Considerations for large scale production of the FCC-hh beam screens

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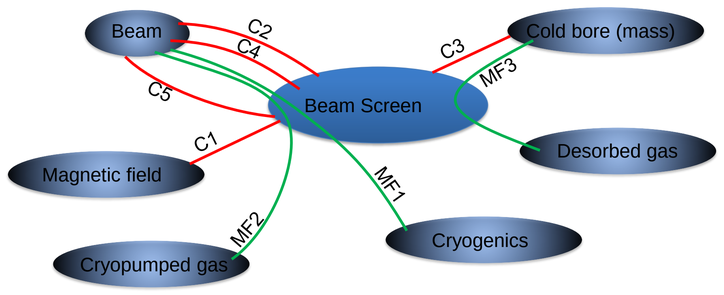
Introduction

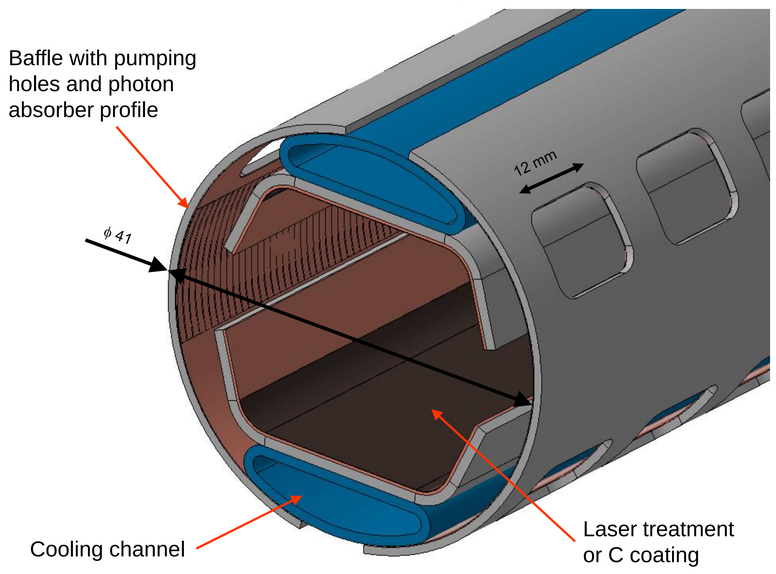
The FCC-hh cryogenic vacuum system relies on a beam screen to mitigate beam stimulated gas desorption and to intercept beam induced synchrotron radiation at a high temperature level (for efficiency consideration).
While its functions are identical to LHC beam screens, FCC-hh, and its high synchrotron radiation power, requires a more complex and complicated design than for LHC. It is based on a distributed photon absorbers with a sawtooth profile cooled by large channel in which helium at 40-60 K, 50 bars circulates. Large pumping holes, hidden from the beam by an internal chamber, offer a large pumping speed to ensure gas-beam scattering lifetime higher than 100h. Finally, a surface treatment is applied on the internal wall to suppress the electron clouds.

Beam Screen functions



MF1 : Intercept beam induced synchrotron radiation power and transfer it to cryogenic cooling fluid
MF2 : Hide the cryopumped gas from beam induced photon impingement
MF3 : Provide sufficient pumping speed of desorbed gas toward the cold bore
C1: Withstand the Lorentz's forces during a quench
C2: Fulfil impedance requirements
C3: Minimise the heat loads to the cold bore
C4: Mitigate electron cloud
C5: Maximize the beam aperture

Beam Screen design



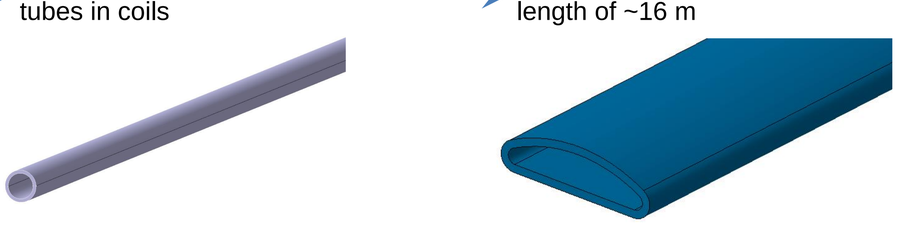
For the series production of the FCC-hh beam screens, the method of manufacturing as well as the mechanical design must consider the technical constraints and the necessity to economically produce around two hundreds of kilometres of beam screens in length of around 15 metres. This will be the subject of a trade-off between performance and cost and to further investigations. Preliminary considerations of possible manufacturing methods are presented hereafter.

Manufacturing methods

To reduce the cost, the beam screen design has been developed integrating the compatibility with reliable technologies adapted to large scale production requirement.

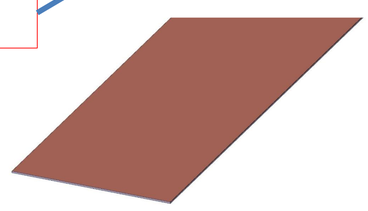
High Mn High N stainless steel casting

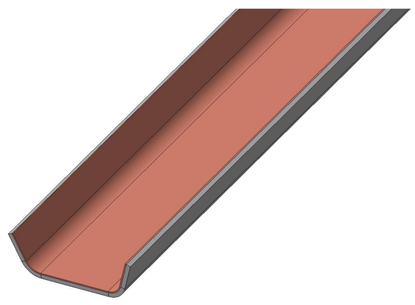
Billets → Cold-drawing of seamless tubes in coils → Forming of cooling tubes in length of ~16 m → Pressure/leak testing → Cleaning

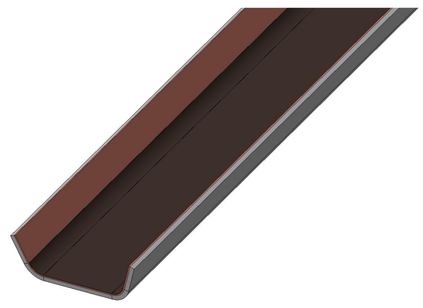


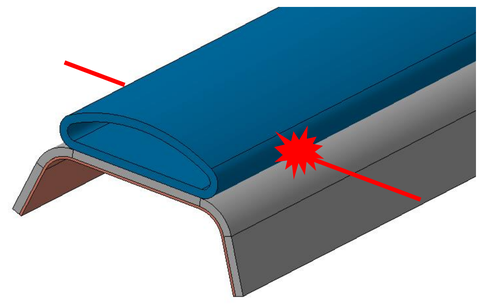
Strip coils → Colaminations → Continuous forming and cutting in ~16m segments → Laser treatment → Cleaning → Laser welding

OFE copper strips



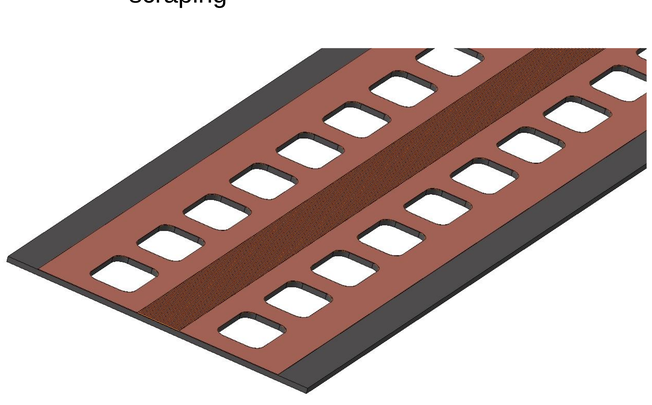


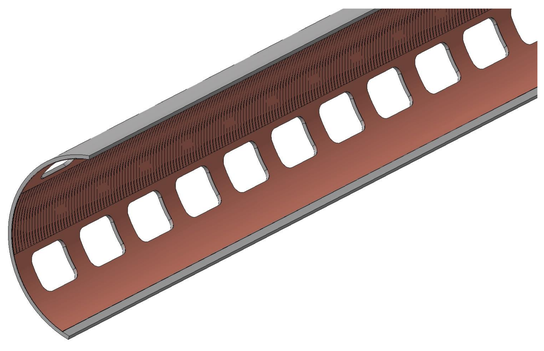


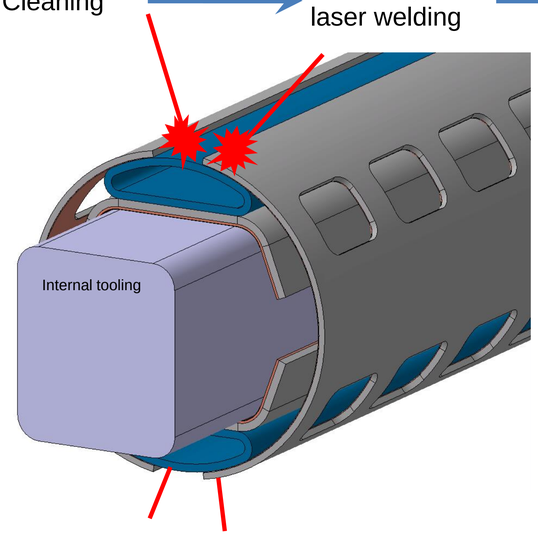


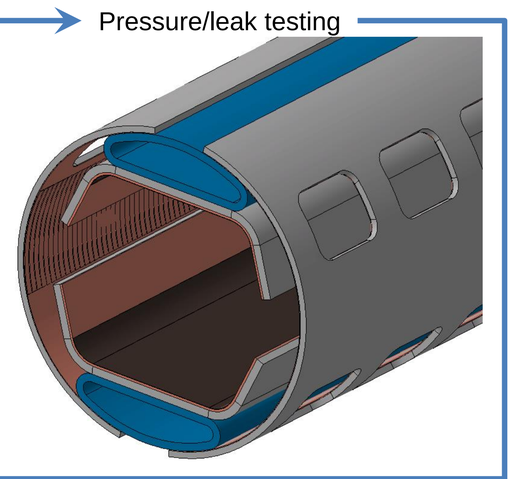
Pressure/leak testing

Continuous punching, scraping → Continuous forming and cutting in ~16m segments → Cleaning → Assembly and laser welding → Pressure/leak testing









Beam screen Finishing

Conclusion and Perspectives

The design of the FCC-hh is compatible with large scale production technologies. This will maintain the costs to reasonable and affordable level. A few (semi-) automatized assembly lines are required to ensure the production within an acceptable timeline. The finishing of the beam screens remains to be studied as well as the extremities, which turn out to be very challenging given the complexity and the limited space allocated for the interconnections.

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