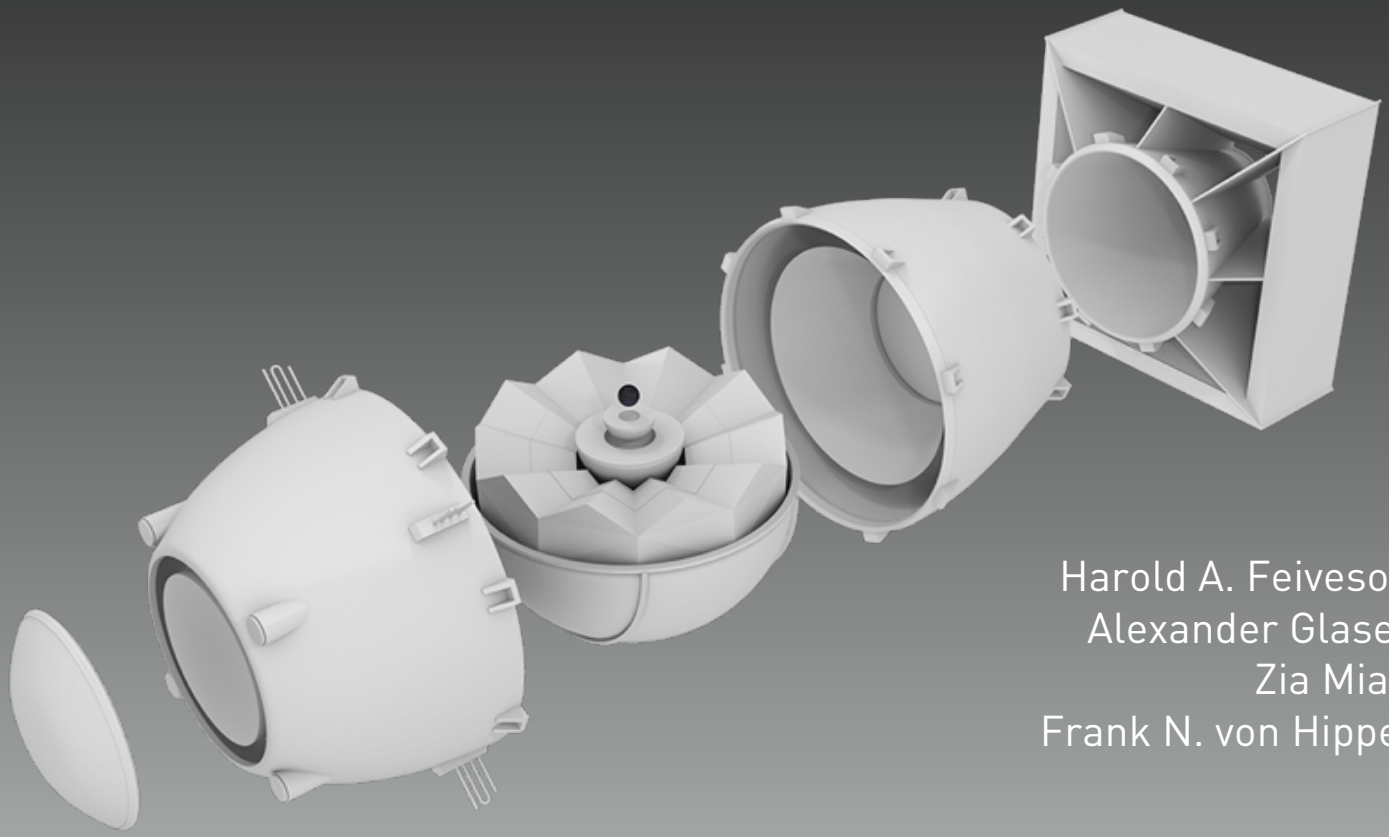
UNMAKING THE BOMB

A FISSILE MATERIAL APPROACH TO NUCLEAR DISARMAMENT AND NONPROLIFERATION



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Part I: The problem

Fissile materials

Nuclear weapons

Stockpiles

Part II: What is to be done

Ending production and use

Storage and disposal

Verification

A tale of two isotopes

Chain-reacting uranium-235

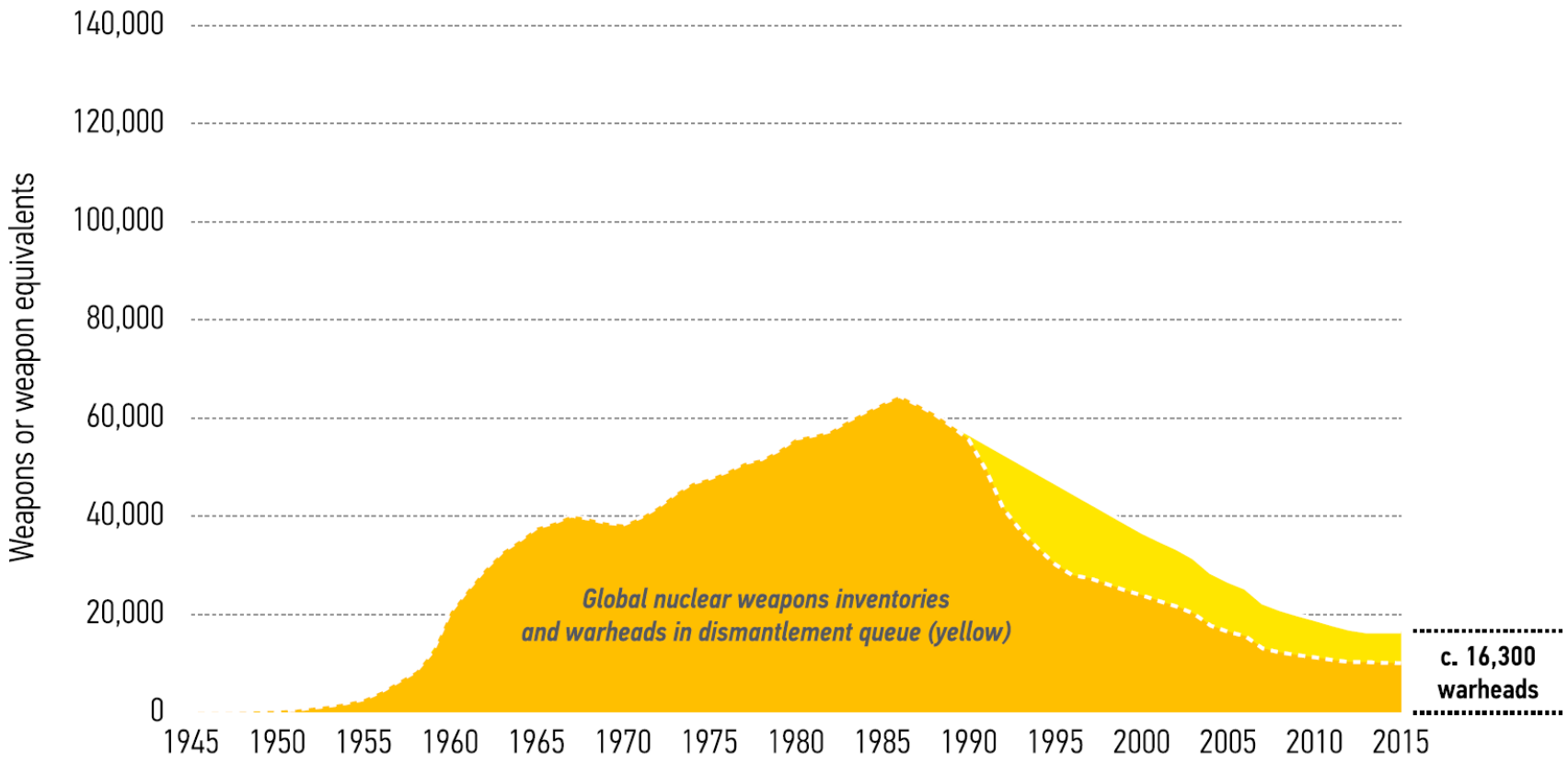
- uranium in nature is 0.7% U-235
- highly-enriched uranium (HEU – mostly over 90% U-235)
- Hiroshima bomb used highly-enriched uranium

Chain-reacting plutonium-239

- Produced in reactors following neutron absorption
- Nagasaki bomb used plutonium

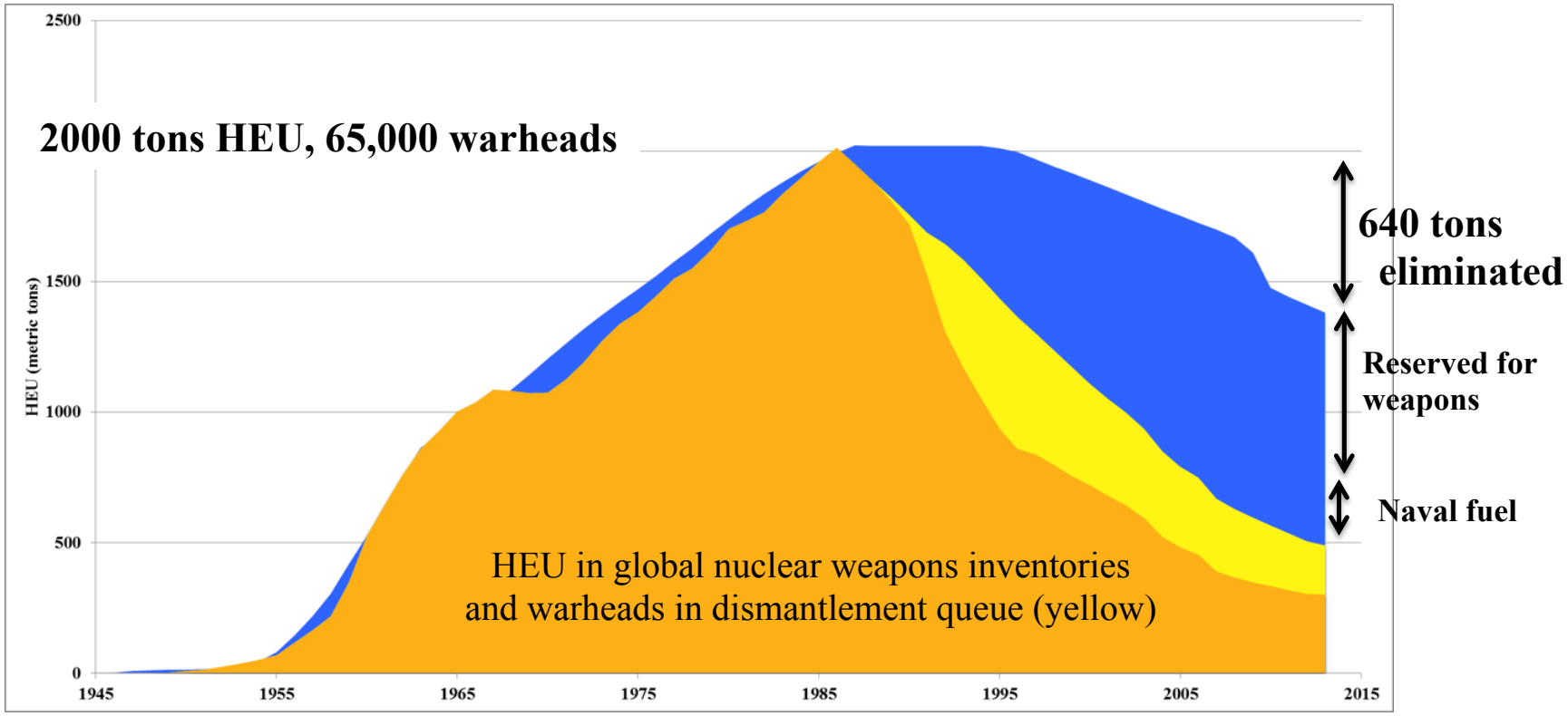
Modern thermonuclear weapons contain HEU and plutonium

Nuclear weapons
global inventory 1945–2014

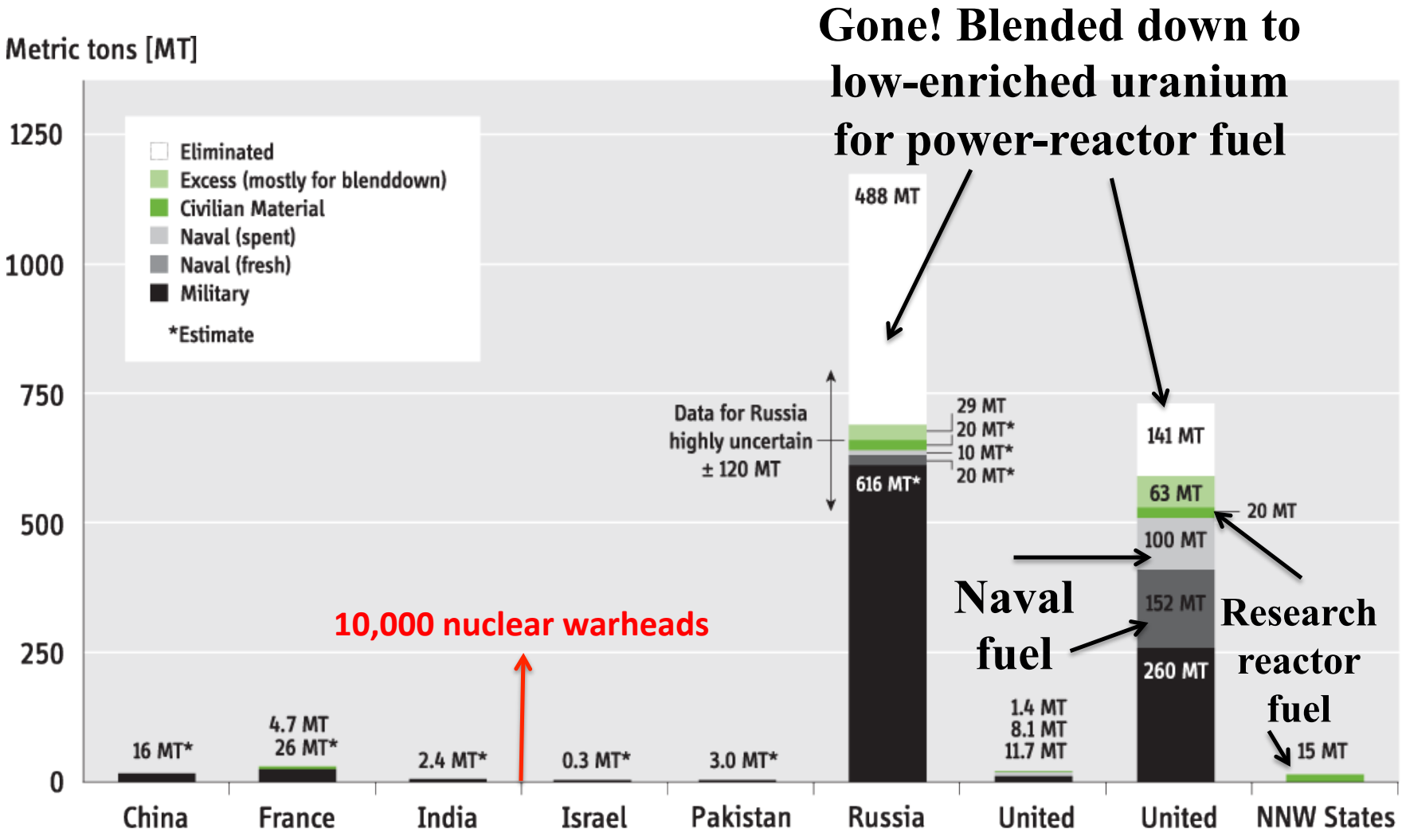


Hans Kristensen and Robert Norris, "Global Nuclear Weapon Inventories, 1945-2013"
Bulletin of the Atomic Scientists, 2013

Nuclear weapons and fissile materials
global inventory of weapon-grade uranium 1945-2014

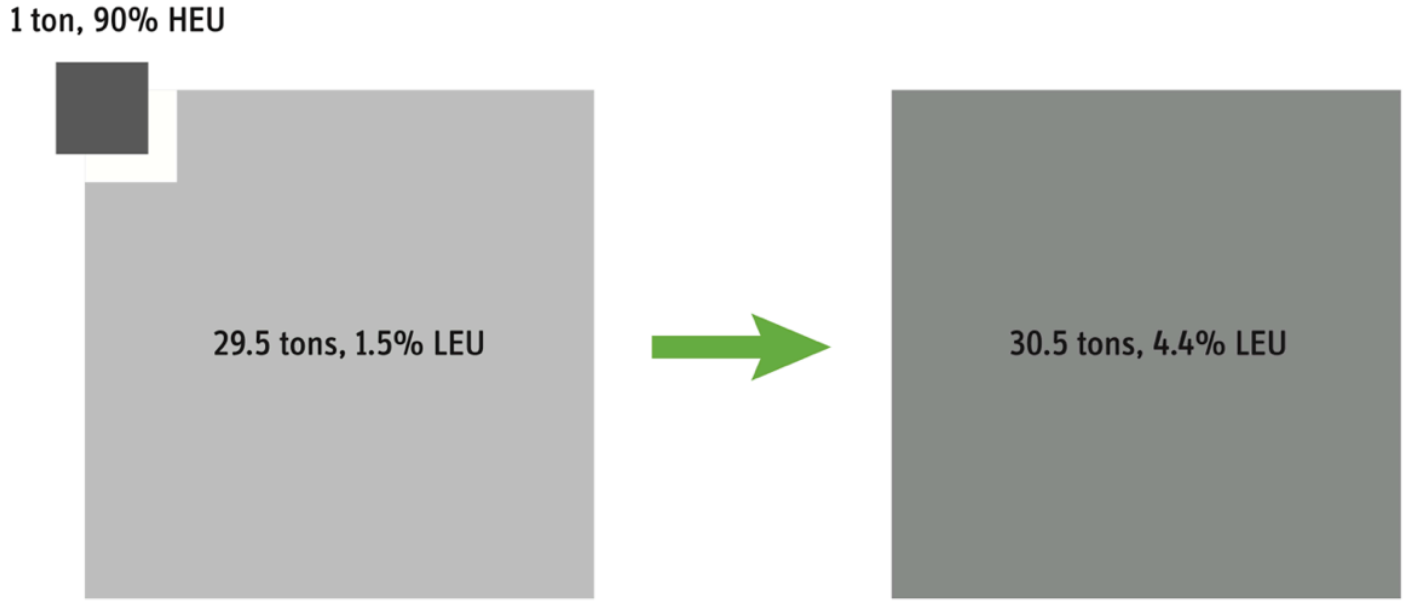


HEU: Legacy of the Cold War



Elimination of highly enriched uranium by blend-down

(Russian process)



500 tons of Russian HEU (90% U-235) – enough for 20,000 weapons blended down from 1993-2013 and sold to fuel U.S. nuclear reactors

141 tons of U.S. HEU blended down during same period

45 tons of U.S. HEU declared excess remaining to be down-blended

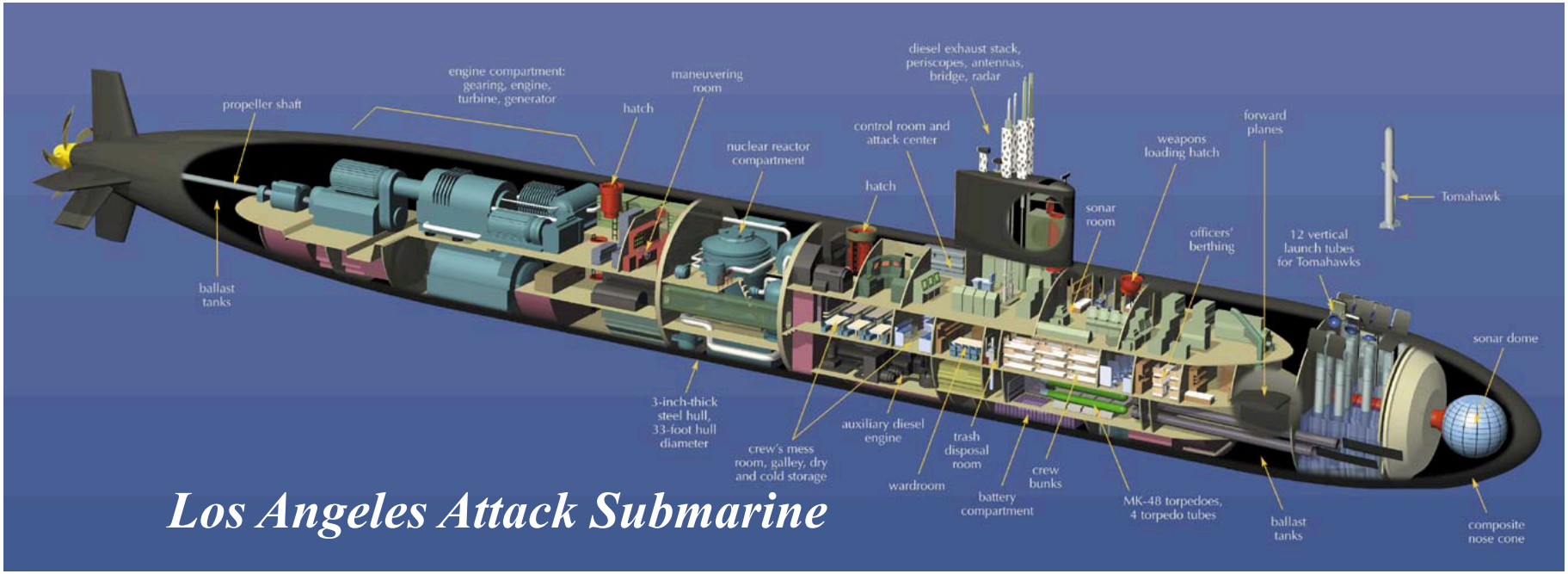
HEU for naval fuel

U.S. has over half of nuclear-powered vessels in the world

U.S. naval fuel stockpile is >100 tons of HEU

Sufficient for > 4,000 nuclear weapons

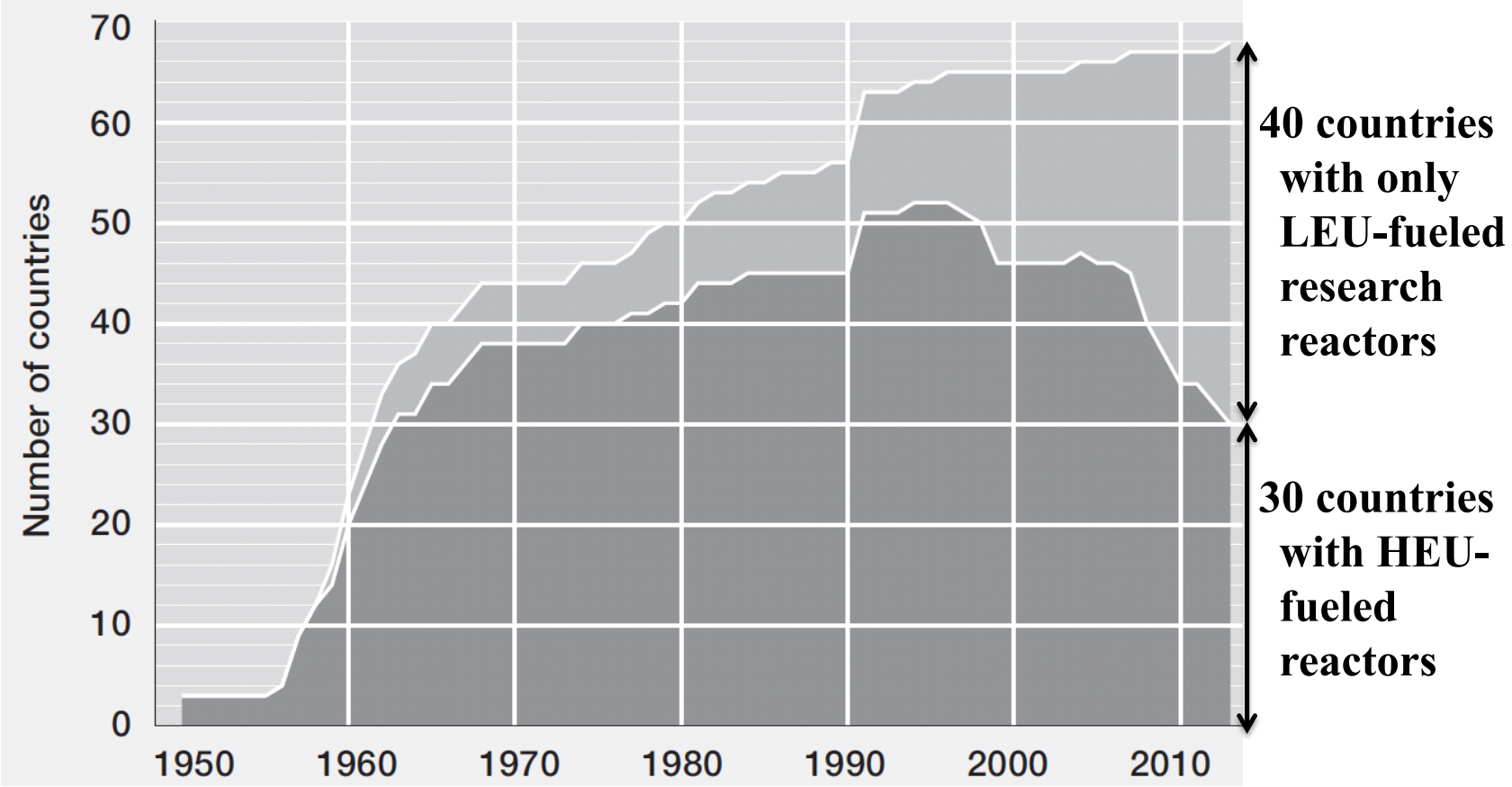
Could power U.S. nuclear navy for 50 years



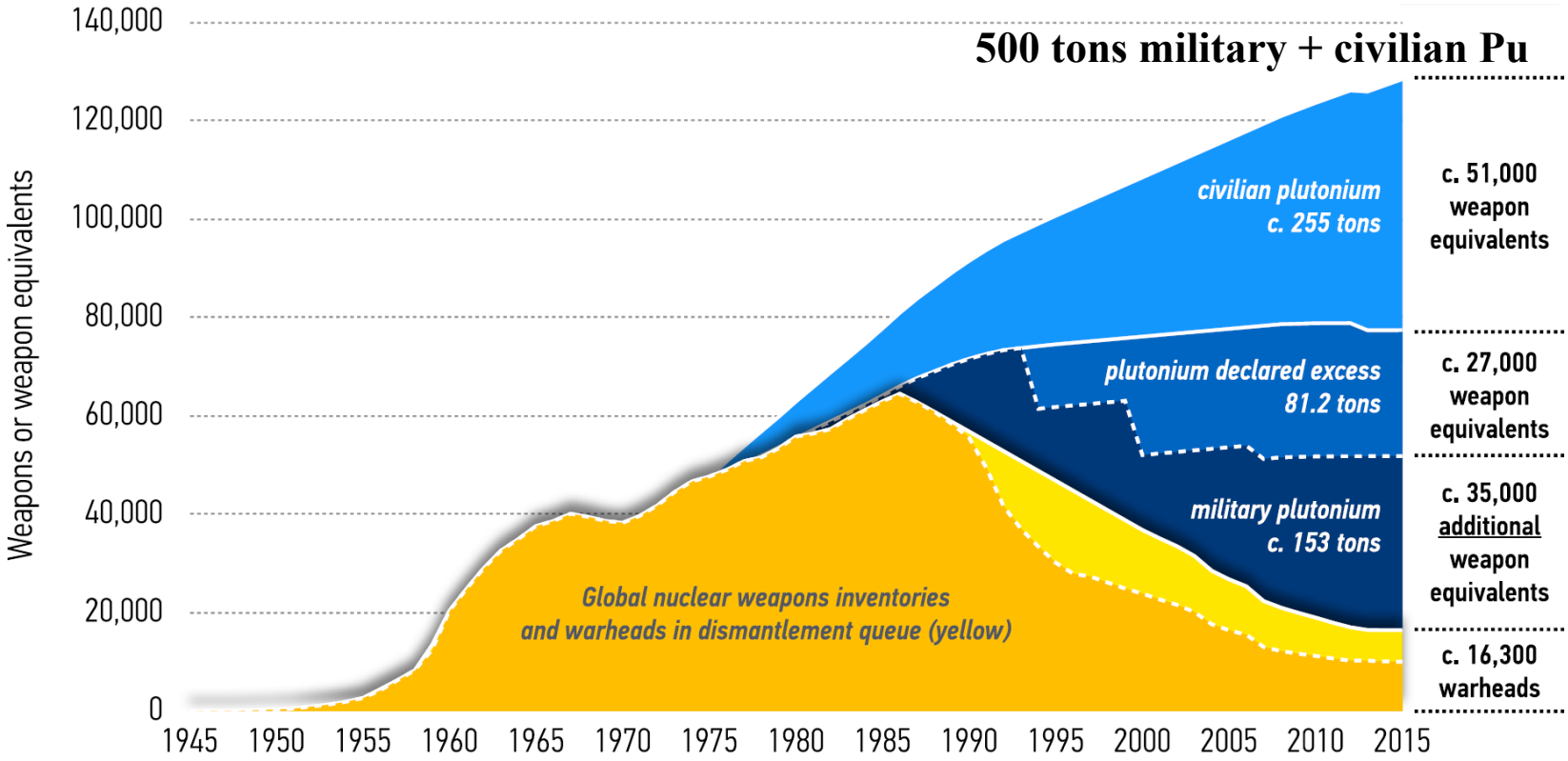
[LEGACY OF ATOMS FOR PEACE]

HEU-fueled research reactors

21 non-weapon states and 9 weapon states left with more than 1 kg of HEU
Russia accounts for half the remaining research reactors worldwide

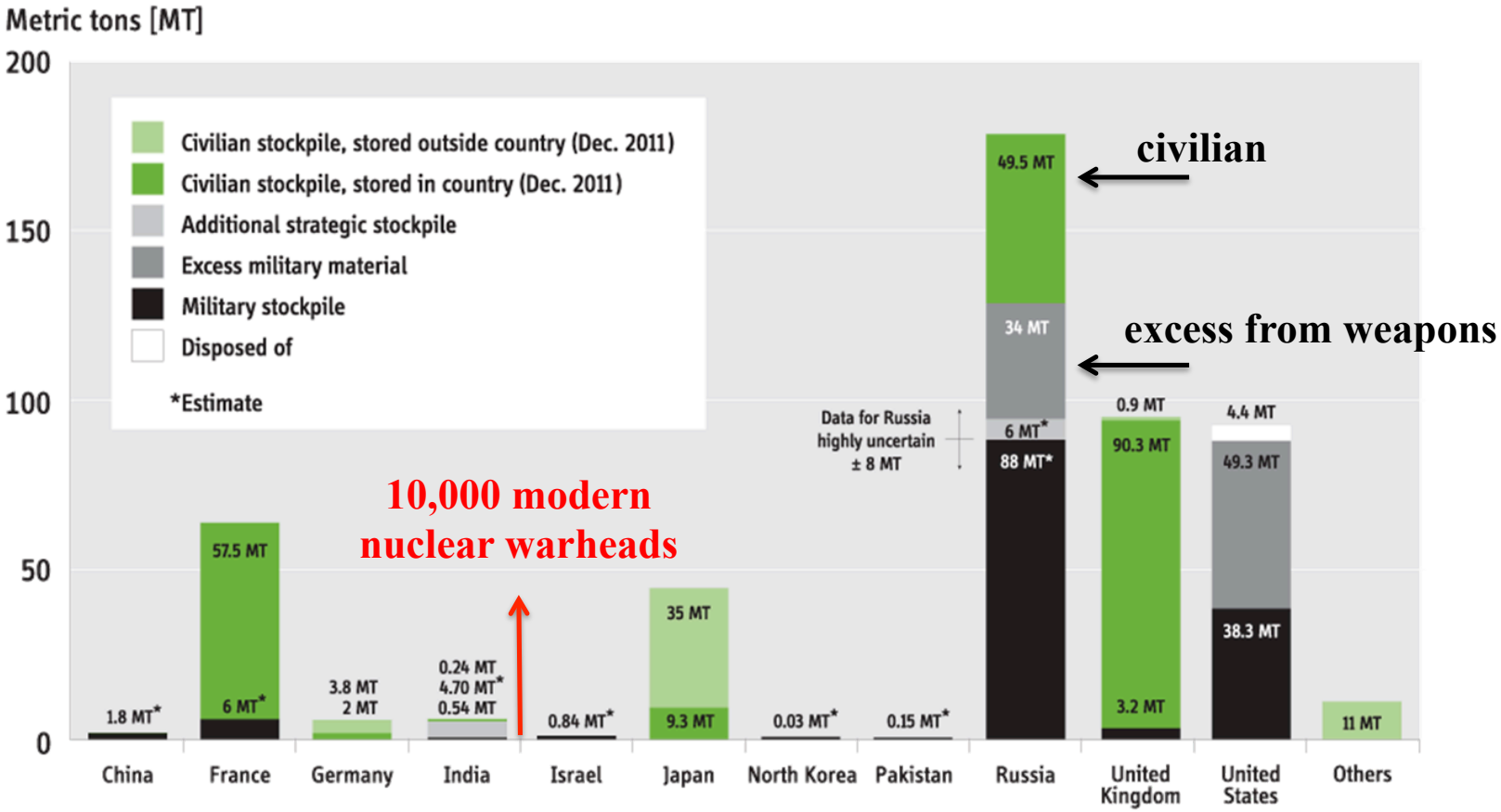


Nuclear weapons and fissile materials
Global inventory of plutonium 1945–2014



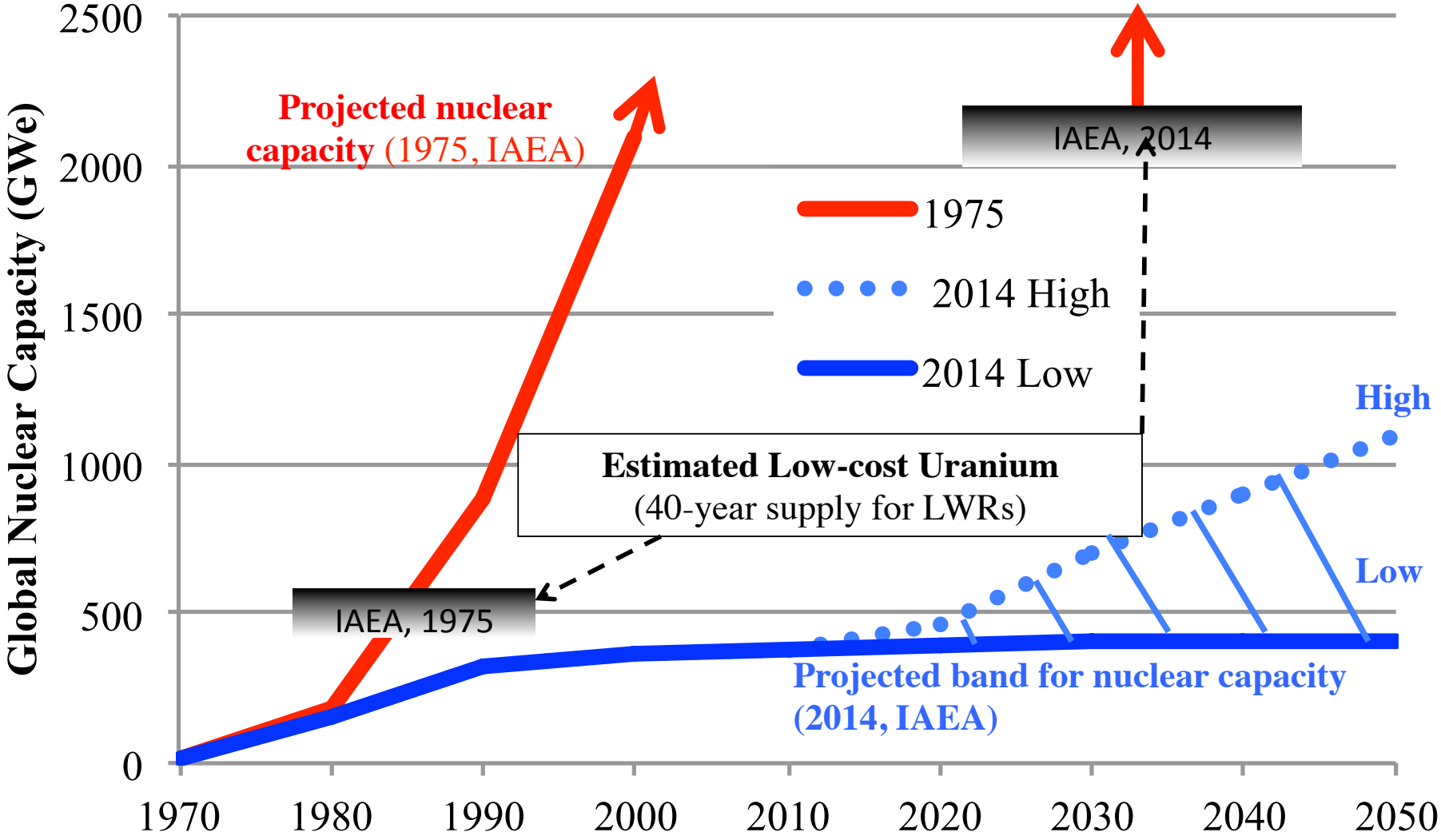
Civilian plutonium: A legacy of the Cold War and breeder reactor dream

Civilian plutonium originally separated from spent fuel to start up breeder reactors especially in France, Japan, Russia & UK



1975: Predicted global need for plutonium breeders

Uranium was expected to run out; plutonium needed to start breeder reactors.
Today, uranium accounts for only a few percent of cost of nuclear power and is "adequate to meet projected requirements for the foreseeable future."



What is to be done

Scientists and the nuclear danger

Princeton

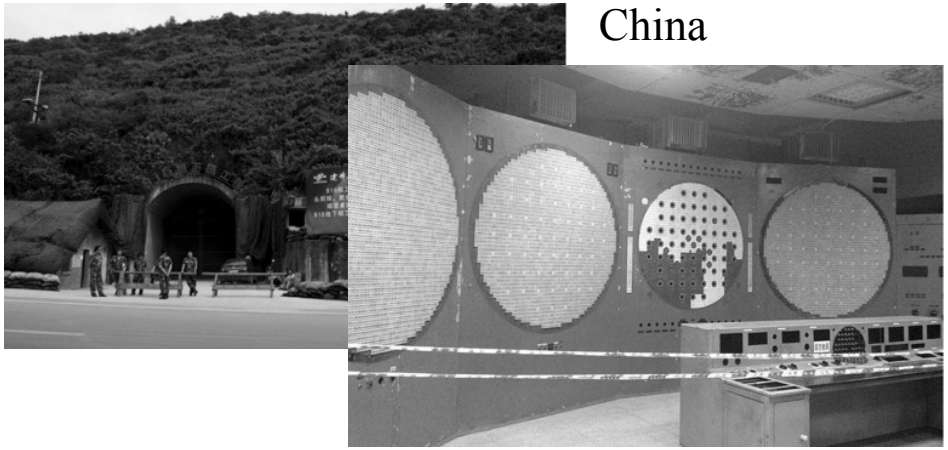
October 3, 1954

Niels Bohr
James Franck
Albert Einstein
and I. I. Rabi

"the use of the new active materials…may be…a perpetual menace to human security"
Niels Bohr, Open Letter to the United Nations, June 9, 1950

Fissile material production for weapons has ended in the P5 states

Russia



China

Military production facilities
have been converted
to peaceful purposes or
are being decommissioned
in France, China, Russia, UK
and the United States

United States

The challenge of ending production of HEU

Continuing production of HEU

- for military use – India, Pakistan, possibly North Korea
- for civilian use – Russia (since 2012)

India increasing power of centrifuges and total capacity producing HEU for submarine fuel (and weapons)

The challenge of ending plutonium separation

Continuing production of plutonium

- for military use – Pakistan, India, Israel (North Korea)
- for civilian use – France, Russia, India, (Japan and China) and UK to stop upon completion of current contracts

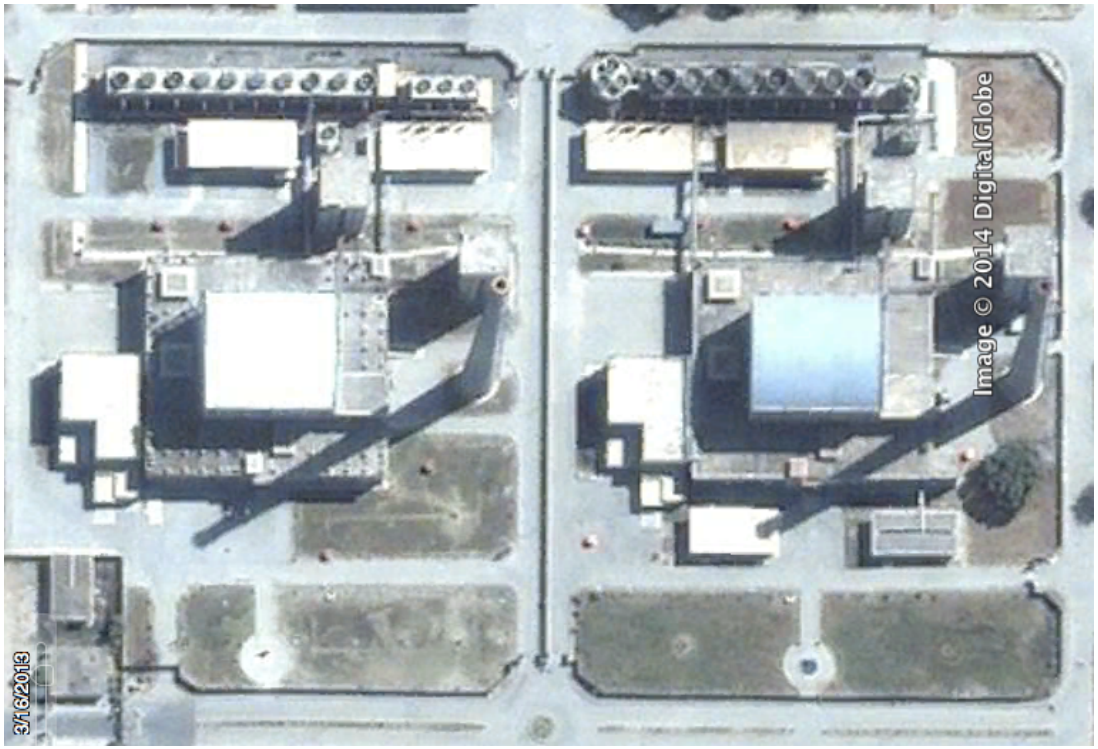
Pakistan

Khushab-3 began operating in 2013

Khushab-2 began operating in 2009/10

Khushab-1 began operating in 1998

Khushab-4 is under construction



FM(C)T +

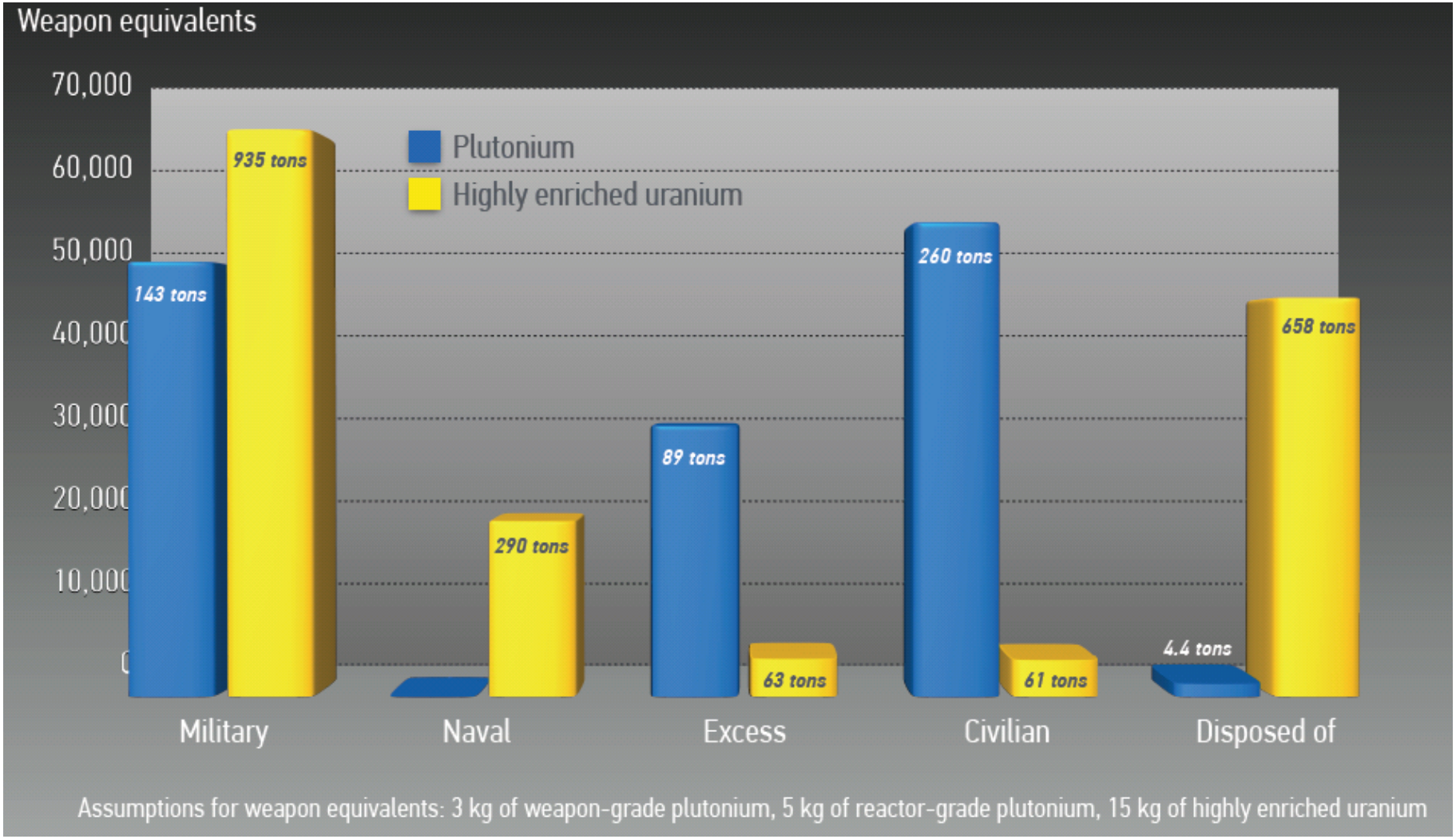
Fissile Material (Cutoff) Treaty

- “a non-discriminatory, multilateral and internationally and effectively verifiable treaty banning the production of fissile material for nuclear weapons or other nuclear explosive devices”

HEU and plutonium production for civilian use should end

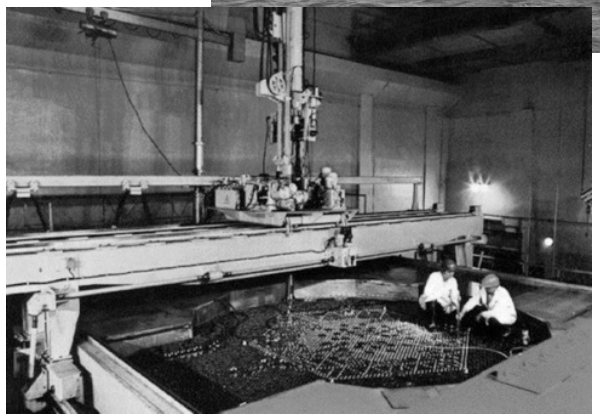
- Would cap global and national stockpiles of fissile materials
- FM(C)T verification would be easier

Global fissile material stockpiles (by category) 2014



Ending use of HEU and plutonium

HEU reactor fuels



US naval fuel and Russian research reactors

Plutonium fuels

France, Russia, India (China)
for power reactors

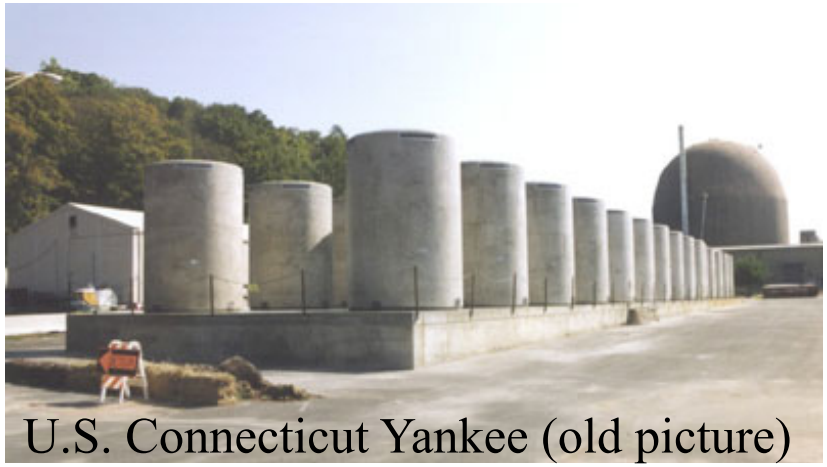
Moving to LEU for naval reactors

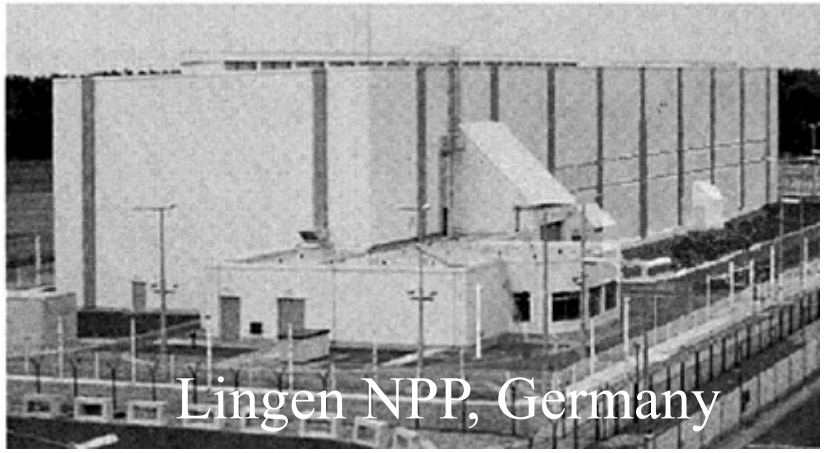
Country	Nuclear ships and submarines	Naval fuel enrichment
U.S.	10 aircraft carriers, 72 submarines	90+%
U.K.	10 submarines	Same as U.S.
Russia	4 cruisers, 29 submarines (+7 icebreakers)	21-90+%
India	1 submarine	Average of 45%?
China	14 submarines	< 20%?
France	1 aircraft carrier, 10 submarines	< 10% going down to 5%
Brazil	submarines under development	<20%
Total	**11 aircraft carriers, 136 submarines +**	

United States: In 2014, U.S. Office of Naval Reactors raised the possibility of developing LEU fuel for next generation vessels

Russia: Developed LEU fuel for its new nuclear-powered icebreaker and for floating nuclear power plant

Leave plutonium inside spent fuel in safe dry-cask storage until geological repositories become available





Only elimination of fissile material can end its threat

Consolidation can reduce risks, but storage is vulnerable

U.S. HEU Materials Facility, Y-12 site secure store with over 100 tons of HEU

About 245 tons of civilian plutonium stored at four sites in Europe and Russia (Sellafield, La Hague, Marcoule, Mayak)

July 2012 break-in through fences due to: “ineptitude in responding to alarms, failures to maintain critical security equipment, over reliance on compensatory measures, misunderstanding of security protocols…”
- official U.S. DOE report

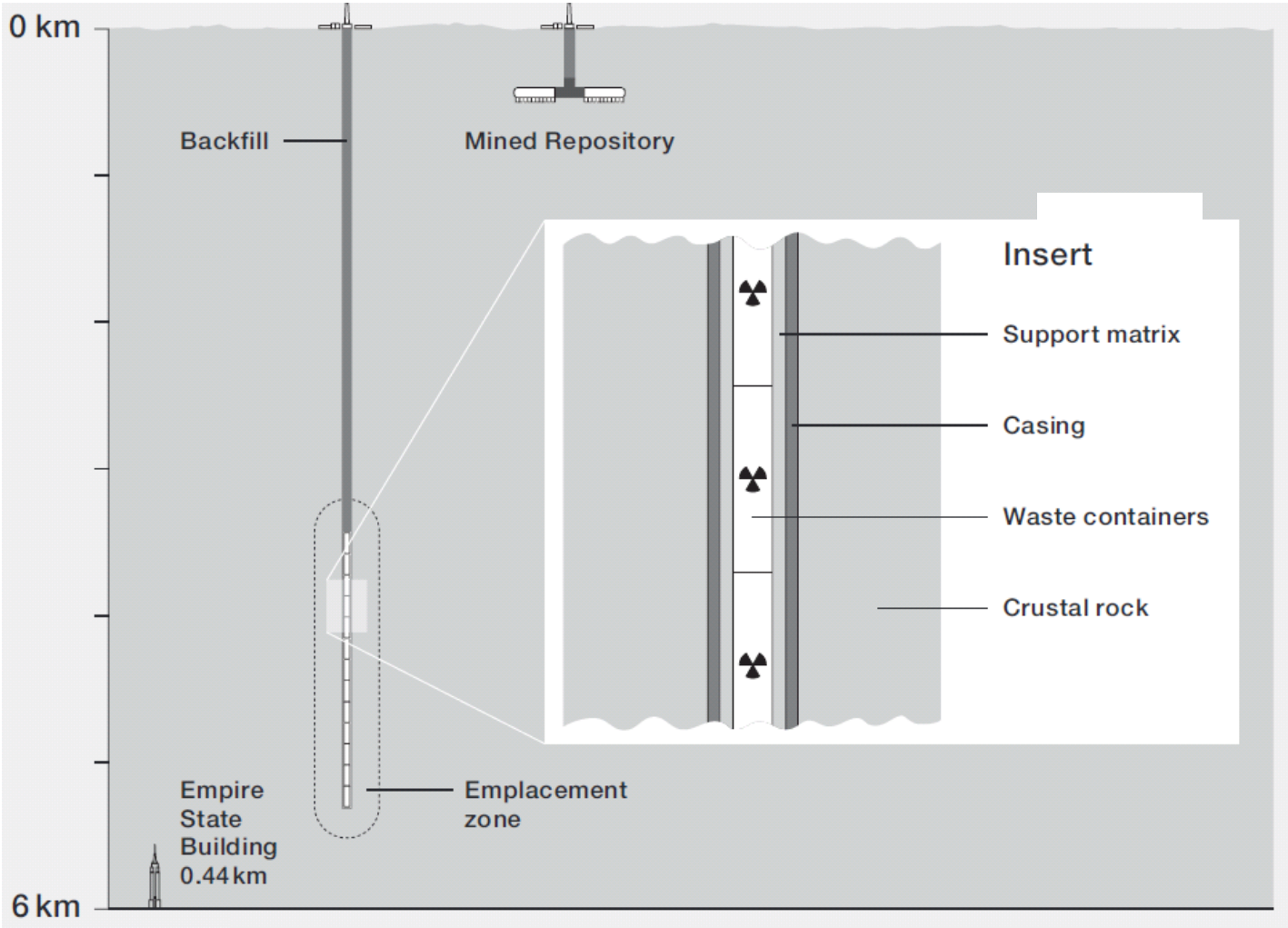
Michael Walli (64); Sister Megan Rice (83); Gregory Boertje-Obed (57)

Megan Rice is serving a sentence of 35 months in prison, the others 62 months each

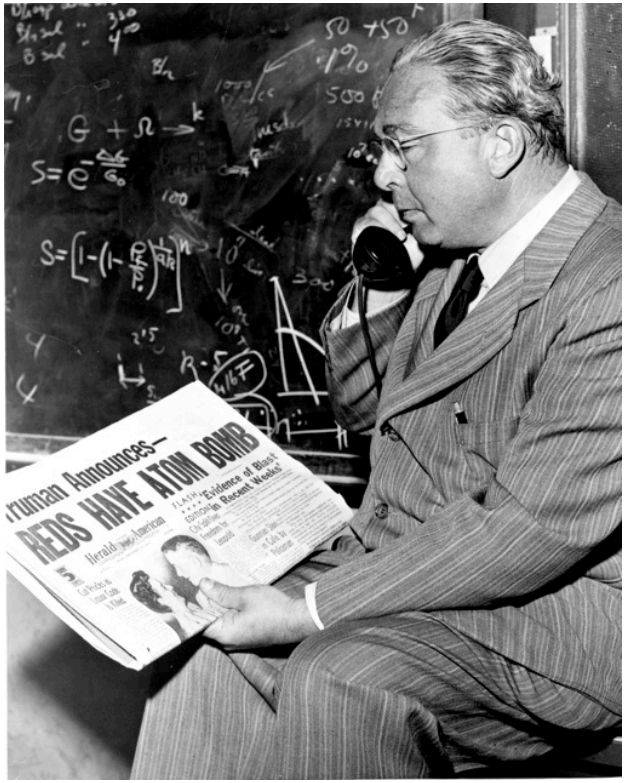
Dispose of separated plutonium in deep boreholes?

Several tons of plutonium could be disposed in a single borehole

Boreholes are then backfilled and sealed



Disarmament, transparency and verification including citizen's verification



Leo Szilard

Joseph Rotblat