



Source: Universal Pictures



SCIENTISTS, ENGINEERS, AND THE CHALLENGES OF TECHNOLOGIES THAT IMPACT EVERYONE AND PUT THE WORLD AT RISK

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Revision 0

BACKGROUND

USA
5,180



U.S. Nuclear Weapon

Russia
5,580



United Kingdom
215



France
300



Israel
80



Pakistan
170



India
170



China
600



North Korea
50



North Korean Nuclear Weapon

For the first time since the end of the Cold War, the number of nuclear weapons in the world is increasing again

In 2024, humanity edged ever closer to catastrophe. Trends that have deeply concerned the Science and Security Board continued, and despite unmistakable signs of danger, national leaders and their societies have failed to do what is needed to change course.

Consequently, we now move the Doomsday Clock from 90 seconds to 89 seconds to midnight—the closest it has ever been to catastrophe. Our fervent hope is that leaders will recognize the world's existential predicament and take bold action to reduce the threats posed by nuclear weapons, climate change, and the potential misuse of biological science and a variety of emerging technologies.



Who are these “clock setters” anyway?

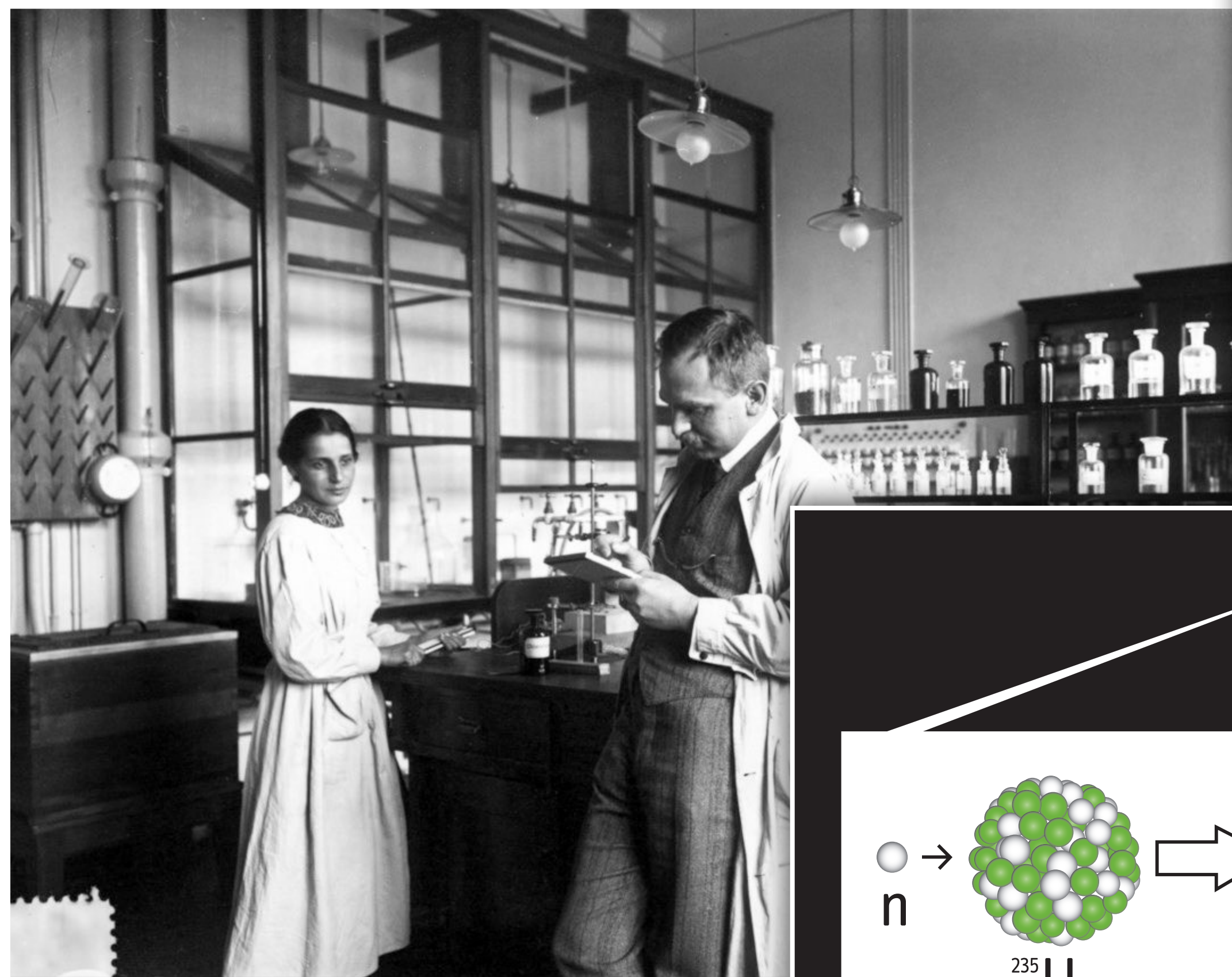


EARLY WARNINGS

How Scientists Intervened in the Nuclear Debate

THE DISCOVERY OF NUCLEAR FISSION

(1938/1939)



Lise Meitner and Otto Hahn, Berlin, c. 1925

No. 3615, FEB. 11, 1939

NATURE

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Letters to the Editor

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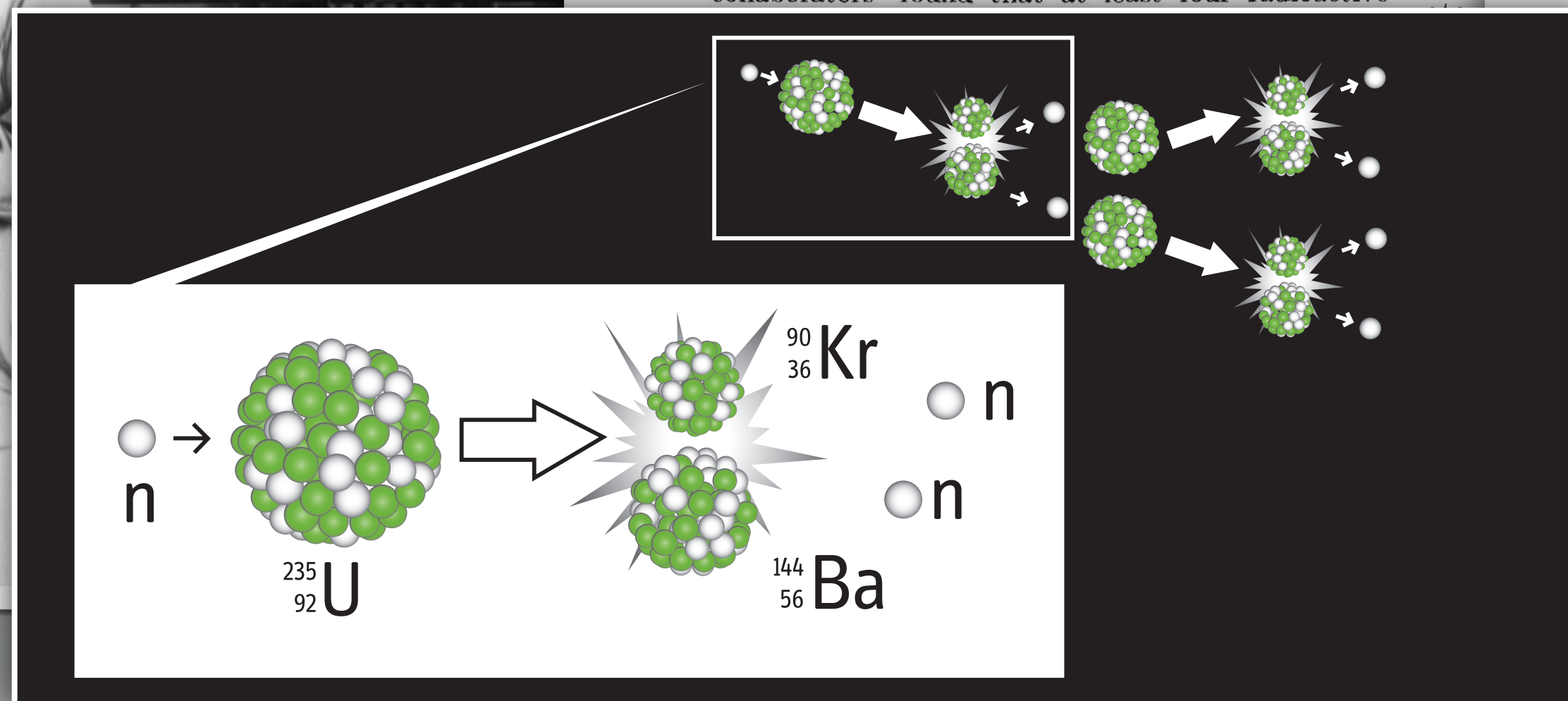
NOTES ON POINTS IN SOME OF THIS WEEK'S LETTERS APPEAR ON P. 247.

CORRESPONDENTS ARE INVITED TO ATTACH SIMILAR SUMMARIES TO THEIR COMMUNICATIONS.

Disintegration of Uranium by Neutrons: a New Type of Nuclear Reaction

ON bombarding uranium with neutrons, Fermi and collaborators¹ found that at least four radioactive

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NATURE

It might be mentioned that the body with half-life 24 min.² which was chemically identified with uranium is probably really ^{238}U , and goes over into an eka-rhenium which appears inactive but may decay slowly, probably with emission of alpha particles. (From inspection of the natural radioactive elements, ^{238}U cannot be expected to give more than one or two beta decays; the long chain of observed decays has always puzzled us.) The formation of this body is a typical resonance process³; the compound state must have a life-time a million times longer than the time it would take the nucleus to divide itself. Perhaps this state corresponds to some highly symmetrical type of motion of nuclear matter which does not favour 'fission' of the nucleus.

LISE MEITNER.

Physical Institute,
Academy of Sciences,
Stockholm.

O. R. FRISCH.

Institute of Theoretical Physics,
University,
Copenhagen.
Jan. 16.

that Hahn and Strassmann were forced to conclude that isotopes of barium ($Z = 56$) are formed as a

two
chain

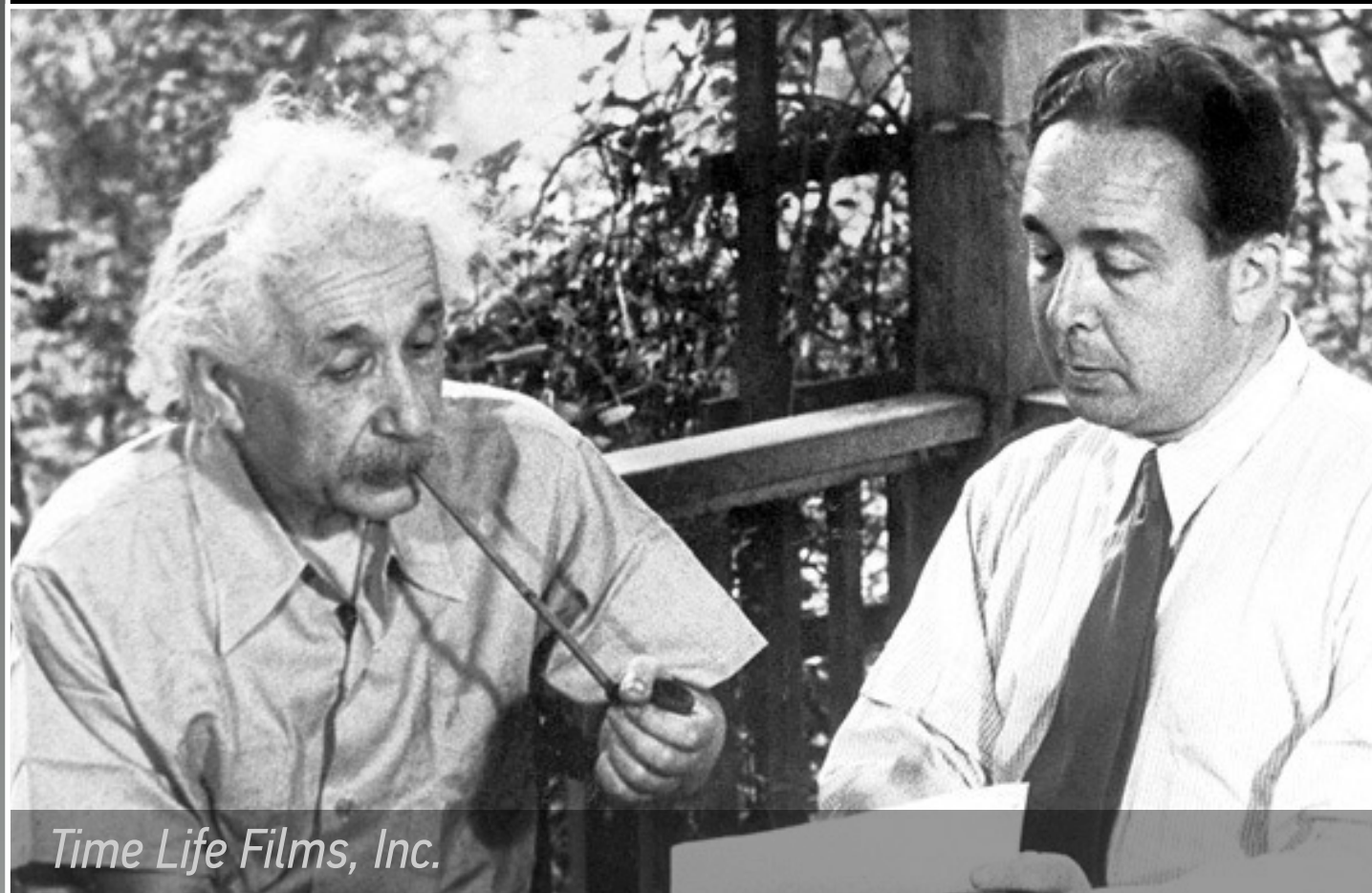
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EARLY INTERVENTIONS

EINSTEIN'S LETTER

August 1939

Szilard and Einstein inform President Roosevelt about the feasibility of a uranium bomb and recommend speeding up experimental work on nuclear fission.



BOHR'S ADVOCACY

July 1944

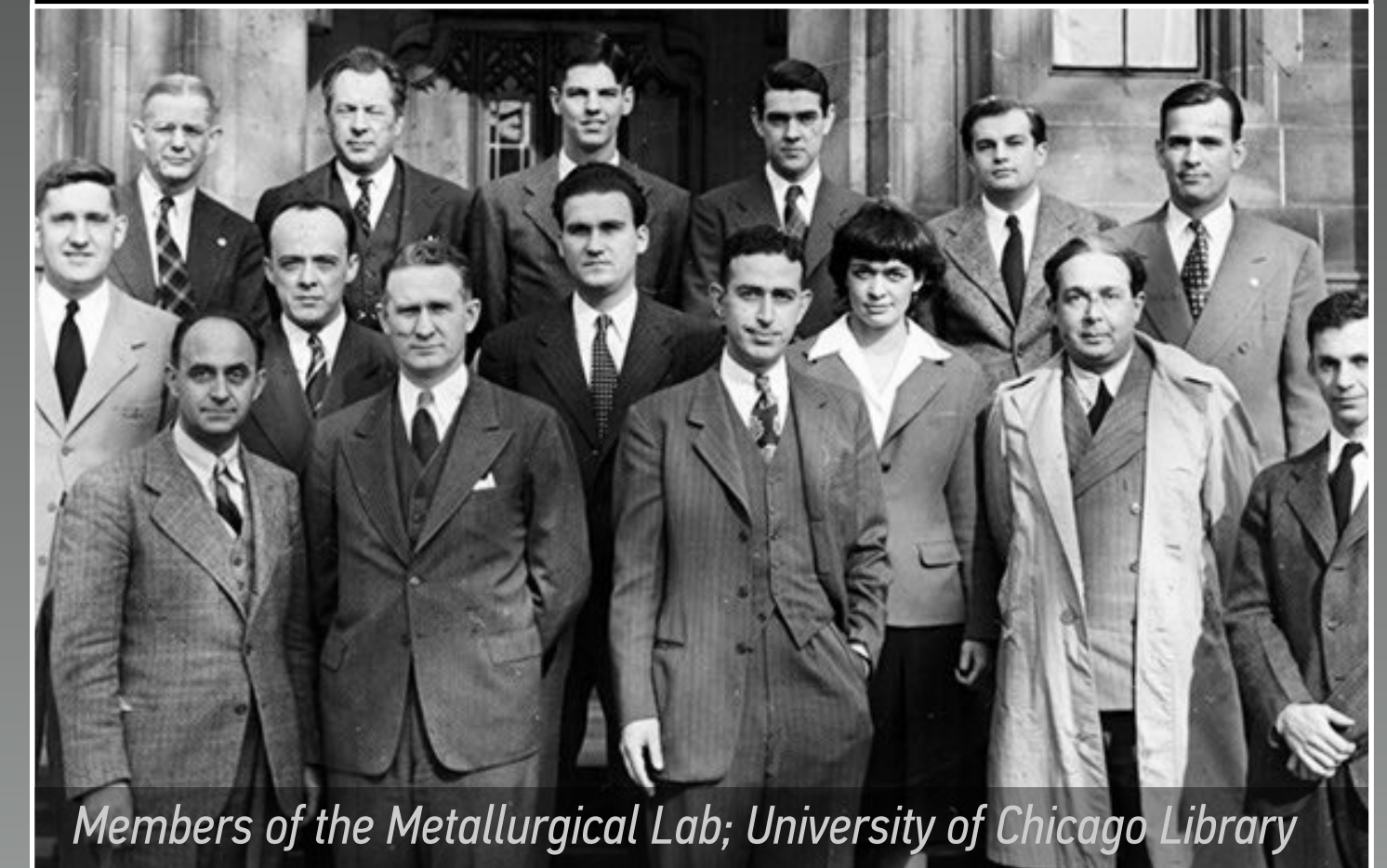
Niels Bohr advocates for not using the atomic bomb without first notifying Stalin, trying to lay the basis for post-war control of nuclear energy.



CHICAGO SCIENTISTS' PETITION

July 1945

"The United States shall not resort to the use of atomic bombs in this war unless the terms which will be imposed upon Japan have been made public in detail ..."



See www.atomicarchive.com/resources/documents/manhattan-project for a collection of documents



Cillian Murphy as J. Robert Oppenheimer
Universal Pictures, 2023

Dear Friend:

I write to you and other friends for help.

Through the release of atomic energy, our generation has brought into the world the most revolutionary force since prehistoric man's discovery of fire. This basic power of the universe cannot be fitted into the outmoded concept of narrow nationalisms. For there is no secret and there is no defense; there is no possibility of control except through the aroused understanding and insistence of the peoples of the world.

We scientists recognize our inescapable responsibility to carry to our fellow citizens an understanding of the simple facts of atomic energy and its implications for society. In this lies our only security and our only hope - we believe that an informed citizenry will act for life and not for death.

We need \$1,000,000 for this great educational task. Sustained by faith in man's ability to control his destiny through the exercise of reason, we have pledged all our strength and our knowledge to this work. I do not hesitate to call upon you to help.

Faithfully yours,

A. Einstein.

**There is no
secret, and there
is no defense.**

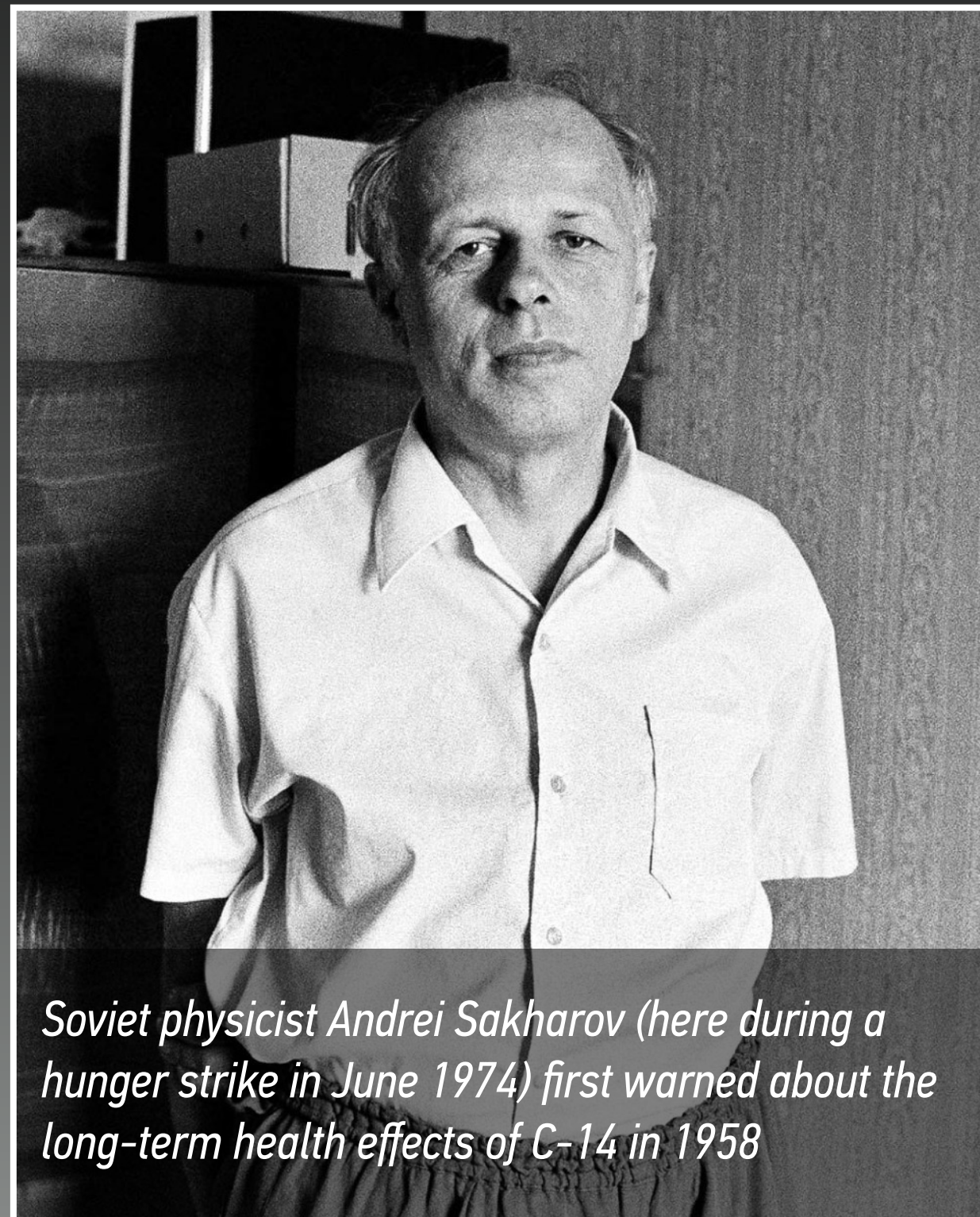
*Albert Einstein on behalf of the
Emergency Committee of Atomic Scientists
Princeton, NJ, December 1946*



90 Nassau Street

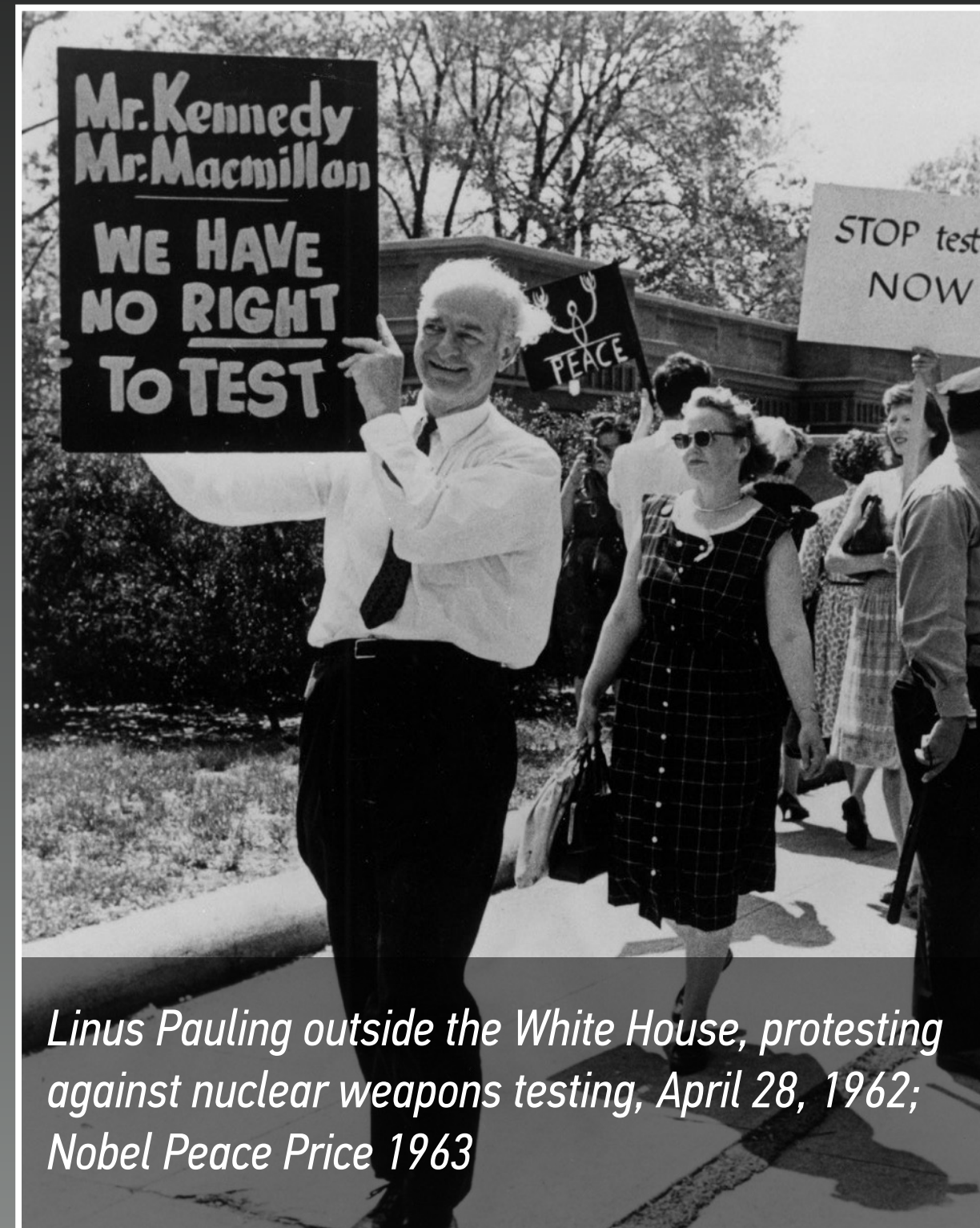
SUPPORTING THE END OF NUCLEAR TESTING

(FIRST IN THE ATMOSPHERE, THEN UNDERGROUND)



Soviet physicist Andrei Sakharov (here during a hunger strike in June 1974) first warned about the long-term health effects of C-14 in 1958

Source: Anonymous



Linus Pauling outside the White House, protesting against nuclear weapons testing, April 28, 1962; Nobel Peace Prize 1962

Source: AIP Emilio Segre Visual Archives



U.S. seismologists with portable seismometers on a granite outcrop in Kazakhstan, July 1986

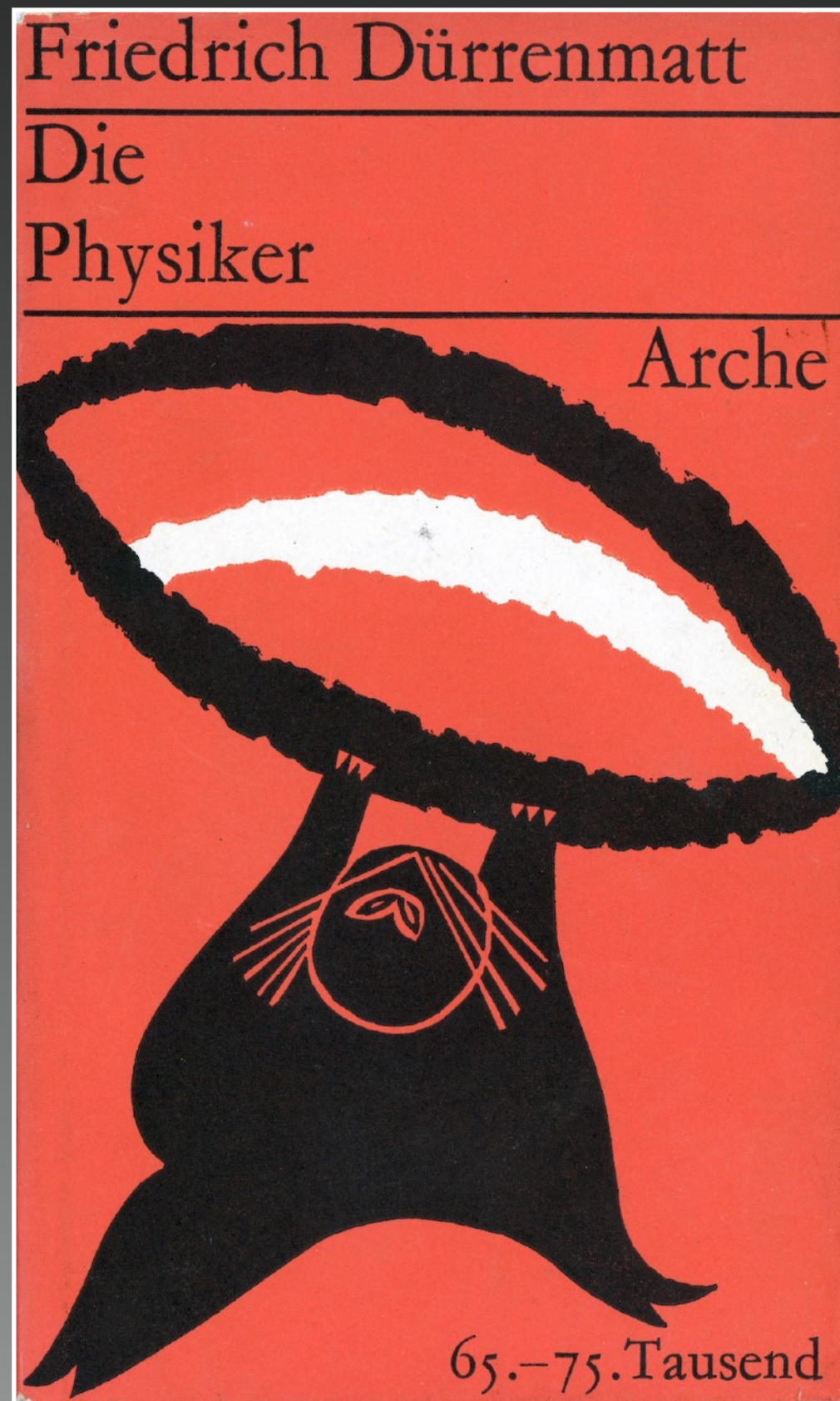
Source: Tom Cochran, NRDC

Frank von Hippel, "The Long-Term Global Health Burden from Nuclear Weapon Test Explosions in the Atmosphere: Revisiting Andrei Sakharov's 1958 Estimates," *Science & Global Security*, 30 (2), 2022, doi.org/10.1080/08929882.2022.2119716

Is There a Special Role &
Responsibility for Scientists?

DÜRRENMATT'S TWENTY-ONE POINTS

THE PHYSICISTS, 1962



...

*16. The content of physics concerns the physicists,
its impact concerns all people.*

17. What concerns everyone can only be resolved by everyone.

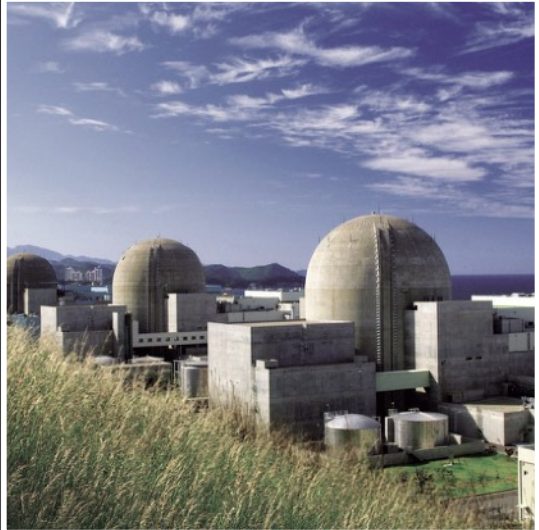
*18. Every attempt by an individual to resolve for themselves
what concerns everyone must fail.*

...

THE "DUAL USE" DILEMMA

(THEN & NOW)

DUAL USE TECHNOLOGY ... THEN



WEAKLY INTEGRATED — OFTEN LARGE, BULKY

Nuclear and space technologies may be entrenched, but they are not deeply embedded in society



SOME ABILITY TO DIFFERENTIATE

Many technologies are used for both civilian and military purposes, but they tend to have distinct features



GOVERNMENT FUNDED AND CONTROLLED

Major inventions of the 20th century emerged from government programs

Source: IAEA (top)

DUAL USE TECHNOLOGY ... NOW



DEEPLY INTEGRATED AND EVOLVING RAPIDLY

Not only true for software but increasingly also for hardware, especially for autonomous systems



OFTEN INDISTINGUISHABLE

Appearance and functionality can be de facto identical; code is inherently versatile



PRIVATELY FUNDED

International competition, trillion-dollar companies; more limited government control in shaping trajectory

Source: [figure.ai](https://www.figure.ai) (middle), [anduril.com](https://www.anduril.com) (bottom)

DISTINGUISHABILITY & INTEGRATION

OFTEN DETERMINE WHETHER COOPERATION ON AND
CONTROL OF A DUAL-USE TECHNOLOGY IS POSSIBLE OR LIKELY

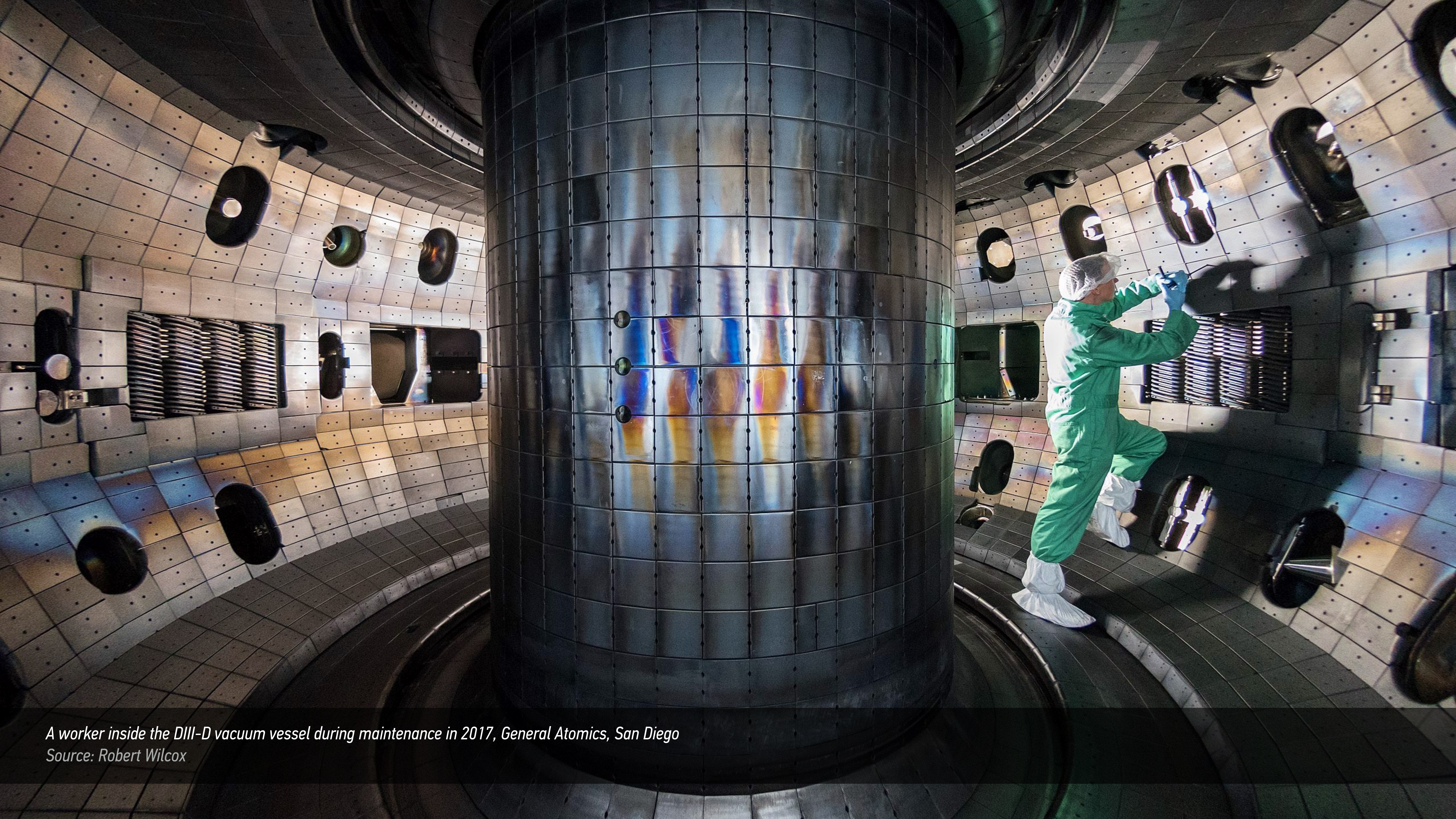
(Vaynman and Volpe, 2023)

		Distinguishability	
		High	Low
Integration	Low	<i>"Permissive zone"</i>	<i>(mixed)</i>
	High	<i>(mixed)</i>	<i>"Dead zone"</i>

Jane Vaynman and Tristan Volpe, *Dual Use Deception: How Technology Shapes Cooperation in International Relations*, *International Organization*, 77(3), 2023

Example #1

NUCLEAR (FUSION) ENERGY



A worker inside the DIII-D vacuum vessel during maintenance in 2017, General Atomics, San Diego
Source: Robert Wilcox

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

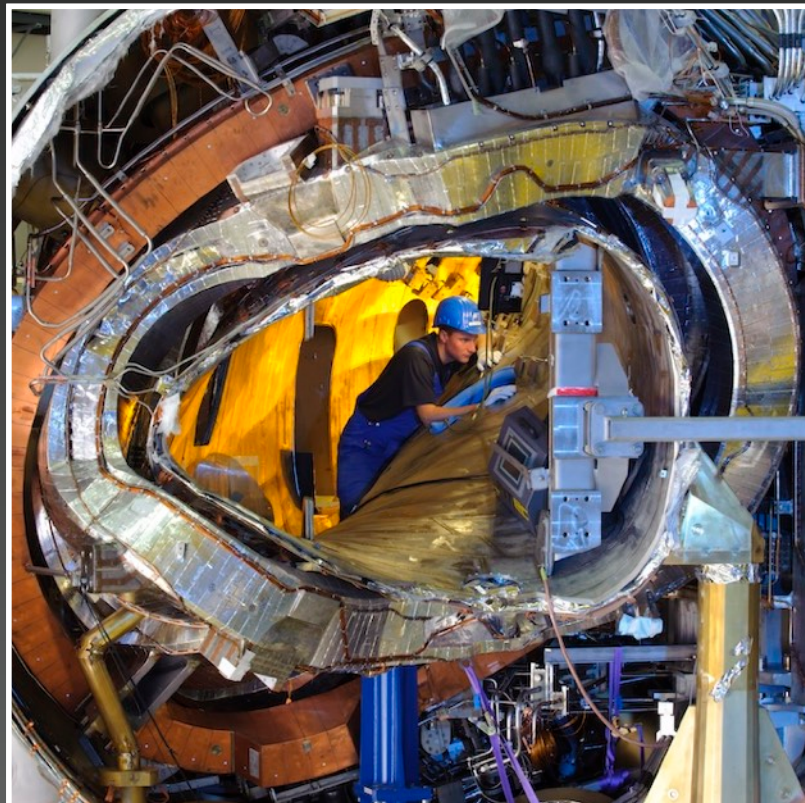
- At least 53 companies are seeking to commercialize fusion energy
- About \$10 billion in funding
- More than 1,000 scientists and engineers recruited per year

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



The Global Fusion Industry in 2025, Fusion Companies Survey by the Fusion Industry Association, Fusion Industry Association, 2025

ADDRESSING DUAL-USE ASPECTS OF FUSION



FUSION TECHNOLOGY

Consider (and prioritize) 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 safety and security concerns

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

Consider and assess accident scenarios

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

Example #2

AI & ROBOTICS

THE PIVOT AGAINST AI REGULATION

“Oftentimes, I think our response is to be too self-conscious, too risk-averse. [...]

To restrict [the development of AI] now would ... mean paralyzing one of the most promising technologies we have seen in generations. [...]

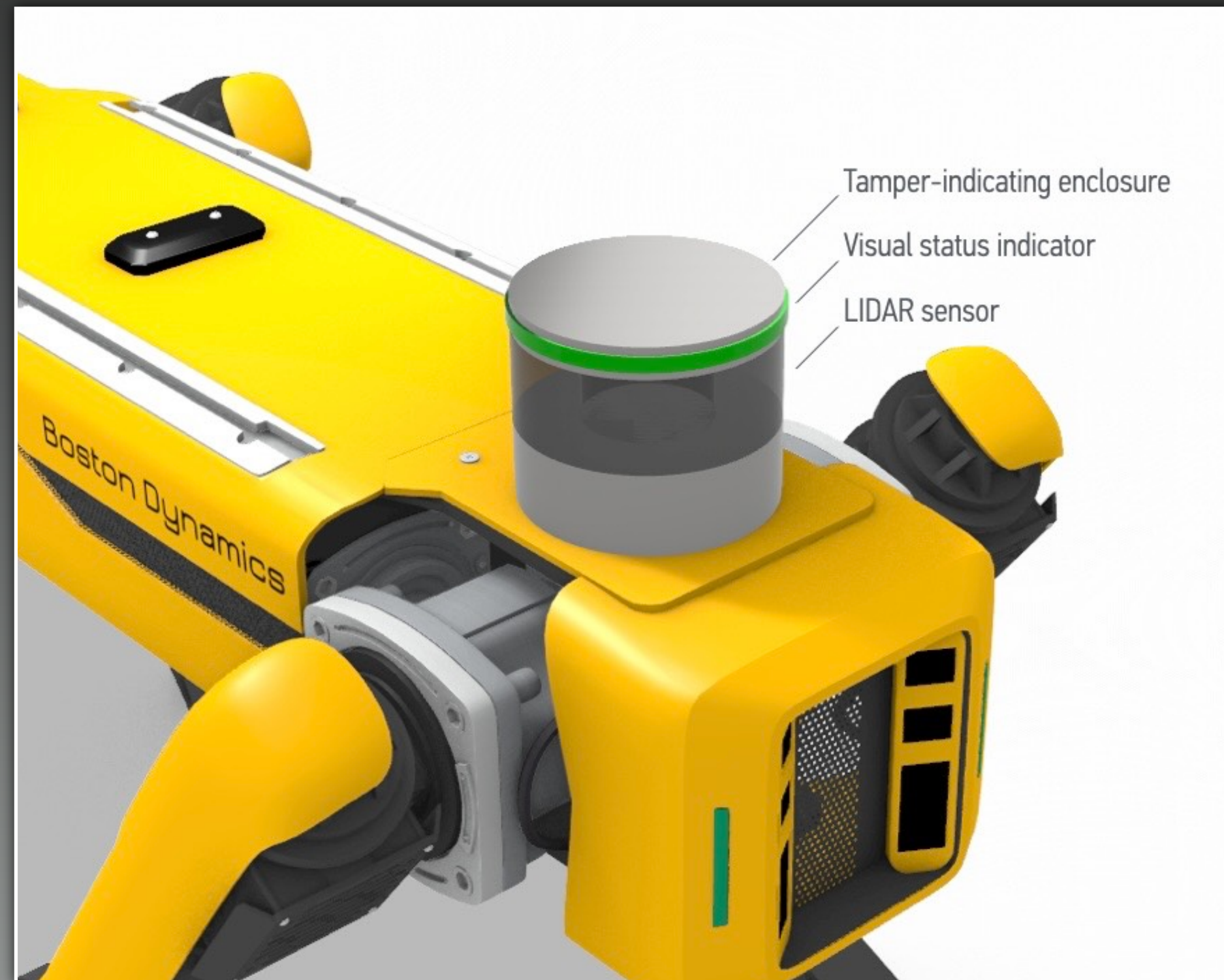
We believe that excessive regulation of the AI sector could kill a transformative industry just as it’s taking off, and we’ll make every effort to encourage pro-growth AI policies. [...]

The AI future is not going to be won by hand-wringing about safety.”

U.S. Vice President J.D. Vance, Paris AI Action Summit, February 11, 2025

LEARNING FROM THE WORLD OF NUCLEAR VERIFICATION

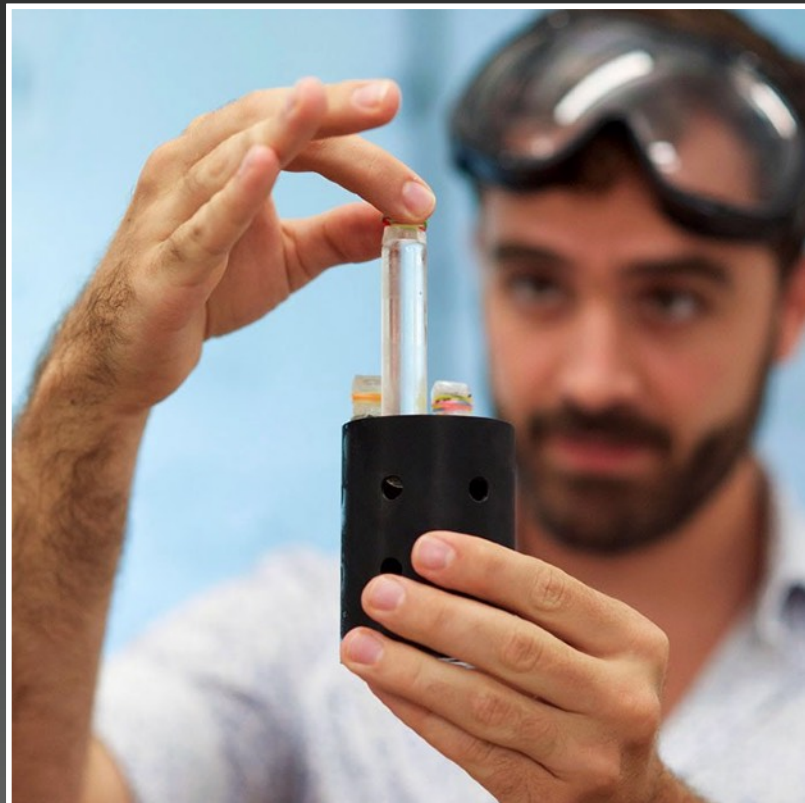
ROBOTS THAT INDICATE & GUARANTEE THEIR “GOOD” INTENTIONS?



Source: Author and Sandia National Laboratories (right)

WHERE DO WE GO FROM HERE?

TOWARD A MORE PEACEFUL FUTURE



“The content of physics concerns the physicists, its impact concerns all people”

- We can be explicit about our goals and vision while also acknowledging potential risks
- Build a community of scientists and look for answers together
- Seek opportunities to shape emerging technologies to make them “dual-use resistant”



“What concerns everyone can only be resolved by everyone”

- Get the message out: policymakers need to know their constituents care
- Scientists and physicists can play an important role in informing policy, even with technical analysis
- Public engagement and pressure was key to major threat reduction efforts in the past

Source: Matt Stanley (top) and Giancarlo Impiglia (bottom)

