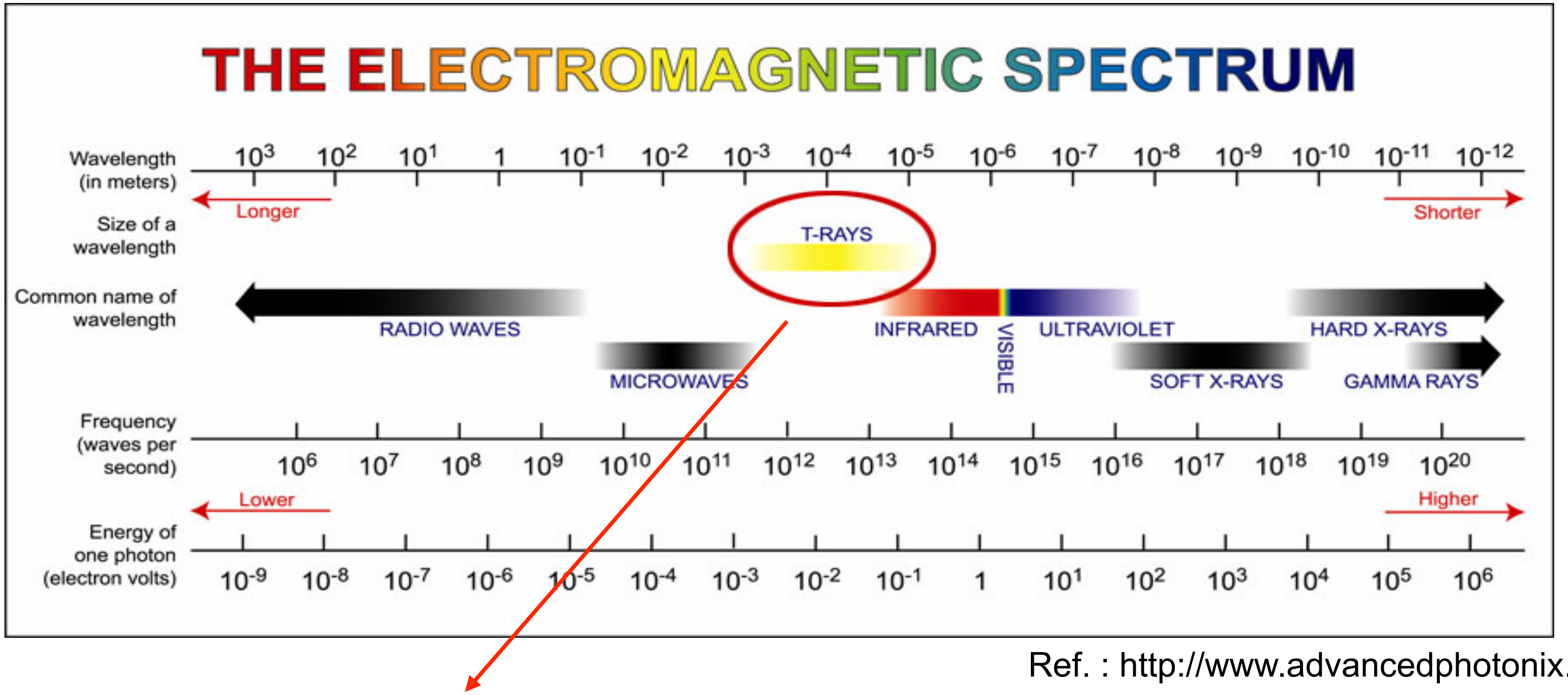
1.Terahertz electromagnetic pulse



Ref. : http://www.advancedphotonix.com

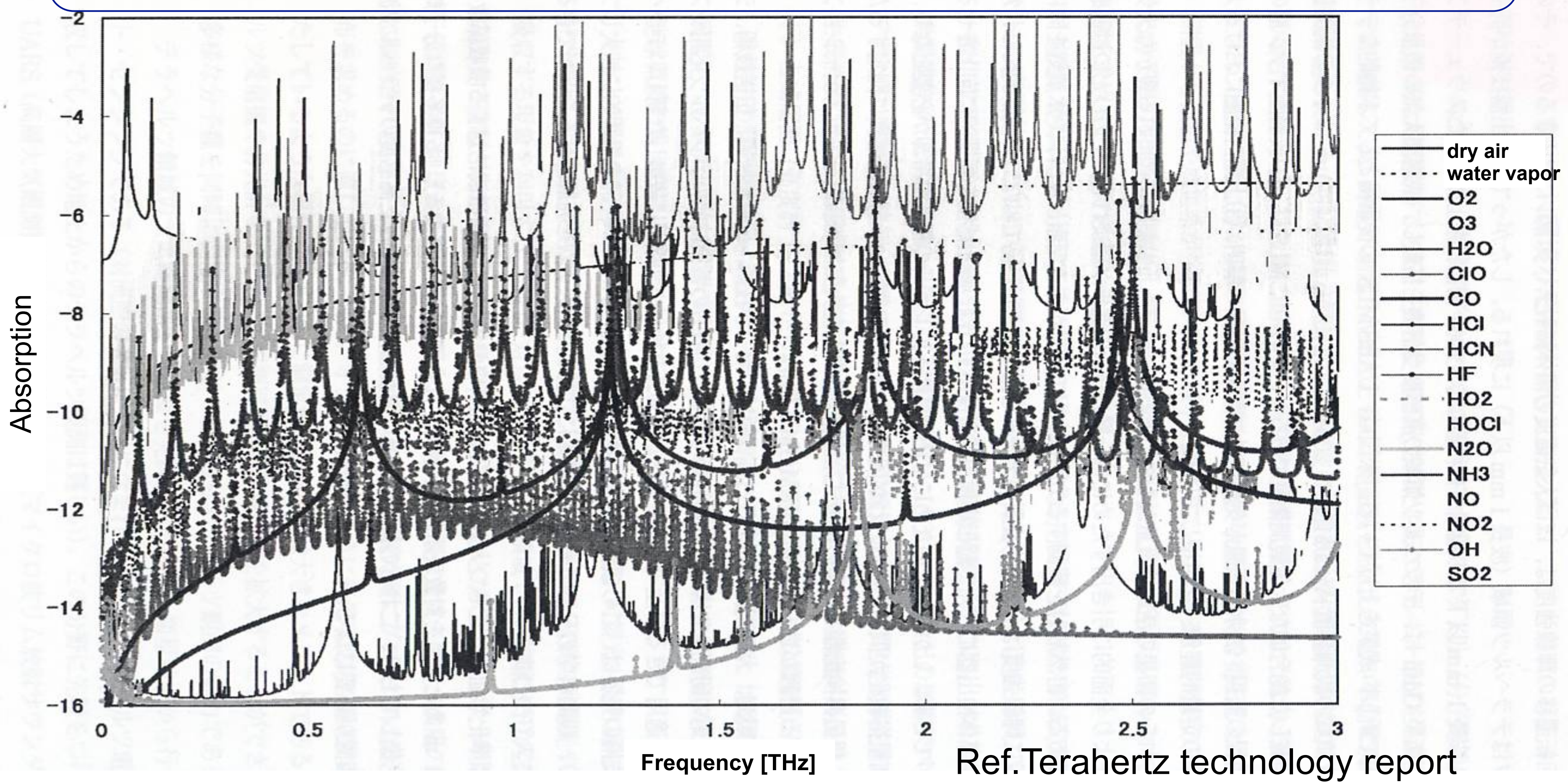
Boundary between light wave and electric wave

Excellent transmittance due to less scattering, free-space propagation,coherent beam,low energy, broadband spectrum,

Spectral fingerprint(gas,drug,vitamin)

2.Application of THz spectroscopy for monitoring of gas molecule

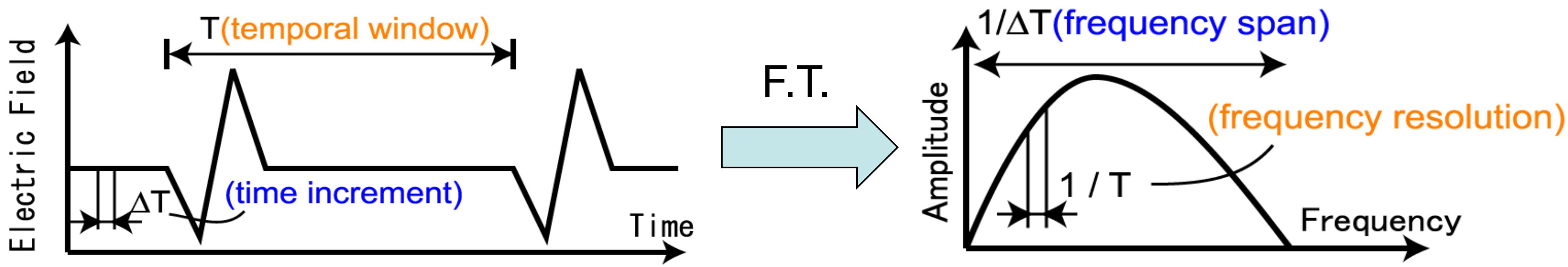
Gas analysis in air is required for air pollution, global warming,and ozone depletion



Ref.Terahertz technology report

<u>High accuracy, high resolusion</u> THz spectroscopy is required!

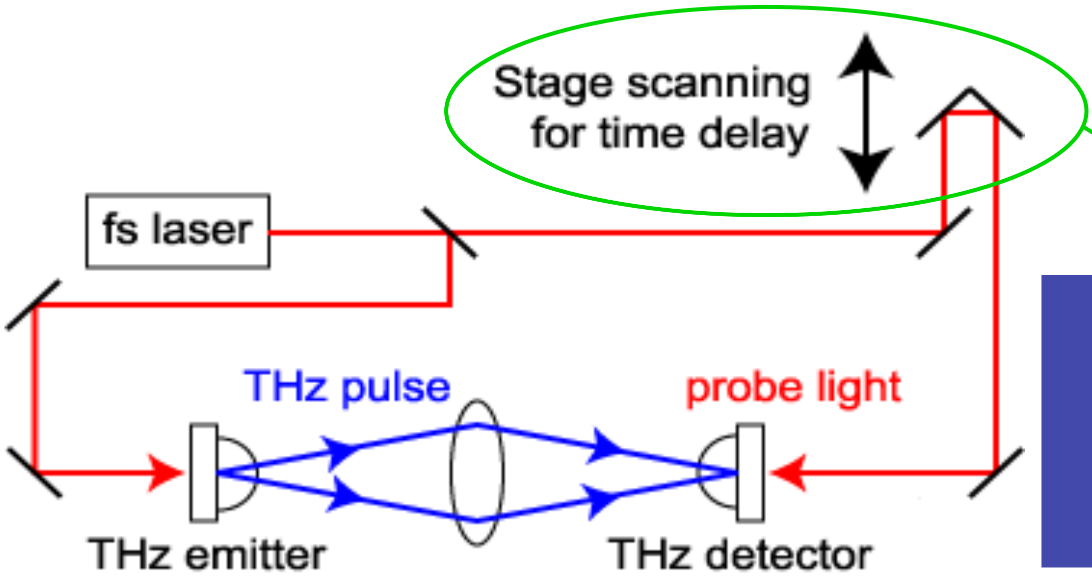
3.THz time-domain spectroscopy (THz-TDS)



Temporal waveform *Fourier spectrum*

Resolution = inverse of temporal window

Accuracy = precision of time delay

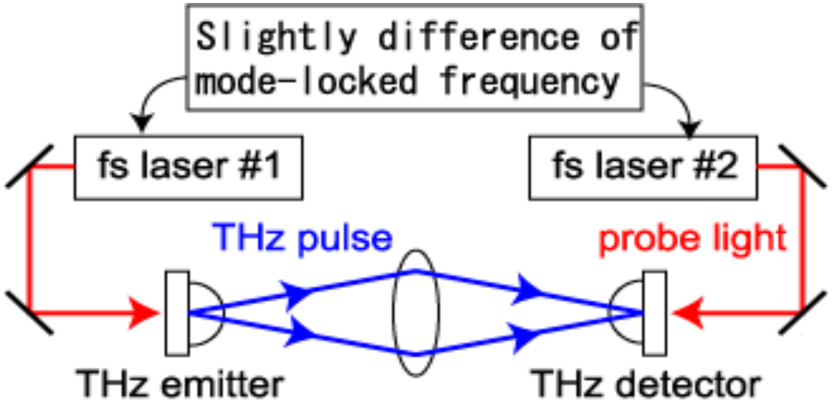


Stage-scanning THz-TDS

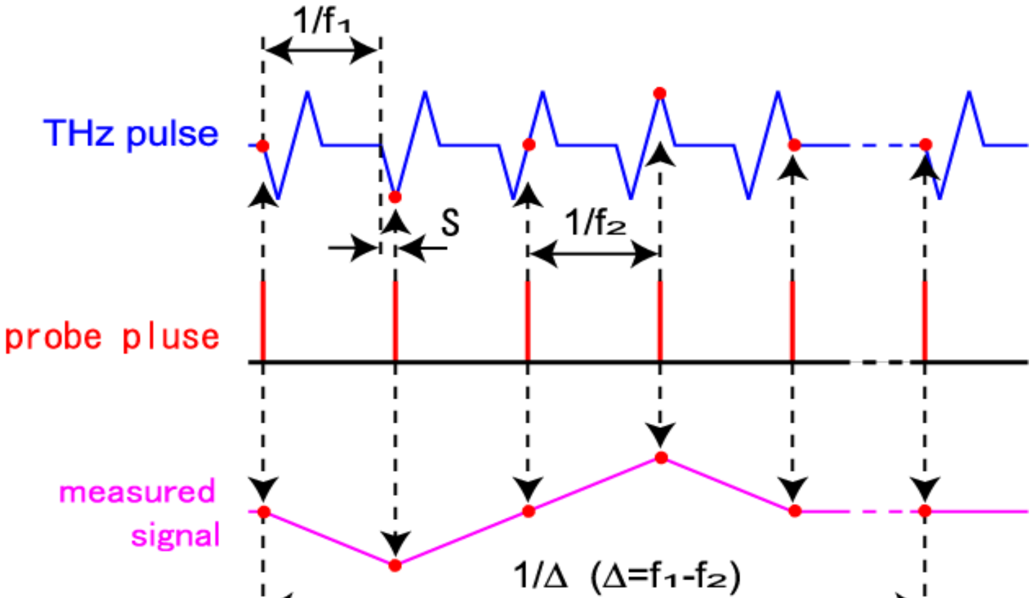
Spectral scaling based on moving of mechanical stage

(1) Trade-off between <u>spectral resolution</u> and measurement time
(2) <u>Spectral accuracy</u> depends on positioning precision of stage

4.Principle of AOS-THz-TDS



Mechanical stage for time delay is unnecessary!



Temporal overlap of THz pulse and probe pulse automatically shifted at every pulse!

Temporal magnification factor

$$M = \frac{1/\Delta}{1/f_1} = \frac{f_1}{\Delta}$$

Sampling interval

$$S = \frac{1}{f_2} - \frac{1}{f_1} = \frac{\Delta}{f_1 f_2}$$

time domain

frequency domain

Frequency range

$$F.Range = \frac{1}{S} = \frac{f_1 f_2}{\Delta}$$

Frequency resolution $= f_1$

Scan rate $= \Delta$

5. *Problem* of previous AOS-THz-TDS system

Previous AOS laser source

Δ: stabilized f_1, f_2: free-running

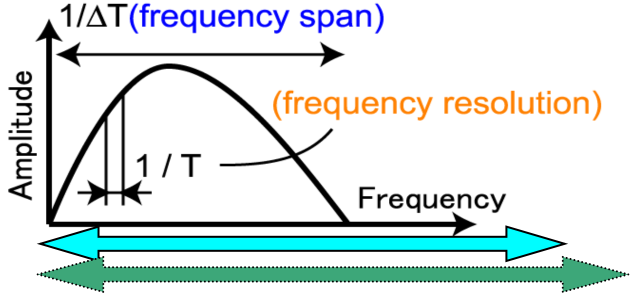
Temporal magnification factor

$$M = \frac{1/\Delta}{1/f_1} = \frac{f_1}{\Delta}$$

f_1: fluctuated by free-running laser

Δ: fixed by laser control

→ **M fluctuates depending on f1**



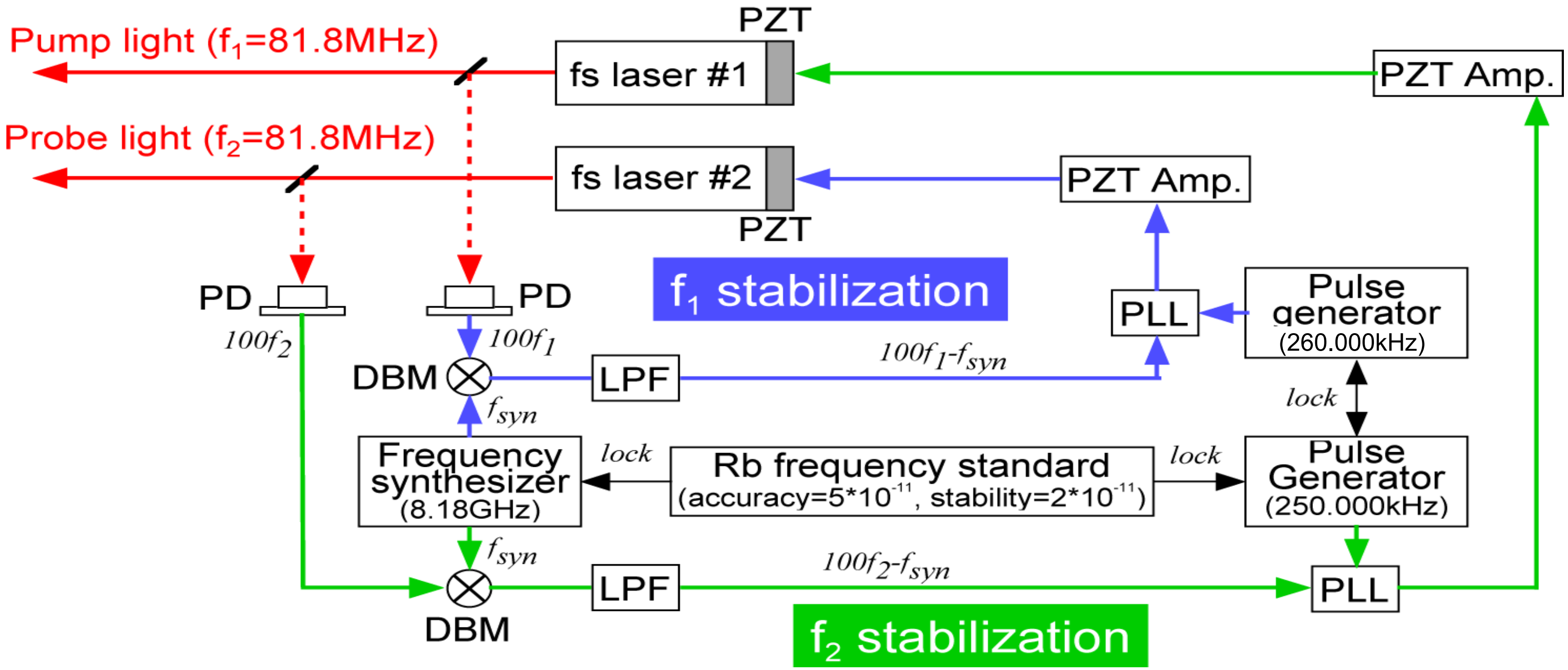
Fluctuation on frequency scale depending on f_1

Decrease of accuracy and resolution in THz-TDS

6. ***New*** AOS laser source

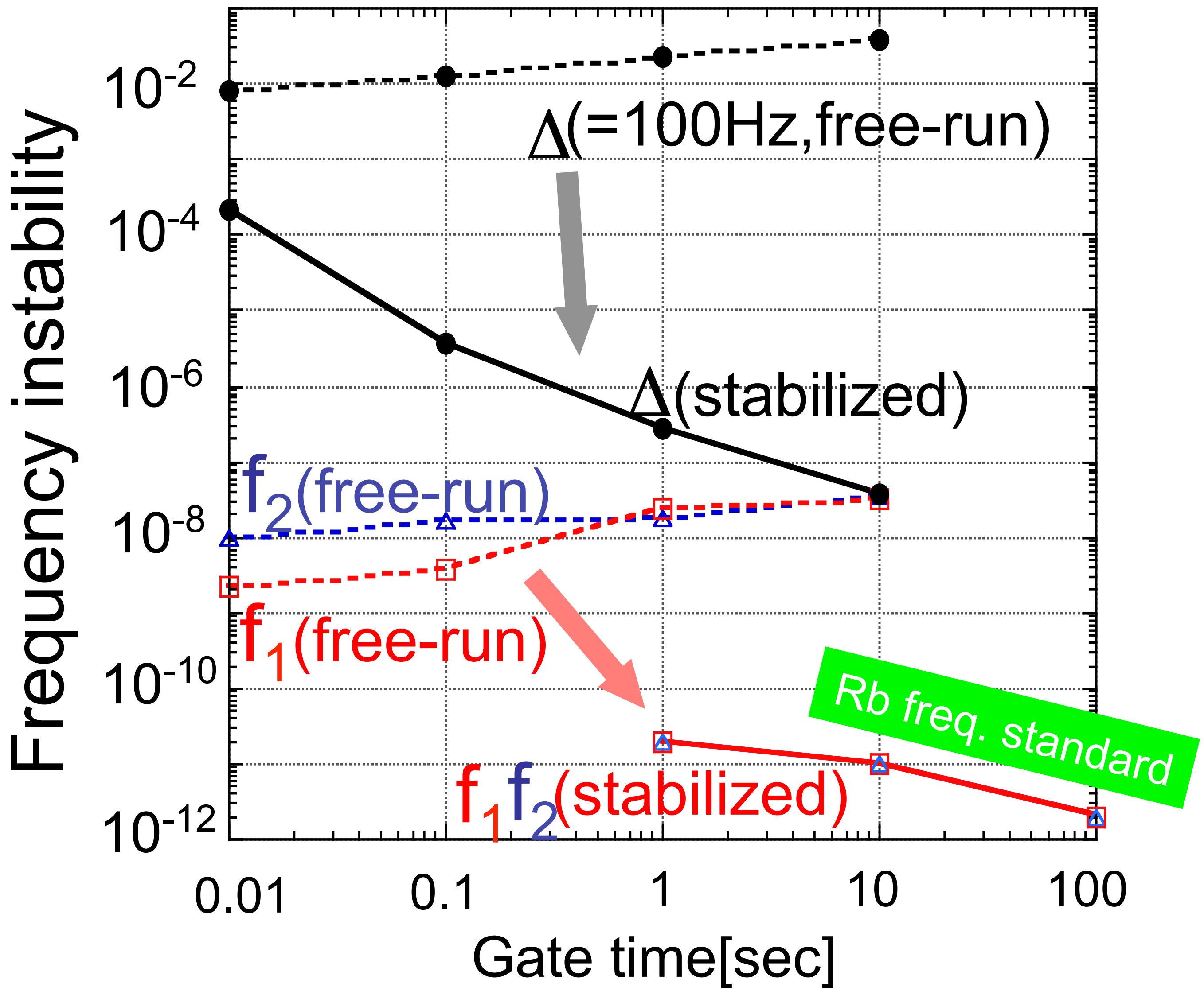
M is fixed and selectable

f_1, f_2, Δ: stabilized
Δ can be set at arbitary frequency

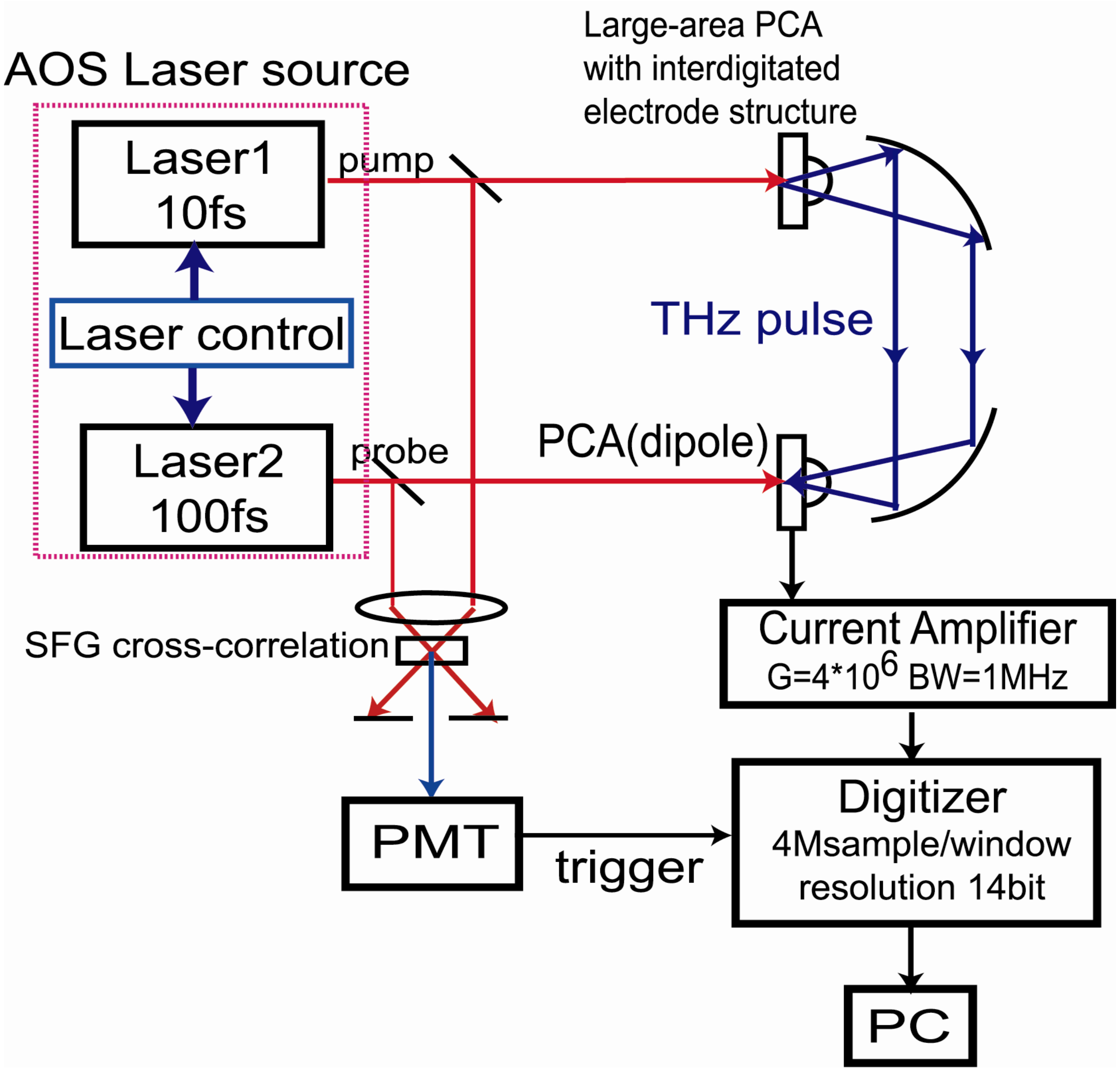


f_1=81,834,630,000Hz, f_2=81,834,630,100Hz
$\Delta = f_1 - f_2$ = 100Hz

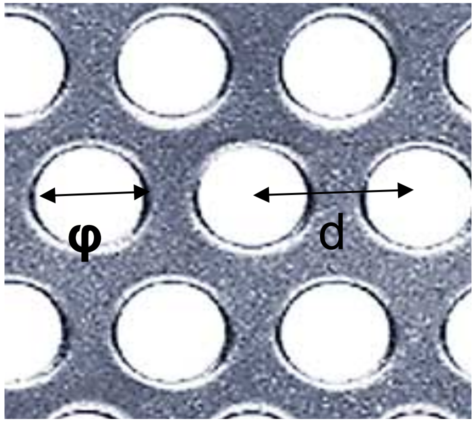
7.Frequency instability of f_1,f_2,and Δ



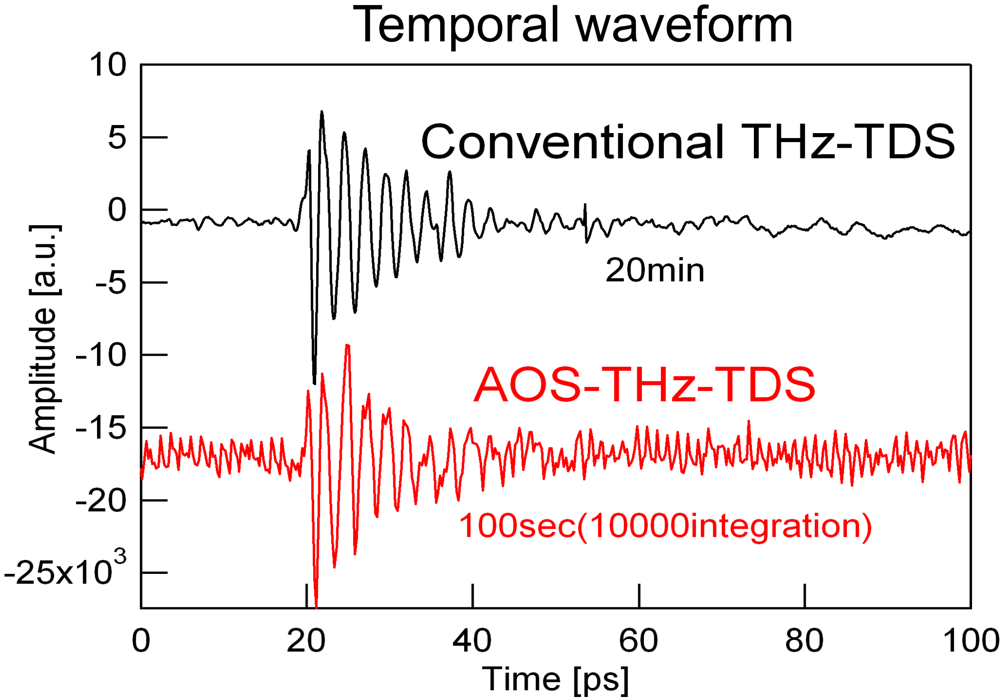
8.Experimental setup

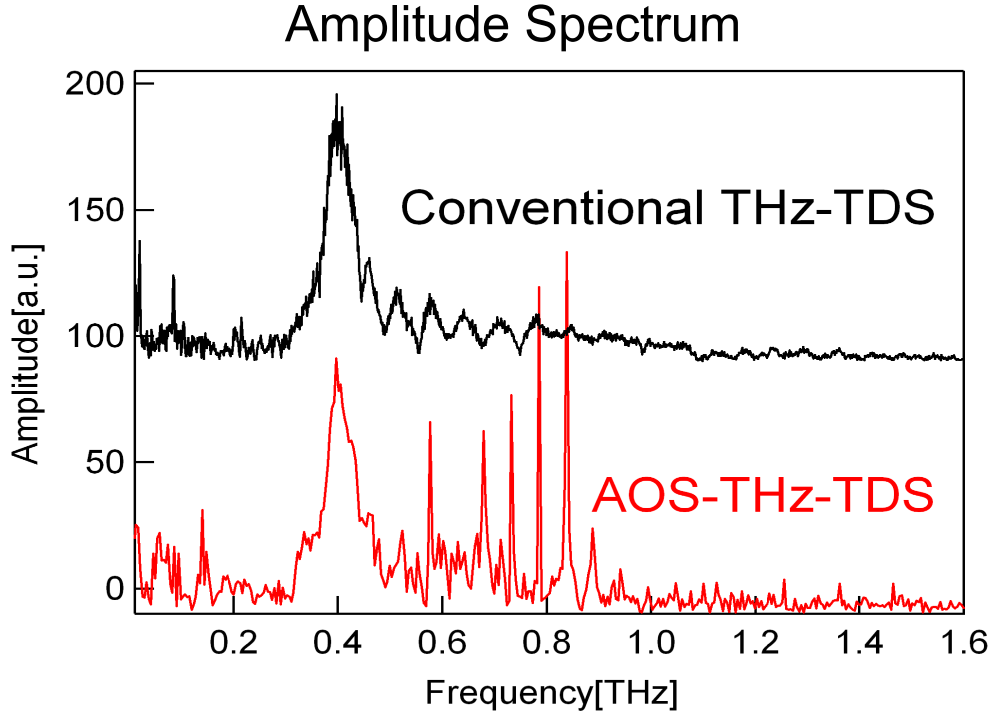


9. Experimental Results(1)
0.4THz Metal Hole Array



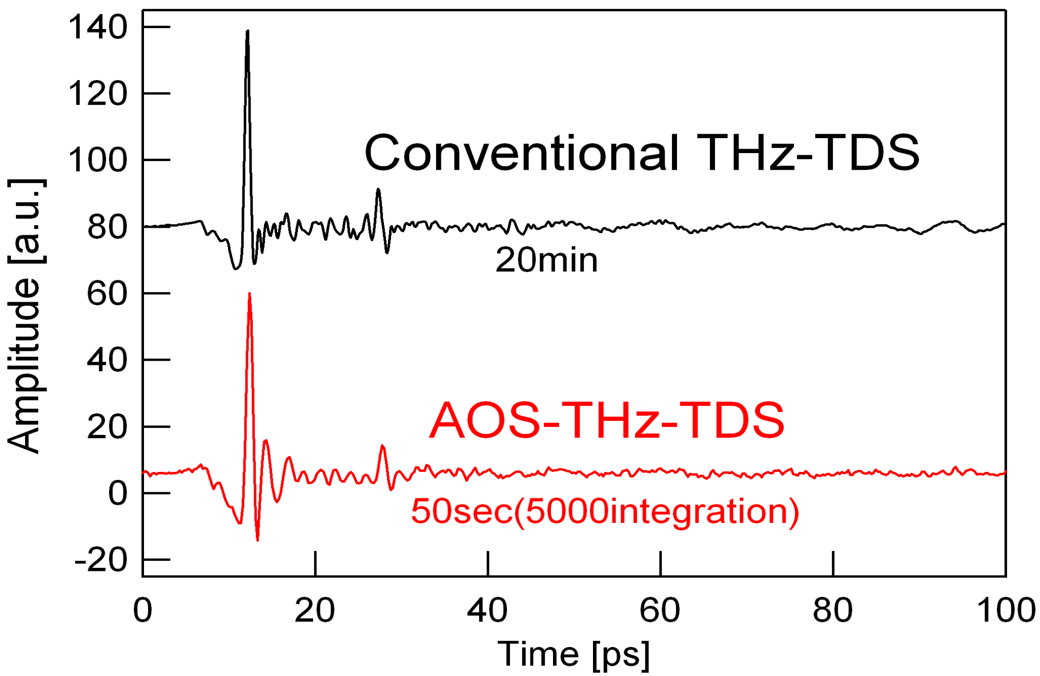
SUS304 plate (t=0.5mm) d=0.75mm,**φ**=0.4mm



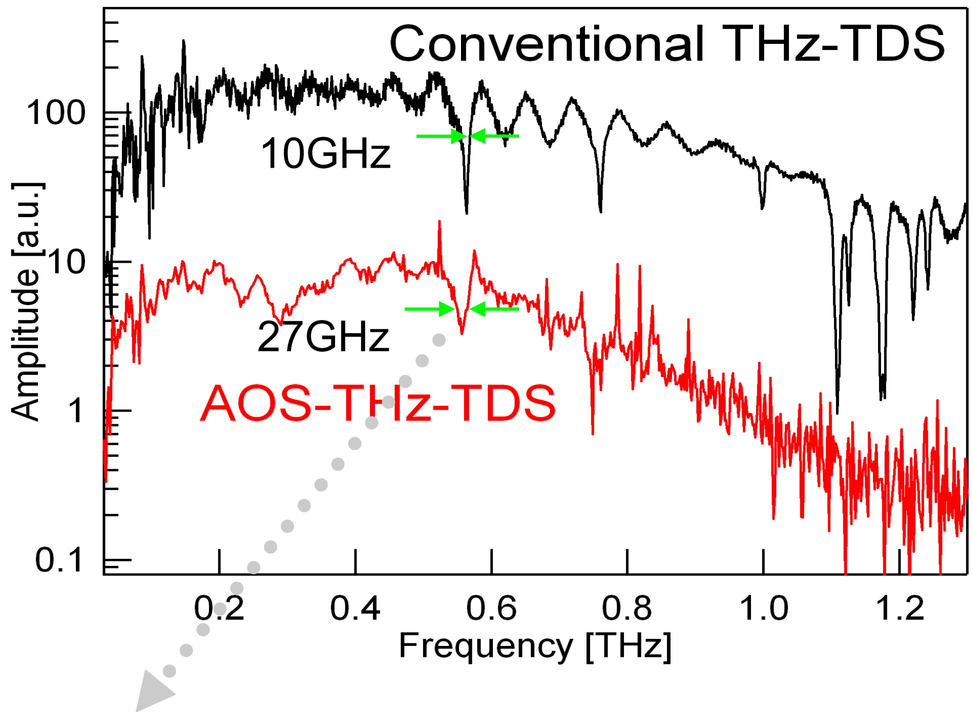


10. Experimental Results(2) Water vapor in room air

Temporal waveform



Amplitude Spectrum



Broadening of absorption line caused by insufficient stability of Δ?

11.Effect of timing jitter between two lasers

Insufficient stability of Δ

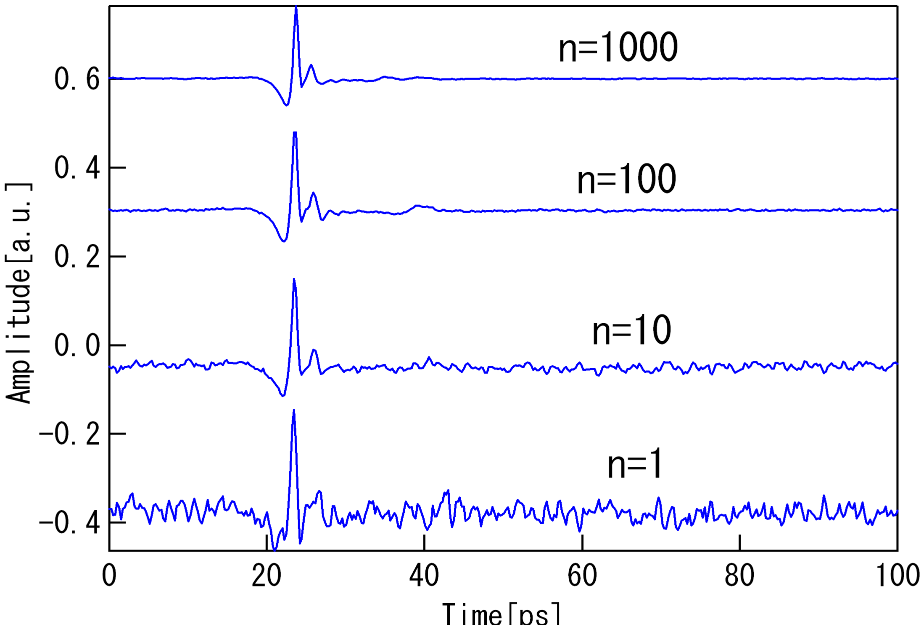
↓

Timing jitter between two lasers

↓

- Inefficient signal averaging (low SNR)
- Smoothing effects due to random timing-jitter (Blurring of fine structures in THz signal)
- Decrease of THz spectral bandwidth
- Decrease of accuracy and resolution in THz-TDS

Effect of signal averaging



Future

(1) Further improvement of stability in Δ
(2) Select of larger Δ value
(fluctuation of Δ is independent of Δ value in new AOS laser source)

Conclusion

(1) New AOS laser source

Stability of f_1 and f_2 = 10^{-11} @10sec
(≒Stability of Rb frequency standard)

(2)Application for water vapor and MHA

Frequency resolution = 27GHz@0.56THz (50sec)

(3)Further improvement of laser stability is needed
for high accuracy, high resolusion AOS-THz-TDS