

# Benefits of Spectral Detectors and Non-Rotating Gantries

## SURESCAN™

## x1000

Multi-Energy Stationary Gantry CT Explosives Detection System

### ***Fixed Source / Sparse View Explosive Detection System***

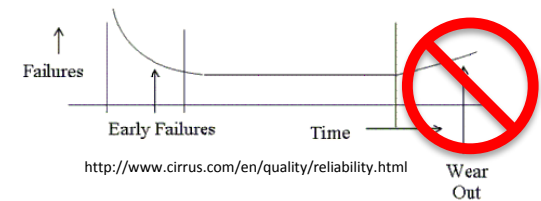
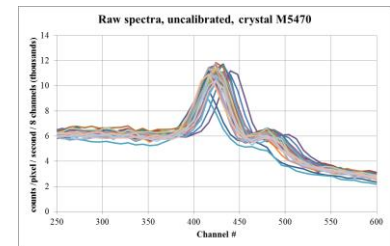
- Fixed switching X-ray Sources
- Spectral Photon Counting Detectors
- Iterative Reconstruction in real-time >50 slices/sec
- **TSA Certified April 2014**



# So What ... Who Cares

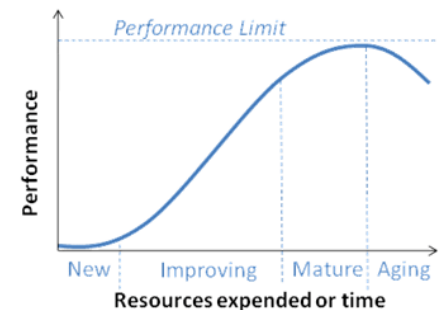
## Why now?

- Fixed source configurations have demonstrated capability to detect thin targets and certify
  - Question is no longer “Will it work?”
  - Question is now “How sparse can you get?”
- Spectral detectors enable material discrimination using Z-effective
  - Multiple sources for CZT and ASICs
  - Choices for number & size of energy bins
- Fixed source configurations offer significant reliability and cost benefits
  - Lower operating stress ... power level, duty cycle, G-forces
  - Minimizes mechanical failure modes ... less “wear-out”



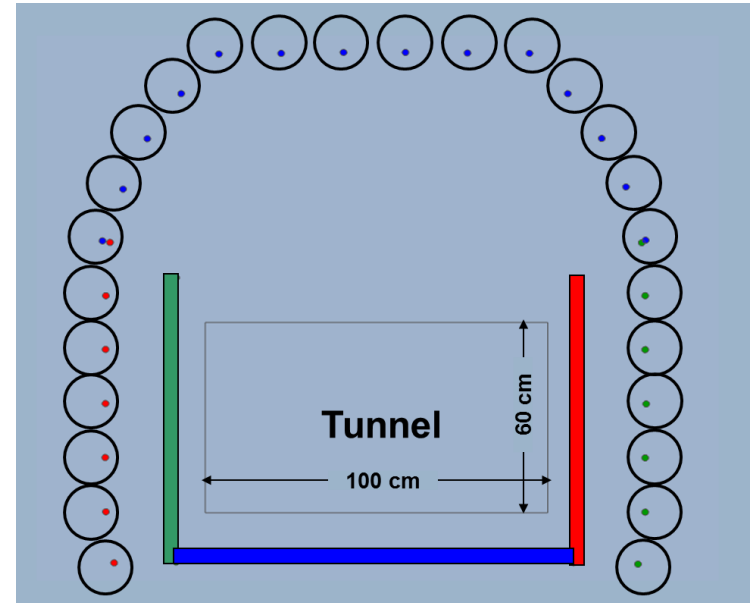
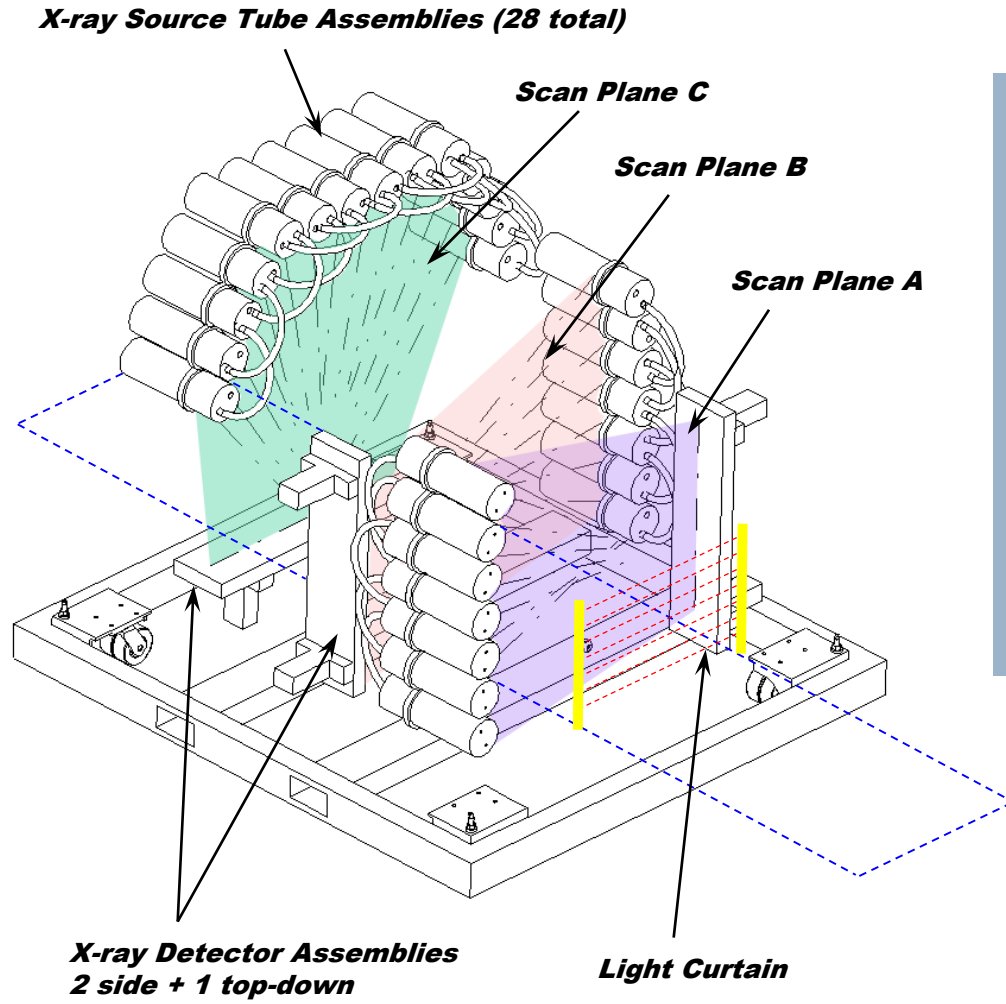
## Why in the future?

- Flexible platform with many degrees of freedom for Compressive Sensing
  - View (measurement) modifications ... order, timing, kVp, spectrum, aperture(s) ...
  - Adaptive measurement scenarios



<https://www.mitre.org/.../assessing-technical-maturity>

# Fixed Source Geometry



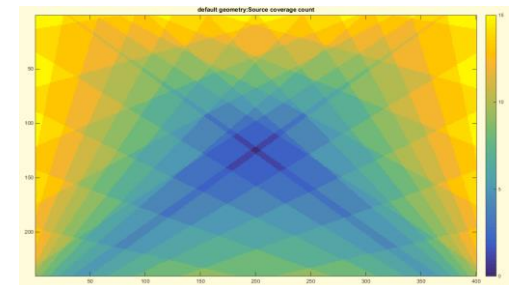
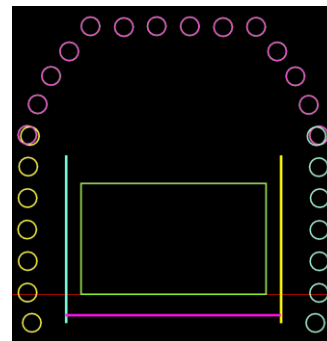
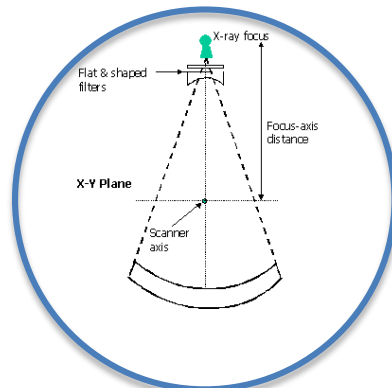
# Fixed Source Scanner Configurations

## Benefits

- Enables wide range of measurement options
  - Source / Detector Placement
  - Source → Multiple Detectors / Multiple Sources → Detector
  - View ordering ... Think Solid State vs Rotating Disk Drives
    - Unlimited view hopping patterns / even adaptive ordering
  - Lower mechanical complexity and stress ... static 1g loads
  - Source redundancy (n out of m sources/views)
  - Multiple high quality 2D projection views
- However ... sparse views
- Wide in-plane acceptance angles / allows more scatter

# Non-Rotating Gantries

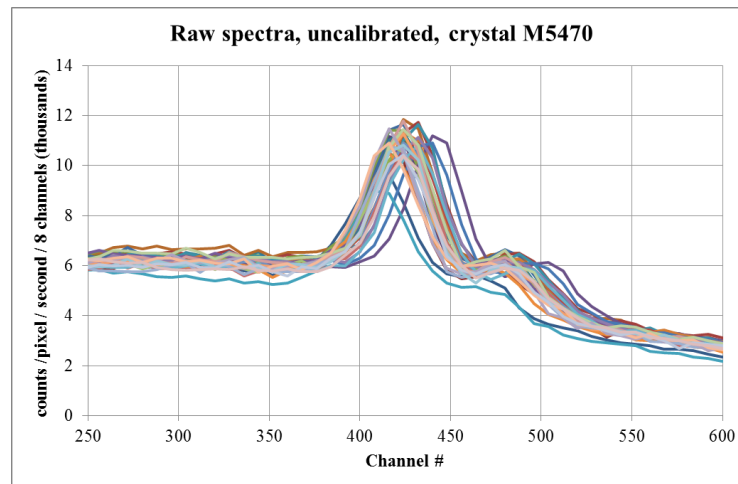
Parameter	Rotating	Fixed Source	Comments
Angular coverage	Full 360 ... redundant data	Fixed sources with 180-degree coverage	✓ Reduce redundant data (measurements)
Dwell (time per view)	Limited to #views per revolution x RPM ... constrained by motion blur	Variable / Adaptive ... constrained by time per slice	✓ Enables sparse views ... compressive sensing
View ordering	Constrained by motion	Random / Adaptive	✓ Minimizes mutual information in sequential views
Reconstruction	Analytic (FBP) or Iterative solutions	Iterative solutions (ART, EM, AM, ...)	✓ Requires more processing ... allows wider range of solutions
Reliability	Mechanical failure modes ... wear-out	Electrical failure curve ... no wear-out	<ul style="list-style-type: none"> <li>✓ Higher availability</li> <li>✓ Lower failure rate</li> <li>✓ Faster repair cycle</li> </ul>



# Multi-Energy Photon Counting Detectors

## Benefits

- Zero noise floor  
... information in every photon ... Low flux
- Direct conversion  
... room temperature operation
- Set gains and trims for consistent, stable performance



- Count rate limited ...  $\sim 10^6$  cps/mm<sup>2</sup>



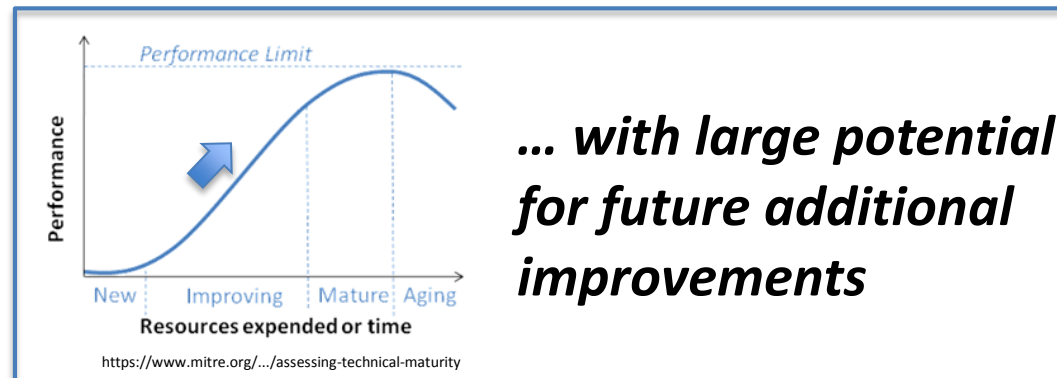
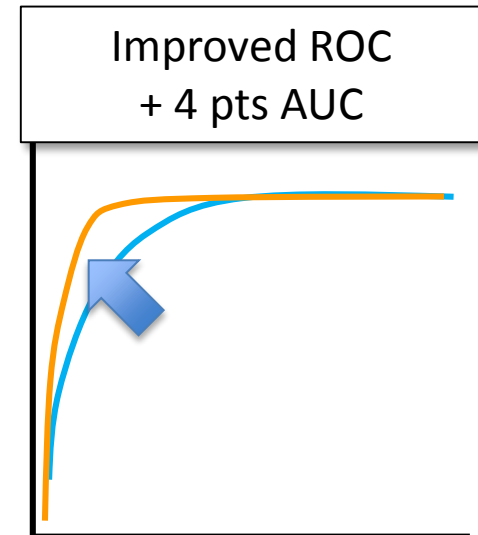
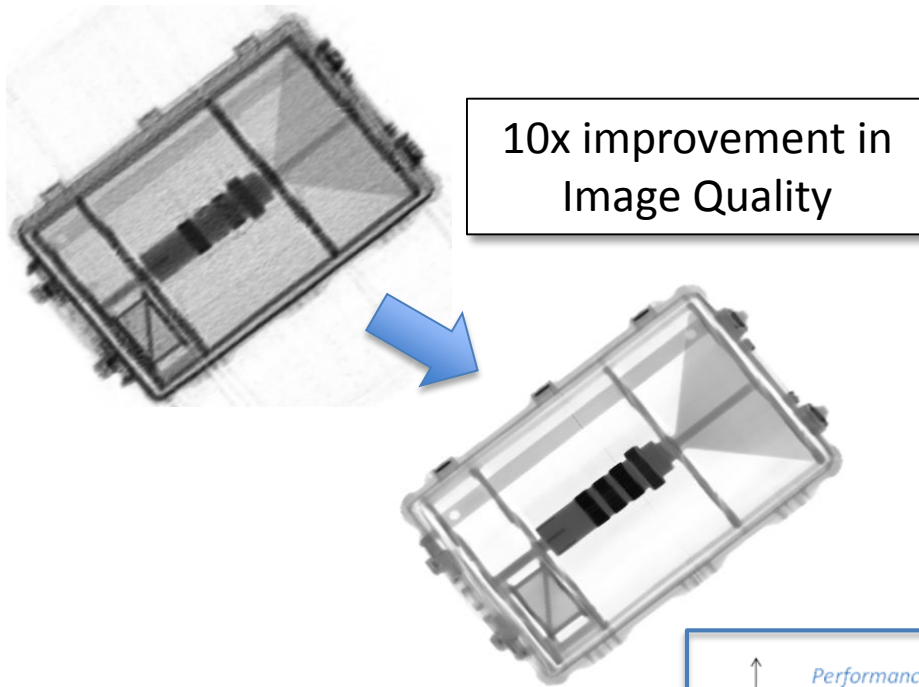
# Spectral Detectors

Parameter	Flux Integrating	Energy Sensitive	Comments
Efficiency	High	High	✓ High efficiency with detectors $\geq$ 2.0 mm thick
Signal Conversion	2-stage conversion Photons $\rightarrow$ light $\rightarrow$ electronic signal	Direct conversion Photons $\rightarrow$ electronic signal	✓ Higher conversion efficiency
Consistency	High	High	✓ More consistent, uniform performance with Traveling Heater Method (THM) devices
Noise Floor	Limited by dark current	No Noise ... every photon counts	✓ Operate at lower flux levels
Energy Resolution	Requires multiple detectors or sources with different energy / filters	$\sim$ 8% FWHM Energy Resolution Multiple energy bins	✓ Uses energy information in every photon
Dynamic Range	Large	Limited by saturation count rate	✓ Trade-off count rate with accuracy of multi-energy information
Electronics	Multiple options	Multiple options (ASICs)	✓ Many options available with open interface to vary/tune operating parameters



# Exploiting Improvements after Certification

SureScan x1000 Scanner ... certified with legacy algorithms  
... *however, using the same data with improved reconstruction*





**BACKUP**

# System Requirements

- **Physical Characteristics**

- Dimensions & weight (W x H x L) 7.3' x 7.5' x 16'; 13,250 lbs
- Operating environment 10°C up to 40°C; 10% to 85%, non-condensing, air-cooled

- **Power requirements**

- Scanner: 400/480/575 VAC +/-5%, 3-phase, 50/60 Hz, 15 amps (typical loads) at 480 VAC
- CT/Multiplexer Rack: 208 VAC, 50/60 Hz; 3 drops (one 15 amps, two 10 amps - typical loads)  
Power consumption Scanner: 7.5 kW typical. 50% less power than rotating gantry

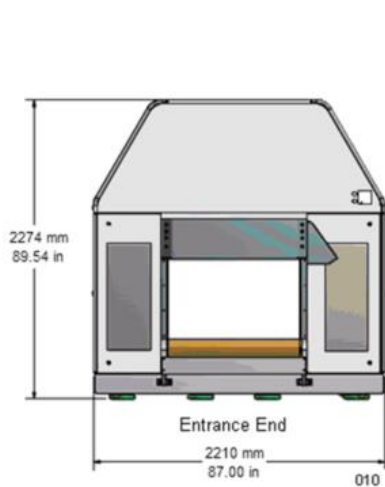


Figure 4: Scanner Dimensions – End View

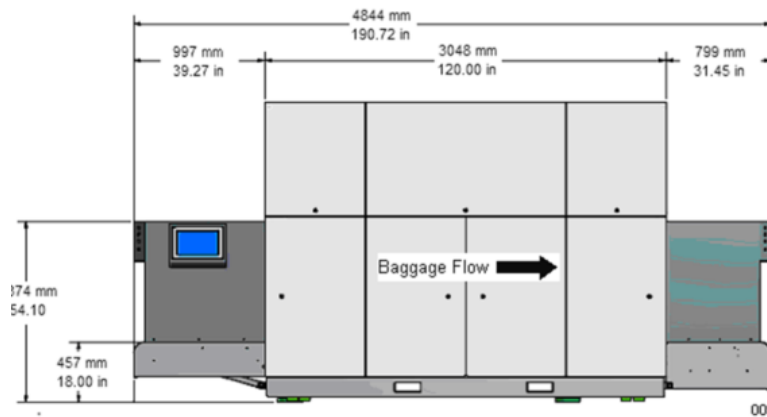


Figure 3: Scanner Dimensions – Side View

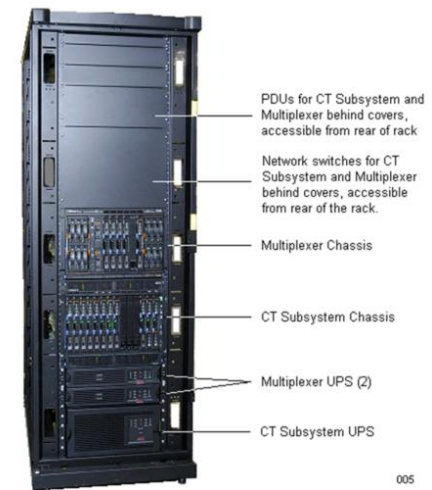


Figure 1: Rack with Front Door and Side Covers Removed