



# Dust in accelerator vacuum systems: Vacuum manipulations and beam screen treatment at LHC

Cédric Garion, TE-VSC

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# Outline

Beam screen functions and features

Manufacturing steps and Storage conditions

Integration in cold masses

Operation

- Venting

- RF ball

- PIM exchange

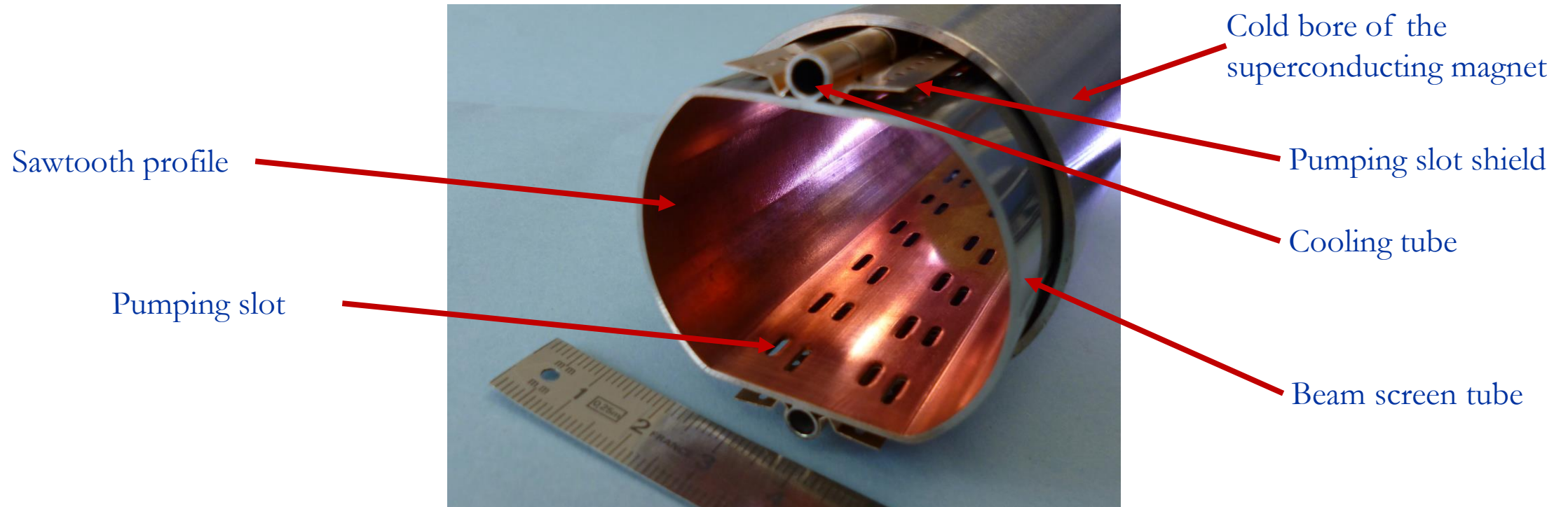
Conclusion

# Beam screen functions and features

Beam screen: First wall seen by the beams in cryogenic magnets.

Main beam screen functions:

- ❑ Ensure vacuum performance.
- ❑ Minimize, intercept and transfer the beam induced heat load to the cryogenics.



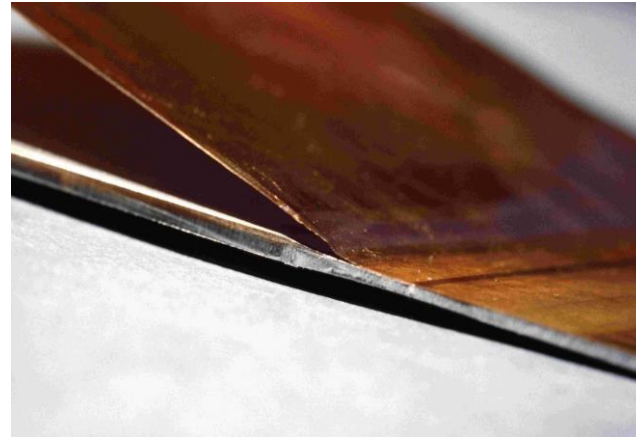
# Manufacturing steps (1)

## Raw material:

- Austenitic stainless steel: 2 mm coiled strip.
- OFE copper: 150  $\mu\text{m}$  coiled strip.

## Beam screen tube manufacturing (97 coils):

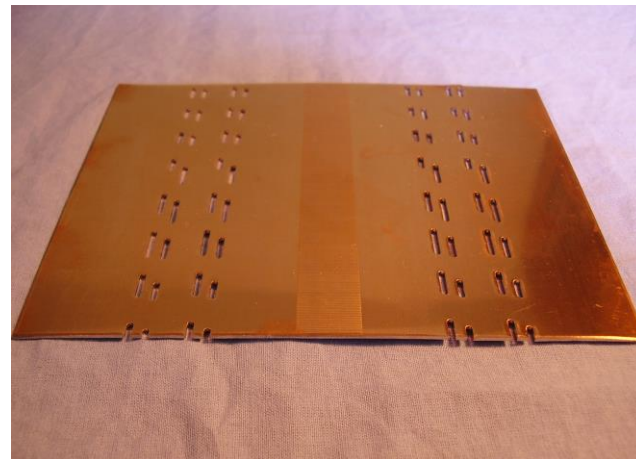
- Copper stainless steel colamination (1 mm stainless steel + 75  $\mu\text{m}$  copper).
- Sawtooth rolling.
- Pumping slot punching.
- Continuous forming; copper removal and welding; cutting.



Colamination



Punching



Beam screen sheet



Beam screen tube production line

# Manufacturing steps (2)

Beam screen finishing: welding of

- Gold plated contact rings.
- Cooling tubes.
- Cooling tube support and fixed point.
- Contact rings.



Beam screen extremity after finishing

Finished beam screens shipped and stored in wooden crates, individually packed in hermetically sealed polyethylene sleeves.



Spot laser weld of the cooling tube to the beam screen tube



# Conditioning at CERN

Cleaning (EDMS 2371237):

- Ultrasound cleaning in detergent bath.
- Final rinsing in demineralized water.
- Drying with alcohol then in air.

Cold leak/pressure test:

- Beam screens installed in a vacuum chamber.
- Cooling down to  $\sim 80\text{K}$ .
- Pressurisation of the cooling tubes at  $\sim 2.5$  bars.
- Venting with  $\text{N}_2$ .

Beam screens transported and stored in metallic boxes with plastic foil protection.



Beam screen cleaning



Beam screen cold test



Beam screen storage from cleaning

# Integration in the cold mass (1)

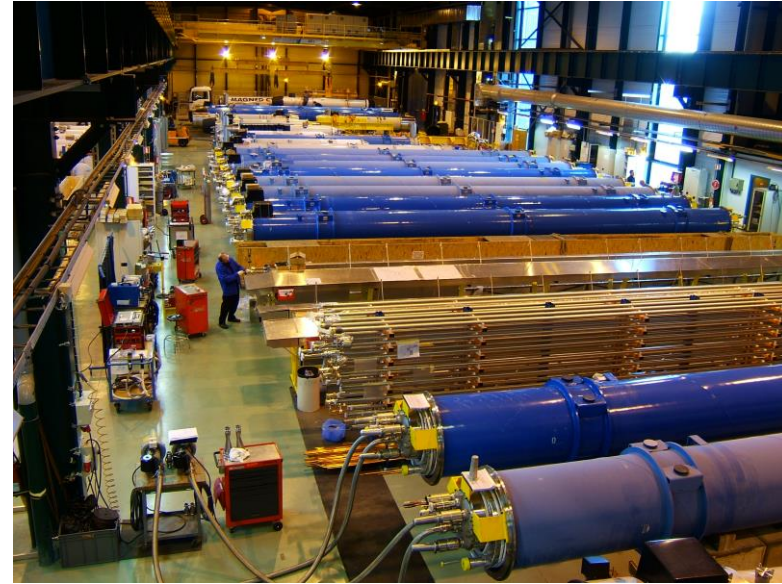
Done at CERN by a contractor following procedures:  
1423318 & 1423322.

Cleaning of the magnet cold bore:

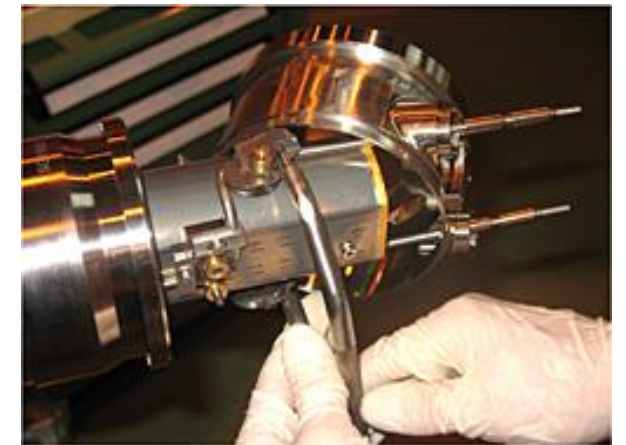
- Cleaning by circulation of detergent.
- Rinsing with demineralized water.
- Drying with filtered air.
- Closed with aluminium foil.

Downstream assembly (sliding point):

- Cut of cooling capillaries: cutting, dressing, boring.
- Bending.
- Bellows mounting and exit tube assembly.
- Welding bellows and cooling tubes with exit tube.  
Tooling with back gas protection.



Beam screen integration facility during LHC installation



Beam screen LHC downstream assembly



# Integration in the cold mass (2)

Insertion in the cold mass:

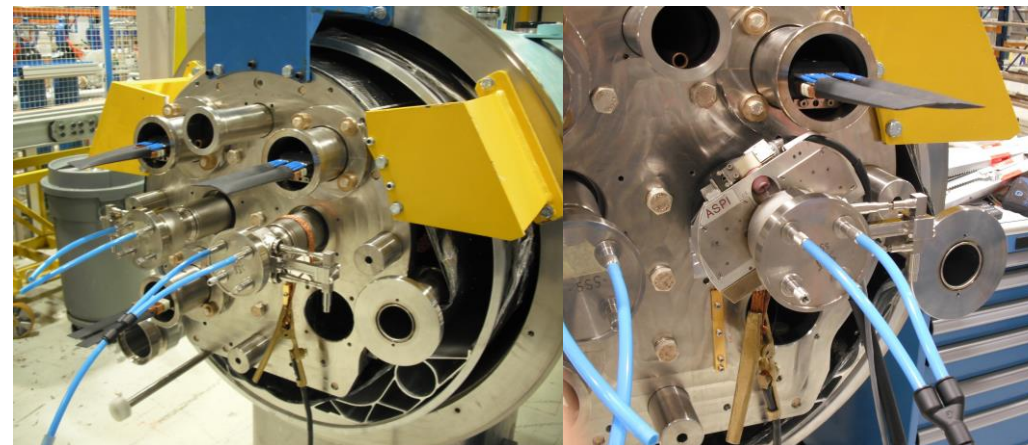
- Manually / 3 persons.
- Protection beam screen extremity with aluminium foil.



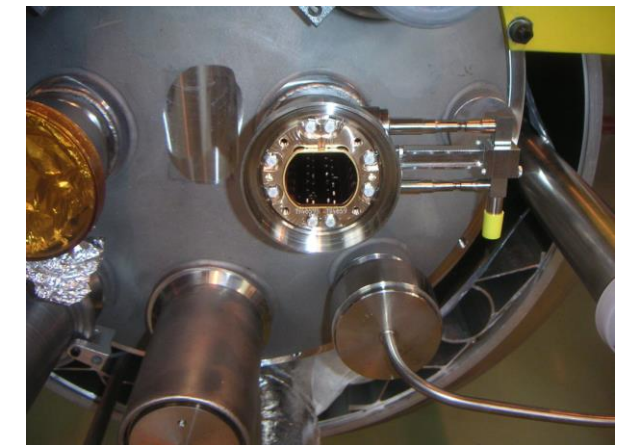
Beam screen insertion in a LHC dipole

Upstream assembly (fixed point):

Mechanical assembly and welding with gas protection



Beam screen insertion in a LHC dipole



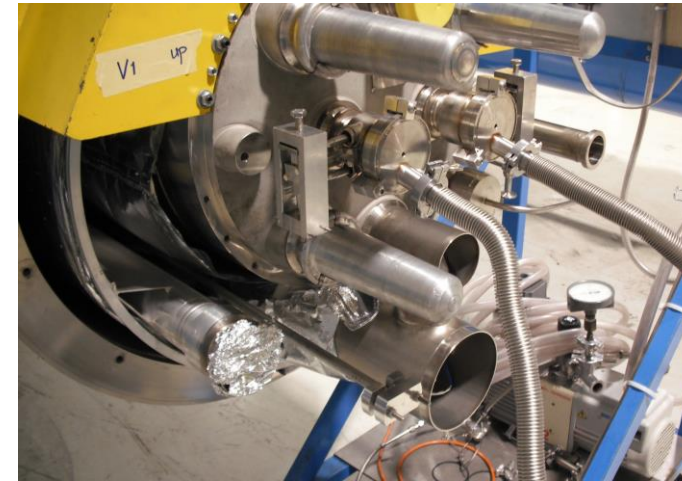
Upstream assembly completed



# Integration in the cold mass (3)

Leak detections (EDMS 35338):

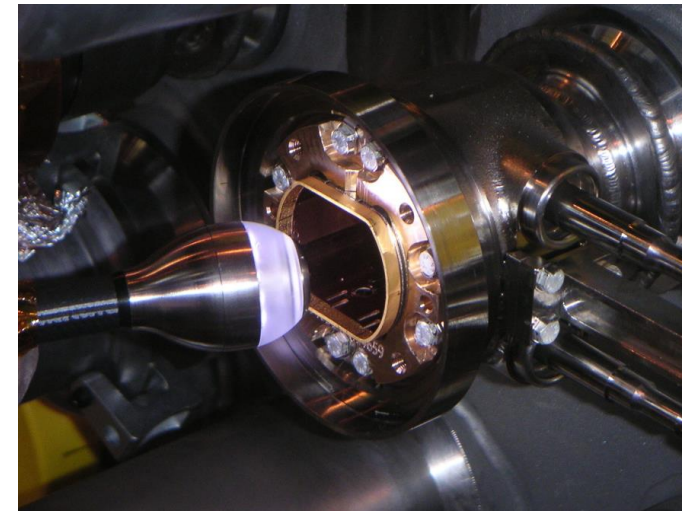
- Beam line under vacuum.
- He pressure in the cooling tubes and in pockets around welds.
- Venting with air.



Leak detection

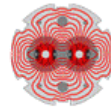
Endoscopic inspections.

Beam vacuum sealed with aluminium flanges.



Endoscopy

# Production timescale

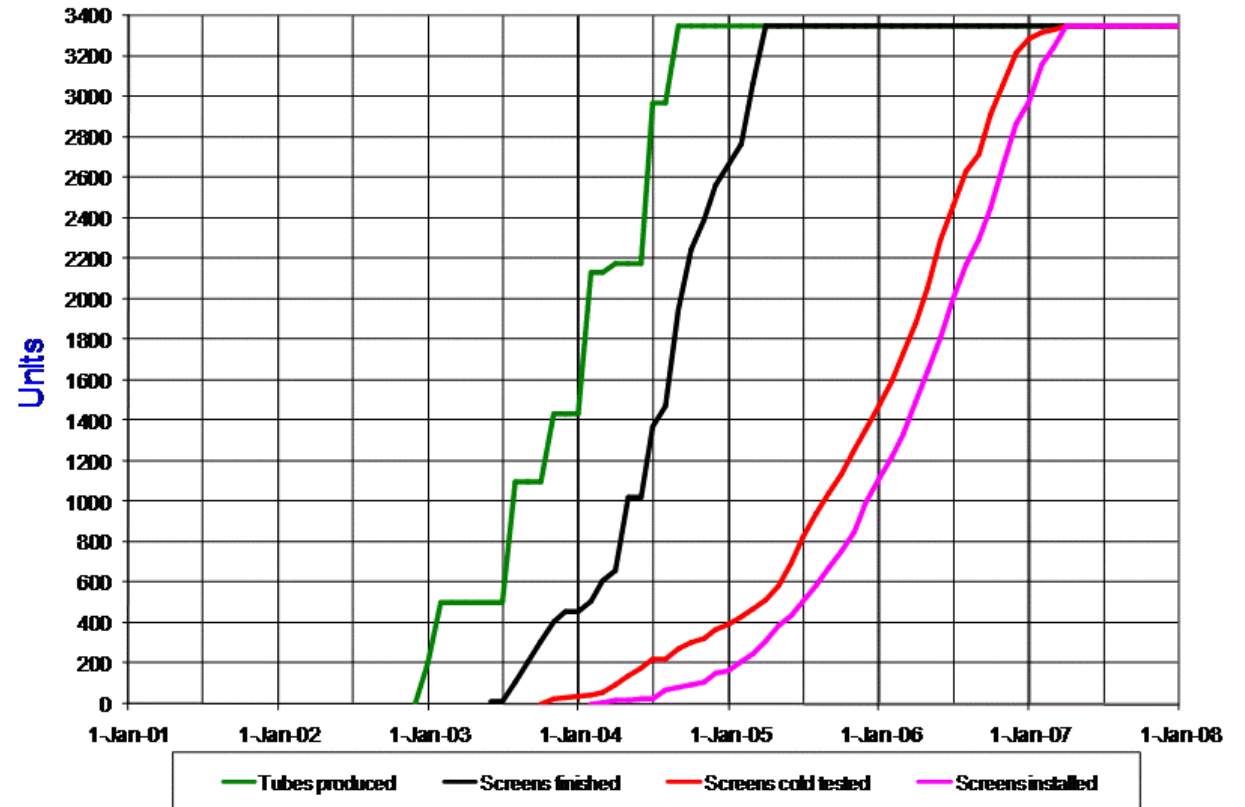


Series production spreaded from 2002 to 2007:

- Raw material:
  - P506: Dec. 2001 – Jan. 2004
  - Colamination: July 2002 – April 2004
- Cooling tubes: March 2003 – March 2004
- Beam screen tubes
- Finishing
- Integration

} See dashboard

Arc and DS beam screens overview



Updated 31 December 2007

Data provided by N. Kos AT-VAC

# Operation

Venting:

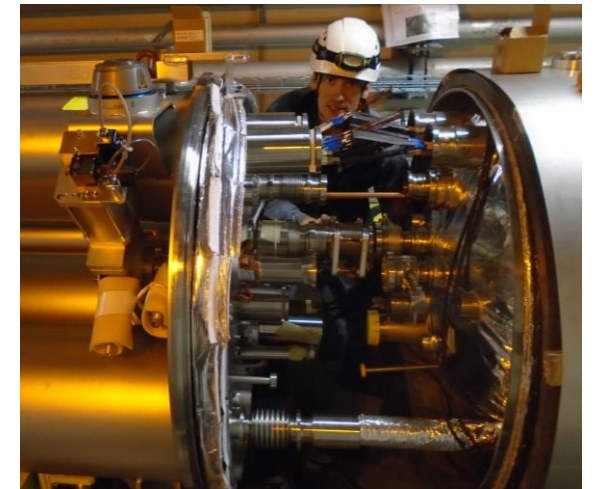
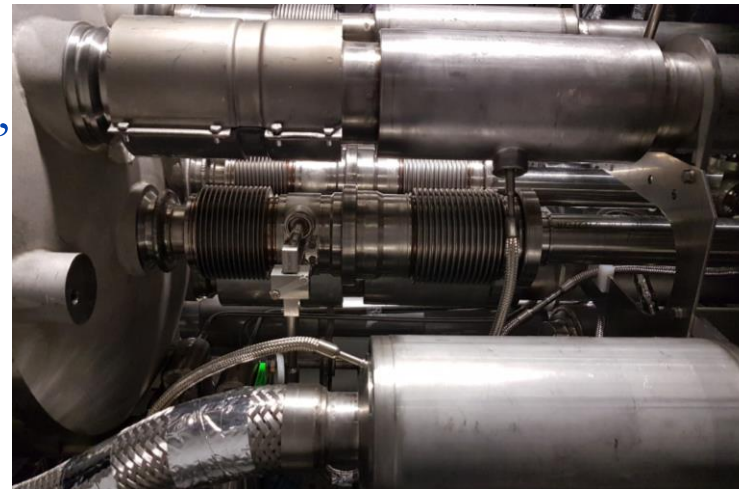
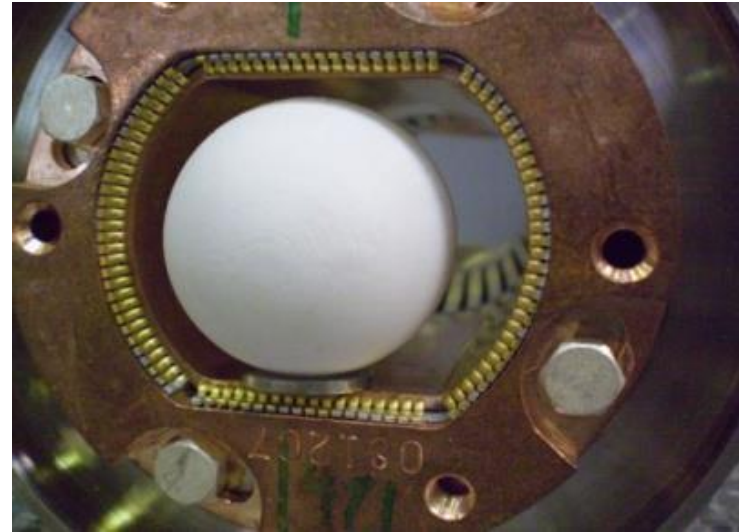
- LS1: N<sub>2</sub>.
- From LS2: N<sub>2</sub>/O<sub>2</sub> mixture (EDMS 2049213).

RF ball test:

- Filtered air, 10 μm, EDMS 1264764.

Plug-In module exchange (EDMS 1318946, 2087106).

Endoscopic inspections (EDMS 1244128).





# Conclusion

LHC beam screens have been manufactured in industry, conditioned and integrated in the cold masses at CERN.

Activities at CERN have been done considering ultra-high vacuum requirements.

Best practices have been applied for the assembly, carried out in large series production environment.

Thanks for your attention  
and  
thanks to VSC colleagues for the different  
materials presented.



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# Arc Beam Screen Manufacturing Steps

	Process	Unit	Qty	Treatment grouping	Comment
Raw material	OFE Cu - 8 tonnes (tbc)	Melt	?	n/a	OFE Cu raw material
	Rolling Cu	150 um (tbc) coiled strip	tbc	n/a	
	P506 St. St. 30 tonnes	Melt	3	n/a	P506 St St raw material
	ESR process ~ 1 tonne	Billet	97	n/a	
	Rolling St. St.	2 mm coiled strip	97	n/a	
Beam screen manufacturing	Colamination	1 mm coiled strip	97	10 coils in 10 batches	Cu thickness, surface resistance - coil start & end
	Saw tooth rolling	1 mm coiled strip	97	10 coils in 10 batches	Saw tooth micrograph
	Slot punching	1 mm coiled strip	97	10 coils in 10 batches	
	Tube forming & welding	Continuous tube from coil	97	1 coil	Gurin
	Cutting into BS tubes	15.5 m tube	2800	45-50 BS in 60 crates	Magnetic permeability & surface resistance on BS of each coil
	Beam screen finishing	15.5 m tube	2800	45-50 BS in 60 crates	Add cooling tubes, end rings and fittings.
Beam screen conditioning & installation	Storage	15.5 m BS	2800	45-50 BS in 60 crates	Wooden crates
	UHV Cleaning	15.5 m BS	2800	14 BS in 200 batches	Wooden crates to metallic 'caisse navette' with 28 BS
	80 K leak test	15.5 m BS	2800	7 BS in 400 batches	28 BS in metallic 'caisse navette'
	Short term storage	15.5 m BS	2800	28 BS in 100 batches	28 BS in metallic 'caisse navette'
	Insertion in cryomagnet	15.5 m BS pair	2464	2 BS in 1232 MB	BV sealed
	Endoscopic inspection	15.5 m BS pair	2464	2 BS in 1232 MB	BV sealed. Sector 8-1 endoscope in tunnel
	External storage	15.5 m BS pair	2464	2 BS in 1232 MB	BV sealed
	Tunnel installation	15.5 m BS pair	2464	1232 MB in 8 sectors	BV sealed until installation of PIM