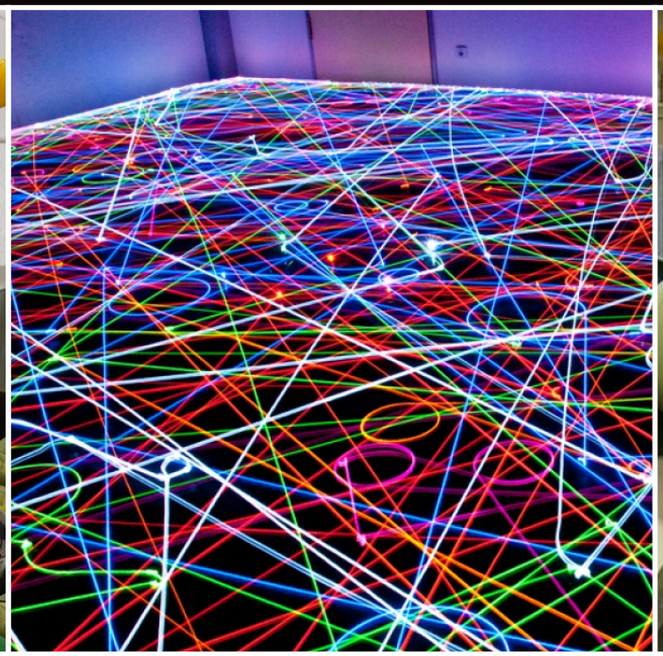
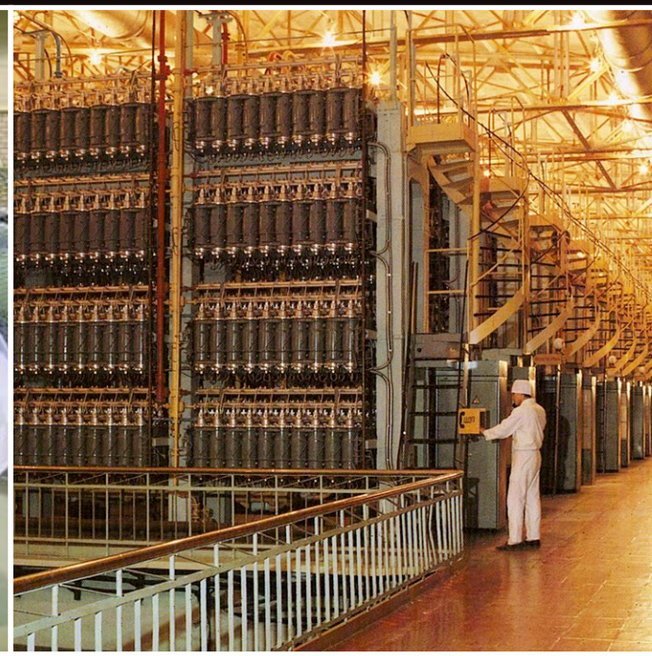





FMCT VERIFICATION

THE ROLE OF NON-INTRUSIVE APPROACHES

Alex Glaser

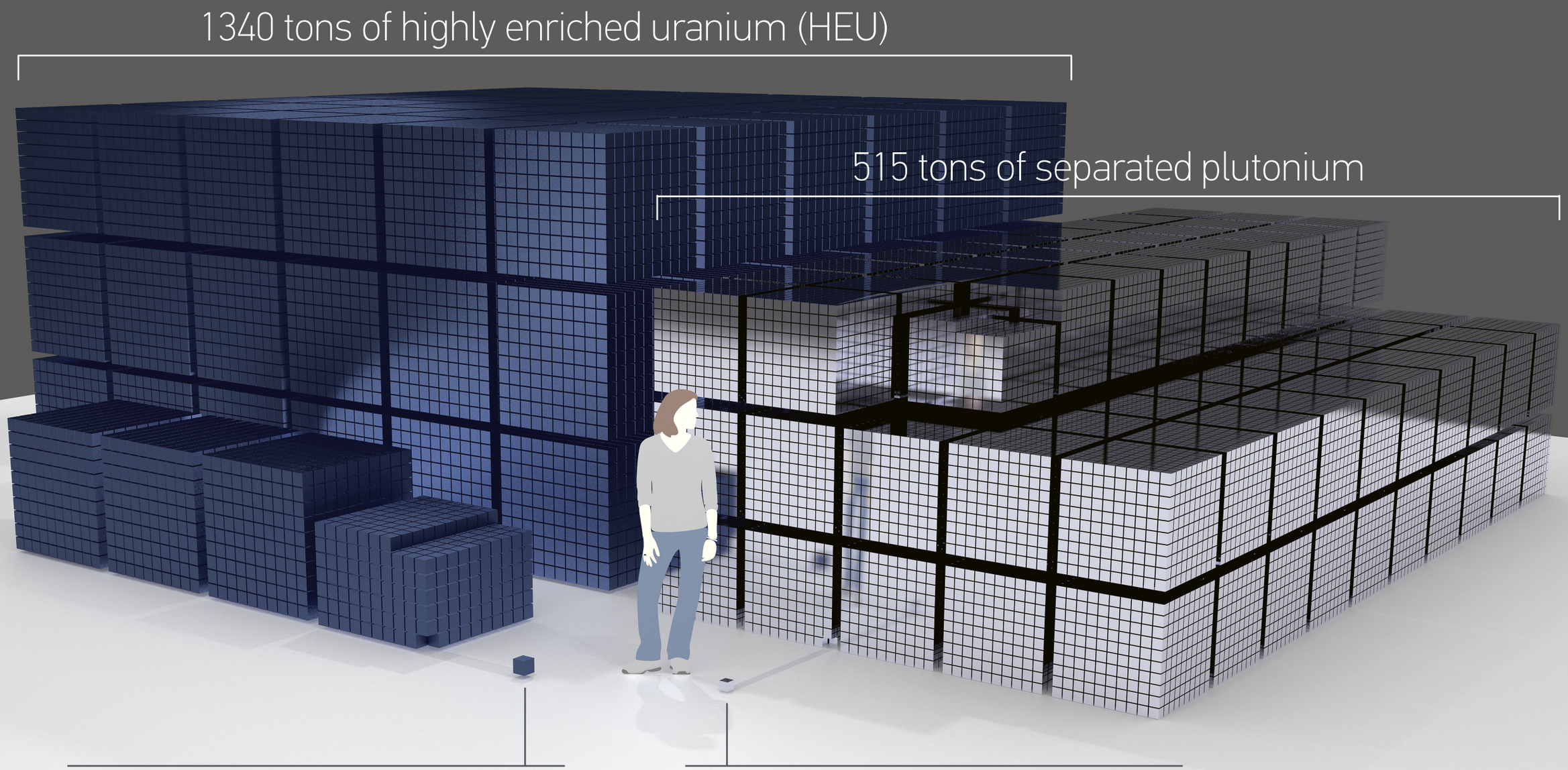
Program on Science and Global Security, Princeton University
International Panel on Fissile Materials

Geneva Centre for Security Policy, Maison de la Paix, March 5, 2018

Revision 1c

Images (from left to right): IAEA, IBRoomba, IAEA, U.S. Department of Energy

There is enough nuclear explosive material worldwide to make over 200,000 nuclear weapons



Each block corresponds to 12 kg of HEU, the amount necessary to make a fission bomb; about 111,670 bombs-worth total

Each block corresponds to 4 kg of plutonium, the amount necessary to make a fission bomb; about 128,750 bombs-worth total

Graphic/concept by Alex Wellerstein and Tamara Patton, October 2017

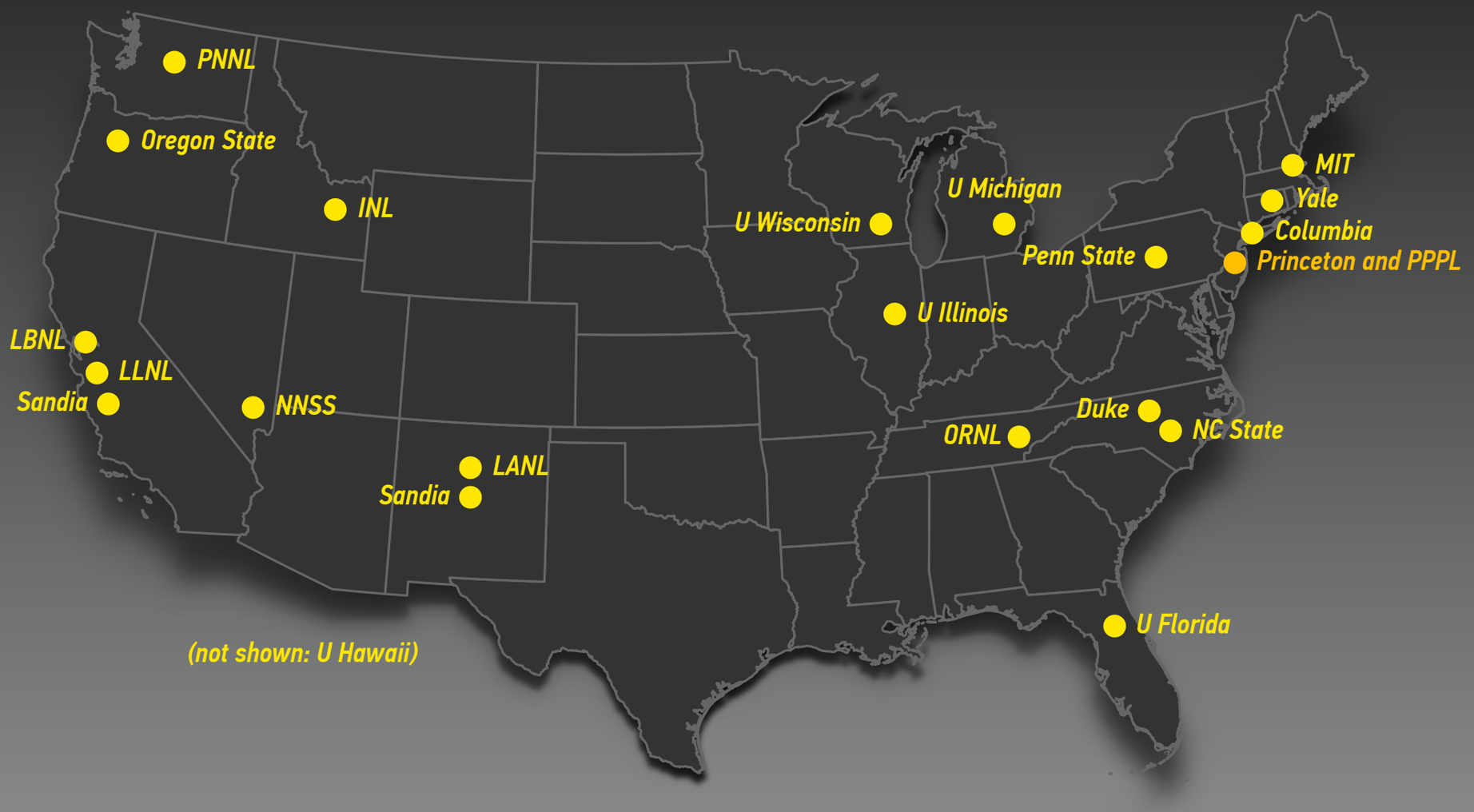
GLOBAL FISSILE MATERIAL REPORT 2008

SCOPE AND VERIFICATION OF A FISSILE MATERIAL (CUTOFF) TREATY

Global Fissile Material Report 2008: Scope and Verification of a Fissile Material (Cutoff) Treaty
International Panel on Fissile Materials, Princeton, NJ, September 2008, www.ipfmlibrary.org/gfmr08.pdf

CONSORTIUM FOR VERIFICATION TECHNOLOGY

A FIVE-YEAR PROJECT FUNDED BY THE U.S. DEPARTMENT OF ENERGY

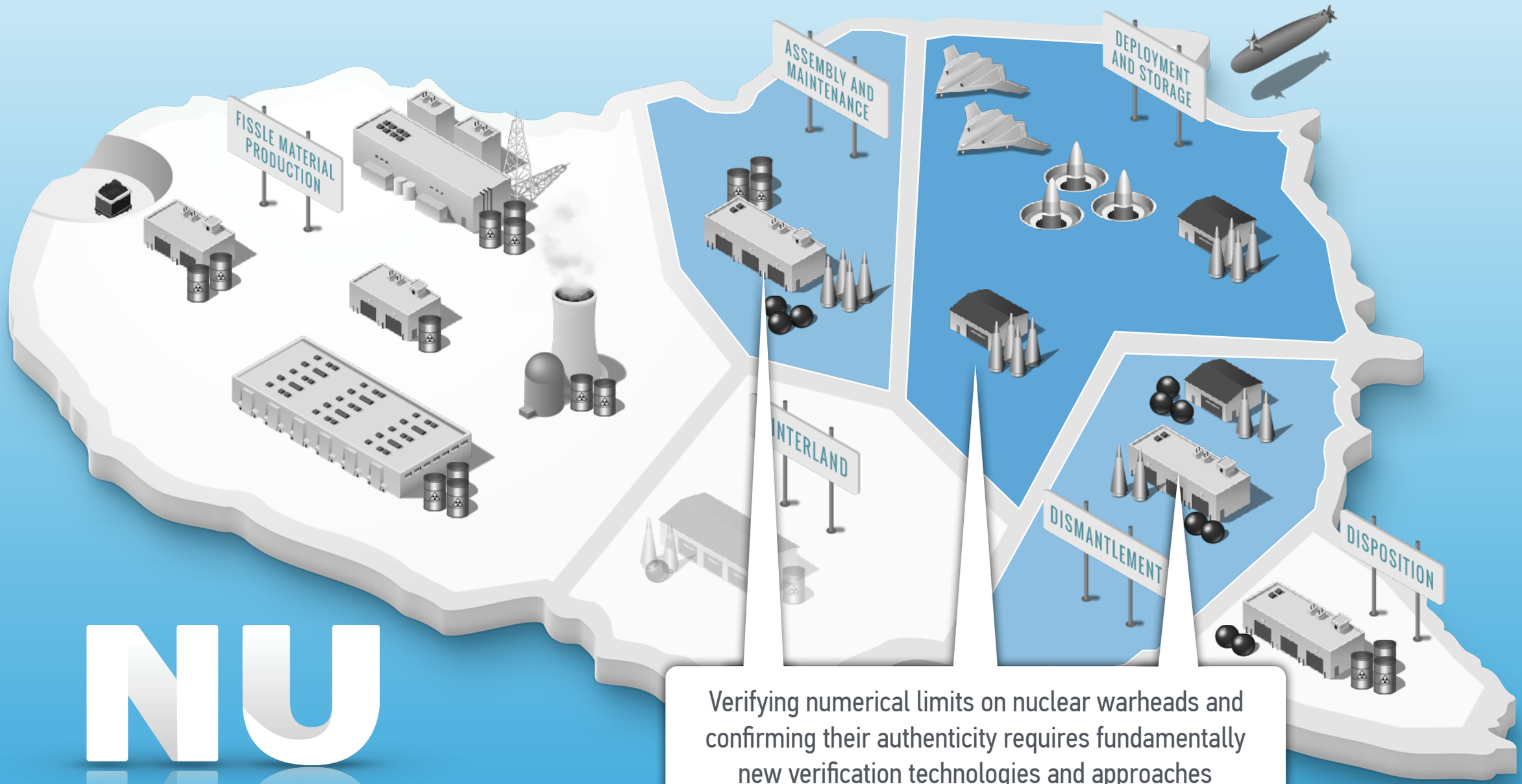


13 U.S. universities and 9 national labs, led by University of Michigan

Princeton participates in the research thrust on disarmament research
(and leads the research thrust of the consortium on policy)

THERE ARE SOME MAJOR VERIFICATION CHALLENGES FOR NUCLEAR ARMS CONTROL

(BUT MOST OF THEM ARE RELATED TO DEEP REDUCTIONS)



Verifying numerical limits on nuclear warheads and confirming their authenticity requires fundamentally new verification technologies and approaches

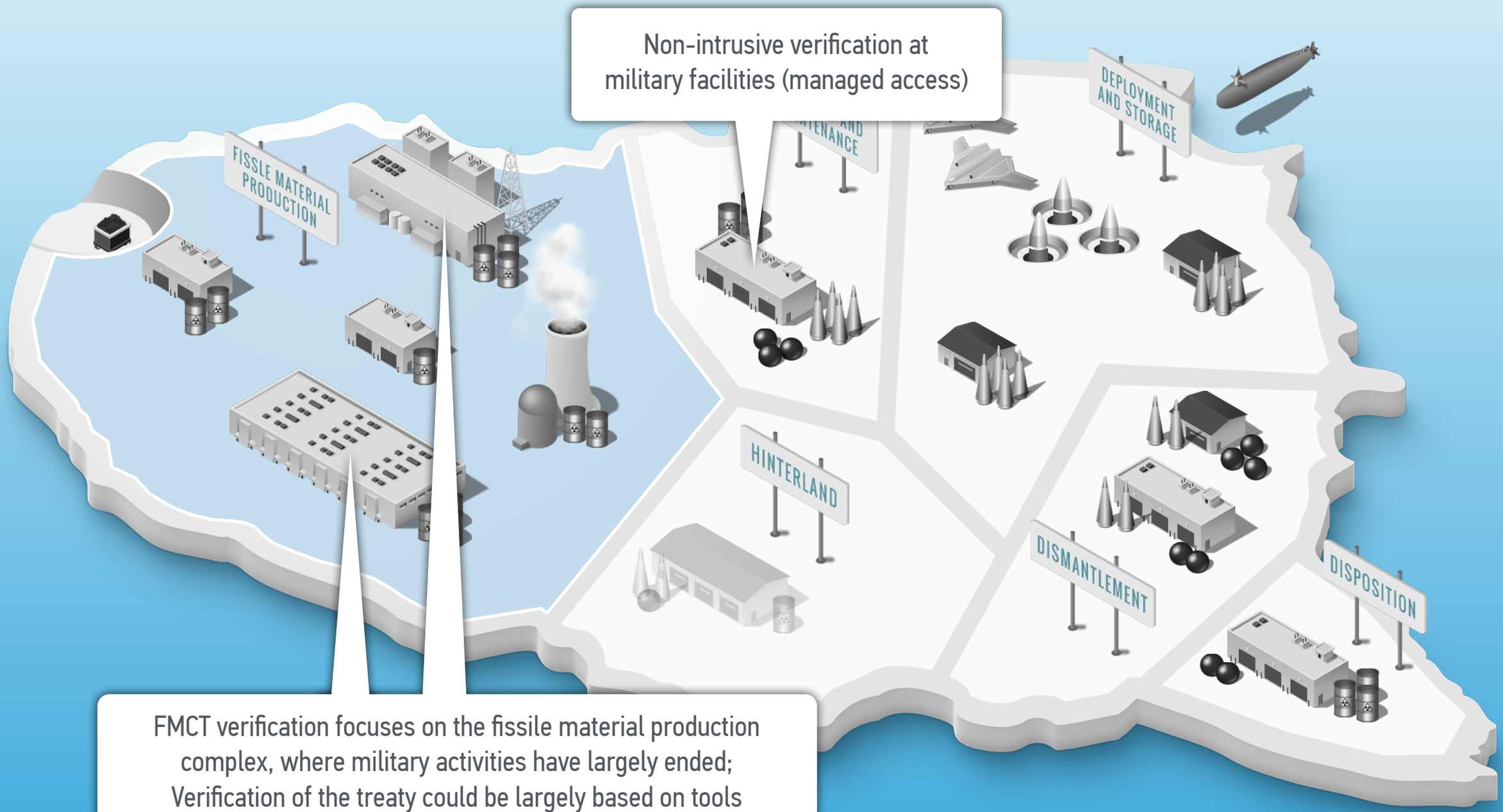
NU

www.verification.nu

Revision 3

VERIFICATION CHALLENGES

FOR A FISSILE MATERIAL CUTOFF TREATY



FMCT verification focuses on the fissile material production complex, where military activities have largely ended; Verification of the treaty could be largely based on tools and approaches developed for implementation of IAEA safeguards

Revision 2

FIVE VERIFICATION CHALLENGES

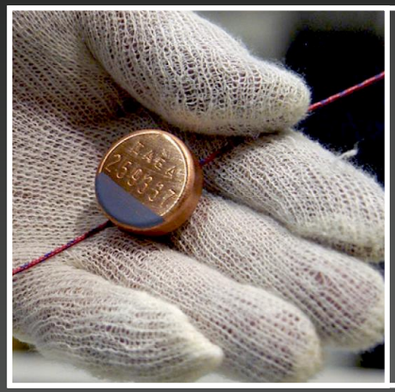
FOR A FISSILE MATERIAL (CUTOFF) TREATY

1. Non-production of HEU at previously operating enrichment plants
2. Non-diversion of plutonium at previously operating reprocessing plants
3. No undeclared enrichment or reprocessing in military nuclear facilities
4. Non-diversion of HEU from the naval fuel cycle
5. Non-diversion of material declared excess in classified form

Minimizing verification (i.e., additional IAEA safeguards) costs

Global Fissile Material Report 2008: Scope and Verification of a Fissile Material (Cutoff) Treaty
International Panel on Fissile Materials, Princeton, NJ, September 2008

UNDERSTANDING NUCLEAR VERIFICATION TECHNOLOGIES AND APPROACHES IN CONTEXT



ROBUSTNESS

How difficult is it to defeat or circumvent the technology?

NON-INTRUSIVENESS (AND INFORMATION SECURITY)

How intrusive is deployment and use of the technology?

for example, does it interfere with operations; is sensitive information put at risk?

SIMPLICITY

How easy is it to deploy and use the technology?

for example, passive systems are generally preferable to active ones

Source: IAEA (top), defenseimagery.mil (middle), author (bottom)

Non-Intrusive FMCT Verification

The Case of Legacy Uranium Enrichment Plants

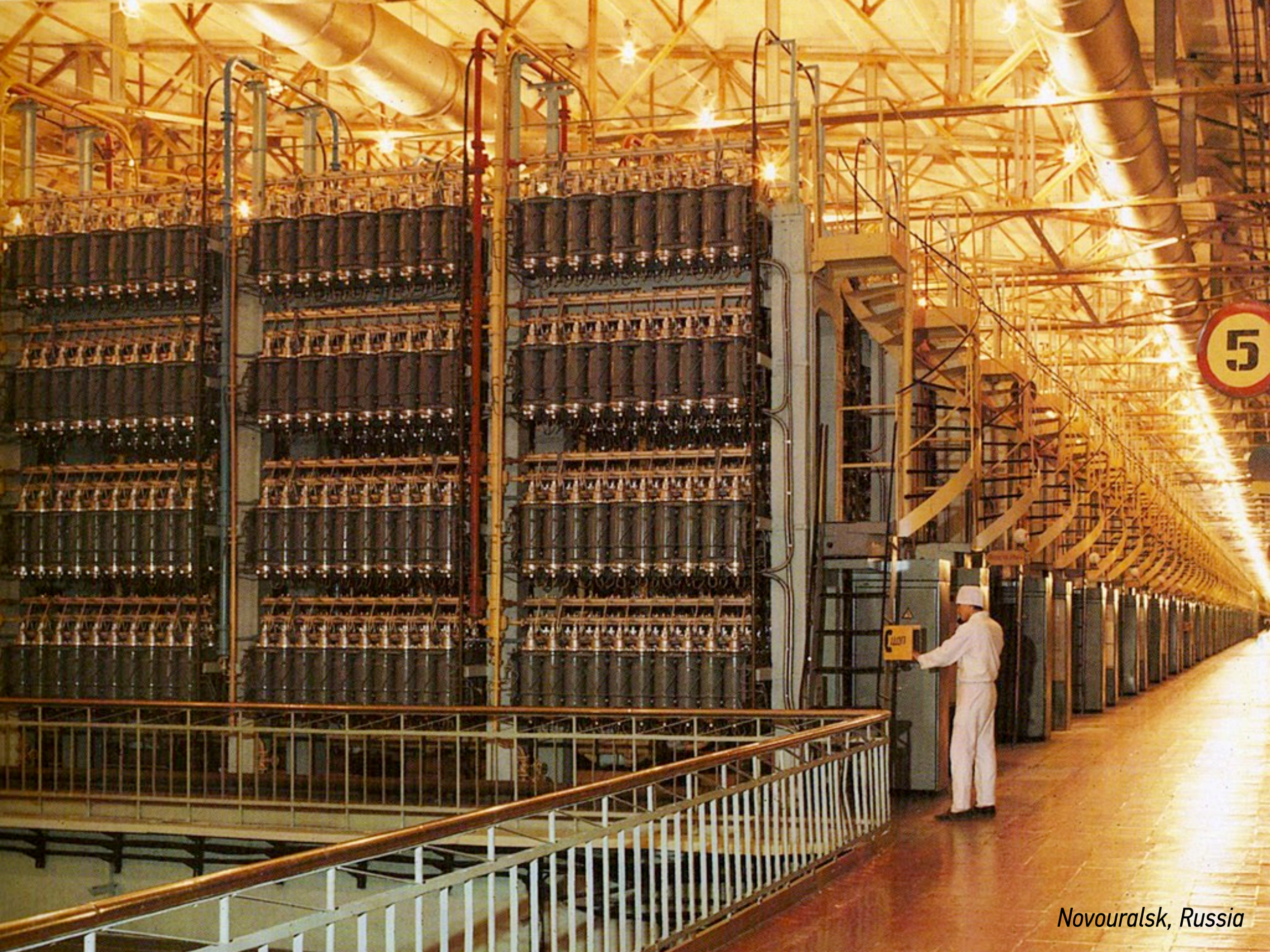
HEU PRODUCTION FOR WEAPONS HAS LARGELY ENDED

BUT CONTINUES IN NON-NPT WEAPON STATES

Country	Military HEU production
United States	1944–1992 *(since 1964 for naval fuel only)*
Russia	1949–1987/88 *(but restarted civilian in 2012)*
United Kingdom	1953–1963 *(but imports from United States)*
China	1964–1987/89 *(unofficial)*
France	1967–1996

Country	Military HEU production
South Africa	1978–1990
Pakistan	since 1983
India	since 1992
Israel	status unknown
North Korea	status unknown *(production possibly ongoing)*

Global Fissile Material Report 2015, International Panel of Fissile Materials, Princeton, December 2015, www.ipfmlibrary.org/gfmr15.pdf



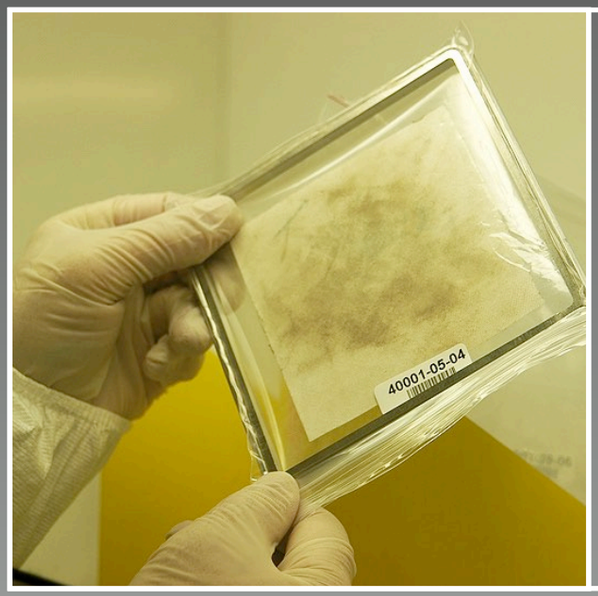
Novouralsk, Russia

ADVANCED SAFEGUARDS TECHNIQUES EXIST

BUT THEY *MAY* NOT BE ADEQUATE FOR FMCT VERIFICATION

ONLINE ENRICHMENT MONITORING

Several types of enrichment (and flow) monitors have been field-tested or are under development; the Online Enrichment Monitor (OLEM) is currently deployed at the Natanz Enrichment plant as part of the Joint Comprehensive Plan of Action (JCPOA)



ENVIRONMENTAL SWIPE SAMPLING

Absence of HEU production could be confirmed with swipe sampling techniques, but legacy particles may limit the usefulness of the technique and reveal information considered sensitive by the host

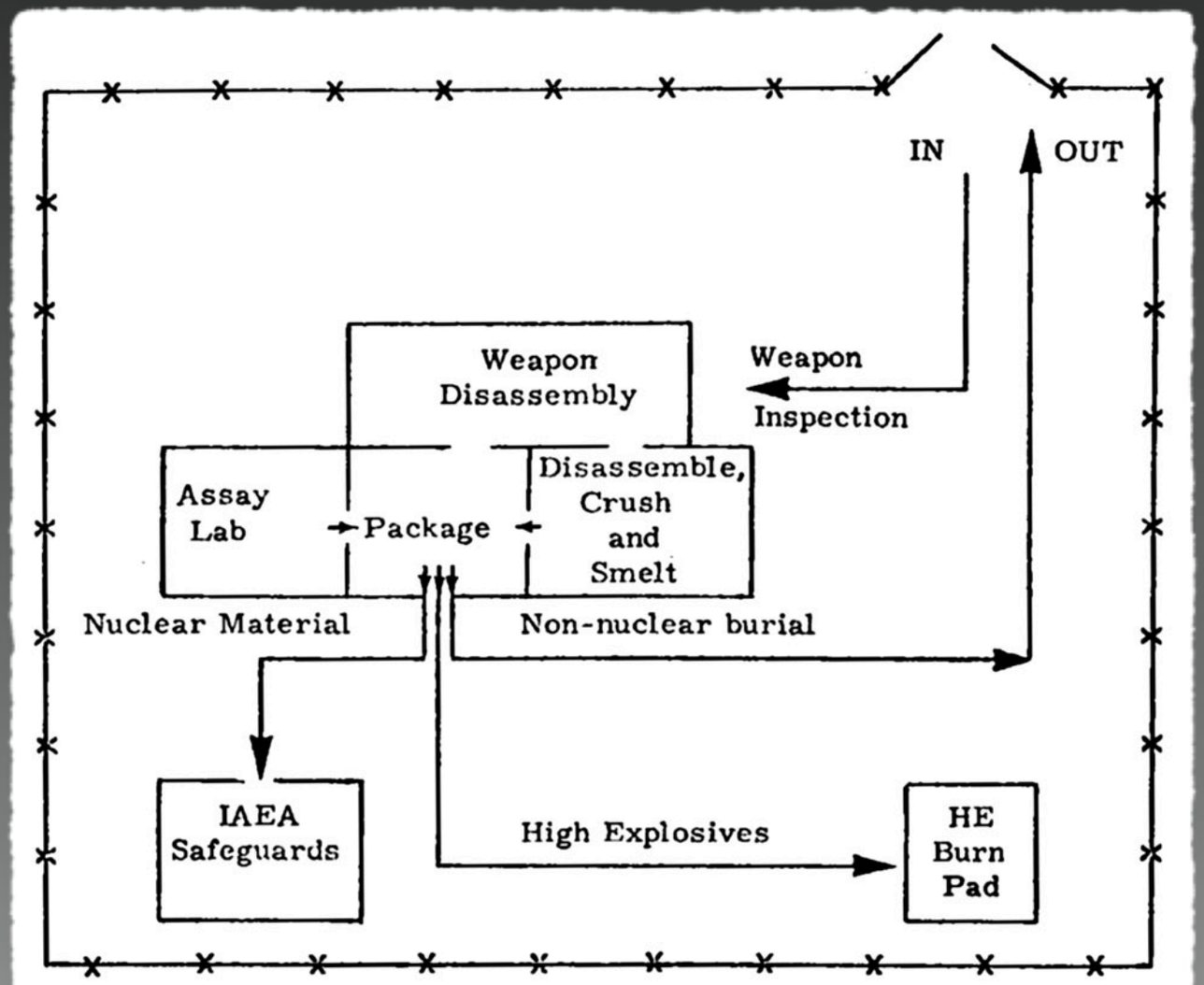
Source: IAEA (top and bottom)

Thinking Outside the Box

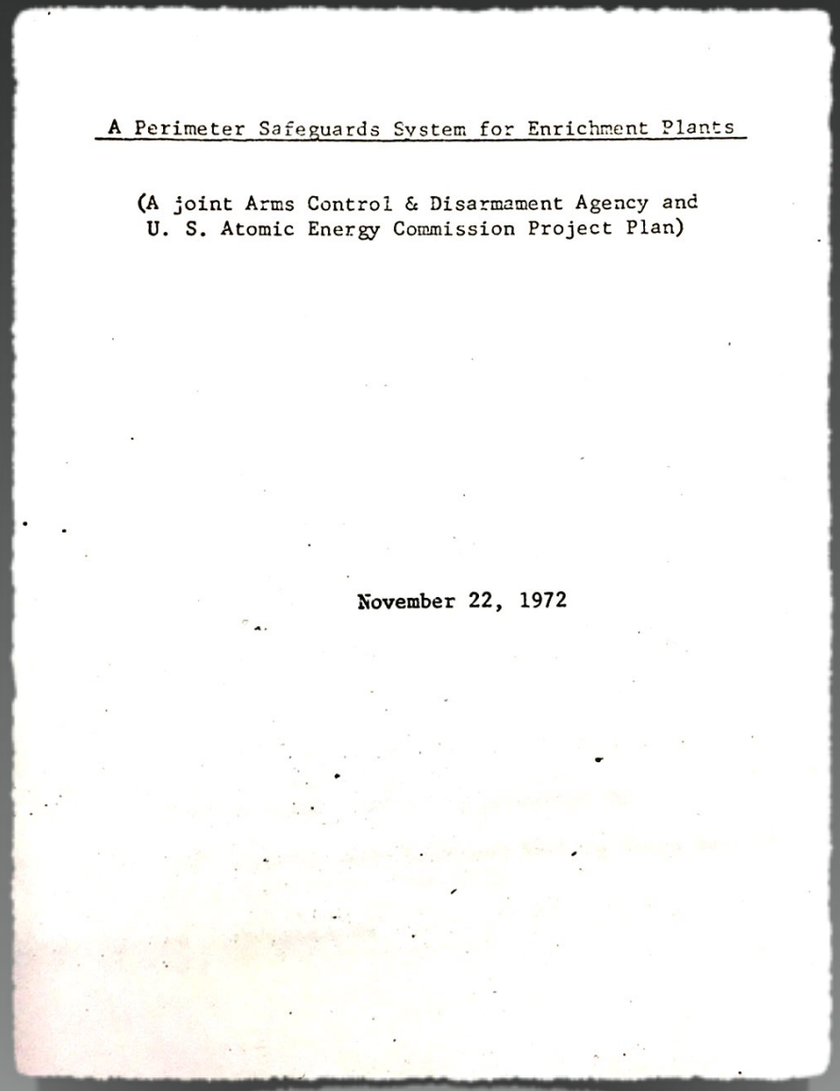
Perimeter-Portal Control Verification for Legacy Enrichment Plants ?

PERIMETER-PORTAL CONTROL VERIFICATION FOR NUCLEAR FACILITIES

(THE IDEA IS NOT NEW)



Field Test FT-34: Demonstrated Destruction of Nuclear Weapons
U.S. Arms Control and Disarmament Agency, January 1969



A Perimeter Safeguards System for Enrichment Plants

(A joint Arms Control & Disarmament Agency and
U. S. Atomic Energy Commission Project Plan)

November 22, 1972

Herbert Kouts, A Perimeter Safeguards System
for Enrichment Plants, November 1972

URANIUM ENTERING AND LEAVING A LARGE ENRICHMENT PLANT

MATERIAL FLOW OVER A TWO-WEEK PERIOD

MATERIAL ENTERING THE PLANT

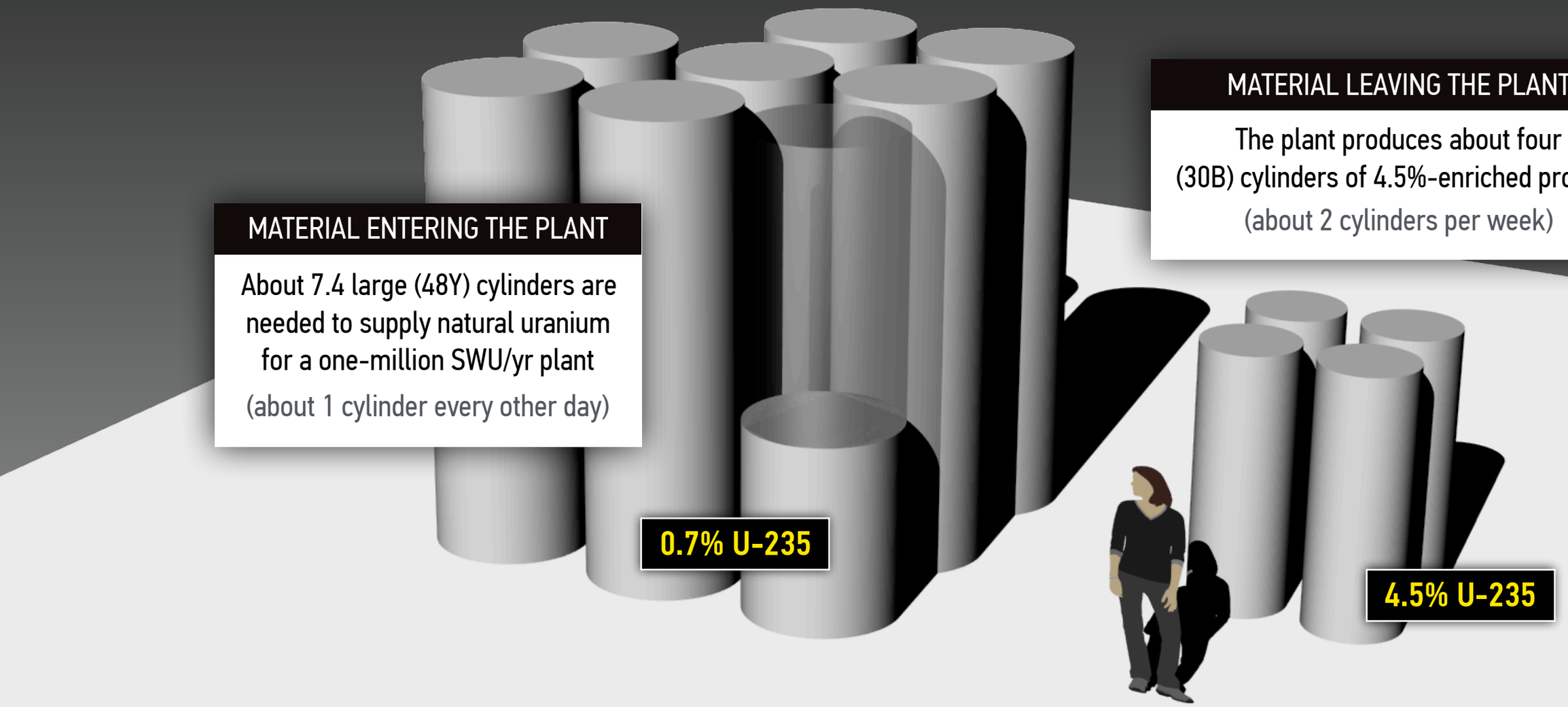
About 7.4 large (48Y) cylinders are needed to supply natural uranium for a one-million SWU/yr plant

(about 1 cylinder every other day)

MATERIAL LEAVING THE PLANT

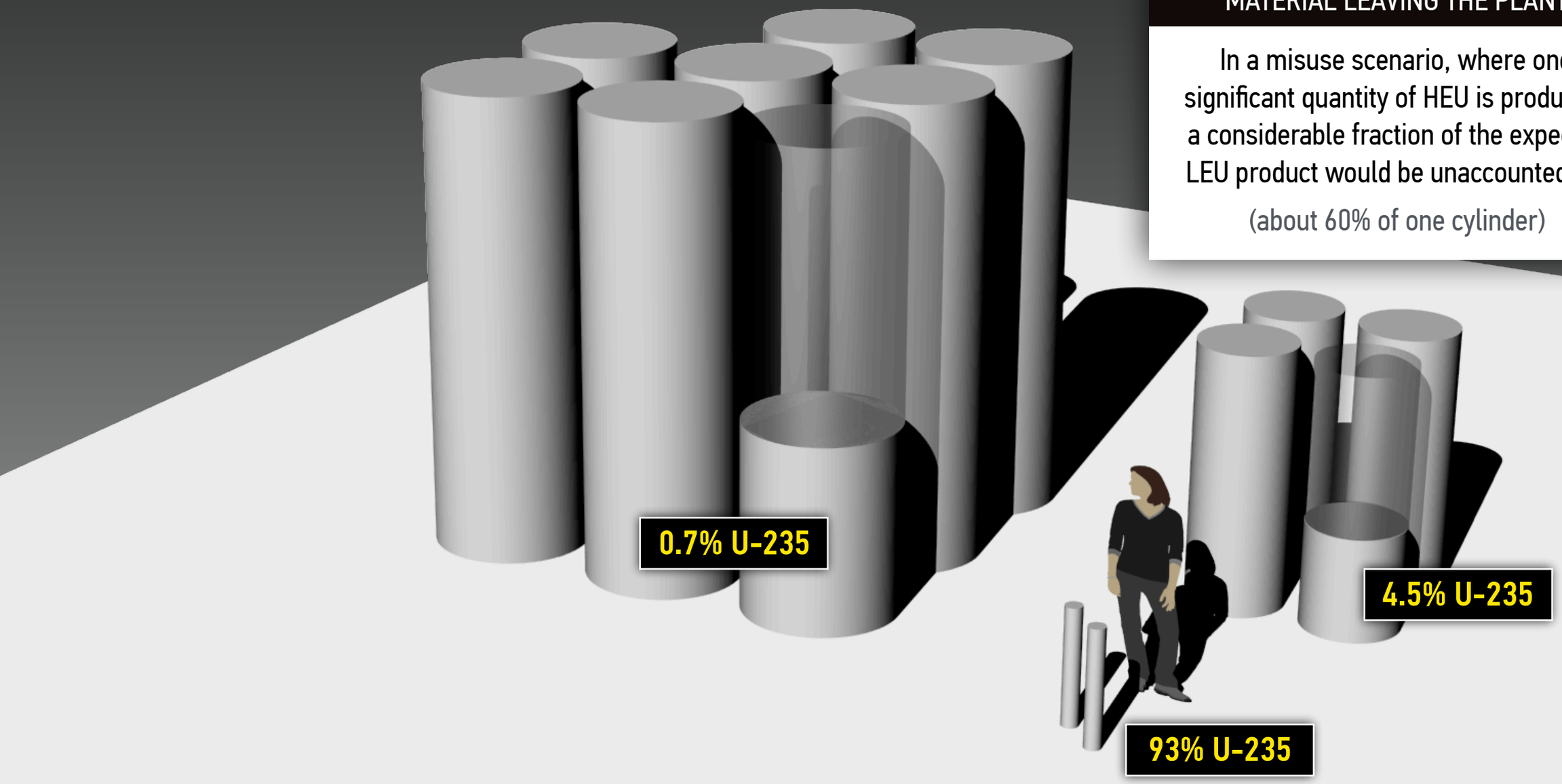
The plant produces about four (30B) cylinders of 4.5%-enriched product

(about 2 cylinders per week)



URANIUM ENTERING AND LEAVING A LARGE ENRICHMENT PLANT

MATERIAL FLOW OVER A TWO-WEEK PERIOD



MATERIAL LEAVING THE PLANT

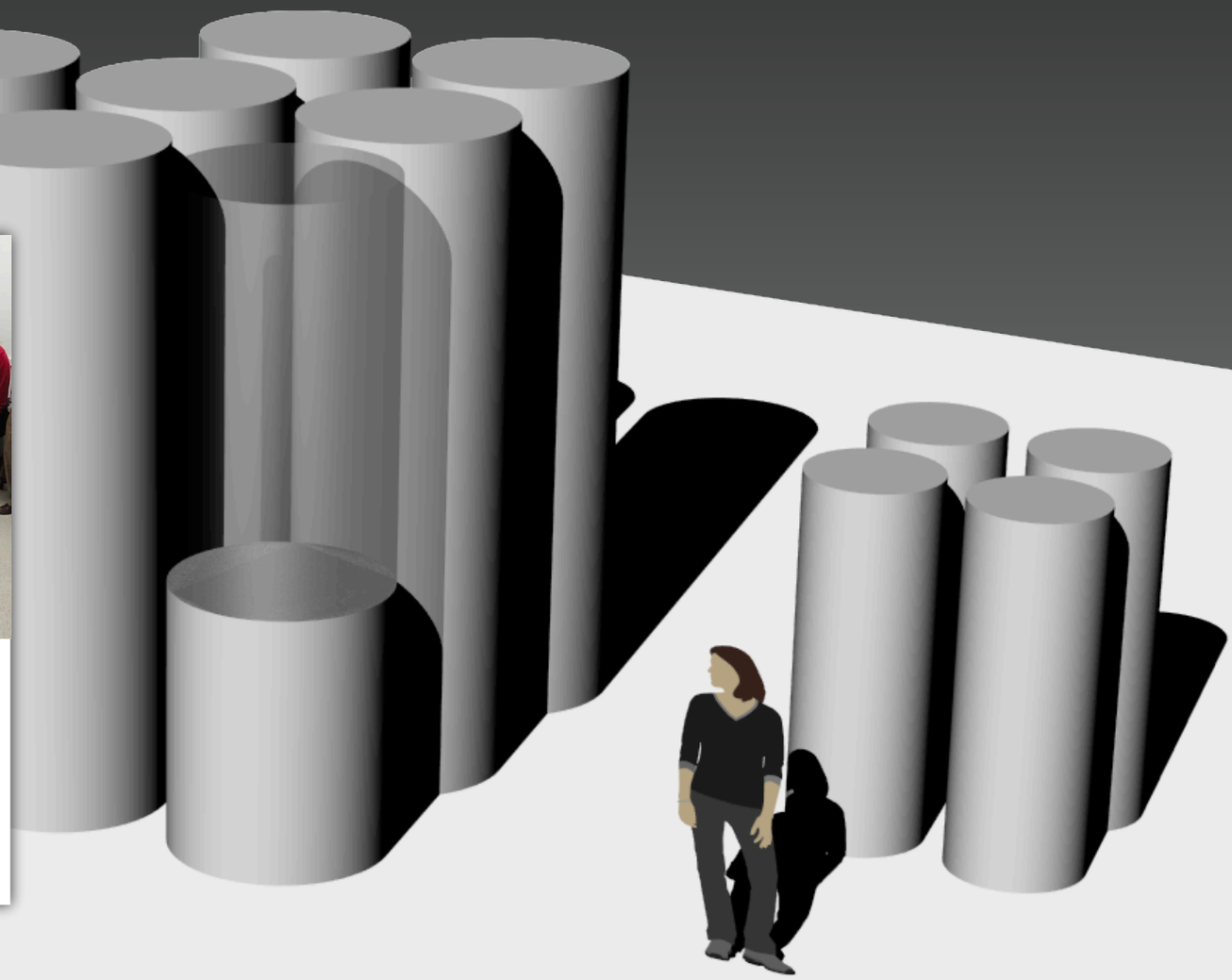
In a misuse scenario, where one significant quantity of HEU is produced, a considerable fraction of the expected LEU product would be unaccounted for

(about 60% of one cylinder)

URANIUM ENTERING AND LEAVING A LARGE ENRICHMENT PLANT

MATERIAL FLOW OVER A TWO-WEEK PERIOD

The IAEA has developed a variety of instruments for attended weighing and nondestructive assay (NDA) of UF_6 cylinders; an unattended cylinder verification station (UCVS) has also been proposed



Source: IAEA (left) and PNNL (right)

See also: L. E. Smith, K. A. Miller, et al., Viability Study for an Unattended UF_6 Cylinder Verification Station: Phase I Final Report, PNNL-25395, May 2016

Perimeter-control system
at the Votkinsk Machine Building Plant
INF Treaty verification

Tabletop model, Sandia National Laboratories
Source: Author

“INSPECTIONS IN THE MATRIX”

CAN VR EXERCISES HELP DEVELOP VIABLE VERIFICATION APPROACHES?

COOPERATIVE VERIFICATION APPROACHES

Cooperative approaches to nuclear security and verification widely recognized as key to building confidence and addressing technical obstacles; however, these programs have all ended, and cooperation on arms-control issues continues only on a very small scale

VIRTUAL REALITY PROJECT

VR may offer a new pathway to support experts and governments in developing a shared, hands-on understanding of the challenges involved in nuclear security and verification

Source: Duncan MacArthur/LANL (top)

SOME CONCLUDING OBSERVATIONS

WHERE WE ARE

De-facto FMCT for non-weapon states already exists (NPT)

Fissile material production for weapon purposes has ended in NPT weapon states

Technical challenges of FM(C)T verification exist, but they are not as significant as the political challenges of FM(C)T negotiation

FMCT VERIFICATION GAPS AND CHALLENGES

Verification of the treaty could be largely based on tools and approaches developed for implementation of IAEA safeguards

Non-intrusive verification approaches could help address security concerns where they exist; opportunities for new research and development

Source: hanford.gov (top) and IAEA Imagebank (bottom)

PRINCETON UNIVERSITY | NUCLEAR FUTURES | LAB