Where THz technology is now?

Present location

Metrology

Technical infrastructure to guarantee reliability of measurement

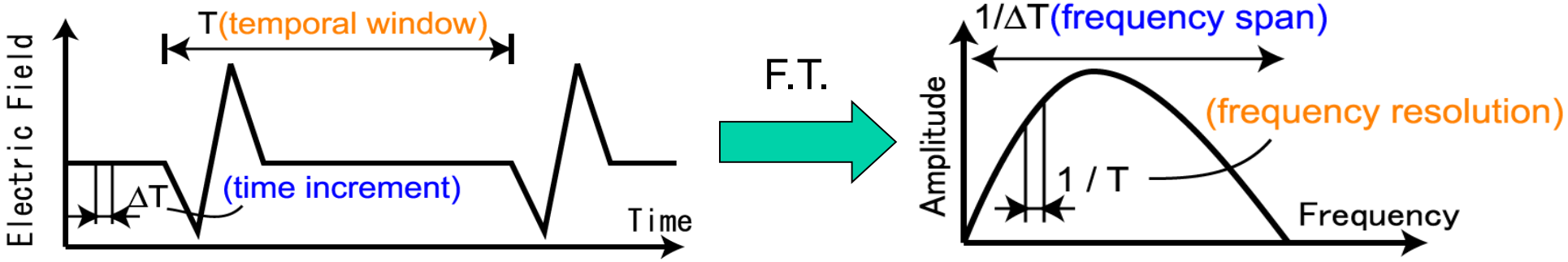
Frequency metrology

Expand the scope of THz applications widely based on high reliability

THz gap of frequency metrology is still exiting because there are lack of frequency standard and traceability in THz region

Reliable THz frequency metrology is required!

THz time-domain spectroscopy

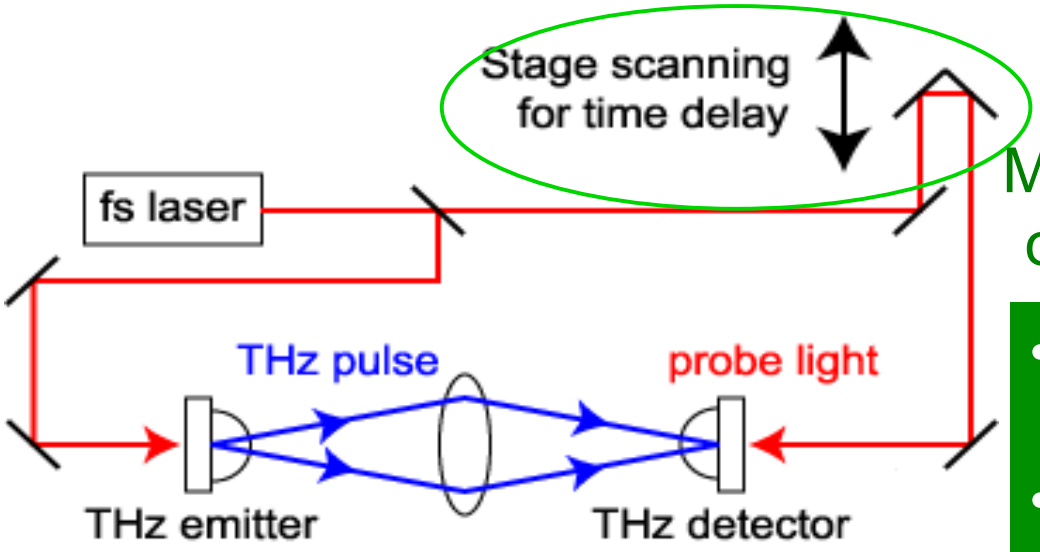


Temporal waveform

Fourier spectra

Spectral resolution
=inverse of time window

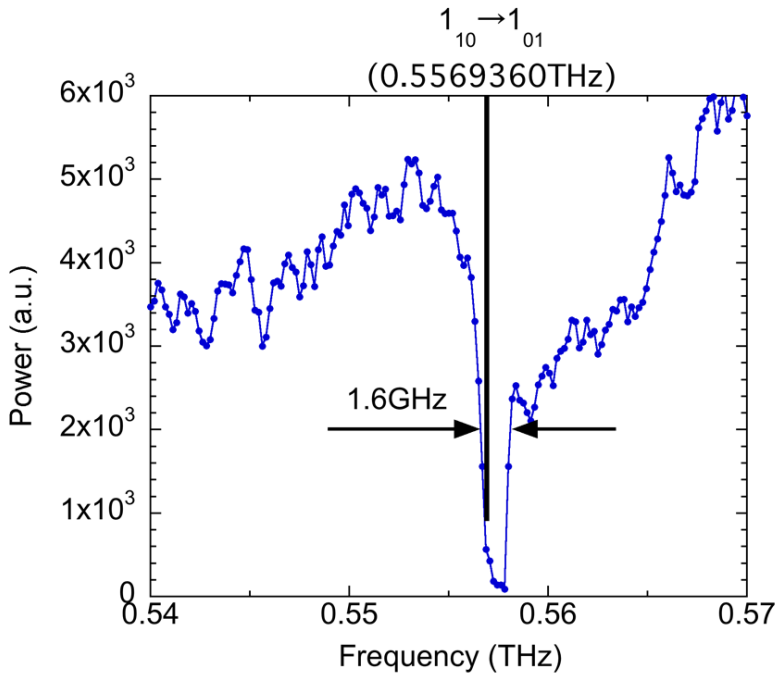
Spectral accuracy
= Precision of time delay

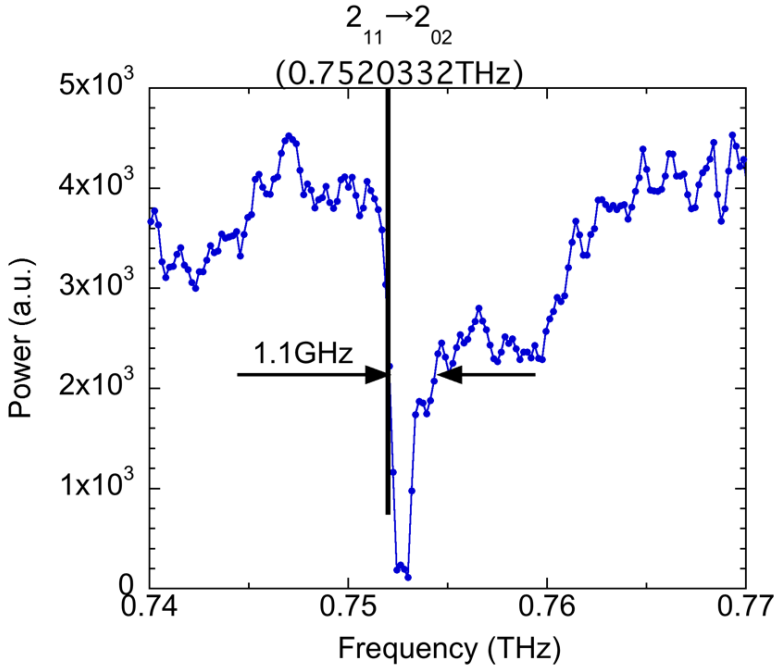


Pump-probe experiment

Marking of frequency scale is based on mechanical movement of stage

- Trade-off between spectral resolution and measurement time
- Spectral accuracy depends on positioning precision of stage



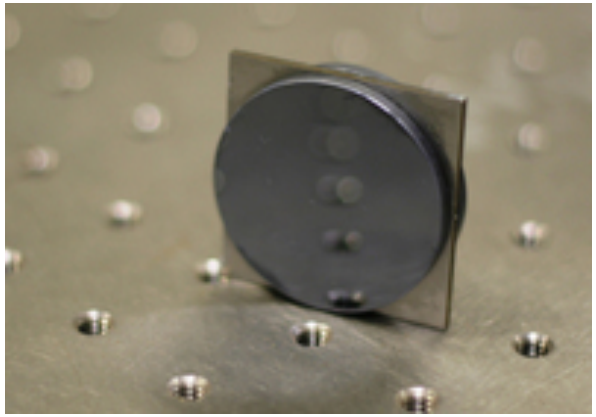


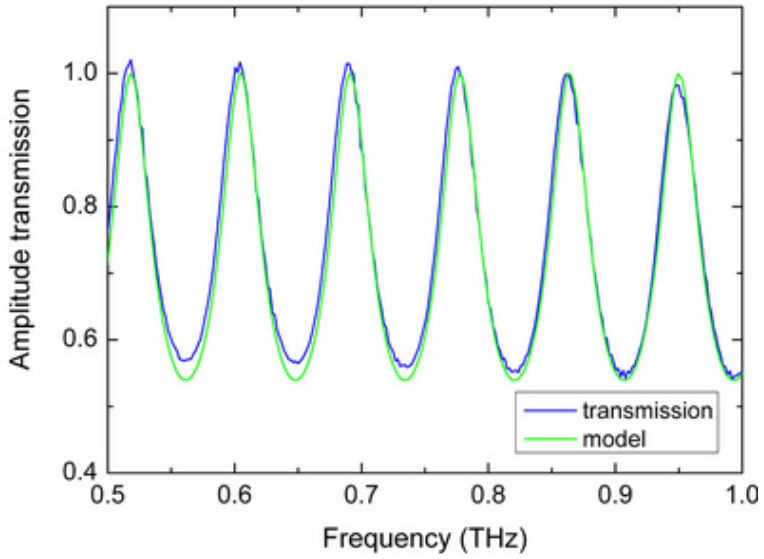
Absorption spectra of low-pressure water vapor

Frequency calibration of THz-TDS

*ref)JOSA B **26**, 1357-1362 (2009).*

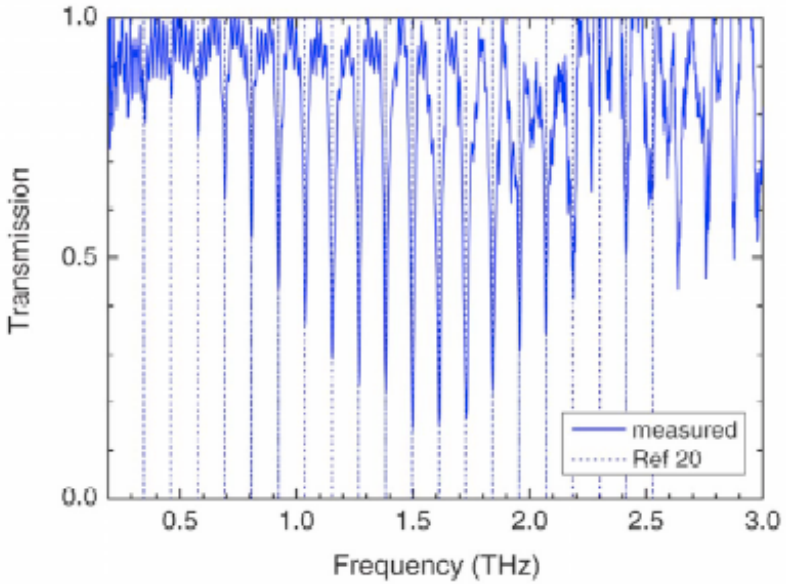
Etalon





Resolution ~ 5 GHz

Gas cell (CO@2 bar)



Resolution < 1 GHz

Approach for reliable frequency metrology

Use transition freq. in atom

- Ideal approach
- Cesium atomic clock
  @microwave region
- Three-photon CPT of Ca ion
  @1.82THz (theoretical)
  *ref) PRL **99**, 013001 (2007).*

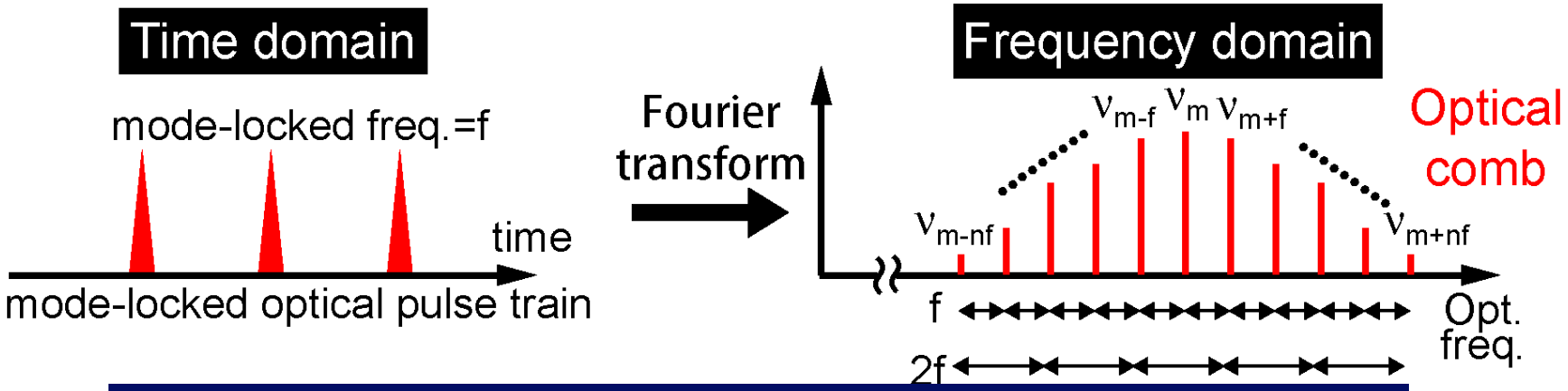
Challenging way to realize this scheme

Deliver from other EM regions

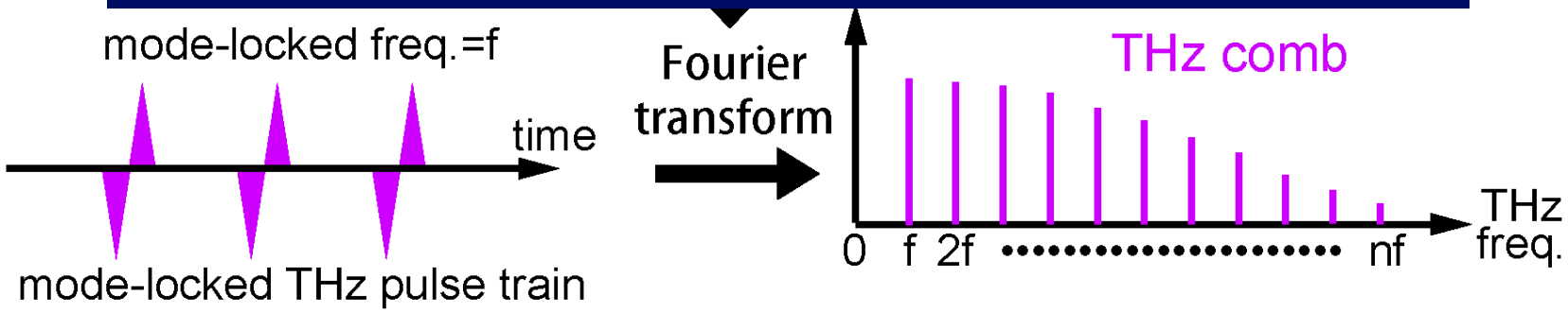
- Practical approach
- Need frequency linker
- Optical comb
  (transfer from microwave to optical regions)
- THz comb
  *ref) APL **88,** 241104 (2006).*

Chance to achieve freq. metrology

Optical comb and THz comb

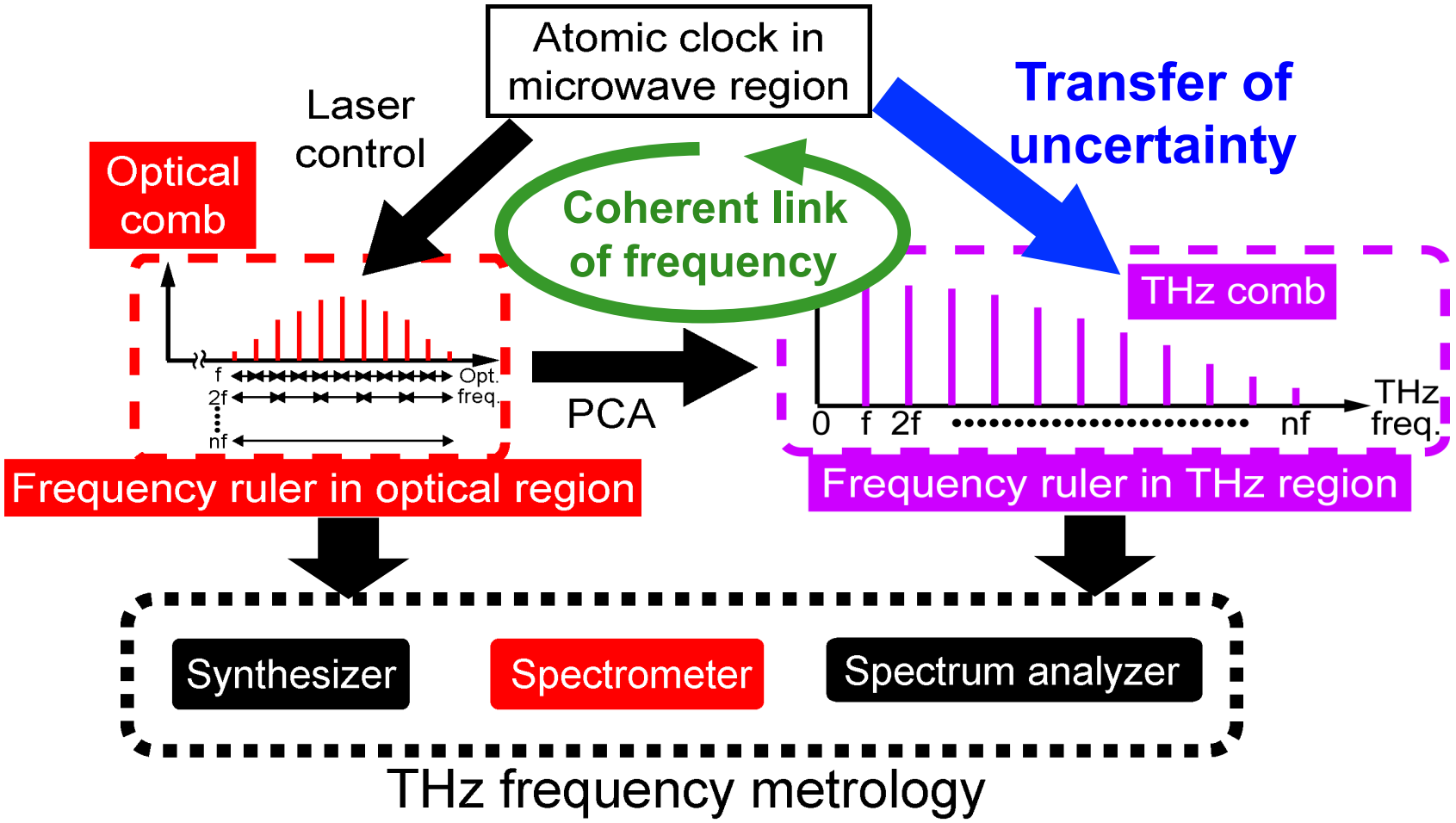


Precise frequency marker for broadband THz spectrum



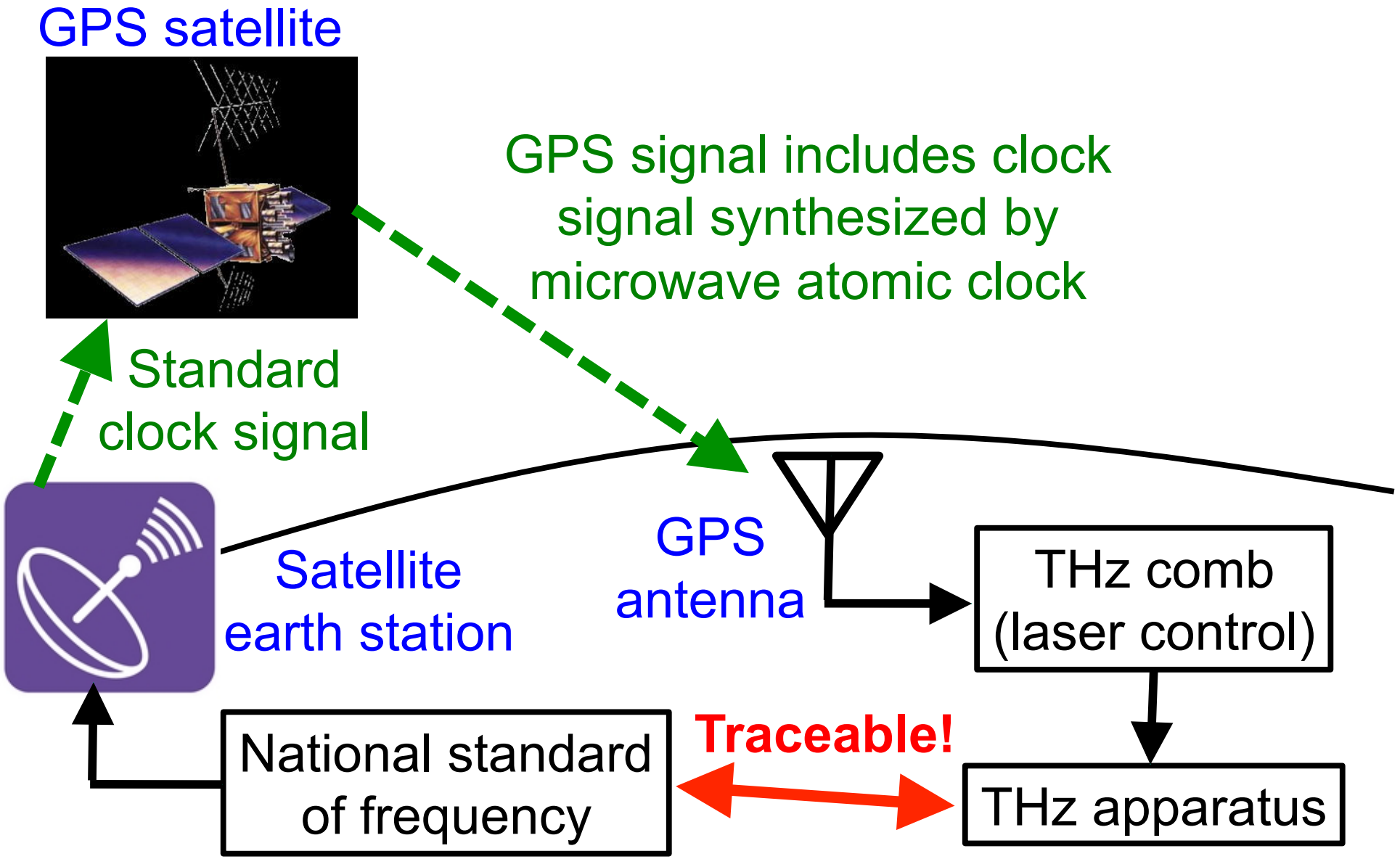
Simple, broadband selectivity, high spectral purity, and absolute frequency calibration

THz frequency metrology based on frequency comb techniques



Same uncertainty as microwave and optical regions

How transfer traceability to THz apparatus?



Which fields need this technique?