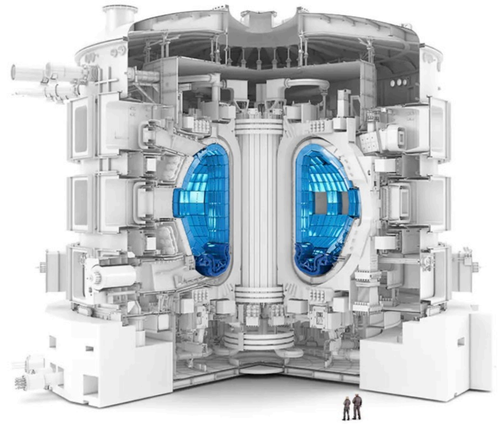


PANEL ON NONPROLIFERATION AND SAFEGUARDS ASPECTS OF FUSION

(SOME VISUALS)

Alexander Glaser
Princeton University

66th Annual INMM Meeting
Washington, DC, August, 2025

Revision 1

NUCLEAR FUSION IN 2025

For many decades, largely a government-led effort, but fusion R&D is increasingly conducted by startups and/or involves public-private partnerships

- At least 45 companies are seeking to commercialize fusion energy
- More than $7 billion in funding
- More than 1,000 scientists and engineers recruited per year

Most concepts pursued for energy applications are based on magnetic confinement fusion and rely on the DT fusion reaction:

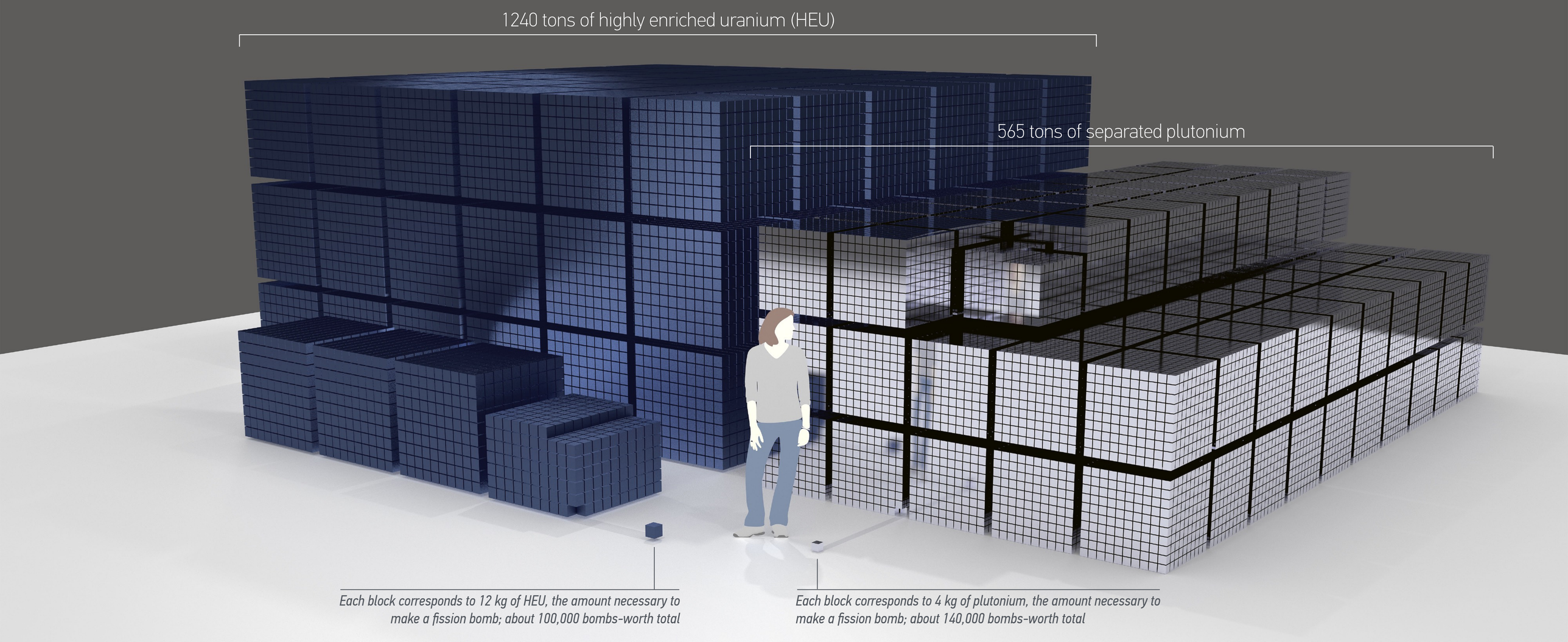
$$D + T \longrightarrow {}^{4}He + n + 17.6\ \mathrm{MeV}$$

In-situ tritium breeding, primarily via: $n + {}^{6}Li \longrightarrow {}^{4}He + T + 4.8\ \mathrm{MeV}$

The Global Fusion Industry in 2024, Fusion Companies Survey by the Fusion Industry Association, Fusion Industry Association, 2024

Graphic/concept by Alex Wellerstein and Tamara Patton
Inventory estimates from fissilematerials.org
Status as of beginning of 2024

There is enough nuclear explosive material in the world to make over 200,000 nuclear weapons



Each block corresponds to 12 kg of HEU, the amount necessary to make a fission bomb; about 100,000 bombs-worth total

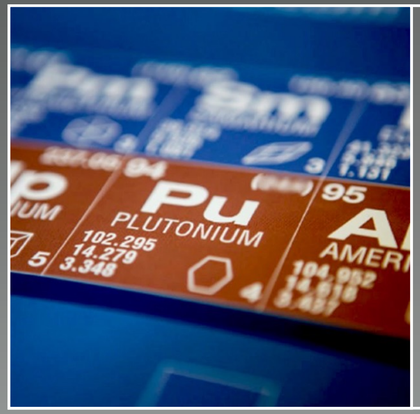
Each block corresponds to 4 kg of plutonium, the amount necessary to make a fission bomb; about 140,000 bombs-worth total

FISSILE MATERIAL PRODUCTION POTENTIAL

OF NUCLEAR FUSION REACTORS

FUSION REACTORS AS NEUTRON-RICH ENVIRONMENTS

Standard operation of a fusion reactor does not involve nuclear materials, which offers significant nonproliferation benefits compared to nuclear fission reactors; the presence of intense neutron fluxes provides an environment, however, that could be used for covert production of fissile materials



HOW MUCH FISSILE MATERIAL COULD POSSIBLY BE PRODUCED?

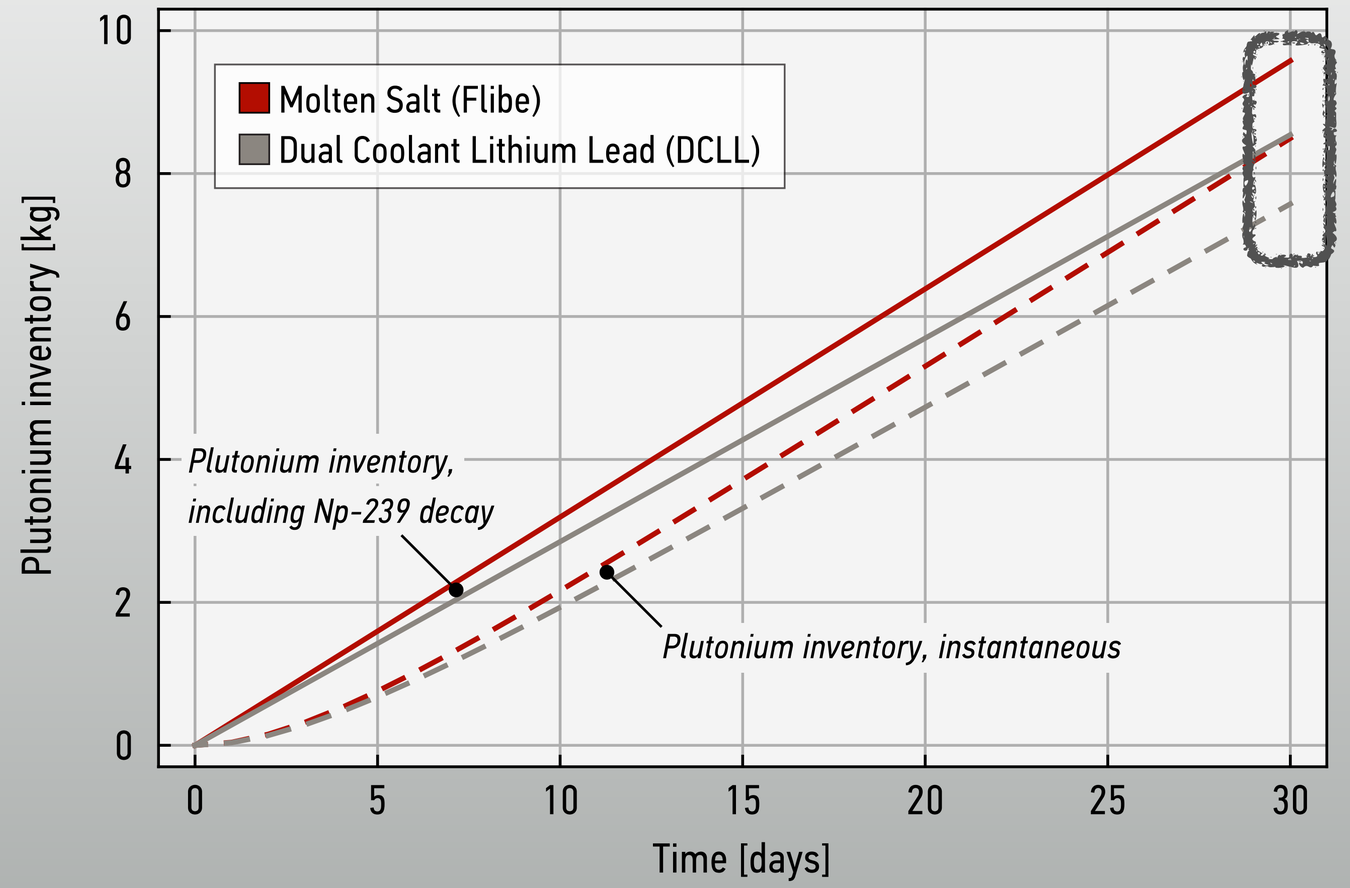
Previous analyses have shown that a commercial-scale reactor with a fusion power of 1500 MW (600–750 MWe) could be used to make on the order of 10 kg of Pu-239 or U-233 per week

A. Glaser and R. J. Goldston, Proliferation Risks of Fusion Energy: Clandestine Production, Covert Production, and Breakout, Nuclear Fusion, 52 (4), 2012

Source: iter.org (top)

PLUTONIUM BUILDUP IN THE BLANKET

(1500 MW OF FUSION POWER; 25 TRISO PARTICLES/CC IN BREEDING CHANNELS)



In the reference scenario, about one significant quantity of plutonium builds up in one month

Depending on the blanket type, 60-85 MW of fission power are generated throughout the process

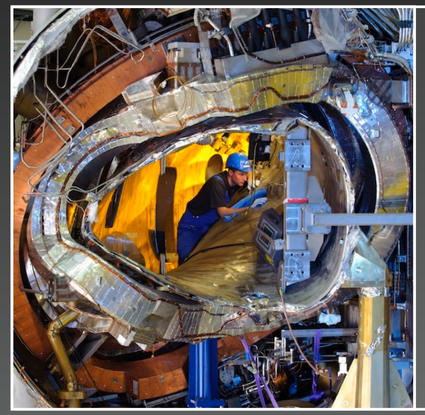
Note that more aggressive production scenarios could deliver 8–10 kilograms of plutonium per week

A. Glaser and R. J. Goldston, Proliferation Risks of Fusion Energy: Clandestine Production, Covert Production, and Breakout, Nuclear Fusion, 52 (4), 2012

A. Glaser, R. J. Goldston, P. Huber, Detectability of Covert Fissile Material Production in Nuclear Fusion Reactors via Antineutrino Emissions, August 2025, arxiv.org/abs/2508.16358

ADDRESSING DUAL-USE ASPECTS OF FUSION

A PROACTIVE APPROACH



FUSION TECHNOLOGY

Consider (and prioritize) system configurations and materials that make military use difficult, especially with regard to fissile material production (and tritium diversion)

Design reactors and other test facilities with inspections and verifiability in mind

POLICY & REGULATION FOR NUCLEAR FUSION

Acknowledge that nuclear fusion reactors can raise security (and safety) concerns

Involve, at an early stage, the International Atomic Energy Agency on how to monitor fusion reactors

Source: Max Planck Institute for Plasma Physics (top) and iaea.org (bottom)