
HOW NUCLEAR WEAPONS WORK



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Topics Covered

- How a nuclear weapon works
 - Weapons Effects
 - Radiation
 - Tactical and Strategic warheads
 - Employment and delivery
 - And nuclear electromagnetic pulse.
-

Nuclear War 101

What is Radiation?

- It's a scary word





What is Radiation?

- It's a scary word
- But it's all around us
 - Light





What is Radiation?

- It's a scary word
- But it's all around us
 - Light
 - Dental - X Rays





What is Radiation?

- It's a scary word
- But it's all around us
 - Light
 - Dental - X Rays
 - Granite countertops





What is Radiation?

- It's a scary word
- But it's all around us
 - Light
 - Dental - X Rays
 - Granite countertops
 - Banana





High School Science




- Protons



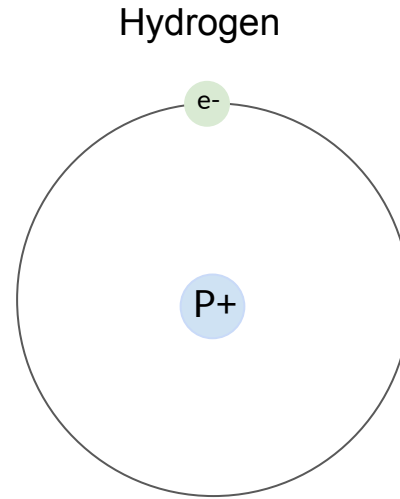
High School Science

- Protons 
- Neutrons 

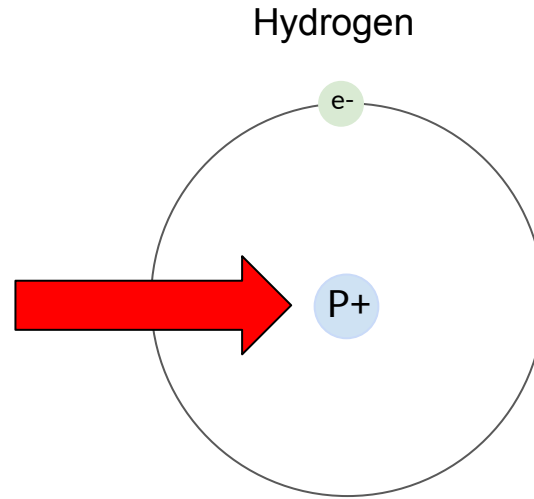
High School Science

- Protons 
- Neutrons 
- Electrons 

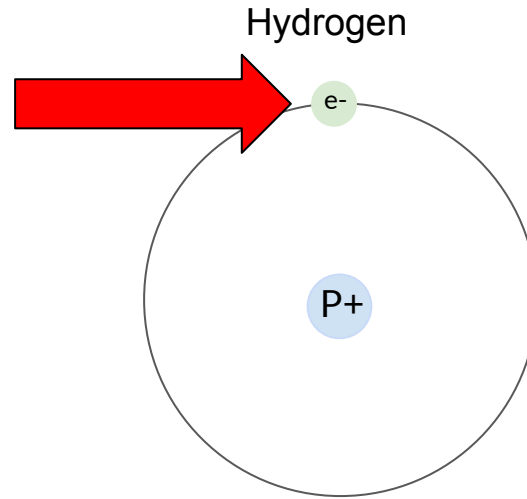
Hydrogen



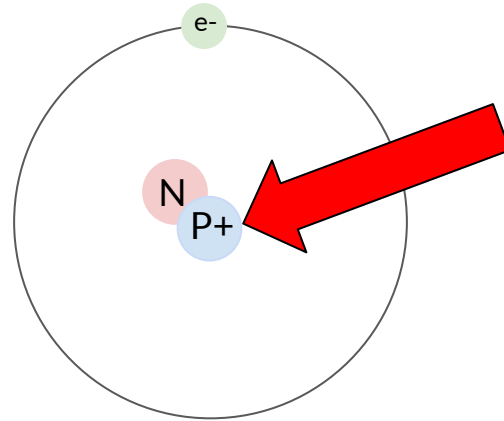
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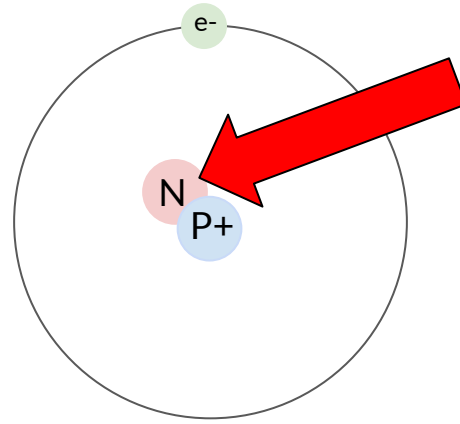
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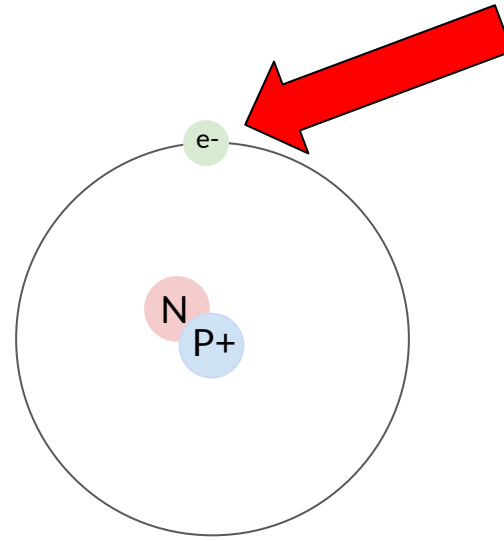
The Atom 101 - Protons



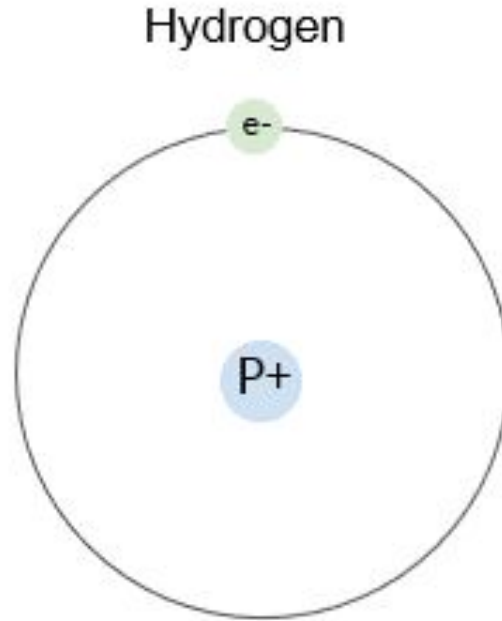
The Atom 101 - Neutrons



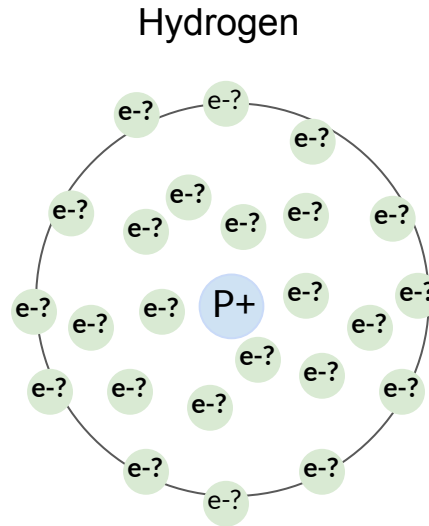
The Atom 101 - Electrons



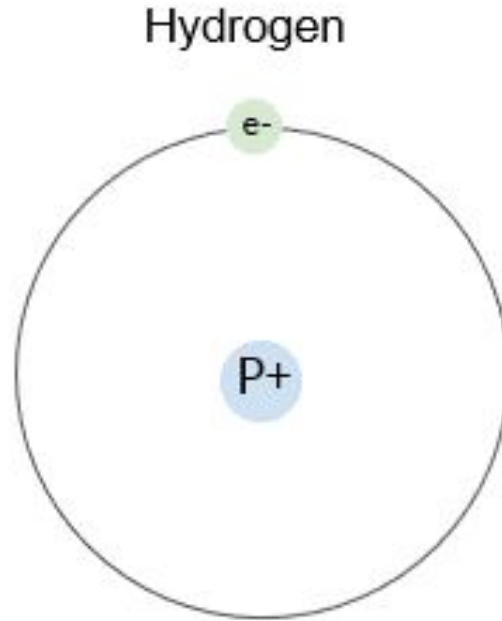
Hydrogen - The electron orbits



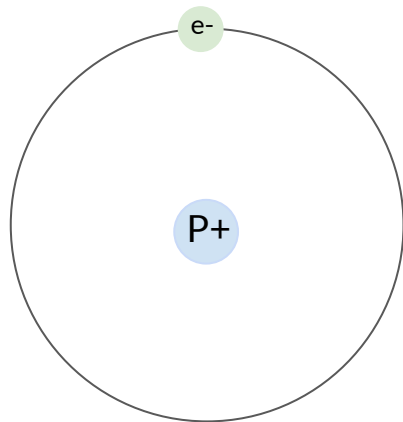
Maybe electrons don't orbit?



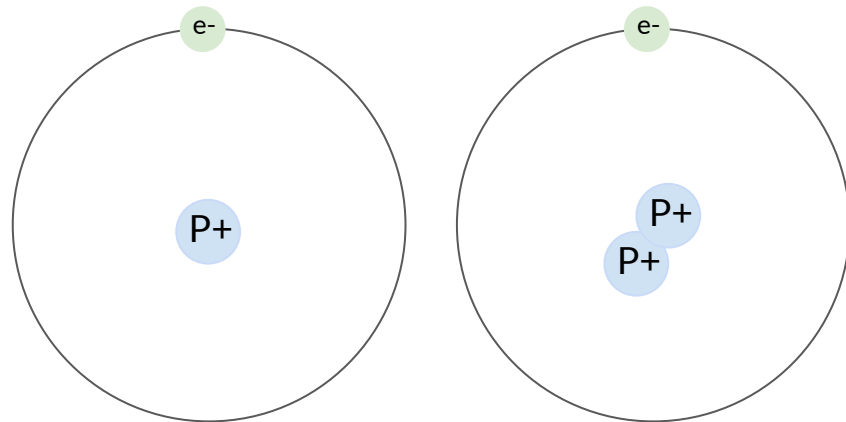
Hydrogen - But let's just say it orbits



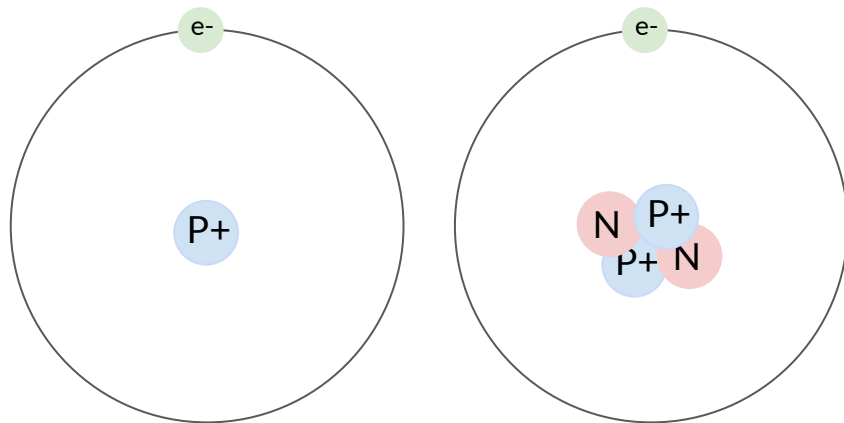
Hydrogen



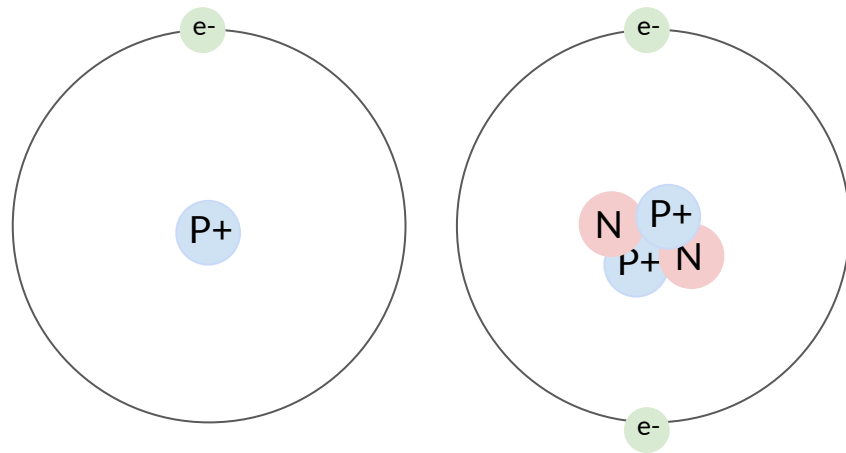
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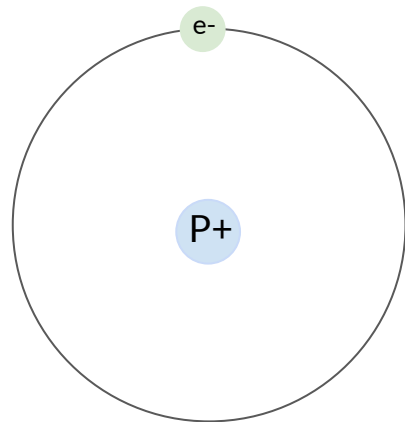
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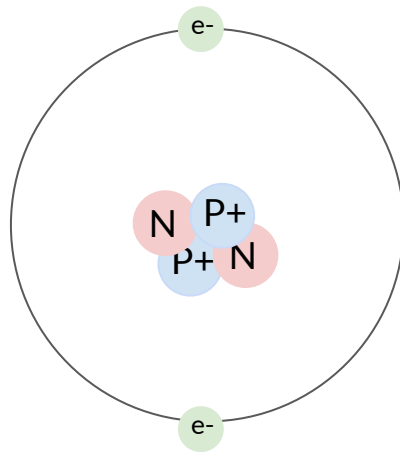
Hydrogen



Hydrogen



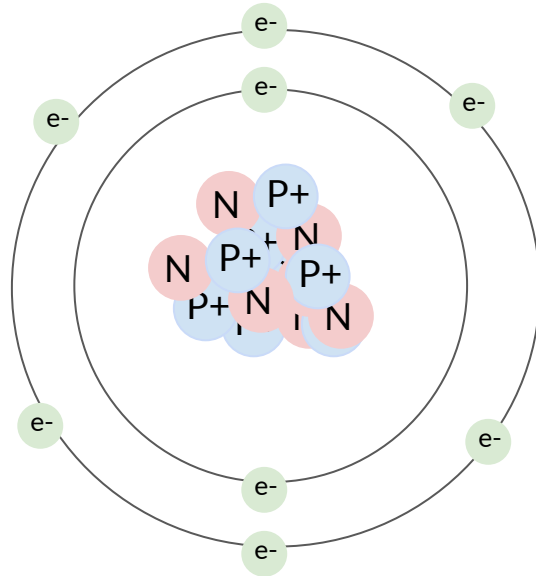
Helium



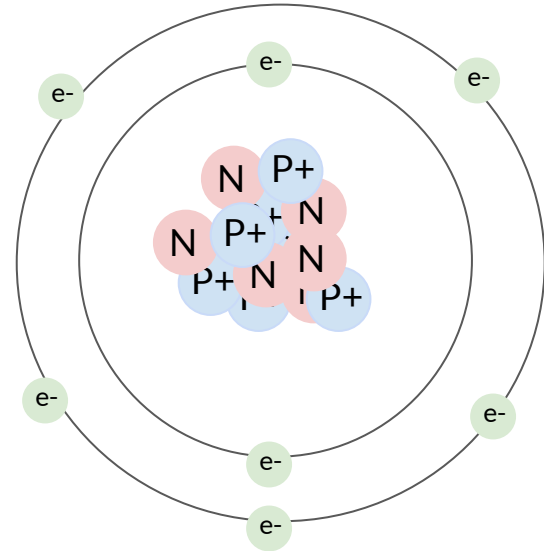
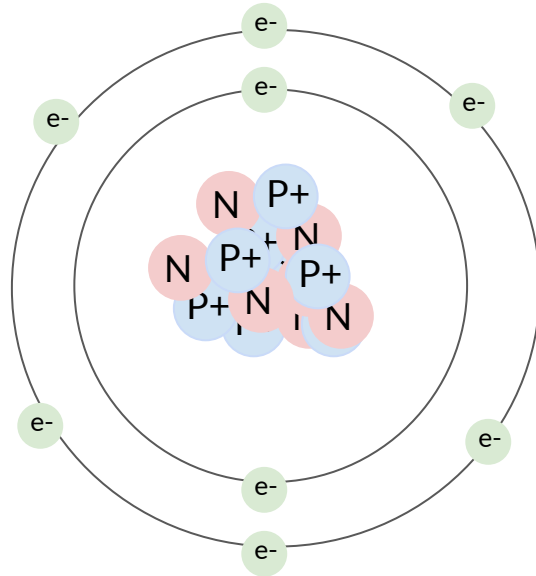
Why does helium “float?”



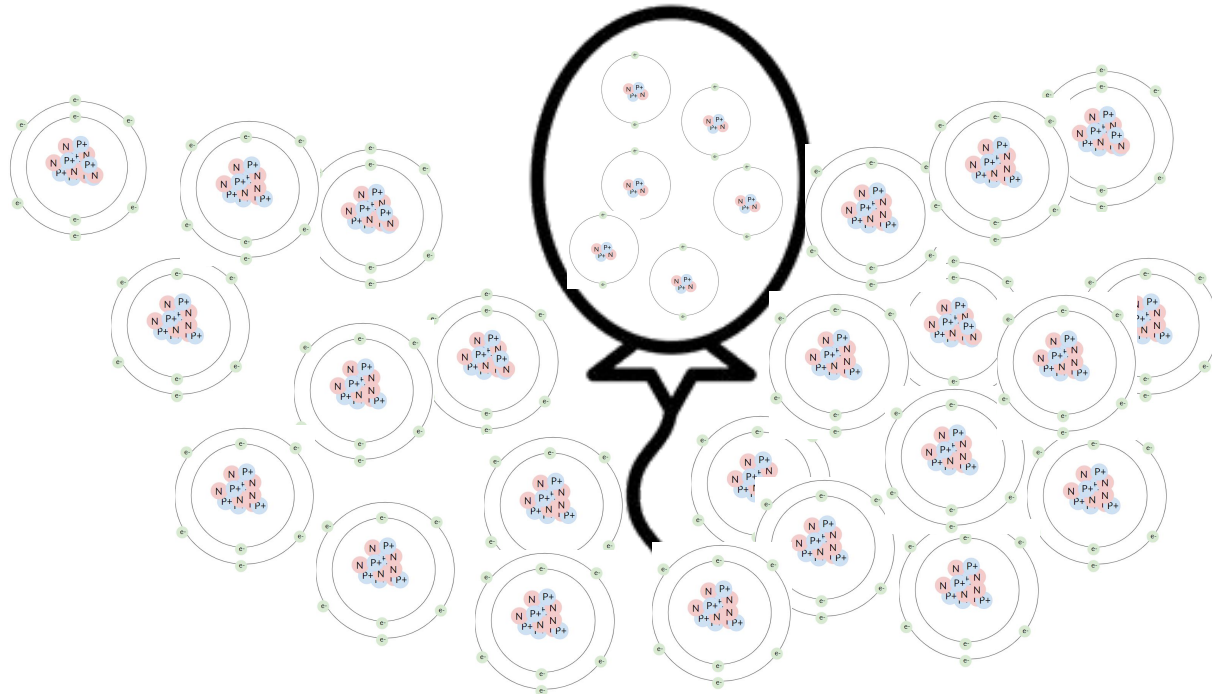
Oxygen



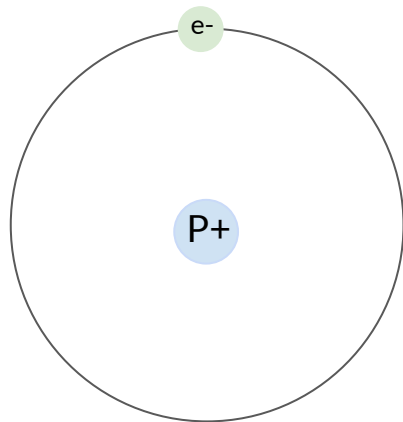
Oxygen and Nitrogen



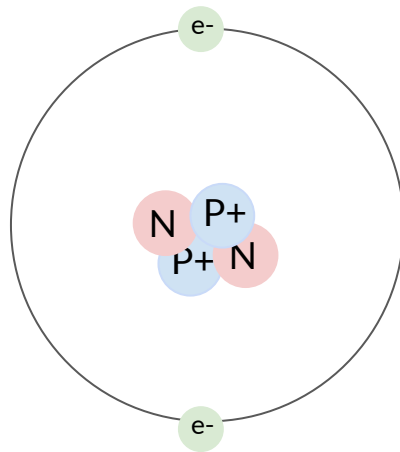
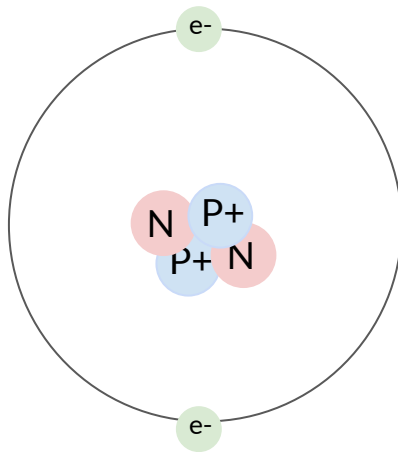
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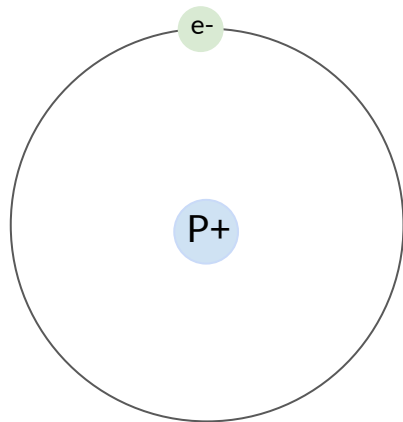
Hydrogen



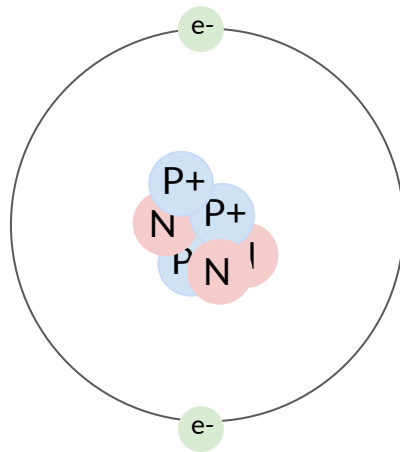
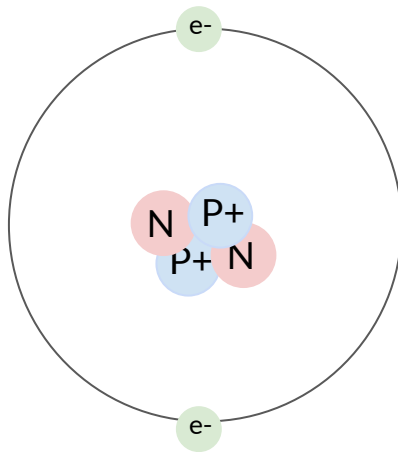
Helium



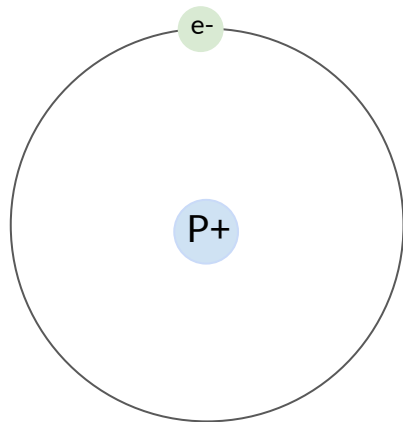
Hydrogen



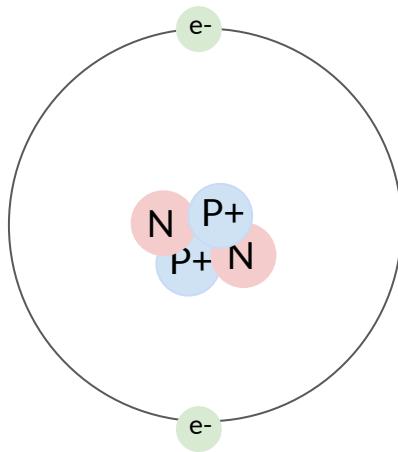
Helium



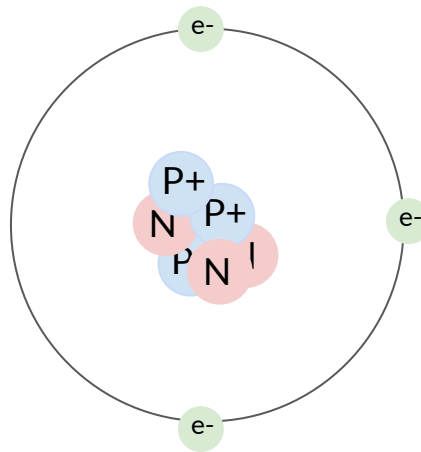
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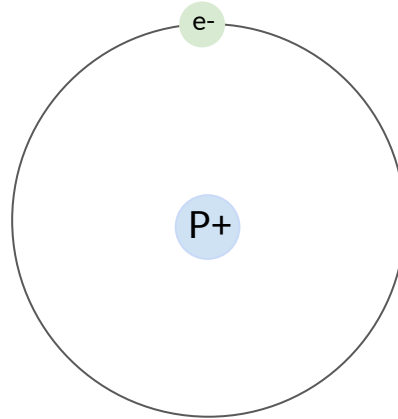
Helium



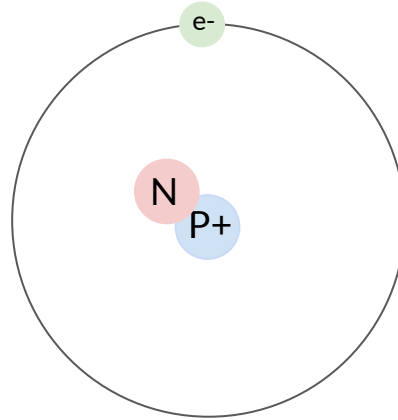
Lithium

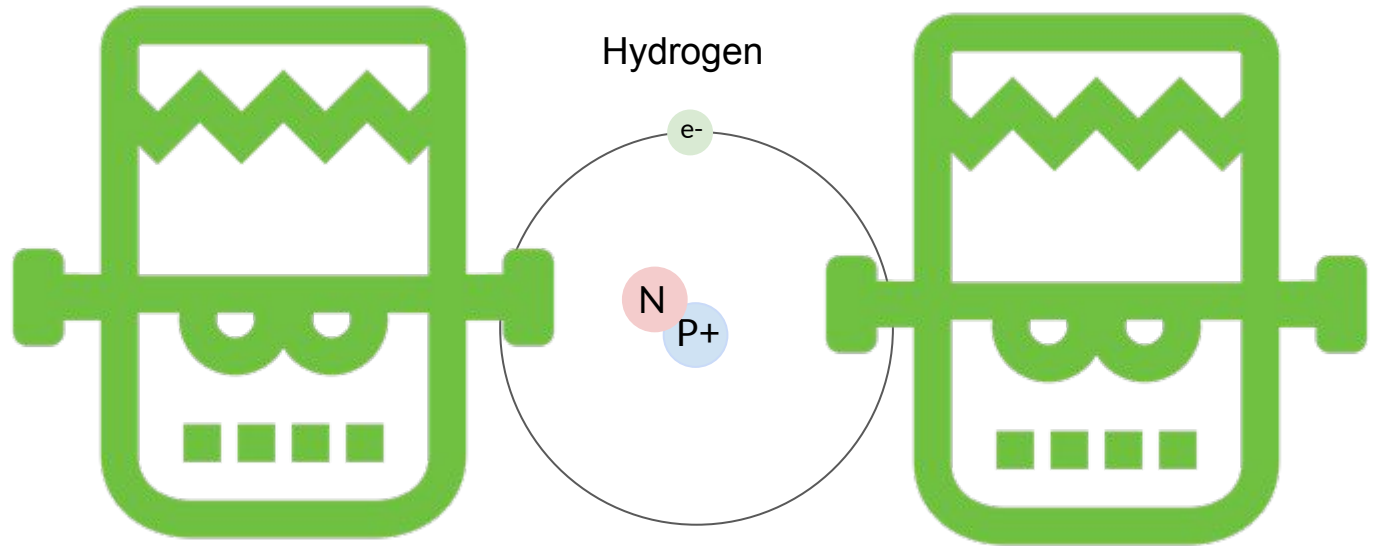


Hydrogen



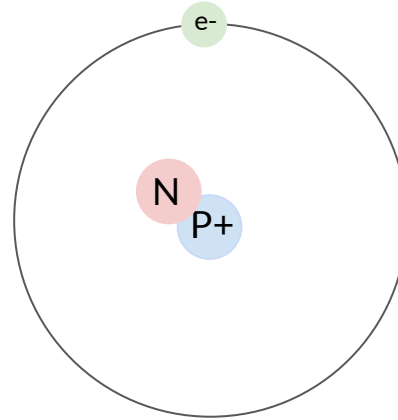
Hydrogen





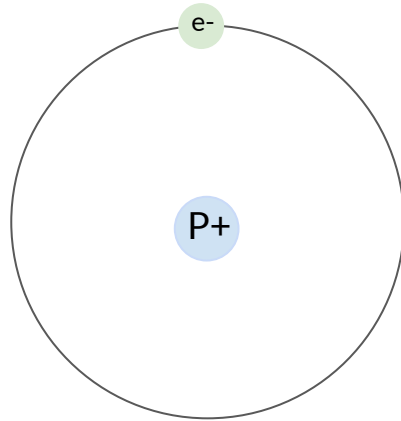
Isotope

Hydrogen



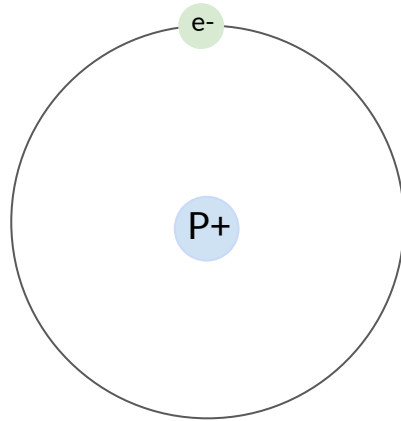
Hydrogen Isotopes

Hydrogen

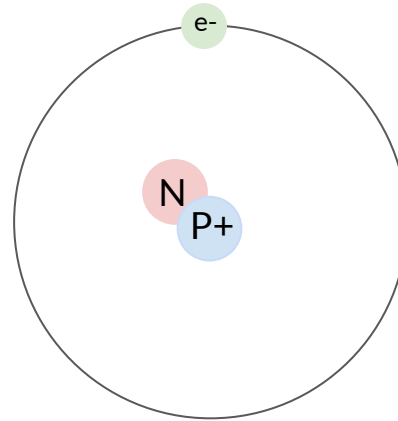


Hydrogen Isotopes

Hydrogen

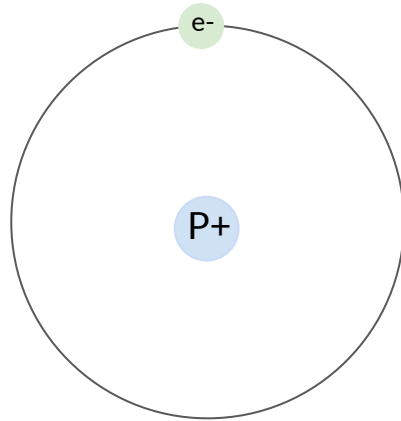


Deuterium

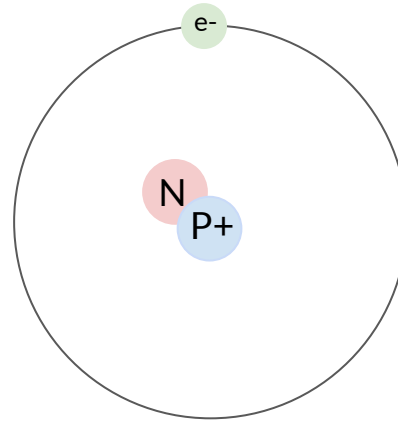


Hydrogen Isotopes

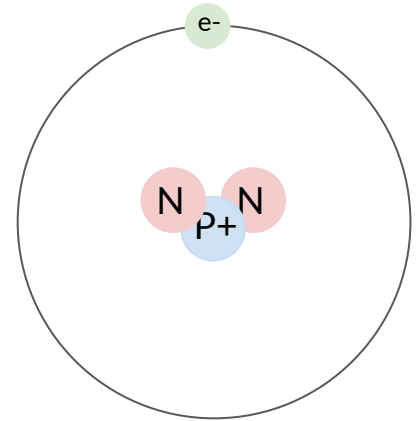
Hydrogen



Deuterium

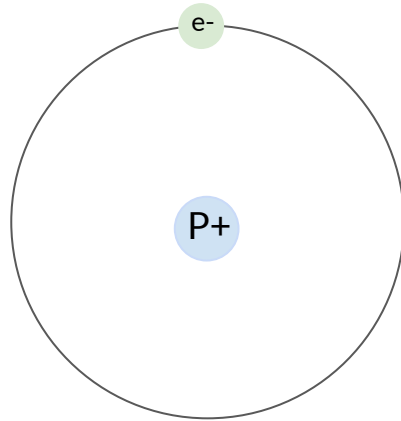


Tritium



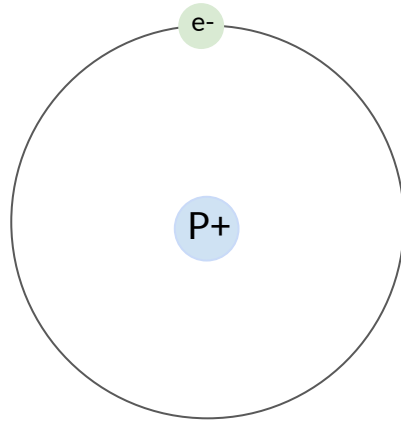
Hydrogen Isotopes

Hydrogen

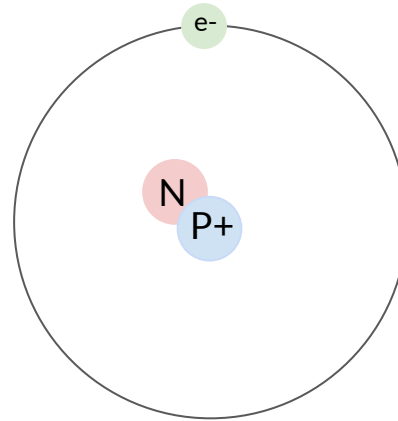


Hydrogen Isotopes

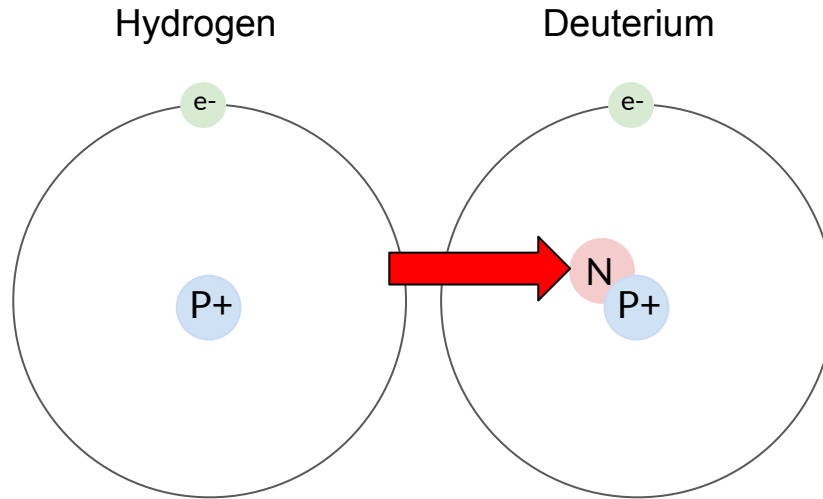
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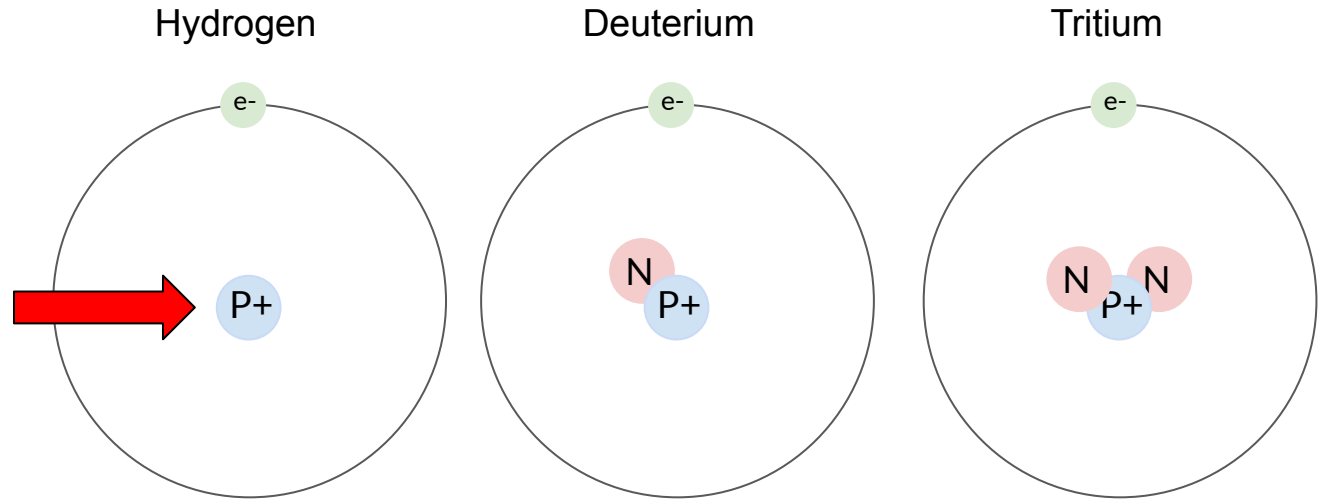
Deuterium



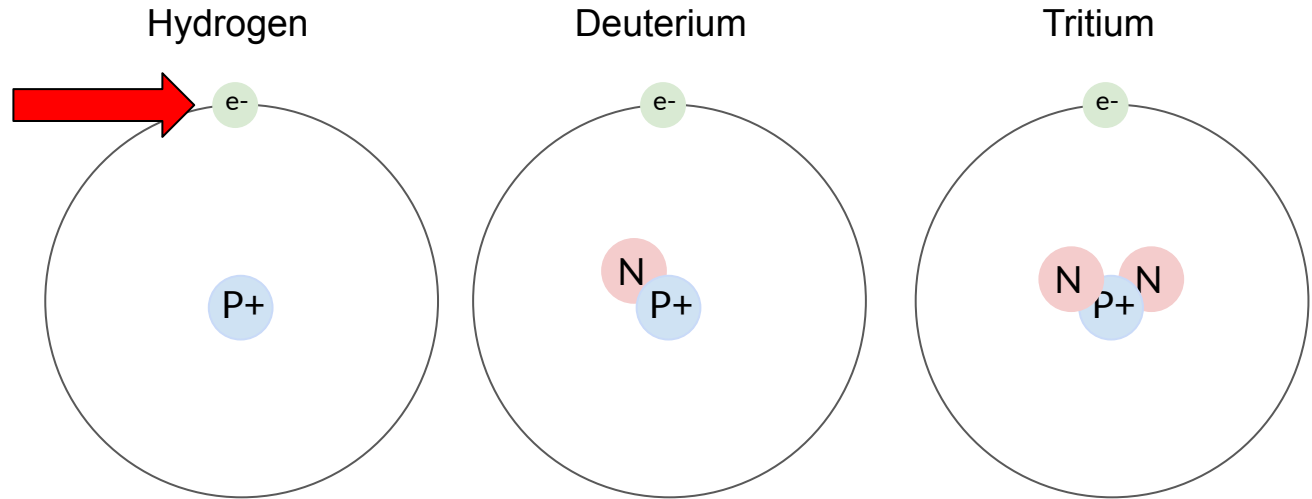
Hydrogen Isotopes



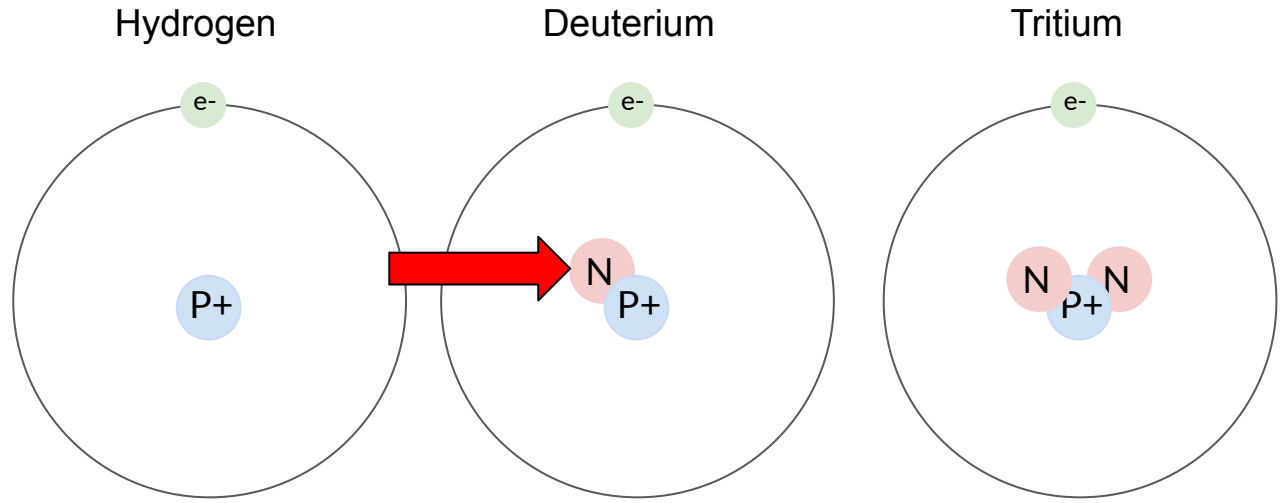
Hydrogen Isotopes



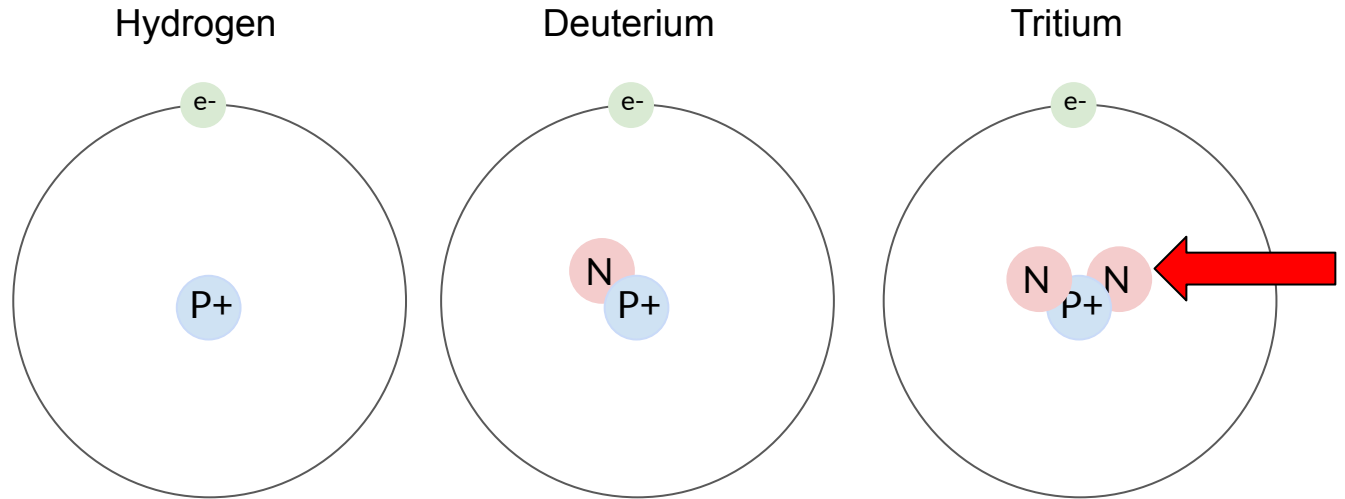
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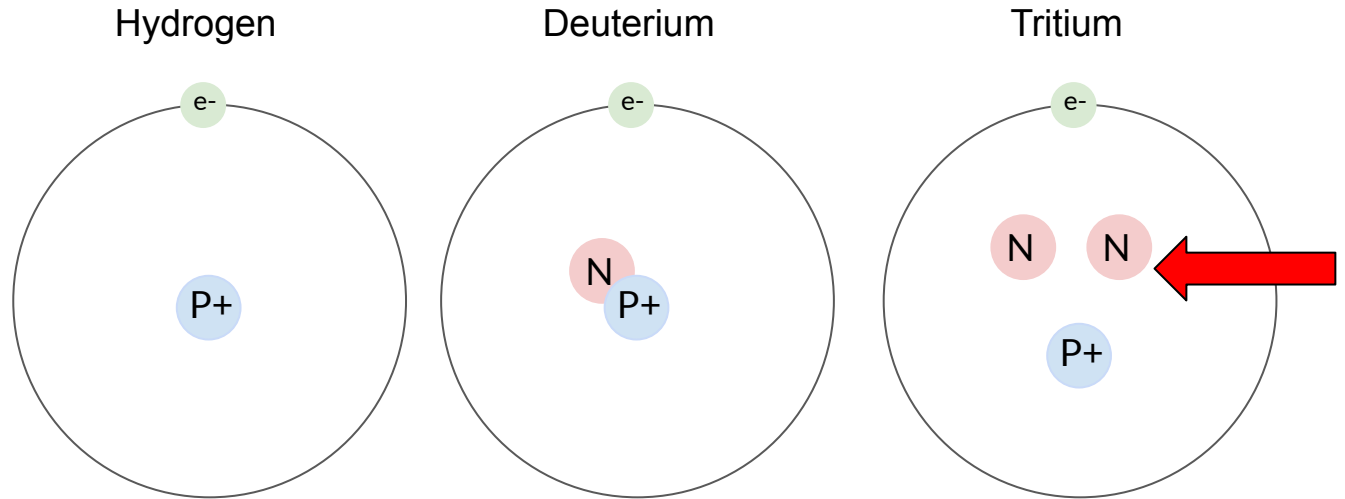
Hydrogen Isotopes



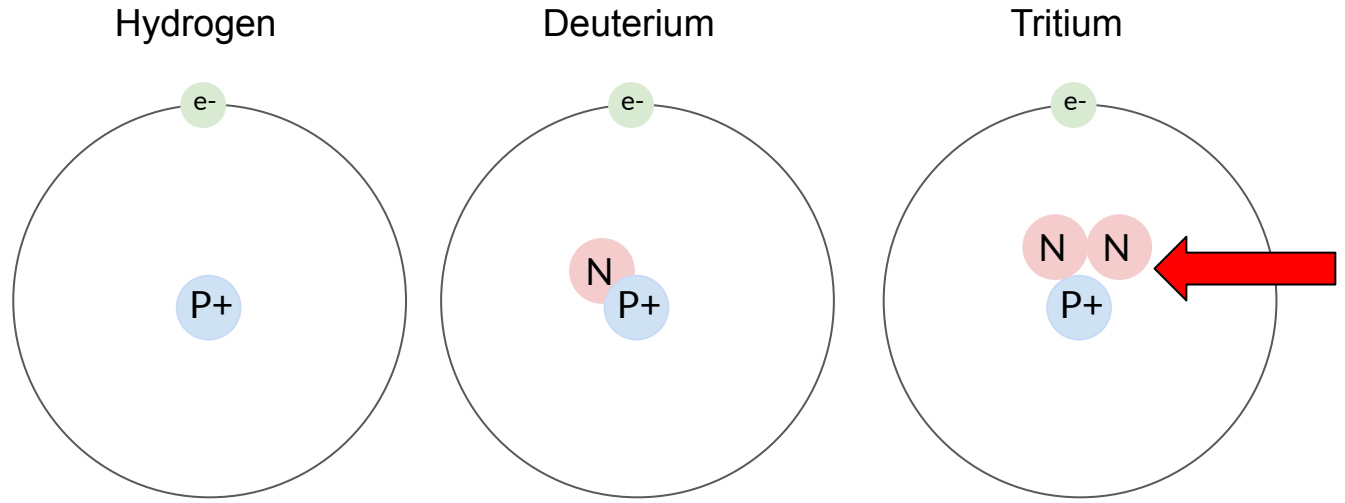
Hydrogen Isotopes



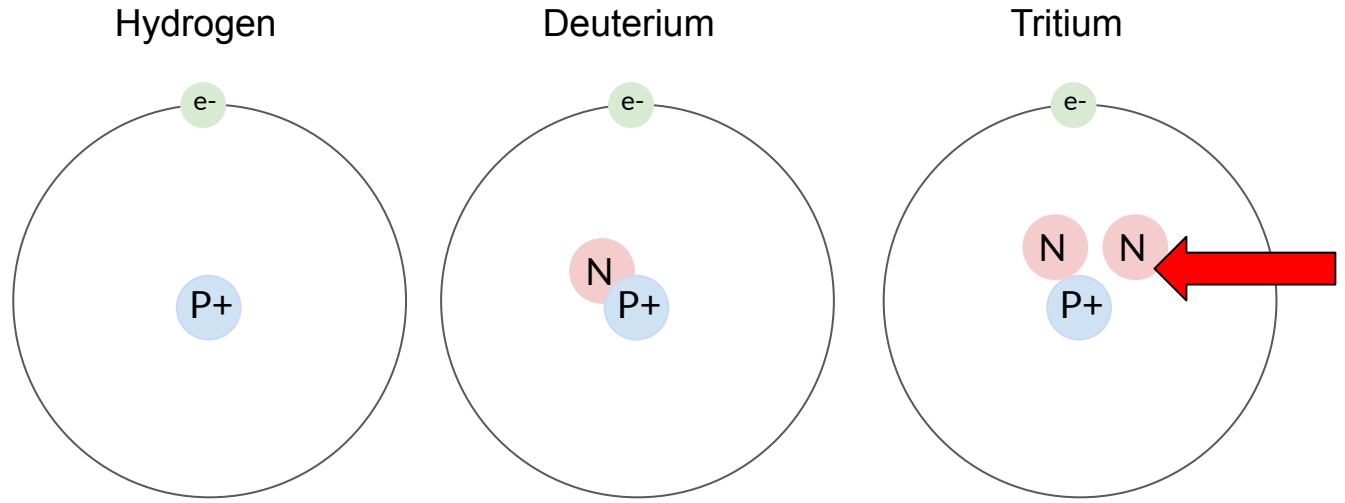
Tritium becomes unstable



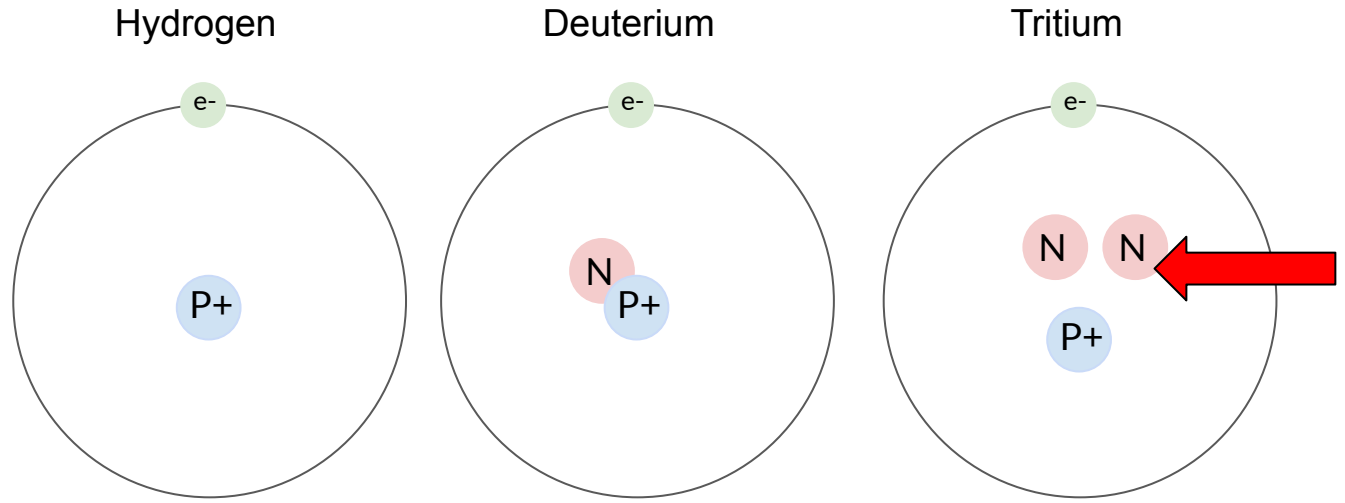
Tritium becomes unstable



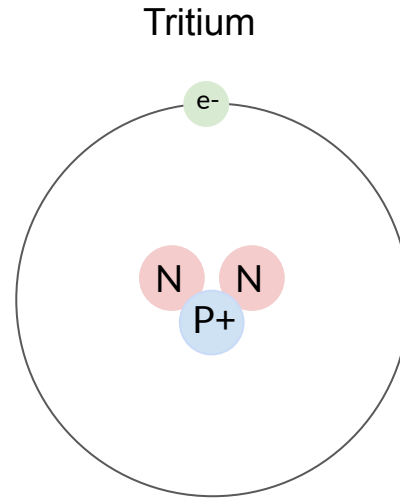
Tritium becomes unstable



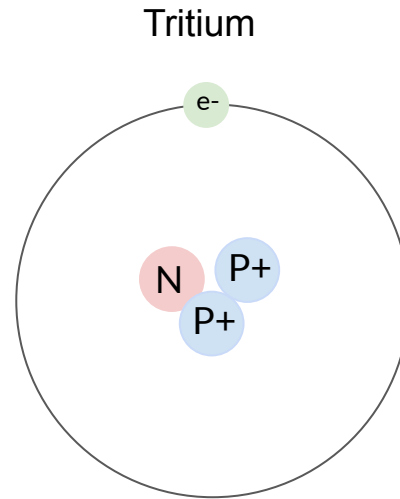
Tritium becomes unstable



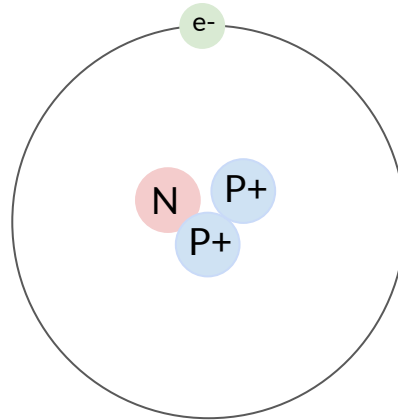
Beta Decay



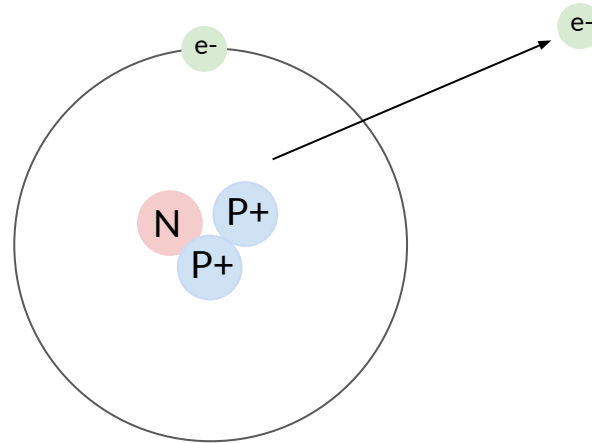
Beta Decay



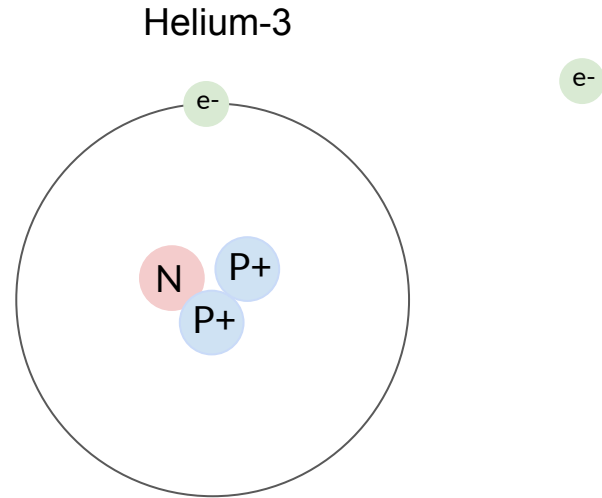
Beta Decay



Beta Decay

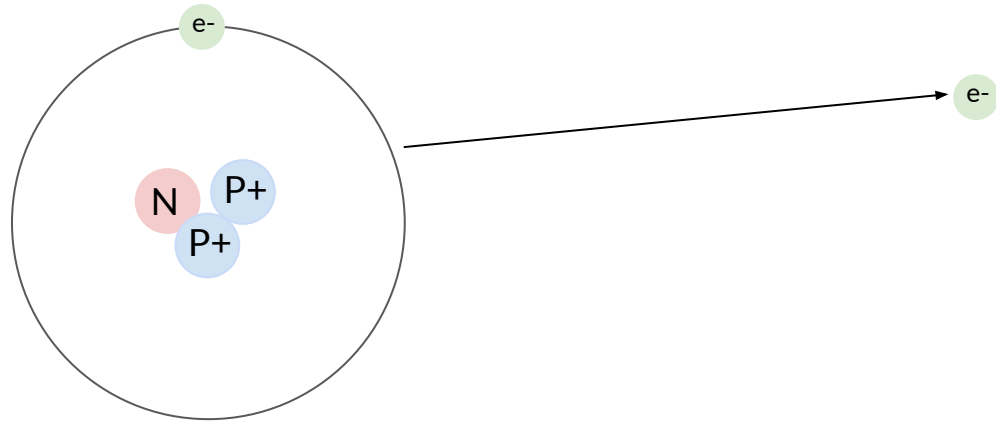


Beta Decay



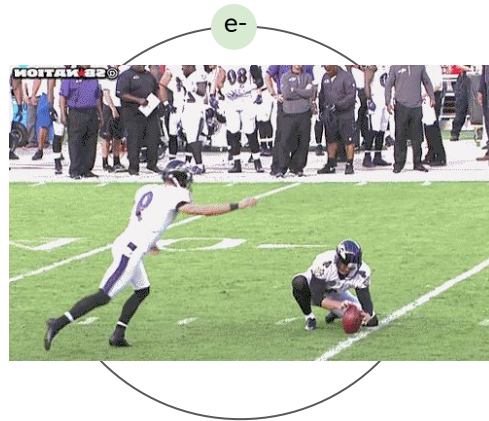
Beta Decay

Helium-3



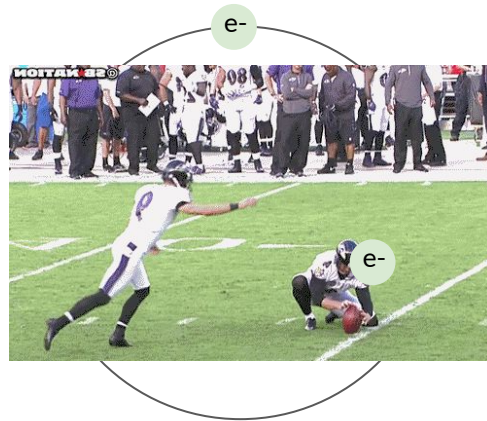
Beta Decay

Helium-3



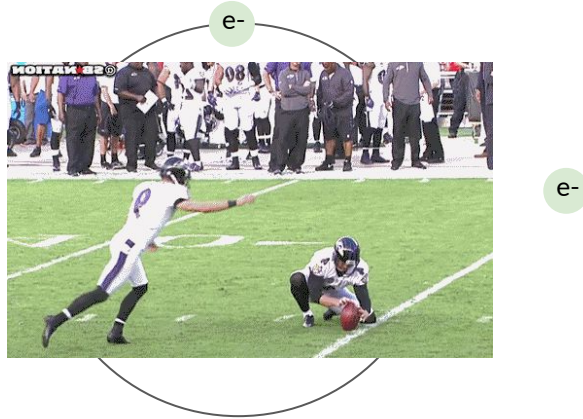
Beta Decay

Helium-3



Beta Decay

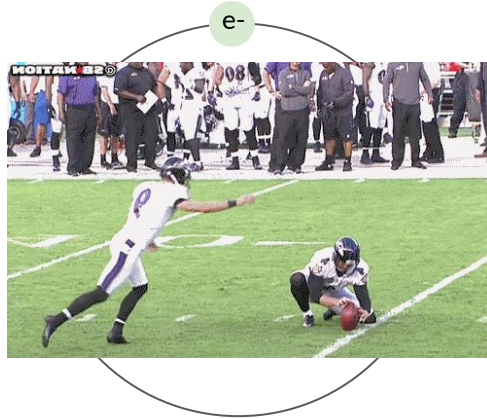
Helium-3



e-

Beta Decay

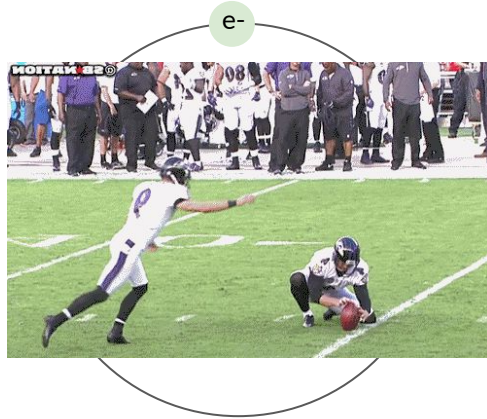
Helium-3



e-

Beta Decay

Helium-3



e-

Beta Decay

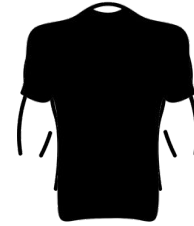
Helium-3

e-



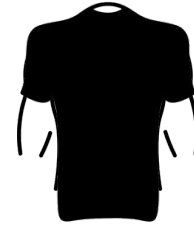
What stops Beta Particles?

e-



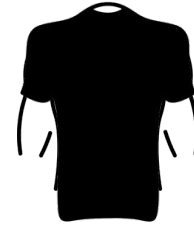
What stops Beta Particles?

e-

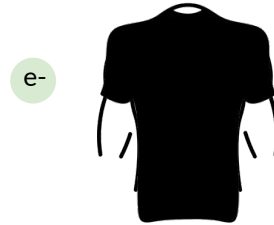


What stops Beta Particles?

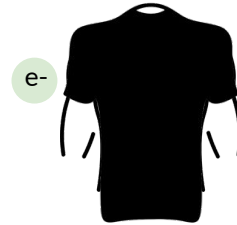
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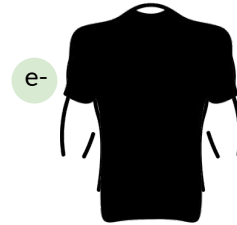
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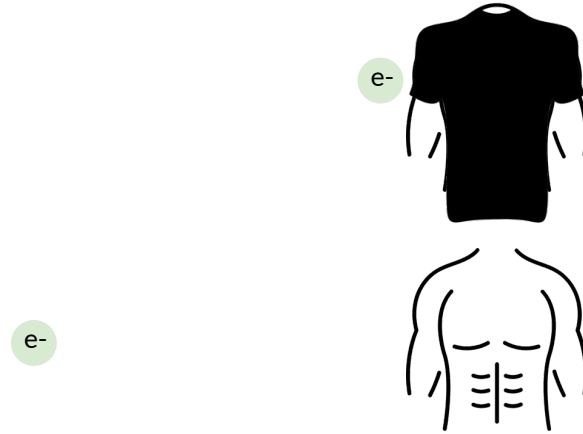
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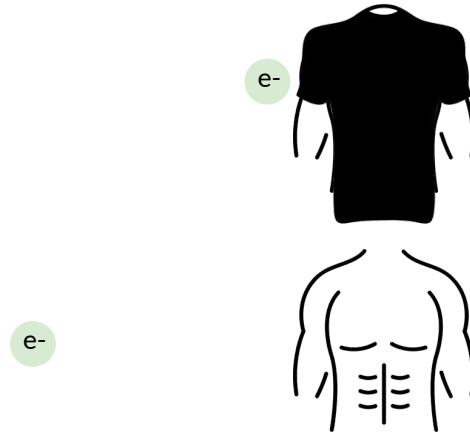
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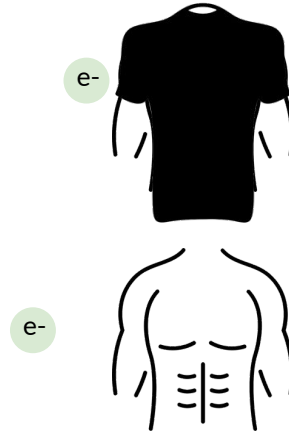
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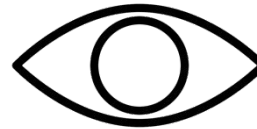
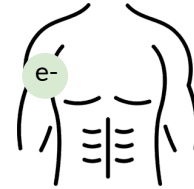
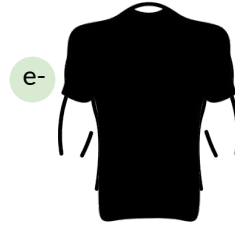
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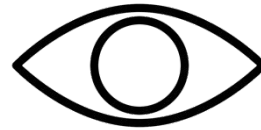
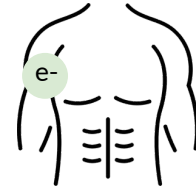
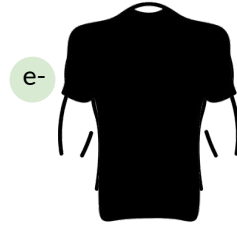
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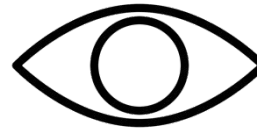
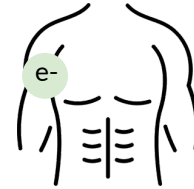
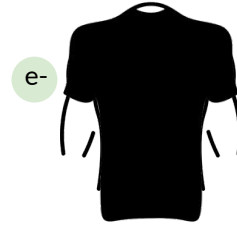
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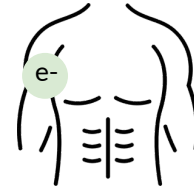
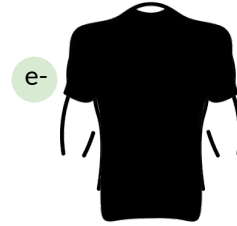
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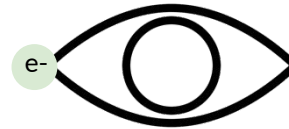
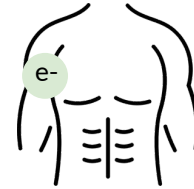
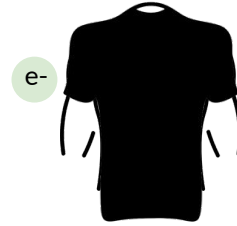
What stops Beta Particles?



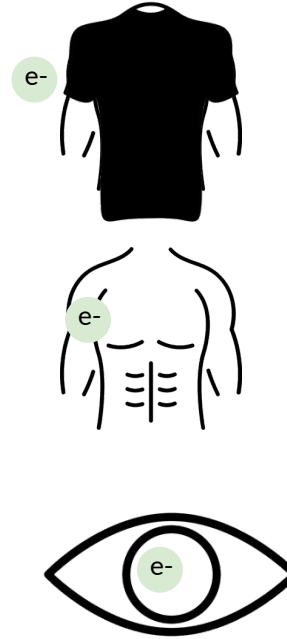
What stops Beta Particles?



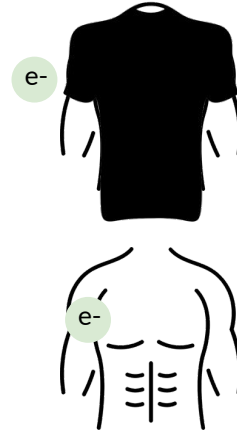
What stops Beta Particles?



What stops Beta Particles?



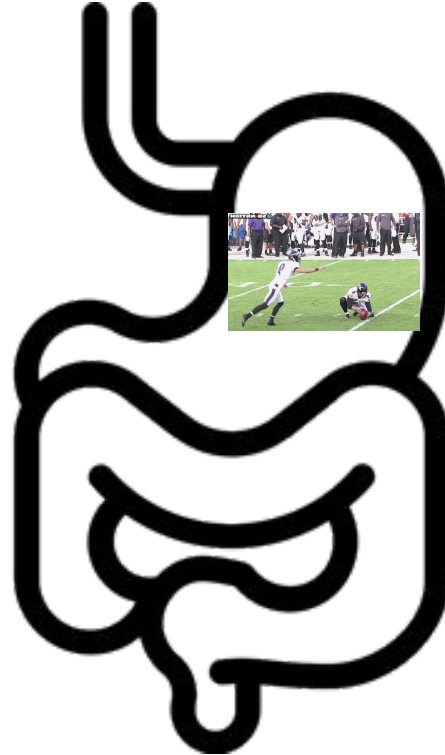
What stops Beta Particles?



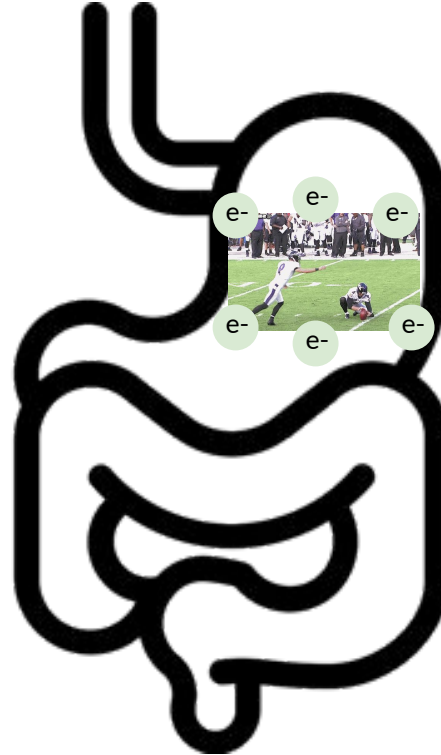
THIS IS BAD 



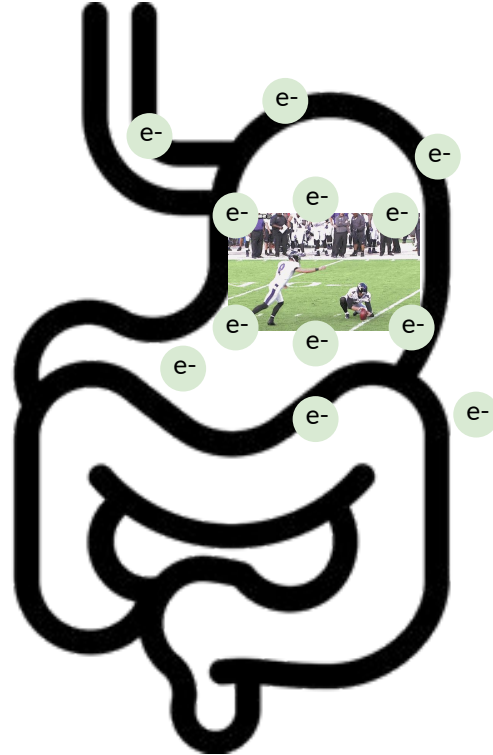
Beta radiation inside the body is bad



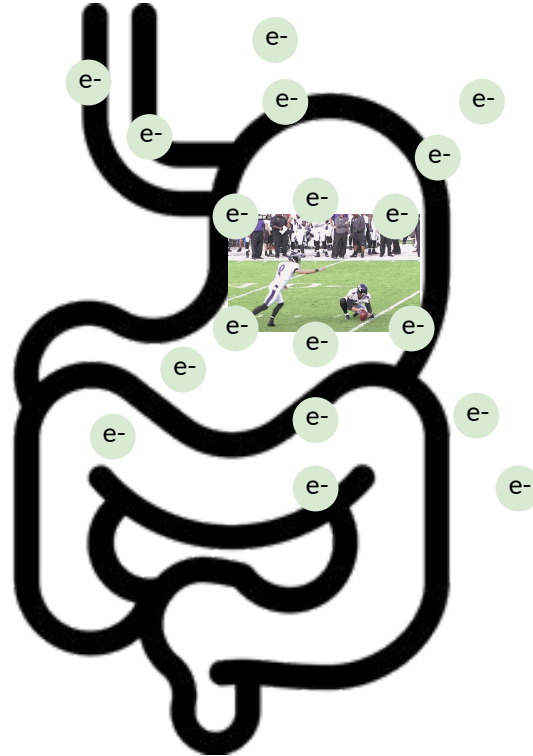
Beta radiation inside the body is bad



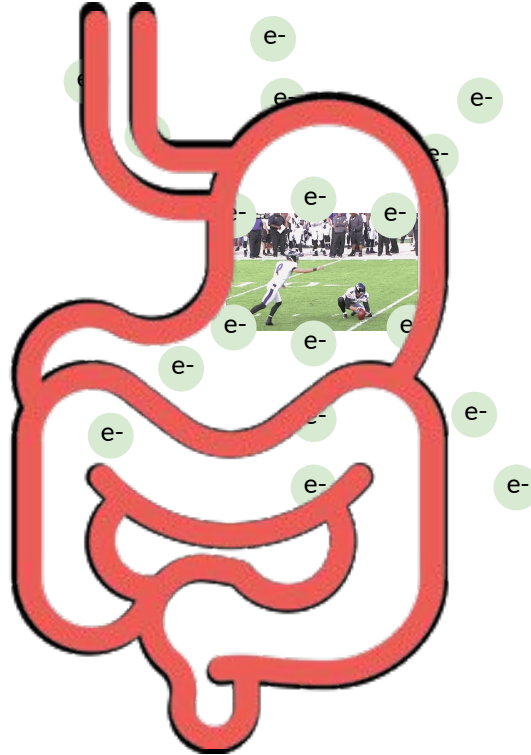
Beta radiation inside the body is bad



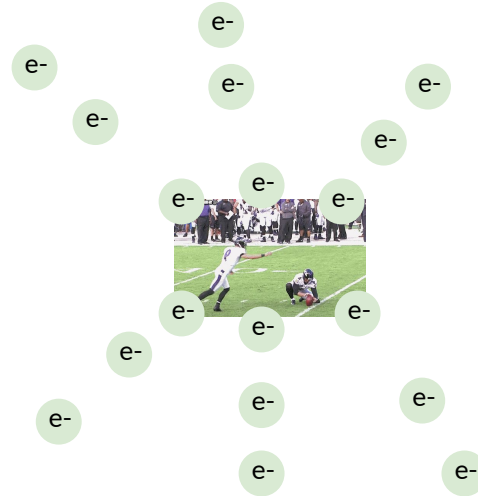
Beta radiation inside the body is bad



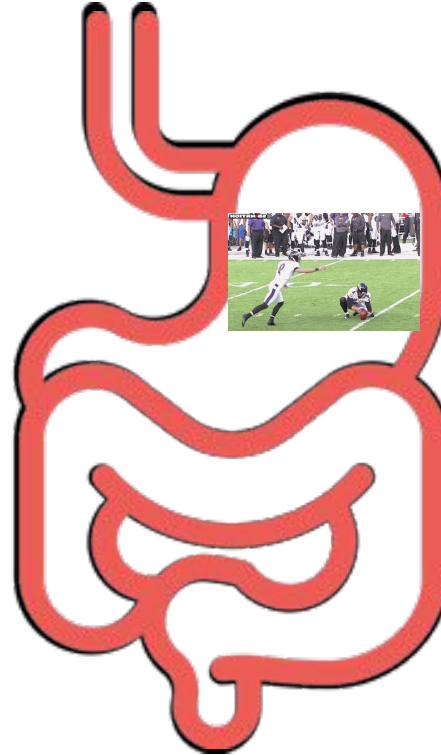
Beta radiation inside the body is bad



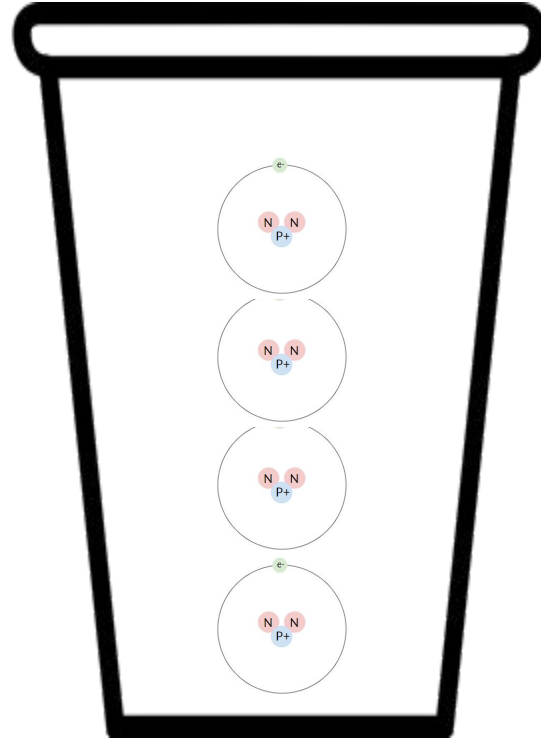
Beta radiation inside the body is bad



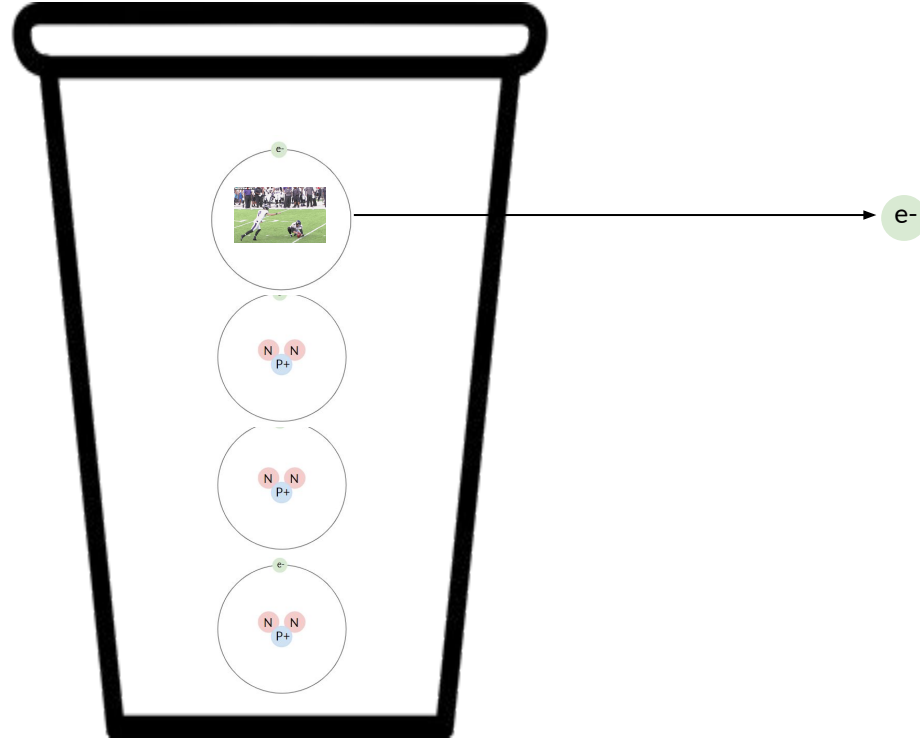
Beta radiation inside the body is bad



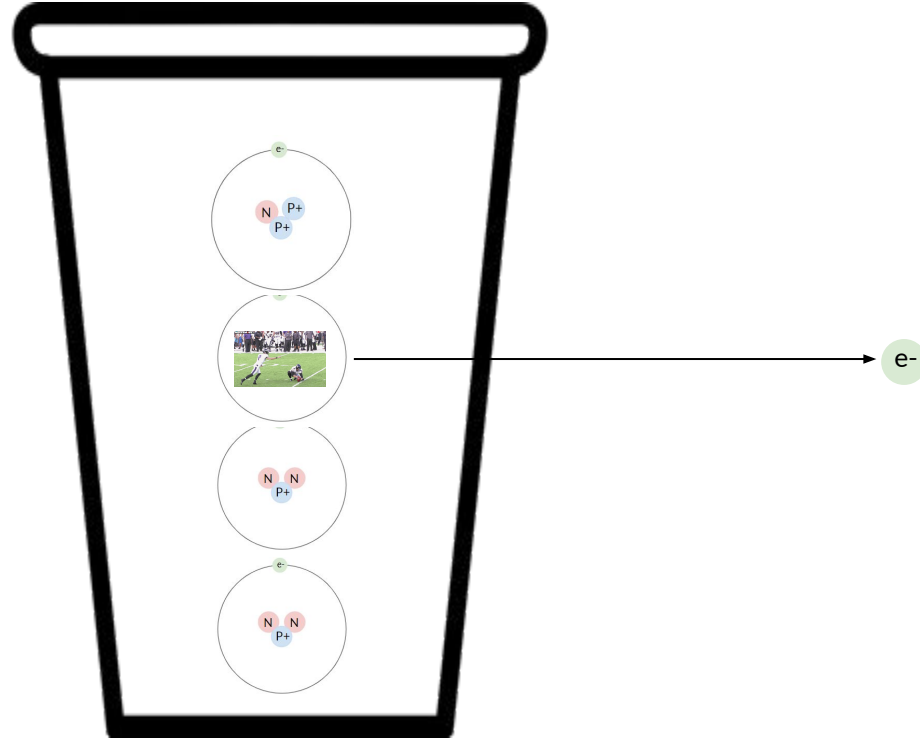
Half Life



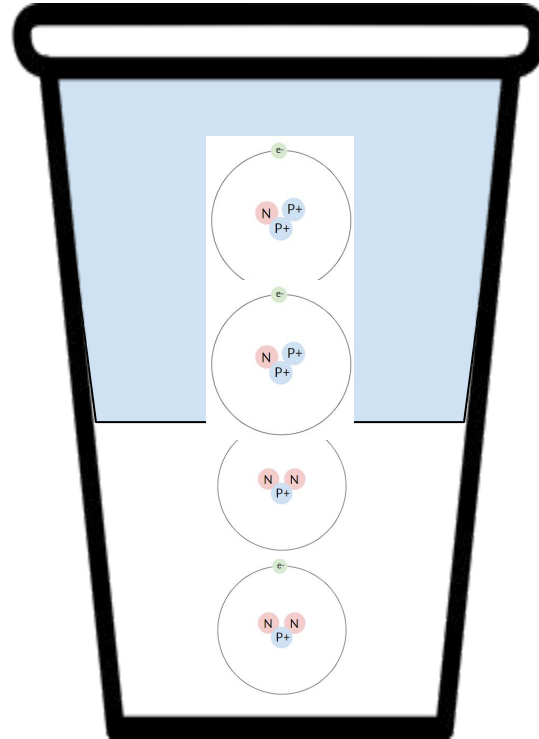
Half Life



Half Life

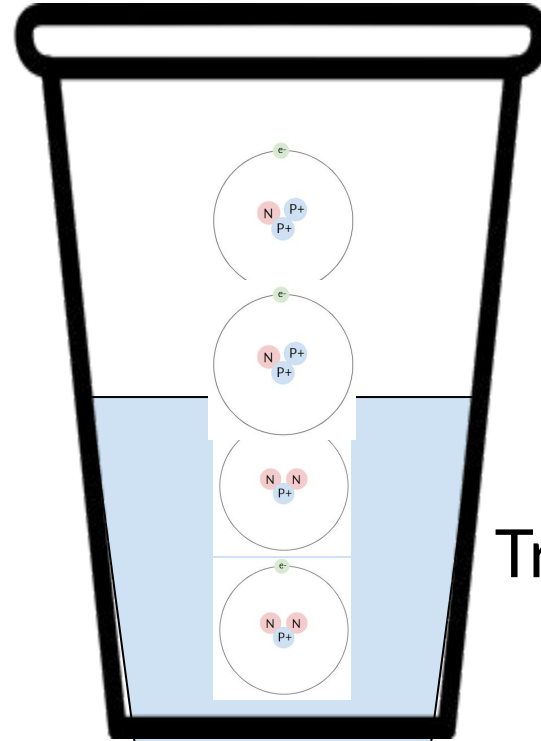


Half Life



Helium-3

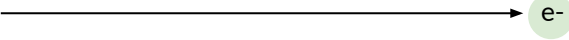
Half Life



Tritium


Types of Radiation

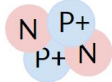
Types of Radiation

Beta 




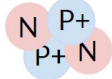
Types of Radiation


Beta \longrightarrow 

Alpha \longrightarrow 

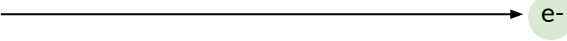
Types of Radiation

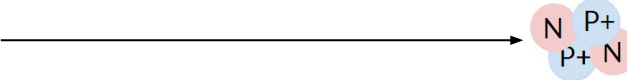
Beta \longrightarrow 

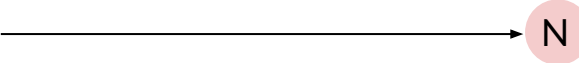
Alpha \longrightarrow 

Neutron \longrightarrow 

Types of Radiation

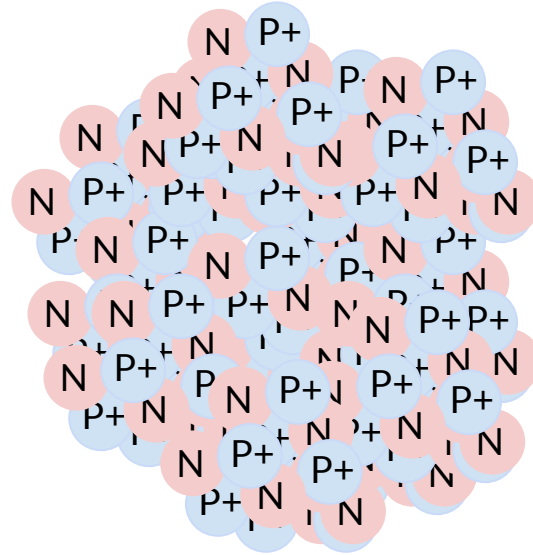
Beta 

Alpha 

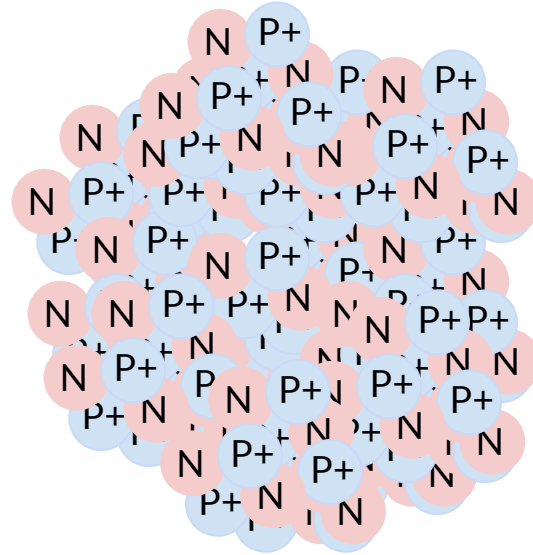
Neutron 

Gamma 

Uranium

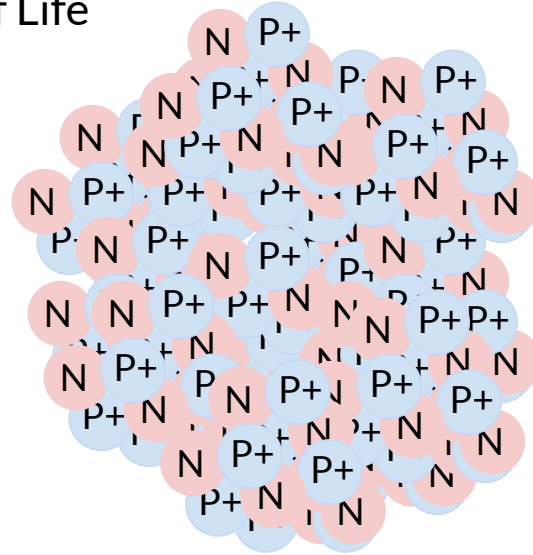


Uranium-238



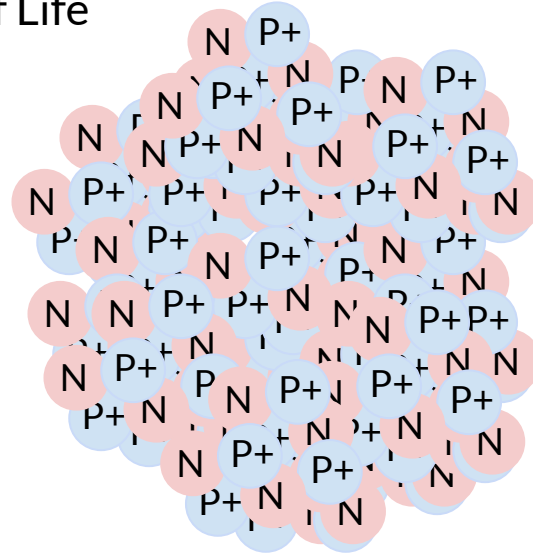
Uranium-238

- 4.468 B Half Life



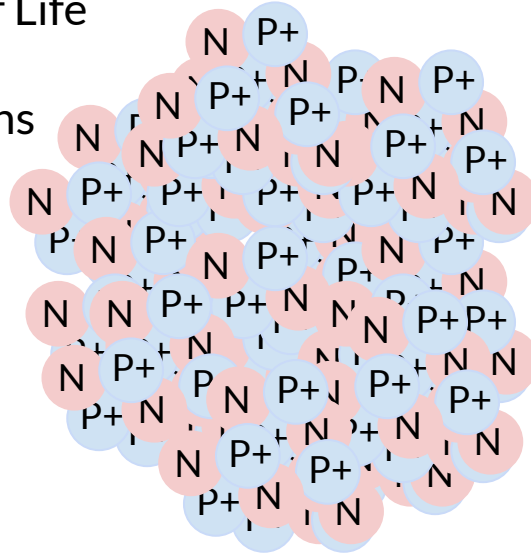
Uranium-238

- 4.468 B Half Life
- 92 Protons

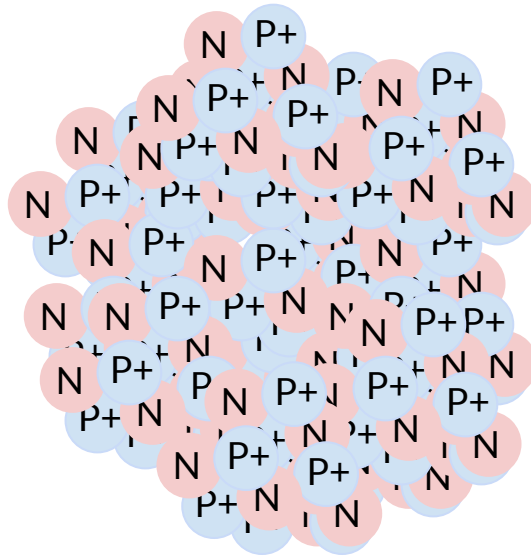


Uranium-238

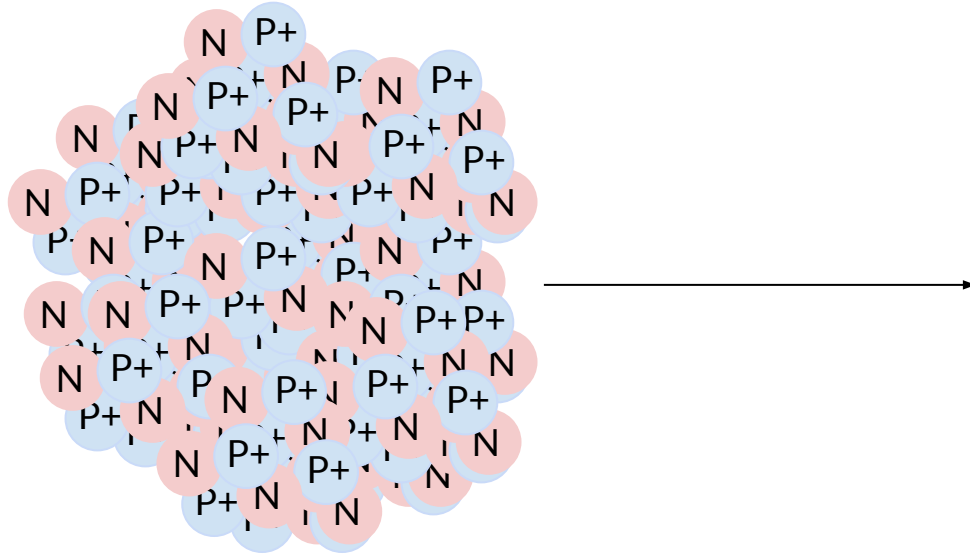
- 4.468 B Half Life
- 92 Protons
- 146 Neutrons



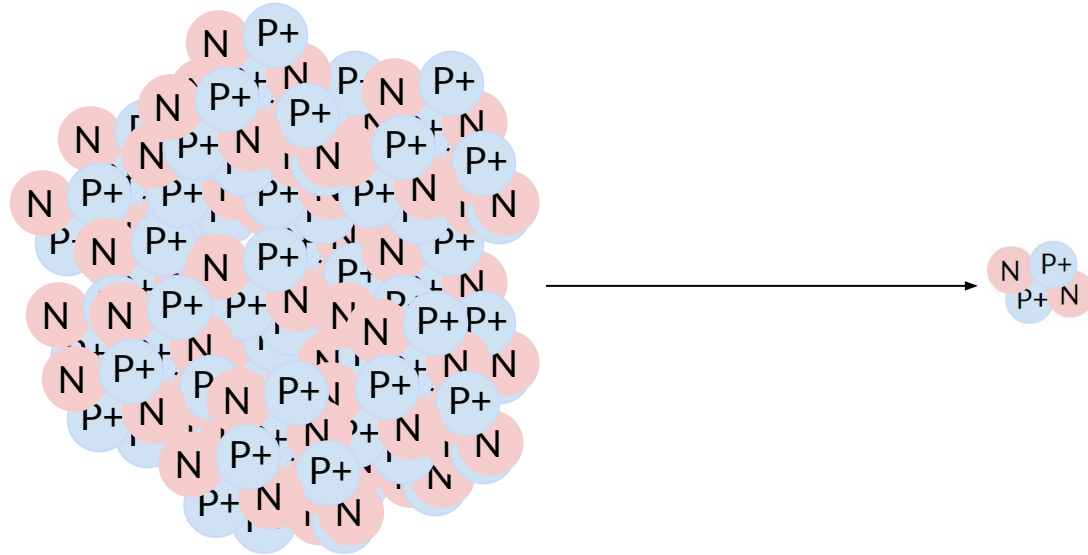
Uranium-238 - Becoming stable



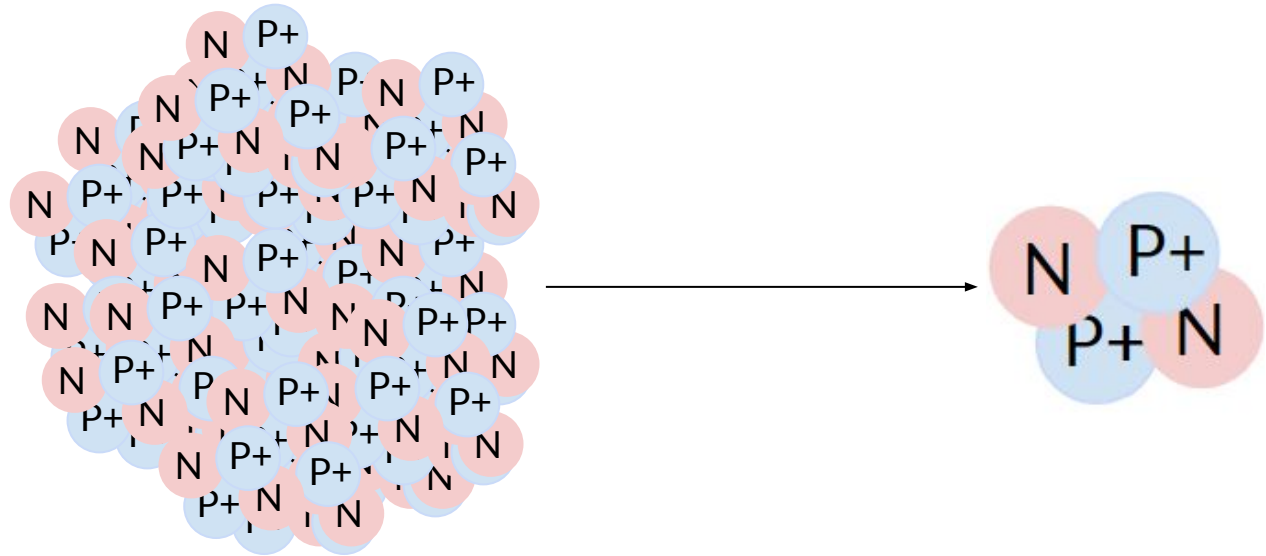
Uranium-238 - Becoming stable



Uranium-238 - Becoming stable

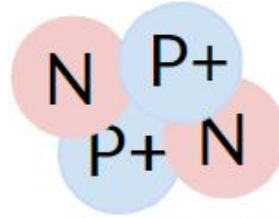


Uranium-238 - Becoming stable



Alpha Compared to Beta.

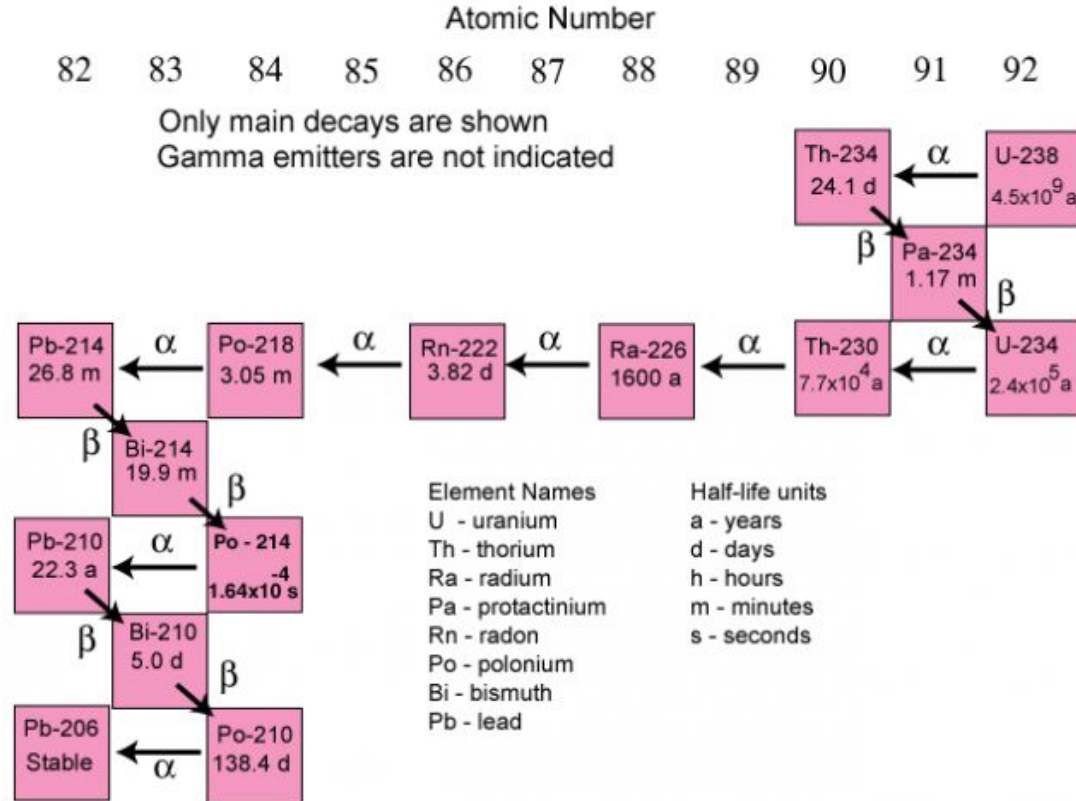
Alpha



Beta →



The Uranium-238 Decay Chain



Isotopes of Uranium



Isotopes of Uranium



Uranium-238



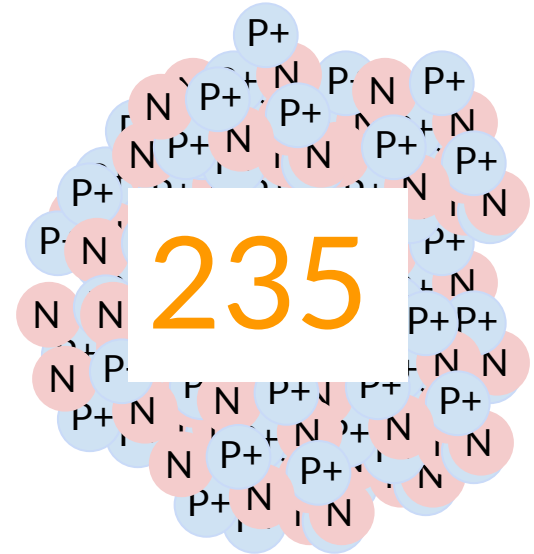
Uranium-235



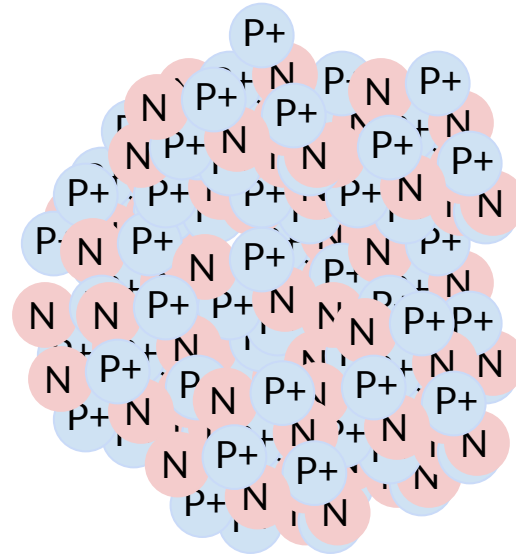
Uranium-238



Uranium-235

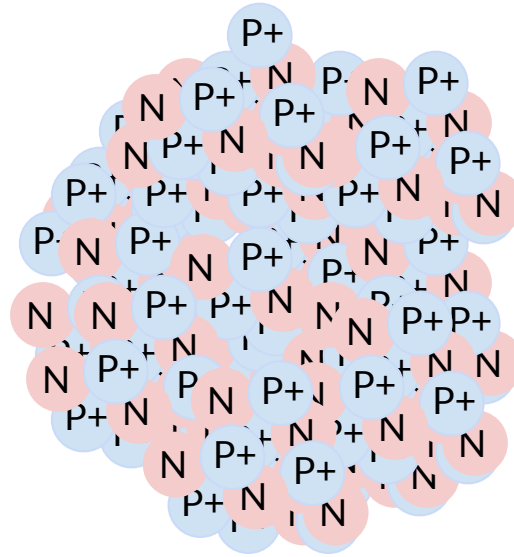


Uranium-235

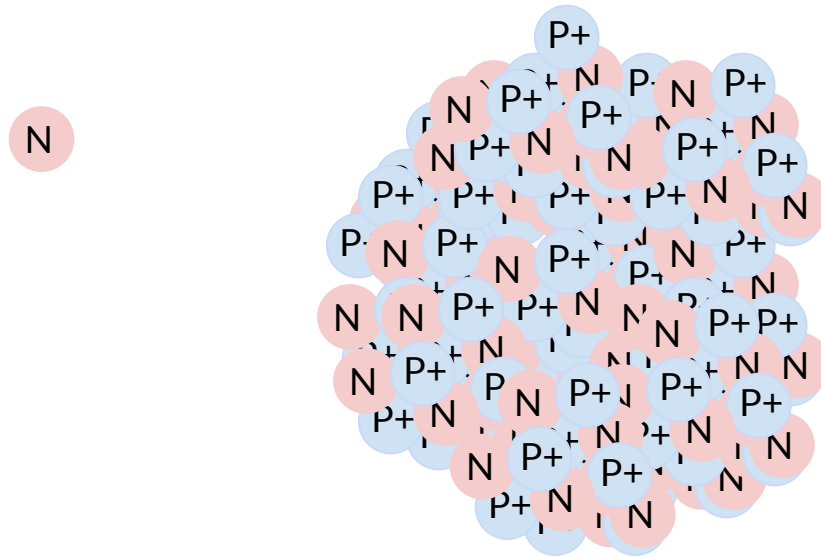


Uranium-235

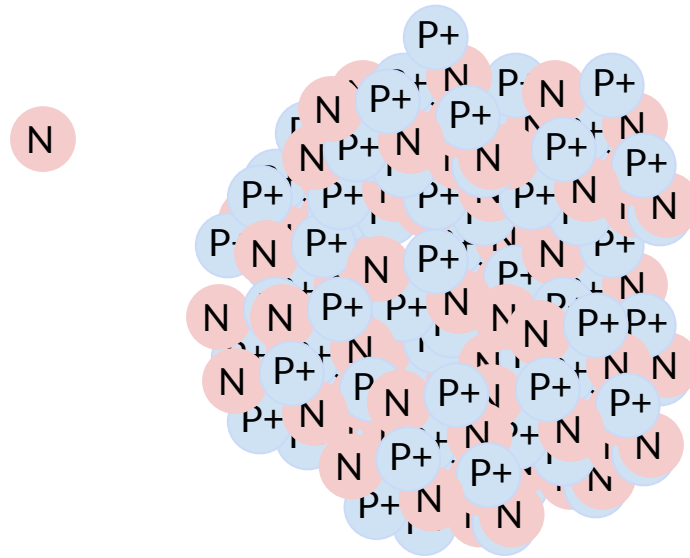
N



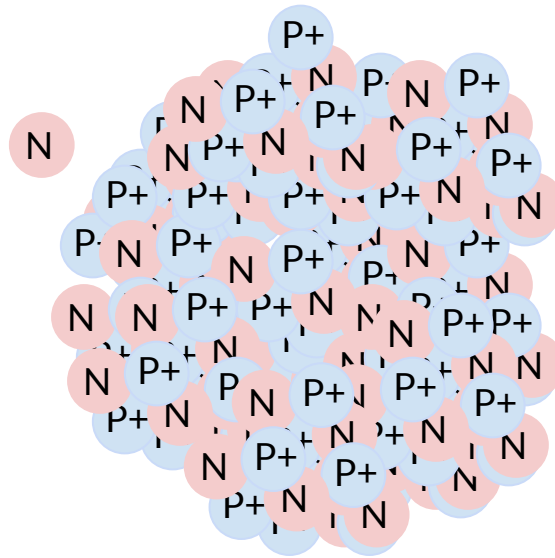
Uranium-235



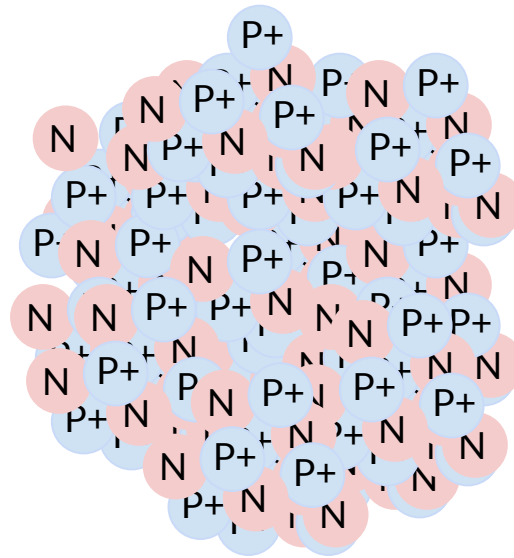
Uranium-235



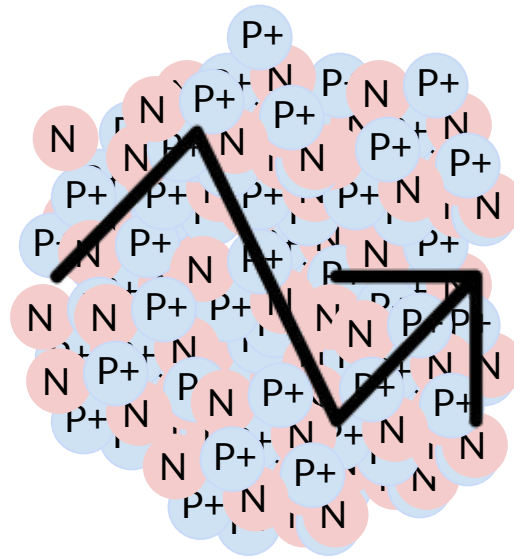
Uranium-235



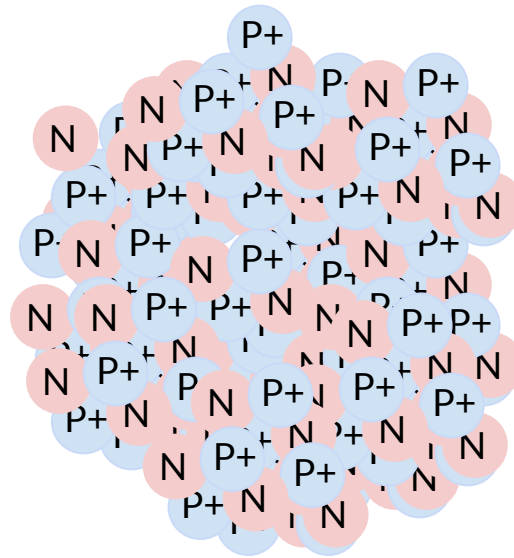
Uranium-235



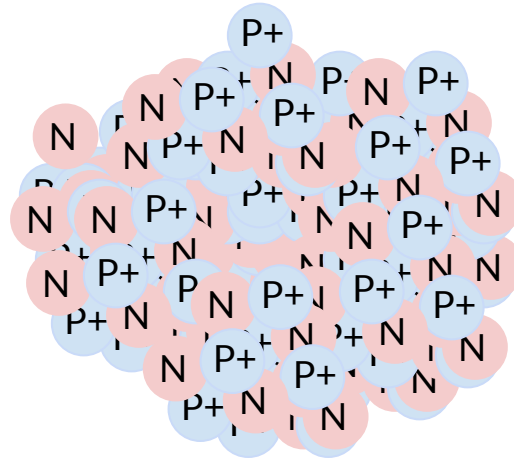
Uranium-235



Uranium-235



Uranium-235





Barium-141

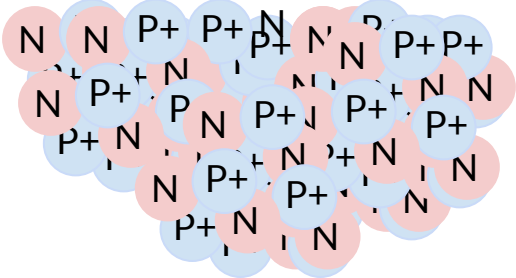
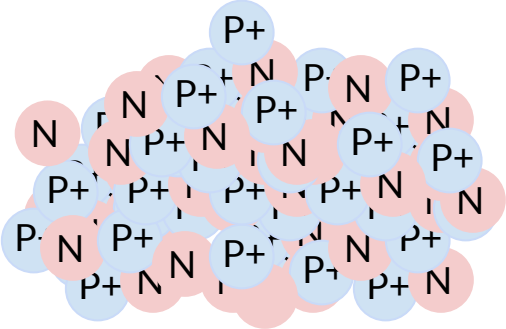
The diagram shows a nucleus of Barium-141, represented as a cluster of 56 protons (P+) and 85 neutrons (N) in a roughly spherical arrangement. A white rectangular box is superimposed on the center of the nucleus, containing the text 'Barium-141' in orange.

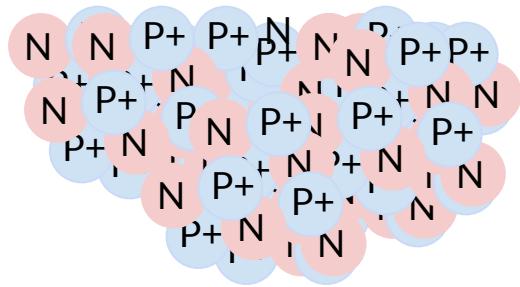
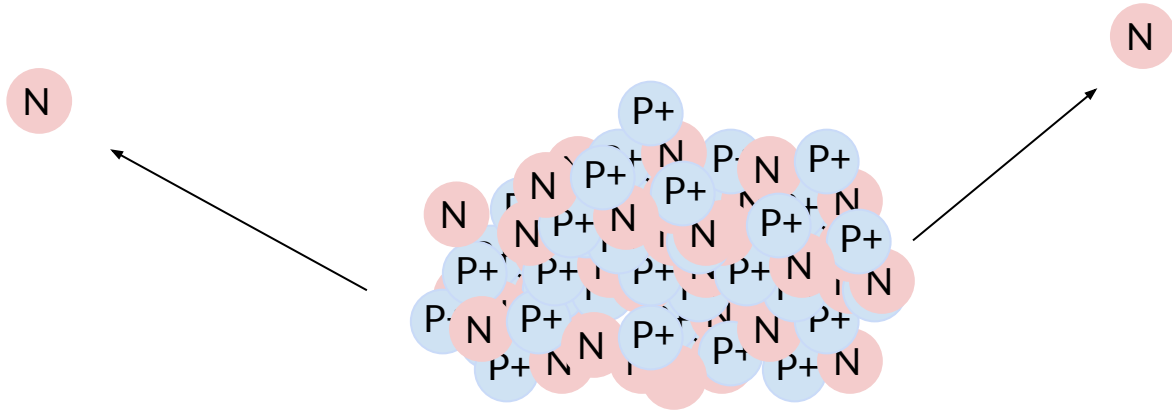


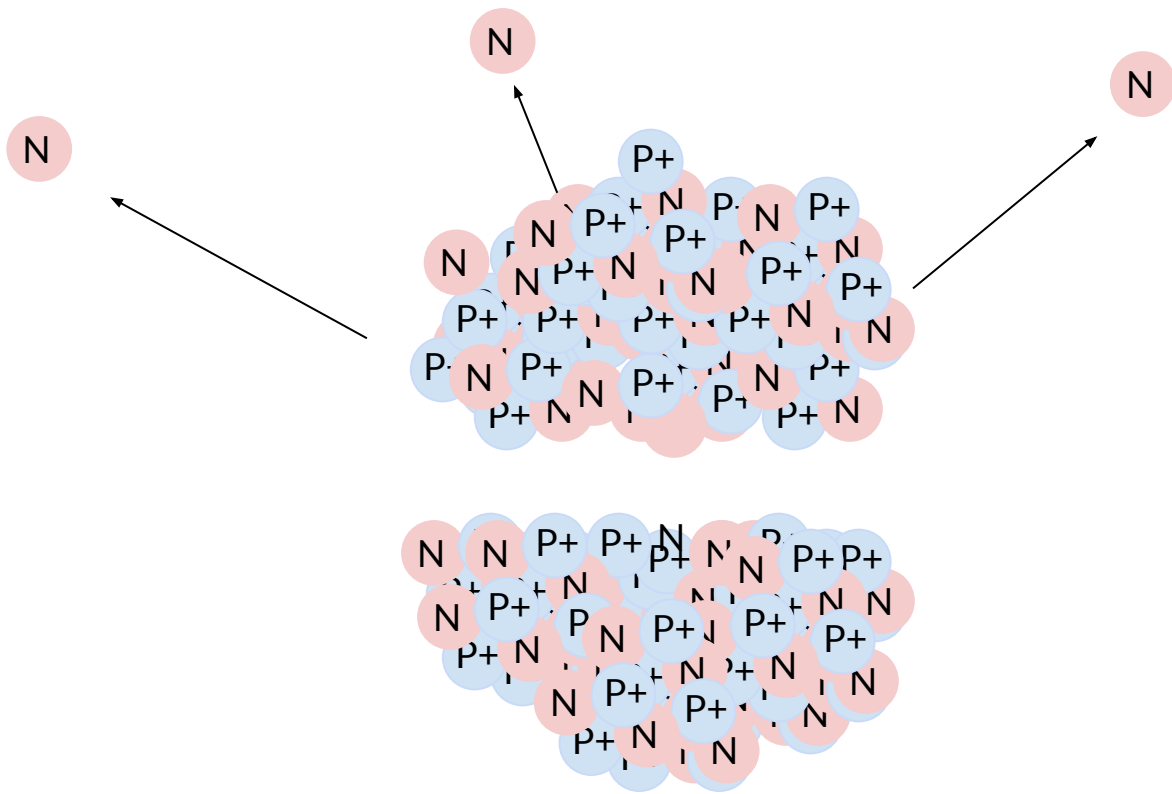
Krypton-92

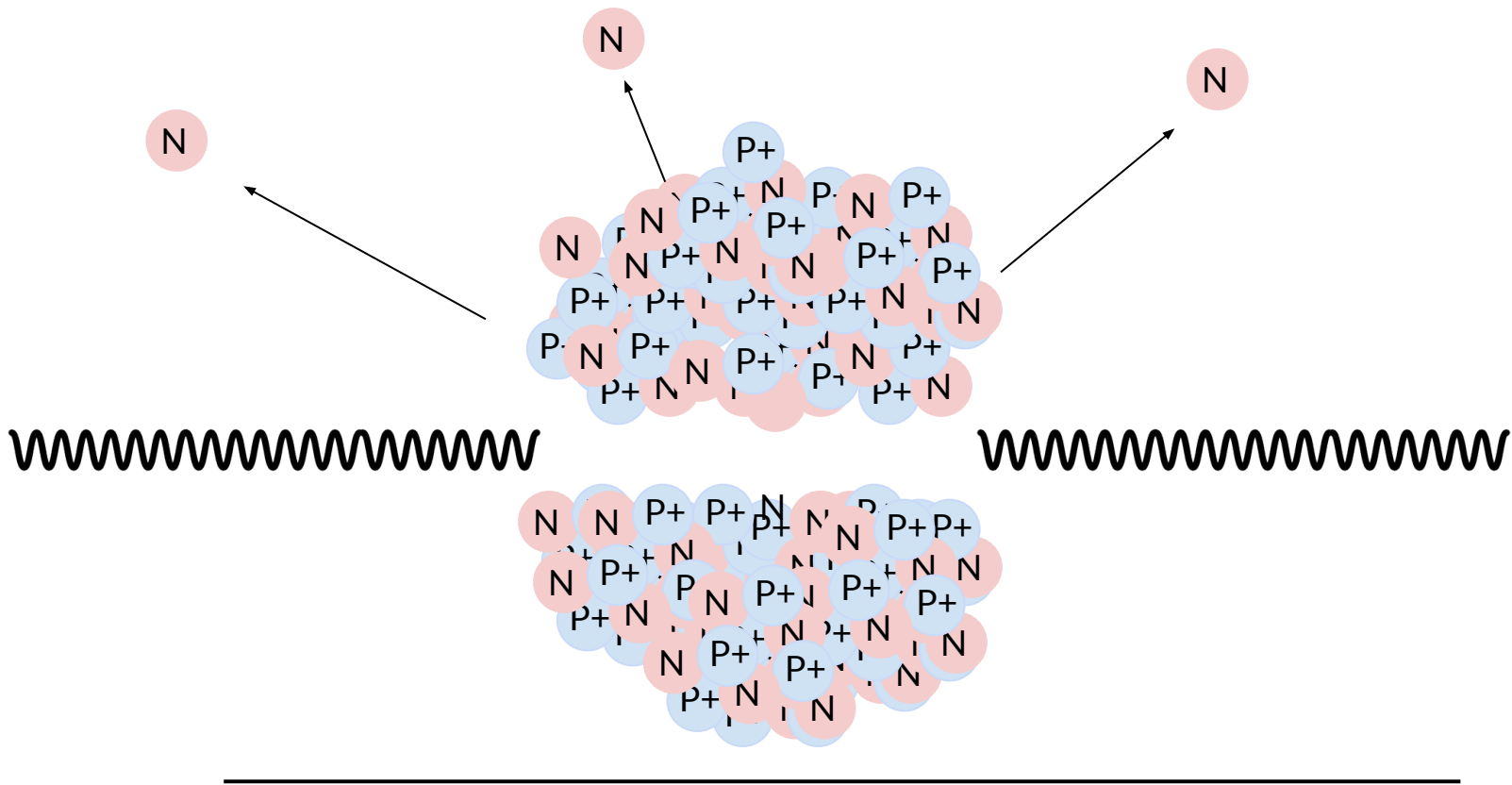
The diagram shows a nucleus of Krypton-92, represented as a cluster of 36 protons (P+) and 56 neutrons (N) in a roughly spherical arrangement. A white rectangular box is superimposed on the center of the nucleus, containing the text 'Krypton-92' in orange.

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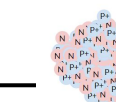
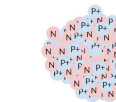
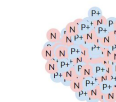
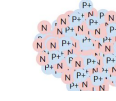
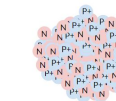
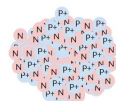
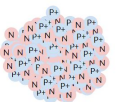
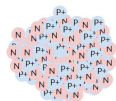
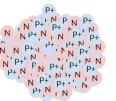
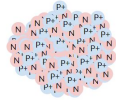
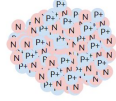
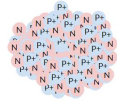
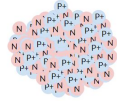
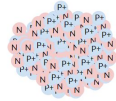








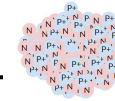
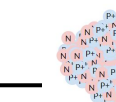
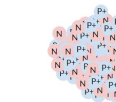
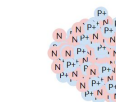
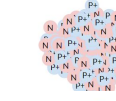
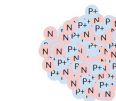
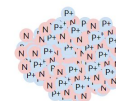
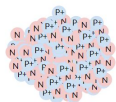
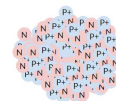
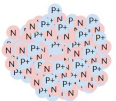
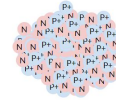
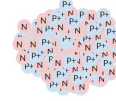
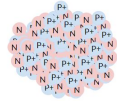
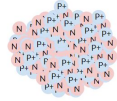
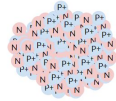
Chain Reaction



N

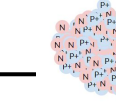
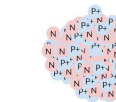
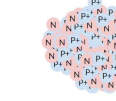
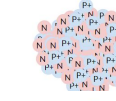
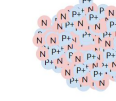
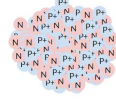
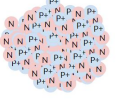
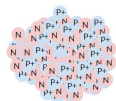
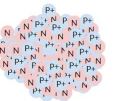
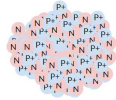
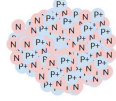
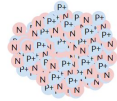
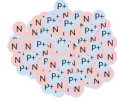
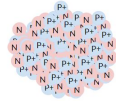
Chain Reaction

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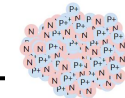
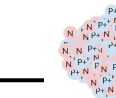
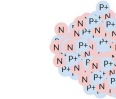
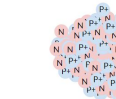
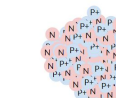
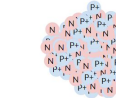
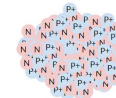
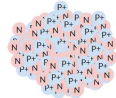
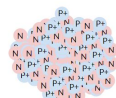
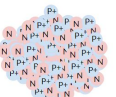
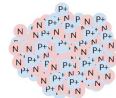
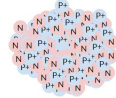
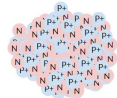
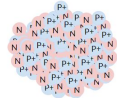
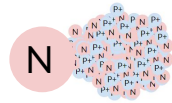


Chain Reaction

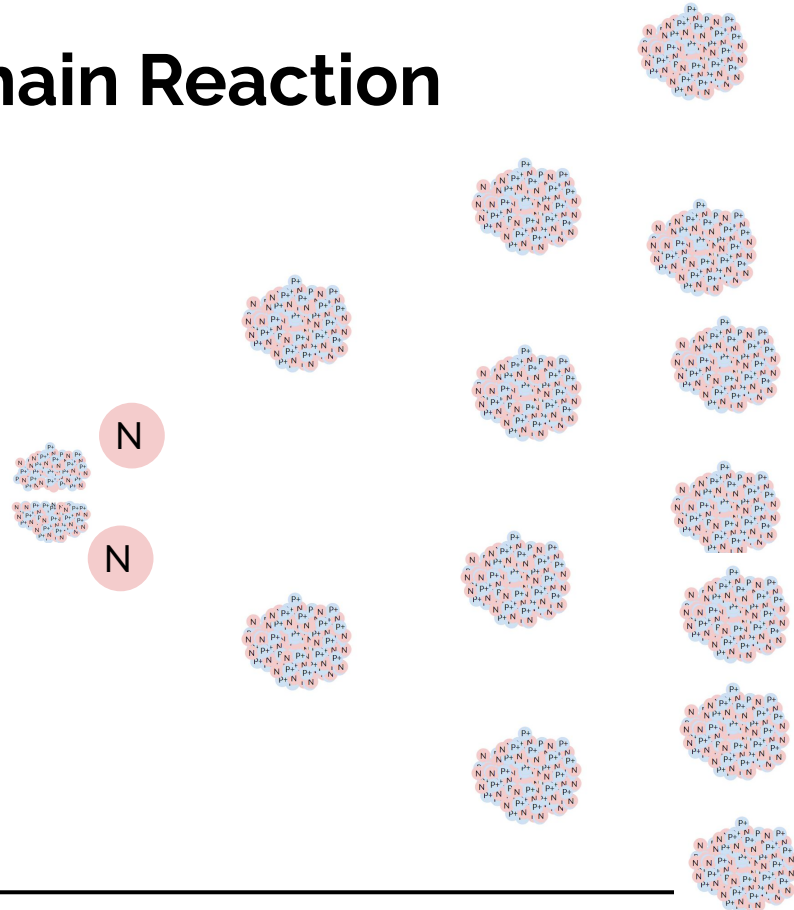
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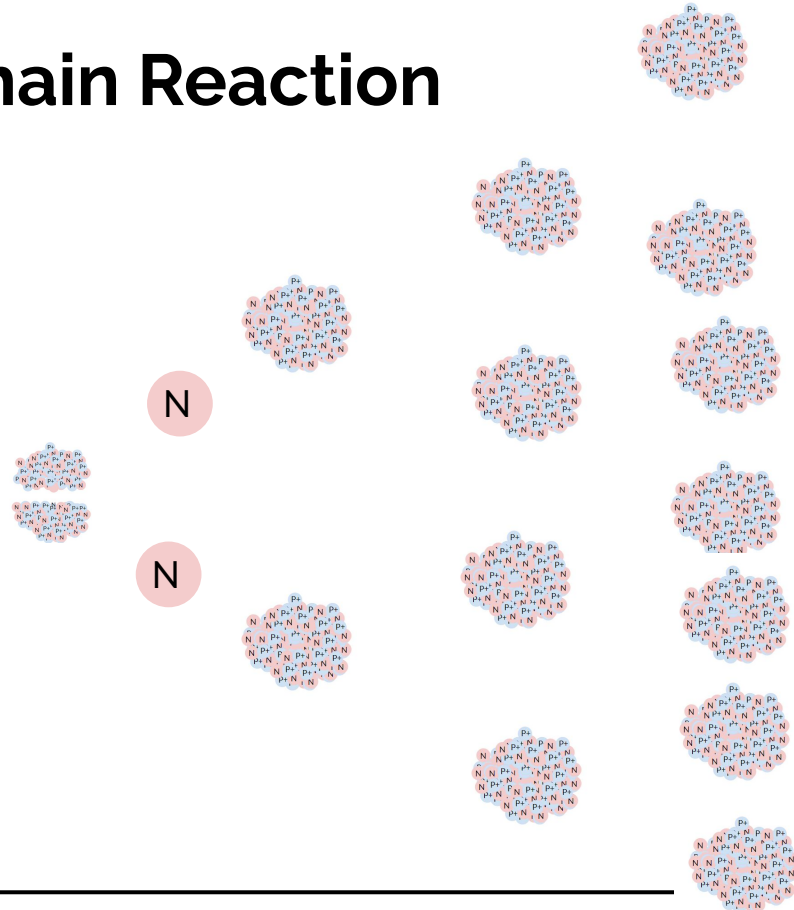
Chain Reaction



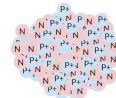
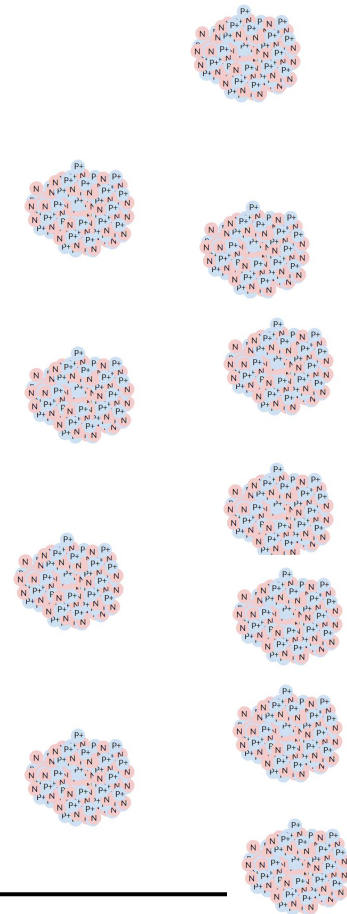
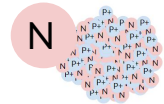
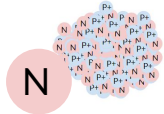
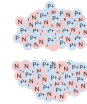
Chain Reaction



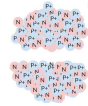
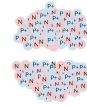
Chain Reaction



Chain Reaction

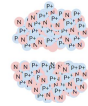


Chain Reaction



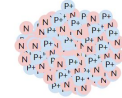
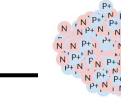
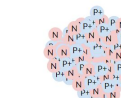
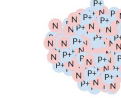
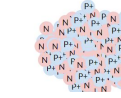
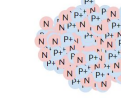
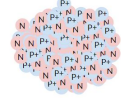
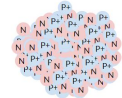
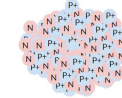
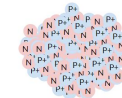
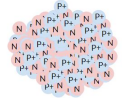
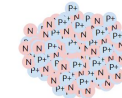
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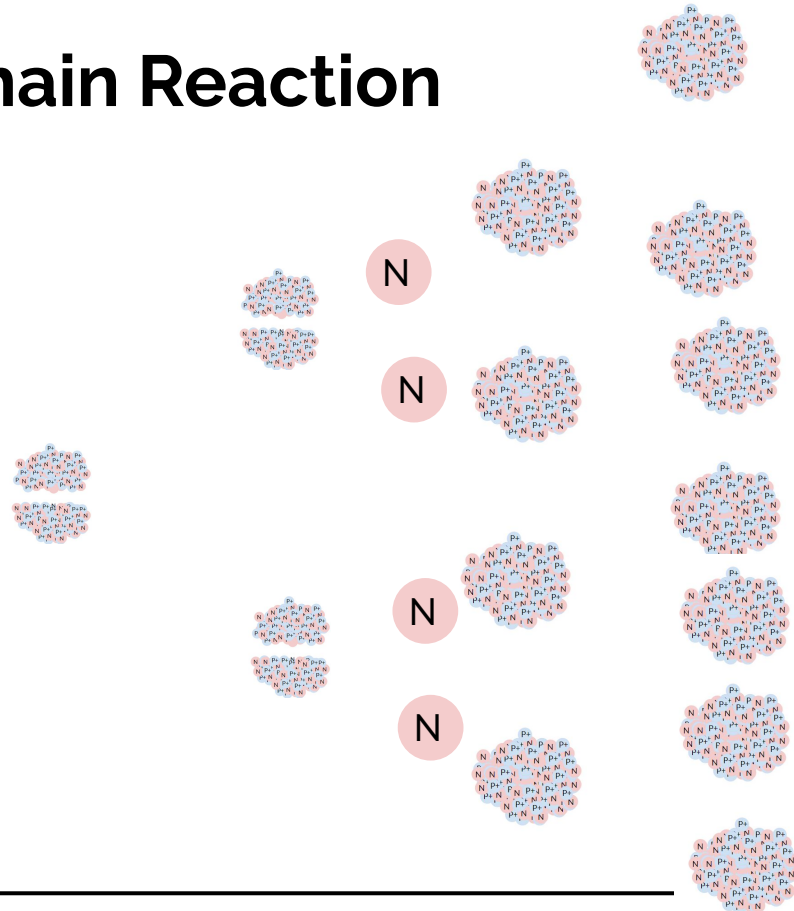


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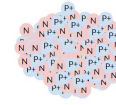
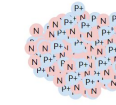
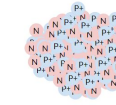
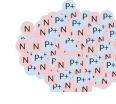
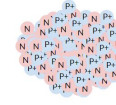
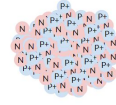
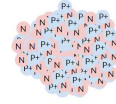
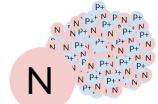
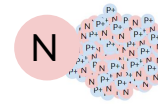
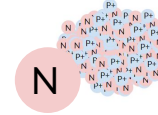
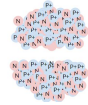
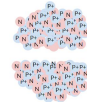
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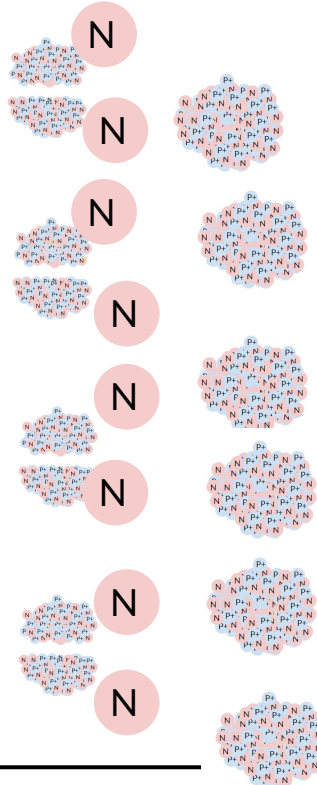
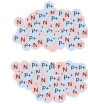
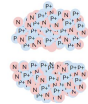
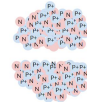
Chain Reaction



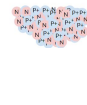
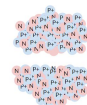
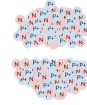
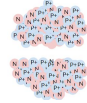
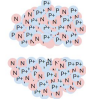
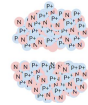
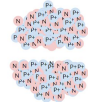
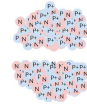
Chain Reaction



Chain Reaction



Chain Reaction



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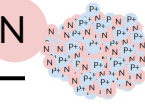
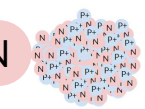
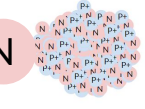
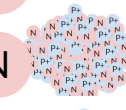
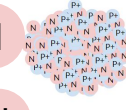
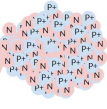
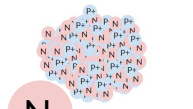
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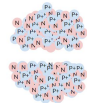
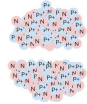
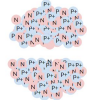
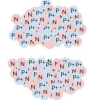
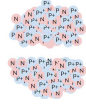
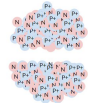
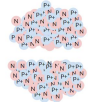
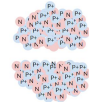
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Chain Reaction

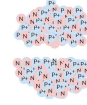


Chain Reaction



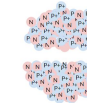
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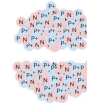
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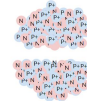
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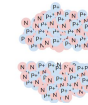
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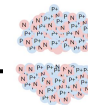
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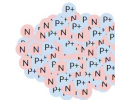
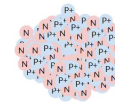
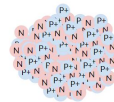
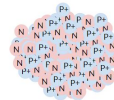


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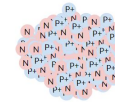
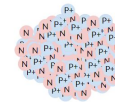
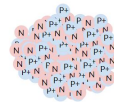
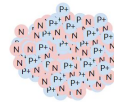
Moderated Reaction



N

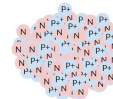
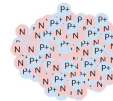
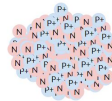
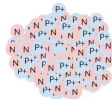
Moderated Reaction

N



Moderated Reaction

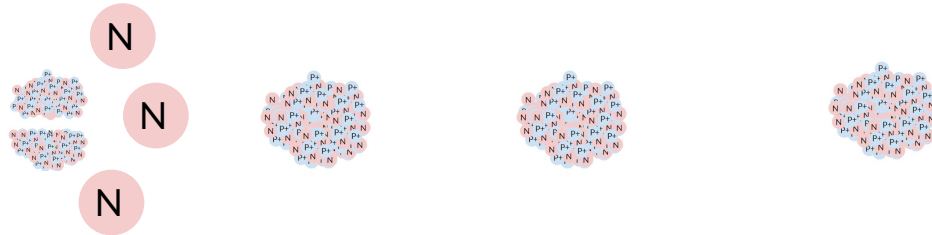
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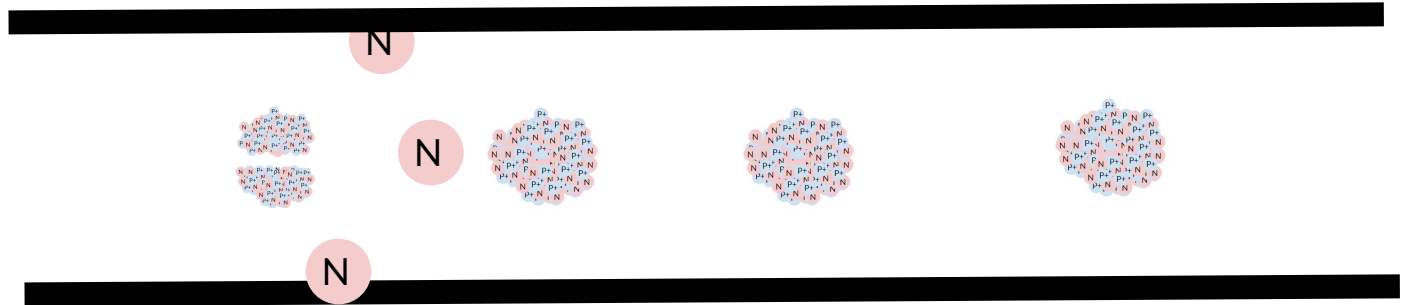
Moderated Reaction



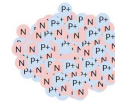
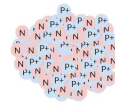
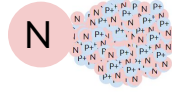
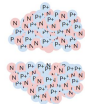
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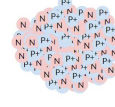
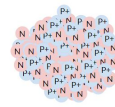
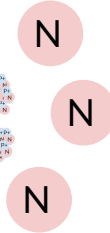
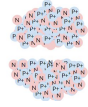
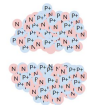
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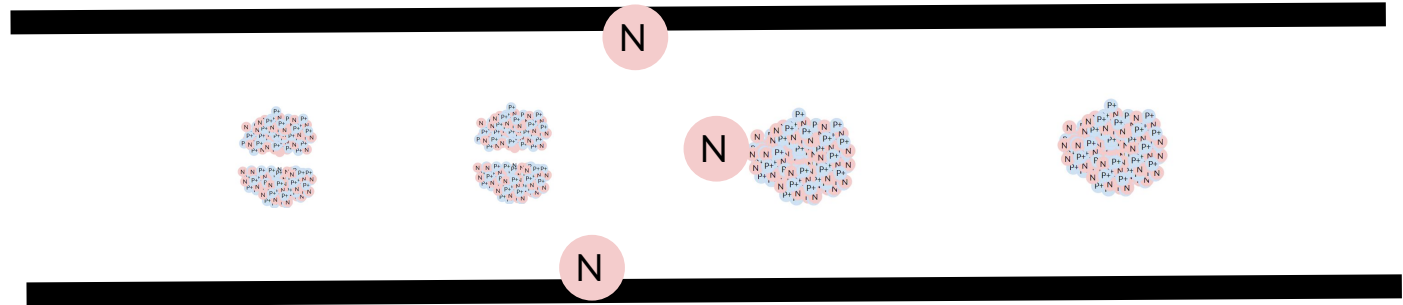
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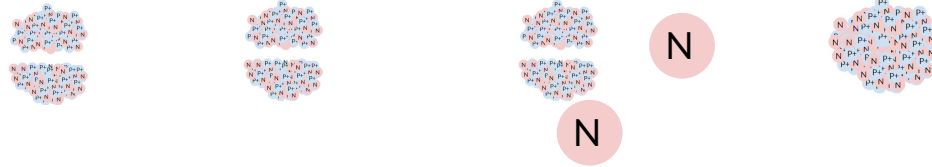
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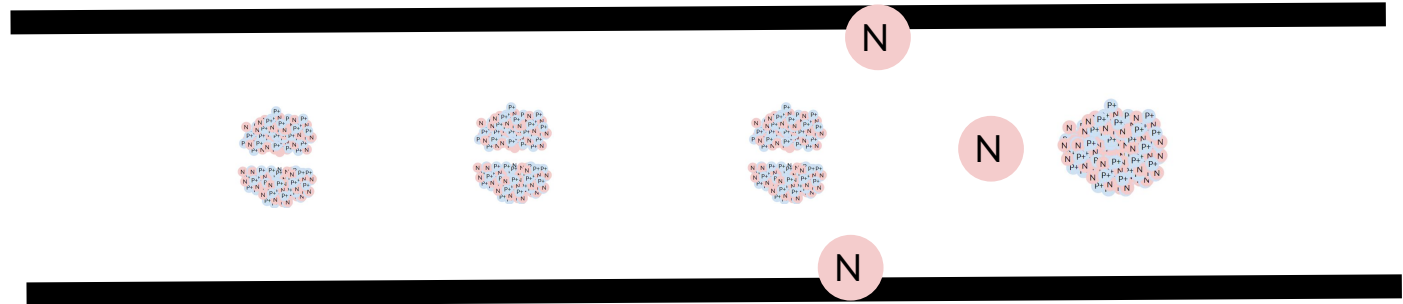
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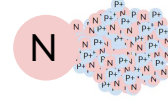
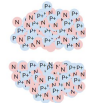
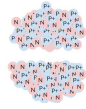
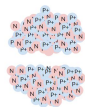
Moderated Reaction



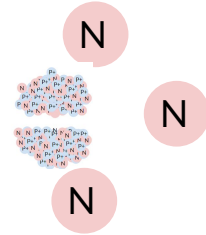
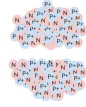
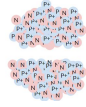
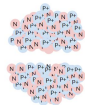
Moderated Reaction



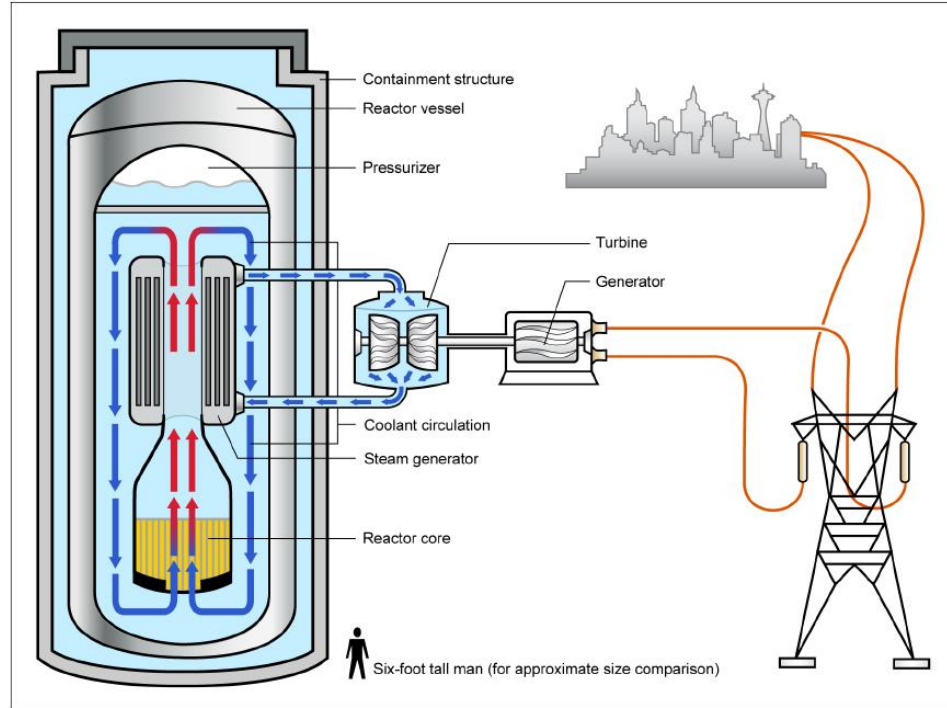
Moderated Reaction



Moderated Reaction

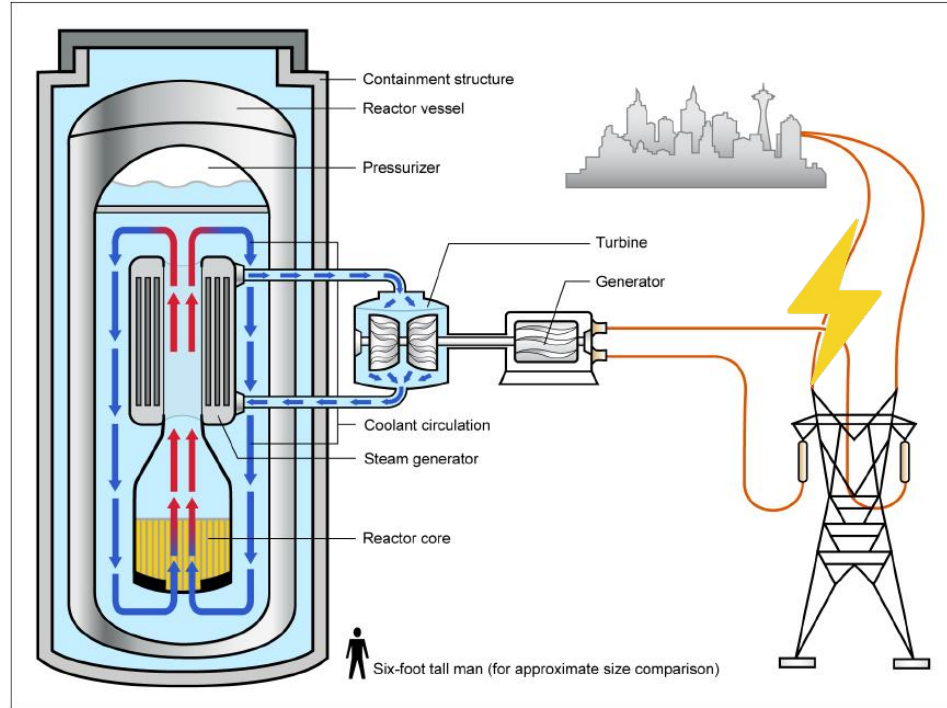


Moderated Reaction



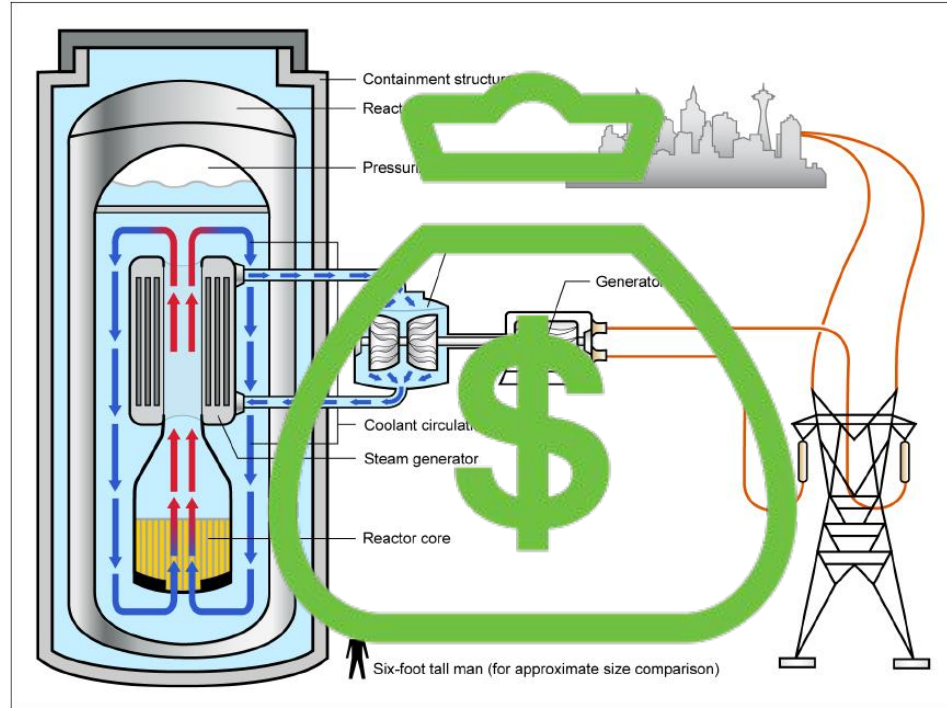
Source: GAO, based on Department of Energy documentation. | GAO-15-652

Moderated Reaction

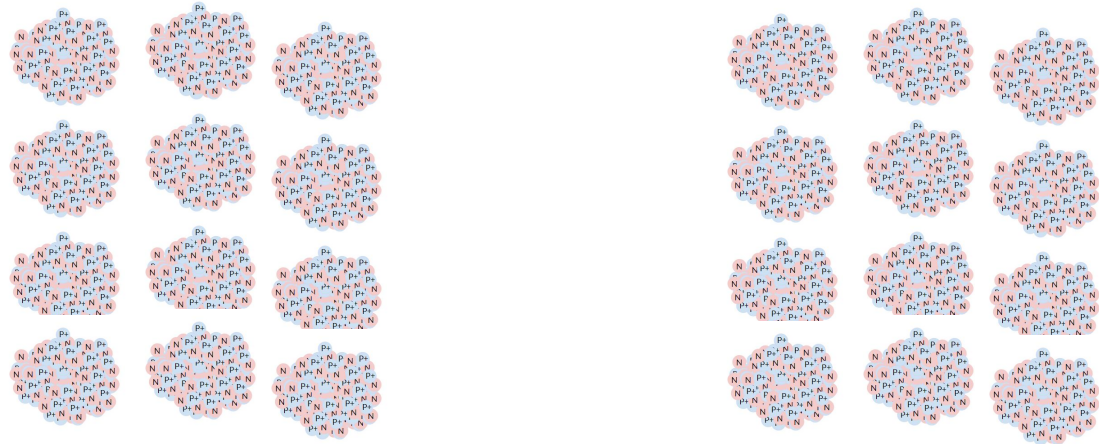


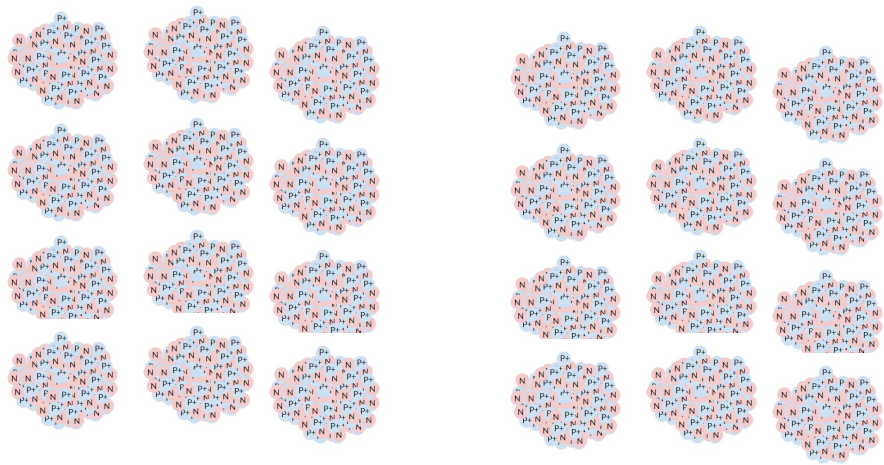
Source: GAO, based on Department of Energy documentation. | GAO-15-652

Moderated Reaction

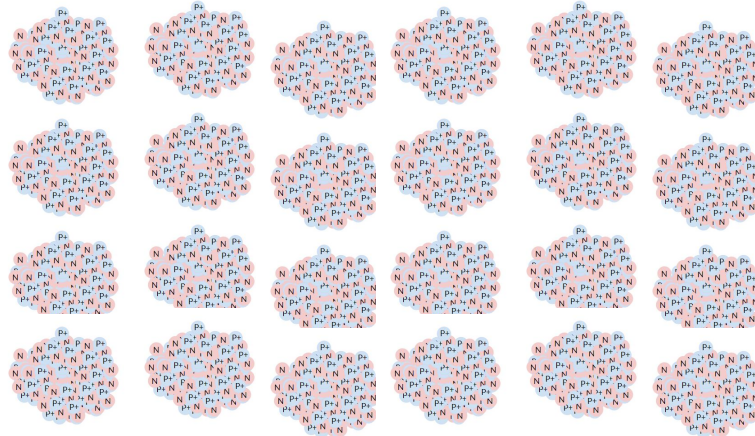


Source: GAO, based on Department of Energy documentation. | GAO-15-652

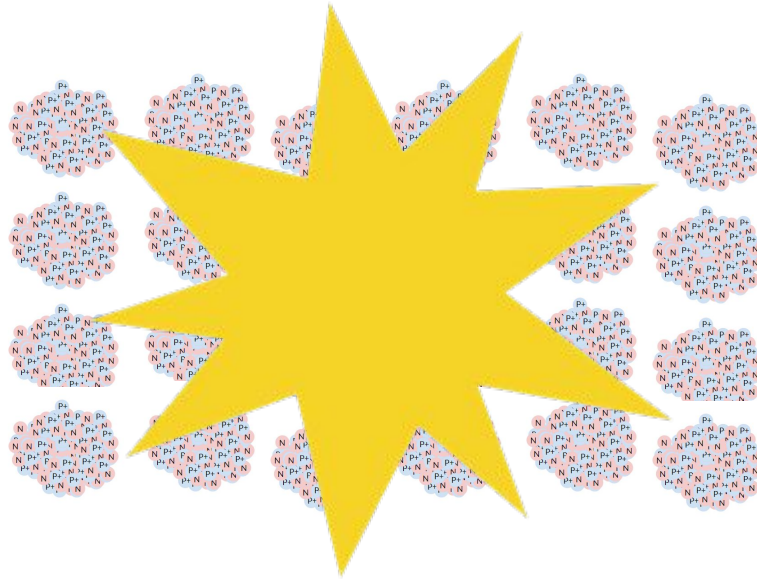




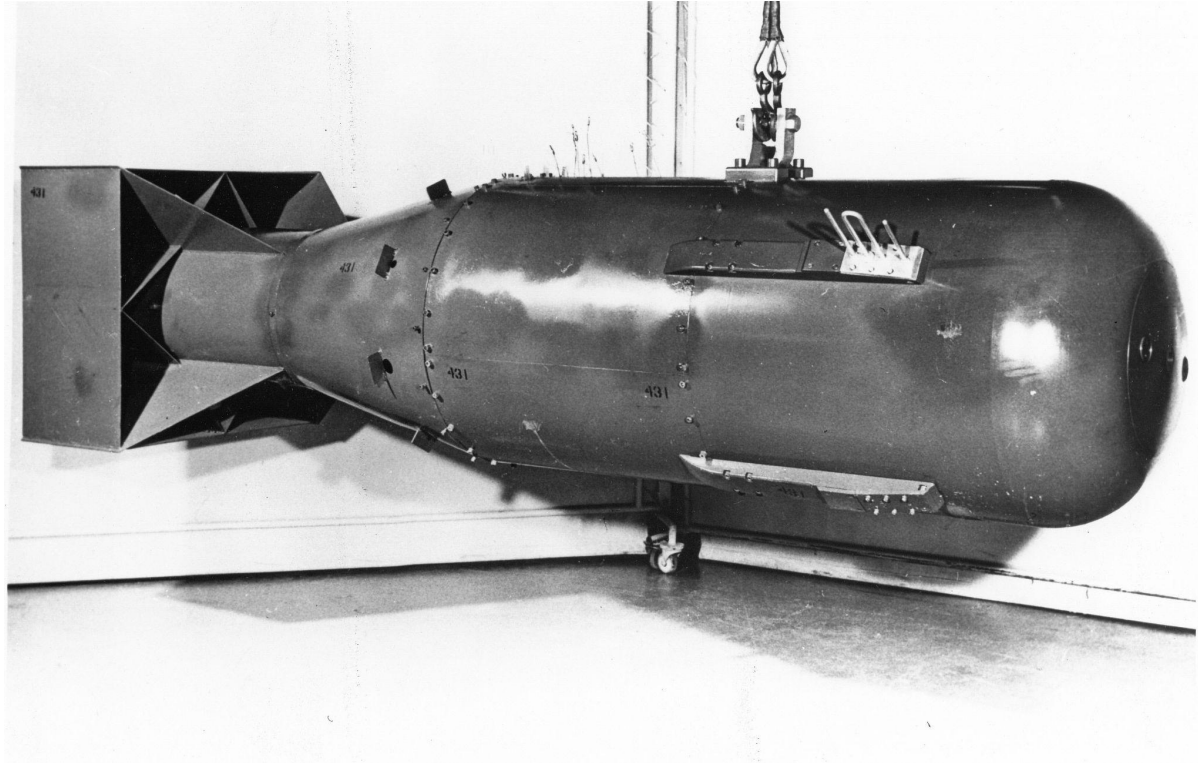
Critical mass



Supercritical



Little Boy - the First Bomb



European Scientists

Scientists / Manhattan Project / Immigration

From sources across the web



Enrico Fermi
1901–1954



Hans Bethe
1906–2005



Leo Szilard
1898–1964



Joseph Rotblat
1908–2005



John von Neumann
1903–1957



Eugene Wigner
1902–1995



James Franck
1882–1964



Emilio Segrè
1905–1989



Stanislaw Ulam
1909–1984



Rudolf Peierls
1907–1995

Einstein-Szilard letter

Albert Einstein
Old Grove Rd.
Nassau Point
Peconic, Long Island

August 2nd, 1939

F.D. Roosevelt,
President of the United States,
White House
Washington, D.C.

Sir:

Some recent work by E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations:

In the course of the last four months it has been made probable - through the work of Joliot in France as well as Fermi and Szilard in America - that it may become possible to set up a nuclear chain reaction in a large mass of uranium, by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

-2-

The United States has only very poor ores of uranium in moderate quantities. There is some good ore in Canada and the former Czechoslovakia, while the most important source of uranium is Belgian Congo.

In view of this situation you may think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reactions in America. One possible way of achieving this might be for you to entrust with this task a person who has your confidence and who could perhaps serve in an unofficial capacity. His task might comprise the following:

a) to approach Government Departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States;

b) to speed up the experimental work, which is at present being carried on within the limits of the budgets of University laboratories, by providing funds, if such funds be required, through his contacts with private persons who are willing to make contributions for this cause, and perhaps also by obtaining the co-operation of industrial laboratories which have the necessary equipment.

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsäcker, is attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.

Yours very truly,
A. Einstein
(Albert Einstein)

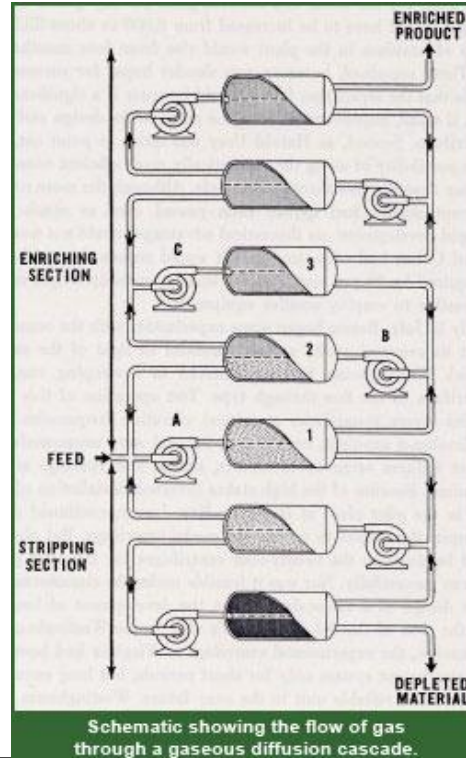
Manhattan Project



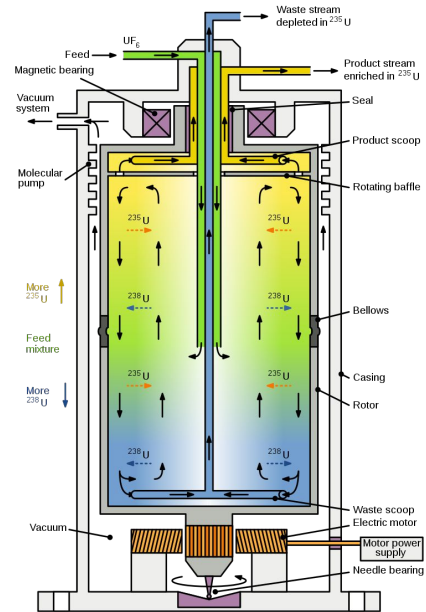
Uranium-235



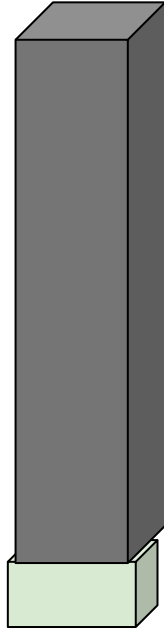
Gas Diffusion Enrichment



Centrifuge Enrichment

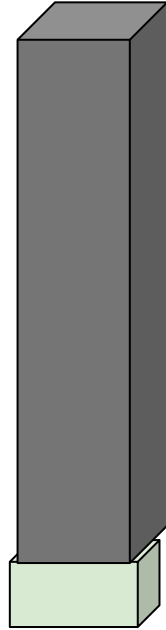


Reactor and Weapons Grade

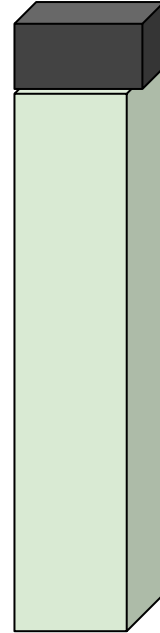


Reactor Grade

Reactor and Weapons Grade

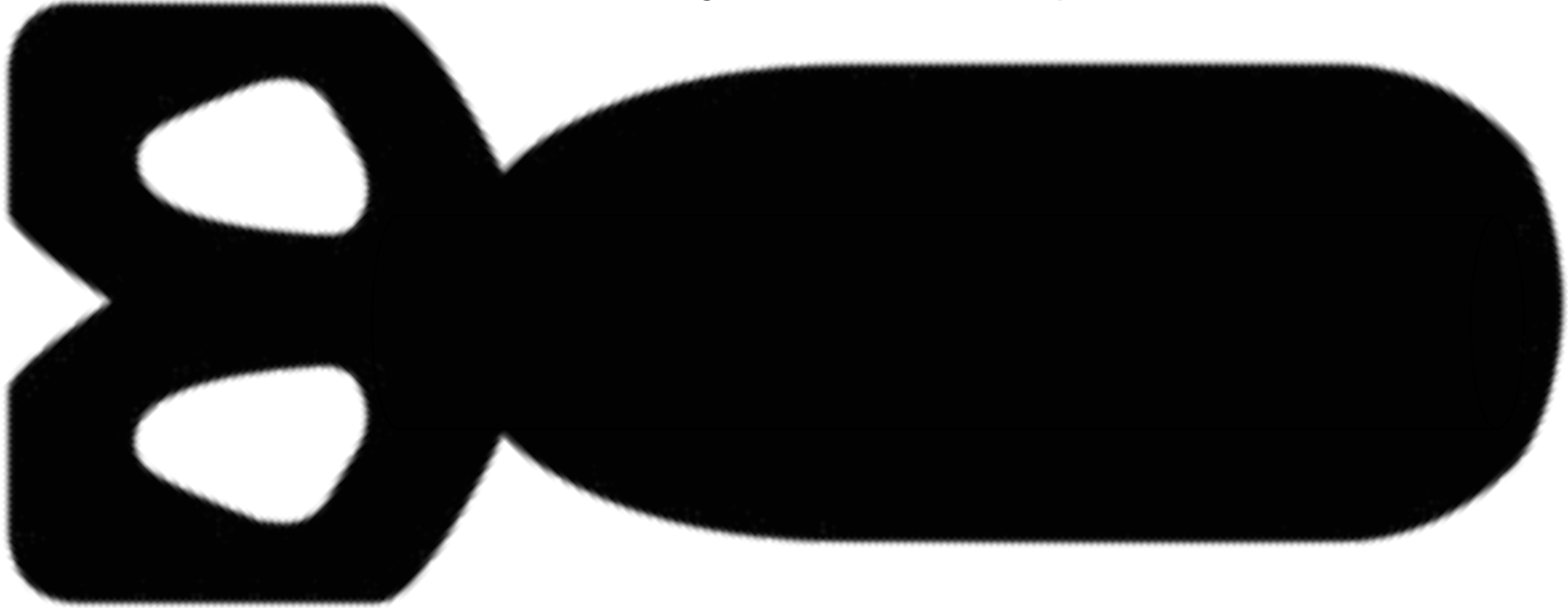


Reactor Grade

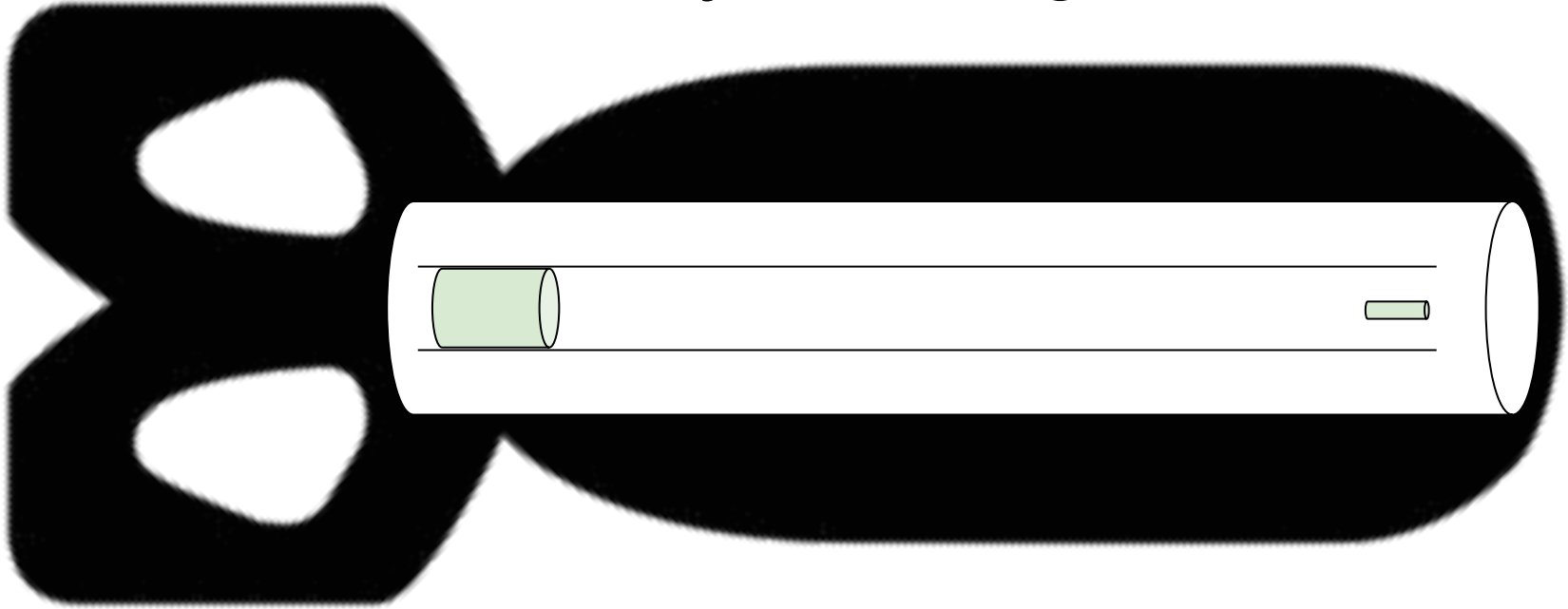


Weapons Grade

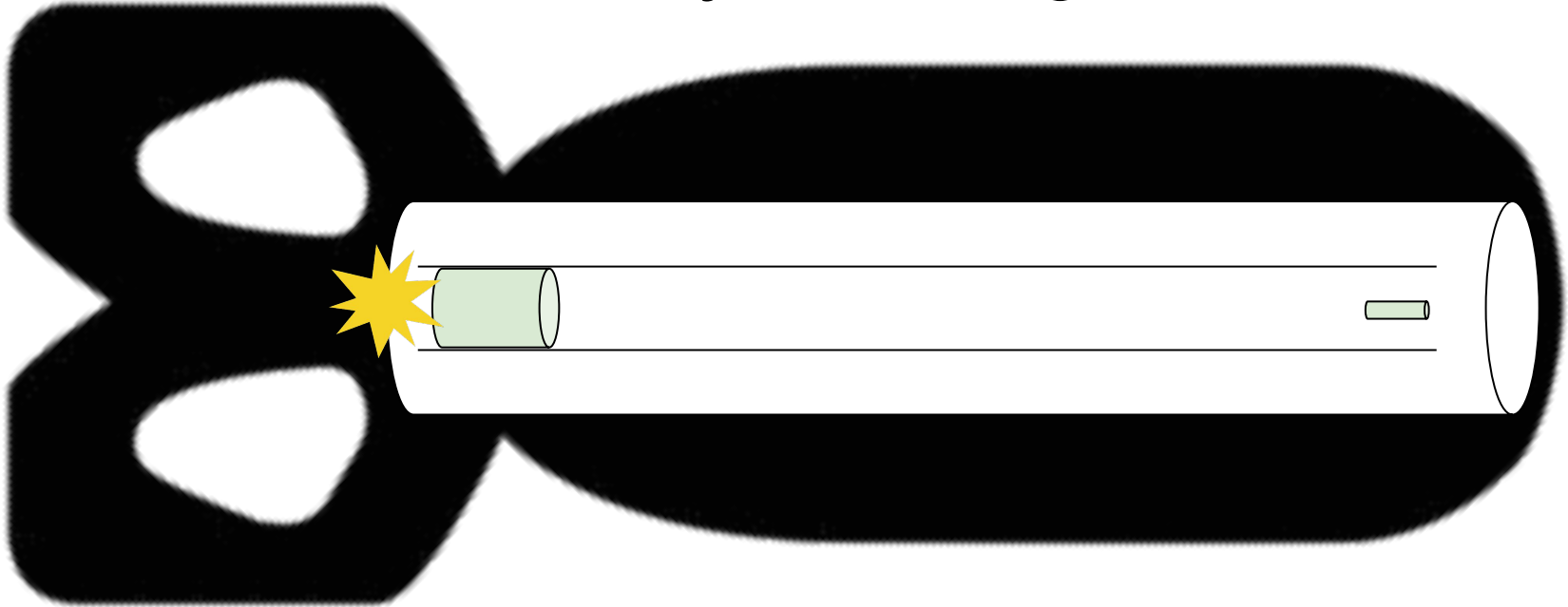
Little Boy Gun Design



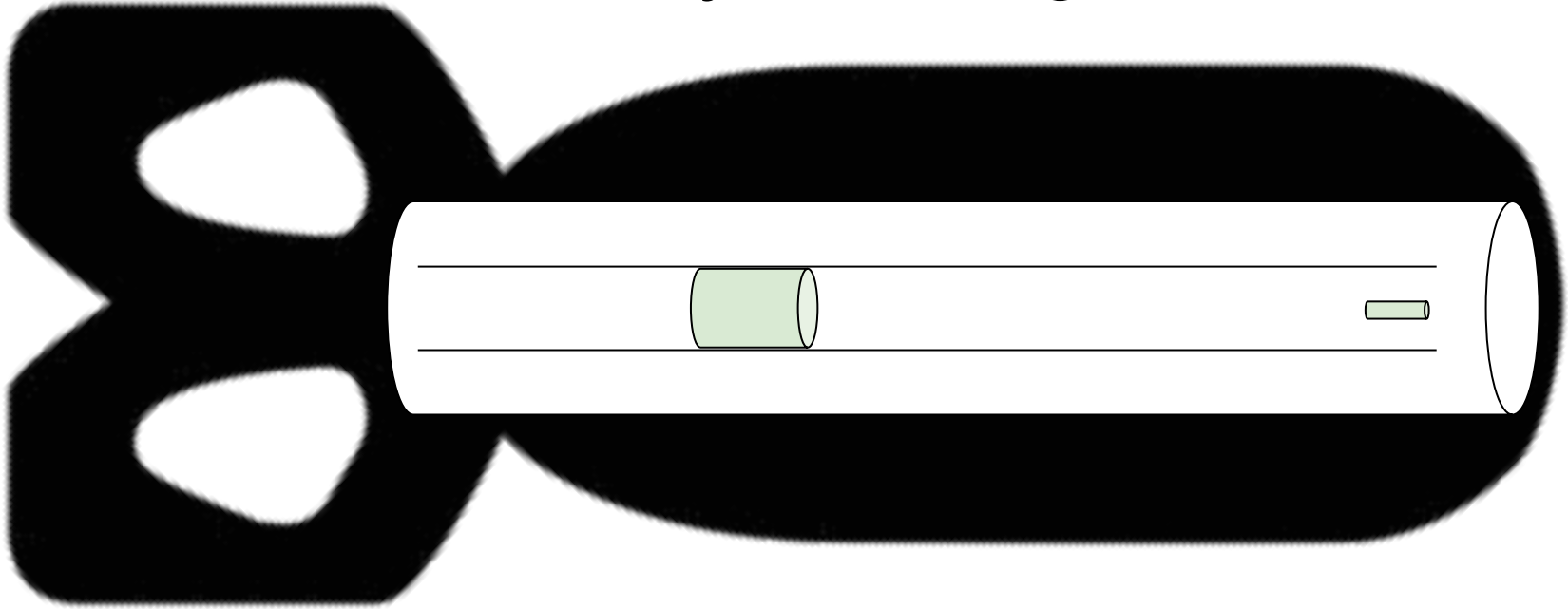
Little Boy Gun Design



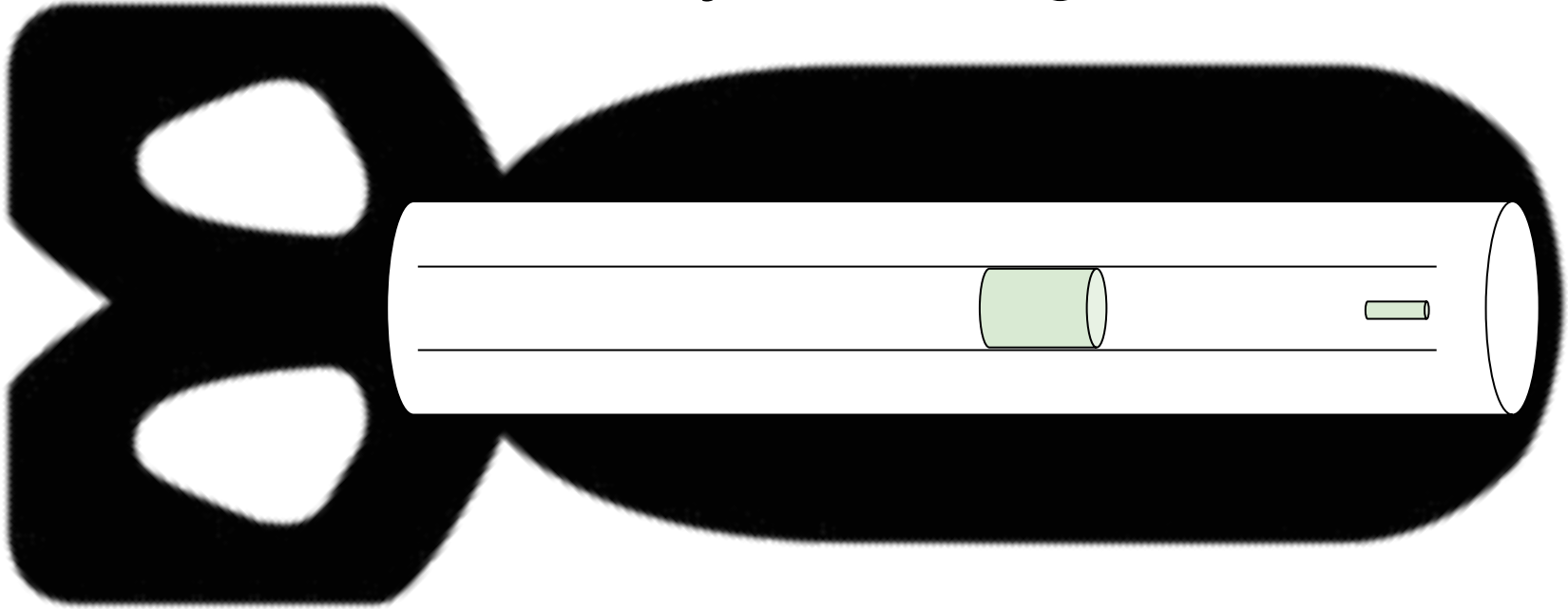
Little Boy Gun Design



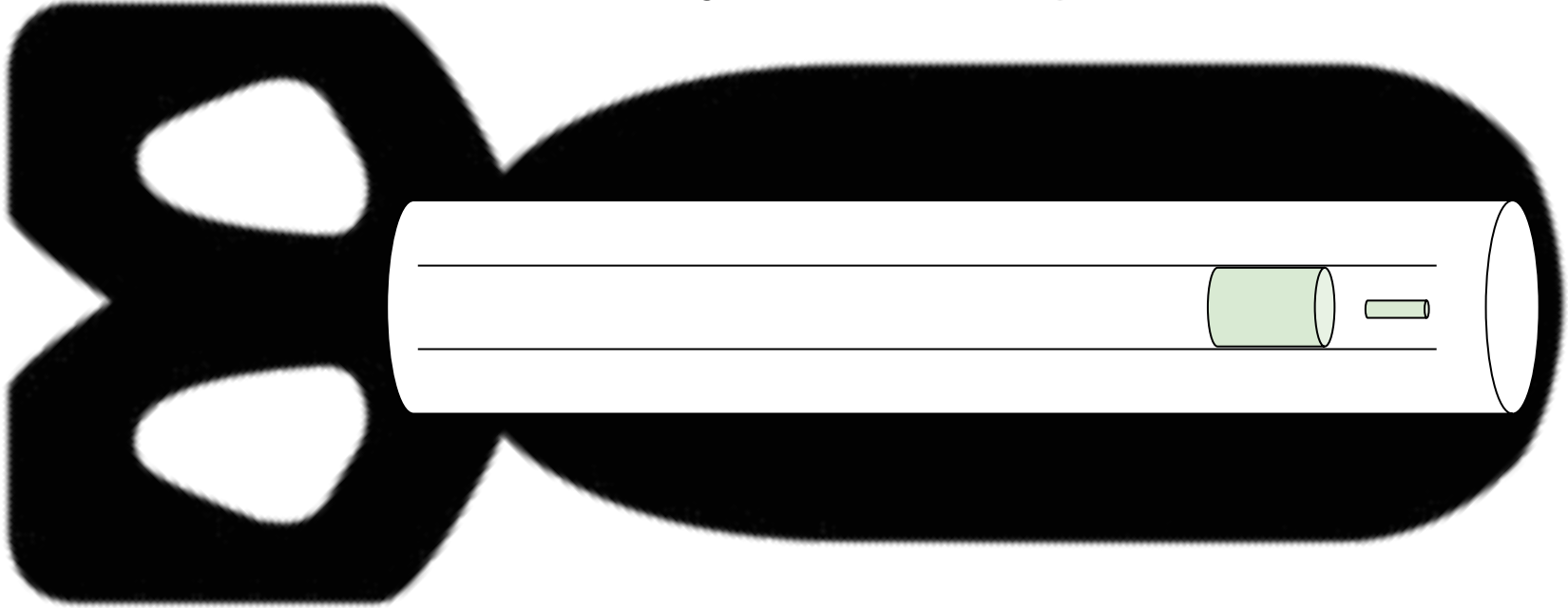
Little Boy Gun Design



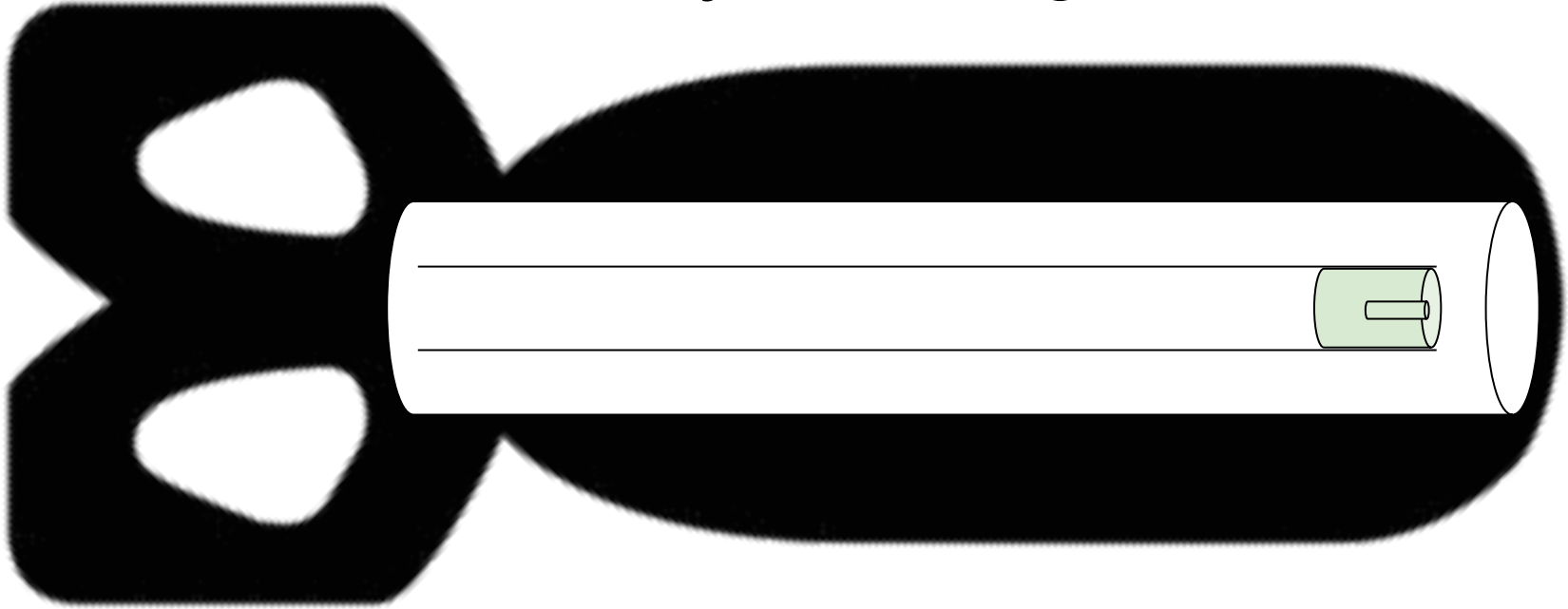
Little Boy Gun Design



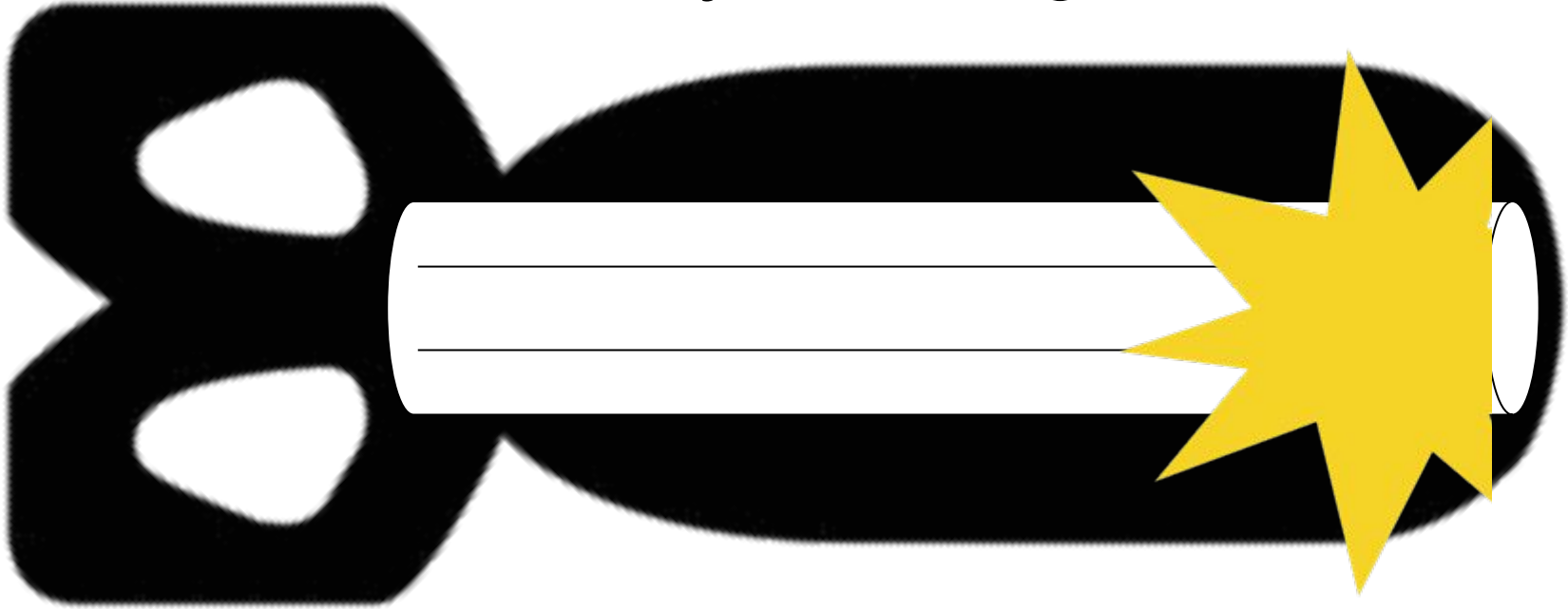
Little Boy Gun Design



Little Boy Gun Design



Little Boy Gun Design



Hiroshima



Measuring Yield

- Kiloton

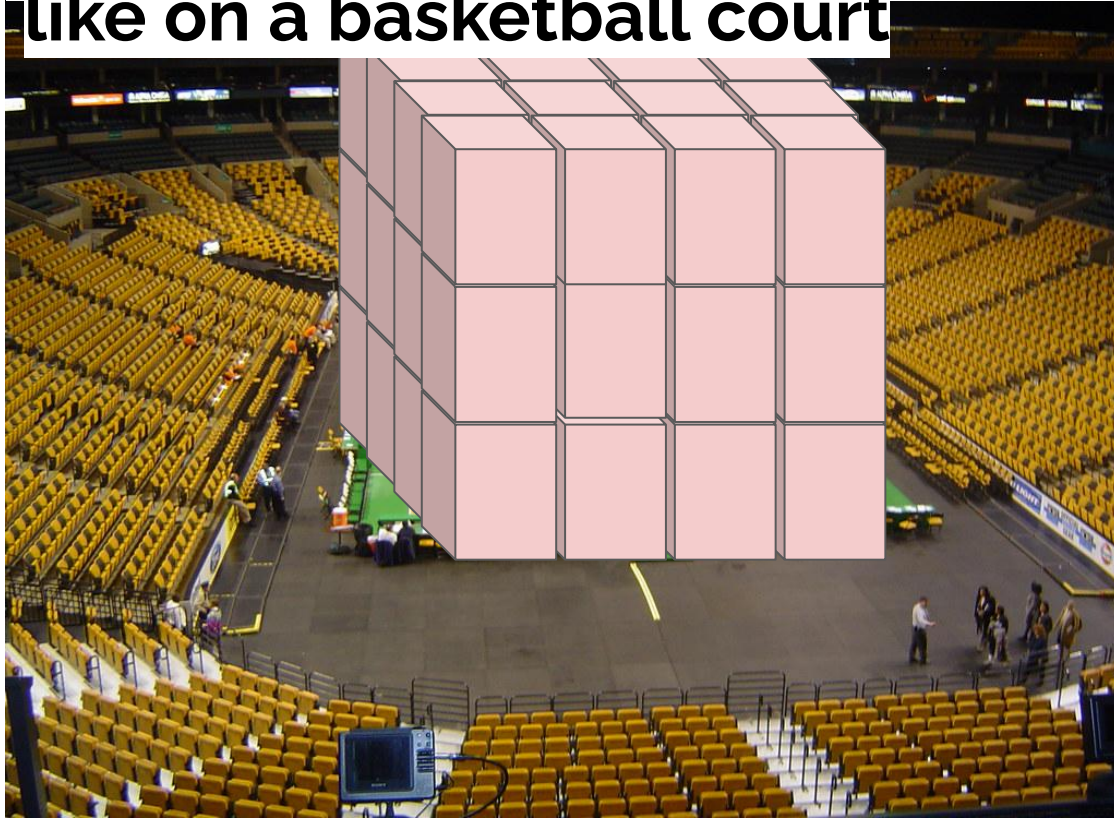


Measuring Yield

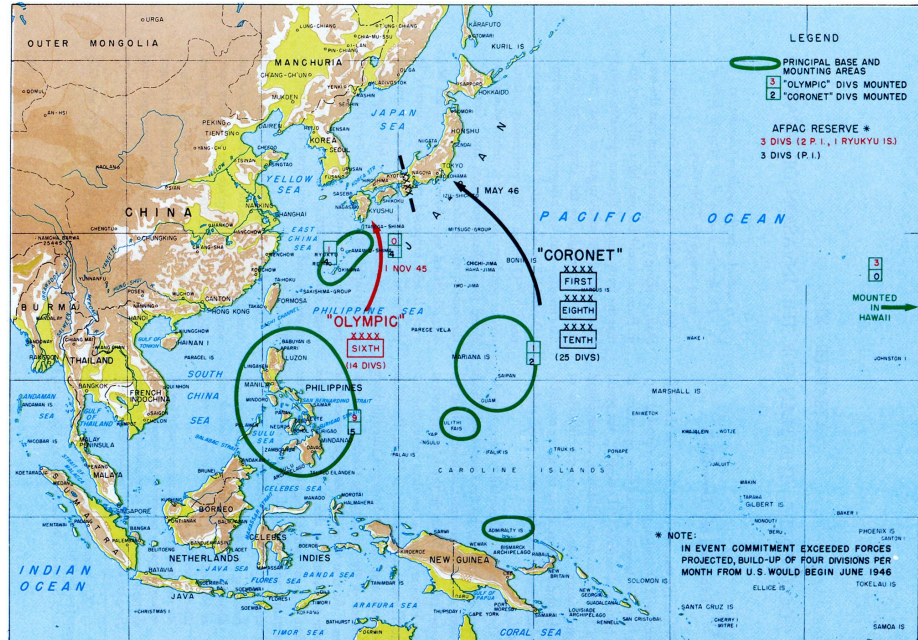
- A kiloton is 1,000 tons of TNT



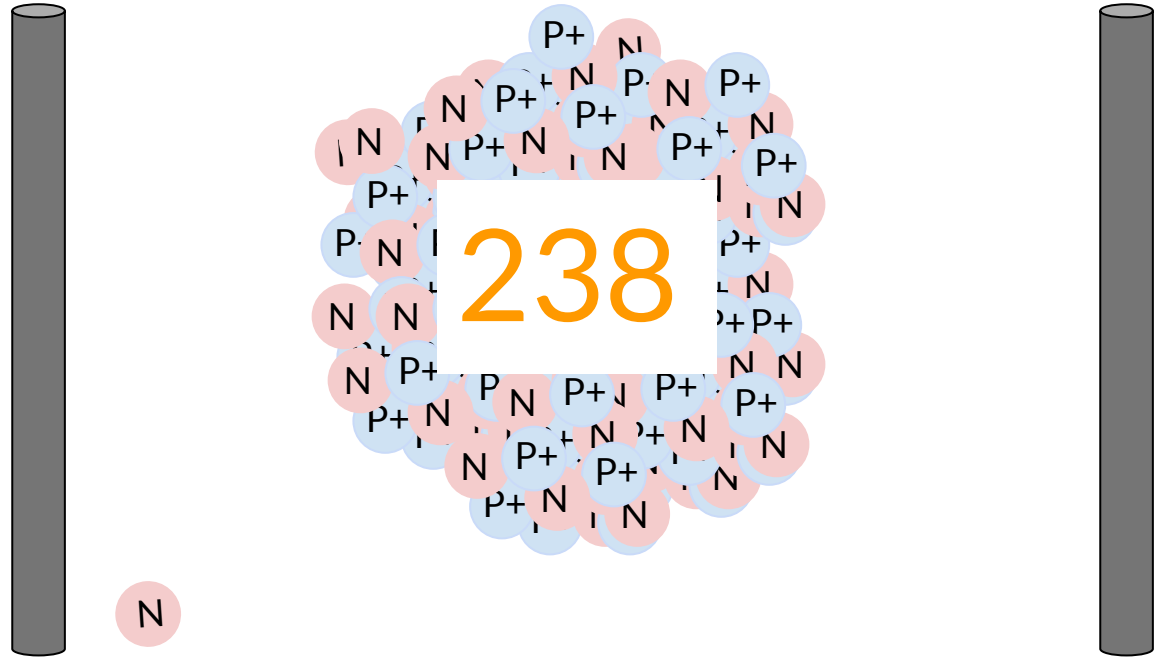
This is (roughly) what it would look like on a basketball court



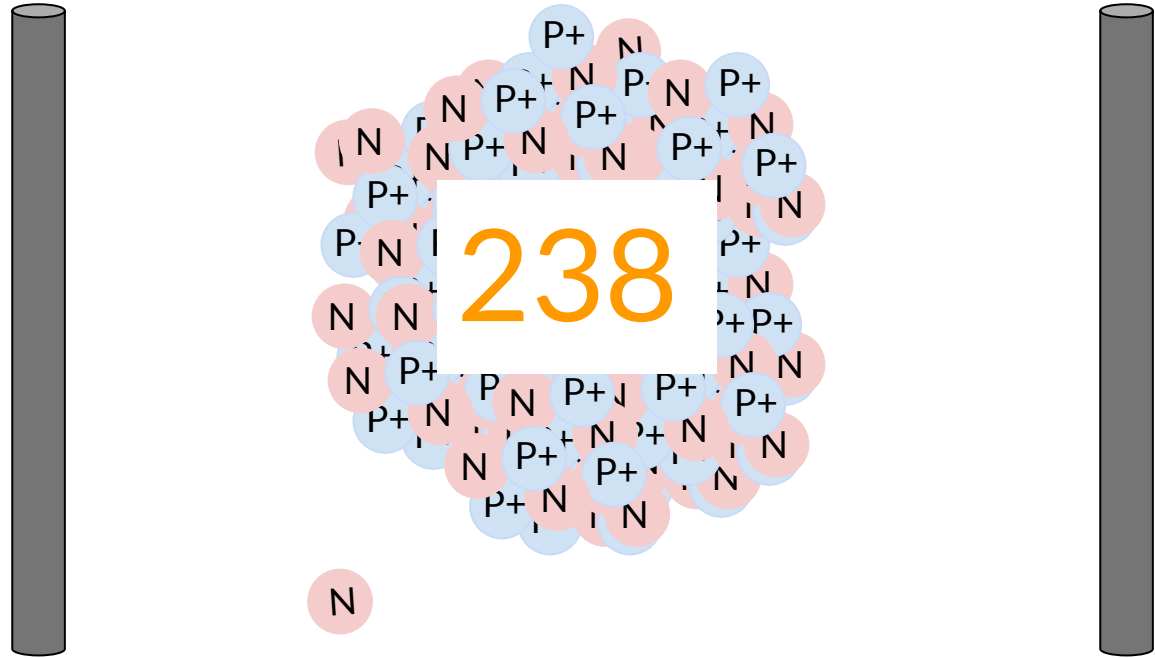
But the invasion of the Japanese Mainland...



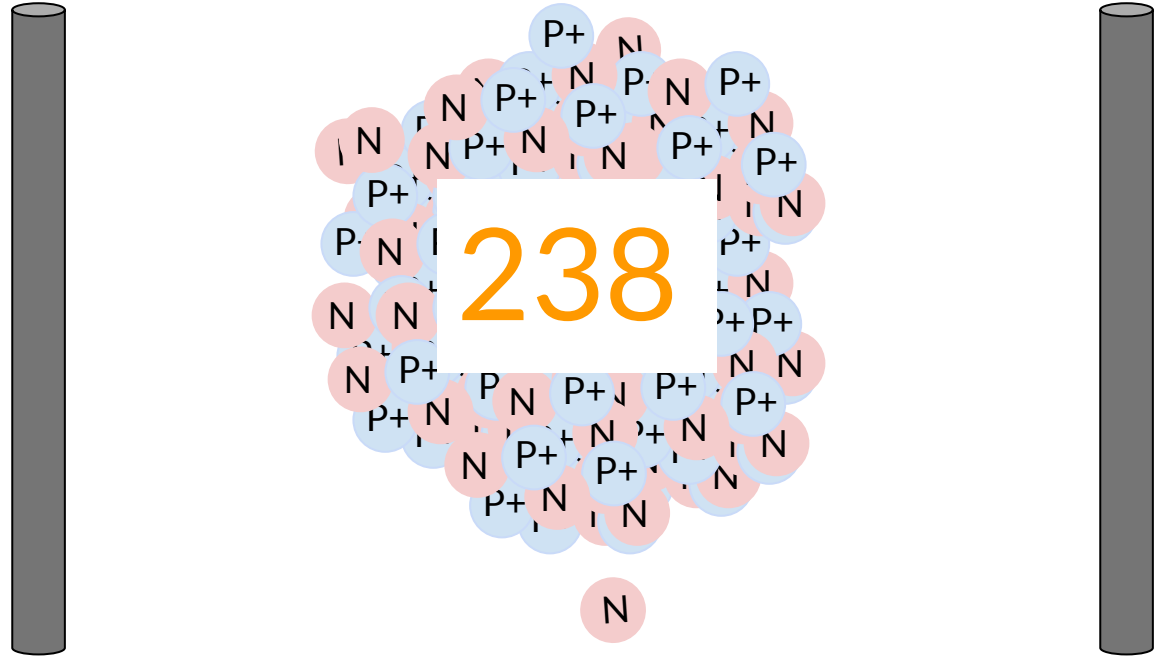
Meanwhile in a nuclear reactor



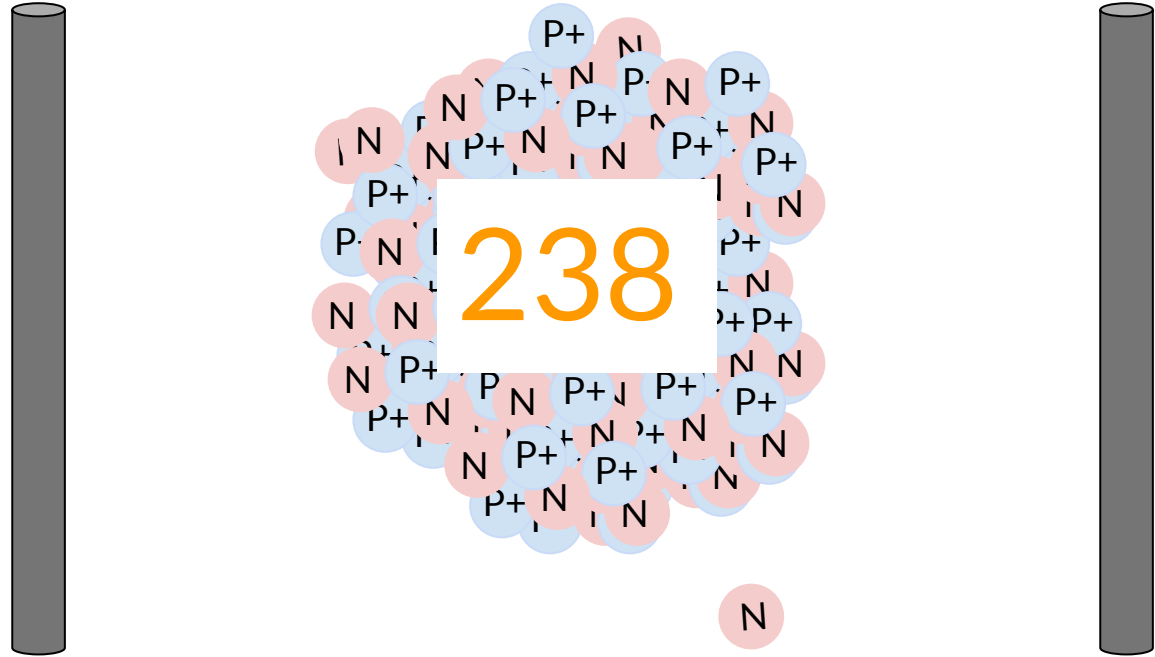
Meanwhile in a nuclear reactor



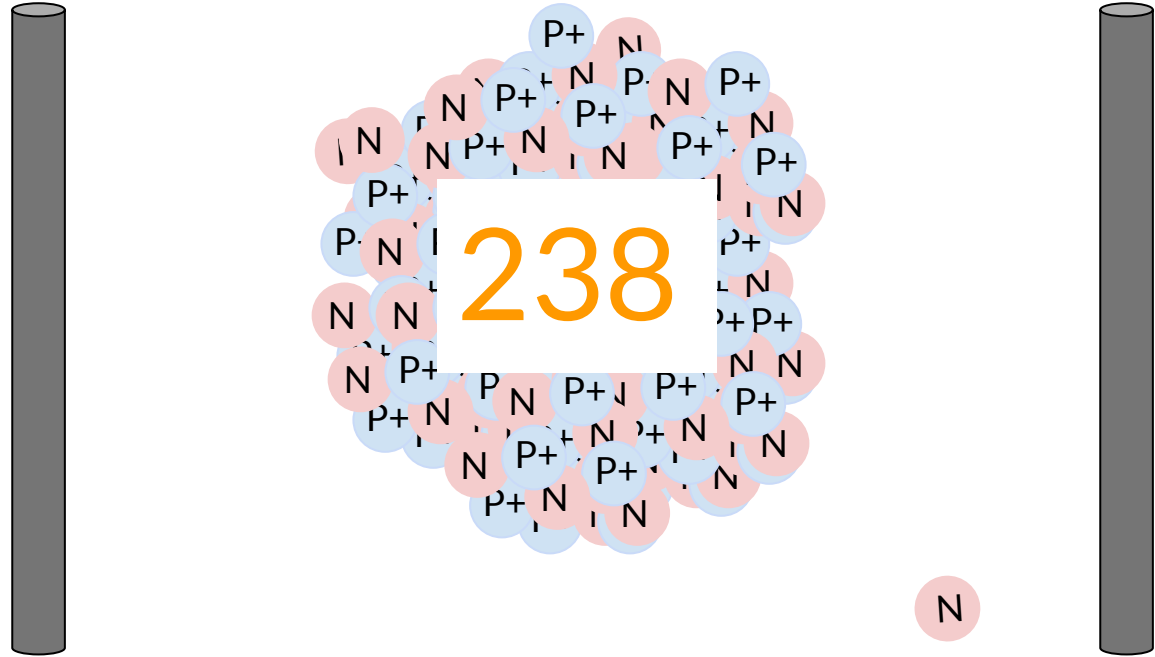
Meanwhile in a nuclear reactor



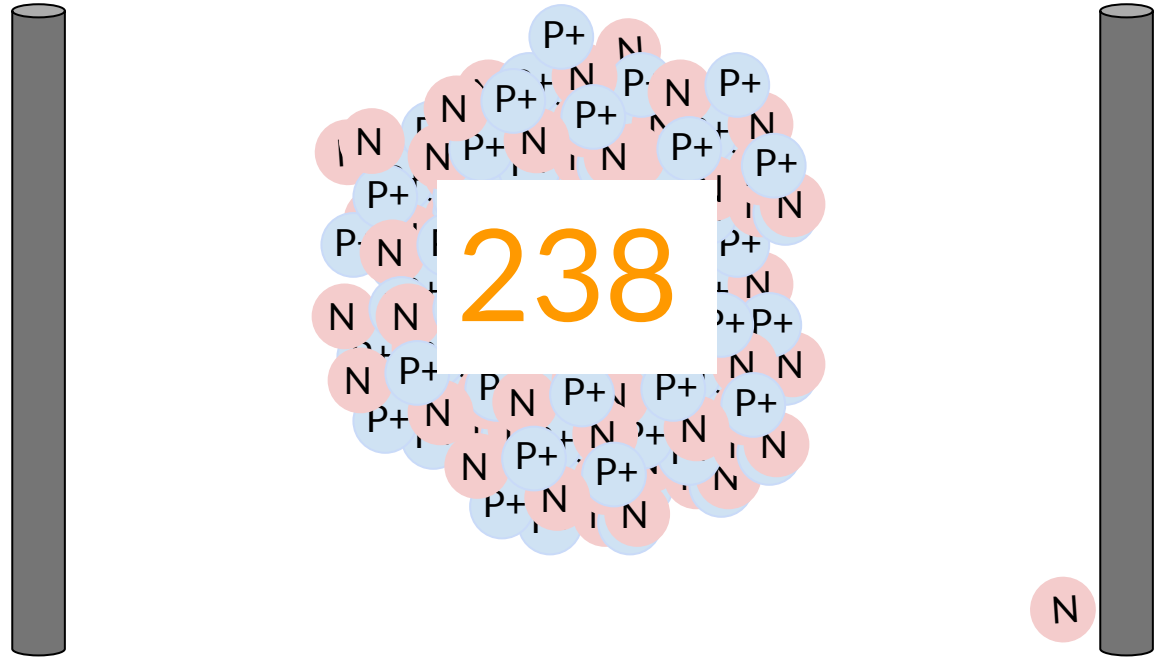
Meanwhile in a nuclear reactor



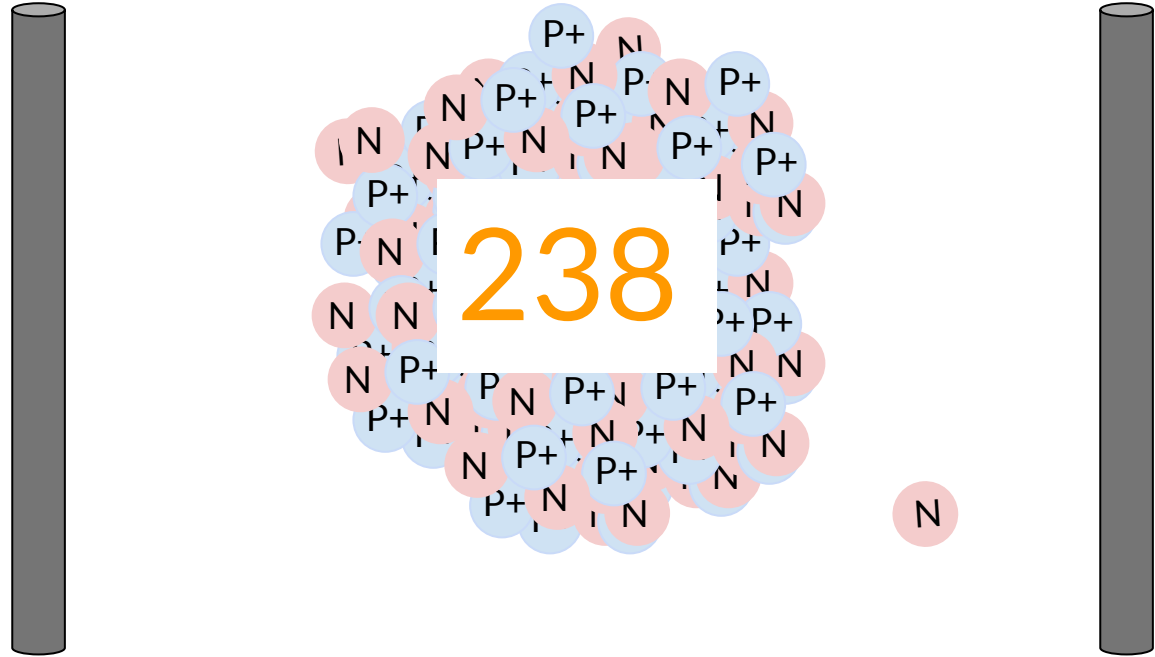
Meanwhile in a nuclear reactor



Meanwhile in a nuclear reactor



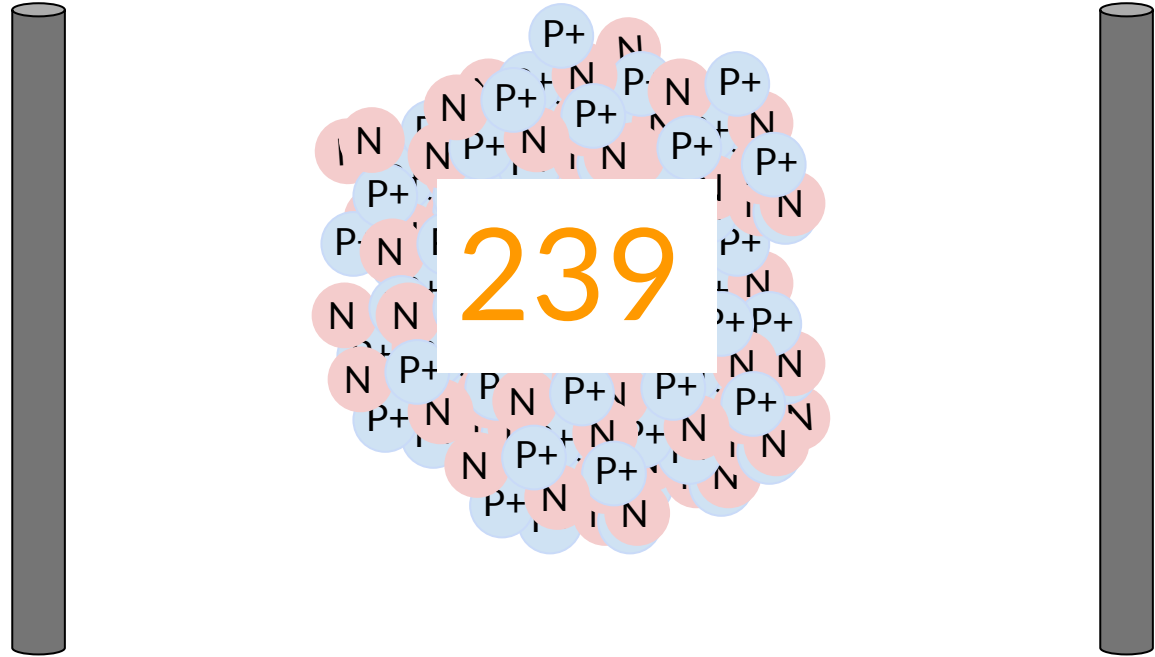
Meanwhile in a nuclear reactor



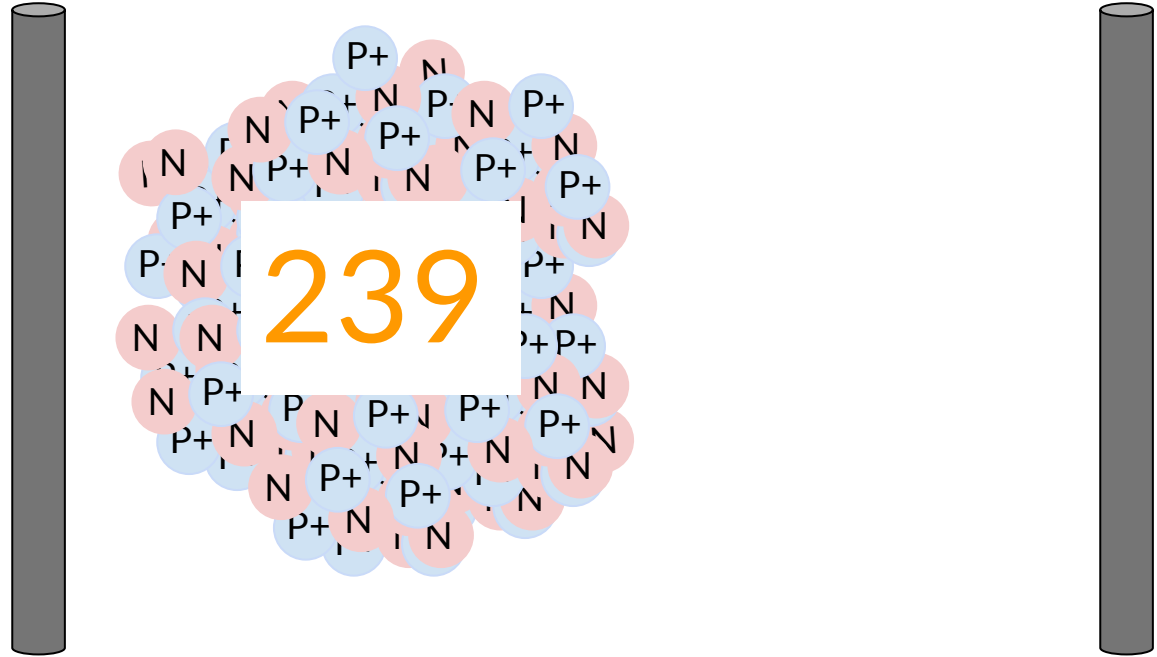
Meanwhile in a nuclear reactor



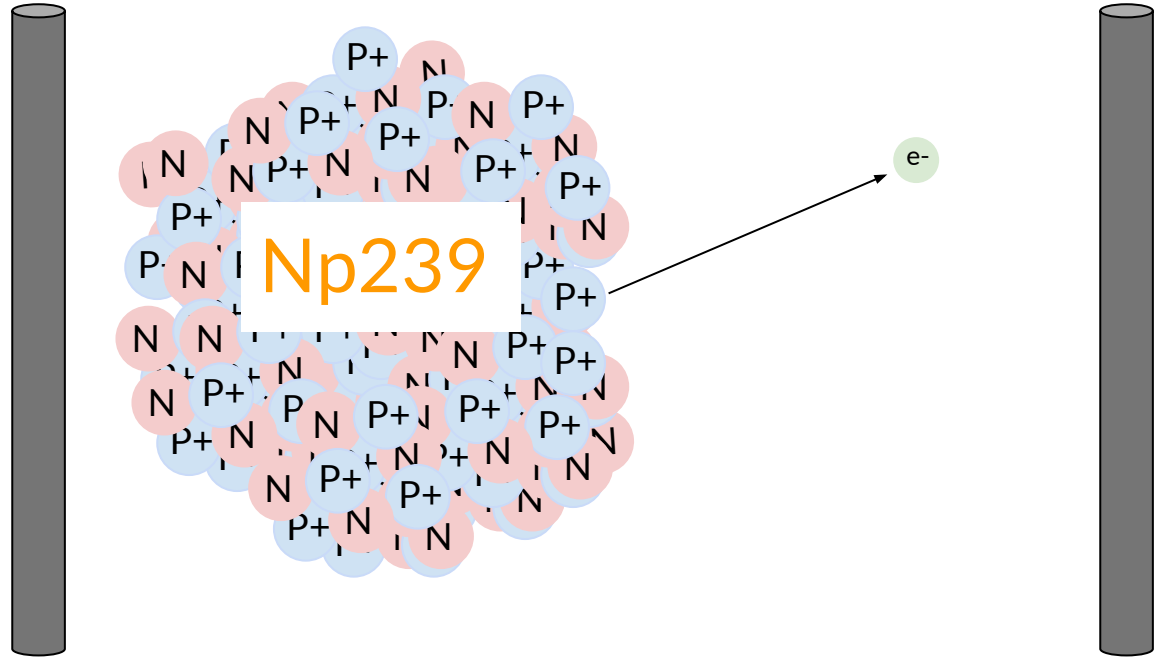
Meanwhile in a nuclear reactor



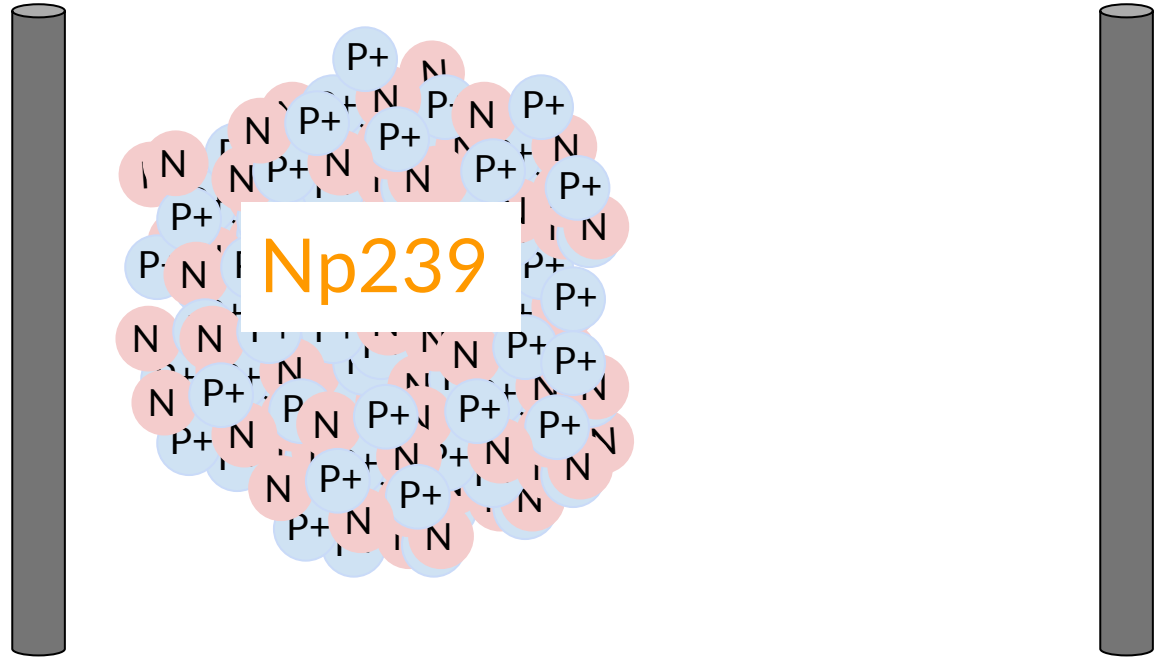
U239 is really unstable



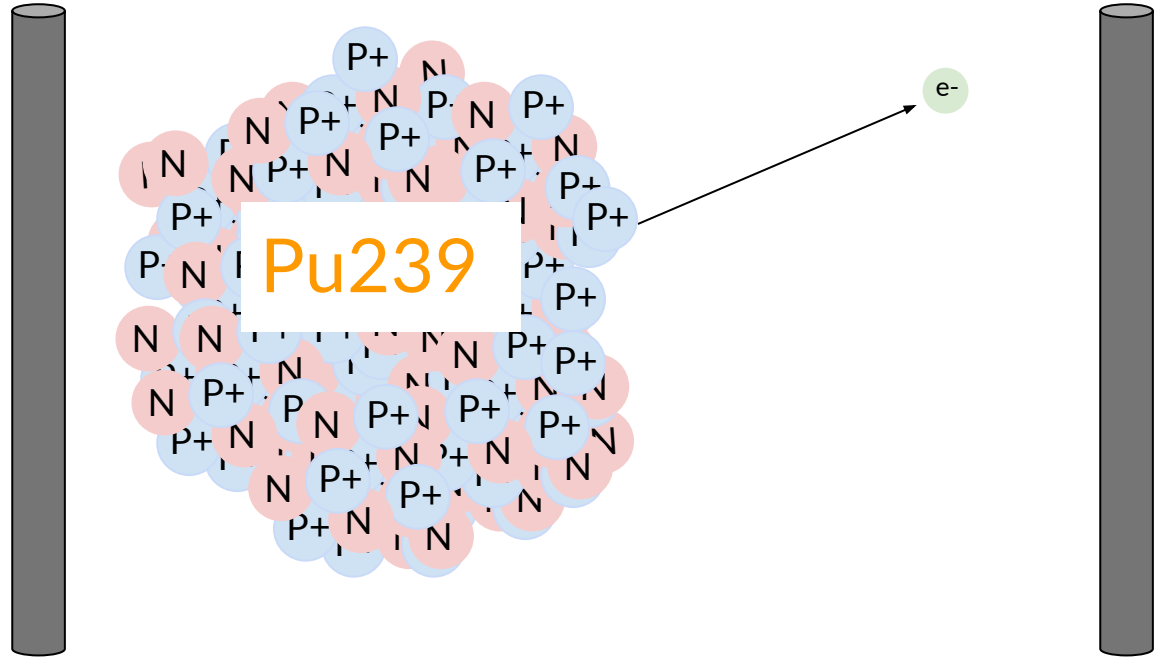
U-239 becomes Np-239



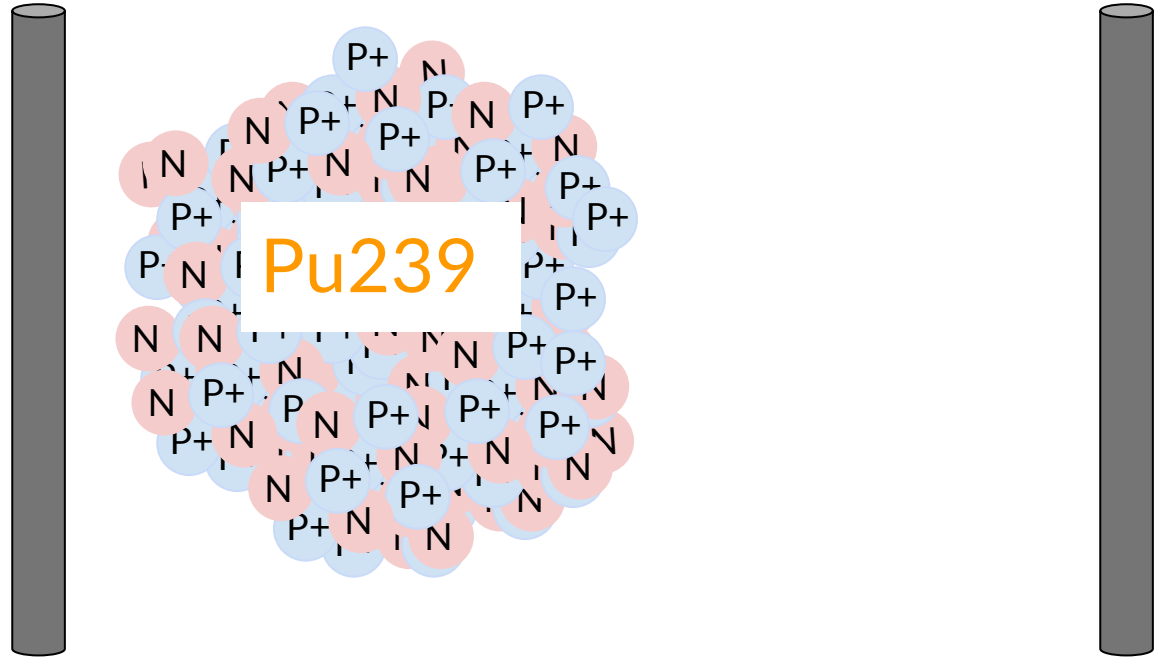
Np-239



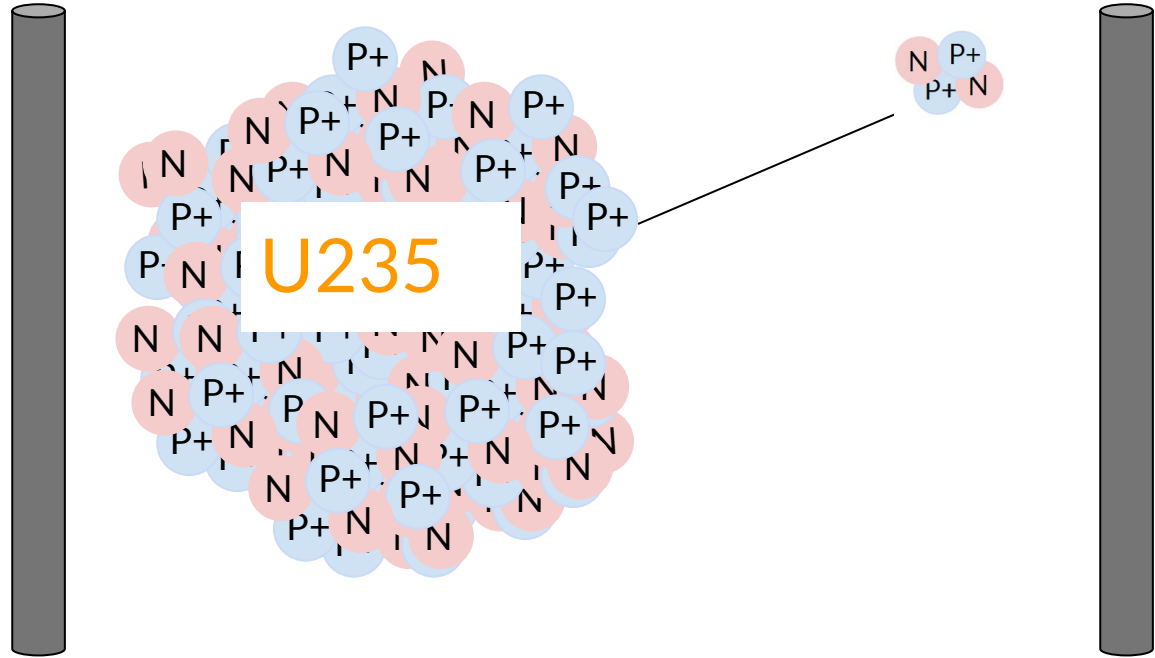
Pu-239



Pu-239



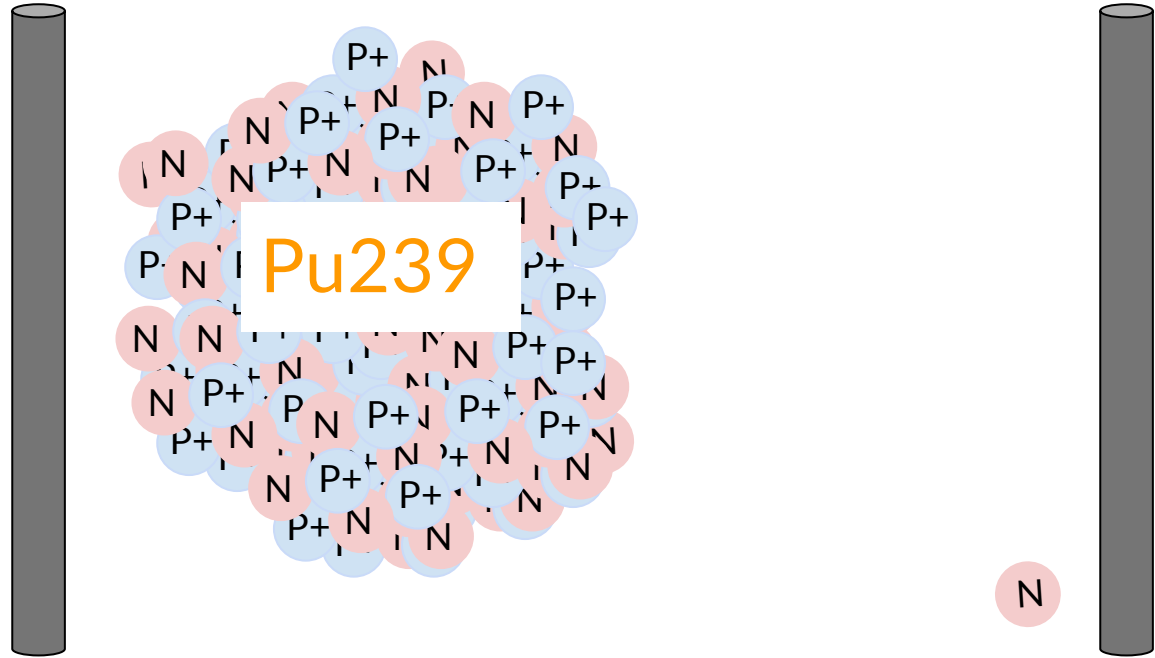
PU-239 becomes U-235



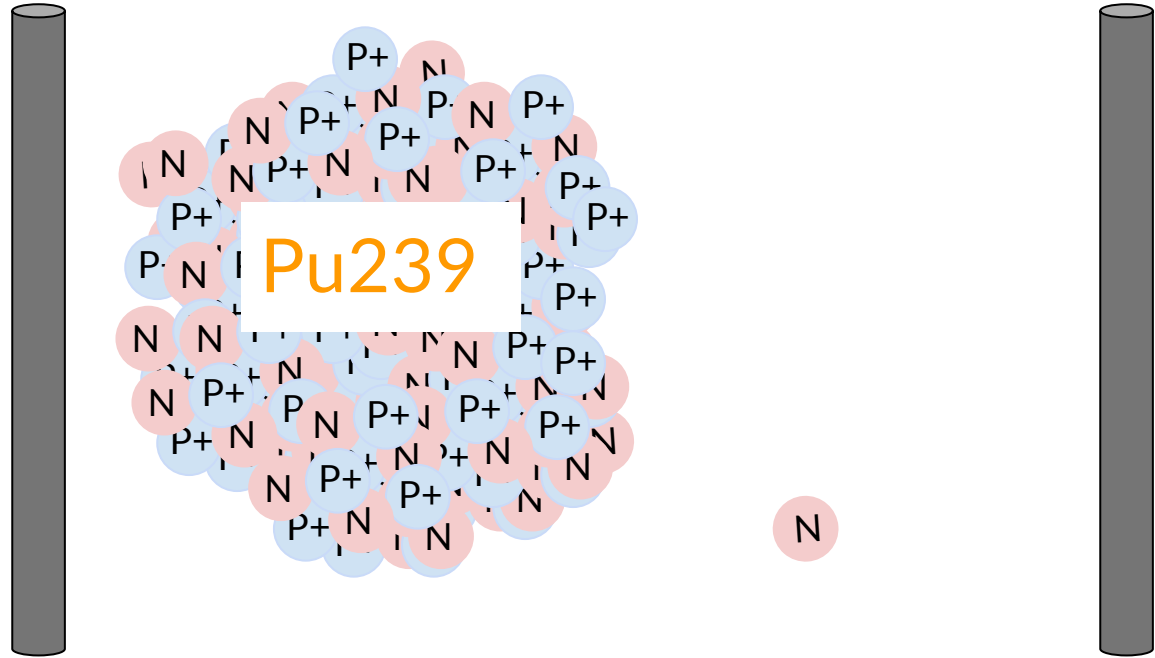
Plutonium-239



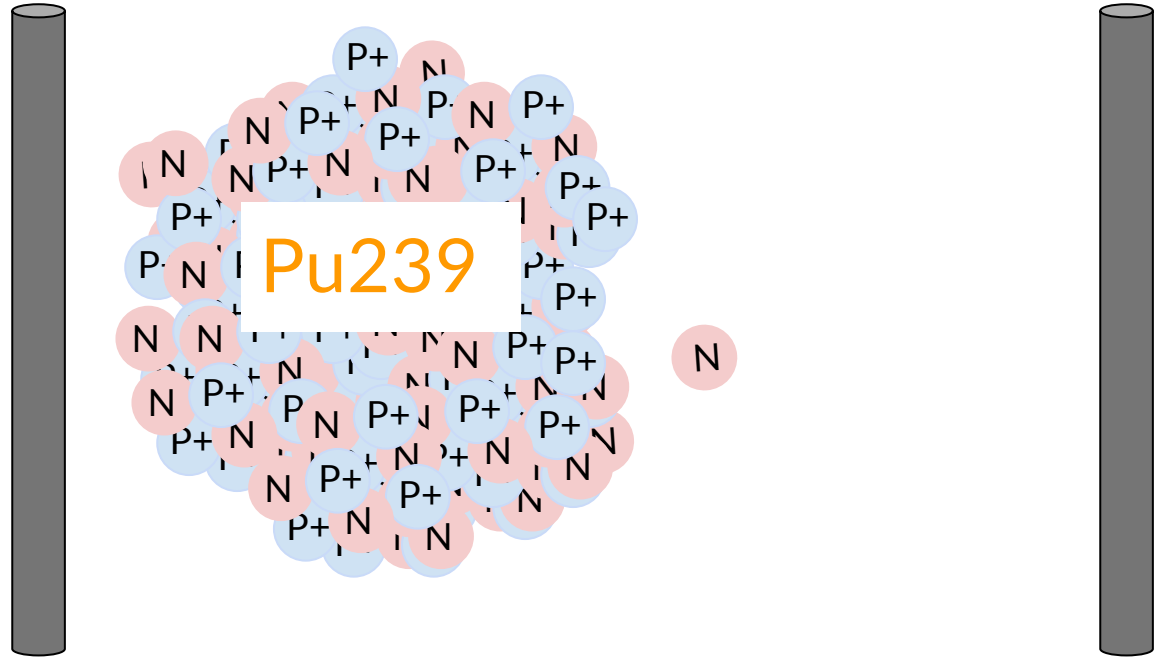
Pu-239



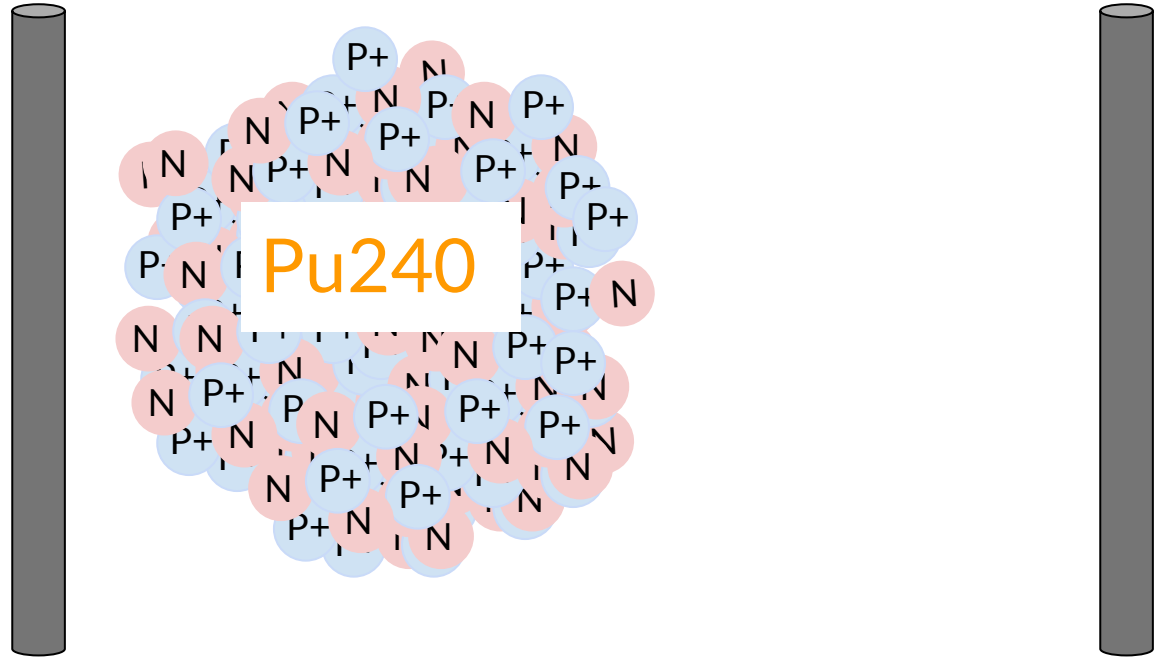
Pu-239



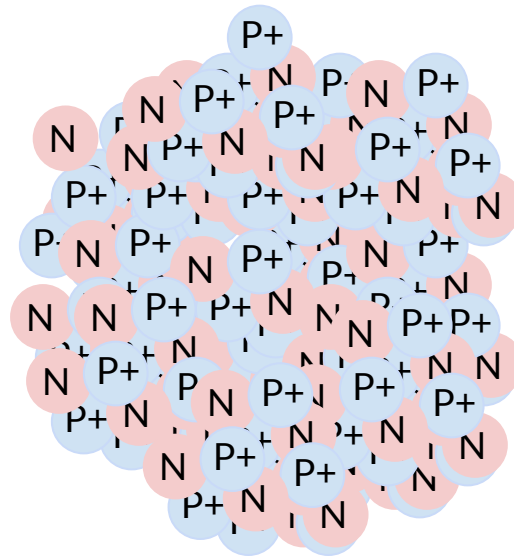
Pu-239



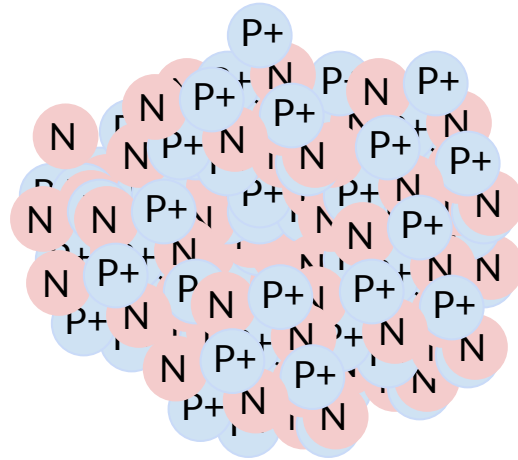
Pu-240

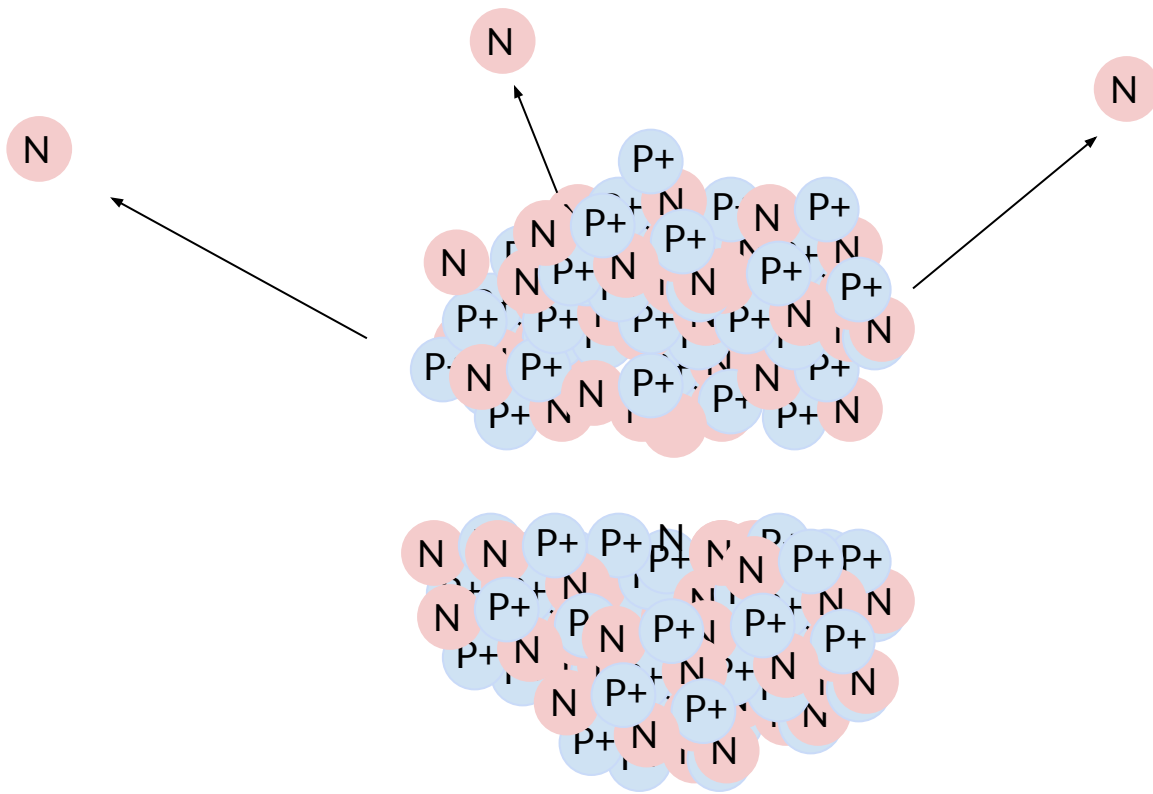


Plutonium-240

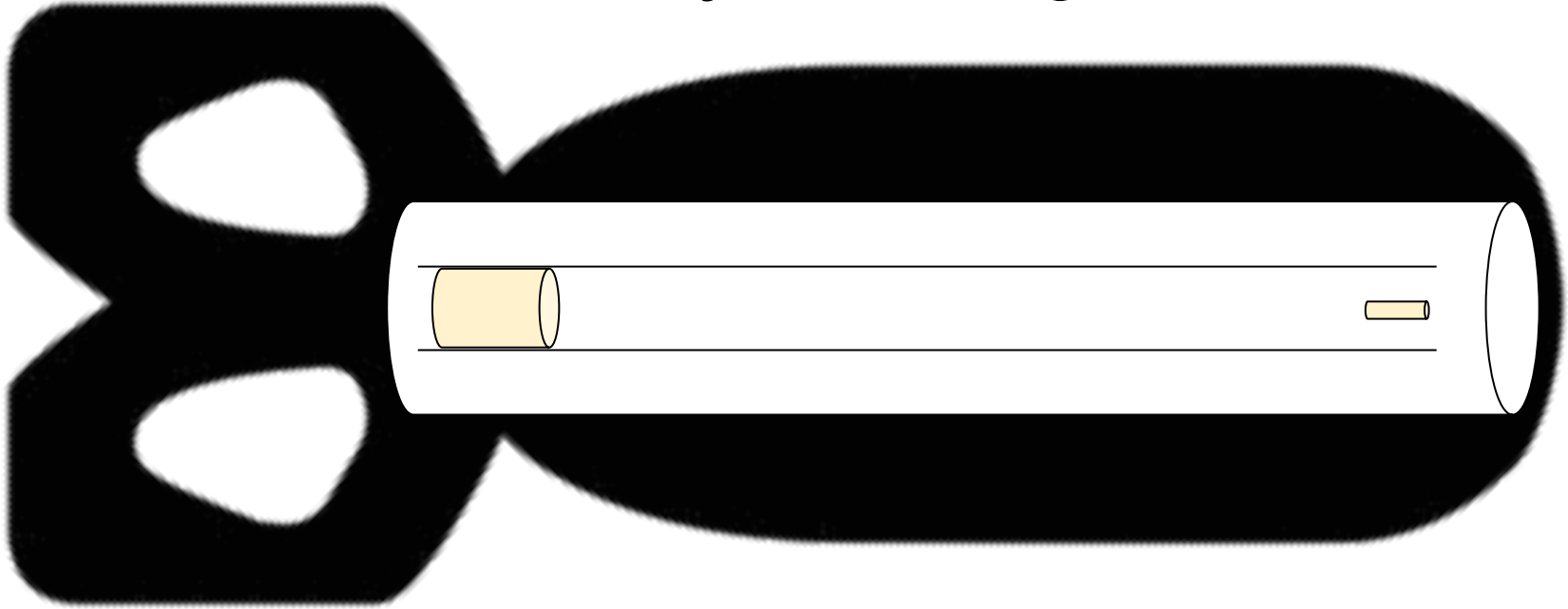


Plutonium-240

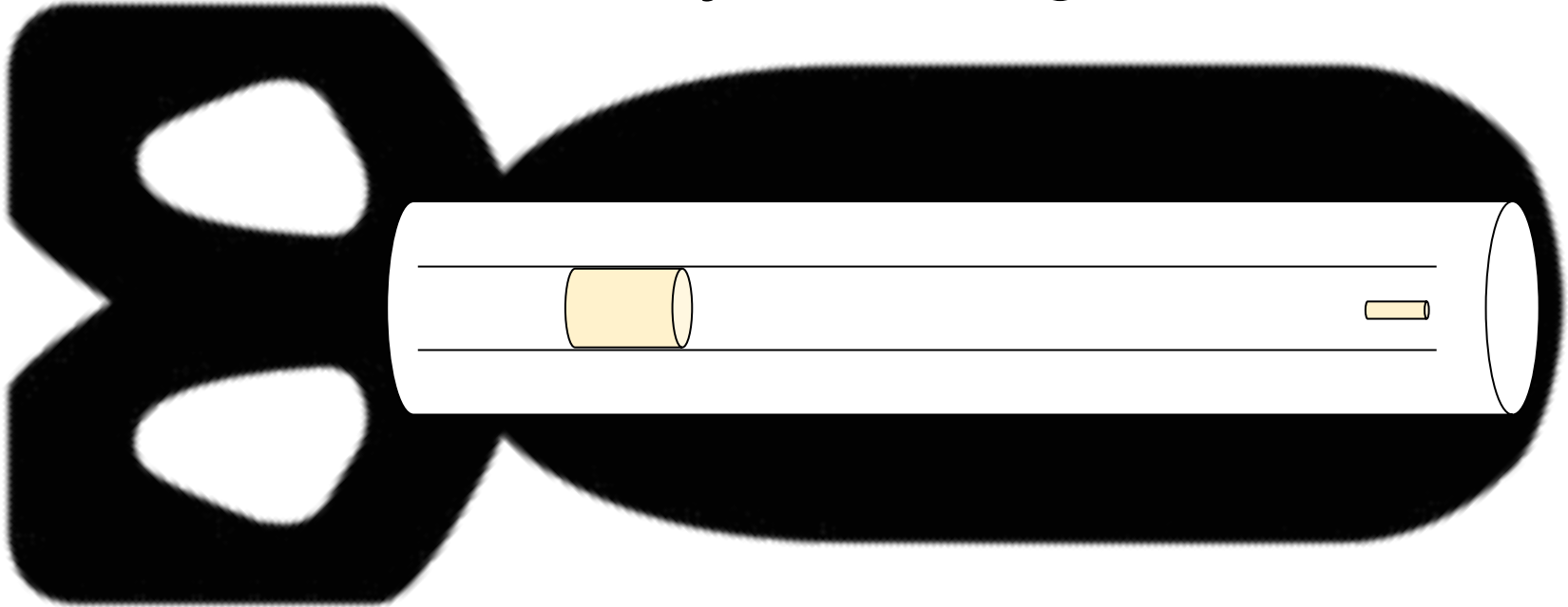




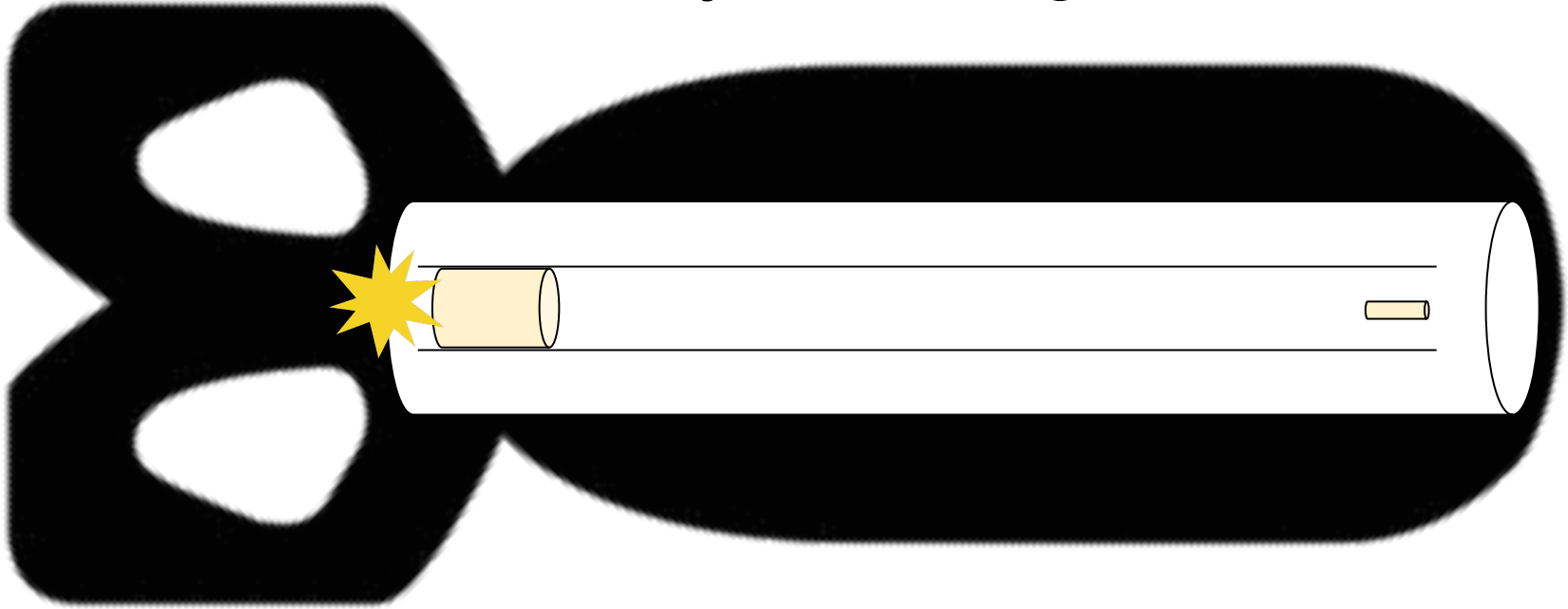
Little Boy Gun Design



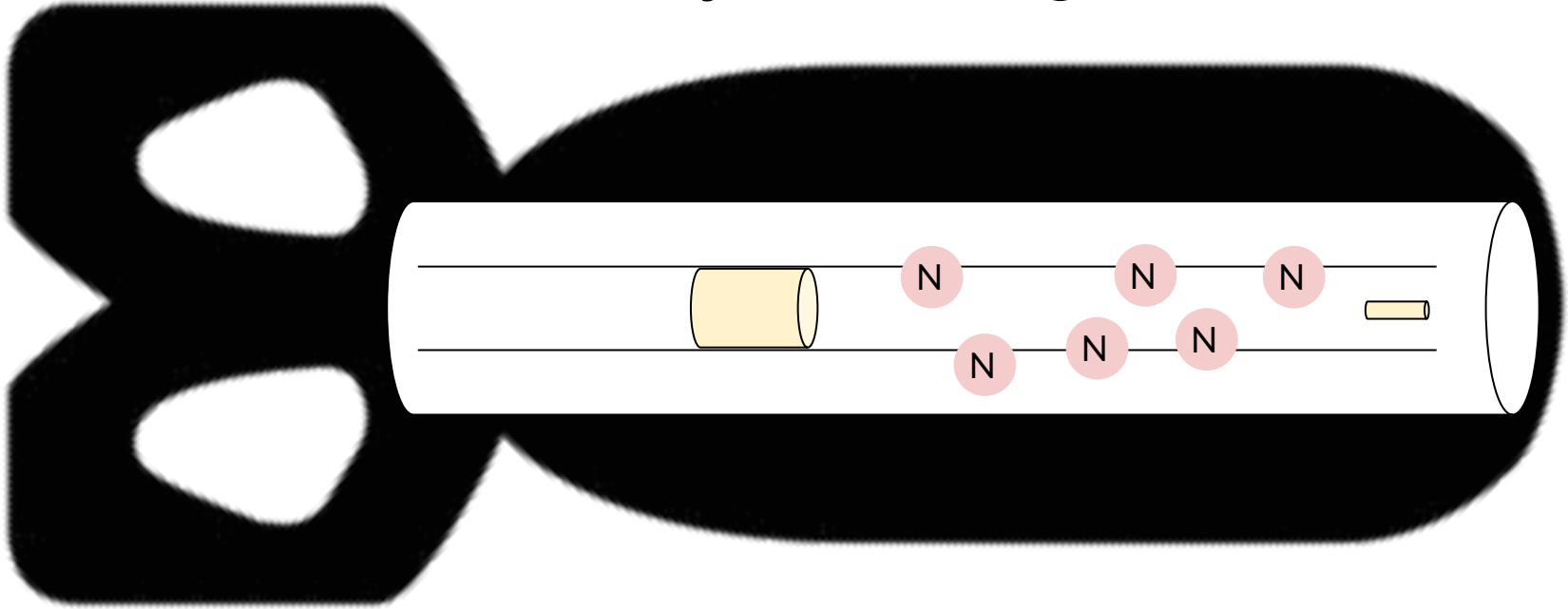
Little Boy Gun Design



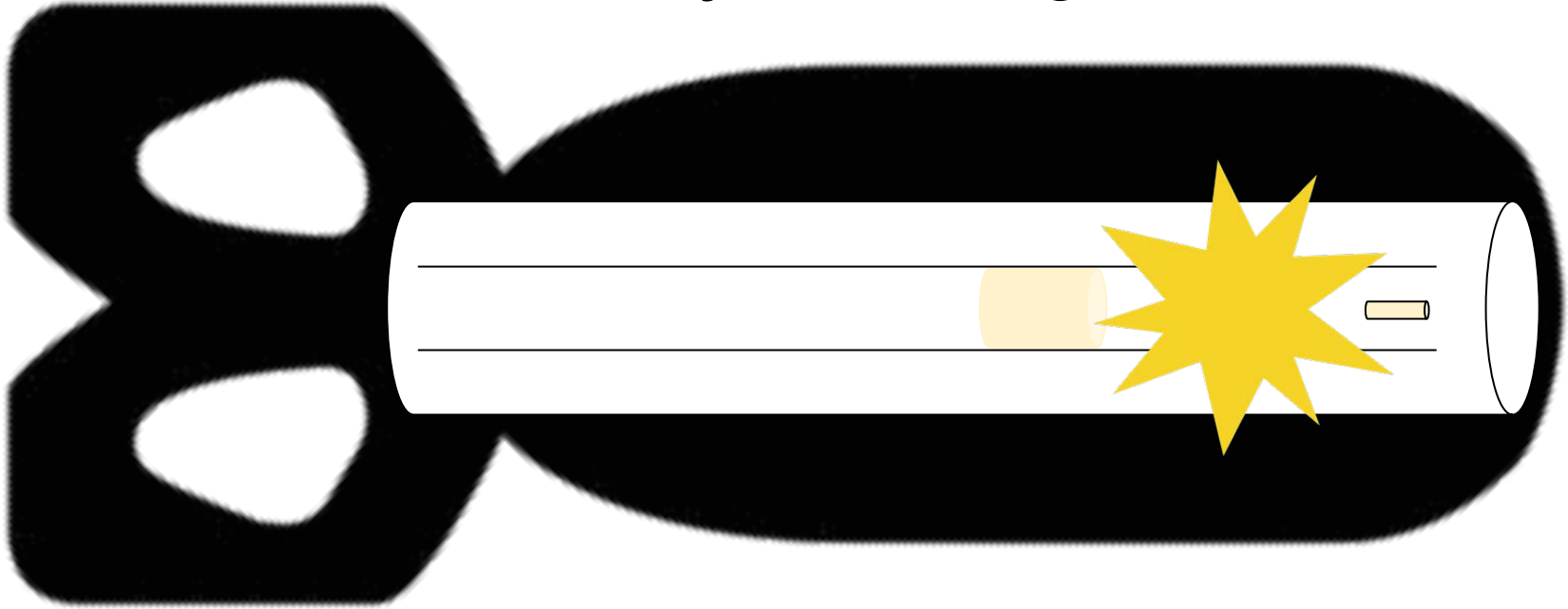
Little Boy Gun Design



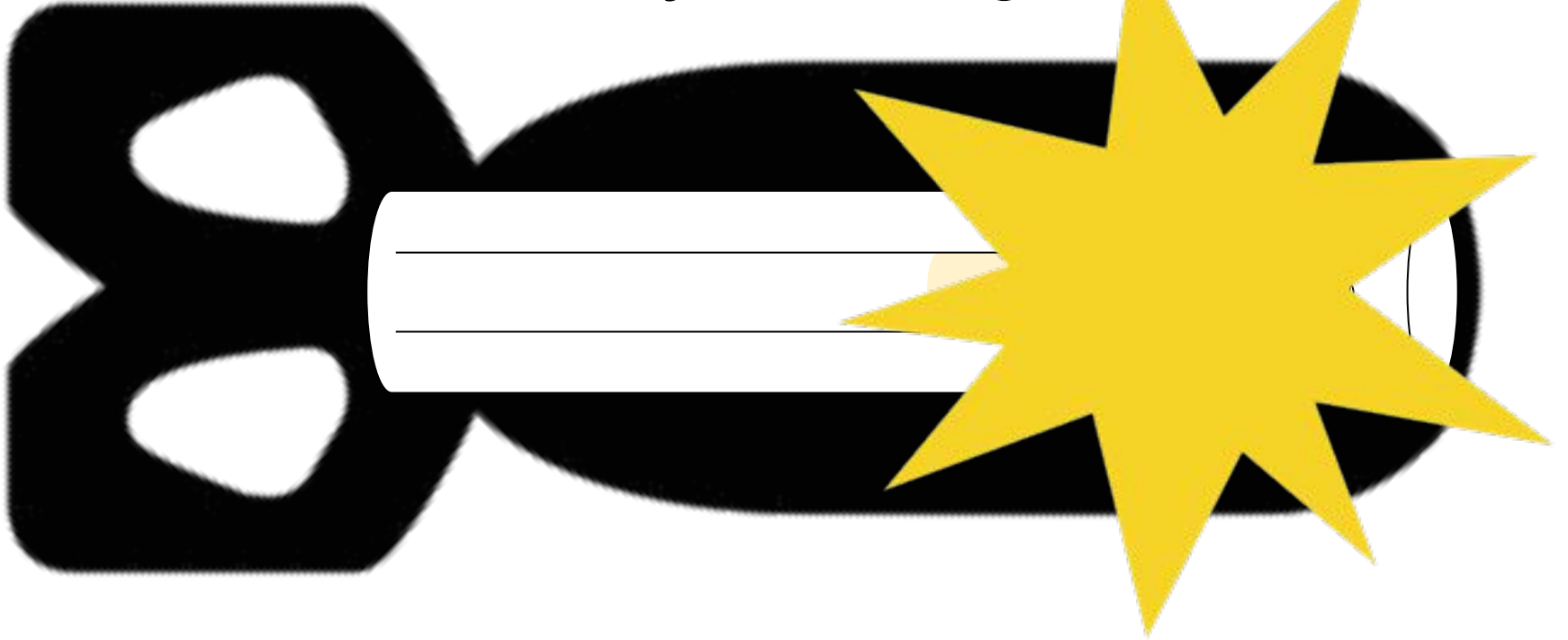
Little Boy Gun Design



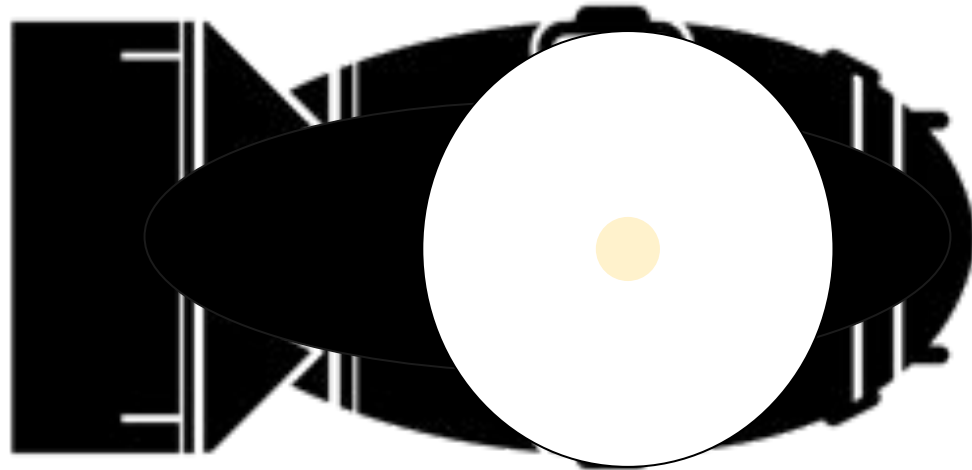
Little Boy Gun Design



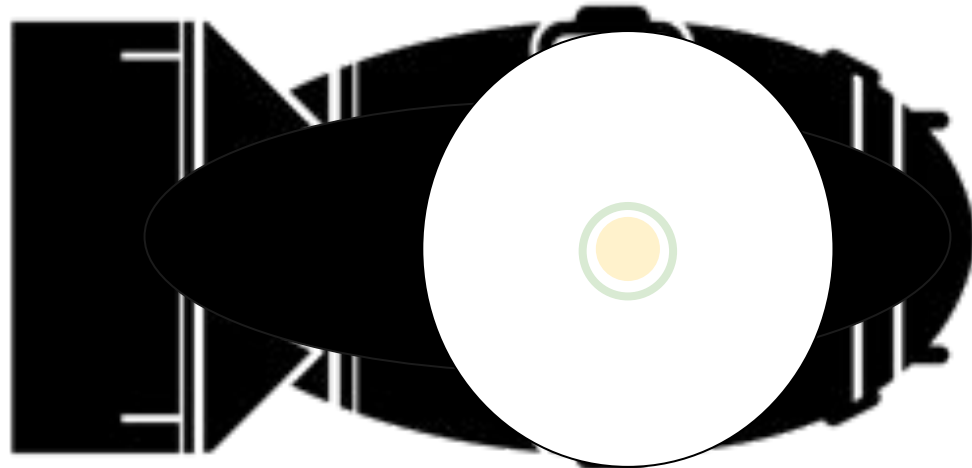
Little Boy Gun Design



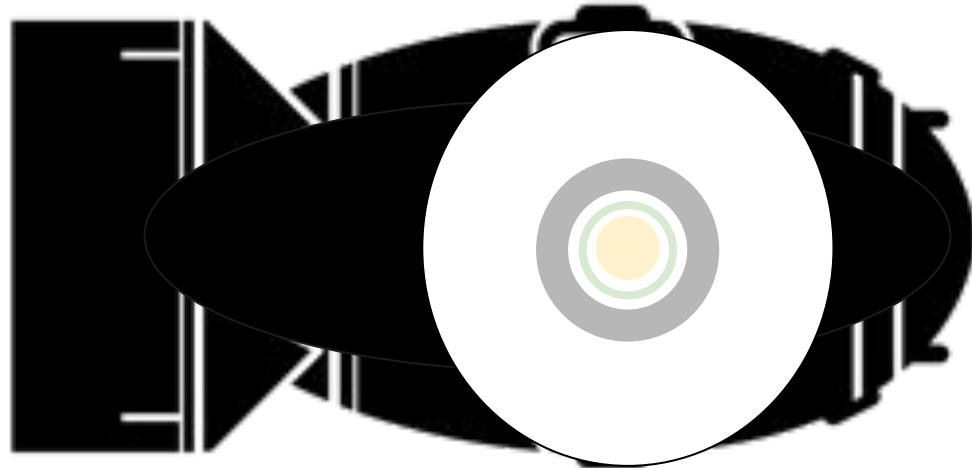
Fat Man



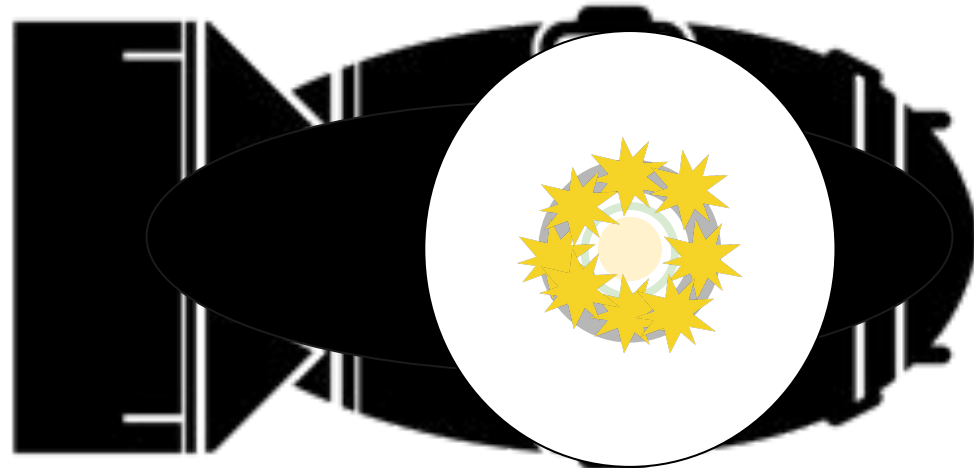
Fat Man



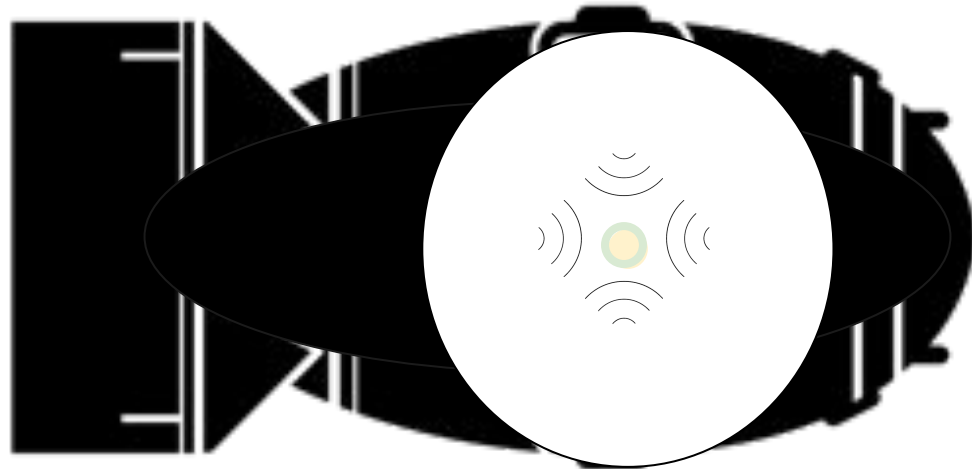
Fat Man



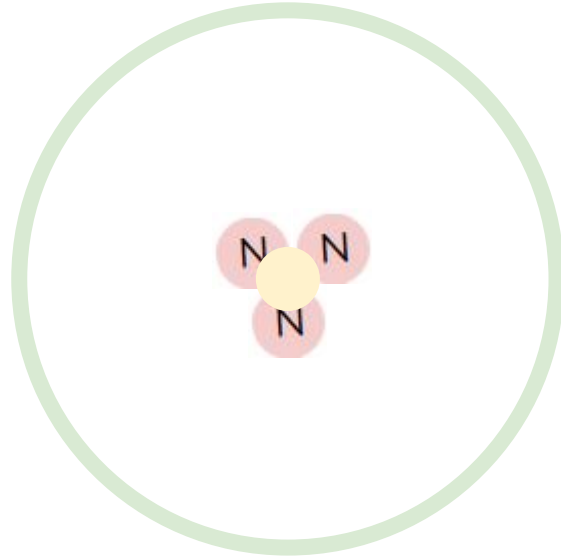
Fat Man



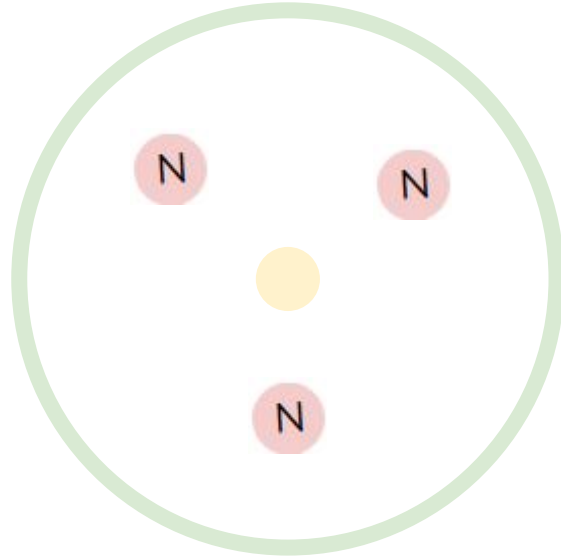
Fat Man



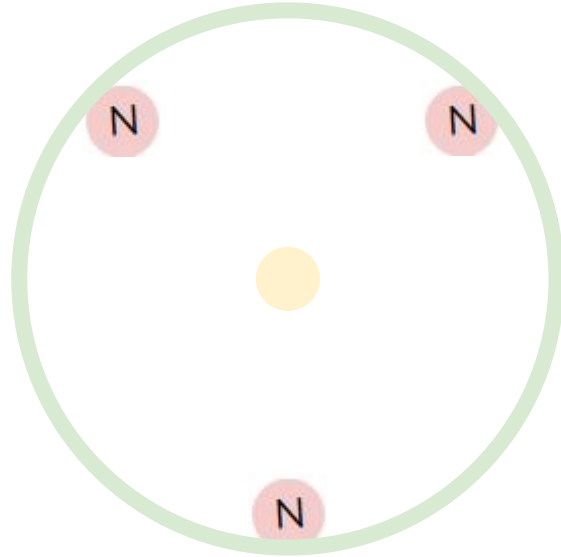
Neutron reflector



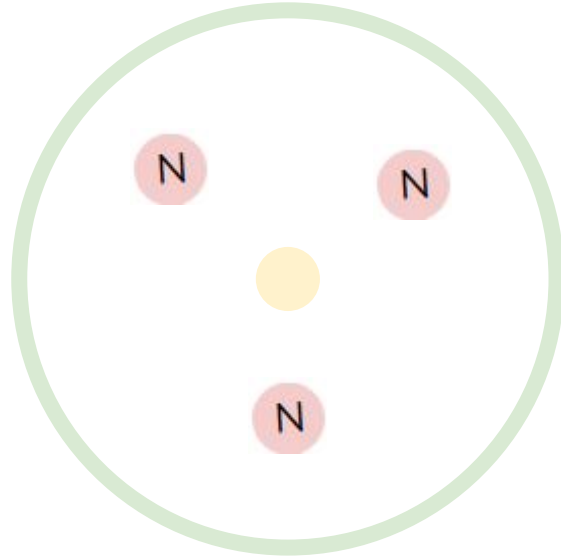
Neutron reflector



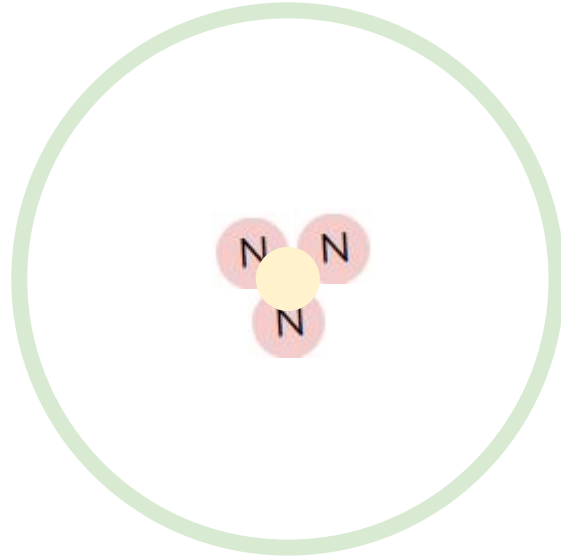
Neutron reflector



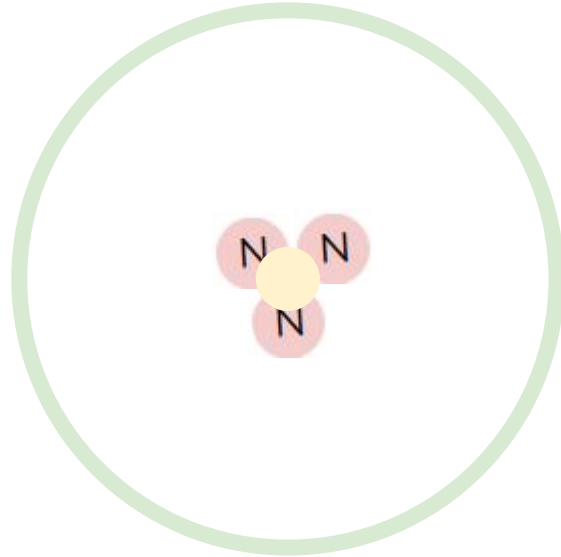
Neutron reflector



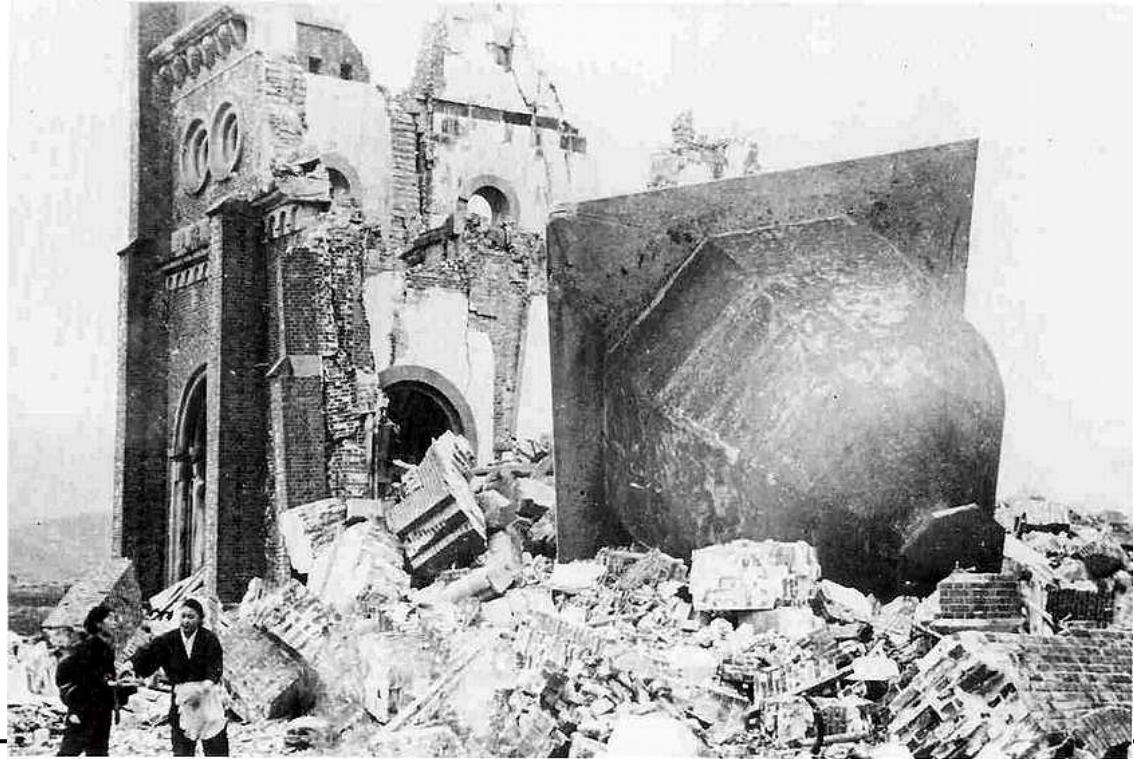
Neutron reflector



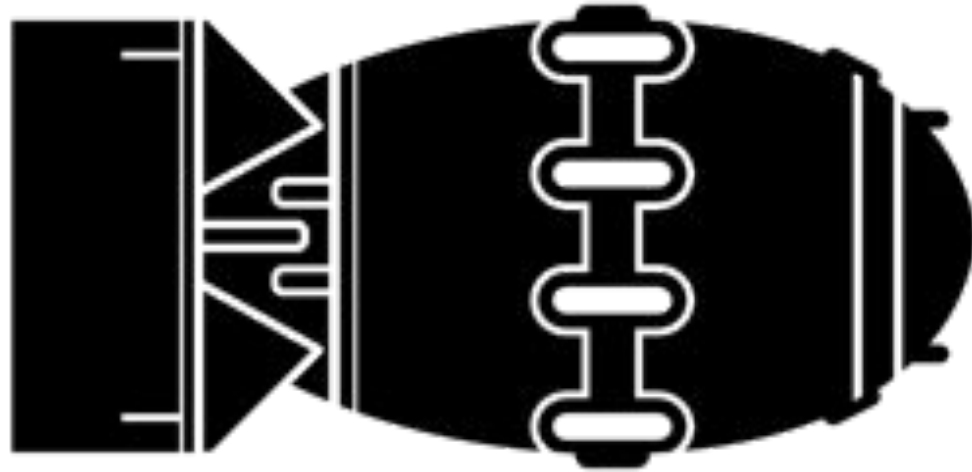
Neutron reflector



Nagasaki, Japan

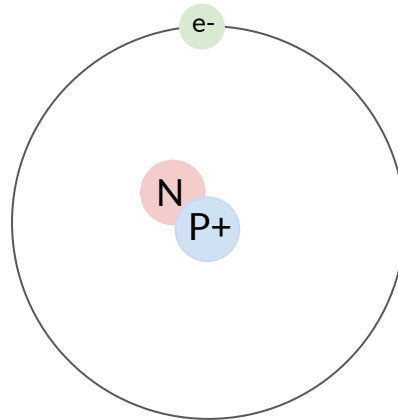


Fat Man

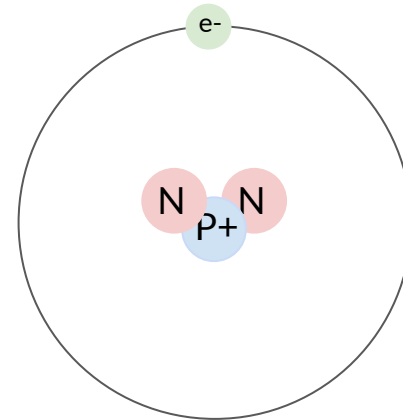


Boosted Fission Weapons

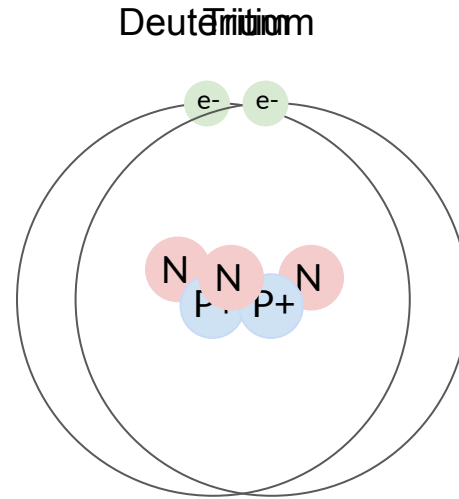
Deuterium



Tritium



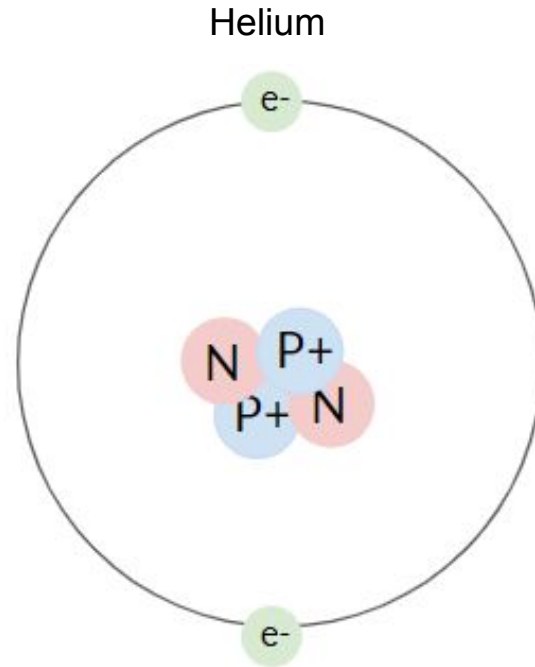
Boosted Fission Weapons



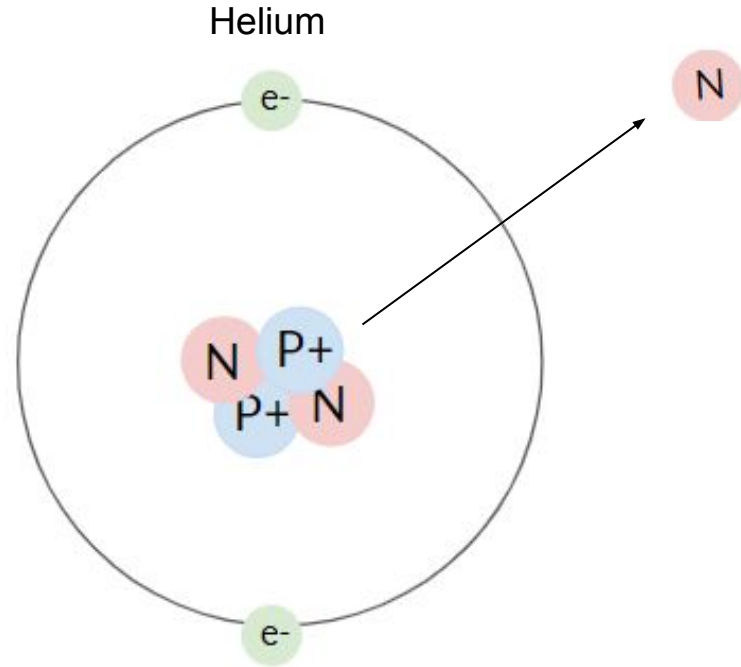
Boosted Fission Weapons



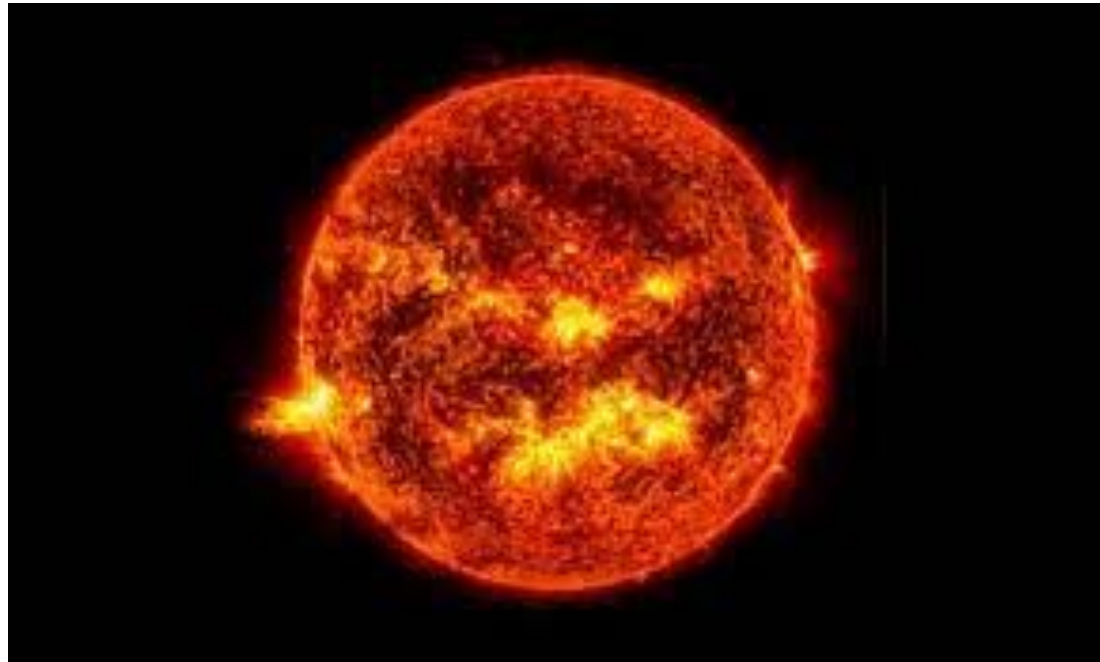
Fusion



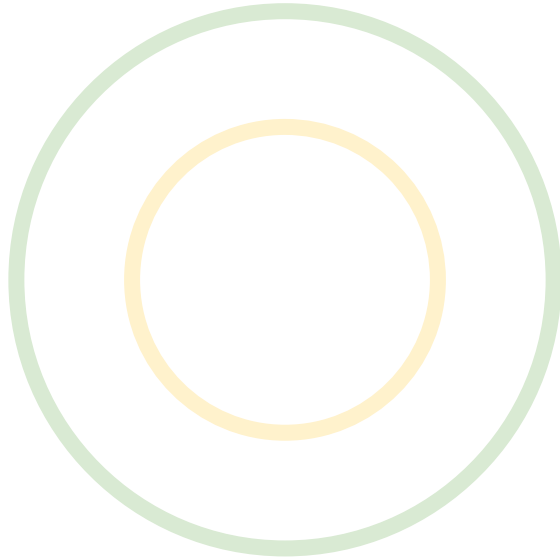
Fusion



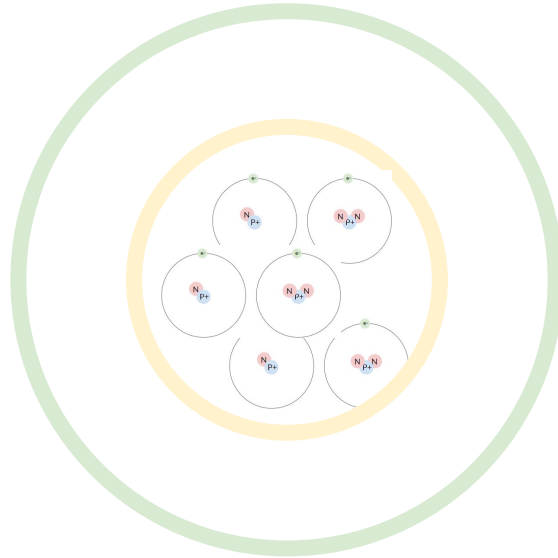
Fusion powers the sun



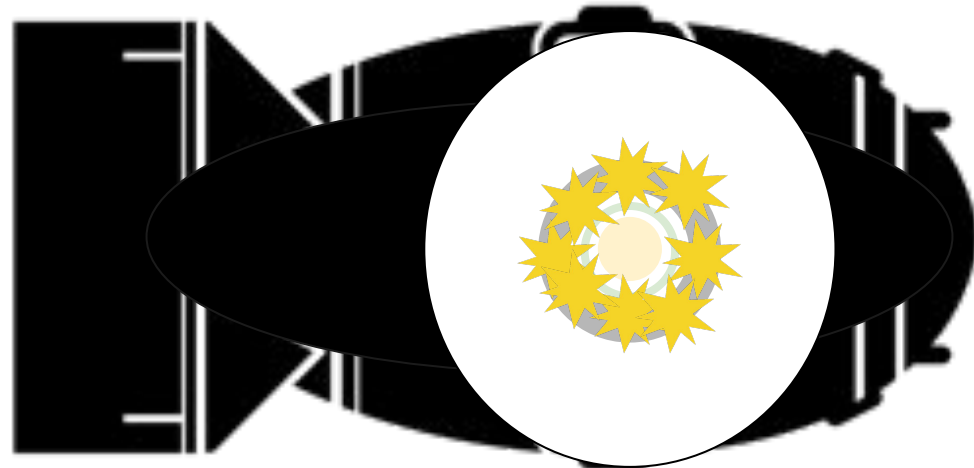
Boosted Fusion



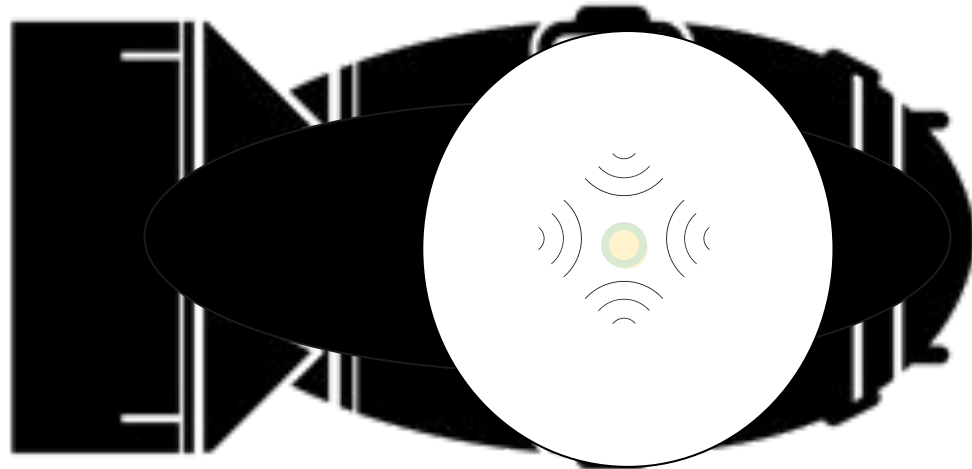
Boosted Fusion



Fat Man

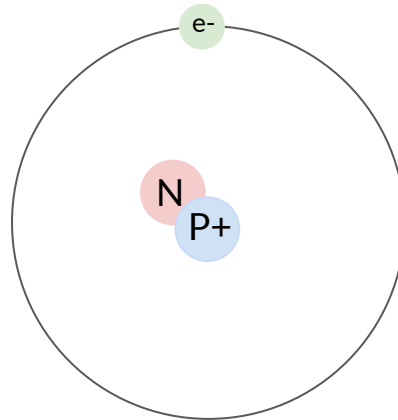


Fat Man

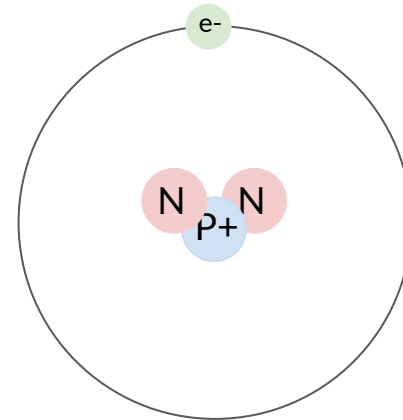


Boosted Fission Weapons

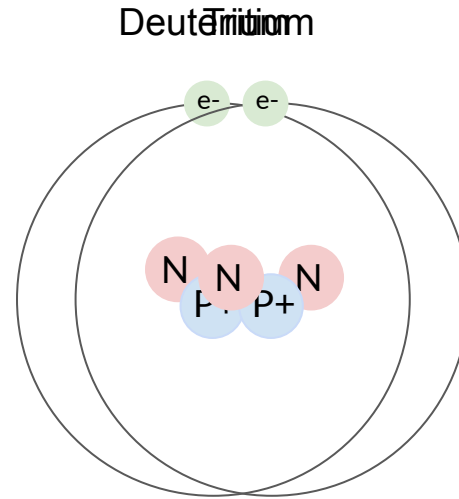
Deuterium



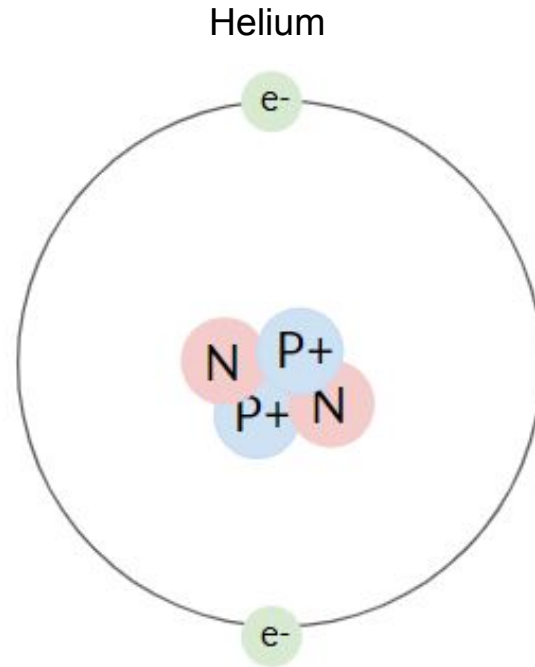
Tritium



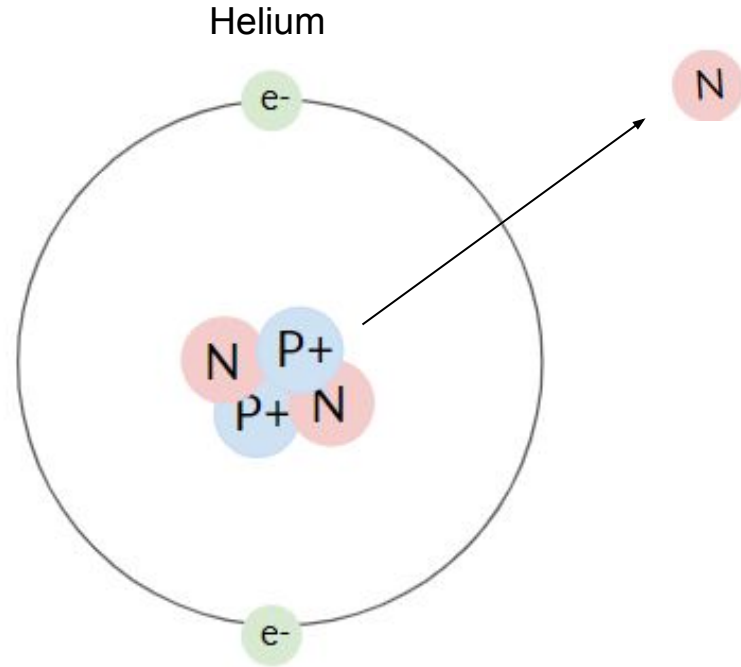
Boosted Fission Weapons



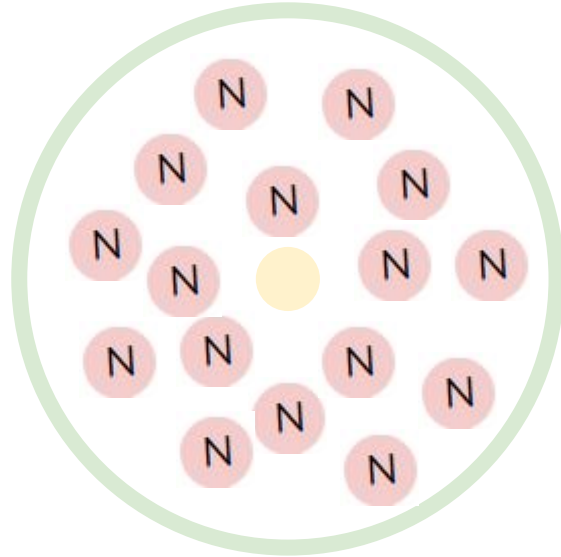
Fusion



Fusion



Neutron reflector



Modern Weapons



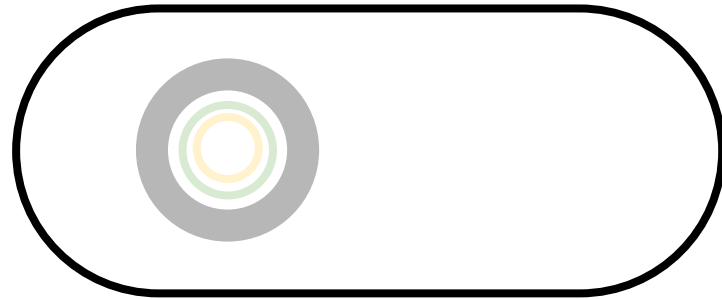
Modern Weapons



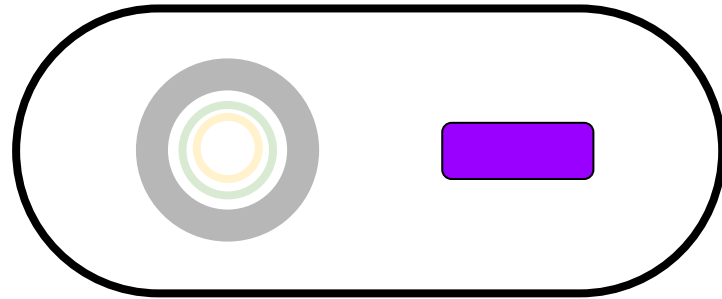
Modern Weapons



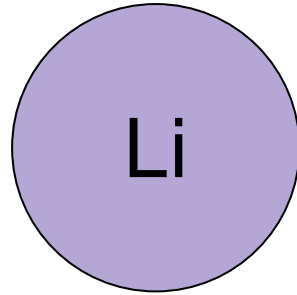
Modern Weapons



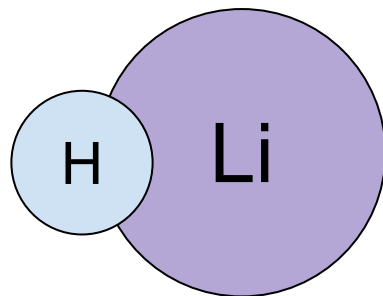
Modern Weapons



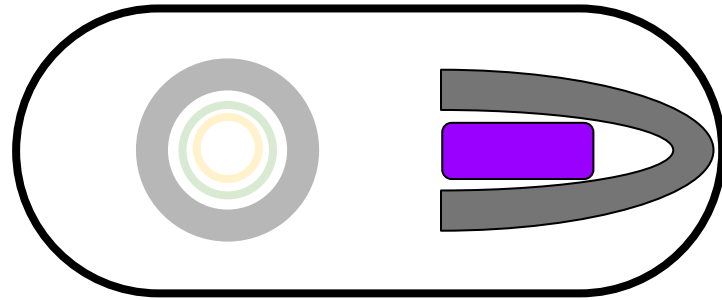
Lithium-6-deuteride



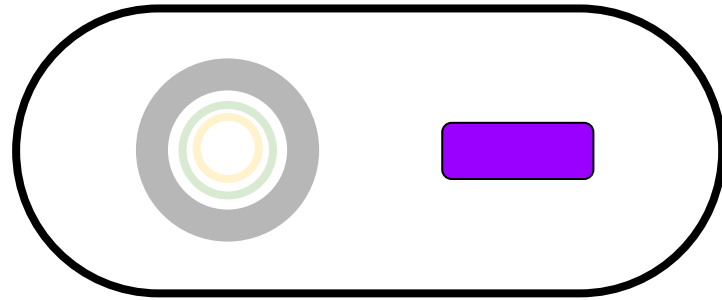
Lithium-6-deuteride



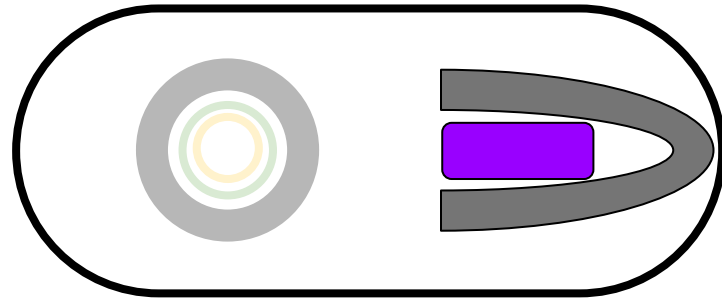
Modern Weapons



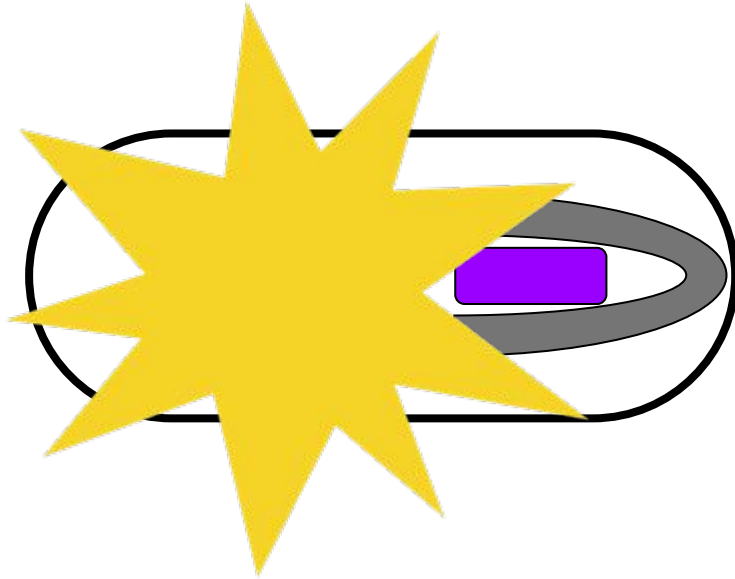
How a modern bomb works



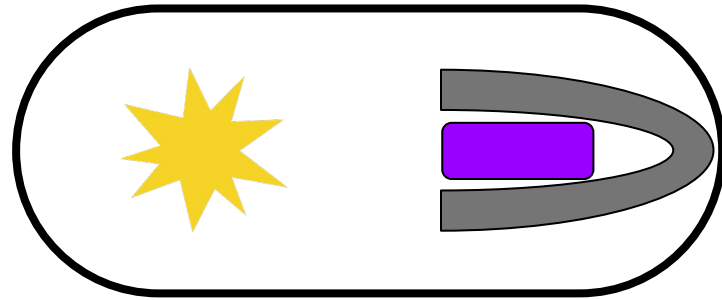
How a modern bomb works



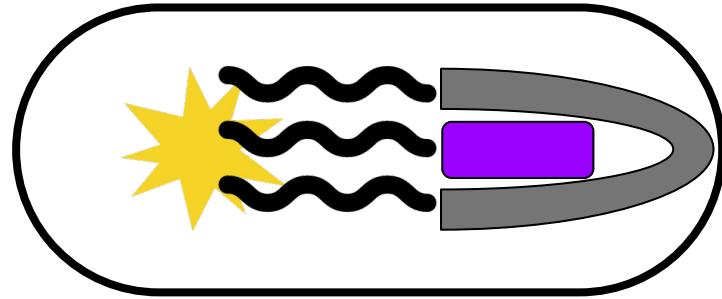
How a modern bomb works



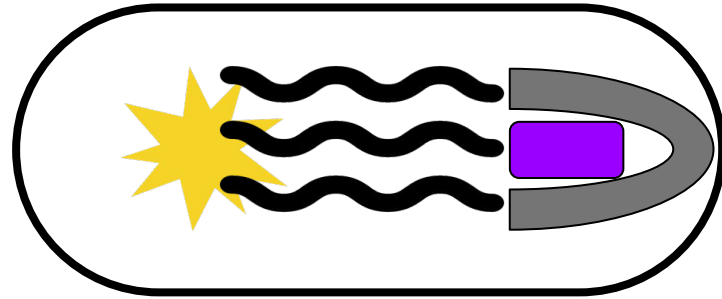
How a modern bomb works



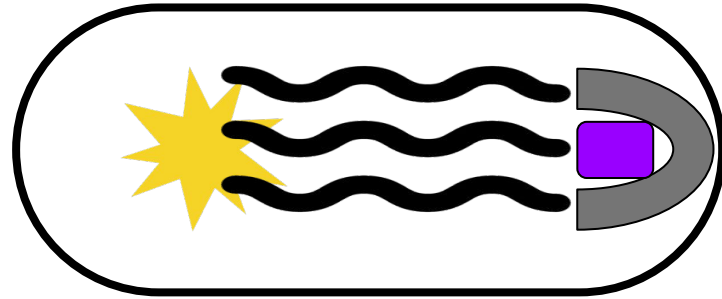
How a modern bomb works



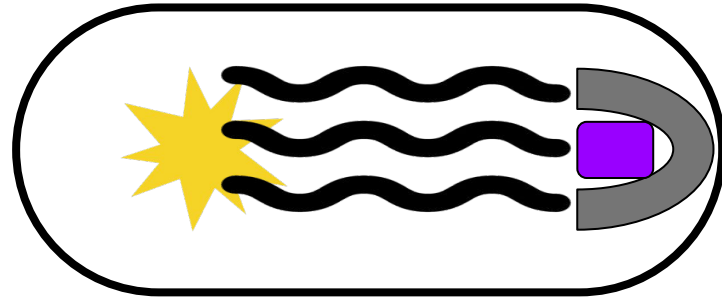
How a modern bomb works



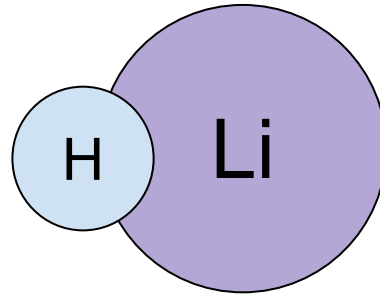
How a modern bomb works



How a modern bomb works

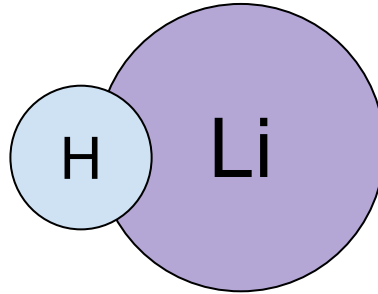


Lithium-6-Deuteride absorbs neutrons



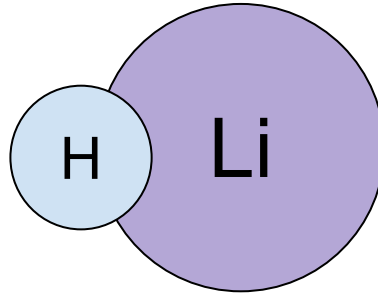
Lithium-6-Deuteride absorbs neutrons

N

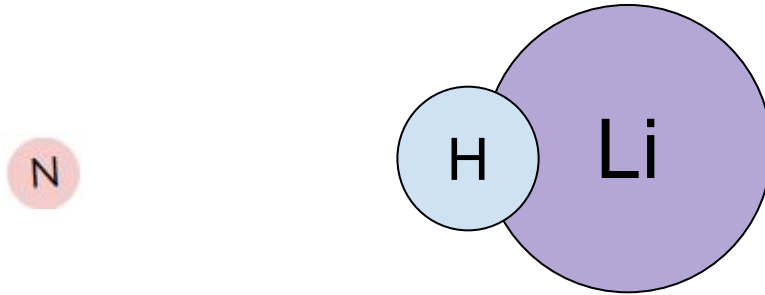


Lithium-6-Deuteride absorbs neutrons

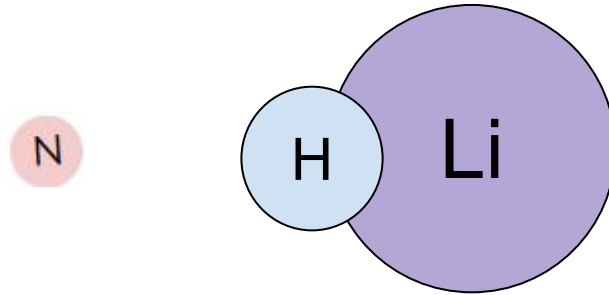
N



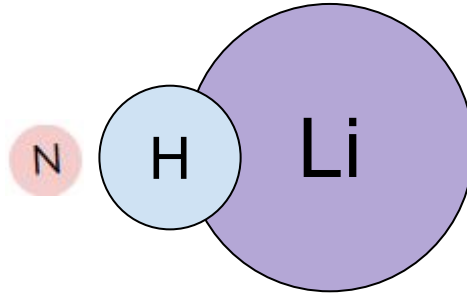
Lithium-6-Deuteride absorbs neutrons



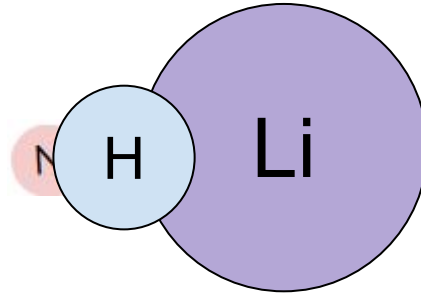
Lithium-6-Deuteride absorbs neutrons



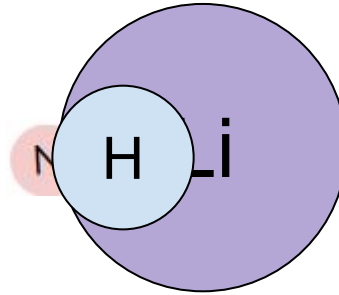
Lithium-6-Deuteride absorbs neutrons



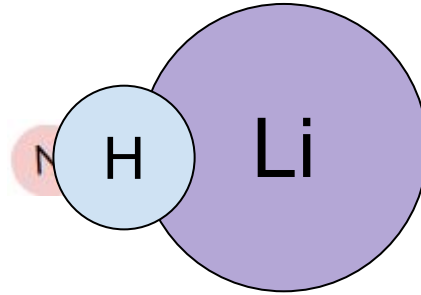
Lithium-6-Deuteride absorbs neutrons



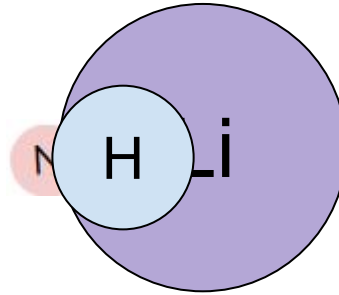
Lithium-6-Deuteride absorbs neutrons



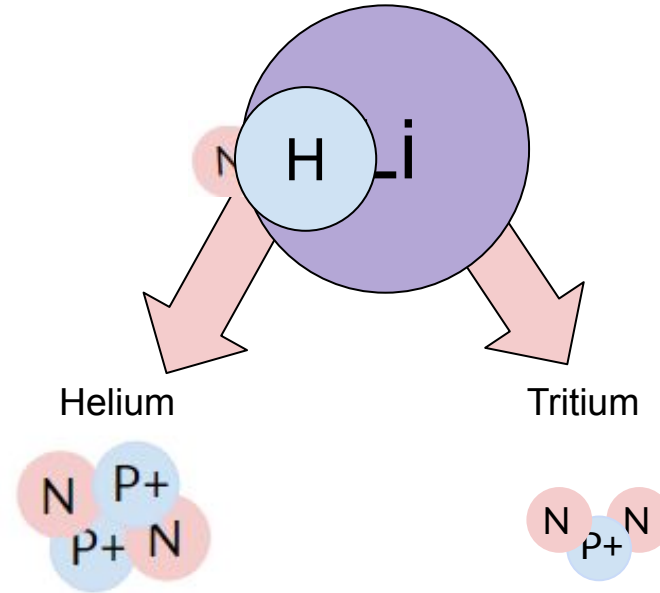
Lithium-6-Deuteride absorbs neutrons



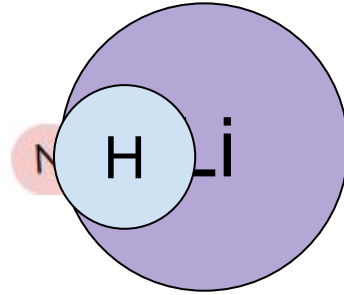
Lithium-6-Deuteride absorbs neutrons



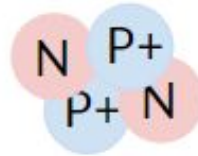
Splitting into Tritium and helium



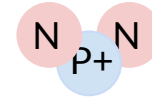
Splitting into Tritium and helium



Helium

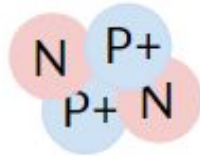


Tritium

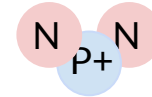


Splitting into Tritium and helium

Helium

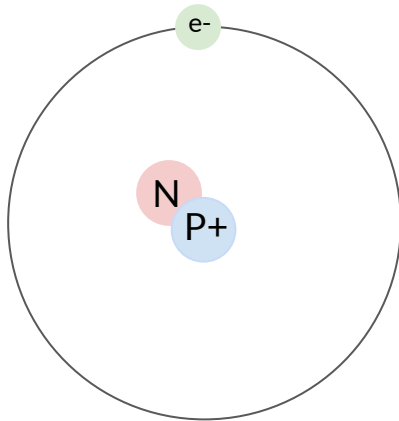


Tritium

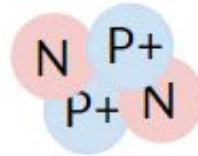


Splitting into Tritium and helium

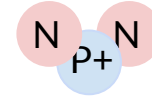
Deuterium



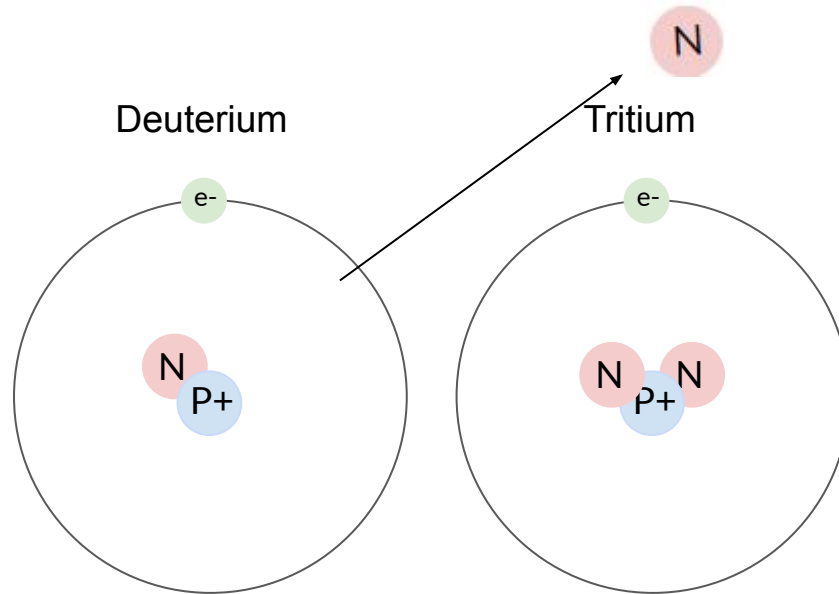
Helium



Tritium

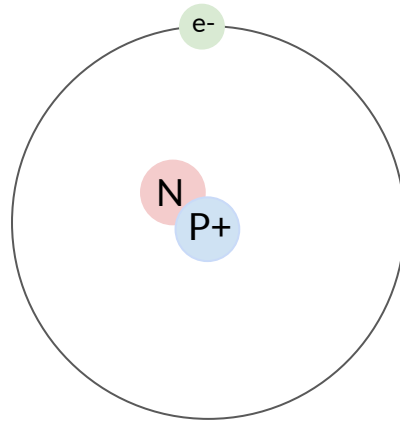


And releasing a Neutron

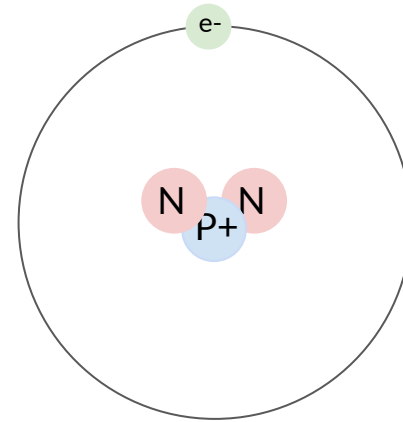


Fusion happens again

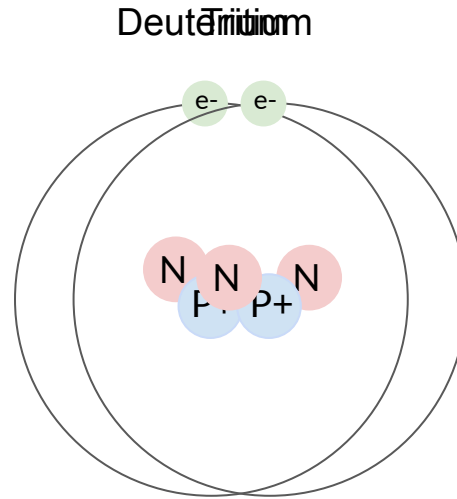
Deuterium



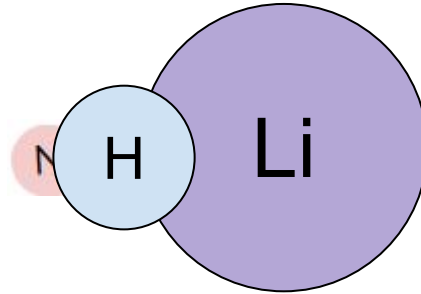
Tritium



Fusion happens again

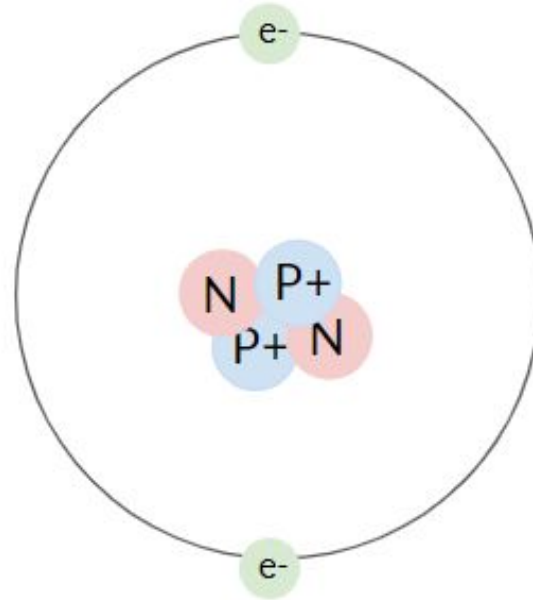


Lithium-6-Deuteride absorbs neutrons



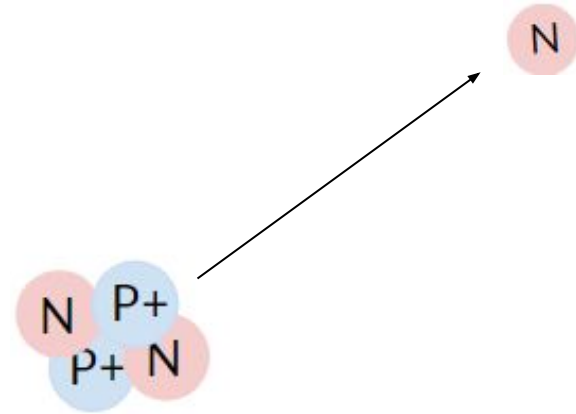
Fusion happens again

Helium

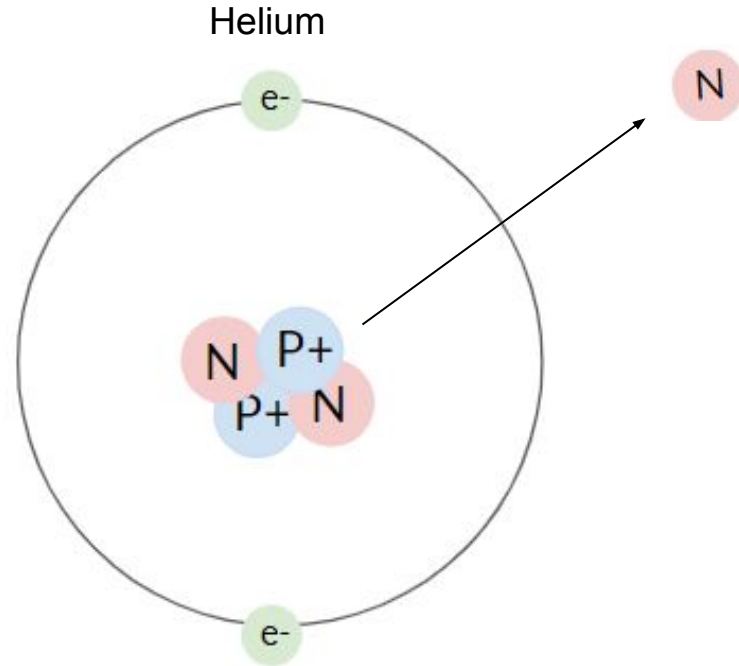


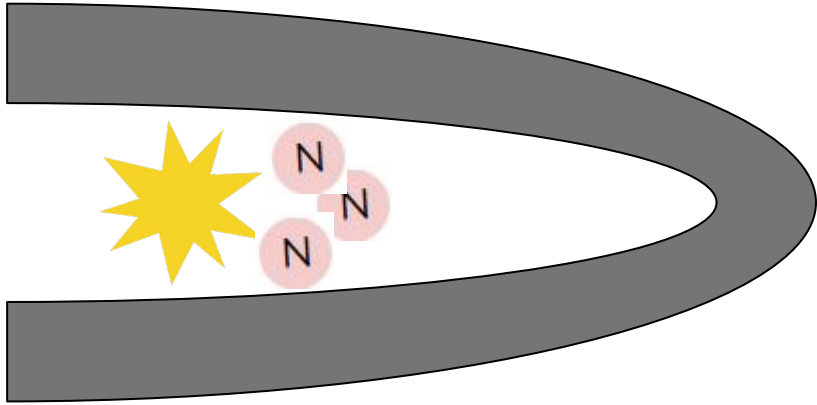
Fusion happens again

Helium



Fusion happens again

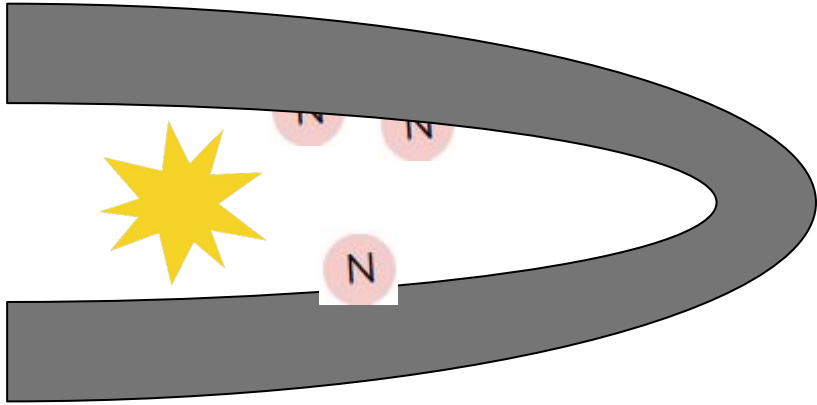


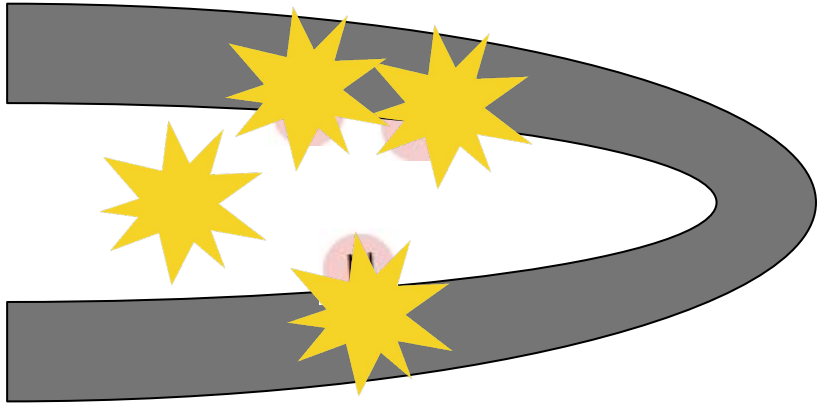


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Nuclear Weapon Effects

- Ionizing radiation 

Nuclear Weapon Effects

- Ionizing radiation 
- Thermal Effects 

Nuclear Weapon Effects

- Ionizing radiation 
- Thermal Effects 
- Blast 

Immediate Ionizing Radiation

- X-rays

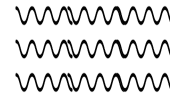


Immediate Ionizing Radiation

- X-rays



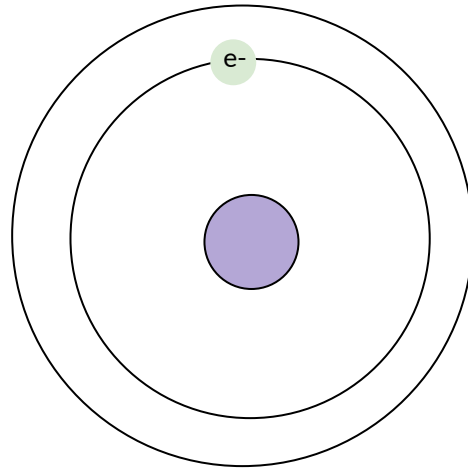
- Gamma rays



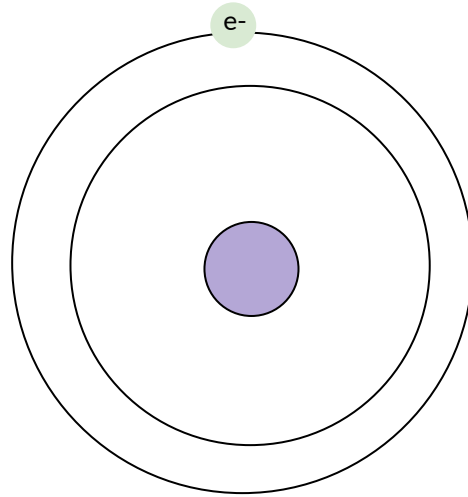
- Neutrons



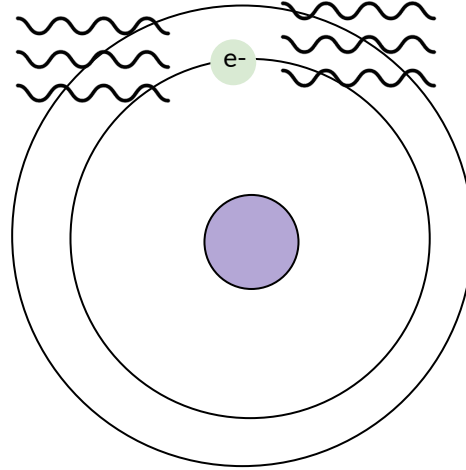
X-rays Produced from electrons



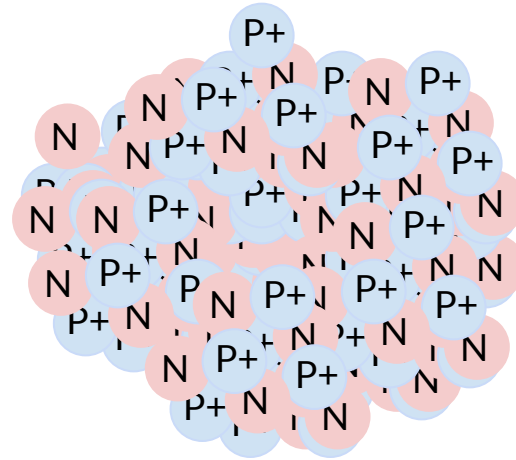
X-rays Produced from electrons



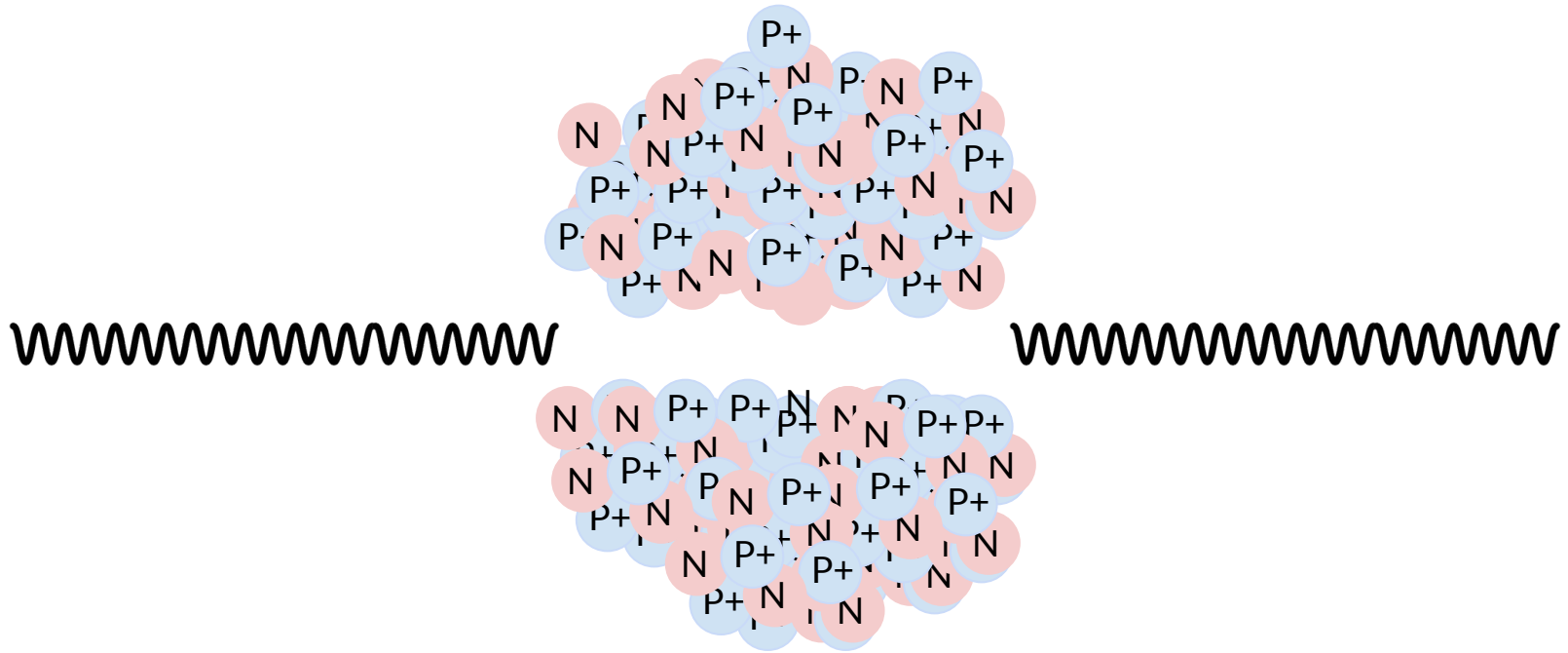
X-rays Produced from electrons



Gamma Rays



Gamma Rays

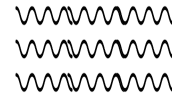


Immediate Ionizing Radiation

- X-rays



- Gamma rays



- Neutrons



X-Rays



X-Rays



What stops gamma rays?

- Water



What stops gamma rays?

- Water



- Concrete



What stops gamma rays?

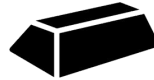
- Water



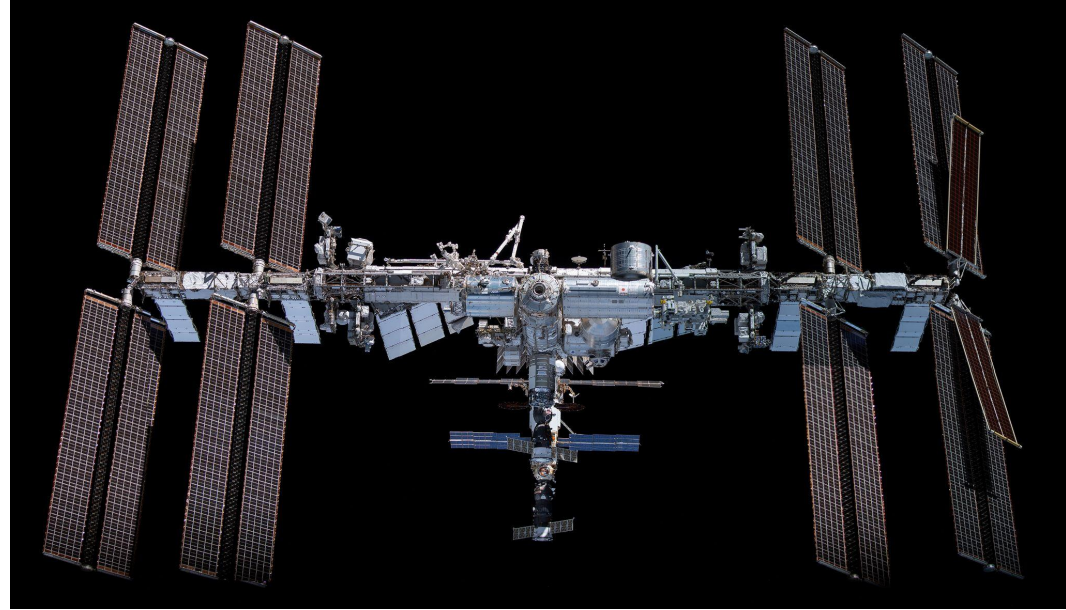
- Concrete



- Lead



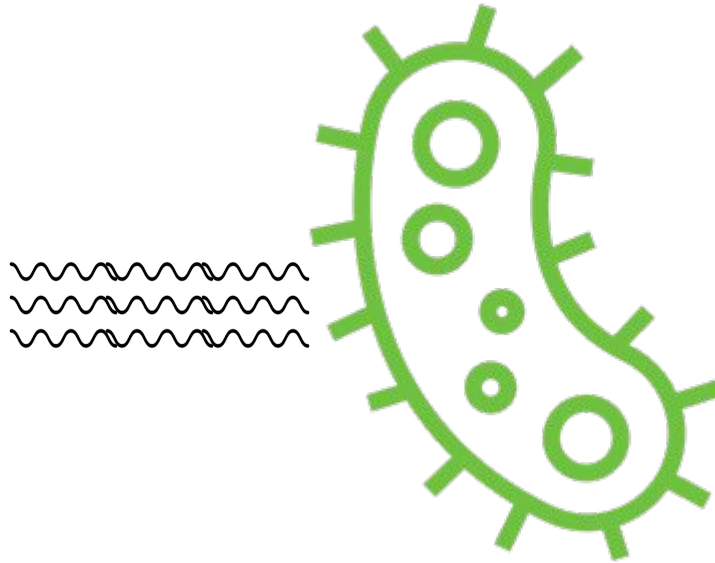
Irradiated food is safe to fly on ISS



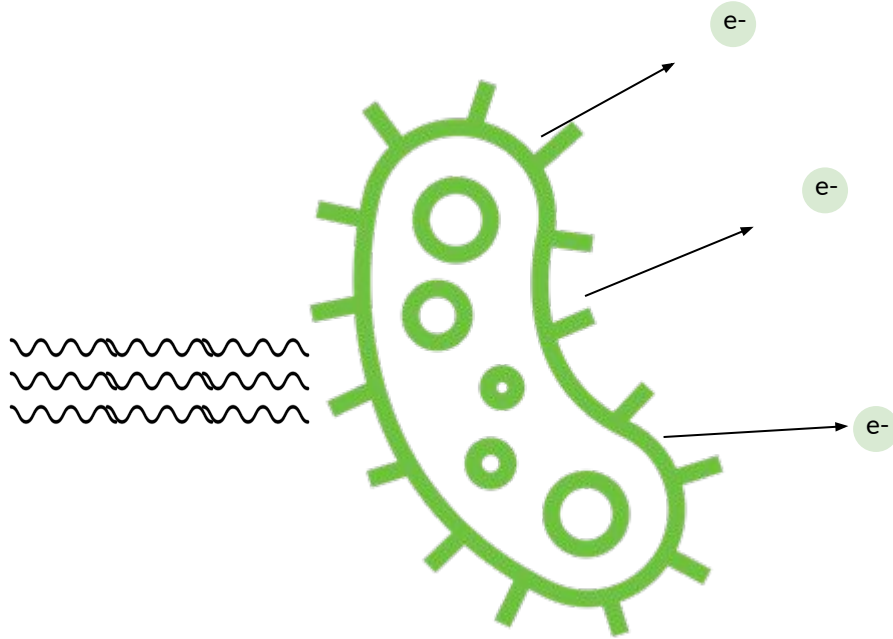
How Gamma Rays kill



How Gamma Rays kill



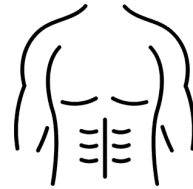
How Gamma Rays kill



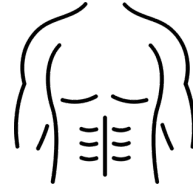
Radiation therapy



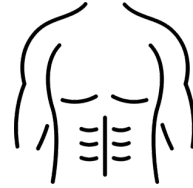
Neutrons



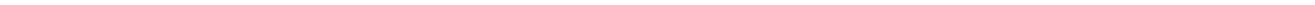
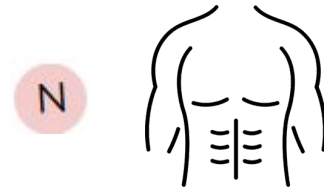
Neutrons



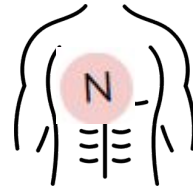
Neutrons



Neutrons



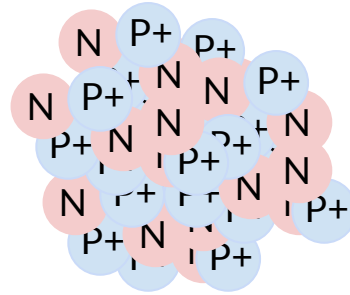
Neutrons



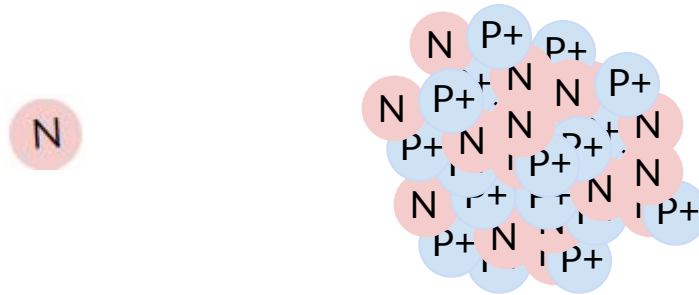
Radioactive Steel



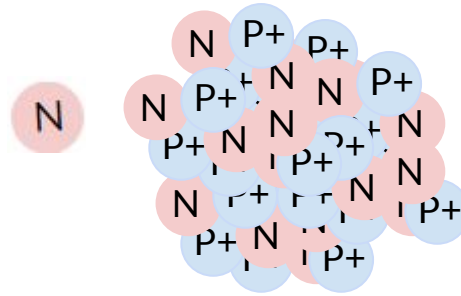
Cobalt-59 in the structural steel



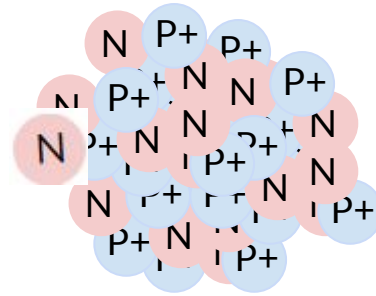
Cobalt-59 in the structural steel



Cobalt-59 in the structural steel



Became Cobalt-60



What stops neutrons?

- Water



- Concrete



Measuring Radiation

- Sievert



Measuring Radiation

- Sievert
- Gray



Measuring Radiation

- Sievert
 - Gray
 - REM
-

Measuring Radiation

- Sievert
 - Gray
 - REM
 - RAD
-

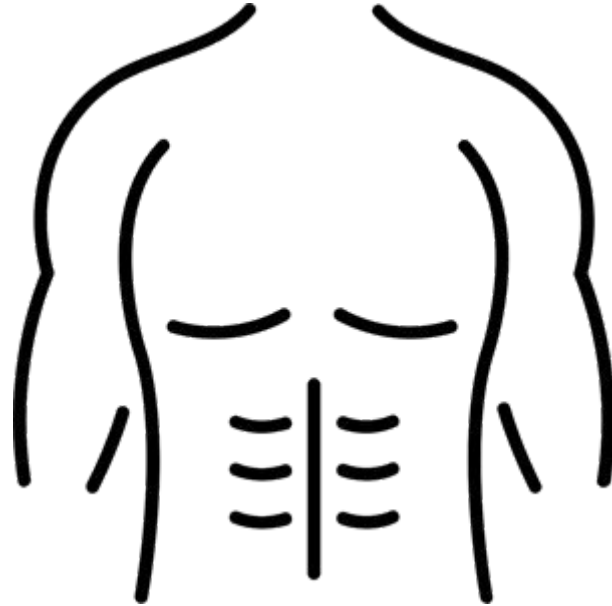
Fukushima made things confusing



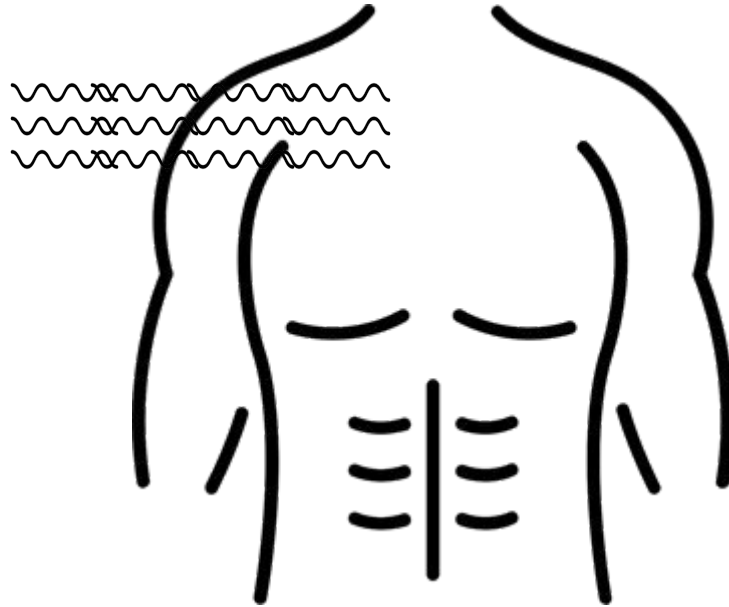
REM - Roentgen Equivalent Man



RAD - Radiation Absorbed Dose



RAD - Radiation Absorbed Dose



Radiation dislodges electrons



Radiation dislodges electrons



Radiation dislodges electrons

e-



Radiation dislodges electrons

e-



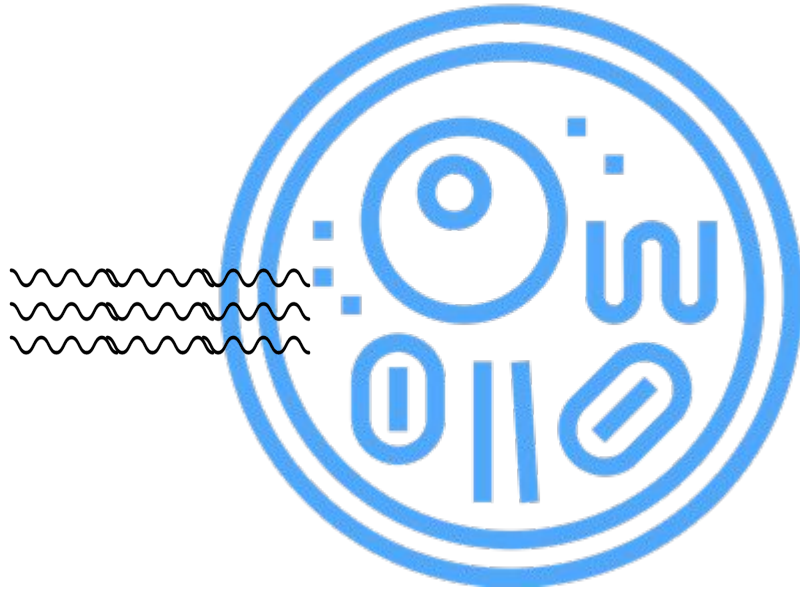
Radiation dislodges electrons



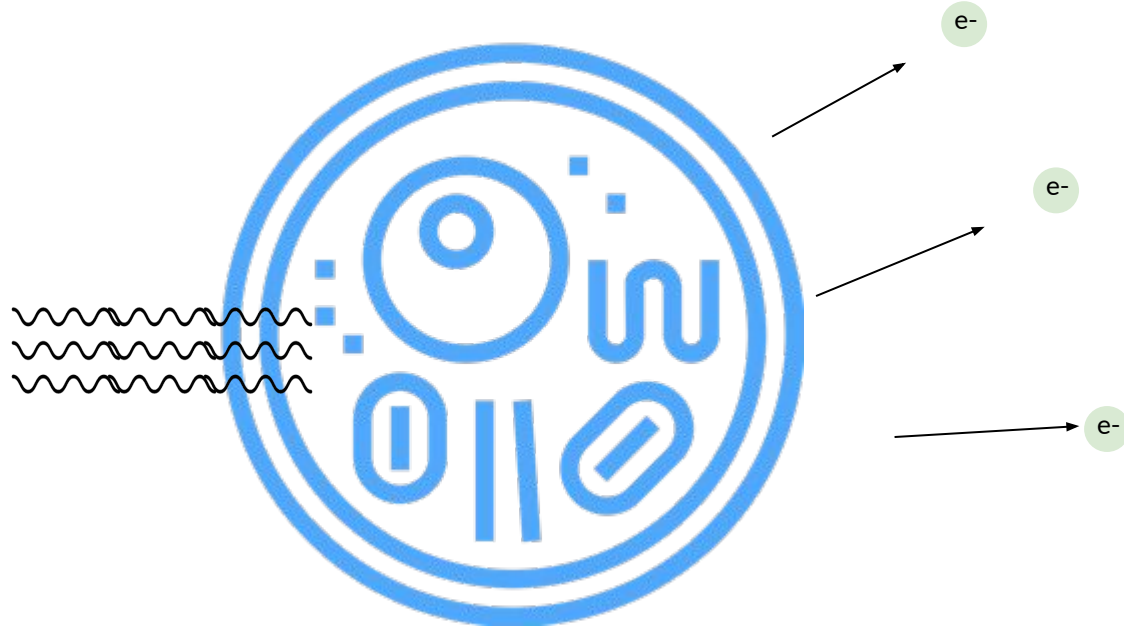
How Radiation Kills



How Radiation Kills



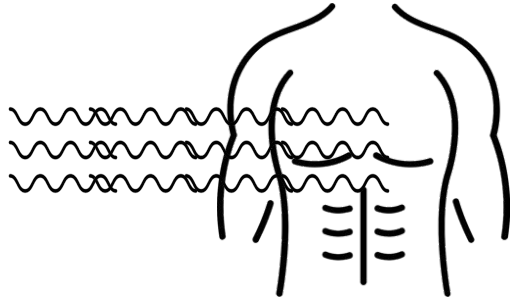
How Radiation Kills



Absorbed, Equivalent and Effective

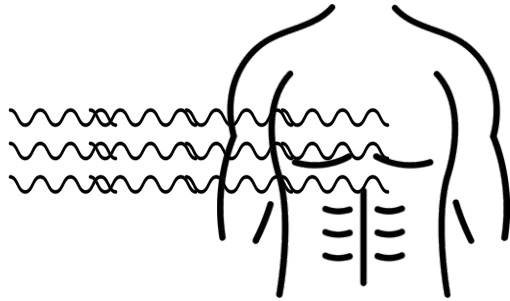
Absorbed, Equivalent and Effective

Absorbed

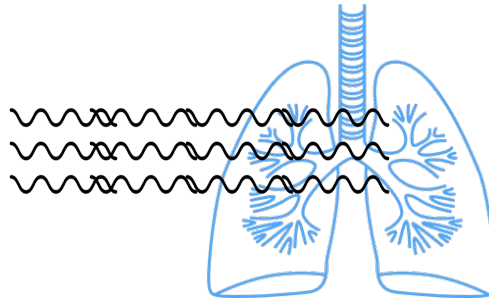


Absorbed, Equivalent and Effective

Absorbed

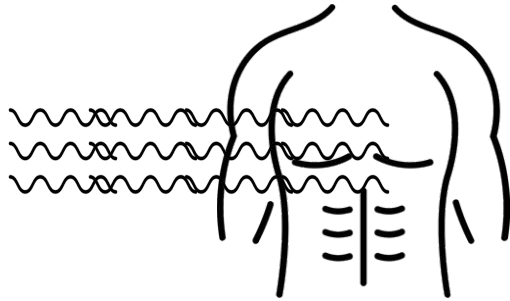


Equivalent

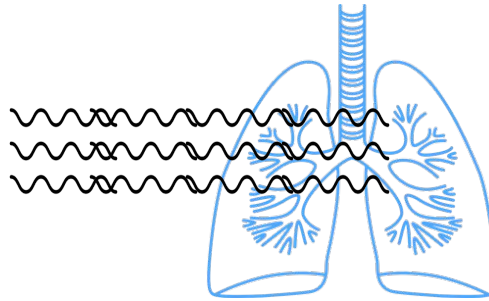


Absorbed, Equivalent and Effective

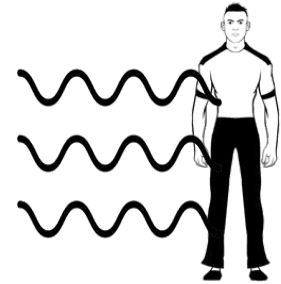
Absorbed



Equivalent



Effective



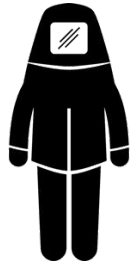
Everyday RAD Dose



Flying ~ 5MR / Trip



Chest X-ray ~ 10 MR / image



RAD Worker ~ 5 REM / year

Radiation health effects chart

20-100 REM

White blood cell loss

Radiation health effects chart

20-100 REM	White blood cell loss
100-200 REM	Vomiting, diarrhea, fatigue; reduction in resistance to infection in hours

Radiation health effects chart

20-100 REM	White blood cell loss
100-200 REM	Vomiting, diarrhea, fatigue; reduction in resistance to infection in hours
200-300 REM	All of the above plus bone marrow damage. 10-35% die within days.

Radiation health effects chart

20-100 REM	White blood cell loss
100-200 REM	Vomiting, diarrhea, fatigue; reduction in resistance to infection in hours
200-300 REM	All above plus bone marrow damage. 10-35% mortality within days.
> 400 REM	All of the above plus almost 100% mortality within days for most.

Potassium Iodide



Diethylenetriamine pentaacetate (DTPA)

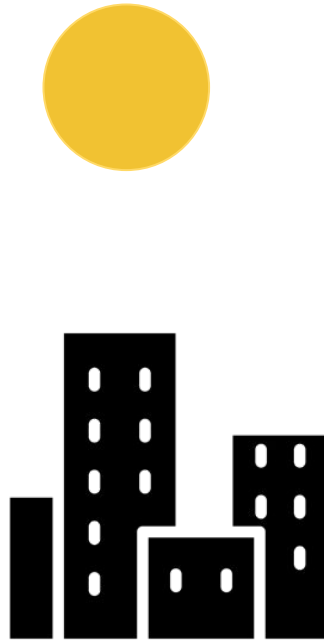


Airburst and surface burst

Airburst



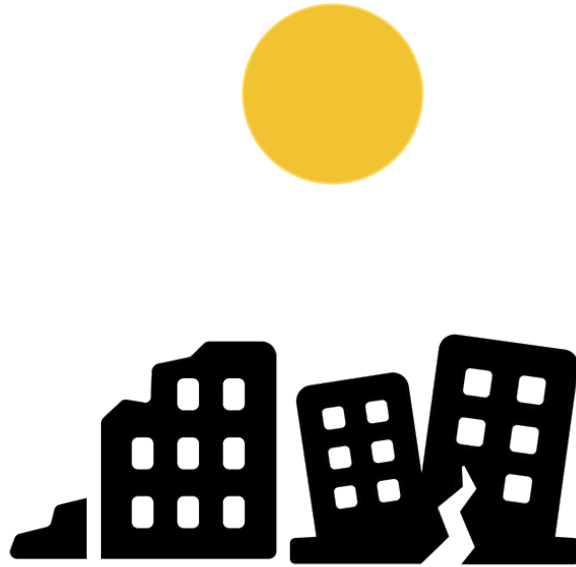
Airburst



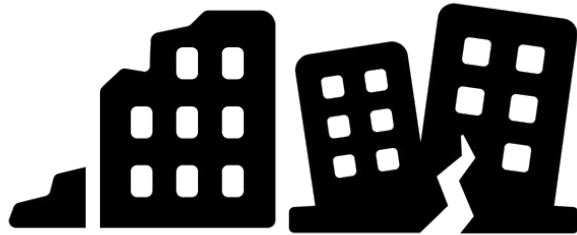
Airburst



Airburst



Airburst



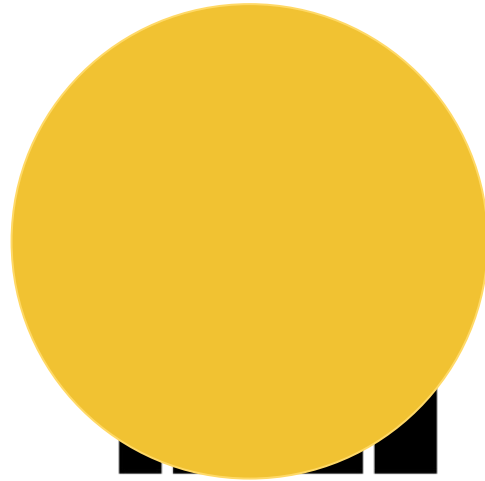
Surface / Ground Burst



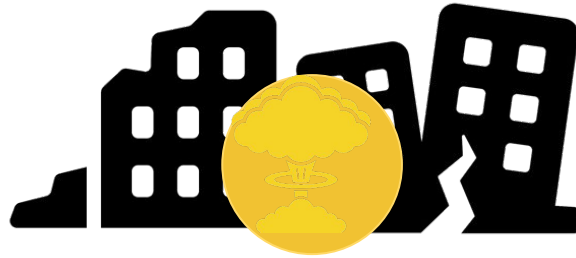
Surface / Ground Burst



Surface / Ground Burst



Surface / Ground Burst



Surface / Ground Burst



Surface / Ground Burst



Surface / Ground Burst



Surface burst for hardened targets



Fallout



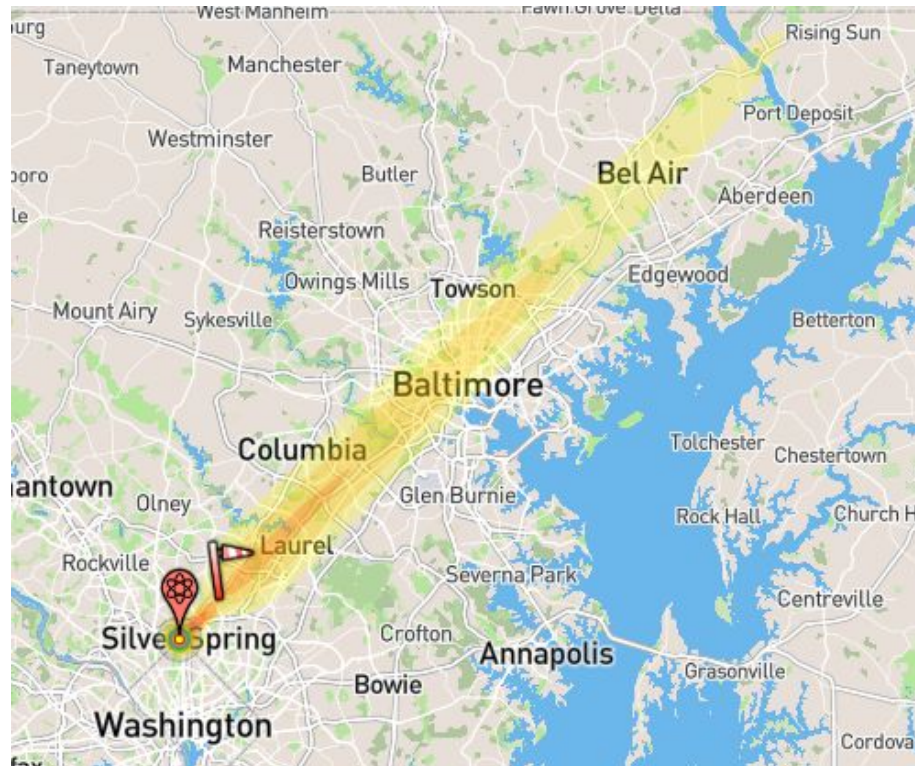
Fallout



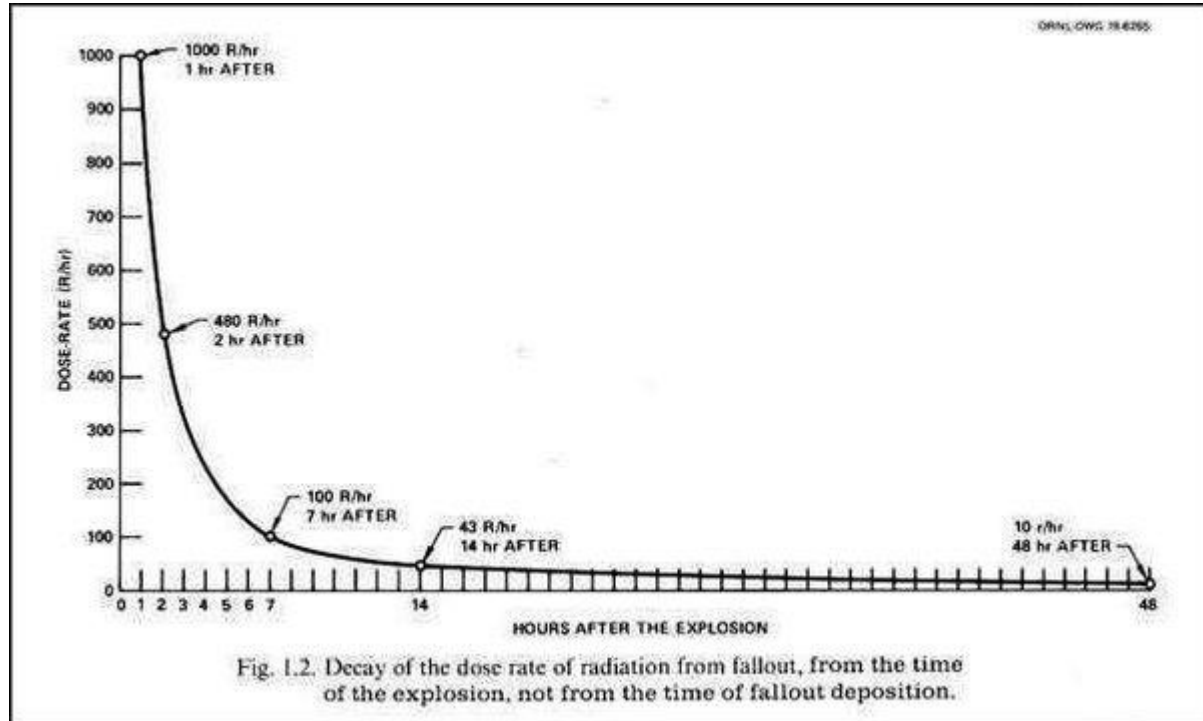
Falout



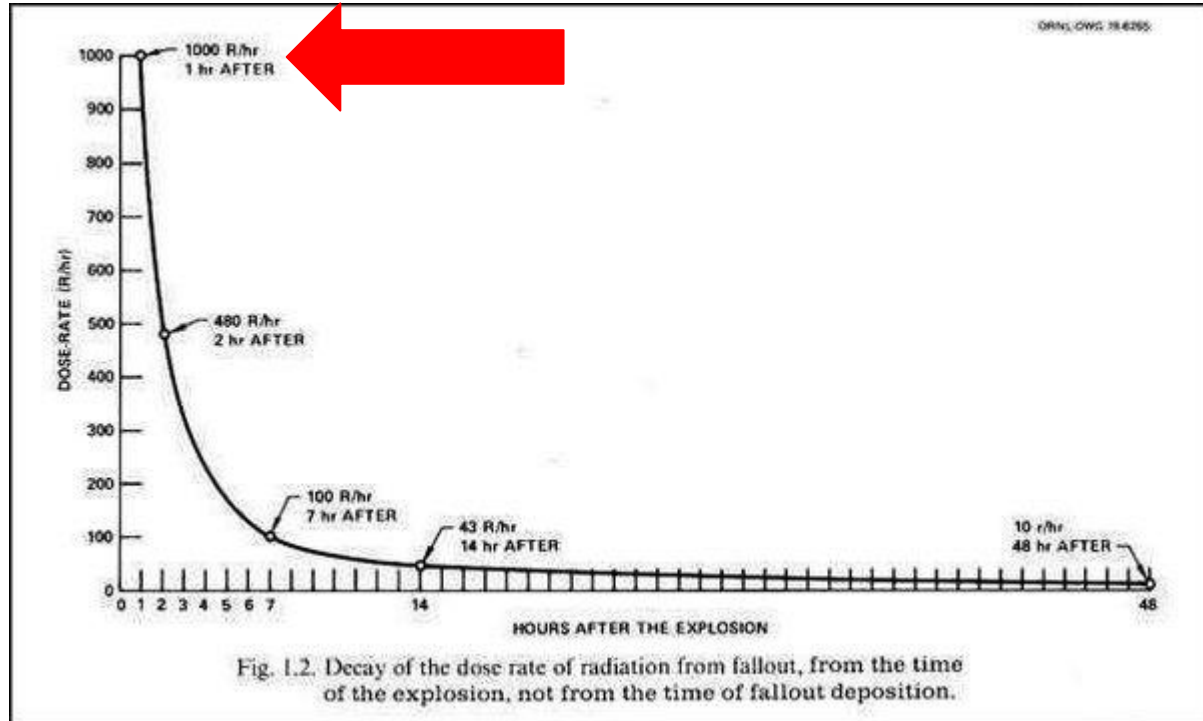
Fallout on a map



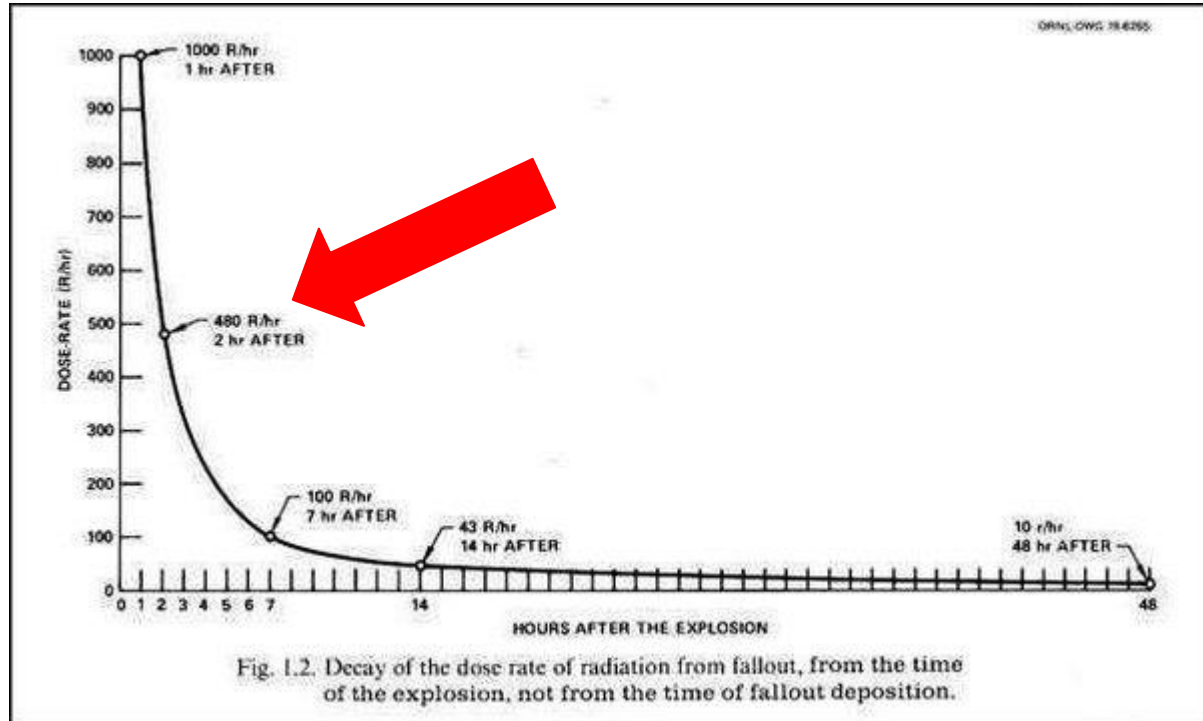
Fallout Decay



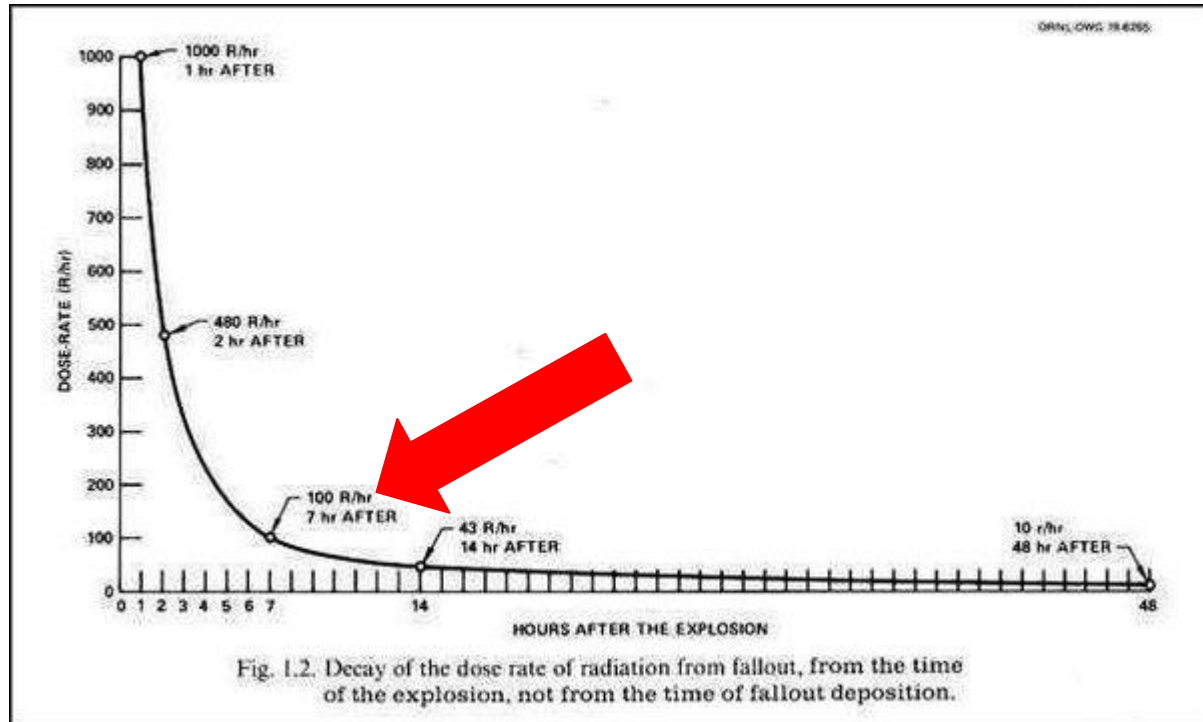
Fallout Decay



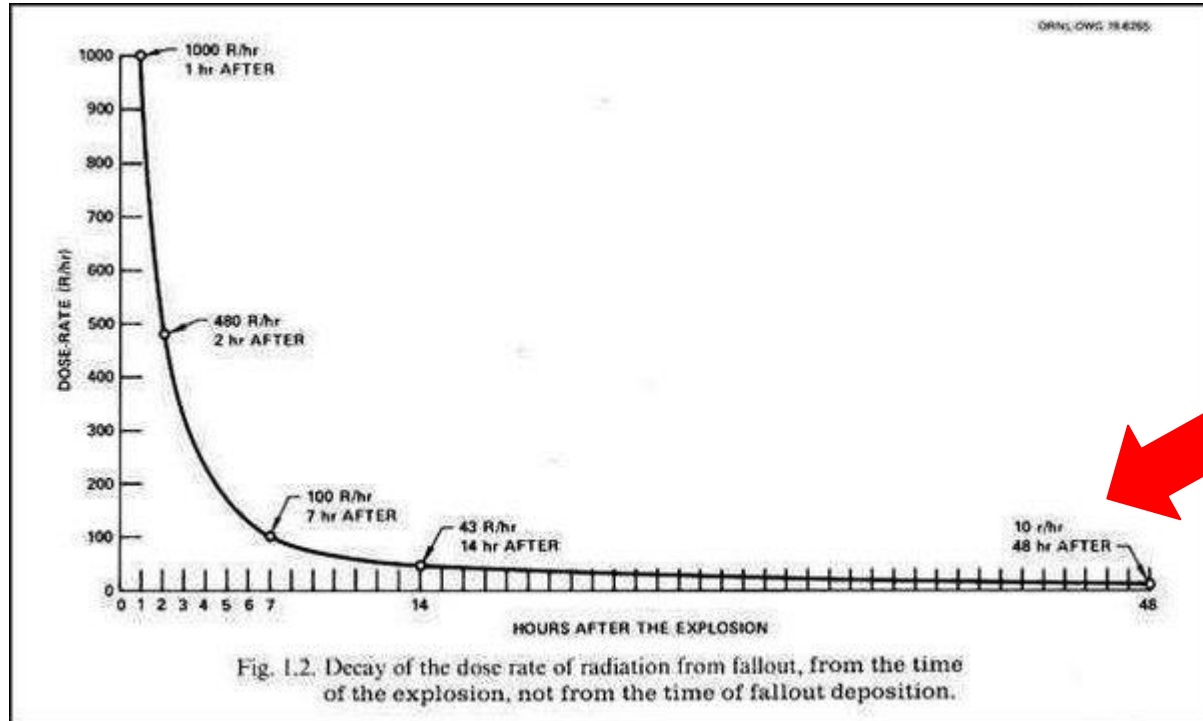
Fallout Decay



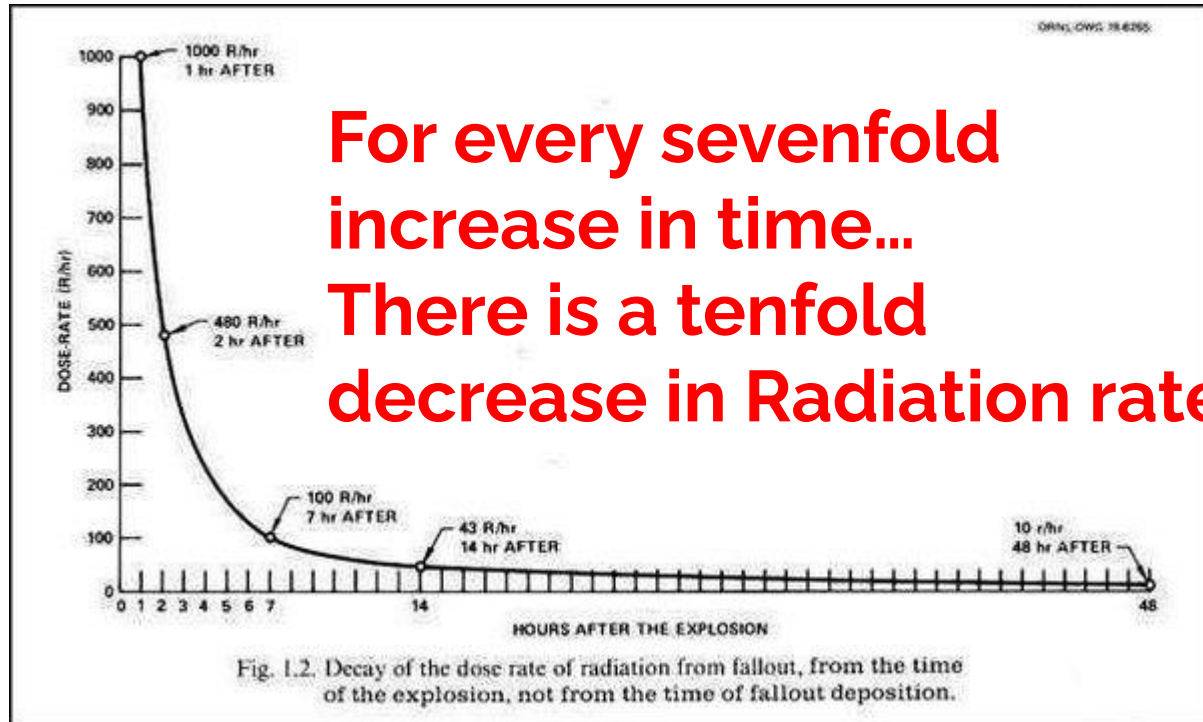
Fallout Decay



Fallout Decay



7/10 Rule



Prevent Exposure:

- Time

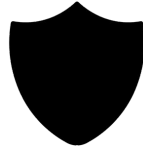


Prevent Exposure:

- Time



- Shielding



Prevent Exposure:

- Time



- Shielding



- Distance



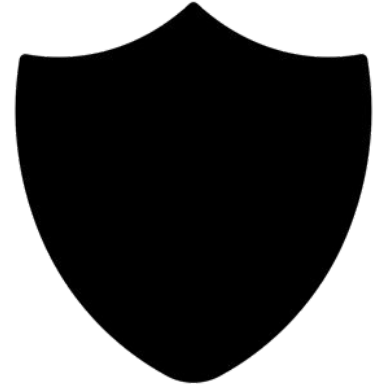
Time

- Limit your exposure by limiting time outside.



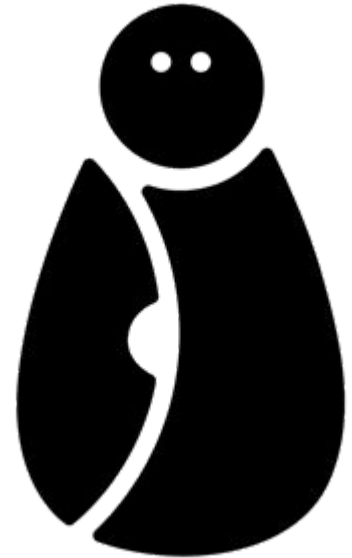
Shielding

- If you are outside find shelter



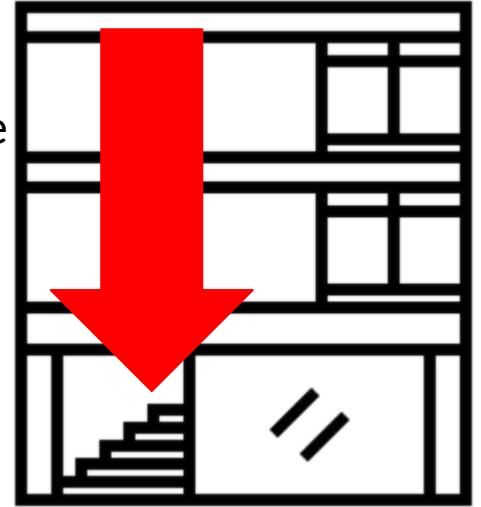
Shielding

- If you are outside find shelter
- Cover yourself with a blanket



Shielding

- If you are outside find shelter
- Cover yourself with a blanket
- Go to a basement or parking garage



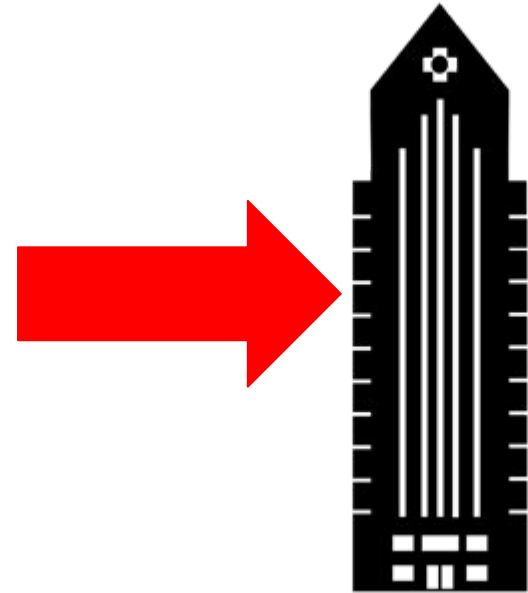
Shielding

- If you are outside find shelter
- Cover yourself with a blanket
- Go to a basement or parking garage
- Put as much shielding between you
And the outside.



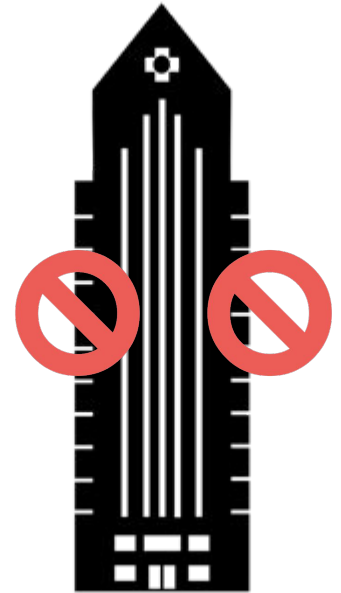
If in a tall building

- Middle floors are safer



If in a tall building

- Middle floors are safer
- Stay away from the windows



If you were outside...

- Take a shower



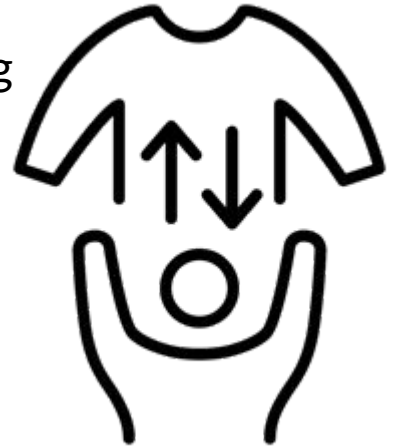
If you were outside...

- Take a shower



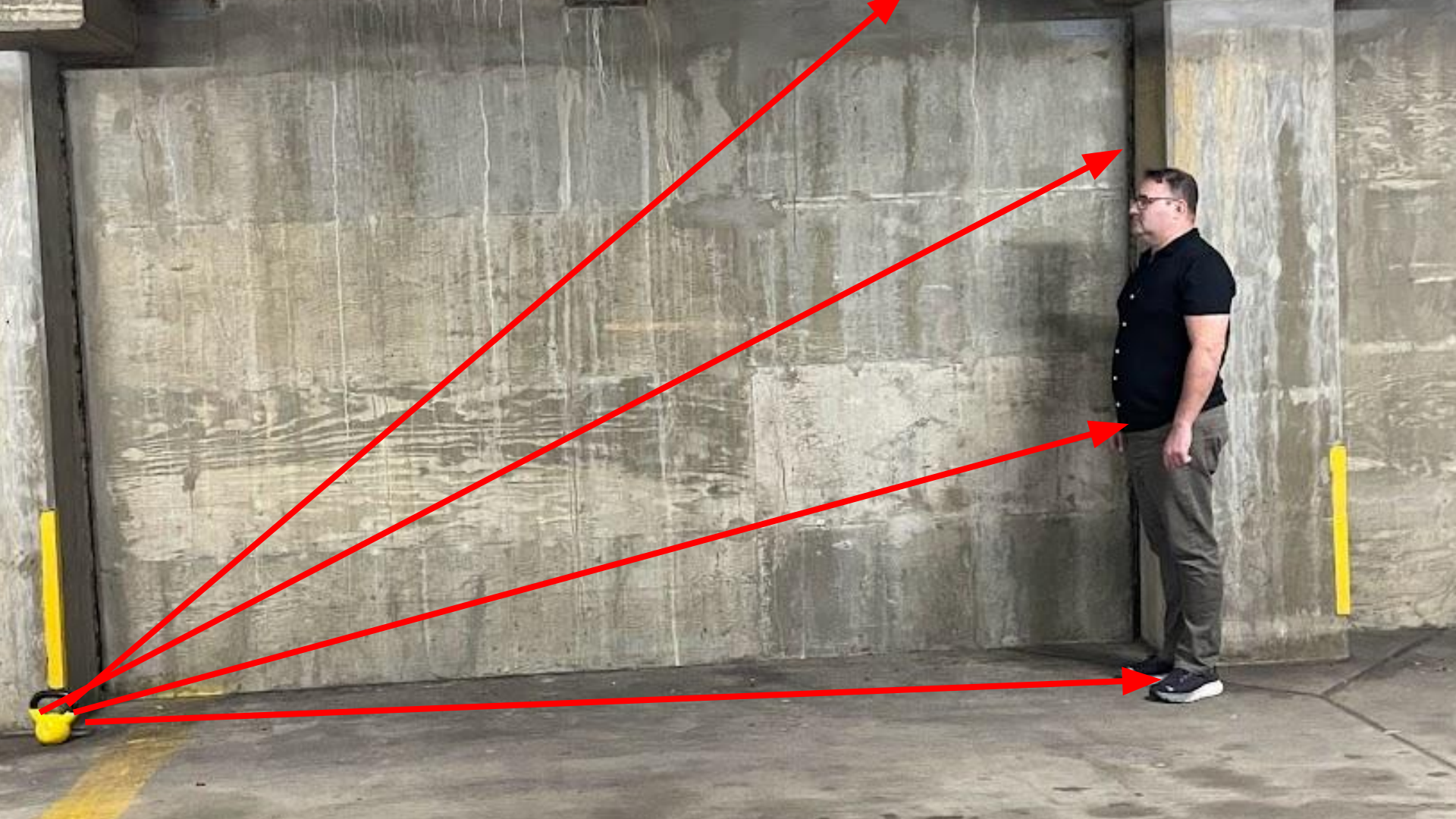
If you were outside...

- Take a shower
- Remove your clothes place them in a bag and discard them in a shielded area.



Don't use conditioner





Inverse square law

- Double your distance and radiation goes down by a factor of four



Stay away from radiation sources

- Puddles are very dangerous and collect fallout



If you have to go outside

- Wear a mask - even a paper mask



If you have to go outside

- Wear a mask - even a paper mask
- Wear goggles or glasses with side-shields



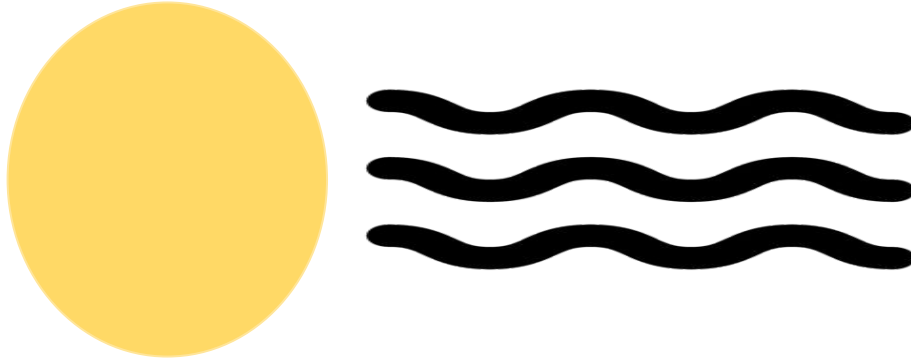
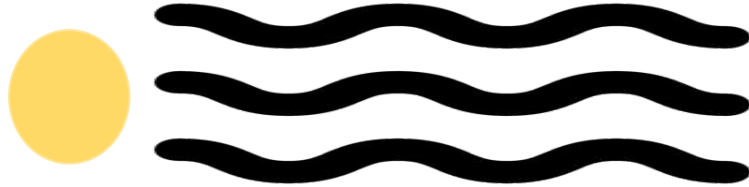
Only bring what you need with you



Don't eat contaminated animals



Size of the bomb doesn't increase Radiation Distance (much)



Destruction Zones



Fireball

Destruction Zones



Almost
100%
Casualties



Many Fatal injuries.
Radiation poisoning, large
buildings damaged or
destroyed.



Fireball

Heavy Damage

Destruction Zones



Destruction Zones



Almost
100%
Casualties



Fireball

Many Fatal injuries.
Radiation poisoning, large
buildings damaged or
destroyed.



Heavy Damage

Partially collapsed
buildings. Major burns
from personnel who were
outside. Minor radiation
poisoning.



Moderate Damage

Broken windows, light
damage and flash burns.
Injuries from flying glass
or vehicle accidents.

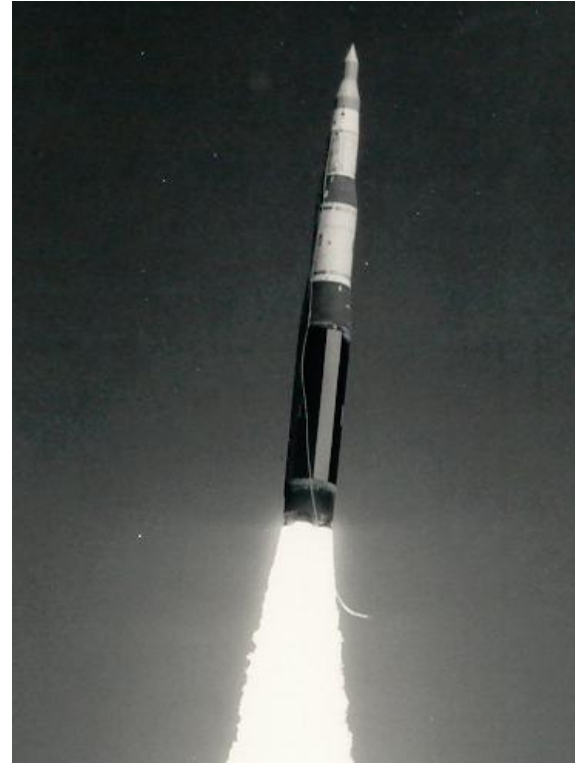


Light Damage

Tactical and Strategic Warheads



Tactical and Strategic Warheads



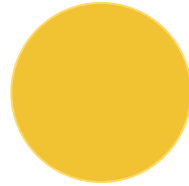
Tactical weapons



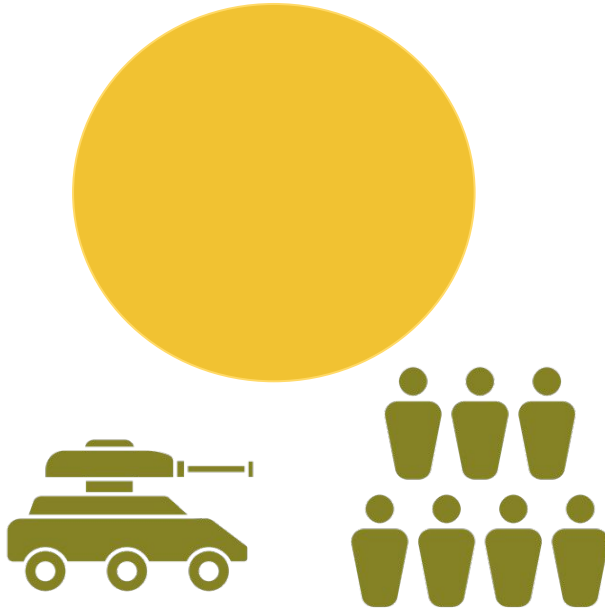
Tactical weapons



Tactical weapons



Tactical weapons



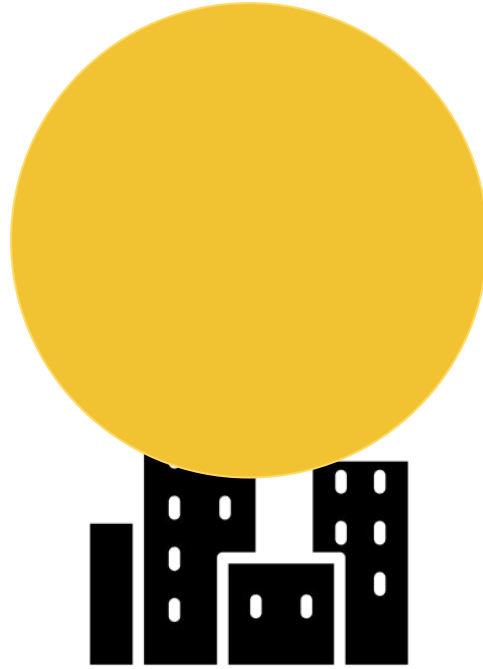
Tactical weapons



Strategic Weapons



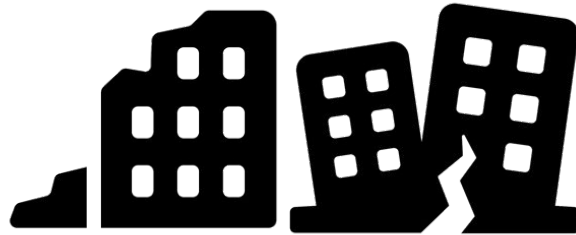
Strategic Weapons



Strategic Weapons



Strategic Weapons



Counterforce and Countervalue

Counterforce and Countervalue

- We need to look at this critically
-

Counterforce and Countervalue

- We need to look at this critically
- Forget about morals, just look at deployment



Counterforce

- Troop Concentrations



Counterforce

- Troop Concentrations



- Military Manufacturing



Counterforce

- Troop Concentrations



- Military Manufacturing



- Shipbuilding



Counterforce

- Troop Concentrations



- Military Manufacturing



- Shipbuilding



- Embarkation ports



Counterforce

- Troop Concentrations



- Military Manufacturing



- Shipbuilding



- Embarkation ports



-
-

Counterforce

- Troop Concentrations



- Military Manufacturing



- Shipbuilding



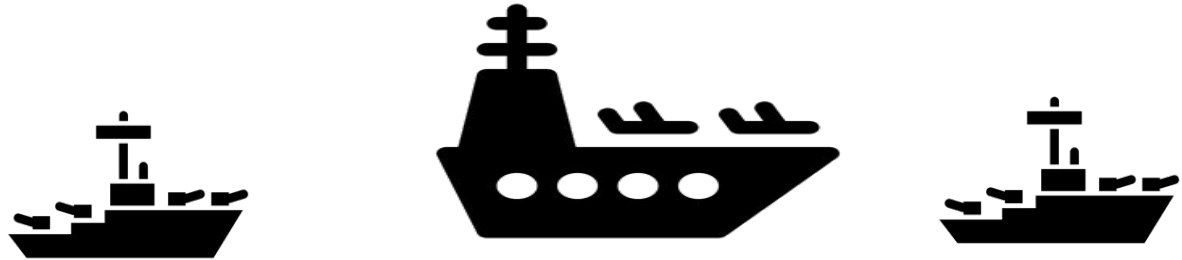
- Embarkation ports



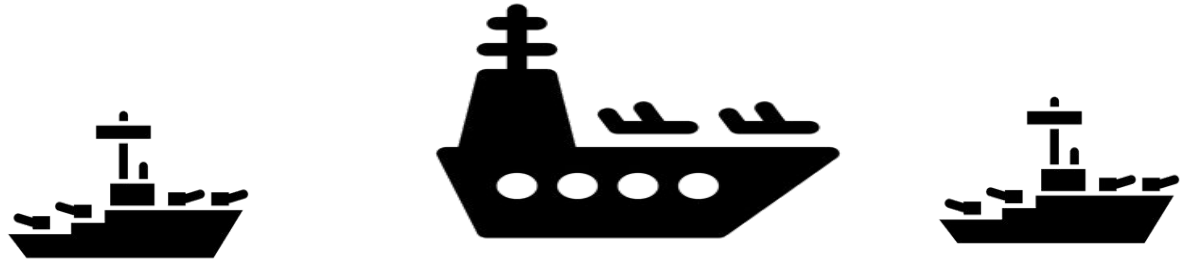
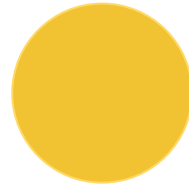
- Missile Silos



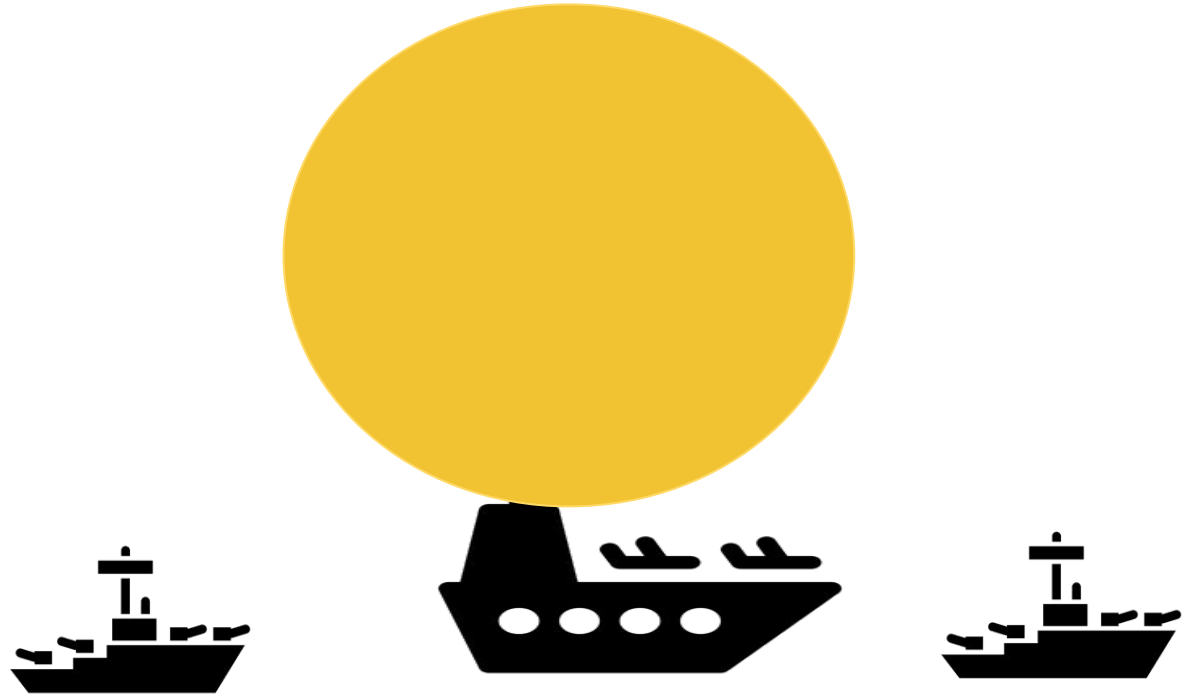
Ships are excellent targets



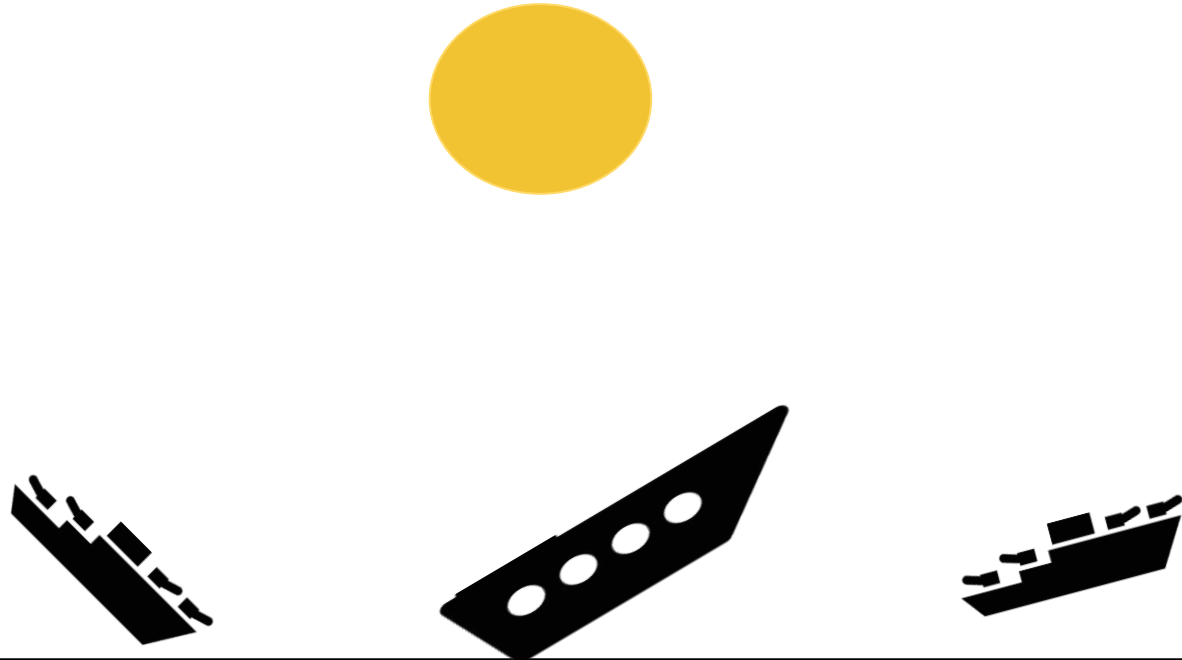
Ships are excellent targets



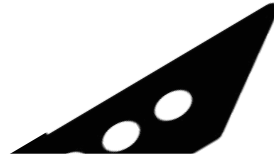
Ships are excellent targets



Ships are excellent targets



Ships are excellent targets



Tactics changed in the 50's and 60's

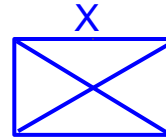
Marines pivoted to helicopters



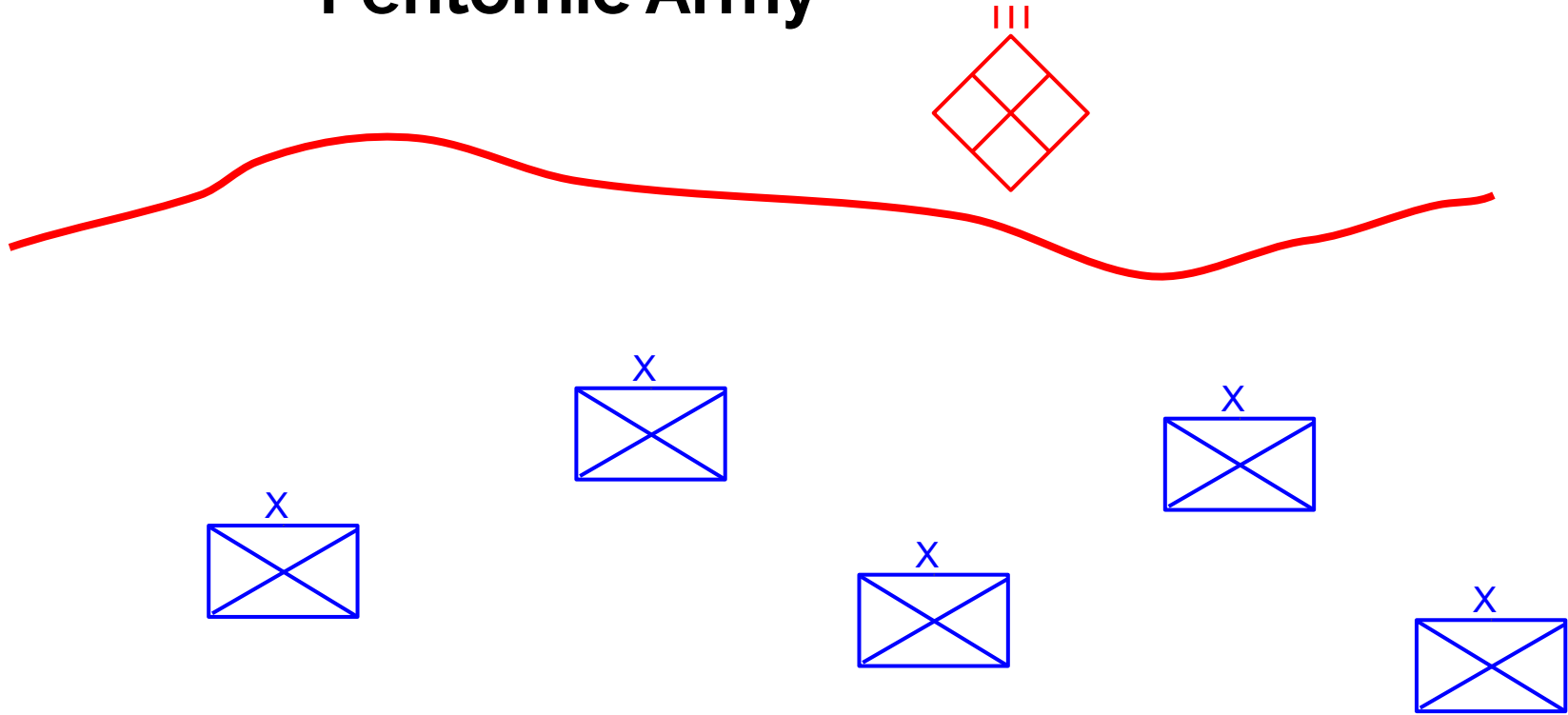
Pentomic Army



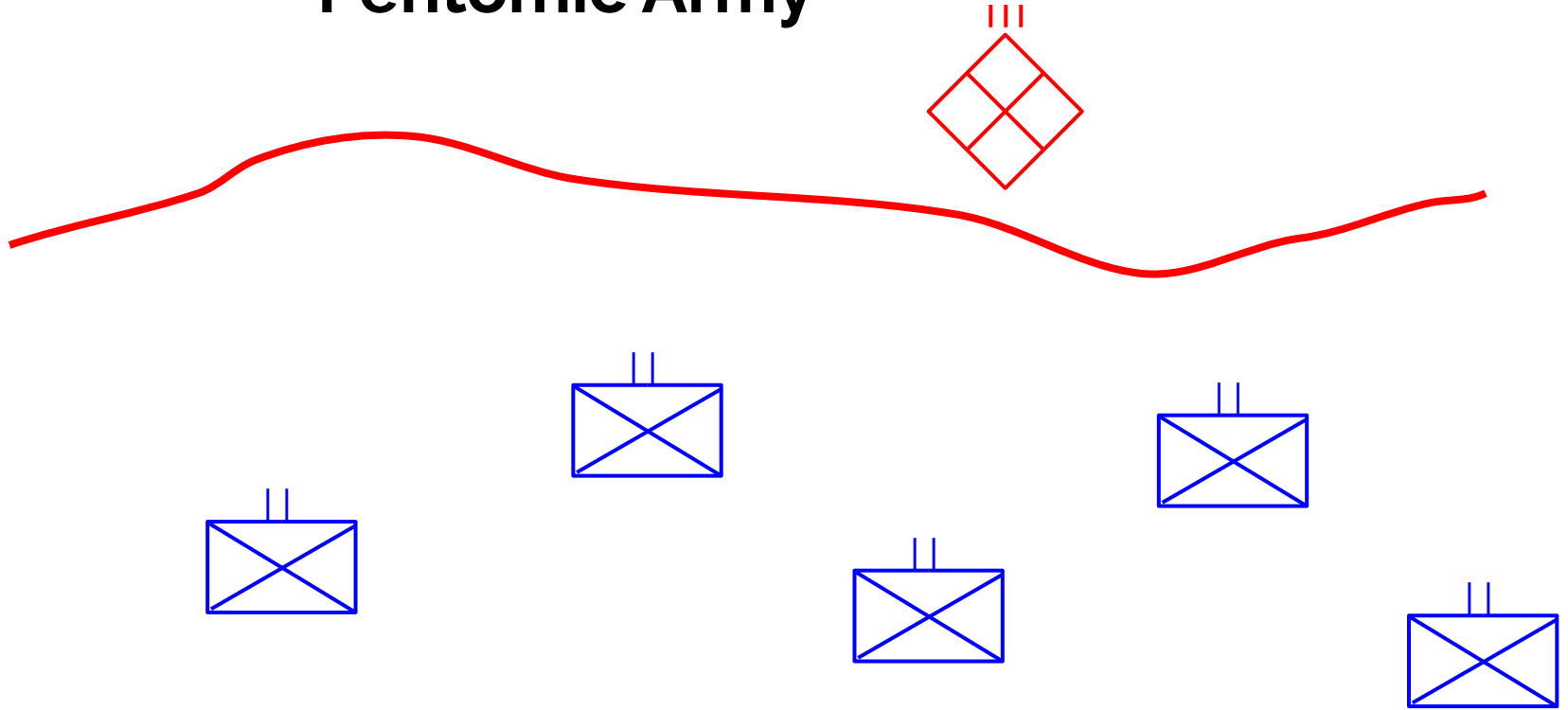
Pentomic Army



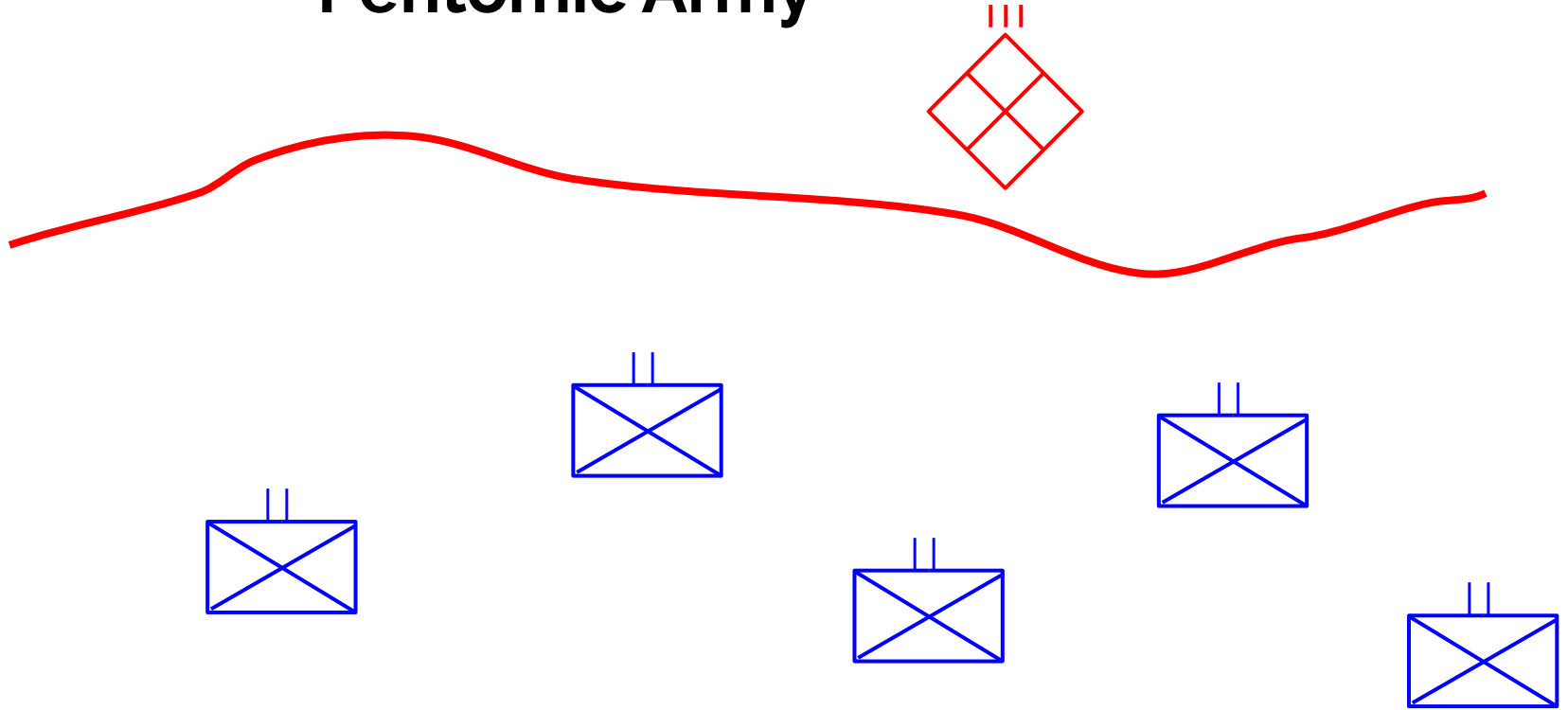
Pentomic Army



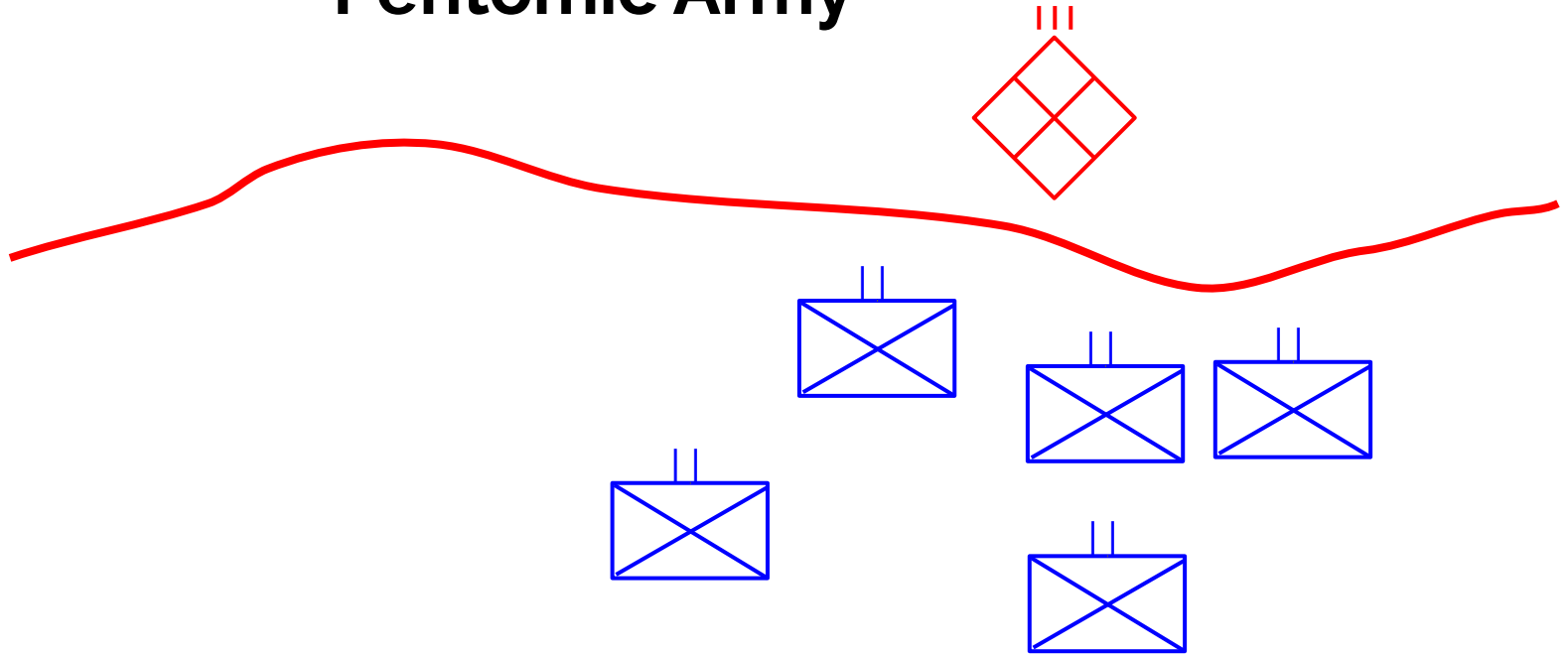
Pentomic Army



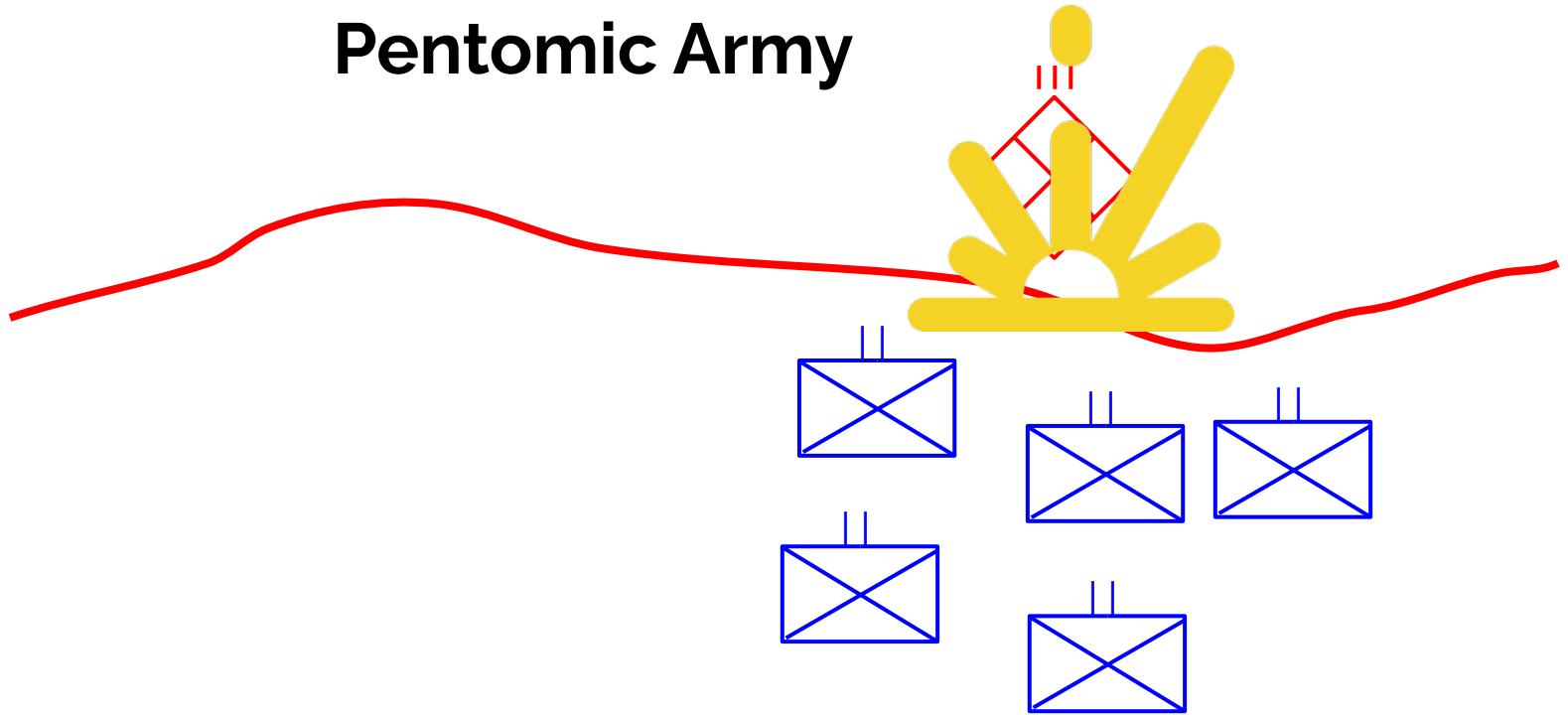
Pentomic Army



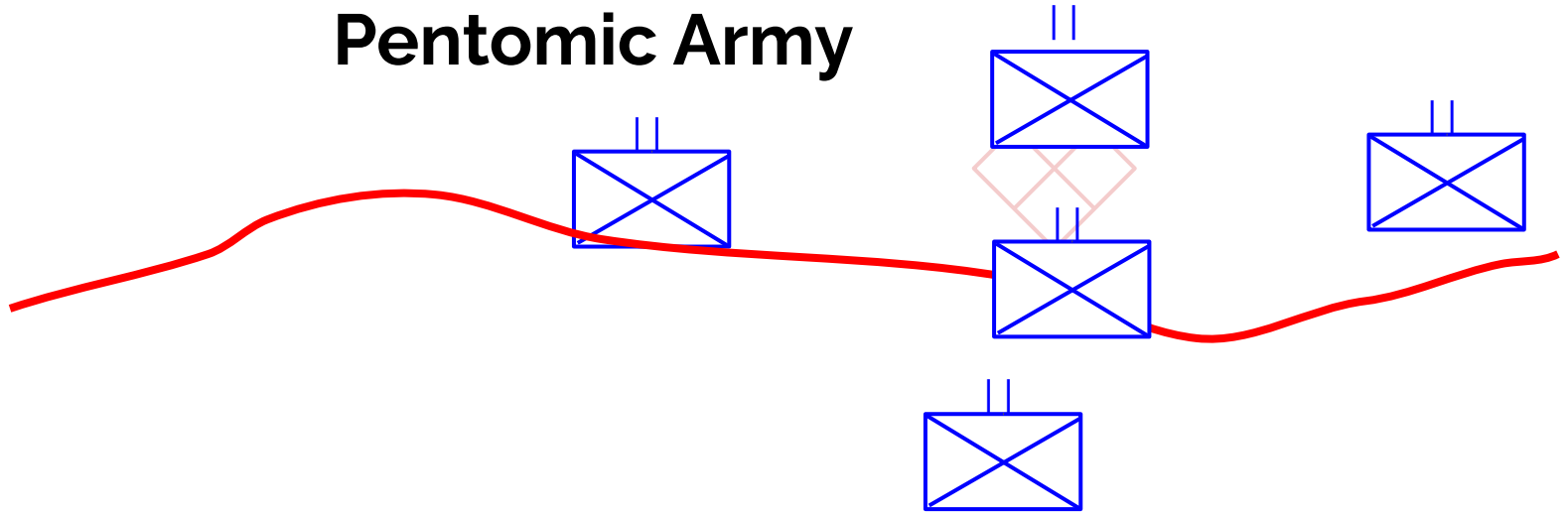
Pentomic Army



Pentomic Army



Pentomic Army



Nuclear weapons at division level



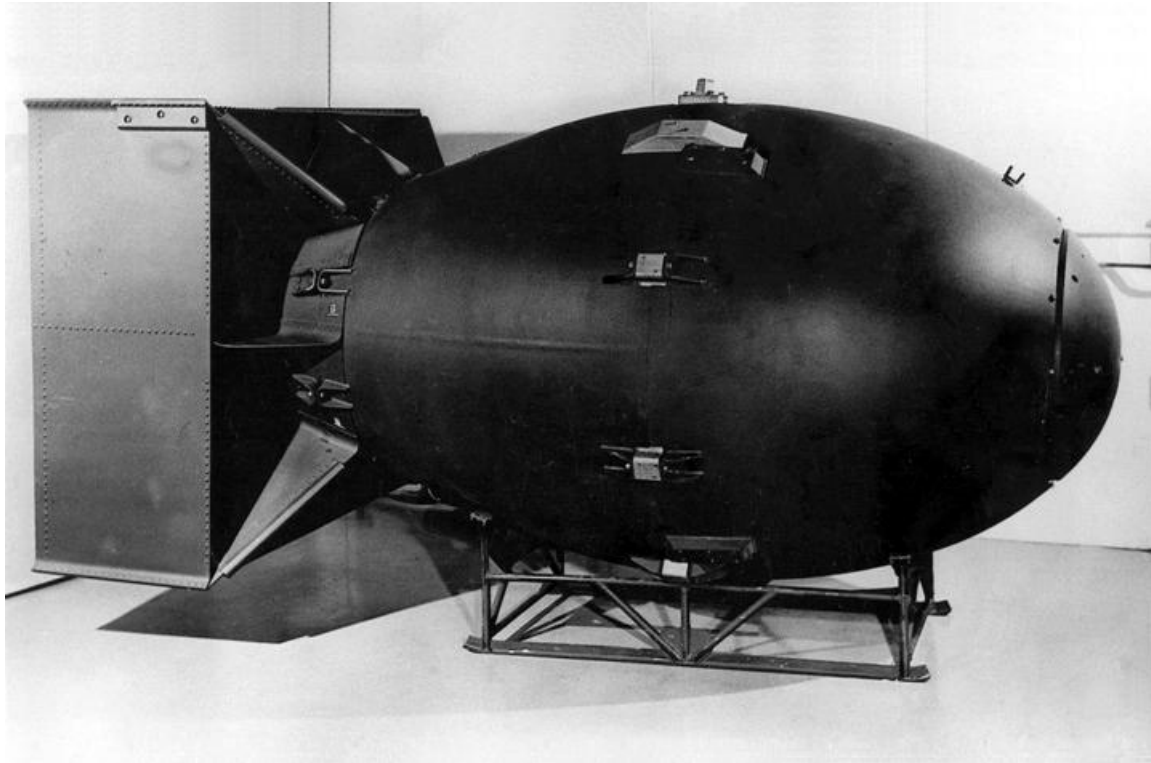
Countervalue



Modern Counter Value Targets

- Walmart
 - Azure / AWS
 - FedEx / UPS
-

Gravity Bombs



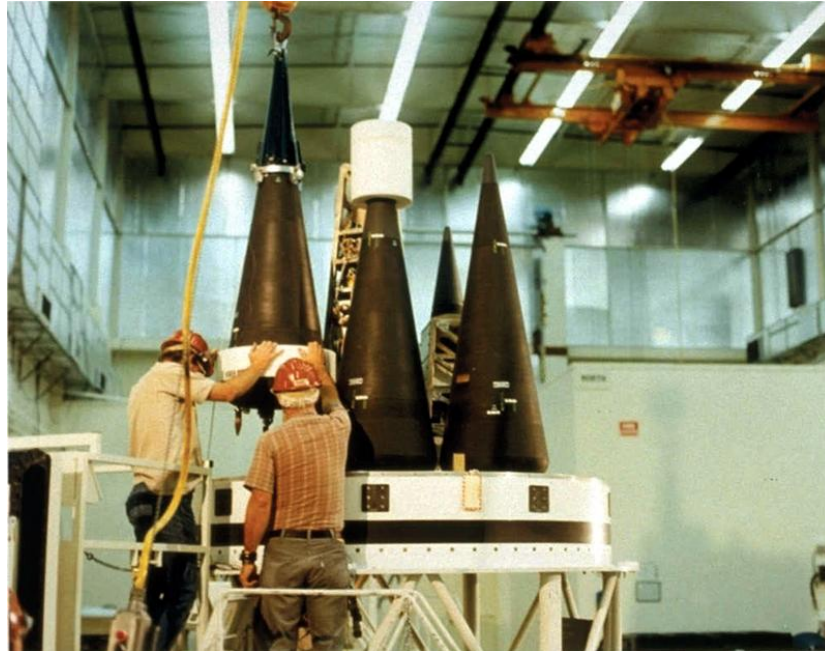
Ballistic Missiles



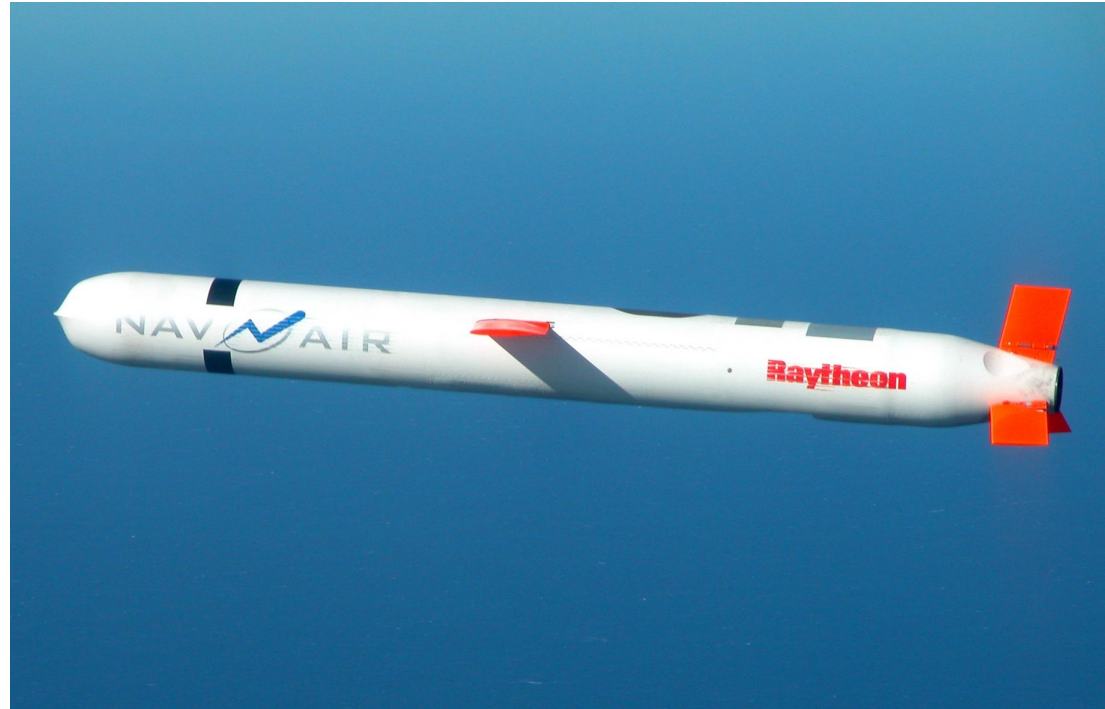
Ballistic Missiles



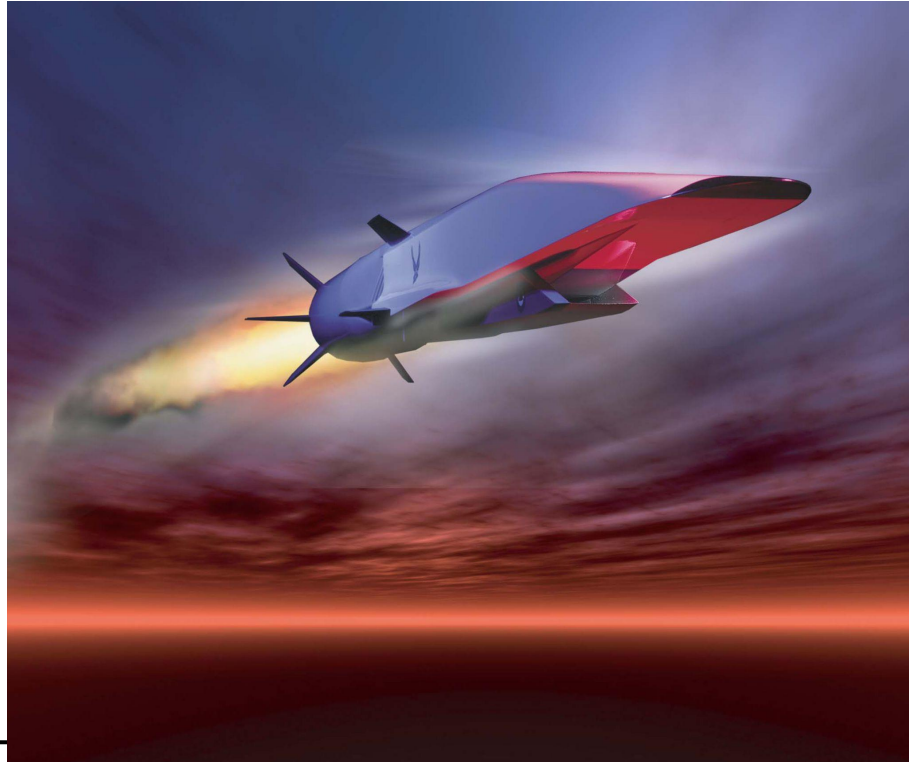
MIRV - Multiple Independently Targetable Reentry Vehicles



Cruise missiles



Hypersonic missiles



Electromagnetic Pulse



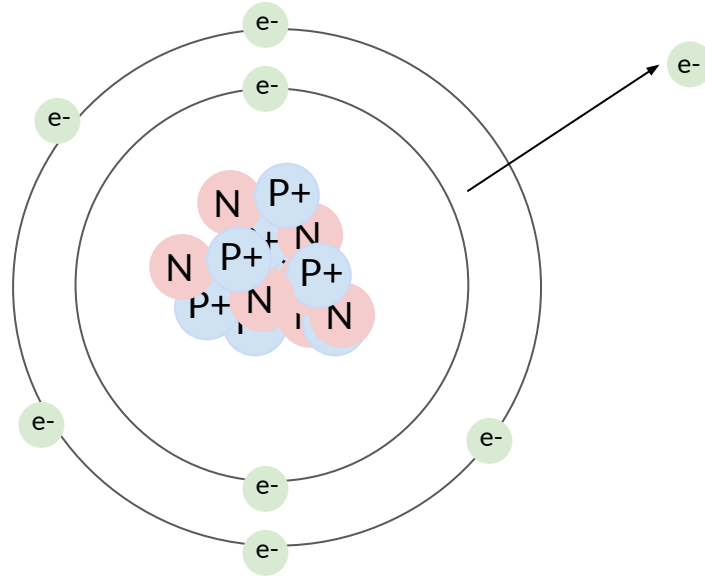
Electromagnetic Pulse



Gamma Rays Ionize air molecules



Gamma Rays Ionize air molecules



Electromagnetic Pulse



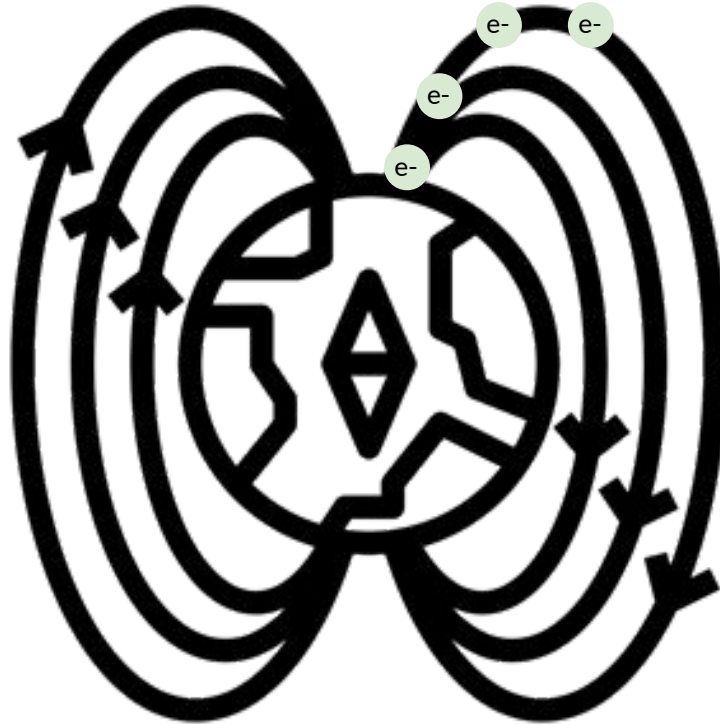
Electromagnetic Pulse



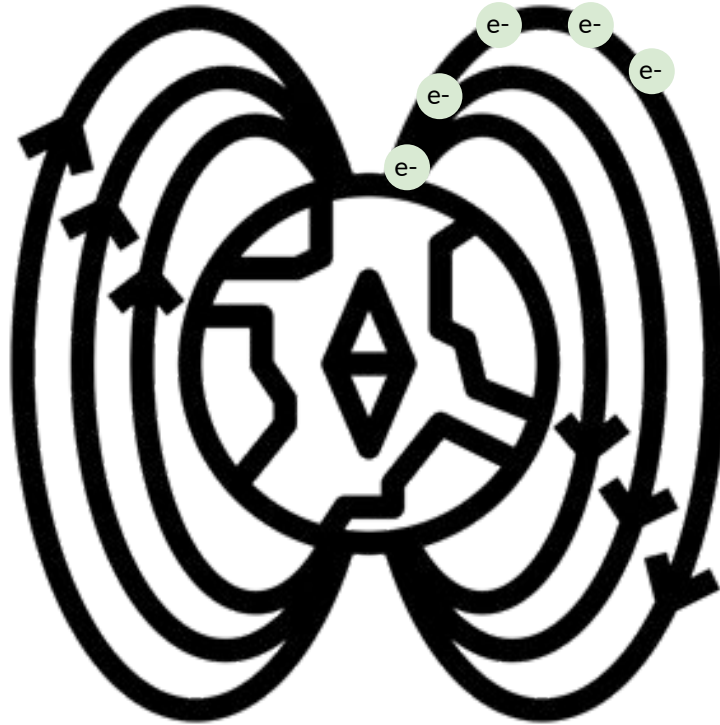
Electromagnetic Pulse



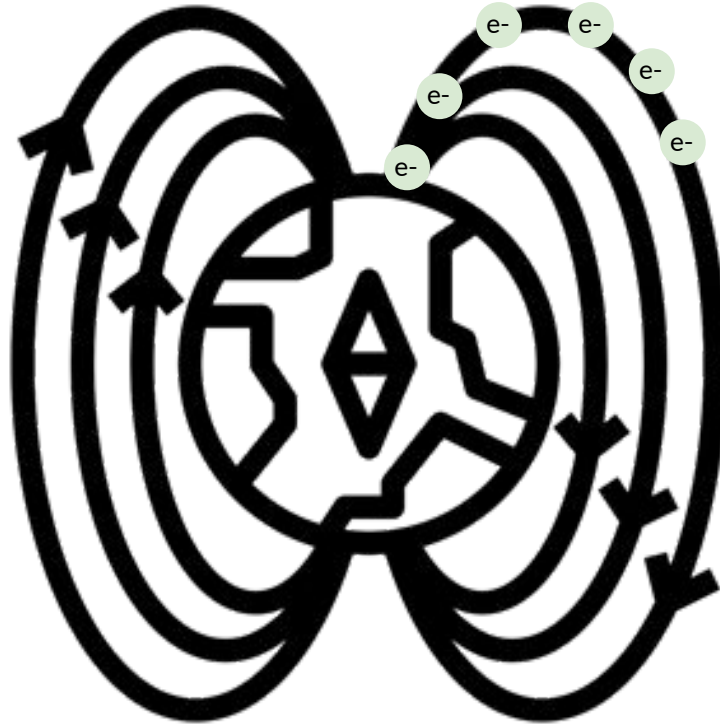
Electromagnetic Pulse



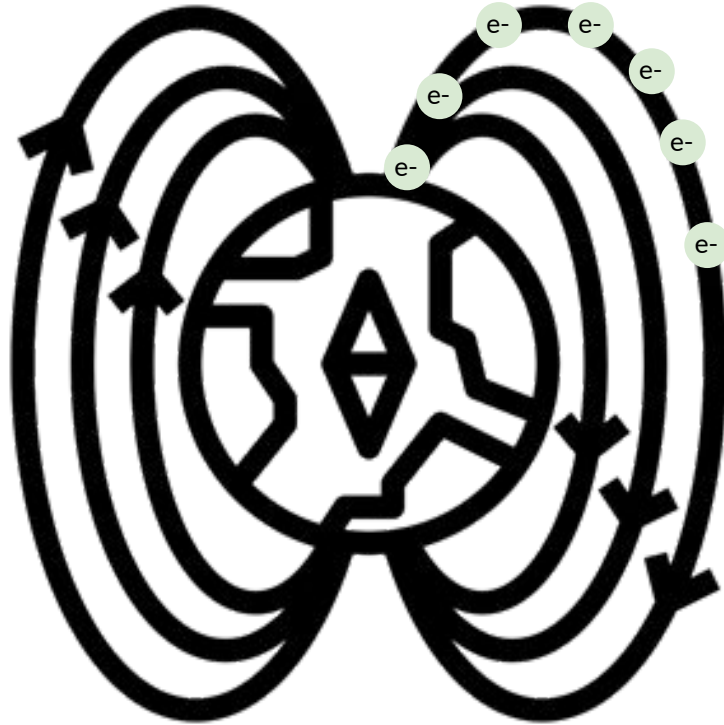
Electromagnetic Pulse



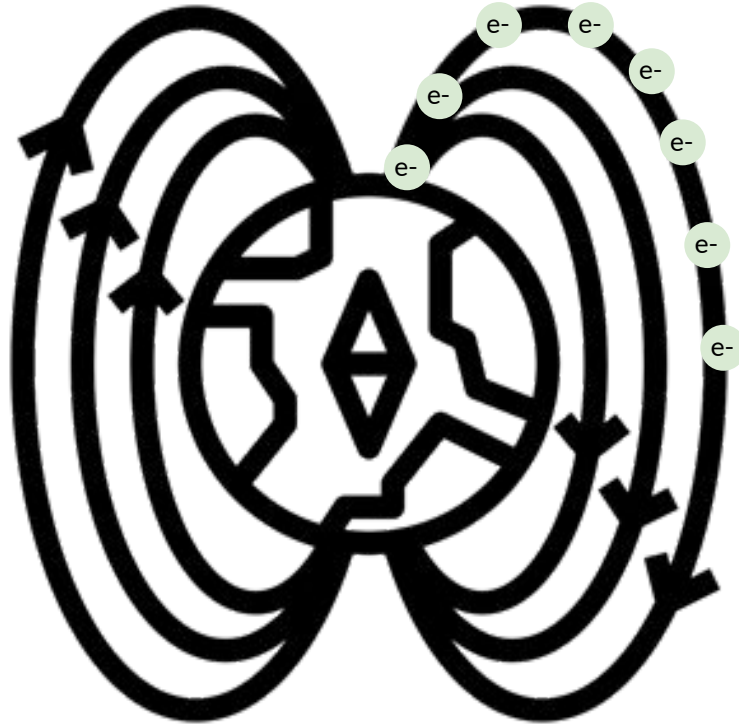
Electromagnetic Pulse



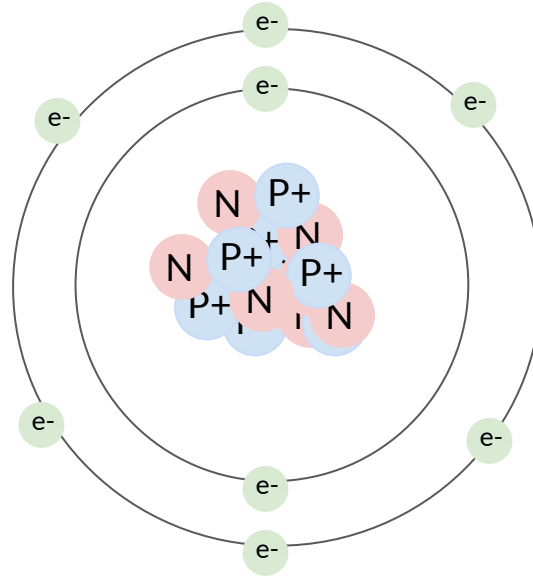
Electromagnetic Pulse



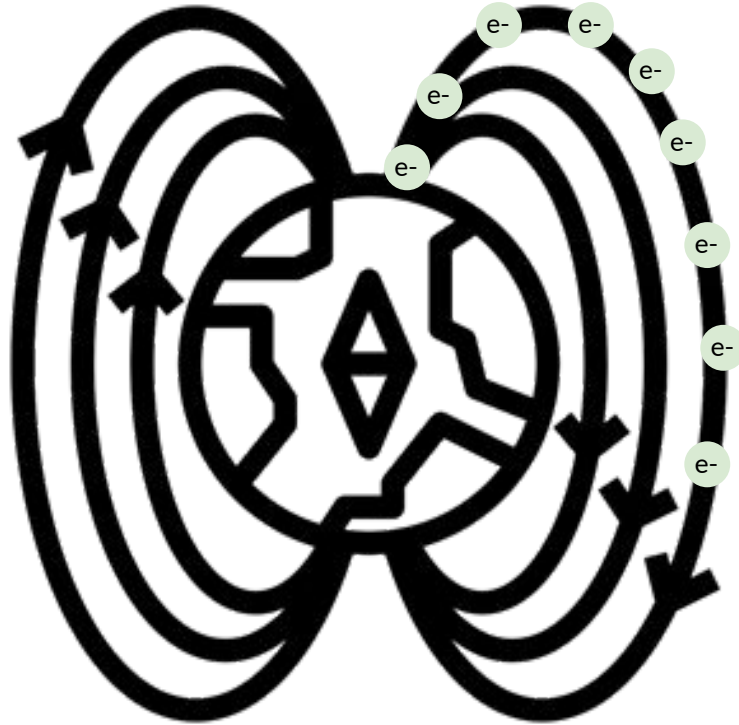
Electromagnetic Pulse



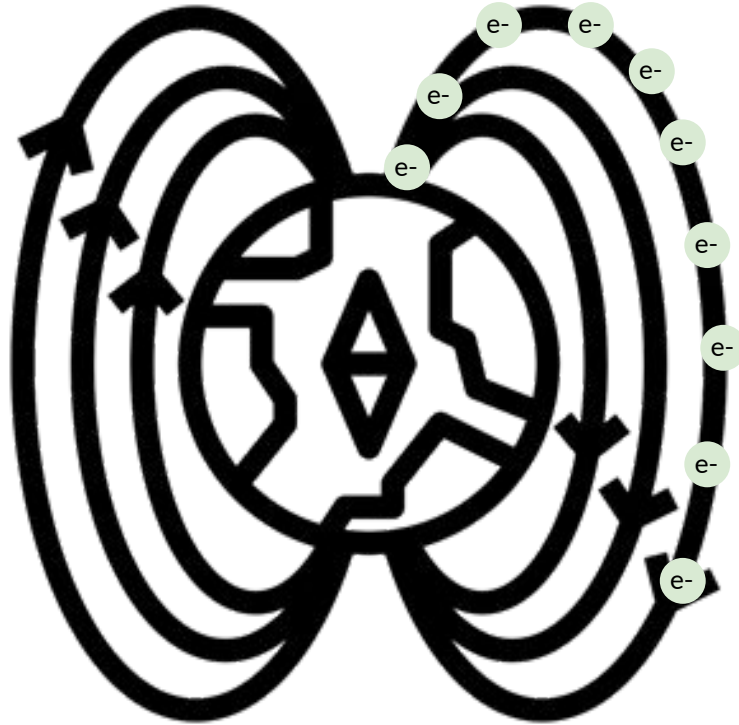
Gamma Rays Ionize air molecules



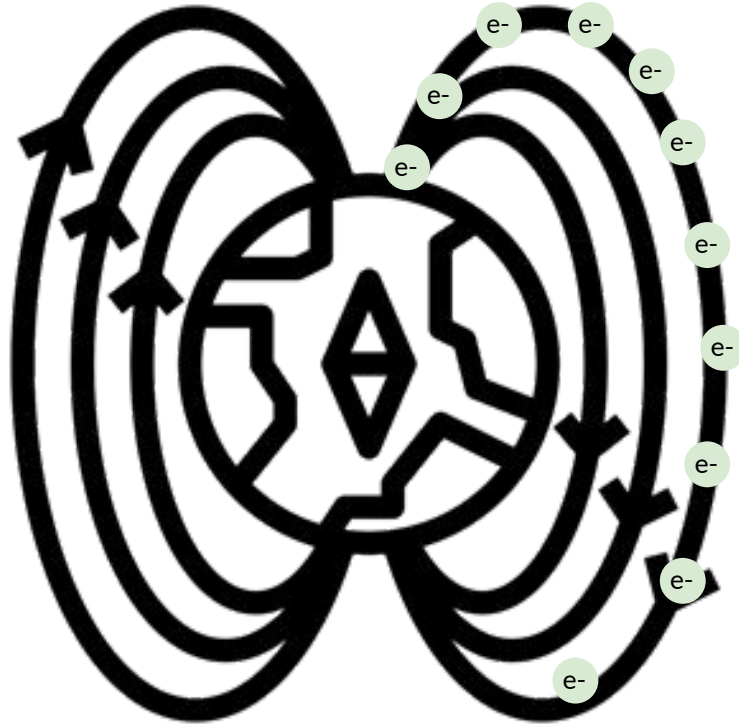
Electromagnetic Pulse



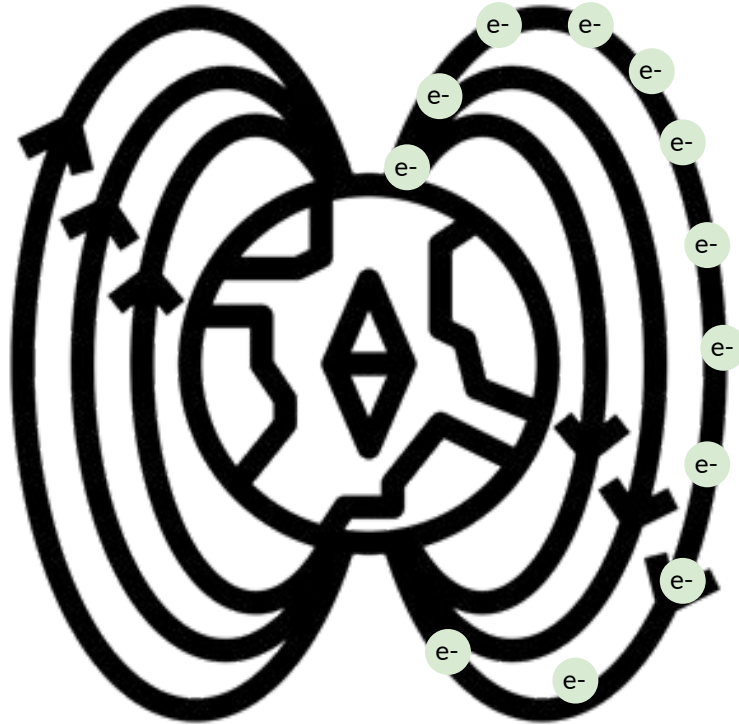
Electromagnetic Pulse



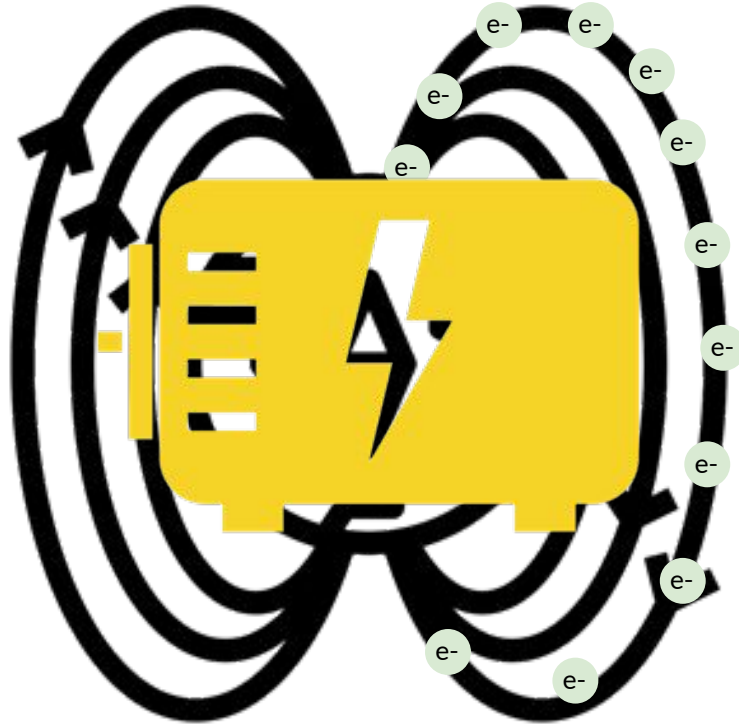
Electromagnetic Pulse



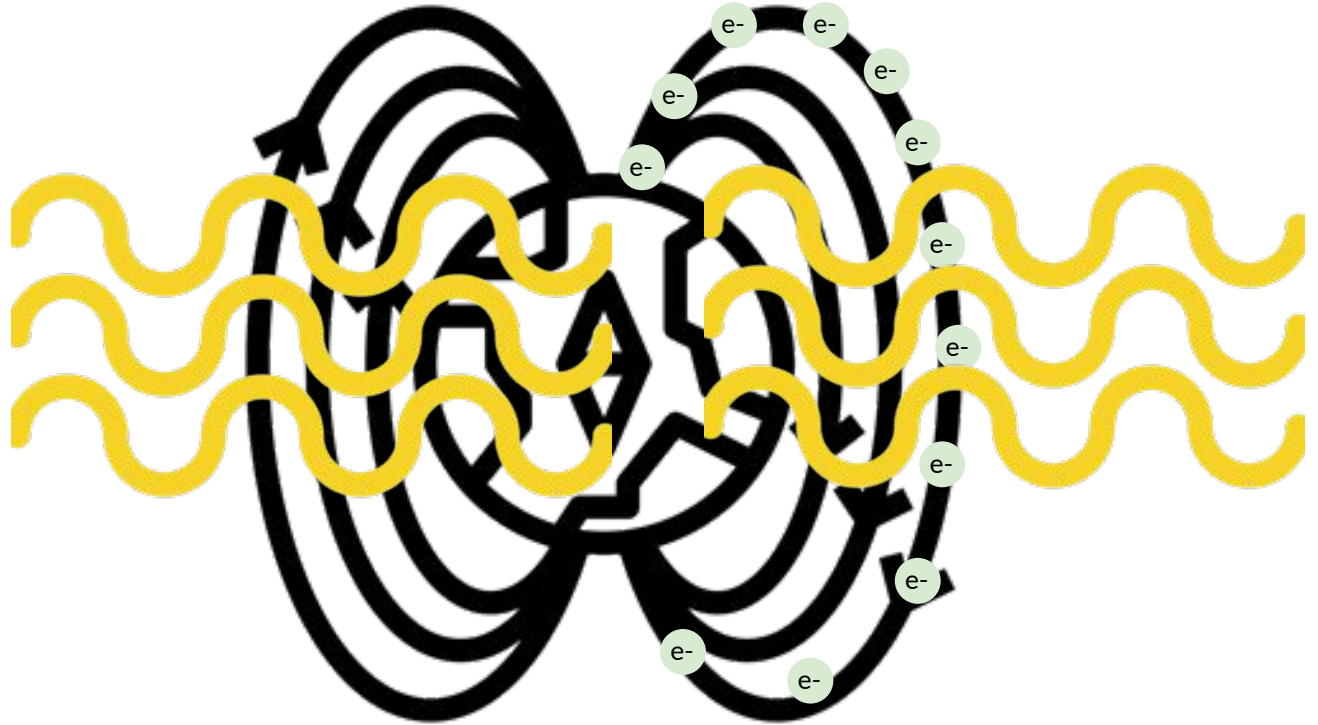
Electromagnetic Pulse



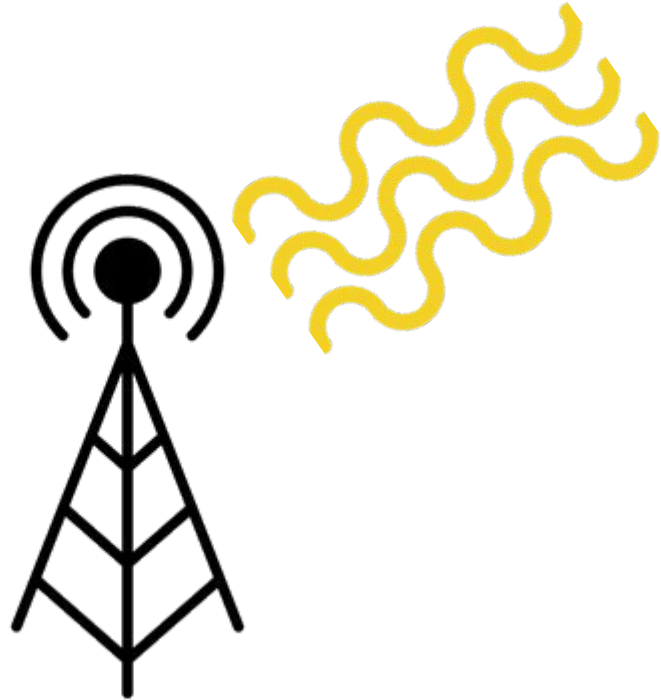
This acts as a generator



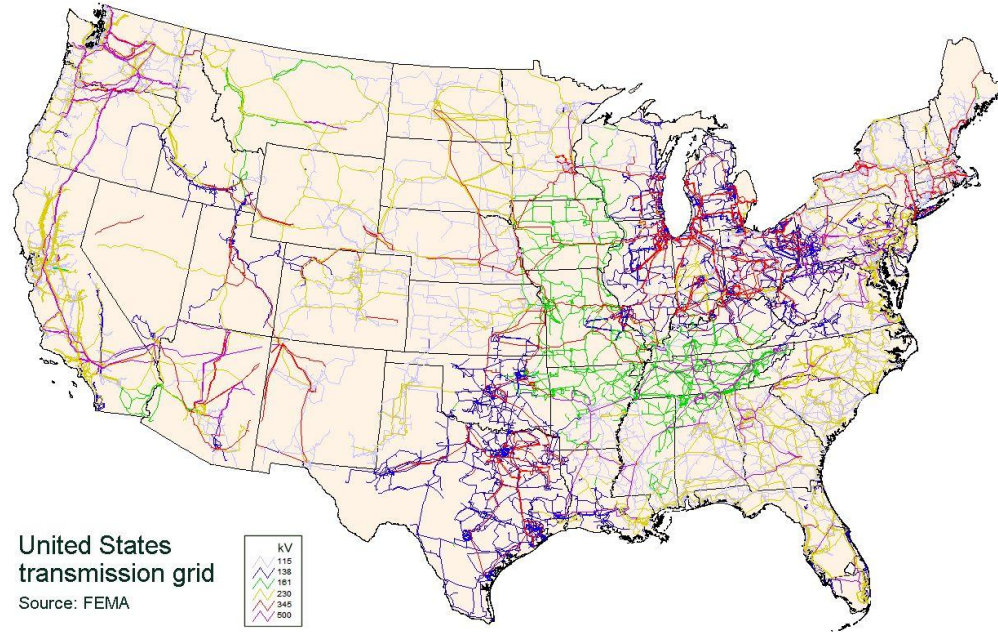
Radio waves are released



Until the waves find an antenna



The US power grid is 16000 miles of antenna



**This was tested in 1962 with Starfish
Prime**



This caused damage 500 miles away

2. Review of the Streetlight Circuit

2.1 Newspaper Accounts (1962)

"The street lights on Ferdinand Street in Manoa and Kawainui Street in Kailua went out at the instant the bomb went off, according to several persons who called police last night," as reported on July 9, 1962, in the *Honolulu Advertiser*, a local paper. The article was reprinted in the Tuesday, February 21, 1984, edition that celebrated the 15th anniversary of Hawaiian statehood. The same article reports that the brilliant flash turned Hawaii's night into day, with the "spectacular pyrotechnic aftermath" lasting for 7 minutes. "It was like turning on all the lights all over the Hawaiian Islands for a super-super athletic contest."

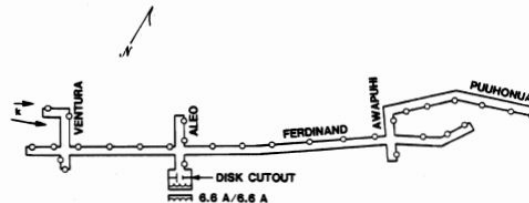
The Saturday, July 28, 1962, edition of the *Honolulu Star-Bulletin* included an article by Robert Scott (of their staff and also a professor at the University of Hawaii) that reviewed "What Happened on the Night of July 8?" He reported that a City-County streetlight department official in Honolulu attributed blown circuit fuses in nine areas to energy from the bomb.

In the April 8, 1967, issue of the *Star-Bulletin*, Cornelius Downes described the fuses that failed, causing about 300 City streetlights to go out. They were "small black plastic rings with two disks of lead separated by thin, clear-plastic washers." The fuses were slightly smaller than a quarter. The article indicated that about two-thirds of Oahu's lighting system used such fuses.

2.2 Mattox Information*

John Mattox³ provided the data for Figure 2 on one streetlight loop that suffered damage: the Ferdinand Street loop in Manoa. His information was based on field work in Hawaii, on discussions with streetlighting personnel, and on the newspaper accounts. Some 30 strings of streetlights failed, about 1% of the lights existing at the time. The failure of 30 strings was well beyond any expectations for severe storms (where ~4 failures were typical). He concludes that the failures are definitely associated with the Starfish explosion.

*1984, with updates from A. S. Lloyd, F. W. Souza, and M. Bentosino

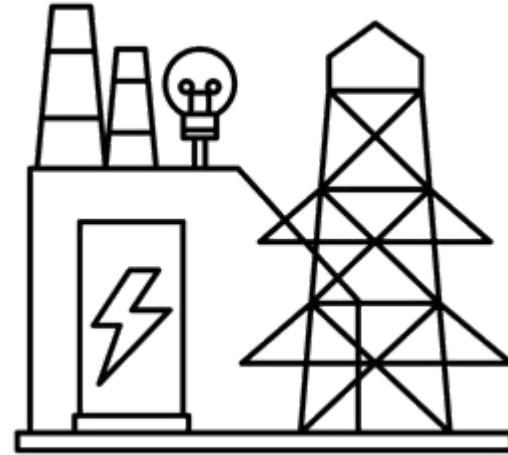


This caused damage 500 miles away

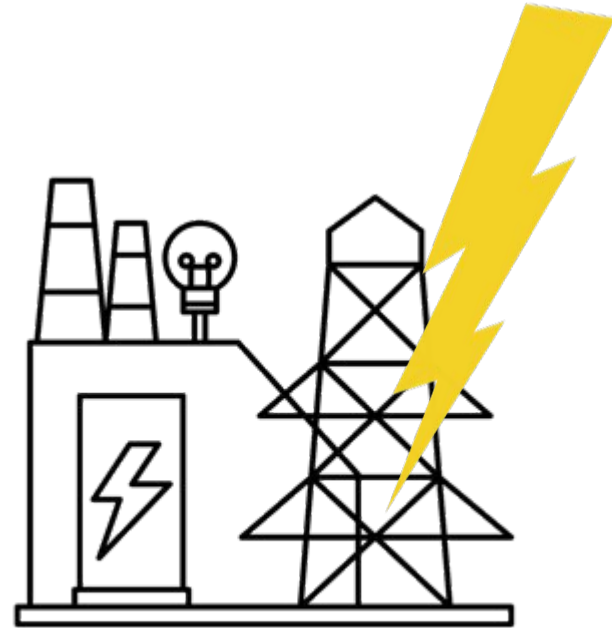
contest.

The Saturday, July 28, 1962, edition of the *Honolulu Star-Bulletin* included an article by Robert Scott (of their staff and also a professor at the University of Hawaii) that reviewed "What Happened on the Night of July 8?" He reported that a City-County streetlight department official in Honolulu attributed blown circuit fuses in nine areas to energy from the bomb.

We deal with EMP all the time



We deal with EMP all the time



**We don't know the modern effects of
EMP.**



In summary

- Radiation is not the boogieman



In summary

- Radiation is not the boogieman
 - You stand a good chance of surviving
-

In summary

- Radiation is not the boogiemán
 - You stand a good chance of surviving
 - Weapons can be delivered in multiple ways
-

In summary

- Radiation is not the boogieman
 - You stand a good chance of surviving
 - Weapons can be delivered in multiple ways
 - You know how EMP works
-