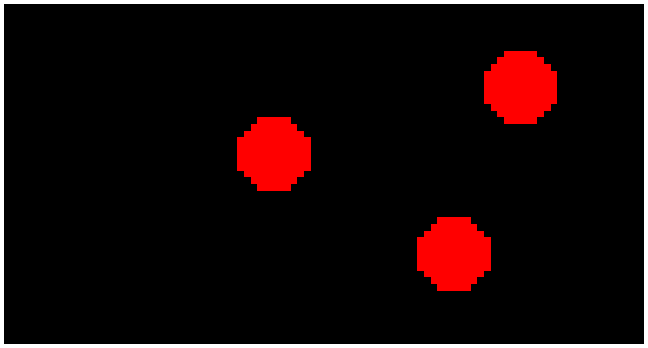
# Weapons of Mass Destruction



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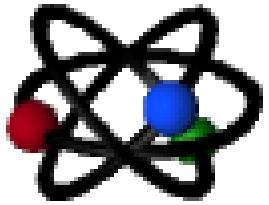
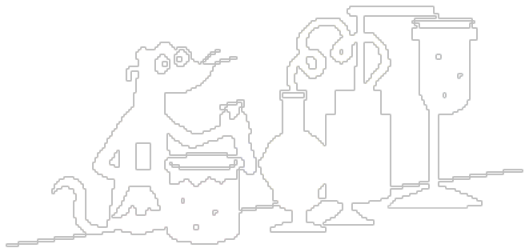
# Talk Outline

- What kills people in wars?
- What are Weapons of Mass Destruction?
- Chemical Weapons
  - Sarin
  - Syria Update
- Nuclear Weapons
  - Fission
  - Fusion
  - Effects
  - Proliferation
  - Some hopeful signs

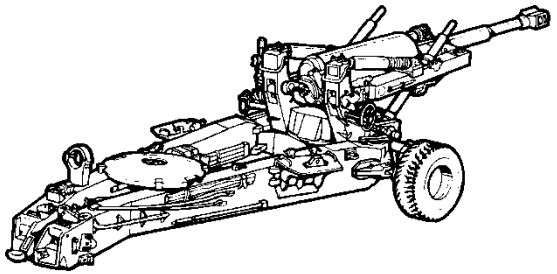


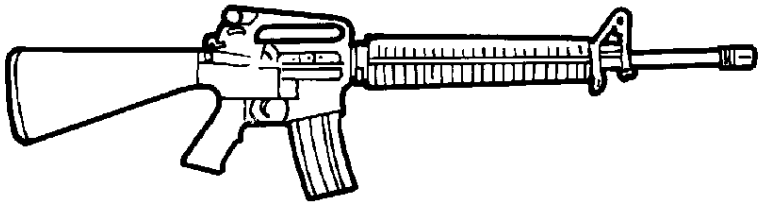


# Major killers in Wars

- Assault Rifles (64%)
- Handguns (10%)
- Landmines (10%)
- Hand grenades, Artillery, Mortars (16%)
- Since 1900: 34 million soldiers and 80 mil in wars world-

Howitzer



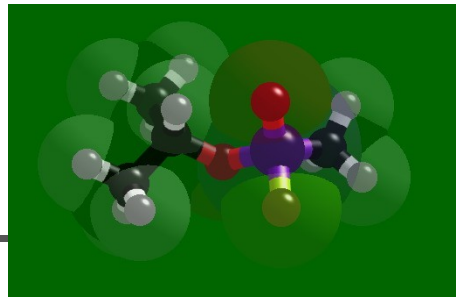


M16

# What are WMDs?

- More powerful than a speeding bullet...
- Able to destroy great masses of humanity, including civilians with a single blow....
- Rarely used but capable of inducing terror when used...
  - Nuclear – A-bombs and H-bombs
  - Chemical – Sarin (nerve gas) and others
  - Biological – Anthrax, Ebola and others

# History of Sarin



- Invented by the Nazis in 1938, it went into production at the end of WWII
- It was NOT the gas used in the gas chambers – that was Zyklon B, a cyanide-based pesticide
- Sarin was produced and stockpiled by US and USSR beginning in 1950
- Following the ratification of the Chemical Weapons Convention (treaty), the stockpiles began to be

# Chemical Weapons Convention

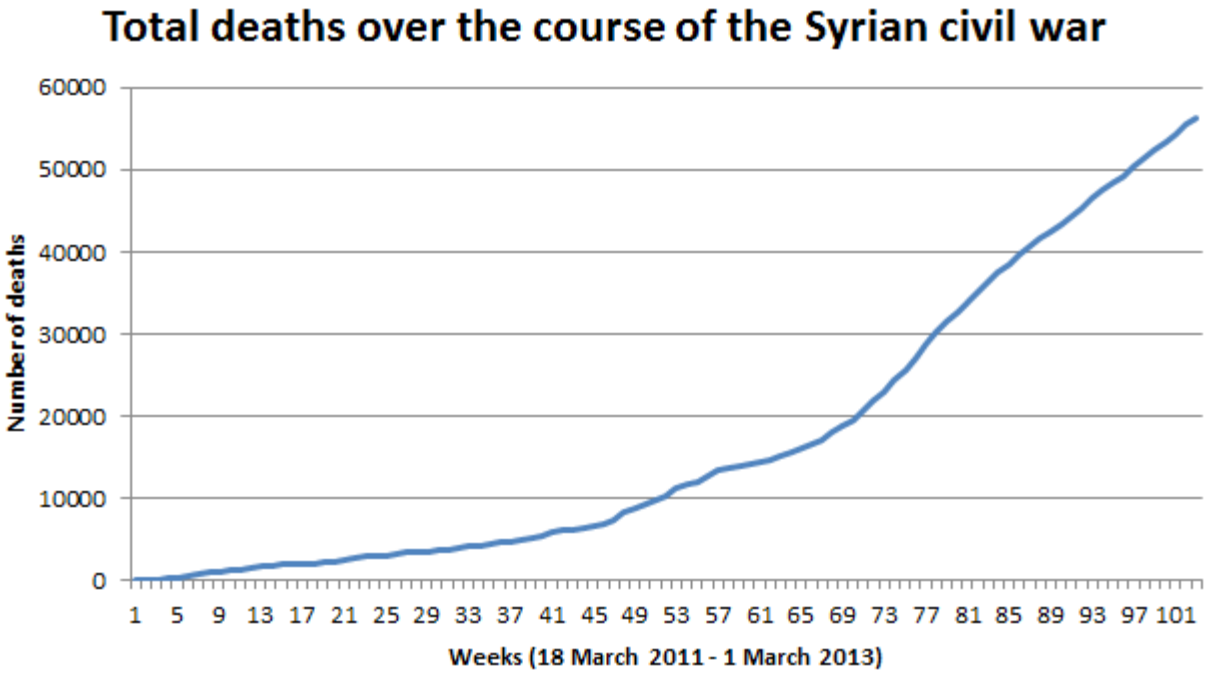
- First disarmament treaty to include a time frame for the elimination of an entire class of weapons of mass destruction
- First multilateral arms control treaty to incorporate an intrusive verification regime
- In force since 4/29/97
- http://www.cwc.gov/
- http://www.opcw.org/

# Use of Sarin in recent times

- Japanese sect used Sarin in 1994 and 1995, killing 8 + 13 people
- Iraq/Hussein used Sarin on the Kurds in 1987-8 and also on Iranian soldiers
  - Attack on Halabjah in March 1988 killed ~4000 Kurds, injured ~10,000
- Sarin gas has killed ~1400 people near Damascus – videos and images are online – did Assad gas his own people?

# Death toll in Syria (2013)

- Estimated at between 80,000 and 100,000 to date since the civil war started in spring 2011 – half



# So why is Sarin so bad?

- Conventional weapons have killed ~100 times more people than Sarin in the Syrian civil war
- Chemical weapons are banned by treaty signed/ratified by all but:
  - Israel
  - Myanmar
  - Syria
  - N. Korea
  - South Sudan
  - Egypt
  - Angola
- It is therefore a “banned”

# But mostly - Sarin is Scary!

- Colorless, odorless liquid that can be easily aerosolized for distribution
- Nerve agent that causes paralysis of muscles, leading to asphyxiation when lung muscles cannot function
- Lethal dose is 0.5 mg for adult human
- Sarin is relatively easy to manufacture – it does not need

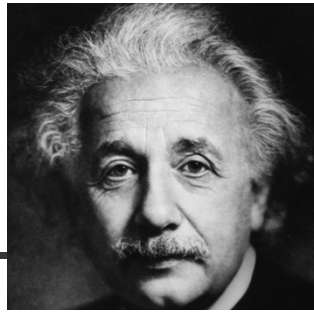
# Getting rid of Sarin

- Can’t bomb factories or storage depots – that would spread toxic materials
- Hard to track because easily concealed and moved around
- Need verifiable process to monitor the stockpile and oversee destruction or removal of materials
- However, it is difficult to prevent new manufacturing unless

# Nuclear weapons – some history

- World War II coincided with advances by physicists in understanding the inner workings of the atom
- These physicists understood that it was possible to release huge amounts of energy by breaking apart or smashing together nuclei of atoms – far more than can be released in chemical reactions, which rely on electrons

# WWED?



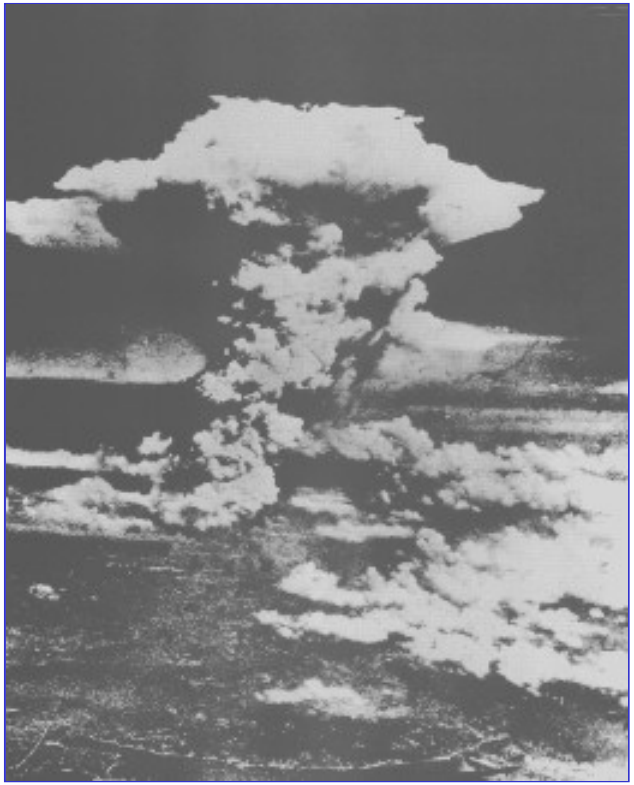
- By 1939 many prominent (mostly Jewish) physicists had fled Europe and resettled in the USA
- Albert Einstein signed a letter to President Roosevelt alerting him to the terrible potential of weaponizing nuclear reactions
- But until Pearl Harbor in 1941, the USA did not invest much in this research

# Manhattan Project


- After 1941, the US began to race Nazi Germany to develop nuclear weapons
- Manhattan Project was really located in Los Alamos, NM
- Most of the funding went to build factories that could produce the materials needed to make the bombs
- The first successful test was Trinity

# Why is an atomic bomb so much worse than a TNT bomb?

- Amount of heat and light energy released is 1000 times greater
- Explosion is accompanied by invisible, penetrating and harmful radiation
- After explosion, radioactive fallout remains and continues to damage living things for days → weeks → years



Ground level view of Hiroshima cloud

# Physical Effects of Nuclear Weapons

- Thermal
  - Fireball → Firestorms
  - Mushroom Cloud
- Initial (prompt) Radiation
  - Alpha particles ($^{4}He^{++}$)
  - Beta particles ($e^{+}$ and $e^{-}$)
  - Gamma-rays ($\gamma$)
  - Neutrons ($n$)

*Trinity*

*Bridge in Hi*

# Physical Effects of Nuclear Weapons

Hiroshima buildings

- Pressure Blast Wave
  - Buildings collapse
- Fallout
  - Radioactive fragments which stick to air particles or dirt that is sucked up mushroom stem
  - 80% falls back down in first day
  - 90% falls back down in first week
  - 10% lasts weeks → years

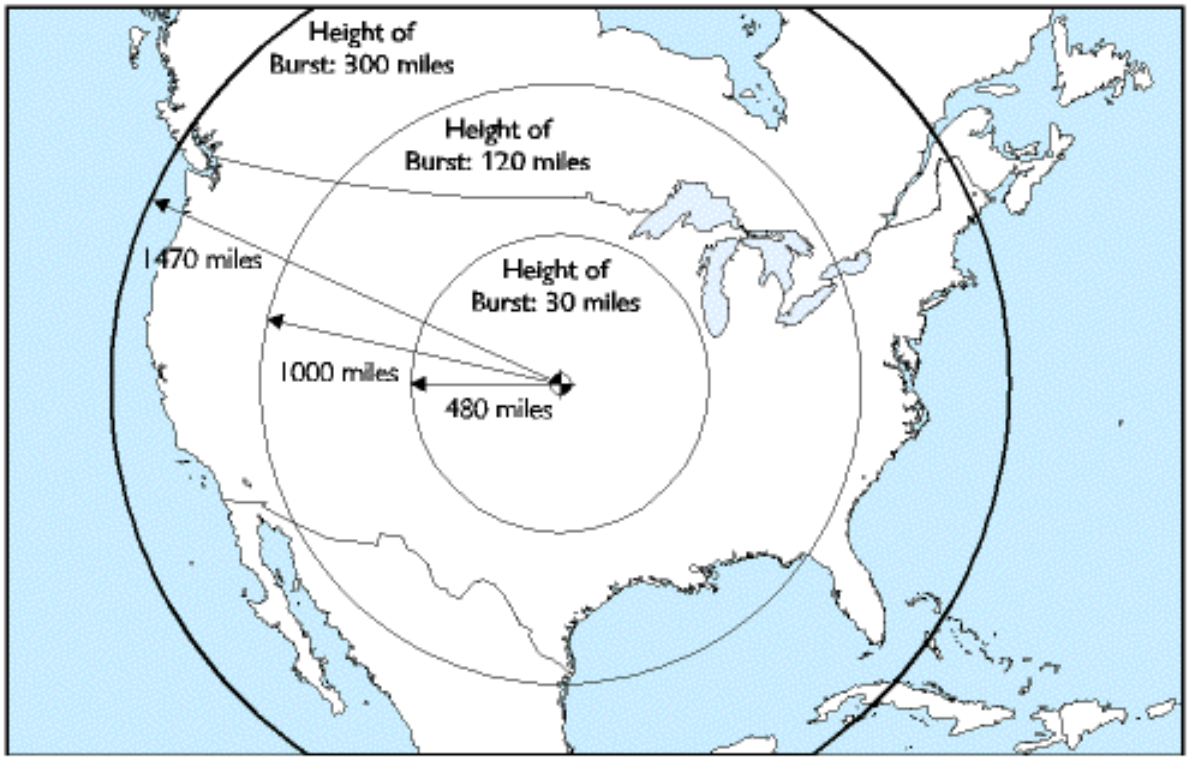
Nagasaki victim

*Google Nuclear Weapon Effects Calculator to try it out on your city!*

# Physical Effects of Nuclear Weapons

- Electromagnetic Pulse
  - Strongest for very high bursts
  - $\gamma$–rays ionize air → electrons
  - Electrons create large currents in air
  - Currents are picked up by power lines
  - Power surges shut down grid, destroy attached electrical devices
- 1.4 Mton airburst in 1962 knocked out lights in Hawaii over 1000 miles away

# Electromagnetic Pulse Effects




**Area Effected by an Electromagnetic Pulse, by Height of Burst**

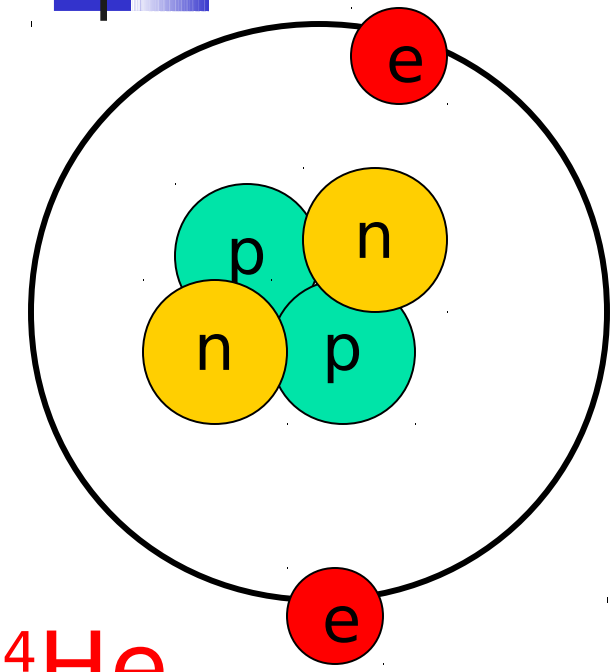
Source: Gary Smith, "Electromagnetic Pulse Threats," testimony before the House National Security Committee, July 16, 1997.

http://www.fas.org/nuke/intro/nuke/emp.htm

# Nuclear Weapons are Scary too!

- Most of the lasting effects are due to radiation, so are odorless and colorless
- Genetic damage and cancers can take 20 or more years to develop
- A single bomb can kill 100,000 people and destroy an entire city
- It does not take much nuclear material to create a big explosion
- However, it does take considerable

# Nuclear physics vs. Chemistry



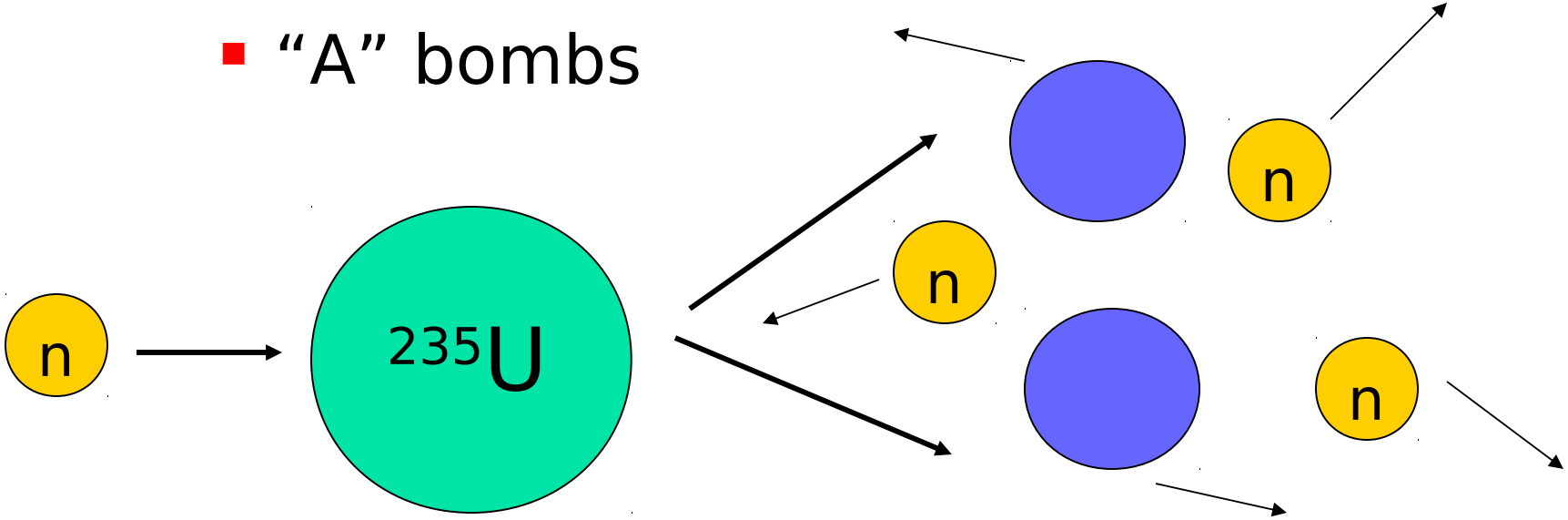

$^{4}He$

Helium Atom:
2 electrons (e)
2 protons (p)
2 neutrons (n)

- Chemistry: change the number of electrons → typical energies involved are a few electron Volts (eV)
- Nuclear physics: change the number of protons or neutrons in the nucleus → typical energies involved are millions of eV (MeV)

# Fission Weapons

- Fission
  - releases energy in elements heavier than Iron
  - Bombard U or Pu with neutrons, they split into fragments, releasing energy
  - “A” bombs



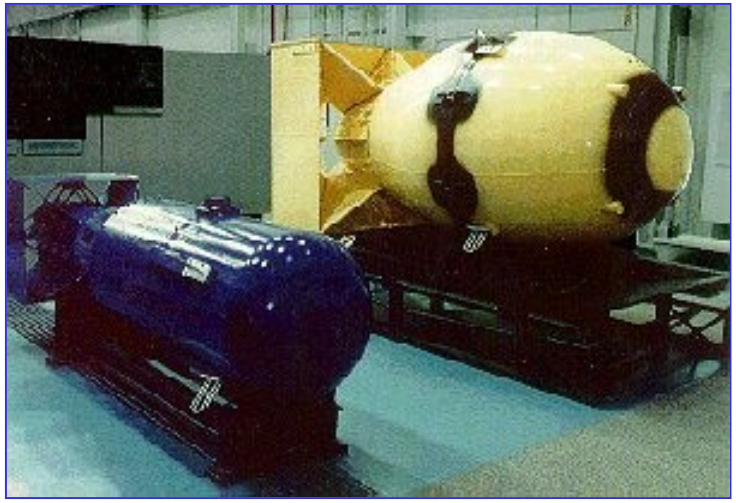
# Critical mass → chain reactions

- When a large enough mass of either $^{235}U$ or $^{239}Pu$ is assembled, a self-sustaining chain reaction results after the first fission is produced.
- The minimum (“critical”) mass of fissile material that can sustain a nuclear chain reaction depends on the density, shape, and type of fissile material, as well as the effectiveness of any surrounding material (called a reflector or tamper) at reflecting neutrons back into the fissioning mass.
- Depleted U is often used in the tamper

# The first “A” bombs

- Trinity – Gadget (7/16/45)
  - Alamagordo test range in New Mexico
  - 20 kTon yield
- Little Boy (8/6/45)
  - Hiroshima
  - 15 kTon yield
- Fat Man (8/9/45)
  - Nagasaki
  - 20 kTon yield

Museum display in NM

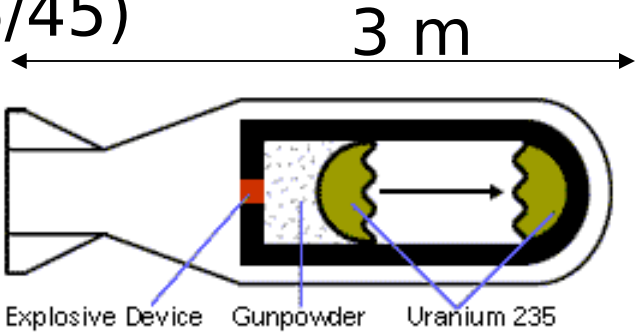


# How to make an “A” bomb

- Use >90% $^{235}U$
- Squeeze and confine evenly
- Reflect neutrons back into $^{235}U$
- Use initial explosive device to

A-bomb dome

Little Boy (Hiroshima 8/6/45)




http://www.pcf.city.hiroshima.jp/peacesite/English/Stage1/1-3/1-3-3E.html

# “Fat Man” style of A-bomb

- High explosives are arranged to form an imploding shock wave which compresses the fissile material to supercriticality

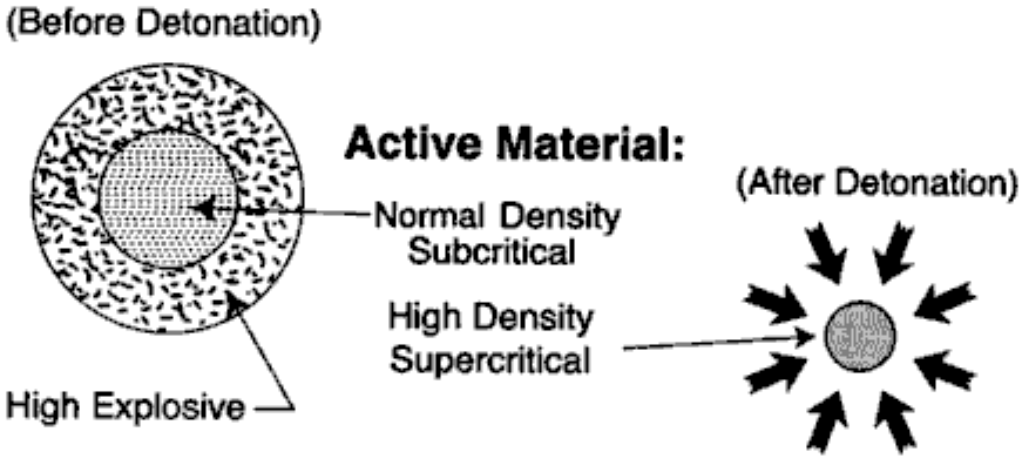
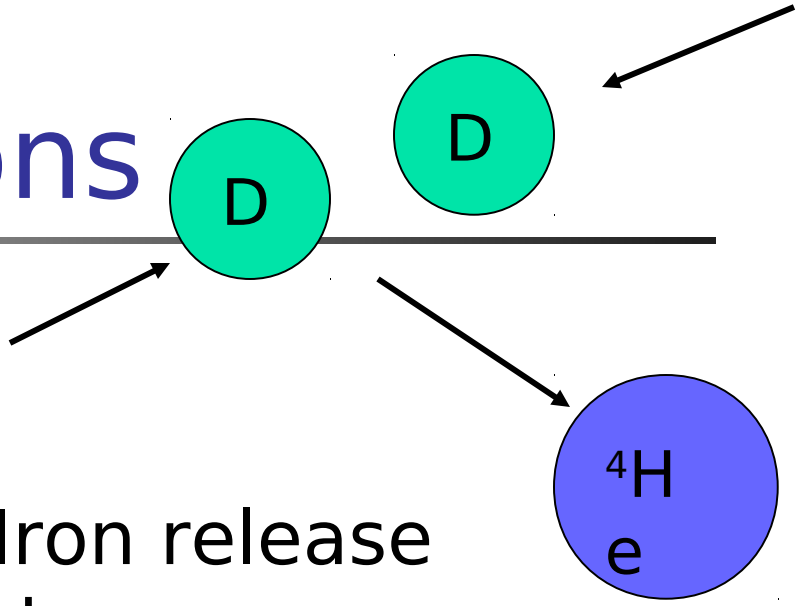



*Figure 2-VIII. Implosion Assembly Principle*

- Burst of neutrons from generator is timed for moment of maximum compression

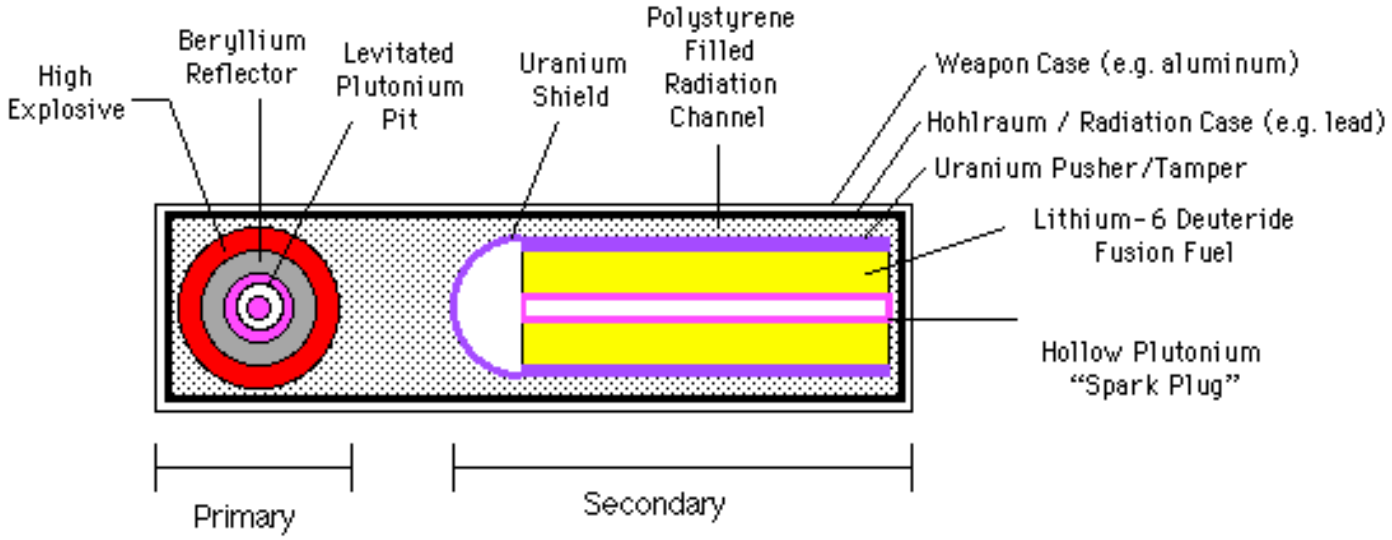
# Fusion Weapons




- Fusion
  - Elements lighter than Iron release energy when combined
  - Deuterium, Tritium, Lithium
  - Reactions that occur inside Sun
  - “H” bombs
- Thermonuclear Reactions
  - Heat from reaction increases reaction rate, so less fuel is needed → “efficient” bomb

# The “secret” of the H-bomb

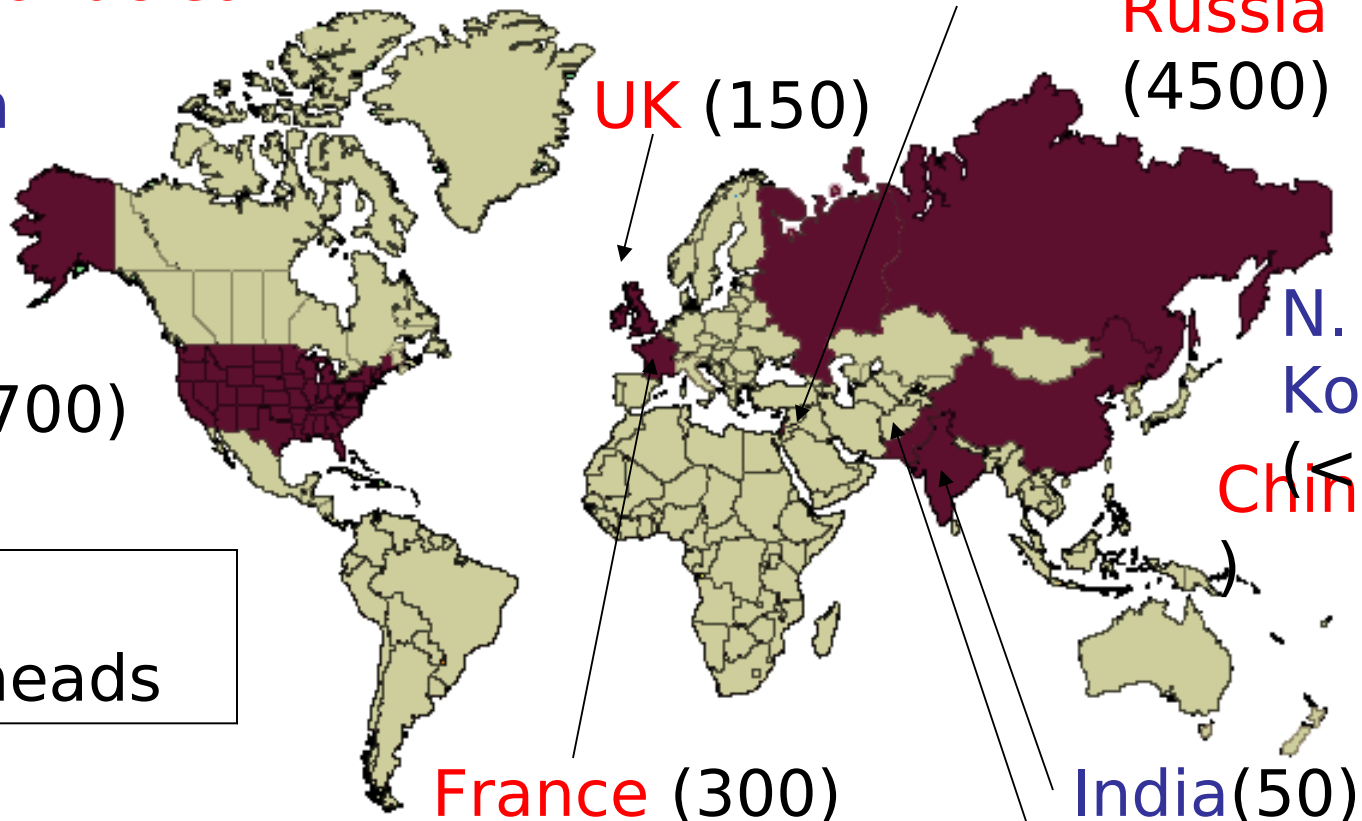
- At the high temperatures of a fission bomb 80% or more of the energy exists as soft X-rays
- The X-rays heat a polystyrene channel, causing plasma which can compress and ignite the second (fusion) stage before the e… …upts it



# How big are the weapons?

- 1 kTon = 1000 tons = 2,000,000 pounds of TNT equivalent
- ~2 pounds of $^{235}U$ → 20 kTons
- Today's warhead is 100-200 kTons
- Largest underground burst: 4.5Mtons
- Largest airburst: 58 Mtons
- Over 1700 known tests since 1945

# Who has nuclear weapons?




http://www.ucsusa.org/assets/documents/nwgs/Wordwide-Nuclear-Arsenals-Fact-Sheet.pdf

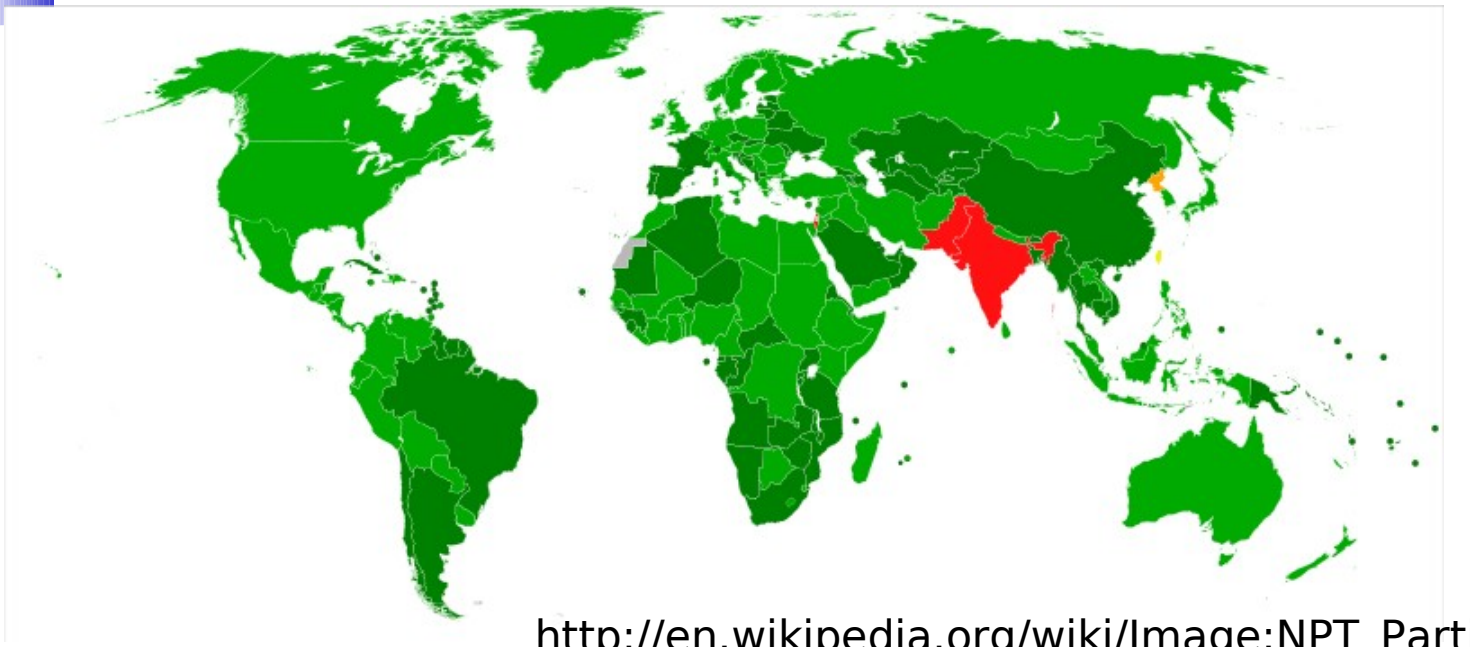
# Nuclear Non-Proliferation Treaty

- Vertical – development of new weapons by the “Big 5”
- Horizontal – spread of weapons to other countries
- “Haves” agree not to spread weapons, materials or technology to “have-nots” – also, to stop vertical proliferation
- “Have-nots” agree not to try to acquire weapons from the “haves,” and will accept inspection and regulation of “peaceful” nuclear technology by IAEA- this stops horizontal proliferation

# Nuclear Non-Proliferation Treaty

- NPT indefinitely extended since May 1995, confirmed again in 2000, reviewed most recently in May 2010
- Now signed by 189 countries
- N. Korea ratified in 1985 then withdrew in 2003. In 2006 and 2009, it conducted nuclear tests.
- Israel, India and Pakistan are still not signatories.
- Iran remains a signatory but is in violation according to 2011 IAEA report which is disputed. This report describes in depth, the country's detonator development, the multiple-point initiation of high explosives, and experiments involving nuclear payload integration into a missile delivery vehicle.

# July 2008 Non-proliferation Treaty Map



http://en.wikipedia.org/wiki/Image:NPT_Participation.svg

- Signed and ratified
- Acceded or succeeded
- Unrecognized state but abiding by treaty
- Withdrawn
- Non-signatory

# Some hopeful signs

- New START (STrategic Arms Reduction Treaty) signed April 8, 2010 by Obama and Medvedev – and then ratified by Senate and put into force on Feb. 5, 2011
  - Limits deployed strategic nuclear warheads to 1,550
  - Limits deployed and non-deployed ICBM, SLBM, and heavy bombers to 800.
  - Limits deployed ICBMs, deployed SLBMs, and deployed heavy bombers to 700
- For the first time in a long time, US and Russia are slowing vertical proliferation

# Some hopeful signs

- 2012 Nuclear Security Summit in Seoul, South Korea (3/26-27/12)
  - Set a target date of 2014 for bringing the amendment of the Convention for the Physical Protection of Nuclear Materials (CPPNM) into force;
  - Several nations (incl. Italy) pledged to eliminate their stocks of fissile material;
  - Agreement between the U.S., France, Belgium and the Netherlands to produce medical isotopes without the use of highly enriched uranium by 2015.
  - Next summit in 2014 in the Netherlands

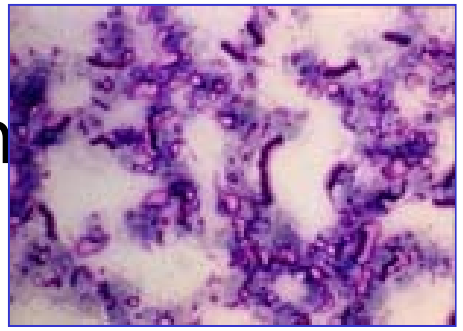
# Additional Resources

- Carnegie Endowment for International Peace
  http://www.ceip.org/
- Biological and Chemical Weapons Resources
  http://www.fas.org/main/content.jsp?formAction=325&projectId=4
- US position on BTWC (2001)
  http://www.fas.org/bwc/news/USPublicPositionsOnProtocol.htm
- CDC Vector Borne Diseases
  http://www.cdc.gov/ncidod/dvbid/index.htm
- Chemical Weapons Convention
  http://www.cwc.gov/
- Federation of American Scientists
  http://www.fas.org
- Iran Watch (Wisconsin Project)
  http://www.iranwatch.org/
- Union of Concerned Scientists
  http://ucsusa.org

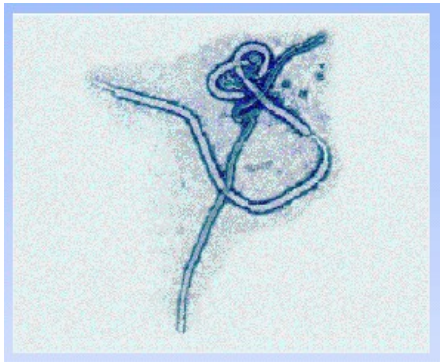
# Biological and Chemical slides

# Types of Biological Weapons

- Bacteria
  - Cause disease by reproducin
  - Single cell organism
  - Typhus, anthrax
- Viruses
  - Multiply only inside host cells
  - Sub-microscopic organisms
  - Ebola, Chikungunya



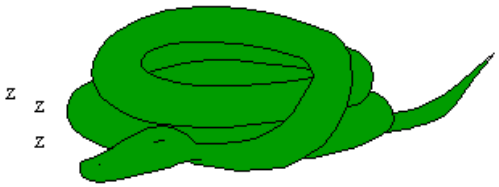
Anthrax



Ebola

# Types of Biological Weapons

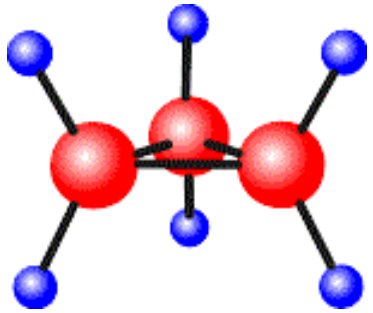
- Rickettsia
  - Larger than viruses
  - Smaller than bacteria
  - From fleas, lice and tic
  - Q-fever




- Toxins
  - Poisons from living things
  - Snake venom
  - Botulinum most lethal known – $<10^{-6}$ g!
  - But some beneficial uses

# Types of Chemical Weapons

- Nerve agents
  - Inhibit enzyme that transmits messages from nerve cells to muscles
  - Lethal dose <1-10 mg
- Mustard agents
  - Blistering of skin, lungs
  - Lethal dose >500 mg



- Hydrogen Cyanide (HCN) gas
  - Prevents blood from carrying oxygen
  - Lethal dose > 120 mg

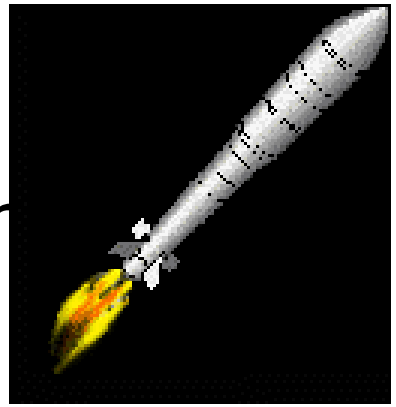
# Types of Chemical Weapons

- Tear gases
  - Cause pain in eyes
  - Do not affect horses or dogs
  - Short term effects
- Arsines
  - Mixed with mustard gas
- Psychotomimetic agents
  - Cause temporary psychosis
  - LSD, atropine

LSD

# Why Use Chemical or Biological Weapons?

- Cheap
- Easy Technology
- Simple delivery system
  - Artillery shells
  - Rocket launchers
  - Aerosol sprays
- Research into biological weapons continues for treating diseases, developing vaccines, anti-toxins, etc.



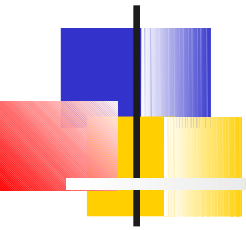
# Chemical/Biological Weapons Problems

- Chemical weapons largely ineffective
- Biological weapons can’t be stored
- Protection against both is relatively easy on the battlefield
- Both are really “weapons of terror” against citizens or “weapons of intimidation” against soldiers rather than “weapons of mass destruction”

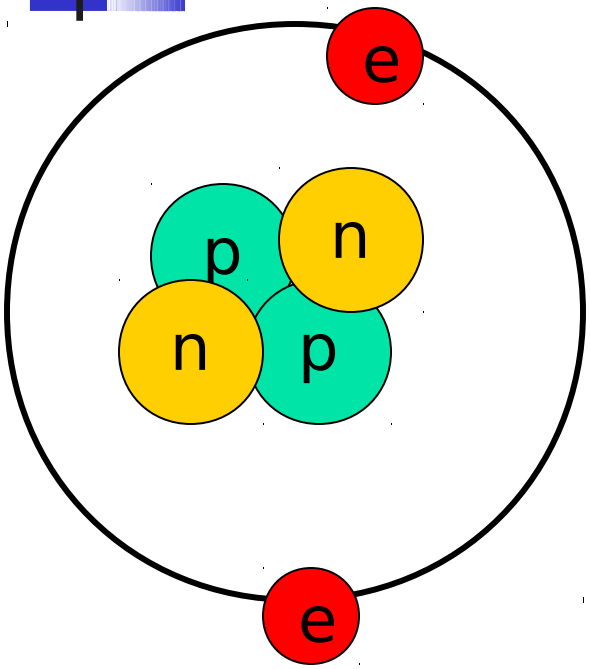
# Biological/Chemical Terrorism

- Since 1900, only ~75 terrorist attacks out of more than 40,000 used Chemical or Biological weapons
- Only 125 people died & ~4000 got sick
- ~20 people died in Japan in the well-publicized nerve gas attacks. This sect also tried to make biological weapons but failed, after spending $1 billion

# Backup Slides



# The Helium Atom




$^{4}He$

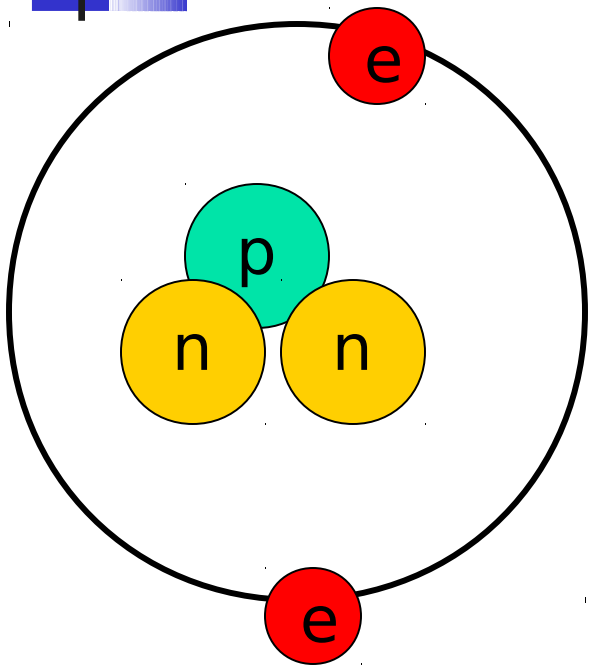
- Two electrons orbiting a nucleus with:

2 protons = Z = atomic number

2 neutrons = N

- Total mass = A = Z+N
- Singly ionized Helium is missing one electron = $^{4}He^{+}$
- Doubly ionized Helium is missing both electrons = $\alpha$ particle = $^{4}He^{++}$

# Isotopes and Elements

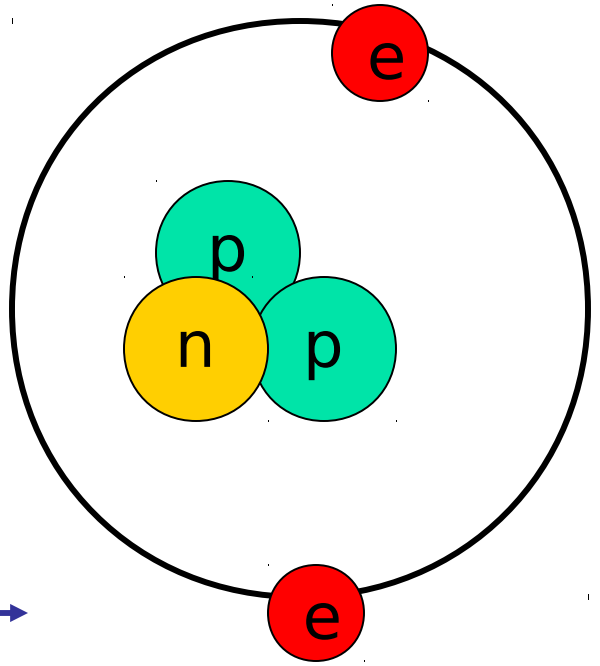



- If Helium loses one of its protons, it becomes a different element

$^{3}H$

- If Helium loses one of its neutrons, it becomes an isotope

$^{3}He$

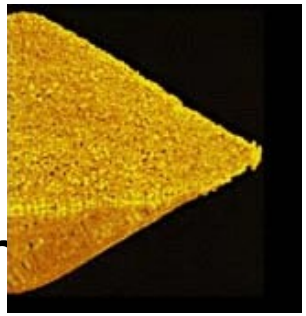


# Materials

- Tritium = $^{3}H$ = very heavy Hydrogen (1p + 2n), used in fusion weapons
- Deuterium = $^{2}H$ = heavy Hydrogen (1p + 1n), used in fusion weapons
- Uranium: $^{238}U$ is >99% in nature $^{235}U$ is ~0.7% in nature – major ingredient in fission weapons
- Plutonium: $^{239}Pu$ is not found in

# Uranium processing

- Uranium is mined as ore from open pits or deep shaft mines, often with the help of extracting solutions
- At nearby mills, ore is crushed and U is extracted, leaving behind radioactive tailings
- Extracted U is then leached (with sulfuric acid) forming a concentrate known as “yellowcake” (aka Uranium oxide $U_3O_8$)
- Yellowcake is then turned into $UF_6$ gas, which can be cooled to a solid for easier transport



# Uranium in power plants

- The “yellowcake” is turned into pellets which are packed into 12’ fuel rods
- Bundles of fuel rods are placed at the cores of nuclear reactors
- The US has ~ 100 nuclear reactors: 2/3 of these are “pressurized” water reactors; 1/3 are “boiling” water reactors. Both heat water to cool the  rods and create electricity

# Enriching Uranium

- Naturally occurring Uranium must be enriched to >90% $^{235}U$ in order to make fission weapons (or to ~5% for nuclear power plants)
- Enrichment methods
  - Gas centrifuge (now being used in Iran and found in Iraq after 1st Gulf War)
  - Gaseous diffusion (used in USA)
  - Electromagnetic isotope separation – (unexpectedly found in Iraq after 1st Gulf War)

# Yongbyon nuclear facility

- Read more at:
  http://www.iht.com/articles/2008/09/25/asia/25korea.php
  http://www.nhk.or.jp/nagahour/indepth_coverage/asia/northkorea/nucle

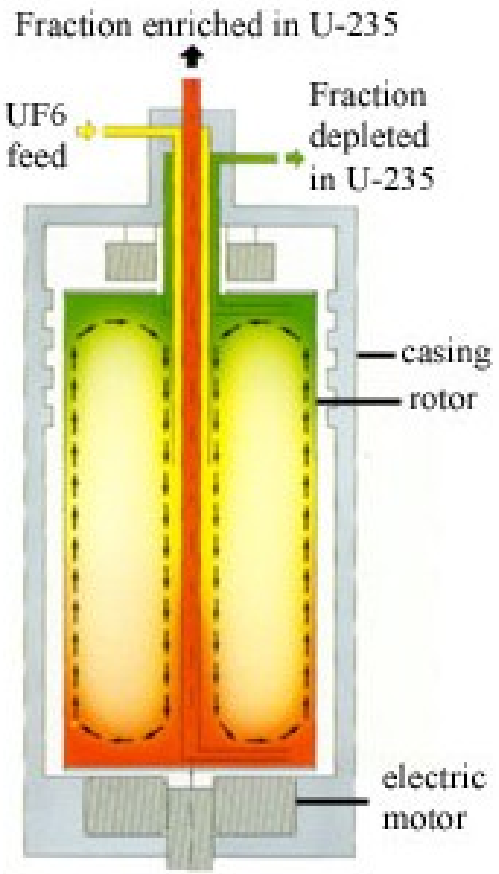
Blowing up cooling tower in June 2008

# Iran's Nuclear Summit

- Following the "New START" and DC Nuclear Summit, Iran held a summit (4/17-18/10)
- "Nuclear Energy for All, Nuclear Weapons for No One"
- Eliminate all nuclear weapons but allow countries to develop nuclear power
- Iran considers itself a "nuclear state" and claims all its enrichment activities are for peaceful purposes.
- Iran insists the US pressure Israel to sign NPT

# Gas centrifuge

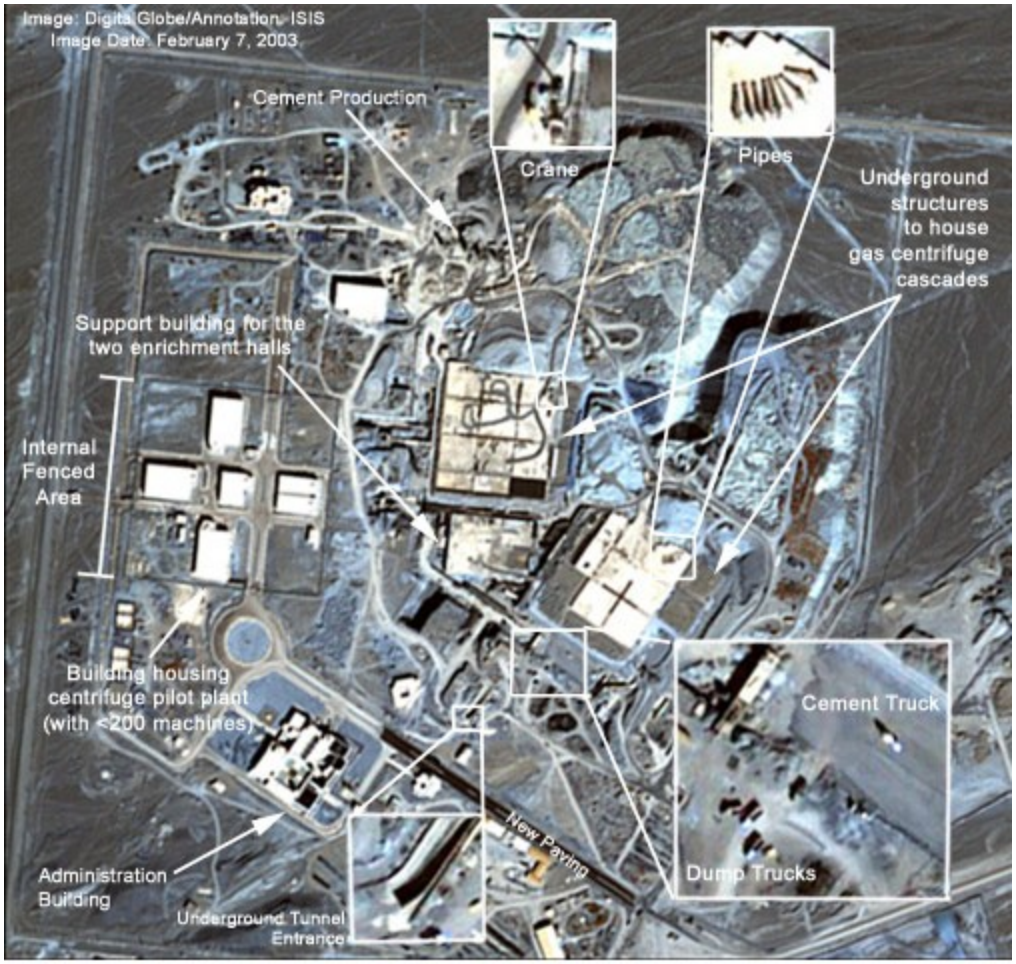
- Uses successive stages to isolate isotopes by weight – lighter mixture is sent on to the next stage, heavier mixture is sent back to the previous stage
- Requires thousands of successive stages to create weapons grade $^{235}U$



# Enriching Uranium in Iran

- As of 2003, Iran was developing an extensive, underground enrichment facility for Uranium
- Most of the centrifuges are underground, in order to withstand aerial attack – only 1-2% would be needed to make sufficient quantities of highly enriched U for a weapons program
- Iran's stated goal for this facility is production of sufficient low-enriched U to generate 6000 MW electricity

# 2003 Image of Natanz, Iran




**Natanz, Iran**

Institute for Science and International Security

Image Credit: DigitalGlobe
Date of Image: 7 February 2003

# Ahmadinejad visits Natanz 4/08

- Inspecting the new IR-2 centrifuges

# New enrichment facility in Iran

- On 9/25/09, Pres. Obama announced that Iran had been building a new enrichment plant in a mountain NE of Qo

# 9/6/10 Update on Iran and U

- IAEA has estimated that since 2007, 2803 kg of low enriched $UF_6$ was produced
- Iran claims to have produced over 20 kg of 20% enriched U, supposedly for a medical reactor – IAEA has not been able to inspect this process
- It takes less time to enrich from 20% to 90% than from 3% (low enriched) to 20%
- Iran has reached "breakout capacity" - the theoretical ability to produce the 20-25 kg highly enriched uranium needed for one functioning warhead.
- US and UN sanctions are in effect.

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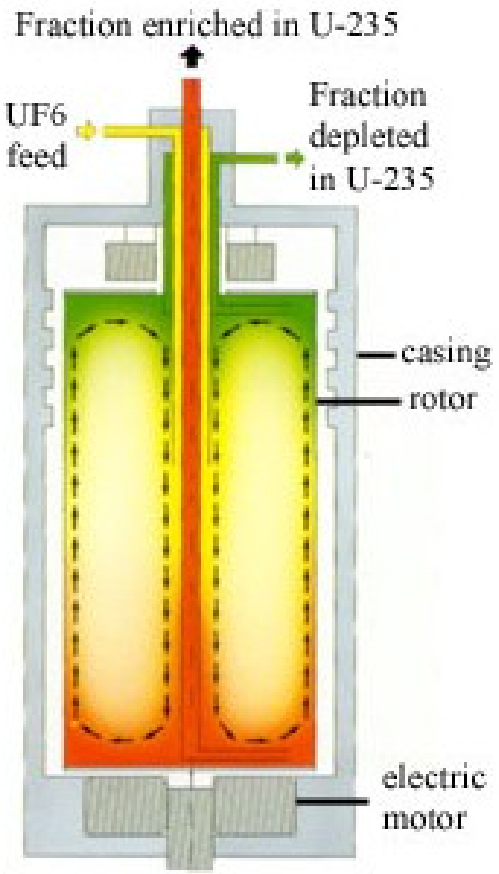

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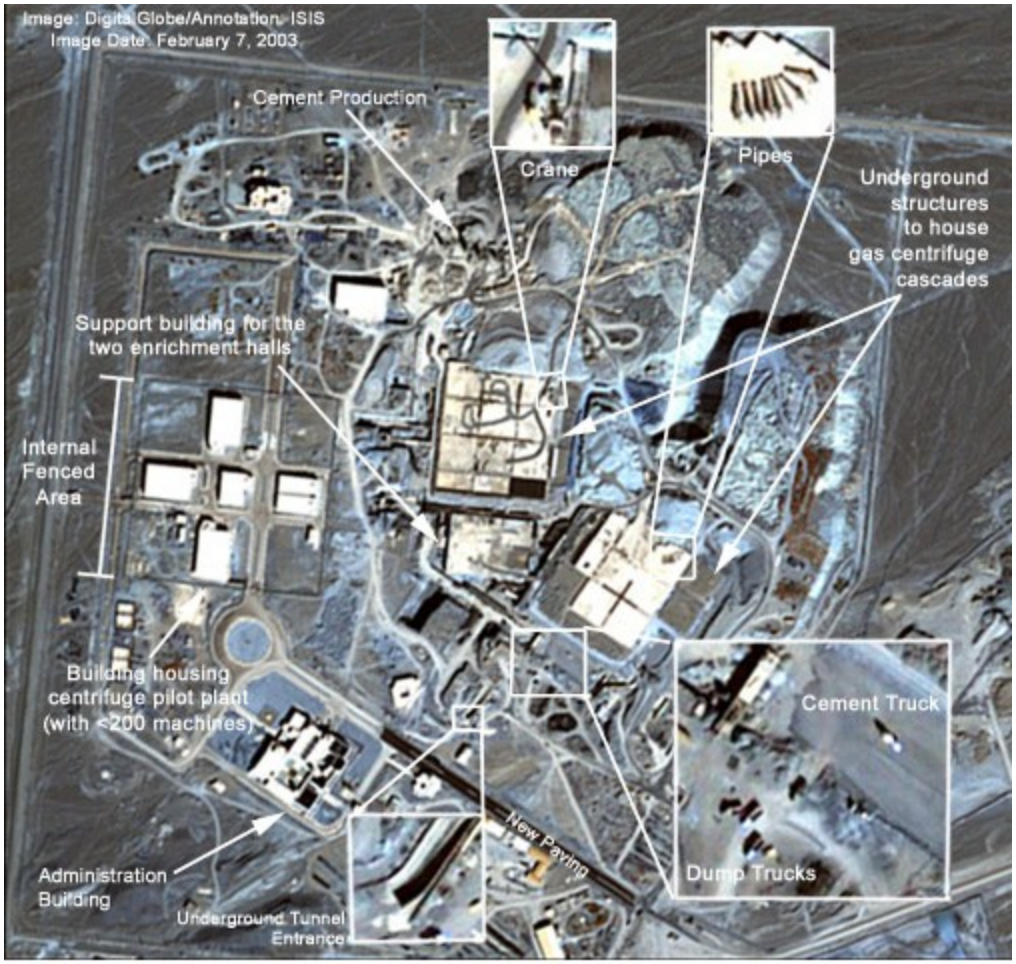


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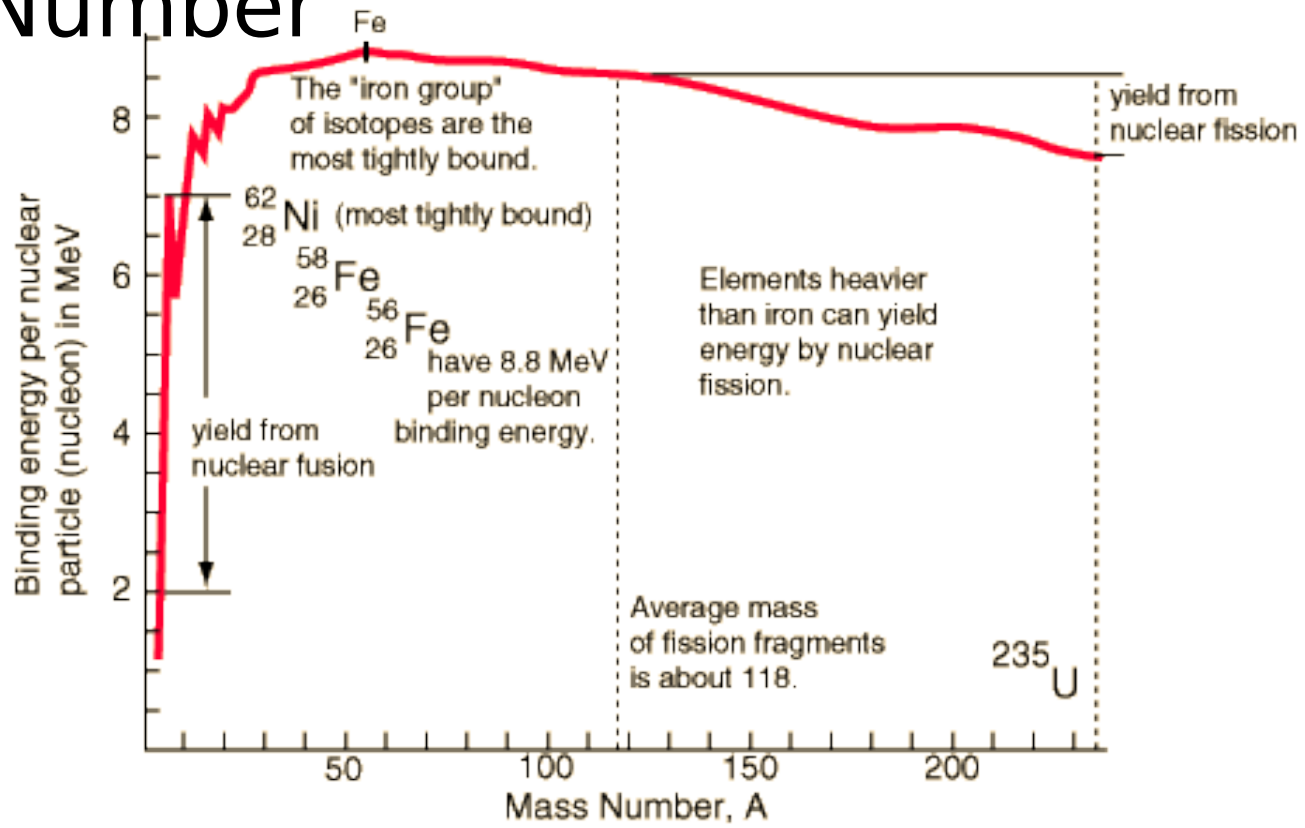
# Radioactivity

- Primordial –
  - formed before Earth's creation
  - long half lives – $^{238}U$ is $4.5 \times 10^9$ y
- Cosmogenic – formed as a result of cosmic ray interactions
  - Examples: $^{14}C$ (5730 y) and $^{3}H$ (12.3 y)
- Man-made – typically in power plants or accelerators
  - Examples: $^{239}Pu$ ($2.4 \times 10^4$ y) and $^{131}I$ (8 d) and also $^{3}H$ (12.3 y)

# Fission or Fusion?

- Nuclear binding energy vs. Mass Number




http://hyperphysics.phy-astr.gsu.edu/hbase/nucene/nucbin.html

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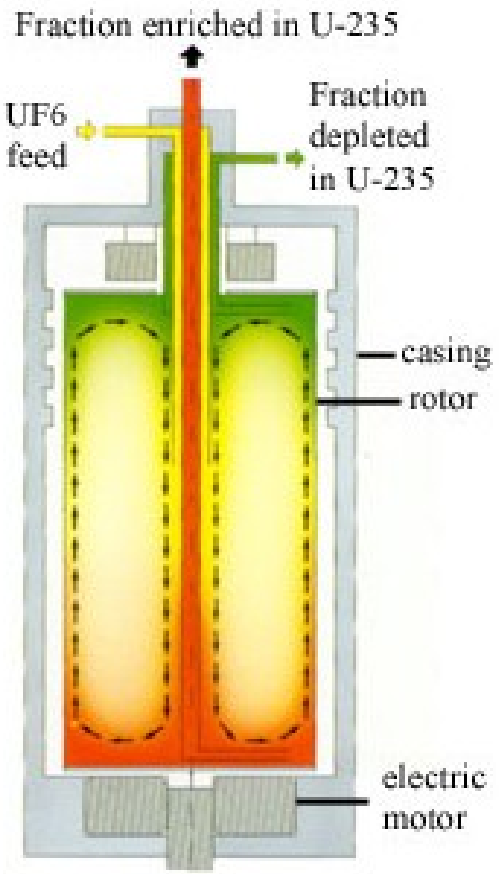
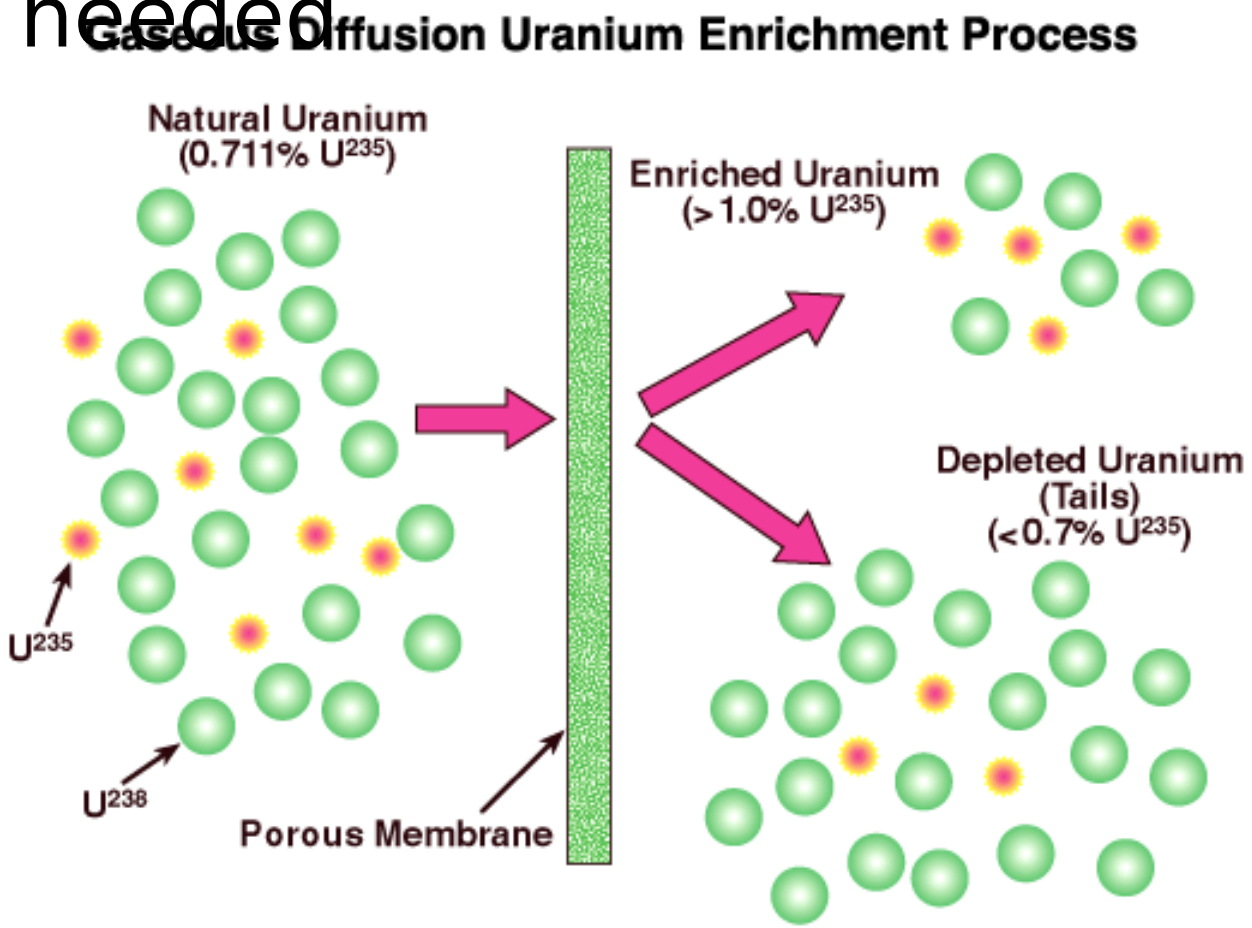


# Gaseous diffusion

- Thousands of diffusion filters needed

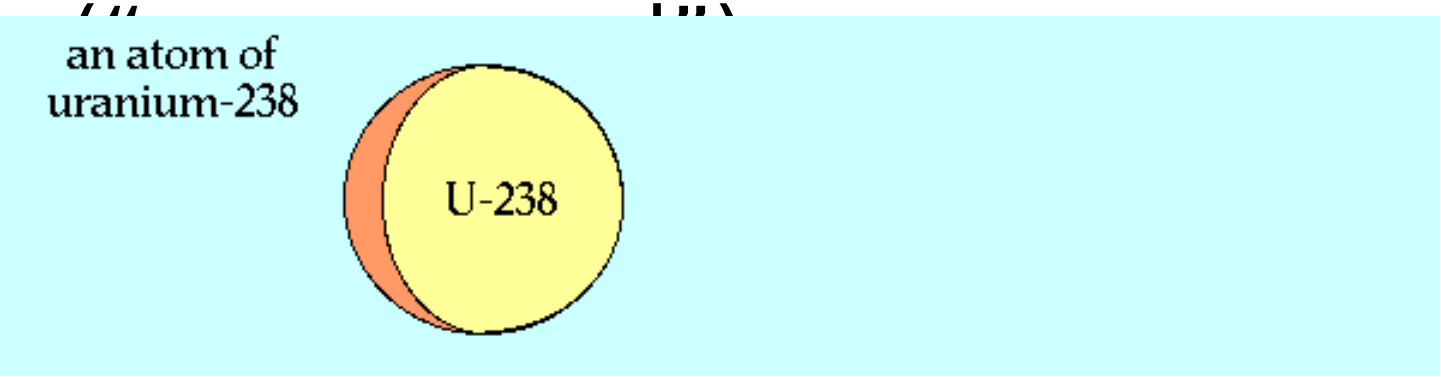


# Electromagnetic isotope separation

- Iraq's extensive EMIS program was unknown until its discovery after the Gulf War by UN inspectors
- Several unreported and disguised facilities were found, capable of creating quantities of weapons grade U
- Huge power requirements for EMIS have precluded use in USA – and were thought to preclude use by others

# Reprocessing Plutonium

- $^{239}Pu$ is a waste product in nuclear power reactors, that is intermixed with other spent reactor fuels
- In order to become weapons grade, it must be separated out



# Reprocessing Plutonium

- Spent reactor fuel is chopped up, by remote control, behind heavy lead shielding.
- Chopped-up pieces are then dissolved in boiling nitric acid, releasing radioactive gases in the process.
- Pu is chemically separated from the acid solution, leaving large quantities of high-level radioactive liquid waste and sludge behind.
- After it has cooled down for several years, the liquid waste is solidified for ultimate disposal, while the separated

# Depleted Uranium

- After isotope separation, the remaining $^{238}U$ is said to be “depleted” as it is missing $^{235}U$ – however, $^{238}U$ is still naturally radioactive
- Uranium is a very dense metal (1.7 x Pb), making it ideal for use in armor and shell casings
- Uranium is pyrophoric – friction causes it to burn
- The USA used depleted Uranium weapons in the Persian Gulf War (1991), in Bosnia (1995), Kosovo (1999) and in Iraq (present war)
- Various health problems have been

# Depleted Uranium

- Depleted Uranium can be put into fuel cells in a nuclear reactor and used to produce weapons grade $^{239}Pu$
- This is why Israel bombed the French-built OSIRAK nuclear reactor in Iraq in 1981

Targets made of depleted U which will be bombarded by neutrons to make Pu

# $^{238}U$ and the first Gulf War

- More than 640,000 pounds of contaminated equipment was left on the battlefields
- US-coalition forces used $^{238}U$ in
  - Large caliber shells fired from tanks
  - Small caliber shells fired from aircraft
  - Sniper bullets
  - Tank armor in 1/3 (2000+) of tanks

# Problems from $^{238}U$ dust

- After burning, $^{238}U$ creates fine radioactive and toxic vapor and dust
- More than 50% of these particles are just the right size to be inhaled, where they lodge in the lungs and remain for years
- It is easily carried by the wind, and stays in the air for hours after impact
- It also easily dissolves in water
- Ground contamination allows resuspension into the air and eventual water contamination
- No ground cleanup has occurred in Iraq

# Problems from $^{238}U$ fragments

- Unburned, $^{238}U$ remains radioactive – is classified as a “low-level” waste, subject to proper disposal and controls
- Fragments corrode with time, creating more dust and contaminated soil
- High levels of radioactivity have been measured from fragments found after the first Gulf War in Iraq, Kuwait and Saudi Arabia

# Health problems

- Many US service people were exposed to depleted Uranium during the first Gulf War
- Local populations in Iraq, Kuwait and Saudi Arabia were also exposed
- Particles can be found in the brain, kidney, bone, reproductive organs, muscle and spleen
- Causing kidney damage, cancers of the lung and bone, non-malignant respiratory disease, skin disorders, neurocognitive disorders, chromosomal damage, and birth defects

# Weapons design considerations

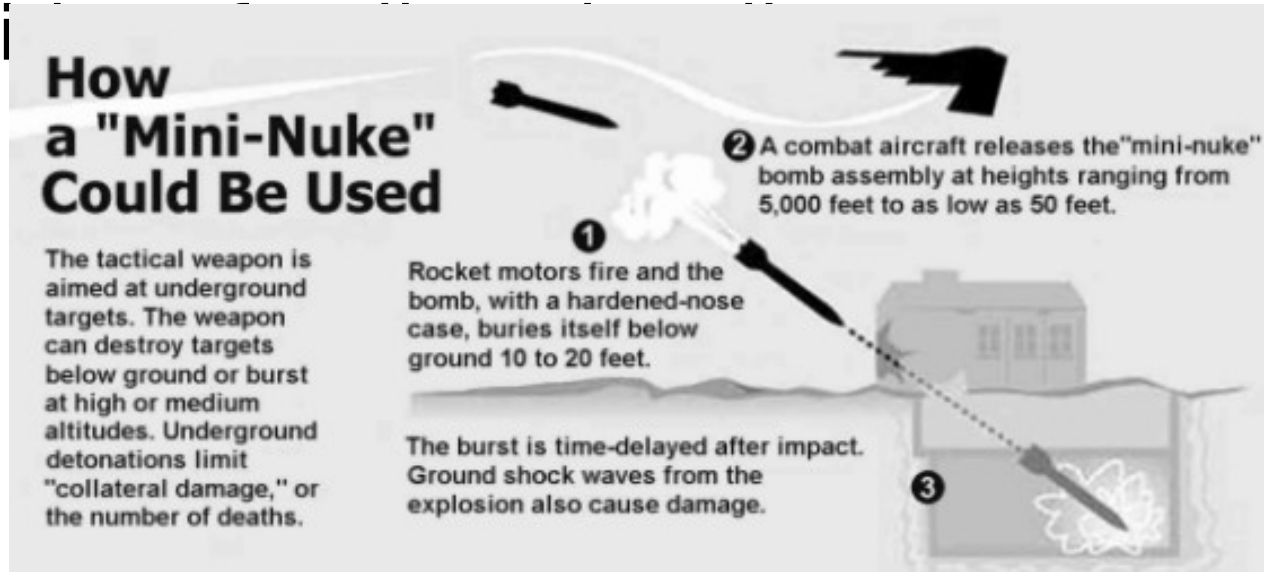
- Fission bombs produce 90% of their output as kinetic energy of fission fragments → fast heat production
- Fusion bombs produce 80% of their output as fast neutrons with <KE> = 14 MeV
- Fast neutrons can produce a fission event of KE=180 MeV, boosting the bomb's "efficiency"
- Most modern weapons therefore consist of at least two stages
  - Primary – fission bomb, often boosted by fusion core produced neutrons
  - Secondary – fusion bomb, with fission "sparkplug" to produce heat that triggers fusion, and extra layers of external fissionable material to boost yield

# Other bomb designs

- Neutron bombs
  - Also known as “enhanced radiation” weapons
  - Designed to lower blast wave, thus sparing buildings, but killing people
  - However buildings do become radioactive
- “Clean” bombs
  - Designed with more fusion, and less fission, → more neutrons and less fallout
  - Needed three stages for sufficient

# Low Yield Nuclear Weapons

- Designed to “threaten hard and deeply buried targets."
- Despite claims to produce less fallout due to underground explosion, a 5 kTon weapon would produce considerable quanti



# Nuclear Weapons Free Zones

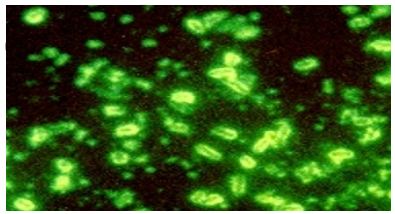
- Latin America and the Caribbean (the 1967 Treaty of Tlatelolco)
- South Pacific (the 1985 Treaty of Rarotonga)
- New treaties underway for
  - Southeast Asia (started December 15, 1995)
  - Africa (started April 11, 1996).

# Comprehensive Test Ban Treaty

- Prohibits all nuclear testing
- Opened for signatures in 1996
- Prevents “Big 5” from developing or testing weapons of new design
- Approved by Russian Duma in 4/00
- Rejected by US Senate in 10/99
- Annex 2 has 44 states – those with nuclear research or reactors – 41 states have signed and 33 have ratified as of 10/05 – India, Pakistan, N Korea have not signed. US, China, Israel, Iran among those who have not ratified.

# Biological Weapons History

- 1300s: Plague spread by infected



Plague bacteria

- 1760s: Native Americans infected by small pox from British blankets
- WWII:
  - Japanese use POWs for anthrax, cholera “research”
  - US develops anthrax bomb, obtains Japanese research results

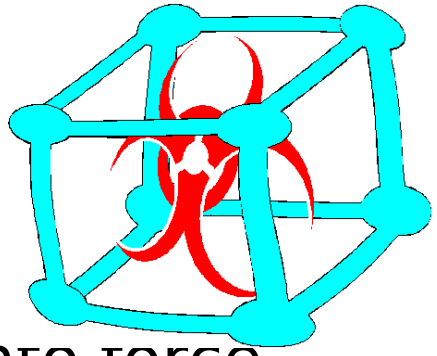
# Biological Weapons History

- 1950: US exposes public to “harmless” bacteria (SF) and germs (NYC, DC)
- 1969: Nixon renounced US use, stockpiles and destroys supplies
- 1972: Biological and Toxin Weapons Convention signed and ratified
- 1975: BTWC in force
- 1970s → present
  - US and biotech research continues…

http://www.fas.org/biosecurity/resource/bioweapons.htm

# Biological and Toxin Weapons Convention

- 162 signatories pledge to
  - Not develop, produce, stockpile, or acquire biological agents or toxins "of types and in quantities that have no justification for prophylactic, protective, and other peaceful purposes,"
  - Not develop weapons and means of delivery.
  - Destroy stockpiles within 9 months of the conventions entry into force.



- 13 signatories not yet ratified (Aug. 2008)

# BTWC Update: Fall 2006

- Discussions still stalemated to add verification provisions to BTWC
- In July 2001, USA officially rejected these provisions, negotiated under Clinton Administration
- Ongoing research projects by USA and others are arguably in violation of the new, strengthened treaty – we do not want these research facilities inspected

http://www.basicint.org/update/BWC0607.htm

# Chemical Weapons History

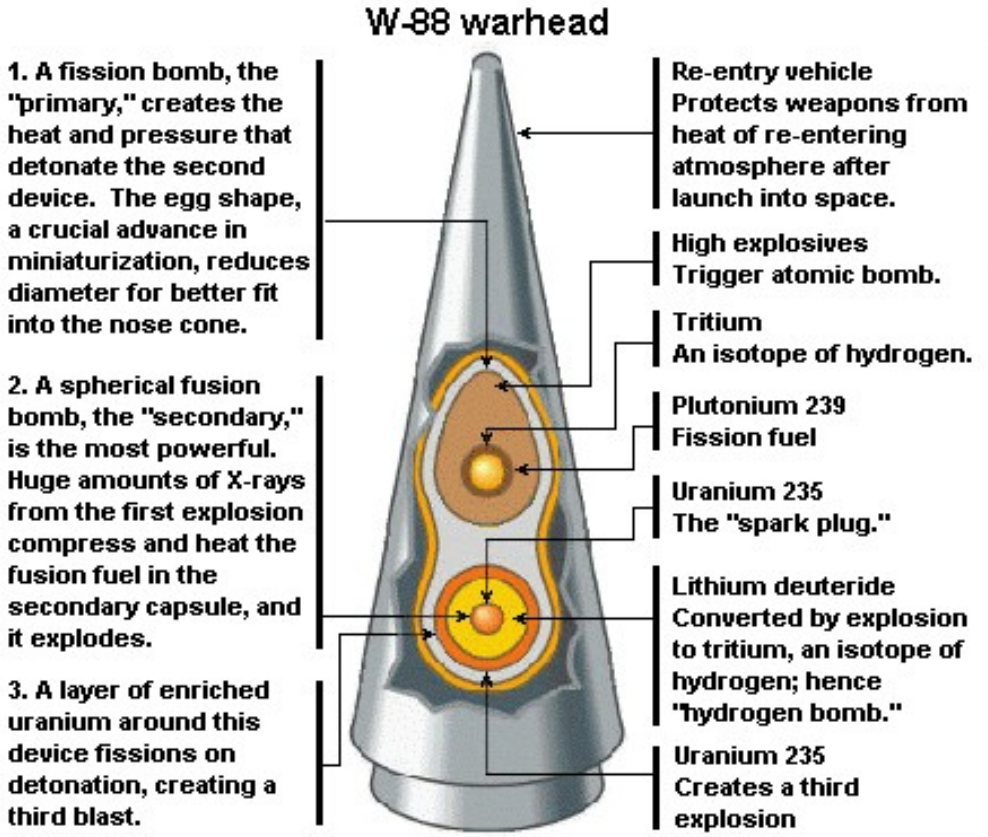
- WWI: Mustard, Phosgene and Chlorine gases used on battlefields
- 1925 Geneva accord prohibits use in battle but development continues
- WWII: Nerve gases made, not used
  - Tabun, Sarin, Soman, VX
- 1968 Open air tests kill sheep in Utah
  - US bans air tests, stops unitary weapons

Not a real dead sheep

# Chemical Weapons History

- 1980s:
  - Iraq uses mustard gas vs. Iran, and possibly HCN vs. Kurds, kills > 5000
  - US proposes complete CW ban, but begins funding binary weapons
  - USSR halts production, starts destroying stockpiles
- 1993:Chemical Weapons Convention opens for signatures
- 2000: 172 signatories, 139 ratifiers

# Fusion weapons



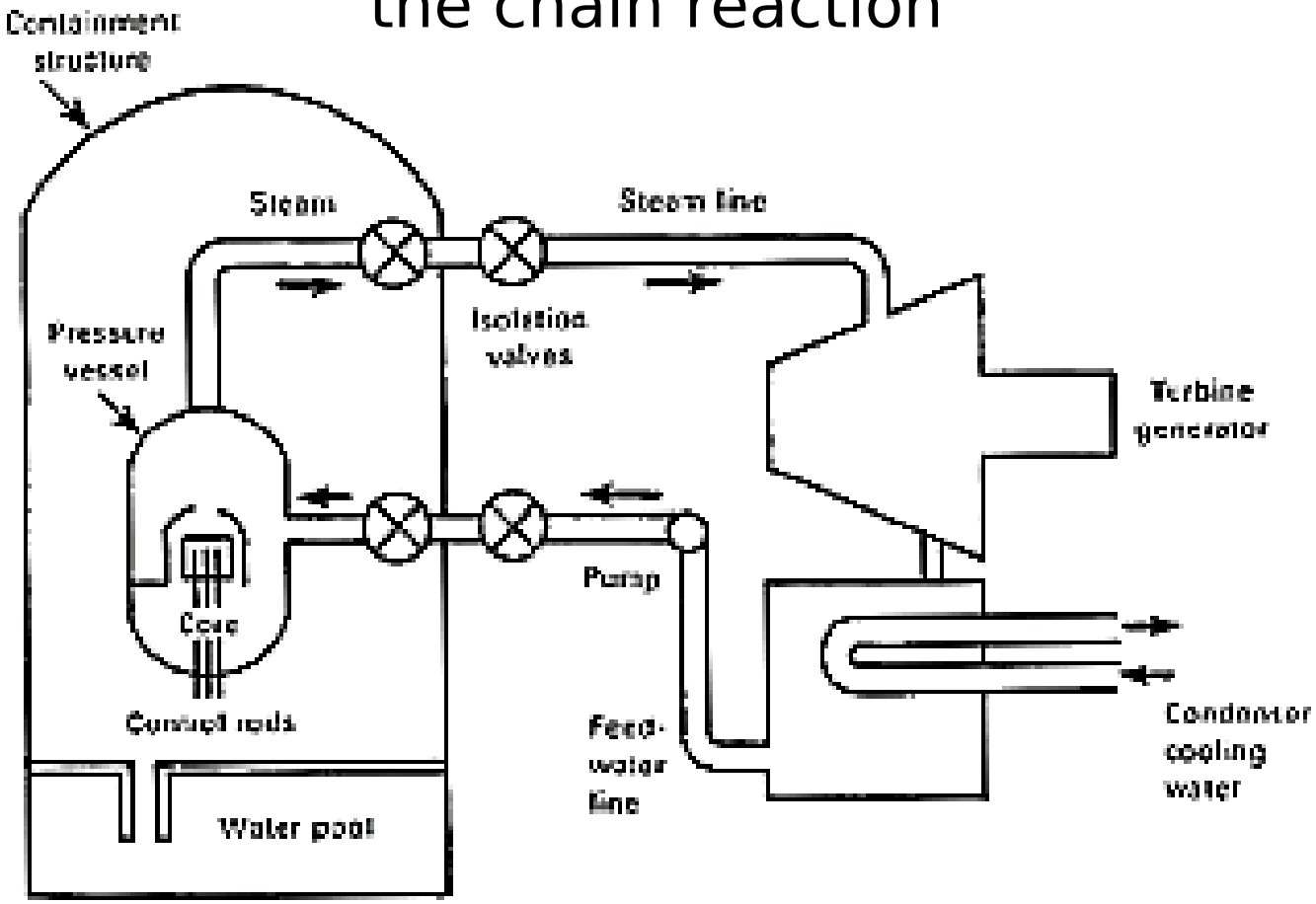


Published due to Wen Ho Lee case

http://www.fas.org/sgp/eprint/morland.html

# Boiling water reactor design

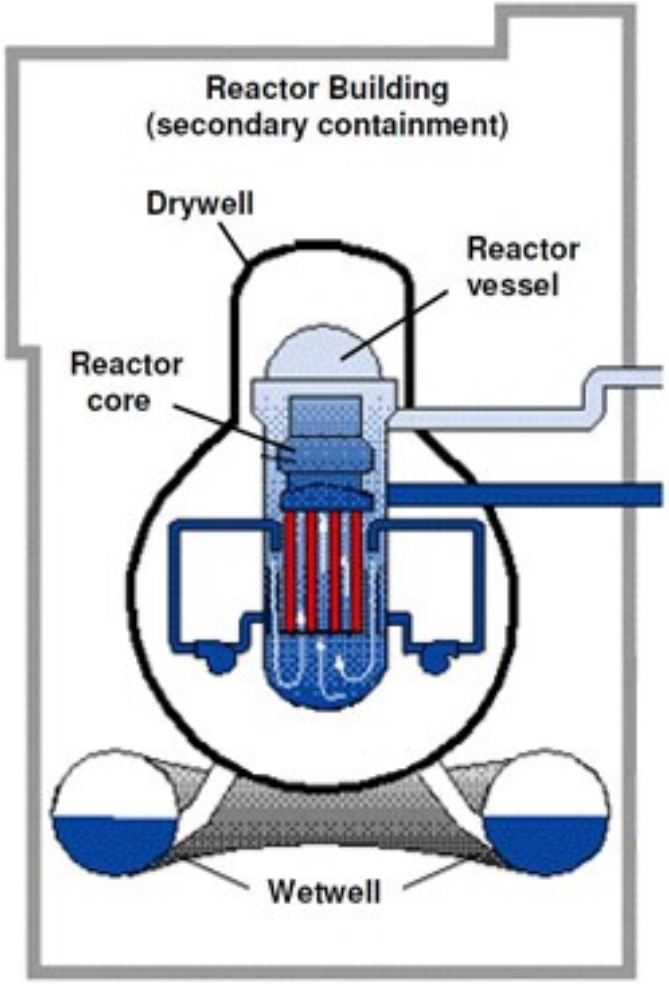
- The water in the core is heated by the energy from the chain reaction




- The heated water spins turbines to produce electricity

"Using a nuclear reactor to boil water is like using a chain saw to cut butter" – Amory Lovins

# BWR Containment design




Mark I containment system.
Figure adapted from *www.nucleartourist.com*

- Used at Fukishima Daiichi
- Primary containment = “drywell” + “wetwell”
- Wetwell connects to drywell with pipes and contains water that is used to cool steam from drywell
- Secondary

# What happened in Japan?

- Earthquake and tsunami led to failure of main and backup power to nuclear power plants
- Power was needed to keep the main reactor vessel cool, as well as cooling the “spent fuel” pools outside the containment building
- As the water boiled off in the reactor vessels (and no new water could be pumped in), the fuel rods were exposed, and started to melt down. Hydrogen gas was produced and exploded in units 1,3

# What happened ? (continued)

- Water began boiling off in spent fuel pools, exposing the used fuel rods near units 1-6
- They too began to melt down
- More melted down fuel in these reactors than the sum of all previous accidents
- Dangerous isotopes released in nuclear accidents are $^{131}I$ (8 d) and $^{137}Cs$ (30 y)
- For more details, see: http://www.ucsusa.org/nuclear_power/nuclear_power_risk/safety/disaster-at-fukushima-anatomy.html

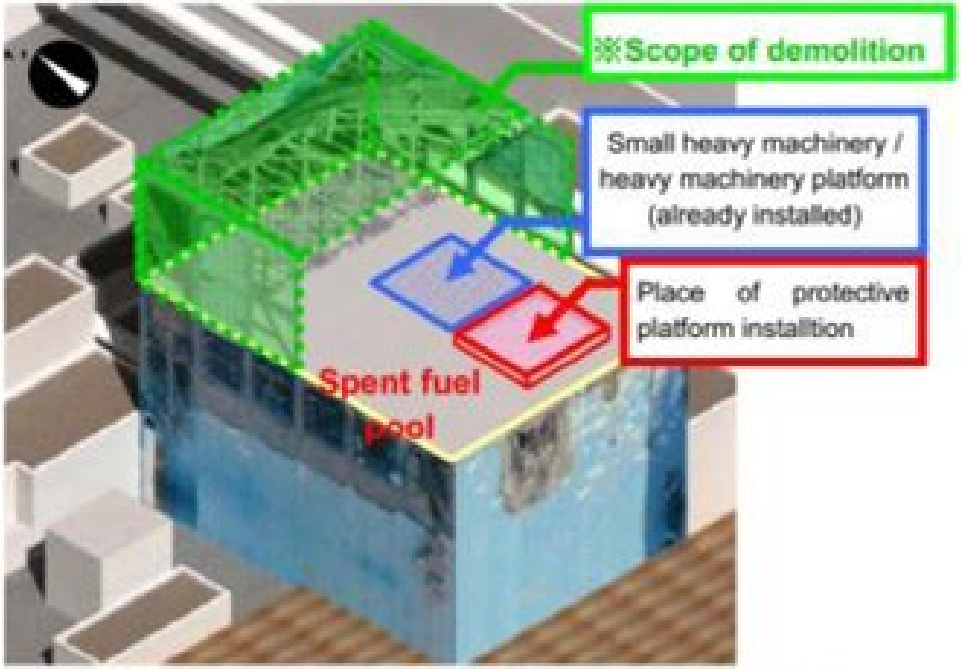
# Fukishima Daiichi aftermath

# Cleanup Efforts 2012

- Planning for a groundwater bypass system that will pump water flowing towards the reactor buildings around the buildings
- An Advanced Liquid Processing System (ALPS) for the removal of $\alpha$ and $\beta$ emitters from waste water has been installed onsite
- To prevent the spread of oceanic contamination installation of an impermeable wall has begun in the area offshore.
- The seabed soil in front of the intake channel has been covered and solidified. Seabed soil in front of the intake channel of Units 1-4 has been covered.
- Radioactive material concentration in the soil has been gradually decreasing since April 2011.
- Plans are underway to close the Unit 2 Reactor Building blowout panel.

# Cleanup Efforts 2012

- In June additional protective platforms were installed at the top of the Unit 4 Spent Fuel Pool. The cover is designed to protect the pool during the demolition of the damaged roof area. Below figure shows the installation of the platform and the area that is scheduled for demolition:

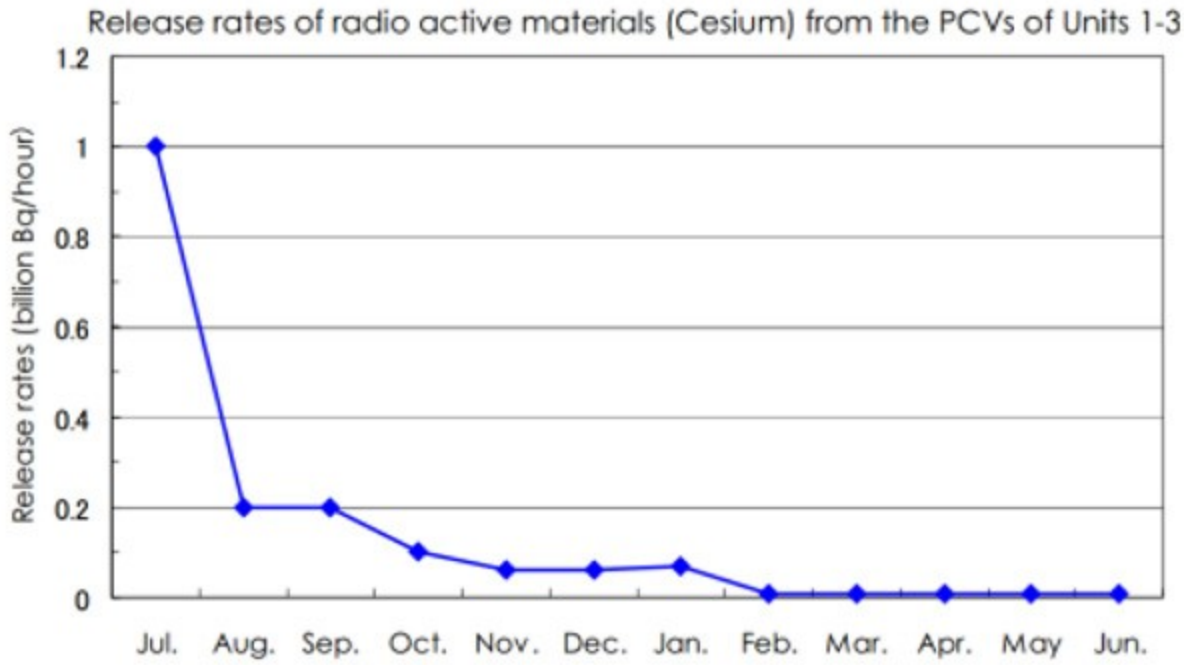



Protective platform installation (image)

Protective platform

# Radiation released

- The highest dose rate measured was 880 mSv/h directly above the reactor well in Unit 2 Reactor Building;
- The total currently release rate of radioactive material from the PCV of Units 1-3 is estimated to be at maximum 0.01 Billion Bq/h. Below is the trend of the total release rate of radioactive material from Units 1-3 sin[illegible]



# North Korean Nuclear Status

- On October 10, 2006 North Korea reported its first underground nuclear test, indicated by a small (~4$^{th}$ magnitude) earthquake, about 0.5 kTons
- IAEA believes that N. Korea has enough weapons-grade Pu for 5-15 bombs
- In 4/09, N. Korea launched a long-range missile, but the third stage did not work.
- On 5/25/09, N. Korea successfully conducted a second underground nuclear test, about the same as Hiroshima (~15 kTons).
- In 7/09, N. Korea launched surface to ship cruise missiles, and also ballistic missiles. All of their successful tests have involved short or medium-range missiles.

# Update on North Korea

- In May 2010, N. Korea announces it has achieved nuclear fusion
- In Jan. 2012, Kim Jong- un (new leader) announced that tests and enrichment were to be suspended, and inspections allowed in exchange for food aid from the USA
- In April 2012, N. Korea tried to launch a satellite, but the rocket exploded, and USA suspended the food aid
- In May 2012, N. Korea began again to construct a reactor containment building which could be used to reprocess fuel.
- Still agreeing to allow in IAEA inspectors, amid concerns that their nuclear complex is well hidden, and may escape detection by the inspectors.

# Are we in danger from N Korea?

- In order to threaten the US, North Korea must have:
  - Working nuclear warhead
  - Working long range delivery system – (still failed) – 3-5 years away?
  - Working electronics triggering for bomb (no evidence yet)
  - Intent to actually bomb another country

  (no clear evidence but entirely possible)