PASSPORT
SYSTEMS INC

FROM THE LAB TO THE MARKETPLACE

A NUCLEAR PHYSICIST IN INDUSTRY PERSPECTIVE

Presented by Bob Ledoux
President, Passport Systems, Inc.
Washington DC
January 2018

Agenda

- Personal Background
- Examples of National Security Projects
- From the Lab to the Marketplace

Professional Background

- MIT 1974-1990 (undergrad to assoc. professor), Ph.D. in experimental nuclear physics.
- President: Radiosurgical and Stereotactic Applications 1990 – 1995. Medical device company commercializing Harvard Medical School radiation therapy technology.
  Medical Technology Transfer from Harvard Medical School
- Partner: Pyramid Technical Consultants 1995 – 2002: Consultants and manufacturers of medical and semiconductor industry sub-systems.
  Consulting/manufacturing medical and semiconductor– mostly internal by MIT collaborations
- President and CEO: Passport Systems, Inc. 2002 – present. Homeland security inspection technologies.
  Security Product Development – MIT, PNNL and LLNL collaborations

Corporate Responsibilities

- No formal education in business administration or finances. Think *learning to swim by being thrown into deep water!*

- First company (2nd employee): Developed business based on technology transfer from Harvard Medical School, FDA submission, selected agent and dealer networks and managed strategic medical partners, primary sales support for first few years. Grew to approximately 20 employees before being acquired.

- Second company (3rd partner): Partnership with both consulting and manufacturing. Many hats (mostly technical), physicist, engineer, product development, 5 employees.

- Passport Systems (1st employee): president and CEO, a founder, CTO, IP and product development. Presently 40 employees.

Ann. Rev. Nucl. Part. Sci. 1988. 38: 119–59

ENERGY DEPOSITION IN HIGH-ENERGY PROTON-NUCLEUS COLLISIONS

Wit Busza and Robert Ledoux

Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139

CONTENTS

1. INTRODUCTION

The energy loss of particles passing through matter is an old and fundamental topic. The part of the loss resulting from interactions with atoms is governed by quantum electrodynamics. It has been thoroughly studied and is well understood. The same cannot be said about the part resulting from interactions with nuclei. Here we believe the process is dominated by quantum chromodynamics (QCD). At long distances, in the so-called nonperturbative regime, the theoretical tools that would allow meaningful calculations to be made have not yet been developed. Here our knowledge

0163–8998/88/1201–0119$02.00

Rev A

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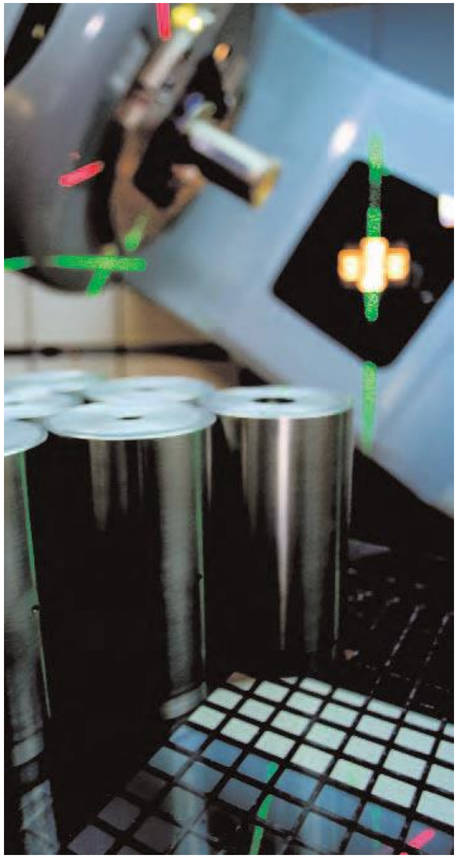
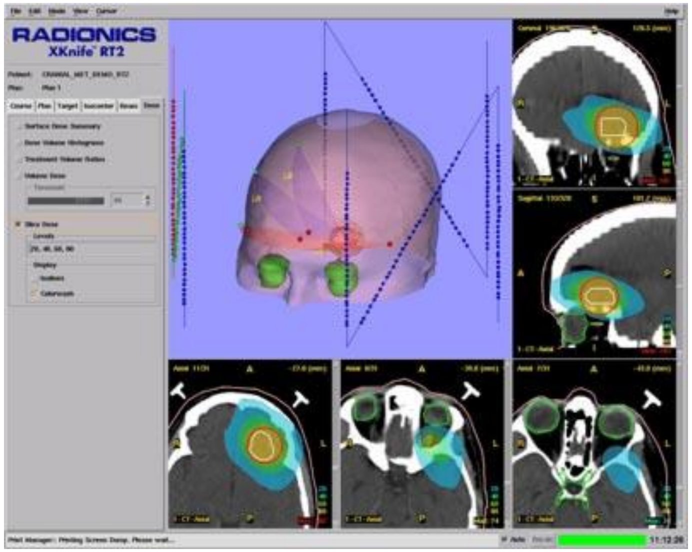
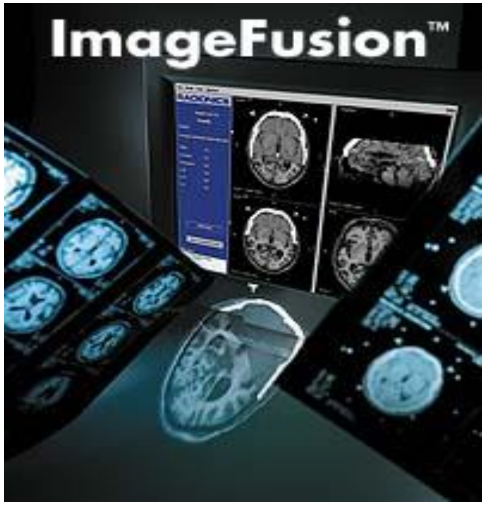
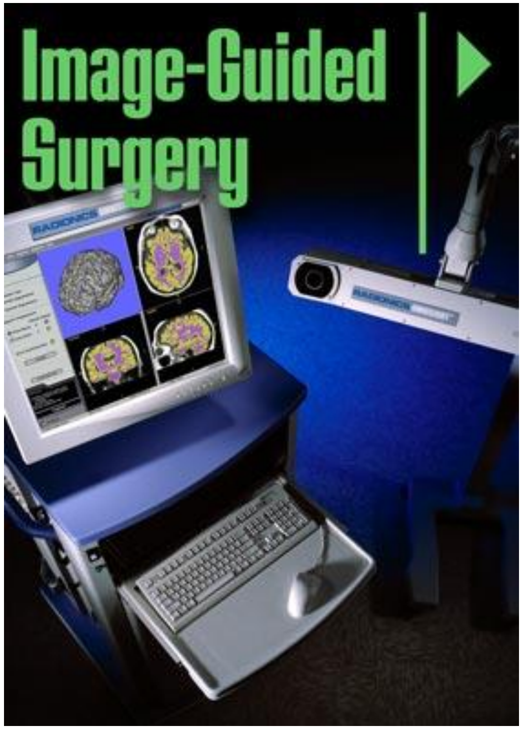
Originally: Radiosurgical and Stereotactic Applications









Technically very innovative
But…
Full service installations, training and support were very important for sales

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T E X T B O O K O F

STEREOTACTIC

A N D

FUNCTIONAL NEUROSURGERY

CHAPTER 38

THE GENERATION OF AND USE OF THREE-DIMENSIONAL IMAGES

Robert J. Ledoux

The technology of medical diagnostic imaging is a rapidly evolving field. The use of computed tomography (CT) and magnetic resonance imaging (MRI) has become commonplace in patient evaluation. Although the technology for acquiring three-dimensional (3-D) data sets has evolved significantly since the first CT scans, the methods of viewing these images have changed more slowly. It is still standard practice to evaluate 3-D image sets by viewing cut films of the two-dimensional (2-D) slices that are often part of the image acquisition process. Newer scanners provide fairly powerful software viewing tools at the scanner console, but it is still not common practice to perform surgery with sophisticated image guidance in the operating theater.

This situation is changing. Many of the traditional stumbling blocks to using 3-D medical images in the operating room are disappearing. For example, the cost of a computer workstation powerful enough to manipulate images in a man-

OVERVIEW OF TOMOGRAPHIC MEDICAL IMAGING

There now exist a variety of techniques for producing 3-D images of a portion of the body, including CT, MRI, positron emission tomography (PET), single photon emission computed tomography (SPECT), and 3-D ultrasound. The most commonly used of these imaging modalities are CT and MRI. CT and MRI differ significantly in terms of the physical properties of the body tissues that are measured and the method by which the spatial location of the tissue element is determined. However, the functional form that the data assume and the manner in which stereotactic localization can be achieved are very similar for CT and MRI. This separation of the method of image acquisition from that of data storage and display makes it possible to generate general tools with which to localize and visualize 3-D data sets.

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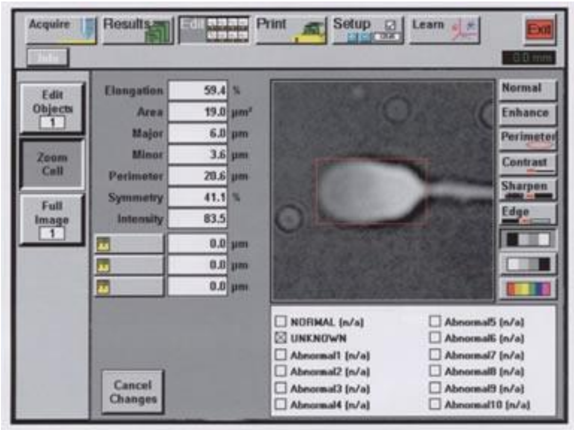
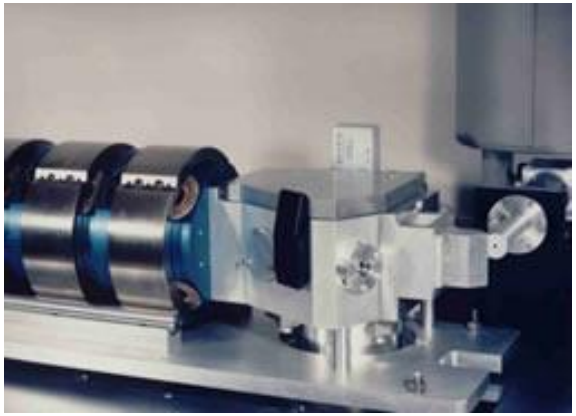
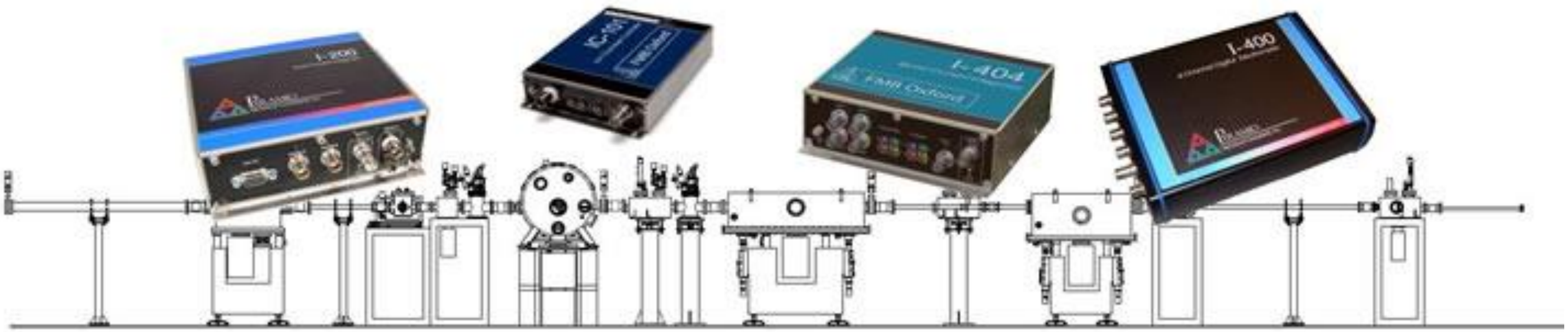
Pyramid Technical Consultants







Agenda

- Personal Background
- Examples of National Security Projects
- From the Lab to the Marketplace

September 11, 2001

Could the Fate of our Nation be Changed by the Contents of One of these Cargo Containers?

NRF – MIT Technology Transfer

5,115,459 A	5/92	Bertozzi
5,420,905 A	5/95	Bertozzi

Nuclear Resonance Fluorescence as applied to cargo inspection

Passport Systems' Humble Beginnings

MIT Feasibility Study Test Bed

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EZ-3D™ – Passport: 3D Z and Density

US007286638B2

(12) **United States Patent**
Ledoux et al.

(10) **Patent No.: US 7,286,638 B2**
(45) **Date of Patent: Oct. 23, 2007**

(54) **METHODS AND SYSTEMS FOR DETERMINING THE AVERAGE ATOMIC NUMBER AND MASS OF MATERIALS**

(75) Inventors: **Robert J. Ledoux**, Harvard, MA (US); **William Bertozzi**, Lexington, MA (US)

(73) Assignee: **Passport Systems, Inc.**, Acton, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 133 days.

(21) Appl. No.: **11/177,758**

(22) Filed: **Jul. 8, 2005**

(65) **Prior Publication Data**

US 2007/0019788 A1 Jan. 25, 2007

Related U.S. Application Data

(60) Provisional application No. 60/586,351, filed on Jul. 8, 2004.

(51) **Int. Cl.**
G01N 23/201 (2006.01)

(52) **U.S. Cl.** **378/88**; 378/57

(58) **Field of Classification Search** 378/5, 378/57, 86, 88
See application file for complete search history.

(56) **References Cited**

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5,115,459 A	5/1992	Bertozzi	378/88
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Bertozzi, William, Poster: Material Identification and Object Imaging Using Nuclear Resonance Fluroescence, Jul. 18, 2003, MIT, Dept. of Energy's Ofc of Nuclear Physics Workshop on the Role of the Nuclear Physics Research Community in Combating Terrosim.

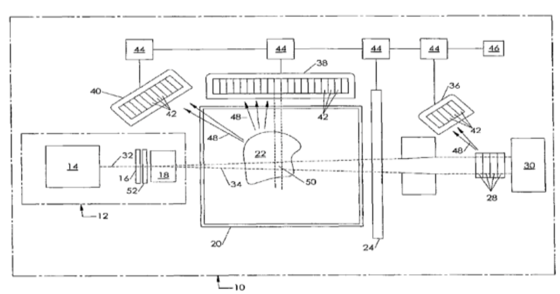
(Continued)

Primary Examiner—Courtney Thomas
(74) *Attorney, Agent, or Firm*—Foley Hoag LLP

(57) **ABSTRACT**

Disclosed herein are methods and systems of scanning a target for potential threats using the energy spectra of photons scattered from the target to determine the spatial distributions of average atomic number and/or mass in the target. An exemplary method comprises: illuminating each of a plurality of voxels of the target with a photon beam; determining an incident flux upon each voxel; measuring the energy spectrum of photons scattered from the voxel; determining, using the energy spectrum, the average atomic number in the voxel; and determining the mass in the voxel using the incident flux, the average atomic number of the material in the voxel, the energy spectrum, and a scattering kernel corresponding to the voxel. An exemplary system may use threat detection heuristics to determine whether to trigger further action based upon the average atomic number and/or mass of the voxels.

59 Claims, 5 Drawing Sheets



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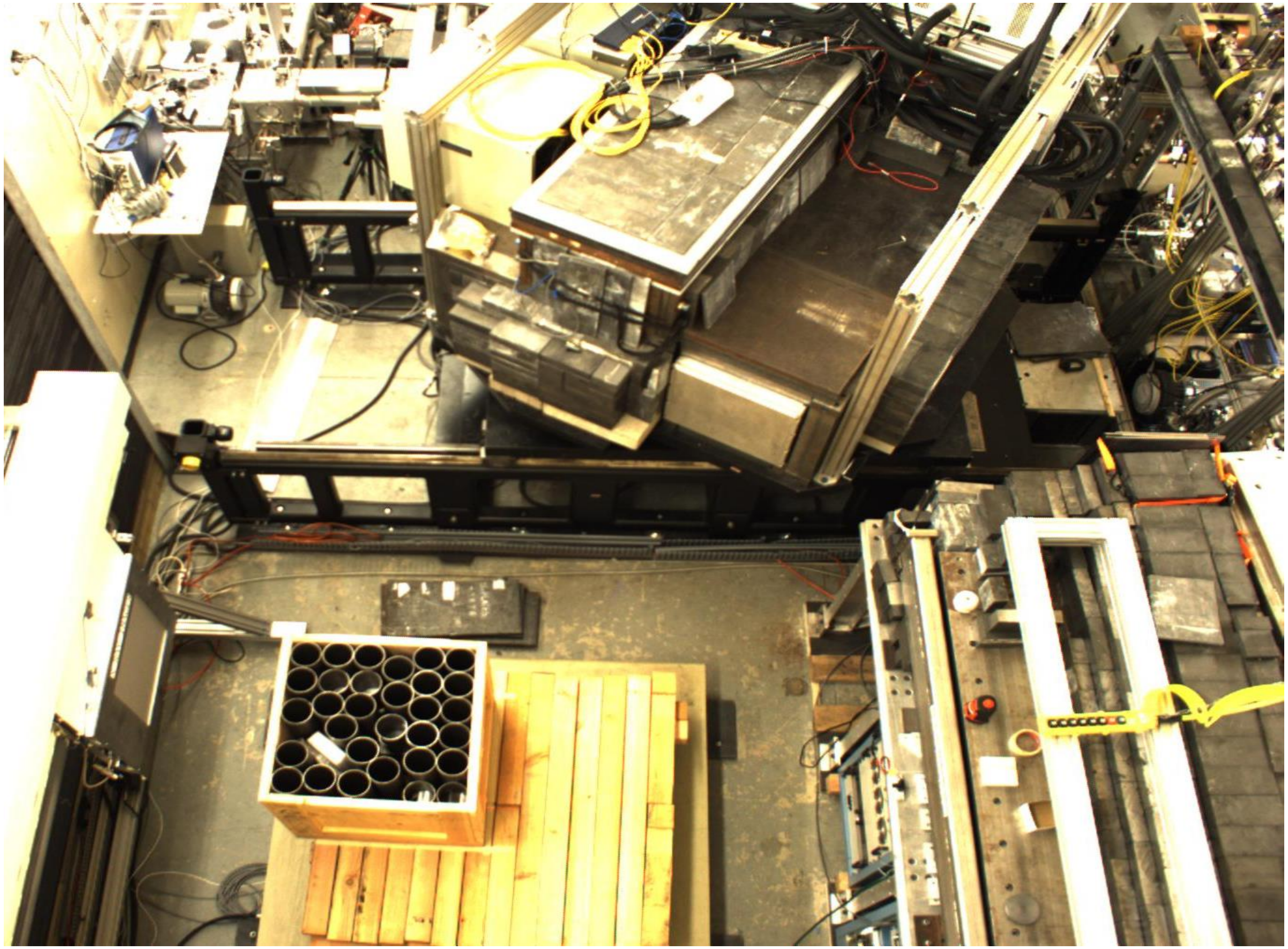
Proof of Concept Test Bed - UCSB



PNPF – Passport: Prompt Neutrons from PF

US008718219B2

(12) **United States Patent**
Bertozzi et al.

(10) **Patent No.: US 8,718,219 B2**
(45) **Date of Patent: May 6, 2014**

(54) **NON-INTRUSIVE METHOD TO IDENTIFY PRESENCE OF NUCLEAR MATERIALS USING ENERGETIC PROMPT NEUTRONS FROM PHOTON-INDUCED FISSION**

(75) Inventors: **William Bertozzi**, Lexington, MA (US); **Robert J. Ledoux**, Harvard, MA (US)

(73) Assignee: **Passport Systems, Inc.**, Billerica, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 1176 days.

(21) Appl. No.: **12/139,050**

(22) Filed: **Jun. 13, 2008**

(65) **Prior Publication Data**

US 2009/0074128 A1 Mar. 19, 2009

Related U.S. Application Data

(60) Provisional application No. 60/944,009, filed on Jun. 14, 2007, provisional application No. 60/971,638, filed on Sep. 12, 2007.

(51) **Int. Cl.**
G01T 3/04 (2006.01)
G01T 3/06 (2006.01)
G21G 1/12 (2006.01)

(52) **U.S. Cl.**
USPC **376/157**; 376/154

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

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Nakamura et al., "Sequential Measurements of Cosmic-Ray Neutron Spectrum and Dose Rate at Sea Level in Sendai, Japan", Journal of Nuclear Science and technology, vol. 42, No. 10, pp. 843-853 (Oct. 2005).*

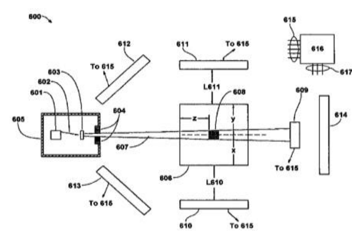
(Continued)

Primary Examiner — Johannes P Mondt
(74) *Attorney, Agent, or Firm* — Stephen B. Deustch; Foley Hoag LLP

(57) **ABSTRACT**

Methods and systems for non-intrusively detecting the existence of fissile materials in a container via the measurement of energetic prompt neutrons are disclosed. The methods and systems use the unique nature of the prompt neutron energy spectrum from photo-fission arising from the emission of neutrons from almost fully accelerated fragments to unambiguously identify fissile material. The angular distribution of the prompt neutrons from photo-fission and the energy distribution correlated to neutron angle relative to the photon beam are used to distinguish odd-even from even-even nuclei undergoing photo-fission. The independence of the neutron yield curve (yield as a function of electron beam energy or photon energy) on neutron energy is also used to distinguish photo-fission from other processes such as (γ, n). Different beam geometries are used to detect localized samples of fissile material and also fissile materials dispersed as small fragments or thin sheets over broad regions. These signals from photo-fission are unique and allow the detection of any material in the actinide region of the nuclear periodic table.

48 Claims, 16 Drawing Sheets



Detector System

Rev A

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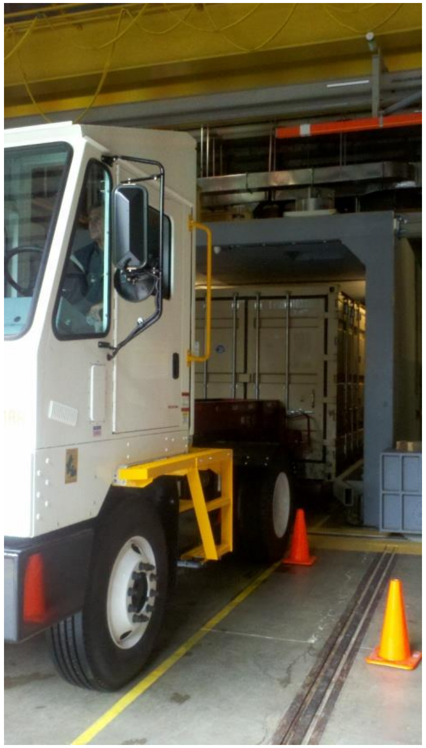
Advanced Technology Demonstration (ATD)



Rev A
PASSPORT SYSTEMS INC

Is This The Best Way to Do This?

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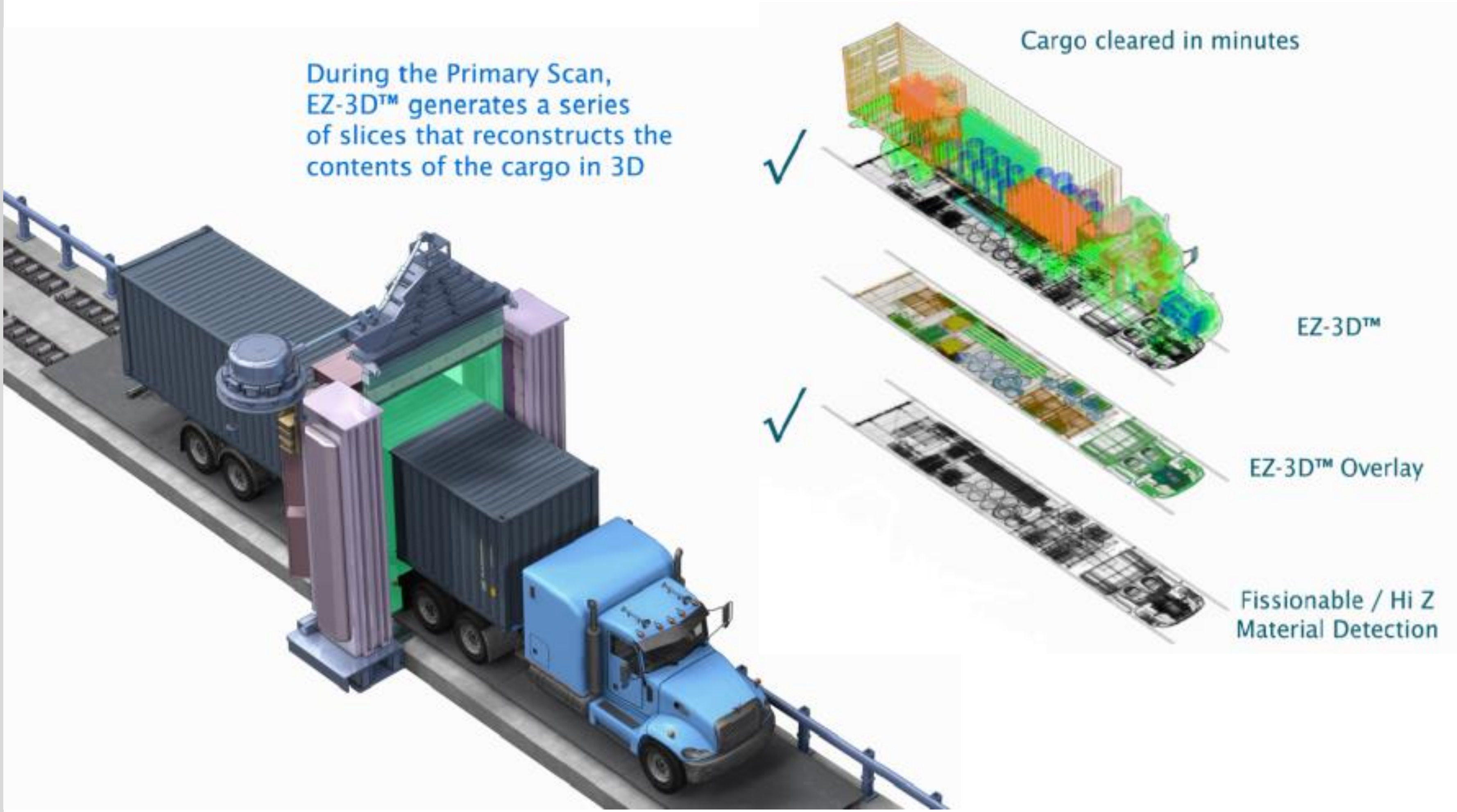
Passport's "Nuclear Photonics" Scanner



This full configuration identifies anomalies and resolves potential threats

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Conley Container Terminal – Artist Rendition

Conley Container Terminal – August 2016

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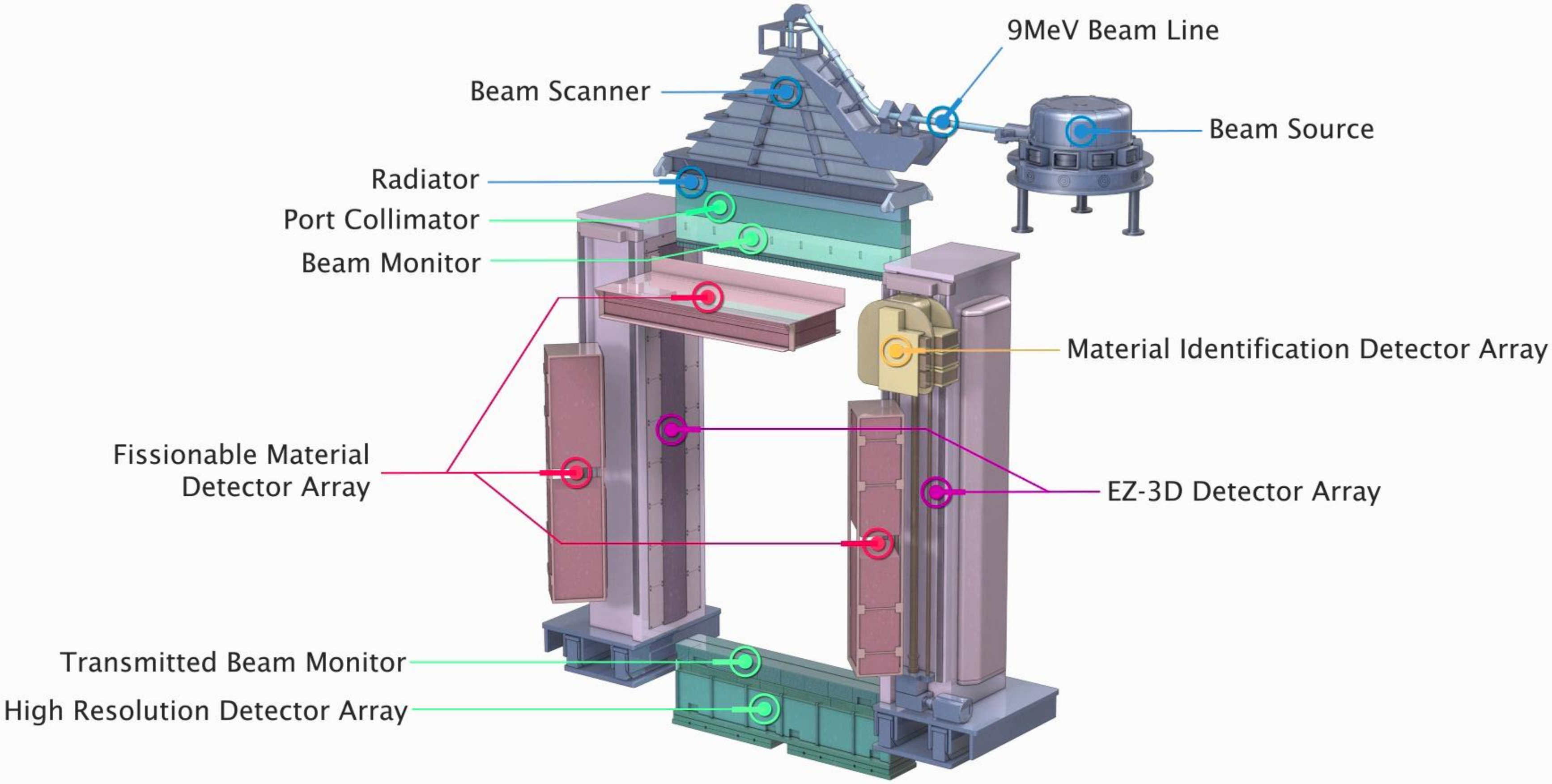
SmartScan 3D^{TM} System Core Technologies



Cargo SmartScan™ System

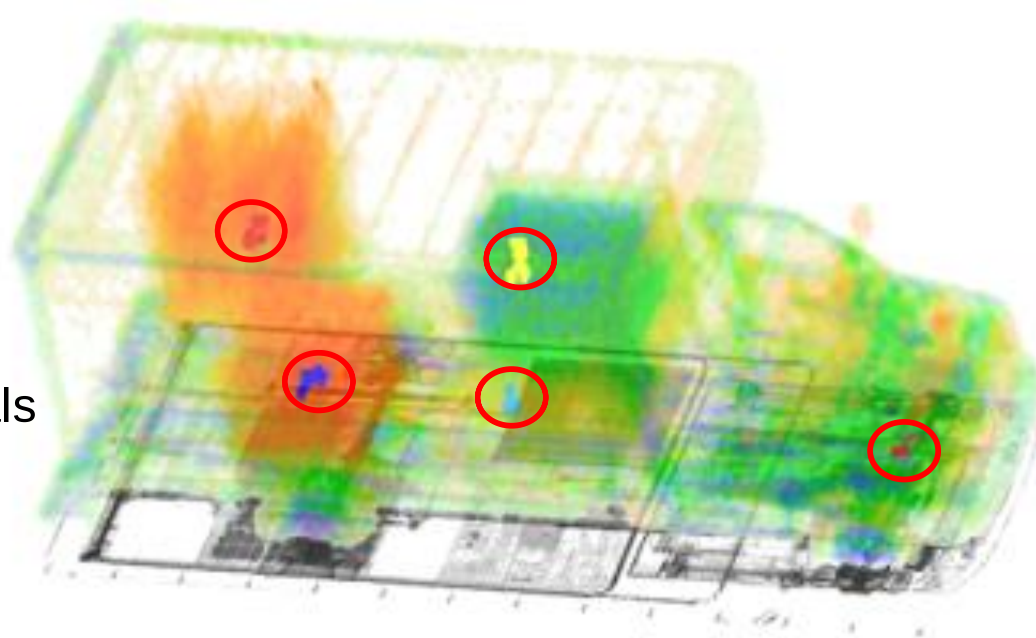
EZ-3D Volumetric Data of Density and Effective Z

Color Scale = Zeff Range

Transparency = Density

Cargos

- Organic
- Inorganic
- Metals
- Dense Metals



Targets

- Tobacco
- C4 Explosive
- Cocaine
- High - Z

- Cargo is scanned slice-by-slice and reconstructed in 3D
- The voxels are aggregated into regions-of-interest
- These ROI's are analyzed for targeted materials

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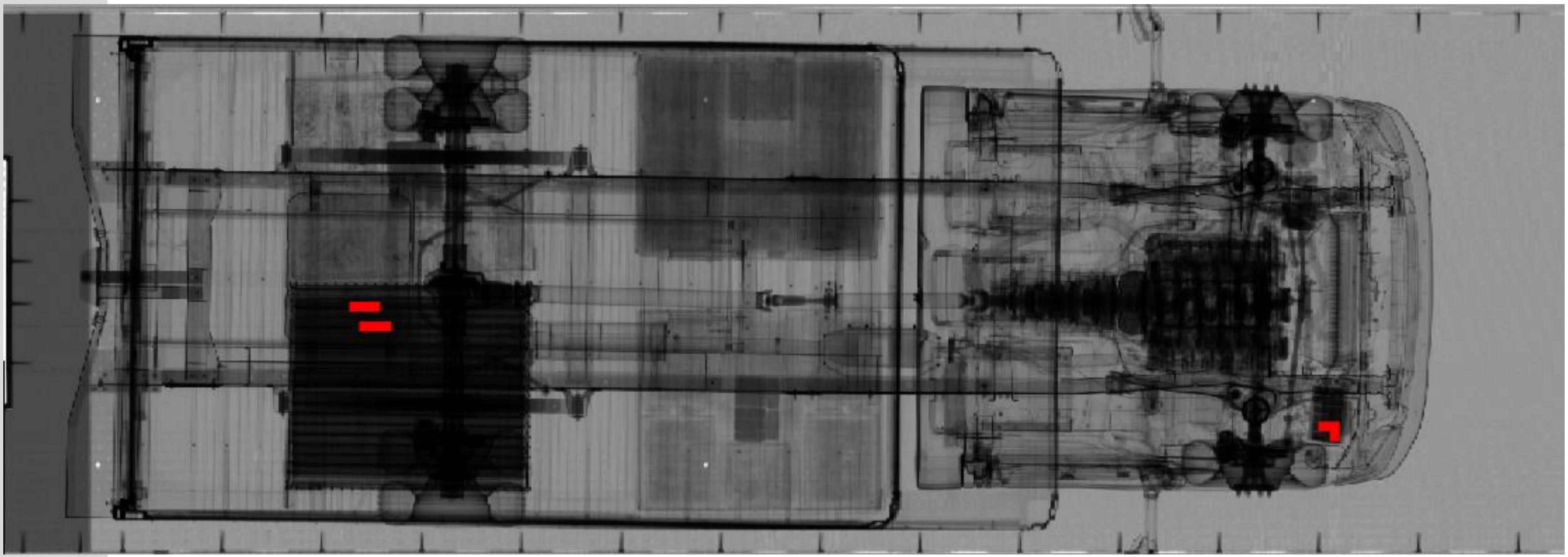
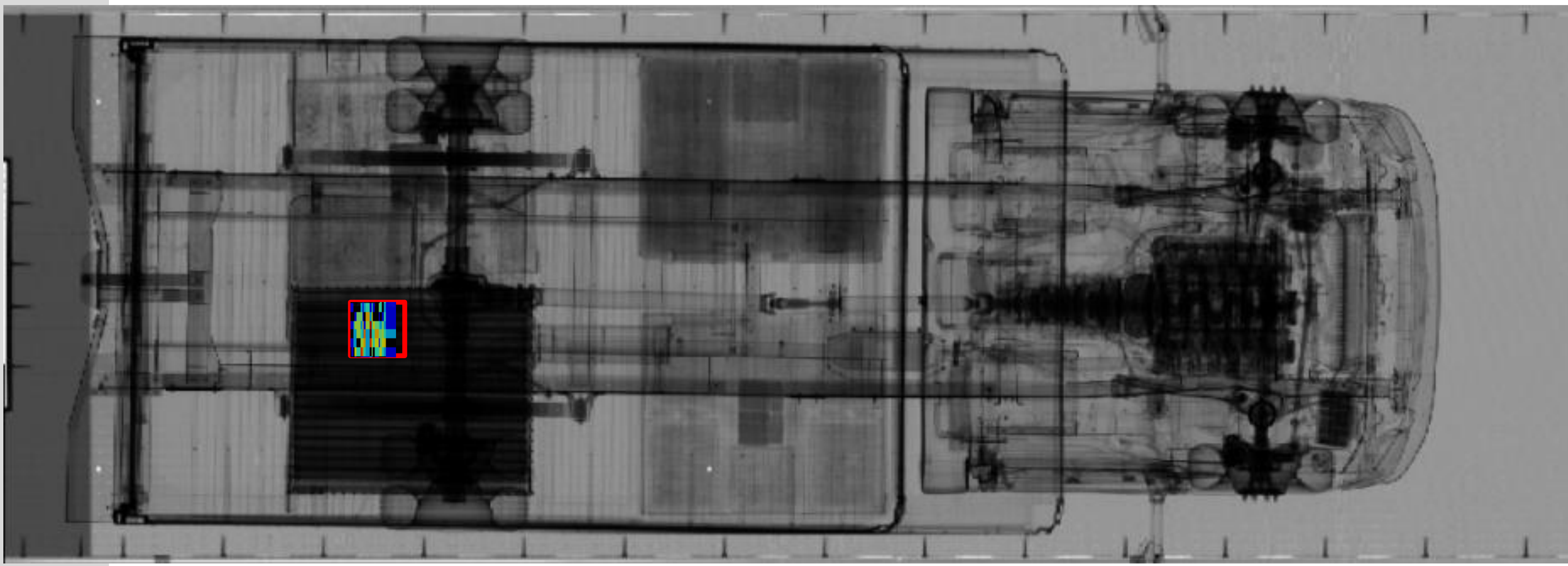
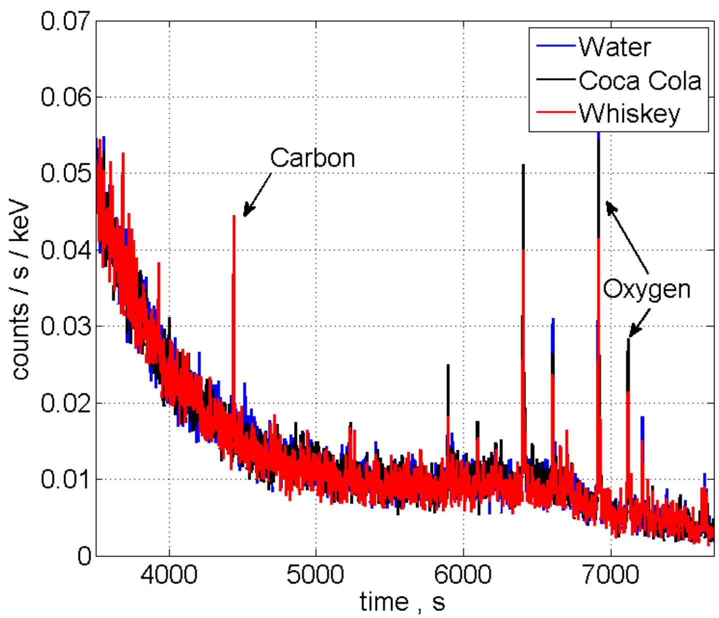
Transmission with Automated High-Z Alarms

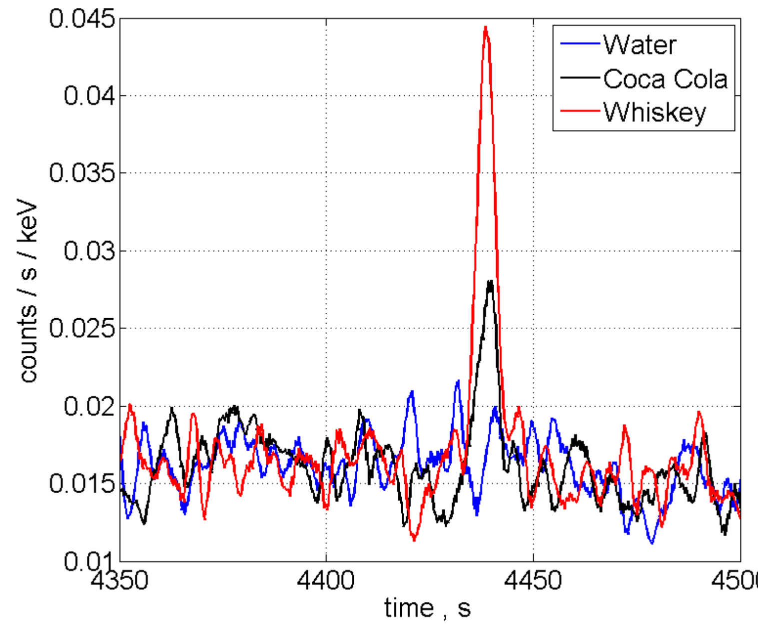


Transmission with Fission Alarms



NRF on Materials



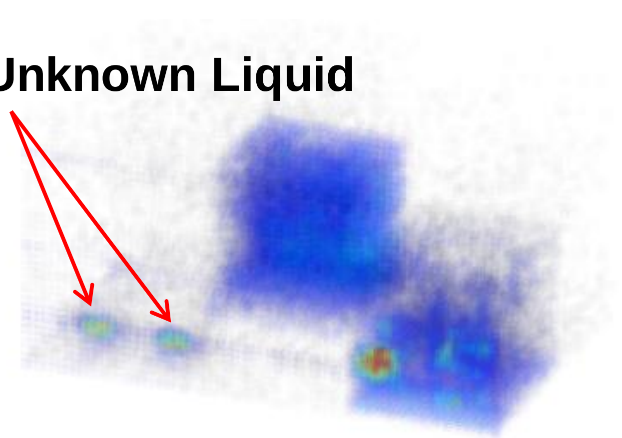


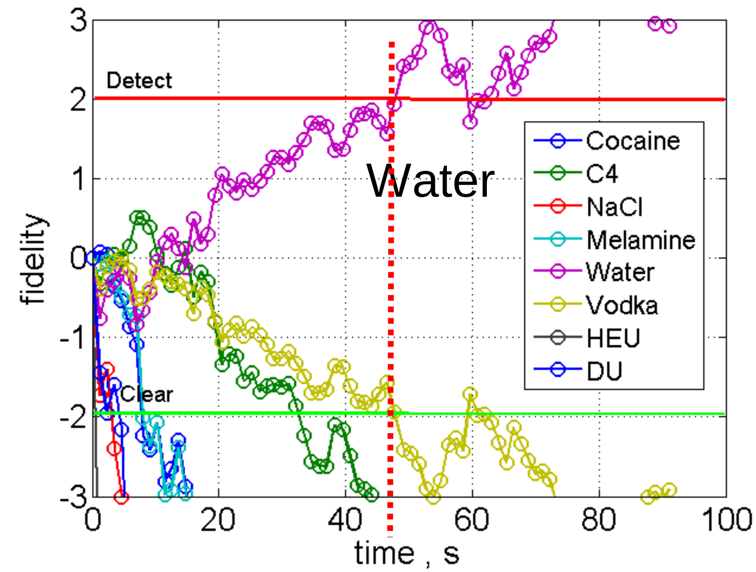
- Materials consist of Isotopes in specific ratios
- Probability that the ratios observed correspond to each material is computed

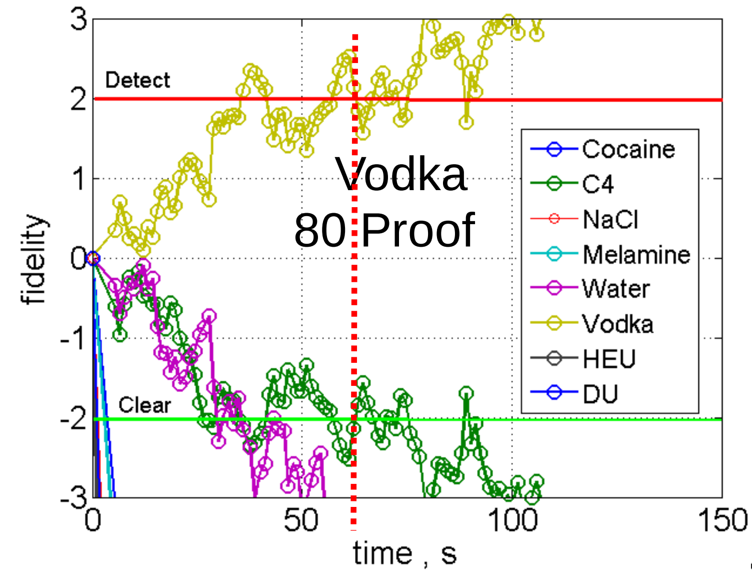
Material	Carbon counts/s	Oxygen counts/s	C/O Ratio
Water	0	0.73	-
Coca Cola	0.14	0.75	0.2 ± 0.014
Whiskey	0.27	0.53	0.5 ± 0.013

Secondary Scan Contraband Identification Example

Bottles of Unknown Liquid







Time to positively identify each with RF : < 2 minutes

The Future: MonoChromatic Photon Beams – Passport

US007409042B2

(12) **United States Patent**
Bertozzi et al.

(10) **Patent No.: US 7,409,042 B2**
(45) **Date of Patent: Aug. 5, 2008**

(54) **USE OF NEARLY MONOCHROMATIC AND TUNABLE PHOTON SOURCES WITH NUCLEAR RESONANCE FLUORESCENCE IN NON-INTRUSIVE INSPECTION OF CONTAINERS FOR MATERIAL DETECTION AND IMAGING**

(75) Inventors: **William Bertozzi**, Lexington, MA (US); **Robert J. Ledoux**, Harvard, MA (US)

(73) Assignee: **Passport Systems, Inc.**, Billerica, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 278 days.

(21) Appl. No.: **11/358,969**

(22) Filed: **Feb. 22, 2006**

(65) **Prior Publication Data**

US 2006/0188060 A1 Aug. 24, 2006

Related U.S. Application Data

(60) Provisional application No. 60/655,043, filed on Feb. 22, 2005.

(51) **Int. Cl.**
G01N 23/201 (2006.01)

(52) **U.S. Cl.** **378/88**; 378/86

(58) **Field of Classification Search** 378/88, 378/86

See application file for complete search history.

(56) **References Cited**

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4,446,568 A		5/1984	Williams et al.	
4,788,704 A		11/1988	Donges et al.	
4,941,162 A	*	7/1990	Vartsky et al.	378/3
4,980,901 A		12/1990	Miller	
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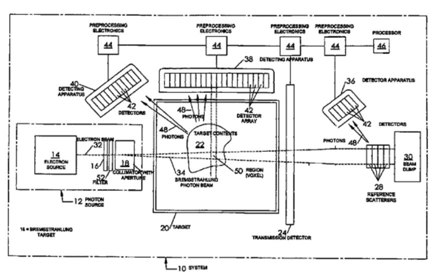
(Continued)

Primary Examiner—Louis M Arana
(74) *Attorney, Agent, or Firm*—Foley Hoag LLP

(57) **ABSTRACT**

Methods and systems for detecting potential items of interest in target samples, using nuclear resonance fluorescence, utilize incident photon spectra that are narrower than traditional bremsstrahlung spectra but overlap nuclear resonances in elements of interest for purposes of detection, such as but not limited to the detection of threats in luggage or containers being scanned.

37 Claims, 9 Drawing Sheets



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Agenda

- Personal Background
- Examples of National Security Projects
- From the Lab to the Marketplace

Is There Technology Worth Transferring? How?

- Are you solving a problem that the marketplace wants or needs?
- How is it better than what is already out there?
  - Performance, Cost, footprint, trendy(?)
- Is there an existing market? If not, why do you think there will be one?
- Who will pay for it? Government or Commercial
- What is the current state of IP?
- How much “secret sauce” or “know how” is required? Can this be sold as a license? Does manpower need to go with it?

How Are You Going to Make This Happen? – The Team

- What is the structure of the team? Is there a leader(s)
- What is the structure of the company? BOD members, employees, consultants
- Does the team have depth and experience
  - Technical: scientific, soft and hard engineering, and IP
  - Commercial: fund raising, manufacturing, corporate relations, etc.
- Time scale: How long a road is anticipated?
- Risk Tolerance: What level of pain tolerance exists (financial, personal, professional)?

Getting Started

- Create initial business plan – shop it around initially to “friends”
- Understand carefully your constraints within your current situation lab, academia and business
- Define the founders and initial investors carefully. Think of “marriage”
- Find a good lawyer for technology transfer – may be willing to take compensation other than $
- Incorporate: very simple these days – be very specific on ownership, rights, BOD members, stock options, etc.
- Immediately get assigned provisional patents to Company

What to watch out for

- Talk is cheap – don't think "that's a great idea" necessarily translates into $
- Try to keep your burn rate low. Everything takes much longer than you think.
- Only hire A players. May take patience and a deep search
- Don't be selfish but always understand what you are giving away and what you are gaining

Why I am Happy I Made the Transition to Work On National Security in Industry

- Direct experience of making a difference on an important problem
- Sheer joy of turning new ideas into a useful product
- Have worked on technically challenging science and engineering problems
- Exciting blend of the technical and human
- Working with some incredibly dedicated professionals
- More flexibility in choosing your blend of risk/security and financial reward

Do You Want to do IT? Know Your Motivations

- Personal
  - Working on a problem of value
  - Financial
  - Change of career…
- Professional
  - What are you trying to get out of this endeavor professionally?
  - What are your strongest assets and where to grow
  - Big versus small organizations
- Financial
  - Short term versus long term goals
  - Know what pain you can stand and for how long

Good Luck!

Thank You