

# The Increasing Peril from Nuclear Arms

*(and how physicists can help reduce the threat)*

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# Motivation

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The nuclear arms threat is as extreme as ever

A few men can end civilization within minutes of deciding to do so  
24/7

Putin, Biden, in particular

Also, Khan, Modi, Xi and others can kill hundreds of million and more

Easy to understand, hard to grasp

Affects everyone, in all nations

The threat can be reduced

But it is off the radar of the public

The international physics community can play a special role in advancing threat reduction

# Today we will review

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- Some technical aspects
- The growing danger
- Some examples of effective policies
- What the physics community can do

Physicists Coalition for Nuclear Threat Reduction  
(launched by the American Physical Society)

We hope to internationalize the effort

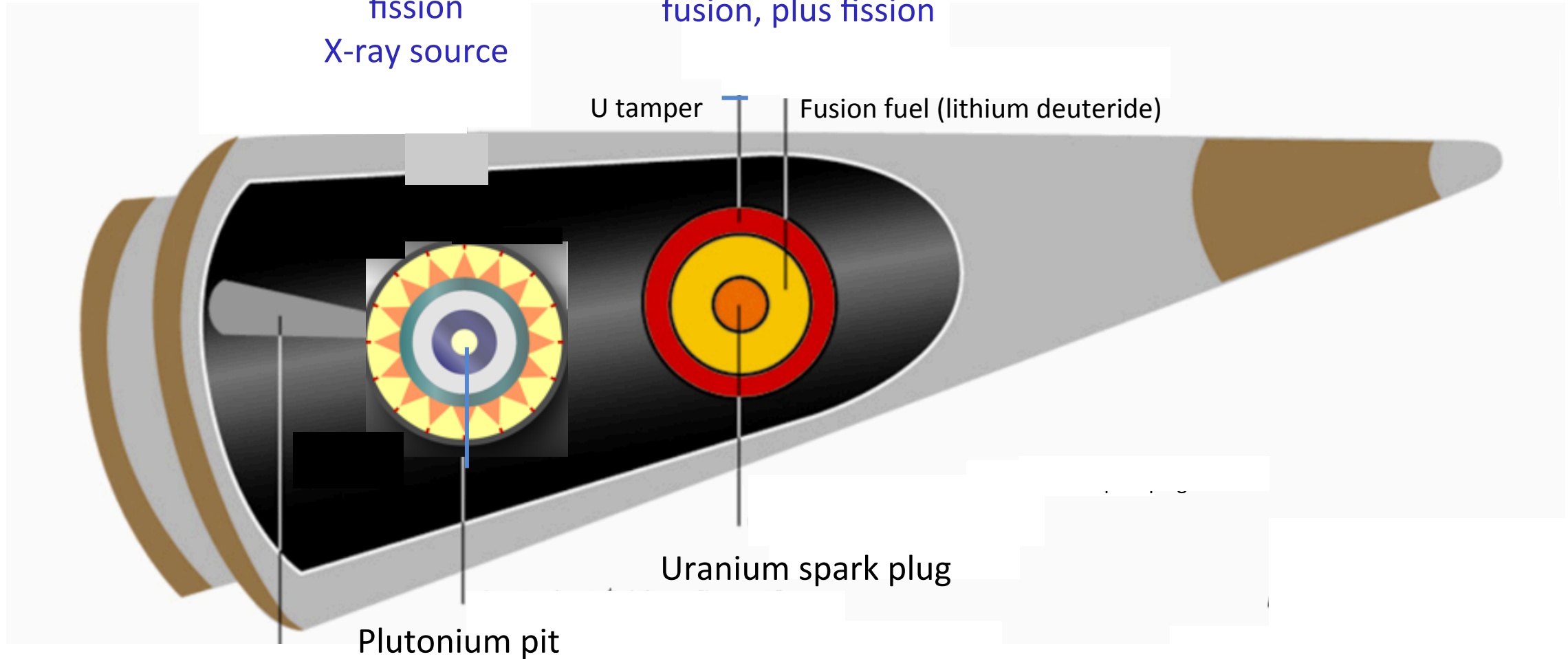
# Two-stage weapon (fission and fusion)

## Primary

chemical implosion  
fission  
X-ray source

## Secondary

X-ray implosion  
fusion, plus fission



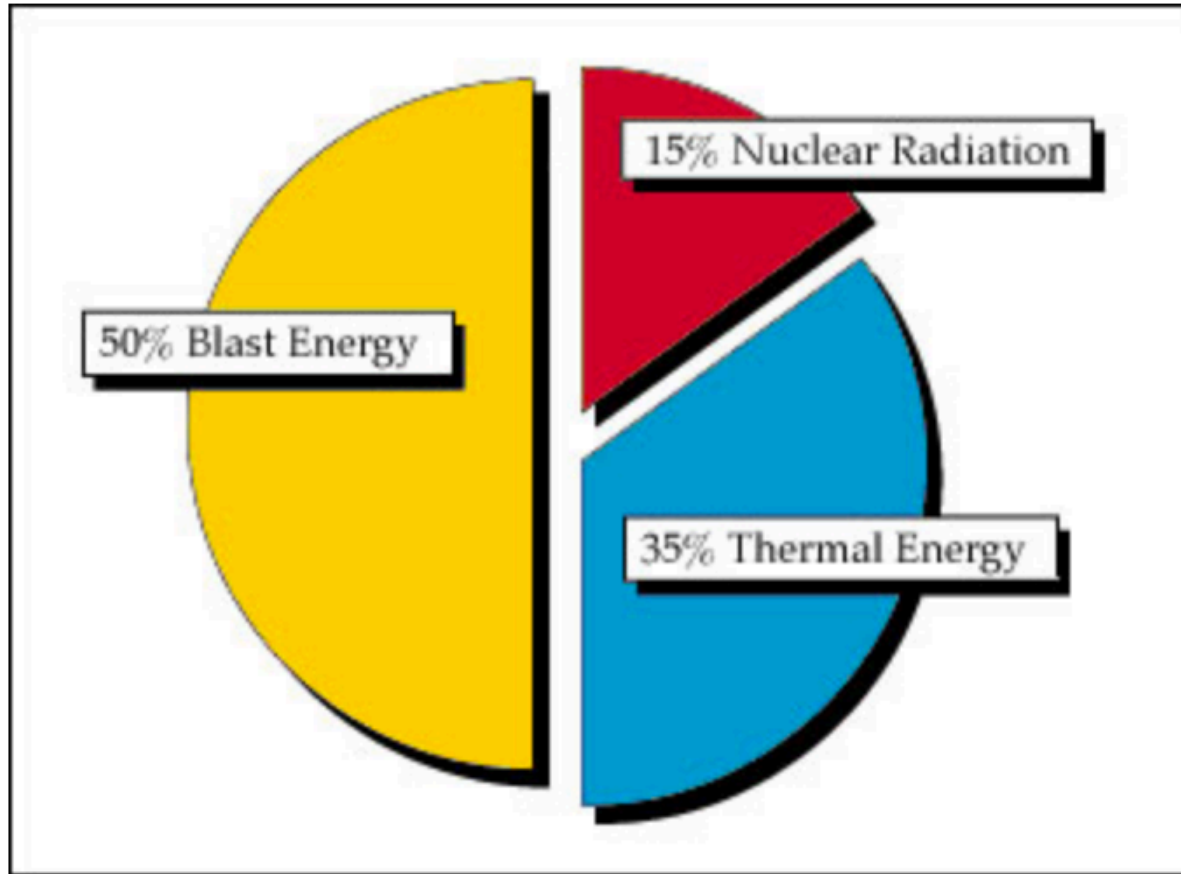
# Bomb yields are enormous

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- Hiroshima bomb: 15 kT (~ 1500 largest conventional bombs)
- Typical warhead today: roughly 300 kT (~ 20 Hiroshima bombs)

# Effects of a single bomb

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Produces fatalities from

- Blast
- Winds
- Flash burns
- Fire radiation

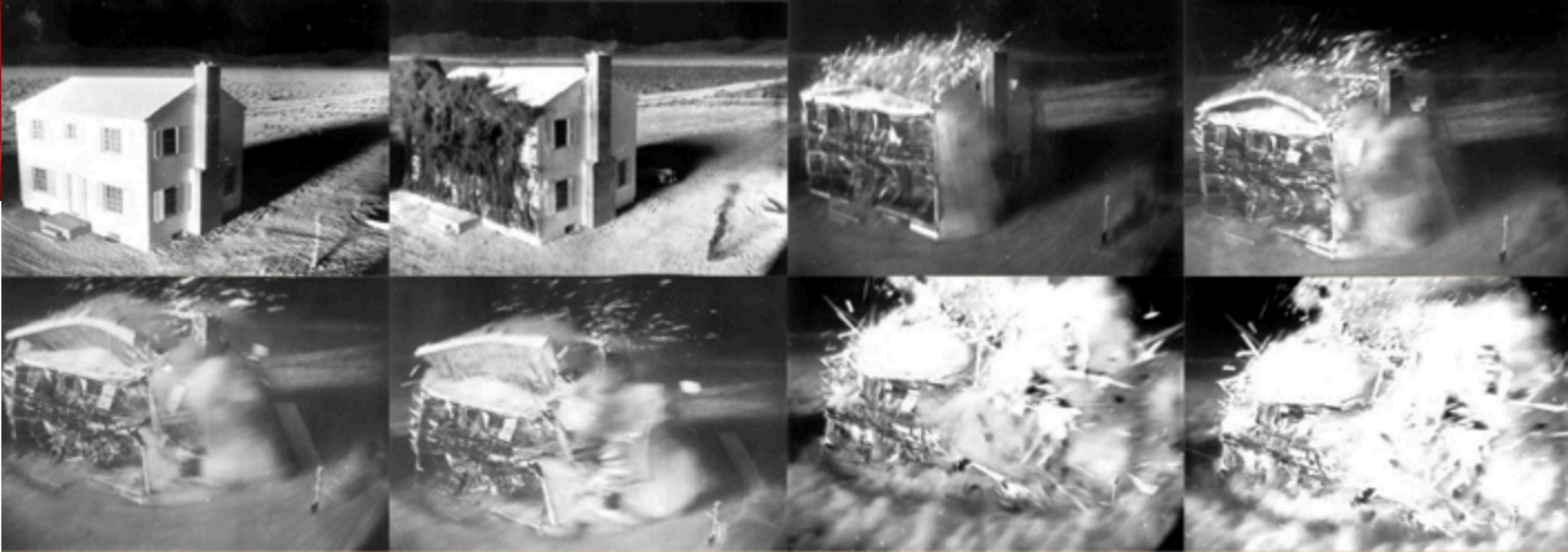
# Effects of blast wave

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At 10 psi overpressure: Commercial buildings destroyed,  
300 mph winds



1953, 16 kT  
Nevada Test  
Site

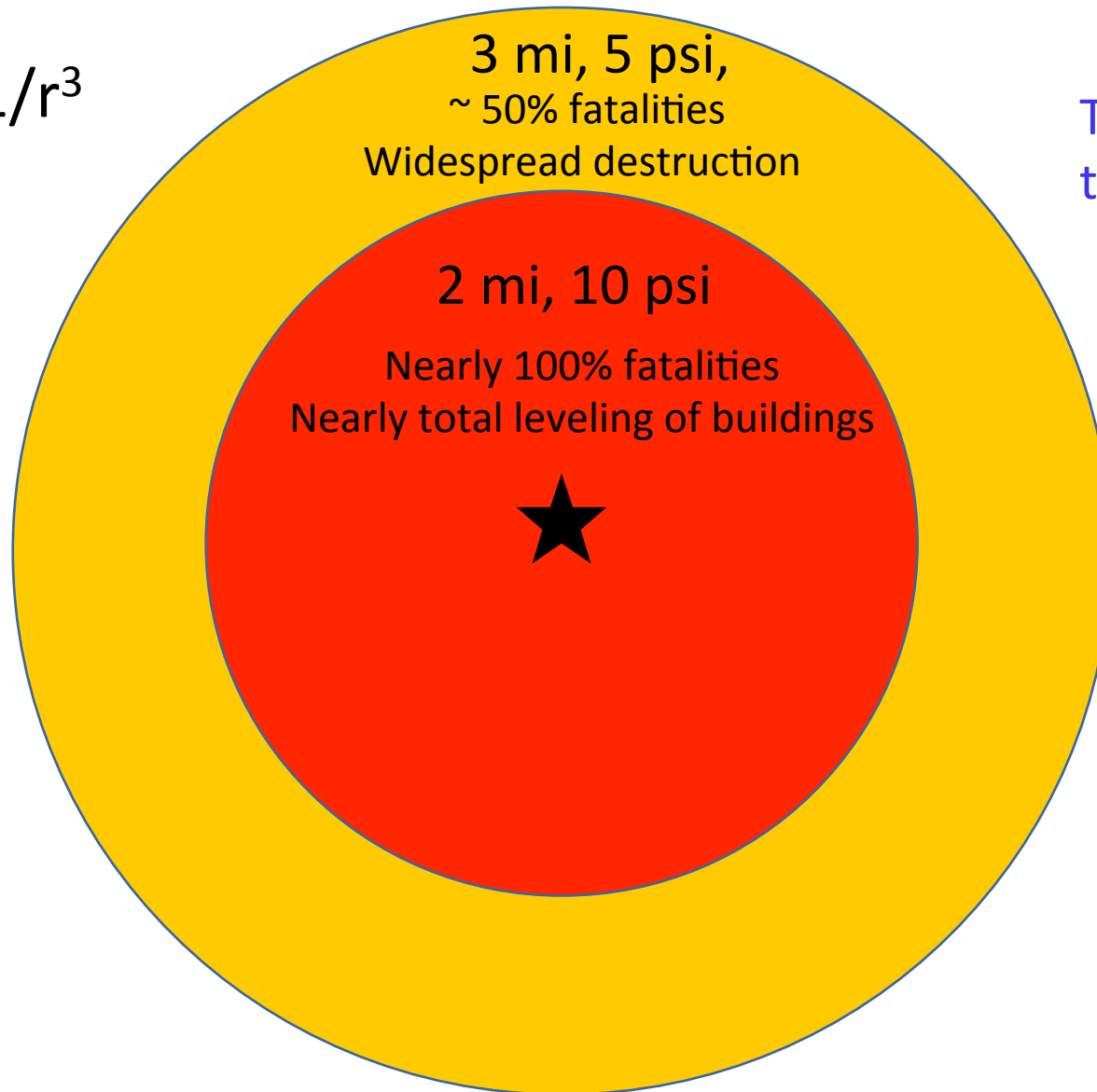


3,500 ft from bomb, 2.3 sec exposure

# Overpressure due to one warhead (350kT at 8,000 ft)

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Pressure  $\sim 1/r^3$



Third degree burns from  
thermal radiation at 4.5 miles

If detonated in New York City,  
1M dead  
2M injured

A weapon of genocide



# The Hiroshima bomb (~ 15 kT)

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*A grim calibration, > 100,000 fatalities,*

Firestorm (4 square miles)



city leveled



# The Hiroshima bomb (~ 15 kT)

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*A grim calibration, > 100,000 fatalities, burns (flash and thermal) and falling debris*  
**city leveled**

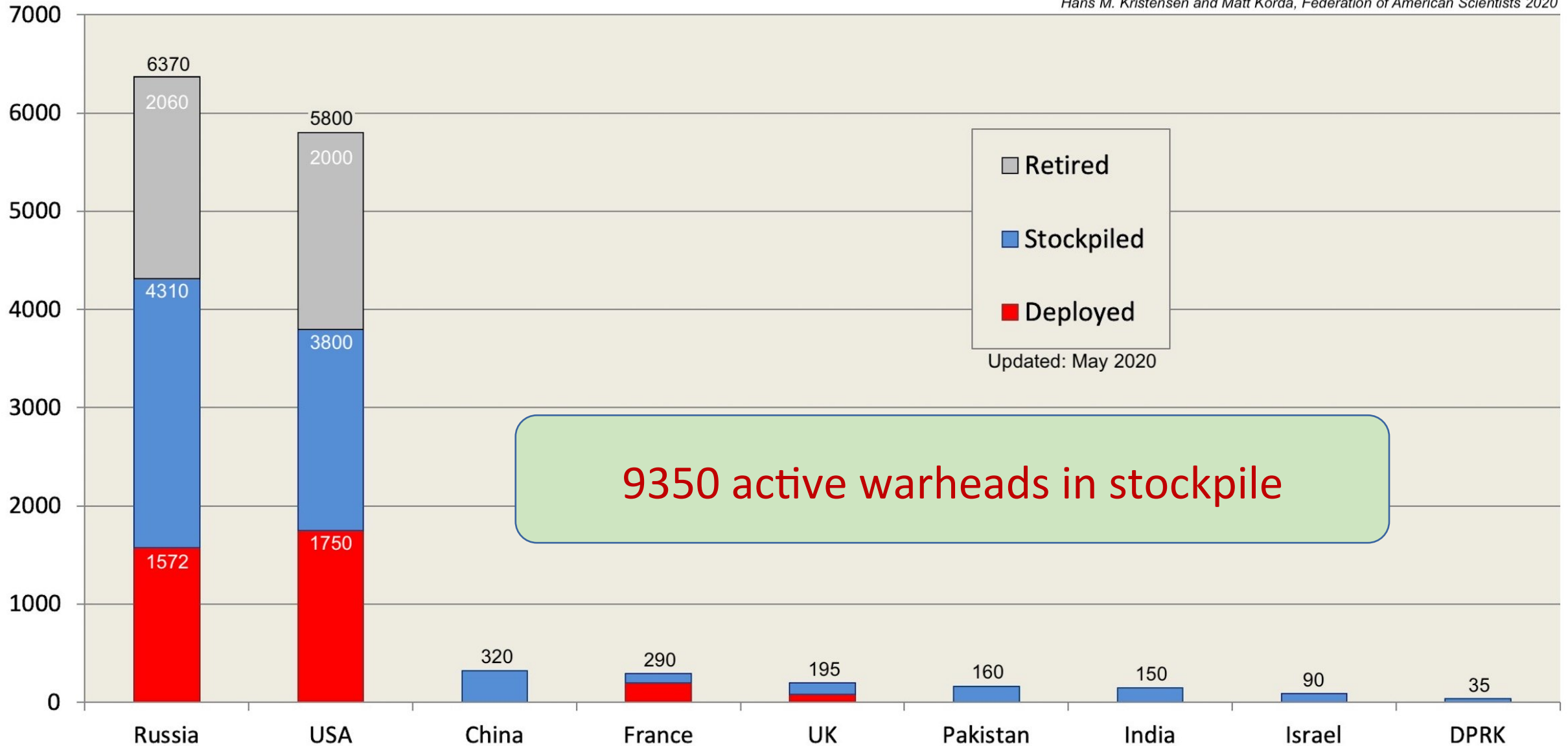
**Size of plutonium pit for  
equivalent bomb**



Nuclear weapons today

# Nuclear warheads spread over nine nations

Hans M. Kristensen and Matt Korda, Federation of American Scientists 2020





# Weapons spread across the nuclear triad

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Submarines.



Survivable, prompt

Bombers



Flexible, recallable

Underground



Prompt

## Total world arsenal

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~ several thousand MT ~ 200,000 Hiroshima bombs  
(WWII bombing totaled 3 MT)

*Can directly kill billions of people*

# Climate disruption

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- Massive fires produce carbon particles (soot)
- Heated by sun, rises to stratosphere (6 – 30 miles)
- Blocks out solar radiation
- Result: temperature and sunlight decrease

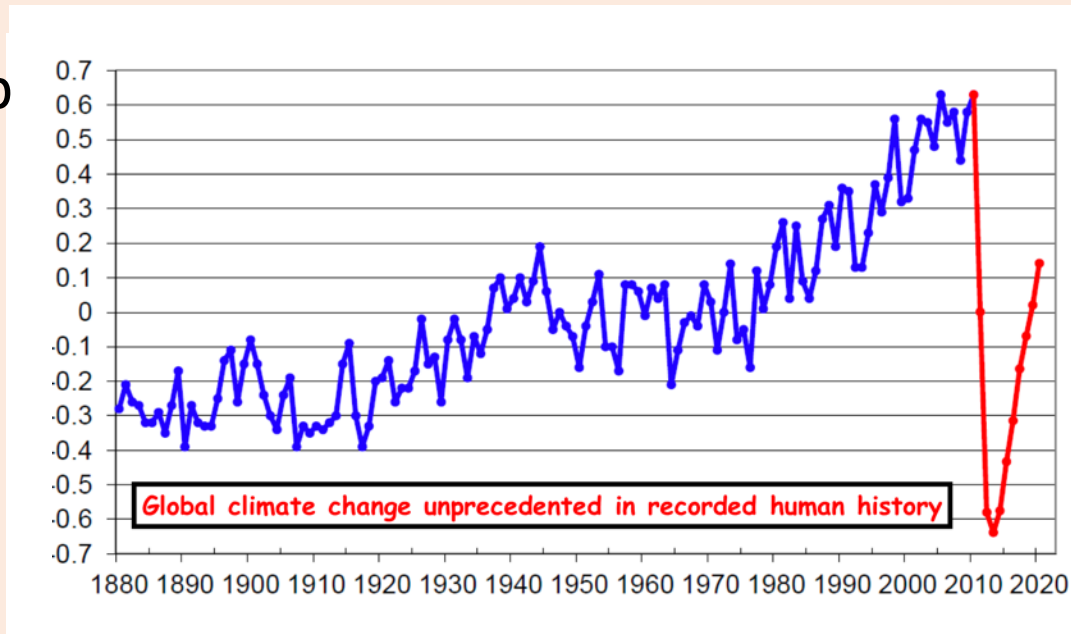


# Recent studies of “regional nuclear war”

- E.g., an India-Pakistan war exploding 100 bombs (Hiroshima size) (~ 0.1% of world arsenal),

## Global average temperature drops

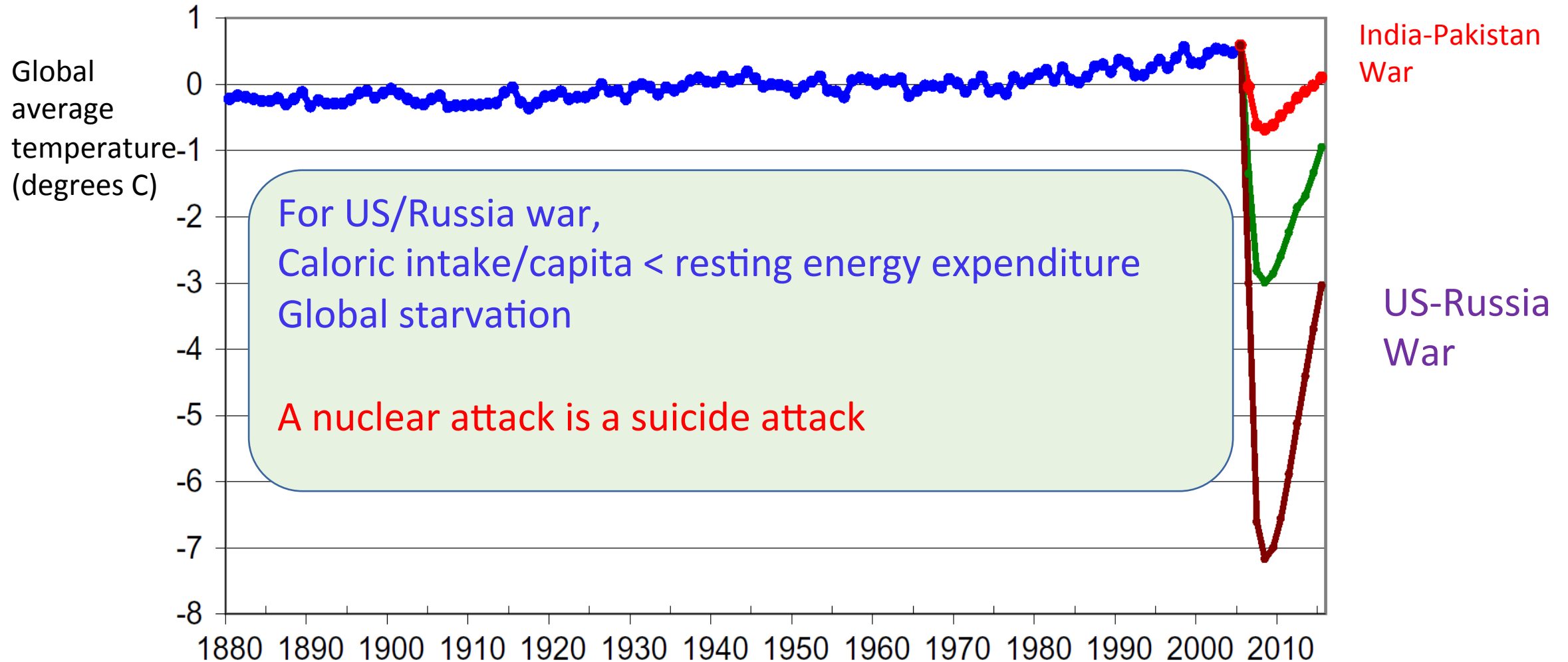
Temp  
(°C)



~ 2B people at risk of famine  
(~ 20M killed in war zone)

Kills innocent, bystanders

# Effect of a full-scale US/Russia war





# Some policies that increase the danger

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- Weapons on "hair trigger" alert
  - 1900 warheads ready to launch in minutes
  - Civilization ending
  - In US, the President sole authority to launch (and likely elsewhere)
- Launch on warning
  - < 10 minutes decision time for nuclear launch
- Absence of no-first-use policy
  - Most nuclear states reserve the right to start a nuclear war,
  - Increases nuclear tension

We have been lucky that there has been no nuclear catastrophe,

There have been many known

close calls

# !False alarms! (2 examples)

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1979: Soviet attack (200 missiles) detected by computer. ICBM missile crews put on high alert, nuclear bombers prepared for takeoff. **Cause: computer simulation mistaken as a real attack**

1995: Russian radar detected a US sub-launched missile to strike in 15 minutes. Russian nuclear forces went on full alert. Yeltsin retrieved nuclear launch codes. **Cause: US scientific rocket to study aurora.**

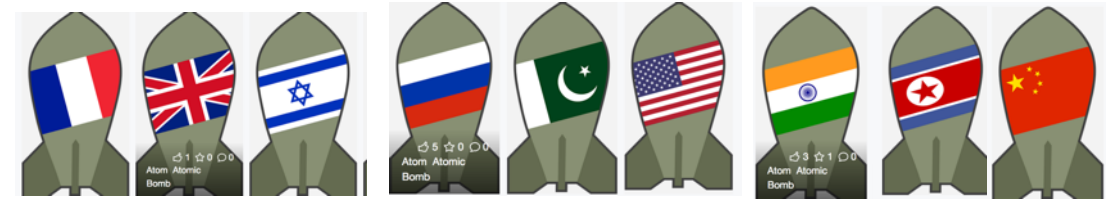
**And many more...**

In all cases, someone judged or intuited the alarm to be false,

Sometimes disobeyed orders to avoid a nuclear response

# Increasing nuclear dangers – a collapsing nuclear world order

- Gradual proliferation, multipolar and complex (more accident-prone, less controllable)



# The increasing nuclear dangers

- Gradual proliferation, multipolar and complex
- New cyber attacks

can provide false warning, or hide real attack

can enable unauthorized use of warhead

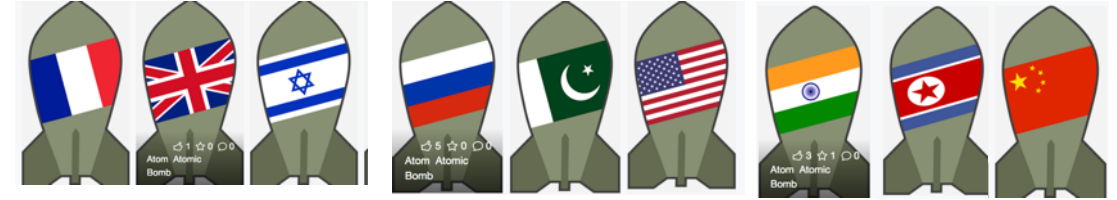
etc



See, for example, Nuclear Threat Initiative report, 2018

# The increasing nuclear dangers

- Gradual proliferation, multipolar and complex
- New cyber attacks
- Collapsing of arms control treaties



**ABM  
Treaty**

US withdrew  
2002

**Iran Nuclear  
Deal**

US withdrew  
2018

**Intermediate  
Nuclear Forces  
Treaty**

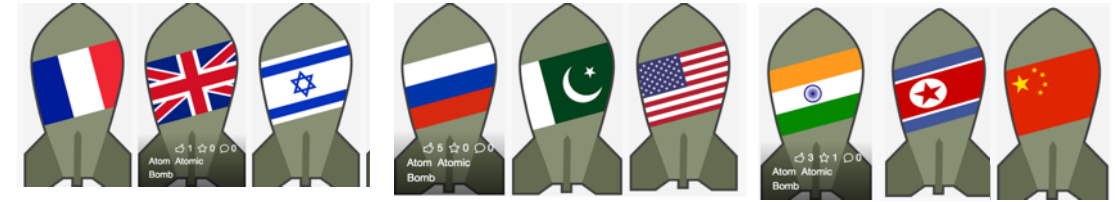
US, Russia withdrew  
2019

**Open Skies  
Treaty**

US, Russia withdrew  
2020

# The increasing nuclear dangers

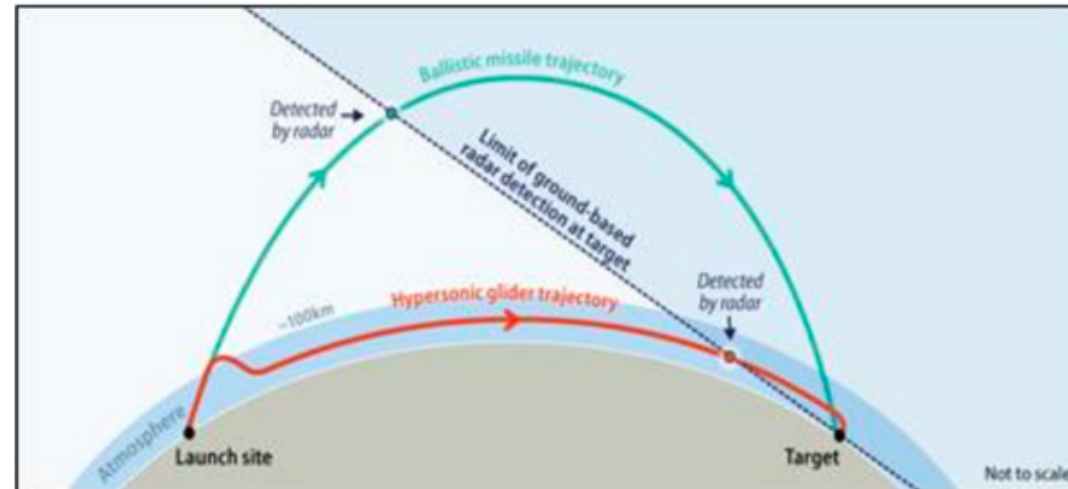
- Gradual proliferation, multipolar and complex
- New cyber attacks
- Near collapse of arms control regime
- A new nuclear arms race!



- Weapon modernization in several nations,  
> \$1T in US (commitment to end of century)

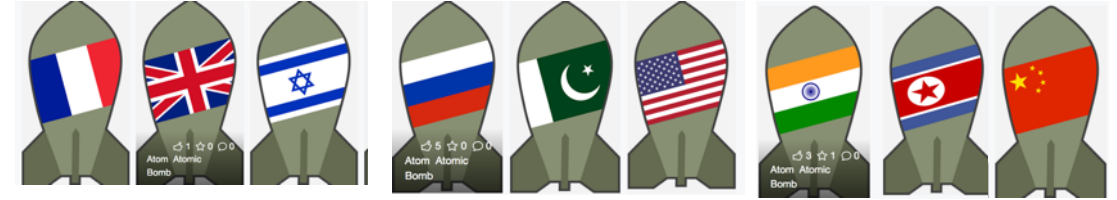


- New weapons and defenses in US, Russia, China (low-yield, hypersonics, torpedos)



# The increasing nuclear dangers

- Gradual proliferation, multipolar and complex
- New cyber attacks
- Near collapse of arms control regime
- A new nuclear arms race



William Perry, former Secretary of Defense:

*“Today [2015], the danger of some sort of a nuclear catastrophe is greater than it was during the Cold War, and most people are blissfully unaware of this danger”*



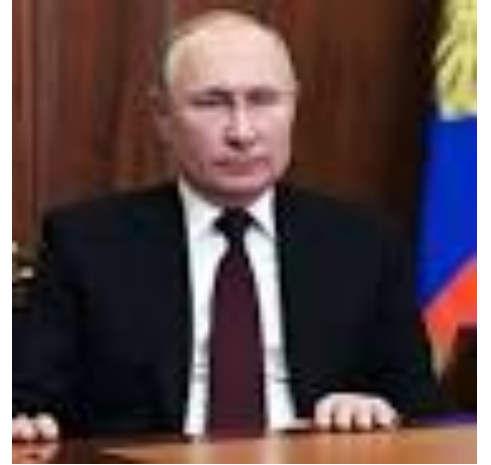
And, during the current Ukraine crisis,

Putin puts Russia's nuclear forces on "combat duty alert"

and he stated

*"Whoever tries to interfere with us .....will lead you to such consequences as you have never experienced in your history."*

*Russia "is today one of the most powerful nuclear states."*



# Some observations

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- The current nuclear risk is predictable, just not the details
- The world is held hostage to the psychology of one man
- The problem is intrinsic to the weapons.  
We are not safe, no matter who owns them.

Public pressure on governments is needed,

Governments can act to reduce the threat

Some examples from the past →

# Nuclear Non-Proliferation Treaty (1970)

Non-nuclear weapon states agreed not to develop weapons.

The five nuclear weapon states agreed to work toward

*“cessation of the nuclear arms race at an early date and to nuclear disarmament.....”*



result:

over 50 years, “only” expanded from 5 to 9 nuclear weapon states,

BUT, nuclear weapon states have not disarmed

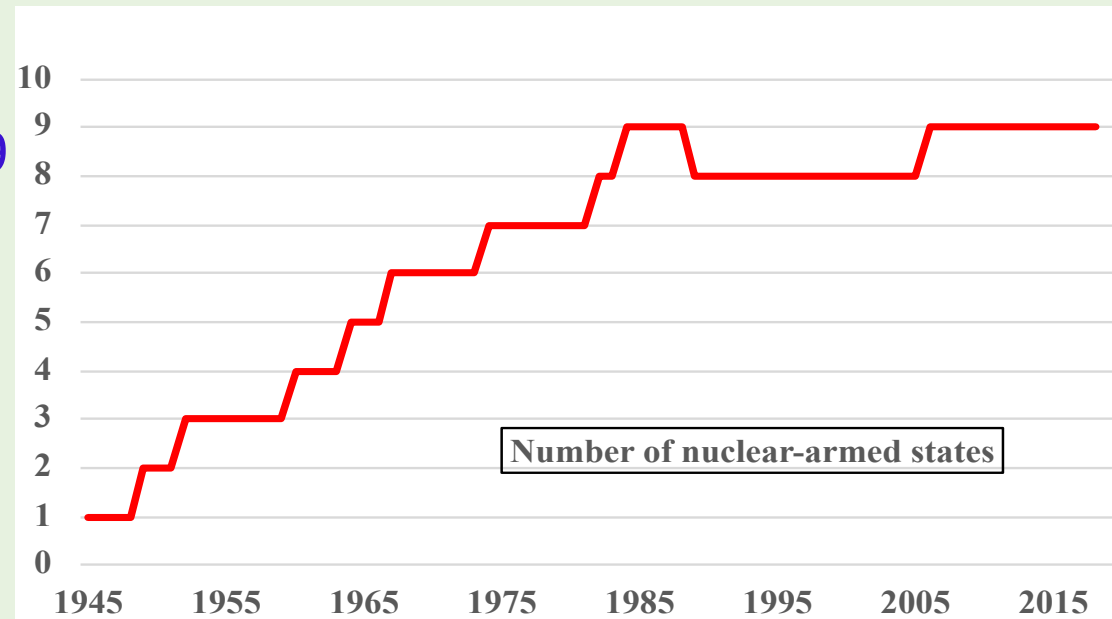
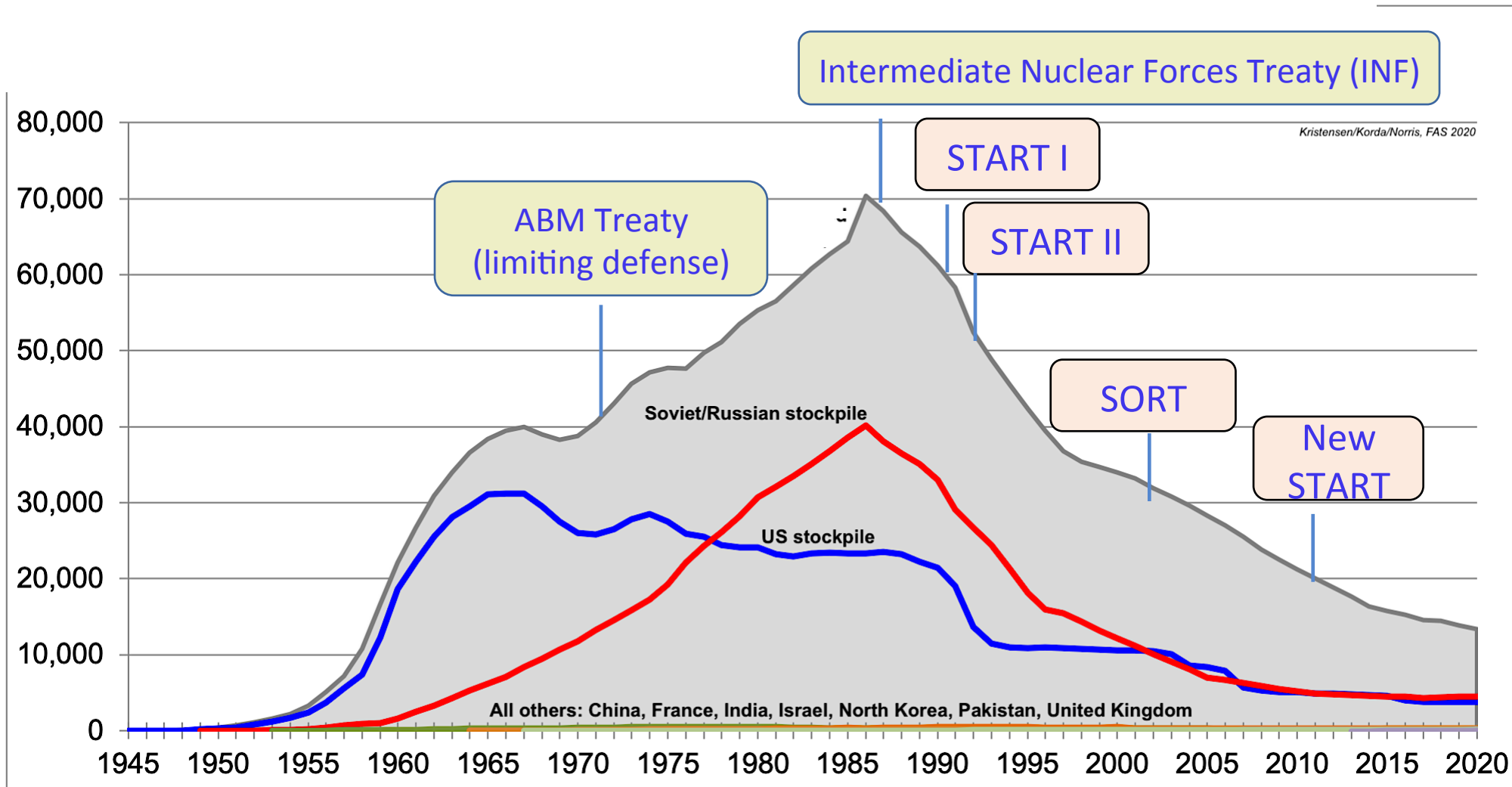


Figure: courtesy of F. von Hippel

# Dramatic reduction in number of warheads



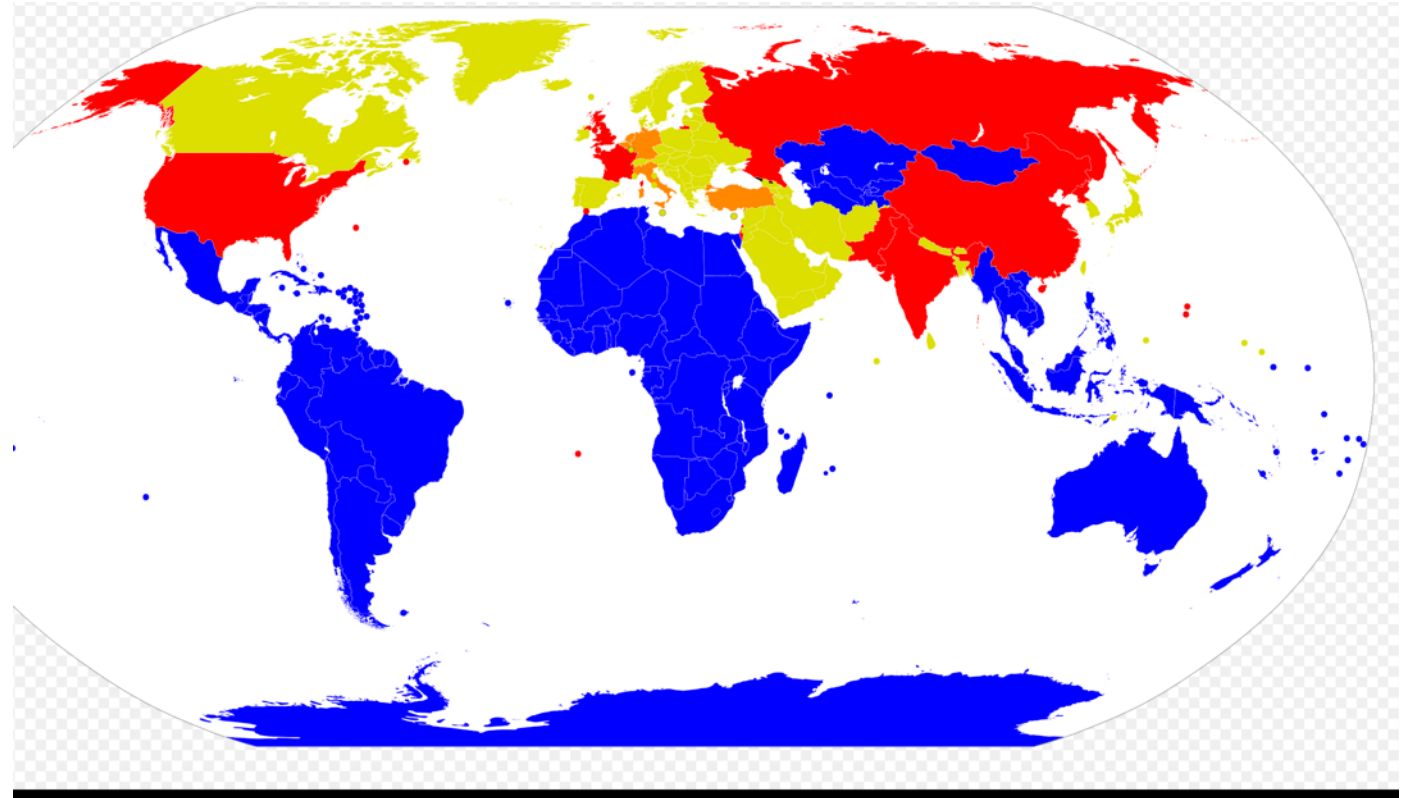
# Nuclear Weapon Free Zones

Six treaties establish regions that prohibit nuclear weapons  
(from manufacture to possession),

Treaties cover: Latin America,  
the South Pacific  
Southeast Asia  
Central Asia  
Africa  
Antarctica



Blue = NWFZ, Red = NW state



All of southern hemisphere

# Physicists as citizen-scientists (since the origins)

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1945 Franck report suggesting demonstration of bomb, no first use (7 signers)

1945 Szilard petition arguing against use, warning of arms race  
(70 signers from Manhattan Project)

1946 Einstein and the Emergency Committee of Atomic Scientists issued warnings

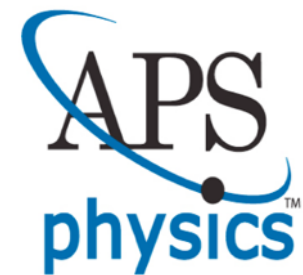
1957 Gottingen Manifesto, 18 German physicists oppose nuclear weapons development

1958 Petition to end nuclear testing; 9000 scientists, 43 nations, led by L. Pauling

H. Bethe: *“I call on all scientists in all countries to cease and desist from work creating, developing, improving and manufacturing further nuclear weapons...”* (1995)

# The Physicists Coalition for Nuclear Threat Reduction

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A national network

(Managed by the Princeton Program on Science and Global Security)

## Goals

- Education: Inform and engage the physics community
- Advocacy: Build the Coalition for organized advocacy  
(by informed citizen-scientists, not experts)

Open to all physical scientists

Can be an influential voice for nuclear threat reduction



# Physicists Coalition: the past two years

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The Coalition leadership Team has

Presented > 100 colloquia, 8 webinars

Recruited 850 members

Coalition members have lobbied the US Congress on specific goals

We are now reaching out internationally,

For dialogue, possible joint activities.....,

There are 9 nuclear weapon states and about 30 states in the US nuclear umbrella,

And the problem affects everyone

Much can be done to put the nuclear genie back in the bottle

Discussion welcome at this meeting

Coalition website: [physicistscoalition.org](http://physicistscoalition.org)

Contact: [sprager@princeton.edu](mailto:sprager@princeton.edu)

