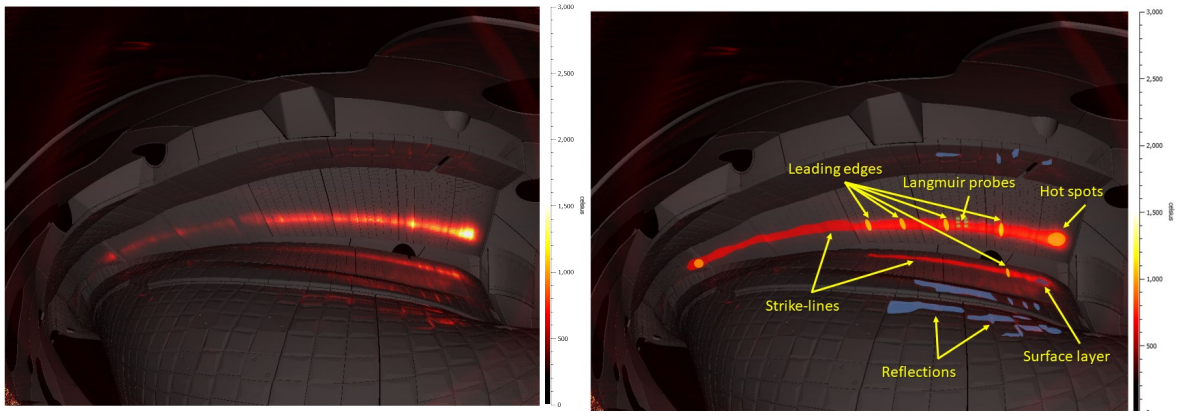
Estimation of the evolution of thermal events on Plasma Facing Components in Wendelstein 7-X

Description

This project is proposed in the context of an ongoing research collaboration with the Institute of Plasma Physics of the Max Planck Institute (IPP-MPI Greifswald branch, Germany).

Wendelstein 7-X is the largest prototype of a fusion reactor of the "Stellarator". The first operation phase (OP1) started in 2017, and IPP offers now a large amount of the resulting data (videos, images) for research. The second operation phase (OP2) will start in 2023.

The proposed project will develop image processing and deep learning tools for detection, tracking and classification of overlapped thermal events on the Plasma Facing Components (PFCs). Thermal events are important for the research, monitoring and safety of the operation of the Physics experiments carried out in the operation phases. In particular, strike-lines, leading edges, hot spots, surface layers, delaminations, reflections from thermal images that observe the plasma during operation.

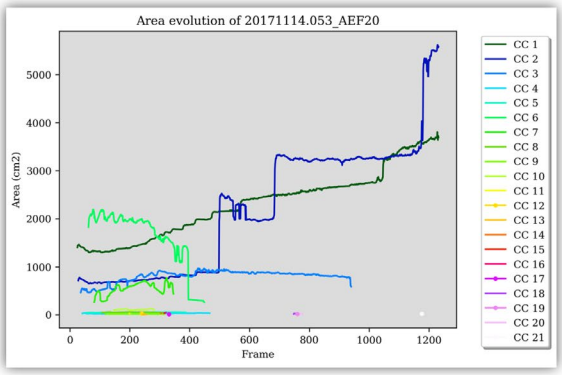


There are safety strategies to stop the experiments when critical areas get too hot (Fast Interlock System). The objective of the current proposal is to estimate when this will happen and cool down the system before it has to be stopped. It will rely on previous works carried out at UPC:

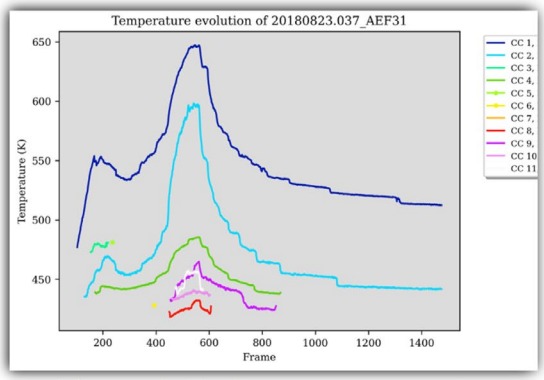
- R. Clemente, "**Detection and classification of thermal events in W7-X**," MsTh MET, ETSETB-UPC Sep-2020
- D. Vizcarro, "**Thermal Image Processing for Plasma Facing Components protection**," BS GRETST, ETSETB-UPC, Jul-2021
- A. Puig Sitjes *et al.*, "**Real-Time Detection of Overloads on the Plasma-Facing Components of Wendelstein 7-X**," *Applied Sciences* 11 (24), Jan. 2021.

Graphs of temporal evolution of areas and temperatures of thermal events have already been built in previous projects. In the current project proposal, we aim at estimating the evolution of a particular thermal event in consecutive frames to be able to react soon enough and avoid having to stop the experiments.

Area evolution of spatio-temporal IR events (cm²)



Evolution of spatio-temporal events temperature over area (K/cm²)



The interest in these topics has grown in recent years. Research teams at JET and medium sized Tokamaks such as WEST are interested in tools proposed by UPC to manage these experimental devices. Most of them prepare the scene for ITER (in Cadarache) and DEMO, the demonstration power plant. Fight against global warming may be better thought this way (See A. H. Boozer, "**Why carbon dioxide makes stellarators so important**," *Nucl. Fusion* 60 (6), 2020).

Project Objectives

- Improve segmentation of overlapped events (leading edges & hot spots over strike-lines)
- Extend the current temporal tracking to overlapped events
- Select features of interest to predict temporal event evolution

Project requirements: C++/python, Deep Learning for image classification

A specific **research initiation grant** (inirec) is available for funding the student during the project.

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340 cc summary:

Wendelstein 7-X is a Stellarator fusion prototype. UPC collaborates with IPP-MPI for a new operation phase to start in 2022. Data is available for research to develop image processing and deep learning tools for detection, tracking and classification of thermal events on Plasma Facing Components, and for the estimation of their evolution.