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Laser-based technique for Nuclear Forensics

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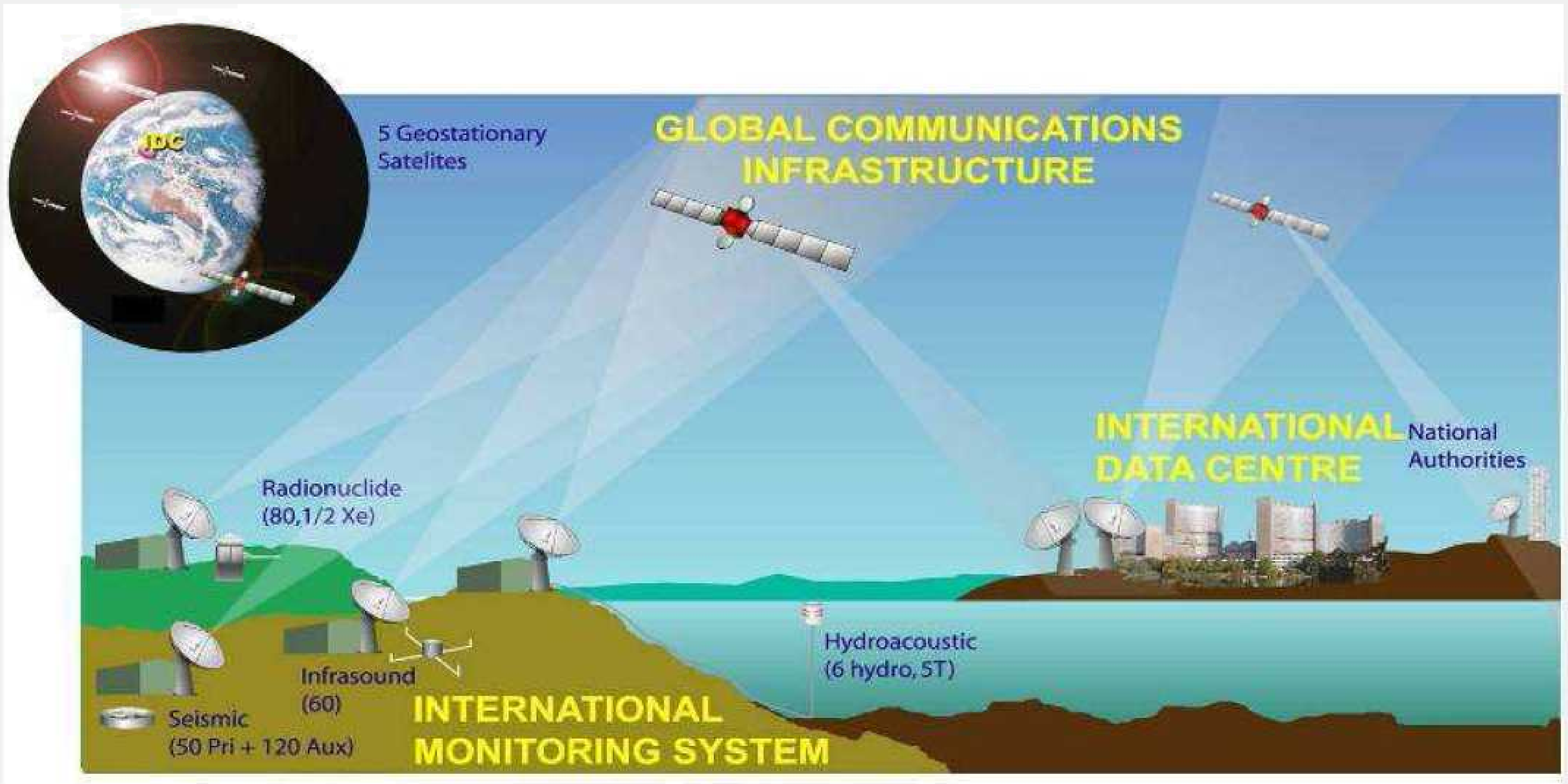
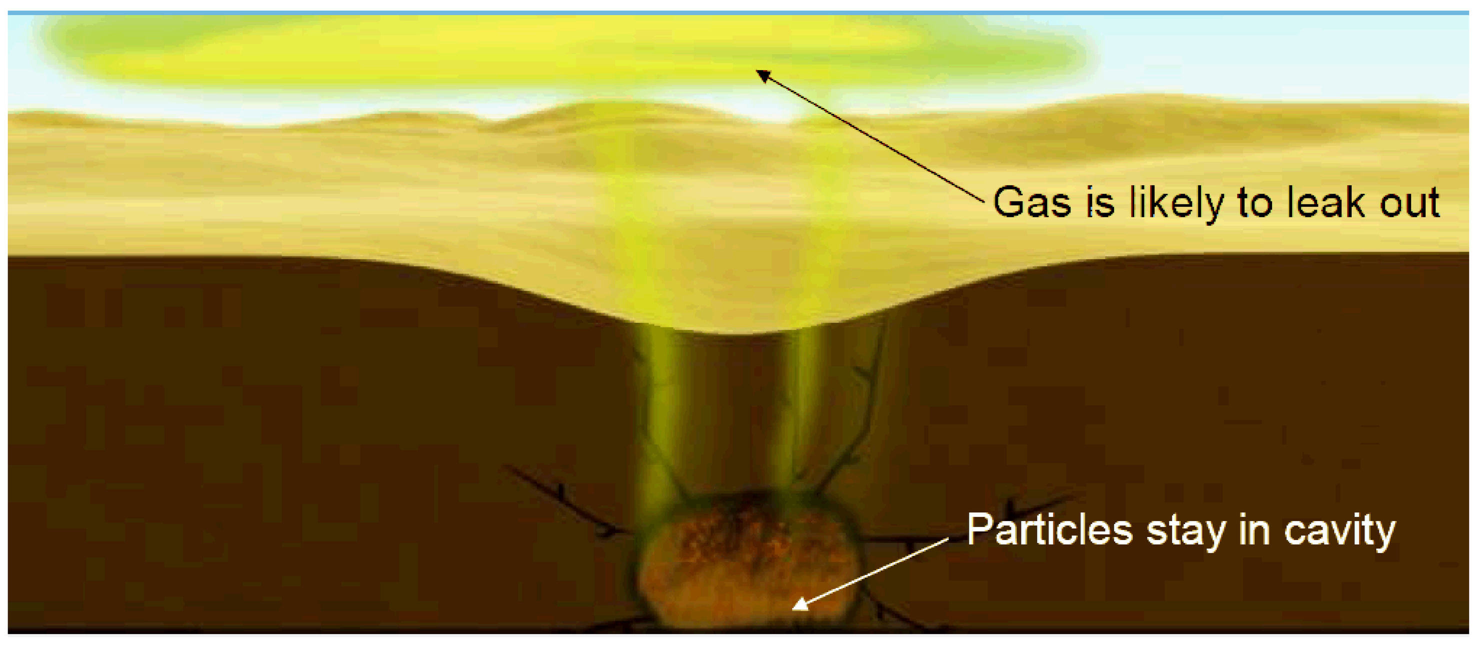
Introduction

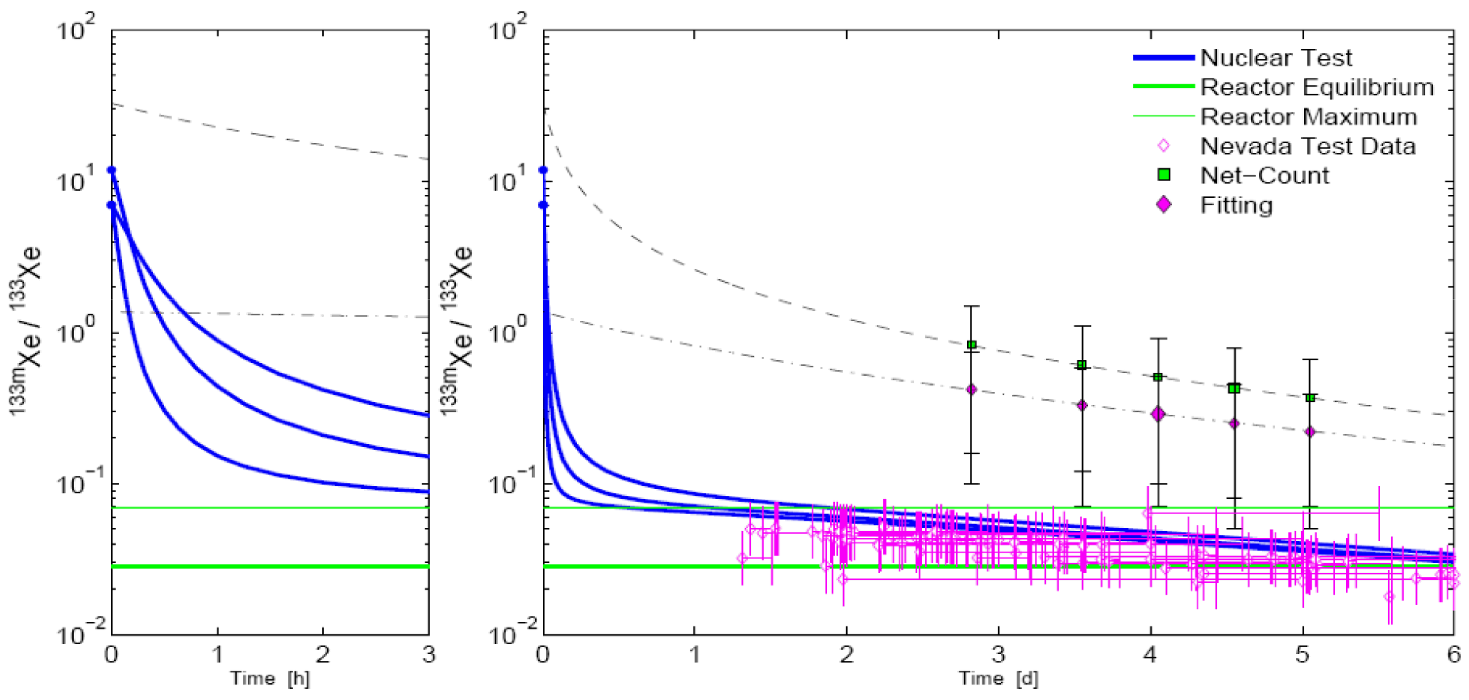


The Comprehensive Test Band Treaty (CTBT) bands all nuclear testing, and ratification of this treaty is one of the goals of the 2010 Nuclear Posture Review. In order for this treaty to be effective, a reliable method for verifying compliance with the treaty is necessary. Several complimentary detection methods are employed to determine if a nuclear test has occurred including: seismology, Infrasound, hydroacoustic, and radio-nuclide identification of noble gas.

Motivations for noble gas detection:



- Detect noble gases
  - Difficult to contain, seeps through soil
  - Xenon gas is a signature released from underground nuclear explosions.
  - Interested in ratios of ^{133m}Xe/ ^{133}Xe, ^{135m}Xe and ^{135}Xe



- Time-efficient
  - After a nuclear test explosion, Xenon levels decrease to normal reactor operation levels in thee hours
  - Requires portable, timely measurement capabilities to verify the presence of a nuclear explosion

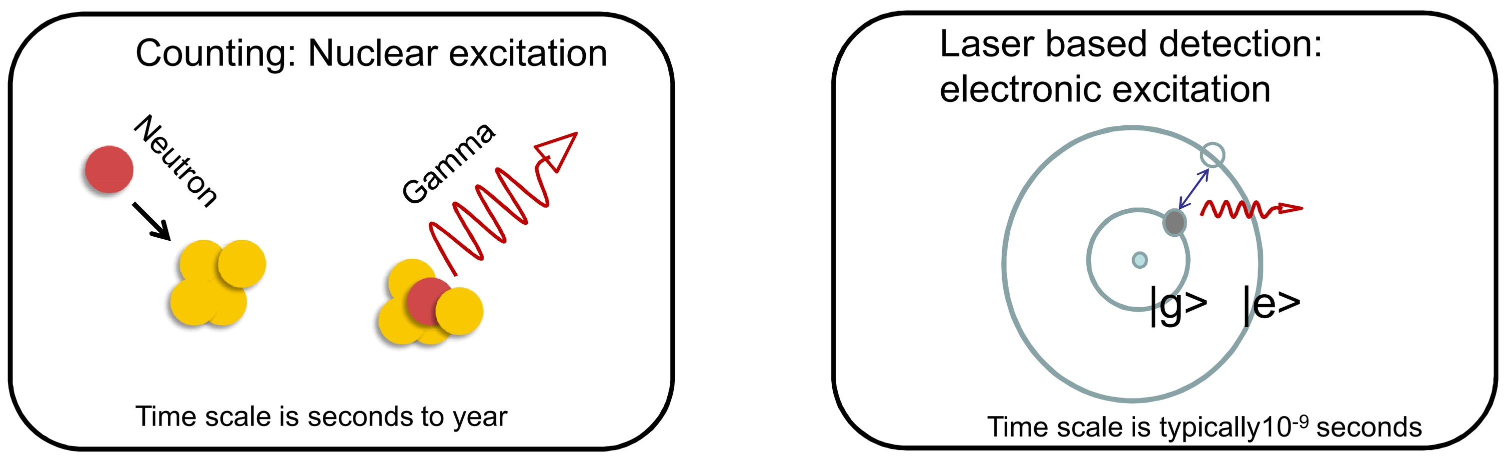
Objective:

Develop a portable, laser-based, trace noble gas detection platform.

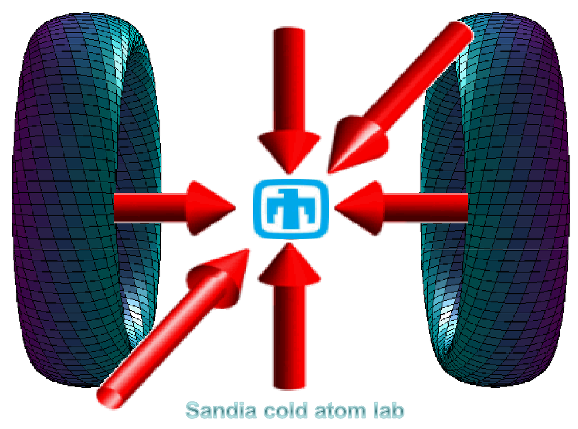
Radiological Counting vs. Laser Based Counting

Radiological Counting	Laser Based Counting
• Measures the decay products of the gas	• Directly measure the atom and the isotope
• Measurement can take hours/days	• With laser cooling and atom trapping can making single-atom detection possible.
• Commercially available detectors	• Small enough to fit on a plane where analysis can be done
• Limited by background radiation	• Measurements taken in minutes

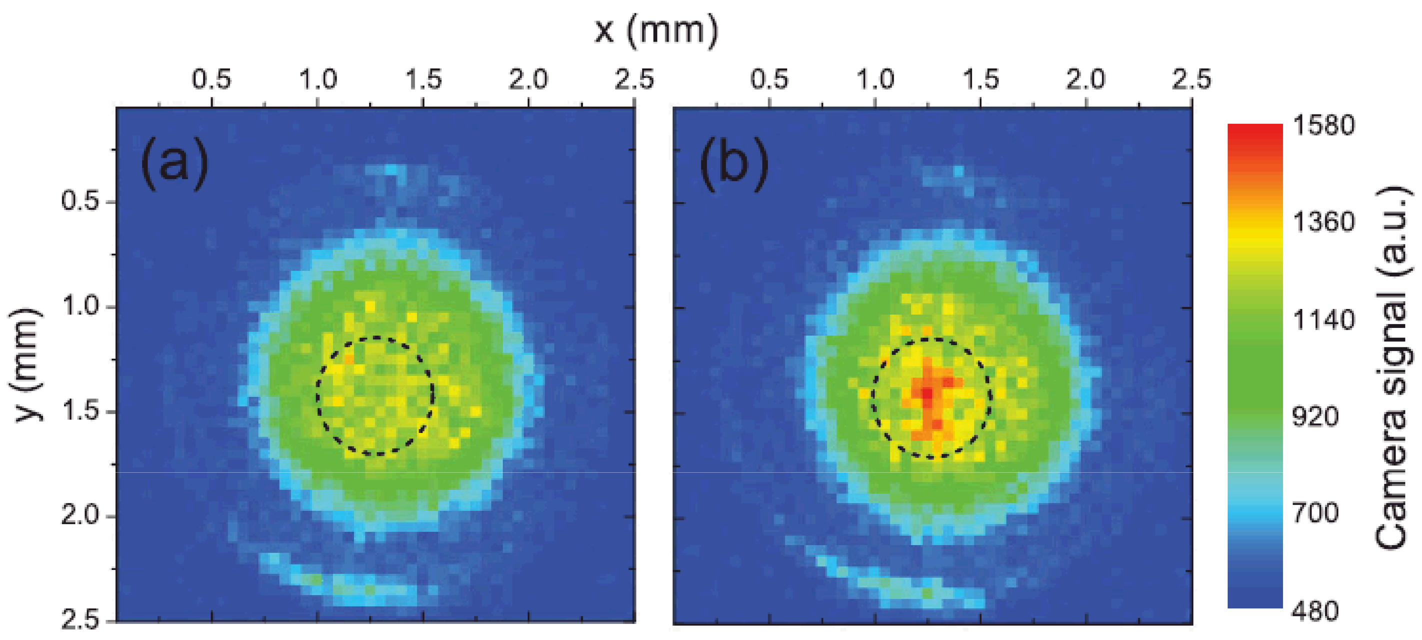
Nuclear Excitation vs. Atomic Excitation:



Methods:



- Laser Cooling/Atom Trapping
  - Lasers slow and concentrate trace gases allowing single atoms to be quantitatively detected.
  - Isotope frequency shifts allow individual isotopes to be distinguished and measured making isotope ratio possible.



Left picture shows no atoms, right picture shows fluorescence emitted by single atoms.

NSSC Collaboration:

- Train students in the development on laser based analyses.
- Development and engineering of state of the art electronics for remote detection.
- Quantitative analysis, data collection, programming, systems modeling and uncertainty quantification.
- Development of the next generation of radio-nuclide detectors.

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