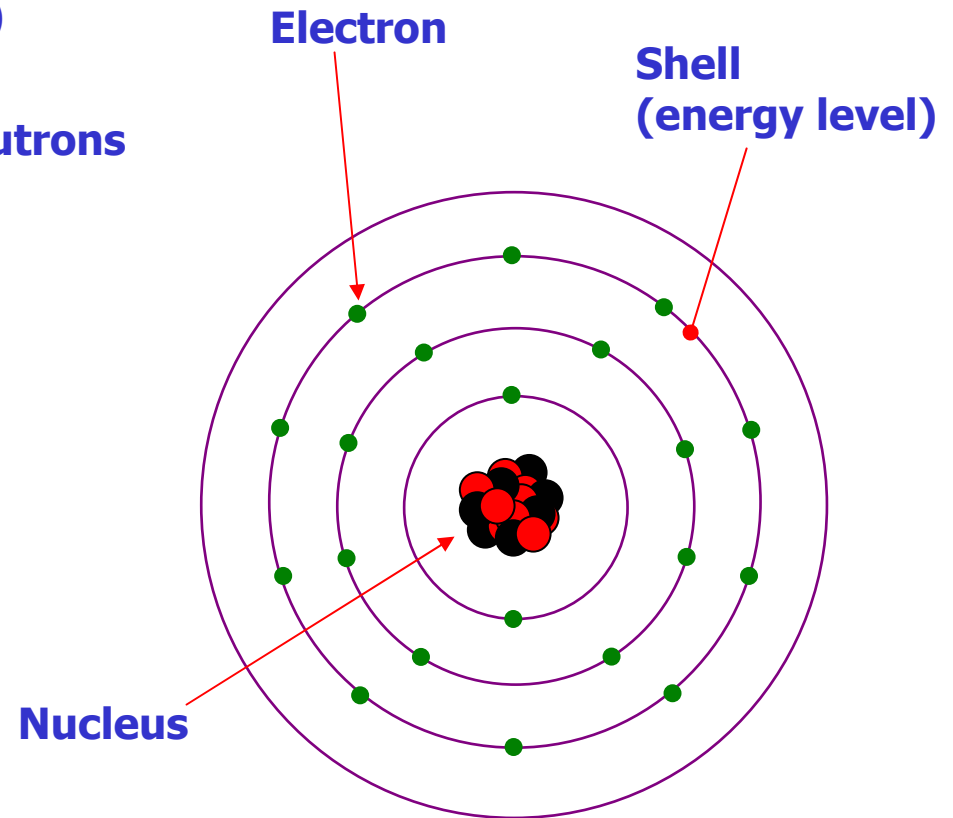
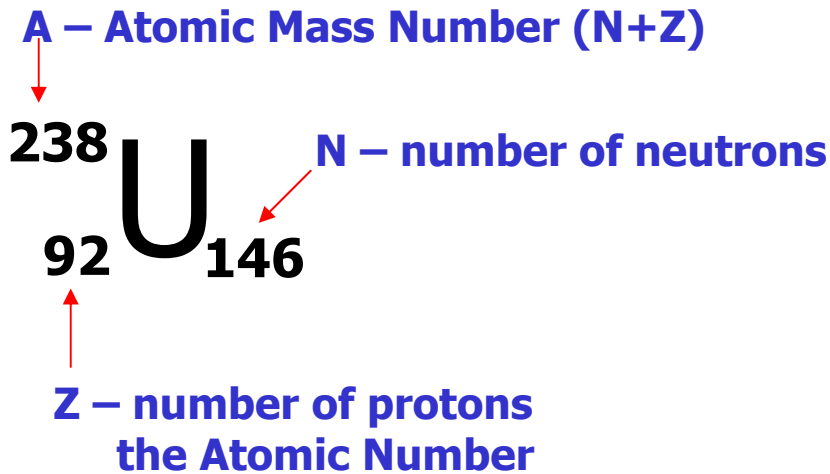


# Refresher on Atomic Structure



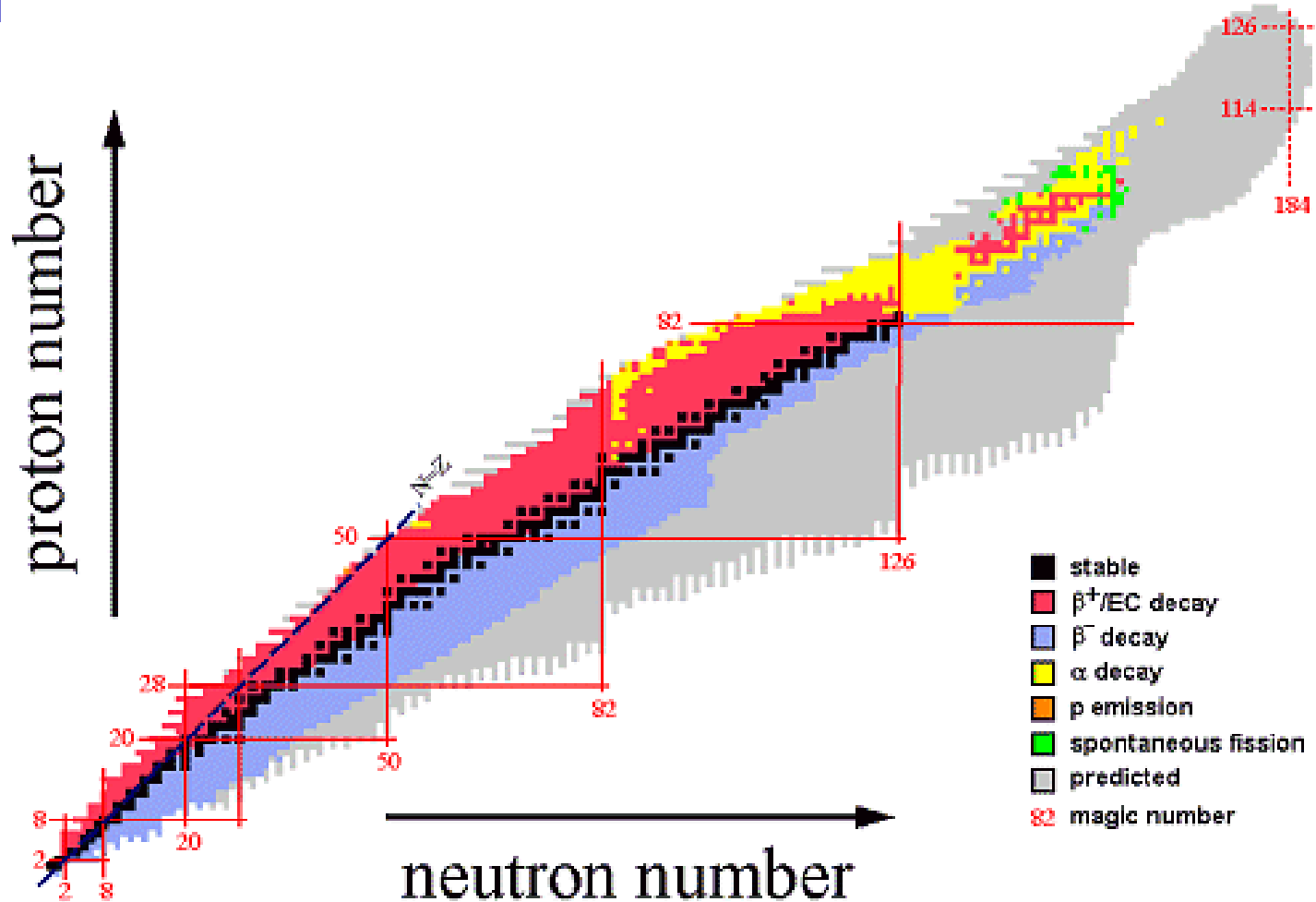


# Stability of the Nucleus

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- 107 known elements: Hydrogen ( $Z=1$ ) to Unnilseptium ( $Z=107$ )
- Many elements exist as different isotopes:  $Z$  is constant but  $N$ , and therefore  $A$ , vary.
- Of the 1600 isotopes in existence 300 are stable (approx).
- Stability is achieved when the optimum proton:neutron ratio exists within the nucleus.
- Unstable nuclei undergo radioactive decay in an attempt to achieve this optimum ratio and become stable.

# Line of Stability & Modes of Decay





# Modes of Decay

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- Alpha
- Beta (+ and -)
- Electron Capture
- Fission
- Proton Emission



# Decay Related Processes

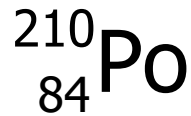
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- Gamma ( $\gamma$ ) Emission
  - Internal Conversion
  - Positron Annihilation
  - Isomeric Transition
- X-ray Emission
  - Auger Effect
  - Bremsstrahlung Production



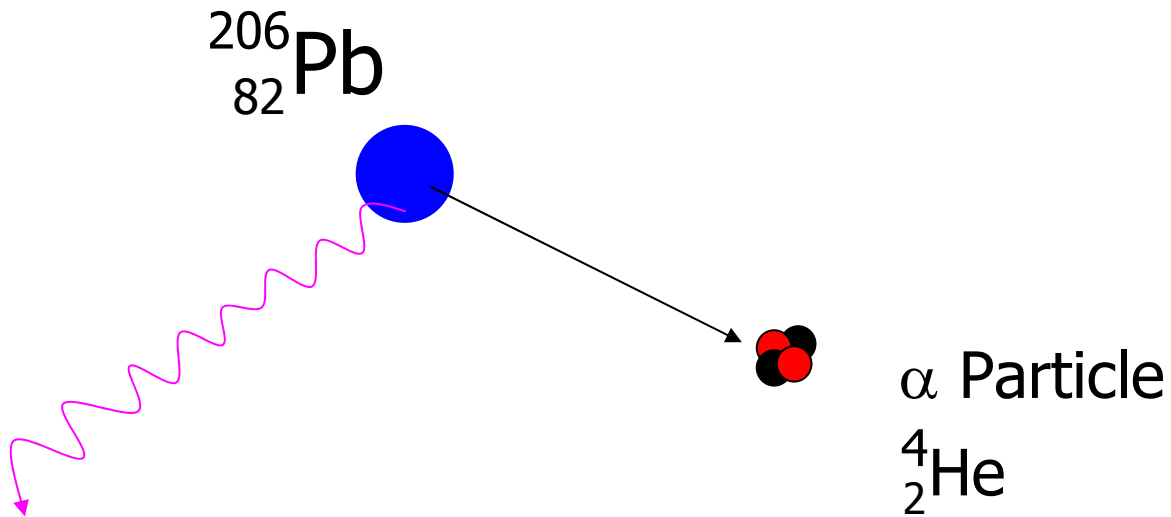
# Alpha Decay $\alpha$

---



Unstable nucleus  
Atomic No  $> 83$

# Alpha Decay $\alpha$

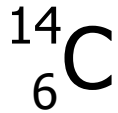


Excited state nucleus sheds excess energy by  $\gamma$  emission



# Beta Decay - $\beta$

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6 Protons

8 Neutrons

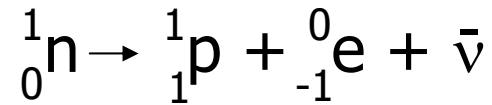
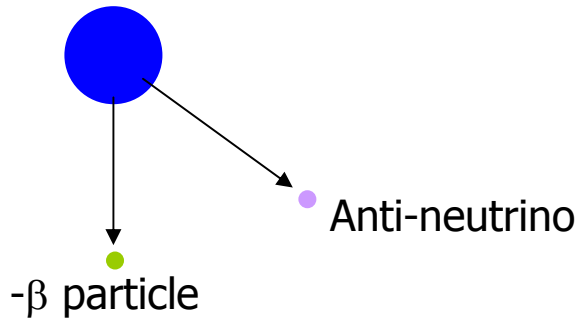
Unstable nucleus

Excess neutrons



# Beta Decay $-\beta$

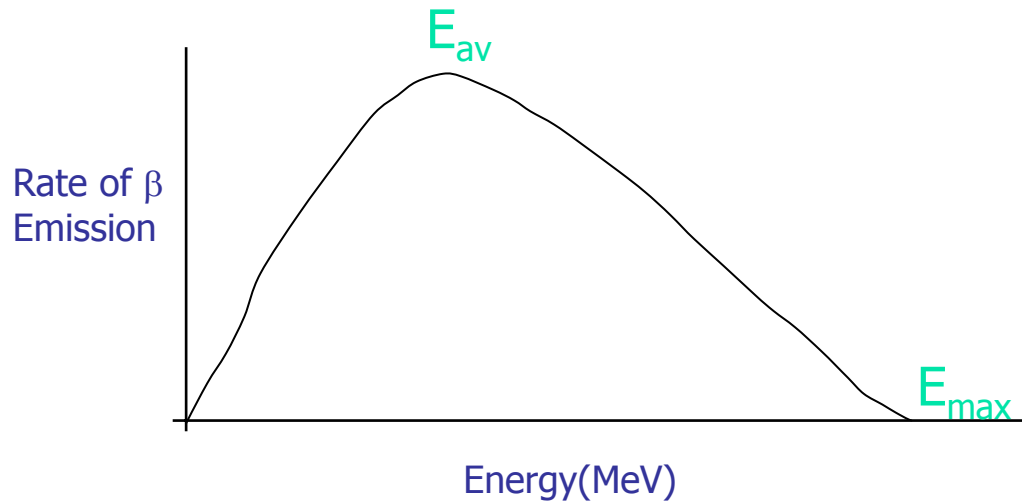
$^{14}_7\text{N}$



7 Protons  
7 Neutrons

Stable nucleus

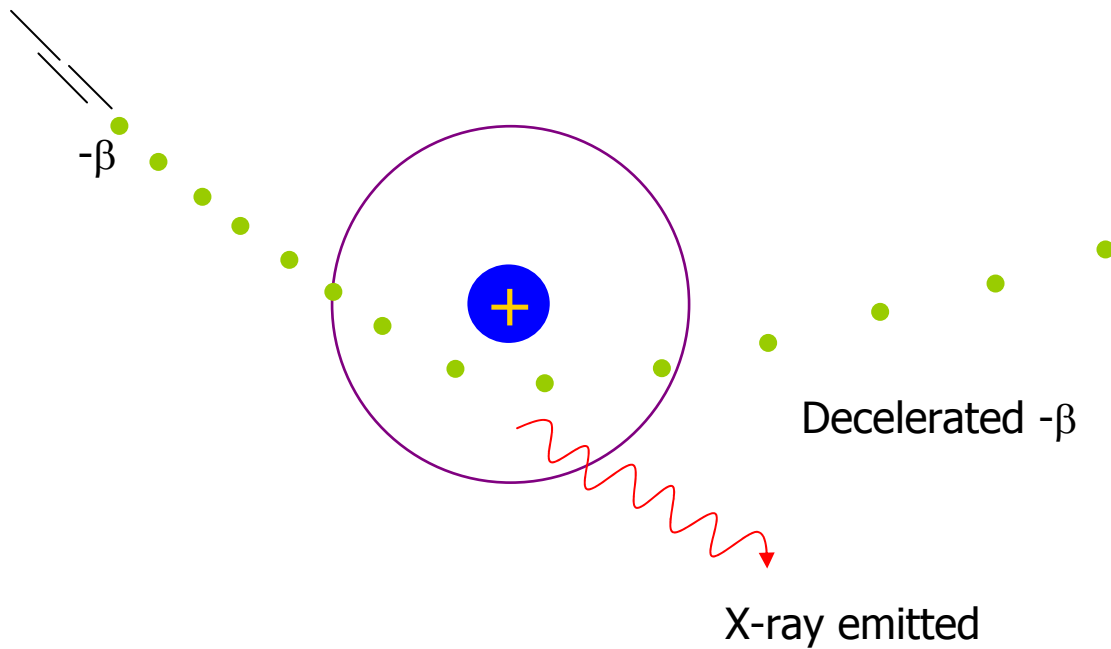
# $\beta$ Particle Energy Spectrum



$$E_{av} = \text{approx } 1/3 E_{max}$$

# Bremsstrahlung

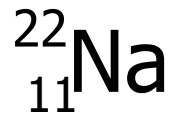
Braking radiation





# Beta Decay + $\beta$

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11 Protons

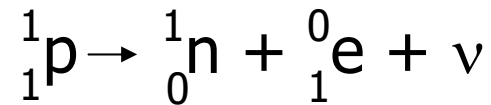
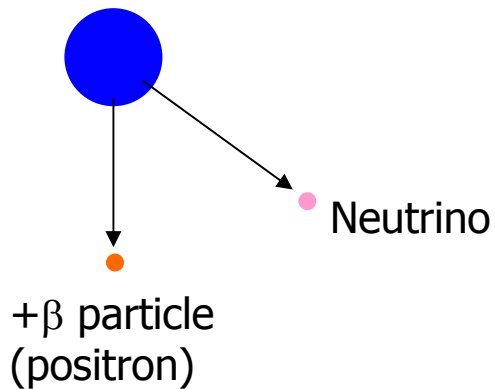
11 Neutrons

Unstable nucleus

Excess protons

# Beta Decay + $\beta$

$^{22}_{10}\text{Ne}$

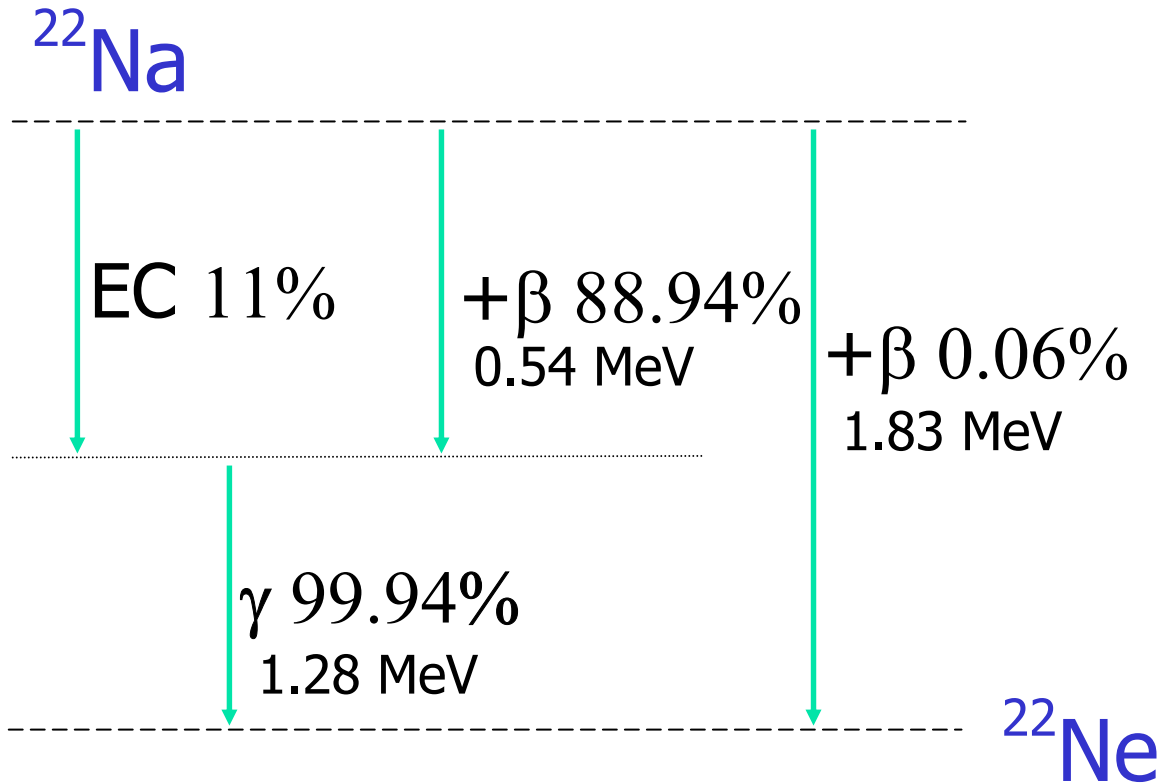


10 Protons

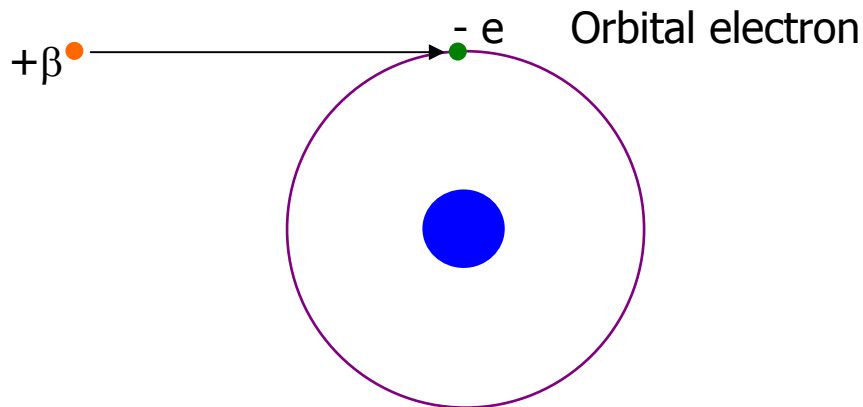
12 Neutrons

Stable nucleus

# <sup>22</sup>Na Decay Scheme



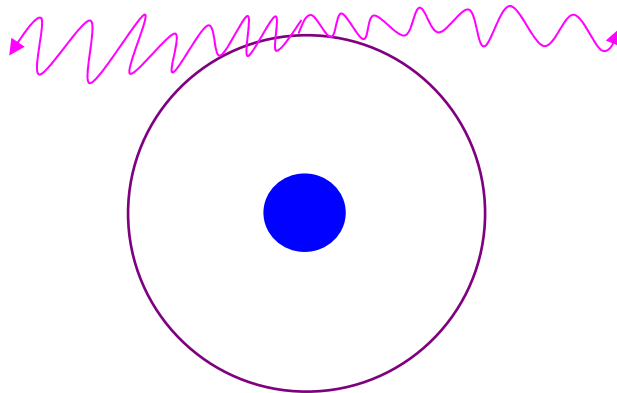
# Positron Annihilation



# Positron Annihilation

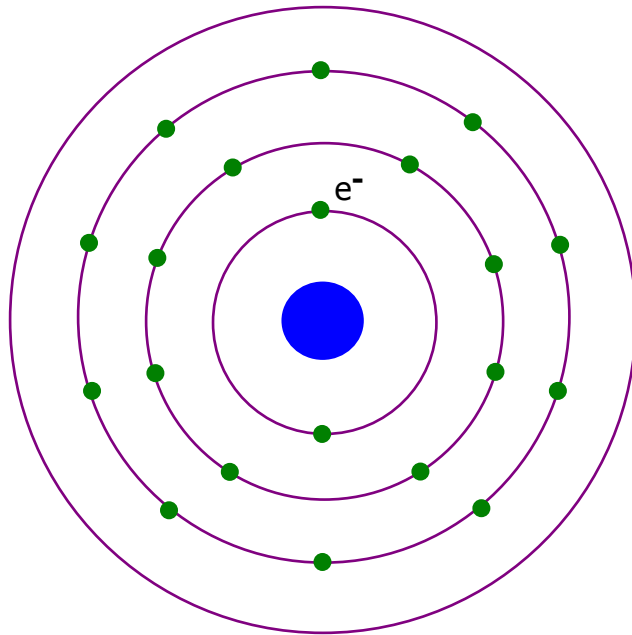
Electron & positron  
are annihilated

Two gamma photons  
are produced (0.511MeV)



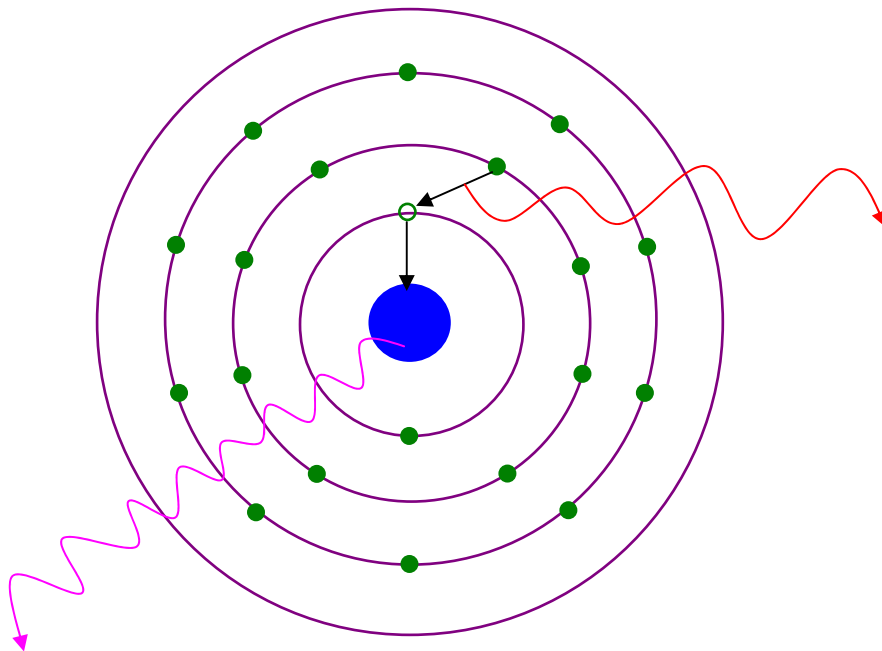
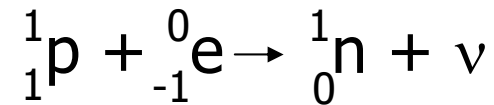


# Electron Capture



Unstable nucleus  
Excess protons  
e.g.  $^{125}_{53}\text{I}$

# Electron Capture

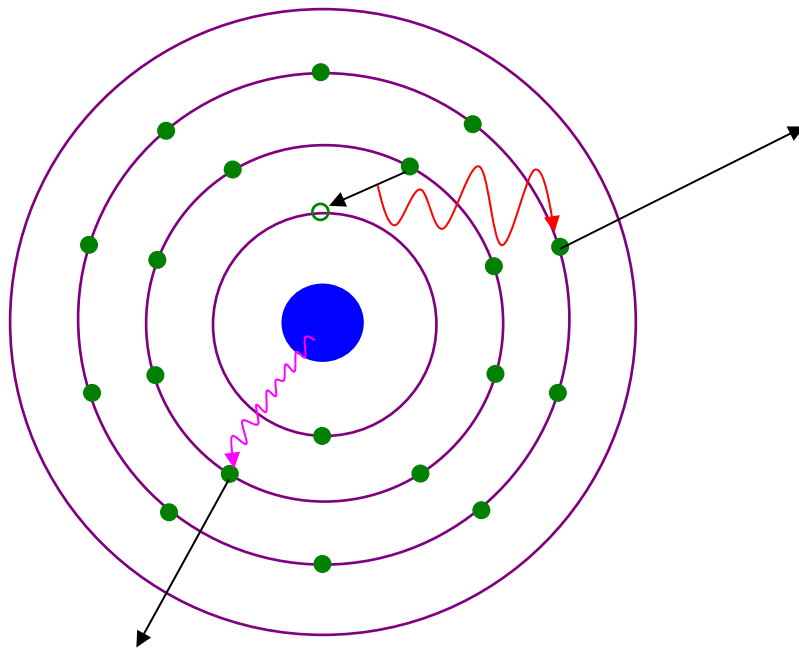


Electrons rearrange to lowest energy state.

X-rays emitted

Excited state nucleus sheds excess energy by  $\gamma$  emission

# Electron Capture



Outer electron ejected  
- the Auger effect

Gamma photon ejects an electron.

Then electrons rearrange to lowest energy state (X-ray emission)  
- Internal Conversion

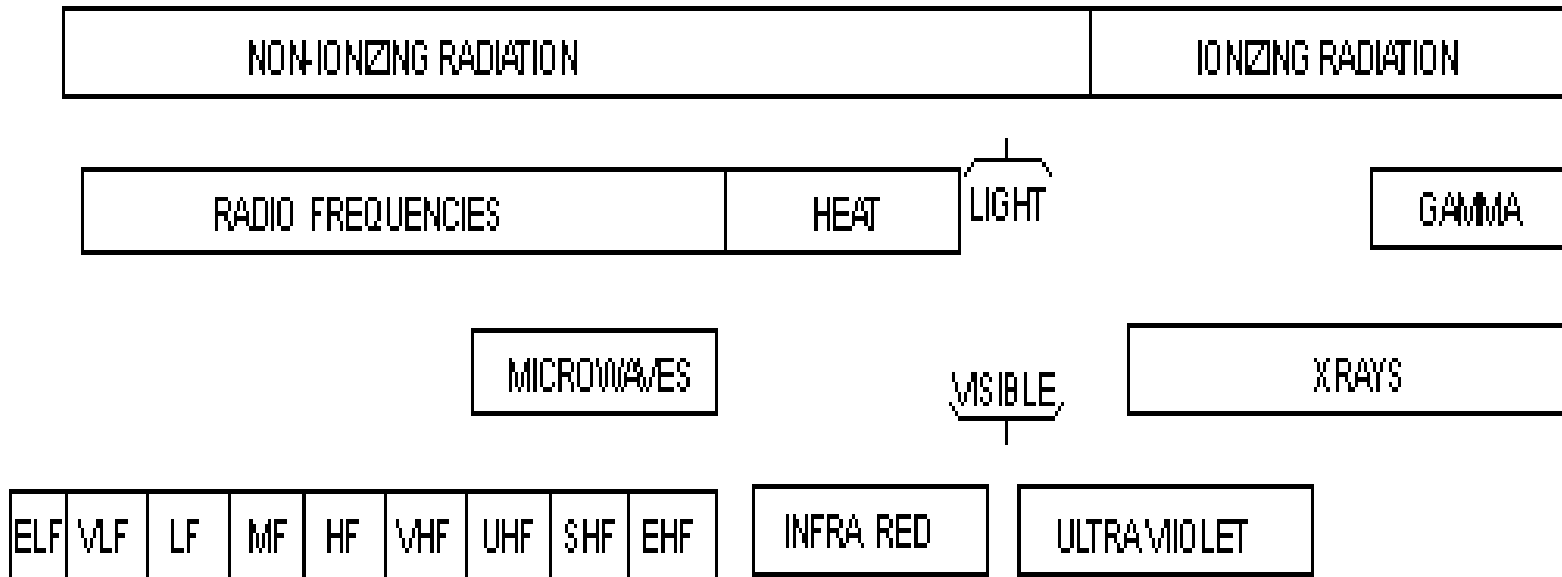


# Notes on $\gamma$ and X-Rays

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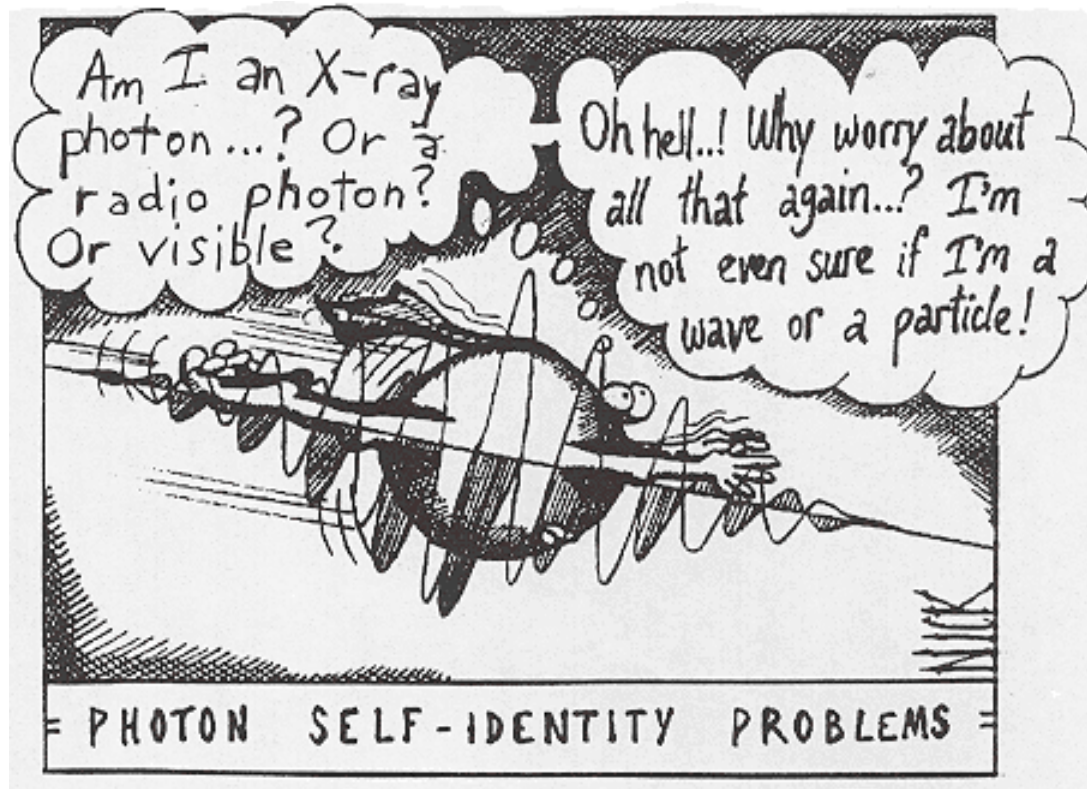
- Both types of electromagnetic radiation (see EM spectrum)
- $\gamma$  has shorter wavelength and higher frequency
- Typically,  $\gamma$  has higher energy
- $\gamma$ -rays originate from the nucleus (except in Positron Annihilation)
- X-rays originate from the electron cloud

# The EM Spectrum



Decreasing wavelength, increasing frequency, increasing energy

# Photon Identity Crisis





# Types of Ionising Radiation

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- Particulate
  - Alpha
  - Beta (+ and -)
- Electromagnetic
  - Gamma
  - X-Ray