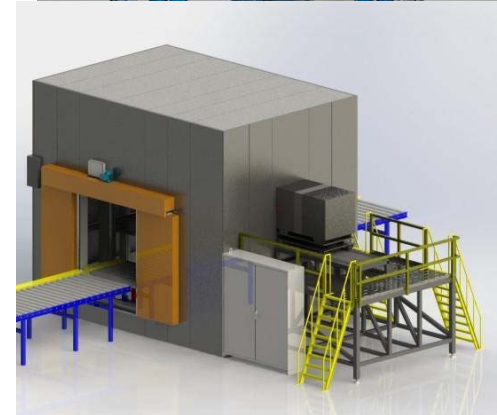
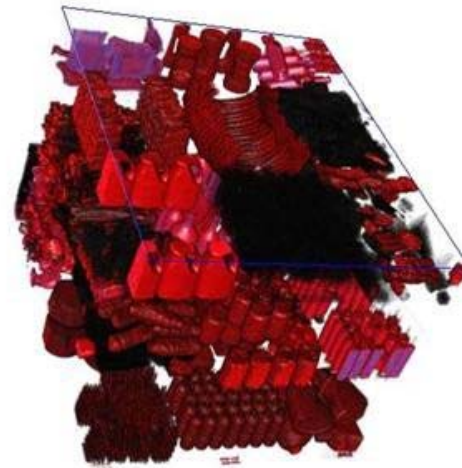
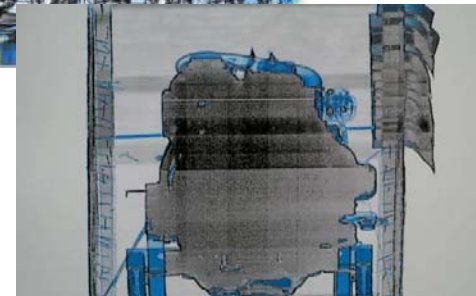
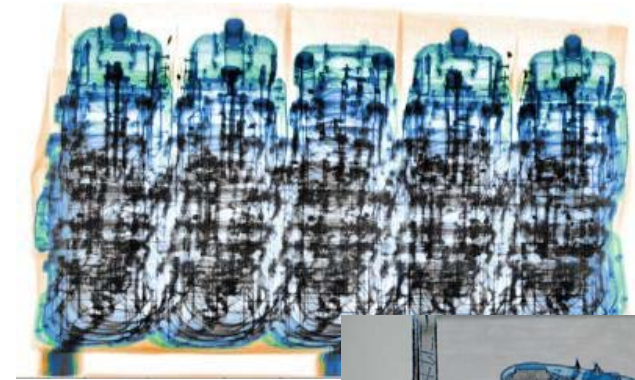
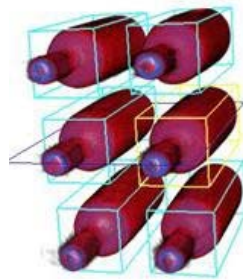


# AIR CARGO SCANNING CHALLENGES

Achieving security at 10,000 false alarms an hour



**Walter Garms**  
**Morpho Detection**  
**ADSA 10**  
**May 6, 2014**

# AIR CARGO PROBLEMS AND APPROACHES

## Security study at overnight air cargo sort facility

### → Break Bulk and Palletized Cargo

- Intense time pressure
- Huge variety of break-bulk items make baggage scanning seem easy
- Large numbers of similar or identical packages
- Customers do not want boxes opened or pallets broken down

### → Palletized cargo is even harder:

- Difficult to penetrate with x-rays
- Often too cluttered to see threats in projection images
- Customers do not want pallets broken down

## Technology and approaches

### → SPAC: Full volume, high energy CT scanner for palletized cargo

- Need help: Scatter correction for high energy flat panels

### → Threat grouping algorithms for identifying multiple or known objects

- Wide open field; lots of room for creative solutions!

### → Risk based approaches

- (only scan boxes with real threats): Yes, go for it, but not on my time!

# AIR CARGO SCREENING STUDY



Study conducted at overnight cargo sort facility

- X-ray for skids (HRH-1500) 400 skids
- CT for packages (CTX-5800) 1100 boxes
- Trace for alarm resolution

(Itemizer DX) 980 samples



# REALITY CHECK: AIR CARGO SORT FACILITY



02:30 - 23:45  
All Quiet...

# 12:30AM: CONTROLLED CHAOS (SEE MOVIE CLIPS IF AVAILABLE)

12:30AM – 2:30AM

→ 20,000 packages

→ 400 skids

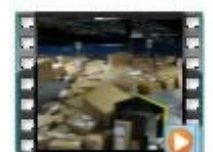
→ 2 hours



05 Incoming Boxes.avi



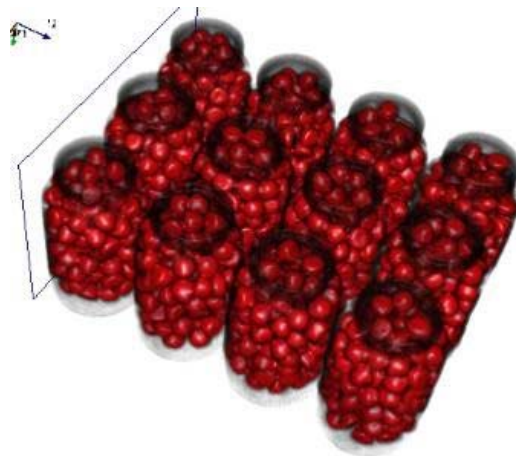
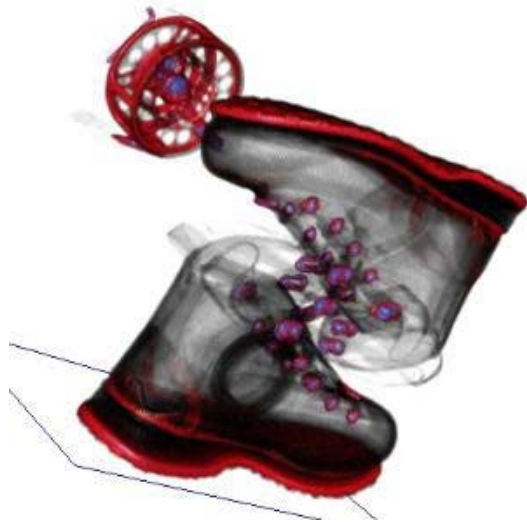
06 Primary Sorting.avi



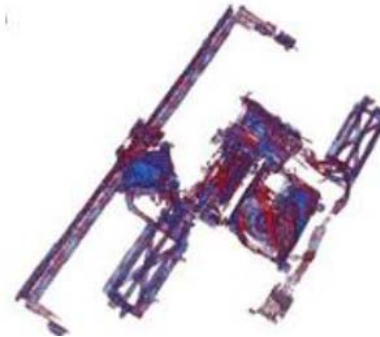
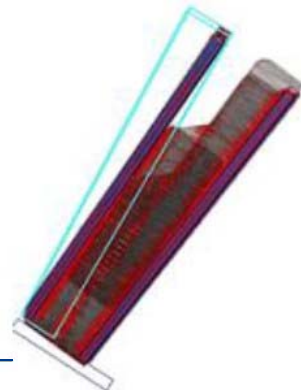
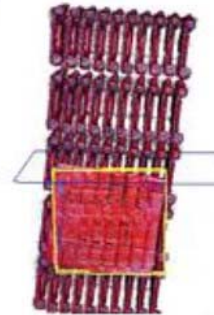
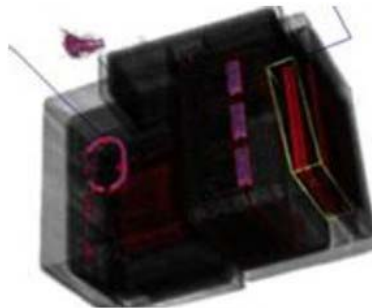
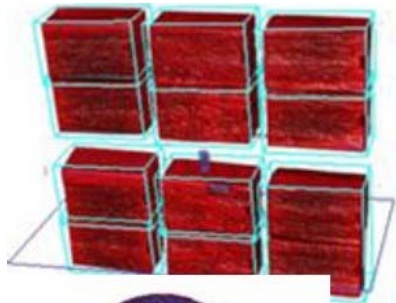
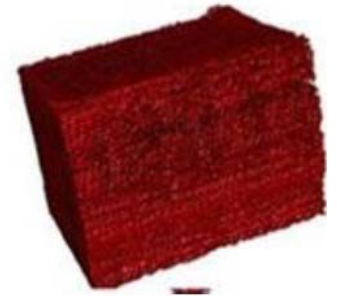
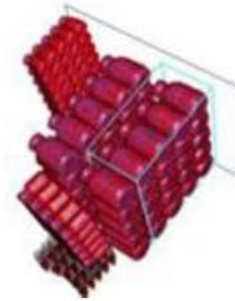
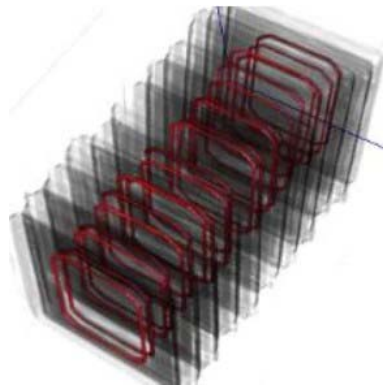
Sorting Area.avi

# FALSE ALARMS IN BREAK BULK

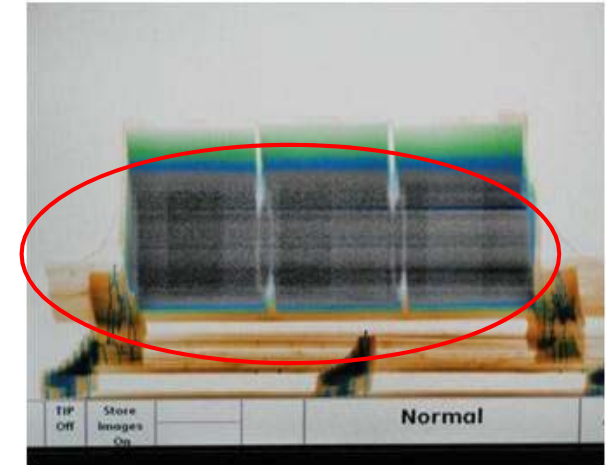
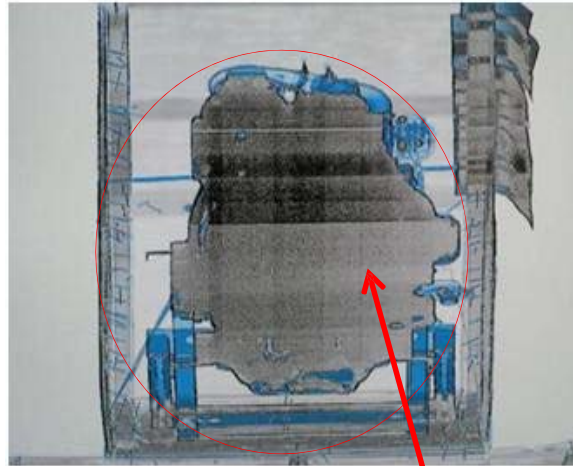
- Huge variety of objects makes baggage scanning seem easy.
- Large numbers of similar or identical objects
- Contents highly dependent on season and location



# DID I MENTION FALSE ALARMS?



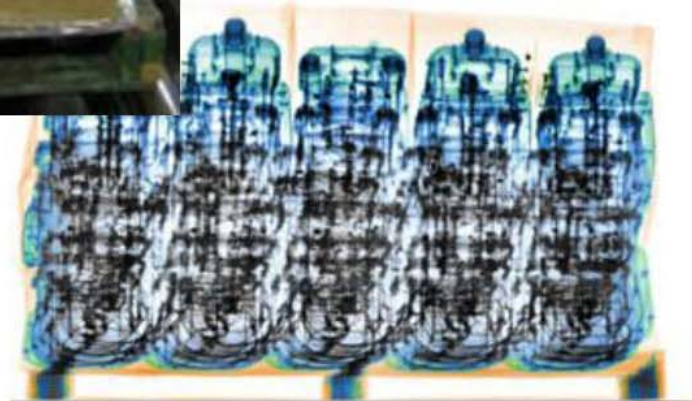
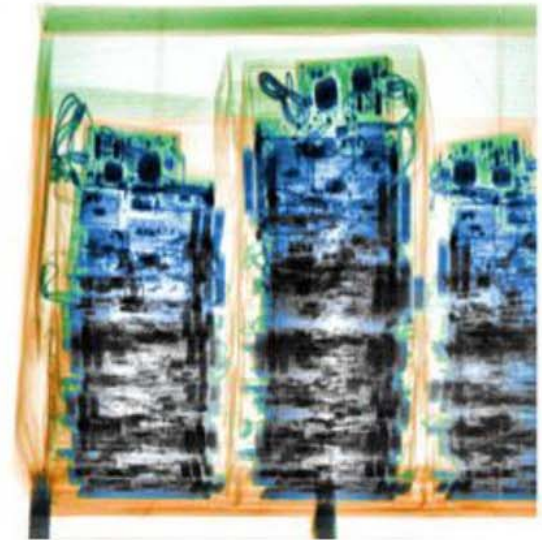
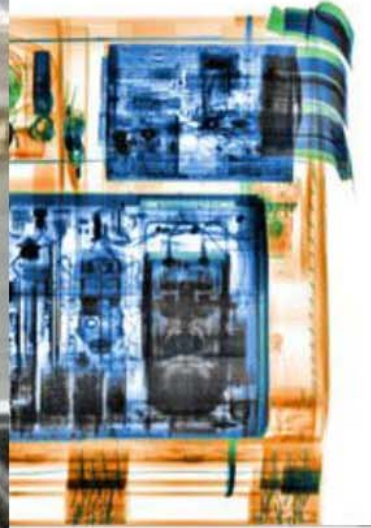
# X-RAY FOR SKIDS - PENETRATION



No useful penetration in circled areas



# X-RAY FOR SKIDS – CLUTTER AND COMPLEXITY



# WHAT'S NEEDED: HIGH ENERGY, HIGH RESOLUTION CT FOR PALLETS

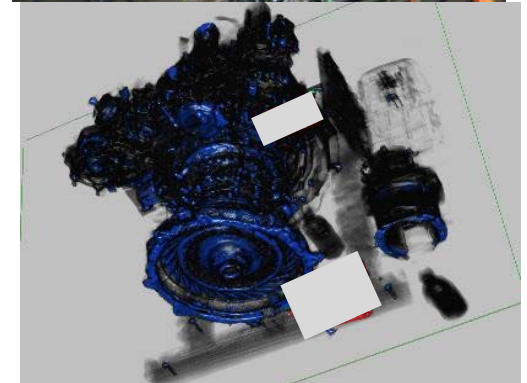
## SPAC: Scanner for palletized air cargo

- Megavolt x-ray source to penetrate dense pallets
- Large area flat panel x-ray detectors
- High resolution Helical Computed Tomography
- Commercially viable throughput

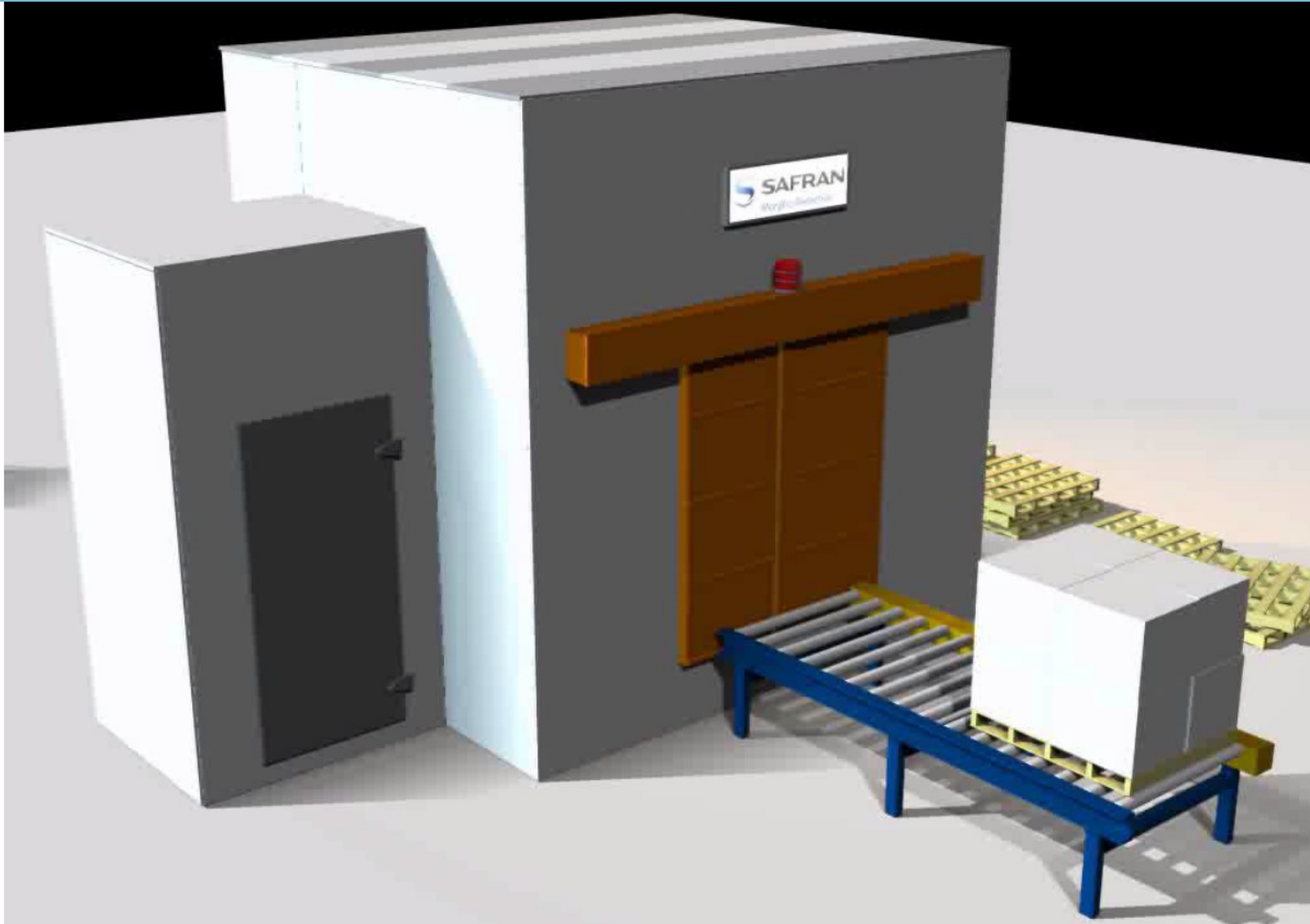
Prototype system built by Morpho Detection in cooperation with TSA

## What is the hard part?

- High energy x-ray scatter in uncollimated flat panels
- Expensive shielding
- Did I mention alarm resolution?



# SPAC CONCEPT (SEE MOVIE CLIP IF AVAILABLE)



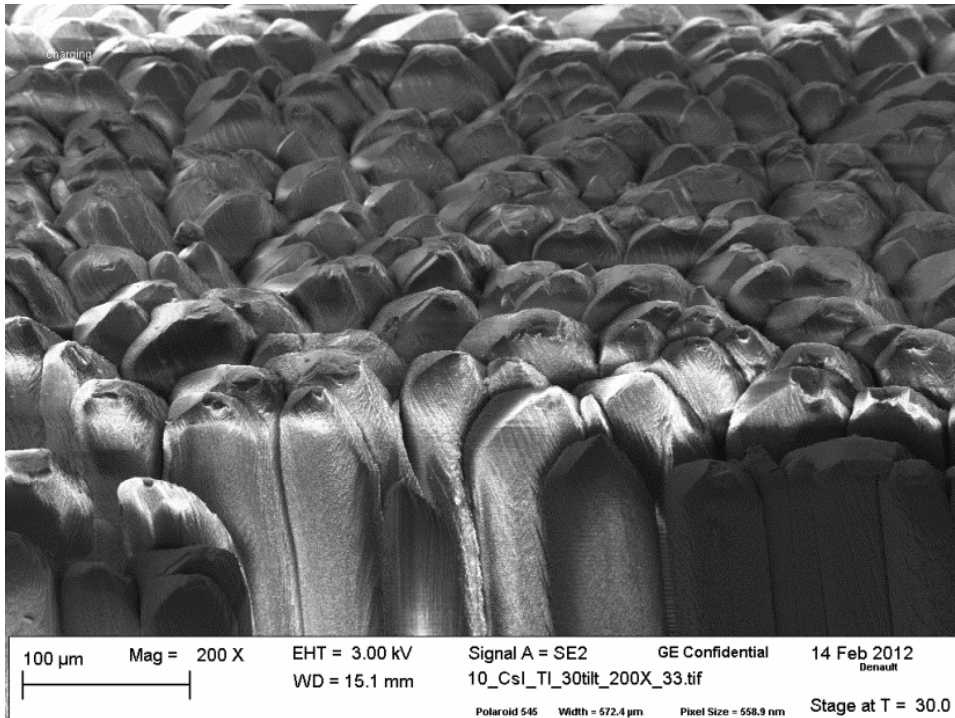
1-SPAC  
Movie.wmv

# PROTOTYPE IMPLEMENTATION

Overview of SPAC system



# MULTIPLE FLAT PANEL X-RAY DETECTOR



Cesium Iodide scintillator needles grown on detector substrate



World's largest area CT x-ray detector?

# SCANNING TURBINE ENGINE (SEE MOVIE CLIPS)



3-Turbine  
Loading.MP4

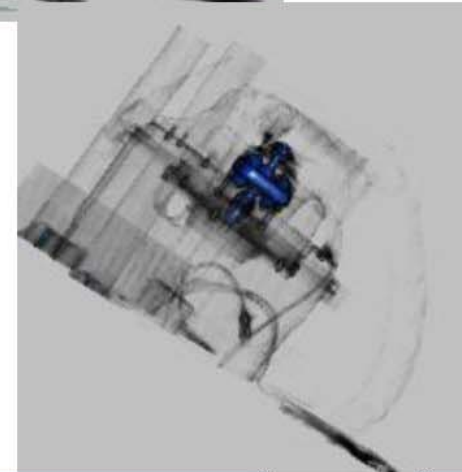
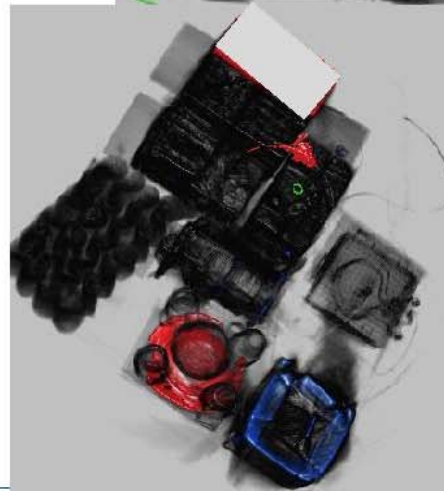
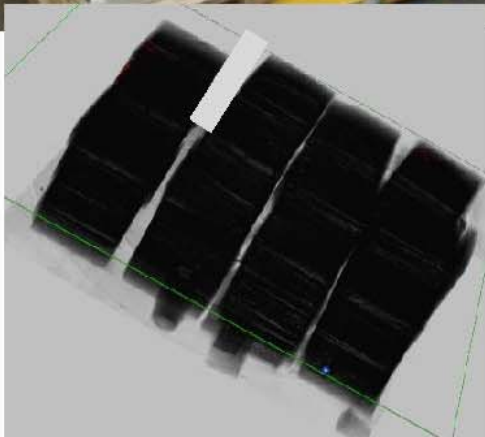
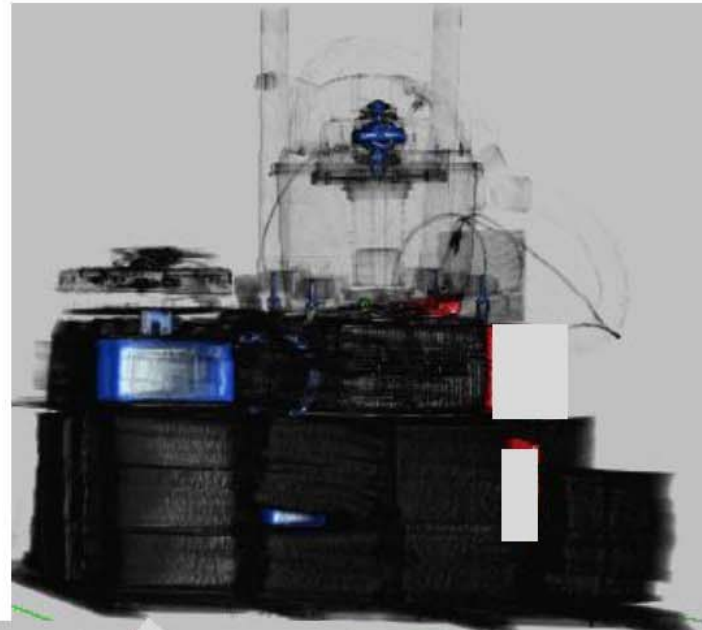


4-Turbine  
Scanning-fast.M  
P4



5-Turbine  
unloading.MP4

# RENDERING SECTIONS OF 3-LAYER PALLET

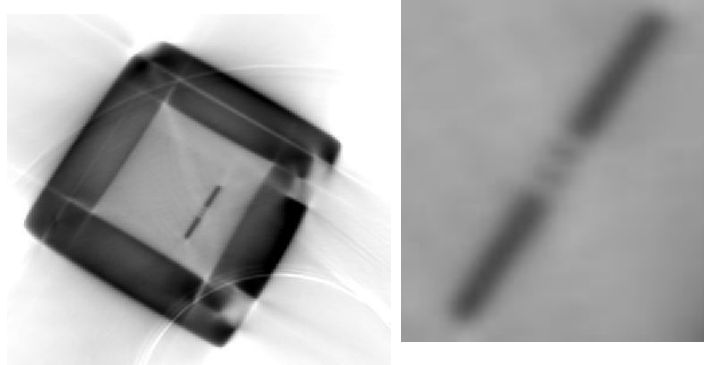


# CT IMAGE RESOLUTION AND PENETRATION

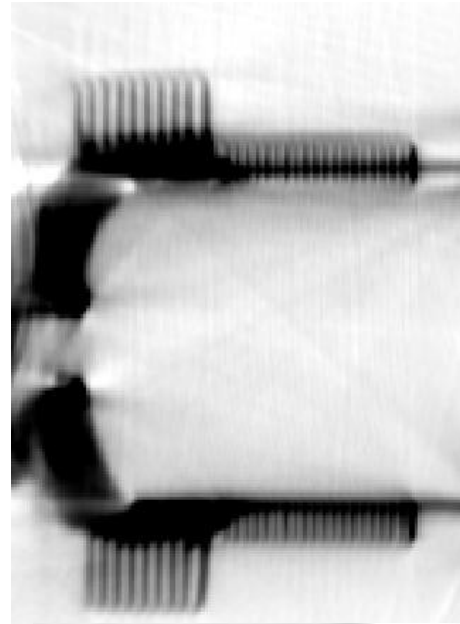


900 cubic inch small aircraft engine cylinder

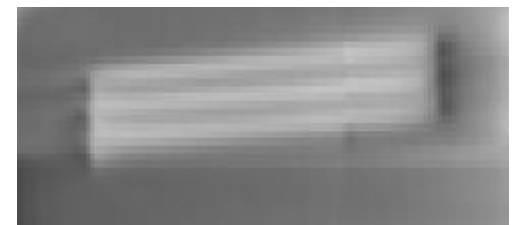
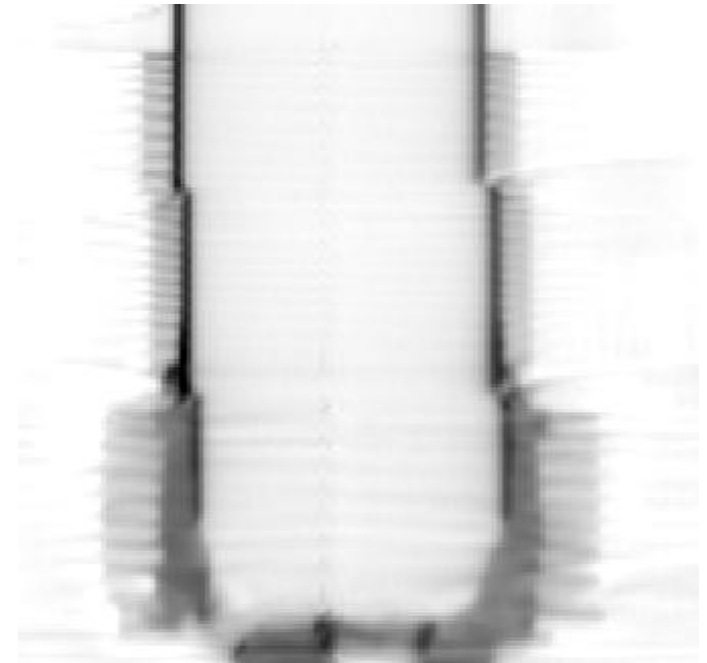
Inside Steel Shielding



Axial CT

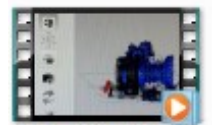
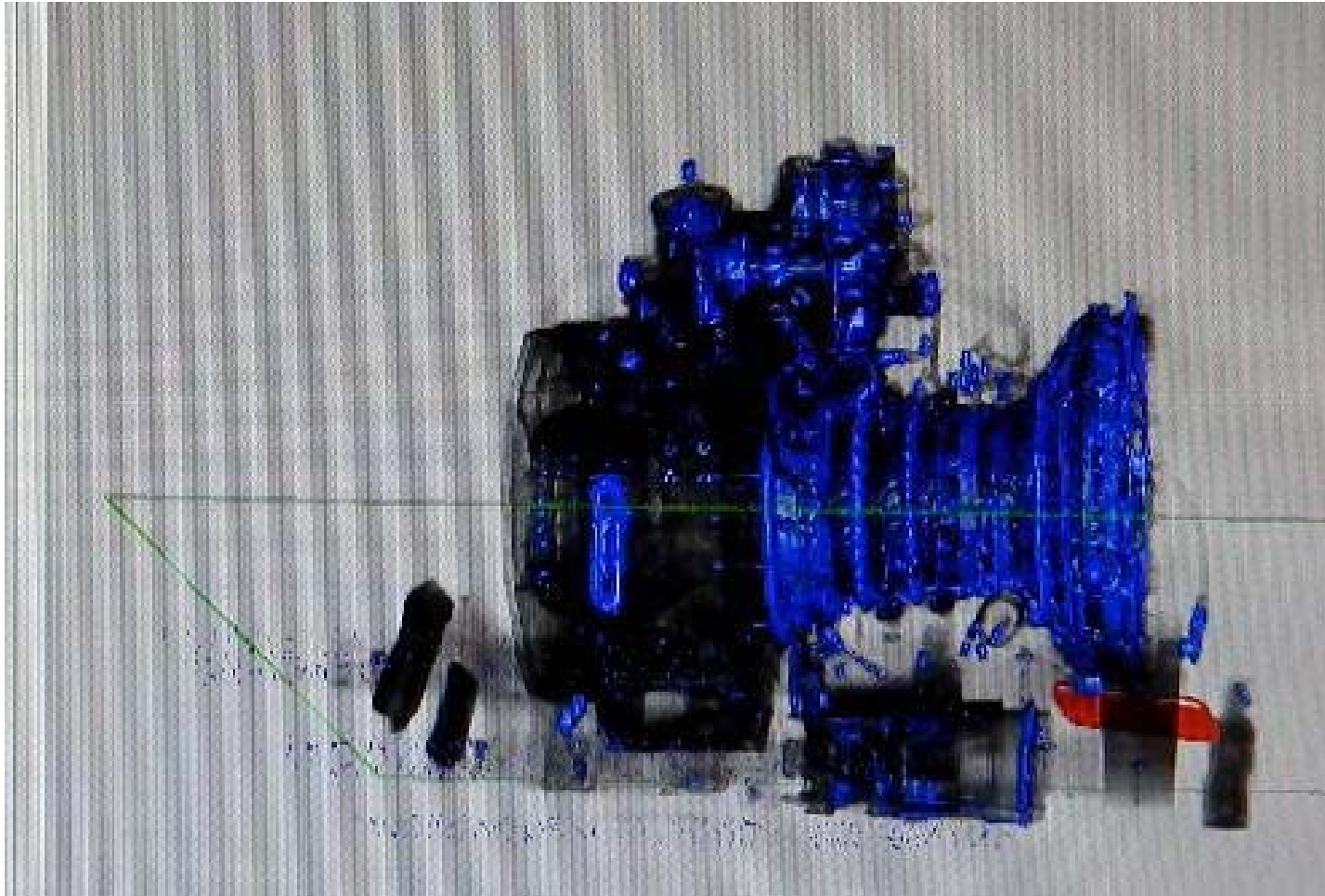


Reformatted -Z direction





# SPAC THREAT RESOLUTION INTERFACE (SEE MOVIE CLIP IF AVAILABLE)

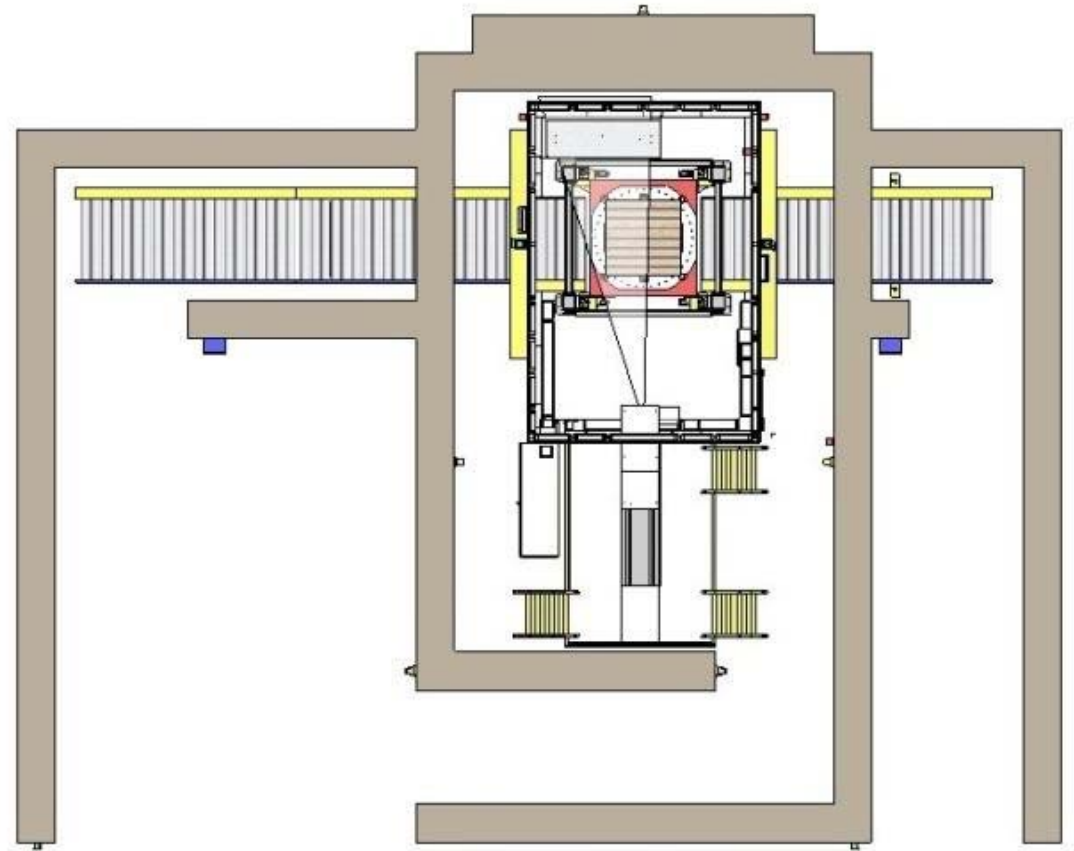


7-Turbine-Render threats.MOV

# PRIMARY AND SECONDARY SHIELDING

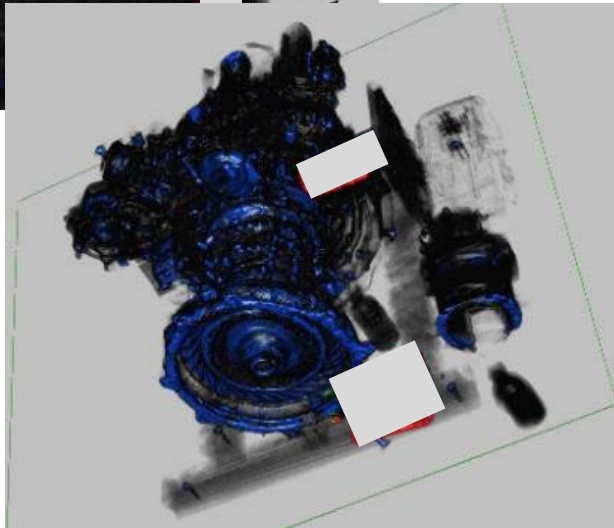
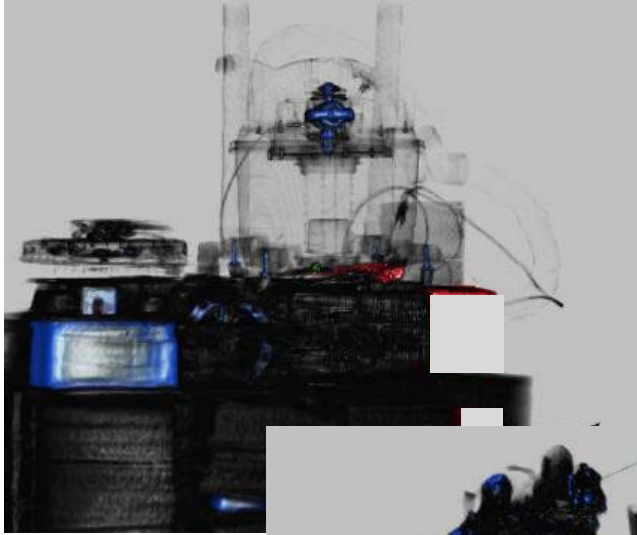


Lead primary shield vault



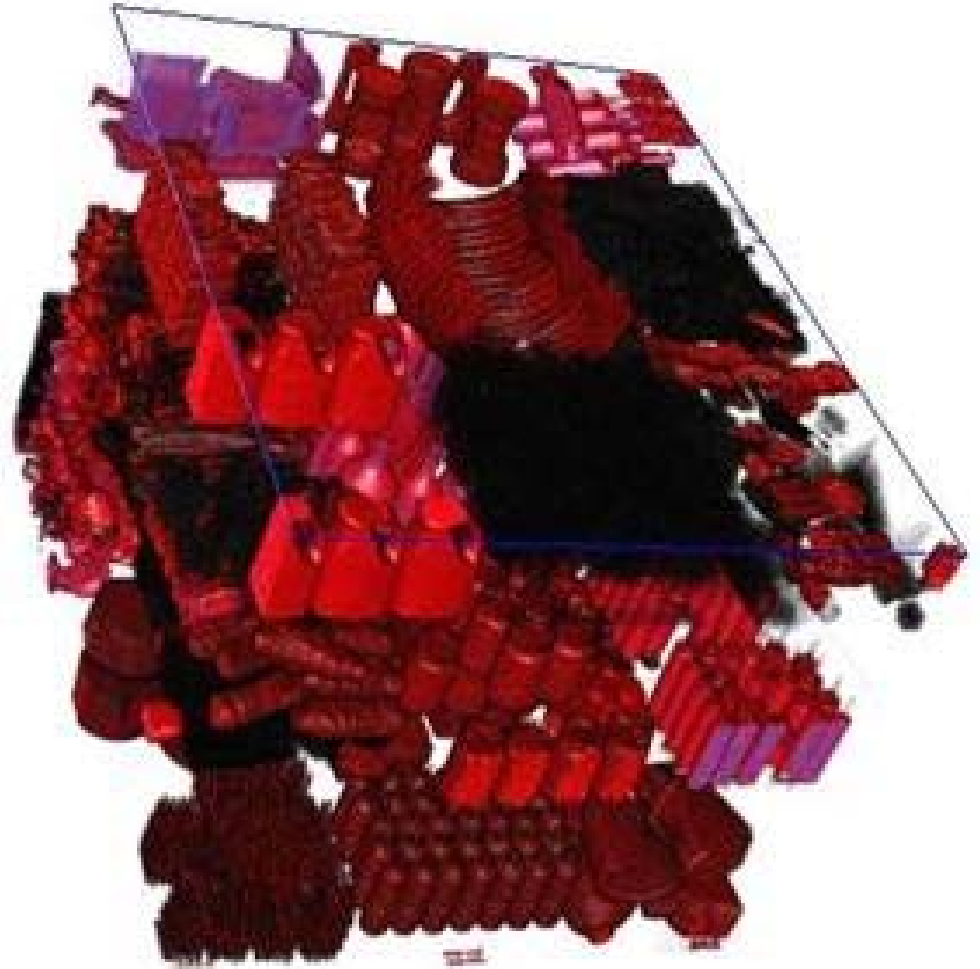
Modular concrete  
secondary shielding (two  
feet thick)

# SPAC AUTOMATIC THREAT RECOGNITION



3D automatic threat detection  
Detects hold baggage EDS threat quantities

Did I mention false alarms?  
Source: Megavolt CT program

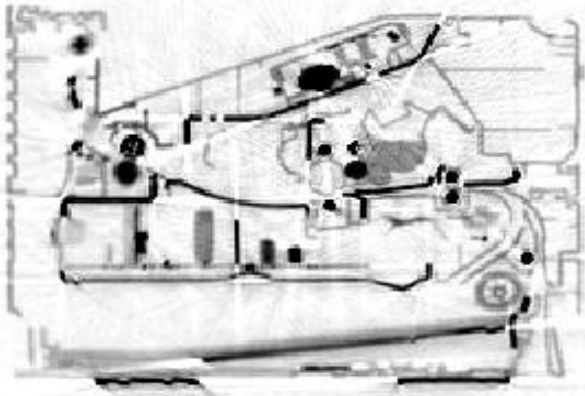


# THREAT CLUSTERING/ANOMALY DETECTION

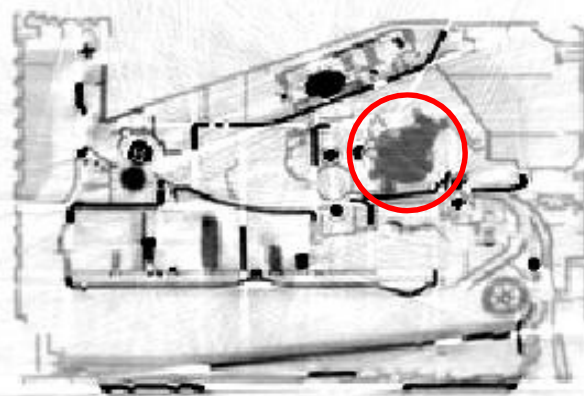
→ **Problem:** Pallets and packages may contain multiple, similar alarms

→ **Solution:** Seen one, seen 'em all?

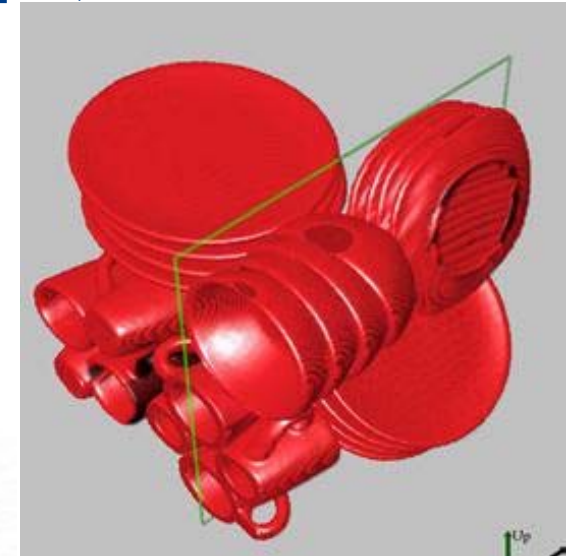
- Use ATR to detect groups of similar threat objects
- GUI Tools to view small differences within a group
- GUI Tools to select and clear entire groups
- Remaining objects receive higher scrutiny



Printer with normal ink cartridge



Ink cartridge filled with explosive simulant



One coffee mug with simulant

# SOME IDEAS FOR CLUSTERING ALGORITHMS

## → One approach:

- Compute multiple features for each object
- Apply clustering algorithms to form groups of similar objects
- Resolve alarms on all object in a group at once.
- Problem: When is “just a little bit different” significant?

## → Another approach

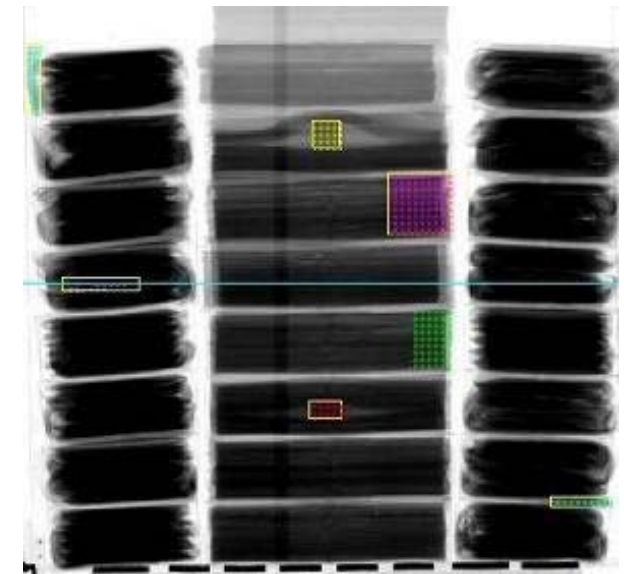
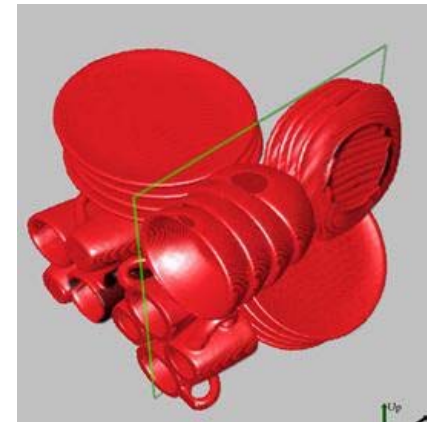
- Identify entire boxes in break bulk
- Find repeating patterns in pallets to identify boxes
- Perform global comparison to find differences

## → How about a library of known objects?

Features and representative images of known objects added to library of “safe”

Compare currently scanned objects to library

Clear duplicates; highlight differences



# RESEARCH OPPORTUNITIES

## Where are we now?

- Sheer volume and pace of air cargo operations stress any solution.
- CT Technology still the best for characterizing objects in air cargo
- CT scanning of entire pallets and containers now possible
- Alarm resolution is the next big hurdle

## → Where can academia help?

- Threat Grouping and clustering algorithms
- Machine learning
- High energy scatter and spectral corrections will make CT numbers more accurate, and objects easier to classify.
- Risk assessment: When does something really need to be scanned?

## → Plenty of room for innovation here!

- If I had money I'd send you some for sure.