ALERT: Awareness and Localization of Explosives-Related Threats

Northeastern University | Boston University | Rensselaer | UMR University of Missouri-Rolla | Texas Tech University | Washington State University

Resilient Personnel Surveillance & Threat Detection using Fused, Layered, Orthogonal Systems

Carey Rappaport
Northeastern University
Boston, MA

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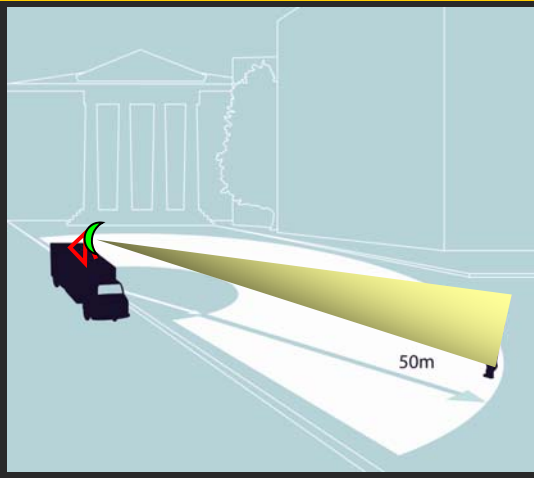
Outline

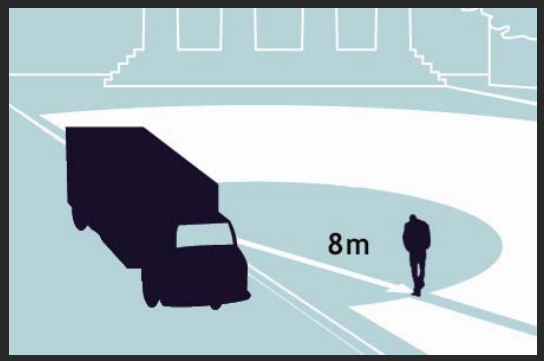
- Threat detection regimes
- Research thrust division
- Distant & Mid-range detection approaches
- Intimately near imaging

Detection Regimes

- Distant targets (10 m to >100 m),
  - Stand-off detection of hazards
  - Far enough away to minimize threat

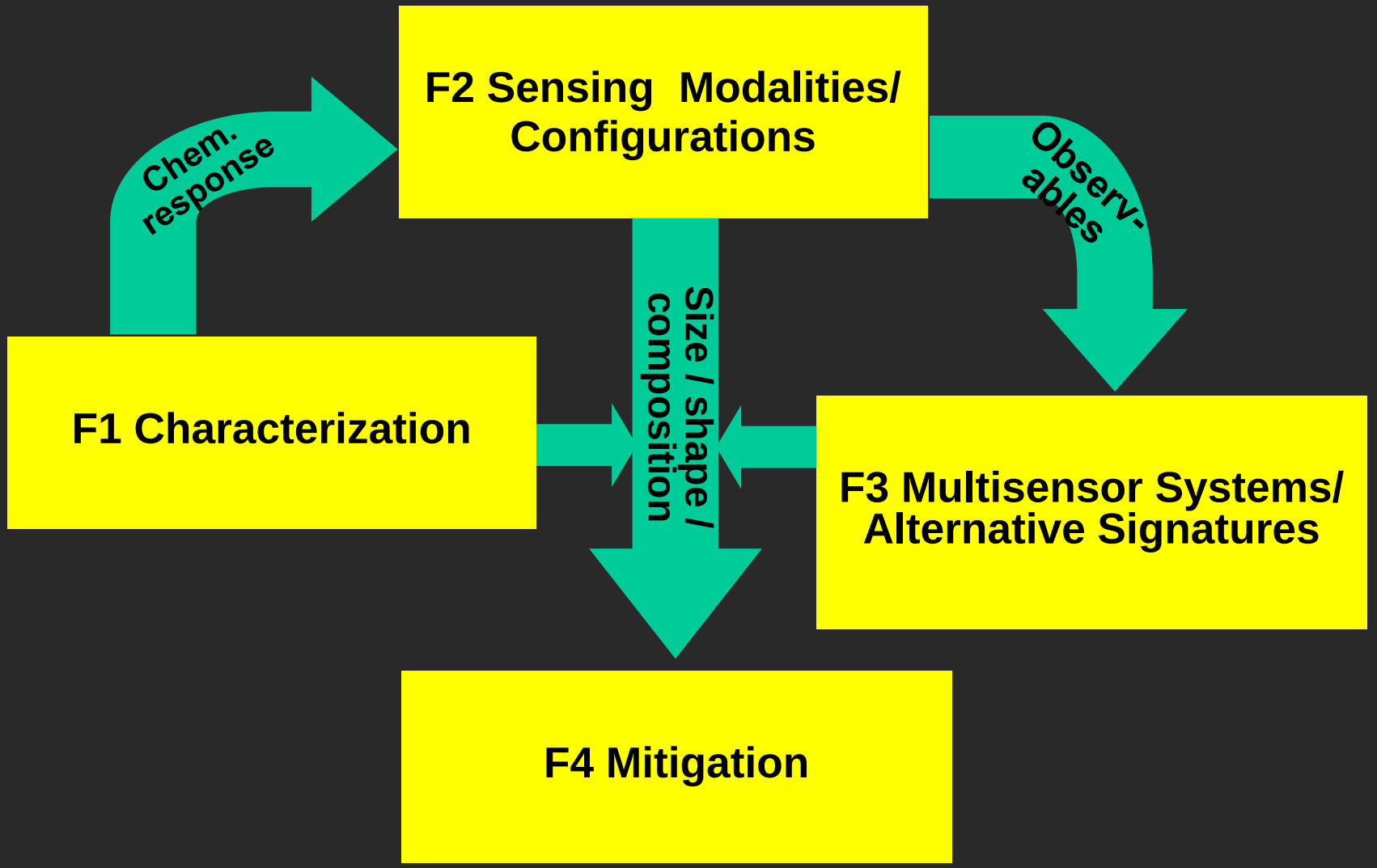


- Mid-range targets (3 to 10m)
  - Enhanced sensing discrimination
  - Not explicitly surrounding target



- Intimately near targets (< 3 m)
  - Non-invasively examined
  - Mostly portal sensors

Sensing Thrust Relates to Other Thrusts



Coordination both across discipline and among thrusts is essential

Detecting and Identifying Explosives

- Sense within hidden / concealed / shielded / non-stationary environments
- Imaging to detect suspicious shapes (video, X-ray)
- Wave-based imaging to detect suspicious shapes (THz, mm-wave radar, acoustics…NMR, video, X-ray)
- Chemical detection to identify suspicious materials (Mass Spec., Ion Mobility Spec., Gas Chrom., "Artificial Dog Nose")
- Material spectral response to characterize molecular structure (Hyperspectral, IR, UV, THz, NQR, LIBS)
- Device electronic response to identify wireless electronic triggers (EM emission sensing)

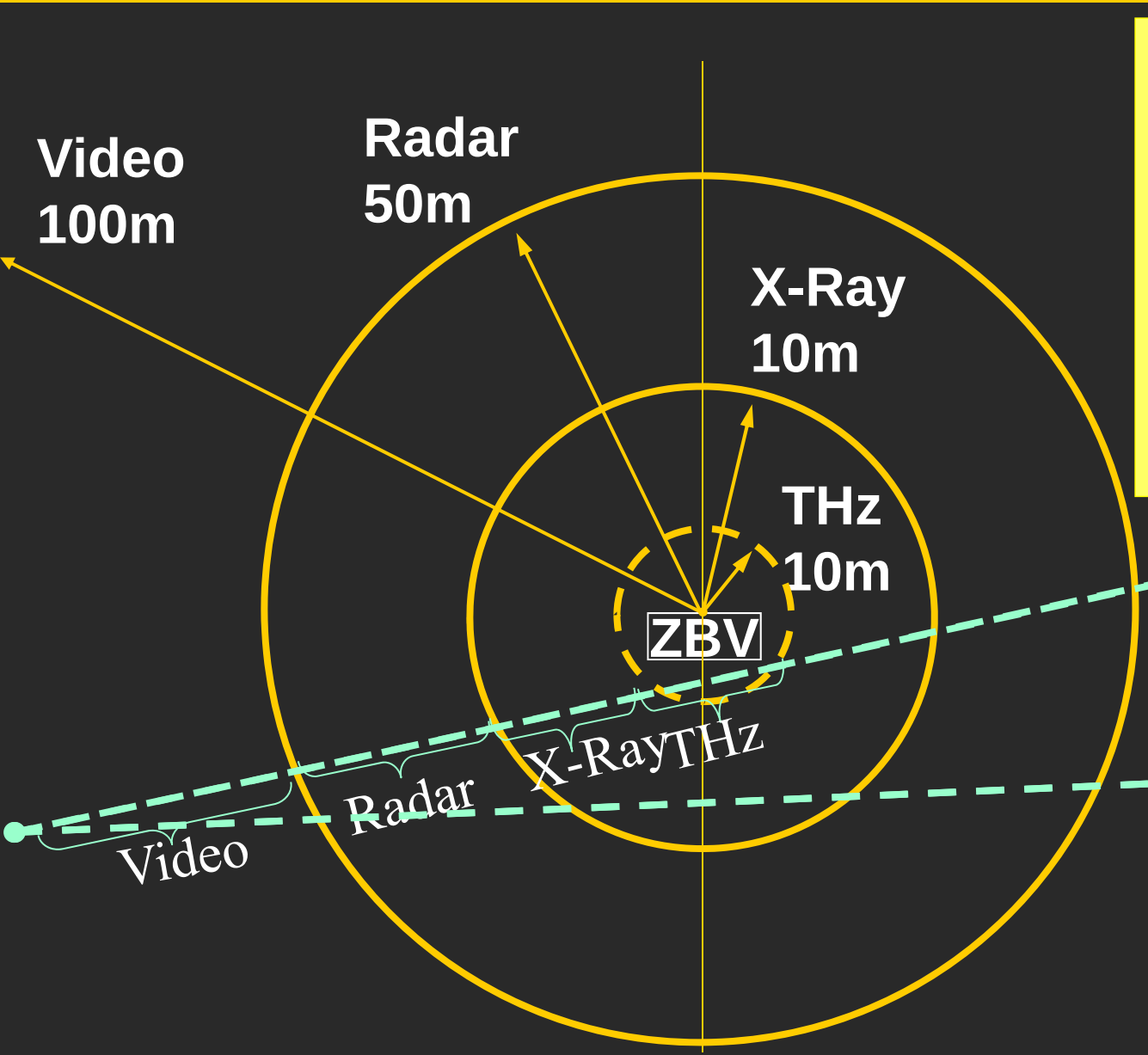
Standoff Explosives Detection

- Detect (not distinguish, not identify) potential explosive threats
  - Safely (eye safe, no ionizing radiation)
  - At standoff distance (>50m)
  - Under clothing
  - Without trace chemicals on clothing
  - Detect shape rather than composition
- Reasonable sensor array
  - Not too big
  - Not too expensive

Overall Suicide Bomber Detection Strategy

- Track individuals: identify suspicious movement (Video)
- Detect anomalies under clothing at distance (Radar)
- Image object under clothing at medium distance (X-Ray)
- Analyze chemical characteristics at medium distance (THz)

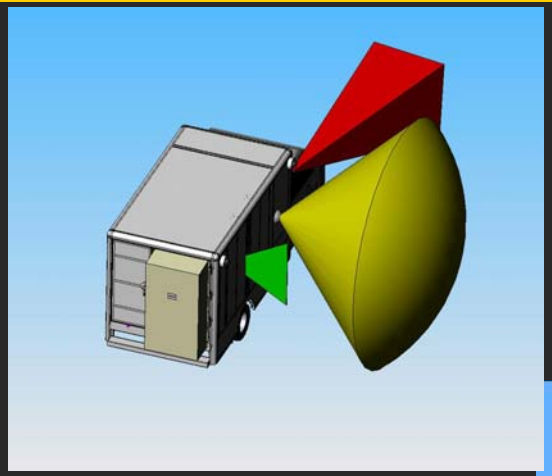
Basic Standoff Detection Geometry



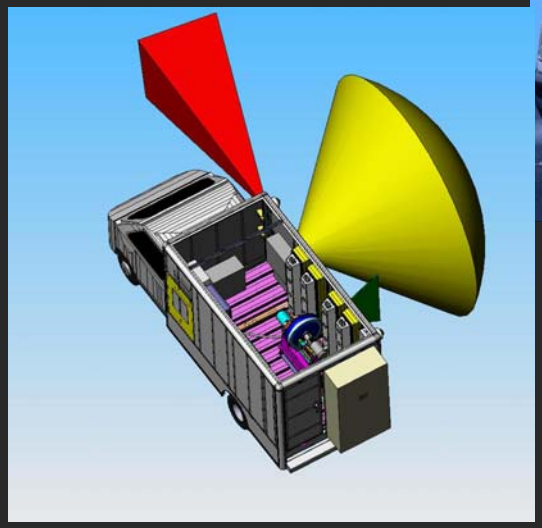
Layered detection within a single package:

- **Intelligent Video**
- **mm-wave Radar**
- **X-Ray Backscatter**
- **THz Spectroscopy**

Combined Layered Standoff Surveillance: AS&E Z-Backscatter Van Platform



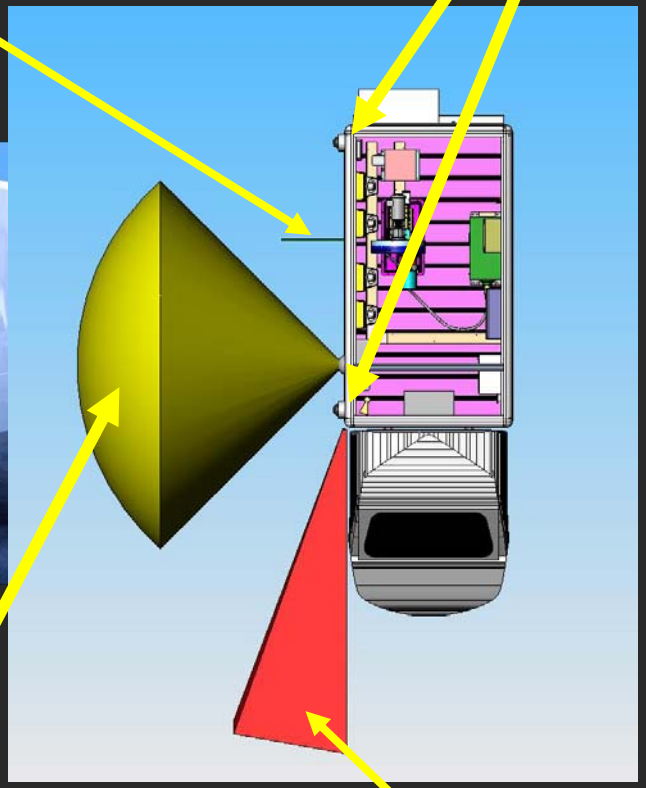
Side View



Top View

X-ray Beam

PTZ Cameras



Terahertz Beam

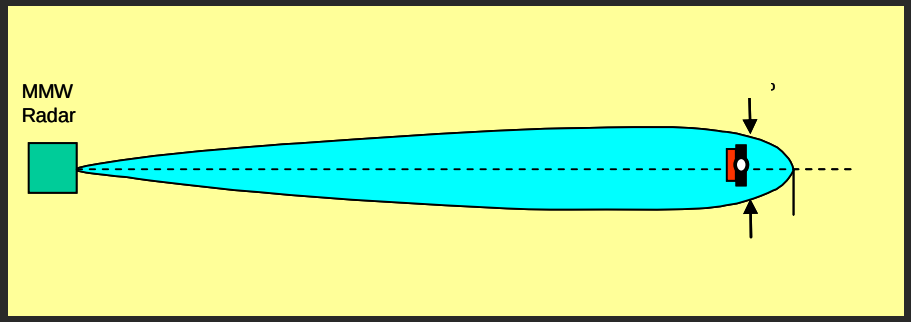
Radar Beam

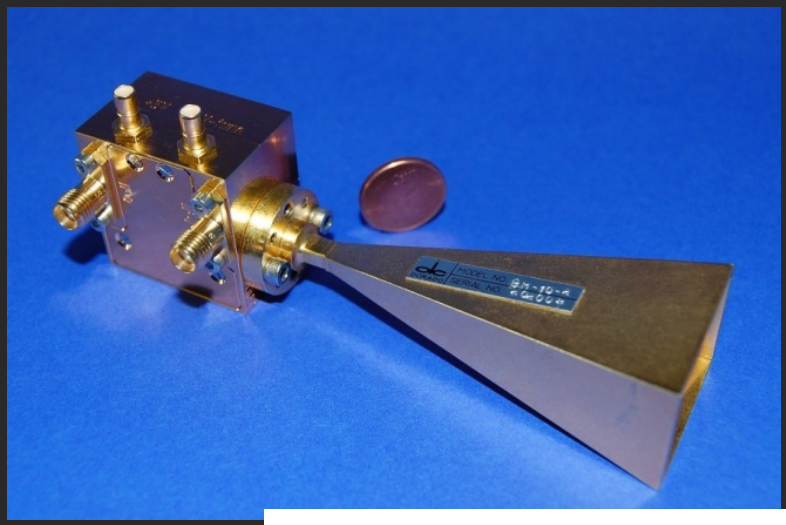
Intelligent Video: Siemens Corp. Research

SCR Technology: Automatically Detect and Track Individuals

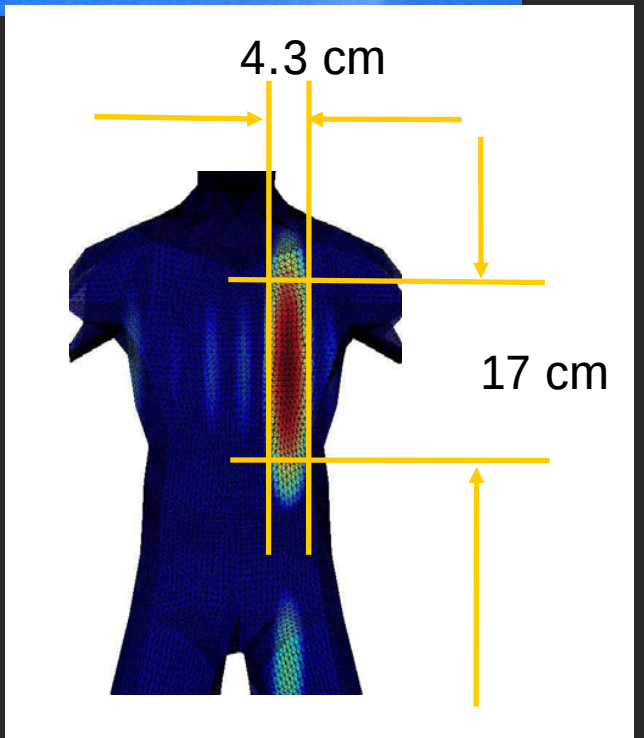
Millimeter Wave Radar Detection

- 50m range
- High resolution at 3 - 4mm wavelength

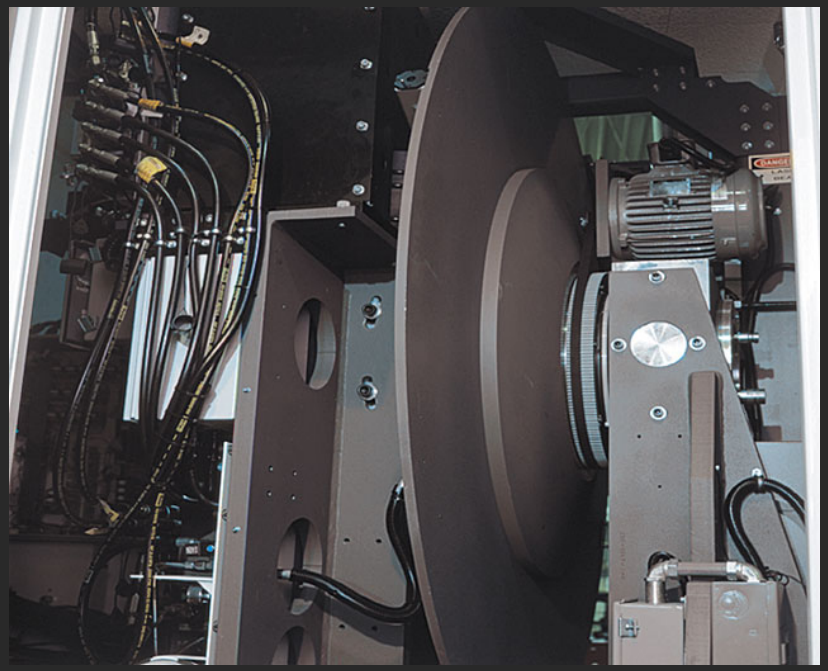




- Single human illumination
- Ave. width of person: 0.5m
- Beamwidth: 0.4 deg.
- Detect people / distinguish hazards through clothes



AS&E X-Ray Backscatter Detection



Chopper Wheel for Generating X-Ray Fan Beam

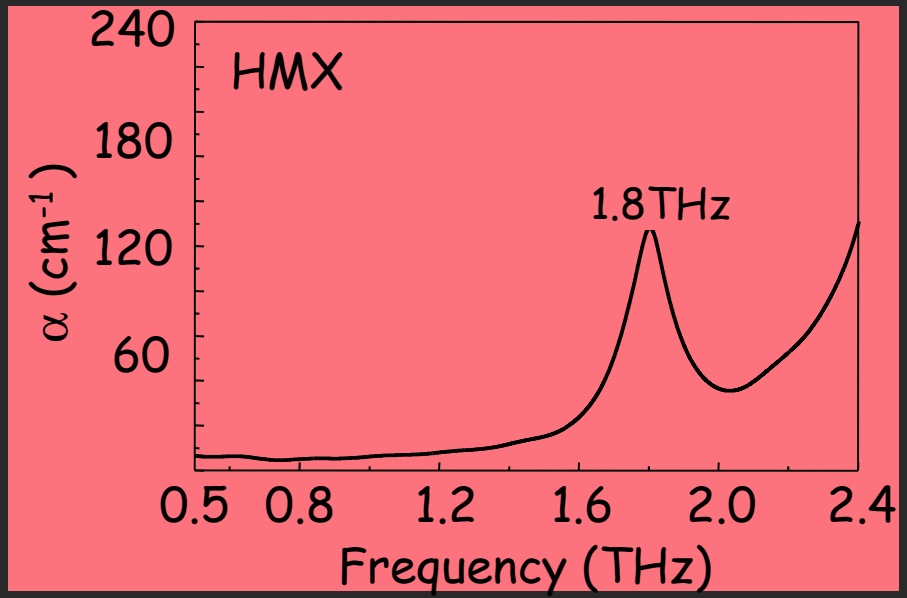
X-Ray Backscatter image Showing Organic / Inorganic Objects

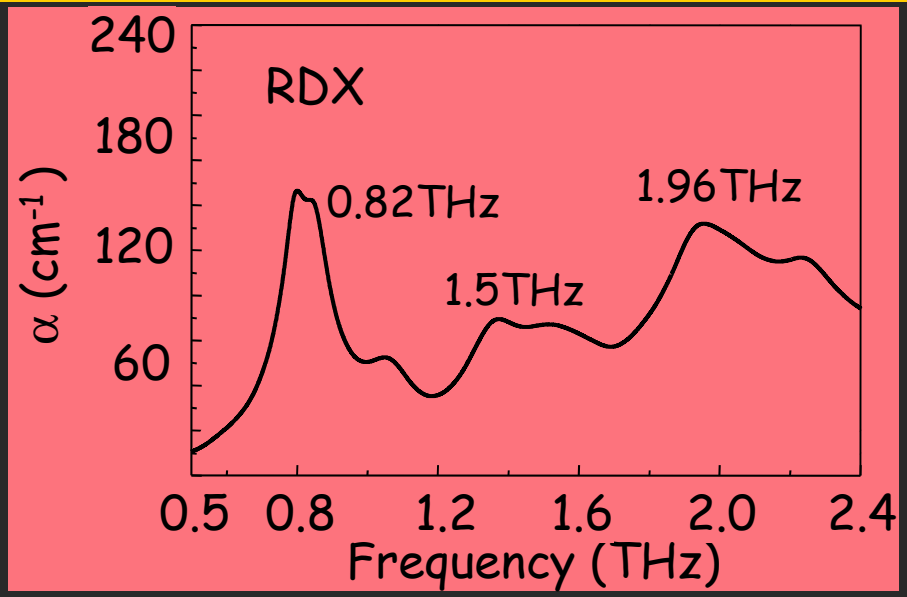
http://www.as-e.com/products_solutions/z_backscatter_transmission.asp

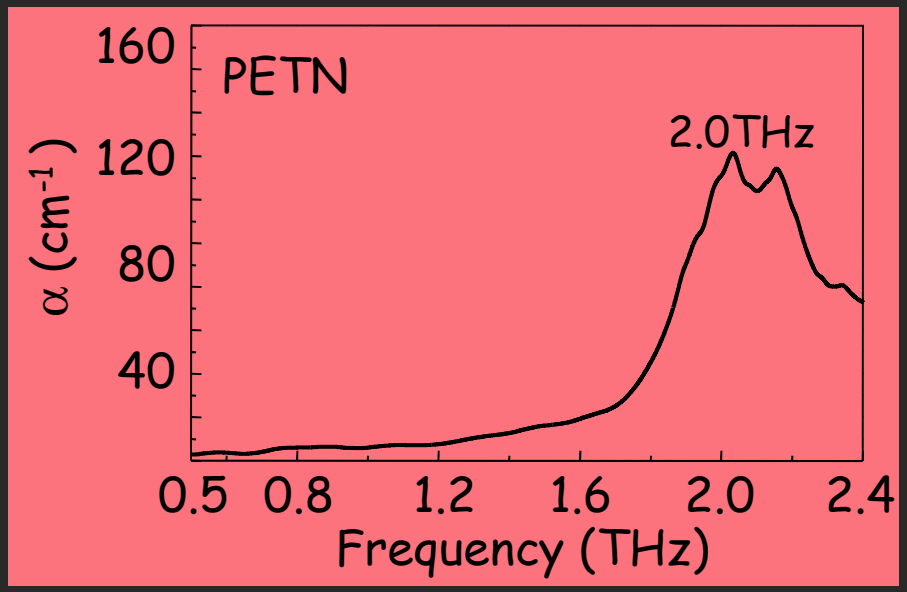
THz Spectroscopy

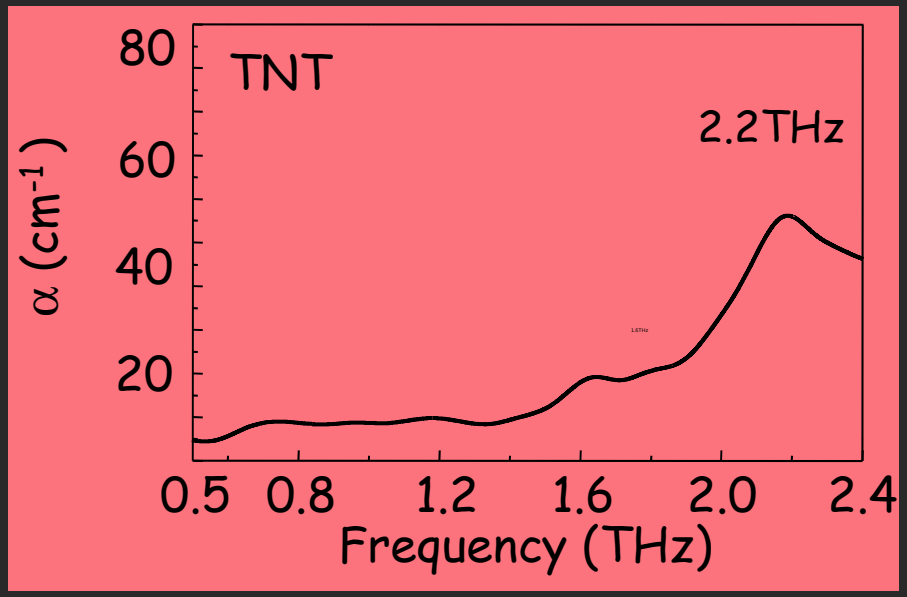
- Frequency range: 500 GHz - 3 THz
- THz waves penetrate most clothing
- Strong spectral discrimination of materials
- Considerable attenuation in air
- Portable source/detectors available

Explosive THz Absorption Spectra-- RPI

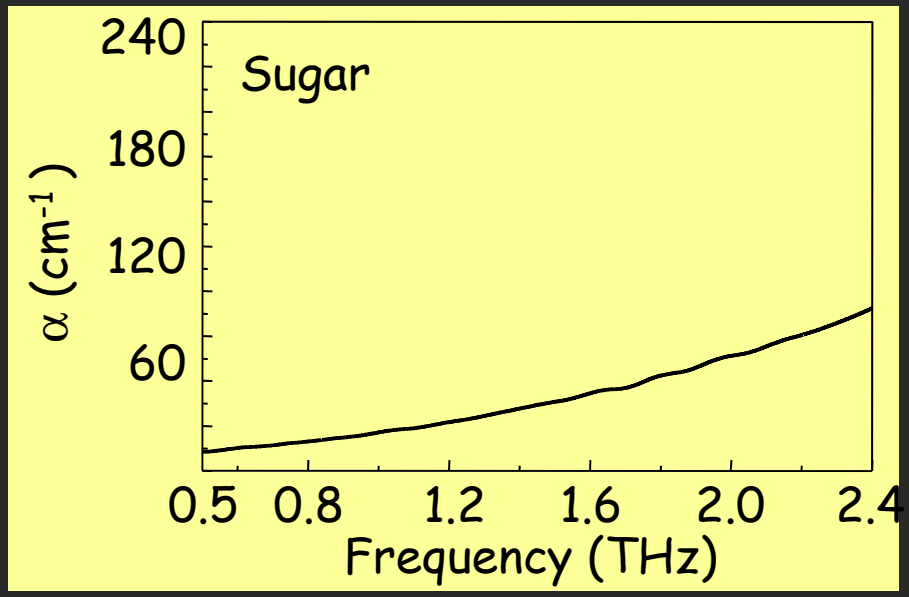


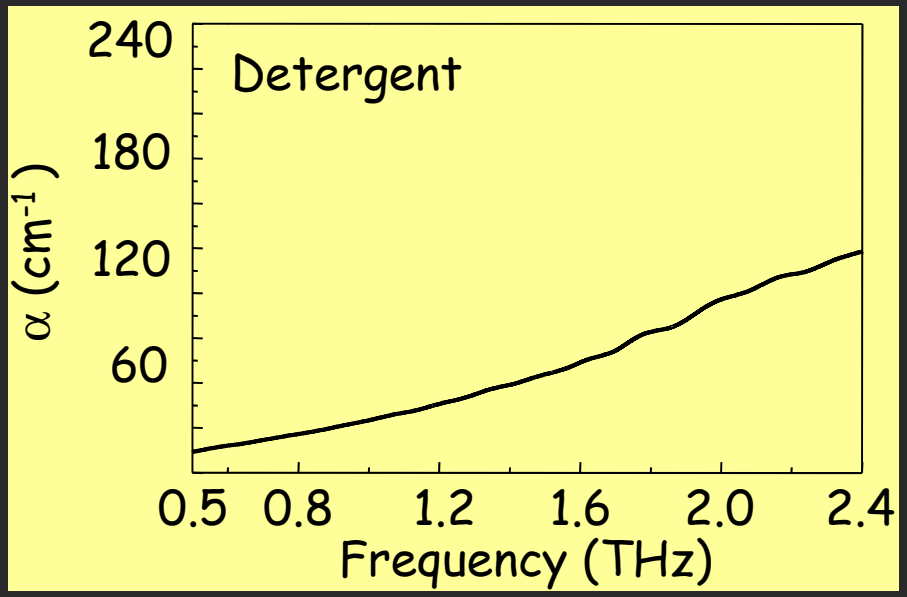


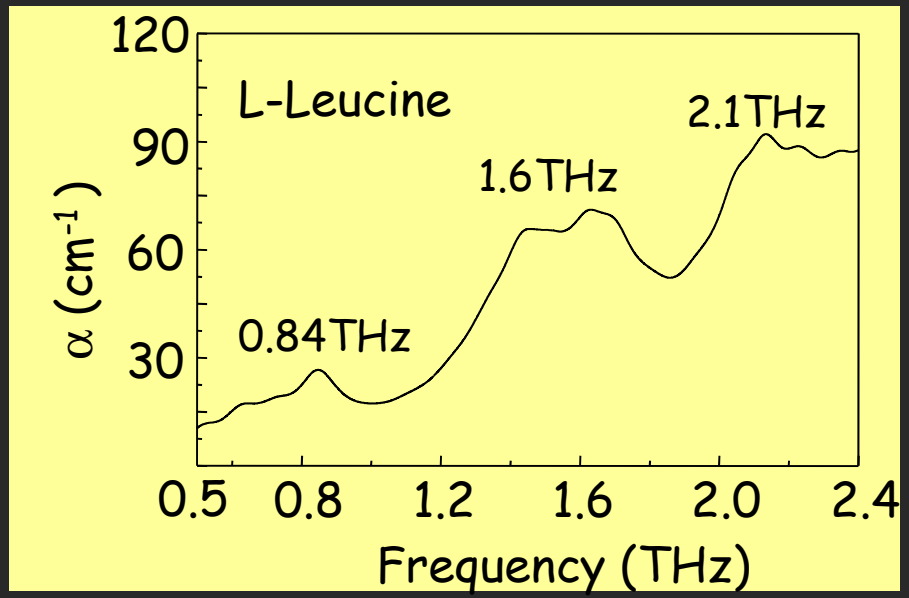


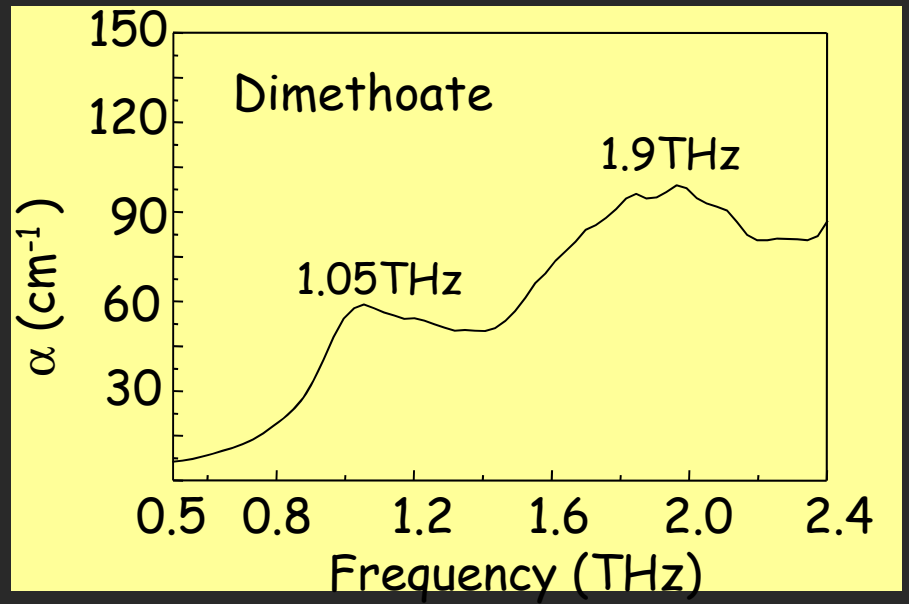


Non-Explosives Absorption Spectra: Distinct from Explosives Spectra

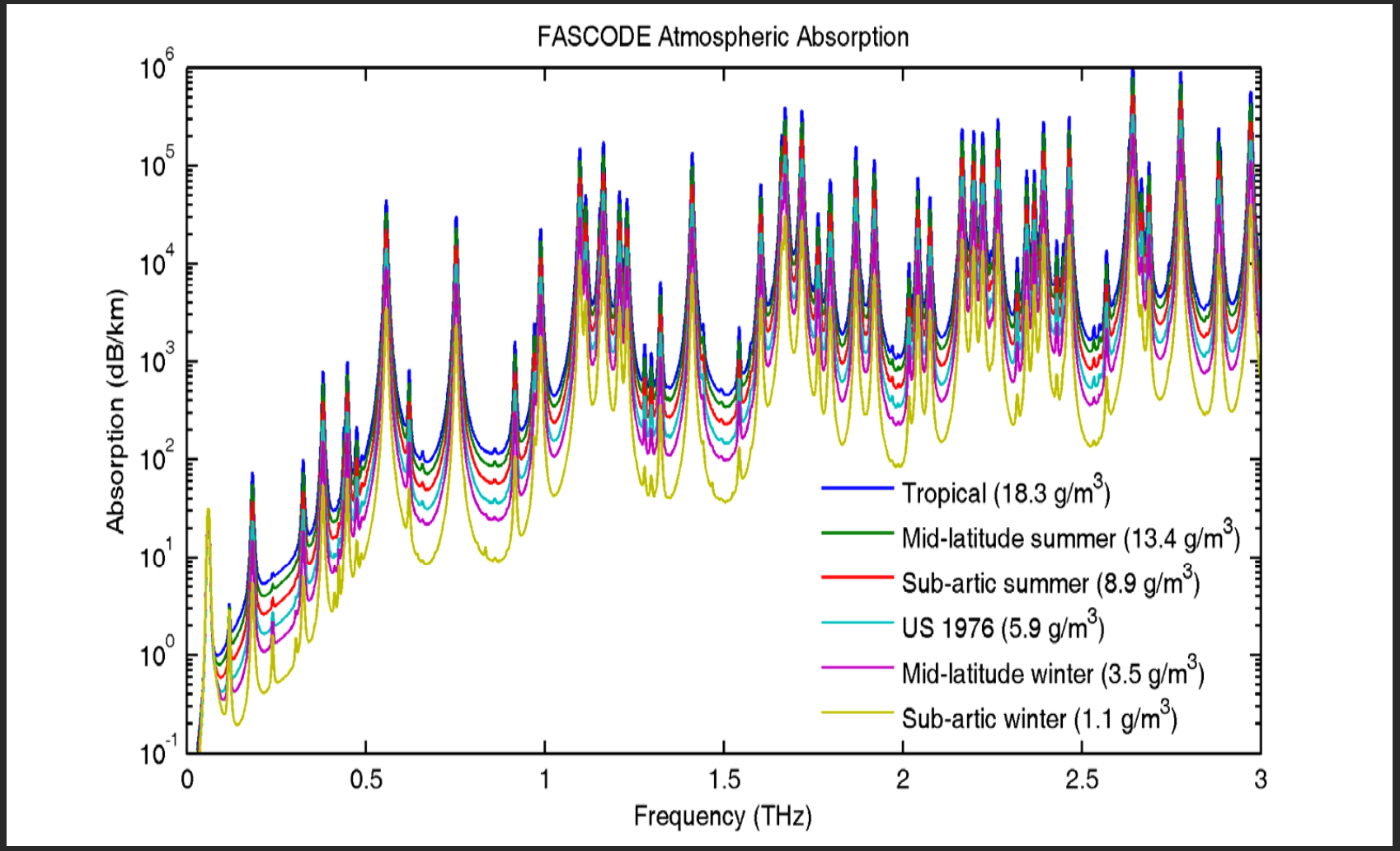








THz Absorption in Air



Intimately Near Detection: Advanced Imaging Technologies (AIT) for Whole Body Imaging

- **NEU Testbed: Unbiased academic-oriented testbed for development and evaluation of multi-modal sensors and algorithms for whole body imaging**
  - **Enable experimentation with new sensing modalities**
    - **Optimize sensor configurations**
    - **Optimize scanning modes**
  - **Explore new algorithm concepts**
    - **Model based vs. Fourier inversion**
    - **High resolution fused imaging**
    - **Automated anomaly detection**
  - **Develop approaches to information fusion and adaptive multisensor processing**

Current State-of-the-Practice Example: L3 ProVision mm-Wave Imager

- TSA qualified Advanced Imaging Technology (AIT) system
- Detects many types of materials based on shape (metallic and non-metallic): liquids, gels, plastics, metals, ceramics
- Uses two linear antenna arrays, scans through 240 degrees
- Limitations
  - "Dead Spots"
  - No spectroscopic info
  - Limited views
  - Poor penetration through leather and metallic clothing
  - No penetration through skin or into body cavities

Whole Body Imaging Sensors with Multimodal Fusion Potential

- **Mm-Wave**
  - Penetrates clothing
  - Distinguishes body-worn objects other than flesh (i.e. metal, explosives, water, plastic)
  - Active system provides target contour info
- **THz**
  - Spectroscopic responses for explosives characterization
  - Penetrates thin clothing
- **X-ray Backscatter**
  - Penetrates all concealing layers
  - Dual energy distinguishes foreign materials
  - Ionizing radiation but very low dosage
- **IR Thermography**
  - Shows unusual heat patterns on body
- **NQR**
  - Non-localizing, but unique explosive discrimination
  - Penetrates throughout body

Whole Body Imaging Testbed at NEU

- Precision portal multi-axis sensor array positioning system
  - Designed to accommodate various types of sensors
    - Separately, for analysis
    - Together, to test fused sensor information
    - Built to be flexible for reconfiguration
- Provide access to raw measurement data
  - Allows specific, modality-based inversion
  - Allows joint modality reconstruction
- Ultimate Goals
  - Establish performance metrics for sensor modalities
  - Develop and evaluate novel inversion and multi-modal threat detection algorithms

Multimodal Sensor Summary

Multiple modalities considered separately and in combination

- No single sensor can detect every threat
- Layer sensing modalities to build detection confidence and confirm threats
- Examine how multiple orthogonal sensors can work simultaneously
- Establish performance metrics and conduct feasibility analysis
- Investigate more-than-additive fused sensing advantages