RCS vacuum chambers discussion summary

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Participants	Antoine Chance, Anton Lechner, Daniel Schulte, David Amorim, Elias Métral, Erik Kvikne, Fulvio Boattini, Jose Somoza, Lisa Soubirou, Luca Bottura, Marco Gast, Stefano Marin

The goal of the discussion was to provide a baseline for the RCS normal conducting magnets vacuum chambers, considering aspects from optics, vacuum, impedance and magnets. The indico page https://indico.cern.ch/event/1423057/ gathers the materials used for the discussion. More materials can be found on the RCS mini-workshop page https://indico.cern.ch/event/1388830/timetable/

Topics discussed

Optics

The horizontal aperture is driven by the beam excursion between injection and ejection energy, and by the beam size. The 6 sigma size is 10 mm, **the horizontal beam width from –6 sigma to +6 sigma is around 20 mm**. The **beam excursion is 20 mm in total.**

The vertical axis doesn't have this beam excursion effect, the beam aperture is driven only by the vertical beam size. The 6 sigma size is 3.5 mm, **the vertical beam width from –6 sigma to +6 sigma is around 7 mm**.

These don't include the effect of errors such as beta-beating from misalignment and power converter settings. The horizontal excursion can be reduced by increasing the normal conducting magnets field.

From optics, an **aperture of 30 mm in horizontal and 10 mm in vertical is a good basis.**

For RCS 3 and RCS 4, the beam excursion will be smaller and the chamber aperture could be adapted consequently.

Materials

The baseline would be a **ceramic chamber with a thin metallic coating on the inner side**. JSomoza showed the example of PSB kicker chambers, made of **6 mm thick ceramic with a 2 um Titanium** (Ti) **coating inside**. Connection between chambers is ensured by metallic flanges brazed to the ceramic. The electrical continuity for the beam image current is ensured by the titanium coating extending to the flange.

Issues with ceramic chambers are their more delicate handling (the brittleness requires careful manipulation), the tighter alignment tolerance (the assembly cannot be forced like metallic chambers, otherwise the chamber would break), and the higher cost than metallic chambers.

Corrugated chambers were also discussed. They are used for example in the PSBooster, and are made of Inconel. However, their production process is also complex and they are more expensive to build than classic metallic chambers. The thickness can also be expected to be in the 5 mm range because of the groove's height.

More information on Titanium coatings can be found in the two following references forwarded by JSomoza:

- W. Vollenberg et al., "Titanium Coating of Ceramics for Accelerator Applications", Proceedings of IPAC2015.
- M. Barnes et al., "Calculation of Metallization Resistivity and Thickness for Medaustron Kickers", Proceedings of IPAC 2011.

Magnets

The **current height between poles for the normal conducting magnets is 30 mm**. The ceramic chamber could be placed directly on the magnet pole, with some insulating layer between the two (material and thickness to be defined). Assuming a 10 mm vertical aperture and a 5mm ceramic thickness, the chamber total height would be 20 mm. Impedance simulations were performed assuming a 20 mm vertical aperture and 5 mm ceramic thickness, such that the chamber total height would be 30 mm.

With ceramic chambers and metallic flanges, the interconnect length between magnets would be at least 30-40 cm.

Radiation shielding

In the RCS, the magnets following a straight section (containing either the RF or the injection/extraction systems) are the most impacted by radiation, but masks would be placed to reduce the impact of radiation showers. **Normal conducting magnets in the arcs are not too much affected by radiation damage**, as shown in SMarin presentation at the RCS workshop. The **main concern is the magnet yoke material, in particular the cobalt content of iron**.

One point to check is the insulation of coils and their supports, that must be radiation hard (using fibber glass for example). FBoattini suggested that the coils insulation could be removed if the spacing between coils can be ensured with their supports, that then need to be made with a radiation hard material.

Impedance

Geometry and chamber materials are the main impedance drivers. Simulations were performed by EKvikne showing that **at least 1 to 10 um of copper coating is needed to shield the ceramic**. The simulations were performed assuming a 10 mm inner radius circular chamber, and a 5 mm thick ceramic chamber. The **impedance simulations will be re-run using a titanium coating** since it has higher resistivity than copper.

Vacuum

A first approximation of the required vacuum level could be computed using the beam acceleration time in the RCS, and the beam lifetime. The vacuum level is not expected to be constraining, since the storage times are very short compared to the collider. To save space, cryo-pumping might be doable with the superconducting magnets (requiring then a beam screen in the superconducting magnets cold bore), allowing to save space in the interconnects.

Radial build proposition

Assuming a rectangular vacuum chamber, Table 1 shows the proposed radial build for the RCS normal conducting magnets chamber horizontal plane. Table 2 shows the radial build for the vertical plane, if the beam aperture is assumed to be 10 mm (5 mm radius). Table 2bis shows the radial build for the vertical plane, if the beam aperture is assumed to be 20 mm (10 mm radius).

The two radial builds are figured in Figure 1 and Figure 2.

Table 1: radial build for the horizontal axis

Element	Thickness	Radius
Beam aperture	15 mm	[0; 14.99 mm[
Titanium coating	10 µm	[14.99 mm; 15.00 mm[
Ceramic	5 mm	[15.00 mm; 20.00 mm[
Insulating layer	1 mm ?	[20.00 mm; 21.00 mm[

Table 2: radial build for the vertical axis, assuming a full beam aperture of 10 mm

Element	Thickness	Radius
Beam aperture	5 mm	[0; 4.99 mm[
Titanium coating	10 µm	[4.99 mm; 5.00 mm[
Ceramic	5 mm	[5.00 mm; 10.00 mm[
Insulating layer	1 mm ?	[10.00 mm; 11.00 mm[

Table 2bis: radial build for the vertical axis, assuming a full beam aperture of 20 mm

Element	Thickness	Radius
Beam aperture	10 mm	[0; 9.99 mm[
Titanium coating	10 µm	[9.99 mm; 10.00 mm[
Ceramic	5 mm	[10.00 mm; 15.00 mm[
Insulating layer	1 mm ?	[15.00 mm; 16.00 mm[

Figure 1: radial build diagram with 10 mm vertical beam aperture

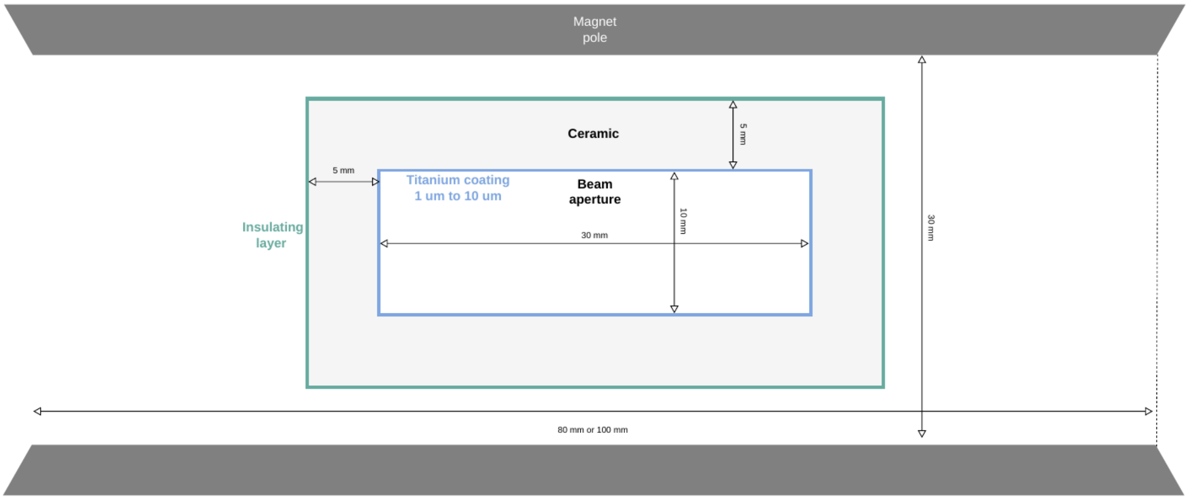

Figure 2: radial build diagram with 20 mm vertical beam aperture