**Supplementary Information**

**Figure S1**

**Experimental details.**

a. The optical measurement set-up. The train of femtosecond pulses is split on a beam splitter (BS) into two parts – one part is used to generate the coherent THz pulses at the emitter and the other for sampling the instant electric field at the electro-optic detector (EOD). The average THz output power is measured by a power detector (PD).

b. Schematic diagram of the coupling of free-space THz pulses into the THz-QCL waveguide. The THz waves are focused by a primary lens (not shown) onto a secondary lens with hemispherical shape. The facet of the waveguide is placed in the beam waist and masked by a gold foil with a pinhole 200x200 µm² in size.

c. Band diagram of one cascade of the THz-QCL active region with the moduli squared of the main electron wave functions. The cascade consists of a sequence of Al₀.₁₅Ga₀.₈₅As (barriers) and GaAs (wells). The dominant optical transition is between the energy states 1 and 2 at 2.9 THz, while states 3-6 form the injector coupling subsequent cascades. At a bias voltage of 21 mV per 100 nm of the cascade, the designed optical transition frequency is 2.9 THz.

**Figure S2**

**Numerical simulation of the temporal response of the two-level system.**

a. System in thermal equilibrium \( n_a/n_b = 0.1 \) (a lossy medium).

b. System with population inversion \( n_b/n_a = 0.1 \) (medium with a gain). The amplitude of the electric field radiated by the two-level system is the same for both cases, but their phase is shifted by \( \pi \). System was driven by single-cycle pulse (black line).

c. The waveform and (d) frequency spectrum of the THz pulse after propagation through the gain medium of 2 mm length. Simulation parameters: homogeneously broadened two-level system with the population inversion, \( n_b/n_a \), of 0.5, the transition frequency of 2.9 THz, and a linewidth of 0.2 THz.