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Verifying Nuclear Disarmament

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Vienna, September 27, 2013

Revision 3

A New Era of Nuclear Disarmament?

"We endorse setting the goal of a world free of nuclear weapons and working energetically on the actions required to achieve that goal."

A World Free of Nuclear Weapons
George P. Shultz, William J. Perry, Henry A. Kissinger, and Sam Nunn
The Wall Street Journal, January 4, 2007

"While the new START treaty is an important step forward, it is just one step on a longer journey. As I said last year in Prague, this treaty will set the stage for further cuts. And going forward, we hope to pursue discussions with Russia on reducing both our strategic and tactical weapons, including non-deployed weapons."

U.S. President Obama, upon signing the New START Treaty, April 2010

Thousands of Nuclear Weapons Are No Longer Deployed and Currently In Storage

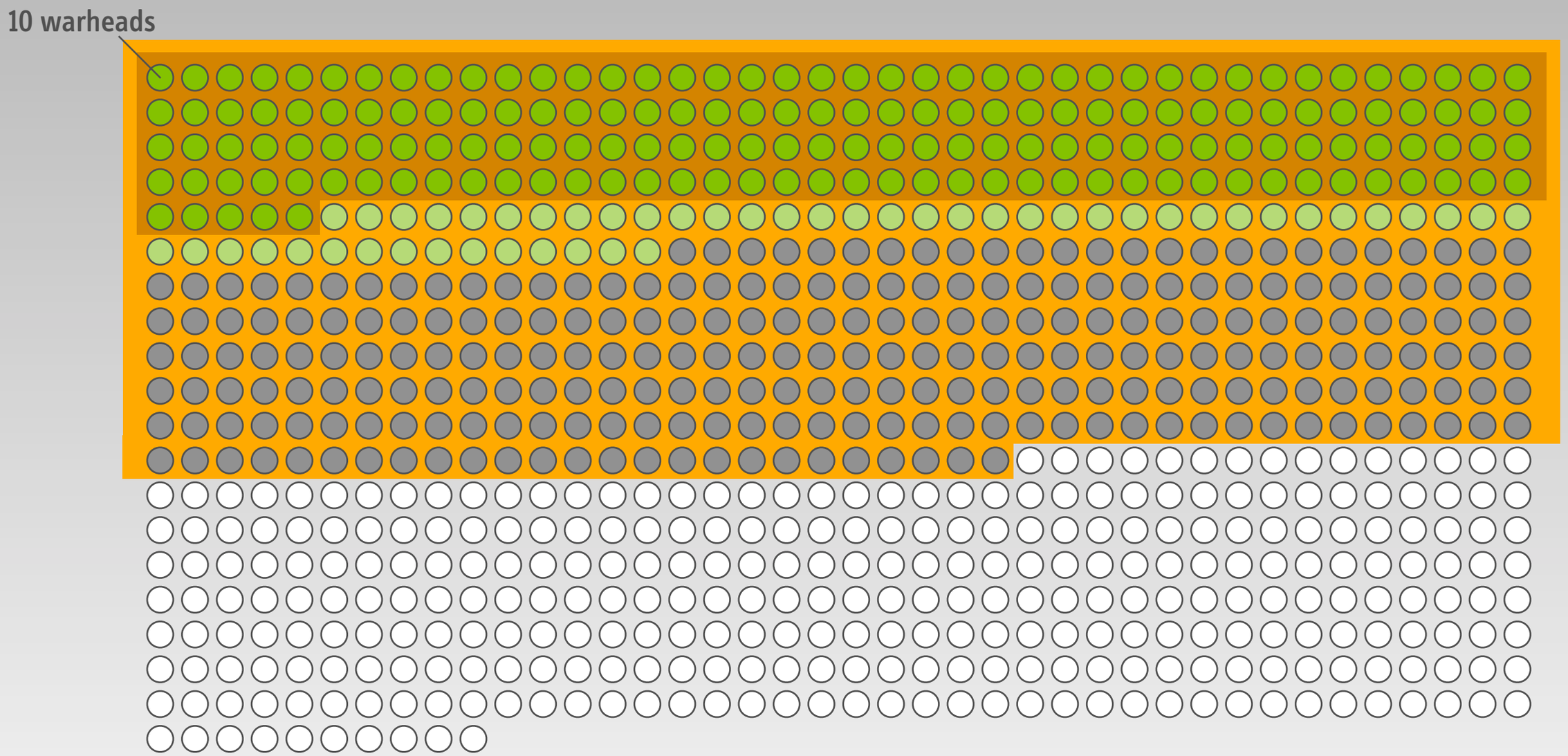
W87/Mk-21 Reentry Vehicles in storage, Warren Air Force Base, Cheyenne, Wyoming

Photo courtesy of Paul Shambroom, www.paulshambroom.com

What Are We Worried About?

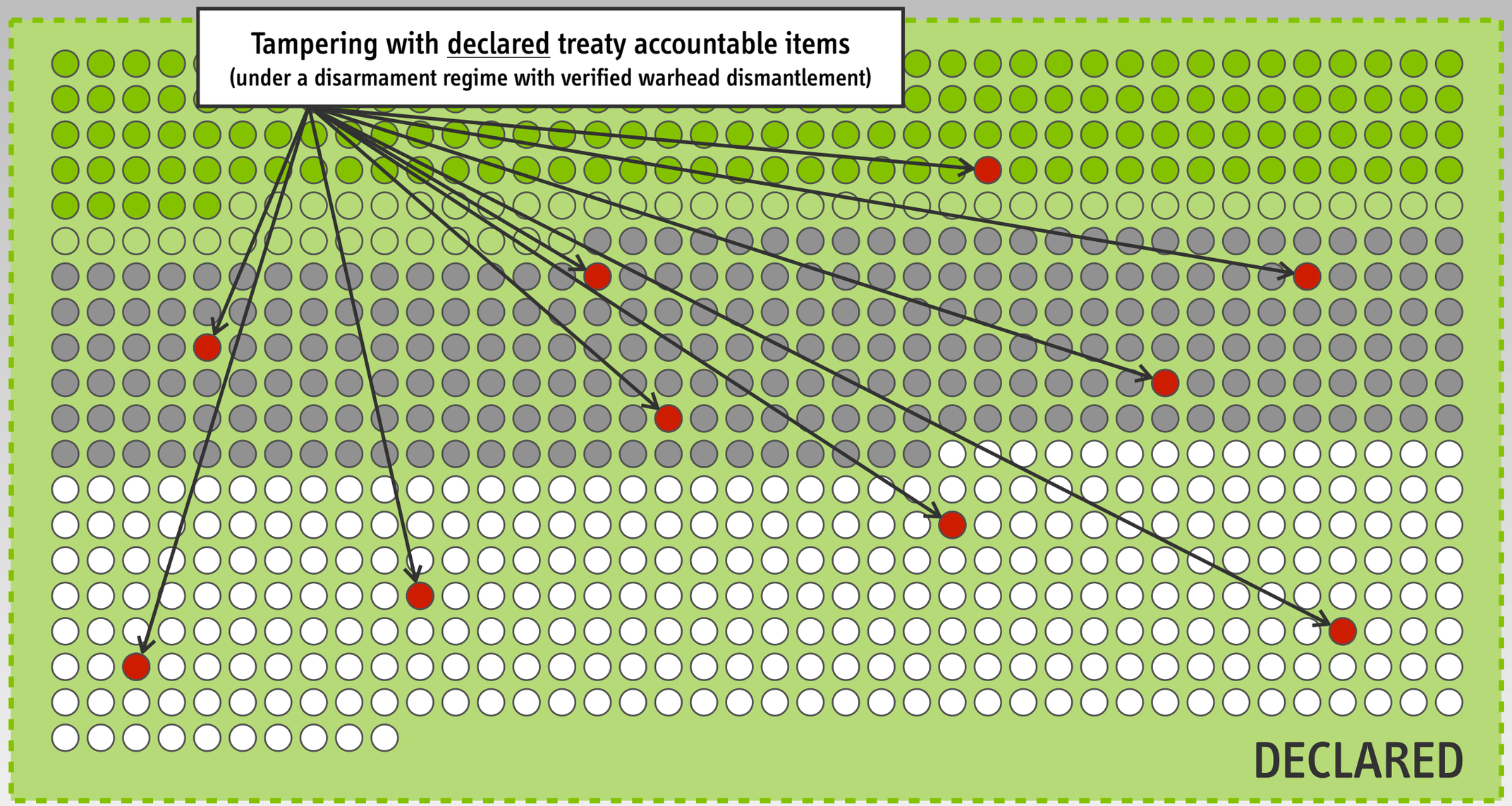
(The Challenges of Nuclear Disarmament Verification)

Example
(U.S. Nuclear Arsenal, 2013)



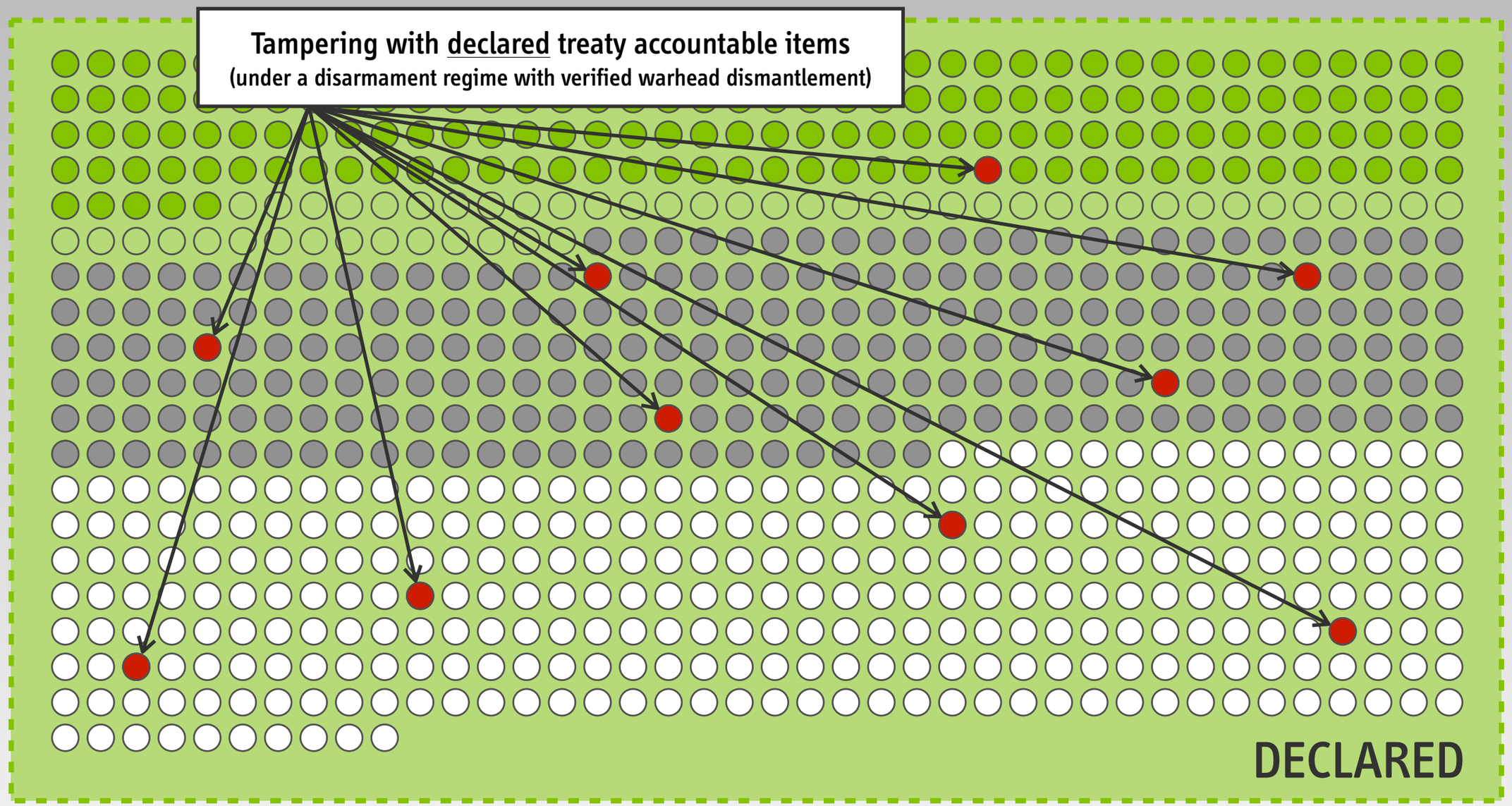
H. M. Kristensen and R. S. Norris, "Global Nuclear Weapons Inventories, 1945–2013," *Bulletin of the Atomic Scientists*, 69 (5), 2013, pp. 75–81

Example
Notional Cheating Scenarios



What About the Secret Nuclear Weapons Stockpile Stashed Away on that Remote Island?

Example
Notional Cheating Scenarios



Keeping undeclared warheads

Main Cheating Scenarios and Associated Verification Challenges

1

Party offers hoax or tampered devices instead of authentic treaty accountable items (TAI) so that real warheads, warhead components, or fissile material can be "diverted" to a secret stockpile of nuclear weapons

⇝ **Verifying the dismantlement of nuclear warheads**

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⇝ **Verifying the non-production of new fissile material for weapons**

(Same challenge for NPT and FMCT)

Interlude

Declarations

(and Nuclear Transparency more generally)

Some Weapon States Have Recognized the Value of Declarations

"The data will ... have valuable nonproliferation benefits by making potential International Atomic Energy Agency safeguards easier to implement."

Declassification of Today's Highly Enriched Uranium Inventories at Department of Energy Laboratories
U.S. Department of Energy, 27 June 1994, www.ipfmlibrary.org/doe06a.pdf

"The U.K. believes that transparency about fissile material acquisition for defence purposes will be necessary if nuclear disarmament is to be achieved."

Historical Accounting for U.K. Defence Highly Enriched Uranium,
U.K. Ministry of Defence, March 2006, www.ipfmlibrary.org/mod06.pdf

United States

May 2010 Declaration of U.S. Nuclear Weapon Stockpile

"As of September 30, 2009, the U.S. stockpile of nuclear weapons consisted of 5,113 [active and inactive] warheads. This number represents an 84 percent reduction from the stockpile's maximum (31,255) at the end of fiscal year 1967, and over a 75 percent reduction from its level (22,217) when the Berlin Wall fell in late 1989."

Increasing Transparency in the U.S. Nuclear Weapons Stockpile, U.S. Department of Defense, Fact Sheet, May 3, 2010
available at www.defense.gov/npr, mirrored at www.ipfmlibrary.org/gov10.pdf

United Kingdom

March 2009 and May 2010 Declarations

"Our operationally available warheads now number fewer than 160"

UK Prime Minister Gordon Brown, March 2009

Total number of nuclear weapons in the UK stockpile does not exceed 225

UK Foreign Secretary William Hague, May 2010, www.twitter.com/WilliamJHague

(4 submarines x 16 missiles per boat x 3 warheads per missile = 192 warheads)

France

March 2008 Announcement by French President N. Sarkozy

"I can tell you that our arsenal will include fewer than 300 nuclear warheads. [...]

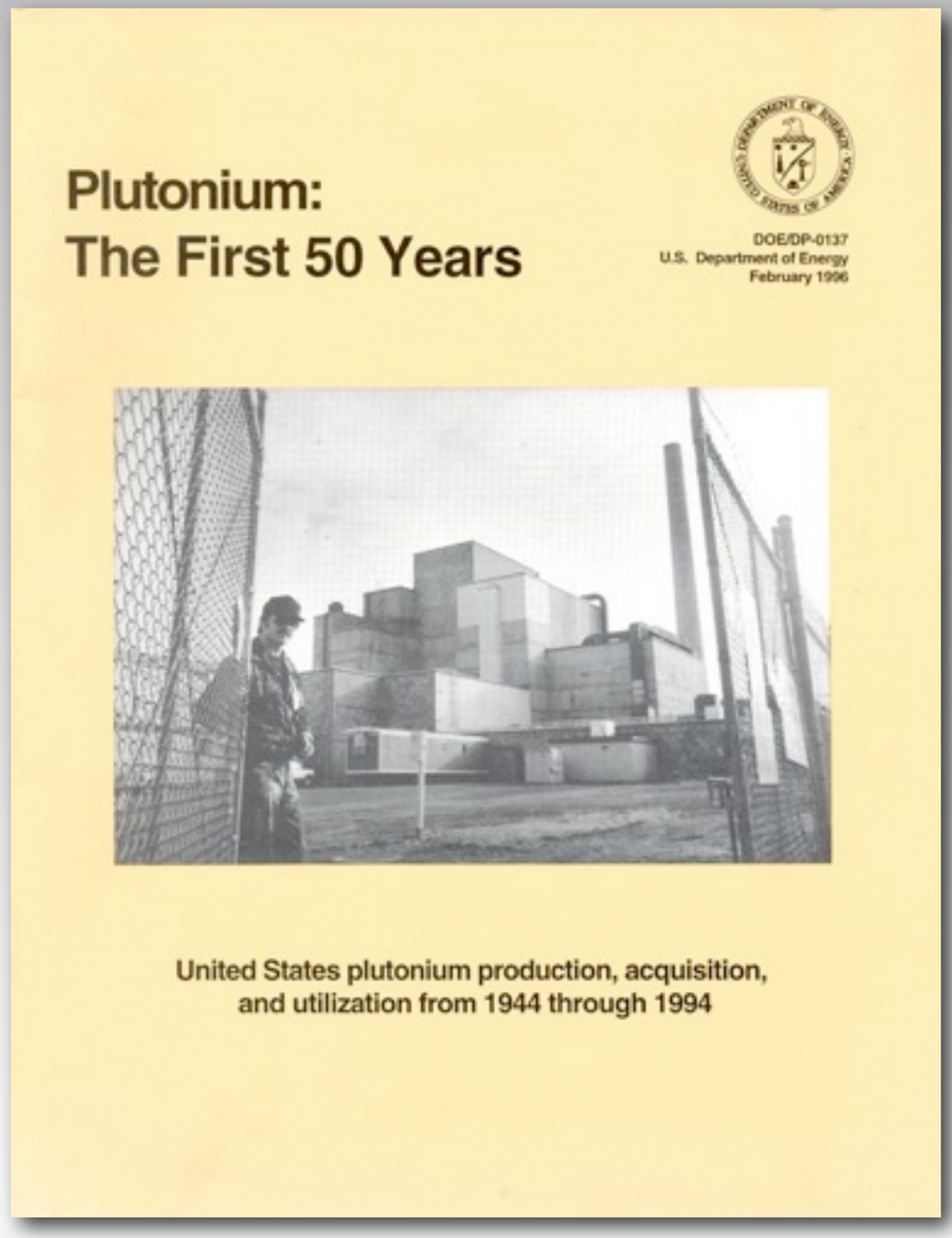
I have decided to invite international experts to observe the dismantlement of our Pierrelatte and Marcoule military fissile material production facilities."

Nicholas Sarkozy, President of the French Republic
Presentation of *"Le Terrible"* in Cherbourg
21 March 2008

Picture galleries available at
www.francetnp2010.fr

Fissile Material Declarations

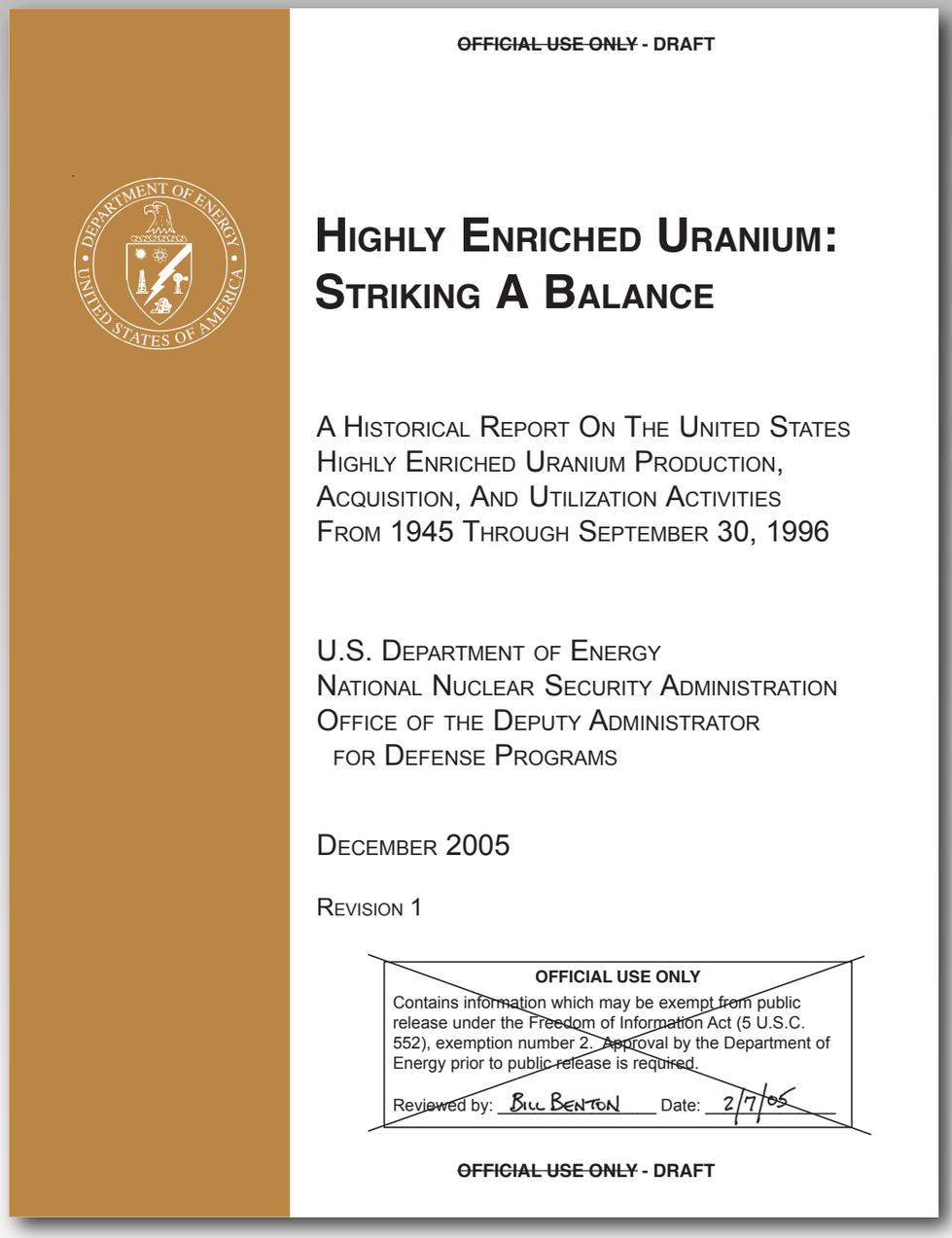
The 1996 and 2001 U.S. Declarations



Plutonium:
The First 50 Years

DOE/DP-0137
U.S. Department of Energy
February 1996

United States plutonium production, acquisition, and utilization from 1944 through 1994



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HIGHLY ENRICHED URANIUM: STRIKING A BALANCE

A HISTORICAL REPORT ON THE UNITED STATES HIGHLY ENRICHED URANIUM PRODUCTION, ACQUISITION, AND UTILIZATION ACTIVITIES FROM 1945 THROUGH SEPTEMBER 30, 1996

U.S. DEPARTMENT OF ENERGY
NATIONAL NUCLEAR SECURITY ADMINISTRATION
OFFICE OF THE DEPUTY ADMINISTRATOR
FOR DEFENSE PROGRAMS

DECEMBER 2005

REVISION 1

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Reviewed by: Bill Benton Date: 2/7/06

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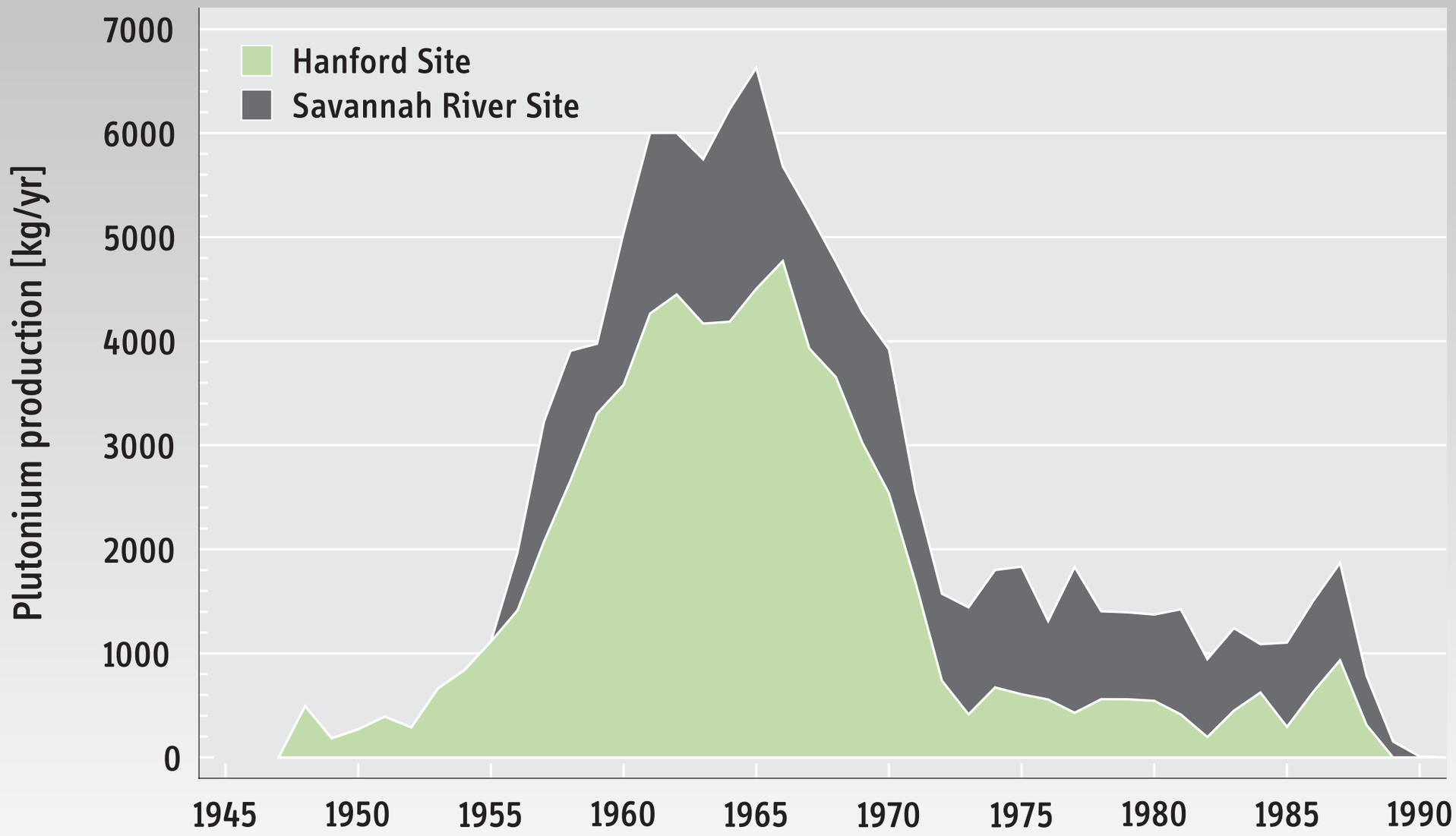
(The 1996 plutonium declaration has been updated in 2012, www.ipfmlibrary.org/doe12.pdf)

Examples from the U.S. Declarations

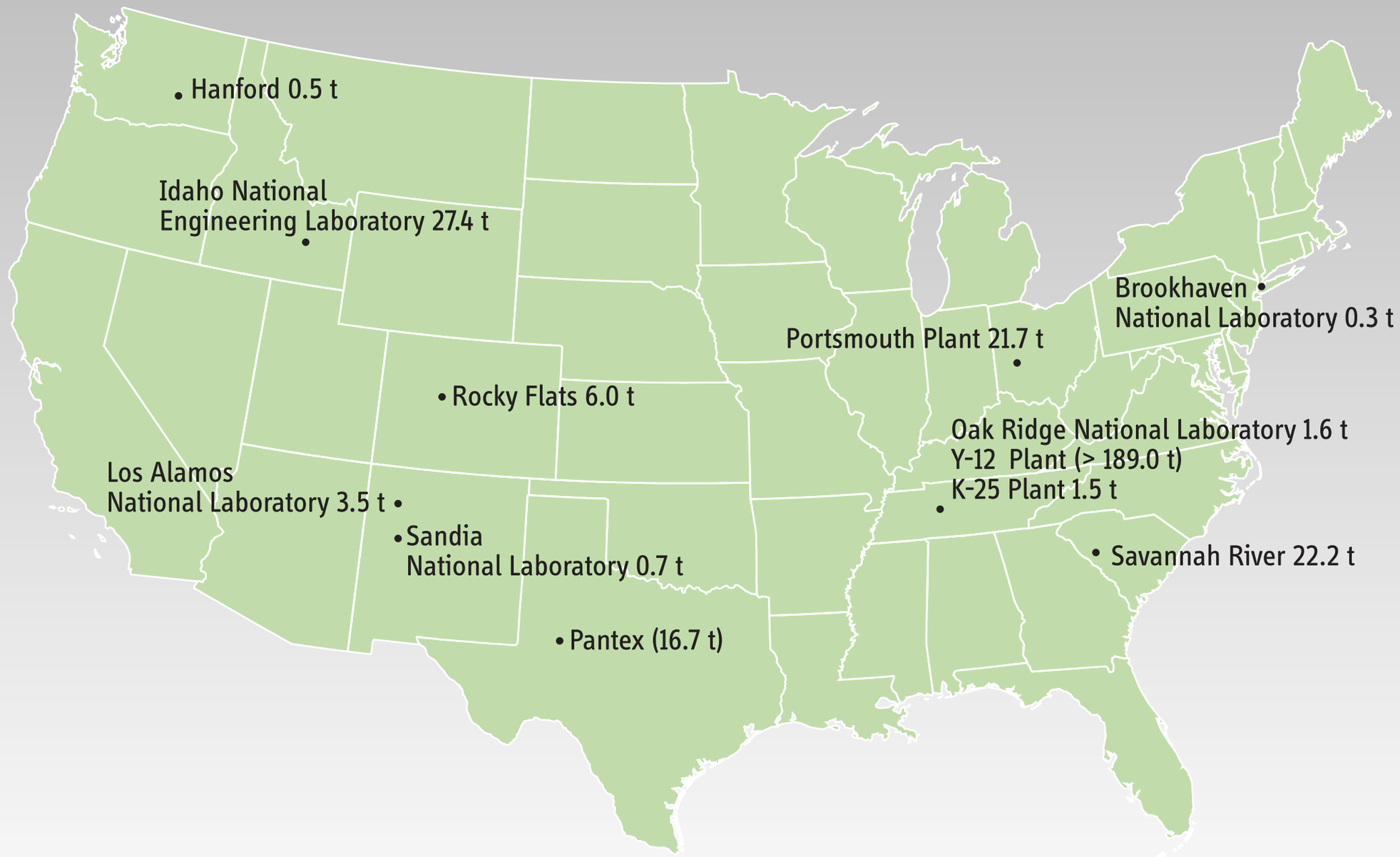
(Plutonium Production by Year and Site)



Plutonium: The First 50 Years: United States Plutonium Production, Acquisition and Utilization from 1944 Through 1994
U.S. Department of Energy, DOE/DP-0137, 1996, www.ipfmlibrary.org/doe96.pdf

Examples from the U.S. Declarations

Stockpile of Highly Enriched Uranium by Location (U.S. DOE Sites, 1996)



Highly Enriched Uranium: Striking a Balance. A Historical Report on the United States Highly Enriched Uranium Production, Acquisition, and Utilization Activities from 1945 through September 30, 1996, U.S. Department of Energy, January 2001 (publicly released in 2006), www.ipfmlibrary.org/doe01.pdf

Nuclear Warhead and Fissile Material Declarations are critical "first steps" in preparation for a deep-cuts nuclear disarmament regime

(more about this at the end)

Main Cheating Scenarios and Associated Verification Challenges

1

Party offers hoax or tampered devices instead of authentic treaty accountable items (TAI) so that real warheads, warhead components, or fissile material can be "diverted" to a secret stockpile of nuclear weapons

⇝ **Verifying the dismantlement of nuclear warheads**

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(Same challenge for NPT and FMCT)

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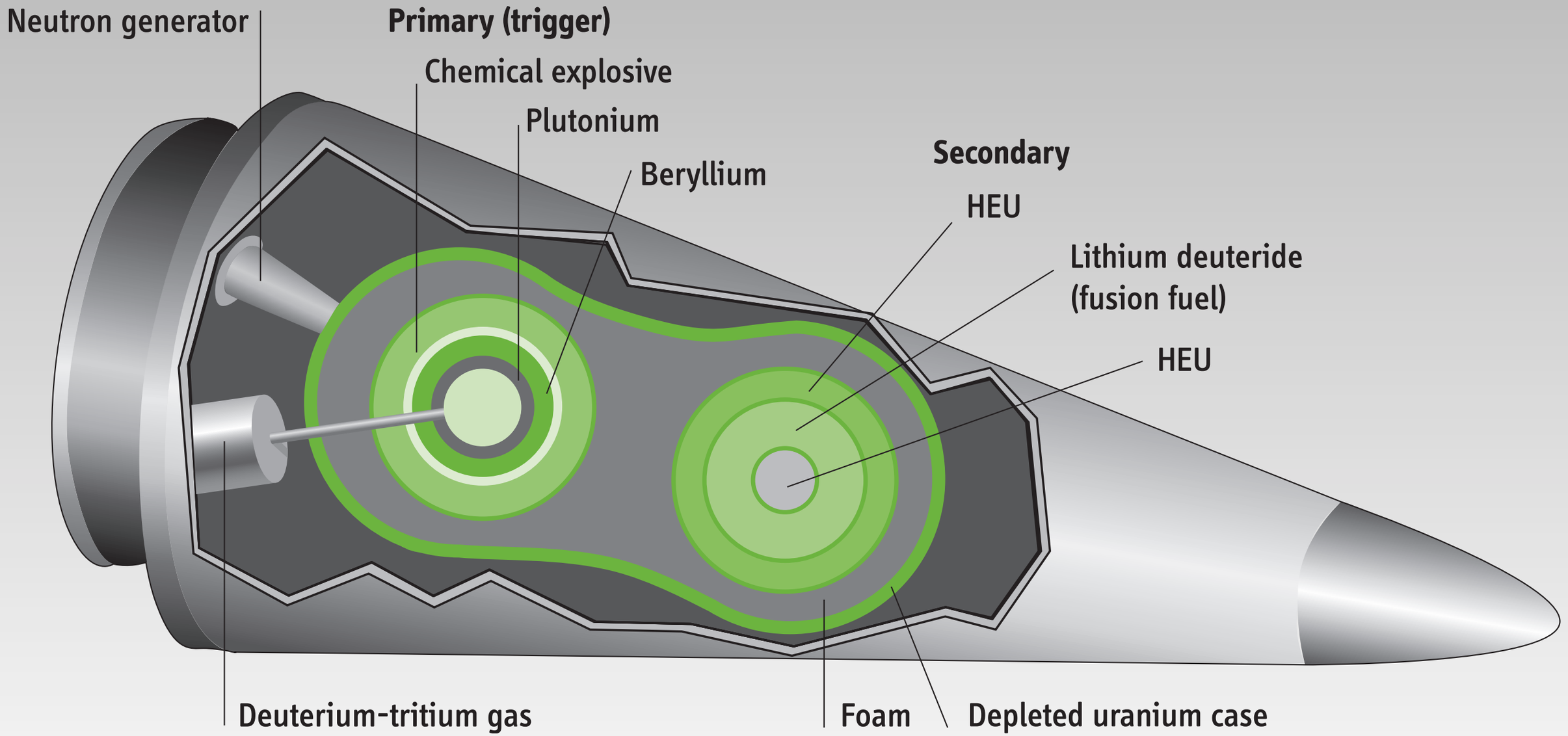
Nuclear Warhead (Dismantlement) Verification

Modern Thermonuclear Warhead

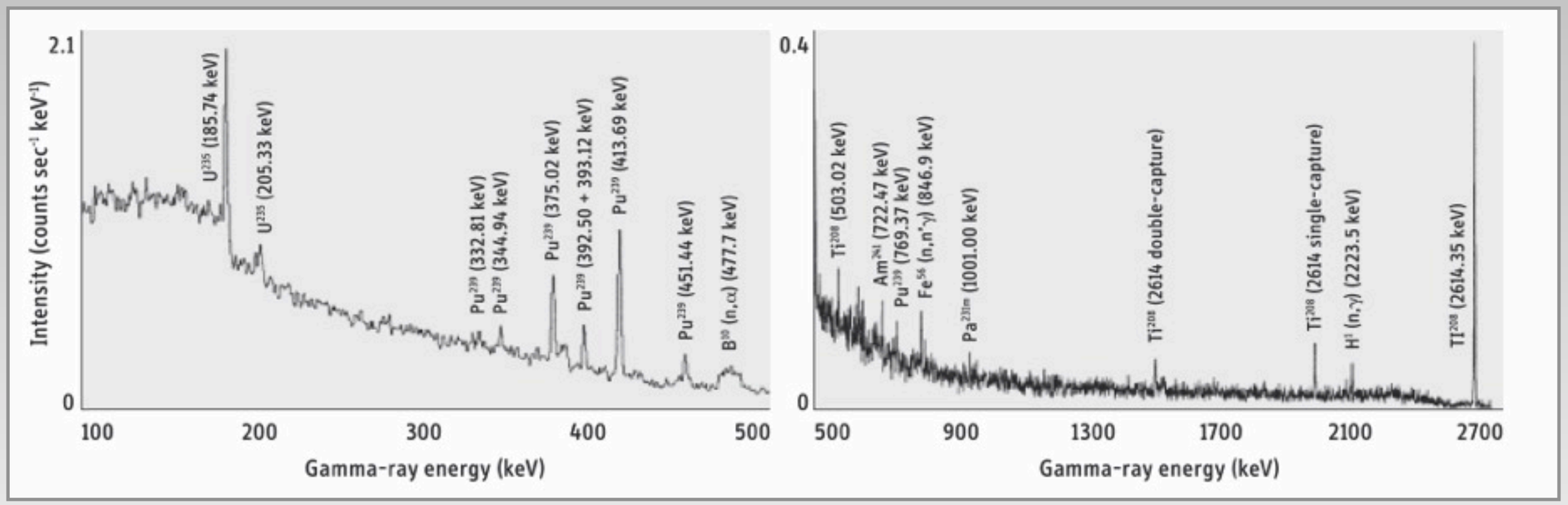


A modern thermonuclear warhead may contain *both* plutonium and highly enriched uranium

(Average estimated values are 3–4 kg and 25 kg of plutonium and HEU, respectively)

Nuclear Warheads Have Unique Signatures

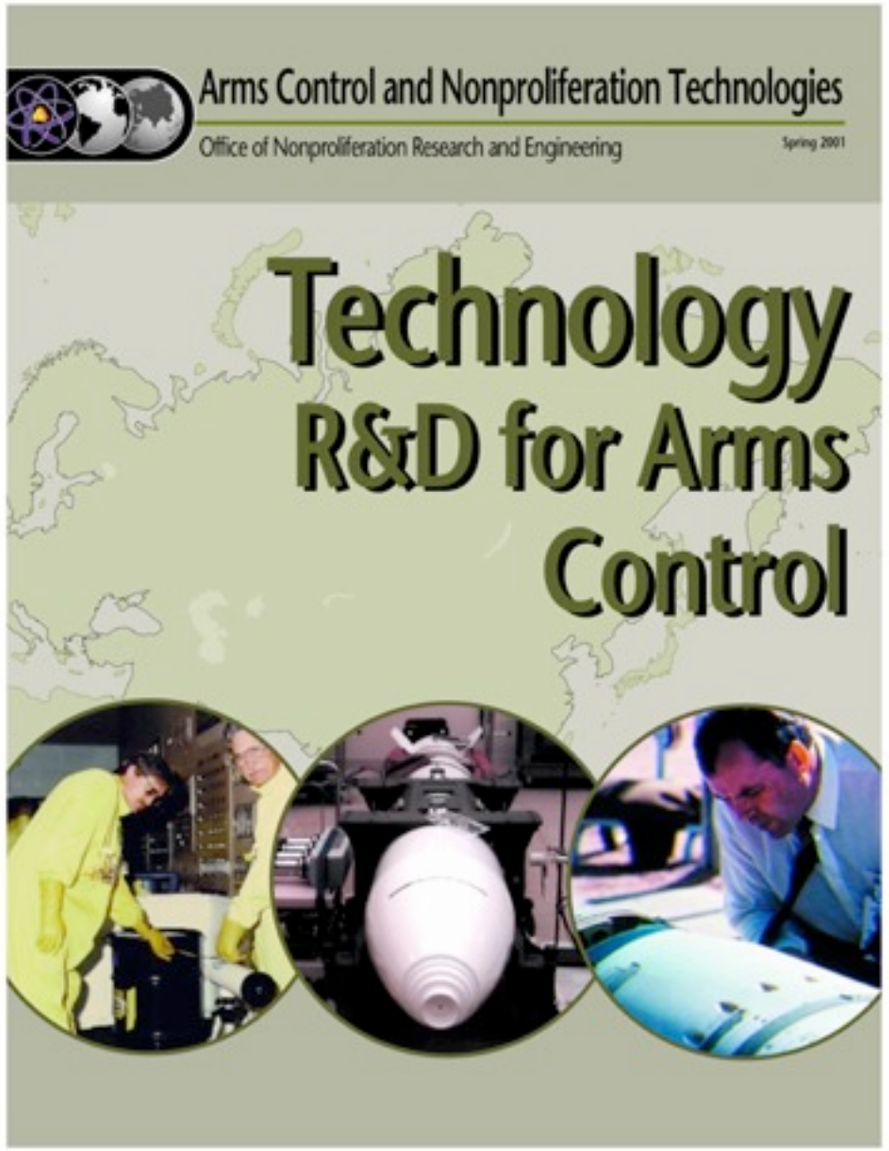
(but most of them are sensitive and cannot be revealed)



Gamma radiation spectrum from a Soviet warhead measured in 1989

Steve Fetter, Thomas B. Cochran, Lee Grodzins, Harvey L. Lynch and Martin S. Zucker
"Measurements of Gamma Rays from a Soviet Cruise Missile," *Science*, Vol. 248, 18 May 1990, pp. 828–834

Inspection Systems for Nuclear Warhead Verification Have Been Under Development Since the 1990s



edited by David Spears, 2001

Attribute Approach

Confirming selected characteristics of an object
in classified form
(for example, the presence/mass of plutonium)

Template Approach

Comparing the radiation signature
from the inspected item with a reference item
("golden warhead") of the same type

Information Barrier

Technologies and procedures that prevent the
release of sensitive nuclear information
(needed for both approaches)

Warhead Dismantlement Verification

Some Precedents Exist and Future Work Can Build on Them

Inspection System developed as part of the 1996–2002 Trilateral Initiative during a demonstration at Sarov
Source: Tom Shea

Visual contact with a mockup nuclear weapon during a UK-Norway Initiative Dismantlement Exercise
Source: UK Norway Initiative, David Keir

Rationale behind verifying warhead dismantlement is to provide confidence that actual warheads are being destroyed and that the fissile material they contained is recovered and accounted for

Many Challenges for Verified Warhead Dismantlement Remain

Development and Demonstration of Practical Inspection Systems

that assure the inspecting party that instrument works as described
and assure the host state that sensitive information is not leaked during the inspection

Trilateral Initiative developed focused only on plutonium

Demonstrate Viability of Cooperation Between Nuclear and Non-nuclear Weapon States

UK Norway Initiative has broken new ground in this area

but secrecy issues tend to make research and development outside the weapons labs difficult

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Verifying the Completeness of Declarations

Life Cycle of a Nuclear Weapon

Making Nuclear Weapons

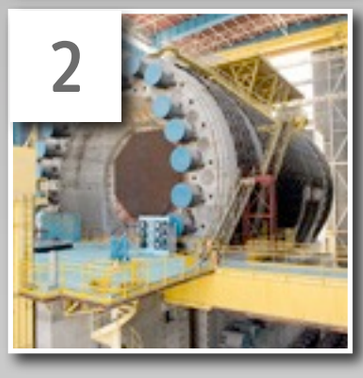
1

Source material (Uranium)

Uranium enrichment

2

2



Plutonium production

3

Production of weapon components

4

Warhead / Weapon assembly

5

Deployment

Dismantling Nuclear Weapons

Source material (Uranium)

Plutonium production or uranium enrichment

Production of weapon components

Warhead / Weapon assembly

Deployment

Warhead / Weapon disassembly

Recovery of weapon components

Recovery of fissile material

Elimination/disposition of fissile material

Key Stages for a Verification Approach

(going beyond verifying limits on deployed nuclear weapons)

Source material (Uranium)

Plutonium production or uranium enrichment

Production of weapon components

Warhead / Weapon assembly

Deployment

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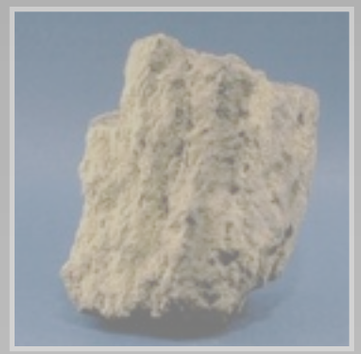

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Production of weapon components

Warhead / Weapon assembly

Deployment

Warhead / Weapon disassembly

Recovery of weapon components

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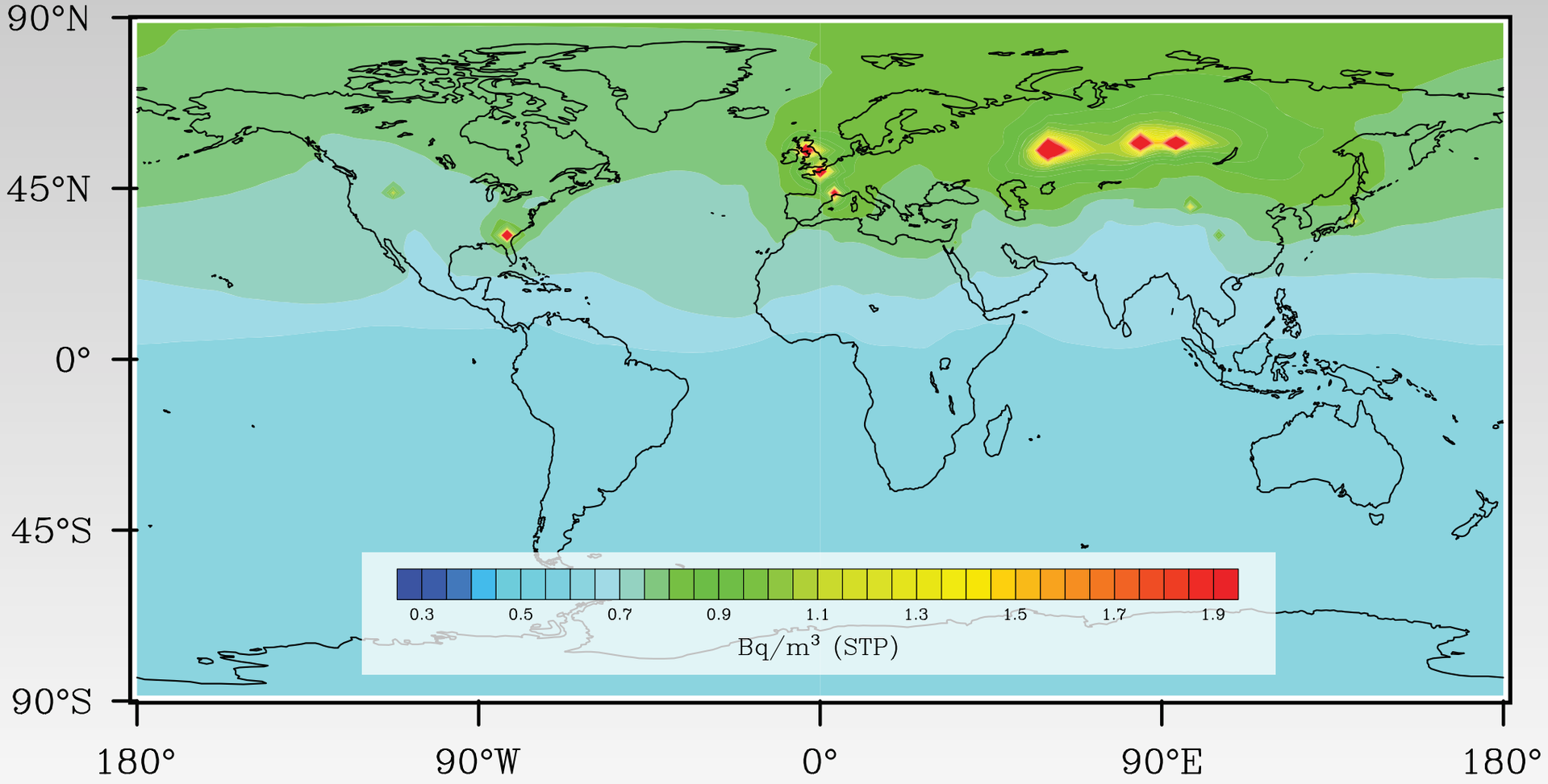
Independent Assessments

(Consistency checks of declarations with or without data sharing)

Many Aspects of Declarations Can Be Reviewed for Consistency Even Without Verification

Historic atmospheric krypton-85 levels have been recorded and can be used to estimate large-scale plutonium production in some nuclear weapon states



Simulated data for MONTH 1981; Ole Ross, *Simulation of Atmospheric Krypton-85 Transport to Assess the Detectability of Clandestine Nuclear Reprocessing*, PhD Thesis, Hamburg University, Germany, 2010

Public Historic Documents Can Often Help Reconstruct Production Histories

Encore une fois [illegible] des Directions de La Hague et de la Cogema a été de minimiser les faits et leurs conséquences possibles, afin de rassurer l'opinion publique française et la clientèle étrangère, faisant prendre ainsi

chaque année en séparant le combustible venant de G2 et G3 (taux de combustion compris entre 700 et 1200 MWJ/t) et le combustible EDF (taux de combustion atteignant 5000 MWJ/t.)

	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Tonnage G2, G3	190	130	320	620	640	760	850	820	960	730	890
Tx de combustion . . .	100	100	100	200	200	300	300	300	400	400	450
Tonnage EDF	—	—	—	—	—	—	—	—	—	—	—
	1970	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**
Tonnage G2 G3	530	570	460	480	240	280	260	170	non connu	non connu	190
Tx de combustion . . .	450	450	500	600	700	800	1000	1200			1200
Tonnage EDF					113	8	25	120	245	280	310

Si jusqu'aux années 1972-73 les tonnages retraités sont très élevés, une des raisons essentielles en est le faible taux de combustion des combustibles.

Le tonnage retraité diminue ensuite sensiblement en

ne. Il est également inférieur aux prévisions faites par la Cogéma au début de l'année 1980 puisque 310 tonnes ont été retraitées alors que les prévisions étaient 365 tonnes.

LES CONDITIONS DE TR[illegible]

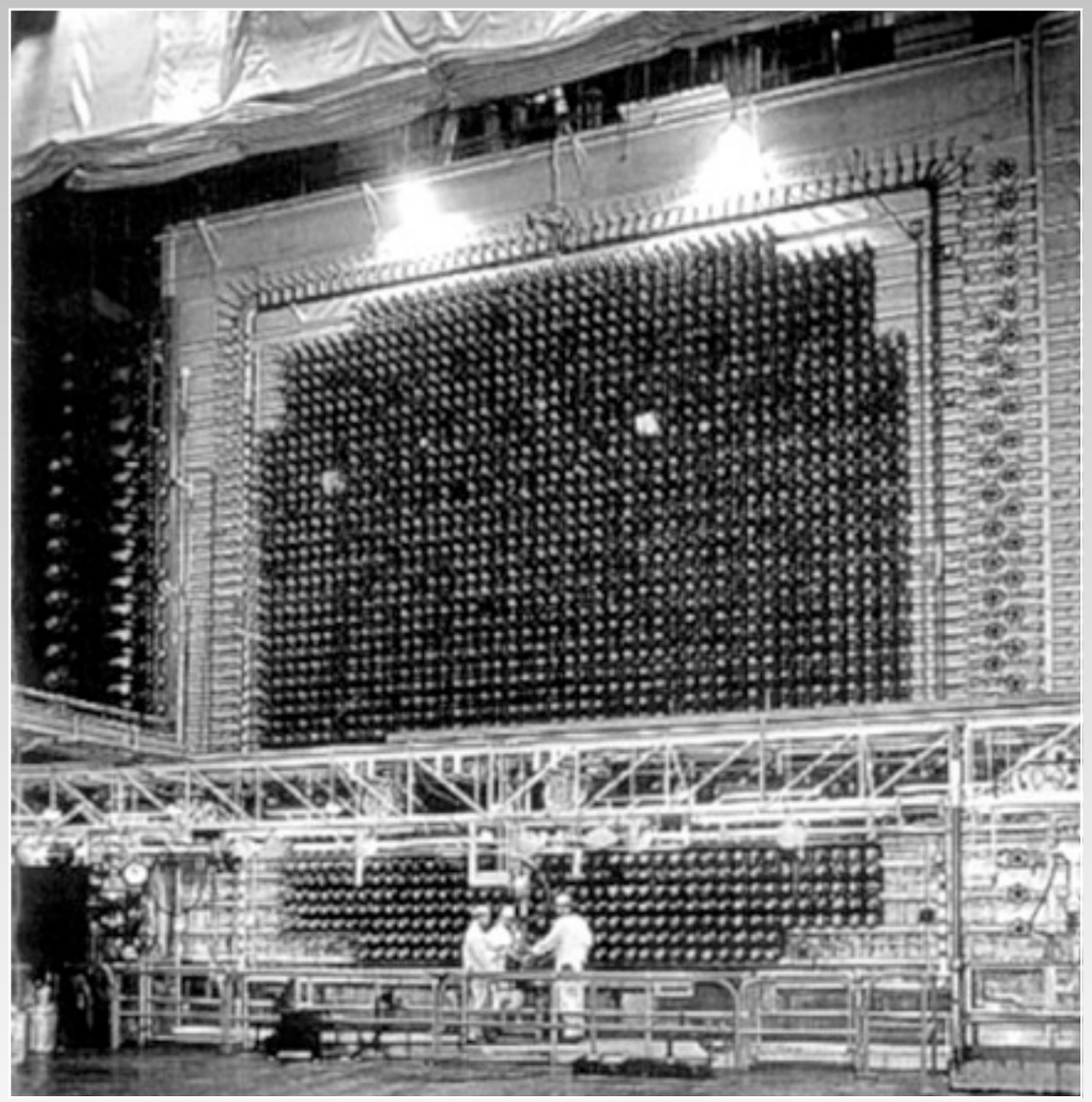
Le retraitement des combustibles irradiés: La situation de la Hague et Marcoule, Analyses et positions de la CFDT
Rayonnement, Syndicat National du Personnel de l'Energie Atomique, No. 92, Février 1981

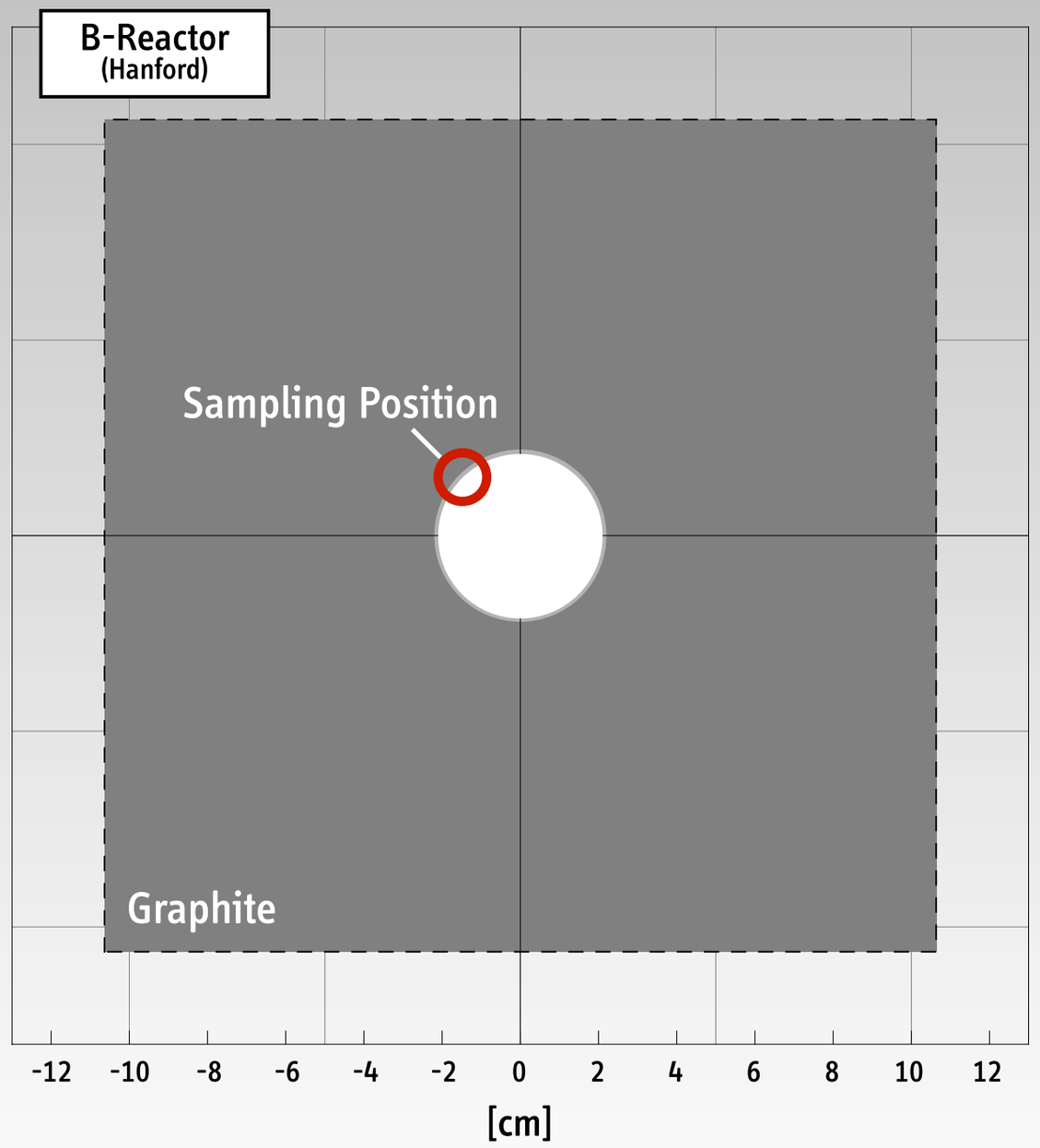
Nuclear Archaeology

(with onsite inspections)

Nuclear Archaeology for Plutonium

(U.S. Hanford B Reactor, 1944–1968)





North Korea's Yongbyon Reactor, 2008

Credit: CNN/Brian Rokus

“The Clock is Ticking”

Shutdown production reactors and enrichment plants are being decommissioned

Shutdown of the last Russian plutonium production reactor ADE-2 in Zheleznogorsk, 2010
Source: U.S. Department of Energy

Demolition of the K-25 uranium enrichment plant began in December 2008 and will be completed in 2012
Source: Bechtel Jacobs

**In many cases, facilities have been temporarily preserved;
but in other cases, environmental concerns (or site stewardship decisions)
have led to the demolition of former production sites**

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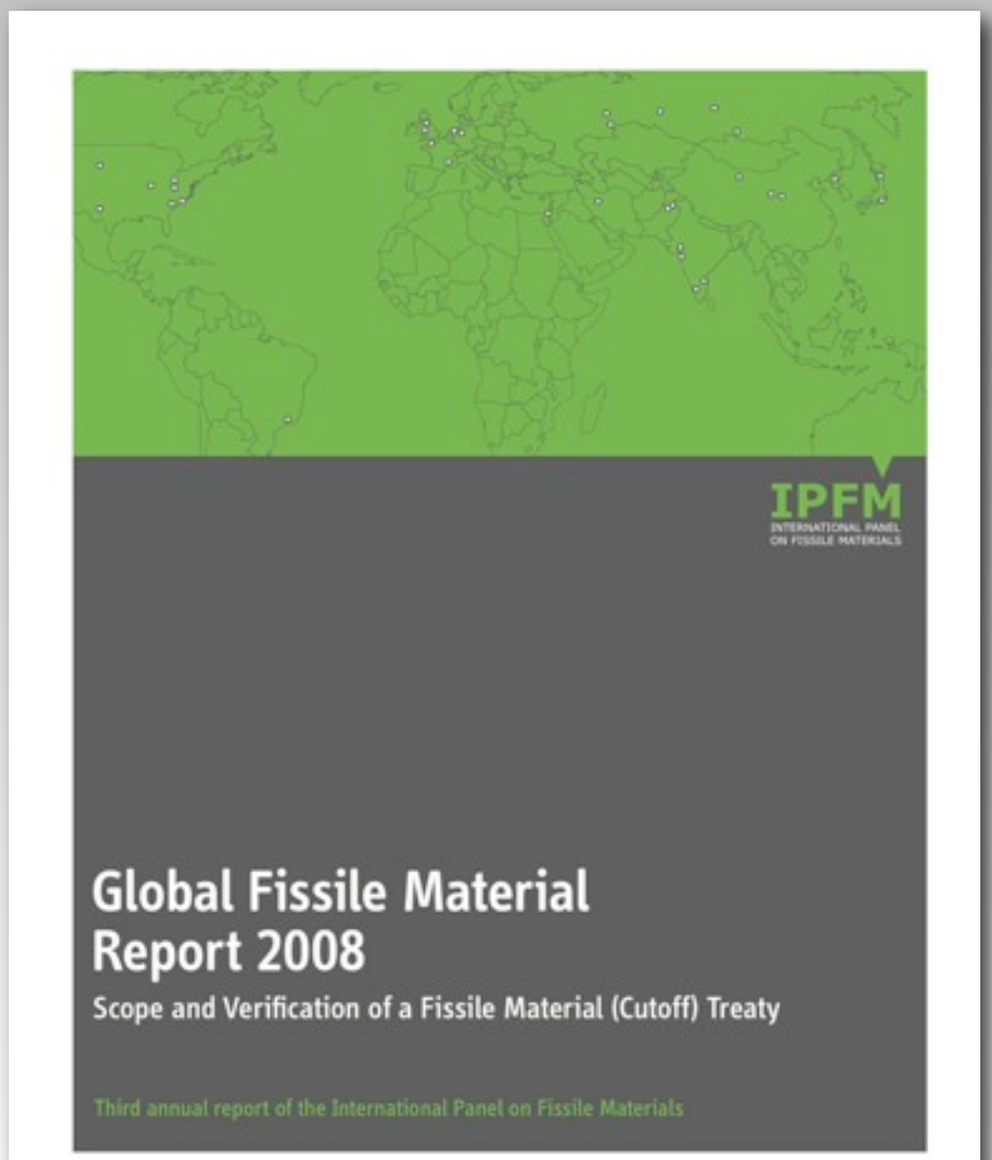
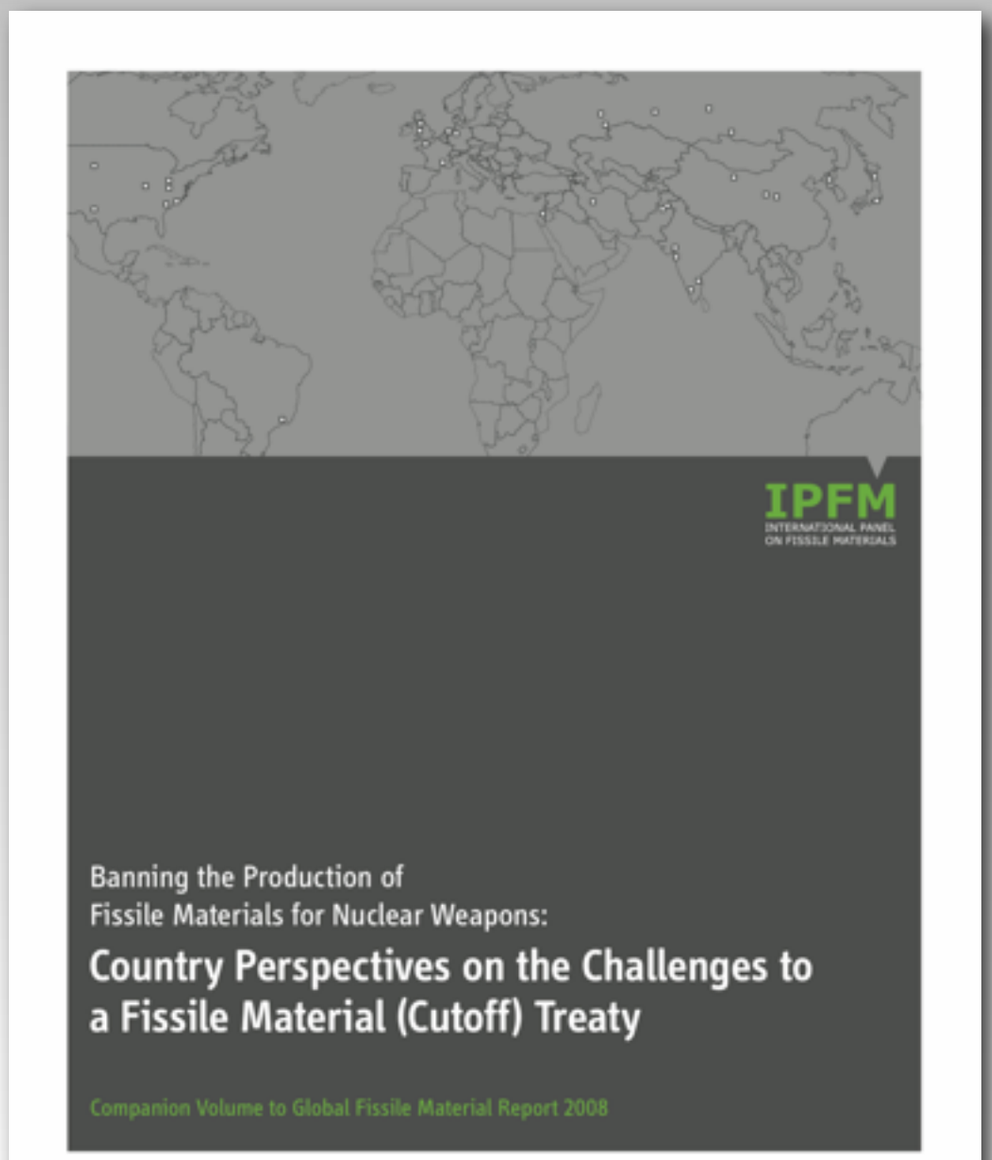
Non-Production of New Fissile Material for Weapons (FMCT Verification)

Global Fissile Material Report 2008

www.ipfmlibrary.org/gfmr08.pdf and www.ipfmlibrary.org/gfmr08cv.pdf





Verification Challenges

1. Shutdown facilities
2. Operational enrichment plants
3. Operational reprocessing plants
4. Challenge inspections at military nuclear sites

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depending on scope of FMCT

5. Naval-reactor fuel cycle
6. Weapon-origin fissile material

Precedents for verification exist in NPT safeguards
in non-weapon states, but some (important) differences

Way Forward / Next Steps

2010 NPT Review Conference

The "Action Plan on Nuclear Disarmament" affirmed:

- " the importance of supporting cooperation among governments, the UN, other international and regional organizations and civil society **aimed at increasing confidence, improving transparency and developing efficient verification capabilities related to nuclear disarmament."**

- " nuclear-weapon States are encouraged to agree as soon as possible on a **standard reporting form and to determine appropriate reporting intervals for the purpose of voluntarily providing standard information."**

Progress report expected at 2014 NPT PrepCom

Repository of information provided by nuclear-weapon States

http://www.un.org/disarmament/WMD/Nuclear/Repository/

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UNODA

United Nations Office for Disarmament Affairs

... strengthening peace and security through disarmament

Repository of information provided by nuclear-weapon States

Information will be made available on this web page once action is taken in accordance with Action 21 of the Final Document of the 2010 Review Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons.

> Action 21: As a confidence-building measure, all the nuclear-weapon States are encouraged to agree as soon as possible on a standard reporting form and to determine appropriate reporting intervals for the purpose of voluntarily providing standard information without prejudice to national security. The Secretary-General of the United Nations is invited to establish a publicly accessible repository, which shall include the information provided by the nuclear-weapon States.

www.un.org/disarmament/WMD/Nuclear/Repository/

Way Forward / Next Steps

By 2015 Review Conference, NPT nuclear weapon-states could:

1. Make initial baseline declarations about total nuclear warhead and fissile material stocks
2. Place additional (and eventually all) civilian, military excess, and waste fissile material under IAEA safeguards
3. Agree to begin preparations to make more detailed historical declarations to build confidence for deeper reductions in warhead and fissile material stocks
4. Agree to launch cooperative pilot verification projects (ideally, in partnership with the IAEA and interested countries)