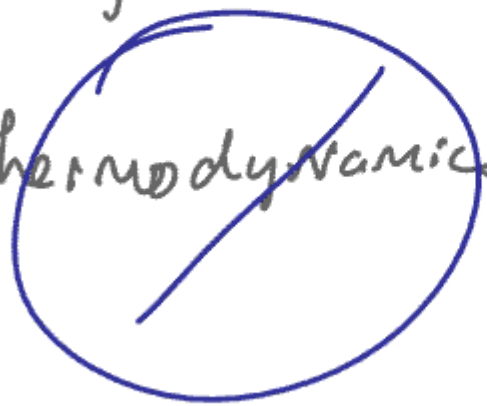
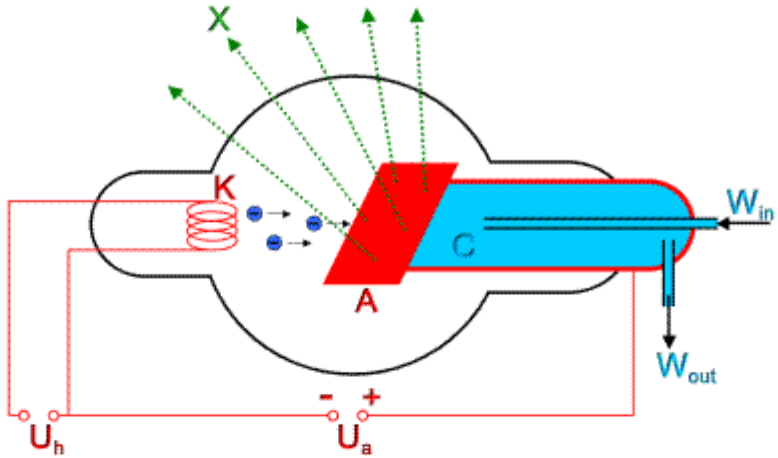
Physics 100 - March 7, 2007

- X-ray and laser reading
- Thermodynamics — for now

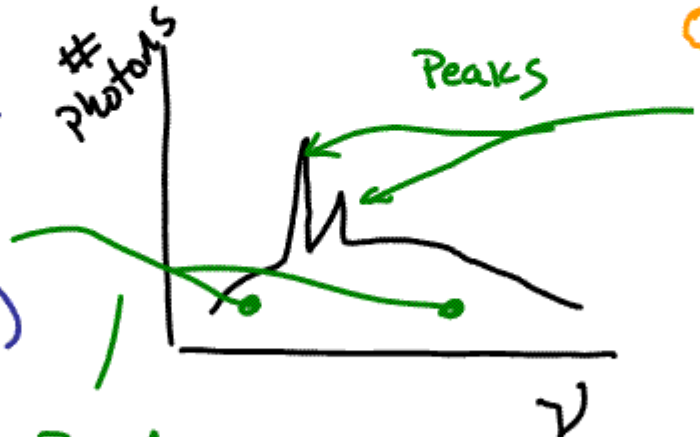


- TA evaluations ... please do

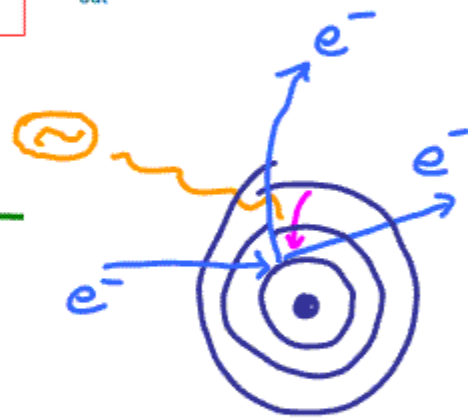
X-rays



electron beam slows down → radiates (Bremsstrahlung)

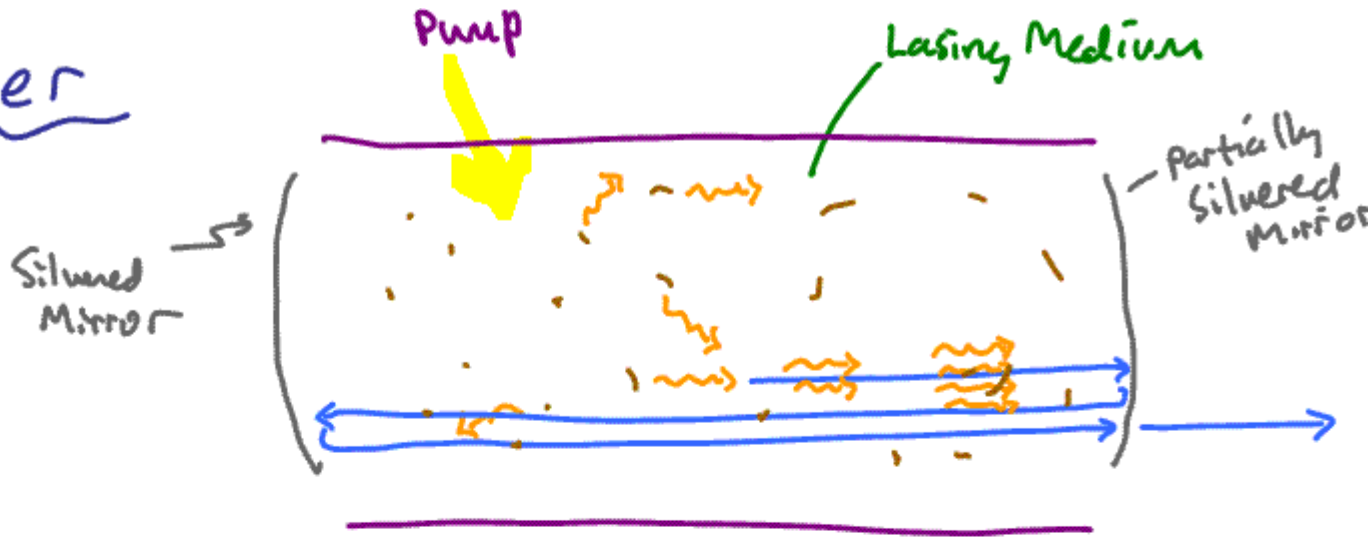


Broad swath of frequencies



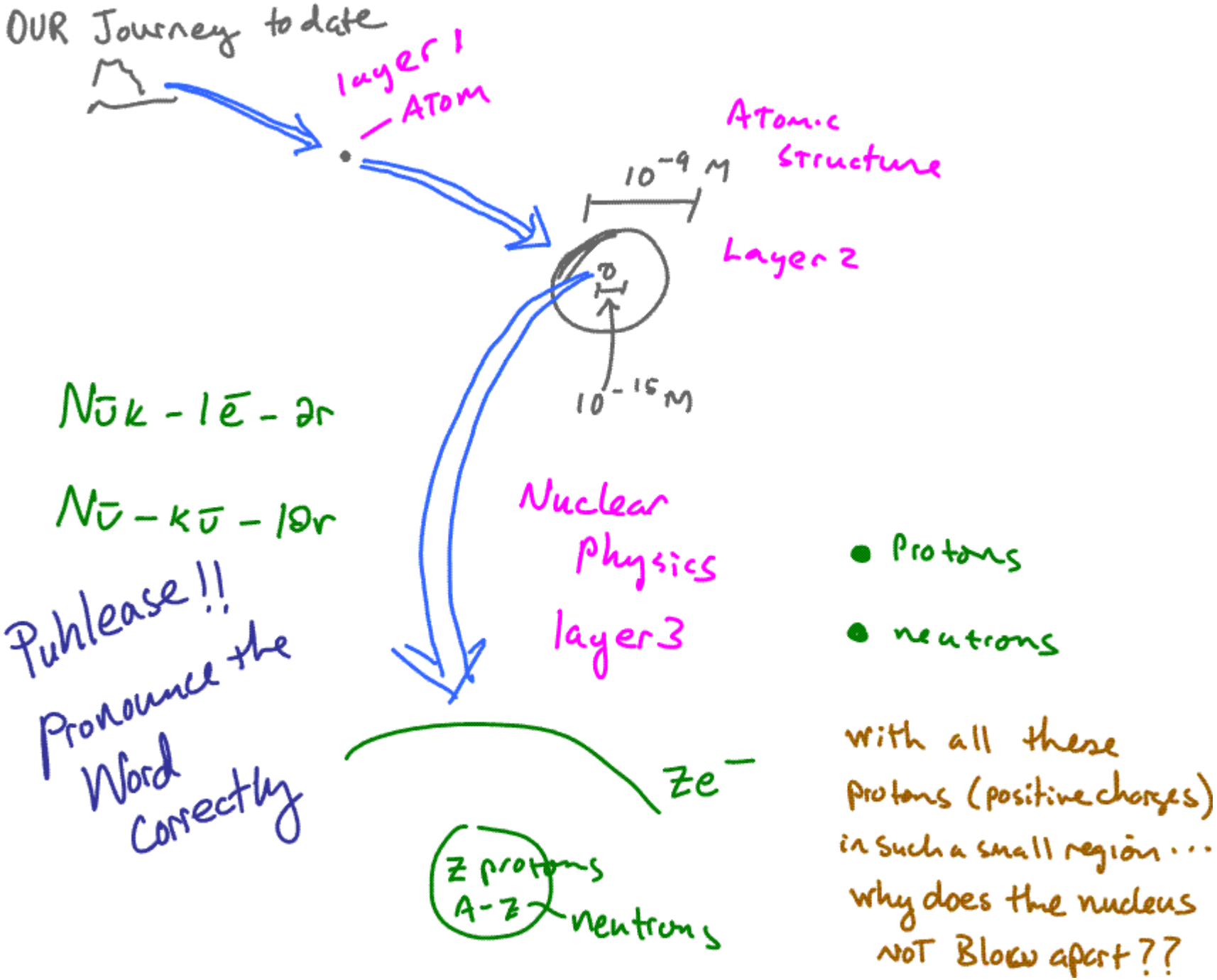
Knock out inner shell e⁻ in large-Z nucleus
outer shell e⁻ cascades down

Laser

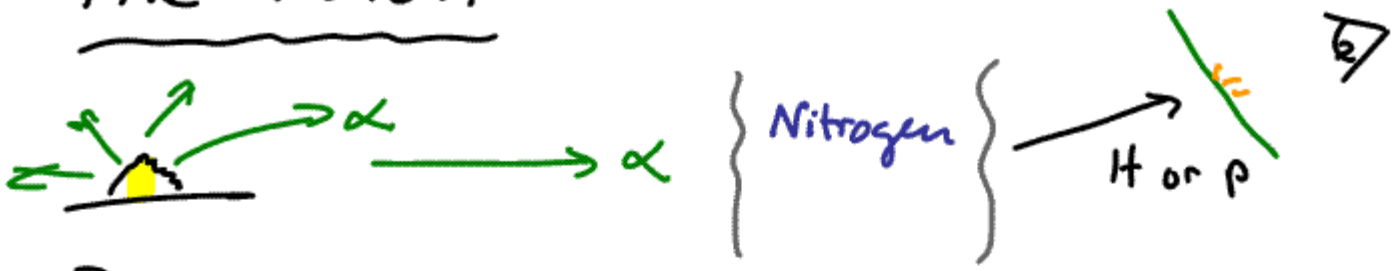


1. Atoms in ground state
2. Pump atoms to higher energy state → Population inversion
   (for example – illuminate with Bright light)
3. Spontaneous emission of light happens
4. Stimulated emission causes "gain" in light
   radiation is coherent

5. Bounces back + forth Many times
   Stimulated emission increased gain
6. Very intense coherent light penetrates partially Silvered Mirror


OUR Journey to date
layer 1
ATOM
Atomic Structure
10^{-9} M
Layer 2
10^{-15} M
Nuclear Physics
layer 3
Nūk - lē - ər
Nū - kū - lər
Puhlease!! Pronounce the Word correctly
Ze⁻
Z protons
A-Z neutrons
• Protons
• neutrons
with all these protons (positive charges) in such a small region... why does the nucleus NOT Blow apart??

The Proton



Rutherford 1918

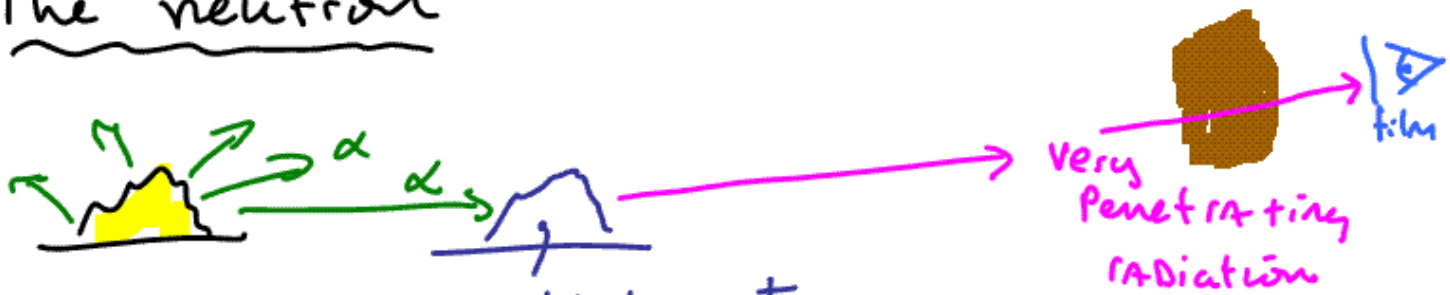
Mass ~ 938 MeV/c^2 = 1 AMU ~ Atomic Mass Unit

Charge = +1

for comparison Mass of electron ~ 0.511 MeV/c^2

Spin = $\frac{1}{2}$ ⟶ Fermion

The neutron



1930 Walther Bothe
H. Becker
(Germany)

1954 Nobel Prize in Physics
"For the coincidence method and his discoveries made therewith"

1932 James Chadwick → 1935 Nobel Prize "For discovery of the neutron"

(England)
Showed this penetrating radiation to NOT be γ-rays
Showed had mass similar to proton and was unchanged

Mass of neutron ~ 940 MeV/c²

electric chg = 0
Spin = 1/2 fermion

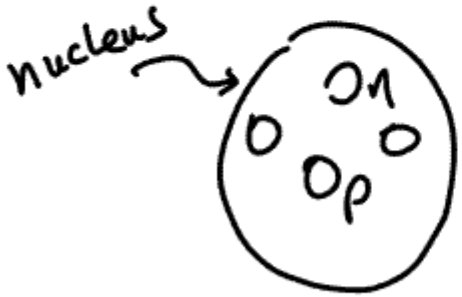
New Attractive force

Strong Nuclear Force

p → ← p

Two protons approach each other → Coulomb repulsion until 10^{-15} m distance

then New Attractive force kicks in and they stick together

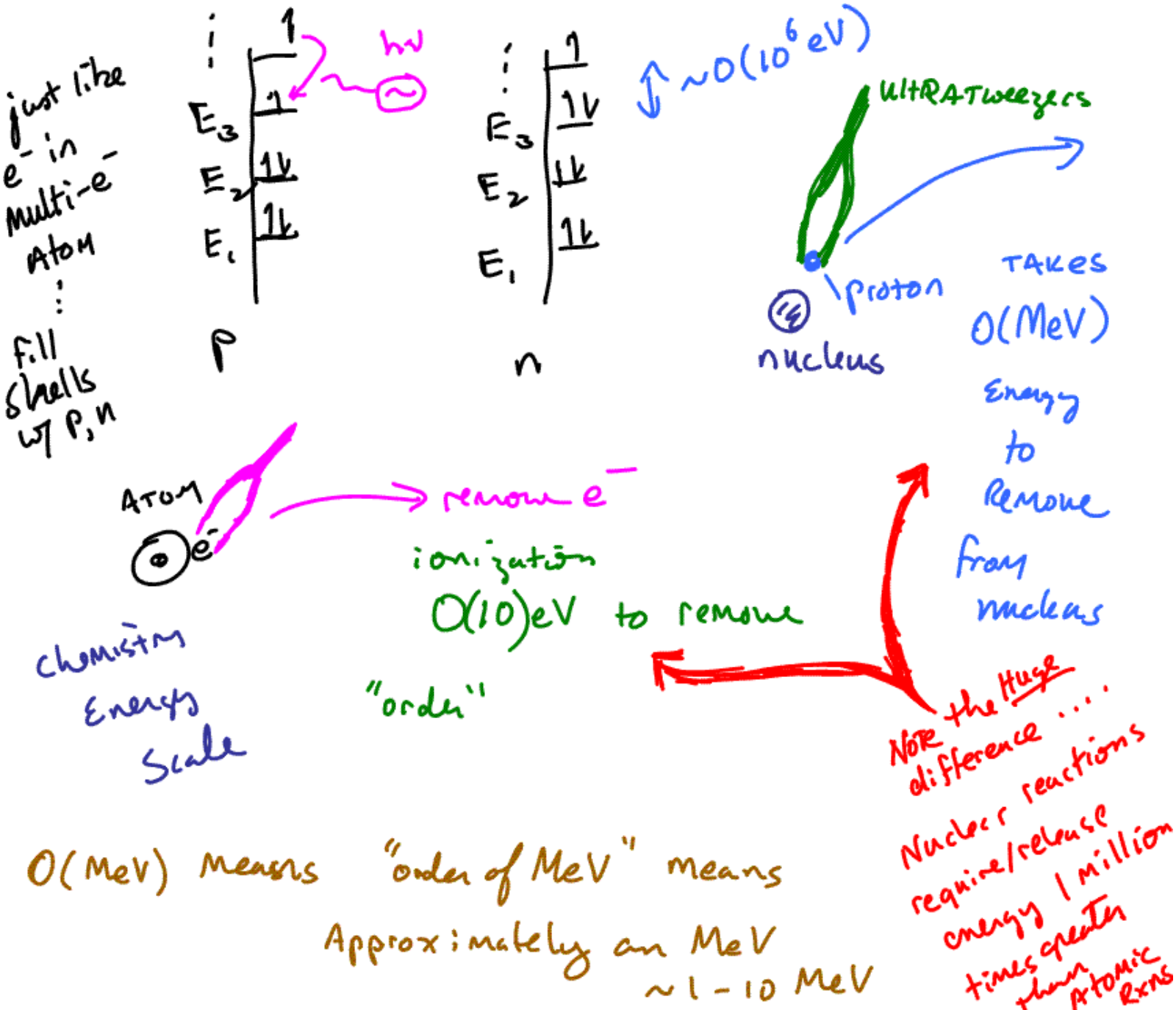


Solve Schrödinger eqn

→ discrete Available energy level (just like the atom!)

p, n ≡ collectively called "nucleons"

Populate "Nuclear" orbitals w/ n, p


just like e⁻ in multi-e⁻ Atom
fill shells w/ p, n
E_3
E_2
E_1
1
1
1
1
1
1
hν
p
n
$\updownarrow \sim O(10^6 eV)$
ULTRATweezers
proton
nucleus
TAKES
O(MeV)
Energy to Remove from nucleus
Atom
e⁻
remove e⁻
ionization
O(10)eV to remove
chemistry Energy Scale
"order"
NOR the Huge difference ....
Nuclear reactions require/release energy 1 million times greater than atomic Rxns
O(MeV) means "order of MeV" means
Approximately an MeV
~1 - 10 MeV

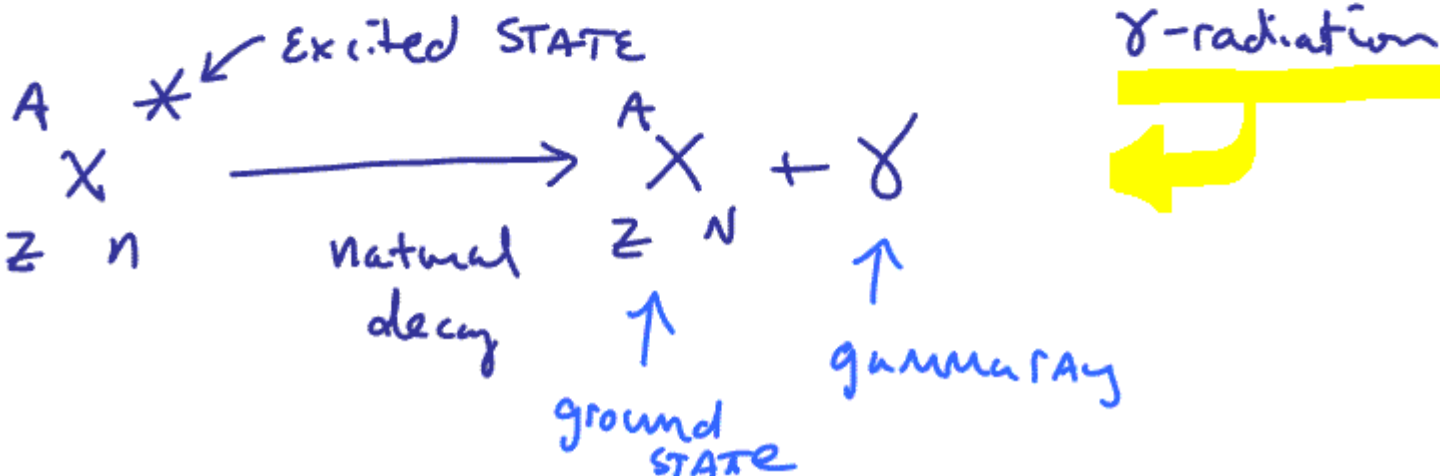
nuclei Symbolized as

X ≡ Atomic Element Symbol
determined by Z

Z ≡ # protons

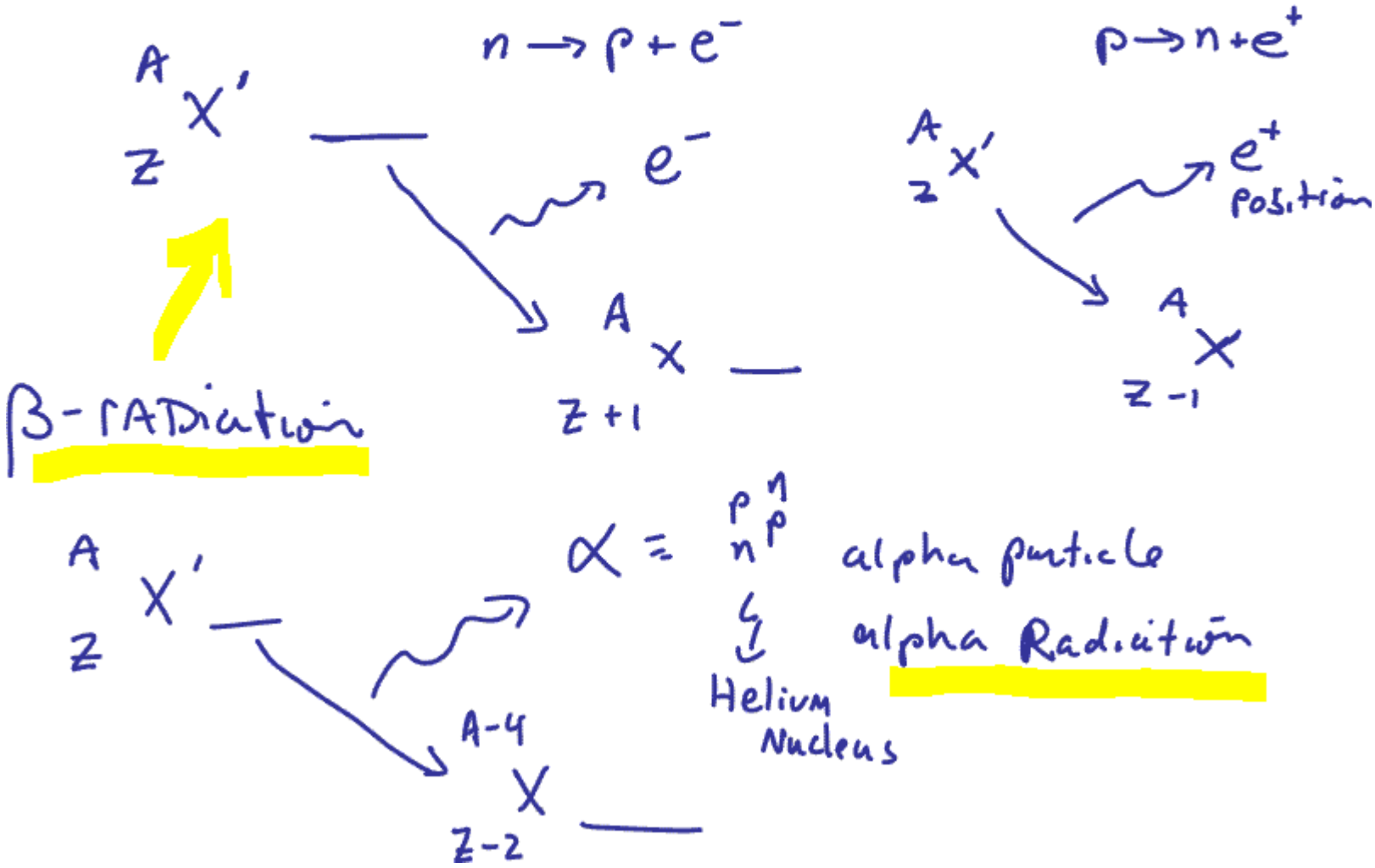
A ≡ ATomic Mass = # p + # n

N = # neutrons



Naturally radioactive substance

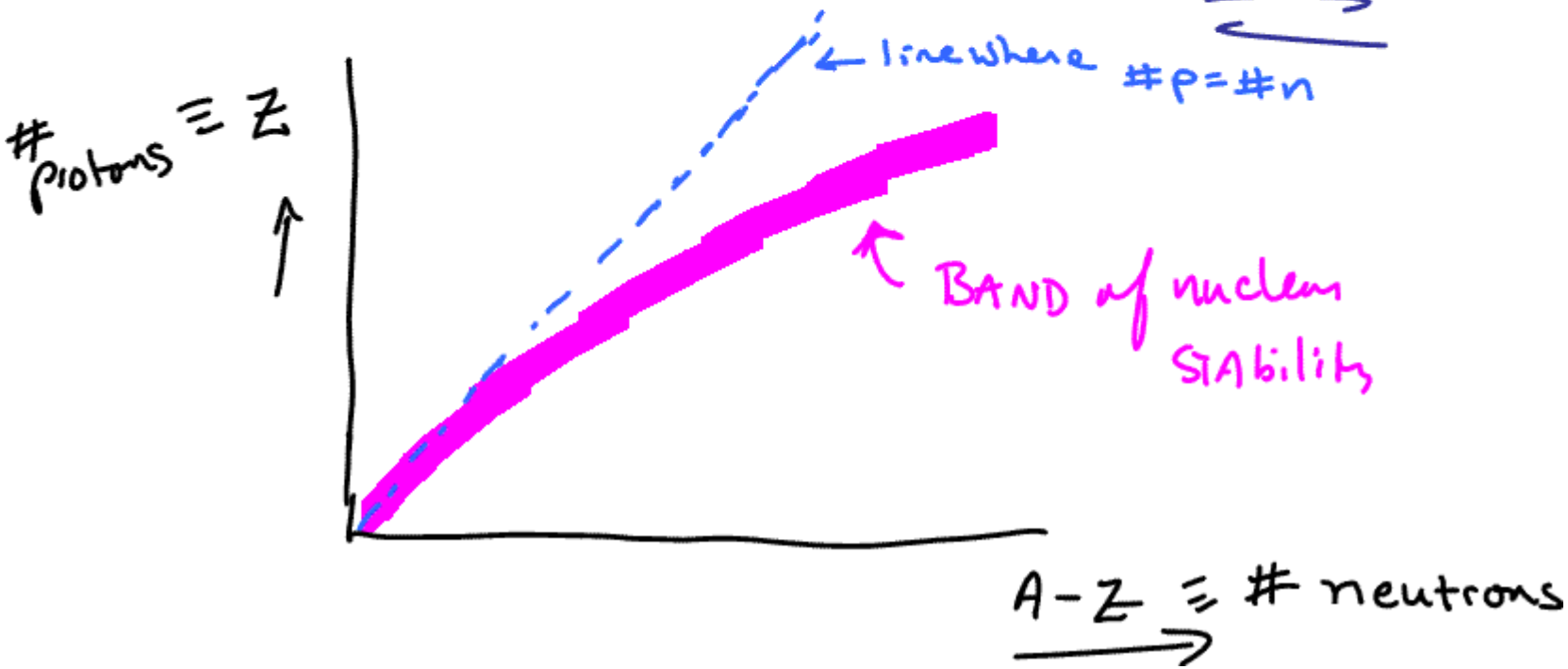
$E = mc^2$



$Z \equiv$ # protons → defines chemistry

neutrons can vary

same Z, diff # neutrons → isotopes



Different nuclei → different numbers of p and n

↳ different nuclear shell structures

Stable nuclei

naturally radioactive → characteristic decay times

decay time characterized

$t_{1/2}$ = half-life ≡ time it takes for ½ atoms in a given sample to decay

units of time

$$\text{activity} = \frac{\Delta N}{\Delta t} \equiv \#\text{decays} = \lambda N$$

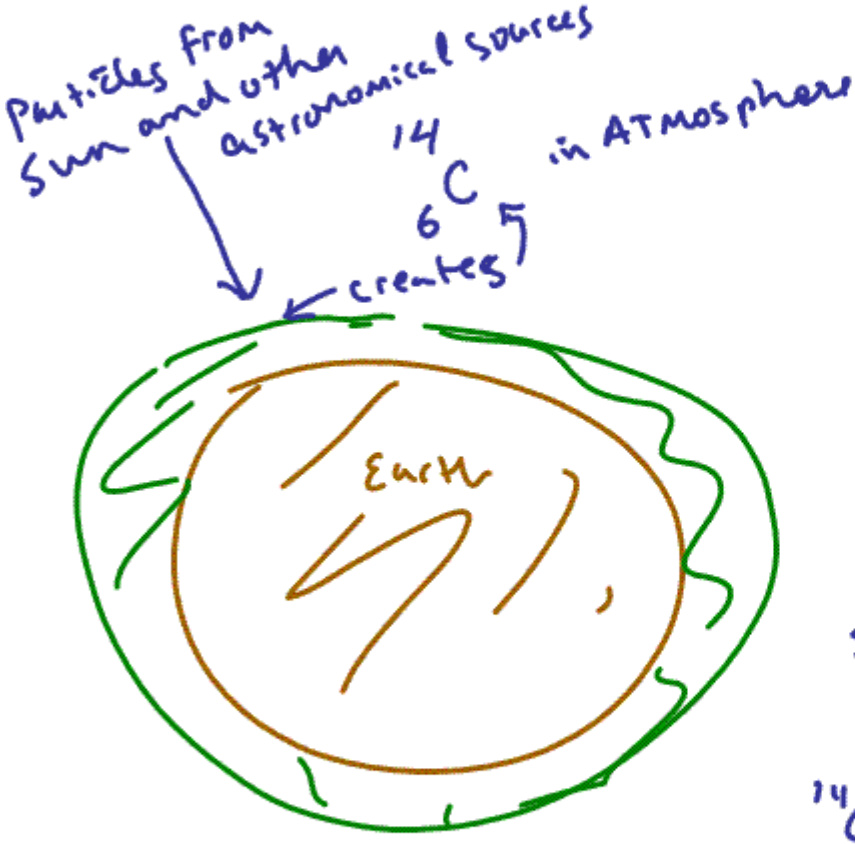
λ ≡ units of $\frac{1}{s}$

λ: decay constant

N: # atoms in sample

$$t_{1/2} = \frac{.693}{\lambda}$$

Radioactive Dating Techniques

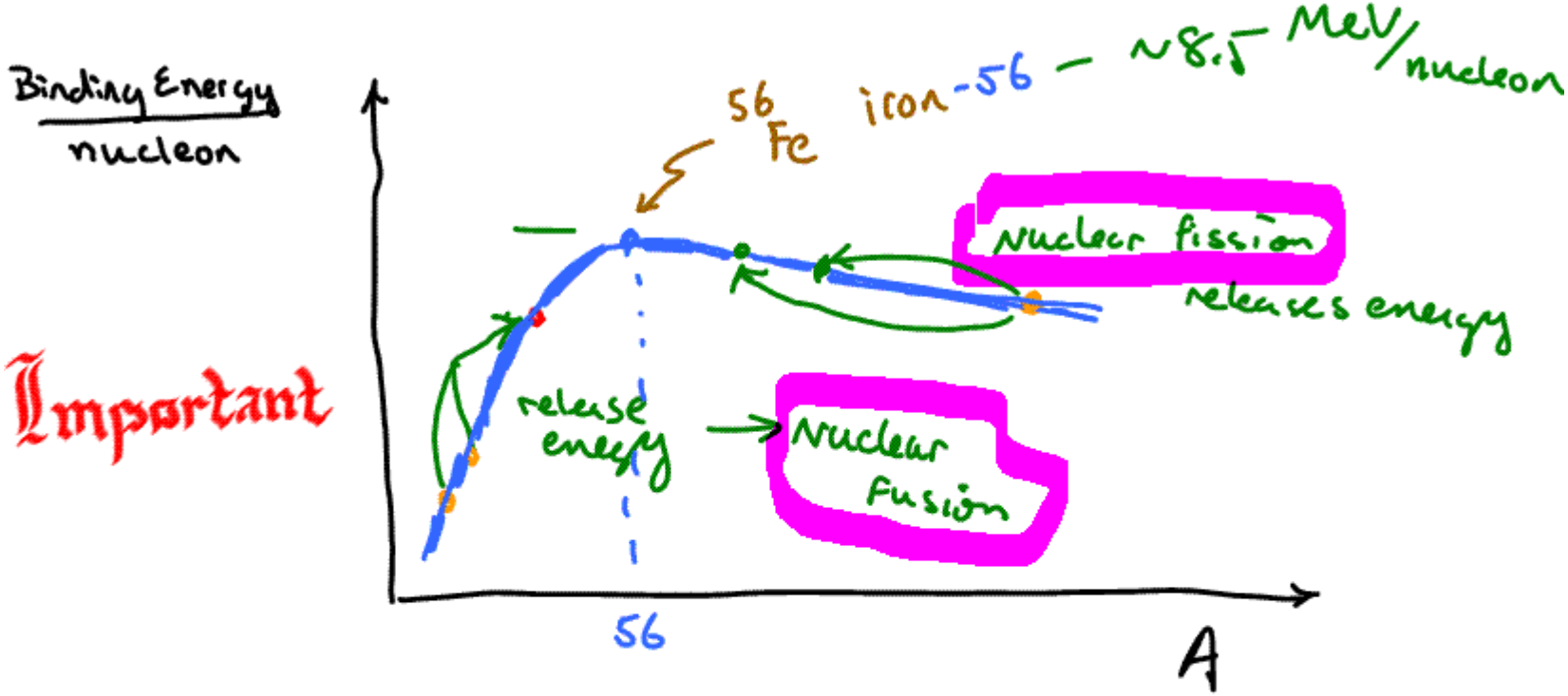


$t_{1/2}$ of ^{14}C = 5730 years

^{14}C naturally decays is incorporated into living bodies. When something dies the incorporation of new ^{14}C stops.

^{14}C in dead material slowly decays

Measure Amount of ^{14}C in sample provides a measure of time since death.



Important

$$^{235}_{92}U + n \rightarrow {}^{93}_{37}Rb + {}^{141}_{58}C + 2n$$

cascade γ γ γ