Demonstration of time-stretch Electro-Optic sampling, with phase-diversity at the Radiation Source ELBE

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The SRF linac-based Radiation Source ELBE operates with picosecond and sub-picosecond bunch length. The accelerator system provides beam in CW mode for two (FIR and MIR) FEL oscillators or for two THz sources comprising a superradiant undulator and coherent diffraction radiation (CDR) source. Performances of these sources depend critically on the bunch length. Single shot bunch length measurements made for every bunch at the repetition rate between 50 and 250 kHz is necessary for complete analysis of the THz sources stability. Electro-optical spectral decoding could fulfill these requirements. One drawback of the spectral decoding is the THz wavelength-dependance of the response function. This wavelength dependance can be very strong and can display zeros within wavelength ranges relevant for measurements. This has dramatic consequences on the temporal resolution, and typically leads to measurements that are strongly deformed versions of the actual THz pulse shapes. For solving this problem, It was suggested recently that THz EO spectral decoding can be upgraded [1] by borrowing a strategy from RF communications and time-stretch, known as the phase-diversity technique [2,3]. In this talk we report about first test of the EO spectral decoding measurements at ELBE which includes the phase-diversity detection scheme. The measurements are performed in single-shot on the THz CDR source. Moreover, the readout was made using the so-called photonic time-stretch technique [4], which allows the THz pulses to be recorded at high repetition rates. The EO system was used to record CDR pulses emitted at 50 KHz repetition rates. However the present measurement system was actually operating at 26 MHz acquisition rate.

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[3] Han, Y., Boyraz, O. & Jalali, B. Ultrawide-Band Photonic Time-Stretch A/D Converter Employing Phase Diversity. IEEE Trans. on Microwave Theory and Techniques 53, 1404 (2005).
[4] Observing microscopic structures of a relativistic object using a time-stretch strategy, 5, 10330 (2015)