

# Physics 100 - March 23, 2009

## Presentations

groups  
formed

| Group | topic                               |
|-------|-------------------------------------|
| A     | Nuclear physics and society         |
| B     | String theory                       |
| C     | Global Positioning System           |
| D     | Search for extra-terrestrial life   |
| E     | Music                               |
| F     | Life and times of a great physicist |
| G     | Radiation - dangers and uses        |

Bombs  
Power  
Terrorism

Some  
Similarity

I was missing preferences from seven of you.  
Let's get that squared away so we can  
make final participant lists

Last Time

# Nuclear Physics

Strong Nuclear force

range of  $\sim 10^{-15}$  m

much stronger than electromagnetic force

Strong Attractive nuclear force

+

Quantum Mechanics  
(Schrödinger equation)



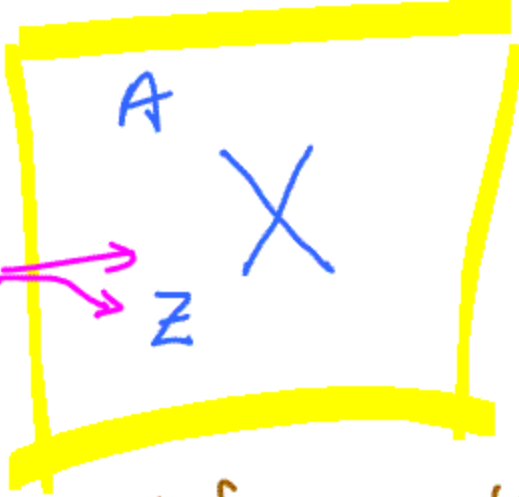
Protons

neutrons

Nucleons populate  
discrete Nuclear quantum states  
(similar to electrons in atom)

MeV energy differences

X, Z  
SAME  
info



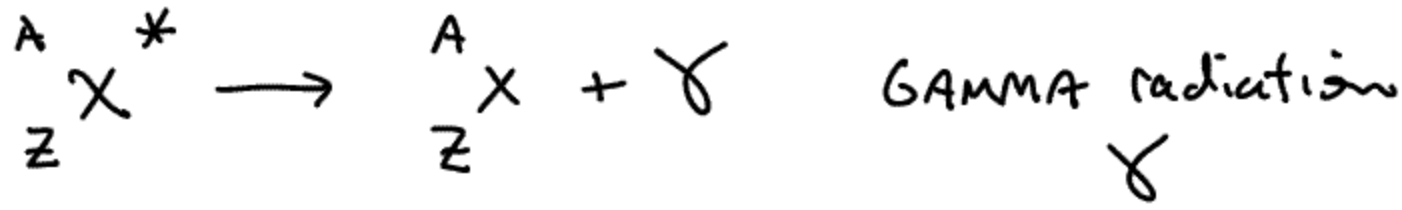
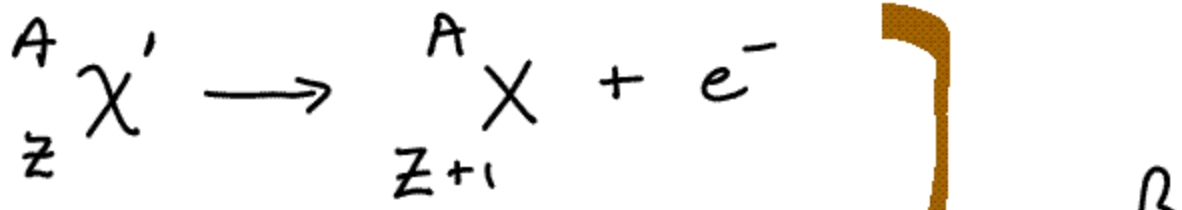
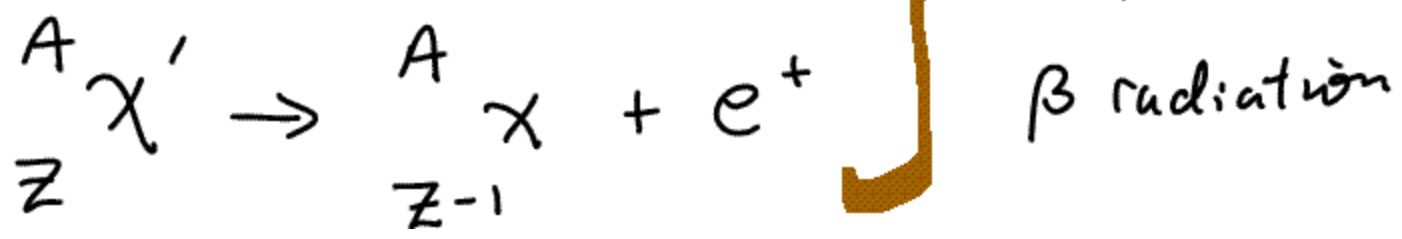
$X \equiv$  Atomic Symbol

$Z \equiv$  # protons

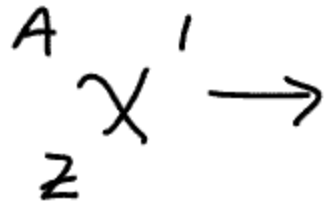
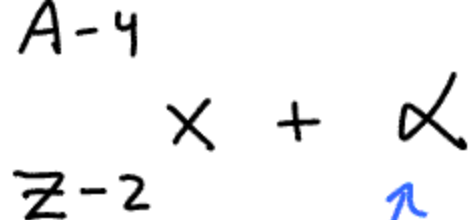
Atomic #

$A \equiv$  Atomic Mass

Symbol for a nucleus  $N \equiv A - Z \equiv$  # neutrons

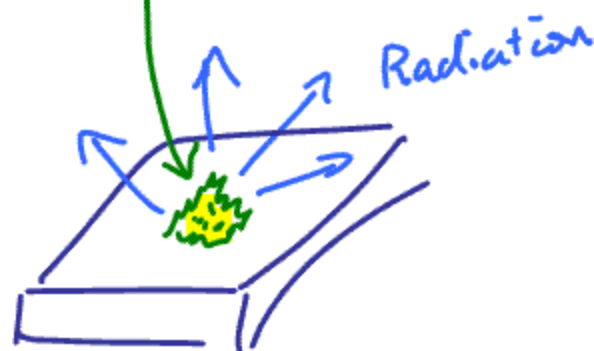


}  $\beta$   
 $\beta$  radiation



Alpha  
radiation

sample of  
Radioactive  
isotope



decay constant

$$\frac{\Delta N}{\Delta t} = \lambda N$$

$N \equiv$  # radioactive  
nuclei in  
sample

Activity  $\equiv$  # nuclei decaying  
per second

$$t_{\frac{1}{2}} = \frac{0.693}{\lambda} \equiv \text{half-life} \equiv \text{time for } \frac{1}{2} \text{ the nuclei to decay}$$

$\left. \begin{matrix} t_{1/2} \\ \lambda \end{matrix} \right\} \equiv$  both characterize how prone a specific type of nucleus is to break down (decay)

large  $\lambda$ , small  $t_{1/2}$  means nuclei prone to decay quickly

Small  $\lambda$ , large  $t_{1/2}$  nuclei tend to stick around longer

$\lambda$  and  $t_{1/2}$  ... measures of the same characteristic

Sort of like a fingerprint for specific type of radioactive nucleus



$N$  atoms in sample  
at time  $= 0$

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

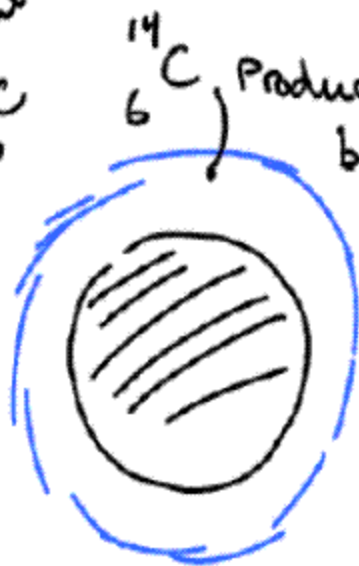
↑  
decay CONSTANT

half life  $\equiv t_{1/2}$  = time for  $\frac{1}{2}$  sample to decay

$$t_{1/2} = \frac{0.693}{\lambda}$$

## Radioactive Dating

Normal  $^{12}_6\text{C}$  contains



$^{14}_6\text{C}$  Produced by cosmic rays hitting atmosphere

$^{14}_6\text{C}$  is naturally radioactive  
 $\beta$ -emitter  
 $t_{1/2} = 5730$  years

- $^{14}_6\text{C}$  incorporated into living tissue
- Stops at death
- $^{14}_6\text{C}/^{12}_6\text{C}$  ratio gives estimate of time since death
- $^{14}_6\text{C}$  concentration in atmosphere varies, calibrate w/ tree rings

A sample of bone

$^{14}\text{C}$  activity to be 25% of that in living material. How old is the bone?

$$^{14}\text{C} \quad t_{\frac{1}{2}} = 5730$$

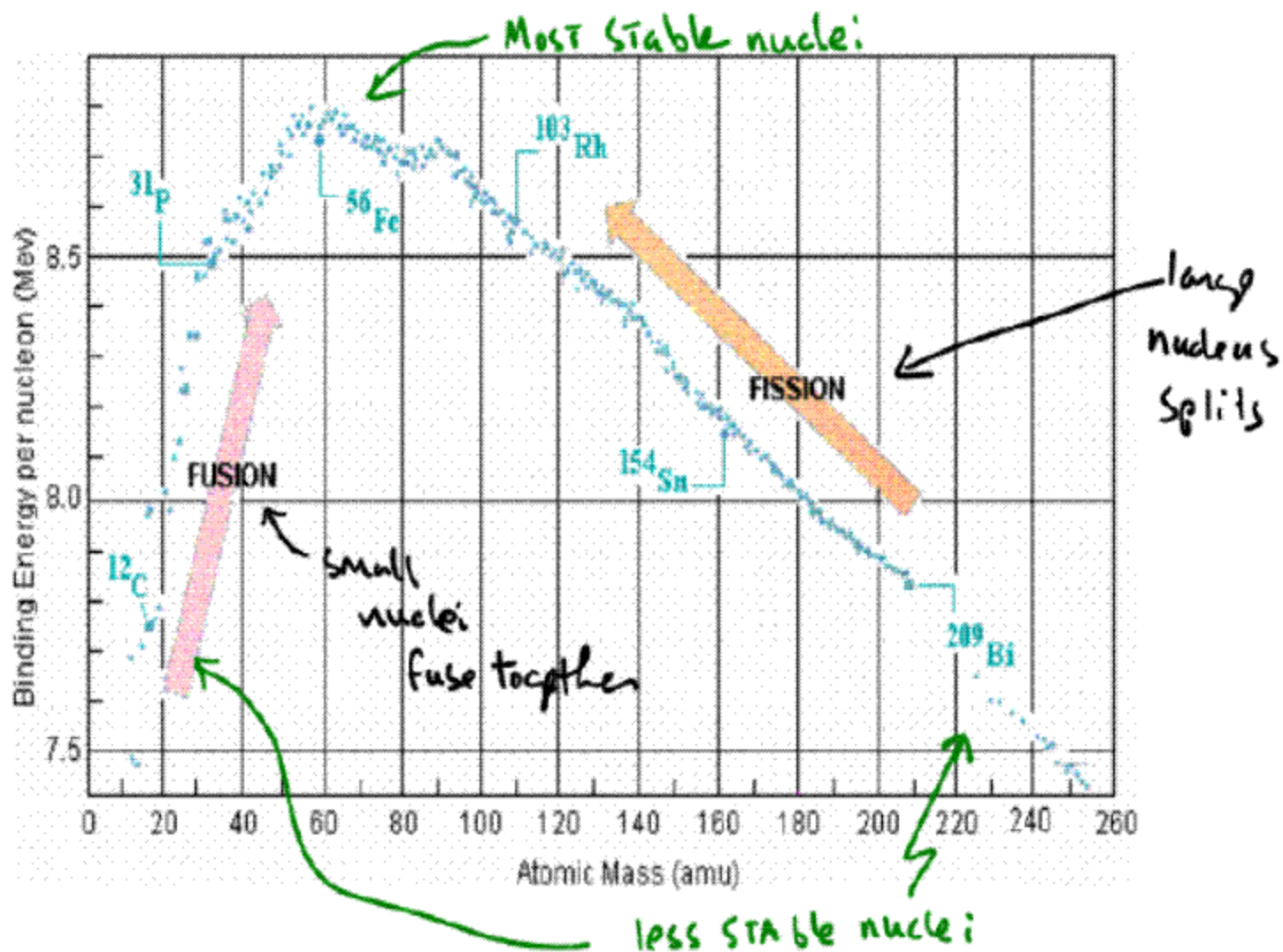
after 1 half life      Activity = 50% of original

after 2      "      "      = 25% of original

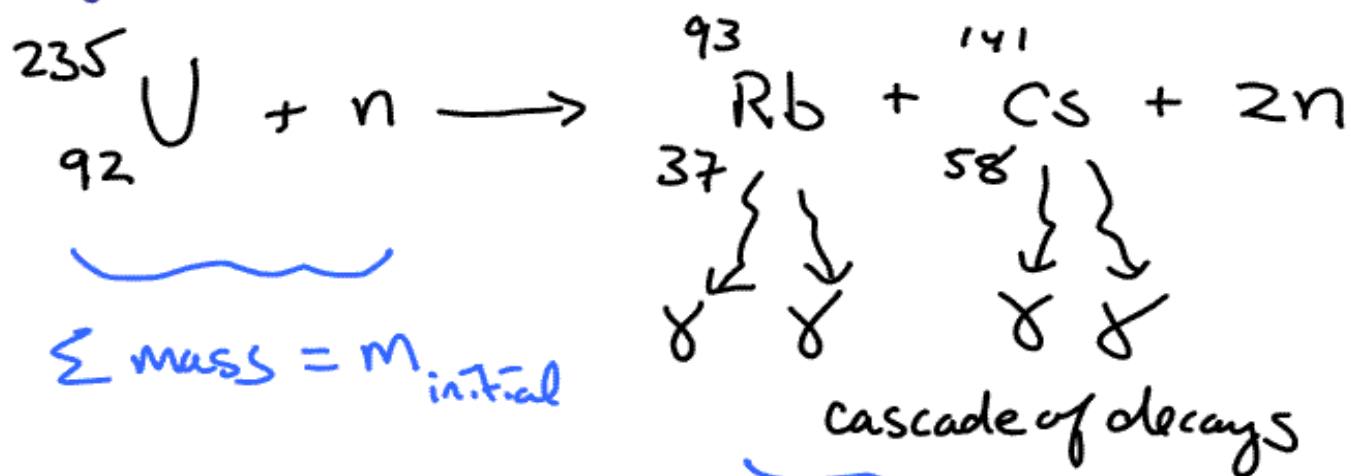
Age  $\sim (2) 5730$  years  $\sim 11,400$  years

# The secret of nuclear power ...

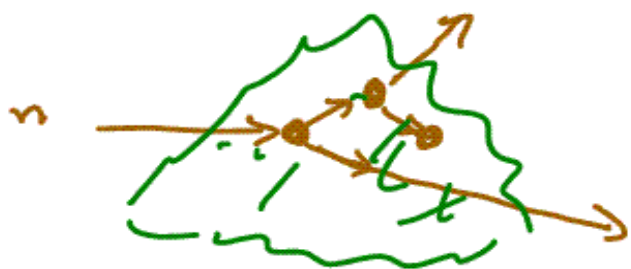
measure of how difficult it is to remove a nucleon (p or n) from the nucleus



A very important nuclear process ...



$$M_{\text{initial}} - M_{\text{final}} > 0 \quad \sum \text{mass} = m_{\text{final}}$$



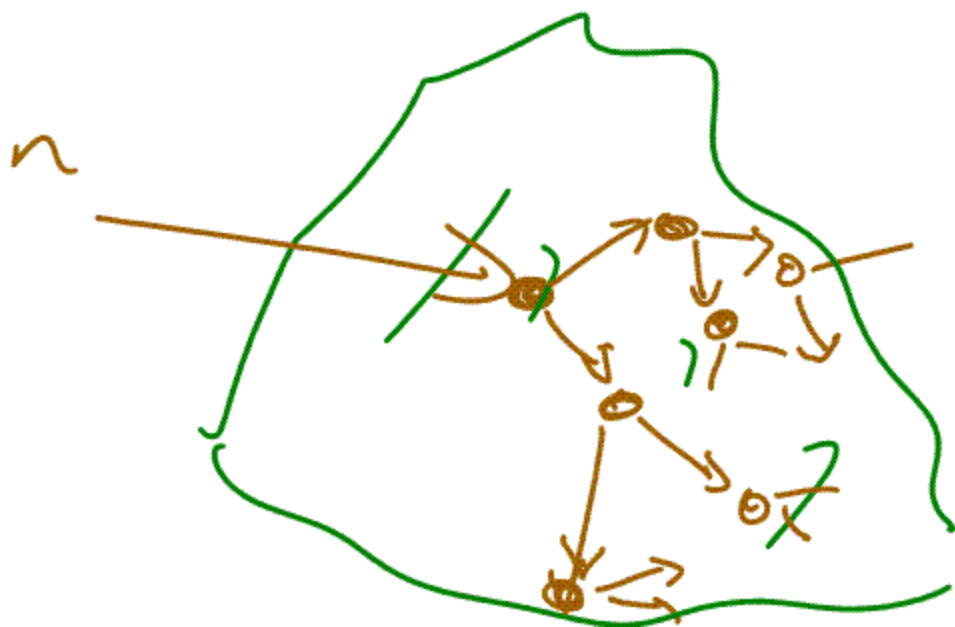
Critical

1 Split per Split



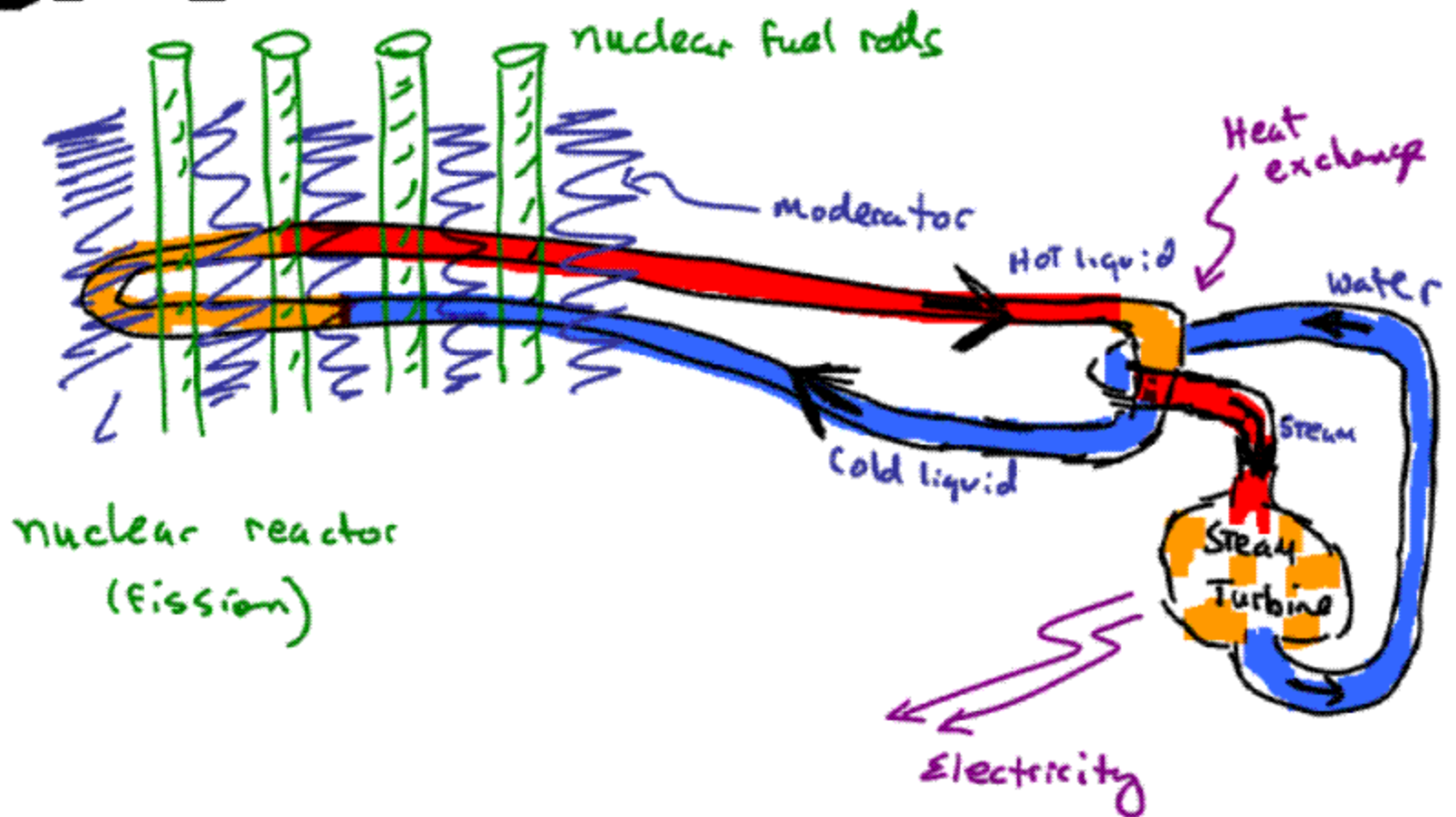
Subcritical

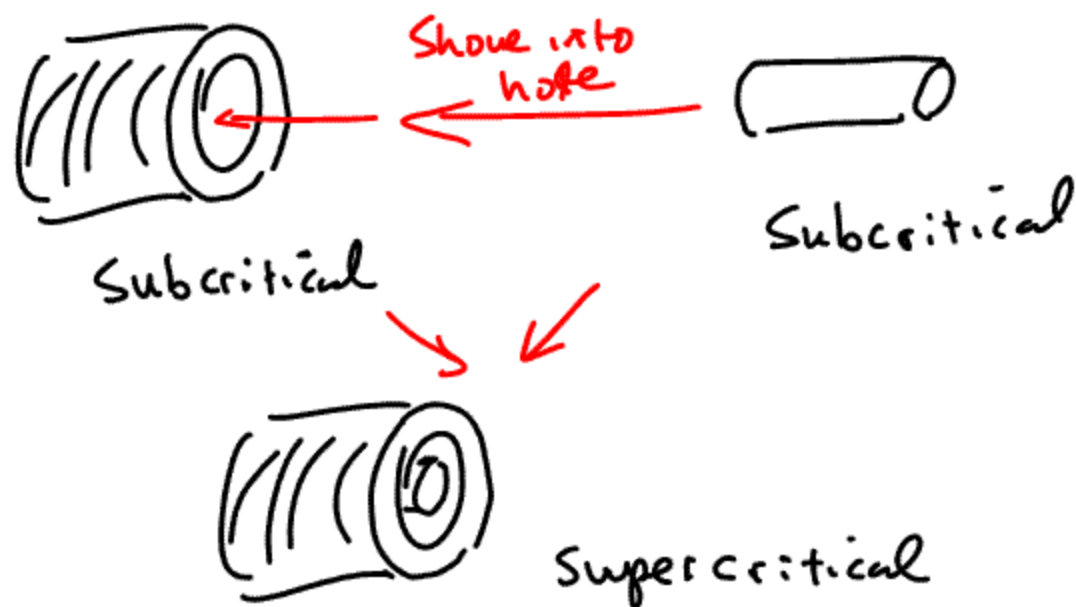
< 1 Split per Split



Supercritical  
> 1 Split per Split

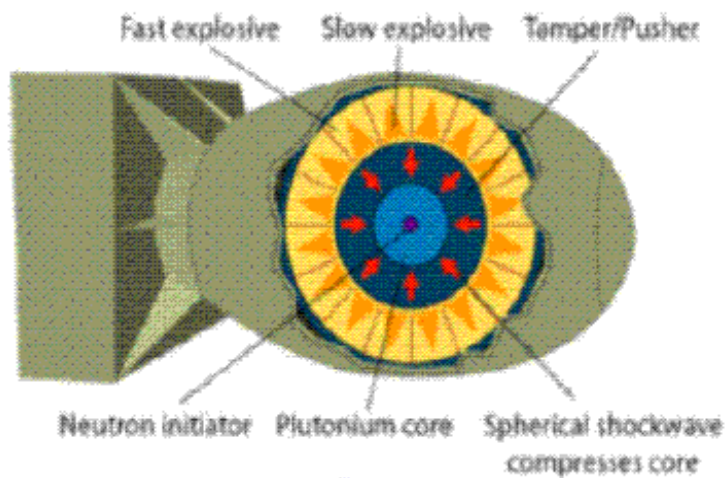
Watch out!





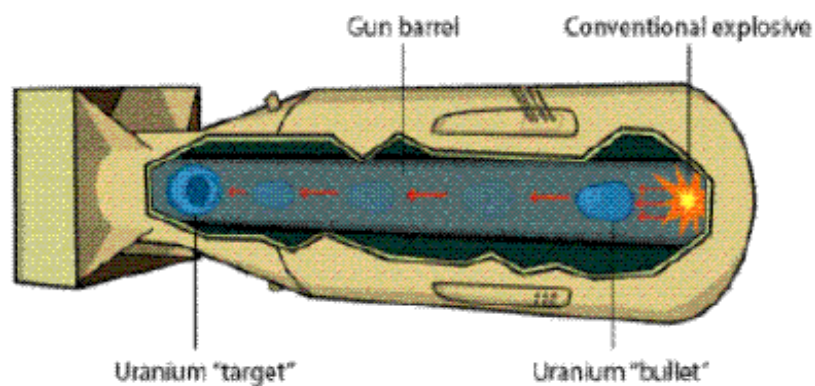
"gun" design for nuclear bomb

... like "little boy" which  
was used on Hiroshima



Similar to Fat Man  
Used on Nagasaki  
Aug. 9, 1945

Similar to Little Boy  
used on Hiroshima  
August 6, 1945



Diagrams  
from  
Wikipedia

