Transportable, High-Power THz Source

H. P. Bluem, A. M. M. Todd
Advanced Energy Systems, Inc.
501 Forrestal Rd., #314
Princeton, NJ 08540 USA
hans_bluem@mail.aesys.net

R. H. Jackson
Consultant
1331 Annapolis Way
Grayson, GA 30017 USA

H. P. Freund
SAIC
McLean, VA 22102 USA

Abstract: *Advanced Energy Systems is developing electron beam based terahertz (THz) sources ranging from man-portable, moderate power devices to transportable high power devices. This paper focuses on the development of a high power source suitable for use from a standard vehicle.*

Keywords: terahertz; THz; high power; transportable

Introduction

Existing THz sources are typically either high power, facility sized sources such as at Jefferson Lab (JLab) [1] or very low power devices. While the power produced from the JLab FEL is copious and it is thus a unique R&D device, the size of the radiation source (65m in length) ensures that users must perform experiments at the facility and that copies of the system are impractical for specific applications. We have therefore considered how to produce a compact, economic source of high-power THz radiation that can be operated where needed and serve to commercialize THz applications requiring high-power.

Present Auston switch THz sources [2] typically produce ≤ 1mW of power and single-frequency quantum cascade lasers (QCL), should deliver up to 100mW above about 2THz [3]. For standoff imaging and spectroscopy applications or high-throughput non-destructive evaluation (NDE), watts of tunable or broadband THz radiation are needed.

We are focused on THz sources based on electron beam radiation mechanisms, as in the JLab FEL, since these sources can, in principle, deliver the power levels we seek. However, certain economic and practical constraints must be considered. Firstly, systems based on photocathode electron sources, while excellent choices for R&D THz generation, are expensive and require maintenance attention. Systems that accelerate electron beams above 9MeV introduce radiation concerns. Consequently, systems utilizing short electron bunches and coherent synchrotron radiation (CSR) in bends or photocathode laser short-pulse techniques [4] are not considered to be readily commercializable.

Source Description

We are developing a tunable source, based on the ubitron concept [5], utilizing an RF gun with an electron beam energy less than 2 MeV [6]. This results in a compact system that is readily carried on a standard vehicle. Our simulations project the source will deliver up to 50W of THz output power, tunable over a large fraction of an octave, with about 50GHz bandwidth. The device will operate at 0.1% duty factor and deliver peak powers of around a MW. Figure 1 shows a representation of the source. The initial prototype will be based on a Chi wiggler [7], though our eventual plans call for a permanent magnet arrangement. The prototype will also be a lower-duty-factor (uncooled for simplicity) device. It is presently in fabrication.

We are also considering integrated systems. The source pulse structure is well matched to detector concepts we have entertained for stand-off detection and high-throughput NDE. We project requiring a few pW/Hz1/2 of noise equivalent power (NEP) from the detectors.

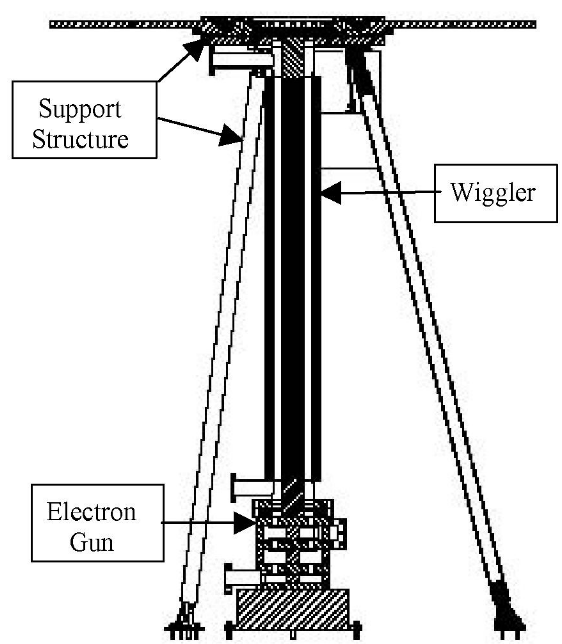

Figure 1. Diagram of the compact THz source.

Steady state simulations of the system gain per pass are shown in Figure 2. This figure shows the gain for an energy spread of 1% and for no energy spread. Even at an energy spread as high as 1%, reasonable gain per pass is possible in the device.

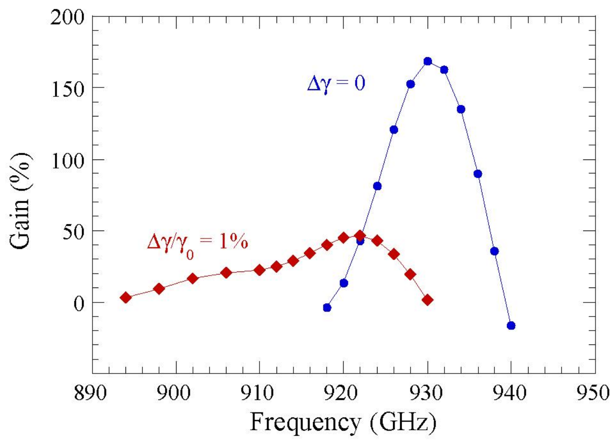

Figure 2. Gain versus frequency for energy spreads of 0% and 1%.

References

1. http://www.jlab.org/FEL/terahertz/
2. D. H. Auston, K. P. Cheung, J. A. Valdmanis and D. A. Kleinman, Phys. Rev. Letters 53, 1555 (1984).
3. R. Kohler et al., "Terahertz semiconductor-heterostructure laser," Nature 417, 156 (2002).
4. J. G. Neumann et al., "Simulations of Electron Beams Pre-Modulated at the Photocathode," to appear in Proc. PAC 2005, Knoxville, TN, May 2005.
5. R. M. Phillips, IRE Trans. Electron Dev. ED-7, 231 (1960).
6. US and European patent applications filed.
7. R. H. Jackson et al., "A Ka-Band CHI Wiggler Free-Electron Maser: Experimental Results," Nucl. Instrum. Meth. A429, 116 (1999).