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Time Resolved Imaging of Longitudinal Modulations in Intense Beams[1]

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The longitudinal evolution of high intensity beams is not well understood despite its importance to the success of such applications as free electron lasers and light sources, heavy ion inertial fusion, and high energy colliders. For example any amplification of current modulations in an FEL photoinjector can lead to unwanted coherent synchrotron radiation further downstream in compression chicanes or bends. A significant factor usually neglected is the coupling to the transverse dynamics which can strongly affect the longitudinal evolution. Previous experiments at the University of Maryland have revealed much about the longitudinal physics of space-charge dominated beams by monitoring the evolution of longitudinal perturbations. For the first time, experimental results are presented here which reveal the effect of longitudinal perturbations on the transverse beam distribution, with the aid of several new diagnostics that capture detailed time-resolved density images. A longitudinal modulation of the particle density is deliberately generated at the source, and its evolution is tracked downstream using a number of diagnostics such as current monitors, high-resolution energy analyzers, as well as the transverse imaging devices. The latter consist of a high-resolution 16-bit gated camera coupled with very fast emitters such as prompt optical transition radiation (OTR) from an alumina screen, or fast Phosphor screens with 3-ns time resolution. Simulations using the particle-in-cell code WARP are applied to cross-check the experimental results. These experiments and especially the comparisons to simulation represent significant progress towards understanding the longitudinal physics of intense beams.

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