



WP12 update with a focus on beam screen production

edms 3171248

V. Baglin for the HL-LHC WP12



<https://indico.cern.ch/event/1421594/overview>



1 -LHC Collaboration Meeting, Genoa, Italy, 7-10 October 2024

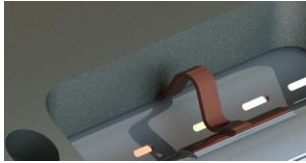
OUTLINE

1. Shielded & non-shielded beam screen
2. Vacuum layout
3. Summary

1. Shielded & non-shielded beam screens

Design of shielded beam screen

- Objective
 - Provide vacuum stability, control gas density
 - Protect the Triplet cold mass** against particle collision debris



Thermal links:

- In copper
- Connected to the absorbers and the cooling tubes or beam screen tube

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
- Heat load: **15-25 W/m**
- 40 cm long

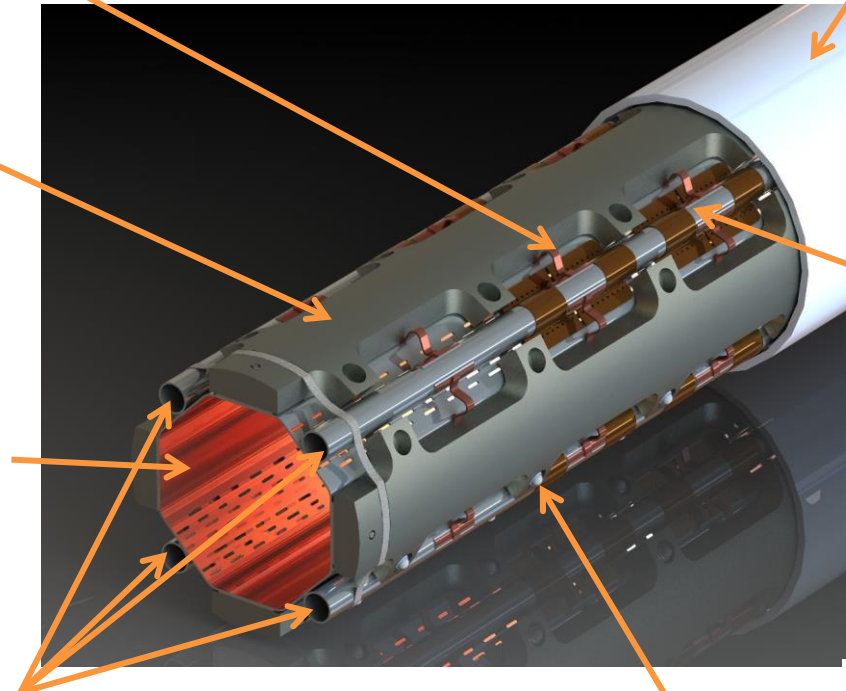


Beam screen tube (BS) at **60-75 K**:

- Perforated tube (~2%) in High Mn High N stainless steel (1600 l/s/m (H₂ at 300K))
- Internal copper layer (75 μm) for impedance
- a-C coating for e- cloud mitigation

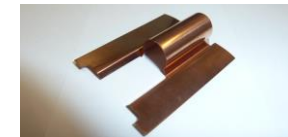
Cooling tubes:

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



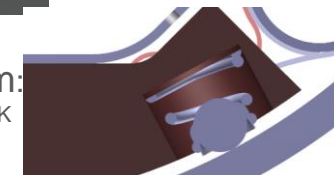
Cold bore (CB)
at **1.9 K**:
4 mm thick tube in 316LN

Pumping slot shield



Elastic supporting system:

Low heat leak to the cold bore tube at 1.9K
Ceramic ball with titanium spring



Cold bores– Procurement completed

- **Contract completed** last July (first delivery in June 2019)
- Manufactured from billets (\varnothing 160mm) in EN 1.4429 grade stainless steel.
 - ID 136.7, H8, 4 mm thick, tolerances 0 +0.063
 - length: 8.7; 7.5; 10.55; 10.85 for resp. D1, CP, Q2 and Q1,Q3
- Reception at CERN:
 - UHV cleaning, metrology (EN-MME), leak testing, OD control, endoscopy
- 41 cold bores delivered to WP3 (out of 44 cold bores)



EN 1.4429 billets



Honing of cold bores



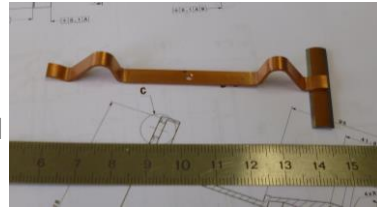
Metrology 3D scanning (EN-MME)

Shielded beam screen – Procurement

- All building parts are at CERN
- Today, enough material ready to produce 11 shielded BS



- Thermal links:**
- 9'900
 - EN-MME
 - 100% received

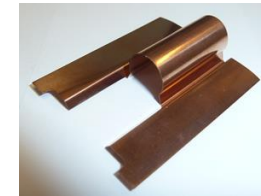
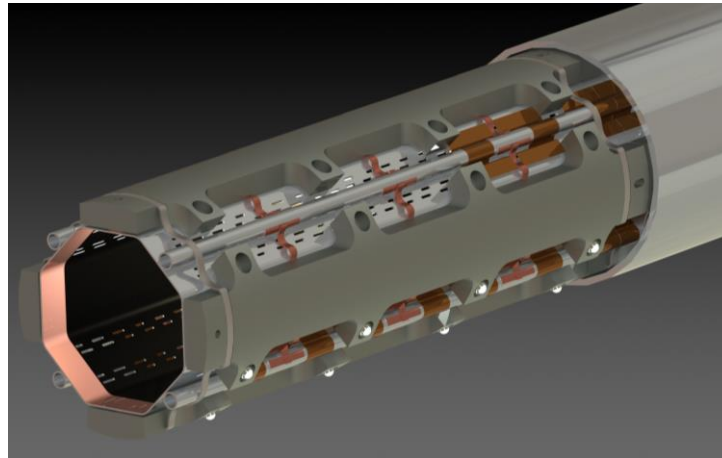


- Brazing thermal links/absorbers:**
- EN-MME
 - 37% completed



- Cold bores:**
- 44/44 delivered

- Tungsten alloy blocks:**
- 3'000
 - 100 % received
 - 64 % cleaned
 - 56 % vacuum acceptance tested.



- Pumping slot shields**
- 25'500
 - 100% received

- P506 pins:**
- 7'200
 - All Q1 and Q2 type at CERN and cleaned



- Ti springs:**
- 12'000
 - 100 % received (Q1 & Q2 types)
 - cleaning on demand

- P506 cooling tubes:**
- At CERN
 - Leak/pressure tests and cleaning completed for shielded and D2 beam screens

- Ti elastic rings:**
- 1'600
 - 100 % received (Q1 & Q2 types)
 - Cleaning on demand



- Ceramic balls:**
- 12'500
 - At CERN, cleaning on demand

Beam screen production overview

- All BS tubes ready
- Pre-assembly phase ongoing

Type	BS tube quantity	Punching	Forming	Tack welding	Long. Welding	Butt welding	BS tube ready	contact ring & cooling tube welding	Pins welding, cleaning, RT leak test	Tungsten assembly	Cold testing	aC coating
Q2...D1	24+8	Finished	Finished	Finished	Finished	Finished	32	11	5	1	0	0
Q1	5+2	Finished	Finished	Finished	Finished	Finished	7	2	0			
D2	10+2	Finished	Finished	Finished	Finished	Finished	12	2 Ongoing	0	-		



All (39+12) BS tubes butt welded and ready for assembly



Cooling tube welding

➔ Beam screen production aligned with magnets deliveries

Tungsten assembly

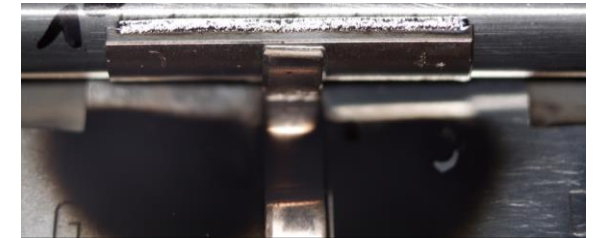
- 24 beam screens for series: one beam screen assembled per month from Q3-24 till Q3-2026
- Then 5 spares assembly Q1-Q2-2027



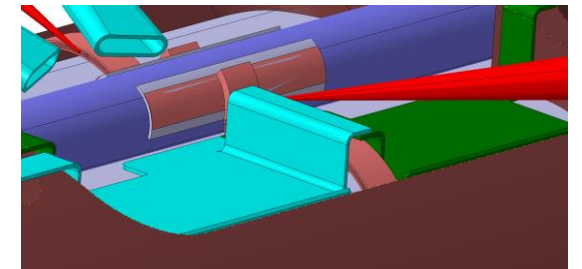
Tungsten assembly



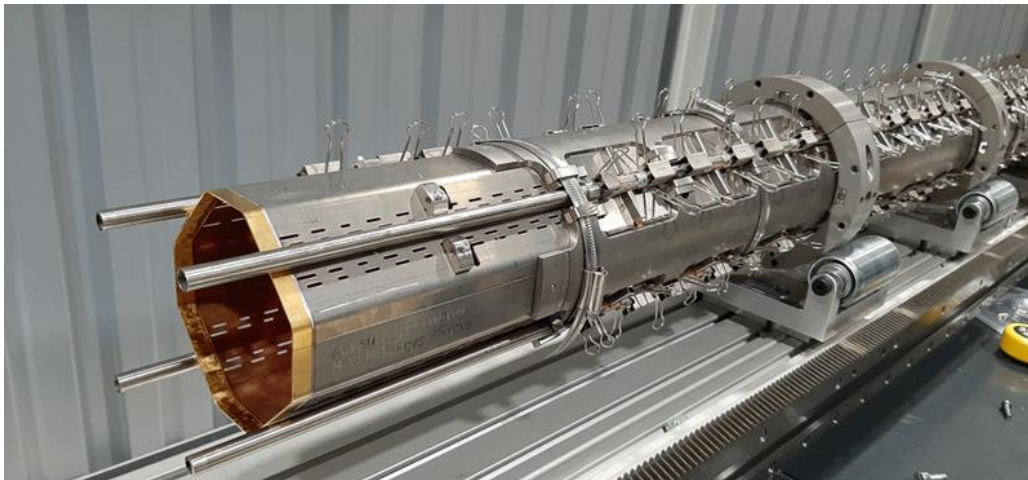
Welding robot



Soot after welding



Temporary shielding to intercept the soot

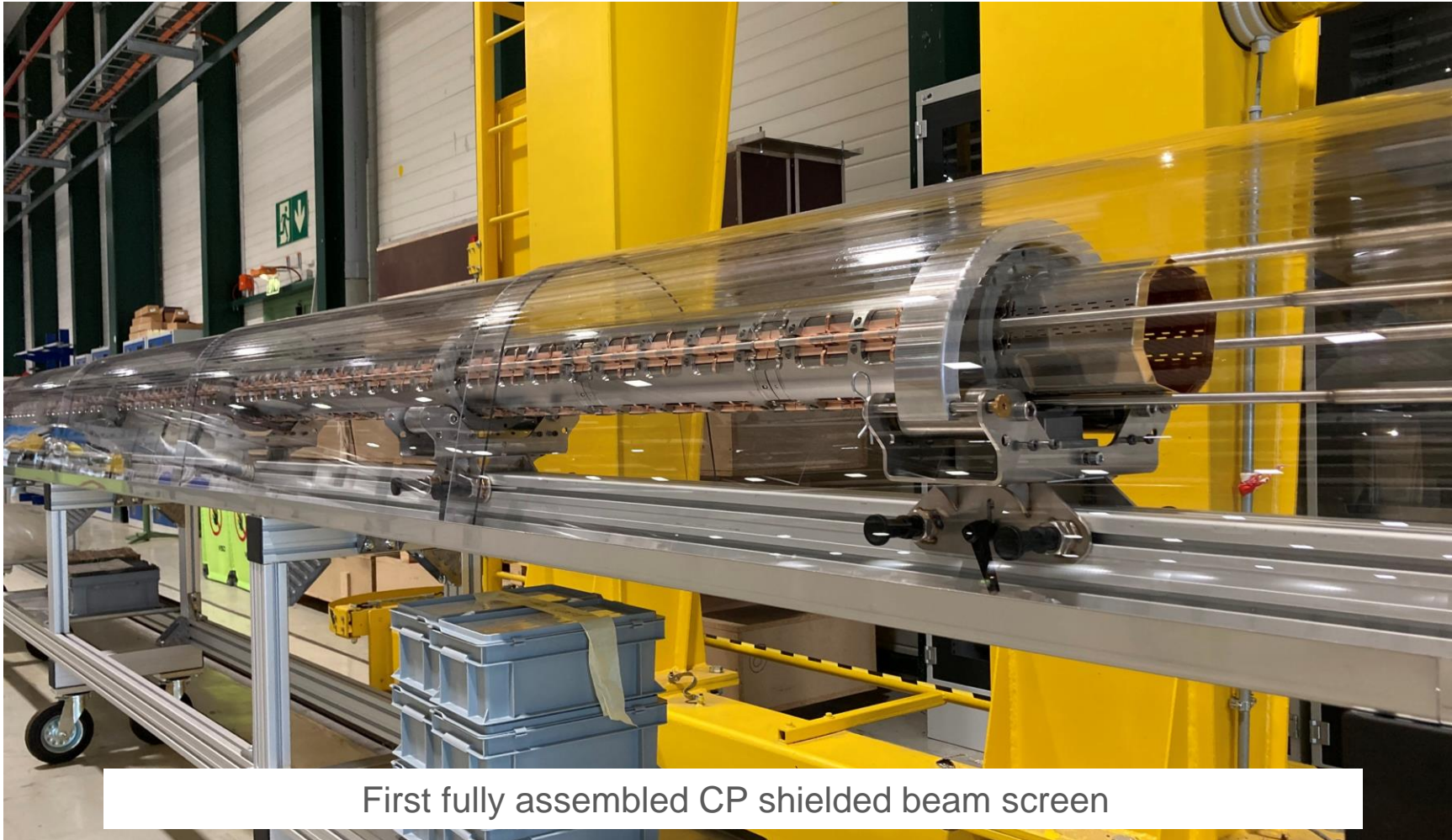


Thermal links laser welding preparation

First fully assembled CP beam screen

Ready for cold testing

- Q2 beam screen under assembly
→ scheduled to be ready by end 2024



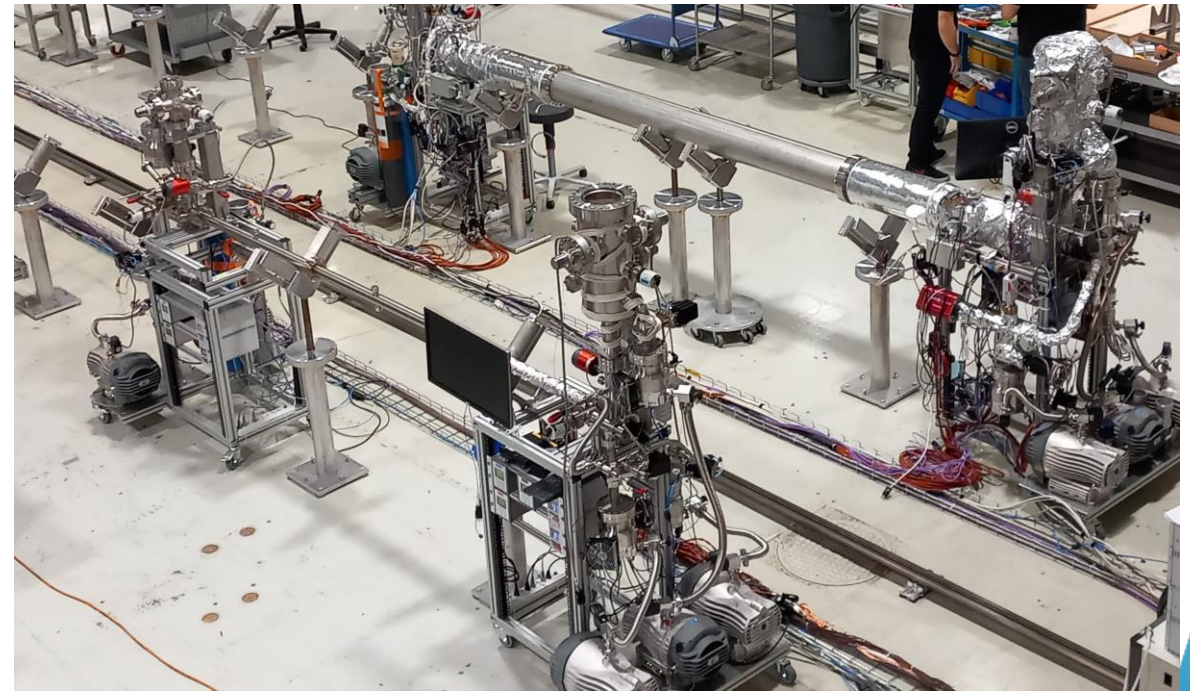
First fully assembled CP shielded beam screen

Cold test & aC coating

- Cold testing and aC coating facilities are ready:
 - First cold testing at liquid nitrogen temperature this month
 - First aC coating of CP beam screen by end 2024
 - then aC coating Q2 beam screen, Jan 2025 → February 2025: ready for insertion !
- aC coatings from Q4-2024 until Q1-2027, then spares



Cold testing coating facility



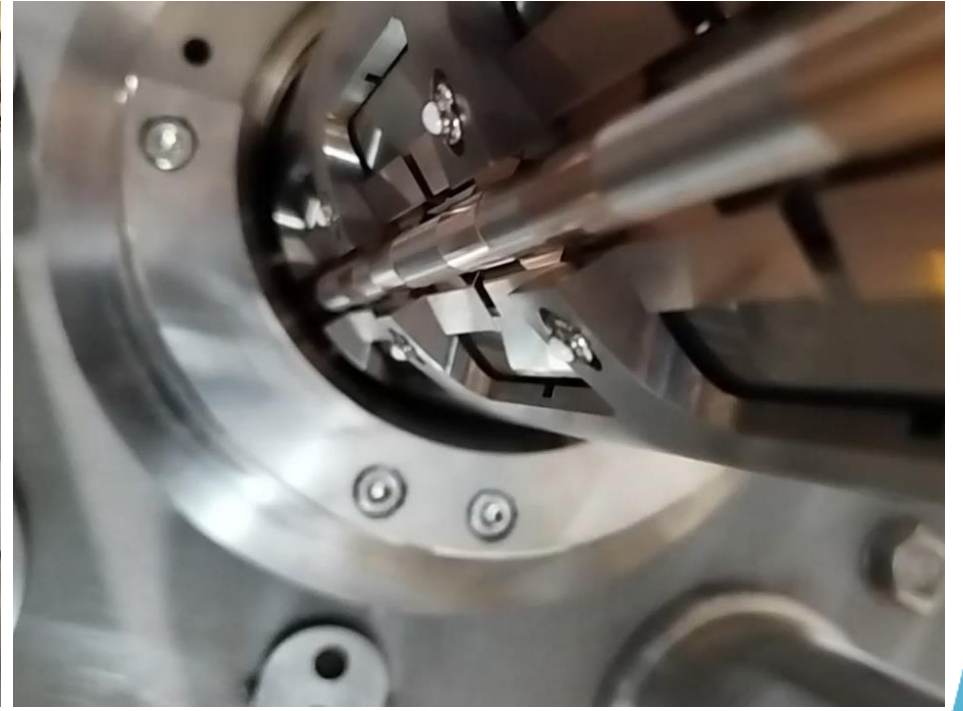
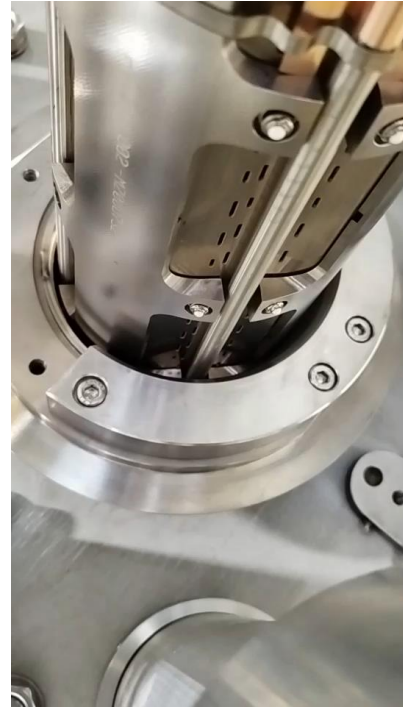
aC coating facility

Beam screen insertion into magnet

- Horizontal insertion of CP beam screen ~ 7 m long, 150 kg into the ID150 mm magnet bore
 - Successful tests → Ready for beam screen insertion into HL-LHC magnets!



Insertion bench



Beam screen insertion tests

Magnets interconnections

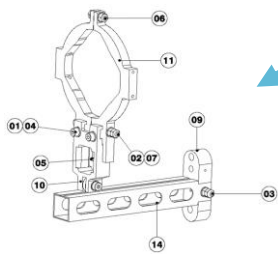
- 20 interconnections
- All parts available by end 2024 → Ready for BS insertion step



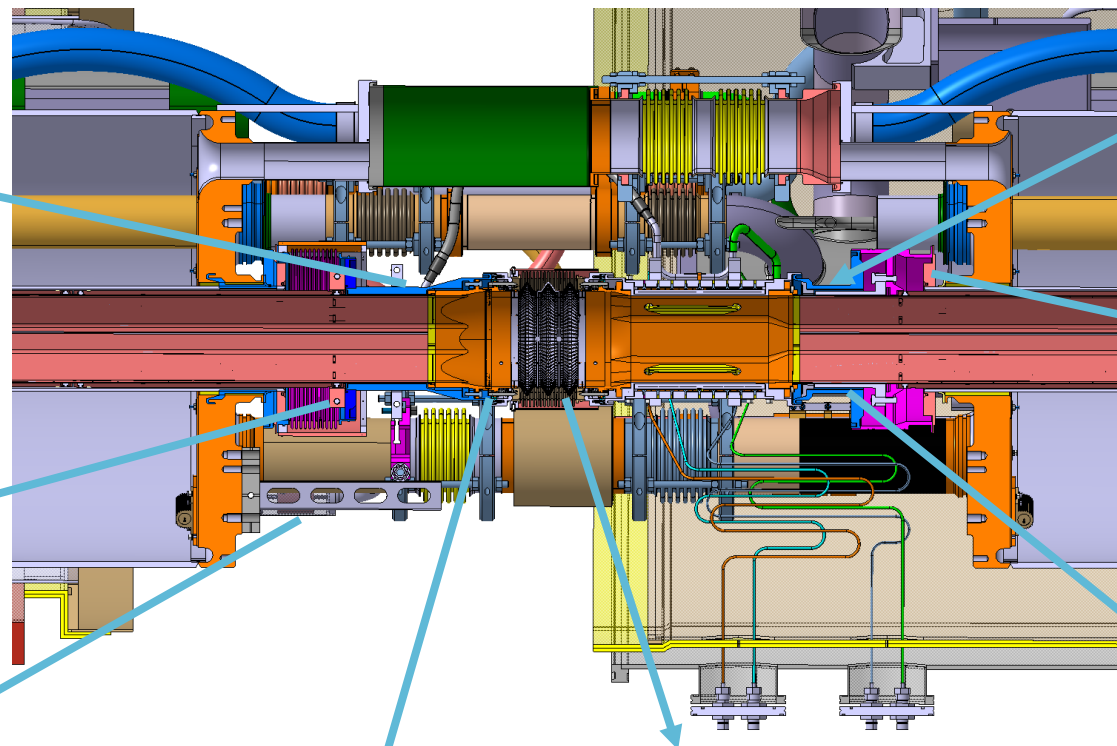
Exit tube
All pre-assembled (35)



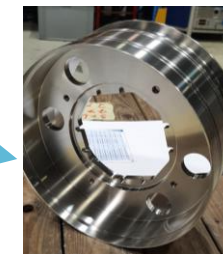
Half-rings
All machined (68)



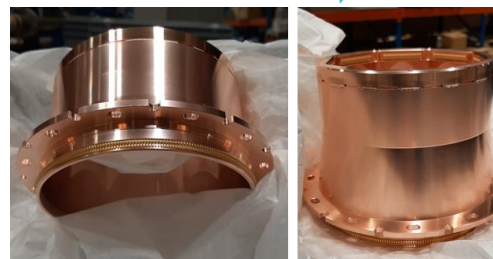
Mobile point
Available, cleaned



Exit flange
All pre-assembled (35)



Fixed point sleeves
All machined (35)



Cu octagonal-circular transition
All produced (36)



PIM with Deformable RF bridge
Completed (30)
First PIM assembled



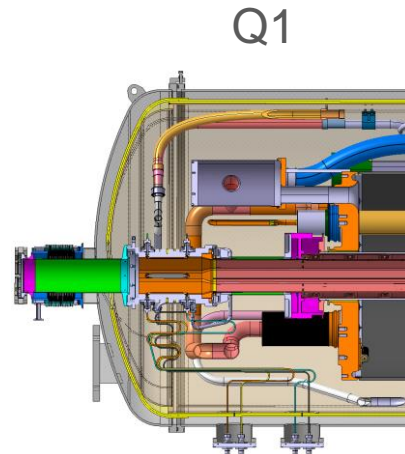
Tungsten absorber
Completed (28)

Q1, D1, & D2 cold to warm transitions

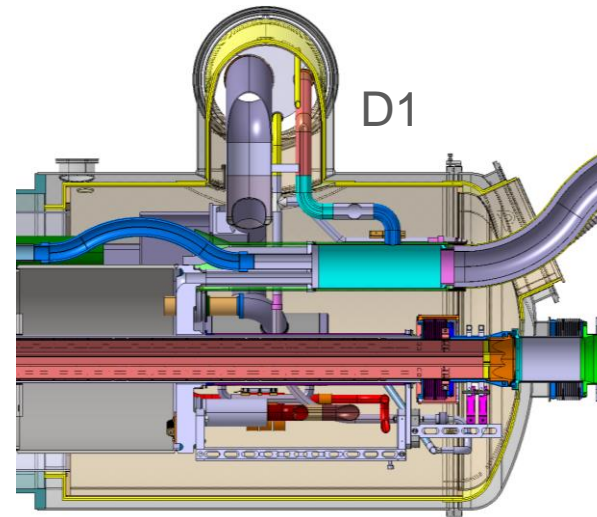
- All CWT transitions assembled: Cu plating and aC coating ongoing
 - First Q1, D1, D2 installation by Q3-2025



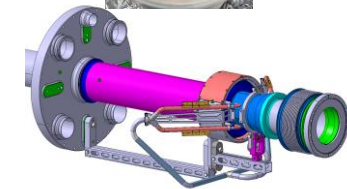
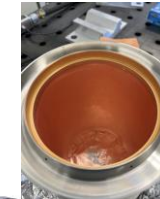
7 assembled
Tooling for Cu plating in progress



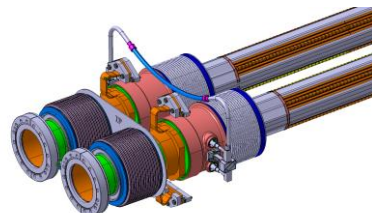
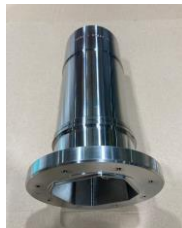
5xQ1+2 spares



5xD1+2 spares

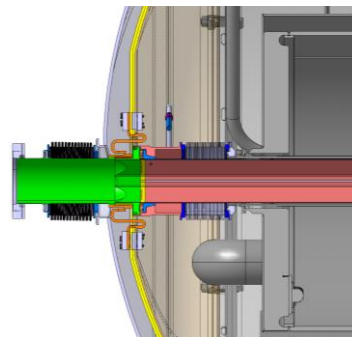


7 Cu plated
7 ready for aC coating



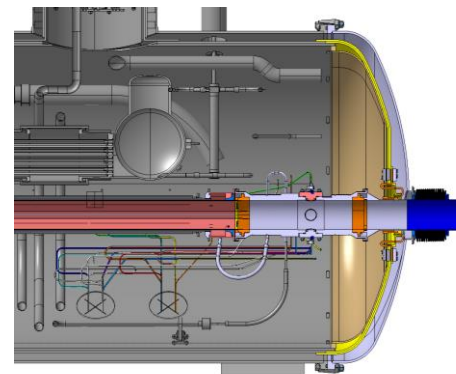
12 assembled
Tooling for Cu plating in progress

D2 IP side

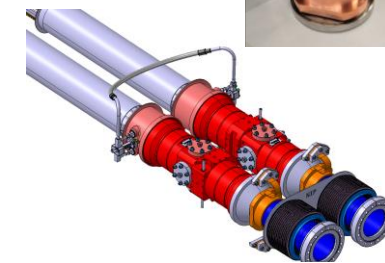
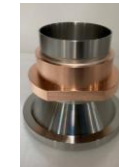


2x5xD2+2 spares

D2 NIP side



2x5xD2+2 spares

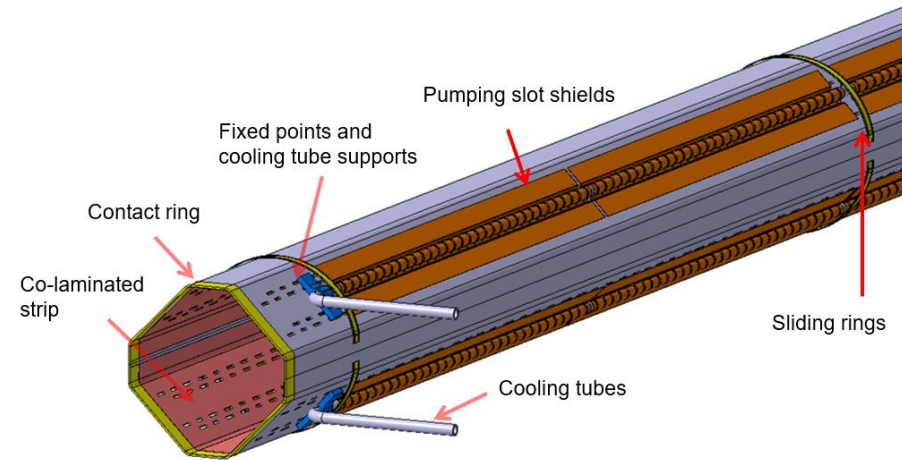


12 assembled
Tooling for Cu plating in progress

Non shielded beam screens

- D2
 - All components delivered; all BS tubes ready (12)
 - Contact ring welding in progress (2/12)
 - Cooling tube welding in progress (2/12)
 - Sliding ring welding under qualification

- ➔ First D2 BS (x2) assembled by end 2024
- ➔ aC coating by Q1 2025
- ➔ Completion expected Q1 2026



D2 cooling tubes tooling

- Q4, Q5, Q10
 - All components available
 - Q4 3D model to be confirmed, drawings by Q1 2026
 - Q5 and Q10 are LHC drawings
 - ➔ BS finishing **starting in Q3 2025**, completion by Q4 2026

- Crab cryomodule beams screens
 - ➔ All RFD and DQW BS ready (aC coated and equipped with pumping slot shields)



RFD beam screen



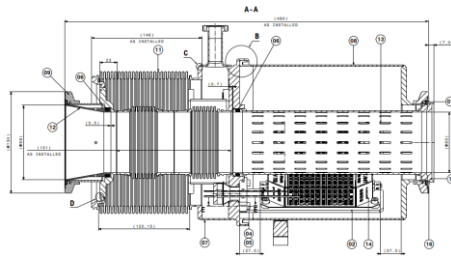
DQW beam screen

2. Vacuum layout

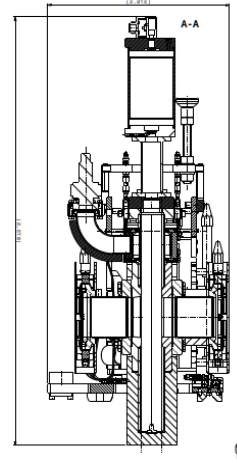
VAX system & Forward chambers

- VAX modules: design completed; production started, delivery end 2025

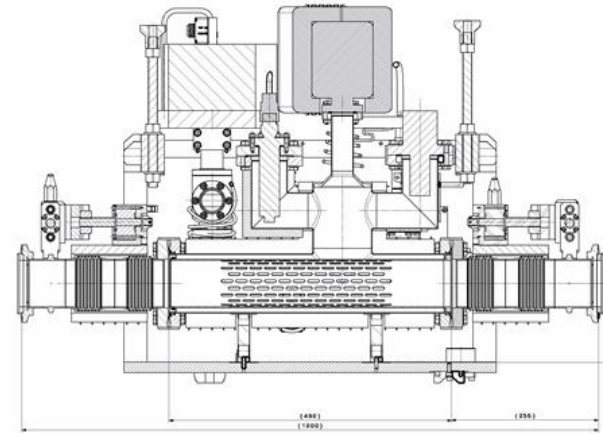
See WP8/WP12 parallel sessions on Tuesday PM and Thursday AM



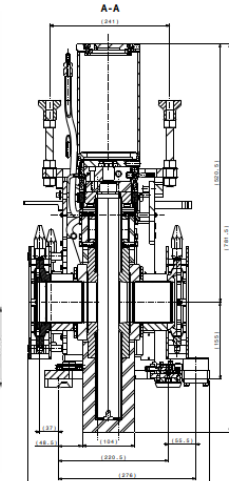
Module Q1-TASX



Module M1



Module M2

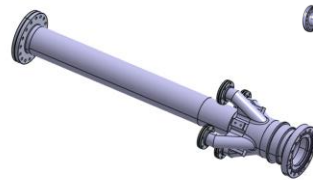


Module M3

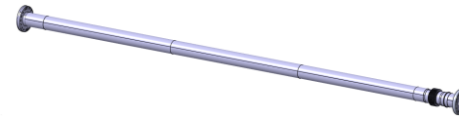
- Forward chambers: design completed, production in preparation, delivery by 2027



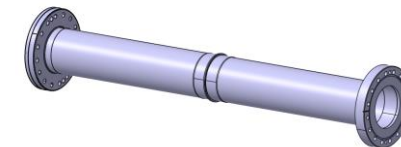
ATLAS new carbon cone



ATLAS VC1JI
Instrumented chamber



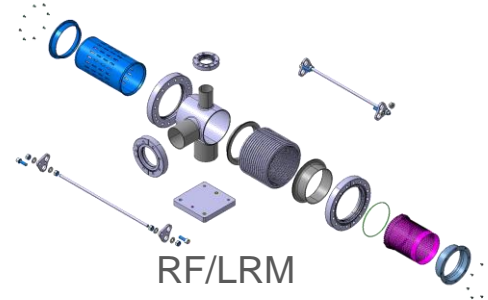
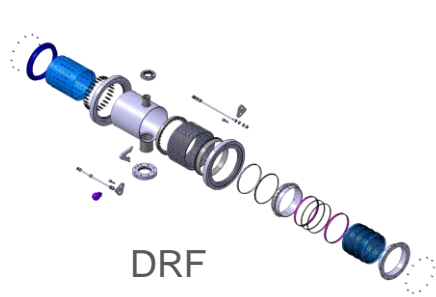
ATLAS VC1JE



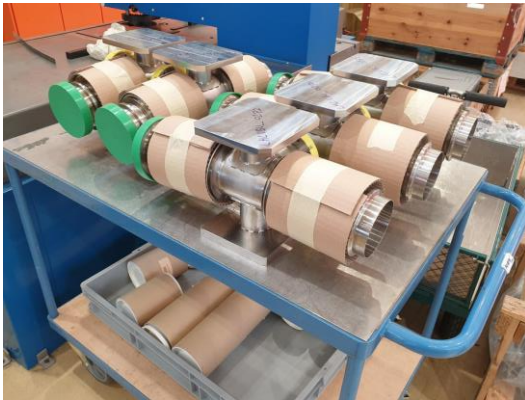
CMS VC5FE
Extension chamber

Warm modules procurement

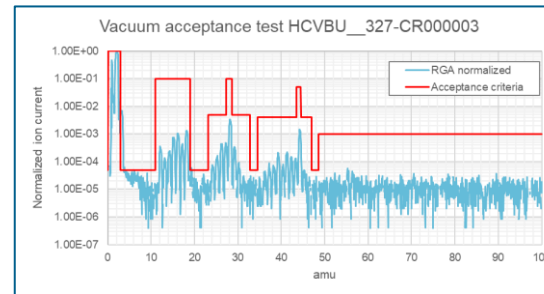
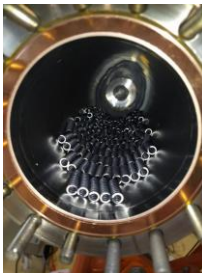
- 284 Vacuum Modules required (DRF, LRM RF, DN63 to DN250)



- Ongoing manufacturing (for optic V1.6) by CERN EN-MME to be completed by end 2024



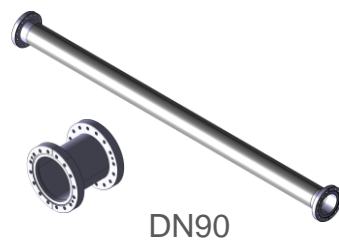
- Then aC, NEG coatings, assembly, vacuum validation



→ Completion expected by end 2025

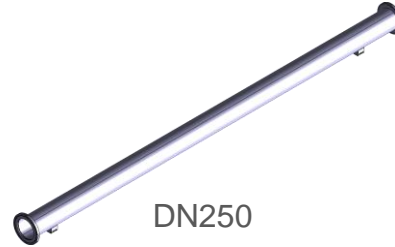
Vacuum chambers procurement

- NEG (1 μm TiZrV) or a-C coated (~ 100 nm)
- Ongoing production of 125 vacuum chambers by CERN EN-MME (new chambers, cut chambers, special chambers and transitions)



DN90

Q4-2025



DN250

Q1-2026



Q4-2025

- Other vacuum chamber to be re-used, modified or cut from existing stock




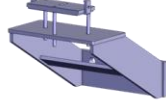
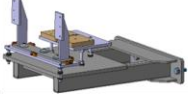
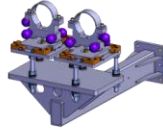

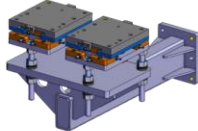





Q4-2025

→ Completion
expected by early 2026

Vacuum supports procurement

- Production by CERN EN-MME
- Ongoing delivery
 - 10 types of supports
 - 116 supports

 Received 	 Validated Delivery in Q4 2024	 No prototype Delivery beginning of 10/2024	 Validated Delivery beginning of 10/2024
 Received 	 Received 	 Validated Delivery in Q4 2024	 Validated Delivery in Q4 2024

- Specific FRAS supports
 - D2-sector valves prototype validated
 - D2 – crab cryomodule prototype under production



D2 – sector valves



D2 – Crab cryomodules

→ Completion expected by mid-2025

Bake-out procurement

- 50 % of the required material is received:
 - power, heating jackets bands and collars, thermocouples, insulation, racks, distributions



- Remaining 50 % was recently ordered

→ Completion
expected by mid 2025

4. Summary

Summary

- The construction of the Vacuum System for HL-LHC is ongoing !
- Beam screens
 - All building parts for beam screens are at CERN
 - All beam screen tubes (x39) are produced.
 - Beam screen pre-assembly phase is ongoing for **all types of beam screens**
 - The **first shielded beam screen** for CP is **fully assembled**
 - Next fully assembled shielded beam screens for **Q2** are following, **ready for insertion by February 2025**
 - During 2025, expected beam screens ready for insertion are:
 - 2x Q1, 4x Q2 , 1x Q3 , 2x CP, 1x D1 and 10x D2
- Vacuum Layout
 - Optic V1.8 is released
 - **Ongoing production** for VAX modules, vacuum chambers, vacuum modules & supports
 - ➔ Full production expected **to be completed by Q1-2026**
 - **Production preparation of forward chambers** for ATLAS and CMS (delivery by 2027)

Thank you for your attention !!!

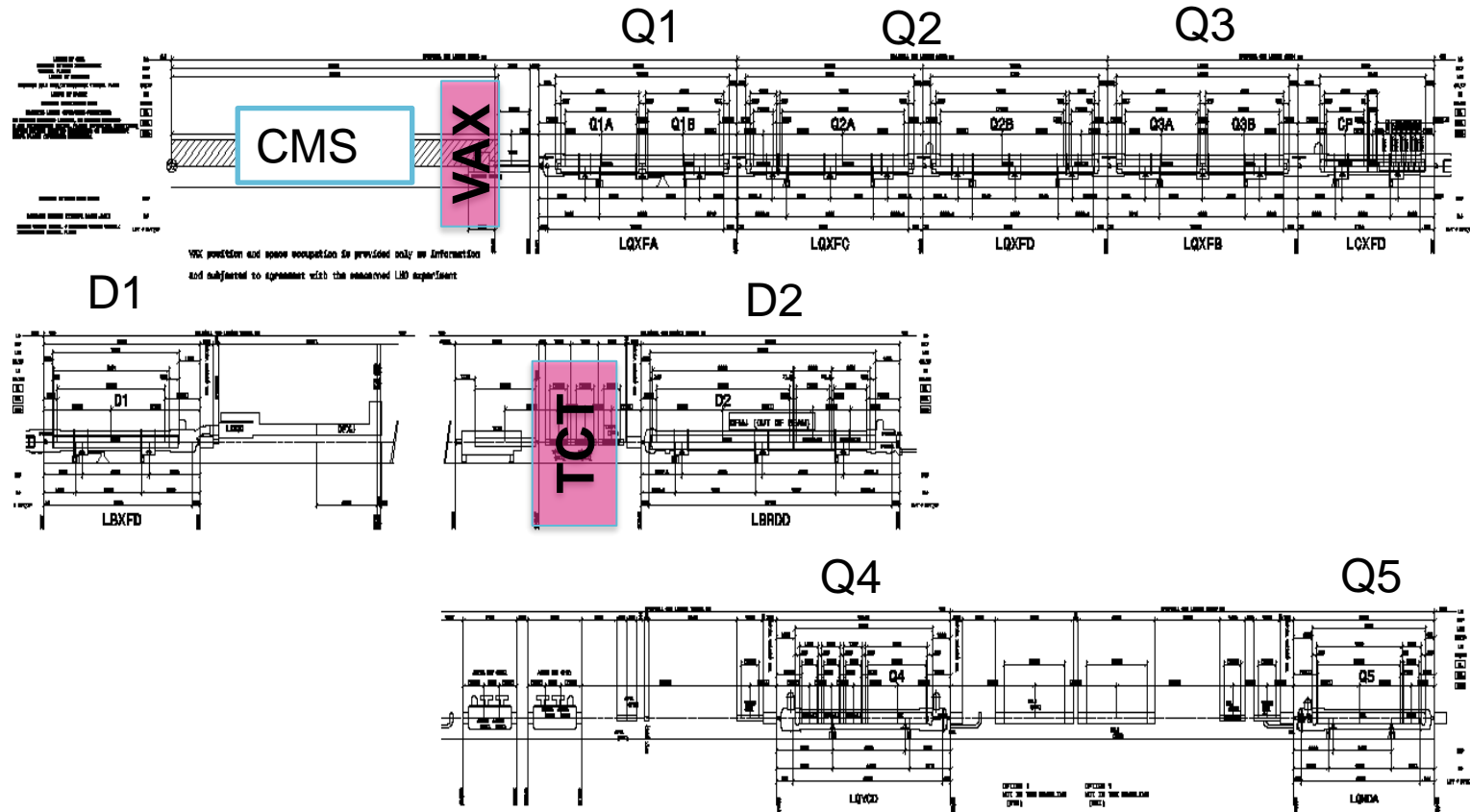


Reserve slides

Vacuum layout overview

- Vacuum sectorisation at cryogenic magnets
- RT vacuum sectors are NEG coated and bake-able
- Re-use LHC components, upgrade when necessary
- Novelty: **Full Remote Alignment** system up to Q5 included (within ± 2.5 mm)

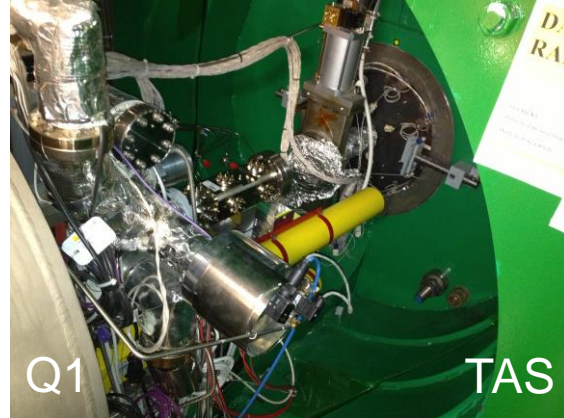
Layout :
IP5 Right



Vacuum Assembly for eXperiments (VAX)

- Objective
 - Avoid human intervention around TAXS in machine and cavern areas
 - Three modules embarking instrumentation and remote connection/disconnection of electrical and pneumatic connectors, and vacuum flanges

Today:
a confined space in LHC



In the Future:
Remote handling for HL-LHC
TAXS at RT a-C coated

