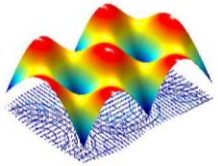


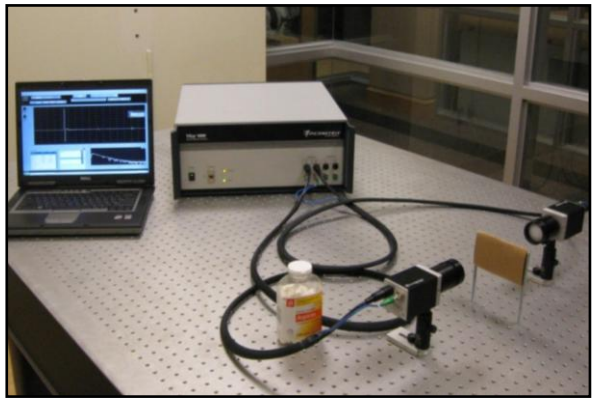


# THz Synthetic Aperture Slides

# NEAR-Lab Imaging Capability

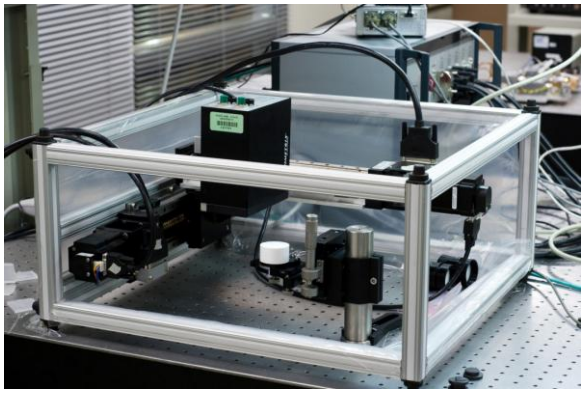
NEAR-Lab
Northwest Electromagnetics & Acoustics Research

## Pulsed THz Spectrometer



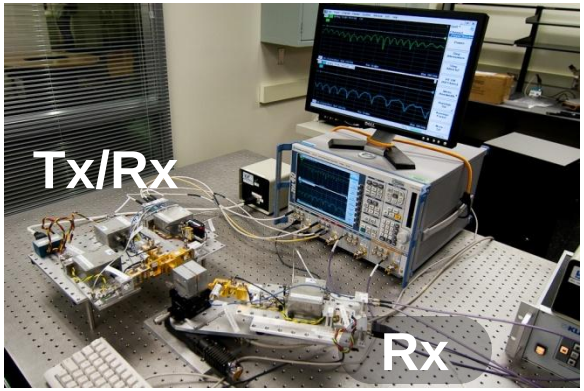
Angle & polarization diversity

## Pulsed THz Imaging System



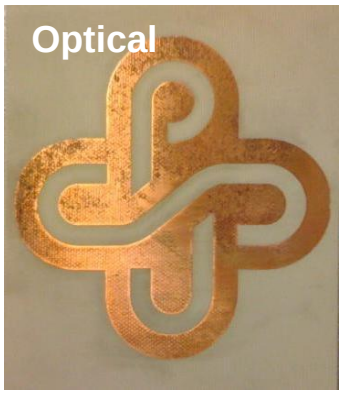
8” x 8” 2D scanning

## CW Swept Frequency




Two port s-parameter measurements
0.045 – 0.780 THz


1 cm




1 cm



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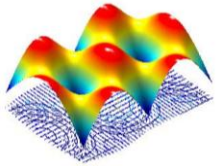




# Processing Approaches for 3D THz Spectroscopy

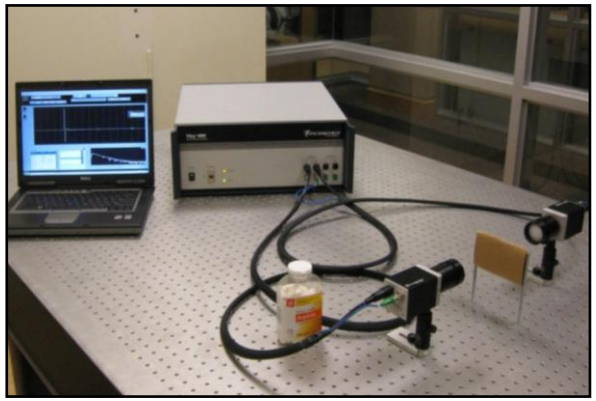
| | Optical Lens | Time-gating | Synthetic aperture processing |
|---|---|---|---|
| Advantages | Optical focus determined by lens (good depth resolution) | Ability to produce multiple images/depths from sensor data* | Ability to produce multiple images/depths from sensor data*; coherent gain from sensor combination |
| Disadvantages | Requires mechanical scanning for multiple depths | Reduces spectral resolution; material properties (phase speed) must be known or assumed | Complexity; material properties (phase speed) must be known or assumed |

*Can scan in x-y to produce 2D image data

# NEAR-Lab Measurement Capability

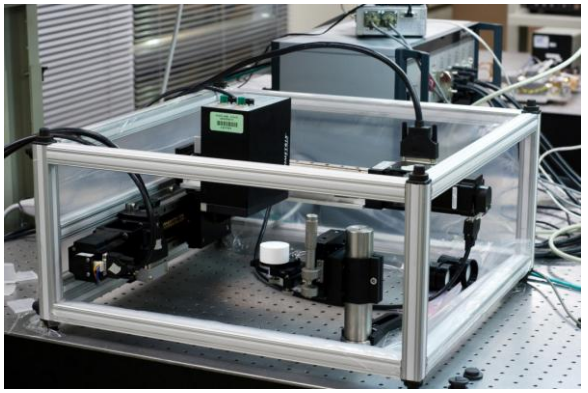
NEAR-Lab
Northwest Electromagnetics & Acoustics Research

## Pulsed THz Spectrometer



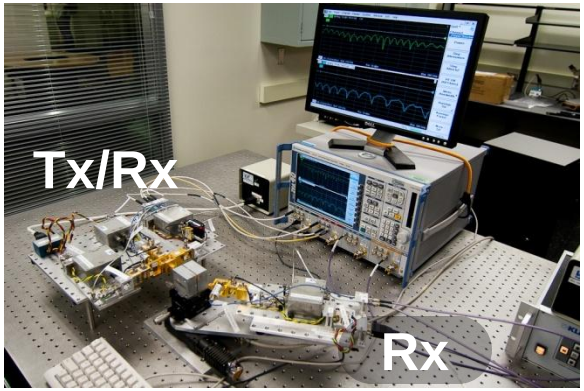
Angle & polarization diversity

## Pulsed THz Imaging System



8” x 8” 2D scanning

## CW Swept Frequency




Two port s-parameter measurements
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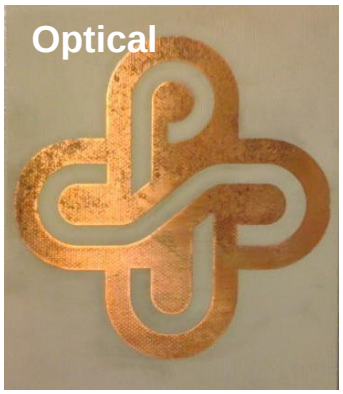
1 cm




1 cm



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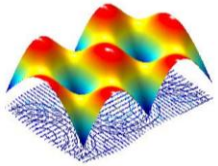
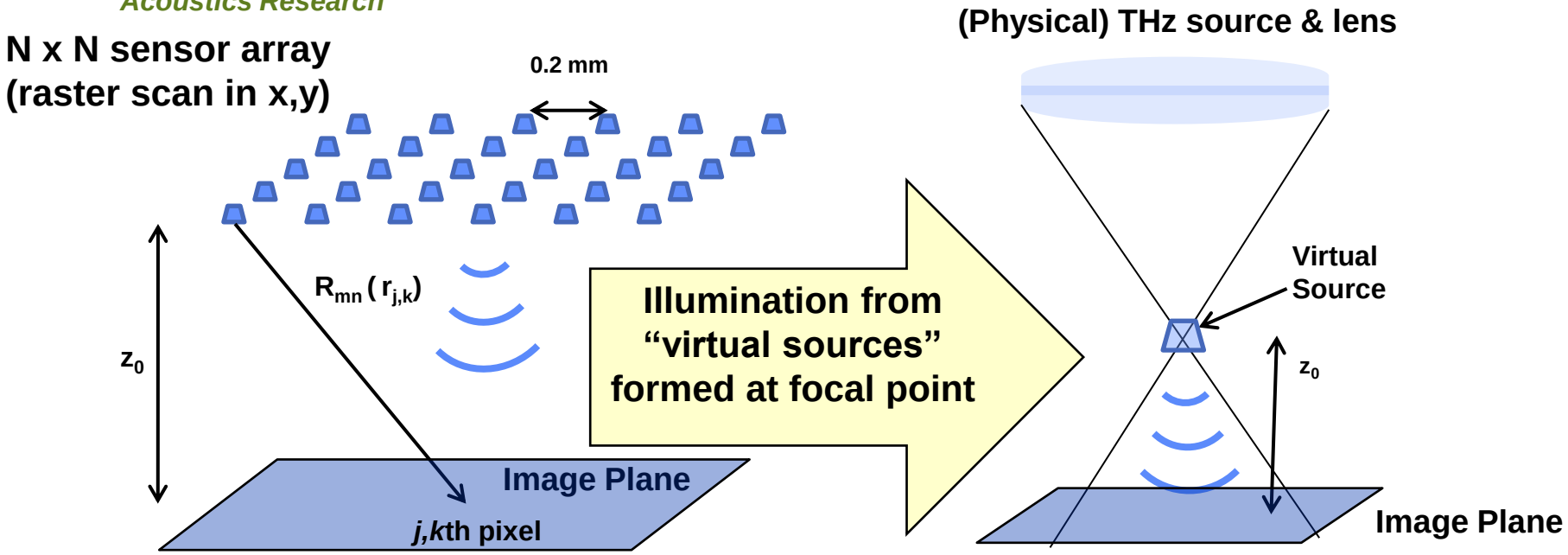




# Synthetic Aperture Processing using a Virtual Image Source

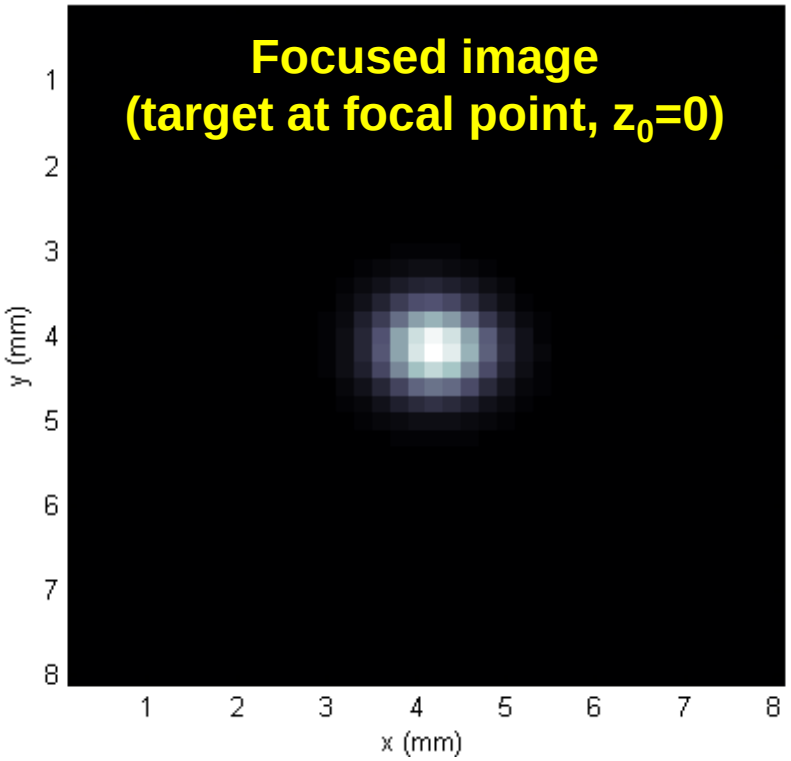


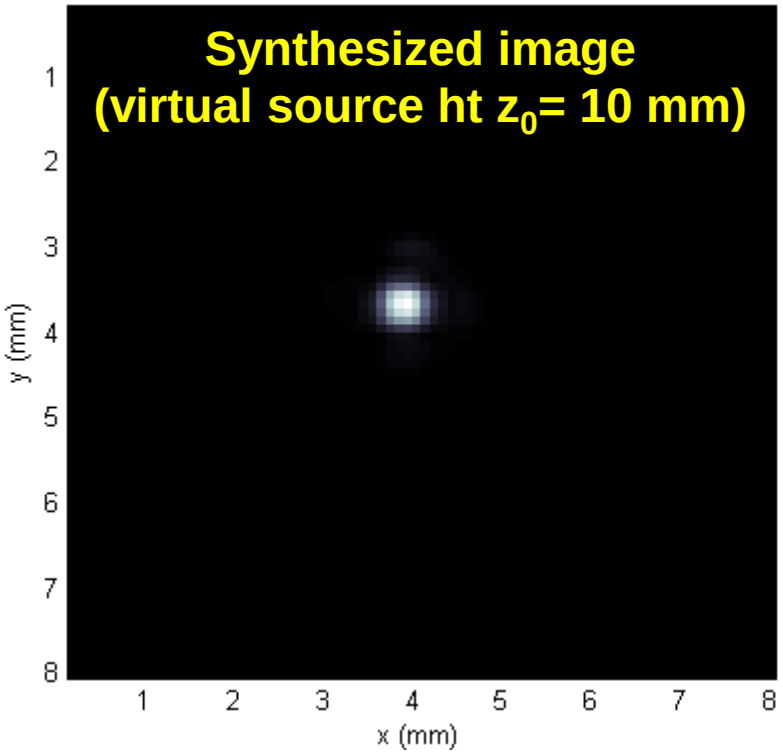

Synthesize image at $z_0$ using coherent addition of sensors:

$$\left| \sum_{m=1}^{N} \sum_{n=1}^{N} E(x_n, y_m, f) \quad F_{mn}(r_{jk}) \quad e^{-2ik_0 R_{mn}(r_{jk})} \right|^2$$

where $F_{mn}$ is a tapering window, and $R_{mn}$ depends on choice of $z_0$

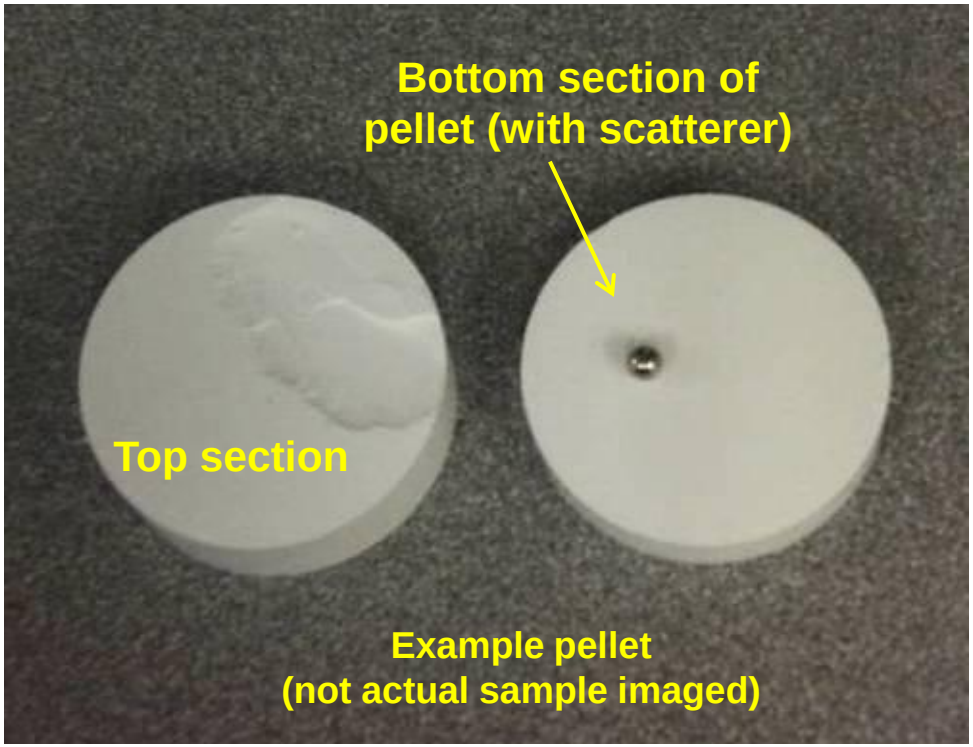
# Synthetic Aperture Image Single Ball Bearing (Target)

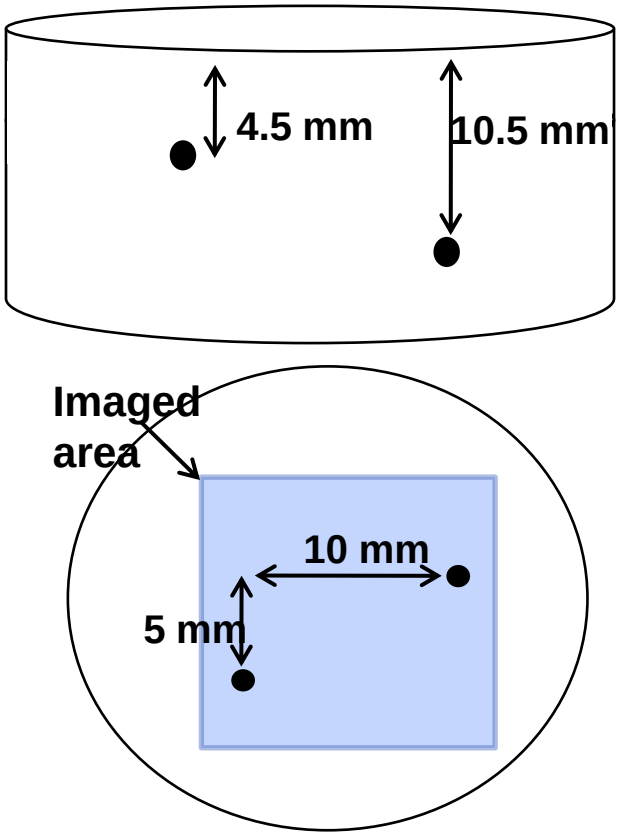



- **Image of single steel ball-bearing (3.9 mm)**
  - **Synthesized image has better resolution achieved from coherent gain (multiple sensor combination)**
  - **Synthesis is depth dependent (image at $z_0$ = 10 mm)**

# Pellet with Embedded Scatterers



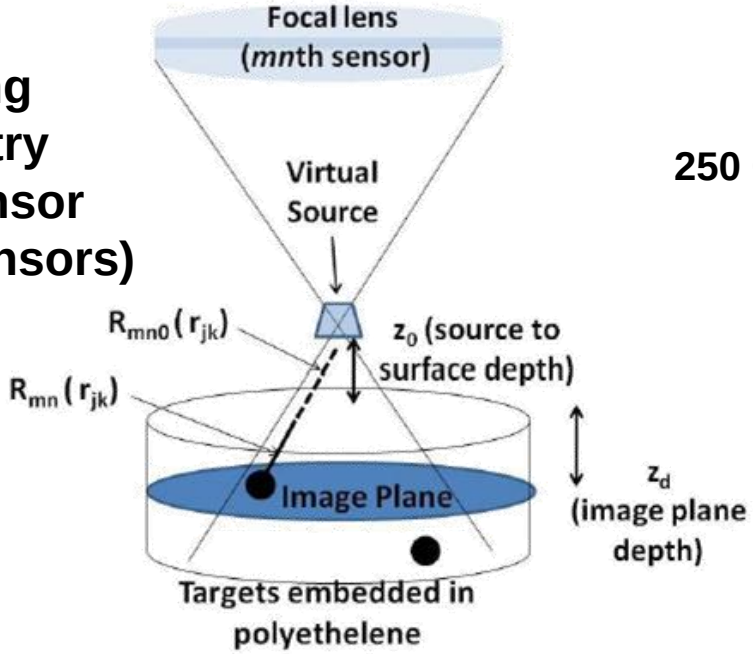




- Two ball bearings (3.9 mm) embedded in polyethylene (PE) pellet
  - Targets offset in depth and lateral position
  - Imaging equation adjusted for phase introduced with PE

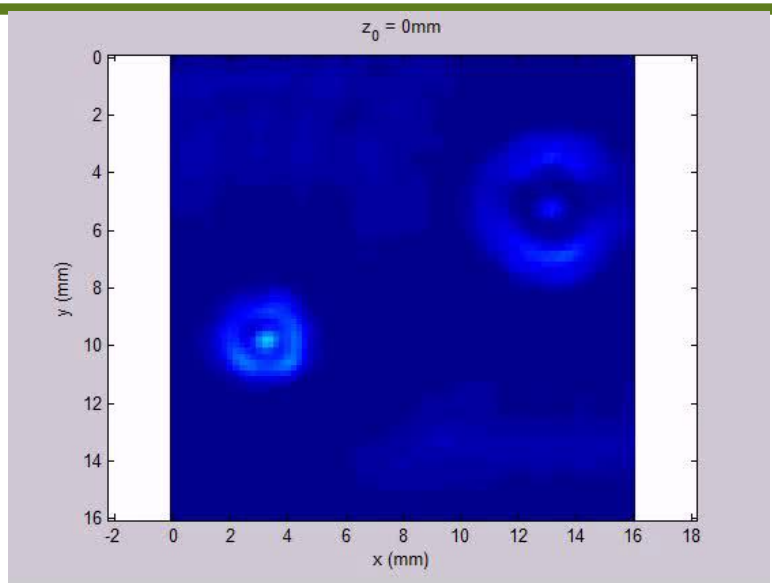
# Depth-Dependent Images using Synthetic Aperture Processing



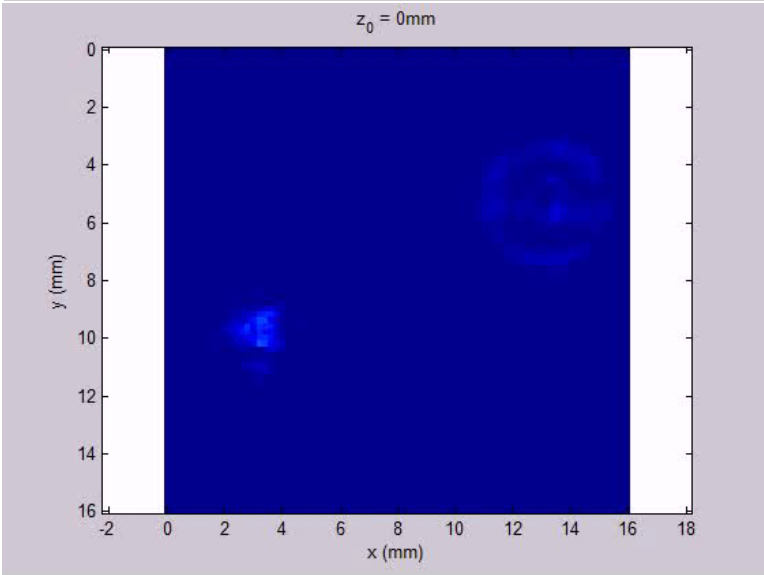
**Imaging geometry *mn*th sensor (50 x 50 sensors)**




250 GHz




500 GHz




- **Movies show images formed at progressive depths $z_d$**
- **Depth resolution proportional to wavelength (get's better with higher frequency)**



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