

# Nuclear Nonproliferation

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What comes to  
mind when you  
think of nuclear  
nonproliferation  
?

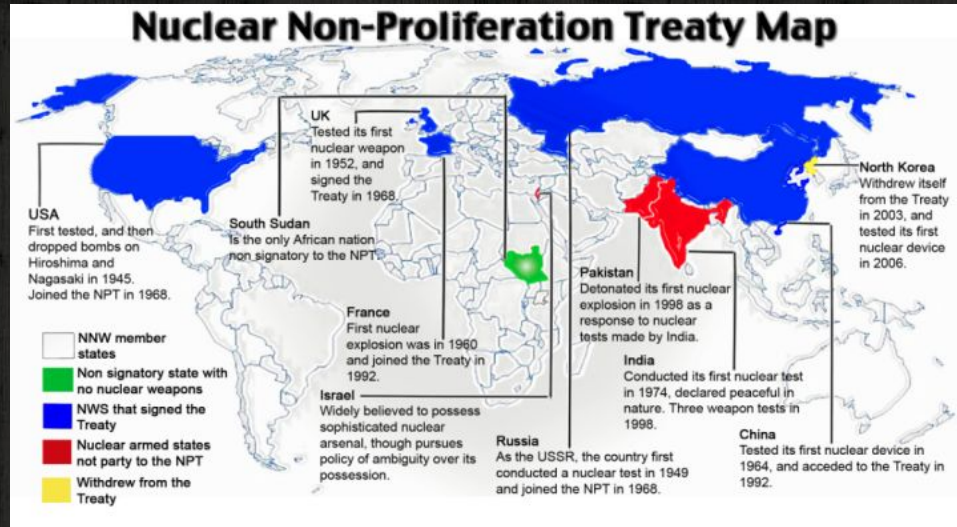


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treaties  
radiation detectors  
dual-use  
arms control  
design verification  
reprocessing  
missiles  
heavy water  
IAEA  
safeguards  
nuclear weapons  
nuclear fuel cycle  
security  
CTBT  
open source  
guards, gates, and guns  
radiological material  
nuclear forensics  
nuclear energy  
disarmament  
dirty bomb  
non-weapons states  
weapons states  
plutonium  
uranium  
delivery vehicle  
NPT  
RDD  
hot cell  
inspections  
declarations  
dual-use  
trialoge

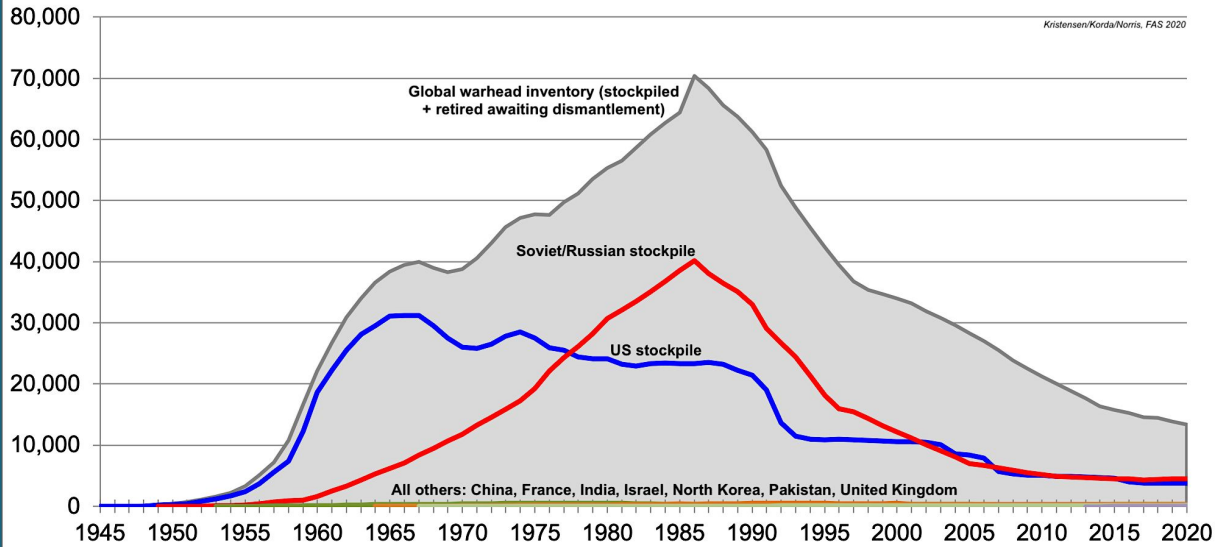
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# Treaty on the Non-Proliferation of Nuclear Weapons (NPT), 1970



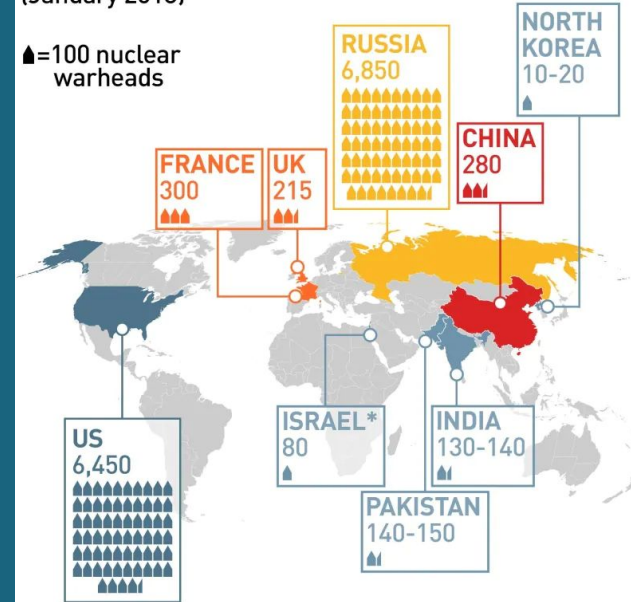
- ◆ 191 signatories
- ◆ Split the world up into “nuclear weapons states” and “non nuclear weapons states”
  - 5 NWS, but 9 countries believed to have weapons
- ◆ NNWS agree not to develop
- ◆ NWS agree not to share tech
- ◆ NWS agree to work towards disarmament

## Estimated Global Nuclear Warhead Inventories 1945-2020



## Estimate of global nuclear weapons (January 2018)

▲=100 nuclear warheads



\*Israel has never confirmed or denied that it has any nuclear weapons.

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*Limiting the spread of nuclear weapons*

*Detecting tests of nuclear explosive devices*

*Working towards fewer nuclear weapons*

*Preventing the theft or loss of nuclear & radiological materials*

*Avoiding the use of nuclear weapons or RDD*

*Allowing for the spread of peaceful nuclear technologies*

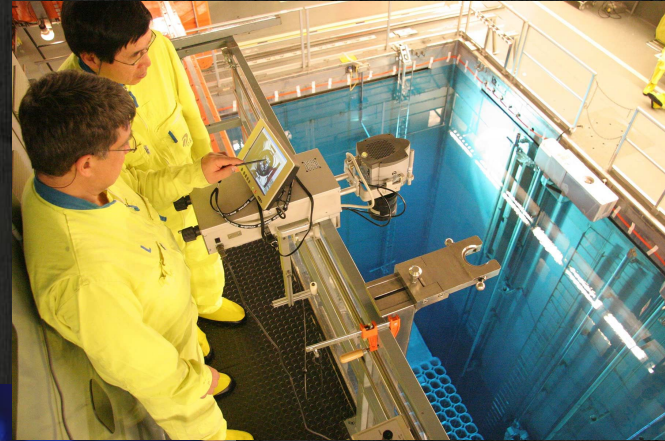
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# Nuclear safeguards

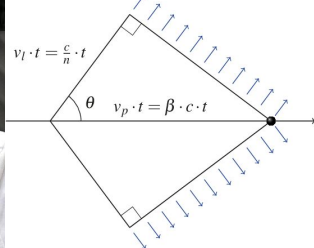
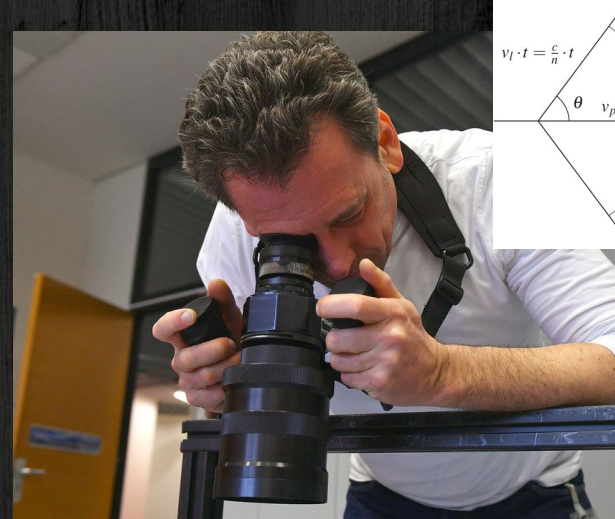
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- ◆ Detecting the misuse of nuclear material **by state actors**
- ◆ “A cross between detectives and accountants”
- ◆ Inspectors take many measurements
  - Non-destructive
    - Mass and inventory
    - Radiation detection
  - Destructive
    - Spectroscopy
    - x-ray fluorescence

Inspection of spent fuel



Mass inspection



Safeguards  
by design

Radiation detectors

# NUCLEAR ENGINEERING AND TECHNOLOGY

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**Original Articles**

**Reactor Physics**  
Investigating Heavy Water Zero Power Reactors with a New Core Configuration Based on Experiment and Calculation Results  
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Open source



DigitalGlobe / 38 North  
February 25, 2018

Satellite  
imagery

- Mobile crane
- Traveling construction crane
- Reactor construction yard (primary)
- 5MWe reactor
- Support building intact
- ELWR entrance
- Electrical transformer switchyard
- Ventilation stack
- Sluiceway
- Pump house
- Vehicles present



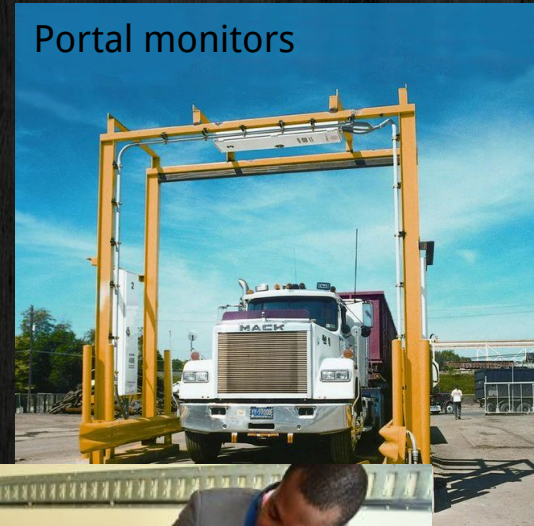
# Nuclear Security

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“Guards, gates, and guns”

- ◆ Defending from non-state actors
- ◆ Material accounting
- ◆ Transportation and packaging of material
- ◆ Tamperproof seals

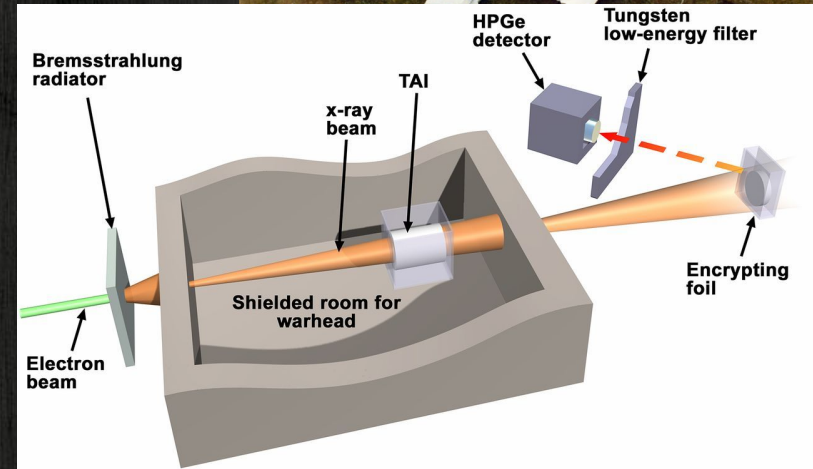
Portal monitors



# Arms Control & Disarmament

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- ◆ Working towards less nuclear weapons
- ◆ Dismantling delivery vehicles
- ◆ Actual warhead verification (someday!)
- ◆ Lots of policy work



# Radiological Response

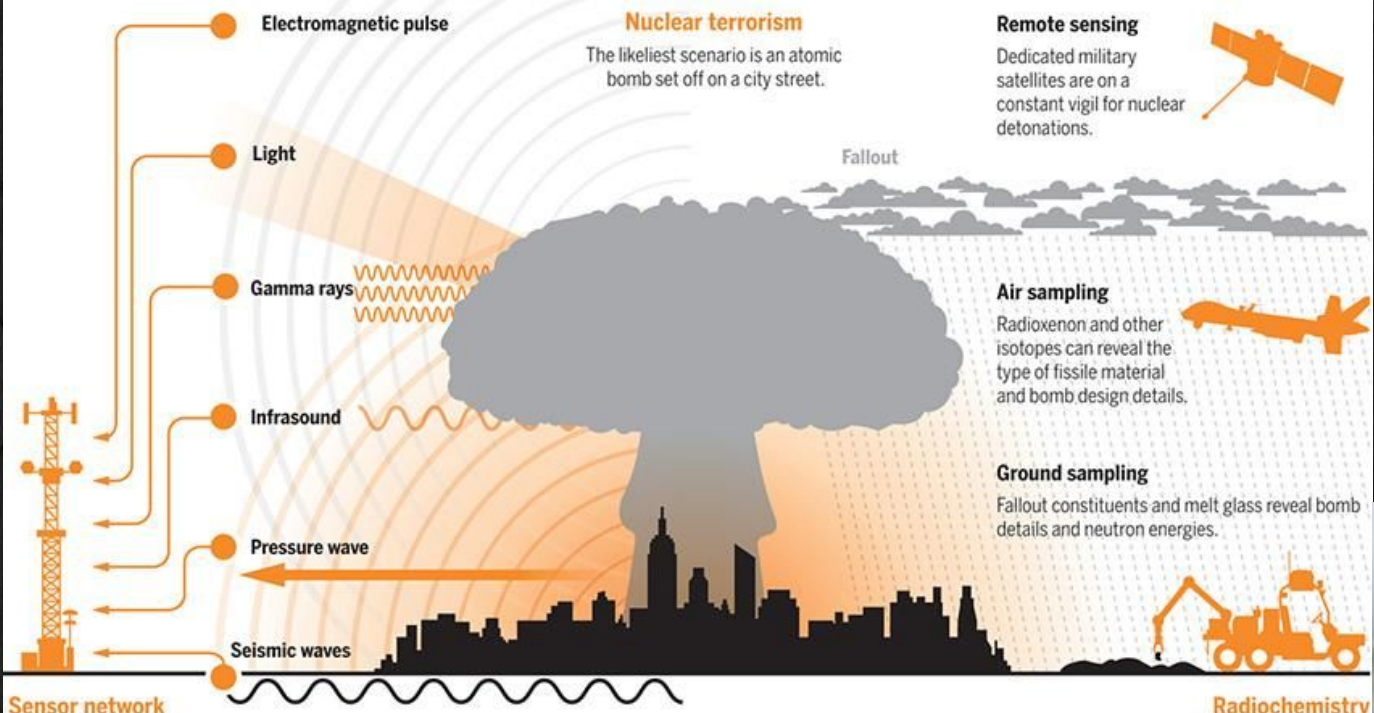
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- ◆ Someone finds suspicious material--now what?
- ◆ Usually police or security force, not experts



# Forensics of a nuclear blast

If an atomic bomb were to detonate in a U.S. city, nuclear sleuths would use a wide range of tools to puzzle out the nature of the blast and who was responsible. Each weapon type has a distinct fingerprint encompassing the waveforms it emits and the fallout it unleashes.



The new Discreet Oculus sensor array, which records electromagnetic emissions and other waveforms, is being deployed in major U.S. cities.

Fallout is a mélange of the vaporized environment—soil and structures that were near the blast—laced with fission products, radioisotopes made in the explosion, and residual nuclear material.

# Nuclear Forensics



# Who hires nuclear engineers into nonproliferation and arms control work?

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- ◆ National labs
- ◆ DOE National Nuclear Security Administration (NNSA)
- ◆ Department of State, Department of Homeland Security
- ◆ Think tanks
  - Nuclear threat initiative (NTI)
  - Institute for Science and International Security
- ◆ IAEA
- ◆ Universities
  - Harvard Project on Managing the Atom
  - James Martin Center for Nonproliferation Studies (CNS)

# Research areas with relevance to nonpro

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- ◆ Radiation detection
  - Gamma
  - Xray
  - Active neutron
  - Passive neutron
  - neutrino
- ◆ Reactor physics
- ◆ Nuclear criticality safety
- ◆ Nuclear fuel cycle and waste management
- ◆ Machine learning
- ◆ Radiochemistry
- ◆ Instrumentation & control
- ◆ Health physics, radiation protection
- ◆ Nuclear physics
- ◆ Thermal hydraulics
- ◆ Remote sensing
- ◆ Nuclear data
- ◆ Storage and transportation
- ◆ Advanced reactors
- ◆ Drones and robotics