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Online diagnostics for high-intensity laser-plasma radiation characterization

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High-intensity laser-plasma interactions are pivotal in advanced scientific research, with applications spanning fundamental physics to medicine. The ELIMAIA (ELI Multidisciplinary Applications of laser-Ion Acceleration) [1-3] beamline at the ELI Beamlines facility, part of the Extreme Light Infrastructure ERIC, offers a cutting-edge platform for studying laser-driven ion acceleration at high repetition rates. For such a beamline, real-time measurements and analysis of the laser-produced radiation are essential characterizing the laser-plasma interaction.
We describe a comprehensive set of online diagnostics developed at the ELIMAIA beamline, enabling immediate and precise analysis of radiation and secondary sources generated from high-intensity laser-plasma interactions. The key diagnostic tools include ion detectors such as online Thomson parabola and semiconductor detectors operating in the Time-of-Flight regime, laser beam diagnostics, and X-ray spectrometers. These tools are integrated with a real-time data acquisition and analysis system.
The diagnostic set was successfully tested in multiple internal and user experiments at ELIMAIA including high repetition rate tests. It has proven invaluable for optimizing ion acceleration and monitoring the quality of laser-target interactions.
Our results highlight the importance of integrating advanced diagnostics in high-intensity laser-plasma research, driving forward the capabilities of next-generation laser facilities.

[1] D. Margarone, "ELIMAIA: A laser-driven ion accelerator for multidisciplinary applications." Quantum Beam Science 2.2 (2018): 8.
[2] F. Schillaci, "The ELIMAIA laser–plasma ion accelerator: Technological commissioning and perspectives." Quantum Beam Science 6.4 (2022): 30.
[3] L. Giuffrida, et al "The ELIMAIA laser-plasma Ion Accelerator: a user platform of high-repetition-rate, ultrahigh intensity, and high stability", in preparation.

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