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X-ray imaging and space resolved spectroscopy of ECR plasmas in compact magnetic traps

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In the frame of the PANDORA (Plasmas for Astrophysics, Nuclear Decays Observation and Radiation for Archaeometry) project, aiming at measuring for the first time in-plasma nuclear β-decays of astrophysical interest, an innovative multi-diagnostic approach to correlate plasma parameters to nuclear activity has been proposed [1, 2]. This is based on several detectors and techniques (Optical Emission Spectroscopy, RF systems, Interferopolarimetry) and here we focus on high resolution spatially-resolved X-ray spectroscopy, performed by means of a X-ray pin-hole camera setup operating in the 0.5-20 keV energy domain. We here present the setup installed at a 14 GHz Electron Cyclotron Resonance (ECR) ion source (ATOMKI, Debrecen), including the description of the multi-layered collimator enabling measurements with a plasma heated by hundreds of watts. The achieved spatial and energy resolution were 0.5 mm and 300 eV at 8 keV, respectively [3]. The innovative analysis algorithm for Photon-Counted images permits to investigate the local plasma emitted spectrum in a High-Dynamic-Range (HDR) mode, by distinguishing fluorescence lines of the materials of the plasma chamber (Ti, Ta) from plasma (Ar) fluorescence lines. This method thus allows a quantitative characterization of warm electrons population in the plasma (and its 2D distribution) which are important for ionization, and to estimate local plasma density and spectral temperatures. Both stable and turbulent plasma regimes have been investigated. The setup and algorithms are now under update including fast shutters and trigger systems in order to allow space and time-resolved plasma spectroscopy during transients, stable and turbulent regimes.

References

[1] D. Mascali et al., EPJ Web of Conf., 227 (2020) 01013
[2] E. Naselli et al., JINST 14 (2019) C10008
[3] S. Biri et al., JINST 16 (2021) P03003

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