Characterization of a Cherenkov diagnostic for fast electrons measurements in tokamak plasmas

F. Bagnato[1,2], A. Romano[1], D. Pacella[1], P. Buratti[1], A. Doria[1], L. Gabellieri[1], E. Giovenale[1], A. Grosso[1], L. Jakubowski[3], V. Piergotti[1], M. Rabinski[3], G. Rocchi[1], A. Sibio[1], B. Tilia[1], J. Zebrowski[3]

[1]*ENEA, Fusion and Nuclear Safety Department, Via E. Fermi 45, 00044 Frascati (RM), Italy*

[2]*Swiss Plasma Centre, EPFL, CH-1015 Lausanne, Switzerland*

[3]*National Centre for Nuclear Research, 7 Andrzeja Soltana Str., 05-400 Otwock, Poland*

Predicting and controlling plasma disruptions in tokamaks is one of the key features for a reliable application of nuclear fusion [1]. In particular, measurements of fast electrons produced in the plasma core and escaping from it are of interest to study processes occurring inside the plasma itself. A Cherenkov diagnostic detector was installed on FTU and its performances have been under investigation to explore these phenomena [2]. In this work, a laboratory characterization of the Cherenkov probe is presented. The contribution of visible light and X-rays up to 85 keV was explored confirming that soft and hard X-rays do not affect the measurement of the probe (about 1%). A first calibration of the Cherenkov probe with an intense electron beam of 2.3 MeV and at high fluxes (10^{12} e^-, much higher than the 10^4 e^- of the radioactive sources) was done at ENEA's Microtron source facility [3]. The characterization was performed together with a spectrometric analysis, which gave a deeper insight of the phenomena occurring inside the detectors. The results show an ionization spectrum, confirming the suspects that the signals observed during plasma discharges are due mainly to luminescence. Nevertheless the validity of the Cherenkov probes as diagnostic tool is not compromised, considering the good correlation with plasma instabilities and runaway electrons (REs) production measured by different diagnostics. Moreover, the direct detection of fast electrons with high time resolution showed interesting features not present in other diagnostics. This configures the Cherenkov as a very promising diagnostic for real time control and monitoring of RE beams for future machines. Thanks to this calibration, REs have been estimated in $8x10^7$ e^- of about 2.3 MeV corresponding to a signal of 2 V in FTU. A more detailed calibration at INFN Laboratory's Beam Test Facility is planned, to test the detector response in a wide range of fluxes and with better precision.

[1] B. Esposito, et al., Plasma Physics and Controlled Fusion 59 (2017) 014044.

[2] F. Causa, et al., Nuclear Fusion 55 (2015) 123021.

[3] M. Perenzoni, et al., Physics and Appl. of Terahertz Radiation, 23 Springer Series in Opt. Sci. 173, Chap. 5.