Academic-industry collaboration on source development for security screening

David Sharp (not an accelerator physicist)

Particle Accelerator and Beams Conference, Lancaster, July 1st 2026

Contents

Who are Rapiscan?

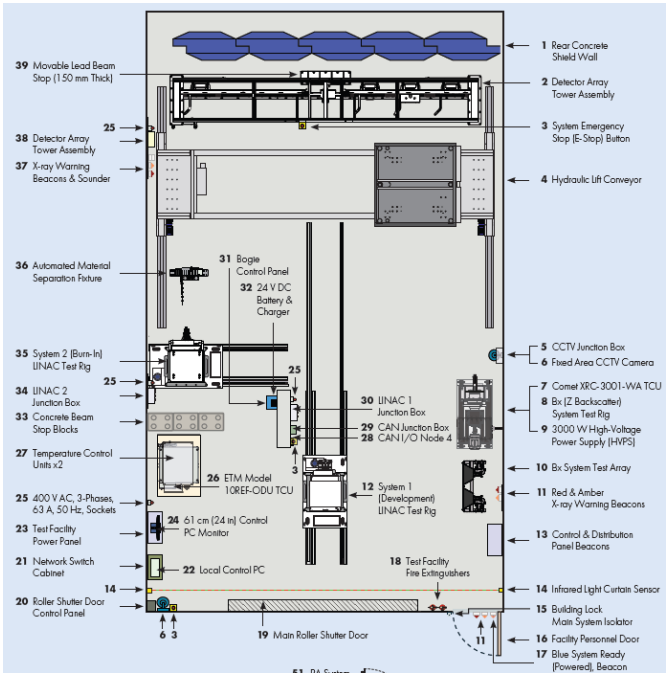
Rapiscan®

Global leaders in security screening technology.

Site based in Biddulph, just north of Stoke-on-Trent (another in Salfords near Gatwick).

Home to our x-ray imaging laboratory, including linac test bunkers, that enable sub-system level performance testing.

Footprint at Daresbury as tenants of the Campus Technology Hub.



X-RAY IMAGING LABORATORY

DEVELOP TEST VALIDATE

SECURITY SOLUTIONS FOR A SAFER WORLD

Cargo & Vehicle Inspection Systems

Rapiscan®

Portals
for Cargo & Trucks

Gantry
for Cargo & Trucks

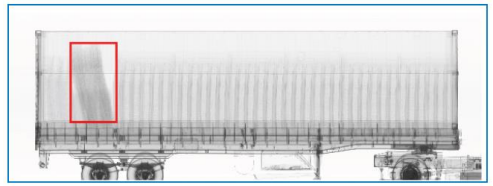
Mobile & Trailer
for Cargo & Trucks

Rail
for Rail Cargo

Portals
for Passenger Vehicles

Air Cargo

Handheld

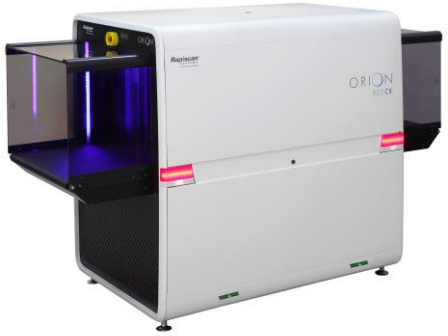


insight®

Intelligent Image Analytics

Aviation and checkpoint inspection

Rapiscan®



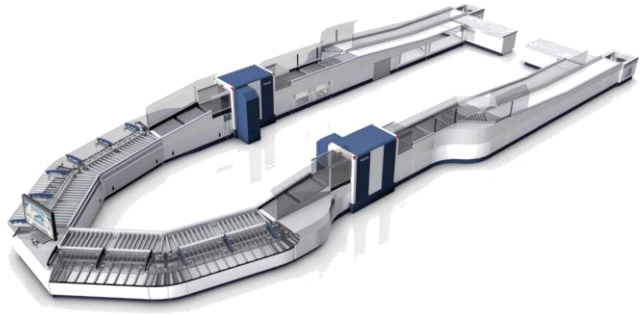
Baggage & Parcel X-ray

EDS for Cabin Baggage

Real-Time Tomography EDS

Trace Detection

People Screening



Tray Return System

Training

Radiation Detection Systems

Rapiscan®

Portal

Mobile

Pedestrian

Conveyor

Portable

Handheld

Complementary Detection Technology:
Transmission X-rays and Z Backscatter X-rays

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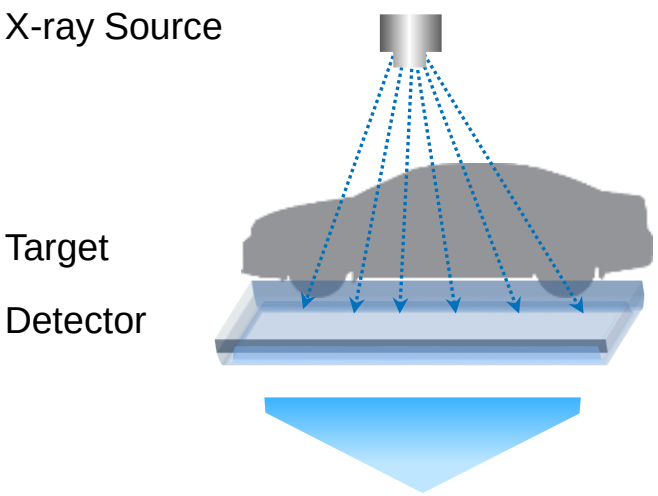
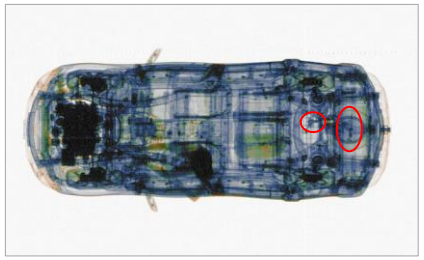
Transmission

X-rays detect by passing an X-ray beam through a target to a detector on the far side.

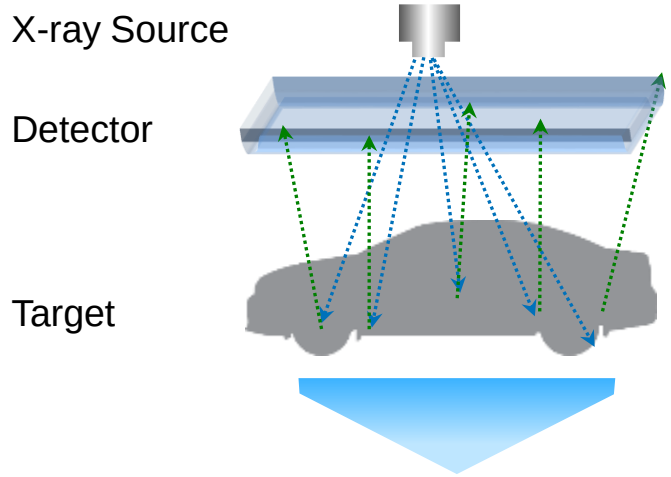


The transmission image reveals two weapons in the rear of the vehicle

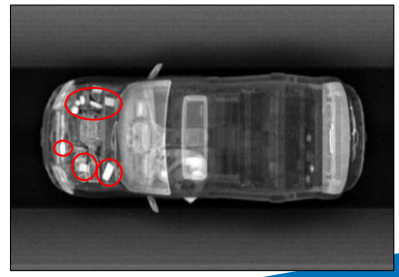


Z Backscatter

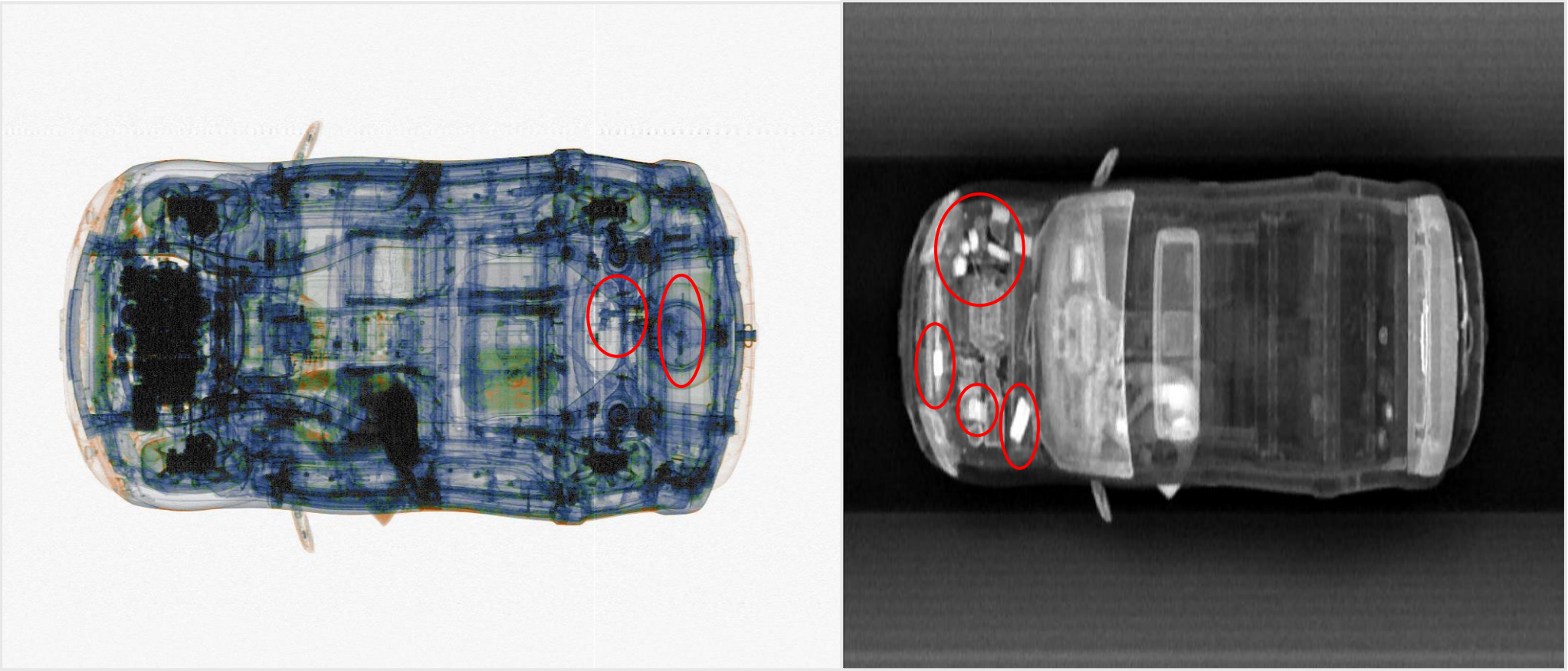
X-rays detect by reflecting an X-ray beam from a target to a detector on the near side, creating a photo-like image that is easy to interpret.



The Z Backscatter image of the same vehicle reveals hidden drugs and currency



Transmission X-rays and Z Backscatter X-rays



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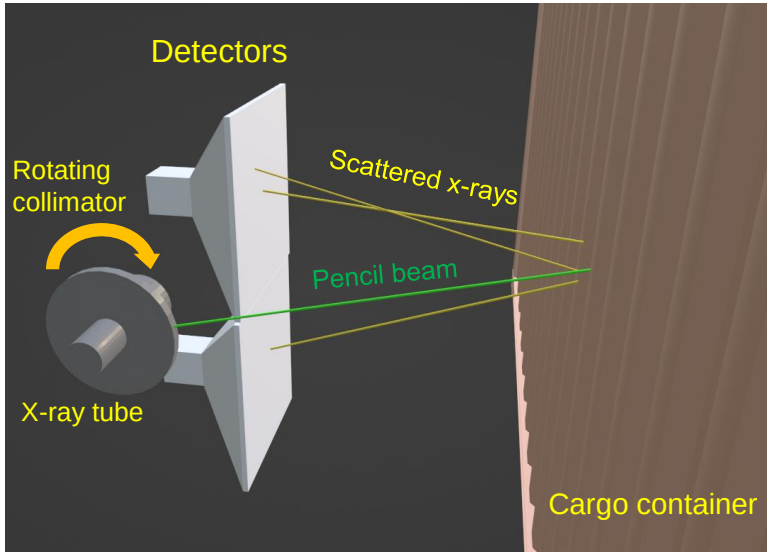
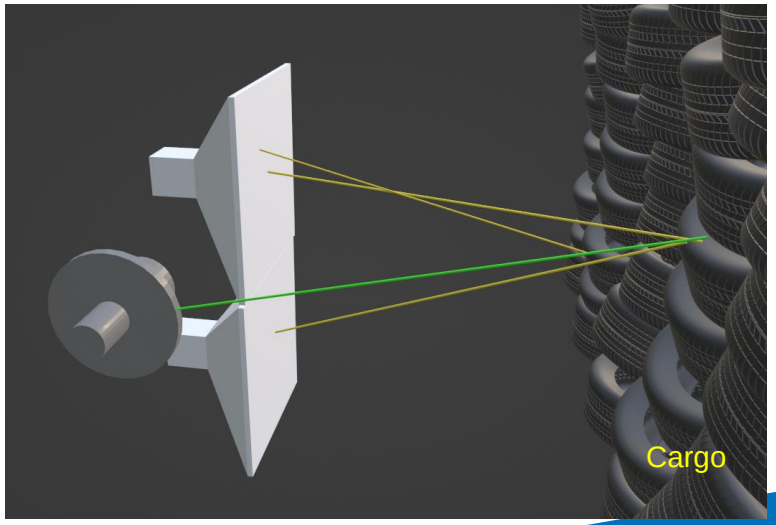
Backscatter (Bx) systems

- X-ray source: **Tube around 200 keV**
- Collimated beam: Rotating pencil beam
- Directed onto object
- Object scatters X rays
- Some X rays reach detectors source-side
- Signal on detectors changes: Scintillator screen – PM tube



Mobile units

Handheld units



Transmission systems

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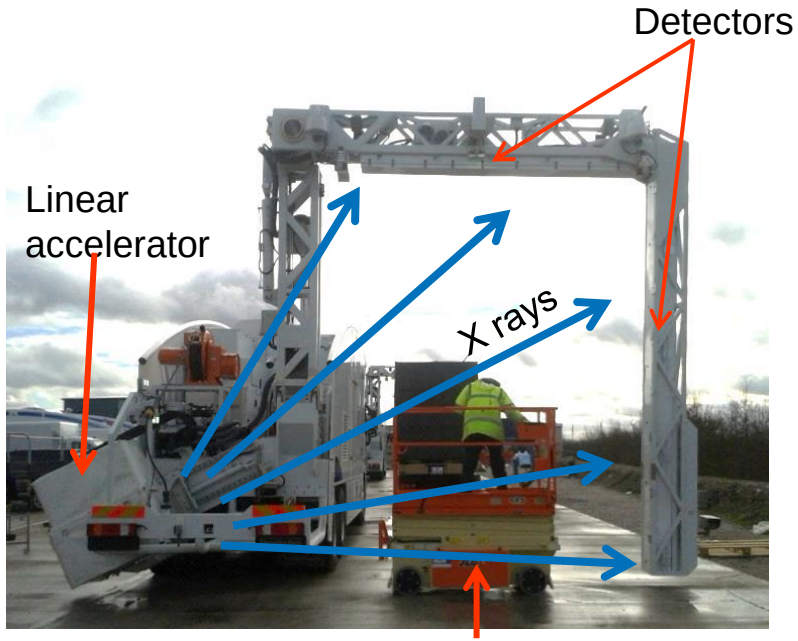
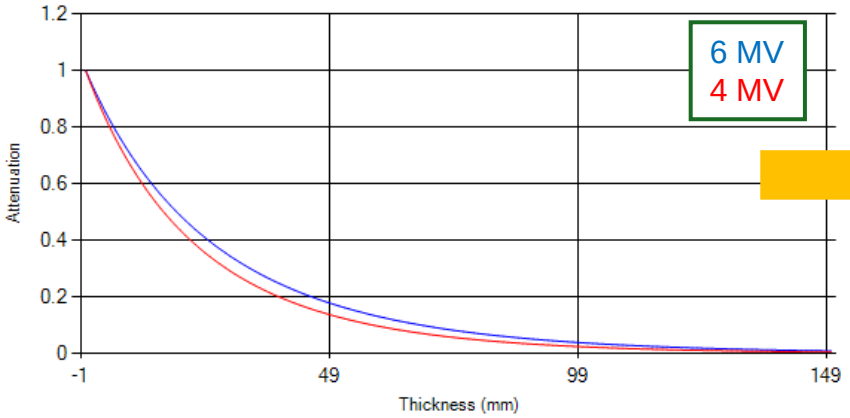
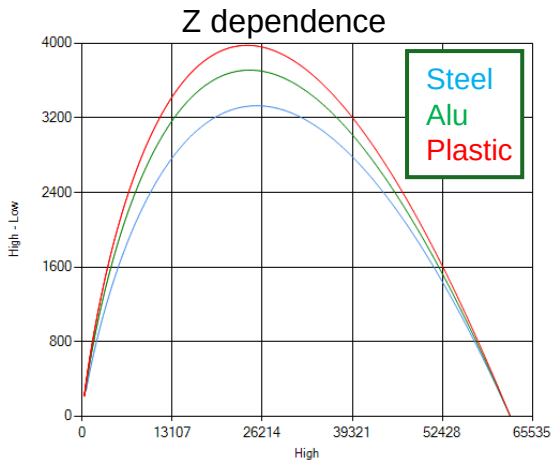
Transmission imaging concept

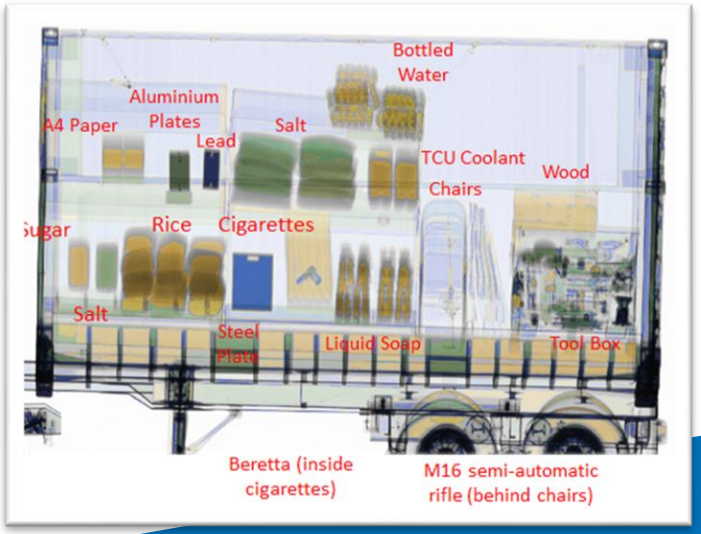
- Linac X-ray source
- Collimated beam
- Directed onto sensitive detectors
- Object between source and detectors
- Object attenuates x-ray beam
- Signal on detectors changes

Dual-energy system 4-6 MeV
- Attenuation through thicknesses of steel
- Observe difference between energies



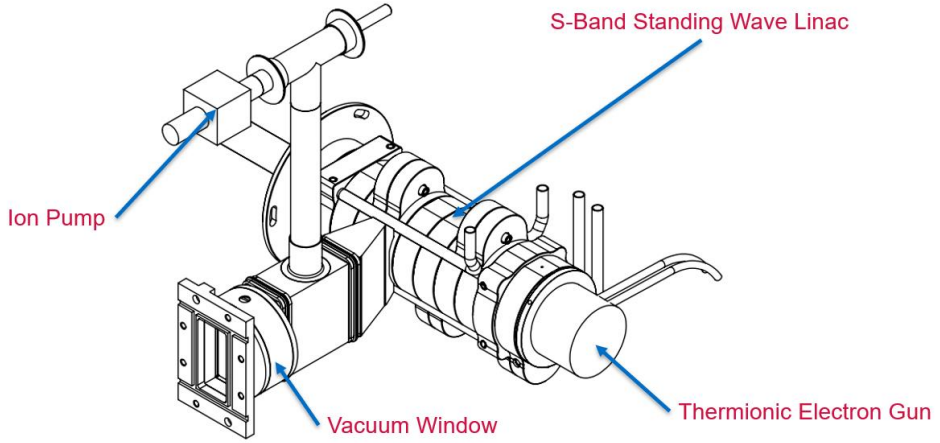






Linacs for Security

- Accelerator design for security is mature and **there has been little development.**
- Linacs used in cargo inspection systems are typically:
  - **Normal conducting electron linacs**
  - Standing wave design
  - Magnetron RF source
  - Self Contained Systems
- Beam energy ranges from 1 to 9 MeV
  - **Typical energies are 2.5MeV and (4)/6MeV**
- Beam currents up to 200mA
- Beam spot size of <2mm
- Repetition rates of up to 800Hz
  - Typically closer to 400Hz



X-ray Source

- **Linac critical to imaging performance** Defines (along with detector geometry) throughput (rep rate), penetration and exclusion zone (dose), material discrimination (stable energy output).
- **Dose Optimisation** We have a legal responsibility to minimise dose to people; this means we need to optimise source design to deliver maximum performance at minimum dose
- **Novel Subsystem Developments** For linear accelerator systems we are open to subsystem developments (RF sources, diagnostics, cavities, electron guns, etc.)
- **Design for Industry** X-ray source development needs to consider how they will be operated (environment, reliability, skill level, size)
- **Cost** For high energy systems the x-ray source is typically the single most expensive component.

Rapiscan®

Leveraging a wider pool of innovative researchers, facilities and expertise for all TRLs

STRATEGIC PARTNERSHIPS

Rapiscan®

Academic Partnerships

Leveraging a wider pool of innovative researchers, facilities and expertise for all TRLs

Expertise in various areas of R&D

- Novel instrumentation and potential new inspection modalities or technologies.
- Algorithm development and data science.
- **New source technologies.**

Lab access and technician support – detector development labs, electronics labs.

Manufacturing capabilities – e.g. laser manufacturing, 3D printing, Rapid prototyping, mechanical workshops, PCB manufacturing.

National facilities – ISIS neutron and muon facility. National Physical Laboratory. Daresbury.

Large pool of researchers – undergraduates, PhDs and postgraduate researchers. **Extra R&D resource!**

STRATEGIC PARTNERSHIPS

Rapiscan®

Industry Partnerships

Leveraging a focussed pool of innovative researchers, facilities and expertise for commercialisation

Expertise in various areas of **applied** R&D

Validating technology in relevant environments.

Deployment of industrial accelerators within a complete system.

Lab access and technician support – detector development labs, HV lab.

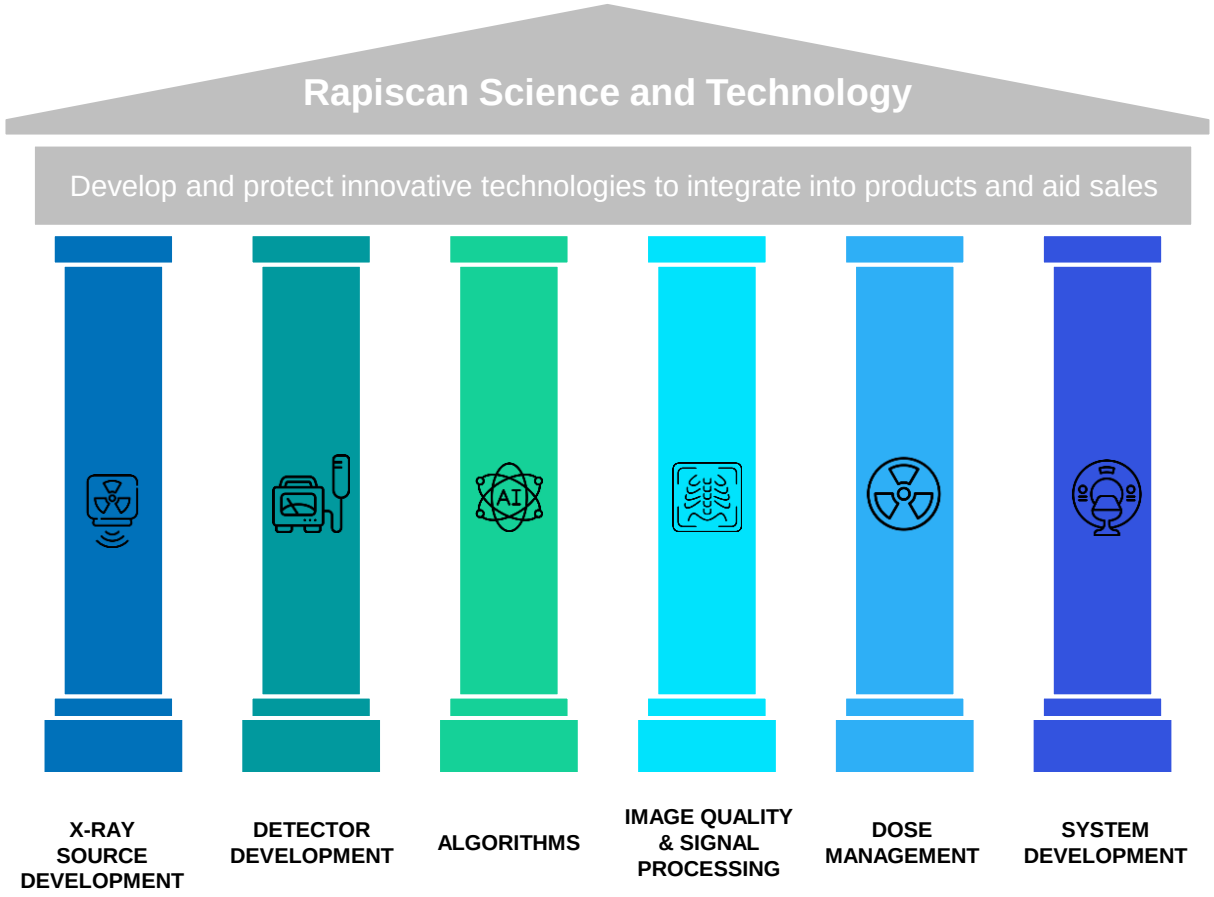
Manufacturing capabilities – engineering support and expertise for system deployment.

Industrial facilities – test facility (access to imaging systems), bunkers for source development (higher TRL).

Pool of researchers and business input–understanding of markets, size, competitive price point.

Funding – access to different funding pipelines

Cargo Science and Technology Group (UK)



Mark Procter
Vice President
Cargo Science & Technology

James Ollier
Science & Technology Manager

Mike Jenkins
Senior X-ray imaging Laboratory Manager

David Sharp
Director Technical Business Development

Joe Crone
Accelerator Scientist

Dre Cristini
Data Scientist

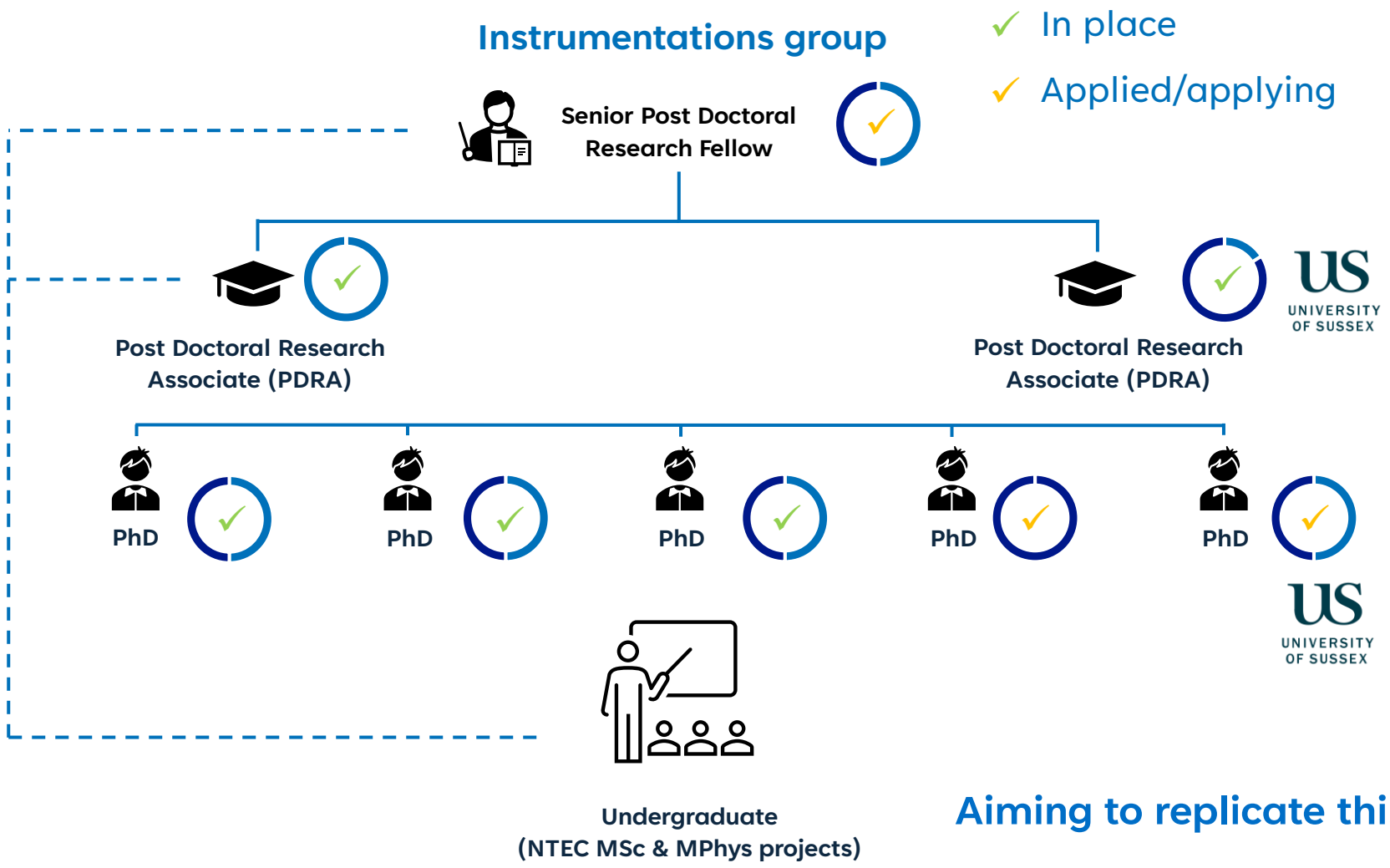
Science and technology team is global.

Stoke team contains a mix of STFC trained scientists (accelerator, nuclear and astro).

Key areas of R&D in detector development, source development, algorithms and image quality.

LEVERAGING ACADEMIA

Innovation in the North-West of UK



✓ In place

✓ Applied/applying

- Targeting Manchester fellow to provide leadership of group – and alignment to industry priorities.
- PDRA (IAA funded) currently employed until December.
- Application for 2.5-year KTA.
- 3 current PhDs (EPSRC,CDT) and 2 proposed projects in rad detection (DFAs).
- Masters projects.

Aiming to replicate this effort in source development

IMPACT CASE CREATION – Pathway to product

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IMPACT CASE CREATION

Demonstrate Value & Evidence-Based Outcomes

DISCOVERY: TRL 1-3

- Sub-surface laser etching of CdWO4 crystals
- Phoswich – dual energy from single device
- Radiological heat mapping using RPMs.
- Neutron transmission imaging
- Active Bx filtering for improved material classification
- Muon imaging for air cargo
- **Electron beam manipulation.**

INCUBATION: TRL 4-6

- Fast scintillators coupled to SiPMs
- **(Electron test beamline design and construction)**

ACCELERATION: TRL 7-9

- **2.5MeV beamline integration.**
- SiPM integration/PMT alternative technology

Range of projects supporting new capabilities for current products as well as new imaging modalities.

Instrumentation and source development

Generation of impact case is **aligned to our goal of transitioning technology to products.**

Shared IP agreements based on market - Rapiscan maintain IP for use in security

Academic collaboration

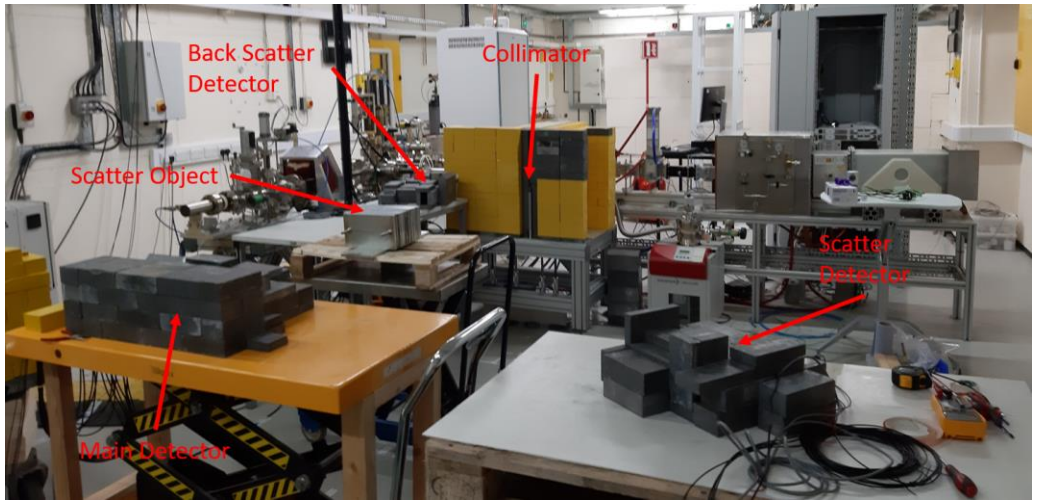
- **New Sources** Future compact sources for x-ray generation (and new imaging modalities).
- **Electron beam manipulation** Investigation of manipulating the electron beam to produce the best x-ray beam in terms of geometry and energy spectrum, making most efficient use of the dose.
- **Electron gun design** Sub system development based on expertise in electron gun – robust operation required.
- **Diagnostics** To explore the above requires development of a diagnostics beamline at Rapiscans sight in Stoke where expertise in diagnostics and vacuum systems is critical. Collaboration with Manchester started.
- **Low energy sources** Interest in pulsed low energy sources <500keV. Future competitive technology to x-ray tubes (filed emission, compact linacs).
- **Terahertz sources for person screening** New technologies for person screening that provide improved performance on current mm-wave.

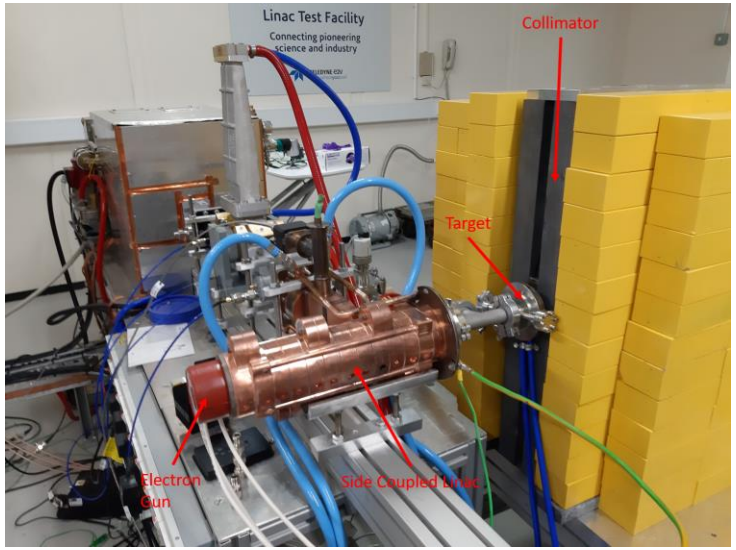
Rapiscan Cockcroft Collaboration

- Rapiscan have been collaborating with the Cockcroft Institute for around 15 years – experimental work on site.
- Collaborations have primarily been through Lancaster University and STFC.
- Work at Daresbury has concentrated on linac development and detector testing.
- Developing on site capability at Rapiscan Innovation Centre (Joe Crone talk).

Collaborative projects

- Projects have included:
- **X-band Linac (2011 to 2014)**
  - Rapiscan, Lancaster and STFC.
  - **Linac Test Facility**
  - Innovation grant and direct funding towards facility use.
- X-ray Time of Flight Evaluation (2015)
  - Rapiscan, Liverpool, UCL and STFC.
  - **Versatile Electron Linear Accelerator – provided pulsed beams.**
  - PhD and Innovation grant with Rapiscan contribution towards facility access.
- Photon Counting Experiments (2019 to 2021)
  - Rapiscan, Manchester and STFC.
  - **Linac Test facility.**
  - **Electronics expertise.**
  - Innovation grant with Manchester.
- New Linac Design for Car Scanner (2020 to 2024)
  - Rapiscan and Lancaster.
  - **Simulations based.**
  - ASHE Doctoral Training Centre PhD.
- Cockcroft Summer Student Program (2024)
  - Rapiscan and Lancaster with 3 students working across two projects (another has started this summer).
    - Detector diagnostics – developing bench top diagnostics that related back to x-ray performance.





Source Development: Case study 2.5MeV

Drive for a low Energy, low Output (reduced dose footprint) source

- Initially 1 MeV, up to 2 cGy/min at 1m @ 100 Hz.

Mobile screening with a small exclusion zone:

- Current mobile screening systems require 40m x 40m exclusion zone ⇒ protect public.
- A low energy and dose rate LINAC can:
  - **significantly reduce the exclusion zone footprint,**
  - **allow scanning in more constrained areas**
  - **allow deployment on a smaller mobile chassis (no need for HGV license).**

Source Development: Case study 2.5MeV

The Cockcroft Institute of Accelerator Science and Technology

Lancaster University

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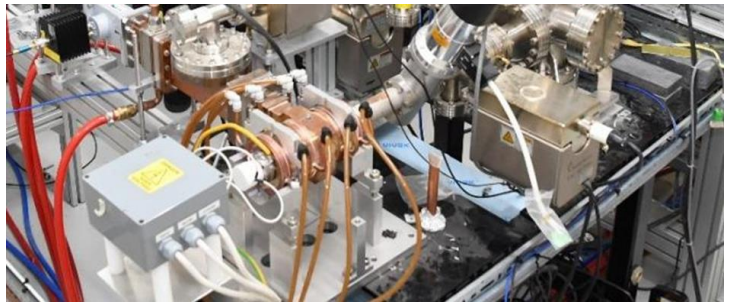
CLASP I – 1 MeV beamline

- X-band technology chosen due to:
- e2V collaboration on electron gun and magnetron.
- Lancaster beamline design.
- Shakespeare engineering manufacturing.
- Rapiscan – x-ray target and imaging.
- Achieved 1.5MeV@10smA.

CLASP II - Move to 2.5 MeV

- Pivot to S-band 2.5MeV beamline design.
- More market opportunity.



KTP?

- KTP submitted with Lancaster to translate technology to Rapiscan.
- Applicable to air cargo screening and medium energy mobiles.

New markets with 2.5MeV system

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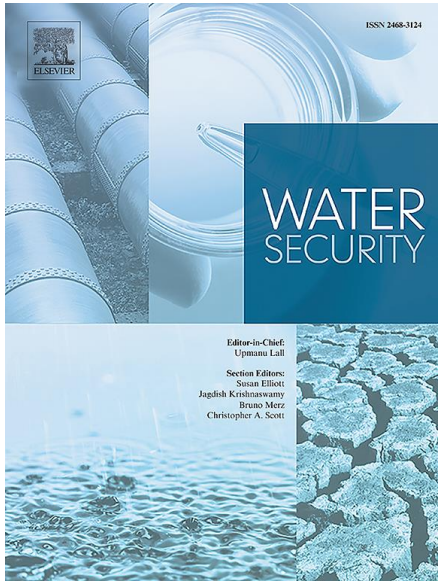
Inspection

- Imaging and Evaluation of people/objects
  - Borders
  - Infrastructure
  - Hardware
  - Cargo

Processing

- Improve, Treat or Protect materials
  - Wastewater
  - Soil
  - Food
  - Materials (leather)
- Typically x-ray or electron beams



Summary

Rapiscan deploy X-ray source technology as part of imaging systems.

- We have specific requirements in the security field

Key areas of R&D for Rapiscan are:

- Understanding and producing ideal energy spectrum.
- Making best use of the dose.
- Stable delivery of dual energies (interleaved verse intrapulse).
- Electron beam irradiation.

Academic-industry partnerships benefit both parties.

- Business partner provides market needs and **commercialisation pathway** (and industrial facilities).
- Academic partner provides expertise in **existing and emerging technology** and R&D resource (and academic facilities).

Our science team is heavily from **STFC background** (2 accelerator, 3 nuclear, 1 astro).

Our academic engagement is predominantly with STFC scientists and labs but collaborative funding predominantly from EPSRC and Innovate sources.