A new platform to infer runaway electrons in fusion plasma phenomena

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Abstract

Nuclear fusion represents a promising and clean energy source. One of the main target in Tokamak plasma is the detection and control of Runaway Electrons (REs). An automatic platform to extract the REs pitch angle is shown. The pitch angle values inferred are the basis for the strategies of REs mitigation and control.

Introduction

REs are beam of electrons within a Tokamak plasma, accelerated to relativistic velocities. They represent one of the major concern in tokamak since the current of the beam could reach very high values after disruptions and potentially cause unrecoverable damages.
Image analysis is a key diagnostic to identify the REs dynamics. The visible images of the intensity and profile of the measured synchrotron radiation are processed, allowing the deduction of the main REs properties. The platform presented is the tool to obtain the velocity pitch angle of the REs.
The images are acquired through the Runaway Electron Imaging and Spectroscopy (REIS) system, a portable diagnostic realized in ENEA-Frascati laboratories [1].

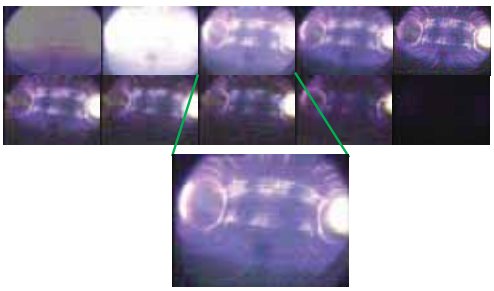

***Fig. 1**: Time sequence of REs visible light image.*

Platform Architecture

***Fig. 2**: Top view of FTU.*

The images analysed are acquired from the CCD camera systems installed in the Frascati Tokamak Upgrade (FTU).
The software used to implement the platform is Matlab®. The goal of the algorithm is to infer the pitch angle values from different plasma discharges in the tokamak machine.
The analytical expression of the pitch angle is determined from the 2D images of the camera, with the same procedure of Yu et al. [2]. Under certain hypothesis it is possible to assume that the detected radiation has an elliptical shape, from which can be deduced the pitch angle parameter.
In the following part the main steps of the Matlab® algorithm are shown. As an example is chosen the image 28, shot #41738, port 3.

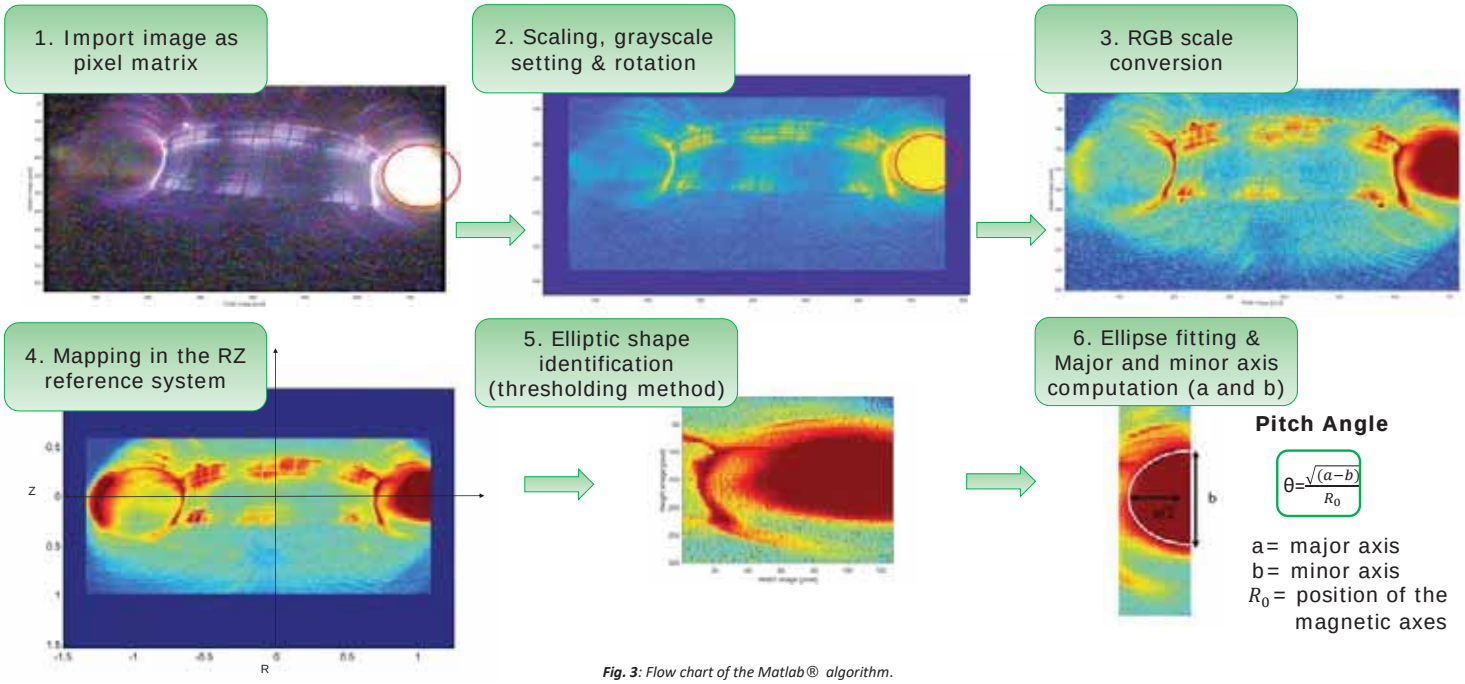

***Fig. 3**: Flow chart of the Matlab® algorithm.*

Results

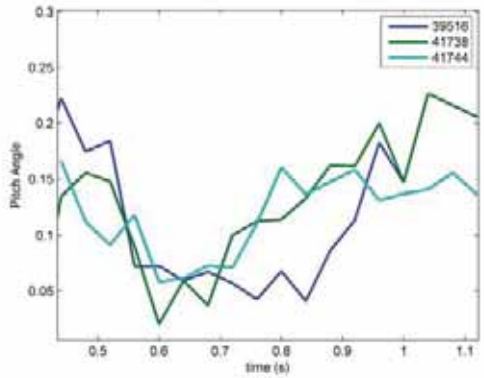

***Fig. 4**: Pitch angle trends.*

The procedure is automatized for all the images of each shot. The trend of the pitch angle values founded is shown in function of the time, in order to evaluate how the pitch angle evolves over time.
The values obtained are putted as input of the "synchrofits routine" of the REIS Software tools. The routine carries out the monoenergetic fit of the spectra for the given pitch angle values.
This procedure allows to obtain the REs energy and number, creating the basis for all the strategies of REs diagnostic and control.

Literature

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[2] Yu, J. H., Hollmann, E. M., Commaux, N., Eidietis, N. W., Humphreys, D. A., James, A. N., ... & Moyer, R. A. (2013). Visible imaging and spectroscopy of disruption runaway electrons in DIII-D. *Physics of Plasmas*, *20*(4), 042113

Publications

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