



# Detection with Spectral X-Ray Detectors and the Complimentary Method of X-Ray Diffraction

Ed Franco, Jonathan Kerner, Winston Chow, Ed Morton, and the team from MultiX



Presented at the ALERT ADSA Workshop 09: New Methods for Explosive Detection for Aviation Security, October 22-23, 2013 Northeastern University, Boston, MA

ONE COMPANY - TOTAL SECURITY

# Conclusions

---

- These Approaches Show Promise for Improving Performance Based on Laboratory Results
  - Multi-energy imaging improves material discrimination and segmentation
  - Coherent x-ray scatter provides material specific signatures
- Additional R&D Required for Aviation Screening
  - Multi-energy imaging and scatter are part of an evolving concept for material identification
  - Development and testing of systems under practical CONOPS
  - Screening for HMEs remains a challenging application
  - Research partnerships may accelerate development

## The Challenge

---

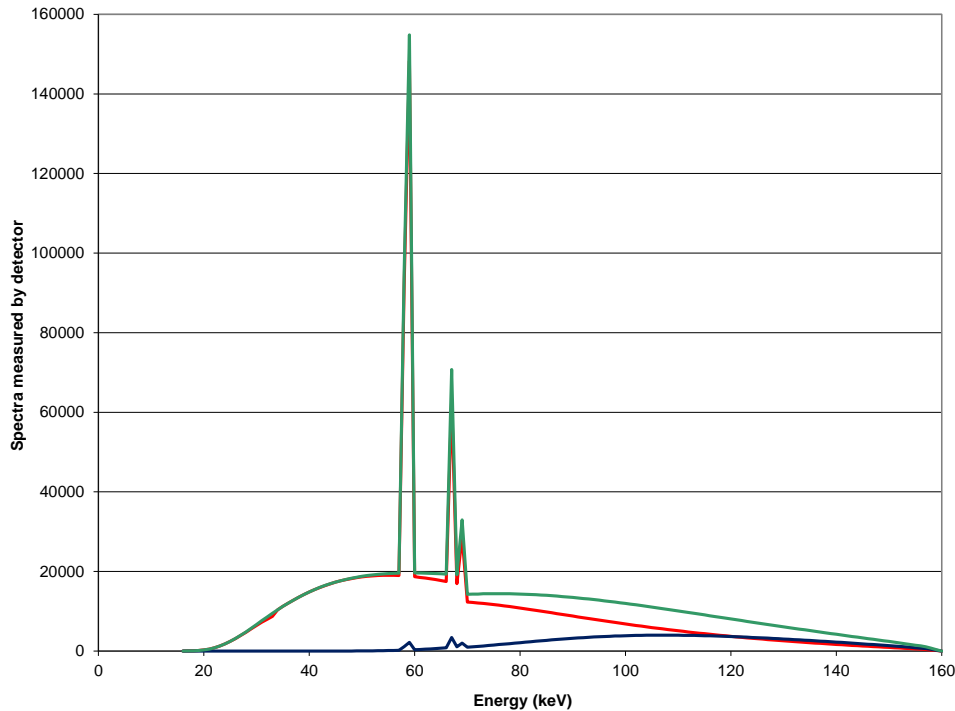
- Dual-Energy Systems are Used to Screen for Aviation Threats
  - Achieves high PD with an operationally acceptable PFA
  - Commercial and military explosives are generally well separated from benign items in  $\rho$ -Zeff space
- Screening for Home Made Explosives (HMEs)
  - HMEs are variable due the way they are produced (raw materials, impurities, and manufacturing processes) and chemical effects (aging)
  - Significant overlap with benign items in  $\rho$ -Zeff space

# Rapiscan Investigating Multiple Approaches to Improve Detection and Reduce False Alarms

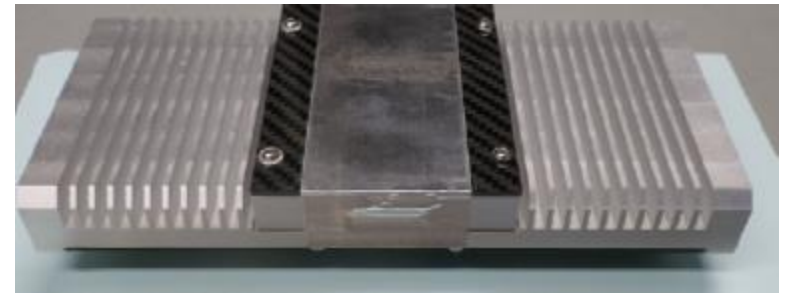
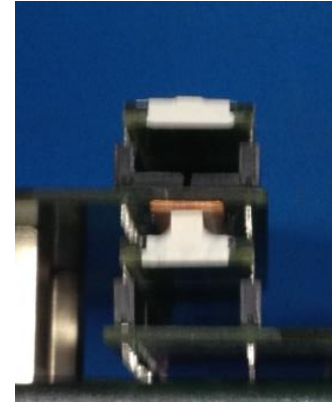
---

- Multi-Energy Imaging
  - Better measurement of  $\rho$  and  $Z_{\text{eff}}$
- Coherent X-Ray Scatter
  - Provides orthogonal signature related to atomic structure
- Other Approaches
  - Tomography
  - Phase contrast
  - Compressive sensing

# Dual-Energy (DE) vs. Multi-Energy (ME) Imaging



— Air LE  
— Air HE  
— Air CdTe



*Calculated absorption in DE and ME detectors*

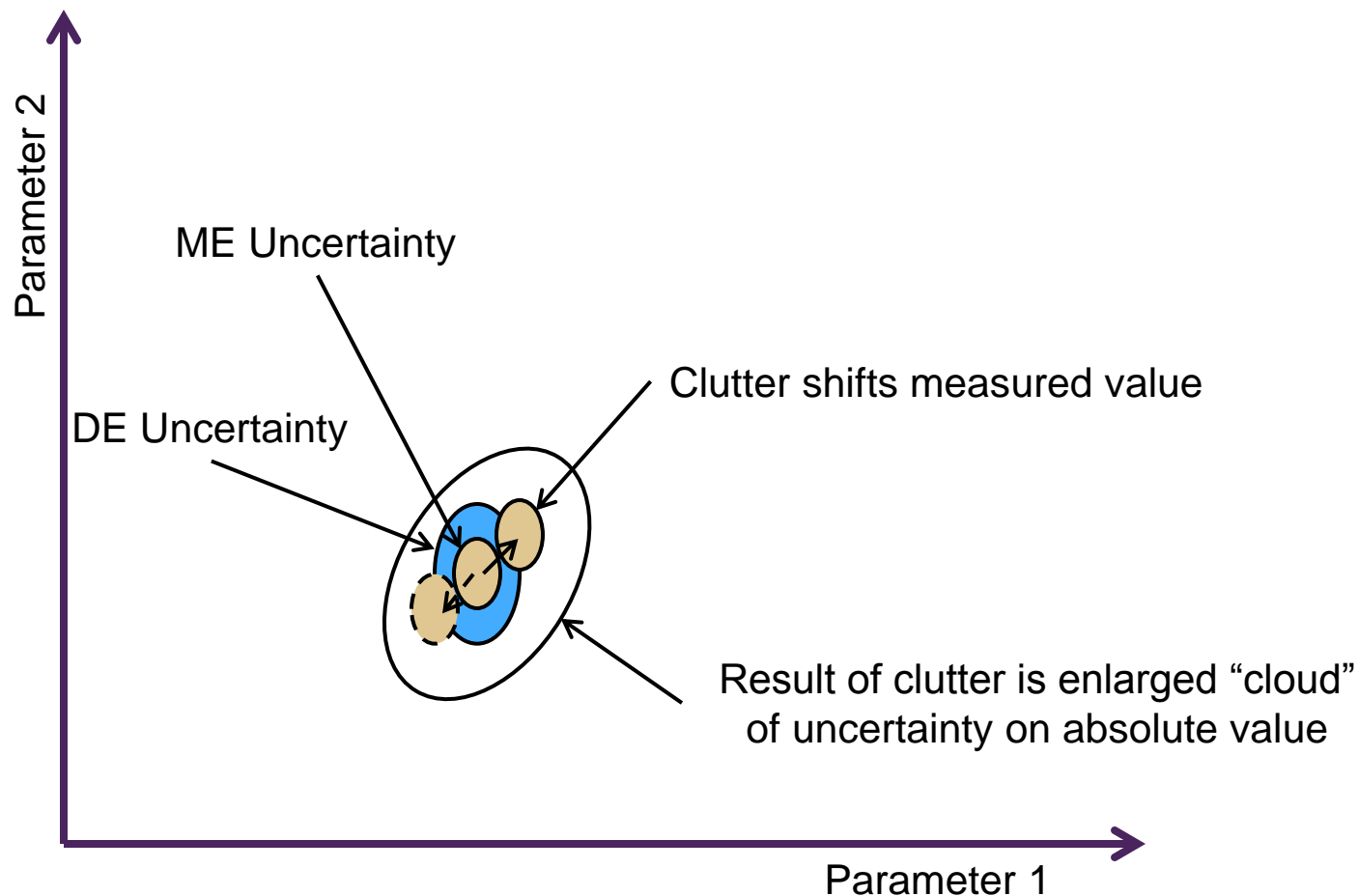
*DE (top) and ME (bottom) detector modules*

- DE uses two broad overlapping LE and HE bands
- ME uses the entire transmitted spectrum

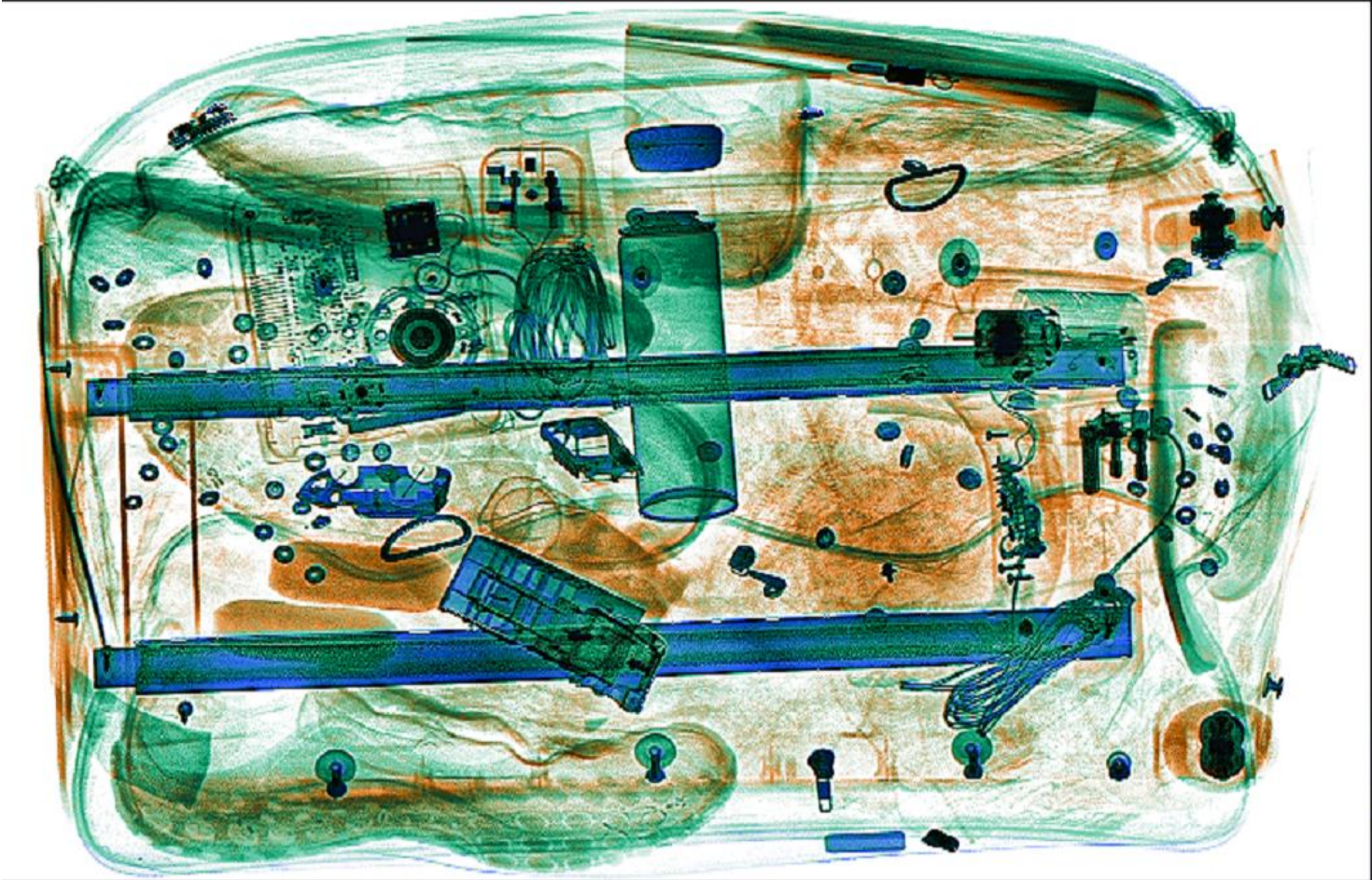
ONE COMPANY - TOTAL SECURITY

**Rapiscan**  
systems  
An OSI Systems Company

# DE vs ME Accuracy



# Effect of Clutter in Bags



ONE COMPANY - TOTAL SECURITY

**Rapiscan**  
systems

An OSI Systems Company

# Multi-Energy Imaging

---

- Benefits
  - Improved material discrimination due to increased accuracy and precision in the measurement of  $Z_{eff}$  and density
  - Improved segmentation due to improved resolution and image quality
- Shows promise for improved PD and PFA
- BUT clutter is a problem in quantitative imaging ...
- Future efforts are focused on cargo, checkpoint, and hold-baggage applications



# Rapiscan has over 10 years experience with XRD and Coherent X-Ray Scatter

- University Collaborations

- “Energy dispersive X-ray scatter for measurement of oil/water ratios”, Luggar, R. D.; Key, M. J.; Morton, E. J.; Gilboy, W. B.; NIM, Sec A, V 422, p. 938-941 (1999).

- Bulk Explosives

- Rapiscan XRD1000 system used XRD for alarm clearing

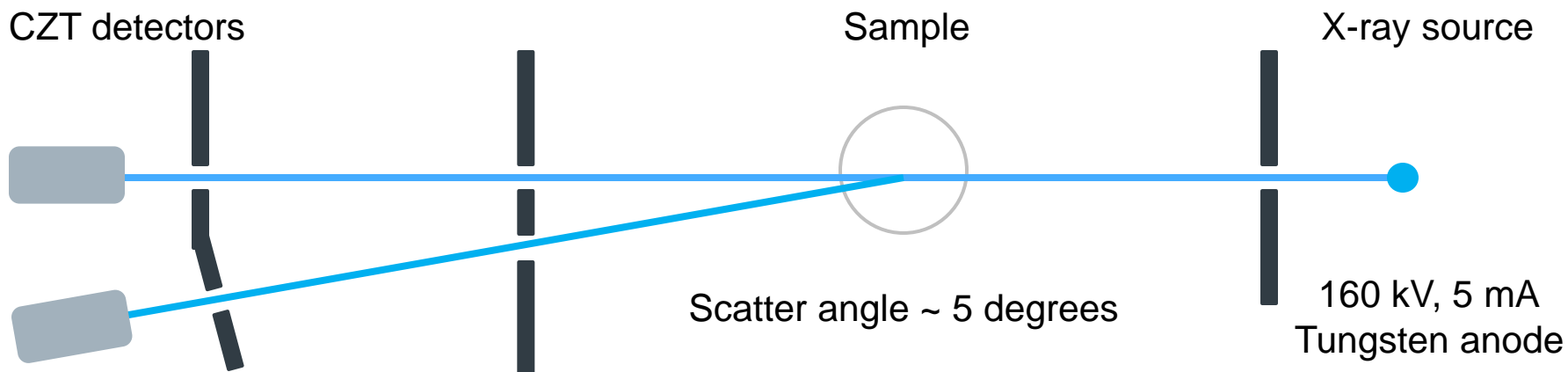
- Home-Made Explosives

- Proprietary technology



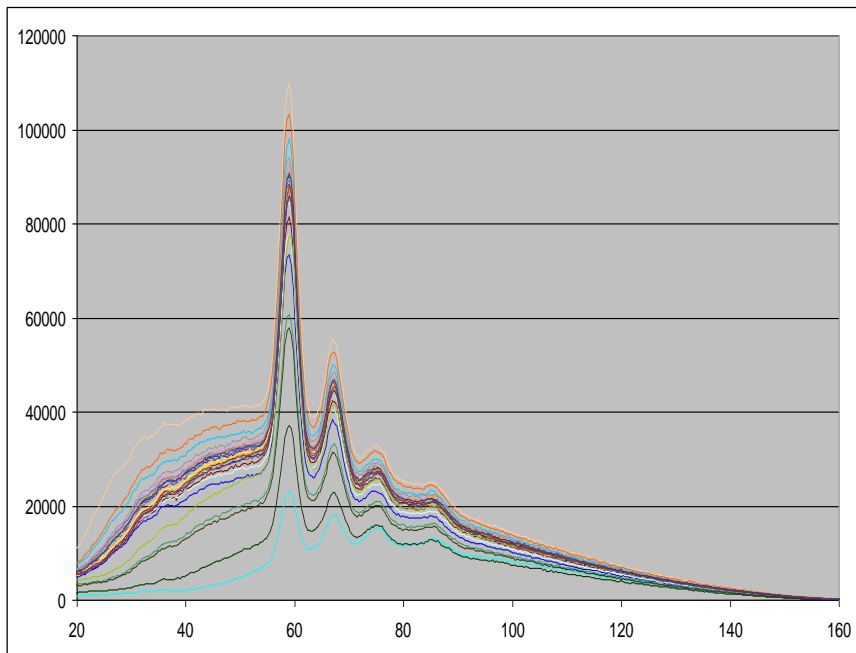
*XRD1000 Baggage Inspection System  
Combined dual-view, dual-energy imaging  
with integrated XRD subsystem*

# Pencil Beam Coherent X-ray Scatter Geometry

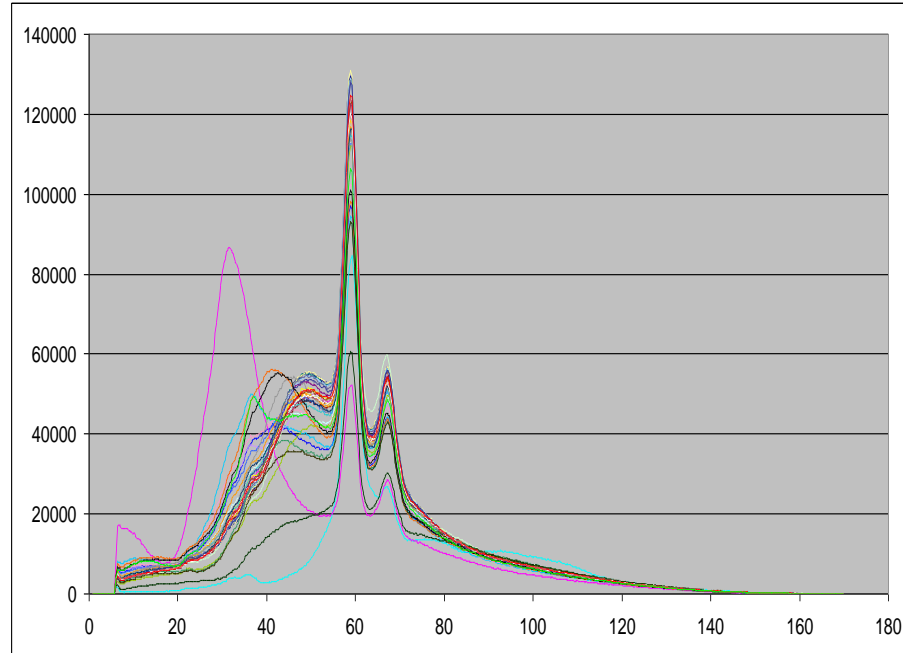


- Pencil beam geometry is very simple
  - However not very efficient
  - Probes only a single point
- Rapiscan is investigating more efficient geometries

# Produces Unique Material-Dependent Transmission and Scatter Signatures



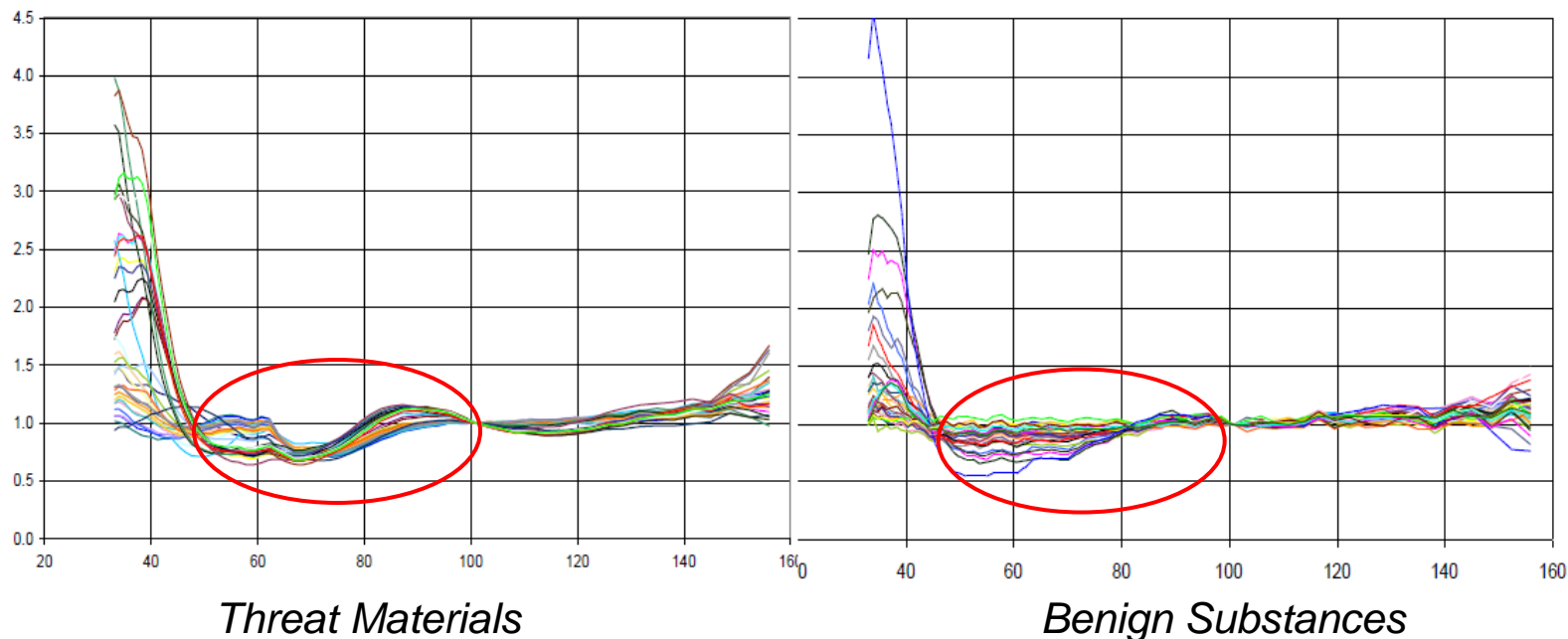
*Raw Transmission Spectra*



*Raw Coherent X-ray Scatter Spectra*

- Bulk and HME explosives
- Stream-of-passenger items

# Processed and Normalized Scatter Signature



- Scatter signatures of threat materials distinguishable from benign materials (see red ovals)
- Can be used in automated classification algorithms

# Conclusions

---

- These Approaches Show Promise for Improving Performance Based on Laboratory Results
  - Multi-energy imaging improves material discrimination and segmentation
  - Coherent x-ray scatter provides material specific signatures
- Additional R&D Required for Aviation Screening
  - Multi-energy imaging and scatter are part of an evolving concept for material identification
  - Development and testing of systems under practical CONOPS
  - Screening for HMEs remains a challenging application
  - Research partnerships may accelerate development