Business Forum 2022 – Granada

Session B3: Basic material technologies and advanced manufacturing techniques

# Industrial opportunities at CERN: focus on materials

[Ignacio.aviles.santillana@cern.ch](mailto:Ignacio.aviles.santillana@cern.ch)

6 October, 2022

**Contents** (specific focus on business opportunities):

- Introduction to the EN/MME group
  - Raw materials
  - CERN Stores, current projects
  - HL – LHC, current projects
  - Miscellaneous
-

# Mechanical & Materials Engineering Group

Courtesy of F. Bertinelli

## Design

- **Design Office**
  - 50+ designers and 15+ engineers
  - CATIA v5 / SmarTeam, ANSYS, LS-Dyna

The **mandate** of the MME group is to provide to the CERN community specific engineering solutions combining **mechanical design, fabrication and material sciences**, using **in-house** and **industry** facilities, for beam accelerator components and physics detectors.

⇒ **Prototypes and development work**

## Materials

- **Technical Subcontracting unit**
- **Material science and engineering**
  - metallurgical analyses, microscopy including FIB, mechanical tests including at cryogenic temperature
- **NDT:** UT, radiography, microtomography
- **Metrology:** 350 m<sup>2</sup> Lab., several CMM

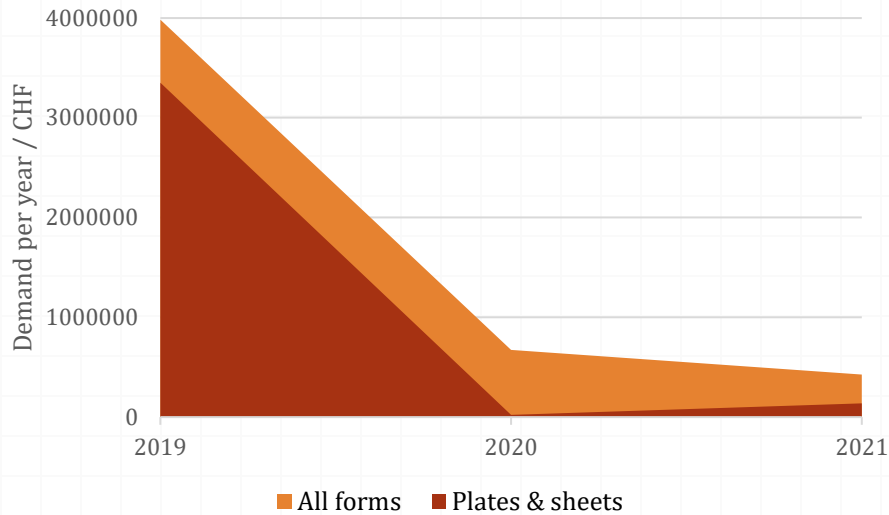
# CERN stores

CERN stores centralize the raw material purchase and assure the availability of strategic materials of the Organization of the most reliable quality

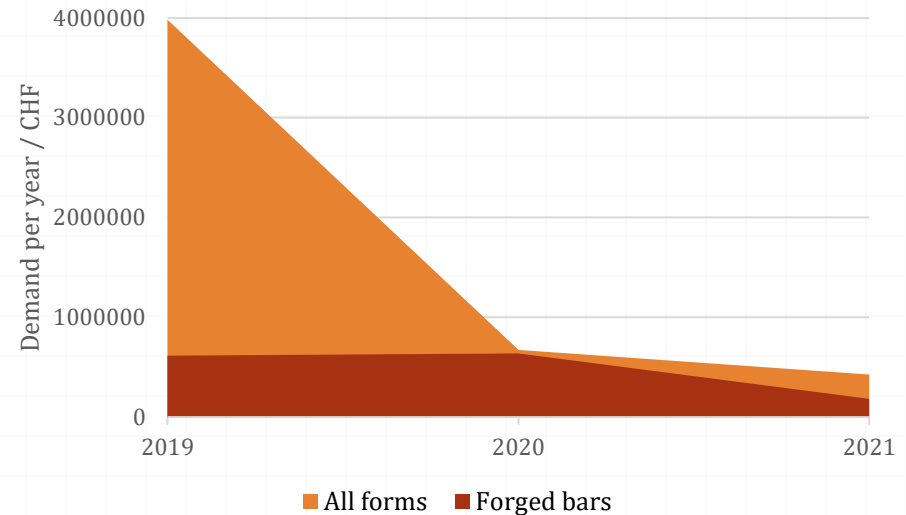
---

# Stainless steel (CERN store specs)

Stainless steel (plates and sheets)



Stainless steel (forged bars)

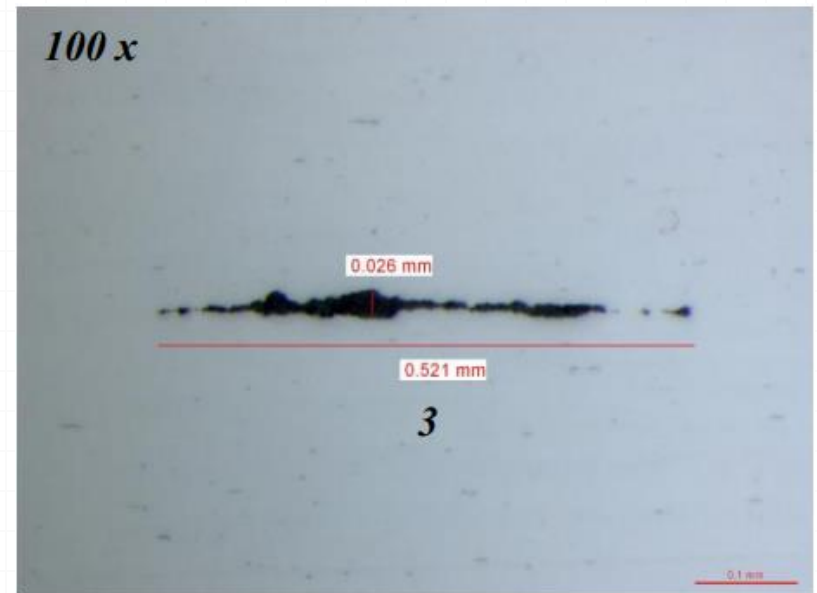


- **Very stringent requirements (high quality):** e.g.
    - Ultrasonic examination
    - Magnetic permeability
    - Inclusion content
    - Grain size
  - Note the 2019 increase of plates & sheets associated to very large contract for superconducting magnets
-

# Stainless steel, special grades and shapes



Very tight requirement on inclusion content to avoid leaks



Strips of 316L grade (1.4441, 1.4435 or 1.4404) for bellows' convolutions:

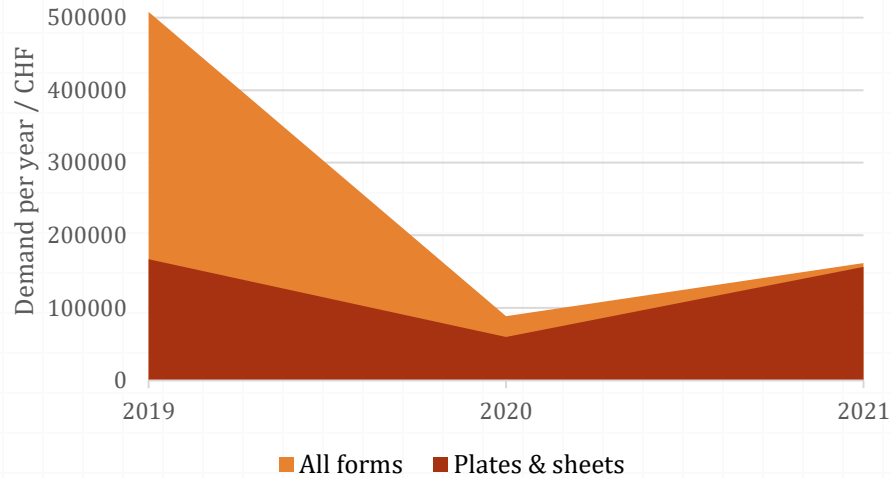
- ESR remelted
- Very low impurities (P&S)
- Composition guarantees:
  - Ferrite free
  - No martensitic transformation after cold work

Courtesy of A. Gerardin

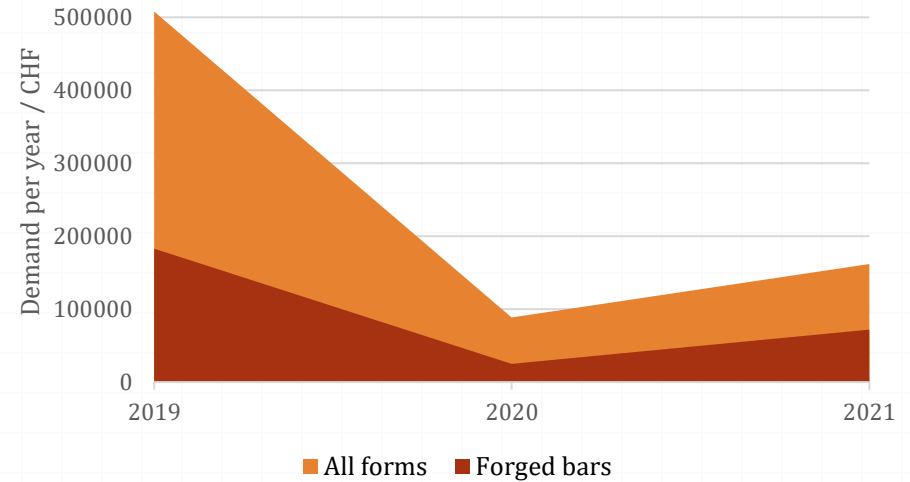
Challenging supply due to limited consumption and scarce availability in small quantities.

# Copper (CERN spec OFE) and copper alloys

Cu and Cu alloys (plates and sheets)



Cu and Cu alloys (forged bars)



Supplied with dedicated technical sheet

⇐ CuCr1Zr TIDVG dump's core & cooling plates

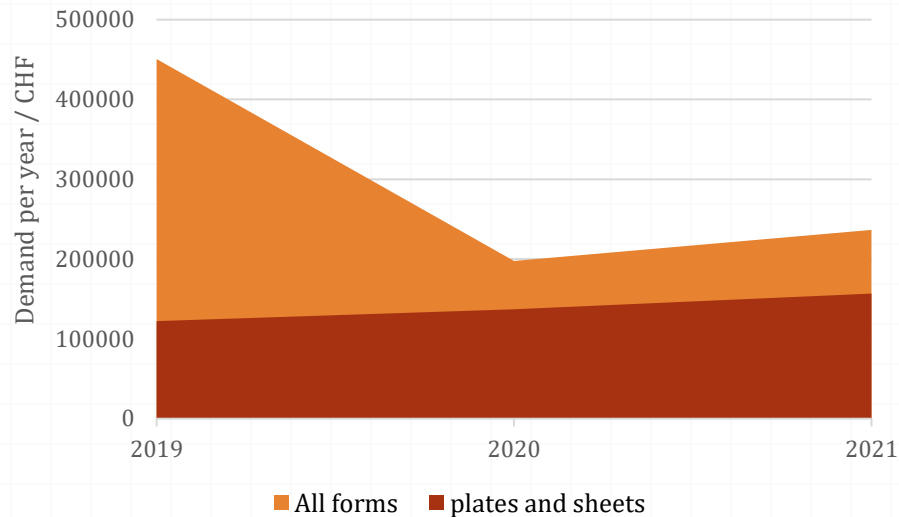
CLIC structure, from OFE – Cu forged bars ⇒

Technical specification for OFE – Cu bars

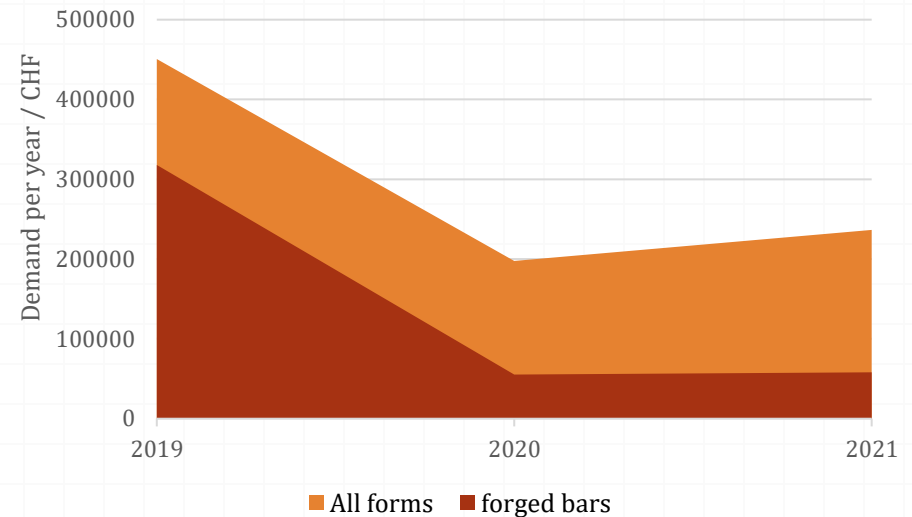


# Aluminium and aluminium alloys

## Al and Al alloys (plates and sheets)



## Al and Al alloys (forged bars)

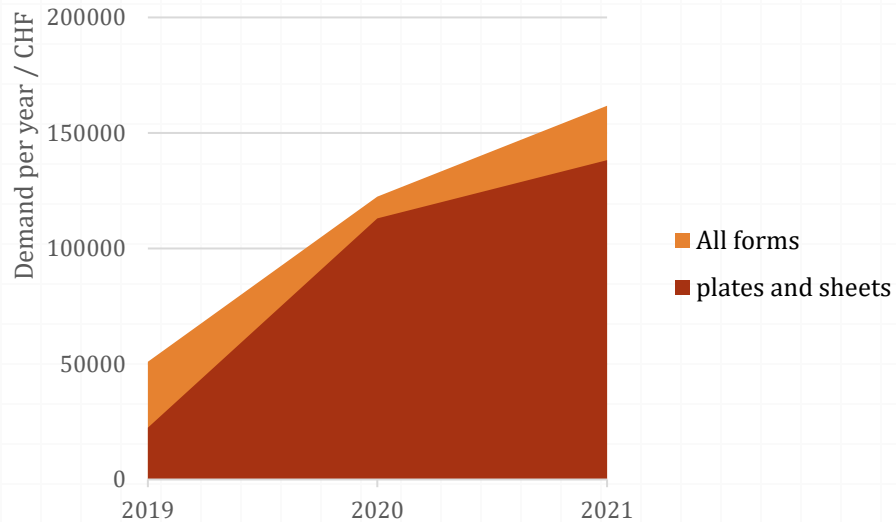


← Forged Al 7075 T6  
for the shells of the  
MQXF quadrupoles

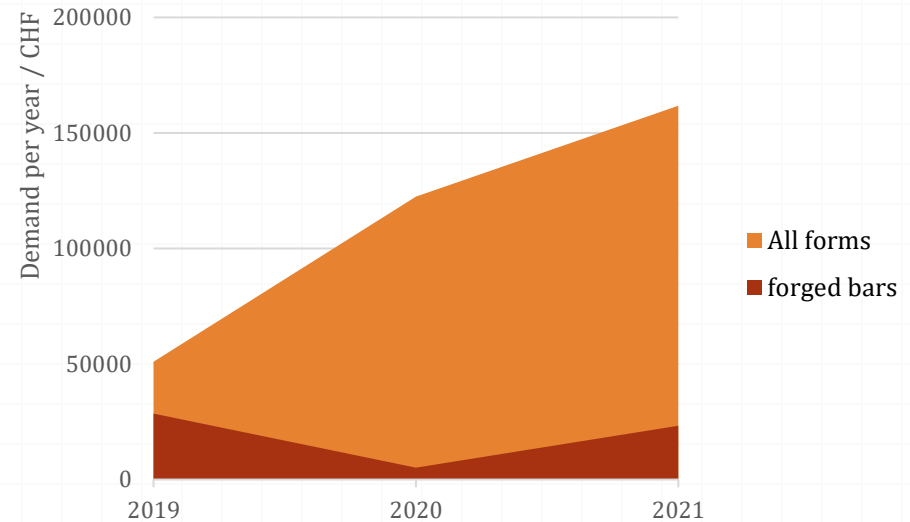
On the lookout of semifinished products of  
Al and Al alloys

# Titanium and Titanium alloys

Ti and Ti alloys (plates and sheets)



Ti and Ti alloys (forged bars)



- Fluctuation of the demand of plates for the crab cavities' He tanks (grade 2).



- Relatively steady demand of bars for the fabrication of flanges (Grade 5 and grade 23).





# Technical specifications

## Stainless Steels

### Sheets/Plates

- 790767 (v.4) Spec. N°1004\_1.4306\_304L\_sheets
- 790771 (v.3) Spec. N°525\_1.4435\_316L\_sheets
- 790774 (v.3) Spec. N°1002\_1.4429\_316LN\_sheets
- 1429406 (v.1) Spec. N°1006\_1.4435\_316L\_sheets for vacuum applications
- 2742861 (v.1) Spec. N°1009\_1.4306\_1.4307\_304L\_sheets/plates for pressure purposes
- 2744317 (v.1) Spec. N°1010\_1.4404\_1.4435\_316L\_sheets/plates for pressure purposes

### Bars

- 790544 (v.4) Spec. N°1003\_1.4306\_304L\_round bars
- 790773 (v.4) Spec. N°1000\_1.4429\_316LN\_round bars
- 1429410 (v.1) Spec. N°1005\_1.4435\_316L\_bars for vacuum applications

### Blanks

- 790775 (v.3) Spec. N°1001\_1.4429\_316LN\_blanks
- 2678520 (v.1) Spec. N° 1007\_1.4462\_S31803\_blanks/hollow shapes
- 2688778 (v.1) Spec. N° 1008\_1.4404\_1.4435\_316L blanks/hollow shapes

### Tubes

- 1380627 (v.3) Spec.N°510\_1.4306-1.4404-1.4435\_304L-316L\_tubes
- 1558993 (v.2) Spec.N°541\_1.4404-1.4435\_316L\_fittings

## Copper

### Sheets/Plates

- 790780 (v.5) Spec. N°2000\_Cu-OFE\_sheets

### Bars/Blanks/Ingots

- 790779 (v.6) Spec. N°2001\_Cu-OFE\_bars-blanks-ingots

### Tubes

### Aluminium alloys

### Blanks

- 1429318 (v.3) Spec. N°618\_EN-AW-2219\_blank

## Technical sheets

### Copper alloys

- 1381626 (v.2) Technical Sheet N°619-1\_CuCr1Zr\_forged blank
- 1405814 (v.1) Technical sheet N°2003\_C10700\_Seamless tubes
- 1405818 (v.1) Technical sheet N°2004\_C10100\_Seamless tubes
- 1417210 (v.1) Material Requirement Sheet N°619-2\_CuCr1Zr\_forged blank
- 1773800 (v.1) Material Requirement Sheet N°619-4\_CuCr1Zr\_forged blank
- 2492779 (v.1) Seamless copper tubes UNS C10100/CW009A Cu-OFE for hydroforming of RF cavities

### Aluminium alloys

- 1516490 (v.3) Technical Sheet N°620-2\_EN AW-5083-H112\_forged blank
- 1553648 (v.2) Technical Sheet N°630-1\_EN AW-7075-T6\_forged bars
- 1762011 (v.2) Technical Sheet N°620-3\_EN AW-5083-H112\_3D forged bars

Challenging supply due to purchasing of small quantities but with very demanding quality requirements (dedicated technical specifications and technical sheets).

# Raw materials: main projects @ CERN stores

Materials	Grade	Form	Estimated
Stainless Steel	316LN EN 1.4429	Rolled and forged round bars	> 750 kCHF; < 5 MCHF
	316LN EN 1.4429	3D forged blanks, rings	> 750 kCHF; < 5 MCHF
	EN 1.4307 / 1.4404 (for pressure purposes)	Sheets and plates	> 200 kCHF, < 750 kCHF
	316L EN 1.4435	Round bars	> 200 kCHF, < 750 kCHF
Copper	CU-OFE	Drawn and forged round bars	> 200 kCHF, < 750 kCHF

Technical specifications are being reviewed by the Raw Material sub committee. Once cleared, these 'dossiers' will be launched.

- **Proposal** to other science laboratories:
  - Our requirements are typically **high quality but low quantities**, so let's combine our needs and **adopt the same Technical Specification(s)**
  - Successfully done between CERN and ITER

HL - LHC



# HL – LHC procurement

- HL has been actively purchasing since 2014: First for prototypes, after for materials and components (+ complex mechanical fabrications) for long lead items (magnets, cavities, SC Link, beam screens...).



Courtesy of H. Garcia Gavela

---

# HL – LHC procurement: main projects

- **Tungsten heavy alloy** – Absorbing material for tertiary collimators blocks and for masks. Q1 2023; **> 200 kCHF, < 750 kCHF**
  - **CuCr1Zr** – Material for tapering for the tertiary collimator's jaws. Q1 2023; **< 200 kCHF**
  - **Graphite** - Absorbing material for secondary collimators blocks and taperings. Procurement Q1 2023; **< 200 kCHF**
  - **Graphitic material** (isostatic Graphite and Sigraflex) for the HL-LHC TDE Dump Cores. Q2 2023; **> 750 kCHF**
  - **Stainless Steel 1.4435** plates for DQW Vacuum Vessel – Tender is ongoing; **< 200 kCHF**
  - **Al 6061-T6** for DQW Thermal Shield – To be purchased in 2023; **< 200 kCHF**
  - **ODS copper** – collimators backstiffeners. Q2 2023; **> 200 kCHF, < 750 kCHF**
-

# HL – LHC procurement: main projects

- **Stainless steel 1.4441/1.4435/1.4404** Strips for series production of ~ 400 HL – LHC bellows. Q1 2023. > 200 kCHF, < 750 kCHF
- **Stainless steel 1.4404/1.4435/1.4306/1.4307** bars for flanges for for series production of ~ 400 HL – LHC bellows. Q1 2023. > 200 kCHF, < 750 kCHF

UHV, cryogenics, pressure equipment...

Typical Dimensions: ~ Ø50, Ø100

Materials:

- Strips: 1.4441, 1.4435 (challenging to supply), 1.4404
- Flanges: 1.4429



We are always on the lookout of reliable bellows fabricators

MISCELLANEOUS

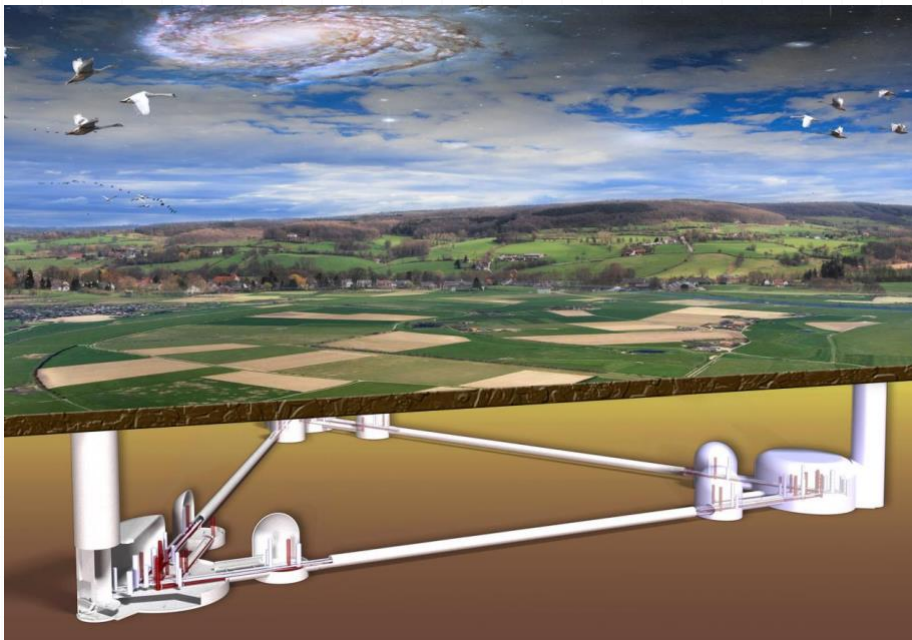


# Steel for vacuum chambers: the Einstein telescope

Quantities: **120 km**;  $\varnothing = 1$  m

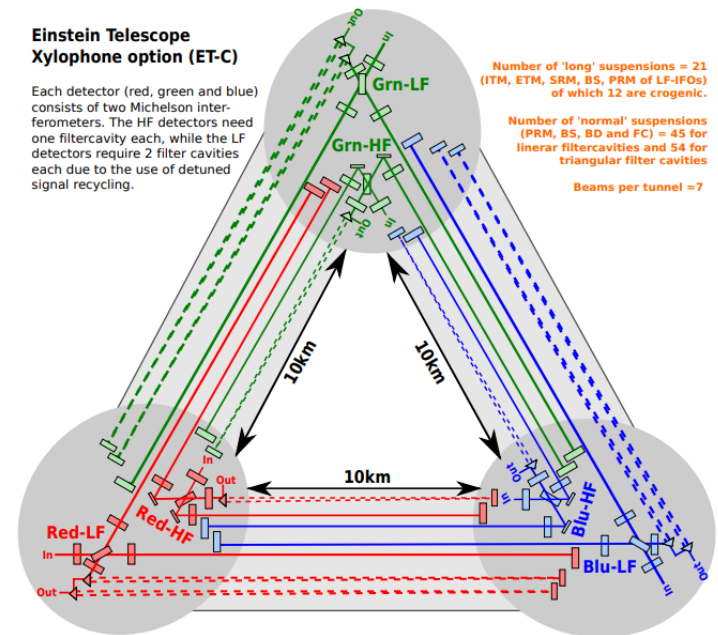
Is it possible to build **UHV chambers** with a **cost effective** solution (mild steel, ultra low carbon steel...)?

Industrial partners for **development & procurement** needed



## Einstein Telescope Xylophone option (ET-C)

Each detector (red, green and blue) consists of two Michelson interferometers. The HF detectors need one filtercavity each, while the LF detectors require 2 filter cavities each due to the use of detuned signal recycling.





Thank-you

