



# TOWARD MULTILATERAL NUCLEAR ARMS CONTROL

## VERIFYING CAPS IN THE NUCLEAR ARSENALS AND REDUCTIONS TO LOW NUMBERS

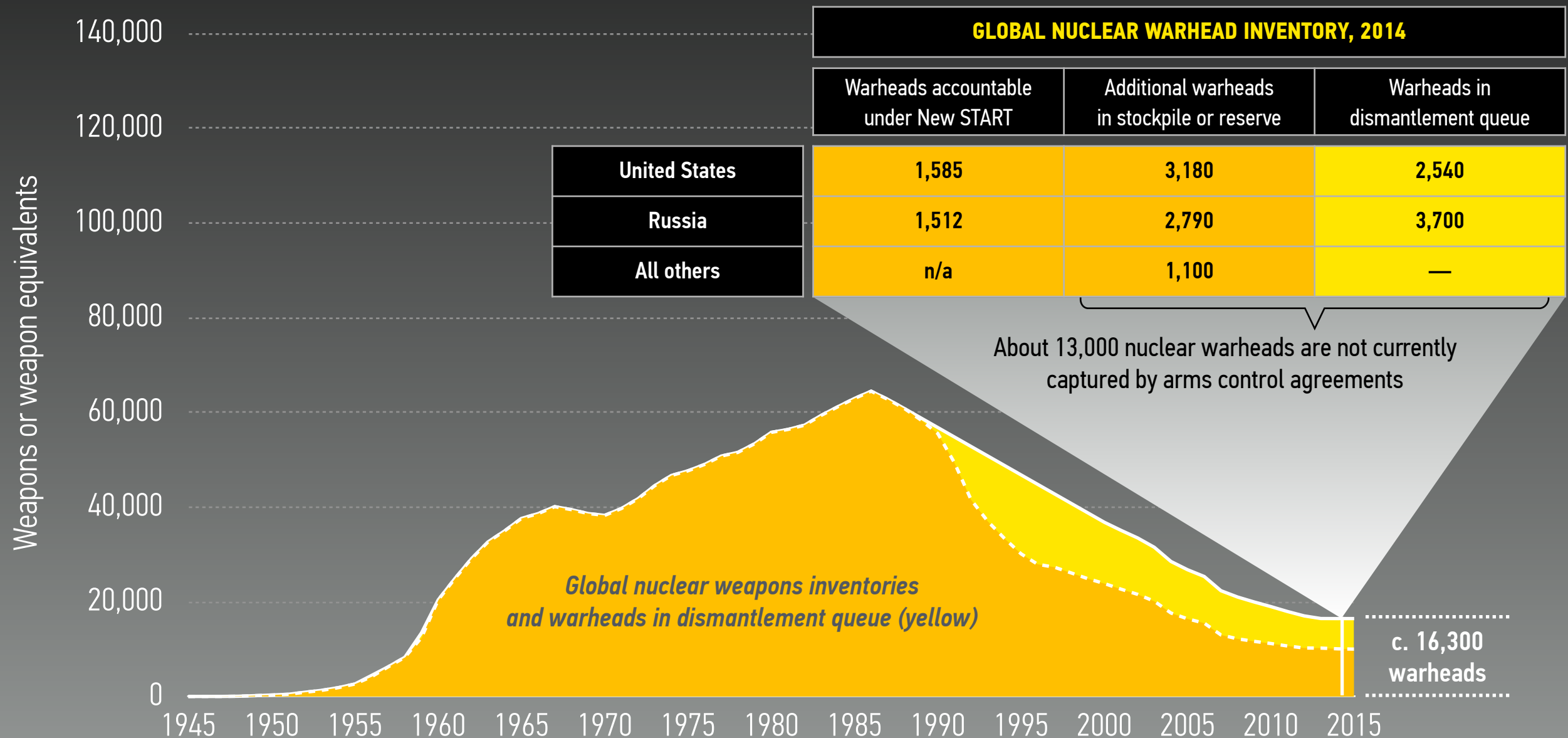
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Princeton University

PIIC Seminar  
Hangzhou, China, October 20, 2014

# GLOBAL NUCLEAR WEAPON INVENTORY

## 1945–2014



Hans M. Kristensen and Robert S. Norris, "Global Nuclear Weapons Inventories, 1945–2013," *Bulletin of the Atomic Scientists*, 69 (5), 2013, 75–81  
 U.S. Department of State; and H. M. Kristensen and R. S. Norris, "Worldwide Deployments of Nuclear Weapons, 2014," *Bulletin of the Atomic Scientists*, 70 (5), 2014



# THOUSANDS OF NUCLEAR WEAPONS

ARE CURRENTLY NON-DEPLOYED (i.e., IN RESERVE OR AWAITING DISMANTLEMENT)



W87/Mk-21 Reentry Vehicles in storage, Warren Air Force Base, Cheyenne, Wyoming  
Photo courtesy of Paul Shambroom, [www.paulshambroom.com](http://www.paulshambroom.com)

# WHAT IS NEW HERE?

## THE CHALLENGES OF DEEP REDUCTIONS AND MULTILATERAL NUCLEAR ARMS CONTROL



### NEW TREATIES MAY INCLUDE NON-DEPLOYED WEAPONS

- Focus on numerical limits on total number of warheads in arsenals
- Need to prepare for the transition from bilateral to multilateral nuclear arms control agreements



### NEW TREATIES MAY REQUIRE BASELINE DECLARATIONS

- Applies to both nuclear warhead and fissile material inventories
- How to bring in countries that currently consider these numbers sensitive?

Source: Paul Shambroom (top) and U.S. Department of Energy (bottom)

# WHAT IS TO BE VERIFIED?

## VERIFICATION CHALLENGES OF NUCLEAR DISARMAMENT AT LOW NUMBERS



### 1. WARHEAD COUNTING AND AUTHENTICATION

- Verify that numerical limit of declared items is not exceeded
- Verify authenticity of warheads prior to dismantlement



### 2. COMPLETENESS OF DECLARATIONS

- How to make sure that no covert warheads exist outside the verification regime?

Source: U.S. Department of Energy (top) and U.S. Department of Defense, [www.defenseimagery.mil](http://www.defenseimagery.mil) (bottom)

VERIFICATION CHALLENGE #1

# WARHEAD COUNTING AND AUTHENTICATION



# TAGGING NUCLEAR WARHEADS

(TRANSFORMING A “NUMERICAL LIMIT” INTO A “BAN ON UNTAGGED ITEMS”)

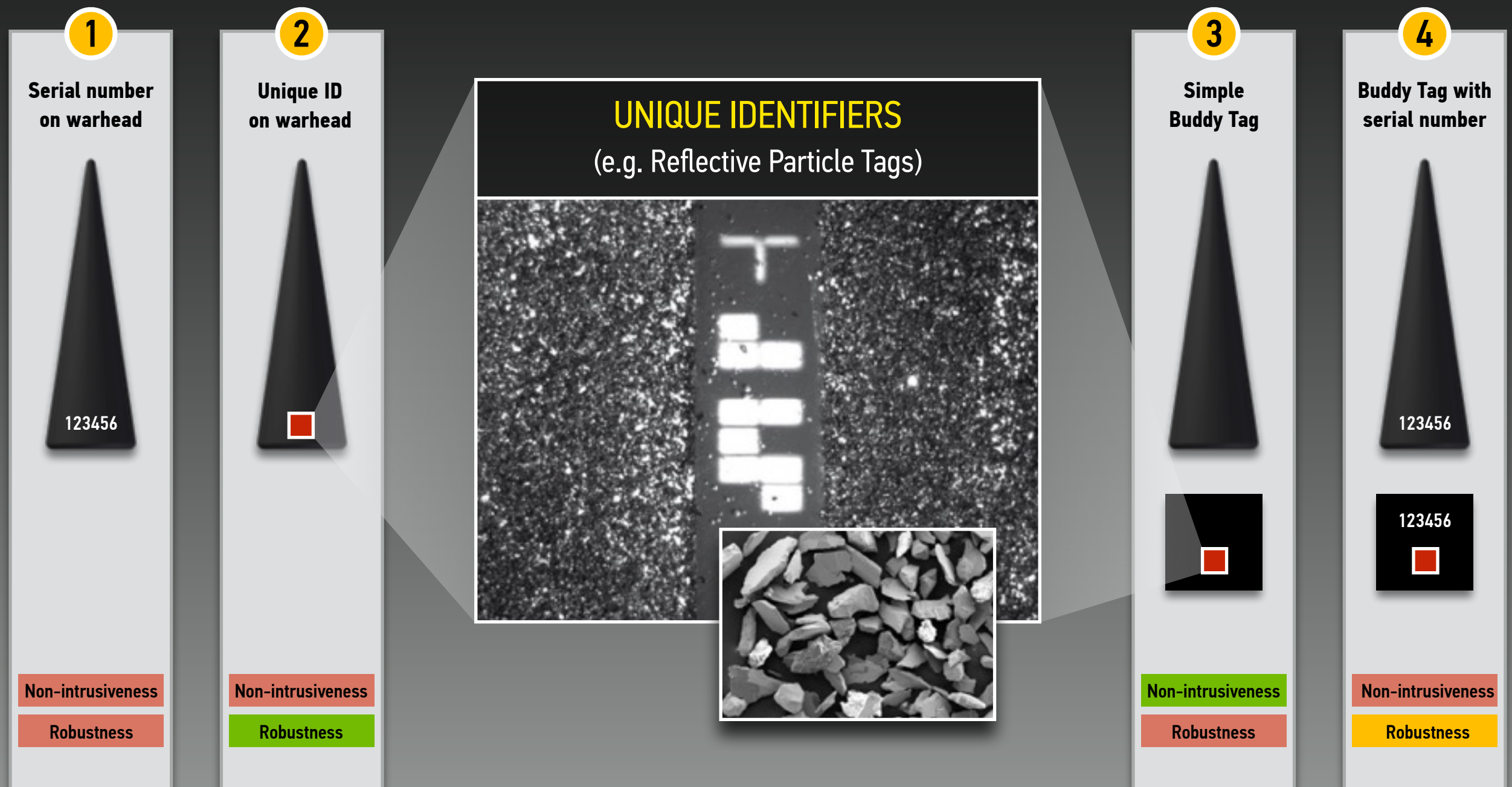


Source: [www.automoblog.net](http://www.automoblog.net)

Steve Fetter and Thomas Garwin, “Using Tags to Monitor Numerical Limits in Arms Control Agreements”  
in Barry M. Blechman, ed., *Technology and the Limitation of International Conflict*, Washington, DC, 1989, pp. 33–54

# WARHEAD COUNTING OPTIONS

WITH VARIOUS LEVELS OF NON-INTRUSIVENESS AND ROBUSTNESS



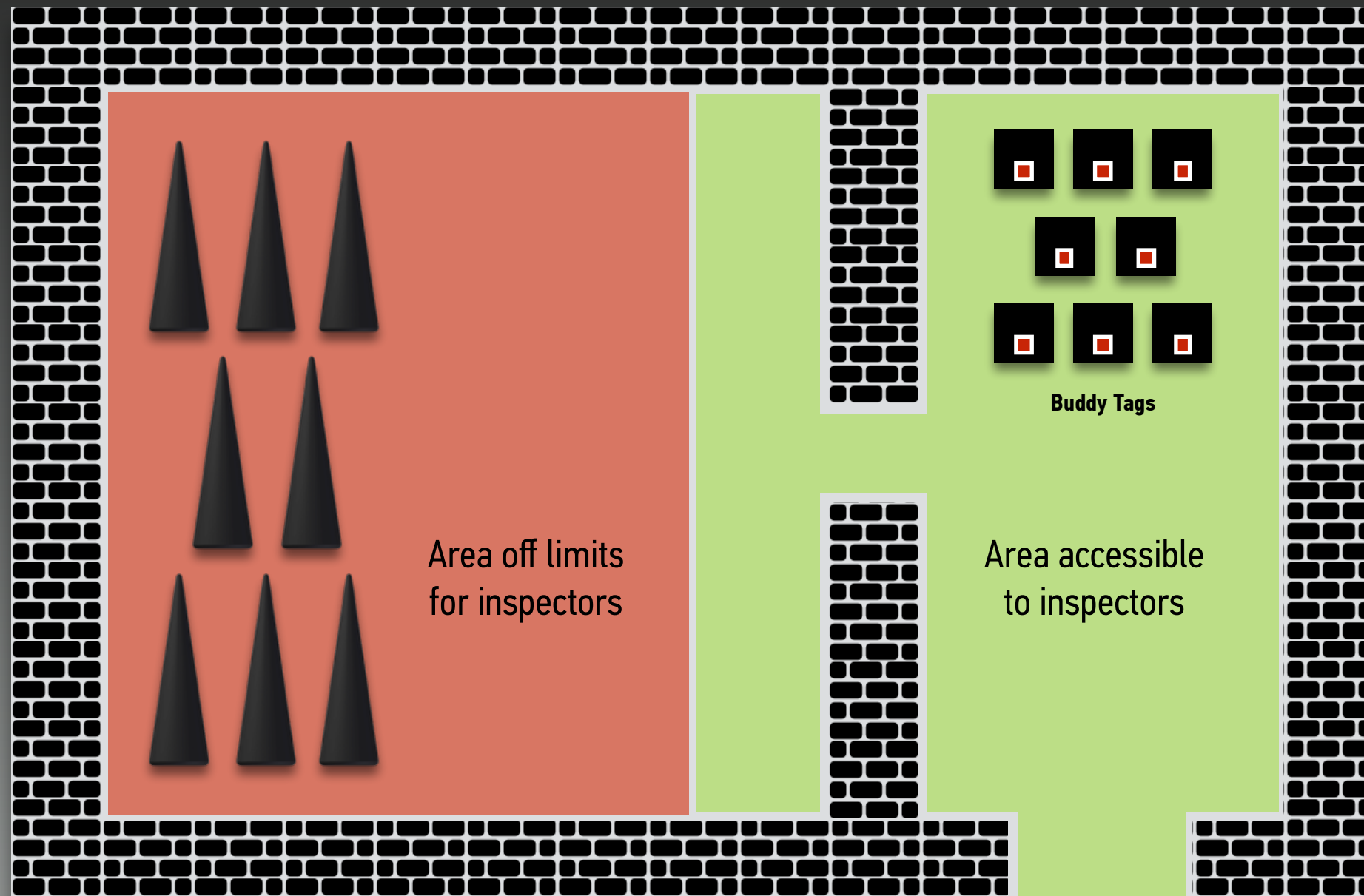
Reflective particle tag concept: A. Gonzales, *Reflective Particle Tag for Arms Control and Safeguards Authentication*, Sandia National Laboratories, 2004

Buddy tag concept: S. E. Jordan, *Buddy Tag's Motion Sensing and Analysis Subsystem*, Sandia National Laboratories, 1991



# OPTION FOR A MINIMALLY INTRUSIVE ONSITE INSPECTION

USING BUDDY TAGS WITHOUT DIRECT ACCESS TO TREATY ACCOUNTABLE ITEMS



Hypothetical nuclear warhead storage facility

# WARHEAD AUTHENTICATION AND VERIFIED WARHEAD DISMANTLEMENT

**IMPORTANT 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*

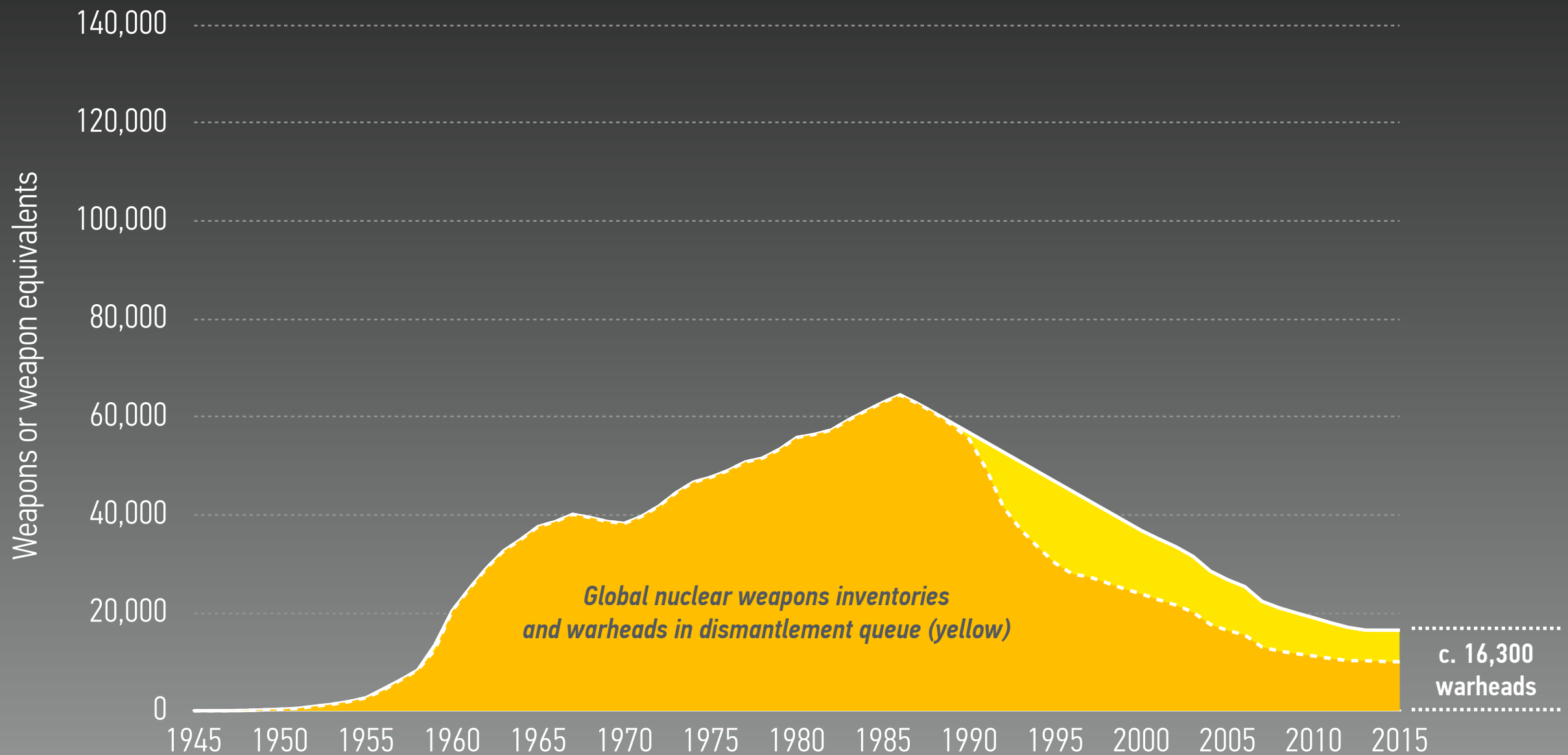
*See for example: Yan Jie and A. Glaser, The Challenge of Nuclear Warhead Verification For Arms Control and Disarmament, this conference*



VERIFICATION CHALLENGE #2

# COMPLETENESS OF DECLARATIONS

# VERIFYING THE COMPLETENESS OF NUCLEAR WARHEAD DECLARATIONS MAY BE IMPRACTICAL BECAUSE MOST WARHEADS NO LONGER EXIST

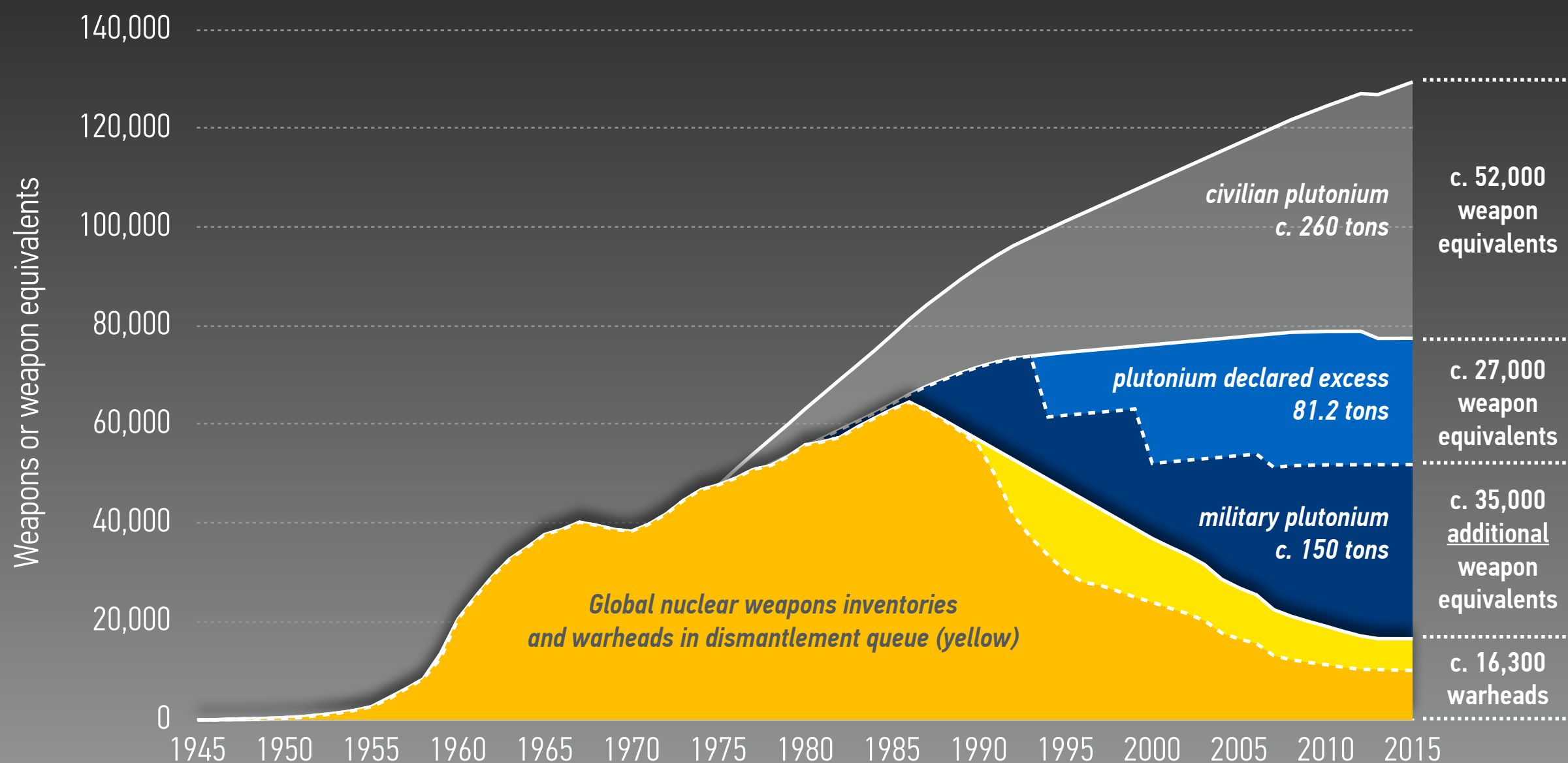


Hans M. Kristensen and Robert S. Norris, "Global Nuclear Weapons Inventories, 1945–2013," *Bulletin of the Atomic Scientists*, 69 (5), 2013, 75–81  
Fissile material estimates and weapon-equivalents are authors' estimates; assuming an average of 3 kg for weapon-grade and 5 kg for reactor-grade plutonium per weapon



# INSTEAD, ESTABLISH CONFIDENCE IN THE COMPLETENESS OF FISSILE MATERIAL DECLARATIONS

## (THE CASE OF SEPARATED PLUTONIUM)



Hans M. Kristensen and Robert S. Norris, "Global Nuclear Weapons Inventories, 1945–2013," *Bulletin of the Atomic Scientists*, 69 (5), 2013, 75–81  
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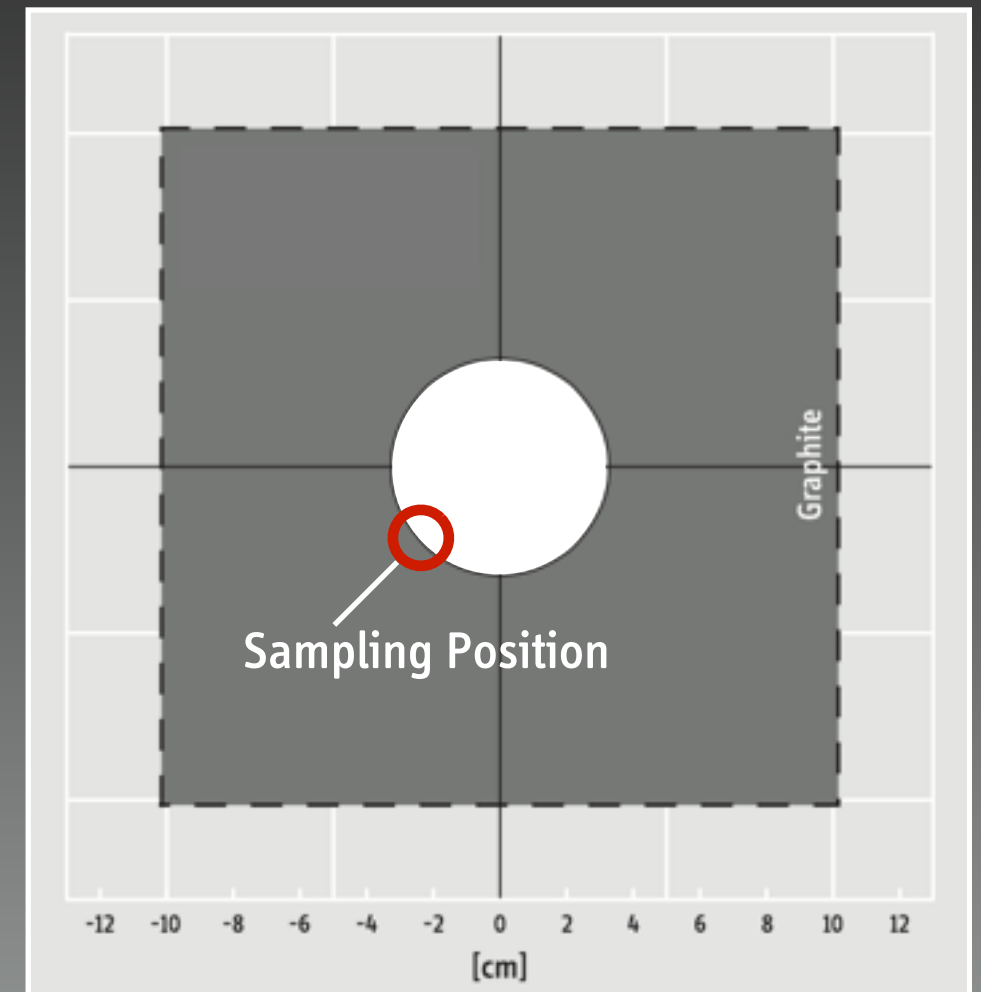
# NUCLEAR ARCHAEOLOGY CAN BE USED TO VERIFY HISTORIC PLUTONIUM PRODUCTION

Nuclear archaeology is based on nuclear forensic techniques and would have been used in the Yongbyon reactor  
Could confirm total plutonium production in North Korea within an uncertainty of  $\pm 2$  kg



The banner reads: "Let's protect Dear General Kim Jong Il desperately!"

Credit: CNN/Brian Rokus, 2008

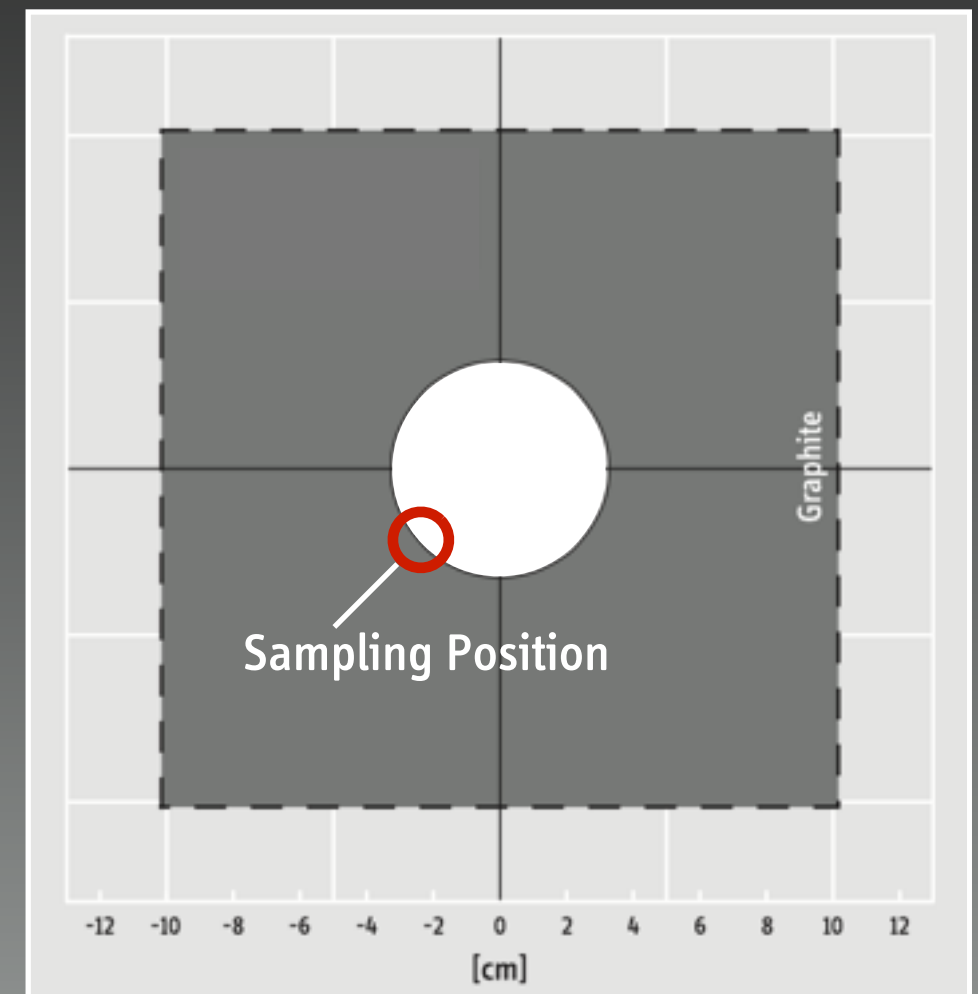
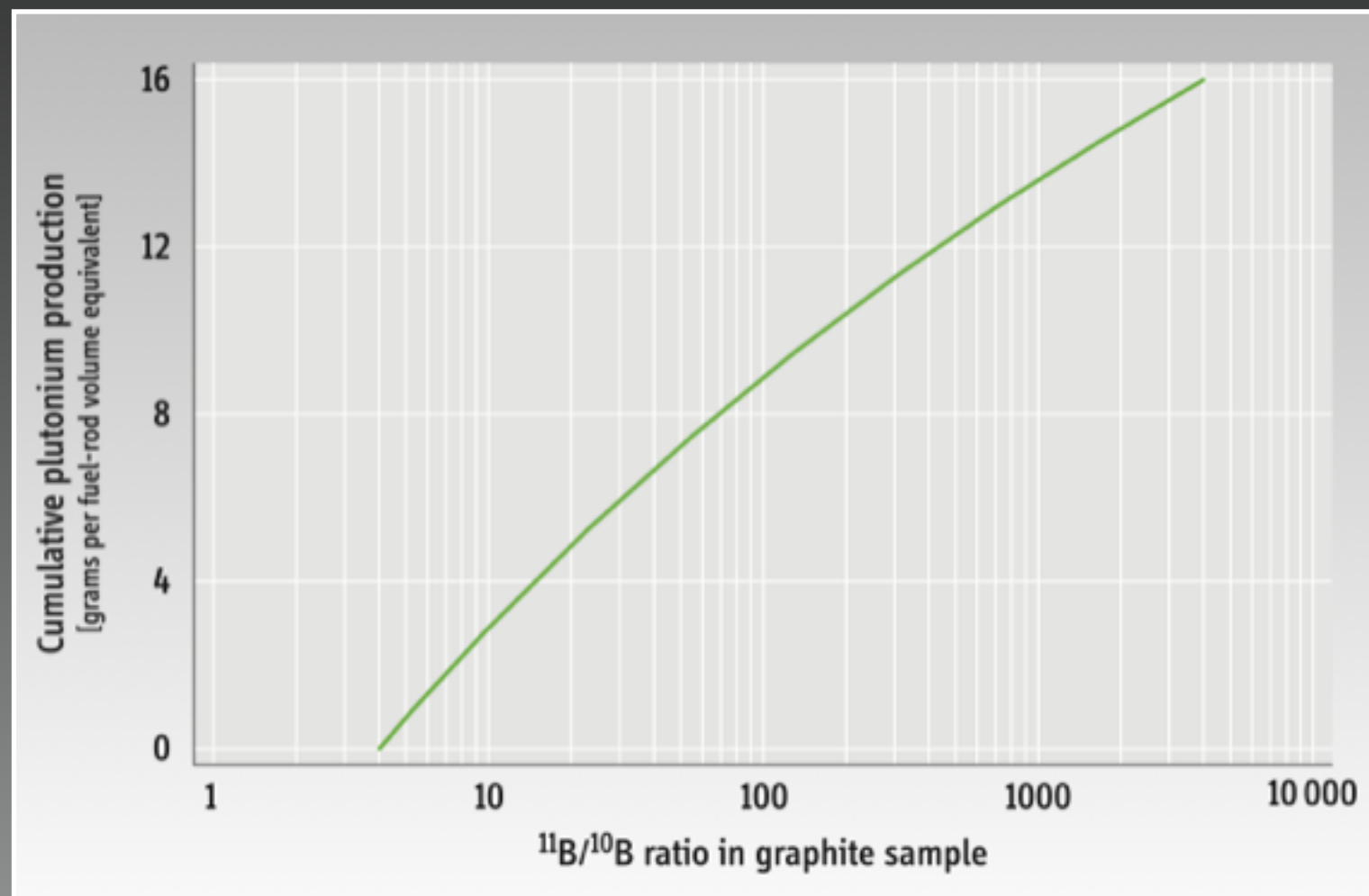


Unit cell of the DPRK Yongbyon reactor



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Jungmin Kang, "Using Graphite Isotope Ratio Method to Verify the DPRK of Plutonium-Production Declaration"  
*Science & Global Security*, 19 (2), 2011

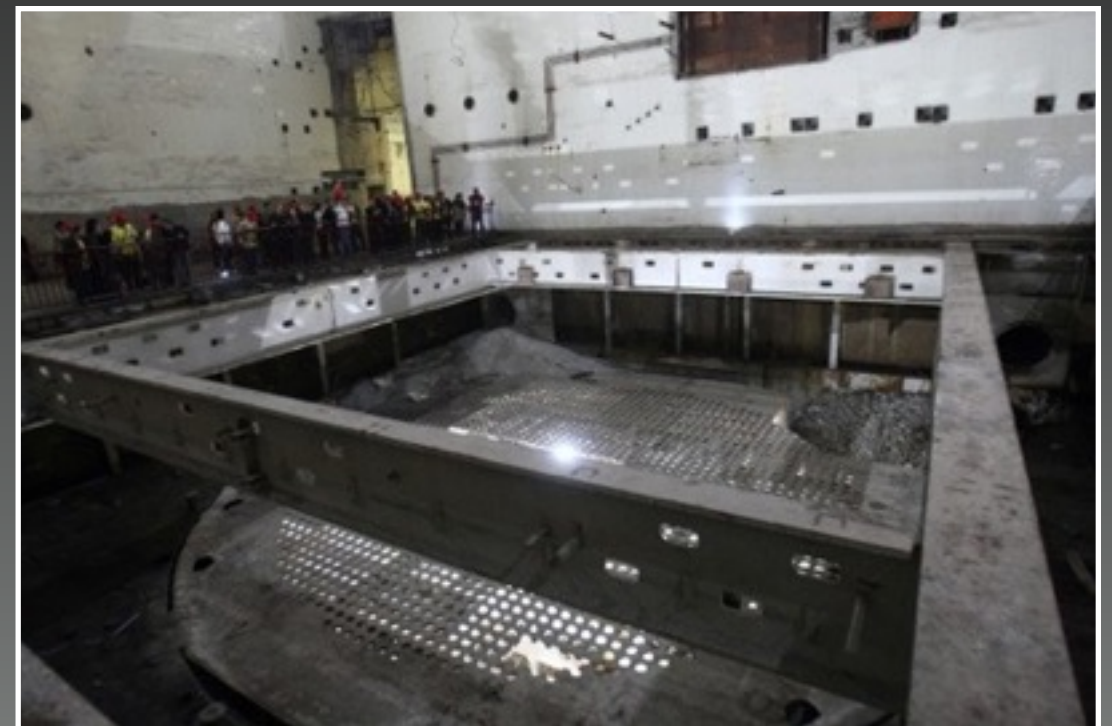
# “THE CLOCK IS TICKING”

SHUTDOWN ENRICHMENT PLANTS AND PRODUCTION REACTORS  
ARE BEING DECOMMISSIONED OR DEMOLISHED



Demolition of the K-25 uranium enrichment plant began in December 2008 and has been completed in 2012

*Source: Bechtel Jacobs*



China's unfinished underground plutonium production complex (Project 816), near Chongqing

*Source: CQTV*



# WAY FORWARD

## PREPARING FOR DEEP REDUCTIONS AND MULTILATERAL NUCLEAR ARMS CONTROL



### STEPS TOWARD VERIFYING NUMERICAL LIMITS ON NUCLEAR ARSENALS

**Jointly develop and demonstrate methods to count and authenticate nuclear warheads**

Focus initially on non-intrusive approaches that are acceptable to all participants (but can accommodate “upgrades”)



### STEPS TOWARD VERIFYING HISTORICAL FISSILE MATERIAL PRODUCTION

**Jointly develop and demonstrate nuclear archaeological methods for all relevant types of production facilities**

Countries could offer “test beds” for joint archaeology exercises  
No need to make full fissile material declarations