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ABSTRACT

Applications accessed by high energy petawatt (HEPW) lasers require complete, single-shot characterization of pulse spatial, temporal, and energy characteristics. We describe techniques that enable single-shot characterization of the temporal shape and pulse contrast of HEPW pulses with $>10^8$ dynamic range over a ns-temporal window. Approaches to measure pulse durations that span two orders of magnitude will be discussed. Finally, we describe a novel implementation of spectrally dispersed two-beam interferometry for measurement of the phase difference between two HEPW pulses. This technique can be applied to dispersion and B-integral measurements in a HEPW system, as well as to achieve precise timing of nanosecond pulses. Lastly, spectrally dispersed interferometry represents an ideal technique to enable coherent addition of HEPW pulses for production of ultrahigh intensities.

It has been suggested recently that high-energy petawatt (HEPW) pulses can be generated by large-scale Nd:glass lasers in a chirped-pulse amplification scheme that utilizes compact folded compressor in a split-beam geometry. Metrology of short pulses in this energy range has also never been attempted and presents many new challenges. We are developing the required metrology techniques for full characterization of the space, time, and cross talk of focused, split-beam short pulses. While the characterization of a single HEPW beam has never been demonstrated, the extension of this characterization to a split-beam system poses additional challenges. Specifically, the metrology has to be capable of diagnosing timing between pulses, phase relationship between pulses, and possible crosstalk.

The most challenging component of the HEPW diagnostics is the single-shot temporal characterization over an extended temporal window (0.5-50 ps) and with high dynamic range ($\sim 10^{10}$) in order to reveal both the main pulse shape and the pulse contrast. Furthermore, if a coherent addition of pulses for energy (CAPE) technique is implemented, it required a measurement of inter-pulse delay and group delay dispersion with interferometric accuracy. [1]

Here we present our work on a single-shot, 200-ps temporal window, high dynamic range third-order-cross correlator (Fig. 1) which utilizes tilted pulse front to achieve the required temporal window. The work on the extending its dynamic range is in progress and will involve spatially variable beam attenuation. For the implementation of the CAPE technique, we have demonstrated the use of spectrally resolved two-beam interferometry to measure inter-beam delay and group delay dispersion with interferometric accuracy. (Fig. 2).

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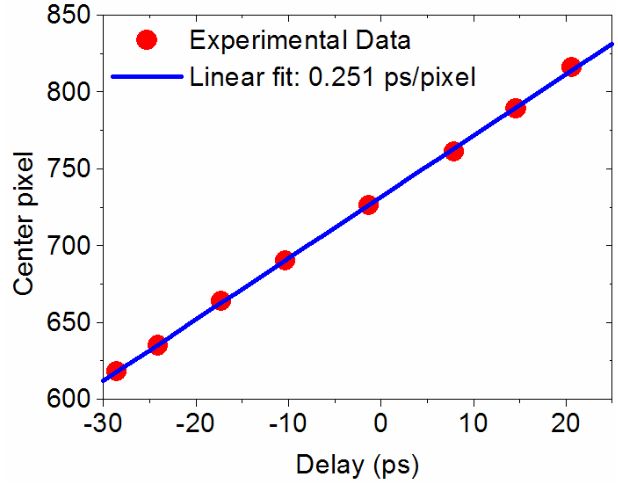

Fig. 1. The measured 17.5 ps/mm of crystal aperture indicates that the full temporal window over 1 cm of crystal aperture is 175 ps in the single-shot third-order cross-correlator. The cross-correlator exhibits good linearity.

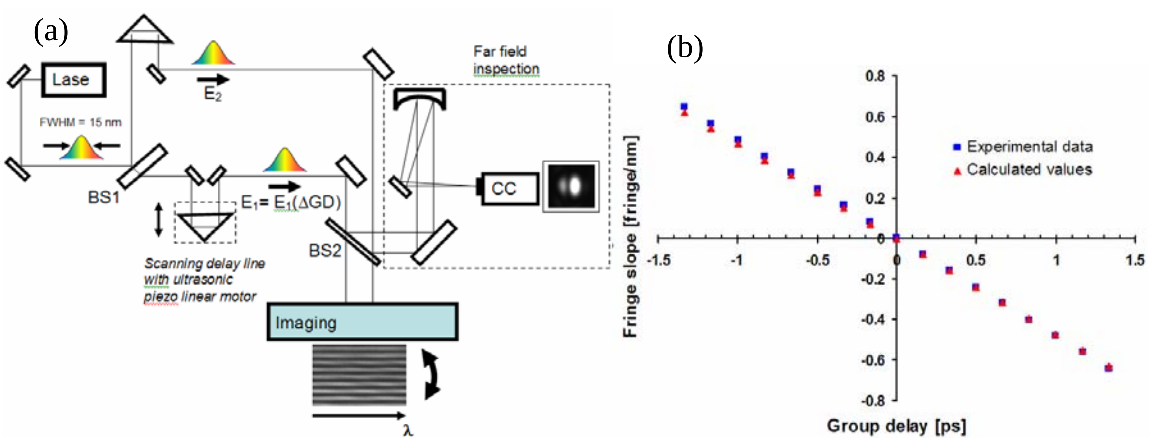

Fig. 2. (a) Spectrally dispersed two-beam interferometry is used for diagnostics of CAPE; (b) the measured group delay difference between two pulses closely matches the calculation

References:

[1] A. Lucianetti, I. Jovanovic, M. C. Rushford, and C. P. J. Barty, “Spectrally-dispersed two-beam-interferometer for the coherent addition of pulse energy,” to be presented at the Conference on Lasers and Electro-Optics, Long Beach, California, May 21-26, 2006.