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Outcomes and Perspectives Arising from Particle-in-Cell Simulation of ECR Ion Sources

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After several years of Particle-in-Cell (PIC) development to study Electron Cyclotron Resonance Ion Sources (ECRIS), we are close to reproducing the experimental behavior with high fidelity. We present some cases where the simulations disclose the reasons for observed behaviors. First, we observed the differences between the HSMDIS** magnetic configuration and the conventional magnetic configuration of 2.45GHz ECRIS. We revealed that these two magnetic configurations use different electromagnetic resonance conditions to ignite the plasma. The different electromagnetic configurations achieved in the steady state explain the different stability and beam intensity performances. An impacting problem of the standard magnetic configuration is the intense erosion of the boron nitride disk in correspondence with the microwave injection side of the plasma chamber. The simulations show the reason for the erosion and how the HSMDIS magnetic configuration produces a limited erosion rate. In perspective, a three-dimensional version of the PIC simulation tool is under development to investigate the electromagnetic configuration of high-charge state ECRIS operating at high frequencies. Different experimental evidence was identified to be studied with the new branch of the simulation tool development.

** L. Neri, L. Celona, "High Stability Microwave Discharge Ion Sources", Nature Scientific Reports 12, 3064 (2022) https://doi.org/10.1038/s41598-022-06937-7

Primary authors: Dr MIRAGLIA, Andrea (INFN-LNS); Dr LARICCHIUTA, Annarita (CNR ISTP); Prof. COCO, Armando (UNICT-DMI); Dr COLONNA, Giampiero (CNR ISTP); Prof. RUSSO, Giovanni (UNICT-DMI); Prof. BILOTTA, Giuseppe (INGV); CASTRO, Giuseppe (INFN-LNS div. Acceleratori); Dr NERI, Lorenzo (INFN-LNS); Dr LEONARDI, Ornella (INFN-LNS); Prof. BOSCARINO, Sebastiano (UNICT-DMI)

Presenter: Dr NERI, Lorenzo (INFN-LNS)

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