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Optical Emission Spectroscopy as non-invasive tool for beam stability monitoring at MedAustron Therapy Center

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MedAustron is a synchrotron-based cancer therapy center located in Austria, where patients are treated with clinical proton and carbon ion beams at energy ranges of 62- 252 MeV and of 120- 400 MeV/u, respectively. The MedAustron injector features three identical Electron Cyclotron Resonance Ion Sources (ECRIS) operated at 14.5 GHz, two of which are used for clinical treatment. The third source, dedicated to non-clinical research, provides helium ion beams and serves as test bench for various experimental activities at the source level. Second generation ECRIS provide stable extracted currents within ±2.5% of the nominal beam current, which are essential for minimizing spill-to-spill intensity fluctuations and ensure stable dose delivery to the patient up to the treatment room. The extracted ion source current stability is generally monitored via ion collectors such as Faraday Cups (FCs), which, as invasive diagnostic technique, cannot be used during clinical treatment. Optical Emission Spectroscopy (OES) is a non-invasive diagnostic tool generally used to characterize the plasma and estimate parameters such as the electron density and the electron temperature. In this work, the extracted current stability generated by a medical ECRIS is investigated using OES. A Charged Coupled Device (CCD) camera equipped with a telephoto lens connected to an optical emission spectrometer operating from 450-830 nm has been used to perform time resolved measurements on three different ion species (proton, carbon and helium ions). The measurements show a clear correlation between intensity variation of characteristic neutrals and ionized atoms emission lines and extracted current instabilities measured at the FC. The results validate OES in the visible range as a potential non-invasive technique for current stability monitoring at the source level for a medical accelerator.

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