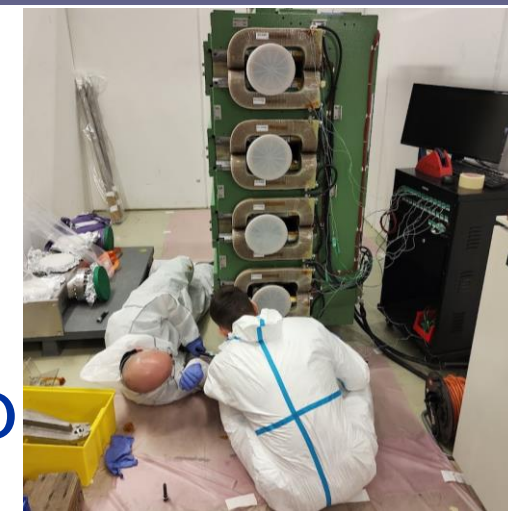
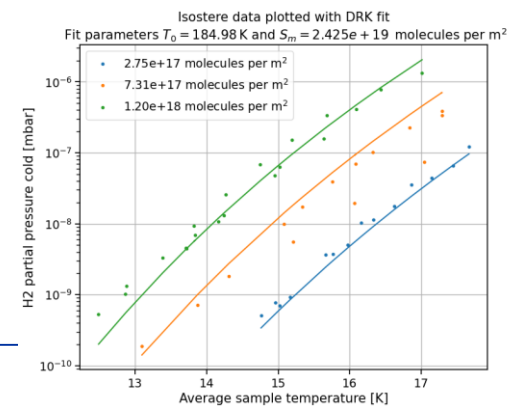


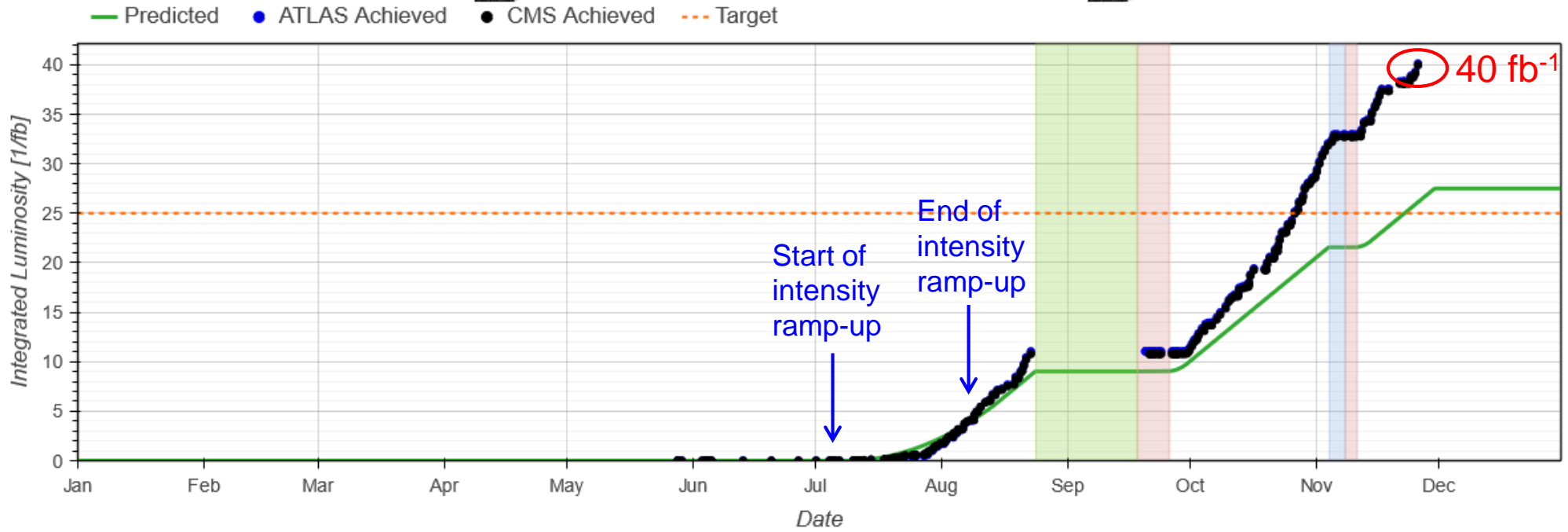
# Technology Department Vacuum, Surfaces and Coatings Group 2022's General Meeting



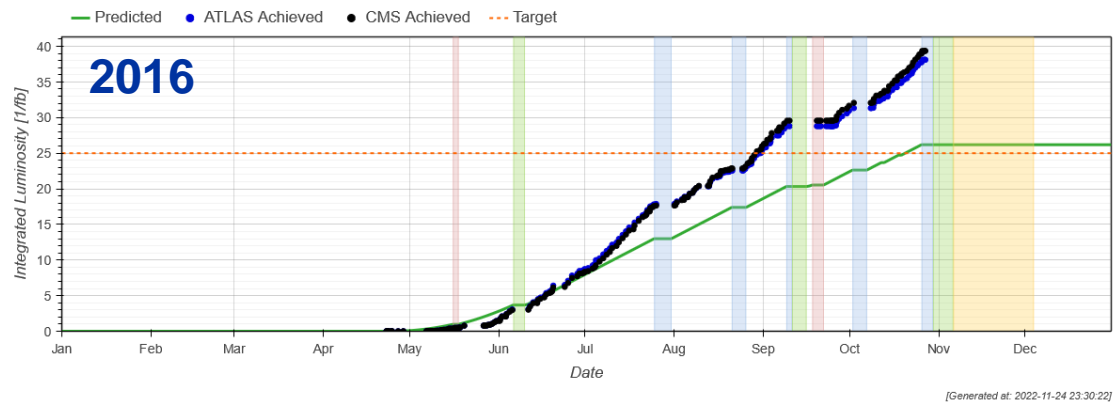
**Paolo Chiggiato**  
Group Leader



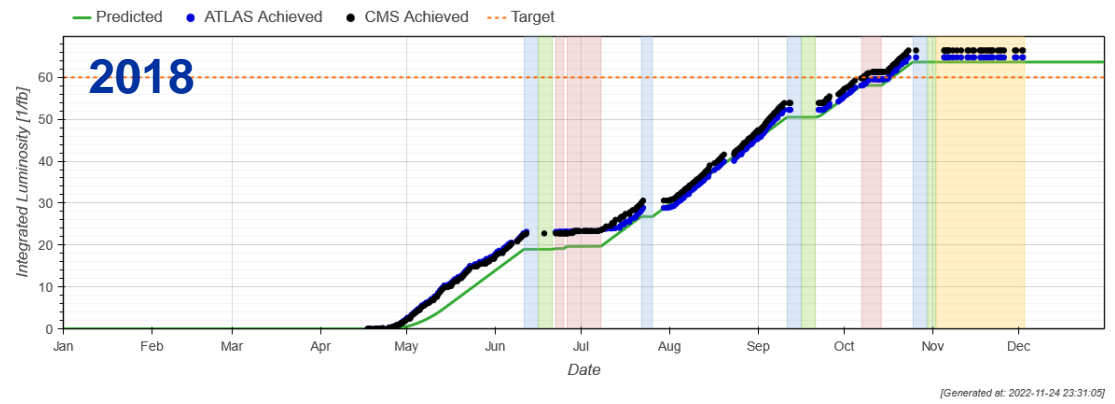
# Outstanding results in 2022



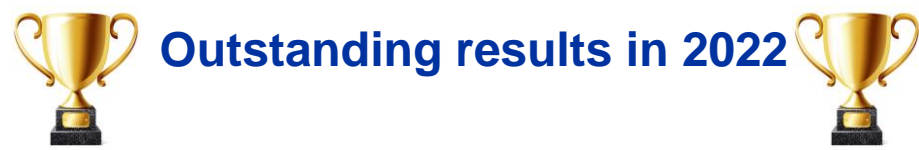
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[Generated at: 2022-11-24 23:30:22]

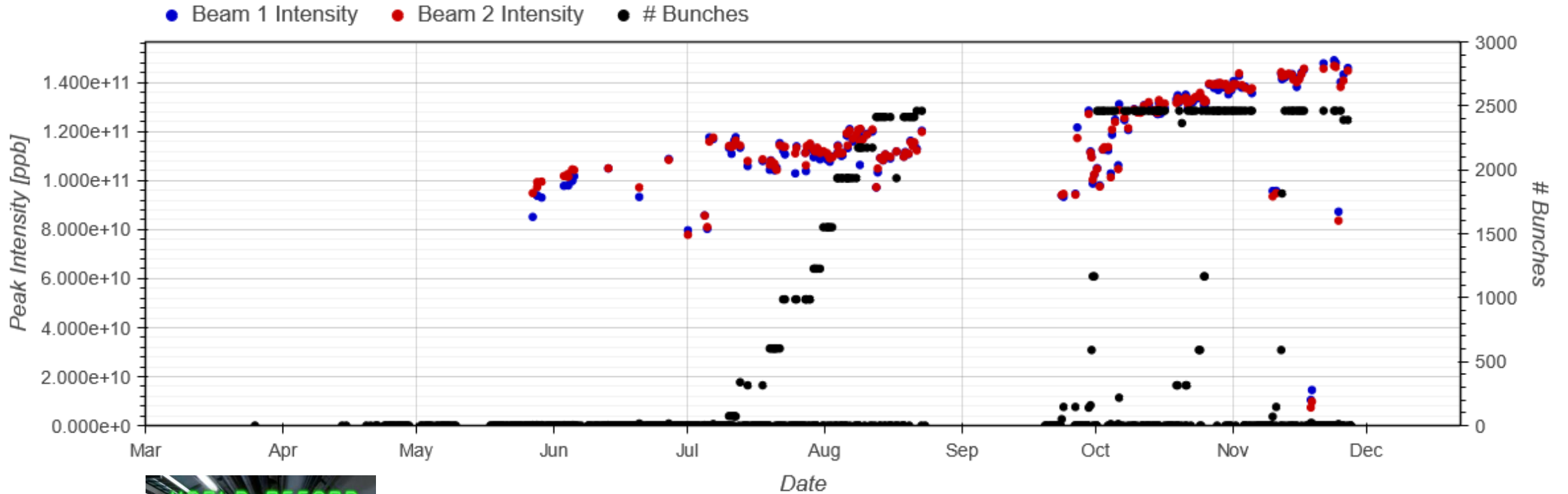


[Generated at: 2022-11-24 23:31:05]



## Outstanding results in 2022

Approached  $1.5 \times 10^{11}$  ppb at start of stable beams. Reached **record stored beam energy** of almost **400 MJ** (enough to melt 550 X 2 kg of Cu)



[Generated at: 2022-11-27 18:17:05]



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

## LINAC4

LINAC4 availability  
**97.3%**

Vacuum fault duration  
**0.5h**

## PSB

PSB availability  
**95.3%**

Vacuum fault duration  
**18.2h**

## PS

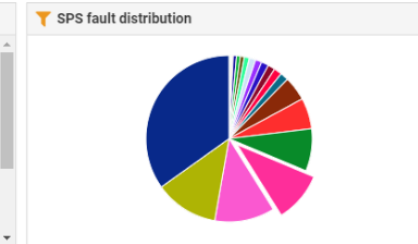
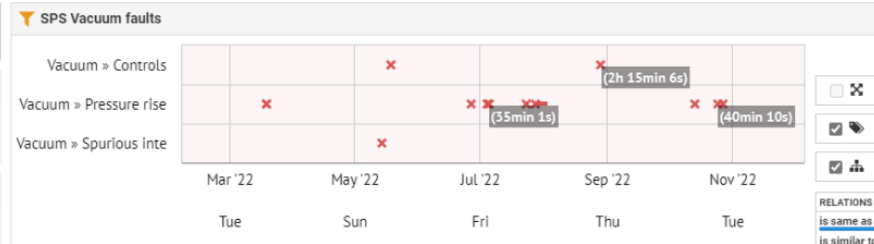
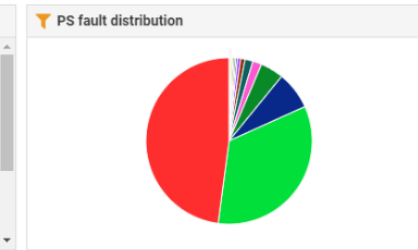
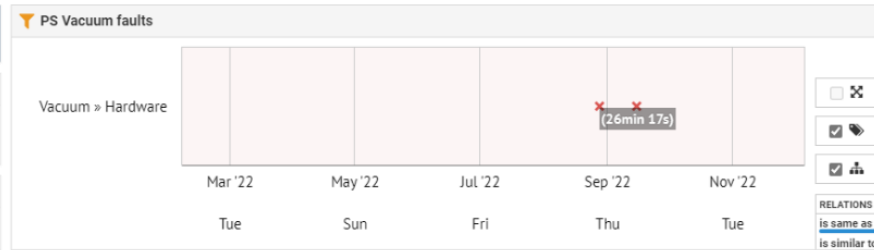
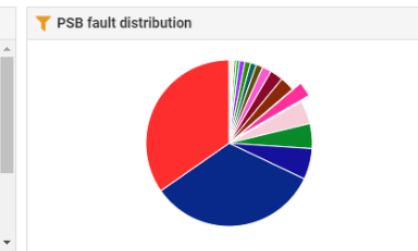
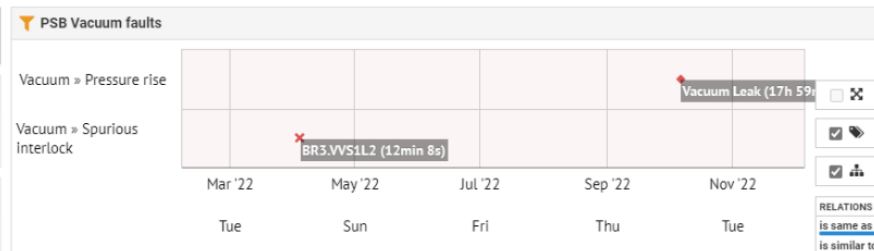
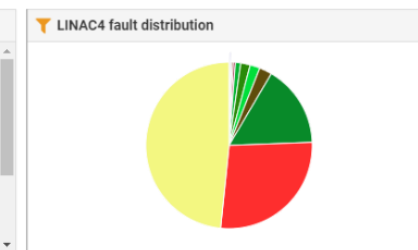
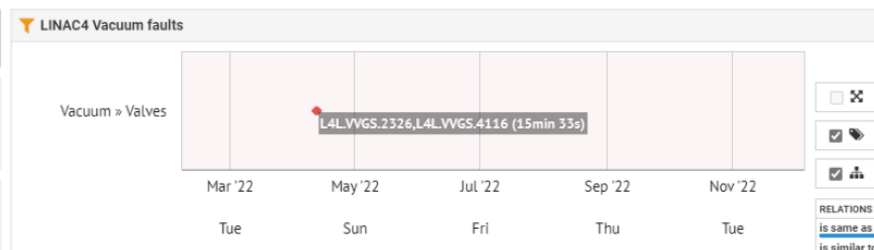
PS availability  
**89.2%**

Vacuum fault duration  
**3.1h**

## SPS

SPS availability  
**80.3%**

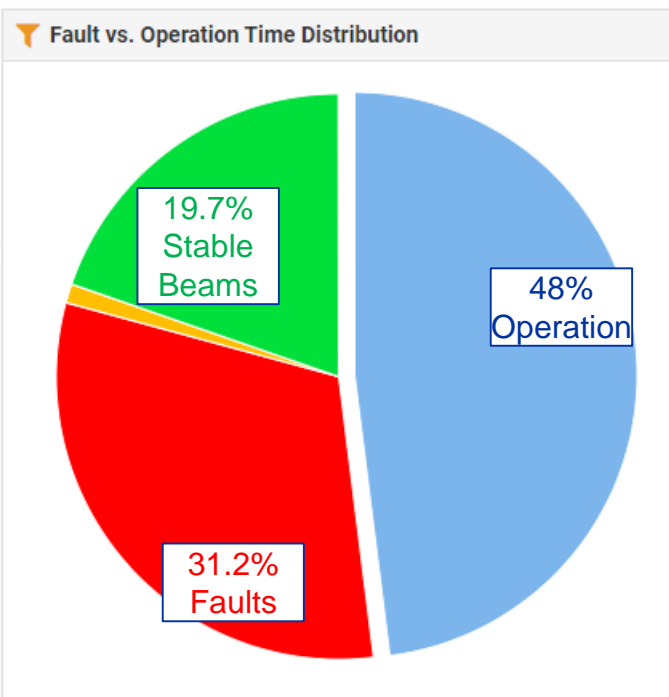
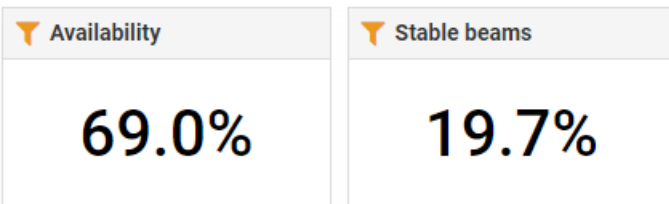
Vacuum fault duration  
**166.3h**



# LHC Operation

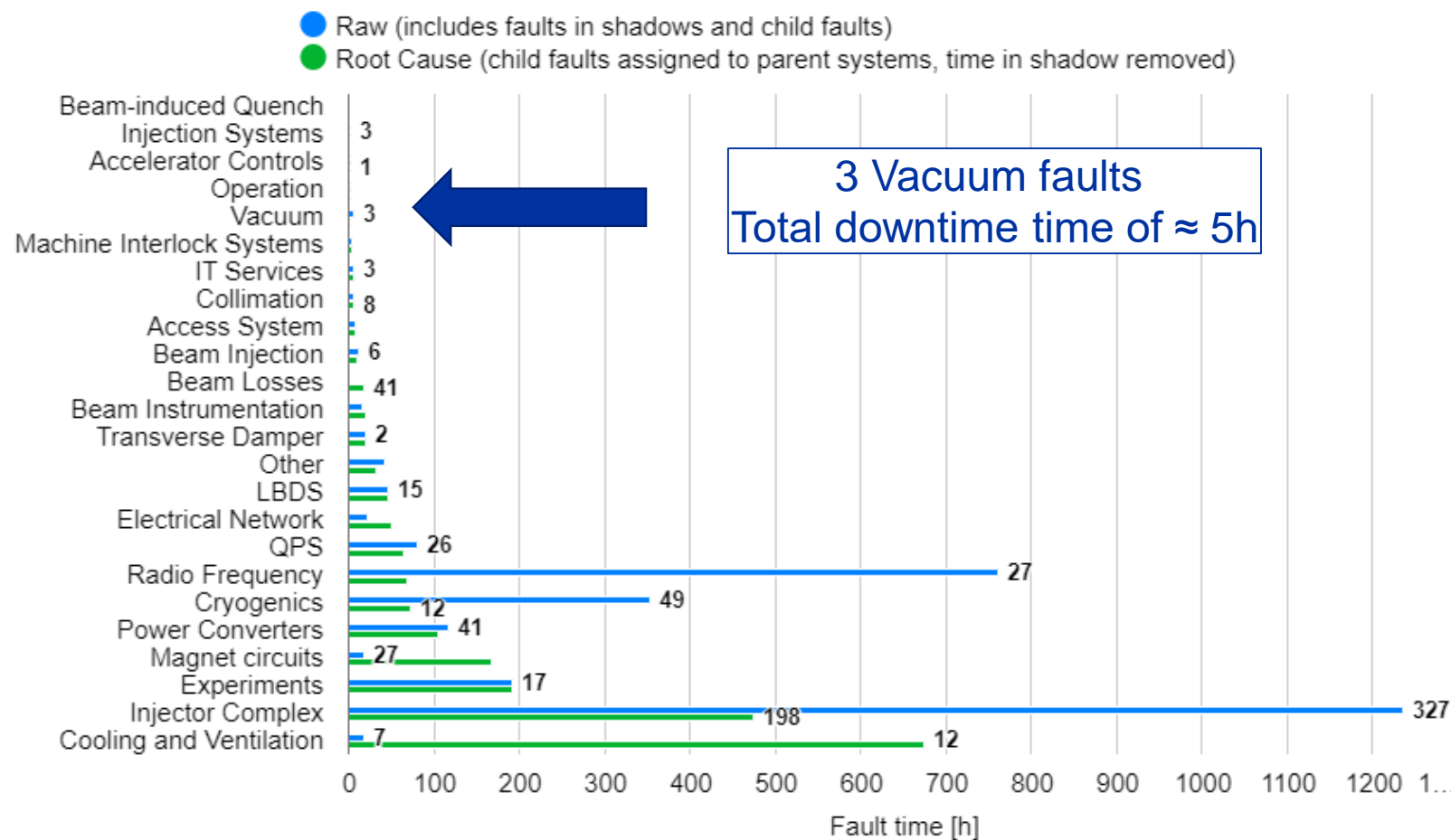


Outstanding results in 2022



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

Total Downtime vs. LHC Impact by System



## 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 1<sup>st</sup> 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



OM



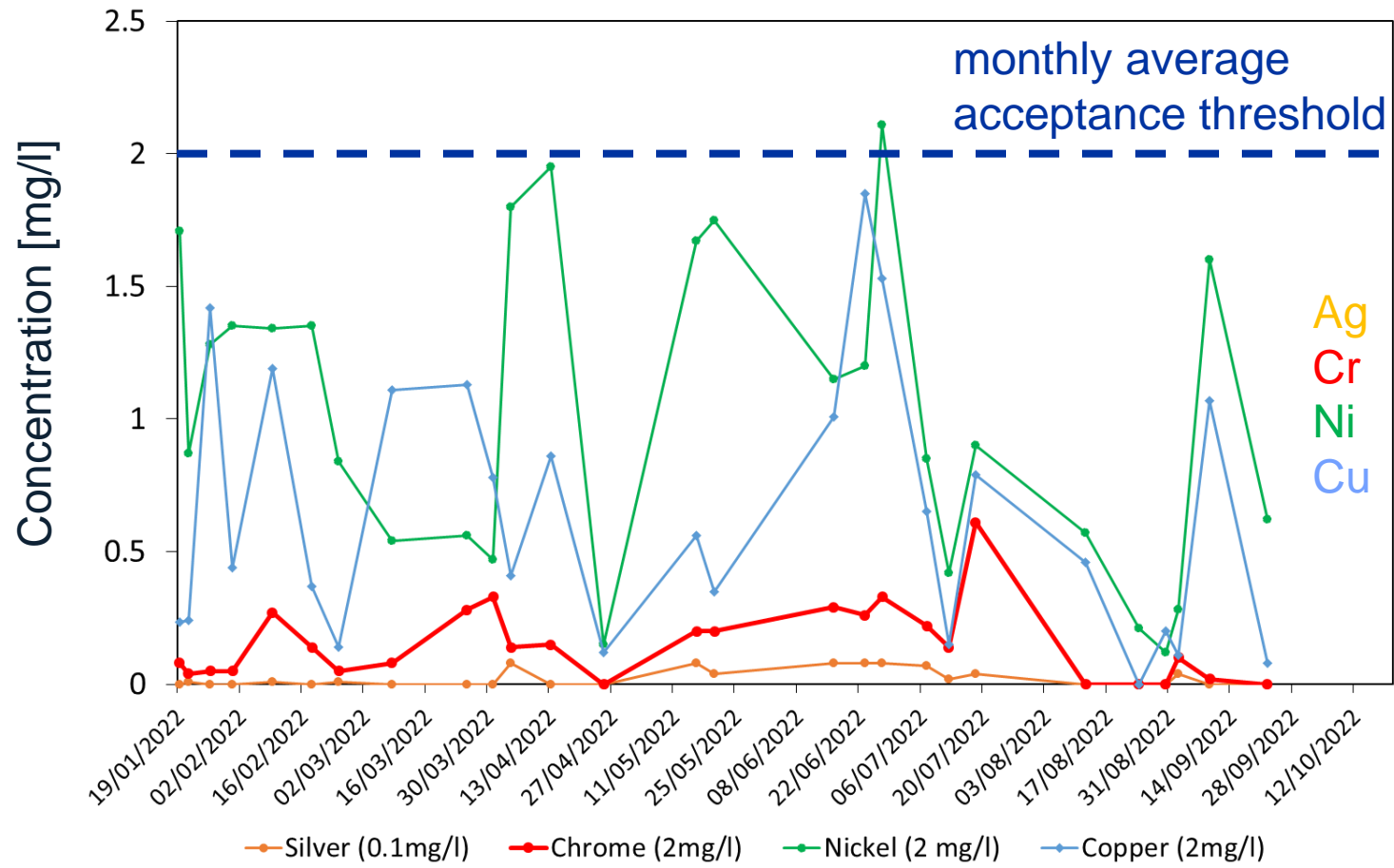
C





# 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

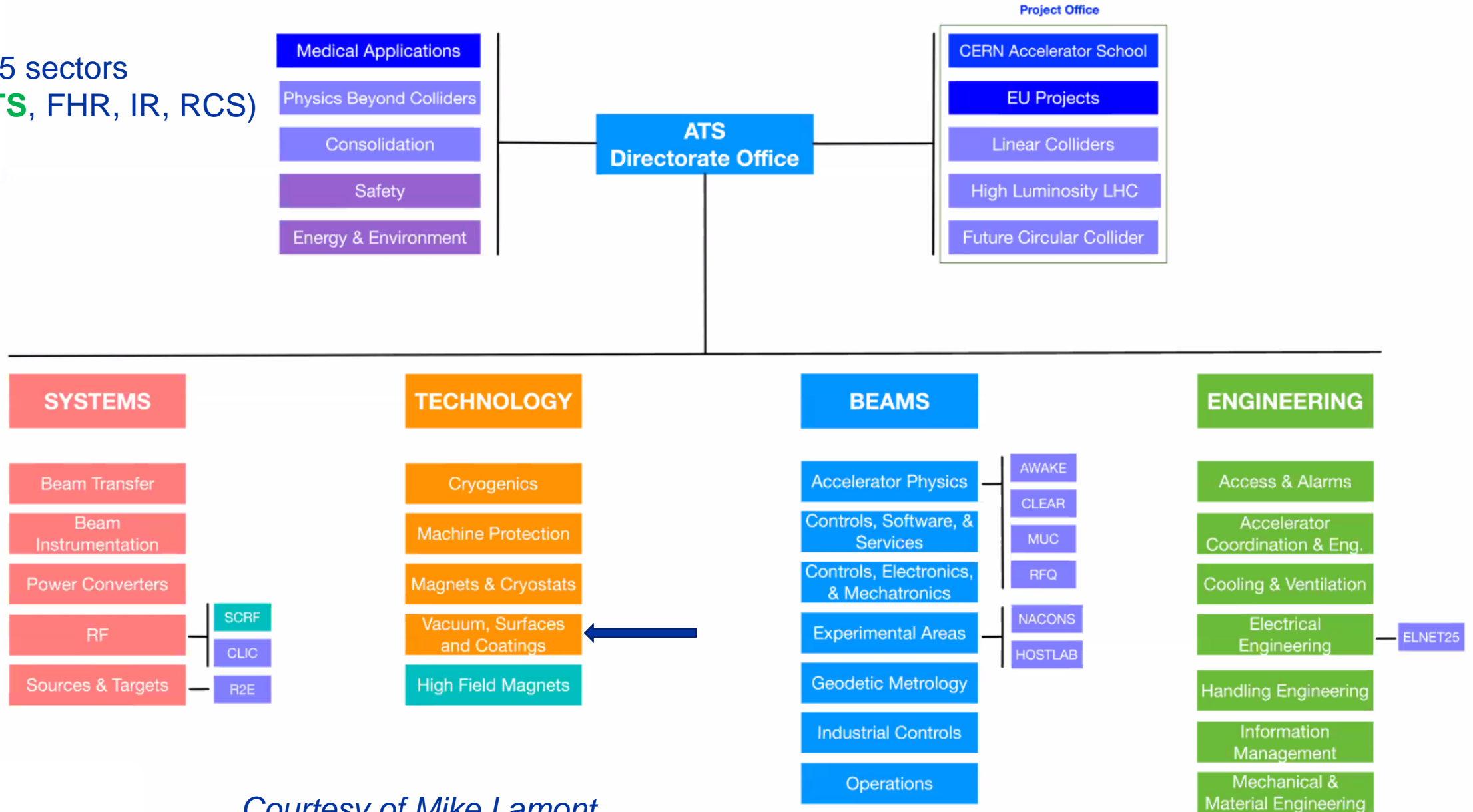
**Our A&T director  
Mike Lamont**



**Our TE Department Head  
José Miguel Jimenez**



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



*Courtesy of Mike Lamont*

## SECRETARIAT



## TE – VSC

## Vacuum, Surfaces &amp; Coatings group



## GL OFFICE



## Vacuum Studies and Measurements (VSM)



## Beam Vacuum Operation (BVO)



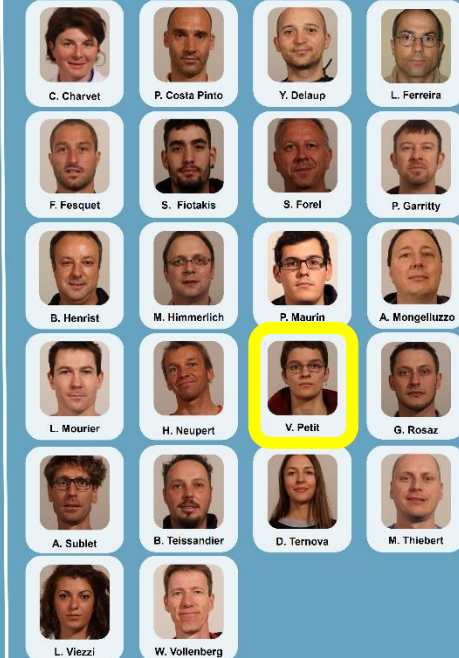
## Design, Logistics &amp; Methods (DLM)



## Interlocks, Controls &amp; Monitoring (ICM)



## Surface, Chemistry Coatings (SCC)



Staff Members

## Left TE-VSC in 2022:






















































- Pablo Prieto (ICM)
- Patrick Lepeule (BVO)
- Claude Collomb Patton (BVO)

## New staff members in TE-VSC:

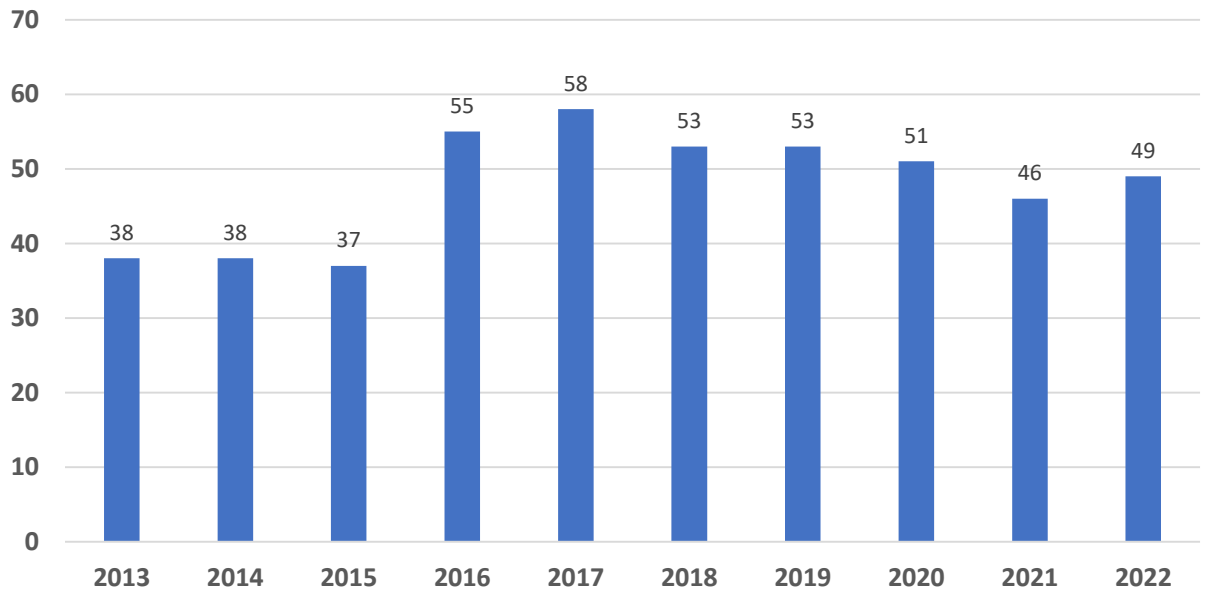
- Benjamin BAYLISS (ICM)
- Valentine PETIT (SCC)

# Student, fellows and collaborators in Nov 2022

**Students & collaborators**

Vacuum Studies and Measurements (VSM)	Beam Vacuum Operation (BVO)	Design, Logistics & Methods (DLM)	Interlocks, Controls & Monitoring (ICM)	Surface, Chemistry Coatings (SCC)
 C. Castro Squitiro FELL 31.01.2024  P. Hevričan FELL 31.01.2024  A. Hooper FELL 31.05.2024	 A. Bissol FELL 31.01.2024  K. Hoponi FELL 31.10.23  R. Hill James FELL 31.05.2023  T. Raski FELL 31.03.2024	 H. Hevričan FELL 31.08.2024  M. Knöck FELL 20.09.2024  B. Rovisco FELL 21.05.2023  M. Sennell FELL 31.05.2024  V. Giovino DOCT 28.02.2023	 J.D. Francisco Rebelo FELL 30.09.2023  J. Staniszewski FELL 30.09.2023  D. Terfinkiy FELL 31.03.2023  S. Gonçalves Soares PJAS 31.12.2023  M. Khatif PJAS 31.12.2022	 T. Agulhon FELL 31.12.2022  M.C. Dienero FELL 20.02.2024  A. Gullard FELL 31.10.2024  S. Lenti FELL 06.11.2023  T. Munka FELL 20.09.2023  A. Rosasco FELL 31.03.2024  T. Nirodhi FELL 20.02.2023  S. Saraglia FELL 20.05.2024  M. Watkins FELL 30.06.2024  N. Souchet TRNE 31.12.22  G. Bellini TRNE 31.08.23  C. Amadio DOCT 31.12.2023  E. Bilo DOCT 31.07.2023  C. Perrone DOCT 28.02.2023  E. Straniero TECH 31.07.23  R. Cimbro COAS 09.05.2021
 P. Kivortz FELL 31.10.2023  J. Repolho Correia FELL 31.12.2023  A. Sibatzi FELL 29.09.2023  E. Terfinkiy TECH 30.06.2023  Q. Duong DOCT 31.03.23  C. Bevilini DOCT 31.10.23  A. Passarelli COAS 31.12.2022	 O. Ribeiro FELL 31.10.2023  X. Sax FELL 31.05.2024  P. Czapkiewicz TECH 31.07.2023  P. Nacidiou TECH 31.07.2023  C. Scaccia DOCT 31.03.2023  A. Gallero PJAS 30.04.2023  I. Lopez Cuevas PJAS 31.03.2023  Y. Mertins PJAS 31.12.2022  T. Silva PJAS 31.10.2023	 R. Perez Martinez PJAS 31.12.2022  F. Niccoli PJAS 31.06.2023	 M. Khatif PJAS 31.12.2022	 E. Straniero TECH 31.07.23  R. Cimbro COAS 09.05.2021

November 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	<del>BREGLIOZZI, Giuseppe Dr.</del> Paolo
SINTUREL	Alexandre Xavier	STAF	FERREIRA SOMOZA, Jose Antonio Dr.
PASQUINO	Chiara	STAF	<del>BREGLIOZZI, Giuseppe Dr.</del> 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	BREGGIOZZI, 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	BREGGIOZZI, Giuseppe Dr.	no
HENNELI	Kristoffer	TE-VSC-BVO	FELL	3	BREGGIOZZI, Giuseppe Dr.	no
RASKA	Tomas	TE-VSC-BVO	FELL	2	SESTAK, Josef Mr.	no
HILL-JAMES	Rowan Cape	TE-VSC-BVO	FELL	3	BREGGIOZZI, Giuseppe Dr.	no
LOPEZ CUEVAS	Isabel	TE-VSC-BVO	PJAS	2	BREGGIOZZI, Giuseppe Dr.	no
NASCIMENTO MARTINS	Vasco Miguel	TE-VSC-BVO	PJAS	2	SESTAK, Josef Mr.	no
GALLORO	Alessio	TE-VSC-BVO	PJAS	2	BREGGIOZZI, Giuseppe Dr.	no
PEREIRA NAVE HENRIQUES DA SILVA	Tomas	TE-VSC-BVO	PJAS	2	BREGGIOZZI, Giuseppe Dr.	no
HANSEN	Jan Helge	TE-VSC-BVO	STAF	2	BREGGIOZZI, Giuseppe Dr.	no
WEVERS	Ivo	TE-VSC-BVO	STAF	3	BREGGIOZZI, Giuseppe Dr.	no
ZELKO	Nicolas	TE-VSC-BVO	STAF	3	BREGGIOZZI, Giuseppe Dr.	no
PAGE	Eric	TE-VSC-BVO	STAF	3	BREGGIOZZI, Giuseppe Dr.	no
CALEGARI	Didier	TE-VSC-BVO	STAF	3	SESTAK, Josef Mr.	no
BREGGIOZZI	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	BREGGIOZZI, Giuseppe Dr.	no
FINELLE	Julien	TE-VSC-BVO	STAF	3	BREGGIOZZI, Giuseppe Dr.	no
SESTAK	Josef	TE-VSC-BVO	STAF	2	BREGGIOZZI, Giuseppe Dr.	no
VAZQUEZ PELAEZ	Cesar	TE-VSC-BVO	STAF	3	BREGGIOZZI, Giuseppe Dr.	no
OWENS	Karl John	TE-VSC-BVO	STAF	3	BREGGIOZZI, Giuseppe Dr.	no

10

12 staff  
members

From 01-2023

November 2022

SECRETARIAT



Corine Hervet



V. Daglo  
VSM Section Leader

Vacuum Studies and Measurements (VSM)



M. Ady, S. Calistri, B. Jenninger, R. Kersevan, S. Meunier



Paolo Chiggiato  
-Group Leader-



G. Bregazzi  
BVO Section Leader

Beam Vacuum Operation (BVO)



D. Calegari, G. Catterozzi, J. Chauve, J. Finella, J. Johnson, K. Owsin, E. Page, J. Sestak, C. Vazquez Polaz, I. Weyers, N. Zelko

# TE – VSC

## Vacuum, Surfaces & Coatings group



C. Garion  
DLM Section Leader

Design, Logistics & Methods (DLM)



C. Ductac, H. Kox, N. Kox, W. Moon, M. Marzace, J. Penz Caputo, H. Rambau, F. Santangelo, A. Vidal



G. Pigry  
ICM Section Leader

Interlocks, Controls & Monitoring (ICM)



B. Baylen, J.R. Alvarez Ferrera, N. Chatzigeorgiou, J. De La Garza S., A. Gutierrez, I. Lebatto Selo, A. Palma E. Rocha, L. Zygareopoulos



Paul Crnkovic  
IVO Group Leader



J. A. Ferreira S.  
IVO Section Leader

Injectors & Insulation Vacuum Operation (IVO)



F. Denavaz, A. Harrison, J. Korkkansa, G. Marica F., A. Michet, C. Paquinio, A. Simoni, N. Thaus

GL OFFICE



P. Geana  
GL Office, Beam, Analysis



M. Taborelli  
SCC Section Leader

Surface, Chemistry Coatings (SCC)



C. Charvet, P. Costa Pinto, Y. Delap, L. Ferreira, F. Faquet, S. Flotakis, S. Forel, P. Garrity, S. Harist, M. Hinzreich, P. Maurin, A. Mongeluzzo, L. Mourier, H. Neupert, V. Peiz, G. Rosaz, A. Sublet, B. Talsandier, D. Ternova, M. Thibout, L. Vizzi, W. Volkenberg

Staff Members

Students & collaborators



A. Anagnostou, C. Castro Sagustin, R. Houdouin, J. Nguyen, F. Schuler, E. Tiberon, G. Wang, C. Zouffou, A. Anagnostou



A. Hemon, B. Kim Jansen, J. Kosta, G. Lohman, P. Caporinello, C. Scazio, A. Galloni, I. Lopez Casas, V. Marini, T. Siva



R. Haidner, M. Krasch, S. Baccini, M. Zanoni, V. Stelmas, S. Pavesi Barbieri, F. Scalet



J.D. Francisco Rebelo, J. Stancanescu, D. Tsyhikty, S. Cavallini Soares, M. Khalil



A. Blaud, X. Ben, P. Santilli



A. Aguilera, M.C. Swardson, A. Guffard, F. Marica, A. Scazio, V. Simioni, M. Savellet, S. Belfini, M. Walker, K. Ben, G. Belfini, C. Borella, R. Ben, C. Pavesi, S. Borella, R. Carino



# 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



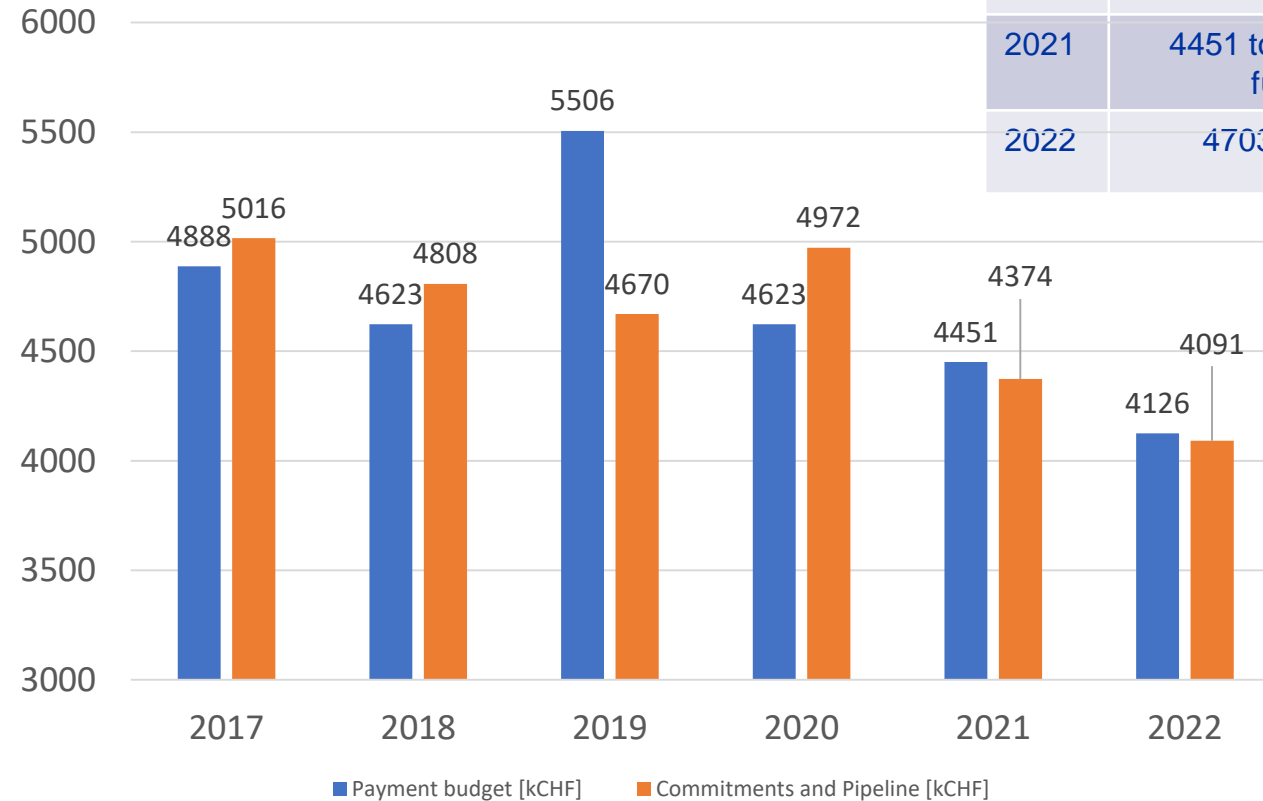


Jan Gossaert, Portrait of a Merchant, 1530  
National Gallery of Art, Washington DC


## 2022 Budget

### 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



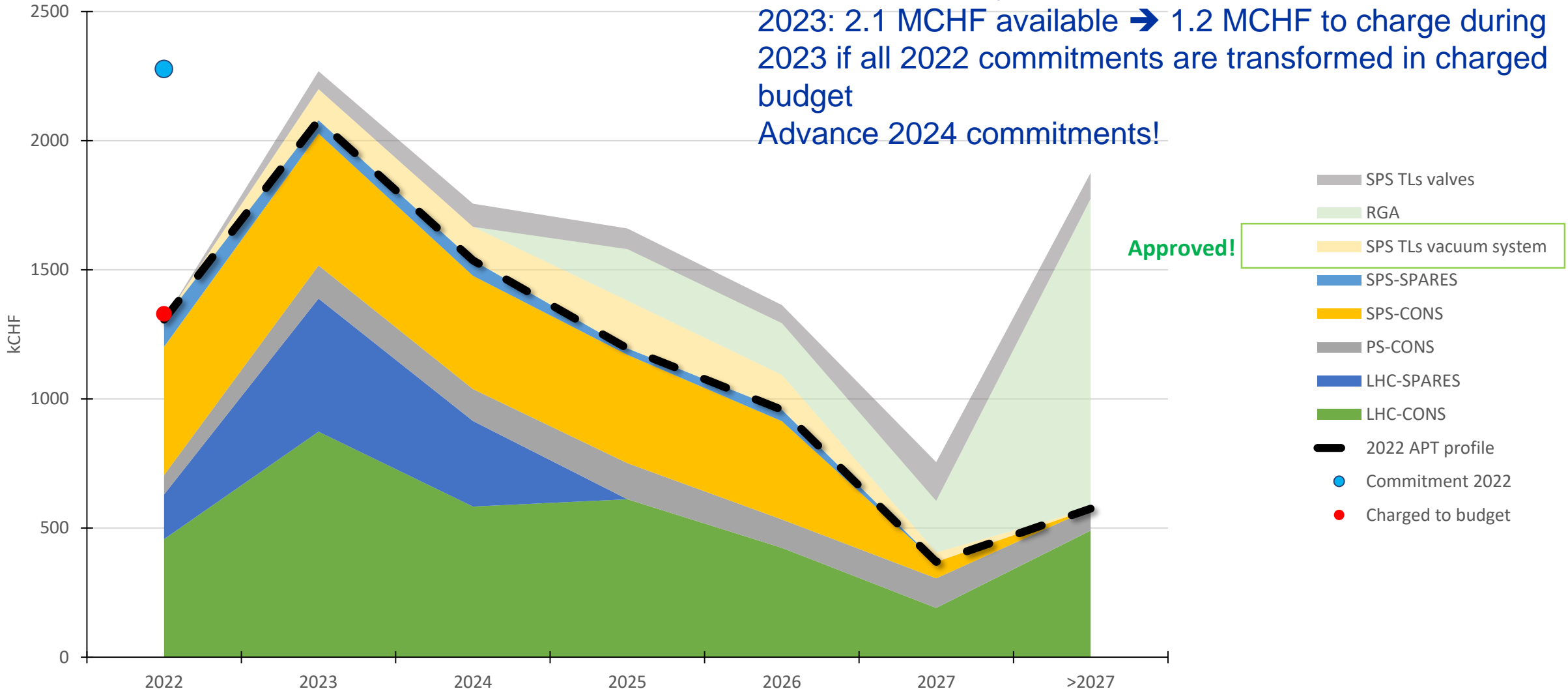
## New requests at Consolidation Day (October 2022)

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

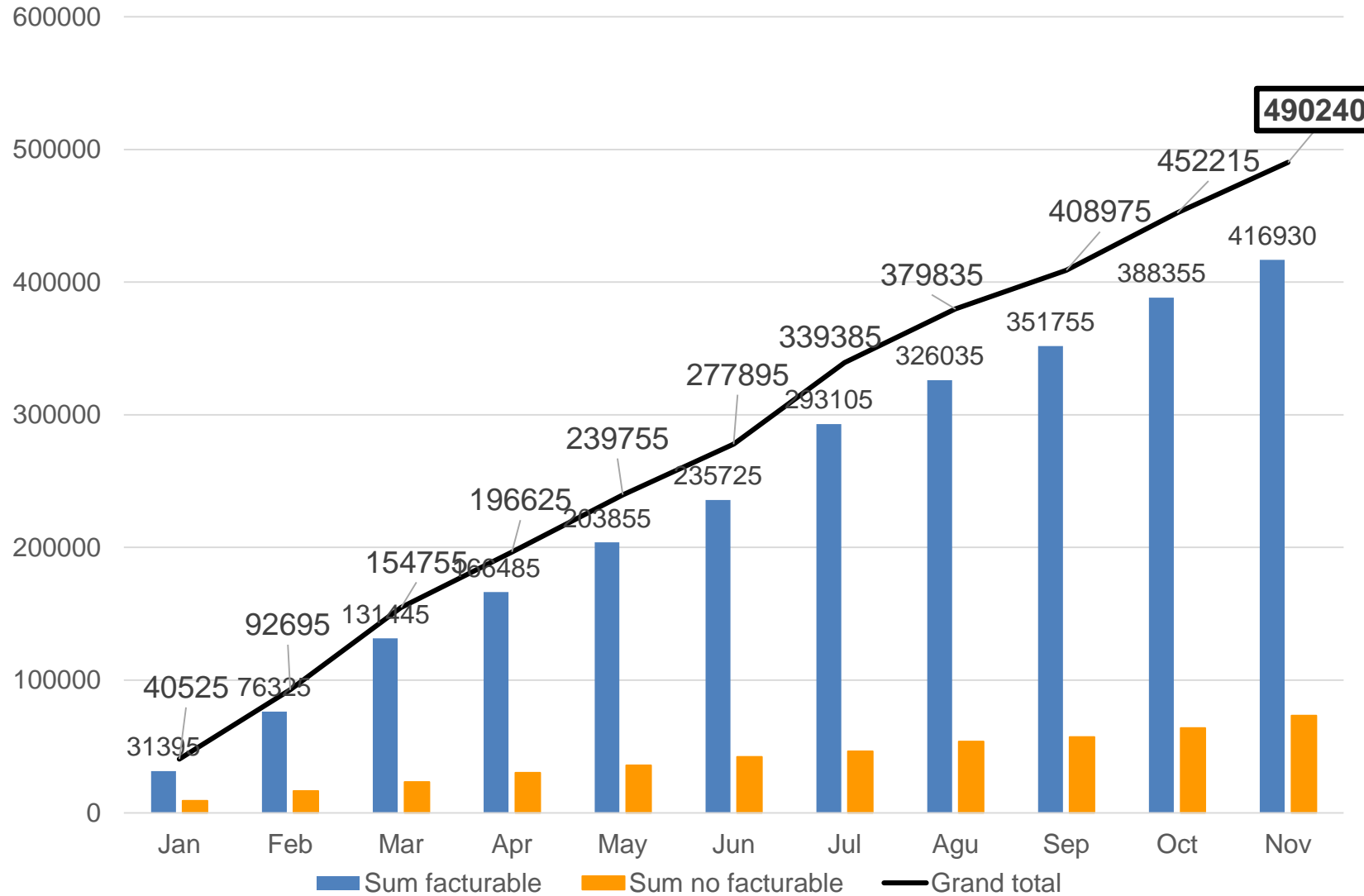
# Consolidation: Proposed spending profile

2022 Budget

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)

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

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

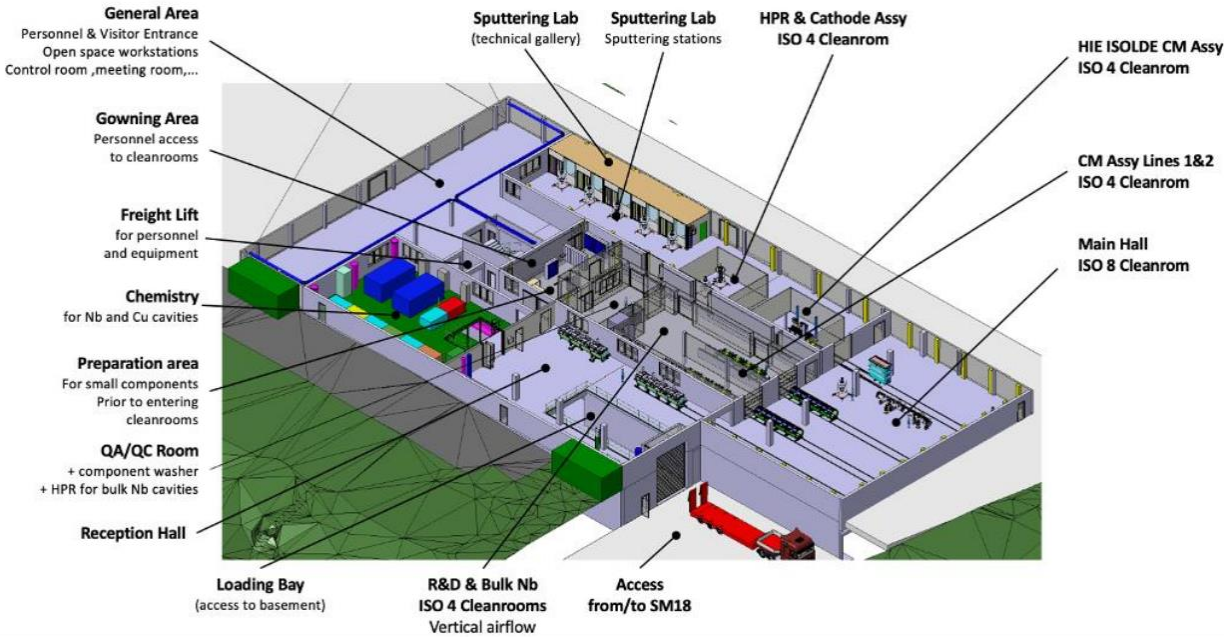
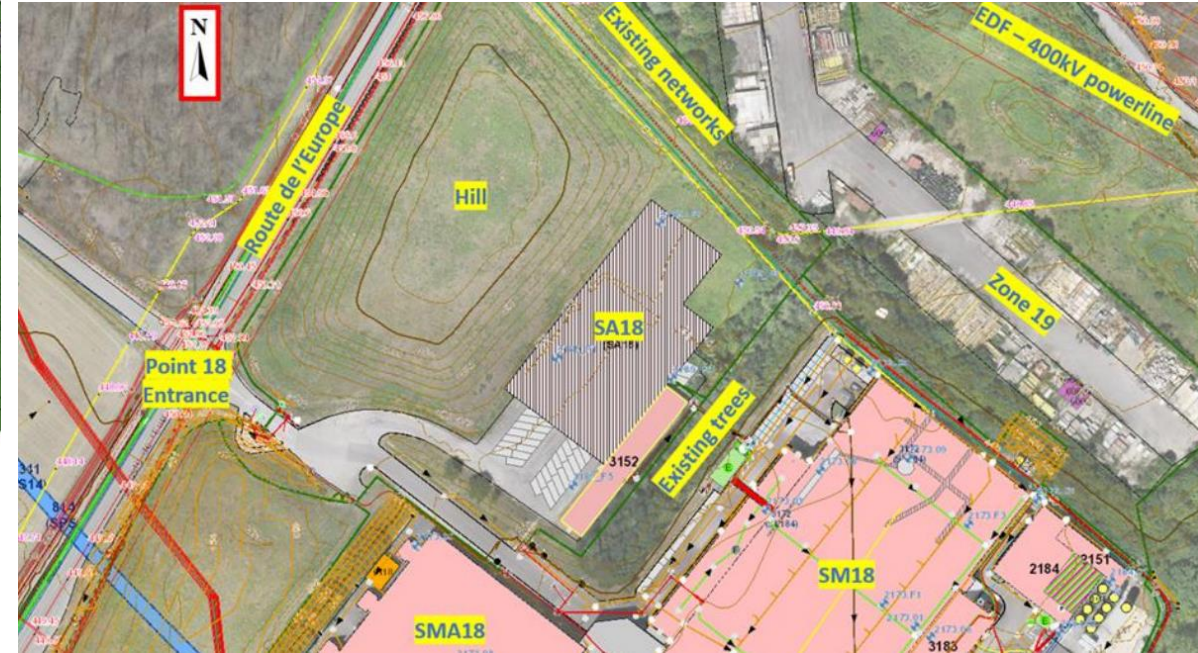
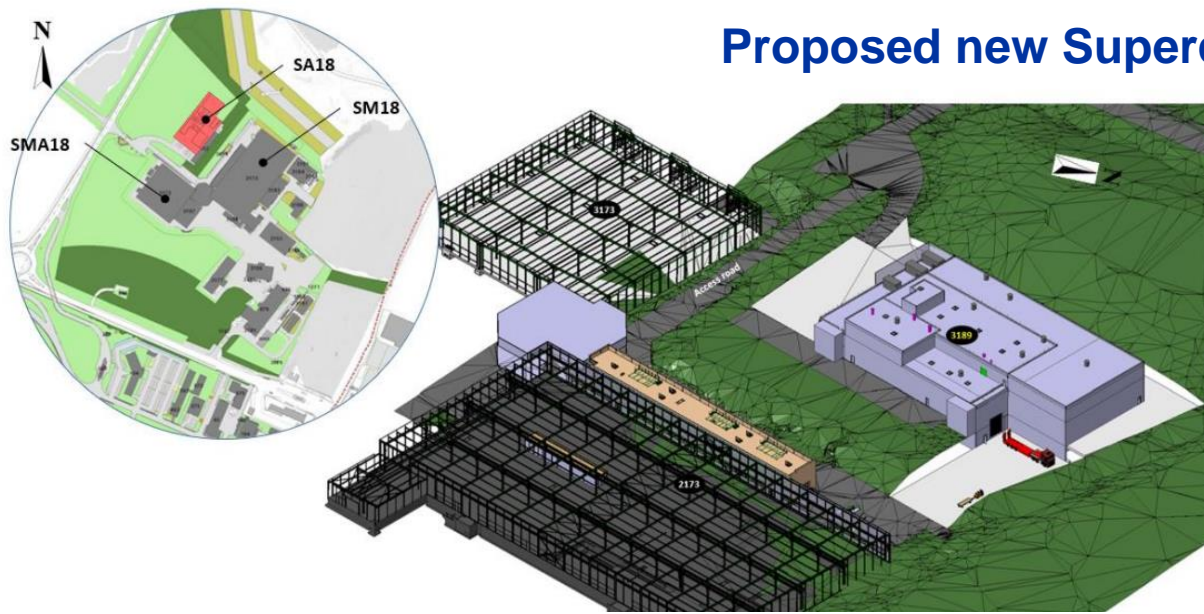
**New contracts:**

**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

	Jan			Feb				Mar			Apr			
Wk	1	2	3	4	5	6	7	8	9	10	11	12	13	
Mo	2	Control System admin. days	9	16	23	30	6	13	20	27	6	13	20	27
Tu	Annual Closure													
We														
Th	Control System admin. days						YETS							
Fr										DSO test				
Sa														
Su														

LHC hand-over to BE-OP (March 10)  
 LHC, T12, T18 and experiments closed (March 12)  
 Start Beam Commissioning (March 27)

**LHC hand-over to OP & DSO test 10 March**

**Beam commissioning starts 27 March**

Rende Steerenberg LMC 30-11

## 2023 – Q2

Wk	May							Jun				Jul	
	14	15	16	17	18	19	20	21	22	23	24	25	26
Mo	3	Easter 10	17	24	1st May 1	8	15	22	Whitsun 29	5	12	19	VdM 26 program
Tu					Scrubbing								
We	Re-commissioning with beam											TS1	
Th							Ascension						
Fr	G. Fri.				Interleaved commissioning & intensity ramp up						MD 1		
Sa													
Su													

### 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	Aug							Sep			Oct		
	27	28	29	30	31	32	33	34	35	36	37	38	39
Mo	3	10	17	24	31	7	14	21	28	4	11	18	25
Tu												TS2	p-p ref run
We				MD 2					High $\beta$ run				
Th										Jeune G.		p-p ref setup	
Fr											MD 3		
Sa												p-p ref run	
Su													Ion setting up

End 25 ns run [08:00]

### 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

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# LHC operation in 2023

## 2023 – Q4

Wk	Nov				Dec								
	40	41	42	43	44	45	46	47	48	49	50	51	52
Mo	2	9	16	23	30	6	13	20	27	4	11	18	Xmas 25
Tu			MD 4										
We													
Th		LHC Pb- Pb ion run						YETS					Annual Closure
Fr													
Sa													
Su													

**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

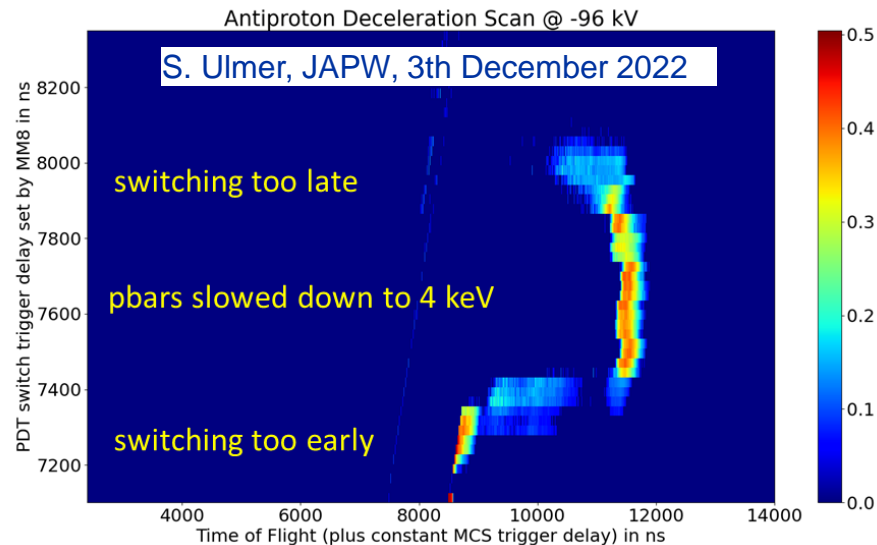
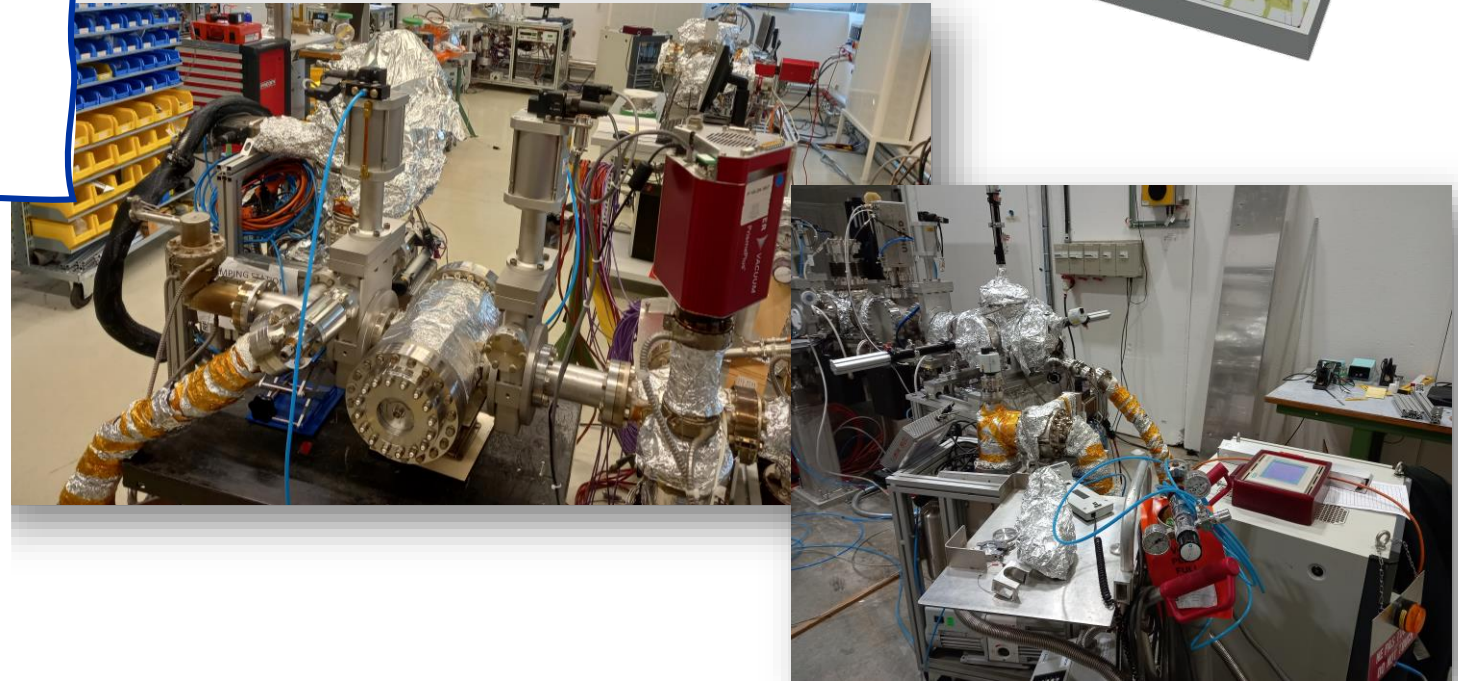
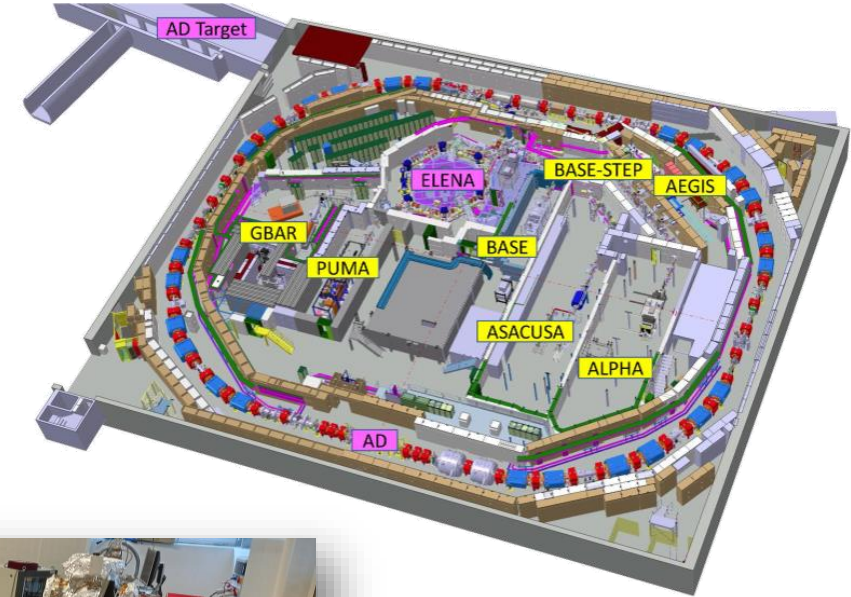


Deceleration of antiprotons from 100 to 4 keV

Design of ISOLDE beam line ongoing

Objectives 2023:

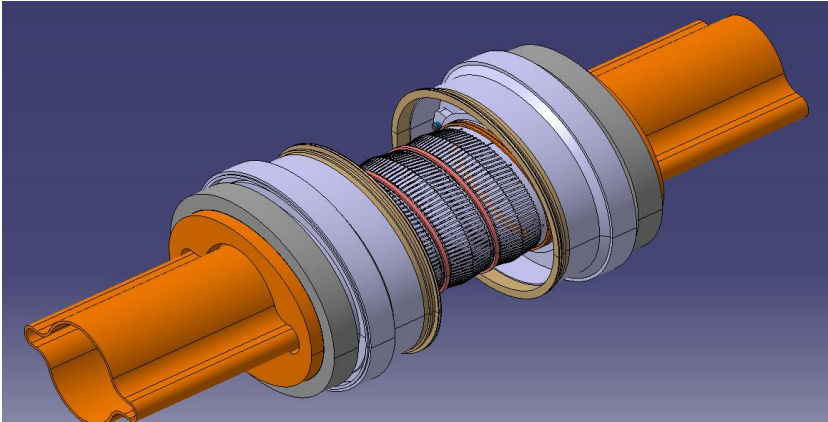
- **First trapping of antiprotons**
- **First attempt to transport antiprotons**



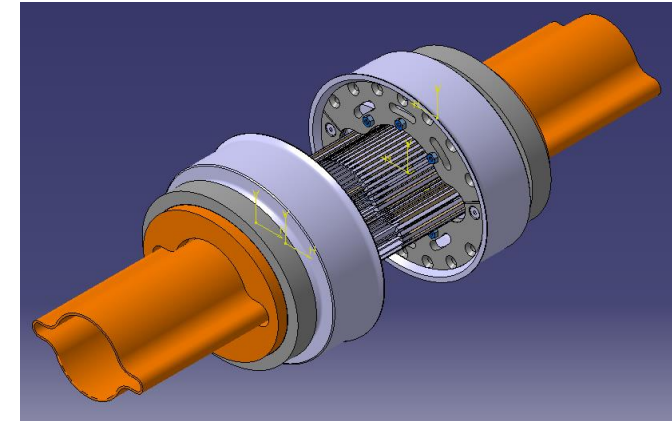
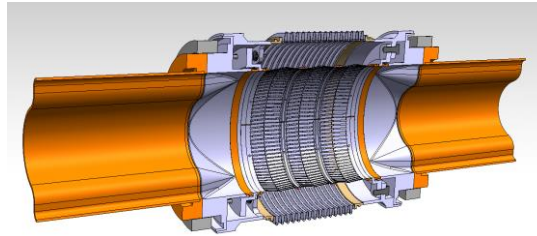
# FCC-ee vacuum system

## FCC-ee design

### Interconnection design:



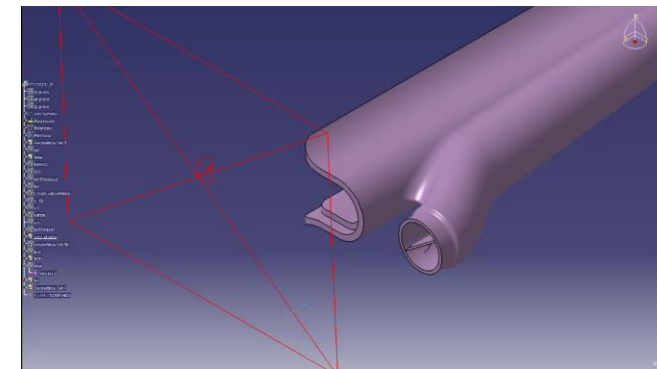
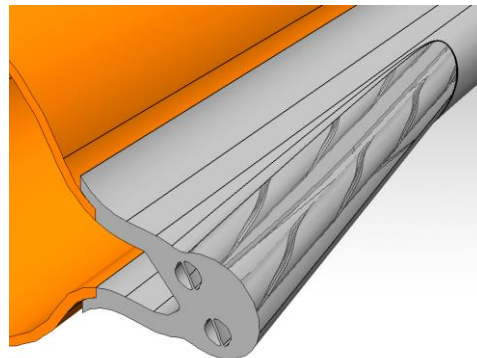
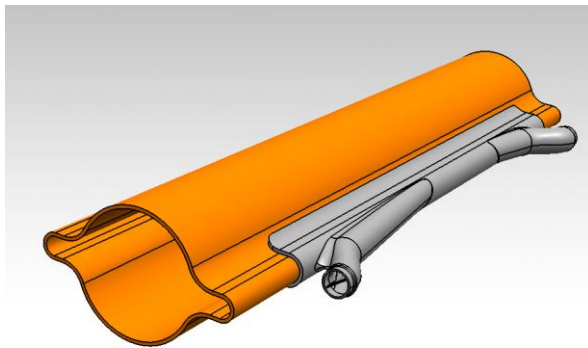
DRF Contact Bridge type



Comb-type

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

### Synchrotron radiation absorber design:

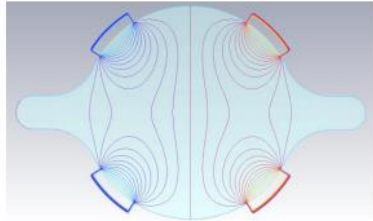


3D model with twisted tape to increase heat transfer coefficient

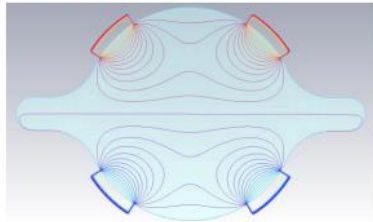
# FCC-ee vacuum system

## FCC-ee design: SMA applications

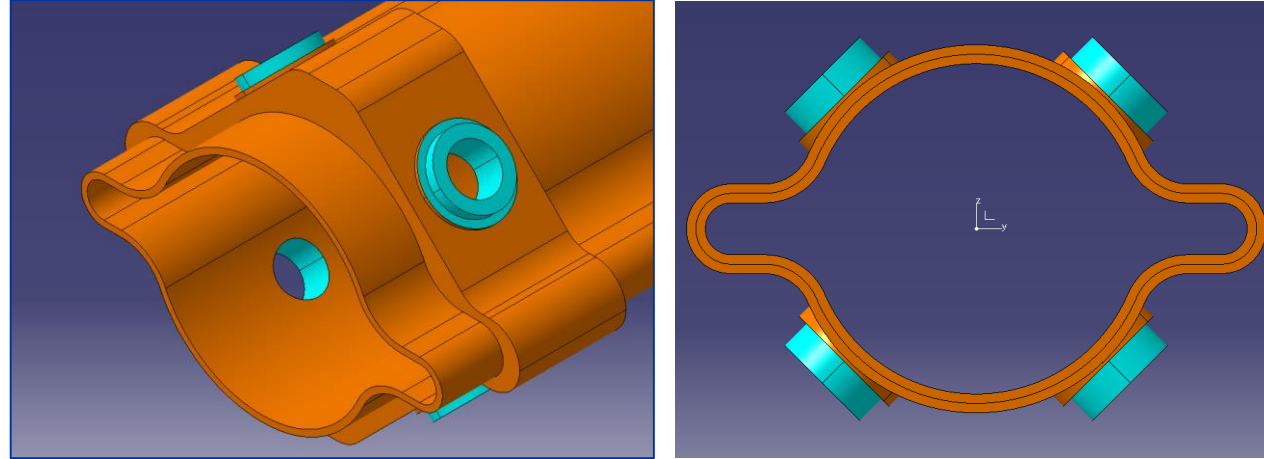
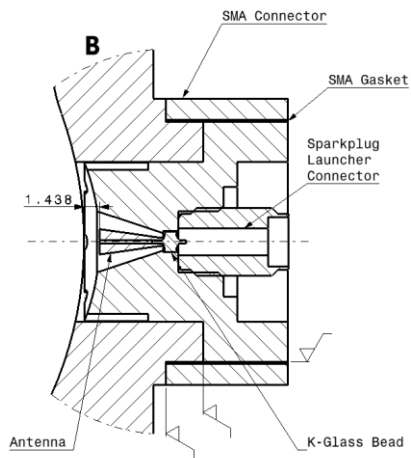
### BPM Design Updated



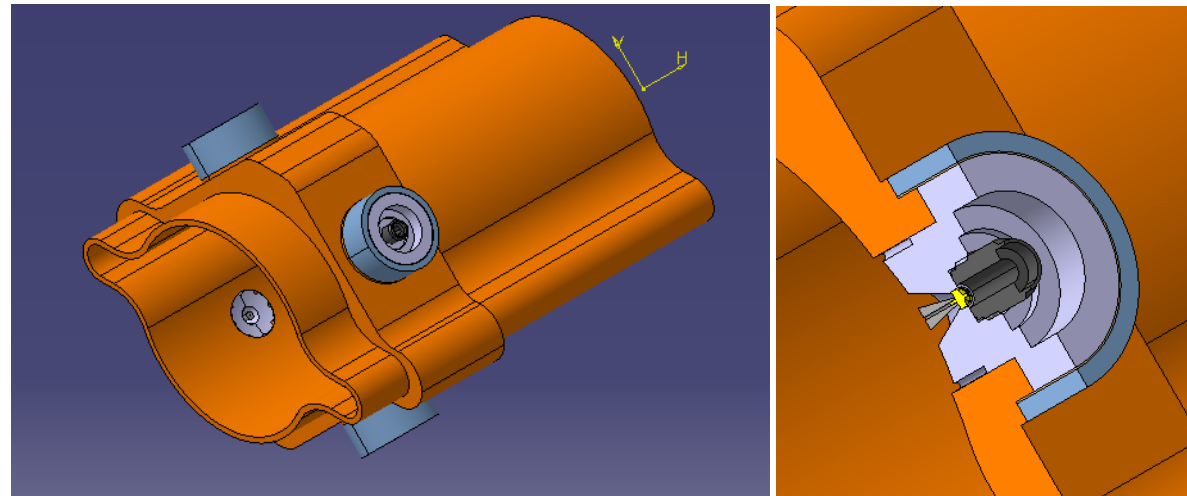
BPM position behaviour: horizontal



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



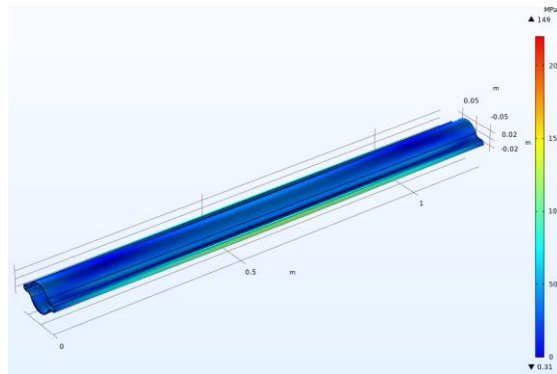
Prototype vacuum chambers delivered.



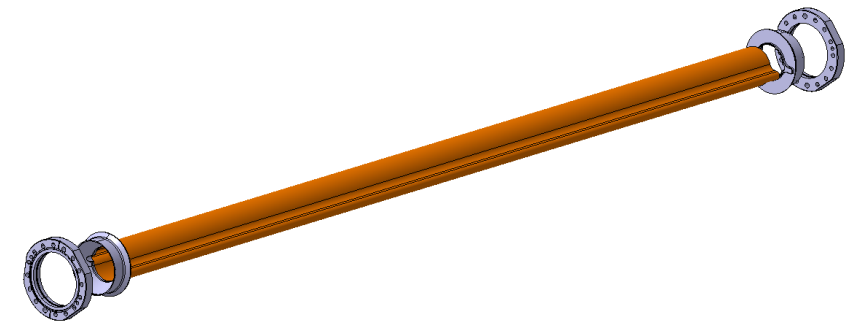
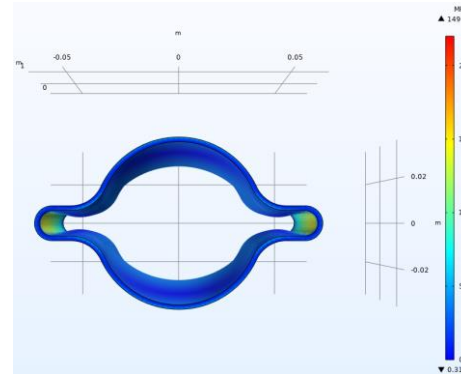
Cold extruded chamber in C10200, 2 mm uniform thickness

Next steps:

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

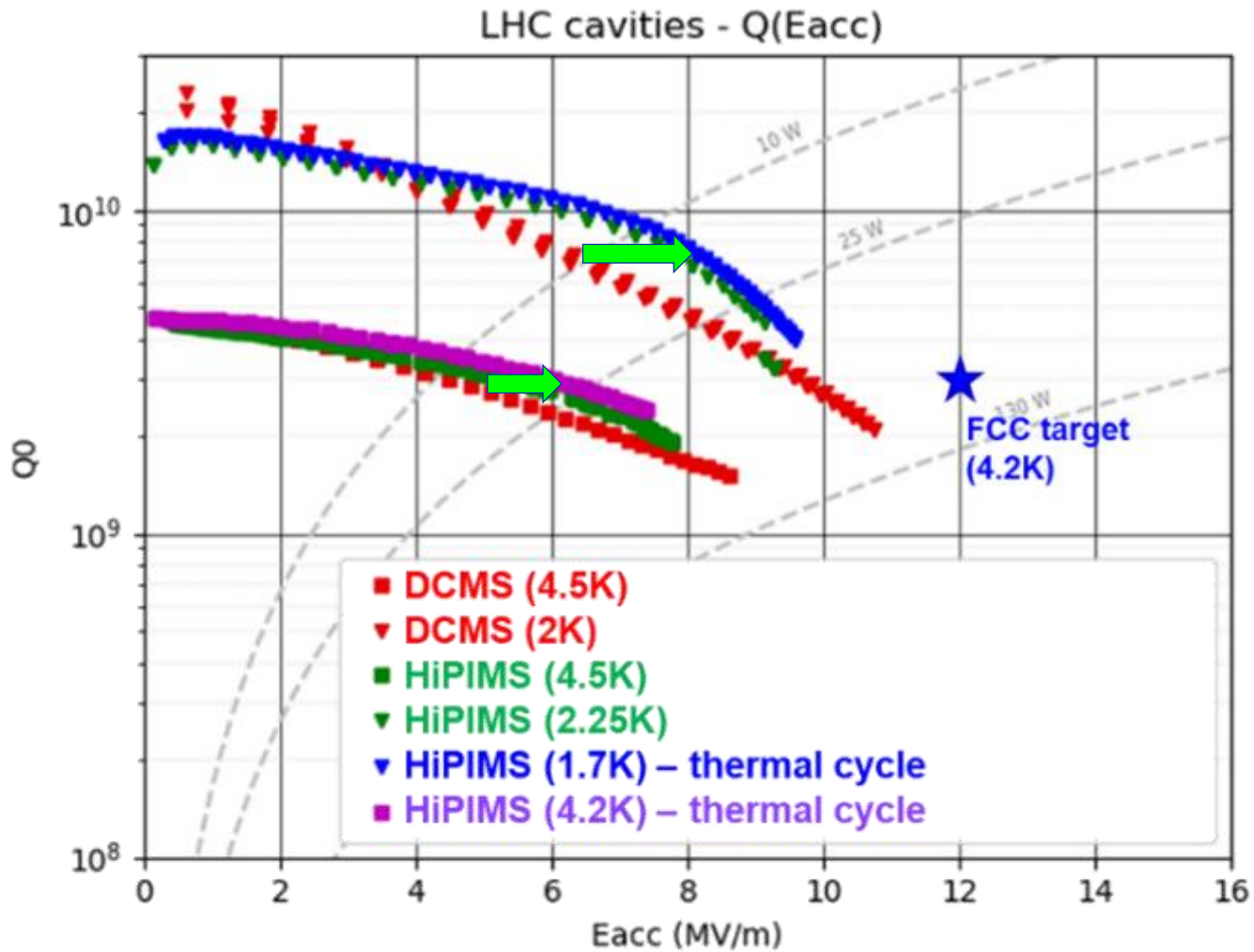


Stress field in the prototype chamber under vacuum



Preliminary study for integration in KARA

# FCC-ee SC-RF cavities: coating optimisation



From DC magnetron sputtering to **HIPIMS**\*

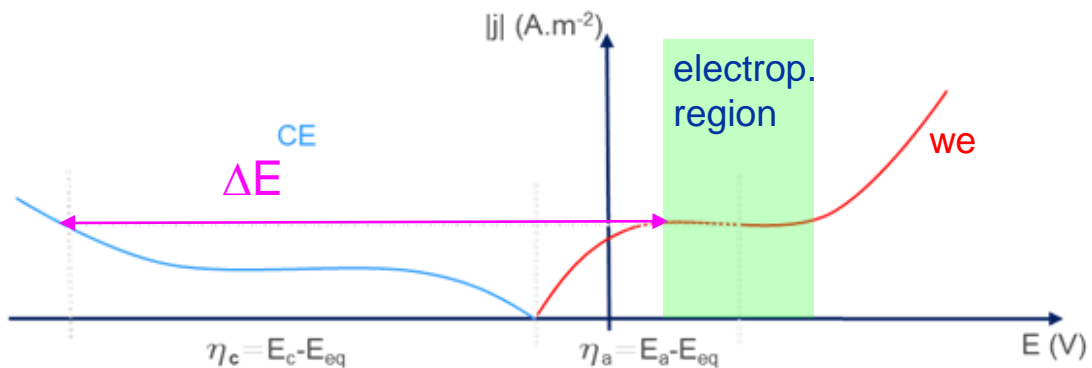
- first LHC-like cavity (400MHz)

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

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



$$\Delta E = U - IR(\text{bath, cables...})$$

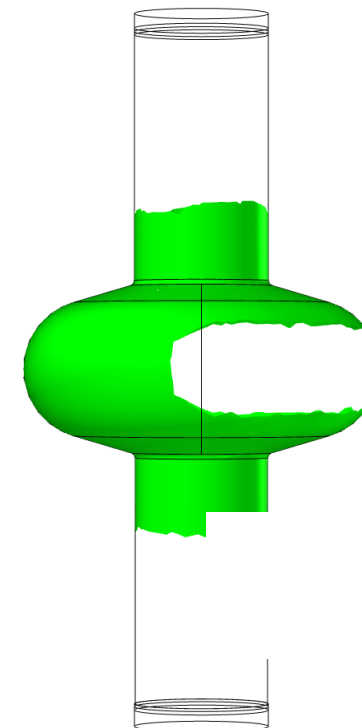
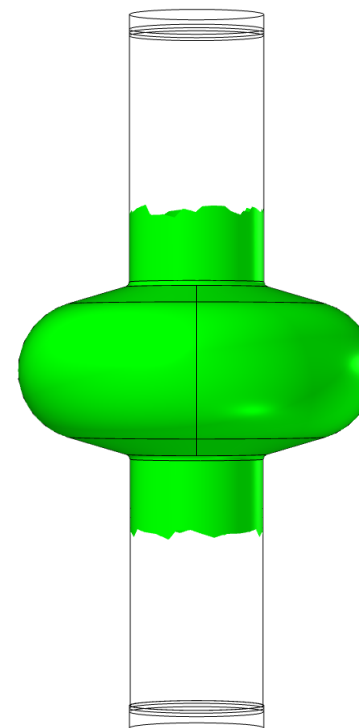
$$j = f(U,$$

- $j$ , Current density
- $U$ , Overall applied tension
- $T_b$ , Bath temperature
- $\tau$ , fluid dynamics
- $S_c/S_a$ , Cathode geometry & Cathodic/Anodic surface rati
- $\sigma_l$ , 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  $2.2 \cdot 10^{-6}$  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,  **$3.1 \cdot 10^{-2}$  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.

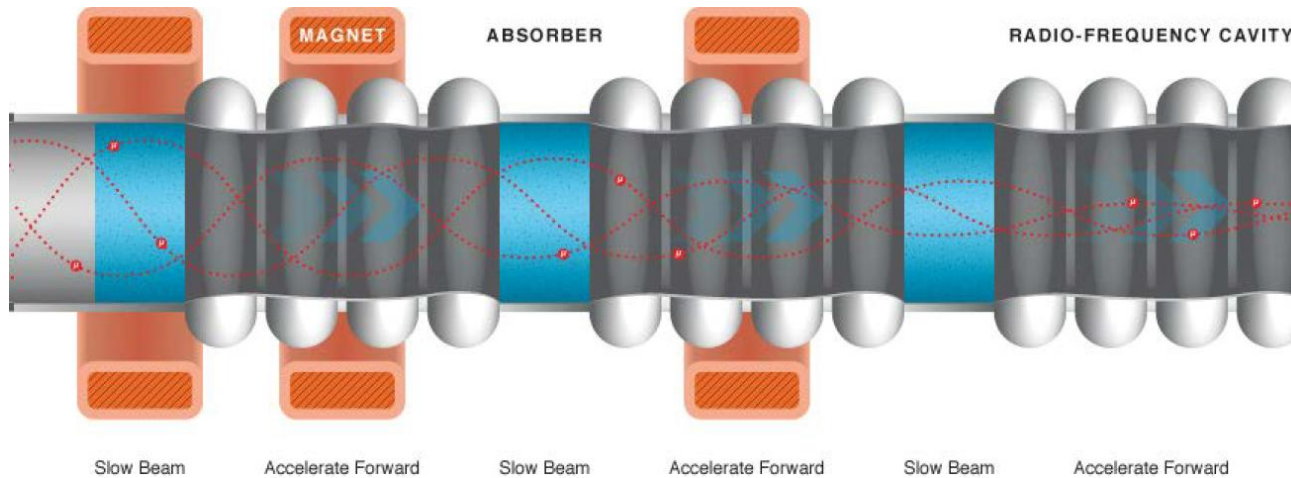
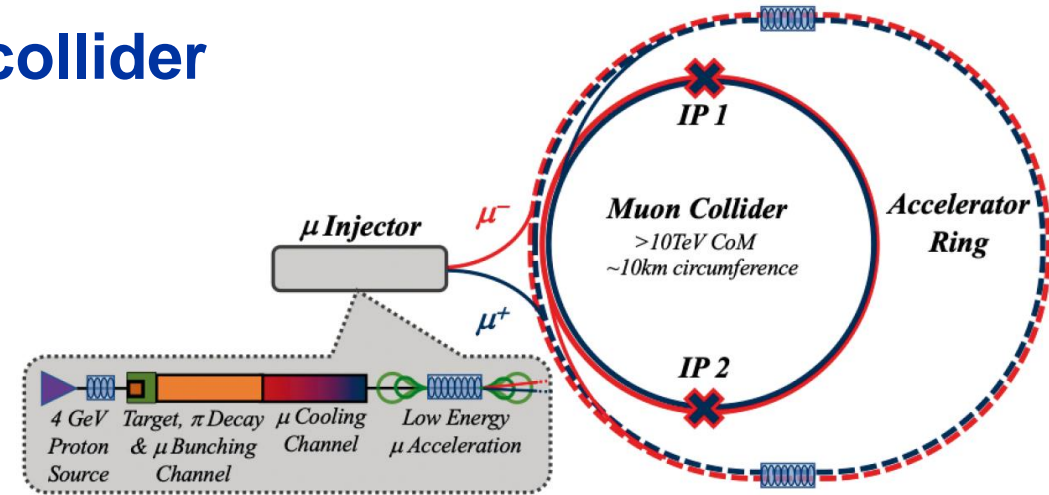
It has **very large transverse and longitudinal emittances**.

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- $\mu\text{m}$  thick 6x6mm  $\text{Si}_2\text{N}_3$  window** at  $\approx 5$  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

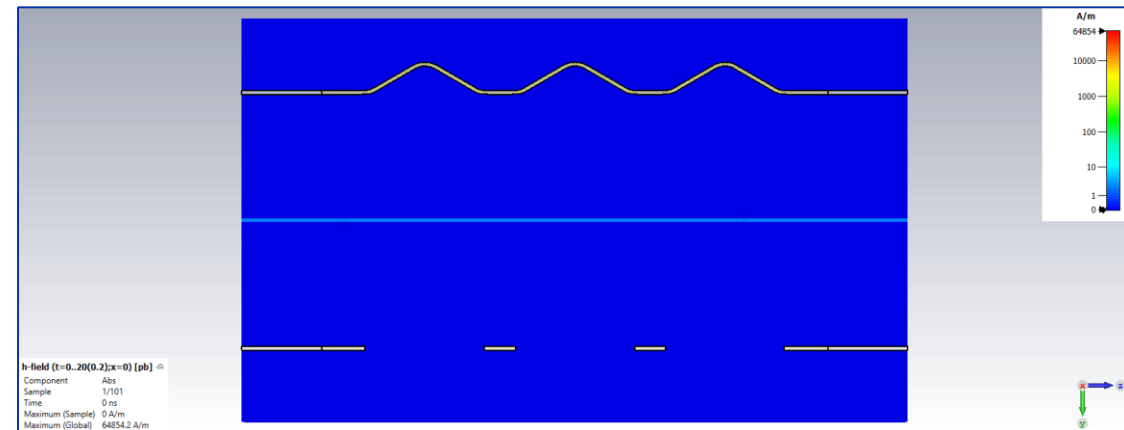
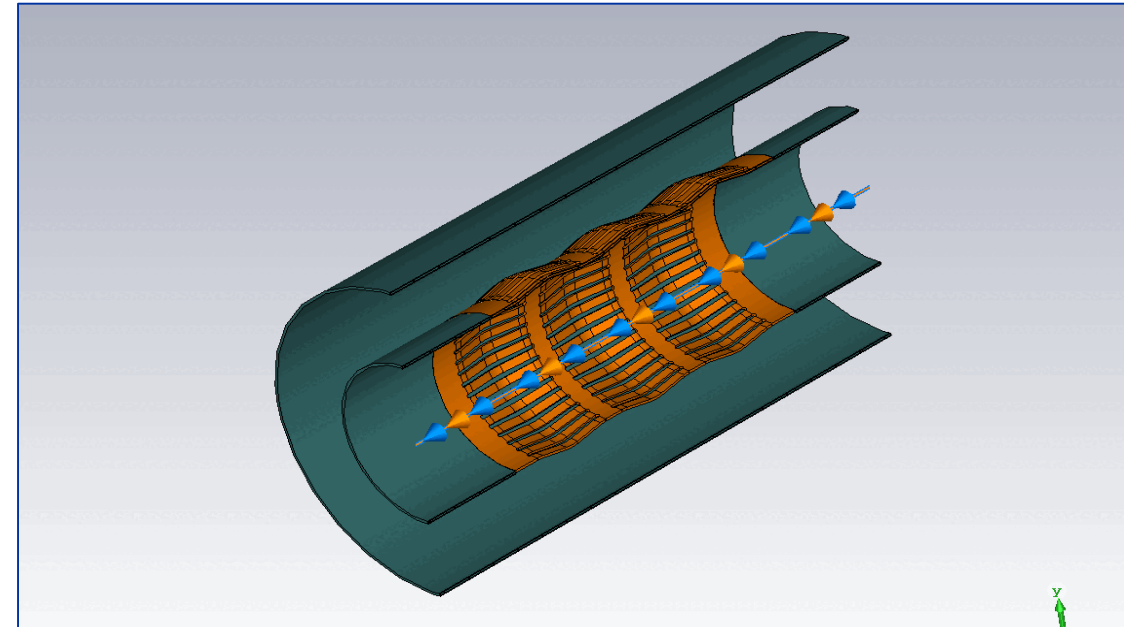
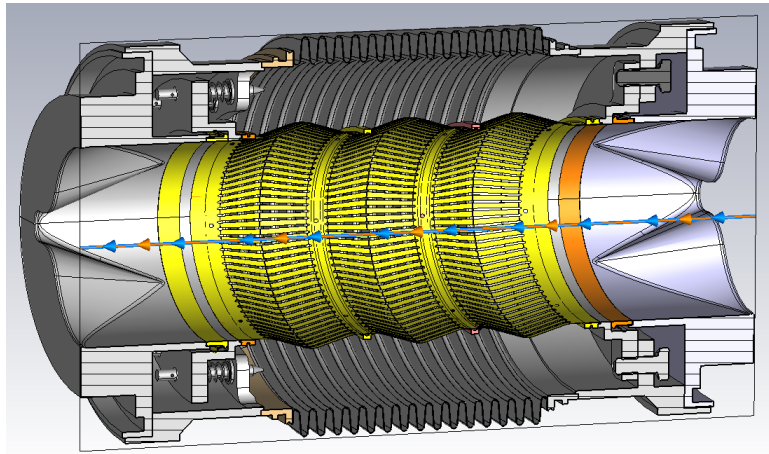
However, **our credibility comes from our services and operational daily work**. Only if we ensure excellent services/operation, we can see **optimistically into the future**.

# Beam impedance of deformable RF bridge

## 3 types of warm modules in HL-LHC

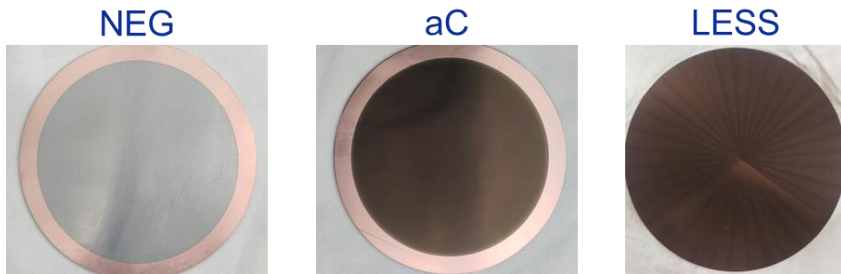
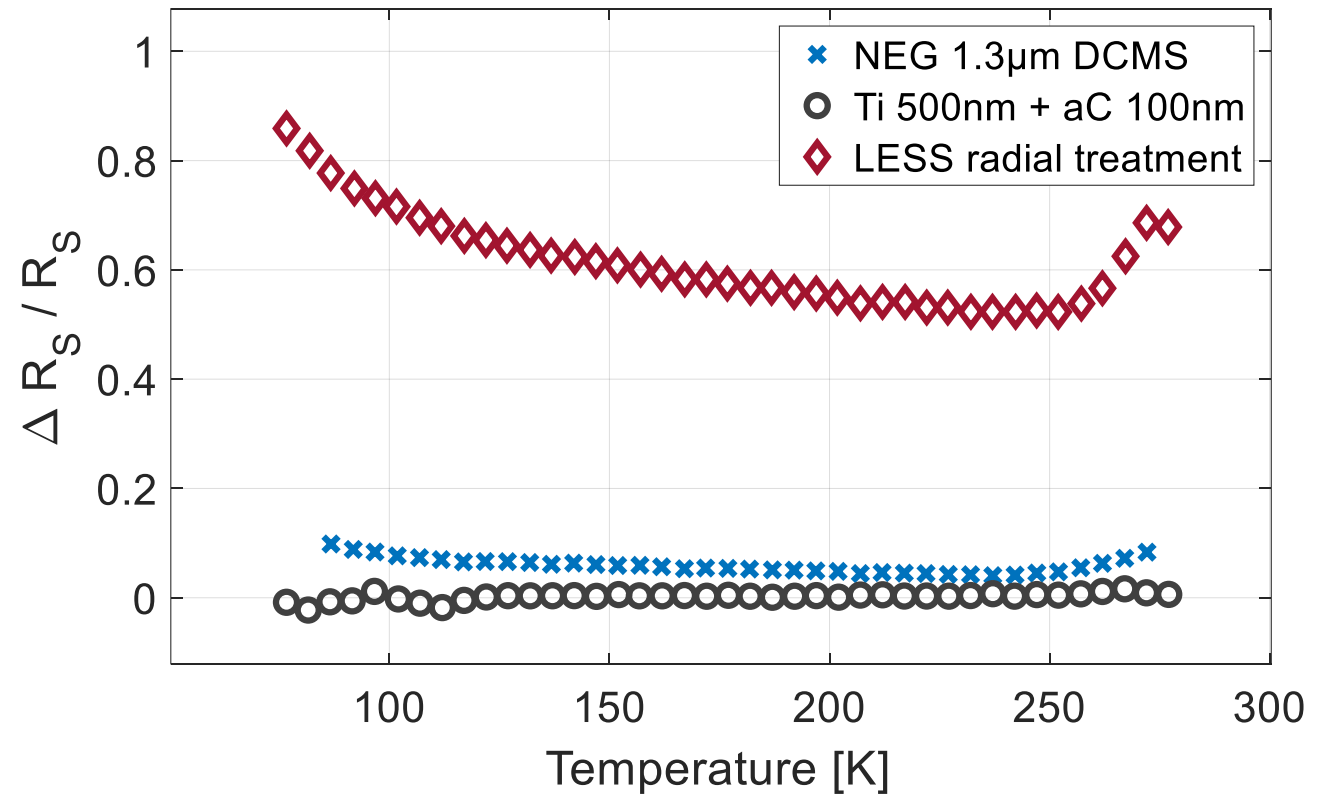
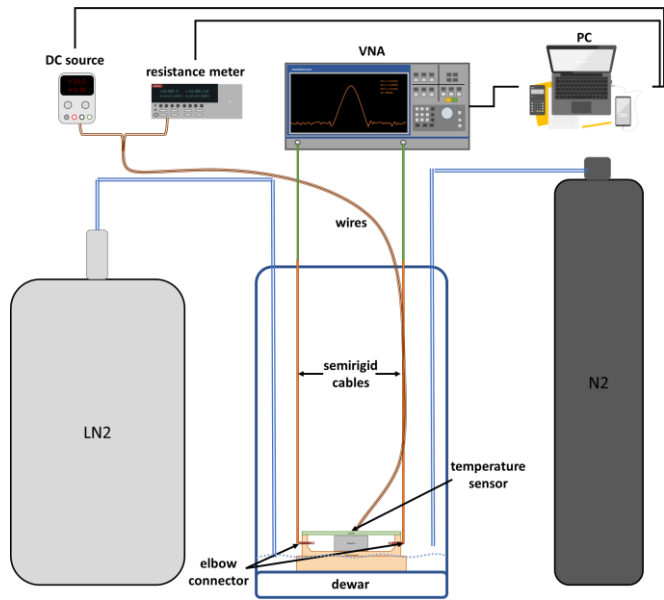
- $\varnothing 63$ ,  $\varnothing 150$ ,  $\varnothing 250$

## Determination of the longitudinal and transverse beam impedance

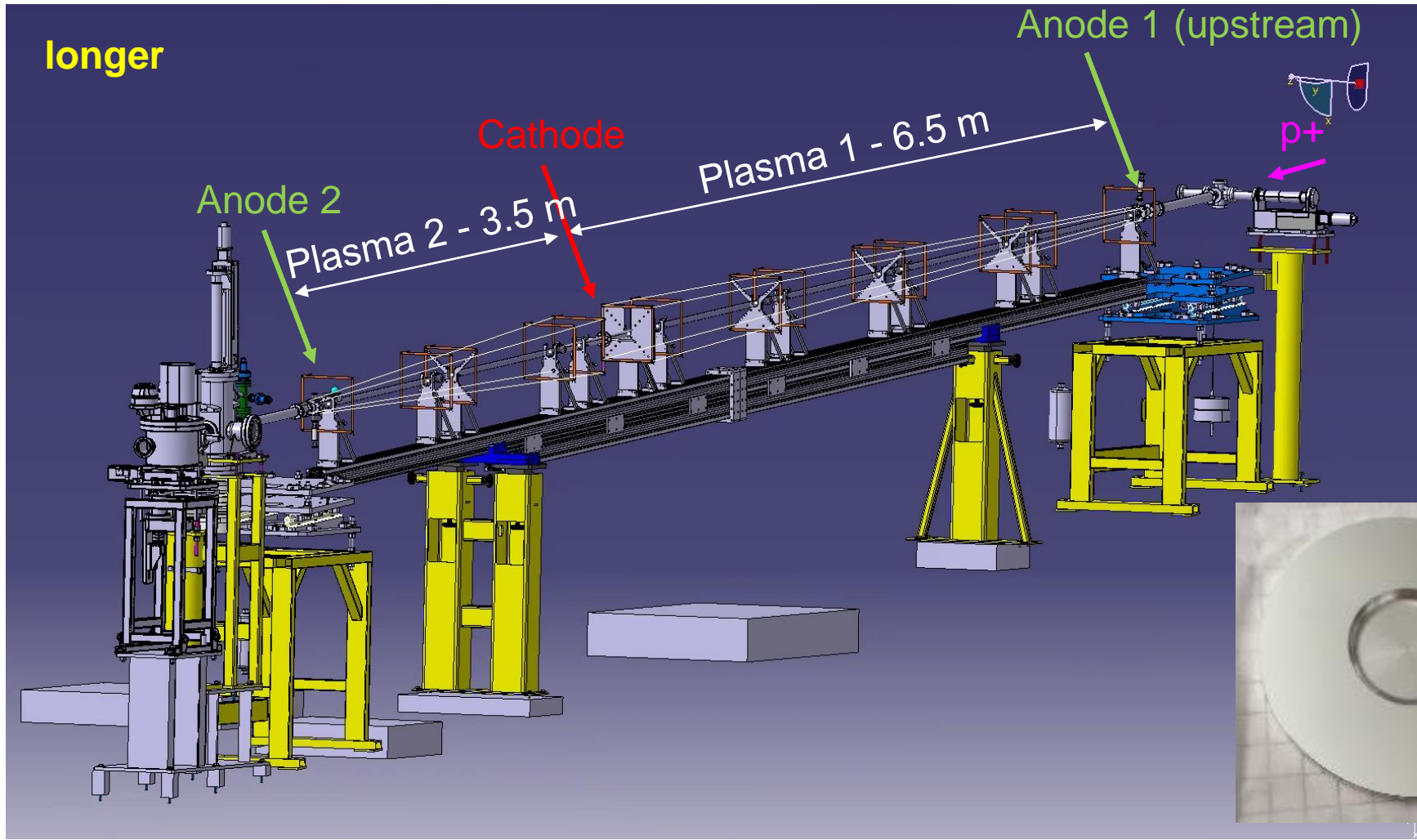


# Surface impedance as a function of temperature

## Coatings and treatments characterisation



# 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

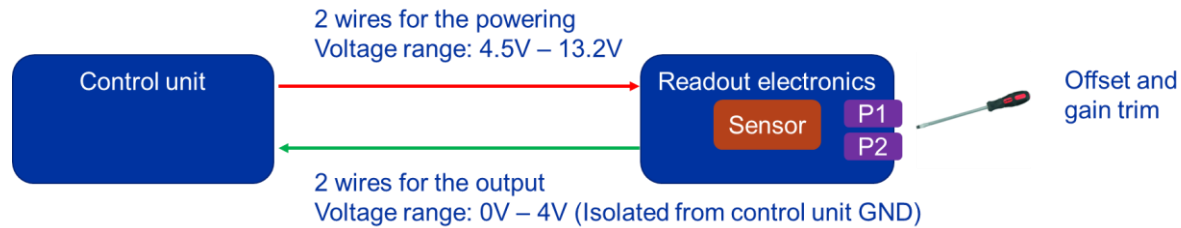


Gasket-like aluminium vacuum window (200  $\mu\text{m}$  thick)

# MEMS low-cost helium detector electronics

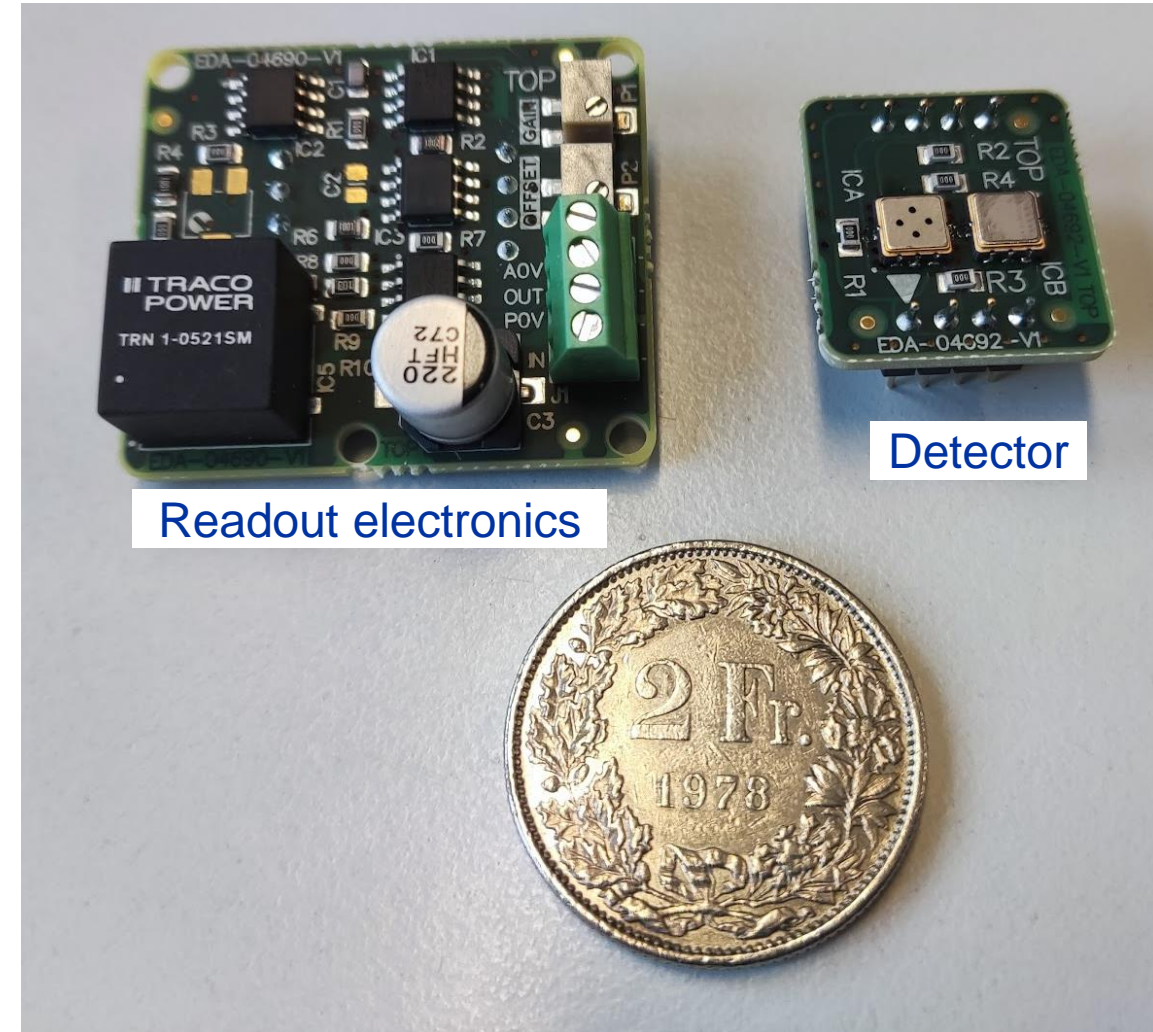
- **MEMS thermal conductivity sensors**

- 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

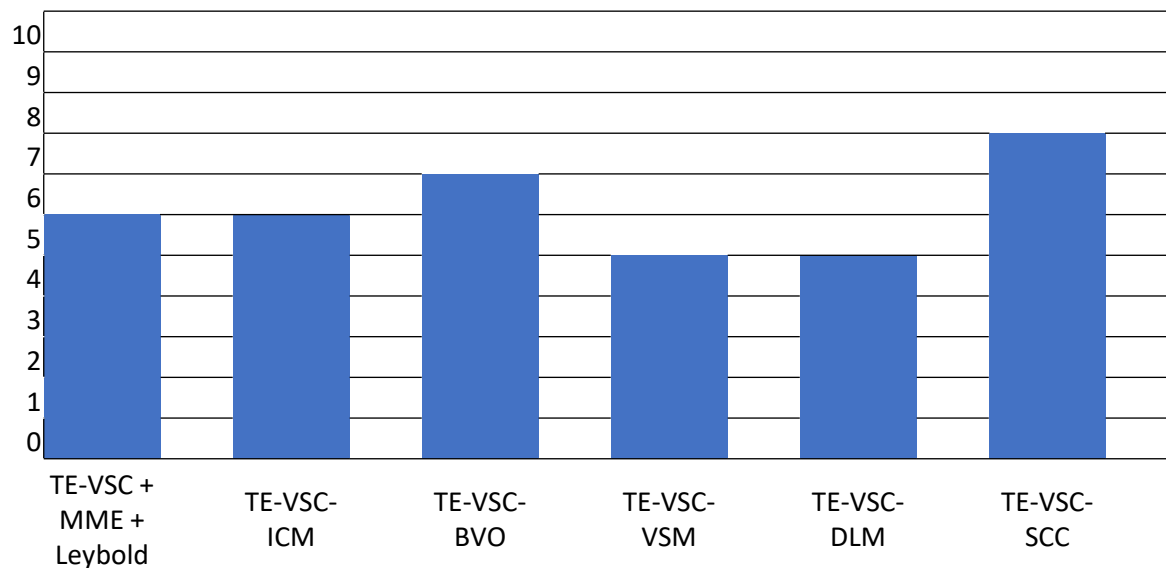


# TE-VSC Seminars: best way to share info in the group, please participate!

**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**.

Number of Seminars during 2022



December 2022	
15 Dec	TE-VSC Plenary <b>NEW</b>
13 Dec	HL-LHC yearly update
06 Dec	Gas propagation in cryogenic tubes // New Sector Valve Control Unit
November 2022	
29 Nov	Leybold Users day at CERN
23 Nov	Joint TE-VSC and EN-MME Seminar on LISA - 23 November 2022
15 Nov	Production of a-C coatings for new HL-LHC beam screens // Advances on Nb3Sn HiPIMS coatings for SRF cavities
09 Nov	Joint Seminar TE-VSC and EN-MME on 9 November 2022
01 Nov	Laser surface treatment setup and development
October 2022	
25 Oct	Scrubbing run results
18 Oct	Degassing and Ultimate vacuum of gauges // Thin self-supported carbon films
04 Oct	New Profibus and 4G mobile equipment connectivity (HW & PLC) // New passivation recipes for copper
September 2022	
20 Sept	FCC-ee vacuum chamber development // Renovation of the HPWR control system
13 Sept	simulations for chemical/electrochemical surface treatments // FCC-ee and hh prototyping
July 2022	
19 Jul	NEG Embrittlement studies // Vacuum vs Polymers
June 2022	



**Merci à vous tous!**