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PUBLICATION

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

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MILESTONE REPORT

BEAM SCREEN MODEL HEAT LOAD AND PHOTO-ELECTRONS DENSITY ANALYSIS

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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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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]

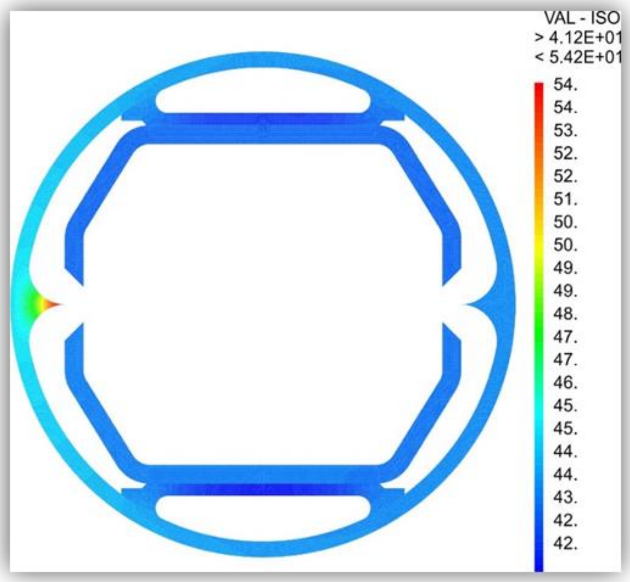

Fig. 1: Temperature distribution with a beam perfectly centered

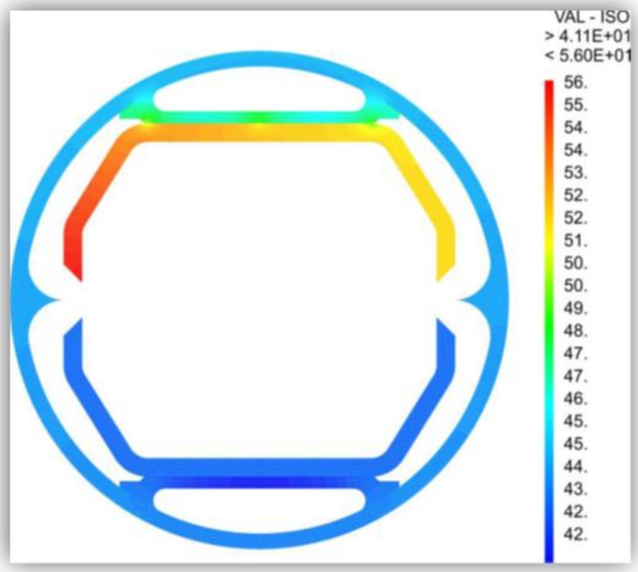

Fig. 2: Temperature distribution with an offset in the beam position

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 distriution 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 $W.K^{-1}.m^{-2}$

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.

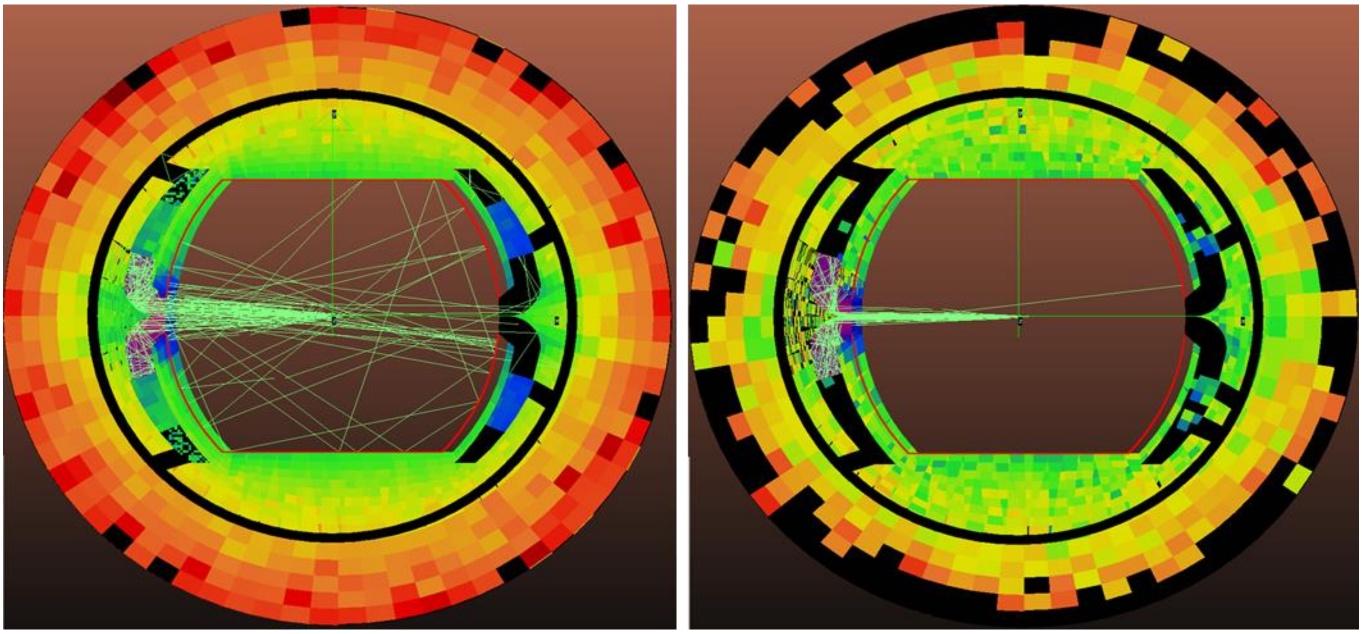

Fig. 3: Photon distribution for perfectly centered beams at 5 TeV (left) and 50 TeV (right).

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 rigth). On the other hand, during injection and the first part of the energy ramp, a significant part of photons are absorbed by the frst 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

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ANNEX: GLOSSARY

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