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Soft X-ray imaging techniques in tokamak plasmas: present status and possible future developments

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This paper is focused on the X-ray tomography system set-up at Tore Supra and the recent developments made to get precise information about plasma features from the raw or inverted data.
The Soft X-ray diagnostic which is implemented on Tore Supra has been recently totally refurbished in order to improve the quality of the measurement and associated treatments. Particular efforts have been made for designing the electronics part where the simultaneous requirements of low noise, high gain and high time resolution placed strong demands on the new system design. It uses 45 viewing lines in a horizontally oriented fan and 37 in a vertical fan providing a poloidal and toroidal resolution of about 3 cm and 10 cm respectively. It records the integrated Soft X-ray emission between 3 to 25 keV using Silicon diodes polarized with a tension of 55V. Acquisition, in VME technology for Real-Time (RT), is split in two: slow (0.125 -1 kHz) and fast (1-250 kHz) signals are simultaneously acquired.
A very accurate calibration of the SXR poloidal tomography cameras at Tore Supra was previously performed, where all the 82 SXR diodes were absolutely calibrated in their X-ray domain, including electronics and geometrical corrections. This is absolutely crucial for real time, because the data cannot be manually validated and the algorithms used for reconstruction and parameter evaluation must rely on good data, otherwise artifacts can affect the results.

The ultimate aim is to use this information in real time for visualisation but also potential feedback, with a particular emphasis on the optimization of the reconstruction techniques and on simple analysis tools developed for an automatic treatment of these inverted data. The issue is to adapt the inversion techniques in order to minimize the required computational time due to the real time constraint, commensurate with the accuracy of tomography cameras and automatic analysis tools. It will be shown that 2-D reconstructions with an arbitrary higher spatial resolution produce no additional information and slow down uselessly the computational time. Particular emphasis of the recent progress made on the optimisation of the free parameters used for the tomographic inversion will be presented. An interesting and very useful application to the reconstruction of the magnetic axis will be then detailed, including a relevant comparison with some results produced by magnetic equilibrium solvers.
Finally, future techniques using advanced imaging detector will be presented. In particular preliminary investigation on Tore Supra about the use of Gas Electron Multiplier (GEM) detector for imaging purposes will be described including also some first observations in situ.

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