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Angularly-resolved reconstruction of streaked betatron X-ray spectra from laser wakefield acceleration experiment

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During a laser wakefield acceleration experiment, accelerated electrons produce betatron X-rays which contain information about the evolution of electron energy as they propagate through the plasma. As the electrons are accelerated, the critical energies of their synchrotron-like X-ray emission spectra change with time. In the case of a transverse density gradient, the wakefield curves towards the region of lower density. Because the electrons are continually radiating, the betatron X-rays streak across the screen of an X-ray CCD camera, converting the critical energy's time dependence into a spatial dependence that can be directly measured with a filter pack. The pack is composed of columns of individual filters made of aluminum or copper of varying thicknesses. Each column is identical and allows us to calculate the critical energy at discrete angular positions. After background subtraction and flattening out spatial nonuniformities, the critical energy is determined by comparing the measured data through each filter in a column with a calculated signal corresponding to a spectrum with a particular critical energy until the difference between them is minimized. By repeating this process for each column, we are able to track the change in critical energy as the X-rays swept across the screen. This provides valuable insight into the electron dynamics over the course of a single shot. This method can be extended to any X-ray source with a nonuniform angular spectrum, given a known functional form of the energy spectrum.

Working group

WG1 : Laser-driven plasma wakefield acceleration

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