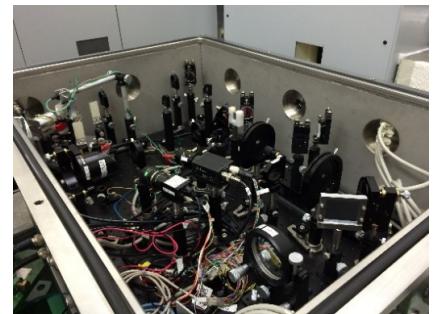
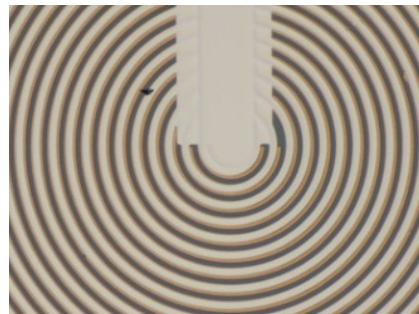


Measurement of Coherent Transition Radiation Using Interferometer and Photoconductive Antenna (FRA1CO06)



K. Kan, J. Yang, M. Gohdo, T. Kondoh, I. Nozawa, and Y. Yoshida
ISIR, Osaka University, Japan

Contents

- Background and purpose
- Photoconductive antenna (PCA)
 - Operation mechanism and fabrication of PCA
- Measurement of coherent transition radiation (CTR)
 - Diagram of interferometer and PCA
 - Frequency and time-domain measurement of CTR
 - Possibility of electric field direction measurement
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Background

Electron beam diagnostics based on THz measurement (bunch length)

Frequency-domain analysis

Grating-type spectrometer

T. Takahashi et al., Phys. Rev. E 50, 4041 (1994).

S. Wesch et al., Nucl. Instrum. Meth. A 665, 40 (2011).

Interferometer

D. Daranciang et al., Appl. Phys. Lett. 99, 141117 (2011).

Z. Wu et al., Rev. Sci. Instrum. 84, 022701 (2013).

I. Nozawa, K. Kan et al., Phys. Rev. ST Accel. Beams 17, 072803 (2014).

Time-domain analysis

Electro-optic sampling (e.g., spectral decoding, temporal decoding, ...)

I. Wilke et al., Phys. Rev. Lett. 88, 124801 (2002).

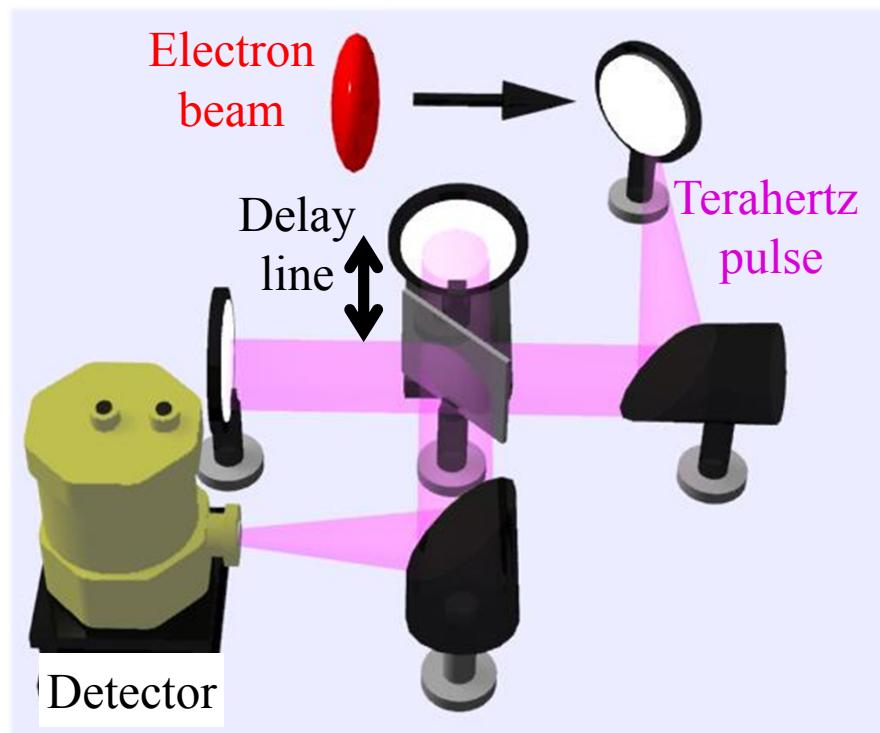
G. Berden et al., Phys. Rev. Lett. 99, 164801 (2007).

Photoconductive antenna (PCA)

???

Combining frequency and time-domain measurement
for electron bunch will clarify more detailed information.

Electron bunch length measurement using an interferometer

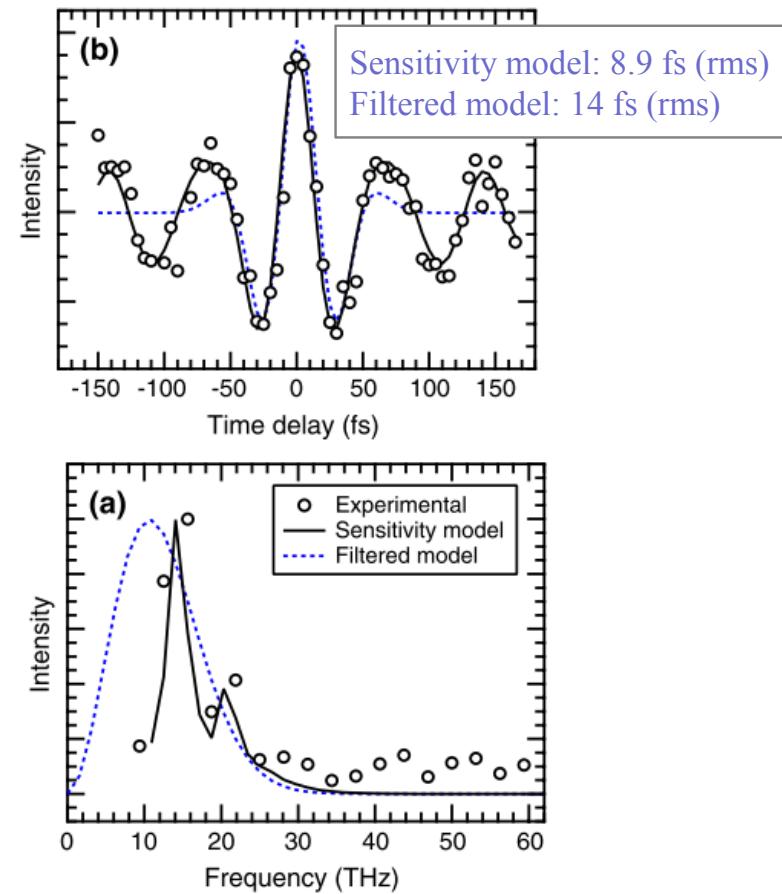


CTR measured by a Michelson interferometer

Beam splitter: HRSi, KBr

Detector: Bolometer, MCT detector

Analysis using an interferometer is limited to frequency-domain.

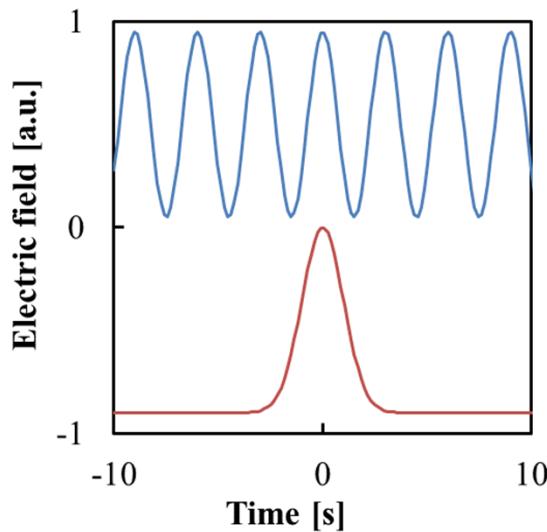


Usage of photovoltaic MCT detector

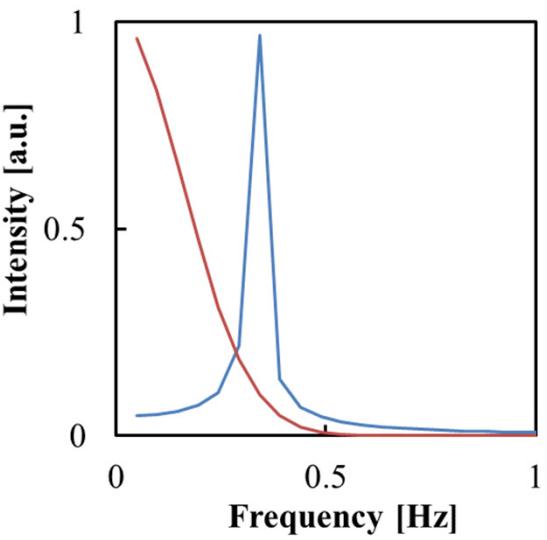
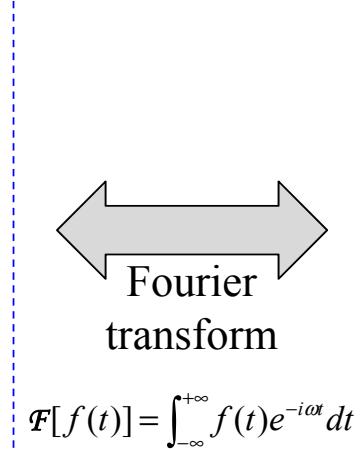
I. Nozawa, K. Kan et al., Phys. Rev. ST Accel. Beams 17, 072803 (2014).

Purpose

To analyze electron bunch length, THz pulse of CTR from electron bunch was measured with time and frequency-domain schemes.



Time-domain

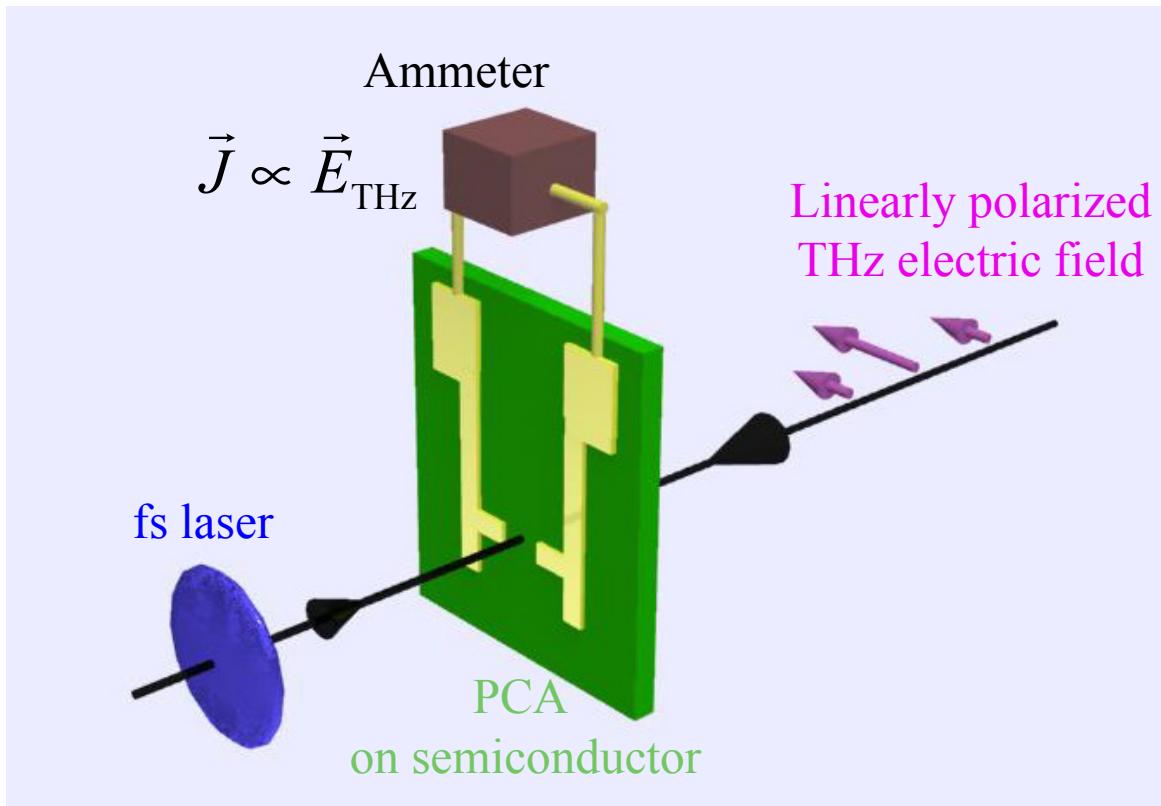


Frequency-domain

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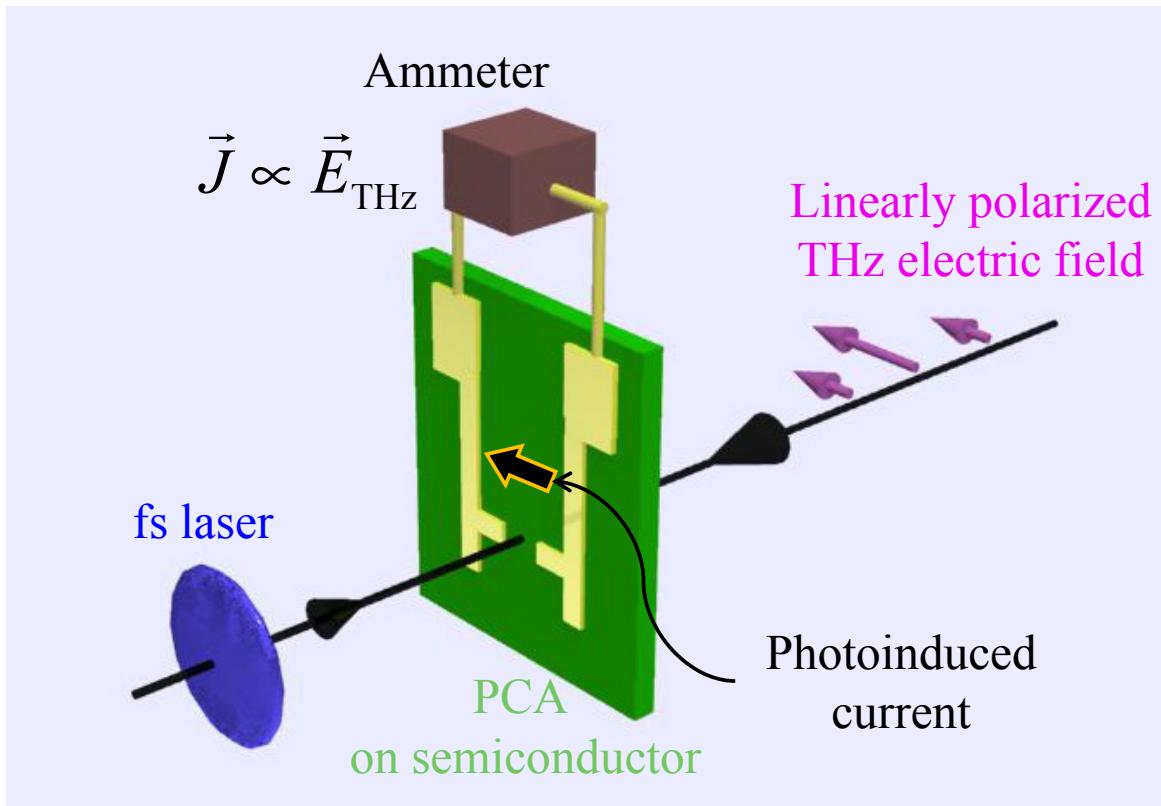
Photoconductive antenna (PCA)



THz detection using PCA driven by femtosecond laser

- Generation of THz pulses according to bias electric field
- Detection of THz pulses by measuring photoinduced current from electrodes
- Polarization of THz pulses
- Detection area

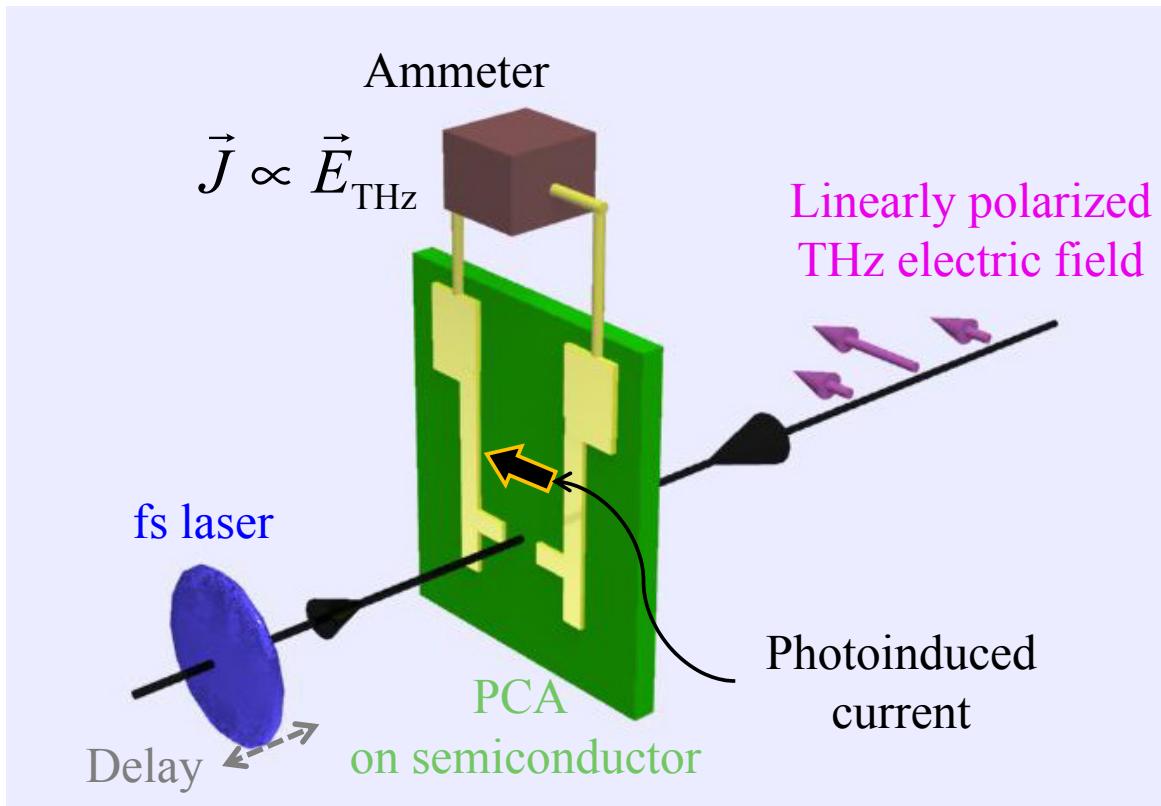
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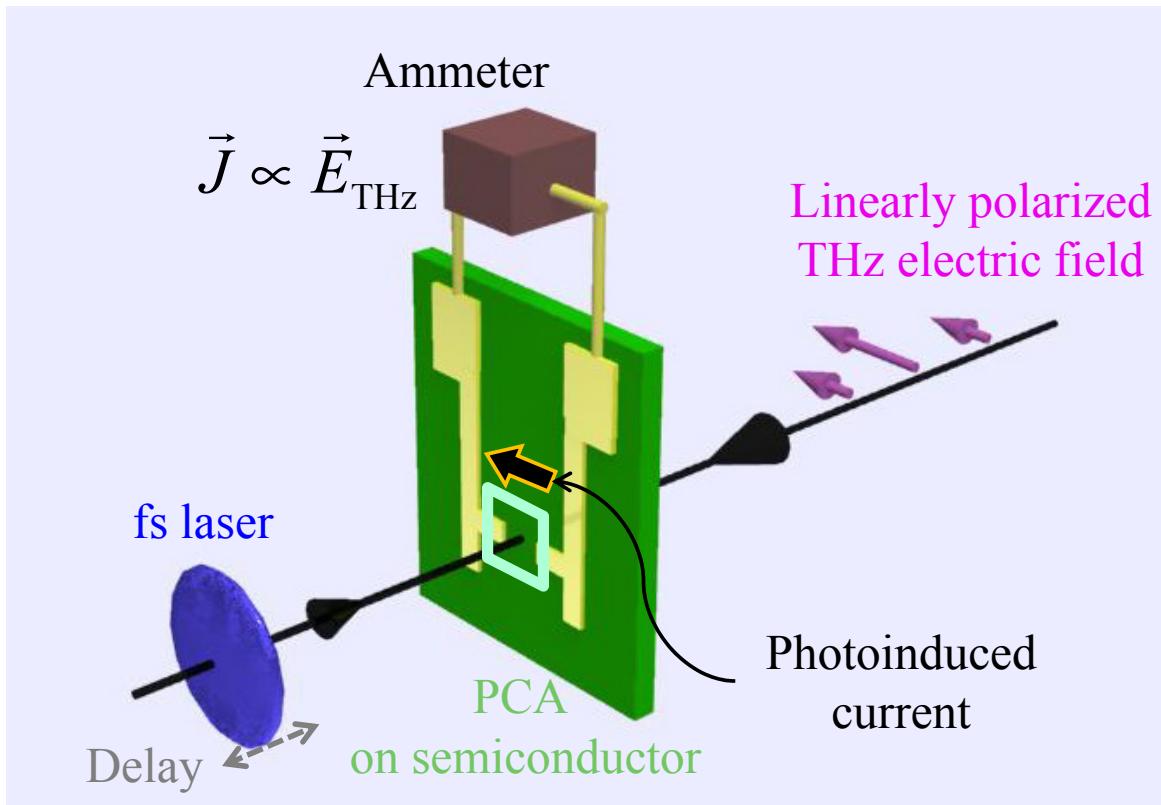
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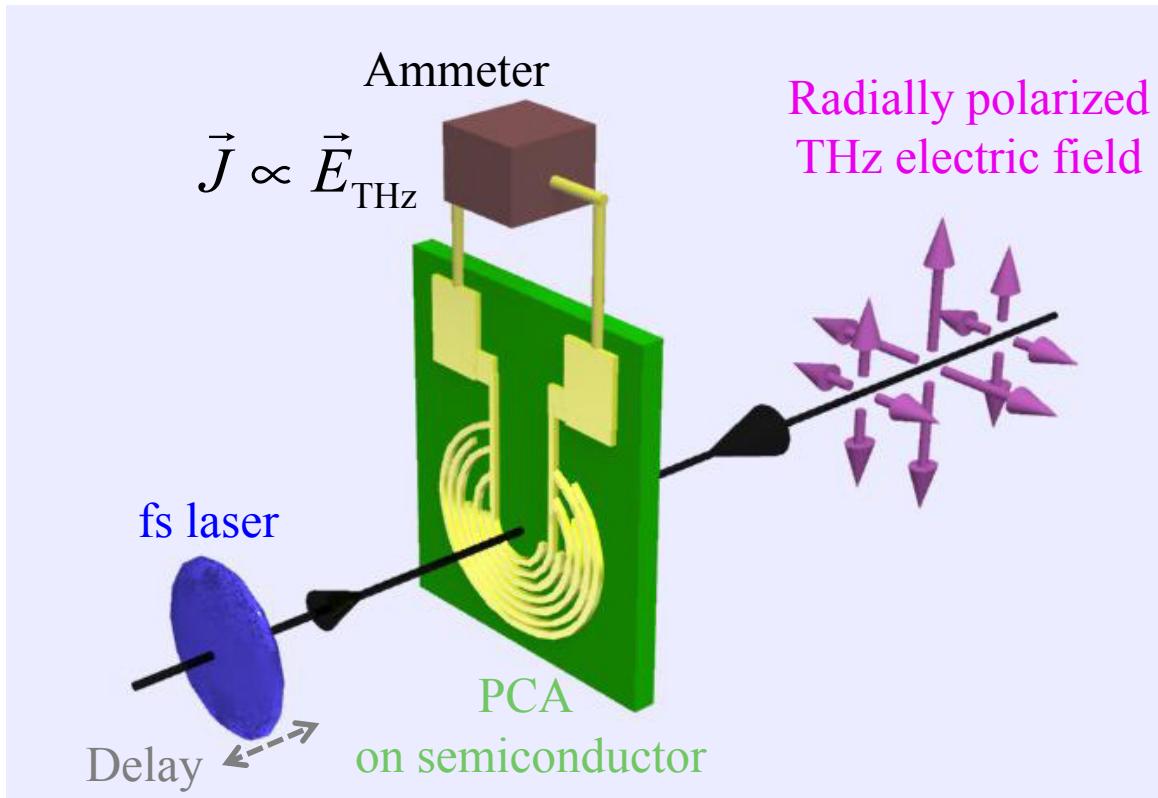
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Measurement of THz electric field of CTR using PCA

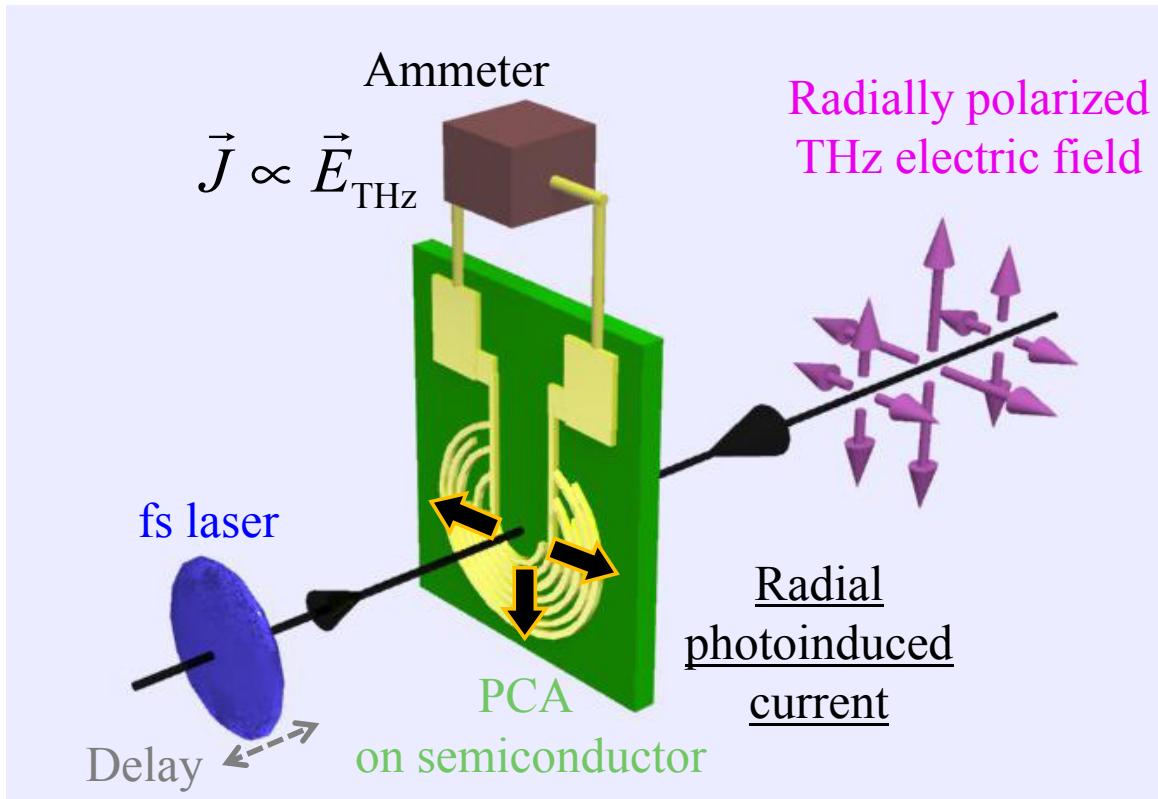


c.f., Fabrication of PCA and
THz generation
K. Kan et al., Appl. Phys.
Lett. 102, 221118 (2013).

THz detection using a PCA in time-domain scheme

- Generation of THz pulses according to bias electric field
 - Detection of THz pulses by measuring photoinduced current from electrodes
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 - Detection area
- **Improving polarization characteristic
and fabrication of large area antenna**

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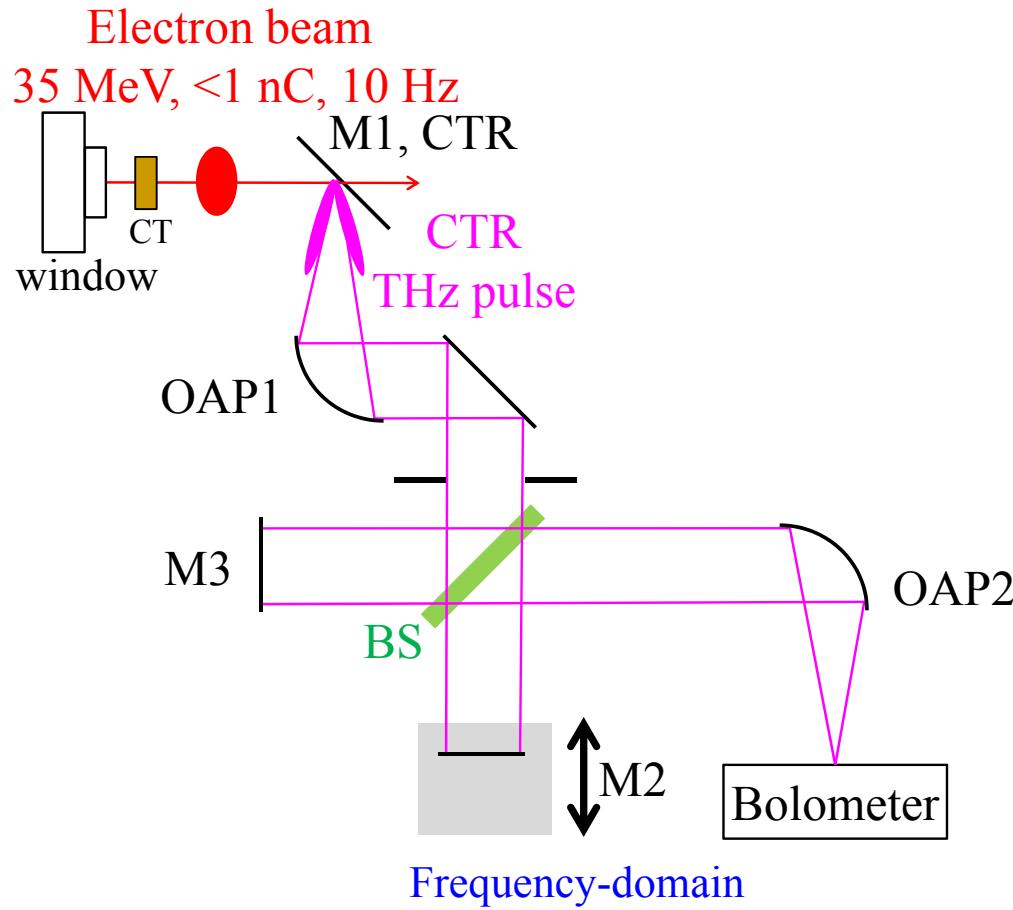
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Frequency and time-domain measurement



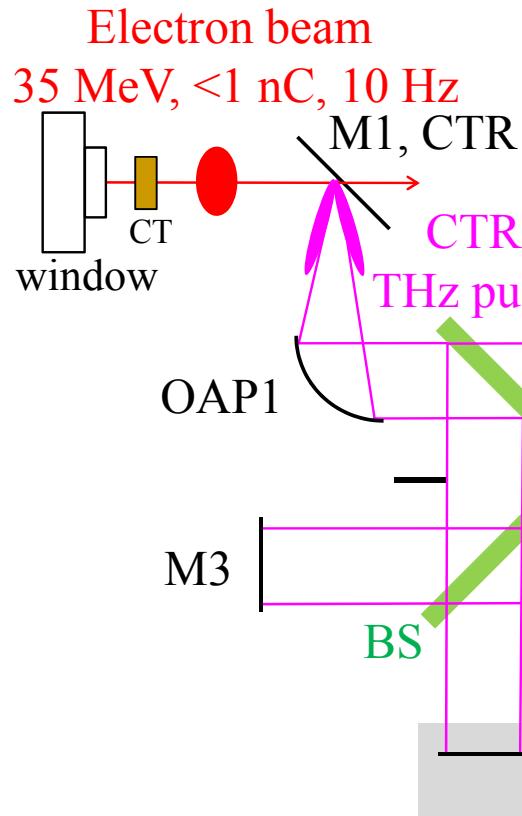
Measurement system of CTR.

M: a plain mirror, OAP: an off-axis parabolic mirror,
BS: a beam splitter, CT: a current transformer.

Conditions

- Picosecond UV pulses for a photocathode-based linac and bunch compressor
- THz generation using CTR
- Vacuum (<100 Pa)
- BS: high-resistivity silicon (0.38 mm thickness)
- Bolometer filter: crystal quartz w/ garnet powder
- PCA substrate: semi-insulating GaAs
- Current measurement: 50Ω termination with an amplifier (NF 5307 Gain100) and oscilloscope (Teledyne LeCroy 204Xi)

Frequency and time-domain measurement



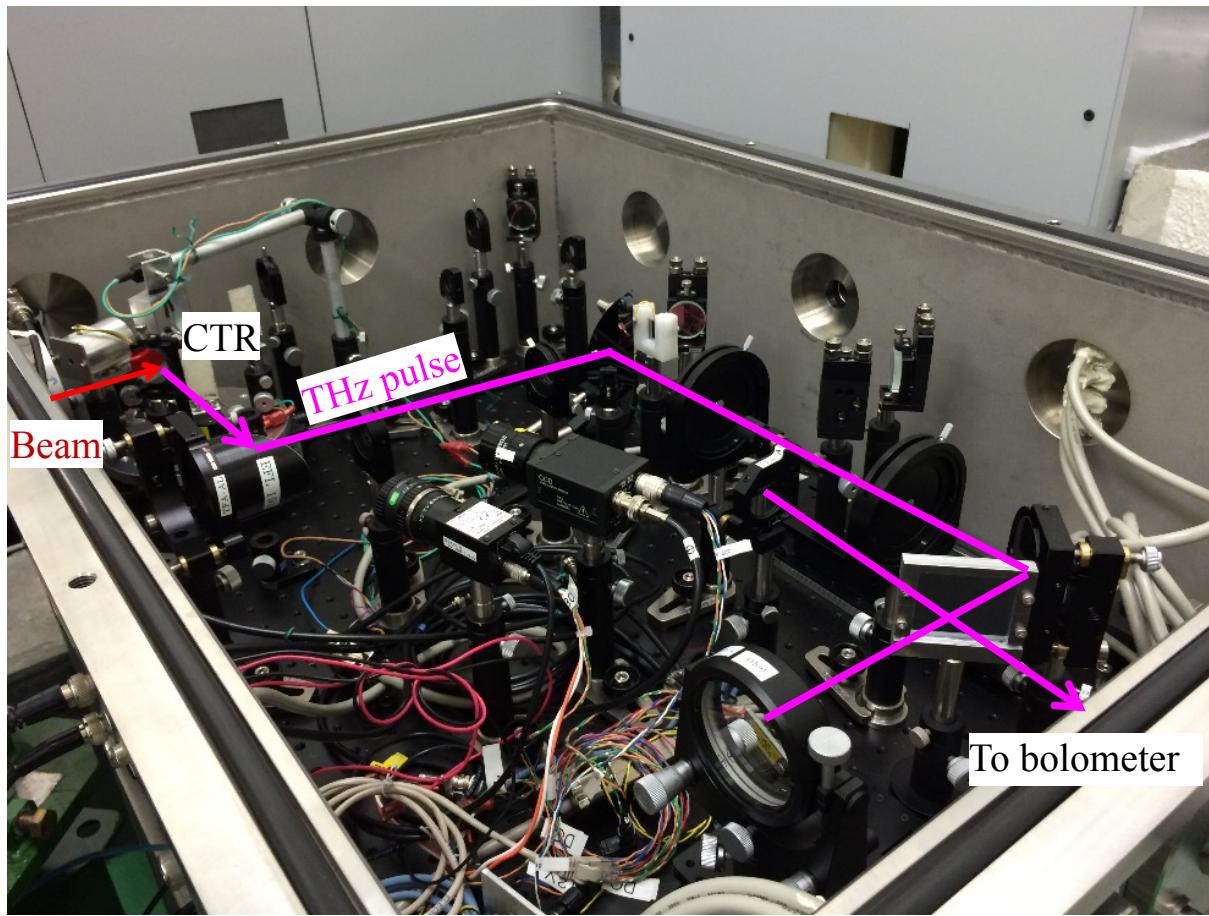
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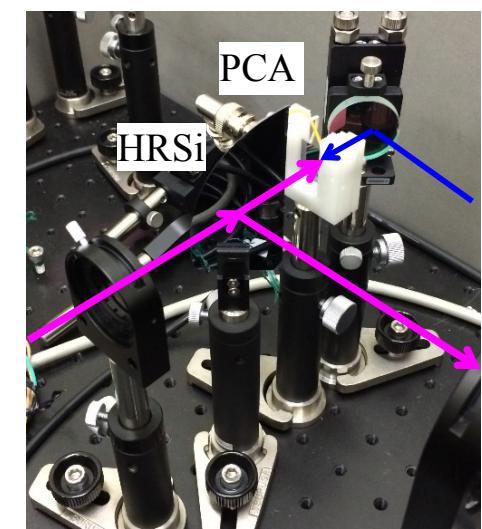
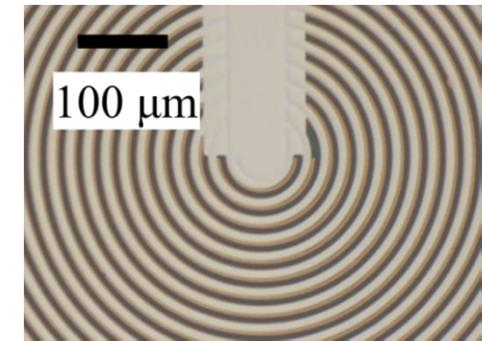
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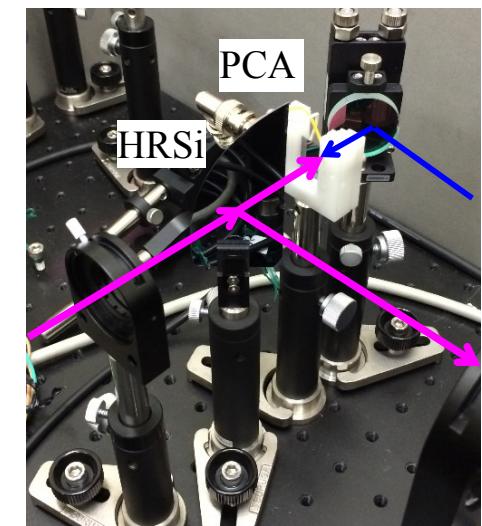
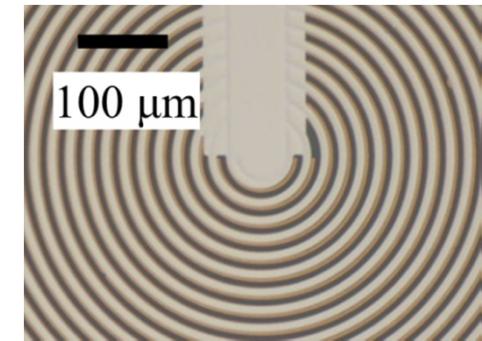
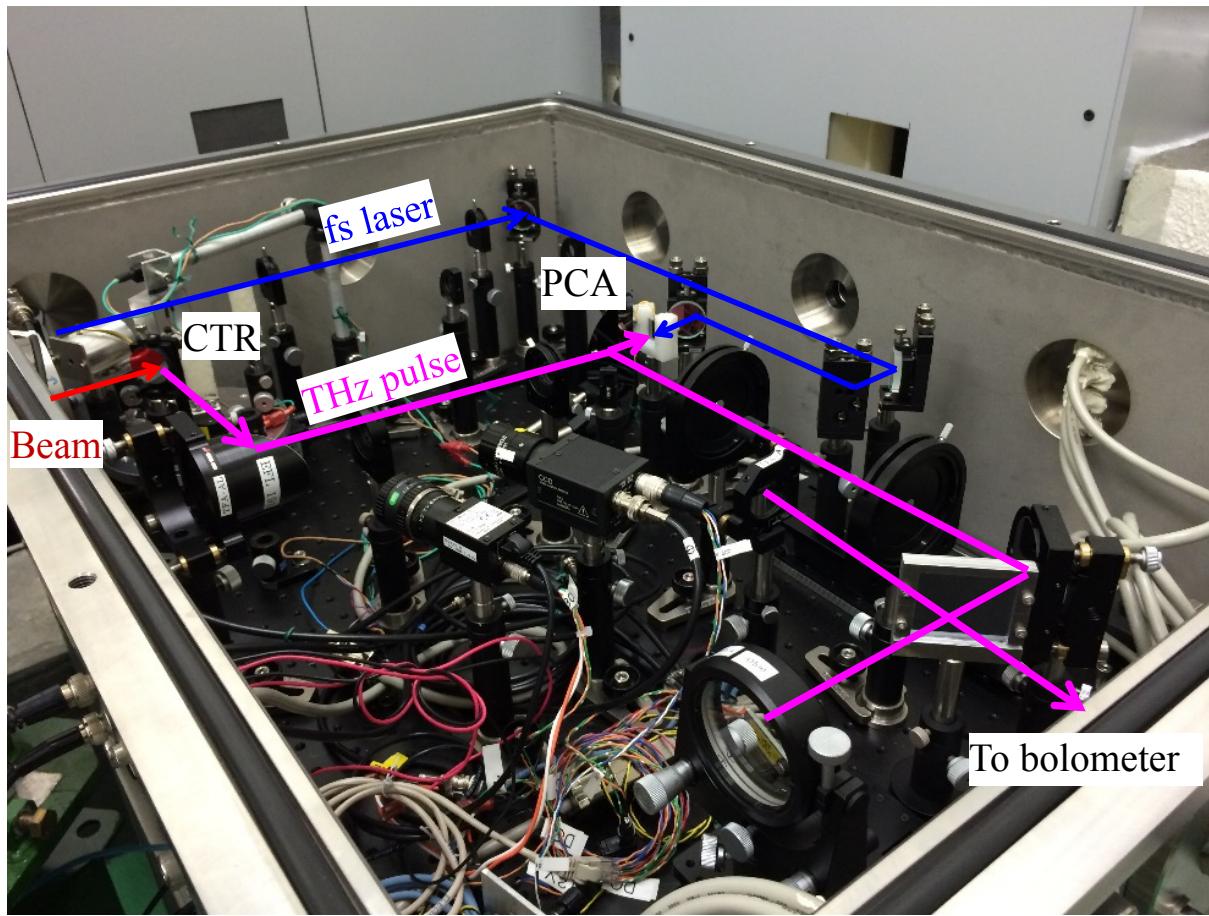
Pictures of measurement system



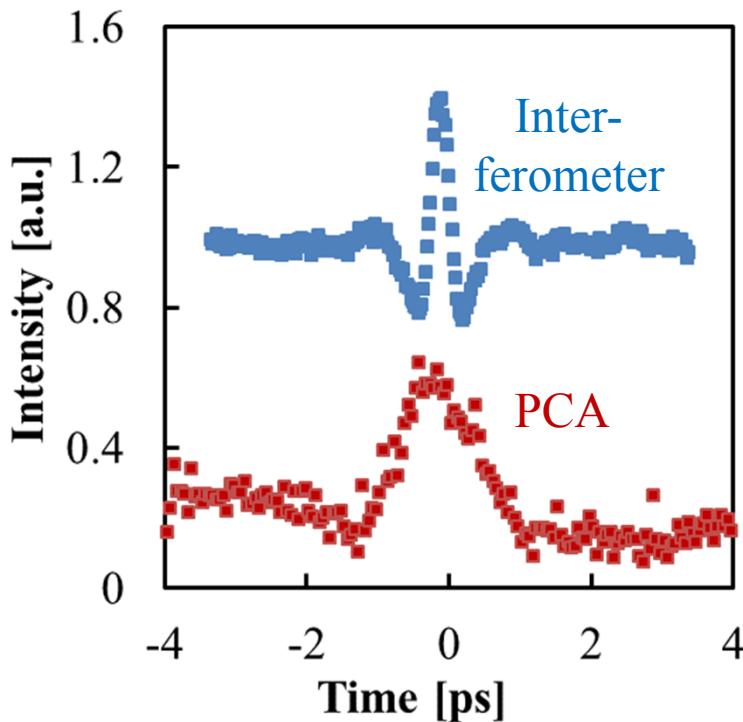
A picture of the measurement system



Pictures of measurement system

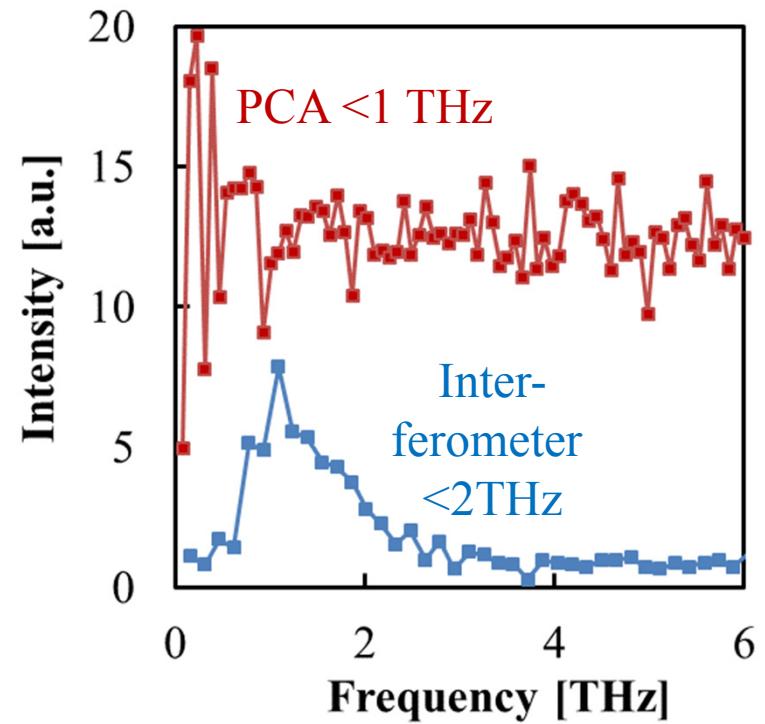


Comparison of results of the interferometer and PCA



Detector outputs as functions of delay lines
with factors and offsets adjusted.

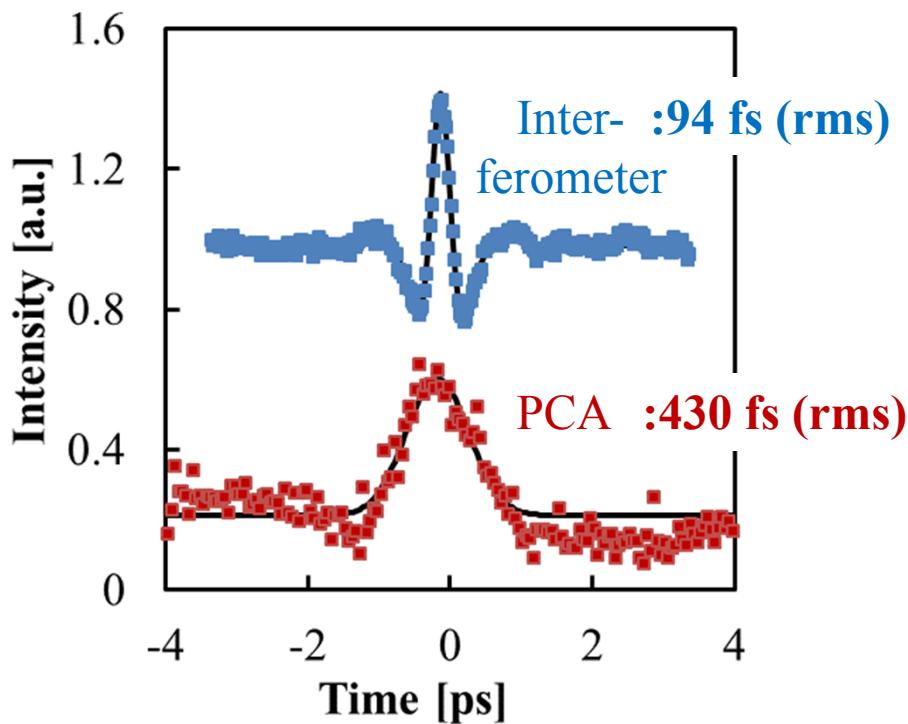
Average: 10, Beam energy: 35 MeV, Charge: 740 pC/pulse, Linac: 100°, fs laser: 300 μJ/pulse,
Interferometer data: fitting based on filtered model (A. Murokh et al., Nucl. Instrum. Meth. A 410, 452 (1998).),
PCA data: Gaussian fitting.



Frequency spectra from time profiles
with only factors adjusted.

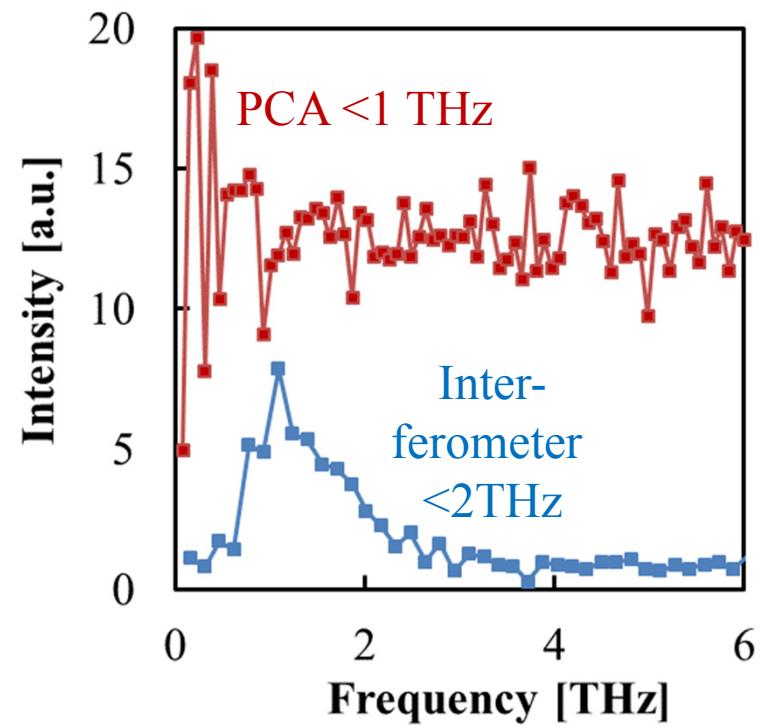
- Frequency and time-domain measurements (sub-ps, <1 THz)
- Need stabilization of PCA

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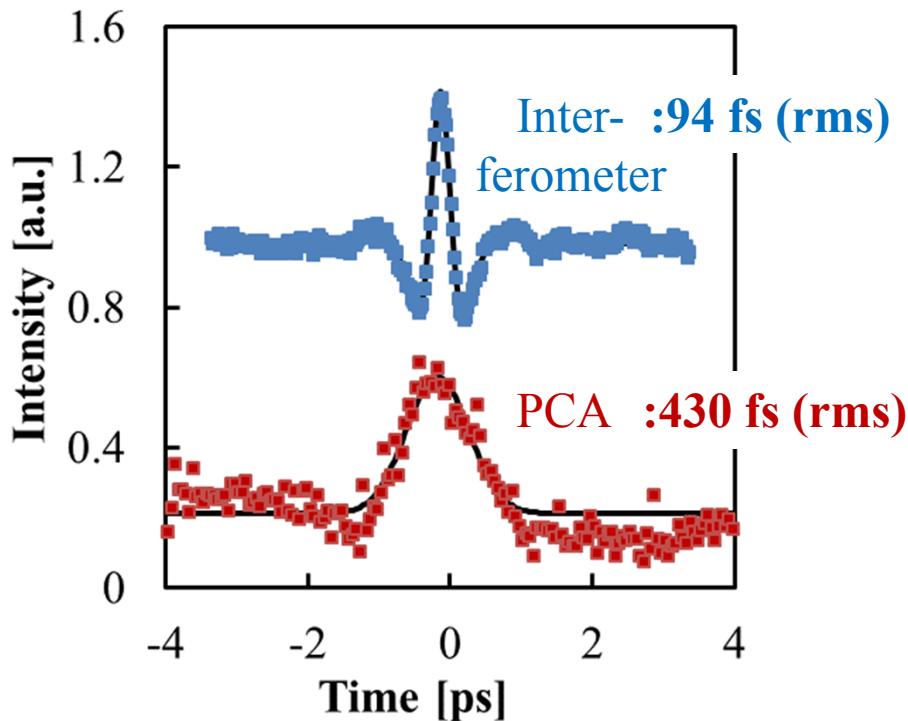
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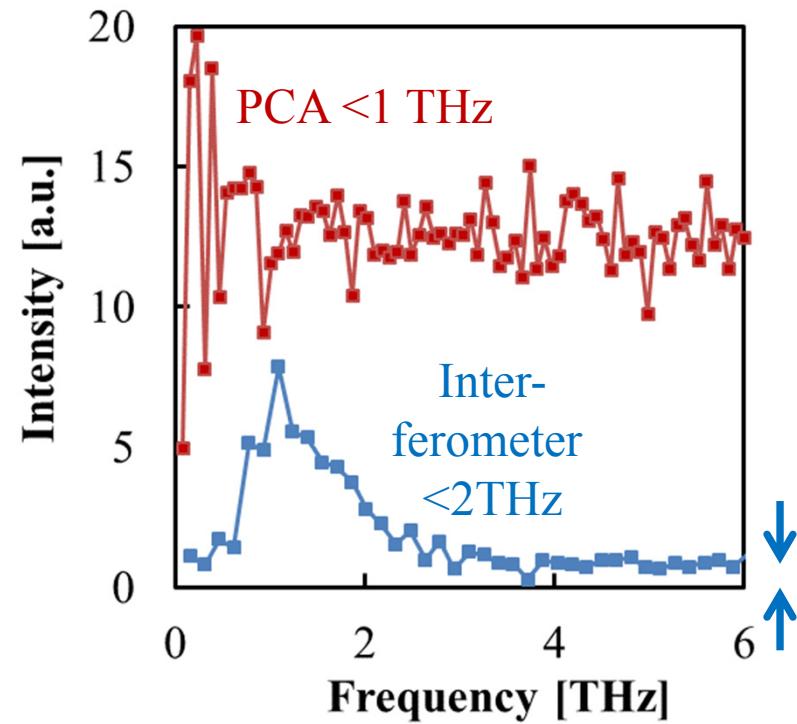
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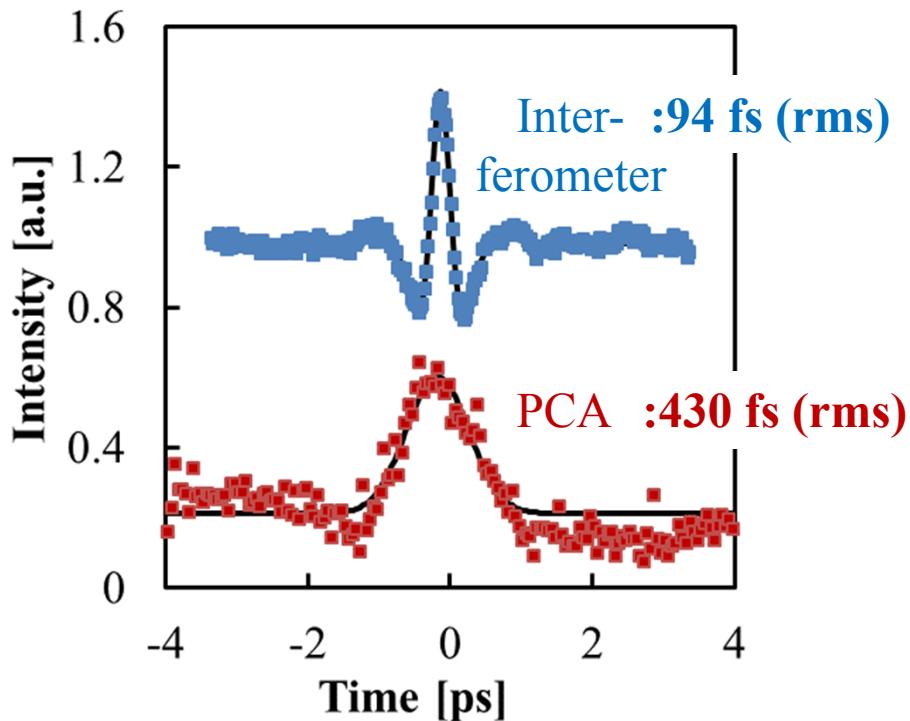
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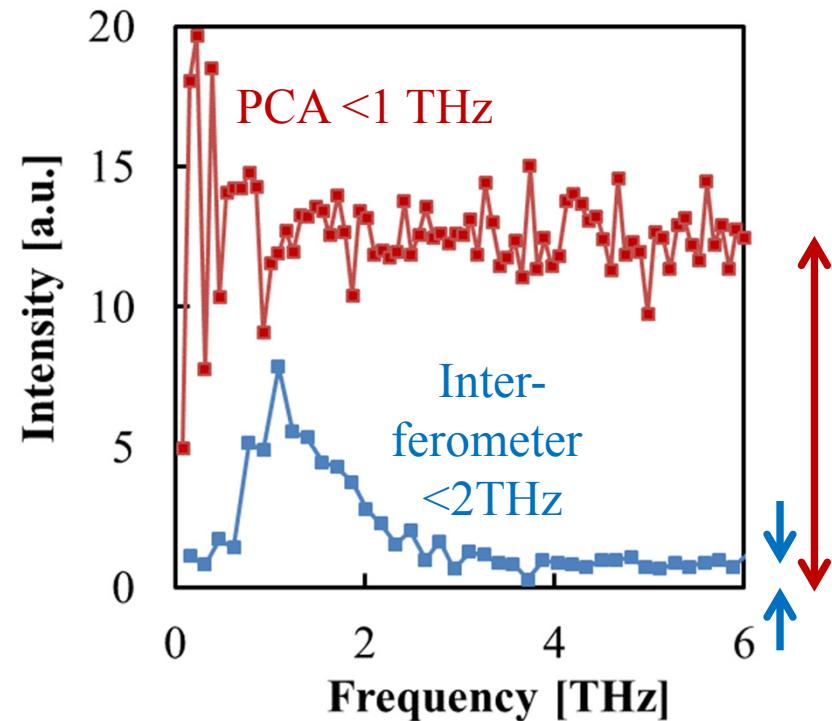
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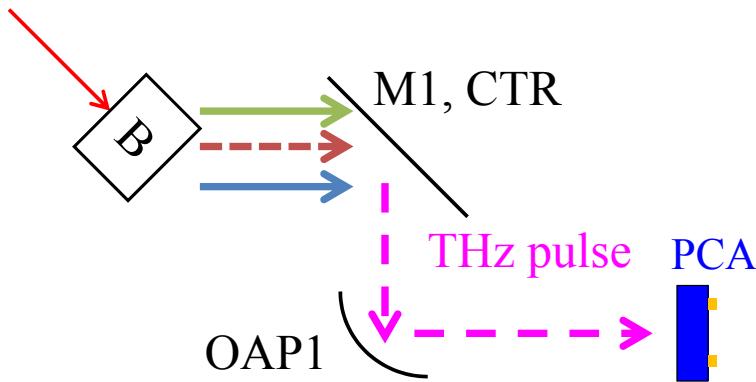
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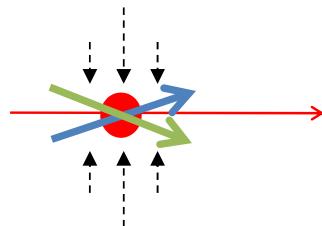
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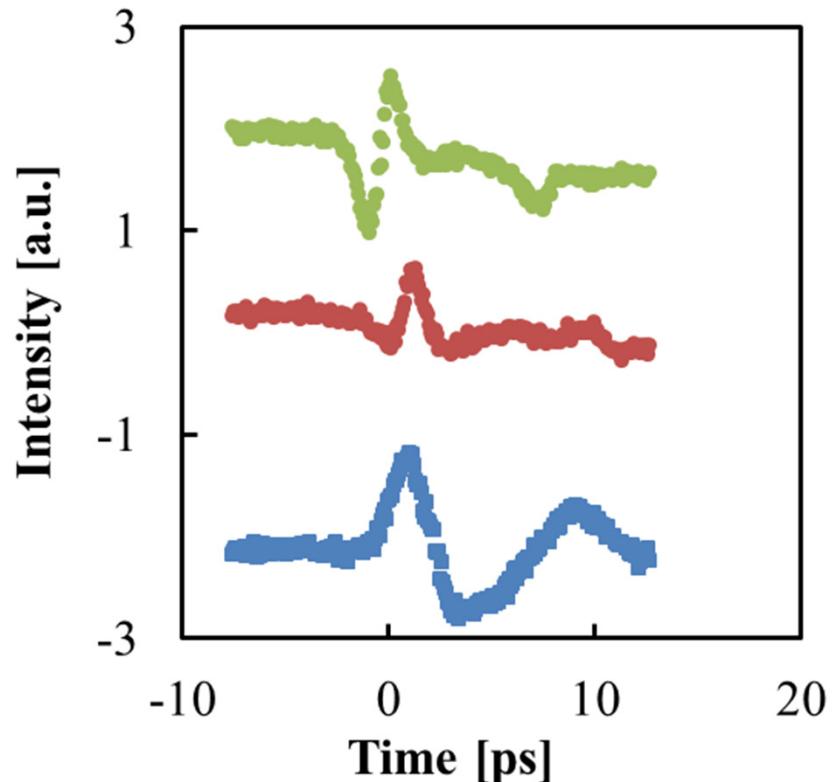
Possibility of electric field direction measurement



Beam trajectory change using a bending magnet (B).



Measurement of electric field from beam in oblique direction?



Profile change due to beam trajectories

Polarity change

(THz electric field and electrodes)

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Summary

- Interferometer and PCA were used for CTR measurement in frequency and time-domain techniques.
 - Electron bunches: 35 MeV and 700 pC
 - Interferometer measurement range : <2 THz, 94 fs rms
 - PCA measurement range : <1 THz, 430 fs rms
 - Possibility of electric field direction measurement
- In the future, broadband detection system of THz pulses and another method will be investigated.

THz generation using PCA : K. Kan et al., Appl. Phys. Lett. 102, 221118 (2013).

This work was supported by JSPS KAKENHI (JP25870404, JP26249146, and JP15H05565), and a Grant for Basic Science Research Projects was received from The Sumitomo Foundation.



Thank you for your kind attentions.