Calculation of radiation heat deposition on EU-DEMO plasma facing components

Introduction

According to the current, pre-conceptual design, the EU-DEMO First Wall (FW) will be made of a 2 mm W layer directly facing the plasma, followed by 2 mm Eurofer structural material. In order not to damage the thin external layer, heat loads distributed onto the FW should be carefully controlled.

In steady-state nominal operation the maximum acceptable load is $\approx 1\ \mathrm{MW/m^2}$ and a detailed evaluation of its actual distribution is necessary to avoid hot-spots or excessive loads over particularly delicate structures. Accurate maps of the power density emitted by both the core region and the SOL of the plasma are then required. Moreover, in case of transient events the limit can be largely exceeded. A typical, deleterious transient event is a plasma disruption, an abrupt switching off of the plasma due to destabilizations triggered by a number of possible causes. Therefore, when the control system detects an upcoming disruption, impurities can be injected in the plasma in the form of shattered pellets (SPI) or massive gas injection (MGI) to mitigate the event [1]. The mitigation aims at enhancing as much as possible the radiation emission, to quickly spread the plasma internal energy onto the entire FW surface. Indeed, on the contrary, during a non-mitigated, naturally-evolving disruption, most of the power impinges on a limited area.

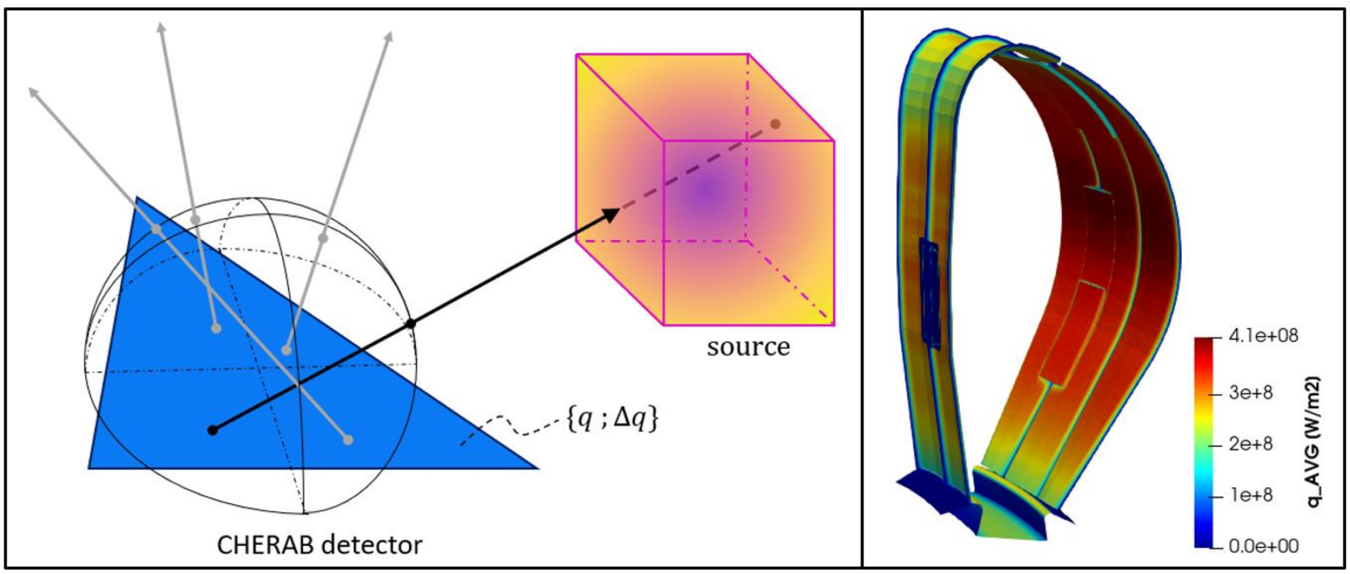

*Figure 1: **Left**: a CHERAB 3D detector shoots rays in the computational environment looking for radiation sources to be sampled. The power load q and its absolute error Δq are returned by the CHERAB code if at least one ray (in black) intercepts a source. **Right**: example of power load distribution over the DEMO FW. Tiny detectors completely cover its surface which encloses the input radiation source (not shown).*

Aim of the work

The target of this work is to precisely assess the radiative load distribution over given surfaces of the EU-DEMO chamber during the steady-state operation and/or a scenario of a mitigated plasma disruption. These "given surfaces" can be the FW with its limiters and/or the Electron Cyclotron (EC) port plug, a plasma-facing device devoted to plasma heating. To acquire information about the power load map, the Monte Carlo ray tracing code CHERAB originally developed at UKAEA is used [2] [3]. This code has already been successfully imported and exploited in Politecnico di Torino and it has been provided with additional useful tools in terms of post-processing.

Keywords: EU-DEMO, First Wall, Electron Cyclotron port plug, power exhaust, radiation loads, steady-state, off-normal operation, numerical modelling, CHERAB, Monte Carlo, ray-tracing

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References

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