Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
National Metrology Institute

Novel THz detectors and their power calibration

Andreas Steiger, Ralf Müller
Physikalisch-Technische Bundesanstalt, Abbestr. 2-12, D-10587 Berlin

Werner Bohmeyer, Karsten Lange
Sensor- und Lasertechnik, Schulstr. 15, D-15366 Neuenhagen

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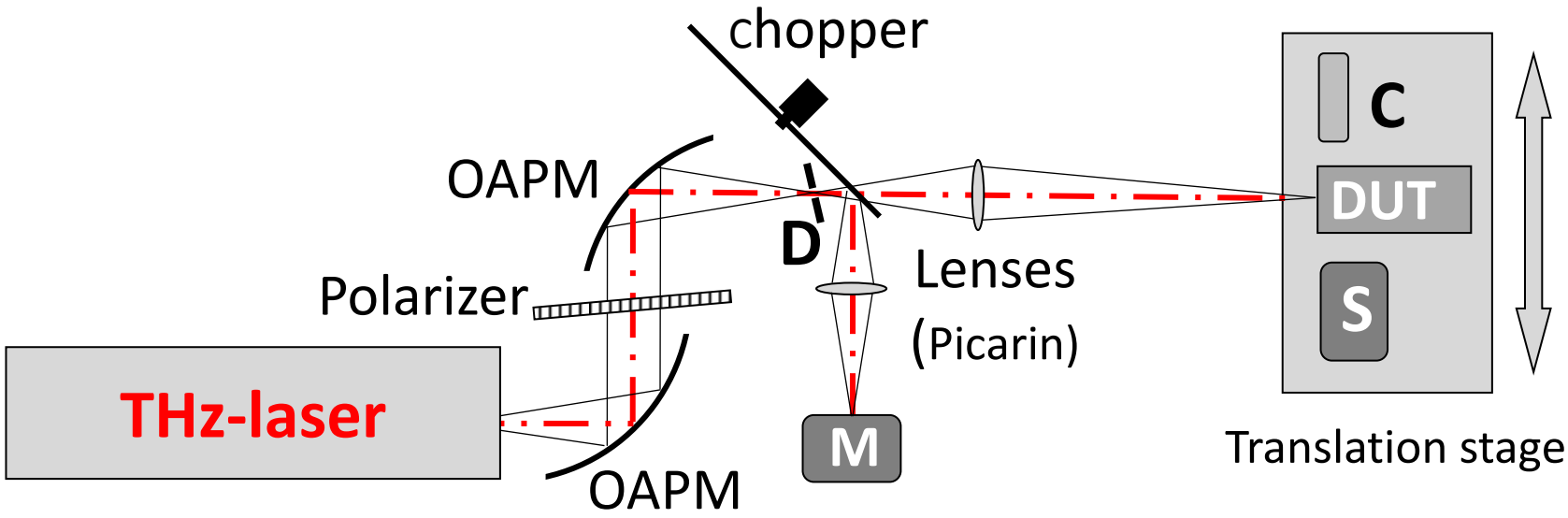
THz Detector Calibration Facility at PTB

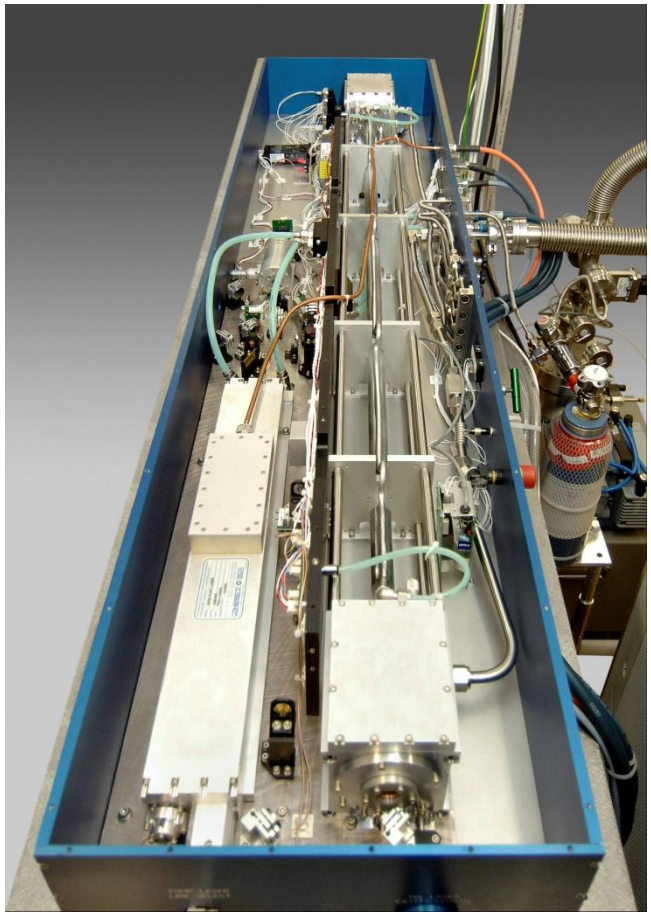
to measure the power responsivity traceable to SI



D – diaphragm as a spatial filter for a Gaussian beam profile
S – standard detector, **M** – monitor detector,
C – THz camera to measure the beam profile

THz Laser to Cover the Range: 1 THz to 5 THz

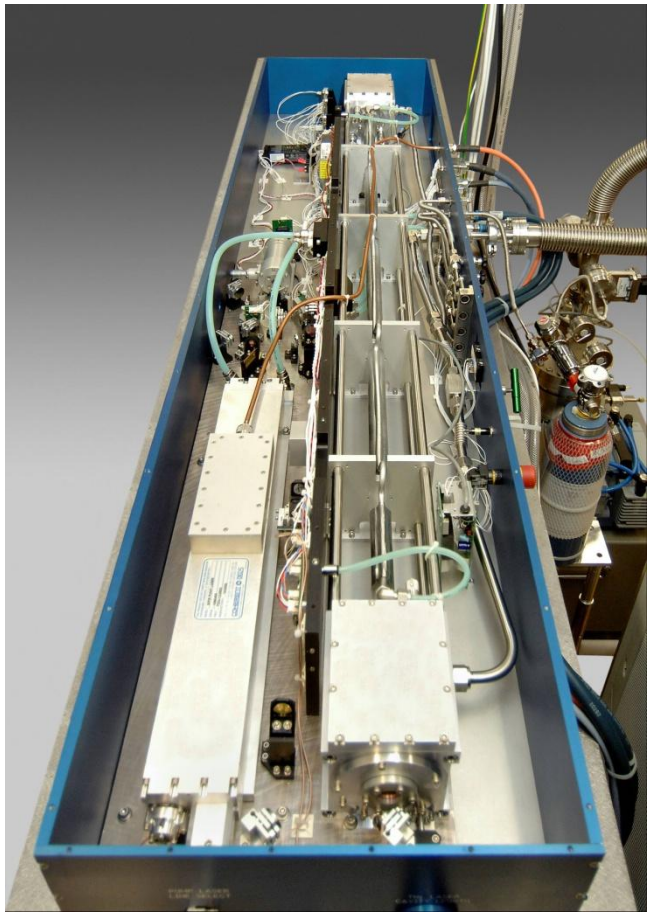
a FIR molecular gas laser operated cw



- optically pumped by a grating tuned CO_2 laser
- CO_2 laser frequency stabilized
- molecular lines in different gases CH_2OH, CH_2F_2 at low pressures
- THz resonator with a hole oc
  spectral range: 1 THz – 5 THz
- stable output: >5 mW

THz Laser to Cover the Range: 1 THz to 5 THz

Now extended to 700 GHz

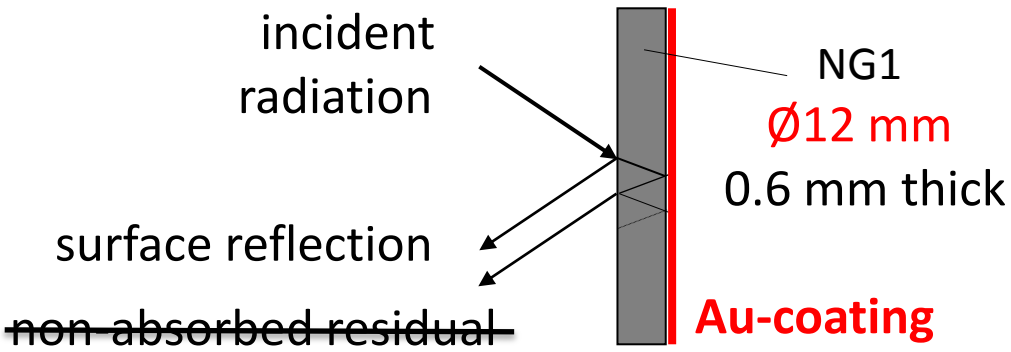


- optically pumped by a grating tuned CO_2 laser
- CO_2 laser frequency stabilized
- molecular lines in different gases CH_2OH, CH_2F_2, and **HCOOH**
- THz resonator with a hole oc
  spectral range: 1 THz – 5 THz
- stable output: >5 mW

THz Standard Detector of PTB

THz Absorber in the range 1 THz – 5 THz

- special NG1 optical glass from SCHOTT (neutral density filter)
- optically polished surface, back side: Au coating



- sufficient absorption for THz frequencies > 0.7 THz
- only radiation losses due to surface reflections

THz Standard Detector of PTB

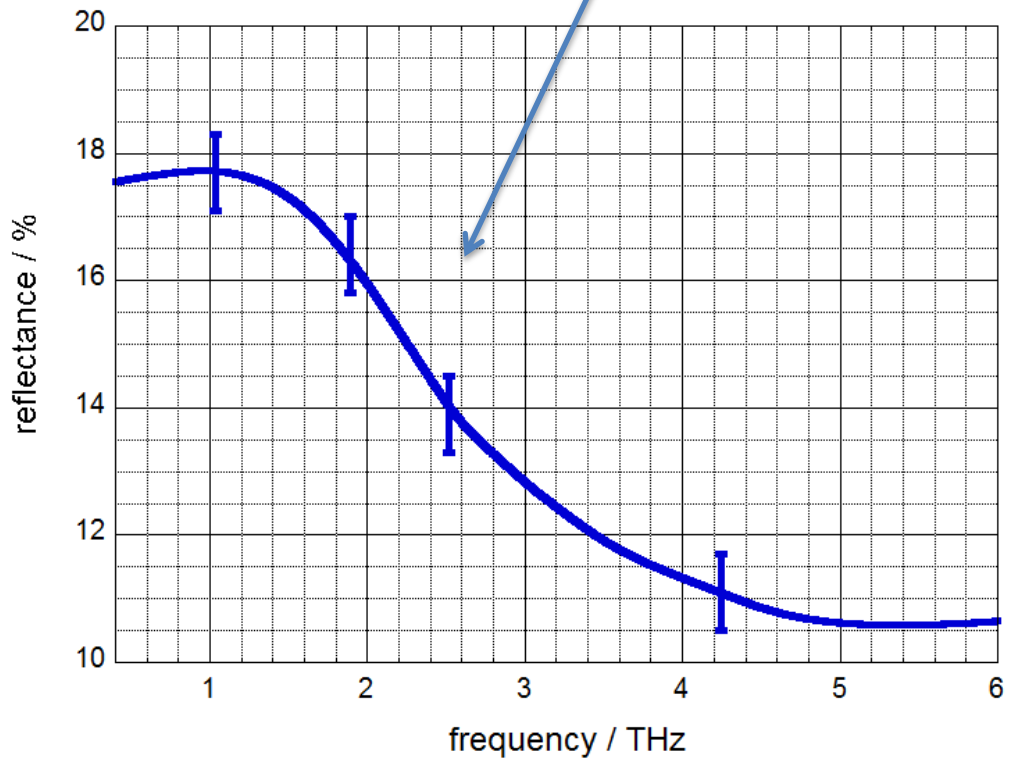
THz Absorber in the range 1 THz – 5 THz

- special NG1 optical glass from SCHOTT (neutral density filter)
- optically polished surface, back side: Au coating
- mounted inside a thermopile:
  model 3A-P from Ophir Optronics
- calibrated at HeNe laser frequency
  with low uncertainty
- only different surface reflections
- model: $s(\nu) = s_{HeNe} \times \frac{1 - R_{HeNe}}{1 - R(\nu)}$

THz Standard Detector of PTB

THz Absorber in the range 1 THz – 5 THz

$$s(\nu) = s_{HeNe} \times \frac{1 - R_{HeNe}}{1 - R(\nu)}$$



THz Detector Calibration Service of PTB

no other NMI can offer this kind of services

- traceable to the International System of Units SI
- spectral responsivity with respect to THz radiant power
- spectral range: 1 THz – 5 THz, now extended to 700 GHz
- standard uncertainty: < 2 %
- offered worldwide to customers by
- for suitable THz detectors

Requirements of Calibratable THz Detectors

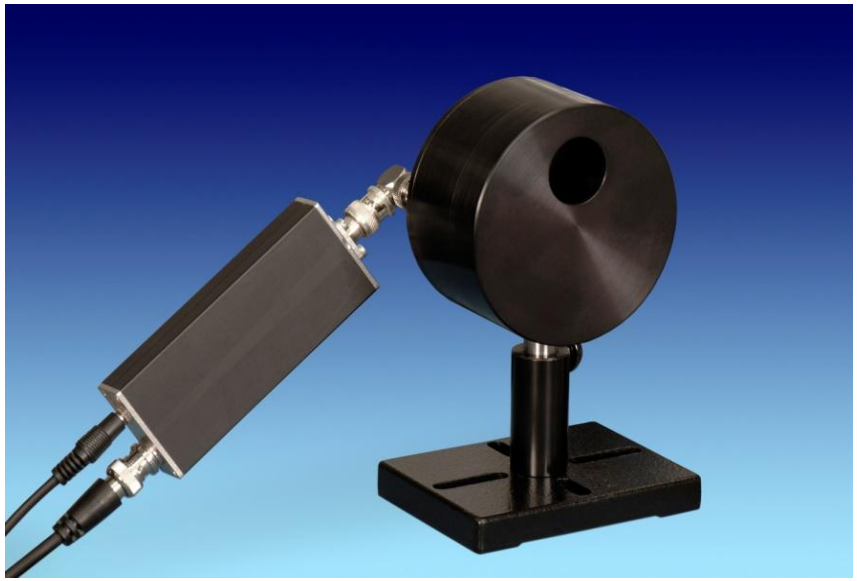
shortcomings of commercial THz detectors

- large sensitive area: > 4 mm in diameter
- homogeneous responsivity: spatial variation < 3 %
- high and linear responsivity: NL < 2 %
- sufficiently fast time response: < 2 s
- known spectral variation: spectrally flat response preferred
- no specular back reflection to the laser: no standing waves
- no polarization dependence even if the detector has to be turned out of normal position to avoid interference

THz Detector Development

in cooperation with *Sensor- und Lasertechnik* Co.

- first result: THz radiation trap detector



- inside: 5 absorptions by 3 sensor elements
- patented 3D-design
- polarization-independent responsivity
- special back paint with CNT

- drawback: difficult to manufacture, works only above 1 THz

Result of THz Detector Development

novel pyroelectric thin film THz detector

- special feature: pyroelectric thin film absorbs by itself

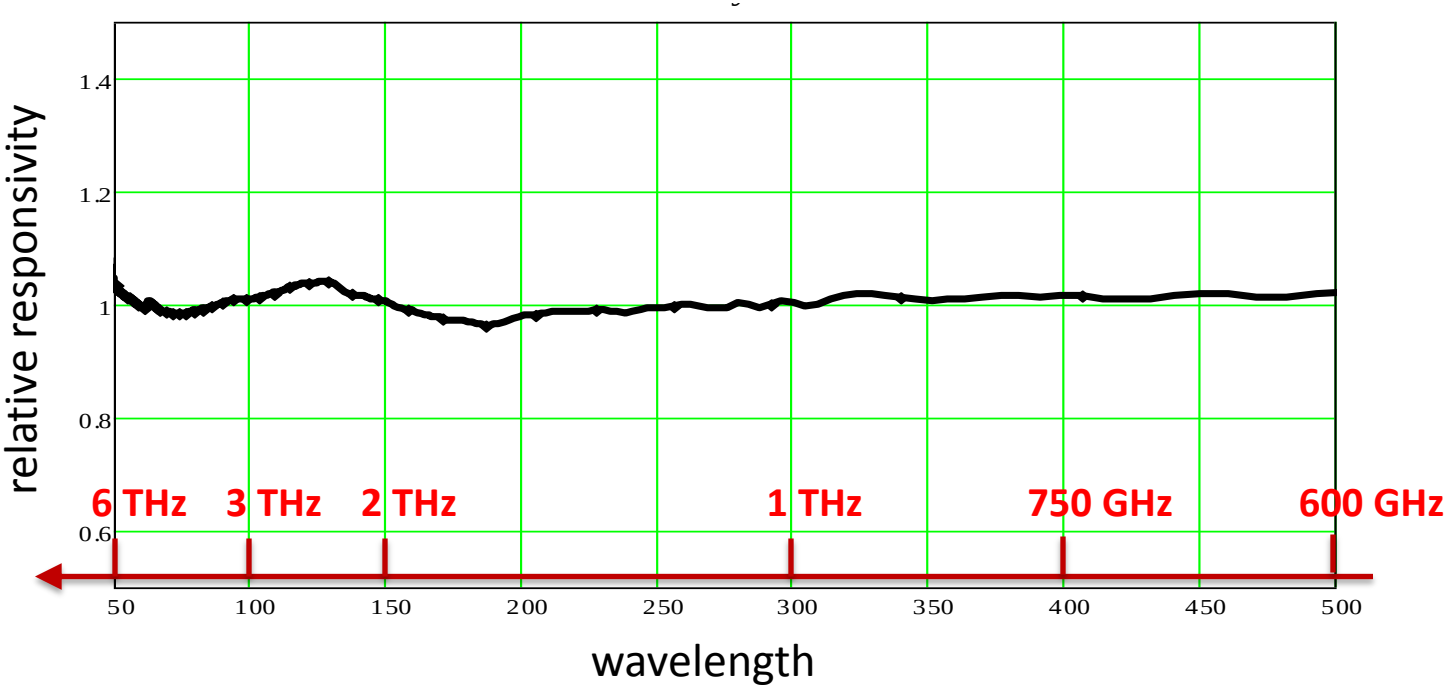
- no additional absorber coating
- based on a thin PVDF-foil
- conductive layers on both sides
- layers made from metal-oxide
- layer thickness adjusted to get 50 % absorbance

- large sensitive diameter < 30 mm, fast rise time <1 ms

Novel Pyroelectric Thin Film THz Detector

spectral uniformity in the THz range

- measured absorptivity yields a flat spectral response

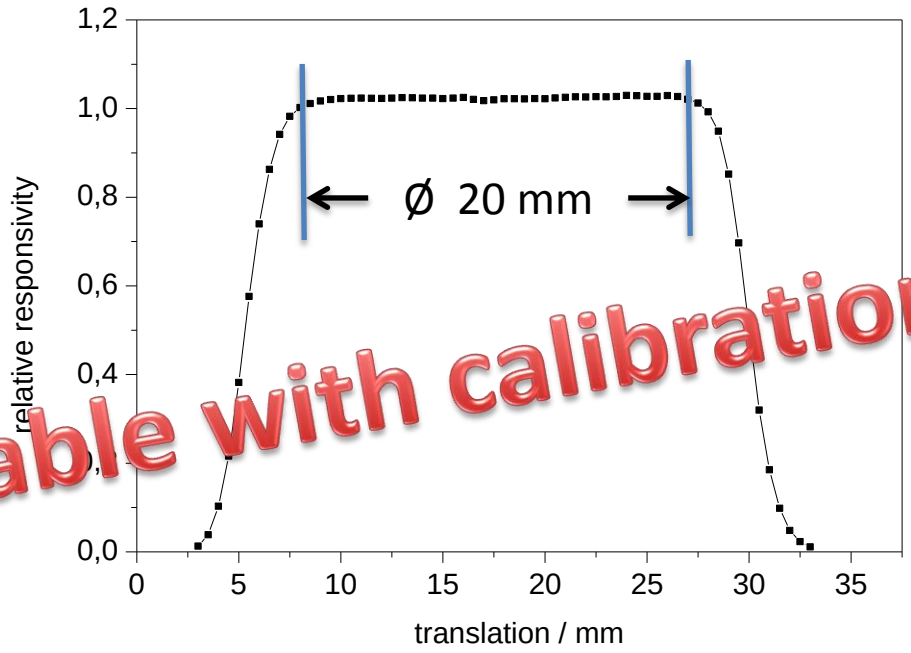


- no spectral absorption features due to the thin PVDF foil

Novel Pyroelectric Thin Film THz Detector

spatial uniformity in the THz range

- measured with a small focus of the THz laser

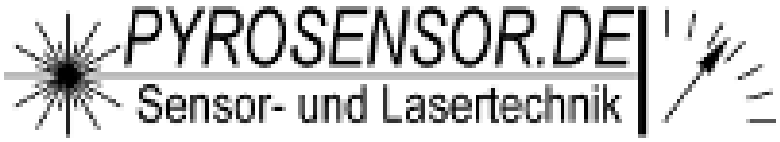


Available with calibration by PTB

- almost perfect spatial homogeneity across the sensitive area

Acknowledgement

- commercial partner



- public funding organisations

Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

Abbestr. 2-12
D-10587 Berlin

Dr. Andreas Steiger
Working group: Terahertz Radiometry

phone: 030 3481-7532
E-Mail: andreas.steiger@ptb.de
www.ptb.de