# Physics/Global Studies 280: Session 11

## Plan for This Session

News and discussion

Module 3: Nuclear Explosions

Module 4: Nuclear Terrorism

News:

THE INDEPENDENT

# US to spend billions on 'ineffective' nuclear weapons in Europe that pose 'terrorism threat'

'It should be assumed that they are targets for terrorism and theft,' arms experts warn

Lucy Pasha-Robinson | @lucypasha | 4 days ago |

A U.S. Air Force F15-E fighter jet takes off from Incirlik airbase in the southern city of Adana, Turkey *Reuters*

The US is preparing to spend billions of dollars upgrading its nuclear weapons programme in Europe, despite the arsenal posing a significant security risk as "targets for terrorism and theft", critics have warned.

Approximately 150 US nuclear weapons are reportedly held on the continent, according to arms experts.

A third of the B61-12 bombs under joint US and Nato control are thought to be stored at Incirlik base in Turkey, and governments of some member states have expressed concern over the implications of storing the weapons so close to Syria.

"Assumptions about the safety and security of US nuclear weapons stored in Europe have been called into question by recent terrorist attacks and political instability. It should be assumed that they are targets for terrorism and theft," a report by the Nuclear Threat Initiative (NTI) found.

# News:

In March 2016, the Pentagon evacuated military families from Incirlik due to "Isisrelated security concerns". In July, the commanding officer of the base was arrested for his alleged role in an attempted coup to topple the Turkish government, according to the NTI.

"This event shows just how quickly assumptions about the safety and security of US nuclear weapons stored abroad can change," the report stated. The NTI also warned the weapons may not serve as a more effective deterrent than those already held by European member states, raising questions about the need for further investment in the scheme. "The argument that forward-deployed US nuclear weapons in Europe serve a military function not already addressed by alliance conventional forces or the strategic nuclear forces of the three nuclear NATO members – particularly, the large and flexible capabilities of the US – has been consistently refuted by current and former defence officials," the NTI said in its report, titled Building a Safe, Secure and Credible Nato Nuclear Posture. The report also argued the B61 bombs serve simply as reassurance to Nato members of the US commitment to defending Europe, with the US strategic Trump says he will expand US nuclear arsenal UN launches major push for nuclear disarmament talks despite US Russia deploys nuclear-capable missiles to border with Nato countries Risk of global conflict at highest level since Cold War, says
Coats missile arsenal acting as a real nuclear deterrent, including Russia.

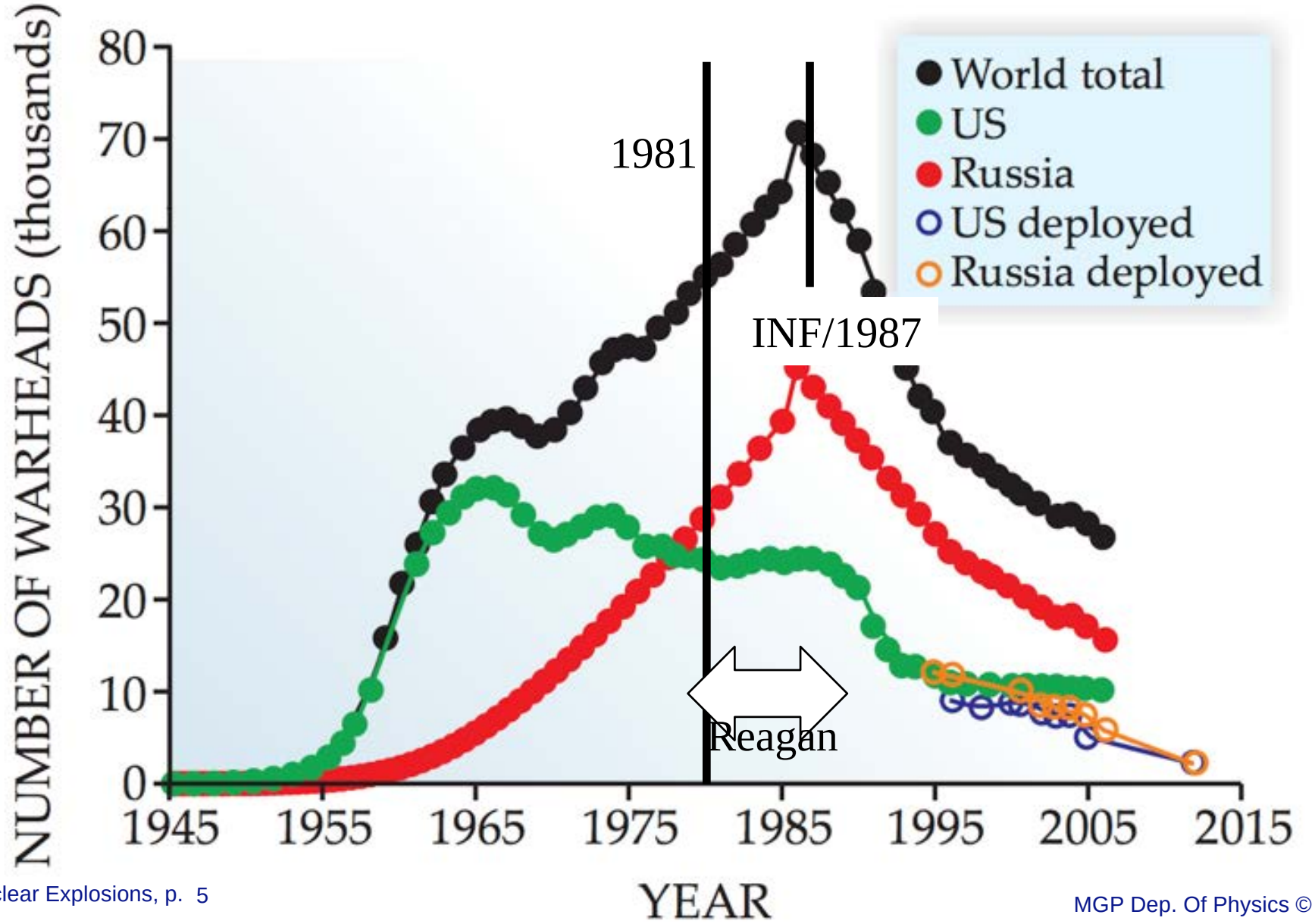
By May 2012, the estimate had increased by 50 per cent to $6bn and by July 2012, the Pentagon's Cost Assessment and Program Evaluation Office informed Congress that the cost would be about $10bn.

# Video Presentation, Ground Zero

(from CBS Reports on The Defense of the United States, aired June-14-1981)

# Context: Arsenals at the Time of CBS Series

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)



# Question related to the video presentation

(A) Which imbalance in nuclear arsenals triggered the concern of military superiority of the SU ?

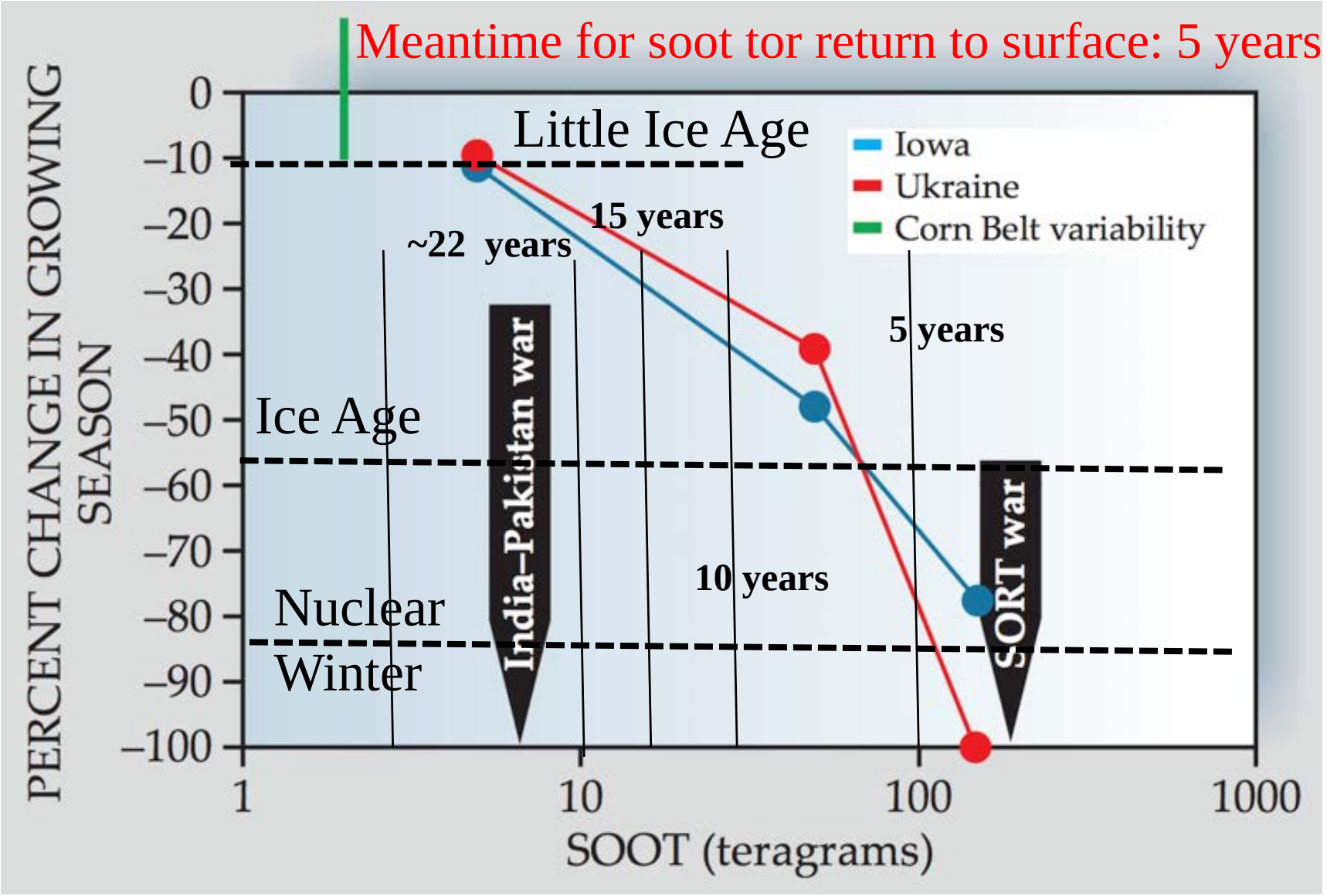
(B) What is the TRIAD ?

(C) Why would there be much more fall out in a US-Russian Nuclear War than following Hiroshima and Nagasaki?

(D) Which society is more vulnerable to Nuclear War, Why?

# How Long from Nuclear Winter to Little Ice Age?

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)



# Nuclear Terrorism

Topics covered in this module:

Part 1: Terrorism and how to counter it

Part 2: Reducing the threat of nuclear terrorism

Sources:

*What Terrorists Want*, by Louise Richardson

*Preventing Catastrophic Nuclear Terrorism,* by Charles D. Ferguson

*Articles on Reading Assignments Page*

# Terrorism and How to Counter It

# The Importance of Understanding Terrorism

**Endeavoring to understand or explain terrorism is not to sympathize with it.**

Instead, understanding the appeal of terrorism is the best way to effective counterterrorism policies.

Example: Gaining an understanding the Shining Path Maoist movement in Peru was much more effective in countering it than attempting to smash it —

- It had 10,000 members in the 1980s and controlled a large area of Peru
- Thousands of armed military and paramilitary forces were deployed over 20 years
- Shining Path and military units killed ~ 70,000 people, but terrorism did not diminish
- Only when the government established a special 70-man intelligence unit to study the Shining Path was it successfully countered
- The intelligence unit discovered that the leadership of the movement was highly centralized and depended on the academic Abimael Guzmán
- They studied everything about him and discovered he had a particular skin condition
- By old-fashioned police work and good electronic intelligence, Guzmán was tracked down though his medical prescription and captured with several of his top lieutenants

*The Shining Path never recovered*

# Terrorism and How to Counter It

Topics covered here and in the readings —

- What is terrorism?
- Where have terrorists come from?
- What causes terrorism?
- The three Rs of terrorism
  *(Revenge, Renown, Reaction)*
- Why do terrorists kill themselves?
- What changed on 9/11 and what did not
- What is to be done?

# Categories of Violent Political Activity (Important)

**Terrorism***: Deliberately* and *violently* targeting *civilians* for *political* purposes (all *4 criteria* must be met)

**Insurgency:** An organized movement aimed at the overthrow of a constituted government through use of subversion and armed conflict. Insurgents may or may not commit terrorist acts.

**Guerilla warfare:** A type irregular warfare and combat in which a small group of combatants use mobile military tactics in the form of ambushes and raids to combat a larger and less mobile formal army. Guerilla warfare is not terrorism.

**Regular armed forces:** Must satisfy the four Hague Convention (Hague IV) conditions (1899 and 1907): (1) be commanded by a person responsible to a party to the conflict, (2) have a fixed distinctive emblem recognizable at a distance, (3) carry arms openly, and (4) conduct operations in accordance with the laws and customs of war.

# What is Terrorism?

Terrorism is **deliberately** and **violently** targeting **civilians** for **political** purposes.

Terrorism often (but not always) has *3 other characteristics* —

1. The point of terrorism is not to defeat the enemy but to send a message.
2. The act and the victim usually have symbolic significance.
3. The *victim* of the violence and the *audience* the terrorists are trying to reach *are not the same*.

# Terrorism Carried Out by Governments – 1

Richardson argues that to have a clear understanding of the behavior of *terrorist groups*, we must understand them as sub-state actors. Although states and their leaders are not *terrorist groups,* states may engage in terrorism.

The terrorism committed by states can be divided into three categories:

**1. State-sponsored terrorism:** State sponsorship of terrorist acts against inhabitants of *other* countries as an instrument of foreign policy.

For example, to hurt other countries without risking the consequences of overtly attacking them (e.g., Libyan support of terrorist acts against U.S. interests during the 1980s, Iraqi support of Palestinian terrorist acts against Israel during the 1990s, Iranian support of terrorism against Israel by Hezbollah in Lebanon and Hamas in Gaza).

For example, as a way to engage in proxy warfare or covertly bring about internal change in another country without risking a direct confrontation (e.g., U.S. support of terrorist groups in Angola and Nicaragua).

# Terrorism Carried Out by Governments – 2

**2.State terrorism:** Use of terrorism by a government against its own citizens, to coerce them into accepting the government's authority (examples: Germany in the 1930s, Argentina in the 1970s, Iraq in the 1980s and 1990s).

**3.War terrorism:** Use of terrorism by a government against the civilians of another country with which it is at war (examples: the German and Allied bombing campaigns in World War II, which damaged London, and destroyed Coventry, Dresden, Hiroshima, Nagasaki, Rotterdam and were deliberate efforts to target civilian populations in order to force the hands of their governments).

Collective punishment of communities that produce partisans is another example of targeting civilians to achieve political ends and is therefore terrorism (example: collective punishment of villages of resistance fighters in the Ukraine, Italy and France through German troops in WWII).

# Understanding Terrorists – 1

Richardson points out that:

- Terrorism, even religious terrorism, is neither new nor the primary preserve of Islam
- Terrorists have sometimes later become statesmen

She argues that the causes of terrorism are not to be found in objective conditions of poverty or privation or in a ruthless quest for dominance, but rather in a "lethal triple cocktail" that combines —

1. a disaffected individual
2. an enabling community
3. a legitimizing ideology

*Richardson argues that terrorists are neither crazy nor amoral but rather are rationally seeking to achieve a set of objectives within self-imposed limits.*

# Understanding Terrorists – 2

Richardson argues that —

- The behavior of terrorists can be understood in terms of
  - ***long-term political objectives***, which differ across groups
  - ***more immediate objectives***, which are shared by terrorists with very different long-term objectives
- Terrorists' generally have much more success achieving their immediate objectives than achieving fundamental change.
- When terrorists act, they are seeking 3 immediate objectives (the "3 Rs"):
  - to exact revenge
  - to achieve renown (glory)
  - to force their adversary to react

# The 3 Standard Initial Reactions to Terrorism

**There are 3 standard phases in an inexperienced society's reaction to terrorism —**

Phase 1: Demonstrate resolve by adopting a draconian response that goes largely unchallenged by the public

Phase 2: Polarization of politics —

- The right demands tougher measures and denounces opponents as unpatriotic
- The left objects to many coercive measures

Phase 3: More reasoned reflection, when —

- Draconian measures have failed to produce the desired results
- The adversary has demonstrated his implacable commitment to harming the nation

# Physics/Global Studies 280: Session 12

## Plan for This Session

Questions about the course

News

The threat of nuclear terrorism

# News:

PHYSICS TODAY

16 Feb 2018 in Politics & Policy

## Laser program at University of Rochester targeted for shutdown

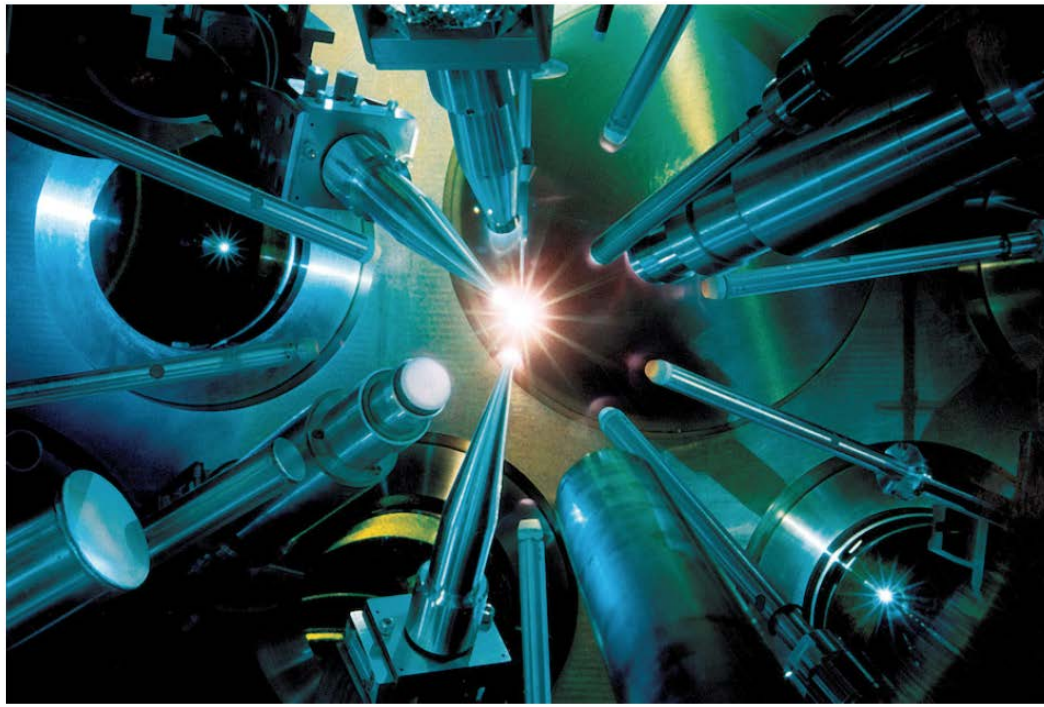
DOE budget proposes closing one of the three facilities that aid in the effort to attain fusion with lasers.

David Kramer

The US Department of Energy intends to close a premier facility that has long led one of the three principal approaches to initiating nuclear fusion through the use of powerful lasers. DOE plans to initiate a "three-year rampdown" of the University of Rochester's Laboratory for Laser Energetics (LLE) in the fiscal year that begins in October, according to a summary of the agency's 2019 budget proposal released on 12 February.

The LLE, which houses the 40-kilojoule Omega laser, is one of three major facilities supported by the inertial confinement fusion (ICF) program of DOE's National Nuclear Security Administration. Complementing work at the much larger National Ignition Facility at Lawrence Livermore National Laboratory, the research at the LLE focuses on a direct-drive approach to ICF, … .

The LLE rampdown is part of a larger 20%, or $104 million, reduction proposed for the overall ICF program.



The Omega laser's 40-kilojoule output is used, among other things, to crush hydrogen pellets and initiate nuclear fusion. The latest presidential budget request proposes shutting down in three years the Rochester, New York, facility housing Omega. Credit: University of Rochester

# News:

PHYSICS TODAY

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DOE budget proposes closing one of the three facilities that aid in the effort to attain fusion with lasers.

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Michael Campbell, LLE director, says he was "completely surprised" by the closure proposal. "I don't understand how such a decision could be made in the absence of any discussion with the program performers," he says, referring to the LLE and the other labs in the ICF program.

Campbell says he suspects that with the recent release of the Trump administration's Nuclear Posture Review, the NNSA decided to place greater emphasis on extending the lifetime of weapons and designing warheads at the expense of the underlying science program. "When these life extension programs are done in the 2030s, where are we going to get the talent that's going to produce the experts?" he says. "How do you test someone who's been doing computer codes? You test them by doing experiments in the real world. Omega, Z, and NIF do that."

Campbell says that two years ago, the directors of the NNSA's three weapons labs had backed continuing all three ICF programs, and that attaining laboratory fusion was "a critical element" of the science in support of the nuclear weapons stockpile. "What has changed in the past two years to make that statement different?" Research at LLE and the other facilities has been funded principally to further nuclear weapons science. The ICF program's main objective has been to achieve ignition, the point at which fusion reactions release more energy than was required to create them.

# Six Basic Rules for Containing Terrorism

Rule 1: Have a defensible and achievable goal

- If the goal of the U.S. is to defeat terrorism or eliminate terrorism, it can never be achieved
- By contrast the goal to capture those responsible for the 9/11 attacks, has been achievable
- *Containing* the threat of terrorism *is* achievable
- By keeping this more modest and concrete goal firmly in sight and planning accordingly, the U.S. can ensure that its short-term tactics do not undermine its long-term goals

Rule 2: Live by your principles

# Six Basic Rules for Containing Terrorism (cont'd)

Rule 3: Know your enemy

Rule 4: Separate the terrorists from their communities

Rule 5: Engage others in countering terrorists with you

Rule 6: Have patience and keep your perspective

**U.S. counterterrorism policy after 9/11 did not initially follow these six rules, but improved with time.**

# Example: US Reaction to 9/11

Richardson argues that the early response was marked by two significant mistakes and two major missed opportunities

Mistakes:

- declaration of a “global war on terror”
- conflation of the threat posed by al-Qaeda with the threat posed by Saddam Hussein

Missed opportunities:

- the opportunity to educate the American public to the realities of terrorism and the costs of U.S. sole superpower status
- the opportunity to mobilize the international community behind the U.S. in a transnational campaign against transnational terrorists

# Impact of 9/11 in the United States

Richardson argues that the declaration of a “global war on terror” — has been a mistake and is likely to fail

She argues for a different approach —

- appreciate the factors driving the terrorists
- deprive them of what they need

# Key Questions for Countering Terrorism

In thinking about counterterrorism policies, the question should *not* be

- Who's tough on terrorists?
- Who's soft on terrorists?

What matters is —

- *What actions are effective against terrorism?*
- *What are their costs?*

We are likely to experience terrorism in the future, just as we have in the past.

We are going to have to learn to live with and accept it as a price of living in a complex world in which communication is relatively easy.

# The Relation of Democracy to Terrorism

Through improved security measures and enhanced intelligence, we can protect ourselves against the most dangerous weapons and the most sophisticated attacks.

It's important to remember that —

- Terrorists cannot derail our democracy by planting a bomb in our midst
- Our democracy can be derailed only if we conclude that it is inadequate to protect us
- Democratic principles are the strongest weapons against terrorists

# Reducing the Threat of Terrorism

Richardson argues we should recognize that —

- Terrorism will continue to be employed as long as it is deemed effective
- Technological developments will make it easier for ever smaller groups to employ weapons of ever greater lethality against us
- Political, social, and economic developments will continue to produce disaffected individuals
- We will never be able to prevent every attack, but we can control our reaction to those attacks

*If we keep terrorist attacks in perspective and recognize that the strongest weapons in our arsenal against terrorism are precisely the hallmarks of democracy that we value, then we can contain the terrorist threat.*

# Reducing the Threat of Nuclear Terrorism

# Reducing the Threat of Nuclear Terrorism

## Two Ongoing Parallel Approaches

1. Invasion and war (has led to insurgencies)
2. Cooperative efforts to secure or intercept nuclear explosive materials

# Delivery Methods Other Than Long-Range Ballistic Missiles Pose Greater Threats

Several countries are capable of developing mechanisms to launch SRBMs, MRBMs, or land-attack cruise missiles from forward-based ships or other platforms.

**U.S. territory is more likely to be attacked with [nuclear weapons] using non-missile delivery means—*most likely from terrorists*—than by missiles, primarily because non-missile delivery means are —**

- **less costly**
- **easier to acquire**
- **more reliable and accurate**

**They also can be used without attribution.**

— *Unclassified summaries of past National Intelligence Estimates of Foreign Missile Developments and the Ballistic Missile Threat Through 2018*

# A possible Scenario

I) Select high profile symbolic target eg NATO summit (Chicago in May of 2012 with all NATO heads of state present)

II) Smuggle fissile material and other weapon components illegally into the country.

III) Rent nearby shop or house to setup nuclear device.

**chicagotribune.com**

**Trial to begin of three charged with planning attacks at NATO summit**

Mary Wisniewski

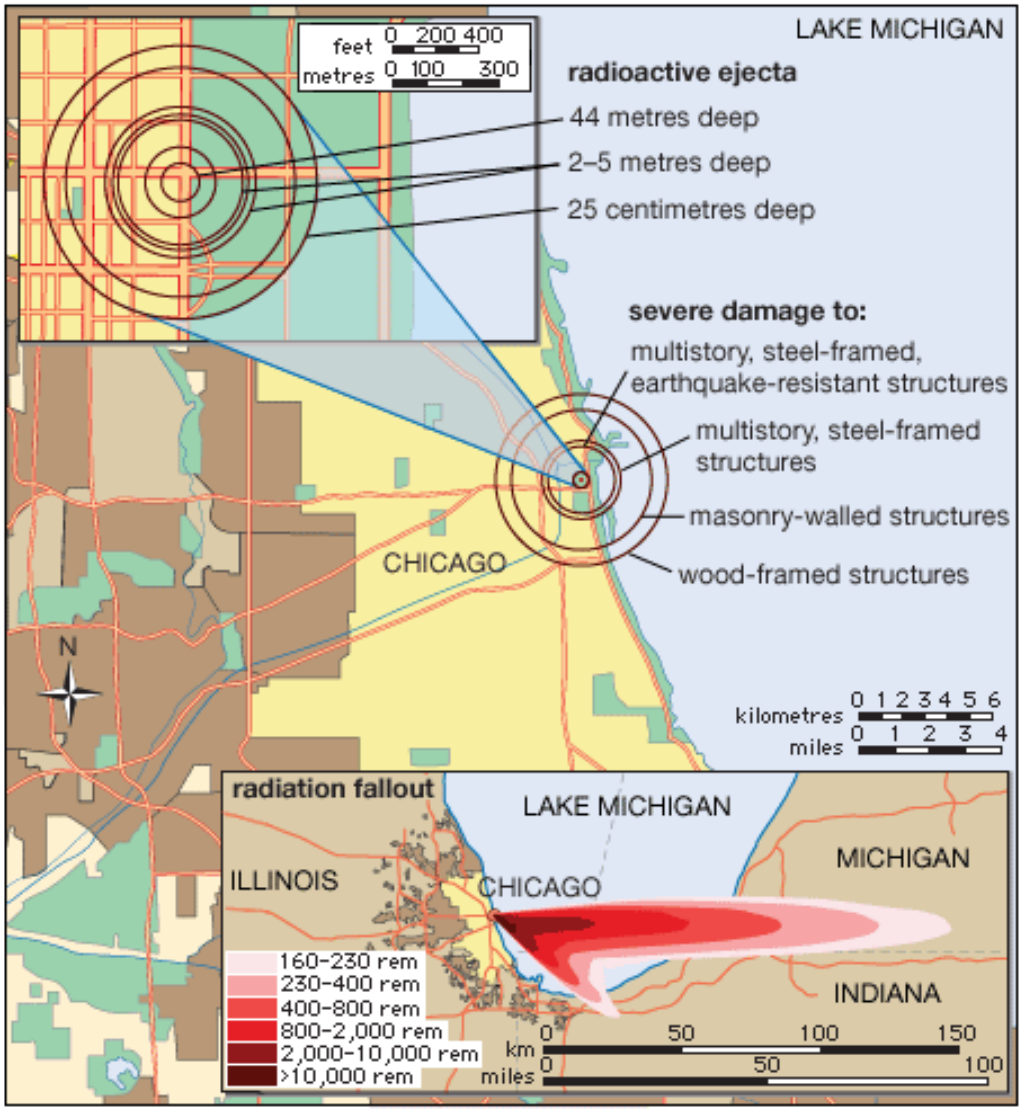
Reuters

7:31 AM CST, January 21, 2014



CHICAGO (Reuters) - Opening statements are due to begin on Tuesday in the trial of three men accused of plotting to attack high-profile targets, including President Barack Obama's re-election campaign headquarters, during the 2012 NATO summit in Chicago.

Brent Betterly, 25, Brian Church, 25, and Jared Chase, 29, are being prosecuted under an Illinois anti-terrorism law adopted after the September 11, 2001 al Qaeda attacks.



# In Pictorial Form …

# The Threat of Nuclear Terrorism

Terrorist pathways to a nuclear bomb —

- Stealing a bomb
- Buying a bomb
- Building a bomb

# Stealing a Bomb

- About 25,000 nuclear weapons are in arsenals, with all but about 1,000 in Russia and the United States
- Stealing a bomb would be difficult but not impossible
- Activating a stolen bomb would be difficult —
  - The weapons of the United States, Britain, China, and France are protected by specialized security codes (permissive action links = “PALs”)
  - Most but not all Russian weapons have PALs
  - Whether the weapons of India, Israel, Pakistan, and North Korea use PALs is unknown

There are serious concerns about the security of Pakistani nuclear weapons and Russian tactical nuclear weapons.

# Buying a Bomb – 1

- Nuclear-armed states are unlikely to sell a nuclear weapon because of the prospect of devastating retaliation
- But deterrence hinges on a credible retaliatory threat and credible evidence that a weapon transfer has occurred
- Gathering evidence that an explosion was produced by a transferred weapon is difficult
- Nuclear forensics and nuclear event attribution programs receive increased attention following the National Defense Authorization Act of 2010

  ➔ Nuclear Forensics and Attribution Act signed 2-16-2010 to establish the National Technical Nuclear Forensics Center within Homeland Securities Domestic Nuclear Defense Office (DNDO).

# Buying a Bomb – 2

More likely routes for terrorists to buy or be given a nuclear weapon —

- Corruption among nuclear custodians
- Nuclear black markets
- A coup that brings to power officials sympathetic to terrorists

Pakistan is of particular concern —

- It has a relatively new nuclear command and control system
- Taliban and al-Qaeda forces have a formidable presence
- Elements in Pakistan's military intelligence agency sympathize with the Taliban
- Concerns with regards to stability: eg. Pakistani leaders have been frequent assassination targets
- The infamous (A.Q. Khan) black market originated in Pakistan

# Building a Bomb – 1

Some problems that terrorist organizations wishing to construct a nuclear explosive would confront —

- Assembling a team of technical personnel
- Substantial financial costs
- Radiation and chemical hazards
- Possibility of detection
- Acquisition of nuclear-explosive material

# Building a Bomb – 2

No terrorist organization currently has the ability to produce weapons-usable enriched uranium.

Hence terrorists would have to acquire already made HEU.

There is enough HEU in worldwide stockpiles to make ~ 30,000 bombs.

Most HEU is under military control, but 40 countries have civilian HEU, including in more than 120 research reactors and related facilities.

The HEU stockpiles most vulnerable to theft are in Pakistan, Russia, and many countries with civilian reactor facilities.

# Building a Bomb – 3

No terrorist organization currently has the ability to make plutonium for a weapon. Nuclear reactors to produce plutonium and reprocessing plants to extract plutonium from spent reactor fuel require resources available only to States.

Hence terrorists would have to seize plutonium from existing stockpiles or receive aid from a State.

There is enough plutonium worldwide to make ~ 30,000 bombs.

Plutonium is under both military and civilian control.

Both pose a risk. The United States, Britain, France, and Russia have stopped producing plutonium for weapons. China may have stopped.

India, Israel, Pakistan and possibly North Korea are continuing to make plutonium for weapons.

# Building a Bomb – 4

To make a Hiroshima-style gun-type bomb, terrorists would need about 50 kg (110 pounds) of weapons-grade HEU.

They could try to reduce the amount needed by using special techniques.

An implosion-type bomb can use either HEU or Pu, but the technical challenges are significant —

- Designing high explosive lenses
- Machining and assembling precision parts
- Triggering the implosion

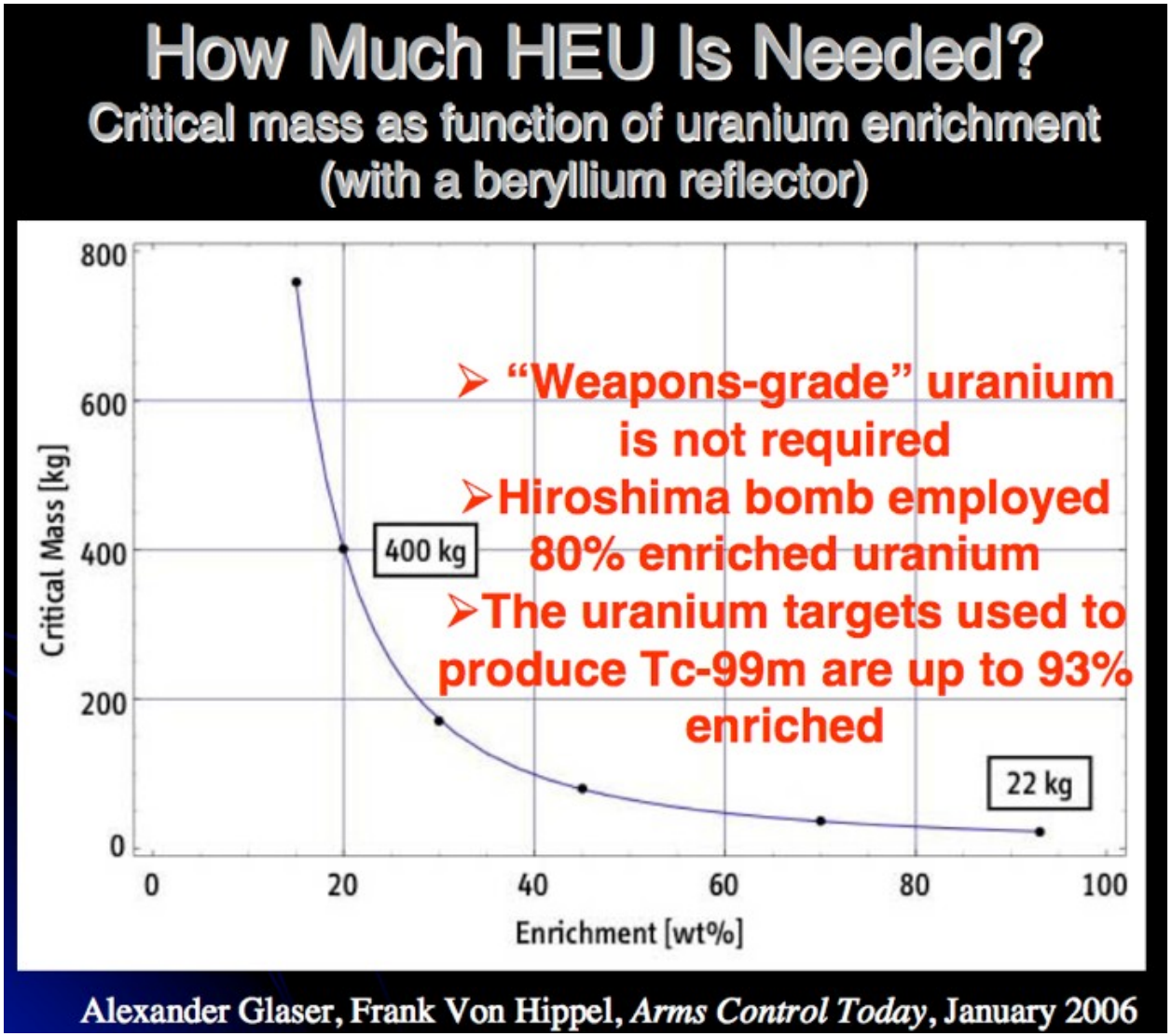
A simple implosion-type bomb would require only 25 kg (55 pounds) of HEU or 4 to 10 kg (9 to 22 pounds) of Pu

Terrorists would be aided by the fact that they would not need to meet military requirements.

***The key barrier for terrorists is acquiring enough HEU.***

# Insecure Nuclear Explosive Materials

# The Problem of Dual Use of Highly Enriched Uranium




HEU is also used in civilian applications: research reactors, medical isotope production.

It is challenging to protect HEU in civilian facilities from theft or from secret transfer of HEU to a clandestine weapons program.

# Availability of Uranium from “Atoms for Peace”

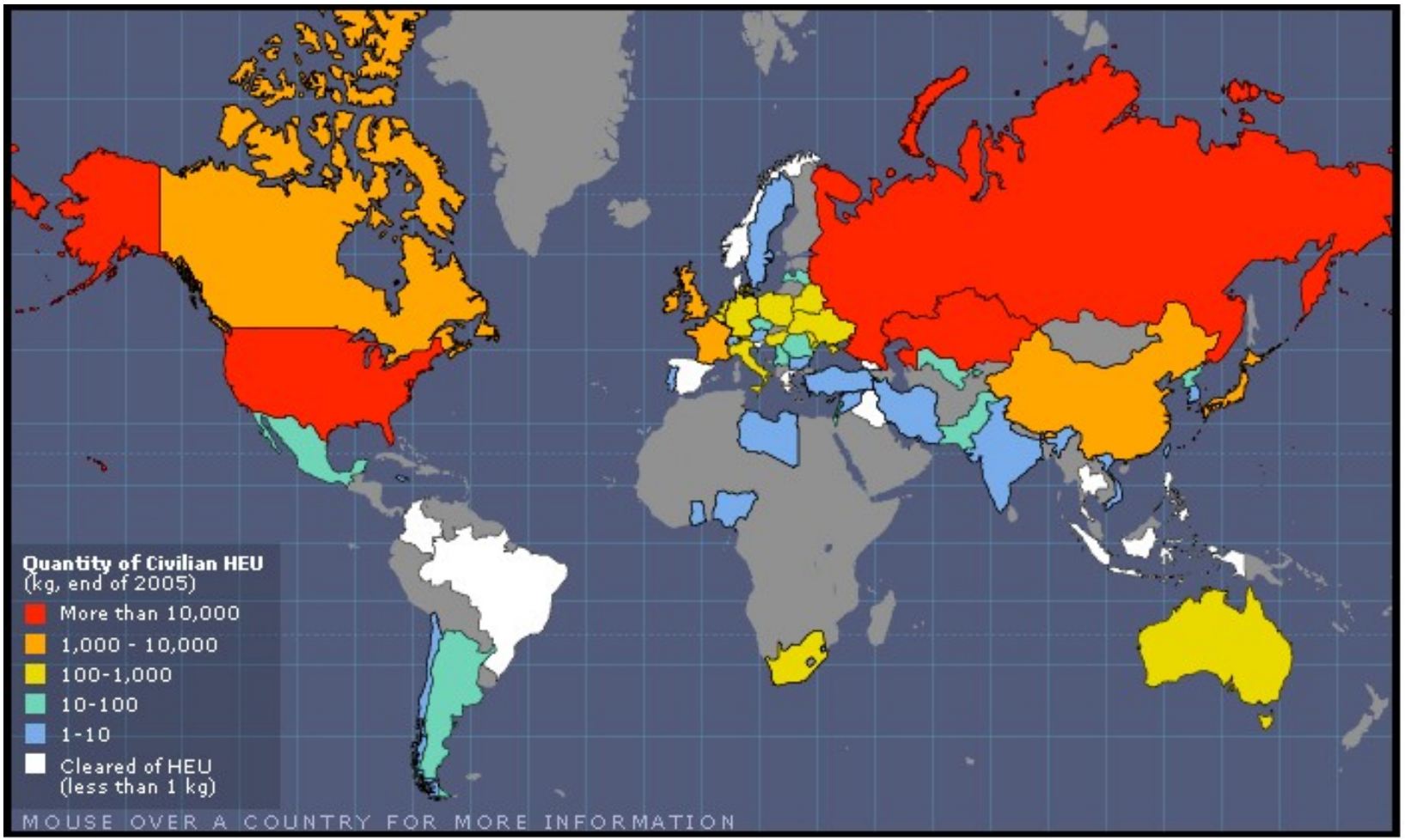
**Atoms for Peace**

- During the 1950s and 1960s, the U.S. Atoms for Peace program and the corresponding Soviet program constructed hundreds of research reactors, including reactors for export to more than 40 other countries.

- These reactors were originally supplied with low-enriched Uranium (LEU), which is not usable for nuclear weapons, but demands for better reactor performance and longer-lived fuel led to a switch to weapons-grade Highly Enriched Uranium (HEU).

- In addition there are important medical applications for isotopes that require HEU for their production.

# Availability of Highly Enriched Uranium
## *Effect of "Atoms for Peace"*



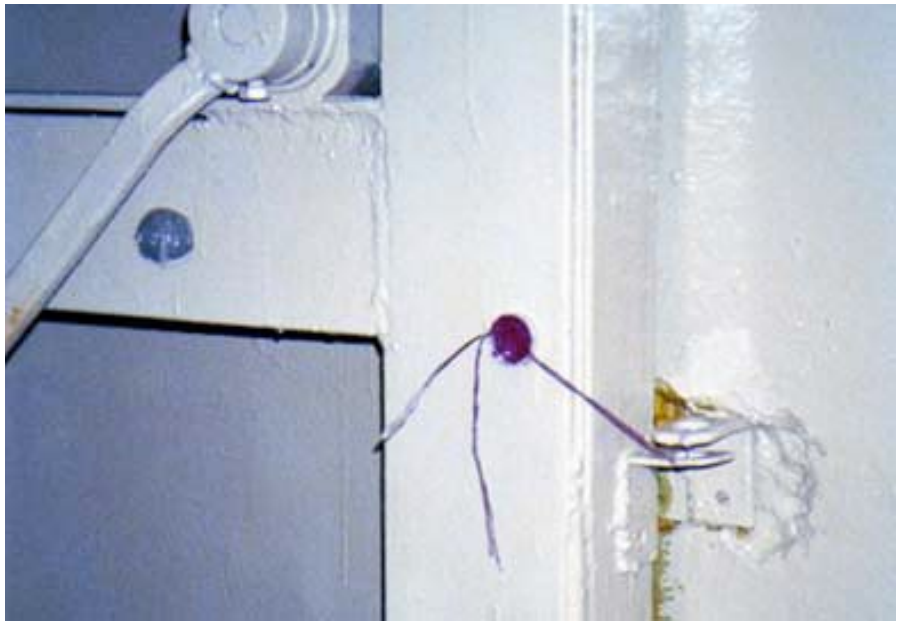
# Availability of Nuclear Weapon Materials in the Former Soviet Union in the 1990s

In 1994, Building 116 at the Kurchatov Institute in Moscow had enough HEU for a bomb at its research reactor, but had an overgrown fence and no intrusion detectors or alarms, an example of the poor state of security at many nuclear facilities after the collapse of the Soviet Union.

# Availability of Nuclear Weapon Materials in the Former Soviet Union in the 1990s

Left and below: Inadequate security measures at former Soviet nuclear facilities, such as the padlock and wax seal shown, would allow easy access to anyone wishing to steal materials.

**The situation in Former Soviet Republics triggered intense efforts to collect and secure nuclear materials. Example, the Global Threat Reduction Initiative (GTRI), collects Pu, HEU and converts civilian HEU reactors to LEU.**



**Much progress has been made in securing nuclear materials in former SU states !**

# Reducing the Threat of Nuclear Terrorism

## Programs to Intercept and Secure Nuclear Materials

# Intercepting Nuclear Weapons and Materials

Terrorists organizations known to have sought nuclear weapons or weapon materials —

- Al-Qaeda
- Jemaah Islamiyah
- Chechnyan Separatists
- Hezbollah
- Aum Shinrikyo

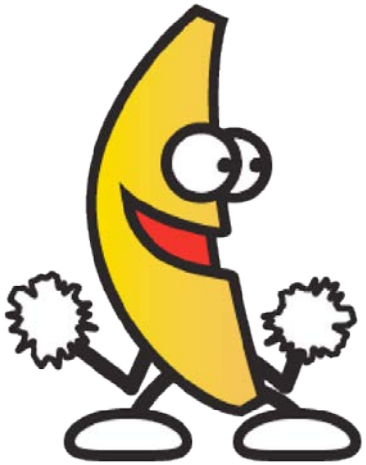
Border Security —

About 15 million shipping containers enter the U.S. each year; only 6% are inspected carefully


A truck passes through a radiation portal monitor at the port of Newark, New Jersey.

# Intercepting Nuclear Weapons and Materials

## What do ceramics, bananas, and kitty litter have to do with border security?



They naturally contain radioactive isotopes and accounted for 80 percent of the over 10,000 radiological false alarms made by portal monitors between May 2001 and March 2005.

# Physics/Global Studies 280: Session 13

## Plan for This Session

**Research Paper Proposal:** due Thursday as online upload + paper copy in class
Important: topic + reference -> come to office hour if there you are uncertain that your references provide enough information on your topic.

**Midterm:** Thursday March 15th, 2:00-3:20pm ➔ modules 1-5: Multiple Choice Qs
+ 1 essay questions

[old exams available on course web-page, 50% of Qs will be from last 3 years]

Vote for Additional Midterm-Office-Hours

(A) Sunday March 11th 1-3pm
(B) Sunday March 11th 3-5pm
(C) Sunday March 11th 4-6pm
(D) Sunday March 11th 5-7pm
(E) Sunday March 11th 6-8pm

PBS video on port scanner from Decision Sciences

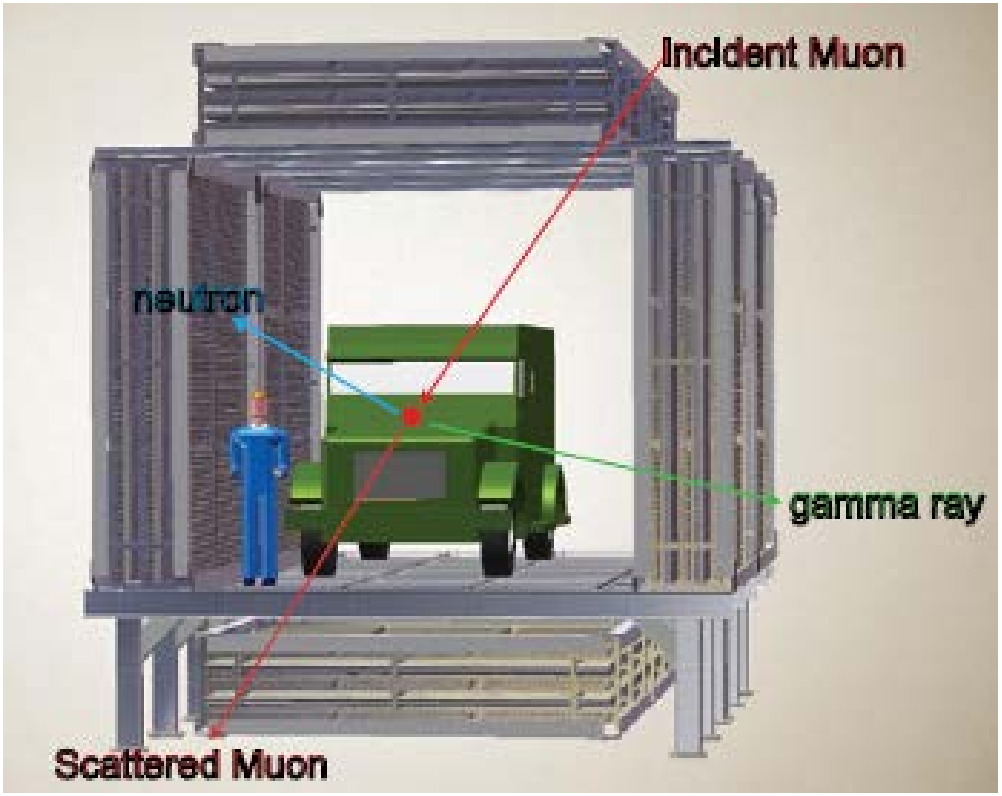
Video Presentation: Last Best Chance

Discussion

# Intercepting Nuclear Weapons and Materials

## Port Scanners: Avoiding False Positive Alarms
## Passive Muon Tomography

Solution: detect scattering of cosmic ray muons of high-z nuclei in nuclear explosive materials ! Very specific, low number of false positive alarms.




**UIUC nuclear physics graduate Dr. Mike Sossong helped to develop this technology at Los Alamos National Laboratory and now is director of research at Decision Science Corporation in San Diego.**

**Dr. Sossong won the 2011 Columbus Scholar Award of the Homeland Security Department for commercializing this technology**

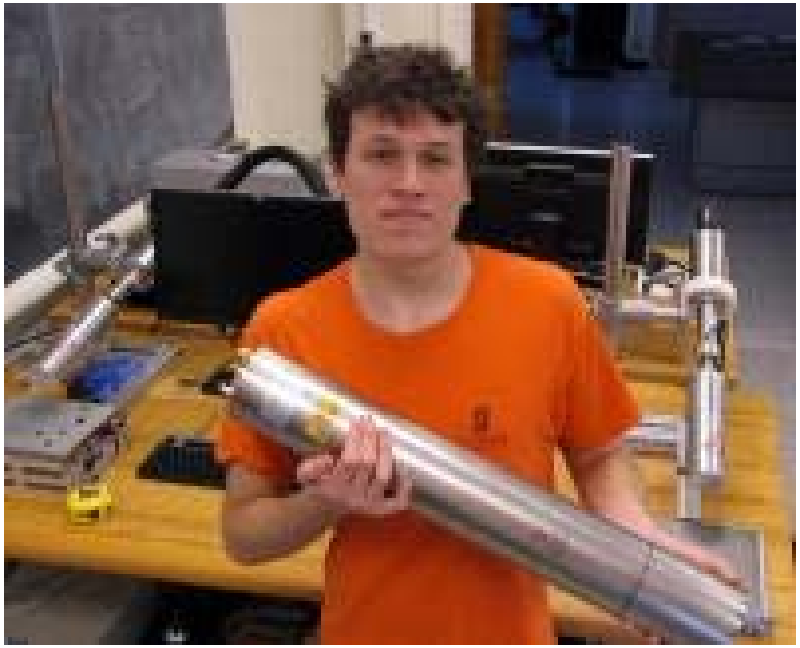
**UIUC NPRE graduate student Aric Tate has started thesis project related to Port scanners based on cosmic rays!**

# Intercepting Nuclear Weapons and Materials

## Research on active interrogation for NEM using neutrons

## Example:

**Brent Heuser, Ling Jian Meng at NPRE**
**"Interrogation of Special Nuclear Material Using the UIUC Pulsed Neutron Facility"**
**funded by the UIUC Engineering College Strategic Research Initiative**



Idea: neutrons get captured by nuclides
In the resulting decay gamma rays of characteristic energy are emitted.

NPRE Student (former 280 TA)
Rick Kustra with a gamma detector used

# Identifying the Sources of Dangerous Nuclear Materials (Nuclear Forensics)

# Nuclear Forensics Definitions

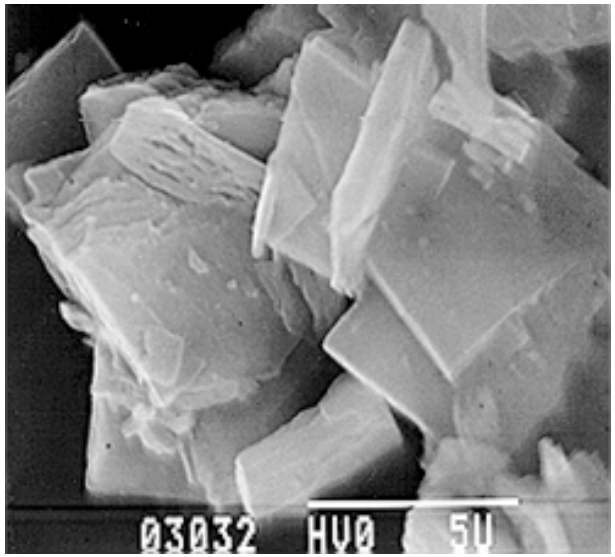
**Nuclear Attribution** is the process of identifying the source of nuclear or radioactive material used in illegal activities, to determine the point of origin and routes of transit involving such material, and ultimately to contribute to the prosecution of those responsible.

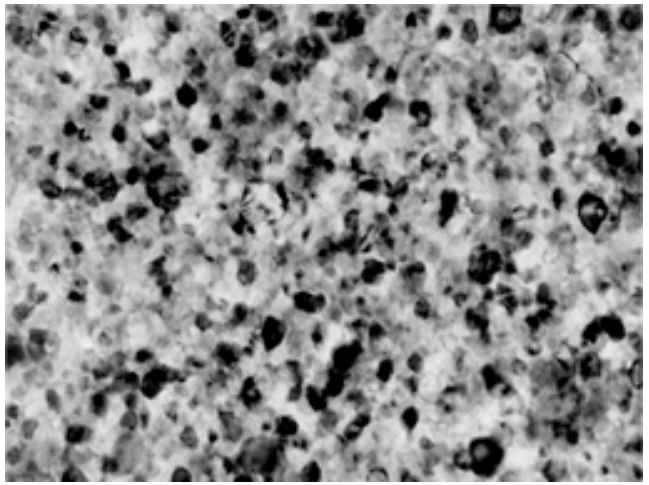
**Nuclear Forensics** is the analysis of intercepted illicit nuclear or radioactive material and any associated material to provide evidence for nuclear attribution.

# Nuclear Forensic Techniques

## Electron Microscopy and Spectroscopy

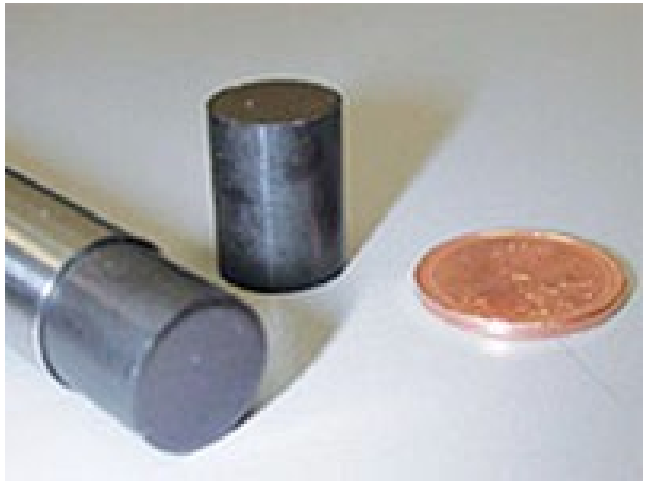
- Typography, morphology, elemental composition, and crystallographic structure
- Scanning Electron Microscopy (SEM) produces images of the surface at high magnification.
- Transmission Electron Microscopy (TEM) uses electrons that pass through the sample to produce images of the internal structure.



***Source: Analyst, 2005: 130***

# Nuclear Forensic Techniques



http://www.nti.org/e_research/cnwm/threat/russia.asp

***Analyst, 2005: 130***

## Profilometry —

- Measures the surface roughness of fuel pellets.
- **Production facilities use two types of grinding procedures** to reach the desired cylindrical shape: dry grinding and wet grinding. Wet grinding produces a smoother finish.

## Size and features —

- The **dimensions of the fuel pellet**, including the height, radius, and the type of hole present (if any), **are specific to certain types of reactors**.

# Nuclear Forensic Techniques: Spectroscopy

Isotopic composition reveals the enrichment process, intended use, and reactor type.

Impurity composition reveals the production process and previous geolocation.

# Nuclear Forensic Techniques

## Age —

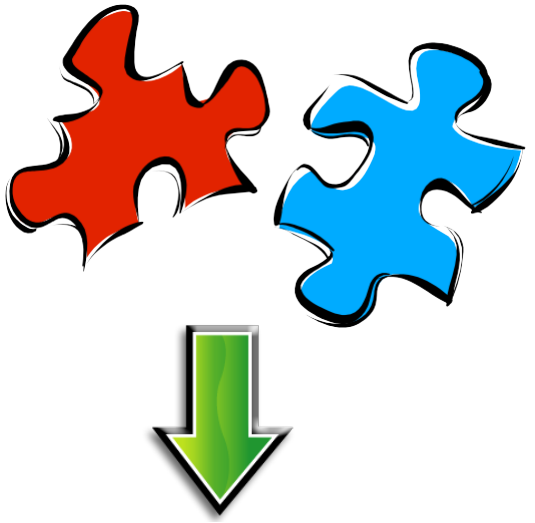
- As a radiological sample gets “older,” the parent isotope disintegrates and its daughter nuclides accumulate.
- Knowledge of the age helps an analyst identify when the material was produced.

## $^{18}O/^{16}O$ Ratio —

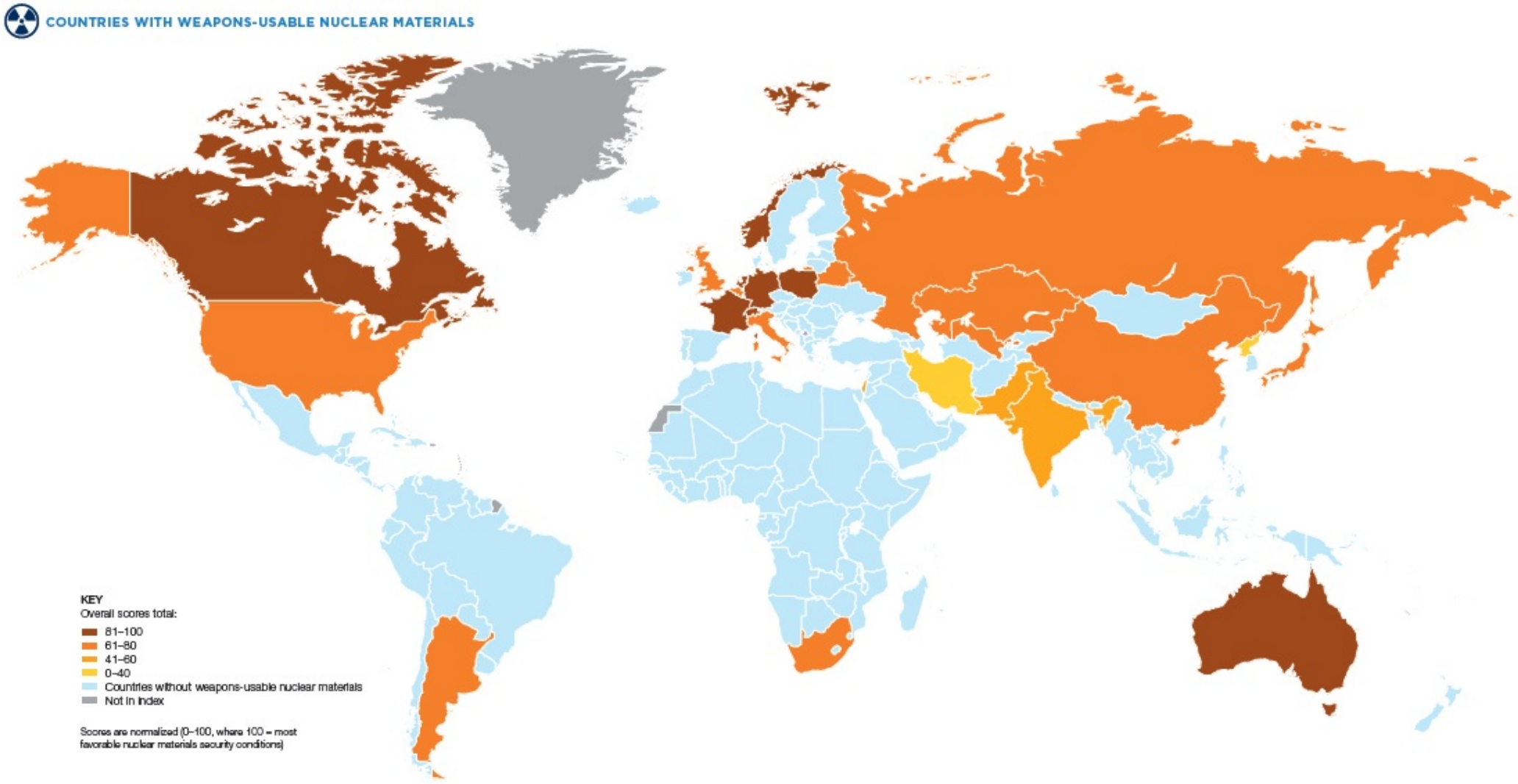
- Certain ratios are observed in rainwater, and these “variations up to 5 percent...depend upon average temperature, average distance from the ocean, and the latitude” (Mayer).
- By these means, an analyst can identify the former geolocation of the material.

# Nuclear Forensic Techniques: Conclusion

- By using the techniques and analysis methods of nuclear forensics, one can create a “nuclear fingerprint” of the material.
- Information, such as material type, reactor type, production plant, production date, enrichment process, intended use, and geolocation, are pieces of the puzzle that must be solved to form a bigger picture of the radiological evidence’s history.



# Securing Vulnerable Nuclear Materials



# (Old) News: A Grand Uranium Bargain

THE NEW YORK TIMES **OP-ED** THURSDAY, OCTOBER 24, 1991

By Thomas L. Neff

CAMBRIDGE, Mass. The Soviet Government is struggling to transform itself economically and politically while maintaining control of more than 24,000 nuclear weapons in the newly independent republics. Mikhail Gorbachev has pledged to dismantle thousands of them, but the bankrupt Government may not be able to pay for doing so in ways that prevent misuse or wider proliferation. There is, however, a way to pay for disarmament that also provides economic motivation to the republics and the central Government.

The warheads contain substantial amounts of valuable material that can be processed for use in commercial nuclear power plants. It may be advantageous for the U.S. to buy or barter for such materials and turn them safely to commercial use. This can be done in ways that protect Western and Soviet commercial and security interests.

Dr. Thomas Neff from the Center of International Studies at Harvard proposed for the US to buy Soviet area weapons material diluted from HEU to LEU at market prices for use in US nuclear power reactors. See Neff's Op-Ed in the NY-Times of 10-24-1991.

- o funds Soviet effort to control > 24,000 nuclear weapons in the newly independent republics.
- o stabilizes western market for LEU reactor fuel.
- o prevents HEU from Soviet stocks to be deviated into black market channels.
- o addresses demands from non-nuclear weapons states in the NPT that superpowers reduce arsenals!
- o commercial value of 500 tons of HEU in 1991 is about $5 Billion.

# The Highly Enriched Uranium Purchase Agreement → the Megatons to Megawatts Program !

- o October-24 1991 Neff's proposal as Op-Ed in the NY-Times
- o August-28 1992 US-Russian negotiations in Moscow start
- o August-31 1992 President George W. Bush announces agreement
- o February-18 1993 20 year US-Russian agreement signed by President Bill Clinton
- o January-14 1994 Commercial contract between United States Enrichment Corporation (USEC) and Techsnabexport (TENEX) a commercial subsidiary Russia's Ministry for Atomic Energy signed: HEU-LEU contract.
- o 1994 to 2013 500 tons of former Soviet weapons HEU diluted to LEU and used as fuel in US civilian nuclear reactors produced up to 10% of US electricity needs.

# The Highly Enriched Uranium Purchase Agreement → the Megatons to Megawatts Program !

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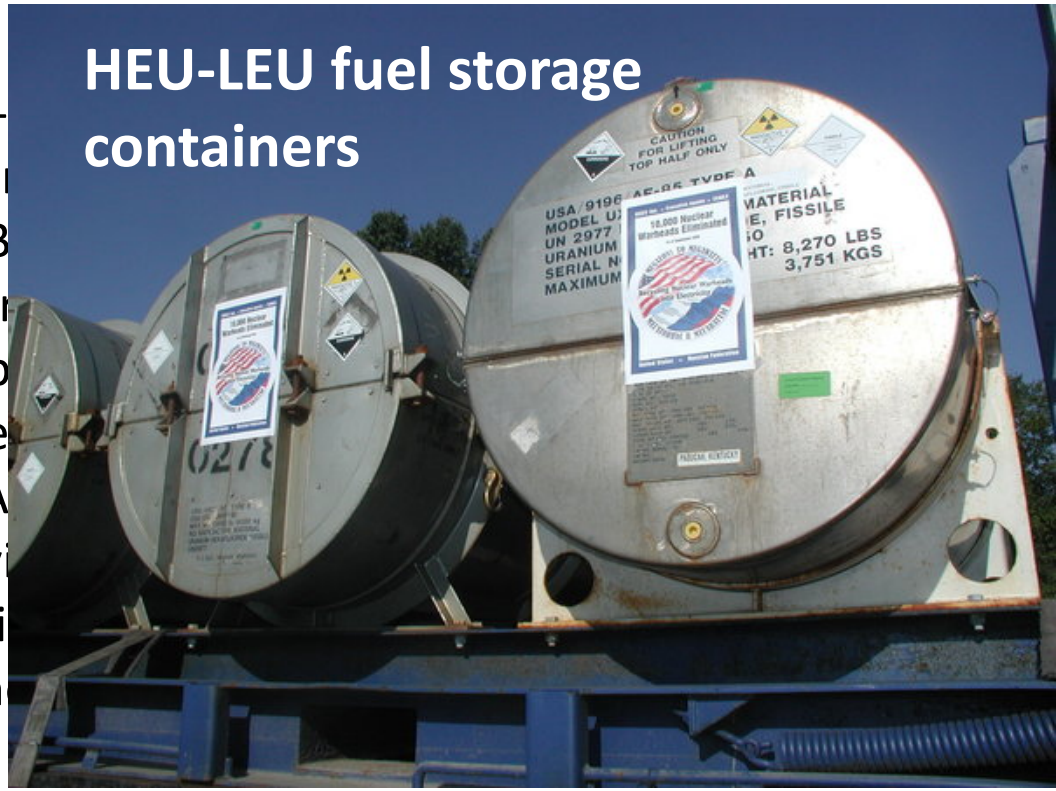


- o largest scale non-proliferation effort to date.
- o prevented HEU from Soviet stocks to be deviated into black market channels.
- o partially addressed demands from non-nuclear weapons states in the NPT that superpowers reduce arsenals.
- o bi-partisan support in the US across Bush-Clinton-Bush-Obama administrations.

# Securing Vulnerable Nuclear Materials

2004 National Nuclear Security Administration (NNSA) establishes Global Threat Reduction Initiative (GTRI) in the Office

➔ identify, secure, remove and/or facilitate the **disposition of high risk vulnerable nuclear and radiological materials** around the world that pose a threat to the United States and the international community.

Three initiatives are:

Convert: **Convert or shutdown research reactors and isotope production facilities** from the use of highly enriched uranium **(HEU) to** low enriched uranium **(LEU)**.
Remove: Remove or confirm the **disposition of excess nuclear and radiological materials**.
Protect: Protect high priority nuclear and radiological materials from theft.

# GTRI Conversions 2004 – 2014

(1) Successfully **converted to LEU fuel or verified the shutdown of 49 HEU research reactors in 25 countries**: Argentina, Australia, Bulgaria, Canada, Chile, China, the Czech Republic, France, Germany, Hungary, India, Japan, Kazakhstan, Libya, the Netherlands, Portugal, Poland, Russia, Ukraine, the United Kingdom, United States, Uzbekistan, and Vietnam.

(2) Verified the **cessation of the use of HEU targets for isotope production in Indonesia**.

(3) Accelerated the **establishment of a reliable supply of the medical isotope molybdenum-99 (Mo-99) produced without HEU** by establishing partnerships with South Africa, Belgium, and the Netherlands to convert Mo-99 production from HEU targets to LEU targets, and with four domestic commercial entities to produce Mo-99 in the United States with non-HEU technologies.

# GTRI Removal Since 2004 - 2014

**(1) Removed or confirmed the disposition of more than 4,100 kilograms of HEU** and plutonium (more than enough material for 165 nuclear weapons).

**(2) Removed all weapons-usable HEU from 16 countries** and Taiwan, including: Greece (December 2005), South Korea (September 2007), Latvia (May 2008), Bulgaria (August 2008), Portugal (August 2008), Romania (June 2009), Taiwan (September 2009), Libya (December 2009), Turkey (January 2010), Chile (March 2010), Serbia (December 2010), Mexico (March 2012), Ukraine (March 2012), Austria (December 2012), and Czech Republic (April 2013).

(3) **Removed more than 36,000 disused and unwanted radiological sources from sites across the United States.**

# GTRI Protection 2004 - 2014

(1) **Completed physical protection upgrades at more than 1,700 buildings in the United States and internationally** with high-activity radiological sources;

(2) Provided **Alarm Response Training to more than 3,000 site security, local law enforcement officers and other first responders** from across the country on responding to a potential incident involving radiological material.

# Countries that have given up all HEU

**Ukraine**

Following Ukraine's commitment at the April 2010 nuclear security summit in Washington to get rid of all of its HEU by 2012. The last HEU, 128 kg, was removed on March 27th from two facilities in the Ukraine.

**South Africa**

NNSA has completed a contract with South Africa for the return of U.S.-origin spent HEU fuel to the United States. the contract, signed in August 2010, covers 6.3 kilograms of U.S.-origin HEU spent fuel. HEU was returned August 2011.

# This Remains a Challenging Process

**Belarus**

Belarus has committed to give up its stockpile of highly enriched uranium (HEU) by the end of 2012.

Prior to the agreement, Belarus, Russia, the United States, and the International Atomic Energy Agency conducted two secret operations in which portions of Belarusian HEU were moved into secure facilities in Russia.

In these operations, a total of 85 kilograms of HEU were transported.

Belarus has suspended the agreement in August 2011 over US protests concerning human right violations in Belarus.

# What We Need To Do

# What We Need to Do (Important)

In the September/October 2006 issue of the Bulletin of the Atomic Scientists, Harvard University professor **Graham Allison discusses a "nuclear 9/11" and concludes that "a nuclear terrorist attack on the United States is more likely than not in the decade ahead**."

*The centerpiece of a strategy to prevent nuclear terrorism must be to* ***deny terrorists access to nuclear weapons or materials***

To accomplish this, he formulates the doctrine of "Three No's" —

1. **No loose nukes**
2. **No new nascent nukes**
3. **No new nuclear weapon states**

# What We Need to Do (Important)

*1. No Loose Nukes*

Insecure nuclear weapons or materials anywhere pose a grave threat to all nations everywhere.

The international community can therefore rightly insist that all weapons and materials—wherever they are—be protected to a standard sufficient to ensure the safety of citizens around the world.

Russia has been the principal focus of concern for the past two decades, but other countries—such as Pakistan, North Korea and India — are of growing concern.

# What We Need to Do (Important)

*2. No New Nascent Nukes*

Construction of any national production facilities for enriching uranium or reprocessing plutonium must be prevented.

The former head of the IAEA, Mohamed ElBaradei, has said that the existing NPT system made a mistake in allowing non-nuclear weapon states to build uranium enrichment and plutonium production plants.

Closing this loophole will require deft diplomacy, imaginative inducements, and demonstrable readiness to employ sanctions to establish a bright line.

# What We Need to Do (Important)

*3. No New Nuclear Weapons States*

This means drawing a line under the current eight nuclear powers (the United States, Russia, Great Britain, France, China, India, Pakistan, and Israel) and unambiguously declaring “no more”.

North Korea poses a decisive challenge to this policy. But if North Korea is accepted as a nuclear weapons state, South Korea and Japan are likely to follow within a decade, making Northeast Asia a far more dangerous place than it is today

The spread of nuclear weapons states makes it more likely that nuclear weapons or materials will be sold to others, including terrorists, or stolen by them.

# Reducing the Threat of Nuclear Terrorism

## Video: “Last Best Chance”

**2005, Nuclear Threat Initiative (NTI)**

# Discussion of “Last Best Chance”

# End of Nuclear Terrorism Module