MULTIBEAM X-RAY CT FOR THE CHECKPOINT

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So What? Who Cares?

- Checkpoint baggage screening has limited ATR and has difficultly with overlapping items, electronics, and liquids due to limited x-ray views.
- Checkpoint baggage screening currently requires passengers to divest liquids and electronics which increases the number of scanned items and frustrates passengers.
- ATR at the checkpoint will increase detection, improve passenger experience, and reduce load on operators.
- ATR may increase PFA, require a significant change in CONOPS, and may not be able to automatically detect edged weapons and firearms.
- ATR requires CT like images. Current CT systems do not easily fit into the current checkpoint.
- Fixed gantry CT systems could be a better fit into the checkpoint, provide faster imaging, and operate more reliably.
- XinRay's Checkpoint CT solution:
  - Combines CNT multibeam tubes with fixed gantry CT geometry.
  - Provides high resolution dual energy CT images with high belt speed in a system that fits into the current checkpoint layout.
  - Has a simple and modular design.

Checkpoint Scanning Solutions

Single/Dual view

- Small footprint
- Fast belt speed
- Low power consumption
- High resolution 2D images
- Lower acquisition & maintenance cost
- Currently Deployed

Challenges:

- Poor material discrimination
  - Overlapping items
  - Divest liquids and laptops
- Rescans only way to change orientation of bag
- Fewer passengers per hour
- High personnel costs

Checkpoint CT (Not Deployed)

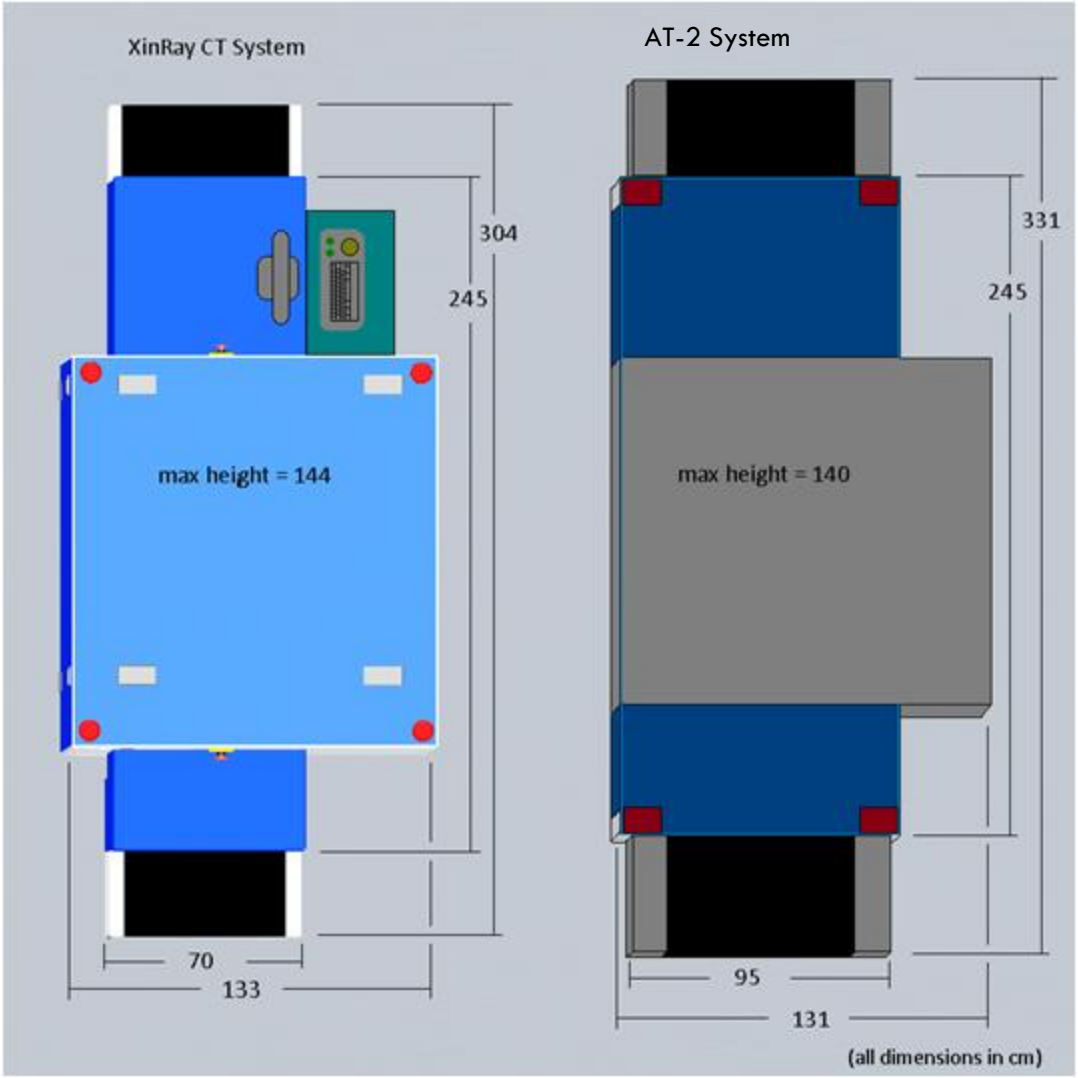
- Improved ATR
- No to need divest bags
- Improved threat detection
- 3D images
- Reduced operator load
- Lower lifetime costs

Challenges:

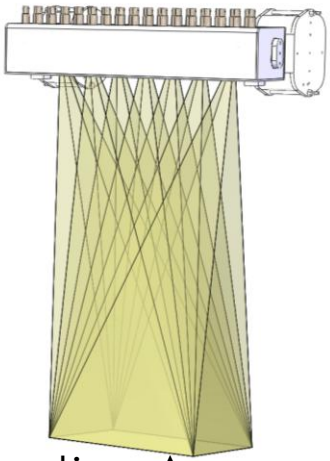
- High acquisition & maintenance costs
- Heavy & large footprint
- Slow belt speed
- High power consumption
- Edge weapons and firearms
- Change in current checkpoint CONOPS
- Increased False Alarm Rate (PFA)

XinRay's Checkpoint CT

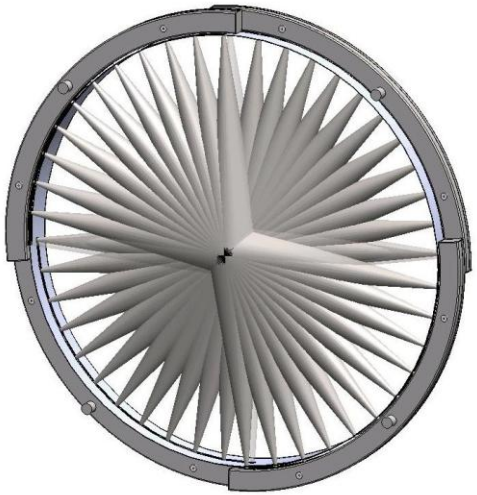
1. More views for a fixed-gantry system: 2.5 focal spots per cm
2. Simple design: conveyor belt is only moving part of the system
3. Footprint, weight, power consumption similar to AT-2
4. High resolution CT images and high resolution 2D projection images
5. Maintains high resolution imaging at high belt speeds
6. Modular and adaptable system design



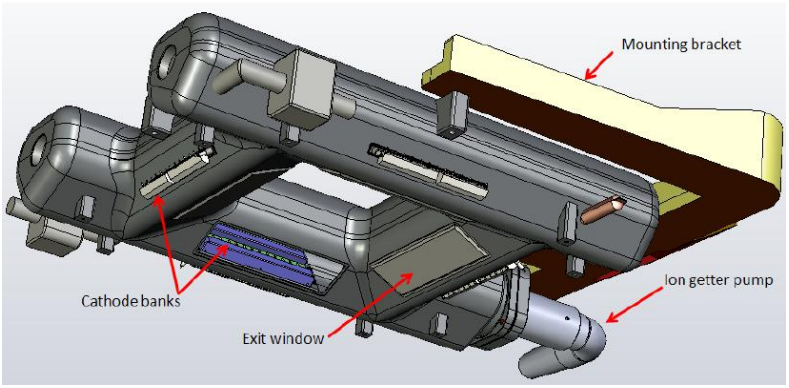
XinRay's Multibeam Tubes



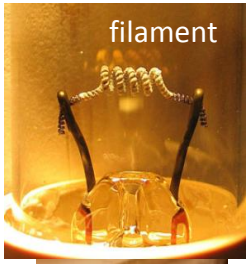
Linear Array

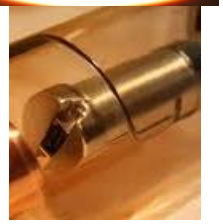


Circular CT Geometry

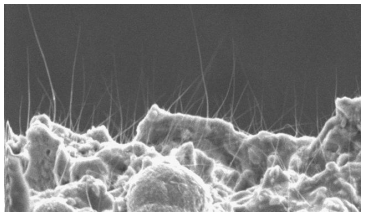


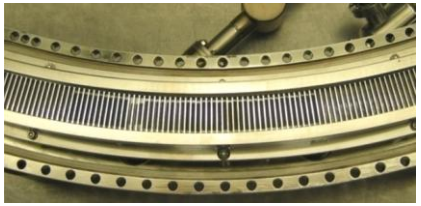
Square geometry for fast tumor tracking



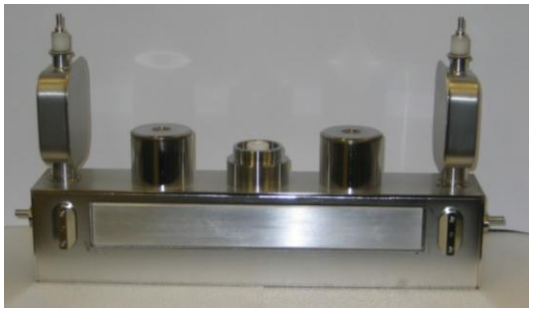


Conventional
X-ray tube technology

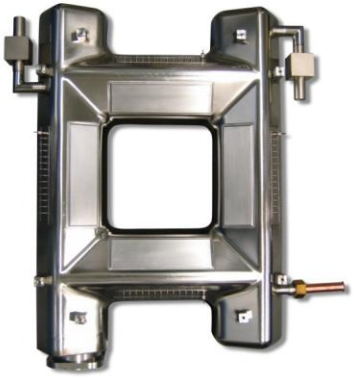




CNT Cold emitter
Technology from UNC



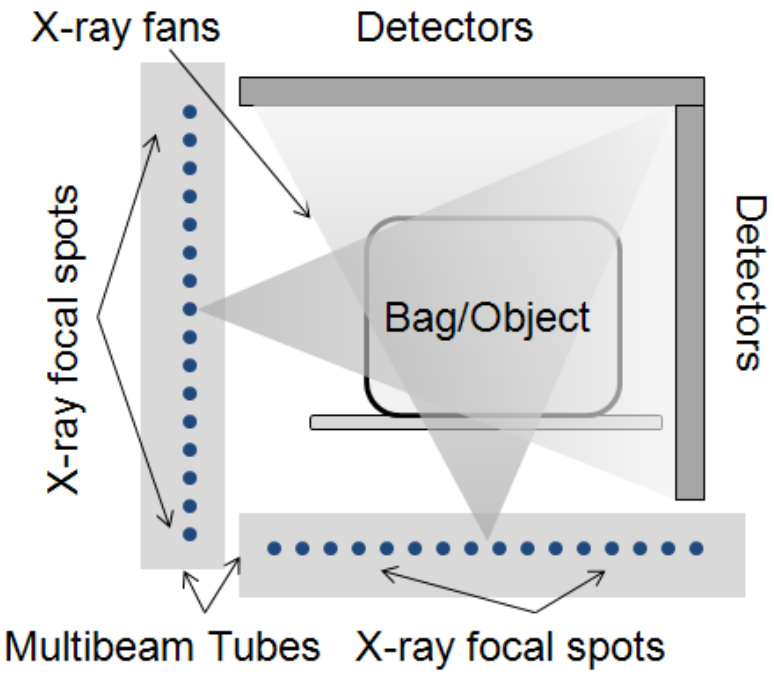
Linear multibeam tube for
3D mammography



Tested in Oncology
department at UNC

Fast switching in any geometry without motion

Fixed Gantry

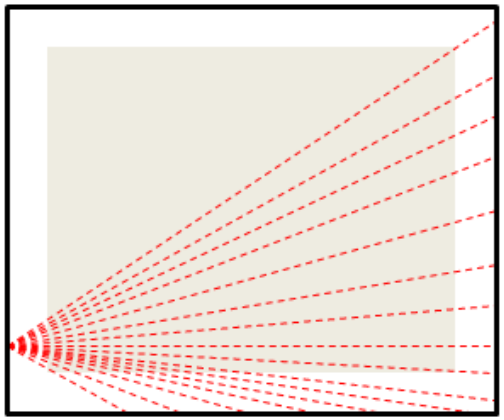


- Faster high resolution imaging:
  - ~70 Hz equivalent CT rotation
  - No motion blur due to moving focal spots
- Allow for more freedom in imaging sequence:
  - Optimize number and distribution of views to maximize image quality and belt speed
  - Variable dwell time, allows for 2D projection images
- Belt is only moving part
  - Reduced failure due to mechanical motion
  - No g-force strain on the system
  - No power required to move gantry
- Everything except tube is off-the shelf, relativity inexpensive, and simple to replace and maintain

Fixed Gantry Reconstruction

Challenges:

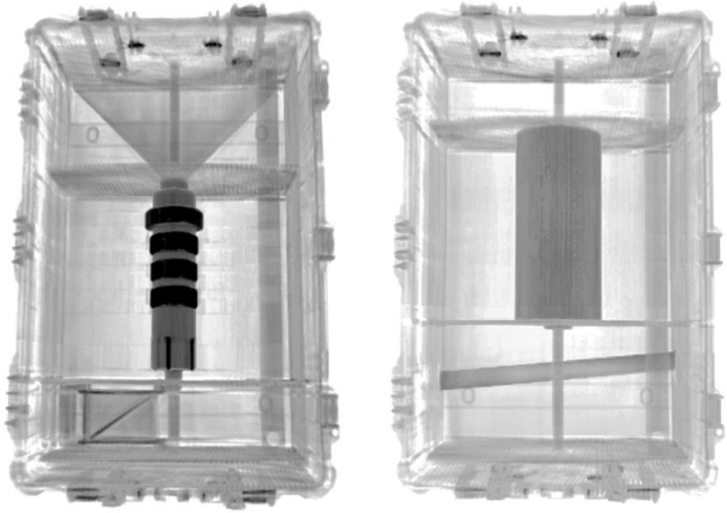
- Lack of circular symmetry
- Increased x-ray scatter
- Iterative reconstruction takes too long



Solutions:

- Iterative reconstruction
- Iterative scatter suppression
- Implement on GPUs

3D Renderings of NIST Phantoms

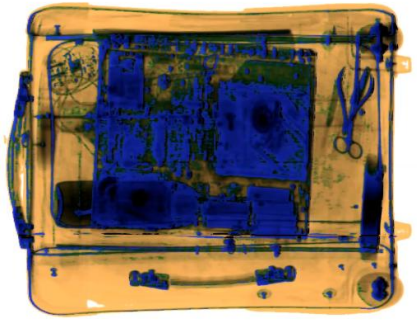


XinRay's Iterative Reconstruction:

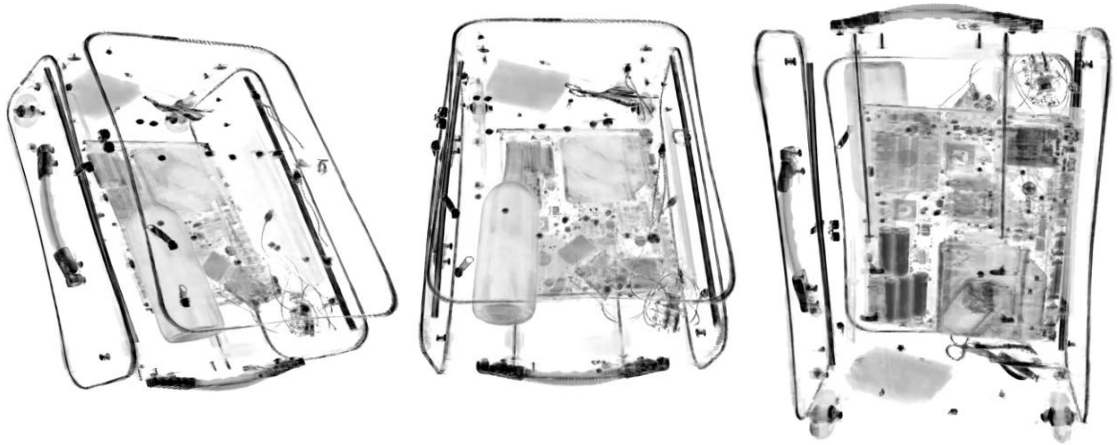
- Real-time dual energy iterative reconstruction with a voxel size of 1.0 mm by 1.0 mm by 1.6 mm.
- Implemented using two GPUs.

Imaging

Projection Image



3D Volume CT Image



- Easier integration into current checkpoint CONOPS
- Allows TSO to screen for edged weapons and firearms
- Allows TSO to screen bags without rescanning at different orientations
- Provides 3D information for EDS quality ATR

CT at the Checkpoint

- New CONOPS
  - Run belt at fast belt speed with minimal stopping of the belt
  - Use ATR to identify explosive threats
  - Allow passengers to keep liquids and electronics in bags
  - Provide 2D projection images to TSO to screen for edge weapons and firearms
  - Use 3D volume images for first level alarm resolution
- Risk-Based Screening
  - Adaptive **imaging** based on individual passenger risk
    - Can increase current, dwell time, and number of views to increase image quality at the cost of belt speed
  - Adaptive ATR algorithms
- Future work
  - Spectral detectors in place of dual energy detectors
  - Adaptive CT imaging

System Reliability

- The key system component lifetime reliability are the multibeam x-ray tubes.
- X-ray tubes have a projected lifetime of 5-6 years so the tubes will have planned replacement once in the lifetime of the system.
- X-ray tubes have built in redundancy to reduce the risk of failure.
- Other system components are off-the shelf and easy to access in the system design, requiring minimal system down time to maintain and/or replace.

System Costs

- System acquisition cost close to existing high-end dual-view imaging systems and significantly less than current small CT systems
- Maintenance costs will be comparable to existing dual-view systems due to:
  - Easy access to system components due to simple system design
  - Reduced mechanical wear down on system
  - Redundancy in the x-ray tubes
- Total Cost of ownership is projected be significantly lower than both CT and dual-view systems due to:
  - Reduced number of operators resulting from:
    - Fewer rescans
    - ATR for identifying explosive threats
    - No need for passengers to divest liquids and electronics
  - Lower maintenance and acquisition cost compared to conventional CT

Questions