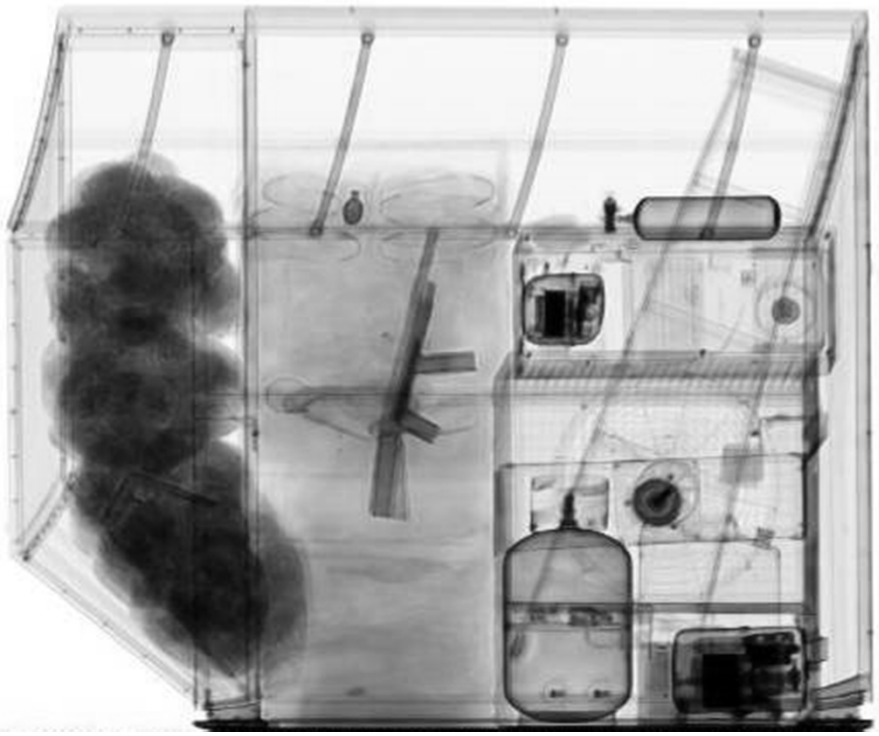

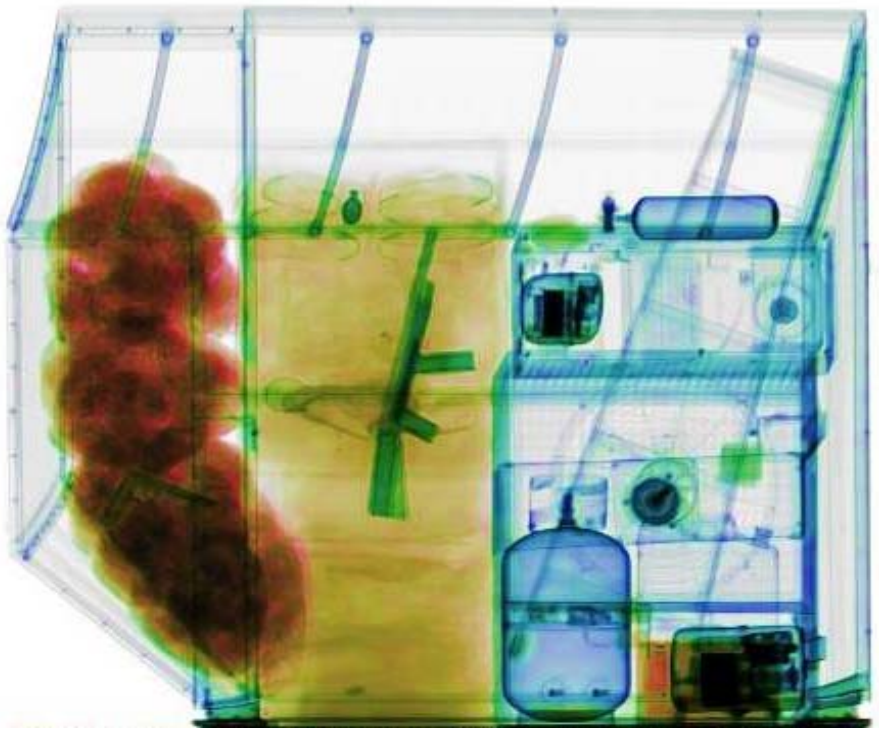

Cargo scanning with X-rays and neutrons and the challenge of effective detection

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CSIRO **MDU Flagship**

ADSA10 – Explosive Detection in Air cargo, Northeastern University, Boston, May 6-7, 2014

Air Cargo Scanning

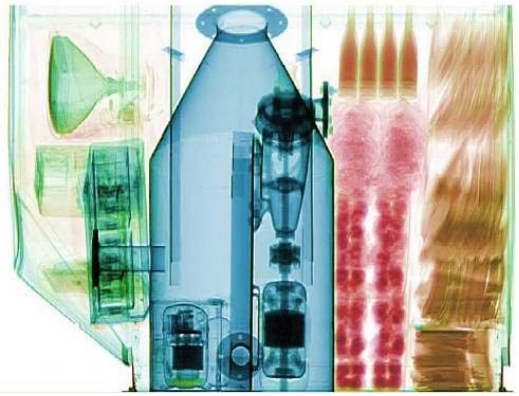
- Only a small fraction of global air cargo is currently examined *physically*
- Cargo volume and levels of scrutiny are expected to increase
- Wide range of potential threats – explosives, weapons, narcotics, prohibited materials, etc
- CSIRO and Nuctech have developed a fast-neutron/X-ray scanner to address the problem

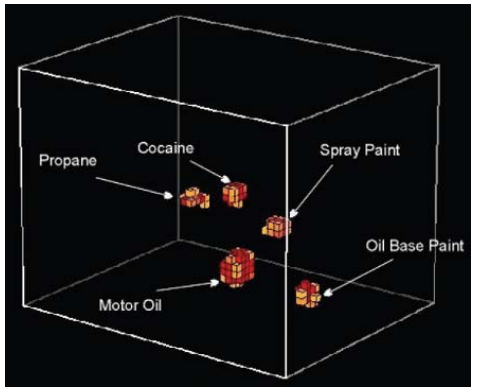
Major challenges

- Scanner - footprint, speed, reliability
- Imaging – small objects in large cargo
- People – effective process

Technology comparisons

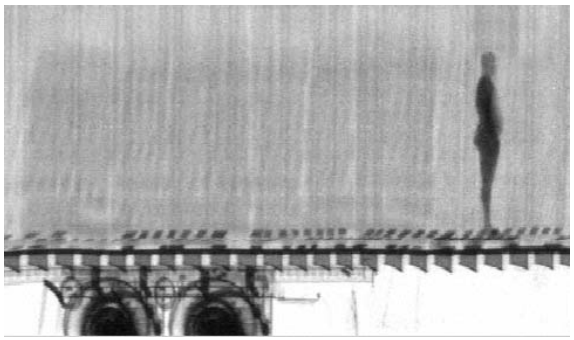
Add parallel neutron source and detectors to X-ray scanner





3D ‘voxel’ techniques
Complex, large systems
3D material discrimination

Neutron radiography
Commercially available
3D material discrimination possible with advanced software tools



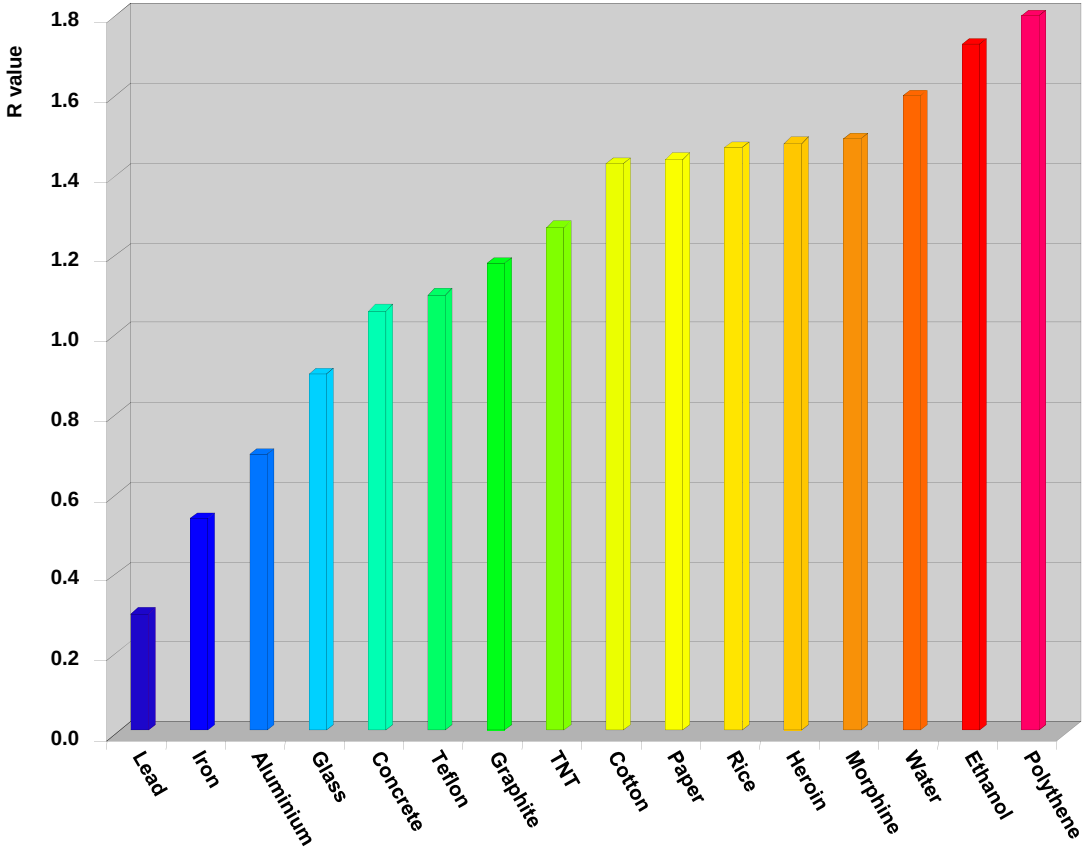
Conventional X-ray
Wide-spread deployment
Little or no material discrimination

High-power accelerator neutron source
Large gamma-ray detection system

AC6015XN Air Cargo Scanner

- Incorporates 6 MV X-ray LINAC and 14 MeV neutron source
- Scanning speed up to 6 m/min (10 cm/sec)
- Small commercial neutron generator (5x10^8 n/s)
- Modular construction for rapid assembly on airport site

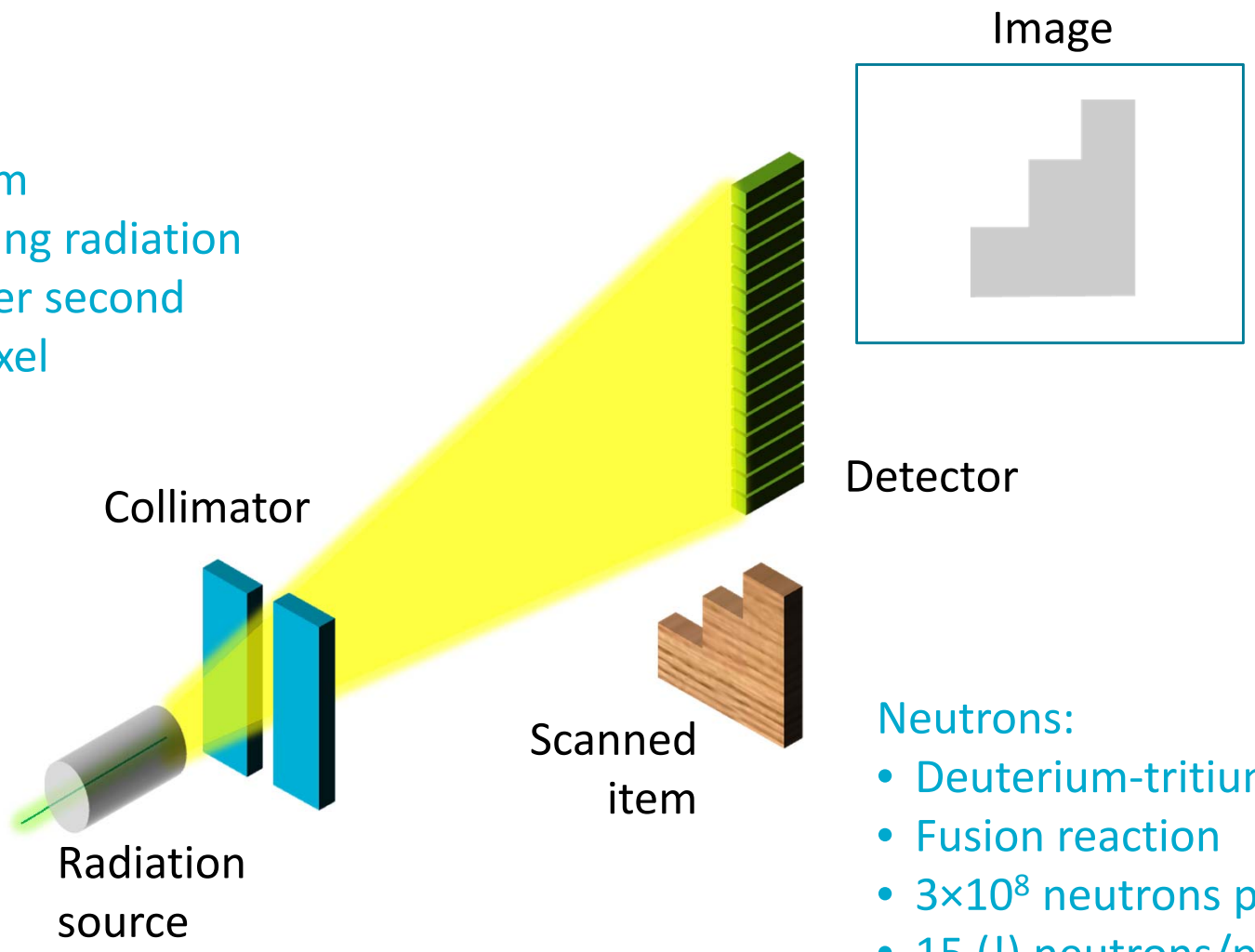
Combined X-ray/neutron imaging



Collecting X-ray and neutron images

X-rays:

- Electron beam
- Bremsstrahlung radiation
- 10^{13} X-rays per second
- 10^{5} X-rays/pixel

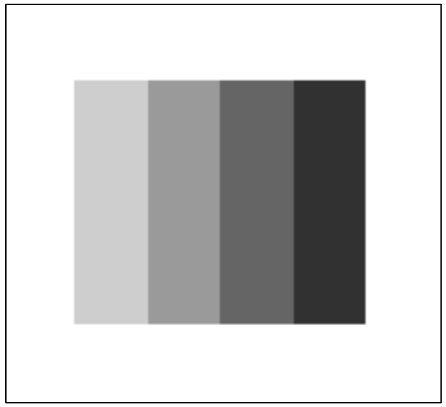


Neutrons:

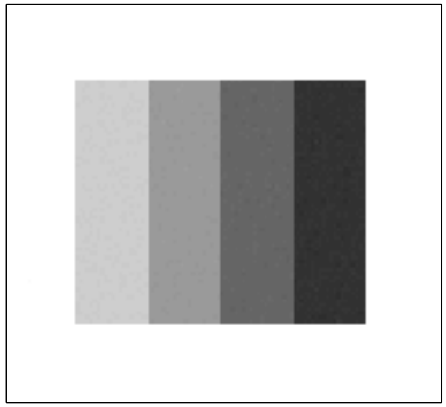
- Deuterium-tritium beam
- Fusion reaction
- 3×10^{8} neutrons per sec
- 15 (!) neutrons/pixel

Statistics and image quality

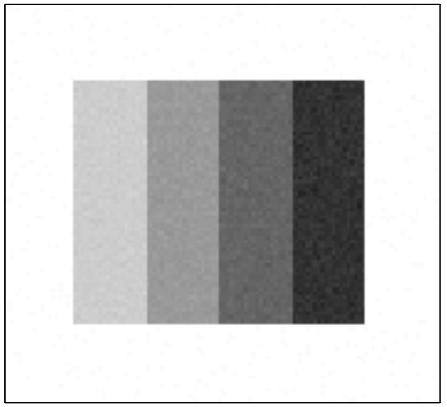
Original image



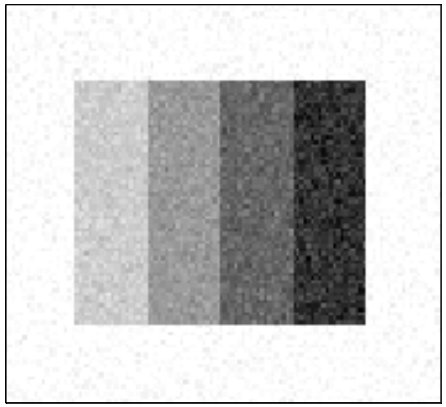
$I_0 = 10^5$



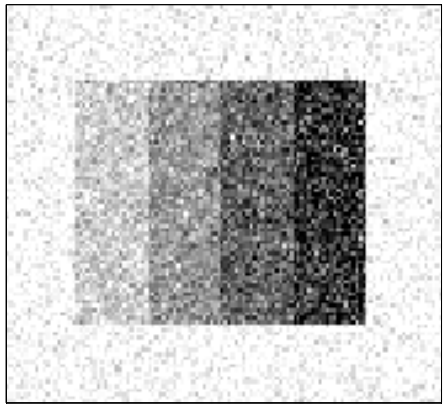
$I_0 = 10^4$



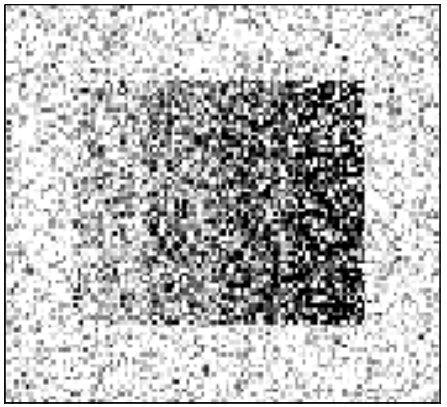
$I_0 = 1000$



$I_0 = 100$

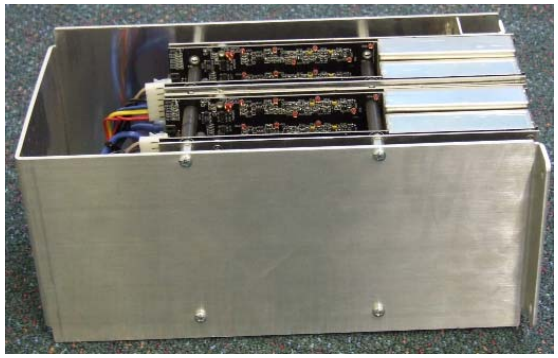


$I_0 = 10$



Solution (1) – improved neutron detectors

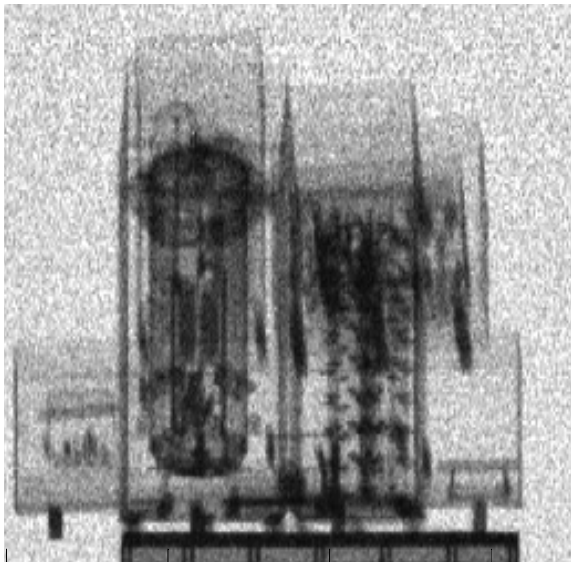
- Major technology development over past decade
- Basic detector element comprises plastic-scintillator, solid-state photodetector, discriminators and counting electronics
- Main drivers - Increased efficiency, reduced form-factor/power consumption/cost, automated calibration and fault-finding



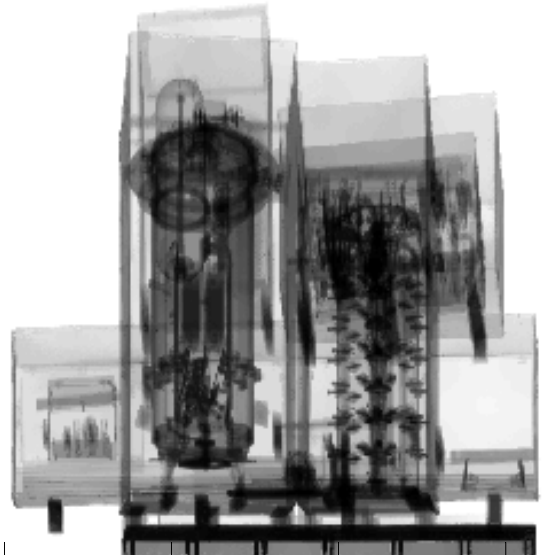
Prototype	Mark 1+2	Mark 3
1 column	4 columns	6 columns
<10% efficiency	10% efficiency	30% efficiency
	×4 overall gain	×20 overall gain

Solution (2) – Image Filtering

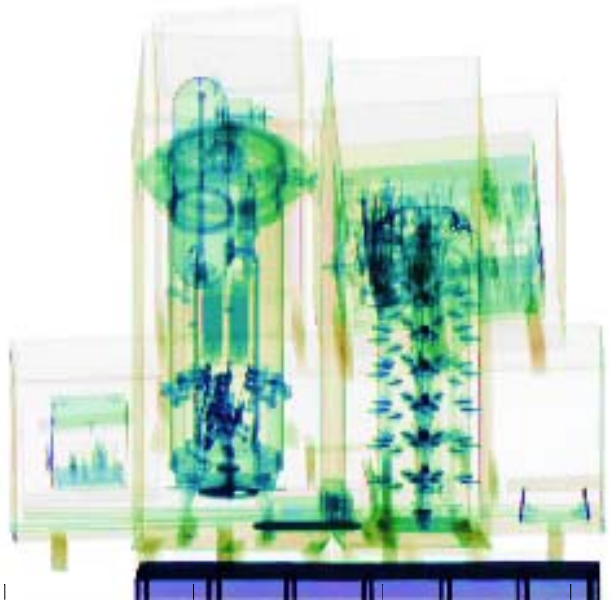
- Problem – low SNR makes it impossible to discriminate real features from noise
- Images of real objects exhibit a high degree of spatial coherence
- Solution – custom image filtering using both neutron and X-ray data



Raw neutron image



Filtered neutron image



Combined image

Effective detection

Scanner

Distinctively shaped items need:

- High-resolution images
- Good penetration

→ **Driven by X-ray performance**

Quantitative materials detection needs:

- Good image filtering
- Accurate R-value determination
- Tools to handle overlapping materials

Process

Agreed image analysis process that optimises detection :

- “Hardwired” image assessment process?
- Adequate training

Efficient targeting and handling strategy for bulk cargo

- Customised to client logistics
- Speed important at cargo hubs

Conclusions

Fast-neutron/X-ray radiography proven for air cargo assessment.

- Scanner footprint being optimised for differing applications
- Reliability of systems optimised
- Imaging quality – enhanced through new filtering approaches
- Effective detection – further work progressing with clients

Thank you

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