From self-organization in relativistic electron bunches to coherent synchrotron light: observation using a photonic time-stretch digitizer

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I. SIMULATION PARAMETERS

Parameters are displayed in Supplementary Table I

Physical machine parameters	
Energy	1.285 GeV
Current	1.625 mA
Momentum compaction factor α	0.724×10^{-3}
Revolution frequency	2.71579 MHz
Bending magnet radius of curvature	5.559 m
Vacuum chamber height	32 mm
Zero current RMS bunch length σ_z	1.21428 mm
Relative RMS energy spread δ	0.47×10^{-3}
Synchrotron damping time	10.4 ms
Synchrotron frequency (νs)	13.5 kHz
Numerical parameters used for the simulations	
Integration mesh size	$20\sigma_z \times 20\delta$
Number of mesh points	896 points × 896 points
Time step	$\frac{1}{4000} \times \frac{1}{\nu_s}$
Number of CPU cores	64

Table I. Parameters corresponding to experimental results and used in the numerical simulation.

II. RECORDED OPTICAL SIGNALS: TIMING AND TYPICAL RAW DATA

At each electron bunch turn, 3 laser pulses are sent to the electro-optic sampling setup:

- Two reference pulses that do not interact with the electron bunch electric field (one only being displayed in the article's Figure 3, for clarity purposes).
- One pulse that interacts with the electron bunch electric field.

The timing of the signals is schematically represented in supplementary Figure 1. The balanced detector's output contains two useful informations:

- The electro-optic (EO) signal.
- A background reference corresponding to "zero electric field".

If the two balanced port were perfectly symmetric as displayed in the figure, this background should be zero. Actually small asymmetries are present, hence the first step of the analysis consists of subtracting the EO and background signals.

A typical experimental raw signal (with nonzero background and EO) is represented in Figure 2.

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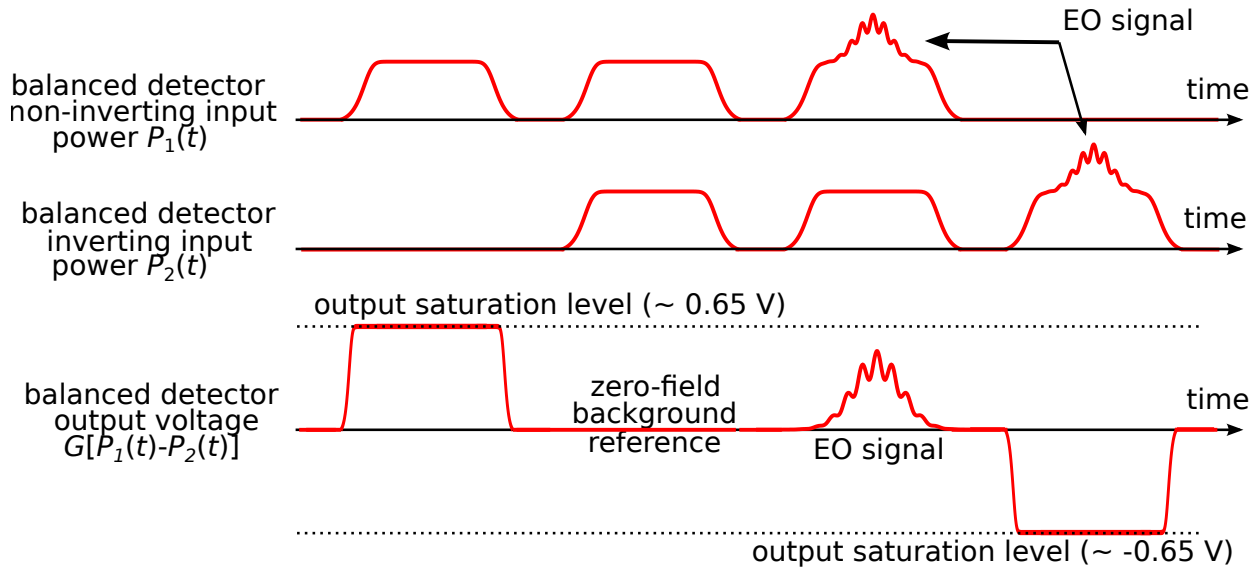

Figure 1. Timing of the signals (illustration) at the balanced photodetector's inputs and output. The two useful output signals are: the electro-optic (EO) signal, and the "zero-field" background. Note that the EO signals at input and output are not to scale.

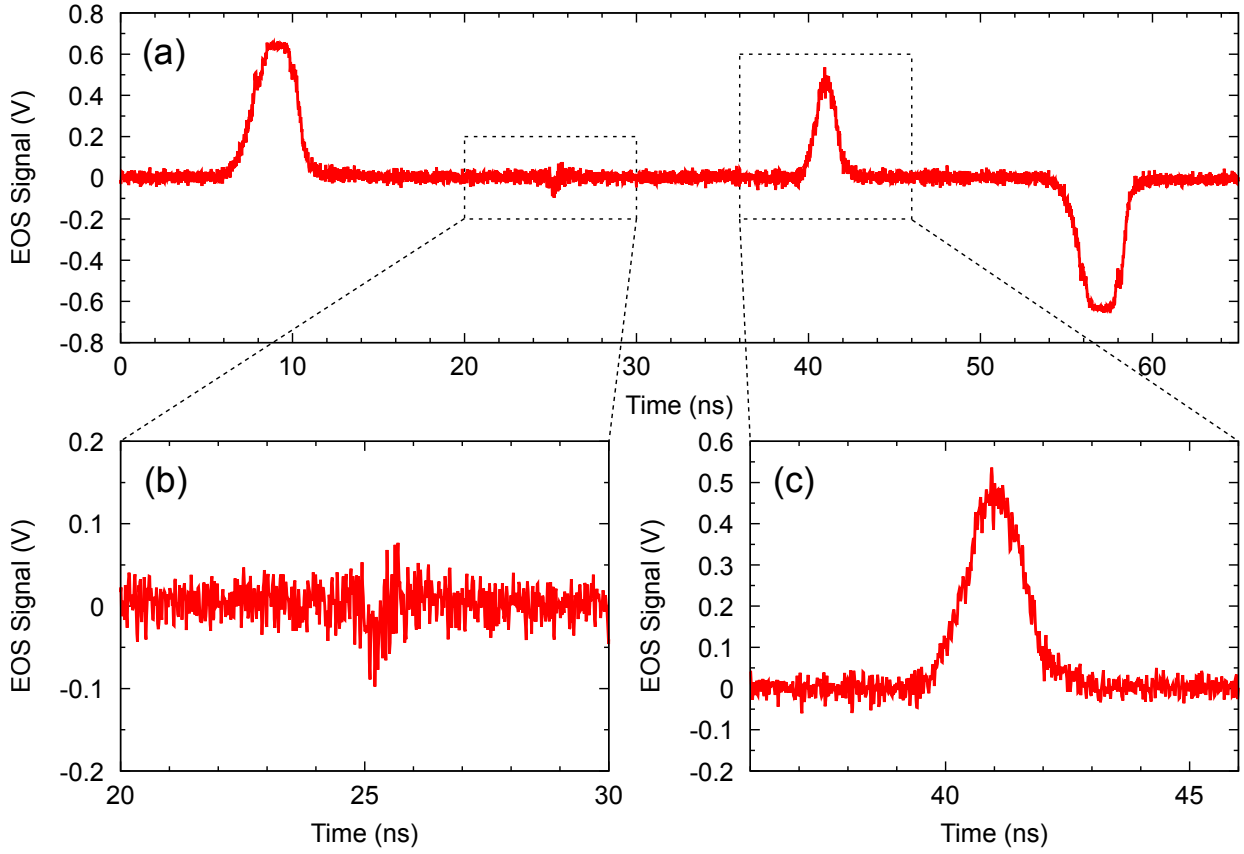

Figure 2. Typical signal at the balanced detector's output (oscilloscope trace). (a) Whole signal. (b) zoom of the background signal, i.e., without electric field. (c) zoom of the electro-optic signal. See supplementary Figure 1 for timing details.