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Gas-Jet Diagnostics for Precision Science at EuPRAXIA

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Precise and reliable beam delivery is of paramount importance across a wide range of multidisciplinary applications, particularly in the medical field, where accuracy in dose administration directly impacts treatment efficacy and patient safety. In this context, non-invasive and real-time beam monitoring technologies play a crucial role by enabling continuous verification of beam parameters without interfering with the beam itself.

At the Cockcroft Institute, a novel, minimally invasive online beam monitoring system has been developed, employing a gas-jet-based Ionization Profile Monitor (IPM). This technology is specifically designed to meet the demanding requirements of medical accelerators, particularly in advanced proton and ion beam therapy. These therapies require highly accurate spatial and dosimetric control of particle beams, and traditional invasive methods often fall short in providing online monitoring during treatment. The gas-jet IPM addresses these limitations by allowing real-time, non-disruptive monitoring of the beam profile through the controlled ionization of a thin gas jet intersecting the beam path.

Beyond its application in medical accelerators, the performance of the gas-jet-based IPM demonstrates its suitability for a broad range of other scientific and industrial domains. These include high-precision material irradiation studies, radioisotope production for medical and industrial use, and beam diagnostics in conventional proton and ion accelerator facilities. The system's ability to provide detailed beam profile information without perturbing the beam makes it a valuable diagnostic tool across these diverse applications.

In this work, the underlying working principles of the gas-jet Ionization Profile Monitor, detailing its design, implementation, and operational mechanisms are presented. Furthermore, its potential to significantly enhance beam diagnostics and control in both clinical and research environments, highlighting its role as a versatile solution to current beam monitoring challenges, is discussed.

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