VeriTainer Radiation Detector For Intermodal Shipping Containers

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Introduction

– There is a clear and pressing need to prevent clandestine importation of WMD via intermodal shipping containers
– Currently, 2% of the 6 million containers (per year) are monitored
– The goal is 100% monitoring
– How to achieve this without significantly impeding commerce?

*House passes $7.4 billion port security bill*, Jonathan Weisman, Washington Post, 5 May 06
VeriSpreader™ Concept

- **Goal:** Scan 100% of containers in the normal flow of commerce
  - No additional processing steps or time
  - Minimize false alarms from NORM

- **Approach:** Integrate neutron and spectroscopic gamma ray detectors into a container crane spreader bar
  - This is the piece of the container crane that directly engages an intermodal shipping container as it is moved onto and off of a container ship
  - Every container handled by the crane spends 30-60 seconds in close proximity to the spreader bar
  - Makes 100% screening feasible, since implemented during the existing handling interval
Typical crane at the Port of Oakland, CA

Container spreader bar
VeriSpreader™
Challenges

– Includes all the challenges of other radiation detection systems
  • Detecting the radiation with adequate sensitivity & resolution
  • Analyzing data to determine threat level

– Additional challenges in packaging & system engineering
  • Mechanical shock when spreader twistlock engages
  • Vibration when spreader bar is moving
  • Thermal fluctuations at end of bar
  • Constant exposure to humid, salty air
  • Robust communications over long distances (hundreds of meters) in noisy environment
VeriSpreader™ Concept

**Radiation Detection Unit (RDU)**
- NaI Scintillator/PMT
- $^3$He Tube
- GammaRad Electronics

- Fiber Optic Junction
- Ethernet Switch
- Spreader Bar
- Control System
- OCR
- Cameras
- Shipping Container

Local Control Station

Remote Monitoring Station

U.S. Patent 6,768,421
Key VeriSpreader™ Components

- Gamma-Rad Spectrometer
  - Ruggedized 76 x 152 mm NaI(Tl) with PMT
  - Digital processor with power supplies
  - Ethernet interface
- $^3$He Neutron Counter
- Radiation Detector Unit packaging
  - Packaging addresses environmental issues
  - Eight RDUs per spreader
- Optical sensor
  - Identify container and twistlock status to control acquisition
- Communication System
  - Ethernet via fiber optic for robust, long distance communications
- Analysis Software
Gamma-Rad Spectrometer

- Ruggedized scintillator & PMT from Scionix, Ltd.
- Amptek’s digital pulse processor and power supplies
Gamma-Rad Spectrometer

- Digital processor includes charge amplifier, digital shaping
- Choice of interfaces: USB, Ethernet, and RS232
- Auxiliary I/O includes counter input, timing & control signals
Gamma-Rad Key Features

– Ruggedized scintillator and PMT assembly

– Digital Processor
  • Integrates shaping amp, fast shaper, multichannel analyzer, microprocessor
  • Software configuration yields many options and adjustable parameters, set remotely, to optimize for specific conditions
  • Finite impulse response improves high count rate performance (better throughput, pile-up rejection, operation at 99% dead time)
  • Better stability and repeatability due to digital components

– Ethernet Interface
  • Robust communication over long distances (100 m)

– Gain stabilization algorithm
  • Operates in software using natural $^{40}$K background
Gamma-Rad Spectra

Spectra typical for 76 x 152 mm NaI(Tl) with PMT

**\(^{137}\)Cs Spectrum**

- 662 keV
- 42 keV (6.4%)

**\(^{60}\)Co Spectrum**

- 1.17 MeV
- 1.33 MeV
- 2.5 MeV sum peak

- 4.8% FWHM
Gamma-Rad Spectra

The graph shows the gamma-ray spectra with different isotopes and their associated energies:

- **133Ba**: 0.356 MeV
- **137Cs**: 0.662 MeV
- **238U**: 1.006 MeV
- **40K**: 1.46 MeV
- **208Tl**: 2615 keV (from 232Th decay)

The x-axis represents energy in keV, and the y-axis represents counts.
Gamma-Rad Spectra

Sensitivity vs resolution: 76 mm NaI(Tl) vs 5x5x3 mm$^3$ CdTe stack
CdTe resolves more peaks but must count vastly longer

Mixed $^{241}\text{Am}$, $^{137}\text{Cs}$, $^{133}\text{Ba}$, $^{60}\text{Co}$, $\text{UO}_3$

Natural $\text{UO}_3$
Gamma-Rad Options

- 10 X 10 X 40 cm$^3$ NaI(Tl)
  <7% FWHM at 662 keV
- 2.5 cm LaCl$_3$
Other VeriSpreader™ Components

Neutron Counter
- Moderated $^3$He detectors with 1 m active length, 50 mm diameter, and 4 atm pressure, supplied by St. Gobain Crystals & Detectors
- Dedicated HV supply and pulser shaper with TTL output

Radiation Detector Unit
- Includes shock mount to reduce shock & vibration levels
- Environmentally sealed to keep out humid, salty air
Software

– Data acquisition and control module
  • Optical system determines twistlock status to control data acquisition
  • Identifies container and associates nuclear data

– Data analysis module
  • Must distinguish NORM from possible threats
    – Background subtraction
    – Isotope identification
    – Threat analysis and reporting
  • Plan to use existing software and algorithms
  • Currently evaluating existing software
Spectra from Oakland Pilot Project

Key result: Good spectra were measured in this environment
- Background integrated for most of a day
- Typical container spectrum (similar to background)
- Chance measurement of declared uranium shipment
Results from Oakland Pilot Project

- Test conducted at Ben E. Nutter Container Terminal at the Port of Oakland
- Monitored 22 ships (6529 containers) from 14 Aug through 25 Oct 2005
- Representative spectra from undeclared containers shown below
Status

– Proof-of-concept prototype was built and tested
– Oakland pilot project demonstrated feasibility of measuring spectra in this environment
– Models and lab data verify sensitivity, spectral quality

Plans for Next Phase

– Build fully functional systems
  • Eight, 76 x 152 mm NaI(Tl) detectors on each spreader
  • Implement spectral analysis software
  • Hardware fabrication and software selection are in progress
– Validate performance in ports