

# Spies, Lies, and Nuclear Threats

James Ely and Richard T. Kouzes  
Pacific Northwest National Laboratory

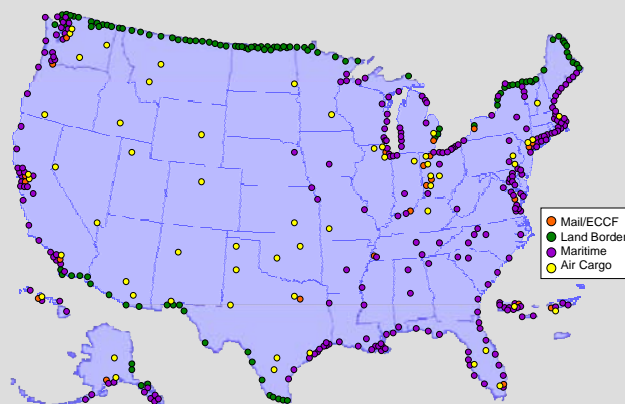


HPS July 2005  
Meeting

PNNL-SA-45766

Pacific Northwest  
National Laboratory  
Operated by Battelle for the  
U.S. Department of Energy

## The Challenge: U.S. Ports of Entry



▶ 307 Ports of Entry  
representing 621 border  
sites to protect

▶ 332,622 vehicles per day  
▶ 57,006 trucks/containers  
per day

▶ 2,459 aircraft per day  
▶ 580 vessels per day

Pacific Northwest National Laboratory  
U.S. Department of Energy 2

## Radiation Portal Monitor Project

- ▶ Technical Requirements
  - Threat definition
  - Technology adaptation
  - System test & evaluation
  - Specification development
  - Data archiving & analysis
  - Modeling
- ▶ Deployment of 2000+ radiation portal monitors
  - Site surveys
  - Design
  - Infrastructure construction
  - Installation and calibration
  - Training
  - Commissioning and turnover
  - Post-deployment operations support



Pacific Northwest National Laboratory  
U.S. Department of Energy 3

## Primary Screening (Tripwire)

- ▶ Radiation screening is one of many activities conducted by CBP
- ▶ Rapidly release the majority of vehicles
- ▶ Survey all vehicles/containers
- ▶ Facilitate the flow of commerce
- ▶ High throughput is an operational necessity
  - 5 to 10 mph drive through →  $\leq 20$  sec/vehicle



Primary Portal  
for Each Lane

Pacific Northwest National Laboratory  
U.S. Department of Energy 4

## Secondary Screening

- ▶ Evaluate all suspect vehicles/items
- ▶ Confirm primary alarm was not an anomaly
- ▶ Identify any real threats within smaller population
- ▶ Resolve cross-talk alarms (multiple-vehicle alarms)
- ▶ More controlled measurement time available per vehicle



Secondary Portal

Pacific Northwest National Laboratory  
U.S. Department of Energy 5

## Four Hypotheses

- ▶ #1: *Currently deployed radiation portal monitors are approaching the limits of passive radiation screening technology.*
- ▶ #2: *NORM is an important factor for border screening, but it is not necessarily an operational limiting factor.*
- ▶ #3: *Medical radionuclides are an operational limiting factor for radiation screening at borders.*
- ▶ #4: *Spectroscopic portal monitors may reduce nuisance rates and might improve operational sensitivity to threats of interest.*

Pacific Northwest National Laboratory  
U.S. Department of Energy 6

# Border Security Examples

*Land Border*



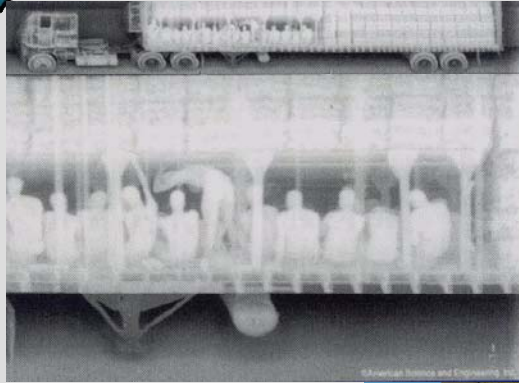
Pacific Northwest National Laboratory  
U.S. Department of Energy 7

# Border Security Examples



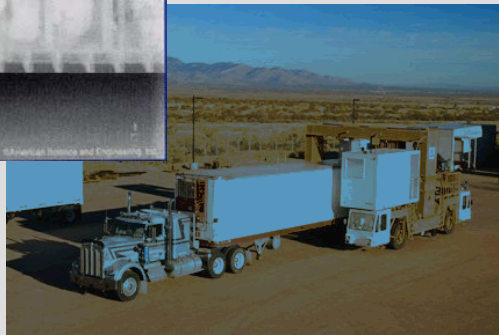
Pacific Northwest National Laboratory  
U.S. Department of Energy 8

## Layered Approach: Imaging



X-ray and gamma-ray transmission or backscatter imaging

AS&E Backscatter Example



Pacific Northwest National Laboratory  
U.S. Department of Energy 9

## Mobile Radiation Portal Monitoring System (mRPM)



- ▶ Standard portal detectors and electronics are mounted on a truck chassis enabling the detectors to be easily moved
- ▶ mRPM can be operated as a pair or individually
- ▶ Two field-able prototype units completed in 2004
- ▶ Deploy in 2005

▶ Mobile RPMs allow for the screening of targeted cargo, for on-dock screening of containers at low volume container terminals, and for the temporary maintenance or enhancement of radiation screening activities at various monitoring locations within a terminal.

Pacific Northwest National Laboratory  
U.S. Department of Energy 10

## “Nuisance” or “Innocent” Alarms

- ▶ fertilizer
- ▶ ceramic glazed materials
- ▶ polishing compounds and abrasives
- ▶ aircraft parts and counter weights
- ▶ kitty litter
- ▶ road salt
- ▶ welding rods
- ▶ propane tanks
- ▶ ore and rock
- ▶ television sets
- ▶ medical radionuclides



Pacific Northwest National Laboratory  
U.S. Department of Energy 11

## Medical Radionuclides

- ▶ Medical sources all have low energy
- ▶ One in 2600 Americans carries radioactive burden
- ▶  $^{99m}\text{Tc}$  (92% of procedures)
- ▶  $^{201}\text{Tl}$  (may contain significant  $^{202}\text{Tl}$ )
- ▶  $^{131}\text{I}$  and  $^{125}\text{I}$
- ▶  $^{67}\text{Ga}$
- ▶  $^{111}\text{In}$
- ▶  $^{103}\text{Pd}$



Pacific Northwest National Laboratory  
U.S. Department of Energy 12

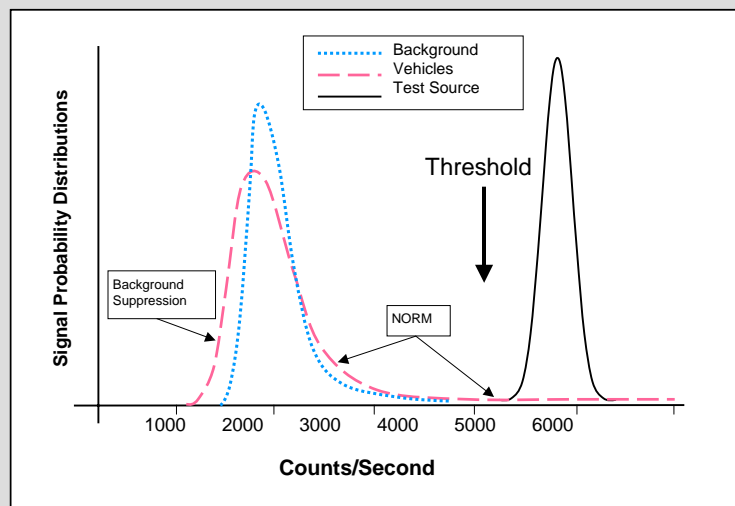
## Example Alarm Data From A Border Crossing

Top 92% of Alarms

	Percent of Loads
Kitty litter	3.4%
Medical (In, I, Tc, Tl)	1.6%
Abrasives	8%
Refractory material	8%
Scouring pads	6%
Mica	5%
Potassium/Potash	5%
Granite slabs	4%
Toilet bowls & tile	4%
Trucks/cars	2%

Pacific Northwest National Laboratory  
U.S. Department of Energy 13

## Distribution of Background and Nuisance Sources



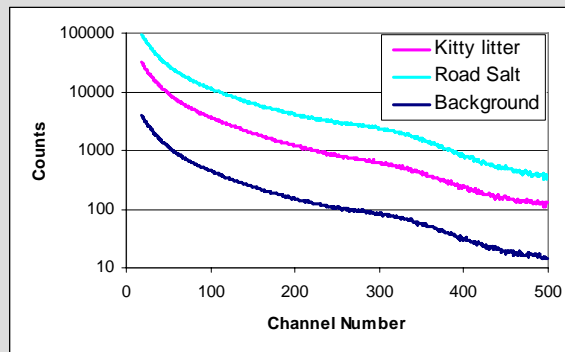
Pacific Northwest National Laboratory  
U.S. Department of Energy 14

## Energy Windowing Algorithms for Enhanced RPM Sensitivity

- ▶ Energy windowing algorithms preferentially alarm on low-energy gamma-ray signals
  - HEU, WGPu & Medical Radionuclides
- ▶ Energy windowing allows gross-threshold changes to avoid some NORM alarms
  - NORM spectra contain a significant high-energy component from U/Th chains and potassium
- ▶ Energy windowing mitigates baseline depression
  - Background spectral ratios nearly constant with and without a vehicle in the portal
- ▶ Increases the need for improved radionuclide identifying devices in secondary

Pacific Northwest National Laboratory  
U.S. Department of Energy 15

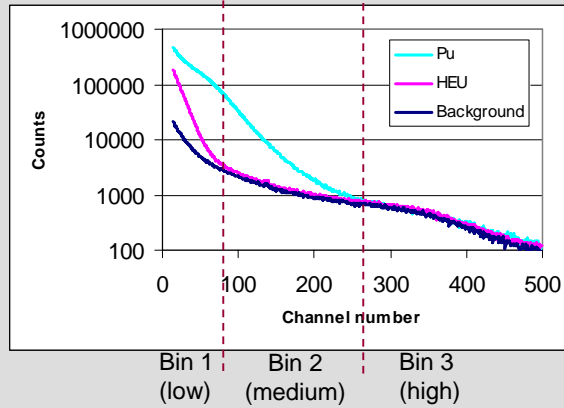
## NORM and Background



- ▶ No full energy peaks - only Compton scattering is present
- ▶ NORM has higher gross activity than background – will cause alarms
- ▶ However shape of NORM energy distribution similar to background

Pacific Northwest National Laboratory  
U.S. Department of Energy 16

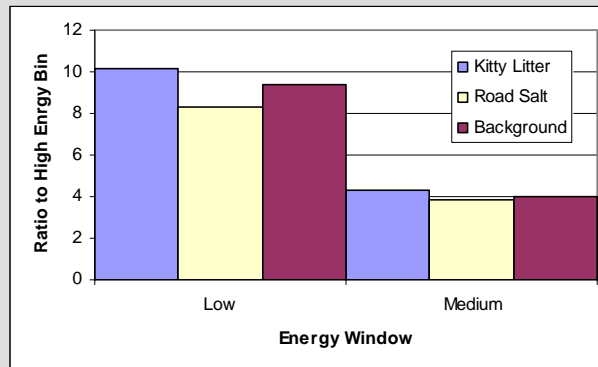
## SNM and Background



- ▶ SNM has different distribution than background
- ▶ For these two sources – 3 energy windows are optimal
- ▶ All spectra are similar in highest energy bin – used for normalization

Pacific Northwest National Laboratory  
U.S. Department of Energy 17

## Energy Windowing NORM Ratios



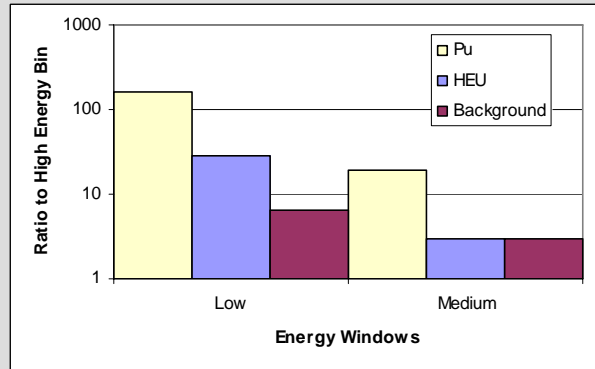
- ▶ Form three energy windows – sum counts in each

$$R_{EW} = \frac{N_{EW}}{N_{HIGH}}$$

- ▶ Form ratio to high energy bin – similar ratios for NORM

Pacific Northwest National Laboratory  
U.S. Department of Energy 18

## Energy Windowing SNM Ratios

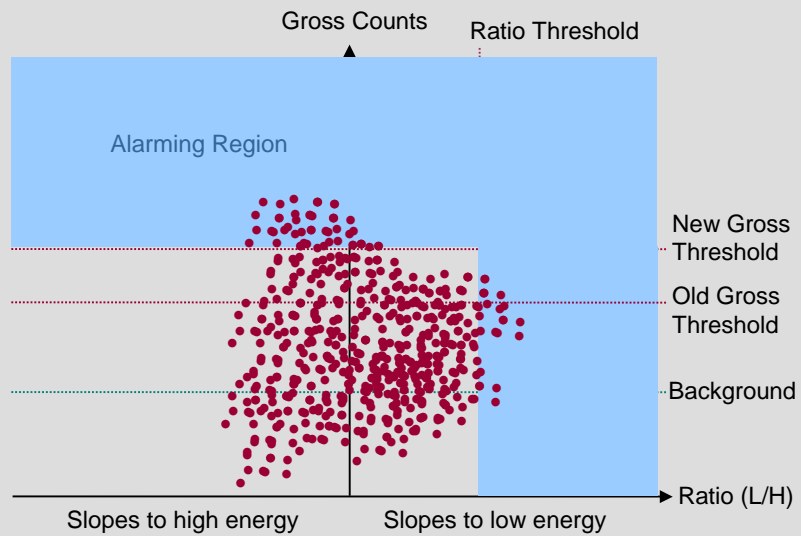


- ▶ Ratios significantly different from background – Note logarithmic scale!
- ▶ HEU can be discriminated using low ratio, Pu using low and medium ratios

$$R_{EW} = \frac{N_{EW}}{N_{HIGH}}$$

Pacific Northwest National Laboratory  
U.S. Department of Energy 19

## Energy Windowing Thresholds



Pacific Northwest National Laboratory  
U.S. Department of Energy 20

## Nal(Tl) Based Spectroscopic Portal Monitor System

- ▶ Pros and cons of Nal(Tl) versus plastic scintillator
  - Higher resolution allows for simultaneous identification
  - Improved NORM rejection
  - Improved identification rate
  - Higher cost
  - Physical limitations of Nal(Tl) such as thermal effects
- ▶ Efficiency requirement
  - Equivalent efficiency to scintillator based RPMs needed
  - e.g. Five 4"x2"x16" Nal(Tl) crystals per panel
- ▶ Automated identification possible

Pacific Northwest National Laboratory  
U.S. Department of Energy 21

## Prototype SPM Example



Handheld RIID

*Developed with DOE NA-22 support*

Pacific Northwest National Laboratory  
U.S. Department of Energy 22

## Requirements for Spectroscopic Portal Monitors

The leading operational needs for SPM systems:

- To improve the secondary processing of alarms for isotopic identification.
- To operate in situations where isotopic identification in primary screening is especially important (e.g., Rail).
- To use on mobile systems for targeted screening or rapid deployments.
- To provide for primary screening where secondary processing space is very limited (e.g., some seaports).

Pacific Northwest National Laboratory  
U.S. Department of Energy 23

## The Justification for Spectroscopic Portal Monitors

SPM deployment can only be justified if:

- ▶ They increase sensitivity to SNM  
and
- ▶ They reduce the operational burden  
and
- ▶ They improve identification

Pacific Northwest National Laboratory  
U.S. Department of Energy 24

## Four Hypotheses, Reiterated

- ▶ #1: *Currently deployed radiation portal monitors are approaching the limits of this current approach to radiation screening.*
- ▶ #2: *NORM is an important factor for border screening, but it is not necessarily an operational limiting factor.*
- ▶ #3: *Medical radionuclides are an operational limiting factor for radiation screening at borders.*
- ▶ #4: *Spectroscopic portal monitors may reduce nuisance rates and might improve operational sensitivity to threats of interest.*