

Detecting Nuclear Materials Smuggling: Combining Radiography and ATS to Improve Container Inspection

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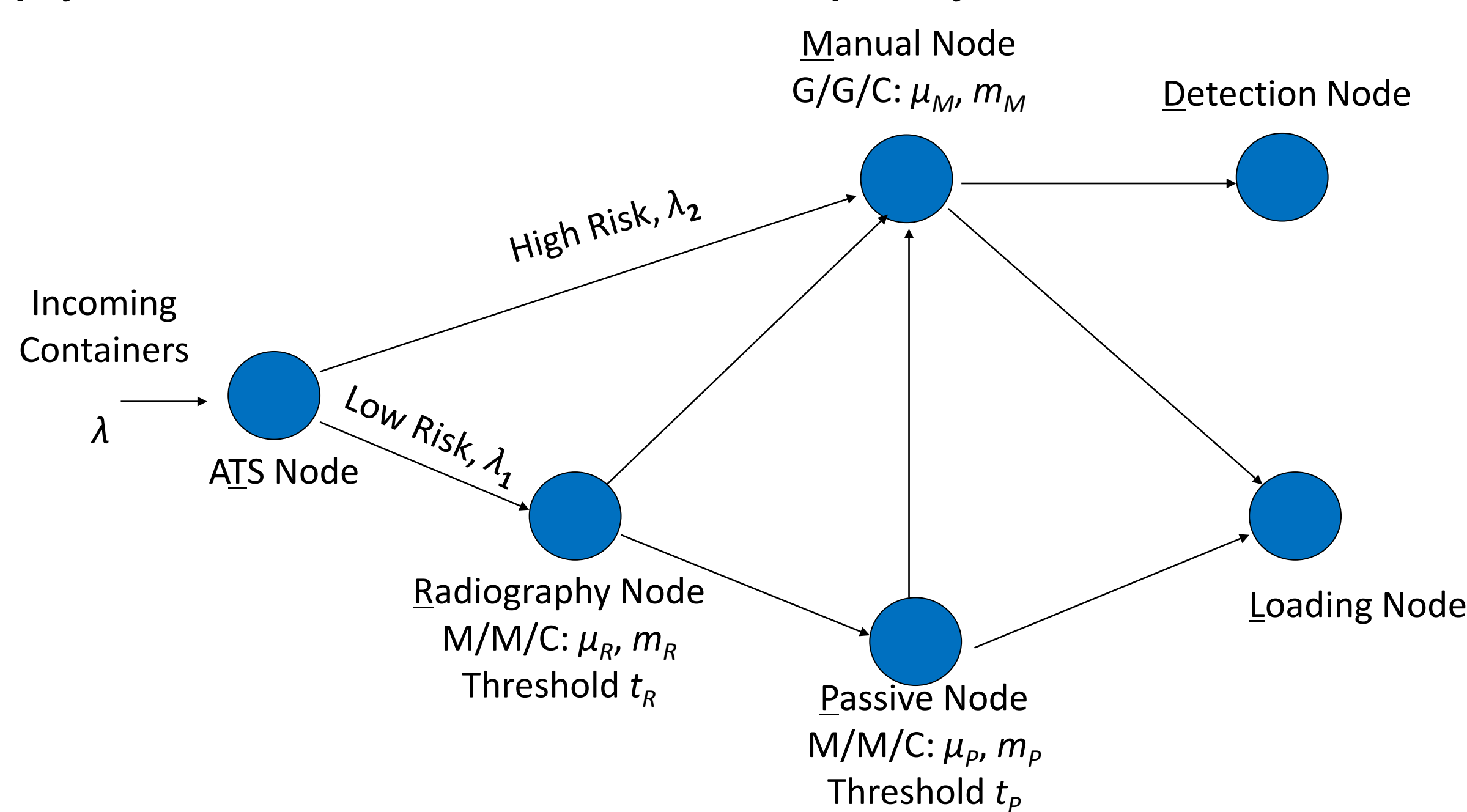
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Objectives

- Model seaborne cargo containers using MCNP
- Investigate impact of container cargo contents on probability of HEU detection
- Investigate the benefits of having a radiography node as well as having a hybrid inspection strategy
- Develop hybrid inspection policy that combines the radiography information and ATS intelligence information

Hybrid Inspection System

- Utilize both intelligence information and the radiography information
- Apply a scenario-based threshold policy



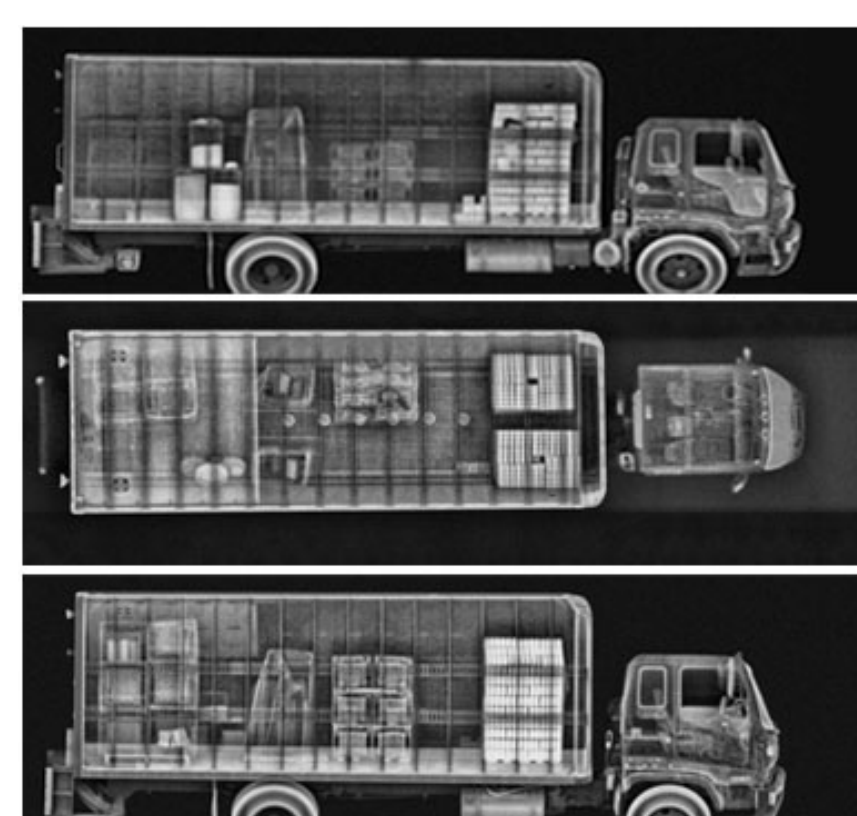
- Inputs: container traffic information (arrival rate and container scenario information) and detector capability (service rate, detection power, and number of each type of detector);
- Performance indices:
 - Detection probability (i.e., a container having HEU eventually arrives at the D-node)
 - System throughput (i.e., how long a container stays in the inspection system, known as sojourn time)

Radiography Node

- Introduce a radiography node, which provides an X-ray imaging of what is inside the container, called a container scenario.
- Based on a given container scenario, calculate a hardness measure and determine which pathway the scenario will go through.

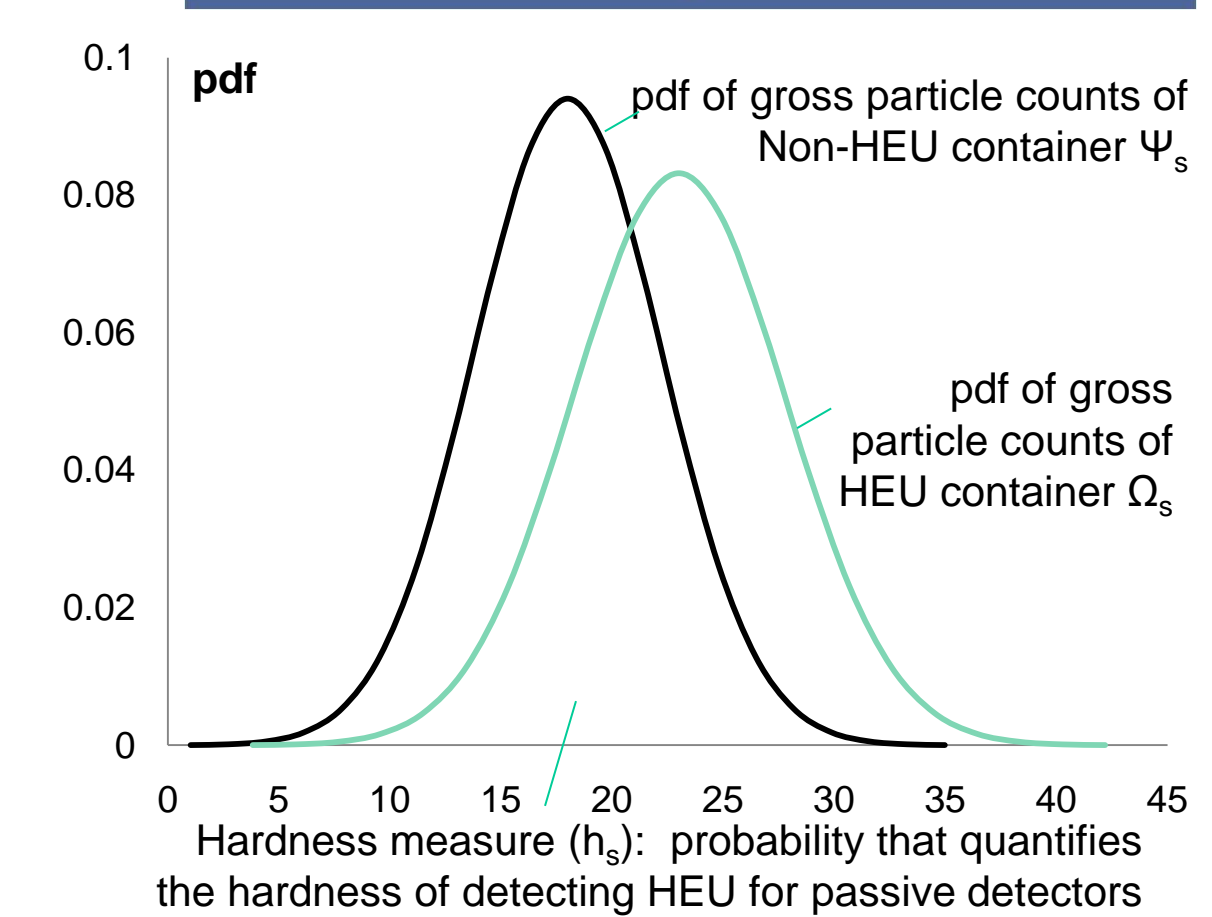
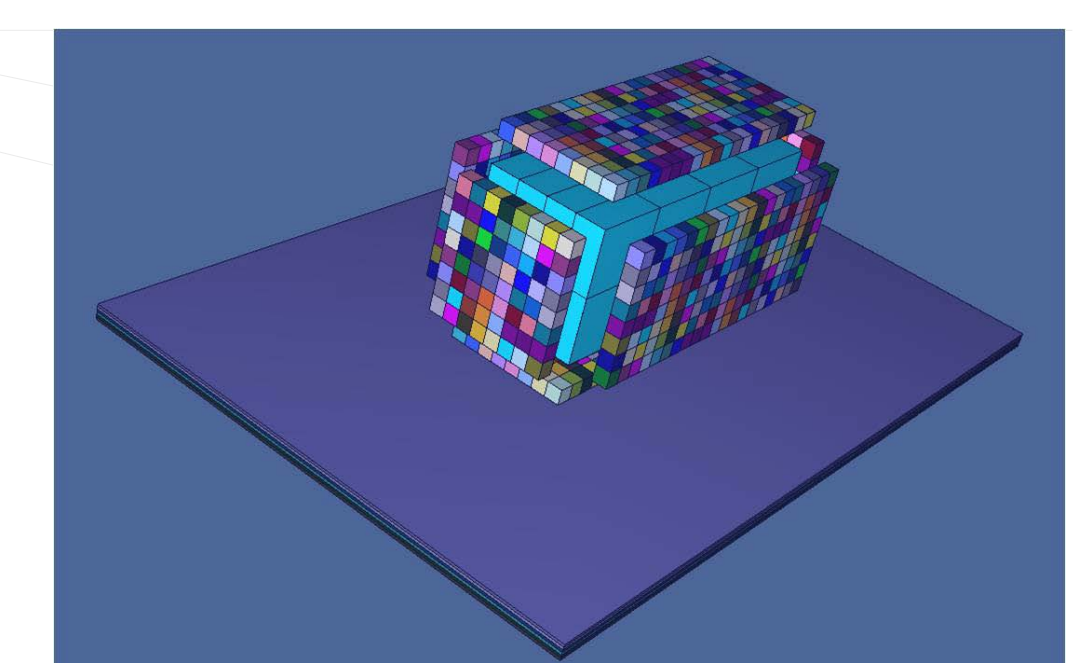


Medium energy X-ray machine: Z Portal



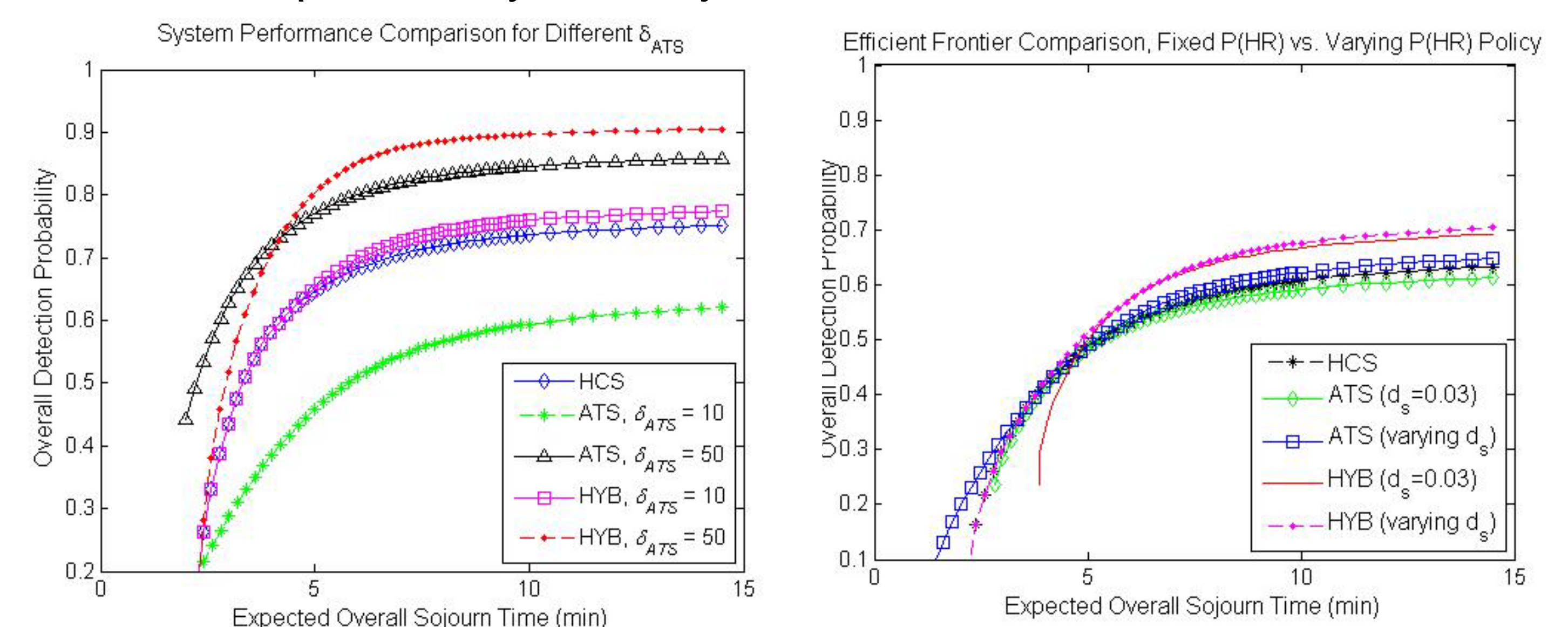
Hardness Measure

- Mimicking the response of a passive detector based on the MCNP simulation.
 - Input: Z-value matrix from X-ray images
 - Output: distribution of the amount of photons we expect to detect for a given scenario q_s with HEU and without HEU
- Hardness measure is the misclassification probability of not being able to detect a certain amount of (shielded) HEU for a given scenario.

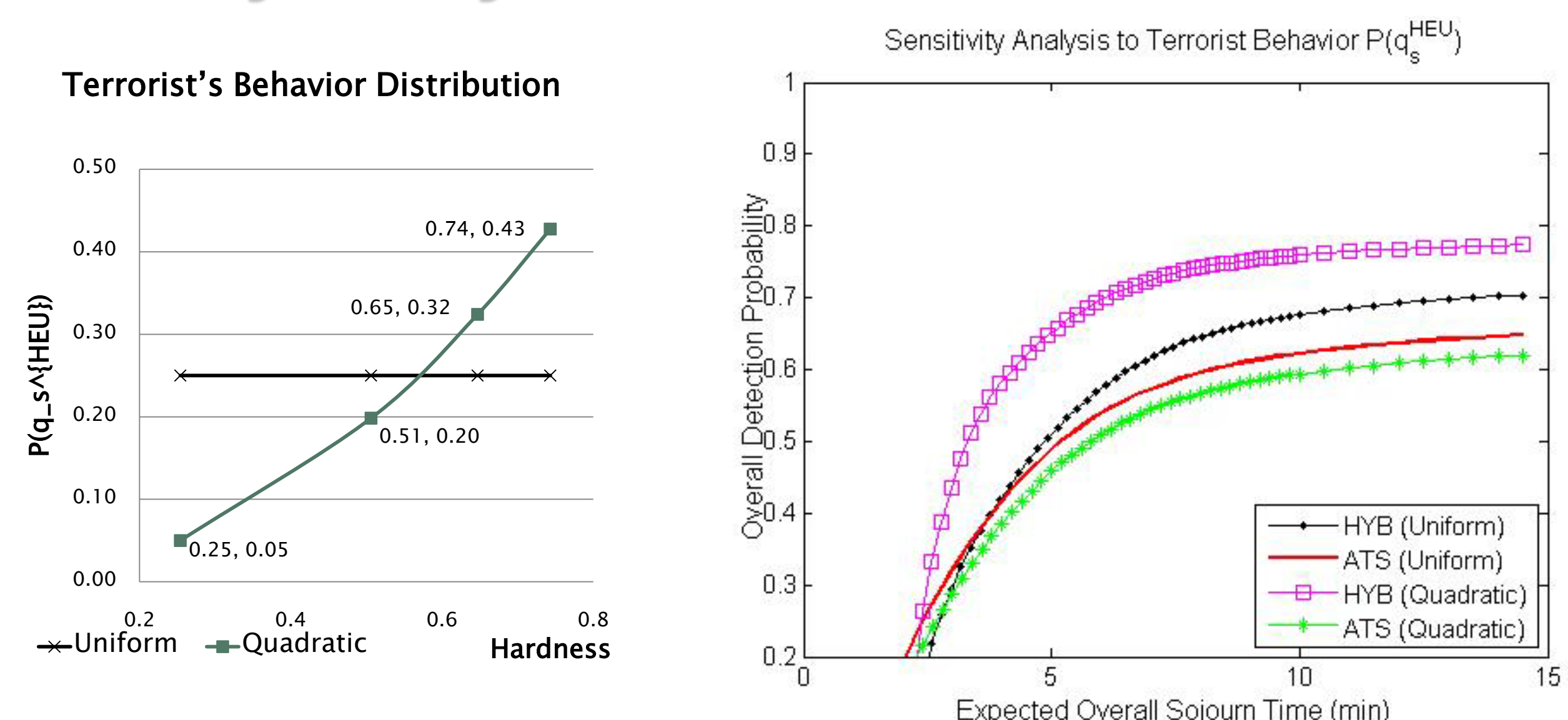


Numerical Example

- In an HEU container, one kg HEU (30% of U-238 and 70% of U-235) with one cm lead shielding is placed in the center of the container.
- Efficient frontiers are generated to show the trade-off between detection probability and sojourn time.



Sensitivity Analysis of Terrorist Behavior



Sensitivity Analysis of Uncertainty of δ_{ATS}

