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Ionoacoustic Monitoring of Ion Bunches: Recent Developments and Applications

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The energy deposition of ions in water generates pressure waves, known as ionoacoustic signals. Ionoacoustic detection offers EMP-resilient diagnostics for (ultra-) short ion bunches over a broad dynamic range, enabling single-shot measurements of beam energy, dose, size, and position. We present recent developments of the I-BEAT detector as an online acoustic monitor for charged-particle beams and detector variants tailored to distinct measurement goals.
The I-BEAT 3D enables three-dimensional reconstruction of bunch position, size, and energy deposition in water. A solid-state variant of I-BEAT 3D enhances acoustic coupling and sensitivity, extending applicability to smaller signals and lower doses while maintaining spatial resolution. To measure broadband, quasi-exponential spectra from laser-accelerated ion beams, TIMBRE introduces specially designed modulator foils that shape the dose-deposition region, compress the dynamic range at the transducer, and imprint a characteristic resonance frequency, thereby improving the signal-to-noise ratio and enabling single-shot recovery of the spatial dose distribution. Ionoacoustic measurements, combined with interferometry, were performed in water near 4 ℃ with heavy-ion beams at SIS-18, revealing distinct axial versus lateral components of the acoustic signal consistent with a directional, non-thermal momentum-transfer contribution to wave generation. These advances support ionoacoustics as a versatile route to online three-dimensional characterisation and towards absolute single-shot dosimetry for conventional and laser-driven sources.

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