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3D structure of microbunched electron beams from plasma wakefield accelerators

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Plasma-wakefield accelerators use tabletop equipment to produce relativistic femtosecond electron bunches. Optical and x-ray diagnostics have established that their charge concentrates within a micron-sized volume, but its sub-micron internal distribution, which critically influences gain in free-electron lasers or particle yield in colliders, has proven elusive to characterize. Here, by simultaneously imaging different wavelengths of coherent optical transition radiation (COTR) that a laser-wakefield-accelerated e-bunch generated when exiting a metal foil, we reveal the structure of the coherently-radiating component of bunch charge. Key features of the images are shown to correlate uniquely with how plasma electrons injected into the wake by either a plasma-density discontinuity, by ionizing high-Z gas-target dopants, or by uncontrolled laser-plasma dynamics. With additional input from electron spectra, spatially-averaged COTR spectra, and particle-in-cell simulations, we reconstruct coherent 3D charge structures. The results demonstrate essential metrology for next-generation compact X-ray free-electron lasers driven by plasma-based accelerators.

Working group

invited speaker

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