DPP14-2014-000977
Abstract for an Invited Paper
for the DPP14 Meeting of
the American Physical Society

First Demonstration of Nonlinear Compton Scattering from LWFA Electrons

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In the next decade, several large-scale laser projects will become operational allowing focused intensities exceeding 10^{23} Wcm^{-2} to be reached for the first time. Theoretical models predict the onset of classical radiation reaction and QED effects which will dramatically alter the plasma dynamics. Such a QED-plasma would enable the generation of conditions analogous to those which are believed to exist in extreme astrophysical environments such as pulsar magnetospheres. While such high fields are not yet observable in the lab frame, they are accessible in the rest frame of a relativistic electron beam, providing a preview of the physics available at next generation facilities. In particular it has been shown that non-linear inverse Compton scattering and quantum corrections play a crucial role as laser intensities exceed $10^{23}\mathrm{Wcm}^{-2}$ yet inverse Compton scattering has not been experimentally observed in the relevant extremely non-linear and quantum regime. An "all-optical collider" setup, whereby a laser wakefield electron bunch collides with a high-intensity laser, will allow this regime to be reached for the first time. En route to these exotic regimes, the collider will provide a unique photon source complimentary to conventional facilities. We present experimental results demonstrating a low divergence gamma ray source ($>$ 4MeV) with short pulse duration ($<$ 50fs). We also demonstrate, for the first time, inverse-Compton scattering of a laser pulse in the very nonlinear regime and show that this scattering process contains much of the physics relevant to laser-solid interactions at 10^{23} Wcm^{-2}. We will outline the theory which supports an experimental campaign aimed at probing the quantum effects which will radically change our understanding of laser-plasma interactions at next generation facilities, aimed at reaching $10^{24}\mathrm{Wcm}^{-2}$.