

NEAR-Lab

Northwest Electromagnetics &  
Acoustics Research

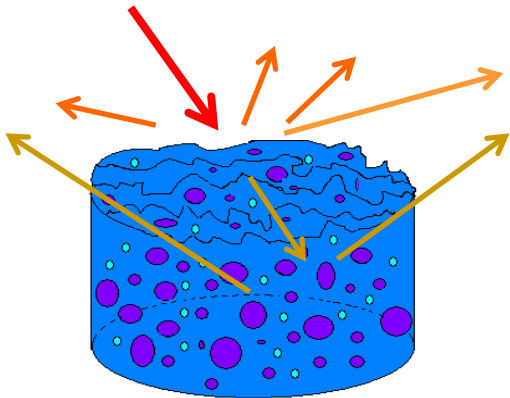
# THz Detection of Explosives & Drugs

Detection of illicit substances is promising due to strong spectral signatures observed for pure samples of many explosives and drugs.

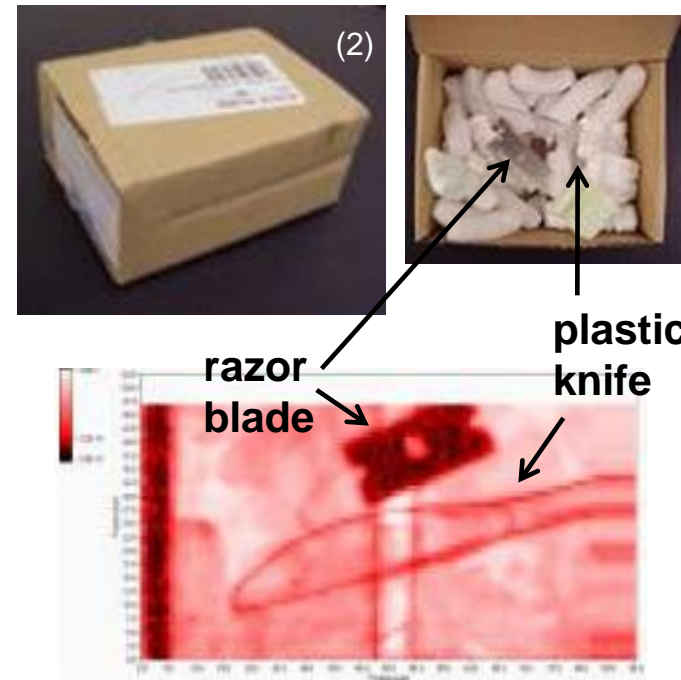
Opacity of these substances requires reflection or scattering geometry for practical screening applications

Spectral signatures are modified by scattering physics:

- rough surface scattering
- scattering from granular particles in the media

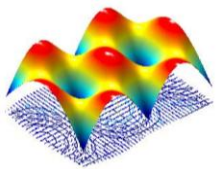


**Approach: combined experimental and theoretical investigation of robust reflection/scattering imaging techniques**



(1) Sheet of simulated explosive (MMW image from Kemp [2006], *Proc. SPIE* 6402)

(2) [http://picometrix.com/pico\\_products/terahertz\\_app\\_exam.asp](http://picometrix.com/pico_products/terahertz_app_exam.asp)

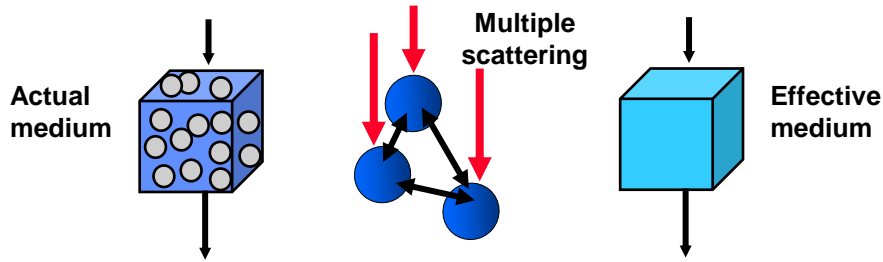


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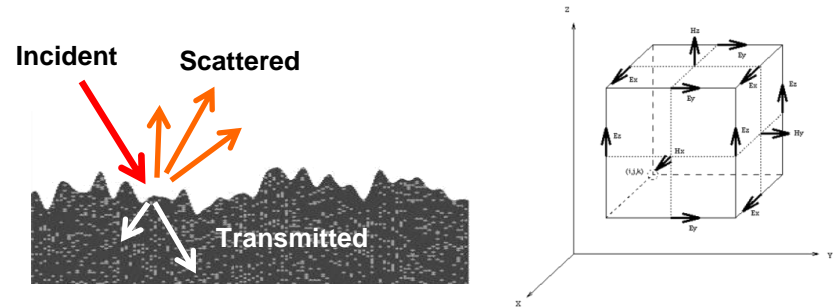
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# NEAR-Lab Scattering Models

## Volume Scattering (Analytic) Quasi-Crystalline Approximation

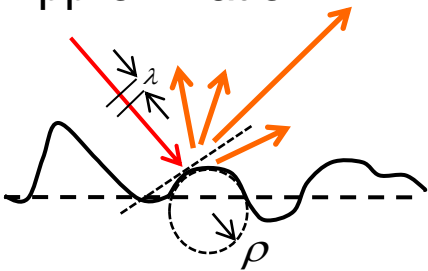


## Volume & Surface Scattering (Numeric) Finite Difference Time Domain (FDTD)

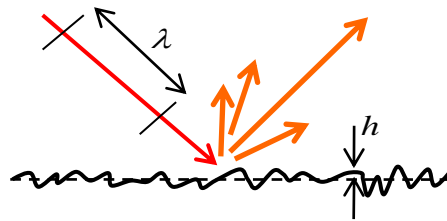


## Surface Scattering (Analytic)

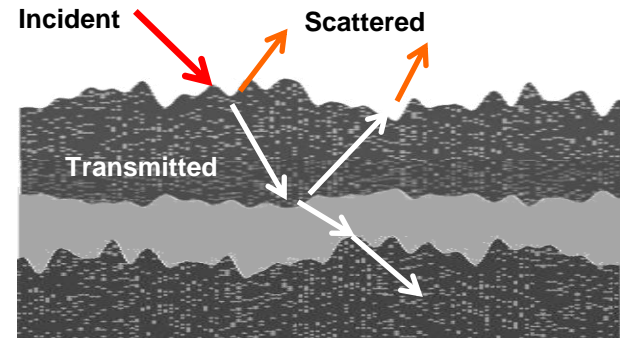
Kirchhoff  
Approximation

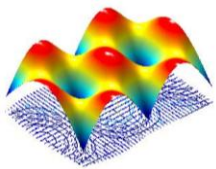


Small Perturbation  
Method



## Layered Media Radiative Transfer

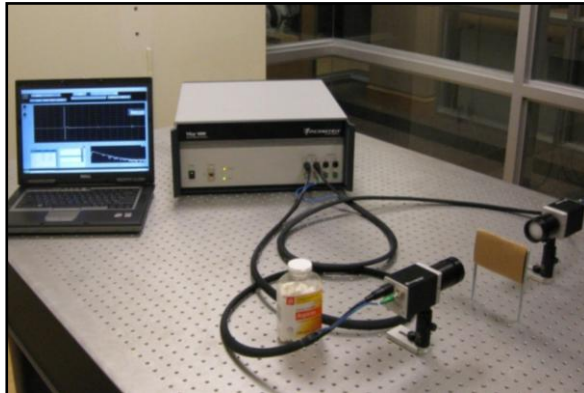




# NEAR-Lab Measurement Capability

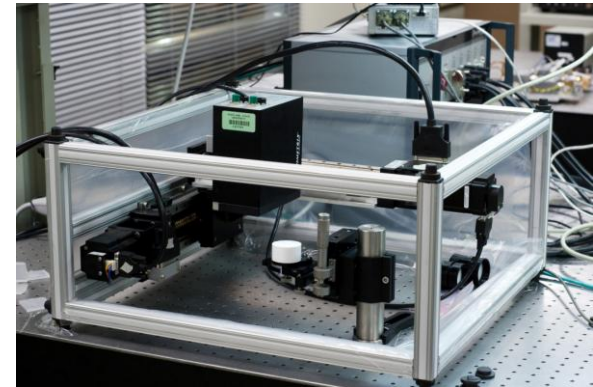
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## Pulsed THz Spectrometer



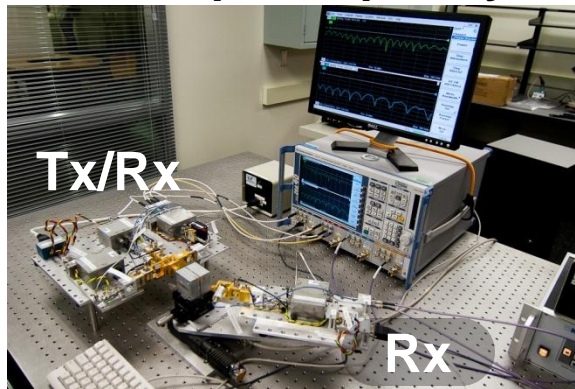
Angle & polarization diversity

## Pulsed THz Imaging System

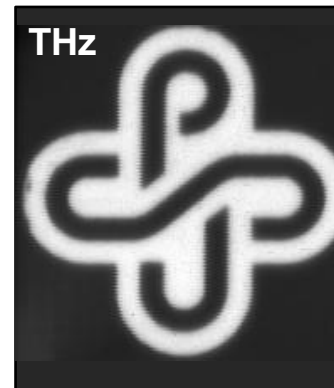


8" x 8" 2D scanning

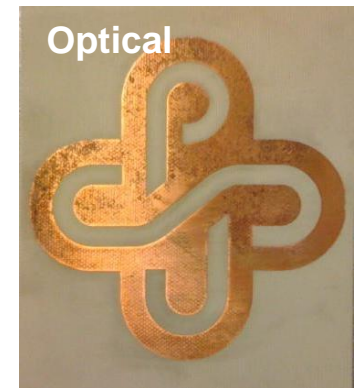
## CW Swept Frequency



Two port s-parameter measurements  
0.045 – 0.780 THz

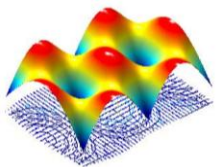


— 1 cm



— 1 cm





# Rough Surface Samples

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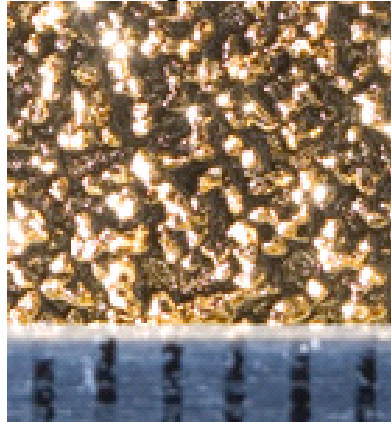
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## Gold-coated sandpaper samples

P40 grit



P80 grit

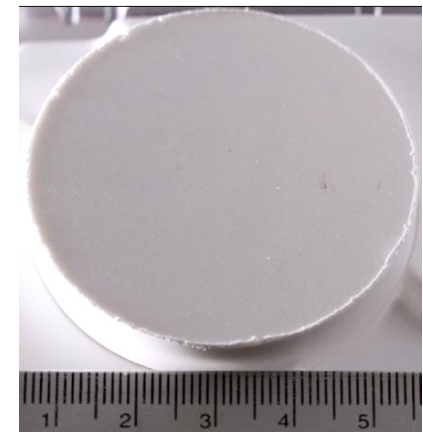


## 80% Lactose (20% PTFE<sup>1</sup>) samples

P40 grit



Smooth



Commercially produced sandpaper used for controlled surface roughness

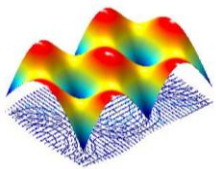
- Gold-coated samples (perfect conductor)
- Explosive simulants (lactose, L-tartaric acid, sucrose) pellets with surface impressions<sup>2</sup>
- Grit size inversely related to roughness; Gaussian rms height  $h$  and correlation length  $L_c$

Sandpaper <sup>3</sup>	$h$ ( $\mu\text{m}$ )	$L_c$ ( $\mu\text{m}$ )
36	191	315
40	132	343
60	78	203
80	55	151
120	21	161

(1) PTFE (DuPont Teflon® 7C) powder was used as an inert pressed binder matrix

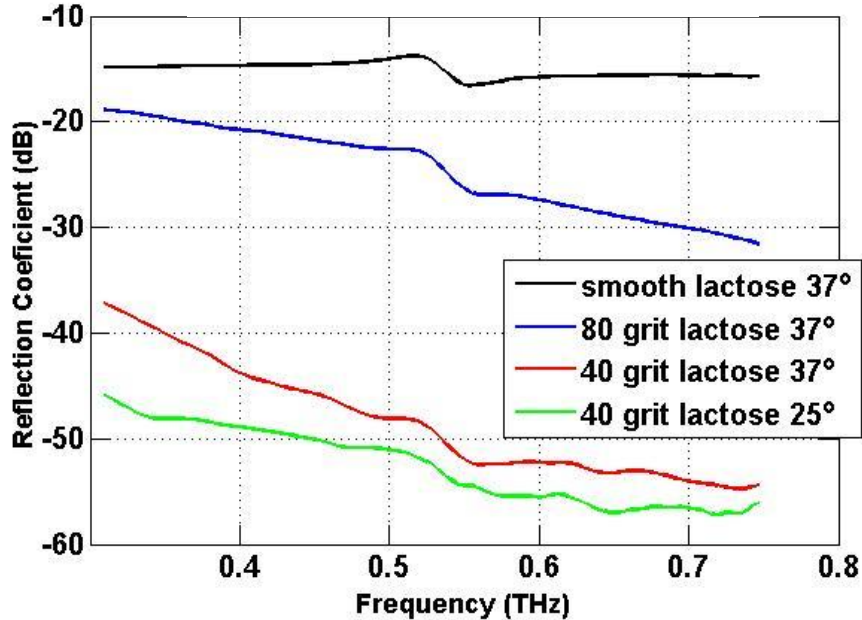
(2) Simulant samples prepared courtesy of John Wilkinson, as part of NATO SET-124 Research Task Group

(3) Pederson et al., Measurement of Rough Surface Spectroscopy, IEEE Ultrasonics Symposium, 1997

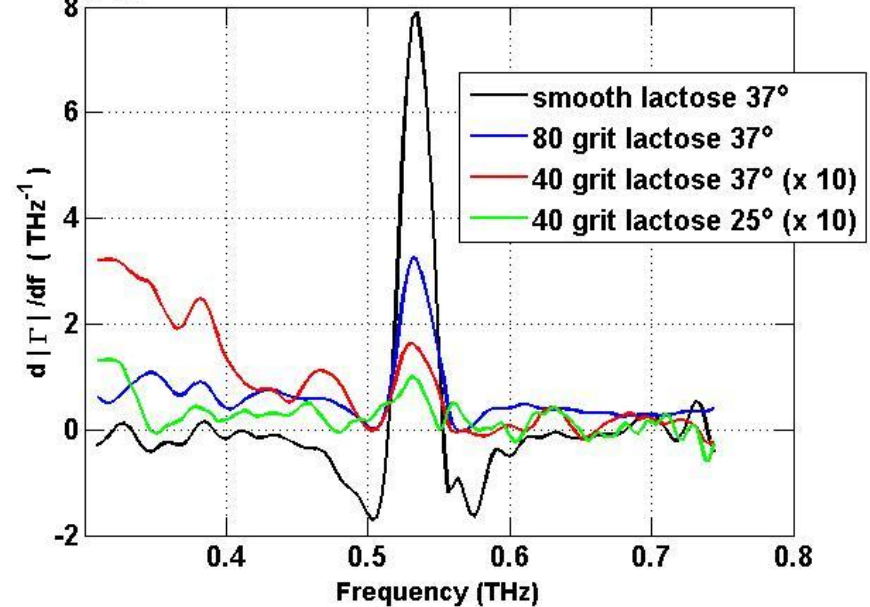


# Lactose Identification from Rough Surface Scattering

## Deconvolved Reflection



## Derivative Signatures



- Scattering complicates signature
  - Introduces roughness-dependent frequency dependence
  - May introduce spurious peaks (without sufficient averaging)
- Material peaks present in both spectral and diffuse signatures – **provided sufficient SNR exists**

