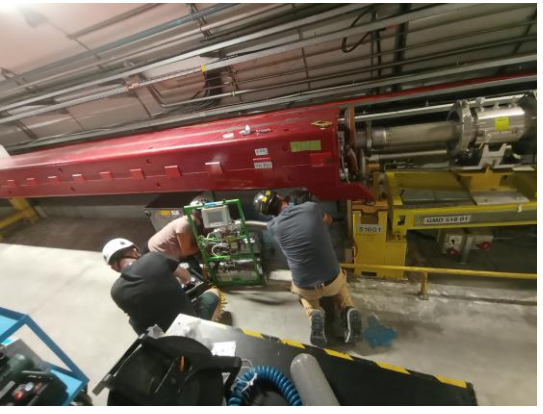
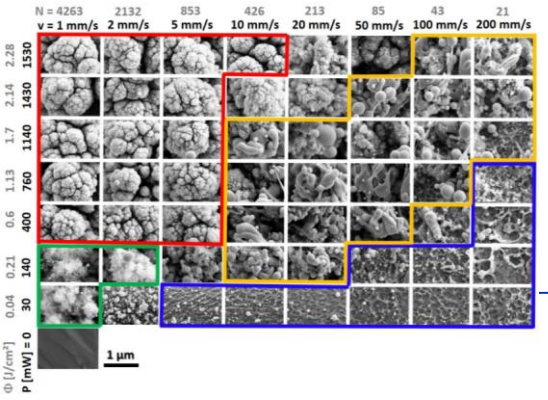
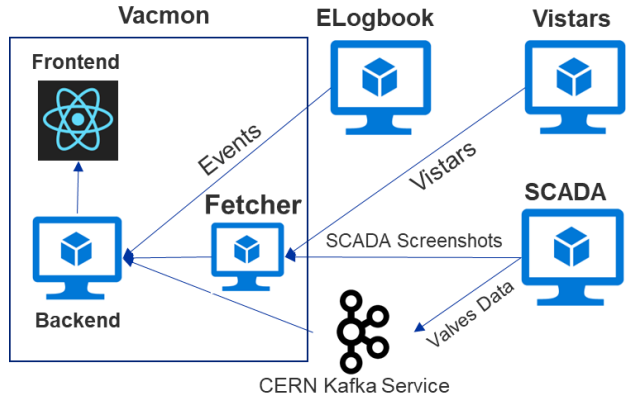
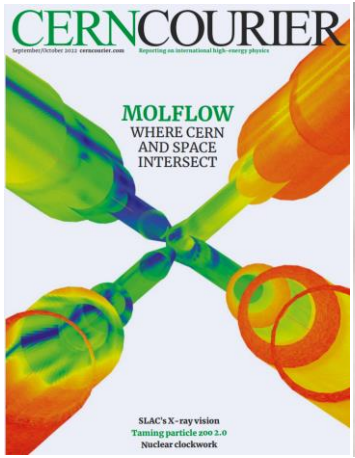
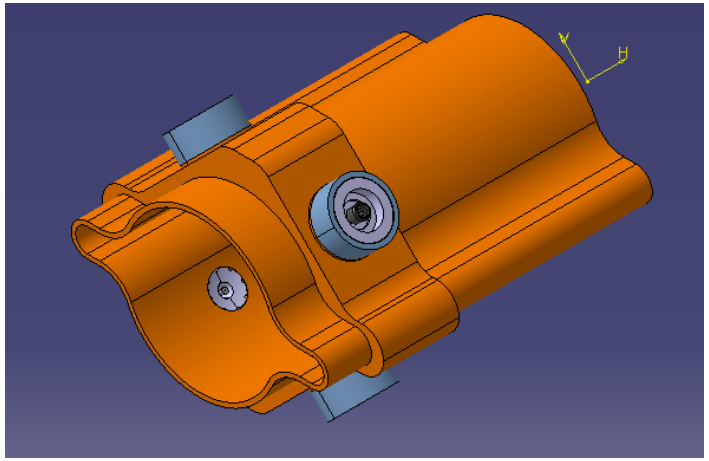
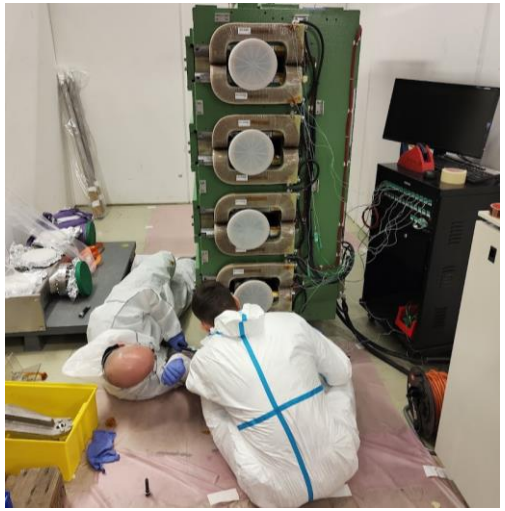








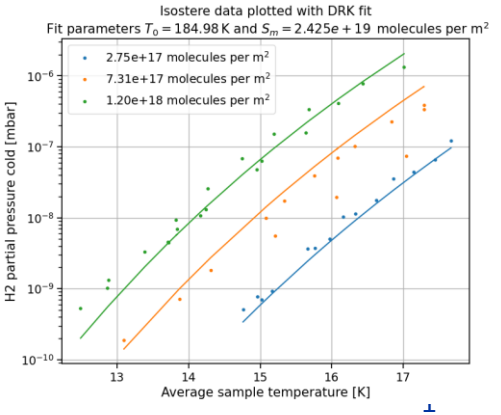




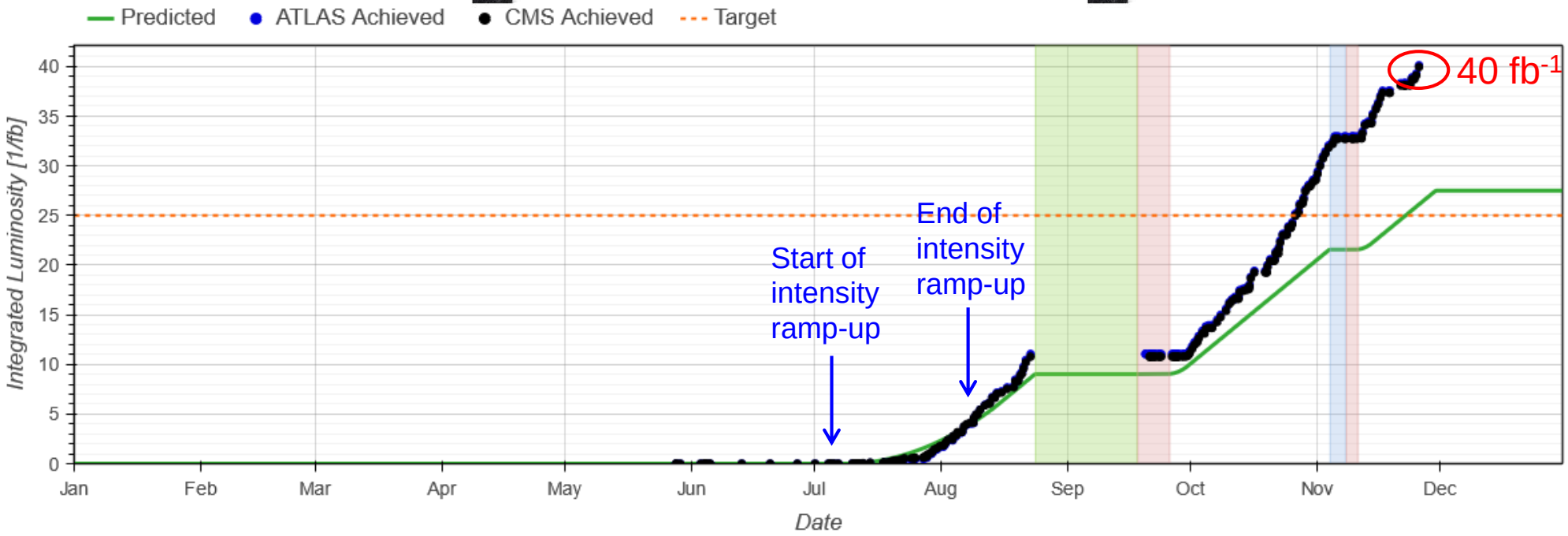
Technology Department

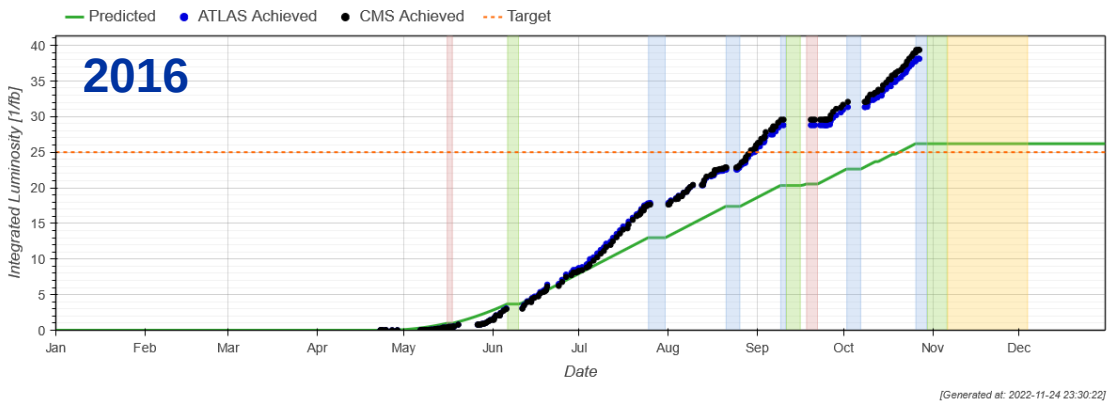
Vacuum, Surfaces and Coatings Group 2022's General Meeting

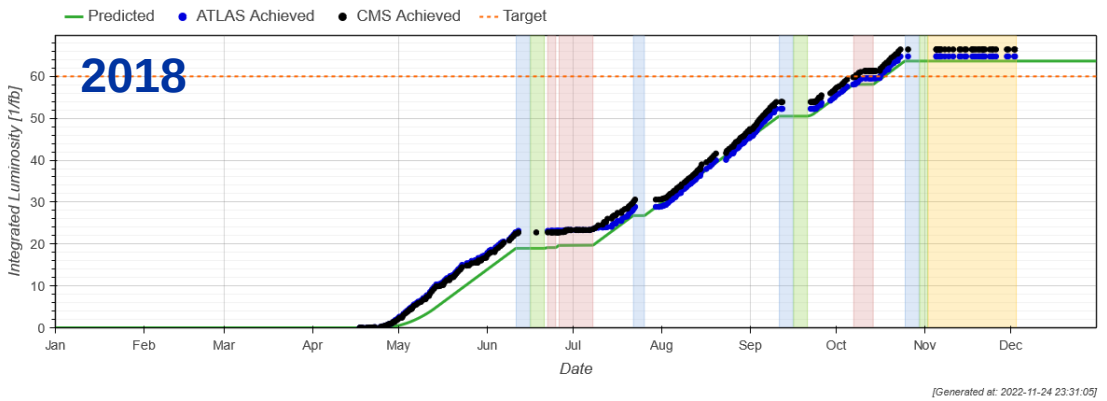
Paolo Chiggiato
Group Leader



Outstanding results in 2022

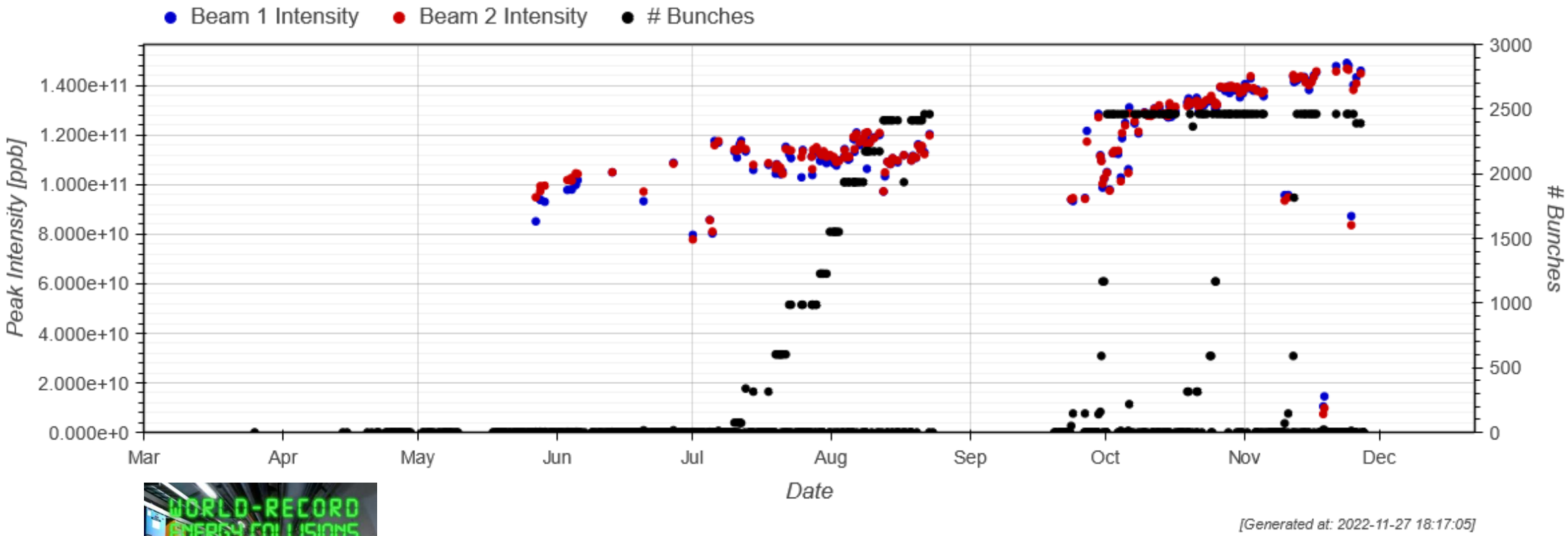






Outstanding results in 2022

Approached **1.5x10^{11} ppb** at start of stable beams. Reached **record stored beam energy** of almost **400 MJ** (enough to melt 550 X 2 kg of Cu)



Fast switching from proton to ions and ions to protons (two days).

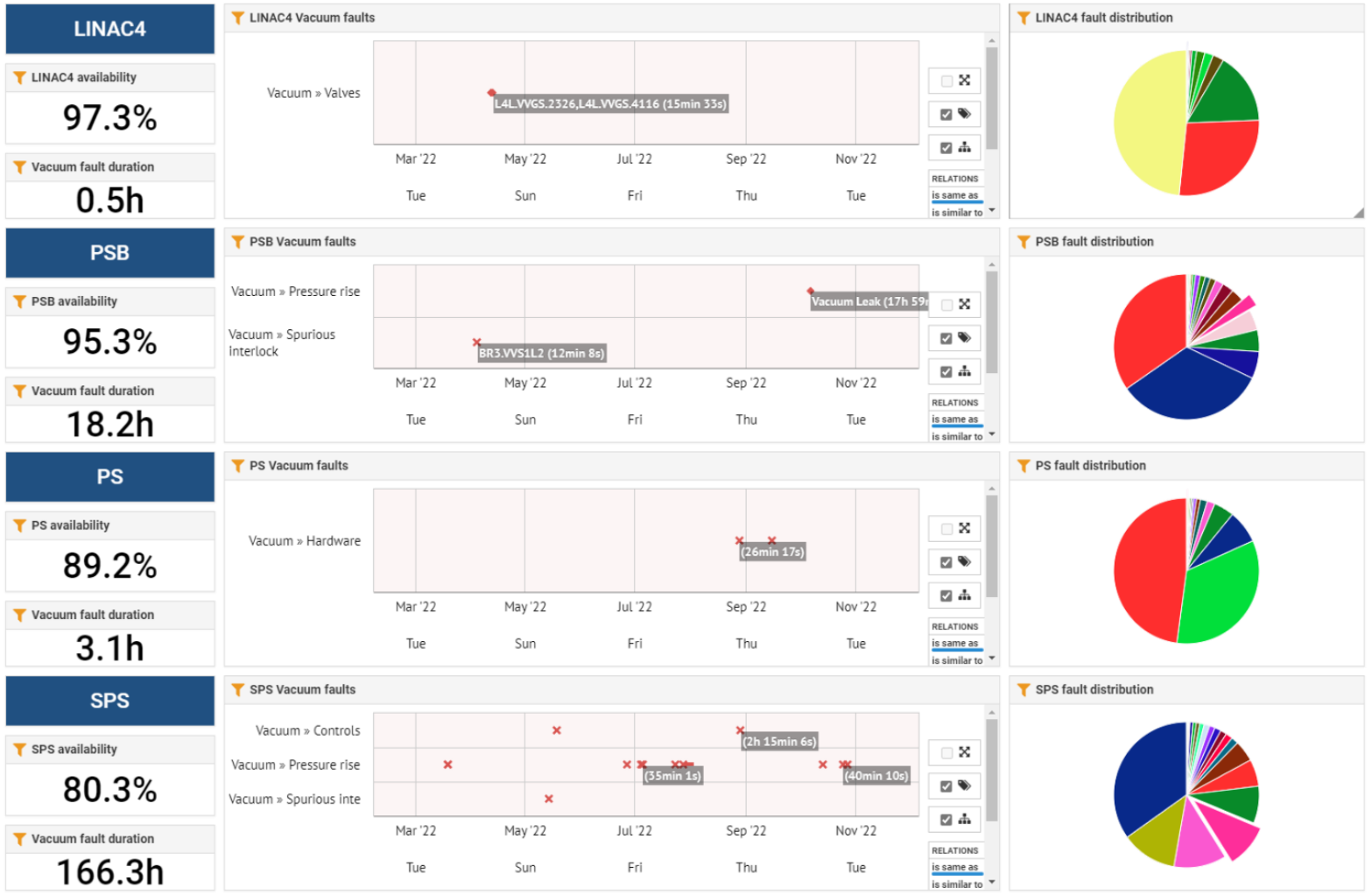
LHC injectors 2022 performance

Outstanding results in 2022

Excellent availability, but still some faults:

- LINAC4: Valves closed due to RF spark (child of another fault)
- PSB: Leak due to faulty RF bypass (spark)
- PS: One solenoid valve burnt in TT2 sector valve
- SPS: TBIU beam strike and BA5 collar mechanical failure

No systematic failure. Most of the failures linked to non VSC origin

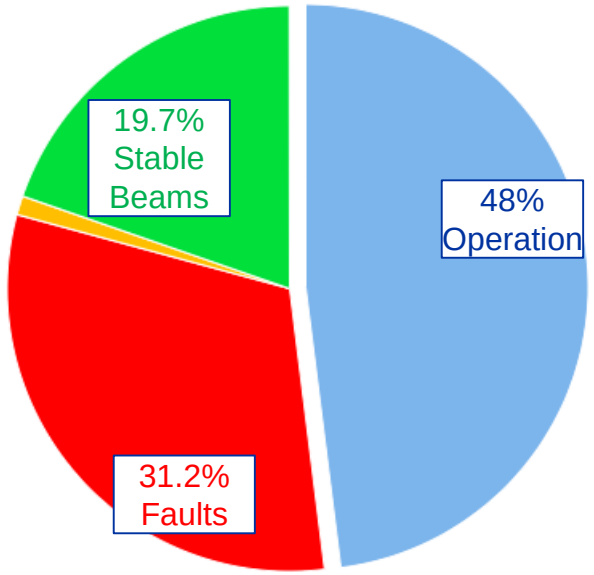


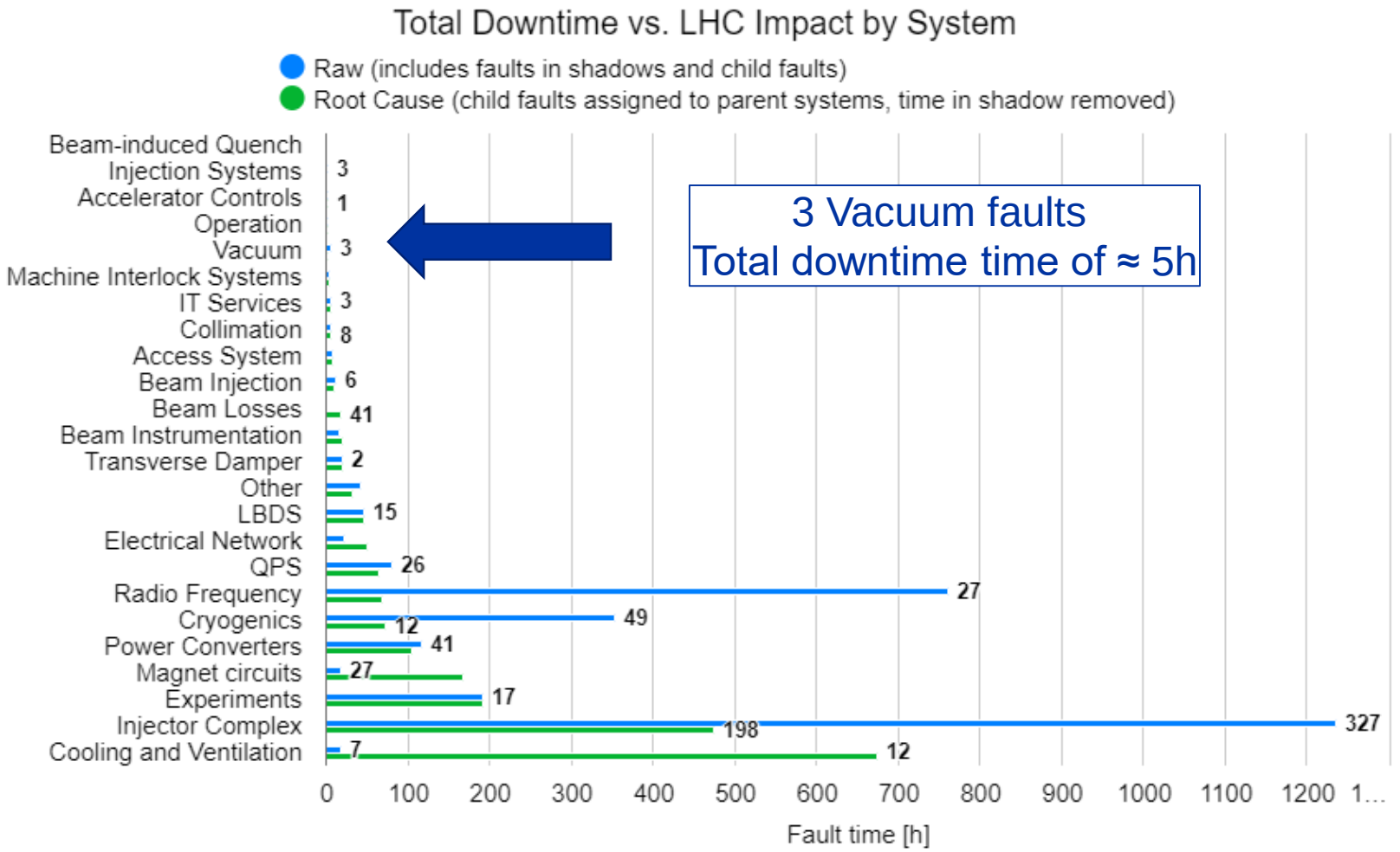
LHC Operation

Outstanding results in 2022

Availability	Stable beams
69.0%	19.7%

Fault vs. Operation Time Distribution





2h due to a TPG300
2h50min due to a sector valve card
15min : Ion pumps stopped for SMOG injection in IP8

A dozen remarkable results in 2022

- **LHC scrubbing run** and intensity ramp-up: monitoring, data analysis and interpretation of pressure variations.
- **LHCb VELO and SMOG-2**: now operational.
- Dibasic ammonium citrate: good candidate to **give up chromic acid** from our surface treatments.
- No measurable heat load in **C-coated beam screen of Q5L8.**
- **First plasma cleaning** of accelerator radioactive equipment: Contaminated ZS tank of PSB, including **simulation.**
- First insertion of a dummy HL-LHC **W-shielded beam screen in real magnet**.
- Installation of a new **Ti window** in the LHC dump lines; first application ever of **SMA in accelerators**.
- **Scada performance study**: loading time and stability.
- **Time stamped push protocol**: no more data lost during pressure monitoring.
- Fault in four **LHC quench protection** power supplies (DQLPR001): **source identified by chemical methods**.
- **Molflow** now time dependent.
- **Gravitational wave telescopes**: ET-CERN agreement signed, LISA-CERN framework ongoing.

Other important results:

SAFETY

Safety (status on 1st Dec 2022)

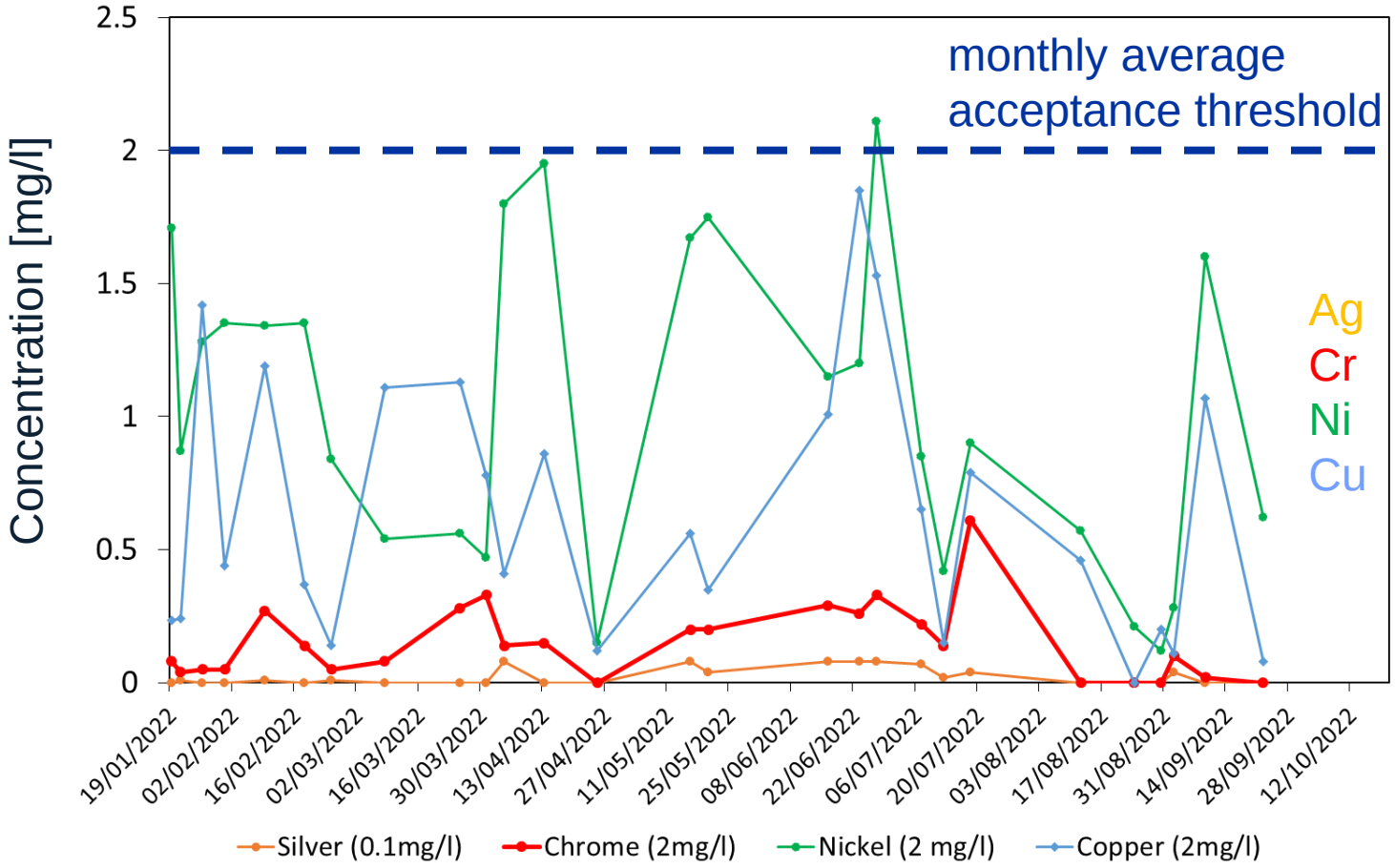
11 incidents
reported in TE-VSC (info from **DSO**)

Eyes	Head	Back	Hand	Fall	Driving or bike riding	Electrical	Radioactivity, contamination	Other
	1		2		5	1		2

0 M **C**

Environmental safety: Waste-water treatment plant

Regular treatment and monitoring of the released effluent **measured by ICP-OES at the Chemistry Lab**.



TE-VSC group structure

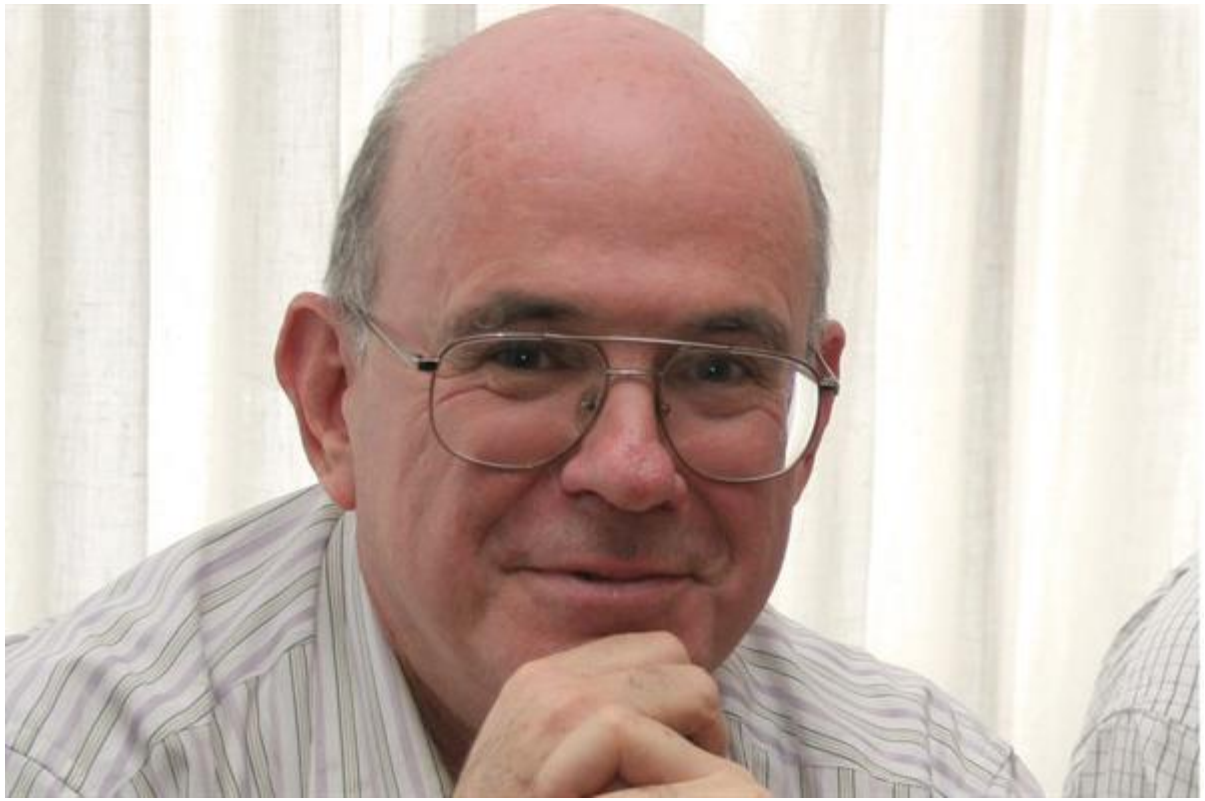
Dec 2022

- Staff: 72
- Fellows: 27
- MPA: 25, including 3 COAS
- ➔ **Total: 124**

Associates for the purpose of international collaboration (MPAc);
Associates for the purpose of exchange of scientists (MPAx);
Associates for the purpose of training (MPAt).

Our director general and president of CERN Council

Director-General of CERN, **Fabiola Gianotti**



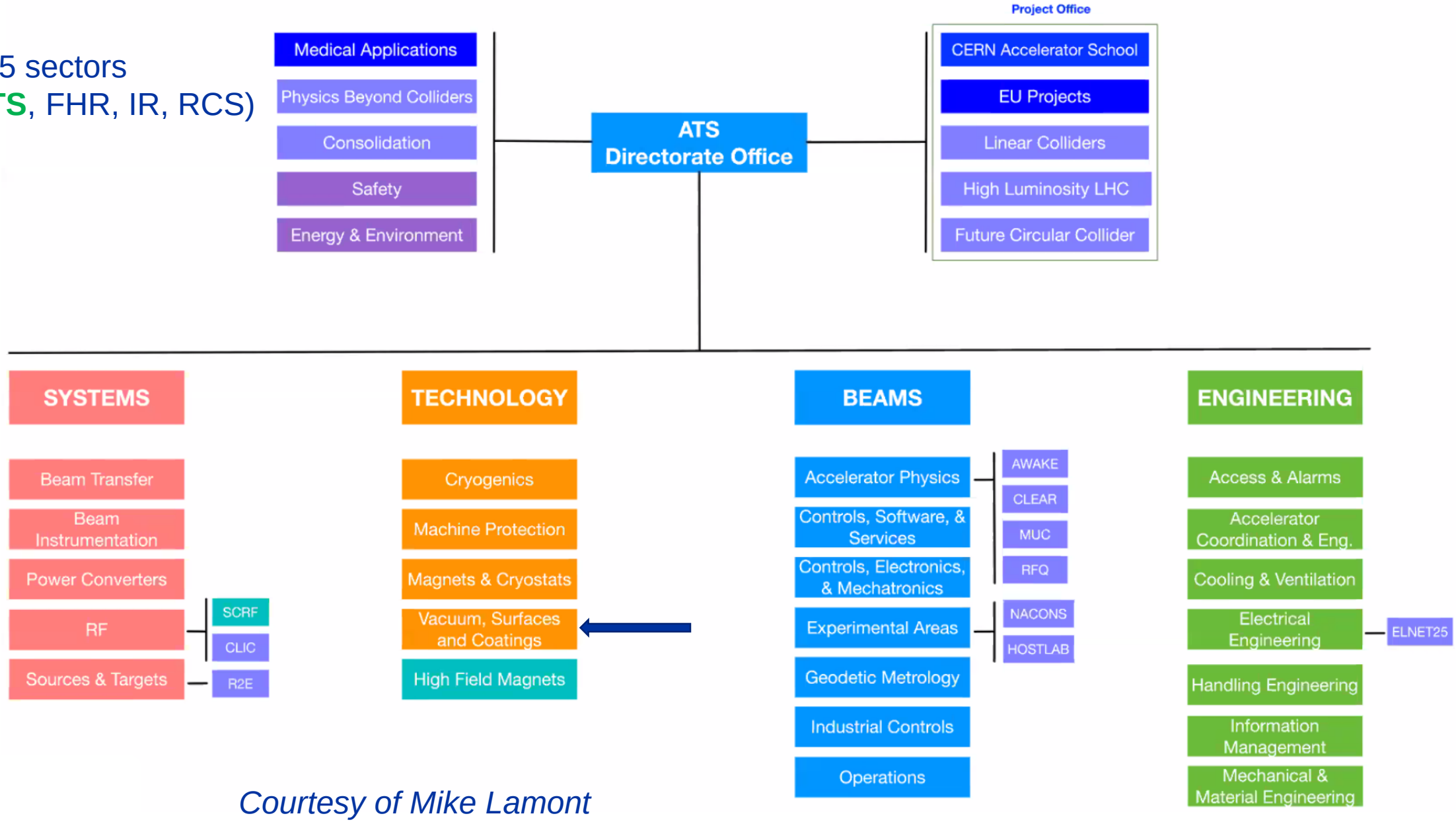
President of the CERN Council, **Eliezer Rabinovici**

Our management

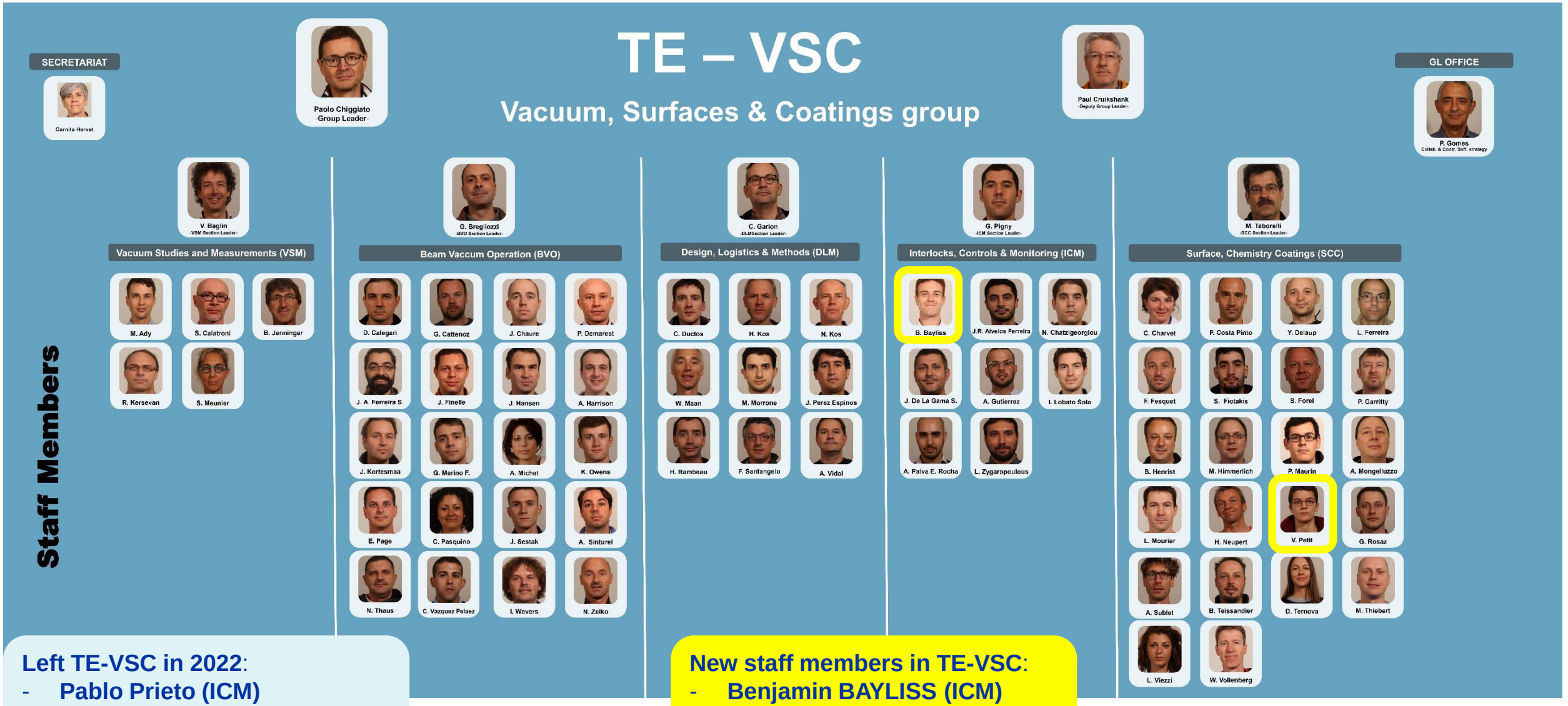
Our A&T director
Mike Lamont

Our TE Department Head
José Miguel Jimenez

CERN: 5 sectors
(DG, **ATS**, FHR, IR, RCS)



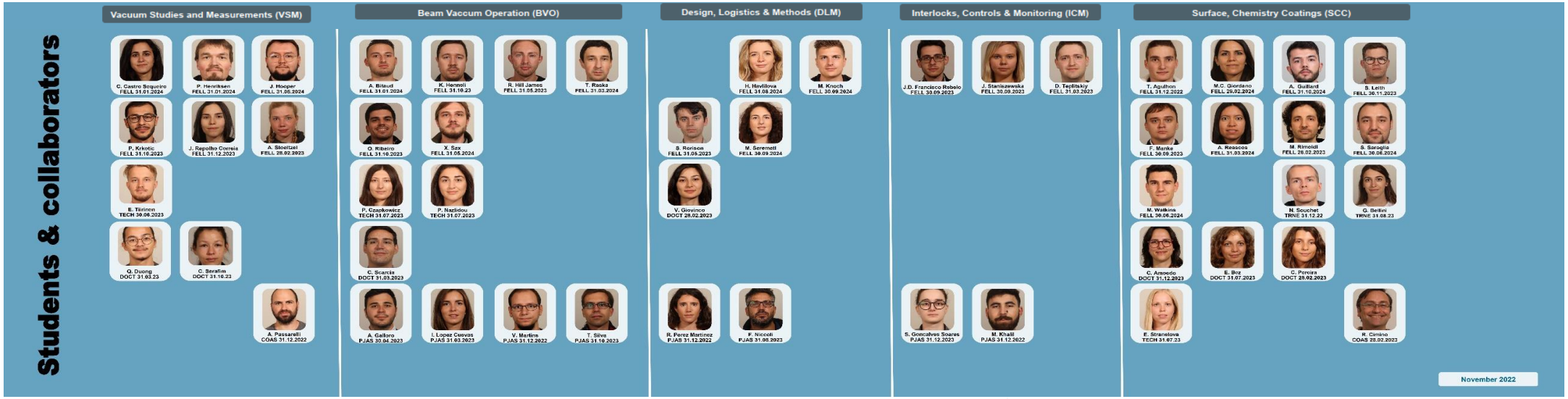
Courtesy of Mike Lamont

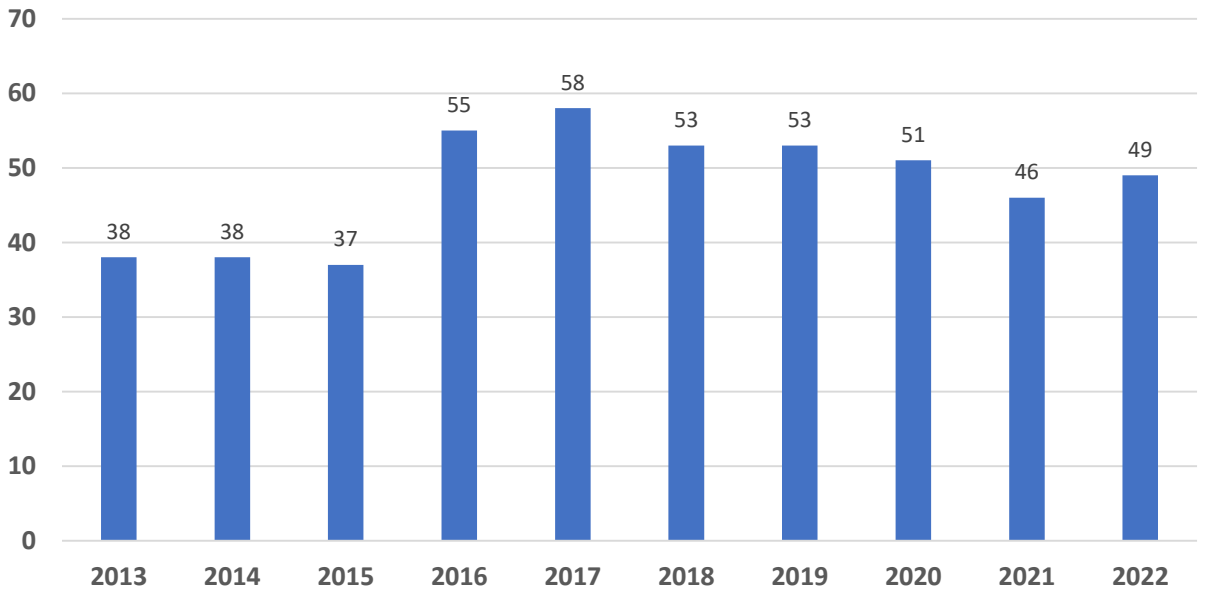


Left TE-VSC in 2022:
- **Pablo Prieto (ICM)**
- **Patrick Lepeule (BVO)**
- **Claude Collomb Patton (BVO)**

New staff members in TE-VSC:
- **Benjamin BAYLISS (ICM)**
- **Valentine PETIT (SCC)**

Student, fellows and collaborators in Nov 2022





12-2022: **49** **(exc. COAS)**
12-2021: **46** **(exc. COAS)**
11-2020: **51** **(exc. COAS)**
11-2019: **53** **(exc. COAS)**
11-2018: **53** **(exc. COAS)**
12-2017: **58** **(exc. COAS)**
12-2016: **55** **(exc. COAS)**
12-2015**: 37** **(exc. COAS)**
12-2014**: 38** **(7 COAS)**

Changes in the TE-VSC group structure

New Section: Insulation and Injectors Vacuum Operation (**IVO)**

Name	First Name	Status Code	Supervisor Name
SAX	Xavier Michel	FELL	FERREIRA SOMOZA, Jose Antonio Dr.
BITAUD	Alexis	FELL	PASQUINO, Chiara Ms.
NAZLIDOU	Panagiota	TECH	FERREIRA SOMOZA, Jose Antonio Dr.
DEMAREST	Paul Richard	STAF	FERREIRA SOMOZA, Jose Antonio Dr.
KORTESMAA	Jarmo	STAF	PASQUINO, Chiara Ms.
THAUS	Nicolas Claude	STAF	FERREIRA SOMOZA, Jose Antonio Dr.
HARRISON	Anthony	STAF	PASQUINO, Chiara Ms.
FERREIRA SOMOZA	Jose Antonio	STAF	~~BREGLIOZZI, Giuseppe Dr.~~ Paolo
SINTUREL	Alexandre Xavier	STAF	FERREIRA SOMOZA, Jose Antonio Dr.
PASQUINO	Chiara	STAF	~~BREGLIOZZI, Giuseppe Dr.~~ Jose
MICHET	Alice Ingrid	STAF	FERREIRA SOMOZA, Jose Antonio Dr.
MERINO FERNANDEZ	Guillermo	STAF	FERREIRA SOMOZA, Jose Antonio Dr.

3

9 staff members

Changes in the TE-VSC group structure

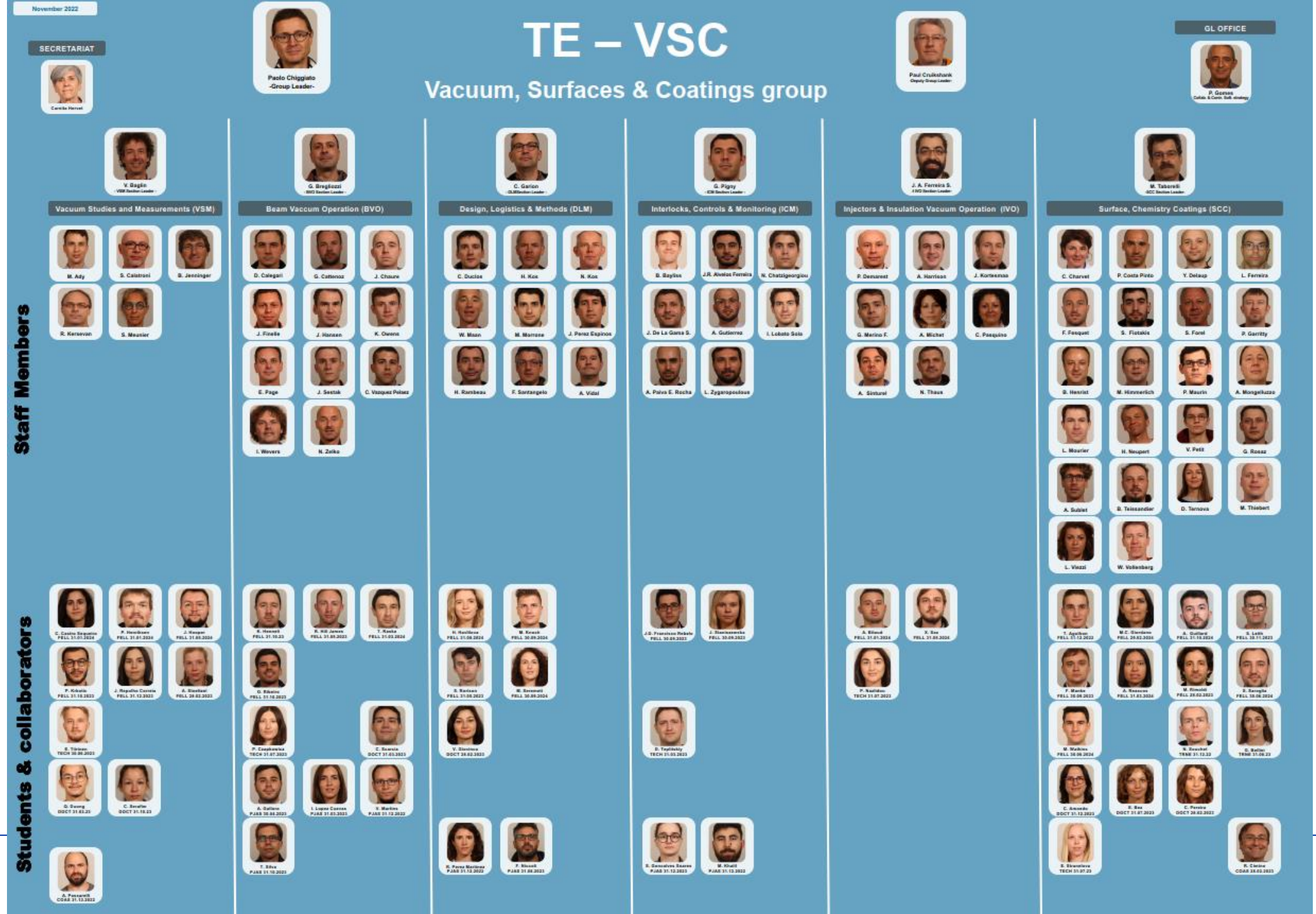
LHC Beam Vacuum Operation
BVO

Name	First Name	Organic Unit	Status Code	Professional Category	Supervisor Name	New Section
SCARCIA	Carlo	TE-VSC-BVO	DOCT	2	BREGLIOZZI, Giuseppe Dr.	no
CZAPKOWICZ	Paulina Gabriela	TE-VSC-BVO	TECH	2	WEVERS, Ivo Mr.	no
REIS E RIBEIRO SANTOS	Orlando Miguel	TE-VSC-BVO	FELL	2	BREGLIOZZI, Giuseppe Dr.	no
HENNELI	Kristoffer	TE-VSC-BVO	FELL	3	BREGLIOZZI, Giuseppe Dr.	no
RASKA	Tomas	TE-VSC-BVO	FELL	2	SESTAK, Josef Mr.	no
HILL-JAMES	Rowan Cape	TE-VSC-BVO	FELL	3	BREGLIOZZI, Giuseppe Dr.	no
LOPEZ CUEVAS	Isabel	TE-VSC-BVO	PJAS	2	BREGLIOZZI, Giuseppe Dr.	no
NASCIMENTO MARTINS	Vasco Miguel	TE-VSC-BVO	PJAS	2	SESTAK, Josef Mr.	no
GALLORO	Alessio	TE-VSC-BVO	PJAS	2	BREGLIOZZI, Giuseppe Dr.	no
PEREIRA NAVE HENRIQUES DA SILVA	Tomas	TE-VSC-BVO	PJAS	2	BREGLIOZZI, Giuseppe Dr.	no
HANSEN	Jan Helge	TE-VSC-BVO	STAF	2	BREGLIOZZI, Giuseppe Dr.	no
WEVERS	Ivo	TE-VSC-BVO	STAF	3	BREGLIOZZI, Giuseppe Dr.	no
ZELKO	Nicolas	TE-VSC-BVO	STAF	3	BREGLIOZZI, Giuseppe Dr.	no
PAGE	Eric	TE-VSC-BVO	STAF	3	BREGLIOZZI, Giuseppe Dr.	no
CALEGARI	Didier	TE-VSC-BVO	STAF	3	SESTAK, Josef Mr.	no
BREGLIOZZI	Giuseppe	TE-VSC-BVO	STAF	2	CHIGGIATO, Paolo Mr.	no
CHAURE	Jerome Gilles	TE-VSC-BVO	STAF	3	SESTAK, Josef Mr.	no
CATTENOZ	Gregory	TE-VSC-BVO	STAF	3	BREGLIOZZI, Giuseppe Dr.	no
FINELLE	Julien	TE-VSC-BVO	STAF	3	BREGLIOZZI, Giuseppe Dr.	no
SESTAK	Josef	TE-VSC-BVO	STAF	2	BREGLIOZZI, Giuseppe Dr.	no
VAZQUEZ PELAEZ	Cesar	TE-VSC-BVO	STAF	3	BREGLIOZZI, Giuseppe Dr.	no
OWENS	Karl John	TE-VSC-BVO	STAF	3	BREGLIOZZI, Giuseppe Dr.	no

10

12 staff members

From 01-2023


November 2022
TE – VSC
Vacuum, Surfaces & Coatings group
SECRETARIAT
Paolo Chiggiato
-Group Leader-
Paul Cruikshank
GL OFFICE
Staff Members
Students & collaborators
Vacuum Studies and Measurements (VSM)
Beam Vaccum Operation (BVO)
Design, Logistics & Methods (DLM)
Interlocks, Controls & Monitoring (ICM)
Injectors & Insulation Vacuum Operation (IVO)
Surface, Chemistry Coatings (SCC)

Budget in 2022

Budget

OP budget and commitments (CET extraction 08-12):

Payment budget: **4.126 MCHF**
Charged to budget code on **recurrent** budget: **2.979** MCHF
Commitment (incl. pipeline) on operation (**recurrent**) : **4.091 MCHF**
(XPS and NEG pumps DR excluded)

PRJ+CONS budget and commitments (CET extraction 08-12):

Payment budget: **7.61 MCHF**
Charged to budget code on **non-recurrent** budget: **6.164 MCHF**

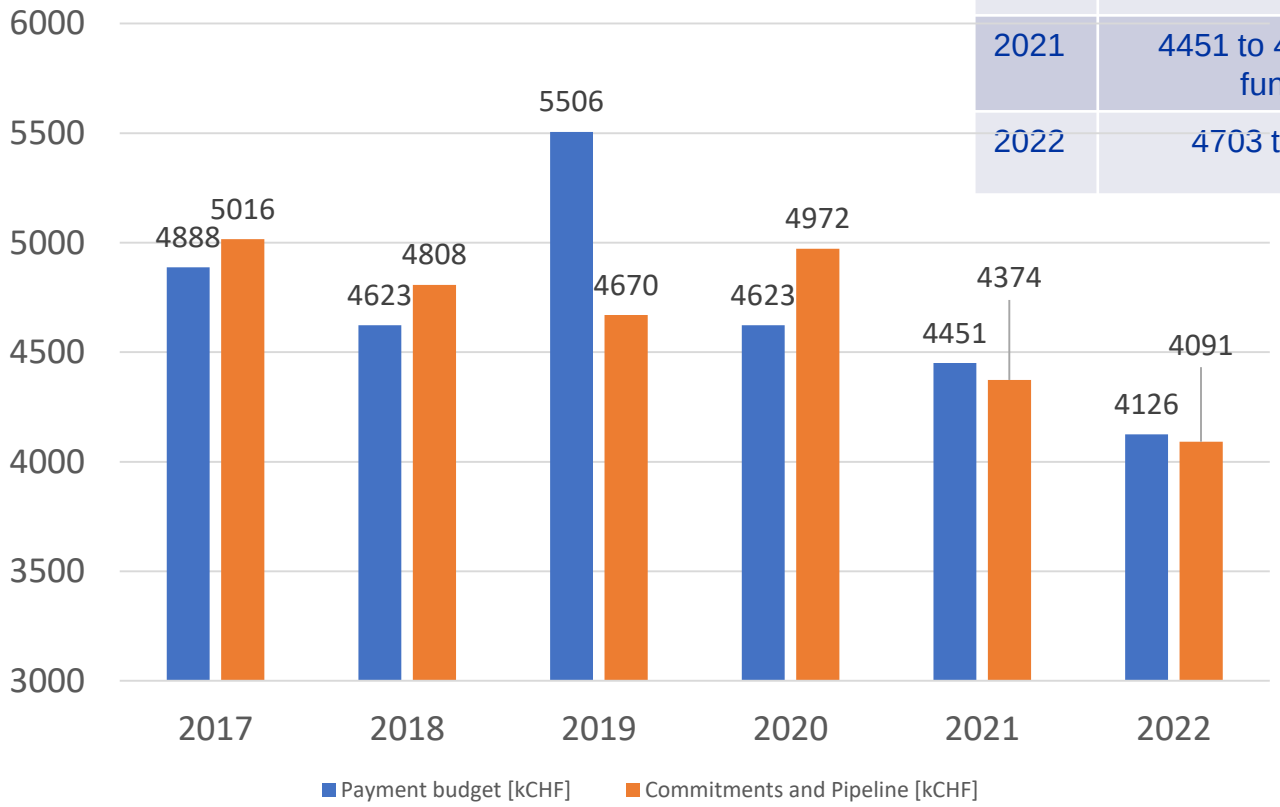
Most important lines of expenditure:

- Blanket contracts
- Industrial support
- EN-MME services
- HL-LHC items and CERN store

Jan Gossaert, Portrait of a Merchant, 1530
National Gallery of Art, Washington DC

Operational budget evolution

Year	Payment budget [kCHF]	Commitments and Pipeline [kCHF]
2017	4888 to 4798 in Dec	5016
2018	4623 to 4453 in Dec	4808
2019	5506 to 4596 in Dec	4670
2020	4623 to 4621 in Dec	4972
2021	4451 to 4551 (DG funds)	4374
2022	4703 to 4126	4091

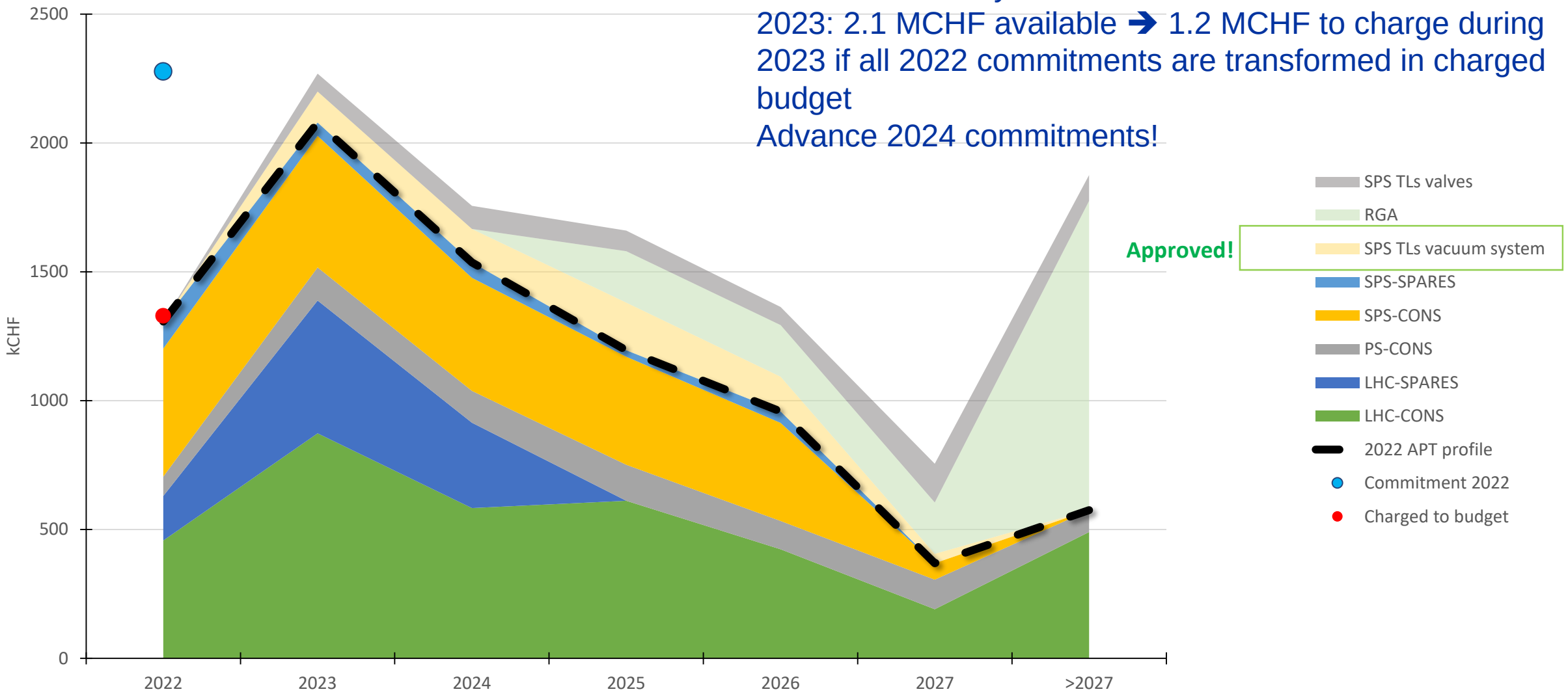


New requests at Consolidation Day (October 2022)

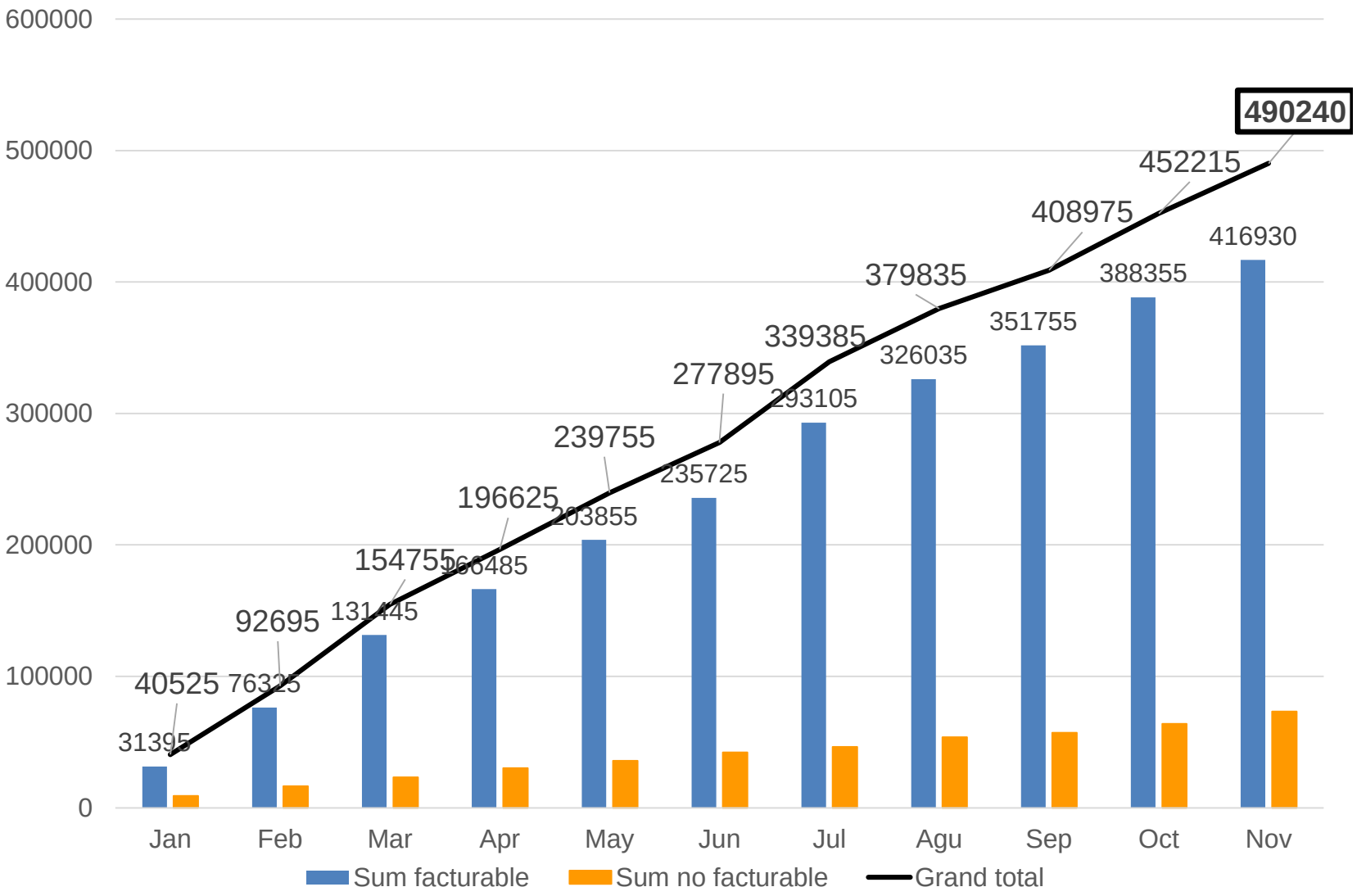
New request #	Short description	Material [kCHF]	M2P [KCHF]	Time frame	Priority
 VSC-1	SPS Transfer Line Vacuum systems consolidation Consolidation of ion pumps (reusing VPIAL from LEP), gauges, spare chambers and windows.	862	FSU: 0.6 Y's G/S: 0 Y's	2023-2027	1
VSC-2	SPS Ring and Transfer Lines Vacuum valve consolidation Consolidation of valve pneumatics (irradiation), old venting valves and VVRs in sectors 6001, 440 and 2002	560	FSU: 0.3 Y's G/S: 0 Y's	2023-2028	2

Consolidation: Proposed spending profile

0.9 MCHF already committed for 2023!
2023: 2.1 MCHF available ➔ 1.2 MCHF to charge during 2023 if all 2022 commitments are transformed in charged budget
Advance 2024 commitments!



Surface treatments: 1639 jobs (status on 30.11.2022)



Total revenue expected at the end of the year: ≈ **440 kCHF**

Last year: 410 kCHF

Industrial support & FSU contracts

VSC coordinator of the IS contract: Jaime Perez Espinos
FSU and IS contract supervision and FSU coordinator: Nico Kos

Status on 12.12.2022 (reference JMT+CET)

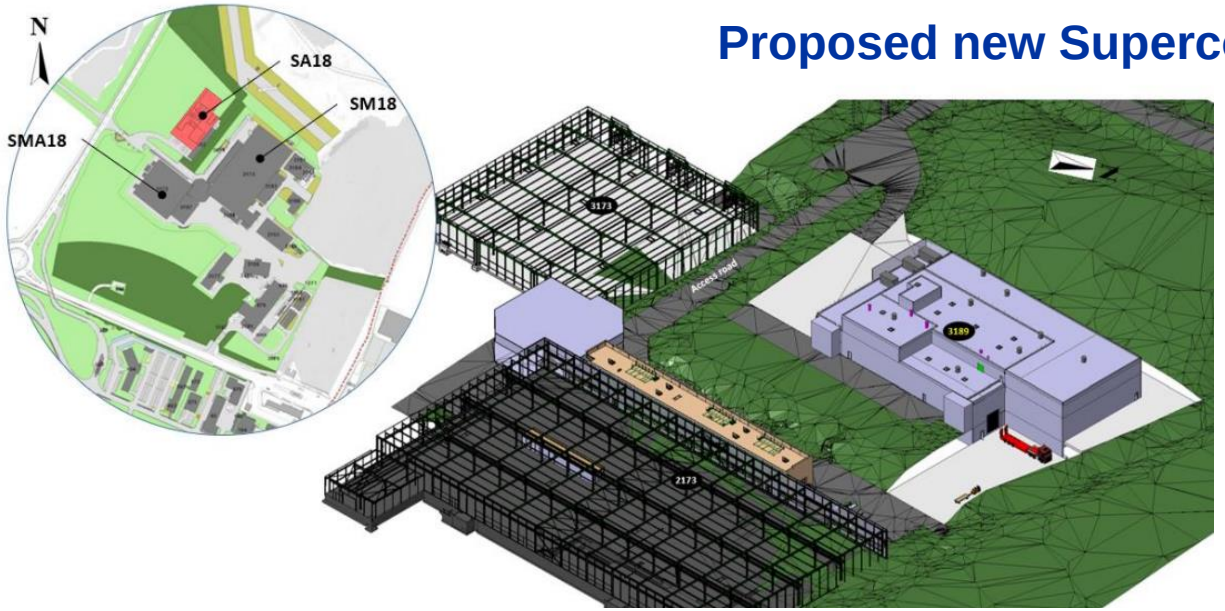
Contract	No. of jobs	Total (kCHF)
S175 (AL4030)*	364 (*CERN-wide: 900*)	455 (*CERN-wide: 1028*)
S144 – Cabling, bakeout and mechanical design	208	381
S145 – Machining, assembly, testing, logistics and mechanical design	144	422
Total	716	1258

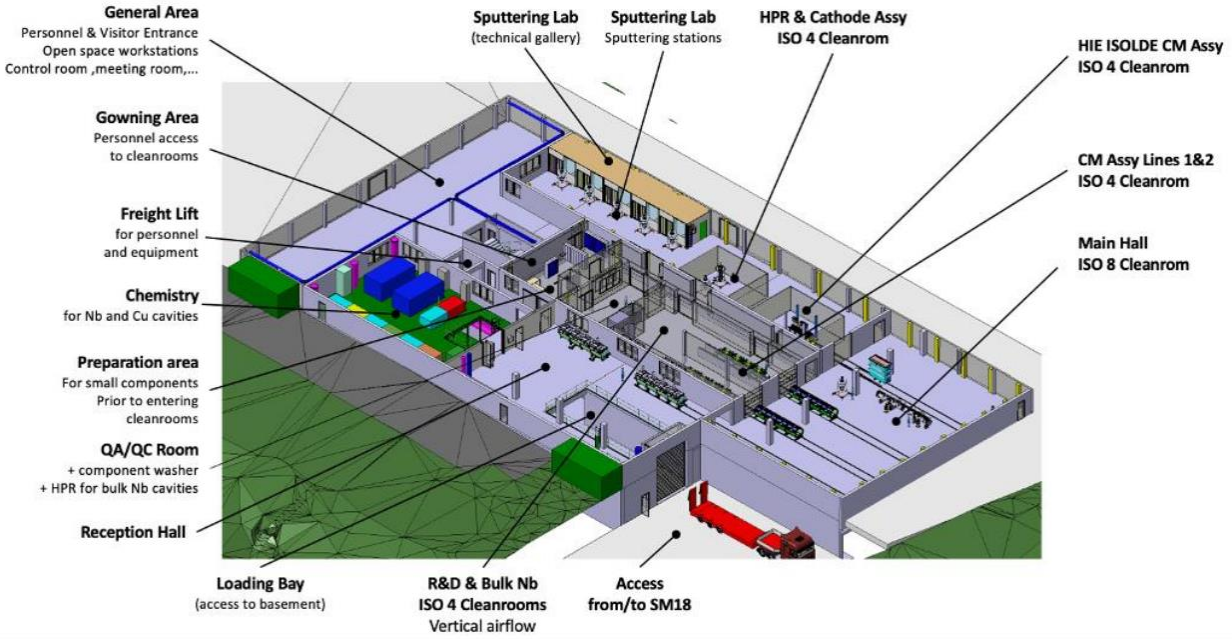
*This includes the cost of jobs, as well as supervision, QA and logistics.

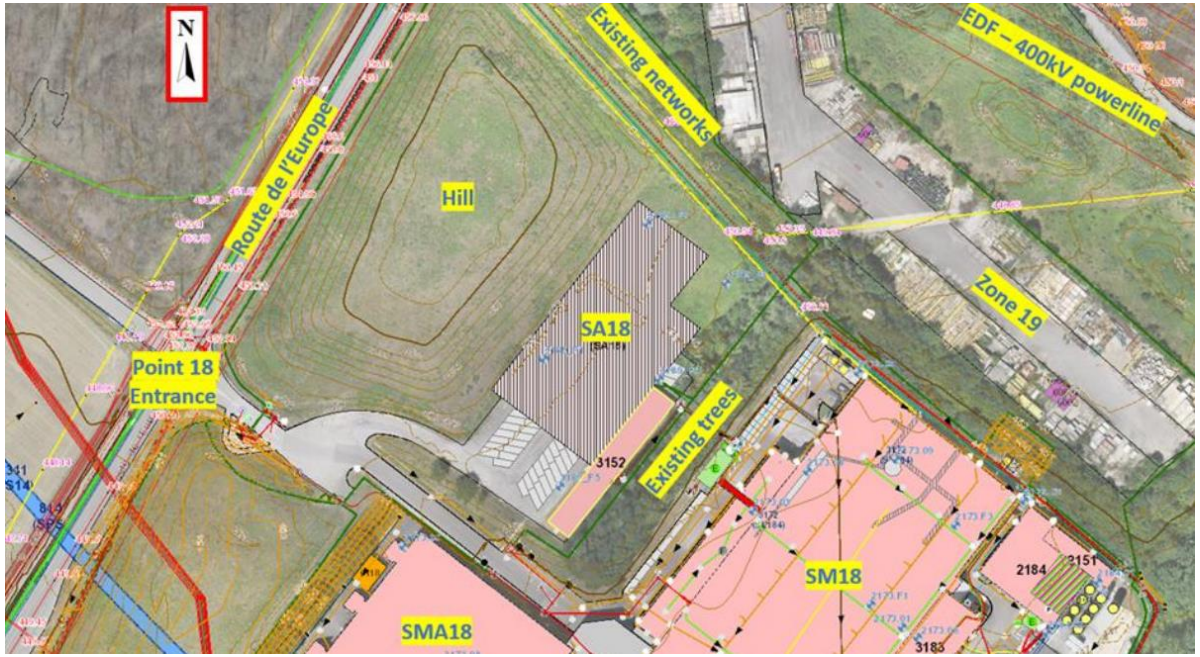
New contracts:
S175, July 2023
S144 and S145, April 2024

Premises

Proposed new Superconducting RF Building







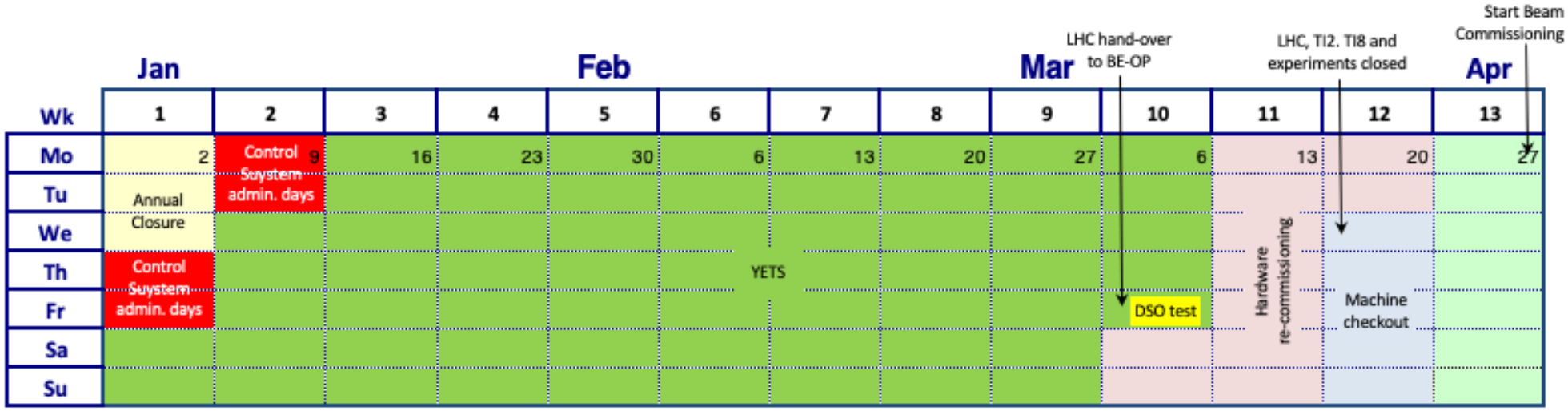
Common facility for the processing of SC cavities and their assembly in cryomodules, **including surface treatments and coating**. B. 118 is going to be converted to other uses.

Cleanrooms, today spread on various location at CERN, will be grouped and organized into the same building.

Waiting for **MTP arbitration in 2023**.

LHC operation in 2023

2023 – Q1

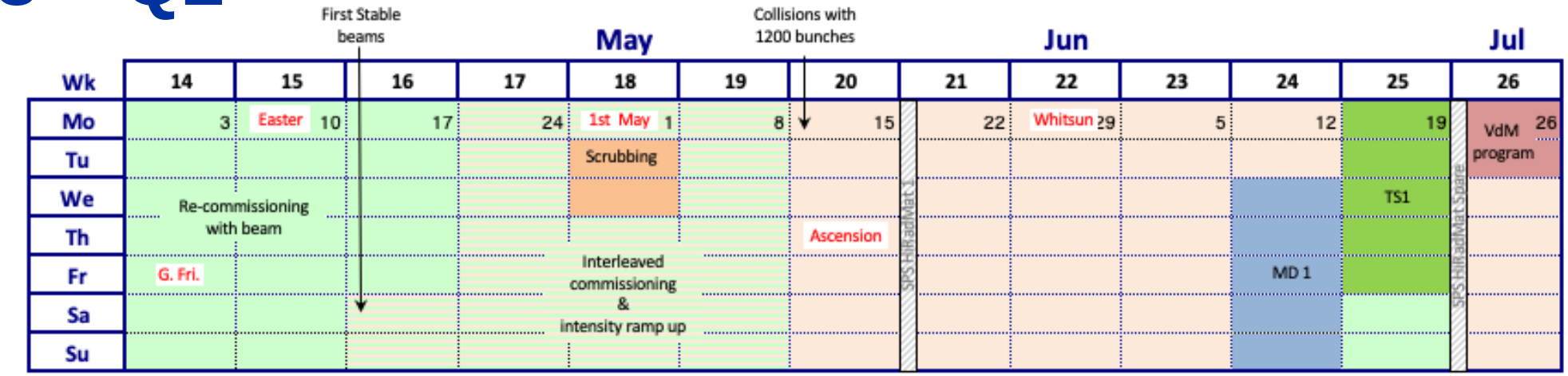


LHC hand-over to OP & DSO test 10 March

Beam commissioning starts 27 March

Rende Steerenberg LMC 30-11

2023 – Q2



Beam commissioning & intensity ramp-up wk14 – wk19

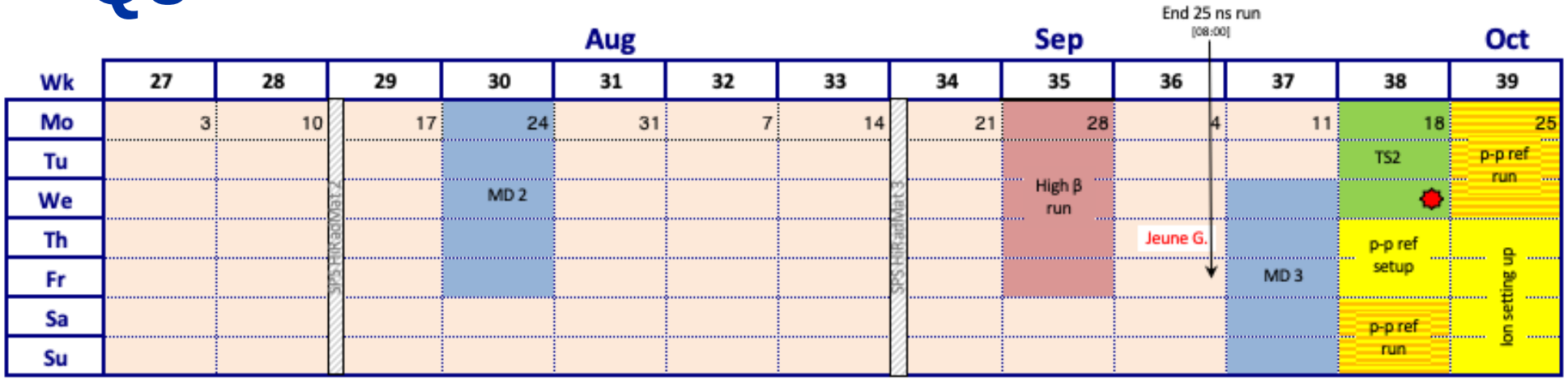
- *First stable beams **22 April***
- *2 day e-cloud scrubbing run*

Start of physics with 1200 bunches 15 May

Technical stop & technical stop recovery wk25

Rende Steerenberg LMC 30-11

2023 – Q3

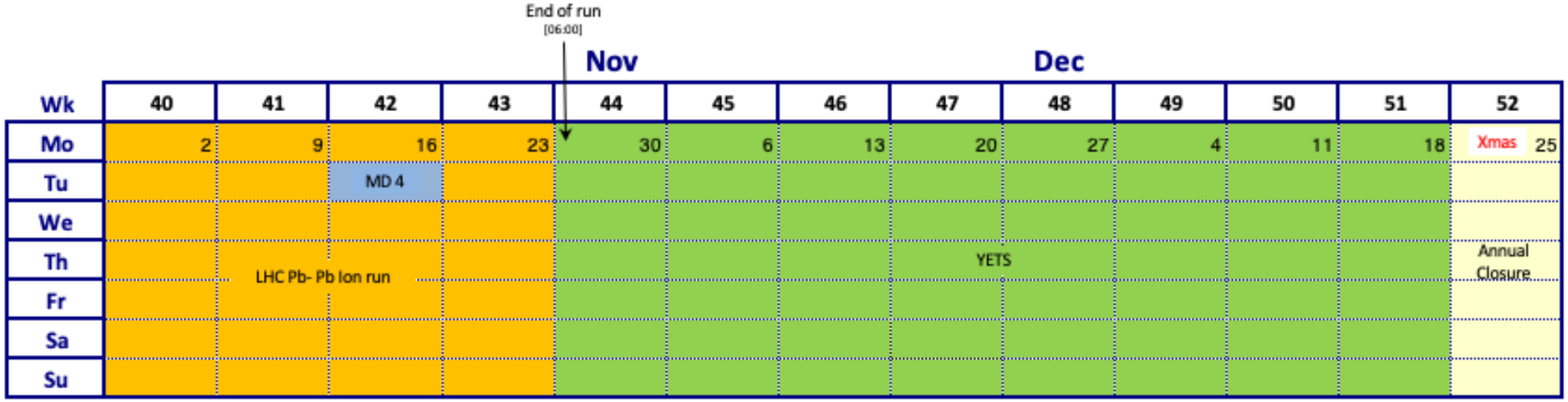


Wk 38 until end of the 2023 run Pb ion run period

- *3-day technical stop for experiment to move in ZDCs – no major activities expected in the LHC machine – quick restart*
- *p-p reference run and its setting-up*
- *Pb ion setting-up*

Rende Steerenberg LMC 30-11

2023 – Q4



Wk40 – Wk43 Pb-Pb ion run

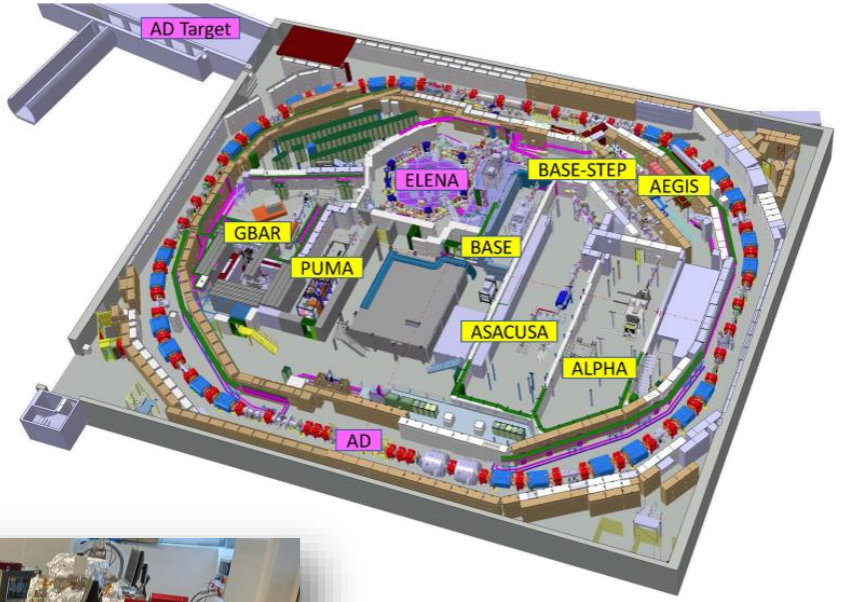
24 hours MD slot on 17 October

End of 2023 run on Monday 30 October @ 06:00

Vacuum at CERN beyond HL-LHC

Antimatter experiments

PUMA

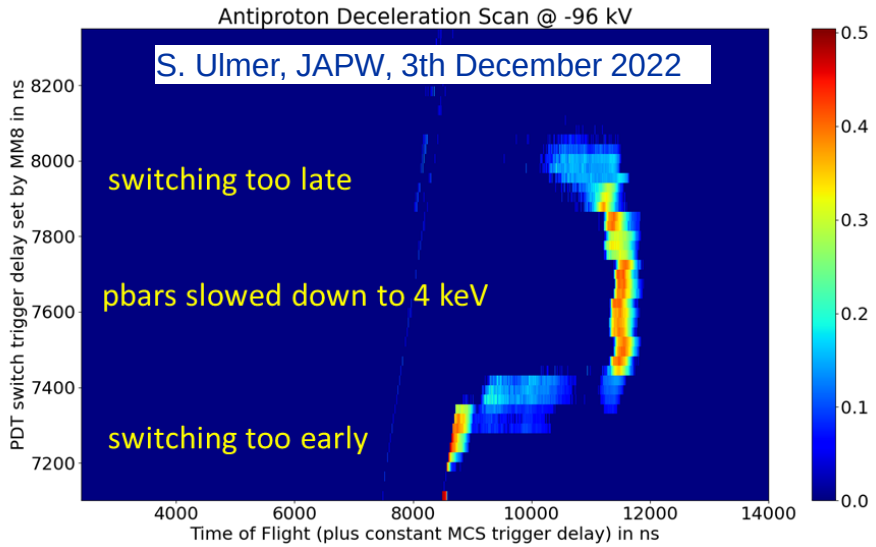


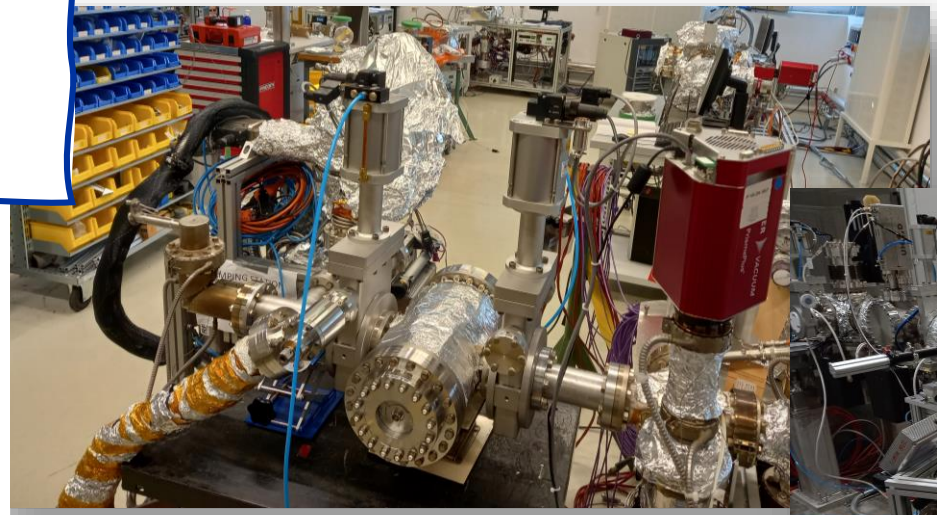
Deceleration of antiprotons from 100 to 4 keV

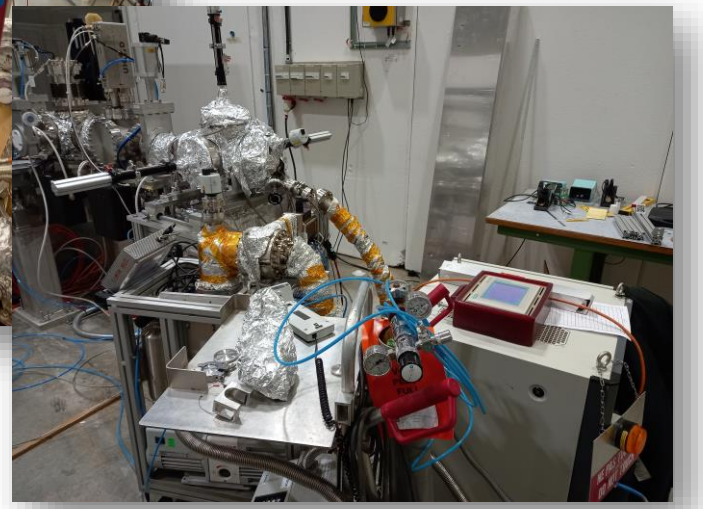
Design of ISOLDE beam line ongoing

Objectives 2023:

- **First trapping of antiprotons**
- **First attempt to transport antiprotons**



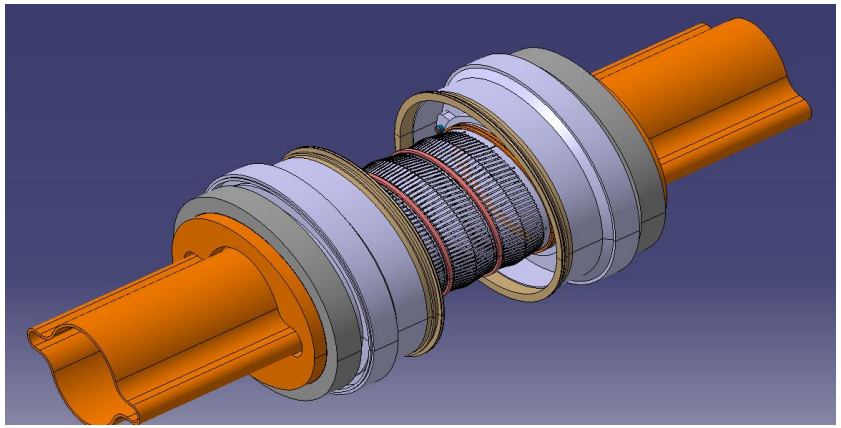




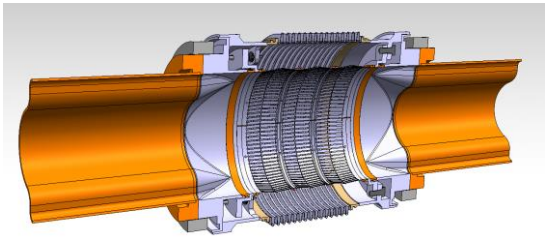
FCC-ee vacuum system

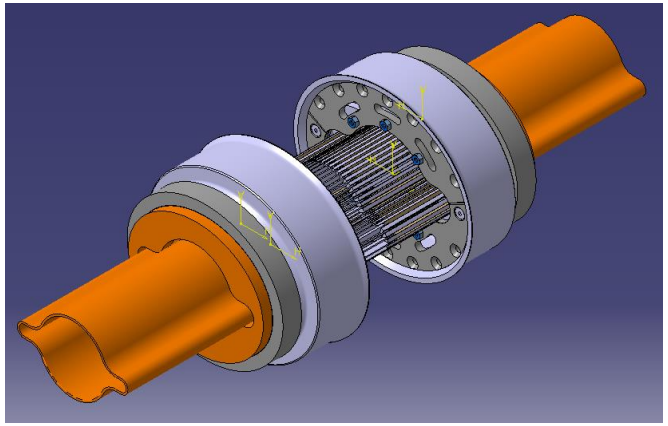
FCC-ee design

Interconnection design:



DRF Contact Bridge type

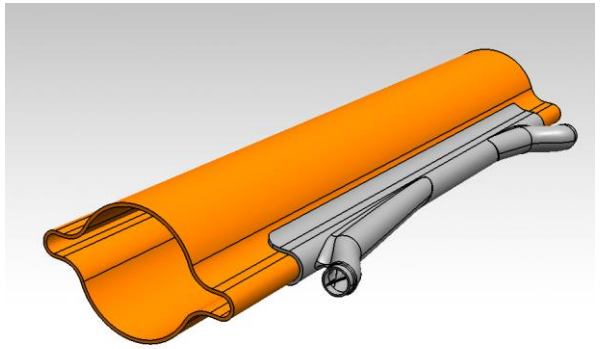


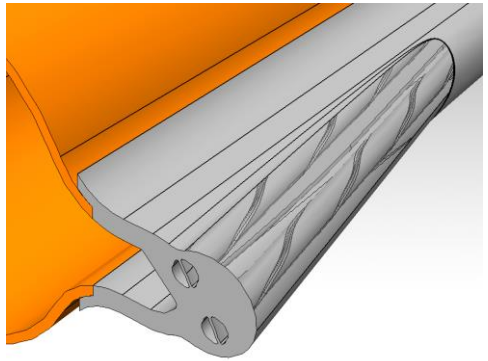


Comb-type

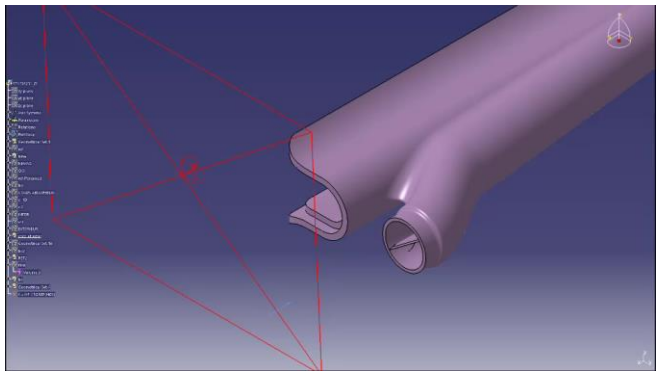
Two designs presented for the interconnection, now undergoing impedance modelling.

Synchrotron radiation absorber design:





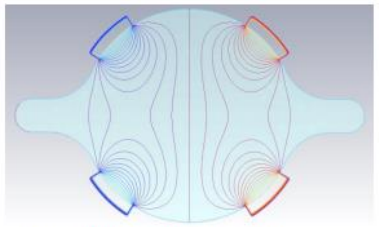
3D model with twisted tape to increase heat transfer coefficient



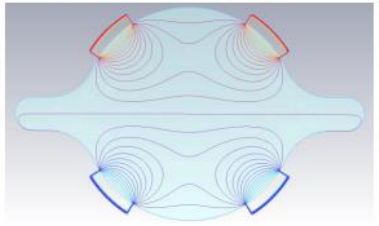
FCC-ee vacuum system

FCC-ee design: SMA applications

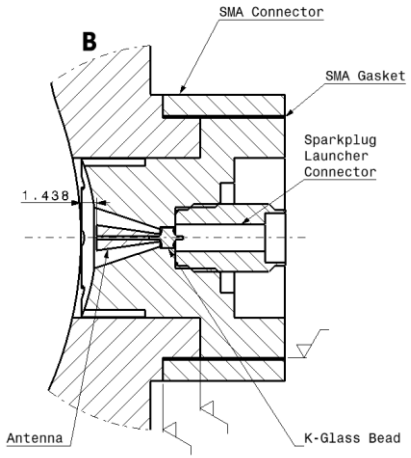
BPM Design Updated

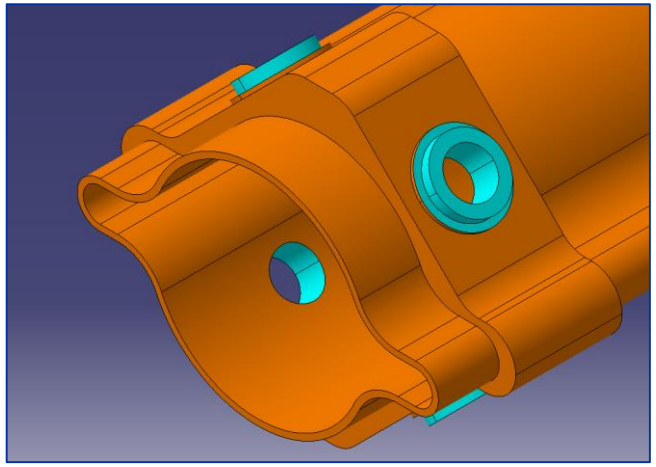


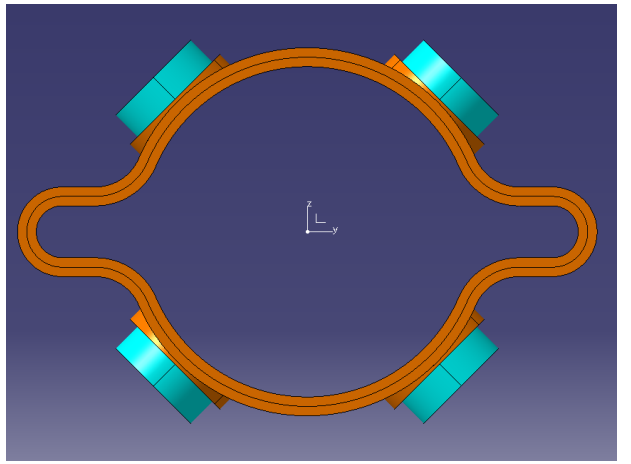
BPM position behaviour: horizontal



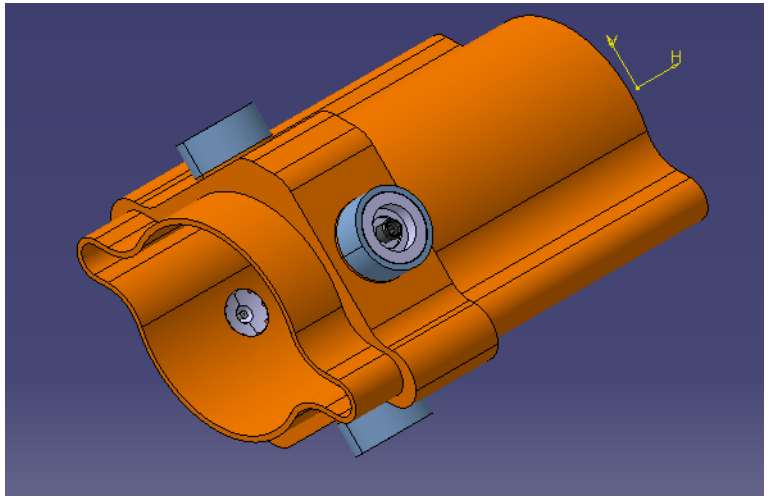
BPM position behaviour: vertical

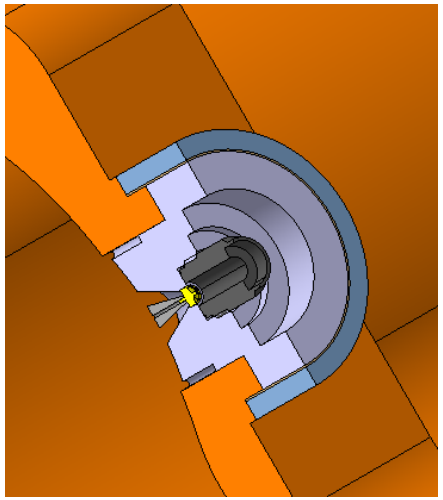






Copper additive manufacturing using cold-spray: Blue area are machined to support **SMA couplers** and pick-up devices





Design update of the FCC-ee BPM block on the vacuum chamber, incorporating the proposed equipment (BPM design given CERN/SY/BI for illustration)

FCC-ee vacuum system

FCC-ee prototyping

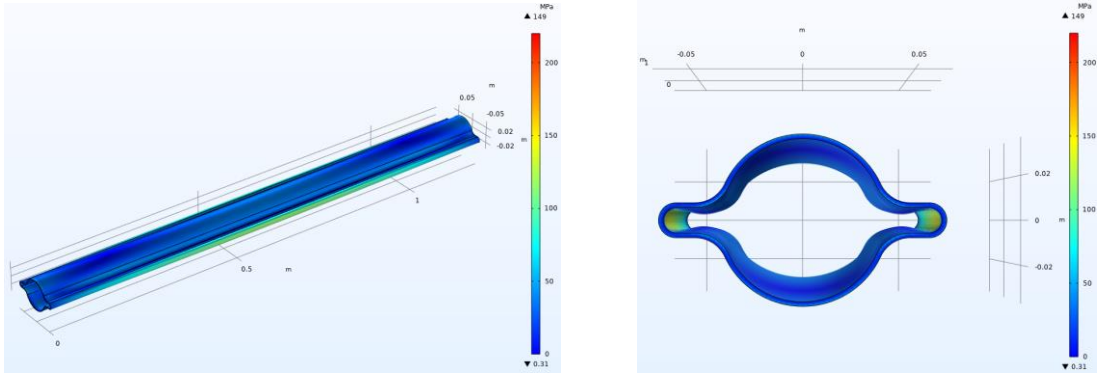
FCC-ee Vacuum Chamber Prototypes

Prototype vacuum chambers delivered.

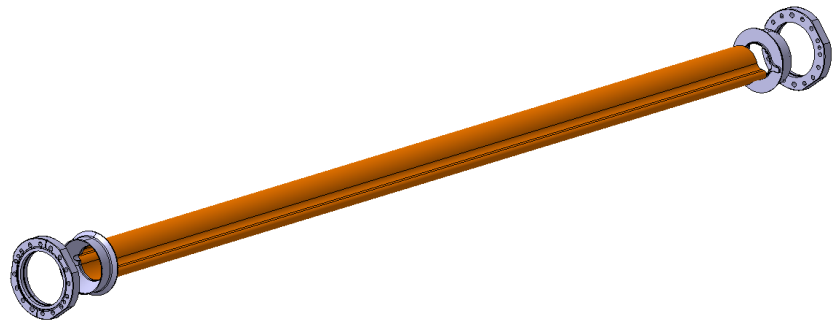
Cold extruded chamber in C10200, 2 mm uniform thickness

Next steps:

- Metallography
- Metrology analysis (create 3D image of 5-m length chamber to compare against baseline design)
- NEG Coating
- **Integration into magnet system**

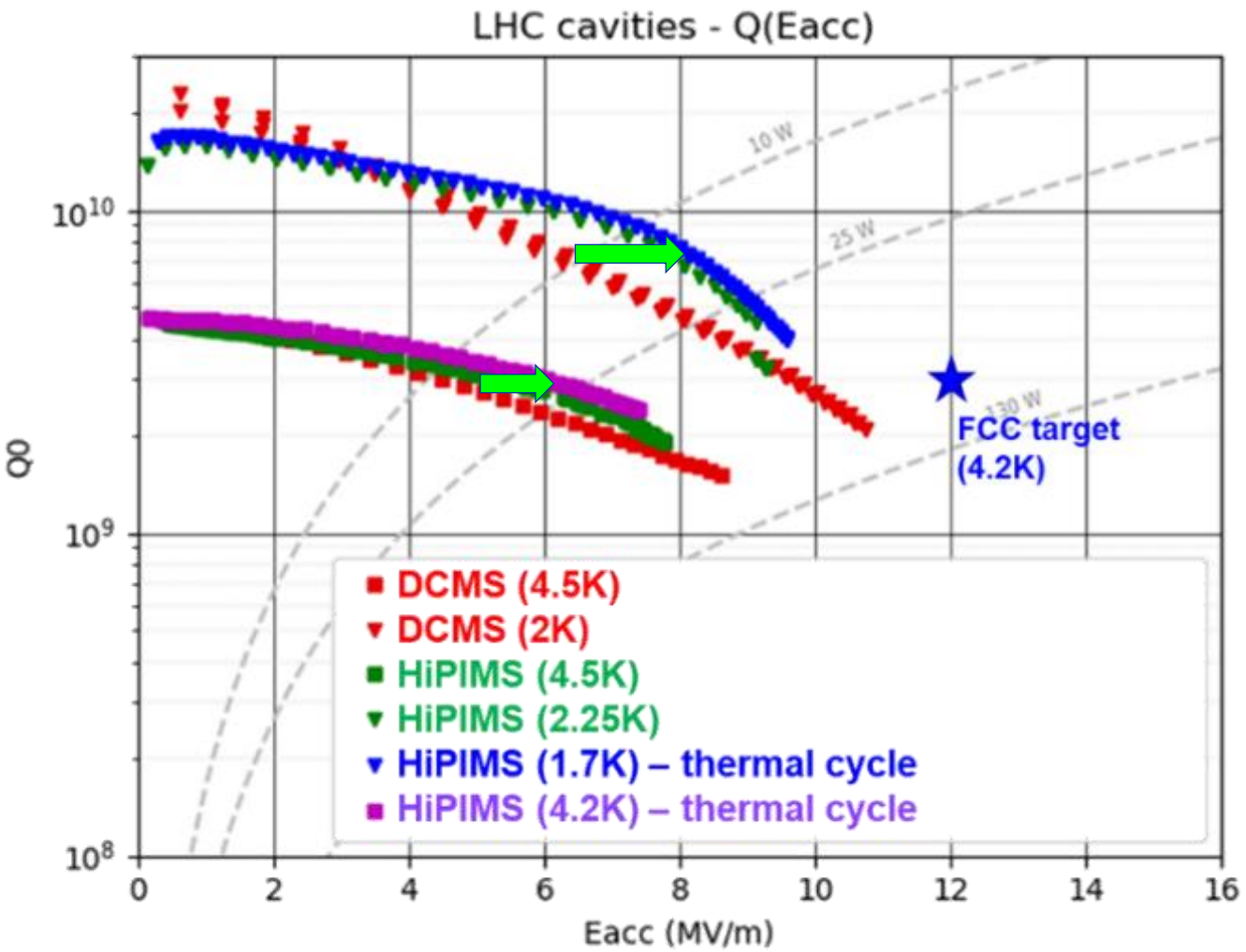


Stress field in the prototype chamber under vacuum



Preliminary study for integration in KARA

FCC-ee SC-RF cavities: coating optimisation



From DC magnetron sputtering to **HIPIMS***:

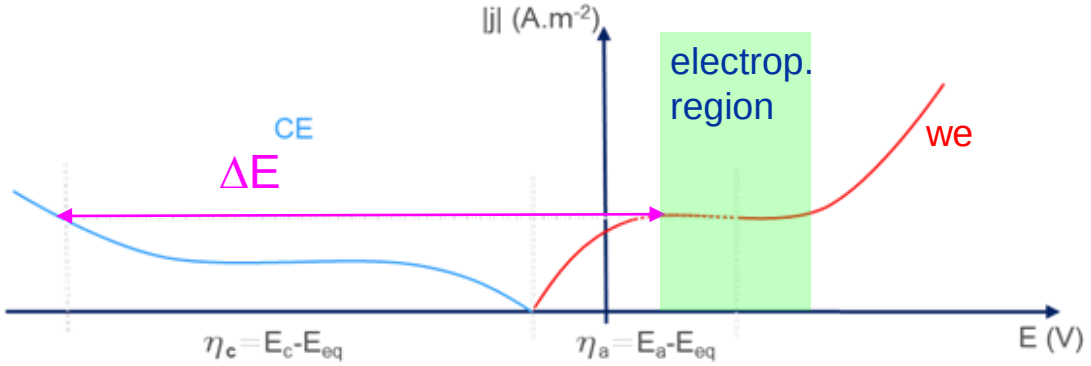
- first LHC-like cavity (400MHz)

-more compact coatings, improve the quality factor Q for the cavity (R_{res} **~ 18 nOhms, Target: <10nOhms**)

NB: on small **1.3GHz the electropolishing+ HIPIMS** proved a surface resistance below **5nOhms**!

*HIPIMS: HIgh Power Impulse Magnetron Sputtering

FCC-ee SC-RF cavities: electropolishing optimisation



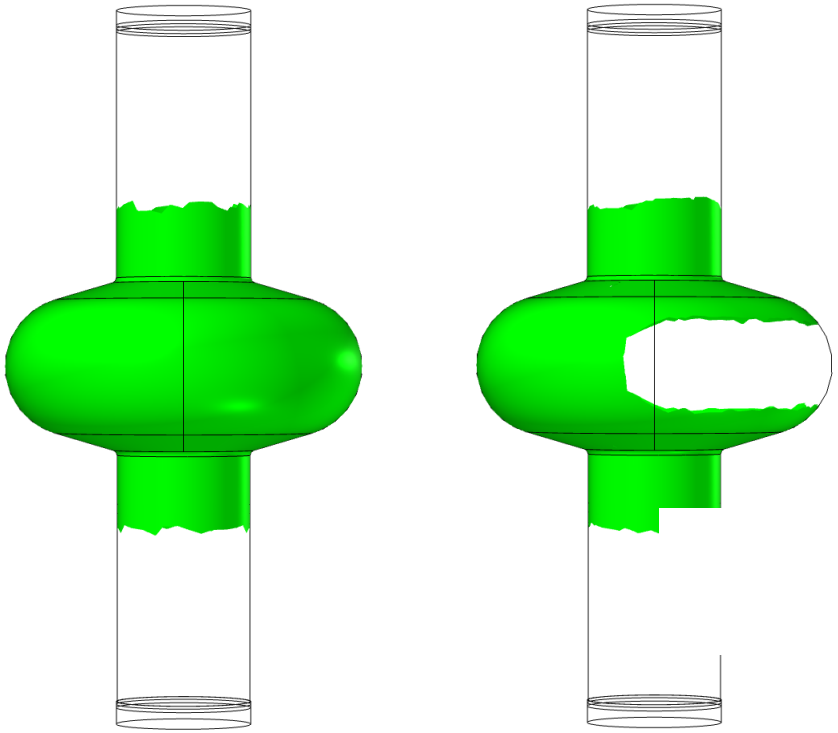
ΔE=U-IR(bath, cables…)

j= f(U,

- j, Current density
- **U, Overall applied tension**
- **T_b, Bath temperature**
- **τ, fluid dynamics**
- Sc/Sa, **Cathode geometry** & Cathodic/Anodic surface rati
- σ_l, Bath conductivity
- [b], Bath composition

1.3GHz
Mass flow rate: 30 L/min
T_b: 15 °C
0.5 rotations per minute
U: 7.4 V

$j = f(\eta_a)$ $j = f(\eta_a, \tau)$



1.3 GHz

Electropolished area

Muon collider

Building muon colliders is **very challenging**.

Muons decay with a **lifetime of 2.2 ·10^{-6} s if at rest**, while in a machine with a centre-of-mass energy of 3 TeV each beam has an energy of 1.5 TeV and the muons have a longer lifetime, **3.1·10^{-2} s**. **In this very short time, the produced muons have to be accelerated and transferred in the collider to make them interact, possibly several times**.

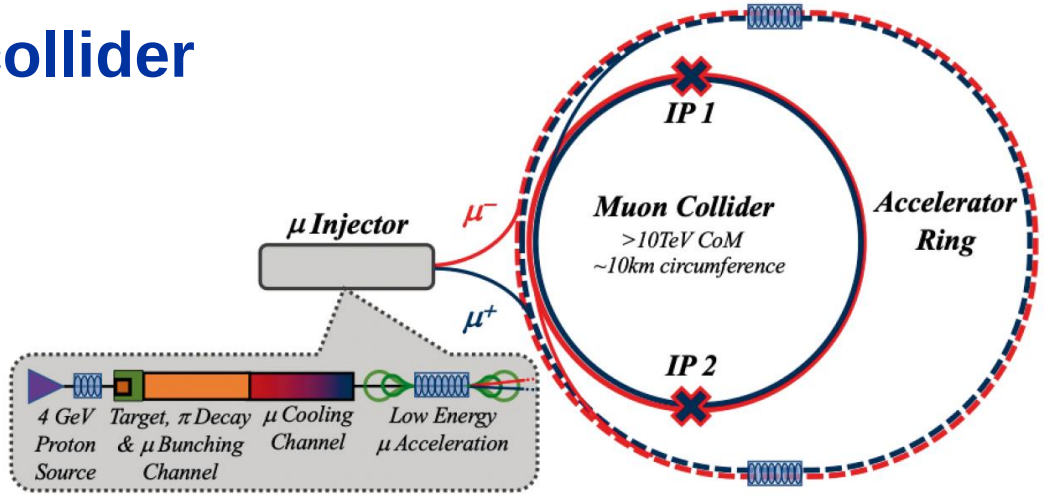
Three stages are needed: muons have to be **produced**, **accelerated** and finally **brought to collision.**

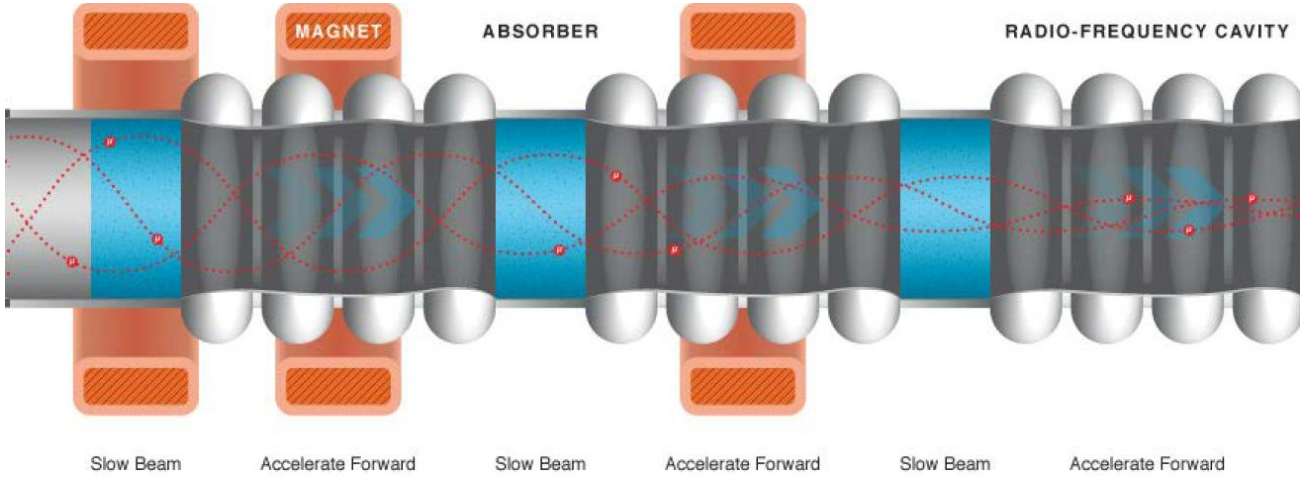
Muons are produced as tertiary particles by decay of pions created with an intense, **typically several MW**, **proton beam interacting with a heavy material target**.

The muon beam is **produced with low energy** and hence a limited lifetime.
It has **very large transverse and longitudinal emittances**.
It needs **to be cooled** by approximately five orders of magnitude in the six-dimensional (6D) transverse and longitudinal phase space.

Muon collider

A **solenoidal cooling channel** was proposed and cooling of muons was demonstrated by using both **liquid hydrogen and lithium hydride absorbers**





Ionization cooling is achieved by reducing the beam momentum through ionization energy loss in absorbers and **replenishing the momentum loss only in the longitudinal direction** through radio frequency (RF) cavities.

TE-VSC participate in the study. Our task is to contribute to the feasibility study of ionisation cooling investigating very thin beam window separating vacuum from liquid hydrogen. Presently we are studying **1-μm thick** 6×6mm **Si_2N_3 window** at ≈5 bar pressure

In period with **limited visibility**, we have to **reinforce and acquire new competences**.

Technological competences are key aspects of our flexibility and ability to join new studies and projects

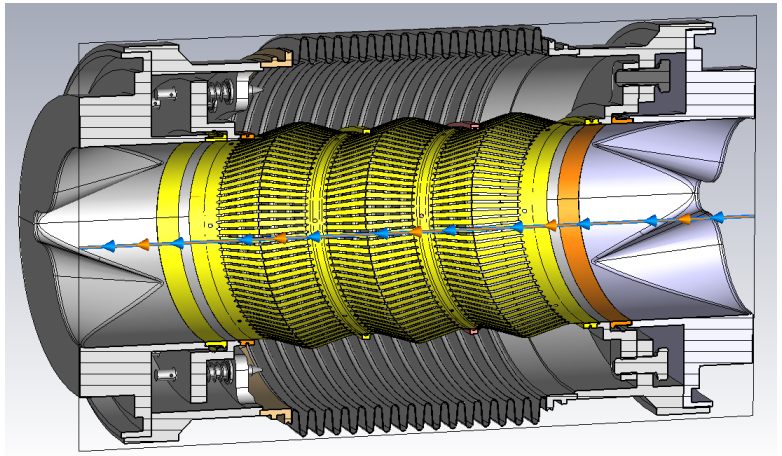
However, **our credibility comes from our services and operational daily work**. Only if we ensure excellent services/operation, we can see **optimistically into the future**.

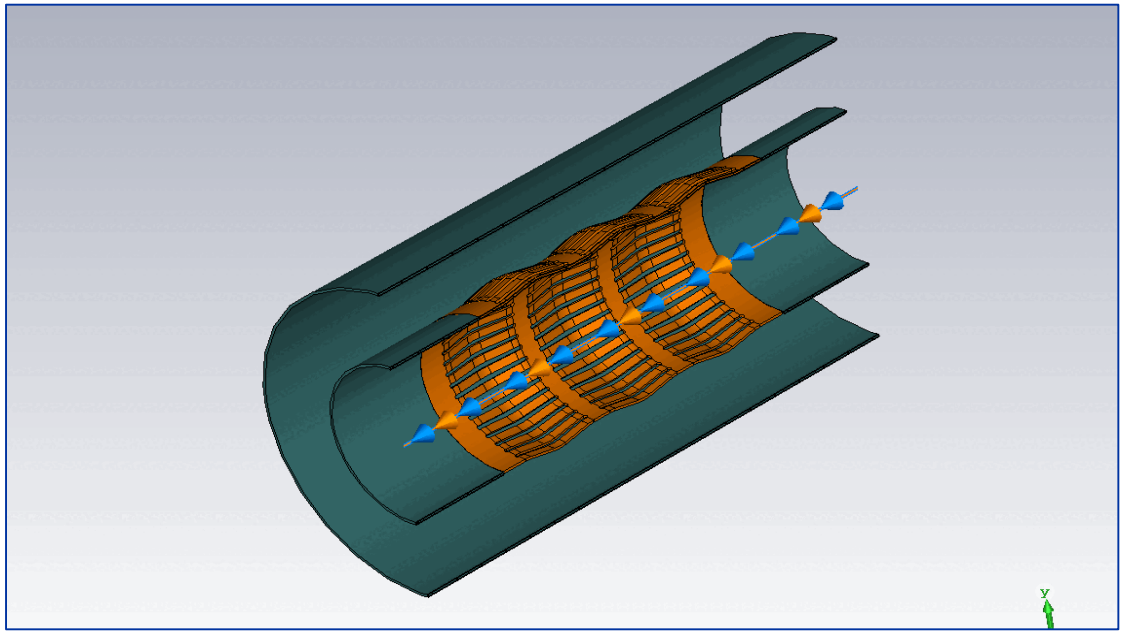
Beam impedance of deformable RF bridge

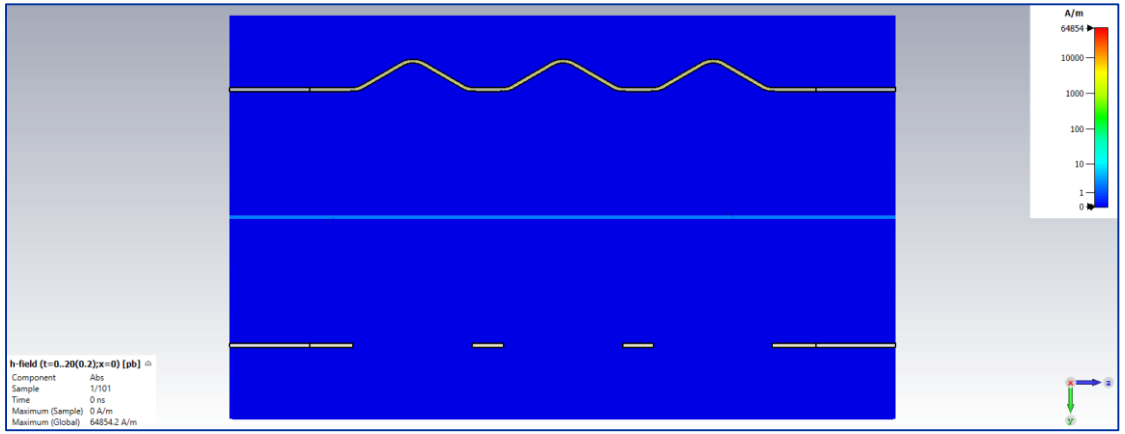
3 types of warm modules in HL-LHC

- Ø63, Ø150, Ø250

Determination of the longitudinal and transverse beam impedance

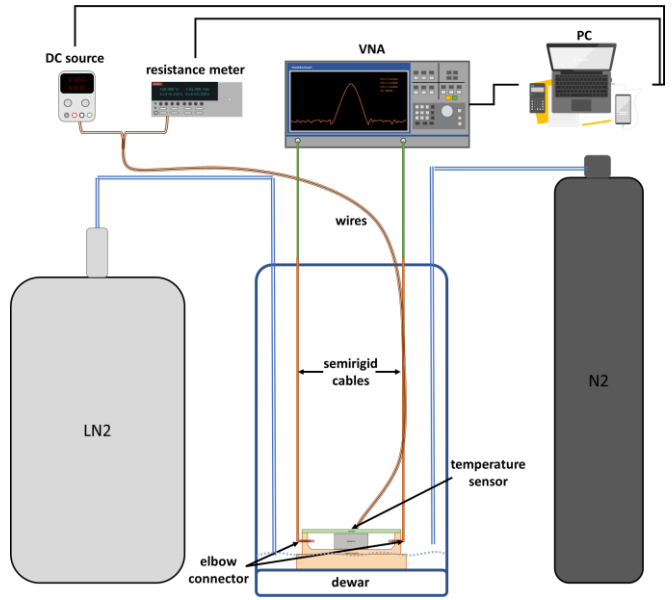


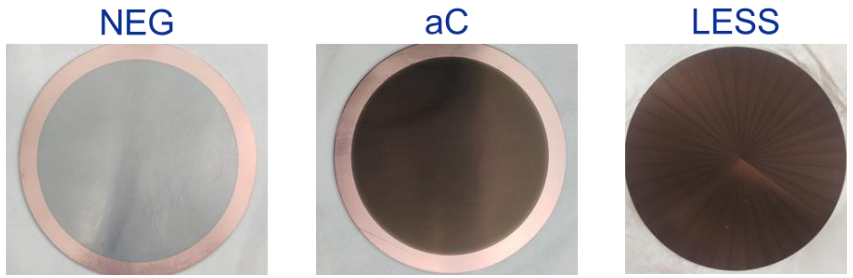


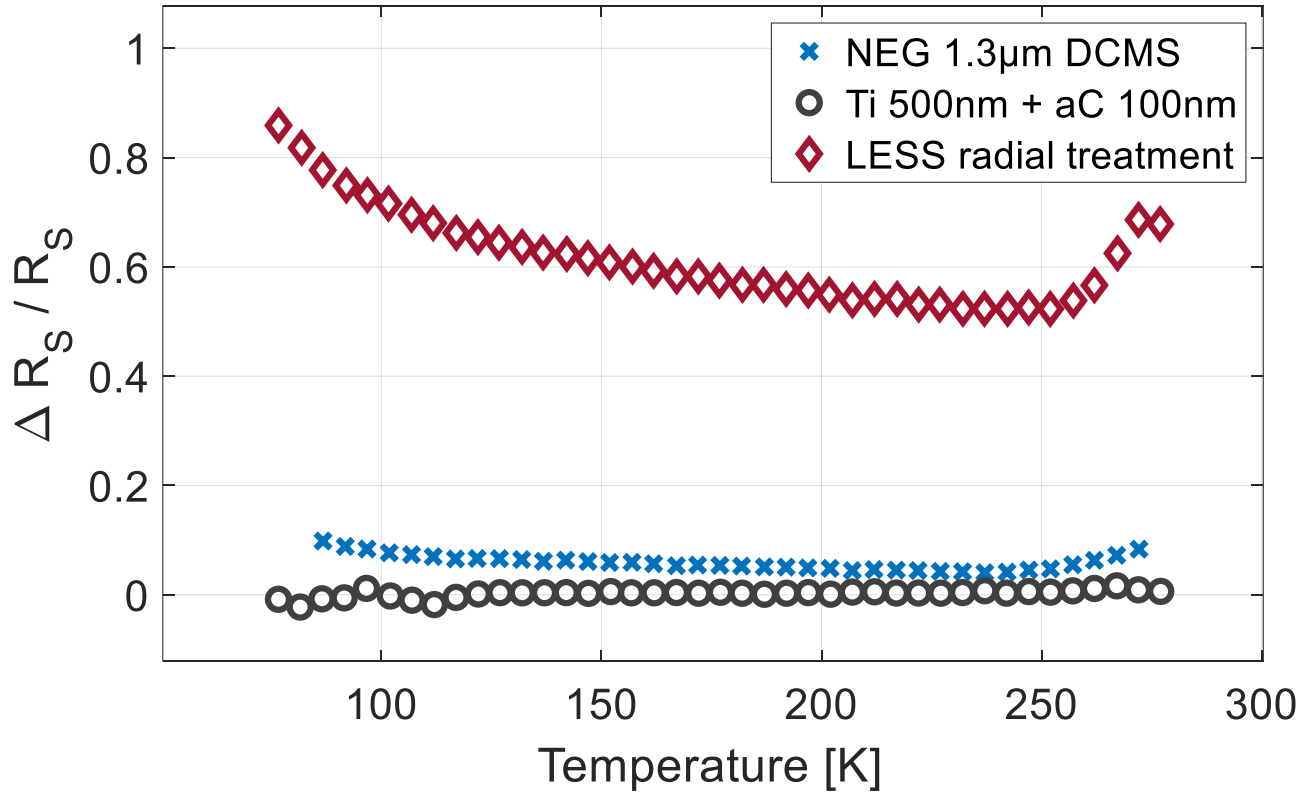


Surface impedance as a function of temperature

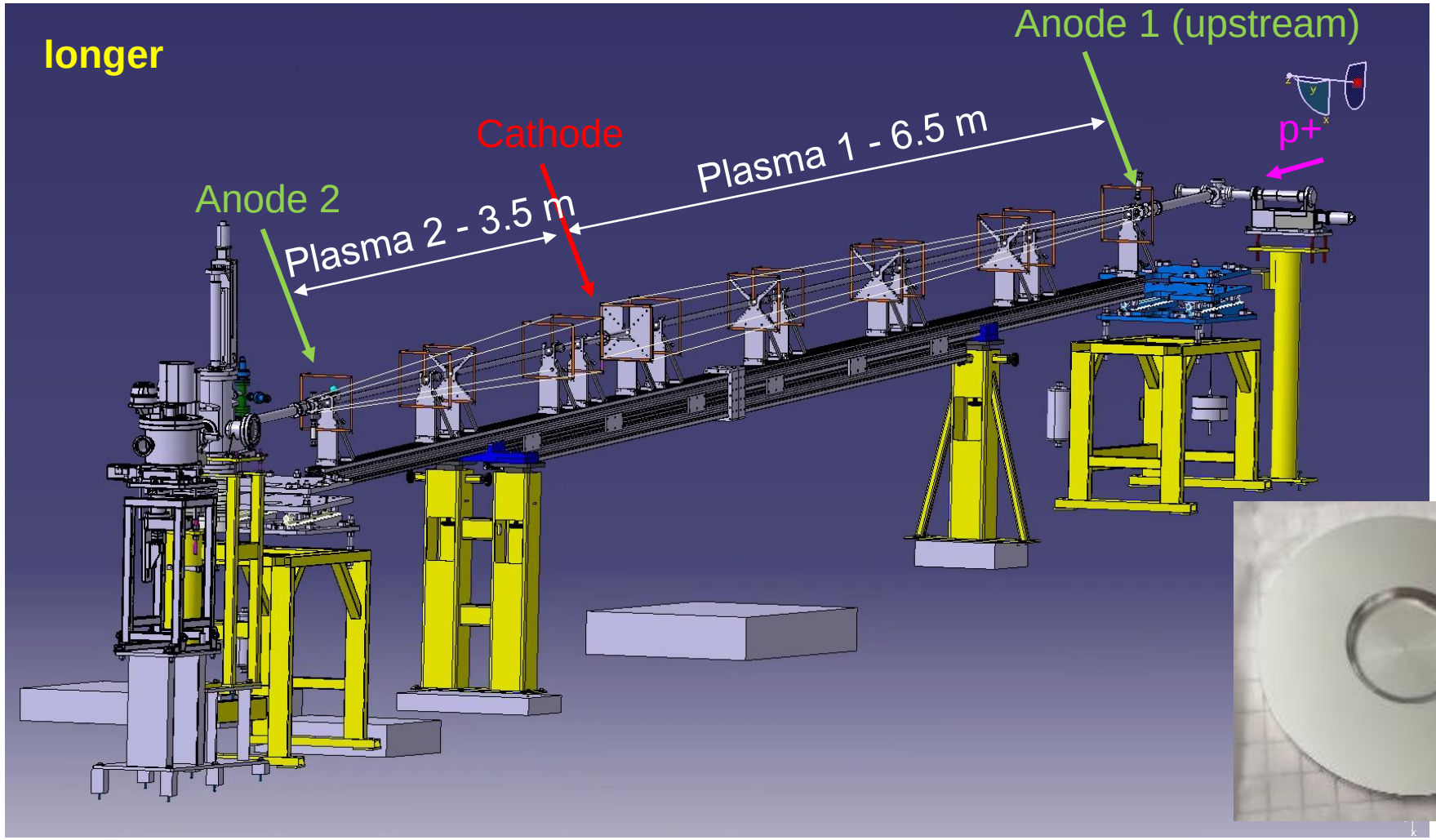
Coatings and treatments caracterisation







Future acceleration techniques: 10-m plasma source for AWAKE tunnel



Extension to 10 m

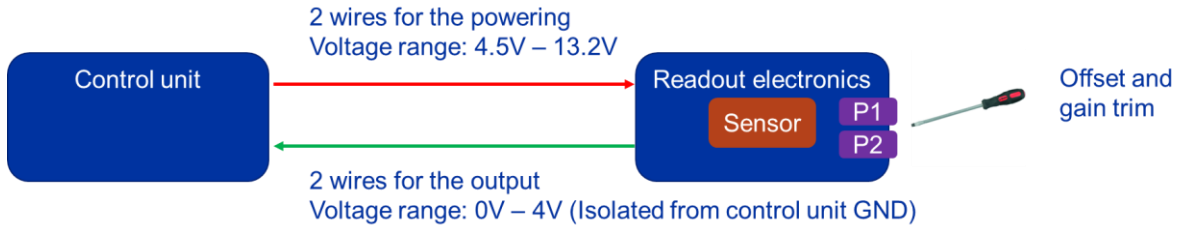
To be inserted in AWAKE tunnel in spring 2023

Test scalability: 2 plasma sources in series

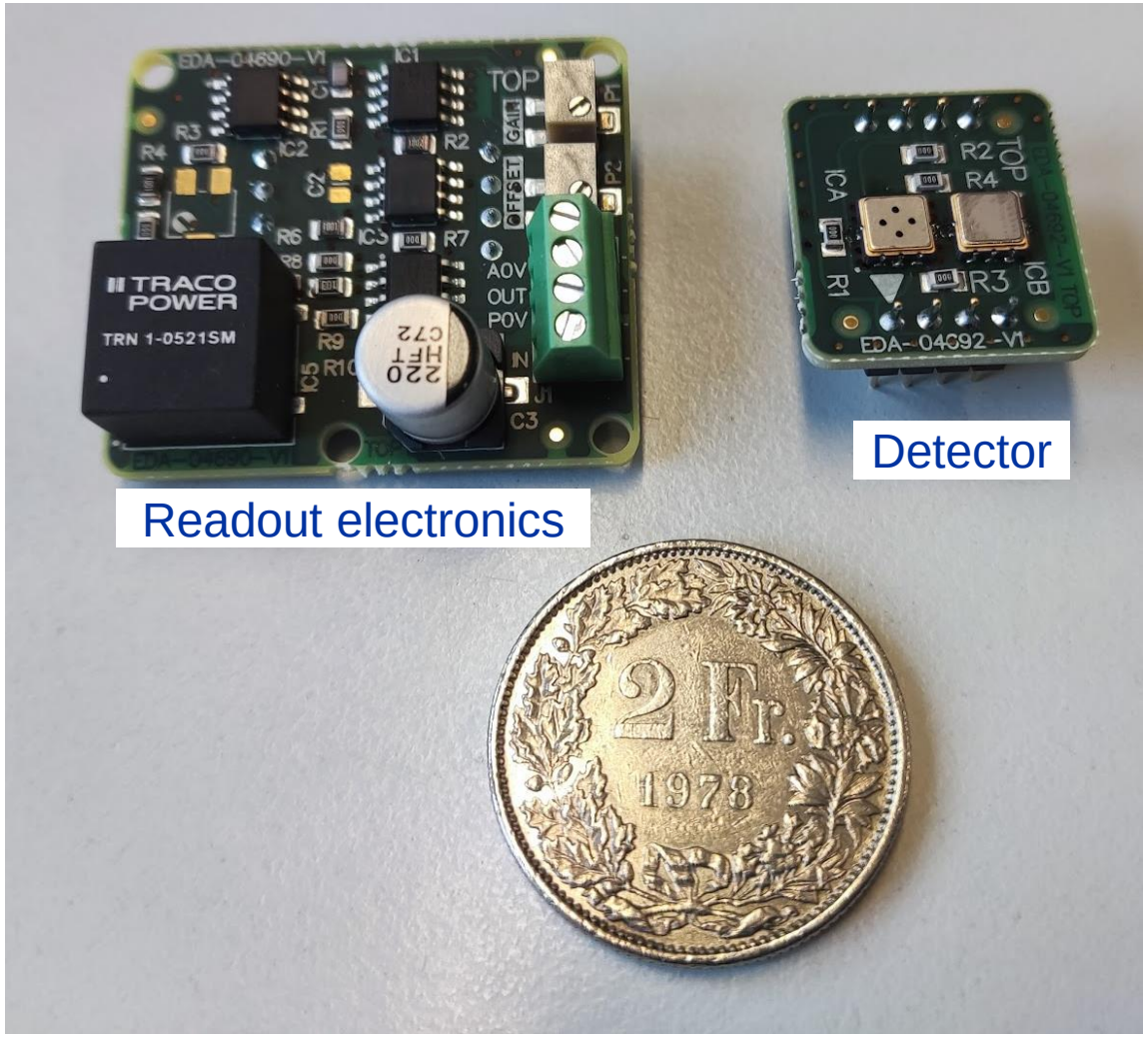
Gasket-like aluminium vacuum window (200 µm thick)

MEMS low-cost helium detector electronics

- **MEMS thermal conductivity sensors**
  - First demonstration prototype fully functional
  - Very small size: 37mm x 29mm x 25mm



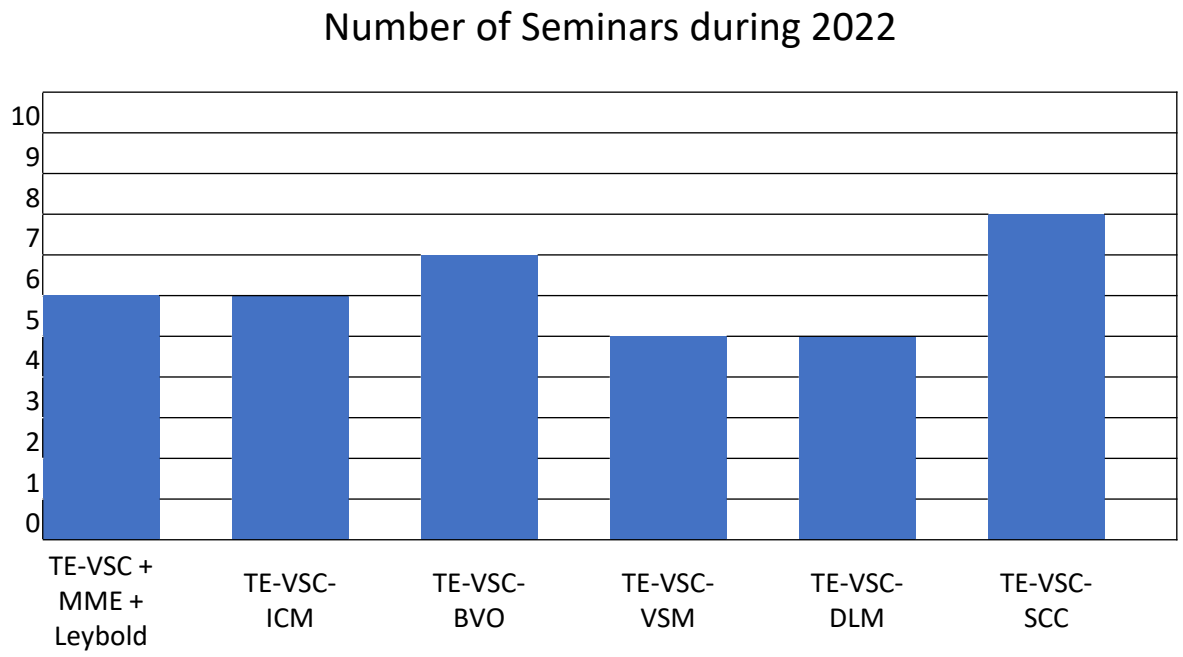
- **Foreseen upgrades for second prototype**
  - Further size reduction
  - Battery powered
  - **Wireless (LoRa)**
  - Radiation tolerant



TE-VSC Seminars: best way to share info in the group, please participate!

38 seminar talks in 22 group meeting, including Leybold's day and two **joint MME-VSC seminars.**

Good collaboration and support from the whole VSC group; excellent way to **share information**.



Merci à vous tous!