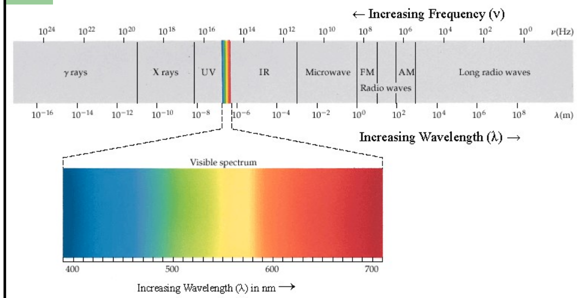
Gamma rays, Fission

~bombs and nuclear power

Gamma radiation

- In gamma radiation no particle is released, just a “packet” of energy.
- Photon- “packet” of energy.
- When an atom has too much energy, it is excited, it’s electrons are in higher energy levels.
- When they fall back to ground state, they release energy as small little bits.
- This energy travels as an electromagnetic wave.

Electromagnetic Spectrum



Nuclear fission

- ~the separating of a nucleus of an atom.
- This is the process used by nuclear power stations (when it is kept under control).
- It is also the process of an atom bomb (when it is allowed to run uncontrolled).

Manhattan Project

- ~construction of the atom bomb, 1942-45
- Several scientists associated with this project were Jewish who fled Nazi Germany. Including Fermi and Einstein.
- After Germany fell, several tried to stop the bombs from ever being used.
- It resulted in the bombing of Hiroshima on Aug 6, 1945 and Nagasaki on Aug 9, 1945.

Pre-Manhattan Project

- Several scientists fled Nazi Germany, but still had some contact with their old colleagues.
- Leo Sziliard and Enrico Fermi built and patented the first nuclear reactor in the United States under the football stadium in the squash courts at the University of Chicago.
- Their reactor was far too small to be useful, but the men understood the implications of their discovery.
- A “super bomb” could be built with this idea and they knew Germany was working on it.

Einstein

- Szilard wrote a letter to Einstein, also a Jewish refugee, about his work and the implications.
- Einstein signed a letter written by Szilard to president Franklin Roosevelt.
- Einstein would later say it was his greatest regret in life.

What is needed

- You need the rare isotope Uranium-235,
- or the artificially created Plutonium-239.
- The U-235 is bombarded with neutrons, the nucleus absorbs one neutron making the highly unstable U-236.
- The nucleus splits in two and releases 3 neutrons.
- This releases a lot more energy at once than regular decay (α or β).

Difficulties

- The hardest part of getting this reaction is having enough fissionable U-235.
- Uranium naturally occurs with about 99.8% U-238.
- U-238 will act the same chemically and physically to U-235, but it is not fissionable.
- Power plants need Enriched Uranium which is about 3-5% U-235
- Bombs need Highly Enriched Uranium (HEU) around 90% U-235

Nuclear Fission Reaction

$$^{235}_{92}U + ^{1}_{0}n \longrightarrow [^{236}_{92}U] \xrightarrow{\text{fission}} ^{93}_{36}Kr + ^{140}_{56}Ba + 3\,^{1}_{0}n + \text{energy}$$

Chain Reaction

- The three neutrons released from the first fission are absorbed by another 3 U-235 atoms.
- These atoms each undergo fission and also release 3 neutrons each (9 total).
- These hit 9 more U-235 and they undergo fission (releasing 27 neutrons).
- Chain Reaction- self sustaining nuclear reaction where one fission causes the fission of others.
- (video)

Chain Reaction Diagram

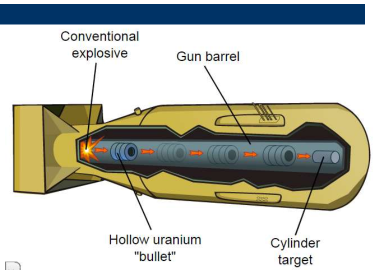
Critical mass

- ~the smallest amount of fissionable material necessary to start a chain reaction.
- The fission of 1 g of U-235 releases as much energy as combusting 2700 **k**g of coal.
- The bomb dropped on Hiroshima, “Little Boy” used U-235. The bomb dropped on Nagasaki, “Fat Man”, used Pu-239.

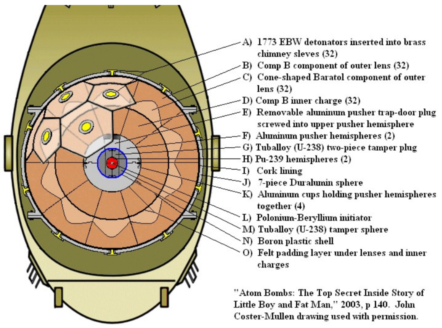
Bombs

- Bombs are rated by what an equivalent mass of TNT would do.
- Little Boy was a 15 kiloton bomb, Fat Man was a 21 kiloton bomb.
- Large atom bombs (fission bombs) can release energy equivalent about 500 kilotons of TNT.
- Hydrogen bombs (Fusion bombs) use fission bombs as their starting device.
- Fusion bombs can release around the same amount of energy as 50 megatons of TNT (100 atom bombs).

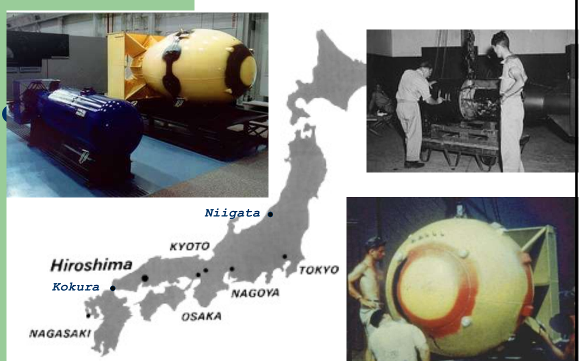
“gun” design of Little Boy

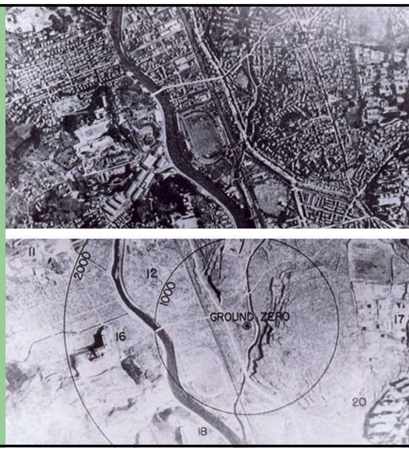


Fat Man implosion bomb design



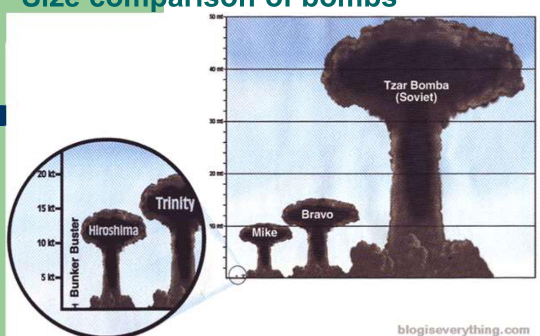
"Atom Bombs: The Top Secret Inside Story of Little Boy and Fat Man," 2003, p 140. John Coster-Mullen drawing used with permission.



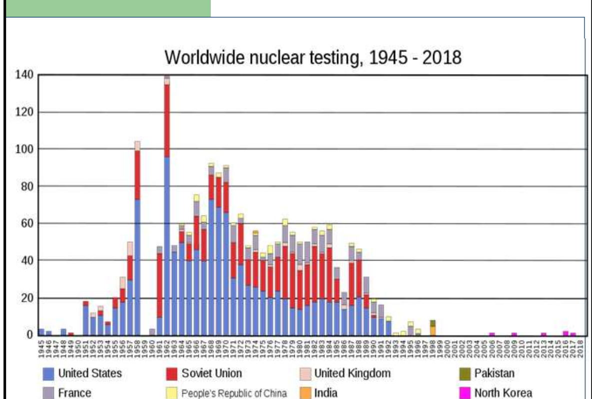


Nagasaki Before and After the Bombing

Size comparison of bombs



- Tsar bomba Largest ever tested (1961)
- All nuclear bombs detonated on the planet



Deaths from war worldwide since WWII