**Runaway Electrons Instability Measurement and Analysis at the COMPASS and FTU Devices**

W. Bin1, F. Napoli2,P. Buratti2,3,4, J. Caloud5, A. Cardinali2,3,6, A. Casolari5,
C. Castaldo2, J. Cerovsky5, O. Ficker5, M. Jerab5, J. Mlynar5, E. Tomesova5,

COMPASS Team5 and FTU Team2

*1 Institute for Plasma Science and Technology, National Research Council (ISTP-CNR), Milano, Italy*

*2 ENEA, Fusion and Nuclear Safety Department, Frascati, Italy*

*3 INAF-IAPS Roma, Roma, Italy*

*4 Dipartimento di Ing. Civile ed Informatica, Università di Roma “Tor Vergata”, Rome, Italy*

*5 Institute of Plasma Physics of the Czech Academy of Sciences, Prague, Czech Republic*

*6 Institute for Complex Systems, National Research Council (ISC-CNR), Politecnico di Torino, Torino, Italy*

Kinetic instabilities can be excited in a tokamak plasma by free energy available from the distribution function of runaway electrons (RE) in the momentum space, owing to its anisotropy, in particular for high RE momentum parallel to the static magnetic field, or due to the presence of a local maximum. The wave-particle interaction, which is the pumping process underlying the instability growth, can occur by means of the Cherenkov and/or anomalous Doppler resonance.

The very first direct observation of unstable waves in a laboratory plasma was performed a few years ago at DIII-D [1], by means of in-vessel radio-frequency (RF) measurements. Further experimental measurement of emissions from RE scenarios then followed, right after, at the COMPASS [2] and Frascati Tokamak Upgrade (FTU) [3, 4] devices, where several families of instabilities have been recorded, in the entire range of toroidal magnetic fields available in these two tokamaks: from the lowest ones, attainable at COMPASS, to the highest ones, typical of FTU. Such a wide range of fields (applied in discharges with different plasma densities) allows covering the overall scenarios expected at ITER, for what the dispersion relation of RE-driven unstable plasma waves is concerned. From a diagnostic point of view, the instability processes are related to the RE dynamics and, therefore, the study of these phenomena can bring to light aspects of the dynamics otherwise hidden and hardly investigable using other diagnostics. Even when the RE density and energy are low, RF emissions are very sensitive to the presence of fast electrons and this holds true also during the early phase of the discharge, when the capabilities of the other diagnostics are generally still limited.

In the present work, a number of results from detection of RE waves are presented. The experiments have been performed at both the COMPASS and FTU devices, under different RE plasma conditions, by means of either ex-vessel or in-vessel antenna systems designed and constructed ad-hoc for this purpose.

*[1] D. A. Spong et al., Phys. Rev. Lett.* ***120****, 155002 (2018)*

*[2] E. Macusova et al., Proc. 47th EPS Conference on Plasma Physics, I2.106 (2021)*

*[3] W. Bin et al., Phys. Rev. Lett.* ***129****, 045002 (2022)*

*[4] W. Bin et al., Rev. Sci. Instrum.* ***93****, 093516 (2022)*