

# Ph.D. Brainstorming Day

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## REIS software – Image Elaboration

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.

## Platform Architecture

The images are acquired through the Runaway Electron Imaging and Spectroscopy (REIS) system, a portable diagnostic realized in ENEA-Frascati laboratories [1].

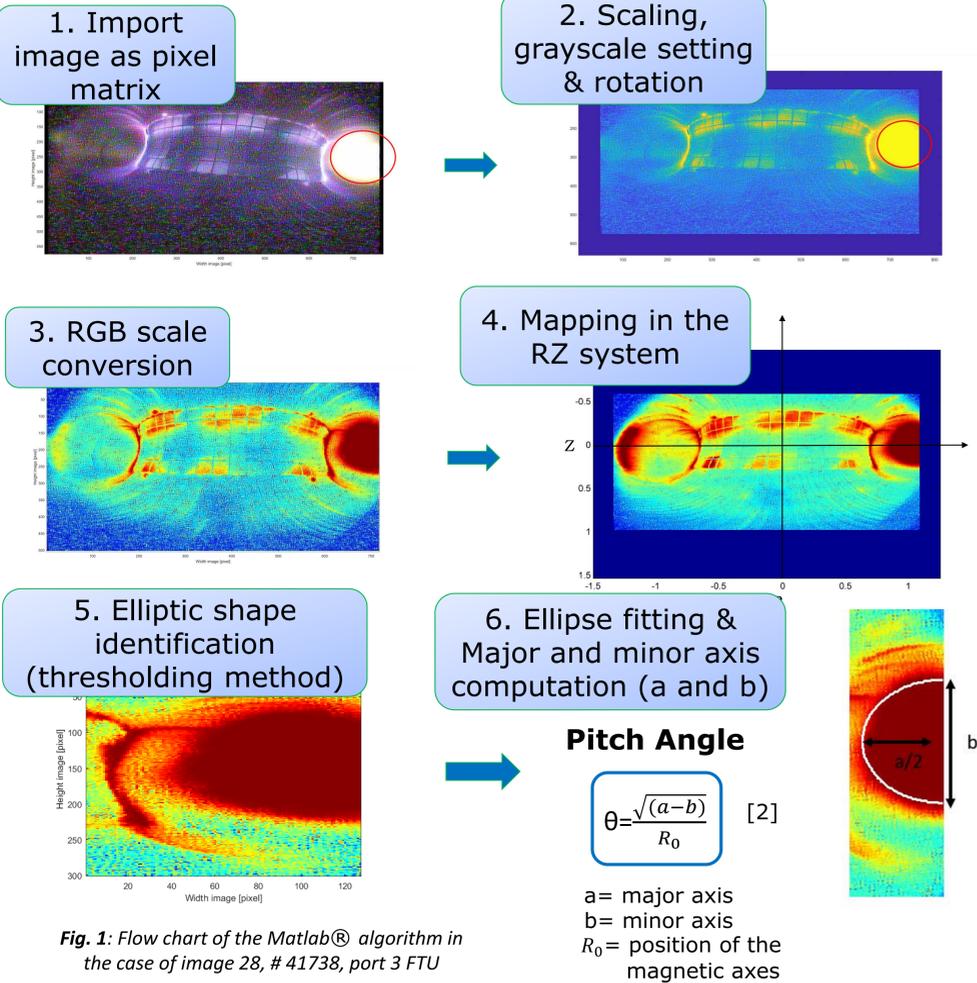


Fig. 1: Flow chart of the Matlab® algorithm in the case of image 28, # 41738, port 3 FTU

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.

## Technical improvements

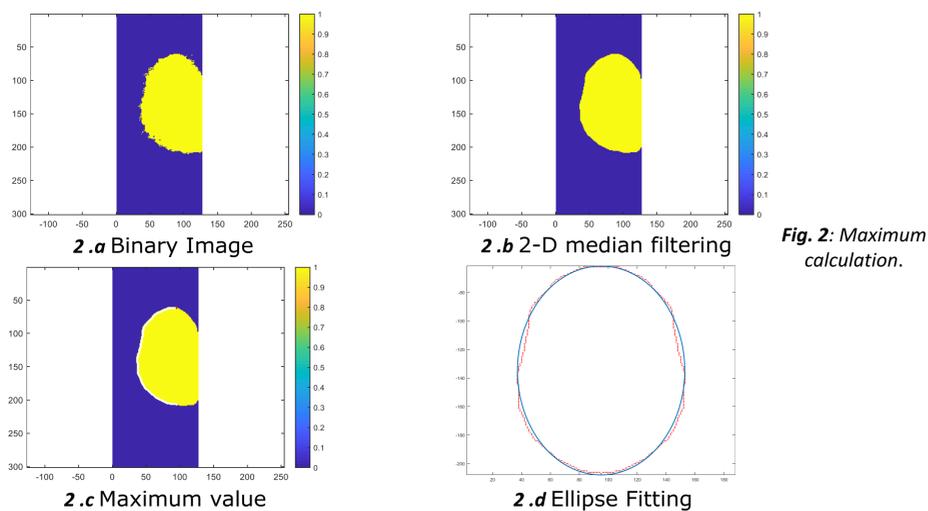


Fig. 2: Maximum calculation.

The algorithm used by the platform was improved by adding a filter processing and the maximum calculation.

## Results

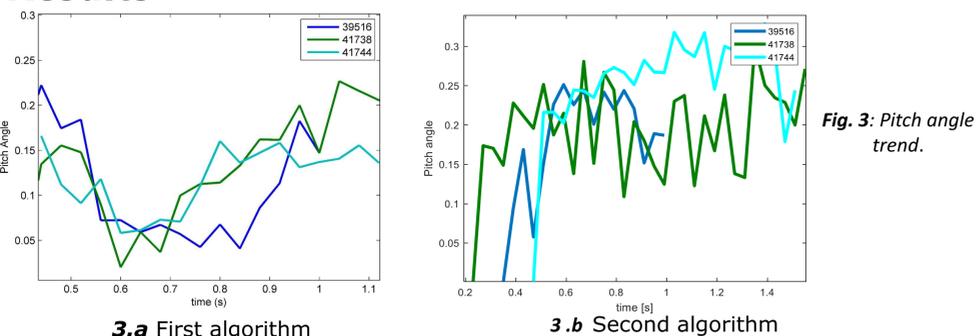


Fig. 3: Pitch angle trend.

The procedure is automatized for all the images of each shot. The trend of the pitch angle values found is shown in function of the time, in order to evaluate how the pitch angle evolves over time. The new method allows to obtain pitch angle values more precise.

## Literature

- [1] Z., Popovic, B. Esposito, P. Buratti, F. Causa, M. Gospodarczyk, D. Carnevale, ..., G. Rocchi. Runaway Electron Synchrotron Spectra in FTU runaway electrons in DIII-D. *Physics of Plasmas*, 20(4), 042113
- [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

## Remote microphone based on speckle

The capability to reconstruct remote sounds through images is very attracting. The audio signals are obtained from the movement of objects in silent videos. Different analysis methods for audio extraction are compared in terms of achieved audio quality and computational effort necessary.

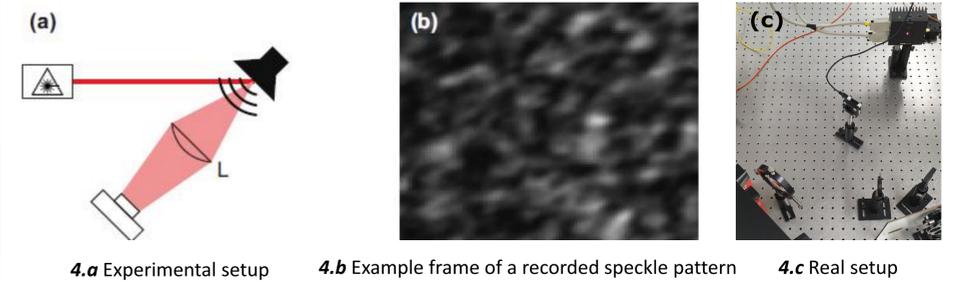


Fig. 4: Experimental setup.

## Methods

Six methods for extracting the audio from the video signal are studied.

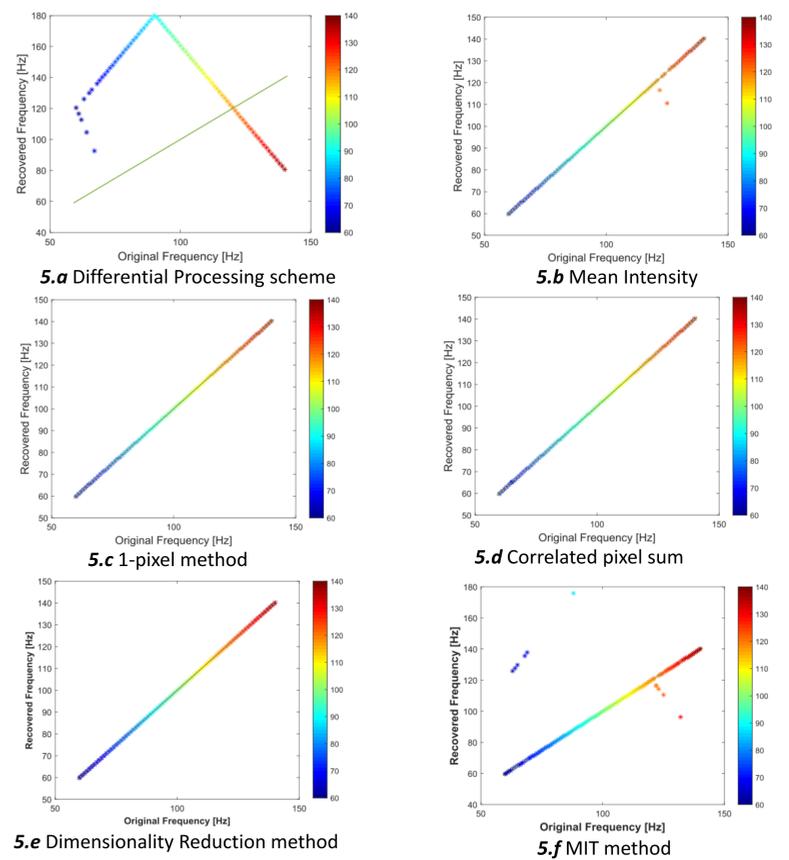


Fig. 5: Methods.

## Results

The different methods are compared by computing the Fast Fourier Transform (FFT), in Matlab® environment. The signal is susceptible to noise and distortion, for this reason, we calculate the Signal-to-noise and distortion ratio (SINAD).

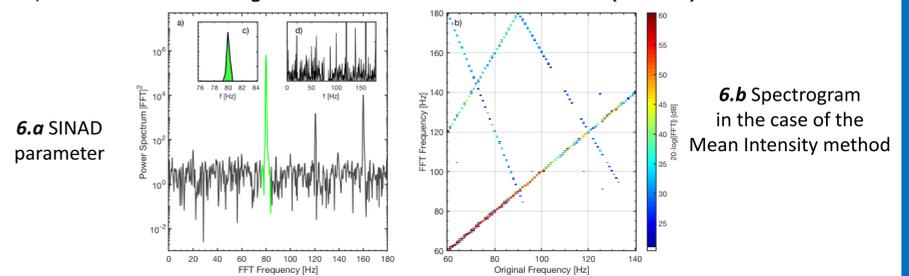


Fig. 6: Methods Fast Fourier Transform (FFT) evaluation.

The performance of the several methods applied are evaluated through the SINAD parameter. Two different cases are shown: increasing amplitude for a fixed frequency and increasing the frequency and keeping constant the signal amplitude.

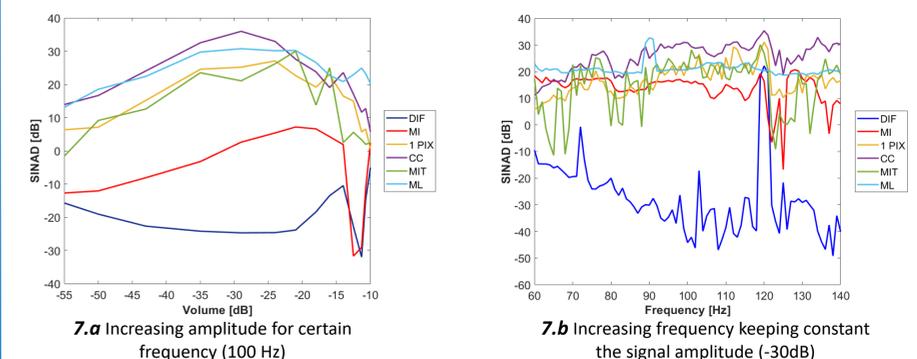


Fig. 7: SINAD values.

The techniques that are investigated have potential for remote sensing of audio, even if between source and receiver there is media that does not let sound waves pass, like vacuum or glass panes.

## Publications

- C. Barcellona, A. Buscarino, F. Causa, C. Corradino, B. Esposito, L. Fortuna, M. Gospodarczyk, G. Mazzitelli, G. Rocchi, V. Piergotti and A. Sibio, A procedure to estimate pitch angle for runaways electrons control in fusion reactors, ECC 19 European Control Conference, June 25-28, 2019, Naples, Italy

