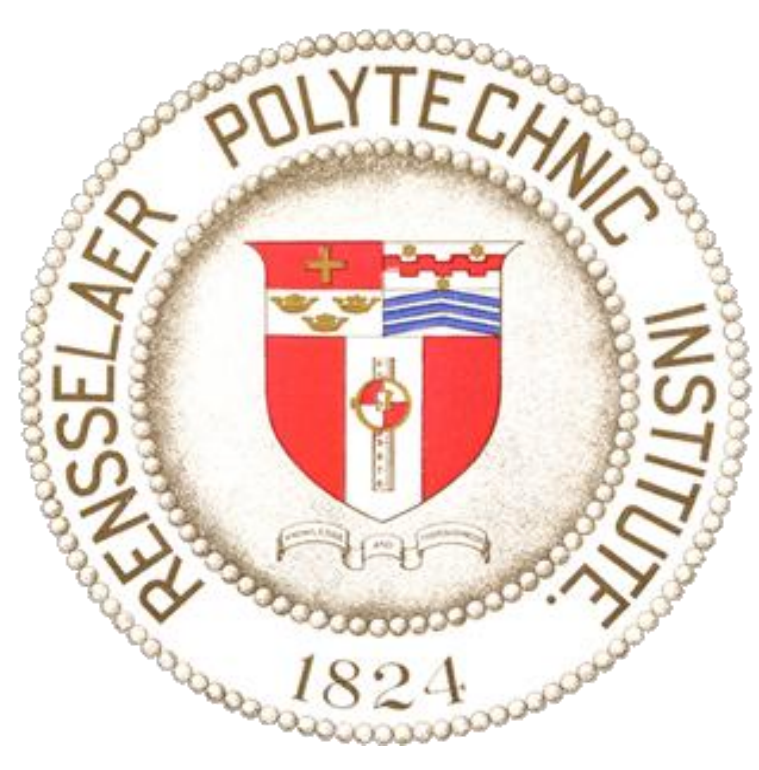




# Remote Broadband THz Wave Generation and Detection



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## Abstract

Remote THz wave generation at a distance up to 30 meter using a interferometric phase compensator with attosecond ( $10^{-18}$ s) phase-control accuracy is presented, as shown in Fig. 1. "All-optical" Two-color THz-REEF is invented for remote THz wave detection at a distance of 10 meter by coherently manipulating the fluorescence emission from asymmetrically ionized gas plasma with a newly invented in-line phase compensator, as shown in Fig. 2 and Fig. 3. The in-line phase compensator (See In-line phase compensator module in Fig. 2) will be commercialized at Zomega Terahertz Corporation.

## Relevance

Remote THz wave sensing and identification of ERCs by directly sending THz waves to the target was previously considered impossible due to the high atmospheric absorption of THz waves in ambient air. Our inventions of sending optical beams instead of THz beams to vicinity of the target generating and detecting THz waves near the target circumvent THz wave attenuation in ambient air. The combination of remote THz wave generation and detection will finally realize THz wave remote sensing and identification of ERCs. These new achievements pave a new pathway for THz wave remote sensing and identification of explosives or other hazardous materials with potential applications in homeland security.

## Technical Approach

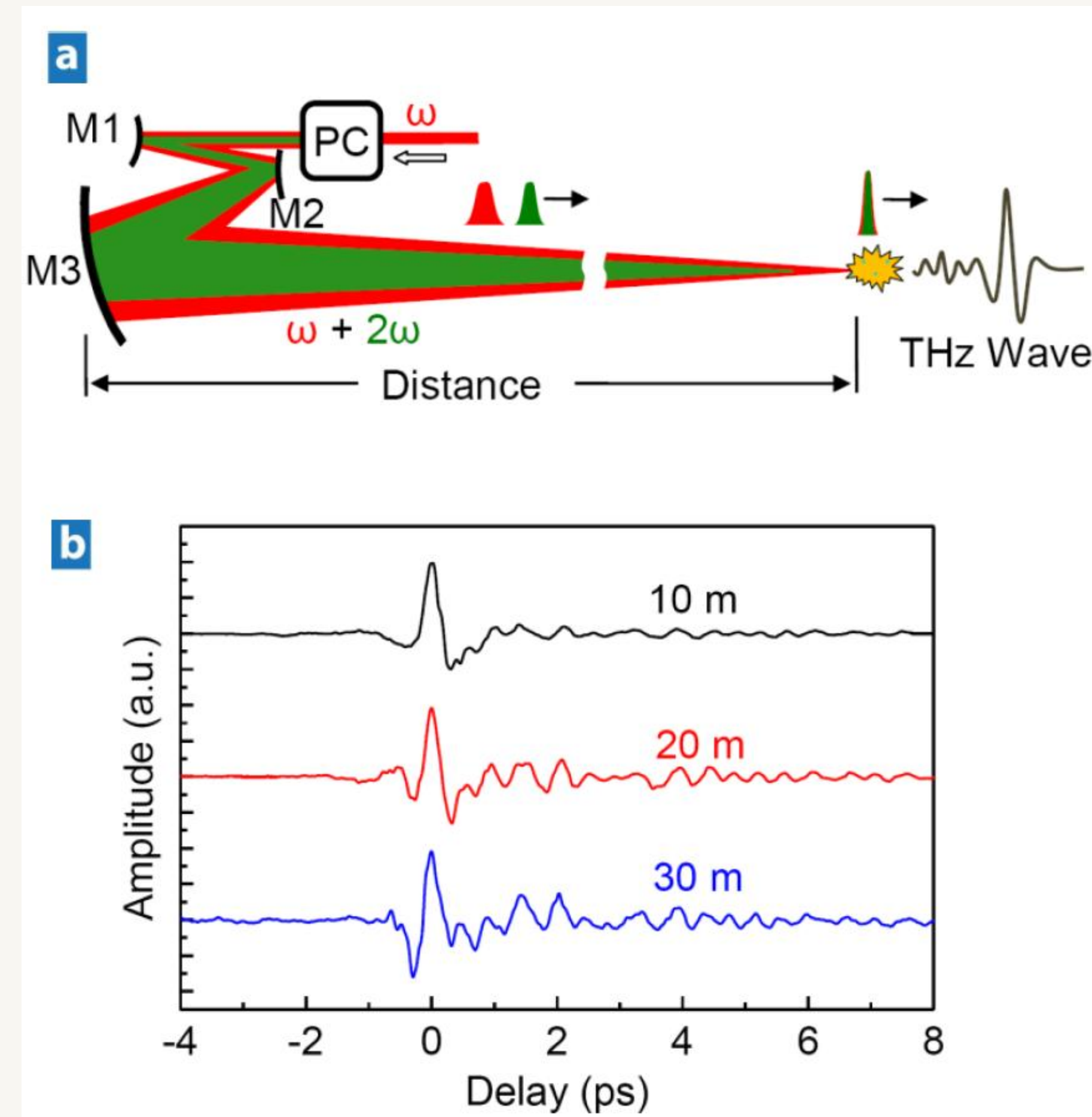


Fig. 1. Remote THz wave generation from laser-induced plasma in ambient air with a phase compensator (PC). (a) Schematic of the setup; (b) THz waveforms generated at 10 m, 20 m, and 30 m, respectively.

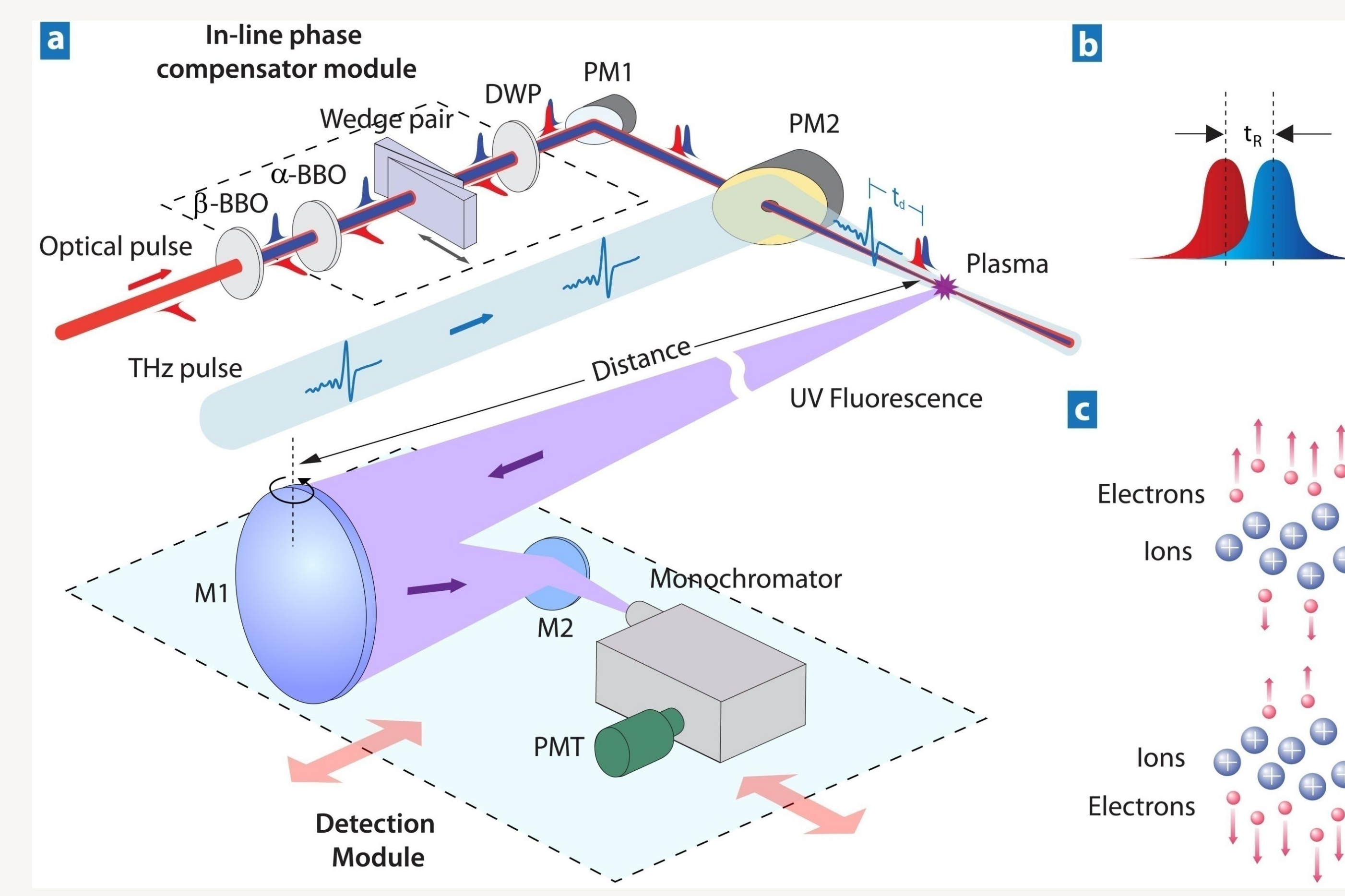


Fig. 2. (a) Schematic of the remote THz wave detection; (b) Temporally delayed two color pulses; (c) Asymmetric electron velocities generated by two-color fields ionization.

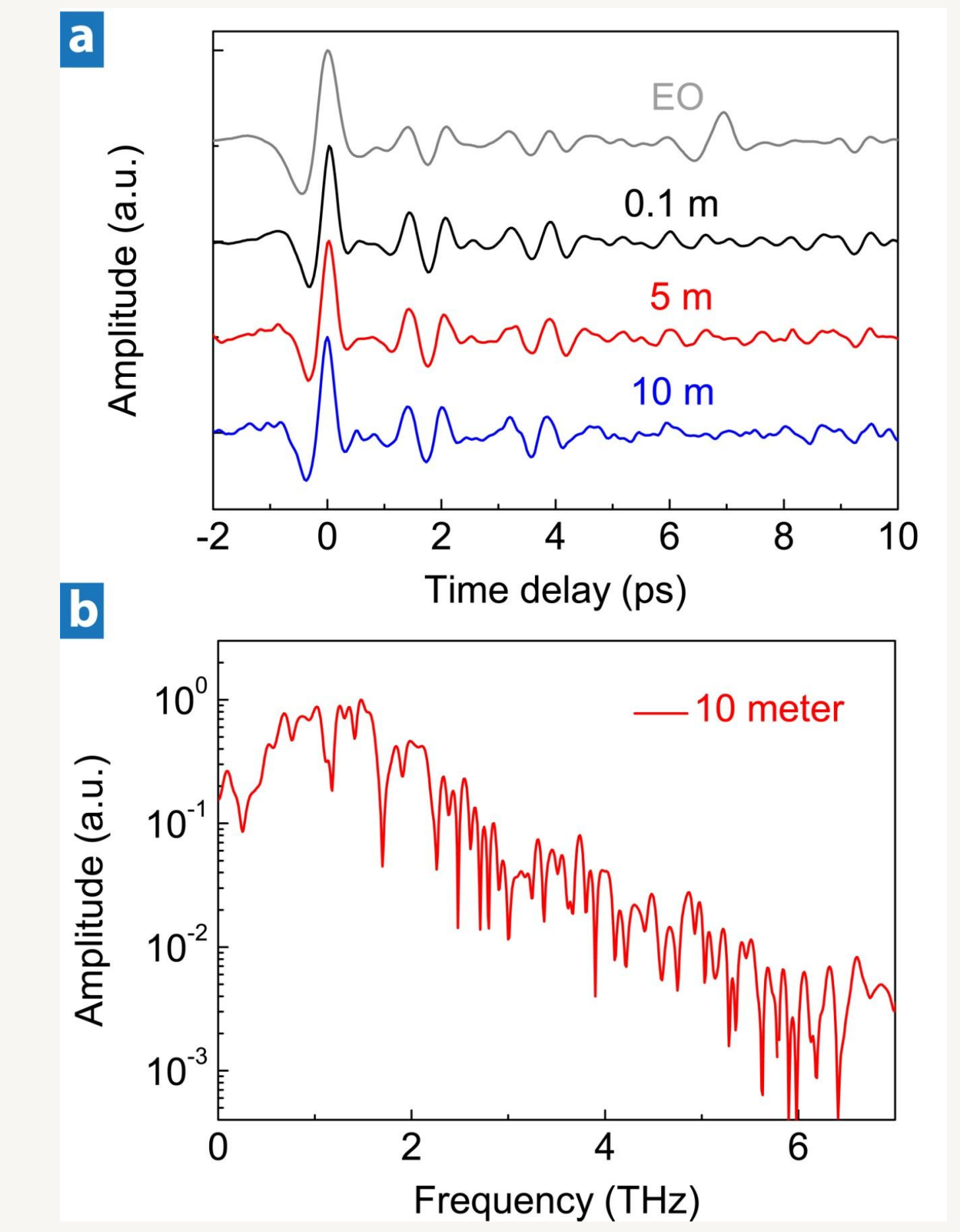


Fig. 3. (a) THz waveforms measured by photoemission at different distances, (b) THz spectrum at distance of 10m.

## Accomplishments Through Current Year

Current year's accomplishments includes standoff THz generation at a distance up to 30 meter (see Fig. 1(b)) and remote THz wave detection at a distance of 10 meter (see Figs. 2 and 3). The combination of standoff THz generation and detection finally realize THz wave remote sensing and identification and is expected to be transferred to customers or end users in Homeland Security.

## Future Work

- Increase the THz electric field generated at standoff distance for higher dynamic range;
- Improve the signal/noise ratio of two-color THz-REEF;
- Increase the distances for remote THz wave generation and detection;
- Combination of the above two approaches for true remote THz wave sensing

## Opportunities for Transition to Customer

The development of remote open-air broadband THz spectroscopy technology is lagging behind the compelling need that exists in homeland security, astronomy and environmental monitoring. The true remote THz wave sensing will find customers in Homeland Security.

## Patent Award and Submission

1. US Patent #7652253 - Method and system for plasma-induced terahertz spectroscopy. Xi-Cheng Zhang, Jianming Dai, and Xu Xie. Awarded on January 26, 2010.
2. Patent disclosure – Method of remote broadband terahertz wave sensing utilizing radiation-enhanced-emission-of-fluorescence from gas plasma. Jingle Liu and X.-C. Zhang. Submitted on 11/10/2008.

## Publications Acknowledging DHS Support

1. J. Liu, J. Dai, S.L. Chin, and X.-C. Zhang, Nature Photonics, 2010. 4: p. 627.
2. J. Dai, J. Liu, and X.-C. Zhang, IEEE JSTQE, 2011. 17: p. 183.
3. J. Liu and X.-C. Zhang, Applied Physics Letters, 2010. 96: p. 041505.
4. J. Liu and X.-C. Zhang, WuLi (Chinese Physics Today), 2010. 39: 419.
5. J. Liu and X.-C. Zhang, IEEE JSTQE, 2011. 17: p. 229.

## Outreaches and Other References

- ❖ Our achievements on THz remote sensing has been highlighted and reported by more than 80 news media worldwide, including BBC, Science Daily, Homeland Security Wire, and etc.
- ❖ Jingle Liu, one of Prof. X.-C. Zhang students, has been nominated for Association of Graduate Schools (NAGS) Doctoral Dissertation Award.