

Exploring the use of Nuclear Resonance Fluorescence (NRF) in Counterfeit Detection

WCO Technology and Innovation Forum Brussels, Belgium November 5-6, 2009

The concepts described herein are the opinion of the author and do not necessarily represent the views of any other parties



Agenda

- Basic concepts - detection and identification of goods in cargo
- Passport Systems work in cargo inspection
- Nuclear Resonance Fluorescence (NRF)
 - Basic principles
 - Equipment used
 - Examples of NRF applicability
- Can NRF be used in cargo validation & counterfeit detection?
- Conclusions and future work

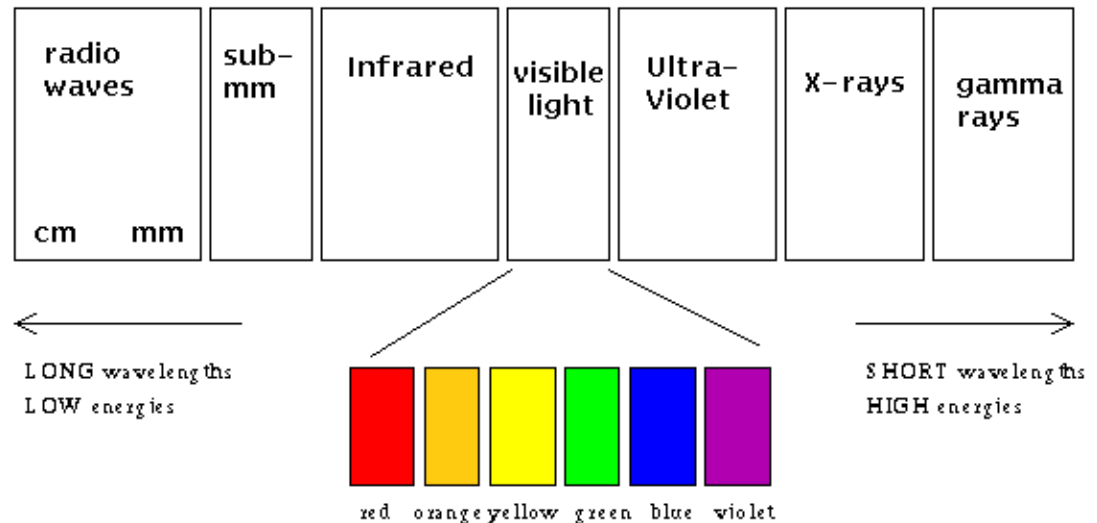
Basics of Non-Intrusive Inspection



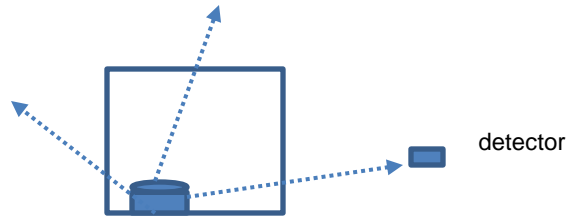
To determine what is inside without opening or damaging the container, a non-destructive probe is required

Nature (laws of physics)
Provides us with a variety
of probes

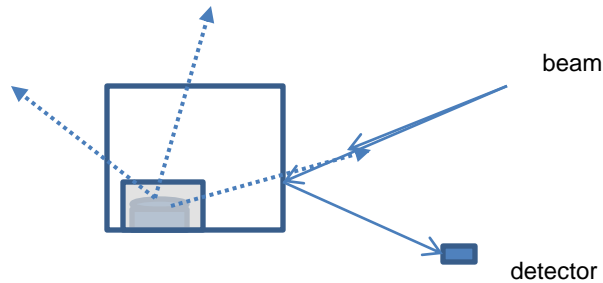
Each of these have
unique properties so can
be best used for specific
applications



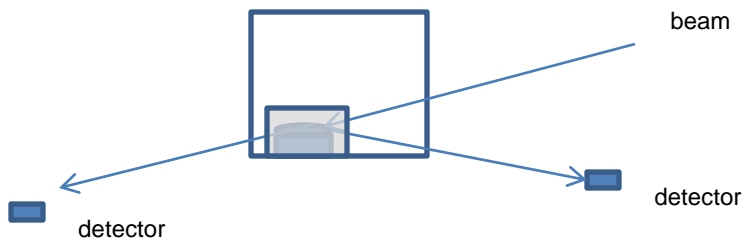
Basics of Non-Intrusive Inspection



Passive Detection



Active Interrogation
surface and or some sub-surface detection



Active Interrogation inside container

Agenda

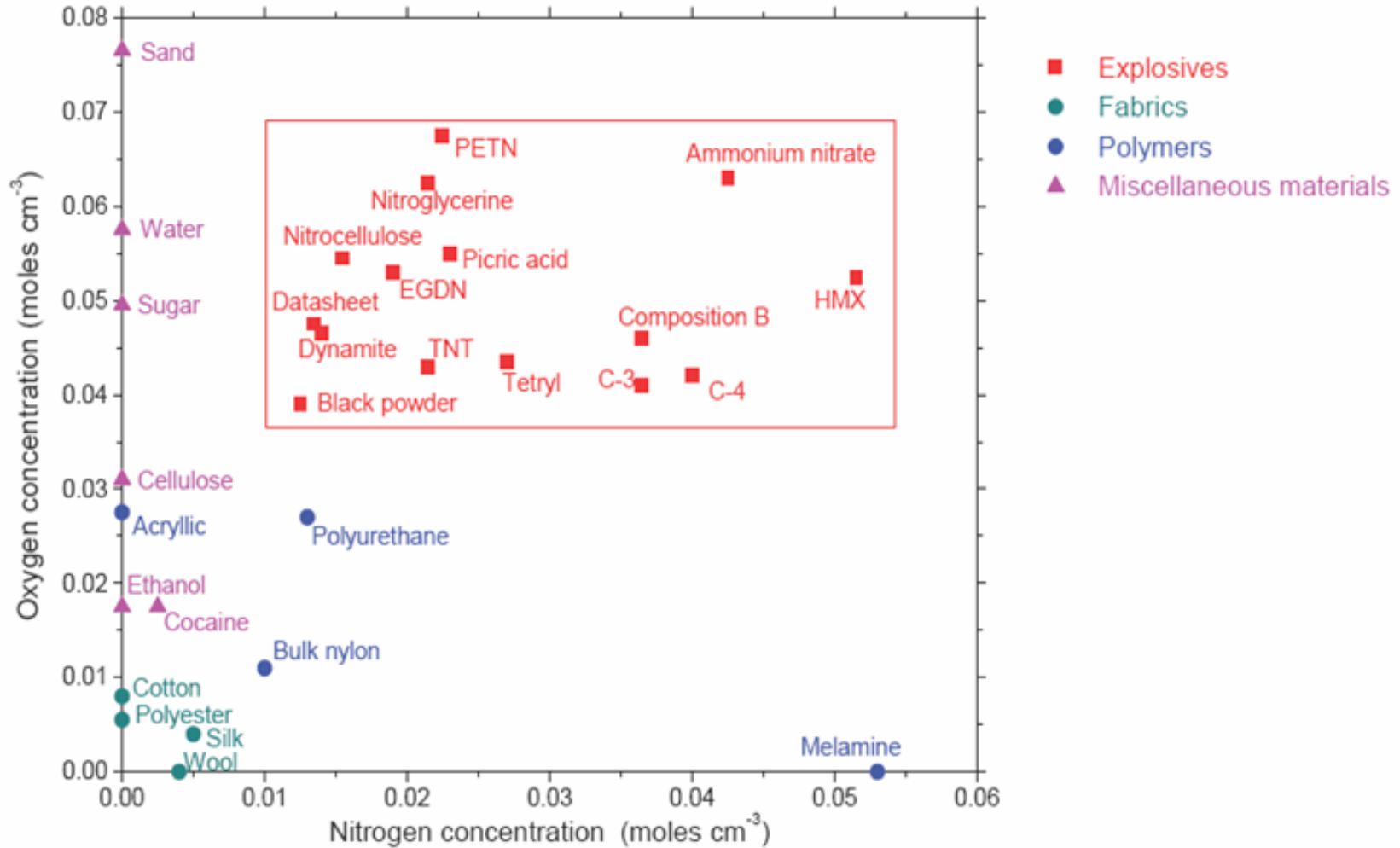
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Passport Systems work in Cargo Inspection

- NRF phenomena known by science for a long time
- How to apply it to cargo inspection – recent
- Isotopic identification made it applicable to detect and identify materials by composition
- Work done to address detection and identification of WMD in cargo

Basic Principles

Material identification via Ratios of Elements



Agenda

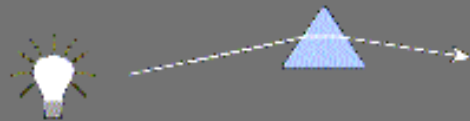
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Basic Principles

Analogy: NRF to Optical Spectrometry

Optical Spectroscopy

NRFI Spectroscopy



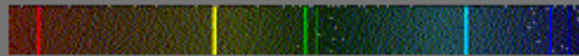
Continuous Spectrum



“Bremsstrahlung” Spectrum



Emission Spectrum



3-D Imaging of Back-angle High-Energy Photons

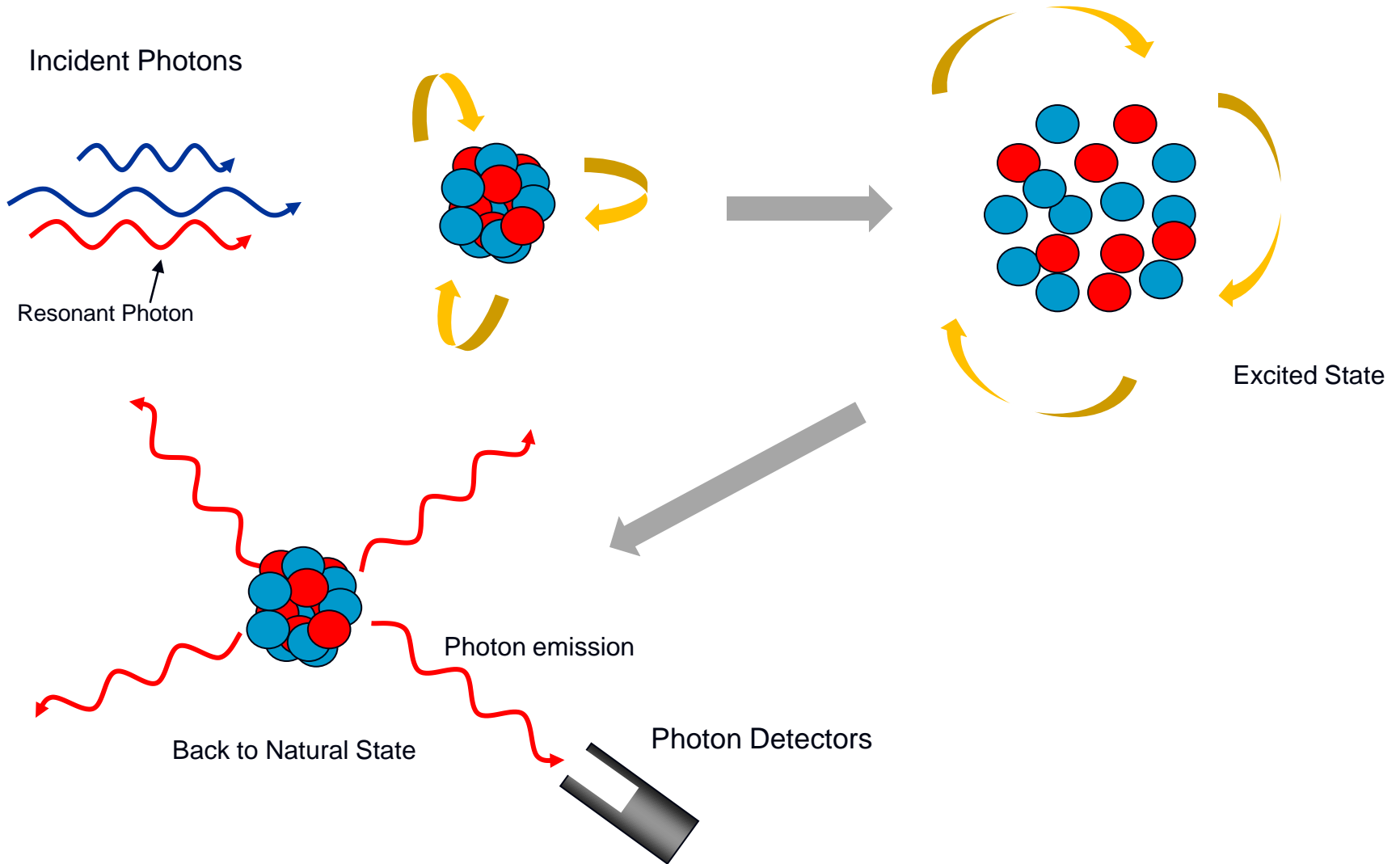


Absorption Spectrum



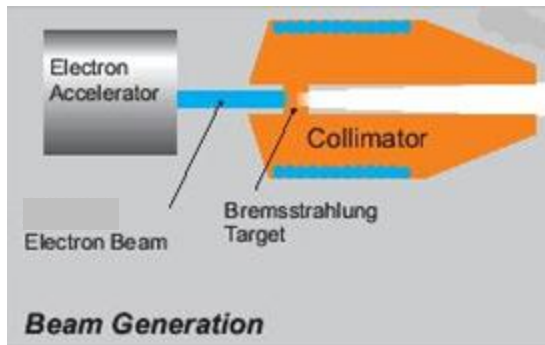
2-D Isotope Specific Transmission Imaging

Basic Principles NRF

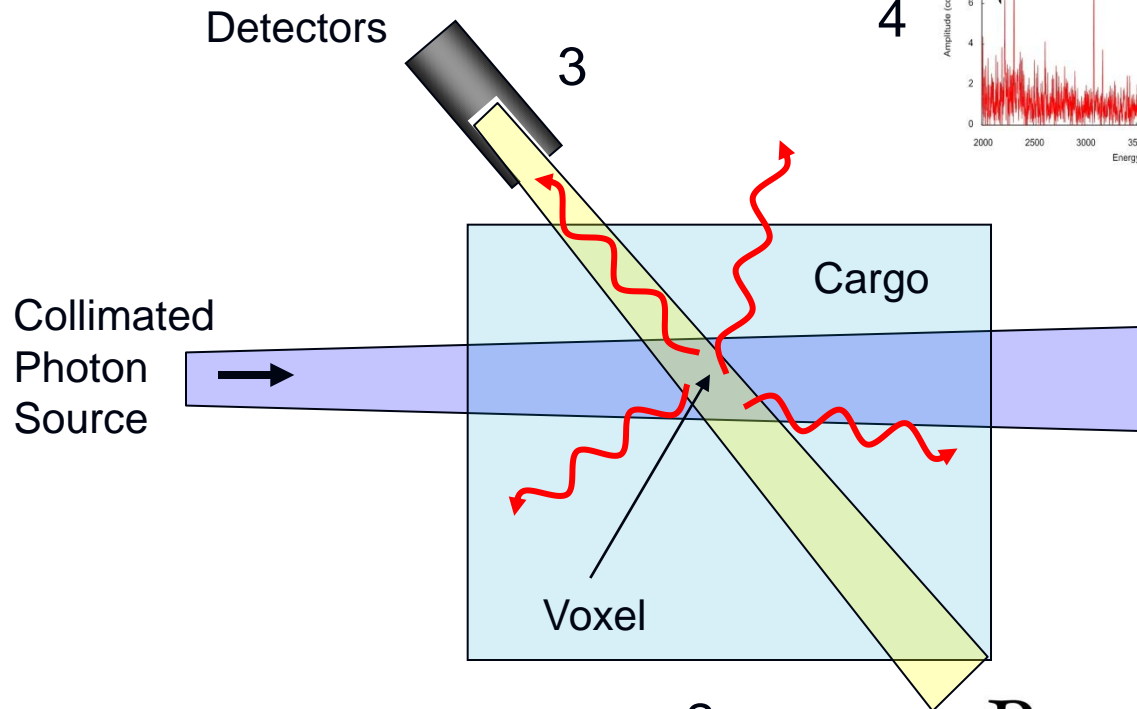


Basic Principles NRF Scanner

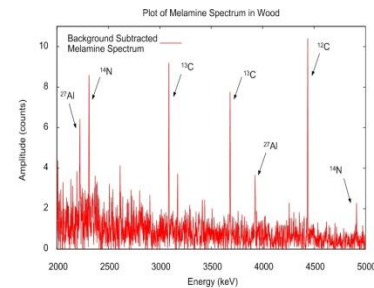
- 1 - Photon beam is generated by an electron accelerator & target and collimated
- 2 - Beam penetrates cargo, excites nuclear states and photons are emitted
- 3 - Collimated detector captures emitted photons with information about the isotopic composition of the material in the intersected volume (voxel)
- 4 - Unique signature is obtained for each isotope



1

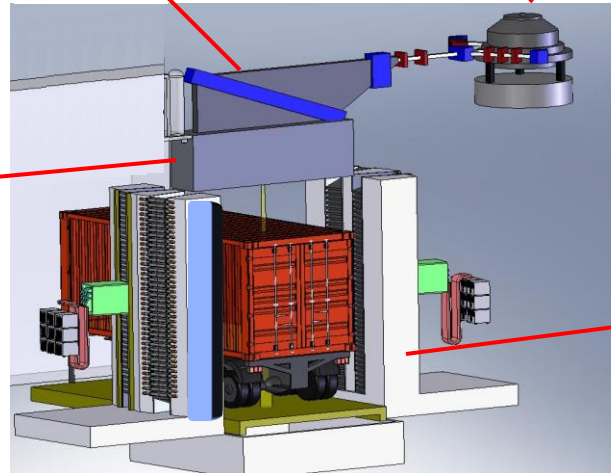
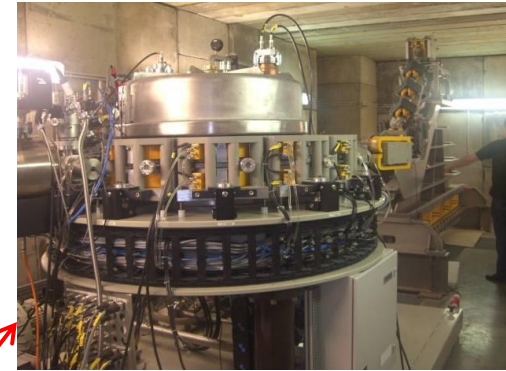


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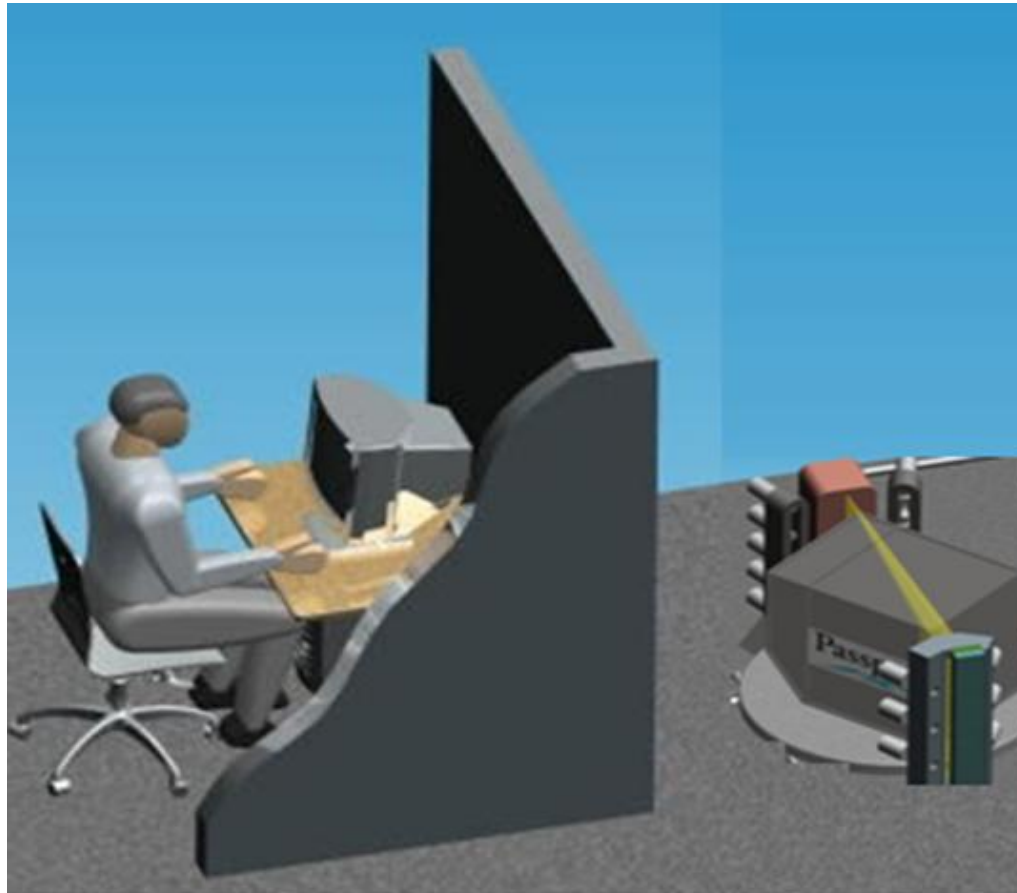


4

Equipment - Full Scale Scanner

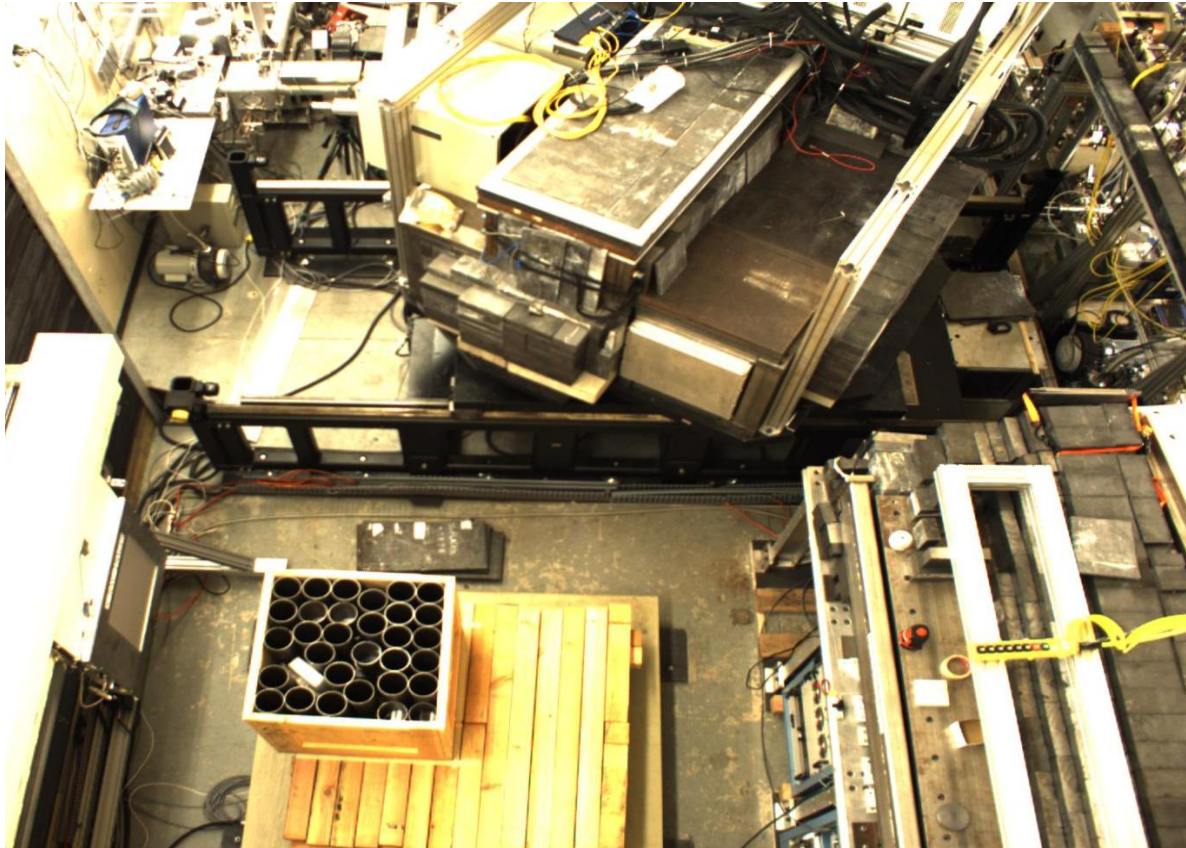


Equipment - Analytical Tool (Forensic Applications)



Laboratory Analysis

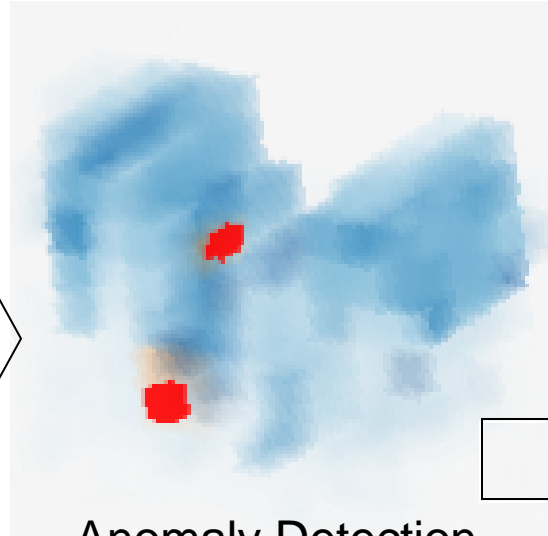
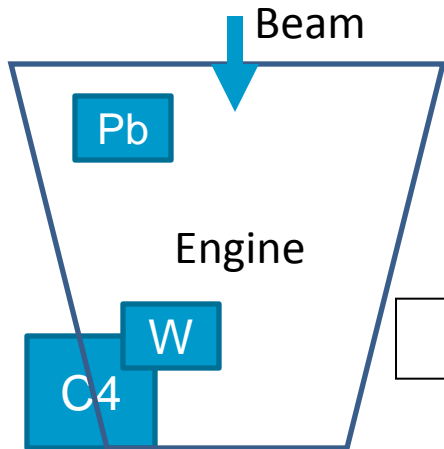
Equipment - NRF measurements



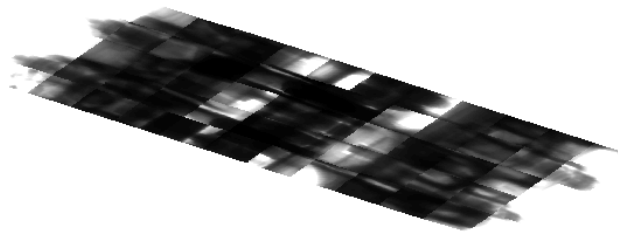
**Proof-of-Concept installation
in California (demonstrations started August 2008)**

Examples of NRF Applicability to Cargo Inspection

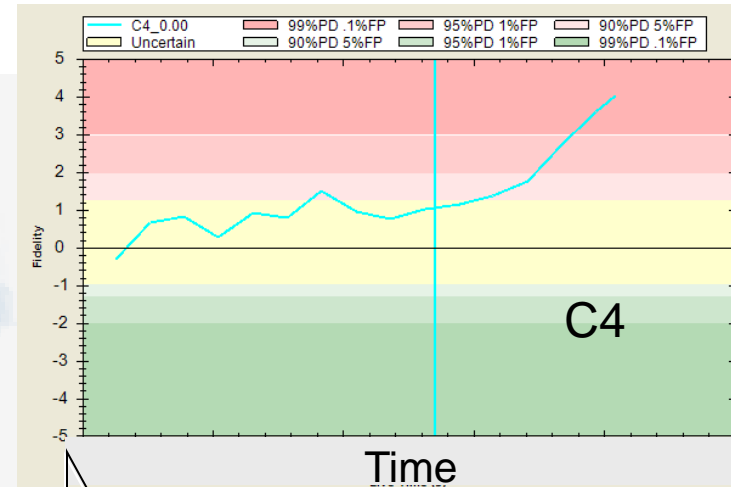
Engine Block with shielding materials and explosives



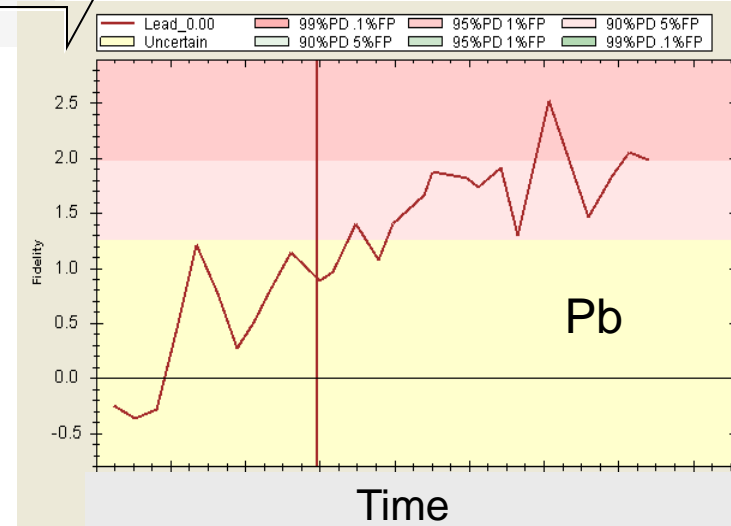
Anomaly Detection & 3-D Location



Transmission X-ray image

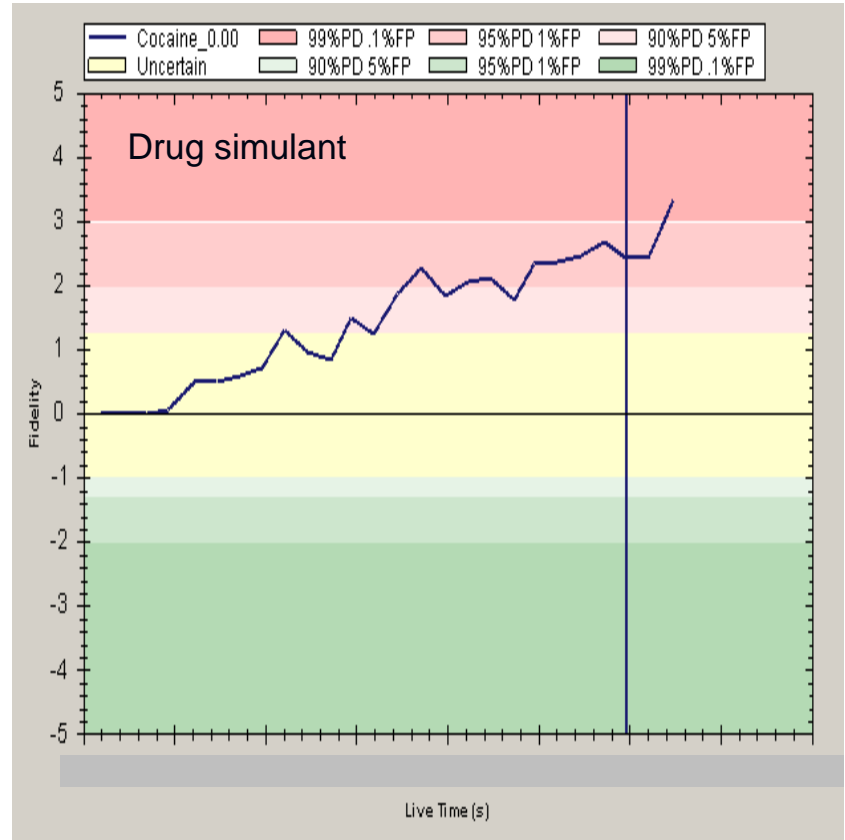


Isotopic ID



Examples of NRF Applicability to Cargo Inspection

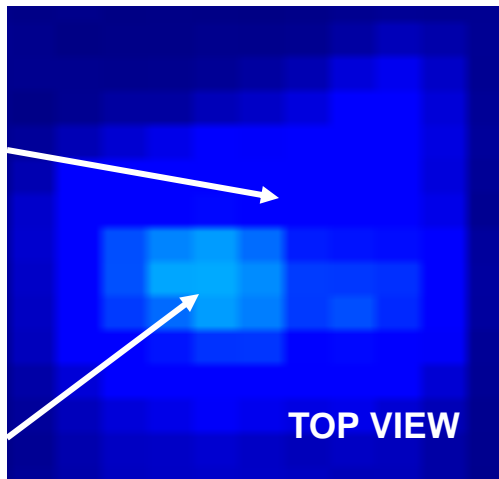
Box of Books With Drug Simulant



NRF DETECTION IN ROI

DRUG IDENTIFIED

Books



TOP VIEW

ANOMALY DETECTED

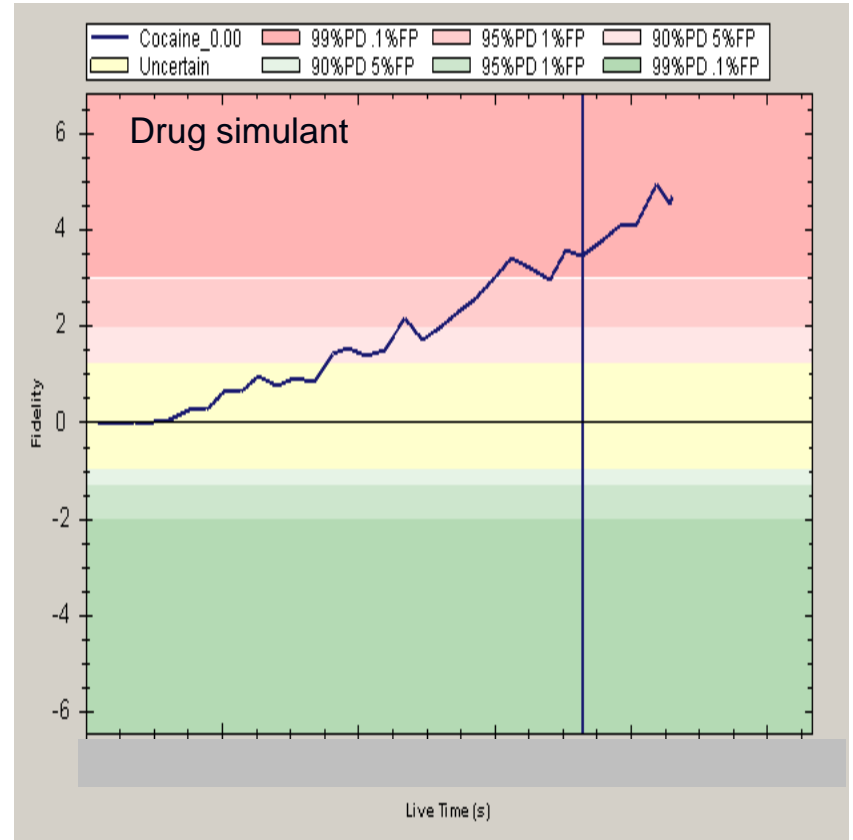
Drug Simulant

REGION OF INTEREST (ROI)

Examples of NRF Applicability to Cargo Inspection Box with Bags of Rice and Drug Simulant



Packed Drug Simulant



NRF DETECTION
DRUG IDENTIFIED

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Can NRF be used in cargo manifest validation and detection of counterfeit products?

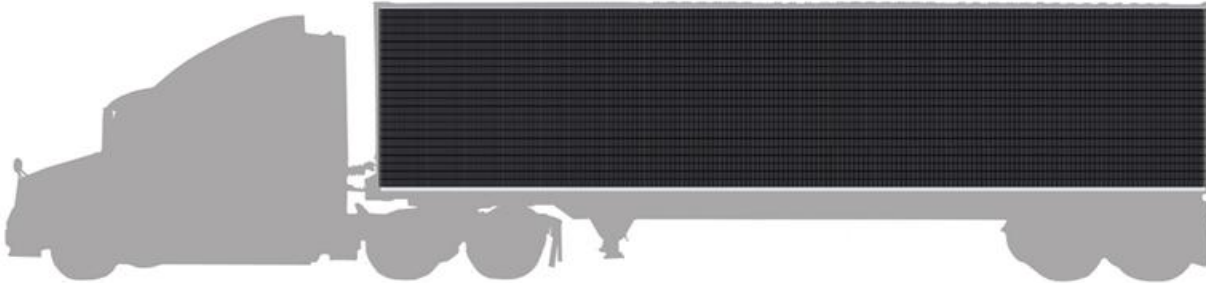
- Cargo validation examples
 - Is it bottled water or alcohol?
 - Is it the correct grade of steel?
 - Is it granite or marble?
 - Is it sugar or cocaine?

- Counterfeit examples
 - Is a cellular phone original (from the legal supplier)?
 - Is a food product trademark and origin claim valid?
 - Is it of the correct quality?
 - Designer goods or knock-offs?

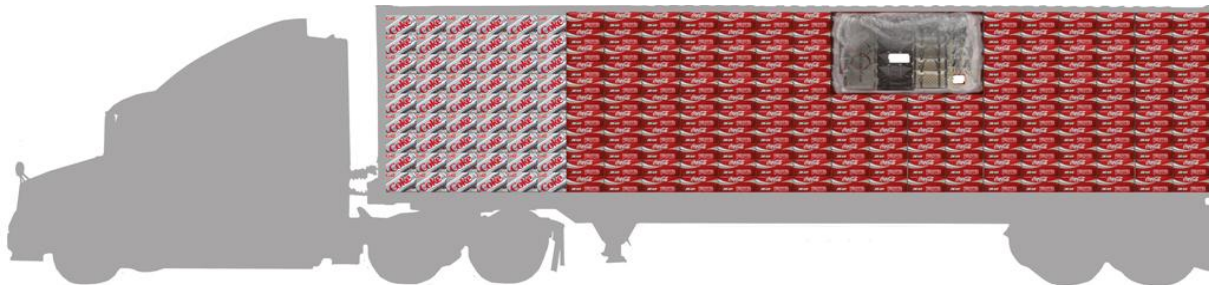
Would it be nice if ...



A container arrived ...



It was promptly scanned ...

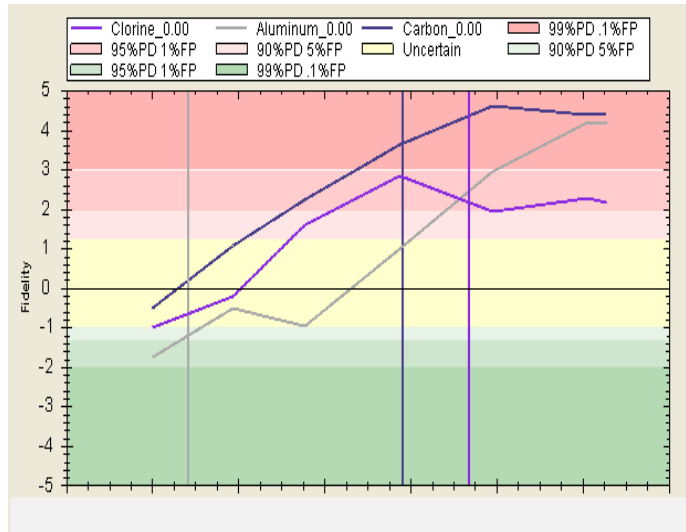


... and cargo was validated non-intrusively?

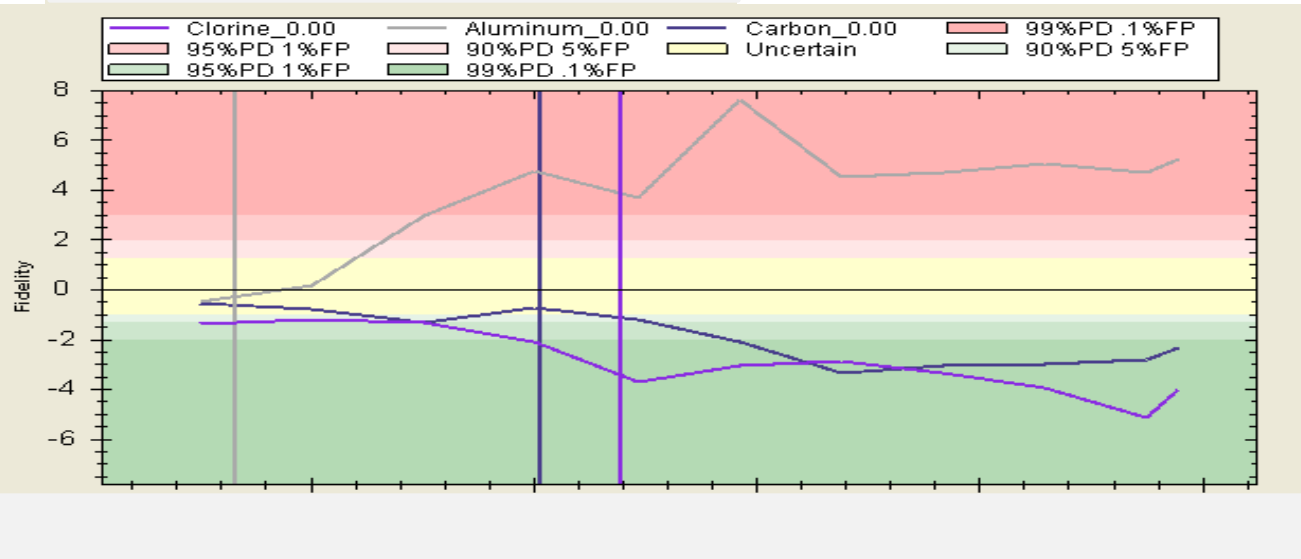
Product Differentiation

Using NRF

Regular Cola

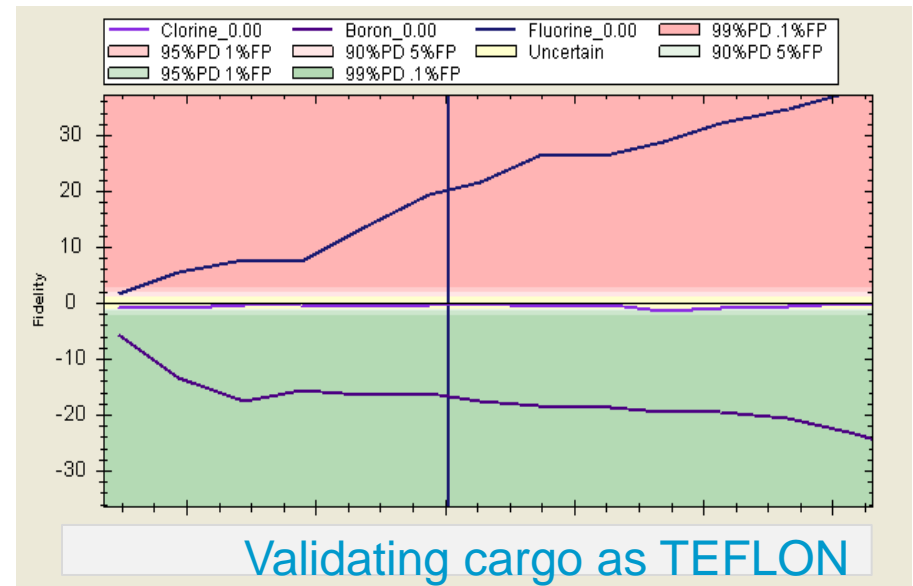
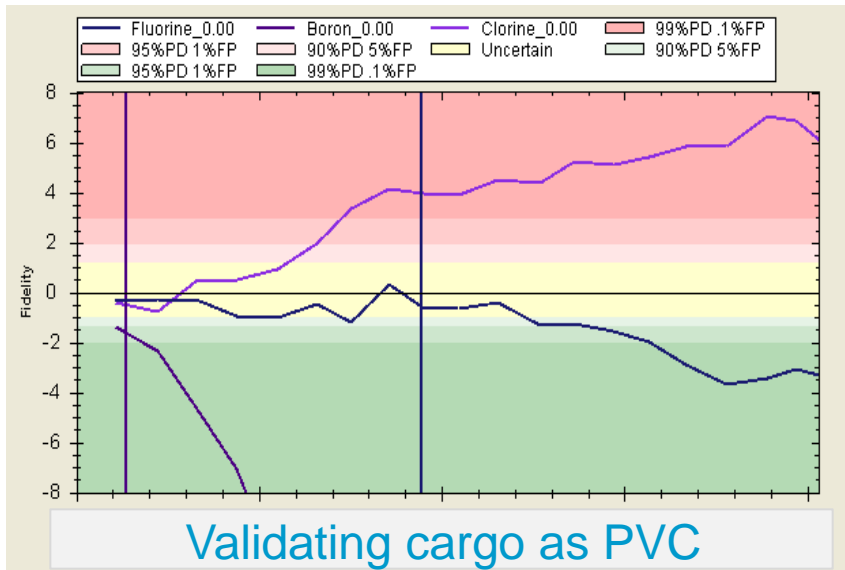


Diet Cola



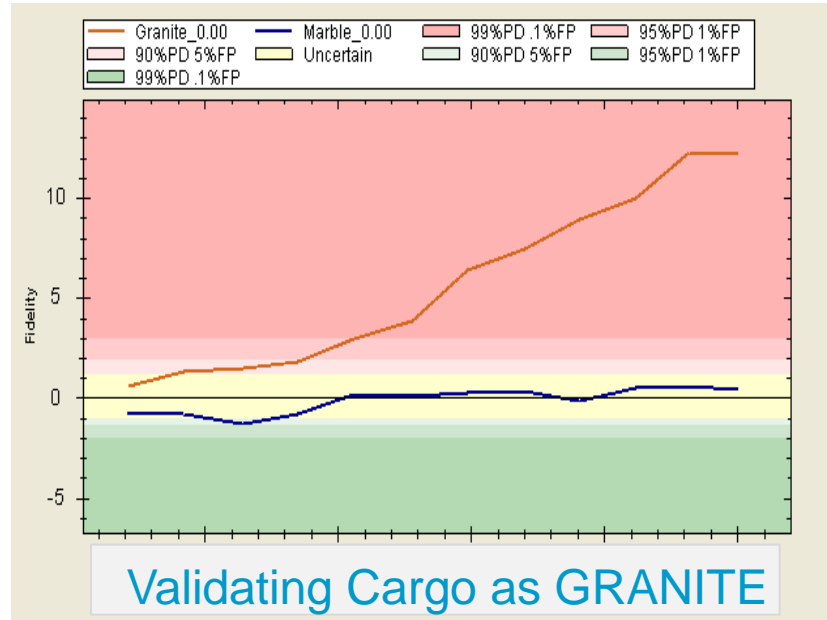
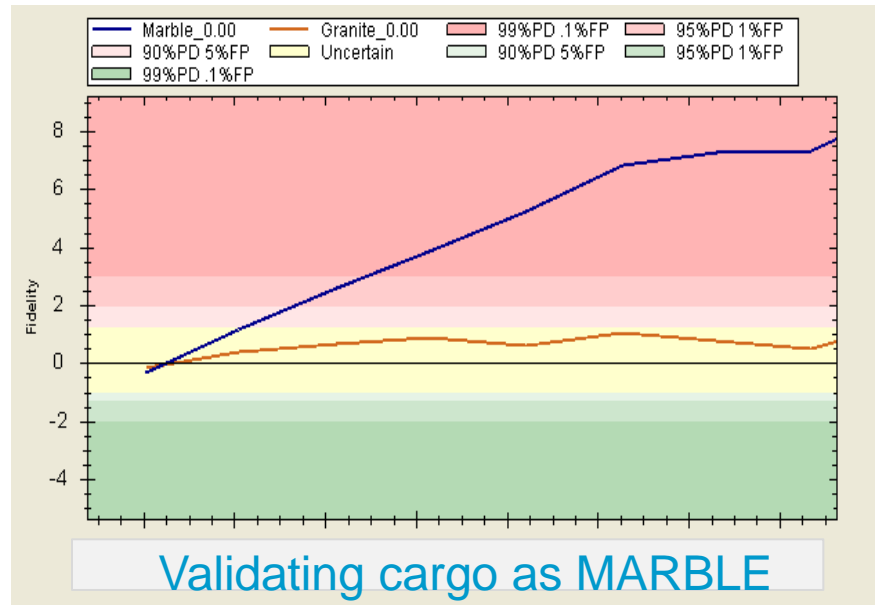
Product Differentiation

Using NRF



Product Differentiation

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Areas of future study

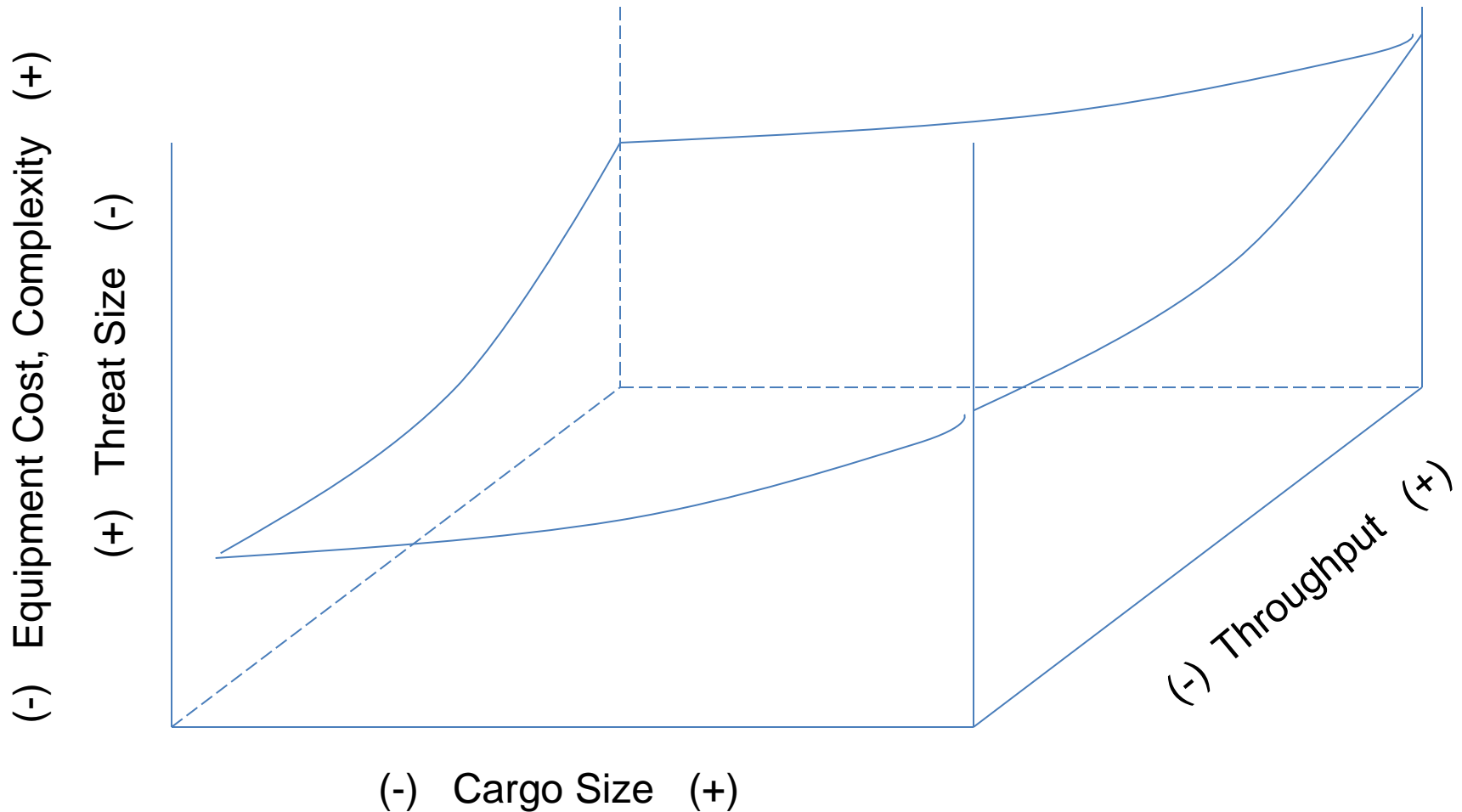
- Differentiation of genuine and fake products
 - Via isotopic ratio measurement – if composition of materials differ
 - Via identification of material used as a marker in the original product
- Differentiation of quality
 - Stainless steel grades
 - Products with similar shape, texture, density
 - Products with unsafe elements
- Determination of origin
 - In cases where isotopic ratios vary with origin or source
 - Food forensics

Areas of future study

Today	Future Answers
Applications analysis	Value to the user (market)?
Proof-of-Concept Prototype experience	Operational environment
Detection differentiation	Systematic detection/identification
Prototype cost	Product cost
Prototype performance	Performance range/limitations

Areas of future study

Trade-offs between cost, size, performance, throughput



Summary

- Can technology distinguish between products in a non-intrusive, non-destructive way?
 - NRF can if products have sufficiently different isotopic ratio composition or make use of a taggant
- If so, can it do so without opening a container?
 - Yes but depends on the cargo and time of inspection available
- How fast could it validate, clear, detect, identify or differentiate products in cargo?
 - To be determined through full scale testing

THANK YOU

