Contribution ID: **25** Type: **not specified**

Space and time-resolved X-ray spectroscopy technique by CCD pinhole camera

Tuesday, 17 June 2025 11:10 (20 minutes)

The X-ray diagnostics is an insightful technique to monitor the emission of magnetically confined plasmas. In the PANDORA (Plasmas for Astrophysics, Nuclear decay Observation and Radiation for Archaeometry) INFN project [1] framework, we here present the newly developed energy-space-time resolved diagnostic tool, consisting of a 400 μm lead pinhole coupled with a 4 MP X-ray CCD camera (sensitive in ~0.6–30 keV energy range) and a Pt-Ir X-ray shutter allowing exposure times of few ms.
The use of CCD devices in single photon counting (SPhC) mode requires the application of imaging reconstruction algorithms to identify each single photon event from a raw image [2]. Despite being the sequential data readout relatively slow and noisy, the CCD features the advantage of high space resolution (square pixel size: 13.5 μm) and high X-ray sensitivity (95% at 8 keV).
Monte Carlo simulations and a test-bench characterization of the CCD camera were performed at LNS to enhance the energy-resolved SPhC technique, providing the data-processed quantum efficiency and energy calibration on several configurations, with an energy resolution of 300 eV FWHM at 8 keV.

Preliminary results will be shown from a recent experimental campaign, performed at the ATOMKI ECR plasma facility [3] on X-ray space- and time-resolved spectroscopy measurements, to reconstruct plasma dynamics in the compact B-minimum magnetic plasma trap.
The X-ray fluorescence filtered imaging technique [2,4] has been applied to spatially investigate the plasma confinement structure in gas mixing configurations, combining Ne, Kr, Ar, Xe.
Time-resolved plasma imaging has been performed to study plasma transients, such as ignition and afterglow plasma decay, observing for the first time the evolution of such phenomena on ms time windows.
Such promising results obtained by the adopted X-ray technique could be of a wide and interdisciplinary interest, spanning from operations of ECR plasma systems such as ion sources, to plasmas for thermonuclear fusion and fundamental research.

References

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Session Classification: Detectors and Detection Techniques