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Numerical Studies of Phase Diversity Electro-Optic Sampled Relativistic Electron Bunches

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The measurement and recording of terahertz (THz) electric fields is of special interest to beam physics, as the electric fields of temporally short relativistic electron bunches have frequency components that extend into the THz range. These frequency components are challenging to measure using conventional methods, as this range of frequencies are too high for electronic systems, and are too low for (most) optical systems. Various pump-probe methods have been developed to record such fields, from the scanning electro-optic sampling technique to the spectral encoding/decoding technique in the field of terahertz time domain spectroscopy. In this paper, we present numerical simulations and studies of the phase diversity electro-optic sampling (DEOS) technique. This involves the treating the THz electric field pulse under interest and a pre-stretched (chirped) femtosecond laser pulse as wave packets co-propagating through an electro-optically active crystal, such as Zinc Telluride and Gallium Phosphide. The phase retardance is then calculated for each frequency in the chirped laser pulse, due to the Pockels effect induced by the pulse with THz frequency components. This pulse is then propagated through a series of optics, and the data on the spectrometers are simulated. Using the maximum-ratio combining technique, we retrieve the electric field and compare the retrieved field to the original field for different crystal lengths and materials. The results of this work will inform the table top DEOS setup, and will inform our eventual designs for an electro-optic sampling setup at the Argonne Wakefield Accelerator.

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Primary authors: KELHAM, Spencer (Northern Illinois University Graduate Student); PIOT, Philippe (Northern Illinois University)

Presenter: KELHAM, Spencer (Northern Illinois University Graduate Student)

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