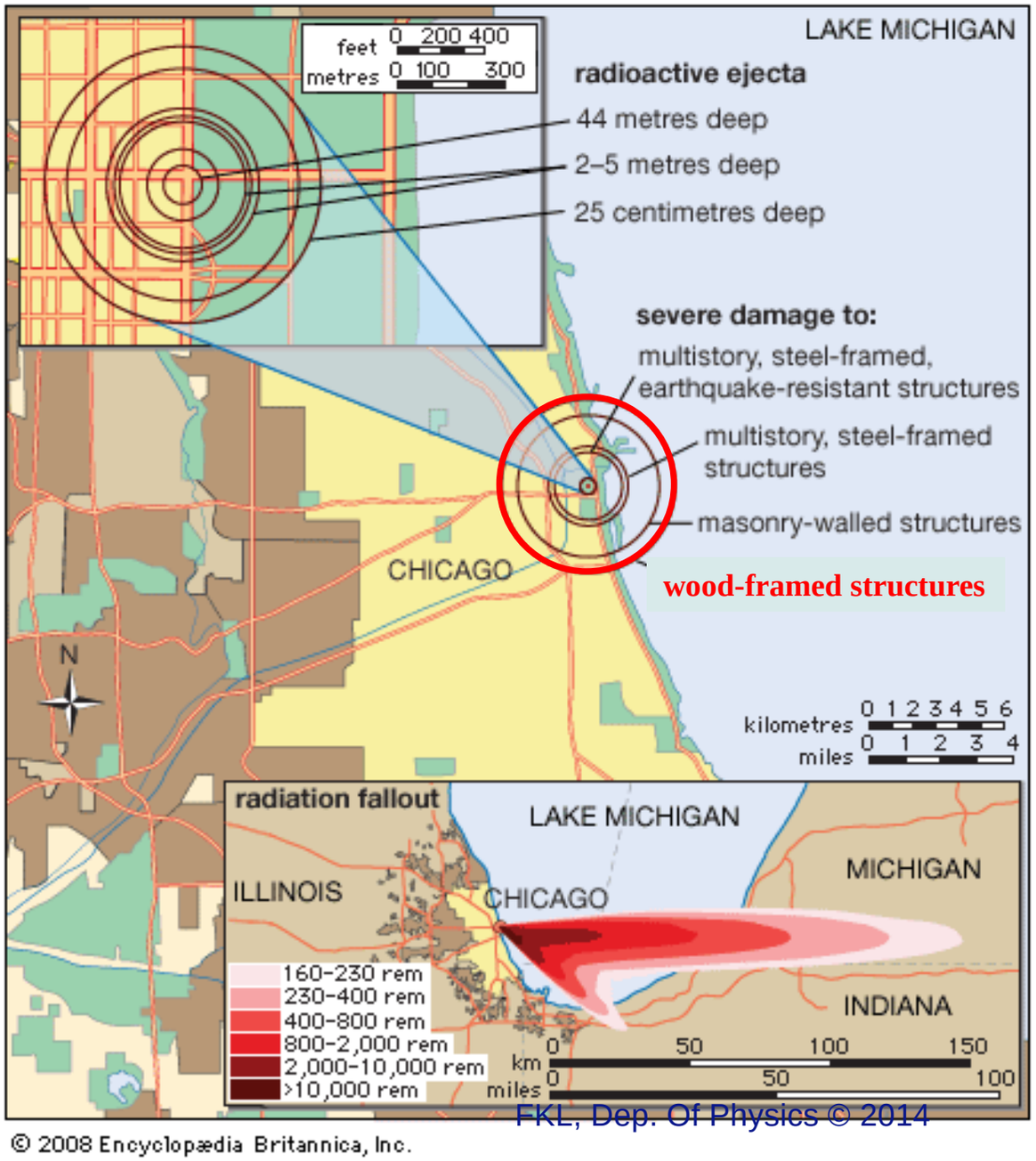
Physics 280: Session 8

Plan for This Session

NEM summary

Module 3:
Effects of nuclear explosions

Impact of a 500 kiloton device detonated in Chicago



IAEA for Talk in Tehran (Wall Street Journal, 2-7)

U.N. Experts to Press Iran on Nuclear Weapons Suspicions

Upcoming Talks in Tehran to Focus on Activity Before 2003

By
Laurence Norman
Feb. 7, 2014 6:34 p.m. ET

BRUSSELS—United Nations experts will press Iran this weekend to start addressing long-standing Western suspicions about the military dimension of past nuclear activities.

Tehran for years denied its nuclear work had any military purpose. But it has stalled on international demands to answer questions about detailed allegations that it has worked on nuclear weapons.

The U.N. nuclear watchdog is seeking explanations about work mainly carried out before 2003 that would enable Iran to one day assemble a nuclear weapon relatively quickly. …

…Western officials said if Iran moves swiftly and fully to answer the concerns, it could avoid being pushed for public disclosure of all past activities and won't be backed into a corner over past statements.

If Iran doesn't convincingly address these questions, it will likely undermine negotiations with six world powers aimed at imposing strict controls over the country's future nuclear activities in return for relief from international sanctions. …

… In last month's paper, Mark Hibbs, Senior Associate, Nuclear Policy Program at the Carnegie Endowment and Andreas Persbo, a nuclear expert at arms verification group VERTIC, said that in at least two cases, the IAEA agreed to shut the file on a country's nuclear program when authorities made a clear decision to convert to purely civilian purposes. South Africa in the early 1990s is one example.

Should P5+1 talks start with "clean slate" as long as Iran answers questions concerning past activities to weaponize nuclear devices?

Two Articles to Read for Writing Labs on Monday

http://online.wsj.com/news/articles/SB10001424052702304450904579369070043715130

http://carnegieendowment.org/2014/01/20/handling-iran-s-weaponization-file/gz1u

Summary Nuclear Explosive Materials (Very Important)

- Uranium —
  - –LEU: < 20% U-235
  - –Weapons-usable HEU: > 20% U-235
  - –Weapons-grade HEU: > 80% U-235

- Plutonium —
  - –Reactor-grade: < 80% Pu-239 (e.g., light-water)
  - –Fuel-grade: 80% to 93% Pu-239
  - –Weapons-grade: > 93% Pu-239

Impact of the 15 kiloton detonation in Hiroshima on wood-framed structures

14p280 Nuclear Explosions, p. 5

Module 3: Effects of Nuclear Explosions

Topics covered in this module —

- Weapons of mass destruction
- Overview of weapon effects
- Effects of thermal radiation
- Effects of blast waves
- Effects of nuclear radiation
- Possible effects of nuclear war

Effects of Nuclear Explosions

Definition:

"Weapons of Mass Destruction"

“Weapons of Mass Destruction”

Even a simple fission device can release *a million times* more destructive energy per kilogram than conventional explosives.

Nuclear weapons are the only weapons that could —

- Kill millions of people almost instantly
- Destroy the infrastructure and social fabric of the United States

While the use of chemical and biological weapons can have grave consequences:

Only nuclear weapons are “weapons of mass destruction” and can threaten the survival of the U.S.

Chemical Weapons

A chemical weapon is a device that releases toxic chemicals.

Release of toxic chemicals in a city would not cause mass destruction but would —

- create fear
- disrupt normal activities
- possibly cause a large number of casualties.

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If dispersed effectively, a chemical agent could contaminate a substantial area.

If toxic enough, it might cause 100s or even 1,000s of casualties, but it would not destroy buildings or vital infrastructure.

Precautions before and rapid medical treatment and decontamination after such a release would reduce substantially the number of casualties, especially for less deadly agents.

Chemical Weapons

gas attack during World War I, 190,000 tons of Gas caused less than 1% of all combat deaths, ~100,000 deaths 1915-1918

Biological Weapons

Release of a biological agent would create fear and disrupt normal activities, but would not cause mass destruction.

In order to cause mass casualties, substantial amounts of agents such as anthrax, smallpox, and plague would have to be converted into tiny particles and then dispersed in an aerosol.

Because these agents are so deadly, the required forms and the equipment needed to disperse them are difficult to come by.

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A pathogen such as anthrax that does not produce contagious disease could be used to attack a particular building or area.

A pathogen such as smallpox that produces a deadly contagious disease would be a "doomsday" weapon, because it could kill millions of people worldwide, including the group or nation that released it.

In countries with an effective public health service, prompt quarantine, vaccination, and other measures could reduce greatly the number of casualties, the area affected, and the time required to get the disease under control.

In less-developed countries, a contagious deadly disease could be devastating.

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Nuclear Weapons

In contrast to a chemical or biological agent, a “small” (10 kiloton) nuclear weapon detonated in a major city would kill more than 100,000 people and reduce tens of square kilometers to rubble almost instantly.

Even a crude nuclear device that fizzled would destroy many square kilometers of a city and kill tens of thousands of people.

A large (1 megaton) nuclear weapon could kill millions of people and destroy hundreds of square kilometers within a few seconds.

Those who survived a nuclear explosion would have to deal with severe physical trauma, burns, and radiation sickness. Vital infrastructure would be destroyed or damaged, and radioactivity would linger for years near and downwind of the explosion.

Unlike the effects of a chemical or biological weapon, the devastating effects of a nuclear weapon on a city cannot be reduced significantly by actions taken before or after the attack.

Radiological Weapons

A radiological weapon is a device that spreads radioactive material
(most likely isotopes used would not be nuclear explosive nuclides!)

Such a weapon is a weapon of mass *disruption*, not mass *destruction.*

Dispersal of a substantial quantity of highly radioactive material in a city would *not* —

- physically damage structures
- immediately injure anyone

It could —

- contaminate a few city blocks with highly radioactive material
- contaminate a larger area with more weakly radioactive material

If explosives were used to disperse the material, the explosion could cause a small amount of damage and some injuries.

Depending on their exposure to radiation and how they were treated afterward —

- 100s or perhaps even 1,000s of people could become sick
- a larger number could have a somewhat higher probability of developing cancer or other diseases later in life

The main effect would be to create fear and disrupt normal activities.

Use of the Term “Weapons of Mass Destruction”

Some lump together as “WMD”—

- radiological weapons (“dirty bombs”)
- chemical weapons
- biological agents
- nuclear weapons

Broadening the definition of “WMD” can have the following consequence:

- nuclear weapons appear no different from other weapons
- make chemical and biological weapons appear as dangerous as nuclear weapons and therefore a justification for war or even nuclear war

This language obscures the profound differences in

- the lethality and destructiveness of these weapons
- the timescales on which their effects are felt
- the possibility of protecting against them (or not)

In Physics 280, we will avoid the term “WMD”. Instead, we will say what we mean: “nuclear weapons”, “chemical weapons”, or “biological weapons”.

Theft of Nuclear Material in November 2013

Stolen cobalt-60 found in Mexico; thieves may be doomed

By Gabriela Martinez and Joshua Partlow, Published: December 4

MEXICO CITY — Mexico's public-health scare turned into a logistical hurdle Thursday as authorities sought to safely put a stolen load of radioactive material back into its container.

As officials worked on the material, federal police and soldiers formed a cordon of several hundred yards around the field in Hueypoxtla where a container of highly radioactive cobalt-60 was abandoned after it was stolen from truck drivers transporting it to a storage facility in central Mexico.

The International Atomic Energy Agency (IAEA) said the "extremely dangerous" cargo of pellets used in hospital radiotherapy machines had been removed from its protective casing, but "there is no indication that it has been damaged or broken up" and there is "no sign of contamination to the area."

The theft of the material sparked international concern because of the possibility that the cobalt-60 could be used … ?

iClicker Question

The theft of Co-60 in Mexico caused international concern as

(A) Co-60 is a fertile material and can be used to breed fissile nuclides.

(B) Co-60 is a NEM and can be used in nuclear weapons.

(C) Co-60 could be used in a radiological weapon.

(D) Co-60 is radioactive, highly toxic and can be dispersed easily as a chemical weapon.

iClicker

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iClicker Question

Could a terrorist group construct a workable bomb using reactor-grade plutonium?

(A) No

(B) Yes, but with difficulty

(C) Yes, easily

iClicker

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Effects of Nuclear Explosions

Overview of Nuclear Explosions

Effects of Nuclear Explosions (Overview)

- Effects of a single nuclear explosion
  - Prompt nuclear radiation
  - Electromagnetic Pulse (EMP)
  - Thermal radiation
  - Blast wave
  - Residual nuclear radiation (“fallout”)
  - Secondary effects (fires, explosions, etc.)

- Possible additional effects of nuclear war
  - World-wide fallout
  - Effects on Earth’s atmosphere and temperature
  - Effects on physical health, medical care, food supply, transportation, mental health, social fabric, etc.

Credit:

Nuclear Energy Released in a Nuclear Explosion

The total energy released is the “yield” Y

Y is measured by comparison with TNT

By definition —

- 1 kiloton (kt) of TNT = 10^{12} calories
- 1 Megaton (Mt) of TNT = 1,000 kt = 10^{15} calories

1 calorie = the energy required to heat 1 gram of H_2O by 1 degree Celsius (C) = 4.2 J

(1 dietary Calorie [Cal] = 1,000 calories = 1 kcal.)

The nuclear energy is released in less than 1 micro second!

Initial Distribution of Energy From Any Nuclear Explosion (Important)

After ~ 1 microsecond —

- Essentially all of the energy has been liberated
- Vaporized weapon debris has moved only ~ 1 m
- Temperature of debris is ~ 10^7 C (~ center of Sun)
- Pressure of vapor is ~ 10^6 atmospheres

The energy is *initially* distributed as follows —

• Low energy X-rays (1 keV)	~ 80%
• Thermal energy of weapon debris	~ 15%
• Prompt nuclear radiation (n, γ, β)	~ 5%

Subsequent Evolution of Nuclear Explosions

What happens next depends on —

- The yield of the weapon
- The environment in which the energy was released

It is largely independent of the weapon design.

iClicker Question

A nuclear weapon test is carried out in space. A satellite 20 miles away is used to measure the energy released from the explosion. What does it find?

(A) The low energy gamma rays have been absorbed by the weapon debris and almost all energy is in the kinetic energy of the debris.

(B) 80% of the energy is carried by low energy gamma rays.

(C) At the distance of the satellite the debris has slowed and all energy is carried by low energy gamma rays.

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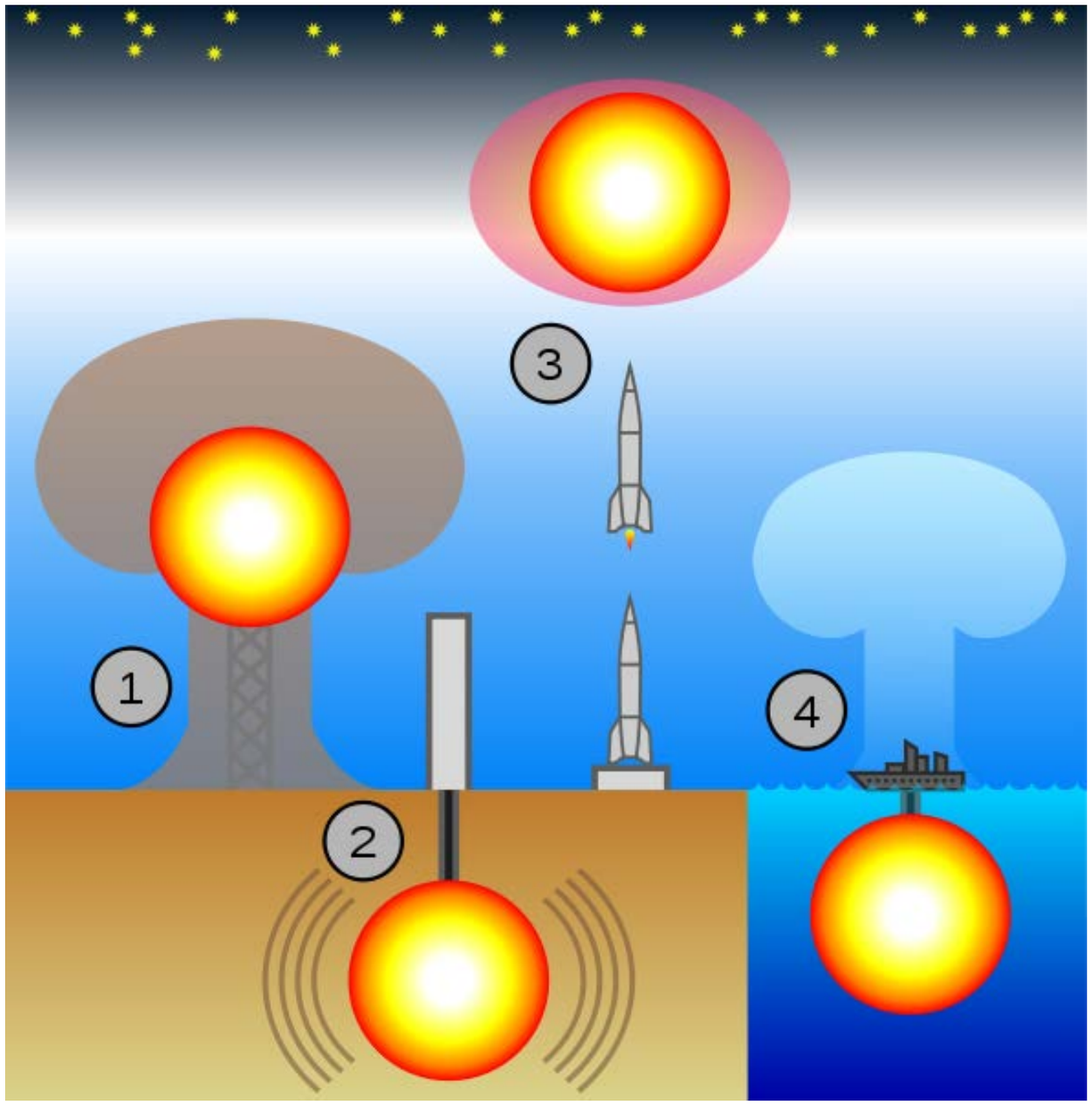
Nuclear Explosions



Credit: Wikipedia (nuclear weapons testing)

Possible environments —

1. Air and surface bursts

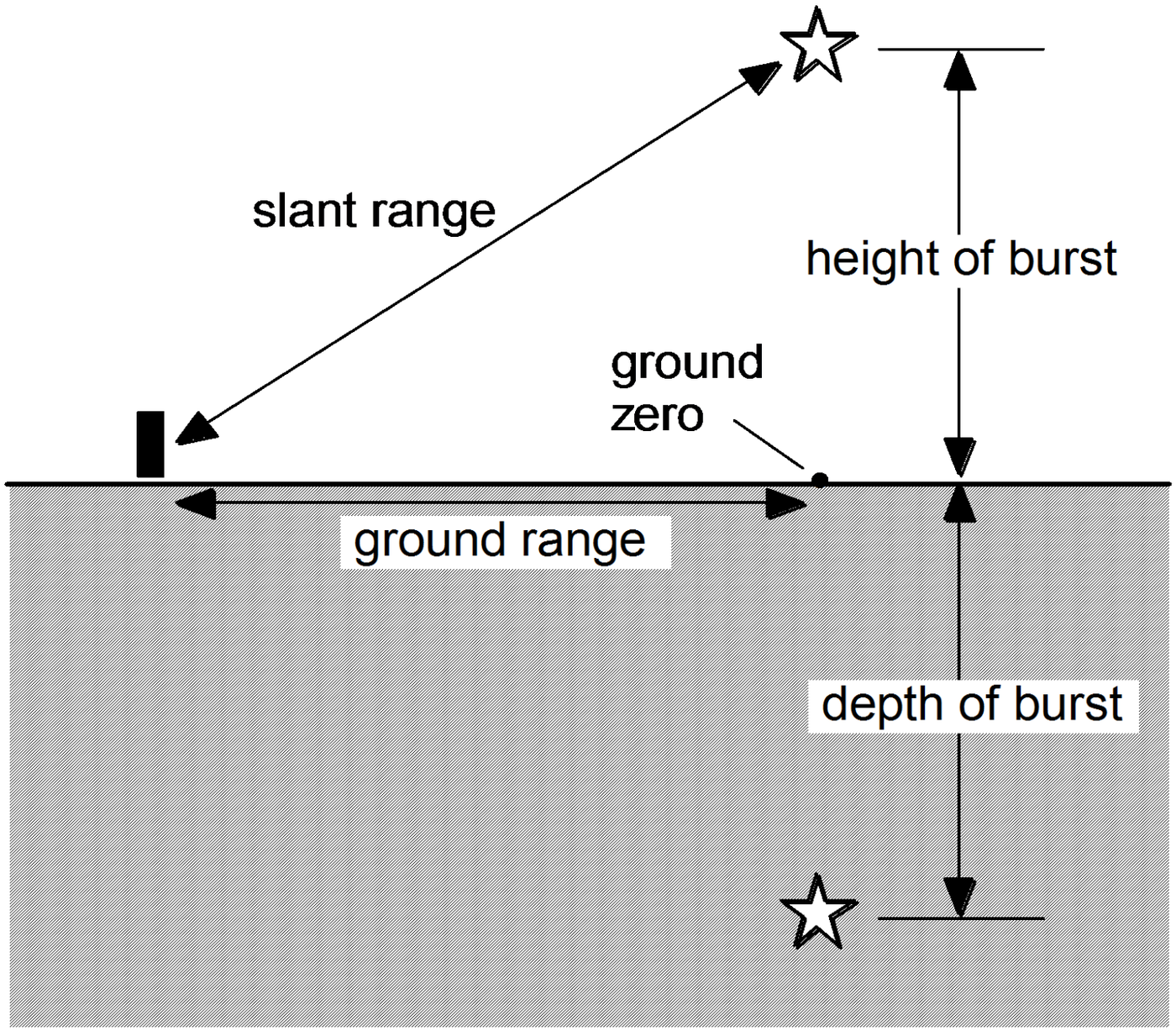
2. Underground bursts

3a. Explosions at high altitude (above 30 km)

3b. Explosions in space

4. Underwater bursts

Nuclear Explosion Geometries

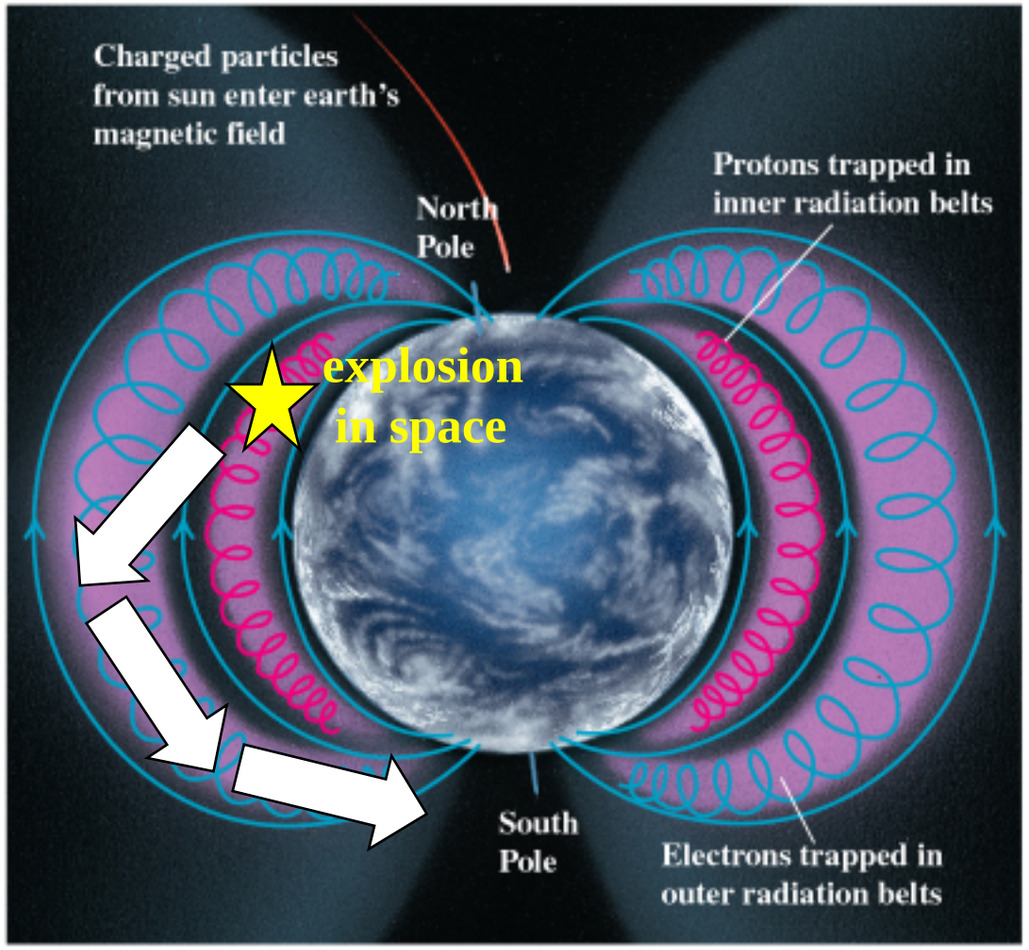


Nuclear Explosions in Space

The U.S. exploded nuclear weapons in space in the late in 1950s and early 1960s –

- Hardtack Series (Johnston Island, 1958)
  - —Teak (1 Mt at 52 miles)
  - —Orange (1 Mt at 27 miles)
- Fishbowl Series (1962)
  - —Starfish (1.4 Mt at 248 miles)
  - —Checkmate (sub-Mt at tens of miles)
  - —Bluegill (sub-Mt at tens of miles)
  - —Kingfish (sub-Mt at tens of miles)

Charged particles trapped in the earch magnetic field Van Allen Radiation Belt



(a)

Led to discovery of the Electromagnetic Pulse (EMP) and damage to satellites by particles trapped in the geomagnetic field

Underground Nuclear Explosions

Fully contained (no venting) —

- No debris from the weapon escapes to atmosphere
- No ejecta (solid ground material thrown up)
- Subsidence crater may form in hours to days
- No radioactivity released (except noble gasses)
- Characteristic seismic signals released

Partially contained (some venting) —

- Throw-out crater formed promptly (ejecta)
- Radiation released (mostly delayed)
- Characteristic seismic signals released
- Venting is forbidden for US and Soviet/Russian explosions by the LTBT (1974) and PNET (1974)

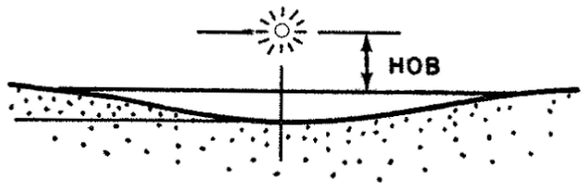
Underground Nuclear Explosions- Nevada Test Site

http://www.nv.doe.gov/library/photos/testprep.aspx

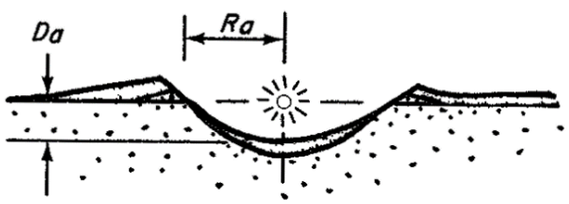
Underground Nuclear Explosions: Test Deployment & Assembly

http://www.nv.doe.gov/library/photos/testprep.aspx

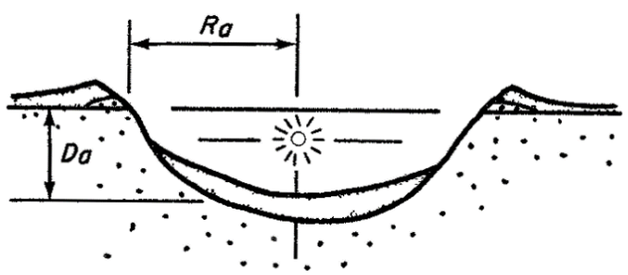
Crater Formation vs DOB



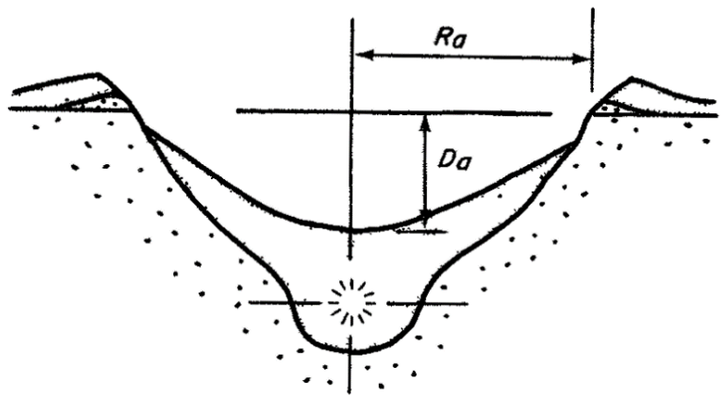
a. NEAR SURFACE BURST



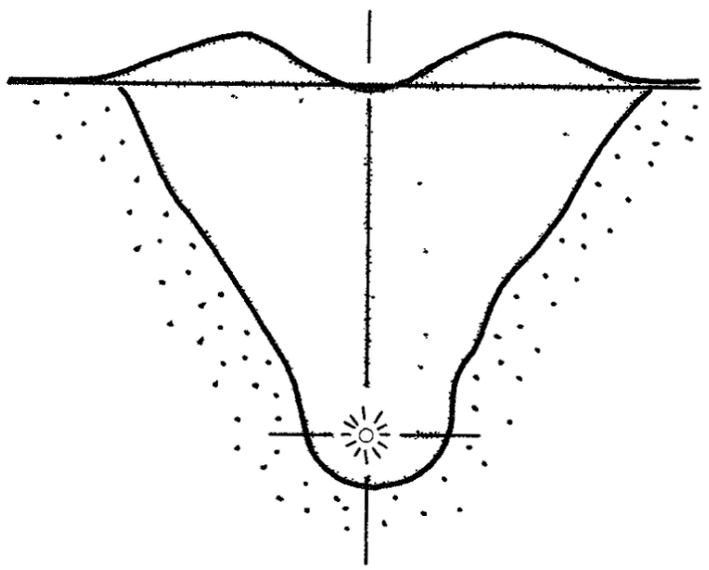
b. SURFACE BURST



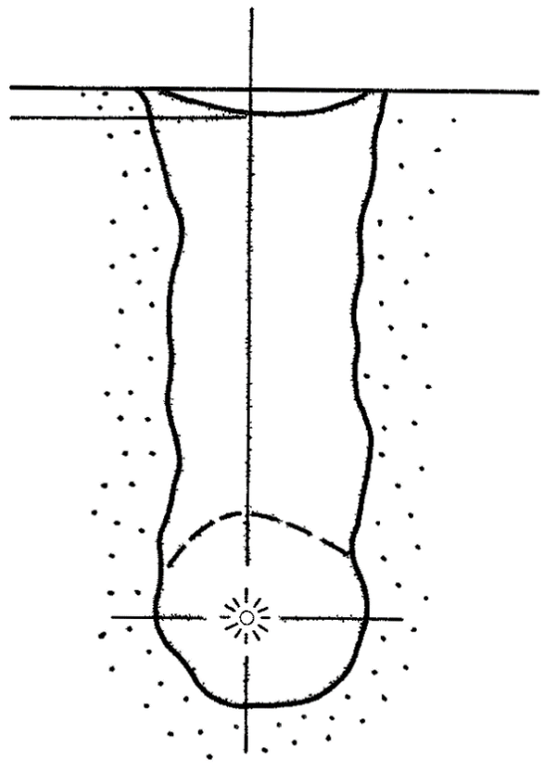
c. SHALLOW DOB



d. OPTIMUM DOB



e. DEEPLY BURIED



f. SUBSIDENCE CRATER

Underground Nuclear Explosions- Nevada Test Site

Total of 904 tests
at the Nevada test site

http://www.nv.doe.gov/library/photos/craters.aspx

iClicker Question

In you opinion, can underground nuclear weapon test be carried out undetected?

(A) Yes, if tested at sufficient depth.

(B) No, radioactive noble gases escape and can be detected.

(C) No, seismic waves caused by the explosion can be detected.

(D) No, sound waves from the explosion travel long distances through earth's crust and can be detected.

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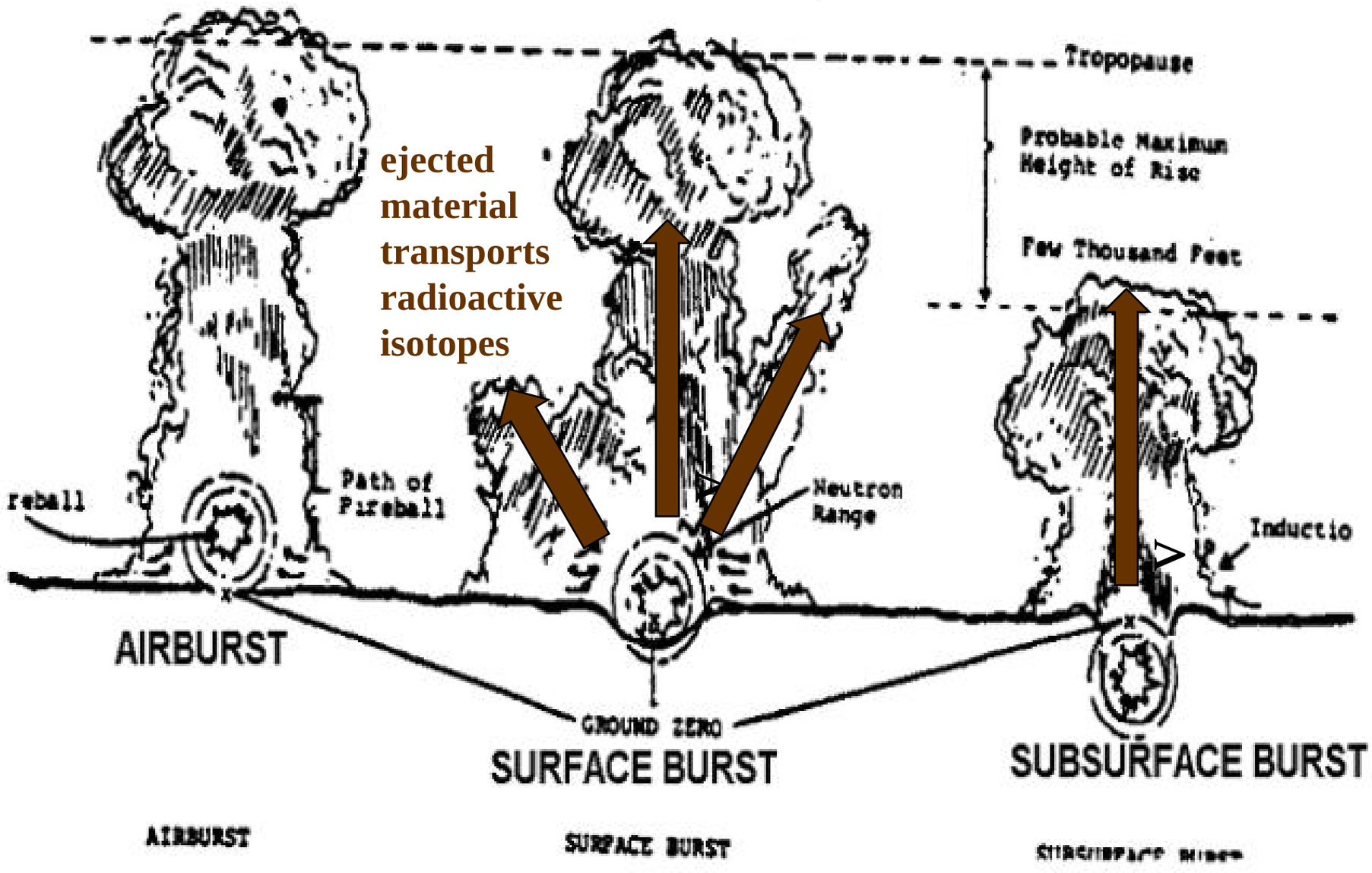
Nuclear Explosions in the Atmosphere or a Small Distance Underground



The amount of radioactive fallout is increased greatly if the fireball ever touches the ground.

Will the Fireball Touch the Ground?

The HOB needed to prevent the fireball from touching the ground increases much more slowly than the yield—a 6x increase in HOB compensates for a 100x increase in Y.

Examples —

- Y = 10 kt
  Fireball touches ground unless HOB > 500 ft
- Y = 100 kt
  Fireball touches ground unless HOB > 1200 ft
- Y = 1 Mt
  Fireball touches ground unless HOB > 3000 ft

Air and Surface Bursts

Sequence of events —

- Fireball forms and rapidly expands

  Example: 1 Mt explosion

Time	Diameter	Temperature
1 ms (= 10^{-3} s)	440 ft	—
10 s	5,700 ft	6,000 C

- Blast wave forms and outruns fireball
- Fireball rises and spreads, forming characteristic mushroom cloud

Physics 280: Session 9

Plan for This Session

Organizational things & Questions:

RE3v1 due on February 20th
Electronic copy: upload by 1pm
Paper copy: 2pm at the beginning of class

News

Module 3: Effects of nuclear explosions (cont'd)

News: North Korean Radiological Weapon?

VOICE

Cheap and Dirty Bombs

Could these creepy chest packs be North Korea's way of threatening radiological war?

BY WILLIAM C. POTTER , JEFFREY LEWIS

During North Korea's July 2013 "Victory Day" parade, spectators were treated to a curious sight: a truckload of soldiers, each strapped into a chest pack festooned with the black and yellow radiation symbol. A few months later, the art world preserved the spectacle. British tour operator Simon Cockerell found oil paintings at a Pyongyang tourist shop depicting a North Korean commando team parachuting into enemy territory carrying the enigmatic satchels.

The parade images and oil paintings suggest commando-delivered nuclear-related devices of some sort -- an understanding consistent with North Korean defectors, who have suggested that the country might possess "backpack" nuclear devices. The United States developed similar munitions, and rumors persist about Russian suitcase nuclear weapons. Few experts, however, believe that North Korea could make a miniature nuclear charge the size of the packs seen in Pyongyang. Given that North Korea appears to

The one possibility that has been largely overlooked is that this nuke-themed accessory might have been North Korea's way of conveying the possibility of its use of radiological dispersal devices, better known as "dirty bombs."

Forgein Policy Magazine, February 17th, 2014

http://www.foreignpolicy.com/articles/2014/02/17/cheap_and_dirty_bombs

Thanks to Julie Chaps for the link!

Reuters:
Talks between Iran and P5+1 Started Today

Iran, powers start talks on final nuclear deal, U.S., Iranians meet

12:56pm EST

By Parisa Hafezi and Louis Charbonneau

VIENNA (Reuters) - Six world powers and Iran began talks on Tuesday in pursuit of a final settlement on Tehran's contested nuclear program in coming months despite caveats from both sides that a breakthrough deal may prove impossible.

Senior U.S. and Iranian officials met separately for nearly 90 minutes on the sidelines of the negotiations in Vienna. Details were not given, but such bilateral talks were inconceivable before the 2013 election of Hassan Rouhani, a relative moderate, as president of Iran. U.S.-Iranian dialogue is seen as crucial to any breakthrough nuclear agreement.

"We're only at the very beginning of this process," a diplomat told Reuters on condition of anonymity after U.S. Under Secretary of State for Political Affairs Wendy Sherman's meeting with Iranian Deputy Foreign Minister Abbas Araqchi.

Sherman headed the U.S. delegation, while Iranian Foreign Minister Mohammad Javad Zarif and Araqchi led Tehran's negotiating team at the table with Britain, China, France, Germany, Russia and the United States.

Iranian Supreme Leader Ayatollah Ali Khamenei, the man with the final say on all matters of state in the Islamic Republic, declared again on Monday that talks between Tehran and six world powers "will not lead anywhere" - while also reiterating that he did not oppose the delicate diplomacy.

Air and Surface Bursts

Sequence of events —

- Fireball forms and rapidly expands

  Example: 1 Mt explosion

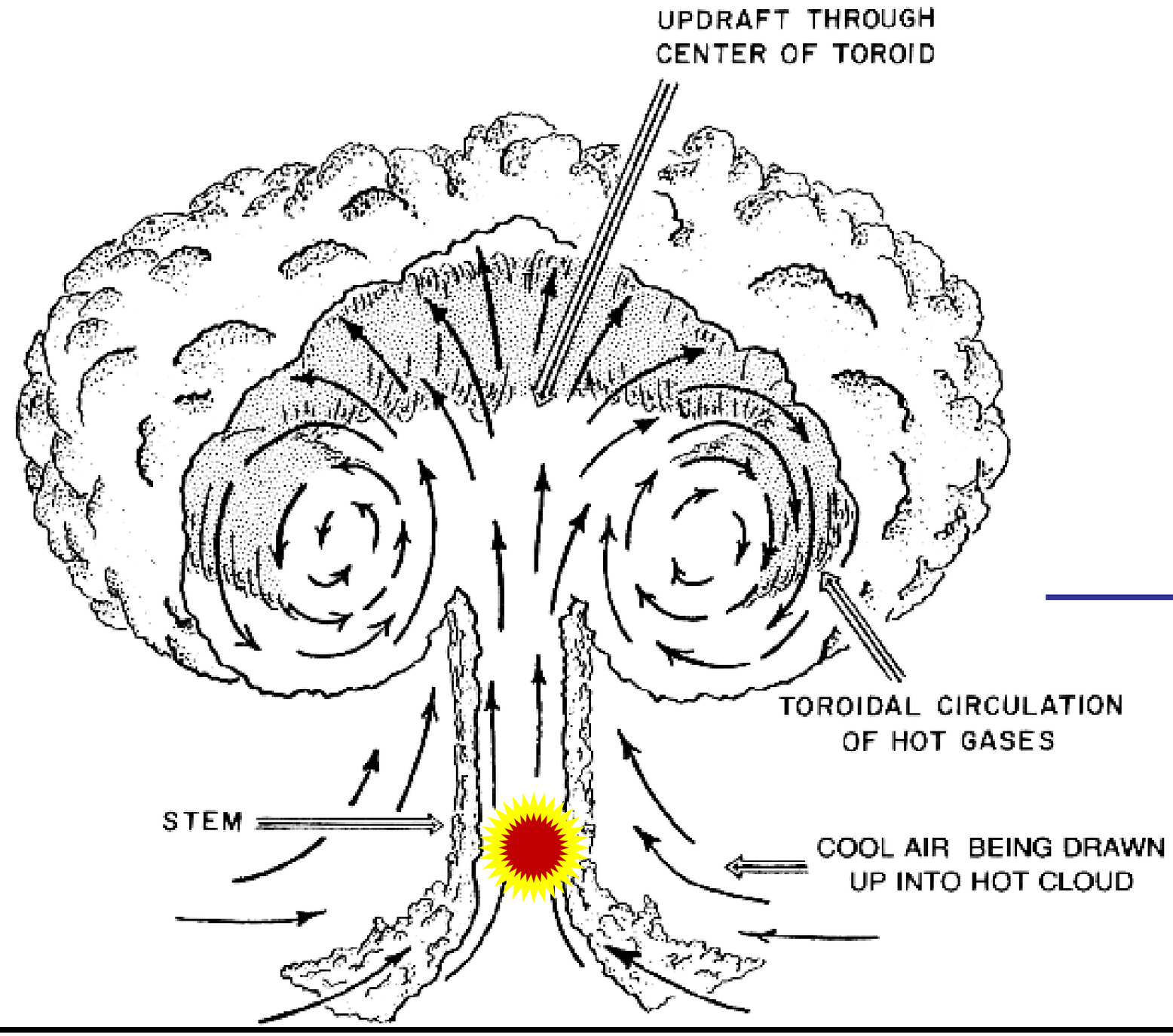
Time	Diameter	Temperature
1 ms (= 10^{-3} s)	440 ft	—
10 s	5,700 ft	6,000 C

- Blast wave forms and outruns fireball
- Fireball rises and spreads, forming characteristic mushroom cloud

Formation of the Mushroom Cloud

- A fireball forms and rises through the troposphere, sucking surrounding air inward and upward
- The moving air carries dirt and debris upward, forming the stem
- The fireball slows and spreads once it reaches the stratosphere

Formation of the Mushroom Cloud



Fireball

Stratosphere

Troposphere

Final Distribution of the Energy of a Large Air Burst (Important)

The *final* distribution of the energy of a large (~ 1 Mt) explosion, in order of appearance —

- Prompt neutrino radiation ~ 5%
  (not counted in the yield)
- Prompt nuclear radiation ~ 5%
- Electromagnetic pulse « 1%
- Thermal radiation ~ 35%
- Blast ~ 50%
- Residual nuclear radiation ~ 10%

Radioactive Fallout from a Nuclear Burst

- Vaporized weapon debris is highly radioactive
- If the fireball touches the ground, rock and earth are also vaporized and become highly radioactive
- The radioactive vapor and particles are carried aloft as the fireball rises and spreads
- Radioactive vapor condenses on the particles in the mushroom cloud
- The cloud (“plume”) is carried downwind
- Large particles “rain out” near ground zero
- Smaller particles are carried much further

Short-Term Physical Effects of a 1 Mt Burst

- Prompt nuclear radiation (lasts ~ 10^{-3} s)
  - —Principally γ, β and neutron radiation
  - —Intense, but of limited range
- Electromagnetic pulse (peak at < 10^{-6} s)
- Thermal radiation (lasts ~ 10 s)
  - —X-ray and UV pulses come first
  - —Heat pulse follows
- Blast (arrives after seconds, lasts < 1 s)
  - —Shockwave = compression followed by high winds
  - —5 psi overpressure, 160 mph winds @ 4 mi
- Residual nuclear radiation (lasts minutes–years)
  - —Principally γ and β radiation

Long-Term Physical Effects

- Fallout
  - —From material sucked into fireball, mixed with weapon debris, irradiated, and dispersed
  - —From dispersal of material from nuclear reactor fuel rods
- Ozone depletion (Mt bursts only)
  - —Caused by nitrogen oxides lofted into the stratosphere
  - —Could increase UV flux at the surface by ~ 2x to ~ 100x
- Soot injected into the atmosphere cools Earth (“nuclear winter”)
  - —Caused by injection of dust, ash and soot into atmosphere

iClicker Question

Is there historic precedence for an explosion ejecting dust, ash and soot into the stratosphere cooling earth ?

(A) Yes, following the nuclear attacks on Hiroshima and Nagasaki

(B) Yes, following the nuclear weapon tests in the 60s

(C) No, at any given time the yield of historic explosions was insufficient to transport very large amounts of dust and soot into the stratosphere.

(D) Yes, following the eruption of the Laki fissure system on Iceland in 1783.

(E) No, Vulcano eruptions cannot propel ash into the stratosphere.

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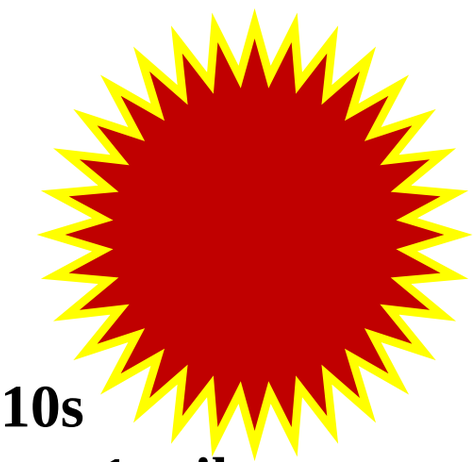
Nuclear Weapon Effects

Effects of Thermal Radiation

Thermal Radiation from the Fireball

- The fireball—like any hot object—emits electromagnetic radiation over a wide range of energies
  - — Initially most is at X-ray energies
  - — But the atmosphere is opaque to X-rays
  - — Absorption of the X-rays ionizes (and heats) the air
  - — The fireball expands rapidly and then cools

- Radiation of lower energy streams outward from surface of the fireball at the speed of light
  - — Atmosphere is transparent for much of this
  - — Energy cascades down to lower and lower energies
    - »Ultraviolet (UV) radiation
    - »Visible light
    - »Infrared (IR) radiation



1 Mt at 10s
Diameter ~ 1 mile
T ~ 6000 ^{o}C (sun surface)

Effects of Thermal Radiation – 1

The seriousness of burn injuries depends on —

- The total energy released (the yield Y)
- Transparency of the atmosphere (clear or fog, etc.)
- The *slant* distance to the center of the burst
- Whether a person is indoors or out, what type of clothing one is wearing, etc.

Effects of Thermal Radiation – 2

Duration and intensity of the thermal pulse —

- 1 s for 10 kt ; 10 s for 1 Mt
- In a transparent atmosphere, the heat flux at a distant point scales as $1/D^2$ where D is the slant range
- In a real atmosphere, absorption and scattering by clouds and aerosols (dust particles) cause a steeper fall-off with D; given by the "transmission factor" T :

  T = 60–70 % @ D = 5 miles on a "clear" day/night

  T = 5–10% @ D = 40 miles on a "clear" day/night

- Atmosphere transmission is as complicated and as variable as the weather

Effects of Thermal Radiation – 3

Typical characteristics —

- Thermal effects are felt before the blast wave arrives
- For Y < 10 kt, direct effects of thermal radiation are lethal only where blast is already lethal
- For Y > 10 kt, direct effects of thermal radiation are lethal well beyond where blast is lethal
- Direct effects of thermal radiation are greatly reduced by shielding
- Indirect effects of thermal radiation (fires, explosions, etc.) are difficult to predict
- Interaction of thermal radiation and blast wave effects can be important

Effects of Thermal Radiation – 4

Some harmful direct effects —

- Flash blindness (temporary)
- Retinal burns (permanent)
  - —Approximately 13 mi on a clear day
  - —Approximately 53 mi on a clear night
- Skin burns
- Ignition of clothing, structures, surroundings

Types of burns —

- Direct (flash) burns: caused by fireball radiation
- Indirect (contact, flame, or hot gas) burns: caused by fires ignited by thermal radiation and blast

Examples of Flash Burns Suffered at Hiroshima and Nagasaki

(a)

(b)

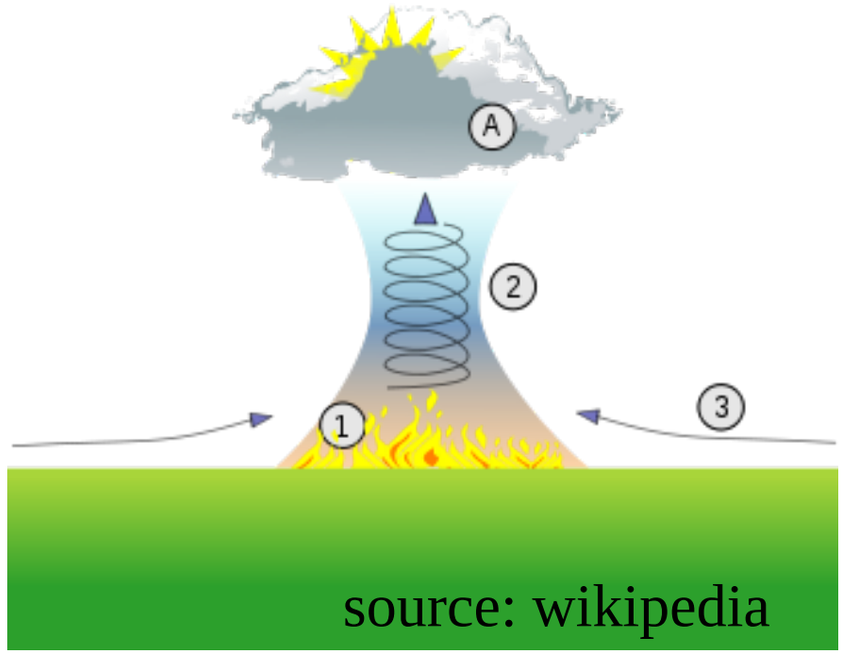
Conflagrations Versus Firestorms

Conflagration —

- Fire spreads outward from the ignition point
- Fire dies out where fuel has been consumed
- The result is an outward-moving ring of fire surrounding a burned-out region

Firestorm —

- Occurs when fires are started over a sizable area and fuel is plentiful in and surrounding the area
- The central fire becomes very intense, creating a strong updraft; air at ground level rushes inward
- The in-rushing air generates hurricane-force winds that suck fuel and people into the burning region
- Temperatures at ground level exceed the boiling point of water and the heat is fatal to biological life



Conflagrations Versus Firestorms

Hamburg after firestorm in July 1943
similar in Dresden, Tokyo and possibly in Hiroshima

Effects of Nuclear Explosions

Effects of Blast Waves

Damaging Effects of a Blast Wave

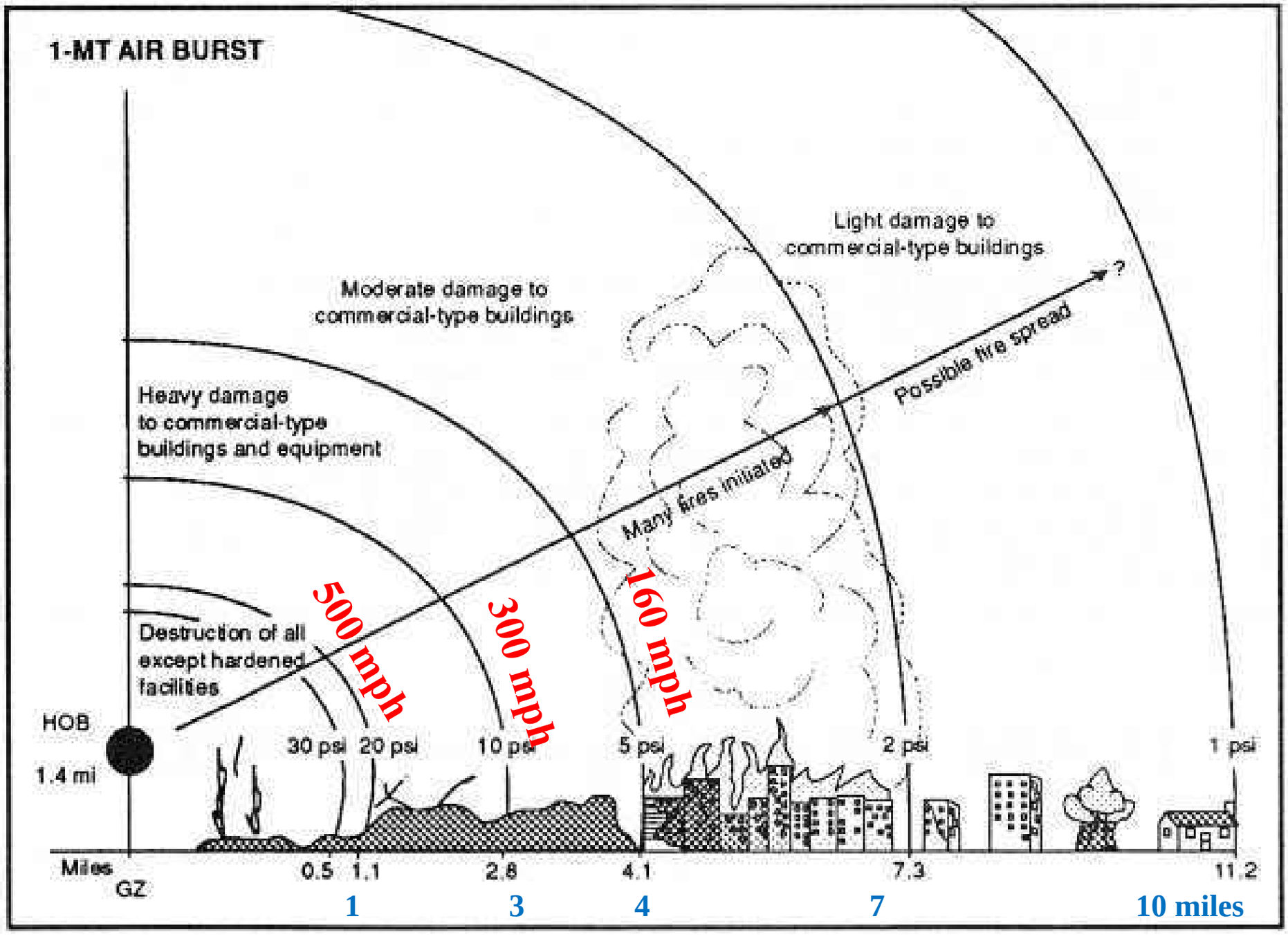
- The blast wave is considered the most militarily significant effect of a nuclear explosion in the atmosphere
- Like any shockwave, a blast wave produces —
  - –A sudden isotropic (same in all directions) pressure P that compresses structures and victims

  This is followed by
  - –A strong outward wind that produces dynamic pressure that blows structures and victims outward
- The two pressures are directly related; both are usually given in psi = pounds per square inch

Blast Wave Pressures and Winds

Pressure (psi)	Dynamic Pressure (psi)	Wind (mph)
200	330	2,078
150	222	1,777
100	123	1,415
50	41	934
20	8	502
10	2	294
5	1	163

Damaging Effects of a Blast Wave



Effects of Shallow Underground Nuclear Explosions

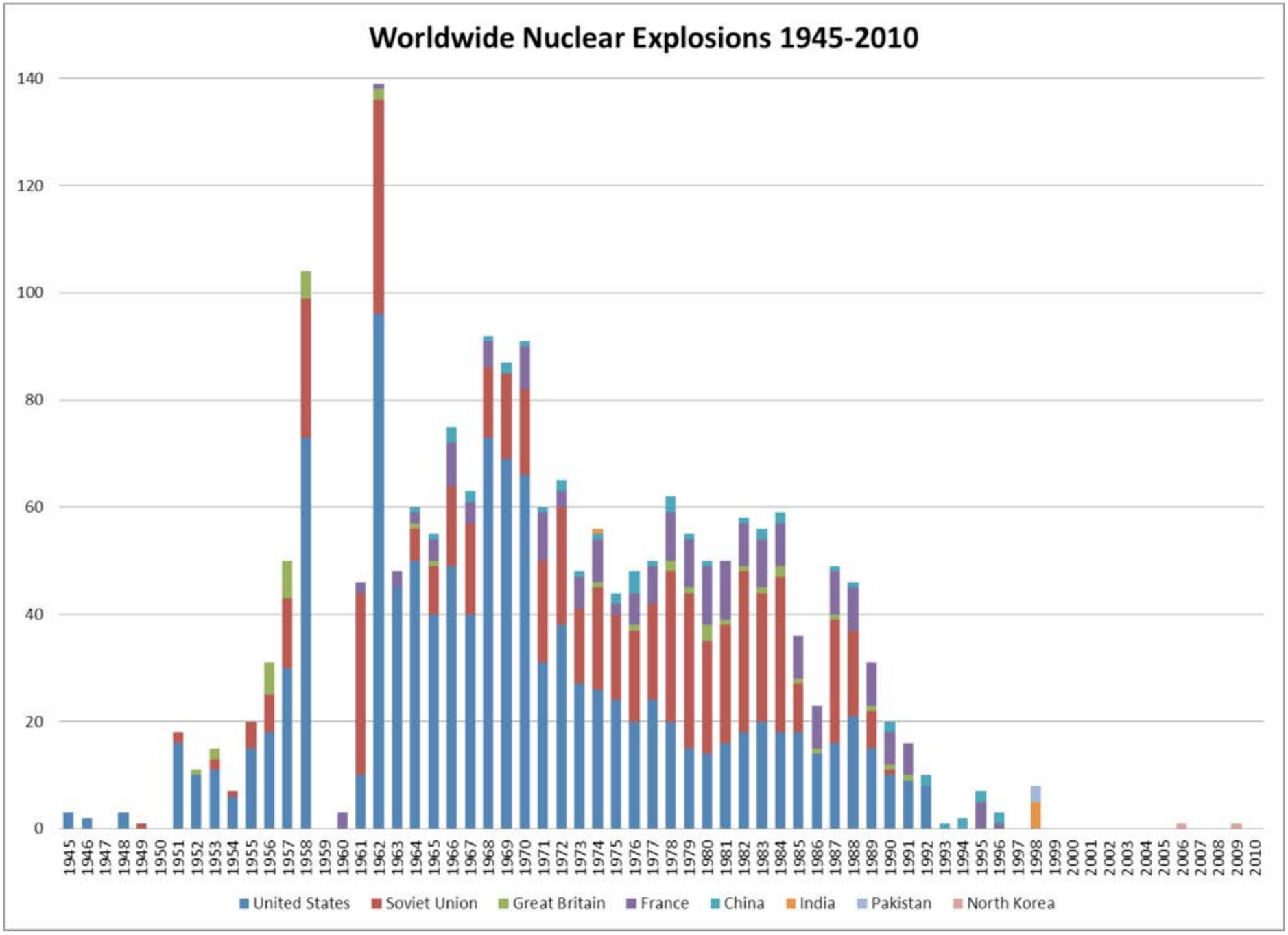
Effects of the Sedan Event (1962)

- Explosive yield: 100 kt
- Depth of burial: 635 feet
- Crater radius: 610 feet
- Crater depth: 320 feet
- Earth displaced: 12 million tons

Effects of Shallow Underground Nuclear Explosions

Example: The Sedan Test (100 kt, 1962)

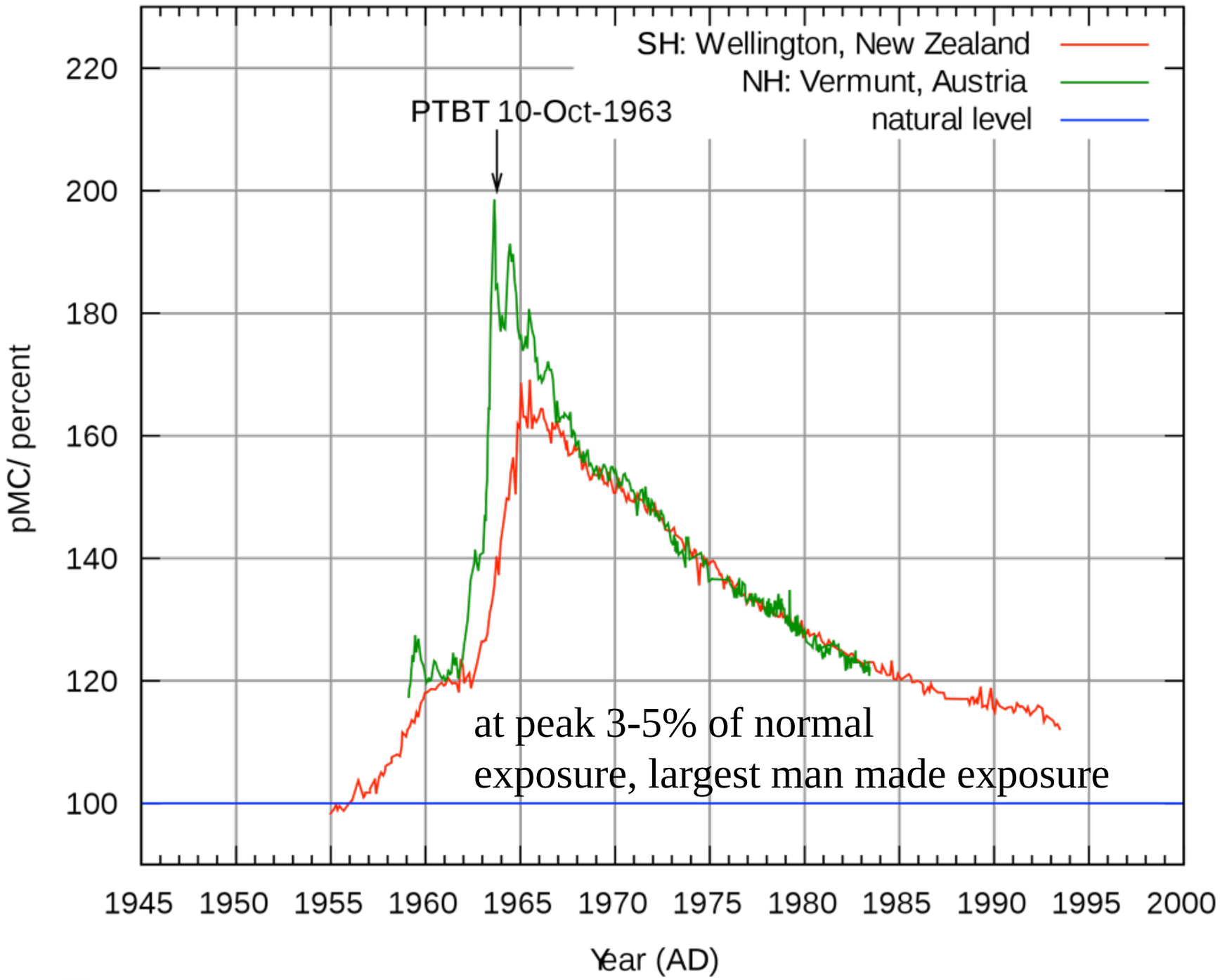
Effects of Nuclear Explosions



Credit: Wikipedia Commons

Effects of Nuclear Explosions

$^{14}C/^{12}C$ in atmospheric CO_2. Source: Hokanomono (Wikipedia)



Fallout Radiation from a 1 Mt Burst

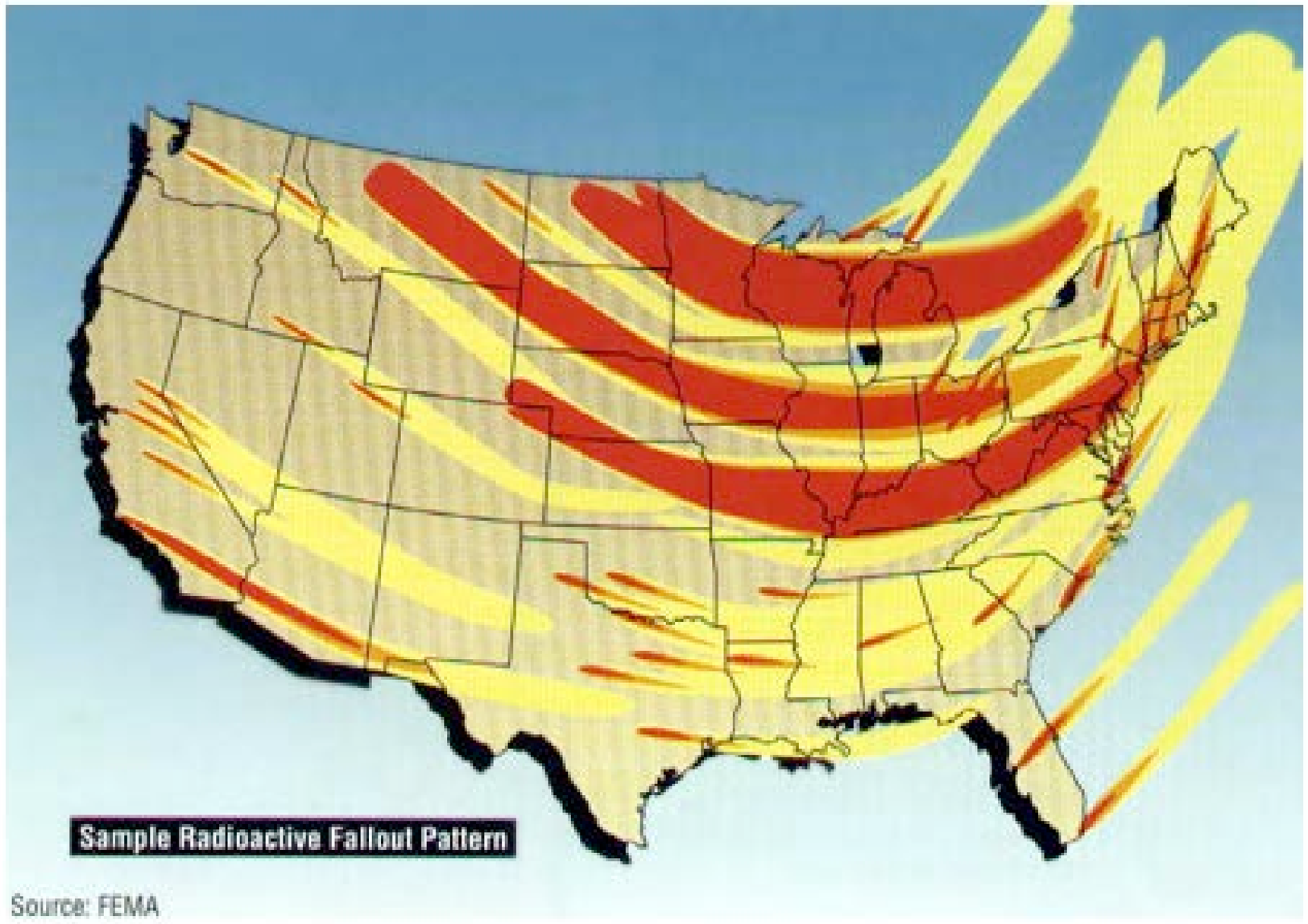
Assume —

- Surface burst
- Wind speed of 15 mph
- Time period of 7 days

Distances and doses —

- 30 miles: 3,000 rem (death within hours; more than 10 years before habitable)
- 90 miles 900 rem (death in 2 to 14 days)
- 160 miles: 300 rem (severe radiation sickness)
- 250 miles: 90 rem (significantly increased cancer risk; 2 to 3 years before habitable)

Effects of Nuclear Explosions



Map of nuclear fallout distribution after a potential nuclear attack on the United States. Source: FEMA

iClicker Question

Which of the following effects of a Megaton explosion would be felt **first** 5 miles away?

(A) Blast

(B) Thermal radiation

(C) Electromagnetic pulse

(D) Residual nuclear radiation (“fallout”)

iClicker

iClicker Answer

Which of the following effects of a Megaton explosion would be felt **first** 5 miles away?

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(B) Thermal radiation

(C) Electromagnetic pulse

(D) Residual nuclear radiation (“fallout”)

iClicker Question

Which of the following effects of a Megaton explosion would be felt **last** 5 miles away?

(A) Blast

(B) Thermal radiation

(C) Electromagnetic pulse

(D) Residual nuclear radiation (“fallout”)

iClicker

iClicker Answer

Which of the following effects of a Megaton explosion would be felt **last** 5 miles away?

(A) Blast

(B) Thermal radiation

(C) Electromagnetic pulse

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iClicker Question

Nuclear Weapon Effects

Which effect listed below carries the largest fraction of the total energy of a Megaton nuclear explosion?

(A) Prompt nuclear radiation

(B) Electromagnetic pulse

(C) Thermal radiation

(D) Blast

(E) Residual nuclear radiation (“fallout”)

iClicker

iClicker Answer

Nuclear Weapon Effects

Which effect listed below carries the largest fraction of the total energy of a Megaton nuclear explosion?

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Physics 280: Session 10

Plan for This Session

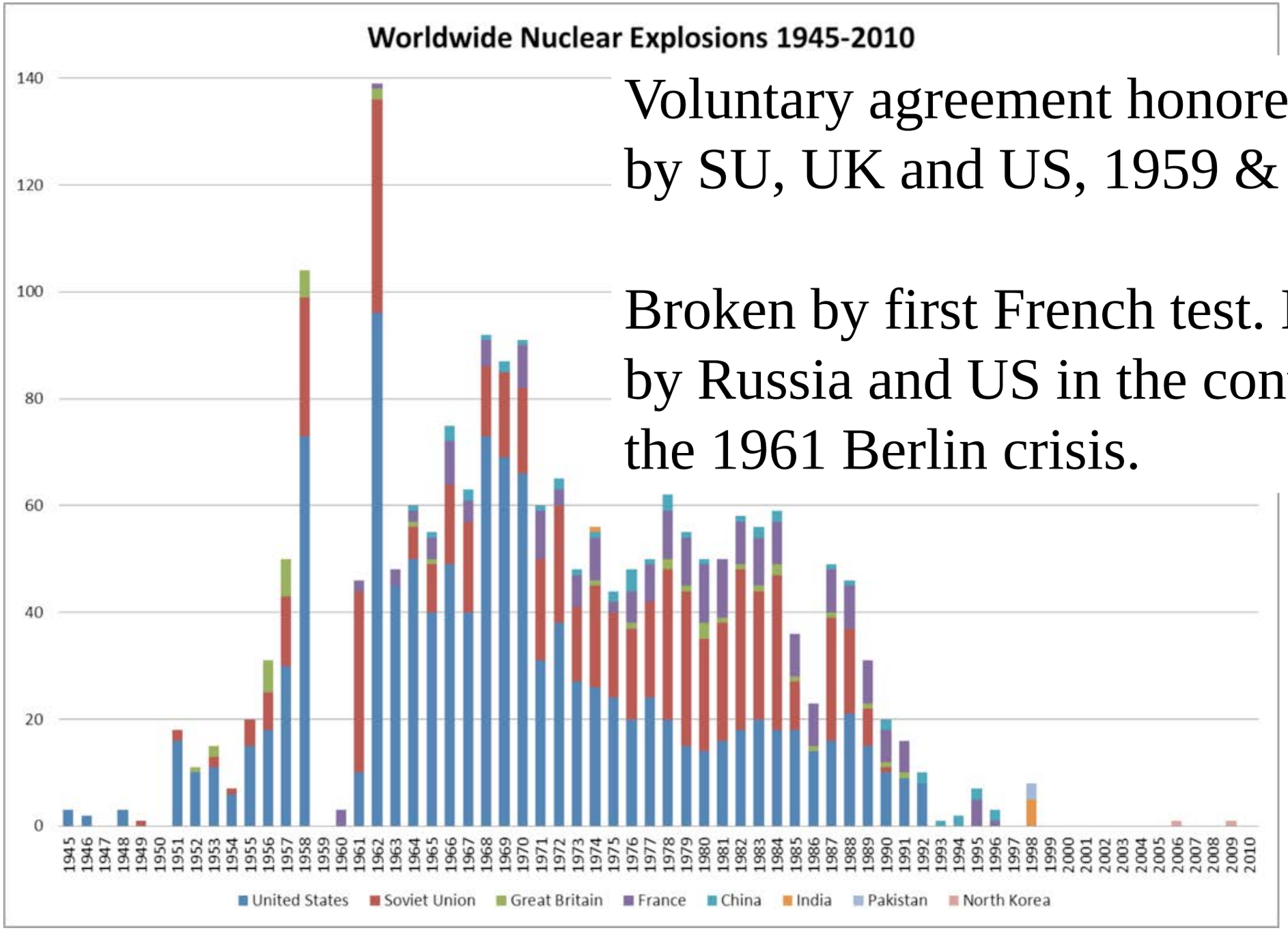
Questions and discussion

News

Nuclear Explosions Conclusion: “Nuclear Winter”

“Ground Zero” Video presentation

Question: Test Moratorium 1959-1960



Voluntary agreement honored by SU, UK and US, 1959 & 1960

Broken by first French test. Broken by Russia and US in the context of the 1961 Berlin crisis.

Credit: Wikipedia Commons

News: 3 Peace Activists Sentenced for Breaking in to Y-12 Complex in Oak Ridge, TN

Elderly nun sentenced to nearly three years for Tennessee nuclear break-in

Tue, Feb 18 2014

By Melodi Erdogan and Jennifer Brake

KNOXVILLE, Tennessee (Reuters) - A U.S. judge sentenced an 84-year-old nun, Sister Megan Rice, on Tuesday to 35 months in prison for breaking into a Tennessee military facility used to store enriched uranium for nuclear bombs.

Two others accused in the case, Michael Walli and Greg Boertje-Obed, were sentenced to 62 months in prison. The three were convicted of cutting fences and entering the Y-12 National Security Complex in Oak Ridge, Tennessee, in July 2012, embarrassing U.S. officials and prompting security changes.

"(Rice) does not have the extensive criminal records the others have. Her crimes are minimal in comparison to the others," U.S. District Judg Amul Thapar said.

The three were also sentenced to three years of supervised release after leaving prison and ordered to pay restitution for the damage they

Reuters Feb-18-2014

According to Post article the activists advanced to a building that holds about 400 tons of HEU !

By Dan Zak, Published: January 28

Washington Post Jan-28-2014

KNOXVILLE, Tenn. — A federal judge has ordered a Catholic nun, a Vietnam veteran and a house painter from Duluth, Minn., to pay full restitution of $53,000 for damaging one of the nation's most secure sites for nuclear weapons production. The three were convicted of sabotage last year for breaking into the facility and were facing sentencing Tuesday.

Falling snow, however, caused U.S. District Court Judge Amul Thapar to suspend the hearing until Feb. 18. The government had asked for the three to be given terms of five to nine years.

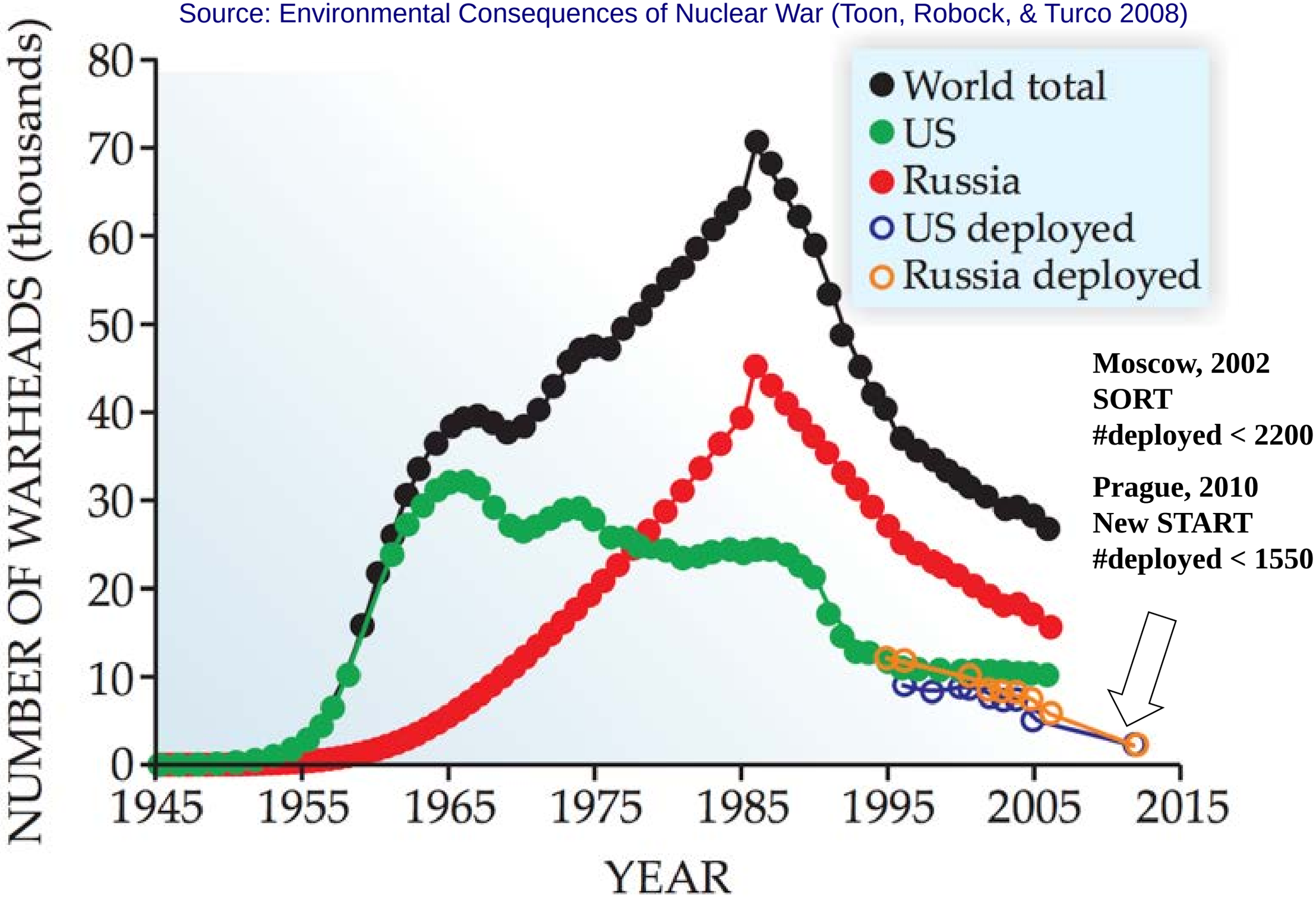
He ordered Michael Walli, who has been based for years at the Dorothy Day Catholic Worker house in Washington, and fellow peace activists Sister Megan Rice and Gregory Boertje-Obed back to jail until the hearing can continue.

In the predawn hours of July 28, 2012, the trio cut through four fences at the Y-12 National Security Complex in nearby Oak Ridge, Tenn., where the fuel for the atomic bomb dropped on Hiroshima, Japan, was produced during the Manhattan Project.

Having essentially circumvented a glitch-ridden security apparatus that cost $150 million a year, they splashed blood and spray-painted biblical messages on the exterior of the building that warehouses an estimated 400 tons of highly enriched uranium — enough to fuel 10,000 nuclear bombs.

Effects of Nuclear War – Input to War Scenarios for Illustration

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)



Moscow, 2002
SORT
#deployed < 2200

Prague, 2010
New START
#deployed < 1550

Effects of Nuclear War: Direct Causalities

For Illustration assume

War fought with 100kT Nuclear Weapons

1,000 weapons detonated on the United States would *immediately* —

- kill 60 million people (20% of the total population)
- injure an additional 40 million people (16% of the total population)

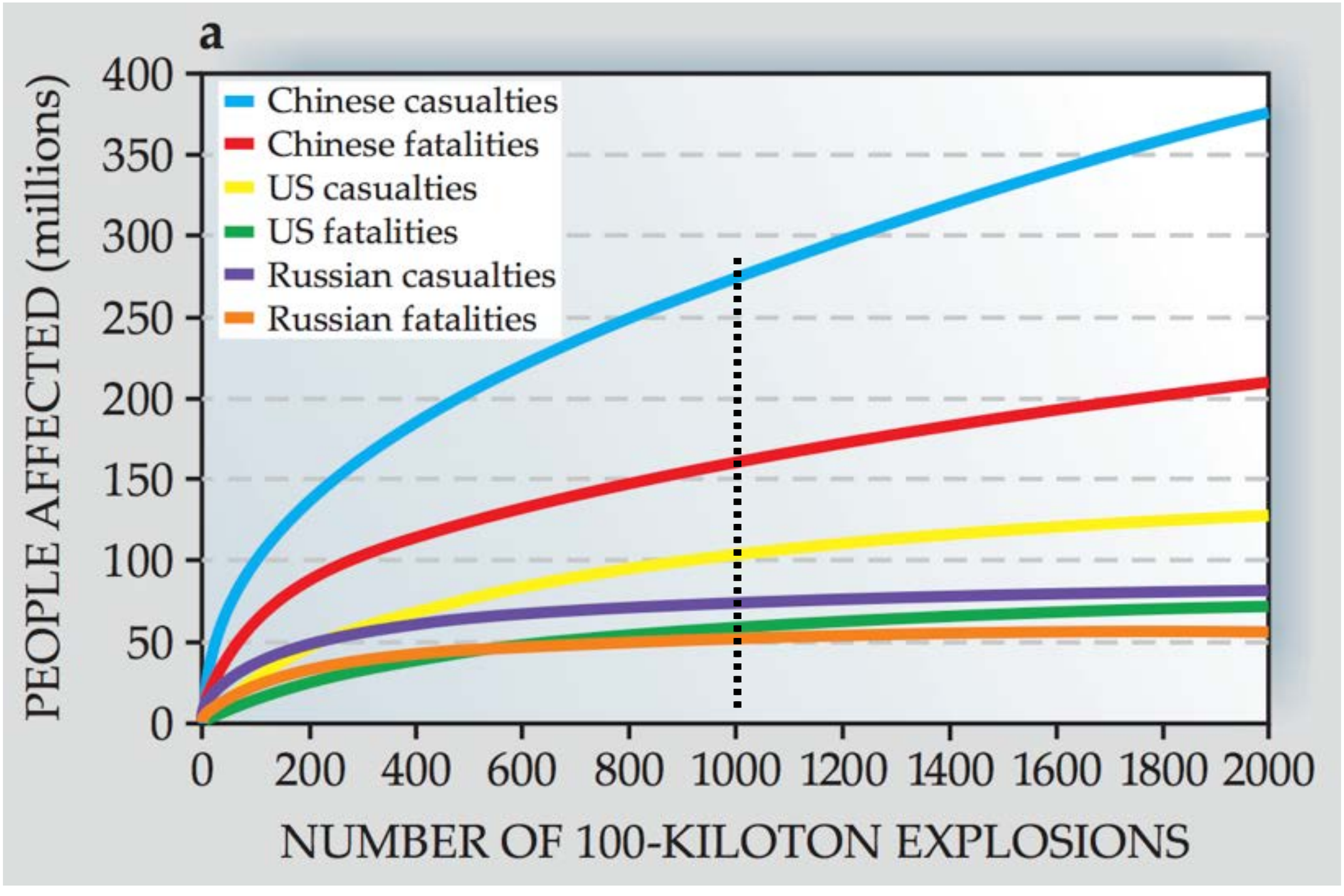
1,000 weapons detonated on Russia would *immediately* —

- kill 50 million people (30% of the total population)
- injure an additional 20 million people (20% of the total population)

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)

Effects of Nuclear War: Direct Causalities

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)



Large Cities in China, Russia and the United States

Country	above 1 Million	100,000 - 1 Millions	10,000 to 100,000
China	59	354	385
Russia	12	203	1291
U.S.	10	285	3376

However, distribution of industrial capabilities is wider in the U.S.

Effects of Nuclear War: Two Scenarios for the Study of Longterm Environmental Effects

Nuclear War Models:

(I) U.S.-Russian ("SORT") war:
2200 x 2 weapons of 100-kt each = 440 Mt total

(II) Regional nuclear war (eg. Pakistan – India):
50 weapons of 15-kt each = 0.75 Mt total

Weapons are assumed to be targeted on industry.

Effects of Nuclear War: Longterm Environmental Effects

Regional Conflict, India and Pakistan with ~ 100 15 kT Warheads

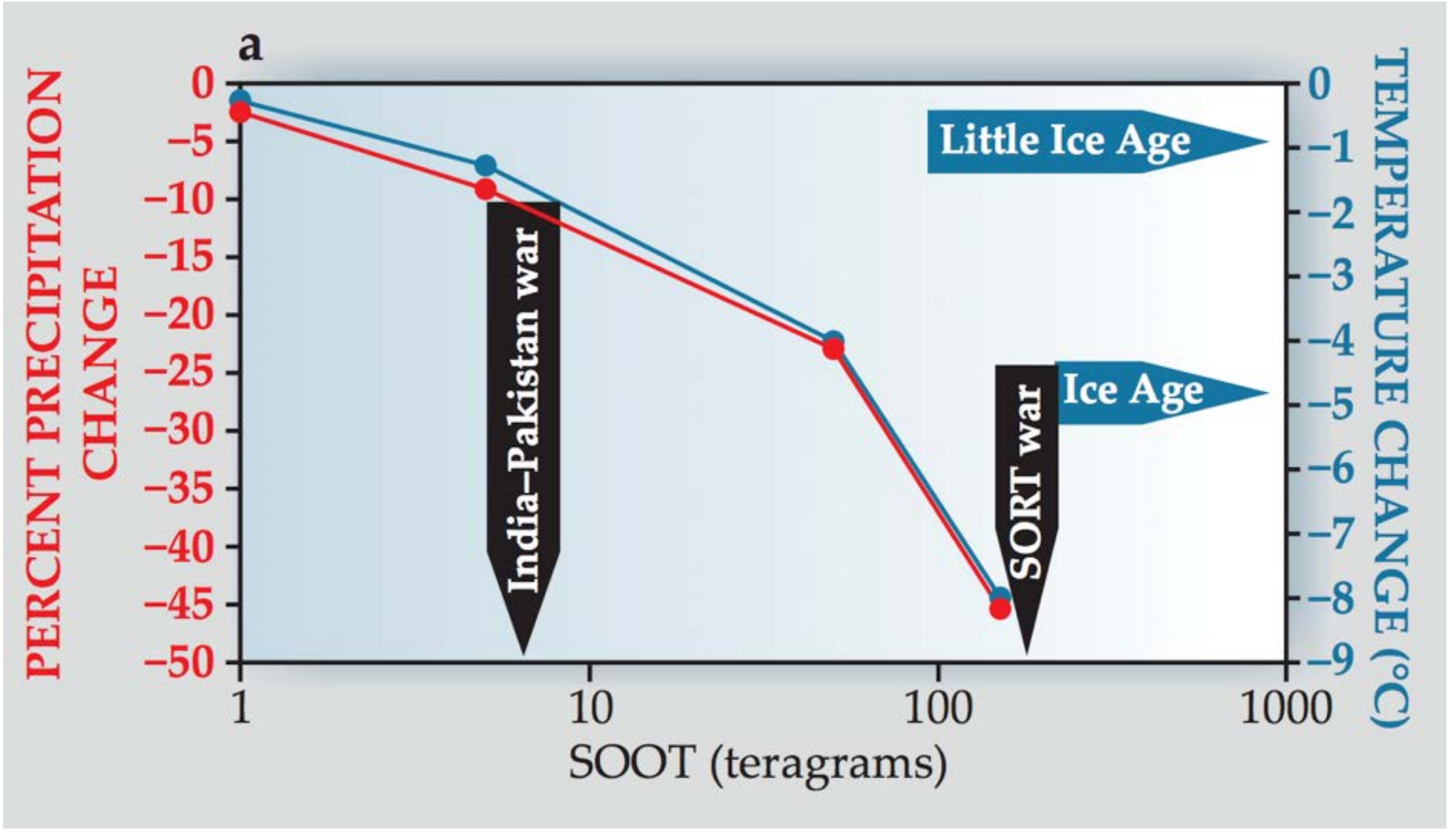
A regional war between India and Pakistan could generate 5 Tg of soot, sufficient to —

- produce the lowest temperatures for 1,000 years on the northern hemisphere, lower than the Little Ice Age or 1816 (“the year without a summer”)
- reduce precipitation in the Asian monsoon region by 40%
- reduce the length of the growing season in the U.S. Midwest by 10%.

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)

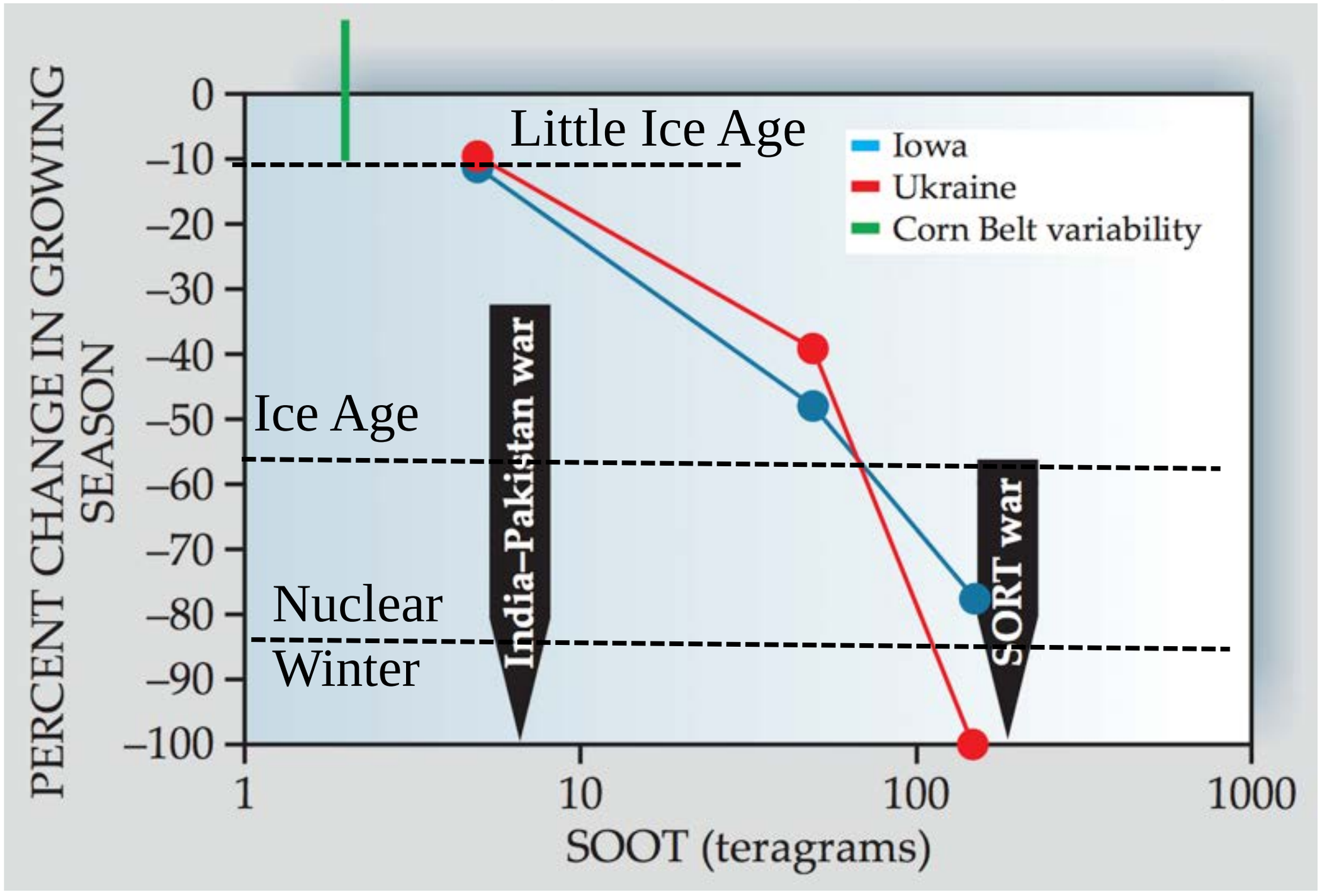
Effects of Nuclear War: Change in Precipitation and Temperature

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)



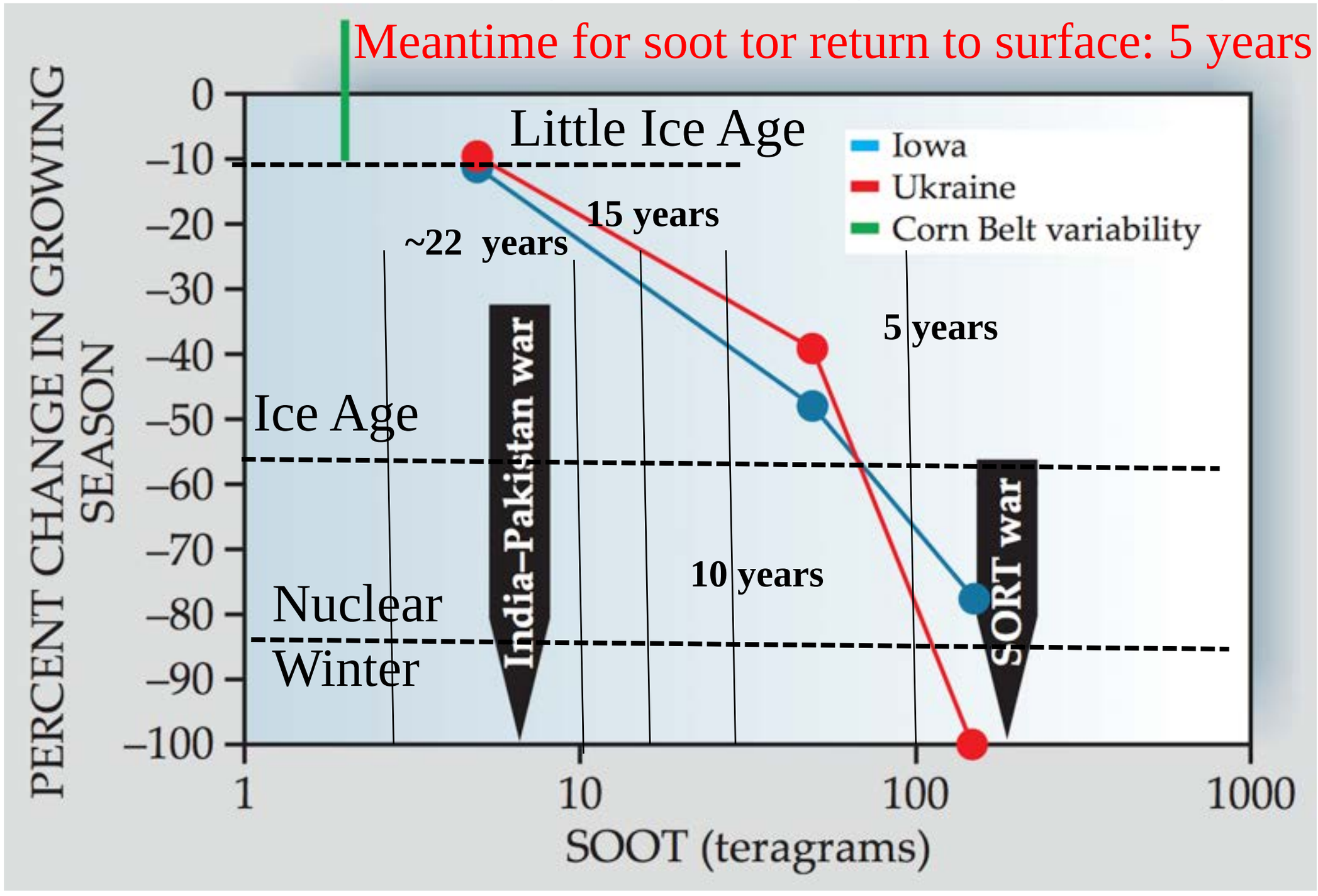
Effects of Nuclear War: Percent Change in Growing Season

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)



How Long from Nuclear Winter to Little Ice Age?

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)



Effects of Nuclear War

Indirect Effects Would Be the Most Important

– ***"Environmental Consequences of Nuclear War"***

(Owen Toon, Alan Robock, & Richard Turco, Physics Today, December 2008)

"What can be said with assurance...is that the Earth's human population has a much greater vulnerability to the indirect effects of nuclear war, including damage to the world's —

- agricultural
- transportation
- energy
- medical
- political
- and social

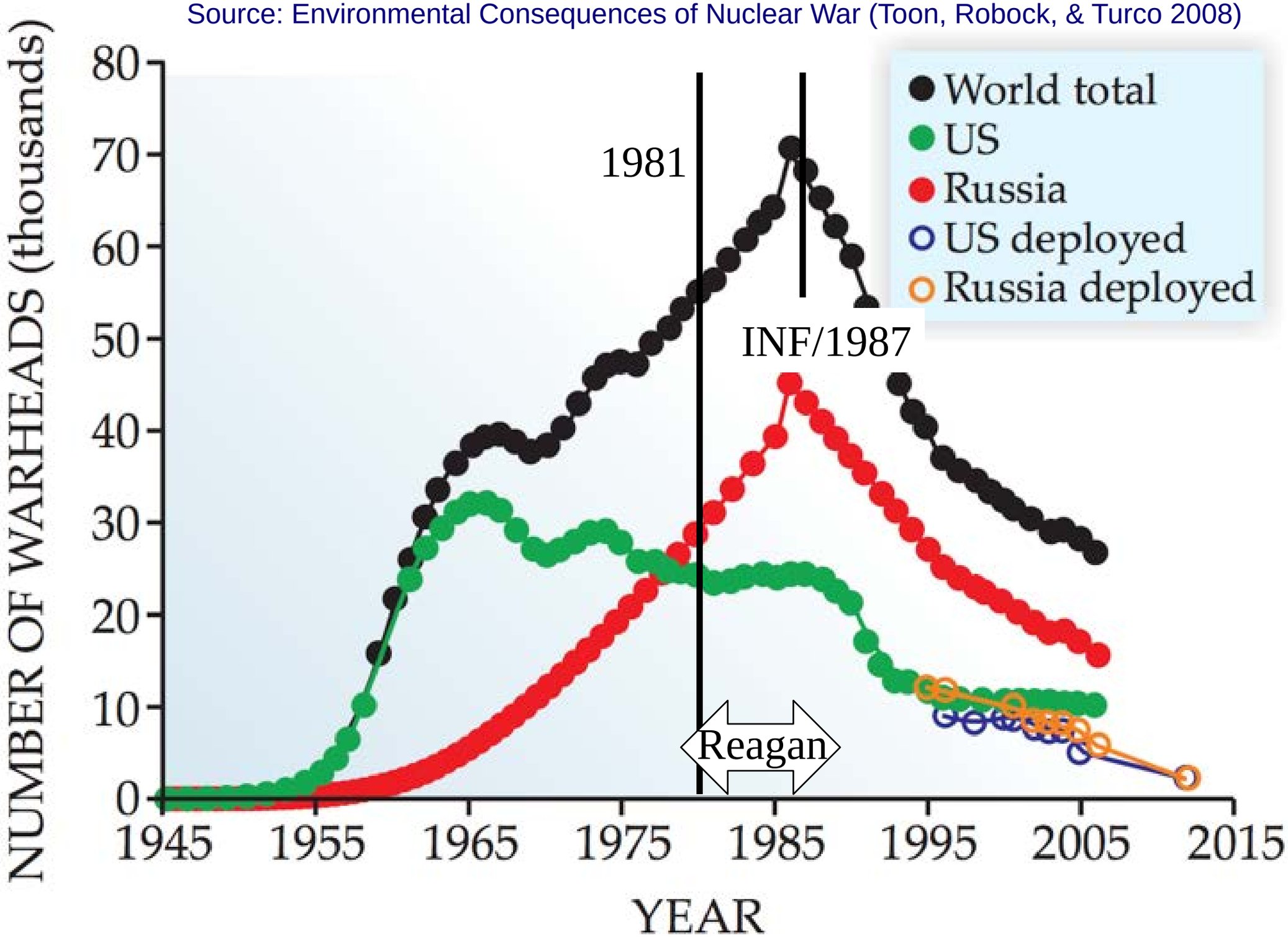
infrastructure than to the direct effects of nuclear war."

Ground Zero

Video Presentation, Ground Zero
(from CBS Reports on The Defense of the United States, aired June-14-1981)

Context: Arsenals at the Time of CBS Series

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)



Questions for Discussion

(A) Which imbalance in nuclear arsenals triggered the concern of military superiority of the SU ?

(B) What is the TRIAD ?

(C) Why would there be much more fall out in a US-Russian Nuclear War than following Hiroshima and Nagasaki?

(D) Which society is more vulnerable to Nuclear War, Why?

iClicker Question

If Soot is transported to the upper atmosphere by an explosion or eruption, what is the meantime for the soot to return to earth's surface?

(A) 1 year

(B) 3 years

(C) 5 years

(D) 10 years

iClicker

iClicker Answer

If Soot is transported to the upper atmosphere by an explosion or eruption, what is the meantime for the soot to return to earth's surface?

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iClicker Question

What would be the impact of a U.S.-Russian (“SORT”) nuclear war with 2200 x 2 weapons of 100-kt each = 440 Mt total on the length of the growing season in the mid west of the United States of America?

(A) Reduction by 5-10% (little ice age)

(B) Reduction by 40-50% (last ice age)

(C) Reduction by 70-80% (no “recent” historic precedence)

iClicker

iClicker Question

What would be the impact of a U.S.-Russian (“SORT”) nuclear war with 2200 x 2 weapons of 100-kt each = 440 Mt total on the length of the growing season in the mid west of the United States of Amercia

(A) Reduction by ~10% (little ice age)

(B) Reduction by 50-60% (last ice age)

(C) Reduction by 80-90% (no “recent” historic precedence)

How Long from Nuclear Winter to Little Ice Age?

Source: Environmental Consequences of Nuclear War (Toon, Robock, & Turco 2008)