Physics 114 - May 2, 2006

- Exam 3 Status

- Final Exam

  May 10 7:15 pM
  → 10:15 pM

  Lower Strong

Oh no! It's my last physics class.

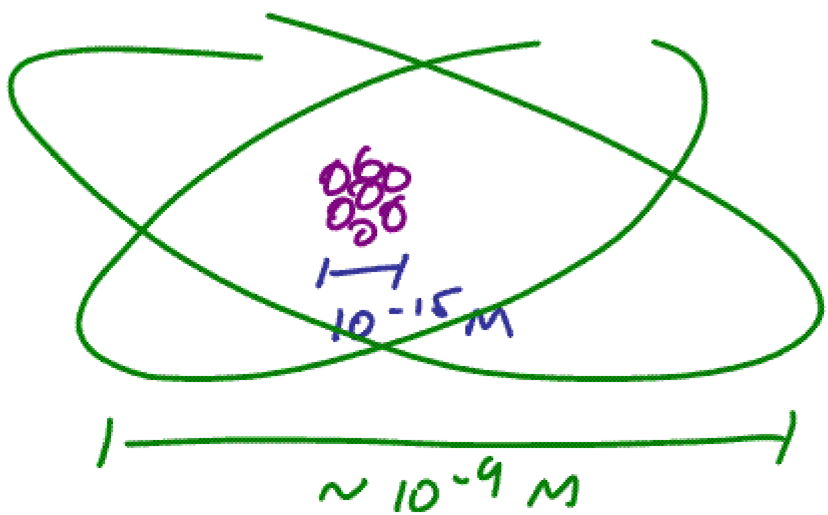
- Calculator ok, $\boxed{1}$ non-Topologically-enhanced 8.5x 11 inch sheet of formulas / Examples
- Q + A session Time/Loc. TBA
- Cumulative, like 2 term exams, 30-40% New material

- Problem Set 14 + Solns Posted on web

- Project Grades

- Grade info endgame

Last Time – Nuclear Physics



Strong Nuclear Force

↳ whatever that is ...

Nuclear density CONSTANT and Very, Very Big

$10^{17}\ kg/m^3$

Fermions

p, n

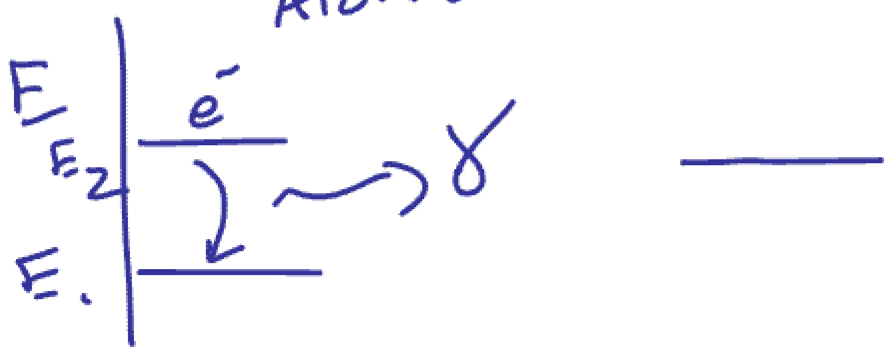
fill w/ ⇒ Nuclear shell structure

$\Delta E \sim MeV$

Get discrete energy levels similar to ATOM p, n exist in allowed states

- n energy
- l orb. Ang. Momentum
- m z comp
- s spin Ang Mom

ATOM



$A \equiv$ Atomic Mass

$^{A}_{Z}X_{N}$ $\quad Z \equiv$ Atomic # $\longrightarrow$ # protons

$N \equiv A - Z =$ # neutrons

Z electrons

$${}^{A}_{Z}X^{*} \longrightarrow {}^{A}_{Z}X + \gamma$$

keV

MeV

γ transform

$$E = mc^2$$

Mass units MeV/c^2 Energy unit

$$M_{electron} = 0.511\ \mathrm{MeV}/c^2$$

$$M_p \approx 938\ \mathrm{MeV}/c^2$$

$1000\ \mathrm{MeV} \equiv \mathrm{GeV}$

$$ {}^{A}_{Z}X' \longrightarrow {}^{A}_{Z+1}X + e^- $$

β-ray emission

$${}^{A}_{Z}X' \longrightarrow {}^{A-4}_{Z-2}X \; + \; {}^{4}_{2}He$$

α-particle

α radiation

Same Z, different A ≡ isotopes
#'s of neutrons

Binding Energy in Nucleus

BE in H Atom

$$m_e c^2 + M_p c^2 = M_H c^2 + 13.6\,\text{eV}$$

$$(A-Z)m_n c^2 + Z m_p c^2 = M_x c^2 + \text{Tot Nuc. B.E.}$$

m_H $\qquad$ AT

$- Z\cancel{m_e}c^2$ $\qquad$ $\cancel{-Zm_ec^2}$

CAN use ATOMIC masses + ignore me + BE ok

$$^{56}Fe \longrightarrow 52103.5 \ MeV/c^2$$

$Z = 26$

$A-Z = 30$

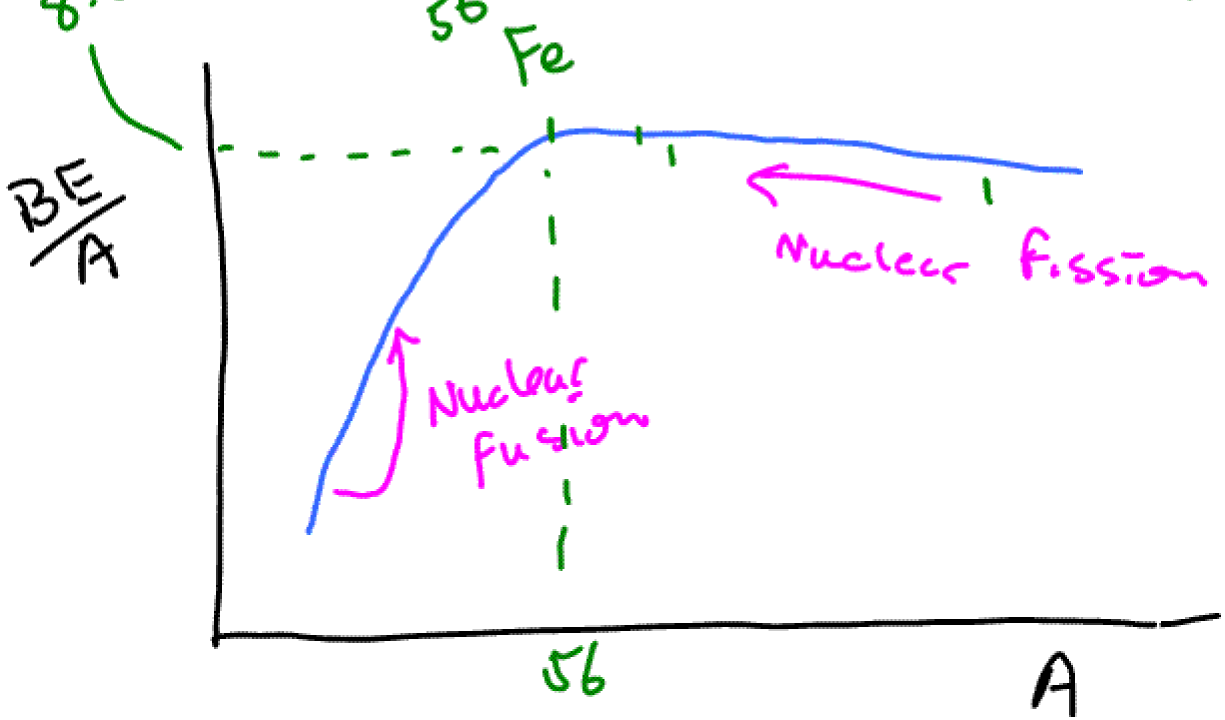
$$(BE)_{^{56}Fe} \left[(30)(939.57) + (26)(938.791) - 52163.5\right]$$

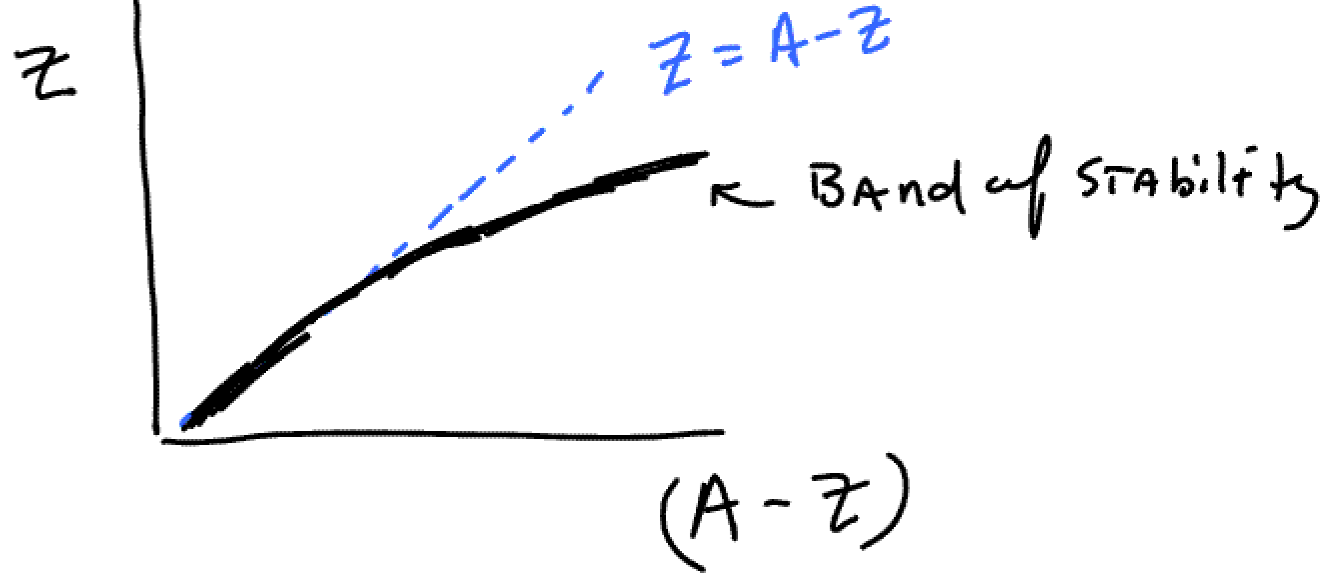
$M_H = 938.791 \ MeV/c^2 \qquad m_n = 939.57 \ MeV/c^2$

$$(BE)_{^{56}Fe} = 492.2 \text{ MeV}$$

$$\text{Binding Energy}/\text{Nucleon} = \frac{492.2 \text{ MeV}}{56}$$

$$= 8.79 \text{ MeV}/\text{nucleon}$$





naturally radioactive

sample N nuclei type X

$$\frac{dN}{dt} \propto N \qquad \boxed{\frac{dN}{dt} = -\lambda N}$$

decay constant
units $\frac{1}{\text{Time}} = s^{-1}$

$$\frac{dN}{dt} \equiv a \equiv \text{Activity}$$

$$\frac{dN}{dt} = -\lambda N$$

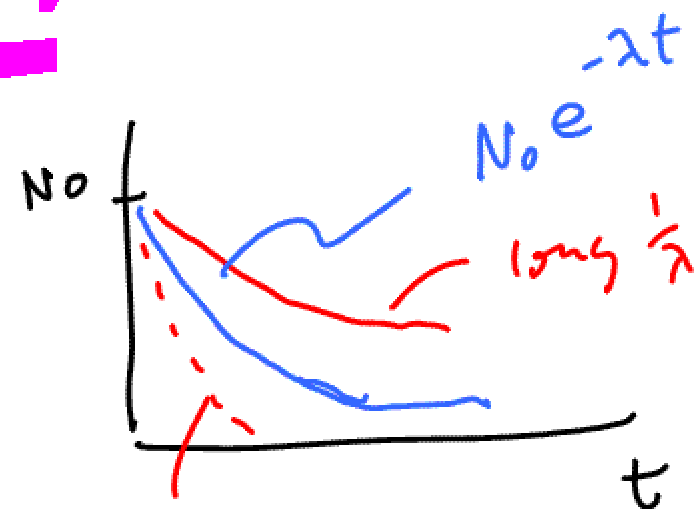
$$\frac{dN}{N} = -\lambda dt$$

$$\ln N = -\lambda t + c$$

$$\boxed{N = N_0 e^{-\lambda t}}$$

$N(t)$

Exponential law of radioactive decay



$$\lambda N = \underbrace{\lambda N_0}_{} e^{-\lambda t}$$

Activ at time t

init Activity

Activity

decays/sec

Meas. in Curies

$$1 \text{ Curie} = 3.7 \times 10^{10} \text{ dec.}/s$$

mCi or μCi

Half life as time it takes for Activity to drop by factor of 2

$T_{1/2}$

$$a = a_0 e^{-\lambda t}$$

$$\frac{1}{2} a_0 = a_0 e^{-\lambda T_{1/2}}$$

$$\boxed{T_{\frac{1}{2}} = \frac{1}{\lambda} \ln 2 = \frac{0.693}{\lambda}}$$

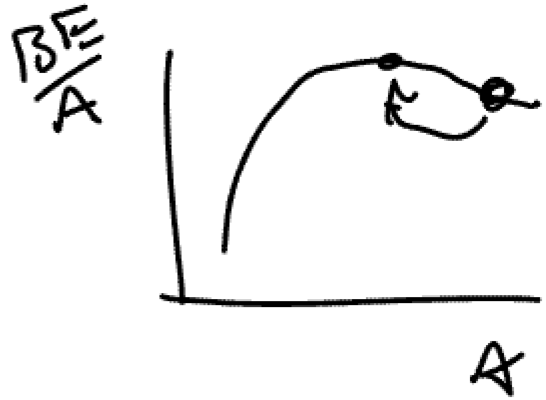
Nuclear Fission

$$^{235}_{92}U + n \longrightarrow {}^{93}_{37}Rb + {}^{141}_{58}Cs + \underline{\underline{2n}}$$

γ

γ

200 MeV in energy



\# neutrons released

START new fusion rxns

$\ll 1$ NO rxn

$= 1$ critical

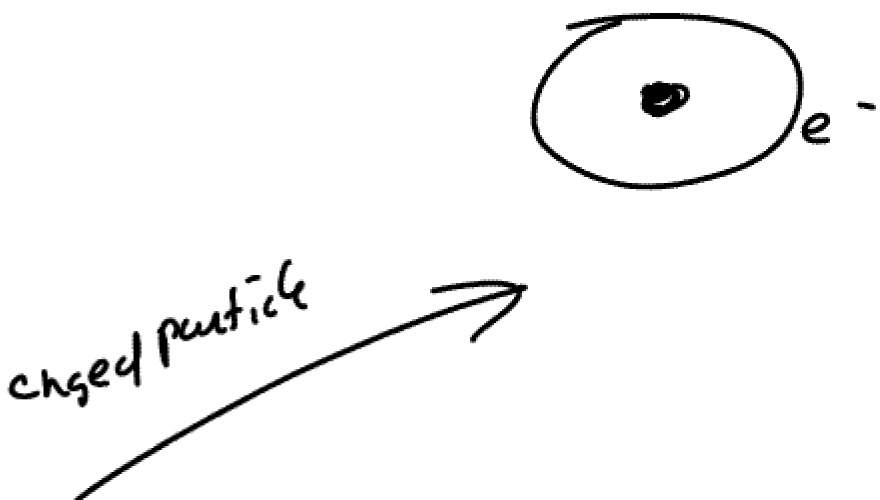
$\gg 1$ BOOM

$^{235}U \sim 0.7\%$

$^{238}U \sim 99.3\%$

Charged Particles

interact w/ matter through ionization



ionizes Atoms

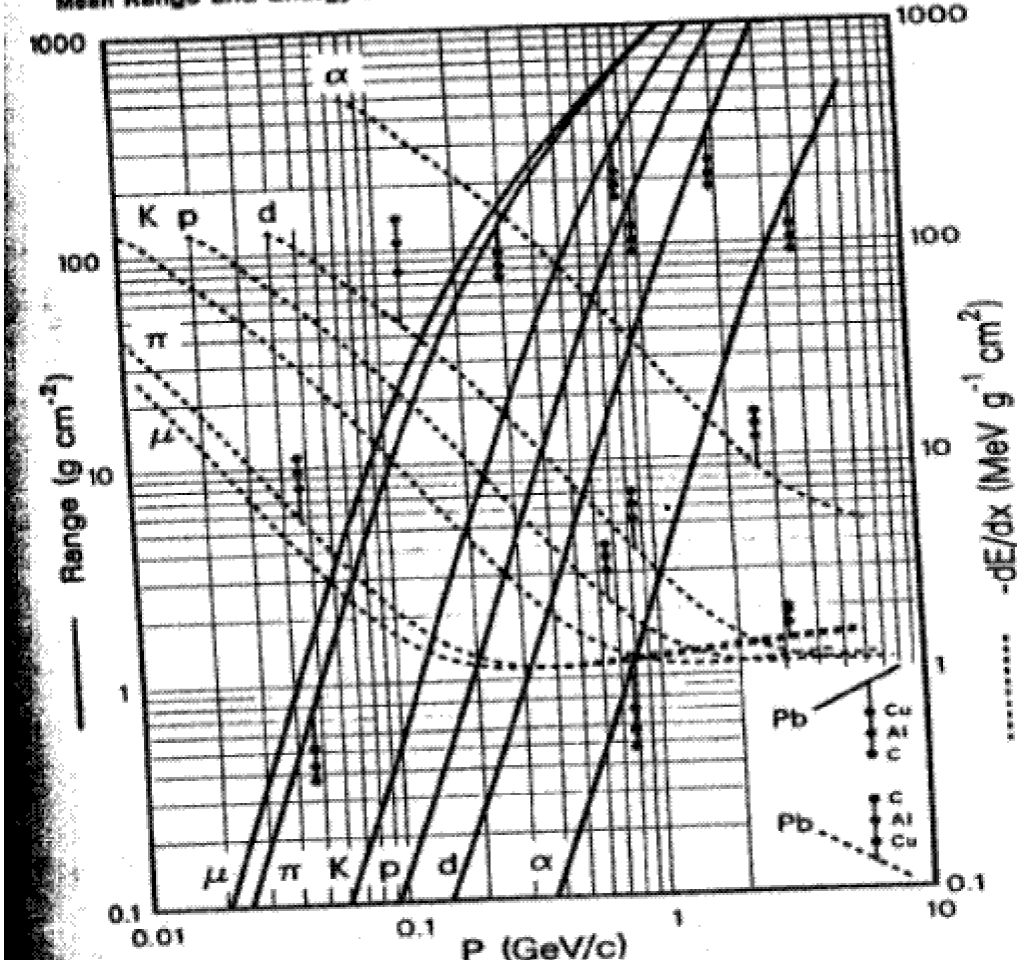
loses energy

range and energy loss per cm depend on the mass and momentum of particle

Figure 2.3 Mean range and energy charged particles in solids. Calculations use the Bethe–Bloch equation with density effect corrections. Refer to the cited reference for a discussion of assumptions and qualifications. (Particle Data Group, Rev. Mod. Phys, 56: S1, 1984.)

PARTICLE DETECTORS, ABSORBERS, AND RANGES

Mean Range and Energy Loss in Lead, Copper, Aluminum, and Carbon

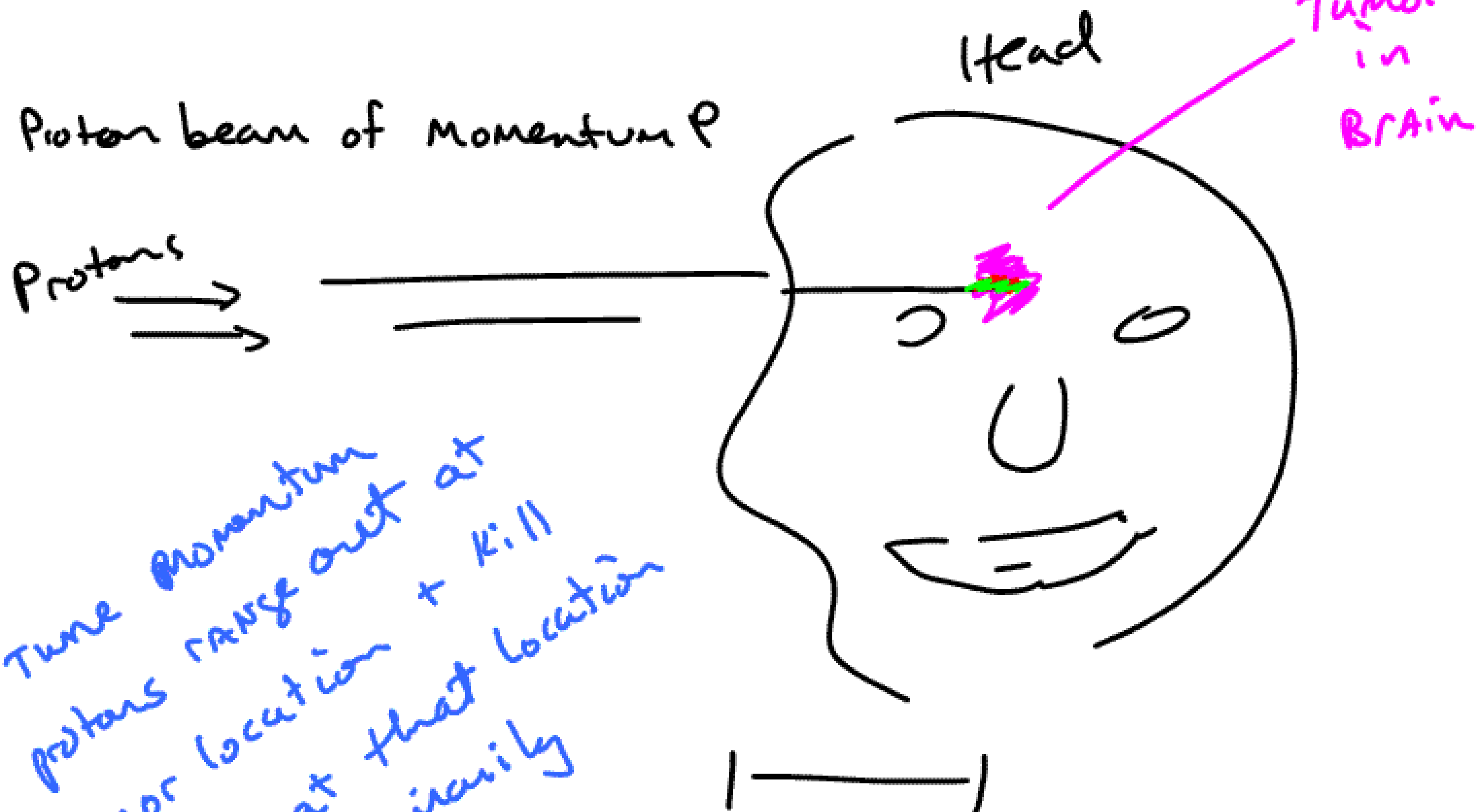


get range in cm when mult by density

Energy loss in material per cm in strange units

Mult. by density to get MeV/cm

CAN use this



range of protons of momentum p

CAN Tune momentum so protons range out at tumor location + kill tissue at that location primarily

ionization energy loss greatest when proton almost stops ... Energy deposition and tissue destruction greatest at end of path