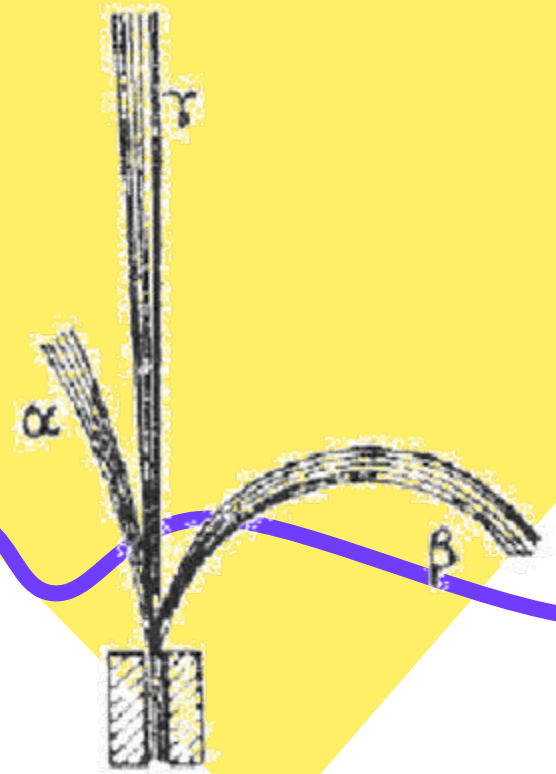
Radioaktivnost

γ



α

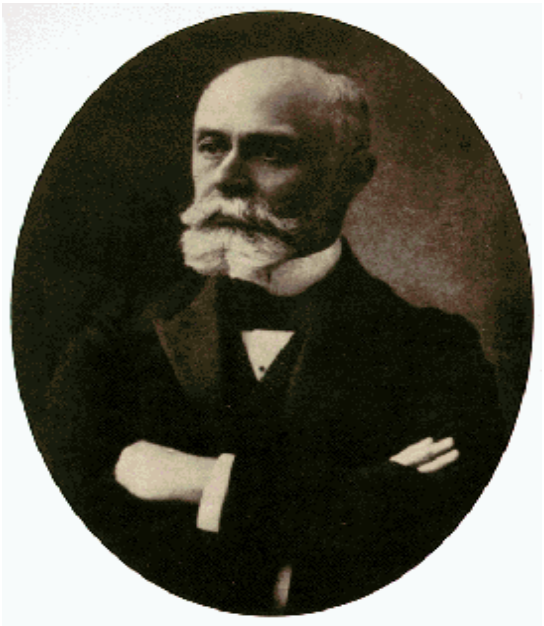
β

Radioaktivnost

- Što je radioaktivnost i kako je pronađena
- Atomske promjene; izotopi
- Vrste radioaktivnosti i radioaktivne čestice
- Prirodna i umjetna radioaktivnost
- Ionizirajuća zračenja
- Apsorbirane godišnje doze, udjeli, mjerne jedinice
- Pravilnosti radioaktivnih raspada
- Korisnost i primjena, opasnosti i zaštita
- Ne ionizirajuća zračenja

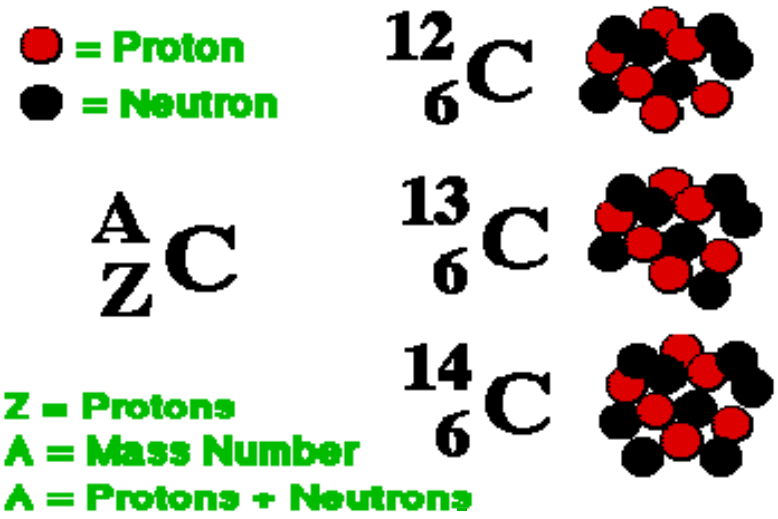
Radioaktivnost - Pronalazak

- 1896 *Becquerel otkriva da nisu svi izotopi atoma stabilni. Atomi mijenjaju strukturu*

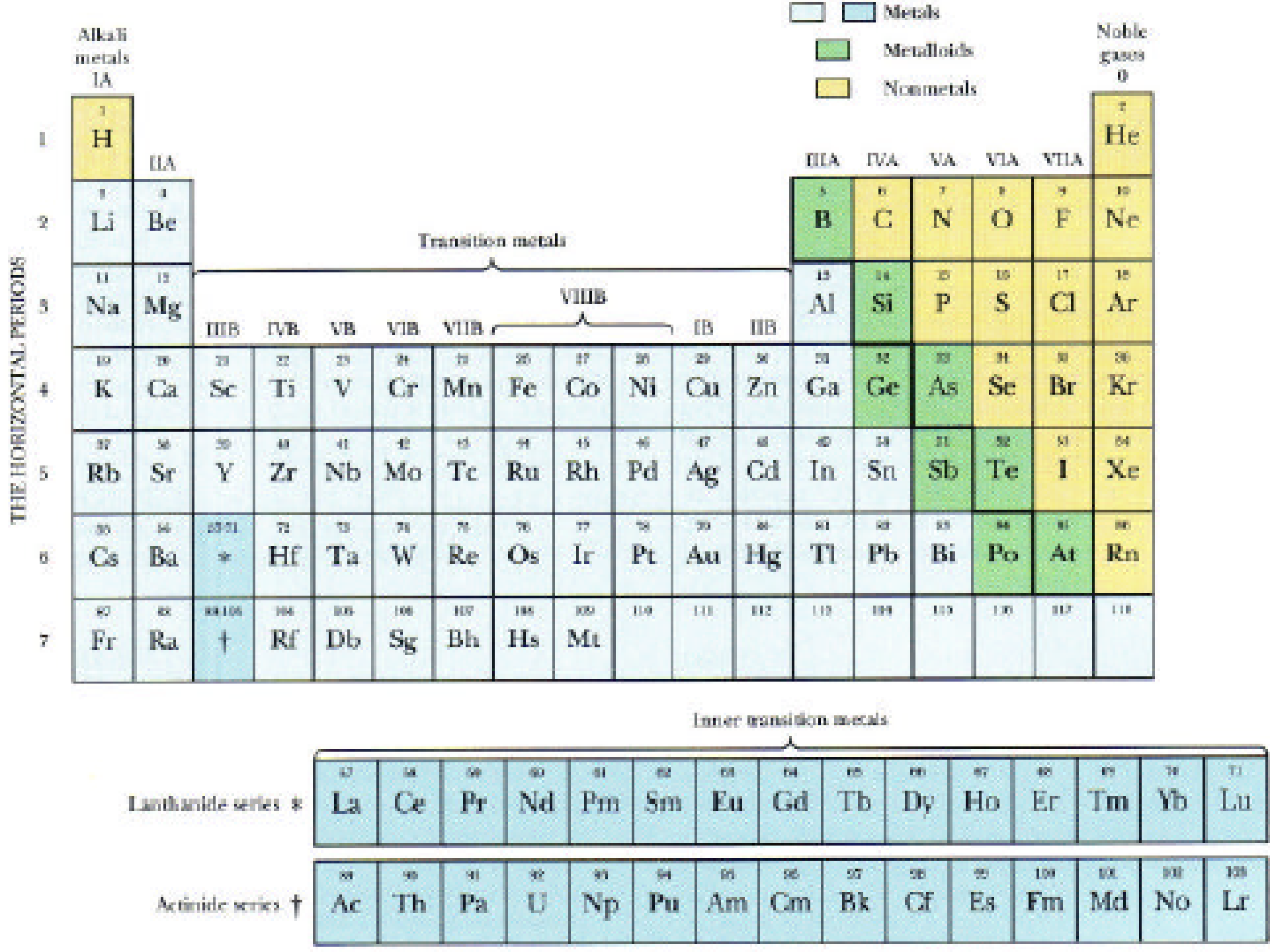


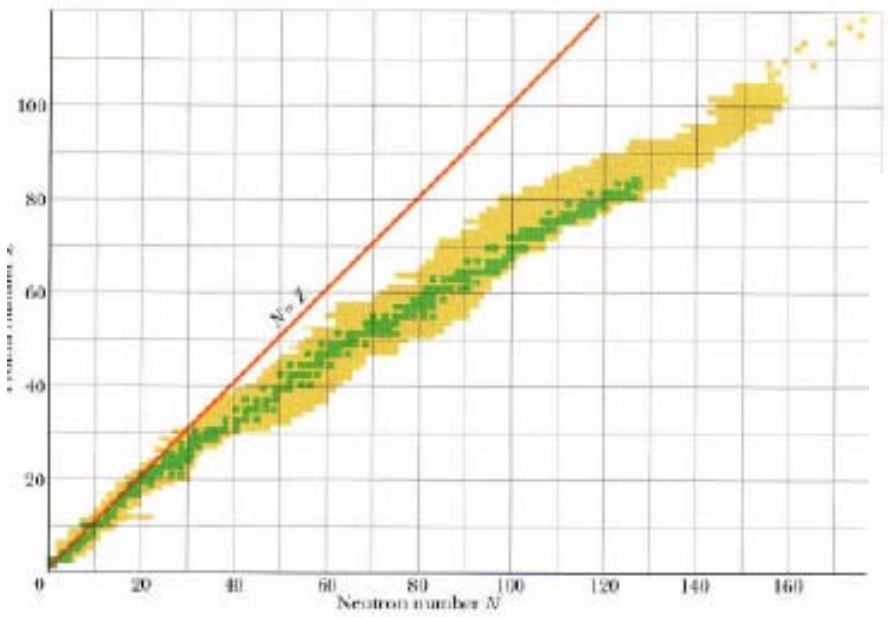
Henri Becquerel

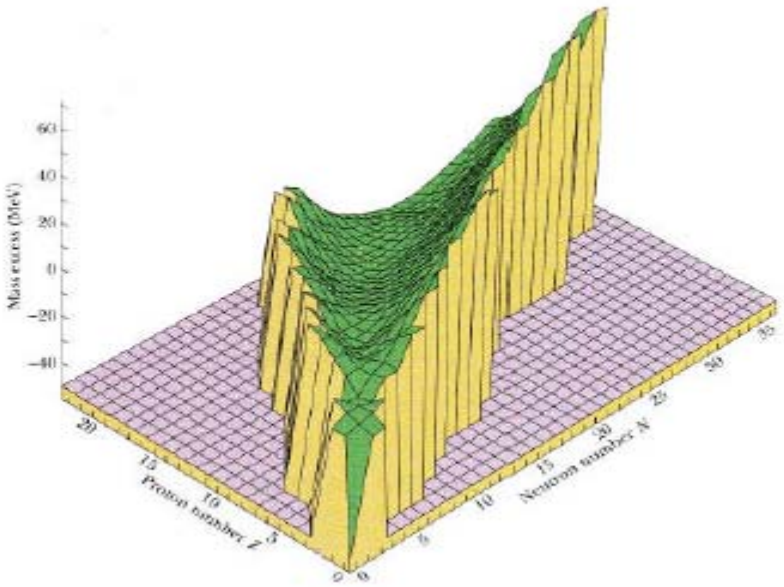
Izotopi

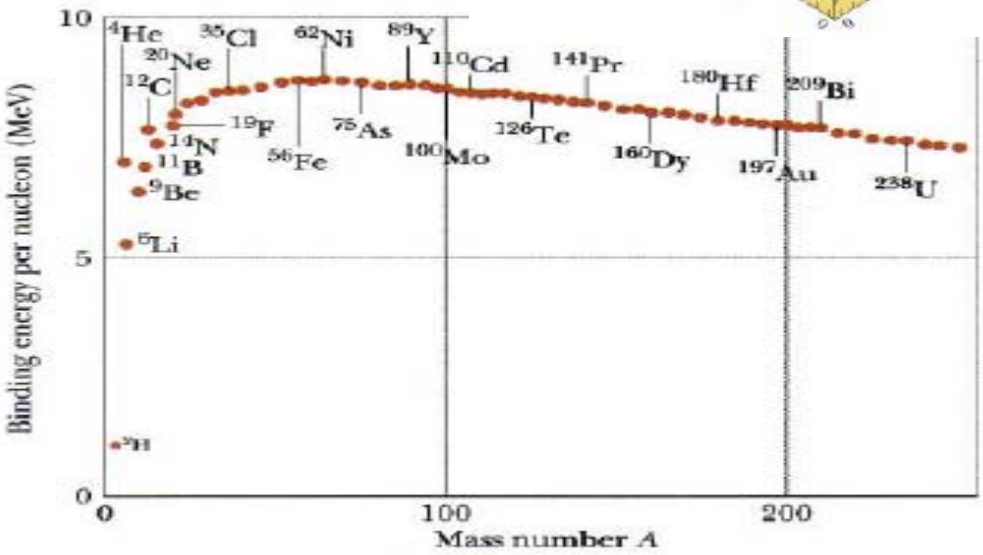


- Atomi s istim brojem protona u jezgri i različitim brojem neutrona nazivaju se izotopi
- Većina atoma ima stabilne i radioaktivne izotope


Metals
Metalloids
Nonmetals
Alkali metals
IA
Noble gases
0
IIA
IIIA
IVA
VA
VIA
VIIA
Transition metals
IIIB
IVB
VB
VIB
VIIB
VIIIB
IB
IIB
THE HORIZONTAL PERIODS
1
2
3
4
5
6
7
H
He
Li
Be
B
C
N
O
F
Ne
Na
Mg
Al
Si
P
S
Cl
Ar
K
Ca
Sc
Ti
V
Cr
Mn
Fe
Co
Ni
Cu
Zn
Ga
Ge
As
Se
Br
Kr
Rb
Sr
Y
Zr
Nb
Mo
Tc
Ru
Rh
Pd
Ag
Cd
In
Sn
Sb
Te
I
Xe
Cs
Ba
*
Hf
Ta
W
Re
Os
Ir
Pt
Au
Hg
Tl
Pb
Bi
Po
At
Rn
Fr
Ra
†
Rf
Db
Sg
Bh
Hs
Mt
Inner transition metals
Lanthanide series *
La
Ce
Pr
Nd
Pm
Sm
Eu
Gd
Tb
Dy
Ho
Er
Tm
Yb
Lu
Actinide series †
Ac
Th
Pa
U
Np
Pu
Am
Cm
Bk
Cf
Es
Fm
Md
No
Lr


N = Z
Neutron number N


Mass excess (MeV)
Proton number Z
Neutron number N

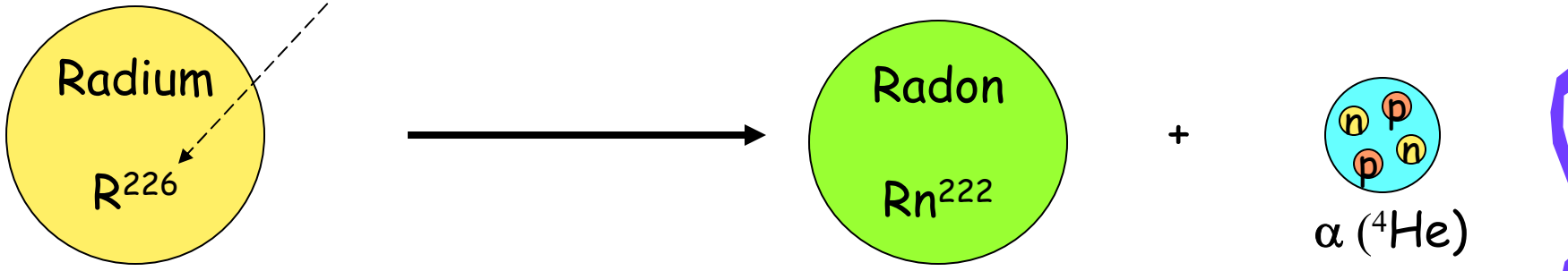

Binding energy per nucleon (MeV)
Mass number A
4He
35Cl
62Ni
89Y
20Ne
110Cd
141Pr
180Hf
209Bi
12C
19F
75As
126Te
14N
56Fe
160Dy
11B
100Mo
197Au
9Be
238U
6Li
2H

Klasifikacija radioaktivnih zračenja

- Čestice:
  - Alfa (α) zračenje
  - Beta (β) zračenje
  - Protoni
  - Neutroni
- Elektromagnetska zračenja:
  - γ-zrake
  - X-zrake

Alfa čestice (α)

Atomska težina:
odražava ukupan broj nukleona u jezgri
Broj protona + broj neutrona



88 protona
138 neutrona

86 protona
136 neutrona

2 protona
2 neutrona

alpha-čestica (α) je jezgra atoma **helija**.

Beta čestice (β)

+

6 protona
8 neutrona

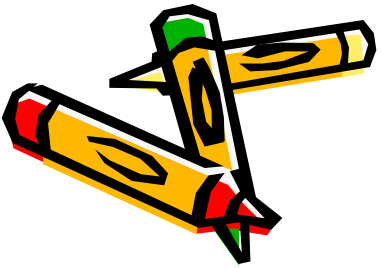
7 protona
7 neutrona

elektron
(beta-čestica)

Konverzija neutrona u proton (zakoni očuvanja)

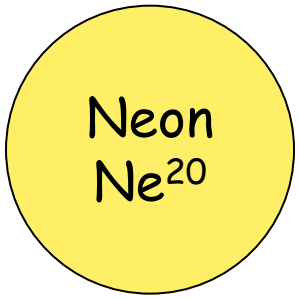
$n \rightarrow p + e \quad (+ \nu)$

neutrino
Povijesno veoma važna priča



Gama čestice (γ)

10 protona
10 neutrona
(pobuđeno stanje)



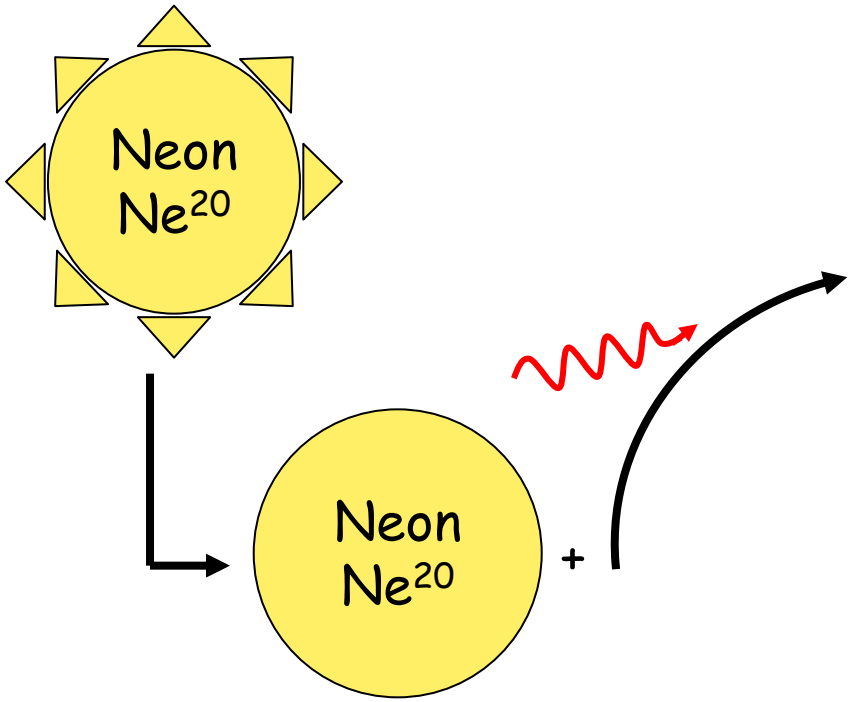
10 protona
10 neutrona
(osnovno stanje)

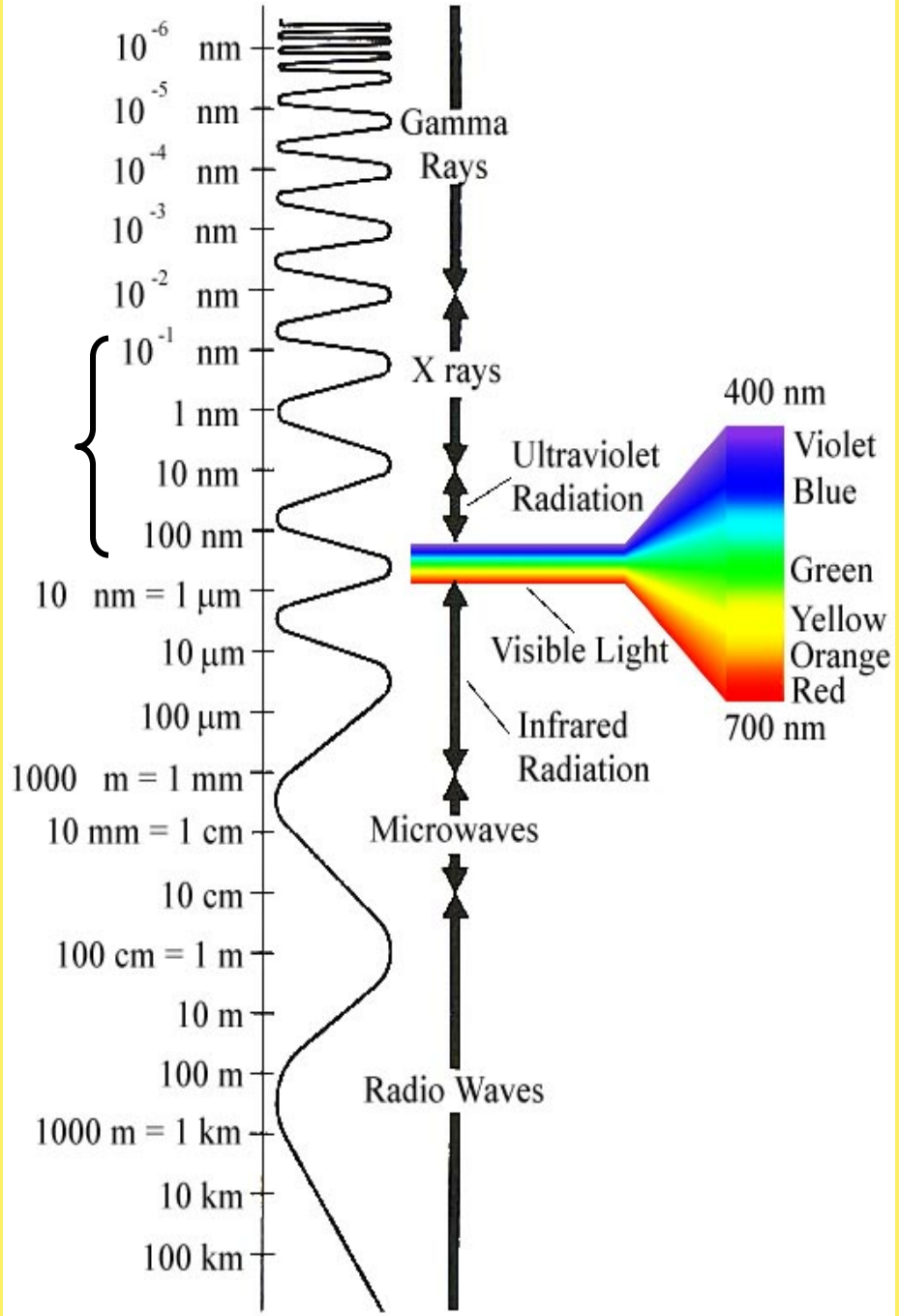
+

gama

gama visokoenergijsko em zračenje

Gama zračenje





Karakteristike ionizirajućih zračenja zračenja

Tipovi radioaktivnosti:

- *Gama* zračenje; velika penetracija
- *Alfa* čestice brzo gube energiju, zaustavlja ih list papira
- *Beta* vrlo brzi elektroni

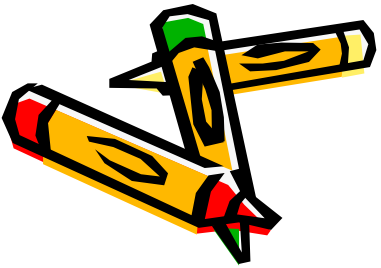
- *Neutroni i protoni*

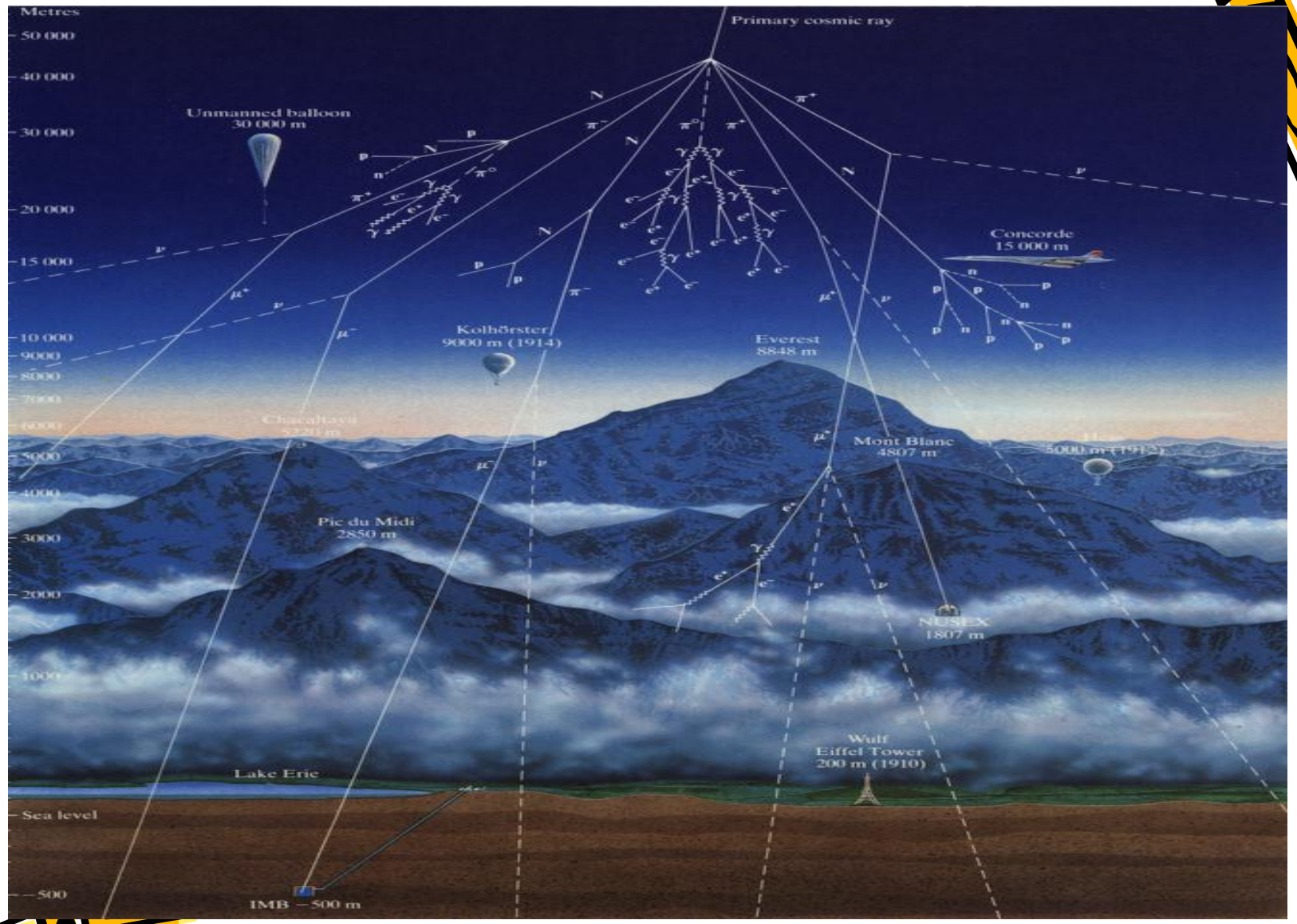
Čestica	masa* (MeV/c^2)	naboj
Gama (γ)	0	0
Beta (β)	~0.5	-1
Alfa (α)	3752	+2
p, n	938	+1,0

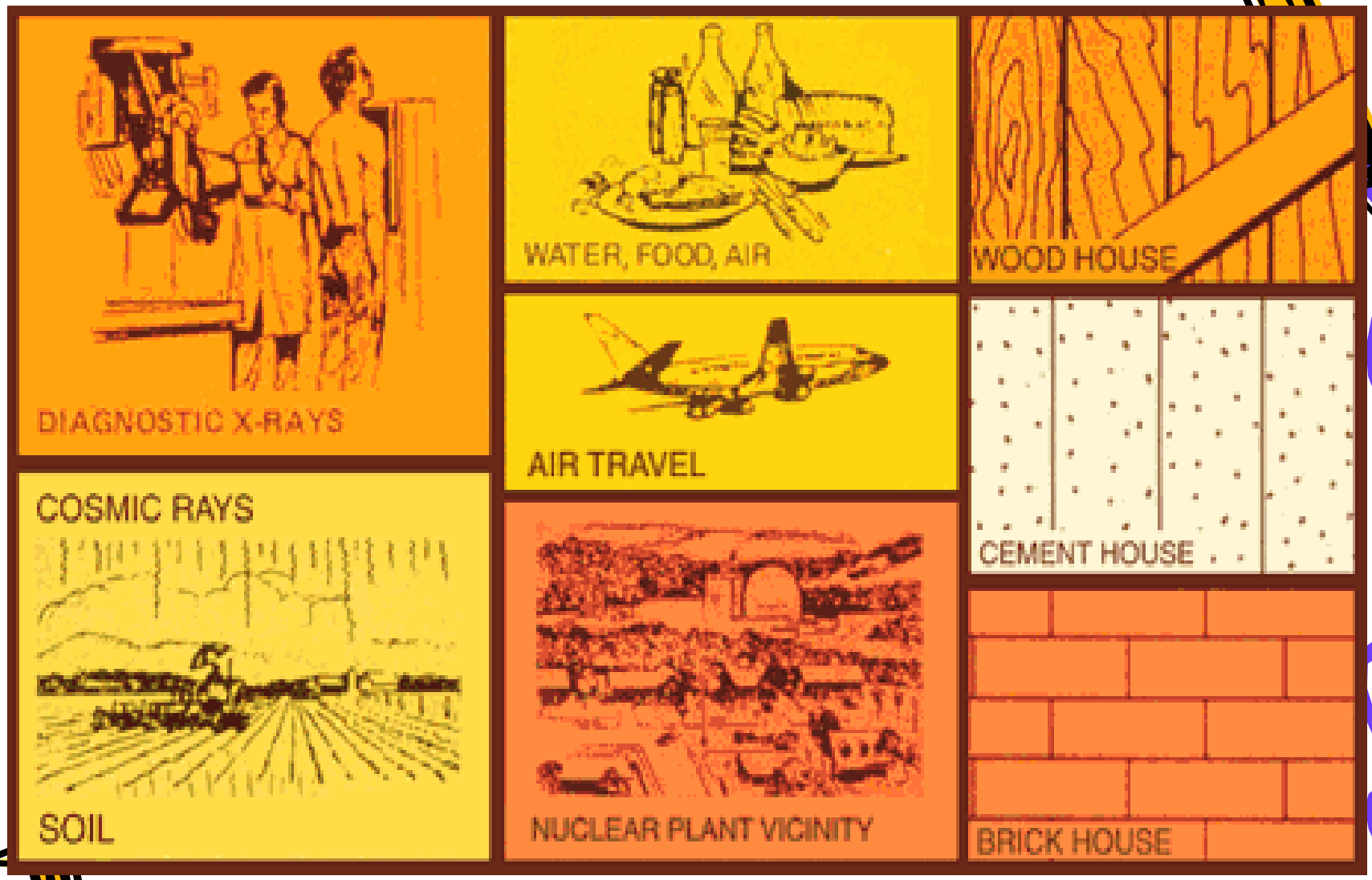
* $m = E / c^2$

Izvori radioaktivnog zračenja

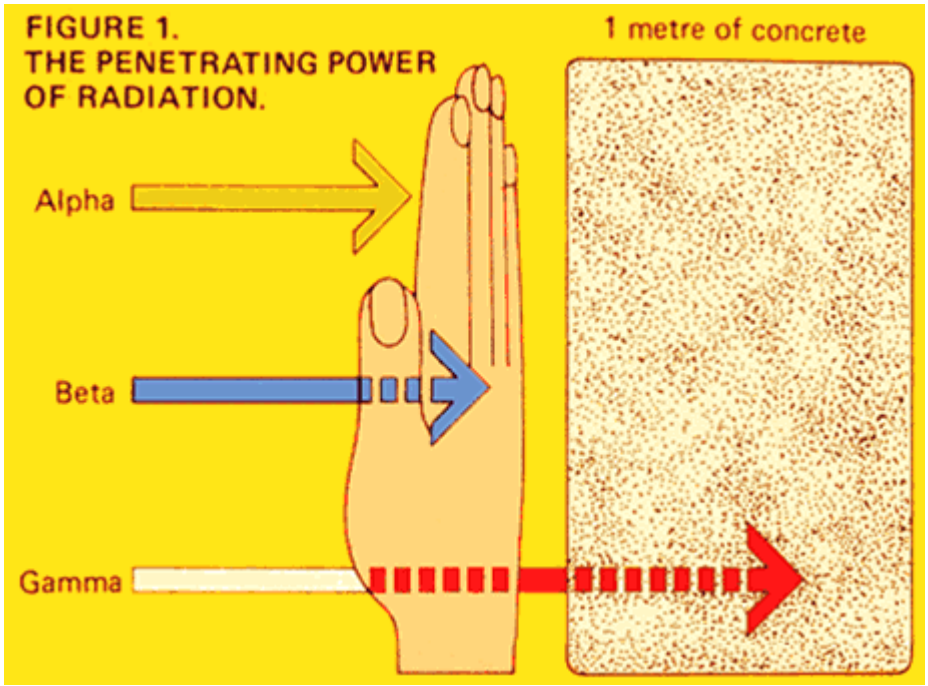
- Prirodni izvori
  - Zemaljski
  - Kozmički
  - Materijali za gradnju
  - Radioaktivni elementi u našem organizmu
- Umjetni izvori
  - Medicinske X-zrake
  - Nuklearna medicina
  - Nuklearne probe
  - Nuklearne elektrane
  - Nuklearne katastrofe




Metres
50 000
40 000
30 000
20 000
15 000
10 000
9000
8000
7000
6000
5000
4000
3000
2000
1000
Sea level
500
Primary cosmic ray
Unmanned balloon
30 000 m
Kolhörster
9000 m (1914)
Everest
8848 m
Concorde
15 000 m
Chacaltaya
5200 m
Mont Blanc
4807 m
Pic du Midi
2850 m
NUSEX
1807 m
Wulf
Eiffel Tower
200 m (1910)
Lake Erie
IMB — 500 m


DIAGNOSTIC X-RAYS
WATER, FOOD, AIR
WOOD HOUSE
AIR TRAVEL
COSMIC RAYS
CEMENT HOUSE
SOIL
NUCLEAR PLANT VICINITY
BRICK HOUSE

Penetracija zračenja



Mjerenje radioaktivnosti

Becquerel (Bq) – jedan raspad u sekundi (1dps)

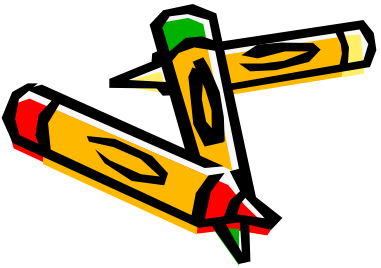
Curie (Ci) = 3.7×10^{10} dps

Gray (Gy) – zračenje koje u 1 kg materijala deponira 1 joule (J) energije

rad = 0.01 Gy

Sievert (Sv) – uključeni težinski faktori zračenja

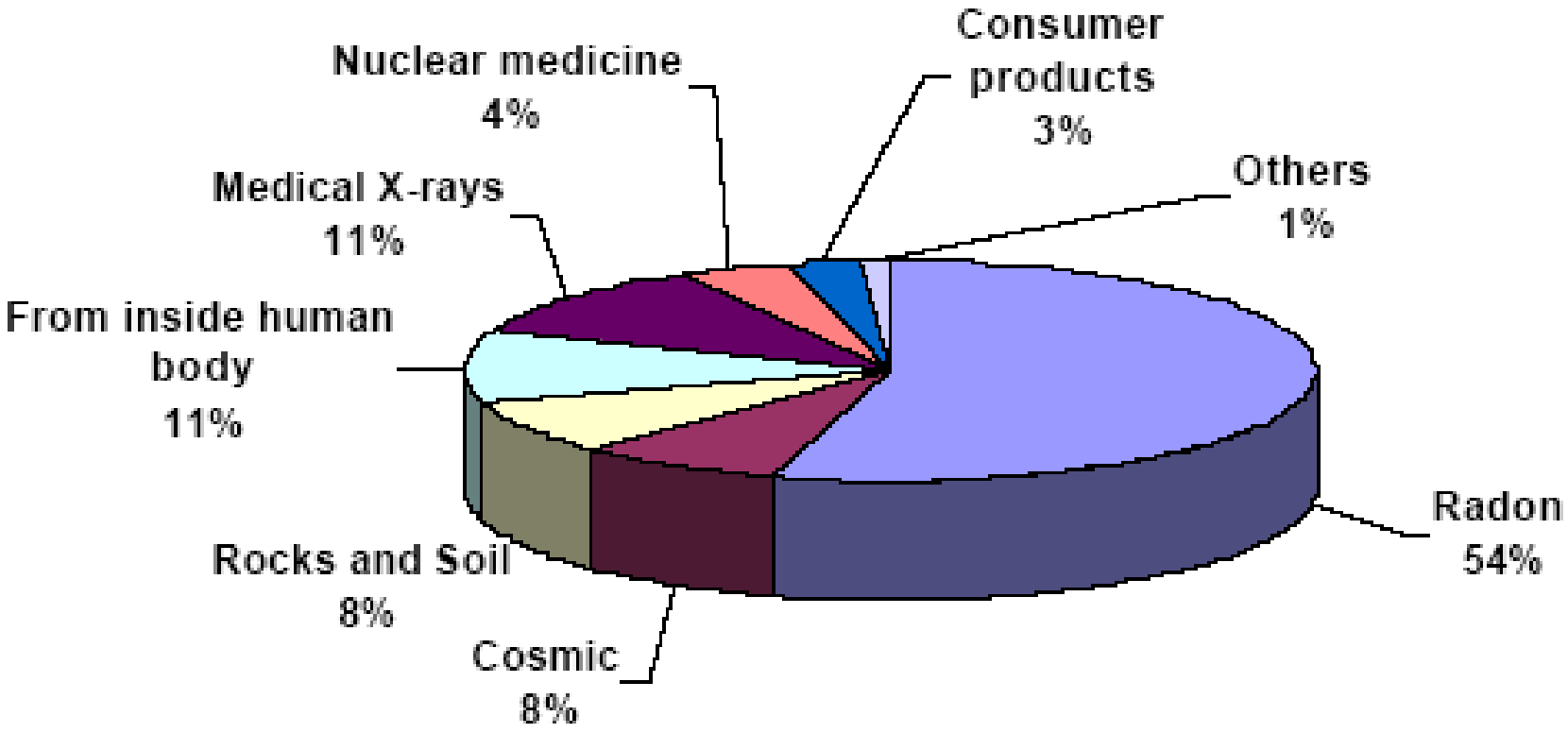
rem = 0.01 Sv



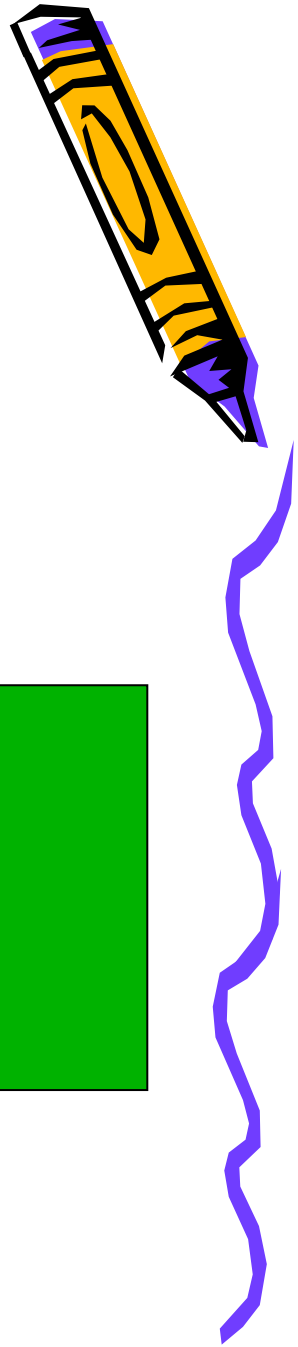
Težinski faktori učinka zračenja na tkiva

α	20
β	1
γ	1
p	10
n	2-20

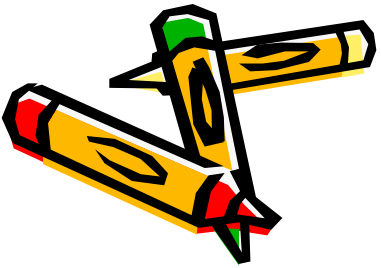
Udjeli u apsorbiranoj dozi za čovjeka (prosječno 360 mrem/god)



Radioaktivni raspad (motivacija)



- Tip zračenja!
- Kako često atom emitira zračenje?
- Ne možemo predvidjeti kada će se atom raspasti!
- Vjerojatnost raspada za svaki pojedini atom
- Poluživot; definicija



Radioaktivni raspad (opća jednadžba)

- Aktivnost (A) = - $dN/dt = \lambda N$

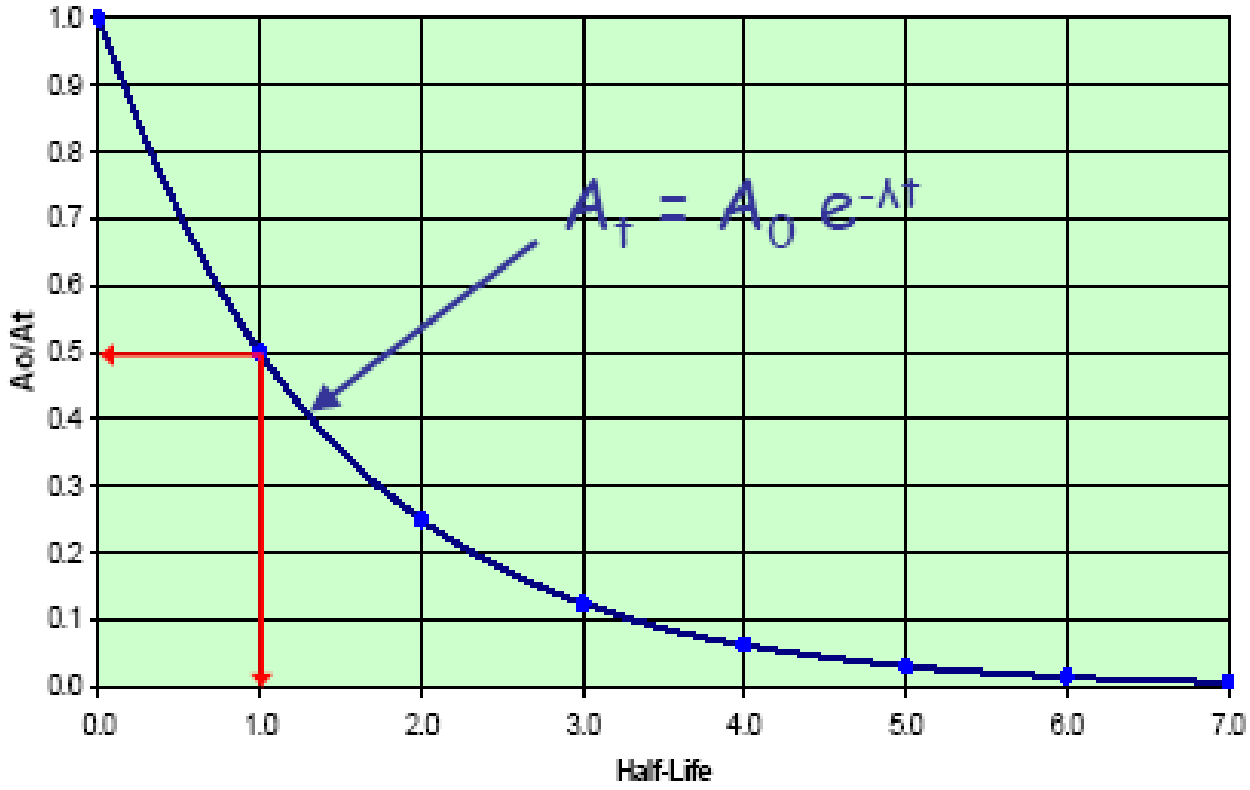
  Gdje je:

  - λ = konstanta raspada (jedinica = 1/vrijeme)
  - N = broj radioaktivnih atoma
- Poluživot ($t_{\frac{1}{2}}$) = $\ln 2/\lambda = 0.693/\lambda$
- Raspad izotopa: $A_t = A_0\, e^{-\lambda t}$

  Gdje je:

  - A_0 = aktivnost u t = 0
  - A_t = aktivnost

Radioaktivni raspad



Poluživot (primjer)

☎ Vrijeme u kojem se raspadne polovica prisutnih radioaktivnih čestica (neutron vrijeme ½ života oko 15 minuta)

☎ Uzmimo da imamo 20000 neutrona, što će biti nakon 1 sat?

Vrijeme	#neutrona	% neutrona u uzorku
Nakon 15 minuta	**10,000**	**(50%)**
Nakon 30 minuta	**5,000**	**(25%)**
Nakon 45 minuta	**2,500**	**(12.5%)**
Nakon 60 minuta	**1,250**	**(6.25%)**

URANIUM 238 (U238) RADIOACTIVE DECAY