Beam screen model heat load and photo-electrons density analysis: Milestone 4.2

Perez Rodriguez, Francisco Jose () et al.

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The research leading to this document is part of the Future Circular Collider Study

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Abstract:

Develop a computer model of the beam screen and report on the analysis of heat load and photo electron densities under the assumed operation conditions. The analysis is made available on the project’s document management system.
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<tr>
<th>Author</th>
<th>Name</th>
<th>Partner</th>
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| Authored by | Francis Perez  
                               Paolo Chiggiato | CIEMAT       
                               CERN         | 27/05/16 |
| Edited by | Julie Hadre  
                               Johannes Gutleber | CERN         | 30/05/16 |
| Reviewed by | Michael Benedikt  
                               Daniel Schulte | CERN         | 31/05/16 |
| Approved by | EuroCirCol Coordination Committee |             | 31/05/16 |
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1. ANALYSIS REPORTS

1.1. HEAT LOAD

The heat transfer of the synchrotron radiation power has been analysed in nominal configuration, i.e. the beam screen perfectly centred (Fig. 1) with respect to the beam and also in extreme conditions with an off-plane beam (Fig. 2). The cooling of the beam screen has been discussed with experts in charge of the cryogenic system and the present design is compatible with the cryogenic requirements (helium pressure, cooling channel geometry).

Temperature [K]

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**Fig. 1:** Temperature distribution with a beam perfectly centered

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**Fig. 2:** Temperature distribution with an offset in the beam position
The thermal analysis shows that in the first case the temperature of the screen is less than 3 K higher than the cooling gas (40 K), while the sharp diffuser attains temperature around 50 K. In case of offset, the temperature of the screen rises up to 55 K in the point of maximum photon impingement. The input data for the calculation are listed here below:

- Heat power deposition: 31 W/m
- Heat deposition distribution based on SynRad+ simulation
- Estimated thermal conductivity of copper at 50 K and 16 T magnetic field: ~ 700 W.m⁻¹.K⁻¹
- Thermal conductivity of stainless steel at 50 K: ~ 6 W.m⁻¹.K⁻¹
- Convection coefficient: 150 W.K⁻¹.m²

The results indicate that the synchrotron radiation thermal load should not perturb the gas pressure in the proposed beam screen.

1.2. PHOTO ELECTRON DENSITIES

The first step of this objective is the simulation of the synchrotron radiation map in the proposed beam screen.

This results was obtained by SYNRAD+ (see Fig. 3). The simulation shows that at the top energy most of the photons, and so the photoelectrons, are expected to impinge in surfaces outside of the beam view, namely in the diffuser and the absorbers (Fig. 3 right). On the other hand, during injection and the first part of the energy ramp, a significant part of photons are absorbed by the first wall of the beam screen; as a consequence, photoelectrons can be accelerated by the beam and trigger electron-cloud related phenomena. The quantitative effect of such ‘escaped’ photons’ is not yet concluded because it need experimental photoelectron yield data for the selected surface treatment that we plan to obtain with the experiment in both ANKA and our laboratory.
2. CONCLUSION AND FUTURE PLANS

The heat load model is completed. The first results show that the temperature rise is compatible with the required gas pressure stability.

The map of photon impingements has been simulated. Most of the photons are driven out of the view of the beam at top energy. The analysis will continue with beams of lower energies. The photoelectron density map will be completed once the experimental data for the proposed surface treatment are available (first semester 2017).
3. REFERENCES

F. Perez, FCC week 2016,  
Available: http://indico.cern.ch/event/438866/timetable/#20160411.detailed  
C. Garion, FCC week 2016  
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ANNEX: GLOSSARY

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
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<tbody>
<tr>
<td>c.m.</td>
<td>Centre of Mass</td>
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<tr>
<td>FCC</td>
<td>Future Circular Collider</td>
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<tr>
<td>FCC-hh</td>
<td>Hadron Collider within the Future Circular Collider study</td>
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<tr>
<td>FODO</td>
<td>Focusing and defocusing quadrupole lenses in alternating order</td>
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<tr>
<td>HE-LHC</td>
<td>High Energy - Large Hadron Collider</td>
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<tr>
<td>HL-LHC</td>
<td>High Luminosity – Large Hadron Collider</td>
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<tr>
<td>IBS</td>
<td>Intra Beam Scattering</td>
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<tr>
<td>IP</td>
<td>Interaction Point</td>
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<tr>
<td>LHC</td>
<td>Large Hadron Collider</td>
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<tr>
<td>Nb3Sn</td>
<td>Niobium-tin, a metallic chemical</td>
</tr>
<tr>
<td>Nb-Ti</td>
<td>Niobium-titanium, a superconducting alloy</td>
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<tr>
<td>RF</td>
<td>Radio Frequency</td>
</tr>
<tr>
<td>RMS</td>
<td>Root Mean Square</td>
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<tr>
<td>SR</td>
<td>Synchrotron Radiation</td>
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<tr>
<td>SSC</td>
<td>Superconducting Super Collider</td>
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