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Role of New Scientific Approaches in Tamper Detection for Nuclear Security

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Challenges of securing weapons, installations, and materials

- Complexity of today's multi-polar nuclear world poses significant challenges for safeguarding nuclear materiel
- Securing materials and controlling unattended areas present technical and operational challenges
- Concerns about the "sophisticated adversary"
  - Rapid advancements and availability of science and technology may make new spoofing methods easier to employ

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What can tamper-indicating devices accomplish?

- **Security**: Provide indelible and unambiguous evidence of intrusion in real-time
- **Verification**: Assist with assuring compliance with international nuclear agreements
- **Inventory control**: Reduce threats of proliferation, theft, vandalism, and sabotage of nuclear materials

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Conventional physical security devices employed today

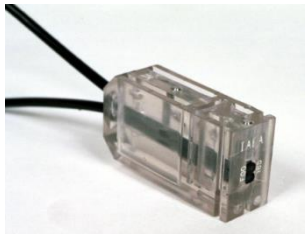
Fiber Optic Seal

Source: http://web.ornl.gov/sci/nsed/gstd/

Passive methods	Active methods
*Adhesive labels	*Electronic seals
*Foils, films	*Fiber optic seals
*Wires, cables	
Glitter paint seals	
*Simple tags and locks	

*Source: R.G. Johnston, 2001, http://cns.miis.edu/npr/pdfs/81john.pdf

Cobra Seal (Passive)



Electro Optical Sealing System (Active)

Source: H. Undem, PNNL, 2008, http://web.ornl.gov/sci/nsed/outreach/presentation/2011/Undem.pdf

These devices may not be the complete solution!

The need for new approaches

"Tamper-proof" devices deemed adequate today may not be tomorrow

- The risk of technological surprise is too great
- It is important to reexamine assumptions since mature technologies today will evolve over time
- Better tamper-indicating approaches are sorely needed to ensure compliance with treaties and nonproliferation agreements

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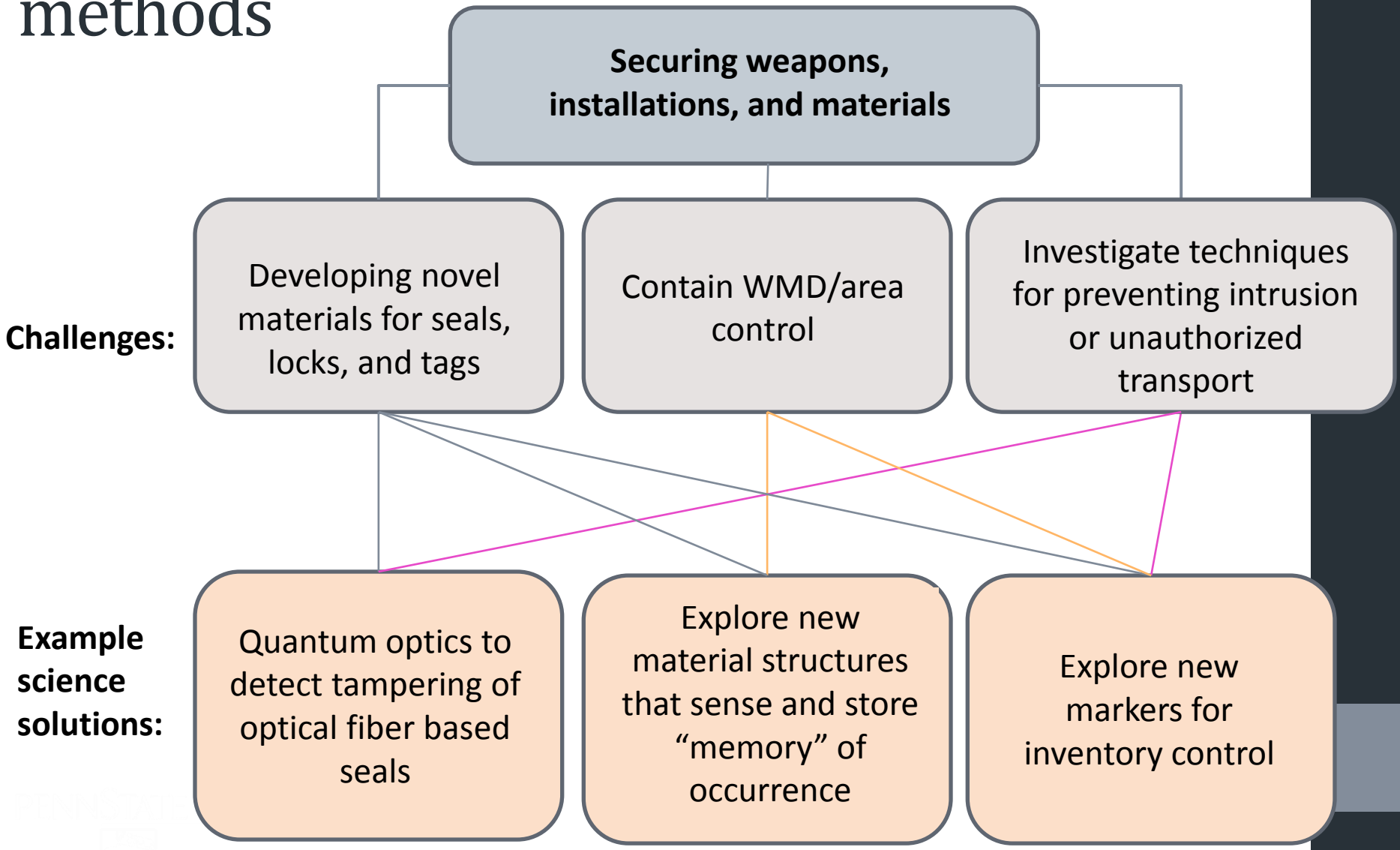
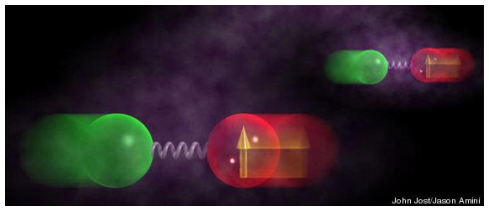
Paths to improved security and control methods



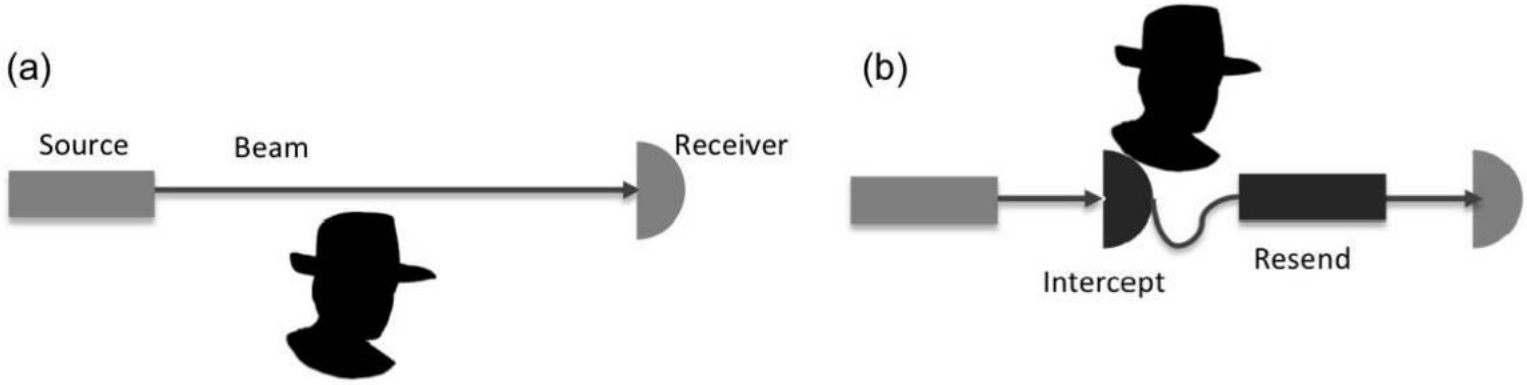
Source: DTRA Thrust Area 5, J9-BA

Quantum science approaches for tamper detection



SCIENCE OPPORTUNITIES:

- Close vulnerability gaps in classical optical sensors
  - Apply techniques from quantum physics for realizing "quantum seals"*
  - Thwart "middle-man attacks" of intercepting-resending optical signals



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*Source: T.S. Humble, *et al.* (2009) "Sensing intruders using entanglement: a photonic quantum fence," Proc. of SPIE, vol. 7342. http://web.ornl.gov/~hqt/publications/ProcSPIE_7342_7342H_2009.pdf

Materials science approaches for tamper detection

SCIENCE OPPORTUNITIES:

- Develop “smart” materials that *sense and respond* to their environment
  - Elicit response from mechanical pressure (e.g. touch)*, chemicals, temperature, radiation, and other stimuli
  - Creation of unique “fingerprints” when material is touched*

- Smart materials could be integrated with electronic systems
  - Alert and respond to a tampering incident in real-time
  - Log when incident occurred

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*Source: Peng Jiang, 2015 DTRA BRTR presentation

New markers for inventory control

There is a need to ensure continuity of chain of custody of materiel

SCIENCE OPPORTUNITIES:

- New methods for tagging materials
- Laser surface authentication for seals*
  - Make unique surface textures that are difficult to reproduce*

- Consider dual-use technologies
  - Anti-counterfeit security labels used in consumer products and currency purposes

*Sources: R.D. Murphy, *et al.* (2013) *Appl Phys Lett,* 102(21).
David P. Adams, 2015 DTRA BRTR presentation

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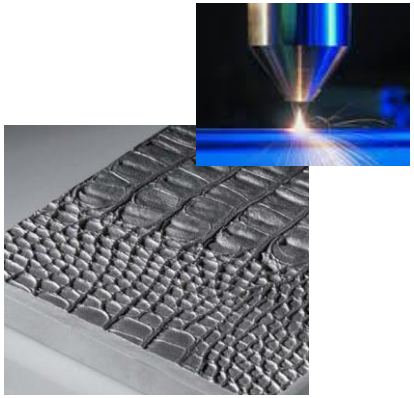

Opportunity for polymer opals in security printing?

Concluding Points

- New scientific avenues can shape landscape for cooperative international nuclear policy
  - Tamper-indicating device(s) serve as ***one*** measure for ensuring confidence in treaty compliance among nations
  - Emerging scientific discoveries may help define new treaty conditions and verification capabilities

- Element of science "push" for nonproliferation treaties and agreements
  - Consider future treaties 10-20 years from now ("treaty after next")

- Consider emerging areas of science and engineering
  - Possible opportunities for dual-use technologies (e.g. commercial sector)

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CTBTO OSI exercise

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