Fissile Material (Cutoff) Treaty

Scope and Verification - Introduction and Overview

IPFM
INTERNATIONAL PANEL
ON FISSILE MATERIALS

Frank von Hippel

Princeton University

United Nations, First Committee, New York, October 10, 2008

Revision 7

About IPFM

Established in January 2006 with MacArthur Foundation 5-year grant

MISSION

to provide the technical basis for policy initiatives to consolidate, and reduce stockpiles of HEU and plutonium and thereby help:

- achieve irreversible nuclear-warhead reductions,
- strengthen the nonproliferation regime, and
- reduce dangers of nuclear terrorism

21 Members from 16 States

7 Weapon States

- Anatoli Diakov (Moscow, Russia)
- Pervez Hoodbhoy (Islamabad, Pakistan)
- Li Bin (Beijing, China)
- Yves Marignac (Paris, France)
- Abdul H. Nayyar (Islamabad, Pakistan)
- R. Rajaraman (Co-Chair, New Delhi, India)
- M. V. Ramana (Bangalore, India)
- Mycle Schneider (Paris, France)
- Shen Dingli (Shanghai, China)
- Frank von Hippel (Co-Chair, Princeton, USA)
- William Walker (St. Andrews, UK)

9 Non-weapon States

- Jean du Preez (South Africa)
- José Goldemberg (São Paolo, Brazil)
- Martin B. Kalinowski (Hamburg, Germany)
- Jungmin Kang (Seoul, South Korea)
- Miguel Marín-Bosch (Mexico City, Mexico)
- Arend Meerburg (Den Haag, Netherlands)
- Henrik Salander (Stockholm, Sweden)
- Ole Reistad (Olso, Norway)
- Annette Schaper (Frankfurt, Germany)
- Tatsujiro Suzuki (Tokyo, Japan)

Princeton University Researchers

Harold Feiveson

Zia Mian

Alexander Glaser

Completed IPFM Reports

(available at www.fissilematerials.org)

Global Fissile Material Reports 2006, 2007, and 2008 (incl. Companion Volume)

Research Reports

#1 Fissile Materials in South Asia: The Implications of the US-India Nuclear Deal
by Zia Mian, A.H. Nayyar, R. Rajaraman, M.V. Ramana (September 2006)

#2 Japan's Spent Fuel and Plutonium Management Challenges
by Tadahiro Katsuta and Tatsujiro Suzuki (September 2006)

#3 Managing Spent Fuel in the United States: The Illogic of Reprocessing
by Frank von Hippel (January 2007)

#4 Spent Nuclear Fuel Reprocessing in France
by Mycle Schneider and Yves Marignac (April 2008)

#5 The Legacy of Reprocessing in the United Kingdom
by Martin Forwood (July 2008)

Forthcoming IPFM Reports

Verification of an FMCT in Weapon-state Reprocessing Plants
by Shirley Johnson

Toward elimination of HEU as a Reactor Fuel
by Ole Reistad, S. Hustveit

Consolidation of Nuclear Materials in Russia
by Pavel Podvig

The History of Fast Breeder Reactors
by Tom Cochran, Gennadi Pshakin, M.V. Ramana, Mycle Schneider, and Tatsujiro Suzuki

Global Fissile Material Report 2008

Scope and Verification of a Fissile Material (Cutoff) Treaty

Overview (Speaker today: Zia Mian)

1. Nuclear Weapon and Fissile Material Stockpiles and Production

A Verified Fissile Material (Cutoff) Treaty (Speaker today: Jean du Preez)

2. Why an FM(C)T is Important
3. Design Choices: Scope and Verification

Verification Challenges (Speaker today: Alexander Glaser)

4. Uranium Enrichment Plants
5. Reprocessing Plants
6. Weapon-origin Fissile Material: The Trilateral Initiative
7. HEU in the Naval-reactor Fuel Cycle
8. Challenge Inspections at Military Nuclear Sites
9. Shutdown Production Facilities

Country Perspectives: Dealing with the Challenges (Speaker today: Frank von Hippel)

Fissile Material (Cutoff) Treaty

Global Stocks of Fissile Materials, 2008

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INTERNATIONAL PANEL
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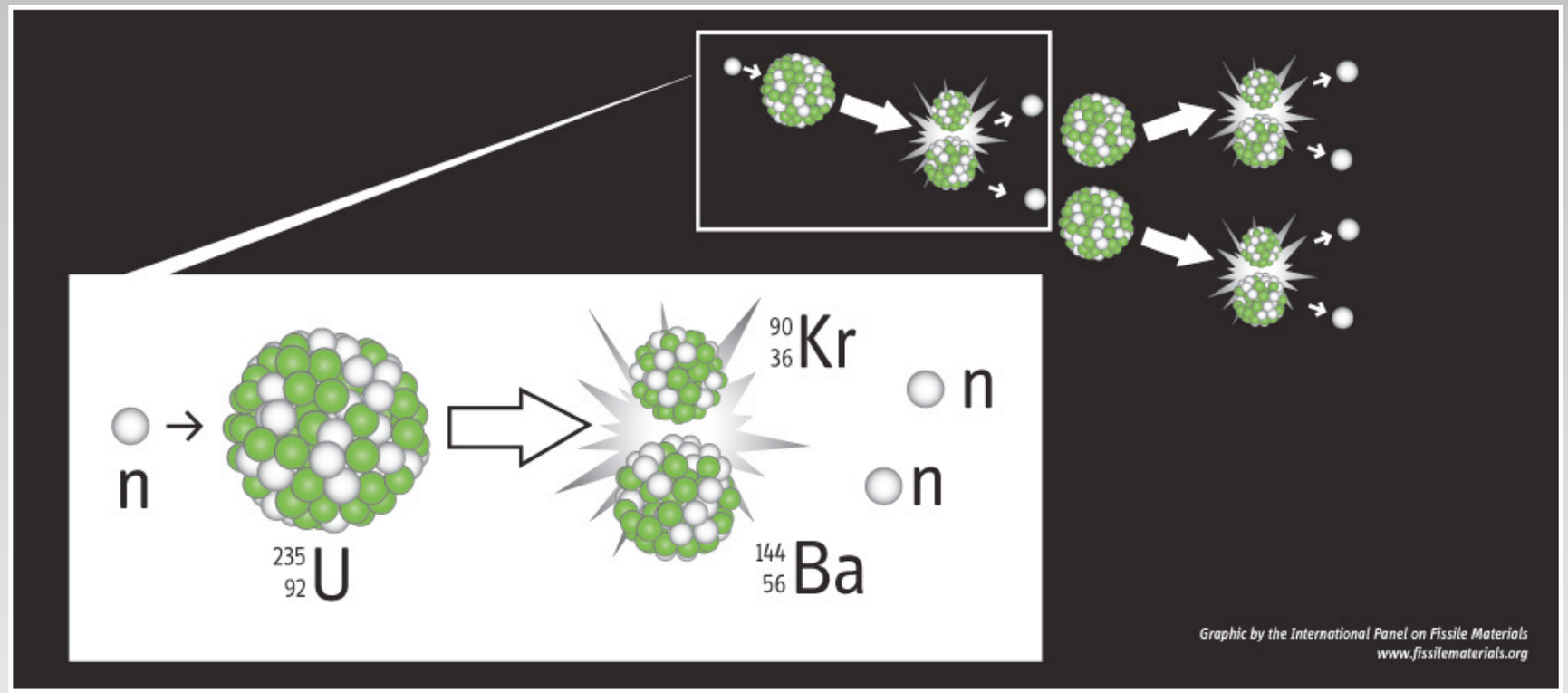
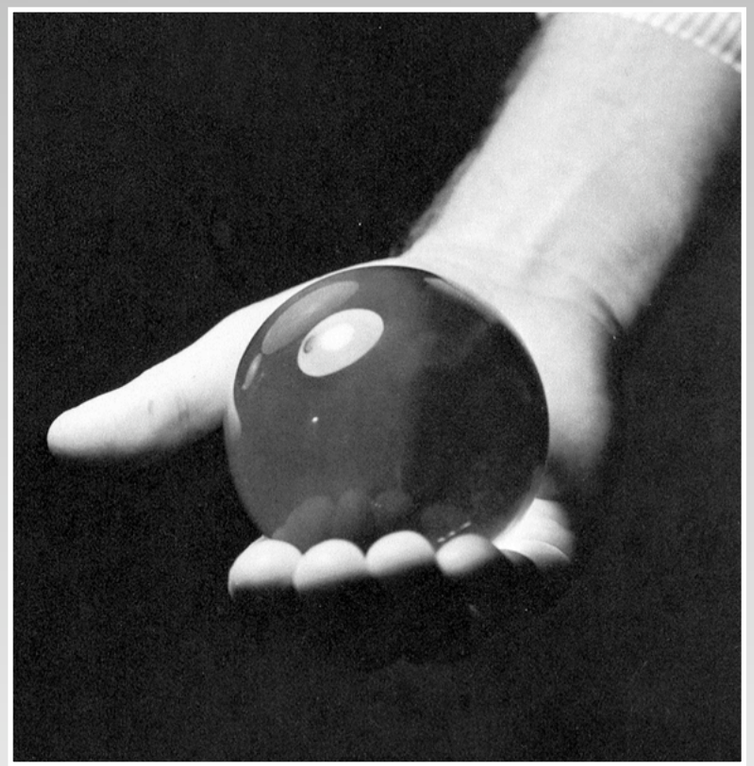
Zia Mian

Princeton University

United Nations, First Committee, New York, October 10, 2008

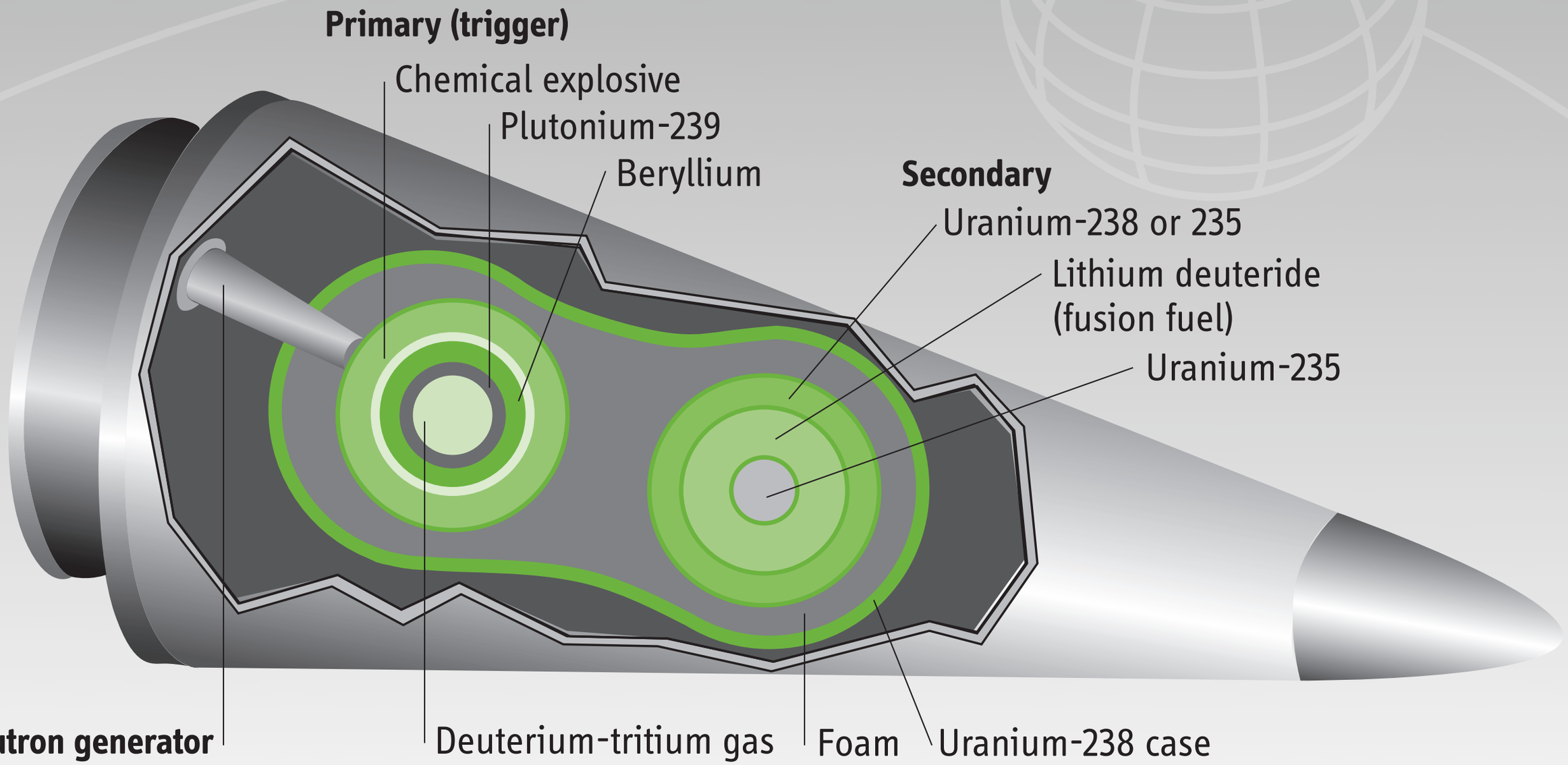
Fissile Materials and Nuclear Weapons





Material that can sustain an explosive fission chain reaction
notably highly enriched uranium or plutonium (of almost any isotopic composition)

Modern Thermonuclear Warhead



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

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

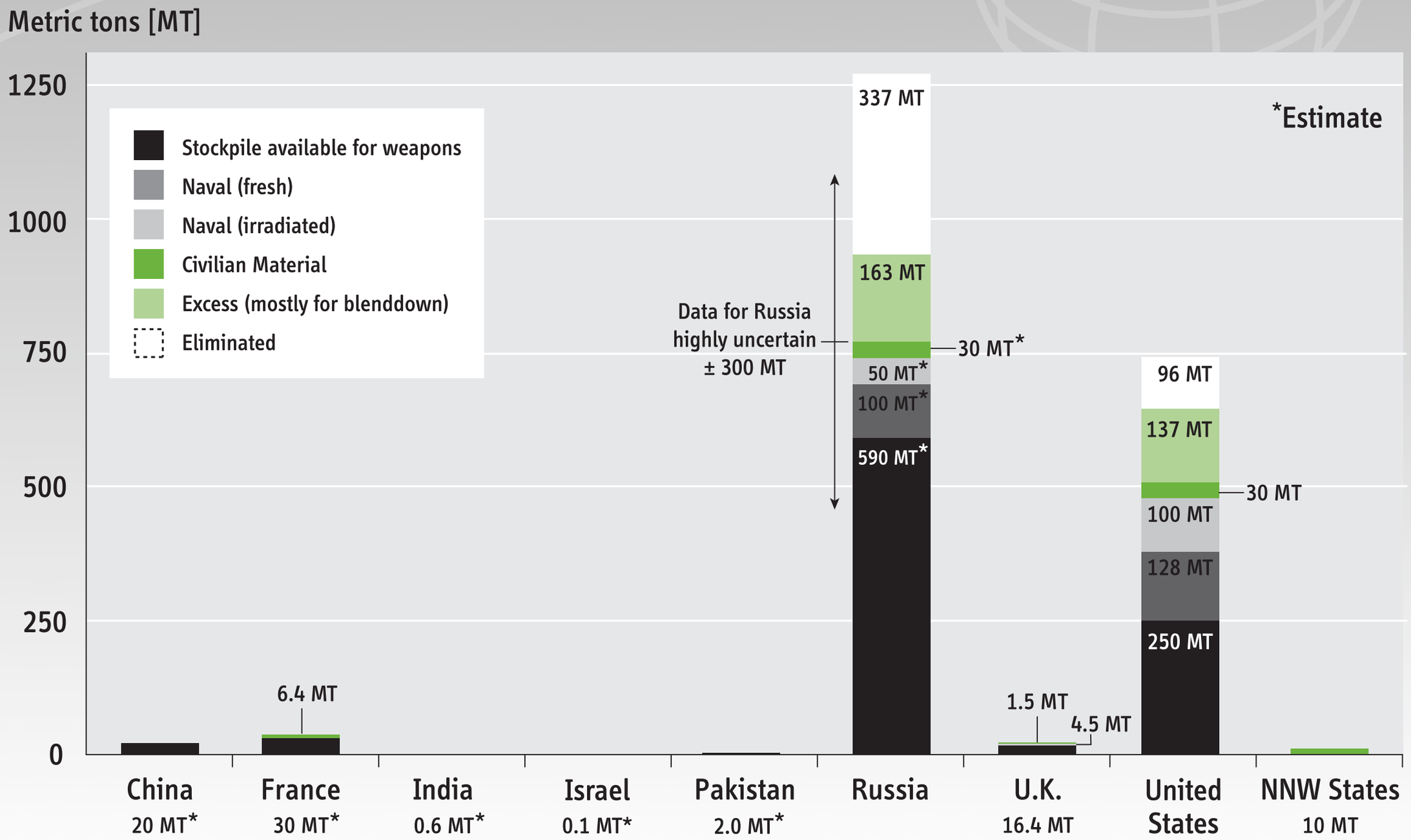
Nuclear Arsenals, 2008

(based on estimates by NRDC/FAS)

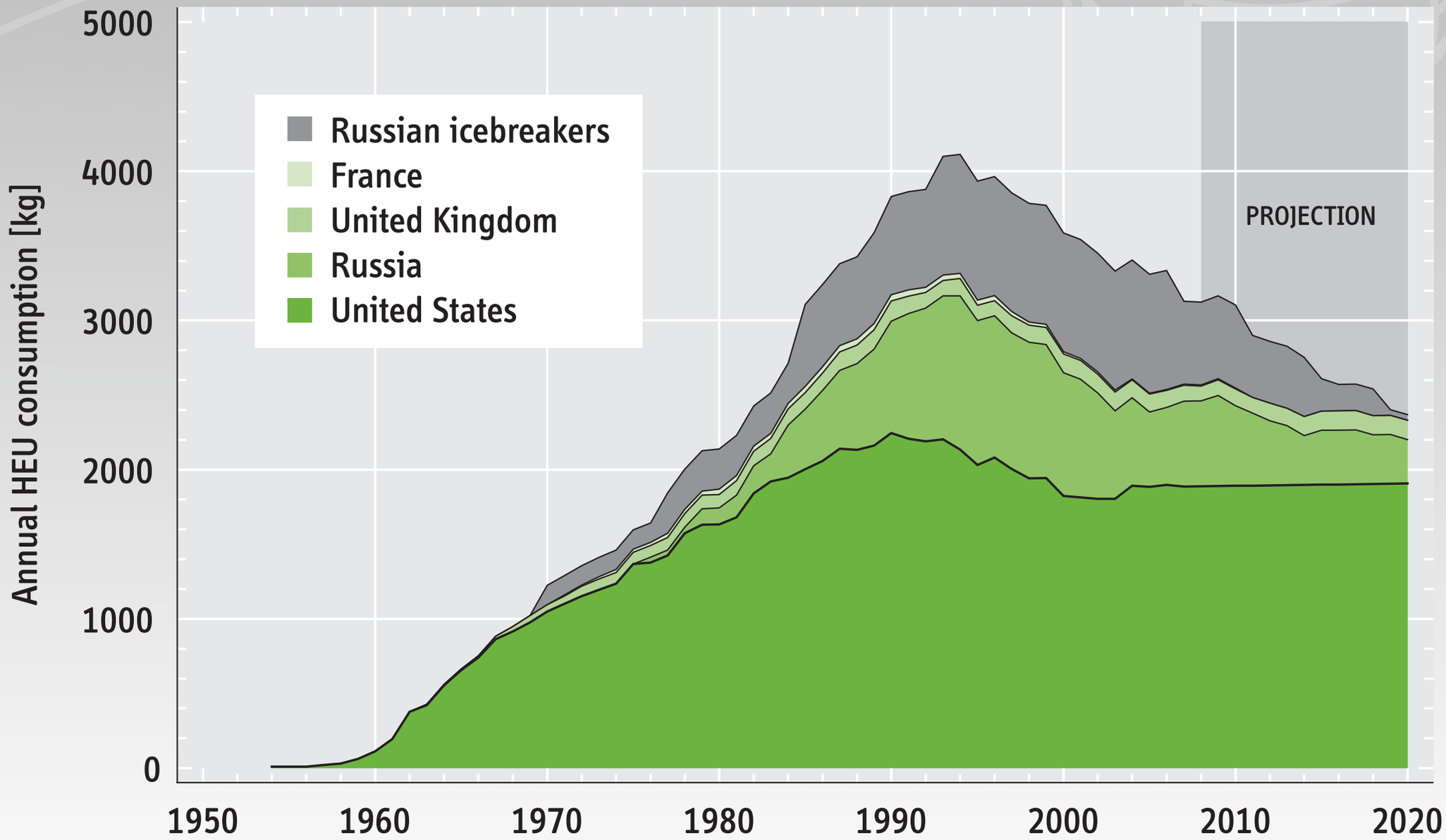
Country	Nuclear Warheads
United States	about 10,000 *(5000 deployed + 5000 awaiting dismantlement)*
Russia	about 10,000 *(large uncertainty as to number awaiting dismantlement)*
France	fewer than 300
United Kingdom	185
China	about 240
Israel	100-200
Pakistan	about 60
India	60-70
North Korea	fewer than 5

HEU Stockpiles, 2008

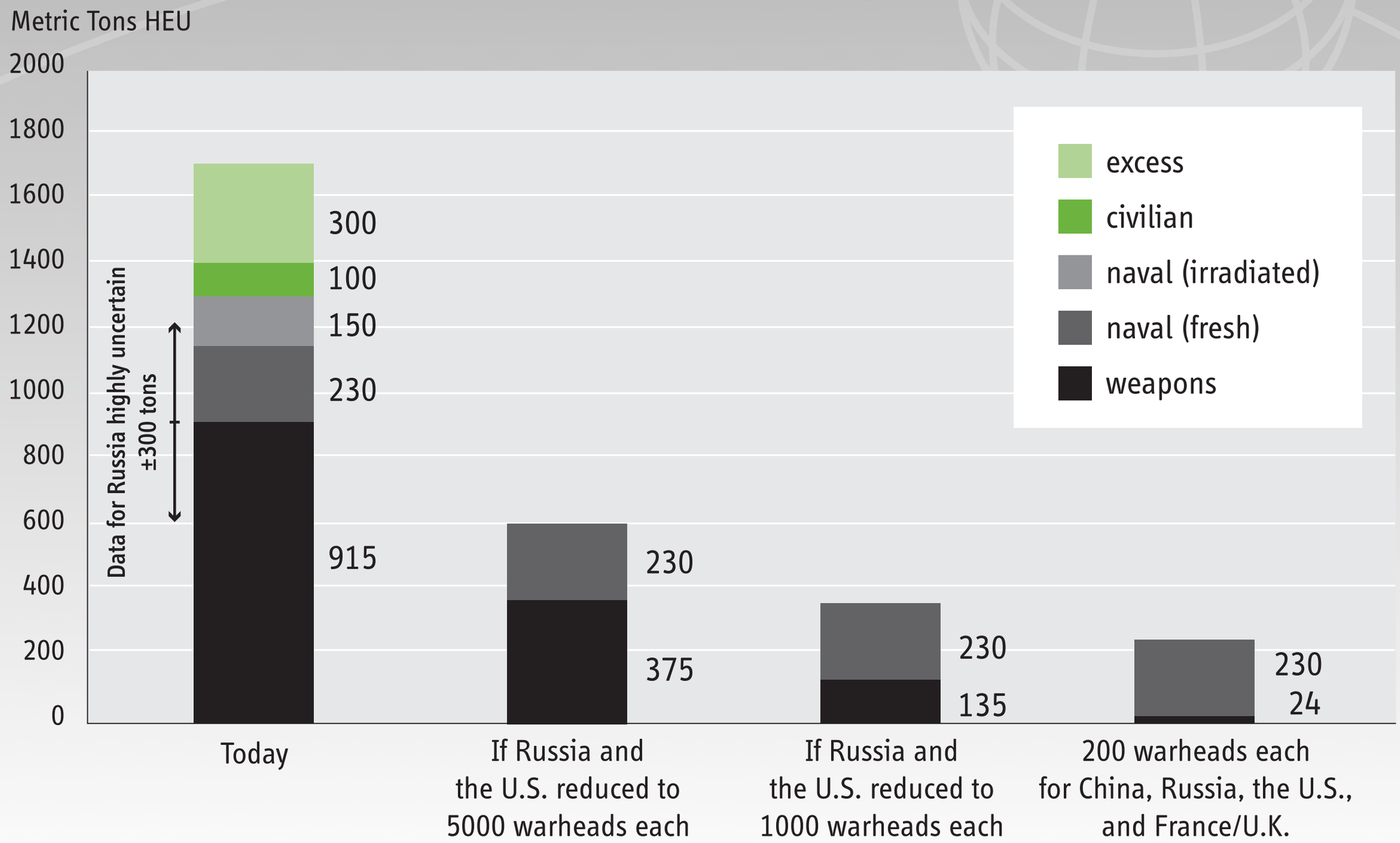
Global stockpile is almost 1700 tons, over 99% is in weapon states



HEU Consumption in Naval Vessels

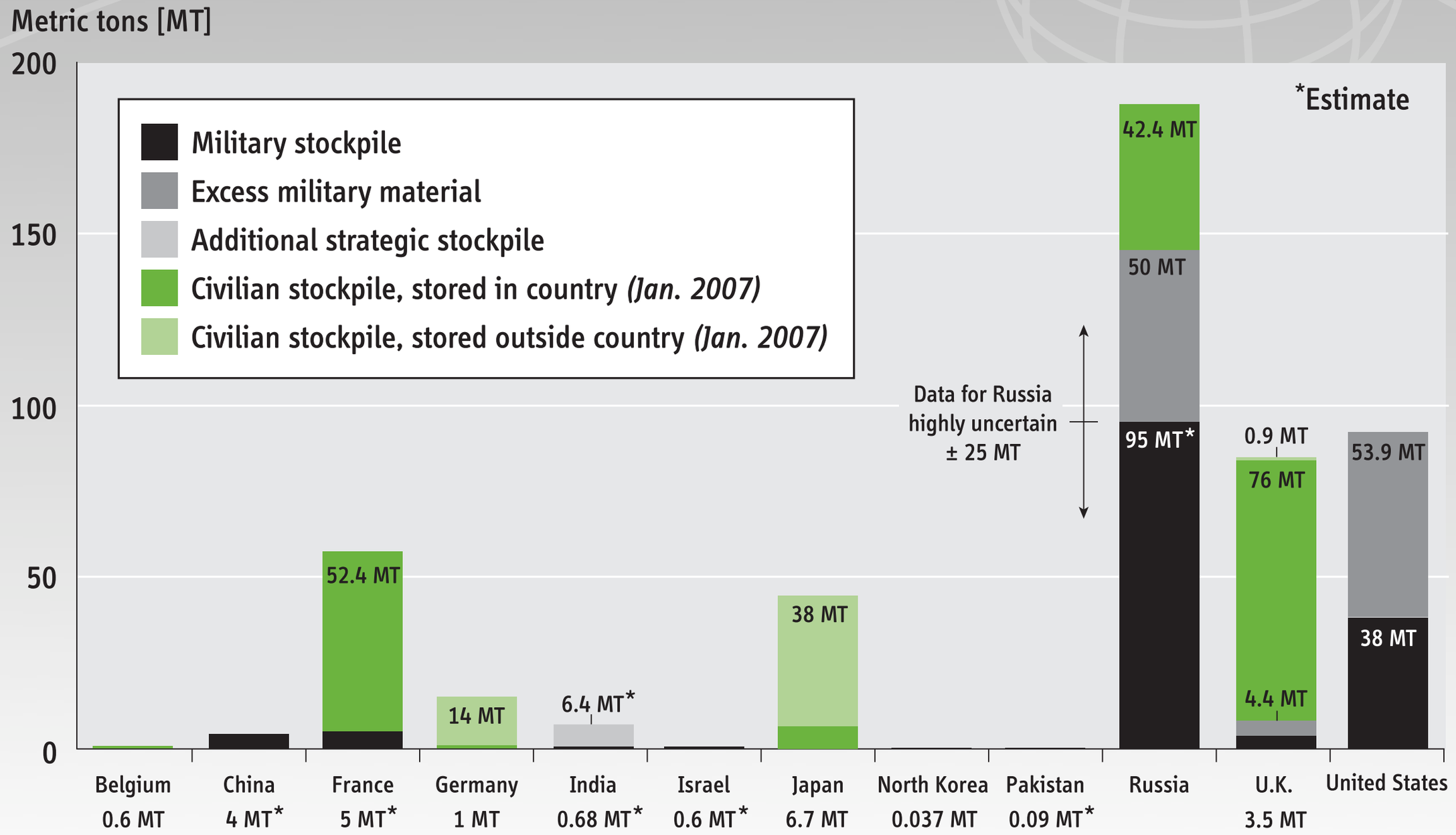


The Naval HEU Problem in a Disarming World

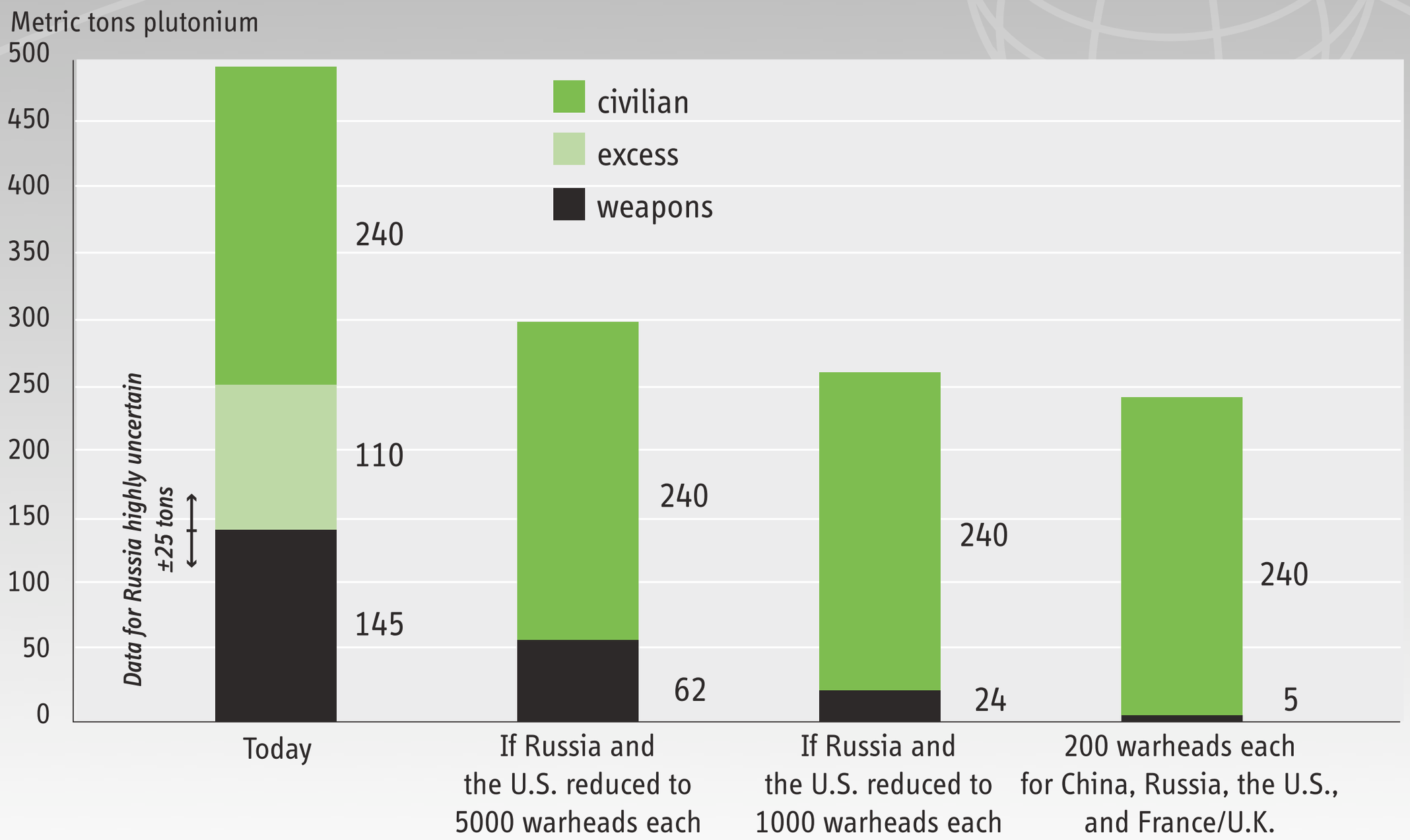


Plutonium Stockpiles, 2008

Global stockpile is 500 tons, half is civilian and this stock is growing



The Civilian Plutonium Problem in a Disarming World



Fissile Material (Cutoff) Treaty

Design Choices

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Jean du Preez

James Martin Center for Nonproliferation Studies, Monterey

United Nations, First Committee, New York, October 10, 2008

IPFM Choices on Two Major Issues

Verification: Yes, by the IAEA.

- **NPT non-weapon states already verified**
  - Comprehensive Safeguards Agreements
- **FM(C)T imposes some NPT requirements on all weapon states**

Pre-existing civilian stocks and materials declared excess for all military purposes: Subject to IAEA monitoring.

- **For excess military stocks: To prevent "re-use" of dismantled material**
  - IAEA monitoring of HEU declared excess for weapons use but reserved for military (e.g. naval propulsion) reactor fuel
  - Under the NPT, non-weapon states also have a right to use HEU for this purpose
- **For pre-existing civilian stocks: Otherwise would have to segregate pre-existing from post-FM(C)T materials in civilian sector**

Article I: Basic Undertakings

1. *Each State Party undertakes not to produce fissile material for nuclear weapons or other nuclear explosive devices.*

[...]

[Additional Paragraphs on non-circumvention and commitment to decommission unused reprocessing and enrichment facilities]

5. *Each State Party undertakes not to use for nuclear weapons or other nuclear-explosive devices fissile materials:*

   i. In its civilian nuclear sector
   ii. Declared as excess for all military purposes
   iii. Declared for use in military reactors.

Article II: Definitions

1. *"Fissile material" means:*

i. Plutonium of any isotopic composition except plutonium whose isotopic composition includes 80 percent or more plutonium-238. *[IAEA definition of "direct-use" material]*

ii. Uranium containing uranium-235 and/or uranium-233 in a weighted concentration equivalent to or greater than 20 percent uranium-235.
[Definition of HEU extended to U-233]

iii. Additional fissile materials suitable for the manufacture of nuclear weapons or other nuclear explosive devices, and changes in the above parametric values, may be decided upon by the Board of Governors of the IAEA.

Article II: Definitions, cont'd

2. "Producing fissile material" means:

i. Separating fissile materials mentioned in paragraph 1 from fission products through reprocessing or any other process.

ii. Enriching any mixture of uranium isotopes to a weighted concentration of uranium-235 and uranium-233 equivalent to or greater than 20 percent uranium-235. [different from U.S. draft]

iii. Increasing the fraction of plutonium-239 in plutonium by any isotopic separation process. [different from U.S. draft]

3. "Production facility" means:

Any facility in which any production of fissile material as defined in Paragraph II.2 is carried out or could be carried out.

Article III: Verification (1/3)

1. *Each State Party undertakes to accept IAEA safeguards to verify its obligations under Article I as described in this Article.*

2. *For those States Parties having a comprehensive safeguards agreement with the IAEA incorporating IAEA-document INFCIRC/153 (corrected) as well as the Model Protocol Additional to the Safeguards Agreements (INFCIRC/540), no further agreements with the IAEA are necessary under this Treaty, unless that State Party intends to use fissile materials for military non-explosive purposes, in which case additional safeguards or arrangements are needed.*

Article III: Verification (2/3)

3. States Parties not having a comprehensive safeguards agreement ... undertake to accept safeguards in an appropriate safeguards agreement to be concluded with the IAEA to verify their obligations under Article I, including:

i) The non-production of fissile materials for nuclear weapons or other nuclear explosive devices and to that end:

a) The disablement, decommissioning and dismantlement of production facilities or their use only for peaceful or military non-explosive purposes, and

b) The absence of any production of fissile materials without safeguards

Article III: Verification (3/3)

3. *[continued]*

   ii) The non-diversion to nuclear weapons, other nuclear explosive devices or purposes unknown of:

   a) All civilian fissile materials, including in spent fuel,

   b) All fissile materials declared excess to any military purpose.

   c) All fissile materials declared for military non-explosive purposes

4. *Negotiation of agreements and arrangements referred to in Paragraphs III.2 and III.3 shall commence within [180] days from the entry into force of this Treaty ...*

Fissile Material (Cutoff) Treaty
Verification Challenges

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ON FISSILE MATERIALS

Alexander Glaser
Princeton University

United Nations, First Committee, New York, October 10, 2008

Verification Challenges

1. Shutdown facilities
2. Operational enrichment plants
3. Operational reprocessing plants
4. Managed access to military nuclear sites
5. Naval-reactor fuel cycle
6. Weapon-origin fissile material

Challenge #1

Shutdown Facilities

Production Periods of Fissile Materials for Military Purposes

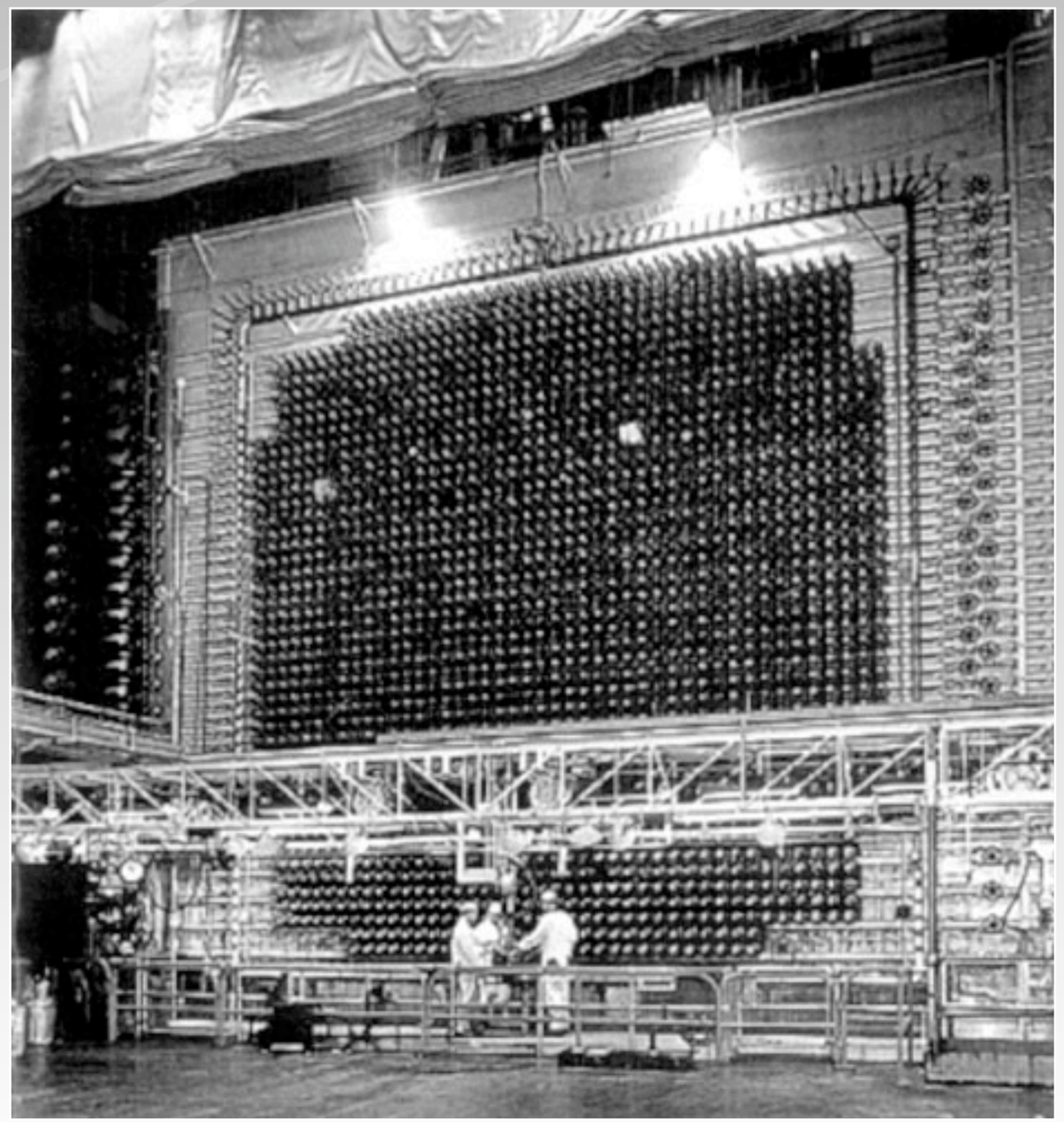
	Pu Production End	HEU Production End
China	1991	1987-89
France	1994	1996
India	*continuing*	*continuing*
Israel	*continuing ?*	*?*
North Korea	*?*	*?*
Pakistan	*continuing*	*continuing*
Russia	1997	1987-88
United Kingdom	1989	1963
United States	1988	1992 *

*1964 for weapons

Challenge #1: Shutdown Facilities

Hanford B Reactor

(United States, 1944-1968)



B-Reactor in 1998

March 2008 Announcement by French President N. Sarkozy

"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

Challenge #2

Enrichment Plants

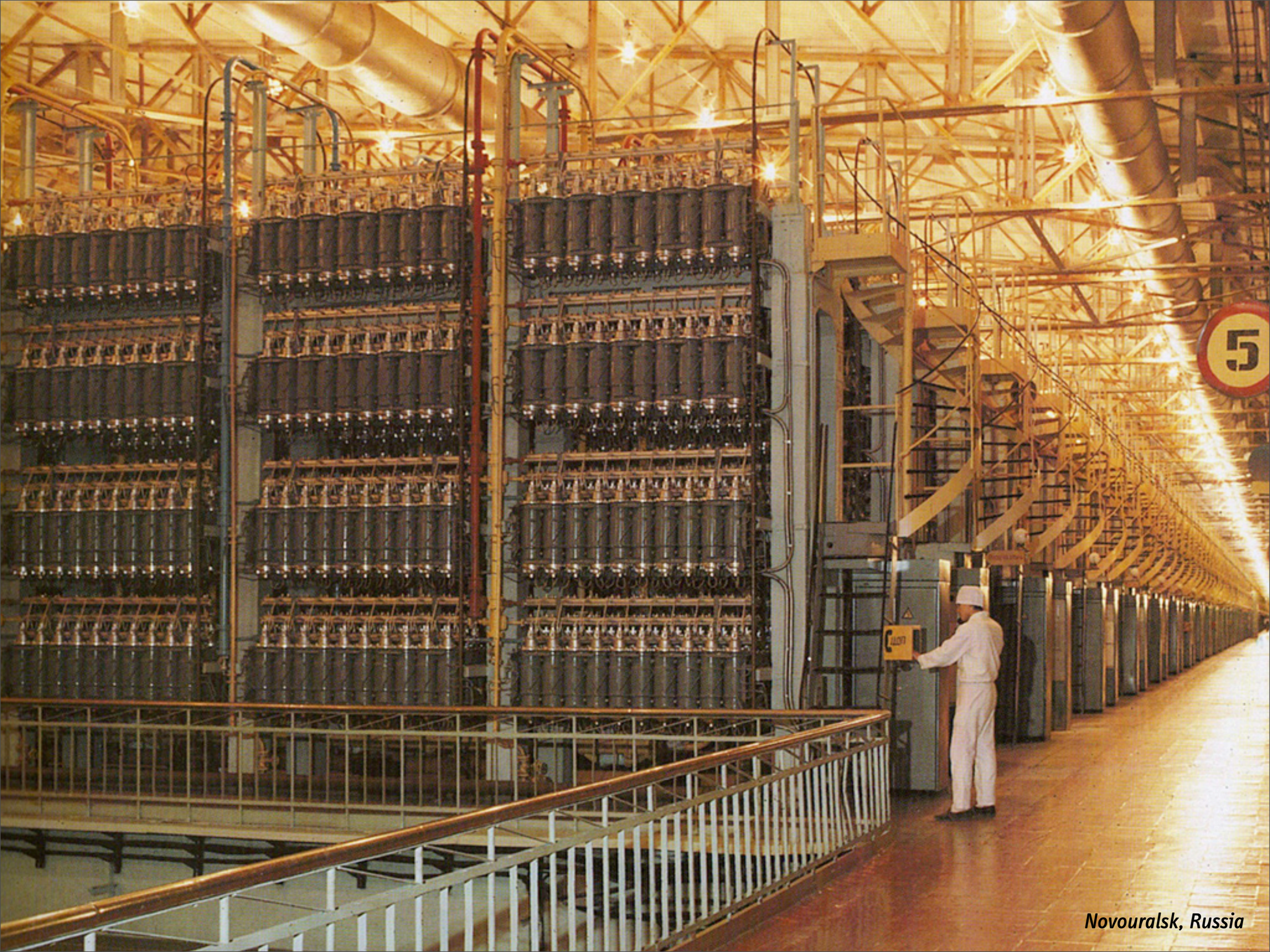
Challenge #2: Enrichment Plants

Centrifuge Enrichment Facilities

(as currently expected for the year 2015)

	Country	Facility	Safeguards Status	Capacity [tSWU/yr]
Non-weapon states	Brazil	Resende	Yes	120
	Germany	Gronau	Yes	4,500*
	Iran	Natanz	Yes	250
	Japan	Rokkasho	Yes	1,050
	The Netherlands	Almelo	Yes	3,500
Weapon states	France	George Besse II	(Yes)	7,500
	U.K.	Capenhurst	Yes	4,000
	United States	Piketon, Ohio	offered	3,500
		Eunice, NM	offered	3,000
		Areva, Idaho	(offered)	3,000
	China	Shaanxi	(Yes)	1,000*
		Lanzhou II	offered	500
	Russia	Angarsk II	(offered)	5,000
		4 others	No	about 30,000
	India	Rattehalli	No	4-10
	Pakistan	Kahuta	No	15-20

*after planned expansions are complete



Novouralsk, Russia

Verification at Previously Operating Enrichment Facilities

Need of Retrofitting Verification Measures in Operating and Potentially HEU-contaminated Plants

Installation/Use of Continuous (or Portable) Enrichment Monitors

Used in some Urenco facilities

Now also installed in Chinese plant using Russian centrifuge technology

Whenever possible, environmental sampling techniques could be used as one of the primary methods to assure that no HEU is produced

Identification of HEU from historic production with isotopic baseline and particle age

Challenge #3

Reprocessing Plants

Challenge #3: Reprocessing Plants

Rokkasho Reprocessing Plant

(now beginning full-scale operation, under IAEA Safeguards)

Up to 8000 kg of plutonium will be separated each year in the new Rokkasho Reprocessing Plant in Japan
Facility absorbs about 20% of the current IAEA Safeguards budget

Verification at Previously Operating Reprocessing Facilities

- Introduce random, short-notice inspection activities to provide more unpredictability and reduce costs

  - 6-8 SNRI/year to replace continuous inspections and monthly IIVs

- Install unattended measurement systems

- Make use of remote monitoring and C/S, where possible

- Require near real-time reporting by operators

Some reduced confidence in meeting current safeguards criteria for existing plants (timeliness of detection)

Challenge #3: Reprocessing Plants

Inspection Effort

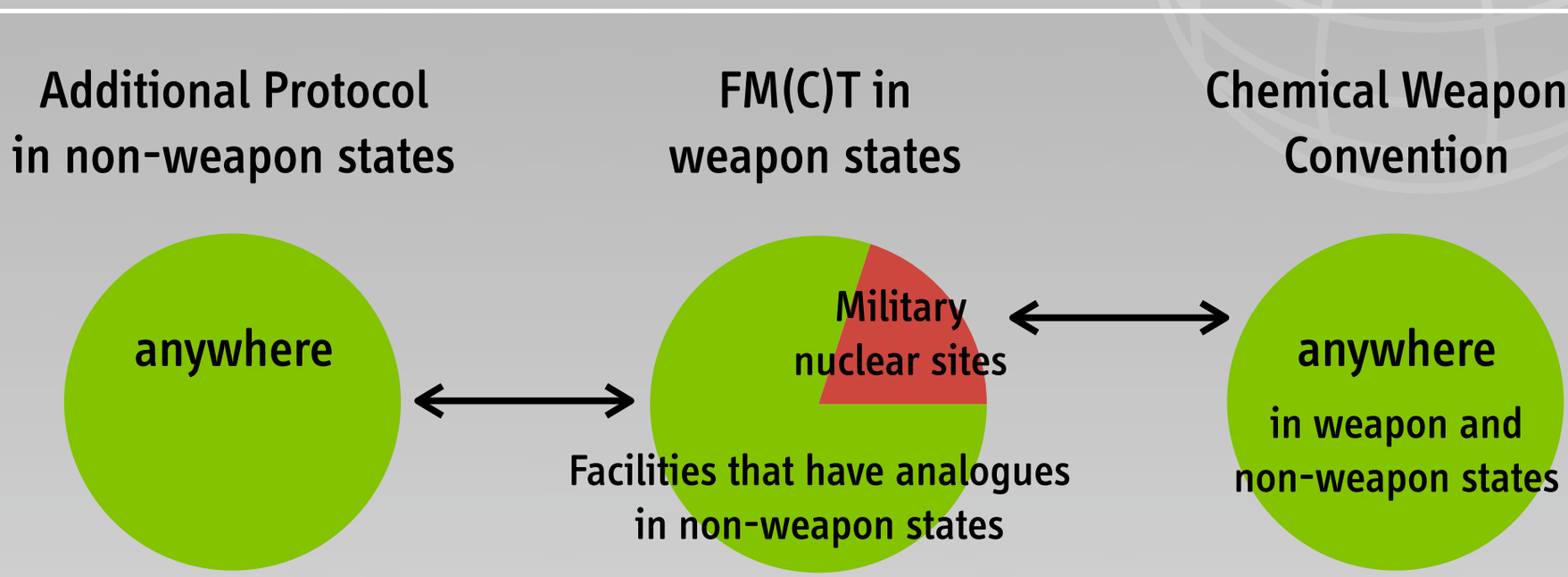
Activity	Inspections per year	Duration	Number of Inspectors	Inspection Effort
Short Notice Random Inspect.	8	5 days	3	120 PDI
Physical Inv. Inspection	1	10 days	5	50 PDI
Other				30 PDI
FM(C)T TOTAL				200 PDI
Rokkasho Reprocess. Plant	Continuous	250 days (operating)	4 (1-2 during shutdown)	1200 PDI

Costs of safeguards: about $2,000 per PDI (Person-day of inspection)

Challenge #4

Challenge Inspections at Military Nuclear Sites

Managed Access Precedents



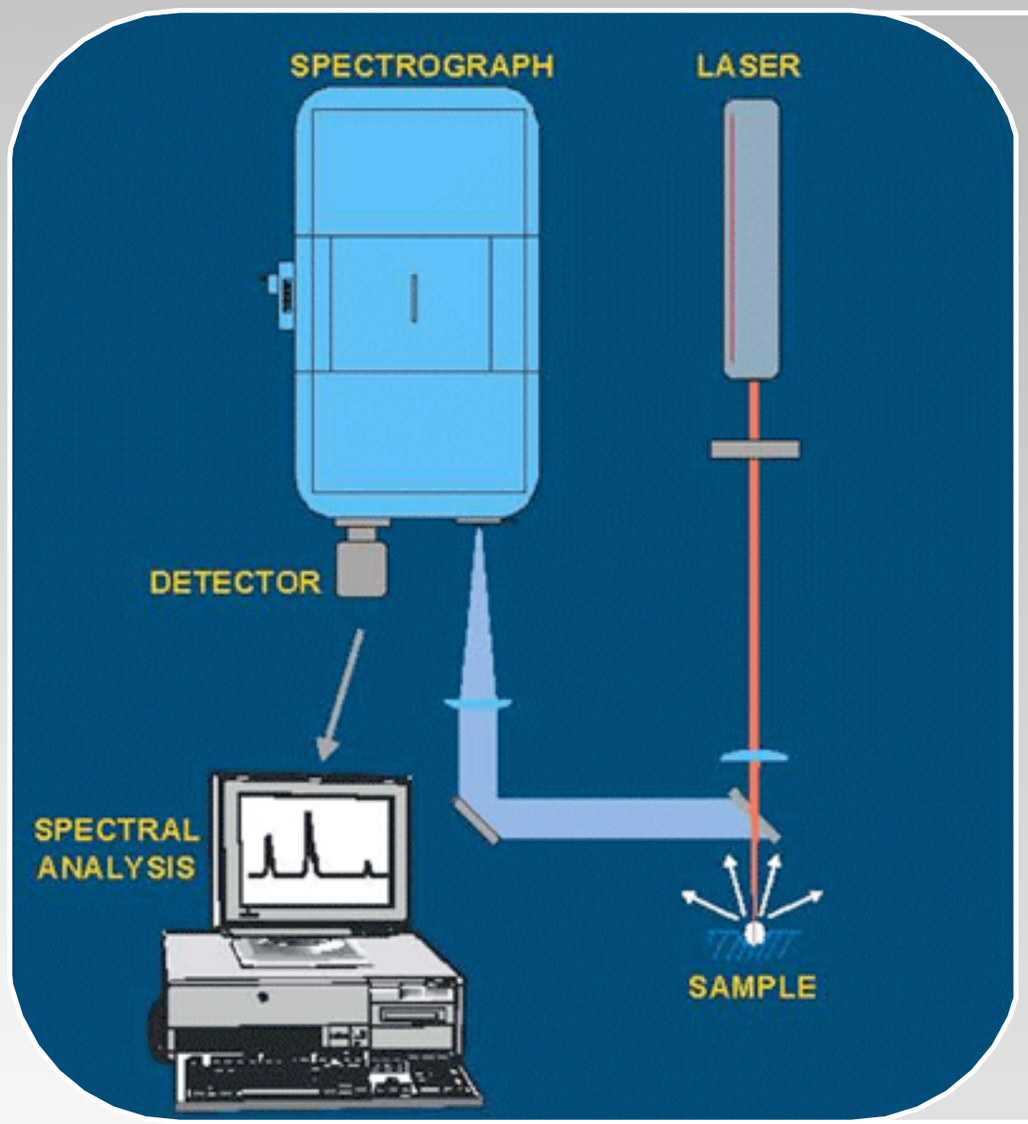
Managed access under the U.S.-IAEA Additional Protocol

(limited by the national-security exclusion)

The U.S. NRC is working with its licensees to plan for IAEA inspections (with managed access)

The U.S. DOE is making similar preparations
for nuclear science, energy, and weapon sites that it controls

Potential Measurements at a Site Where Undeclared Enrichment is Suspected



IAEA, Canadian Safeguards Support Program

Laser-induced breakdown spectroscopy

Detection of deposits on walls (or elsewhere) containing UO_2F_2 from leaked UF_6

Answers to pre-programmed questions communicated through information barrier ("yes" or "no")

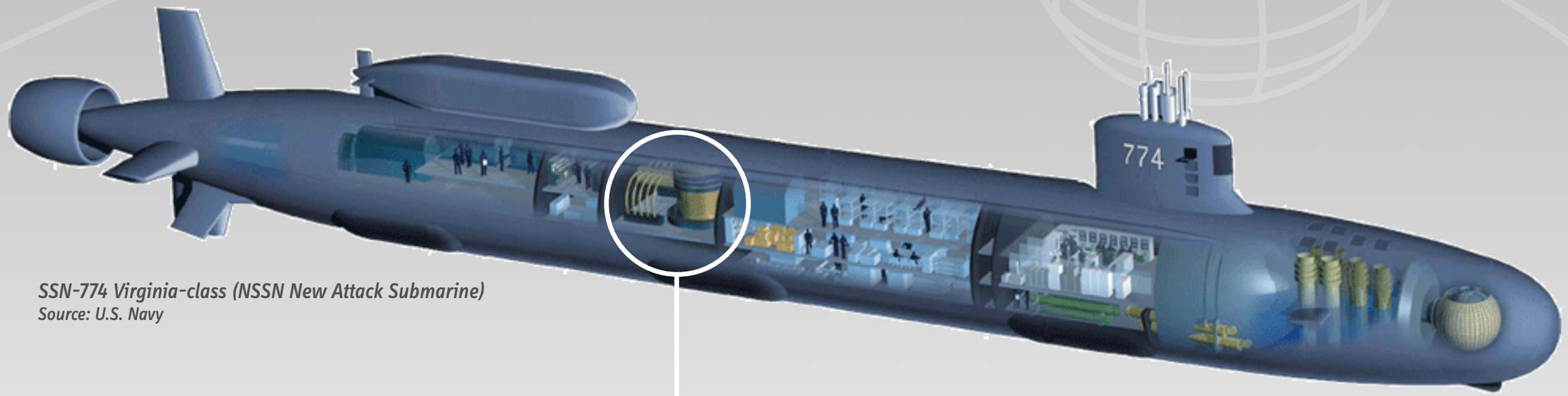
Challenges #5 and #6

HEU in the Naval-reactor Fuel Cycle

(and Weapon-origin Fissile Materials)

Challenge #5: HEU in the Naval-reactor Fuel Cycle

HEU Stockpiles for Naval Fuel



SSN-774 Virginia-class (NSSN New Attack Submarine)
Source: U.S. Navy

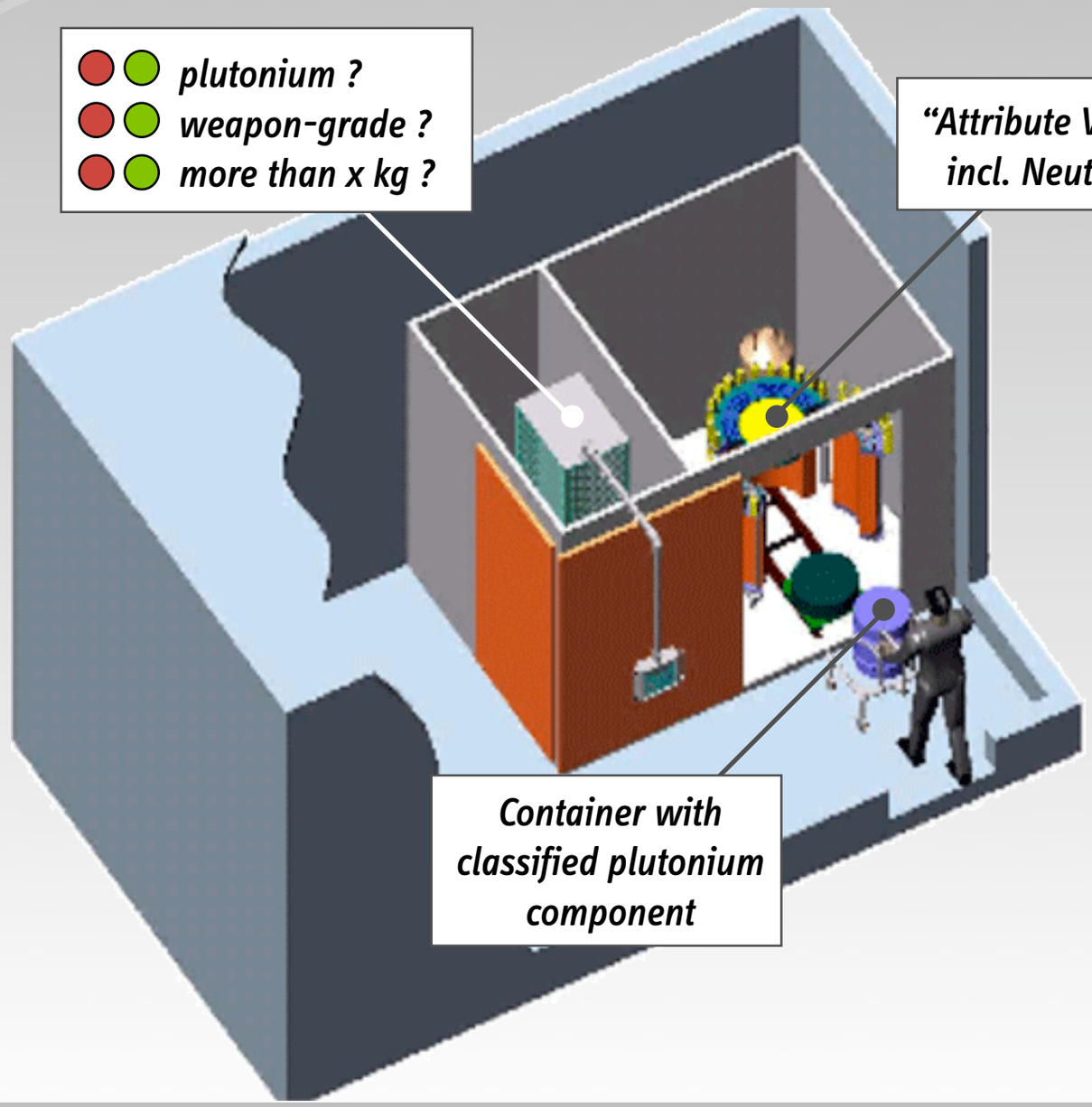
The United States, Russia, and the United Kingdom use HEU to fuel naval vessels
(mostly submarines; the U.S. and U.K. vessels are fueled with weapon-grade uranium)

The U.S. fleet currently requires about 2000 kg of weapon-grade uranium per year

The United States has reserved 128 tons of excess weapon-grade uranium (enough for 5,000 nuclear weapons) for future use in naval reactors

Non-Diversion of Material Declared Excess for Weapon Purposes

(while in classified form)



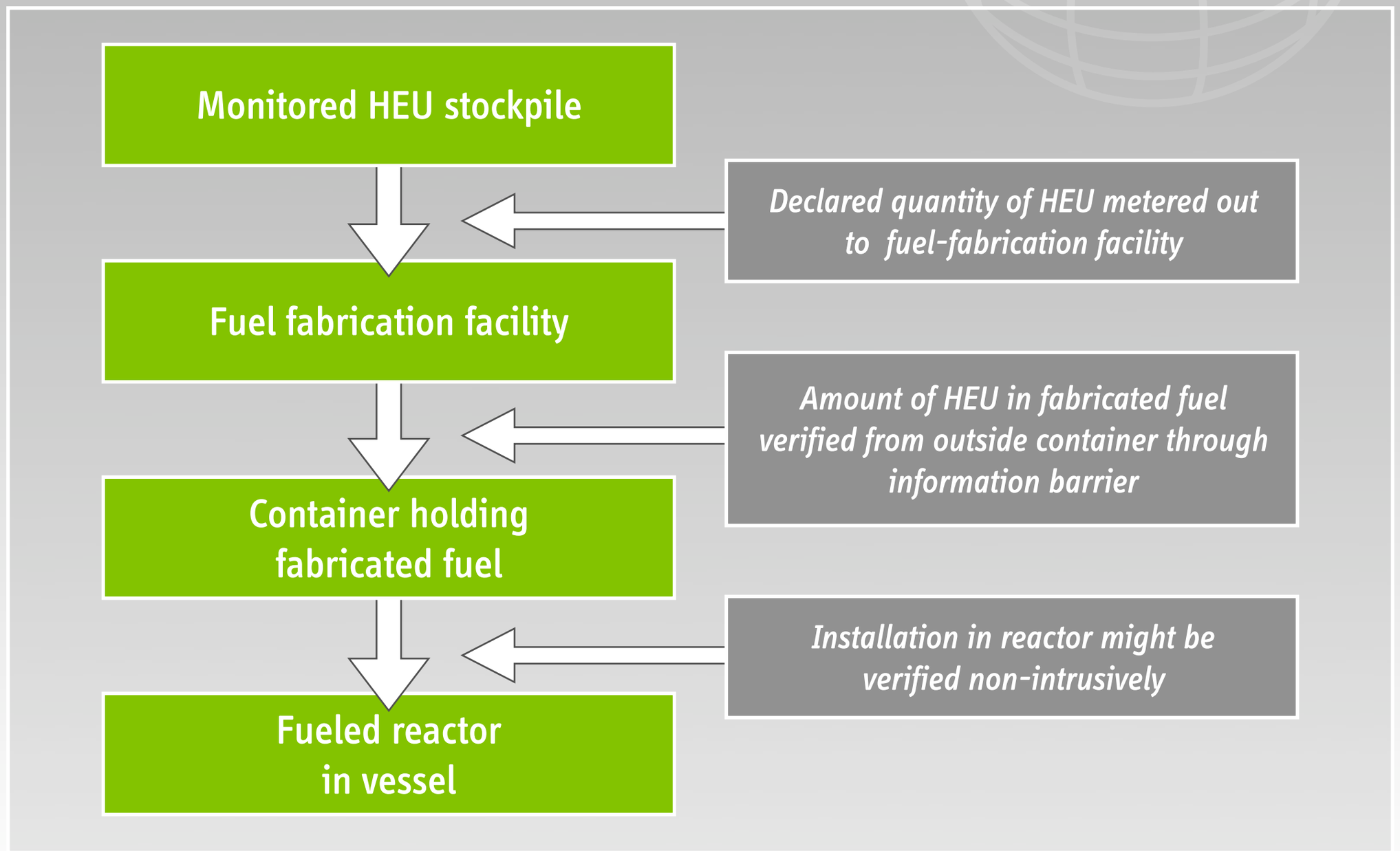
1996-2002 Trilateral Initiative developed approach to determine that a container holds more than a threshold amount of weapon-grade plutonium

Results communicated by red or green lights through information barrier

IPFM is working on corresponding approach for HEU components

Challenge #5: HEU in the Naval-reactor Fuel Cycle

Non-Diversion of HEU Set Aside For Naval (and Tritium Production) Reactors



Country Perspectives
Dealing with the Challenges to an FM(C)T

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Frank von Hippel
Princeton University

United Nations, First Committee, New York, October 10, 2008

Revision 3

Dealing with the Challenges

SOME ISSUES

How much is enough?

Intrusiveness of verification

Pre-existing stocks of civilian materials

How Much is Enough?

India and Pakistan (and Israel?) still producing

Have to decide how big a "minimum deterrent" must be

China keeping its options open as long as future U.S. offensive and defensive threat to China's deterrent remains unclear

The next U.S. Government should reassure China through confidence-building and arms-control measures (on missile defense and space)

Intrusiveness of Verification

- France and U.K. have accepted (NPT-type) verification at civilian facilities by Euratom
- U.S. has offered all of its civilian facilities for IAEA safeguards but is sensitive about IAEA inspections at military facilities
- Russia wants to minimize intrusiveness
- China worried that inspections at shutdown production facilities could reveal sensitive information about its nuclear stockpile
- Israel does not want to compromise its policy of “opacity”
- India and Pakistan potentially also concerned about intrusive inspections
- BUT: All (except Israel) have ratified the CWC, which permits managed-access inspections at any site

Pre-existing Civilian Stocks

- Many non-weapon states want civilian nuclear activities subject to same safeguards in ALL states.

- Many weapon states prefer an FMCT "focused" on materials produced after Treaty comes into force.

- Having both safeguarded and unsafeguarded fissile materials–possibly in the same facilities–seems more complex than putting all fissile materials in civilian sector under safeguards.

- French and U.K. civilian fissile materials already under Euratom safeguards and U.S. civilian fissile materials in voluntary offer.

Conclusion

The technical challenges of FM(C)T verification are significant
but probably not as significant as
the political challenges of FM(C)T negotiation

The costs of FM(C)T verification could be
less than the current IAEA safeguards budget

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Scope and Verification

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